DISCRETE SEMICONDUCTORS

Low-frequency Power Transistors and Hybrid IC Power Modules

BOOK SC05 1992

Philips Semiconductors

PHILIPS

Low frequency power transistors and hybrid IC power modules

Contents

TYPE SURVEY

SURVEY OF TRANSISTORS WITH CURRENTS UP TO 8 A

I_C (A)	V_{CEO} (V) MIN.	V_{CEO} (V) MAX.	TYPE	ENVELOPE SOT32	SOT223	TO-220	SOT186
1	40	100	npn			TIP29 - 29C	TIP29F - 29CF
			pnp			TIP30 - 30C	TIP30F - 30CF
1.5	45	80	npn	BD135 - 139			
			pnp	BD136 - 140			
	60	80	npn	BD228 - 230			
			pnp	BD229 - 231			
2	45	80	npn	BD233 - 237			
			pnp	BD234 - 238			
3		20	npn	BD329			
			pnp	BD330			
		45	npn	BD131			
			pnp	BD132			
	40	100	npn			TIP31 - 31C	TIP31F - 31CF
			pnp			TIP32 - 32C	TIP32F - 32CF
	45	120	npn		BDS933 - 941	BD933 - 941	BD933F - 941F
			pnp		BDS934 - 942	BD934 - 942	BD934F - 942F
	22	45	npn		BDS943 - 947		
			pnp		BDS944 - 948		
	60	120	npn		BDS949 - 955		
			pnp		BDS950 - 956		
	45	60	npn		BDS201 - 203		
			pnp		BDS202 - 204		
		80	npn		BDS77		
			pnp		BDS78		
4	22	80	npn	BD433 - 441			
			pnp	BD434 - 442			
	60	120	npn	BD719 - 725			
			pnp	BD720 - 726			
5	22	45	npn			BD943 - 947	BD943F - 947F
			pnp			BD944 - 948	BD944F - 948F
	60	120	npn			BD949 - 955	BD949F - 955F
			pnp			BD950 - 956	BD950F - 956F
	60	80	npn	BDX35 - 37			
6	40	100	npn			TIP41 - TIP41C	TIP41F - TIP41CF
			pnp			TIP42 - TIP42C	TIP42F - TIP42CF

SURVEY OF TRANSISTORS WITH CURRENTS UP TO 8 A

I_C (A)	V_{CEO} (V)		TYPE	ENVELOPE			
	MIN.	MAX.		SOT32	SOT223	TO-220	SOT186
8	45	60	npn			BD201 - 203	BD201F - 203F
			pnp			BD202 - 204	BD202F - 204F
		80	npn			BDX77	BDX77F
			pnp			BDX78	BDX78F

SURVEY OF TRANSISTORS WITH CURRENTS GREATER THAN 8 A

I_C (A)	V_{CEO} (V)		TYPE	ENVELOPE			
	MIN.	MAX.		TO-220	SOT186	SOT93	SOT199
10	40	100	npn			TIP33 - 33C	
			pnp			TIP34 - 34C	
		60	npn	TIP3055T			
			pnp	TIP2955T			
	60	100	npn	BDT91 - 95	BDT91F - 95F	BDV91 - 95	BDV91F - 95F
			pnp	BDT92 - 96	BDT92F - 96F	BDV92 - 96	BDV92F - 96F
15		60	npn			TIP3055	
			pnp			TIP2955	
	60	120	npn	BDT81 - 87	BDT81F - 87F		
			pnp	BDT82 - 88	BDT82F - 88F		

SURVEY OF DARLINGTONS WITH CURRENTS UP TO 8 A

I_C (A)	V_{CEO} (V) MIN.	V_{CEO} (V) MAX.	TYPE	ENVELOPE SOT32	SOT223	TO-220	SOT186	SOT82
1	45 (V_{CER})	80 (V_{CER})	npn	BDX42 - 44				
			pnp	BDX45 - 47				
3	60	120	npn		BDS61 - 61C			
			pnp		BDS60 - 60C			
	45	120	npn		BDS643 - 651			
			pnp		BDS644 - 652			
4	60	100	npn			TIP110 - 112		
			pnp			TIP115 - 117		
	45	120	npn	BD675 - 683				
			pnp	BD676 - 684				
	45	80	npn	BD675A - 79A				
			pnp	BD676A - 80A				
	60	120	npn			BDT61 - 61C	BDT61F - 61CF	
			pnp			BDT60 - 60C	BDT60F - 60CF	
5	60	100	npn			TIP120 - 122		
			pnp			TIP125 - 127		
6	60	120	npn					BD331 - 337
			pnp					BD332 - 338
8	45	120	npn			BD643 - 651	BD643F - 651F	
			pnp			BD644 - 652	BD644F - 652F	
	60	100	npn			TIP130 - 132		
			pnp			TIP135 - 137		

SURVEY OF DARLINGTONS WITH CURRENTS GREATER THAN 8 A

I_C (A)	V_{CEO} (V) MIN.	V_{CEO} (V) MAX.	TYPE	ENVELOPE TO-220	SOT186	SOT93	SOT199
10	60	120	npn	BDT63 - 63C	BDT63F - 63CF		
			pnp	BDT62 - 62C	BDT62F - 62CF		
	60	100	npn			TIP140 - 142	
			pnp			TIP145 - 147	
12	60	120	npn	BDT65 - 65C	BDT65F - 65CF	BDV65 - 65C	BDV65F - 65CF
			pnp	BDT64 - 64C	BDT64F - 64CF	BDV64 - 64C	BDV64F - 64CF
16	80	150	npn			BDV67A - 67D	BDV67AX - 67DX
			pnp			BDV66A - 66D	BDV66AX - 66DX

SELECTION GUIDE

DARLINGTONS IN SOT82 ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD331	npn	6	60	60	60	173
BD332	pnp	6	60	60	60	183
BD333	npn	6	80	80	60	173
BD334	pnp	6	80	80	60	183
BD335	npn	6	100	100	60	173
BD336	pnp	6	100	100	60	183
BD337	npn	6	120	120	60	173
BD338	pnp	6	120	120	60	183

TRANSISTORS IN TO-126 (SOT 32) ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD135	npn	1.5	45	45	8	65
BD136	pnp	1.5	45	45	8	75
BD226	npn	1.5	45	45	12.5	121
BD227	pnp	1.5	45	45	12.5	131
BD137	npn	1.5	60	60	8	65
BD138	pnp	1.5	60	60	8	75
BD228	npn	1.5	60	60	12.5	121
BD229	pnp	1.5	60	60	12.5	131
BD139	npn	1.5	80	100	8	65
BD140	pnp	1.5	80	100	8	75
BD230	npn	1.5	80	100	12.5	121
BD231	pnp	1.5	80	100	12.5	131
BD233	npn	2	45	45	25	141
BD234	pnp	2	45	45	25	149
BD235	npn	2	60	60	25	141
BD236	pnp	2	60	60	25	149
BD237	npn	2	80	100	25	141
BD238	pnp	2	80	100	25	149
BD329	npn	3	20	32	15	157
BD330	pnp	3	20	32	15	165
BD131	npn	3	45	70	15	47
BD132	pnp	3	45	45	15	57
BD433	npn	4	22	22	36	193
BD434	pnp	4	22	22	36	203
BD435	npn	4	32	32	36	193
BD436	pnp	4	32	32	36	203

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD437	npn	4	45	45	36	193
BD438	pnp	4	45	45	36	203
BD439	npn	4	60	60	36	193
BD440	pnp	4	60	60	36	203
BD441	npn	4	80	80	36	193
BD442	pnp	4	80	80	36	203
BD719	npn	4	60	60	36	283
BD720	pnp	4	60	60	36	291
BD721	npn	4	80	80	36	283
BD722	pnp	4	80	80	36	291
BD723	npn	4	100	100	36	283
BD724	pnp	4	100	100	36	291
BD725	npn	4	120	120	36	283
BD726	pnp	4	120	120	36	291
BDX35	npn	5	60	100	15	705
BDX36	npn	5	60	120	15	705
BDX37	npn	5	80	120	15	705

DARLINGTONS IN TO-126 (SOT32) ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDX42	npn	1	45*	60	1.25	713
BDX45	pnp	1	45*	60	1.25	721
BDX43	npn	1	60*	80	1.25	713
BDX46	pnp	1	60*	80	1.25	721
BDX44	npn	1	80*	90	1.25	713
BDX47	pnp	1	80*	90	1.25	721
BD675	npn	4	45	60	40	249
BD675A	npn	4	45	60	40	259
BD676	pnp	4	45	45	40	267
BD676A	pnp	4	45	45	40	275
BD677	npn	4	60	80	40	249
BD677A	npn	4	60	80	40	259
BD678	pnp	4	60	60	40	267
BD678A	pnp	4	60	60	40	275
BD679	npn	4	80	100	40	249
BD679A	npn	4	80	100	40	259
BD680	pnp	4	80	80	40	267
BD680A	pnp	4	80	80	40	275

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD681	npn	4	100	120	40	249
BD682	pnp	4	100	100	40	267
BD683	npn	4	120	140	40	249
BD684	pnp	4	120	120	40	267

Note

1. * V_{CER}.

