Semiconductors

Book S3 1988

Small-signal transistors

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SMALL-SIGNAL TRANSISTORS

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	page
BC107			45				(125–500)			2		65
BC108	n-p-n	TO-18	20	100	300	25	(125–900)	2	> 300	2		65
BC109			20				(240–900)			1,2	low-noise type	65
BC140	n-p-n	TO-39	40	1000	3700	45*	40–250	100	> 50			79
BC141			60									79
BC160	p-n-p	TO-39	40	1000	3700	45*	40–250	100	> 50			83
BC161			60									83
BC177			45				(75–260)			–		87
BC178	p-n-p	TO-18	25	100	300	25	(125–500)	2	150	–		87
BC179			20				(125–500)			1,2	low-noise type	87
BC327			45									99
BC327A	p-n-p	TO-92 var.	60	500	800	25	100–600	100	100	–	driver and output stages	99
BC328			25									99
BC337			45									105
BC337A	n-p-n	TO-92 var.	60	500	800	25	100–600	100	200	–	driver and output stages	105
BC338			25									105
BC368	n-p-n	TO-92 var.	20	1000	800	25	85–375	500	60	–	class-B audio output stage	111
BC369	p-n-p	TO-92 var.	20	1000	800	25	85–375	500	60	–		119
BC375	n-p-n	TO-92 var.	20	1000	800	25	60–340	150	150	–	output stage	127
BC376	p-n-p	TO-92 var.	20	1000	800	25	60–340	150	150	–		129
BC546			65				(110–450)					135
BC547	n-p-n	TO-92 var.	45	100	500	25	(110–800)	2	300	2	driver stage audio amplifier	135
BC548			30				(110–800)					135
BC549	n-p-n	TO-92 var	30	100	500	25	(240–800)	2	300	1,4	low-noise stage	145
BC550			45									145

* 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	page
BC556			65				(75–475)					157
BC557	p-n-p	TO-92 var.	45	100	500	25	(75–800)	2	150	2	driver stage audio amp.	157
BC558			30				(75–800)					157
BC559	p-n-p	TO-92 var.	30	100	500	25	(125–800)	2	150	1,2	low-noise types	163
BC560			45							1		163
BC635			45				40–250					171
BC637	n-p-n	TO-92 var.	60	1000	1000	25	40–160	150	130	–	driver stage	171
BC639			80				40–160					171
BC636			45									177
BC638	p-n-p	TO-92 var.	60	1000	1000	25	40–250	150	50	–	driver stage	177
BC640			80									177
BCY56	n-p-n	TO-18	45	100	300	25	100–450	2	85	1,5	low-noise types	191
BCY57			20				200–800		100			191
BCY58	n-p-n	TO-18	32	200	330	45	(125–700)	2	> 150	2	switching	195
BCY59			45									195
BCY70			40							2,0		209
BCY71	p-n-p	TO-18	45	200	350	25	> 100	10	450	0,8	low-noise types	209
BCY72			25							2,0		209
BCY78	p-n-p	TO-18	32	200	345	45	(125–700)	2	180	2	switching	225
BCY79			45									225
BCY87*										< 3	pre-stages of	233
BCY88*	p-n-p	TO-71	40	30	150	25	100–450	0,05	> 10	< 4	differential amplifier	233
BCY89*										< 4	long-tailed pairs	233

* 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	page
MPS6513			30				> 60					523
MPS6514	n-p-n	SOT-54	25	100	625	25	> 90	100				523
MPS6515			25				> 150					523
MPS6517			40				> 60					525
MPS6518	p-n-p	SOT-54	40	100	625	25	> 90	100				525
MPS6519			25				> 150					525
MPS6520	n-p-n	TO-92	25	100	625	25	200–400	2		< 3	low noise amplifier	527
MPS6521							300–600					527
MPS6522	p-n-p	TO-92	25	100	625	25	200–400	2		< 3	low noise amplifier	
MPS6523							400–600					
MPSA05	n-p-n	TO-92	60	500	625	25	> 50	10	>100		driver stage	531
MPSA06			80									531
MPSA55	p-n-p	TO-92	60	500	625	25	> 50	100	>50		driver stage	537
MPSA56			80									537
2N930	n-p-n	TO-18	45	30	300	25	100–350 150–600	10	80	2,5 2,0	low-level, low-noise amplifier	579
2N2483	n-p-n	TO-18	60	50*	360	25	<500	10	80	4	low-level, low noise amplifiers	623
2N2484							<800			3		623
2N4030			60				40–120		>100			661
2N4031	p-n-p	TO-39	80	1000	800	25	40–120	100	>100		large-signal, low-noise,	661
2N4032			60				100–300		>150		low-power	661
2N4033			80				100–300		>150			661
2N4123	n-p-n	TO-92	30	200	350	25	(50–200)		>250	6		665
2N4124			25				(120–480)		>300	5	small-signal, low-power	665
2N4125	p-n-p	TO-92	30	200	350	25	(50–200)	2	>200	5		667
2N4126			25				(120–480)		>250	4		667

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} at mW	T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe}) at	I_C mA	f_T MHz typ.	F dB typ.	remarks	page
2N4400	n-p-n	TO-92	40	600	625	25	50–150	100	>200		driver stage	669
2N4401							100–300		>250			669
2N4402	p-n-p	TO-92	40	600	625	25	50–150	150	>150		driver stage	673
2N4403			40	600			100–300	150	>200			673
2N5086	p-n-p		50	50			150	1	> 40	3	low noise	677
2N5087			50	50			250	1	> 40	2		677
2N5088	n-p-n	TO-92	30	50	625	25	350	1	> 50	3	low noise	681
2N5089												681
2N5400	p-n-p	TO-92	120	600	625	25	40–180	10	>100	8	high-voltage driver	685
2N5401			150				60–240	10	>100	8		685
2N5550	n-p-n	TO-92	140	600	625	25	60–250	10	>100	10	high-voltage driver	693
2N5551			160				60–250	10	>100	8		693

* I_{CM}.

Transistors for h.f. 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	C_{re} pF typ.	f_T MHz typ.	F dB typ. at	f MHz	remarks	page
BF198	n-p-n	TO-92 var.	30	25	500	25	>10	15	0,20	400	3	35	gain-controlled TV i.f. amp.	241
BF199	n-p-n	TO-92 var.	25	25	500	25	>38	7	0,30	550			output video i.f. amp.	255
BF240	n-p-n	TO-92 var.	40	25	250	25	67–220	1	0,34	380	3,5	0,2	a.m. mixers and i.f. amp. in a.m./f.m. receivers	261
BF241							36–125			350				261
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	265
BF370	n-p-n	TO-92 var.	15	100	500	25	>40	10	1,6	>500			large signal, i.f. amp.	271

* C_{br}

Transistors for h.f. applications

			RATINGS				CHARACTERISTICS							
type number	polarity	envelope	V_{CEO} V	I_C mA	P_{tot} mW at	T_{amb} °C	h_{FE} at	I_C mA	C_{re} pF	f_T MHz	F db at	f MHz	remarks	page
BF420	n-p-n	TO-92 var.	300 ▲	50	830	25	> 50	25	1,0	> 60			class-B video output	275
BF421	p-n-p	TO-92 var.	300 ▲	50	830	25	> 50	25	1,1	> 60			class-B video output	281
BF422	n-p-n	TO-92 var.	250	50	830	25	> 50	25	1,0	> 60			class-B video output	275
BF423	p-n-p	TO-92 var.	250	50	830	25	> 50	25	1,1	> 60			class-B video output	281
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.	287 287
BF483 BF485 BF487	n-p-n	TO-92 var.	250 300 350	100	830	25	> 50	25	1,4	> 70			video output	291 291 291
BF494	n-p-n	TO-92 var.	20	30	300	75	typ. 115	1	0,85	260	4	100	osc.,i.f. amp. in a.m./f.m. receivers	295
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	303
BF496	n-p-n	TO-92 var.	20	20	300	75	> 12	2	0,80	550	2	100	gain-controlled v.h.f. amp.	311
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.	315
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.	317
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.	319
BF967	p-n-p	SOT-37	30	20	160	55	> 15	3	0,45	900	4	800	gain-controlled v.h.f. amp.	323
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	329
BF970A	p-n-p	SOT-37	40	30	160	55	> 25	3		900	4,7	800		331
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	334
BFR54	n-p-n	TO-92 var.	15	500*	500	25	> 40	10		> 500			freq. multipliers	337

For data on tetrode-MOS-FET types for v.h.f./u.h.f. applications see Handbook Field-effect transistors.

▲ V_{CER}.
* I_{CM}. ** T_{mb}.

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	f_T MHz	F dB	at f MHz	remarks	page
MPSA42 MPSA43	n-p-n	TO-92	300 200	500	625	25	> 40	30		> 50			high voltage, switching	535 535
MPSA92 MPSA93	p-n-p	TO-92	300 200	500	625	25	> 25	30		> 50			high voltage, switching	541 541

Transistors for switching 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	f_T MHz typ.	t_{off} ns max.	at I_C mA	remarks	page
BC516	p-n-p	TO-92 var.	30	400	625	25	>30,000	20	220			darlington transistors	131
BC517	n-p-n	TO-92 var.	30	400	625	25	>30,000	20	220				133
BCX58 BCX59	n-p-n	TO-92 var.	32 45	200	450	25			> 125				183 183
BCX78 BCX79	p-n-p	TO-92 var.	32 45	200	450	25			> 200				187 187
BCY58 BCY59	n-p-n	TO-18	32 45	200	330	45	80–1000	10	280	800	10		195 195
BCY65	n-p-n	TO-18	60	200	330	45	200–330	2	⩾ 125	800	10		205
BCY70 BCY71 BCY72	p-n-p	TO-18	40 45 25	200	350	25	> 100	10	450	420 420	10 10	BCY71 is low-noise version	209 209 209
BCY78 BCY79	p-n-p	TO-18	32 45	200	345	45	80–1000	10	180	800	10	amplifying and switching	225 225

Transistors for switching applications

type number	polarity	envelope	V_{CEO} V	RATINGS I_C mA	RATINGS P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE}	at I_C mA	f_T MHz typ.	t_{off} ns max.	I_C mA	remarks	page
BFT44	p-n-p	TO-39	300	500	5000	50**	50–150	10	70	125	500		345
BFT45			250										345
BFX34	n-p-n	TO-39	60	2000	5000	25**	40–150	2000	> 70	1200	5000	inverter and switching regulators	353
BFY50	n-p-n	TO-39	35	1000	5000	50**	typ. 112	150	140	360	150	general purpose	359
BFY51			30				typ. 123		160				359
BFY52			20				typ. 142		185				359
BFY55	n-p-n	TO-39	35	1000	800	25	40-120	150	> 60				379
BSR50	n-p-n	TO-92 var.	45*	1000	800	25	>2000	500		1500	500	Darlington transistors	423
BSR51			60*										423
BSR52			80*										423
BSR60	p-n-p	TO-92 var.	45*	1000	800	25	>2000	500		1500	500	Darlington transistors	429
BSR61			60*										429
BSR62			80*										429
BSS38	n-p-n	TO-92 var.	100	100	500	25	> 20	4	> 60	1000	15	driver for numerical indicator tube	435
BSS50	n-p-n	TO-39	45*	1000	5000	25**	>2000	500		1000	500	Darlington transistors	439
BSS51			60*										439
BSS52			80*										439
BSS60	p-n-p	TO-39	45*	1000	5000	25**	>2000	500		1500	500	Darlington transistors	447
BSS61			60*										447
BSS62			80*										447
BSS68	p-n-p	TO-92 var.	100	100	500	25	> 30	25	> 50			general purpose	455
BSV15	p-n-p	TO-39	40	1000	5000	25*	40–250	100	> 50	650	100	general purpose	459
BSV16			60										459
BSV17			80										459
BSV64	n-p-n	TO-39	60	2000	5000	50*	> 40	2000	100	1200	5000	high-current saturation characteristics	469

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

Transistors for switching applications

type number	polarity	envelope	RATINGS: V_{CEO} V	RATINGS: I_C mA	RATINGS: 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	page
BSW66A	n-p-n	TO-39	100	1000	5000	25*	> 30	500	130	900	500	general purpose	475
BSW67A			120										475
BSW68A			150										475
BSX19	n-p-n	TO-18	15	500**	360	25	20– 60	10	> 400	15		high-speed saturated switching and h.f. amplifier applications	483
BSX20							40–120		> 500	18			483
BSX32	n-p-n	TO-39	40	1000	800	25	30– 60	10	> 300	60	500		495
BSX45	n-p-n	TO-39	40	1000	6250	25*	40–250	100	> 50	850	100	general purpose	499
BSX46			60				40–250						499
BSX47			80				40–160						499
BSX59	n-p-n	TO-39	45	1000	800	25	30– 90	500	450	60	500	very high speed core-driving purposes	511
BSX60			30						475	70			511
BSX61			45						475	100			511
MPSA13	n-p-n	TO-92	30	500	625	25	> 5,000	10	> 125			darlington transistors	533
MPSA14							>10,000						533
MPSA42	n-p-n	TO-92	300	500	625	25	> 40	30	> 50			high voltage, h.f.	535
MPSA43			200										535
MPSA63	p-n-p	TO-92	30	500	625	25	> 5,000	10	> 125			darlington transistors	539
MPSA64							>10,000						539
MPSA92	p-n-p	TO-92	300	500	625	25	> 25	30	> 50			high voltage, h.f.	541
MPSA93			200										541
PH2222	n-p-n	TO-92 var.	30	800	625	25	> 75	10	> 250	285	150		543
PH2222A			40						> 300				543
PH2369	n-p-n	TO-92 var.	15	500**	500	25	40–120	10	> 500	18	10		547
PH2907	p-n-p	TO-92 var.	40	600	625	25	100–300	150	> 200	100	150		557
PH2907A			60										557
PH5415	p-n-p	TO-92 var.	200	1000	625	25	30–150	50	> 15			high-voltage switching	561
PH5416	p-n-p	TO-92 var.	300	1000	625	25	30–120	50	> 15				561

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

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	page
PN2222 PN2222A	n-p-n	TO-92	30 40	600	625	25	100–300	150	> 250	285	150		563 563
PN2369 PN2369A	n-p-n	TO-92	15	600	625	25	40–120	10		18	10		567 567
PN2907 PN2907A	p-n-p	TO-92	40 60	600	625	25	100–300	150	> 200	100	150		571 571
PN3439 PN3440	n-p-n	TO-92	350 250	1,000	625	25	> 30 > 40	2 20	> 70			high voltage	575 575
PN5415 PN5416	p-n-p	TO-92	200 350	1,000	625	25	30–150 30–120	50	> 15			high voltage	577 575
2N1613	n-p-n	TO-39	(50)	500**	800	25	40–120	150	> 60			d.c. and high-speed amplifiers	583
2N1711	n-p-n	TO-39	(50)	1000**	800	25	100–300	150	> 70				591
2N1893	n-p-n	TO-39	80	500	3000	25*	40–120	150	> 50				595
2N2219 2N2219A	n-p-n	TO-39	30 40	800	800	25	100–300	150	> 250 > 300	285	150	high-speed switching	599 599
2N2222 2N2222A	n-p-n	TO-18	30 40	800	500	25	100–300	150	250 300	285	150	high-speed switching	605 605
2N2297	n-p-n	TO-39	35	1000	800	25	40-120	150	> 60				611
2N2369	n-p-n	TO-18	15	500*	360	25	40–120	10	> 500	18	10	very high speed saturated switching	615
2N2369A	n-p-n	TO-18	15	200	360	25	> 40	10	> 500	18	10	very high speed saturated switching	619
2N2904 2N2904A	p-n-p	TO-39	40 60	600	600	25	40–120	150	> 200	100	150	high-speed switching and driver applications	627 627
2N2905 2N2905A	p-n-p	TO-39	40 60	600	600	25	100–300	150	> 200	100	150	high-speed switching and driver applications	635 635

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

Transistors for switching applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks	page
			V_{CEO} (V_{CER}) V	I_C mA	P_{tot} at mW	T_{amb} (T_{case}) °C	h_{FE} at	I_C mA	f_T MHz typ.	t_{off} at ns max.	I_C mA		
2N2906	p-n-p	TO-18	40	600	400	25	40–120	150	> 200	100	150	high-speed switching and driver applications	639
2N2906A			60										639
2N2907	p-n-p	TO-18	40	600	400	25	100–300	150	> 200	100	150	high-speed switching and driver applications	643
2N2907A			60										643
2N3019	n-p-n	TO-39	80	1000	800	25	100–300	150	> 100			amplifiers and medium-speed switching	647
2N3020							40–120	150	> 80				647
2N3053	n-p-n	TO-39	40	700	5000	(25)	50–250	150	> 100	–	–	medium-speed switching	651
2N3903	n-p-n	TO-92	40	200	350	25	50–150	10	> 250	225	10	high-speed saturated switching	653
2N3904							100–300	10	> 300	250	10		653
2N3905	p-n-p	TO-92	40	200	350	25	50–150	10	> 200	260	10		657
2N3906							100–300		> 250	300			657
2N4030	p-n-p	TO-39	60	1000	800	25	> 25	500	> 100	400	500	large signal, low-noise, low-power	661
2N4031			80				> 25	500	> 100				661
2N4032			60				> 70	500	> 150				661
2N4033			80				> 70	500	> 150				661
2N5400	p-n-p	TO-92	120	600	625	25	> 40	10	> 100			high-voltage switching	685
2N5401			150				> 60	10	> 100				685
2N5415	p-n-p	TO-39	200	1000	1000	50	30–150	50	> 15	850**	50	high-voltage general purpose amplifier applications	689
2N5416			300				30–120	50					689
2N5550	n-p-n	TO-92	140	60	625	25	> 60	10	> 100			high-voltage switching	693
2N5551			160				> 80	10	> 100				693

** Typical value.

P-N-P-N DEVICES

Programmable unijunction transistors

type number	envelope	RATINGS				CHARACTERISTICS			remarks	page
		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.		
BRY39	TO-72	70	175	2,5	20	5	25	80	characteristics measured	395
BRY56	TO-92 var,	70	175	2,5	20	5	2	80	with R_G = 10 kΩ	419

Silicon controlled switches

type number	envelope	RATINGS					CHARACTERISTICS				remarks	page
		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	391
BRY39	TO-72	70	175	2,5	275	25	1,4	1,0	1,5	8	with R_G = 10 kΩ	401

Thyristor tetrode

type number	envelope	RATINGS				CHARACTERISTICS at T_j = 25 °C					remarks	page
		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.		
BRY39	TO-72	250	2,5	3	20	0,5	1	–1	–100	3	V_{RRMmax} = 70 V	411

TYPE NUMBER SURVEY

(alpha numerical)

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

type number	▲	envelope	V_{CEO} V	I_C mA	page	type number	▲	envelope	V_{CEO} V	I_C mA	page
BC107	n	TO-18	45	100	65	BCX78	p	TO-92 var.	32	200	187
BC108	n	TO-18	20	100	65	BCX79	p	TO-92 var.	45	200	187
BC109	n	TO-18	20	100	65	BCY56	n	TO-18	45	100	191
BC140	n	TO-39	40	1000	79	BCY57	n	TO-18	20	100	191
BC141	n	TO-39	60	1000	79	BCY58	n	TO-18	32	200	195
BC160	p	TO-39	40	1000	83	BCY59	n	TO-18	45	200	195
BC161	p	TO-39	60	1000	83	BCY65	n	TO-18	60	200	205
BC177	p	TO-18	45	100	87	BCY70	p	TO-18	40	200	209
BC178	p	TO-18	25	100	87	BCY71	p	TO-18	45	200	209
BC179	p	TO-18	20	100	87	BCY72	p	TO-18	25	200	209
BC327	p	TO-92 var.	45	500	99	BCY78	p	TO-18	32	200	225
BC327A	p	TO-92 var.	60	500	99	BCY79	p	TO-18	45	200	225
BC328	p	TO-92 var.	25	500	99	BCY87	p	TO-71	40	30	233
BC337	n	TO-92 var.	45	500	105	BCY88	n	TO-71	40	30	233
BC337A	n	TO-92 var.	60	500	105	BCY89	n	TO-71	40	30	233
BC338	n	TO-92 var.	25	500	105	BF198	n	TO-92 var.	30	25	241
BC368	n	TO-92 var.	20	1000	111	BF199	n	TO-92 var.	25	25	255
BC369	p	TO-92 var.	20	1000	119	BF240	n	TO-92 var.	40	25	261
BC375	n	TO-92 var.	20	1000	127	BF241	n	TO-92 var.	40	25	261
BC376	p	TO-92 var.	20	1000	129	BF324	p	TO-92 var.	30	25	265
BC516	p	TO-92 var.	30	400	131	BF370	n	TO-92 var.	15	100	271
BC517	n	TO-92 var.	30	400	133	BF420	n	TO-92 var.	300**	50	275
BC546	n	TO-92 var.	65	100	135	BF421	p	TO-92 var.	300**	100	281
BC547	n	TO-92 var.	45	100	135	BF422	n	TO-92 var.	250	50	275
BC548	n	TO-92 var.	30	100	135	BF423	p	TO-92 var.	250	100	281
BC549	n	TO-92 var.	30	100	145	BF450	p	TO-92 var.	40	25	287
BC550	n	TO-92 var.	45	100	145	BF451	p	TO-92 var.	40	25	287
BC556	p	TO-92 var.	65	100	157	BF483	n	TO-92 var.	250	100	291
BC557	p	TO-92 var.	45	100	157	BF485	n	TO-92 var.	300	100	291
BC558	p	TO-92 var.	30	100	157	BF487	n	TO-92 var.	350	100	291
BC559	p	TO-92 var.	30	100	163	BF494	n	TO-92 var.	20	30	295
BC560	p	TO-92 var.	45	100	163	BF495	n	TO-92 var.	20	30	303
BC635	n	TO-92 var.	45	1000	171	BF496	n	TO-92 var.	20	20	311
BC636	p	TO-92 var.	45	1000	177	BF926	p	TO-92 var.	20	25	315
BC637	n	TO-92 var.	60	1000	171	BF936	p	TO-92 var.	20	25	317
BC638	p	TO-92 var.	60	1000	177						
BC639	n	TO-92 var.	80	1000	171						
BC640	p	TO-92 var.	80	1000	177						
BCX58	n	TO-92 var.	32	200	183						
BCX59	n	TO-92 var.	45	200	183						

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

▲ n = n-p-n; p = p-n-p.

type number	▲	envelope	V_{CEO} V	I_C mA	page
BF939	p	TO-92 var.	25	20	319
BF967	p	SOT-37	30	20	323
BF970	p	SOT-37	35	30	329
BF970A	p	SOT-37	35	30	331
BF979	p	SOT-37	20	30	334
BFR54	n	TO-92 var.	15	500*	337
BFT44	p	TO-39	300	500	345
BFT45	p	TO-39	250	500	345
BFX34	n	TO-39	60	2000	353
BFY50	n	TO-39	35	1000	359
BFY51	n	TO-39	30	1000	359
BFY52	n	TO-39	20	1000	359
BFY55	n	TO-39	35	1000	379
BR101	p^1	TO-72	50	175	391
BRY39(P)	p^1	TO-72	70	175	395
BRY39(S)	p^1	TO-72	70	175	401
BSY39(T)	p^1	TO-72	70	—	411
BRY56	p^1	TO-92 var.	70	175	419
BSR50	n	TO-92 var.	45**	1000	423
BSR51	n	TO-92 var.	60**	1000	423
BSR52	n	TO-92 var.	80**	1000	423
BSR60	p	TO-92 var.	45**	1000	429
BSR61	p	TO-92 var.	60**	1000	429
BSR62	p	TO-92 var.	80**	1000	429
BSS38	n	TO-92 var.	100	100	435
BSS50	n	TO-39	45**	1000	439
BSS51	n	TO-39	60**	1000	439
BSS52	n	TO-39	80**	1000	439
BSS60	p	TO-39	45**	1000	447
BSS61	p	TO-39	60**	1000	447
BSS62	p	TO-39	80**	1000	447
BSS68	p	TO-92 var.	100	100	455
BSV15	p	TO-39	40	1000	459
BSV16	p	TO-39	60	1000	459
BSV17	p	TO-39	80	1000	459
BSV64	n	TO-39	60	2000	469
BSW66A	n	TO-39	100	1000	475
BSW67A	n	TO-39	120	1000	475
BSW68A	n	TO-39	150	1000	475
BSX19	n	TO-18	15	500*	483
BSX20	n	TO-18	15	500*	483
BSX32	n	TO-39	65	1000	495
BSX45	n	TO-39	40	1000	499
BSX46	n	TO-39	60	1000	499
BSX47	n	TO-39	80	1000	499
BSX59	n	TO-39	45	1000	511
BSX60	n	TO-39	30	1000	511
BSX61	n	TO-39	45	1000	511
MPS6513	n	SOT-54	30	100	523
MPS6514	n	SOT-54	25	100	523
MPS6515	n	SOT-54	25	100	523
MPS6517	p	SOT-54	40	100	525
MPS6518	p	SOT-54	40	100	525
MPS6519	p	SOT-54	25	100	525
MPS6520	n	TO-92	25	100	527
MPS6521	n	TO-92	25	100	527
MPS6522	p	TO-92	25	100	529
MPS6523	p	TO-92	25	100	529
MPSA05	n	TO-92	60	500	531
MPSA06	n	TO-92	80	500	531
MPSA13	n	TO-92	30	500	533
MPSA14	n	TO-92	30	500	533
MPSA42	n	TO-92	300	500	535
MPSA43	n	TO-92	200	500	535
MPSA55	p	TO-92	60	500	537
MPSA56	p	TO-92	80	500	537
MPSA63	p	TO-92	30	500	539
MPSA64	p	TO-92	30	500	539
MPSA92	p	TO-92	300	500	541
MPSA93	p	TO-92	200	500	541
PH2222	n	TO-92 var.	30	800	543
PH2222A	n	TO-92 var.	40	800	543
PH2369	n	TO-92 var.	15	500*	547
PH2907	p	TO-92 var.	40	600	557
PH2907A	p	TO-92 var.	60	600	557
PH5415	p	TO-92 var.	200	1000	561
PH5416	p	TO-92 var.	300	1000	561
PN2222	n	TO-92	30	600	563
PN2222A	n	TO-92	40	600	563
PN2369	n	TO-92	15	600	567
PN2369A	n	TO-92	15	600	567
PN2907	p	TO-92	40	600	571
PN2907A	p	TO-92	60	600	571
PN3439	n	TO-92	400	1000	575
PN3440	n	TO-92	300	1000	575
PN5415	p	TO-92	200	1000	577
PN5416	p	TO-92	350	1000	577

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

▲ n = n-p-n; p = p-n-p; p^1 = p-n-p-n.

type number	▲	envelope	V_{CEO} V	I_C mA	page	type number	▲	envelope	V_{CEO} V	I_C mA	page
2N930	n	TO-18	45	30	579	2N4031	p	TO-39	80	1000	661
2N1613	n	TO-39	50**	1000*	583	2N4032	p	TO-39	60	1000	661
2N1711	n	TO-39	50**	1000	591	2N4033	p	TO-39	80	1000	661
2N1893	n	TO-39	80	500	595	2N4123	n	TO-92	30	200	665
2N2219	n	TO-39	30	800	599	2N4124	n	TO-92	25	200	665
2N2219A	n	TO-39	40	800	599	2N4125	p	TO-92	30	200	667
2N2222	n	TO-18	30	800	605	2N4126	p	TO-92	25	200	667
2N2222A	n	TO-18	40	800	605	2N4400	n	TO-92	40	600	669
2N2297	n	TO-39	35	1000	611	2N4401	n	TO-92	40	600	669
2N2369	n	TO-18	15	500*	615	2N4402	p	TO-92	40	600	673
2N2369A	n	TO-18	15	200	619	2N4403	p	TO-92	40	600	673
2N2483	n	TO-18	60	50*	623	2N5086	p	TO-92	50	50	677
2N2484	n	TO-18	60	50*	623	2N5087	p	TO-92	50	50	677
2N2904	p	TO-18	40	600	627	2N5088	n	TO-92	30	50	681
2N2904A	p	TO-39	60	600	627	2N5089	n	TO-92	25	50	681
2N2905	p	TO-39	40	600	635	2N5400	p	TO-92	120	600	685
2N2905A	p	TO-39	60	600	635	2N5401	p	TO-92	150	600	685
2N2906	p	TO-39	40	600	639	2N5415	p	TO-39	200	1000	689
2N2906A	p	TO-18	60	600	639	2N5416	p	TO-39	300	1000	689
2N2907	p	TO-18	40	600	643	2N5550	n	TO-92	160	600	693
2N2907A	p	TO-18	60	600	643	2N5551	n	TO-92	180	600	693
2N3019	n	TO-39	80	1000	647						
2N3020	n	TO-39	80	700	647						
2N3053	n	TO-39	40	700	651						
2N3903	n	TO-92	40	200	653						
2N3904	n	TO-92	40	200	653						
2N3905	p	TO-92	40	200	657						
2N3906	p	TO-92	40	200	657						
2N4030	p	TO-39	60	1000	661						

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

▲ n = n-p-n; p = p-n-p.

CONVERSION LIST

(conventional type number to SMD type number)

conventional type	microminiature type
BA243	BAT18
BA314	BAS17
BA480	BAT17
BA481	BAT17
BA482	BA682
BA483	BA683
BAT85	BAT54
	BAT74
BAV10	BAS56
BAV18	BAV100
BAV19	BAS19
	BAV101
BAV20	BAS20
	BAV102
BAV21	BAS21
BAW62	BAS16
	BAS28
	BAS32
	BAV70
	BAV99
	BAW56
BAX12	BAS29
	BAS31
	BAS35
BB405	BBY31
BB809	BBY40
BC107	BC847
	BCW71/72
BC107A	BC847A
	BCW71
BC107B	BC847B
	BCW72
BC108	BC848
	BCW31-33
BC108A	BC848A
	BCW31
BC108B	BC848B
	BCW32
BC109	BC849
	BCF32/33
BC109B	BC849B
	BCF32
BC109C	BC849C
	BCFC33
BC146/01	BC849B
	BCF32
BC146/02	BC849B/C
	BCF32/33
BC146/03	BC849C
	BCF33
BC156	BCV26
BC157	BCV27
BC177	BC857
	BCW69/70
BC177A	BC857A
	BCW69
BC177B	BC857B
	BCW70
BC178	BC858
	BCW29/30
BC178A	BC858A
	BCW29
BC178B	BC858B
	BCW30
BC179	BC859
	BCF29/30
BC179A	BC859A
	BCF29
BC179B	BC859B
	BCF30
BC200/01	BC859B
	BCF29
BC200/02	BC859B/C
	BCF29/30
BC200/03	BC859C
	BCF30
BC327	BC807
	BCX17
BC327-16	BC807-16
BC327-25	BC807-25
BC327-40	BC807-40
BC327A	
BC328	BC808
BC328-16	BC808-16
BC328-25	BC808-25
BC328-40	BC808-40
BC337	BC817
	BCX19
BC337-16	BC817-16
BC337-25	BC817-25
BC337-40	BC817-40
BC338	BC818
	BCX20
BC338-16	BC818-16
BC338-25	BC818-25
BC338-40	BC818-40
BC368	BC868
BC369	BC869
BC516	BCV26
BC517	BCV27
BC546	BC846
	BCV71/72
BC546A	BC846A
	BCV71
BC546B	BC846B
	BCV72
BC547	BC847
	BCW71/71/81
BC547A	BC847A
	BCW71
BC547B	BC847B
	BCW72
BC547C	BC847C
	BCW81
BC548	BC848
	BCW31-33
BC548A	BC848A
	BCW31
BC548B	BC848B
	BCW32
BC548C	BC848C
	BCW33
BC549	BC849
	BCF32/33
BC549B	BC849B
	BCF32
BC549C	BC849C
	BCF33
BC550	BC850
	BCF81
BC550B	BC850B
BC550C	BC850C
BC556	BC856
	BCW89
BC556A	BC856A
	BCW89

conventional type	microminiature type
BC556B	BC856B
BC557	BC857
	BCW69/70
BC557A	BC857A
	BCW69
BC557B	BC857B
	BCW70
BC557C	BC857C
BC558	BC858
	BCW29/30
BC558A	BC858A
	BCW29
BC558B	BC858B
	BCW30
BC558C	BC858C
BC559	BC859
	BCF29/30
BC559A	BC859A
	BCF29
BC559B	BC859B
	BCF30
BC559C	BC859C
BC560	BC860
	BCF70
BC560A	BC860A
BC560B	BC860B
	BCF70
BC560C	BC860C
BC635	BCX54
BC635-6	BCX54-6
BC635-10	BCX54-10
BC635-16	BCX54-16
BC636	BCX51
BC636-6	BCX51-6
BC636-10	BCX51-10
BC636-16	BCX51-16
BC637	BCX55
BC637-6	BCX55-6
BC637-10	BCX55-10
BC637-16	BCX55-16
BC638	BCX52
BC638-6	BCX52-6
BC638-10	BCX52-10
BC638-16	BCX52-16
BC639	BCX56
BC639-6	BCX56-6
BC639-10	BCX56-10
BC639-16	BCX56-16
BC640	BCX53
BC640-6	BCX53-6
BC640-10	BCX53-10
BC640-16	BCX53-16

conventional type	microminiature type
BCX58	BCW60
BCX59	BCX70
BCX78	BCW61
BCX79	BCX71
BCY56	BC850B
	BCF70
BCY57	BC849
	BCF32/33
BCY58	BC849
	BCW60 fam.
BCY58-VII	BCW60A
BCY58-VIII	BC849B
	BCW60B
BCY58-IX	BC849B
	BCW60C
BCY58-X	BC849C
	BCW60D
BCY59	BC850
	BCX70 fam.
BCY59-VII	BCX70G
BCY59-VIII	BC850B
	BCX70H
BCY59-IX	BC850B
	BCX70J
BCY59-X	BC850C
	BCX70K
BCY65	BCV71
	BCV72
BCY70	BC860
	BCF70
BCY71	BC860
	BCF70
BCY72	BC859
	BCF29/30
BCY78	BC859
	BCW61 fam.
BCY78-VII	BC859A
	BCW61A
BCY78-VIII	BC859A/B
	BCW61B
BCY78-IX	BC859B
	BCW61C
BCY78-X	BV859C
	BCW61D
BCY79	BC860
	BCX71 fam.
BCY79-VII	BC860A
	BCX71G
BCY79-VIII	BC860A/B
	BCX71H
BCY79-IX	BC860B
	BCX71J

conventional type	microminiature type
BD135	BCX54
BD135-6	BCX54-6
BD135-10	BCX54-10
BD135-16	BCX54-16
BD136	BCX51
BD136-6	BCX51-6
BD136-10	BCX51-10
BD136-16	BCX51-16
BD137	BCX55
BD137-6	BCX55-6
BD137-10	BCX55-10
BD137-16	BCX55-16
BD138	BCX52
BD138-6	BCX52-6
BD138-10	BCX52-10
BD138-16	BCX52-16
BD139	BCX56
BD139-6	BCX56-6
BD139-10	BCX56-10
BD139-16	BCX56-16
BD140	BCX53
BD140-6	BCX53-6
BD140-10	BCX53-10
BD140-16	BCX53-16
BDX42	BST50
BDX43	BST51
BDX44	BST52
BDX45	BST60
BDX46	BST61
BDX47	BST61
BF198	
BF199	BFS20
BF240	BF840
BF241	BF841
BF324	BF824
BF370	BSV52
	BF570
BF410A	BF510
BF410B	BF511
BF410C	BF512
BF410D	BF513
BF419	BST40
BF420	BF620
	BF820
BF421	BF621
	BF821
BF422	BF622
	BF822
BF423	BF623
	BF823
BF450	BF550
BF451	

conventional type	microminiature type	conventional type	microminiature type	conventional type	microminiature type
BF457	BST40	BFW11	BFR30	BSX45-10	BSR40/41
BF458	BST40	BFW12	BFR31	BSX45-16	BSR41
BF459	BST39	BFW13	BFT46	BSX46	BSR40/41
BF469	BF622	BFW16A	BFQ17	BSX46-6	BSR40
BF470	BF623	BFW30	BFR53	BSX46-10	BSR40/41
BF471	BF620	BFW92	BFS17	BSX46-16	BSR41
BF472	BF621	BFW93	BFR53	BSX47	BSR42/43
BF494	BFS19	BFX29	BSR16	BSX47-6	BSR42
BF494B	BFS19	BFX30	BSR16	BSX47-10	BSR42/43
BF495	BFS18	BFX84	BSR40	BSY95A	BSV52
BF495C	BFS18	BFX85	BSR41	BZX55	BZX84
BF495D	BFS18	BFX86	BSR41	BZX79	BZX84
BF606A	BF660	BFX87	BSR16		BZV55
BF819	BST40	BFX88	BSR15	BZV85	BZV49
BF857	BST40	BFY50	BSR40	MPS6513	BC848A
BF858	BST40	BFY51	BSR40	MPS6514	BC848A
BF859	BST39	BFY52	BSR40	MPS6515	BC848B
BF869	BF622	BFY55	BSR40	MPS6517	BC858A
BF870	BF623	BFY90	BFS17	MPS6518	BC858A
BF871	BF620	BR101	BRY62	MPS6519	BC858B
BF872	BF621	BRY39	BRY62	MPS6520	BC859B
BF926	BF660	BRY56	BRY61	MPS6521	BC859C
BF936	BF536	BSR50	BST50	MPS6522	BC859B
BF939		BSR51	BST51	MPS6523	BC859C
BF960	BF989	BSR52	BST52	MPSA05	PMBTA05
BF964	BF994	BSR60	BST60	MPSA06	PMBTA06
	BF994S	BSR61	BST61	MPSA13	PMBTA13
BF966	BF996	BSR62	BST62	MPSA14	PMBTA14
	BF996S	BSS38	BSS64	MPSA42	PMBTA42
BF967	BF767	BSS50	BST50	MPSA43	PMBTA43
BF970	BF569	BSS51	BST51	MPSA55	PMBTA55
BF970A	BF569	BSS52	BST52	MPSA56	PMBTA56
BF979	BF579	BSS60	BST60	MPSA63	PMBTA63
BF980	BF990	BSS61	BST61	MPSA64	PMBTA64
BF981	BF991	BSS62	BST62	MPSA92	PMBTA92
BF982	BF992	BSS68	BSS63	MPSA93	PMBTA93
BFG65	BFG67	BSV15	BSR30/31	PH2222	BSR13
BFQ23	BFT93	BSV15-6	BSR30	PH2222A	BSR14
BFQ24	BFT93	BSV15-10	BSR30/31	PH2369	BSV52
BFQ34	BFQ18A	BSV15-16	BSR31	PH2907	BSR15
BFQ34T	BFQ18A	BSV16	BSR30/31	PH2907A	BSR16
BFQ51	BFT92	BSV16-6	BSR30	PN2222	PMBT2222
BFQ52	BFT92	BSV16-10	BSR30/31		BSR13
BFQ65	BFQ67	BSV16-16	BSR31	PN2222A	PMBT2222A
BFR54	BSV52	BSV17	BSR32/33		BSR14
BFR90	BFR92A	BSV17-6	BSR32	PN2369	PMBT2369
BFR91	BFR93A	BSV17-10	BSR32/33		BSV52
BFR96	BFQ19	BSX19	BSV52	PN2369A	PMBT2369A
BFR96S	BFQ19	BSX20	BSV52	PN2907	PMBT2907
BFT24	BFT25	BSX32			BSR15
BFT44	BST16	BSX45	BSR40/41	PN2907A	PMBT2907A
BFT45	BST15/16	BSX45-6	BSR40		BSR16

conventional type	microminiature type
PN3439	BST39
PN3440	BST40
PN5415	BST15
PN5416	BST16
1N4148	BAS16
	BAV90
	BAV99
	BAW56
1N5225B	PMLL5225B
to	to
1N5267B	PMLL5267B
2N929	BC850
2N930	BNC850
	BCF81
2N1613	BSR40
2N1711	BSR41
2N1893	BSR42
2N2219	BSR13
2N2219A	BSR14
2N2222	BSR13
	PMBT2222
2N2222A	BSR14
	PMBT2222A
2N2297	BSR40
2N2368	BSV52
2N2369	BSV52
2N2369A	BSV52
2N2483	BC850B
2N2484	BC850B/C
2N894A	BSR12
2N2905	BSR15
2N2905A	BSR16
2N2907	BSR15
	PMBT2907
2N2907A	BSR16
	PMBT2907A
2N3019	BSR43
2N3020	BSR42
2N3053	BSR40/41
2N3903	BSR17
	PMBT3903
2N3904	BSR17A
	PMBT3904
2N3905	BSR18
2N3906	BSR18A
	PMBT3906
2N4400	PMBT4400
2N4401	PMBT4401
2N4402	PMBT4402
2N4403	PMBT4403
2N4030	BSR30
2N4031	BSR32

conventional type	microminiature type
2N4032	BSR31
2N4033	BSR33
2N4123	BSR17
2N4124	BSR18
2N4856	BSR56
2N4857	BSR57
2N4858	BSR58
2N5086	PMBT5086
2N5087	PMBT5087
2N5088	PMBT5088
2N5089	PMBT5089
2N5415	BST15
2N5416	BST16
2N6428	PMBT6428
2N6429	PMBT6429

GENERAL

Type designation

Rating systems

Letter symbols

SOAR curves

Soldering recommendations
for SOT-37 and SOT-103 envelopes

s-parameters

TO-92
variant transistors on tape

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.

"Although not all type numbers accord with the Pro Electron system, the following explanation is given for the ones that do."

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

* When these serial numbers are exhausted the serial number for consumer types may be extended to four figures, and that for industrial types to three figures.

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

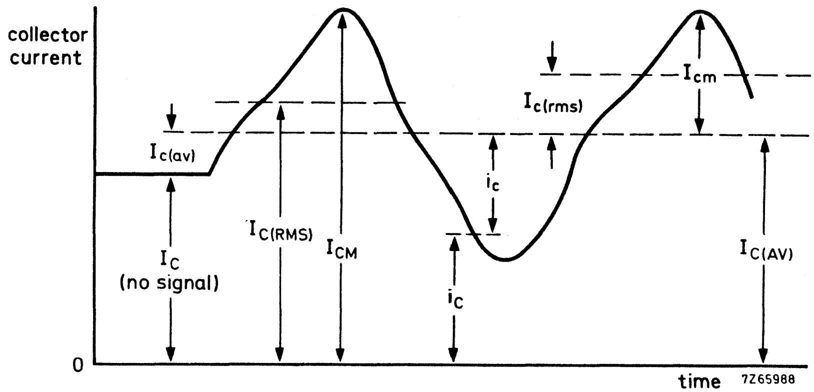
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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 PARAMETERE METERS

Defenition

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}

TRANSISTOR SAFE OPERATING AREA

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

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

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

Collector current

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

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

Collector-emitter voltage

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

Power dissipation

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

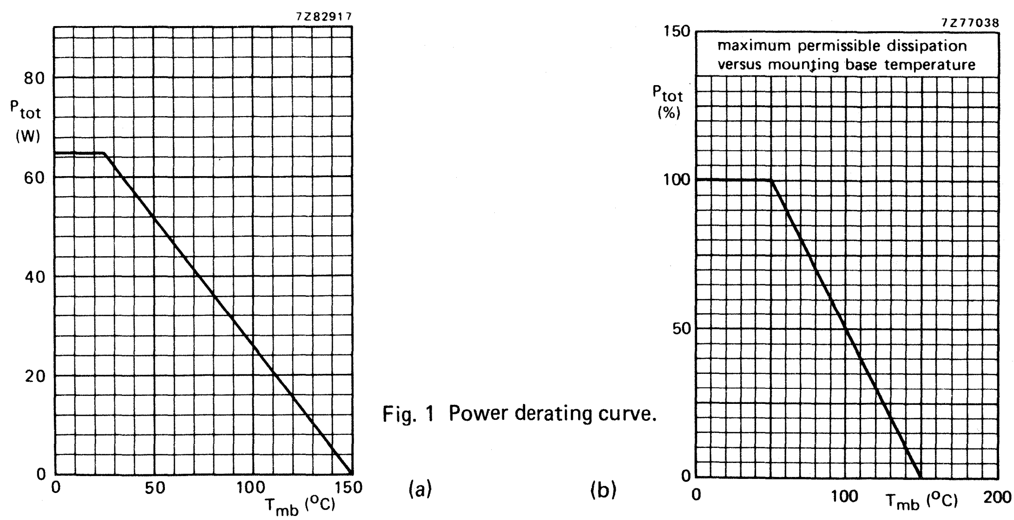


Fig. 1 Power derating curve.

Total power dissipation is given by

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

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

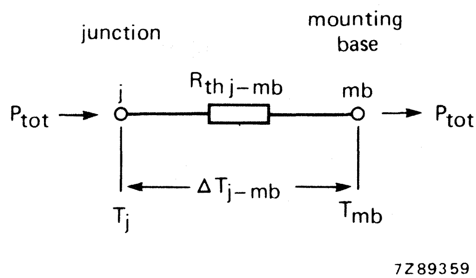


Fig. 2 Heat transport in a transistor with power dissipation constant with respect to time.

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

For pulsed operation a higher dissipation is permitted, because

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

Analogy with

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

yields

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

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

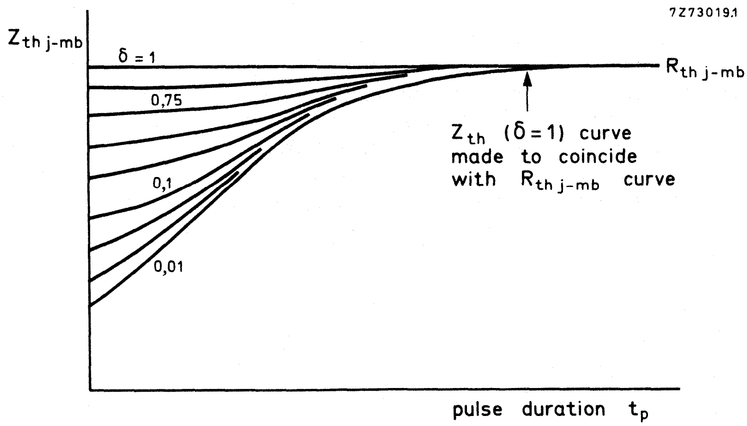


Fig. 3 A typical family of $Z_{th\ j\text{-}mb}$ curves for a power transistor.

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

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

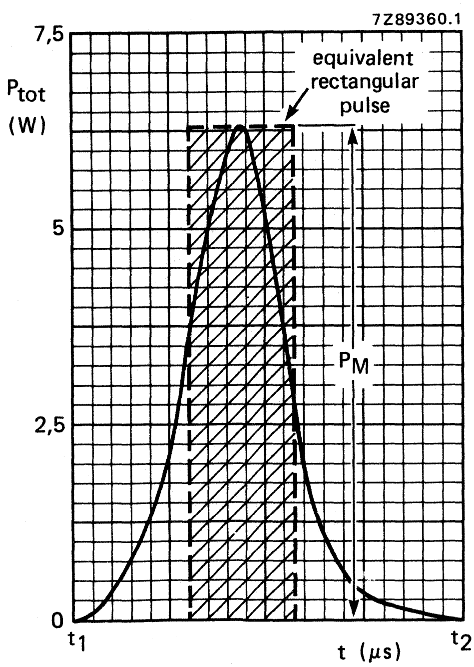


Fig. 4.

Second breakdown

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

THE SOAR BOUNDARIES

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

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

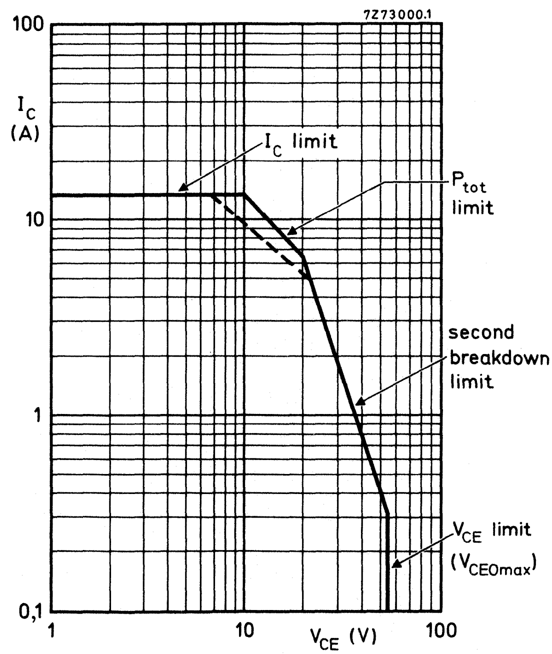


Fig. 5 A typical SOAR graph with boundaries named.

EXTENDING THE SOAR FOR SINGLE-SHOT AND REPETITIVE PULSED OPERATION

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

I_{CMmax}

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

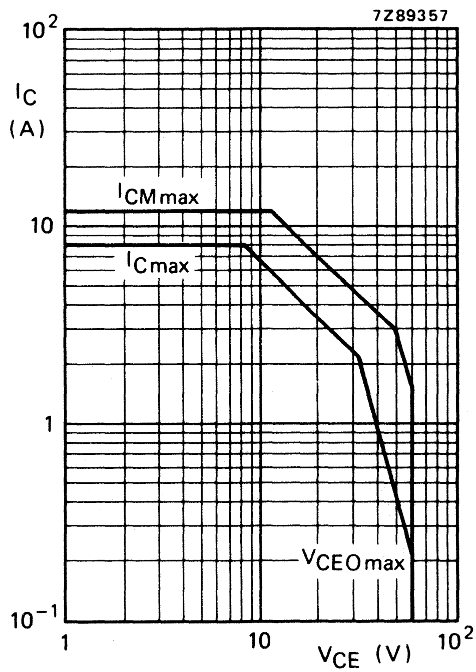


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

$P_{tot\ max}$

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

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

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

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

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

→ $T_{j\ max}$ = 150 °C; T_{mb} = 80 °C; t_p = 0,2 ms and δ = 0,1.

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

$$P_{tot\ Mmax} = \frac{150 - 80}{0,5} = 140\ \text{W}.$$

Thus from an arbitrary point (say 7 A, 20 V) we can draw a line parallel to the $P_{tot\ max}$ line (see Fig. 6).

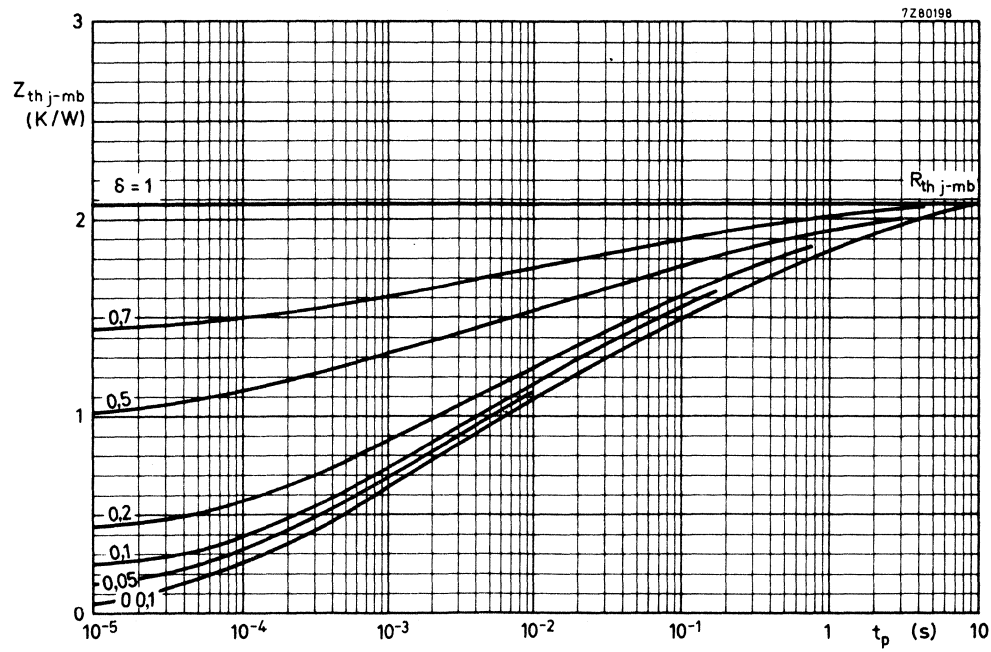


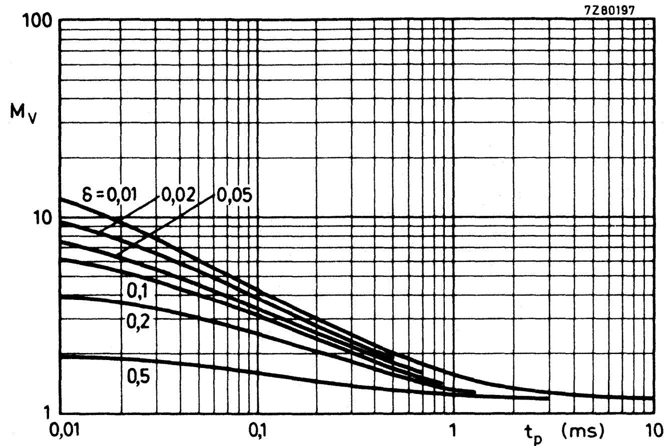
Fig. 7 Transient thermal impedance for example.

Second breakdown

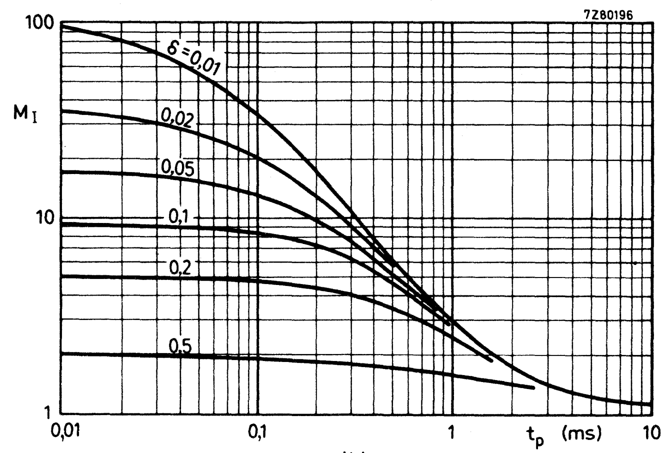
The permissible extension to the second breakdown boundary is found with the aid of two multiplying factors:

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

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



(a)



(b)

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

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

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

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

$I_{C(B')} = I_{C(B)} \times M_I$.

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

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

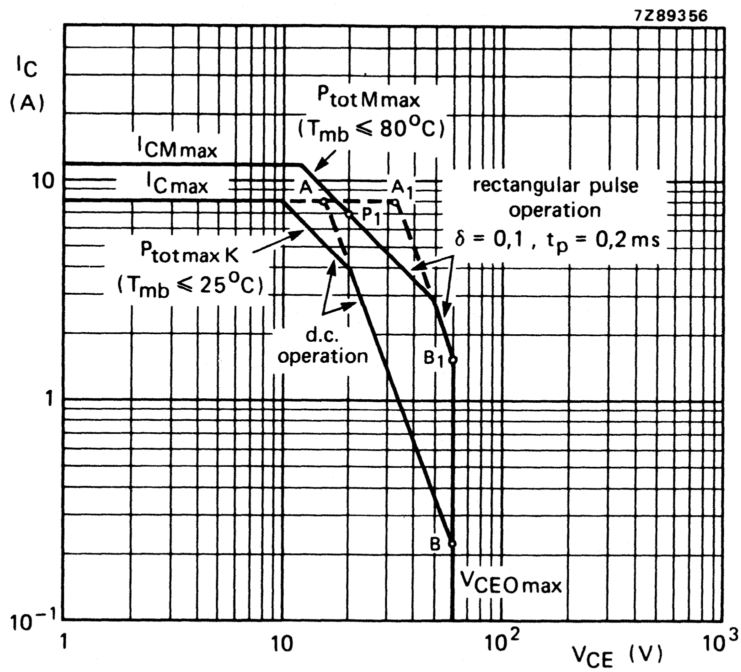


Fig. 9 Construction of the pulse operating area.

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

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

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

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

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

PULSE TRAINS AND COMPOSITE WAVEFORMS

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

Thermal considerations

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

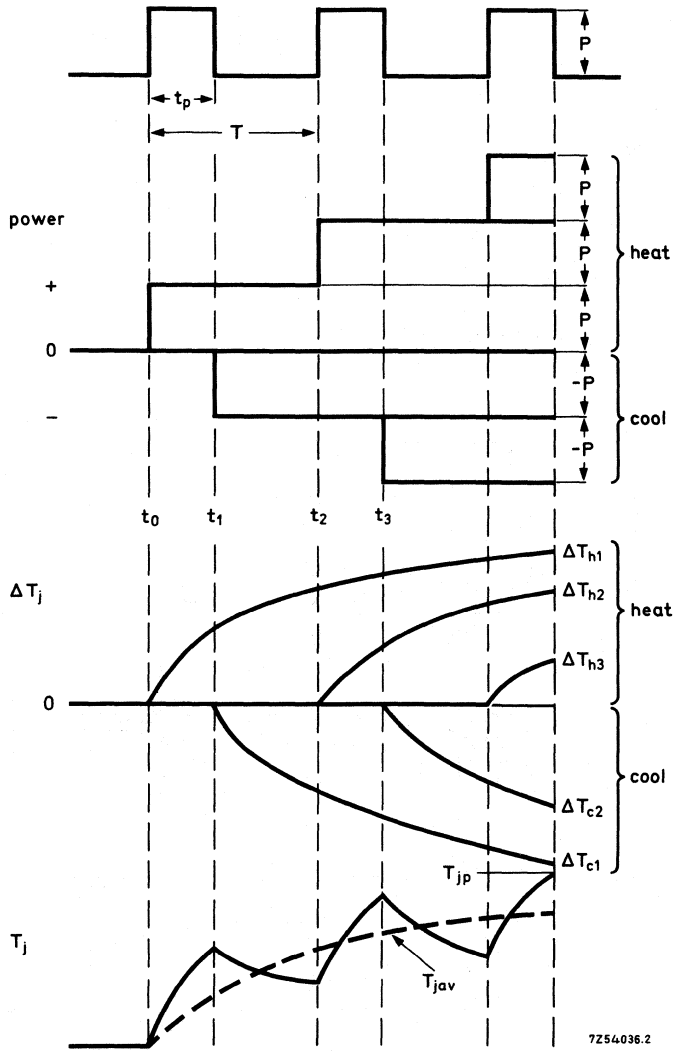


Fig. 10 The heating effect of three equidistant, equal-magnitude pulses. $T_{j\,av}$ is the average junction temperature. P = 100 W, t_p = 100 μs; T = 1 ms and δ = 0,1.

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

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

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

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

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

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

and

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

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

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

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

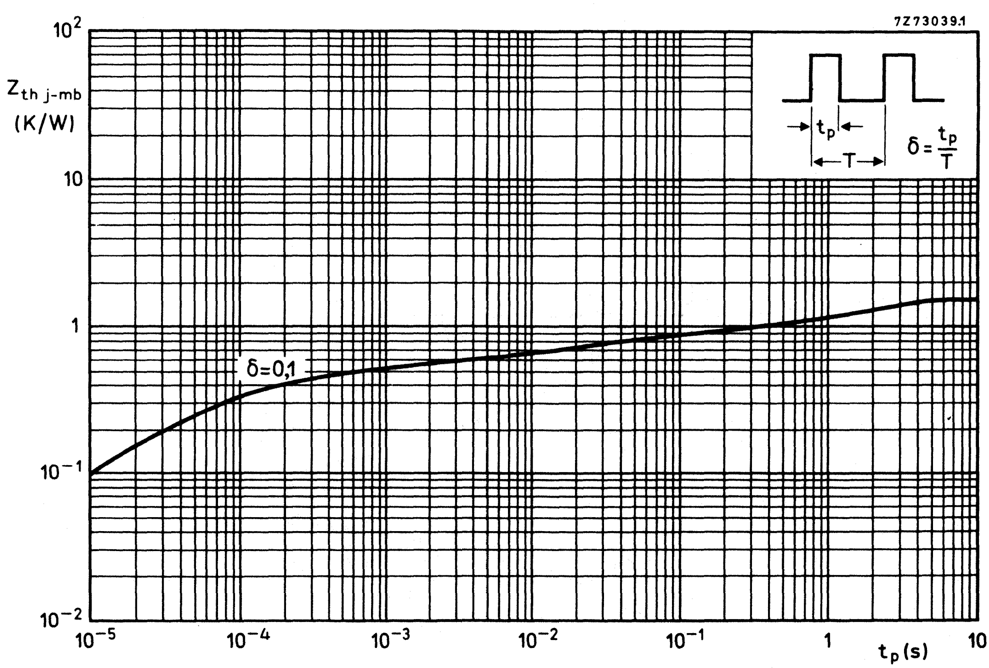


Fig. 11 Curve of $Z_{th\ j\text{-}mb} = f(t_p)$.

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

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

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

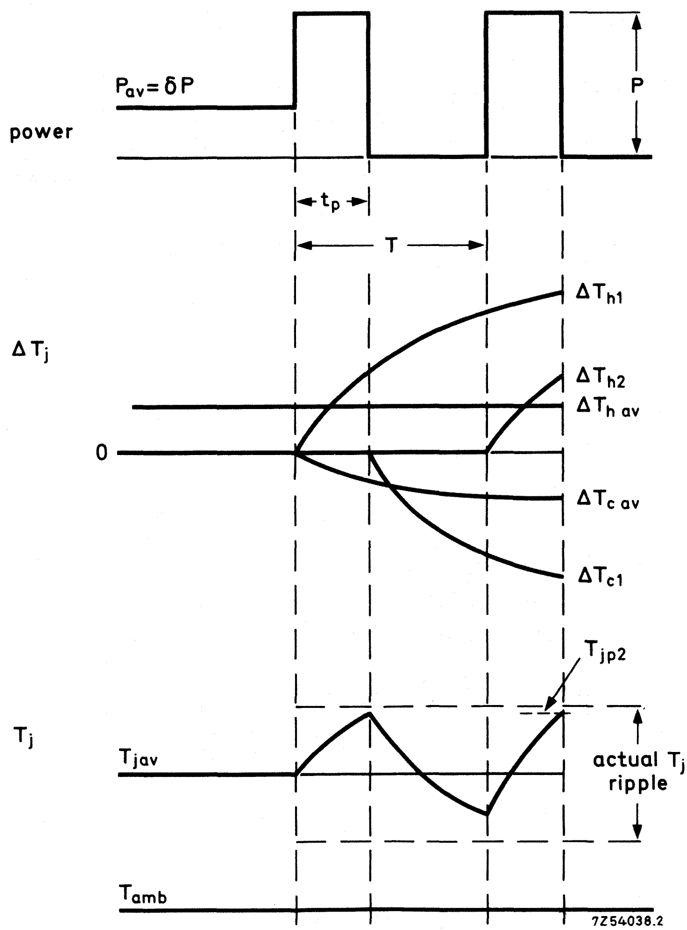


Fig. 12.

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

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

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

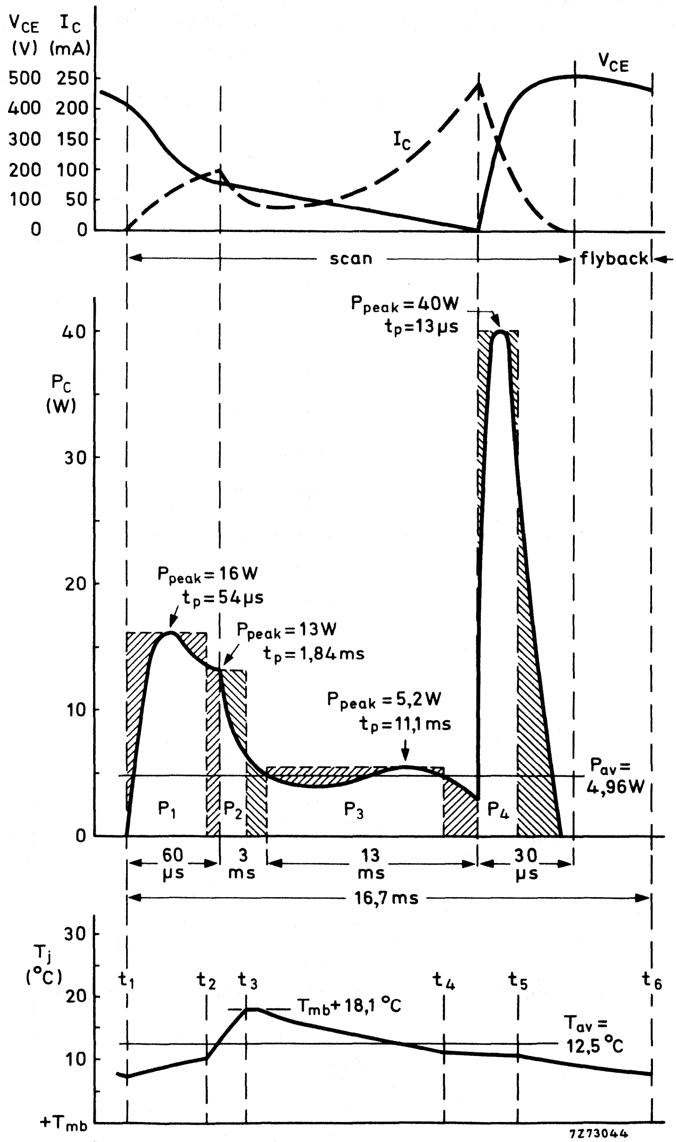


Fig. 13 Power waveforms showing their division into rectangular pulses and the junction temperature variations which they cause.

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

$$T_{j\text{-}mb(t1)} = P_{av} R_{th\ j\text{-}mb} - P_{av} Z_{th\ j\text{-}mb(16,1\ ms)} + P_1 Z_{th(16,1\ ms)}.$$

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

$$-P_1 Z_{th(16,04\ ms)} + P_2 Z_{th(16,04\ ms)}.$$

For t_3 yet another two terms:

$$-P_3 Z_{th(13,02\ ms)} + P_4 Z_{th(13,03\ ms)}.$$

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

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

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

EXAMPLE OF A SOAR CALCULATION

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

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

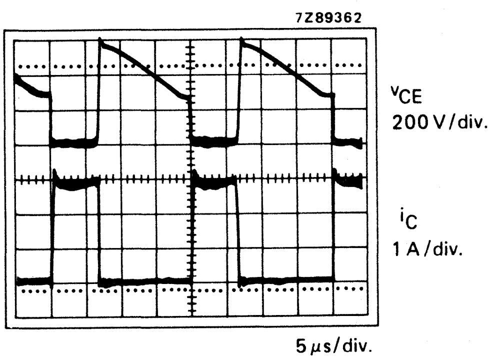


Fig. 14 Collector-current and collector-emitter voltage waveforms of a BU426A transistor in a 200 W SMPS.

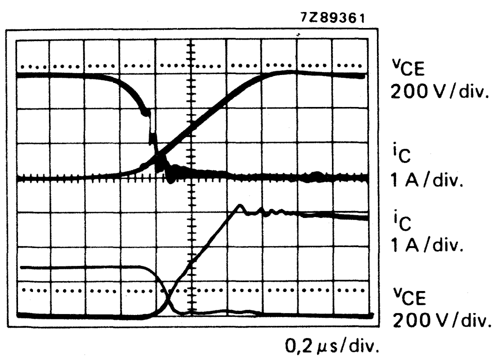


Fig. 15 Waveforms during turn-on and turn-off (lower part).

The duration of this equivalent pulse train is then given by

$$t_p' = \frac{P_{tot\,av} \times T}{P'_M} \text{ and } \delta' = \frac{t'_p}{T}.$$

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

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

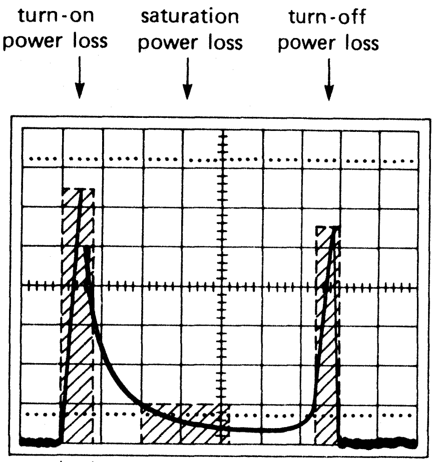


Fig. 16 Power loss and resultant rectangular power pulses.

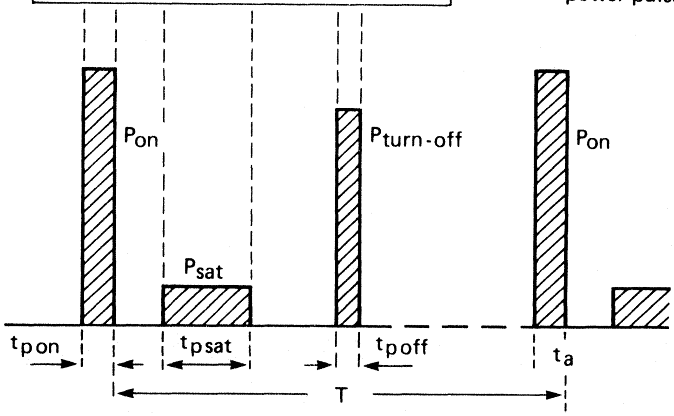


Fig. 17.

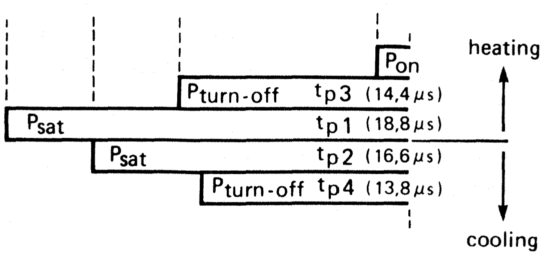


Fig. 18.

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

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

From

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

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

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

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

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

From

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

$$P_{tot\ av} = \delta_{on} \times P_{on} + \delta_{sat} \times P_{sat} + \delta_{turn\text{-}off} \times P_{off}$$

$$= 0{,}04 \times 66 + 0{,}11 \times 10 + 0{,}03 \times 56 = 5{,}4 \text{ W}.$$

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

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

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

The pulse SOAR can be calculated using M_I, M_V and Z_{th} factors as described earlier. The turn-on, saturation and turn-off power pulses should be combined into a single pulse of amplitude P′ equal to the highest amplitude power pulse (here, P_{on}) and duration t_p'.

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

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

$$t_p' + \delta' T = 1{,}64\ \mu s.$$

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

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

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

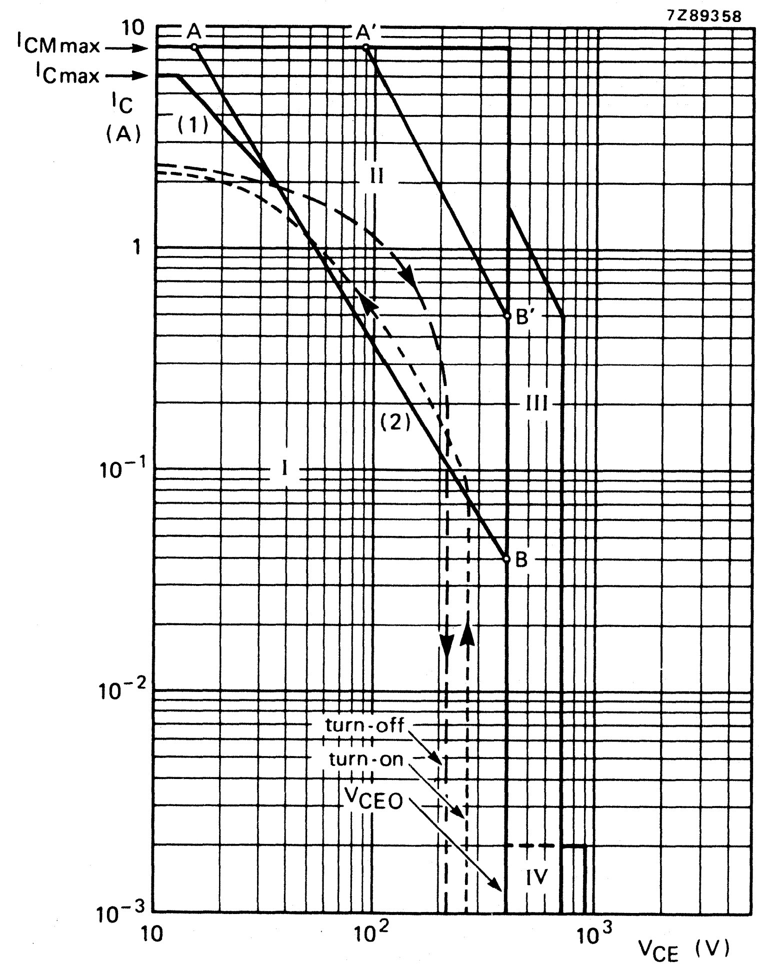


Fig. 19 Safe Operating ARea BU426A at $T_{mb} \leqslant 73\ ^oC$.

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

SOLDERING RECOMMENDATIONS SOT-37 AND SOT-103

Transistors in SOT-37 and SOT-103 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.

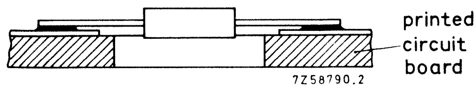


Fig. 1

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.

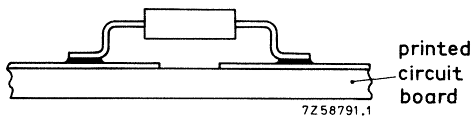


Fig. 2

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.

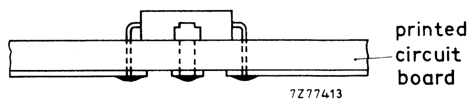
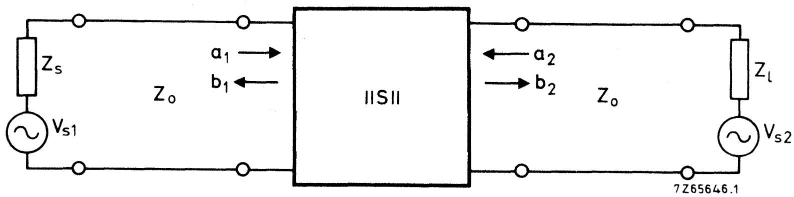


Fig. 3

Solder temperature	max.	260 °C
Soldering time	max.	5 s

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.



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

$$b_1 = \frac{V_{r1}}{\sqrt{Z_o}} \qquad b_2 = \frac{V_{r2}}{\sqrt{Z_o}} \qquad ^{1)}$$

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 $Z_l = Z_o = 50\,\Omega$ 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 $Z_s = Z_o = 50\,\Omega$ 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 $Z_l = Z_o = 50\,\Omega$ and $V_{s2} = 0$.

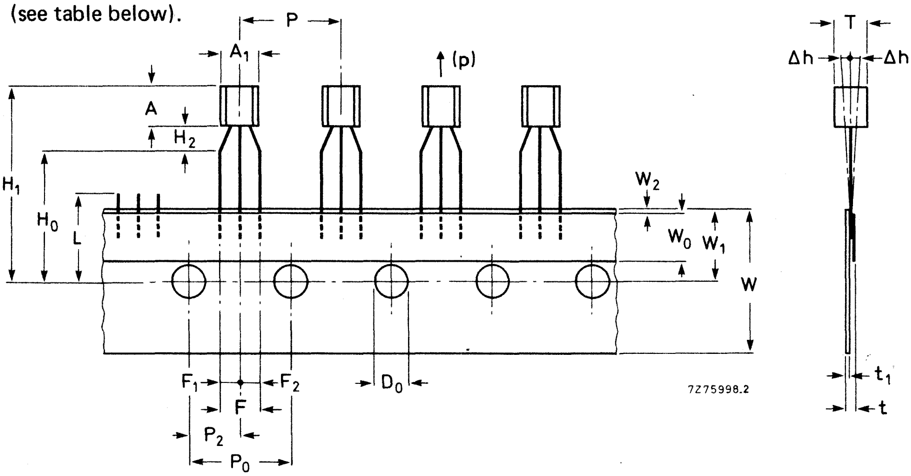
$s_o = s_{22}$ = Output reflection coefficient.
The complex ratio of the reflected wave and the incident wave at the output, under the conditions $Z_s = Z_o = 50\,\Omega$ and $V_{s1} = 0$.

TO-92 VARIANT TRANSISTORS ON TAPE

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see table below).



Item	Symbol	Specifications				Remarks
		min.	nom.	max.	tol.	
Body width	A_1	4,0		4,8		
Body height	A	4,8		5,2		
Body thickness	T	3,9		4,2		
Pitch of component	P		12,7		± 1	
Feed hole pitch	P_o		12,7		± 0,3	Cumulative pitch error 1,0 mm/20 pitch
Feed hole centre to component centre	P_2		6,35		± 0,4	To be measured at bottom of clinch
Distance between outer leads	F		5,08		+ 0,6 −0,2	
Component alignment	Δh		0	1		At top of body
Tape width	W		18		± 0,5	
Hold-down tape width	W_o		6		± 0,2	
Hole position	W_1		9		+ 0,7 −0,5	
Hold-down tape position	W_2		0,5		± 0,2	
Lead wire clinch height	H_o		16		± 0,5	
Component height	H_1			32,25		
Length of snipped leads	L			11,0		
Feed hole diameter	D_o		4		± 0,2	
Total tape thickness	t			1,2		t_1 0,3-0,6
Lead-to-lead distance	F_1, F_2		2,54		+ 0,4 −0,1	
Clinch height	H_2			3		
Pull-out force	(p)	6N				

PACKING

The transistors are supplied on tape in boxes (ammopack) or on reels. The number per reel is 1600 and per ammobox 2000*.

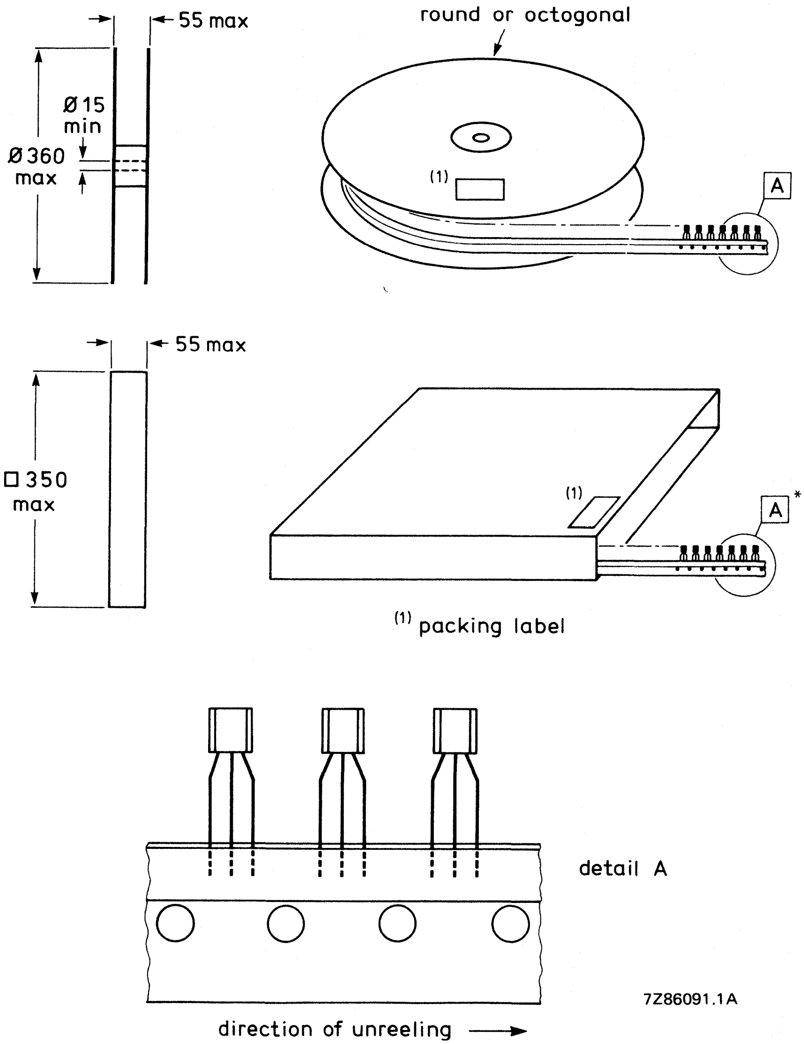


Fig. 2 Dimensions (in mm) of reel and box.

DROPOUTS

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

TAPE SPLICING

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

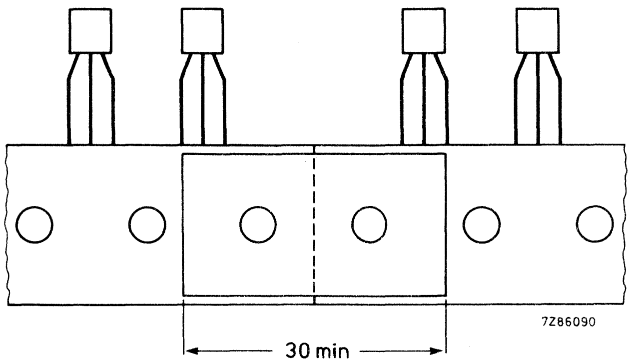


Fig. 3 Jointing tape with splicing patch.

* The ammobox has 80 layers of 25 transistors each.
Each layer contains 25 transistors plus one empty position in order to fold the layer correctly.
The ammobox is accessible from both sides enabling the user to choose between "normal" (see Fig. 2) and "reverse" tape.

DEVICE DATA

in alpha numerical sequence

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

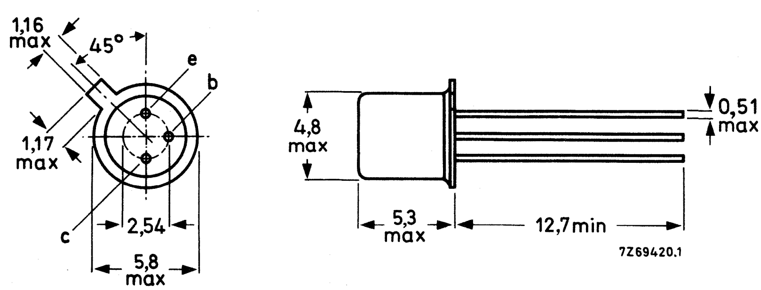
			BC107	BC108	BC109	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	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).

Products approved to CECC 50 002-076/078.

RATINGS

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

			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
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.		300		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	$R_{th\,j\text{-}a}$	=	0,5	K/mW
From junction to case	$R_{th\,j\text{-}c}$	=	0,2	K/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*				
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

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

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

Collector capacitance at f = 1 MHz $I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	2,5	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

			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

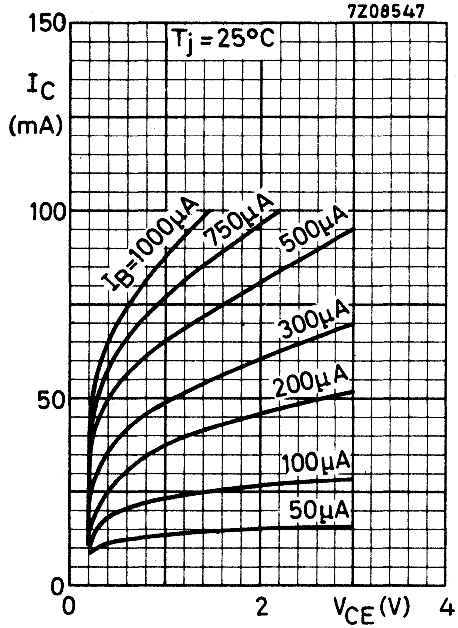


Fig. 2.

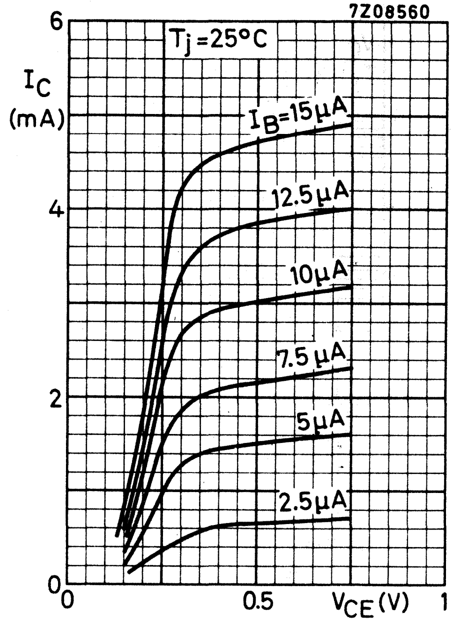


Fig. 3.

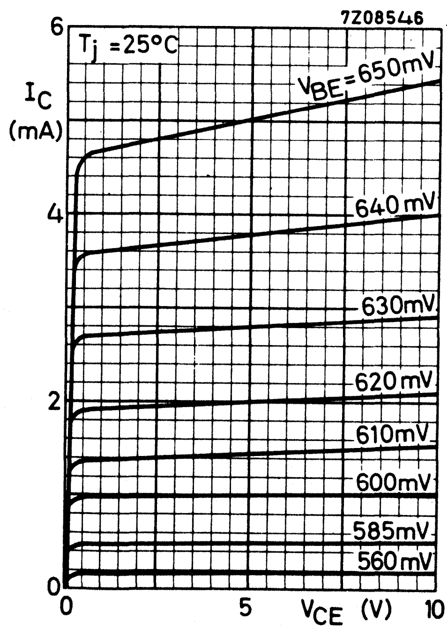


Fig. 4.

Typical behaviour of collector current versus collector-emitter voltage

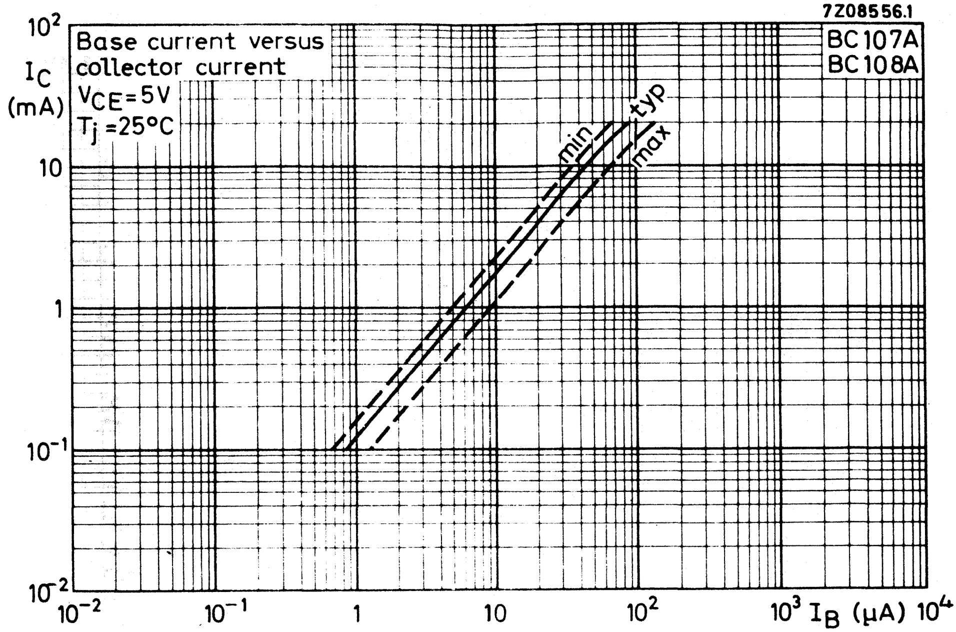

7Z08556.1
Base current versus
collector current
V_{CE} = 5 V
T_j = 25 °C
BC107A
BC108A
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

Fig. 5.

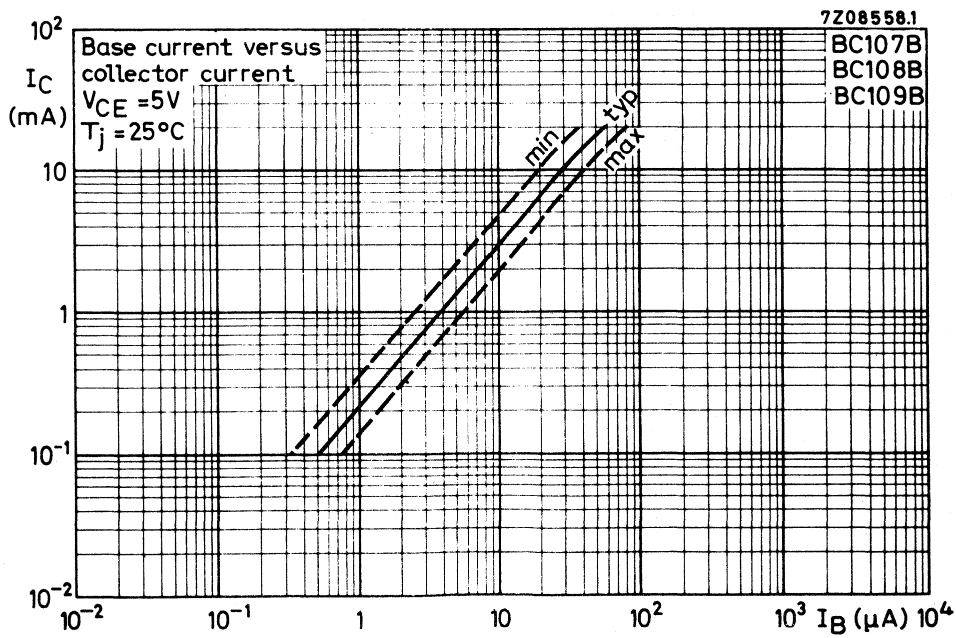

7Z08558.1
Base current versus
collector current
V_{CE} = 5 V
T_j = 25 °C
BC107B
BC108B
BC109B
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

Fig. 6.

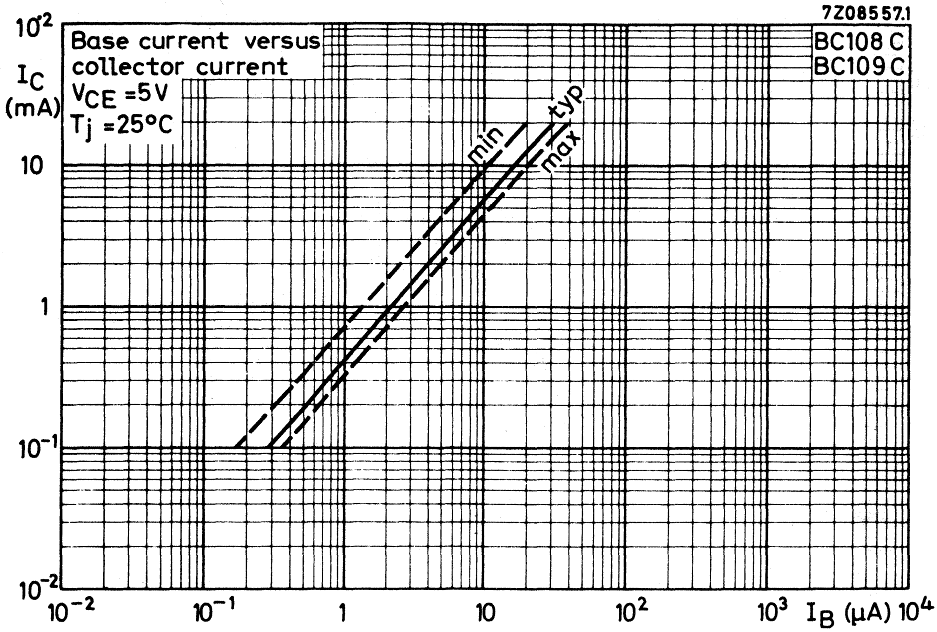


Fig. 7.

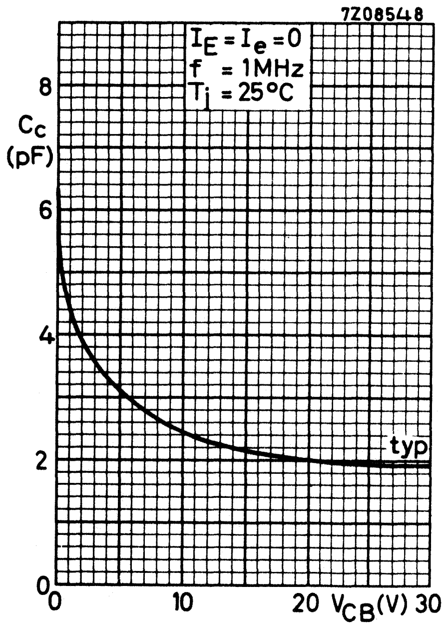


Fig. 8.

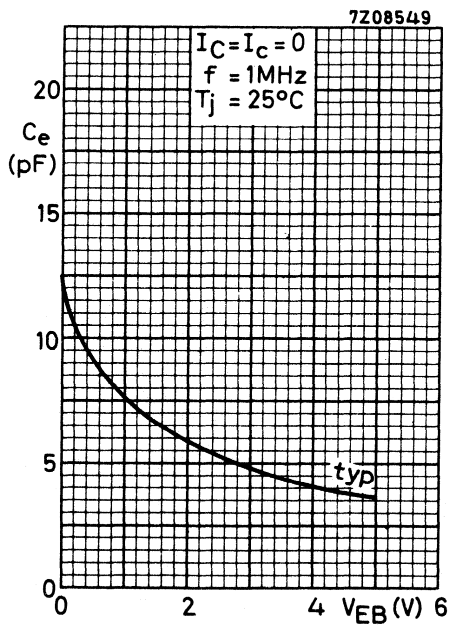


Fig. 9.

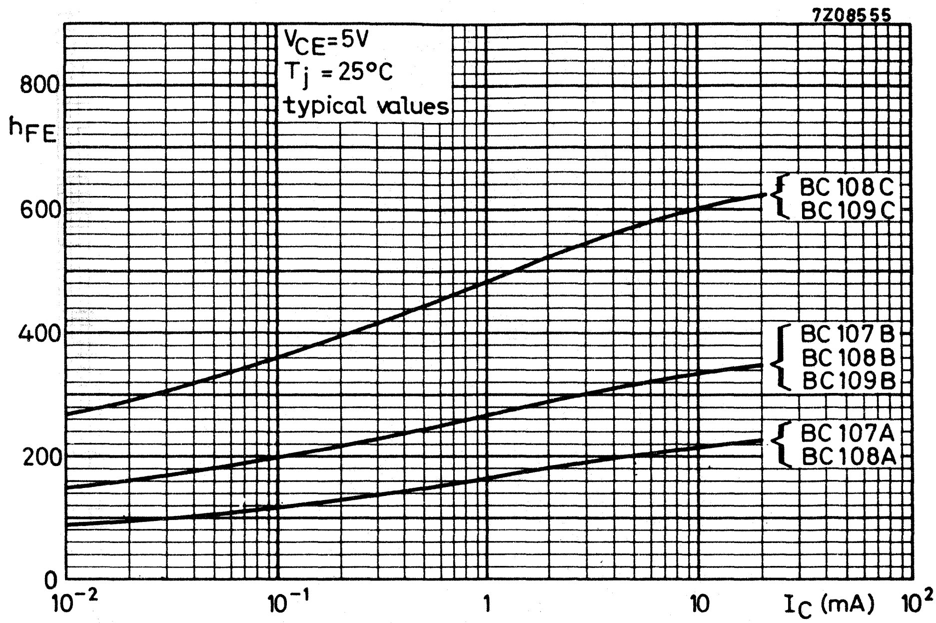

7Z08555
V_{CE}=5V
T_j =25°C
typical values
800
h_{FE}
600
400
200
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2
BC 108 C
BC 109 C
BC 107 B
BC 108 B
BC 109 B
BC 107A
BC 108A

Fig. 10.

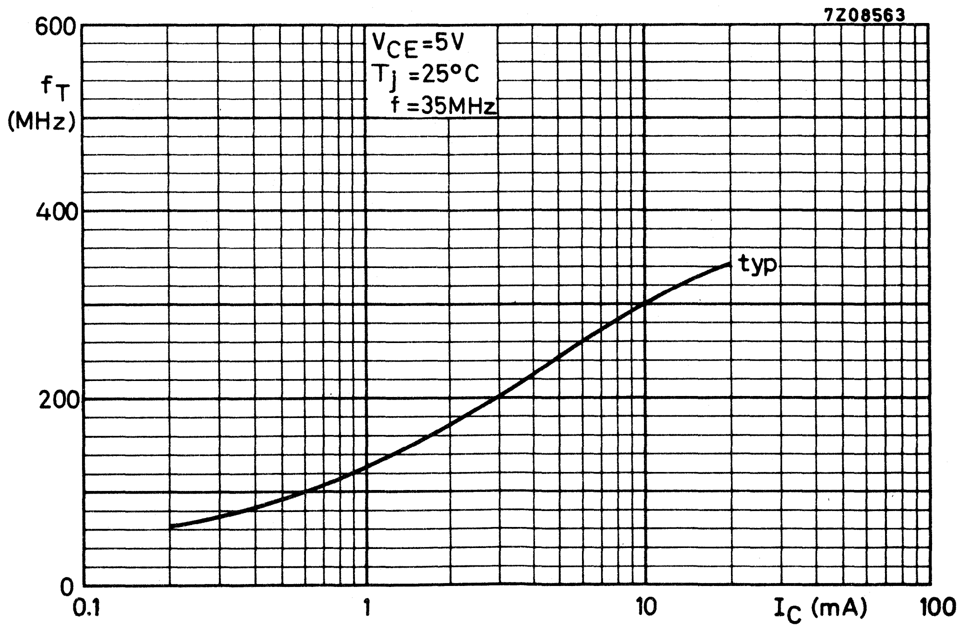

7Z08563
600
V_{CE}=5V
T_j =25°C
f =35MHz
f_T
(MHz)
400
200
0
0.1
1
10
I_C (mA)
100
typ

Fig. 11.

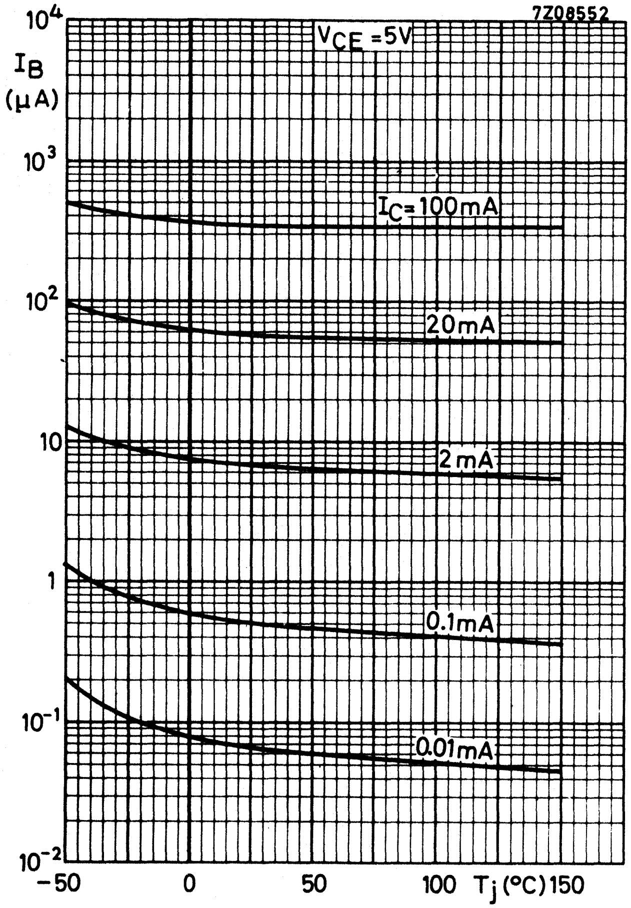


Fig. 12. Typical behaviour of base current versus junction temperature.

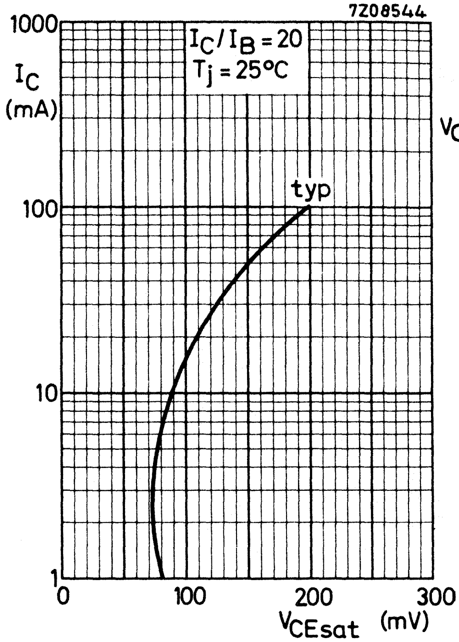


Fig. 13.

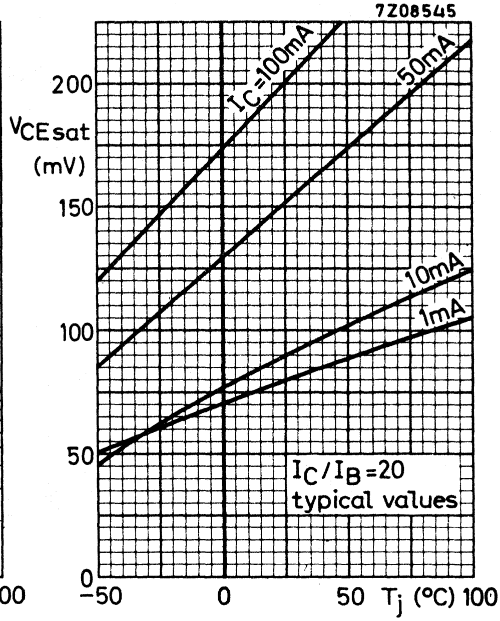


Fig. 14.

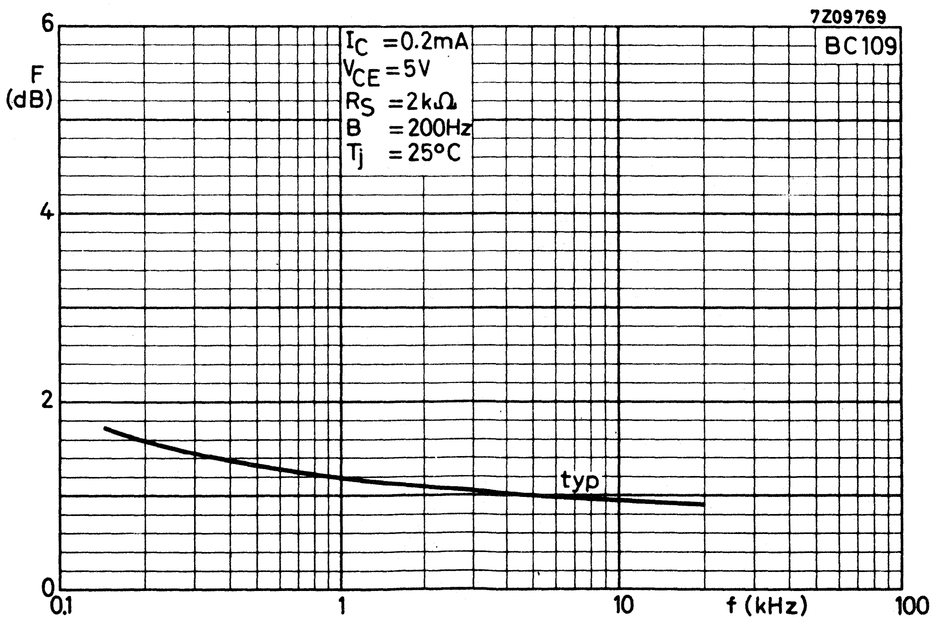


Fig. 15.

Curves of constant noise figure

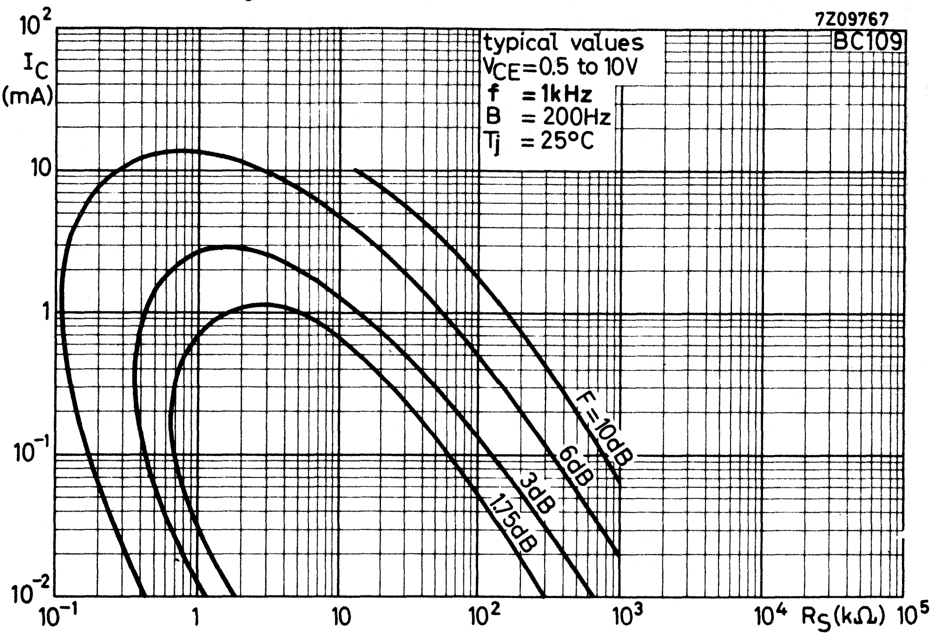


Fig. 16.

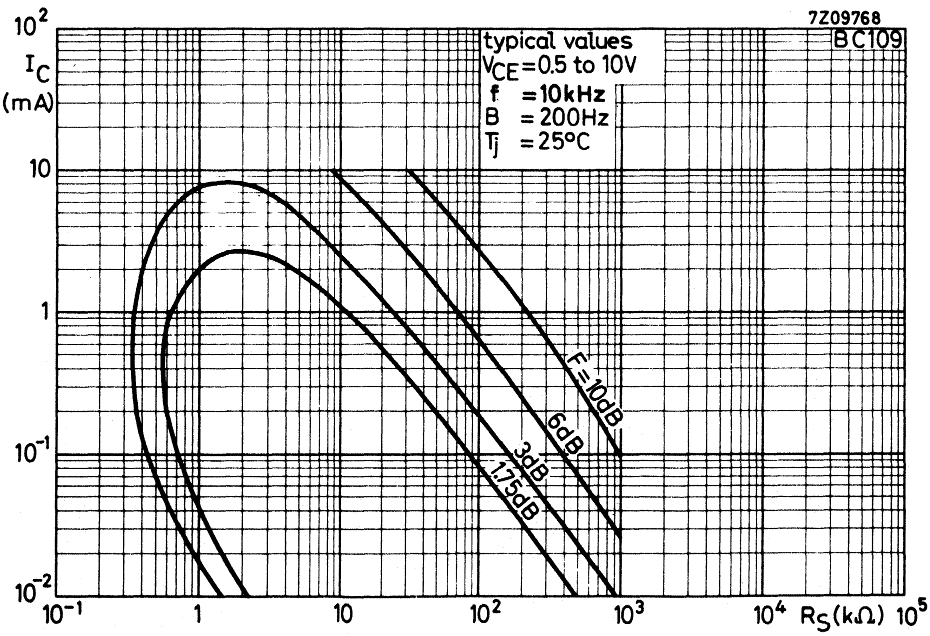


Fig. 17.

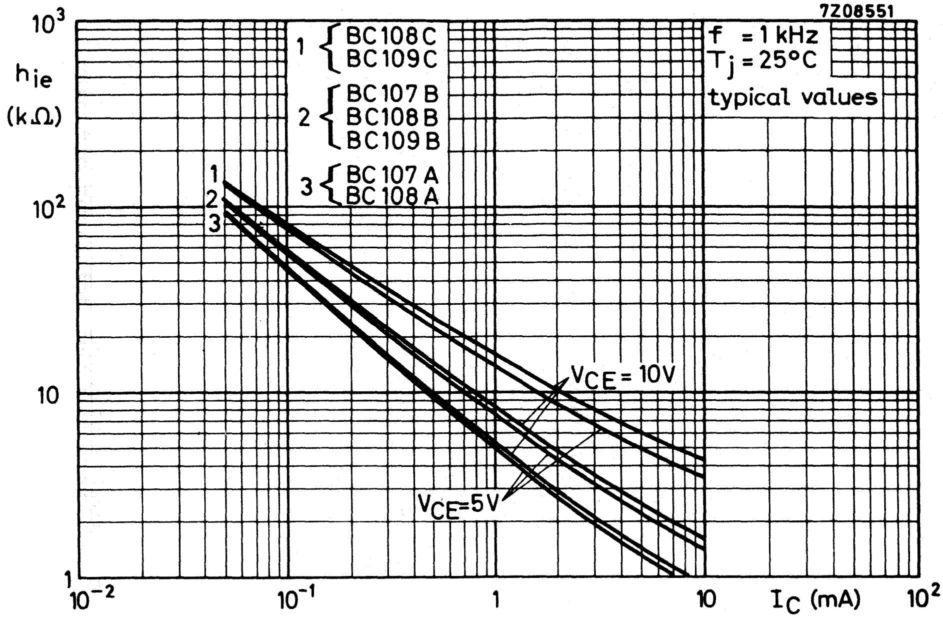

7Z08551
h_{ie}
(kΩ)
1 { BC108C, BC109C
2 { BC107B, BC108B, BC109B
3 { BC107A, BC108A
f = 1 kHz
T_j = 25 °C
typical values
V_{CE} = 10 V
V_{CE} = 5 V
I_C (mA)

Fig. 18.

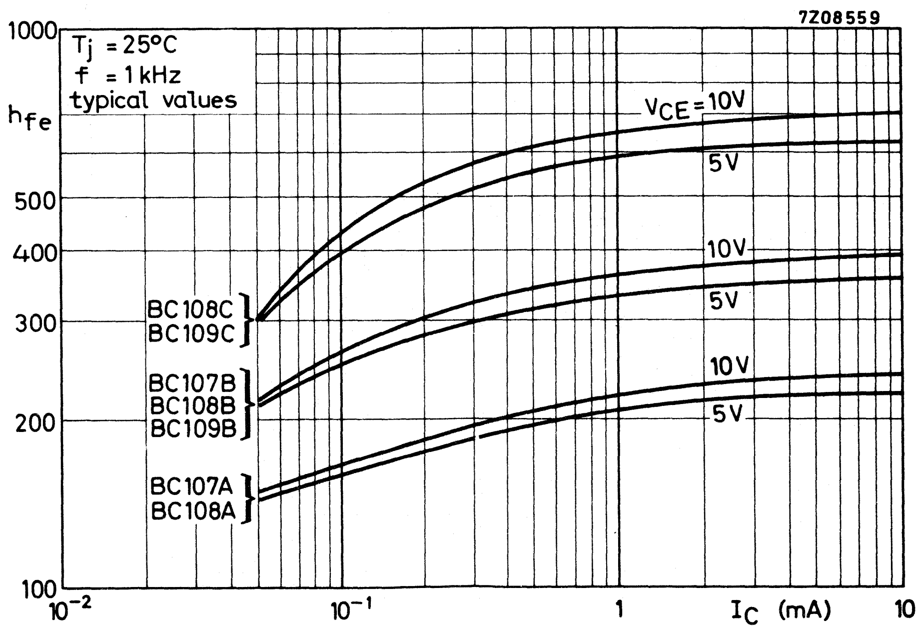

7Z08559
T_j = 25 °C
f = 1 kHz
typical values
h_{fe}
V_{CE} = 10 V
5 V
10 V
5 V
10 V
5 V
BC108C
BC109C
BC107B
BC108B
BC109B
BC107A
BC108A
I_C (mA)

Fig. 19.

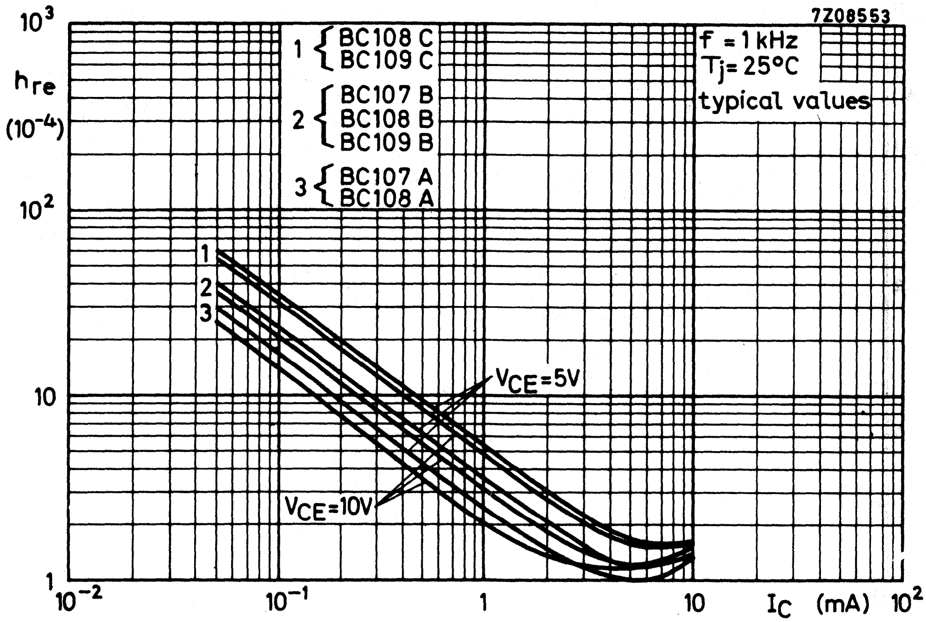

7Z08553
1 {BC108 C, BC109 C}
2 {BC107 B, BC108 B, BC109 B}
3 {BC107 A, BC108 A}
f = 1 kHz
Tj = 25°C
typical values
h_{re} (10^{-4})
V_{CE}=5V
V_{CE}=10V
I_C (mA)

Fig. 20.

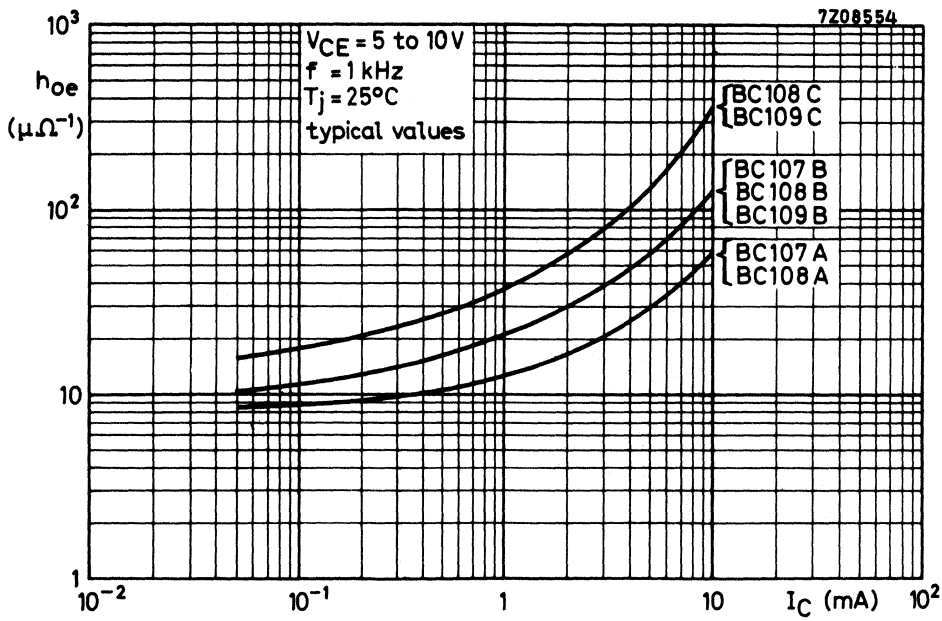

7Z08554
V_{CE} = 5 to 10 V
f = 1 kHz
Tj = 25°C
typical values
h_{oe} ($\mu\Omega^{-1}$)
BC108 C, BC109 C
BC107 B, BC108 B, BC109 B
BC107 A, BC108 A
I_C (mA)

Fig. 21.

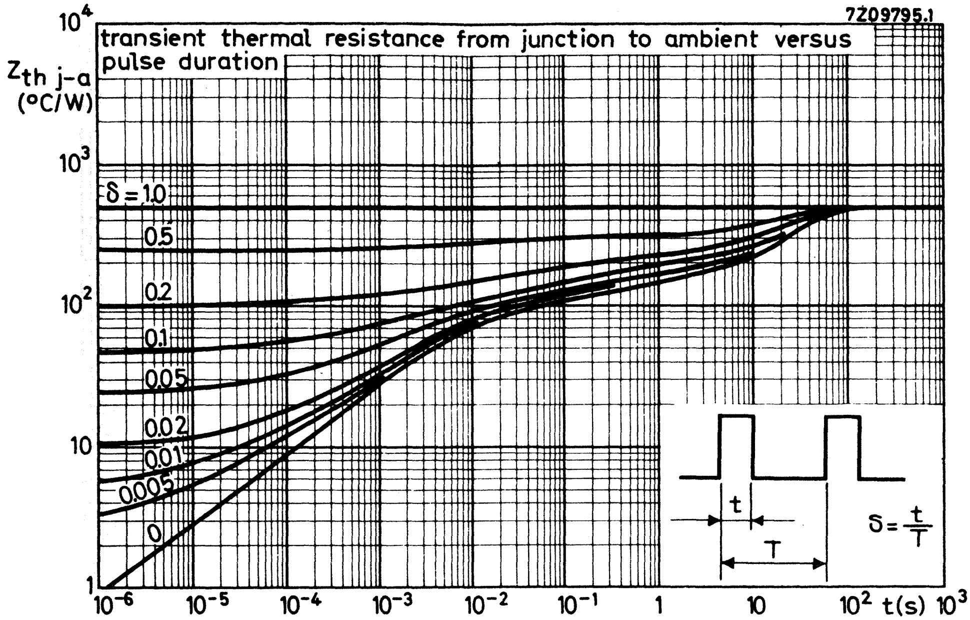

7Z09795.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
$\delta = \frac{t}{T}$

Fig. 22.

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

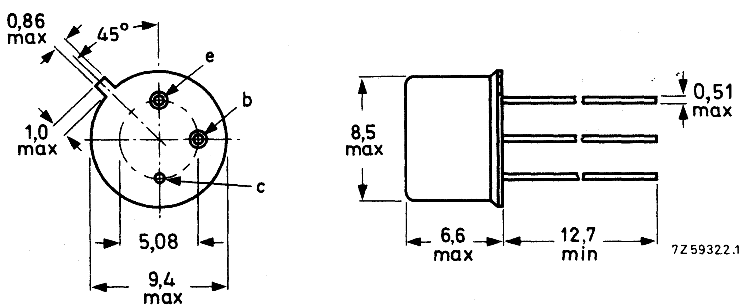
			BC140-10 BC141-10	BC140-16 BC141-16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	63	100
		<	160	250

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)

			BC140	BC141	
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
Collector current (d.c.)	I_C	max.	1		A
Base current (d.c.)	I_B	max.	100		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/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

			BC140-10 BC141-10	BC140-16 BC141-16
D.C. current gain → I_C = 100 μA; V_{CE} = 1 V	h_{FE}	typ. >	40 63	90 100
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	typ. <	100 160	160 250
I_C = 1 A; V_{CE} = 1 V	h_{FE}	typ.	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}	<	250 ns
Turn-off time	t_{off}	<	850 ns

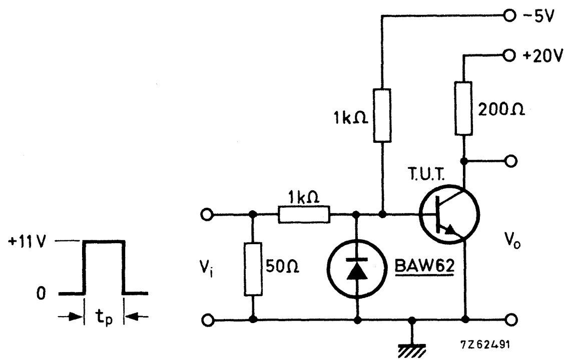


Fig. 2 Test circuit.

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 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

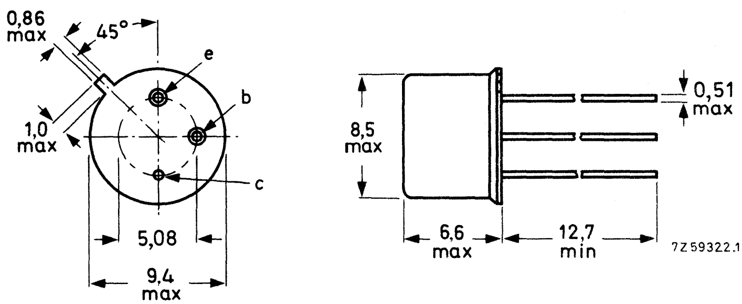
			BC160-10 BC161-10	BC160-16 BC161-16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	63	100
		<	160	250

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)

			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
Collector current (d.c.)	$-I_C$	max.	1		A
Base current (d.c.)	$-I_B$	max.	100		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specfied

Collector cut-off current $V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	typ. <	10 100	nA nA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$; 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. <	1,0 1,7	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	<	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			BC160-10 BC161-10	BC160-16 BC161-16
$-I_C$ = 100 µA; $-V_{CE}$ = 1 V	h_{FE}	typ.	80	120
		>	63	100
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	100	160
		<	160	250
$-I_C$ = 1 A; $-V_{CE}$ = 1 V	h_{FE}	typ.	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

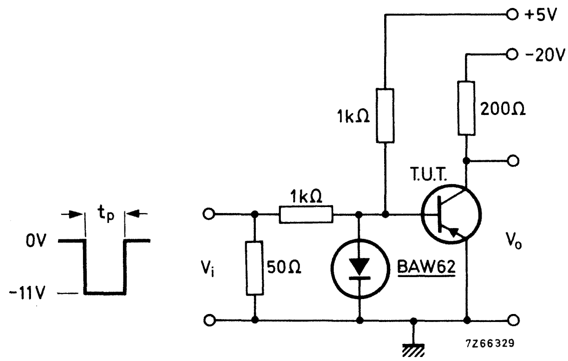


Fig. 2 Test circuit.

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

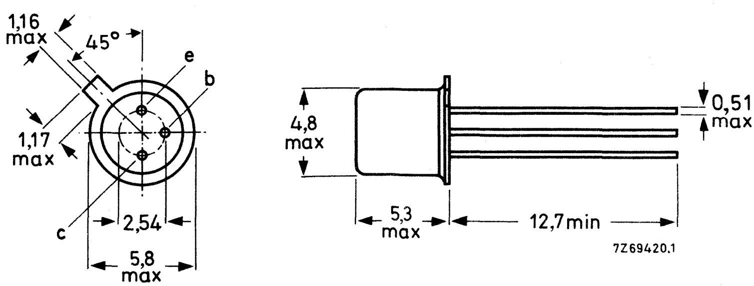
			BC177	BC178	BC179	
Collector-emitter voltage (+ V_{BE} = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	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)

			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
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
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		300		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	$R_{th\ j\text{-}a}$	=	0,5	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,2	K/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

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

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

			BC177	BC178	BC179
Small signal current gain at f = 1 kHz $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	> <	75 260	75 500	125 500
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 dB
f = 1 kHz; B = 200 Hz	F	typ. <	2 10	2 10	1 dB 4 dB

			BC177 BC178	BC177A BC178A BC179A	BC177B 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}	> <	75 260	125 260	240 500

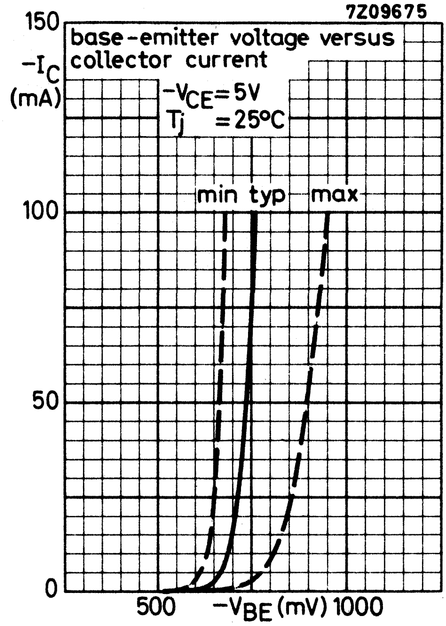


Fig. 2.

Typical behaviour of collector current versus collector-emitter voltage

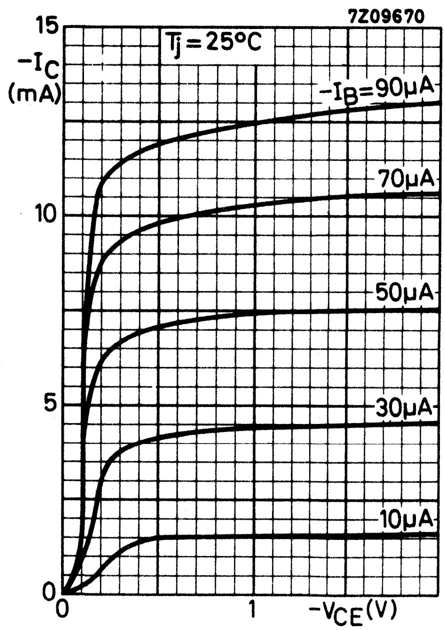


Fig. 3.

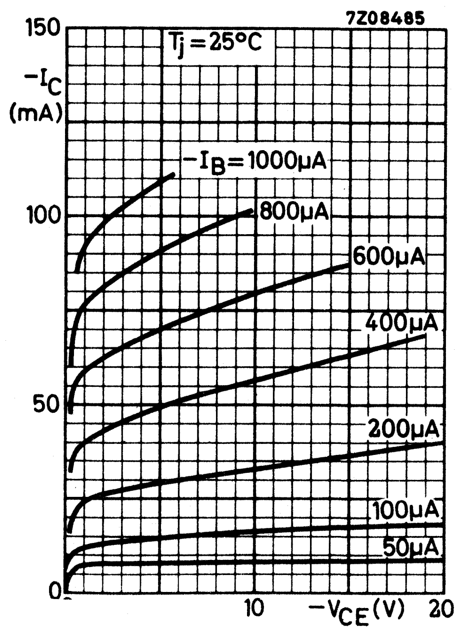


Fig. 4.

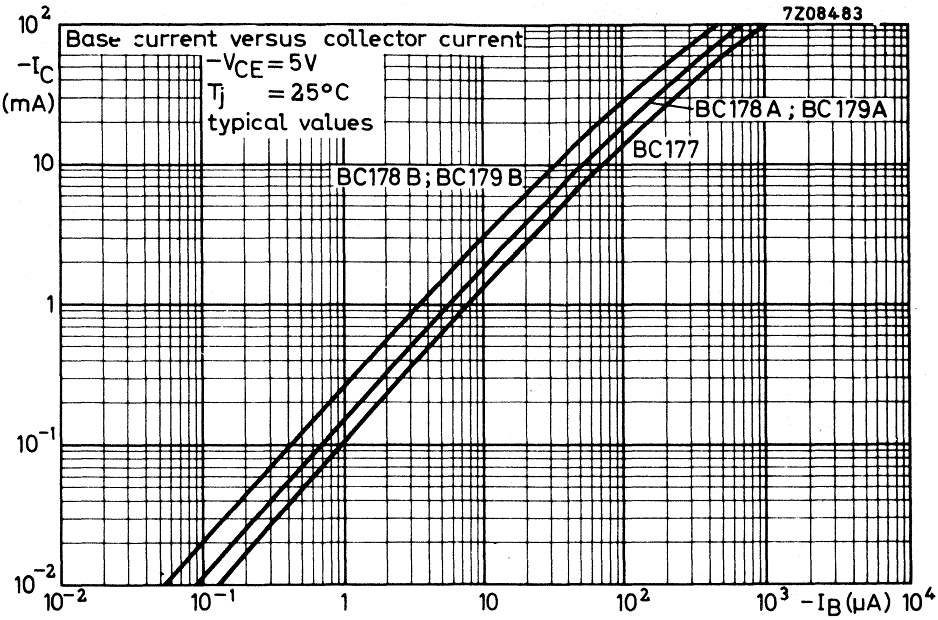

7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC178 A ; BC179A
BC177
BC178 B ; BC179 B
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

Fig. 5.

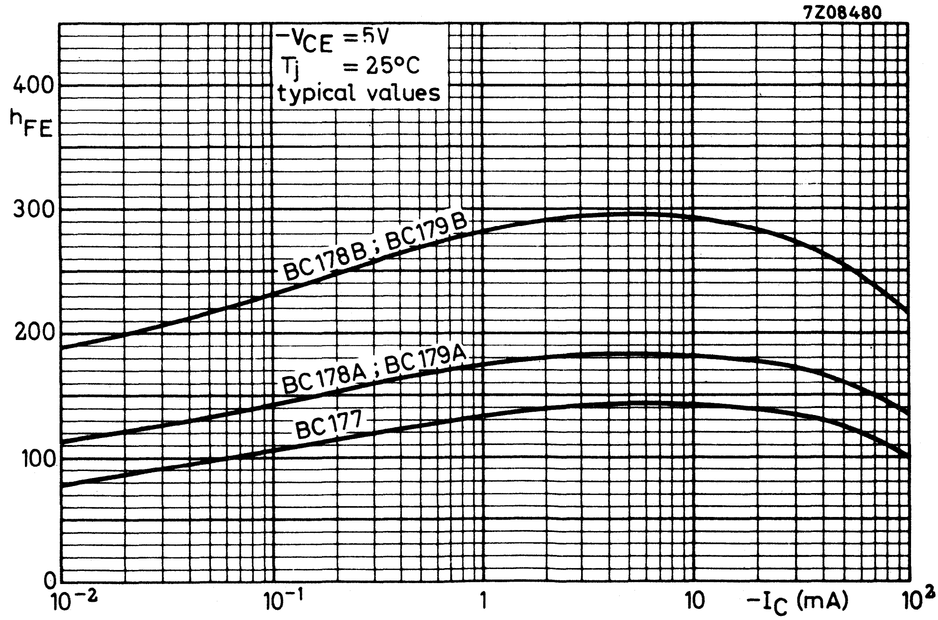

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC178B ; BC179B
BC178A ; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 6.

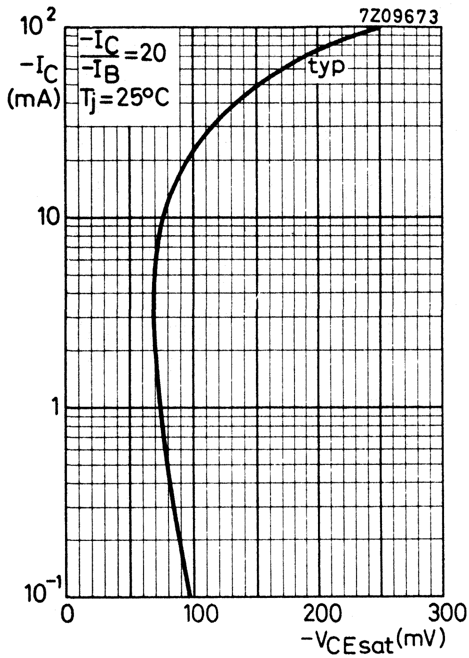


Fig. 7.

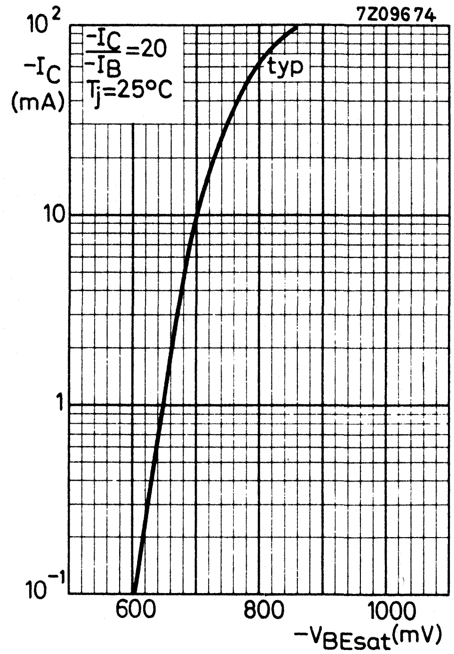


Fig. 8.

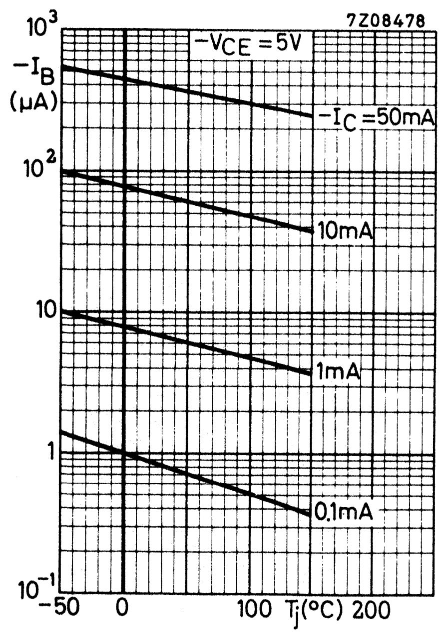


Fig. 9.

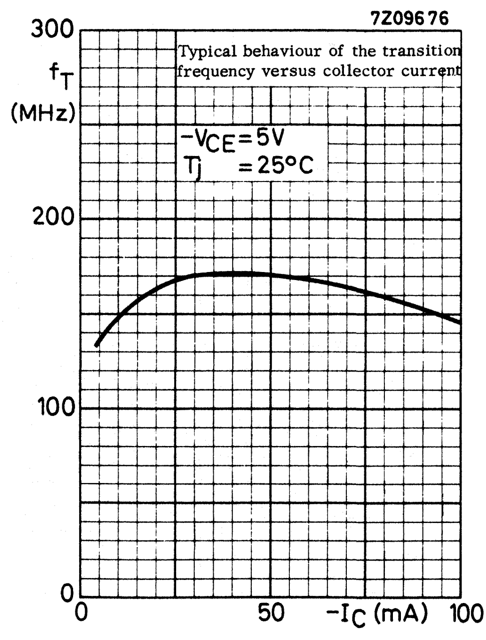


Fig. 10.

Typical behaviour of base current versus junction temperature.

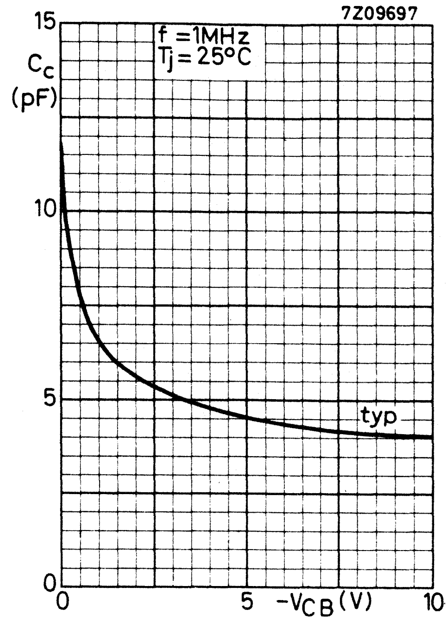

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
-VCB (V)
10

Fig. 11.

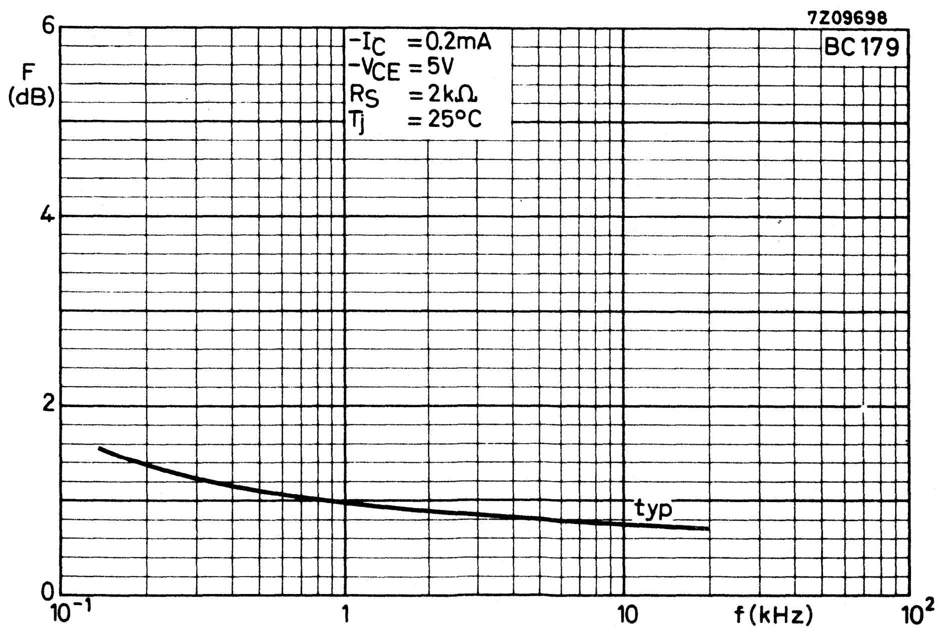

7Z09698
BC 179
-IC = 0.2mA
-VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10⁻¹
1
10
f (kHz)
10²

Fig. 12.

Curves of constant noise figure

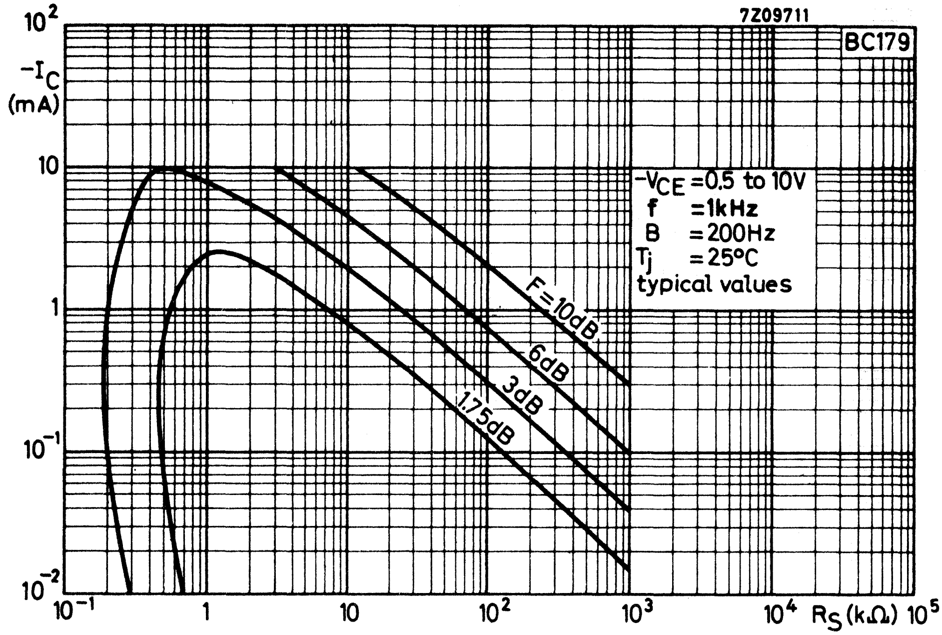


Fig. 13.

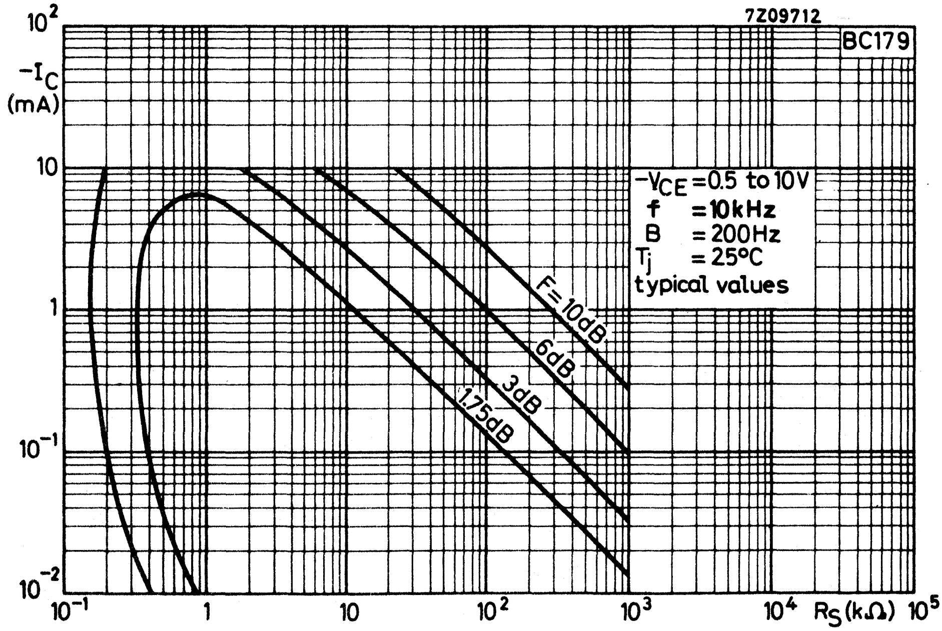


Fig. 14.

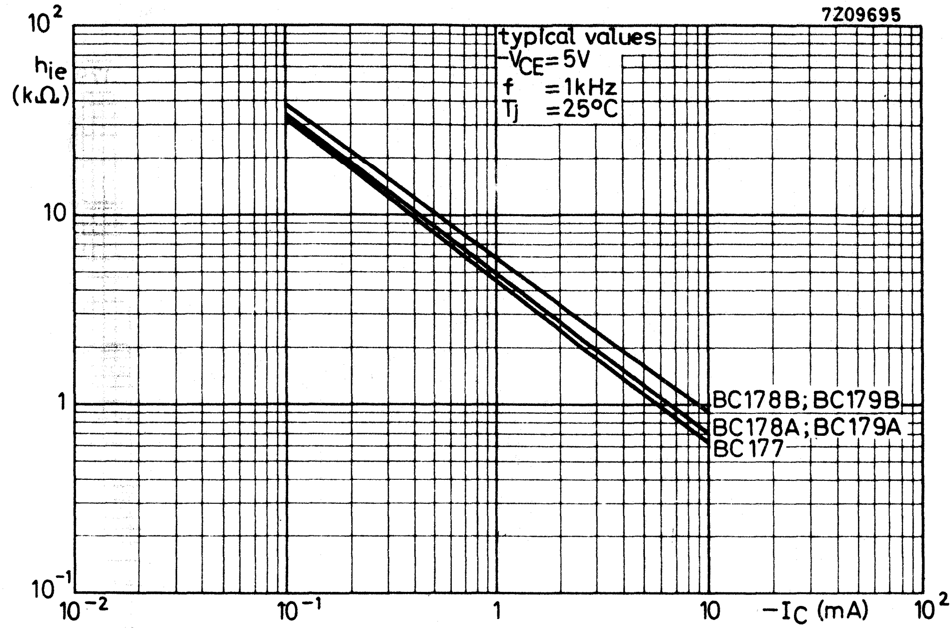

7Z09695
h_{ie} (kΩ)
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC178B; BC179B
BC178A; BC179A
BC177
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 15.

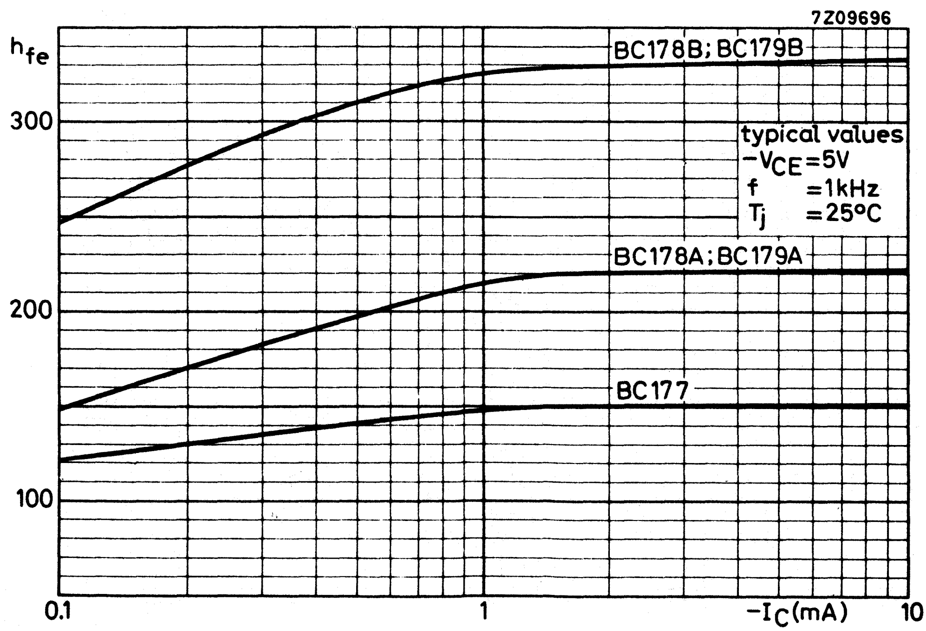

7Z09696
h_{fe}
BC178B; BC179B
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC178A; BC179A
BC177
300
200
100
0.1
1
$-I_C$(mA)
10

Fig. 16.

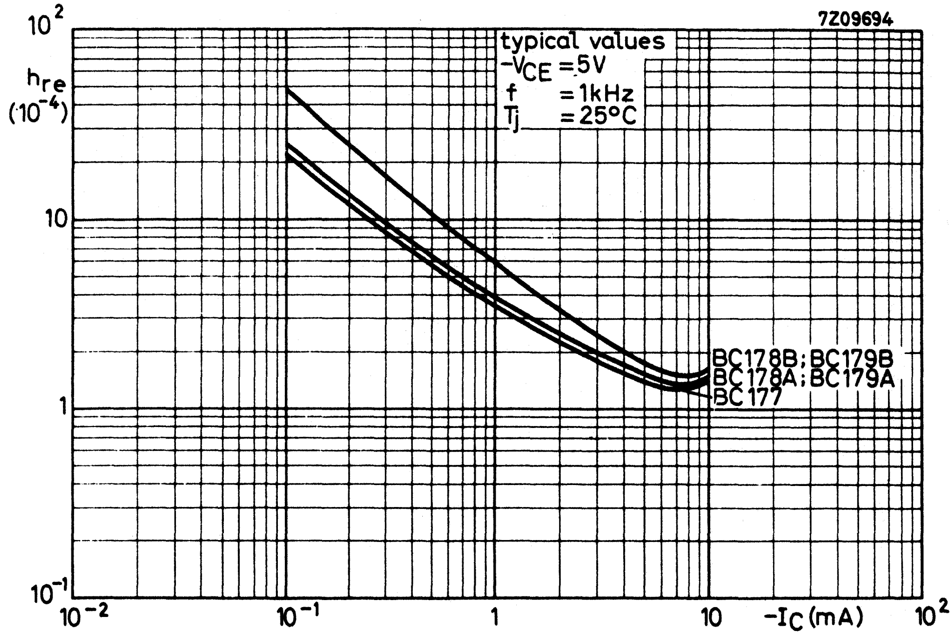

7Z09694
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re}
(10^{-4})
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177

Fig. 17.

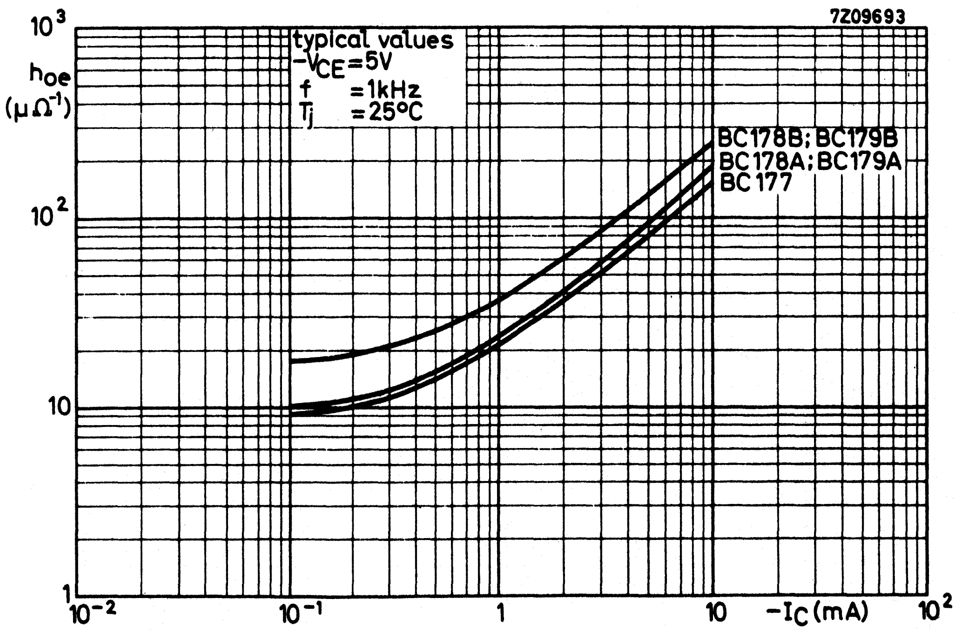

7Z09693
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe}
($\mu\Omega^{-1}$)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177

Fig. 18.

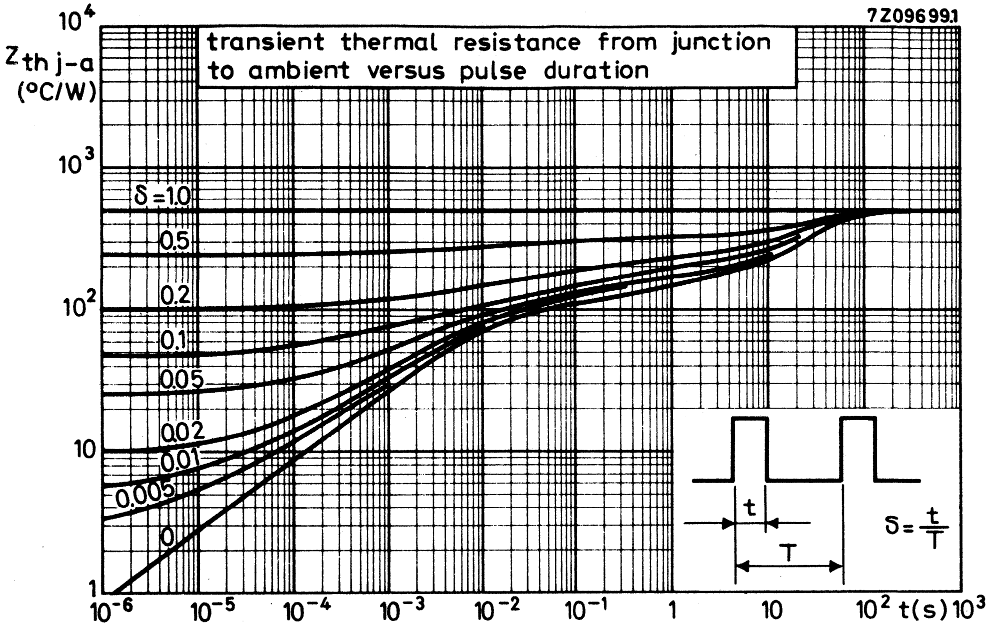

7Z09699.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
$\delta = \frac{t}{T}$

Fig. 19.

SILICON PLANAR EPITAXIAL TRANSISTORS

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

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

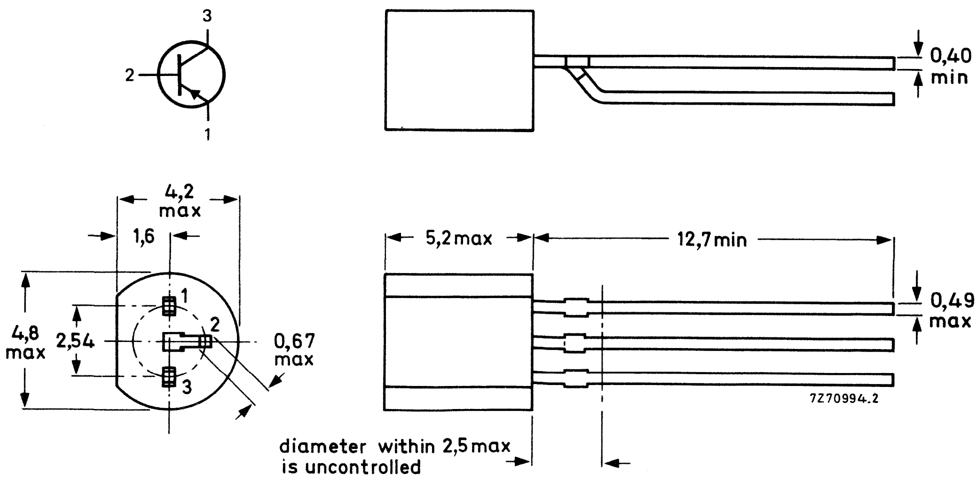
QUICK REFERENCE DATA

			BC327	BC327A	BC328	
Collector-emitter voltage ($V_{BE} = 0$)	$-V_{CES}$	max.	50	60	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	25	V
Collector current (peak value)	$-I_{CM}$	max.		1000		mA
Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max.		800		mW
Junction temperature	T_j	max.		150		^{o}C
Transition frequency at f = 35 MHz $-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.		100		MHz
D.C. current gain $-I_C = 100$ mA; $-V_{CE} = 1$ V	h_{FE}			100 to 600		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

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

THERMAL RESISTANCE

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

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

CHARACTERISTICS

T_j = 25 °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
BC327A	h_{FE}		100 to 400
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

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

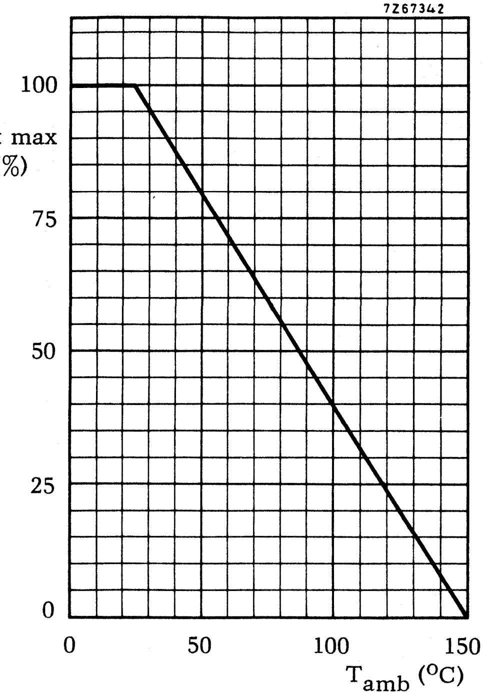

7Z67342
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

Fig. 2.

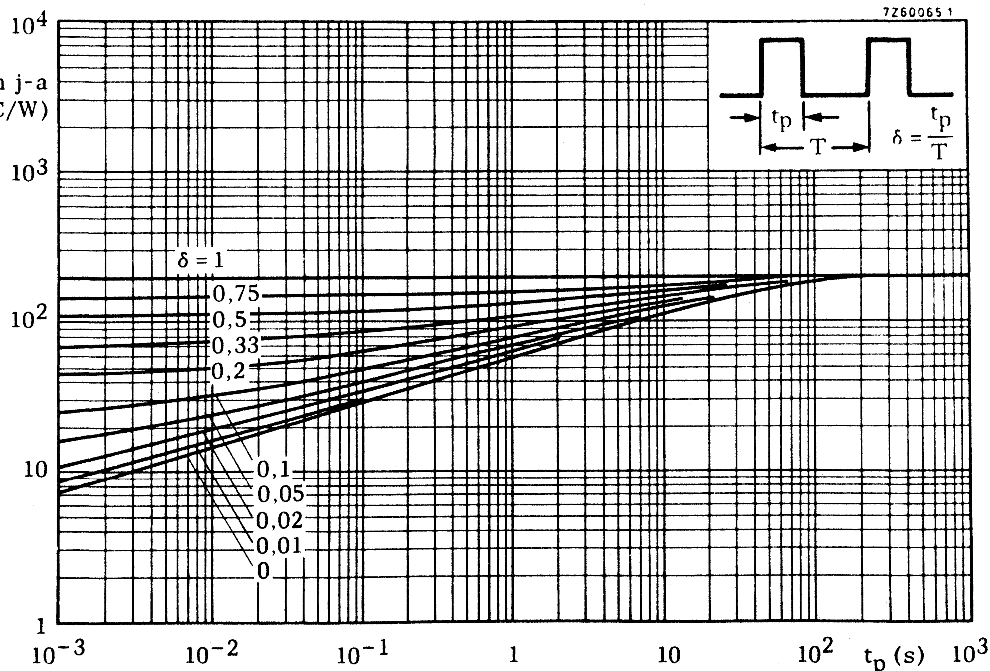

7Z60065 1
10^4
$Z_{th\ j\text{-}a}$ (°C/W)
10^3
10^2
10
1
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3

Fig. 3.

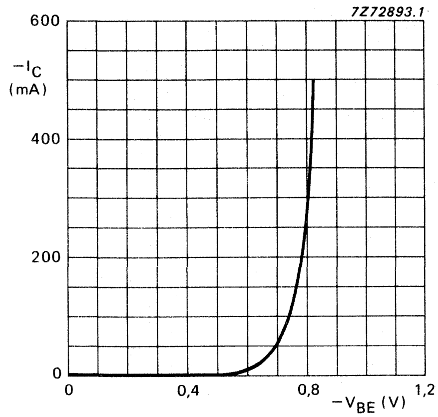


Fig. 4 $-V_{CE} = 1$ V; $T_j = 25$ °C; typical values.

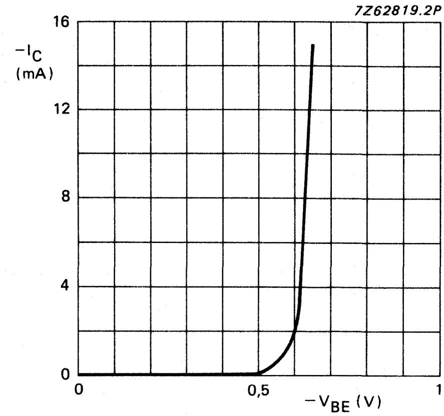


Fig. 5 $-V_{CE} = 5$ V; $T_j = 25$ °C; typical values.