TRANSISTORS IN TO-202 ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD825	npn	1	45	45	8	299
BD826	pnp	1	45	45	8	307
BD827	npn	1	60	60	8	299
BD828	pnp	1	60	60	8	307
BD829	npn	1	80	100	8	299
BD830	pnp	1	80	100	8	307
BD839	npn	1.5	45	45	10	315
BD840	pnp	1.5	45	45	10	323
BD841	npn	1.5	60	60	10	315
BD842	pnp	1.5	60	60	10	323
BD843	npn	1.5	80	100	10	315
BD844	pnp	1.5	80	100	10	323

TRANSISTORS IN SOT223 ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	I_{CM} (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDS933	npn	3	6	45	45	8	447
BDS934	pnp	3	6	45	45	8	453
BDS935	npn	3	6	60	60	8	447
BDS936	pnp	3	6	60	60	8	453
BDS937	npn	3	6	80	100	8	447
BDS938	pnp	3	6	80	100	8	453
BDS939	npn	3	6	100	120	8	447
BDS940	pnp	3	6	100	120	8	453
BDS941	npn	3	6	120	140	8	447
BDS942	pnp	3	6	120	140	8	453
BDS943	npn	3	7	22	22	8	459
BDS944	pnp	3	7	22	22	8	467
BDS945	npn	3	7	32	32	8	459

TRANSISTOR TYPE	POLARITY	I_C (A)	I_{CM} (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDS946	pnp	3	7	32	32	8	467
BDS947	npn	3	7	45	45	8	459
BDS948	pnp	3	7	45	45	8	467
BDS949	npn	3	7	60	60	8	475
BDS950	pnp	3	7	60	60	8	483
BDS951	npn	3	7	80	80	8	475
BDS952	pnp	3	7	80	80	8	483
BDS953	npn	3	7	100	100	8	475
BDS954	pnp	3	7	100	100	8	483
BDS955	npn	3	7	120	120	8	475
BDS956	pnp	3	7	120	120	8	483
BDS201	npn	3	7	45	60	8	421
BDS202	pnp	3	7	45	60	8	427
BDS203	npn	3	7	60	60	8	421
BDS204	pnp	3	7	60	60	8	427
BDS77	npn	3	7	80	100	8	421
BDS78	pnp	3	7	80	100	8	427

DARLINGTONS IN SOT223 ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	I_{CM} (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDS60	pnp	3	6	60	60	8	405
BDS61	npn	3	6	60	60	8	413
BDS60A	pnp	3	6	80	80	8	405
BDS61A	npn	3	6	80	80	8	413
BDS60B	pnp	3	6	100	100	8	405
BDS61B	npn	3	6	100	100	8	413
BDS60C	pnp	3	6	120	120	8	405
BDS61C	npn	3	6	120	120	8	413
BDS643	npn	3	7	45	60	8	433
BDS644	pnp	3	7	45	45	8	439
BDS645	npn	3	7	60	80	8	433
BDS646	pnp	3	7	60	60	8	439
BDS647	npn	3	7	80	100	8	433
BDS648	pnp	3	7	80	80	8	439
BDS649	npn	3	7	100	120	8	433
BDS650	pnp	3	7	100	100	8	439
BDS651	npn	3	7	120	140	8	433
BDS652	pnp	3	7	120	120	8	439

TRANSISTORS IN TO-220 (SOT78) ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP29	npn	1	40	80	30	733
TIP30	pnp	1	40	80	30	747
TIP29A	npn	1	60	100	30	733
TIP30A	pnp	1	60	100	30	747
TIP29B	npn	1	80	120	30	733
TIP30B	pnp	1	80	120	30	747
TIP29C	npn	1	100	140	30	733
TIP30C	pnp	1	100	140	30	747
TIP31	npn	3	40	80	40	761
TIP32	pnp	3	40	80	40	777
BD933	npn	3	45	45	30	331
BD934	pnp	3	45	45	30	345
BD935	npn	3	60	60	30	331
BD936	pnp	3	60	60	30	345
TIP31A	npn	3	60	100	40	761
TIP32A	pnp	3	60	100	40	777
BD937	npn	3	80	100	30	331
BD938	pnp	3	80	100	30	345
TIP31B	npn	3	80	120	40	761
TIP32B	pnp	3	80	120	40	777
BD939	npn	3	100	120	30	331
BD940	pnp	3	100	120	30	345
TIP31C	npn	3	100	140	40	761
TIP32C	pnp	3	100	140	40	777
BD941	npn	3	120	140	30	331
BD942	pnp	3	120	140	30	345
BD943	npn	5	22	22	40	357
BD944	pnp	5	22	22	40	371
BD945	npn	5	32	32	40	357
BD946	pnp	5	32	32	40	371
BD947	npn	5	45	45	40	357
BD948	pnp	5	45	45	40	371
BD949	npn	5	60	60	40	385
BD950	pnp	5	60	60	40	395
BD951	npn	5	80	80	40	385
BD952	pnp	5	80	80	40	395
BD953	npn	5	100	100	40	385
BD954	pnp	5	100	100	40	395

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BD955	npn	5	120	120	40	385
BD956	pnp	5	120	120	40	395
TIP41	npn	6	40	80	65	805
TIP42	pnp	6	40	80	65	821
TIP41A	npn	6	60	100	65	805
TIP42A	pnp	6	60	100	65	821
TIP41B	npn	6	80	120	65	805
TIP42B	pnp	6	80	120	65	821
TIP41C	npn	6	100	140	65	805
TIP42C	pnp	6	100	140	65	821
BD201	npn	8	45	60	60	85
BD202	pnp	8	45	60	60	103
BD203	npn	8	60	60	60	85
BD204	pnp	8	60	60	60	103
BDX77	npn	8	80	100	60	85
BDX78	pnp	8	80	100	60	103
BDT91	npn	10	60	60	90	609
BDT92	pnp	10	60	60	90	619
TIP2955T	pnp	10	60	70	75	891
TIP3055T	npn	10	60	70	75	901
BDT93	npn	10	80	80	90	609
BDT94	pnp	10	80	80	90	619
BDT95	npn	10	100	100	90	609
BDT96	pnp	10	100	100	90	619
BDT81	npn	15	60	60	125	593
BDT82	pnp	15	60	60	125	601
BDT83	npn	15	80	80	125	593
BDT84	pnp	15	80	80	125	601
BDT85	npn	15	100	100	125	593
BDT86	pnp	15	100	100	125	601
BDT87	npn	15	120	120	125	593
BDT88	pnp	15	120	120	125	601

DARLINGTONS IN TO-220 (SOT 78) ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDT60	pnp	4	60	60	50	491
BDT61	npn	4	60	60	50	507
TIP110	npn	4	60	60	50	837
TIP115	pnp	4	60	60	50	843
BDT60A	pnp	4	80	80	50	491
BDT61A	npn	4	80	80	50	507
TIP111	npn	4	80	80	50	837
TIP116	pnp	4	80	80	50	843
BDT60B	pnp	4	100	100	50	491
BDT61B	npn	4	100	100	50	507
TIP112	npn	4	100	100	50	837
TIP117	pnp	4	100	100	50	843
BDT60C	pnp	4	120	120	50	491
BDT61C	npn	4	120	120	50	507
TIP120	npn	5	60	60	65	849
TIP125	pnp	5	60	60	65	855
TIP121	npn	5	80	80	65	849
TIP126	pnp	5	80	80	65	855
TIP122	npn	5	100	100	65	849
TIP127	pnp	5	100	100	65	855
BD643	npn	8	45	60	62.5	213
BD644	pnp	8	45	45	62.5	231
BD645	npn	8	60	80	62.5	213
BD646	pnp	8	60	60	62.5	231
TIP130	npn	8	60	60	70	861
TIP135	pnp	8	60	60	70	867
BD647	npn	8	80	100	62.5	213
BD648	pnp	8	80	80	62.5	231
TIP131	npn	8	80	80	70	861
TIP136	pnp	8	80	80	70	867
BD649	npn	8	100	120	62.5	213
BD650	pnp	8	100	100	62.5	231
TIP132	npn	8	100	100	70	861
TIP137	pnp	8	100	100	70	867
BD651	npn	8	120	140	62.5	213
BD652	pnp	8	120	120	62.5	231
BDT62	pnp	10	60	60	90	525
BDT63	npn	10	60	60	90	543

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDT62A	pnp	10	80	80	90	525
BDT63A	npn	10	80	80	90	543
BDT62B	pnp	10	100	100	90	525
BDT63B	npn	10	100	100	90	543
BDT62C	pnp	10	120	120	90	525
BDT63C	npn	10	120	120	90	543
BDT64	pnp	12	60	60	125	561
BDT65	npn	12	60	60	125	577
BDT64A	pnp	12	80	80	125	561
BDT65A	npn	12	80	80	125	577
BDT64B	pnp	12	100	100	125	561
BDT65B	npn	12	100	100	125	577
BDT64C	pnp	12	120	120	125	561
BDT65C	npn	12	120	120	125	577

TRANSISTORS IN SOT186 ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP29F	npn	3	40	80	19	739
TIP30F	pnp	3	40	80	19	753
TIP31F	npn	3	40	80	22	769
TIP32F	pnp	3	40	80	22	785
BD933F	npn	3	45	45	19	339
BD934F	pnp	3	45	45	19	351
BD935F	npn	3	60	60	19	339
BD936F	pnp	3	60	60	19	351
TIP29AF	npn	3	60	100	19	739
TIP30AF	pnp	3	60	100	19	753
TIP31AF	npn	3	60	100	22	769
TIP32AF	pnp	3	60	100	22	785
BD937F	npn	3	80	100	19	339
BD938F	pnp	3	80	100	19	351
TIP29BF	npn	3	80	120	19	739
TIP30BF	pnp	3	80	120	19	753
TIP31BF	npn	3	80	120	22	769
TIP32BF	pnp	3	80	120	22	785
BD939F	npn	3	100	120	19	339
BD940F	pnp	3	100	120	19	351

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP29CF	npn	3	100	140	19	739
TIP30CF	pnp	3	100	140	19	753
TIP31CF	npn	3	100	140	22	769
TIP32CF	pnp	3	100	140	22	785
TIP29DF	npn	3	120	160	19	739
BD941F	npn	3	120	140	19	339
BD942F	pnp	3	120	140	19	351
TIP30DF	pnp	3	120	160	19	753
TIP31DF	npn	3	120	160	22	769
TIP32DF	pnp	3	120	160	22	785
BD943F	npn	5	22	22	22	365
BD944F	pnp	5	22	22	22	379
BD945F	npn	5	32	32	22	365
BD946F	pnp	5	32	32	22	379
BD947F	npn	5	45	45	22	365
BD948F	pnp	5	45	45	22	379
BD949F	npn	5	60	60	22	393
BD950F	pnp	5	60	60	22	403
BD951F	npn	5	80	80	22	393
BD952F	pnp	5	80	80	22	403
BD953F	npn	5	100	100	22	393
BD954F	pnp	5	100	100	22	403
BD955F	npn	5	120	120	22	393
BD956F	pnp	5	120	120	22	403
TIP41F	npn	6	40	80	32	813
TIP42F	pnp	6	40	80	32	829
TIP41AF	npn	6	60	100	32	813
TIP42AF	pnp	6	60	100	32	829
TIP41BF	npn	6	80	120	32	813
TIP42BF	pnp	6	80	120	32	829
TIP41CF	npn	6	100	140	32	813
TIP42CF	pnp	6	100	140	32	829
BD201F	npn	8	45	60	32	95
BD202F	pnp	8	45	60	32	113
BD203F	npn	8	60	60	32	95
BD204F	pnp	8	60	60	32	113
BDX77F	npn	8	80	100	32	95
BDX78F	pnp	8	80	100	32	113
BDT91F	npn	10	60	60	32	617

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDT92F	pnp	10	60	60	32	627
BDT93F	npn	10	80	80	32	617
BDT94F	pnp	10	80	80	32	627
BDT95F	npn	10	100	100	32	617
BDT96F	pnp	10	100	100	32	627
BDT81F	npn	15	60	60	36	599
BDT82F	pnp	15	60	60	36	607
BDT83F	npn	15	80	80	36	599
BDT84F	pnp	15	80	80	36	607
BDT85F	npn	15	100	100	36	599
BDT86F	pnp	15	100	100	36	607
BDT87F	npn	15	120	120	36	599
BDT88F	pnp	15	120	120	36	607

DARLINGTONS IN SOT186 ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDT60F	pnp	4	60	60	25	499
BDT61F	npn	4	60	60	25	517
BDT60AF	pnp	4	80	80	25	499
BDT61AF	npn	4	80	80	25	517
BDT60BF	pnp	4	100	100	25	499
BDT61BF	npn	4	100	100	25	517
BDT60CF	pnp	4	120	120	25	499
BDT61CF	npn	4	120	120	25	517
BD644F	pnp	8	45	45	20	241
BD643F	npn	8	45	60	20	223
BD645F	npn	8	60	80	20	223
BD646F	pnp	8	60	60	20	241
BD647F	npn	8	80	100	20	223
BD648F	pnp	8	80	80	20	241
BD649F	npn	8	100	120	20	223
BD650F	pnp	8	100	100	20	241
BD651F	npn	8	120	140	20	223
BD652F	pnp	8	120	120	20	241
BDT62F	pnp	10	60	60	36	535
BDT63F	npn	10	60	60	36	553
BDT62AF	pnp	10	80	80	36	535
BDT63AF	npn	10	80	80	36	553

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDT62BF	pnp	10	100	100	36	535
BDT63BF	npn	10	100	100	36	553
BDT62CF	pnp	10	120	120	36	535
BDT63CF	npn	10	120	120	36	553
BDT64F	pnp	12	60	60	39	569
BDT65F	npn	12	60	60	39	585
BDT64AF	pnp	12	80	80	39	569
BDT65AF	npn	12	80	80	39	585
BDT64BF	pnp	12	100	100	39	569
BDT65BF	npn	12	100	100	39	585
BDT64CF	pnp	12	120	120	39	569
BDT65CF	npn	12	120	120	39	585

TRANSISTORS IN SOT93 ENVELOPE

TRANSISTOR TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP33	npn	10	40	80	80	793
TIP34	pnp	10	40	80	80	799
BDV91	npn	10	60	60	100	693
BDV92	pnp	10	60	60	100	699
TIP33A	npn	10	60	100	80	793
TIP34A	pnp	10	60	100	80	799
BDV93	npn	10	80	80	100	693
BDV94	pnp	10	80	80	100	699
TIP33B	npn	10	80	120	80	793
TIP34B	pnp	10	80	120	80	799
BDV95	npn	10	100	100	100	693
BDV96	pnp	10	100	100	100	699
TIP33C	npn	10	100	140	80	793
TIP34C	pnp	10	100	140	80	799
TIP2955	pnp	15	60	100	100	885
TIP3055	npn	15	60	100	100	895

DARLINGTONS IN SOT93 ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP140	npn	10	60	60	125	873
TIP145	pnp	10	60	60	125	879
TIP141	npn	10	80	80	125	873

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
TIP146	npn	10	80	80	125	879
TIP142	npn	10	100	100	125	873
TIP147	pnp	10	100	100	125	879
BDV64	pnp	12	60	60	125	629
BDV65	npn	12	60	60	125	647
BDV64A	pnp	12	80	80	125	629
BDV65A	npn	12	80	80	125	647
BDV64B	pnp	12	100	100	125	629
BDV65B	npn	12	100	100	125	647
BDV64C	pnp	12	120	120	125	629
BDV65C	npn	12	120	120	125	647
BDV66A	pnp	16	80	100	175	665
BDV67A	npn	16	80	100	200	679
BDV66B	pnp	16	100	120	175	665
BDV67B	npn	16	100	120	200	679
BDV66C	pnp	16	120	140	175	665
BDV67C	npn	16	120	140	200	679
BDV66D	pnp	16	150	160	175	665
BDV67D	npn	16	150	160	200	679

DARLINGTONS IN SOT199 ENVELOPE

DARLINGTON TYPE	POLARITY	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	PAGE
BDV64F	pnp	12	60	60	50	637
BDV65F	npn	12	60	60	50	655
BDV64AF	pnp	12	80	80	50	637
BDV65AF	npn	12	80	80	50	655
BDV64BF	pnp	12	100	100	50	637
BDV65BF	npn	12	100	100	50	655
BDV64CF	pnp	12	120	120	50	637
BDV65CF	npn	12	120	120	50	655
BDV66AF	pnp	16	80	100	60	671
BDV67AF	npn	16	80	100	60	685
BDV66BF	pnp	16	100	120	60	671
BDV67BF	npn	16	100	120	60	685
BDV66CF	pnp	16	120	140	60	671
BDV67CF	npn	16	120	140	60	685
BDV66DF	pnp	16	150	160	60	671
BDV67DF	npn	16	150	160	60	685

ACCESSORIES

CLIP MOUNTING

ENVELOPE	DIRECT MOUNTING	INSULATED MOUNTING		
	CLIP	MICA	ALUMINA	CLIP
TO-126 (SOT32)	56353	56354		56353
SOT82	56353	56354		56353
TO-220 (SOT78)	56363	56369	56367	56364
SOT186	56363			
SOT93	56379	56378		56379
SOT199	56379			

SCREW MOUNTING

ENVELOPE	DIRECT MOUNTING		INSULATED MOUNTING			
	METAL WASHER	MOUNTING SIZE	MICA WASHER	INSULATED BUSH	METAL WASHER	MOUNTING SIZE
TO-126 (SOT32)	56326	M3				
up to 300 V			56387a	56387b	56326	M2.5
TO-220 (SOT78)	56360a	M3				
up to 800 V			56359b	56359c	56360a	M3
up to 1000 V			56359b	56359d	56360a	M3
SOT186	56360a	M3				
SOT93		M4	56368a	56368b		M3
SOT199		M4				

The accessories included in this section can be supplied on request. Details of their use can be found in the chapter entitled 'Mounting Instructions'.

GENERAL

TRANSISTOR RATINGS

The ratings are presented as voltage, current, power and temperature ratings. The list of these ratings and their definitions is given as follows:

Transistor voltage ratings

Collector to base voltage ratings

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

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

Emitter to base voltage ratings

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

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

Collector to emitter voltage ratings

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

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

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

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

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

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

Fig. 1 is divided into two areas:

The permissible area of operation under all conditions of base drive provided the dissipation rating is not exceeded (area 1) and the area where operation is allowable under certain specified conditions (area 2). To assist in determining the rating in this second area, further curves are provided relating the voltage rating to external circuit conditions, for example:

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

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

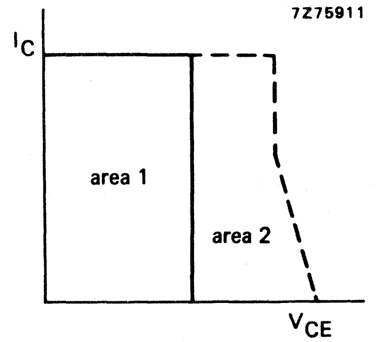


Fig. 1 Permissible operation areas.

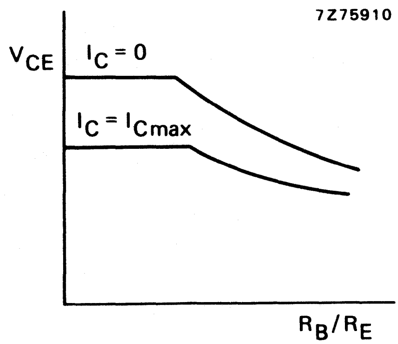


Fig. 2 Effect of collector current on permissible operation areas.

It should be noted that when R_E is shunted by a capacitor, the collector voltage V_{CE}, during switching, must be restricted to a value which does not rely on the effect of R_E.
In the case of an inductive load, when an energy rating is given, it may be permissible to operate outside the rated area provided the specified energy rating is not exceeded.

Transistor current ratings

Collector current ratings

I_{Cmax}	The maximum permissible collector current. Without further qualification, the DC value is implied.
$I_{C(AV)max}$	The maximum permissible average value of the total collector current
I_{CM}	The maximum permissible instantaneous value of the total collector current.

Emitter current ratings

I_{Emax}	The maximum permissible emitter current. Without further qualification, the DC value is implied.
$I_{E(AV)max}$	The maximum permissible average value of the total emitter current.
$I_{ER(AV)max}$	The maximum permissible average value of the total emitter current when operating in the reverse emitter-base breakdown region.
I_{EM}	The maximum permissible instantaneous value of the total emitter current.
I_{ERM}	The maximum permissible instantaneous value of the total reverse emitter current allowable in the reverse breakdown region.

Base current ratings

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

Transistor power ratings

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

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

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

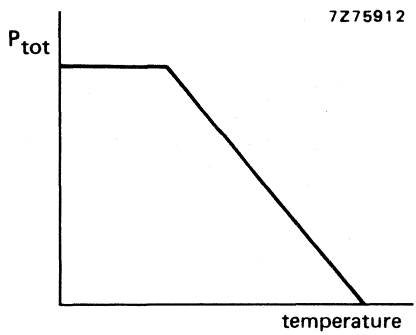


Fig. 3 Permissible total power dissipation.

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

The efficiency of this clip or heatsink is measured in terms of its thermal resistance ($R_{th\ h}$) normally expressed in degrees kelvin per watt (K/W). For mounting base rated devices, the added effect of the contact resistance ($R_{th\ i}$) must be taken into account.