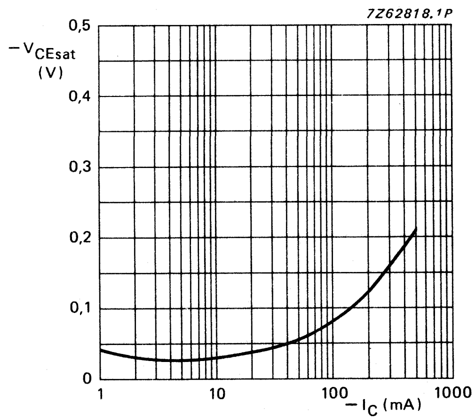


Fig. 6 $I_C/I_B = 10$; $T_j = 25$ °C; typical values.

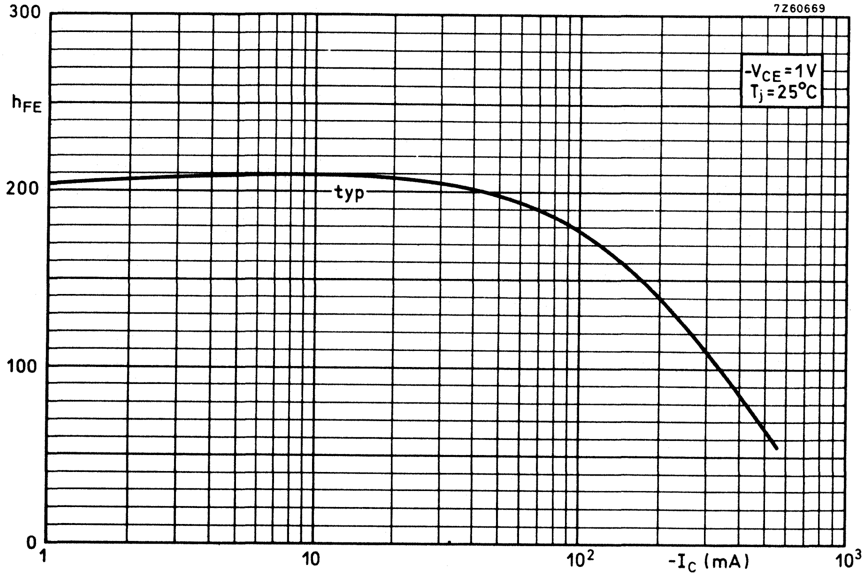

7Z60669
300
h_{FE}
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 1 V
T_j = 25 °C
typ

Fig. 7.

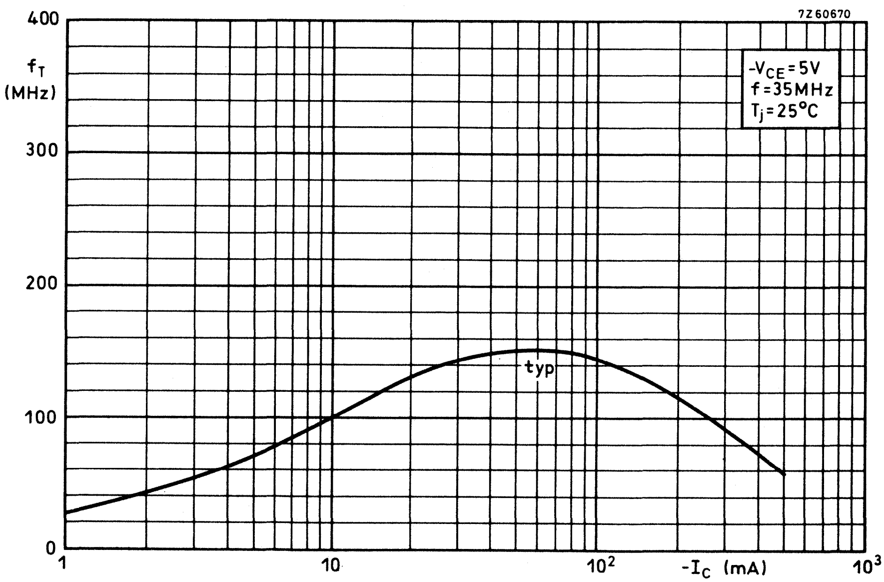

7Z60670
400
f_T
(MHz)
300
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 5 V
f = 35 MHz
T_j = 25 °C
typ

Fig. 8.

SILICON PLANAR EPITAXIAL TRANSISTORS

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

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

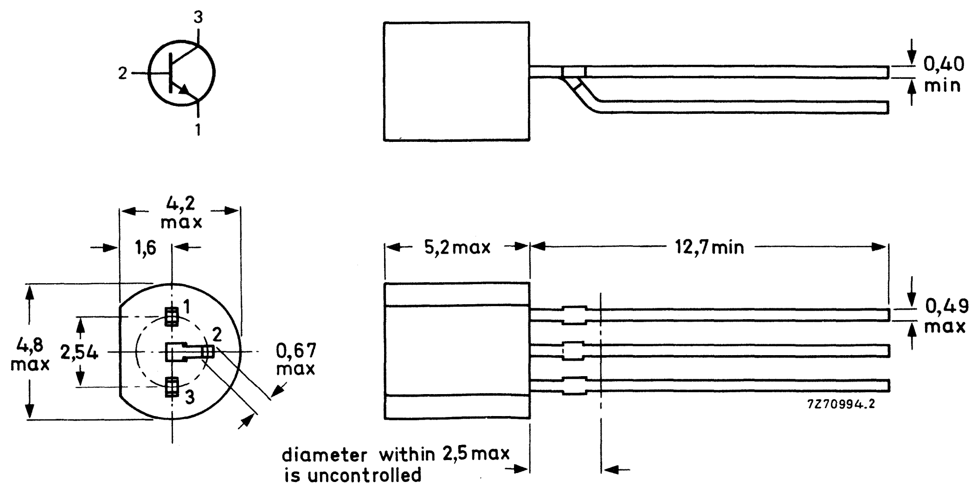
QUICK REFERENCE DATA

			BC337	BC337A	BC338	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	60	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	25	V
Collector current (peak value)	I_{CM}	max.		1000		mA
Total power dissipation up to T_{amb} = 25 °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
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}			100 to 600		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

			BC337	BC337A	BC338	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	60	30	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	45	60	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		500		mA
Collector current (peak value)	I_{CM}	max.		1000		mA
Emitter current (peak value)	$-I_{EM}$	max.		1000		mA
Base current (d.c.)	I_B	max.		100		mA
Base current (peak value)	I_{BM}	max.		200		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.		625		mW
up to T_{amb} = 25 °C	P_{tot}	max.		800		mW*
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

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

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

CHARACTERISTICS

T_j = 25 °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
BC337A	h_{FE}		100 to 400
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

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

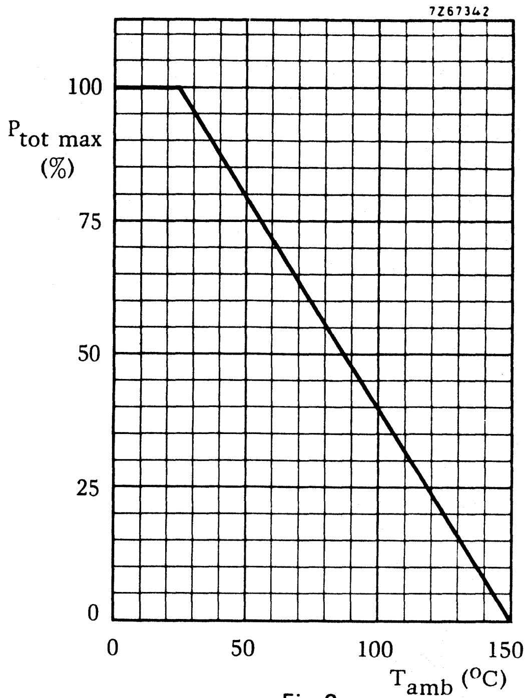

7Z67342
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

Fig. 2.

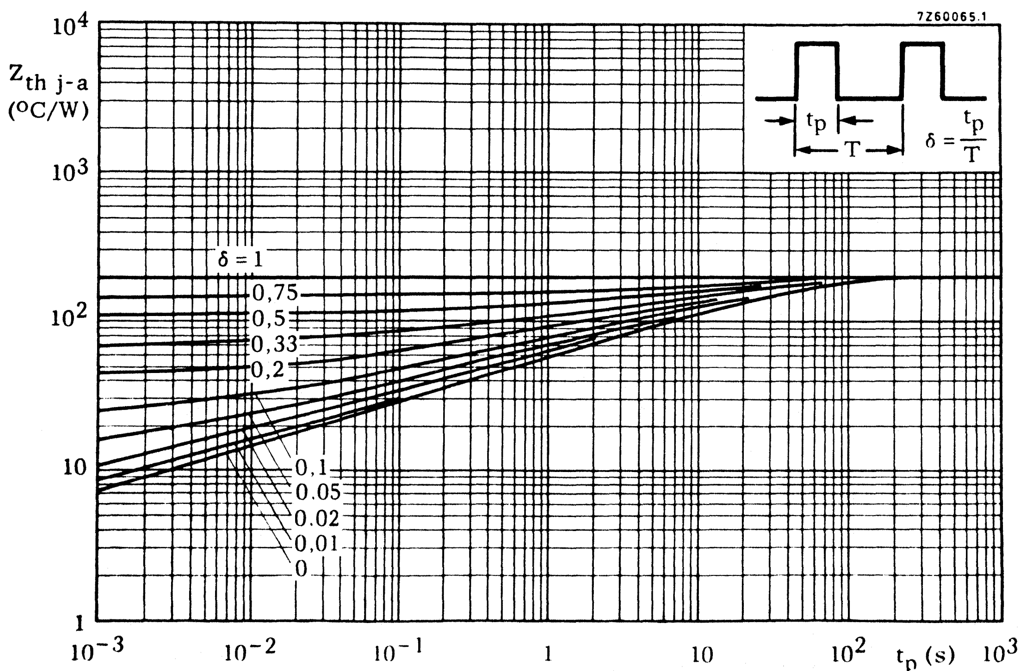

7Z60065.1
10^4
$Z_{th\ j-a}$ (°C/W)
10^3
10^2
10
1
δ = 1
0,75
0,5
0,33
0,2
0,1
0.05
0.02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3

Fig. 3.

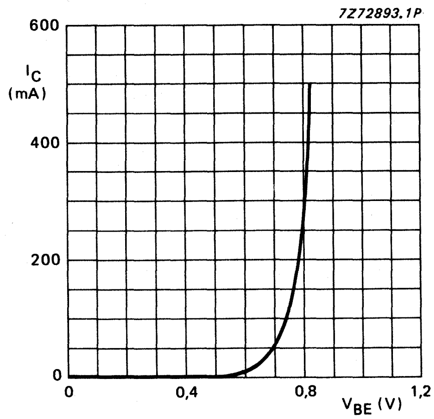


Fig. 4 V_{CE} = 1 V; T_j = 25 °C; typical values.

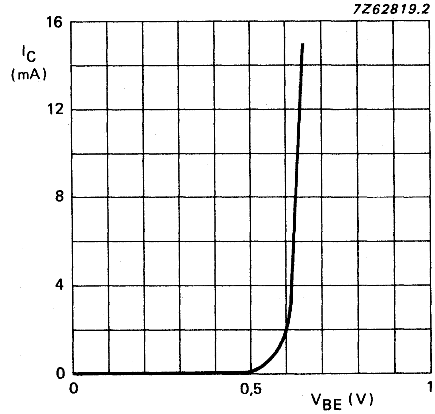


Fig. 5 V_{CE} = 5 V; T_j = 25 °C; typical values.

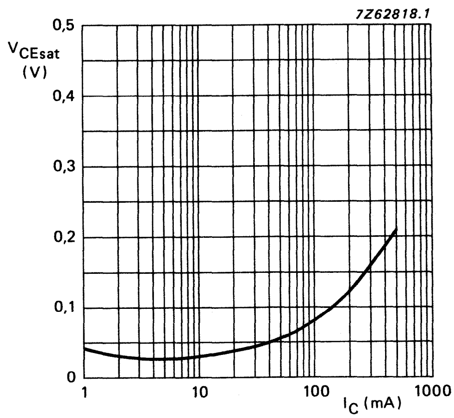


Fig. 6 I_C/I_B = 10; T_j = 25 °C; typical values.

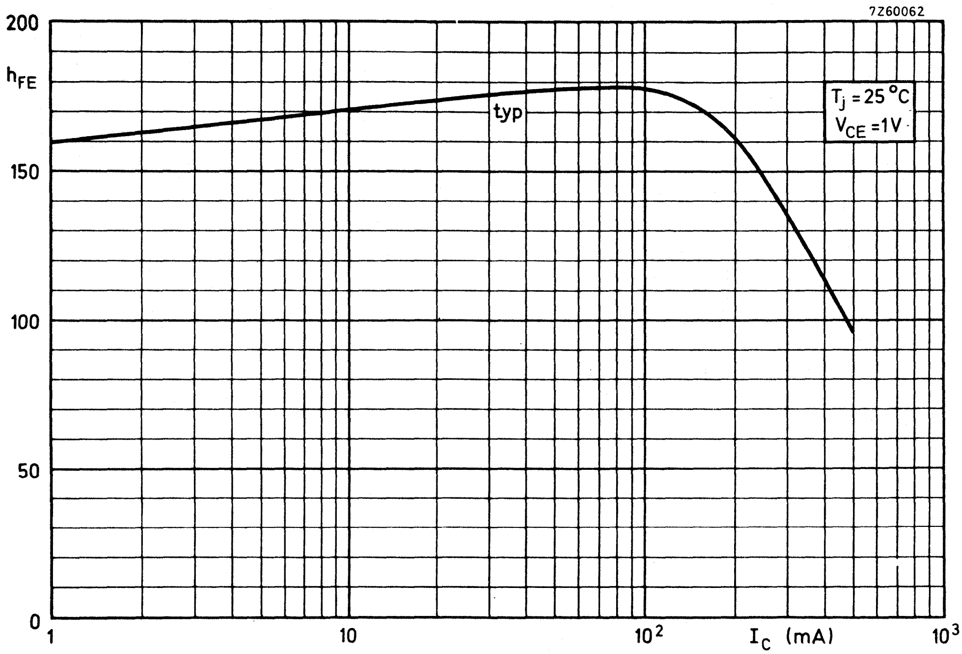


Fig. 7.

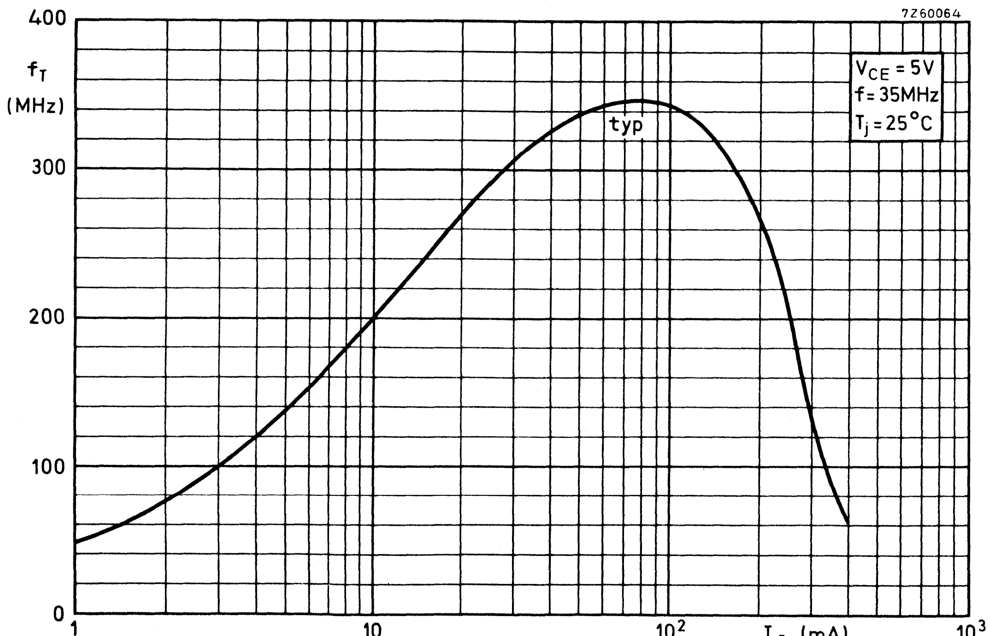


Fig. 8.

APPLICATION INFORMATION, see BC327; BC328.

SILICON PLANAR EPITAXIAL TRANSISTOR

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

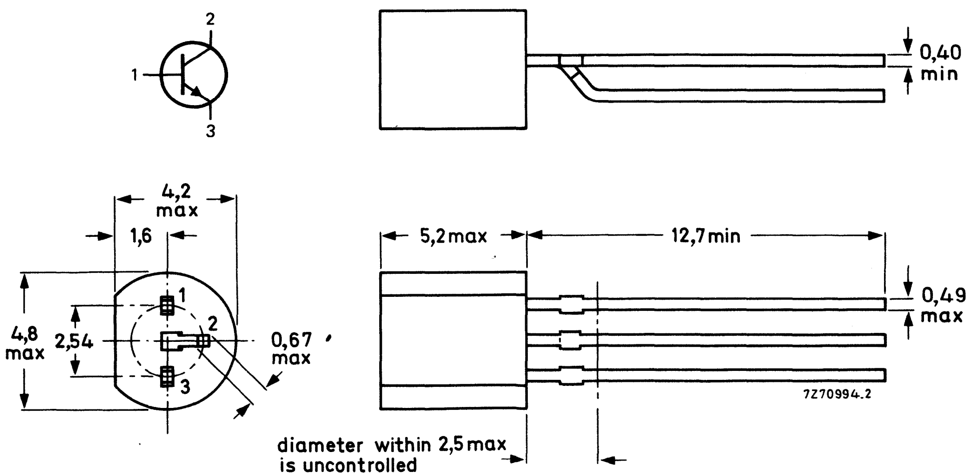
QUICK REFERENCE DATA

Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{amb} = 25 °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 at f = 35 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

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

* Transistor mounted on printed-circuit board, maximum 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

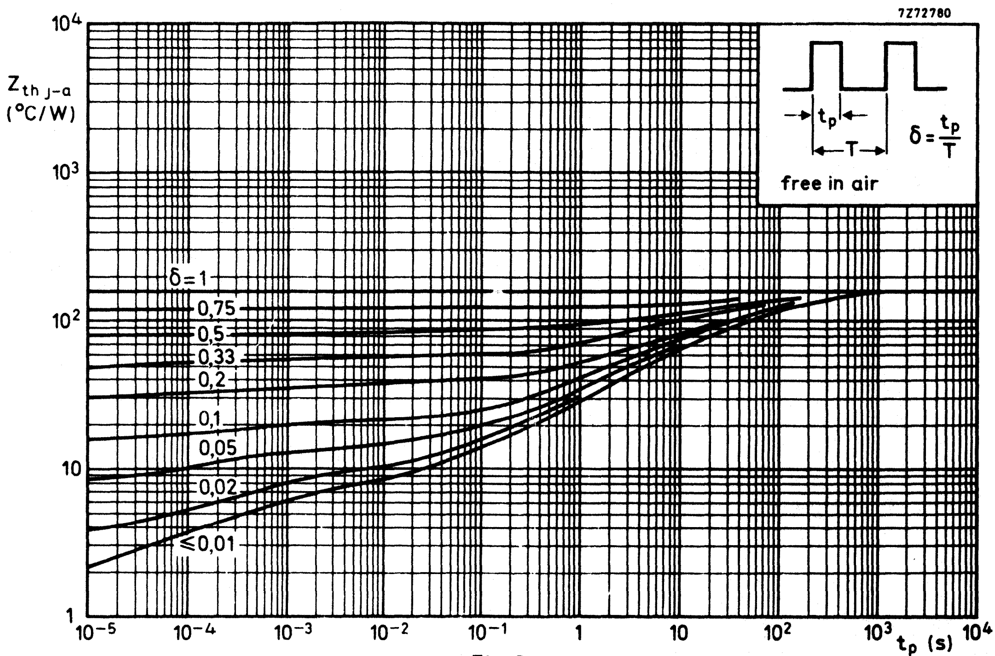

7Z72780
$Z_{th\ j-a}$ (°C/W)
$\delta = \frac{t_p}{T}$
free in air
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

Fig. 2.

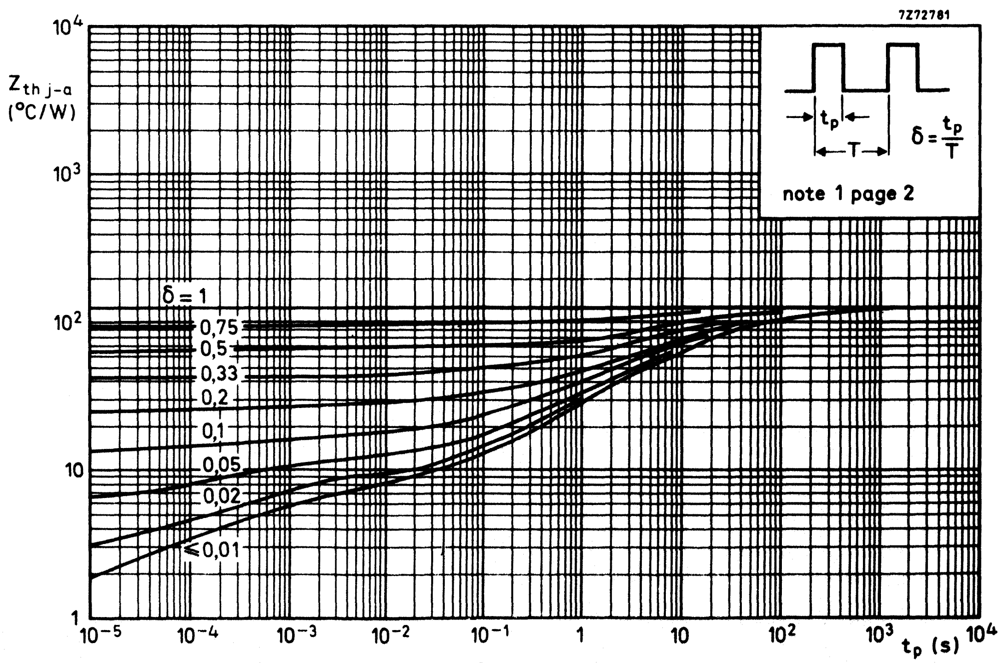

7Z72781
$Z_{th\ j-a}$ (°C/W)
$\delta = \frac{t_p}{T}$
note 1 page 2
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

Fig. 3.

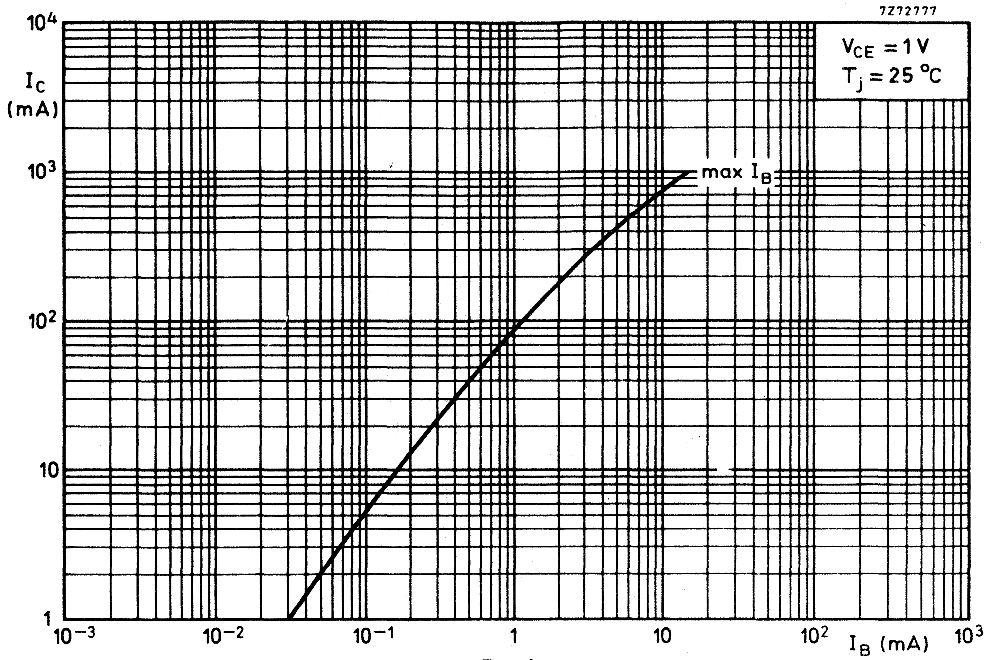

7Z72777
V_{CE} = 1 V
T_j = 25 °C
I_C (mA)
10^4
10^3
10^2
10
1
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

Fig. 4.

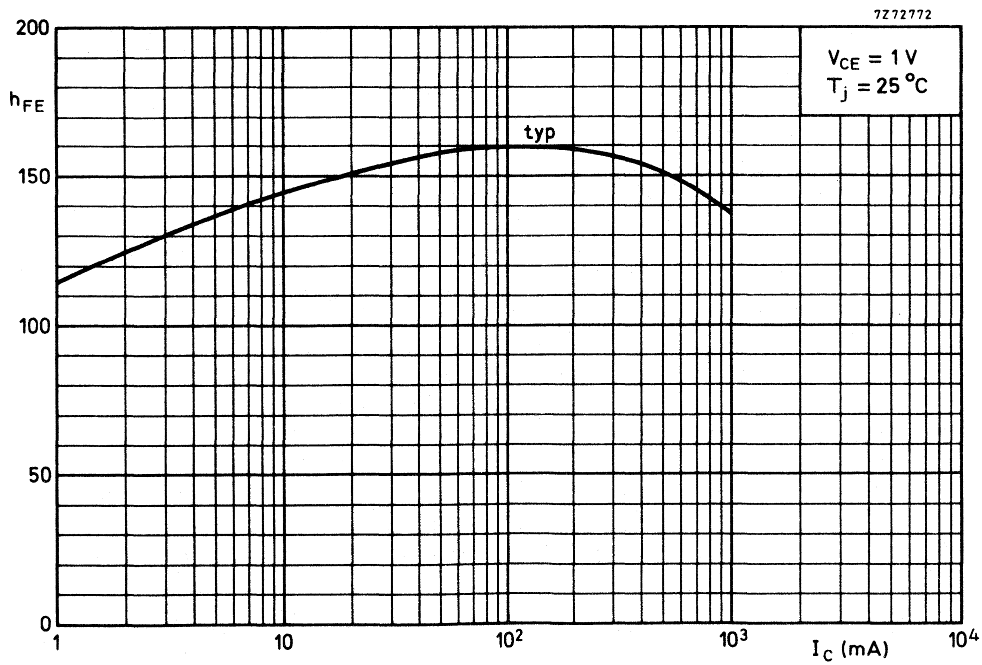

7Z72772
V_{CE} = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
1
10
10^2
10^3
I_C (mA)
10^4

Fig. 5.

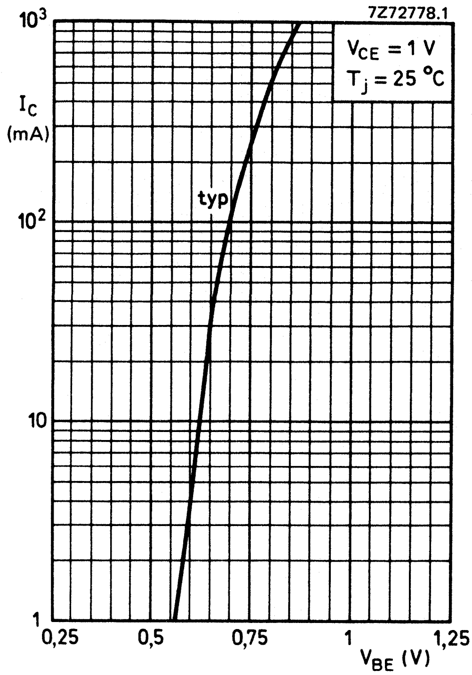


Fig. 6.

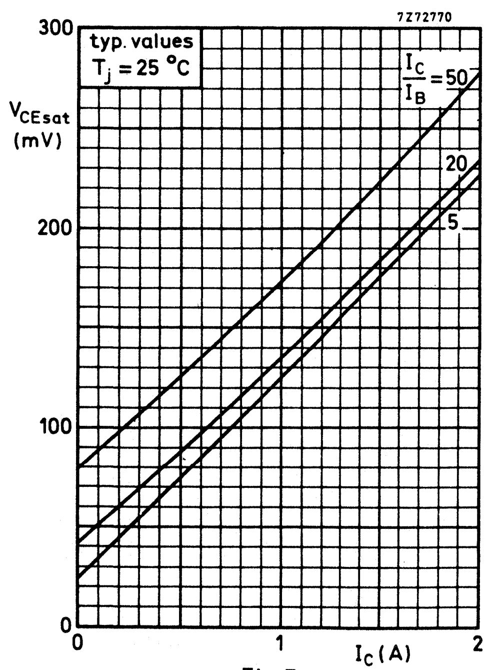


Fig. 7.

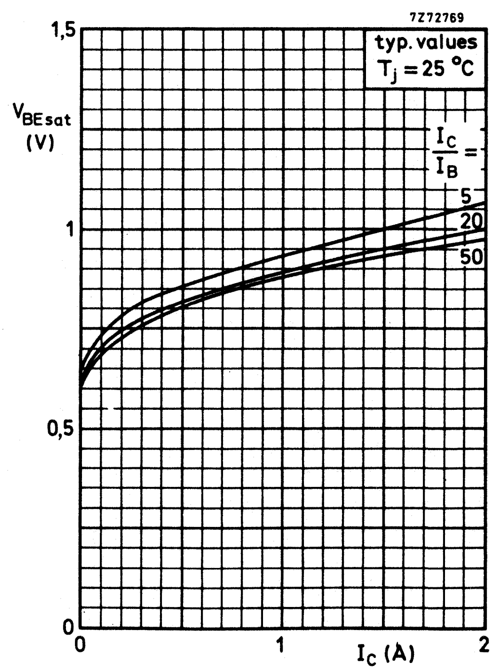


Fig. 8.

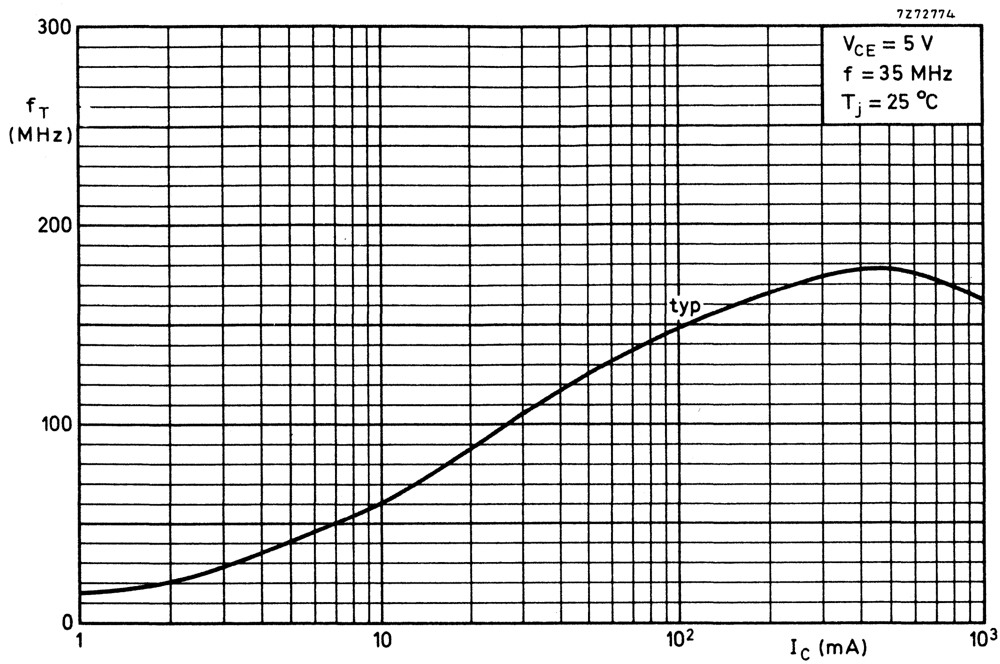

7Z72774
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
f_T
(MHz)
300
200
100
0
typ
1
10
10^2
I_C (mA)
10^3

Fig. 9.

SILICON PLANAR EPITAXIAL TRANSISTOR

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

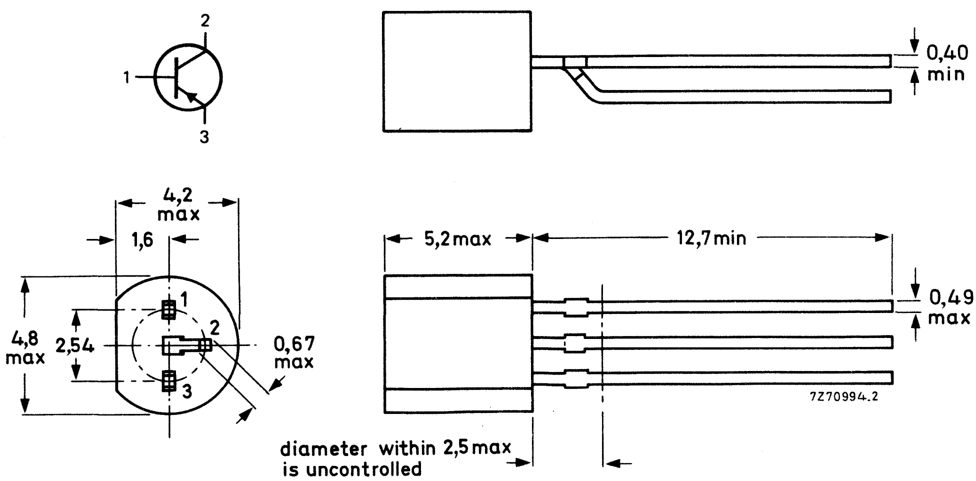
QUICK REFERENCE DATA

Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	2	A
Total power dissipation up to T_{amb} = 25 °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 at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

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

* Transistor mounted on printed-circuit board, maximum 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

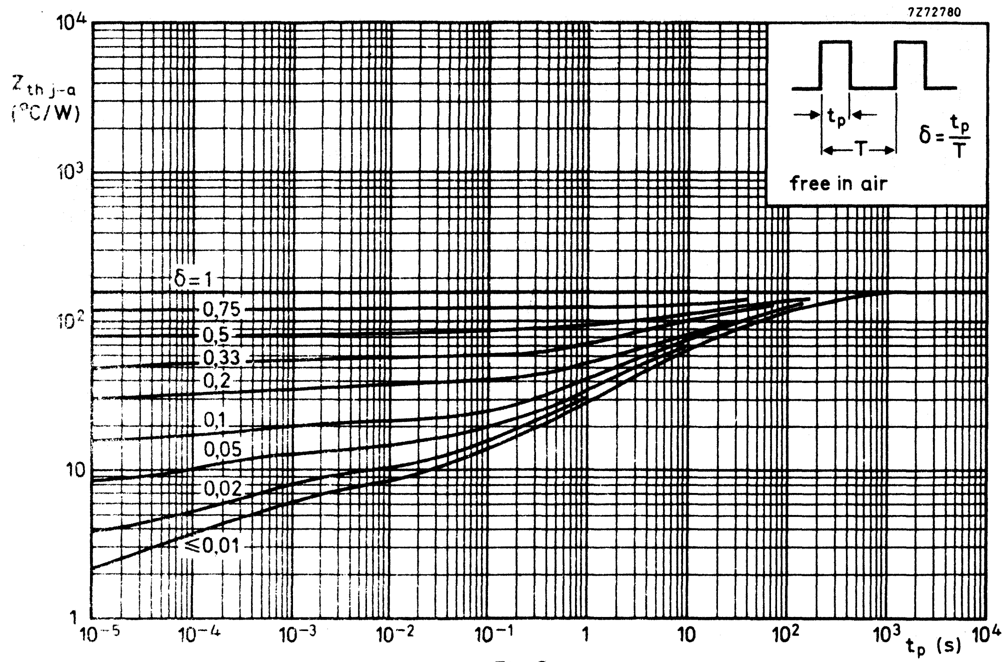

7Z72780
10^4
$Z_{th\ j-a}$
(°C/W)
10^3
10^2
10
1
t_p
T
$\delta = \frac{t_p}{T}$
free in air
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (s)
10^4

Fig. 2.

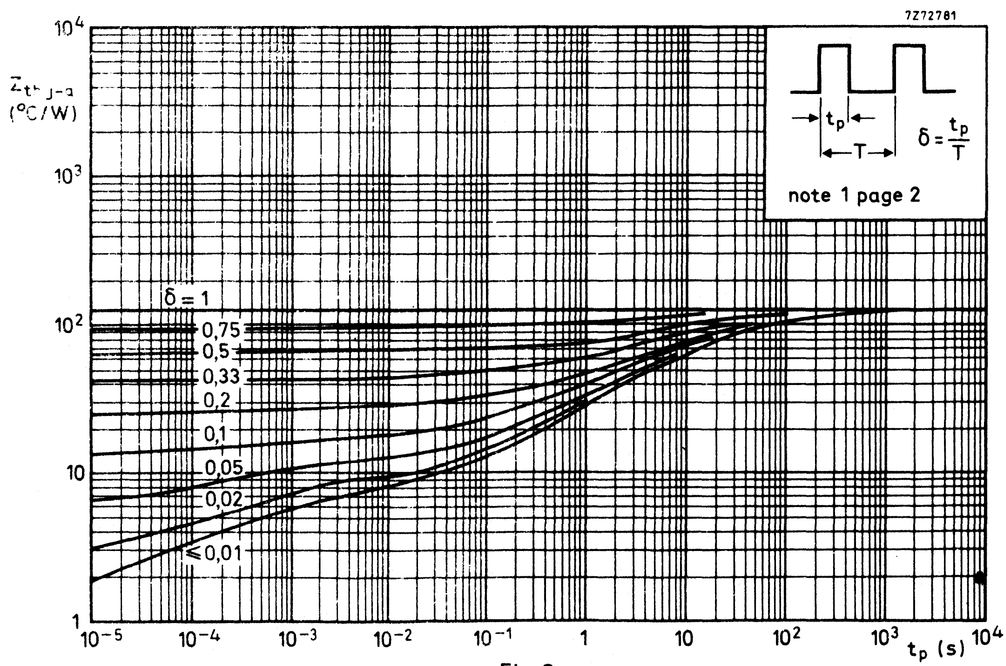

7Z72781
10^4
$Z_{th\ j-a}$
(°C/W)
10^3
10^2
10
1
t_p
T
$\delta = \frac{t_p}{T}$
note 1 page 2
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (s)
10^4

Fig. 3.

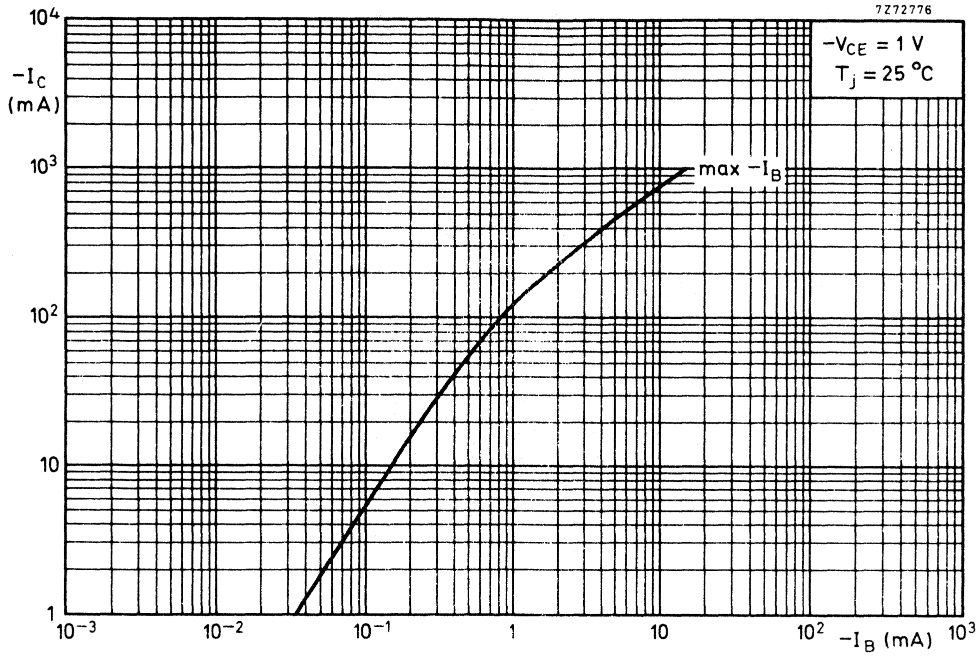

7Z72776
$-V_{CE} = 1$ V
$T_j = 25$ °C
$-I_C$ (mA)
10^4
10^3
10^2
10
1
max $-I_B$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

Fig. 4.

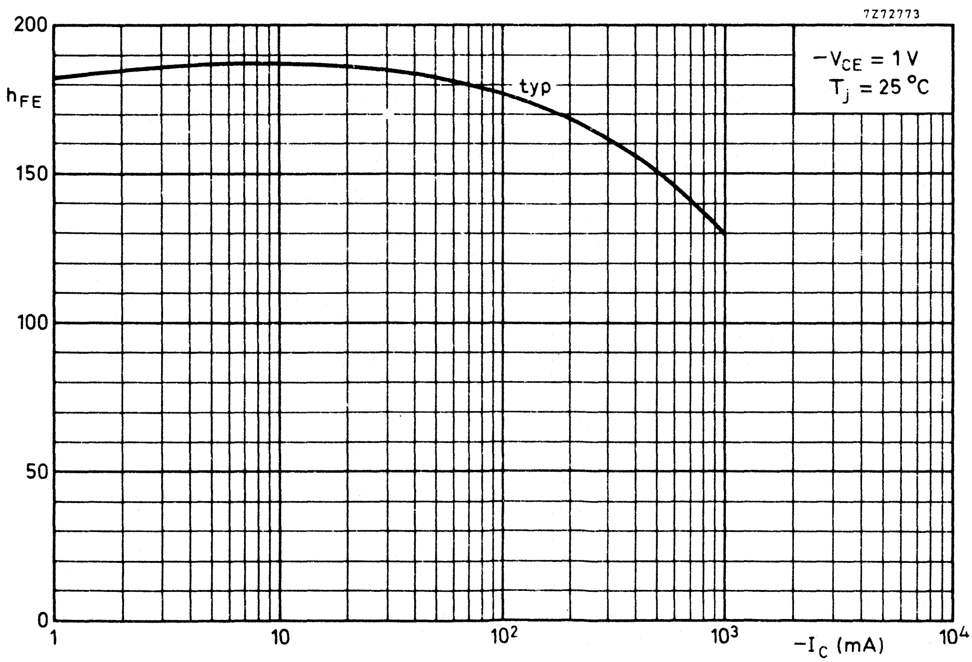

7Z72773
$-V_{CE} = 1$ V
$T_j = 25$ °C
h_{FE}
200
150
100
50
0
typ
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 5.

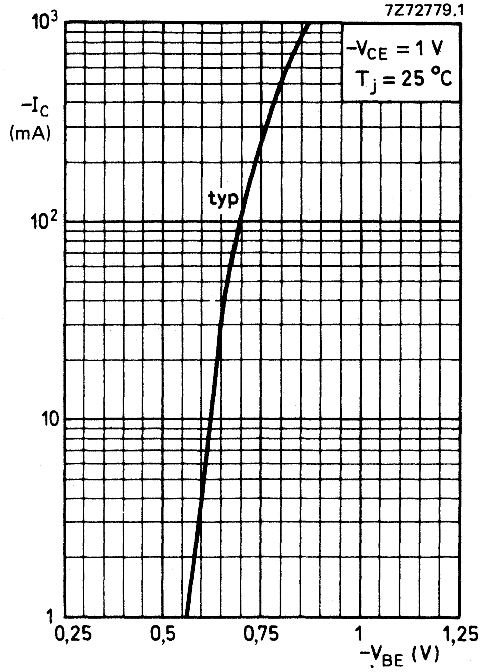


Fig. 6.

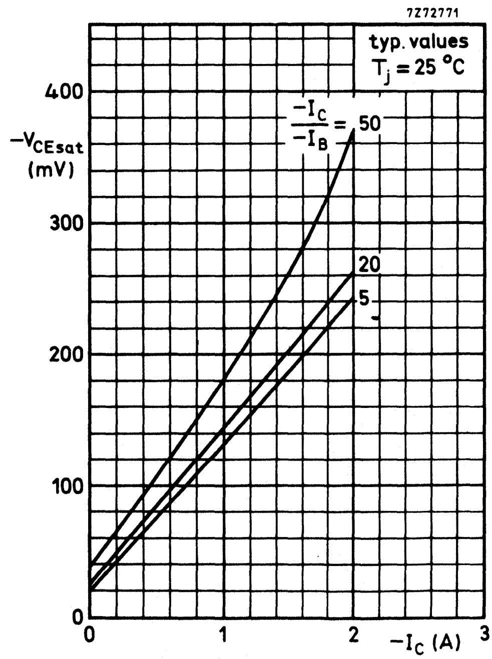


Fig. 7.

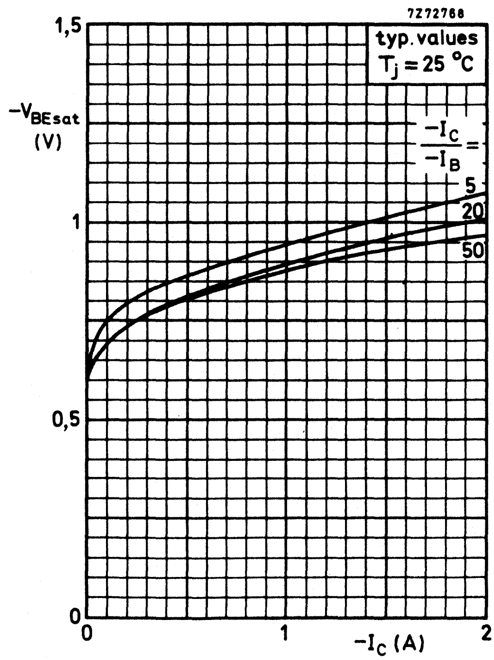


Fig. 8.

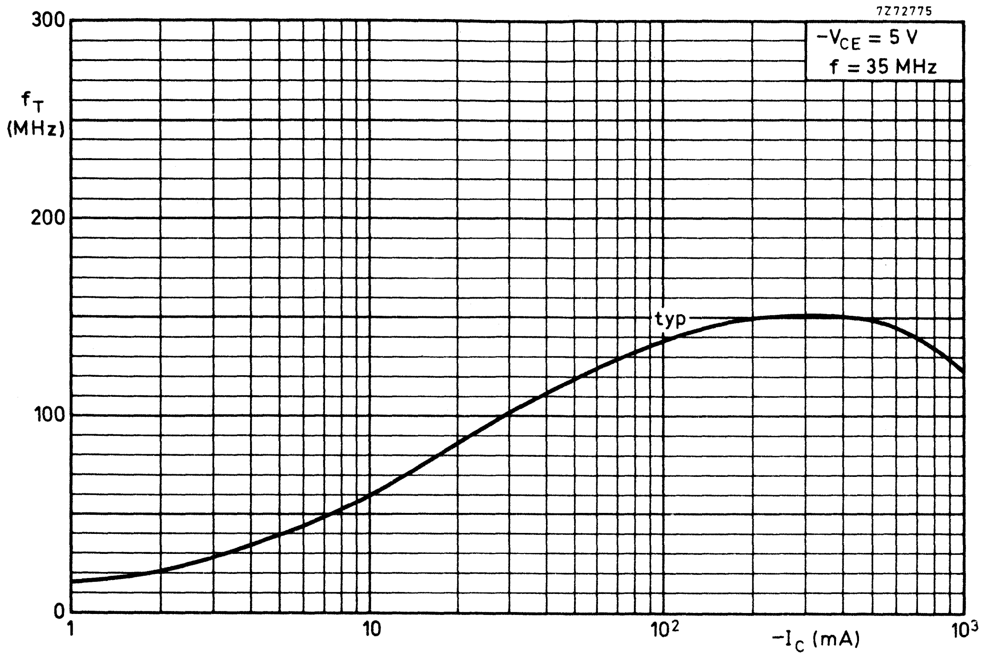


Fig. 9.

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.

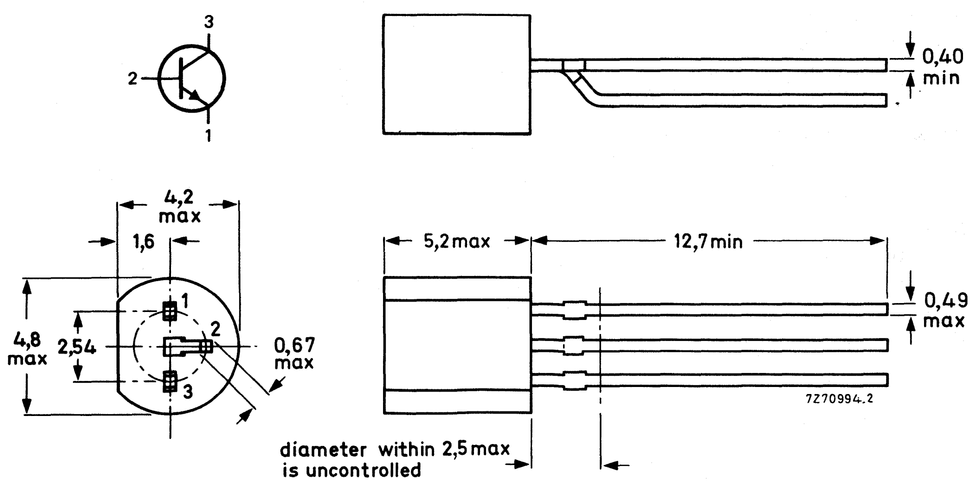
QUICK REFERENCE DATA

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	$R_{th\ j\text{-}a}$	=	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.	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

* 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.

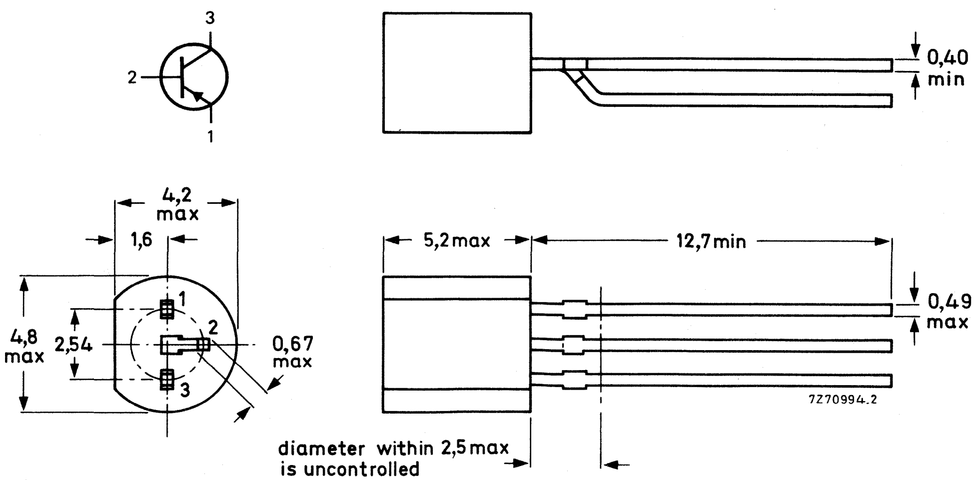
QUICK REFERENCE DATA

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

* 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 DARLINGTON TRANSISTOR

P-N-P silicon planar darlington transistor in a plastic TO-92 envelope.

N-P-N complement is BC517.

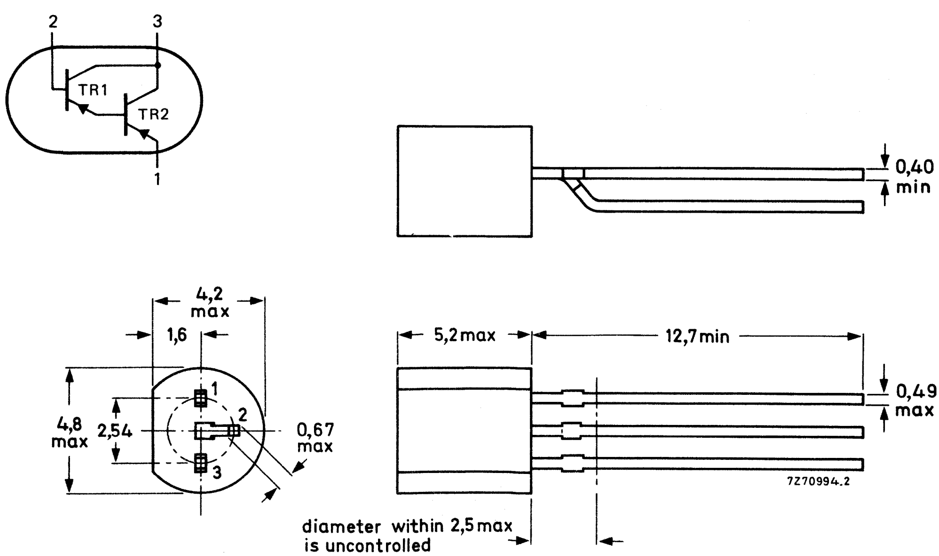
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector current	$-I_C$	max.	400	mA
Junction temperature	T_j	max.	150	^oC
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	625	mW
D.C. current gain $-I_C = 20$ mA; $-V_{CE} = 2$ V	h_{FE}	>	30 000	
Collector-emitter saturation voltage $-I_C = 100$ mA; $-I_B = 0,1$ mA	$-V_{CEsat}$	max.	1	V
Transition frequency at f = 100 MHz $-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	220	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V
Collector current	$-I_C$	max.	400	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	mW
Junction temperature	T_j	max.	150	°C
Storage temperature	T_{stg}	−65 to + 150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	max.	200	K/W
From junction to case	$R_{th\ j\text{-}c}$	max.	90	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise stated

Collector cut-off current V_{CB} = 30 V	$-I_{CBO}$	max.	100	nA
Collector-emitter breakdown voltage $-I_C$ = 2 mA	$-V_{(BR)CEO}$	min.	30	V
Collector-base breakdown voltage	$-V_{(BR)CBO}$	min.	40	V
Emitter-base breakdown voltage	$-V_{(BR)EBO}$	min.	10	V
D.C. current gain $-I_C$ = 20 mA; $-V_{CE}$ = 2 V	h_{FE}	>	30 000	
Collector-emitter saturation voltage $-I_C$ = 100 mA; $-I_B$ = 0,1 mA	$-V_{CEsat}$	max.	1	V
Base-emitter voltage I_C = 10 mA; V_{CE} = 5 V	$-V_{BE}$	max.	1,4	V
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	220	MHz

SILICON PLANAR DARLINGTON TRANSISTOR

N-P-N silicon planar darlington transistor in a plastic TO-92 envelope.
P-N-P complement is BC516.

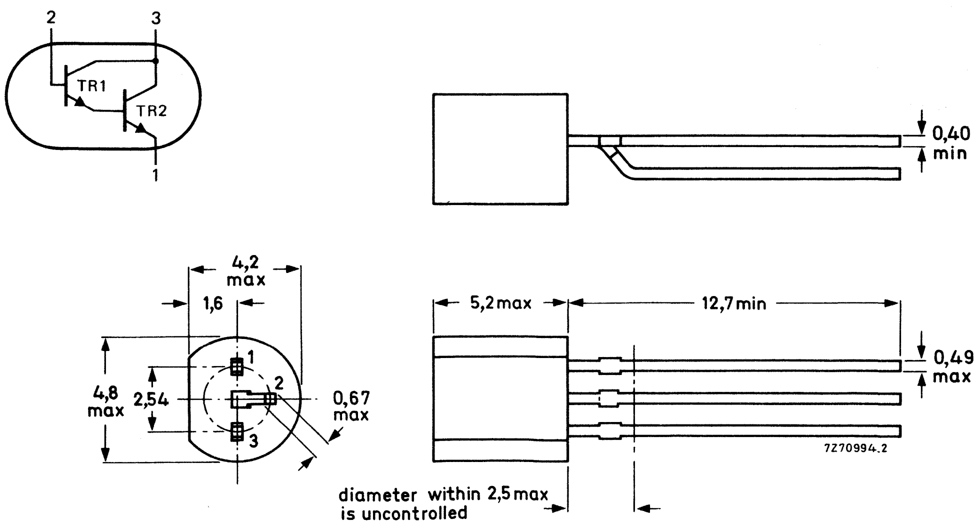
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector current	I_C	max.	400	mA
Junction temperature	T_j	max.	150	°C
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	mW
D.C. current gain I_C = 20 mA; V_{CE} = 2 V	h_{FE}	>	30 000	
Collector-emitter saturation voltage I_C = 100 mA; I_B = 0,1 mA	V_{CEsat}	max.	1	V
Transition frequency at f = 100 MHz I_C = 30 mA; V_{CE} = 5 V	f_T	typ.	220	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	10	V
Collector current	I_C	max.	400	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	mW
Junction temperature	T_j	max.	150	°C
Storage temperature	T_{stg}		−65 to + 150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	max.	200	K/W
From junction to case	$R_{th\ j\text{-}c}$	max.	90	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise stated

Collector cut-off current V_{CB} = 30 V	I_{CBO}	max.	100	nA
Collector-emitter breakdown voltage I_C = 2 mA	$V_{(BR)CEO}$	min.	30	V
Collector-base breakdown voltage	$V_{(BR)CBO}$	min.	40	V
Emitter-base breakdown voltage	$V_{(BR)EBO}$	min.	10	V
D.C. current gain I_C = 20 mA; V_{CE} = 2 V	h_{FE}	>	30 000	
Collector-emitter saturation voltage I_C = 100 mA; I_B = 0,1 mA	V_{CEsat}	max.	1	V
Base-emitter voltage I_C = 10 mA; V_{CE} = 5 V	V_{BE}	max.	1,4	V
Transition frequency at f = 100 MHz I_C = 30 mA; V_{CE} = 5 V	f_T	typ.	220	MHz

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.

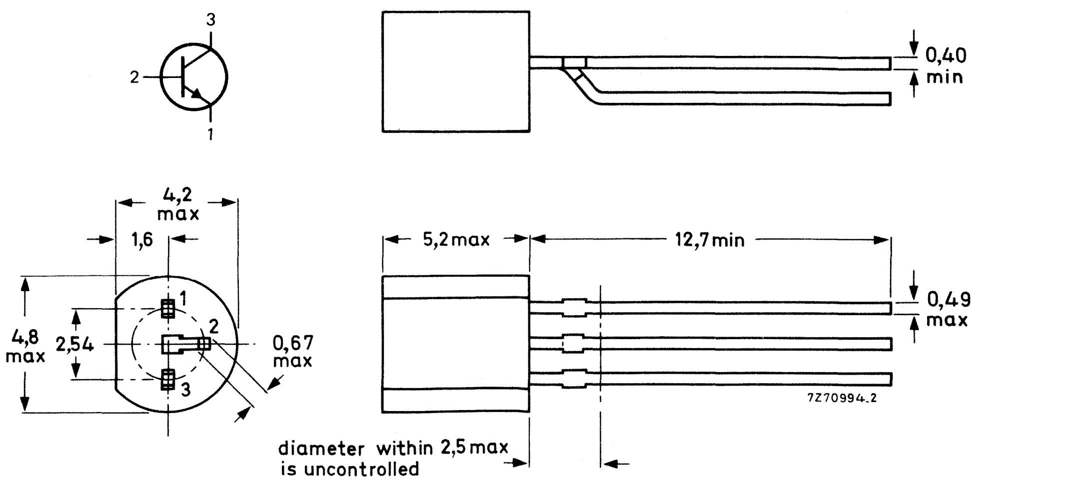
QUICK REFERENCE DATA

			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
D.C. current gain I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	110	110	←
		<	450	800	800	
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

Fig. 1 TO-92 variant.



RATINGS

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

			BC546	BC547	BC548	
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

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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW
Storage temperature	T_{stg}		−65 to + 150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,15	K/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*				
$I_C = 2$ 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

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

Saturation voltage*				
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
Collector capacitance at f = 1 MHz I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	2,5	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
Small signal current gain at f = 1 kHz I_C = 2 mA; V_{CE} = 5 V	h_{fe}		125 to 900	

			BC546	BC547	BC548	
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

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

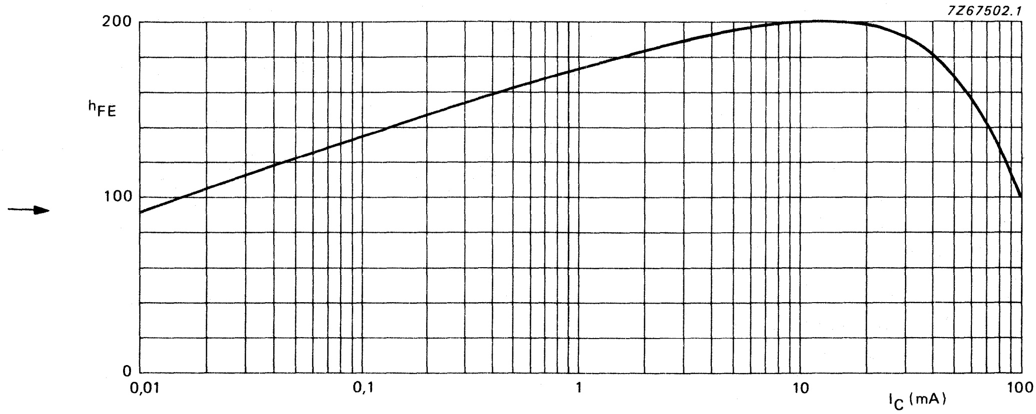


Fig. 2 BC546A, BC547A and BC548A
V_{CE} = 5 V; T_j = 25 °C; typical values.

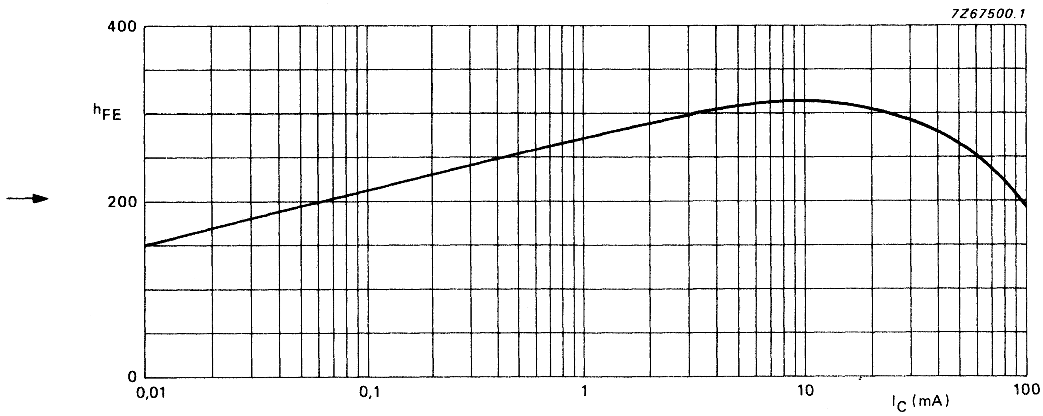


Fig. 3 BC546B, BC547B and BC548B
V_{CE} = 5 V; T_j = 25 °C; typical values.

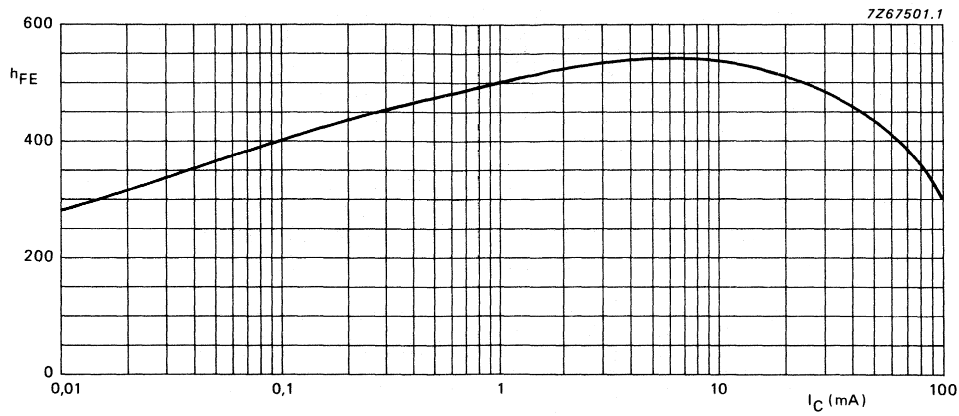


Fig. 4 BC547C and BC548C
V_{CE} = 5 V; T_j = 25 °C; typical values.

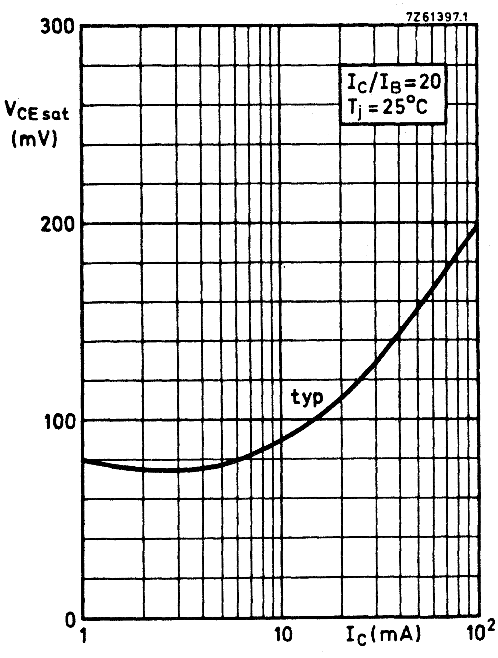


Fig. 5.

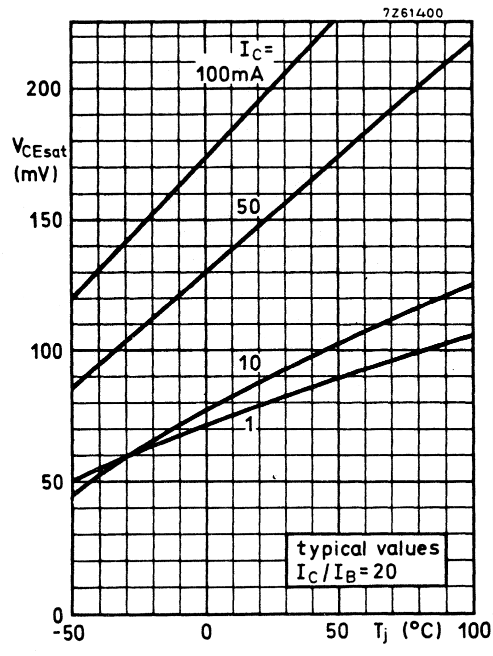


Fig. 6.

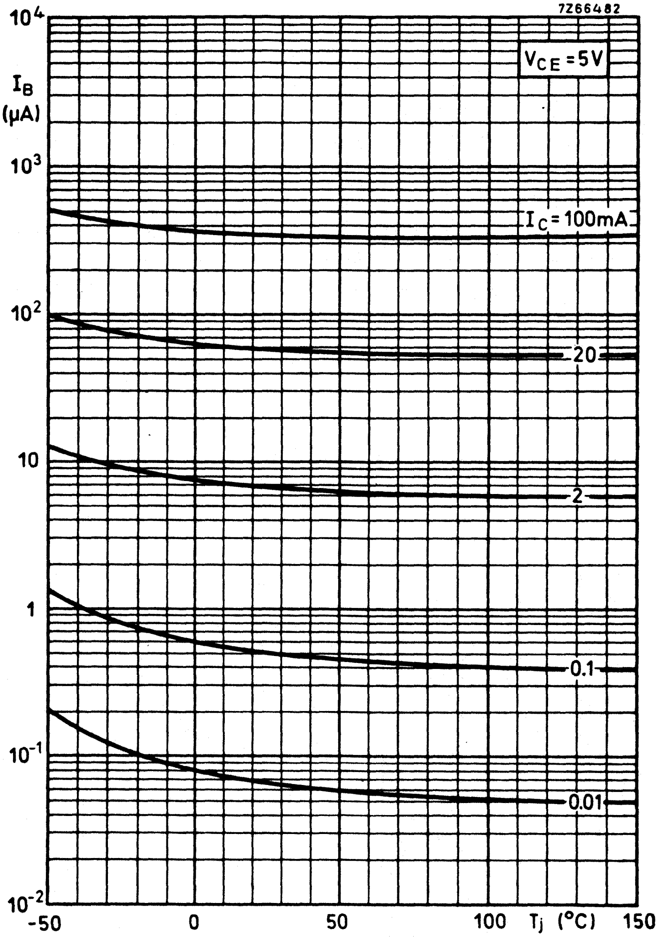

7Z66482
$V_{CE} = 5V$
I_B (μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
$I_C = 100mA$
20
2
0.1
0.01
-50
0
50
100
T_j (°C)
150

Fig. 7.

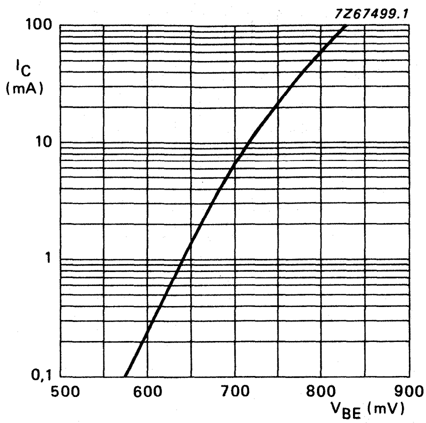


Fig. 8 V_{CE} = 5 V; T_j = 25 °C; typical values.

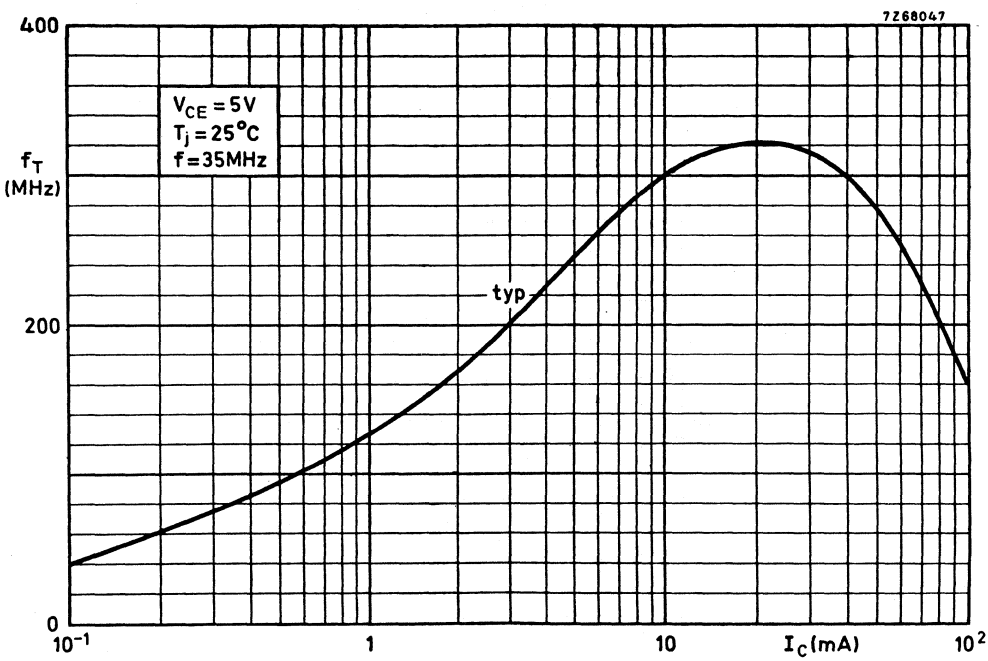


Fig. 9.

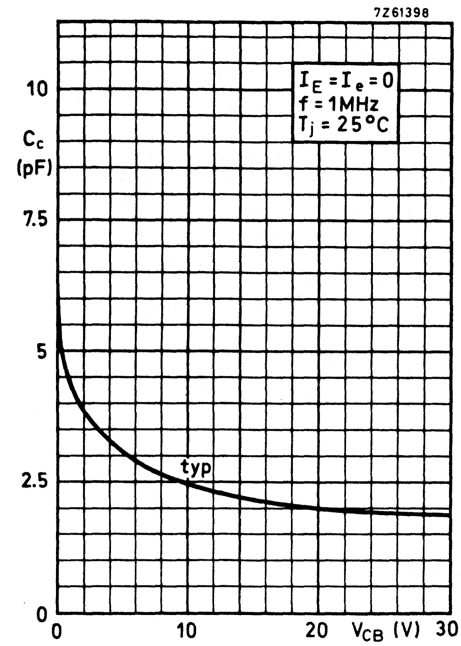

7Z61398
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
C_c (pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30

Fig. 10.

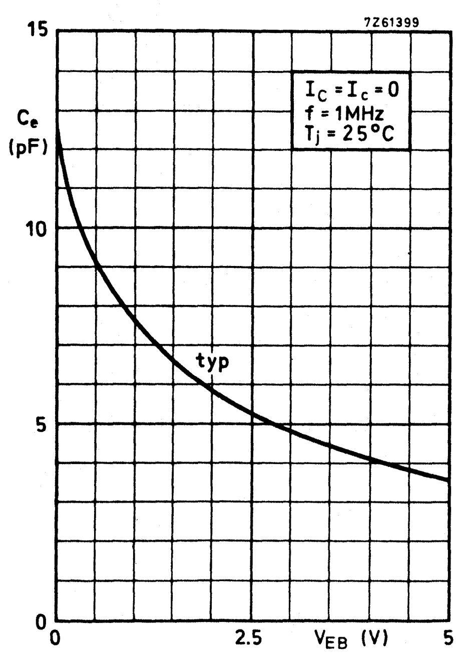

7Z61399
$I_C = I_c = 0$
f = 1MHz
$T_j = 25°C$
C_e (pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5

Fig. 11.

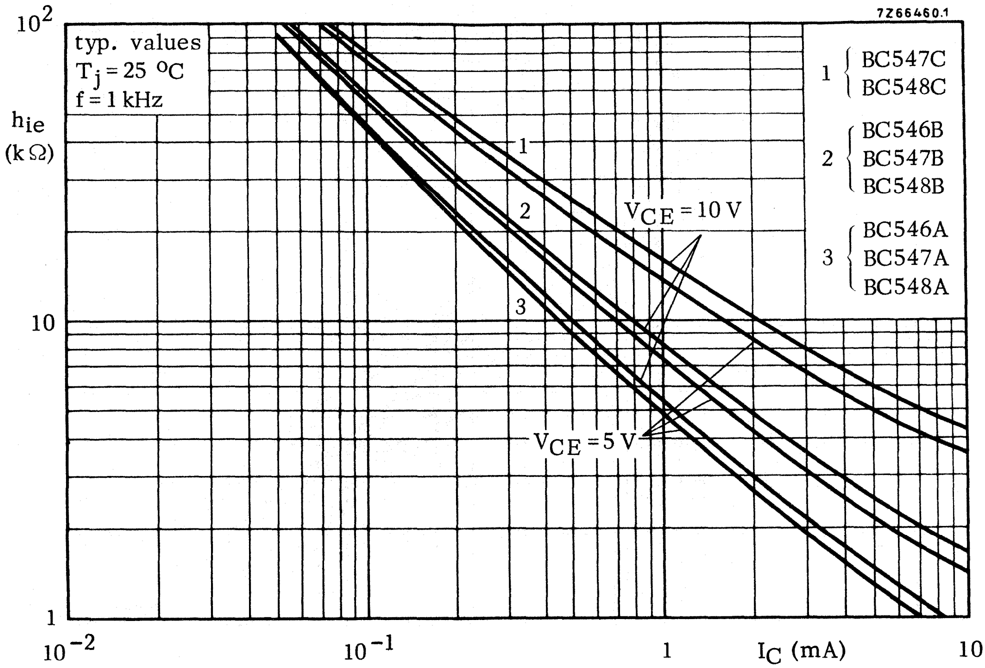

7Z66460.1
10^2
typ. values
$T_j = 25\ ^oC$
f = 1 kHz
h_{ie}
(k Ω)
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10
1
2
3
$V_{CE} = 10$ V
$V_{CE} = 5$ V
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A

Fig. 12.

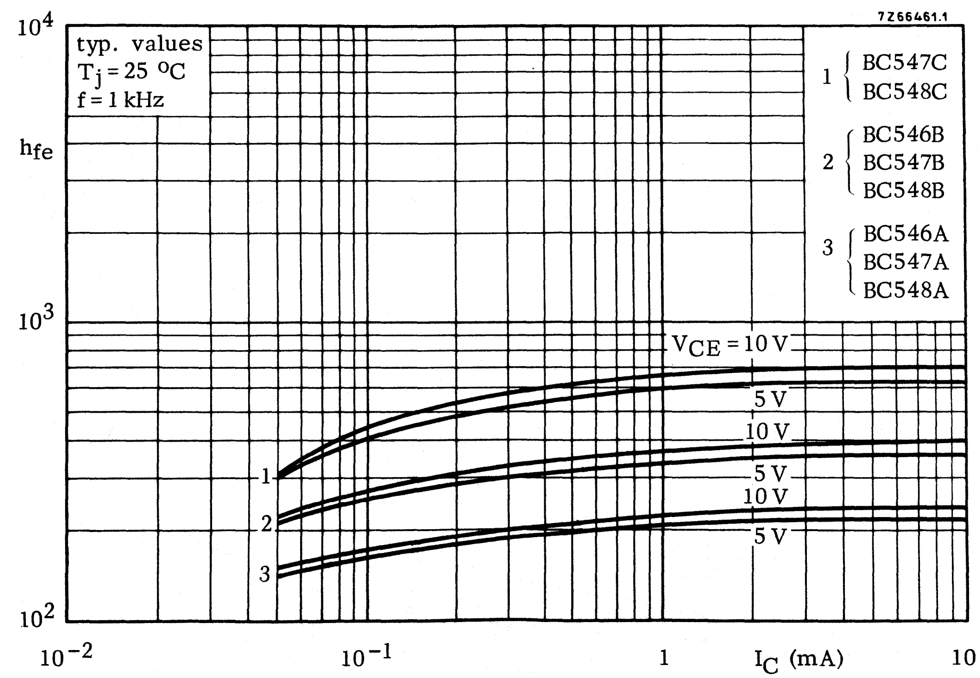

7Z66461.1
10^4
typ. values
$T_j = 25\ ^oC$
f = 1 kHz
h_{fe}
10^3
10^2
10^{-2}
10^{-1}
1
I_C (mA)
10
$V_{CE} = 10$ V
5 V
10 V
5 V
10 V
5 V
1
2
3
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A

Fig. 13.

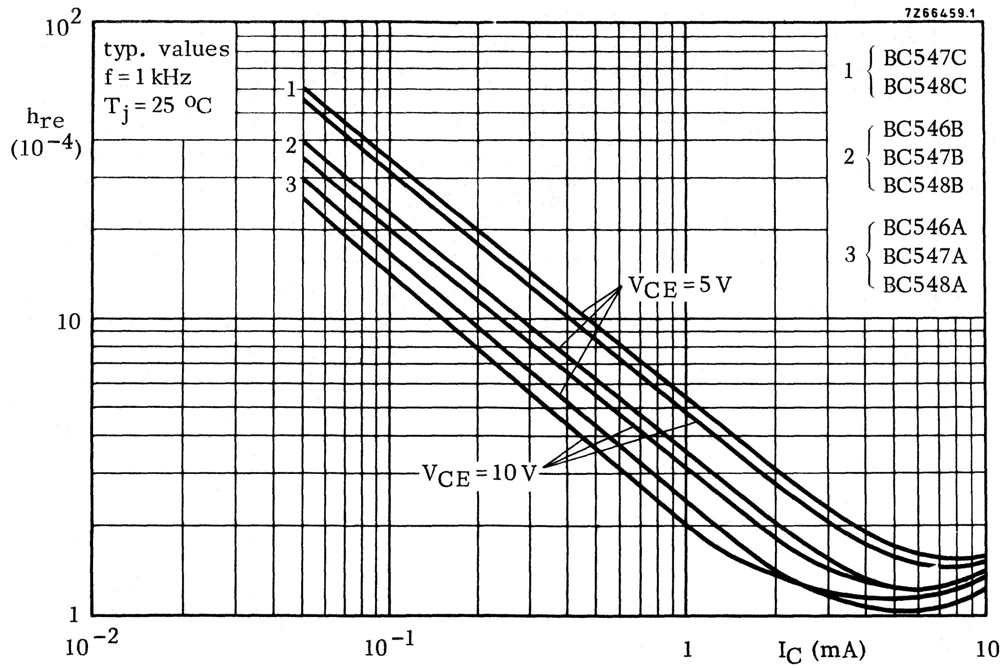

7Z66459.1
typ. values
f = 1 kHz
T_j = 25 °C
h_{re}
(10^{-4})
10^2
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A
V_{CE} = 5 V
V_{CE} = 10 V

Fig. 14.

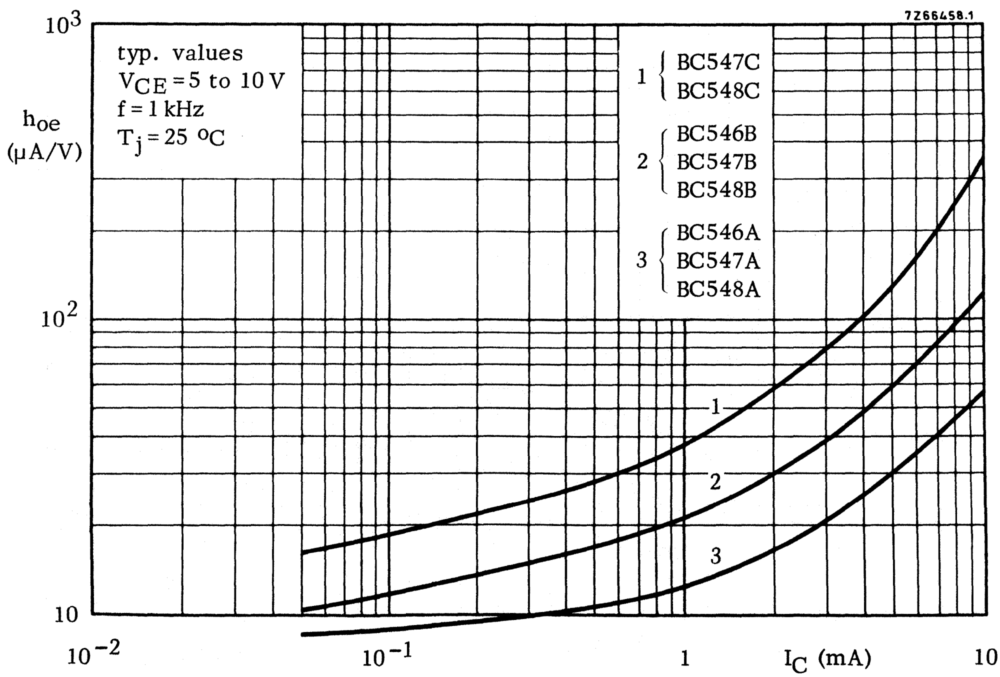

7Z66458.1
typ. values
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (mA)
10
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A

Fig. 15.

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.

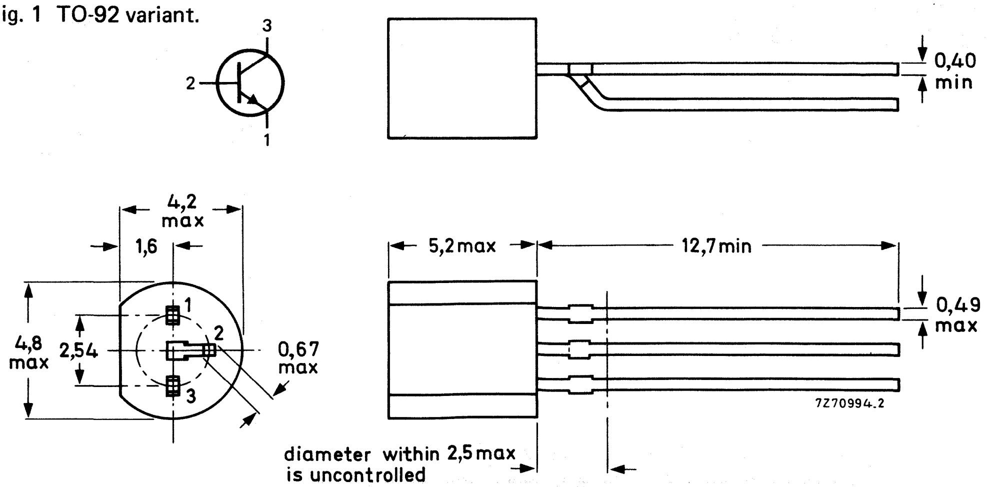
QUICK REFERENCE DATA

			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
D.C. current gain I_C = 2 mA; V_{CE} = 5 V	h_{FE}	> <	200 800	200 800	
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

Fig. 1 TO-92 variant.



RATINGS

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

			BC549	BC550	
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
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	$R_{th\,j\text{-}a}$	=	0,25	K/mW
From junction to case	$R_{th\,j\text{-}c}$	=	0,15	K/mW

CHARACTERISTICS

T_j = 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 **				
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

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

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.		2,5 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
Small signal current gain at f = 1 kHz				
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{fe}		125 – 900	←

			BC549	BC550
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

→

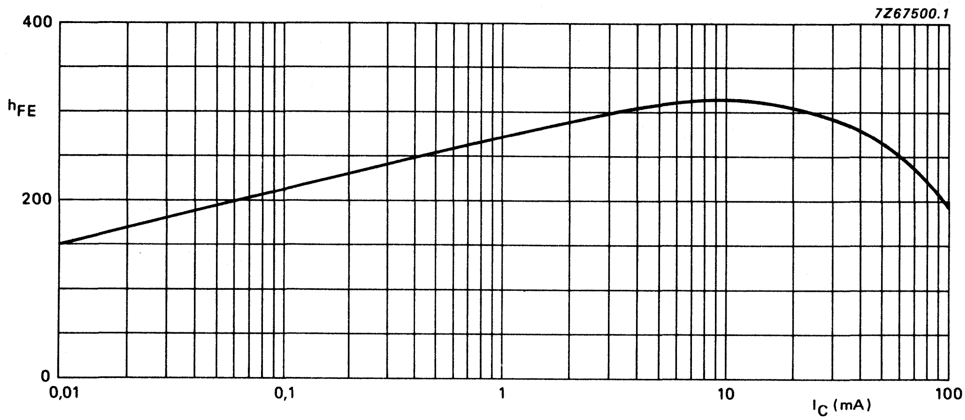


Fig. 2 BC549B and BC550B; V_{CE} = 5 V; T_j = 25 °C; typical values.

→

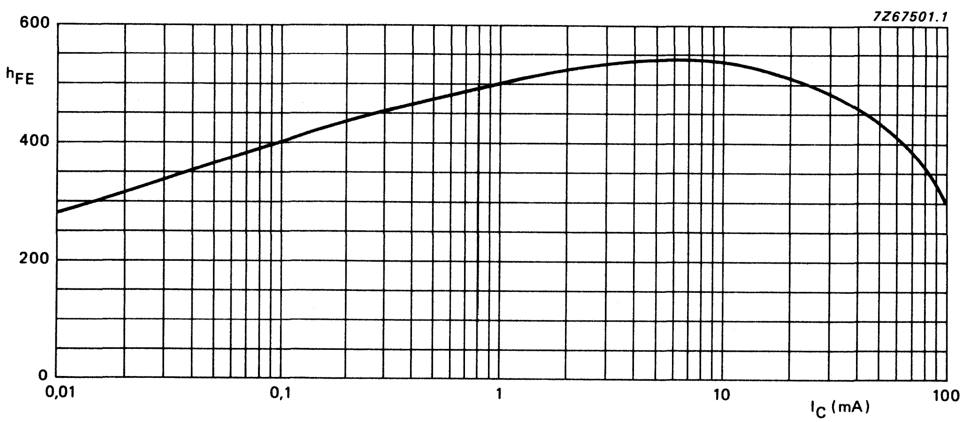


Fig. 3 BC549C and BC550C; V_{CE} = 5 V; T_j = 25 °C; typical values.

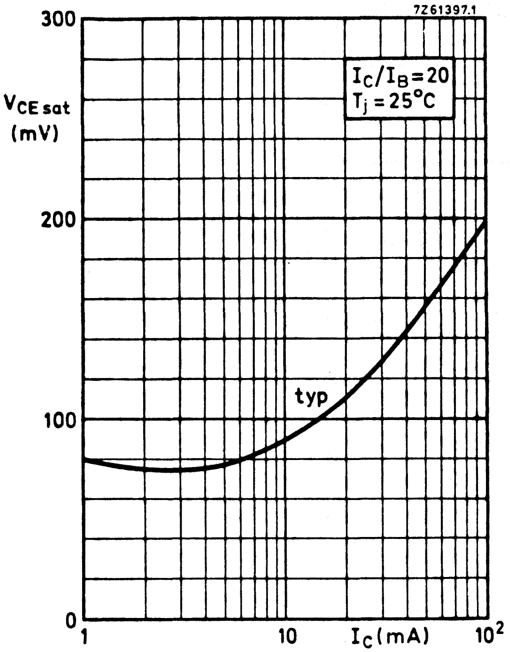


Fig. 4.

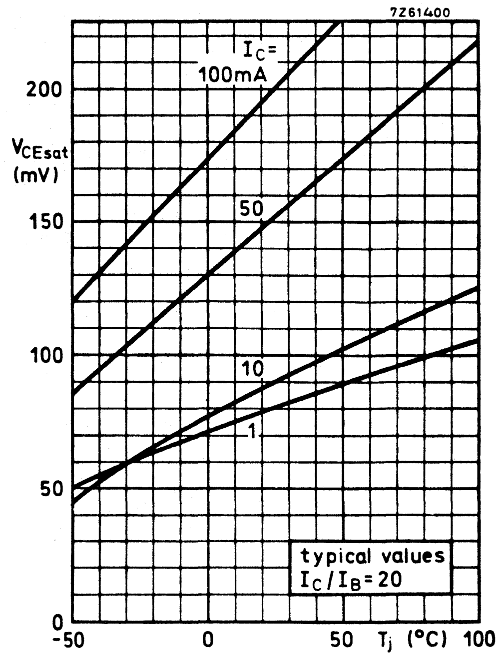


Fig. 5.

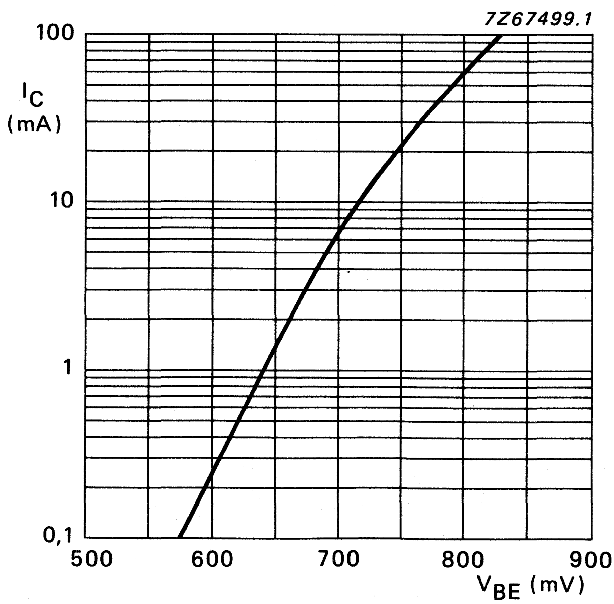


Fig. 6 $V_{CE} = 5$ V; $T_j = 25$ °C; typical values.

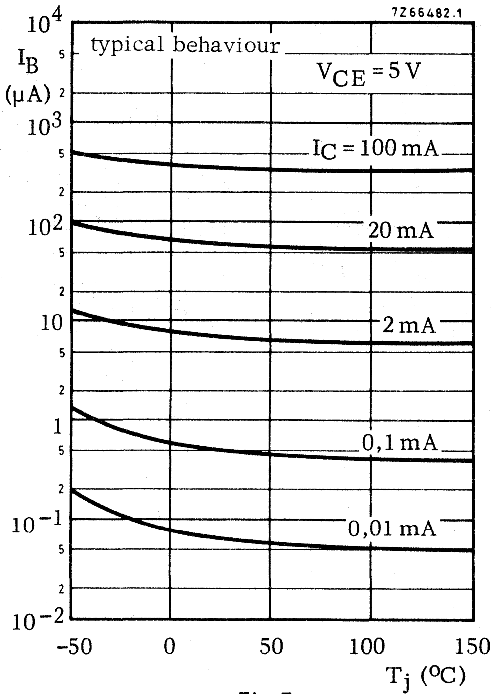

7Z66482.1
typical behaviour
V_{CE} = 5 V
I_C = 100 mA
20 mA
2 mA
0,1 mA
0,01 mA
I_B (μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
−50
0
50
100
150
T_j (°C)

Fig. 7.

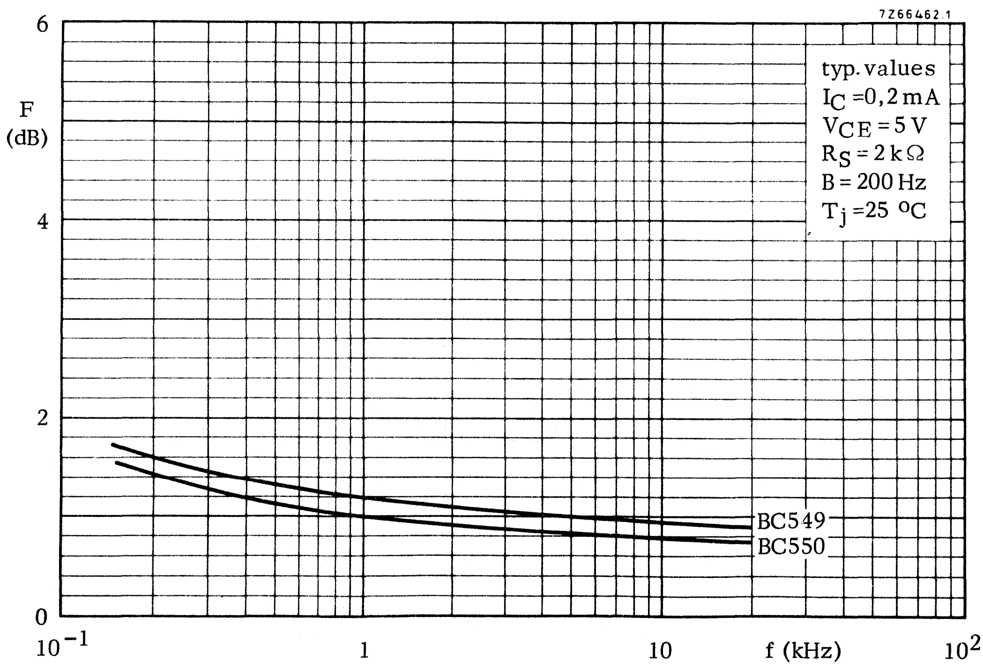

7Z66462.1
typ. values
I_C = 0,2 mA
V_{CE} = 5 V
R_S = 2 kΩ
B = 200 Hz
T_j = 25 °C
BC549
BC550
F (dB)
6
4
2
0
10^{-1}
1
10
f (kHz)
10^2

Fig. 8.

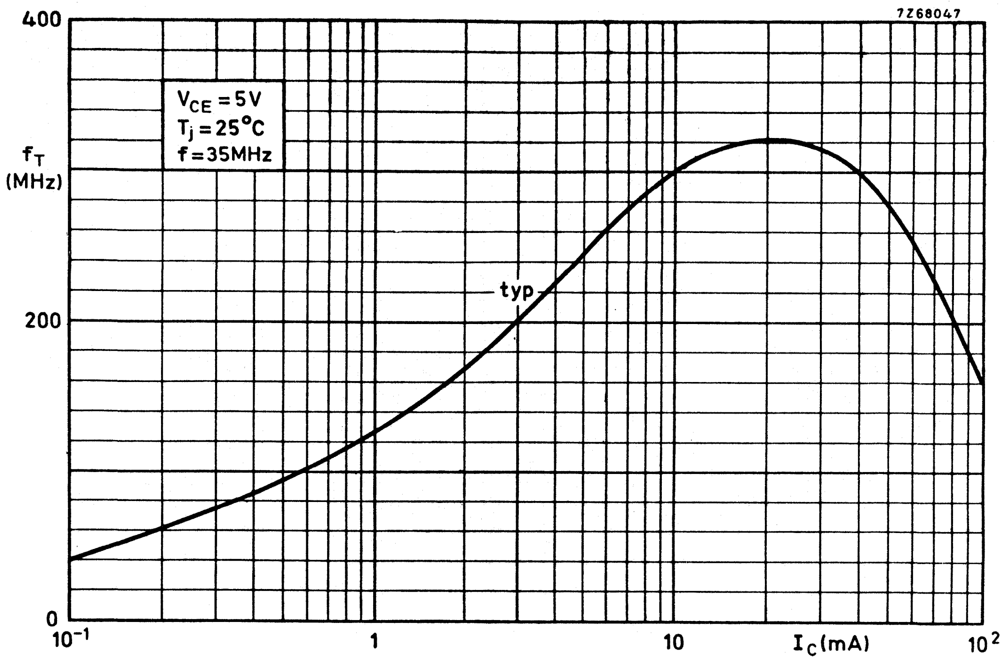


Fig. 9.

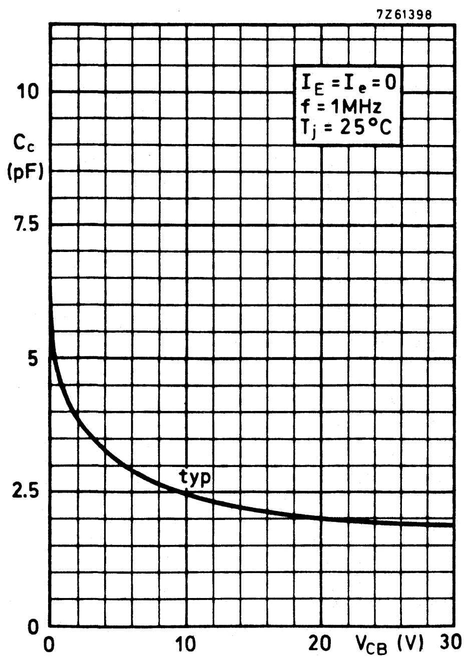


Fig. 10.

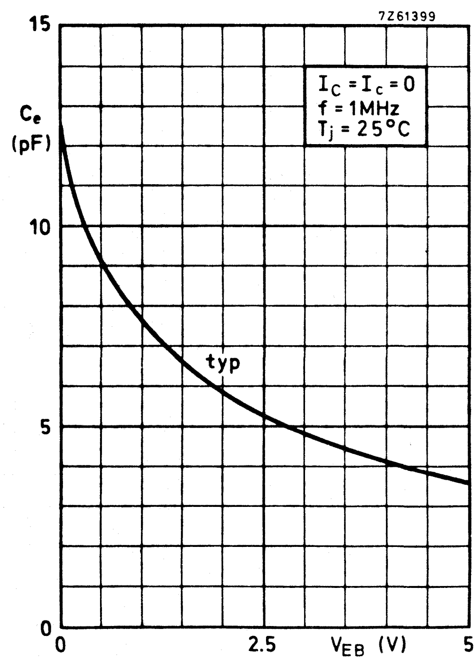


Fig. 11.

Curves of constant noise figure

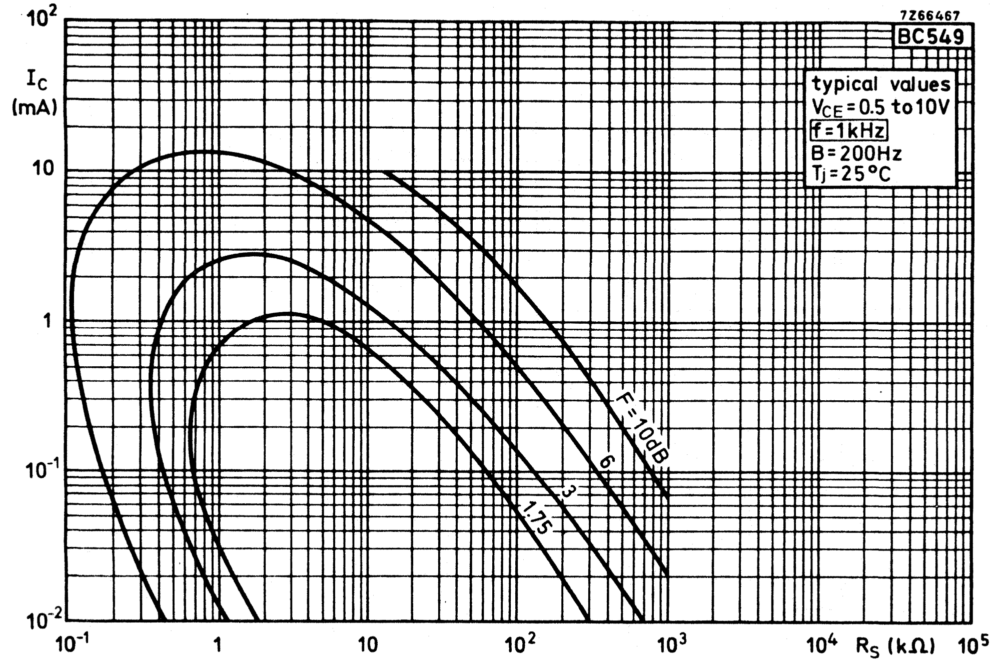


Fig. 12.

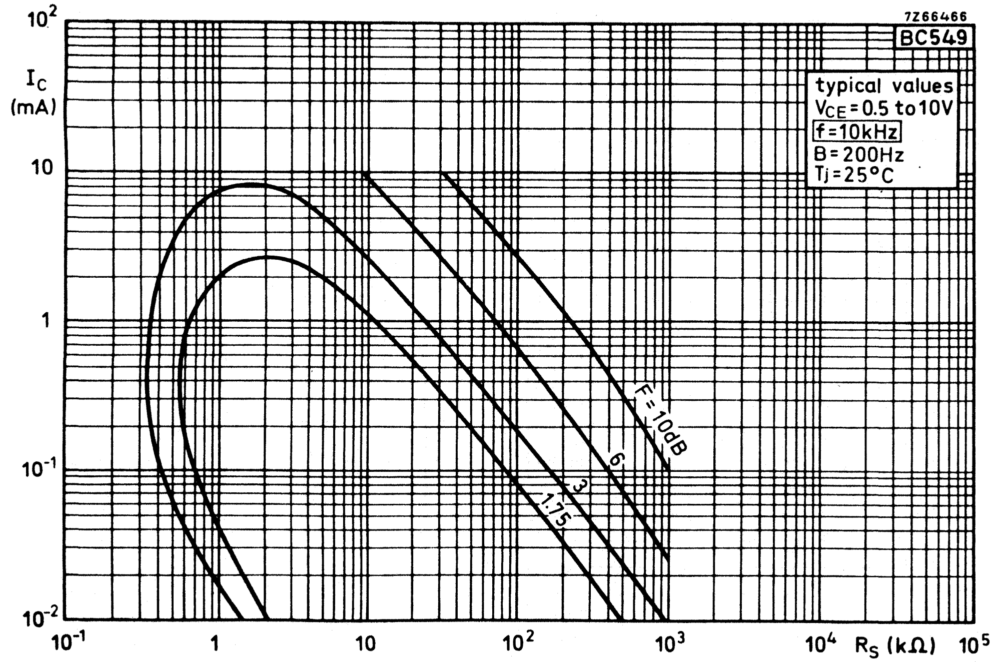


Fig. 13.

Curves of constant noise figure

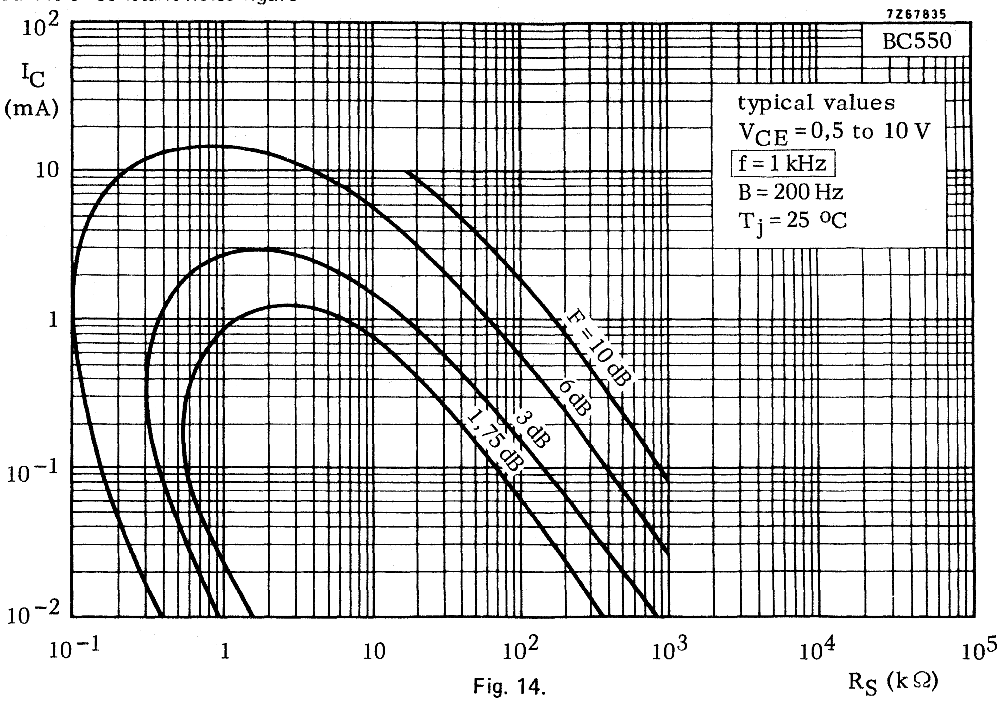


Fig. 14.

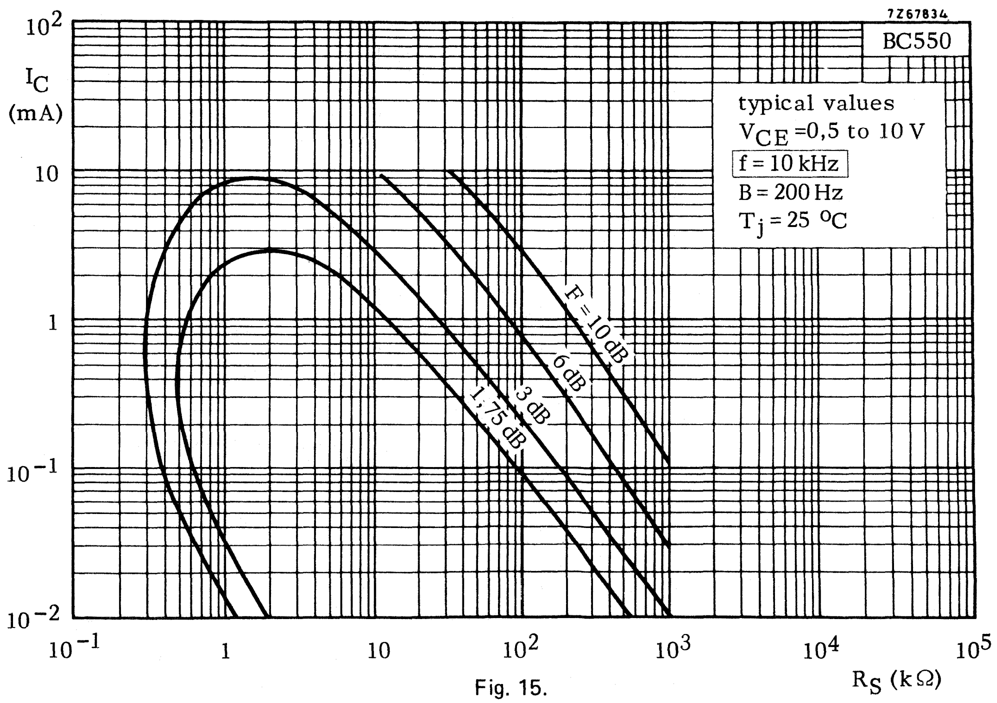


Fig. 15.

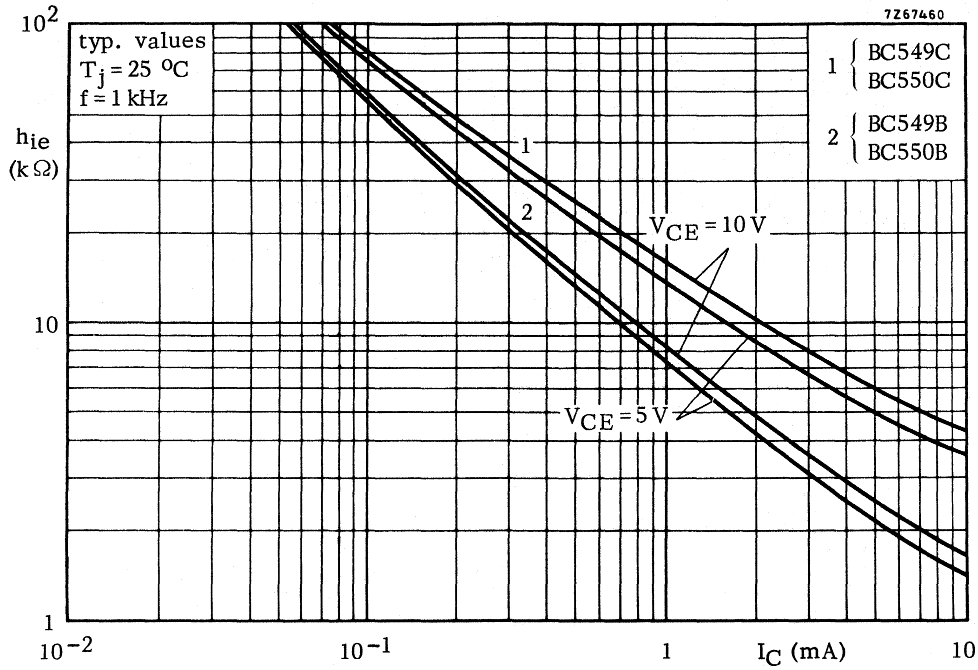

7Z67460
typ. values
$T_j = 25\ ^oC$
f = 1 kHz
h_{ie}
(k Ω)
1 { BC549C BC550C
2 { BC549B BC550B
1
2
$V_{CE} = 10\ V$
$V_{CE} = 5\ V$
10^2
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10

Fig. 16.

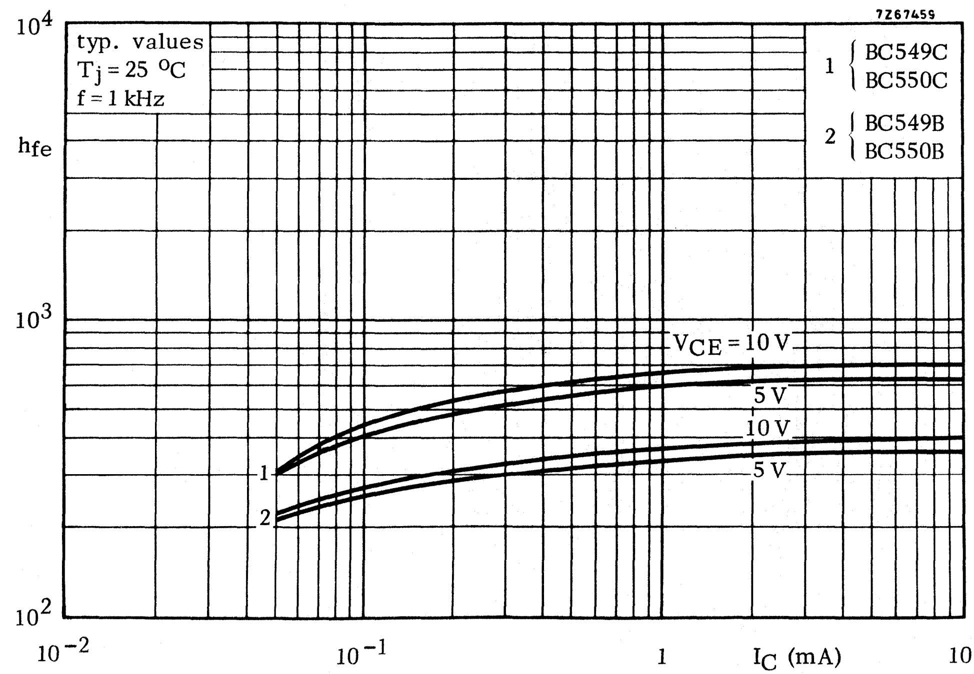

7Z67459
typ. values
$T_j = 25\ ^oC$
f = 1 kHz
h_{fe}
1 { BC549C BC550C
2 { BC549B BC550B
$V_{CE} = 10\ V$
5 V
10 V
5 V
1
2
10^4
10^3
10^2
10^{-2}
10^{-1}
1
I_C (mA)
10

Fig. 17.

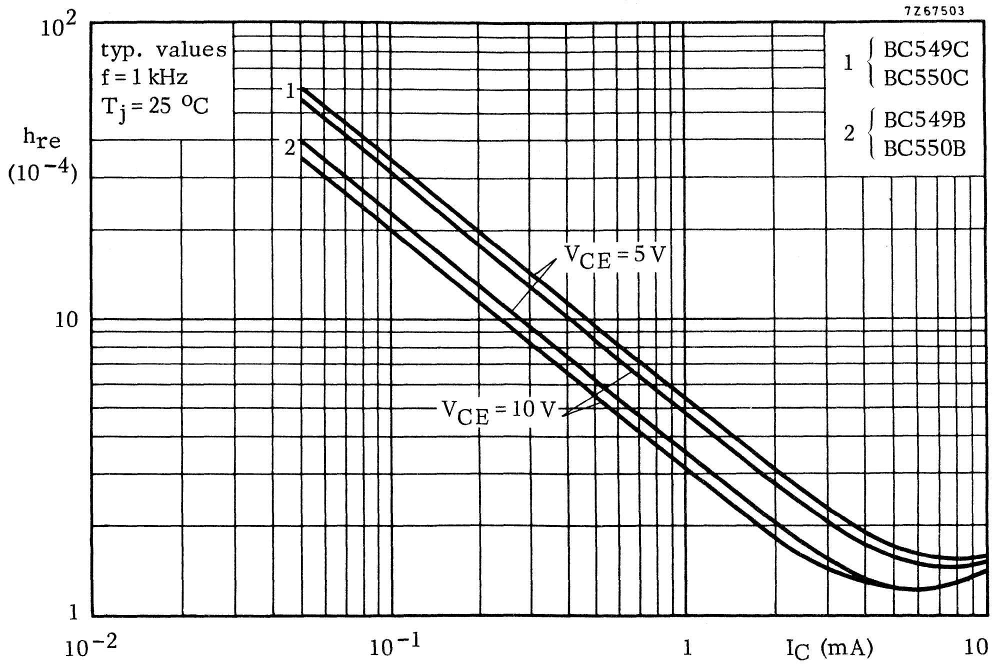

7Z67503
typ. values
f = 1 kHz
T_j = 25 °C
1 { BC549C BC550C
2 { BC549B BC550B
h_{re} (10^{-4})
V_{CE} = 5 V
V_{CE} = 10 V
10^2
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10

Fig. 18.

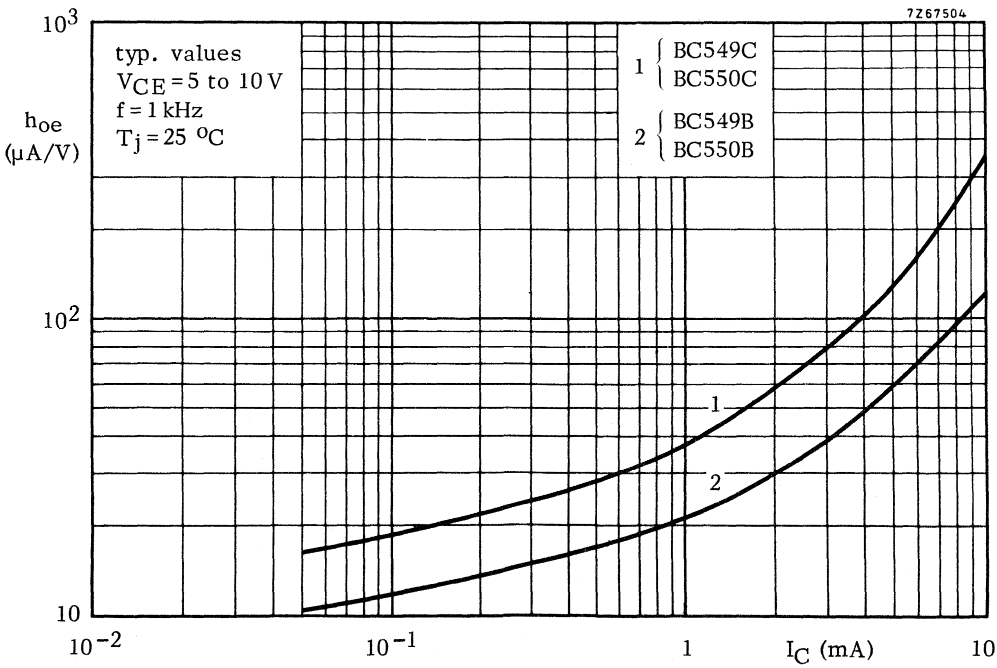

7Z67504
typ. values
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25 °C
1 { BC549C BC550C
2 { BC549B BC550B
h_{oe} (μA/V)
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (mA)
10

Fig. 19.

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.

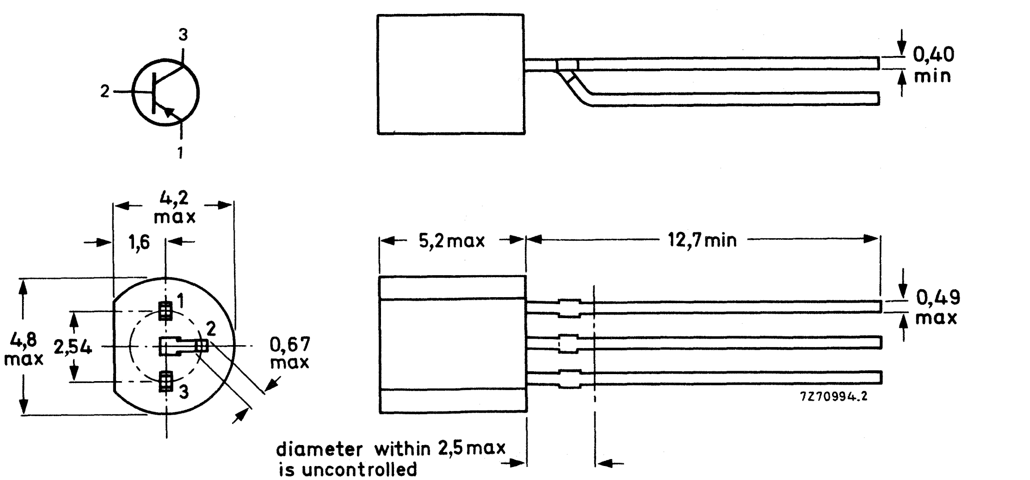
QUICK REFERENCE DATA

			BC556	BC557	BC558	
Collector-emitter voltage (+ V_{BE} = 0 V)	$-V_{CES}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	V
D.C. current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	75	75	75	
		<	475	800	800	
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
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.		200		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-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} = 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.	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.	60	mV
		<	300	mV
	$-V_{BEsat}$	typ.	750	mV
$-I_C$ = 100 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	typ.	180	mV
		<	650	mV
	$-V_{BEsat}$	typ.	930	mV

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

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CE} = 10$ V	C_c	typ.	4	pF
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	200	MHz
Small-signal current gain at f = 1 kHz				
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}		75 to 900	
Noise figure at $R_S = 2$ kΩ				
$-I_C = 200$ μA; $-V_{CE} = 5$ V		typ.	2	dB
f = 1 kHz; B = 200 Hz	F	<	10	dB

D.C. current gain

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

h_{FE}		BC556	BC557 BC558	BC556A BC557A BC558A	BC556B BC557B BC558B	BC557C BC558C
	>	75	75	125	220	420
	<	475	800	250	475	800

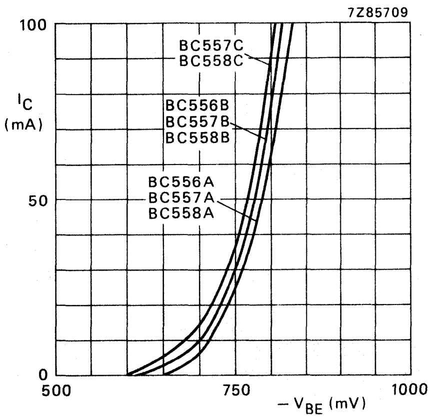


Fig. 2 $-V_{CE} = 5$ V; $T_j = 25$ °C.

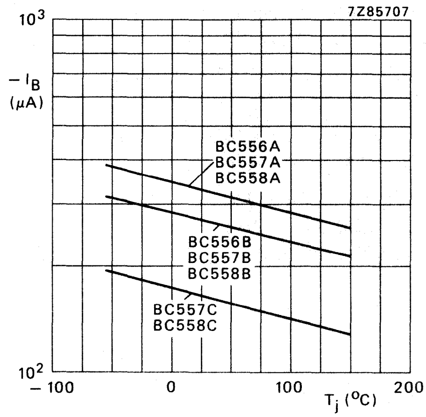


Fig. 3 $-V_{CE} = 5$ V; $I_C = 50$ mA.

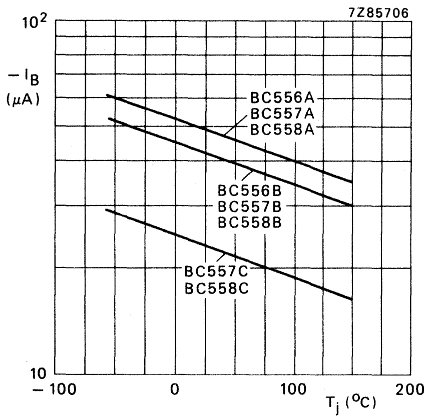


Fig. 4 $-V_{CE} = 5$ V; $I_C = 10$ mA.

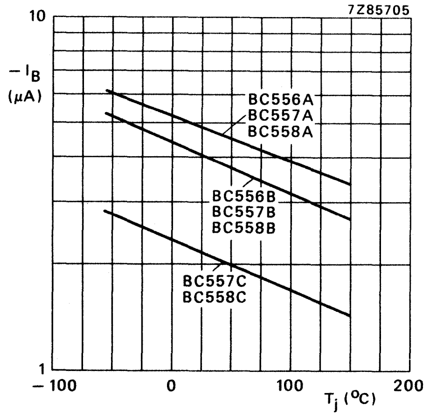


Fig. 5 $-V_{CE} = 5$ V; $I_C = 1$ mA.

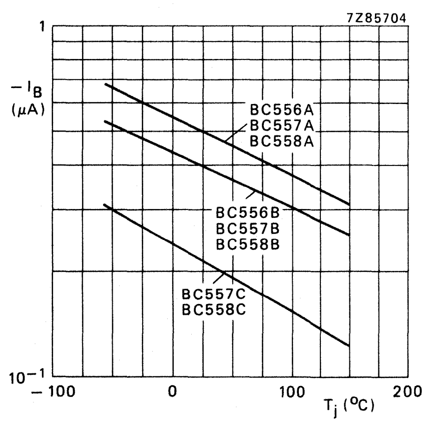


Fig. 6 $-V_{CE} = 5$ V; $I_C = 0{,}1$ mA.

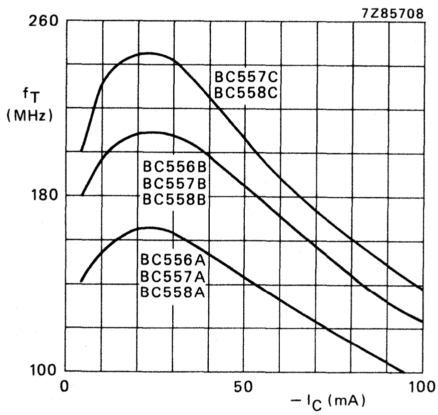


Fig. 7 $-V_{CE} = 5$ V; $T_j = 25$ °C; f = 35 MHz.

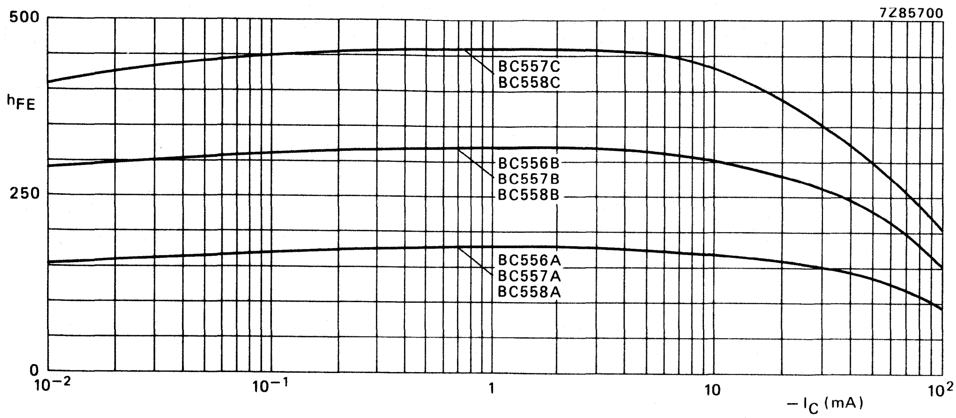


Fig. 8 $-V_{CE} = 5$ V; $T_j = 25$ °C.

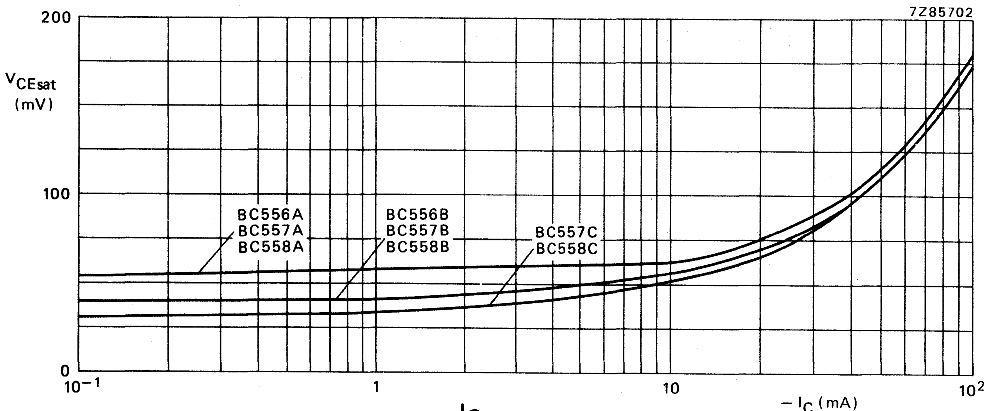


Fig. 9 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

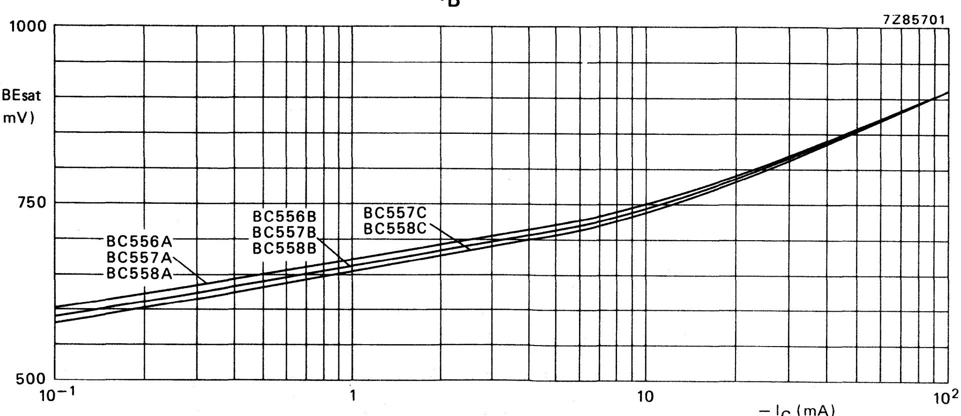


Fig. 10 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

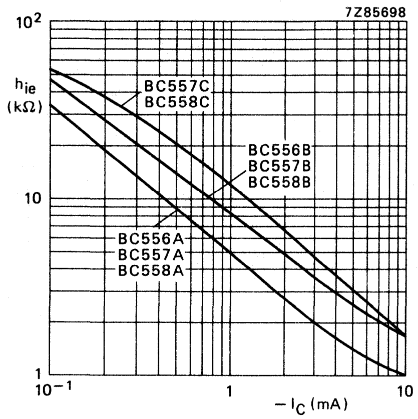


Fig. 11.

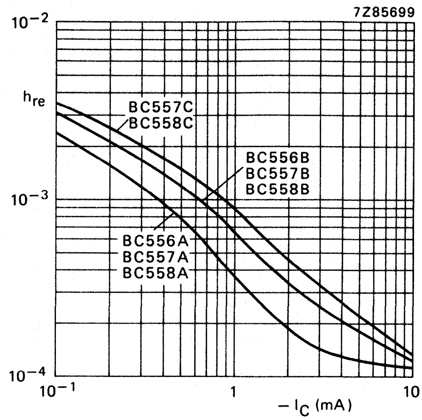


Fig. 12.

For Figs 11, 12, 13 and 14 the following conditions apply: $-V_{CE}$ = 5 V; f = 1 kHz; T_j = 25 °C.

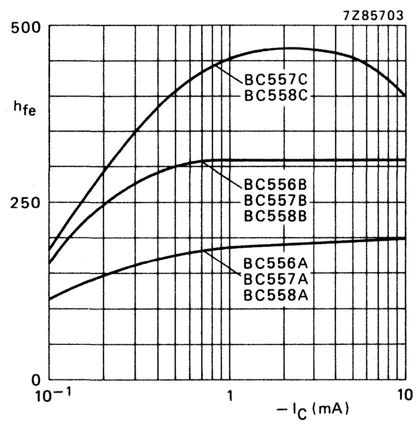


Fig. 13.

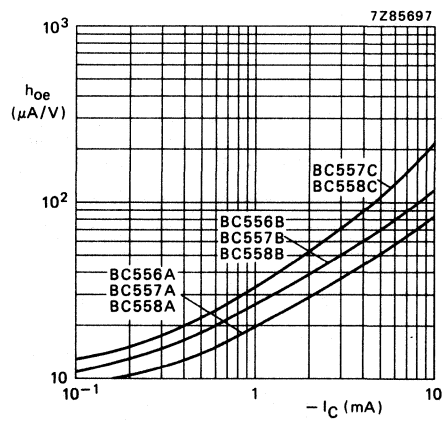


Fig. 14.

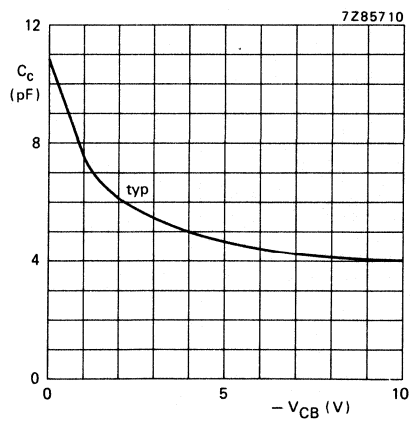


Fig. 15 f = 1 MHz; T_j = 25 °C.

SILICON PLANAR EPITAXIAL TRANSISTORS

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

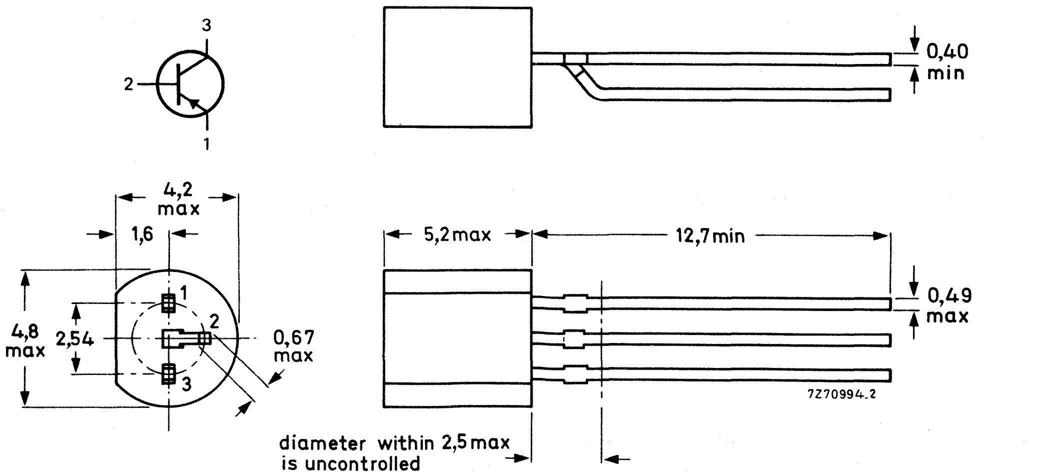
QUICK REFERENCE DATA

			BC559	BC560	
Collector-emitter voltage ($+V_{BE} = 0$ V)	$-V_{CES}$	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
D.C. current gain $-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	>	125	125	
		<	800	800	
Transition frequency $-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	200	200	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	1	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	<	4	4	dB
f = 10 kHz to 50 Hz (equivalent noise voltage)	V_N	<	–	0,11	μV ←

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

			BC559	BC560	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	50	V
→ Collector-emitter voltage ($+V_{BE} = 0$ V)	$-V_{CES}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Emitter-base voltage (open collector)	$-V_{CBO}$	max.	5	5	V
Collector current (d.c.)	$-I_C$	max.	100		mA
Collector current (peak value)	$-I_{CM}$	max.	200		mA
Emitter current (peak value)	I_{EM}	max.	200		mA
Base current (peak value)	$-I_{BM}$	max.	200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	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.	60	mV
		<	300	mV
	$-V_{BEsat}$	typ.	750	mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ.	180	mV
		<	650	mV
	$-V_{BEsat}$	typ.	930	mV

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ.		4 pF
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ B	f_T	typ.		200 MHz
Small-signal current gain at f = 1 kHz				
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}			125 to 900 ←

Noise figure at $R_S = 2$ kΩ					
$-I_C = 200$ μA; $-V_{CE} = 5$ V			BC559	BC560	
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 $-I_C = 200$ μA; $-V_{CE} = 5$ V f = 10 Hz to 50 Hz; $T_{amb} = 25$ °C	V_n	<	–	0,11	μV

			BC559 BC560	BC559A BC560A	BC559B BC560B	BC559C BC560C	
D.C. current gain							
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	>	125	125	220	420	
		<	800	250	475	800	←

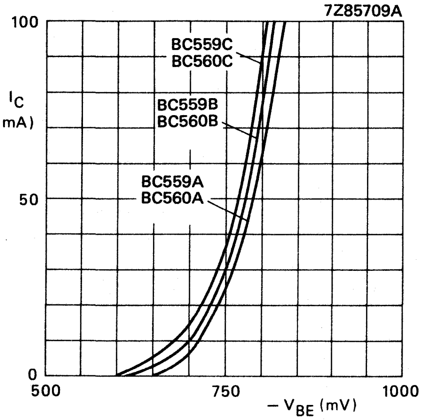


Fig. 2 $-V_{CE} = 5$ V; $T_j = 25$ °C.

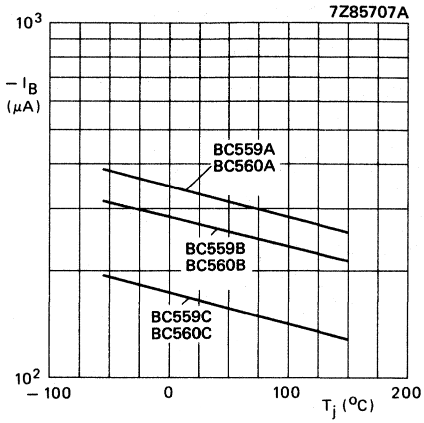


Fig. 3 $-V_{CE} = 5$ V; $I_C = 50$ mA.

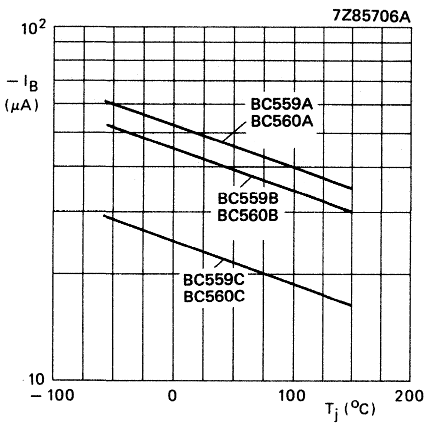


Fig. 4 $-V_{CE} = 5$ V; $I_C = 10$ mA.

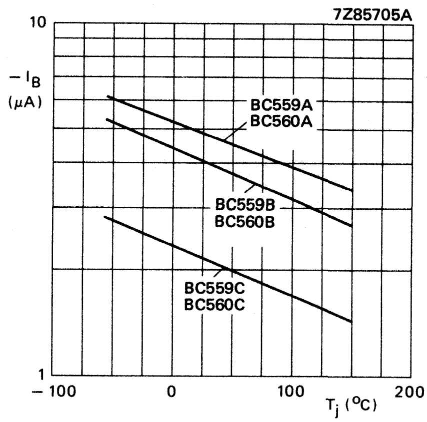


Fig. 5 $-V_{CE} = 5$ V; $I_C = 1$ mA.

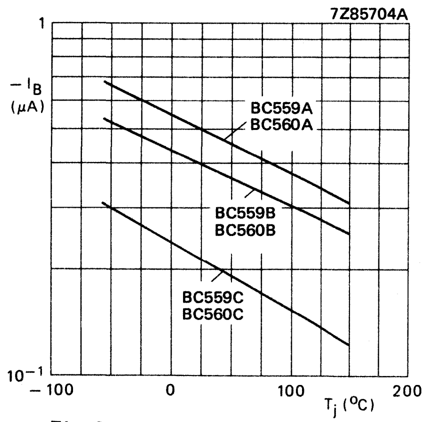


Fig. 6 $-V_{CE} = 5$ V; $I_C = 0{,}1$ mA.

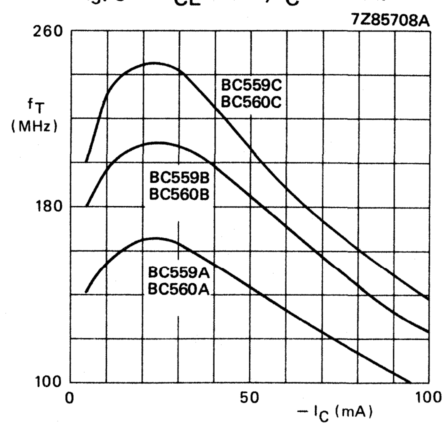


Fig. 7 $-V_{CE} = 5$ V; $T_j = 25$ °C; f = 35 MHz.

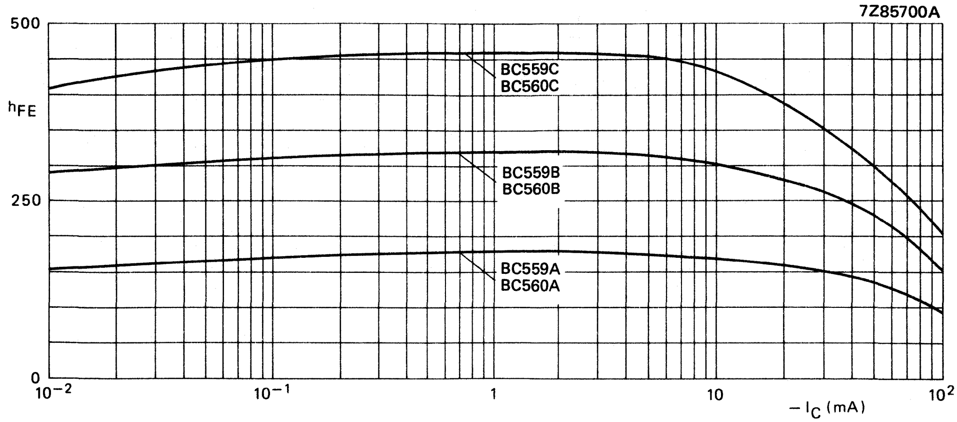


Fig. 8 $-V_{CE} = 5$ V; $T_j = 25$ °C.

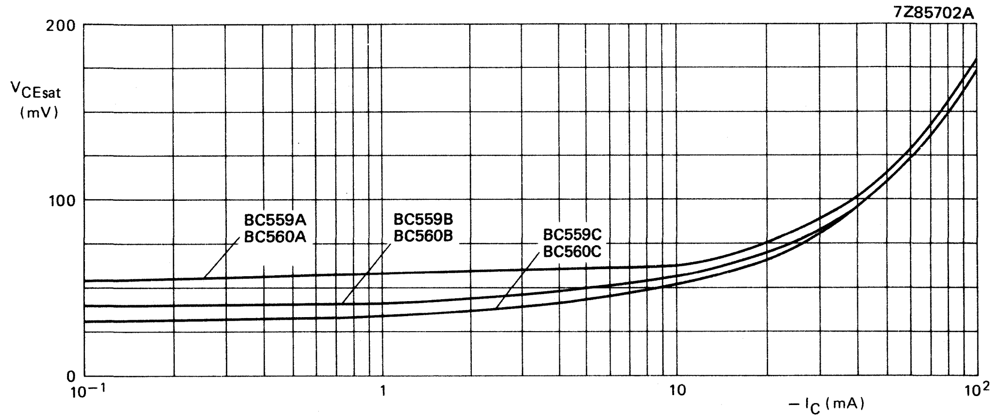


Fig. 9 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

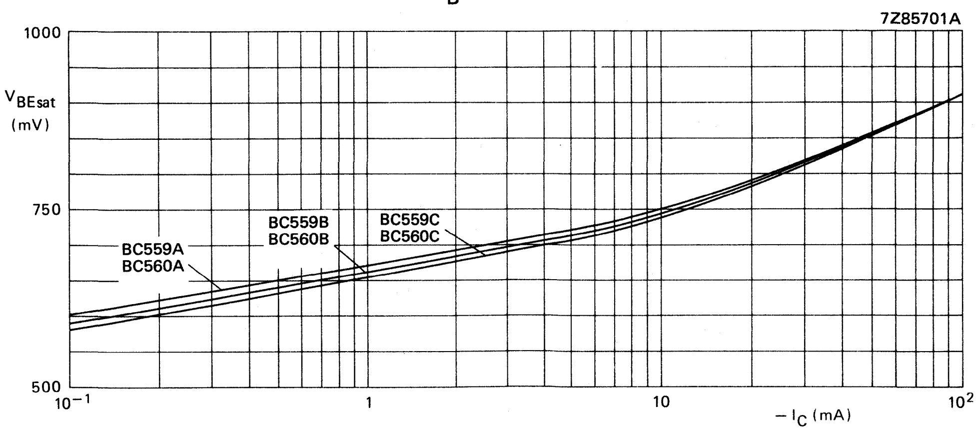


Fig. 10 $\frac{-I_C}{-I_B} = 20$; $T_j = 25$ °C.

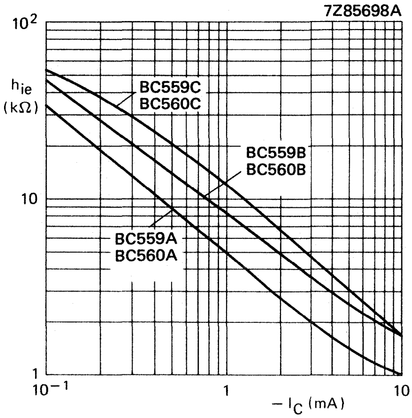


Fig. 11.

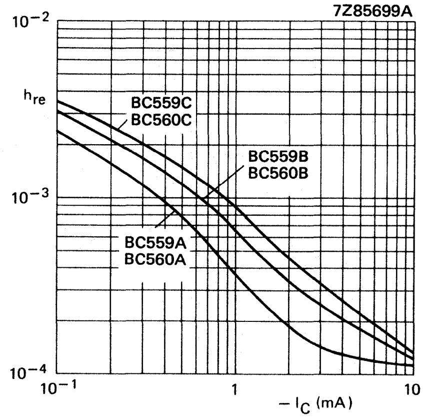


Fig. 12.

For Figs 11, 12, 13 and 14 the following conditions apply: $-V_{CE}$ = 5 V; f = 1 kHz; T_j = 25 °C.

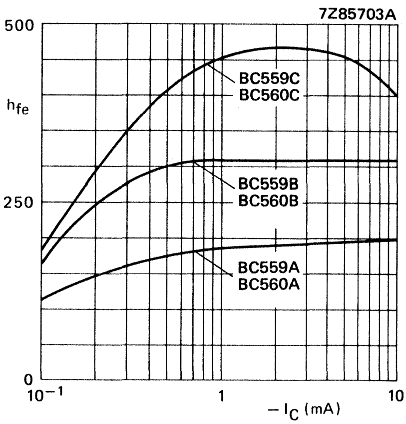


Fig. 13.

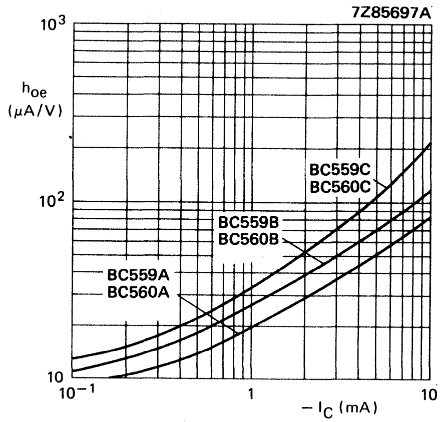


Fig. 14.

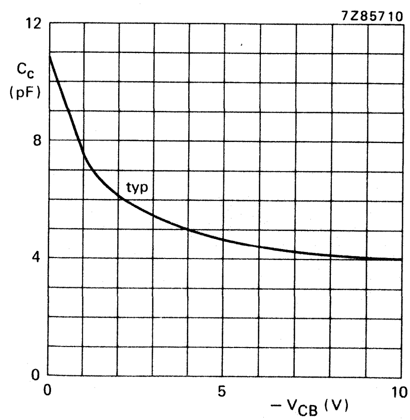


Fig. 15 f = 1 MHz; T_j = 25 °C.

curves of constant noise figure

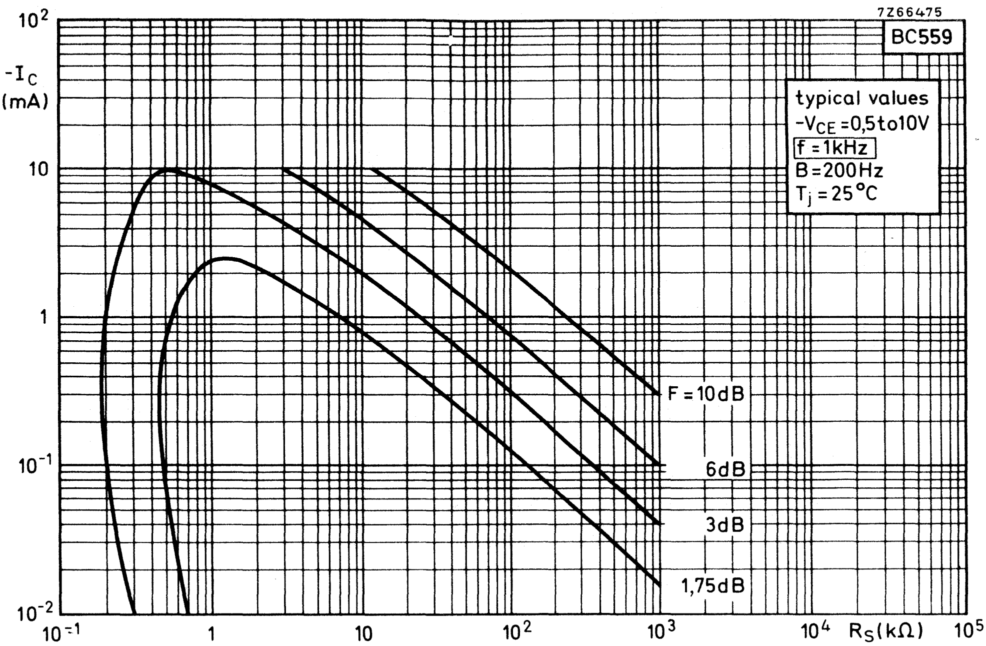


Fig. 16.

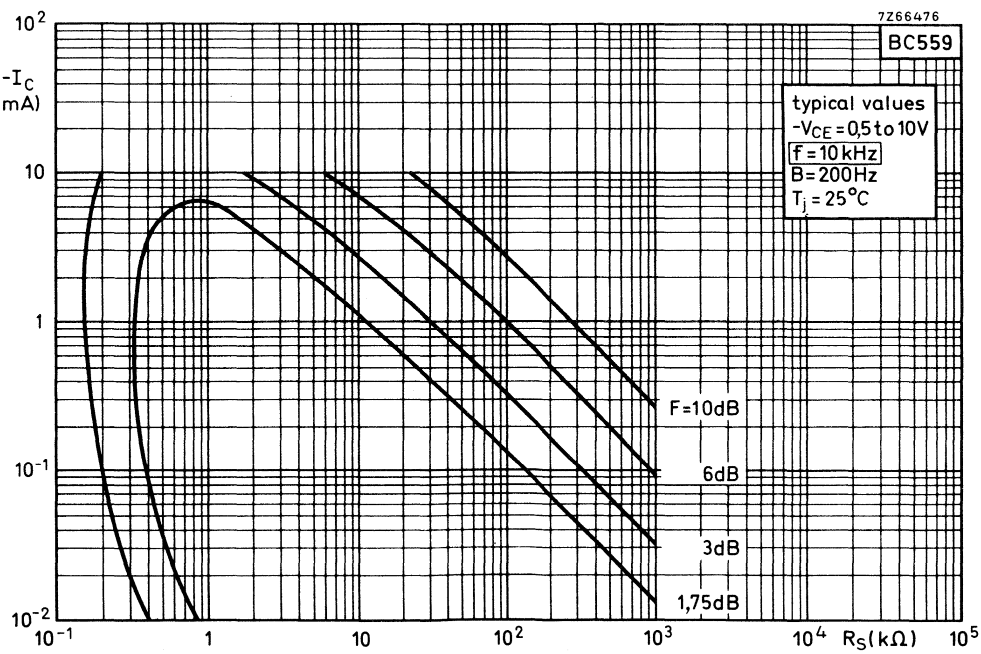


Fig. 17.

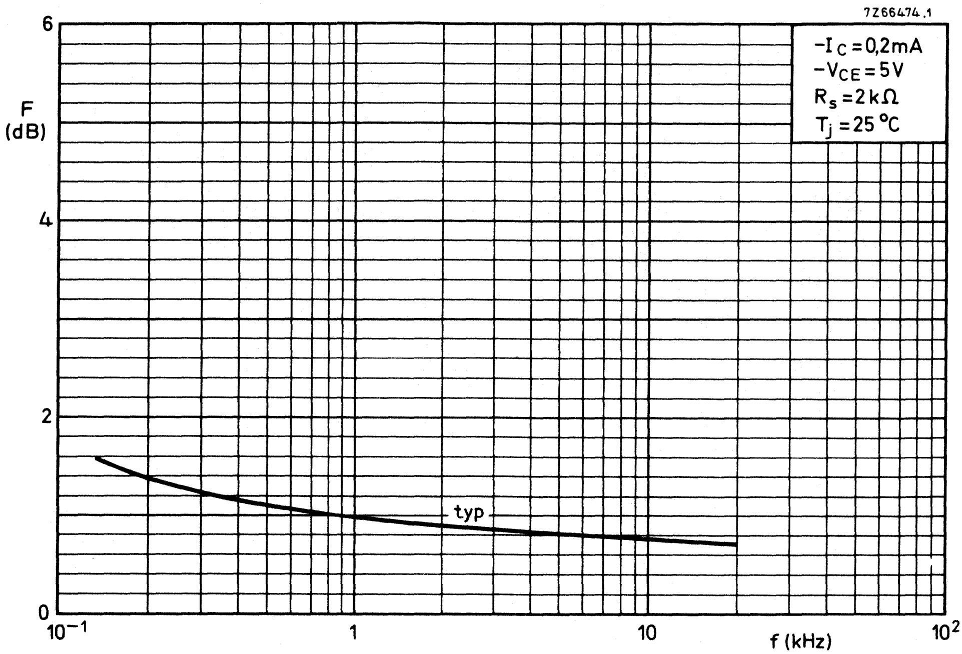

7Z66474.1
$-I_C = 0,2 mA$
$-V_{CE} = 5 V$
$R_s = 2 k\Omega$
$T_j = 25\ ^oC$
F
(dB)
6
4
2
0
typ
10^{-1}
1
10
10^2
f (kHz)

Fig. 18.

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.

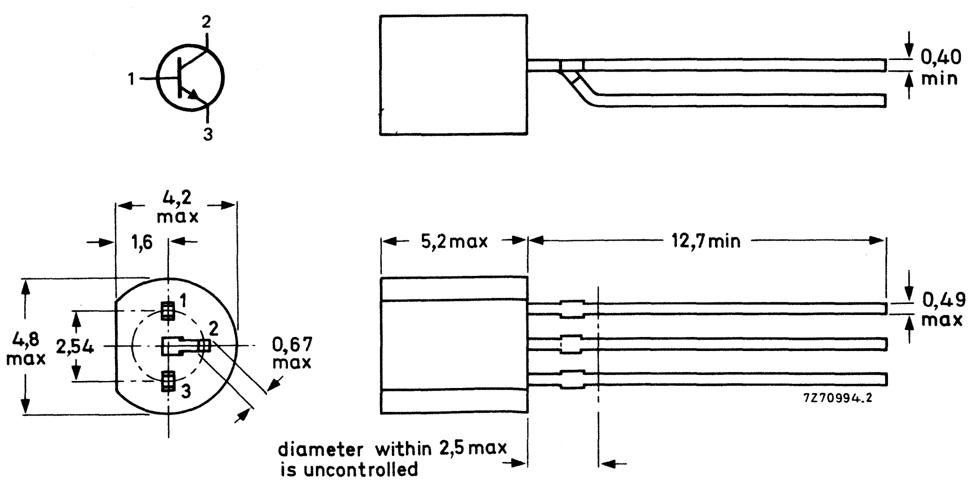
QUICK REFERENCE DATA

			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	250	250	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	130	130	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

			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

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
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*
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
From junction to ambient	$R_{th\ j\text{-}a}$	=	125	K/W*
From junction to case	$R_{th\ j\text{-}c}$	=	60	K/W

* 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				
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	
$I_C = 150$ mA; $V_{CE} = 2$ V*	h_{FE}	> <	40 250	
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	130	MHz

←

* BC635-10 BC637-10 BC639-10	h_{FE}	> <	63 160
BC635-16 BC637-16 BC639-16	h_{FE}	> <	100 250

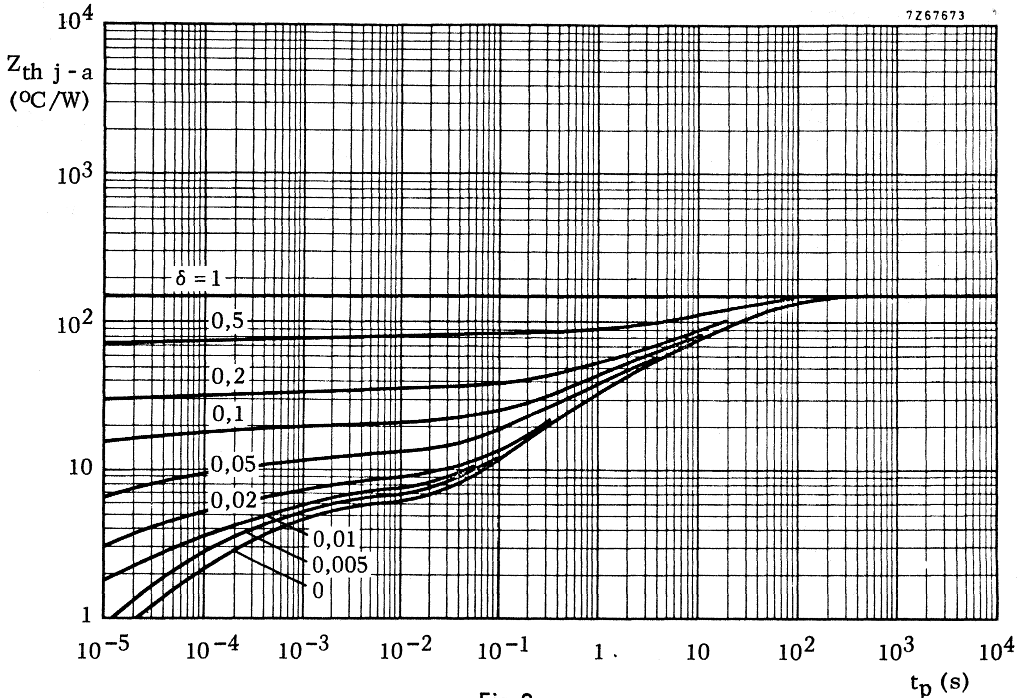

7Z67673
10^4
$Z_{th\ j-a}$
(°C/W)
10^3
δ = 1
0,5
10^2
0,2
0,1
10
0,05
0,02
0,01
0,005
0
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

Fig. 2.