The effect of heatsinks of various thermal resistance and contact resistance is often included in Fig. 3.

The relationship between maximum permissible power dissipation, ambient temperature and thermal heatsink resistance is given as:

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

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

For the calculation of pulse power operation P_P, the maximum pulse power is obtained using Fig. 4.

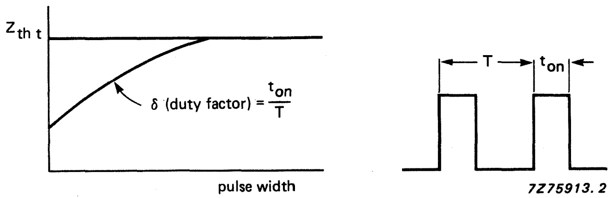


Fig. 4 Pulse power operation.

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

$$P_P = \frac{T_j - T_{amb} - P_S \times R_{th\ j\text{-}a}}{Z_{th\ t} + \delta\,(R_{th\ c\text{-}a})}$$

where $Z_{th\ t}$ and d are given in Fig. 4 and $R_{th\ c\text{-}a}$ is the thermal resistance between case and ambient for case rated device. For mounting base rated device, it is equal to $R_{th\ h} + R_{th\ i}$ and is zero for free air rated device because the effect of the temperature rise of the case over the ambient for a pulse train is already included in $Z_{th\ t}$.

Temperature ratings

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

RATING SYSTEMS

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

DEFINITIONS OF TERMS USED

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

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

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

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

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

Note
Limiting conditions may be either maxima or minima.

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

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

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

DESIGN MAXIMUM RATING SYSTEM

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

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

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

DESIGN CENTRE RATING SYSTEM

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

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

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

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

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

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

Subscripts

A, a	Anode terminal
(AV), (av)	Average value
B, b	Base terminal, for MOS devices: Substrate
(BR)	Breakdown
C, c	Collector terminal
D, d	Drain terminal
E, e	Emitter terminal
F, f	Forward
G, g	Gate terminal
K, k	Cathode terminal
M, m	Peak value
O, o	As third subscript: The terminal not mentioned is open circuited
R, r	As first subscript: Reverse. As second subscript: Repetitive. As third subscript: With a specified resistance between the terminal not mentioned and the reference terminal.
(RMS), (rms)	Root-mean-square 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 DC values.

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

a) continuous (DC) 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 (DC) current flowing into the second base terminal

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

Subscripts for multiple devices

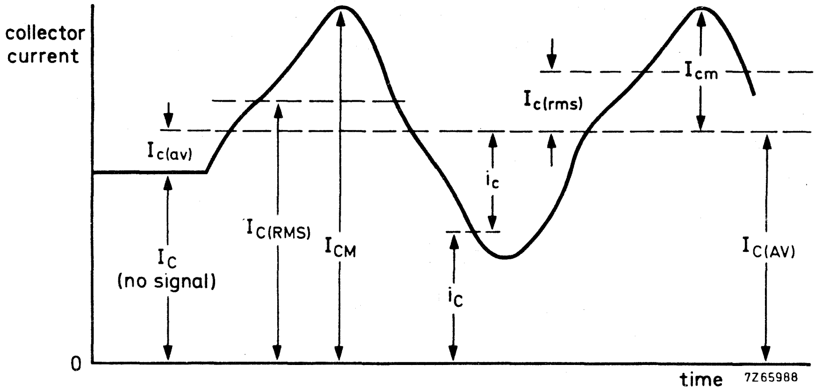
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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

V_{1C-2C} = continuous (DC) 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 (DC) current and a varying component.



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

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 **(DC current gain)**

R_E = **DC 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 (SOAR)

There are two main limiting factors which affect the power handling ability of a transistor; the average junction temperature and the second-breakdown.

To indicate these limitations, the data sheets contain safe operating area curves specific to the type and, for reliable operation of the transistor, the I_C/V_{CE} limits shown by these curves must never be exceeded.

The purpose of this chapter is to enable design engineers to make optimum use of the information.

Average junction temperature

Heat dissipation in the collector-base junction flows through the thermal resistance $R_{th\ j\text{-}mb}$ between junction and mounting base, see Fig. 1.

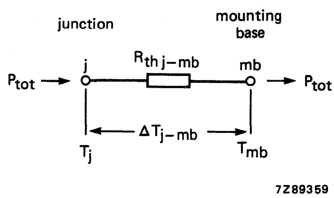


Fig. 1 Heat transport in a transistor with power dissipation constant with respect to time.

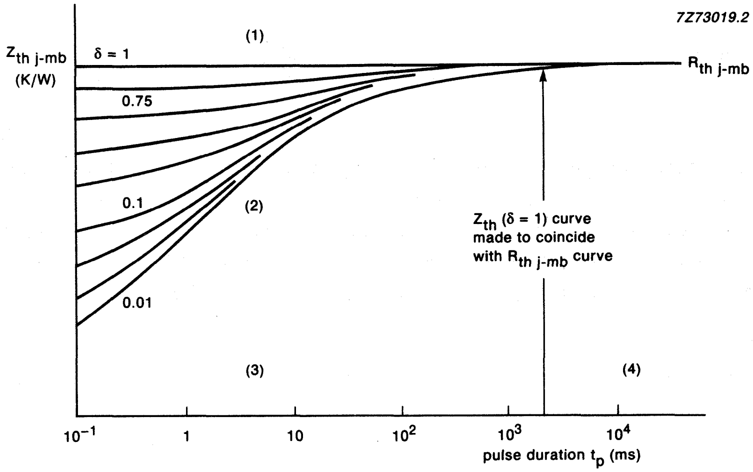
For steady-state (DC) operation the junction temperature will increase to:

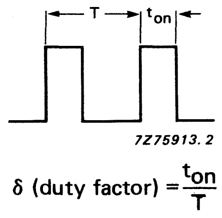
$$T_j = T_{mb} + P_{tot} \times R_{th\ j\text{-}mb}$$

For pulse operation the junction temperature will be:

$$T_j = T_{mb} + P_{tot} \times Z_{th\ j\text{-}mb}$$

During pulsed operation the junction has no time to be fully heated and will wholly or partly cool during the interval between pulses. For this reason a higher heat dissipation is permitted, see Fig. 2.





(1) DC line.
(2) Single pulse line.
(3) Pulse conditions.
(4) Steady-state conditions.

Fig. 2 A typical family of $Z_{th\ j\text{-}mb}$ curves for a power transistor.

This curve may be presented with either absolute figures ($Z_{th\ j\text{-}mb}$) or as normalized thermal impedance (NTI), where:

$$NTI = \frac{Z_{th\ j\text{-}mb}}{R_{th\ j\text{-}mb}}$$

Maximum allowable dissipation

Total power dissipation in a transistor is given by:

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

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

The maximum allowable power dissipation is limited by the maximum allowable junction temperature for the constant power curves (P_{tot}) and by second breakdown for the second-breakdown curves, see Fig. 3.

Constant power curves

P_{tot} can be calculated as follows:

For steady-state conditions (DC);

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

For pulsed conditions;

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

In most cases the maximum power dissipation ($P_{tot\ max}$ DC) specified in a data sheet is for a given mounting base temperature. This is usually T_{mb} = 25 °C but may be much higher.

For transistors in fully isolated envelopes (SOT186 and SOT199, ISOTOP), the maximum dissipation can not be referenced to the mounting base, therefore, the data sheets specify a given heatsink temperature (T_h) which may be calculated as follows:

For steady-state conditions (DC)

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

For pulsed conditions

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

Again the temperature specified in a data sheet is usually T_h = 25 °C but may be much higher. The total thermal resistance/impedance includes the transfer resistance from the case to heatsink under specific mounting conditions.

Second breakdown curves

In the forward biased condition second-breakdown is a thermally triggered avalanche effect which once started will destroy the transistor. The mechanism can be understood by considering the device 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 gather in these, raising their temperature and further lowering their forward voltage drop. Current will concentrate still further, leading to local overheating and eventually a short circuit between emitter and collector.

This effect can occur under various conditions:

Forward Biased up to V_{CEOmax}
Forward Biased with $V_{CE} > V_{CEO\ max}$
Reverse Biased up to V_{CESmax}

In the data sheets, safe operating area curves for the first condition are given for every power transistor; curves showing extensions for the safe operating area for the last two conditions are only specified for power switching transistors.

FORWARD BIASED SAFE OPERATION AREA UP TO V_{CEOmax}

Four operating limits form the boundaries of the forward biased safe operating area up to V_{CEOmax}:

Maximum collector current I_C or I_{CM}
Maximum collector-emitter voltage V_{CEOmax}
Maximum power dissipation P_{tot}
Second-breakdown limit S/B sat

To cover the widest range of applications FB-SOAR curves are specified for both DC and pulse operation.

At steady state conditions (DC)

Fig. 3 shows a DC FB-SOAR curve plotted on a log-log grid. The right-hand boundary is formed by V_{CEOmax} which extends up to a collector current of 300 V, above this point as I_{CE} 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 power dissipation, from this point I_C must be reduced with increasing V_{CE} forming the constant power curve of the maximum power dissipation boundary.

This maximum power dissipation boundary will normally intersect the second breakdown boundary at some point.

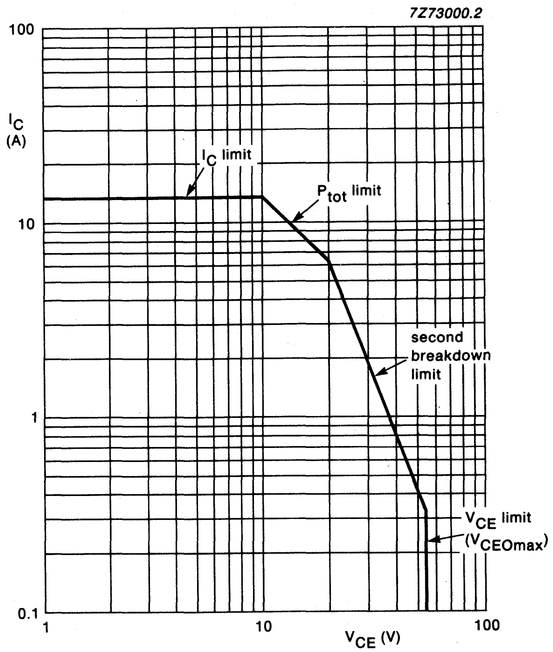
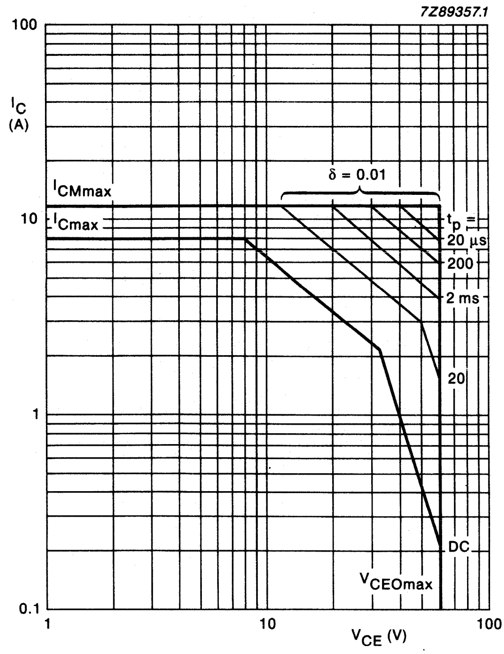


Fig. 3 A typical DC SOAR graph with boundaries defined.

At pulsed conditions

With the exception of DC FB-SOAR data sheets for power transistors contain a set of curves that apply under specific pulse conditions, that are normally at a duty factor of $\delta = 0.01$ and a pulse length of 20 ms or less.

An example of the FB-SOAR extension for single-shot and repetitive pulsed operation is shown in Fig. 4.



These curves for pulsed conditions are derived from the DC curve with the aid of the thermal impedance curves shown in Fig. 2.

All curves apply to the stated temperature (T_{mb} or T_h) above which derating must be applied.
A power derating curve of the form shown in Fig. 5 is given in the data sheets from which maximum allowable power dissipation for P_{tot} and S/B sat can be calculated for any T_{mb} or T_h up to $T_{j\ max}$.

Fig. 4 Maximum collector current and collector-emitter voltage for DC and pulsed conditions.

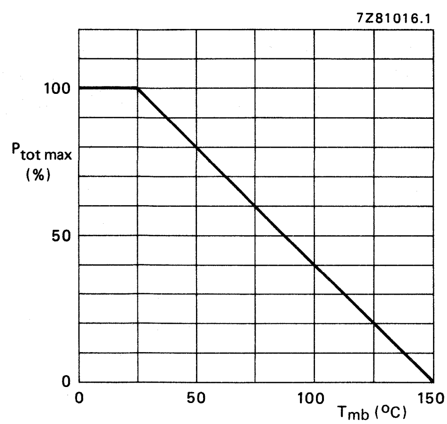
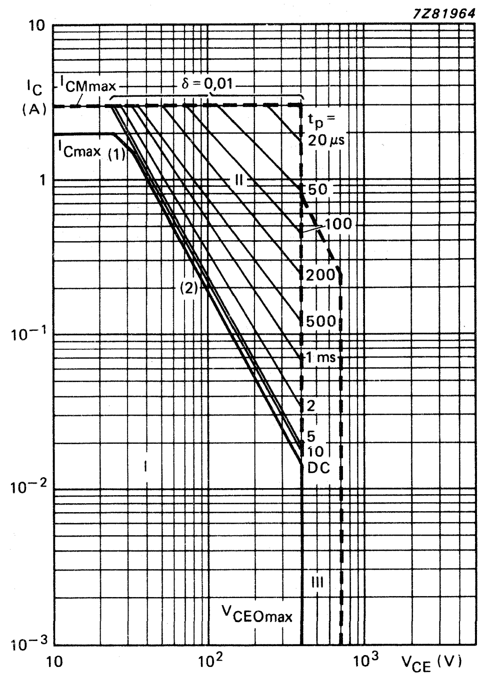


Fig. 5 Power derating curve, maximum permissible dissipation as a function of mounting base temperature.

FORWARD BIASED SAFE OPERATING AREA WITH $V_{CE} > V_{CEOmax}$



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.
III Area of permissible operation during turn-on in single transistor converters, providing $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 6.0\ \mu s$.

Fig. 6 Safe operating area at $T_{mb} \leqslant 25\ ^oC$.

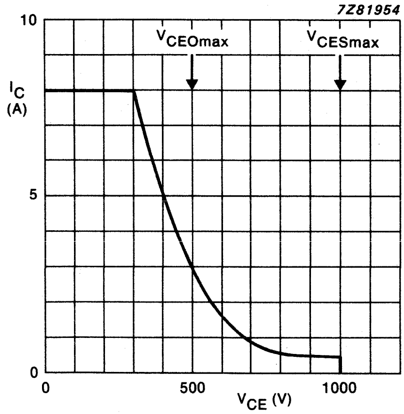
For switching power transistors in inductive load applications such as flyback converters, the collector-emitter voltage normally exceeds the rated V_{CEOmax} limit in the non-inductive stage. The collector current will rise steeply at turn on while the collector-emitter voltage is still greater than V_{CEOmax}. Under these conditions the collector current must be held to a safe level by means of load line shaping etc.

Fig. 6 shows FB-SOAR with an extension for turn-on (area III), (this is not temperature dependent and therefore derating at higher temperatures is not necessary).

REVERSE BIASED SAFE OPERATING AREA UP TO V_{CESmax} (RB-SOAR)

At turn-off of inductive loaded transistors, where in most cases the base to emitter junction is reverse biased, the collector to emitter voltage will rise steeply to a high level while the collector is still conducting. Under these conditions the collector voltage must be held to a safe level by means of clamping, snubbing etc.

The safe level of operation is contained in the data sheets in the form shown in Fig. 7.



This turn-off extension is not temperature dependent and so derating at higher temperatures is not necessary.

Fig. 7 Reverse biased area of permissible operation during turn-off, providing that $T_{mb} \leqslant 100\ ^oC$; $V_{BE\ off} = 5$ V; $I_C/I_B \geqslant 5$.

HOW TO USE THE SOAR INFORMATION FROM THE DATA SHEETS

When the intended function of the power transistor and its application is decided, a suitable device can be selected using the following ratings from the quick reference data:

Collector current	I_C or I_{CM}
Collector voltage	V_{CEO} or V_{CES}
Maximum allowable dissipation	P_{tot}
Maximum allowable junction temperature	T_j
Required gain	h_{FE}
Required speed	t_f or f_T

Now determine the following parameters for the intended application.

Duty factor	d
Maximum operational ambient temperature	T_{amb}
Maximum operational worse case average dissipation	P_{wc}

The next step is to calculate the required thermal resistance of the heatsink ($R_{th\ h\text{-}a}$) as follows:

For direct mounted devices:

$$R_{th\ h\text{-}a} = \frac{T_j - T_{mb}}{P_{wc}} - (R_{th\ j\text{-}mb} + R_{th\ mb\text{-}h})$$

For fully isolated devices:

$$R_{th\ h\text{-}a} = \frac{T_j - T_{mb}}{P_{wc}} - R_{th\ j\text{-}h}$$

Also calculate the mounting base temperature (T_{mb} or T_h) as follows:

For direct mounted devices:

$$T_{mb} = T_{amb} + P_{wc}\,(R_{th\ h\text{-}a} + R_{th\ mb\text{-}h})$$

For fully isolated devices:

$$T_h = T_{amb} + P_{wc} \times R_{th\ h\text{-}a}$$

The SOAR data sheet curves, thermal impedance and derating may now be used to construct a safe operating area for the device, (this is adaptable to the conditions for the application e.g. T_{mb} , pulse time and duty factor).

The last step is to measure the I_C/V_{CE} locus in your application and check that it does not exceed the previously constructed SOAR graph. In switching applications check also the extensions for turn-on and turn-off.

If the SOAR of the prefered transistor does not fit, select the nearest suitable device or modify the circuitry.

TRANSISTOR DATA

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope for general purpose, medium power applications. P-N-P complement is BD132.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz I_C = 0,25 A; V_{CE} = 5 V	f_T	>	60	MHz

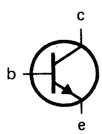
MECHANICAL DATA

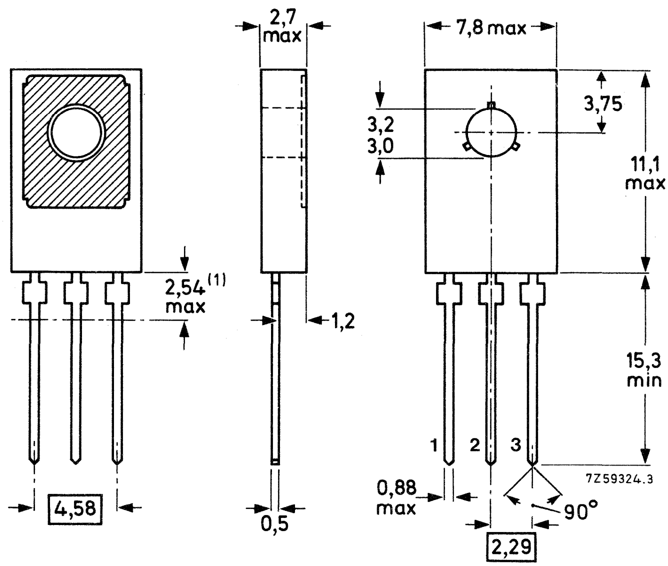
Dimensions in mm

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

Collector connected to metal part of mounting surface.

Pinning
1 = emitter
2 = collector
3 = base





See also chapters Mounting instructions and Accessories.