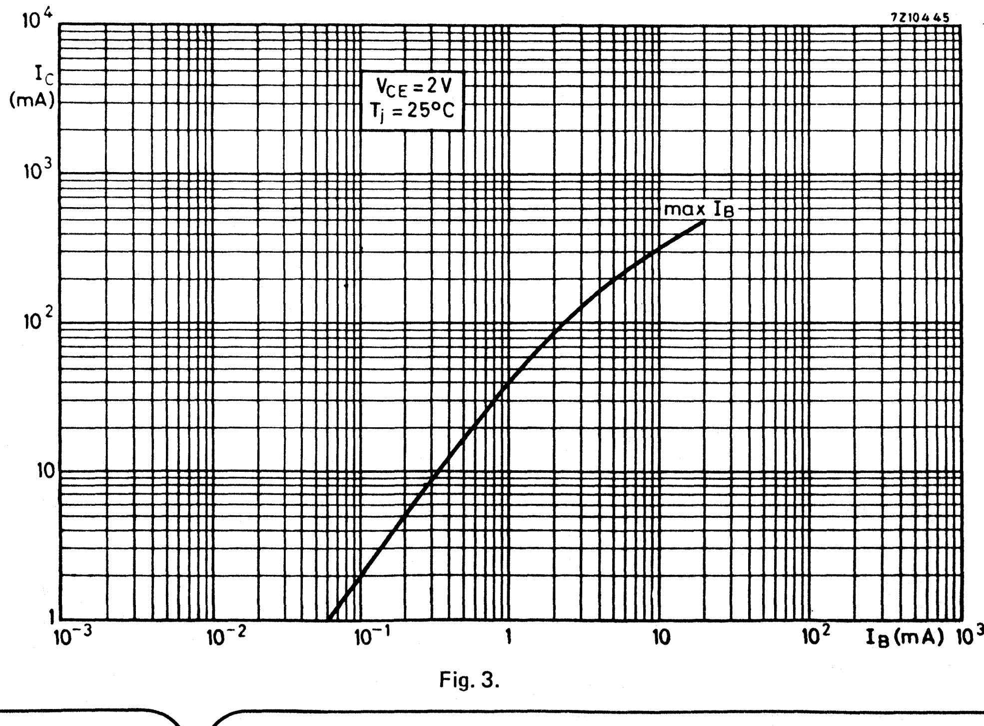

7Z10445
10^4
I_C
(mA)
$V_{CE} = 2\,V$
$T_j = 25\,°C$
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

Fig. 3.

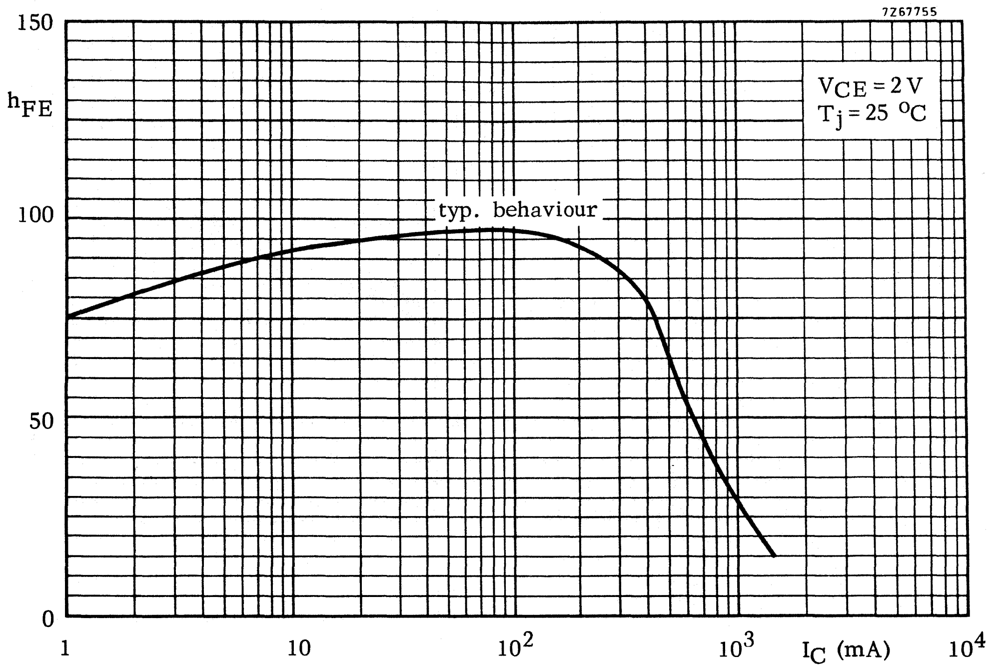


Fig. 4.

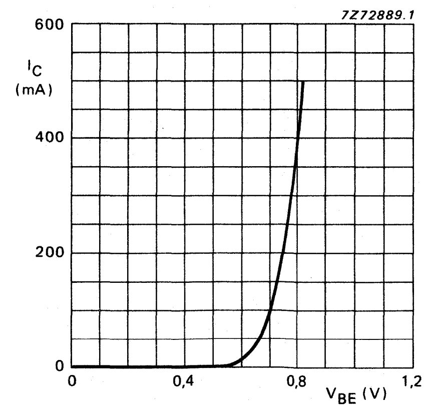


Fig. 5 $V_{CE} = 2$ V; $T_j = 25\ ^oC$; typical values.

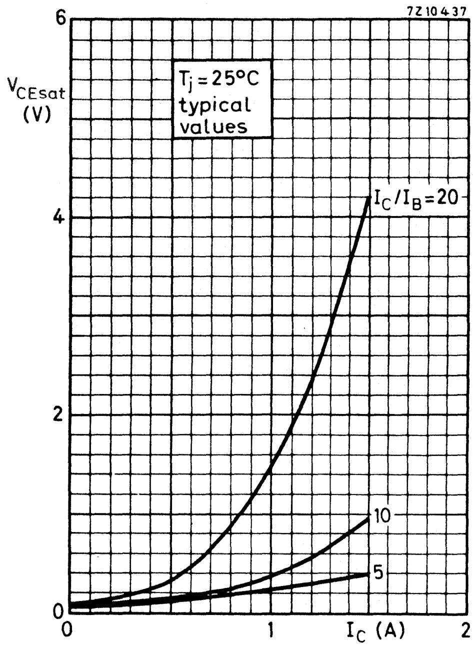


Fig. 6.

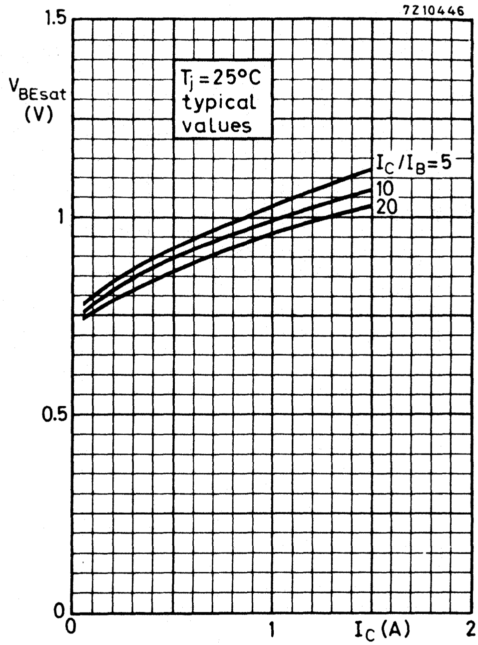


Fig. 7.

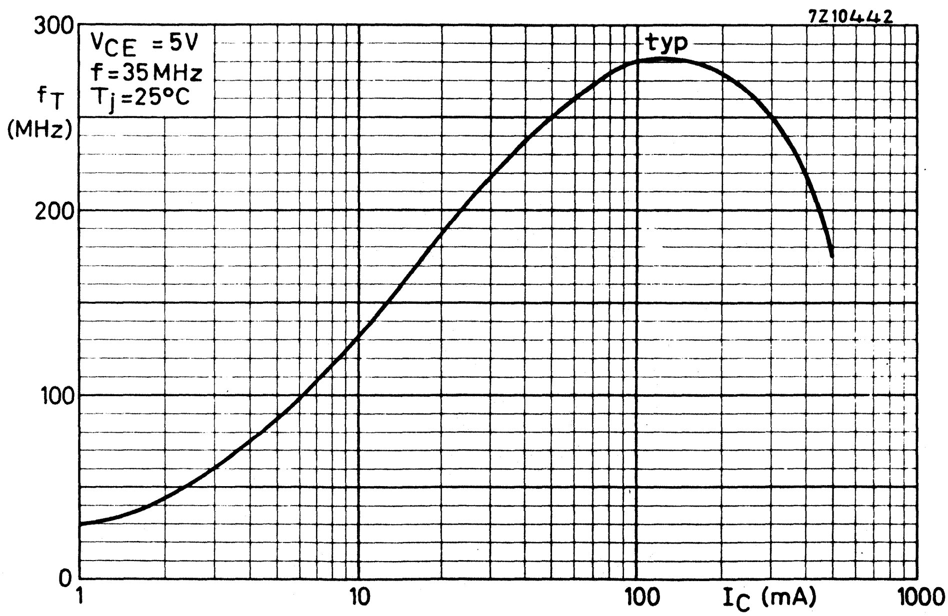


Fig. 8.

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.

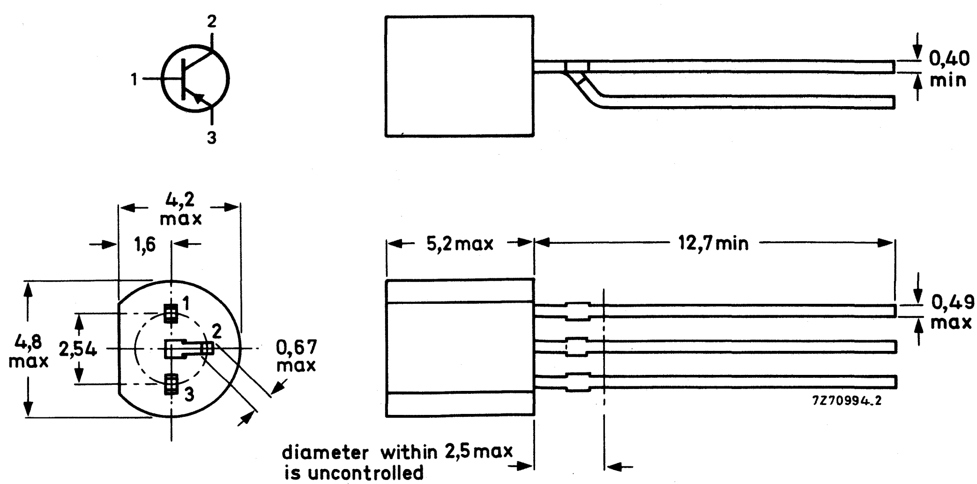
QUICK REFERENCE DATA

			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	250	250	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

			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
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
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*
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
From junction to ambient	$R_{th\ j\text{-}a}$	=	125	K/W*
From junction to case	$R_{th\ j\text{-}c}$	=	60	K/W

* 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			
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
$-I_C = 150$ mA; $-V_{CE} = 2$ V*	h_{FE}	> <	40 250
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	50 MHz

* BC636-10 BC638-10 BC640-10	h_{FE}	> <	63 160
BC636-16 BC638-16 BC640-16	h_{FE}	> <	100 250

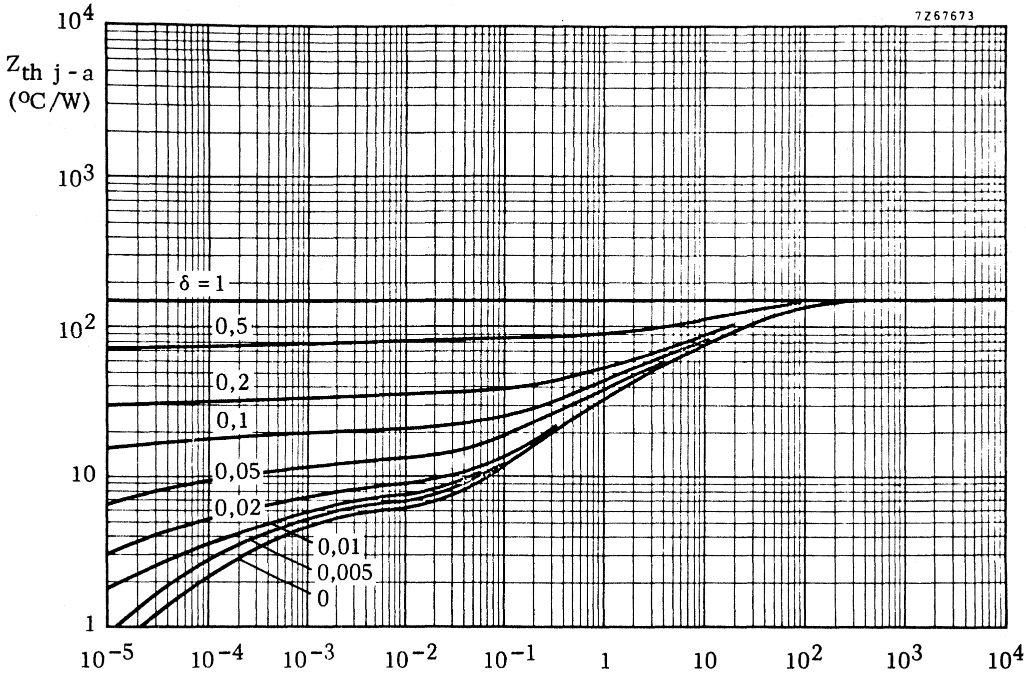

7Z67673
10^4
$Z_{th\ j-a}$ (°C/W)
10^3
$\delta = 1$
10^2
0,5
0,2
0,1
10
0,05
0,02
0,01
0,005
0
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

Fig. 2.

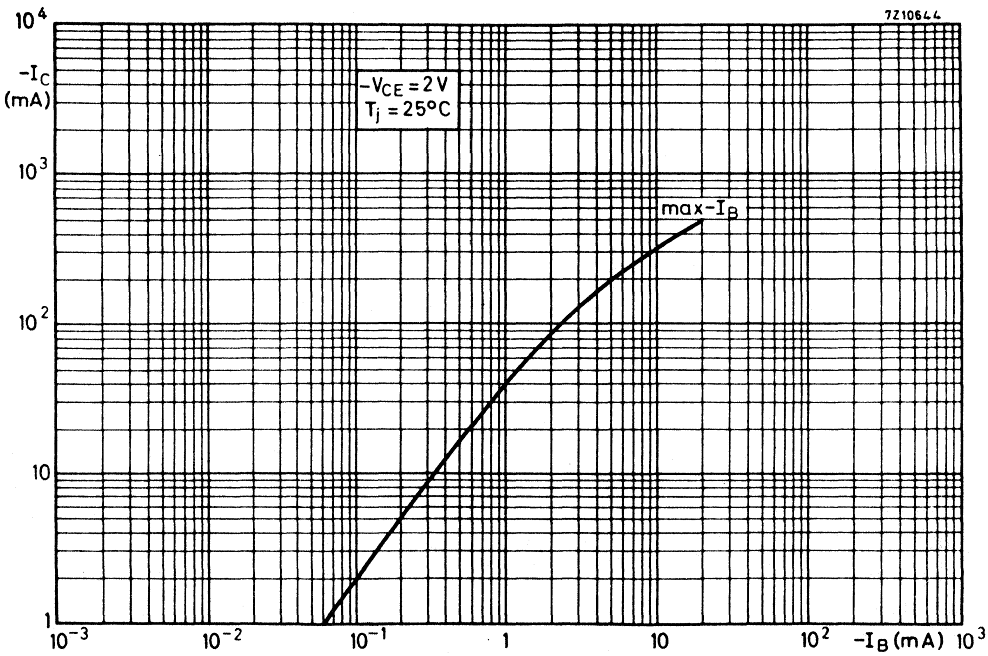

7Z10644
10^4
$-I_C$ (mA)
$-V_{CE} = 2\ V$
$T_j = 25\,^{\circ}C$
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

Fig. 3.

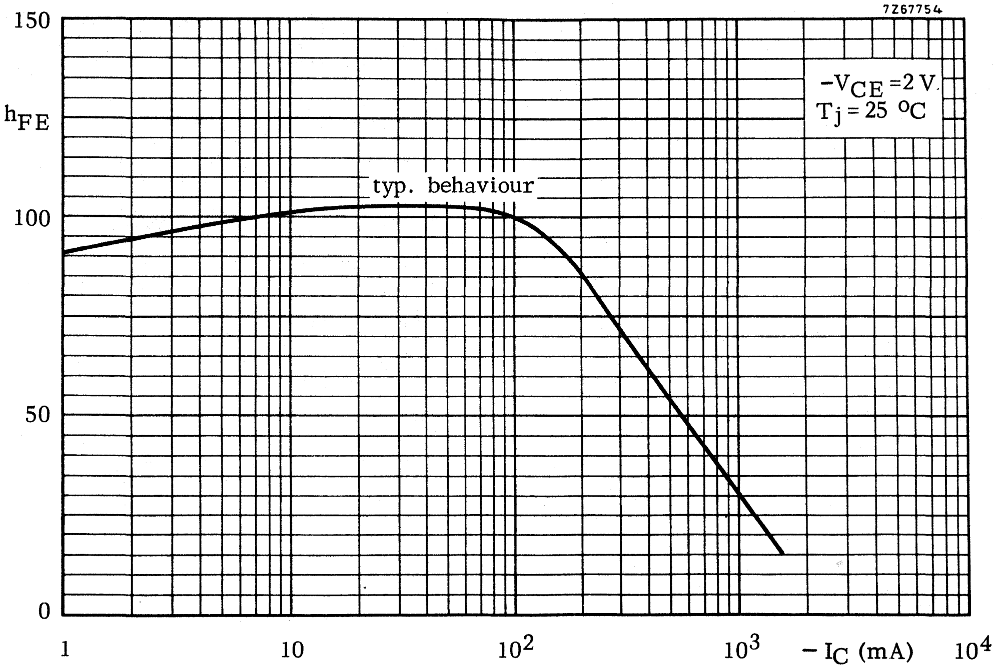


Fig. 4.

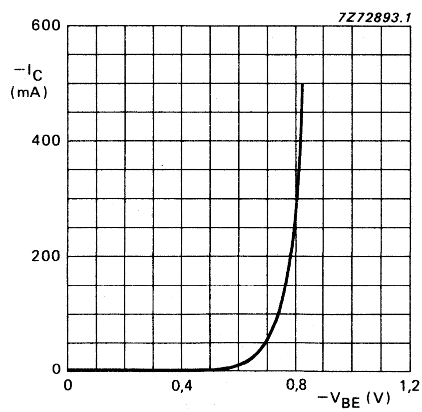


Fig. 5 $-V_{CE} = 2$ V; $T_j = 25$ °C; typical values.

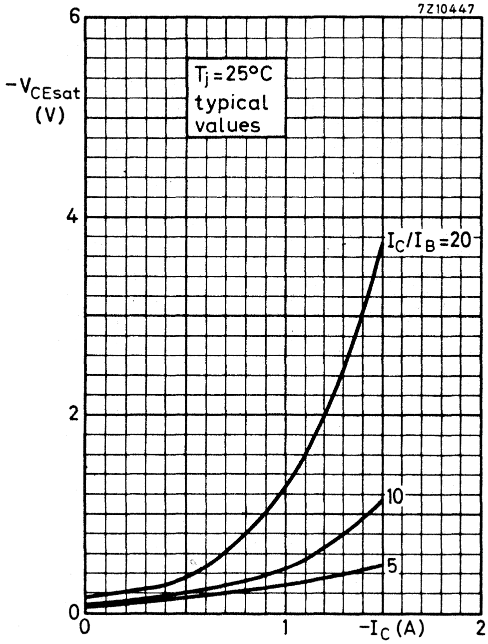


Fig. 6.

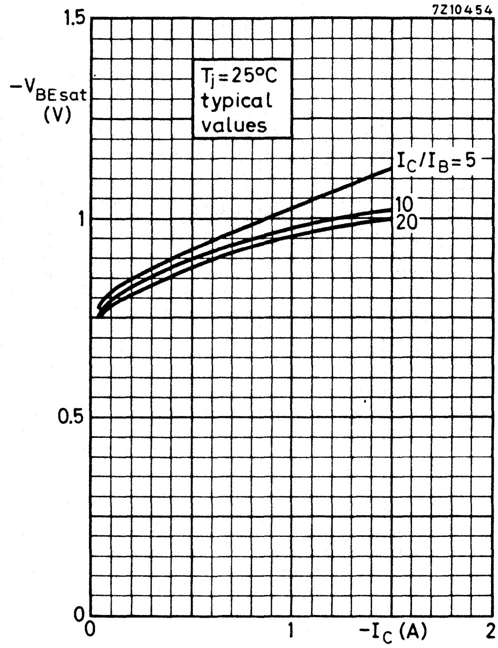


Fig. 7.

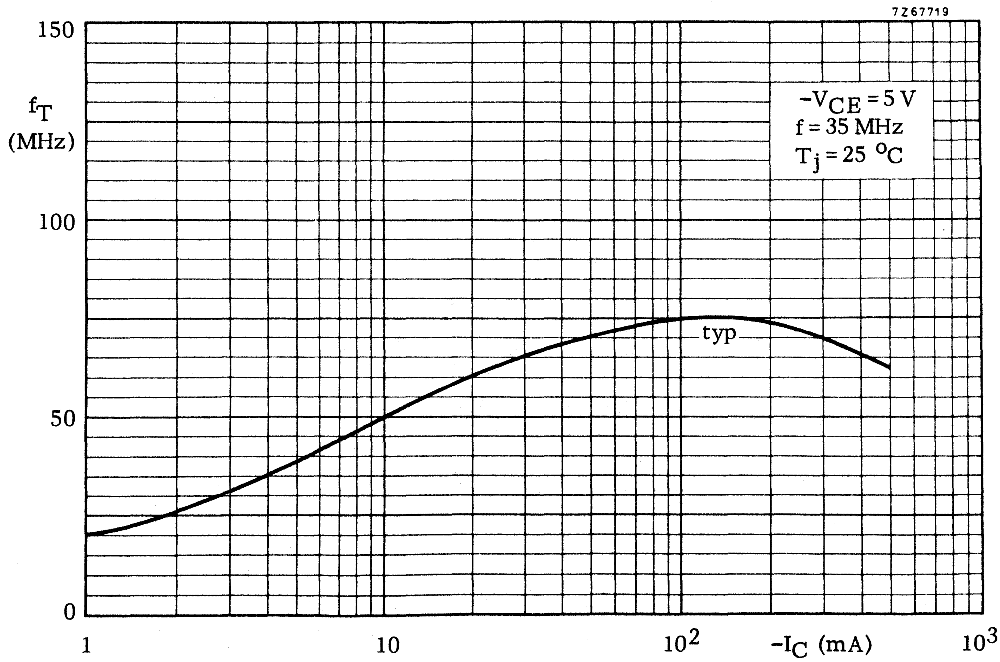


Fig. 8.

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N silicon planar epitaxial transistors in a plastic TO-92 envelope.

P-N-P complementary types are BCX78 and BCX79.

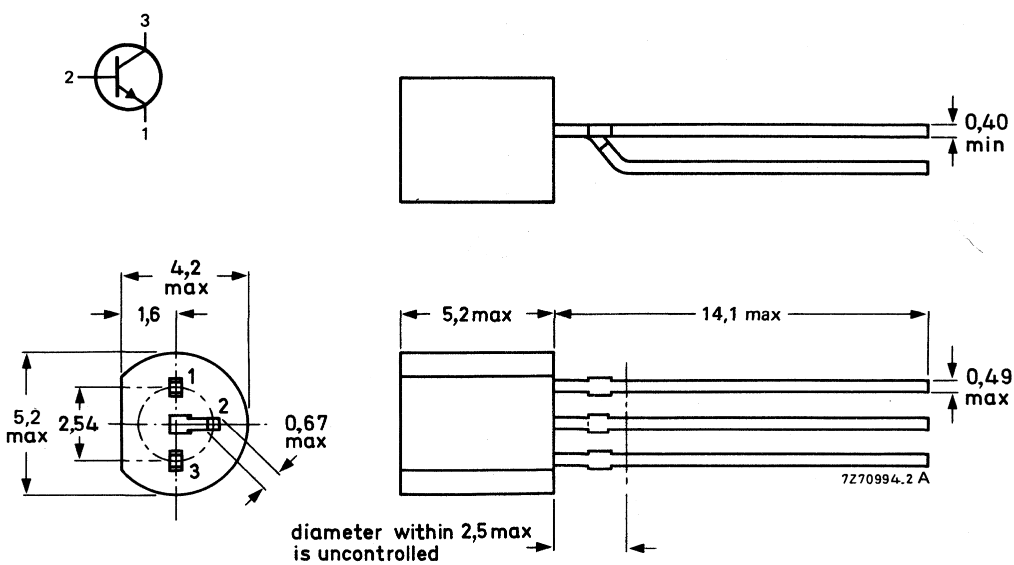
QUICK REFERENCE DATA

			BCX58	BCX59	
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Collector-emitter voltage (emitter to base)	V_{CES}	max.	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7		V
Collector current (peak)	I_{CM}	max.	200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	450		mW
Junction temperature	T_j	max.	150		°C
Transition frequency	f_T	>	125		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			BCX58	BCX59	
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Collector-emitter voltage (emitter to base)	V_{CES}	max.	32	45	V
Emitter-base voltage	V_{EBO}	max.	7		V
Collector current (d.c.)	I_C	max.	100		mA
Collector current (peak value)	I_{CM}	max.	200		mA
Base current (d.c.)	I_B	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	450		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−55 to +150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	280	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCX58	BCX59	
Collector-emitter current					
V_{CE} = 32 V	I_{CES}	<	10		nA
V_{CE} = 32 V; T_j = 125 °C	I_{CES}	<	2,5		μA
V_{CE} = 32 V; V_{BE} = 0,2 V; T_j = 100 °C	I_{CEX}	<	20		μA
Collector-emitter current					
V_{CE} = 45 V	I_{CES}	<		10	nA
V_{CE} = T_j = 125 °C	I_{CES}	<		2,5	μA
V_{CE} = 45 °C; V_{BE} = 0,2 V; T_j = 100 °C	I_{CEX}	<		20	μA
Emitter-base current					
V_{EBO} = 5 V	I_{EBO}	<	20	20	nA
Collector-emitter breakdown voltage					
I_C = 10 mA	$V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
I_{EBO} = 1 μA	$V_{(BR)EBO}$	>	7		V
Collector-emitter saturation voltage					
I_C = 100 mA; I_B = 2,5 mA	V_{CEsat}	<	0,5		V
I_C = 100 mA; I_B = 2,5 mA	V_{BEsat}	<	1,0		V
Collector-base capacitance at 1 MHz					
V_{CBO} = 10 V	C_{cb}	<	4,5		pF

			BCX58	BCX59	
Emitter-base capacitance at 1 MHz					
V_{EBO} = 0,5 V	C_{eb}	>	15		pF
Transition frequency at f = 100 MHz					
I_C = 10 mA; V_{CE} = 5 V	f_T	<	125		MHz
Noise figure at f = 1 kHz					
I_C = 0,2 mA; V_{CE} = 5 V; R_S = 2 kΩ	F	<	6		dB
		typ.	2		dB

type		BCX58, BCX59				BCX58
h_{FE} group		7	8	9	10	BCX59
V_{CE} (V)	I_C (mA)	h_{FE}	h_{FE}	h_{FE}	h_{FE}	V_{BE} (V)
5	0,01	78	145 (>20)	220 (>40)	300 (>100)	0,5
5	2	170	250	350	500	0,62
		(120 – 220)	(180 – 310)	(250 – 460)	(380 – 630)	(0,55 – 0,7)
1	10	190	260	380	550	0,7
		(>80)	(120 – 400)	(160 – 630)	(240 – 1000)	
1	100	>40	>45	>60	>60	0,83

DEVELOPMENT DATA

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P silicon planar epitaxial transistors in a plastic TO-92 envelope.

N-P-N complementary types are BCX58 and BCX59.

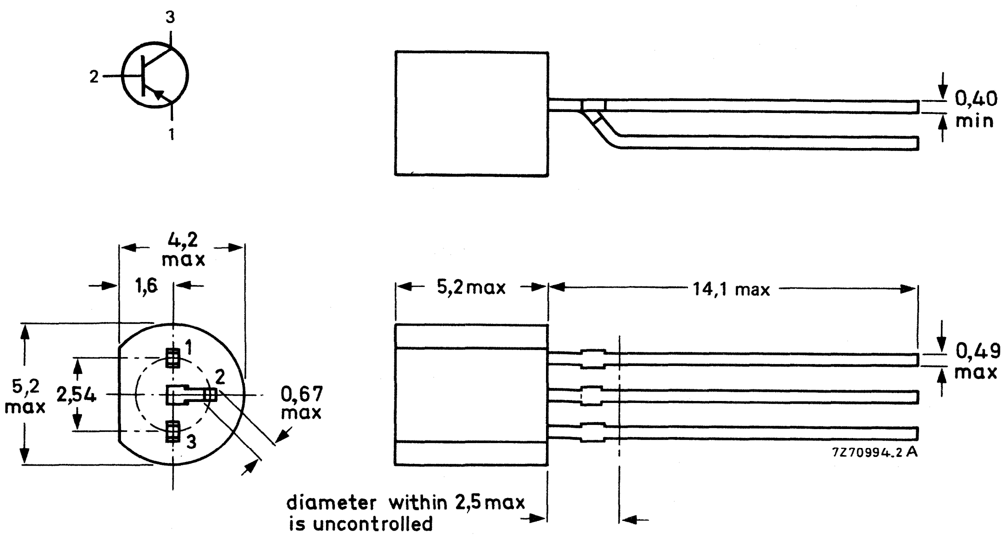
QUICK REFERENCE DATA

			BCX78	BCX79	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Collector-emitter voltage (emitter to base)	$-V_{CES}$	max.	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current (peak)	$-I_{CM}$	max.	200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	450		mW
Junction temperature	T_j	max.	150		°C
Transition frequency	f_T	>	200		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			BCX78	BCX79	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Collector-emitter voltage (emitter to base)	$-V_{CES}$	max.	32	45	V
Emitter-base voltage	$-V_{EBO}$	max.	5		V
Collector current (d.c.)	$-I_C$	max.	100		mA
Collector current (peak value)	$-I_{CM}$	max.	200		mA
Base current (d.c.)	$-I_B$	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	450		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−55 to +150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	max.	280	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCX78	BCX79	
Collector-emitter current					
$-V_{CE}$ = 32 V	$-I_{CES}$	<	10		nA
$-V_{CE}$ = 32 V; T_j = 125 °C	$-I_{CES}$	<	2,5		μA
$-V_{CE}$ = 32 V; $-V_{BE}$ = 0,2 V; T_j = 100 °C	$-I_{CEX}$	<	20		μA
Collector-emitter current					
$-V_{CE}$ = 45 V	$-I_{CES}$	<		10	nA
$-V_{CE}$ = T_j = 125 °C	$-I_{CES}$	<		2,5	μA
$-V_{CE}$ = 45 °C; $-V_{BE}$ = 0,2 V; T_j = 100 °C	$-I_{CEX}$	<		20	μA
Emitter-base current					
$-V_{EBO}$ = 4 V	$-I_{EBO}$	<	20	20	nA
Collector-emitter breakdown voltage					
$-I_C$ = 10 mA	$-V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$-I_{EBO}$ = 1 μA	$-V_{(BR)EBO}$	>	5		V
Collector-emitter saturation voltage					
$-I_C$ = 100 mA; $-I_B$ = 2,5 mA	$-V_{CEsat}$	<	0,6		V
$-I_C$ = 100 mA; $-I_B$ = 2,5 mA	$-V_{BEsat}$	<	1,0		V
Collector-base capacitance at 1 MHz					
$-V_{CBO}$ = 10 V	C_{cb}	<	4,5		pF
Emitter-base capacitance at 1 MHz					
$-V_{EBO}$ = 0,5 V	C_{eb}	<	15		pF

			BCX78	BCX79	
Transition frequency at f = 100 MHz					
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	>	200		MHz
Noise figure at f = 1 kHz					
$-I_C$ = 0,2 mA; $-V_{CE}$ = 5 V; R_S = 2 kΩ	F	<	6		dB
		typ.	2		dB

type		BCX78, BCX79				BCX78
h_{FE} group		7	8	9	10	BCX79
$-V_{CE}$ (V)	$-I_C$ (mA)	h_{FE}	h_{FE}	h_{FE}	h_{FE}	$-V_{BE}$ (V)
5	0,01	140	200 (>30)	270 (>40)	340 (>100)	0,55
5	2	170	250	350	500	0,65
		(120 – 220)	(180 – 310)	(250 – 460)	(380 – 630)	(0,6 – 0,7)
1	10	180	260	360	500	0,68
		(>80)	(120 – 400)	(160 – 630)	(240 – 1000)	
1	100	>40	>45	>60	>60	0,76 (<0,9)

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

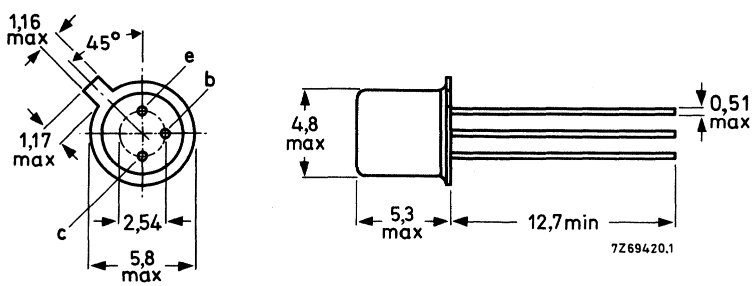
			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	V
Collector current (d.c.)	I_C	max.	100	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	mW
Junction temperature	T_j	max.	175	175	°C
D.C. current gain 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).

Products approved to CECC 50 002-164.

RATINGS (Limiting values)*

			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

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Storage temperature range	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	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,2	K/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** 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

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

** V_{BE} decreases with about 2 mV/K at increasing temperature.

		BCY56		BCY57	
D.C. current gain					
$I_C = 10\ \mu A$; $V_{CE} = 5\ V$	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	μS ←
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					
$I_C = 200\ \mu A$; $V_{CE} = 5\ V$; $R_S = 2\ k\Omega$					
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

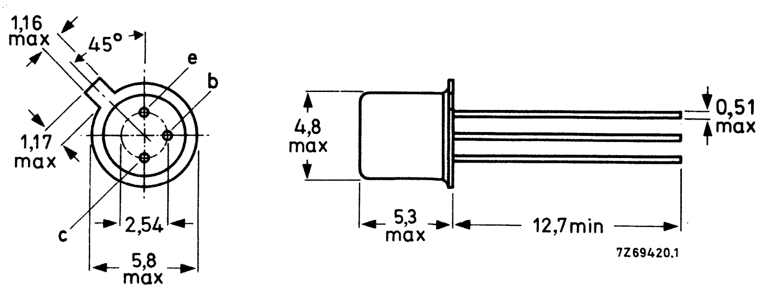
			BCY58–VII	VIII	IX	X	
			BCY59–VII	VIII	IX	X	
Small-signal current gain at T_j = 25 °C; I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	175	250	350	
		<	250	350	500	700	
Transition frequency at f = 100 MHz; I_C = 10 mA; V_{CE} = 5 V	f_T	>	150				MHz
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 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).

Products approved to CECC 50 002-030/031.

RATINGS

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

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

Collector current	I_C	max.	200	mA
Base current	I_B	max.	50	mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	1000	mW
Storage temperature range	T_{stg}		−65 to + 200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCY58	BCY59	
Collector cut-off currents					
V_{CE} = 32 V; V_{BE} = 0	I_{CES}	<	10		nA
V_{CE} = 45 V; V_{BE} = 0	I_{CES}	<		10	nA
V_{CE} = 32 V; V_{BE} = 0; T_j = 150 °C	I_{CES}	<	10		μA
V_{CE} = 45 V; V_{BE} = 0; T_j = 150 °C	I_{CES}	<		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 μA	$V_{(BR)EBO}$	>	7	7	V

Base emitter voltage				
I_C = 10 μA; V_{CE} = 5 V	V_{BE}	typ.	0,5	V
I_C = 20 μA; V_{CE} = $V_{CEO\,max}$; T_j = 100 °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
		typ.	875	mV
			750 to 1200	mV
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	5,0	pF
Emitter capacitance at f = 1 MHz				
I_C = I_c = 0; V_{EB} = 0,5 V	C_e	<	15	pF
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	>	150	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

CHARACTERISTICS (continued)

			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}	typ.	2,7	3,6	4,5	7,5	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1,5	2	3	3	10^{-4}
Small signal current gain	h_{fe}	typ.	200	260	330	520	
→ Output admittance	h_{oe}	typ.	18	24	30	50	μS

Switching times

$I_C = 10$ mA; $I_B = 1$ mA; $-I_{BM} = 1$ mA
$R1 = 5$ 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

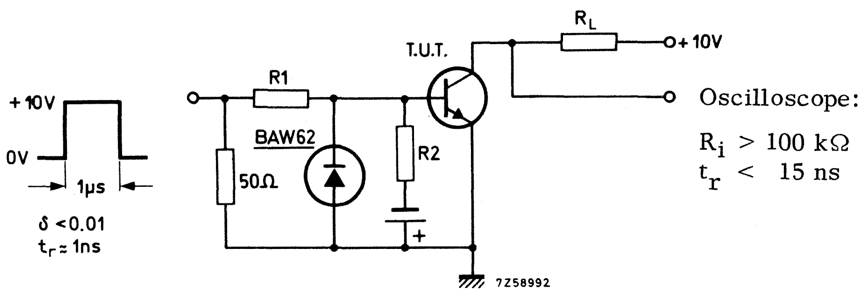


Fig. 2 Test circuit for switching times.

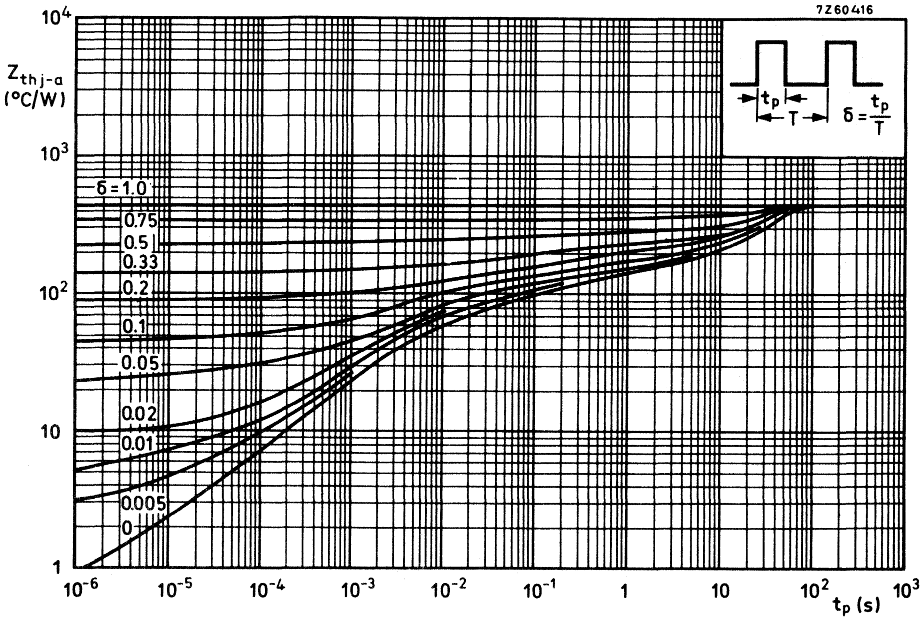


Fig. 3.

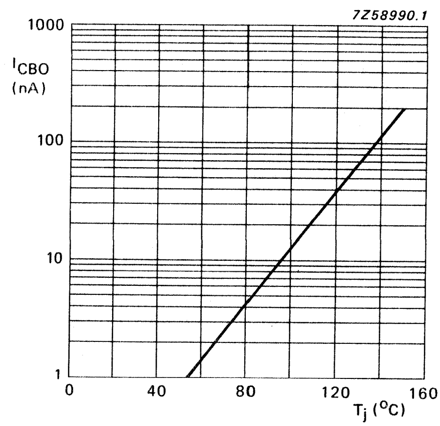


Fig. 4 V_{CB} = 32 V (BCY58); 45 V (BCY59); typical values.

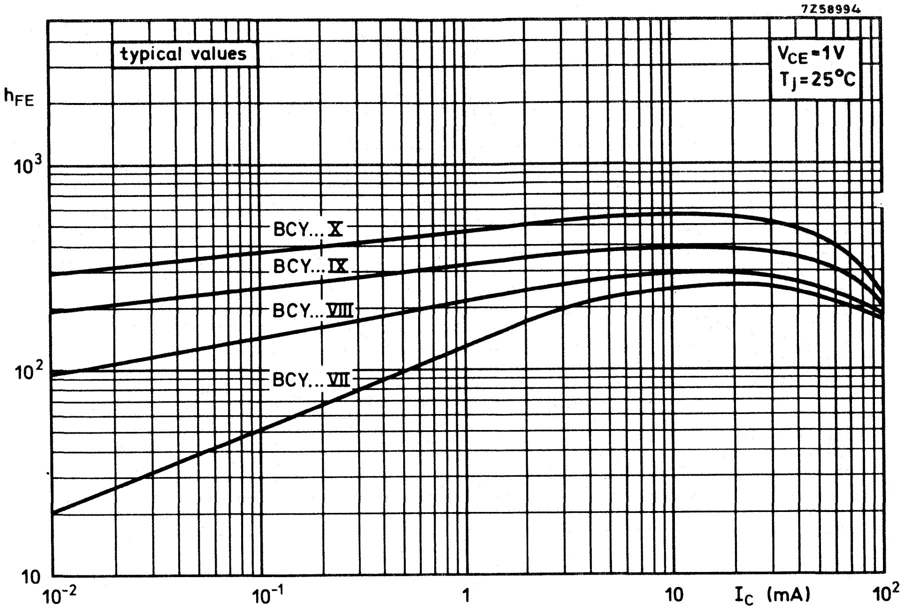


Fig. 5.

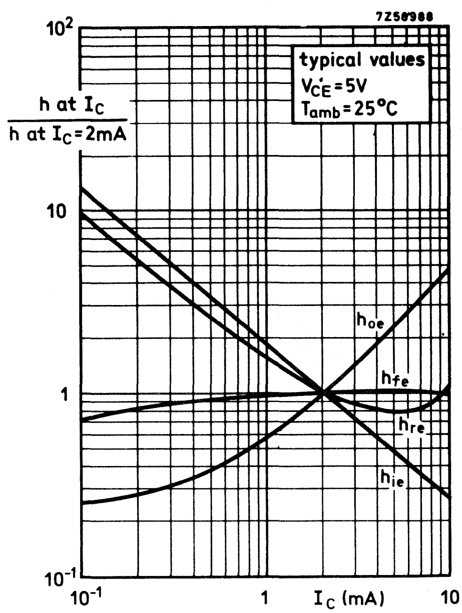


Fig. 6.

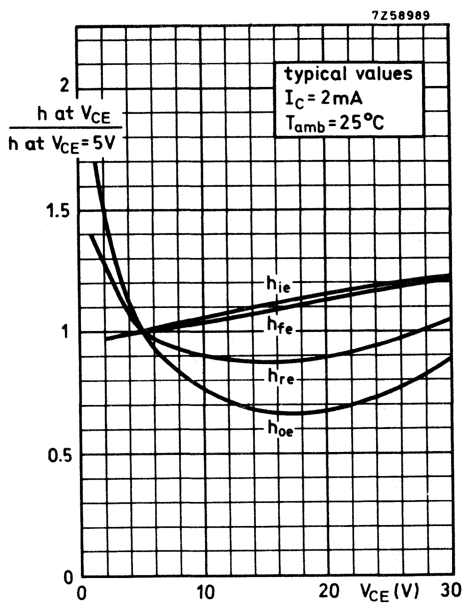


Fig. 7.

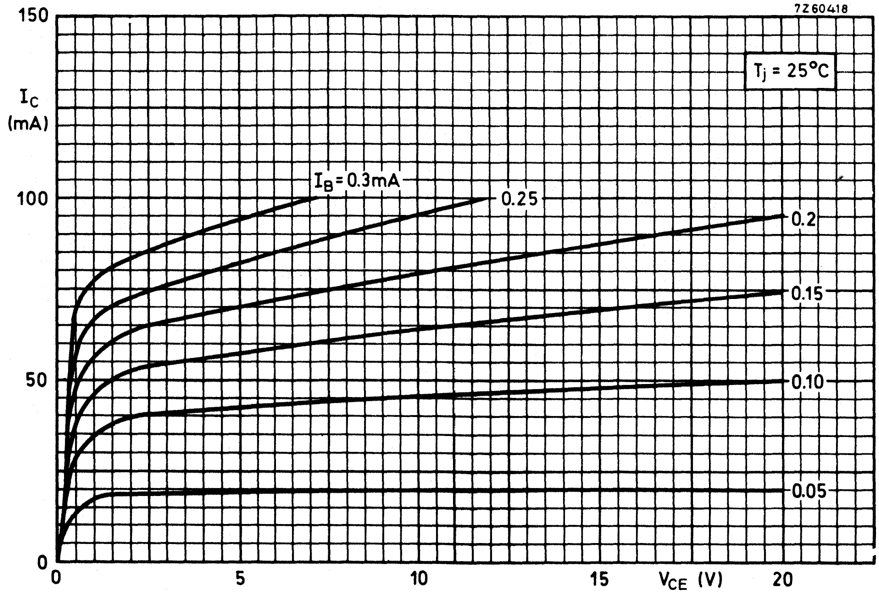


Fig. 8.

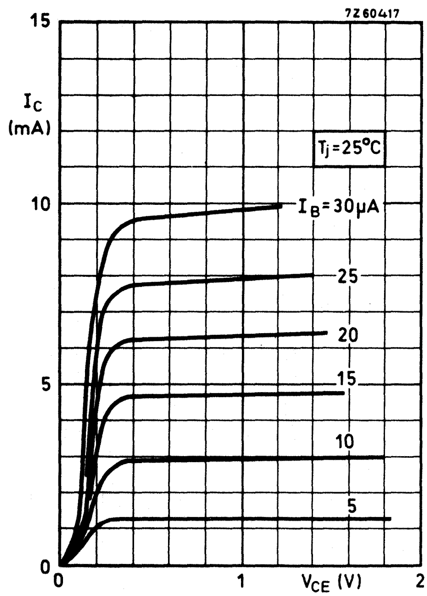


Fig. 9.

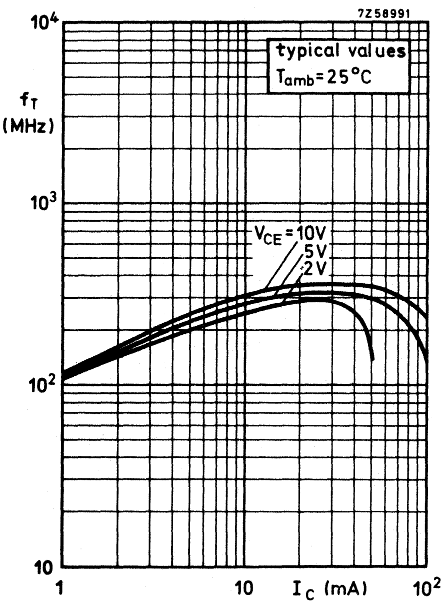


Fig. 10.

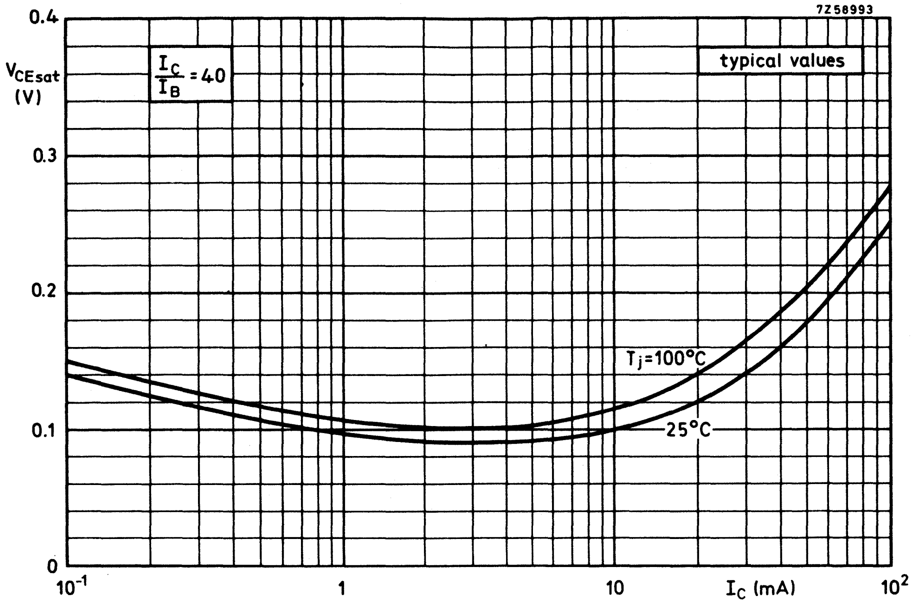

7Z58993
0.4
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 40$
typical values
0.3
0.2
$T_j = 100°C$
0.1
25°C
0
10^{-1}
1
10
I_C (mA)
10^2

Fig. 11.

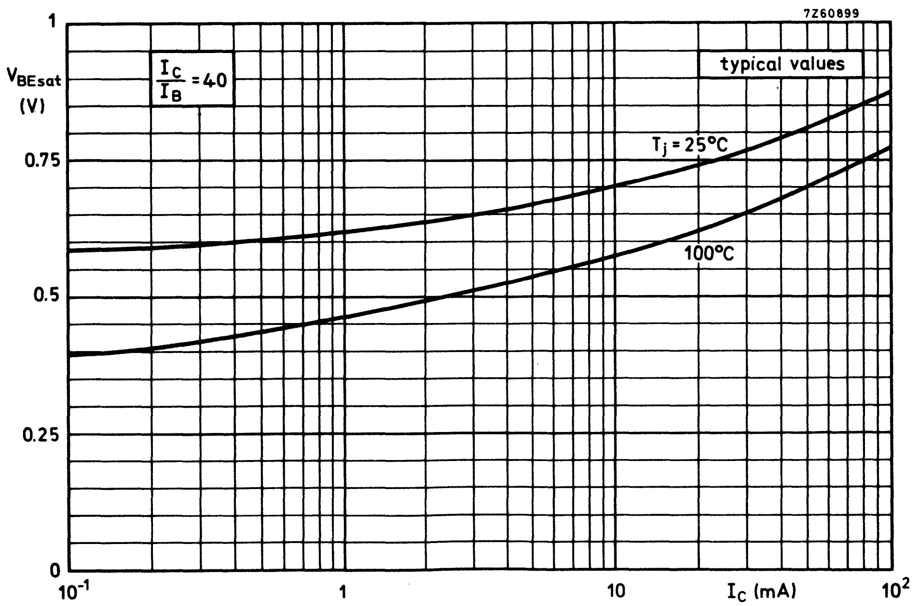

7Z60899
1
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 40$
typical values
0.75
$T_j = 25°C$
100°C
0.5
0.25
0
10^{-1}
1
10
I_C (mA)
10^2

Fig. 12.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-18 metal envelope with the collector connected to the case and designed for use in amplifier and switching applications.

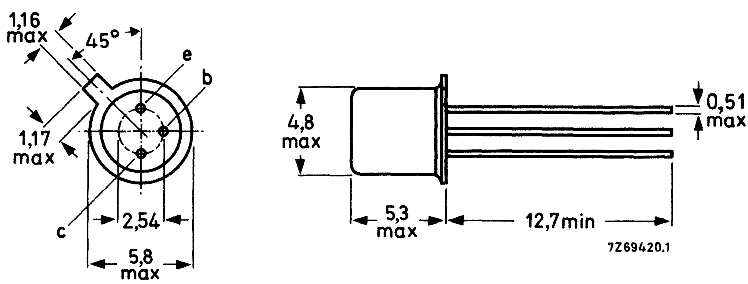
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	V_{CEO}	max.	60			V
Collector current (d.c.)	I_C	max.	200			mA
Total power dissipation						
up to T_{case} = 45 °C	P_{tot}	max.	1000			mW
up to T_{amb} = 45 °C	P_{tot}	max.	330			mW
Junction temperature	T_j	max.	200			°C
		BCY65-VII		VIII	IX	
Small-signal current gain at f = 1 kHz		≥	125	175	250	
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	typ.	200	260	330	
		≤	250	350	500	
Transition frequency at f = 100 MHz						
I_C = 10 mA; V_{CE} = 5 V	f_T	≥	125			MHz
Noise figure at R_S = 2 kΩ						
I_C = 200 μA; V_{CE} = 5 V;						
f = 1 kHz; B = 200 Hz	F	≤	6			dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.



Collector connected to case.

RATINGS (up to $T_{j\,max}$)

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

Collector-emitter voltage				
$V_{BE} = 0$	V_{CES}	max.	60	V
open base	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Collector current (d.c.)	I_C	max.	200	mA
Base current (d.c.)	I_B	max.	50	mA
Total power dissipation				
up to $T_{case} = 45\ ^oC$	P_{tot}	max.	1000	mW
up to $T_{amb} = 45\ ^oC$	P_{tot}	max.	330	mW
Junction temperature	T_j	max.	200	^oC
Storage temperature	T_{stg}		−65 to + 200	^oC

THERMAL RESISTANCE

From junction to ambient	$R_{th\,j\text{-}a}$	max.	0,45	K/W
From junction to case	$R_{th\,j\text{-}c}$	max.	0,15	K/W

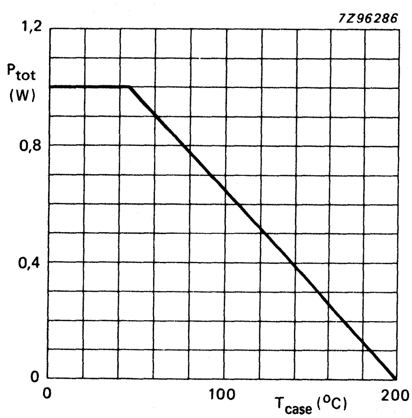


Fig. 2 Total power dissipation versus case temperature.

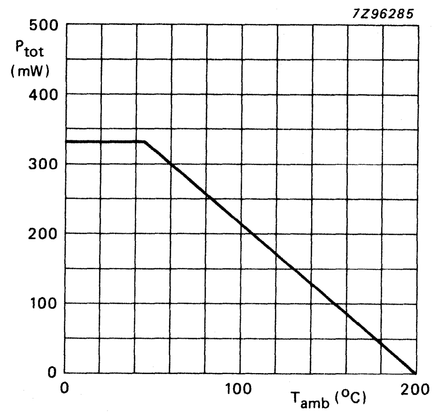


Fig. 3 Total power dissipation versus ambient temperature.

CHARACTERISTICS

T_{amb} = 25 °C unless indicated otherwise

Collector cut-off currents			
V_{CE} = 60 V; V_{BE} = 0	I_{CES}	⩽	10 nA
V_{CE} = 60 V; V_{BE} = 0; T_{amb} = 150 °C	I_{CES}	⩽	10 μA
V_{CE} = 60 V; V_{BE} = 0,2 V; T_{amb} = 100 °C	I_{CEX}	⩽	20 μA
Emitter cut-off current			
V_{EB} = 5 V; I_C = 0	I_{BEO}	⩽	10 nA
Collector-emitter breakdown voltage			
I_B = 0; I_C = 2 mA	$V_{(BR)CEO}$	⩾	60 V
Emitter-base breakdown voltage			
I_C = 0; I_E = 1 μA	$V_{(BR)EBO}$	⩾	7 V
Base-emitter voltage			
V_{CE} = 5 V; I_C = 10 μA	V_{BE}	typ.	500 mV
V_{CE} = 5 V; I_C = 2 mA			550 to 700 mV
V_{CE} = 1 V; I_C = 10 mA	V_{BE}	typ.	700 mV
V_{CE} = 1 V; I_C = 50 mA		typ.	760 mV
Saturation voltages			
I_C = 10 mA; I_B = 0,25 mA	V_{CEsat}	⩽	350 mV
	V_{BEsat}		600 to 850 mV
I_C = 50 mA; I_B = 1,25 mA	V_{CEsat}	⩽	700 mV
	V_{BEsat}	⩽	1200 mV
Transition frequency at f = 100 MHz			
I_C = 10 mA; V_{CE} = 5 V	f_T	⩾	125 MHz
Noise figure at R_S = 2 kΩ			
I_C = 200 μA; V_{CE} = 5 V; f = 1 kHz; B = 200 Hz	F	⩽	6 dB
Collector capacitance at f = 1 MHz			
V_{CB} = 10 V; I_E = 0	C_c	⩽	6 pF
Emitter capacitance at f = 1 MHz			
V_{EB} = 0,5 V; I_C = 0	C_e	⩽	15 pF

D.C. current gain			BCY65-VII	BCY65-VIII	BCY65-IX
V_{CE} = 5 V; I_C = 10 μA	h_{FE}	⩾	–	20	40
		typ.	20	95	190
V_{CE} = 5 V; I_C = 2 mA	h_{FE}	⩾	120	180	250
		typ.	170	250	350
		⩽	220	310	460
V_{CE} = 1 V; I_C = 10 mA	h_{FE}	⩾	80	120	160
		typ.	250	300	390
		⩽	–	400	630
V_{CE} = 1 V; I_C = 50 mA	h_{FE}	⩾	40	45	60

			BCY65-VII	BCY65-VIII	BCY65-IX	
h-parameters f = 1 kHz; T_{amb} = 25 °C; V_{CE} = 5 V; I_C = 2 mA						
		⩾	1,6	2,5	3,2	kΩ
input impedance	h_{ie}	typ.	2,7	3,6	4,5	kΩ
		⩽	4,5	6,0	8,5	kΩ
reverse voltage transfer ratio	h_{re}	typ.	$1,5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	
		⩾	125	175	250	
small-signal current gain	h_{fe}	typ.	200	260	330	
		⩽	250	350	500	
output admittance	h_{oe}	typ.	18	24	30	µs
		⩽	30	50	60	µs

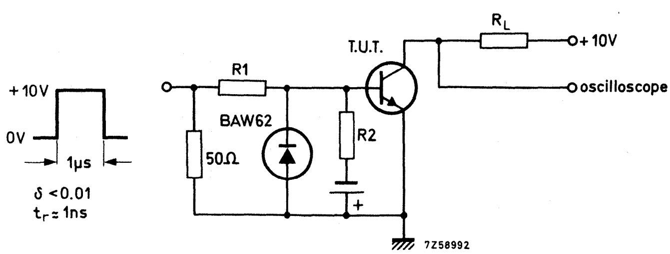
Switching times (see Fig. 4)

I_C = 10 mA; I_B = $-I_{BM}$ = 1 mA
R_1 = R_2 = 5 kΩ; R_L = 990 Ω; V_{BB} = 5 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 = 50 mA; I_B = $-I_{BM}$ = 5 mA
R_1 = 1 kΩ; R_2 = 1,3 kΩ; R_L = 195 Ω; V_{BB} = 4,7 V

delay time	t_d	typ.	15	ns
rise time	t_r	typ.	50	ns
turn-on time	t_{on}	typ.	65	ns
		⩽	150	ns
storage time	t_s	typ.	300	ns
fall time	t_f	typ.	150	ns
turn-off time	t_{off}	typ.	450	ns
		⩽	800	ns



Oscilloscope:
$R_i > 100$ kΩ
$t_r < 15$ ns

Fig. 4 Test circuit.

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

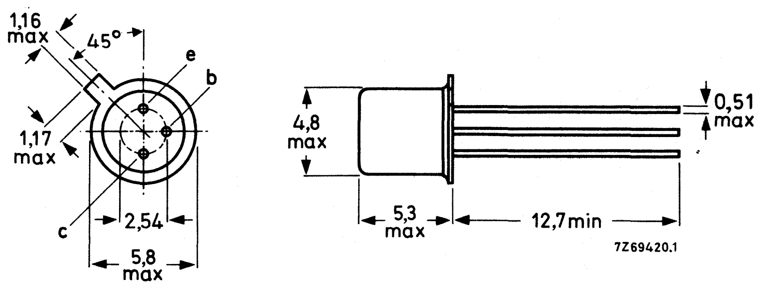
			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Junction temperature	T_j	max.		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).

Products approved to CECC 50 002-079/081.

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

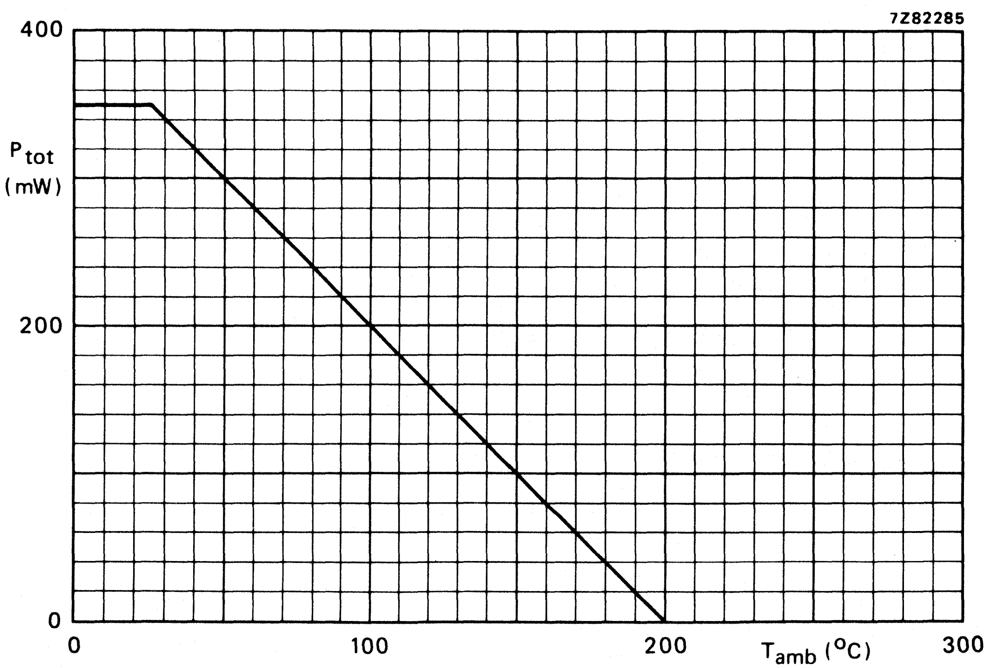


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCY70	BCY71	BCY72	
Collector cut-off current						
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	500	500	500	nA
$I_E = 0; -V_{CB} = 40$ V	$-I_{CBO}$	<	10	50	–	nA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 100$ °C	$-I_{CBO}$	<	0,5	2,0	–	μA
$I_E = 0; -V_{CB} = 25$ V	$-I_{CBO}$	<	–	–	50	nA
$I_E = 0; -V_{CB} = 25$ V; $T_j = 100$ °C	$-I_{CBO}$	<	–	–	2,0	μA
$-V_{CE} = 50$ V; $-V_{EB} = 3,0$ V	$-I_{CEX}$	<	20	–	–	nA
Emitter cut-off current						
$I_C = 0; -V_{EB} = 4,0$ V	$-I_{EBO}$	<		10		nA
$I_C = 0; -V_{EB} = 4,0$ V; $T_j = 100$ °C	$-I_{EBO}$	<		2,0		μA
$I_C = 0; -V_{EB} = 5,0$ V	$-I_{EBO}$	<		500		nA
Saturation voltages						
$-I_C = 10$ mA; $-I_B = 10$ mA	$-V_{CEsat}$	<		250		mV
	$-V_{BEsat}$	<		600 to 900		mV
$-I_C = 50$ mA; $-I_B = 5,0$ mA	$-V_{CEsat}$	<		500		mV
	$-V_{BEsat}$	<		1200		mV
D.C. current gain						
$-I_C = 10$ μA; $-V_{CE} = 1,0$ V	h_{FE}	>		60		
$-I_C = 0,1$ mA; $-V_{CE} = 1,0$ V	h_{FE}	>		80		
$-I_C = 1,0$ mA; $-V_{CE} = 1,0$ V	h_{FE}	>		100		
$-I_C = 10$ mA; $-V_{CE} = 1,0$ V	h_{FE}	>		100		
$-I_C = 10$ mA; $-V_{CE} = 1,0$ V **BCY71**	h_{FE}	<		400		
$-I_C = 50$ mA; $-V_{CE} = 1,0$ V	h_{FE}	>		45		
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	<		6,0		pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0; -V_{EB} = 1,0$ V	C_e	<		8,0		pF
Transition frequency at T_{amb} = 25 °C						
$-I_C = 10$ mA; $-V_{CE} = 20$ V; f = 100 MHz	f_T	>	250	250	250	MHz
$-I_C = 100$ μA; $-V_{CE} = 20$ V; f = 10,7 MHz	f_T	>	–	15	–	MHz
Noise figure						
$-I_C = 100$ μA; $-V_{CE} = 5,0$ V; f = 10 Hz to 10 kHz; $R_S = 2,0$ kΩ	F	<	6,0	2,0	6,0	dB
h-parameters (common emitter)						
$-I_C = 10$ mA; $-V_{CE} = 10$ V; f = 1 kHz; T_{amb} = 25 °C						
Input impedance	h_{ie}	typ.	–	4,0	–	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	–	2,1	–	10^{-4}
Small-signal current gain	h_{fe}	typ.	–	325	–	
Output admittance	h_{oe}	typ.	–	20	–	μS

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

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

delay time	t_d	<	35 ns
rise time	t_r	<	35 ns
turn-on time	t_{on}	<	65 ns
storage time	t_s	<	350 ns
fall time	t_f	<	80 ns
turn-off time	t_{off}	<	420 ns

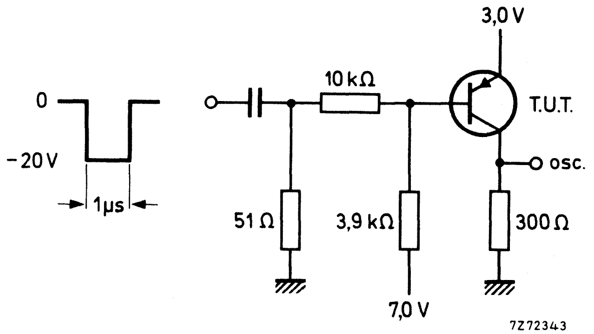


Fig. 3 Test circuit.

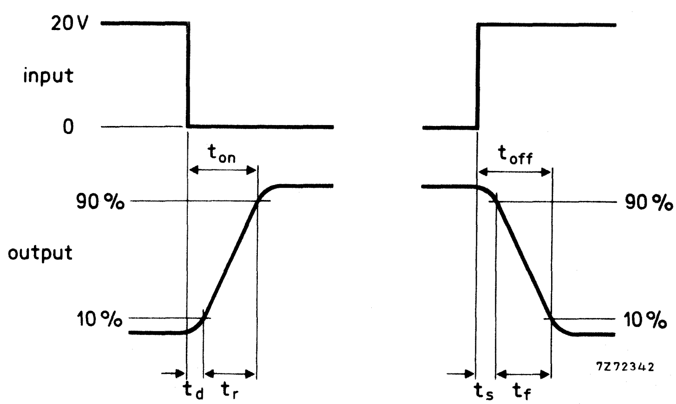


Fig. 4 Switching waveforms.

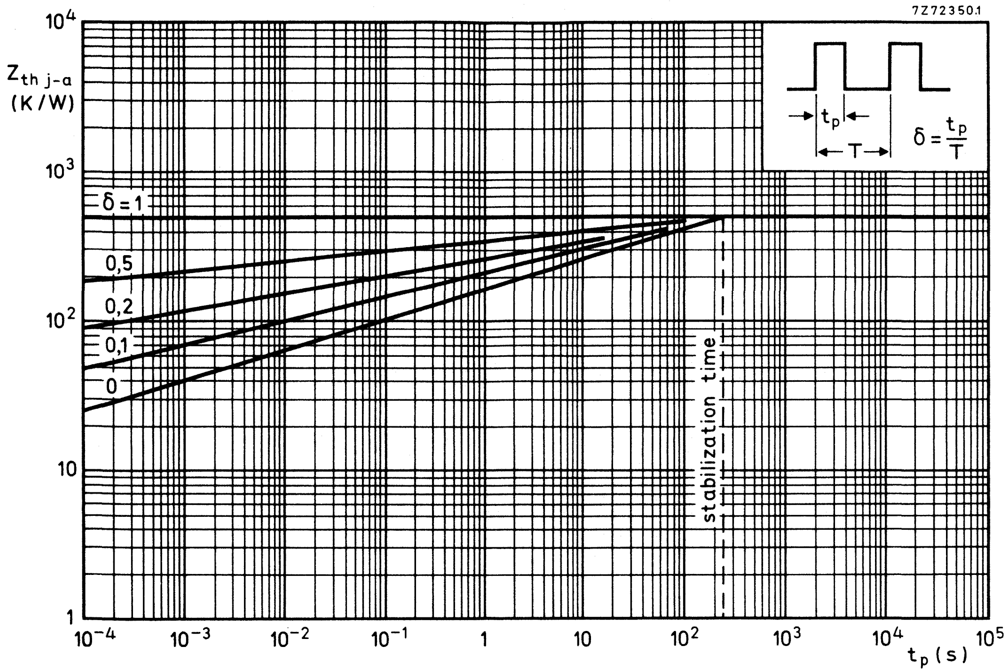

7Z72350.1
$Z_{th\ j-a}$ (K/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0
stabilization time
t_p
T
$\delta = \frac{t_p}{T}$
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
10^5
t_p (s)

Fig. 5.

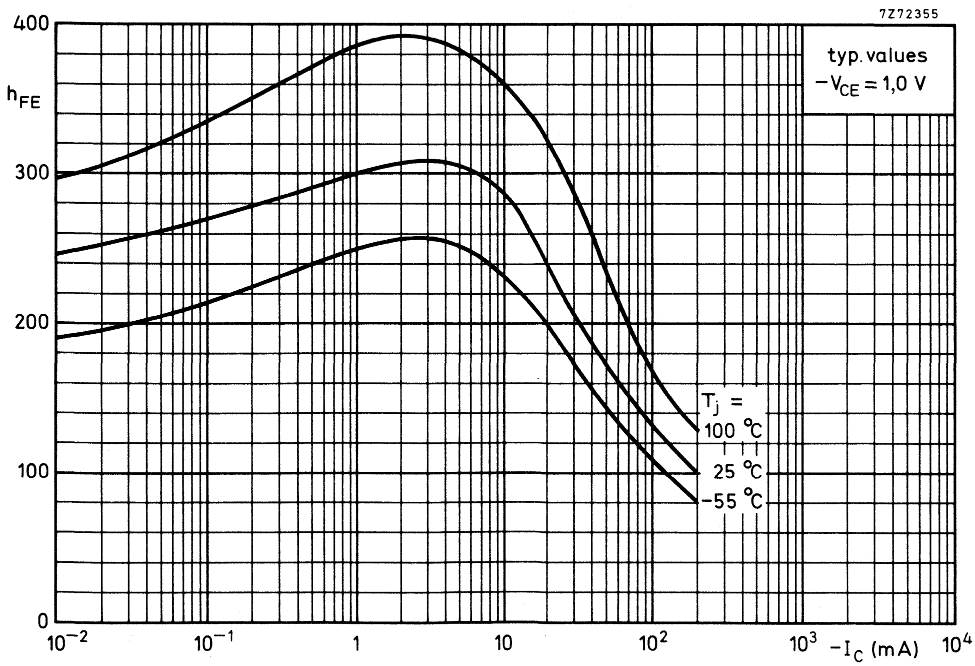

7Z72355
typ. values
$-V_{CE} = 1,0$ V
h_{FE}
400
300
200
100
0
T_j =
100 °C
25 °C
−55 °C
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 6.

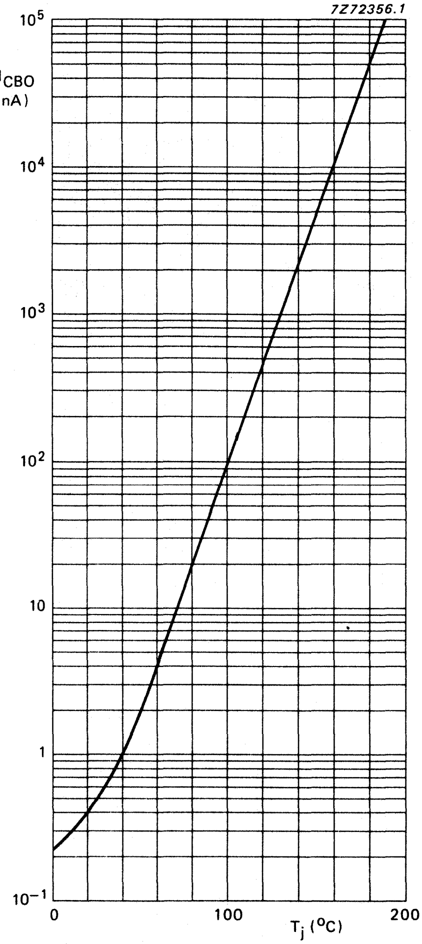


Fig. 7 $-V_{CB}$ = 40 V for BCY70 and BCY71; $-V_{CB}$ = 25 V for BCY72; typical values.

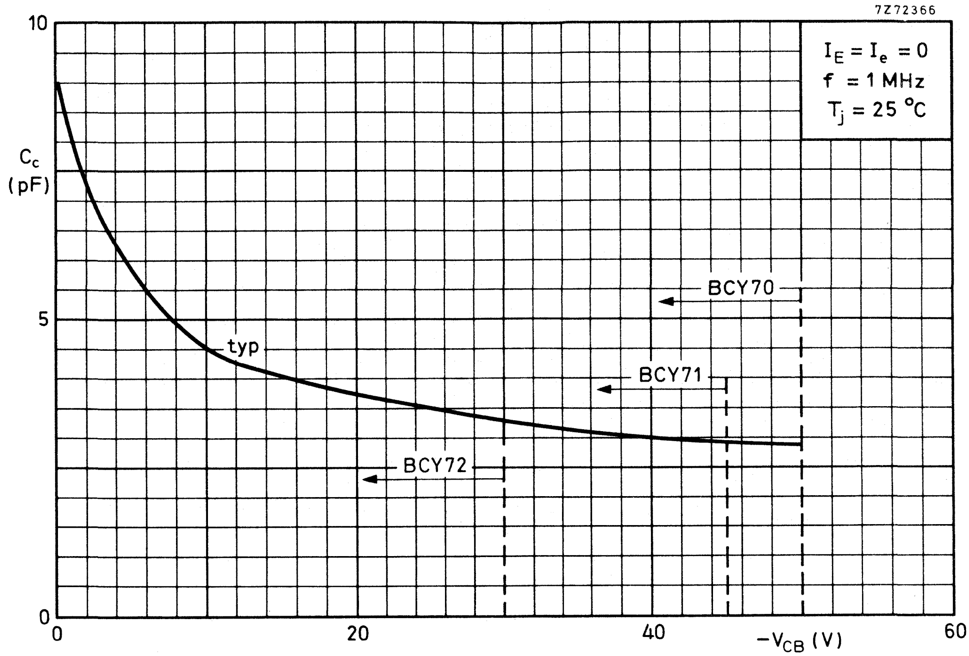

7Z72366
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
10
5
0
0
20
40
60
$-V_{CB}$ (V)
typ
BCY70
BCY71
BCY72

Fig. 8.

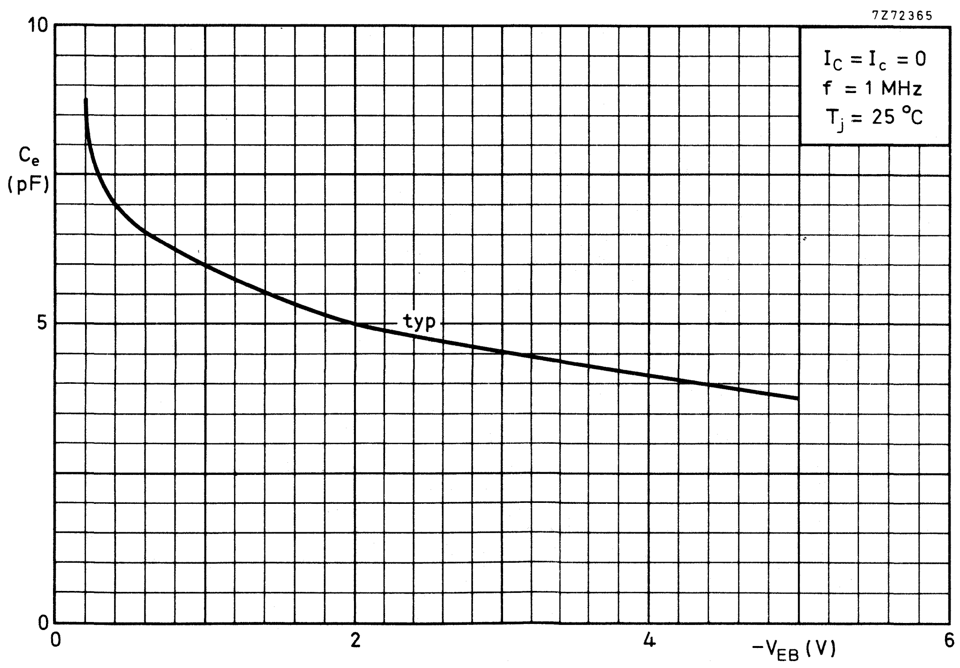

7Z72365
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
10
5
0
0
2
4
6
$-V_{EB}$ (V)
typ

Fig. 9.

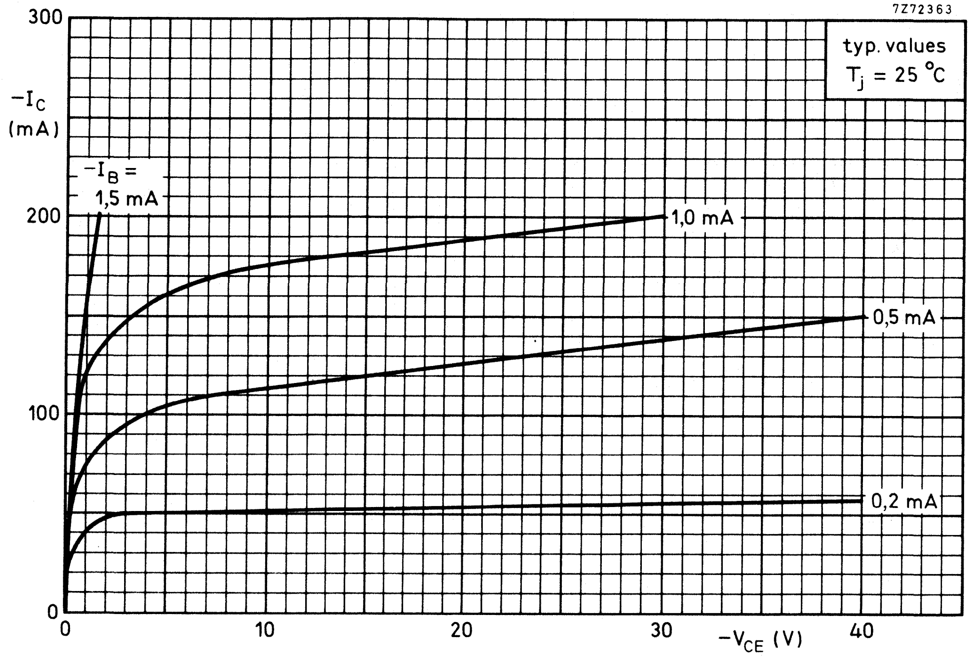

7Z72363
typ. values
$T_j = 25\ ^\circ C$
$-I_C$ (mA)
300
200
100
0
$-I_B =$ 1,5 mA
1,0 mA
0,5 mA
0,2 mA
0
10
20
30
40
$-V_{CE}$ (V)

Fig. 10.

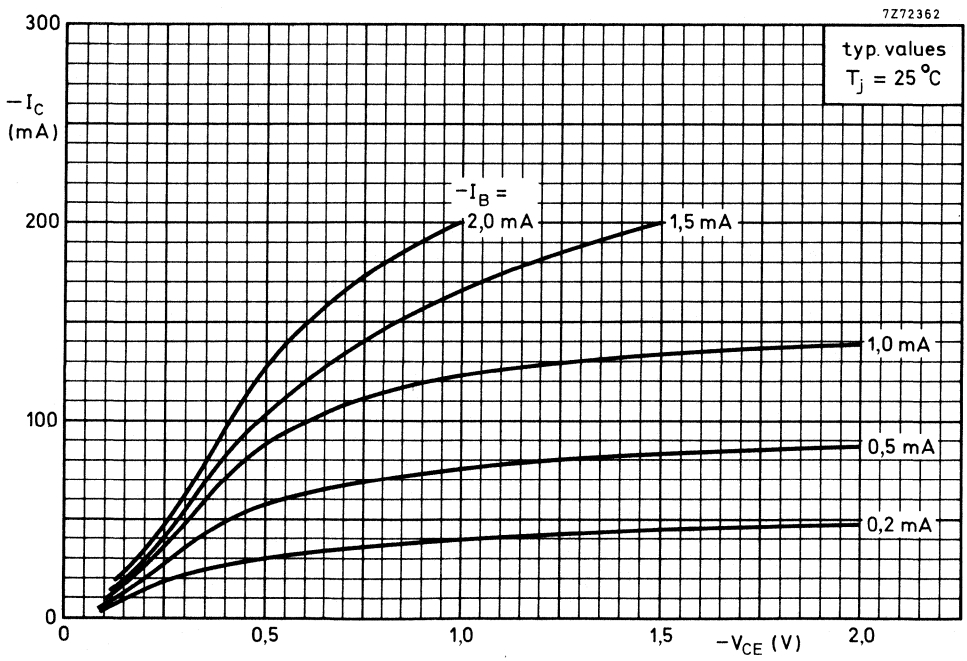

7Z72362
typ. values
$T_j = 25\ ^\circ C$
$-I_C$ (mA)
300
200
100
0
$-I_B =$ 2,0 mA
1,5 mA
1,0 mA
0,5 mA
0,2 mA
0
0,5
1,0
1,5
2,0
$-V_{CE}$ (V)

Fig. 11.

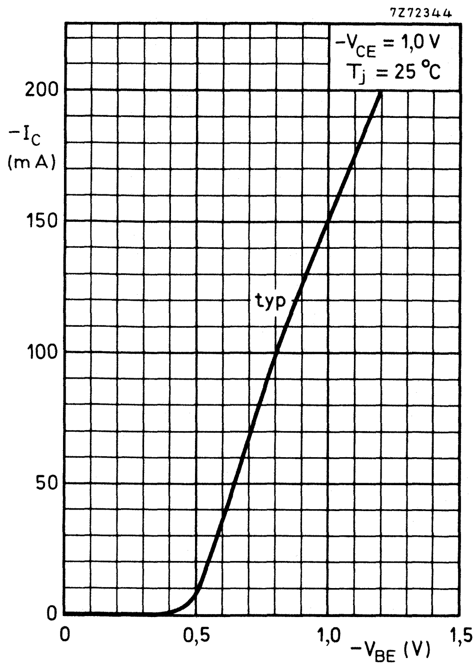


Fig. 12.

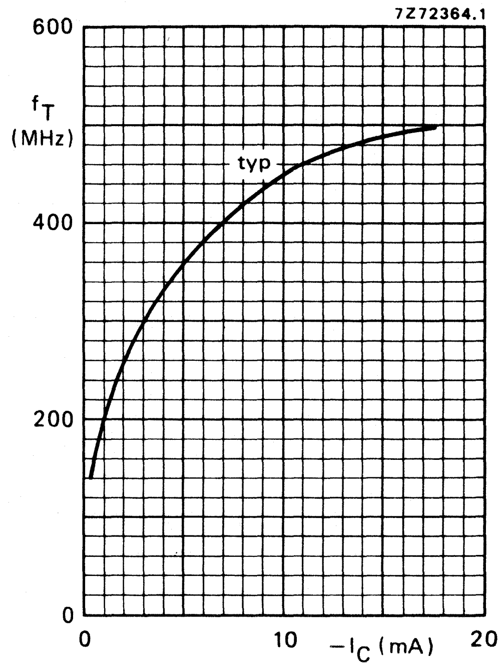


Fig. 13 $-V_{CE}$ = 20 V; f = 100 MHz; T_{amb} = 25 °C.

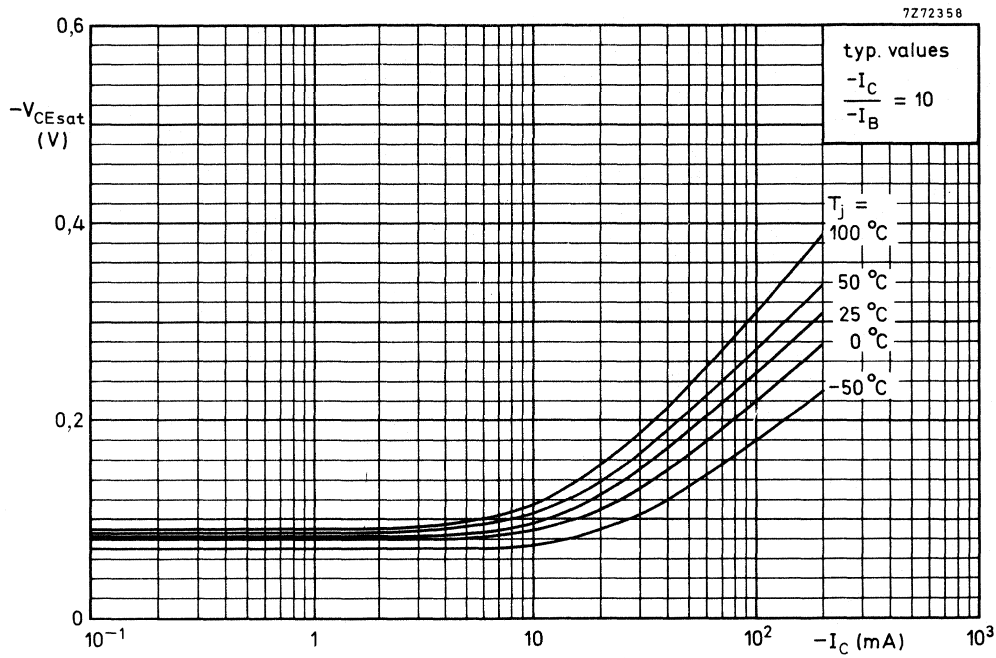

7Z72358
typ. values
$\frac{-I_C}{-I_B}$ = 10
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
-50 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 14.

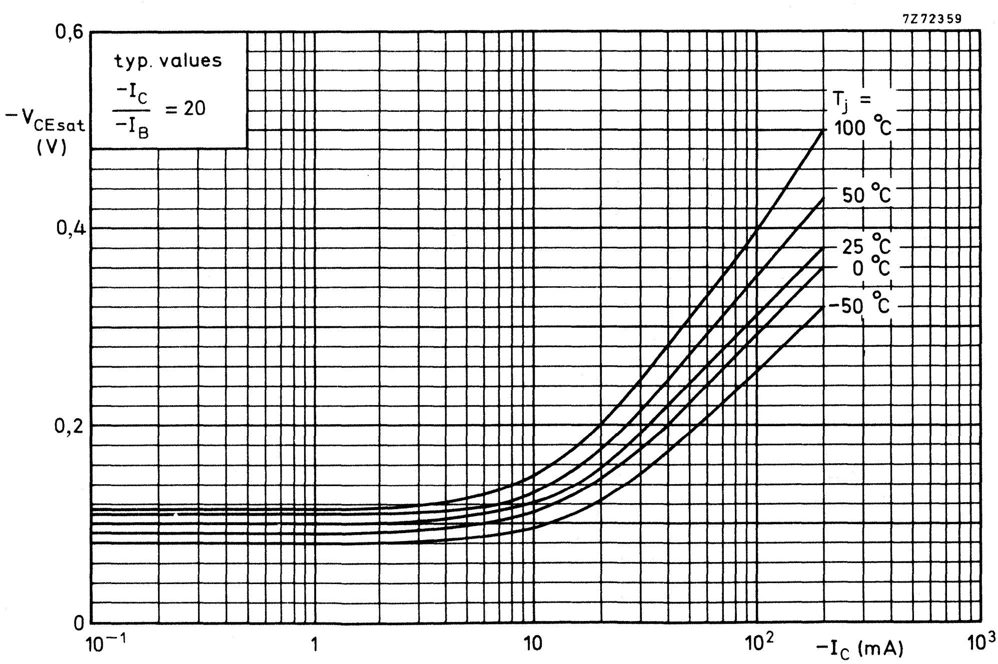

7Z72359
typ. values
$\frac{-I_C}{-I_B}$ = 20
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
-50 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 15.

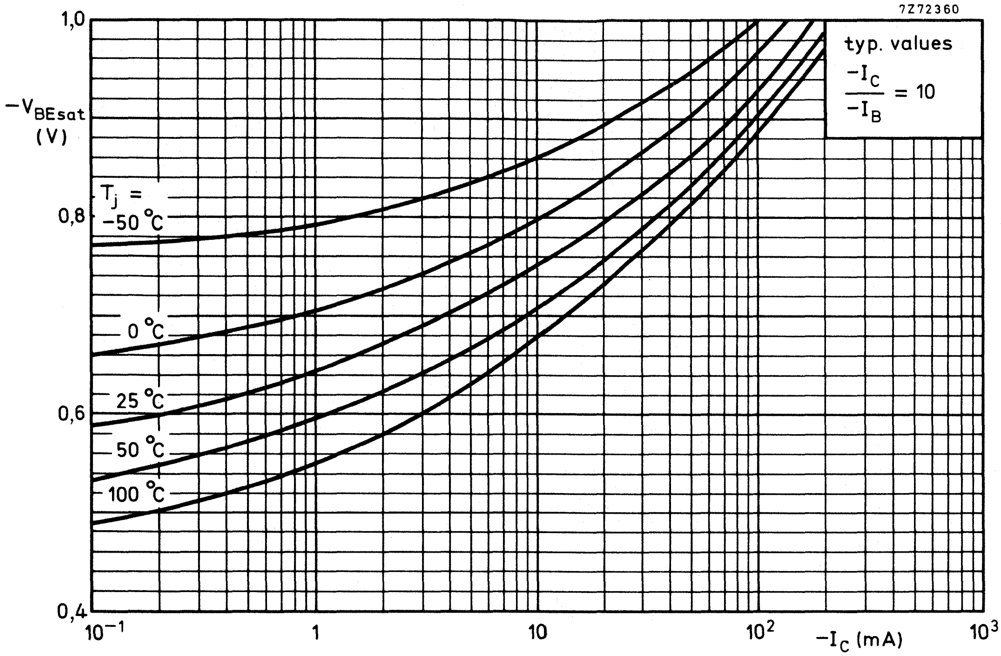

7Z72360
typ. values
$\frac{-I_C}{-I_B} = 10$
$-V_{BEsat}$ (V)
1,0
0,8
0,6
0,4
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 16.

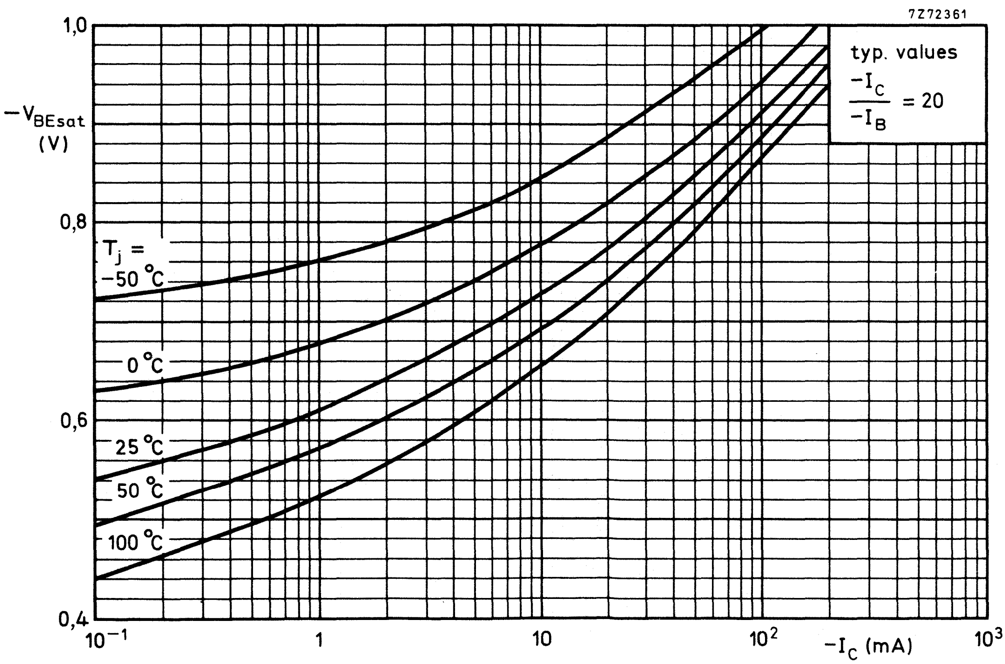

7Z72361
typ. values
$\frac{-I_C}{-I_B} = 20$
$-V_{BEsat}$ (V)
1,0
0,8
0,6
0,4
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 17.

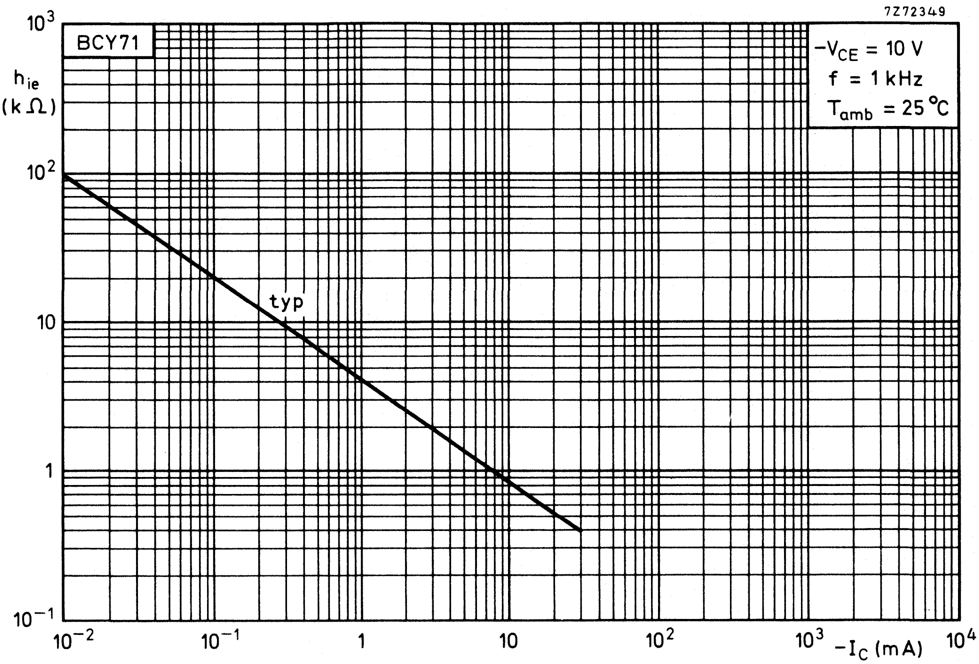

7Z72349
BCY71
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
h_{ie} (kΩ)
10^3
10^2
10
1
10^{-1}
typ
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 18.

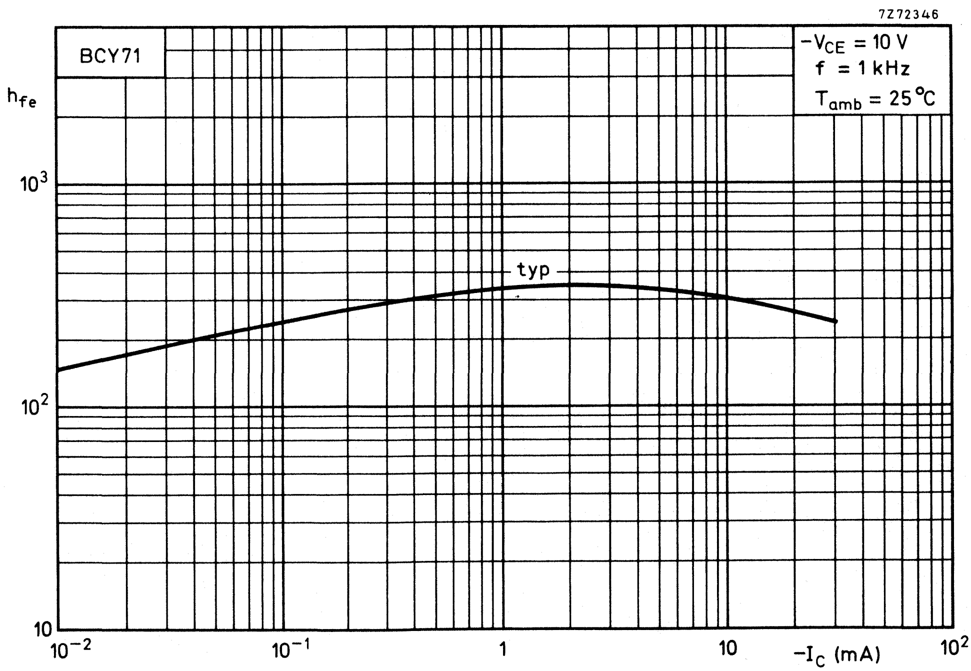

7Z72346
BCY71
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
h_{fe}
10^3
10^2
10
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 19.

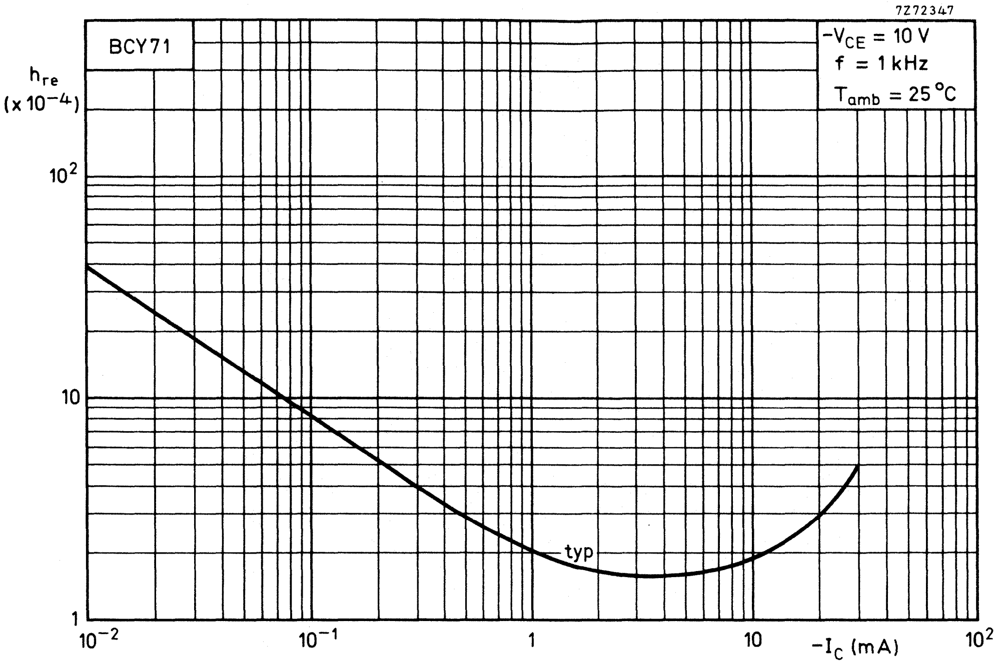

7Z72347
BCY71
h_{re} ($\times 10^{-4}$)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
10^2
10
1
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 20.

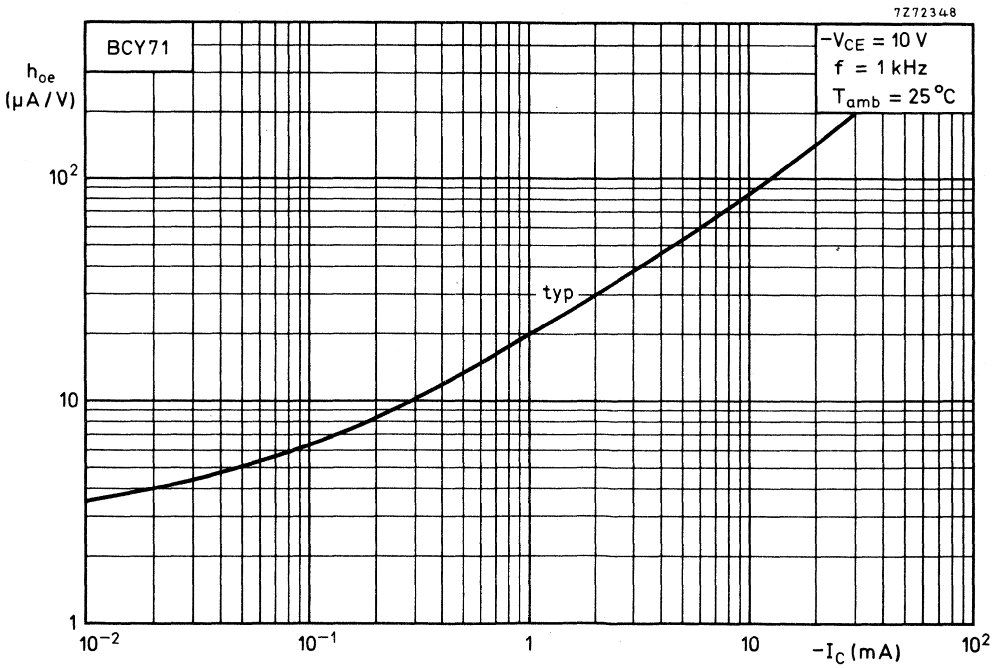

7Z72348
BCY71
h_{oe} (μA / V)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
10^2
10
1
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 21.

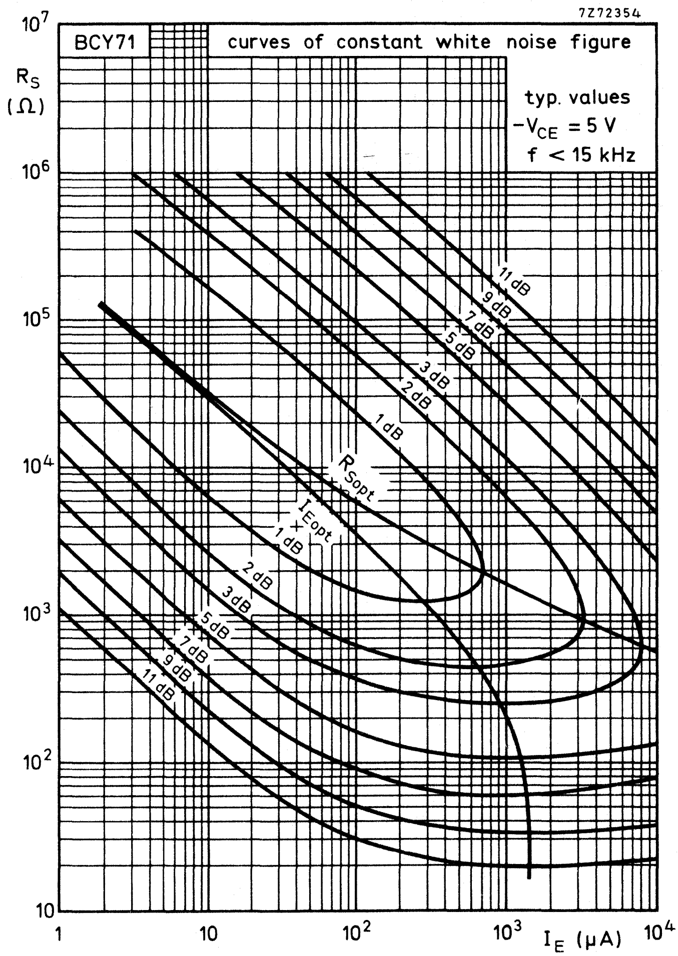


Fig. 22.

See also the graph and text on next page.

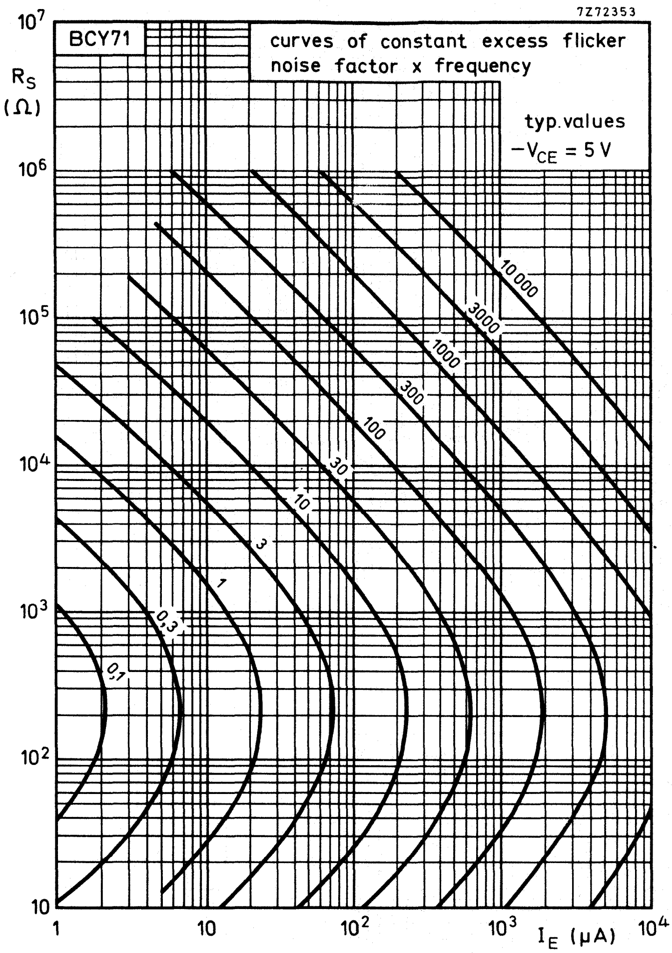


Fig. 23.

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 preceding page.

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. 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.

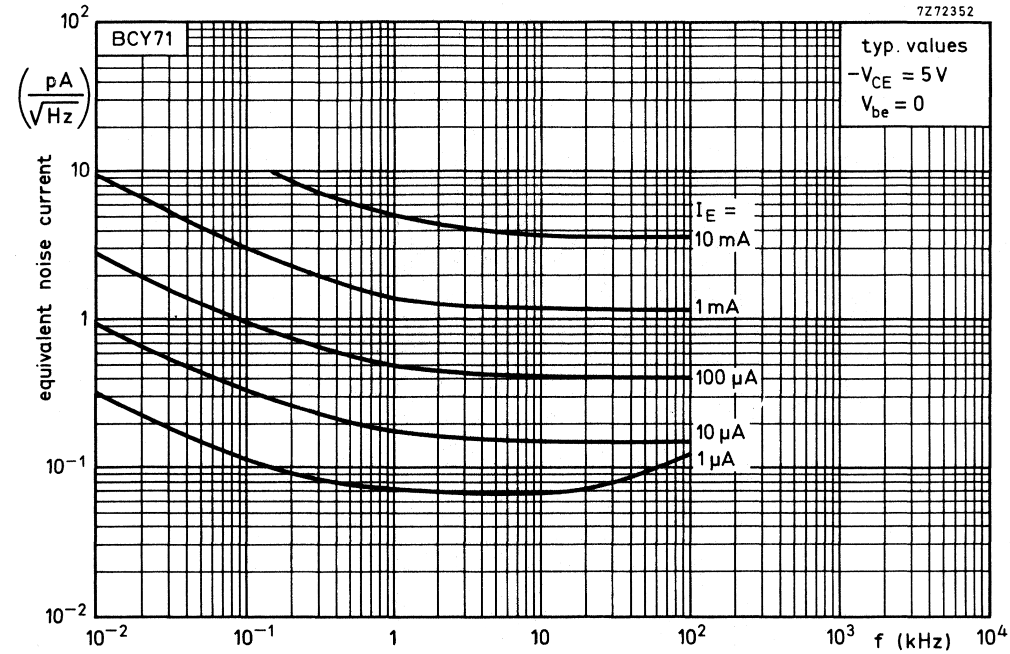

7Z72352
BCY71
typ. values
$-V_{CE} = 5\,V$
$V_{be} = 0$
$\left(\frac{pA}{\sqrt{Hz}}\right)$
equivalent noise current
I_E =
10 mA
1 mA
100 μA
10 μA
1 μA
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
f (kHz)
10^4

Fig. 24.

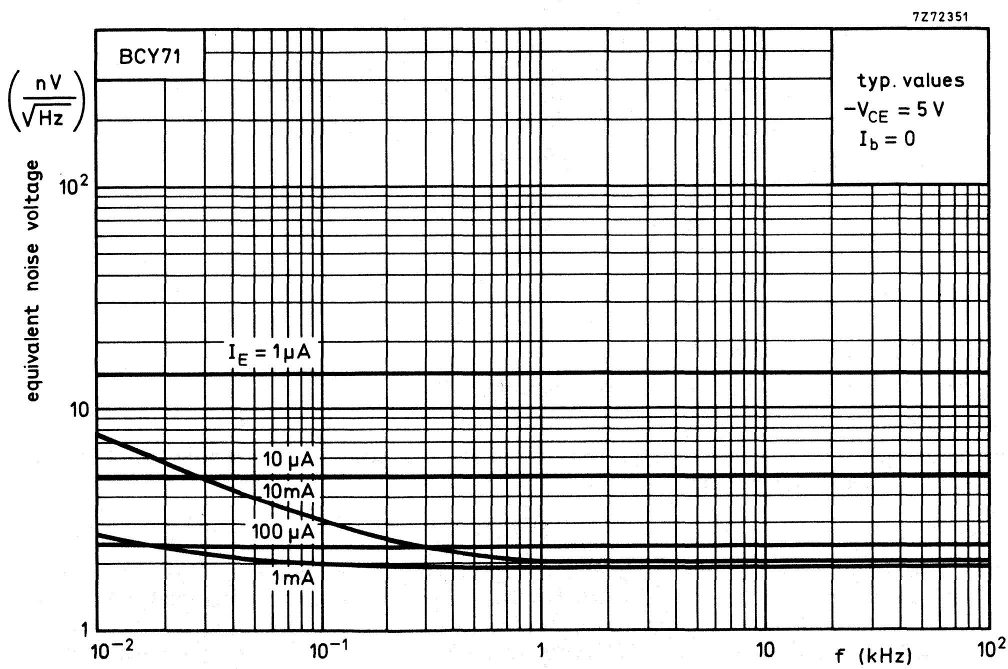

7Z72351
BCY71
typ. values
$-V_{CE} = 5\,V$
$I_b = 0$
$\left(\frac{nV}{\sqrt{Hz}}\right)$
equivalent noise voltage
$I_E = 1\,\mu A$
10 μA
10mA
100 μA
1mA
10^2
10
1
10^{-2}
10^{-1}
1
10
f (kHz)
10^2

Fig. 25.

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}	$>$ $<$	125 250	175 350	250 500	350 700

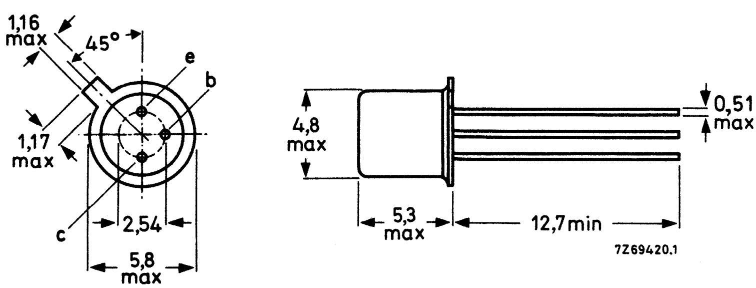
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	180	MHz
Noise figure at R_S = 2 kΩ $-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 1 kHz; B = 200 Hz	F	typ.	2	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-079/081.

RATINGS

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

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

Collector current (d.c.)	$-I_C$	max.	200	mA
Base current (d.c.)	$-I_B$	max.	20	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
Storage temperature	T_{stg}		−65 to 200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			BCY78	BCY79	
Collector cut-off currents					
$V_{BE} = 0; -V_{CE} = 25$ 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
$V_{BE} = 0; -V_{CE} = -V_{CEO\,max}$	$-I_{CES}$	<	100	100	nA
$-V_{EB} = 0{,}2$ V; $-V_{CE} = -V_{CEO\,max}$; $T_{amb} = 100$ °C	$-I_{CEX}$	<	20	20	μA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	20	20	nA
Collector-emitter breakdown voltage					
$V_{BE} = 0; -I_C = 10$ μA	$-V_{(BR)CES}$	>	32	45	V
$I_B = 0; -I_C = 2$ mA	$-V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0; -I_E = 1$ μA	$-V_{(BR)EBO}$	>	5		V
Base-emitter voltage					
$-I_C = 10$ 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
Saturation voltages					
$-I_C = 10$ 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
Transition frequency at f = 35 MHz					
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	180		MHz

Collector capacitance at f = 1 MHz							
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	<			7,0		pF
Emitter capacitance at f = 1 MHz							
$I_C = I_c = 0; -V_{EB} = 0,5$ V	C_e	<			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}	typ.	200	260	330	520	
Output admittance	h_{oe}	typ.	18	24	30	50	µS

Switching times

$-I_{C\,on} = 10$ mA; $-I_{B\,on} = I_{B\,off} = 1$ 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

$-I_{C\,on} = 100$ mA; $-I_{B\,on} = I_{B\,off} = 10$ 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

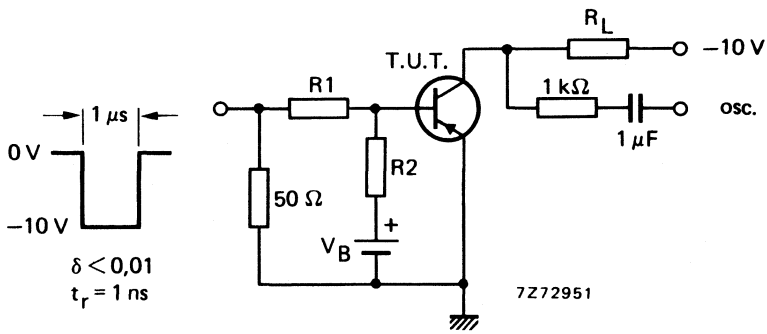


Fig. 2 Test circuit.

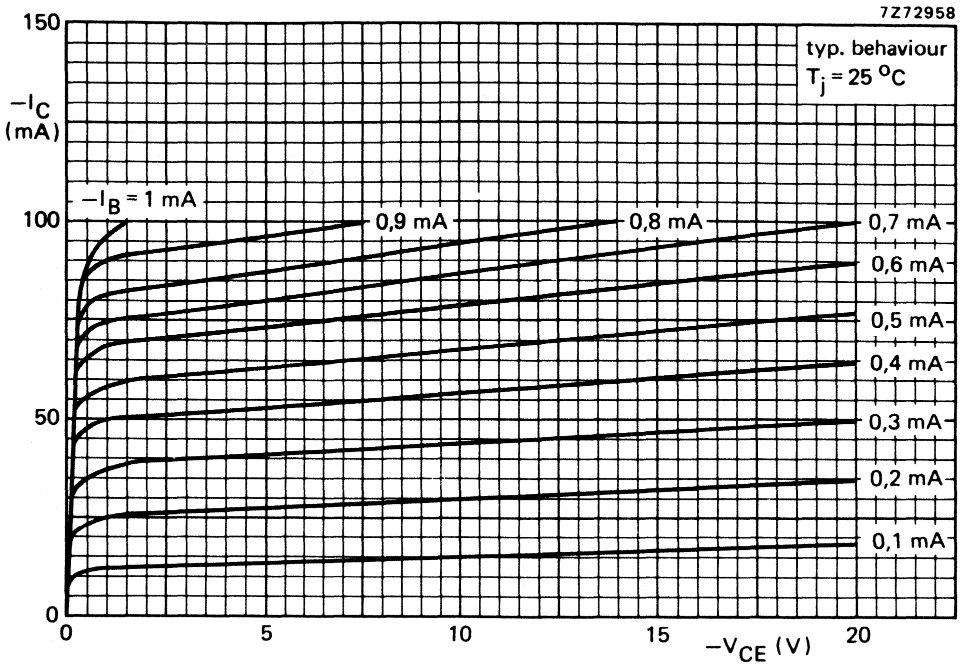


Fig. 3.

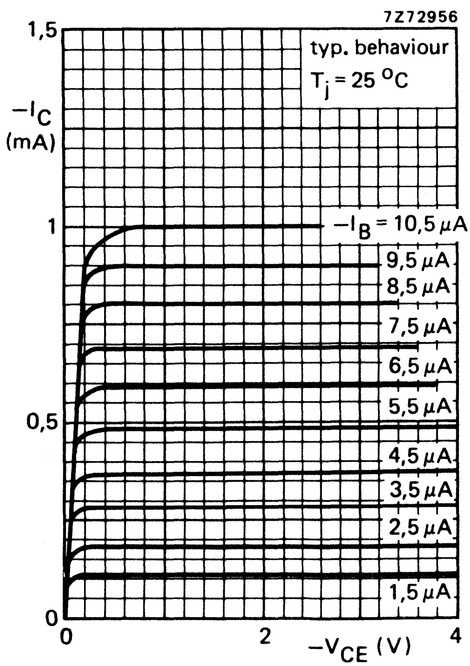


Fig. 4.

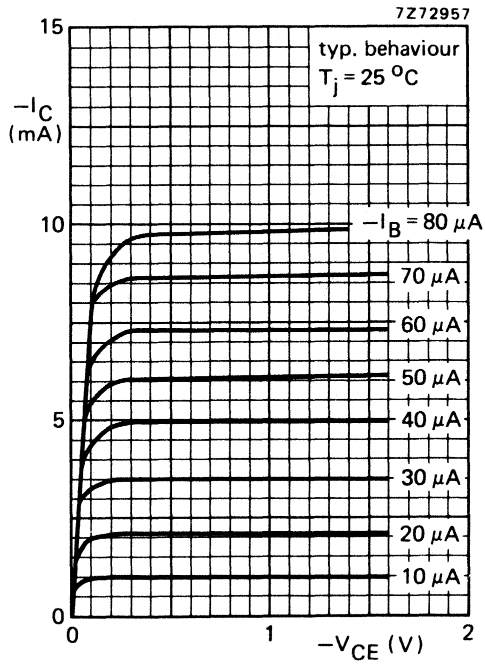


Fig. 5.

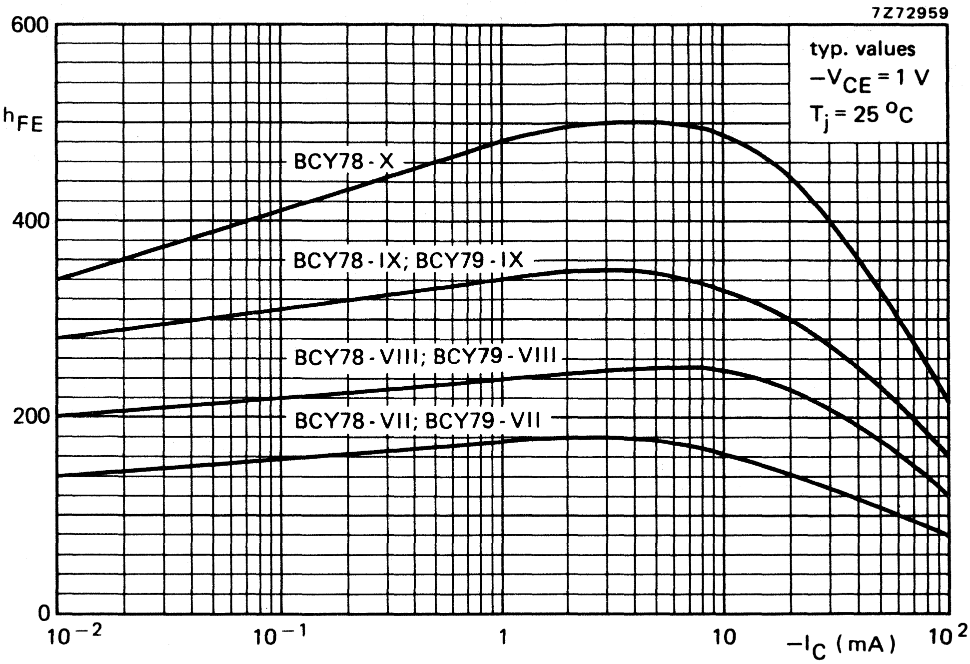

7Z72959
600
400
200
0
h_{FE}
typ. values
$-V_{CE} = 1$ V
$T_j = 25$ °C
BCY78 - X
BCY78 - IX; BCY79 - IX
BCY78 - VIII; BCY79 - VIII
BCY78 - VII; BCY79 - VII
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 6.

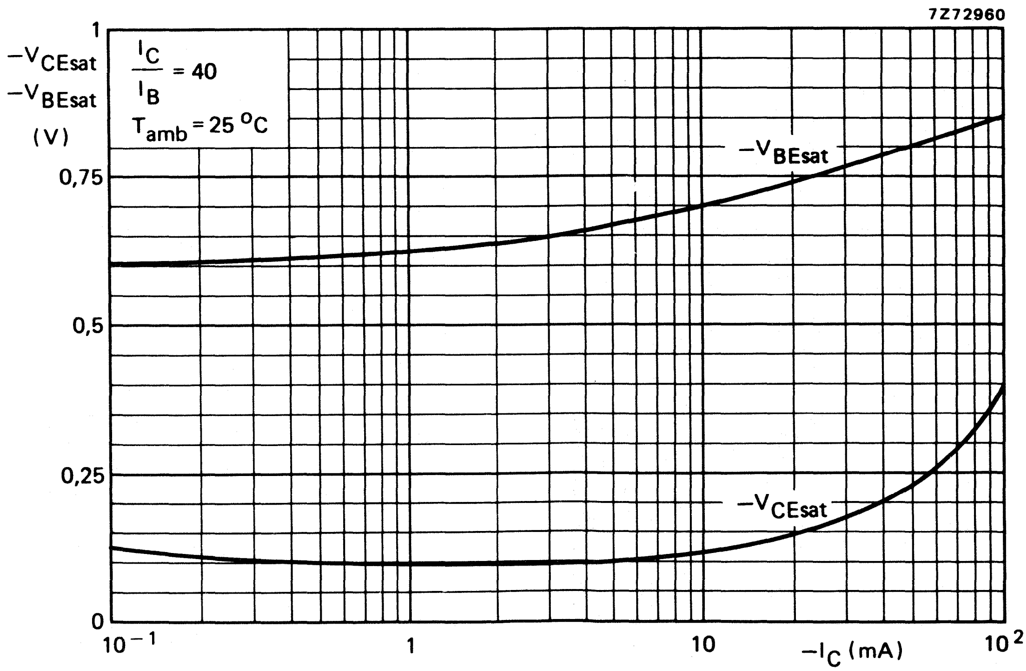

7Z72960
1
$-V_{CEsat}$
$-V_{BEsat}$
(V)
0,75
0,5
0,25
0
$\frac{I_C}{I_B} = 40$
$T_{amb} = 25$ °C
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 7.

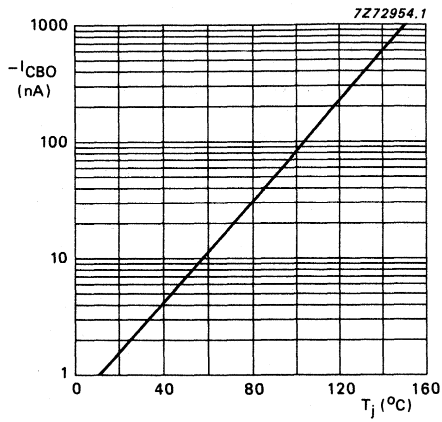


Fig. 8 $-V_{CB}$ = 25 V for BCY78;
$-V_{CB}$ = 35 V for BCY79;
typical values.

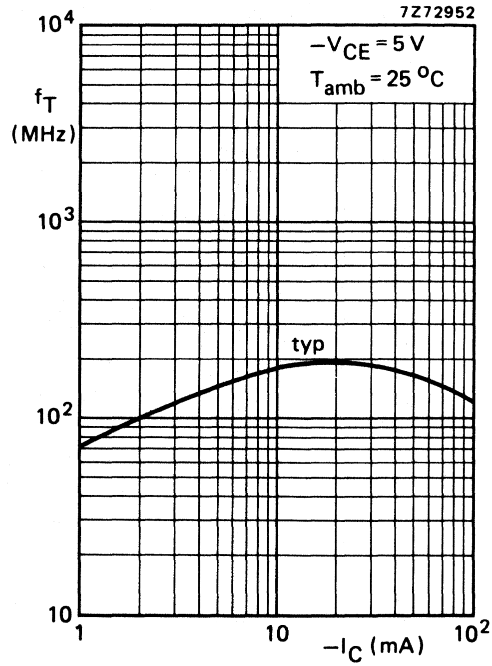


Fig. 9.

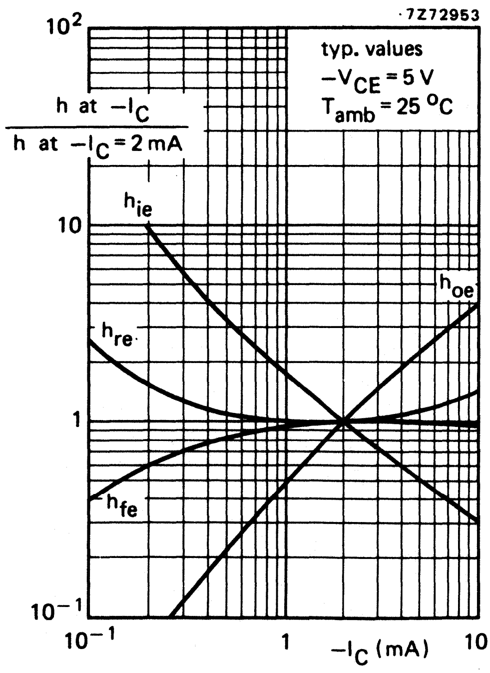


Fig. 10.

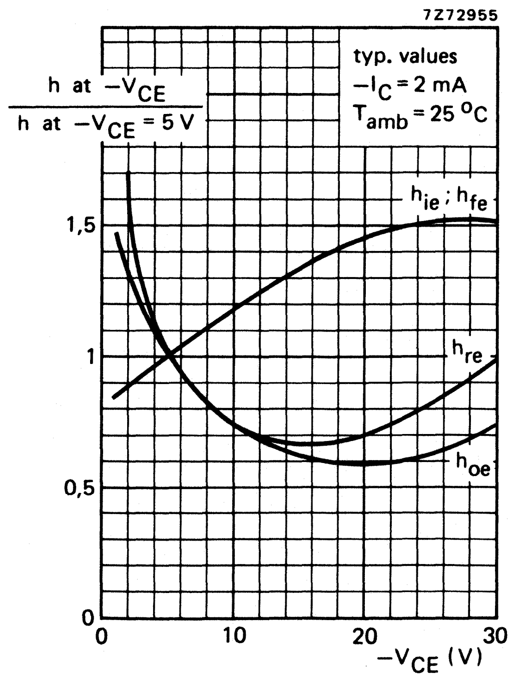


Fig. 11.

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 $V_{1B-1E} = V_{2B-2E}$	$\|I_{1B}-I_{2B}\|$	<	25	80	300	nA
Equivalent differential voltage change with temperature *	$\left\|\frac{\Delta V}{\Delta T}\right\|$	<	3	6	10	μV/K
Equivalent differential current change with temperature *	$\left\|\frac{\Delta I}{\Delta T}\right\|$	<	0,5	2	10	nA/K

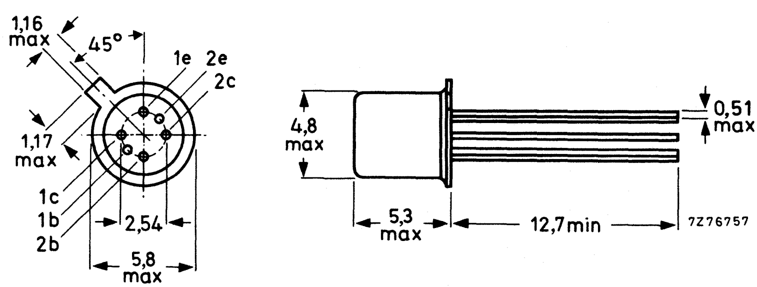
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-71.

All leads insulated from the case

Accessories:
56263 (cooling fin).



* T_{amb} = –20 °C to +90 °C.

RATINGS (see after Fig. 9)

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 ($V_{1C\text{-}1B} = V_{2C\text{-}2B} \leq 10$ 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 $V_{1B\text{-}1E} = V_{2B\text{-}2E}$	I_{1C}/I_{2C}	0,9-1,11	0,8-1,25	0,67-1,5	
Difference between base-emitter voltages $I_{1C} = I_{2C}$	$\lvert V_{1B\text{-}1E} - V_{2B\text{-}2E}\rvert$	< 3	6	10	mV
Difference between base currents $V_{1B\text{-}1E} = V_{2B\text{-}2E}$	$\lvert I_{1B}\text{-}I_{2B}\rvert$	< 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

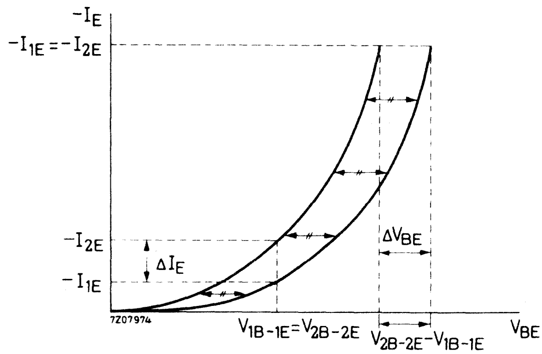


Fig. 2.

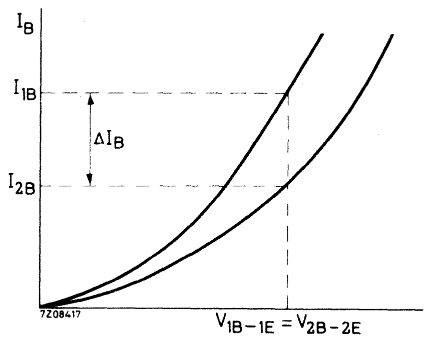


Fig. 3.

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

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

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

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

In the equivalent circuit the transistors are considered to be drift free.

All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

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

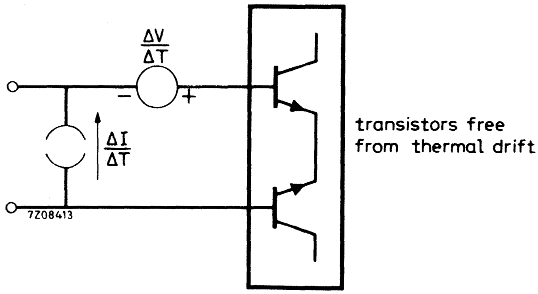


Fig. 4.

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:

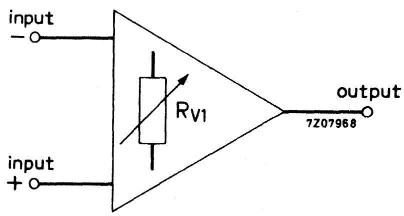


Fig. 5.

Equivalent differential voltage change with temperature

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

Equivalent differential current change with temperature

			BCY87	BCY88	BCY89	
$T_{amb} = -20$ to $+90$ °C	$\left\lvert\frac{\Delta I}{\Delta T}\right\rvert$	<	0,5	2	10	nA/K

Test methods

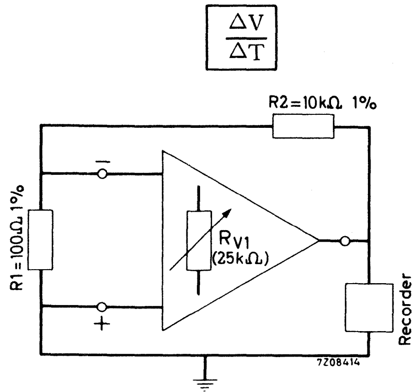


Fig. 6.

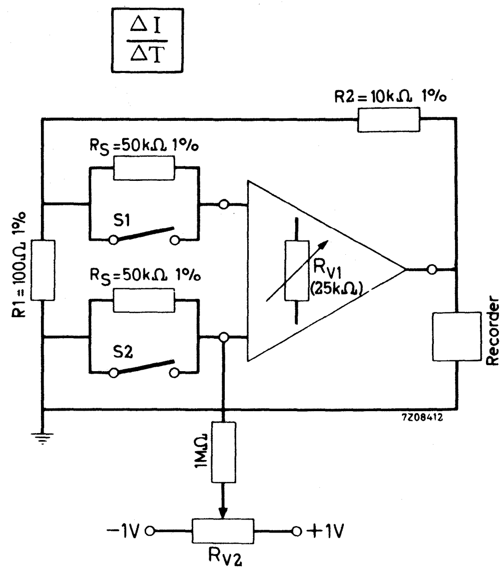


Fig. 7.

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)*. The amplifier temperature is then adjusted to T_2 between −20 to + 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 $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

* 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.

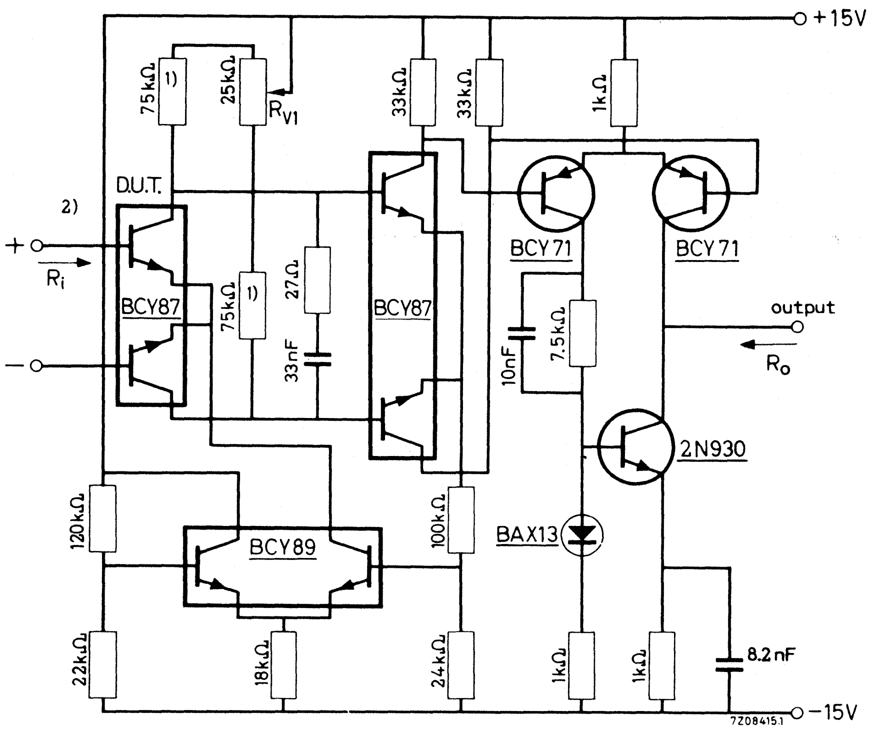


Fig. 8.

1) Relative temperature coefficient $< 10^{-5}/^{\circ}C$.
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
Maximum common mode input voltage range			± 10 V
Maximum output current			± 2,5 mA
Maximum output voltage			± 10 V
Input resistance	R_i		100 kΩ
Output resistance	R_o	typ.	20 kΩ
Common mode rejection ratio			10^5

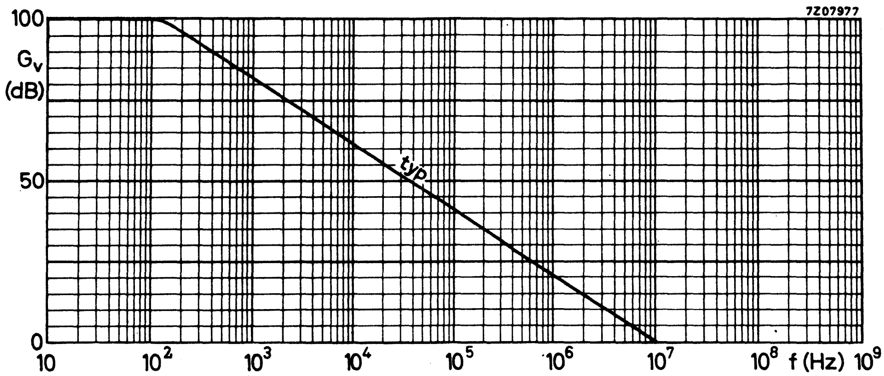


Fig. 9.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	45 V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	40 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	30 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150 mW
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 K/mW

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant. The BF198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

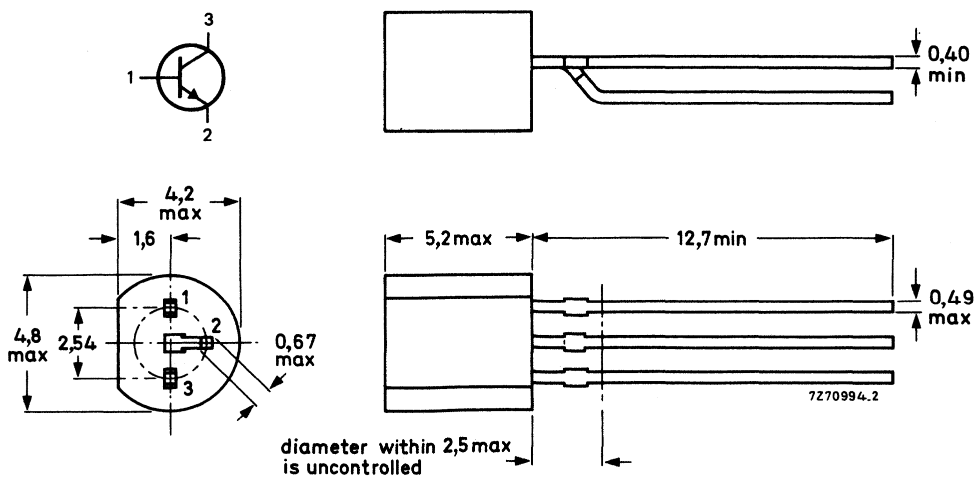
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{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

Dimensions in mm

Fig. 1 TO-92 variant.



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

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V
Collector current (d. c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Storage temperature range	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	K/mW

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	mS
Input capacitance	C_{ie}	typ.	37	35	pF
Feedback admittance	$\lvert y_{re}\rvert$	typ.	47	60	µS
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\lvert y_{fe}\rvert$	typ.	105	100	mS
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	µS
Output capacitance	C_{oe}	typ.	1,3	1,3	pF
Maximum unilateralized power gain $G_{UM} = 10 \log \frac{\lvert y_{fe}\rvert^2}{4 g_{ie} g_{oe}}$; I_C = 4 mA; V_{CE} = 10 V	G_{UM}	typ.	42	39	dB

1) V_{BE} decreases by about 1,7 mV/K 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.

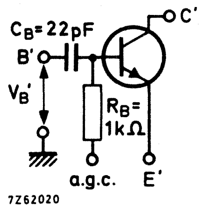


Fig. 2

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 Figs. 3 to 6.

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 Figs. 5 and 6.

Graphs of the y-parameters are on Figs. 13 to 28.

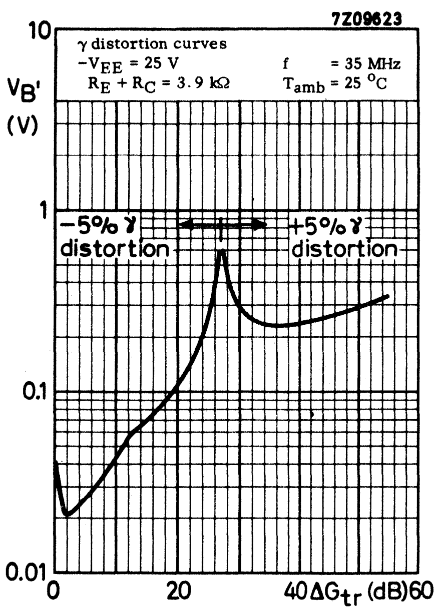


Fig. 3

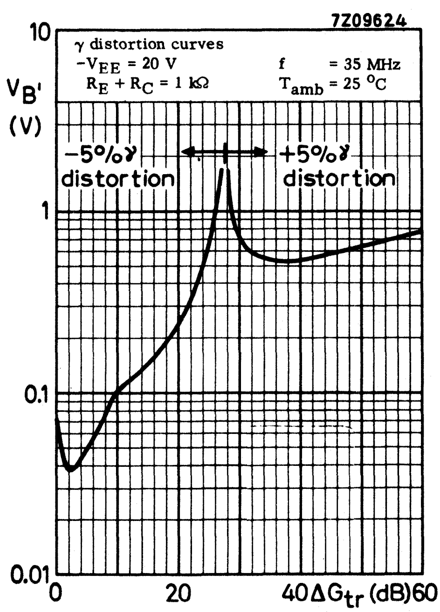


Fig. 4

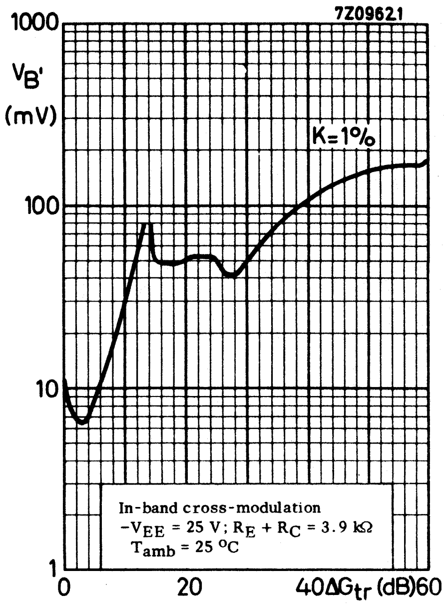

7Z09621
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

Fig. 5

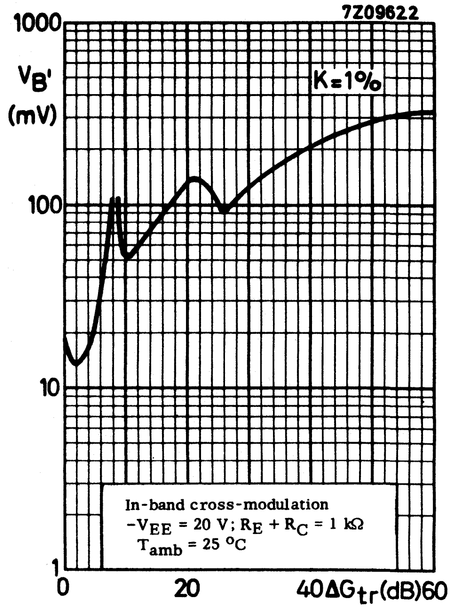

7Z09622
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

Fig. 6

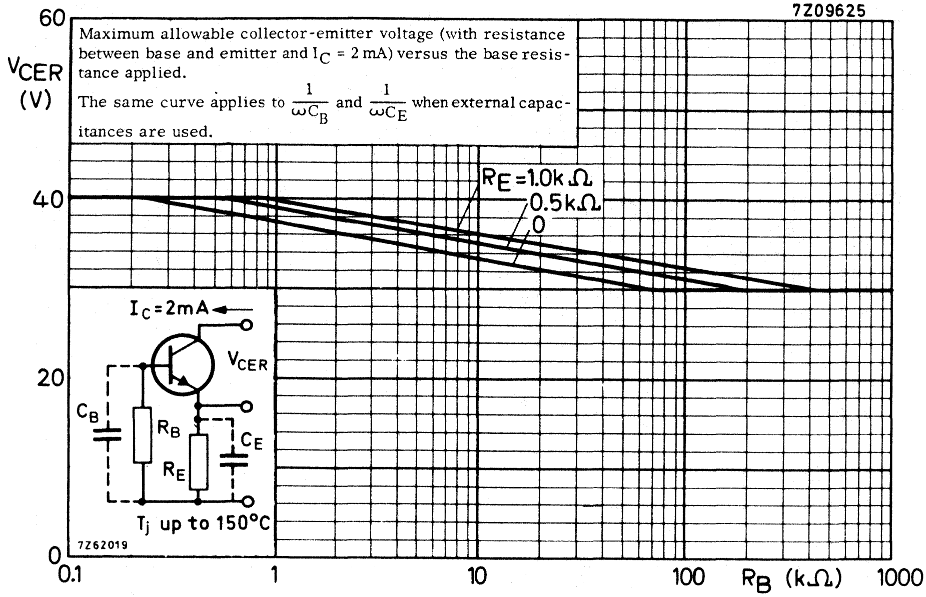


Fig. 7

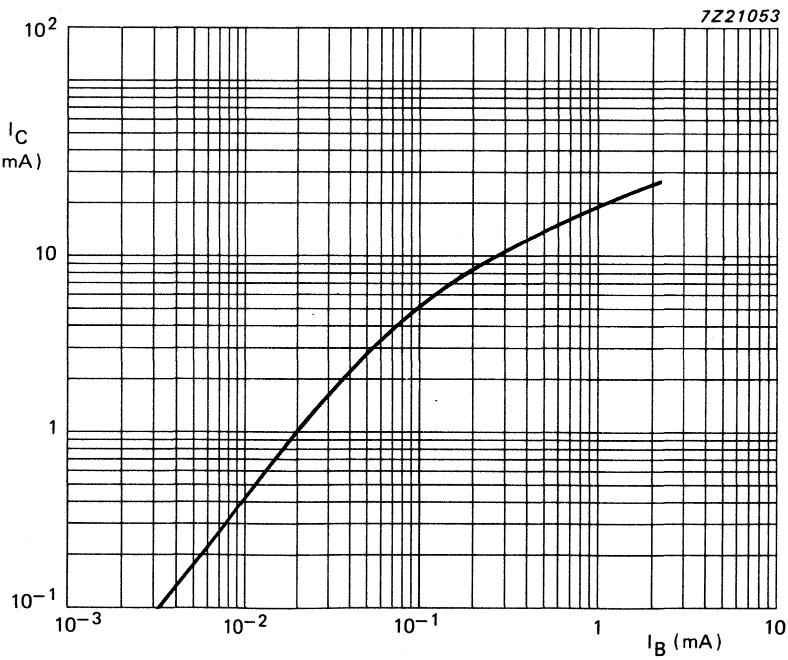


Fig. 8 Base current as a function of collector current; V_{CE} = 10 V; T_j = 25 °C; typical values.

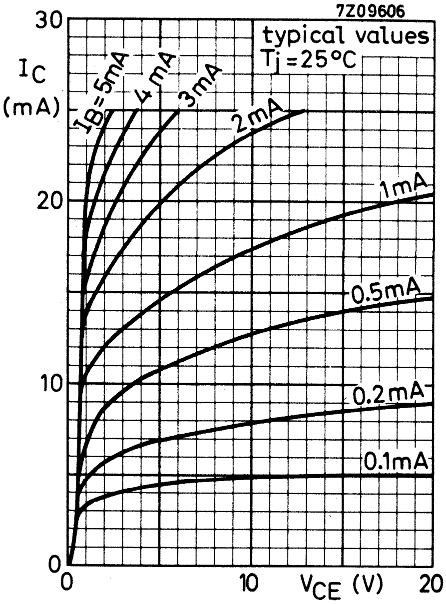


Fig. 9

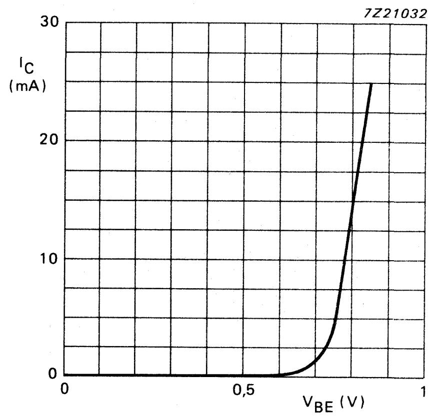


Fig. 10 V_{CE} = 10 V; T_j = 25 °C; typical values.

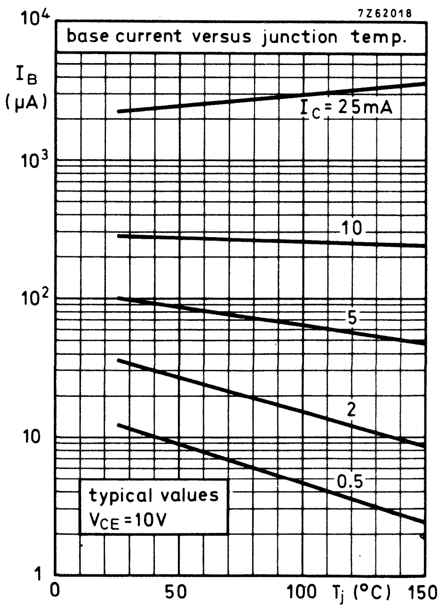


Fig. 11

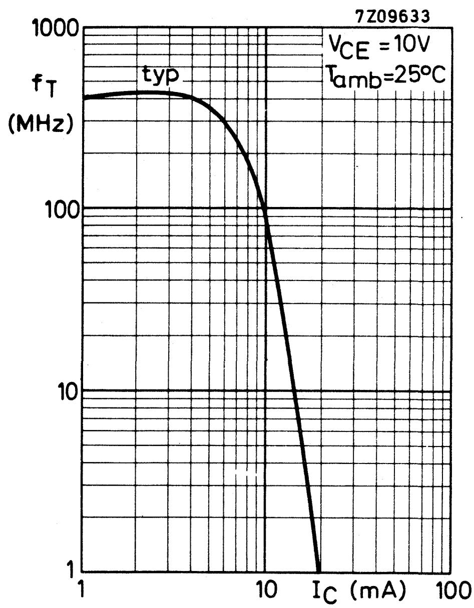


Fig. 12

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

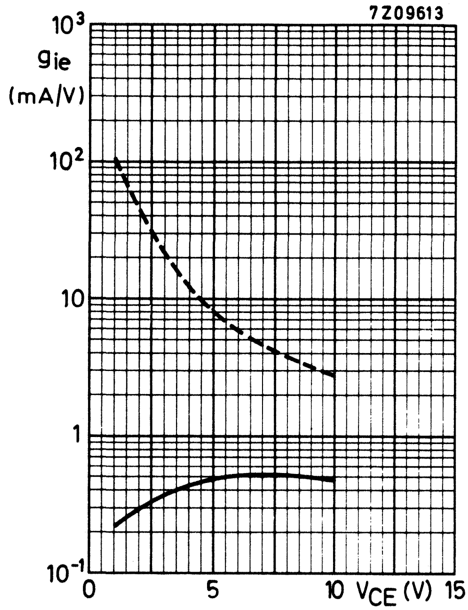


Fig. 13

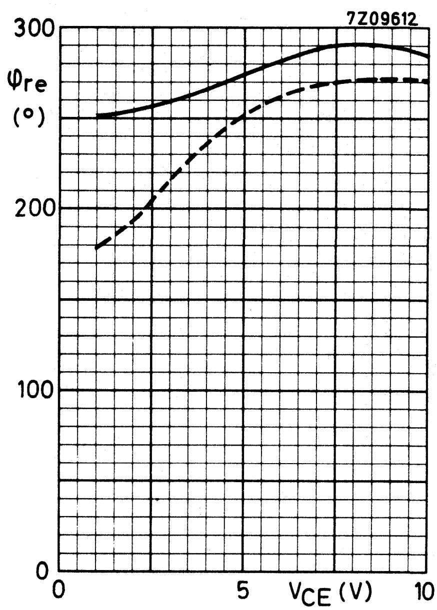


Fig. 14

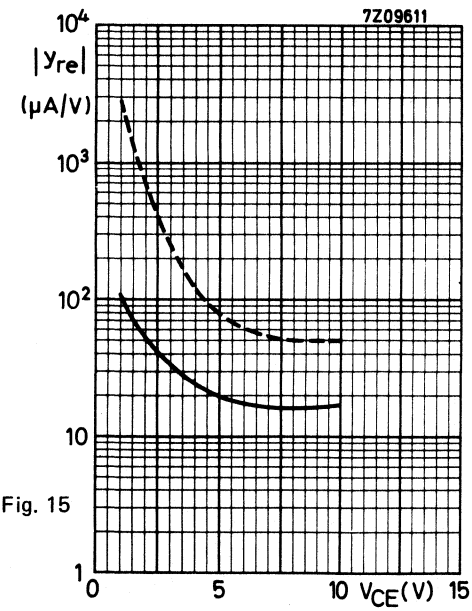


Fig. 15

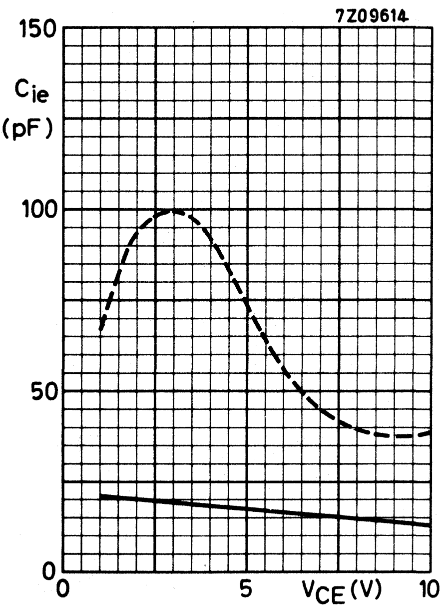


Fig. 16

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

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

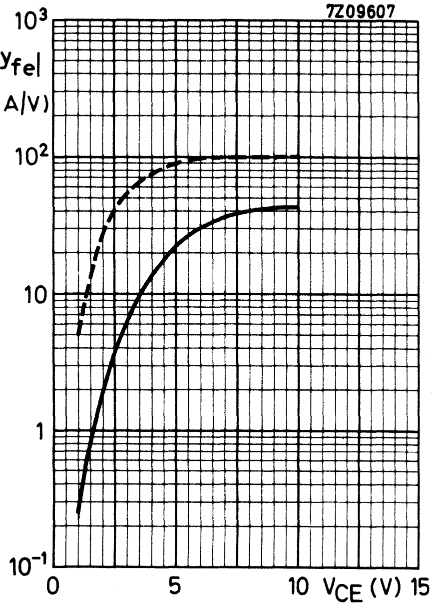


Fig. 17

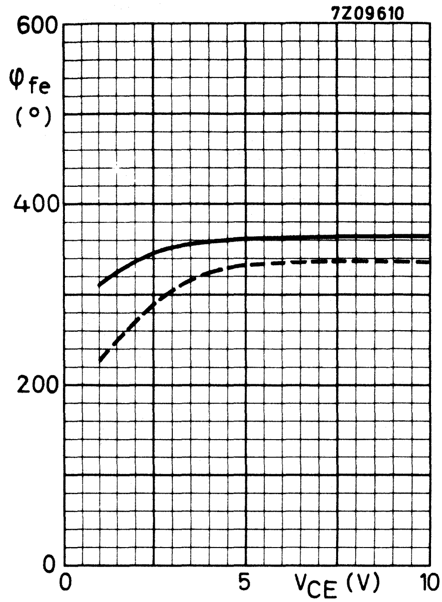


Fig. 18

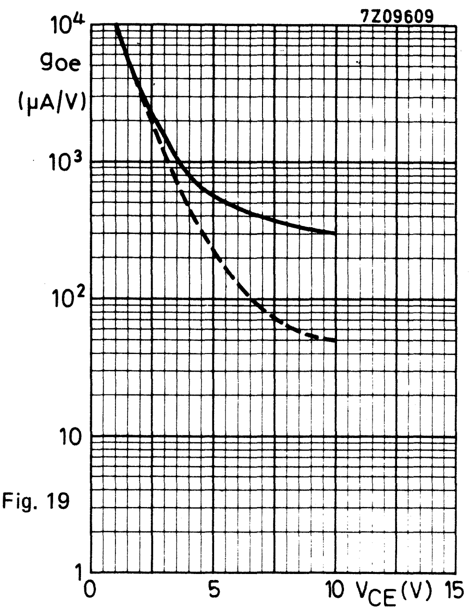


Fig. 19

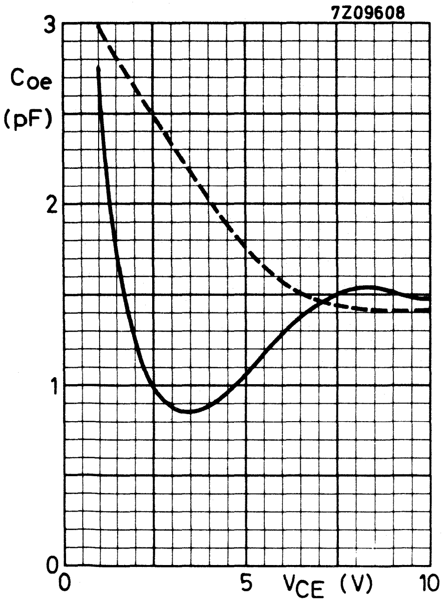


Fig. 20

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

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

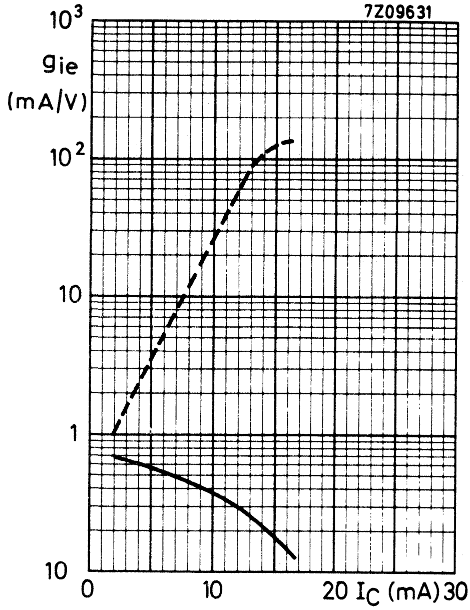


Fig. 21

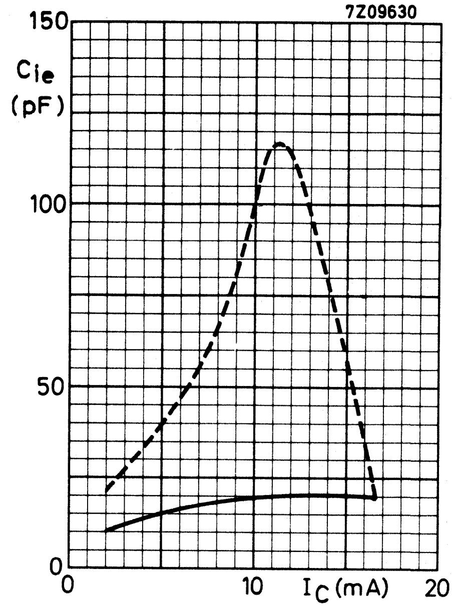


Fig. 22

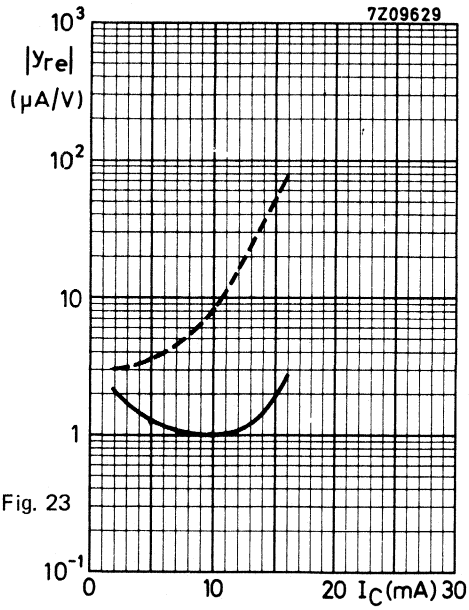


Fig. 23

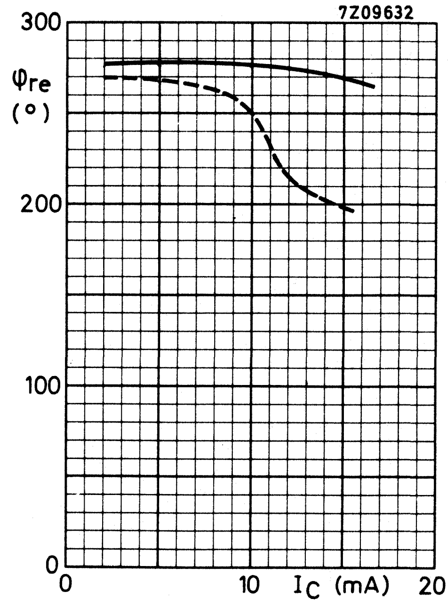


Fig. 24

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on Fig. 2 (dashed curves apply to the transistor only).