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

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (peak value)	I_{BM}	max.	0,5	A
Reverse base current (peak value)	$-I_{BM}$	max.	0,5	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	6	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	5 μA
$I_E = 0$; $V_{CB} = 50$ V; $T_j = 150$ °C	I_{CBO}	<	500 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5 μA
Saturation voltages			
$I_C = 0,5$ A; $I_B = 50$ mA	V_{CEsat}	<	0,3 V
	V_{BEsat}	<	1,2 V
$I_C = 2$ A; $I_B = 200$ mA	V_{CEsat}	<	0,7 V
	V_{BEsat}	<	1,5 V
D.C. current gain			
$I_C = 0,5$ A; $V_{CE} = 12$ V	h_{FE}	>	40
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	20
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	60 pF
Transition frequency at f = 35 MHz			
$I_C = 0,25$ A; $V_{CE} = 5$ V; $T_{amb} = 25$ °C	f_T	>	60 MHz
D.C. current gain ratio of the complementary pairs			
$I_C = 0,5$ A; $V_{CE} = 12$ V	h_{FE1}/h_{FE2}	<	1,2

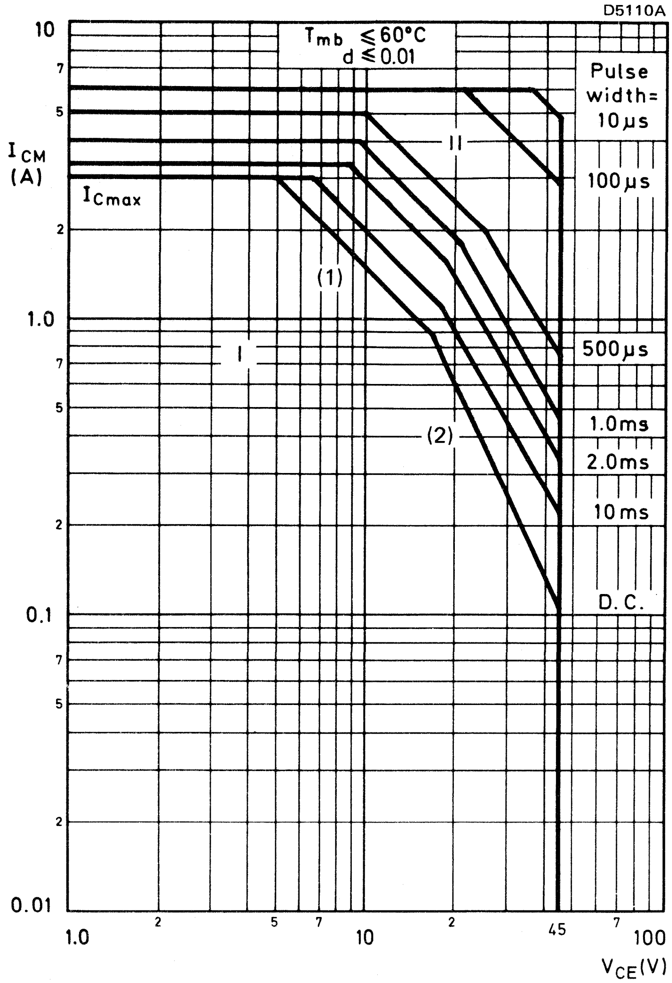


Fig. 2 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

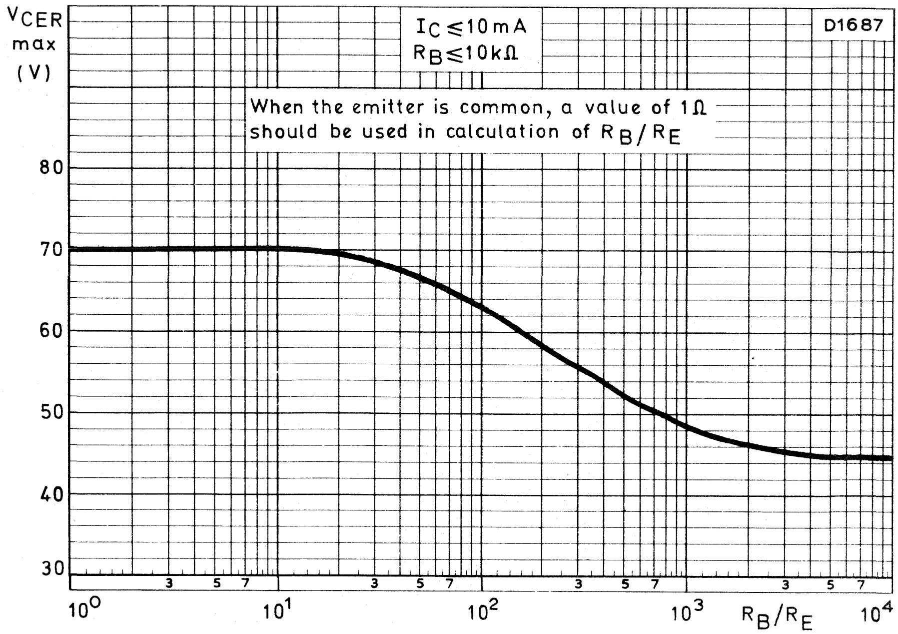


Fig. 3 Maximum allowable collector-emitter voltage as a function of base-emitter resistance.

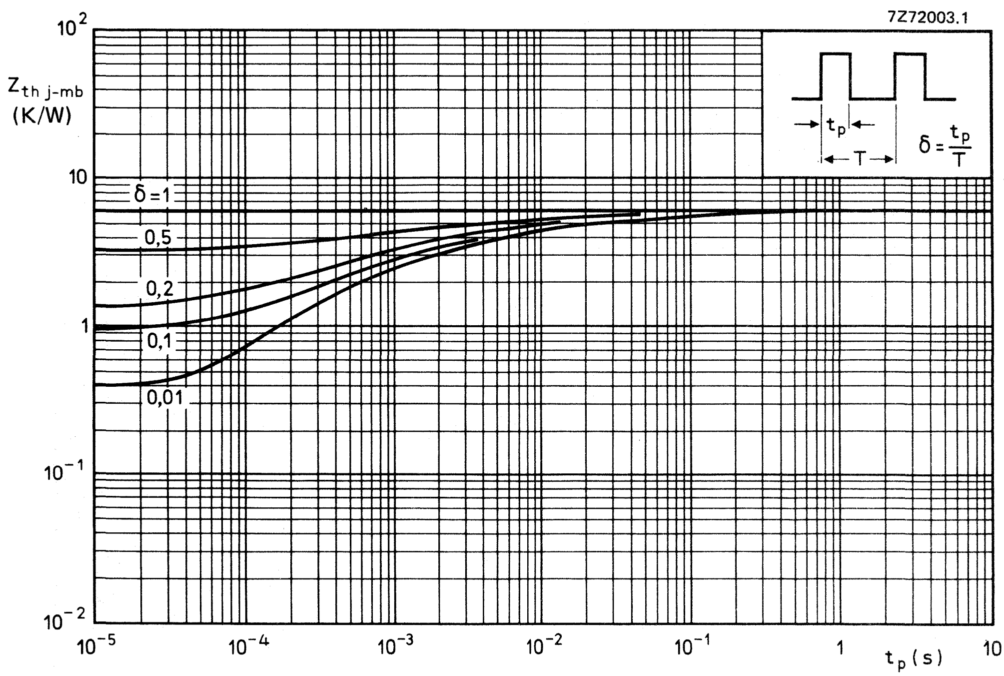


Fig. 4 Pulse power rating chart.

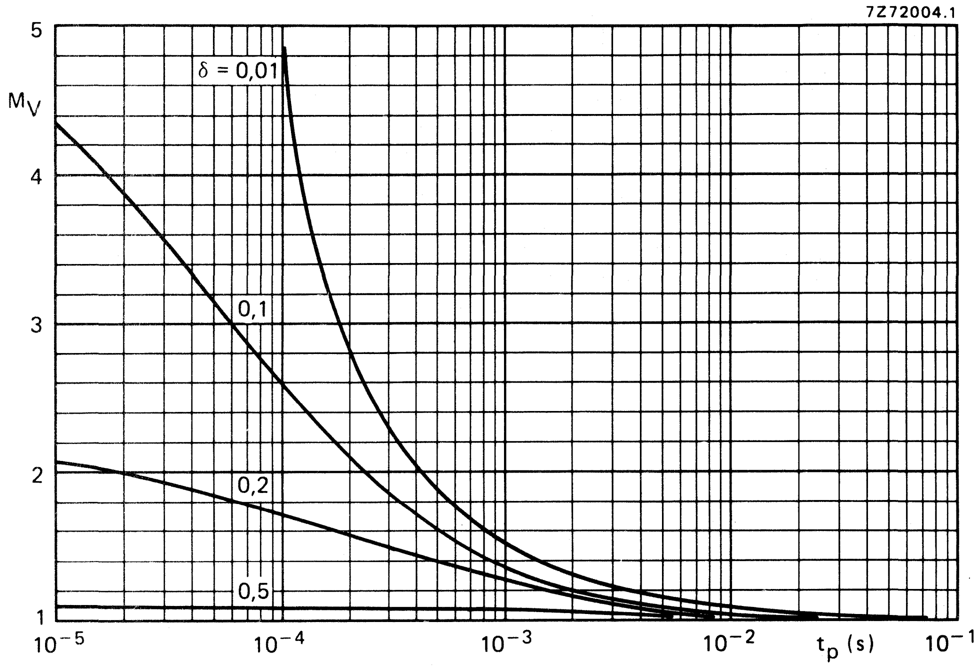


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

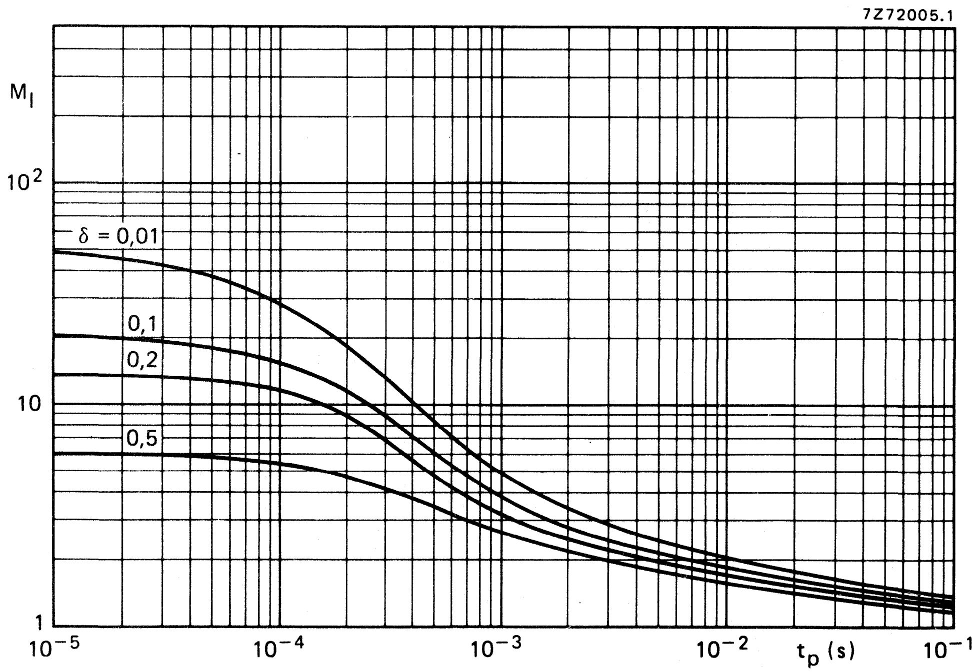


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

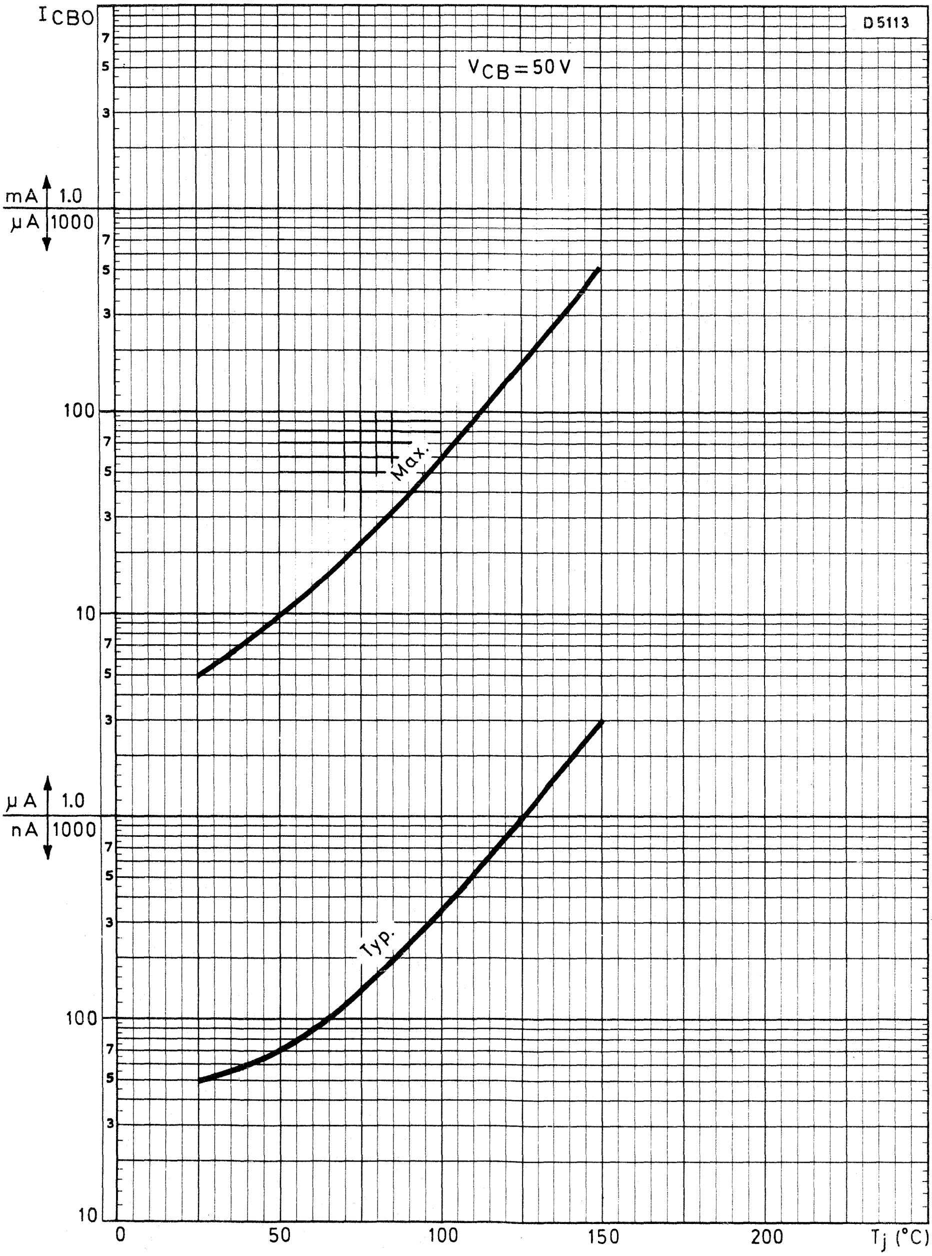


Fig. 7 Collector-base current (open emitter) as a function of the junction temperature.

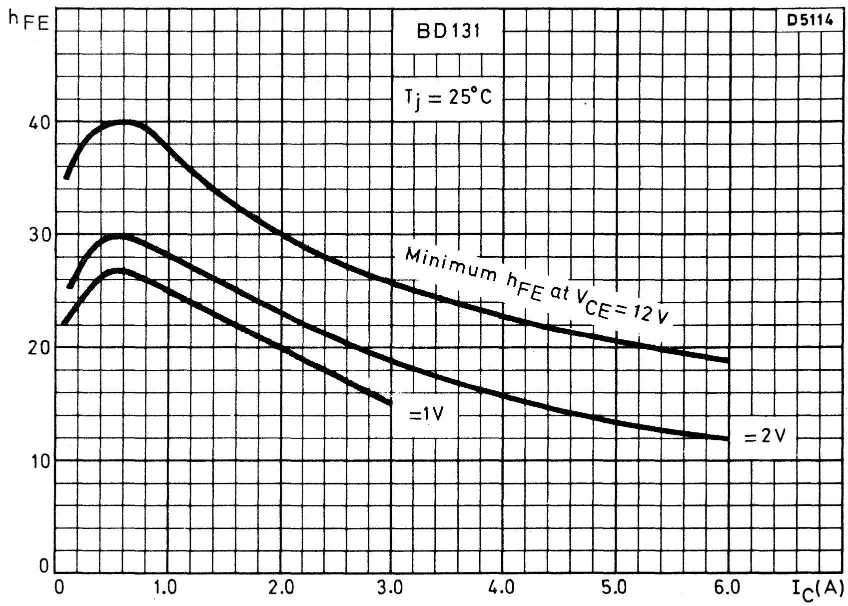

hFE
BD131
D5114
Tj = 25°C
40
30
20
10
0
Minimum hFE at VCE = 12 V
=1V
=2V
0
1.0
2.0
3.0
4.0
5.0
6.0
IC(A)

Fig. 8.

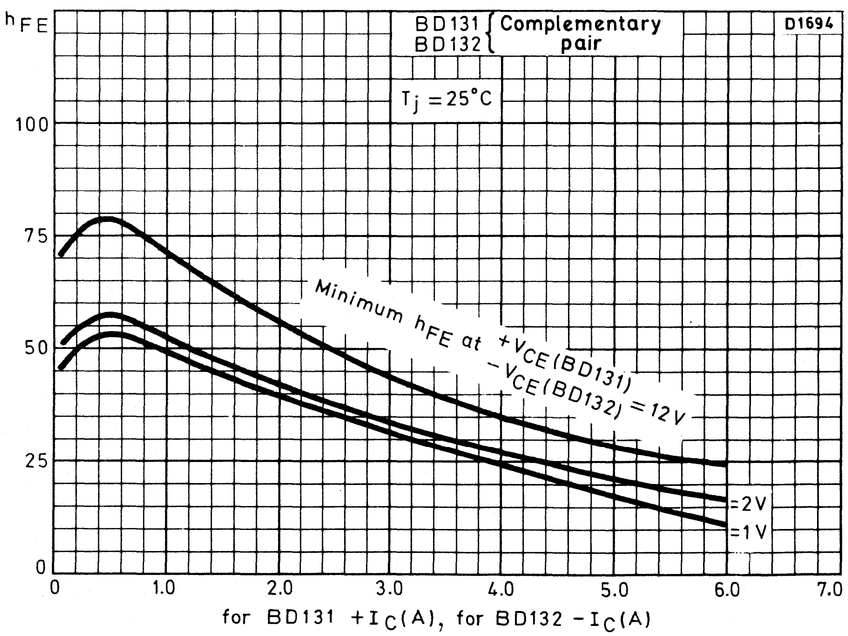

hFE
BD131
BD132
Complementary pair
D1694
Tj = 25°C
100
75
50
25
0
Minimum hFE at +VCE(BD131) −VCE(BD132) = 12 V
=2V
=1V
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
for BD131 +IC(A), for BD132 −IC(A)

Fig. 9.

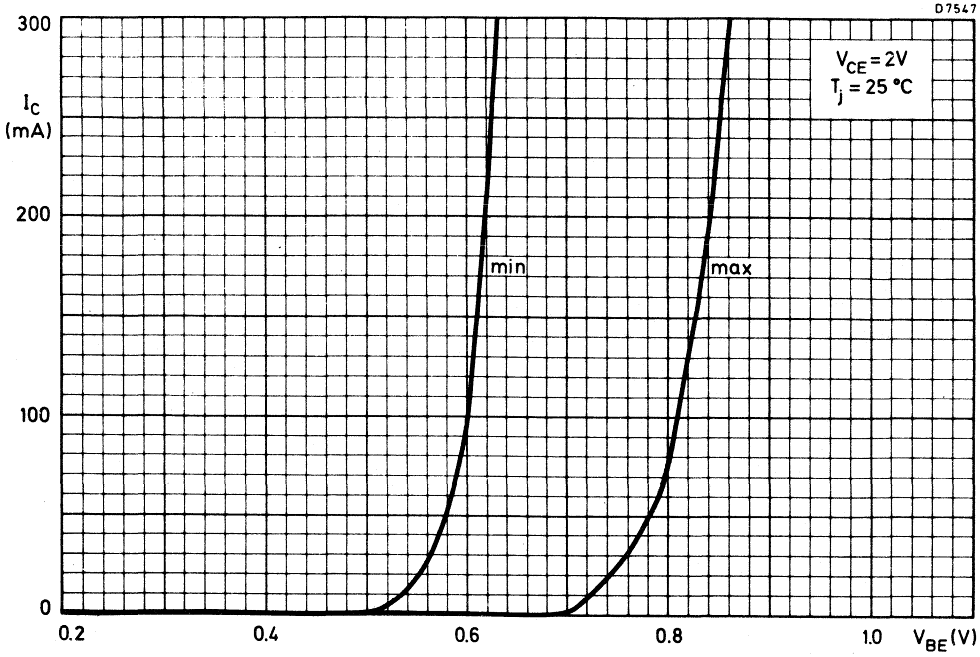

D7547
300
I_C
(mA)
200
100
0
0.2
0.4
0.6
0.8
1.0
V_{BE}(V)
min
max
$V_{CE} = 2V$
$T_j = 25\ °C$

Fig. 10.