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

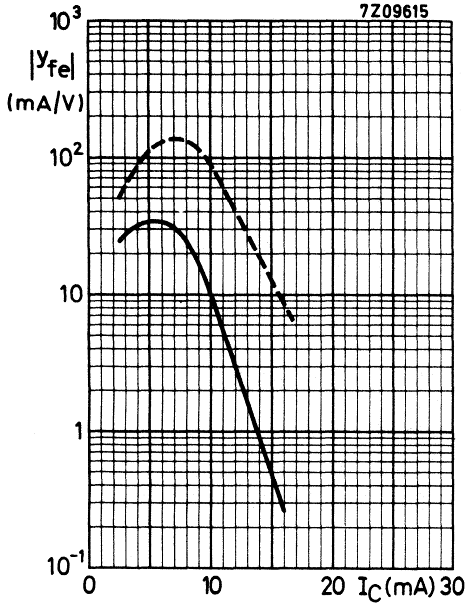


Fig. 25

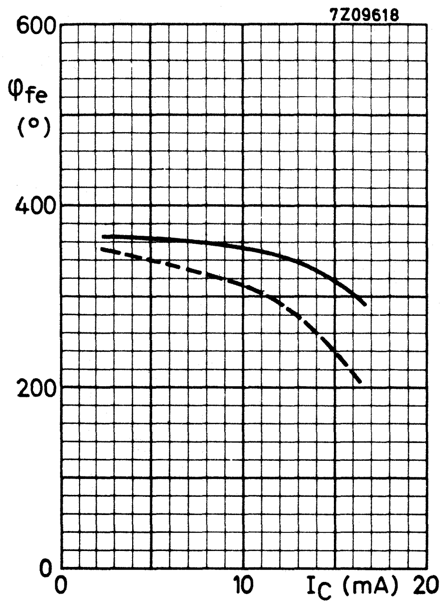


Fig. 26

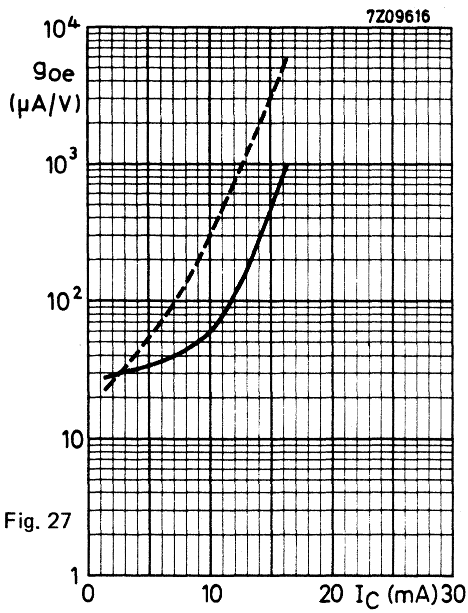


Fig. 27

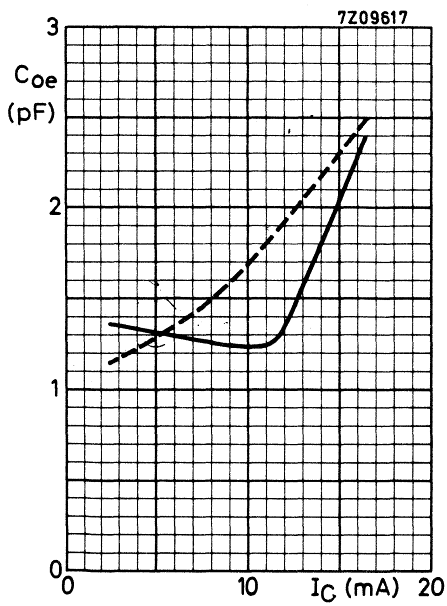


Fig. 28

y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on **Fig. 2** (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 kΩ; $-V_{EE}$ = 25 V

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

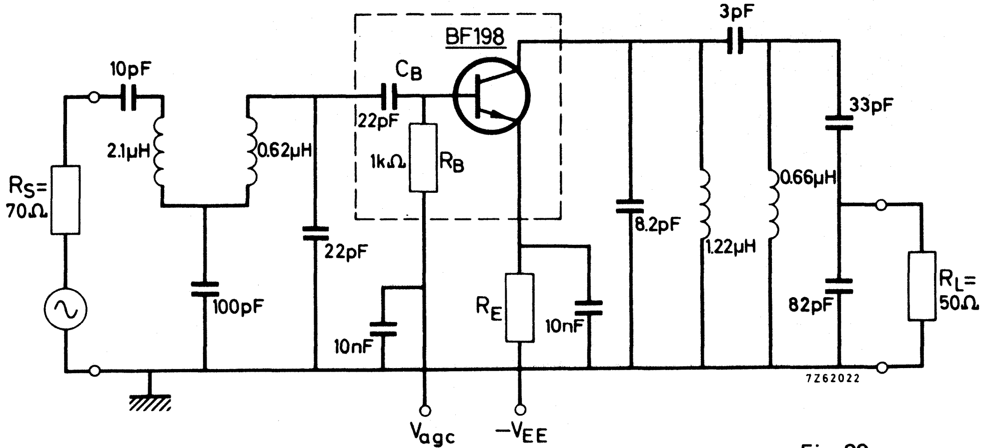


Fig. 29

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

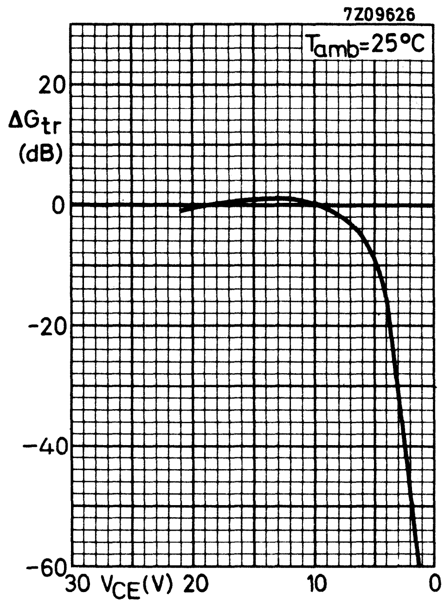


Fig. 30

Current gain control

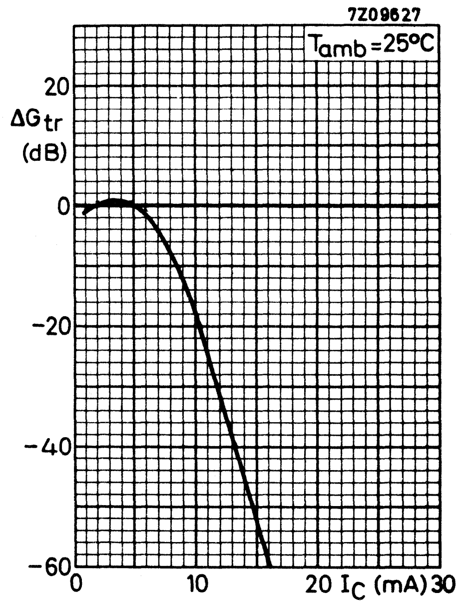


Fig. 31

Curves of constant gain reduction

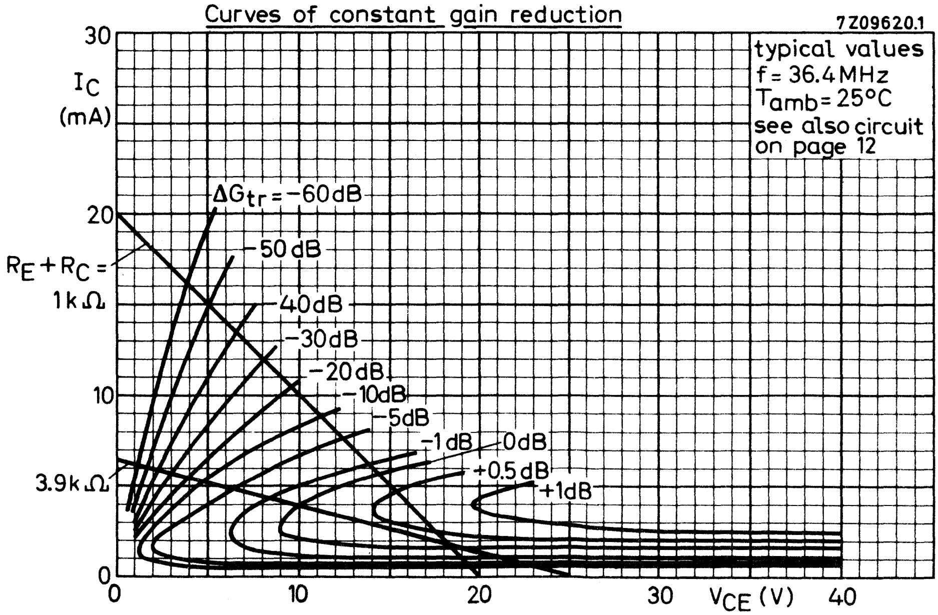


Fig. 32

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.

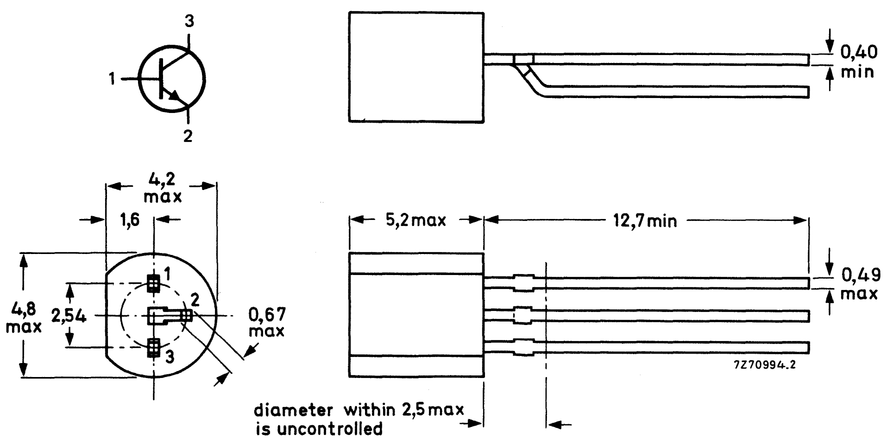
QUICK REFERENCE DATA

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)

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V
Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Storage temperature range	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	K/mW

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 mS
input capacitance	C_{ie}	typ.	55 pF
feedback admittance	$\|y_{re}\|$	typ.	75 μS
phase angle of feedback admittance	φ_{re}	typ.	268°
transfer admittance	$\|y_{fe}\|$	typ.	220 mS
phase angle of transfer admittance	φ_{fe}	typ.	338°
output conductance	g_{oe}	typ.	80 μS
output capacitance	C_{oe}	typ.	2,0 pF
Maximum unilateral power gain $G_{UM} = 10 \log \frac{\|y_{fe}\|^2}{4 g_{ie} g_{oe}}$ $I_C = 7$ mA; $V_{CE} = 10$ V	G_{UM}	typ.	44,4 dB

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

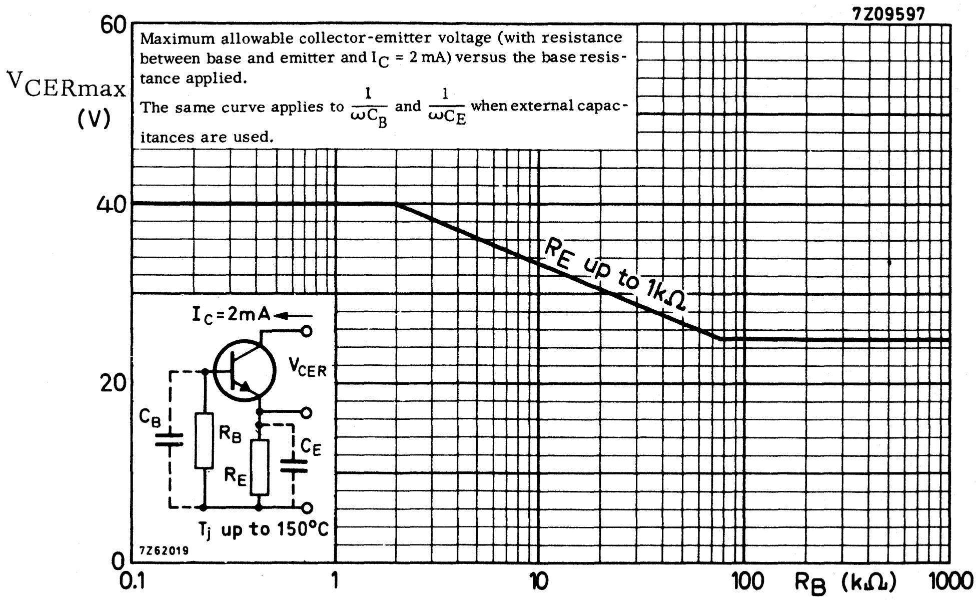

7Z09597
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CERmax} (V)
60
40
20
0
0.1
1
10
100
1000
R_B (kΩ)
R_E up to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 150°C
7Z62019

Fig. 2.

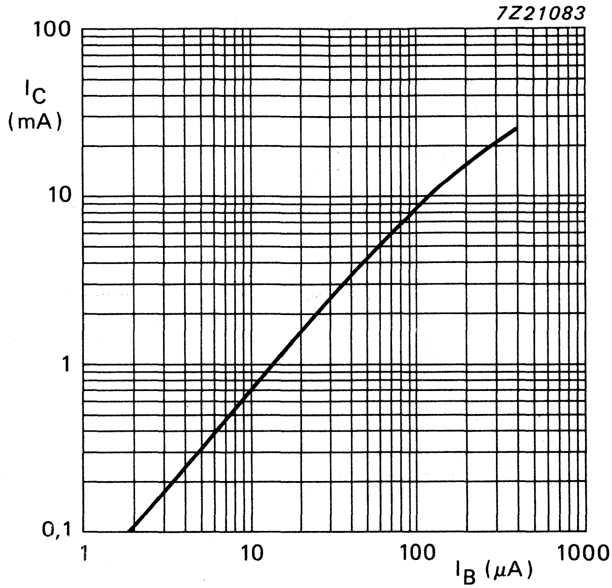


Fig. 3 V_{CE} = 10 V; T_j = 25 °C; typical values.

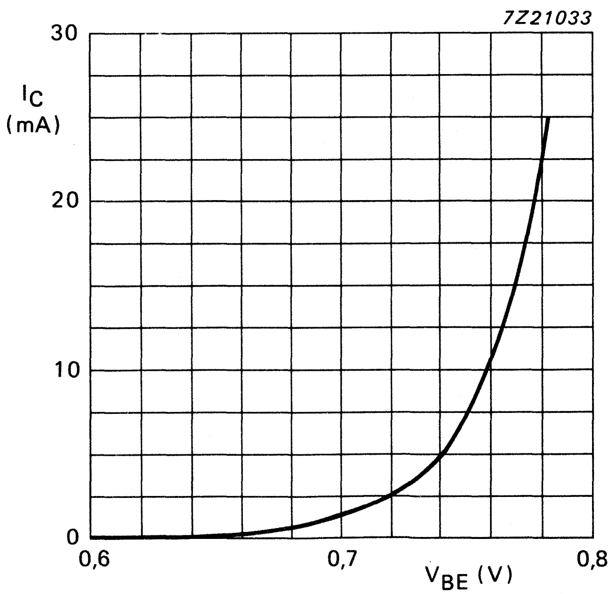


Fig. 4 V_{CE} = 10 V; T_j = 25 °C; typical values.

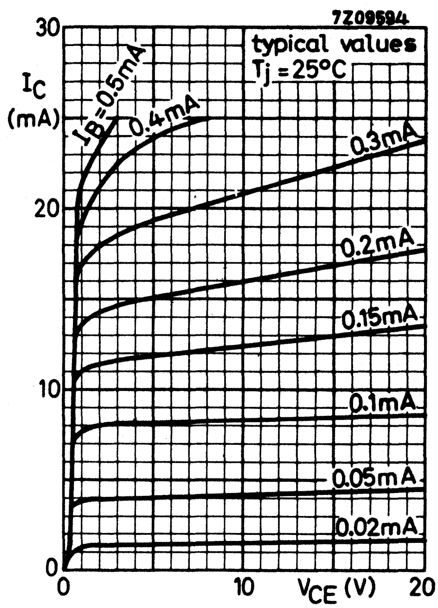


Fig. 5.

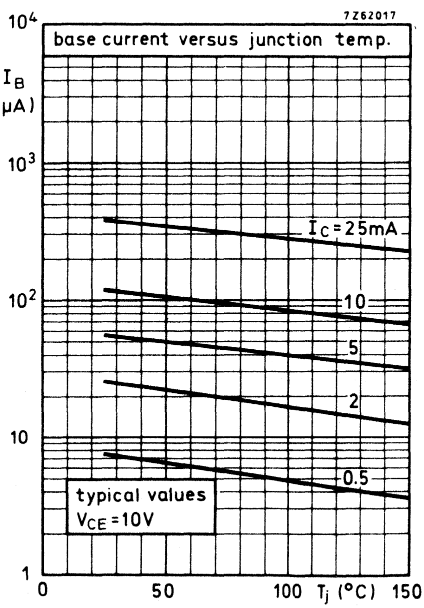


Fig. 6.

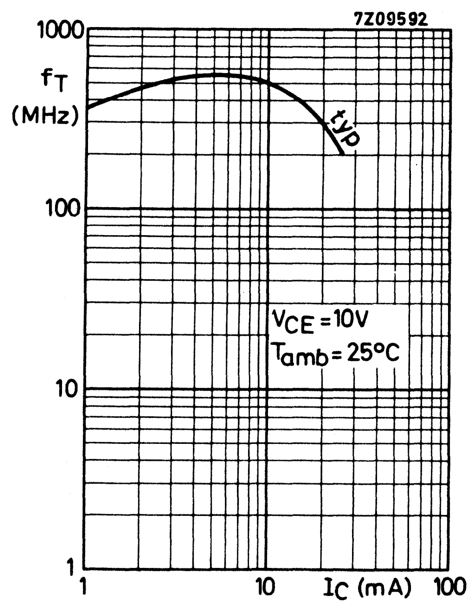


Fig. 7.

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.

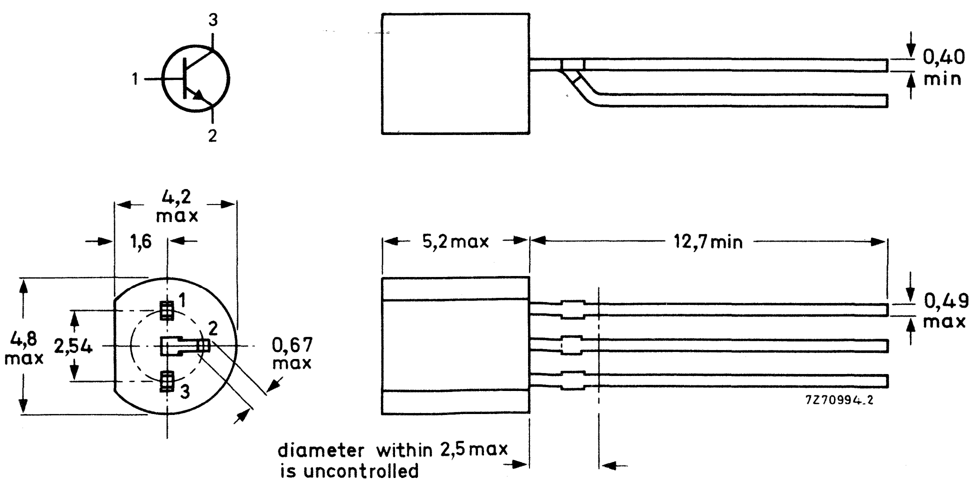
QUICK REFERENCE DATA

			BF240	BF241	
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	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

Fig. 1 TO-92 variant.



RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	40 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40 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}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420 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		
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
Noise figure I_C = 1 mA; V_{CE} = 10 V R_S = 200 Ω; f = 0,2 MHz	F	typ. <	1,5 3,5	2,0 3,5	dB dB

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	mS
Input capacitance	C_{ie}	typ.	17	14	23	19	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mS
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	μS
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	0,75	18	0,75	18	μS
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	mS
Input capacitance	C_{ie}	typ.	25	pF
Transfer admittance	$\|y_{fe}\|$	typ.	125	mS
Output conductance	g_{oe}	typ.	62	μS
Output capacitance	C_{oe}	typ.	1	pF

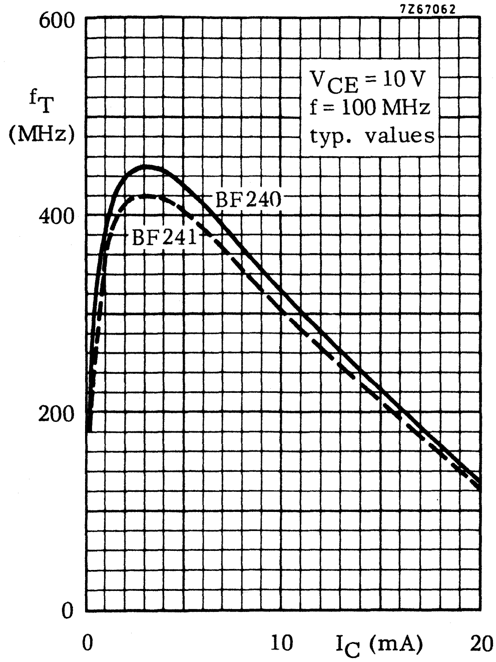

7Z67062
600
400
200
0
f_T
(MHz)
V_{CE} = 10 V
f = 100 MHz
typ. values
BF240
BF241
0
10
I_C (mA)
20

Fig. 2.

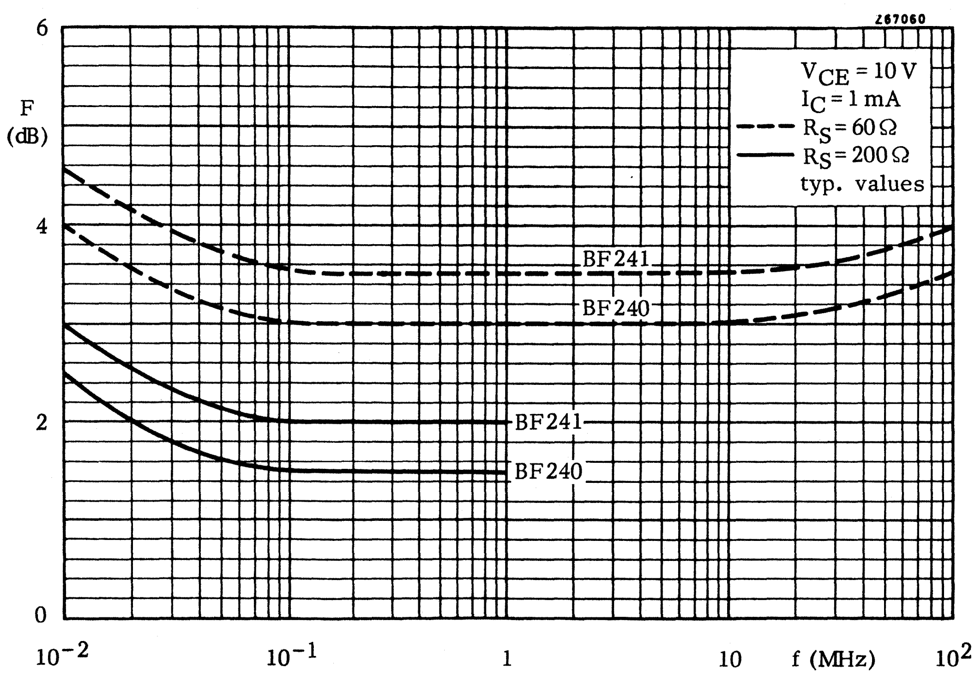

Z67060
6
4
2
0
F
(dB)
V_{CE} = 10 V
I_C = 1 mA
R_S = 60 Ω
R_S = 200 Ω
typ. values
BF241
BF240
BF241
BF240
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

Fig. 3.

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.

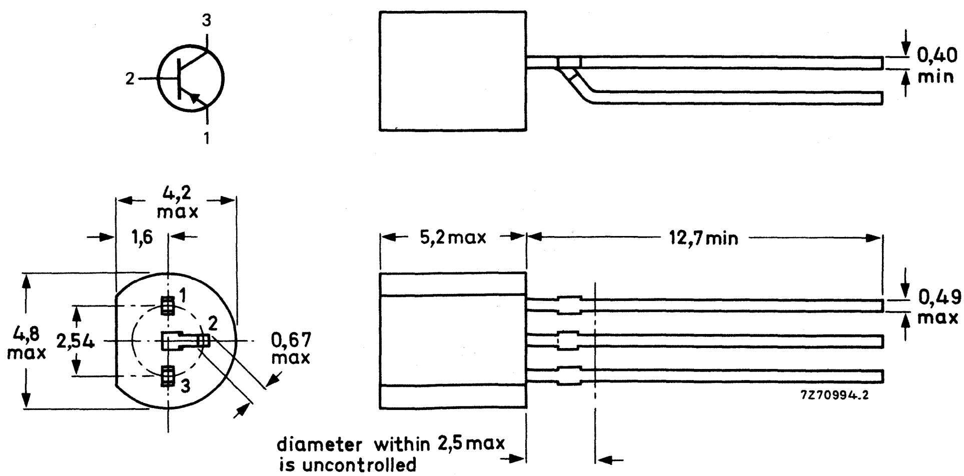
QUICK REFERENCE DATA

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

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.	30	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}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

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; $G_S = 16,7$ mS	F	typ.	3	dB
$-I_C = 5$ mA; $-V_{CE} = 10$ V; $G_S = 6,7$ mA/V; $-jB_S = 5$ mS	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	mS
Input capacitance	$-C_{ib}$	typ.	64	pF
Transfer admittance	$\|y_{fb}\|$	typ.	100	mS
Phase angle of transfer admittance	φ_{fb}	typ.	147°	
Output conductance	g_{ob}	typ.	40	μS
Output capacitance	C_{ob}	typ.	1,25	pF
Feedback admittance	$\|y_{rb}\|$	typ.	220	μS
Phase angle of feedback admittance	$-\varphi_{rb}$	typ.	85°	

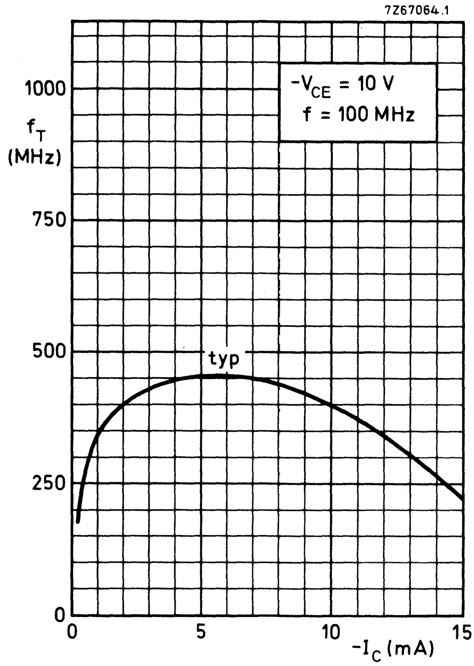

7Z67064.1
$-V_{CE}$ = 10 V
f = 100 MHz
f_T
(MHz)
1000
750
500
250
0
typ
0
5
10
15
$-I_C$ (mA)

Fig. 2

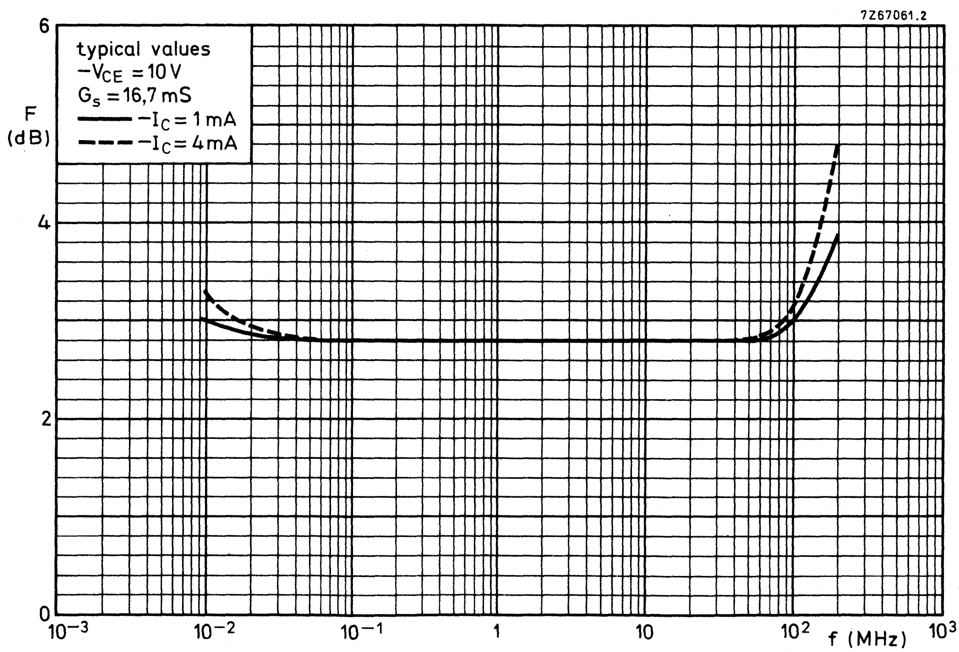

7Z67061.2
typical values
$-V_{CE}$ = 10 V
G_s = 16,7 mS
$-I_C$ = 1 mA
$-I_C$ = 4 mA
F
(dB)
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
f (MHz)
10^3

Fig. 3

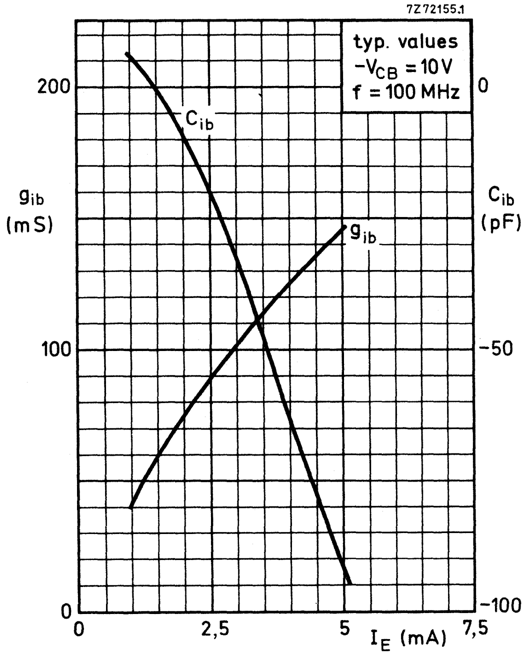


Fig. 4

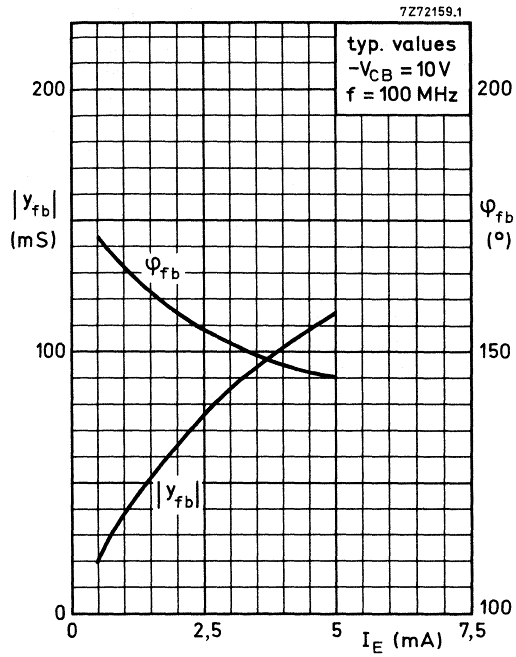


Fig. 5

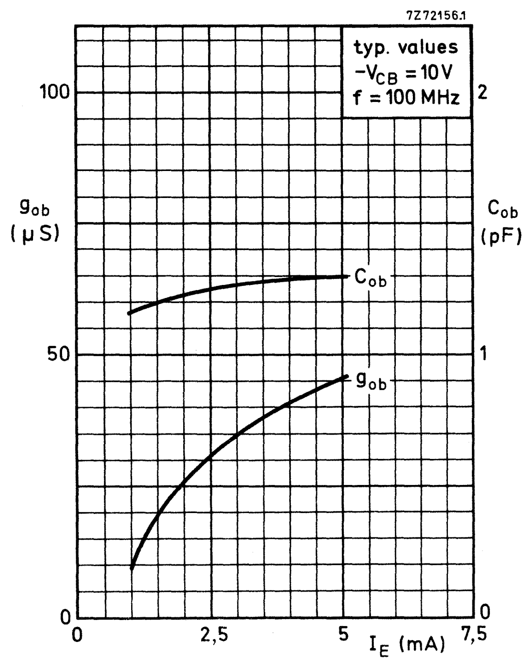


Fig. 6

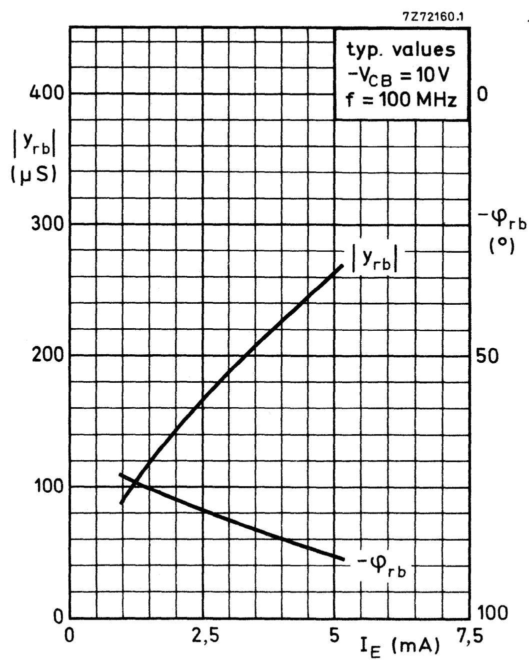


Fig. 7

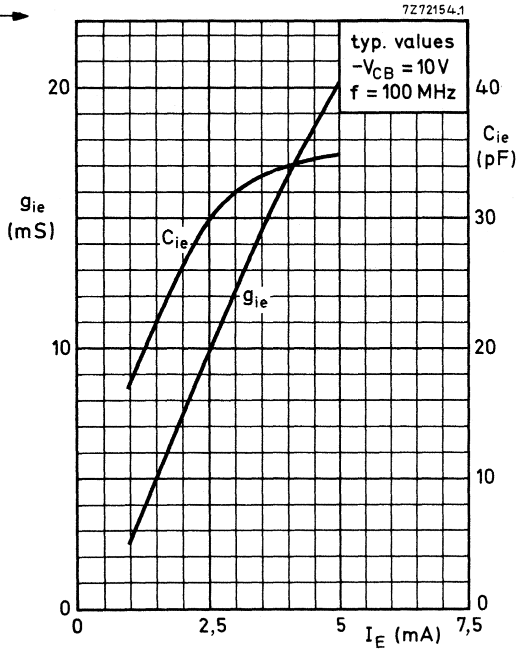


Fig. 8

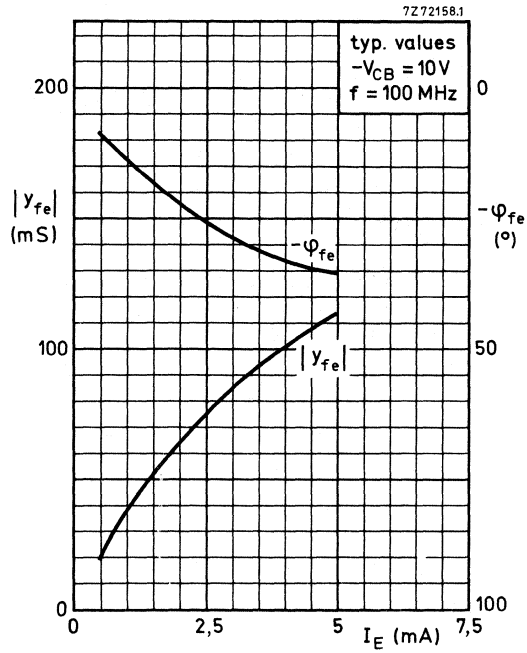


Fig. 9

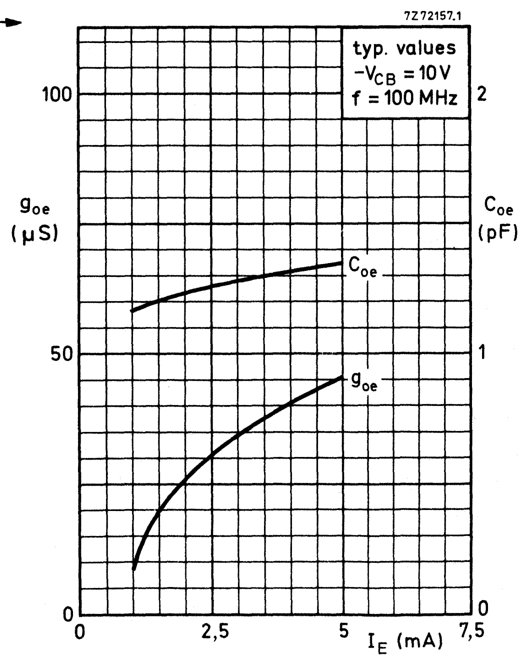


Fig. 10

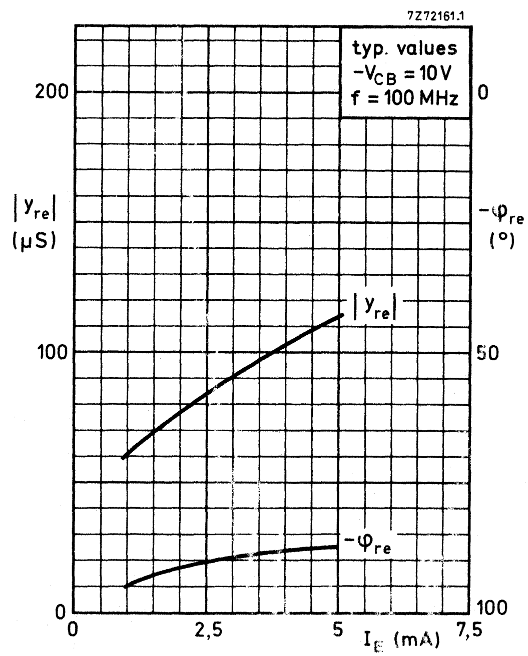


Fig. 11

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope, intended for use in large-signal handling i.f. pre-amplifiers of TV receivers in combination with surface acoustic wave filters.

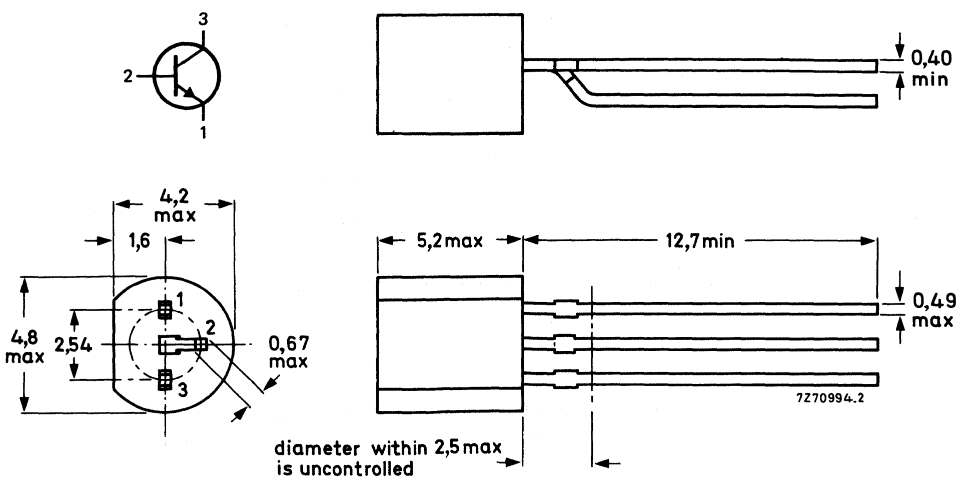
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 100 MHz I_C = 40 mA; V_{CE} = 10 V	f_T	>	490	MHz
Voltage gain at f = 36 MHz (see Fig. 4) I_C = 20 mA; V_{CE} ≈ 10,4 V	G_v	typ.	24	dB
Interference voltage for K = 1% (see Fig. 4)	$V_{(int)rms}$	typ.	120	mV

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5	V
Collector current (d.c.)	I_C	max.	100	mA
Total power dissipation up to T_{amb} = 25 °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

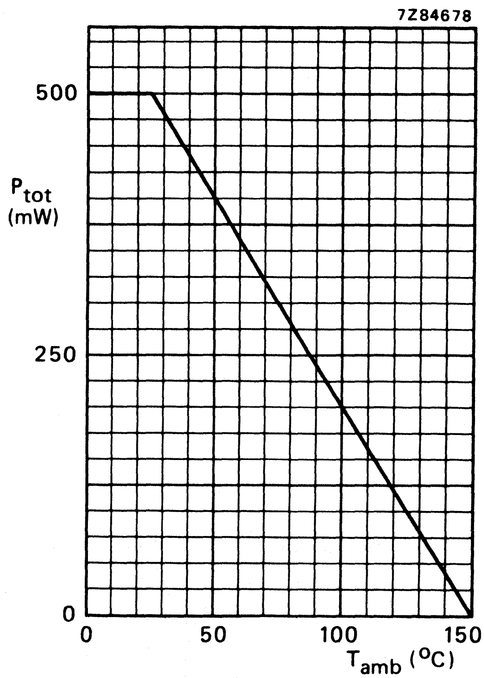


Fig. 2 Power dissipation derating curve as a function of ambient temperature.

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; $T_j = 125$ °C	I_{CBO}	<	30 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 2$ V	I_{EBO}	<	100 nA
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
$I_C = 40$ mA; $V_{CE} = 10$ V	f_T	>	490 MHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2,2 pF ←
Emitter capacitance at f = 1 MHz			
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4,5 pF
Feedback capacitance at f = 1 MHz			
$I_C = 0$; $V_{CE} = 10$ V	C_{re}	typ.	1,6 pF ←

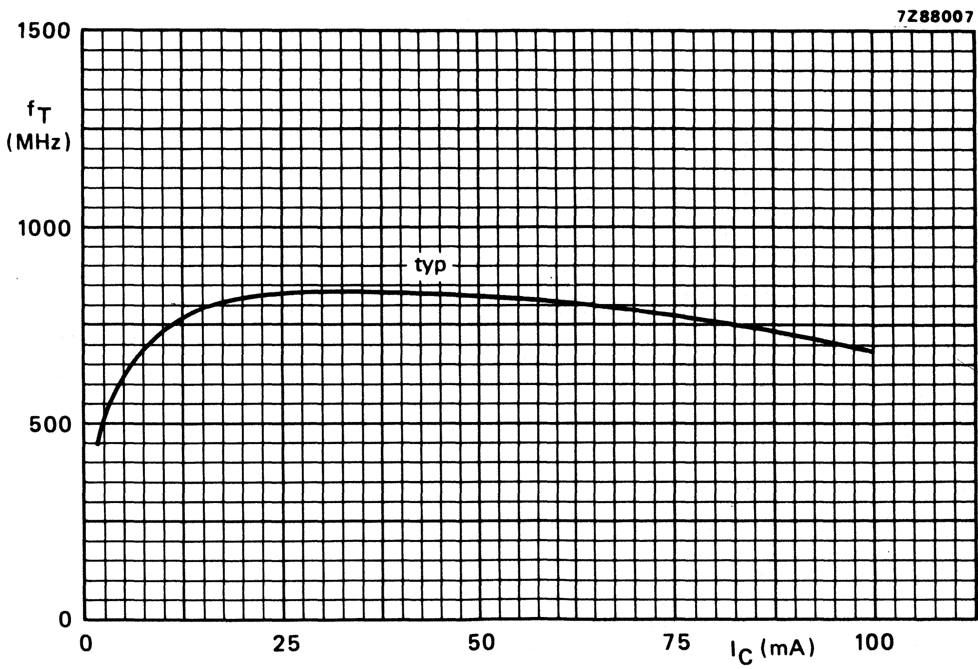
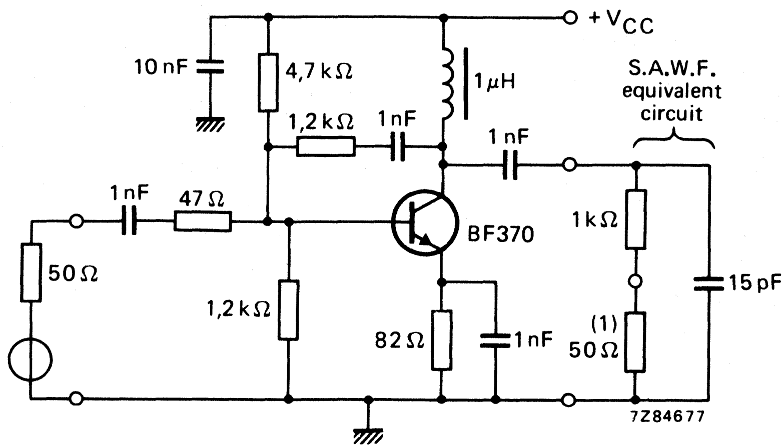


Fig. 3 $V_{CE} = 10$ V; $T_j = 25$ °C.

APPLICATION INFORMATION



(1) Test instrument load.

Fig. 4 Large-signal handling i.f. preamplifier for surface acoustic wave filter.

Performance

Supply voltage	V_{CC}	=	12 V
Collector current	I_C	=	20 mA
Measuring frequency	f_i	=	36 MHz
Input impedance	Z_i	typ.	50 Ω//1 pF
Output impedance	Z_o	<	100 Ω
Voltage gain G_v (in dB) $= 20 \log \frac{V_o}{V_i}$	G_v	typ.	24 dB
Interference voltage for K = 1%*	$V_{(int)rms}$	typ.	120 mV

* Input terminal voltage at 50 Ω internal resistance of signal generator, interference frequency 40 MHz, 80% modulated with 1 kHz.

SILICON EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelope primarily intended for class-B video output stages in colour television and professional monitor equipment. P-N-P complements are BF421 and BF423.

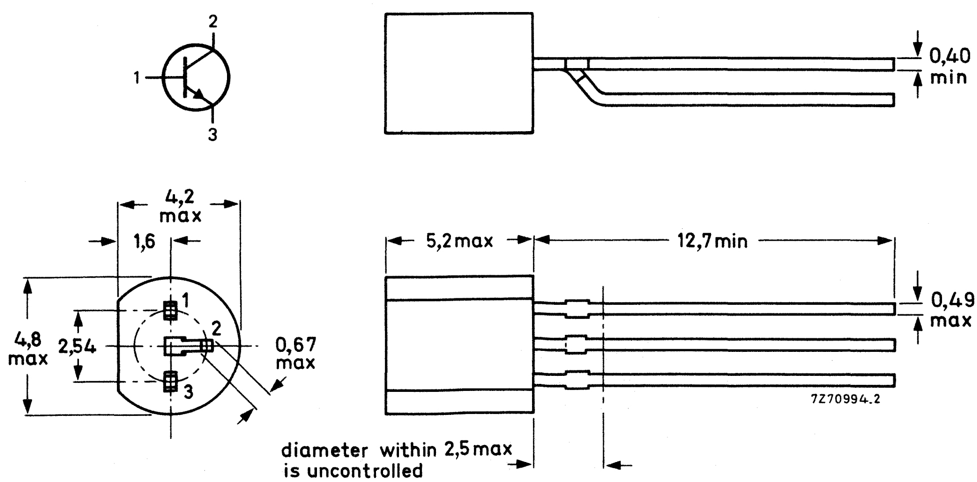
QUICK REFERENCE DATA

			BF420	BF422	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	250	V
Collector-emitter voltage	V_{CER}	max.	300		V
	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_C = 10 mA; V_{CE} = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz I_C = 0; V_{CE} = 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)

			BF420	BF422	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	250	V
Collector-emitter voltage					
R_{BE} = 2,7 kΩ	V_{CER}	max.	300		V
I_B = 0	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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

			BF420	BF422	
Collector cut-off currents					
I_E = 0; V_{CB} = 200 V	I_{CBO}	<	10	10	nA
R_{BE} = 2,7 kΩ; V_{CE} = 200 V; T_j = 150 °C	I_{CER}	<	10	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
Saturation voltage					
I_C = 30 mA; I_B = 5 mA	V_{CEsat}	<	0,6		V
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz					
I_C = 0; V_{CE} = 30 V	C_{re}	<	1,6		pF

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

** 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.

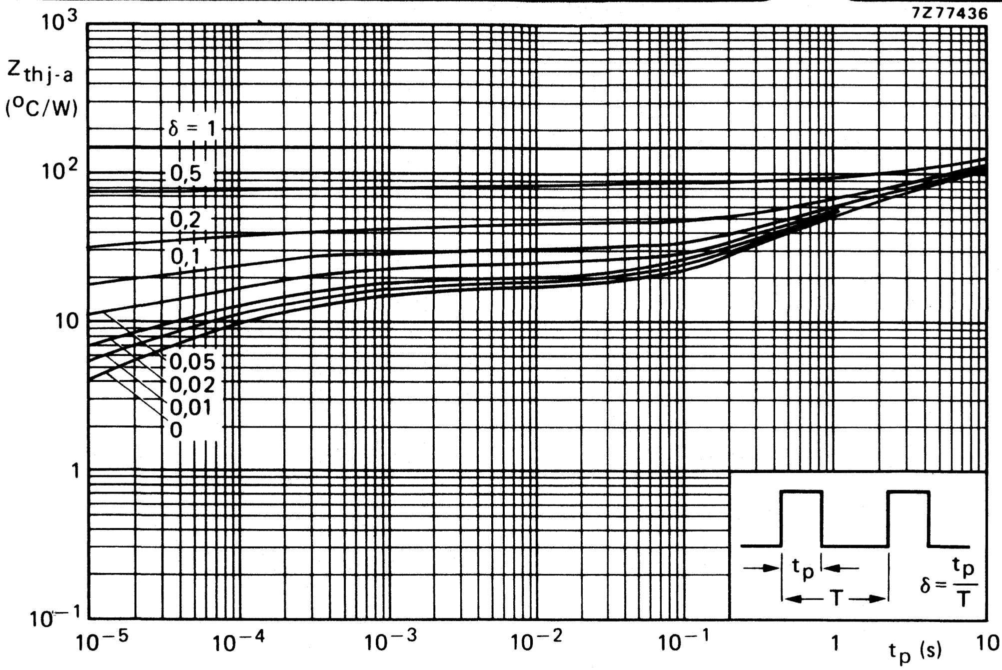


Fig. 2 Thermal impedance from junction to ambient versus pulse duration. Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

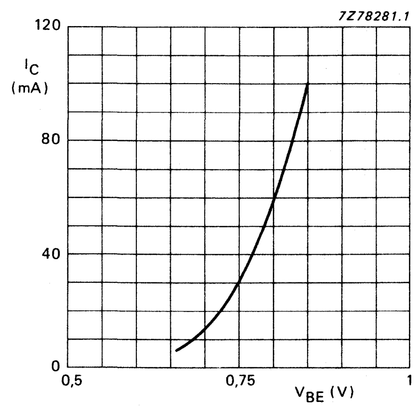


Fig. 3. V_{CE} = 20 V; T_j = 25 °C.

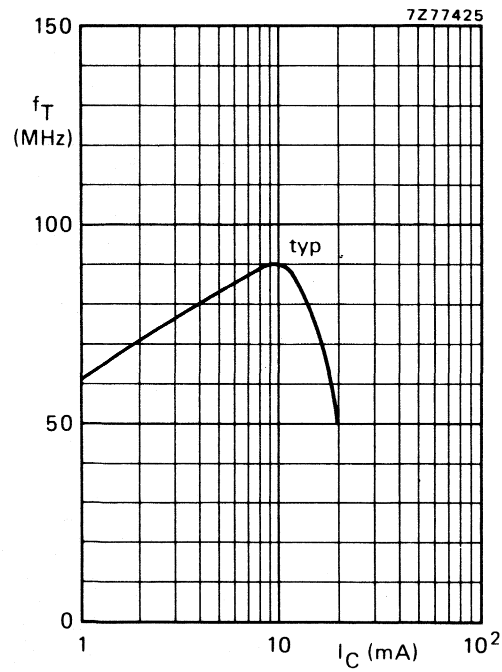


Fig. 4 V_{CE} = 10 V; T_j = 25 °C; f = 35 MHz.

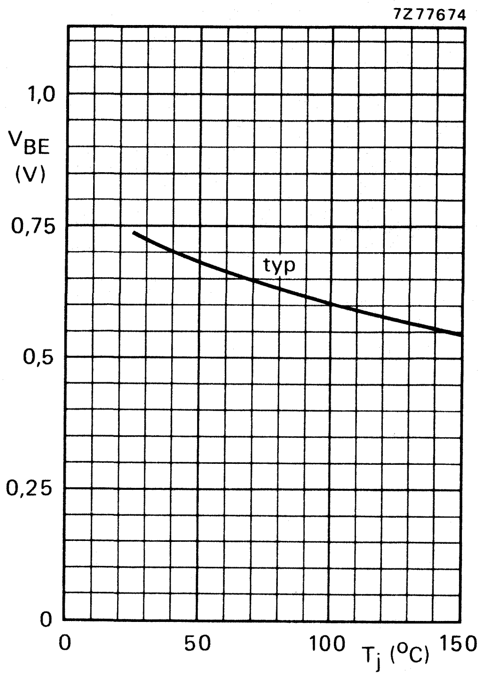


Fig. 5 I_C = 25 mA; V_{CE} = 20 V.

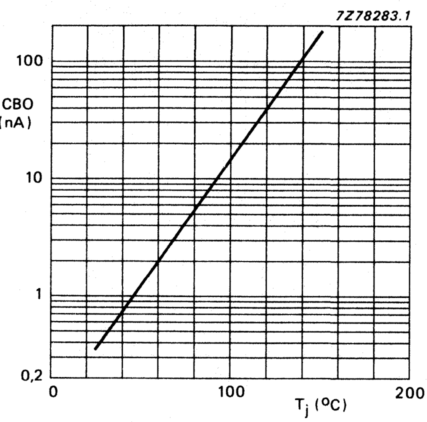


Fig. 6 V_{CB} = 200 V; typical values.

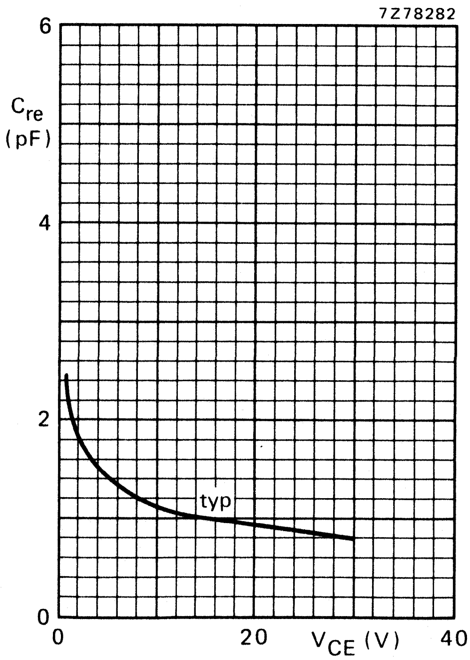


Fig. 7 I_C = 0; f = 1 MHz; T_j = 25 °C.

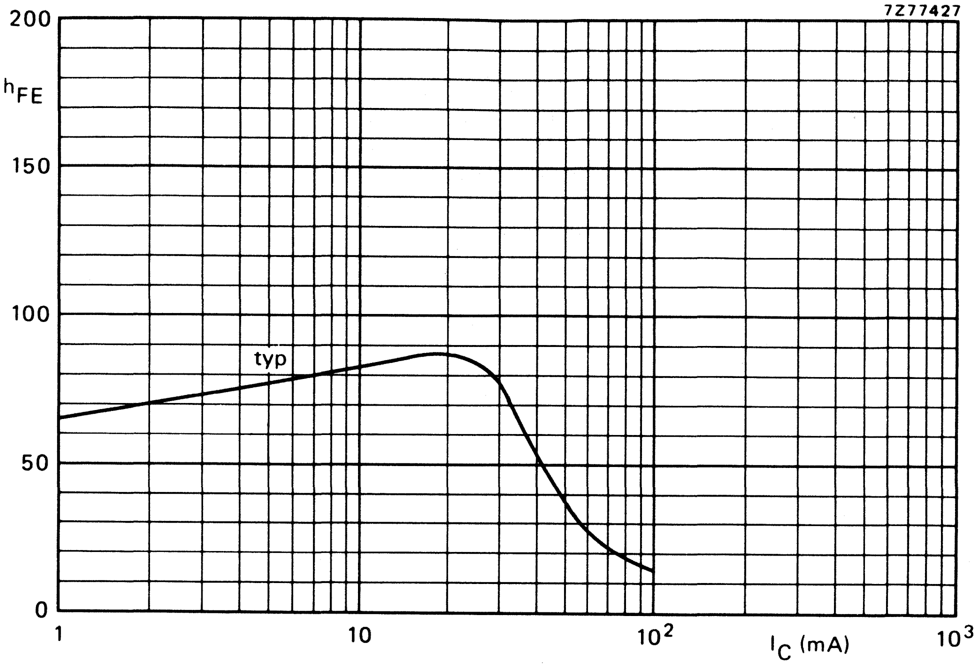


Fig. 8 V_{CE} = 20 V; T_j = 25 °C.

SILICON EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 variant envelope primarily intended for class-B video output stages in colour television and professional monitor equipment. N-P-N complements are BF420 and BF422.

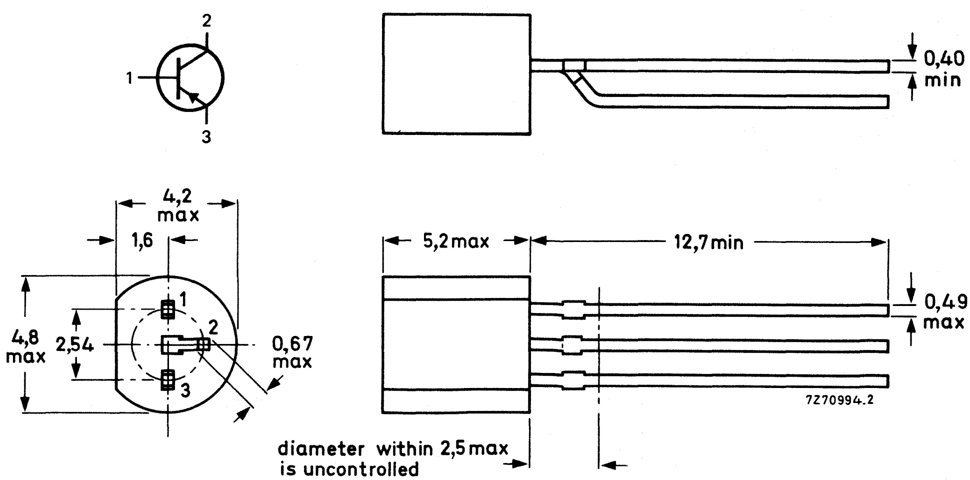
QUICK REFERENCE DATA

			BF421	BF423	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage	$-V_{CER}$	max.	300		V
	$-V_{CEO}$	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 $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz $-I_C$ = 0; $-V_{CE}$ = 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)

			BF421	BF423	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage					
R_{BE} = 2,7 kΩ	$-V_{CER}$	max.	300		V
I_B = 0	$-V_{CEO}$	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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

			BF421	BF423	
Collector cut-off currents					
$I_E = 0; -V_{CB} = 200$ V	$-I_{CBO}$	<	10	10	nA
$R_{BE} = 2{,}7$ kΩ; $-V_{CE} = 200$ V; $T_j = 150$ °C	$-I_{CER}$	<	10	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
→ Saturation voltage					
$-I_C = 30$ mA; $-I_B = 5$ mA	$-V_{CE\ sat}$	<	0,6		V
Transition frequency					
$-I_C = 10$ mA; $-V_{CE} = 10$ V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz					
$-I_C = 0; -V_{CE} = 30$ V	C_{re}	<	1,6		pF

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

** 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.

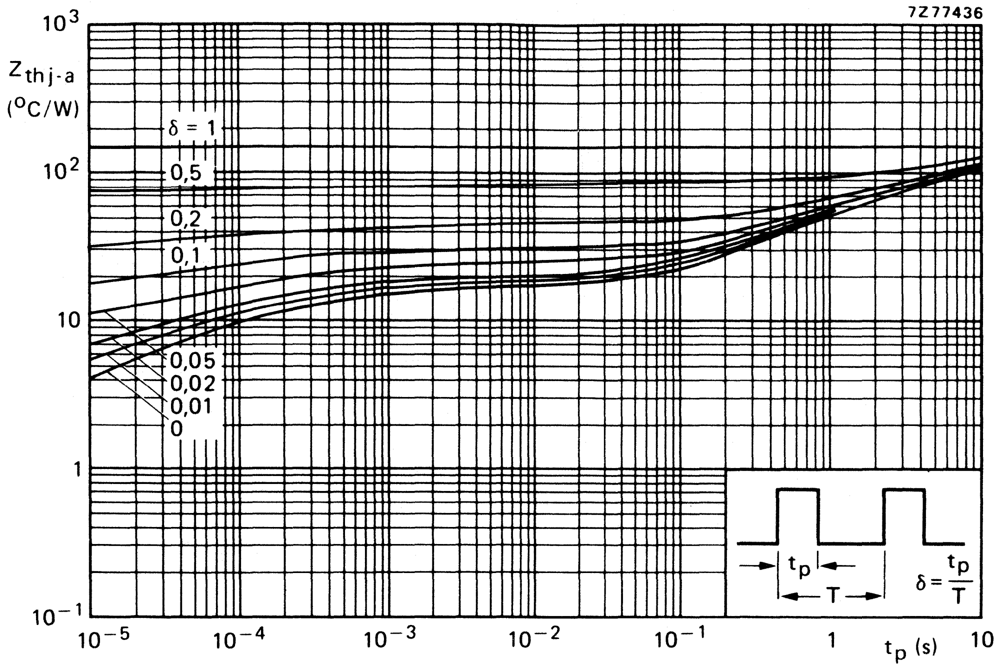


Fig. 2 Thermal impedance from junction to ambient versus pulse duration. Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

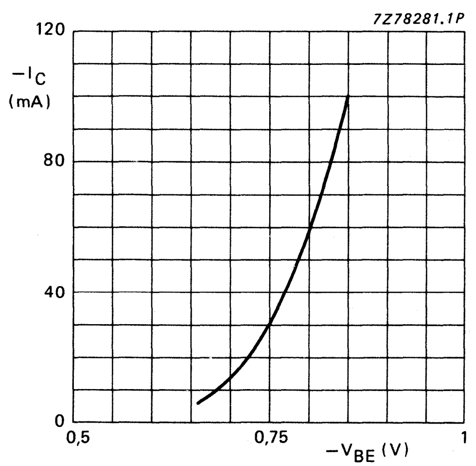


Fig. 3 $-V_{CE}$ = 20 V; T_j = 25 °C.

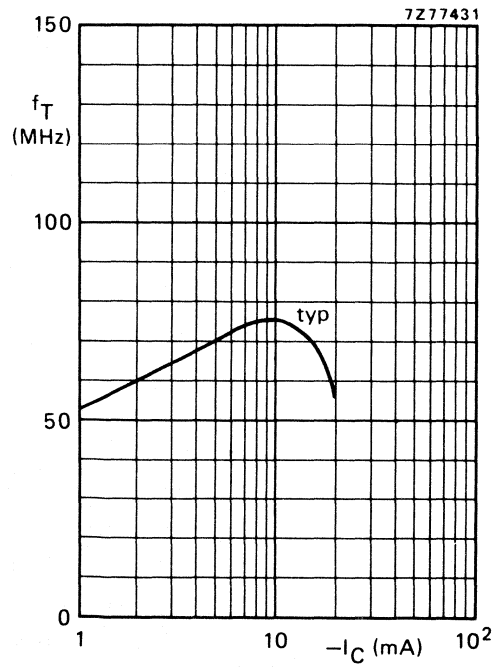


Fig. 4 $-V_{CE}$ = 10 V; T_j = 25 °C; f = 35 MHz.

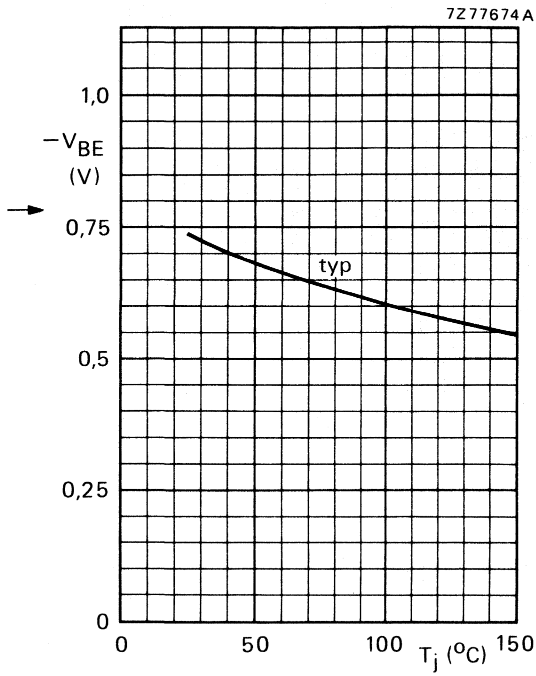


Fig. 5 $-I_C$ = 25 mA; $-V_{CE}$ = 20 V.

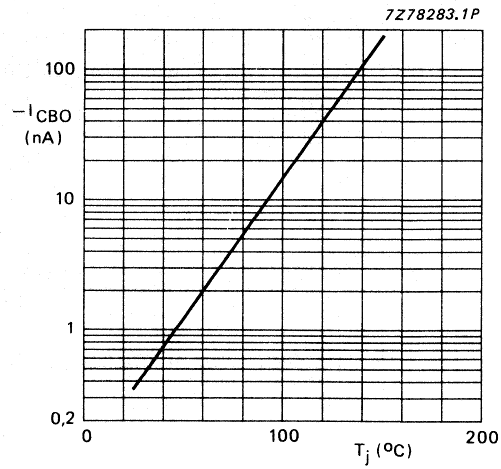


Fig. 6 $-V_{CB}$ = 200 V; typical values.

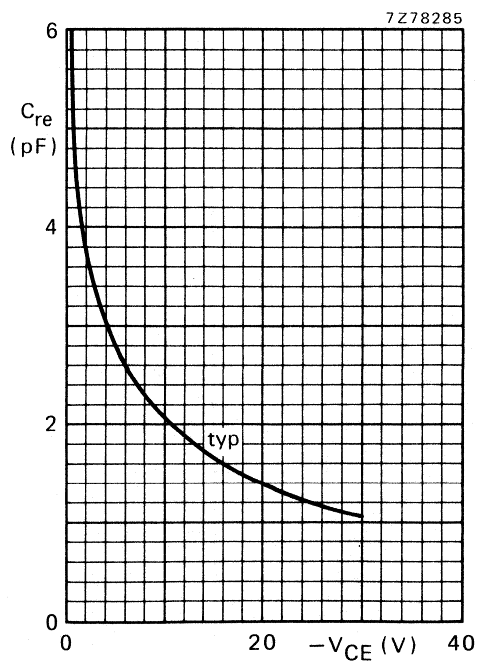


Fig. 7 I_C = 0; f = 1 MHz; T_j = 25 °C.

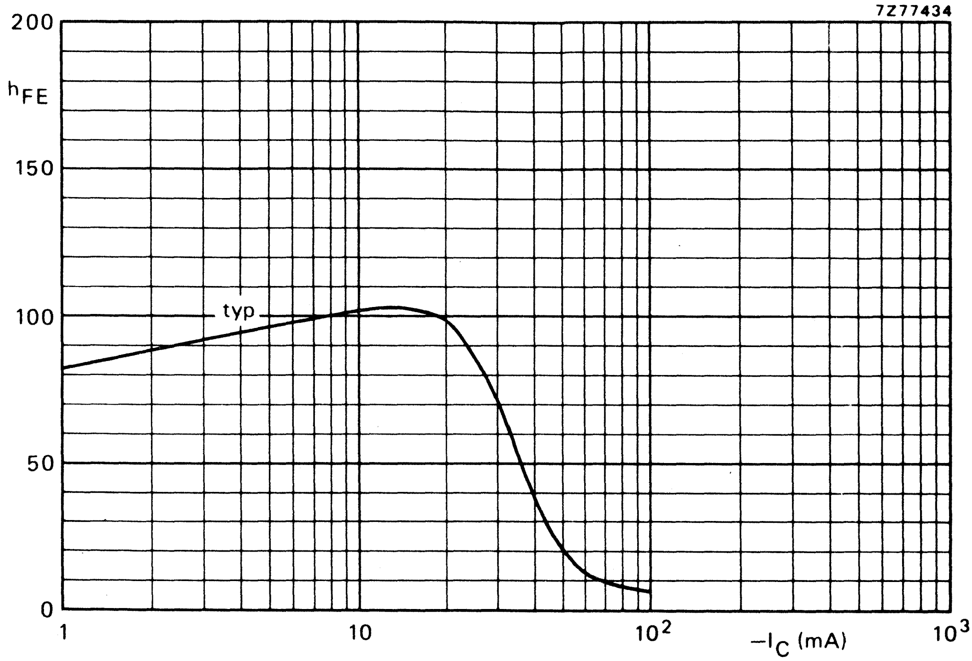


Fig. 8 Typical values at $-V_{CE}$ = 20 V; T_j = 25 °C.

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.

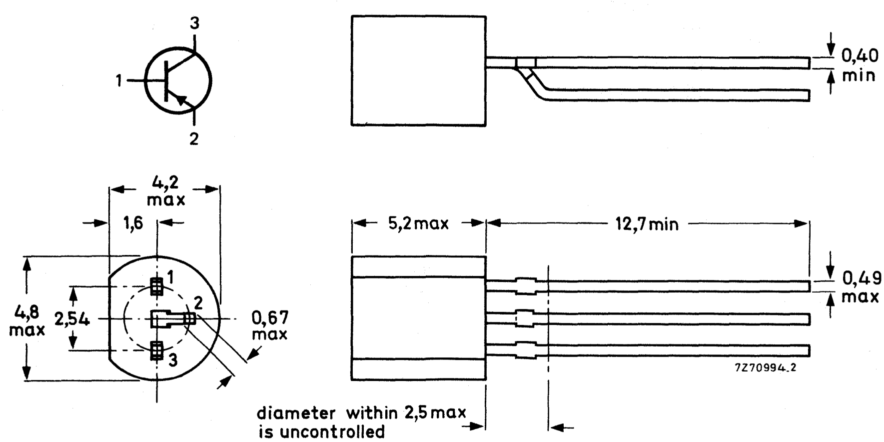
QUICK REFERENCE DATA

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

Fig. 1 TO-92 variant.



RATINGS

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	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}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	420	K/W

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		$-I_{CB)}$	<	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
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	pG
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	mS
Input capacitance	C_{ie}	typ.	20	13	30	20	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mS
Phase angle of transfer admittance	φ_{fe}	typ.	0°	0°	0°	0°	
Output conductance	g_{oe}	typ.	8	10	8	10	μS
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	1	24	1	24	μS
Phase angle of feedback admittance	φ_{re}	typ.	270°	270°	270°	270°	

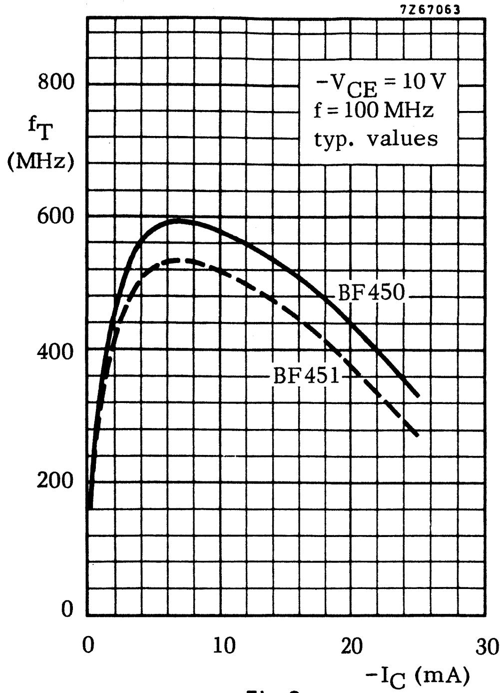

7Z67063
$-V_{CE}$ = 10 V
f = 100 MHz
typ. values
f_T
(MHz)
800
600
400
200
0
BF450
BF451
0
10
20
30
$-I_C$ (mA)

Fig. 2.

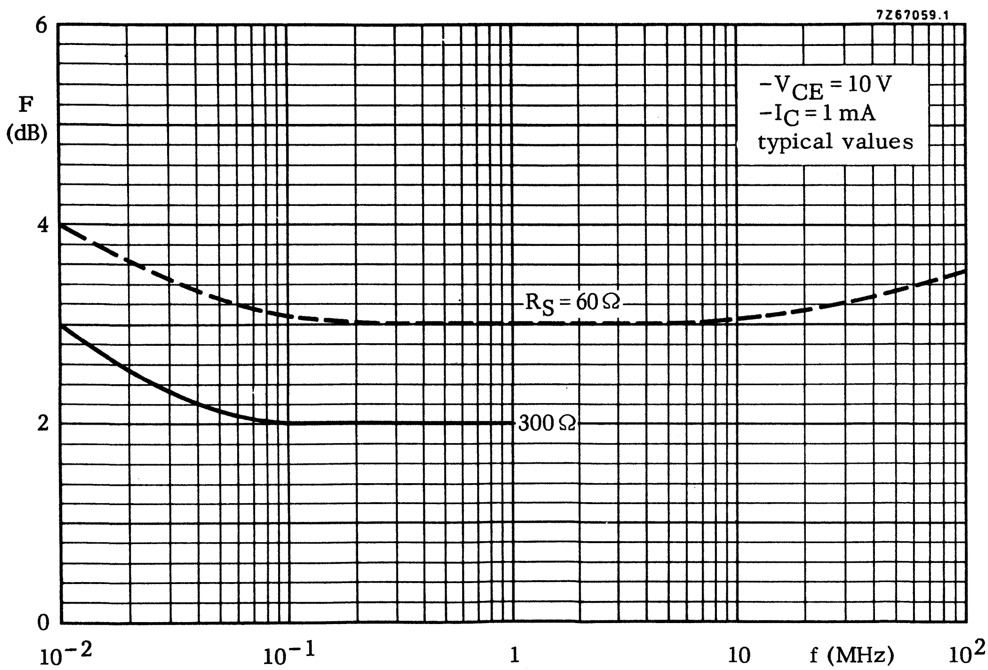

7Z67059.1
$-V_{CE}$ = 10 V
$-I_C$ = 1 mA
typical values
F
(dB)
6
4
2
0
R_S = 60 Ω
300 Ω
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

Fig. 3.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-92 variant envelope and intended for use in video output stages in black-and-white and in colour television receivers.

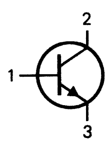
QUICK REFERENCE DATA

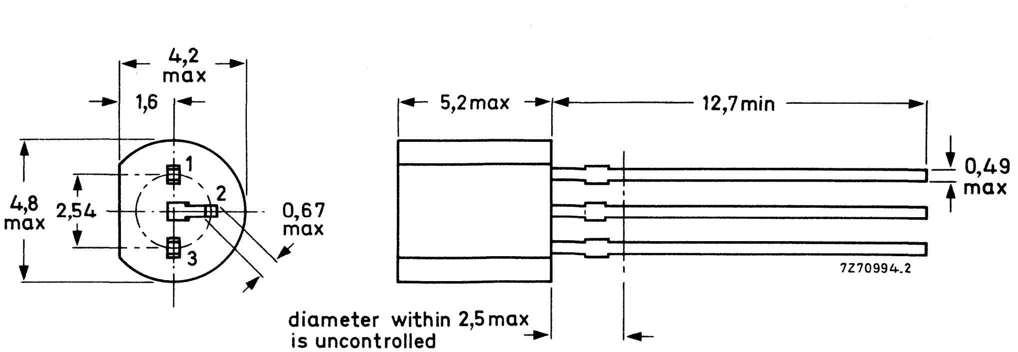
			BF483	BF485	BF487	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	350	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	300	350	V
Collector current (peak value)	I_{CM}	max.		100		mA
Total power dissipation (free air)	P_{tot}	max.		830		mW
D.C. current gain I_C = 25 mA; V_{CE} = 20 V	h_{FE}	⩾		50		
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T			70 to 110		MHz
Junction temperature	T_j	max.		150		°C

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





RATINGS

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

			BF483	BF485	BF487	
Collector-base voltage (open emitter)	V_{CBO}	max.	300	350	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	300	350	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current						
d.c.	I_C	max.		50		mA
peak value	I_{CM}	max.		100		mA
Total power dissipation in free air 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 when mounted on a p.c. board and mounting pad for collector lead minimum 10 mm x 10 mm and maximum lead length 4 mm	$R_{th\ j\text{-}a}$	max.	150	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; V_{CB} = 300 V	I_{CBO}	$\leqslant$	20	nA
Collector-emitter cut-off current				
V_{CE} = 250 V; R_{BE} = 2,7 kΩ; T_j = 150 °C	I_{CER}	$\leqslant$	20	μA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	$\leqslant$	10	μA
High-frequency knee voltage				
→ I_C = 25 mA; T_j = 150 °C	V_{CEK}	$\leqslant$	20	V
D.C. current gain				
I_C = 25 mA; V_{CE} = 20 V	h_{FE}	$\geqslant$	50	
I_C = 40 mA; V_{CE} = 20 V	h_{FE}	$\geqslant$	20	
Transition frequency				
$-I_E$ = 10 mA; V_{CB} = 10 V	f_T		70 to 110	MHz
Feedback capacitance at f = 1 MHz				
$I_E = 0$; V_{CB} = 30 V	C_{re}	$\leqslant$	1,4	pF

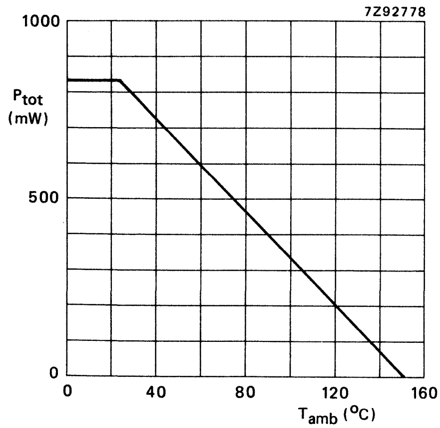


Fig. 2 Maximum permissible power dissipation.

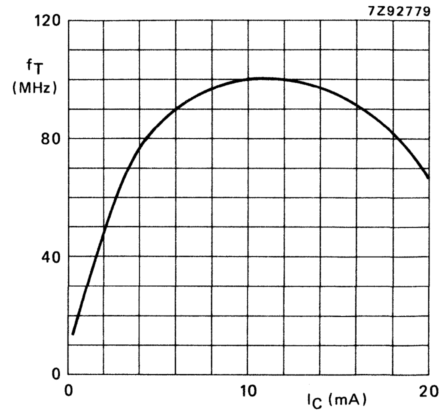


Fig. 3 V_{CE} = 10 V; f = 100 MHz; typical values.

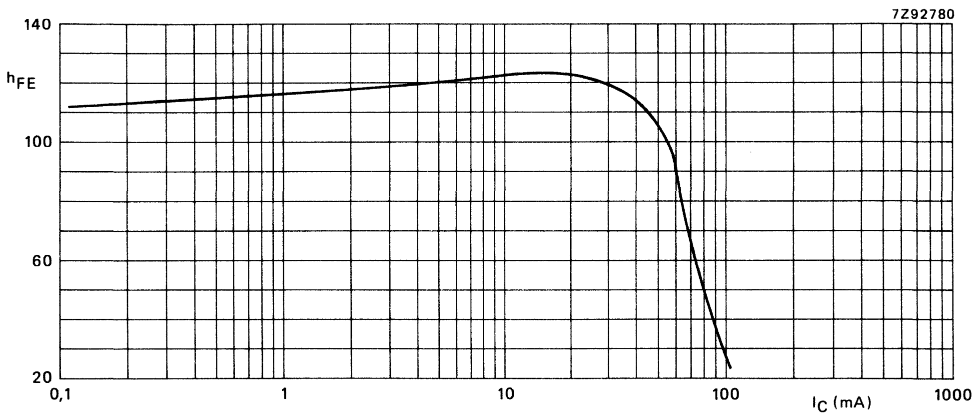


Fig. 4 T_j = 25 °C; V_{CE} = 20 V; typical values.

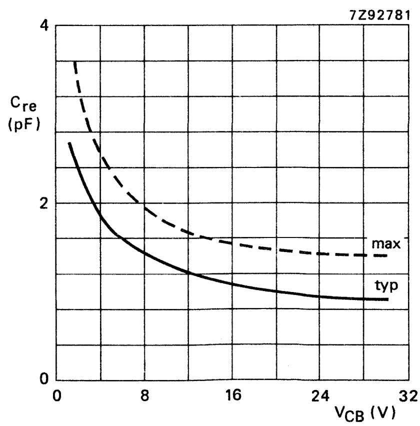


Fig. 5 I_E = 0; f = 1 MHz.

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.

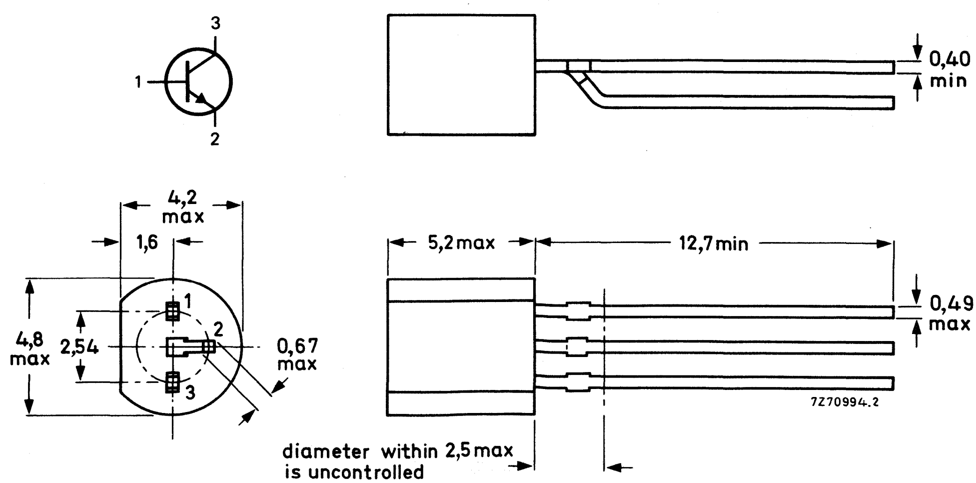
QUICK REFERENCE DATA

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

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.	5 V
Collector current (d.c.)	I_C	max.	30 mA
Collector current (peak value)	I_{CM}	max.	30 mA
Total power dissipation up to T_{amb} = 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	$R_{th\ j\text{-}a}$	=	0,25 K/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

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 2)	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
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 mS; f = 0,2 MHz	F	typ.	1,5 dB
G_S = 1,5 mS; f = 1,0 MHz	F	typ.	1,2 dB
G_S = 10 mS; f = 100 MHz	F	typ.	4 dB
Conversion noise figure			
I_C = 1 mA; V_{CE} = 10 V			
G_S = 0,6 mS; f = 0,2 MHz	F_c	typ.	3 dB
G_S = 1,2 mS; f = 1,0 MHz	F_c	typ.	2 dB

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

2) BF494B I_B 4,5 to 10 µA

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 mS
Input susceptance	$-b_{ib}$	typ.	3 mS
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	500 μS
Phase angle of feedback admittance	φ_{rb}	typ.	272°
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	33 mS
Phase angle of transfer admittance	φ_{fb}	typ.	150°
Output conductance	g_{ob}	typ.	22 μS
Output susceptance	b_{ob}	typ.	1,1 mS

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 mS
Output conductance	g_{oe}	< 13,5	11,5 μS

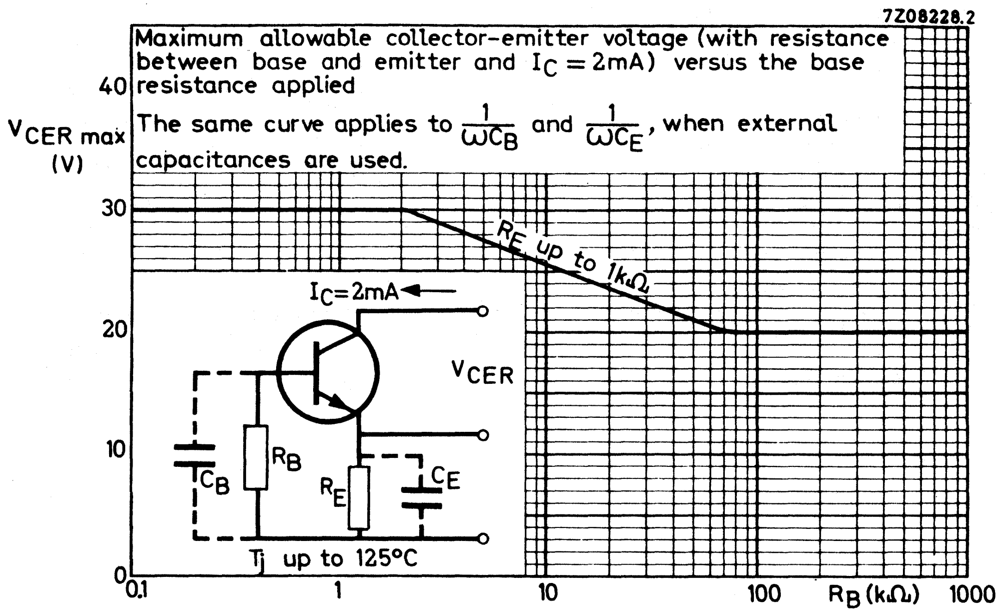

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)
0
10
20
30
40
0.1
1
10
100
1000

Fig. 2.

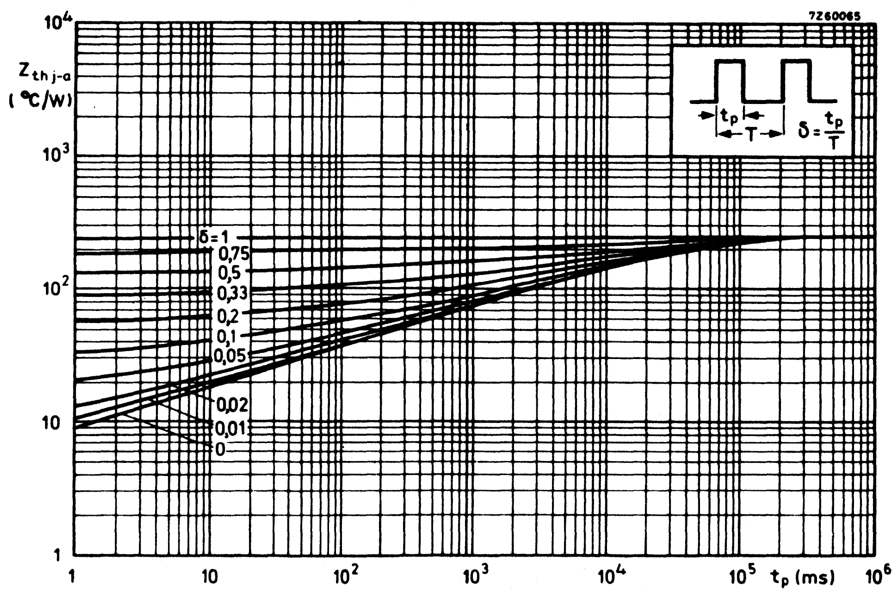

7Z60065
$Z_{th\,j\text{-}a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
1
10
10^2
10^3
10^4
10^5
10^6
t_p (ms)

Fig. 3.

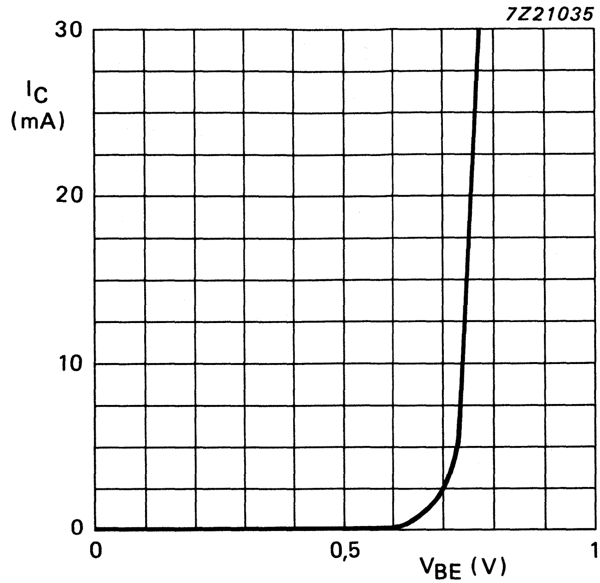


Fig. 4 V_{CE} = 2 V; T_j = 25 °C; typical values.

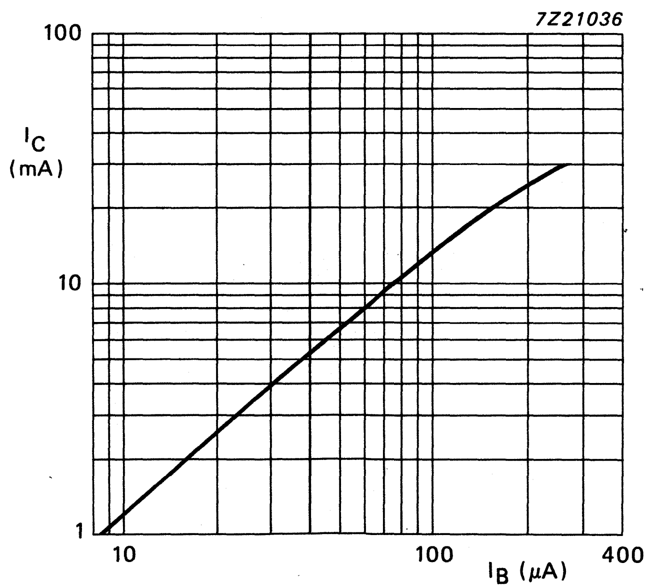


Fig. 5 V_{CE} = 2 V; T_j = 25 °C; typical values.

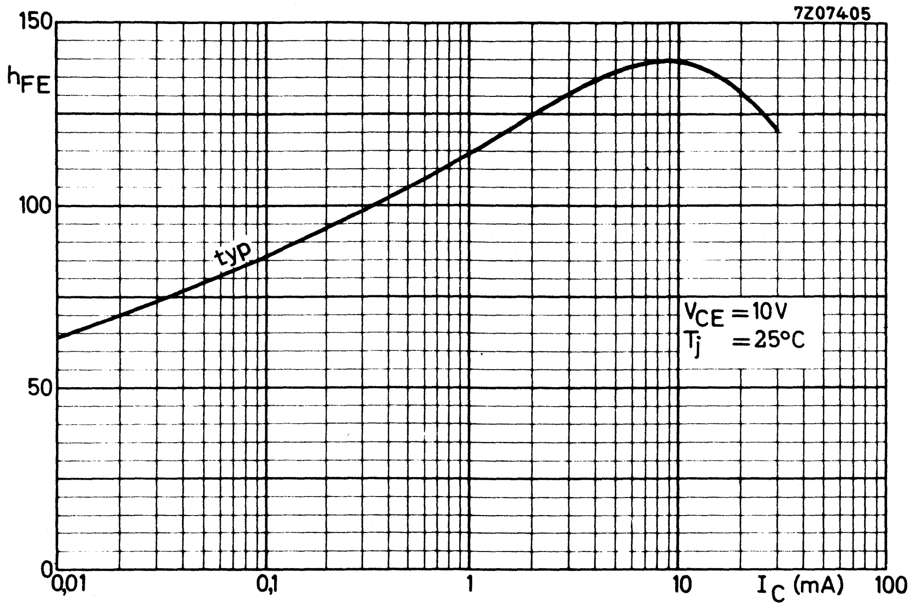

7Z07405
150
h_{FE}
100
typ
V_{CE} = 10 V
T_j = 25°C
50
0
0,01
0,1
1
10
I_C (mA)
100

Fig. 6.

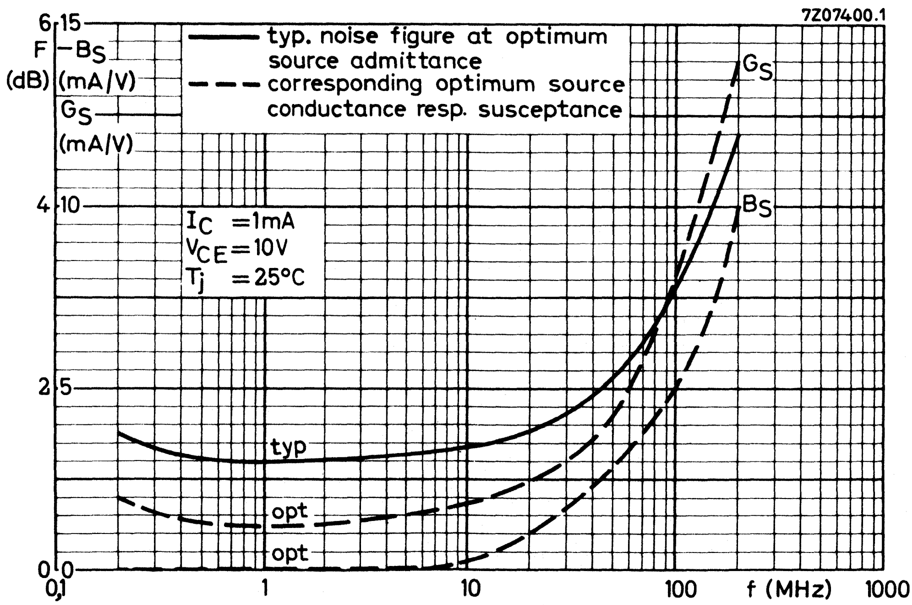

7Z07400.1
6
15
F
(dB)
$-B_S$
(mA/V)
G_S
(mA/V)
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
4
10
I_C = 1 mA
V_{CE} = 10 V
T_j = 25°C
2
5
typ
opt
opt
G_S
B_S
0
0
0,1
1
10
100
f (MHz)
1000

Fig. 7.

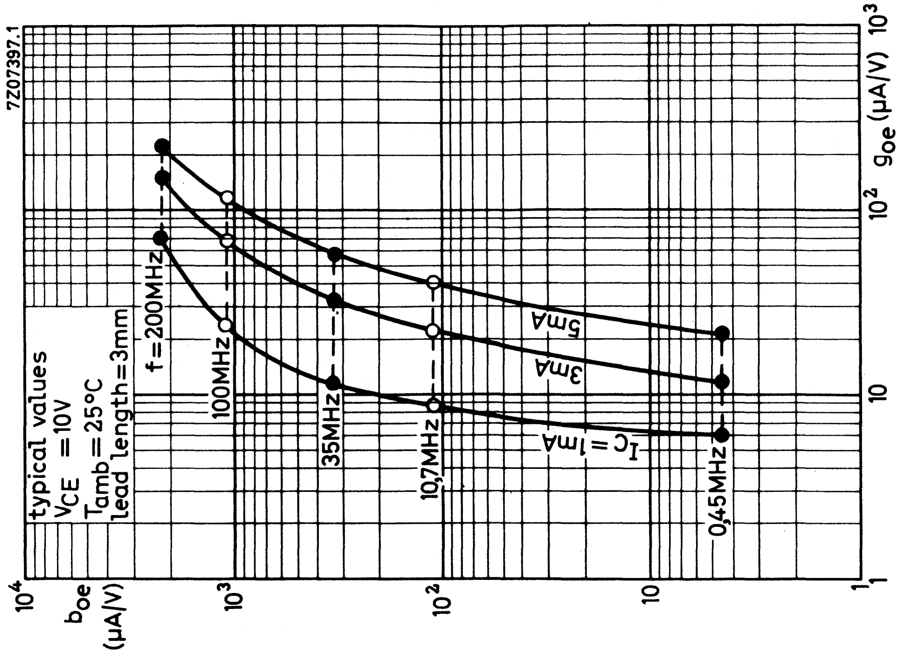

7Z07397.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{oe} (μA/V)
g_{oe} (μA/V)

Fig. 8.

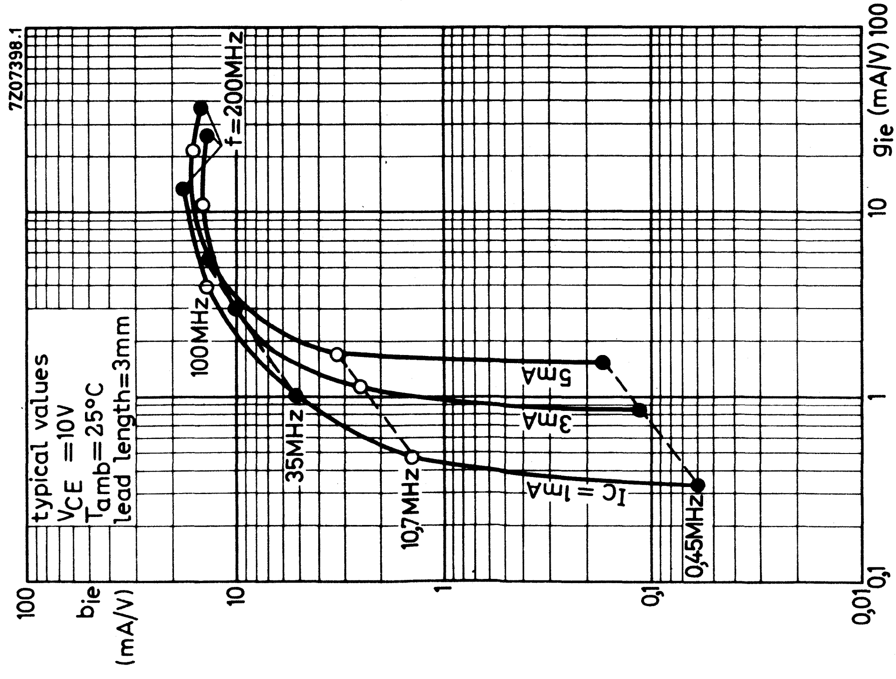
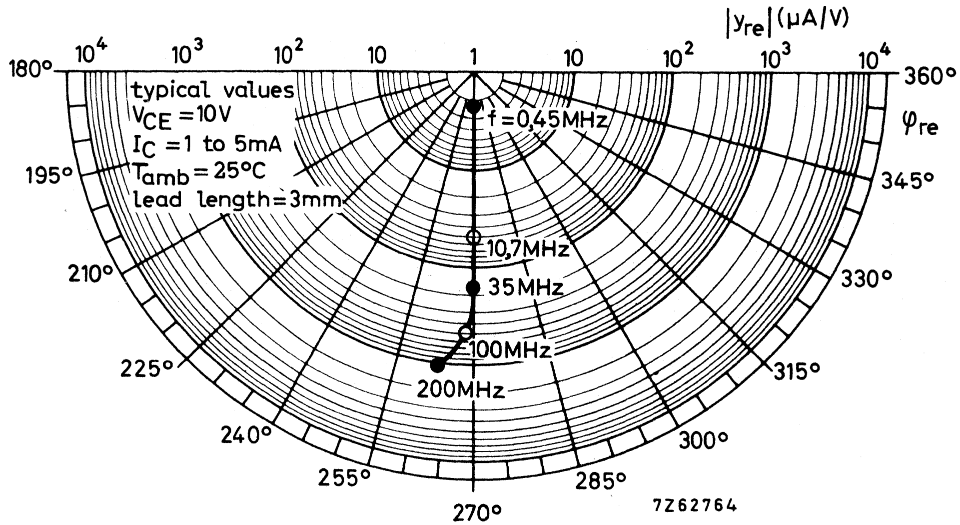
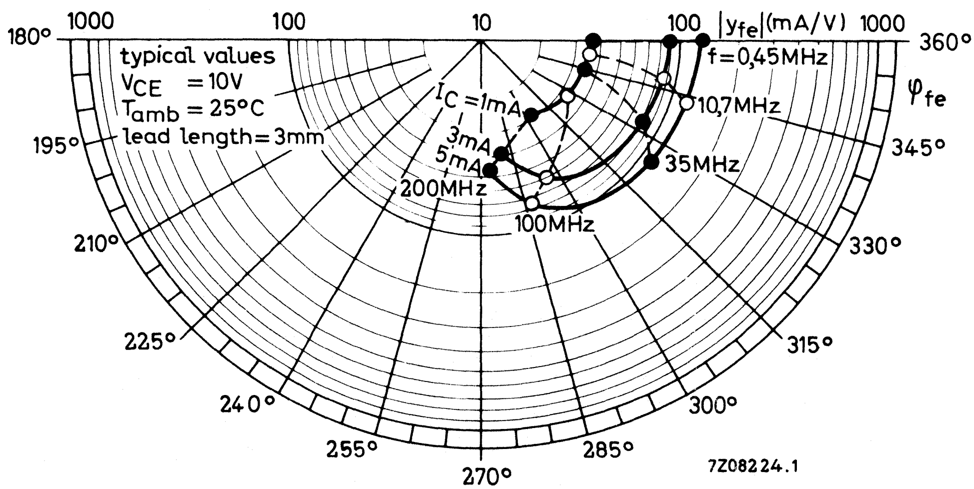

7Z07398.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{ie} (mA/V)
g_{ie} (mA/V)

Fig. 9.



|yre| (μA/V)
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4
180°
360°
φre
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
7Z62764

Fig. 10.



1000
100
10
100
|yfe| (mA/V)
1000
180°
360°
φfe
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
7Z08224.1

Fig. 11.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of car radios where a low noise figure at low source impedance is required.

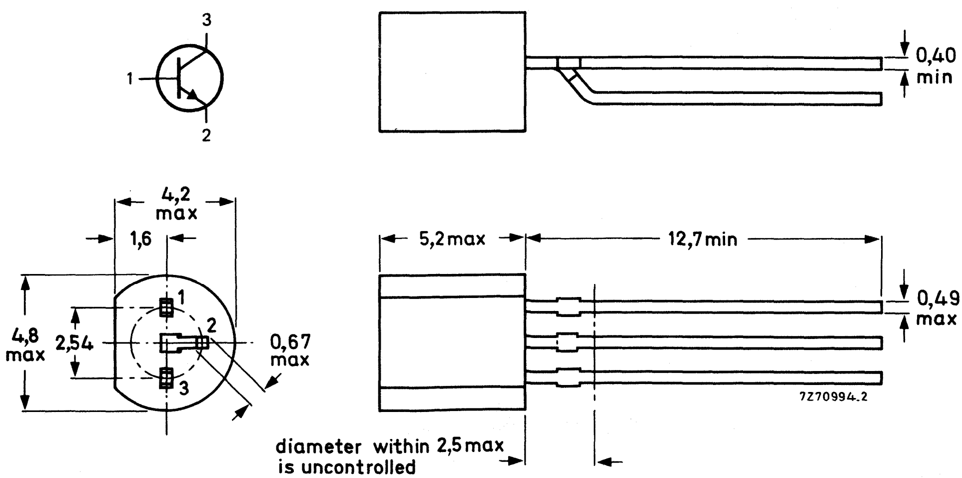
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 75 °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

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.	5 V
Collector current (d.c.)	I_C	max.	30 mA
Collector current (peak value)	I_{CM}	max.	30 mA
Total power dissipation up to T_{amb} = 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	$R_{th\,j\text{-}a}$	=	0,25 K/mW

CHARACTERISTICS

T_j = 25 °C

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 [2]	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
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 mS; f = 1 MHz	F	typ.	3,5 dB
G_S = 10 mS; f = 100 MHz	F	typ.	4 dB
Conversion noise figure			
I_C = 1 mA; V_{CE} = 10 V			
G_S = 1,2 mS; f = 0,2 MHz	F_c	typ.	4 dB
G_S = 1,5 mS; f = 1 MHz	F_c	typ.	2,5 dB

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

2) BF495C I_B 8 to 15 μA
BF495D I_B 13 to 28 μA

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	mS
Input susceptance	$-b_{ib}$	typ.	1	mS
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	490	µS
Phase angle of feedback admittance	φ_{rb}	typ.	272	°
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	34	mS
Phase angle of transfer admittance	φ_{fb}	typ.	144	°
Output conductance	g_{ob}	typ.	12	µS
Output susceptance	b_{ob}	typ.	1,1	mS

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	mS
Output conductance	g_{oe}	<	9,5	7,0	µS

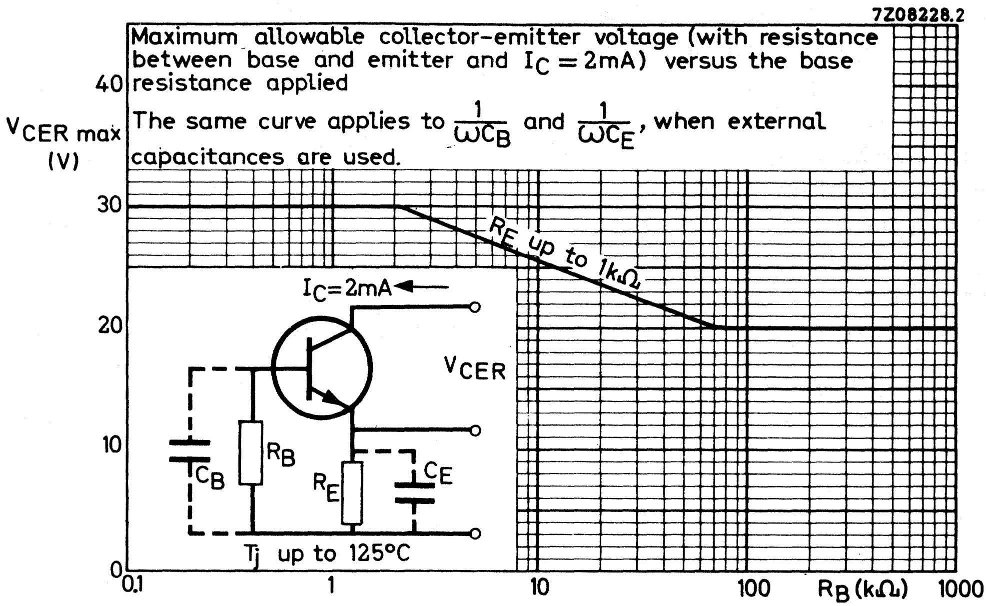

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000
RE up to 1kΩ
$I_C = 2mA$
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 125°C

Fig. 2.

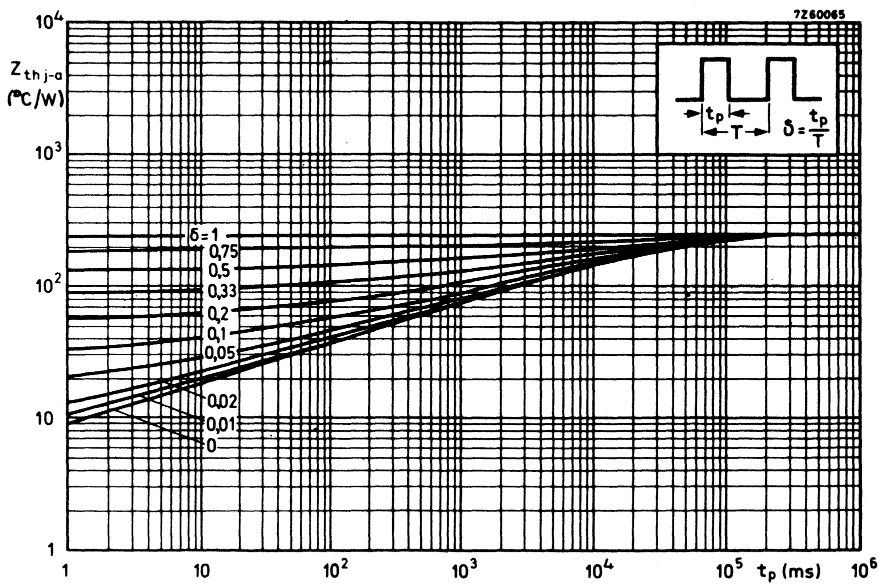

7Z60065
$Z_{th\,j\text{-}a}$ (°C/W)
10^4
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 3.

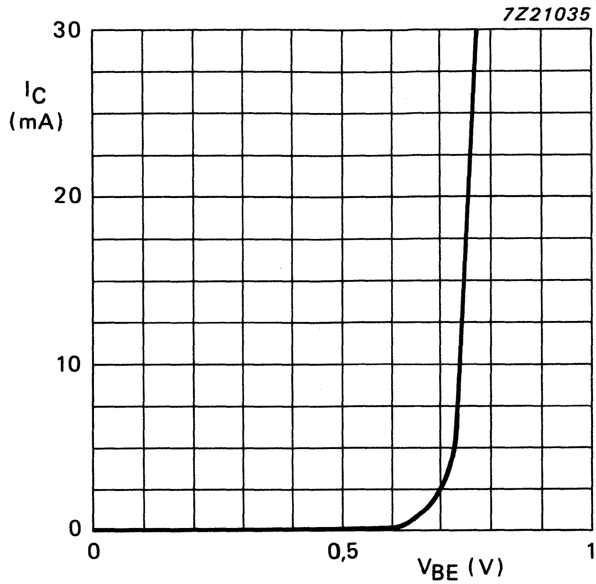


Fig. 4 V_{CE} = 2 V; T_j = 25 °C; typical values.

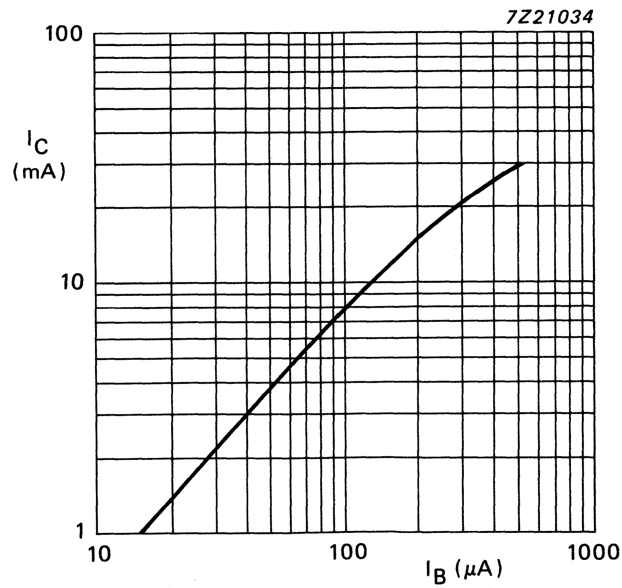


Fig. 5 V_{CE} = 2 V; T_j = 25 °C; typical values.

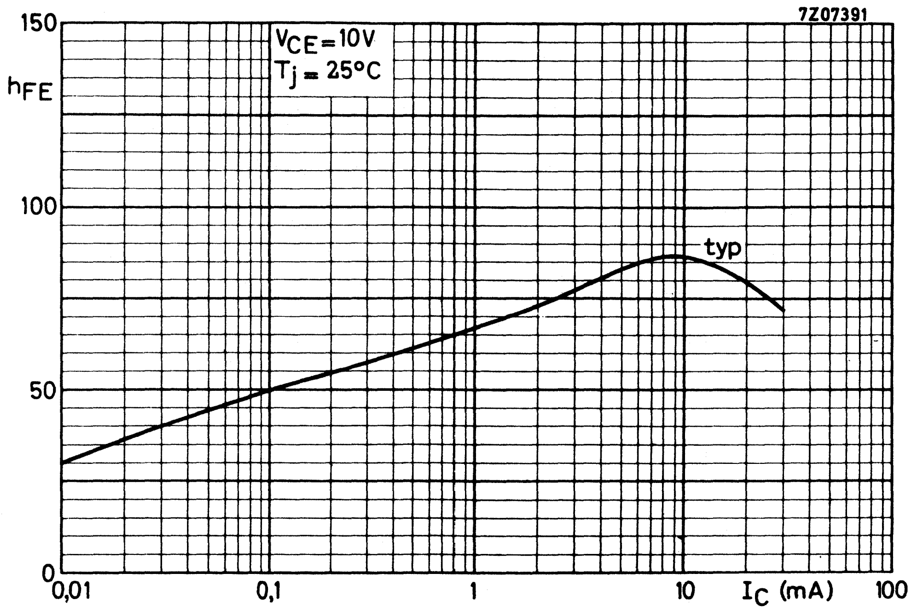

7Z07391
150
h_{FE}
100
50
0
$V_{CE} = 10 V$
$T_j = 25 °C$
typ
0,01
0,1
1
10
I_C (mA)
100

Fig. 6.

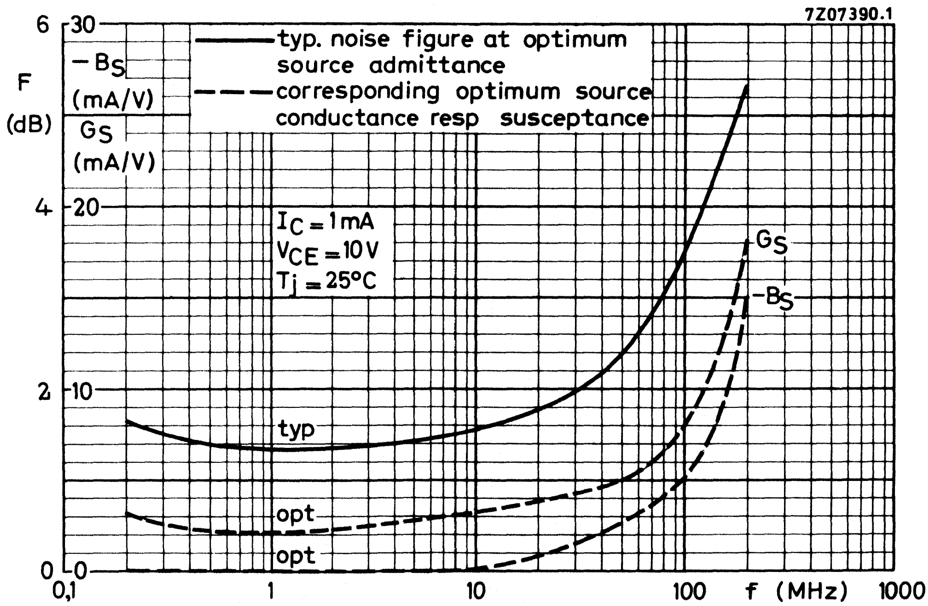

7Z07390.1
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
F (dB)
$-B_S$ (mA/V)
G_S (mA/V)
6
30
4
20
2
10
0
0
$I_C = 1 mA$
$V_{CE} = 10 V$
$T_j = 25 °C$
typ
opt
opt
G_S
$-B_S$
0,1
1
10
100
f (MHz)
1000

Fig. 7.

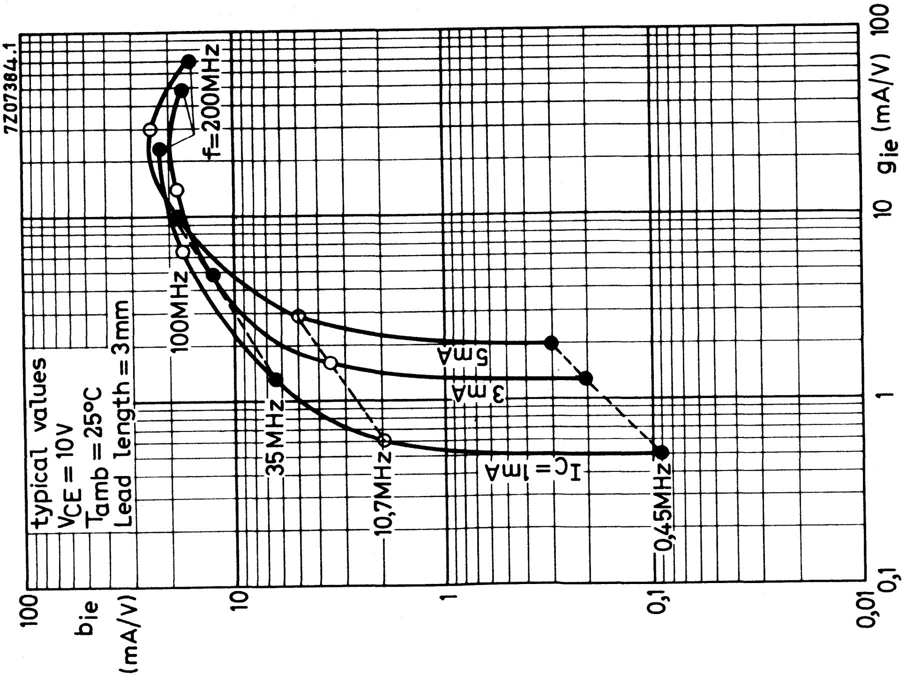

7Z07384.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA
b_{ie} (mA/V)
g_{ie} (mA/V)
100
10
1
0,1
0,01
0,1
1
10
100

Fig. 8.

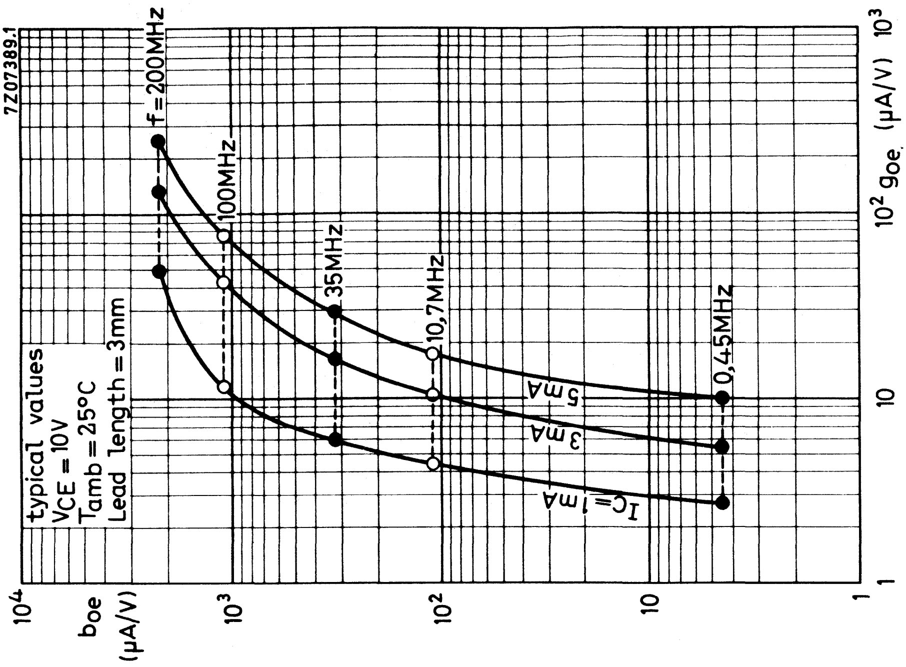

7Z07389.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA
b_{oe} (μA/V)
g_{oe} (μA/V)
10^4
10^3
10^2
10
1
1
10
10^2
10^3

Fig. 9.

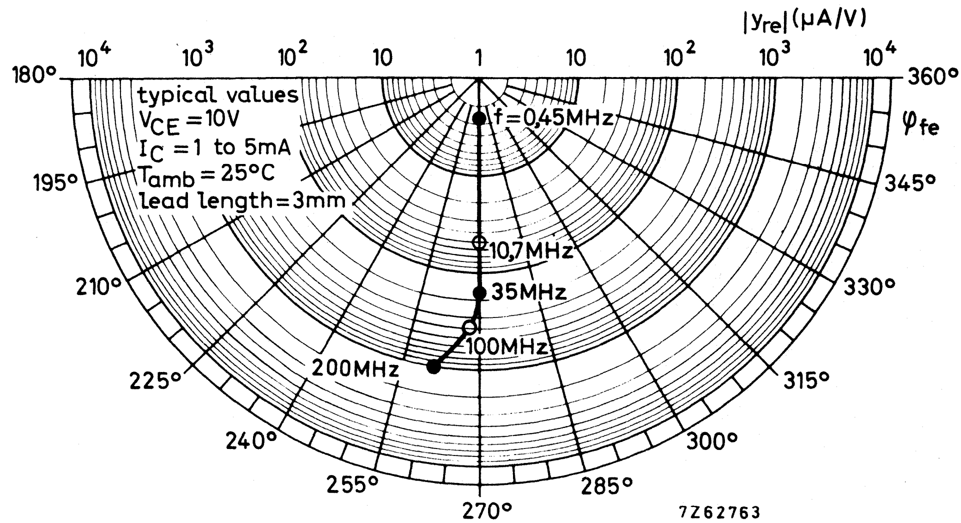

|y_re| (μA/V)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_fe
typical values
V_CE = 10V
I_C = 1 to 5mA
T_amb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
7Z62763

Fig. 10.

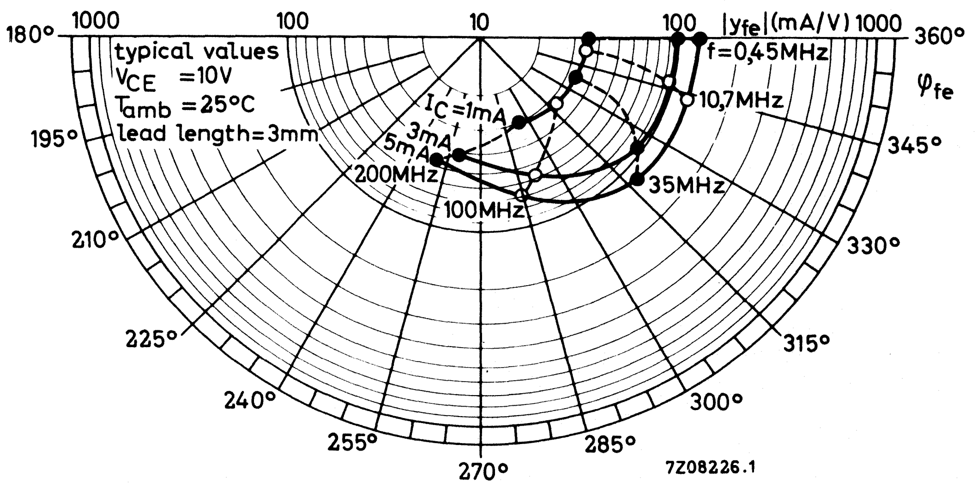

1000 100 10 100 |y_fe| (mA/V) 1000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_fe
typical values
V_CE = 10V
T_amb = 25°C
lead length = 3mm
I_C = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
7Z08226.1

Fig. 11.

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.

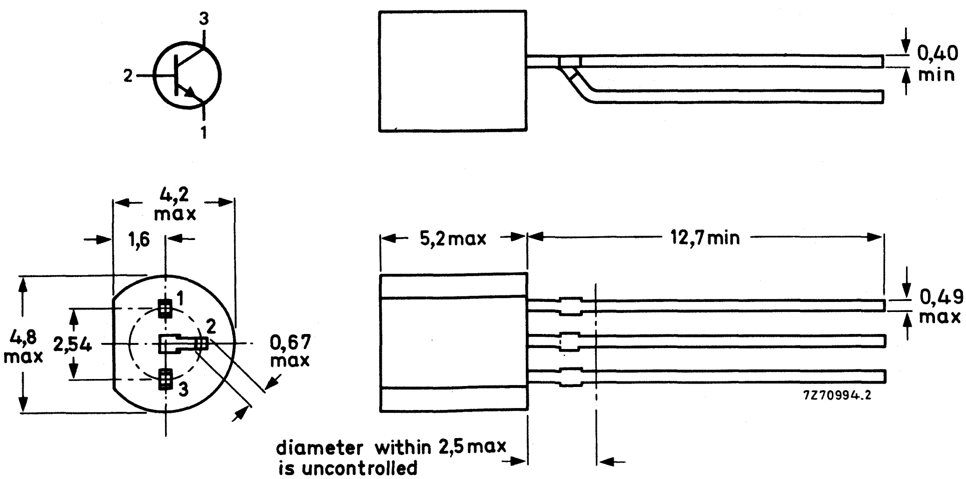
QUICK REFERENCE DATA

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 ($R_{BE} \leqslant 1$ 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}	−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

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)

$$G_{UM} = 10 \log \frac{|Y_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E$ = 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 mS
Input susceptance	$-b_{ib}$	typ.	15 mS
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	190 mS
Phase angle of feedback admittance	φ_{rb}	typ.	280°
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	66 mS
Phase angle of transfer admittance	φ_{fb}	typ.	155°
Output conductance	g_{ob}	typ.	15 μS
Output susceptance	b_{ob}	typ.	660 μS

y-parameters at f = 50 MHz (common base)
$-I_E$ = 3 mA; V_{CB} = 10 V

Input conductance	g_{ib}	typ.	9,5 mS
Input susceptance	$-b_{ib}$	typ.	12 mS
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	100 μS
Phase angle of feedback admittance	φ_{rb}	typ.	270°
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	95 mS
Phase angle of transfer admittance	φ_{fb}	typ.	160°
Output conductance	g_{ob}	typ.	10 μS
Output susceptance	b_{ob}	typ.	350 μS

y-parameters at f = 200 MHz (common base)
$-I_E$ = 3 mA; V_{CB} = 10 V

Input conductance	g_{ib}	typ.	70 mS
Input susceptance	$-b_{ib}$	typ.	46 mS
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	340 μS
Phase angle of feedback admittance	φ_{rb}	typ.	275°
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	85 mS
Phase angle of transfer admittance	φ_{fb}	typ.	130°
Output conductance	g_{ob}	typ.	75 μS
Output susceptance	b_{ob}	typ.	1,3 mS

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.

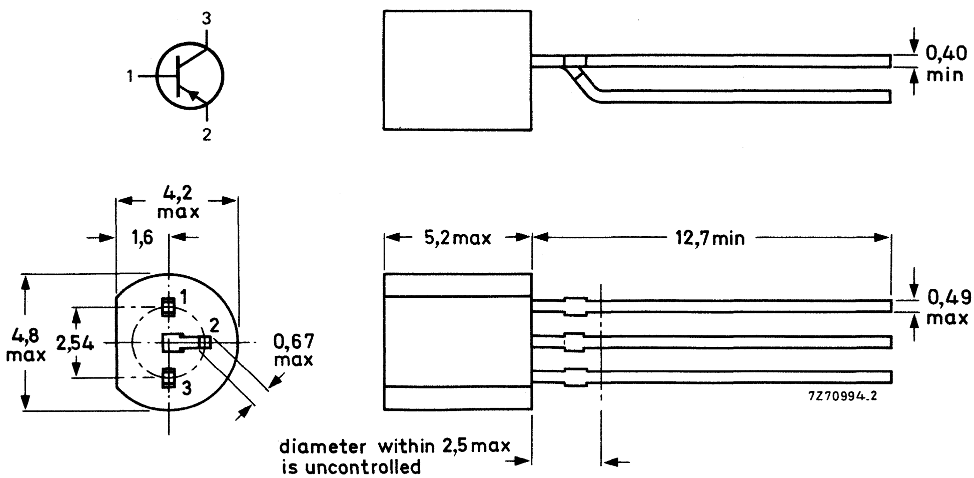
QUICK REFERENCE DATA

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}	−65 to +	150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	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. 400 to	500 700	MHz 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 6	dB 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}	$>$ typ.	14 17,5	dB 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.

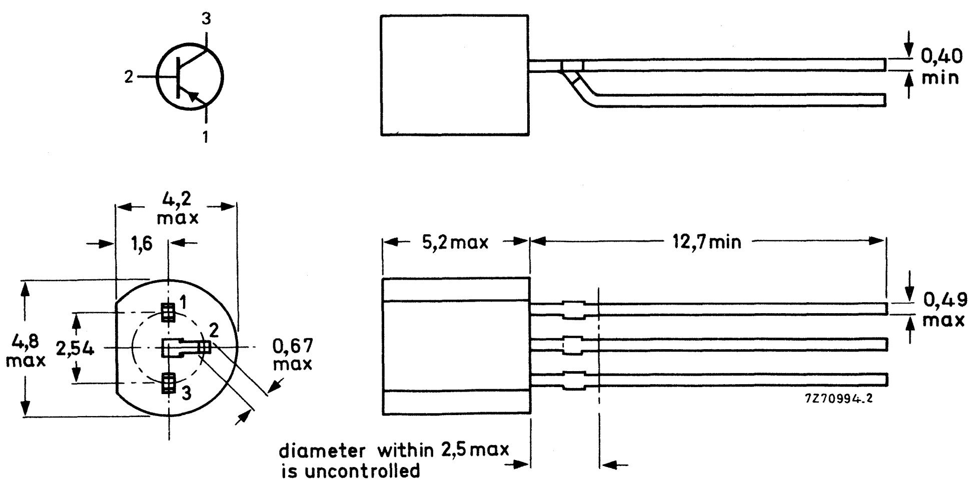
QUICK REFERENCE DATA

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}		−65 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	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; $R_S = 50\ \Omega$	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}	> typ.	14 dB 17,5 dB

SILICON PLANAR TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for application as a gain controlled preamplifier in v.h.f. tuners.

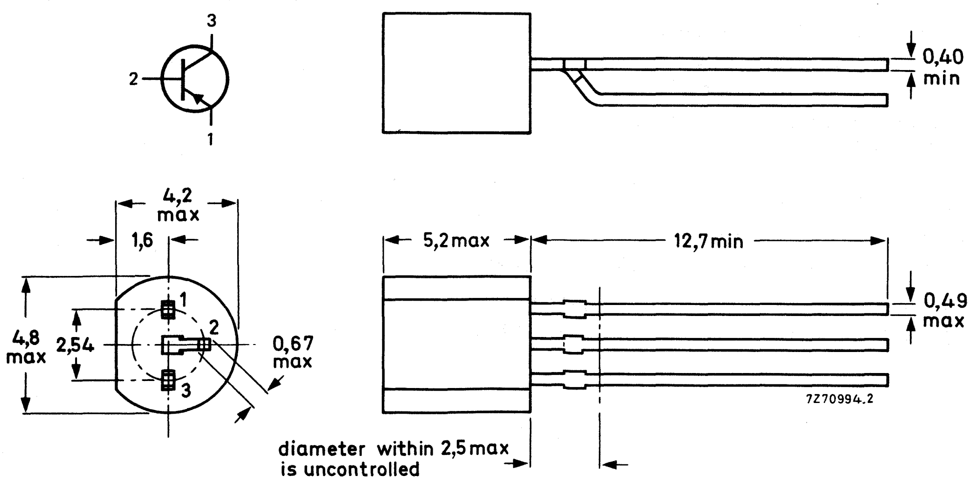
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to T_{amb} = 55 °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}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	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. <	55 125	μA 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. <	135 160	fF fF
Noise figure at f = 200 MHz $I_E = 2$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 1$ kΩ	F	typ. <	2,5 4	dB dB
Transducer gain (common base) at f = 200 MHz $I_E = 2$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 1$ kΩ	G_{tr}	typ.	16	dB

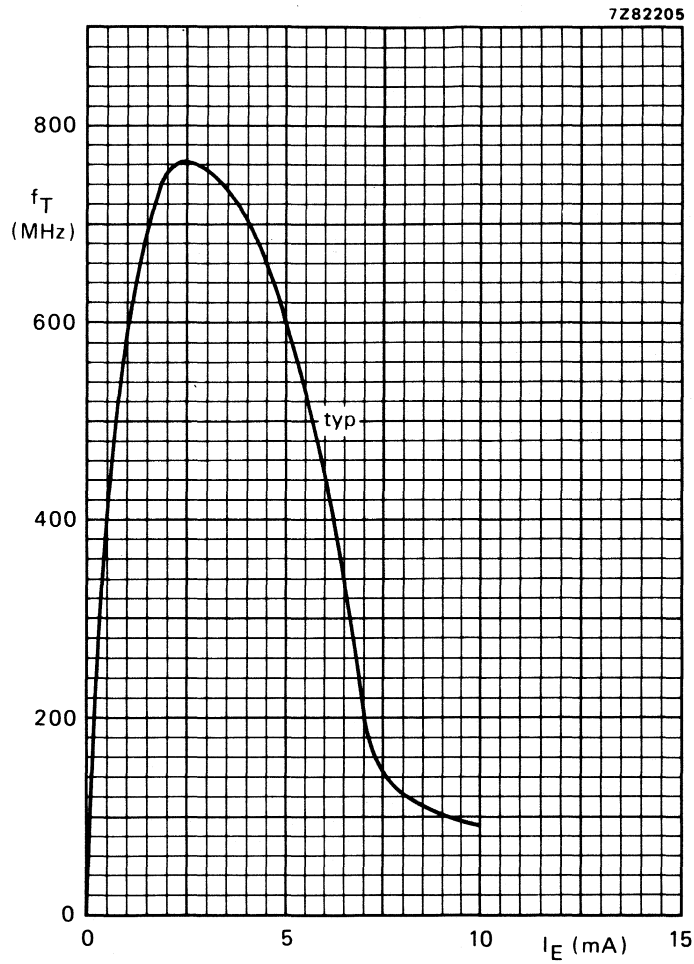


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 ^{o}C.

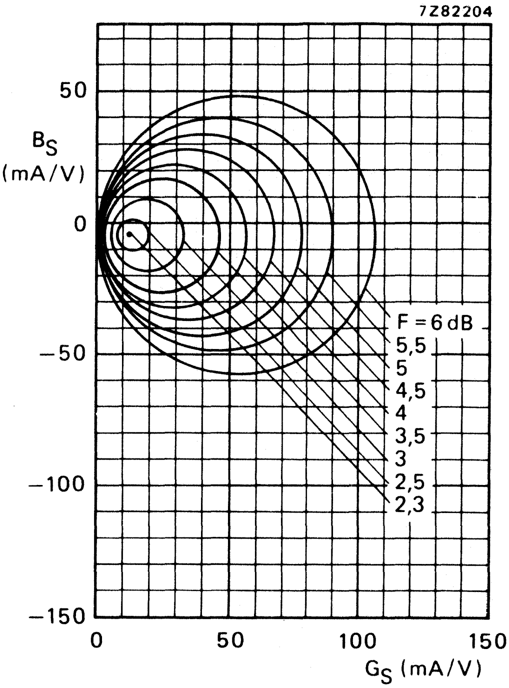


Fig. 3 Circles of constant noise figure.
$-V_{CB}$ = 10 V; I_E = 2 mA; f = 200 MHz;
T_{amb} = 25 °C; typical values.

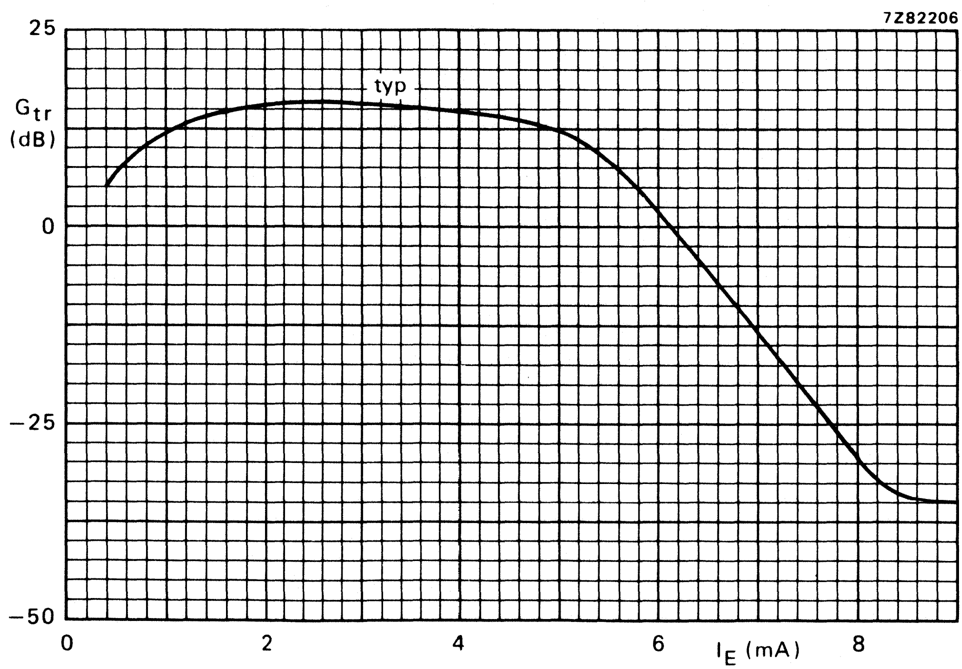


Fig. 4 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 920 Ω; R_S = 60 Ω; f = 200 MHz; T_{amb} = 25 °C.

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

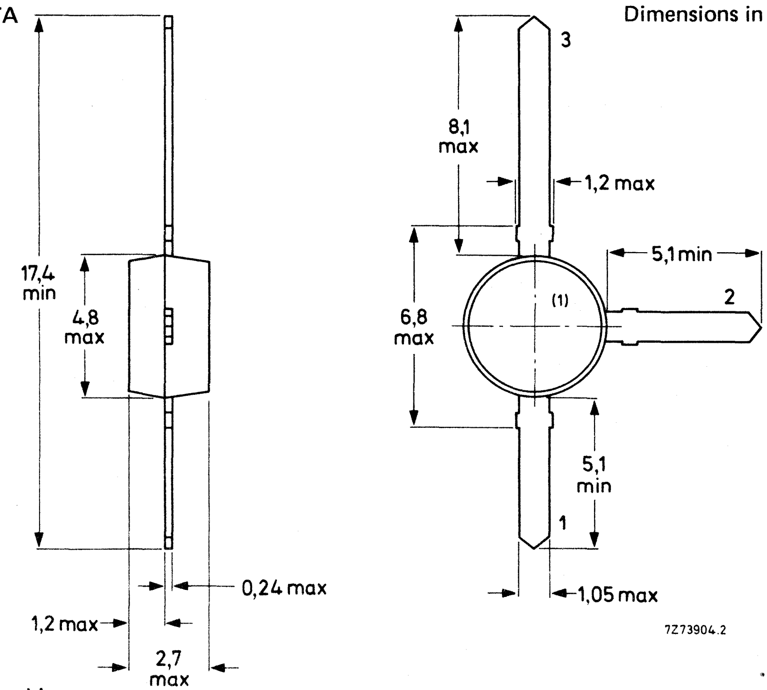
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector current (d.c.)	$-I_C$	max.	20	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 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.

Products approved to CECC 50 002-127

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

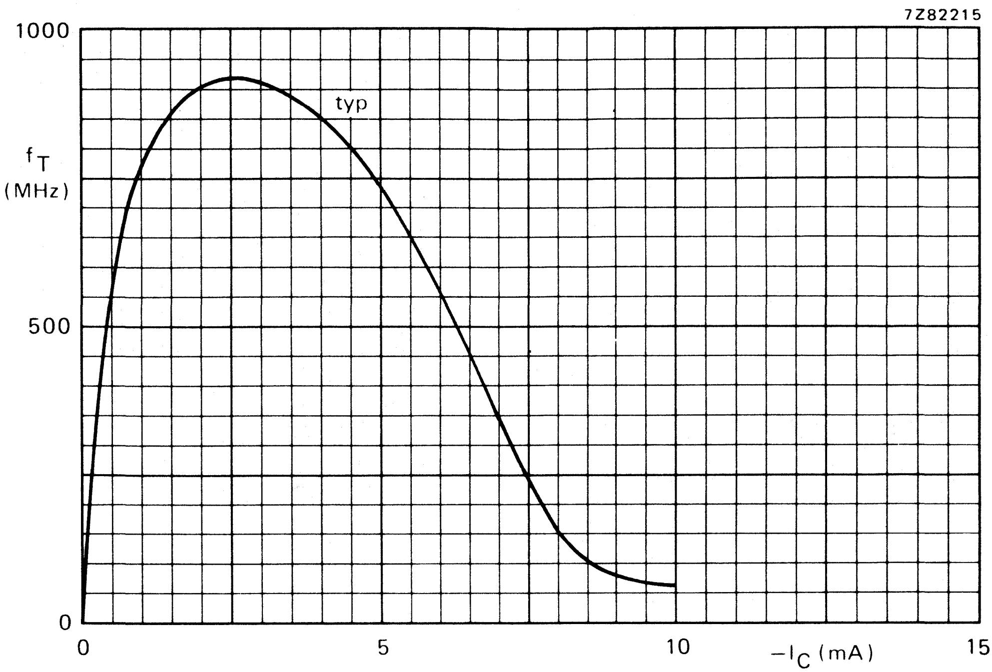


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 °C.

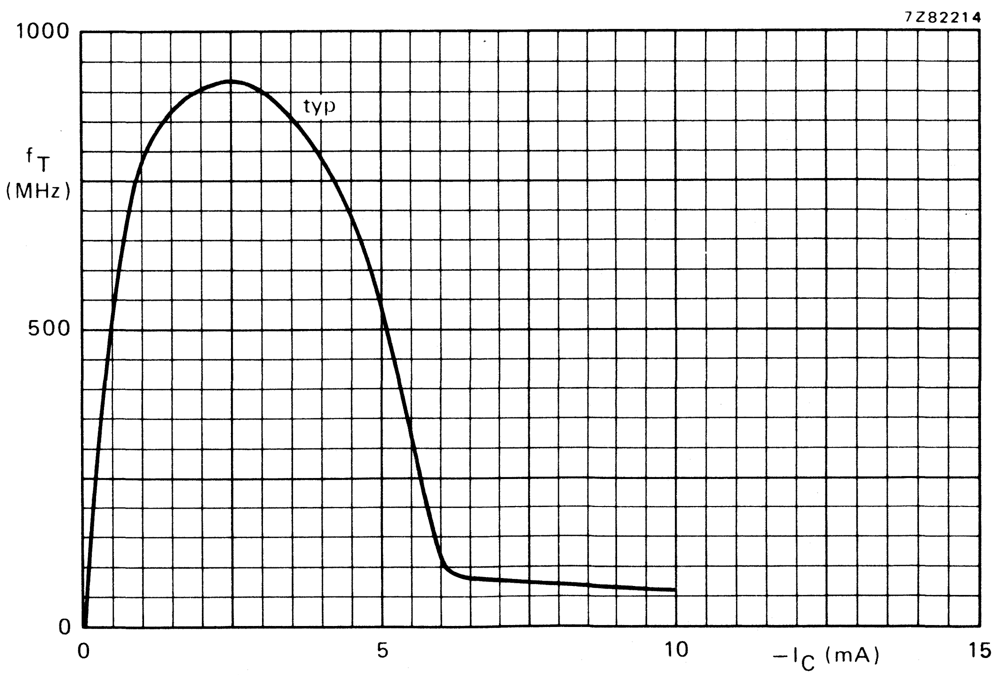


Fig. 3 $-V_{CC}$ = 12 V; R_C = 1 kΩ; f = 100 MHz; T_{amb} = 25 °C.

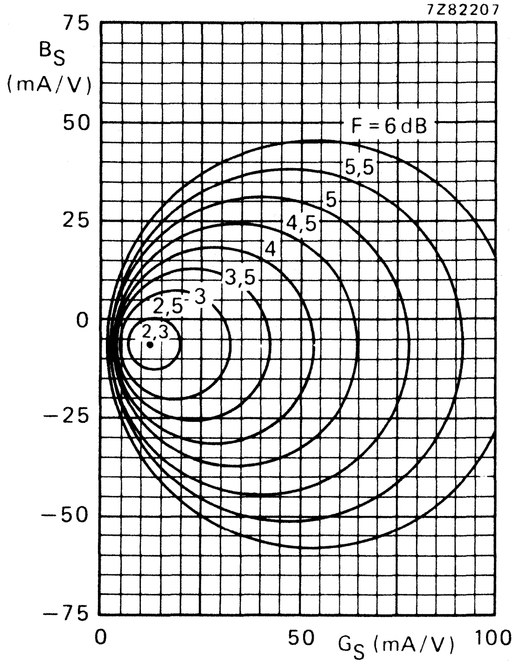


Fig. 4 Circles of constant noise figure.

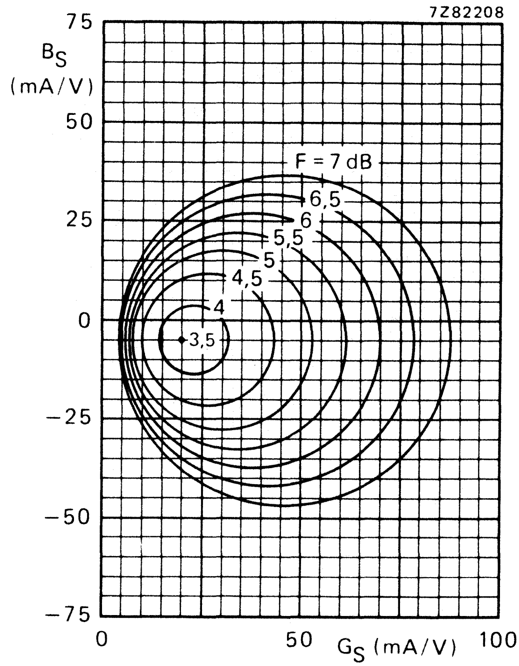
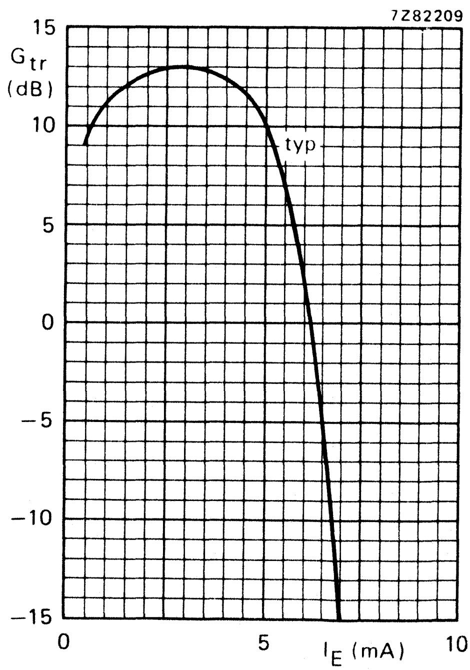


Fig. 5 Circles of constant noise figure.



Measuring conditions:

Fig. 4 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 200 MHz; T_{amb} = 25 °C; typical values.

Fig. 5 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 800 MHz; T_{amb} = 25 °C; typical values.

Fig. 6 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 500 Ω; f = 800 MHz; T_{amb} = 25 °C.

Conditions for Figs 7 to 10: I_E = 3 mA; $-V_{CB}$ = 10 V; T_{amb} = 25 °C; typical values.

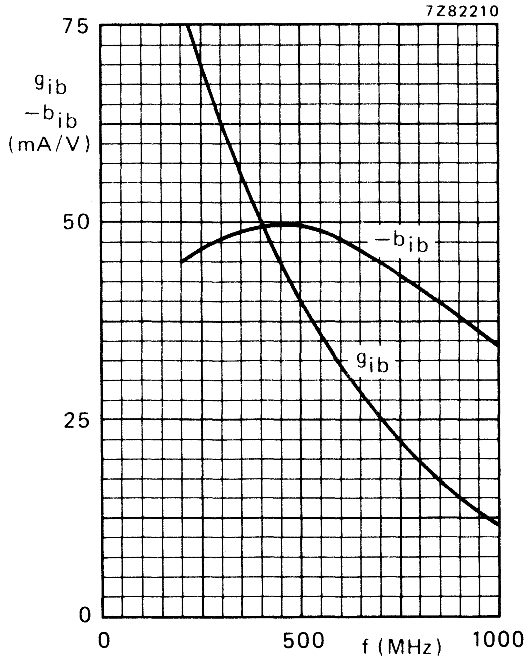


Fig. 7.

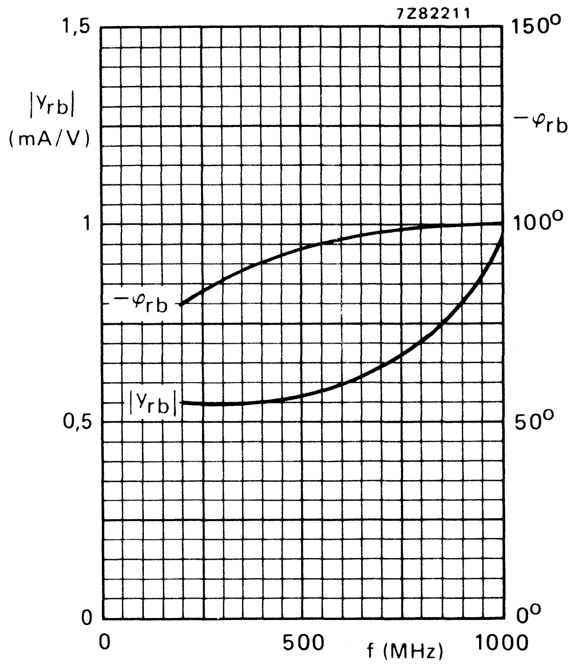


Fig. 8.

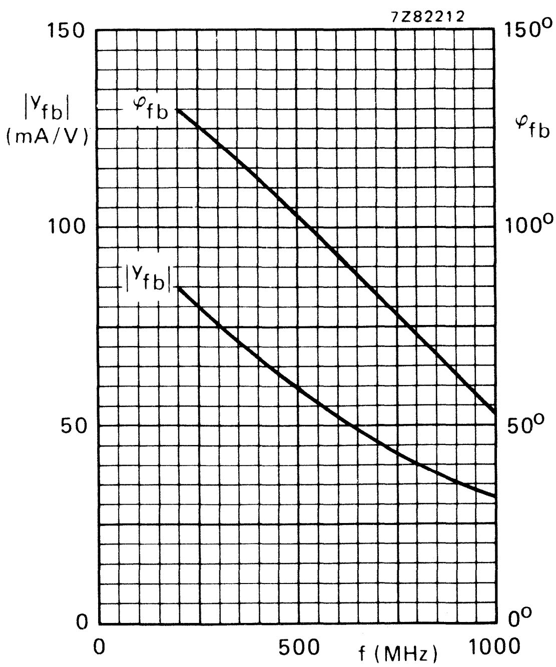


Fig. 9.

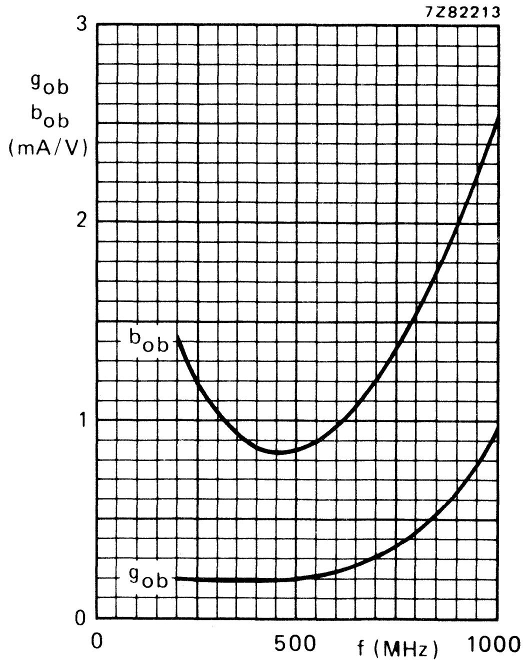


Fig. 10.

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

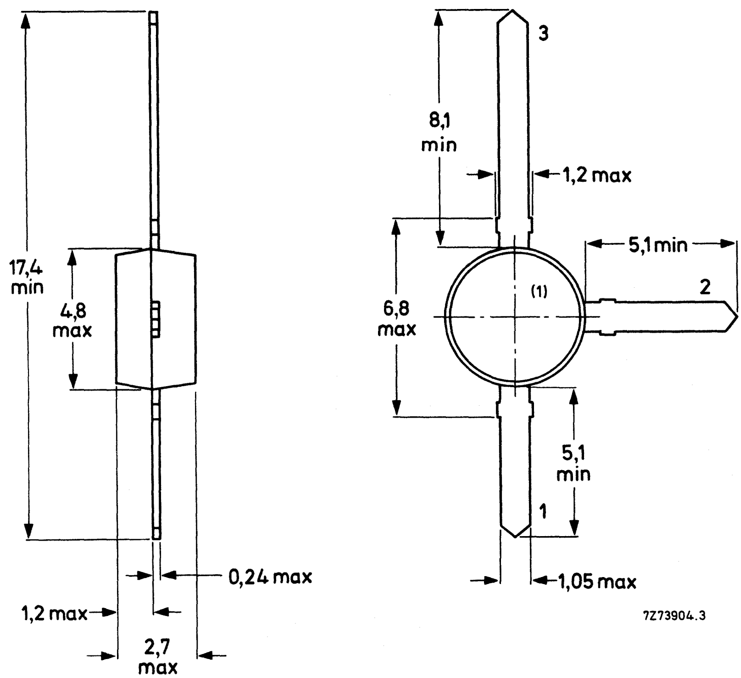
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35	V
Collector current (d.c.)	$-I_C$	max.	30	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 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; $-V_{CB}$ = 10 V	C_{re}	typ.	475	fF
Noise figure at R_S = 60 Ω 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 Ω; R_L = 500 Ω	G_{tr}	>	13,0	dB
		typ.	14,5	dB

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

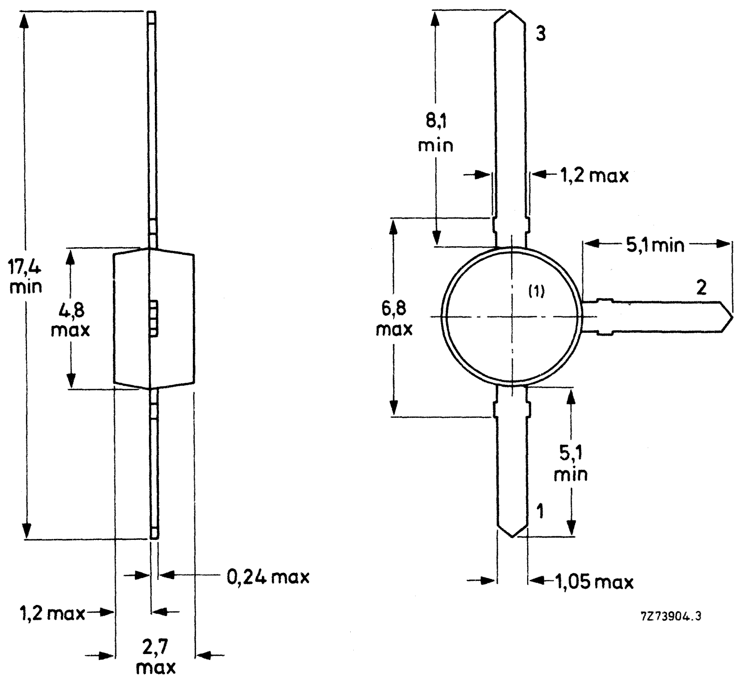
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35 V
Collector current (d.c.)	$-I_C$	max.	30 mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160 mW
Junction temperature	T_j	max.	150 °C
Transition frequency I_E = 3 mA; $-V_{CB}$ = 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 ^oC	P_{tot}	max.	160	mW
Storage temperature	T_{stg}	−55 to + 150		^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	600	K/W

CHARACTERISTICS

T_{amb} = 25 ^oC

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				
$I_E = 3$ 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.	170	fF
$I_E = 1$ mA; $-V_{CB} = 10$ V	C_{re}	typ.	450	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.	15,0	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

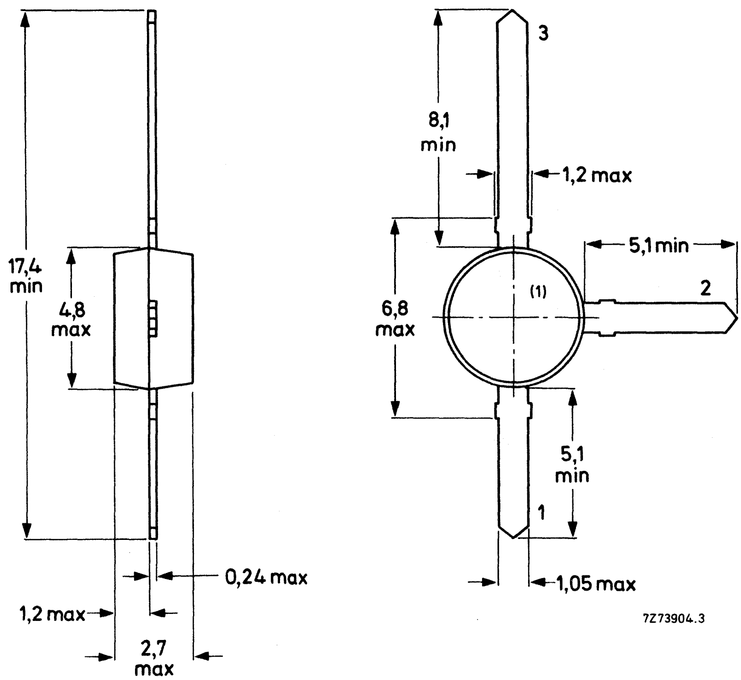
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	30	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	140	mW
Junction temperature	T_j	max.	125	°C
Transition frequency at f = 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

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 μA	$-V_{(BR)CBO}$	>	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 μA	$-V_{(BR)EBO}$	>	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 Ω; R_L = 500 Ω	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 Ω; R_L = 500 Ω	G_{tr}	typ.	16	dB

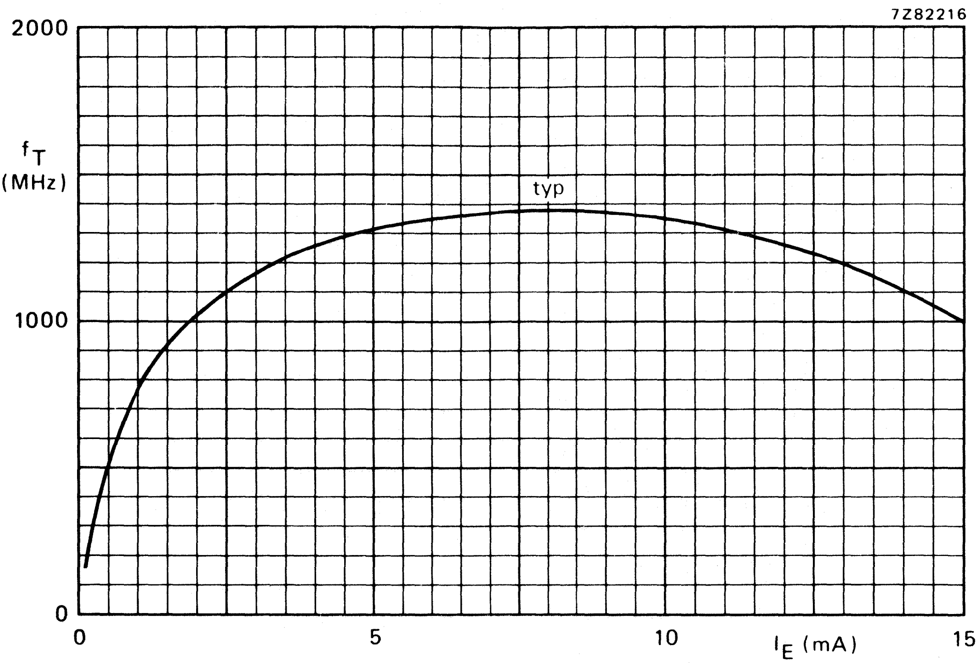


Fig. 2 $-V_{CB}$ = 10 V; T_j = 25 °C.

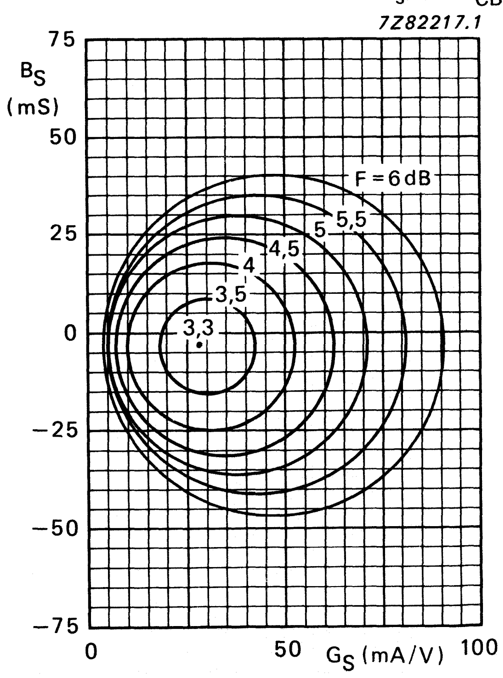


Fig. 3 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 200 MHz; T_{amb} = 25 °C; typical values.

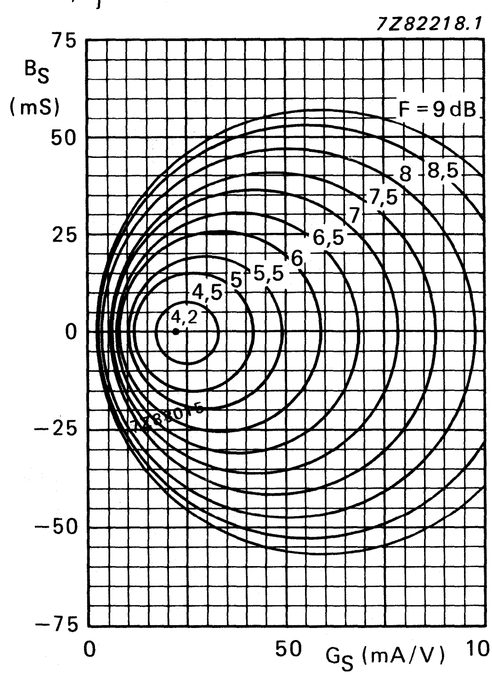


Fig. 4 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz; T_{amb} = 25 °C; typical values.

Conditions for Figs 5 to 8: I_E = 10 mA; ——— $-V_{CB}$ = 10 V; - - - - $-V_{CB}$ = 5 V; T_{amb} = 25 °C; typical values.

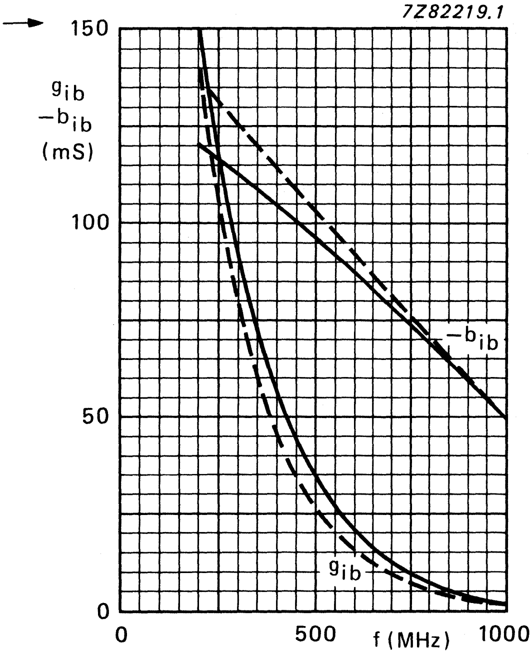


Fig. 5.

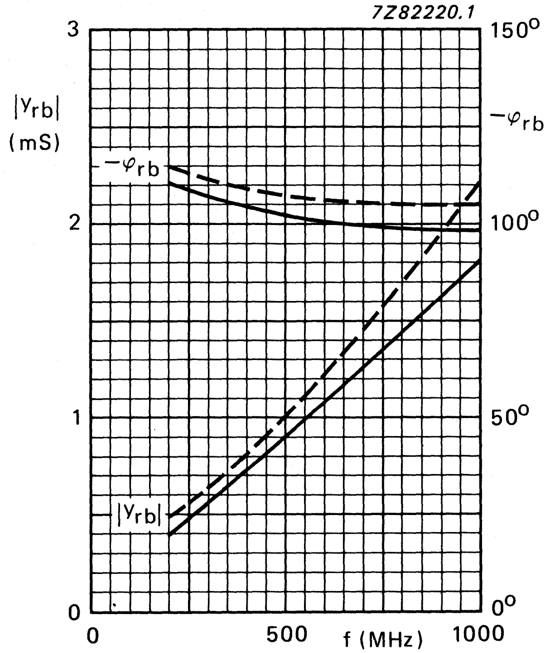


Fig. 6.

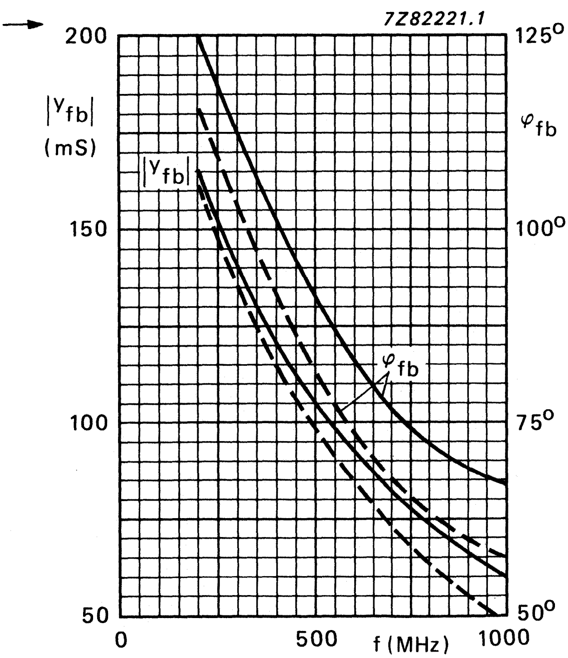


Fig. 7.

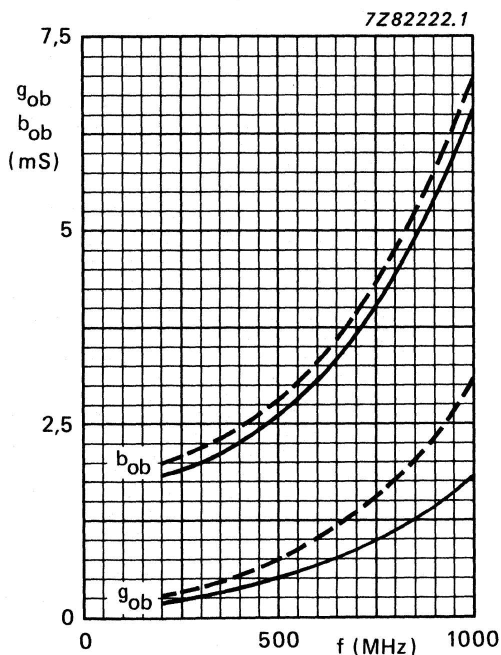


Fig. 8.

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.

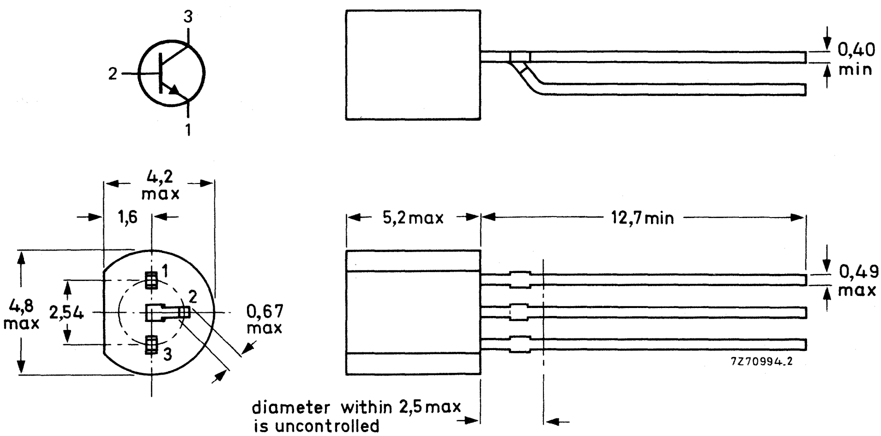
QUICK REFERENCE DATA

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; $t_p = 10\ \mu s$)	I_{CM}	max.	500	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW
Storage temperature	T_{stg}	−65 to + 150		^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_{amb} = 25\ ^oC$ 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; $T_j = 125\ ^oC$	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
$I_C = 40$ 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)

$$G_{UM} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

$I_C = 10$ mA; $V_{CE} = 10$ V; f = 200 MHz	G_{UM}	typ.	19	dB

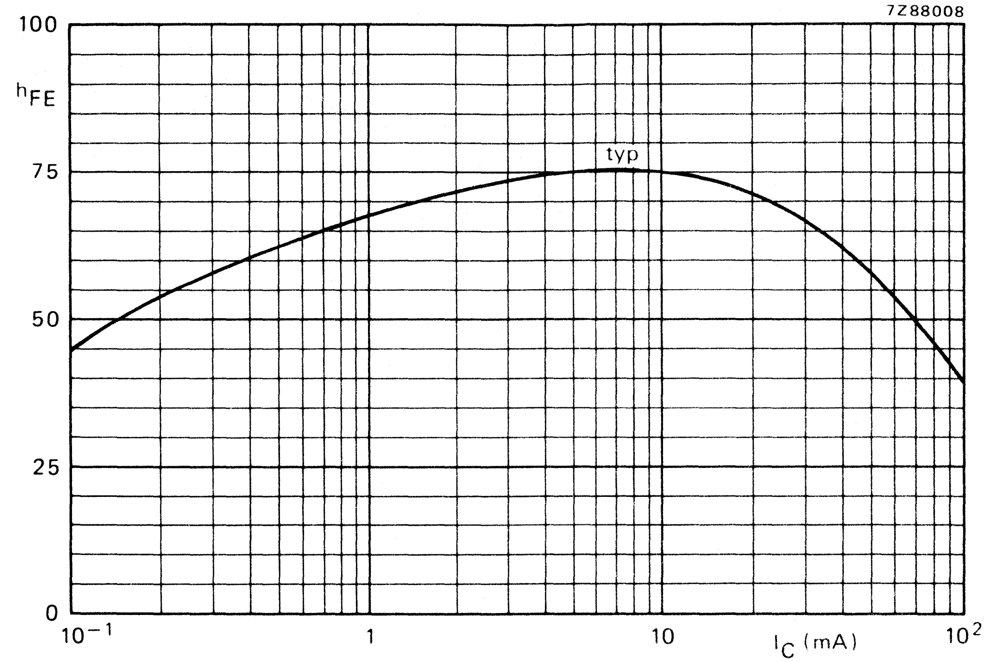


Fig. 2 V_{CE} = 1 V; T_j = 25 °C.

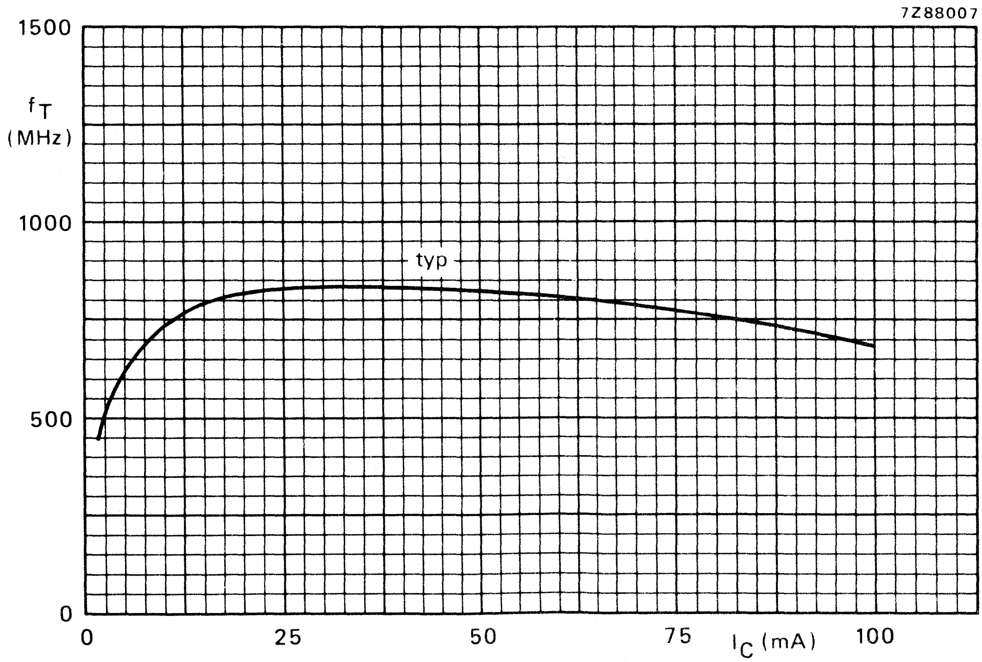


Fig. 3 V_{CE} = 10 V; T_j = 25 °C.

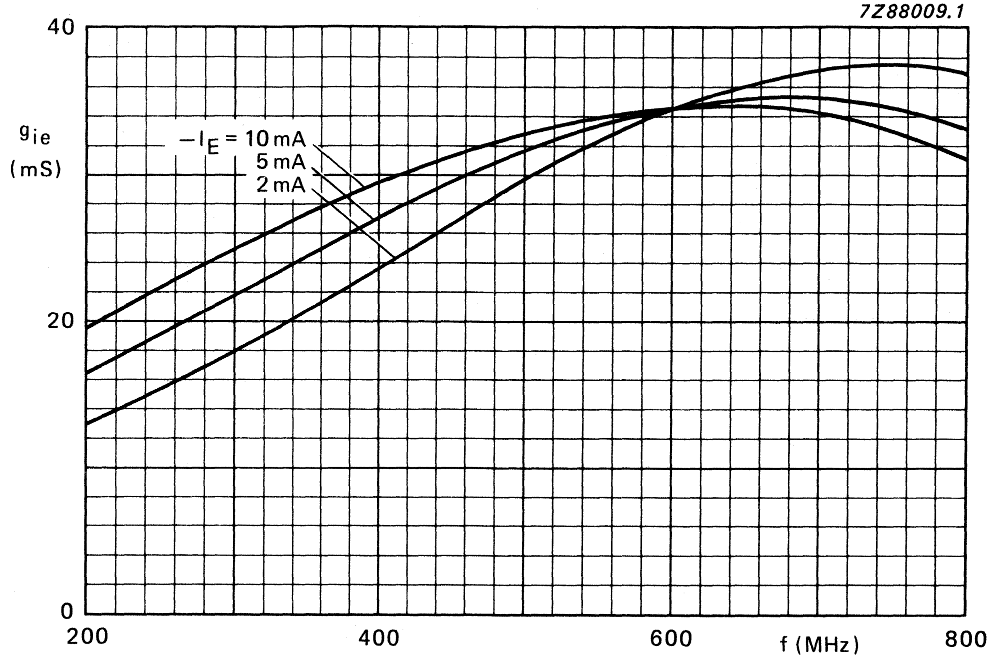


Fig. 4 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

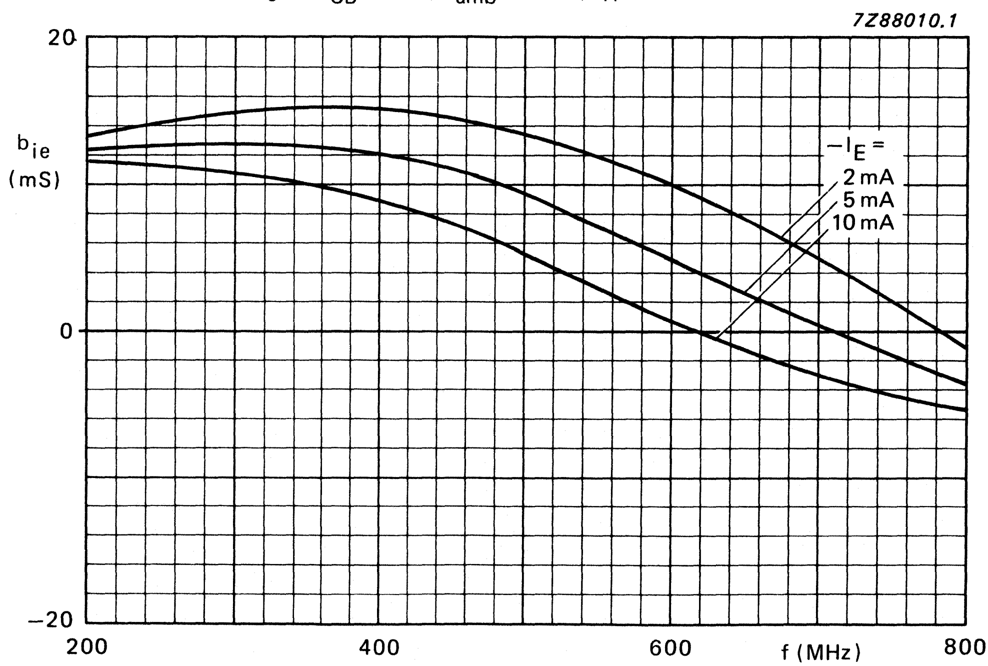


Fig. 5 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

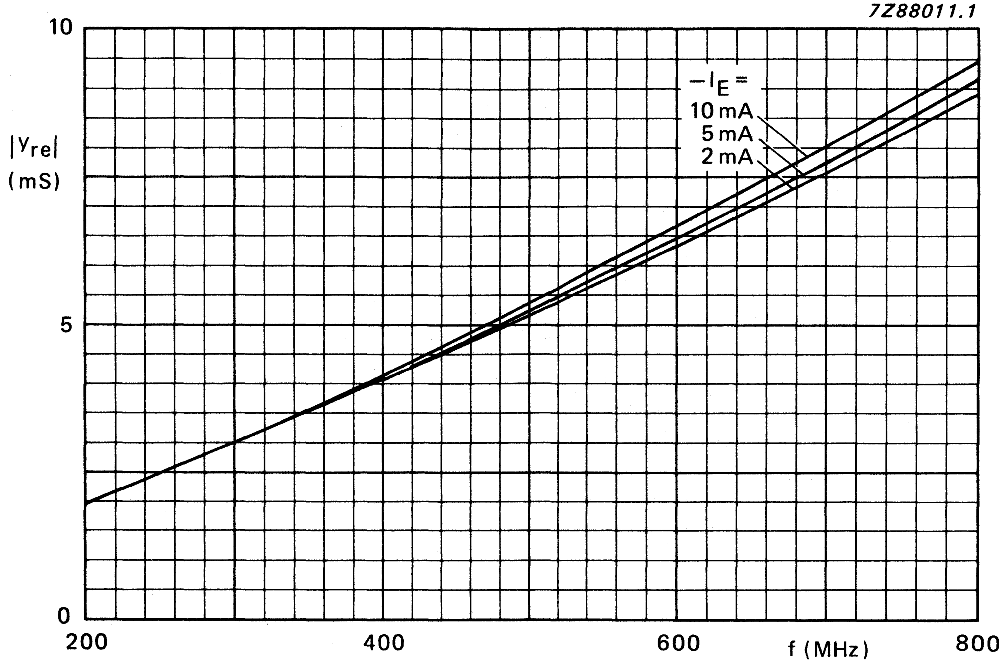


Fig. 6 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

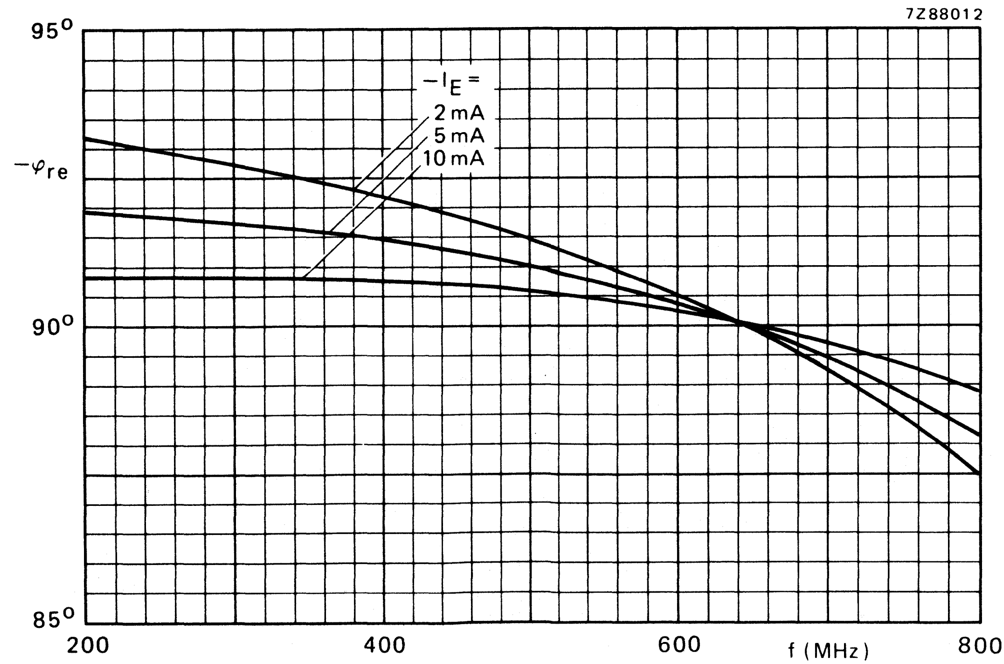


Fig. 7 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

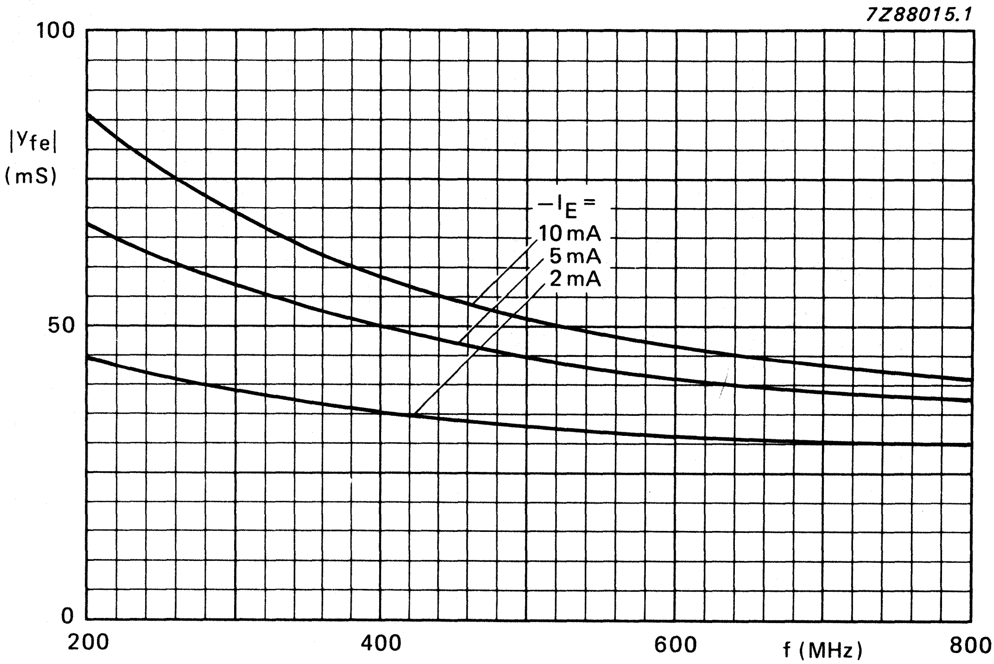


Fig. 8 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

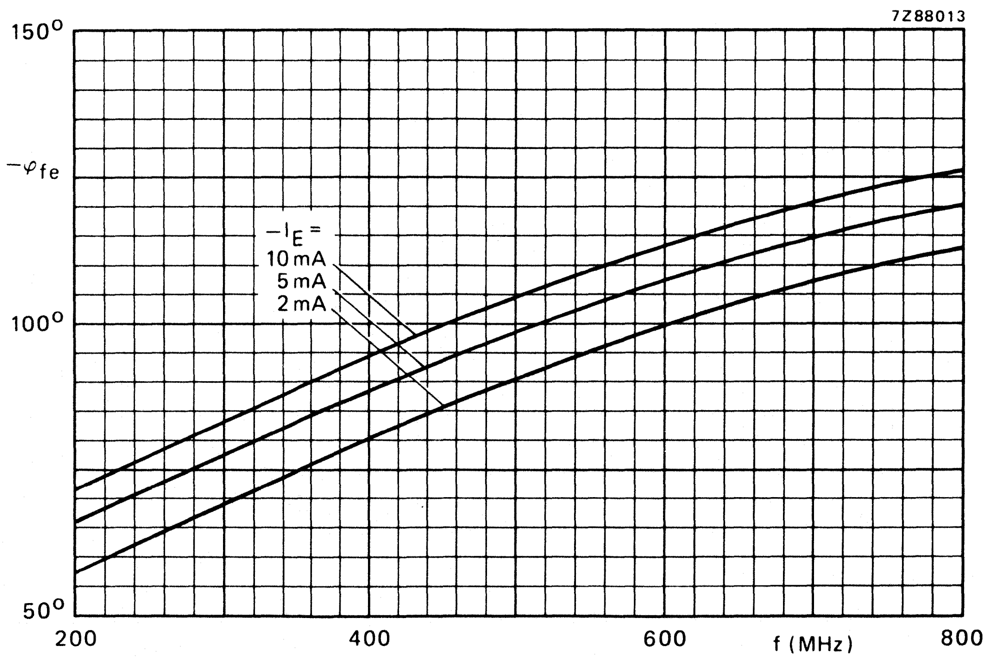


Fig. 9 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

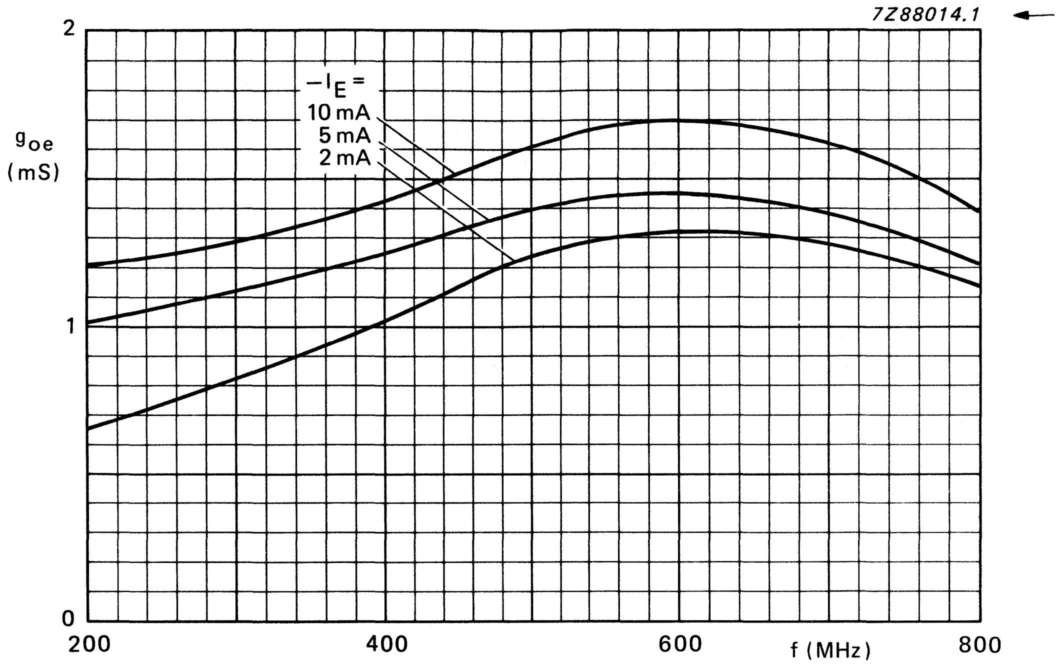


Fig. 10 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

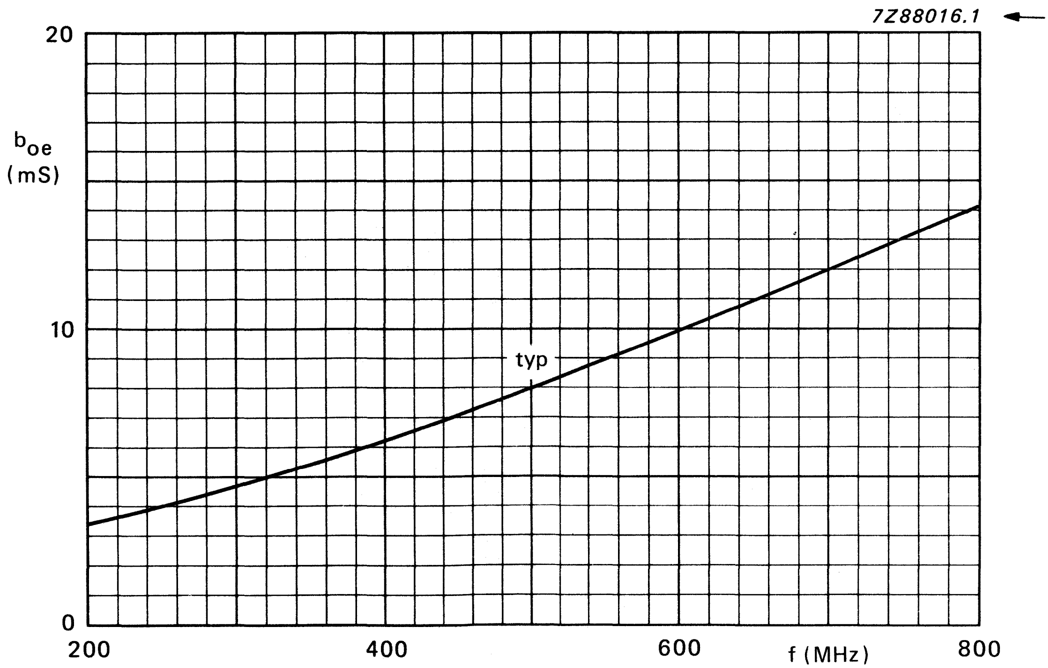


Fig. 11 V_{CB} = 10 V; $-I_E$ = 2 to 10 mA; T_{amb} = 25 °C

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Planar epitaxial transistors in TO-39 metal envelopes, intended as general purpose amplifiers and switching devices in industrial and telephone applications.

QUICK REFERENCE DATA

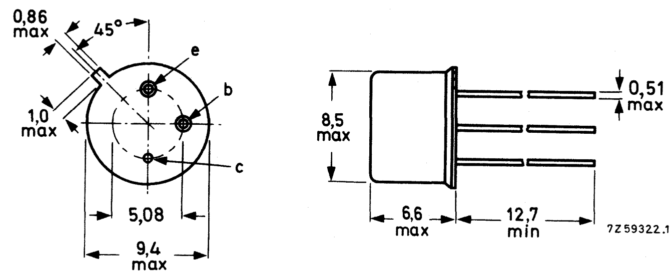
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Collector current (d.c.)	$-I_C$	max.	0,5		A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
D.C. current 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.



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)

			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
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

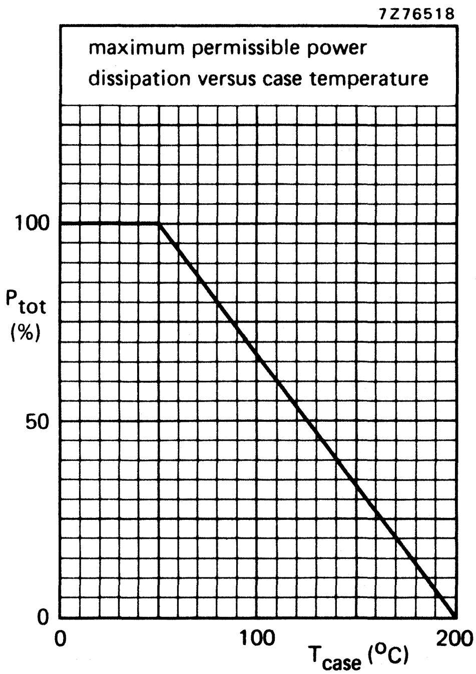


Fig. 2.

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	$R_{th\,j\text{-}c}$	=	30	K/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
			BFT44	**BFT45**	
Collector-emitter sustaining voltage					
$-I_C = 10$ mA; $I_B = 0$; L = 25 mH	$-V_{CEOsust}$	>	300	250	V*

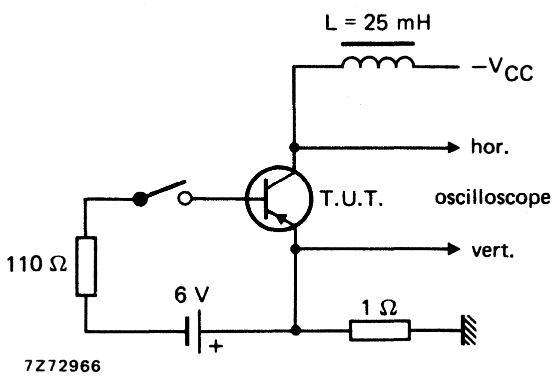


Fig. 3 Test circuit for $V_{CEOsust}$.

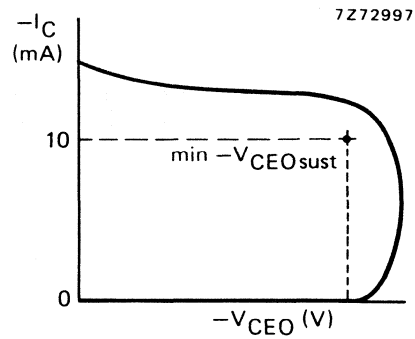


Fig. 4 Oscilloscope display for $V_{CEOsust}$.

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**
	BFT45	$-V_{CEsat}$	<	3,0	V**
		$-V_{BEsat}$	<	1,2	V**
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	**
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 20$ V		C_c	<	15	pF

* $-V_{CC}$ = 0 to 50 V; f = 400 Hz; δ = 0,5 (see also test circuit).
** Measured under pulse conditions: t_p = 300 μs; δ ⩽ 0,02.

CHARACTERISTICS (continued)

T_j = 25 °C

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

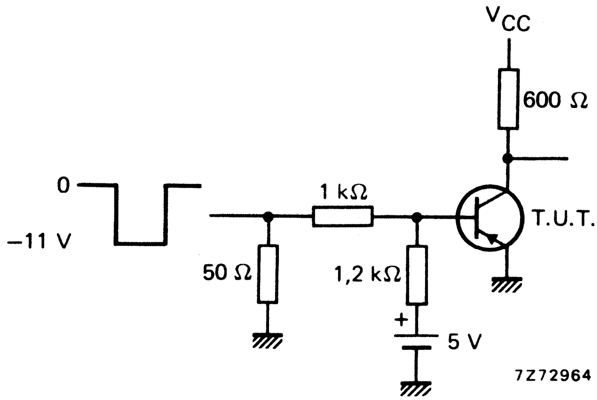


Fig. 5 Test circuit 1.

V_{CC} = −31 V
t_p = 10 μs

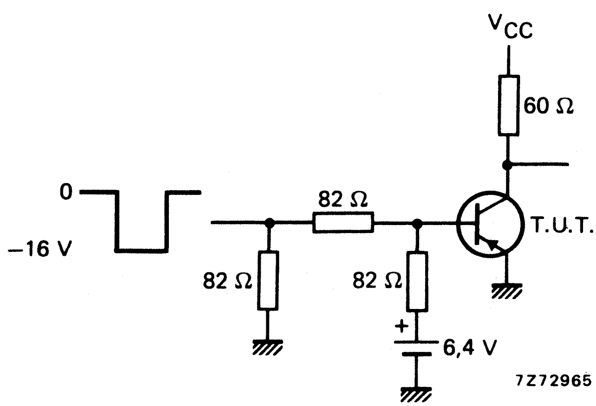


Fig. 6 Test circuit 2.

V_{CC} = −31 V
t_p = 10 μs

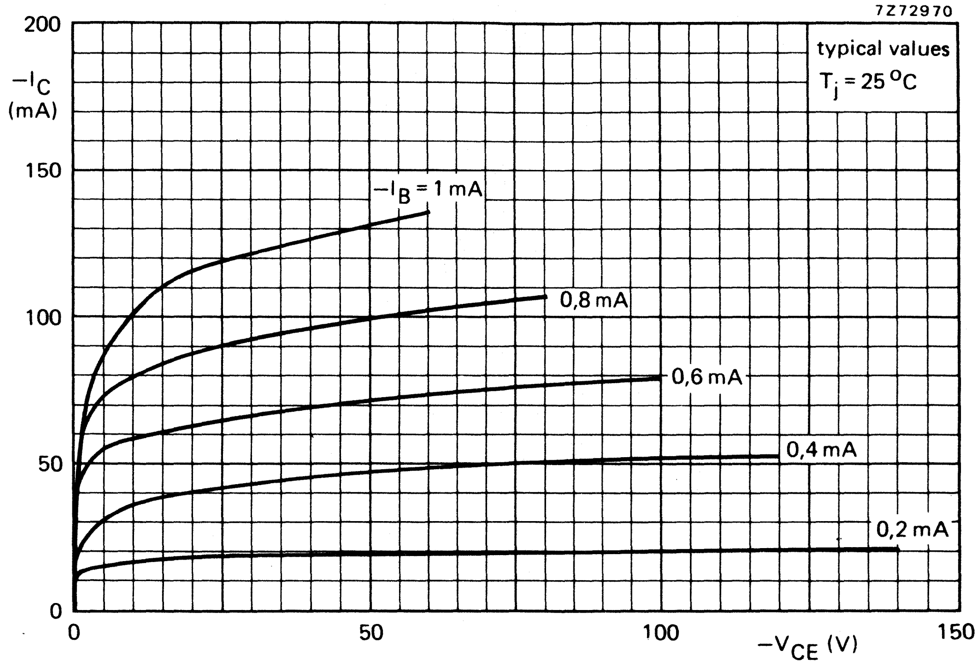

7Z72970
typical values
$T_j = 25\ ^oC$
$-I_C$ (mA)
200
150
100
50
0
$-I_B = 1$ mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
0
50
100
150
$-V_{CE}$ (V)

Fig. 7.

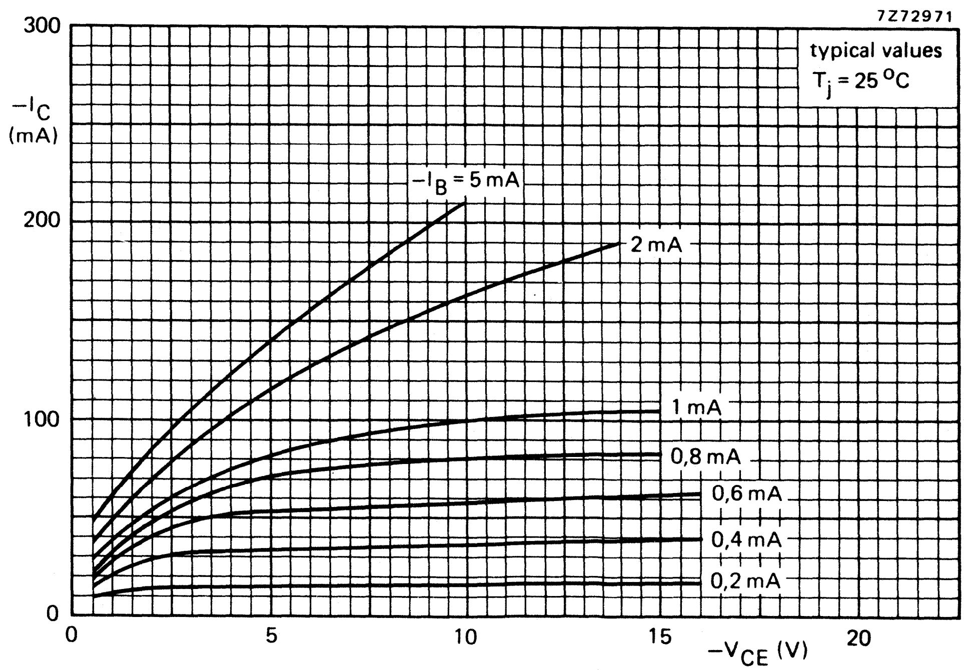

7Z72971
typical values
$T_j = 25\ ^oC$
$-I_C$ (mA)
300
200
100
0
$-I_B = 5$ mA
2 mA
1 mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
0
5
10
15
20
$-V_{CE}$ (V)

Fig. 8.

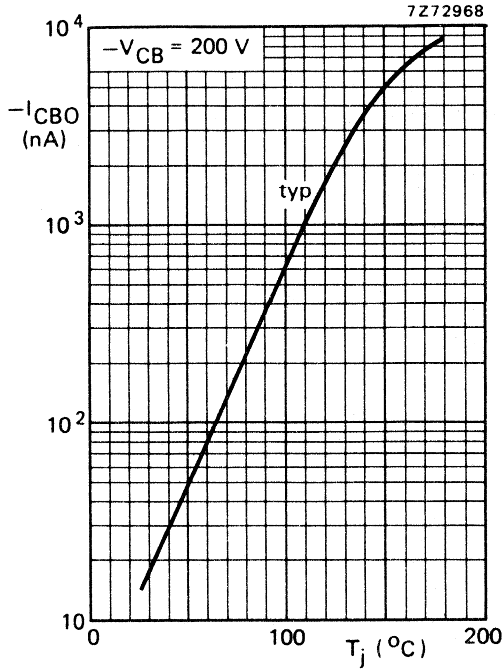


Fig. 9.

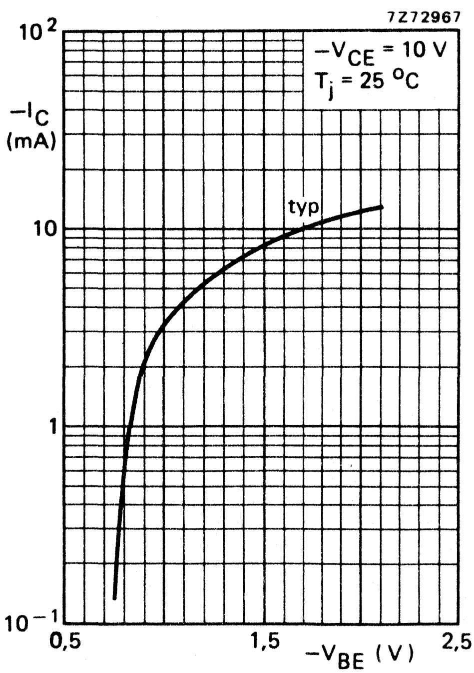


Fig. 10.

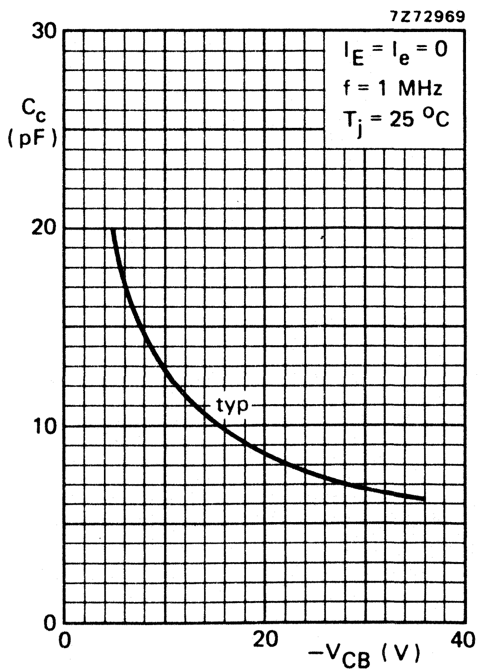


Fig. 11.

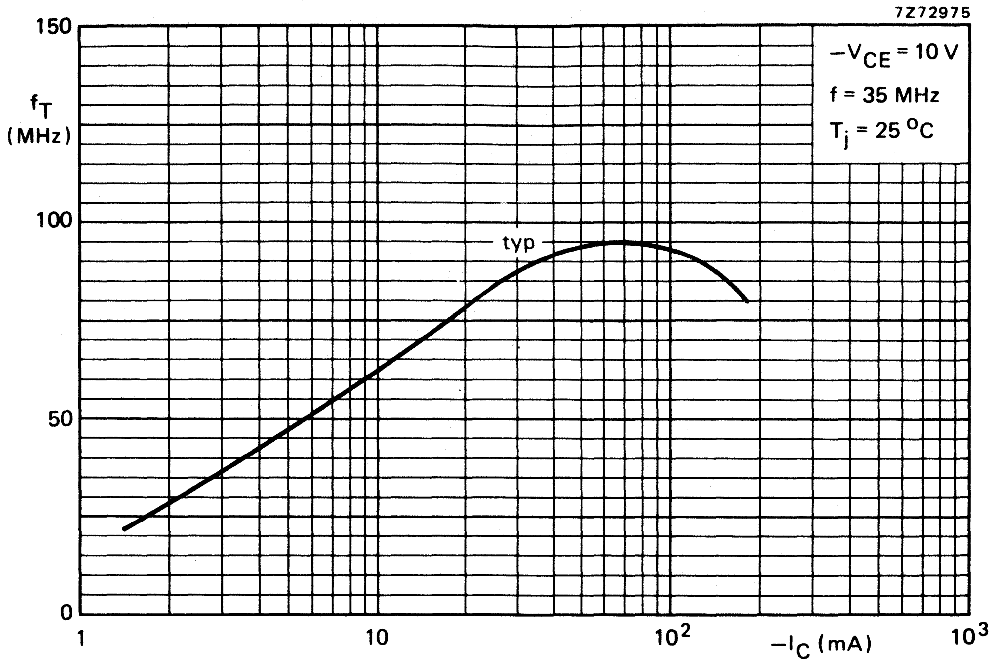

7Z72975
$-V_{CE} = 10$ V
f = 35 MHz
$T_j = 25\ ^oC$
f_T (MHz)
150
100
50
0
typ
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 12.

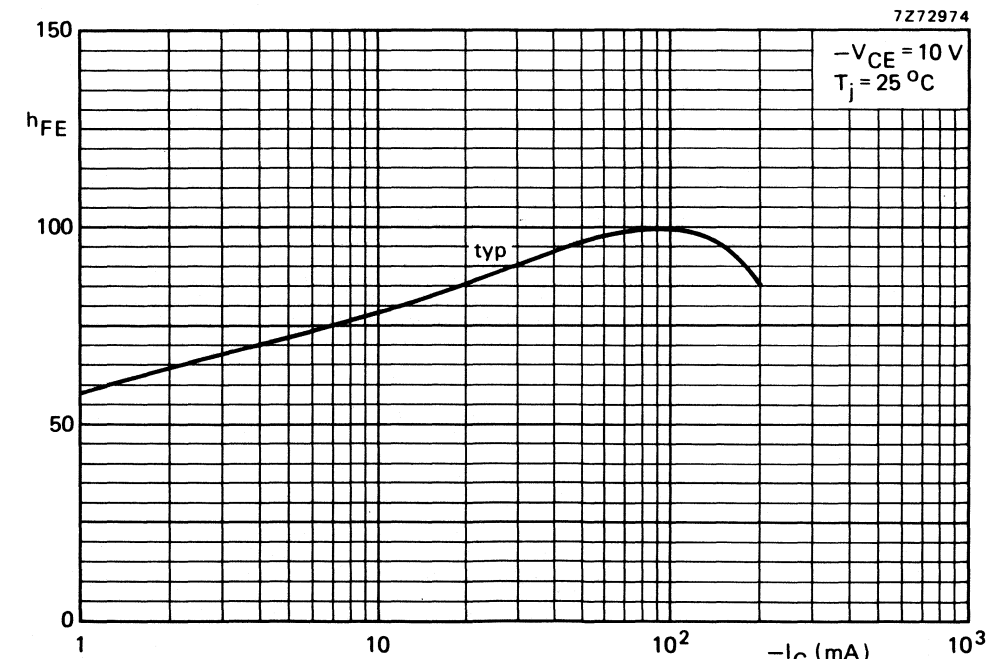

7Z72974
$-V_{CE} = 10$ V
$T_j = 25\ ^oC$
h_{FE}
150
100
50
0
typ
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 13.

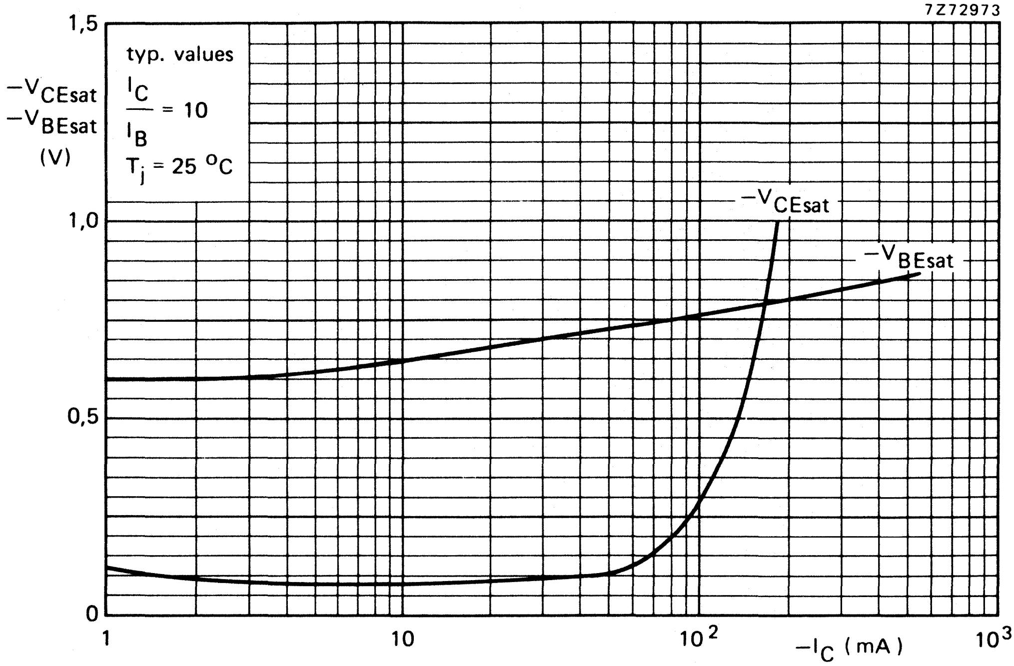

7Z72973
1,5
typ. values
$-V_{CEsat}$
$-V_{BEsat}$
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
1,0
$-V_{CEsat}$
$-V_{BEsat}$
0,5
0
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 14.

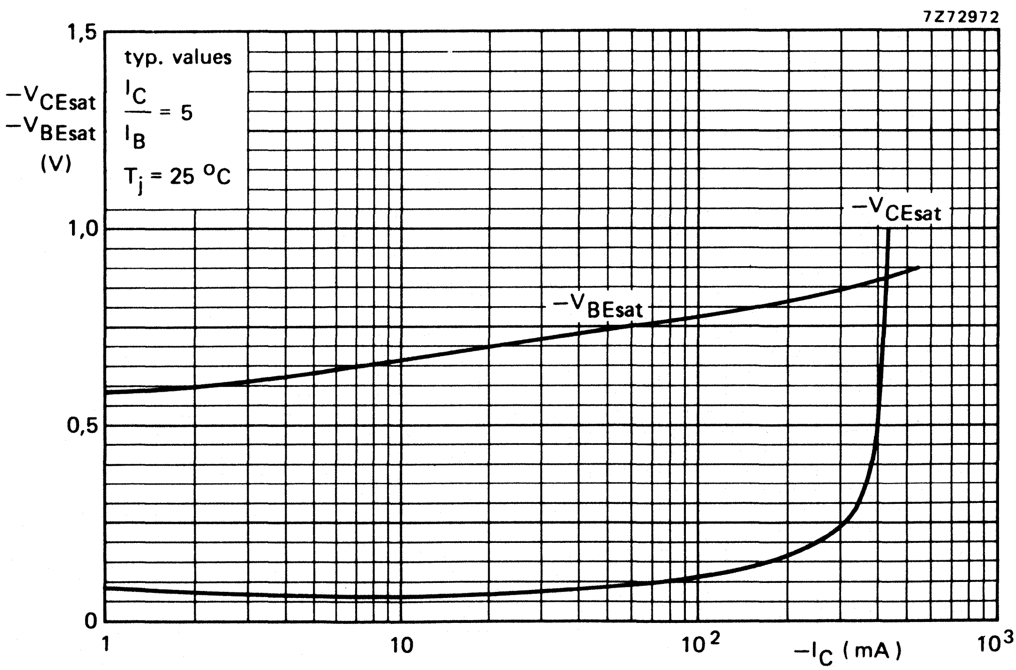

7Z72972
1,5
typ. values
$-V_{CEsat}$
$-V_{BEsat}$
(V)
$\frac{I_C}{I_B} = 5$
$T_j = 25\ ^oC$
1,0
$-V_{CEsat}$
$-V_{BEsat}$
0,5
0
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 15.

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

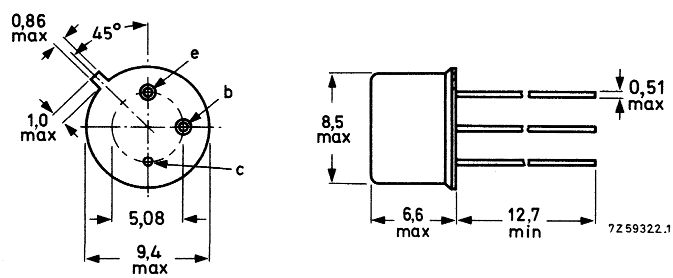
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 2 A; V_{CE} = 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.

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.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
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
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
Storage temperature	T_{stg}		−55 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	$R_{th\ j\text{-}c}$	=	35	K/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}	<	10 μA ←
Saturation voltage 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 ←
Emitter-capacitance at f = 1 MHz I_C = I_c = 0; V_{EB} = 0,5 V	C_e	typ.	440 pF
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	> typ.	70 MHz 100 MHz
Turn on time when switched from $-V_{BE}$ = 2,0 V to I_C = 5 V; 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

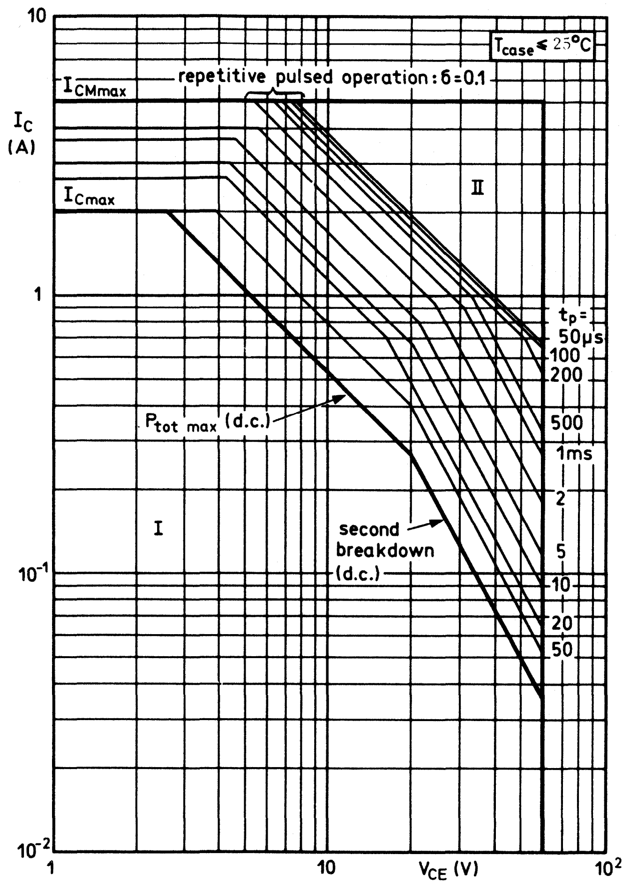


Fig. 2.

Safe Operation Area with the transistor forward biased

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

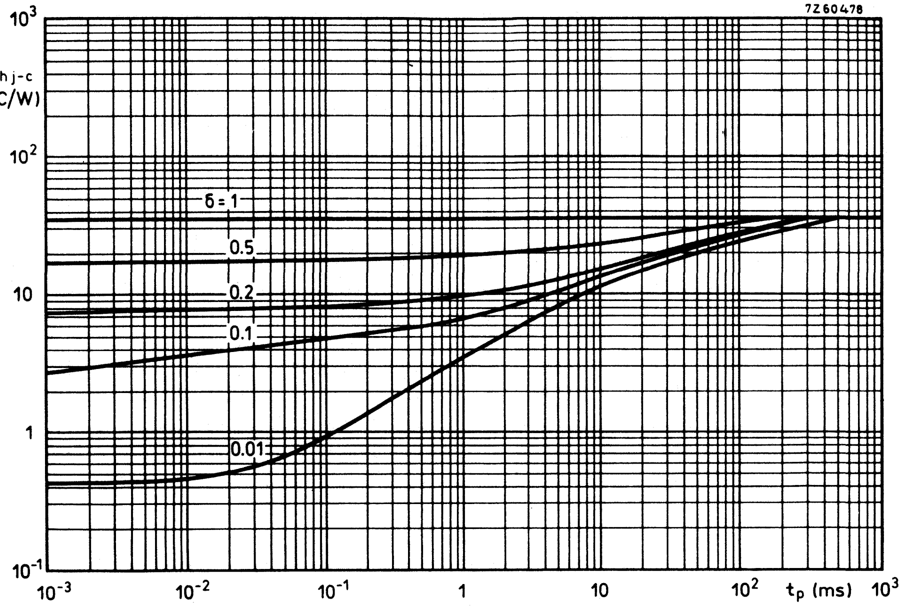

7Z60478
$Z_{th\ j-c}$
(°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

Fig. 3.

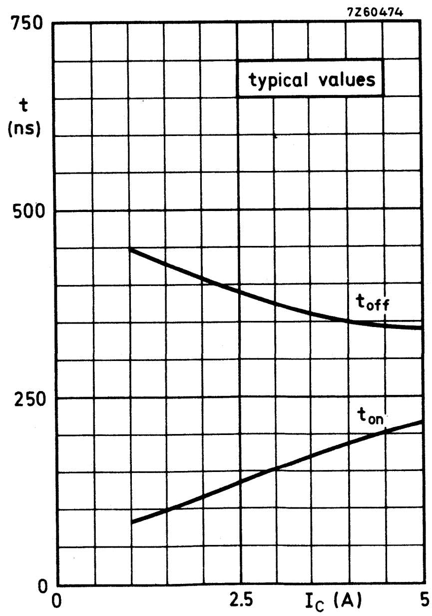

7Z60474
typical values
t
(ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5

Fig. 4.

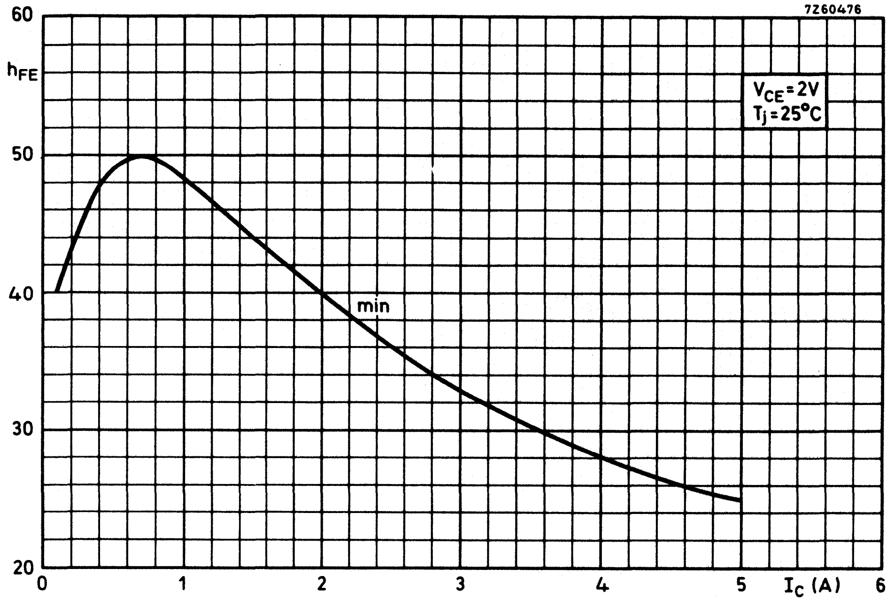


Fig. 5.

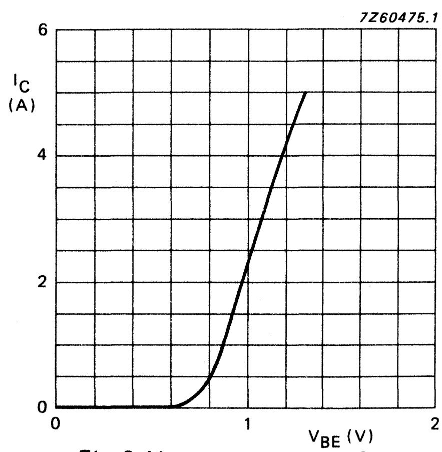


Fig. 6 V_{CE} = 2 V; T_j = 25 °C; typical values.

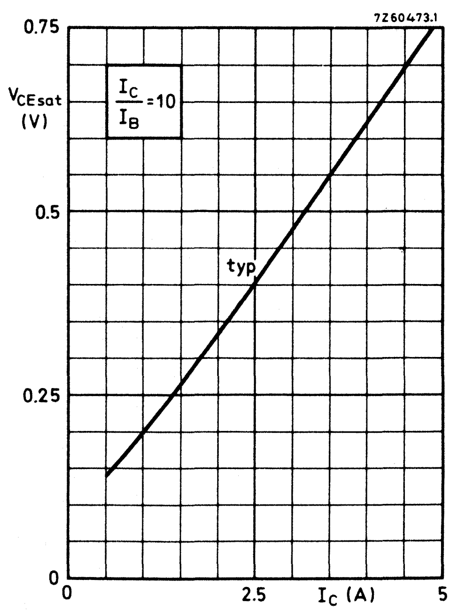


Fig. 7.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes intended for general purpose industrial applications.

QUICK REFERENCE DATA

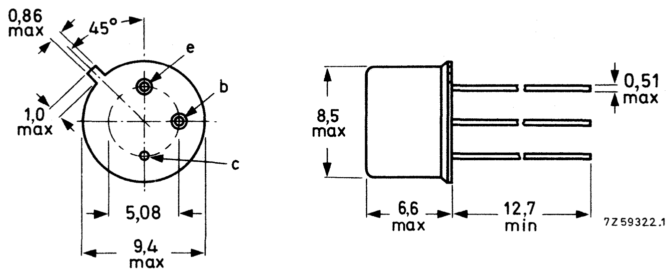
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
Total power dissipation up 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}	> typ.	30 112	40 123	60 142	
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).

Products approved to CECC 50 002-089.

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. $T_{amb} \leq 25^oC$		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

BFY50

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 80V$, $I_E = 0$	-	–	500	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	–	30	μA
	$V_{CB} = 60V$, $I_E = 0$	-	–	50	nA
	$V_{CB} = 60V$, $I_E = 0$, $T_j = 100^oC$	-	–	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	–	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	–	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	–	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	20	–	-	
	$I_C = 150mA$, $V_{CE} = 10V$	30	–	-	
	$I_C = 500mA$, $V_{CE} = 10V$	20	–	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	–	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	0.20	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	0.70	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	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

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$,
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		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}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	–	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	750	-	Ω
h_{re}		-	0.85	–	$\times 10^{-4}$
h_{fe}		–	80	-	
h_{oe}		-	35	–	μS

BFY51

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 60V$, $I_E = 0$	-	–	500	nA
	$V_{CB} = 60V$, $I_E = 0$, $T_j = 100^oC$	-	–	30	μA
	$V_{CB} = 40V$, $I_E = 0$	-	–	50	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^oC$	-	–	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	–	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	–	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	–	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	30	–	-	
	$I_C = 150mA$, $V_{CE} = 10V$	40	–	-	
	$I_C = 500mA$, $V_{CE} = 10V$	25	–	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	–	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	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 $I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$, $-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$					
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}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	–	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	–	750	–	Ω
h_{re}		–	0.85	–	$\times 10^{-4}$
h_{fe}		–	80	–	
h_{oe}		–	35	–	µS

BFY52

ELECTRICAL CHARACTERISTICS ($T_j = 25^{\circ}C$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 40V$, $I_E = 0$	-	–	500	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^{\circ}C$	-	–	30	μA
	$V_{CB} = 30V$, $I_E = 0$	-	–	50	nA
	$V_{CB} = 30V$, $I_E = 0$, $T_j = 100^{\circ}C$	-	–	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	–	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	–	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^{\circ}C$	-	–	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	30	–	-	
	$I_C = 150mA$, $V_{CE} = 10V$	60	–	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	–	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	–	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	0.20	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	–	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	–	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	–	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	–	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

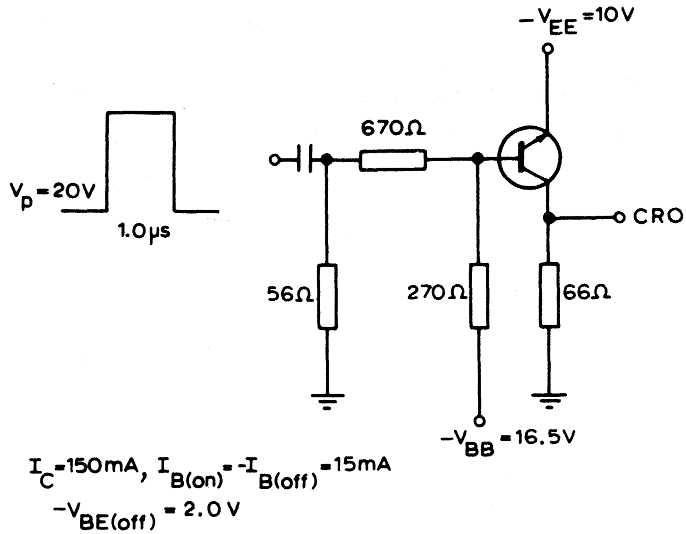


Fig. 2 Test circuit.

Switching waveforms

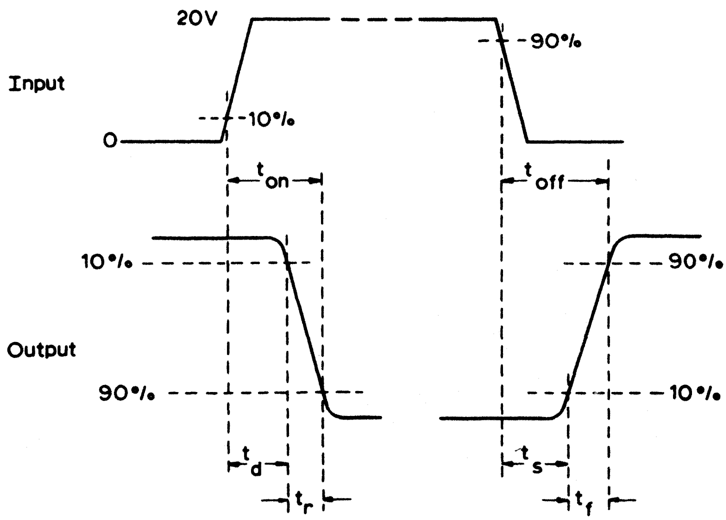


Fig. 3 Waveforms.

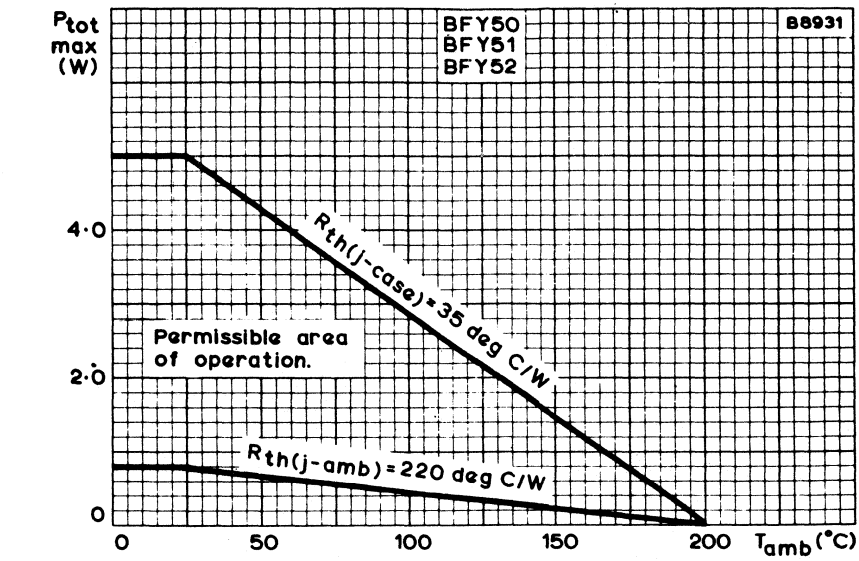

P_tot max (W)
BFY50
BFY51
BFY52
B8931
4·0
2·0
0
Permissible area of operation.
Rth(j-case) = 35 deg C/W
Rth(j-amb) = 220 deg C/W
0
50
100
150
200
T_amb (°C)

Fig. 4.

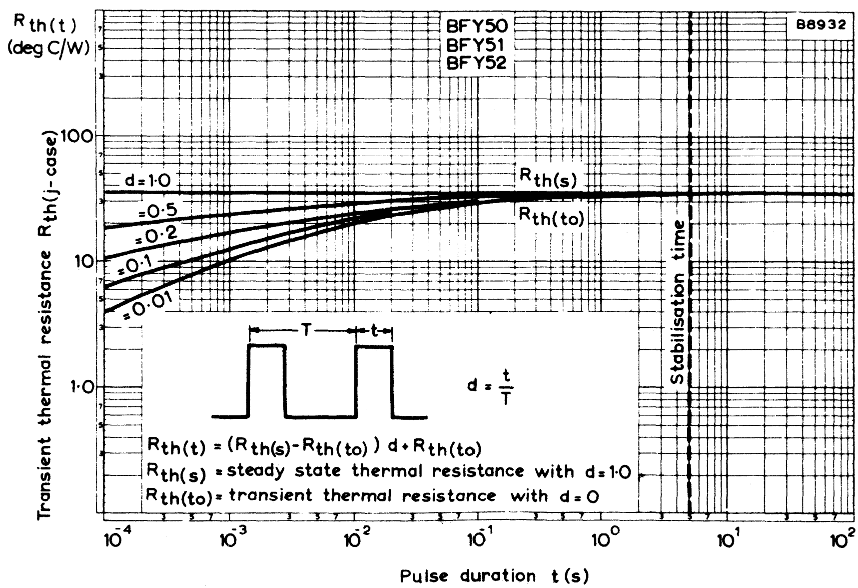

Rth(t) (deg C/W)
BFY50
BFY51
BFY52
B8932
100
10
1·0
Transient thermal resistance Rth(j-case)
d = 1·0
= 0·5
= 0·2
= 0·1
= 0·01
Rth(s)
Rth(to)
Stabilisation time
T
t
d = t/T
Rth(t) = (Rth(s) - Rth(to)) d + Rth(to)
Rth(s) = steady state thermal resistance with d = 1·0
Rth(to) = transient thermal resistance with d = 0
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
Pulse duration t (s)

Fig. 5.

→

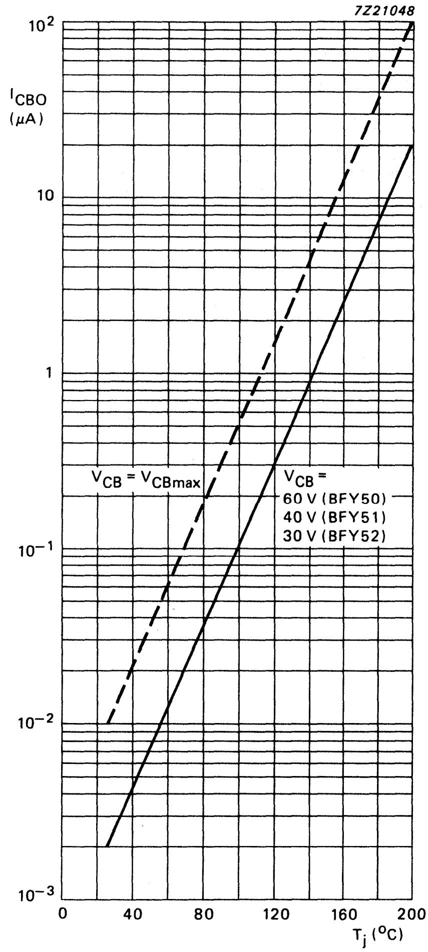


Fig. 6 $I_E = 0$.

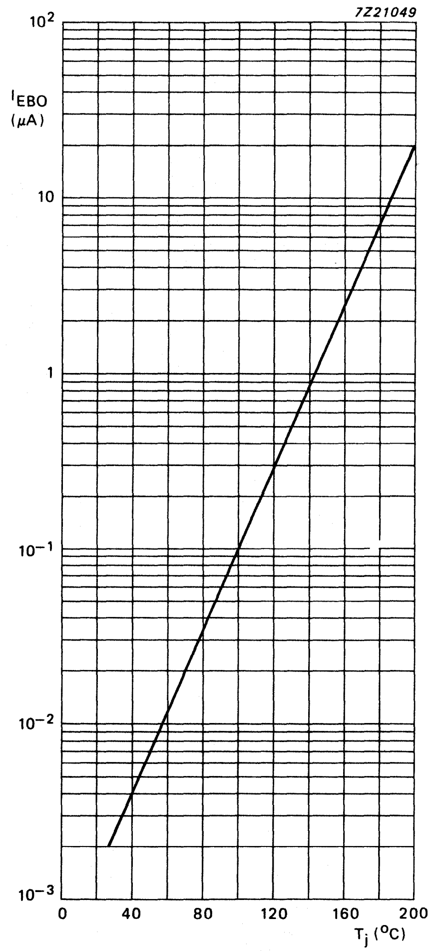


Fig. 7 V_{EB} = 5,0 V; I_C = 0; typical values.

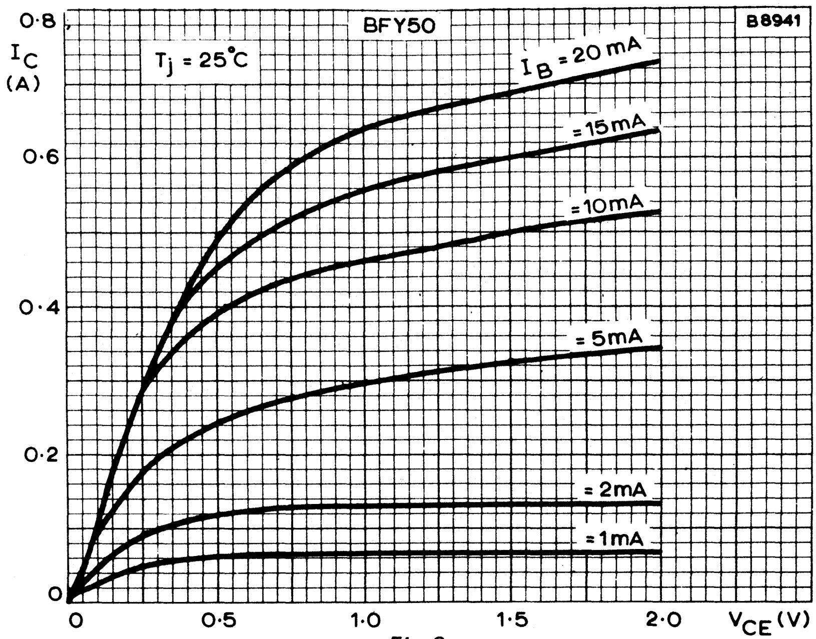

0·8
I_C
(A)
0·6
0·4
0·2
0
BFY50
B8941
T_j = 25°C
I_B = 20 mA
= 15 mA
= 10 mA
= 5 mA
= 2 mA
= 1 mA
0
0·5
1·0
1·5
2·0
V_{CE} (V)

Fig. 8.

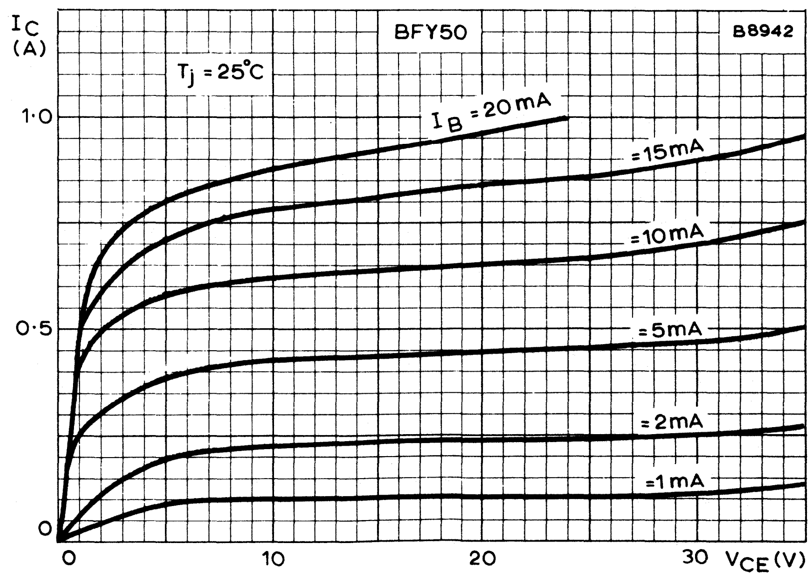

I_C
(A)
1·0
0·5
0
BFY50
B8942
T_j = 25°C
I_B = 20 mA
= 15 mA
= 10 mA
= 5 mA
= 2 mA
= 1 mA
0
10
20
30
V_{CE} (V)

Fig. 9.

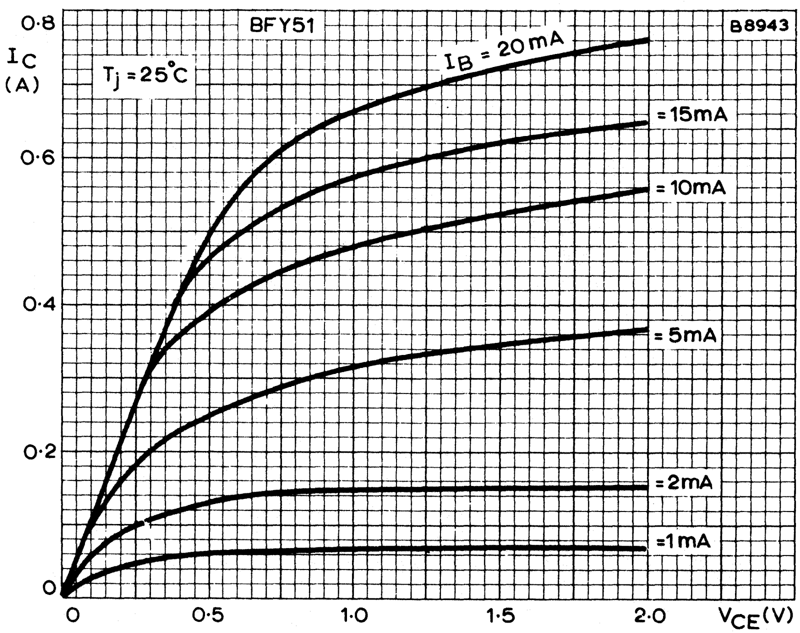

0·8
I_C
(A)
0·6
0·4
0·2
0
BFY51
B8943
$T_j = 25°C$
$I_B = 20 mA$
= 15mA
= 10mA
= 5mA
= 2mA
= 1mA
0
0·5
1·0
1·5
2·0
V_{CE} (V)

Fig. 10.

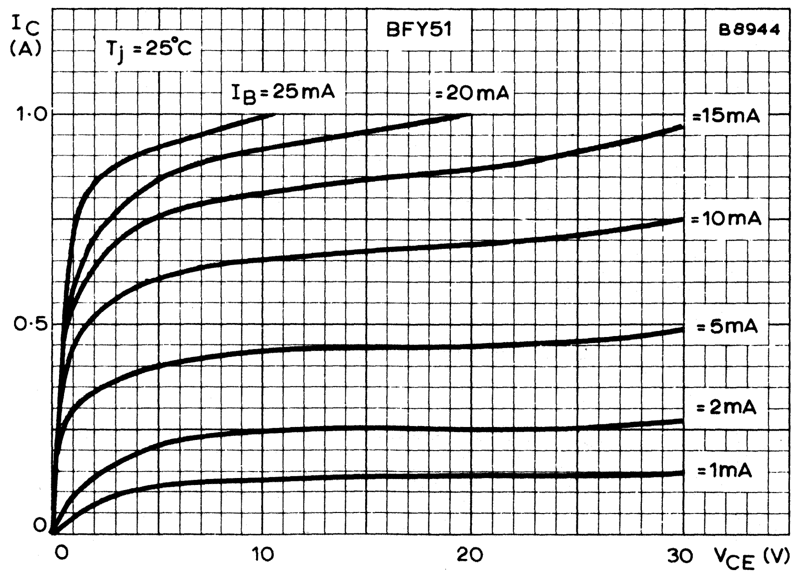

I_C
(A)
1·0
0·5
0
BFY51
B8944
$T_j = 25°C$
$I_B = 25 mA$
= 20mA
= 15mA
= 10mA
= 5mA
= 2mA
= 1mA
0
10
20
30
V_{CE} (V)

Fig. 11.

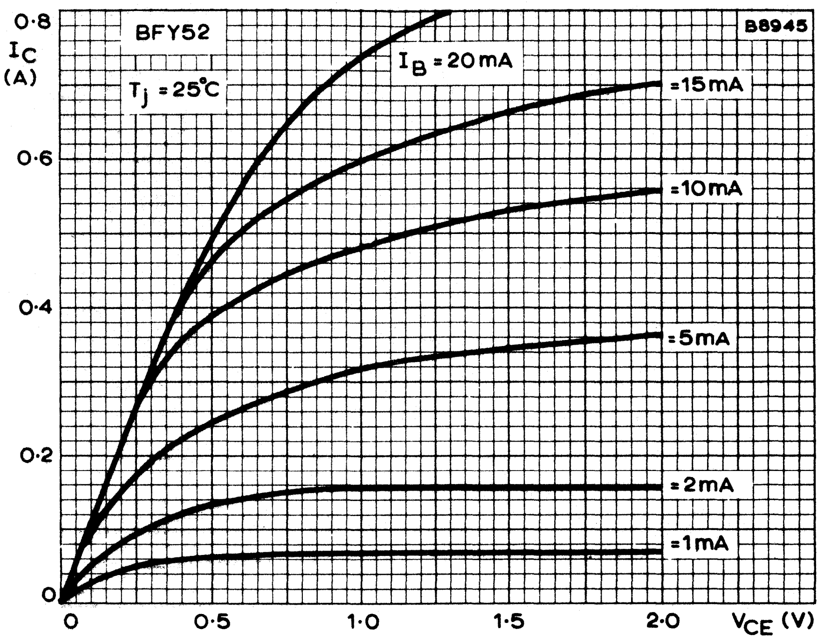

0·8
I_C
(A)
BFY52
T_j = 25°C
B8945
I_B = 20 mA
= 15 mA
= 10 mA
= 5 mA
= 2 mA
= 1 mA
0·6
0·4
0·2
0
0
0·5
1·0
1·5
2·0
V_{CE} (V)

Fig. 12.

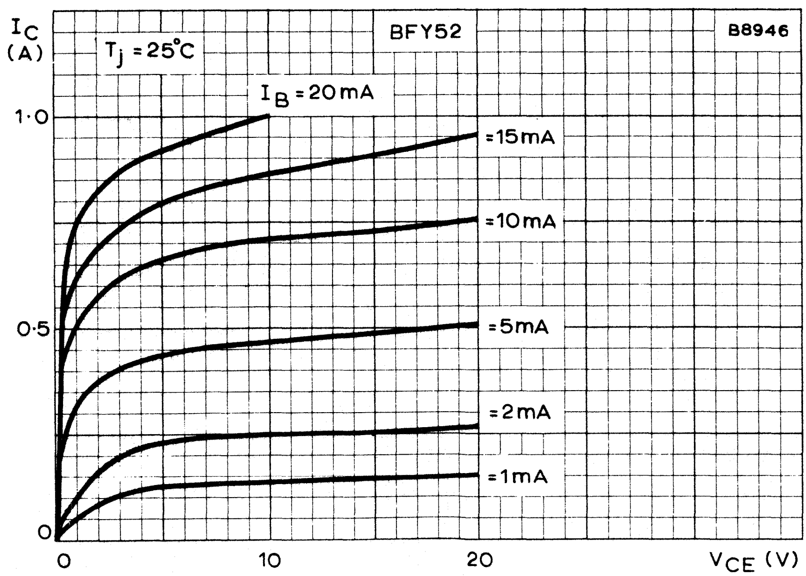

I_C
(A)
T_j = 25°C
BFY52
B8946
I_B = 20 mA
1·0
= 15 mA
= 10 mA
0·5
= 5 mA
= 2 mA
= 1 mA
0
0
10
20
V_{CE} (V)

Fig. 13.

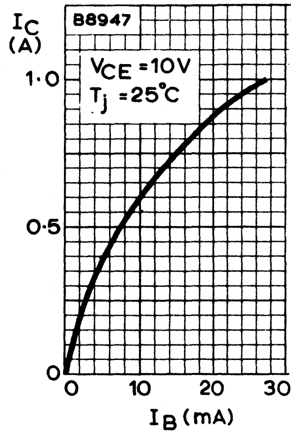


Fig. 14.

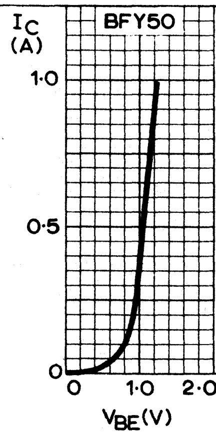


Fig. 15.

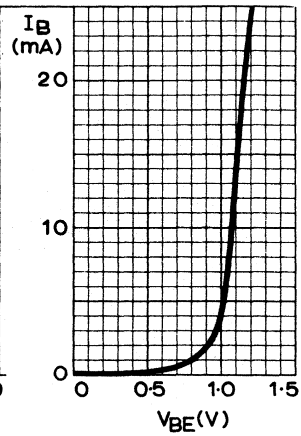


Fig. 16.

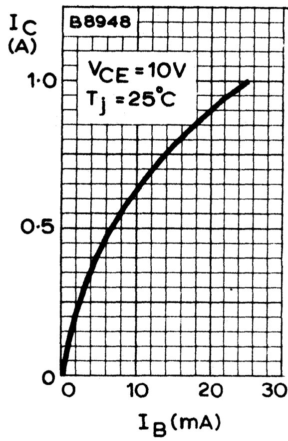


Fig. 17.

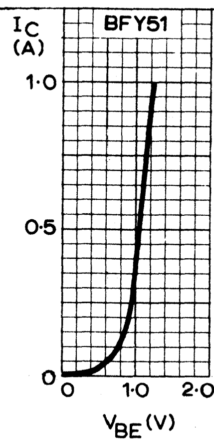


Fig. 18.

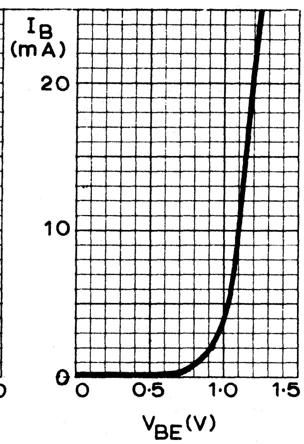


Fig. 19.

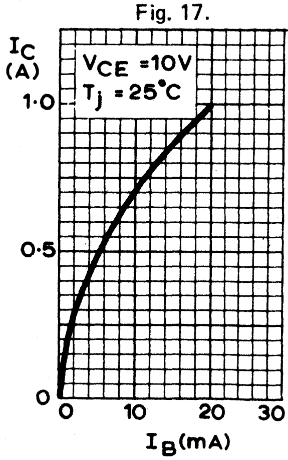


Fig. 20.

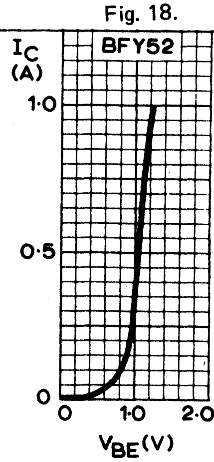


Fig. 21.

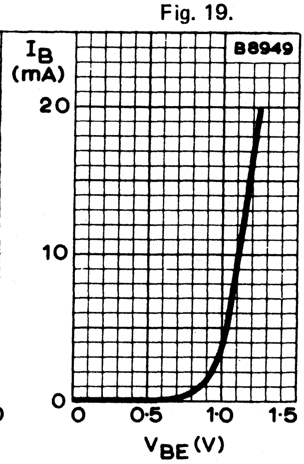


Fig. 22.

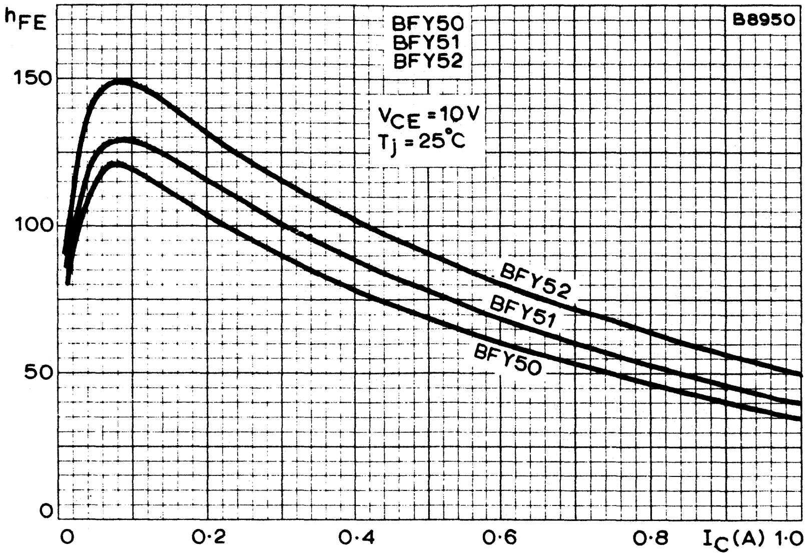

hFE
BFY50
BFY51
BFY52
B8950
150
100
50
0
VCE = 10 V
Tj = 25°C
BFY52
BFY51
BFY50
0
0·2
0·4
0·6
0·8
IC (A) 1·0

Fig. 23.

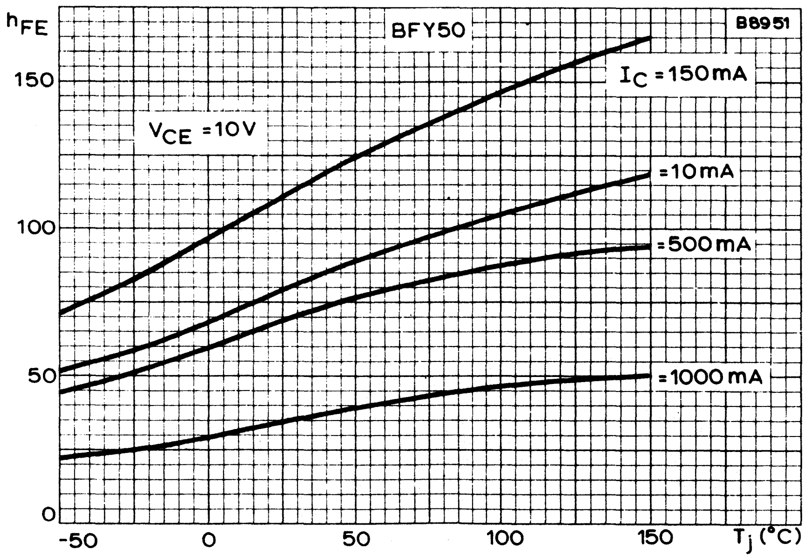

hFE
BFY50
B8951
150
100
50
0
VCE = 10V
IC = 150 mA
= 10 mA
= 500 mA
= 1000 mA
-50
0
50
100
150
Tj (°C)

Fig. 24.

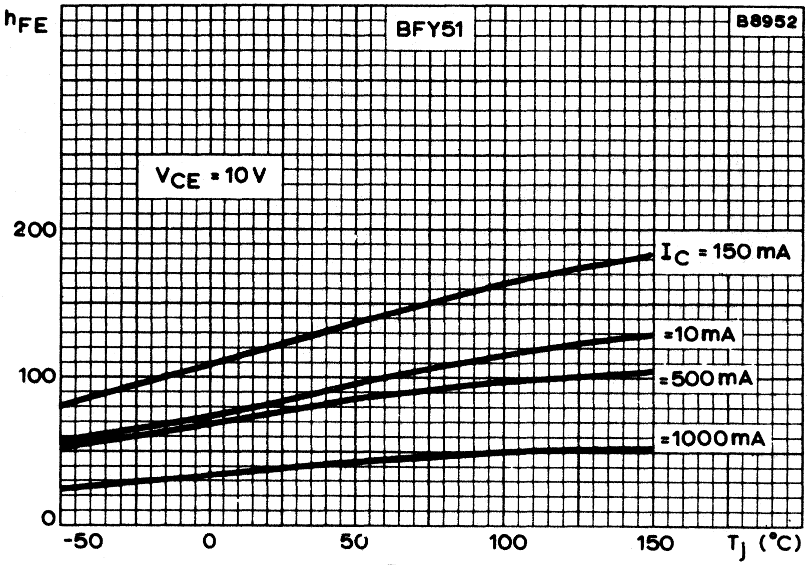

hFE
BFY51
B8952
VCE = 10 V
IC = 150 mA
= 10 mA
= 500 mA
= 1000 mA
200
100
0
-50
0
50
100
150
Tj (°C)

Fig. 25.

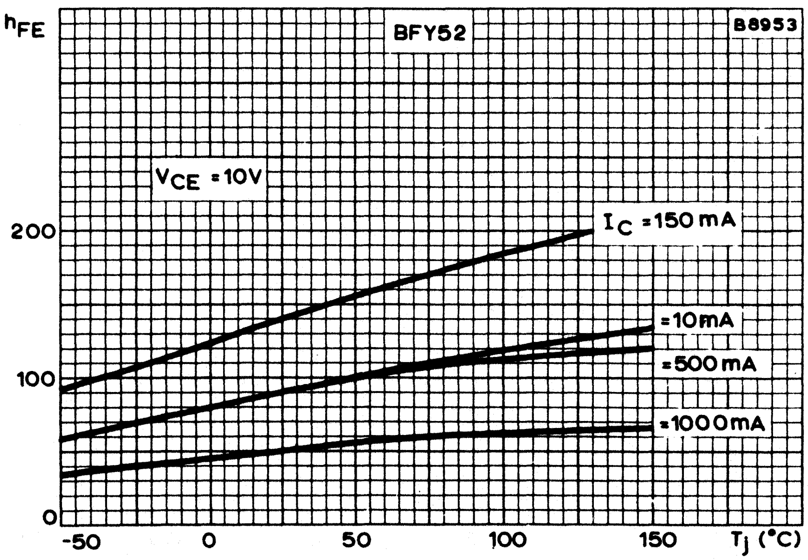

hFE
BFY52
B8953
VCE = 10 V
IC = 150 mA
= 10 mA
= 500 mA
= 1000 mA
200
100
0
-50
0
50
100
150
Tj (°C)

Fig. 26.

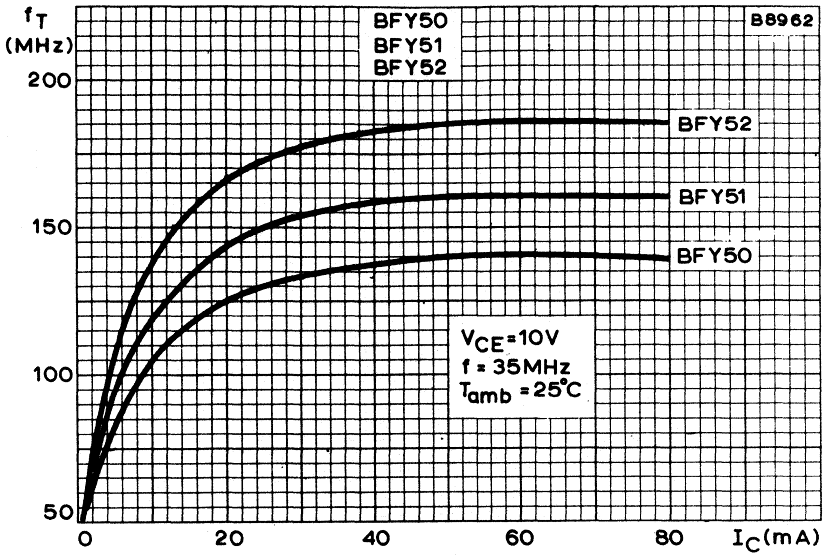


Fig. 27.

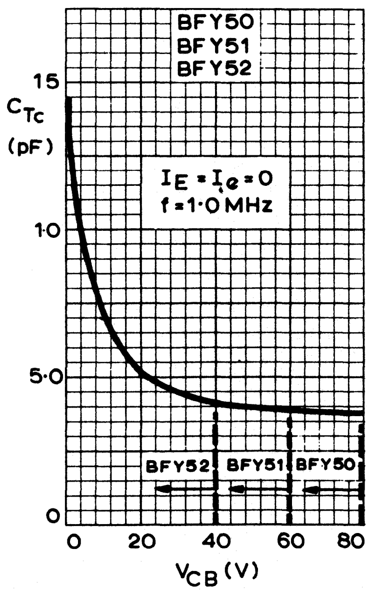


Fig. 28.

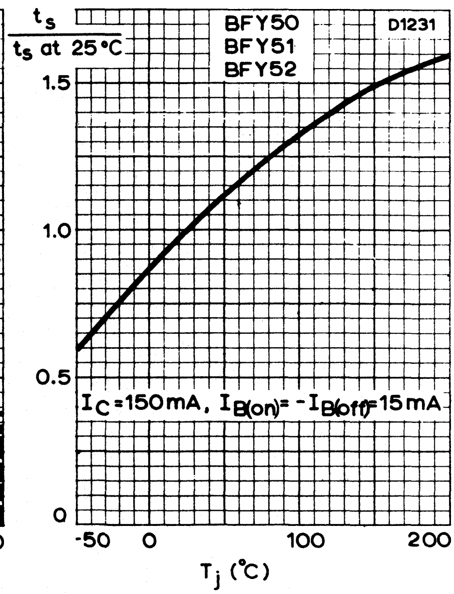


Fig. 29.

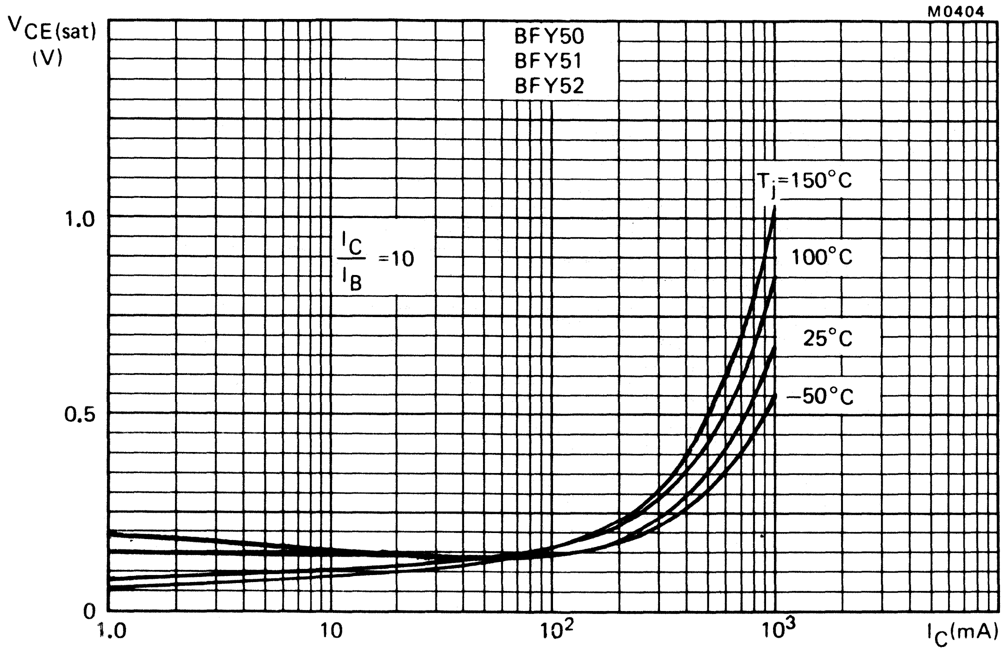

M0404
$V_{CE(sat)}$ (V)
BFY50
BFY51
BFY52
$\frac{I_C}{I_B} = 10$
$T_j = 150°C$
100°C
25°C
−50°C
1.0
0.5
0
1.0
10
10^2
10^3
I_C(mA)

Fig. 30.

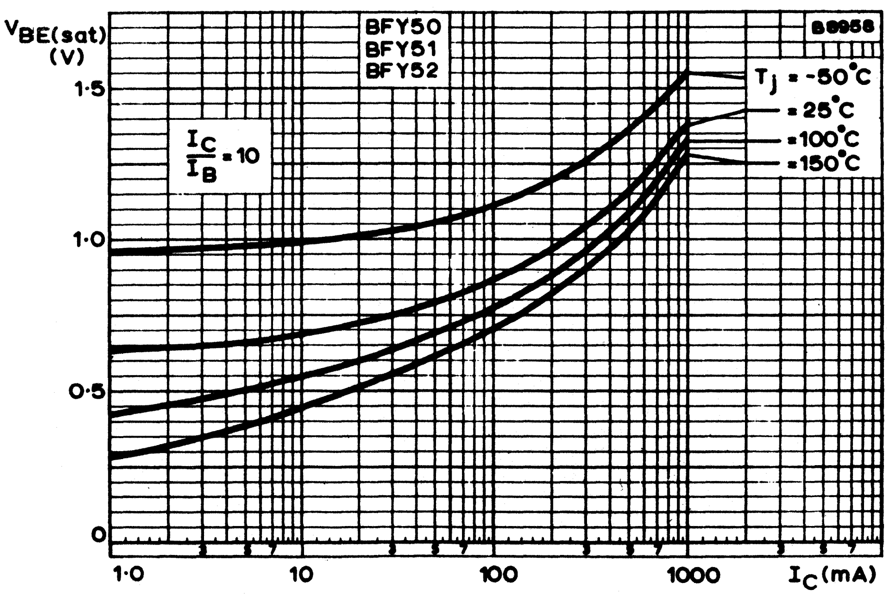

$V_{BE(sat)}$ (V)
BFY50
BFY51
BFY52
B8958
$\frac{I_C}{I_B} = 10$
$T_j = -50°C$
= 25°C
= 100°C
= 150°C
1·5
1·0
0·5
0
1·0
10
100
1000
I_C (mA)

Fig. 31.

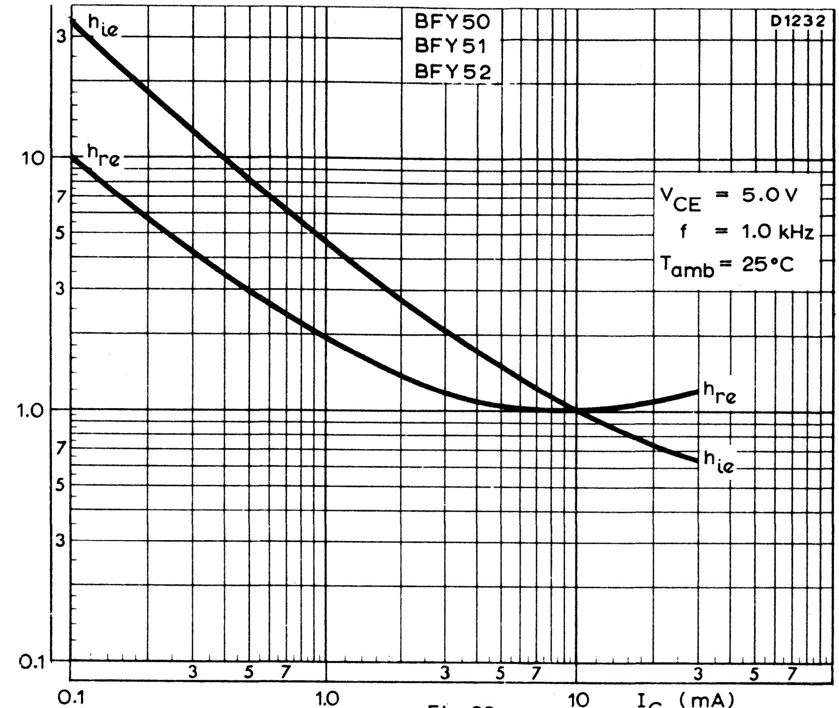

BFY50
BFY51
BFY52
D1232
h_{ie}
h_{re}
V_{CE} = 5.0 V
f = 1.0 kHz
T_{amb} = 25°C
3
10
7
5
3
1.0
7
5
3
0.1
0.1
3 5 7
1.0
3 5 7
10
3 5 7
I_C (mA)

Fig. 32.

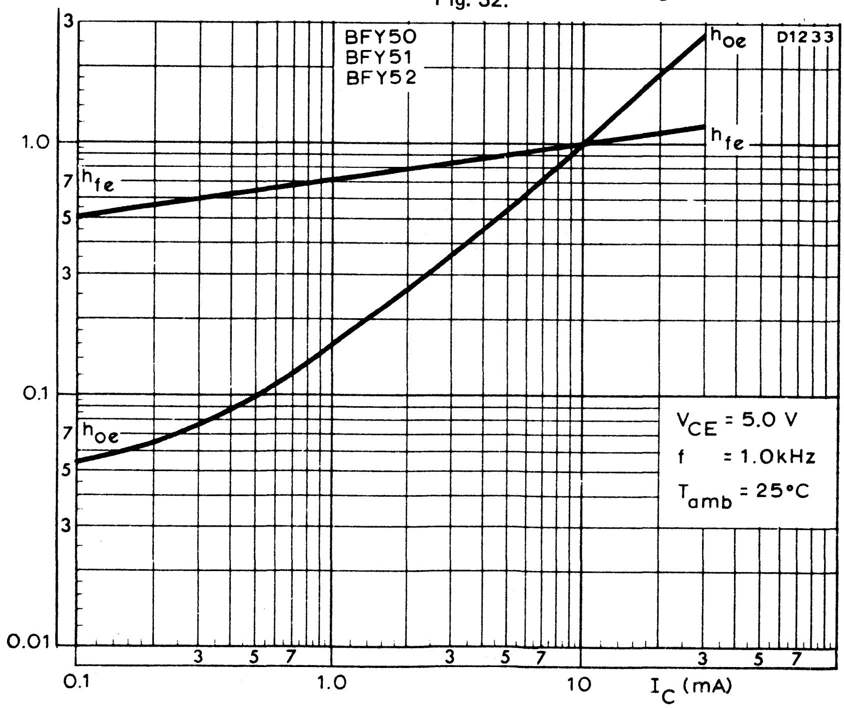

BFY50
BFY51
BFY52
D1233
h_{oe}
h_{fe}
V_{CE} = 5.0 V
f = 1.0kHz
T_{amb} = 25°C
3
1.0
7
5
3
0.1
7
5
3
0.01
0.1
3 5 7
1.0
3 5 7
10
3 5 7
I_C (mA)

Fig. 33.

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

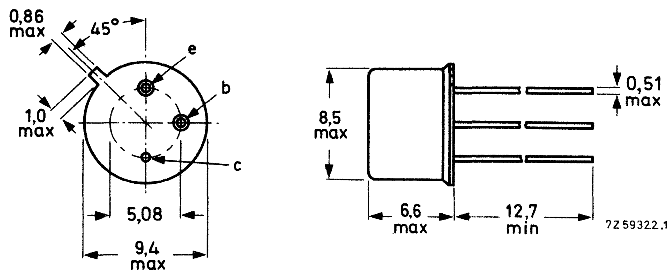
Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 10 V	h_{FE}		40 to 120	
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 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	V
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
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
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	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,035	K/mW

CHARACTERISTICS

T_j = 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; $T_j = 150$ °C	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 *) **)	V_{CEsat}	<	1,0 V
	V_{BEsat}	<	1,6 V
Sustaining voltage			
$I_C = 30$ mA; $I_B = 0$ **	$V_{CEOsust}$	>	35 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
$I_C = 1$ 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

* Measured with a lead length of 1 cm.

** Measured under pulsed conditions to avoid excessive dissipation. Pulse duration = 300 μs; duty cycle $\delta < 0{,}01$.

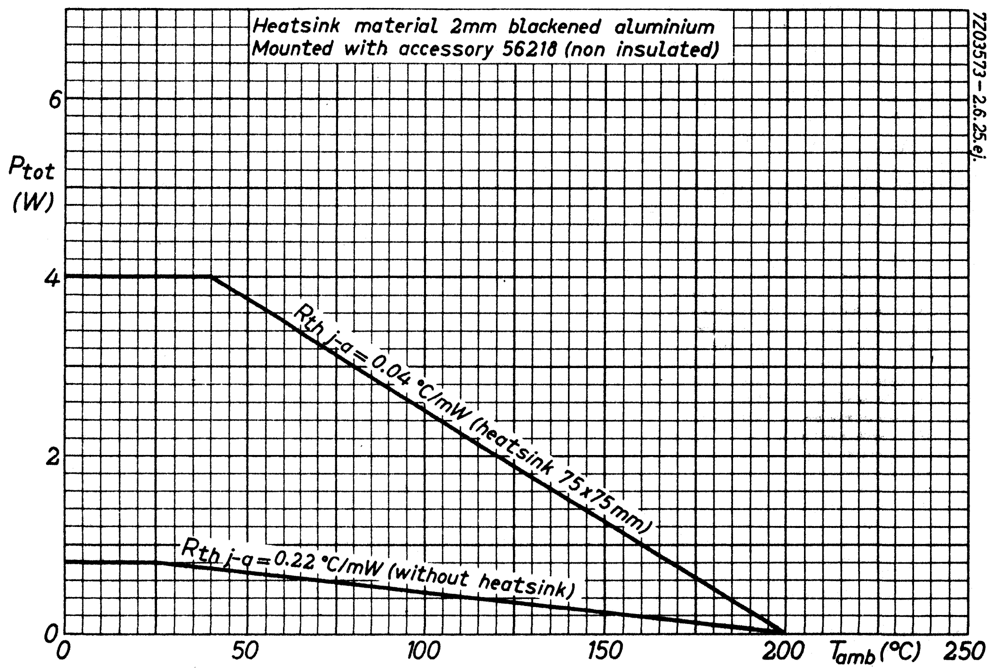

Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573-2.6.25.ej.
Ptot (W)
6
4
2
0
0
50
100
150
200
Tamb (°C)
250
Rth j-a = 0.04 °C/mW (heatsink 75x75mm)
Rth j-a = 0.22 °C/mW (without heatsink)

Fig. 2.

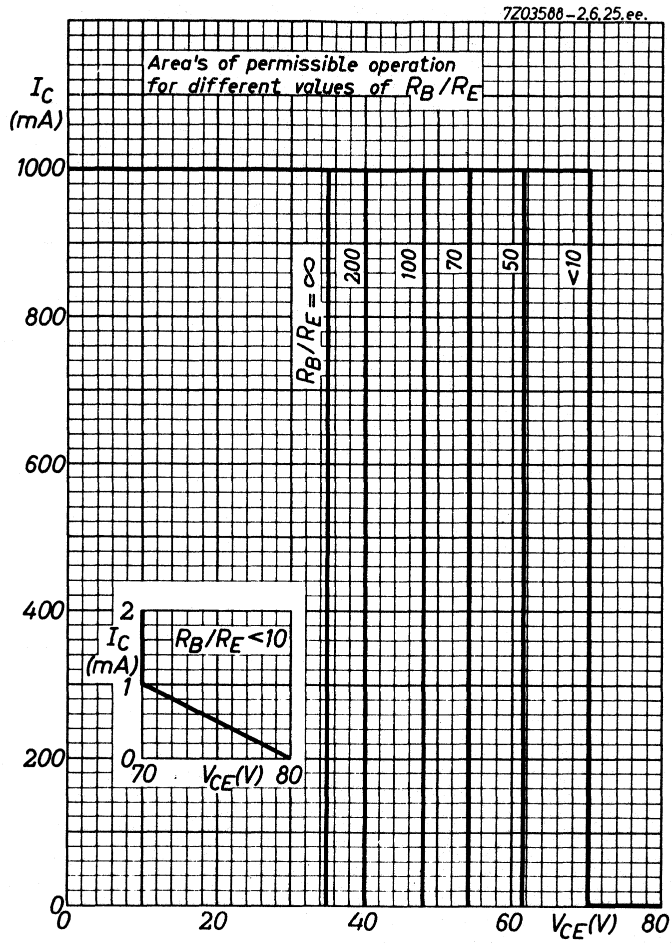

7Z03588-2.6.25.ee.
Area's of permissible operation
for different values of R_B/R_E
I_C
(mA)
1000
800
600
400
200
0
$R_B/R_E = \infty$
200
100
70
50
<10
0
20
40
60
V_{CE}(V)
80
2
I_C
(mA)
1
0
R_B/R_E<10
70
V_{CE}(V)
80

Fig. 3.

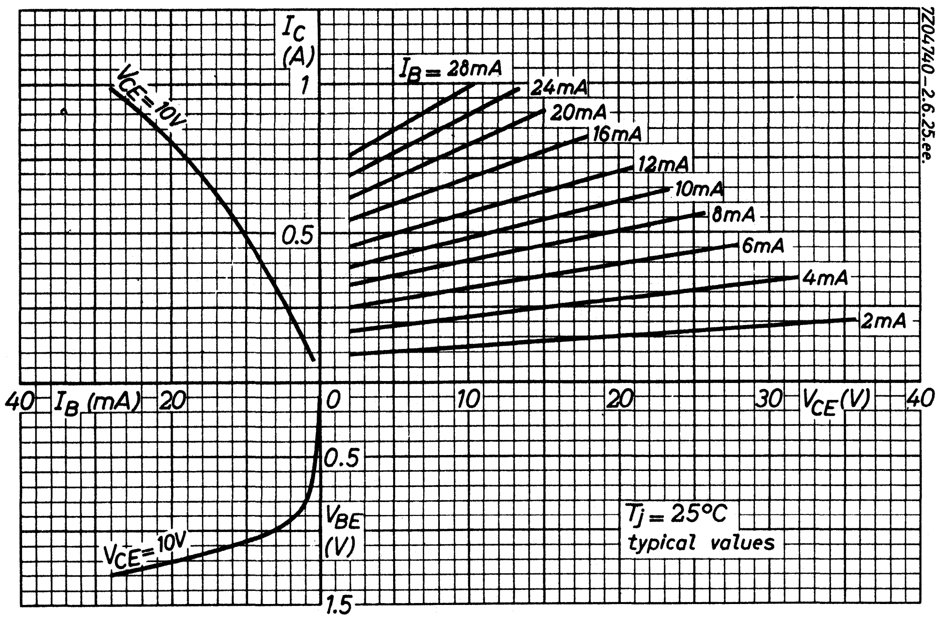

7Z04740-2.6.25.ee.
I_C (A)
1
0.5
V_{CE} = 10V
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values

Fig. 4.

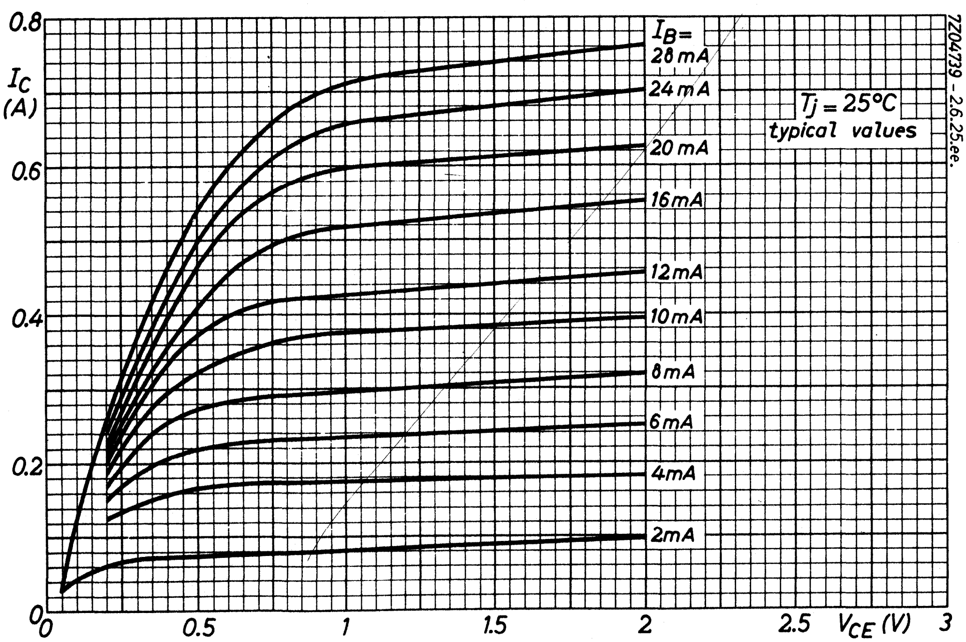

7Z04739-2.6.25.ee.
0.8
I_C (A)
0.6
0.4
0.2
0
I_B =
28 mA
24 mA
20 mA
16 mA
12 mA
10 mA
8 mA
6 mA
4mA
2mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3

Fig. 5.

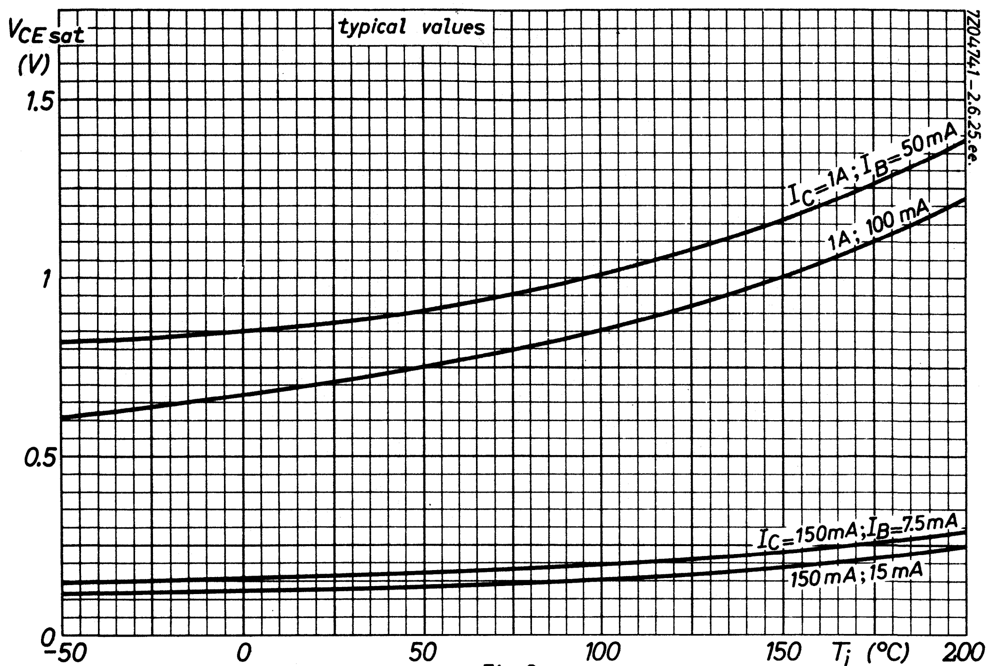

$V_{CE\,sat}$ (V)
typical values
7Z04741 - 2.6.25.ee.
I_C=1A; I_B=50 mA
1A; 100 mA
I_C=150mA; I_B=7.5mA
150 mA; 15 mA
1.5
1
0.5
0
−50
0
50
100
150
200
T_j (°C)

Fig. 6.

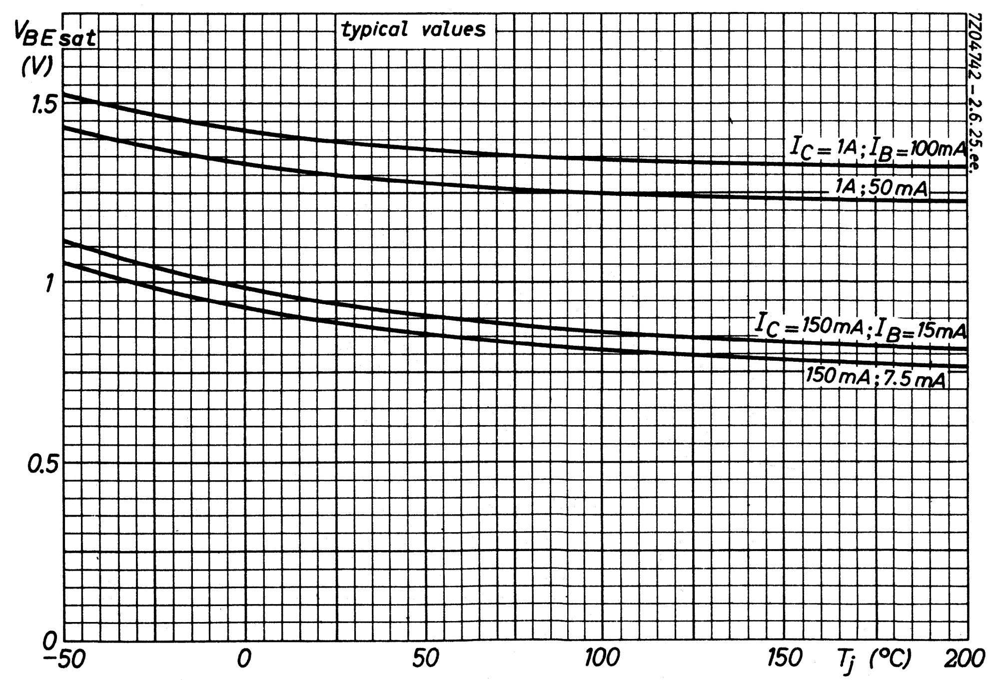
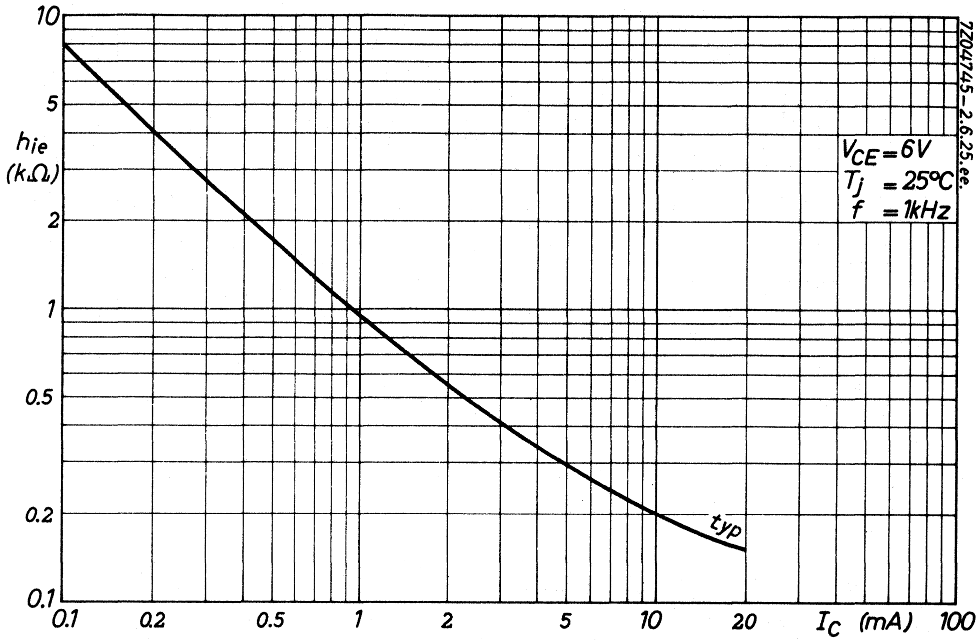
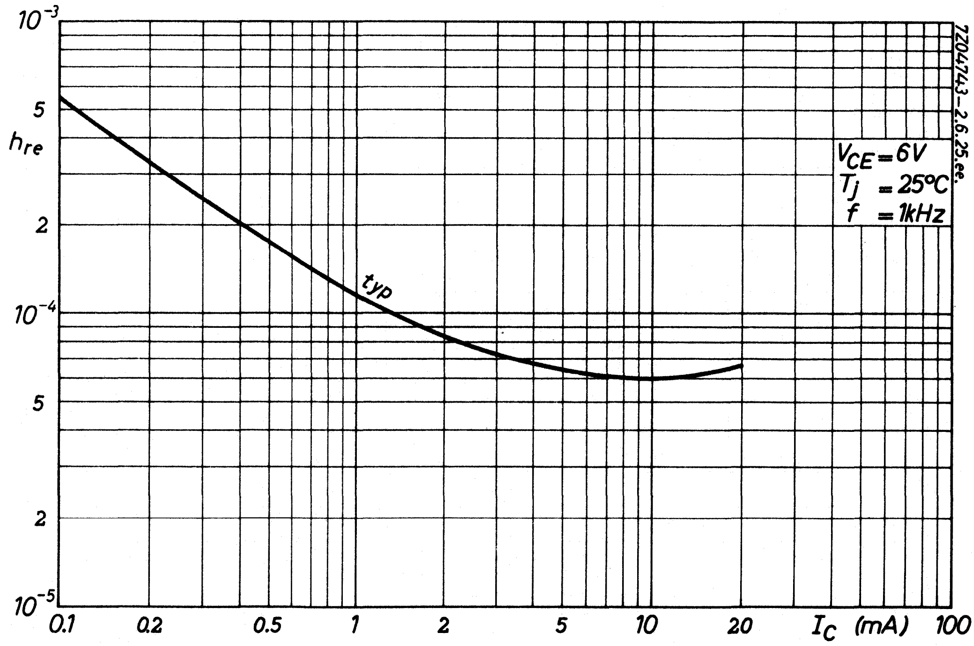

$V_{BE\,sat}$ (V)
typical values
7Z04742 - 2.6.25.ee.
I_C = 1A; I_B =100mA
1A; 50 mA
I_C =150mA; I_B=15mA
150 mA; 7.5 mA
1.5
1
0.5
0
−50
0
50
100
150
200
T_j (°C)

Fig. 7.



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
7Z04745-2.6.25.ee.
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ

Fig. 8.



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
7Z04743-2.6.25.ee.
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ

Fig. 9.

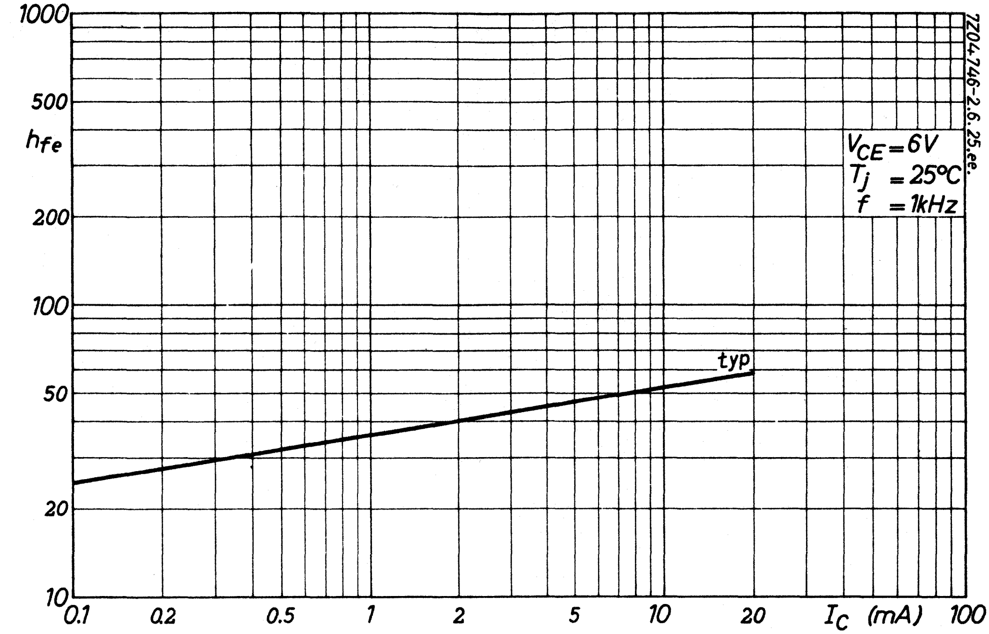

7Z04746-2.6.25.ee.
1000
500
h_{fe}
200
100
50
20
10
$V_{CE} = 6V$
$T_j = 25^\circ C$
$f = 1kHz$
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

Fig. 10.

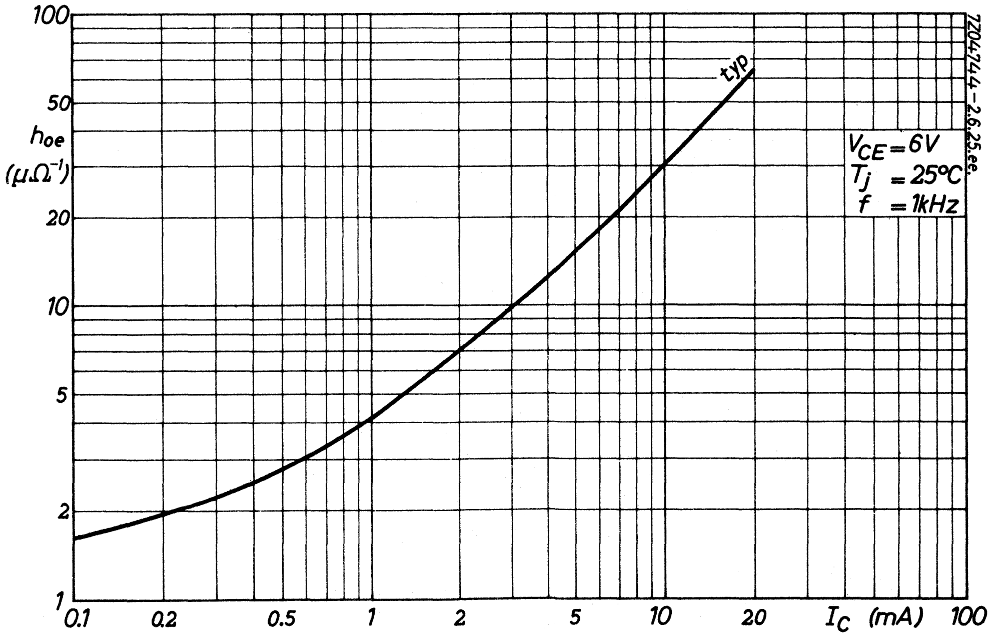

7Z04744-2.6.25.ee.
100
50
h_{oe}
$(\mu\Omega^{-1})$
20
10
5
2
1
$V_{CE} = 6V$
$T_j = 25^\circ C$
$f = 1kHz$
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

Fig. 11.

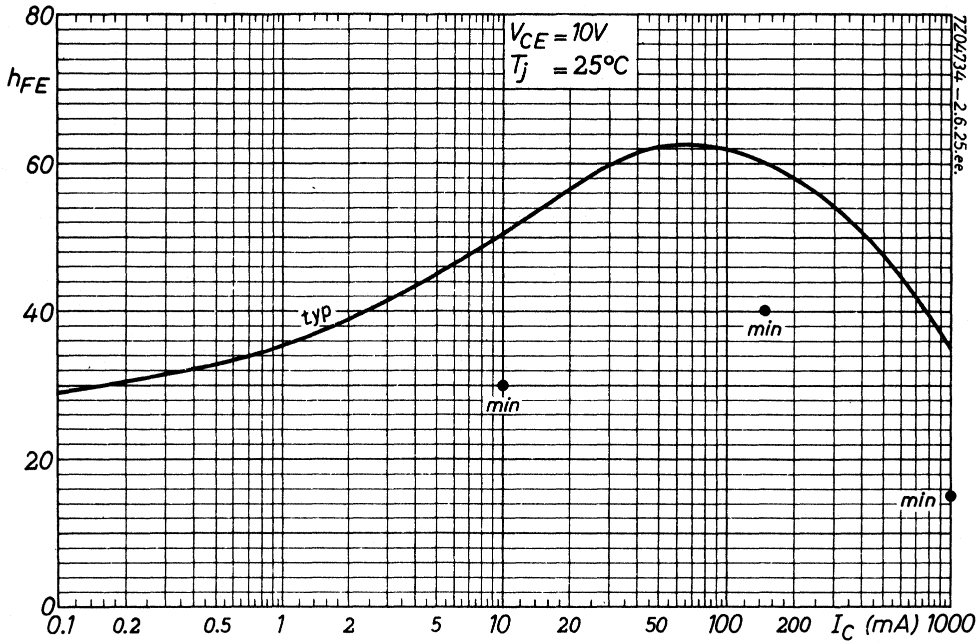

7Z04734 – 2.6.25.ee.
V_{CE} = 10V
T_j = 25°C
h_{FE}
80
60
40
20
0
typ
min
min
min
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_C (mA)
1000

Fig. 12.

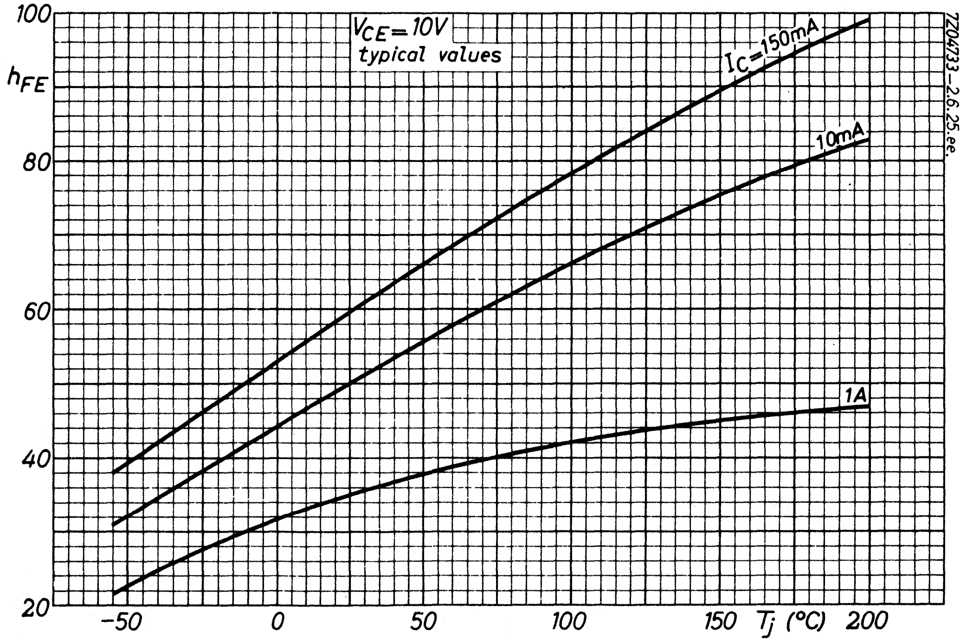

7Z04733 – 2.6.25.ee.
V_{CE} = 10V
typical values
h_{FE}
100
80
60
40
20
I_C = 150mA
10mA
1A
−50
0
50
100
150
T_j (°C)
200

Fig. 13.

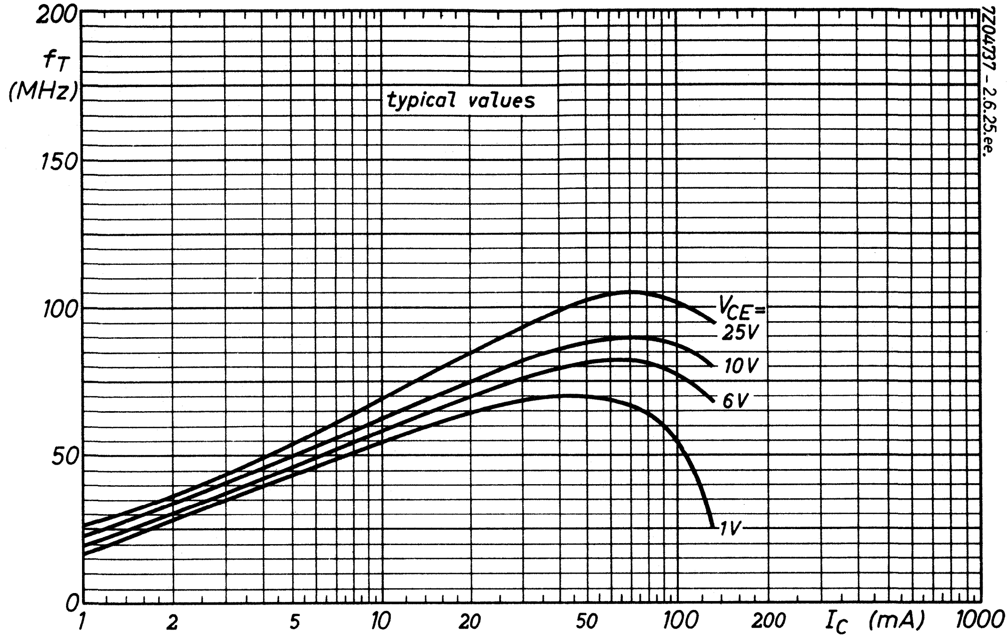

7Z04737 - 2.6.25.ee.
200
f_T
(MHz)
typical values
150
100
50
0
V_{CE} =
25V
10V
6V
1V
1
2
5
10
20
50
100
200
I_C (mA)
1000

Fig. 14.

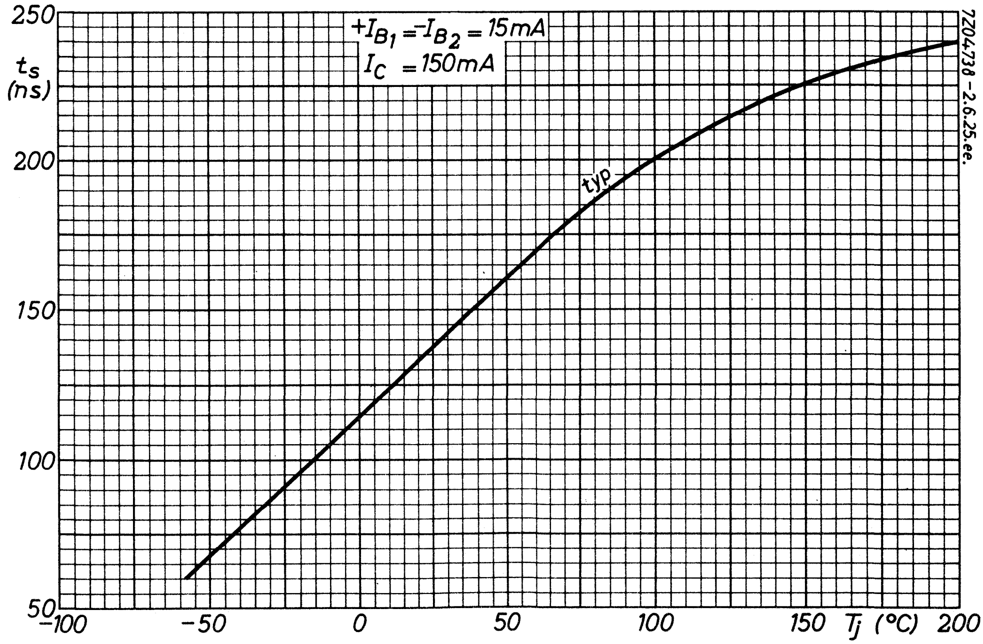

7Z04738 - 2.6.25.ee.
250
t_s
(ns)
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
200
typ
150
100
50
−100
−50
0
50
100
150
T_j (°C)
200

Fig. 15.

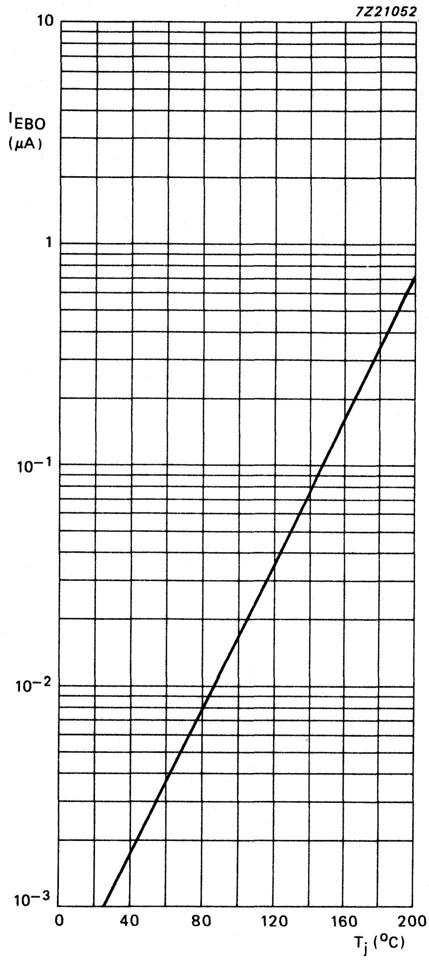


Fig. 16 V_{EB} = 5 V; typical values.

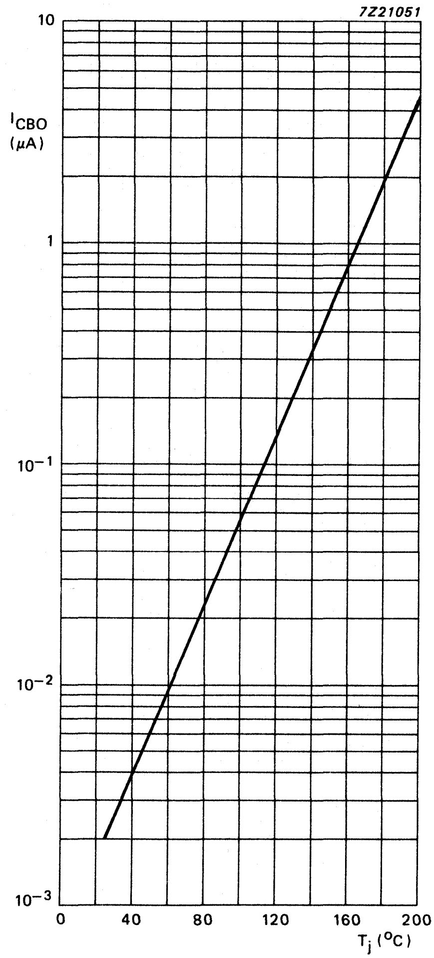


Fig. 17 V_{CB} = 60 V; typical values.

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

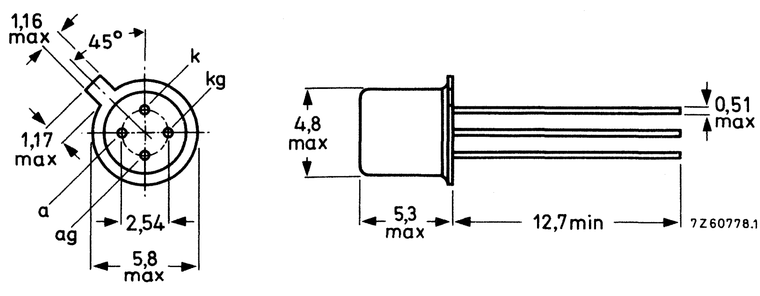
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Repetitive peak emitter current (peak value)	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; R_{KG-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

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.	−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	V *
Emitter current (d.c.)	I_E	max.	175	−175	mA
Repetitive peak emitter current (peak value) t_p = 10 μs; δ = 0,01	I_{ERM}	max.	2,5	−2,5	A
Collector current (d.c.)	I_C	max.	−	175	mA **
Collector current (peak value)	I_{CM}	max.	−	175	mA
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	$R_{th\ j\text{-}a}$	=	0,45	K/mW

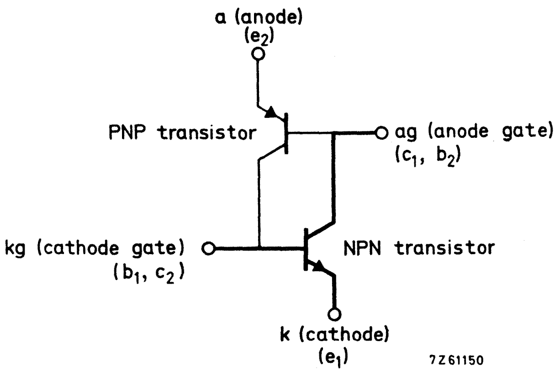
* Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.

** Provided the I_E rating will not be exceeded.

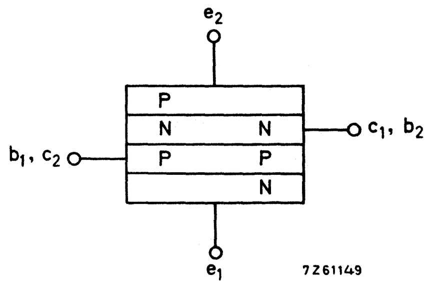
MEANING OF SYMBOLS, used in the schematic presentation of the S.C.S.

2 transistors equivalent circuit

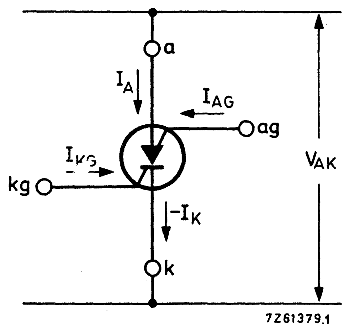
n-p-n transistor + p-n-p transistor



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)

Individual N-P-N transistor

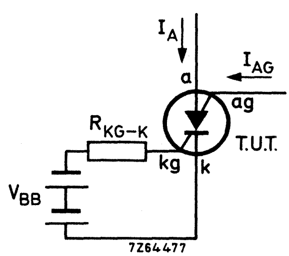
Saturation voltages			
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500 mV
	V_{BEsat}	<	900 mV
D.C. current gain			
$I_C = 10$ mA; $V_{CE} = 2$ V	h_{FE}	>	50
Transition frequency			
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300 MHz
Collector capacitance			
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5 pF
Emitter 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 $R_{KG\text{-}K} = 10\ k\Omega$			
$I_A = 50$ 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 $R_{KG\text{-}K} = 10\ k\Omega$			
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0 mA



PROGRAMMABLE UNIJUNCTION TRANSISTOR

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper etc.

QUICK REFERENCE DATA

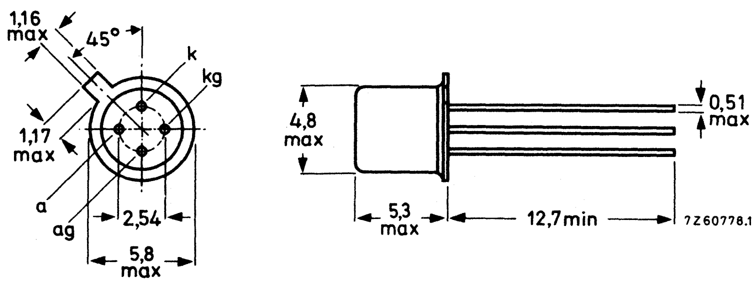
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Operating junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	25	μA

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.

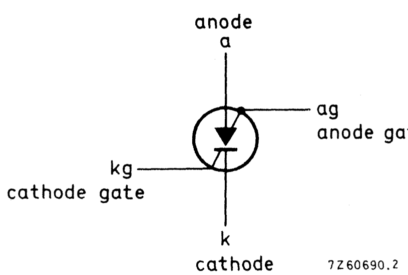


Fig. 2.

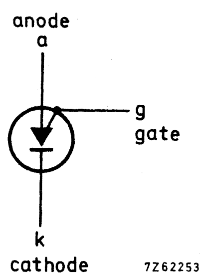


Fig. 3.

CHARACTERISTICS

T_{amb} = 25 °C

Peak point current			
V_S = 10 V; R_G = 10 kΩ	I_P	<	5 μA
V_S = 10 V; R_G = 1 MΩ	I_P	<	1 μA
Valley point current			
V_S = 10 V; R_G = 10 kΩ	I_V	>	25 μA
V_S = 10 V; R_G = 1 MΩ	I_V	<	50 μA

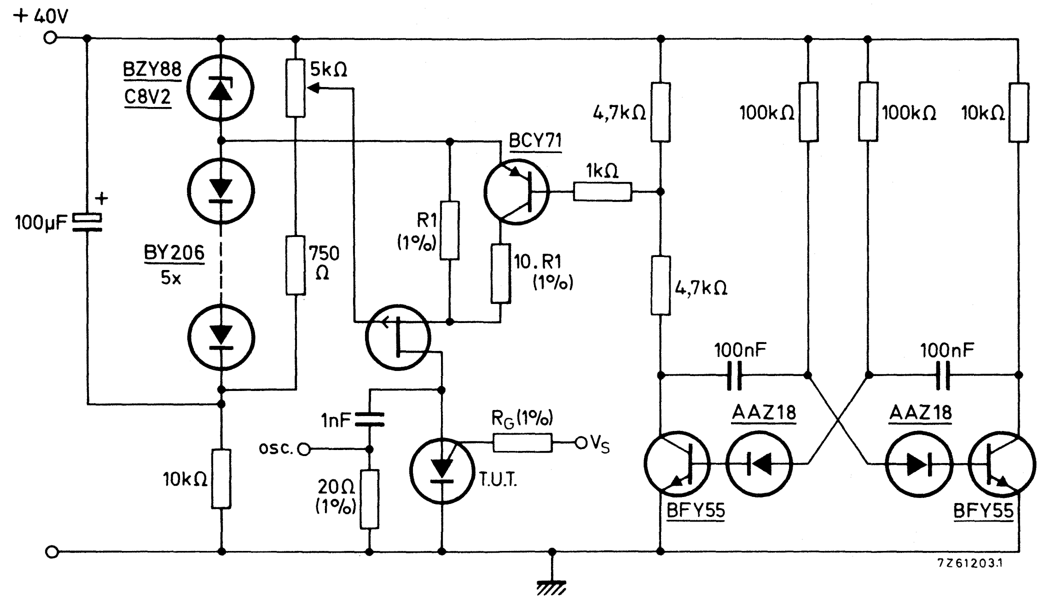


Fig. 4 Practical test circuit:
1. Remove BCY71 during measurement of I_P.
2. Value of R1 depends on the voltage range of voltmeter.

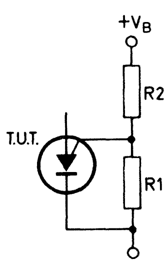


Fig. 5 **BRY39P** with "program" resistors R1 and R2.

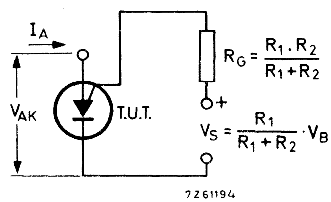


Fig. 6 Equivalent test circuit for characteristics testing.

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) $V_{offset} = V_P - V_S$ ($I_A = 0$)			

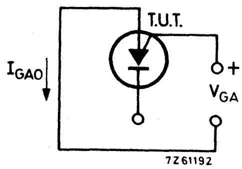


Fig. 7.

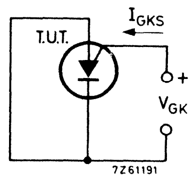


Fig. 8.

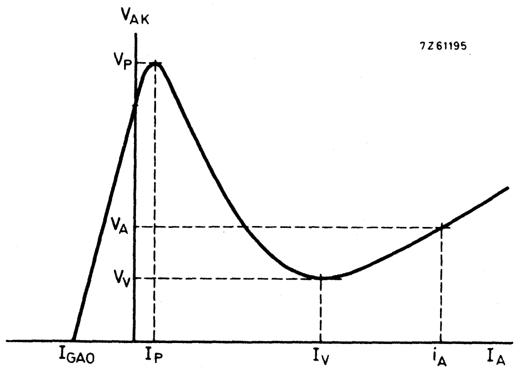


Fig. 9.

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

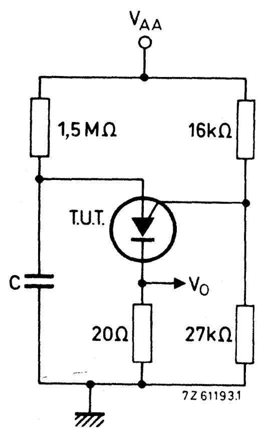


Fig. 10.

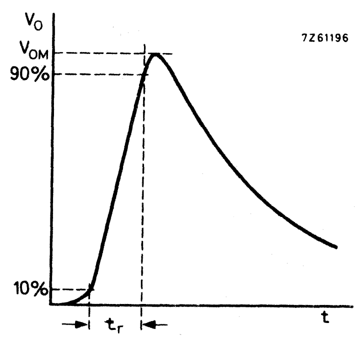


Fig. 11.

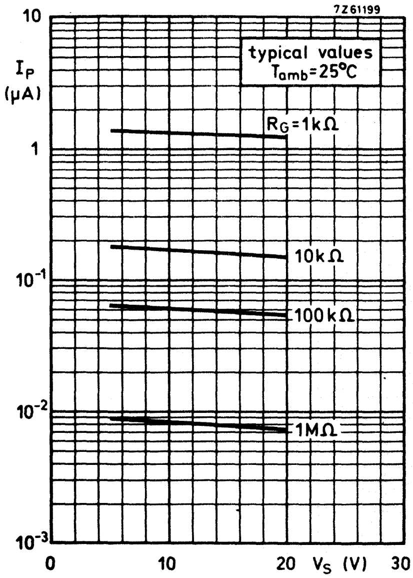


Fig. 12.

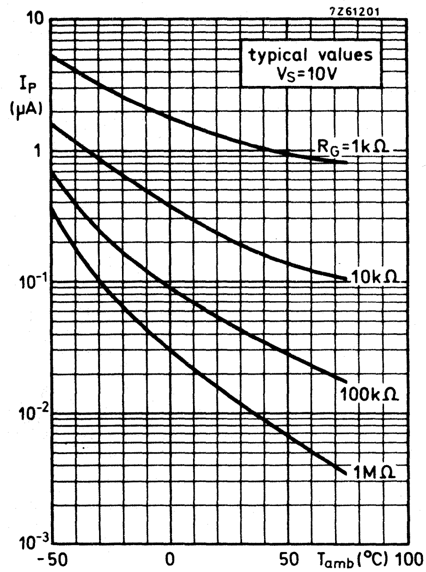


Fig. 13.

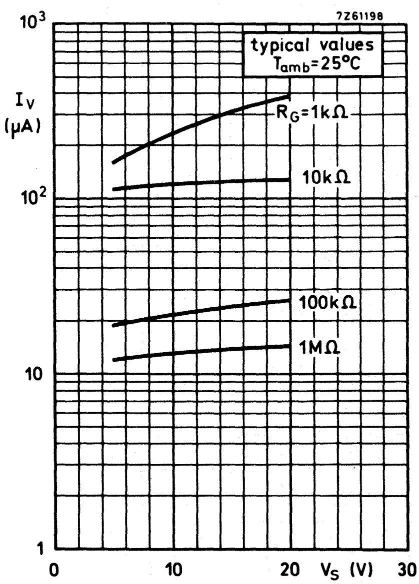


Fig. 14.

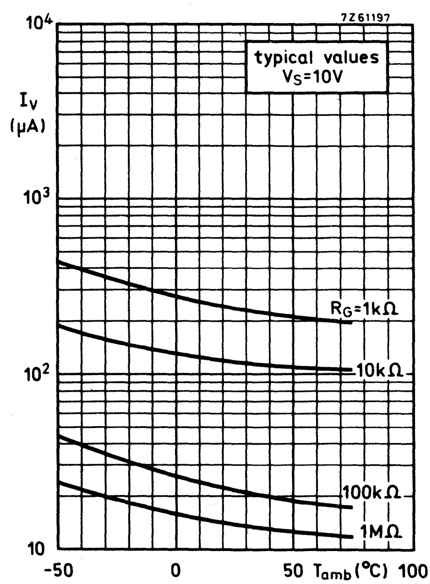


Fig. 15.

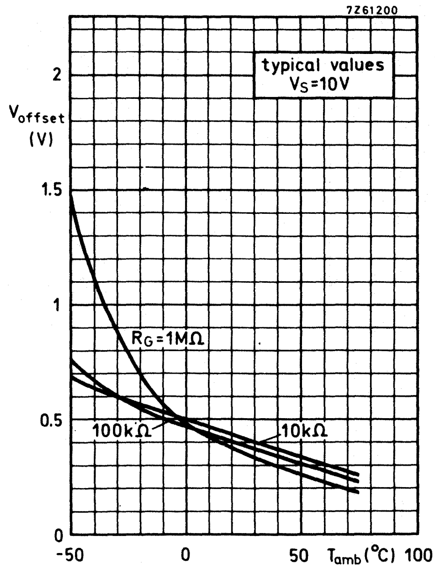

7Z61200
typical values
V_S=10V
V_{offset}
(V)
2
1.5
1
0.5
0
R_G=1MΩ
100kΩ
10kΩ
-50
0
50
T_{amb} (°C)
100

Fig. 16.

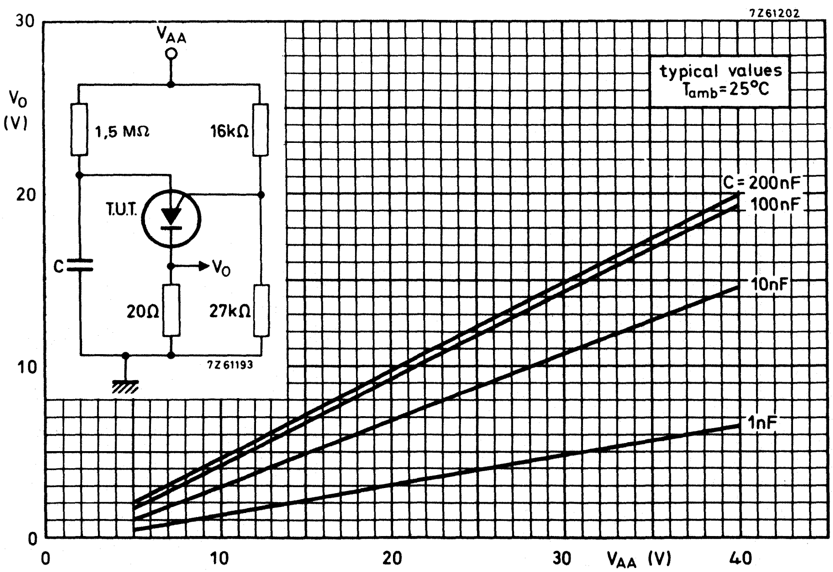

7Z61202
typical values
T_{amb}=25°C
V_O
(V)
30
20
10
0
V_{AA}
1,5 MΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
7Z61193
C = 200nF
100nF
10nF
1nF
0
10
20
30
V_{AA} (V)
40

Fig. 17.

SILICON CONTROLLED SWITCH

The BRY39 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for switching applications. It is an integrated p-n-p/n-p-n transistor pair, with all electrodes accessible.

QUICK REFERENCE DATA

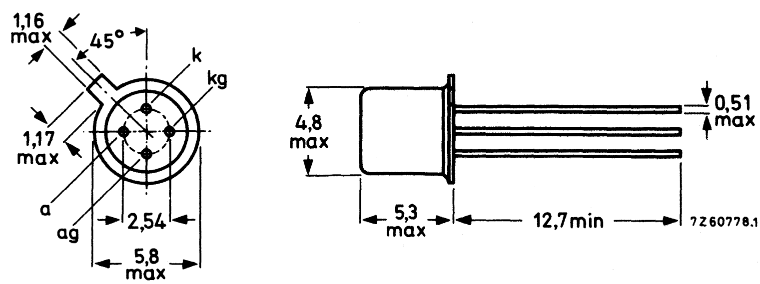
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Operating junction temperature	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

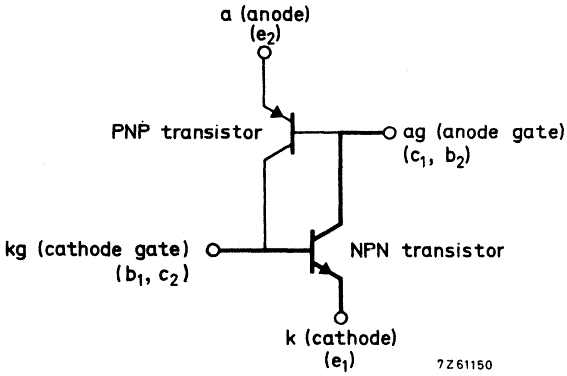


Fig. 2 Two transistor equivalent circuit.

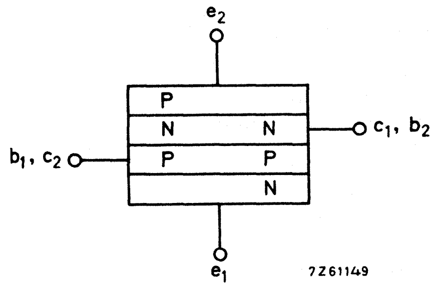


Fig. 3 P-N-P-N silicon controlled switch structure.

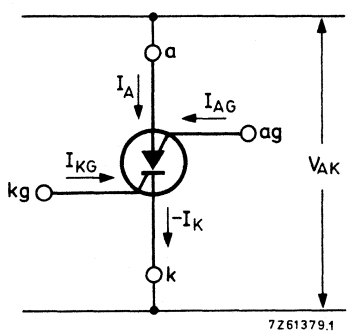


Fig. 4 Silicon controlled switch symbol.

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 $R_{KG\text{-}K} = 10$ 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 $R_{KG\text{-}K} = 10$ kΩ (see Fig. 5)			
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0 mA

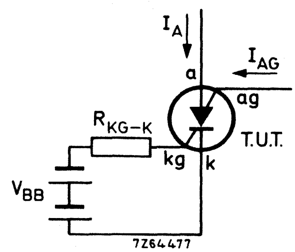


Fig. 5.

Switching times (see Figs 6 to 11)

Turn-on time when switched from

$-V_{KG-K}$ = 0,5 V to + V_{KG-K} = 4,5 V

R_{KG-K} = 1 kΩ	t_{on}	<	0,25 μs
R_{KG-K} = 10 kΩ	t_{on}	<	1,50 μs

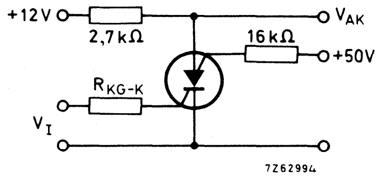


Fig. 6.

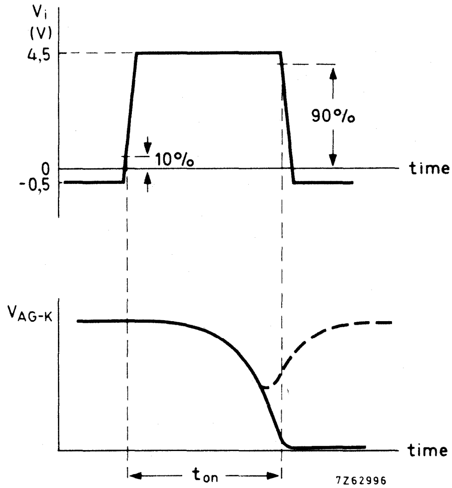


Fig. 7 Pulse duration increased until dashed curve disappears.

Turn-off time (see also Figs 8 and 9)

R_{KG-K} = 1 kΩ	t_q	<	5 μs
R_{KG-K} = 10 kΩ	t_q	<	8 μs
R_{KG-K} = 10 kΩ; T_j = 125 °C	t_q	<	15 μs

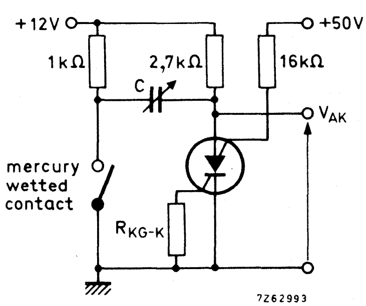


Fig. 8.

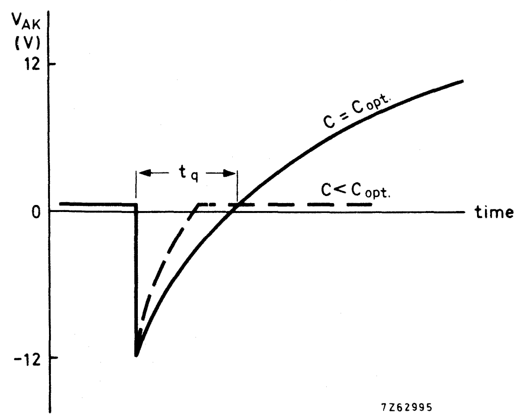


Fig. 9 Capacitance increased until at C = C_{opt} dashed curve disappears.

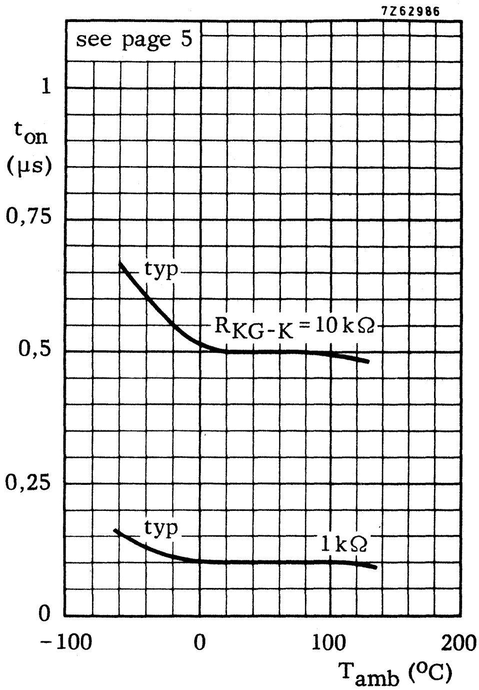


Fig. 10.

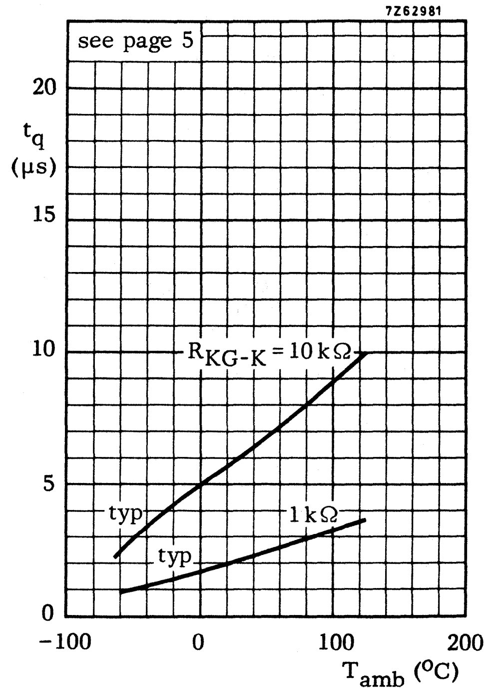


Fig. 11.

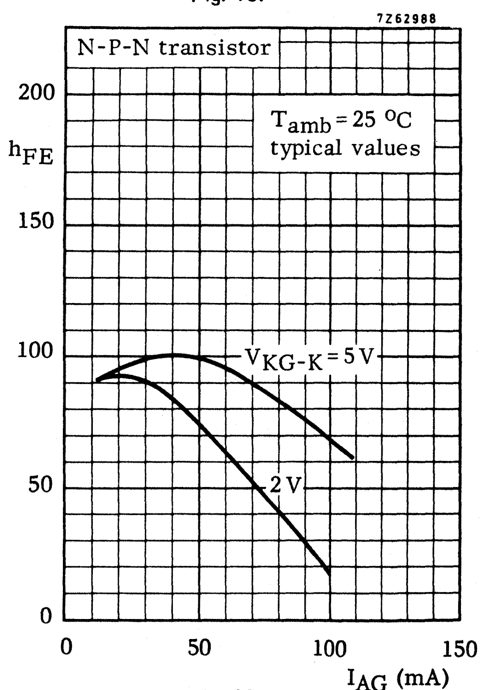


Fig. 12.

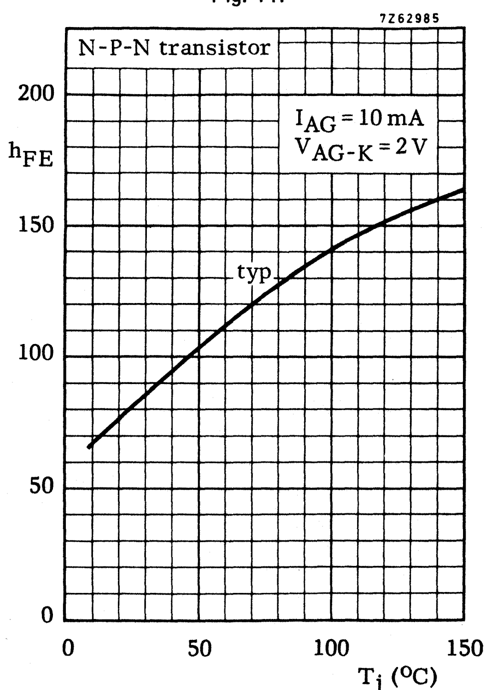


Fig. 13.

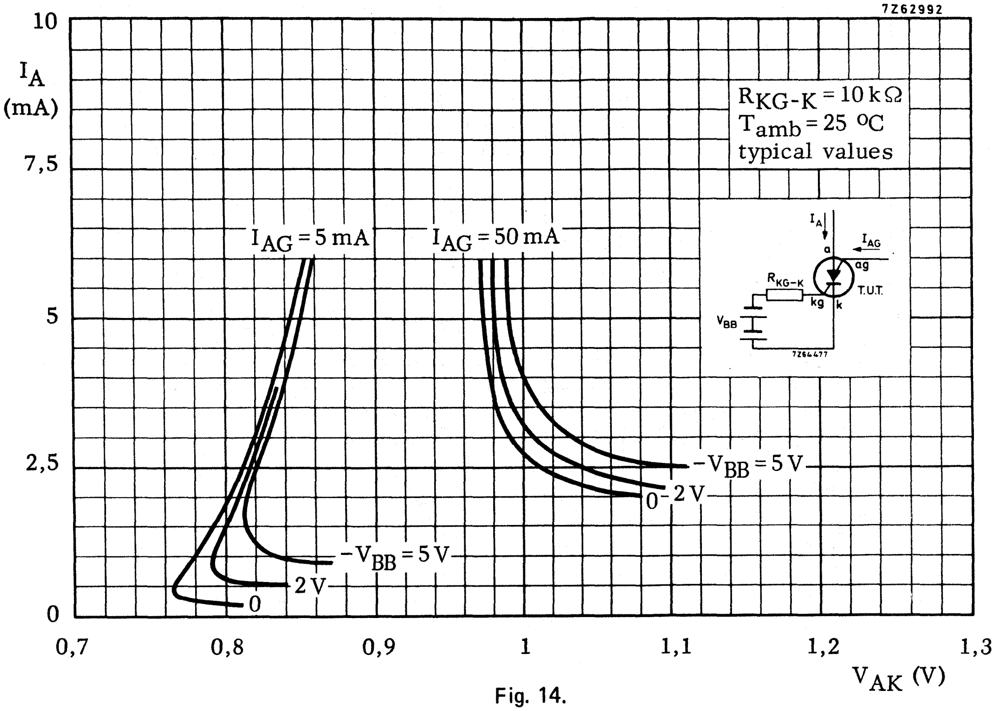

7Z62992
10
I_A
(mA)
7,5
5
2,5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
$R_{KG-K} = 10\,k\Omega$
$T_{amb} = 25\ ^oC$
typical values
$I_{AG} = 5\,mA$
$I_{AG} = 50\,mA$
$-V_{BB} = 5\,V$
2 V
0
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

Fig. 14.

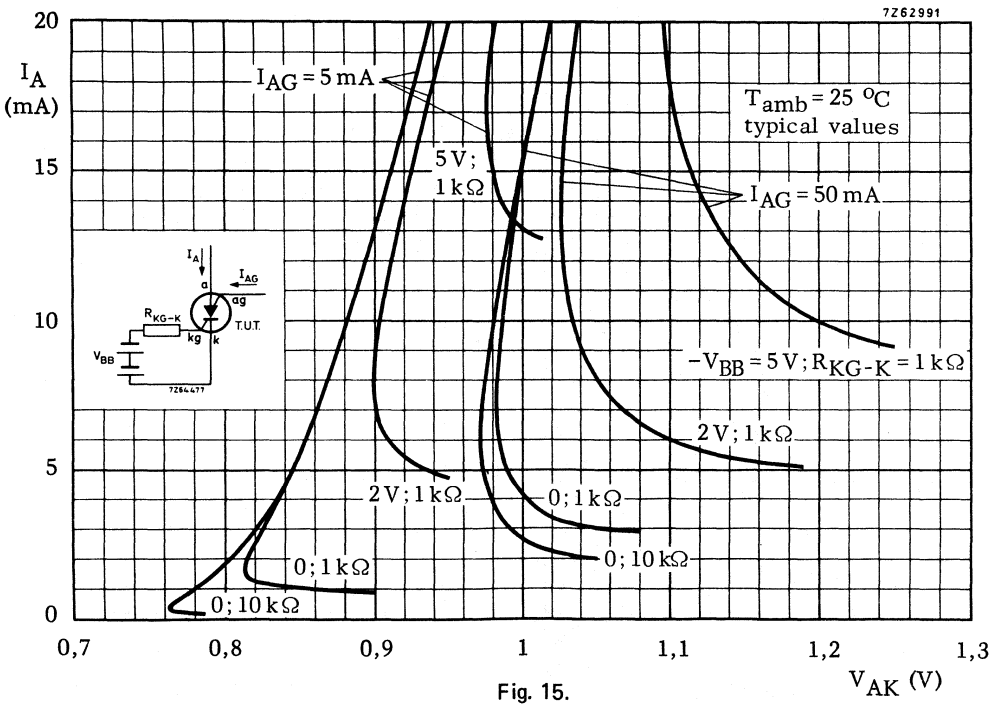

7Z62991
20
I_A
(mA)
15
10
5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
$T_{amb} = 25\ ^oC$
typical values
$I_{AG} = 5\,mA$
$I_{AG} = 50\,mA$
5 V;
1 kΩ
$-V_{BB} = 5\,V; R_{KG-K} = 1\,k\Omega$
2 V; 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
0; 1 kΩ
0; 10 kΩ
0; 10 kΩ
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

Fig. 15.

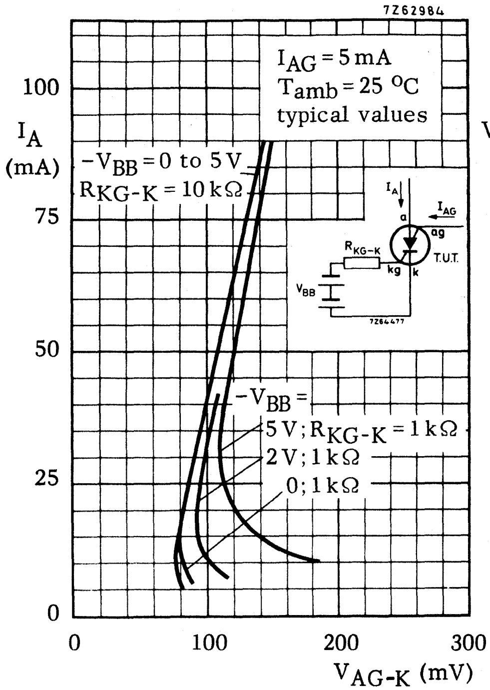


Fig. 16.

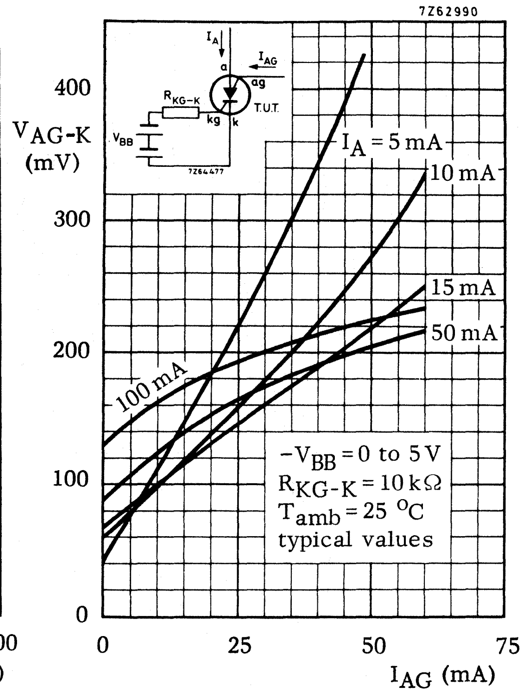


Fig. 17.

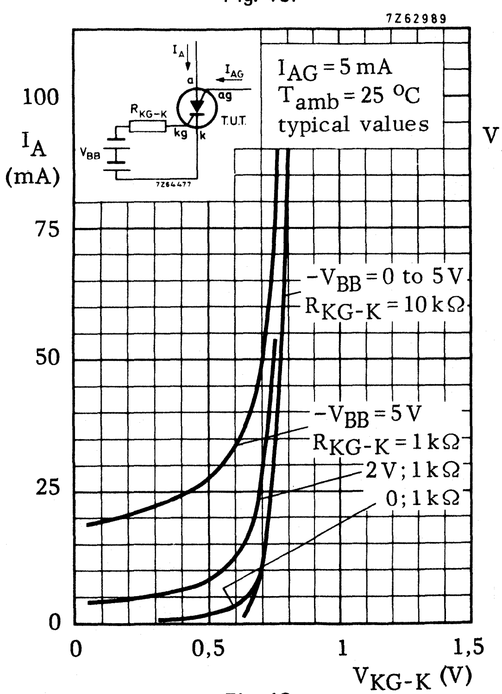


Fig. 18.

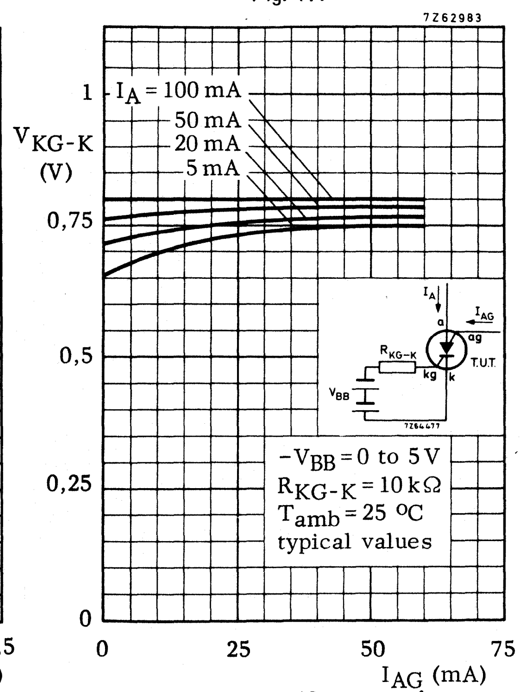


Fig. 19.

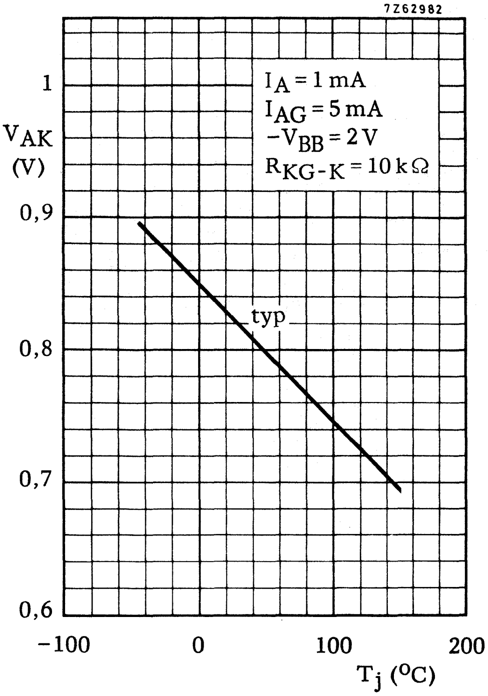


Fig. 20.

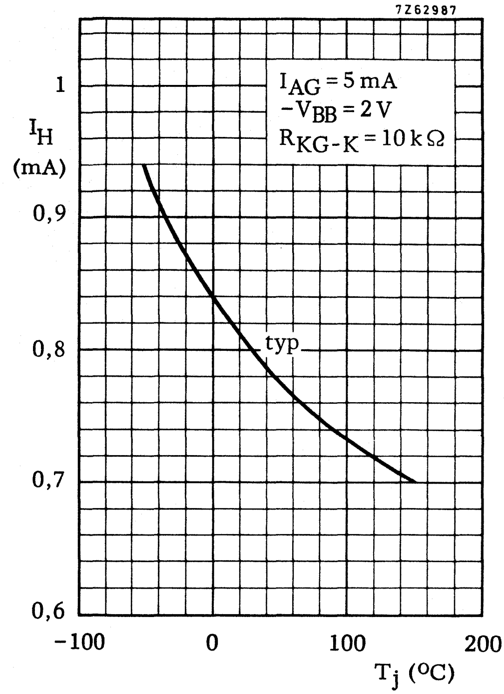


Fig. 21.

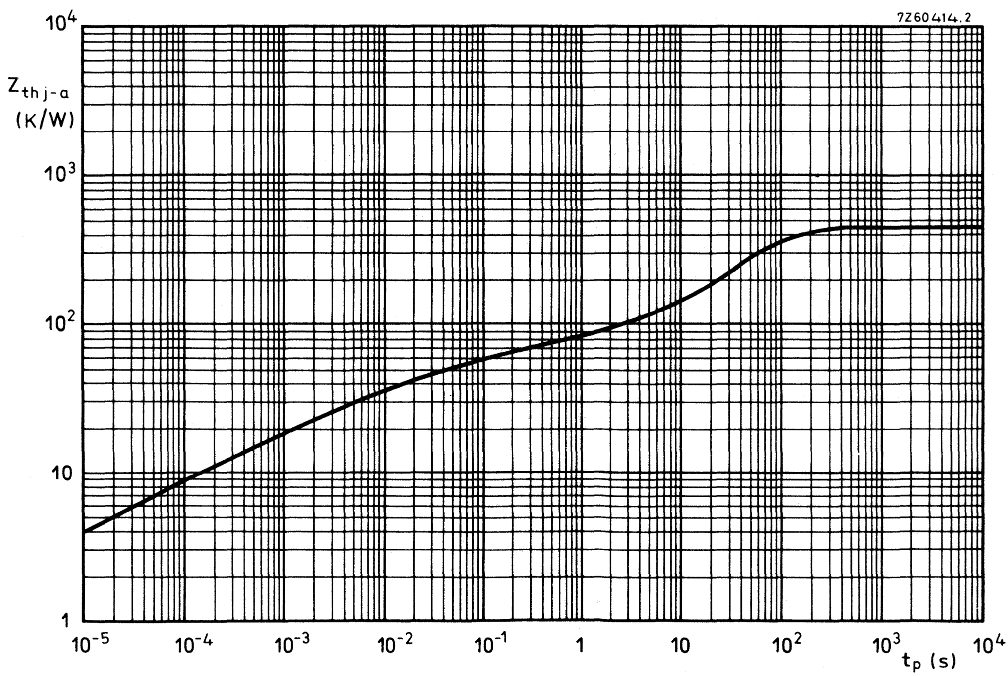


Fig. 22 Thermal impedance from junction to ambient versus pulse duration.

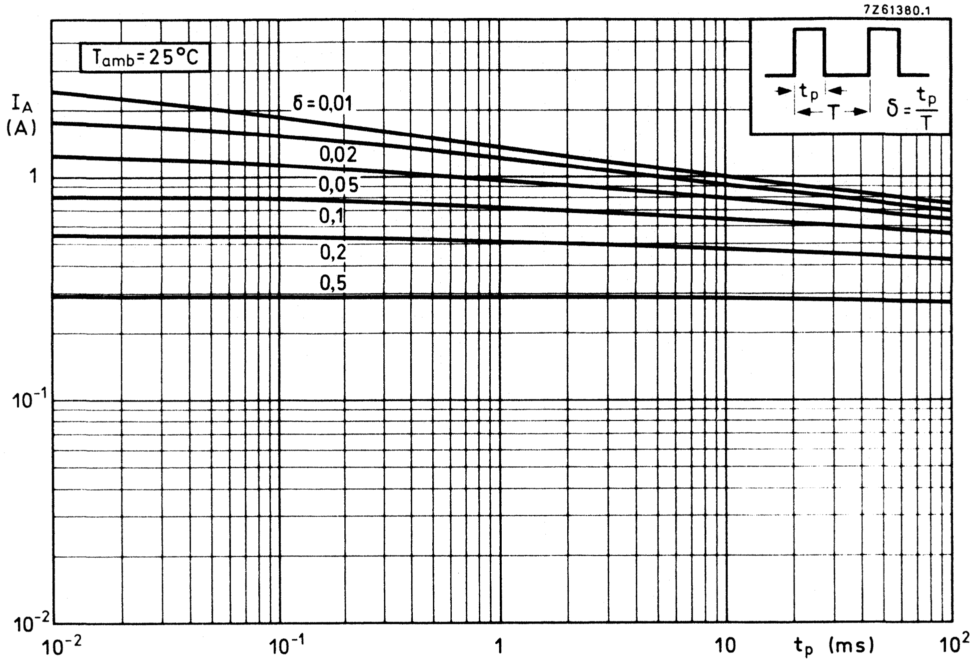

7Z61380.1
T_{amb} = 25 °C
I_A (A)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
$\delta = \frac{t_p}{T}$
t_p (ms)

Fig. 23.

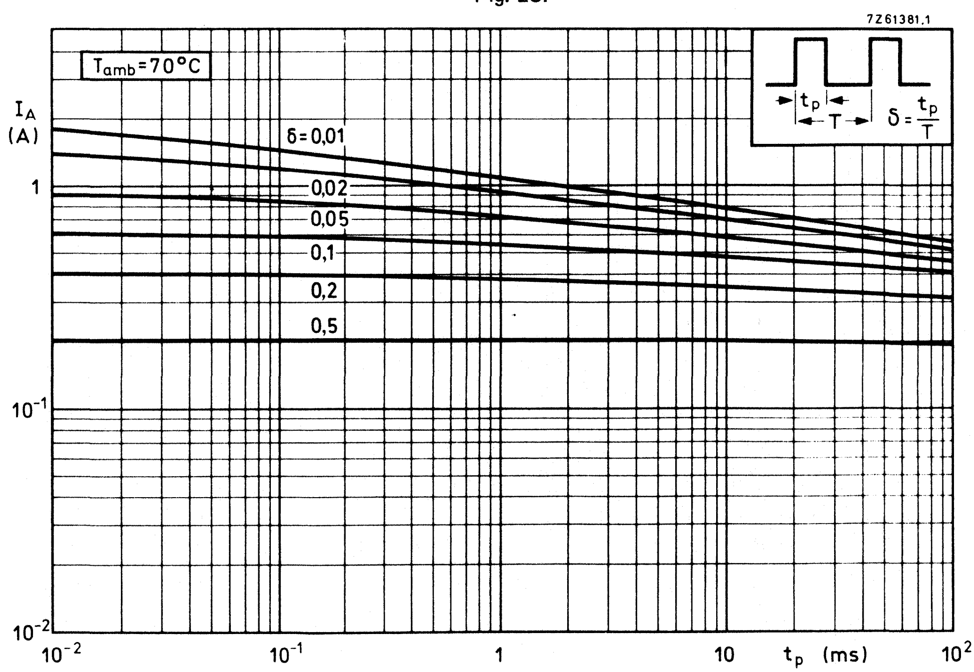

7Z61381.1
T_{amb} = 70 °C
I_A (A)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
$\delta = \frac{t_p}{T}$
t_p (ms)

Fig. 24.

THYRISTOR TETRODE

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in low-power switching applications such as relay and lamp drivers, sensing network for temperature and as a trigger device for thyristors and triacs.

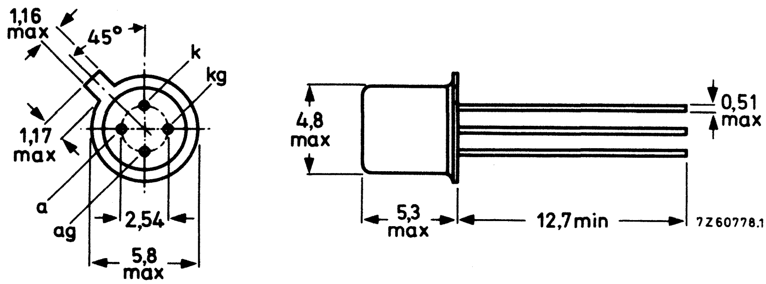
QUICK REFERENCE DATA

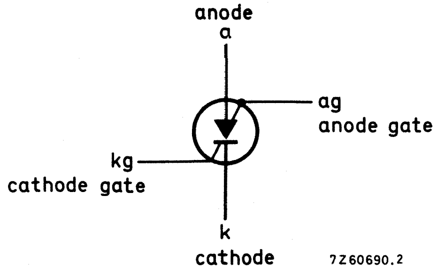
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70	V
Average on-state current	$I_{T(AV)}$	max.	250	mA
Non-repetitive peak on-state current	I_{TSM}	max.	3	A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO—72; Anode gate connected to case.





Accessories supplied on request: 56246 (distance disc).

RATINGS

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

Anode to cathode

Non-repetitive peak voltages	$V_{DSM} = V_{RSM}$	max.	70	V*
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70	V*
Continuous voltages	$V_D = V_R$	max.	70	V*
Average on-state current up to T_{case} = 85 °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	$\frac{dV_D}{dt}$**			
Off-state current		typ.	1	nA
V_D = 70 V; T_j = 25 °C	I_D	<	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

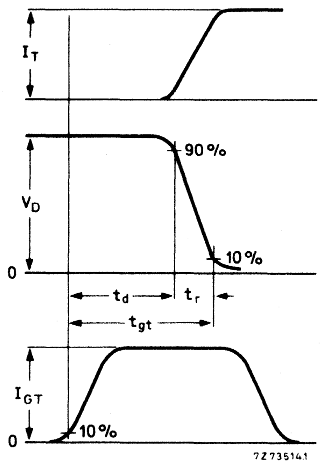


Fig.2 Gate-controlled turn-on time definition.

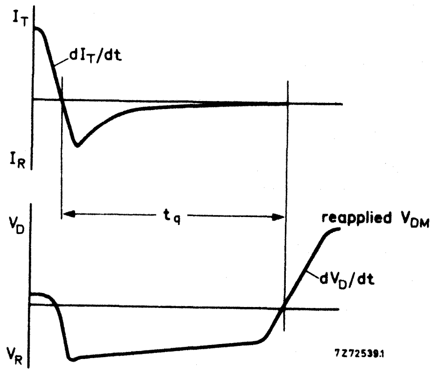


Fig.3 Circuit-commutated turn-off time definition.

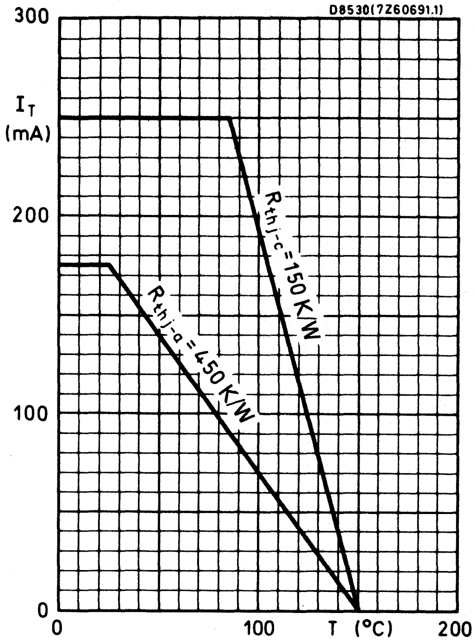


Fig.4

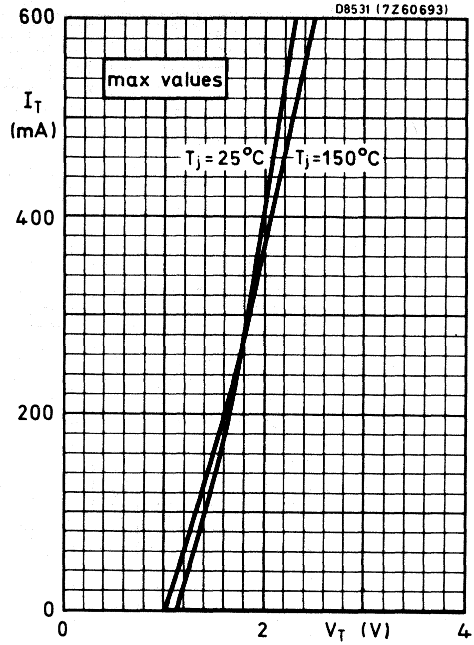


Fig.5

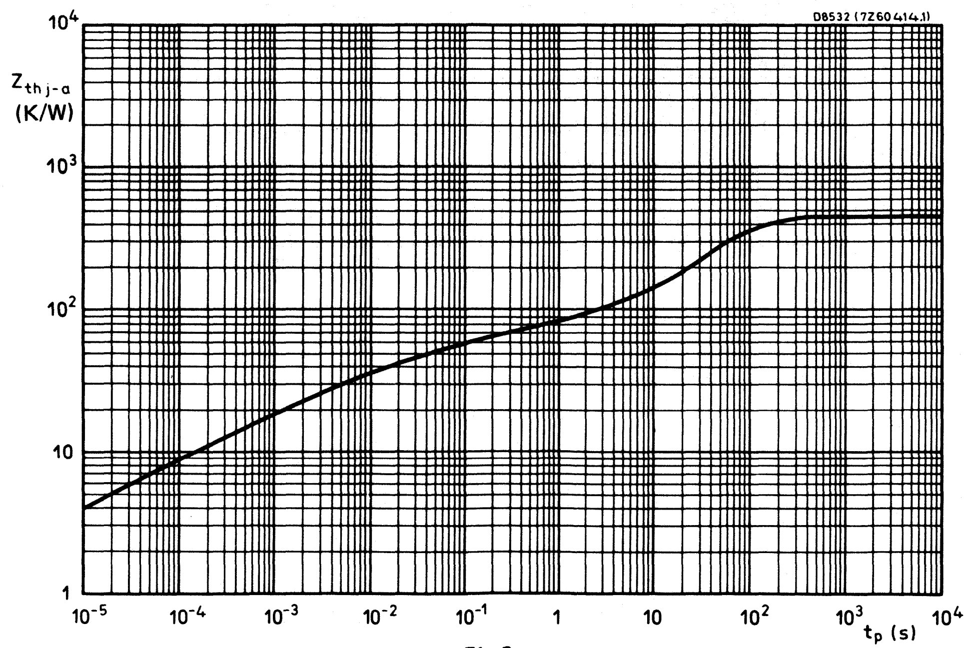


Fig.6

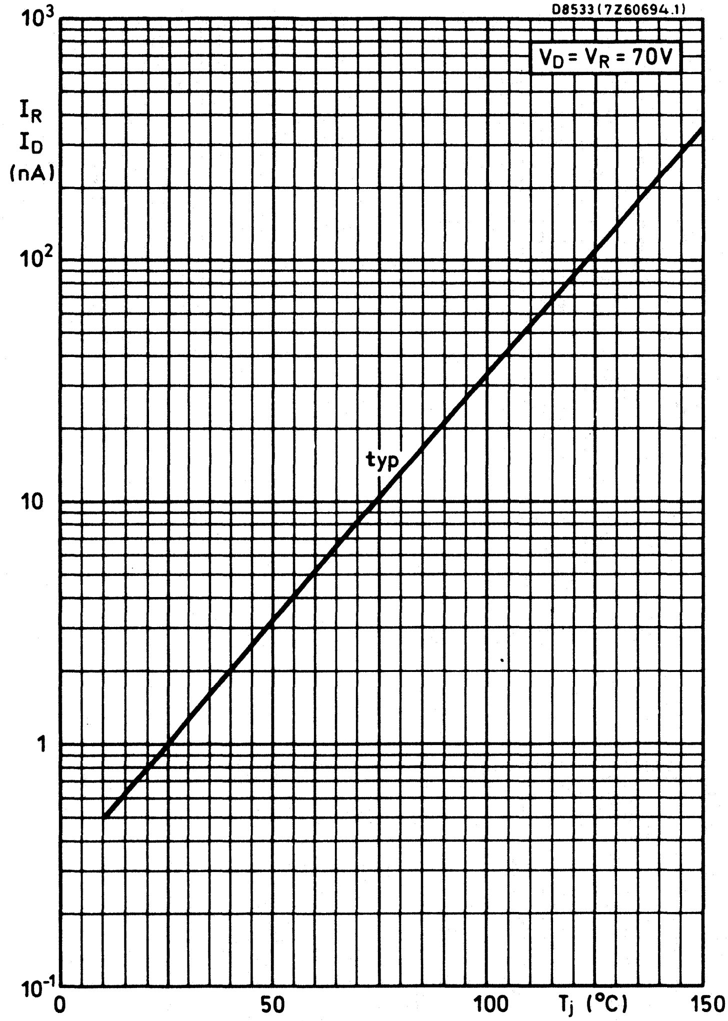

D8533 (7Z60694.1)
$V_D = V_R = 70V$
I_R
I_D
(nA)
10^3
10^2
10
1
10^{-1}
typ
0
50
100
T_j (°C)
150

Fig.7

APPLICATION INFORMATION

Sensing network

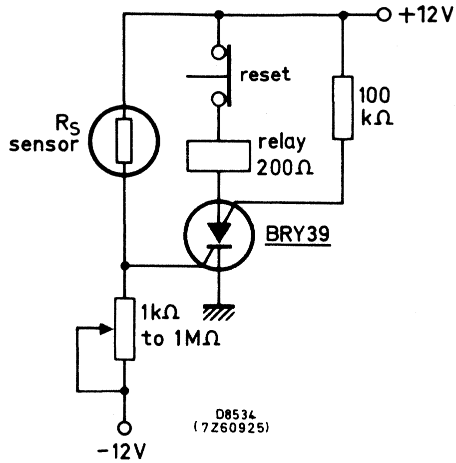


Fig.8

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.

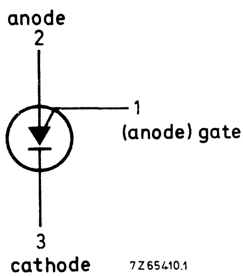
QUICK REFERENCE DATA

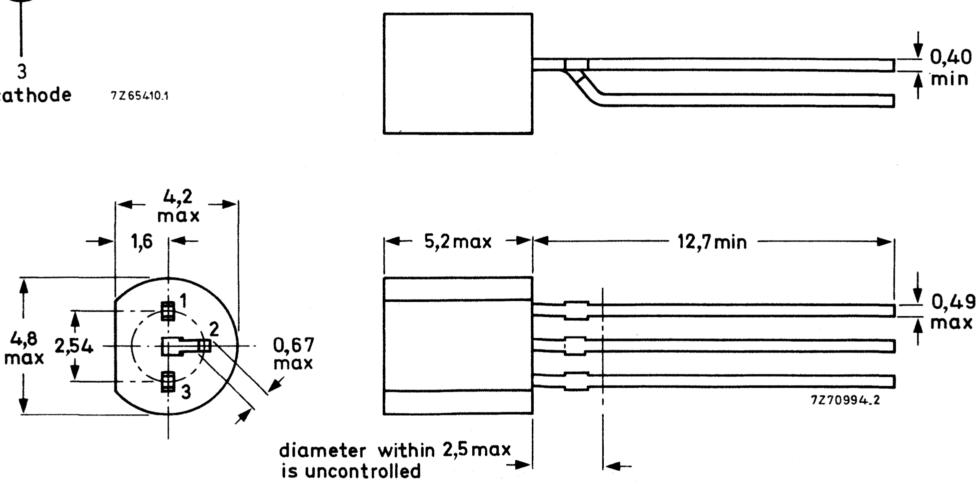
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (average)	$I_{A(AV)}$	max.	175	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

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_{GA}	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

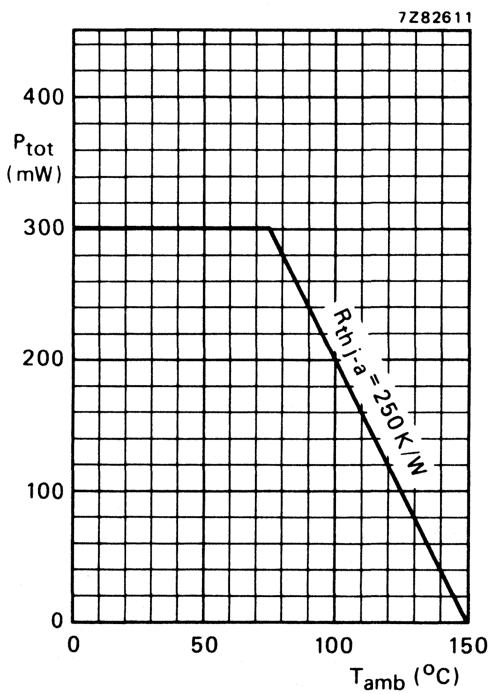


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

Peak point current (see Fig. 10)			
$V_S = 10\ V$; $R_G = 10\ k\Omega$	I_P	<	5 μA
$V_S = 10\ V$; $R_G = 100\ k\Omega$	I_P	<	2 μA
Valley point current (see Fig. 10)			
$V_S = 10\ V$; $R_G = 10\ k\Omega$	I_V	>	50 μA
$V_S = 10\ V$; $R_G = 100\ k\Omega$	I_V	>	5 μA

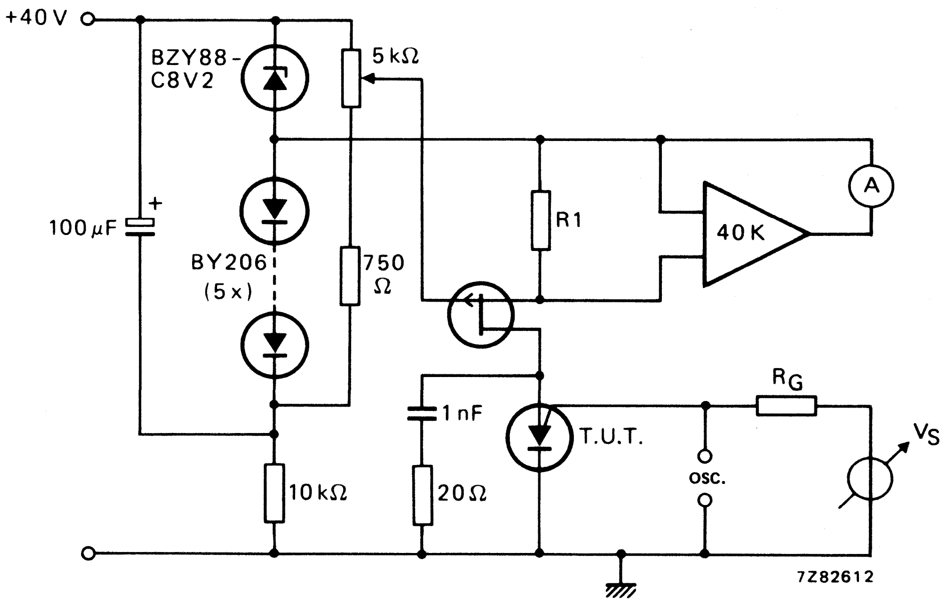


Fig. 3 Measuring circuit for I_P and I_V by means of value of R1. $R1 = \frac{1}{I_A}$ (that is maximum voltage drop over R1 is 1 V). Internal resistance of oscilloscope is 10 MΩ.

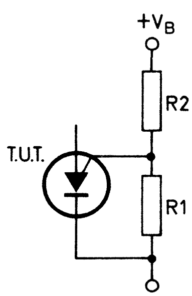


Fig. 4 **BRY56** with "program" resistors R1 and R2.

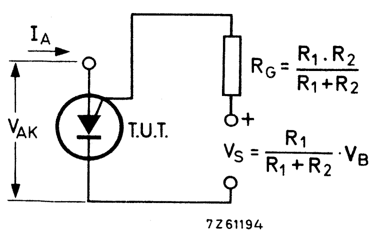


Fig. 5 Equivalent test circuit for characteristics testing.

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

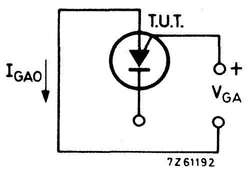


Fig. 6.

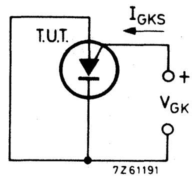


Fig. 7.

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

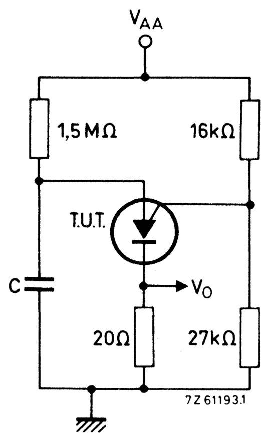


Fig. 8.

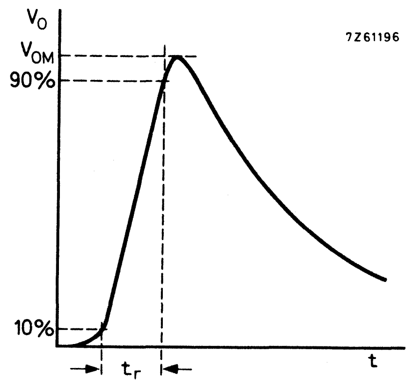


Fig. 9.

7Z82610

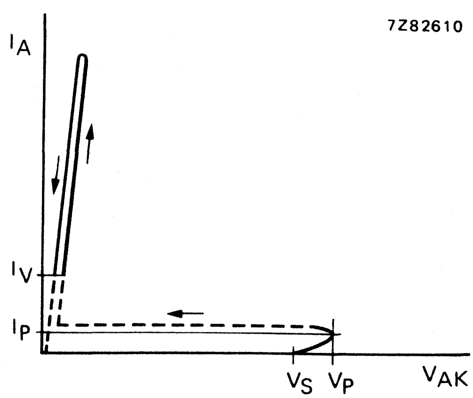


Fig. 10.

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.

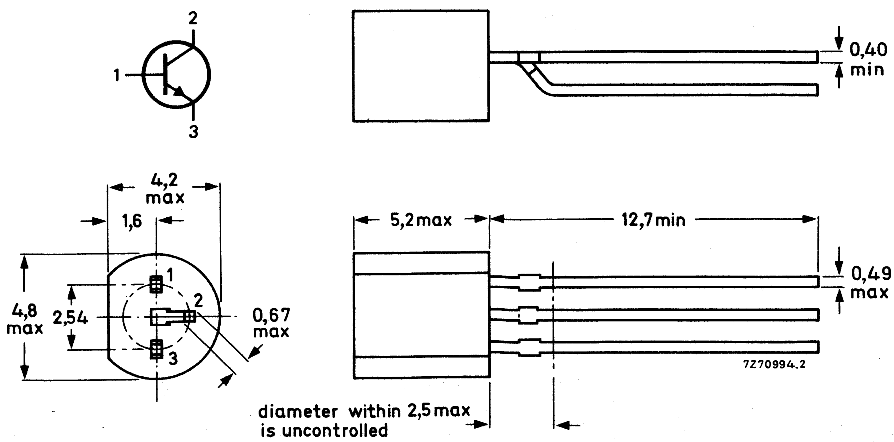
QUICK REFERENCE DATA

			BSR50	BSR51	BSR52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	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	90	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

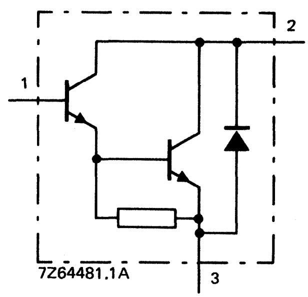


Fig. 2 Circuit diagram.

* 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

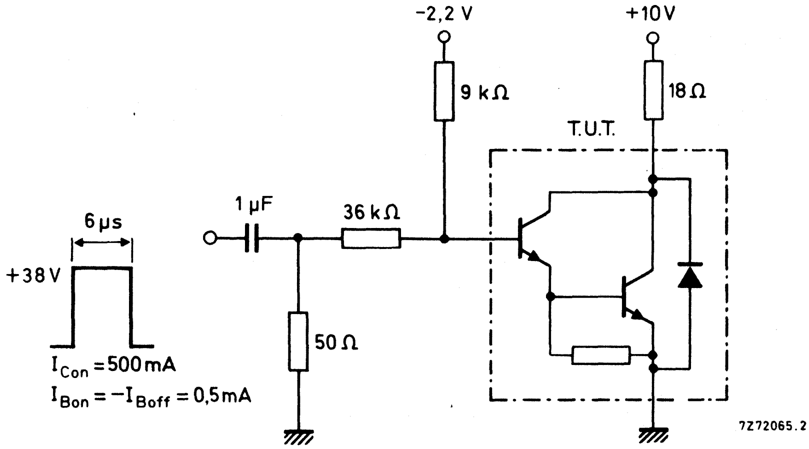


Fig. 3 Test circuit for 500 mA switching.

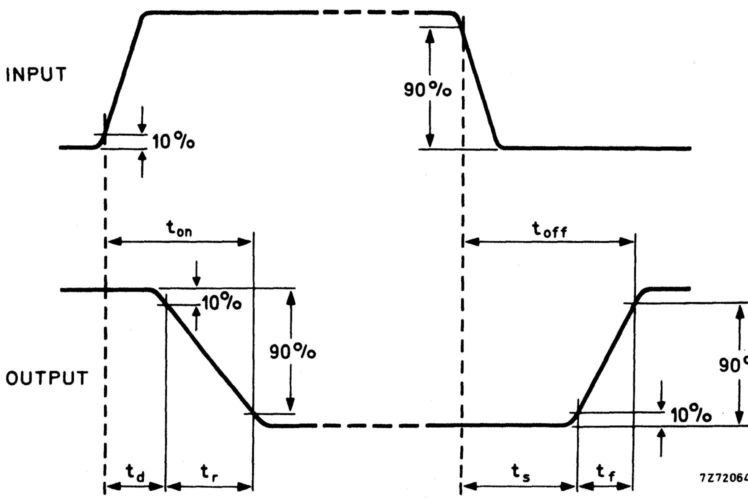


Fig. 4 Switching waveforms.

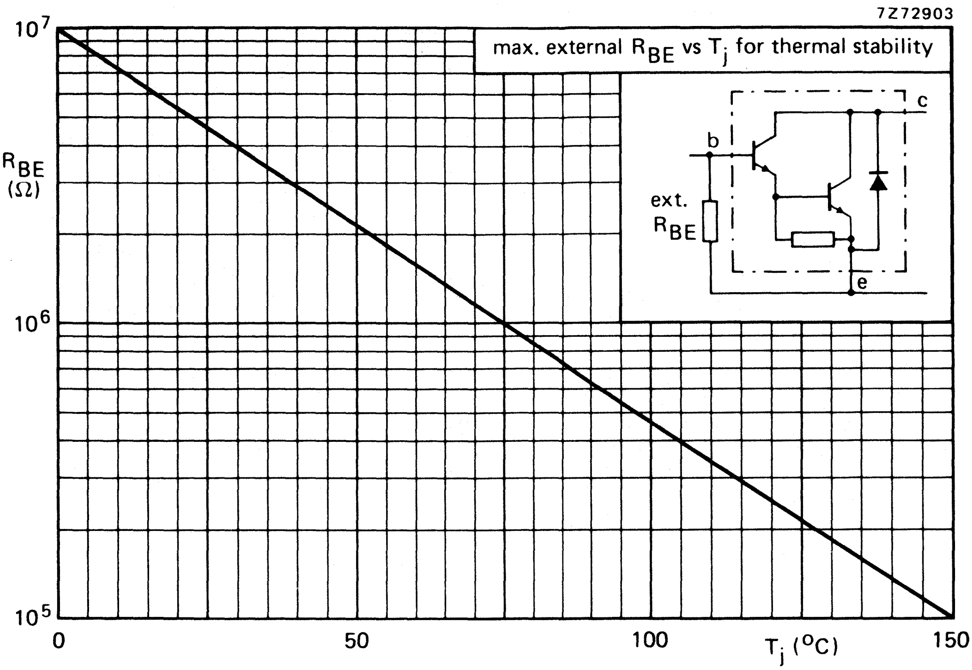


Fig. 5.

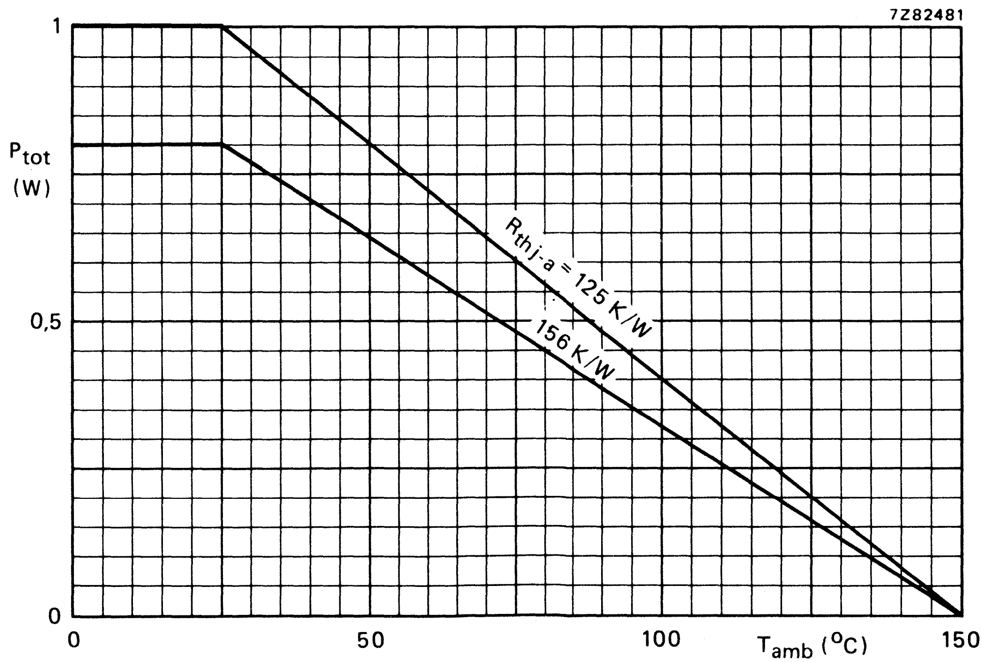


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

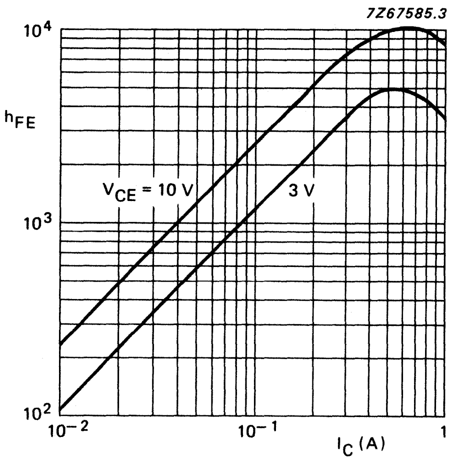


Fig. 7 T_j = 25 °C; typical values.

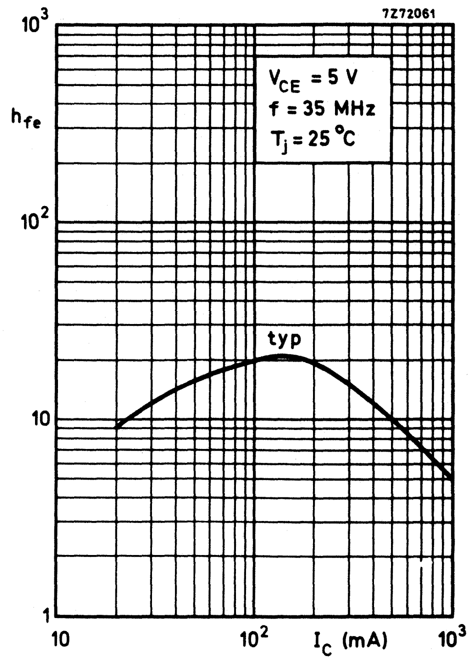


Fig. 8.

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.

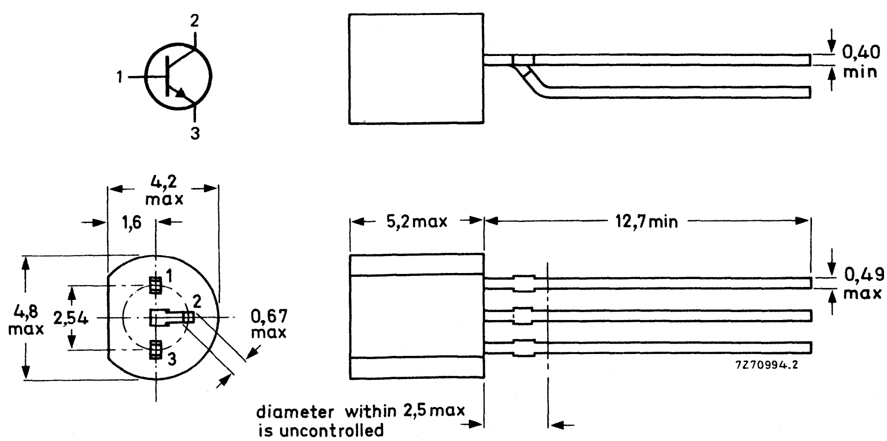
QUICK REFERENCE DATA

			BSR60	BSR61	BSR62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	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	90	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

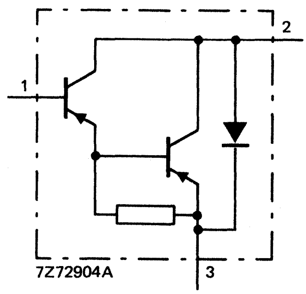


Fig. 2 Circuit diagram.

* 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

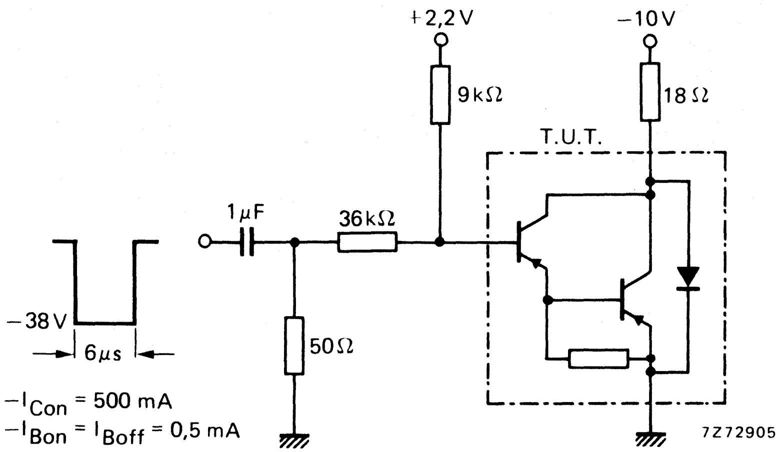


Fig. 3 Test circuit for 500 mA switching.

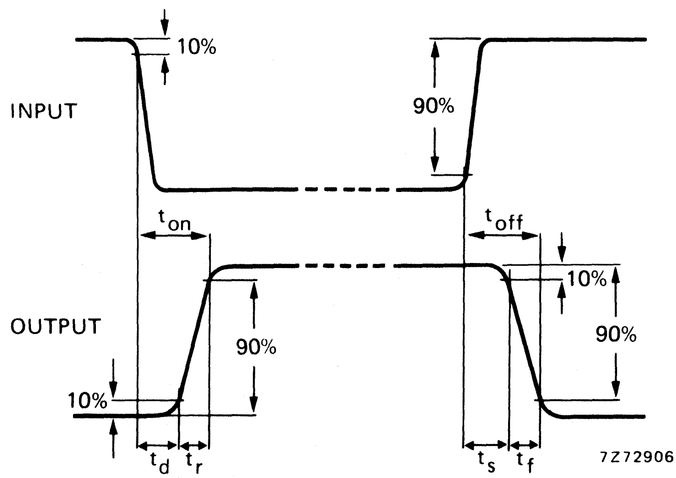


Fig. 4 Switching waveforms.

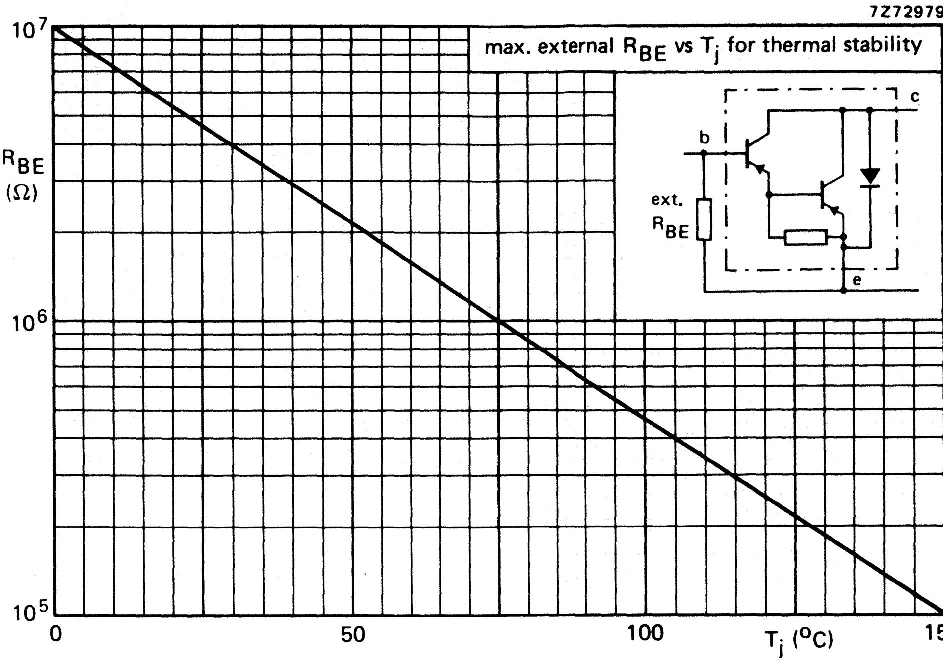


Fig. 5.

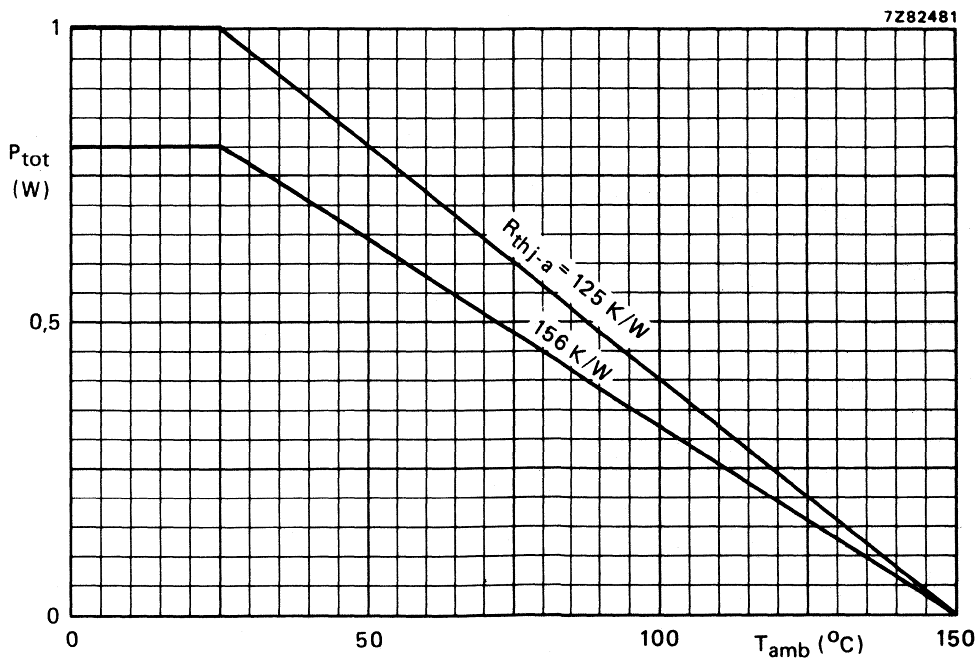


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

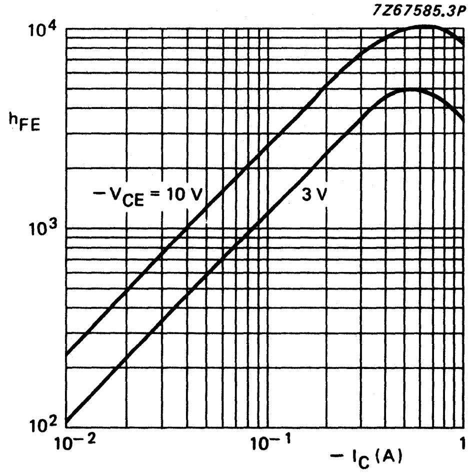


Fig. 7 T_j = 25 °C.

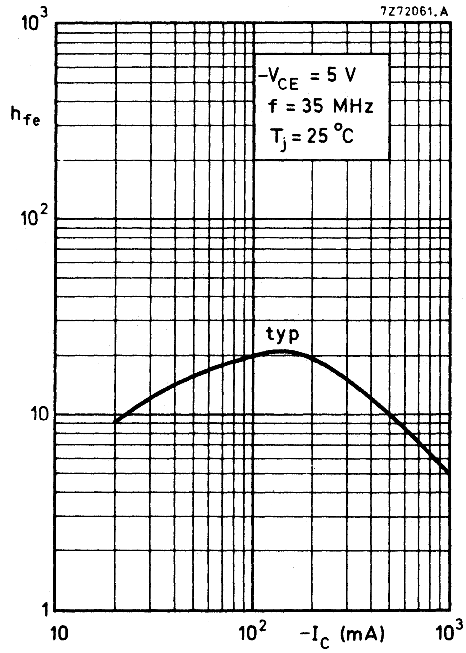


Fig. 8.

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

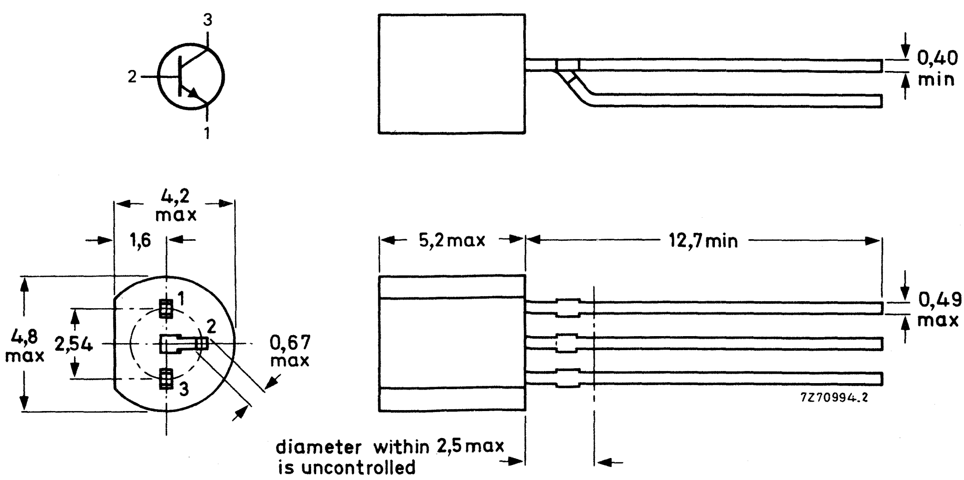
Note

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

Fig. 1 TO-92 variant.



RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	120 V*
Collector-emitter voltage (open base)	V_{CEO}	max.	100 V*
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c. or averaged over any 20 ms period)	$I_{C(AV)}$	max.	100 mA
Collector current (peak value)	I_{CM}	max.	250 mA
Total power dissipation up to T_{amb} = 25 °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

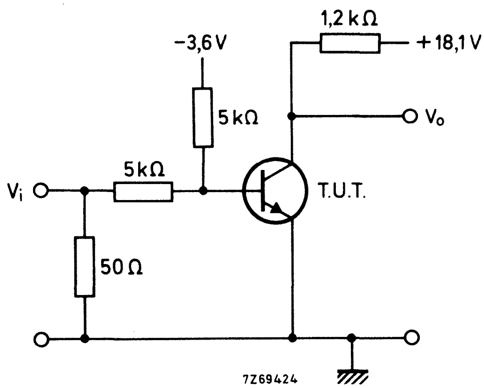
Collector cut-off current			
$I_E = 0$; V_{CB} = 90 V	I_{CBO}	<	200 nA
$I_E = 0$; V_{CB} = 90 V; T_j = 150 °C	I_{CBO}	<	50 μA
$V_{BE} = 0$; V_{CE} = 80 V; T_j = 85 °C	I_{CES}	<	20 μA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 4 V	I_{EBO}	<	200 nA
$I_C = 0$; V_{EB} = 4 V; T_j = 150 °C	I_{EBO}	<	50 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

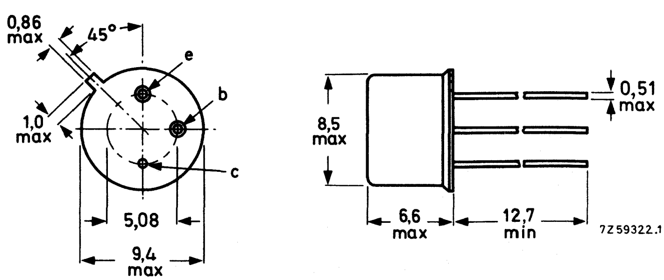
				BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)		V_{CBO}	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)		V_{CER}	max.	45	60	80	V
Collector current (d.c.)		I_C	max.		1,0		A
Total power dissipation							
up to T_{amb} = 25 °C		P_{tot}	max.		0,8		W
up to T_{case} = 25 °C		P_{tot}	max.		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

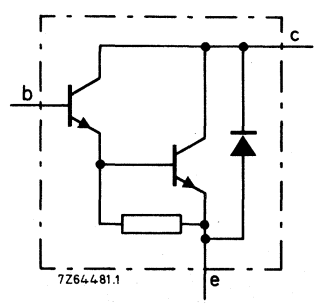
MECHANICAL DATA

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).

Products approved to CECC 50 004-073, available on request.

RATINGS

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

			BSS50	BSS51	BSS52	
→ Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	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

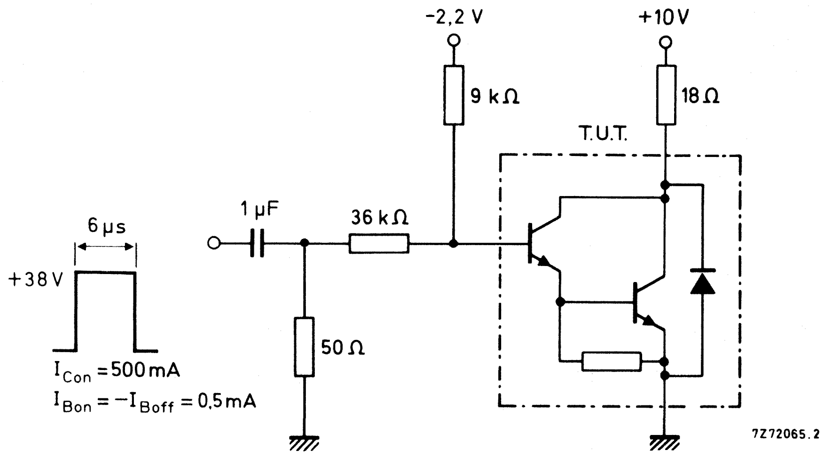


Fig. 2 Test circuit for 500 mA switching.

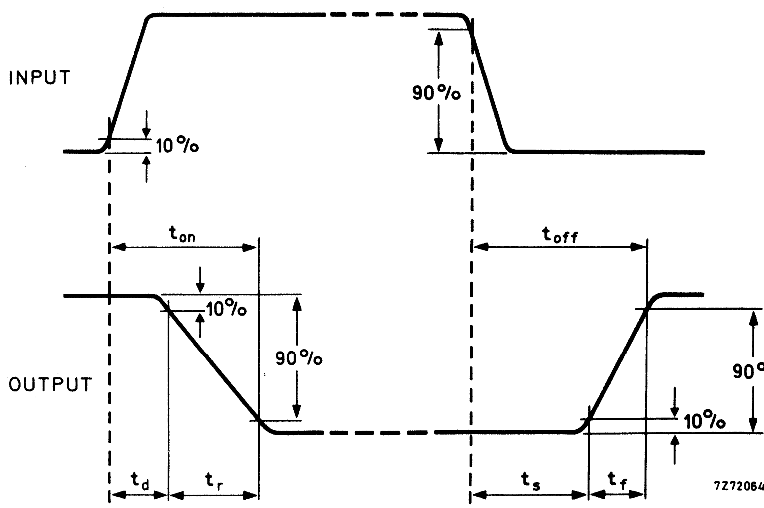


Fig. 3 Switching waveforms.

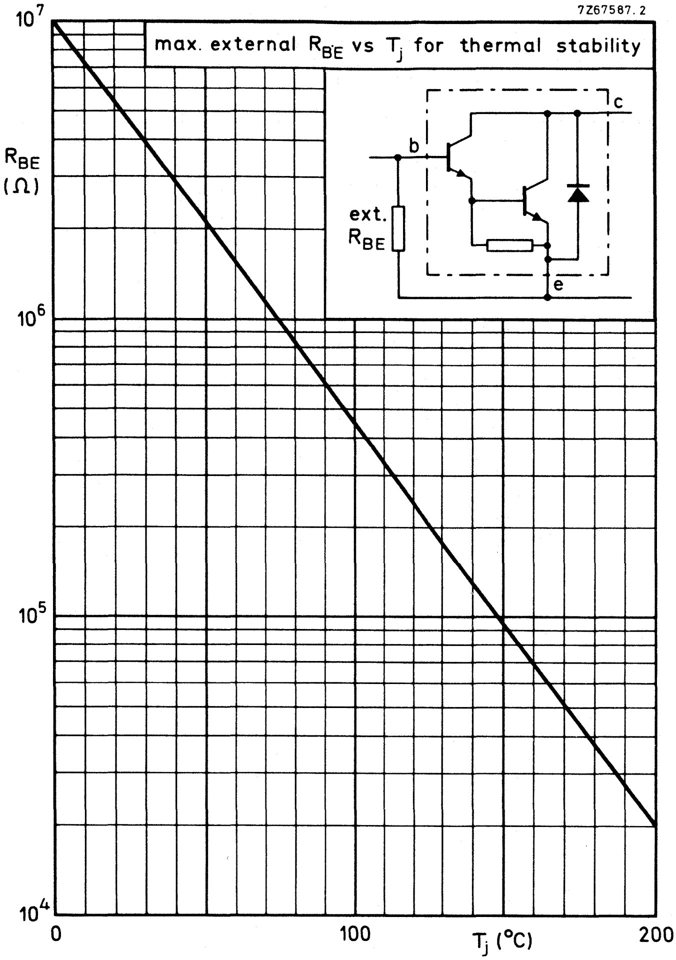

7Z67587.2
max. external R_{BE} vs T_j for thermal stability
R_{BE}
(Ω)
10^7
10^6
10^5
10^4
0
100
200
T_j (°C)
ext.
R_{BE}
b
c
e

Fig. 4.

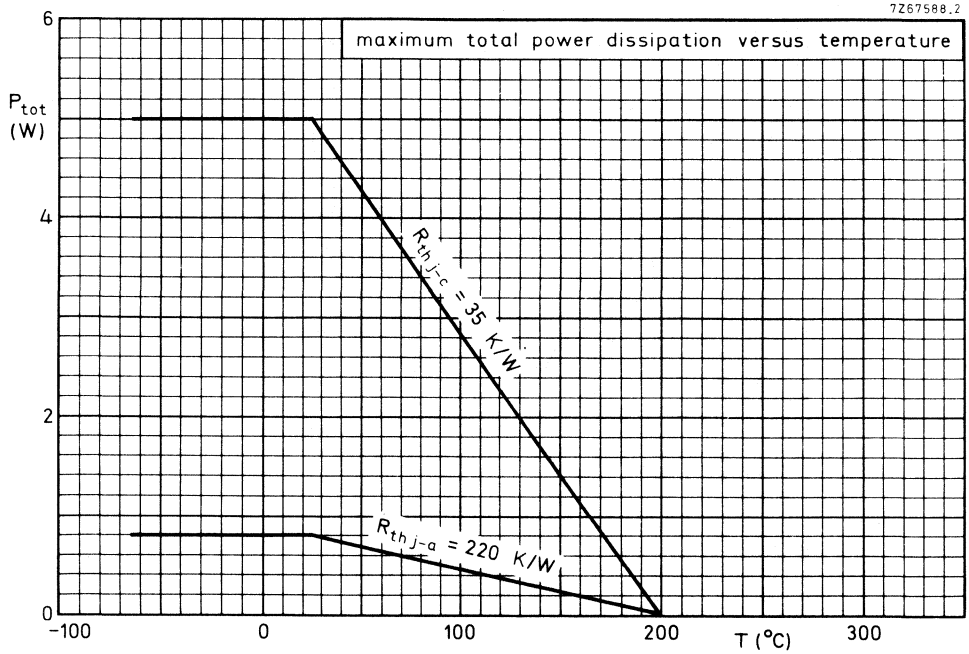

7Z67588.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
$R_{th\,j-c}$ = 35 K/W
$R_{th\,j-a}$ = 220 K/W
−100
0
100
200
300
T (°C)

Fig. 5.

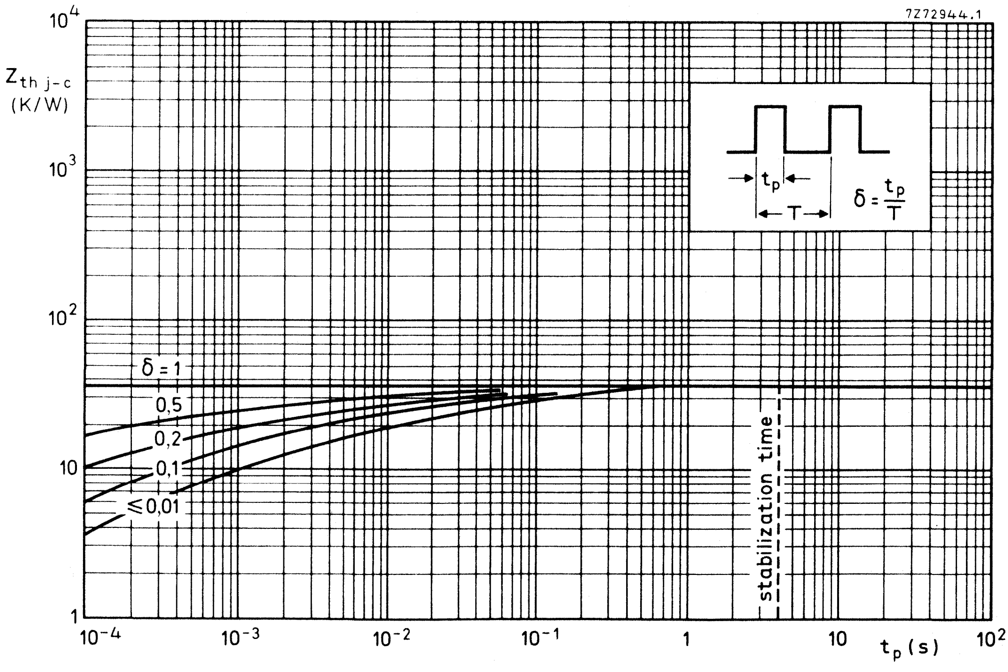

7Z72944.1
$Z_{th\,j-c}$ (K/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
stabilization time
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)

Fig. 6.

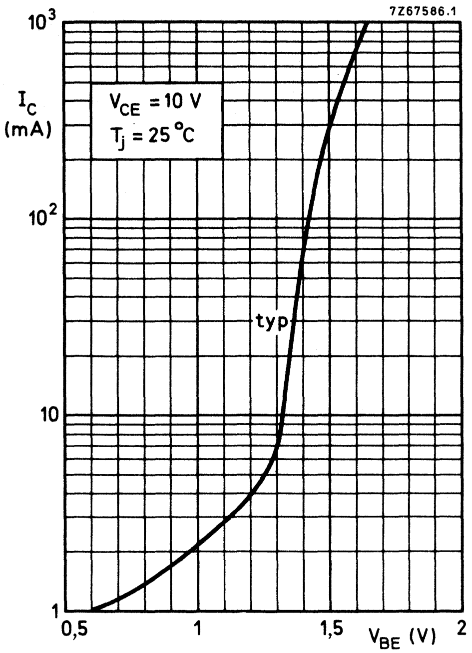


Fig. 7.

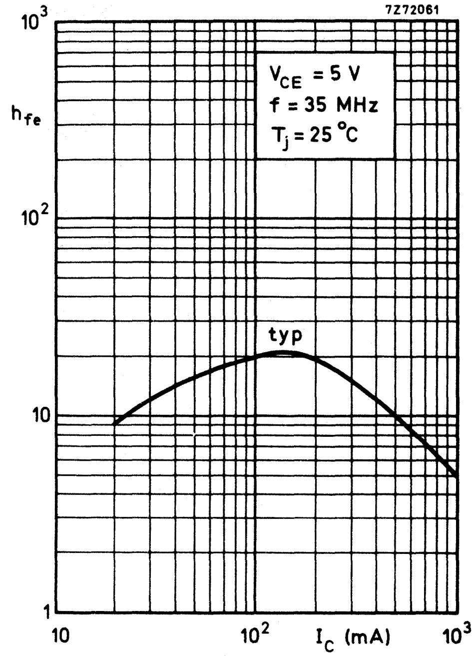


Fig. 8.

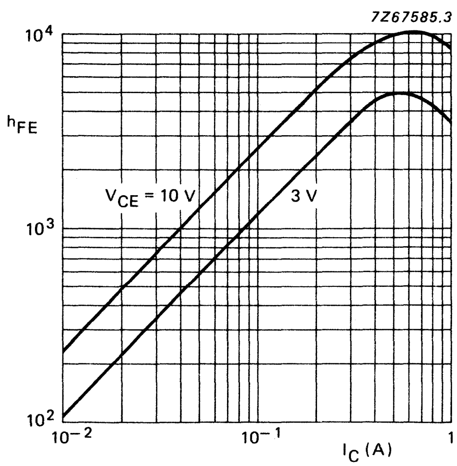


Fig. 9 T_j = 25 °C; typical values.

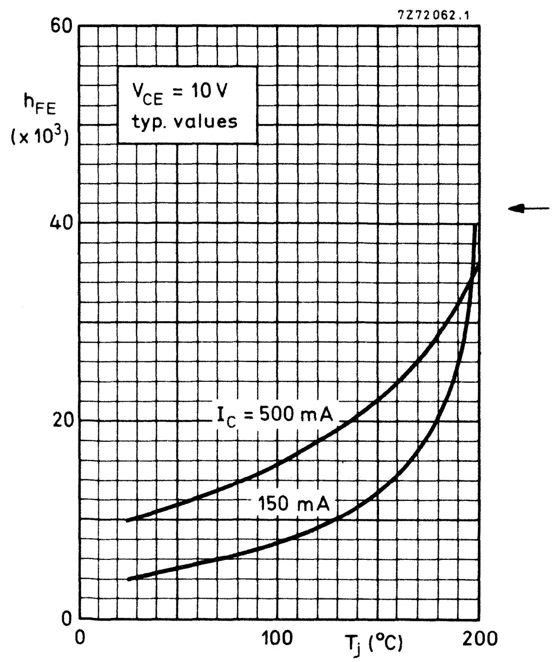


Fig. 10.

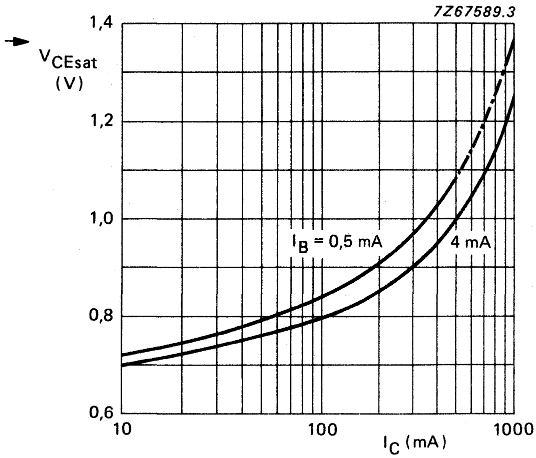


Fig. 11 T_j = 25 °C; typical values.

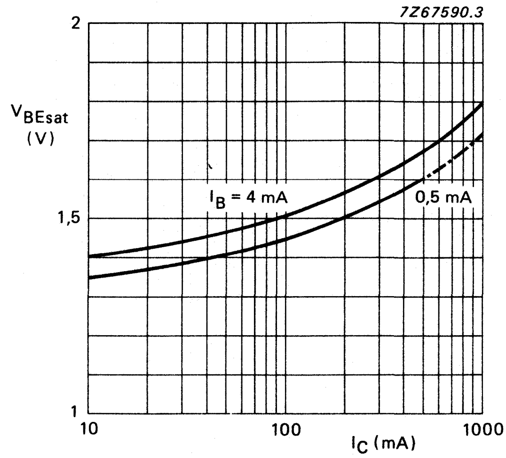


Fig. 12 T_j = 25 °C; typical values.

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

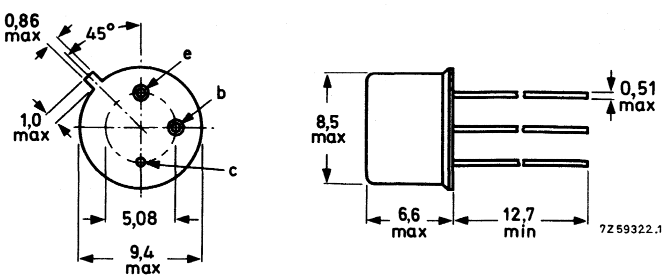
			BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage (see Fig. 4)	$-V_{CER}$	max.	45	60	80	V
Collector current (d.c.)	$-I_C$	max.		1,0		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		0,8		W
up to T_{case} = 25 °C	P_{tot}	max.		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

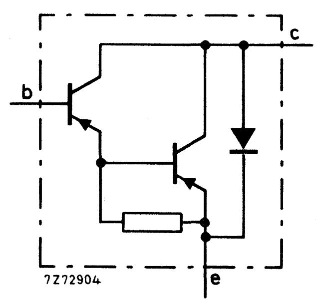
MECHANICAL DATA

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).

Products approved to CECC 50 004-074.

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	90	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

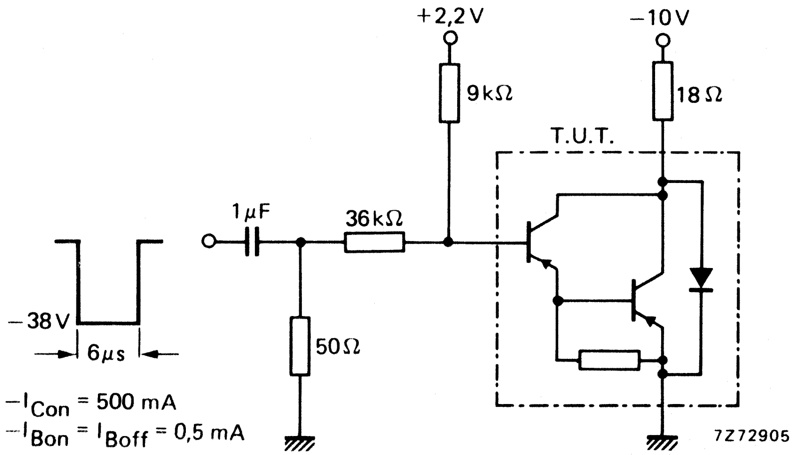


Fig. 2 Test circuit for 500 mA switching.

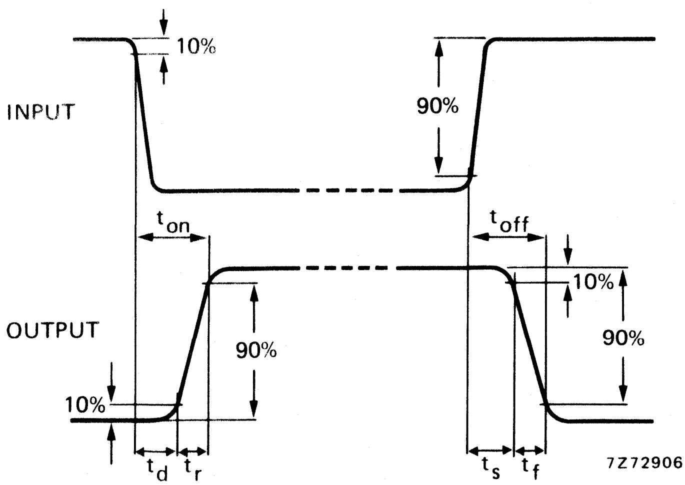


Fig. 3 Switching waveforms.

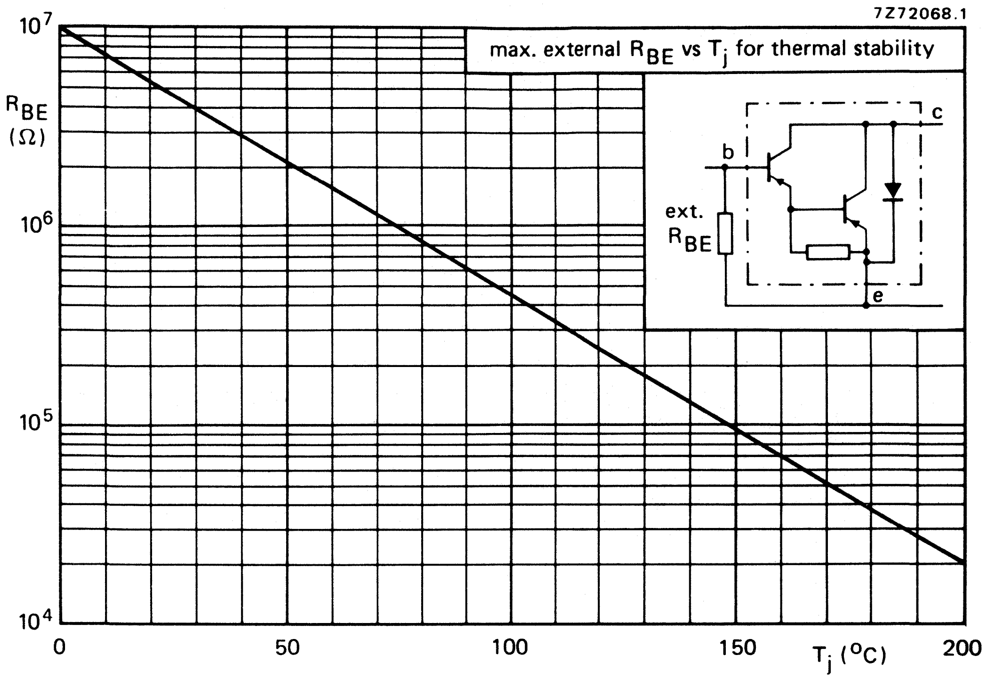

7Z72068.1
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
50
100
150
200
T_j (°C)
c
b
ext. R_{BE}
e

Fig. 4.

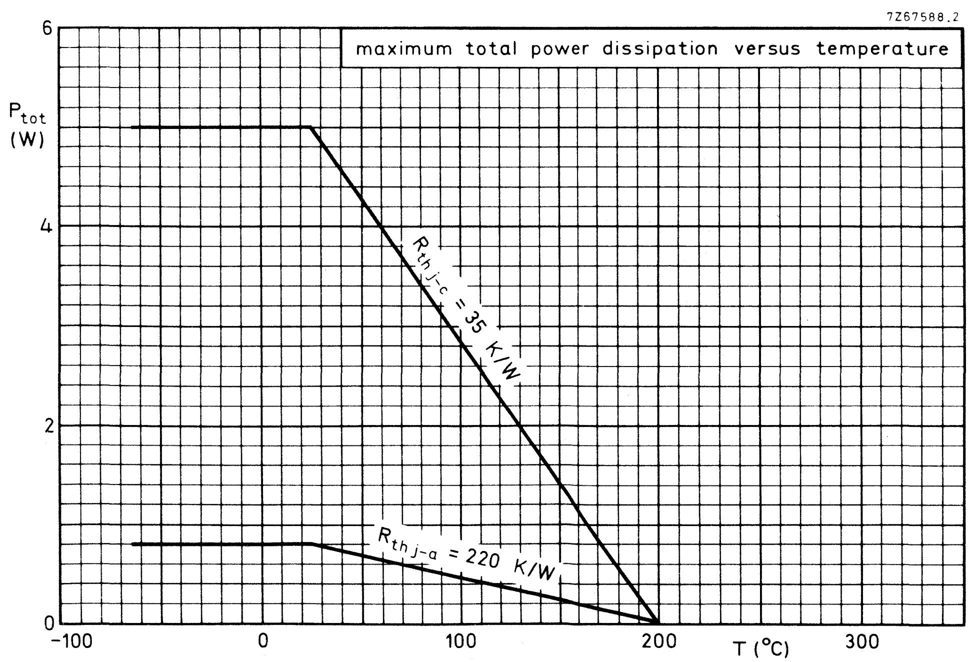

7Z67588.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
−100
0
100
200
300
T (°C)
$R_{th\,j-c}$ = 35 K/W
$R_{th\,j-a}$ = 220 K/W

Fig. 5.

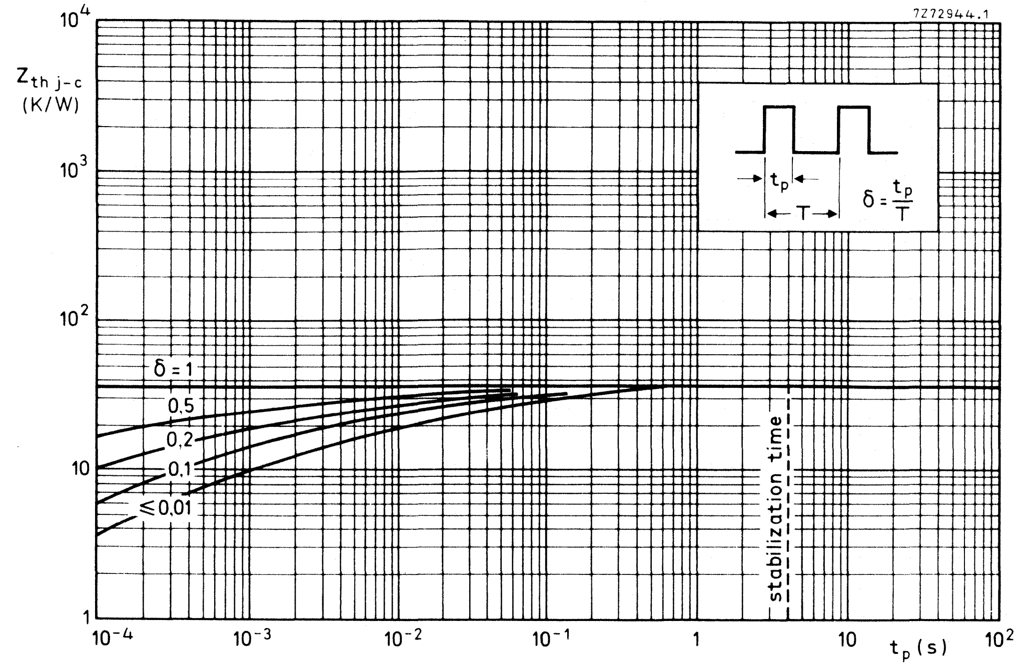


Fig. 6 Thermal impedance as a function of pulse duration.

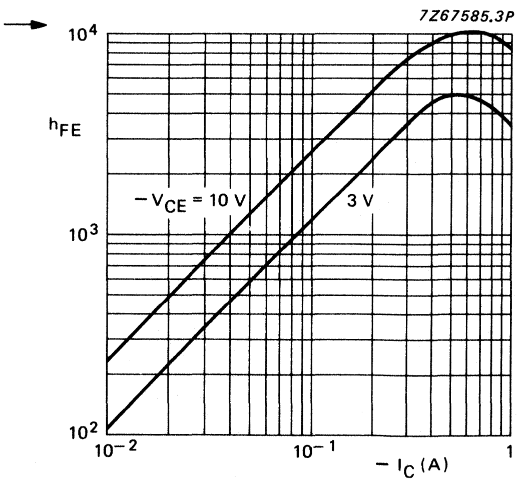


Fig. 7 T_j = 25 °C; typical values

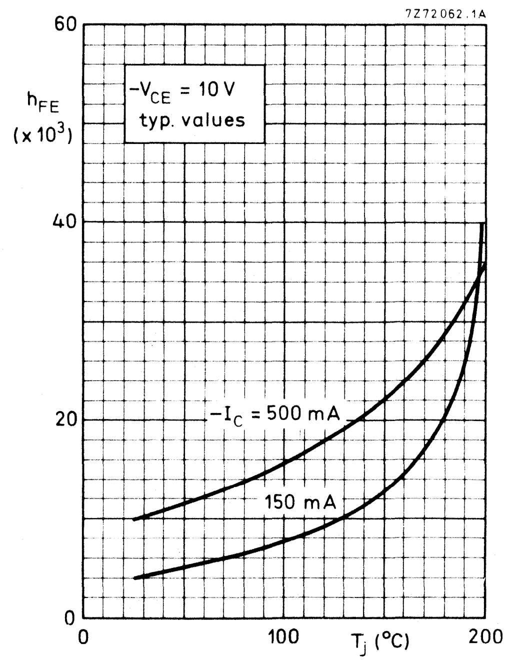


Fig. 8.

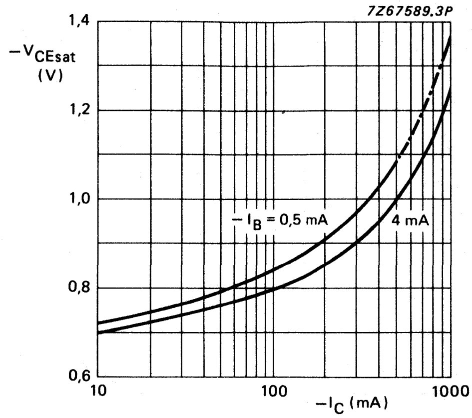

7Z67589.3P
$-V_{CEsat}$ (V)
1,4
1,2
1,0
0,8
0,6
$-I_B$ = 0,5 mA
4 mA
10
100
1000
$-I_C$ (mA)

Fig. 9.

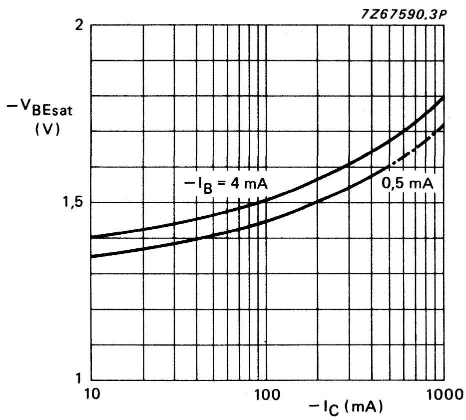
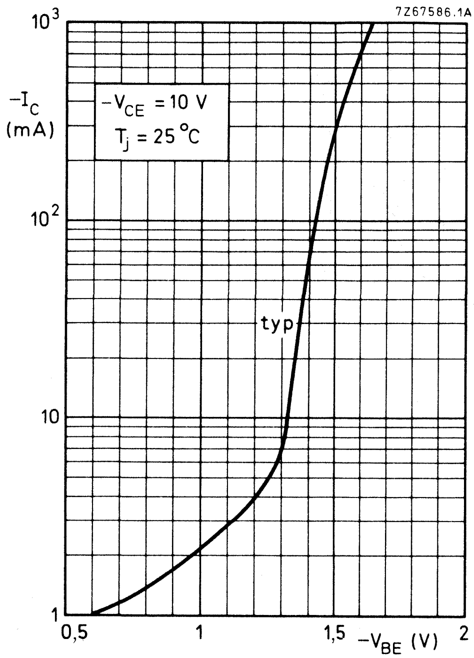
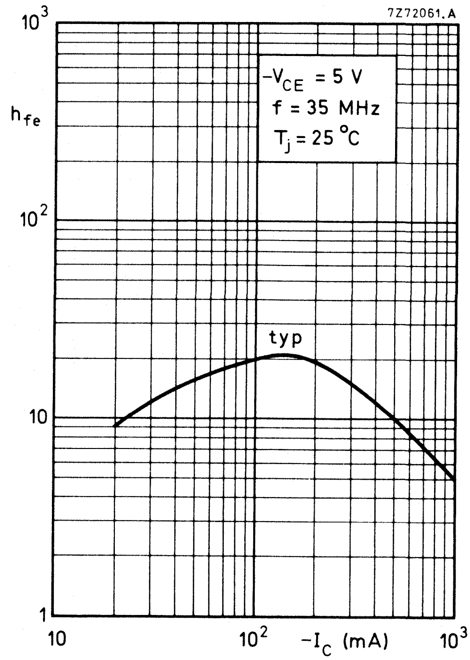

7Z67590.3P
$-V_{BEsat}$ (V)
2
1,5
1
$-I_B$ = 4 mA
0,5 mA
10
100
1000
$-I_C$ (mA)

Fig. 10.



7Z67586.1A
$-I_C$ (mA)
$-V_{CE}$ = 10 V
T_j = 25 °C
typ
10^3
10^2
10
1
0,5
1
1,5
2
$-V_{BE}$ (V)

Fig. 11.



7Z72061.A
h_{fe}
$-V_{CE}$ = 5 V
f = 35 MHz
T_j = 25 °C
typ
10^3
10^2
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.

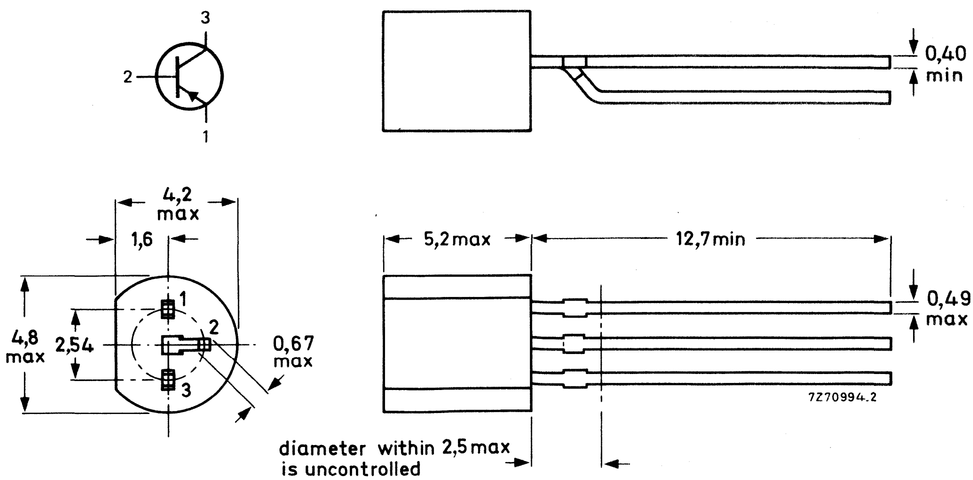
QUICK REFERENCE DATA

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

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.	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
Collector current (d.c.)	$-I_C$	max.	100	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	K/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

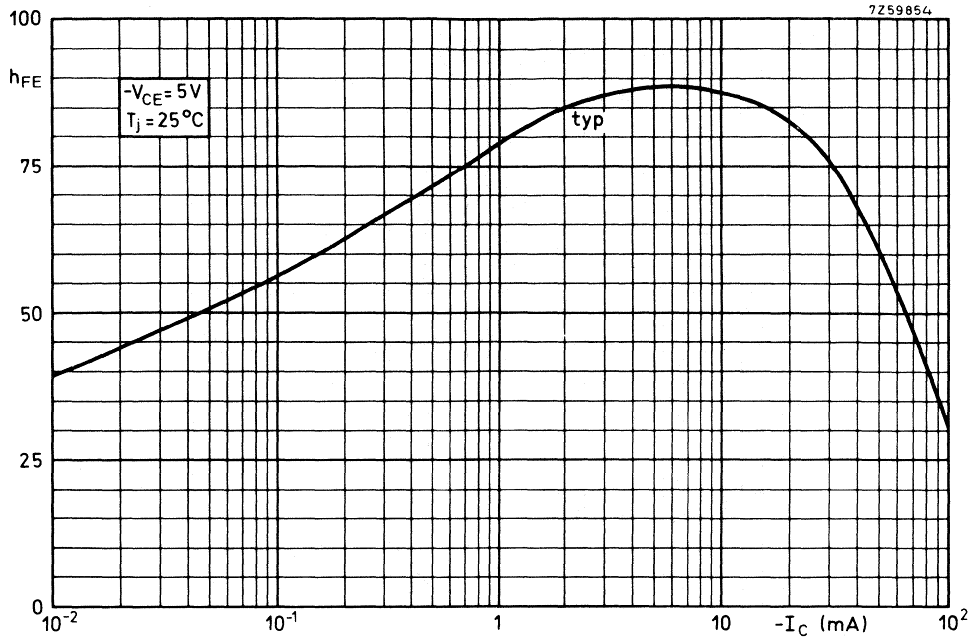

7Z59854
100
h_{FE}
$-V_{CE} = 5V$
$T_j = 25°C$
typ
75
50
25
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 2.

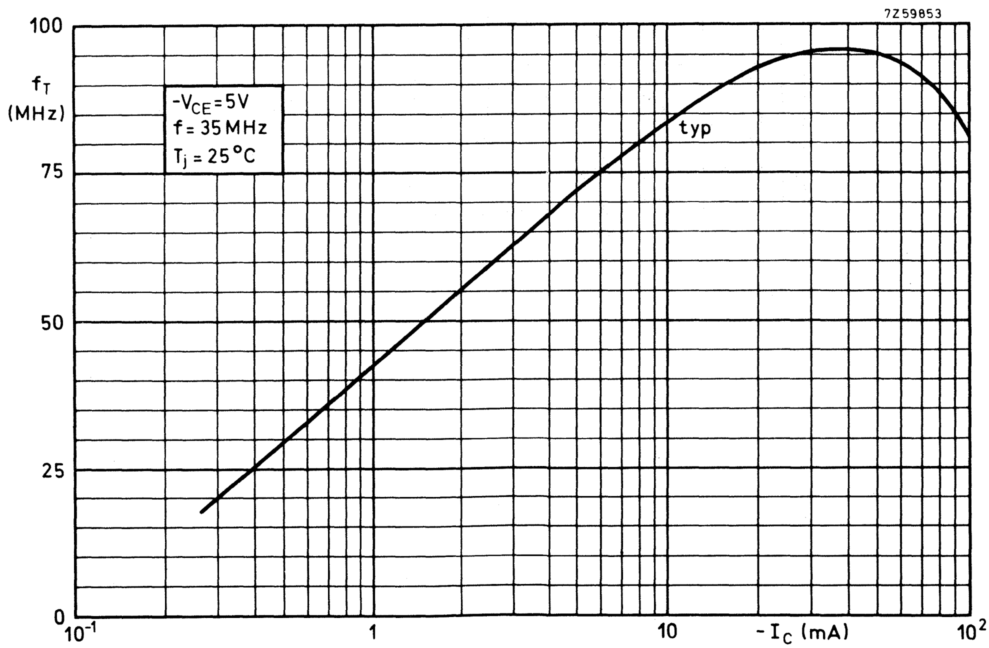

7Z59853
100
f_T
(MHz)
$-V_{CE} = 5V$
f = 35 MHz
$T_j = 25°C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 3.

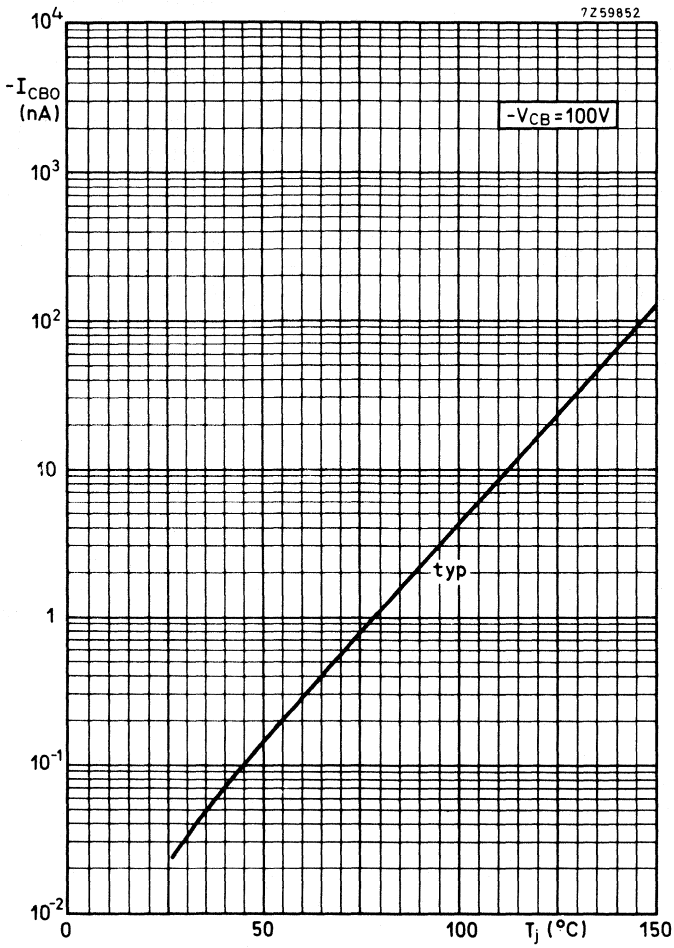

7Z59852
$-I_{CBO}$ (nA)
$-V_{CB} = 100V$
typ
T_j (°C)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150

Fig. 4.

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

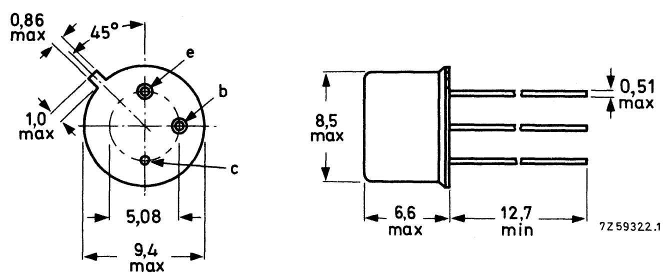
		BSV15–10 BSV16–10 BSV17–10	BSV15–16 BSV16–16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	63–160	100–250

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).

Products approved to CECC 50 002-131.

RATINGS

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

			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
Collector current (d.c.)	$-I_C$	max.		1,0		A
Base current (d.c.)	$-I_B$	max.		200		mA
Total power dissipation						
up to $T_{amb} = 25\ ^oC$	P_{tot}	max.		0,8		W
up to $T_{case} = 25\ ^oC$	P_{tot}	max.		5,0		W
up to $T_{mb} = 50\ ^oC$	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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	30	K/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; δ = 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)

			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}	>	20	30	
		typ.	75	120	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	100	160	
			63 to 160	100 to 250	
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	>	25	35	
		typ.	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

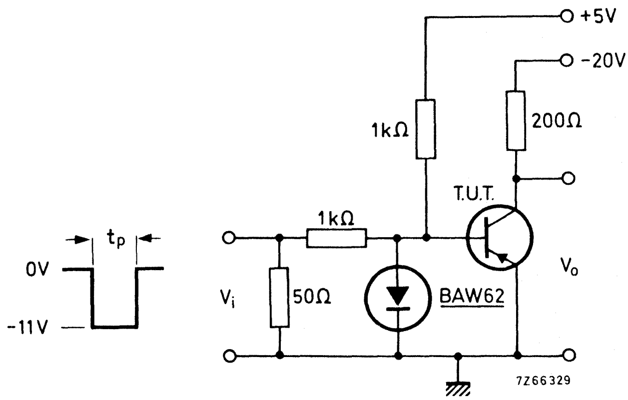


Fig. 2 Test circuit.

Pulse generator:

Pulse duration	tp	⩾ 10 μs
Rise time	t_r	⩽ 15 ns
Fall time	t_f	⩽ 15 ns
Source impedance	R_S	= 50 Ω

Oscilloscope:

Rise time	⩽ 15 ns
Input impedance	⩾ 100 kΩ

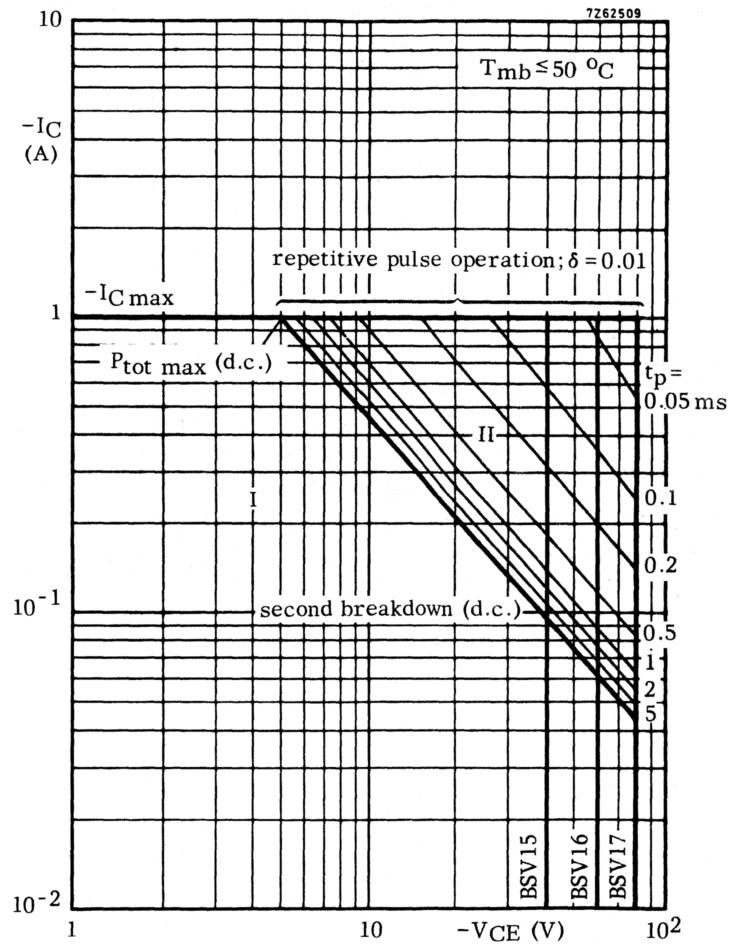


Fig. 3.

Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

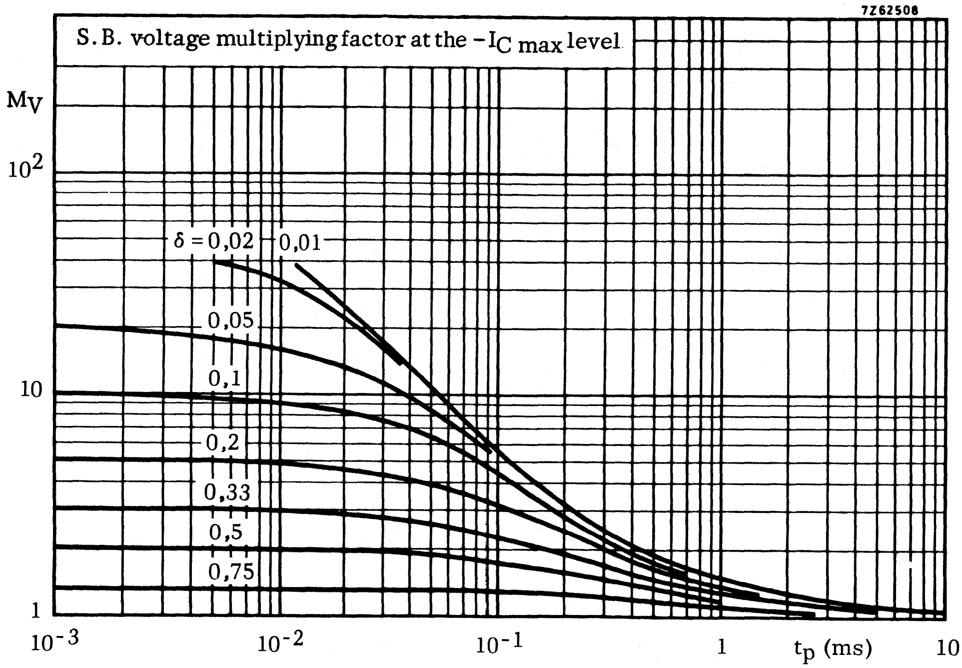

7Z62508
S.B. voltage multiplying factor at the $-I_C$ max level
M_V
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 4.

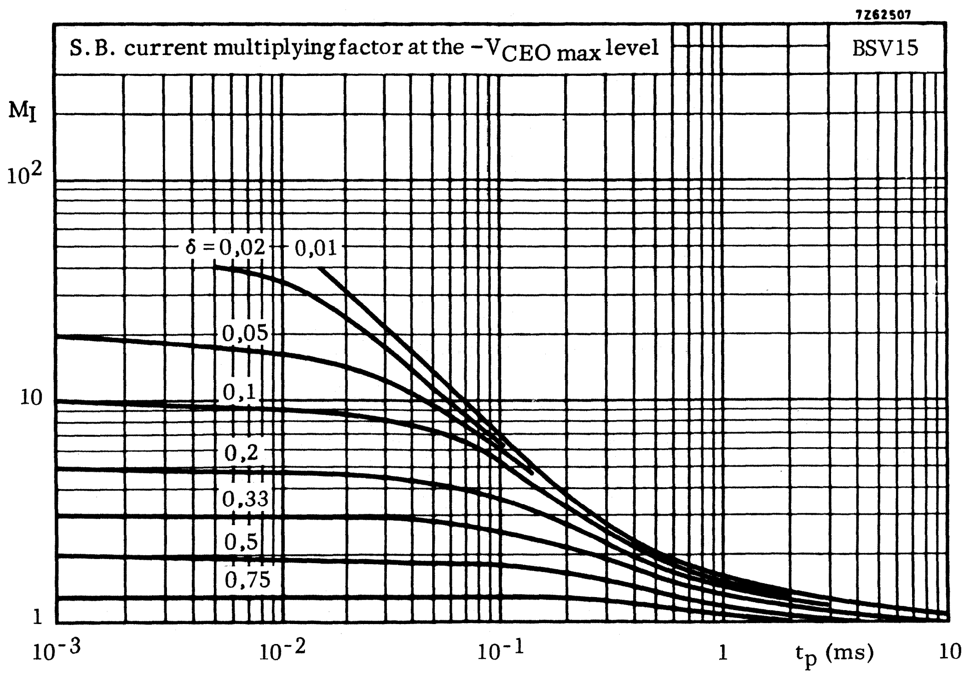

7Z62507
S.B. current multiplying factor at the $-V_{CEO}$ max level
BSV15
M_I
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 5.

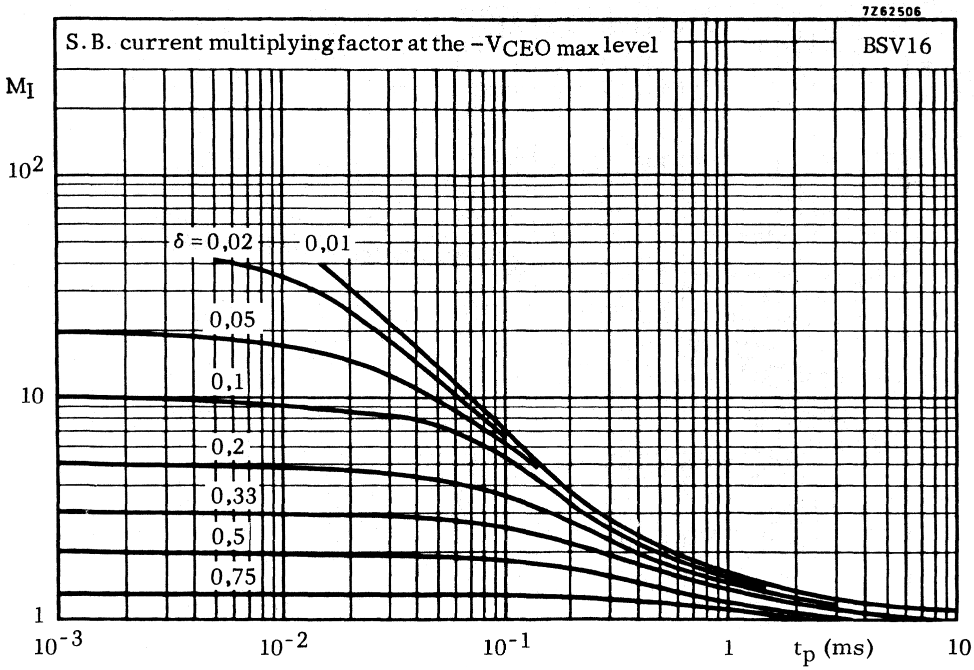

7Z62506
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV16
M_I
10^2
10
1
$\delta = 0{,}02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 6.

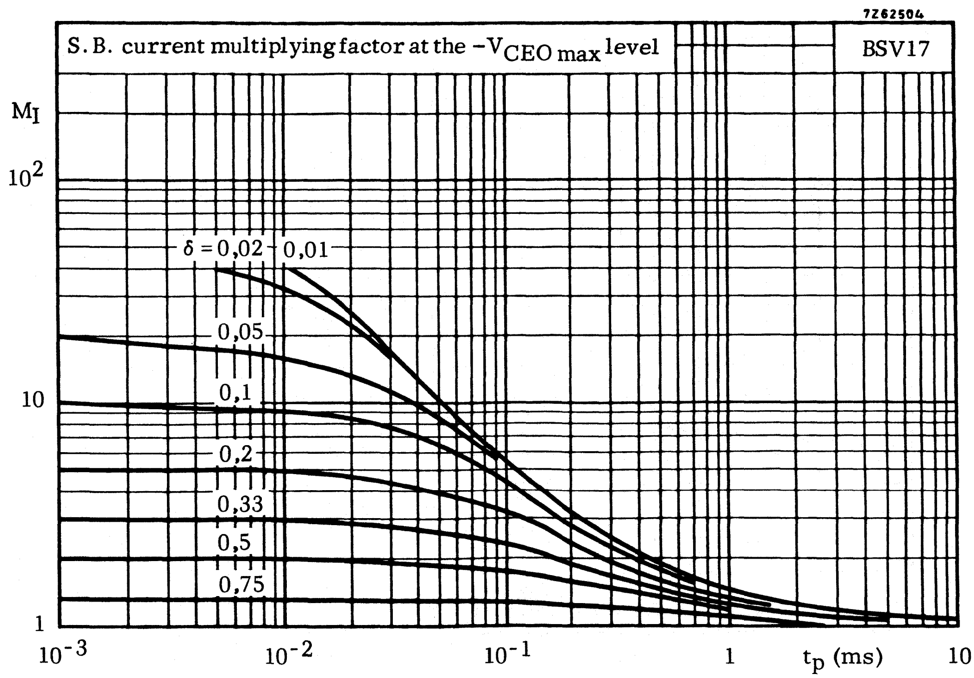

7Z62504
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV17
M_I
10^2
10
1
$\delta = 0{,}02$
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 7.

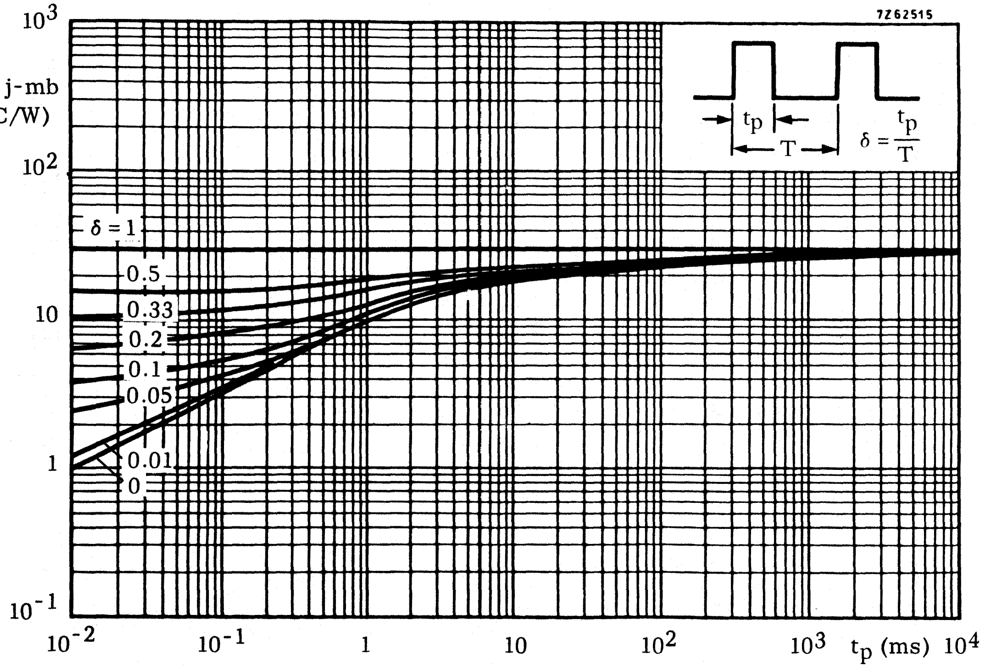

7Z62515
$Z_{th\ j\text{-}mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0.5
0.33
0.2
0.1
0.05
0.01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

Fig. 8.

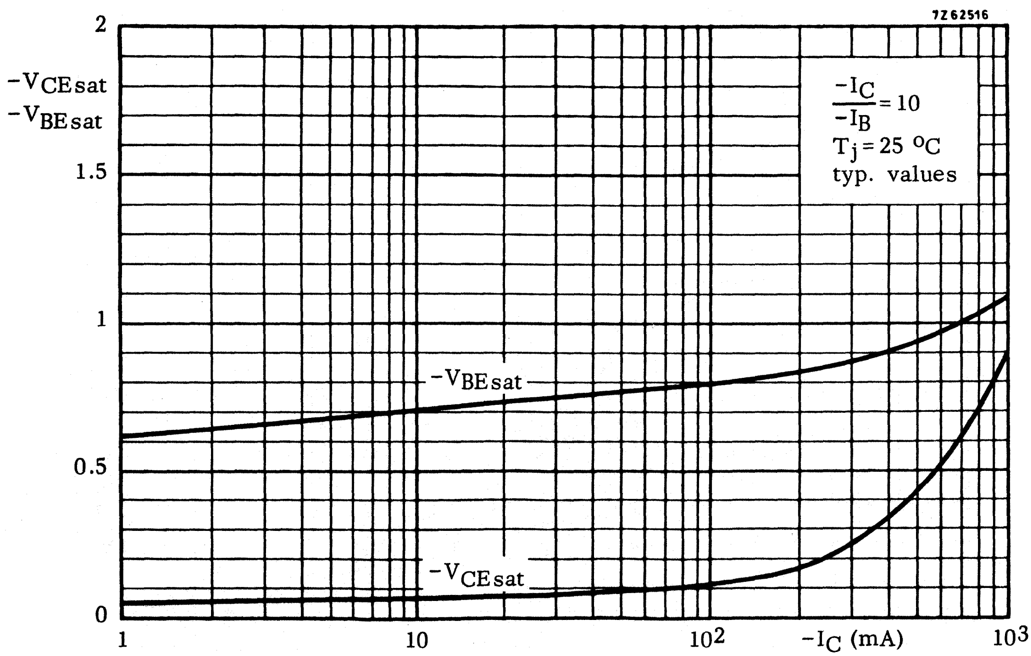

7Z62516
$-V_{CEsat}$
$-V_{BEsat}$
2
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25$ °C
typ. values
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 9.

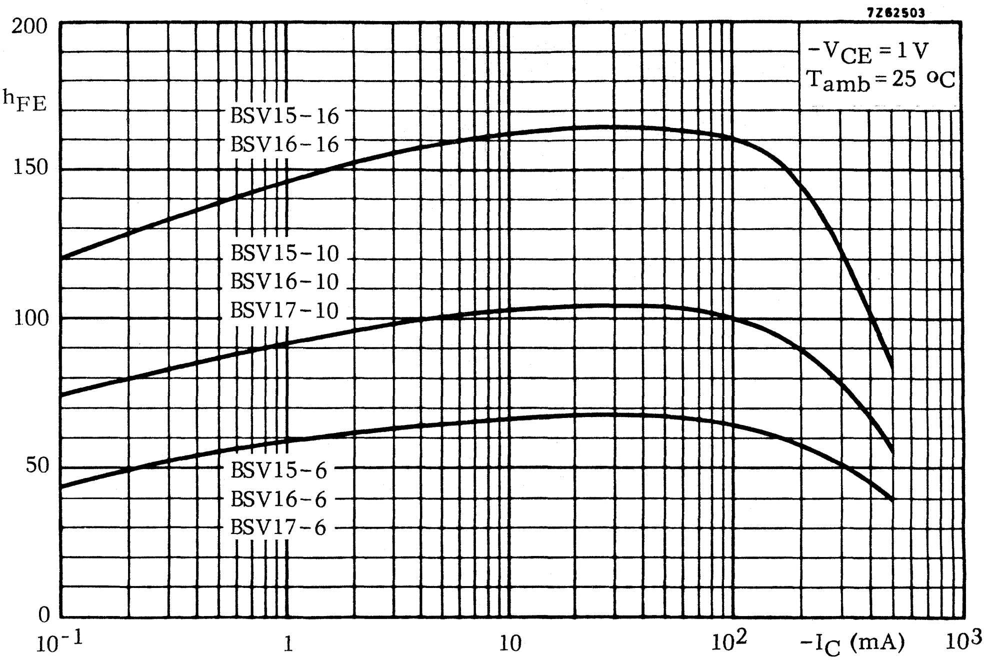

7Z62503
$-V_{CE} = 1\ V$
$T_{amb} = 25\ ^oC$
h_{FE}
BSV15-16
BSV16-16
BSV15-10
BSV16-10
BSV17-10
BSV15-6
BSV16-6
BSV17-6
200
150
100
50
0
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 10.

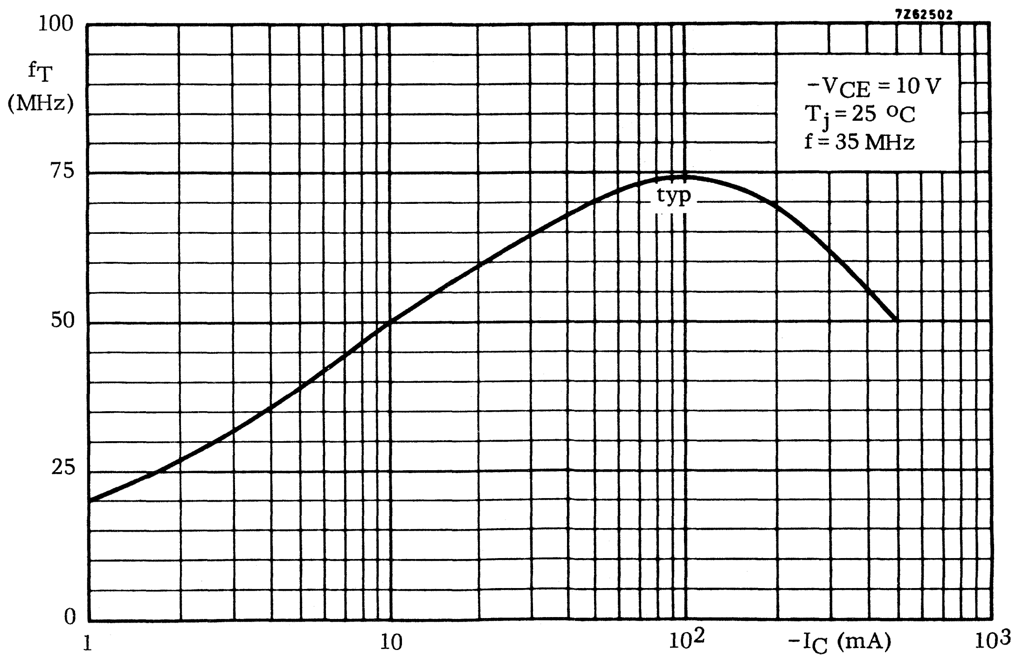

7Z62502
$-V_{CE} = 10\ V$
$T_j = 25\ ^oC$
f = 35 MHz
f_T
(MHz)
typ
100
75
50
25
0
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 11.

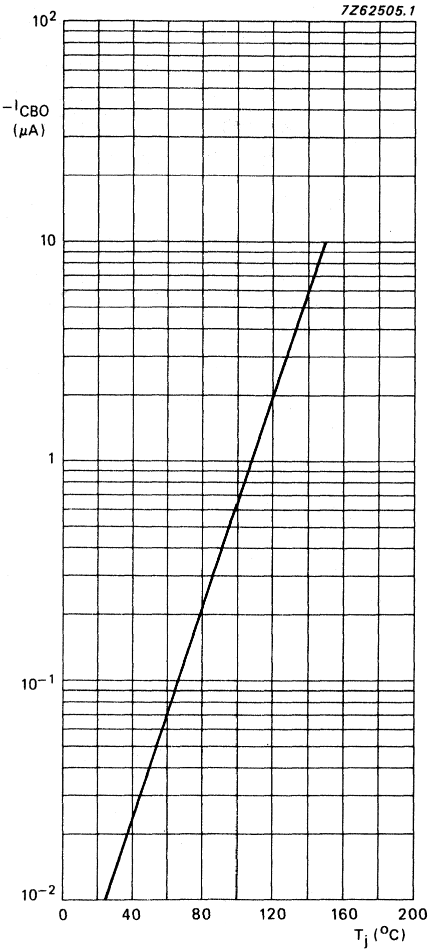


Fig. 12.

$-V_{CBO}$ = 40 V; BSV15;
$-V_{CBO}$ = 60 V; BSV16;
$-V_{CBO}$ = 80 V; BSV17;
typical values.

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

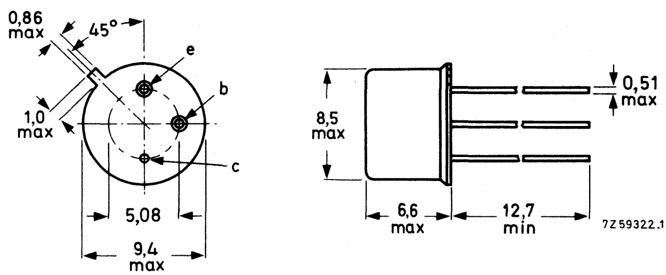
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	175	°C
D.C. current gain I_C = 2 A; V_{CE} = 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.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	100 V
Collector-emitter voltage ($R_{BE} \leqslant 50\ \Omega$)	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
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
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0 W
Storage temperature	T_{stg}		−55 to +175 °C
Junction temperature	T_j	max.	175 °C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	25 K/W

CHARACTERISTICS

T_j = 25 °C

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

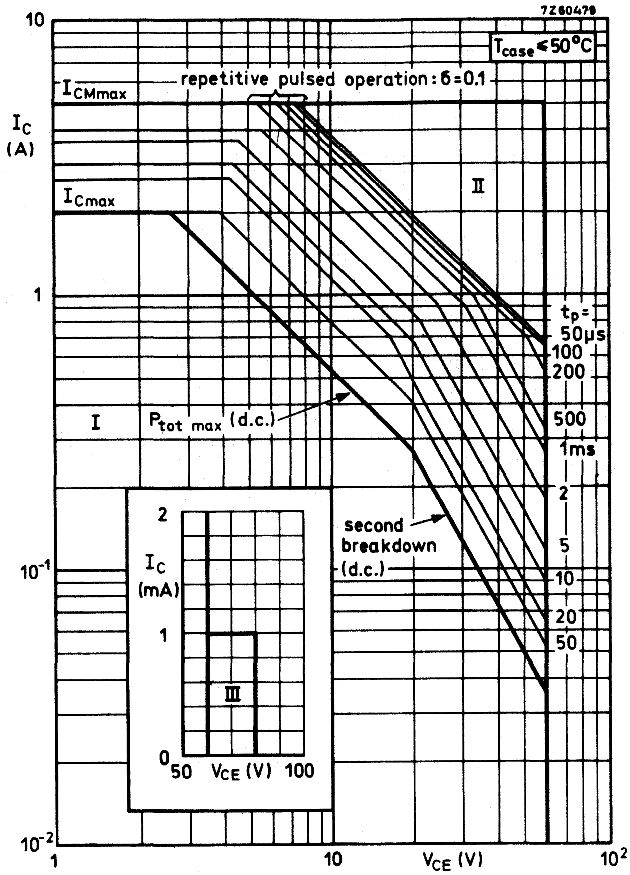


Fig. 2.

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 $R_{BE} \leqslant 50\ \Omega$.

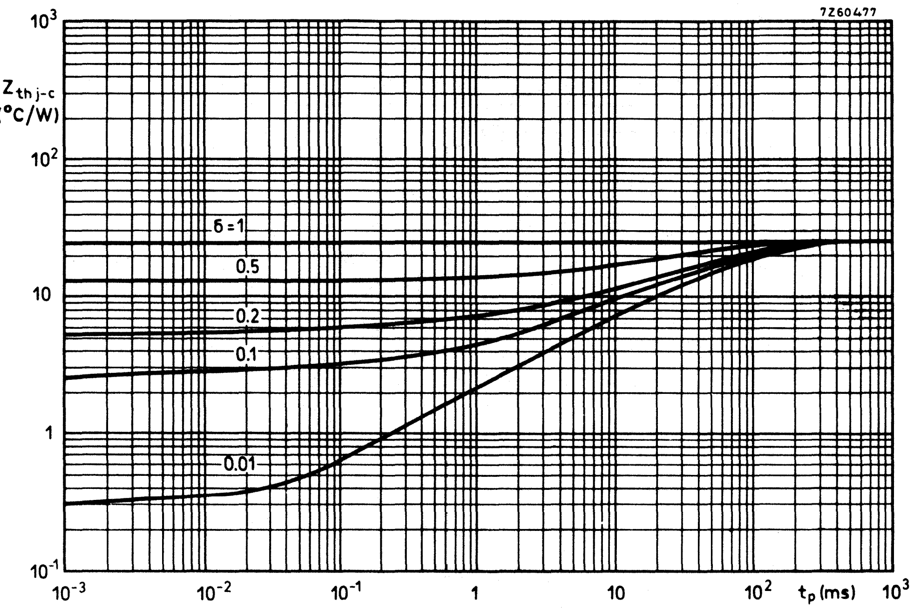

7Z60477
$Z_{th\,j-c}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

Fig. 3.

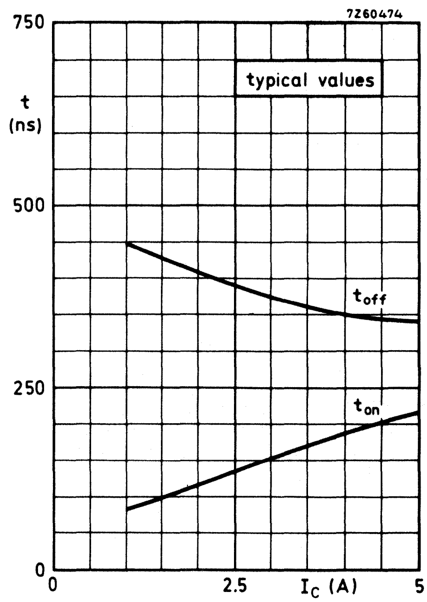

7Z60474
750
500
250
0
t (ns)
typical values
t_{off}
t_{on}
0
2.5
I_C (A)
5

Fig. 4.

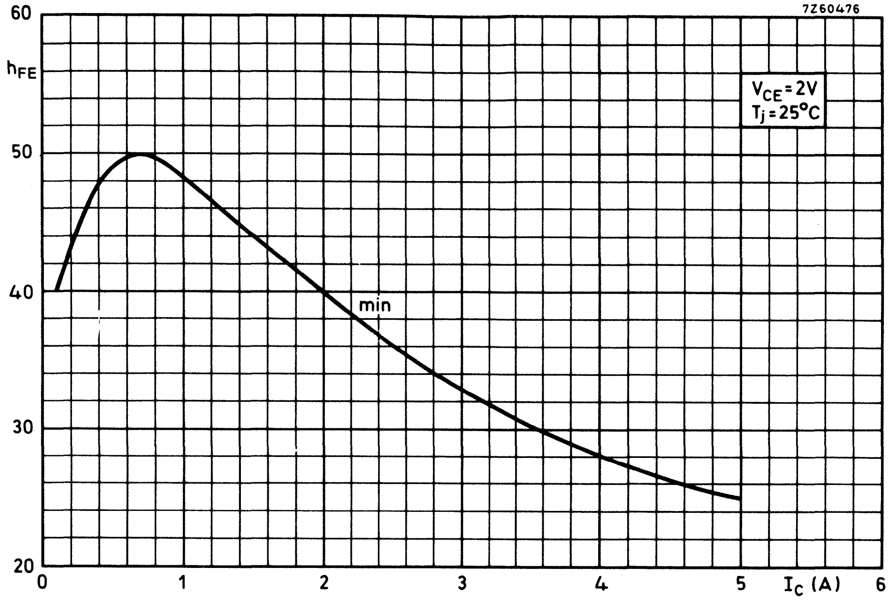


Fig. 5.

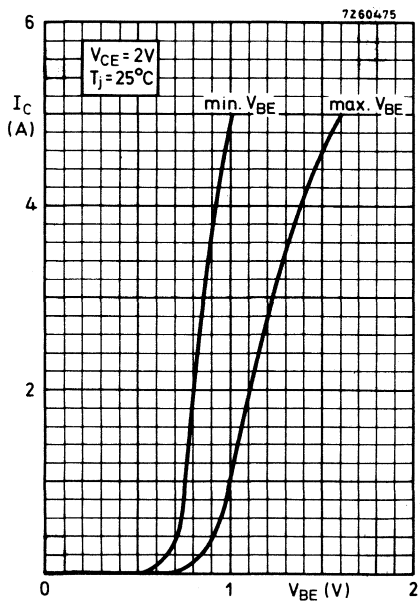


Fig. 6.

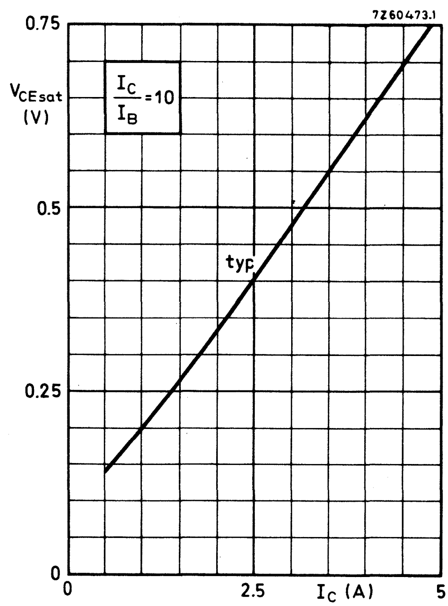


Fig. 7.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors primarily intended for general purpose industrial and switching applications.

QUICK REFERENCE DATA

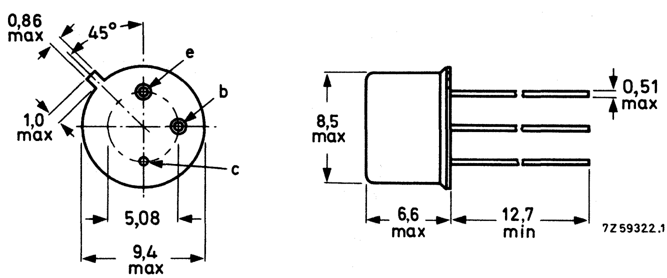
			BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	120	150	V
Collector current (peak value)	I_{CM}	max.		2		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Collector-emitter saturation voltage 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).

Products approved to CECC 50 004-040.

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; $t_p \leqslant 20$ 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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		100		µA
$I_E = 0$; $V_{CB} = \frac{1}{2}V_{CBOmax}$	I_{CBO}	<		100		nA
$I_E = 0$; $V_{CB} = \frac{1}{2}V_{CBOmax}$; $T_j = 150\ ^oC$	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

D.C. current gain			
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30
I_C = 100 mA; V_{CE} = 5 V	h_{FE}	>	40
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30
I_C = 1,0 A; V_{CE} = 5 V	h_{FE}	>	10
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

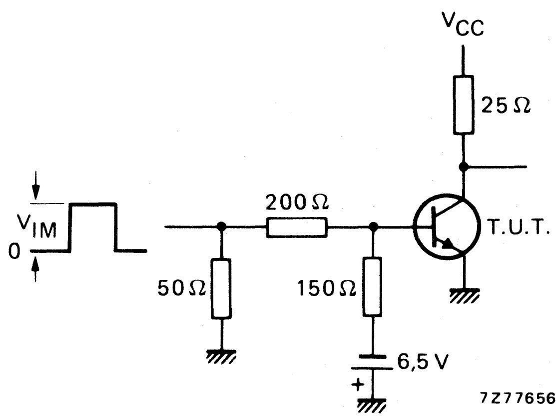


Fig. 2 Test circuit for saturated switching characteristics.
V_{CC} = 13 V; V_{IM} = 21 V.

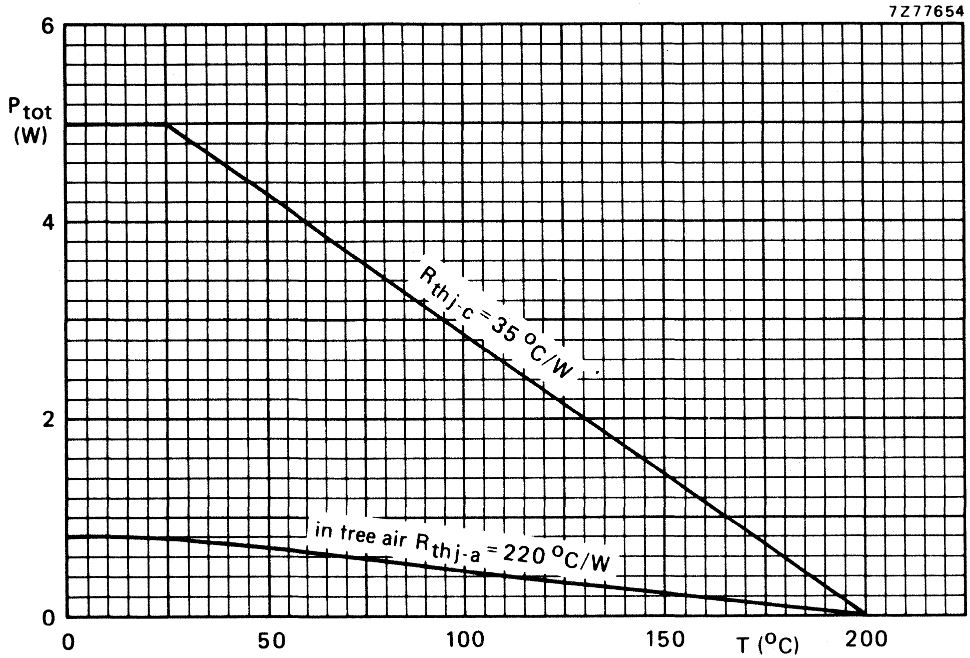


Fig. 3 Maximum permissible power dissipation versus temperature.

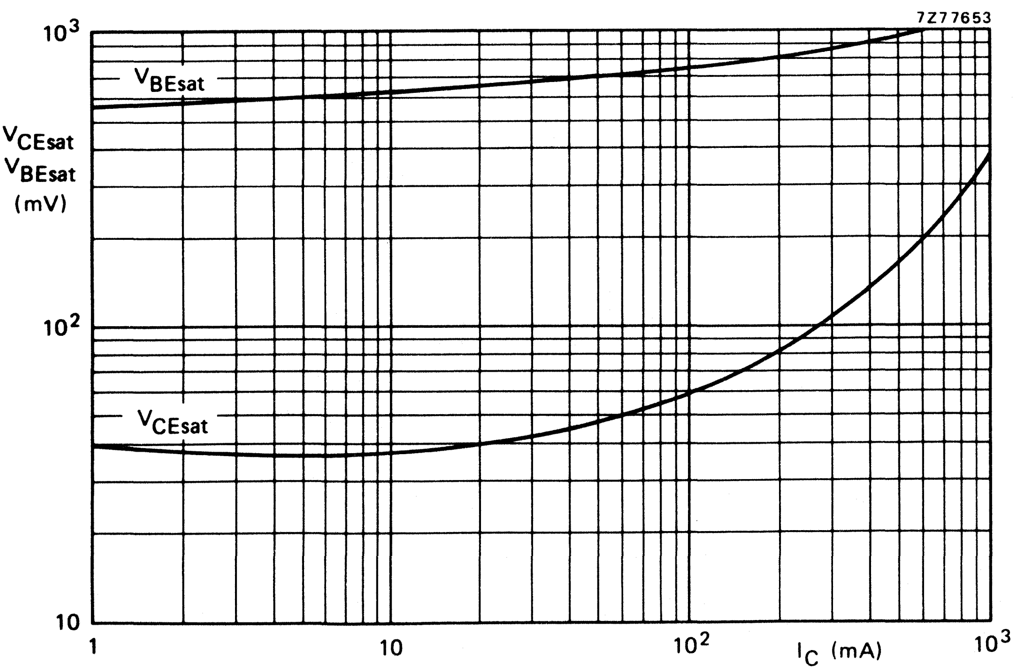


Fig. 4 $I_C/I_B = 10$; $T_j = 25$ °C; typical values.

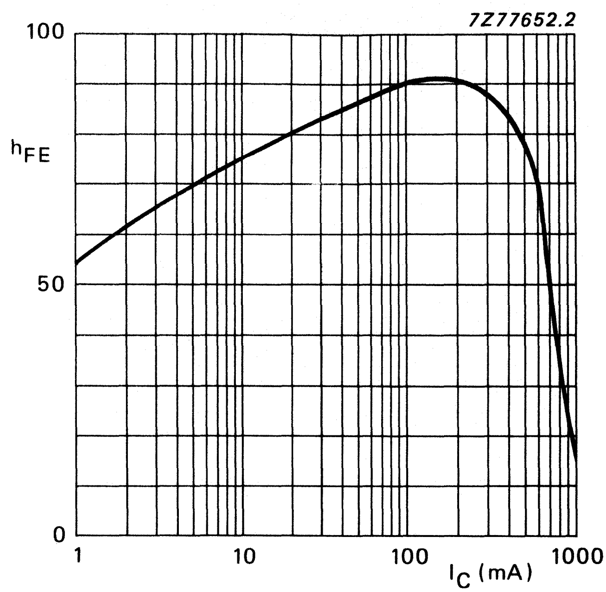


Fig. 5 V_{CE} 5 V; T_j = 25 °C; typical values.

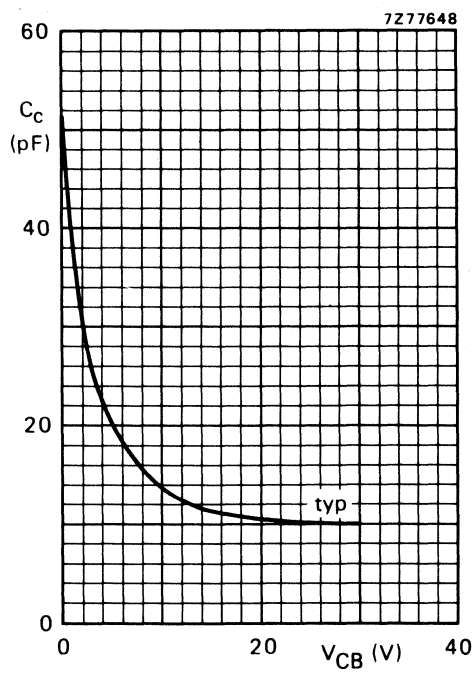


Fig. 6 $I_E = I_e = 0$; T_j = 25 °C.

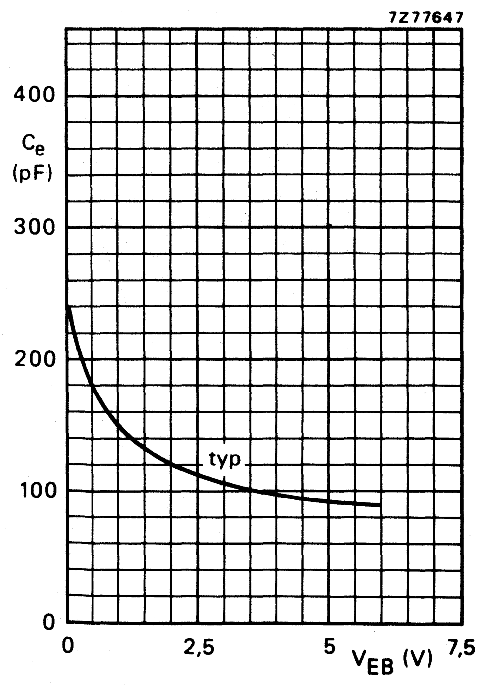


Fig. 7 $I_C = I_c = 0$; T_j = 25 °C.

→

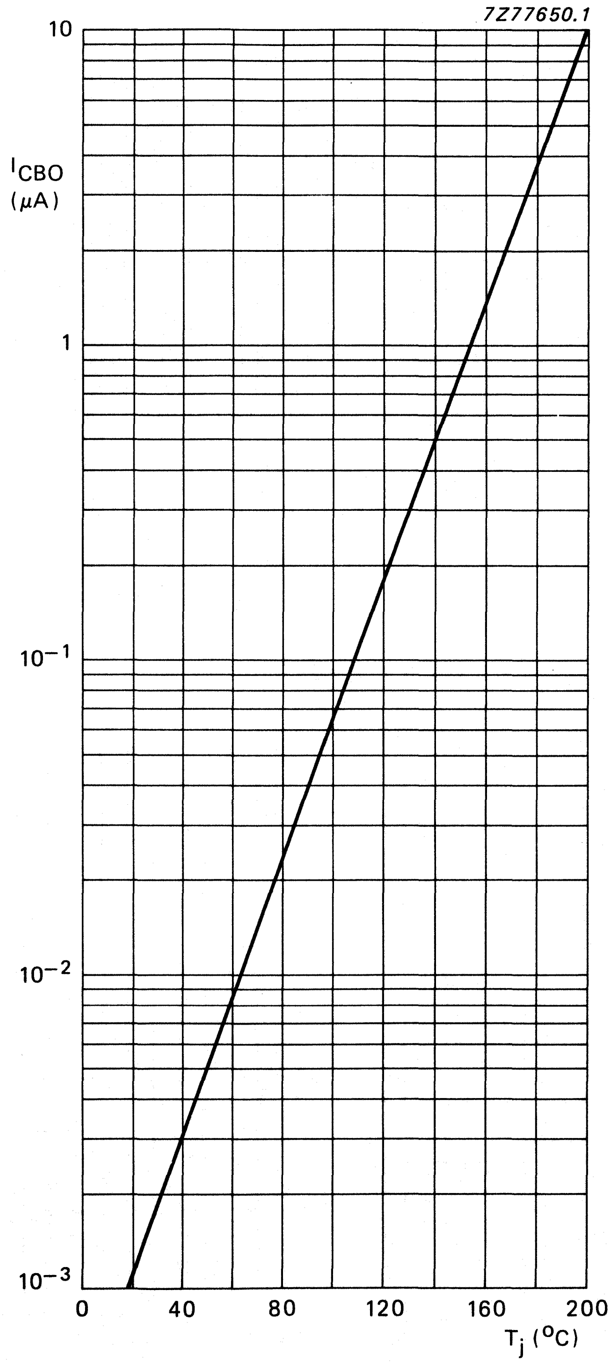


Fig. 8 $V_{CB} = V_{CBOmax}$; typical values.

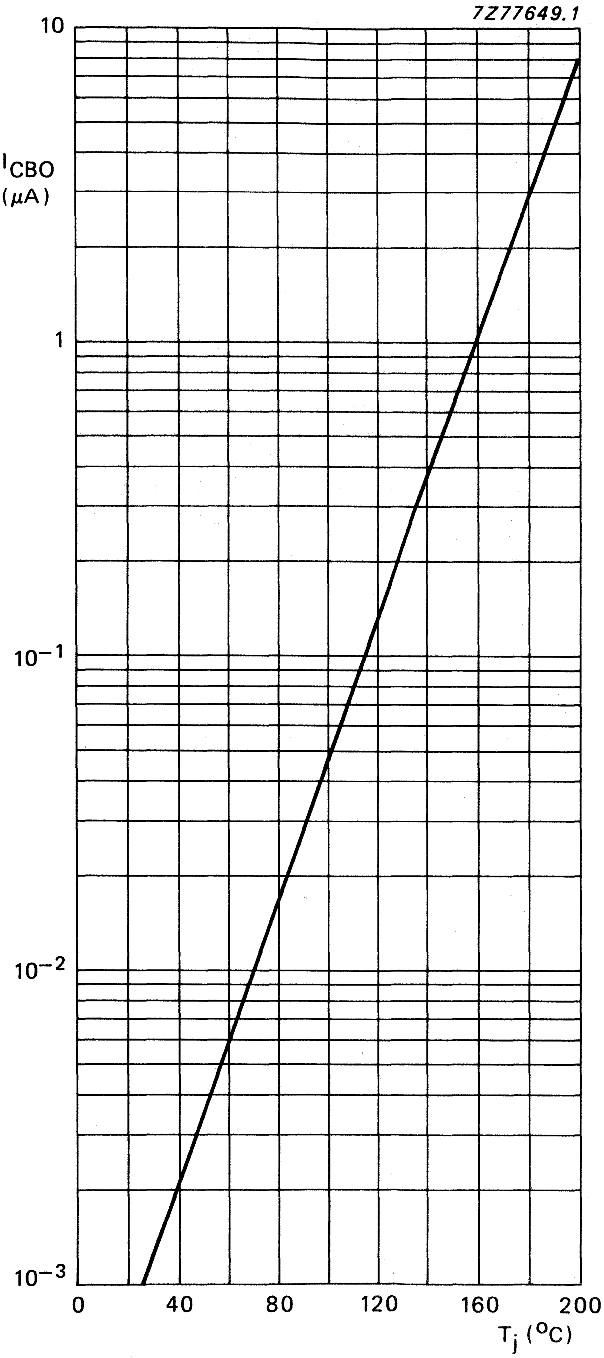


Fig. 9 $V_{CB} = ½V_{CBOmax}$; typical values.

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. See Figs 10 and 11.

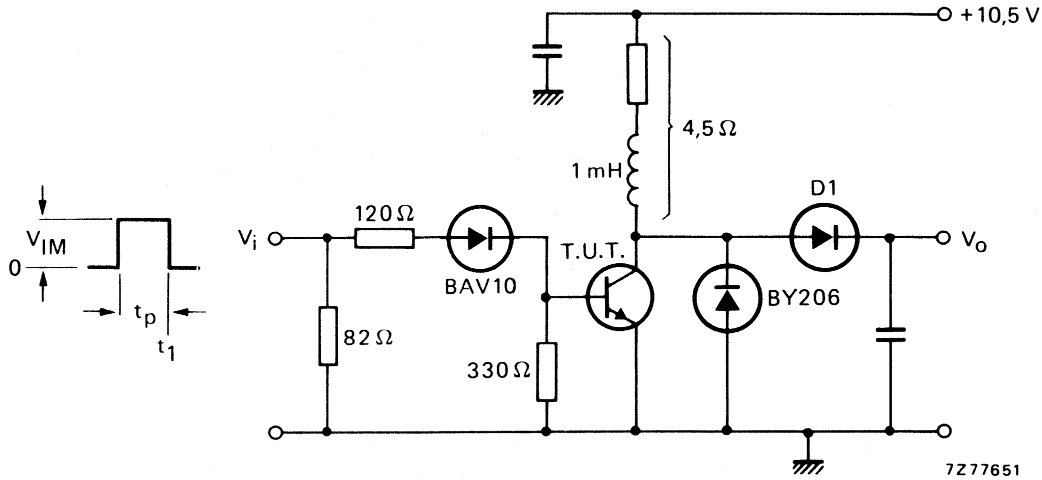


Fig. 10 Test circuit: V_{IM} = 50 V; t_p = 3 ms; $\delta \leqslant$ 0,03.
D1 = BY206 or combinations of suitable faster diodes.
V_o Adjusted to make $V_{(CL)}$ equal to rated V_{CEOmax} (see Fig. 11).

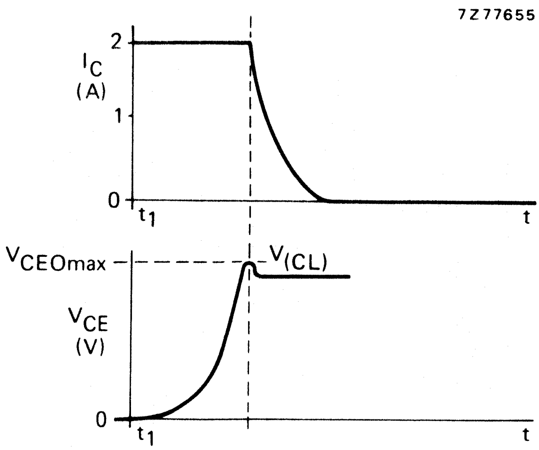


Fig. 11 Waveforms.

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

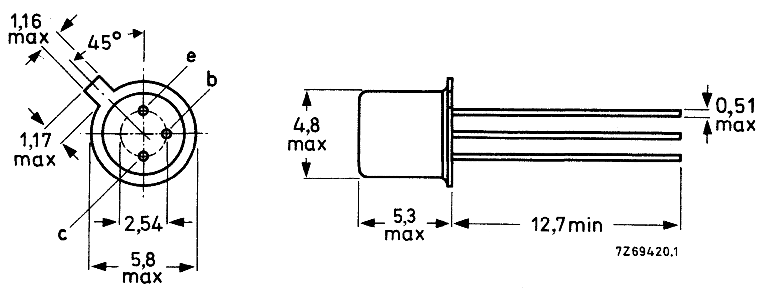
			BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	40	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	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 in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5	V
Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	360	mW
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	$R_{th\ j\text{-}a}$	=	0,48	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,15	K/mW

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)				
$I_C = 30$ μA; $V_{CE} = 20$ 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)

D.C. current gain

		BSX19	BSX20	
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 relevant Figs.)				
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	typ. 5	6	ns
		< 10	13	ns

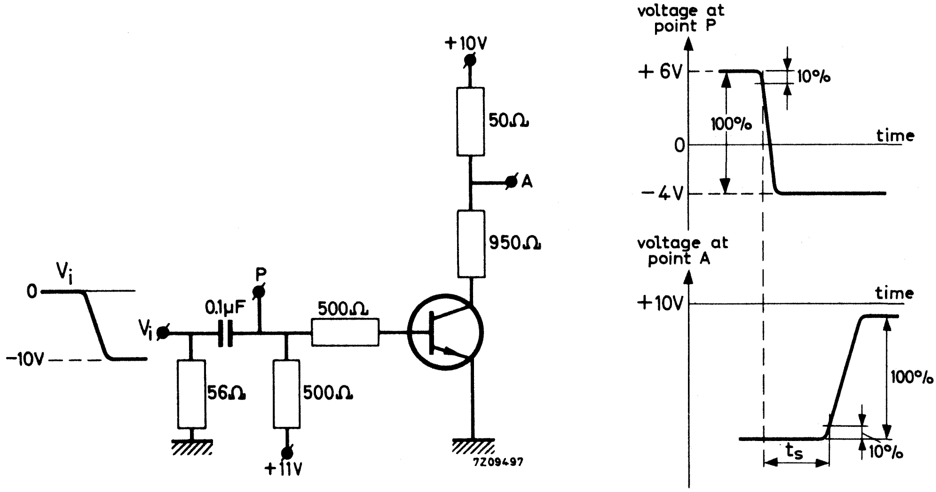


Fig. 2 Test circuit and timing waveforms.

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)

Switching times

Turn on time (see also relevant Figs.)

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 relevant Figs.)

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

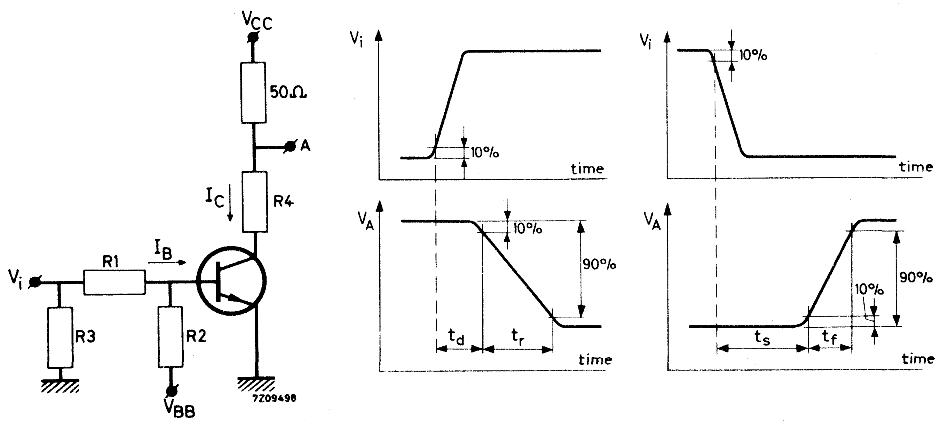


Fig. 3 Test circuit and timing waveforms.

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.

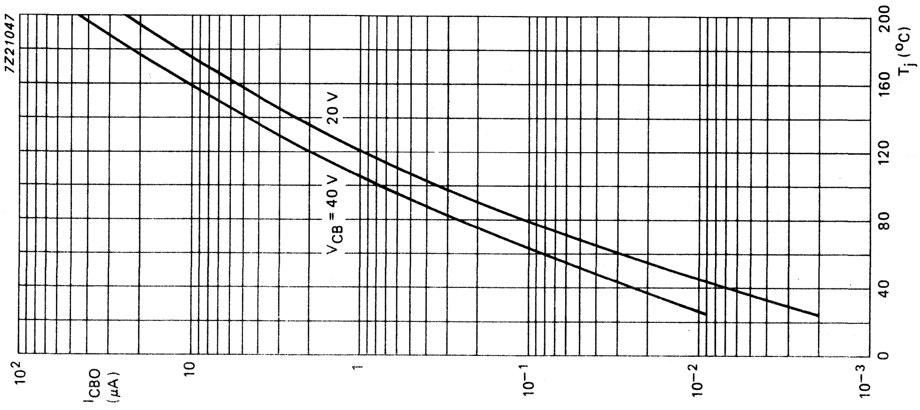

7Z21047
I_{CBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
V_{CB} = 40 V
20 V
T_j (°C)
0
40
80
120
160
200

Fig. 4

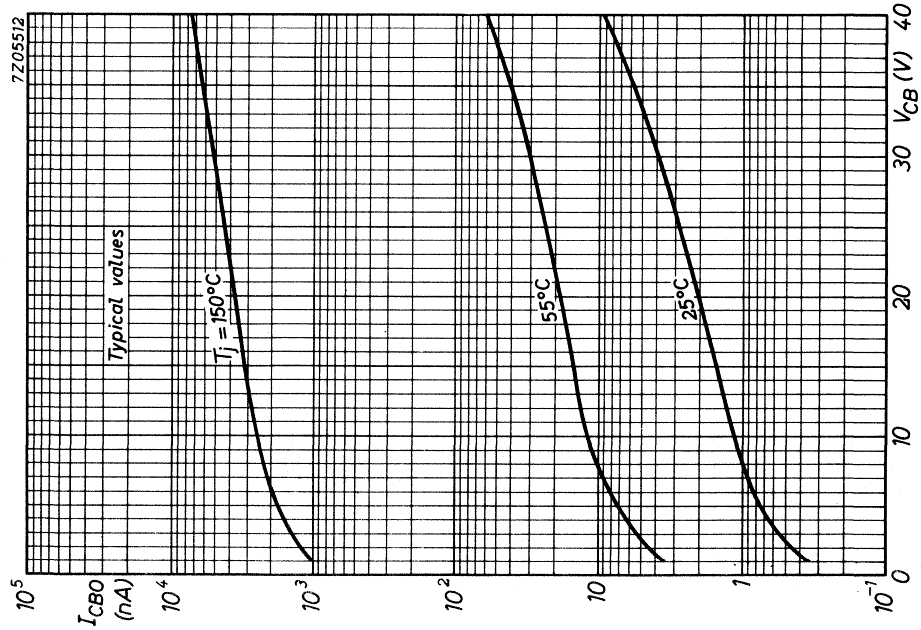

7Z05512
Typical values
T_j = 150°C
55°C
25°C
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
V_{CB} (V)
0
10
20
30
40

Fig. 5

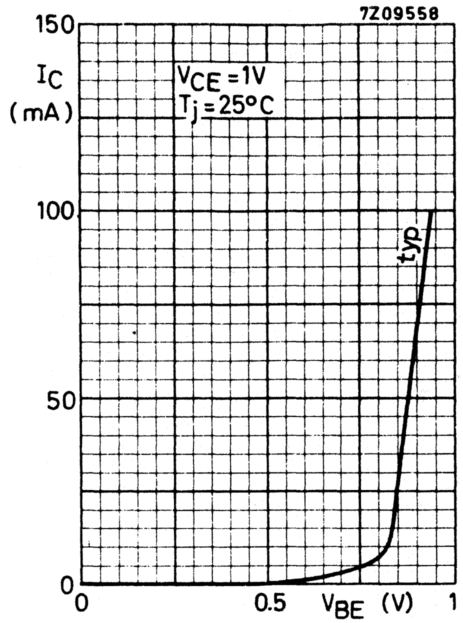

7Z09558
150
I_C
(mA)
V_{CE} = 1V
T_j = 25°C
100
typ
50
0
0
0.5
V_{BE} (V)
1

Fig. 6

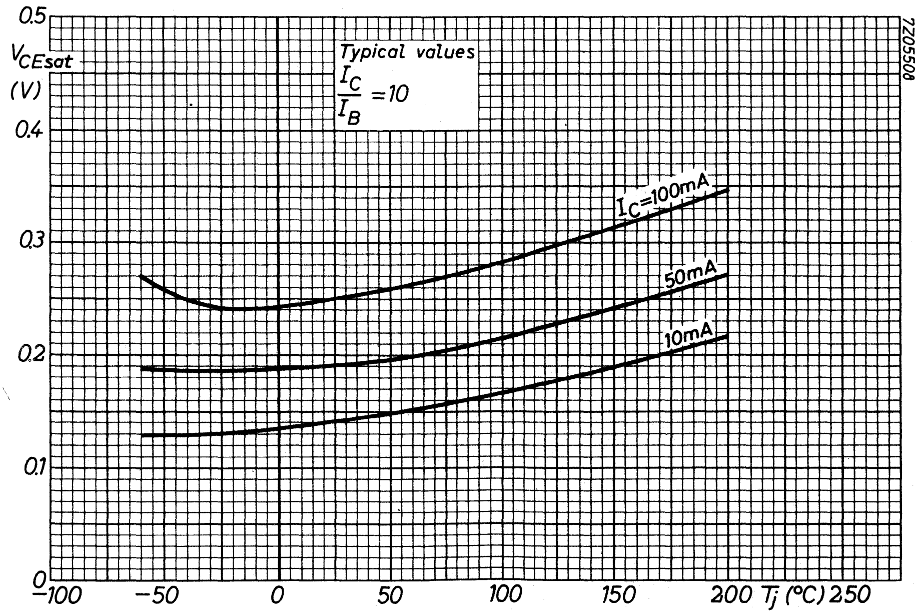

0.5
V_{CEsat}
(V)
0.4
0.3
0.2
0.1
0
Typical values
$\frac{I_C}{I_B}$ = 10
I_C=100mA
50mA
10mA
7Z05508
−100
−50
0
50
100
150
200
T_j (°C)
250

Fig. 7

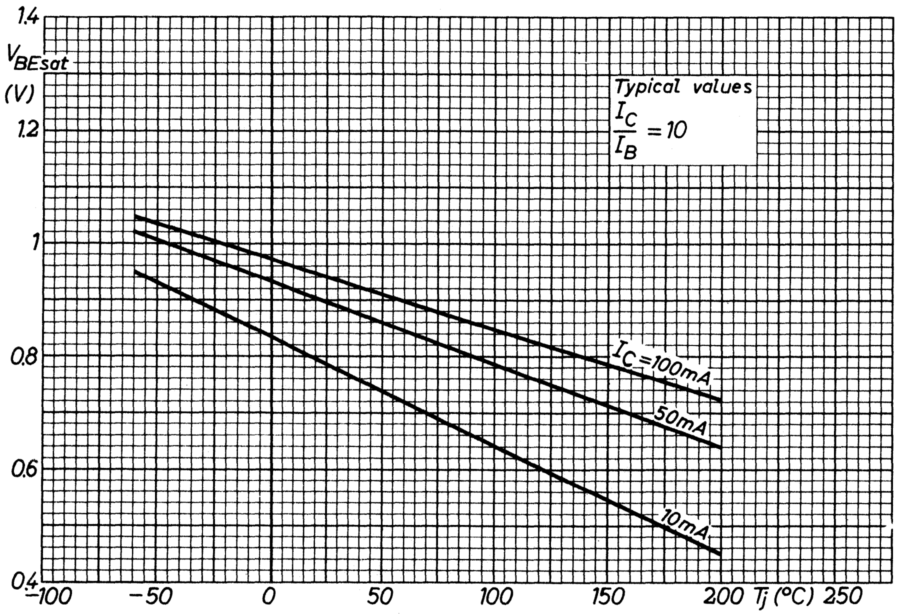

Typical values
$\frac{I_C}{I_B} = 10$
V_{BEsat} (V)
1.4
1.2
1
0.8
0.6
0.4
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
T_j (°C)
250

Fig. 8

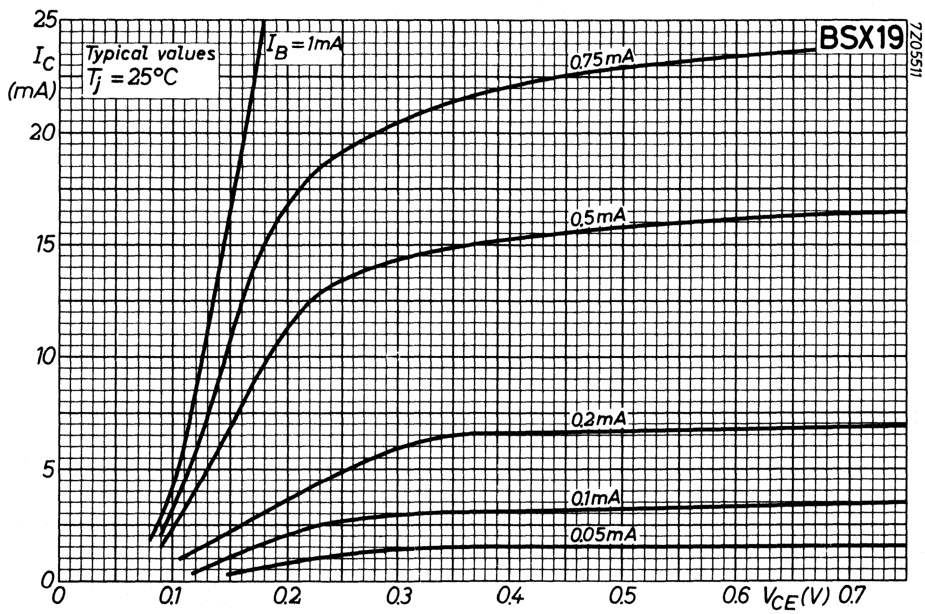

Typical values
T_j = 25°C
BSX19
7Z05511
I_C (mA)
25
20
15
10
5
0
I_B = 1mA
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
0
0.1
0.2
0.3
0.4
0.5
0.6
V_{CE} (V)
0.7

Fig. 9

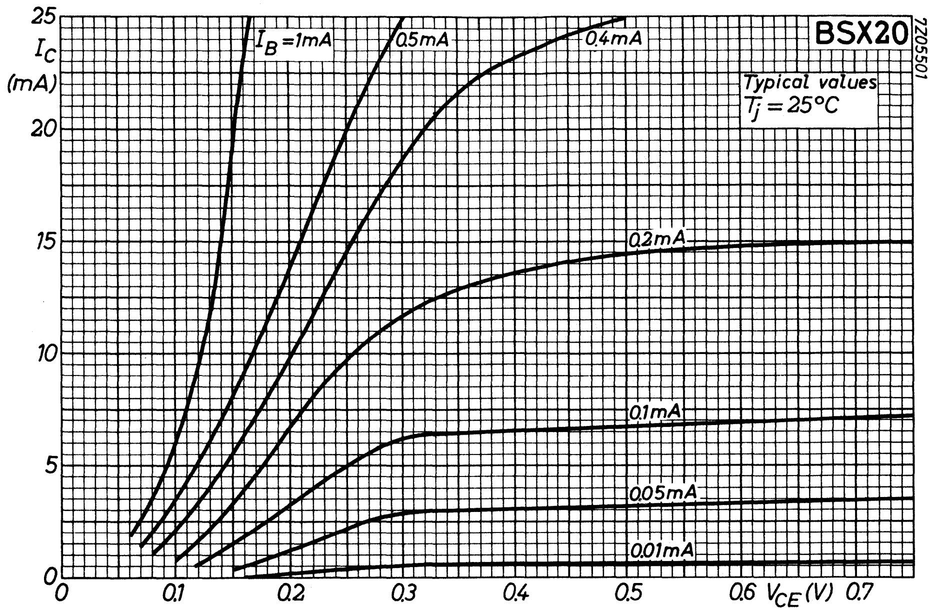


Fig. 10

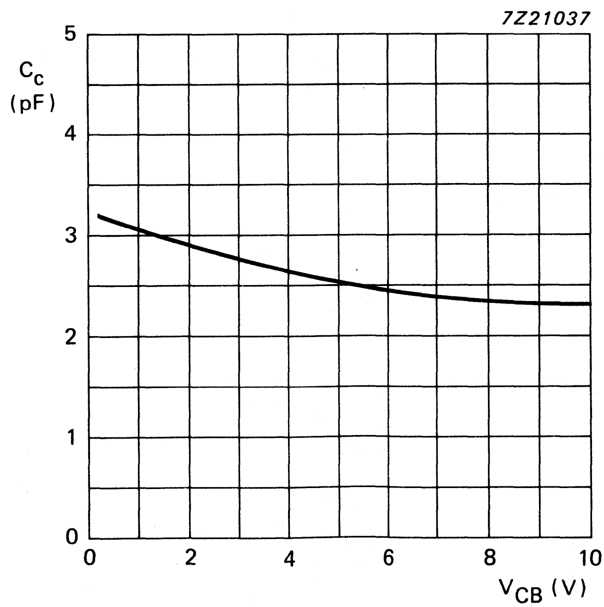


Fig. 11 $T_j = 25\ ^oC$; f = 1 MHz; $I_E = I_e = 0$

→

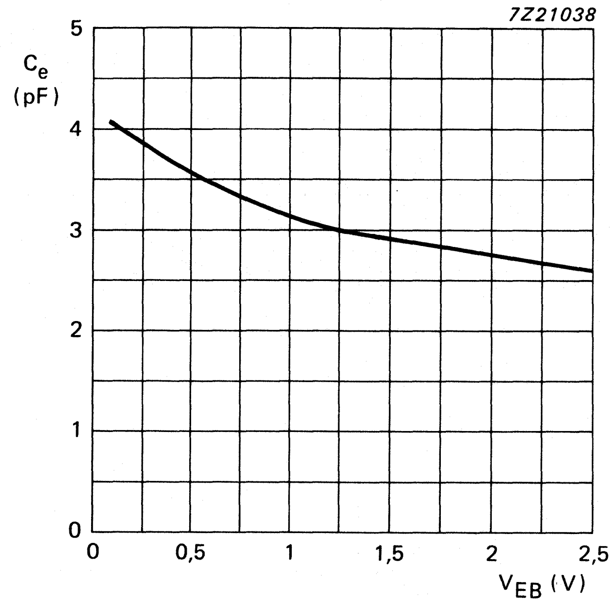


Fig. 12 T_j = 25 °C; f = 1 MHz; I_C = I_c = 0

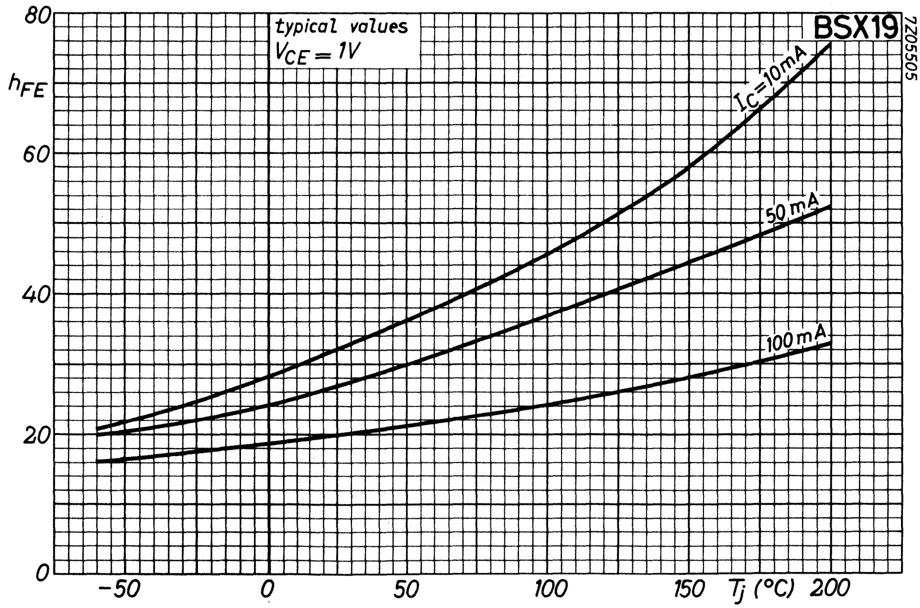


Fig. 13

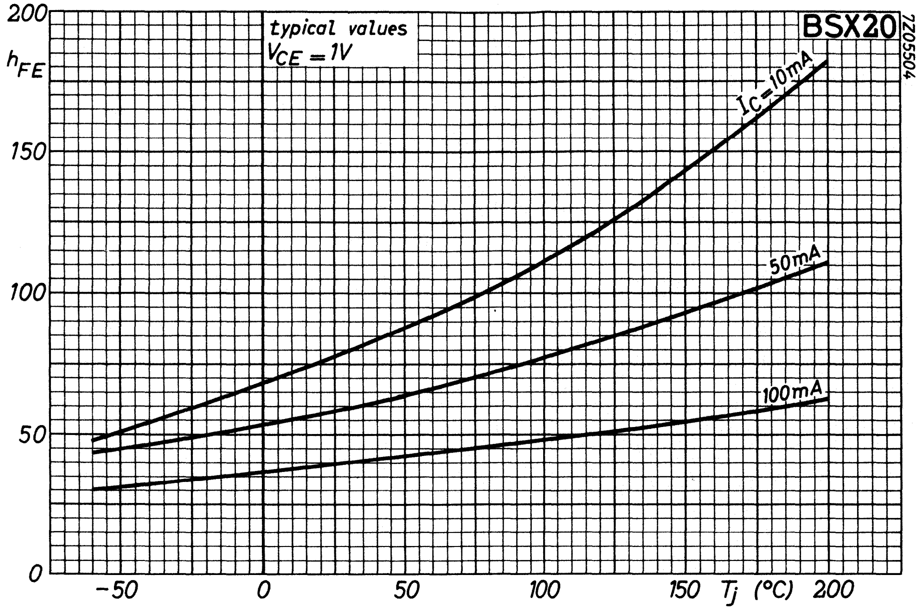

200
h_{FE}
150
100
50
0
typical values
$V_{CE} = 1V$
BSX20
7Z05504
$I_C = 10mA$
50mA
100mA
−50
0
50
100
150
T_j (°C)
200

Fig. 14

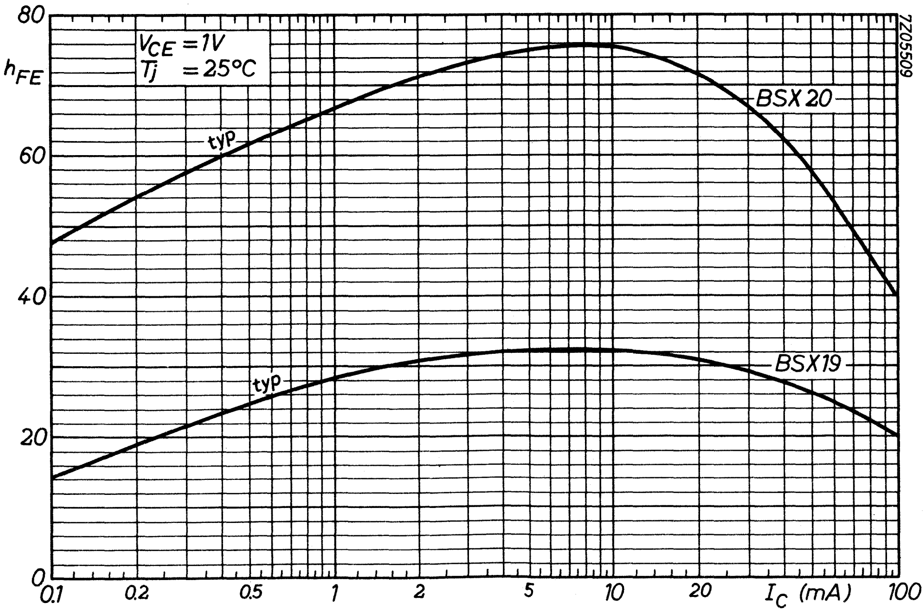

80
h_{FE}
60
40
20
0
$V_{CE} = 1V$
$T_j = 25°C$
7Z05509
typ
BSX 20
typ
BSX19
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

Fig. 15

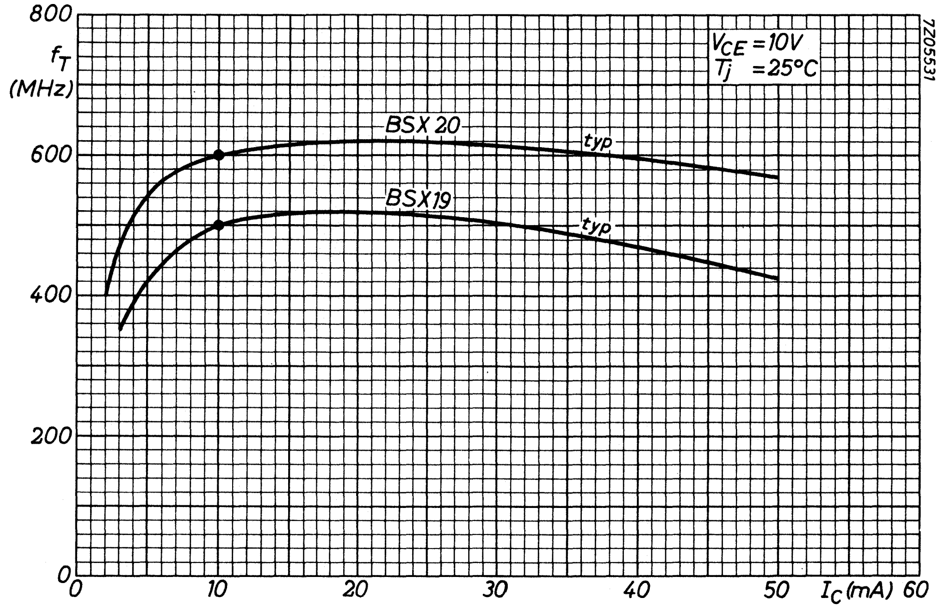

800
f_T
(MHz)
600
400
200
0
0
10
20
30
40
50
I_C (mA)
60
V_{CE} = 10V
T_j = 25°C
BSX 20
typ
BSX19
typ
7Z05531

Fig. 16

SILICON PLANAR EPITAXIAL TRANSISTOR

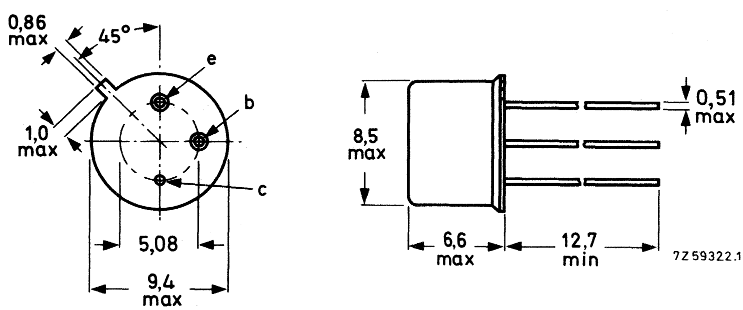
N-P-N silicon planar epitaxial transistor in a TO-39 encapsulation.
The BSX32 is designed for use in high current switching applications.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	65	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Collector current	I_C	max.	1	A
D.C. current gain I_C = 1 A; V_{CE} = 5 V	h_{FE}	min. typ.	20 60	
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j		−55 to 200	°C
Transition frequency at f = 100 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	min.	300	MHz

Fig. 1 TO-39.

Dimensions in mm



RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	65	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Collector current	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	3,5	W
Storage temperature	T_{stg}		−55 to 200	°C
Junction temperature	T_j		−55 to 200	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}case}$	max.	50	K/W
From junction to ambient	$R_{th\ j\text{-}amb}$	max.	219	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current $I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	max.	4	μA
Collector-base breakdown voltage $I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	min.	65	V
Emitter-base breakdown voltage $I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	min.	6	V
Collector-emitter sustaining voltage $I_B = 0$; $I_C = 10$ mA	$V_{CEOsust}$	min.	40	V
Saturation voltages* $I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	typ. max.	0,17 0,25	V V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	typ. max.	0,36 0,5	V V
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	typ. max.	0,6 0,85	V V
$I_C = 100$ mA; $I_B = 10$ mA	V_{BEsat}	typ. max.	0,8 0,9	V V
$I_C = 500$ mA; $I_B = 50$ mA	V_{BEsat}	max.	1,5	V
$I_C = 1$ A; $I_B = 100$ mA	V_{BEsat}	max.	2	V

* Pulsed: pulse duration = 300 μs; duty cycle = 1%.

CHARACTERISTICS (continued)

D.C. current gain*				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	min.	30	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	min. max.	60 150	
I_C = 500 mA; V_{CE} = 1 V	h_{FE}	min. typ.	25 60	
I_C = 1 A; V_{CE} = 5 V	h_{FE}	min. typ.	20 60	
I_C = 100 mA; V_{CE} = 1 V; T_{amb} = –55 °C	h_{FE}	min.	30	
I_C = 500 mA; V_{CE} = 1 V; T_{amb} = –55 °C	h_{FE}	min.	15	
Transition frequency at f = 100 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	min.	300	MHz
Emitter-base capacitance at f = 1 MHz I_C = 0; V_{EB} = 0,5 V	C_{eb}	max.	55	pF
Collector-base capacitance at f = 1 MHz I_E = 0; V_{CB} = 10 V	C_{cb}	max.	10	pF
Turn-off time I_C = 500 mA; V_{CC} = 30 V I_{B1} = 50 mA	t_{on}	max.	35	ns
Turn-off time I_C = 500 mA; V_{CC} = 30 V I_B = $-I_{B2}$ = 50 mA	t_{off}	max.	60	ns

* Pulsed: pulse duration = 300 μs; duty cycle = 1%.

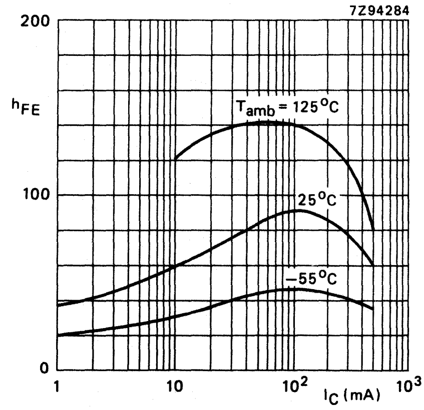


Fig. 2 D.C. current gain; V_{CE} = 1 V.

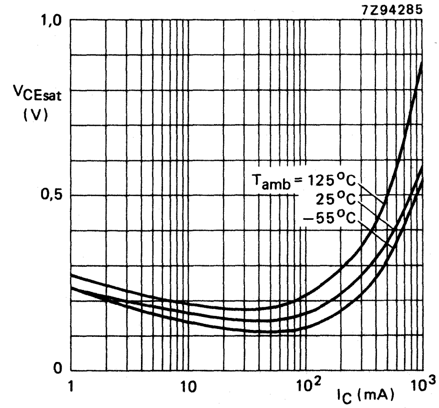


Fig. 3 Collector-emitter saturation voltage; I_C = 10 x I_B.

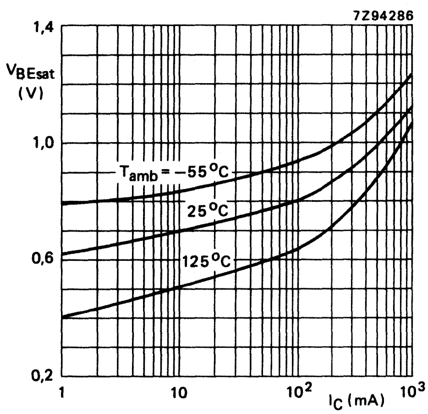


Fig. 4 Base-emitter saturation voltage; I_C = 10 x I_B.

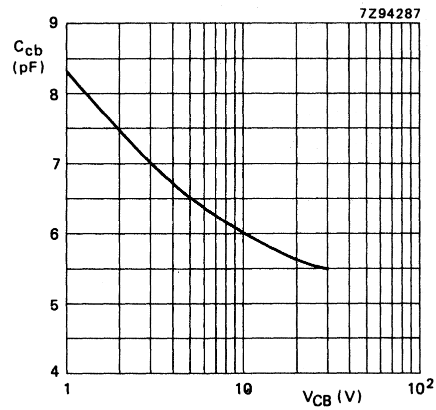


Fig. 5 Collector-base capacitance; I_E = 0.

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

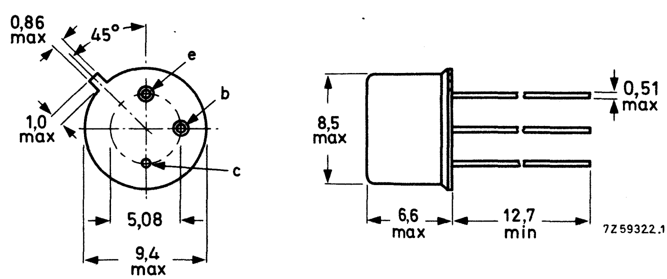
			BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	63	100
		<	160	250

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).

Products approved to CECC 50 002-174.

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}	<	30	30	–	nA
V_{BE} = 0; V_{CE} = 60 V; T_{amb} = 150 °C	I_{CES}	<	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}	<	2,00	2,00	2,00	V
Saturation voltage						
I_C = 1000 mA; I_B = 100 mA	V_{CEsat}	<	1,0	1,0	–	V
I_C = 500 mA; I_B = 25 mA	V_{CEsat}	<	–	–	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

→

			BSX45−10 BSX46−10 BSX47−10	BSX45−16 BSX46−16	
D.C. current gain					
$I_C = 100\ \mu A$; $V_{CE} = 1\ V$	h_{FE}	>	15	25	
		typ.	40	90	
$I_C = 100\ mA$; $V_{CE} = 1\ V$	h_{FE}	>	63	100	
		typ.	100	160	
		<	160	250	
$I_C = 500\ mA$; $V_{CE} = 1\ V$	h_{FE}	>	25	35	
		typ.	40	60	
$I_C = 1\ A$; $V_{CE} = 1\ V$	h_{FE}	typ.	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

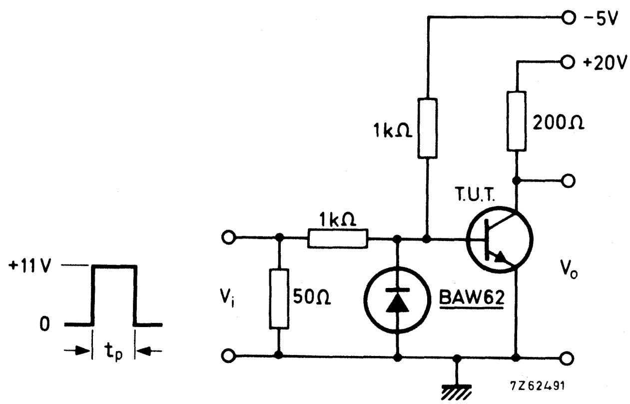


Fig. 2 Switching times test circuit.

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

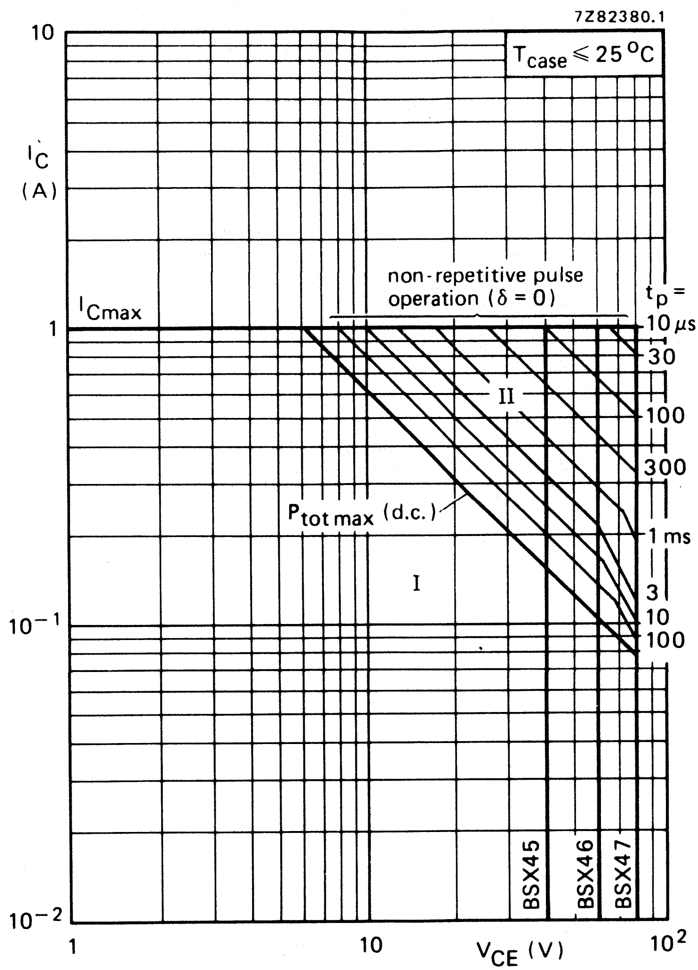


Fig. 3 Safe Operating ARea; $T_{case} \leqslant 25$ °C*.

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. $t_p < 3$ μs, assume 3 μs values for Z_{th}.)

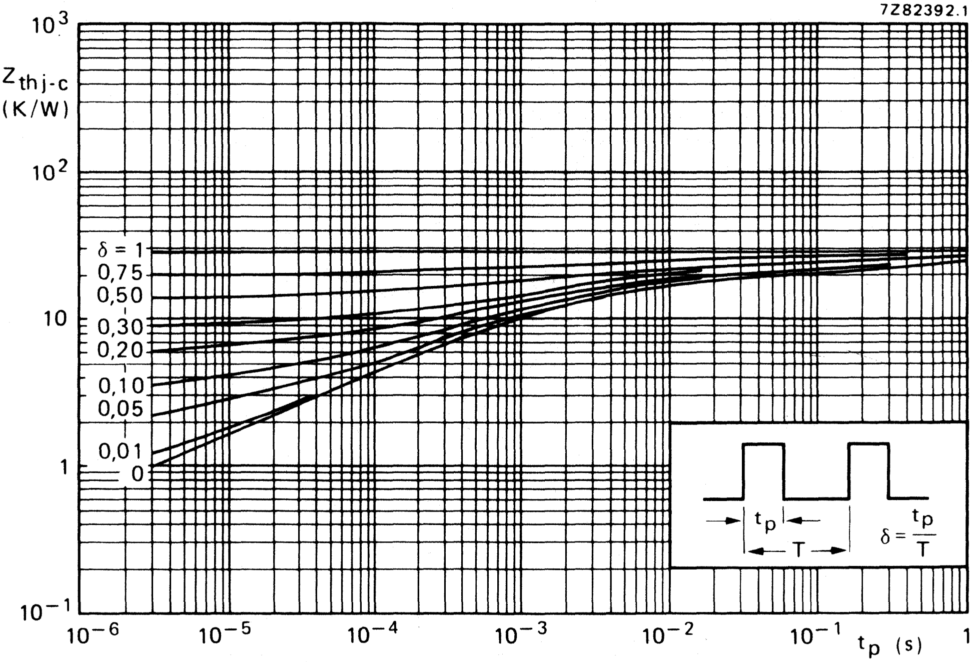


Fig. 4 Thermal impedance versus pulse duration. Stabilization time is 10 s.

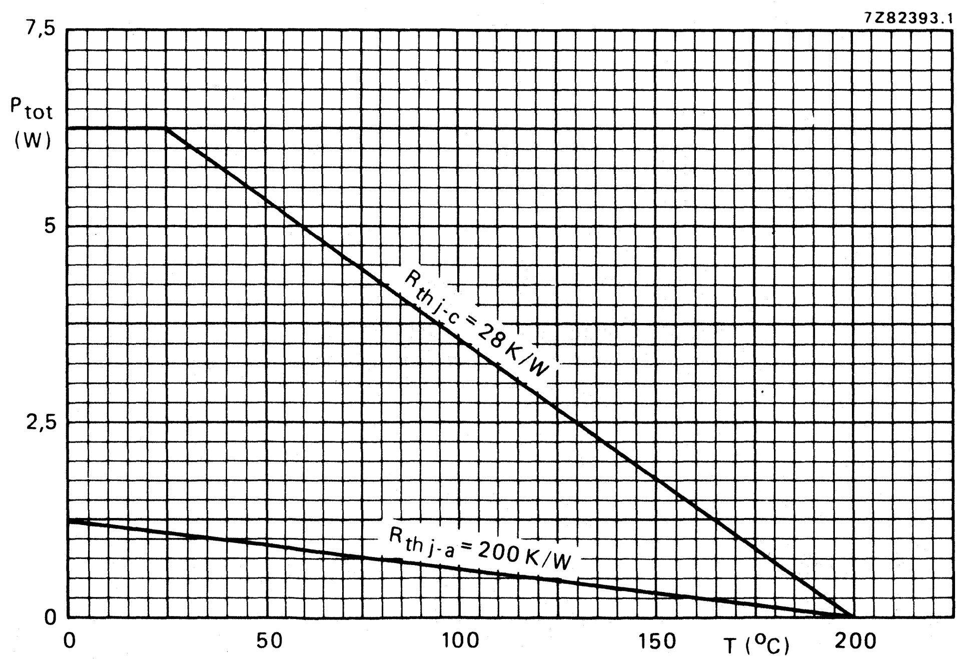


Fig. 5 Maximum permissible power dissipation as a function of temperature.

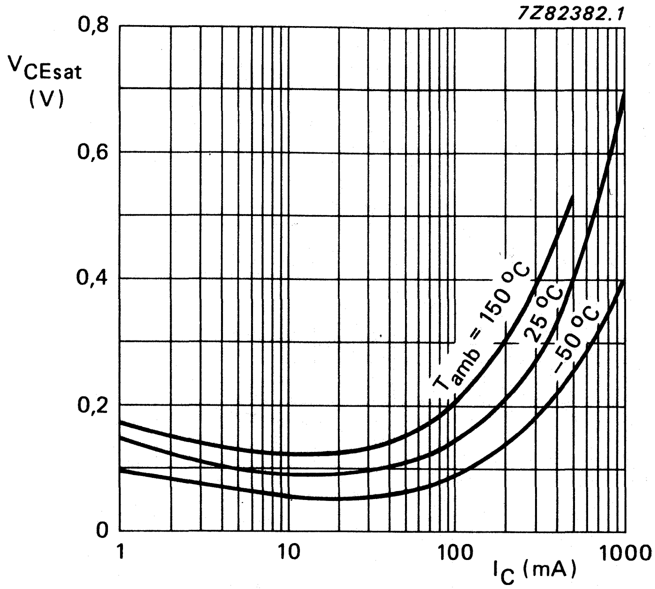


Fig. 6 I_C/I_B = 10; —— typical values; at T_{amb} = 25 °C.

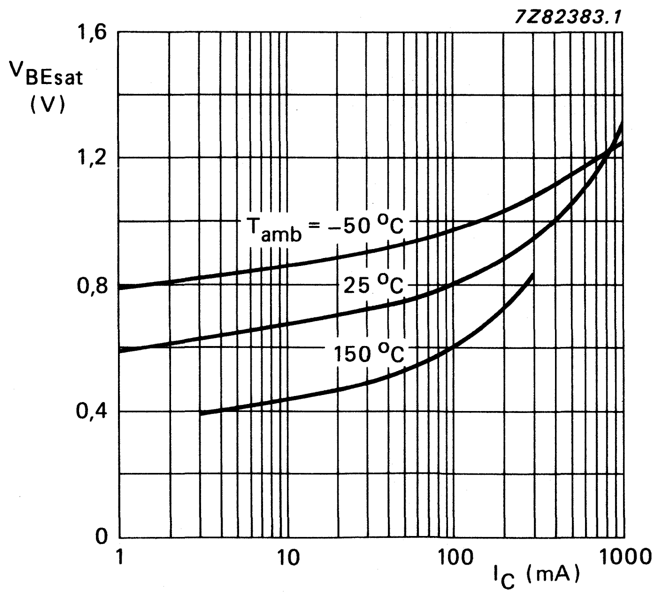


Fig. 7 I_C/I_B = 10; —— typical values; at T_{amb} = 25 °C.

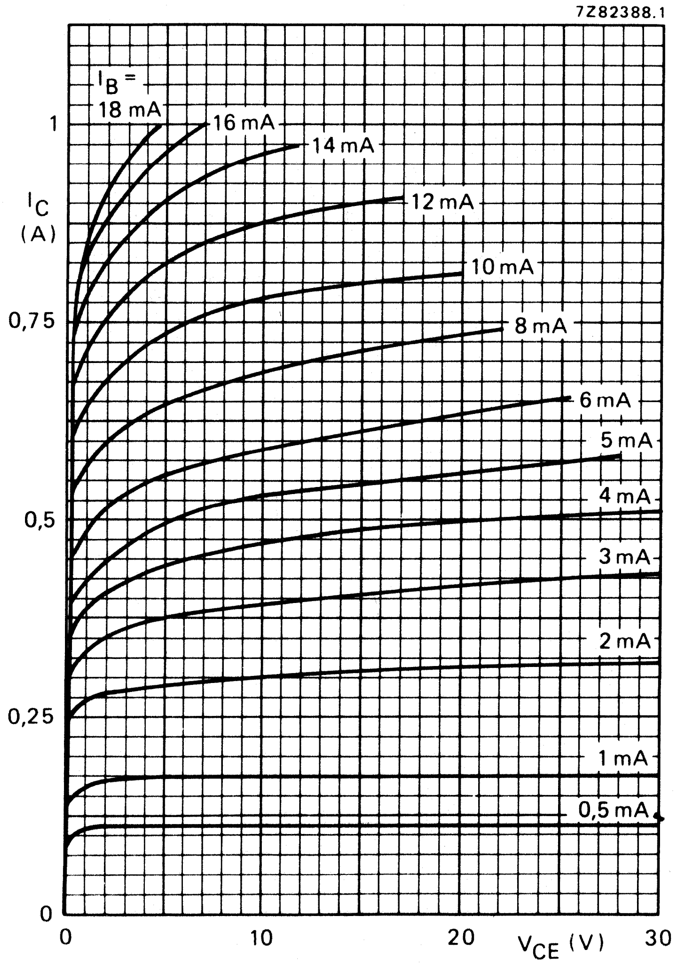


Fig. 8 Typical values; T_j = 25 °C.

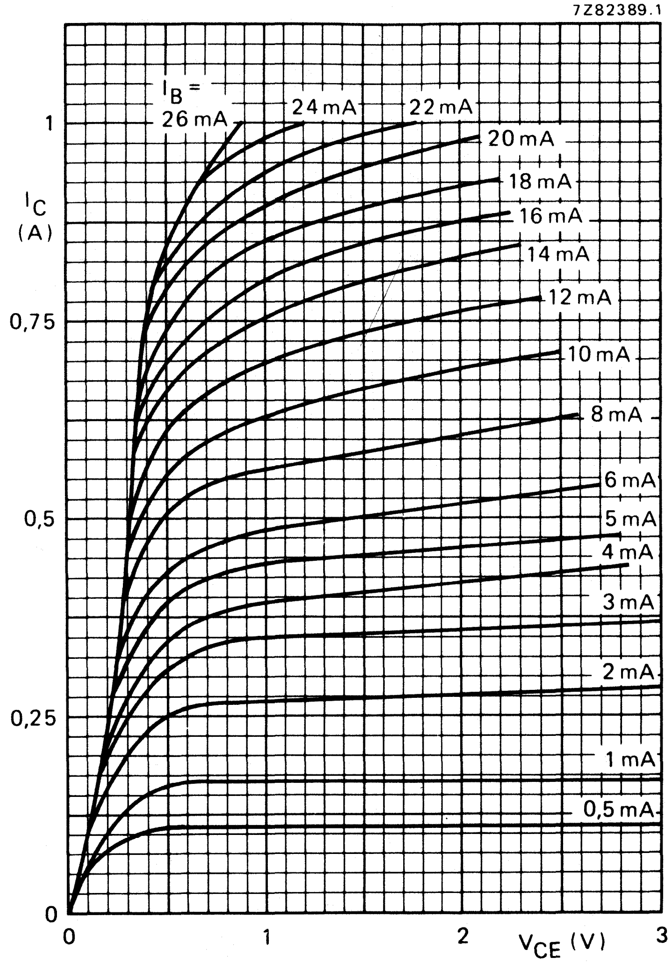


Fig. 9 Typical values; T_j = 25 °C.

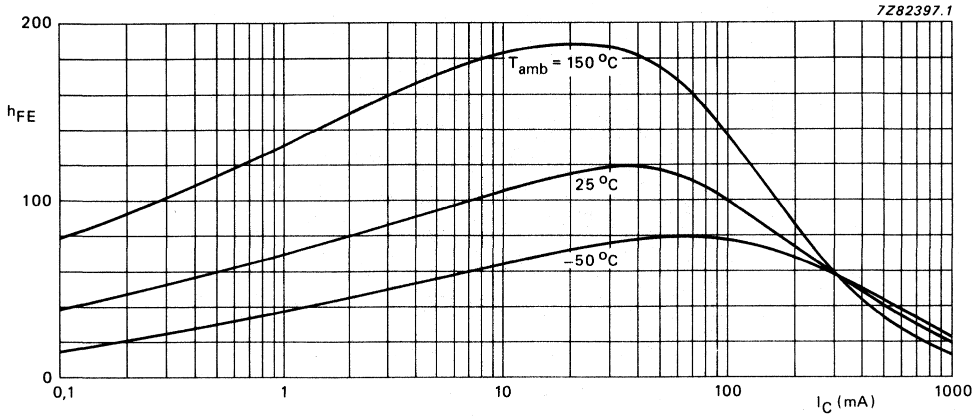


Fig. 10 V_{CE} = 1 V; ——typical values; T_{amb} = 25 °C; Group−10.

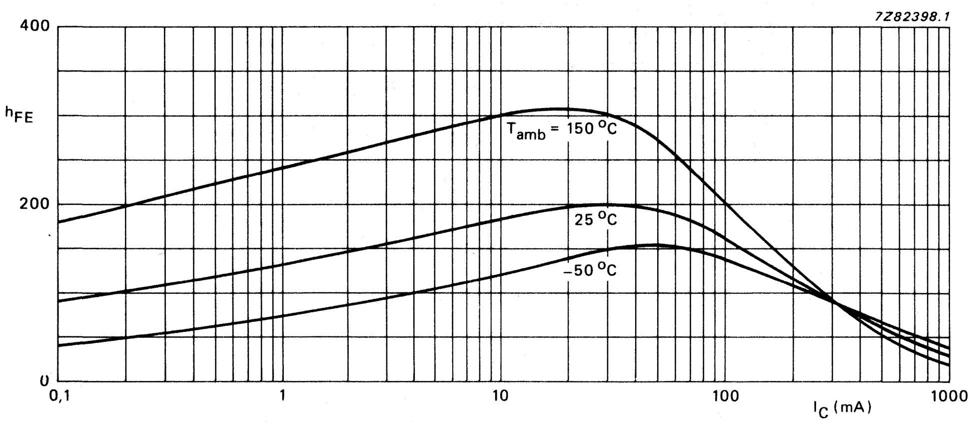


Fig. 11 V_{CE} = 1 V; ——typical values; T_{amb} = 25 °C; Group−16.

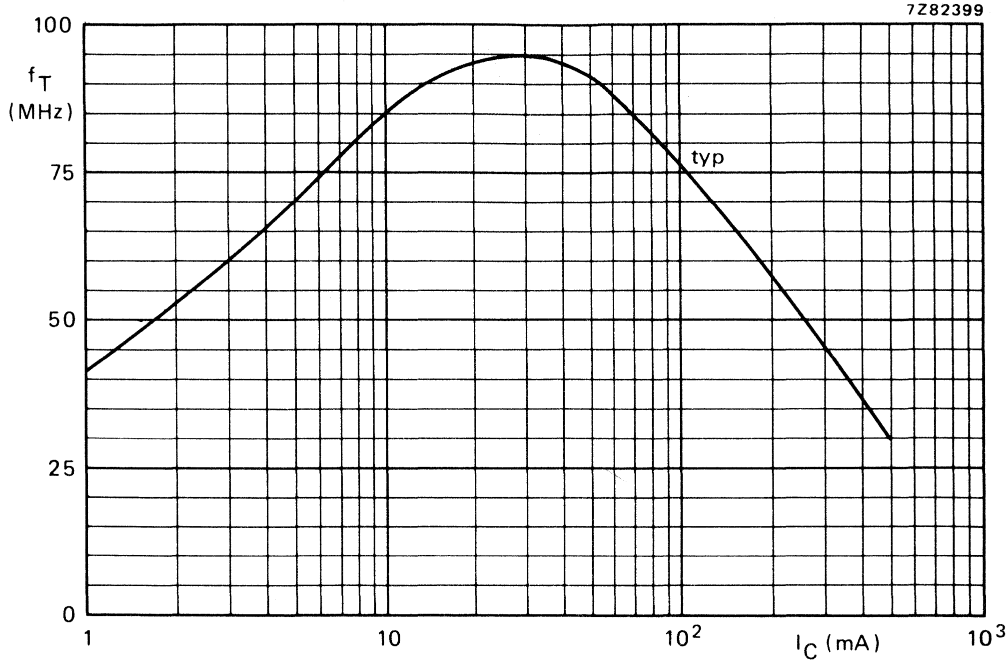


Fig. 12 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

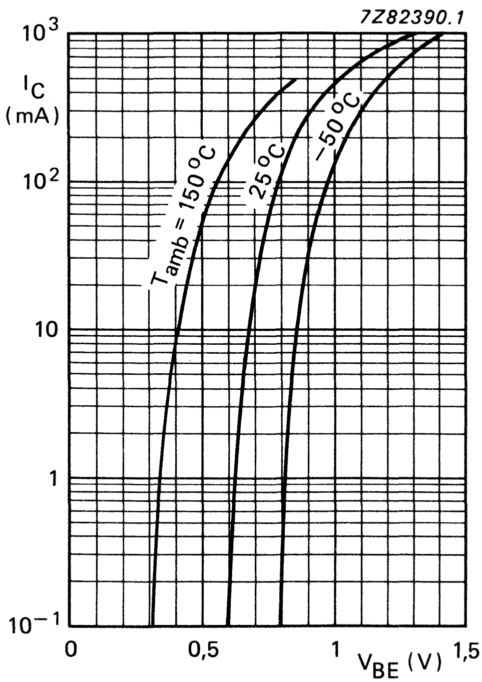


Fig.13 V_{CE} = 1 V; —— typical values; T_{amb} = 25 °C.

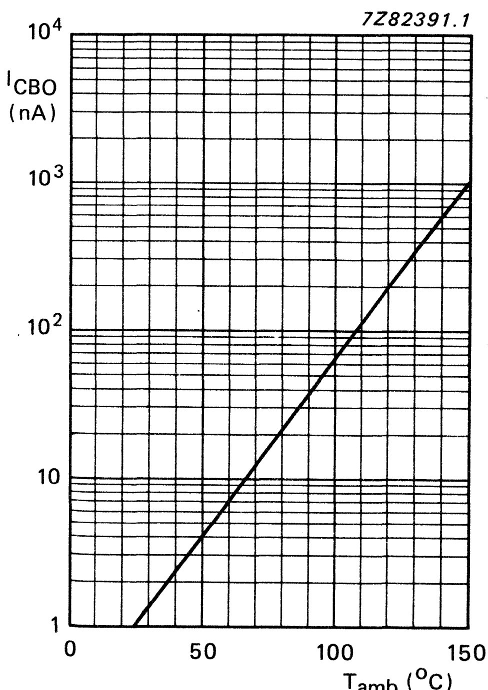


Fig. 14 V_{CBO} = 60 V for **BSX45** and **BSX46**; V_{CBO} = 80 V for **BSX47**; typical values.

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

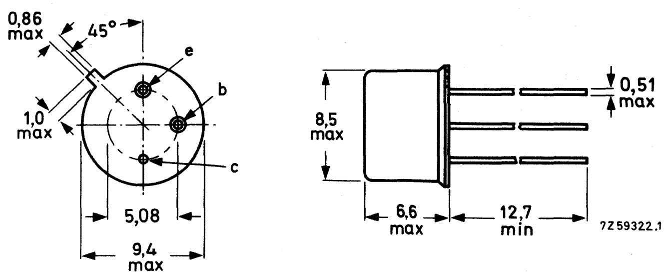
			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	200	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	>	250	250	250	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)

			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

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
Total power dissipation 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 ambient in free air	$R_{th\ j\text{-}a}$	=	220	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	43	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	35	K/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	←
$I_C = 500$ 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	←
Transition frequency						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	250	250	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

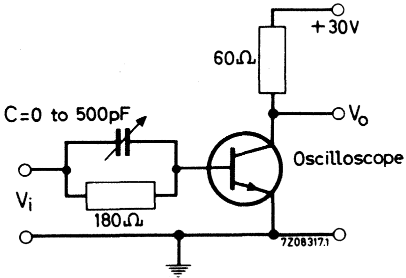
CHARACTERISTICS

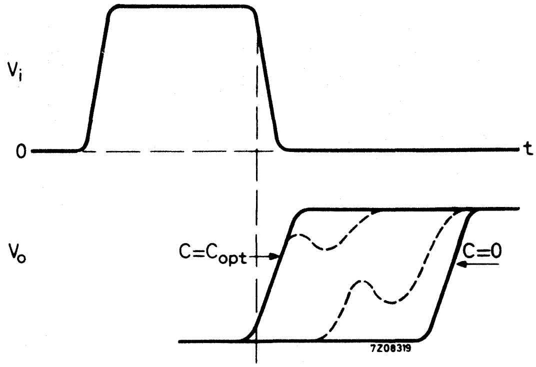
T_j = 25 °C unless otherwise specified

Recovered charge

I_C = 500 mA; I_B = 50 mA | BSX60 | Q_s | < | 5 nC

Test circuit:





Adjust C from zero to C_{opt}

$Q_s = C_{opt} \cdot V_i$

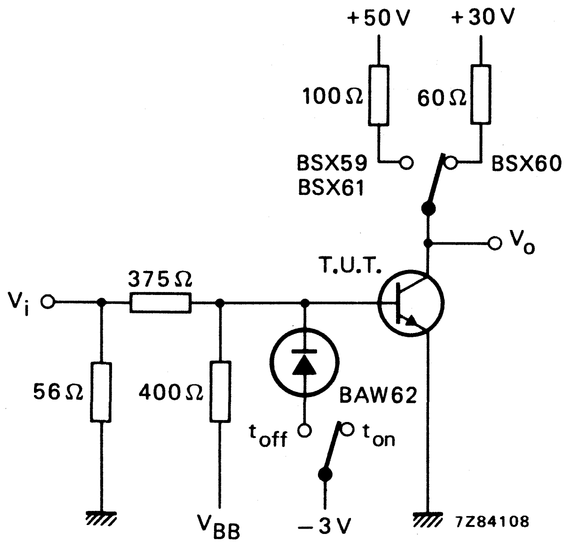
Pulse generator:

Pulse duration $t_p = 10\ \mu s$

Duty cycle $\delta = 0{,}02$

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.

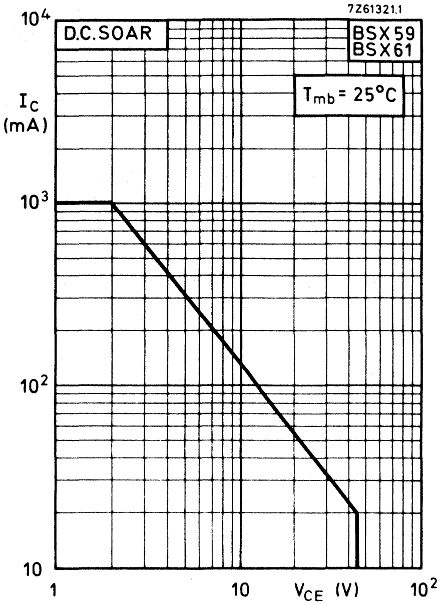


Fig. 5.

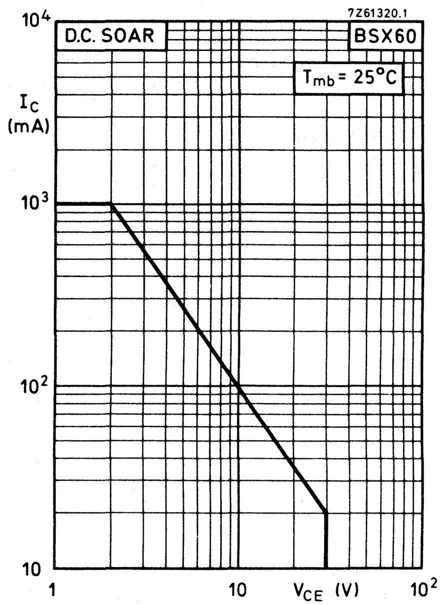


Fig. 6.

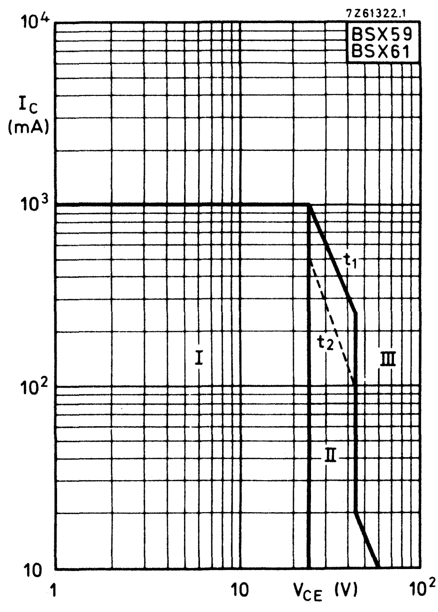


Fig. 7.

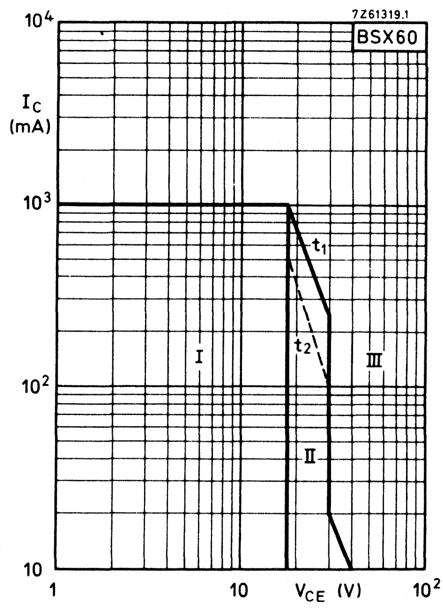


Fig. 8.

I Region of permissible operation during switching off with $-V_{BB} = 4$ V; $R_{BE} = 39\ \Omega$.

II Permissible extension for repetitive pulsed operation.

t_1 limits operations with $t_p \leqslant 0{,}1\ \mu s$; $\delta = 0{,}25$

t_2 limits operations with $t_p \leqslant 1\ \mu s$; $\delta = 0{,}25$

III Operation in this area is not allowed.

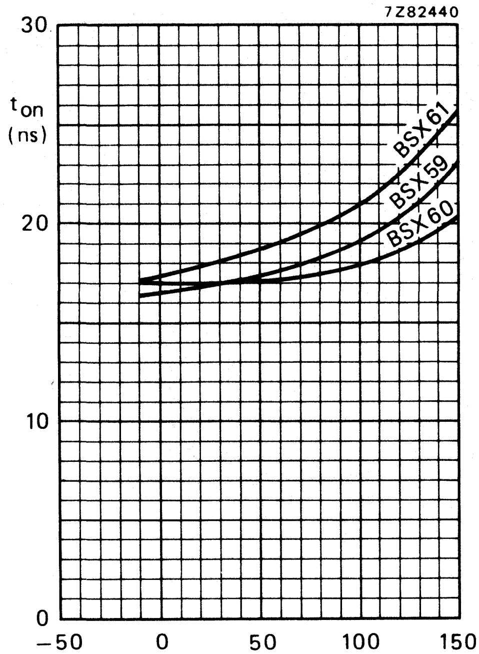


Fig. 9 $-V_{BEoff}$ = 2 V; I_{Con} = 500 mA; I_{Bon} = 50 mA; typ. values. (See also Fig. 4).

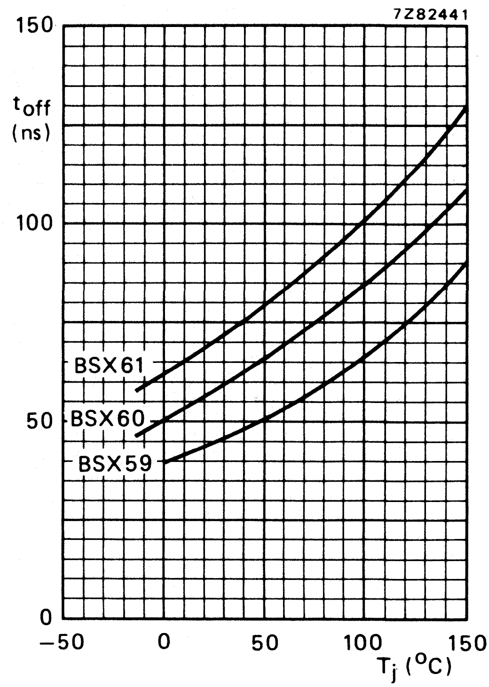


Fig. 10 I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 50 mA; typical values. (See also Fig. 4).

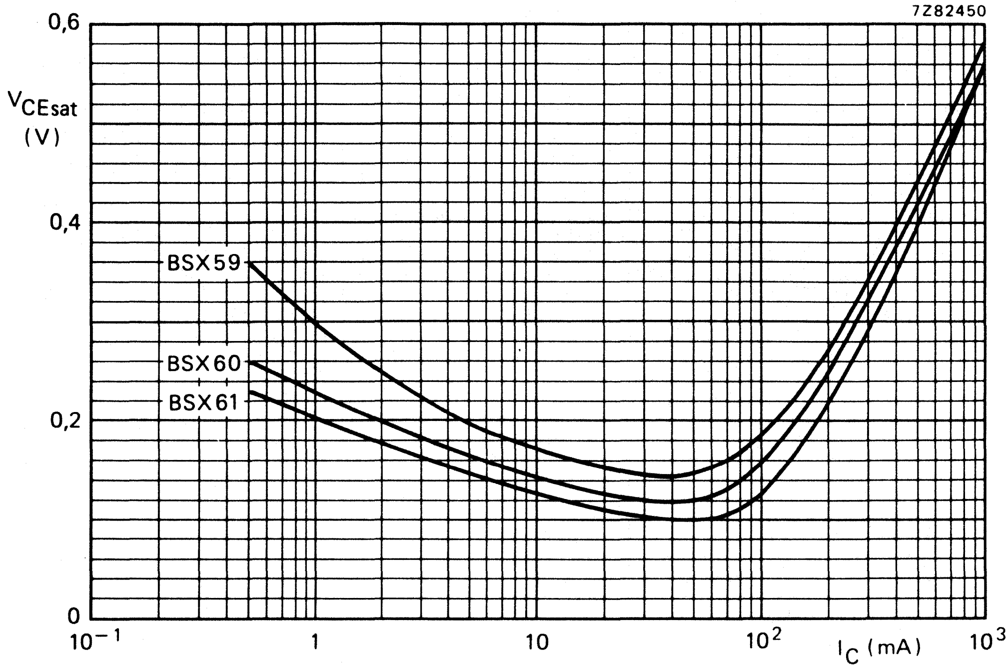


Fig. 11 $I_C/I_B = 10$; $T_j = 25$ °C; typical values.

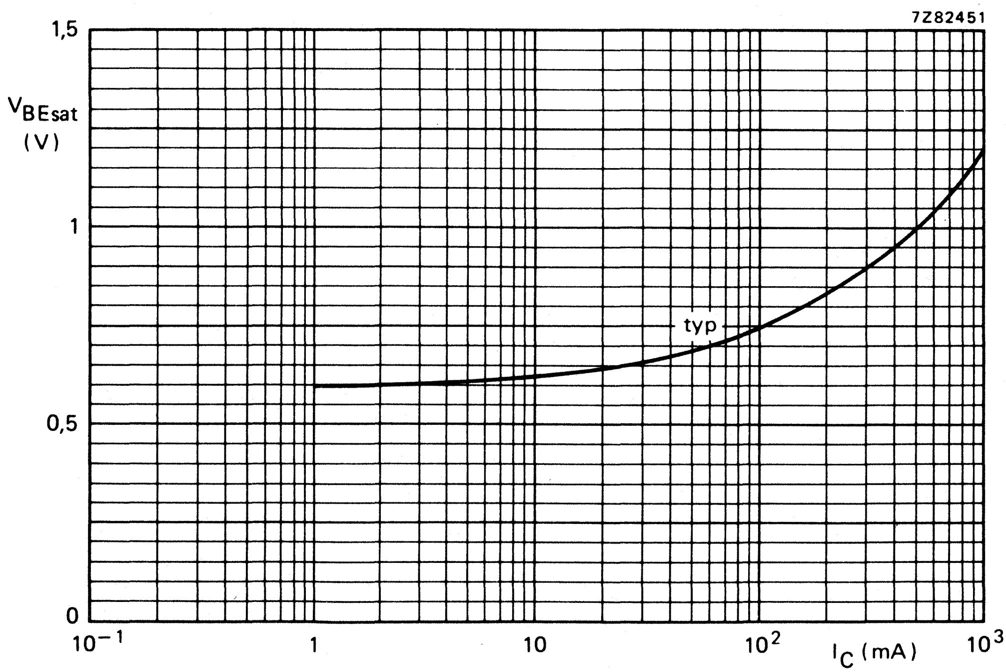


Fig. 12 $I_C/I_B = 10$; $T_j = 25$ °C.

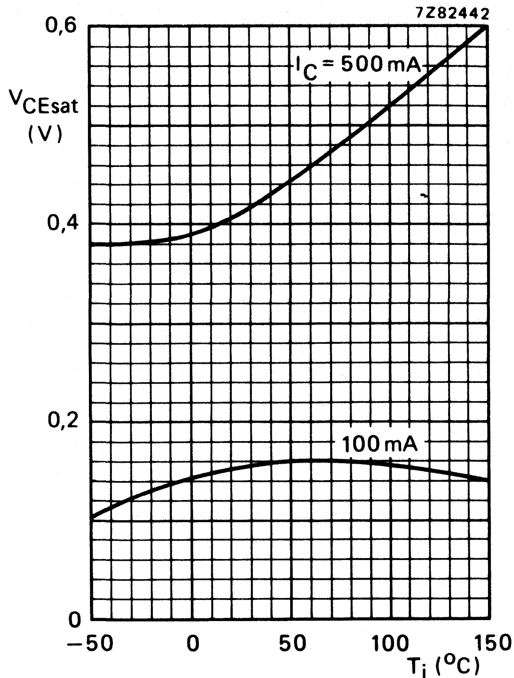


Fig. 13 I_C/I_B = 10; typical values.

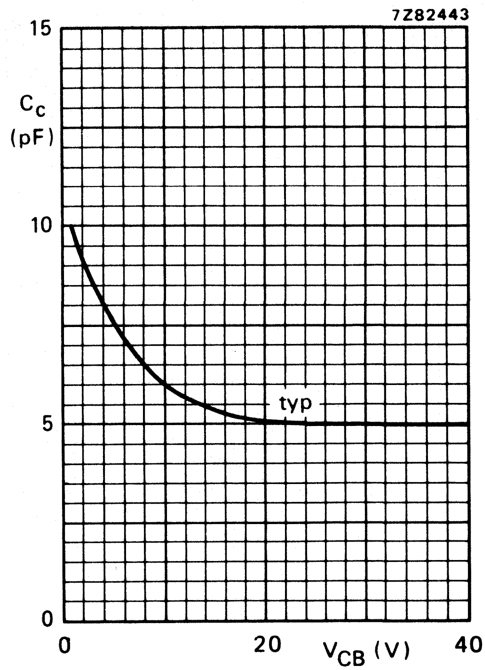


Fig. 14 $I_E = I_e = 0$; f = 1 MHz; T_j = 25 °C.

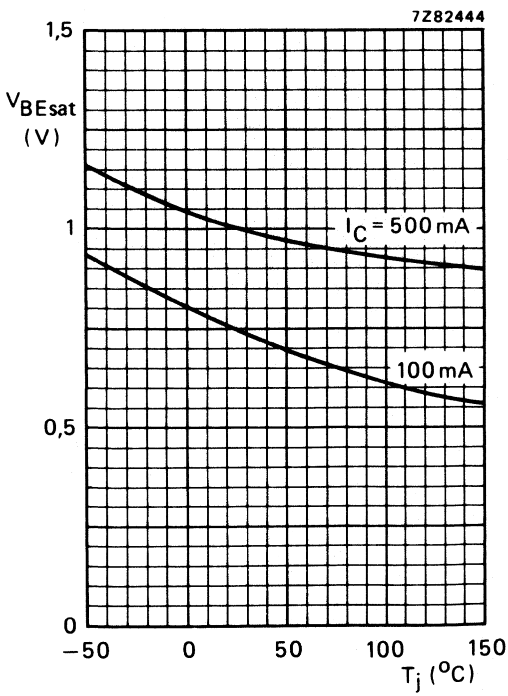


Fig. 15 I_C/I_B = 10; typical values.

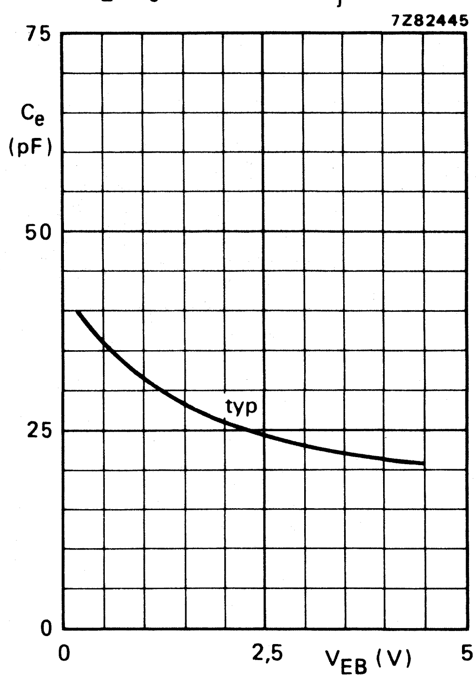


Fig. 16 $I_C = I_c = 0$; f = 1 MHz; T_j = 25 °C.

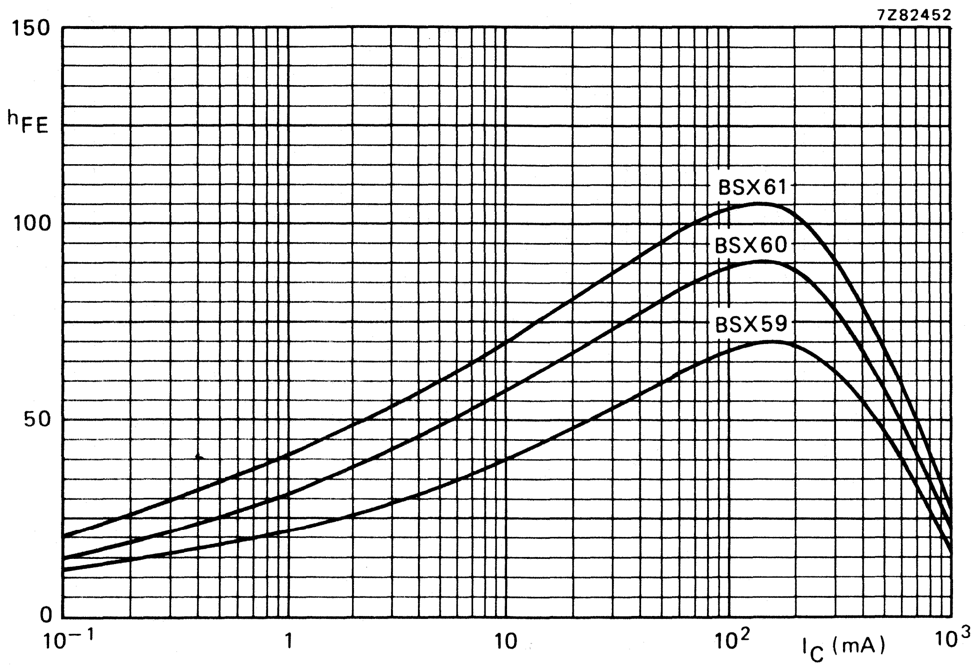


Fig. 17 V_{CE} = 1 V; T_j = 25 °C; typical values.

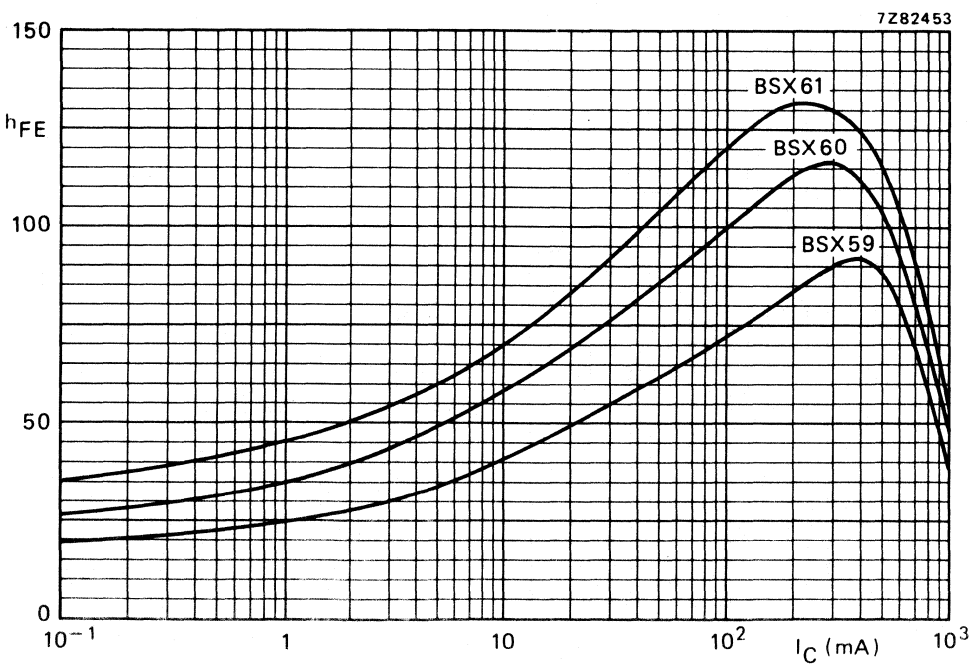


Fig. 18 V_{CE} = 5 V; T_j = 25 °C; typical values.

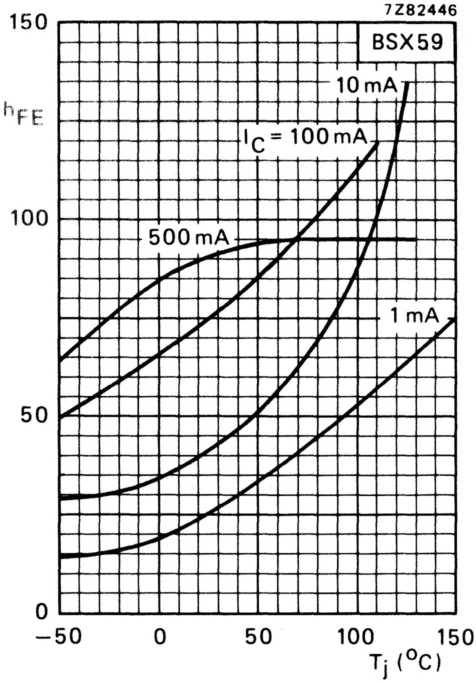


Fig. 19 V_{CE} = 5 V; typical values.

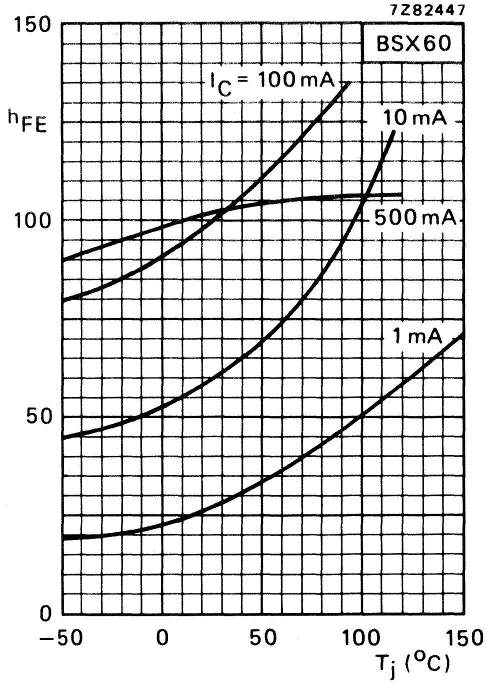


Fig. 20 V_{CE} = 5 V; typical values.

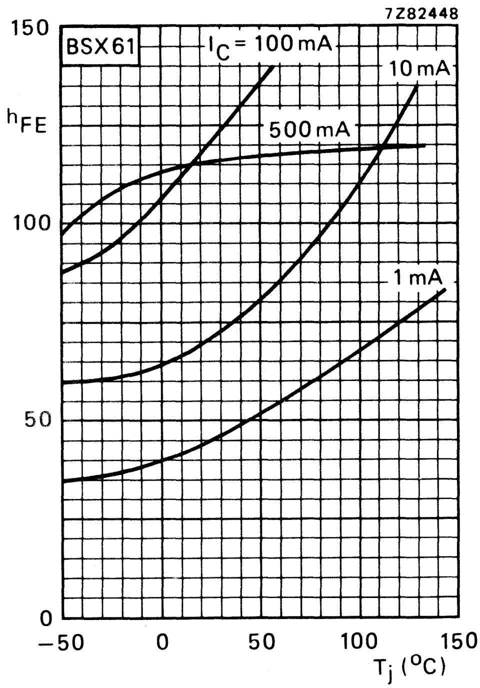


Fig. 21 V_{CE} = 5 V; typical values.

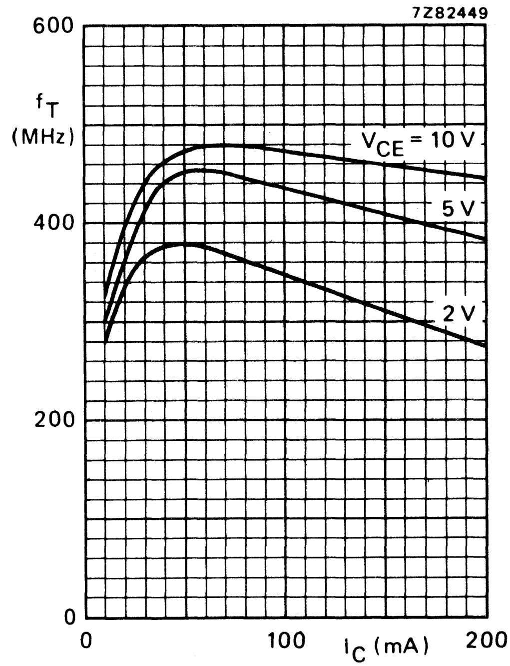


Fig. 22 f = 100 MHz; T_j = 25 °C; typ. values.

AMPLIFIER TRANSISTOR

General purpose n-p-n transistors in TO-92 envelopes. The complementary types are MPS6517 to MPS6519.

QUICK REFERENCE DATA

			MPS6513	6514	6515	
Collector-emitter voltage	V_{CEO}	max.	30	25	25	V
Collector current (d.c.)	I_C	max.	100	100	100	mA
D.C. current gain I_C = 100 mA; V_{CE} = 10 V	h_{FE}	>	60	90	150	
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		625		mW

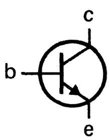
MECHANICAL DATA

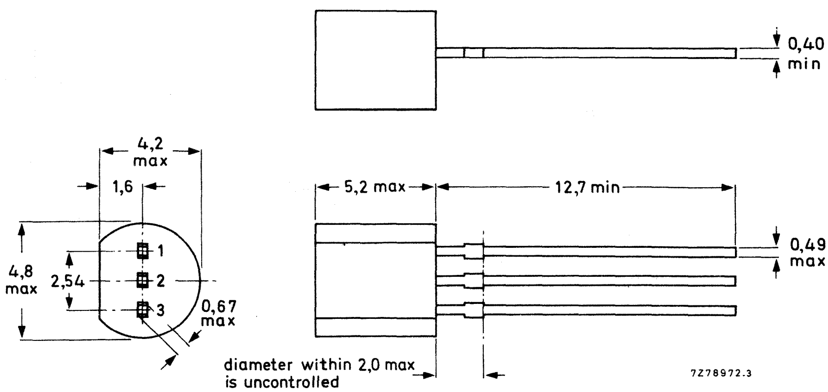
Dimensions in mm

Fig. 1 TO-92.

Pinning;

1 = collector
2 = base
3 = emitter





RATINGS

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

			MPS6513	6514	6515	
Collector-emitter voltage	V_{CEO}	max.	30	25	25	V
Collector-base voltage	V_{CBO}	max.		40		V
Emitter-base voltage	V_{EBO}	max.		4,0		V
Collector current (d.c.)	I_C	max.		100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		625		mW
Storage temperature range	T_{stg}			−55 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPS6513	6514	6515	
Collector-emitter breakdown voltage I_C = 0,5 mA; I_B = 0	$V_{(BR)CEO}$	>	30	25	25	V
Emitter-base breakdown voltage I_E = 10 μA; I_C = 0	$V_{(BR)EBO}$	>	4,0	4,0	4,0	V
Collector cut-off current V_{CB} = 30 V; I_E = 0	I_{CBO}	<	50	50	50	nA
D.C. current gain I_C = 2 mA; V_{CE} = 10 V	h_{FE}	=	90 to 180	150 to 300	250 to 500	
I_C = 100 mA; V_{CE} = 10 V	h_{FE}	>	60	90	150	
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	<		0,5		V
Output capacitance V_{CB} = 10 V; I_E = 0; f = 100 kHz	C_{obo}	<		3,5		pF

AMPLIFIER TRANSISTOR

General purpose p-n-p transistors in TO-92 envelopes. The complementary types are MPS6513 to MPS6515.

QUICK REFERENCE DATA

			MPS6517	6518	6519	
Collector-emitter voltage	$-V_{CEO}$	max.	40	40	25	V
Collector current (d.c.)	$-I_C$	max.	100	100	100	mA
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 10 V	h_{FE}	>	60	90	150	
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		625		mW

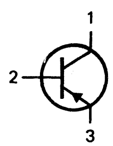
MECHANICAL DATA

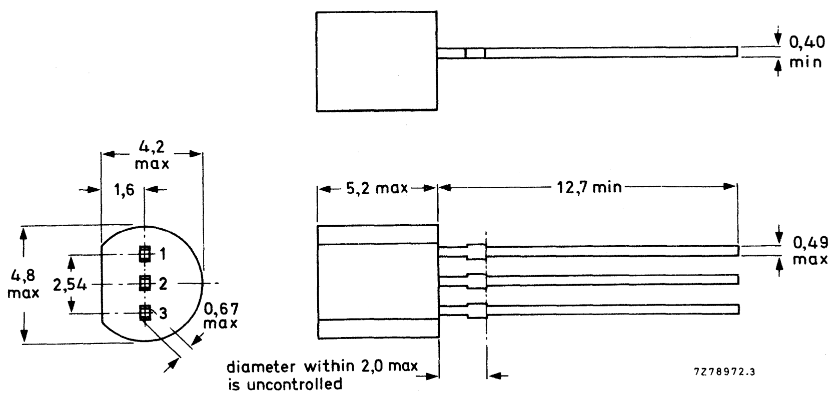
Dimensions in mm

Fig. 1 TO-92.

Pinning;

1 = collector
2 = base
3 = emitter





RATINGS

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

			MPS6517	6518	6519	
Collector-emitter voltage	$-V_{CEO}$	max.	40	40	25	V
Collector-base voltage	$-V_{CBO}$	max.	40	40	25	V
Emitter-base voltage	$-V_{EBO}$	max.		4,0		V
Collector current (d.c.)	$-I_C$	max.		100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		625		mW
Storage temperature range	T_{stg}			−55 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPS6517	6518	6519	
Collector-emitter breakdown voltage $-I_C$ = 0,5 mA; I_B = 0	$-V_{(BR)CEO}$	>	40	40	25	V
Emitter-base breakdown voltage $-I_E$ = 10 µA; I_C = 0	$-V_{(BR)EBO}$	>	4,0	4,0	4,0	V
Collector cut-off current $-V_{CB}$ = 30 V; I_E = 0	$-I_{CBO}$	<	50	50	–	nA
$-V_{CB}$ = 20 V; I_E = 0	$-I_{CBO}$	<	–	–	50	nA
D.C. current gain $-I_C$ = 2 mA; $-V_{CE}$ = 10 V	h_{FE}	=	90 to 180	150 to 300	250 to 500	
$-I_C$ = 100 mA; $-V_{CE}$ = 10 V	h_{FE}	>	60	90	150	
Collector-emitter saturation voltage $-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	<		0,5		V
Output capacitance $-V_{CB}$ = 10 V; I_E = 0; f = 100 kHz	C_{obo}	<		3,5		pF

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N small-signal transistors in plastic TO-92 envelope intended for low-noise applications in audio equipment.

Complementary types are MPS6522 and MPS6523.

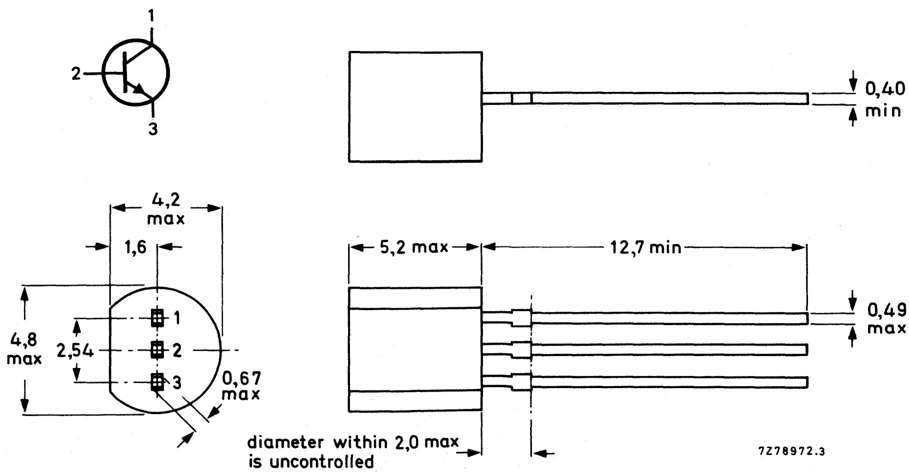
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	V_{CEO}	max.	25		V
Collector-base voltage (open emitter)	V_{CBO}	max.	40		V
Collector current (d.c.)	I_C	max.	100		mA
Total device dissipation up to T_{amb} = 25 ^oC	P_{tot}	max.	625		mW
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,5		V
			MPS6520	MPS6521	
D.C. current gain I_C = 100 μA; V_{CE} = 10 V	h_{FE}	min.	100	150	
I_C = 2 mA; V_{CE} = 10 V	h_{FE}	min.	200	300	
		max.	400	600	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,0	V
Collector current (d.c.)	I_C	max.	100	mA
Total device dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector-emitter breakdown voltage $I_B = 0$; I_C = 0,5 mA	$V_{(BR)CEO}$	min.	25	V
Emitter-base breakdown voltage I_E = 10 μA; $I_C = 0$	$V_{(BR)EBO}$	min.	4,0	V
Collector cut-off current V_{CB} = 30 V; $I_E = 0$	I_{CBO}	max.	50	nA
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,5	V
Output capacitance at f = 100 kHz V_{CB} = 10 V; $I_E = 0$	C_o	max.	3,5	pF
Noise figure at T_{amb} = 25 °C I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ; f = 10 Hz to 10 kHz	F	max.	3,0	dB

			MPS6520	MPS6521
D.C. current gain I_C = 100 μA; V_{CE} = 10 V	h_{FE}	min.	100	150
I_C = 2 mA; V_{CE} = 10 V	h_{FE}	min.	200	300
		max.	400	600

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P small-signal transistors in plastic TO-92 envelope intended for low-noise applications in audio equipment.

Complementary types are MPS6520 and MPS6521.

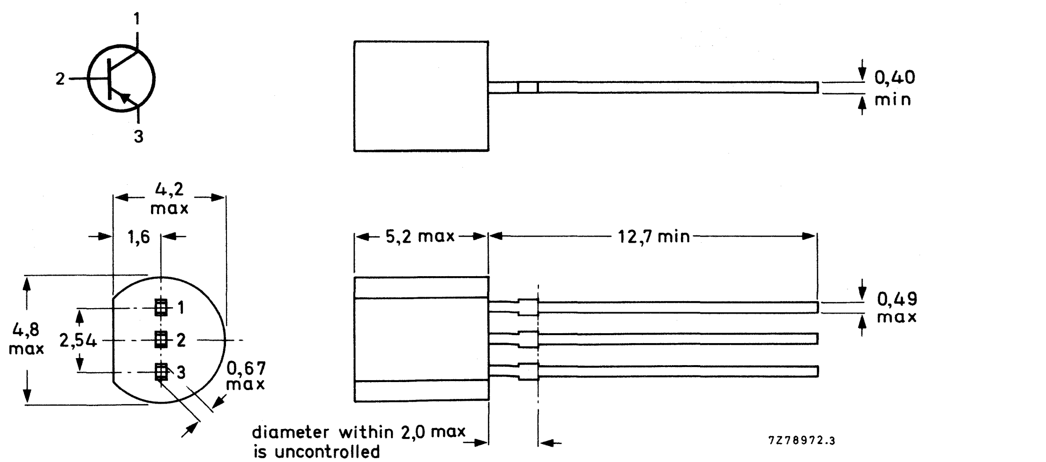
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25		V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25		V
Collector current (d.c.)	$-I_C$	max.	100		mA
Total device dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	max.	0,5		V
			MPS6522	MPS6523	
D.C. current gain $-I_C$ = 100 μA; $-V_{CE}$ = 10 V	h_{FE}	min.	100	150	
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	200	300	
		max.	400	600	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4,0	V
Collector current (d.c.)	$-I_C$	max.	100	mA
Total device dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector-emitter breakdown voltage $I_B = 0$; $-I_C = 0,5$ mA	$-V_{(BR)CEO}$	min.	25	V
Emitter-base breakdown voltage $-I_E = 10\ \mu A$; $I_C = 0$	$-V_{(BR)EBO}$	min.	4,0	V
Collector cut-off current $-V_{CB} = 30$ V; $I_E = 0$	$-I_{CBO}$	max.	50	nA
Collector-emitter saturation voltage $-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	max.	0,5	V
Output capacitance at f = 100 kHz $-V_{CB} = 10$ V; $I_E = 0$	C_o	max.	3,5	pF
Noise figure at T_{amb} = 25 °C $-I_C = 10\ \mu A$; $-V_{CE} = 5$ V; $R_S = 10\ k\Omega$; f = 10 Hz to 10 kHz	F	max.	3,0	dB

			MPS6522	MPS6523
D.C. current gain $-I_C = 100\ \mu A$; $-V_{CE} = 10$ V	h_{FE}	min.	100	150
$-I_C = 2$ mA; $-V_{CE} = 10$ V	h_{FE}	min.	200	300
		max.	400	600

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N silicon planar epitaxial transistors in plastic TO-92 envelope for general purpose applications.

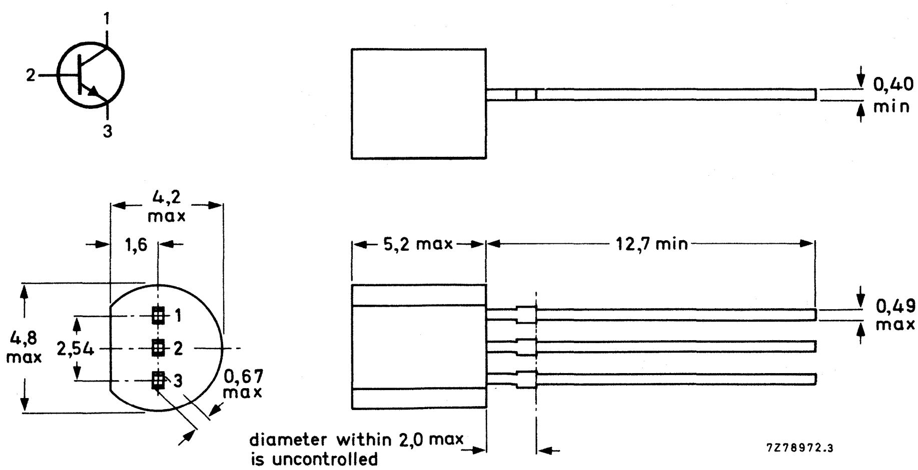
QUICK REFERENCE DATA

			MPSA05	MPSA06	
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	V
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage I_C = 100 mA; I_B = 10 mA	V_{CEsat}	max.	0,25		V
D.C. current gain I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	min.	50		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			MPSA05	MPSA06	
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	V
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	V
Emitter-base voltage (open collector)	V_{EBO}		4,0		V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPSA05	MPSA06	
Collector-emitter breakdown voltage $I_B = 0$; I_C = 1,0 mA	$V_{(BR)CEO}$		60	80	V
Emitter-base breakdown voltage I_E = 100 μA; $I_C = 0$	$V_{(BR)EBO}$		4,0		V
Collector-emitter cut-off current $I_B = 0$; V_{CE} = 60 V	I_{CEO}	max.	0,1		μA
Collector cut-off current $I_E = 0$; V_{CB} = 60 V	I_{CBO}	max.	0,1		μA
$I_E = 0$; V_{CB} = 80 V	I_{CBO}	max.		0,1	μA
D.C. current gain I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	min.	50		
I_C = 100 mA; V_{CE} = 1,0 V	h_{FE}	min.	50		
Saturation voltage I_C = 100 mA; I_B = 10 mA	V_{CEsat}	max.	0,25		V
Base-emitter ON-voltage I_C = 100 mA; V_{CE} = 1,0 V	$V_{BE(on)}$	max.	1,2		V
Transition frequency at f = 100 MHz* I_C = 10 mA; V_{CE} = 2,0 V	f_T	min.	100		MHz

* f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SILICON PLANAR EPITAXIAL DARLINGTON TRANSISTORS

N-P-N silicon planar epitaxial darlington transistors in plastic TO-92 envelope for general purpose applications.

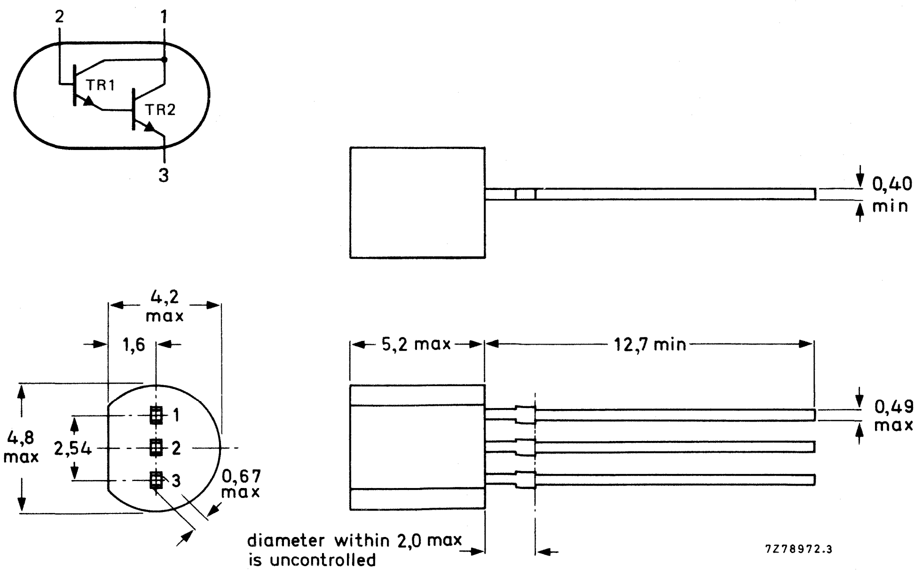
QUICK REFERENCE DATA

			MPSA13	MPSA14	
Collector-emitter voltage $V_{BE} = 0$	V_{CES}	max.	30		V
Collector-base voltage (open emitter)	V_{CBO}	max.	30		V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at $T_{amb} = 25\ ^oC$	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $I_C = 100$ mA; $I_B = 0{,}1$ mA	V_{CEsat}	max.	1,5		V
D.C. current gain $I_C = 10$ mA; $V_{CE} = 5{,}0$ V	h_{FE}	min.	5000	10 000	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			MPSA13	MPSA14	
Collector-emitter voltage $V_{BE} = 0$	V_{CES}	max.	30		V
Collector-base voltage (open emitter)	V_{CBO}	max.	30		V
Emitter-base voltage (open collector)	V_{EBO}	max.	10		V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at $T_{amb} = 25\ ^oC$	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		^oC
Junction temperature	T_j	max.	150		^oC

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			MPSA13	MPSA14	
Collector-emitter breakdown voltage $I_B = 0$; $I_C = 100\ \mu A$	$V_{(BR)CES}$	min.	30		V
Collector cut-off current $I_E = 0$; $V_{CB} = 30\ V$	I_{CBO}	max.	0,1		μA
Emitter cut-off current $I_C = 0$; $V_{BE} = 10\ V$	I_{EBO}	max.	0,1		μA
D.C current gain $I_C = 10\ mA$; $V_{CE} = 5{,}0\ V$	h_{FE}	min.	5000	10 000	
$I_C = 100\ mA$; $V_{CE} = 5{,}0\ V$	h_{FE}	min.	10 000	20 000	
Saturation voltage $I_C = 100\ mA$; $I_B = 0{,}1\ mA$	V_{CEsat}	max.	1,5		V
Base-emitter ON-voltage $I_C = 100\ mA$; $V_{CE} = 5{,}0\ V$	$V_{BE(on)}$	max.	2,0		V
Transition frequency at f = 100 MHz* $I_C = 10\ mA$; $V_{CE} = 5{,}0\ V$; $T_{amb} = 25\ ^oC$	f_T	min.	125		MHz

* f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

HIGH VOLTAGE SILICON PLANAR TRANSISTORS

N-P-N high voltage silicon planar transistors in plastic TO-92 envelope for use in general purpose applications.

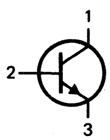
QUICK REFERENCE DATA

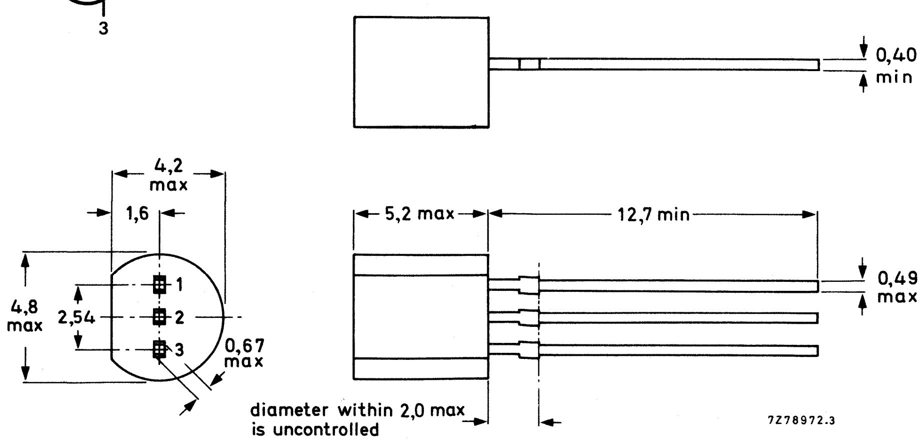
			MPSA42	MPSA43	
Collector-emitter voltage (open base)	V_{CEO}	max.	300	200	V
Collector-base voltage (open emitter)	V_{CBO}	max.	300	200	V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage I_C = 20 mA; I_B = 2,0 mA	V_{CEsat}	max.	0,5		V
D.C. current gain I_C = 30 mA; V_{CE} = 10 V	h_{FE}	min.	40		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.





RATINGS

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

			MPSA42	MPSA43	
Collector-emitter voltage (open base)	V_{CEO}	max.	300	200	V
Collector-base voltage (open emitter)	V_{CBO}	max.	300	200	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6,0		V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPSA42	MPSA43	
Collector-emitter breakdown voltage* $I_B = 0$; I_C = 1,0 mA	$V_{(BR)CES}$		300	200	V
Collector-base breakdown voltage $I_E = 0$; I_C = 100 μA	$V_{(BR)CBO}$		300	200	V
Emitter-base breakdown voltage $I_C = 0$; I_E = 100 μA	$V_{(BR)EBO}$		6,0		V
Collector cut-off current $I_E = 0$; V_{CB} = 200 V	I_{CBO}	max.	0,1		μA
$I_E = 0$; V_{CB} = 160 V	I_{CBO}	max.		0,1	μA
Emitter cut-off current $I_C = 0$; V_{BE} = 6,0 V	I_{EBO}	max.	0,1		μA
$I_C = 0$; V_{BE} = 4,0 V	I_{EBO}	max.		0,1	μA
D.C. current gain* I_C = 1 mA; V_{CE} = 10 V	h_{FE}	min.	25		
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	min.	40		
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	min.	40		
Saturation voltages* I_C = 20 mA; I_B = 2,0 mA	V_{CEsat}	max.	0,5		V
I_C = 20 mA; I_B = 2,0 mA	V_{BEsat}	max.	0,9		V
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	min.	50		MHz
Collector-base capacitance at f = 1 kHz V_{CB} = 20 V; $I_E = 0$	C_{cb}	max.	3,0	4,0	pF

* Pulse test: pulse width ⩽ 300 μs, duty cycle ⩽ 2%.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P silicon planar epitaxial transistors in plastic TO-92 envelope for general purpose applications.

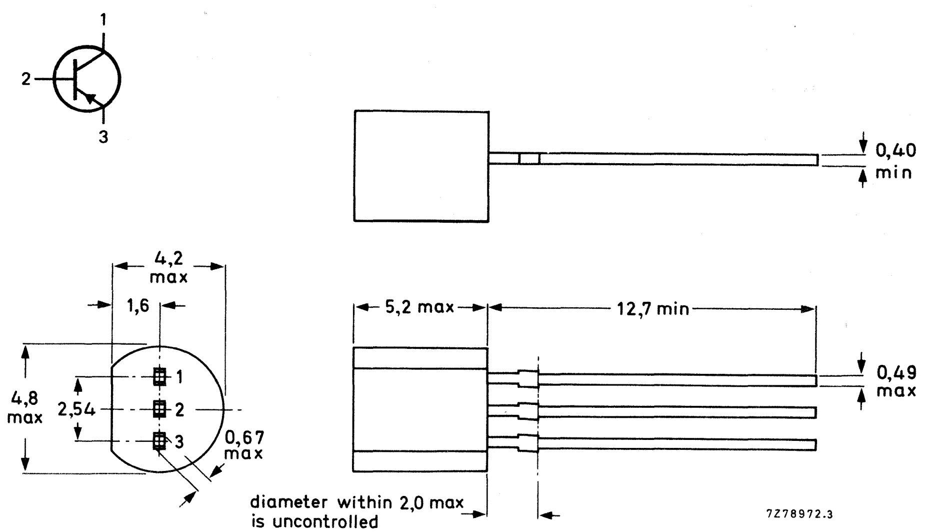
QUICK REFERENCE DATA

			MPSA55	MPSA56	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector current (d.c.)	$-I_C$	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C$ = 100 mA; $-I_B$ = 10 mA	$-V_{CEsat}$	max.	0,25		V
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1,0 V	h_{FE}	min.	50		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			MPSA55	MPSA56	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4,0		V
Collector current (d.c.)	$-I_C$	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPSA55	MPSA56	
Collector-emitter breakdown voltage I_B = 0; I_C = 1,0 mA	$-V_{(BR)CEO}$	min.	60	80	V
Emitter-base breakdown voltage $-I_E$ = 100 μA; $-I_C$ = 0	$-V_{(BR)EBO}$	min.	4,0		V
Collector cut-off current I_E = 0; $-V_{CB}$ = 60 V	$-I_{CBO}$	max.	0,1		μA
I_E = 0; $-V_{CB}$ = 80 V	$-I_{CBO}$	max.		0,1	μA
Collector-emitter cut-off current I_B = 0; $-V_{CE}$ = 60 V	$-I_{CEO}$	max.	0,1	0,1	μA
D.C. current gain $-I_C$ = 10 mA, $-V_{CE}$ = 1,0 V	h_{FE}	min.	50		
$-I_C$ = 100 mA; $-V_{CE}$ = 1,0 V	h_{FE}	min.	50		
Saturation voltage $-I_C$ = 100 mA; $-I_B$ = 10 mA	$-V_{CEsat}$	max.	0,25		V
Base-emitter ON-voltage $-I_C$ = 100 mA; $-V_{CE}$ = 1,0 V	$-V_{BE(on)}$	max.	1,2		V
Transition frequency at f = 100 MHz* $-I_C$ = 100 mA; $-V_{CE}$ = 1,0 V	f_T	min.	50		MHz

* f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

P-N-P DARLINGTON TRANSISTORS

P-N-P darlington transistors in a plastic TO-92 envelope for general purpose applications.

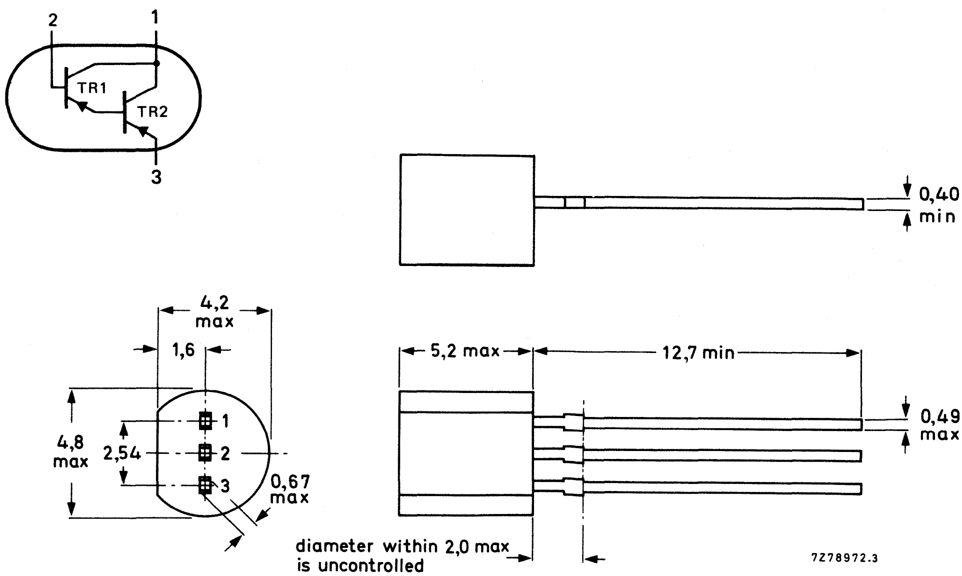
QUICK REFERENCE DATA

			MPSA63	MPSA64	
Collector-emitter voltage $V_{BE} = 0$	$-V_{CES}$	max.	30		V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30		V
Collector current (d.c.)	$-I_C$	max.	500		mA
Total device dissipation at $T_{amb} = 25\ ^oC$	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C = 100$ mA; $-I_B = 0{,}1$ mA	$-V_{CEsat}$	max.	1,5		V
D.C. current gain $-I_C = 10$ mA; $-V_{CE} = 5{,}0$ V	h_{FE}	min.	5000	10 000	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			MPSA63	MPSA64	
Collector-emitter voltage $V_{BE} = 0$	$-V_{CES}$	max.	30		V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30		V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10		V
Collector current (d.c.)	$-I_C$	max.	500		mA
Total device dissipation at $T_{amb} = 25\ ^oC$	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		^oC
Junction temperature	T_j	max.	150		^oC

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			MPSA63	MPSA64	
Collector-emitter breakdown voltage $-I_C = 100\ \mu A$; $-V_{BE} = 0$	$-V_{(BR)CES}$	min.	30		V
Collector cut-off current $I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	max.	100		nA
Emitter cut-off current $I_C = 0$; $-V_{BE} = 10$ V	$-I_{EBO}$	max.	100		nA
D.C. current gain $-I_C = 10$ mA; $-V_{CE} = 5{,}0$ V	h_{FE}	min.	5000	10 000	
$-I_C = 100$ mA; $-V_{CE} = 5{,}0$ V	h_{FE}	min.	10 000	20 000	
Saturation voltage $-I_C = 100$ mA; $-I_B = 0{,}1$ mA	$-V_{CEsat}$	max.	1,5		V
Base-emitter ON-voltage* $-I_C = 100$ mA; $-V_{CE} = 5{,}0$ V	$-V_{BE(on)}$		2,0		V
Transition frequency at f = 100 MHz* $-I_C = 100$ mA; $-V_{CE} = 5{,}0$ V	f_T	min.	125		MHz

* f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

HIGH VOLTAGE SILICON PLANAR TRANSISTORS

P-N-P high voltage silicon planar transistors in plastic TO-92 envelope for general purpose applications.

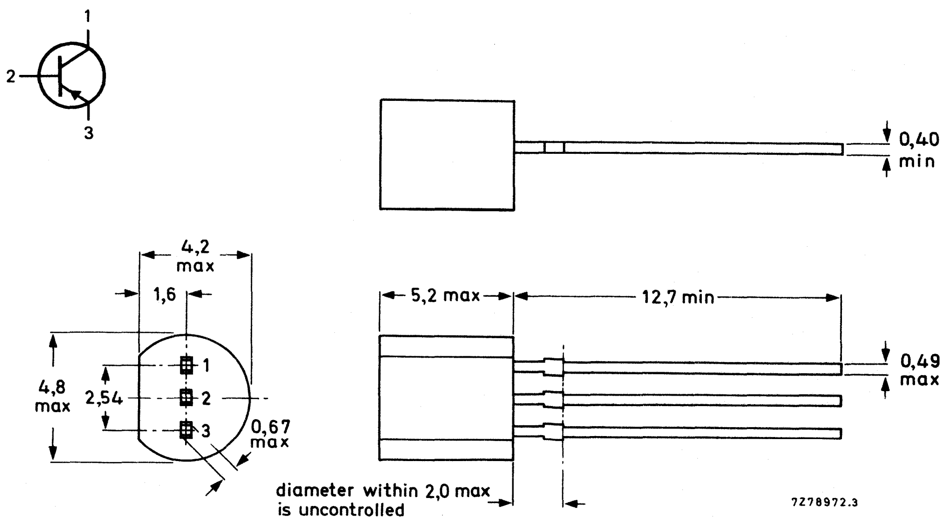
QUICK REFERENCE DATA

			MPSA92	MPSA93	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	200	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	200	V
Collector current (d.c.)	$-I_C$	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C$ = 20 mA; $-I_B$ = 2,0 mA	$-V_{CEsat}$	max.	0,5		V
D.C. current gain $-I_C$ = 30 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	25		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			MPSA92	MPSA93	
Collector-emitter voltage (open base)	V_{CEO}	max.	300	200	V
Collector-base voltage (open emitter)	V_{CBO}	max.	300	200	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5,0		V
Collector current (d.c.)	I_C	max.	500		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			MPSA92	MPSA93	
Collector-emitter breakdown voltage $I_B = 0$; $-I_C$ = 1,0 mA	$-V_{(BR)CEO}$	min.	300	200	V
Collector-base breakdown voltage $I_E = 0$; $-I_C$ = 100 μA	$-V_{(BR)CBO}$	min.	300	200	V
Emitter-base breakdown voltage $I_C = 0$; $-I_E$ = 100 μA	$-V_{(BR)EBO}$	min.	5,0		V
Collector cut-off current $I_E = 0$; $-V_{CB}$ = 200 V	$-I_{CBO}$	max.	0,25		μA
$I_E = 0$; $-V_{CB}$ = 160 V	$-I_{CBO}$	max.		0,25	μA
Emitter cut-off current $I_C = 0$; $-V_{BE}$ = 3,0 V	$-I_{EBO}$	max.	0,1		μA
D.C. current gain* $-I_C$ = 1,0 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	25		
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	40		
$-I_C$ = 30 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	25		
Saturation voltages* $-I_C$ = 20 mA; $-I_B$ = 2,0 mA	$-V_{CEsat}$	max.	0,5		V
$-I_C$ = 20 mA; $-I_B$ = 2,0 mA	$-V_{BEsat}$	max.	0,9		V
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	min.	50		MHz
Collector-base capacitance at f = 1 MHz $-V_{CB}$ = 20 V; $I_E = 0$	C_{cb}	max.	6,0	8,0	pF

* Pulse test: pulse width ⩽ 300 μs, duty cycle ⩽ 2%.

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelopes, primarily intended for switching and linear applications.

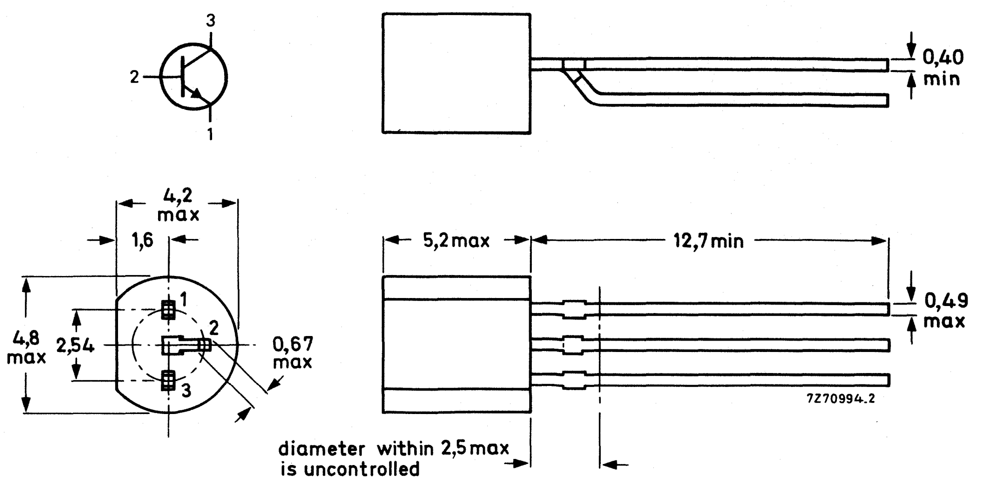
QUICK REFERENCE DATA

			PH2222	PH2222A	
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.	625	625	mW
Junction temperature	T_j	max.	150	150	°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_{Con} = 150 mA; I_{Bon} = $-I_{Boff}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA of **PH2222** and **PH2222A**

Dimensions in mm

Fig. 1 TO-92 variant.



RATINGS

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

			PH2222	PH2222A	
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.	625		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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PH2222	PH2222A	
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
Breakdown voltages					
I_E = 0; I_C = 10 μA	$V_{(BR)CBO}$	>	60	75	V
I_B = 0; I_C = 10 mA	$V_{(BR)CEO}$	>	30	40	V
I_C = 0; I_E = 10 μA	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages *					
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

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 0,02$.

			PH2222	PH2222A	
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*	h_{FE}	>	50	50	
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	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	$r_{bb'} C_{b'c}$	<	–	150	ps
h-parameters (common emitter)					
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz					
Input impedance	h_{ie}	>	–	2	kΩ
		<	–	8	kΩ
Reverse voltage transfer ratio	h_{re}	<	–	8	10^{-4}
Small-signal current gain	h_{fe}	>	–	50	
		<	–	300	
Output admittance	h_{oe}	>	–	5	µS
		<	–	35	µS
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz					
Input impedance	h_{ie}	>	–	0,25	kΩ
		<	–	1,25	kΩ
Reverse voltage transfer ratio	h_{re}	<	–	4	10^{-4}
Small-signal current gain	h_{fe}	>	–	75	
		<	–	375	
Output admittance	h_{oe}	>	–	25	µS
		<	–	200	µS
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

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 0{,}02$.

→ **Switching times** (between 10% and 90% levels) for **PH2222A**

Turn-on time when switched to I_{Con} = 150 mA (see Fig. 2)

delay time	t_d	<	10 ns
rise time	t_r	<	25 ns

Turn-off time when switched from I_{Con} = 150 mA (see Fig. 3)

storage time	t_s	<	225 ns
fall time	t_f	<	60 ns

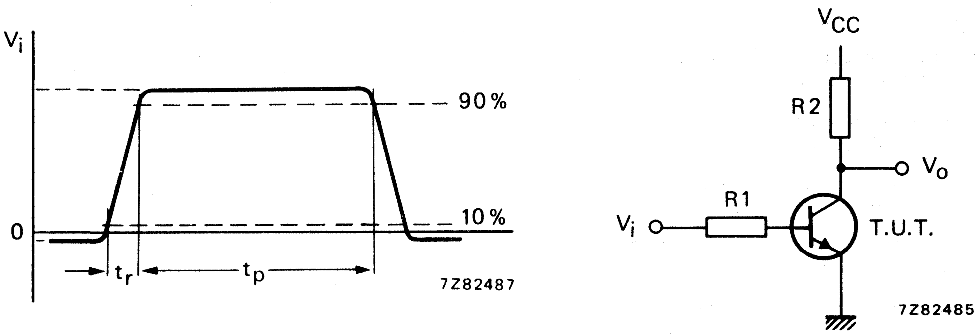


Fig. 2 Input waveform and test circuit for determining delay time and rise time.

V_i = –0,5 V to + 9,9 V; V_{CC} = + 30 V; R1 = 619 Ω; R2 = 200 Ω.

Pulse generator:				Oscilloscope:			
pulse duration	t_p	⩽	200 ns	input impedance	Z_i	>	100 kΩ
rise time	t_r	⩽	2 ns	input capacitance	C_i	<	12 pF
duty factor	δ	=	0,02	rise time	t_r	<	5 ns

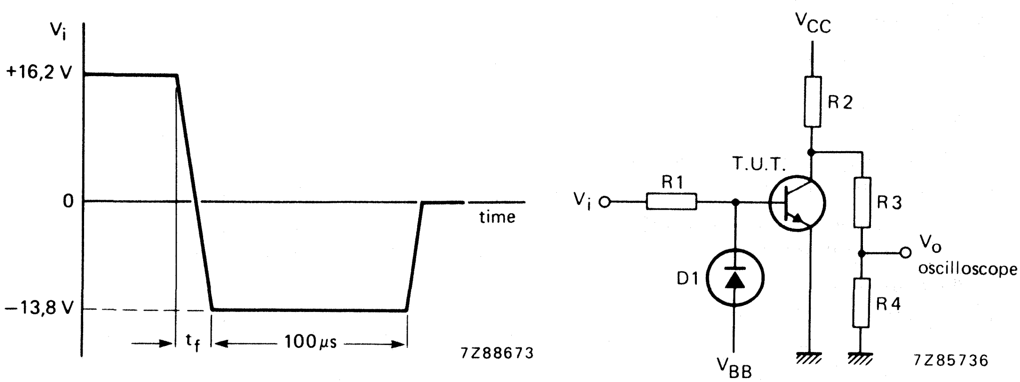


Fig. 3 Input waveform and test circuit for determining storage time and fall time.

V_{CC} = + 30 V; V_{BB} = –3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

Pulse generator:				Oscilloscope:			
fall time	t_f	<	5 ns	input impedance	Z_i	>	100 kΩ
				input capacitance	C_i	<	12 pF
				rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL SWITCHING TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope intended for high-speed switching applications.

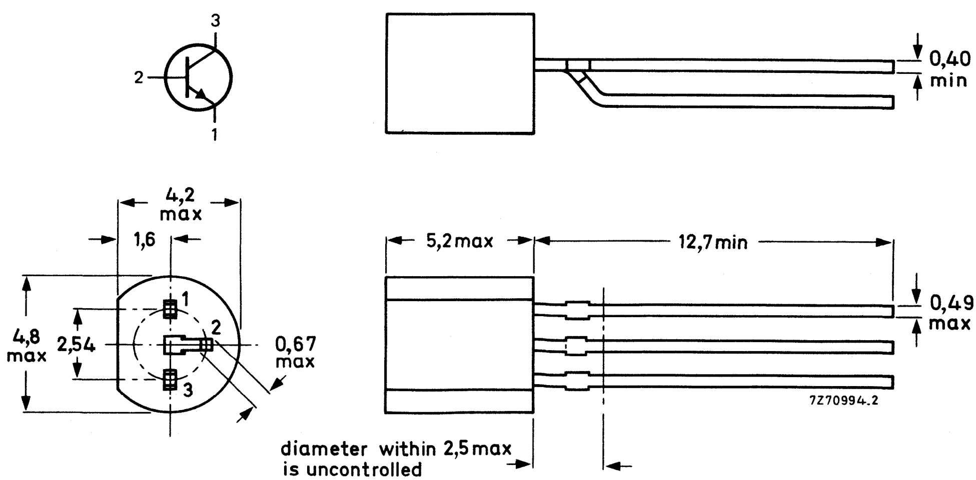
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{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 °C	P_{tot}	max.	500	mW
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
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}	−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 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

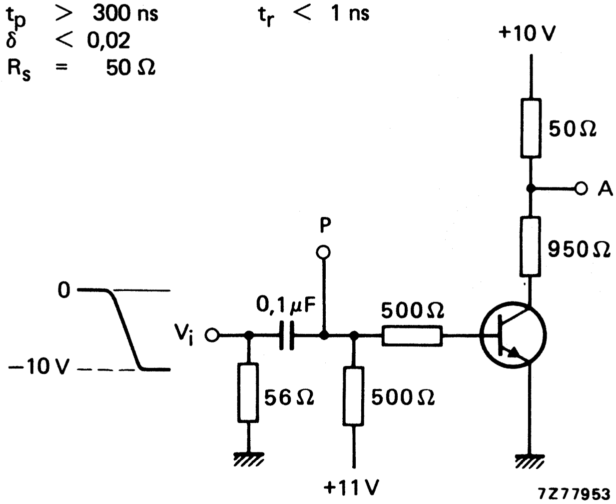
Storage time (see Fig. 2)				
$I_{Con} = I_{Bon} = -I_{Boff}$ = 10 mA	t_s	typ.	6	ns
		<	13	ns

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



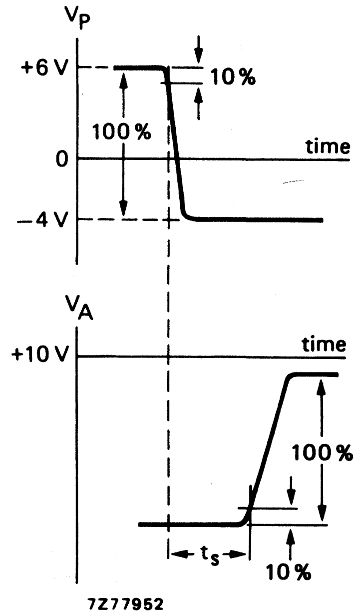


Fig. 2 Test circuit and waveforms.

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)

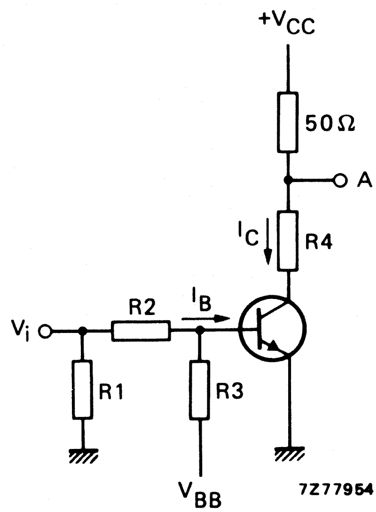
I_{Con} = 10 mA; I_{Bon} = 3 mA; $-I_{Boff}$ = 1,5 mA	t_{off}	<	18	ns
I_{Con} = 100 mA; I_{Bon} = 40 mA; $-I_{Boff}$ = 20 mA	t_{off}	<	21	ns

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



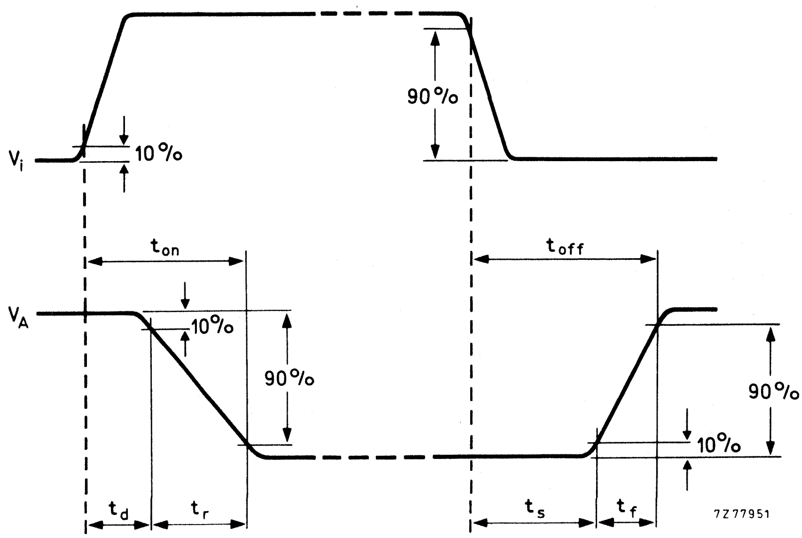


Fig. 3 Test circuit and waveforms.

							turn-on time			turn-off time	
I_{Con} mA	I_{Bon} mA	I_{Boff} mA	V_{CC} V	R1 Ω	R2; R3 kΩ	R4 Ω	V_{BB} V	V_{BE} V	V_i V	V_{BB} V	V_i V
10	3	−1,5	3	50	3,30	220	−3,0	−1,50	15	12,0	−15
100	40	−20	6	56	0,33	0	−4,5	−2,25	20	15,3	−20

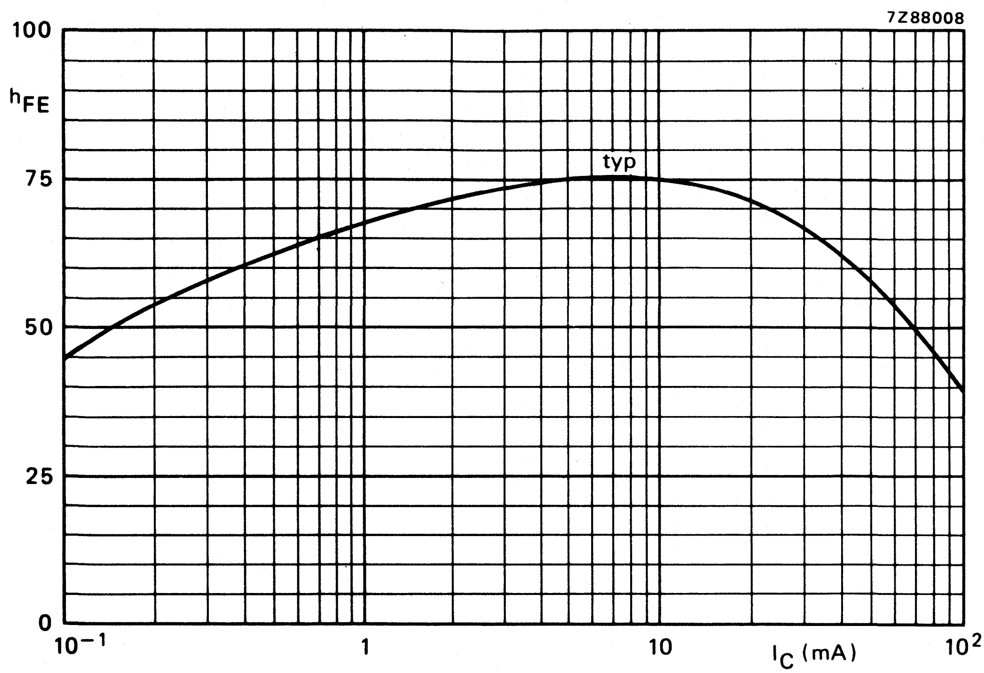


Fig. 4 V_{CE} = 1 V; T_j = 25 °C.

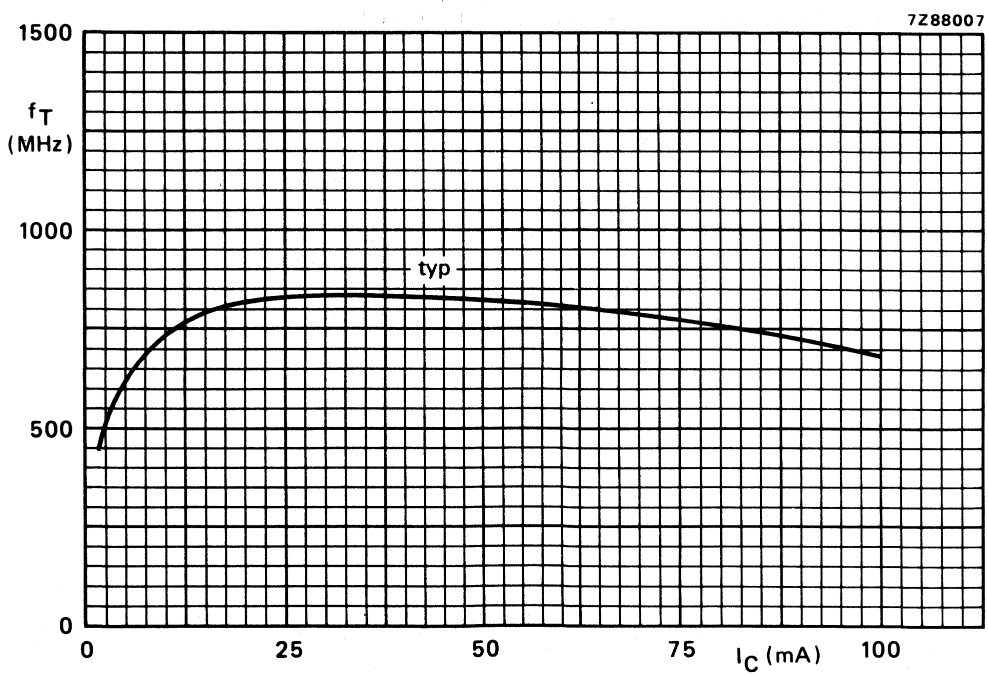


Fig. 5 V_{CE} = 10 V; T_j = 25 °C.

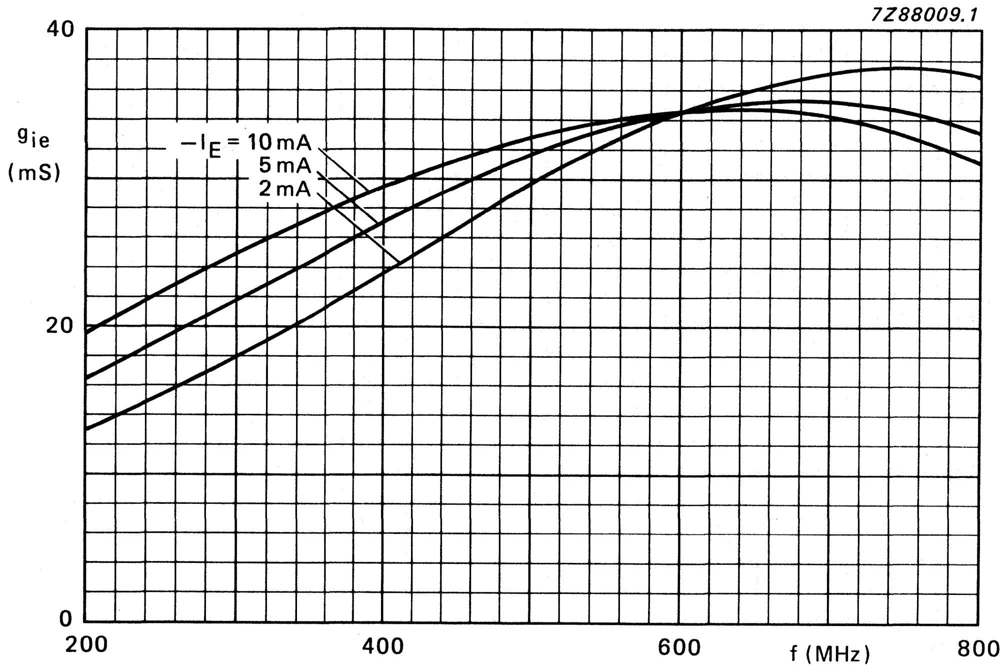


Fig. 6 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

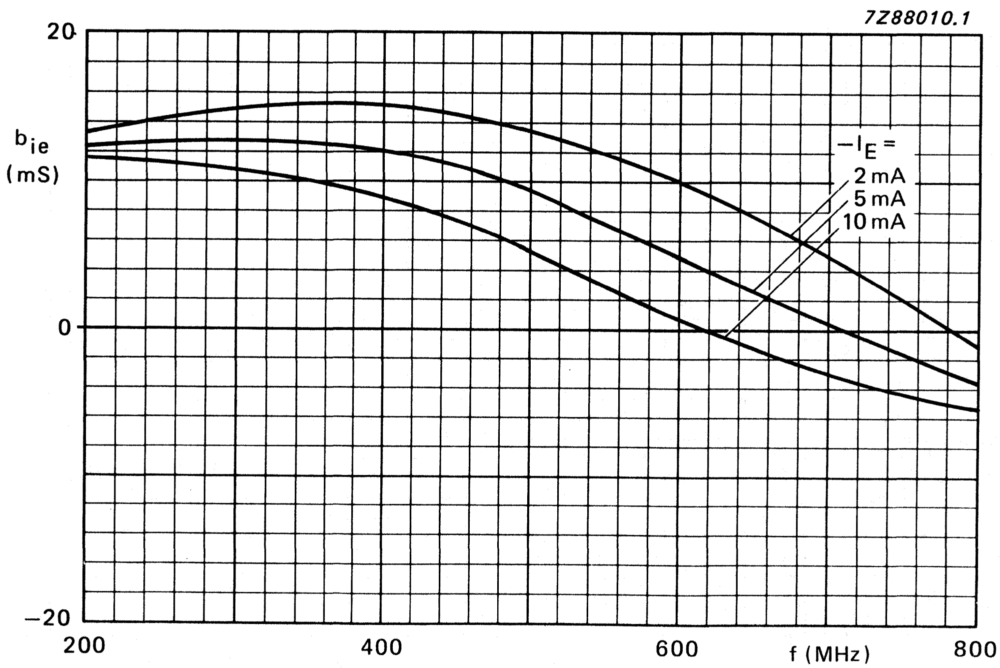


Fig. 7 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

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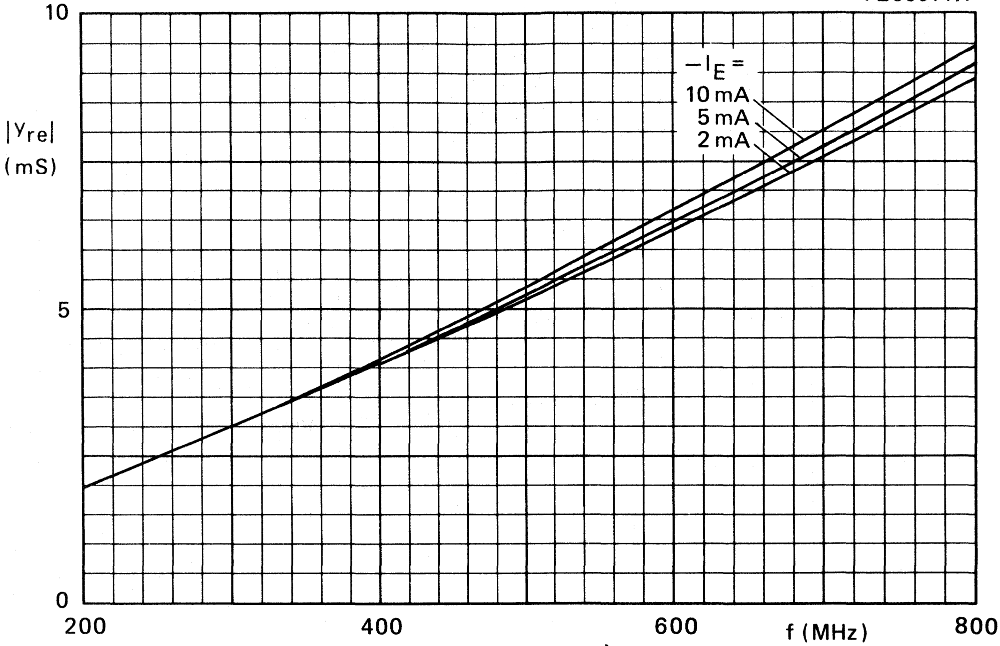


Fig. 8 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

7Z88012

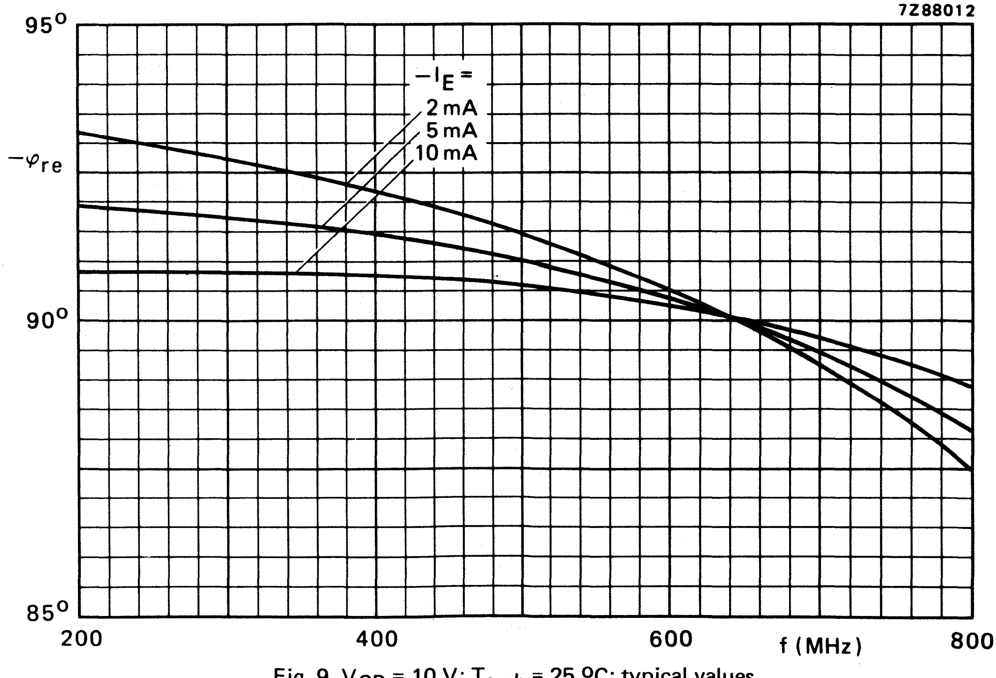


Fig. 9 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

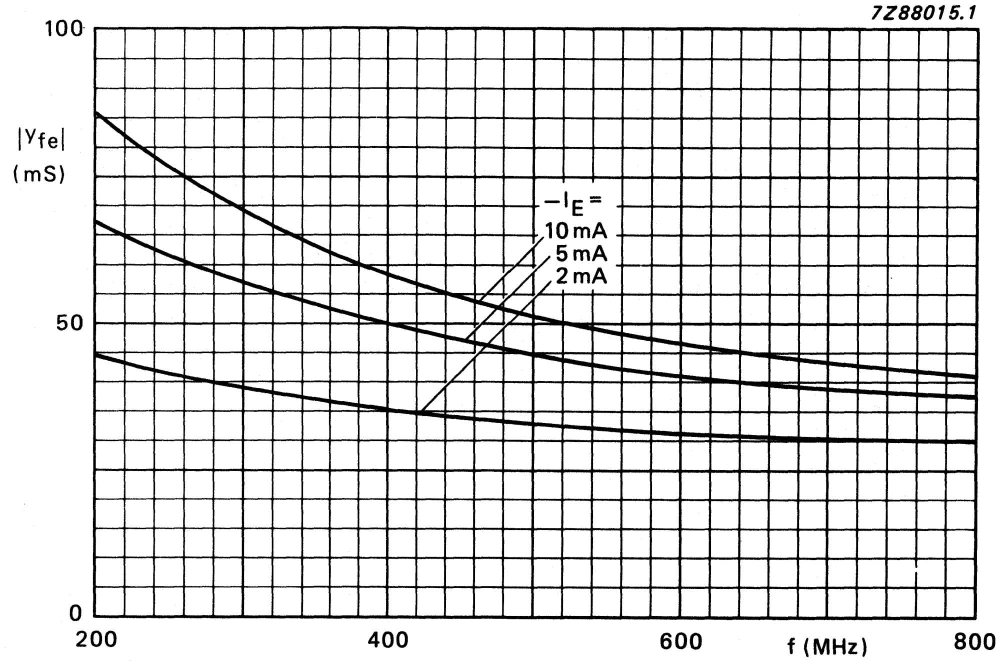


Fig. 10 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

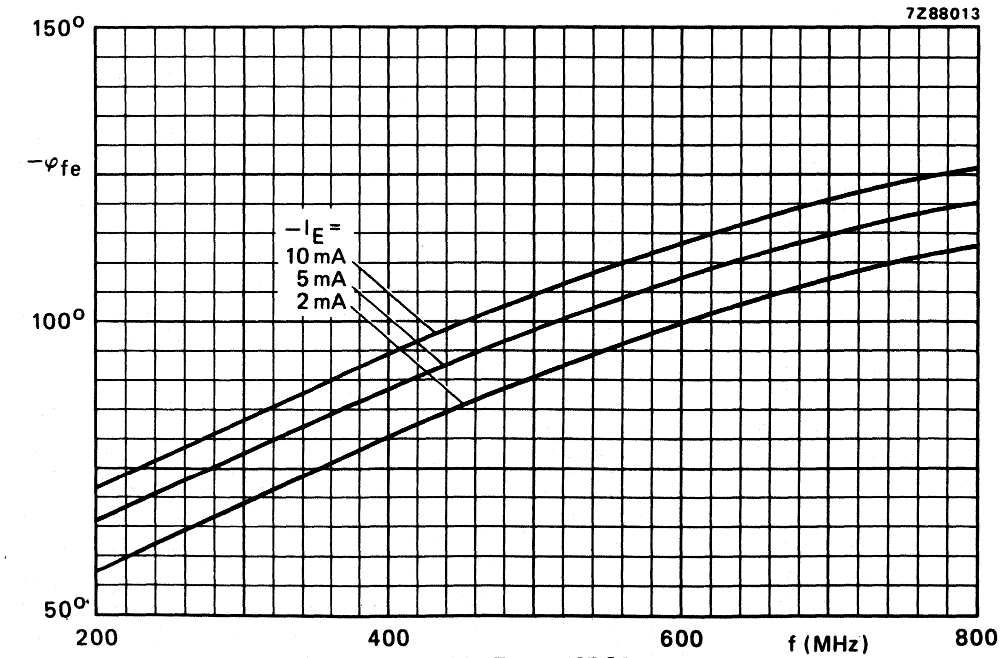


Fig. 11 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

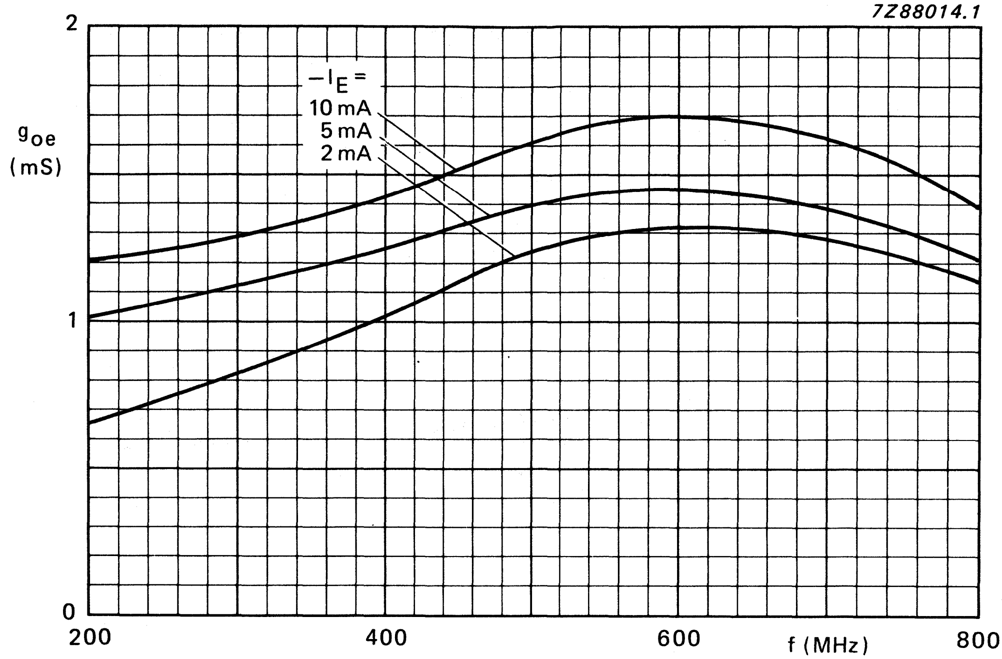


Fig. 12 V_{CB} = 10 V; T_{amb} = 25 °C; typical values.

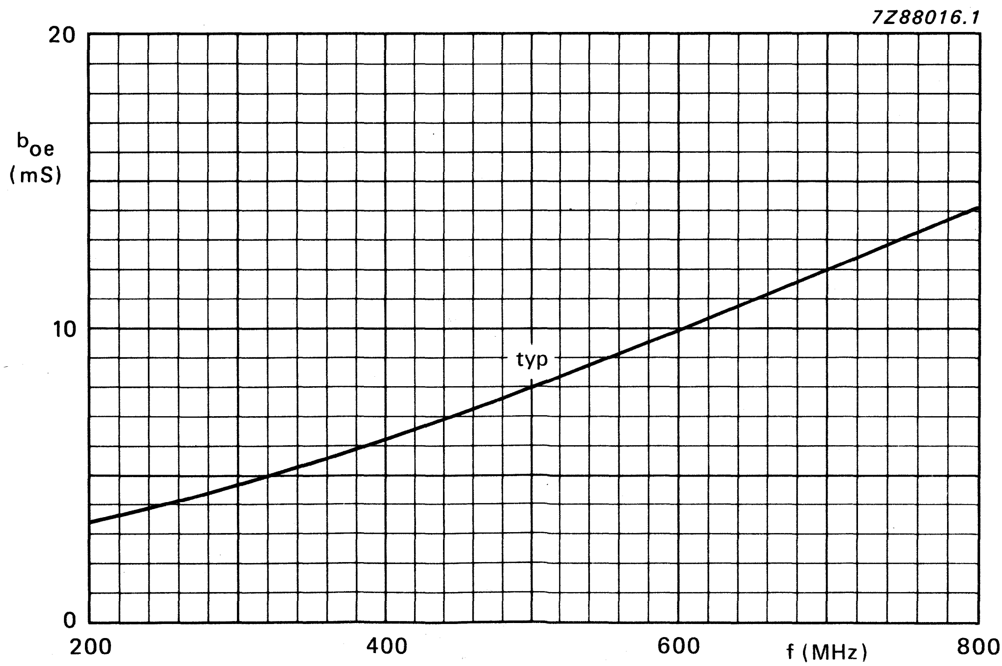


Fig. 13 V_{CB} = 10 V; $-I_E$ = 2 to 10 mA; T_{amb} = 25 °C.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P medium power transistors in plastic TO-92 variant envelopes, primarily designed for high-speed switching and driver applications for industrial service.

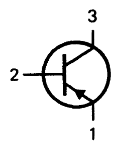
QUICK REFERENCE DATA

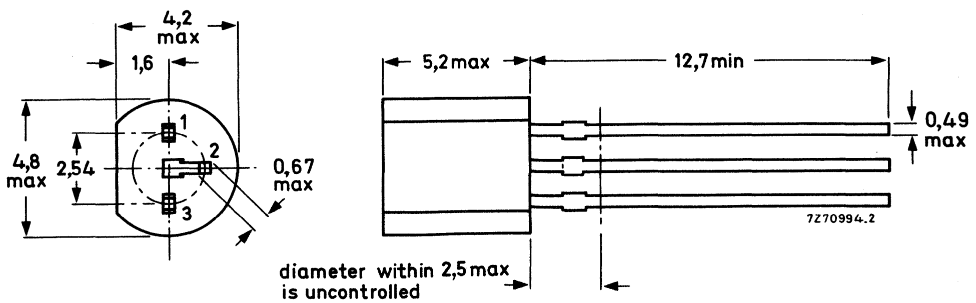
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	PH2907	$-V_{CEO}$	max.	40	V
	PH2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	625	mW
Junction temperature		T_j	max.	150	°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 of **PH2907** and **PH2907A**

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.	60	V
→ Collector-emitter voltage (open base)	**PH2907**	$-V_{CEO}$	max.	40	V
	PH2907A	$-V_{CEO}$	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.	625	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

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

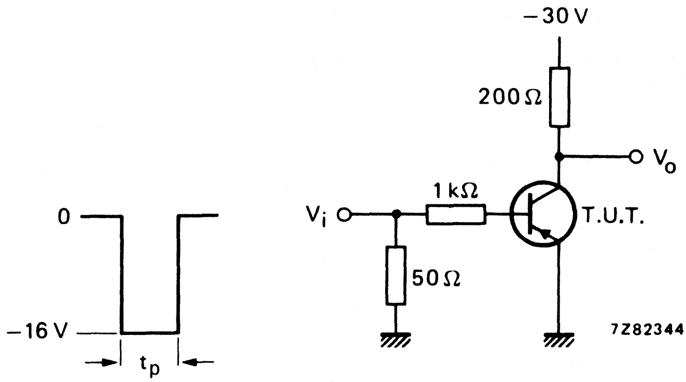


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

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

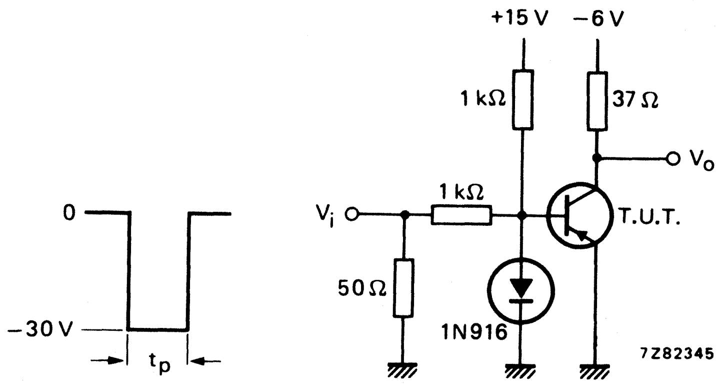


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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 P-N-P HIGH-VOLTAGE TRANSISTORS

P-N-P high-voltage small-signal transistors, primarily intended for use in telephony applications and encapsulated in a TO-92 variant envelope.

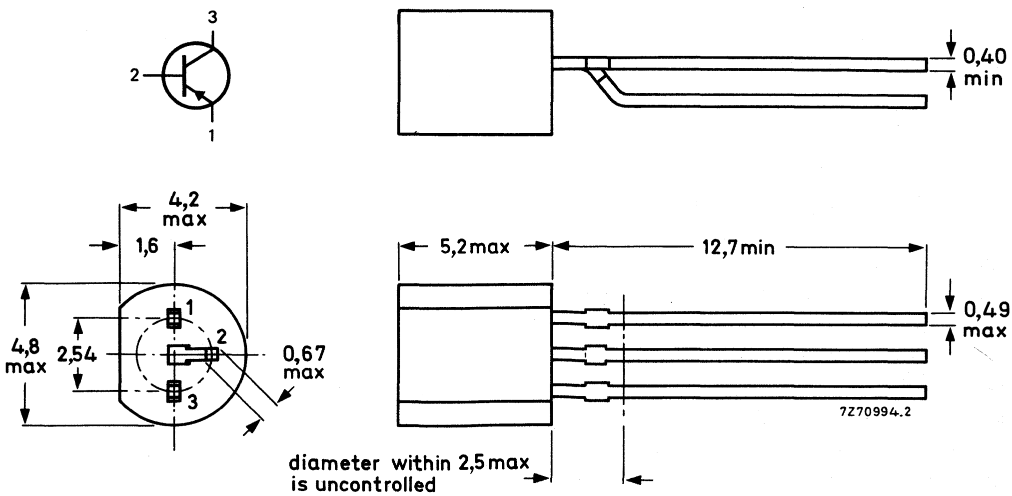
QUICK REFERENCE DATA

			PH5415	PH5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current	$-I_C$	max.	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage $-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	<	0,8	0,8	V
D.C. current gain $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	30	
		<	150	120	

MECHANICAL DATA

Dimension in mm

Fig. 1 TO-92 variant.



RATINGS

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

			PH5415	PH5416	
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.	4,0	6,0	V
Collector current (d.c.)	$-I_C$	max.	1,0		A
Base current	$-I_B$	max.	0,5		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−65 to 150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PH5415	PH5416	
Collector cut-off currents					
$I_E = 0$; $-V_{CB} = 175$ V	$-I_{CBO}$	<	0,1		μA
$I_E = 0$; $-V_{CB} = 280$ V	$-I_{CBO}$	<		0,1	μA
$I_B = 0$; $-V_{CE} = 150$ V	$-I_{CEO}$	<	1,0		μA
$I_B = 0$; $-V_{CE} = 250$ V	$-I_{CEO}$	<		1,0	μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	1,0		μA
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<		1,0	μA
Collector-emitter sustaining voltage $I_B = 0$; $-I_C = 50$ mA	$-V_{CEOsust}$	>	200	300	V
Saturation voltages $-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	0,8	0,8	V
	$-V_{BEsat}$	<	1,0	1,0	V
D.C. current gain $-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	30	
	h_{FE}	<	150	120	
Transition frequency at f = 5 MHz $-I_C = 10$ mA; $-V_{CE} = 10$ V; $T_{amb} = 25$ °C	f_T	>	15		MHz
Small-signal current gain at f = 5 MHz $-I_C = 10$ mA; $-V_{CE} = 10$ V; $T_{amb} = 25$ °C	h_{fe}	>	25		
Real part (Re) of input impedance (h_{ie}) $-V_{CE} = 10$ V; $-I_C = 5$ mA; f = 1 MHz; $T_{amb} = 25$ °C	$Re(h_{ie})$	<	300		Ω
Input capacitance at f = 1 MHz $I_C = 0$; $-V_{EB} = 5$ V; $T_{amb} = 25$ °C	C_e	<	75		pF
Output capacitance at f = 1 MHz $I_E = 0$; $-V_{CB} = 10$ V; $T_{amb} = 25$ °C	C_c	<	15		pF

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N silicon planar epitaxial transistors in a plastic TO-92 envelope primarily intended for linear and switching applications.

P-N-P complement is PN2907/2907A.

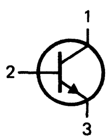
QUICK REFERENCE DATA

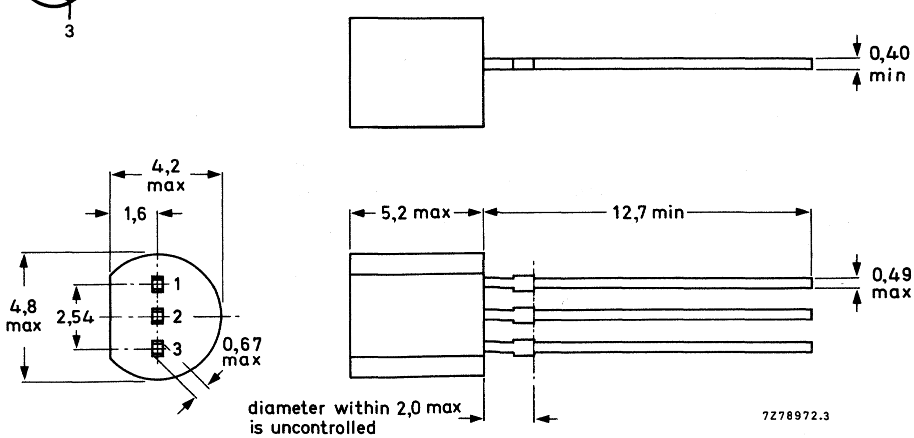
			PN2222	PN2222A	
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector current (d.c.)	I_C	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage I_C = 150 mA; I_B = 15 mA	V_{CEsat}	max.	0,4	0,3	V
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	min.	100		
		max.	300		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.





RATINGS

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

			PN2222	PN2222A	
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5,0	6,0	V
Collector current (d.c.)	I_C	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PN2222	PN2222A	
Collector-emitter breakdown voltage $I_B = 0$; I_C = 10 mA	$V_{(BR)CEO}$	min.	30	40	V
Collector-base breakdown voltage $I_E = 0$; I_C = 10 μA	$V_{(BR)CBO}$	min.	60	75	V
Emitter-base breakdown voltage I_E = 10 μA; $I_C = 0$	$V_{(BR)EBO}$	min.	5,0	6,0	V
Base cut-off current V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{BEX}	max.	–	20	nA
Collector cut-off current V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	max.	–	10	nA
Emitter cut-off current $I_C = 0$; V_{EB} = 3 V	I_{EBO}	max.	–	10	nA
Collector cut-off current $I_E = 0$; V_{CB} = 50 V	I_{CBO}	max.	10	–	nA
$I_E = 0$; V_{CB} = 60 V	I_{CBO}	max.	–	10	nA
$I_E = 0$; V_{CB} = 50 V; T_{amb} = 125 °C	I_{CBO}	max.	10	–	μA
$I_E = 0$; V_{CB} = 60 V; T_{amb} = 125 °C	I_{CBO}	max.	–	10	μA

DEVELOPMENT DATA

			PN2222	PN2222 / PN2222A	PN2222A	
D.C. current gain						
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	min.		35		
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	min.		50		
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	min.		75		
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = −55 °C	h_{FE}	min.	−		35	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	min.		100		
		max.		300		
I_C = 150 mA; V_{CE} = 1 V	h_{FE}	min.	30	50	−	
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	min.	30		40	
Saturation voltages						
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	max.	0,4		0,3	V
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	min.	1,6		1,0	V
I_C = 150 mA; I_B = 15 mA	V_{BEsat}	max.	1,3		−	V
I_C = 150 mA; I_B = 15 mA	V_{BEsat}	min.			0,6	V
		max.			1,2	V
I_C = 500 mA; I_B = 50 mA	V_{BEsat}	max.	2,6		2,0	V
Transition frequency at f = 100 MHz						
I_C = 20 mA; V_{CE} = 20 V ; T_{amb} = 25 °C	f_T	min.	250		300	MHz
Output capacitance at f = 1 MHz						
I_E = 0; V_{CB} = 10 V	C_c	max.		8,0		pF
Input capacitance at f = 1 MHz						
I_C = 0; V_{EB} = 0,5 V	C_e	max.	30		25	pF
Input impedance at f = 1 kHz						
I_C = 1 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{ie}	min.	−		2,0	kΩ
		max.	−		8,0	kΩ
I_C = 10 mA; V_{CE} = 10 V ; T_{amb} = 25 °C	h_{ie}	min.	−		0,25	kΩ
		max.	−		1,25	kΩ
Voltage feedback ratio at f = 1 kHz						
I_C = 1 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{re}	max.	−		$8{,}0 \times 10^{-4}$	
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{re}	max.	−		$4{,}0 \times 10^{-4}$	
Small-signal current gain at f = 1 kHz						
I_C = 1 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{fe}	min.	−		50	
		max.	−		300	
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{fe}	min.	−		75	
		max.	−		375	
Output admittance at f = 1 kHz						
I_C = 1 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{oe}	min.	−		5,0	μS
		max.	−		35	μS
I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{oe}	min.	−		25	μS
		max.	−		200	μS
Collector-base time constant						
I_E = 20 mA; V_{CB} = 20 V; f = 31,8 MHz; T_{amb} = 25 °C	$r_{b'}C_c$	max.	−		150	ps

			PN2222	PN2222A
Noise figure at $R_S = 1\ k\Omega$				
$I_C = 100\ \mu A$; $V_{CE} = 10\ V$;				
$f = 1\ kHz$; $T_{amb} = 25\ ^oC$	F	max.	–	4,0 dB
Switching times at $T_{amb} = 25\ ^oC$				
Turn-on time (see Fig. 2)				
$I_C = 150\ mA$; $I_{Bon} = 15\ mA$				
$V_{CC} = 30\ V$; $V_{EB(off)} = 0,5\ V$				
delay time	t_d	max.	–	10 ns
rise time	t_r	max.	–	25 ns
Turn-off time (see Fig. 3)				
$I_C = 150\ mA$; $I_{Bon} = I_{Boff} = 15\ mA$				
$V_{CC} = 30\ V$				
storage time	t_s	max.	–	225 ns
fall time	t_f	max.	–	60 ns

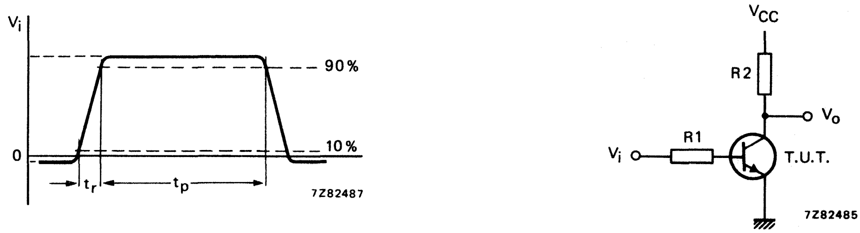


Fig. 2 Input waveform and test circuit for determining delay time and rise time.

$V_i = -0,5\ V$ to $+\ 9,9\ V$; $V_{CC} = +\ 30\ V$; $R1 = 619\ \Omega$; $R2 = 200\ \Omega$.

Pulse generator:				Oscilloscope:			
pulse duration	t_p	$\leqslant$	200 ns	input impedance	Z_i	>	100 kΩ
rise time	t_r	$\leqslant$	2 ns	input capacitance	C_i	<	12 pF
duty factor	δ	=	0,02	rise time	t_r	<	5 ns

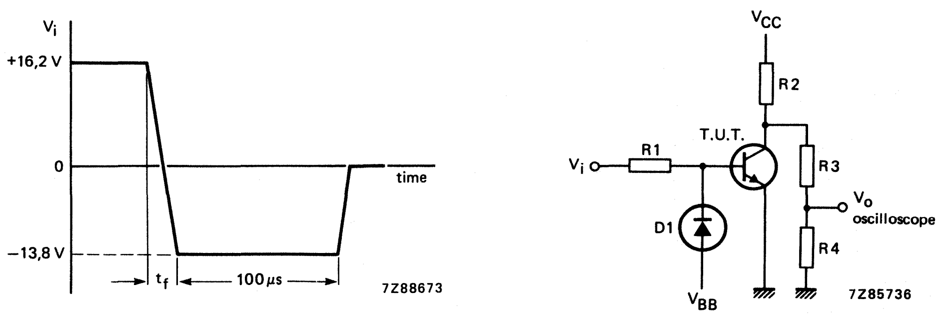


Fig. 3 Input waveform and test circuit for determining storage time and fall time.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N silicon planar epitaxial transistor in plastic TO-92 envelope intended for switching applications.

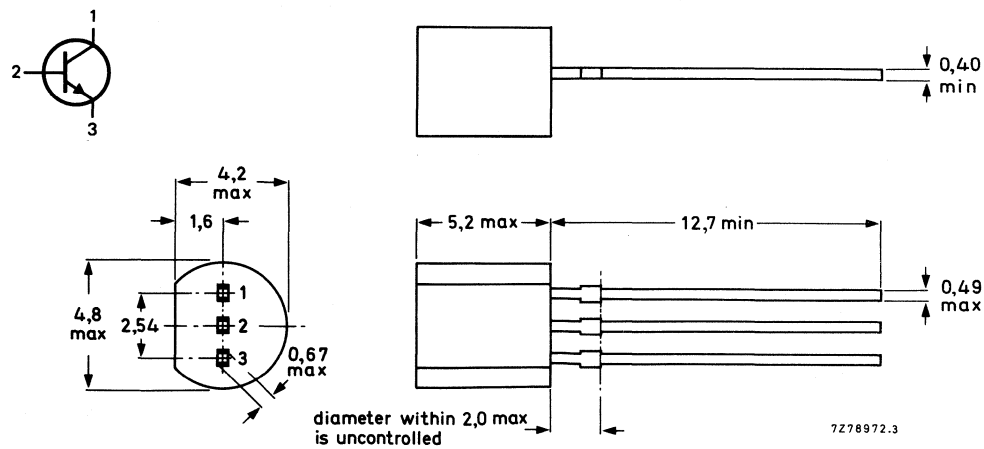
QUICK REFERENCE DATA

Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector-base voltage (open emitter)		V_{CBO}	max.	40	V
Collector current (d.c.)		I_C	max.	600	mA
Total device dissipation up to T_{amb} = 25 °C		P_{tot}	max.	625	mW
Collector-emitter saturation voltage					
I_C = 10 mA; I_B = 1 mA	PN2369	V_{CEsat}	max.	0,25	V
I_C = 10 mA; I_B = 1 mA	PN2369A	V_{CEsat}	max.	0,20	V
D.C. current gain					
I_C = 10 mA; V_{CE} = 1 V	PN2369	h_{FE}	min.	40	
			max.	120	
I_C = 10 mA; V_{CE} = 0,35 V	PN2369A	h_{FE}	min.	40	
			max.	120	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5	V
Collector current (d.c.)	I_C	max.	500	mA
Total device dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector-emitter breakdown voltage $I_B = 0$; I_C = 10 mA		$V_{(BR)CEO}$	min.	15	V
Collector-emitter breakdown voltage I_B = 10 μA; $V_{BE} = 0$		$V_{(BR)CES}$	min.	40	V
Collector-base breakdown voltage $I_E = 0$; I_C = 10 μA		$V_{(BR)CBO}$	min.	40	V
Emitter-base breakdown voltage I_E = 10 μA; $I_C = 0$		$V_{(BR)EBO}$	min.	4,5	V
Collector cut-off current					
V_{CB} = 20 V; $I_E = 0$		I_{CBO}	max.	0,4	μA
V_{CB} = 20 V; $I_E = 0$; T_A = 125 °C		I_{CBO}	max.	30	μA
D.C. current gain					
I_C = 10 mA; V_{CE} = 1 V	PN2369	h_{FE}	min.	40	
			max.	120	
I_C = 10 mA; V_{CE} = 1 V; T_{amb} = 125 °C		h_{FE}	min.	20	
I_C = 100 mA; V_{CE} = 2 V		h_{FE}	min.	20	
I_C = 10 mA; V_{CE} = 0,35 V	PN2369A	h_{FE}	min.	40	
			max.	120	
I_C = 30 mA; V_{CE} = 0,40 V		h_{FE}	>	30	
I_C = 100 mA; V_{CE} = 1,0 V		h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 0,35 V; T_{amb} = −55 °C		h_{FE}	>	20	

Saturation voltages				
I_C = 10 mA; I_B = 1 mA	PN2369	V_{CEsat}	max.	0,25 V
I_C = 10 mA; I_B = 1 mA		V_{BEsat}	min. max.	0,70 V 0,85 V ←
I_C = 10 mA; I_B = 1 mA	PN2369A	V_{CEsat}	<	0,20 V
I_C = 30 mA; I_B = 3 mA		V_{CEsat}	<	0,25 V
I_C = 100 mA; I_B = 10 mA		V_{CEsat}	<	0,50 V
I_C = 10 mA; I_B = 10 mA		V_{CEsat}	<	0,30 V
I_C = 10 mA; I_B = 1 mA		V_{CEsat}	min. max.	0,70 V 0,85 V
Output capacitance at f = 1 MHz I_E = 0; V_{CB} = 5 V		C_c	max.	4 pF
Small-signal current gain at f = 100 MHz I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C		h_{fe}	min.	5

Switching times

Storage time (see Fig. 2) I_{Bon} = I_{Boff} = I_C = 10 mA; T_{amb} = 25 °C	t_s	typ. max.	5 ns 13 ns
Turn-on time (see Fig. 3) I_C = 10 mA; V_{CC} = 3 V; I_{Bon} = 3 mA; T_{amb} = 25 °C	t_{on}	typ. max.	8 ns 12 ns
Turn-off time (see Fig. 3) I_C = 10 mA; V_{CC} = 3 V; I_{Bon} = 3 mA; I_{Boff} = 1,5 mA; T_{amb} = 25 °C	t_{off}	typ. max.	10 ns 18 ns

DEVELOPMENT DATA

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

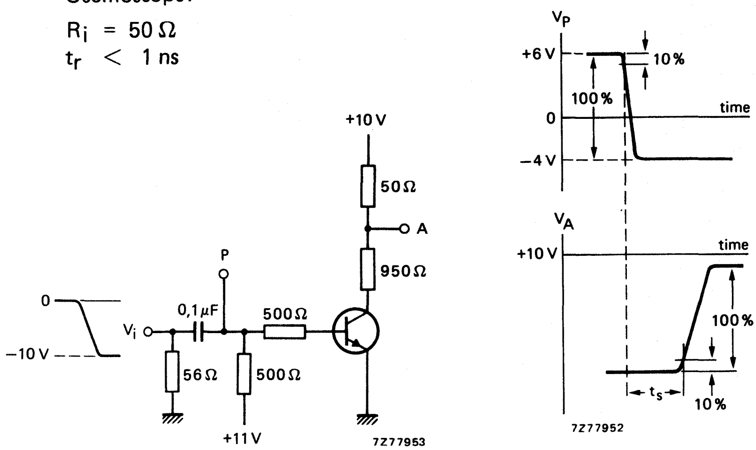


Fig. 2 Test circuit and waveforms.

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

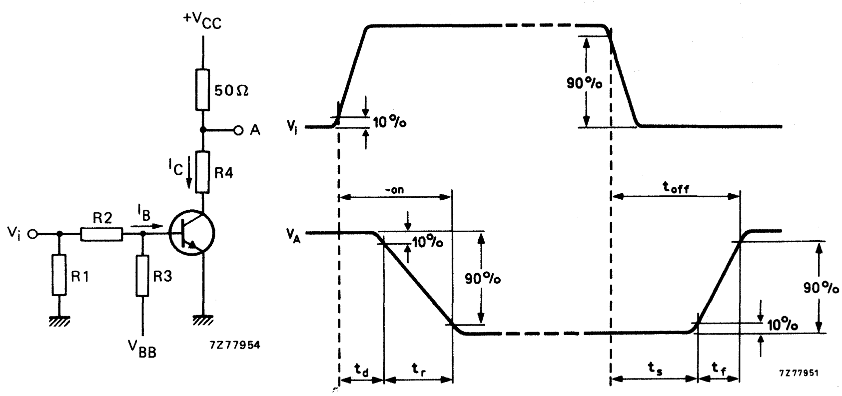


Fig. 3 Test circuit and waveforms.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P silicon planar epitaxial transistors in plastic TO-92 envelope for general purpose applications.
N-P-N complement is PN2222/A.

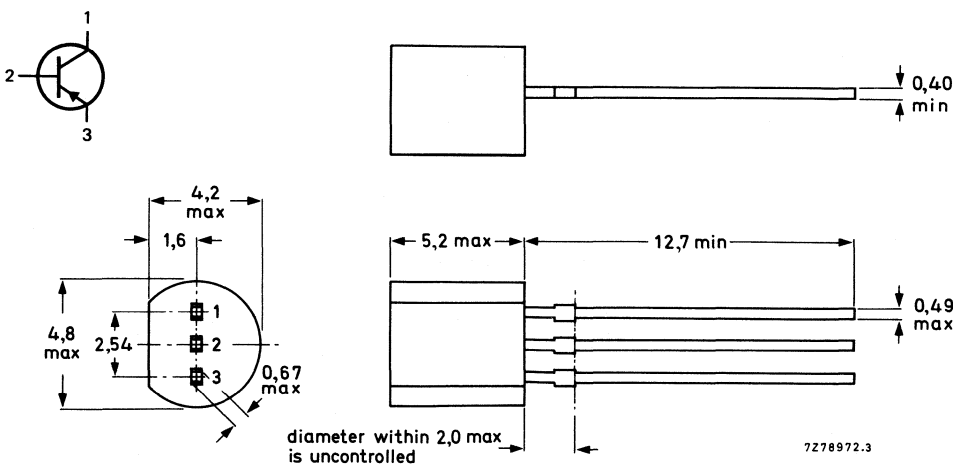
QUICK REFERENCE DATA

			PN2907	PN2907A	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60		V
Collector current (d.c.)	$-I_C$	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	max.	0,4		V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	100		
		max.	300		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			PN2907	PN2907A	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60		V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0		V
Collector current (d.c.)	$-I_C$	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PN2907	PN2907A	
Collector-emitter breakdown voltage $I_B = 0$; $-I_C$ = 10 mA	$-V_{(BR)CEO}$	min.	40	60	V
Collector-base breakdown voltage $I_E = 0$; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	min.	60		V
Emitter-base breakdown voltage $-I_E$ = 10 μA; $I_C = 0$	$-V_{(BR)EBO}$	min.	5,0		V
Base cut-off current $-V_{CE}$ = 30 V; $-V_{BE}$ = 0,5 V	$-I_{BEX}$	max.	50		nA
Collector cut-off current $-V_{CE}$ = 30 V; $-V_{BE}$ = 0,5 V	$-I_{CEX}$	max.	50		nA
Collector cut-off current $I_E = 0$; V_{CB} = 50 V	$-I_{CBO}$	max.	20	10	nA
$I_E = 0$; V_{CB} = 50 V; T_{amb} = 125 °C	$-I_{CBO}$	max.	20	10	μA
D.C. current gain $-I_C$ = 0,1 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	35	75	
$-I_C$ = 1,0 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	50	100	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	75	100	
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	100	100	
		max.	300	300	
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	min.	30	50	

			PN2907 / PN2907A	
Saturation voltages				
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	max.	0,4	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	max.	1,6	V
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{BEsat}$	max.	1,3	V
$-I_C = 150$ mA; $-I_B = 50$ mA	$-V_{BEsat}$	max.	2,6	V
Transition frequency at f = 100 MHz				
$-I_C = 50$ mA; $-V_{CE} = 20$ V; $T_{amb} = 25$ °C	f_T	min.	200	MHz
Output capacitance at f = 1 MHz				
$I_E = 0$; $-V_{CB} = 10$ V; $T_{amb} = 25$ °C	C_c	max.	8,0	pF
Input capacitance at f = 1 MHz				
$I_C = 0$; $-V_{EB} = 2,0$ V; $T_{amb} = 25$ °C	C_e	max.	30	pF

Switching times

Turn-on time (see Fig. 2)				
$-I_C = 150$ mA; $-I_{Bon} = 15$ mA; $-V_{CC} = 30$ V	t_{on}	max.	45	ns
delay time	t_d	max.	10	ns
rise time	t_r	max.	40	ns
Turn-off time (see Fig. 3)				
$-I_C = 150$ mA; $-I_{Bon} = I_{Boff} = 15$ mA; $-V_{CC} = 6,0$ V	t_{off}	max.	100	ns
storage time	t_s	max.	80	ns
fall time	t_f	max.	30	ns

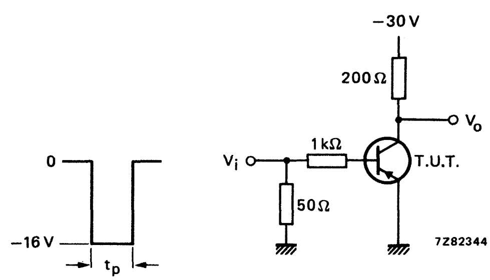


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

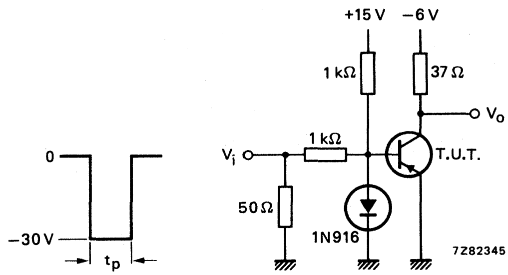


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	f	=	150 Hz
pulse duration	t_p	=	200 ns
rise time	t_r	$\leqslant$	2 ns
output impedance	Z_o	=	50 Ω

Oscilloscope (see Figs 2 and 3)

rise time	t_r	$\leqslant$	5 ns
input impedance	Z_i	$\leqslant$	10 MΩ

SILICON N-P-N HIGH-VOLTAGE TRANSISTORS

N-P-N high-voltage small-signal transistors in a TO-92 envelope and intended for use in telephony and professional communication equipment.

Complementary type is PN5415/5416.

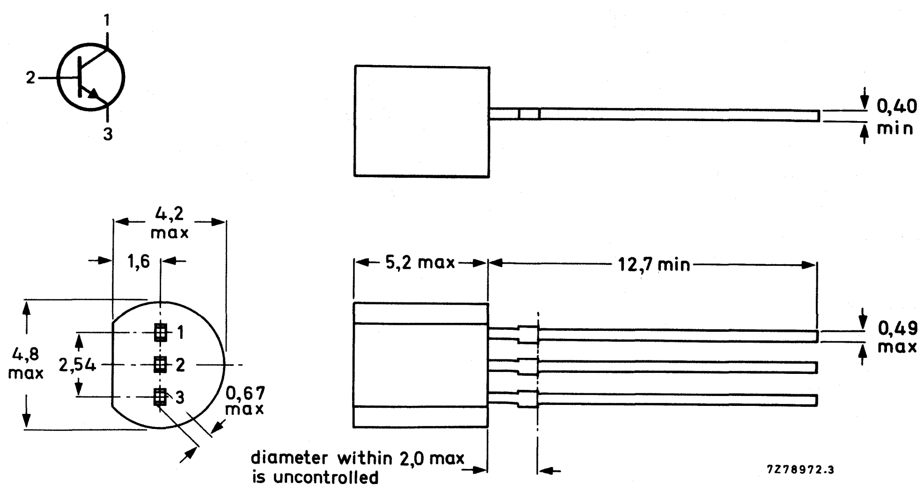
QUICK REFERENCE DATA

			PN3439	PN3440	
Collector-base voltage (open emitter)	V_{CBO}	max.	400	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	250	V
Collector current (d.c.)	I_C	max.	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage I_C = 50 mA; I_B = 4 mA	V_{CEsat}	<	0,5	0,5	V
D.C. current gain I_C = 2 mA; V_{CE} = 10 V	h_{FE}	>	30		
I_C = 20 mA; V_{CE} = 10 V	h_{FE}	>		40	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			PN3439	PN3440	
Collector-base voltage (open emitter)	V_{CBO}	max.	400	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5,0		V
Collector current (d.c.)	I_C	max.	1,0		A
Base current	I_B	max.	0,5		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_j		−65 to 150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PN3439	PN3440	
Collector cut-off currents					
$I_E = 0$; V_{CB} = 360 V	I_{CBO}	<	0,1		μA
$I_E = 0$; V_{CB} = 250 V	I_{CBO}	<		0,1	μA
$I_B = 0$; V_{CE} = 300 V	I_{CEO}	<	1,0		μA
$I_B = 0$; V_{CE} = 200 V	I_{CEO}	<		1,0	μA
Emitter cut-off current $I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	10	10	μA
Collector-emitter sustaining voltage $I_B = 0$; I_C = 50 mA	V_{CEOsus}	>	350	250	V
Saturation voltages I_C = 50 mA; I_B = 4 mA	V_{CEsat}	<	0,5	0,5	V
	V_{BEsat}	<	1,3	1,3	V
D.C. current gain					
I_C = 2 mA; V_{CE} = 10 V	h_{FE}	>	30		
I_C = 20 mA; V_{CE} = 10 V	h_{FE}	>		40	
Transition frequency at f = 5 MHz I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	f_T	>	70		MHz
Small-signal current gain at f = 1 kHz I_C = 5 mA; V_{CE} = 10 V; T_{amb} = 25 °C	h_{fe}	>	25		
Real part (Re) of input impedance (h_{ie}) V_{CE} = 10 V; I_C = 5 mA; f = 1 MHz; T_{amb} = 25 °C	$Re(h_{ie})$	<	300		Ω
Input capacitance at f = 1 MHz $I_C = 0$; V_{EB} = 5 V; T_{amb} = 25 °C	C_e	<	20		pF
Output capacitance at f = 1 MHz $I_E = 0$; V_{CB} = 10 V; T_{amb} = 25 °C	C_c	<	2,0		pF

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

P-N-P high-voltage small-signal transistors in a TO-92 envelope and intended for use in telephony and professional communication equipment.

Complementary type is PN3439/3440.

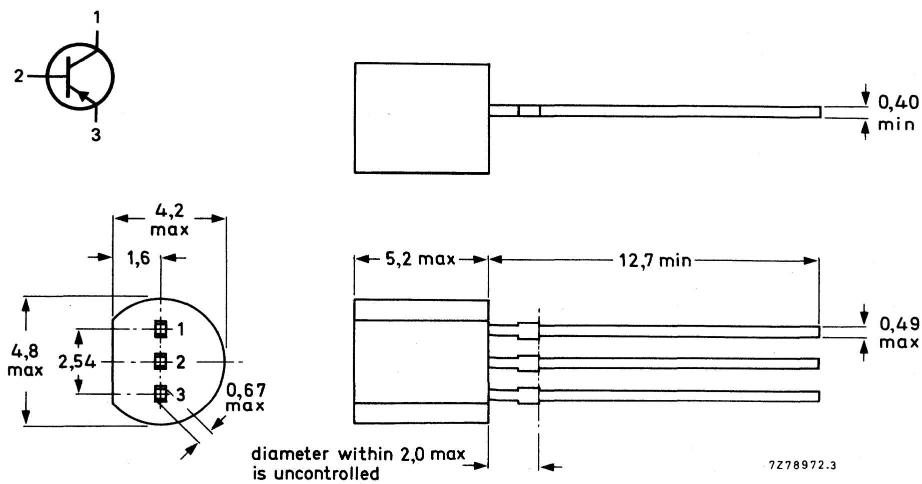
QUICK REFERENCE DATA

			PN5415	PN5416	
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.	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage $-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	<	0,8	0,8	V
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-92.



RATINGS

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

			PN5415	PN5416	
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.	4,0	6,0	V
Collector current (d.c.)	$-I_C$	max.	1,0		A
Base current	$-I_B$	max.	0,5		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Junction temperature	T_j	max.	150		°C
Storage temperature range	T_{stg}		−65 to 150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			PN5415	PN5416	
Collector cut-off currents					
$I_E = 0; -V_{CB} = 175$ V	$-I_{CBO}$	<	0,1		μA
$I_E = 0; -V_{CB} = 280$ V	$-I_{CBO}$	<		0,1	μA
$I_B = 0; -V_{CE} = 150$ V	$-I_{CEO}$	<	1,0		μA
$I_B = 0; -V_{CE} = 250$ V	$-I_{CEO}$	<		1,0	μA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	1,0		μA
$I_C = 0; -V_{EB} = 6$ V	$-I_{EBO}$	<		1,0	μA
Collector-emitter sustaining voltage $I_B = 0; -I_C = 50$ mA	$-V_{CEOsus}$	>	200	300	V
Saturation voltages $-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	0,8	0,8	V
	$-V_{BEsat}$	<	1,0	1,0	V
D.C. current gain $-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	30	
		<	150	120	
Transition frequency at f = 5 MHz $-I_C = 10$ mA; $-V_{CE} = 10$ V; $T_{amb} = 25$ °C	f_T	>	15		MHz
Small-signal current gain at f = 5 MHz $-I_C = 10$ mA; $-V_{CE} = 10$ V; $T_{amb} = 25$ °C	h_{fe}	>	25		
Real part (Re) of input impedance (h_{ie}) $-V_{CE} = 10$ V; $-I_C = 5$ mA; f = 1 MHz; $T_{amb} = 25$ °C	$Re(h_{ie})$	<	300		Ω
Input capacitance at f = 1 MHz $I_C = 0; -V_{EB} = 5$ V; $T_{amb} = 25$ °C	C_e	<	75		pF
Output capacitance at f = 1 MHz $I_E = 0; -V_{CB} = 10$ V; $T_{amb} = 25$ °C	C_c	<	15		pF

N-P-N SILICON PLANAR TRANSISTOR

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

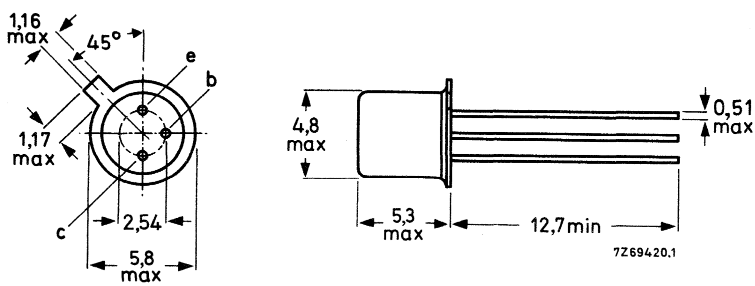
Collector-base voltage (open emitter)	V_{CBO}	max.	45 V
Collector-emitter voltage (open base)	V_{CEO}	max.	45 V
Collector current (peak value)	I_{CM}	max.	60 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300 mW
Junction temperature	T_j	max.	175 °C
D.C. current gain at T_j = 25 °C I_C = 10 μA; V_{CE} = 5 V	h_{FE}	> <	100 300
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	> <	150 600
Transition frequency I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ.	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 dB 3 dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector-emitter voltage at $V_{EB} = 0$	V_{CES}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
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
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW
Storage temperature	T_{stg}	−65 to +	175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,5	K/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,25	K/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
D.C. current gain			
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	100 to 300	
I_C = 10 μA; V_{CE} = 5 V; T_j = −55 °C	h_{FE}	> 20	
I_C = 500 μA; V_{CE} = 5 V	h_{FE}	> 150	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	150 to 600	
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 5 V	C_c	< 8	pF
Transition frequency			
I_C = 0,5 mA; V_{CE} = 5 V	f_T	> 50	MHz
Cut-off frequency			
I_C = 0,5 mA; V_{CE} = 5 V	f_{hfe}	> 100	kHz
Noise figure (f = 10 Hz to 15 kHz)			
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ	F	typ. 2	dB
		< 3	dB
h parameters at f = 1 kHz			
I_C = 1 mA; V_{CE} = 5 V			
Input impedance	h_{ie}	typ. 10,0	kΩ
Reverse voltage transfer	h_{re}	typ. 5,5	10^{-4}
Small signal current gain	h_{fe}	typ. 350	
		150 to 600	
Output admittance	h_{oe}	typ. 25	μS

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

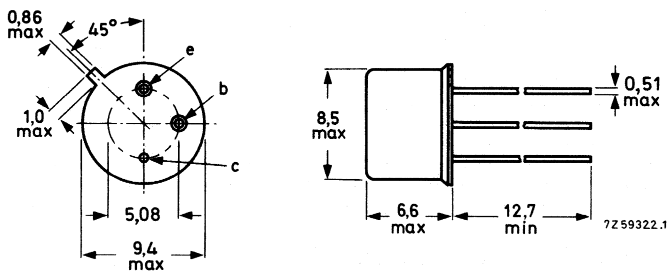
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 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).

Products approved to CECC 50 002-104.

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.

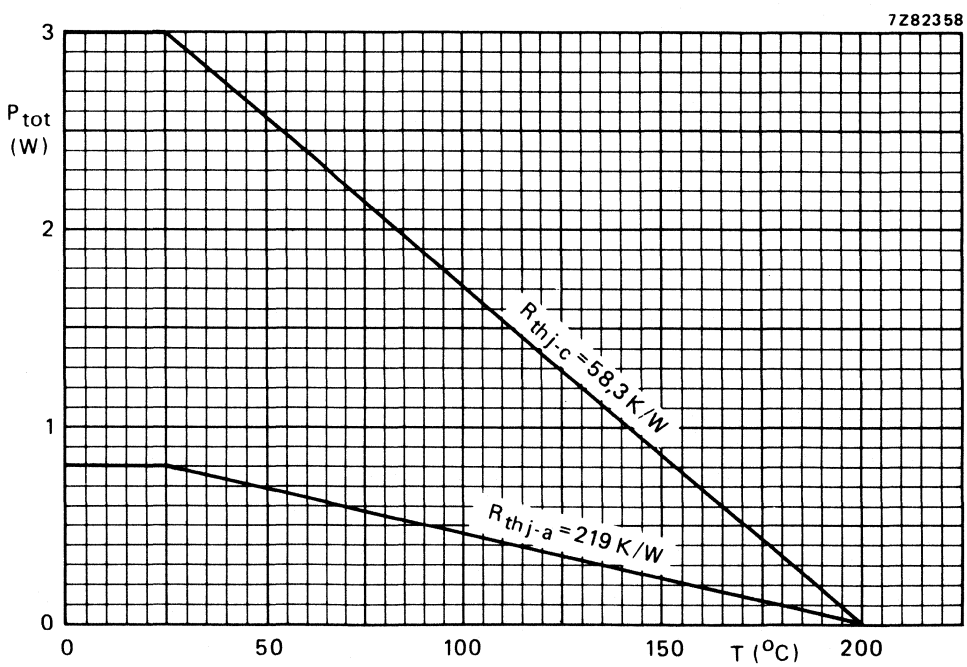


Fig. 2 Maximum permissible total power dissipation as a function of temperature.

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; $R_{BE} \leqslant 10\ \Omega$	$V_{(BR)CER}$	>	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; $\delta \leqslant 0{,}02$.

Output admittance		
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{ob}	0,05 to 0,5 μS
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{ob}	0,05 to 0,5 μS
Total switching time (see Figs 3 to 6)		
$I_{Con} = 50$ mA; $V_{BEon} = -V_{BEoff} = 1$ V	$t_{on} + t_{off}$	< 30 ns

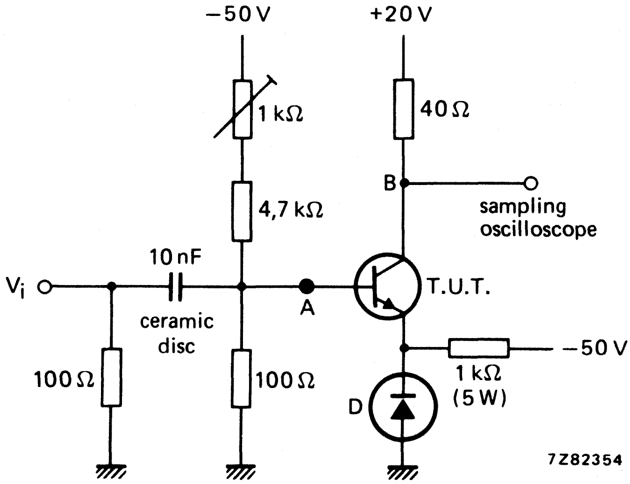


Fig. 3 Turn-on plus turn-off measuring circuit. D = BAW62.

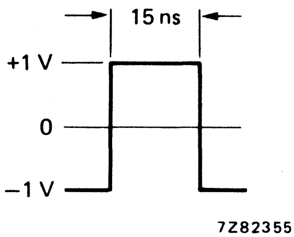


Fig. 4 Waveform at "A".
Pulse generator: t_r; t_f < 1 ns.

Fig. 5 Waveform at "B".

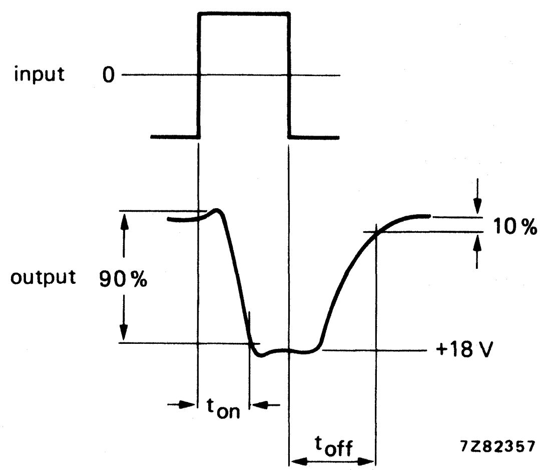


Fig. 6 Turn-on and turn-off time.

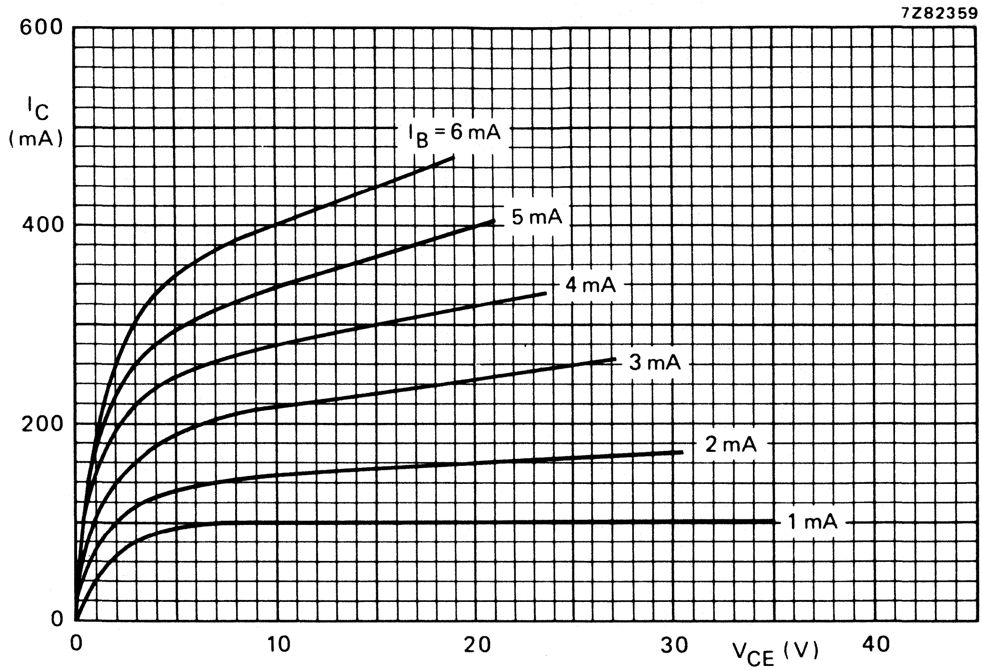


Fig. 7 T_j = 25 °C; typical values.

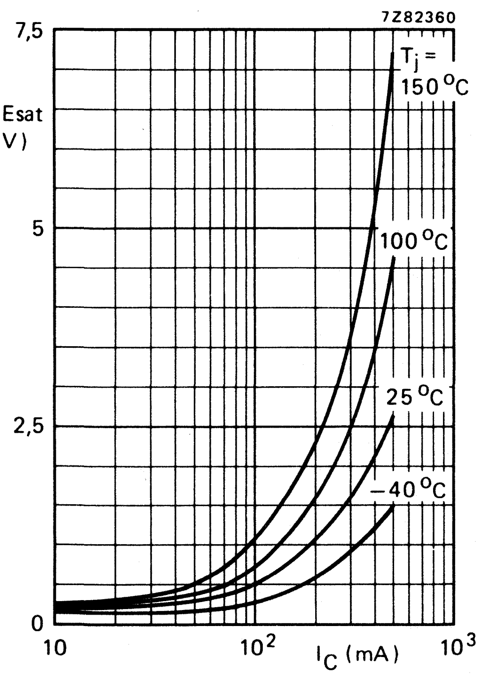


Fig. 8 I_C/I_B = 10; typical values.

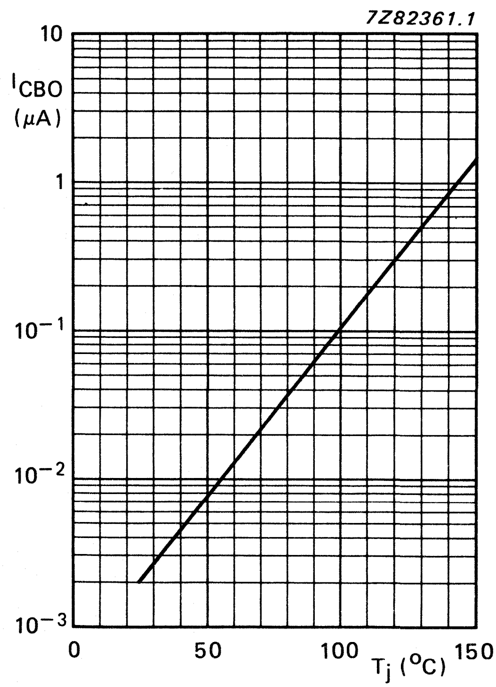


Fig. 9 V_{CB} = 60 V; typical values.

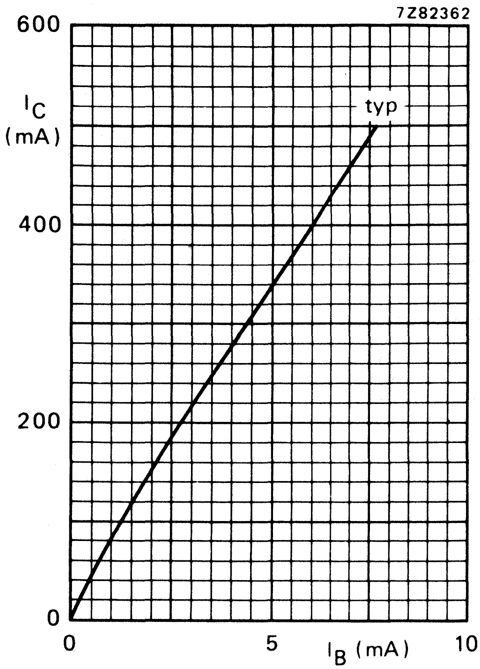


Fig. 10 V_{CE} = 10 V; T_j = 25 °C.

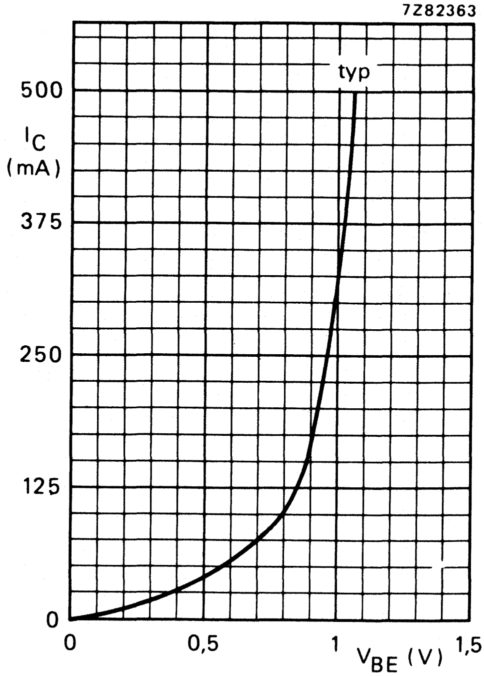


Fig. 11 V_{CE} = 10 V; T_j = 25 °C.

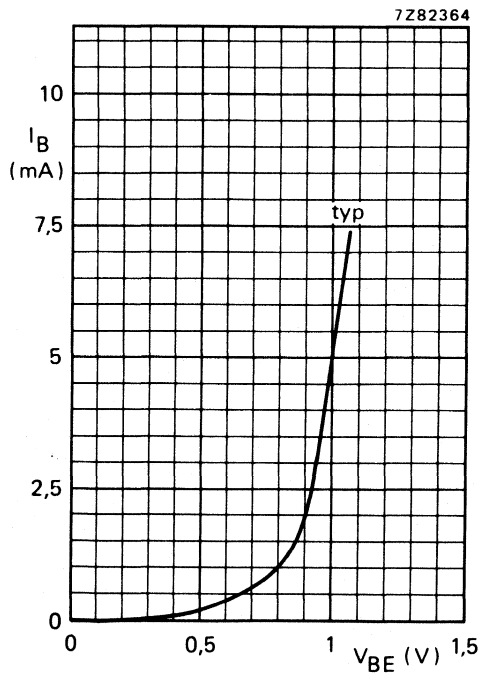


Fig. 12 V_{CE} = 10 V; T_j = 25 °C.

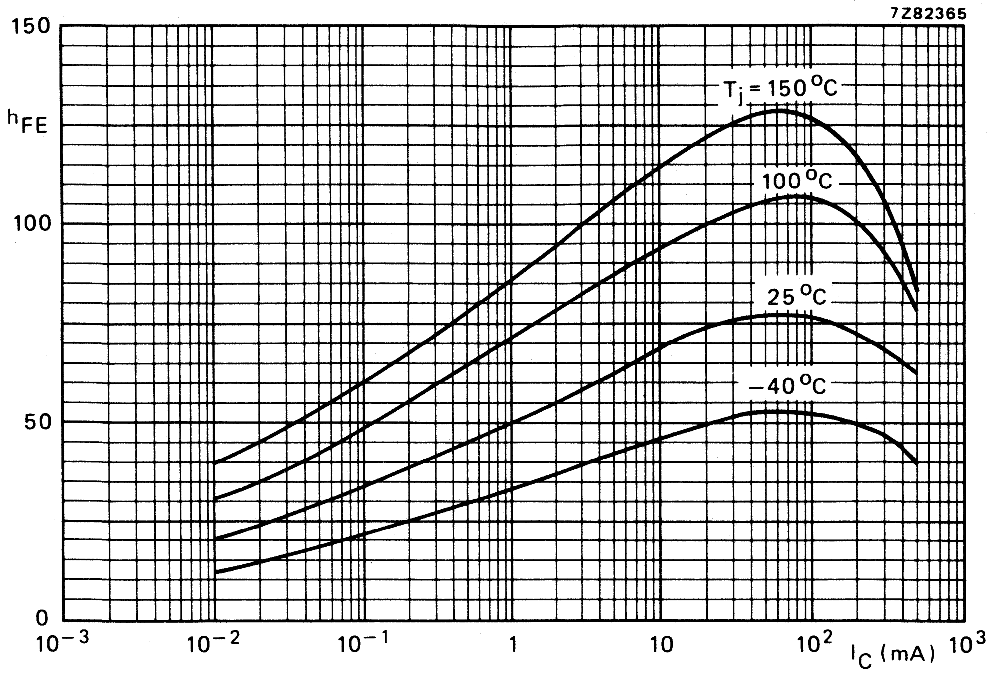


Fig. 13 V_{CE} = 10 V; typical values.

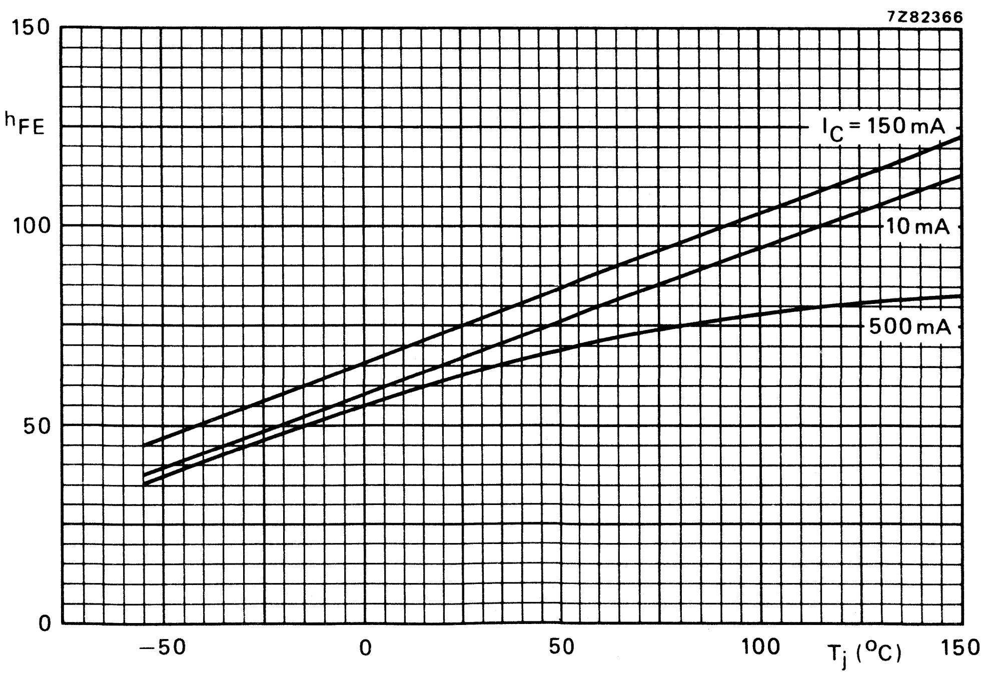


Fig. 14 V_{CE} = 10 V; typical values.

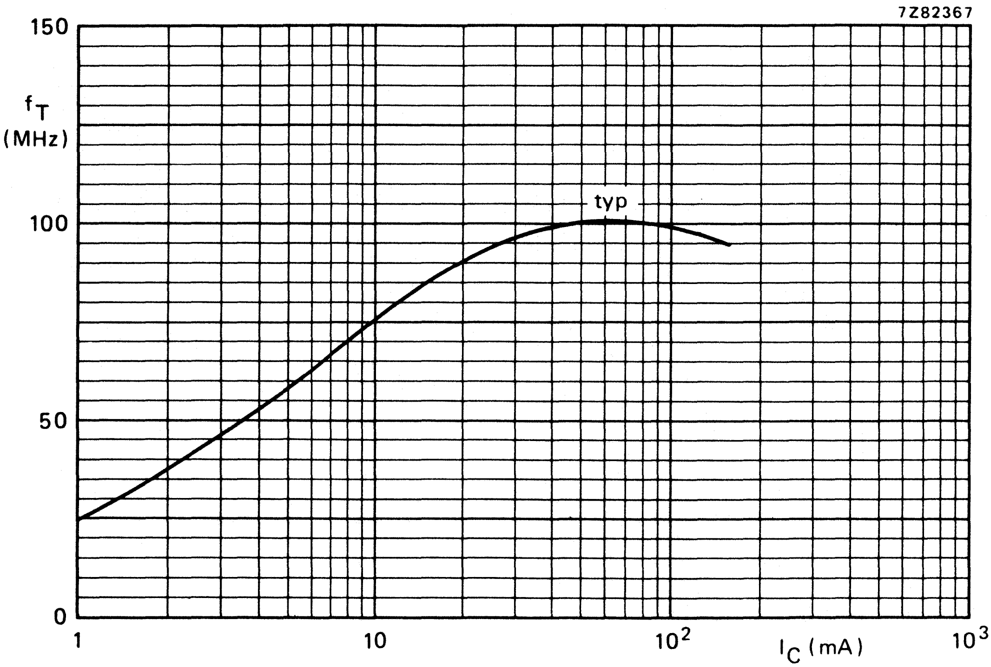


Fig. 15 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

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

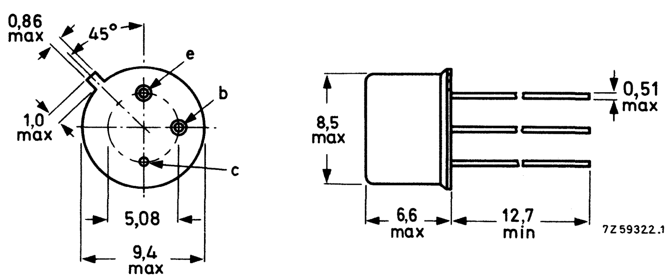
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		100 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).

Products approved to CECC 50 002-104.

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 μS
I_C = 5,0 mA; V_{CE} = 10 V	h_{ob}	0,05 to 0,5 μS

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

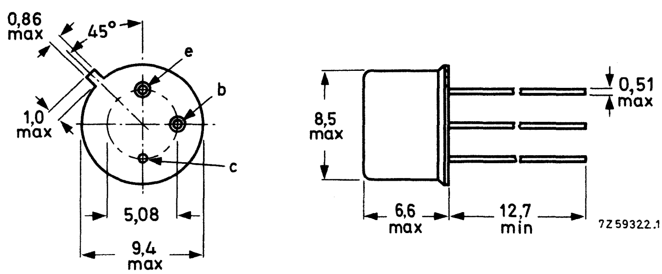
Collector-base voltage (open emitter)	V_{CBO}	max.	120 V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	100 V
Collector current (d.c.)	I_C	max.	500 mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	3,0 W
Junction temperature	T_j	max.	200 °C
D.C. current gain			
I_C = 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	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).

Products approved to CECC 50 002-104.

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.	80	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Collector current (d.c.)	I_C	max.	500	mA
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

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			
$I_E = 0$; $V_{CB} = 90$ 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 *			
$I_C = 100$ mA; $R_{BE} \geqslant 10\ \Omega$	$V_{CERsust}$	>	100 V
$I_C = 30$ mA; $I_B = 0$	$V_{CEOsust}$	>	80 V
Saturation voltages *			
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	5,0 V
	V_{BEsat}	<	1,3 V
$I_C = 50$ mA; $I_B = 5$ mA	V_{CEsat}	<	1,2 V
	V_{BEsat}	<	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 *	h_{FE}	>	35
$I_C = 150$ mA; $V_{CE} = 10$ V *	h_{FE}		40 to 120

* Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t ⩽ 300 μs, duty cycle $\delta < 0{,}02$.

CHARACTERISTICS (continued)

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 μS
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 μS
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 2N2219 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

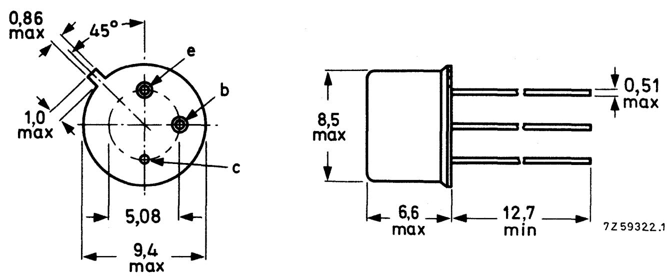
			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current 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).

Products approved to CECC 50 004-029.

RATINGS

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

			2N2219	2N2219A	
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.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	3		W
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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	K/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

* Applicable up to I_C = 500 mA

			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 *					
$I_C = 150$ 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; $T_{amb} = -55\ ^oC$	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V *	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V *	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V *	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

* Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

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	μS
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	μS
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 wsitched 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

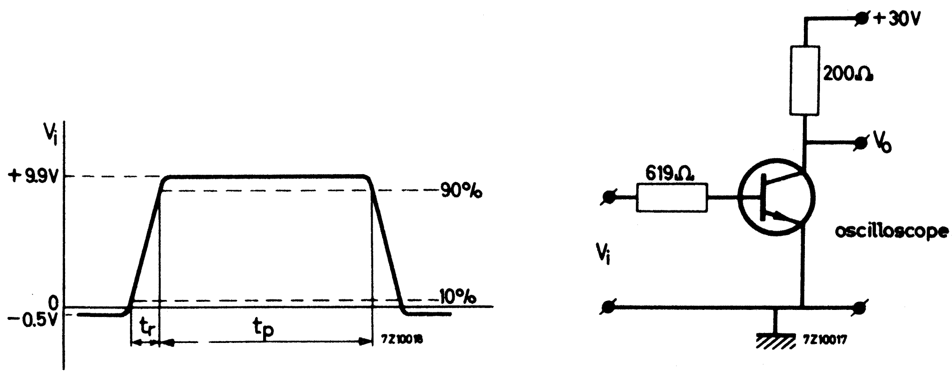


Fig. 2 Test circuit and waveforms.

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

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

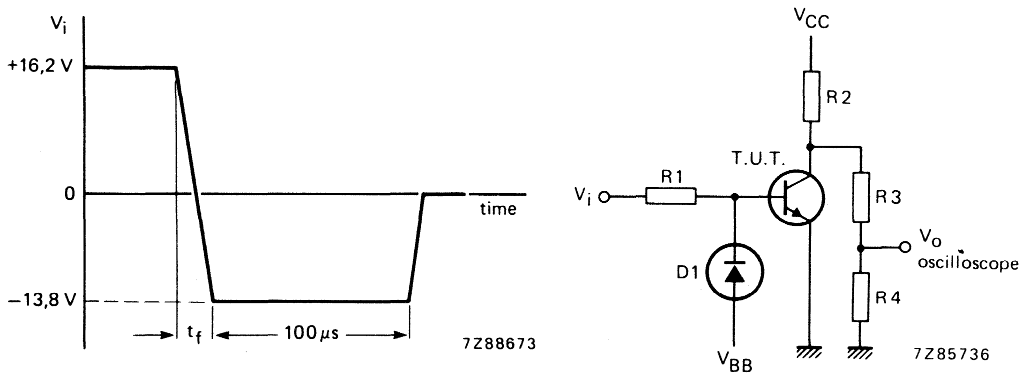


Fig. 3 Test circuit and waveform.
V_{CC} = + 30 V; V_{BB} = −3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

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

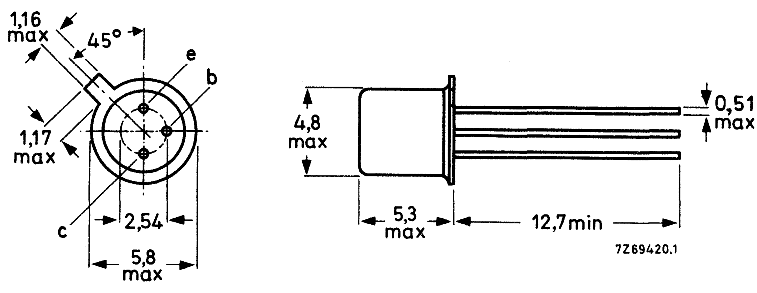
			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	200	200	°C
D.C. current 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).

Products approved to CECC 50 004-030, available on request.

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.

			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 *					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,4	0,3	V
	V_{BEsat}	>	–	0,6	V
	V_{BEsat}	<	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; $T_{amb} = -55\ ^oC$	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V *	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V *	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V *	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

* Pulse duration ⩽ 300 μs; duty cycle ⩽ 2%.

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 μS
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 μS
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz			**2N2222**	**2N2222A**
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

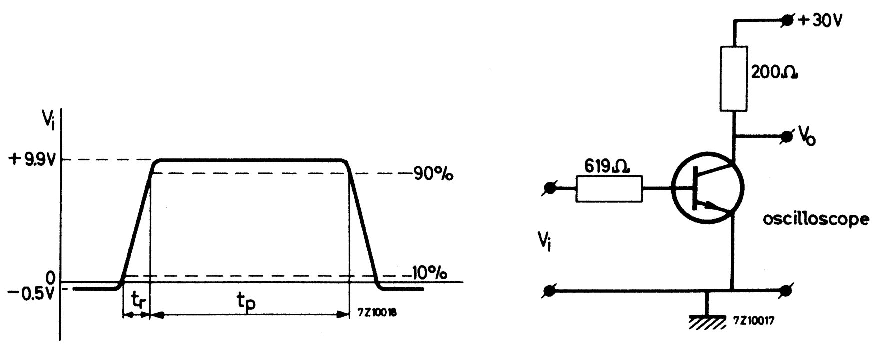


Fig. 2 Test circuit and waveform.

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

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

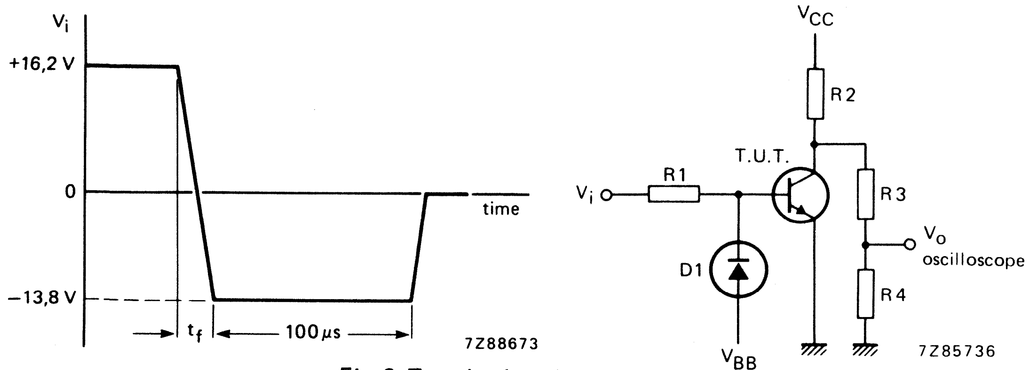


Fig. 3 Test circuit and waveform.

V_{CC} = + 30 V; V_{BB} = −3 V; R1 = 1 kΩ; R2 = 200 Ω; R3 = 20 kΩ; R4 = 50 Ω; D1 = 1N916.

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.

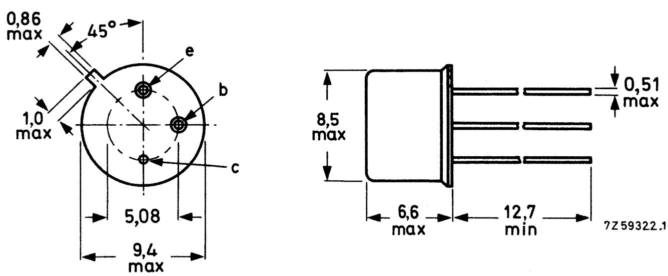
QUICK REFERENCE DATA

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 transistor in a TO-18 metal envelope with the collector connected to the case. The 2N2369 is primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

QUICK REFERENCE DATA

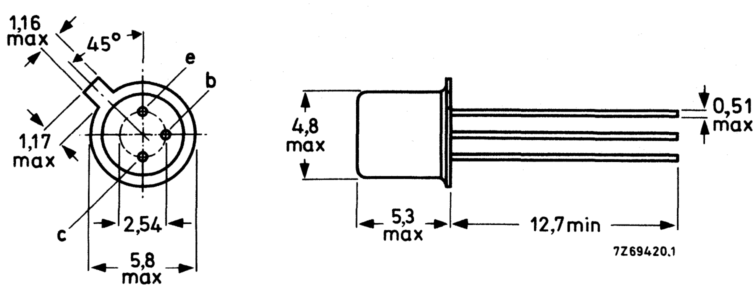
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
Transition frequency I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
Storage time $I_C = I_B = -I_{BM}$ = 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)	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
Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	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	$R_{th\ j\text{-}a}$	=	480	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	145	K/W

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 *				
I_C = 10 mA; $I_B = 0$	$V_{CEOsust}$	>	15	V*
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*				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_j = –55 °C	h_{FE}	>	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	20	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz

* Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t = 300 μs; duty cycle δ = 0,01.

CHARACTERISTICS (continued)

$T_j = 25\ ^oC$

Storage time			
$I_C = I_B = -I_{BM} = 10$ mA	t_s	<	13 ns ←

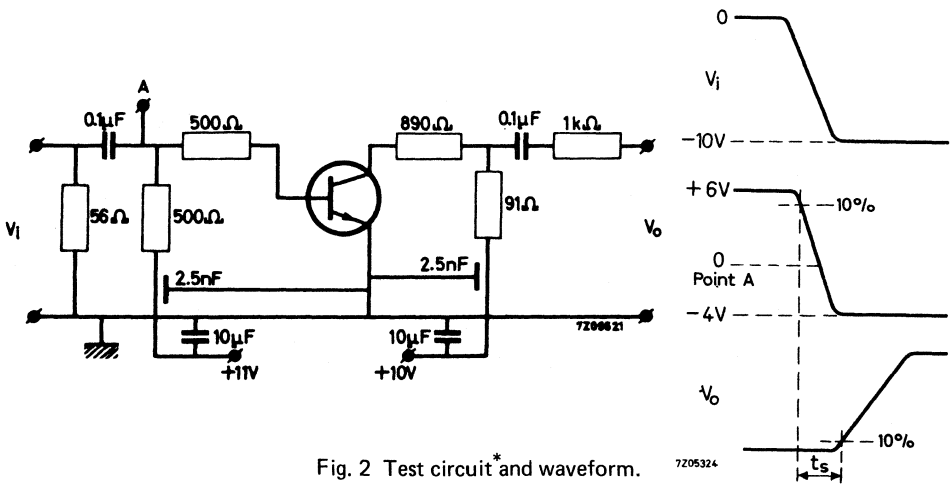


Fig. 2 Test circuit* and waveform.

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	t_{off}	<	18 ns ←

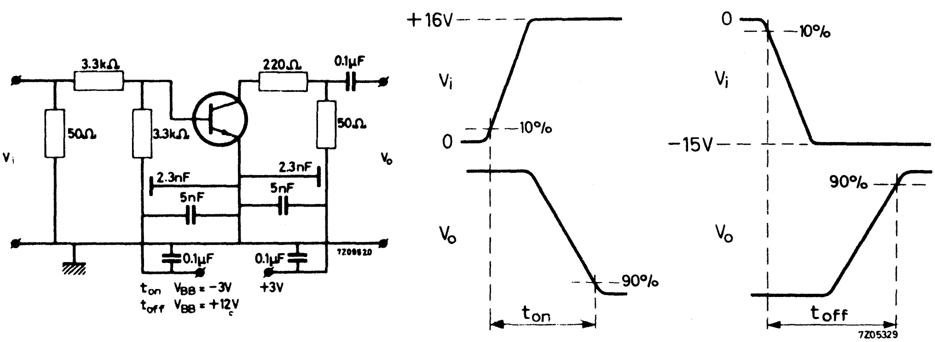


Fig. 3 Test circuit* and waveform.

* 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

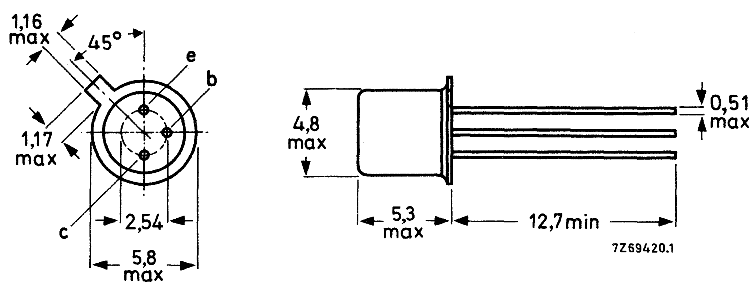
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 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; $\delta \leqslant$ 0,02.

Storage time (see Figs 2 and 3) $I_{Con} = I_{Bon} = -I_{Boff} = 10$ mA	t_s	<	13	ns

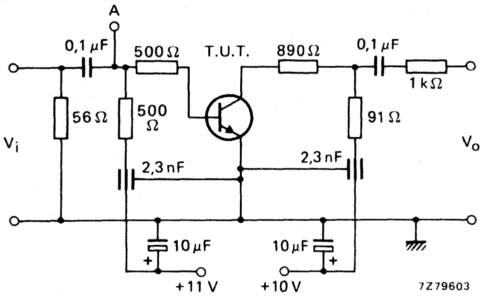


Fig. 2 Storage time test circuit.

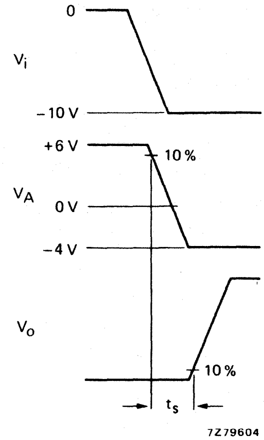


Fig. 3 Waveforms at input, point A and output.

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

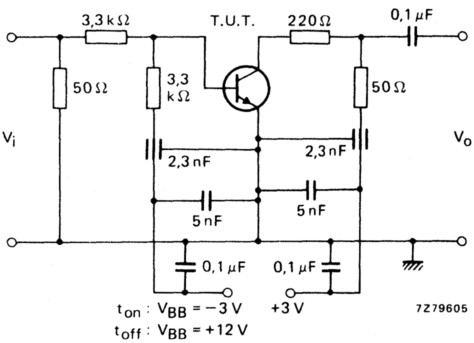


Fig. 4 Turn-on and turn-off test circuit.

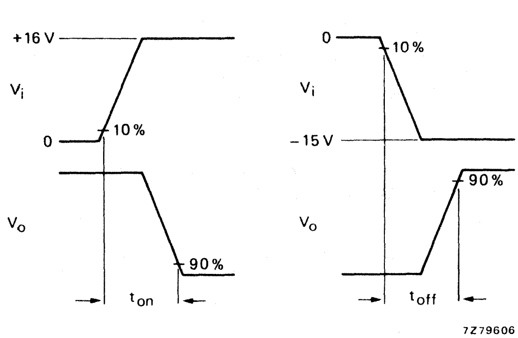


Fig. 5 Input and output waveforms.

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

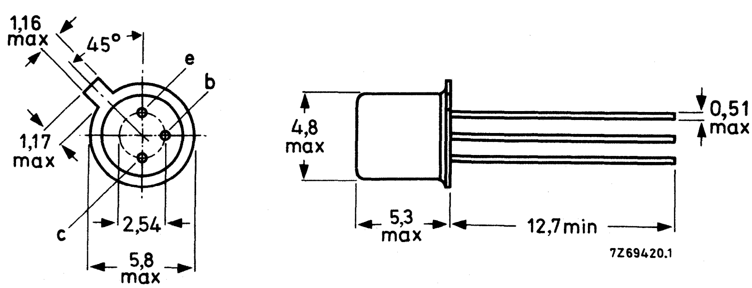
			2N2483	2N2484	
Collector-base voltage (open emitter)	V_{CBO}	max	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	60	V
Collector current (peak value)	I_{CM}	max	50	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	360	360	mW
Junction temperature	T_j	max	200	200	°C
D.C. current gain at T_j = 25 °C I_C = 10 µA; V_{CE} = 5 V	h_{FE}	> <	40 120	100 500	
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 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.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Collector current (peak value)	I_{CM}	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	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	$R_{th\ j\text{-}a}$	=	480	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N2483	2N2484	
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
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*	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
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 transferq	h_{re}	<	8	8	10^{-4}
Small signal current gain	h_{fe}		80 to 450	150 to 900	
Output admittance	h_{oe}	<	30	40	μS

* Measured under pulsed conditions to prevent excessive dissipation. Pulse duration $t < 300$ μs; duty cycle $\delta < 0{,}01$.

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

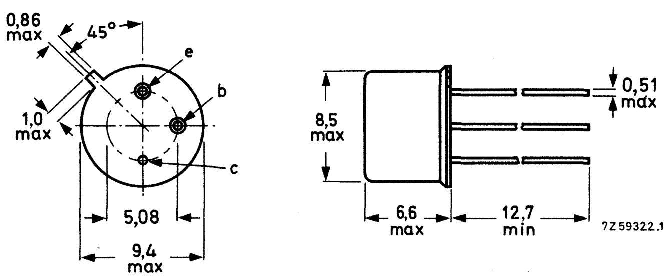
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	**2N2904**	$-V_{CEO}$	max.	40 V
	2N2904A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6 W
Junction temperature		T_j	max.	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).

Products approved to CECC 50 002-102.

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: $t_p \leq 300$ μs; $\delta \leq 0{,}02$.

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

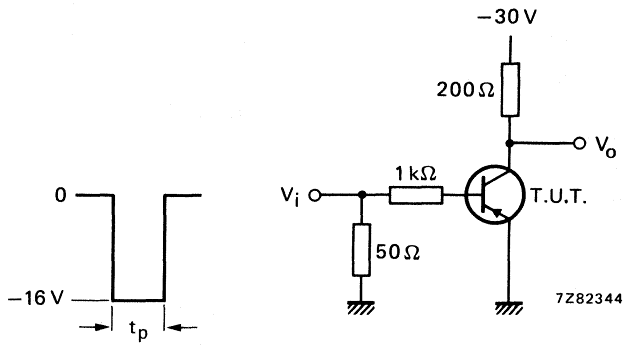


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

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

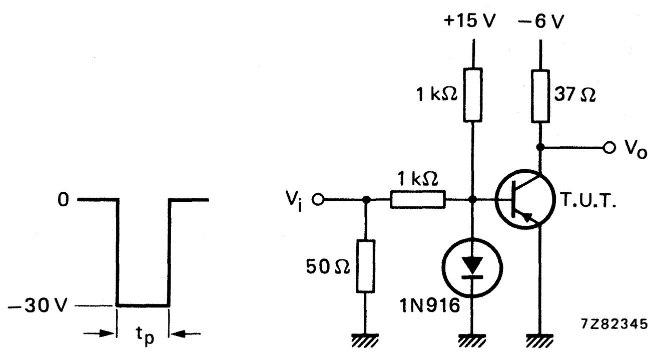


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

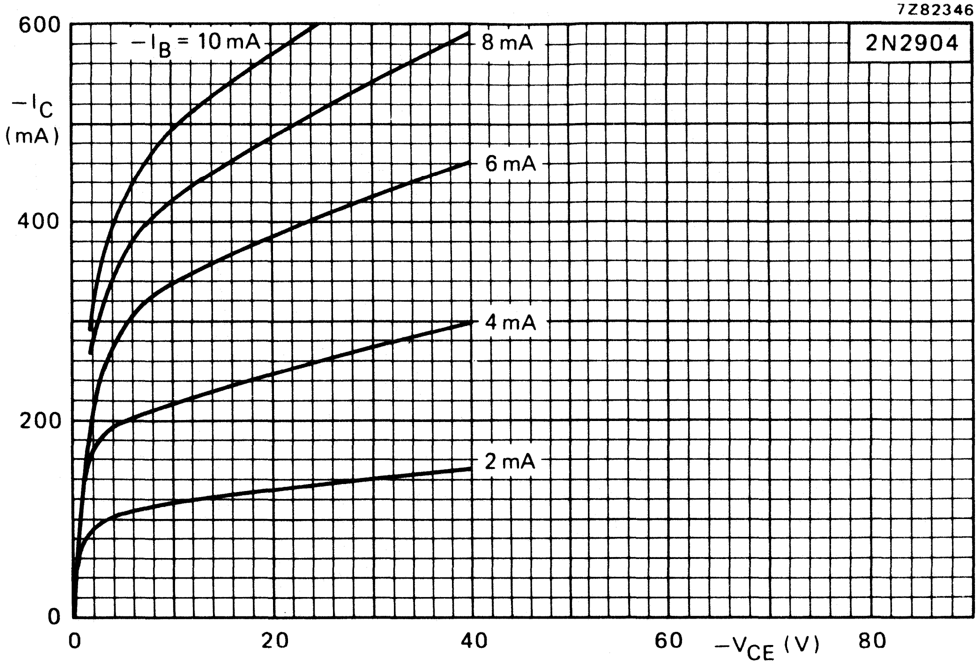


Fig. 4 Typical values; T_j = 25 °C.

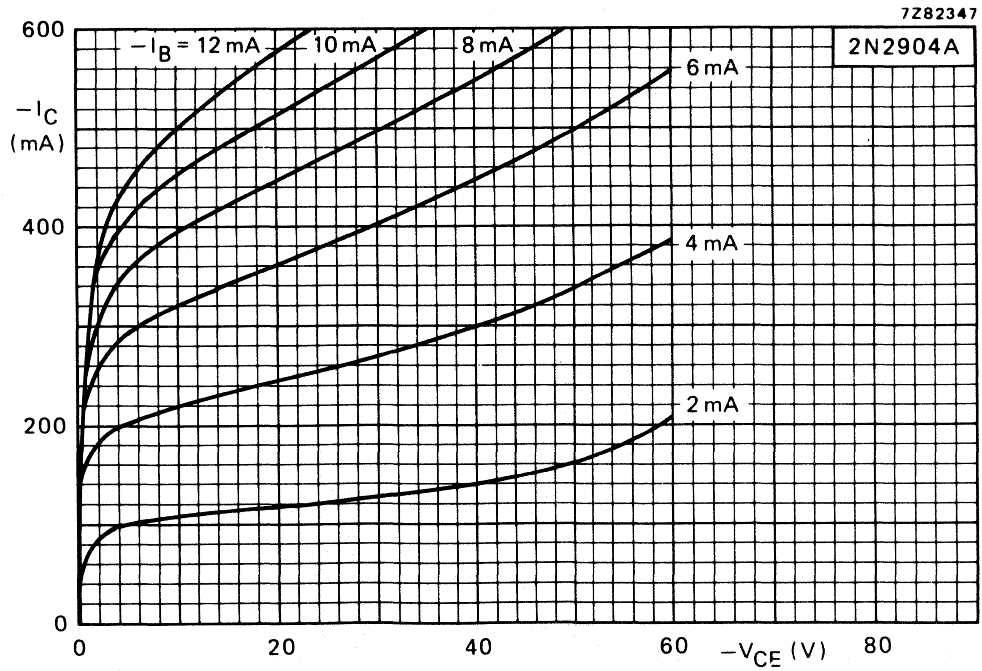


Fig. 5 Typical values; T_j = 25 °C.

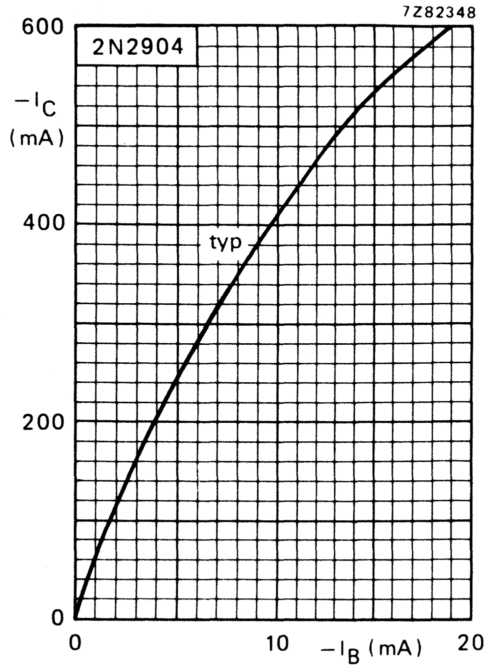


Fig. 6 $-V_{CE} = 5,0$ V; $T_J = 25$ °C.

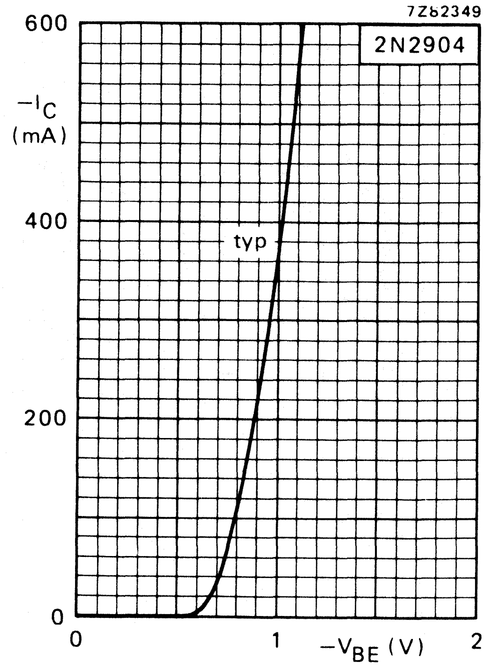


Fig. 7 $-V_{CE} = 5,0$ V; $T_j = 25$ °C.

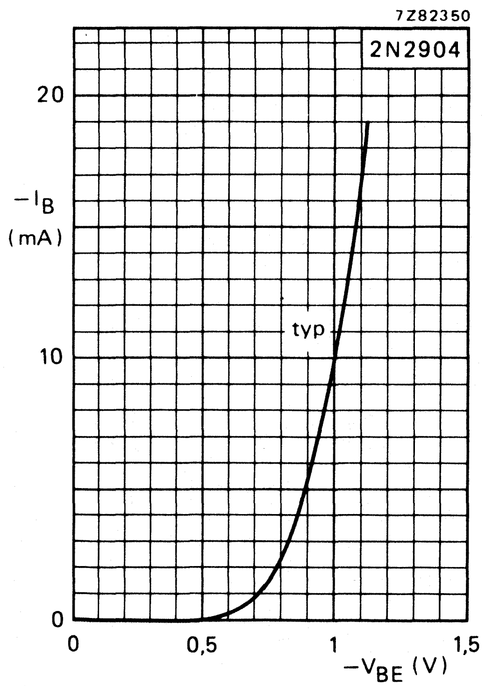


Fig. 8 $-V_{CE} = 5,0$ V; $T_j = 25$ °C.

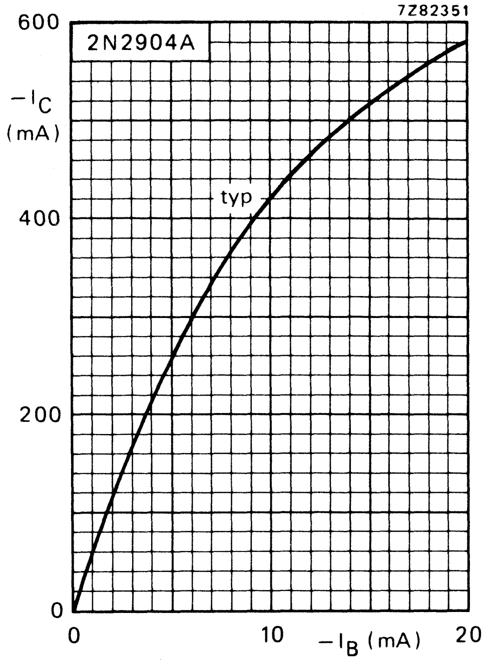


Fig. 9 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

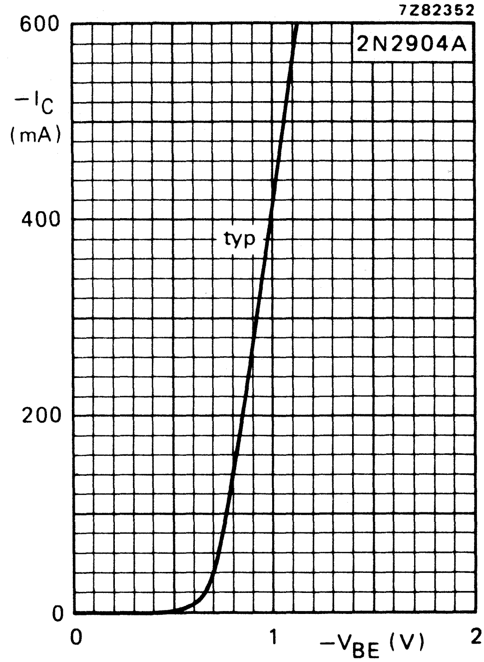


Fig. 10 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

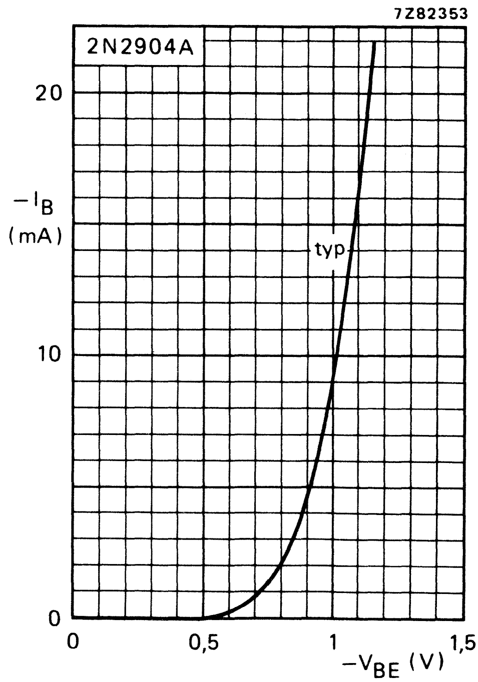


Fig. 11 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

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

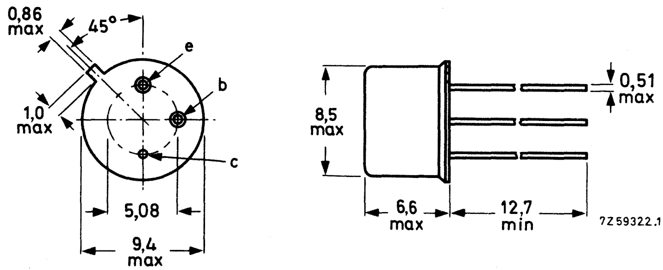
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2905	$-V_{CEO}$	max.	40	V
	2N2905A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6	W
Junction temperature		T_j	max.	200	°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).

Products approved to CECC 50 002-102.

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 $T_{amb} = 25$ °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

			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; $t_p \leq 300$ μs; $\delta \leq 0,02$.

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

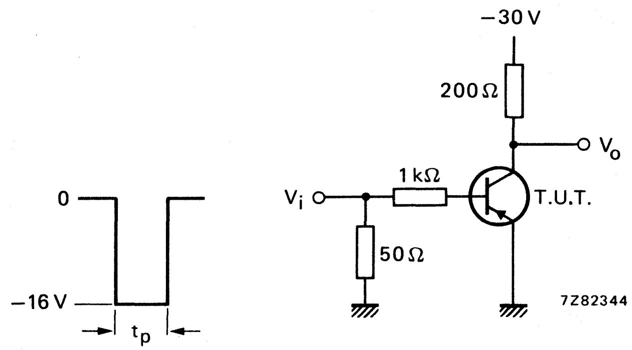


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

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

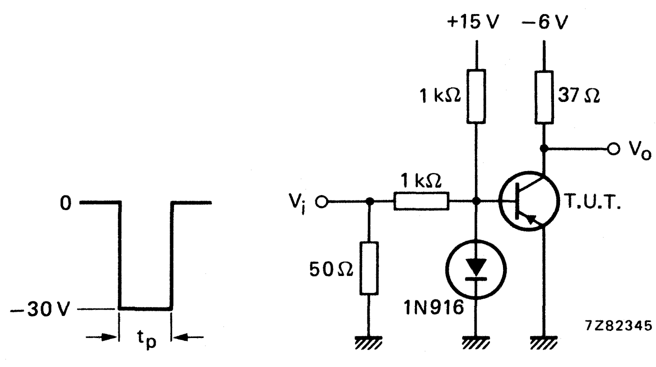


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

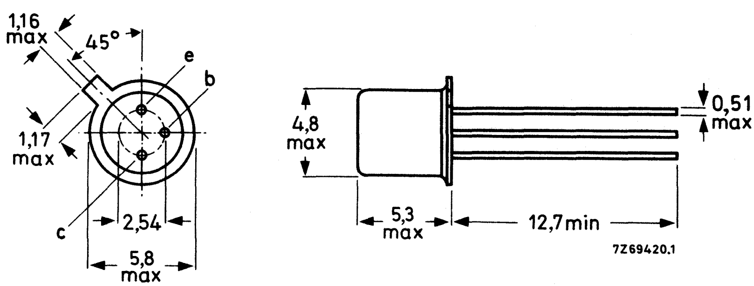
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2906	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	200	°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).

Products approved to CECC 50 002-103.

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

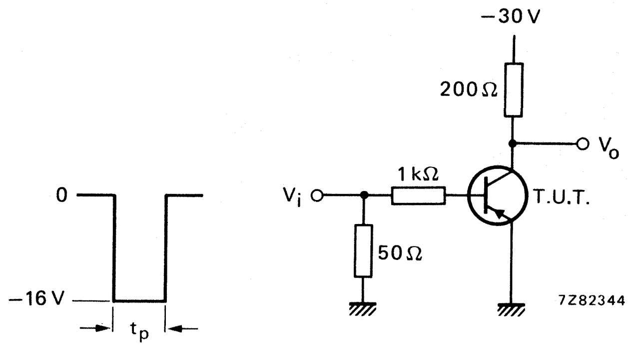


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

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

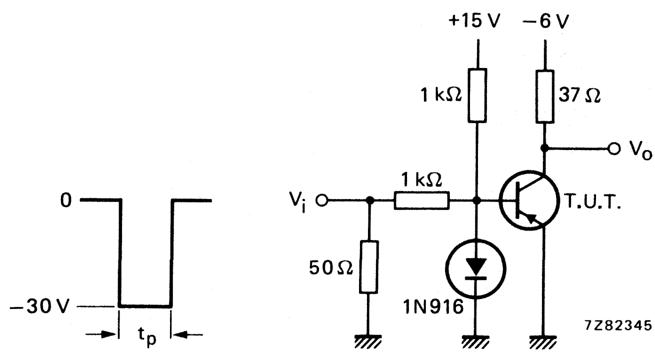


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

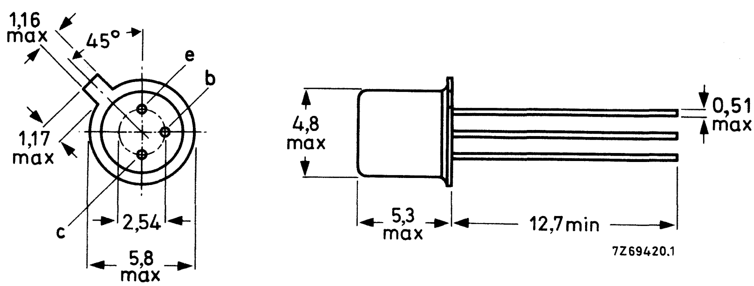
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	**2N2907**	$-V_{CEO}$	max.	40	V
	2N2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	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).

Products approved to CECC 50 002-103.

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

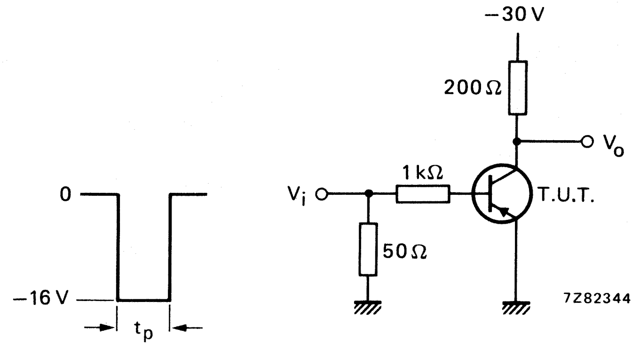


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

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

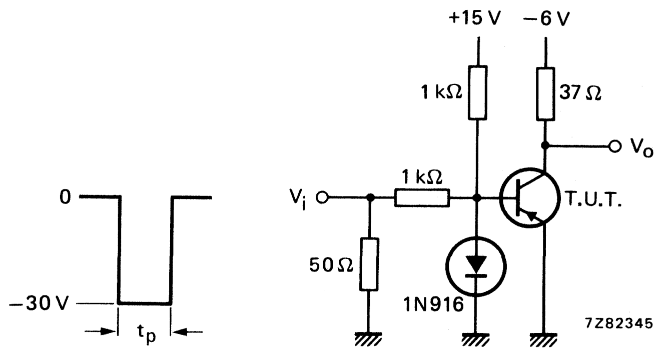


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

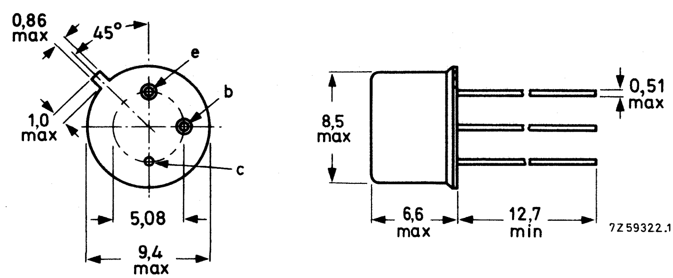
Collector-base voltage (open emitter)	V_{CBO}	max.	140		V
Collector-emitter voltage (open base)	V_{CEO}	max.	80		V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°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).

Products approved to CECC 50 002-175.

RATINGS

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

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
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
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	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/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 *
$I_C = 0$; $I_E = 100$ 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 *
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5	V *

* Measured under pulse conditions: $t_p = 300\ \mu s$; $\delta \leqslant 0{,}01$.

			2N3019	2N3020	
D.C. current gain *					
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

* Measured under pulse conditions: t_p = 300 μs; $\delta \leqslant 0{,}01$.

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

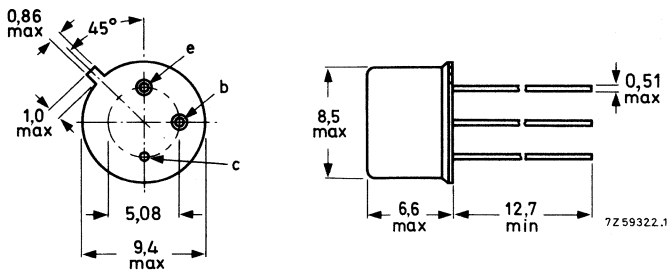
Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (d.c.)	I_C	max.	700	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	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 PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

P-N-P complements are 2N3905 and 2N3906.

QUICK REFERENCE DATA

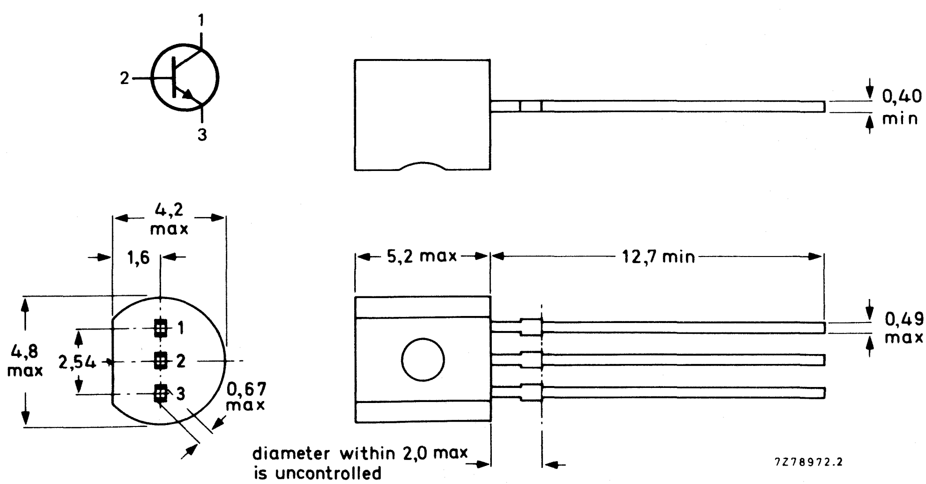
Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (d.c.)	I_C	max.	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	mW
Junction temperature	T_j	max.	150	°C

			2N3903	2N3904	
D.C. current gain I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	50	100	
		<	150	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}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	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	μS

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

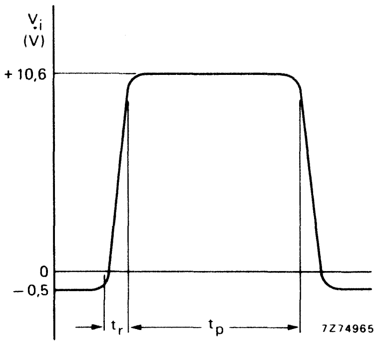


Fig. 2 Input waveform; $t_r < 1$ ns; $t_p = 300$ ns; $\delta = 0{,}02$.

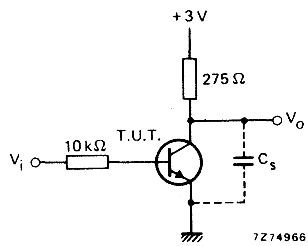


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

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

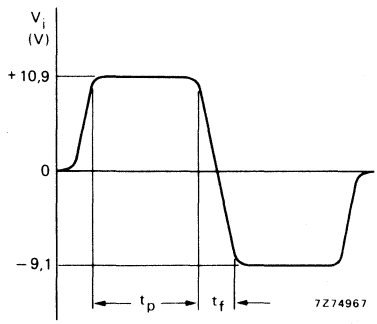


Fig. 4 Input waveform; $t_f < 1$ ns; 10 μs $< t_p <$ 500 μs; $\delta = 0{,}02$.

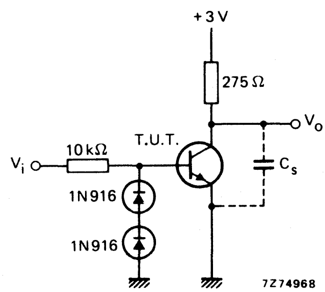


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

N-P-N complements are 2N3903 and 2N3904.

QUICK REFERENCE DATA

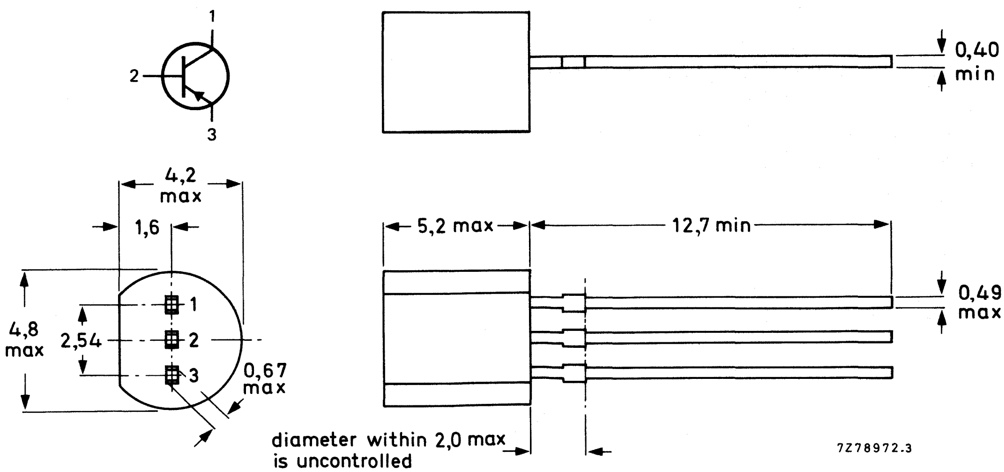
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	V
Collector current (d.c.)	$-I_C$	max.	200	mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350	mW
Junction temperature	T_j	max.	150	°C

			2N3905	2N3906	
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	50	100	
		<	150	300	
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250	MHz
Storage time $-I_{Con}$ = 10 mA; $-I_{Bon}$ = I_{Boff} = 1 mA	t_s	<	200	225	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.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	200 mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350 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	$R_{th\ j\text{-}a}$	=	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	$-V_{CEsat}$	<	250 mV
	$-V_{BEsat}$		650 to 850 mV
$-I_C$ = 50 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	<	400 mV
	$-V_{BEsat}$	<	950 mV

			2N3905	2N3906
D.C. current gain *				
$-I_C$ = 0,1 mA; V_{CE} = 1 V	h_{FE}	>	30	60
$-I_C$ = 1 mA; V_{CE} = 1 V	h_{FE}	>	40	80
$-I_C$ = 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	<	4,5	4,5 pF
Emitter capacitance at 100 kHz ⩽ f ⩽ 1 MHz $I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	<	10	10 pF
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250 MHz
Noise figure at R_S = 1 kΩ $-I_C$ = 100 μA; $-V_{CE}$ = 5 V f = 10 Hz to 15,7 kHz	F	<	5	4 dB

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

		2N3905	2N3906	
h-parameters (common emitter) $-I_C = 1$ mA; $-V_{CE} = 10$ V; f = 1 kHz				
Input impedance	h_{ie}	0,5 to 8	2 to 12	kΩ
Reverse voltage transfer ratio	h_{re}	0,1 to 5	0,1 to 10	10^{-4}
Small-signal current gain	h_{fe}	50 to 200	100 to 400	
Output admittance	h_{oe}	1 to 40	3 to 60	µS
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				
Delay time	t_d	< 35	35	ns
Rise time	t_r	< 35	35	ns

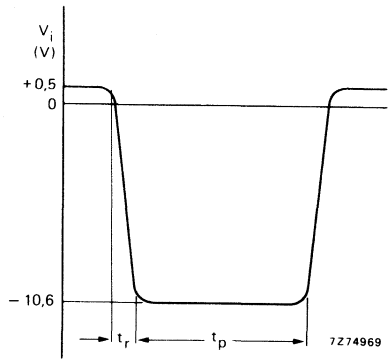


Fig. 2 Input waveform; $t_r < 1$ ns; $t_p = 300$ ns; $\delta = 0,02$.

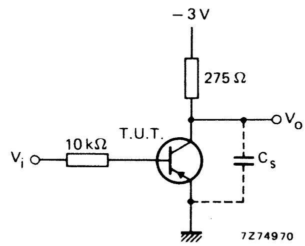


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

		2N3905	2N3906	
Turn-off time (see Figs 4 and 5) $-I_{Con} = 10$ mA; $-I_{Bon} = I_{Boff} = 1$ mA				
Storage time	t_s	< 200	225	ns
Fall time	t_f	< 60	75	ns

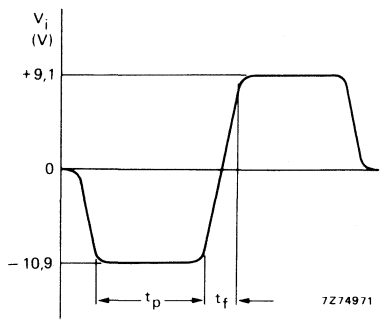


Fig. 4 Input waveform; $t_f < 1$ ns; $10\ \mu s < t_p < 500\ \mu s$; $\delta = 0,02$.

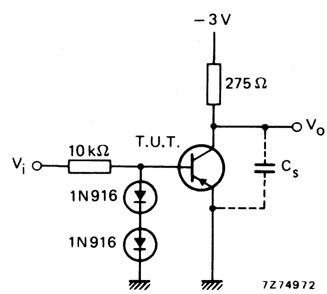


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

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

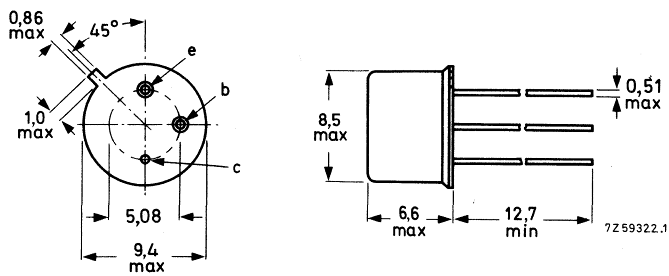
			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
Junction temperature	T_j	max.	200		°C
			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	
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
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.	4,0		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	$R_{th\ j\text{-}a}$	=	218	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	44	K/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 *
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V

* Measured under pulse conditions: $t_p = 300$ μs; $\delta \leqslant 0{,}01$.

			2N4030 2N4032	2N4031 2N4033	
Base-emitter voltage					
$-I_C$ = 500 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	<	1,1	1,1	V *
$-I_C$ = 1000 mA; $-V_{CE}$ = 1,0 V	$-V_{BE}$	<	1,2	–	V *
Saturation voltages					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0,15	0,15	V
	$-V_{BEsat}$	<	0,90	0,90	V *
$-I_C$ = 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 *						
$-I_C$ = 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	
$-I_C$ = 5000 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

* Measured under pulse conditions: t_p = 300 μs; $\delta \leqslant$ 0,01.

Switching times

$-I_{Con}$ = 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

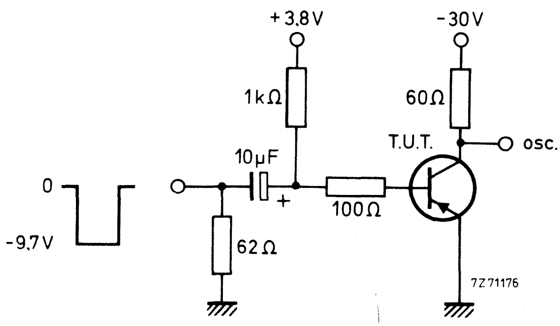


Fig. 2 Switching circuit.

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

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

P-N-P complements are 2N4125 and 2N4126.

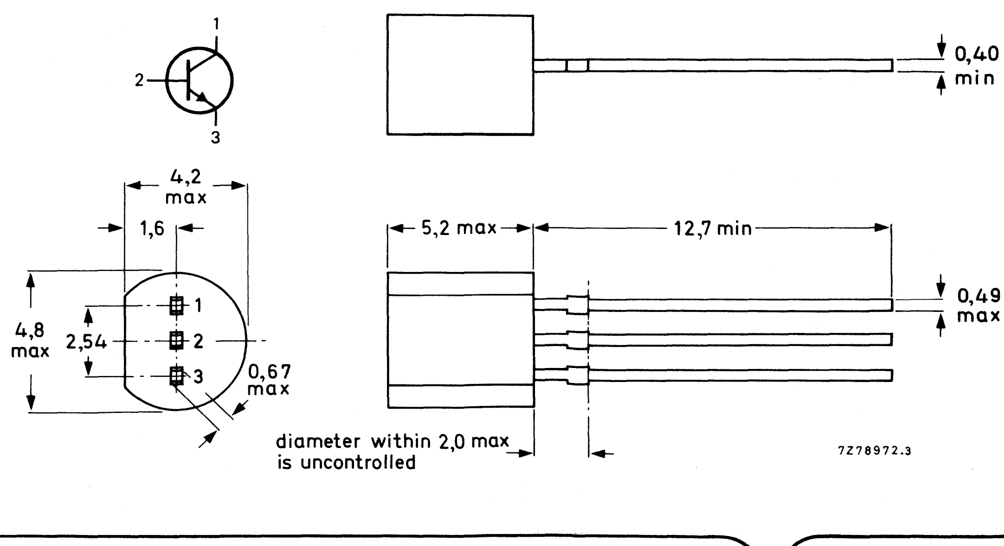
QUICK REFERENCE DATA

			2N4123	2N4124	
Collector-base voltage (open emitter)	V_{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 up to 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}	> <	50 200	120 480	
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 up to T_{amb} = 25 °C	P_{tot}	max.	350		mW
→ Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1000		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	$R_{th\ j\text{-}a}$	=	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 PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

N-P-N complements are 2N4123 and 2N4124.

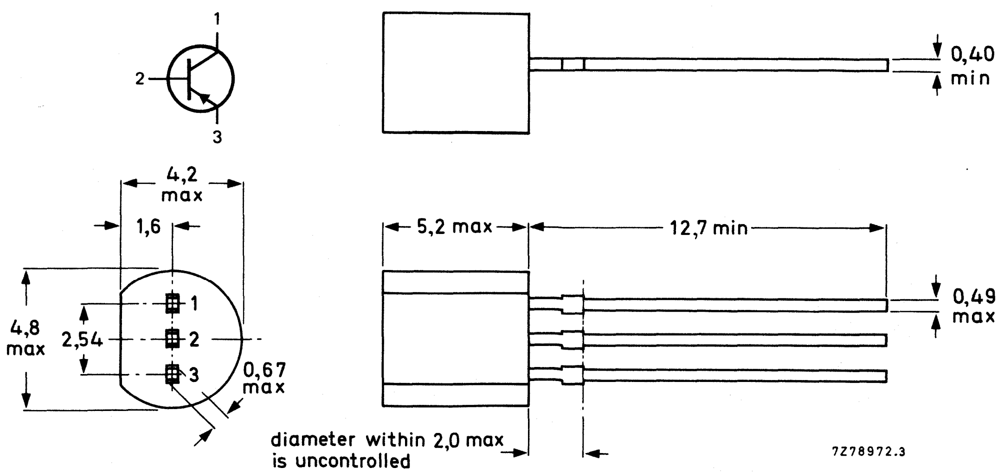
QUICK REFERENCE DATA

			2N4125	2N4126	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	25	V
Collector current (d.c.)	$-I_C$	max.	200	200	mA
Total power dissipation up to 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}	> <	50 200	120 480	
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250	MHz
Noise figure at R_S = 1 kΩ $-I_C$ = 100 μA; $-V_{CE}$ = 5 V f = 10 Hz to 15,7 kHz	F	<	5	4	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N4125	2N4126	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4		V
Collector current (d.c.)	$-I_C$	max.	200		mA
→ Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	350		mW
→ Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1000		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	$R_{th\ j\text{-}a}$	=	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	$-V_{CEsat}$	<	400	mV
	$-V_{BEsat}$	<	950	mV

			2N4125	2N4126	
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	<	4,5	4,5	pF
Emitter capacitance at f = 100 kHz $I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	<	10	10	pF
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>	200	250	MHz
Noise figure at R_S = 1 kΩ $-I_C$ = 100 μA; $-V_{CE}$ = 5 V f = 10 Hz to 15,7 kHz	F	<	5	4	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 PLANAR EPITAXIAL TRANSISTORS

N-P-N silicon planar epitaxial transistors in plastic TO-92 envelope for use in general purpose applications.

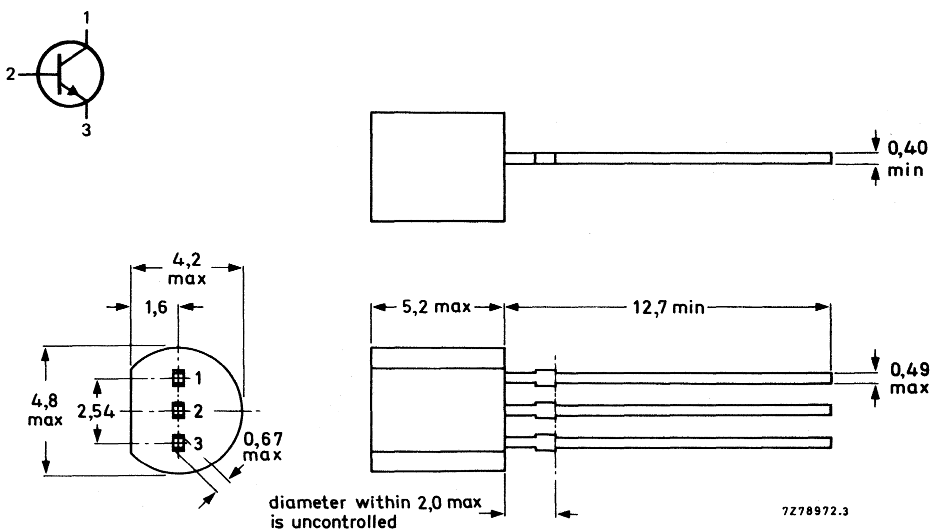
QUICK REFERENCE DATA

			2N4400	2N4401	
Collector-emitter voltage (open base)	V_{CEO}	max.	40		V
Collector-base voltage (open emitter)	V_{CBO}	max.	60		V
Collector current (d.c.)	I_C	max.	600		mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	max.	0,75		V
D.C. current gain I_C = 100 mA; V_{CE} = 2 V	h_{FE}	min.	50	150	
		max.	100	300	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N4400	2N4401	
Collector-emitter voltage (open base)	V_{CEO}	max.	40		V
Collector-base voltage (open emitter)	V_{CBO}	max.	60		V
Emitter-base voltage (open collector)	V_{EBO}	max.	6		V
Collector current (d.c.)	I_C	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N4400	2N4401	
Collector-emitter breakdown voltage I_B = 0; I_C = 1 mA	$V_{(BR)CEO}$	min.	40		V
Collector-base breakdown voltage I_E = 0; I_C = 0,1 mA	$V_{(BR)CBO}$	min.	60		V
Emitter-base breakdown voltage I_E = 0,1 mA; I_C = 0	$V_{(BR)EBO}$	min.	6		V
Base cut-off current V_{CE} = 35 V; $-V_{BE}$ = 0,4 V	I_{BEX}	max.	0,1		μA
Collector cut-off current V_{CE} = 35 V; $-V_{BE}$ = 0,4 V	I_{CEX}	max.	0,1		μA
D.C. current gain I_C = 0,1 mA; V_{CE} = 1 V	h_{FE}	min.	20		
I_C = 1 mA; V_{CE} = 1 V	h_{FE}	min.	20	40	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	min.	40	80	
I_C = 150 mA; V_{CE} = 1 V	h_{FE}	min.	50	100	
		max.	150	300	
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	min.	20	40	
Saturation voltages I_C = 150 mA; I_B = 15 mA	V_{CEsat}	max.	0,4		V
	V_{BEsat}	min.	0,75		V
		max.	0,95		V
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	max.	0,75		V
	V_{BEsat}	max.	1,2		V

			2N4400	2N4401	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 10 V	f_T	min.	200	250	MHz
Collector-base capacitance I_E = 0; V_{CB} = 5 V; f = 100 kHz	C_c	max.	6,5	6,5	pF
Emitter-base capacitance I_C = 0; V_{BE} = 0,5 V; f = 100 kHz	C_e	max.	30	30	pF
Input impedance at f = 1 kHz I_C = 1 mA; V_{CE} = 10 V	h_{ie}	min. max.	0,5 7,5	1,0 15	kΩ kΩ
Voltage feedback ratio at f = 1 kHz I_C = 1 mA; V_{CE} = 10 V	h_{re}	min. max.	0,1 8,0	0,1 8,0	$\times 10^{-4}$ $\times 10^{-4}$
Small-signal current gain I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	min. max.	20 250	40 500	
Output admittance at f = 1 kHz I_C = 1 mA; V_{CE} = 10 V	h_{oe}	min. max.	1,0 30	1,0 30	µS µS

Switching times (resistive load)

			2N4400 / 2N4401	
Turn-on time I_C = 150 mA; I_{B1} = 15 mA; V_{CC} = 30 V; V_{EB} = 2 V				
delay time	t_d	max.	15	ns
rise time	t_r	max.	20	ns
Turn-off time I_C = 150 mA; I_{B1} = I_{B2} = 15 mA; V_{CC} = 30 V				
storage time	t_s	max.	225	ns
fall time	t_f	max.	30	ns

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P silicon planar epitaxial transistors in plastic TO-92 envelope for use in general purpose applications.

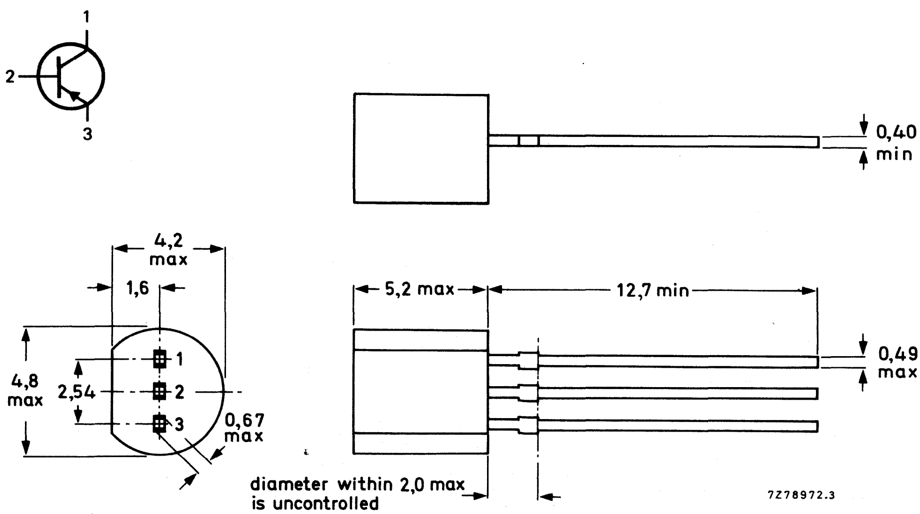
QUICK REFERENCE DATA

			2N4402	2N4403	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	40	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	40	V
Collector current (d.c.)	$-I_C$	max.	600	600	mA
Total device dissipation at T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Collector-emitter saturation voltage $-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	max.	0,75	0,75	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	min.	50	150	
		max.	100	300	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N4402	2N4403	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40		V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40		V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current (d.c.)	$-I_C$	max.	600		mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N4402	2N4403	
Collector-emitter breakdown voltage I_B = 0; $-I_C$ = 1 mA	$-V_{(BR)CEO}$	min.	40		V
Collector-base breakdown voltage I_E = 0; $-I_C$ = 0,1 mA	$-V_{(BR)CBO}$	min.	40		V
Emitter-base breakdown voltage $-I_E$ = 0,1 mA; I_C = 0	$-V_{(BR)EBO}$	min.	5		V
Base cut-off current $-V_{CE}$ = 35 V; V_{BE} = 0,4 V	$-I_{BEX}$	max.	0,1		μA
Collector cut-off current $-V_{CE}$ = 35 V; V_{BE} = 0,4 V	$-I_{CEX}$	max.	0,1		μA
D.C. current gain $-I_C$ = 0,1 mA; $-V_{CE}$ = 1 V	h_{FE}	min.		30	
$-I_C$ = 1 mA; $-V_{CE}$ = 1 V	h_{FE}	min.	30	60	
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	min.	50	100	
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	min.	50	150	
		max.	150	300	
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	h_{FE}	min.	20		
Saturation voltages $-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	max.	0,4		V
	$-V_{BEsat}$	min.	0,75		V
		max.	0,95		V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	max.	0,75		V
	$-V_{BEsat}$	max.	1,3		V

			2N4402	2N4403	
Transition frequency at f = 100 MHz $-I_C$ = 20 mA; $-V_{CE}$ = 10 V	f_T	min.	150	200	MHz
Collector-base capacitance I_E = 0; $-V_{CB}$ = 10 V; f = 140 kHz	C_{cb}	max.	8,5	8,5	pF
Emitter-base capacitance I_C = 0; $-V_{BE}$ = 0,5 V; f = 140 kHz	C_{eb}	max.	30	30	pF
Input impedance at f = 1 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{ie}	min. max.	0,75 7,5	1,5 15	kΩ kΩ
Voltage feedback ratio at f = 1 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{re}	min. max.	0,1 8,0	0,1 8,0	$\times 10^{-4}$ $\times 10^{-4}$
Small-signal current gain $-I_C$ = 1 mA; $-V_{CE}$ = 10 V; f = 1 kHz	h_{fe}	min. max.	30 250	60 500	
Output admittance at f = 1 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{oe}	min. max.	1,0 100	1,0 100	µS µS

Switching times (resistive load)

Turn-on time $-I_C$ = 150 mA; $-I_{B1}$ = 15 mA; $-V_{CC}$ = 30 V; $-V_{EB}$ = 2 V				
delay time	t_d	max.	15	ns
rise time	t_r	max.	20	ns
Turn-off time $-I_C$ = 150 mA; $-I_{B1}$ = I_{B2} = 15 mA; $-V_{CC}$ = 30 V				
storage time	t_s	max.	225	ns
fall time	t_f	max.	30	ns

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P small-signal transistors in plastic TO-92 envelope intended for low-noise stages in audio equipment. Complementary types are 2N5088/2N5089.

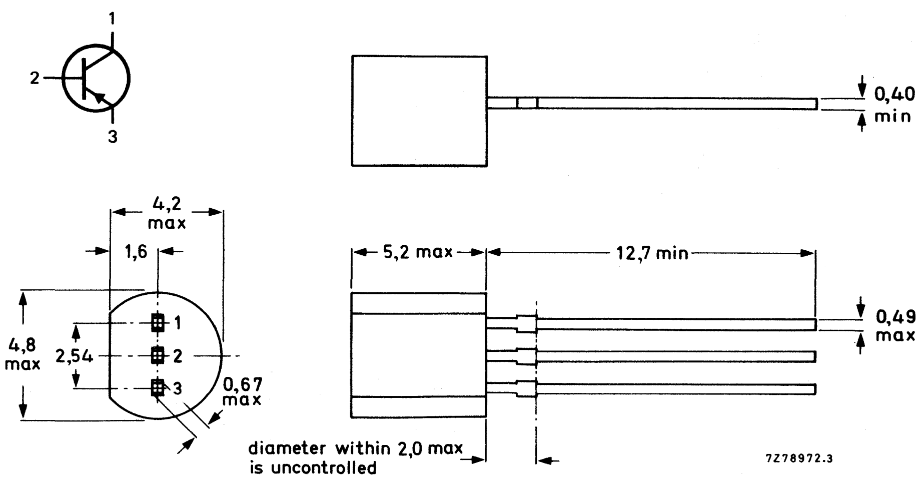
QUICK REFERENCE DATA

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	50		V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50		V
Collector current (d.c.)	$-I_C$	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Collector-emitter saturation voltage $-I_C$ = 10 mA; $-I_B$ = 1 mA	$-V_{CEsat}$	max.	0,3		V
			2N5086	2N5087	
D.C. current gain $-I_C$ = 1 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	150	250	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

Collector-emitter voltage (open base)	$-V_{CEO}$	max.	50	V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3,0	V
Collector current (d.c.)	$-I_C$	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	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	$R_{th\ j\text{-}a}$	=	200	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector-emitter breakdown voltage $I_B = 0$; $-I_C$ = 1 mA	$-V_{(BR)CEO}$	min.	50	V
Collector-base breakdown voltage $I_E = 0$; $-I_C$ = 100 μA	$-V_{(BR)CBO}$	min.	50	V
Collector cut-off current $-V_{CB}$ = 10 V; $I_E = 0$	$-I_{CBO}$	max.	10	nA
$-V_{CB}$ = 35 V; $I_E = 0$	$-I_{CBO}$	max.	50	nA
Emitter cut-off current $-V_{EB}$ = 3 V; $I_C = 0$	$-I_{EBO}$	max.	50	nA
Collector-emitter saturation voltage $-I_C$ = 10 mA; $-I_B$ = 1 mA	$-V_{CEsat}$	max.	0,3	V
Base-emitter ON-voltage $-I_C$ = 1 mA; $-V_{CE}$ = 5 V	$-V_{BEon}$	max.	0,85	V
Transition frequency at f = 20 MHz $-I_C$ = 500 μA; $-V_{CE}$ = 5 V	f_T	min.	40	MHz
Collector capacitance at f = 100 kHz $-V_{CB}$ = 5 V; $I_E = 0$	C_c	max.	4,0	pF

			2N5086	2N5087
D.C. current gain $-I_C$ = 100 μA; $-V_{CE}$ = 5 V	h_{FE}	min.	150	250
		max.	500	800
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	150	250
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	150	250
Small-signal current gain at f = 1 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 5 V	h_{fe}	min.	150	250
		max.	600	900

			2N5086	2N5087	
Noise figure at $-V_{CE}$ = 5 V; T_{amb} = 25 °C					
$-I_C$ = 20 μA; R_S = 10 kΩ; f = 10 Hz to 15,7 kHz	F	max.	3,0	2,0	dB
$-I_C$ = 100 μA; R_S = 3 kΩ; f = 1 kHz	F	max.	3,0	2,0	dB

DEVELOPMENT DATA

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N small-signal transistor in plastic TO-92 envelope intended for low-noise stages in audio equipment. Complementary types are 2N5086/2N5087.

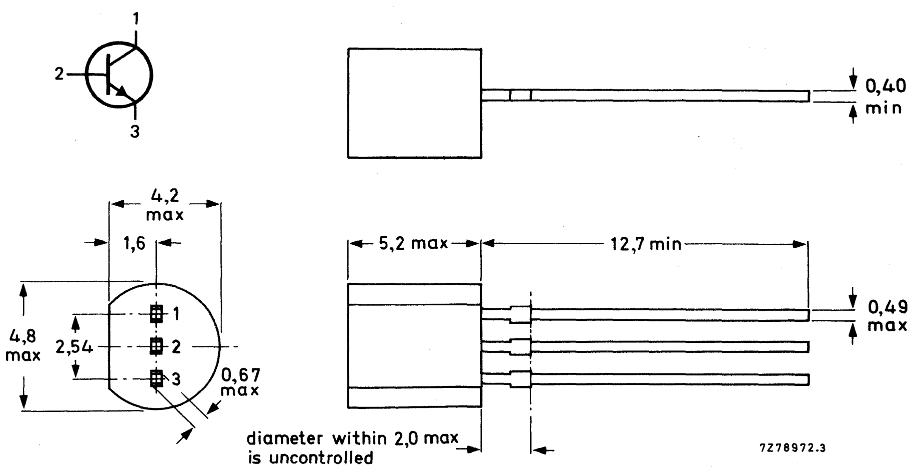
QUICK REFERENCE DATA

			2N5088	2N5089	
Collector-emitter voltage (open base)	V_{CEO}	max.	30	25	V
Collector-base voltage (open emitter)	V_{CBO}	max.	35	30	V
Collector current (d.c.)	I_C	max.	50	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625	625	mW
Collector-emitter saturation voltage I_C = 10 mA; I_B = 1 mA	V_{CEsat}	max.	0,5	0,5	V
D.C. current gain I_C = 1 mA; V_{CE} = 5 V	h_{FE}	min.	350	450	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N5088	2N5089	
Collector-emitter voltage (open base)	V_{CEO}	max.	30	25	V
Collector-base voltage (open emitter)	V_{CBO}	max.	35	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4,5		V
Collector current (d.c.)	I_C	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	625		mW
Storage temperature range	T_{stg}		−55 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N5088	2N5089	
Collector-emitter breakdown voltage $I_B = 0$; I_C = 1 mA	$V_{(BR)CEO}$	min.	30	25	V
Collector-base breakdown voltage $I_E = 0$; I_C = 100 μA	$V_{(BR)CBO}$	min.	35	30	V
Collector cut-off current V_{CB} = 20 V; $I_E = 0$	I_{CBO}	max.	50		nA
Emitter cut-off current V_{EBoff} = 3 V; $I_C = 0$	I_{EBO}	max.	50		nA
V_{EBoff} = 4,5 V; $I_C = 0$	I_{EBO}	max.	100		nA
Collector-emitter saturation voltage I_C = 10 mA; I_B = 1 mA	V_{CEsat}	max.	0,5		V
Base-emitter ON-voltage I_C = 10 mA; V_{CE} = 5 V	V_{BEon}	max.	0,8		V
Transition frequency at f = 20 MHz I_C = 500 μA; V_{CE} = 5 V	f_T	min.	50		MHz
D.C. current gain I_C = 100 μA; V_{CE} = 5 V	h_{FE}	min.	300	400	
		max.	900	1200	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	min.	350	450	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	300	400	
Small-signal current gain at f = 1 kHz I_C = 1 mA; V_{CE} = 5 V	h_{fe}	min.	350	450	
		max.	1400	1800	
Noise figure at R_S = 10 kΩ; T_{amb} = 25 °C I_C = 100 μA; V_{CE} = 5 V; f = 10 Hz to 15,7 kHz	F	max.	3,0	2,0	dB

Collector capacitance at f = 100 kHz			
V_{CB} = 5 V; I_E = 0	C_c	max.	4,0 pF
Emitter capacitance at f = 100 kHz			
V_{BE} = 0,5 V; I_C = 0	C_e	max.	10 pF

DEVELOPMENT DATA

SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

P-N-P high-voltage small-signal transistors for general purposes and especially in telephony applications and encapsulated in a TO-92 envelope.

N-P-N complements are 2N5550 and 2N5551.

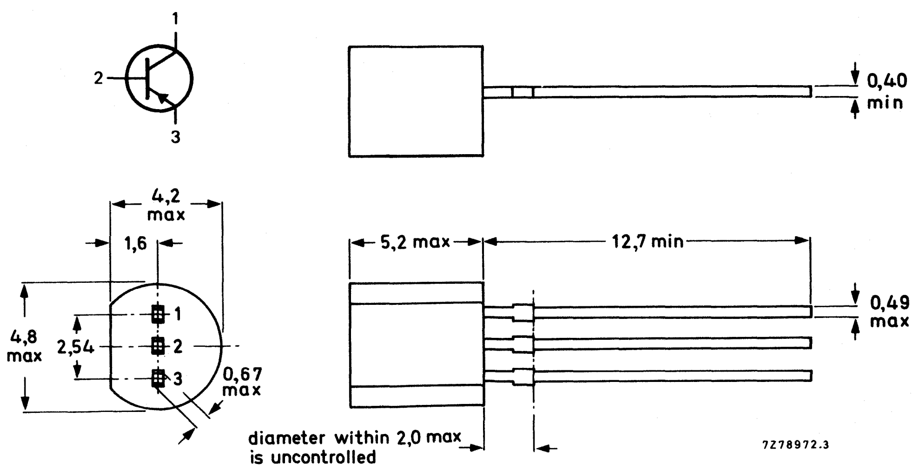
QUICK REFERENCE DATA

			2N5400	2N5401	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	130	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	120	150	V
Collector current	$-I_C$	max.	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,5	0,5	V
D.C. current gain I_C = 10 mA; V_{CE} = −5 V	h_{FE}	min.	40	60	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N5400	2N5401	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	130	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	120	150	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current	$-I_C$	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−65 to + 150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\,j\text{-}a}$	max.	250	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N5400	2N5401	
Collector cut-off current					
$I_E = 0$; $-V_{CB}$ = 100 V	$-I_{CBO}$	max.	100		nA
$I_E = 0$; $-V_{CB}$ = 120 V	$-I_{CBO}$	max.		50	nA
$I_E = 0$; $-V_{CB}$ = 100 V; T_{amb} = 100 °C	$-I_{CBO}$	max.	100		μA
$I_E = 0$; $-V_{CB}$ = 120 V; T_{amb} = 100 °C	$-I_{CBO}$	max.		50	μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB}$ = 4,0 V	$-I_{EBO}$	max.	50	50	nA
Breakdown voltages					
I_C = 1,0 mA; $I_B = 0$	$-V_{(BR)CEO}$	min.	120	150	V
I_C = 100 μA; $I_E = 0$	$-V_{(BR)CBO}$	min.	130	160	V
$I_C = 0$; I_E = 10 μA	$-V_{(BR)EBO}$	min.	5,0	5,0	V
Saturation voltages					
$-I_C$ = 10 mA; $-I_B$ = 1,0 mA	$-V_{CEsat}$	max.	0,2	0,2	V
	$-V_{BEsat}$	max.	1,0	1,0	V
$-I_C$ = 50 mA; $-I_B$ = 5,0 mA	$-V_{CEsat}$	max.	0,5	0,5	V
	$-V_{BEsat}$	max.	1,0	1,0	V
D.C. current gain					
I_C = 1,0 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	30	50	
I_C = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	40	60	
		max.	180	240	
I_C = 50 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	40	50	
Small-signal current gain					
I_C = 1,0 mA; $-V_{CE}$ = 10 V; f = 1 kHz	h_{fe}	min.	30	40	
		max.	200	200	
Output capacitance at f = 1 MHz					
$I_E = 0$; $-V_{CB}$ = 10 V	C_o	max.	6	6	pF

			2N5400	2N5401	
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	min. max.	100 400	100 300	MHz MHz
Noise figure at R_S = 1 kΩ I_C = 250 μA; $-V_{CE}$ = 5 V; f = 10 Hz to 15,7 kHz	F	max.	8	8	dB

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

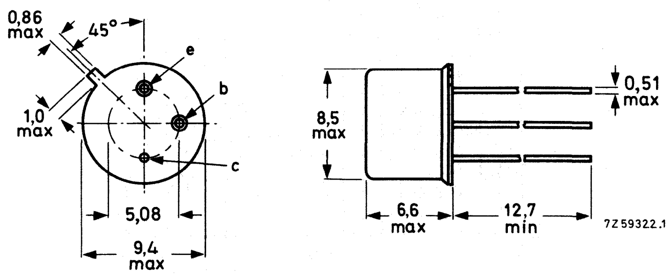
			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current (d.c.)	$-I_C$	max.	1	1	A
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1	1	W
Junction temperature	T_j	max.	200	200	°C
D.C. current 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)

			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
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_{case} = 25 °C	P_{tot}	max.	10		W
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1		W

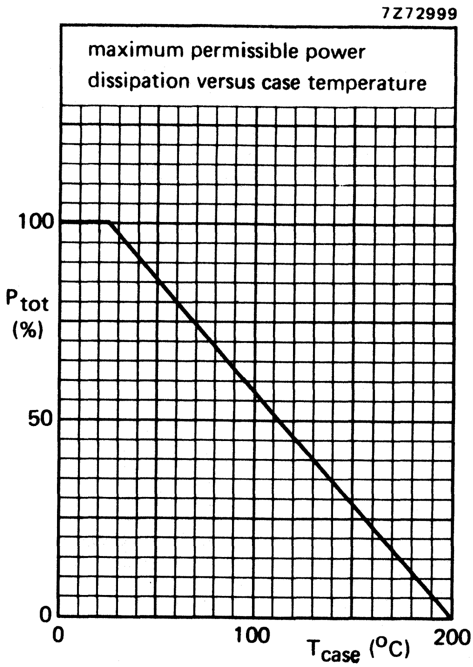


Fig. 2.

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

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	17,5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	150	K/W

CHARACTERISTICS

T_{case} = 25 °C unless otherwise specified

			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* ←

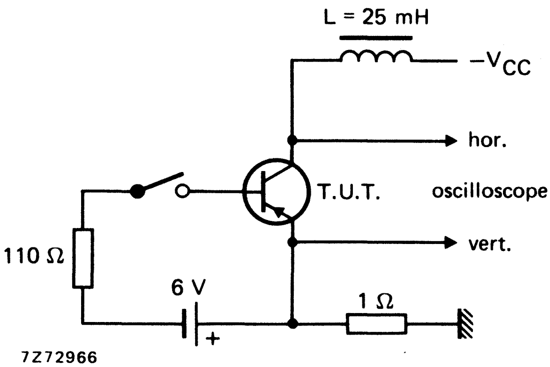


Fig. 3 Test circuit for $V_{CEOsust}$.

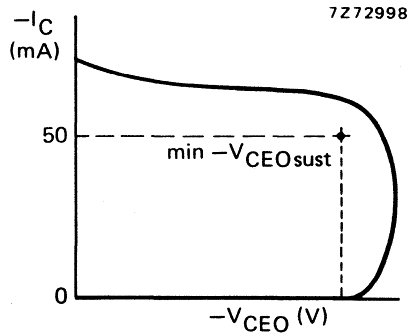


Fig. 4 Oscilloscope display for $V_{CEOsust}$.

			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

* Measured under pulse conditions to avoid excessive dissipation.

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 N-P-N HIGH-VOLTAGE TRANSISTORS

N-P-N high-voltage small-signal transistors for general purposes and especially telephony applications and encapsulated in a TO-92 envelope.

P-N-P complements are 2N5400 and 2N5401.

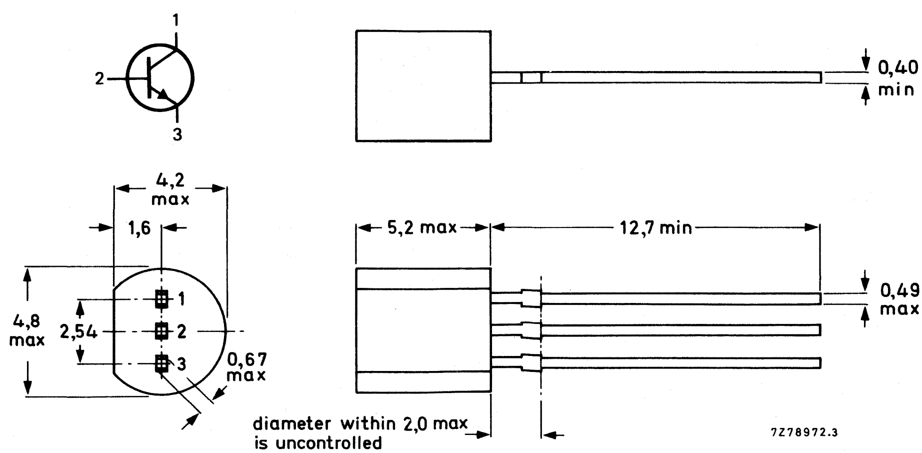
QUICK REFERENCE DATA

			2N5550	2N5551	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	180	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	160	V
Collector current	I_C	max.	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150	150	°C
Collector-emitter saturation voltage I_C = 50 mA; I_B = 5 mA	V_{CEsat}	max.	0,25	0,20	V
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



RATINGS

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

			2N5550	2N5551	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	180	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	160	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6		V
Collector current	I_C	max.	600		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500		mW
Junction temperature	T_j	max.	150		°C
Storage temperature	T_{stg}		−65 to + 150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	max.	250	K/W

CHARACTERISTICS

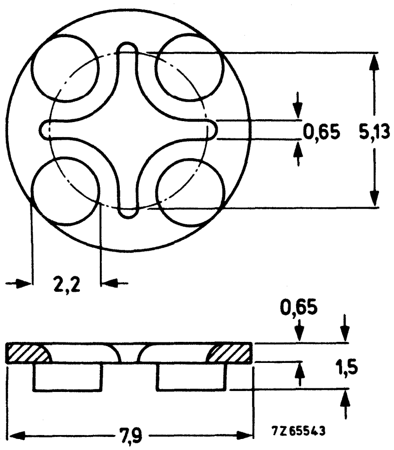
T_{amb} = 25 °C unless otherwise specified

			2N5550	2N5551	
Collector cut-off current					
$I_E = 0$; V_{CB} = 100 V	I_{CBO}	max.	100		nA
$I_E = 0$; V_{CB} = 120 V	I_{CBO}	max.		50	nA
$I_E = 0$; V_{CB} = 100 V; T_{amb} = 100 °C	I_{CBO}	max.	100		μA
$I_E = 0$; V_{CB} = 120 V; T_{amb} = 100 °C	I_{CBO}	max.		50	μA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 4,0 V	I_{EBO}	max.	50	50	nA
Breakdown voltages					
I_C = 1,0 mA; $I_B = 0$	$V_{(BR)CEO}$	min.	140	160	V
I_C = 100 μA; $I_E = 0$	$V_{(BR)CBO}$	min.	160	180	V
$I_C = 0$; I_E = 10 μA	$V_{(BR)EBO}$	min.	6,0	6,0	V
Saturation voltages					
I_C = 10 mA; I_B = 1,0 mA	V_{CEsat}	max.	0,15	0,15	V
	V_{BEsat}	max.	1,0	1,0	V
I_C = 50 mA; I_B = 5,0 mA	V_{CEsat}	max.	0,25	0,20	V
	V_{BEsat}	max.	1,2	1,0	V
D.C. current gain					
I_C = 1,0 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	60	80	
		max.	250	250	
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	min.	20	30	
Small-signal current gain					
I_C = 1,0 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	min.	50	50	
		max.	200	200	
Output capacitance at f = 1 MHz					
$I_E = 0$; V_{CB} = 10 V	C_o	max.	6	6	pF
Input capacitance at f = 1 MHz					
$I_C = 0$; V_{EB} = 0,5 V	C_i	max.	30	30	pF

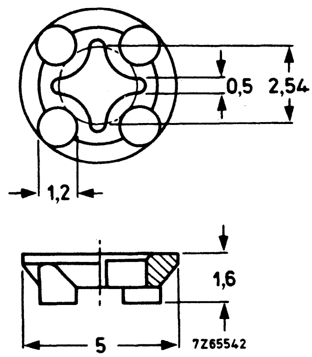
			2N5550	2N5551	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 10 V	f_T	min.	100	100	MHz
		max.	300	300	MHz
Noise figure at R_S = 1 kΩ I_C = 250 μA; V_{CE} = 5 V; f = 10 Hz to 15,7 kHz	F	max.	10	8	dB

MECHANICAL DATA

Dimensions in mm



Distance disc 56245 for TO-5 or TO-39; insulating material.

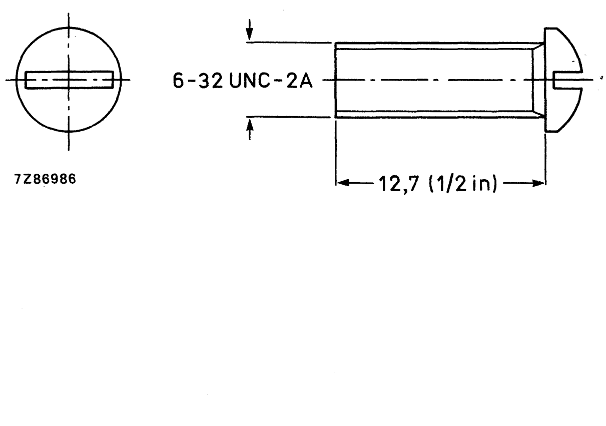


Distance disc 56246 for TO-18 or TO-72; insulating material.

Maximum permissible temperature: 100 °C.

ROUND HEAD SCREW 6-32 UNC-2A

Available, upon request, under type number 56396 or 12 NC code number 9390 298 10xx0.



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INDEX OF TYPE NUMBERS

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

Mm = Microminiature semiconductors for hybrid circuits
SD = Small-signal diodes
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes

type no.	book	section	type no.	book	section	type no.	book	section
BBY39	S1	T	BC639	S3	Sm	BCW69;R	S7	Mm
BBY40	S7/S1	Mm/T	BC640	S3	Sm	BCW70;R	S7	Mm
BC107	S3	Sm	BC807	S7	Mm	BCW71;R	S7	Mm
BC108	S3	Sm	BC808	S7	Mm	BCW72;R	S7	Mm
BC109	S3	Sm	BC817	S7	Mm	BCW81;R	S7	Mm
BC140	S3	Sm	BC818	S7	Mm	BCW89;R	S7	Mm
BC141	S3	Sm	BC846	S7	Mm	BCX17;R	S7	Mm
BC160	S3	Sm	BC847	S7	Mm	BCX18;R	S7	Mm
BC161	S3	Sm	BC848	S7	Mm	BCX19;R	S7	Mm
BC177	S3	Sm	BC849	S7	Mm	BCX20;R	S7	Mm
BC178	S3	Sm	BC850	S7	Mm	BCX51	S7	Mm
BC179	S3	Sm	BC856	S7	Mm	BCX52	S7	Mm
BC264A	S5	FET	BC857	S7	Mm	BCX53	S7	Mm
BC264B	S5	FET	BC858	S7	Mm	BCX54	S7	Mm
BC264C	S5	FET	BC859	S7	Mm	BCX55	S7	Mm
BC264D	S5	FET	BC860	S7	Mm	BCX56	S7	Mm
BC327;A	S3	Sm	BC868	S7	Mm	BCX58	S3	Sm
BC328	S3	Sm	BC869	S7	Mm	BCX59	S3	Sm
BC337;A	S3	Sm	BCF29;R	S7	Mm	BCX70*	S7	Mm
BC338	S3	Sm	BCF30;R	S7	Mm	BCX71*	S7	Mm
BC368	S3	Sm	BCF32;R	S7	Mm	BCX78	S3	Sm
BC369	S3	Sm	BCF33;R	S7	Mm	BCX79	S3	Sm
BC375	S3	Sm	BCF70;R	S7	Mm	BCY56	S3	Sm
BC376	S3	Sm	BCF81;R	S7	Mm	BCY57	S3	Sm
BC516	S3	Sm	BCV26	S7	Mm	BCY58	S3	Sm
BC517	S3	Sm	BCV27	S7	Mm	BCY59	S3	Sm
BC546	S3	Sm	BCV61	S7	Mm	BCY65	S3	Sm
BC547	S3	Sm	BCV62	S7	Mm	BCY70	S3	Sm
BC548	S3	Sm	BCV63	S7	Mm	BCY71	S3	Sm
BC549	S3	Sm	BCV64	S7	Mm	BCY72	S3	Sm
BC550	S3	Sm	BCV65	S7	Mm	BCY78	S3	Sm
BC556	S3	Sm	BCV71;R	S7	Mm	BCY79	S3	Sm
BC557	S3	Sm	BCV72;R	S7	Mm	BCY87	S3	Sm
BC558	S3	Sm	BCW29;R	S7	Mm	BCY88	S3	Sm
BC559	S3	Sm	BCW30;R	S7	Mm	BCY89	S3	Sm
BC560	S3	Sm	BCW31;R	S7	Mm	BD131	S4a	P
BC635	S3	Sm	BCW32;R	S7	Mm	BD132	S4a	P
BC636	S3	Sm	BCW33;R	S7	Mm	BD135	S4a	P
BC637	S3	Sm	BCW60*	S7	Mm	BD136	S4a	P
BC638	S3	Sm	BCW61*	S7	Mm	BD137	S4a	P

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
T = Tuner diodes

P = Low-frequency power transistors

P = Low-frequency power transistors

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microniature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
WBT = Wideband transistors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
RT = Tripler
Sm = Small-signal transistors
ThM = Thyristor modules
WBM = Wideband hybrid IC modules
WBT = Wideband transistors

* = series
FET = Field-effect transistors
RFP = R.F. power transistors and modules
ThM = Thyristor modules
WBM = Wideband hybrid IC modules

type no.	book	section	type no.	book	section	type no.	book	section
BLW33	S6	RFP	BLX94C	S6	RFP	BRY62	S7	Mm
BLW34	S6	RFP	BLX95	S6	RFP	BS107	S5	FET
BLW50F	S6	RFP	BLX96	S6	RFP	BS170	S5	FET
BLW60	S6	RFP	BLX97	S6	RFP	BSD10	S5	FET
BLW60C	S6	RFP	BLX98	S6	RFP	BSD12	S5	FET
BLW76	S6	RFP	BLY87A	S6	RFP	BSD20	S5/7	FET
BLW77	S6	RFP	BLY87C	S6	RFP	BSD22	S5/7	FET
BLW78	S6	RFP	BLY88A	S6	RFP	BSD212	S5	FET
BLW79	S6	RFP	BLY88C	S6	RFP	BSD213	S5	FET
BLW80	S6	RFP	BLY89A	S6	RFP	BSD214	S5	FET
BLW81	S6	RFP	BLY89C	S6	RFP	BSD215	S5	FET
BLW83	S6	RFP	BLY90	S6	RFP	BSR12;R	S7	Mm
BLW84	S6	RFP	BLY91A	S6	RFP	BSR13;R	S7	Mm
BLW85	S6	RFP	BLY91C	S6	RFP	BSR14;R	S7	Mm
BLW86	S6	RFP	BLY92A	S6	RFP	BSR15;R	S7	Mm
BLW87	S6	RFP	BLY92C	S6	RFP	BSR16;R	S7	Mm
BLW89	S6	RFP	BLY93A	S6	RFP	BSR17;R	S7	Mm
BLW90	S6	RFP	BLY93C	S6	RFP	BSR17A;R	S7	Mm
BLW91	S6	RFP	BLY94	S6	RFP	BSR18;R	S7	Mm
BLW95	S6	RFP	BPF24	S8b	PDT	BSR18A;R	S7	Mm
BLW96	S6	RFP	BPW22A	S8a/b	PDT	BSR19; A	S7	Mm
BLW97	S6	RFP	BPW50	S8a/b	PDT	BSR20; A	S7	Mm
BLW98	S6	RFP	BPW71	S8b	PDT	BSR30	S7	Mm
BLW99	S6	RFP	BPX25	S8b	PDT	BSR31	S7	Mm
BLX13	S6	RFP	BPX29	S8b	PDT	BSR32	S7	Mm
BLX13C	S6	RFP	BPX40	S8b	PDT	BSR33	S7	Mm
BLX14	S6	RFP	BPX41	S8b	PDT	BSR40	S7	Mm
BLX15	S6	RFP	BPX42	S8b	PDT	BSR41	S7	Mm
BLX39	S6	RFP	BPX61	S8b	PDT	BSR42	S7	Mm
BLX65	S6	RFP	BPX61P	S8b	PDT	BSR43	S7	Mm
BLX65E	S6	RFP	BPX71	S8b	PDT	BSR50	S3	Sm
BLX65ES	S6	RFP	BPX72	S8b	PDT	BSR51	S3	Sm
BLX67	S6	RFP	BR100/03	S2b	Th	BSR52	S3	Sm
BLX68	S6	RFP	BR101	S3	Sm	BSR56	S7/S5	Mm/FET
BLX69A	S6	RFP	BR210*	S2a	Th	BSR57	S7/S5	Mm/FET
BLX91A	S6	RFP	BR216*	S2a	Th	BSR58	S7/S5	Mm/FET
BLX91CB	S6	RFP	BR220*	S2a	Th	BSR60	S3	Sm
BLX92A	S6	RFP	BRY39	S3	Sm	BSR61	S3	Sm
BLX93A	S6	RFP	BRY56	S3	Sm	BSR62	S3	Sm
BLX94A	S6	RFP	BRY61	S7	Mm	BSS38	S3	Sm

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
PDT = Photodiodes or transistors
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
Th = Thyristors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
Th = Thyristors
Tri = Triacs

* = series
PM = Power MOS transistors
R = Rectifier diodes
SP = Low-frequency switching power transistors

* = series
LED = Light-emitting diodes
M = Microwave transistors
Mm = Microminiature semiconductors for hybrid circuits
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

* = series
A = Accessories
I = Infrared devices
LED = Light-emitting diodes
M = Microwave transistors
PhC = Photocouplers
SEN = Sensors

FET = Field-effect transistors
I = Infrared devices
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P = Low-frequency power transistors
PhC = Photocouplers
R = Rectifier diodes
SD = Small-signal diodes
SEN = Sensors
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
St = Rectifier stacks
WBM = Wideband hybrid IC modules

* = series
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M = Microwave transistors
P = Low-frequency power transistors
PhC = Photocouplers
R = Rectifier diodes
SD = Small-signal diodes
Vrf = Voltage reference diodes

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FET = Field-effect transistors
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
RFP = R.F. power transistors and modules
SD = Small-signal diodes
Sm = Small-signal transistors
WBT = Wideband transistors

A = Accessories
FET = Field-effect transistors
Ph = Photoconductive devices
PhC = Photocouplers
Sm = Small-signal diodes

DATA HANDBOOK SYSTEM

DATA HANDBOOK SYSTEM

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

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INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

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S4b **High-voltage and switching power transistors**

S5 **Field-effect transistors**

S6 **R.F. power transistors and modules**

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