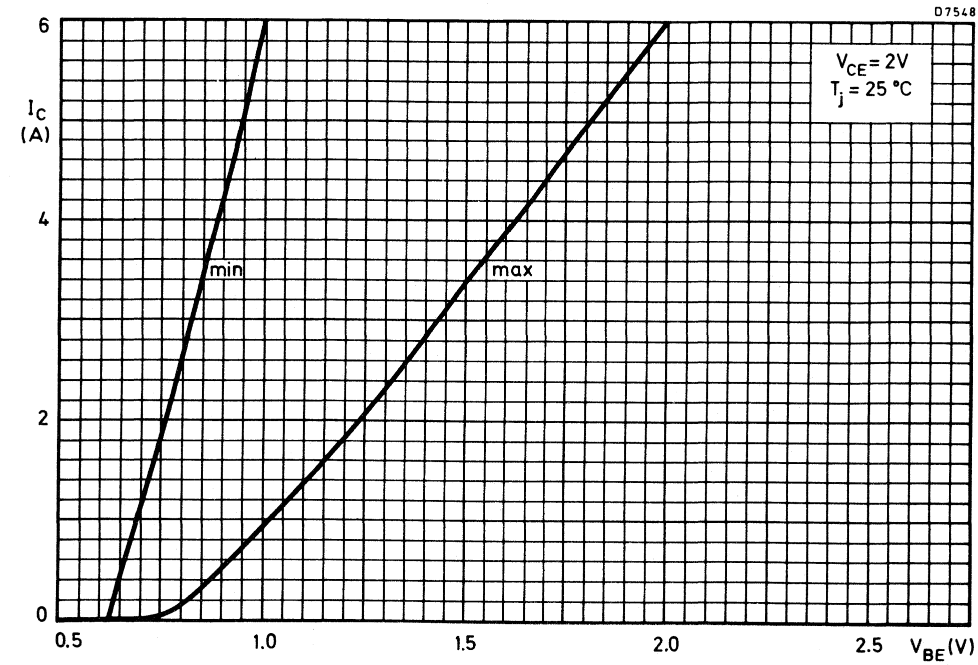

D7548
6
I_C
(A)
4
2
0
0.5
1.0
1.5
2.0
2.5
V_{BE}(V)
min
max
$V_{CE} = 2V$
$T_j = 25\ °C$

Fig. 11.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope for general purpose, medium power applications. N-P-N complement is BD131.

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 (d.c.)	$-I_C$	max.	3	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz $-I_C$ = 0,25 A; $-V_{CE}$ = 5 V	f_T	>	60	MHz

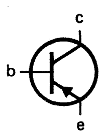
MECHANICAL DATA

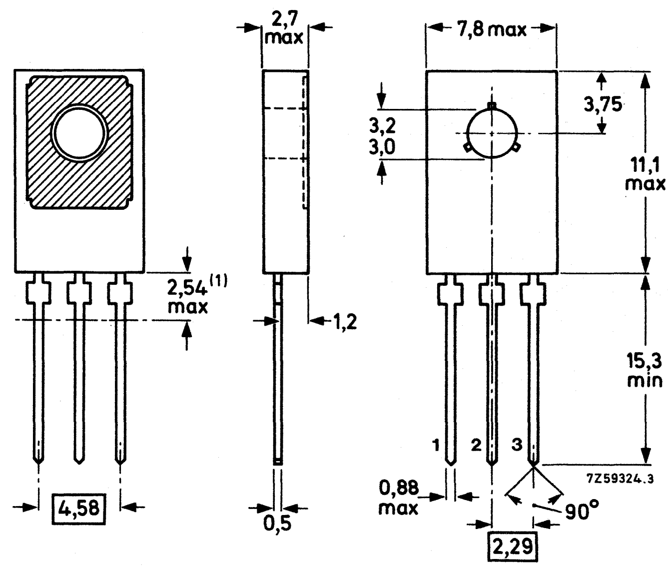
Dimensions in mm

Fig. 1 TO-126 (SOT-32)

Collector connected to metal part of mounting surface.

Pinning
1 = emitter
2 = collector
3 = base





See also chapters Mounting instructions and Accessories.

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

RATINGS

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V
Collector current (d.c.)	$-I_C$	max.	3	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Base current (peak value)	$-I_{BM}$	max.	0,5	A
Reverse base current (peak value)	$+I_{BM}$	max.	0,5	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	6	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB}$ = 40 V	$-I_{CBO}$	<	5	μA
$I_E = 0$; $-V_{CB}$ = 40 V; T_j = 150 °C	$-I_{CBO}$	<	500	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 3 V	$-I_{EBO}$	<	5	μA
Saturation voltages				
$-I_C$ = 0,5 A; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,3	V
	$-V_{BEsat}$	<	1,2	V
$-I_C$ = 2 A; $-I_B$ = 200 mA	$-V_{CEsat}$	<	0,7	V
	$-V_{BEsat}$	<	1,5	V
D.C. current gain				
$-I_C$ = 0,5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	20	
Transition frequency at f = 35 MHz				
$-I_C$ = 0,25 A; $-V_{CE}$ = 5 V; T_{amb} = 25 °C	f_T	>	60	MHz
D.C. current gain ratio of the complementary pairs				
$-I_C$ = 500 mA; $-V_{CE}$ = 12 V	h_{FE1}/h_{FE2}	<	1,2	

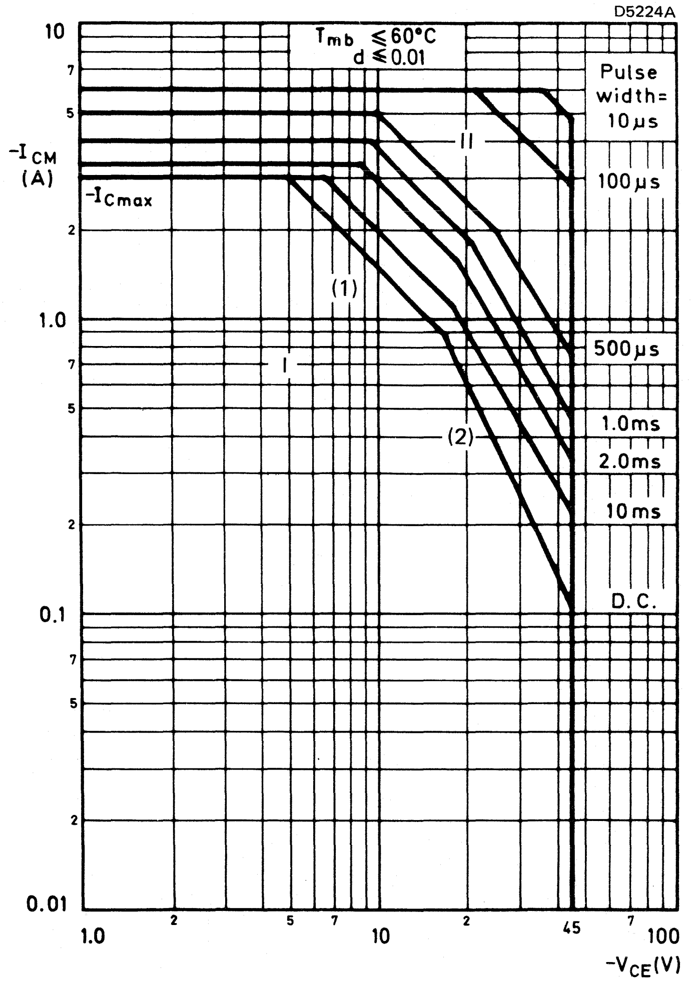


Fig. 2 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

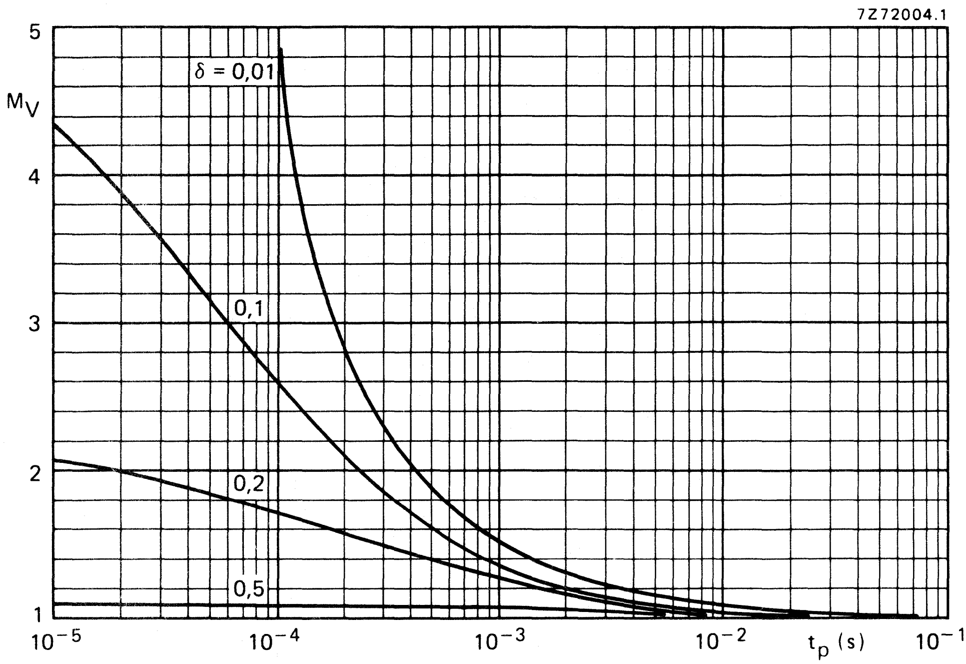


Fig. 3 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

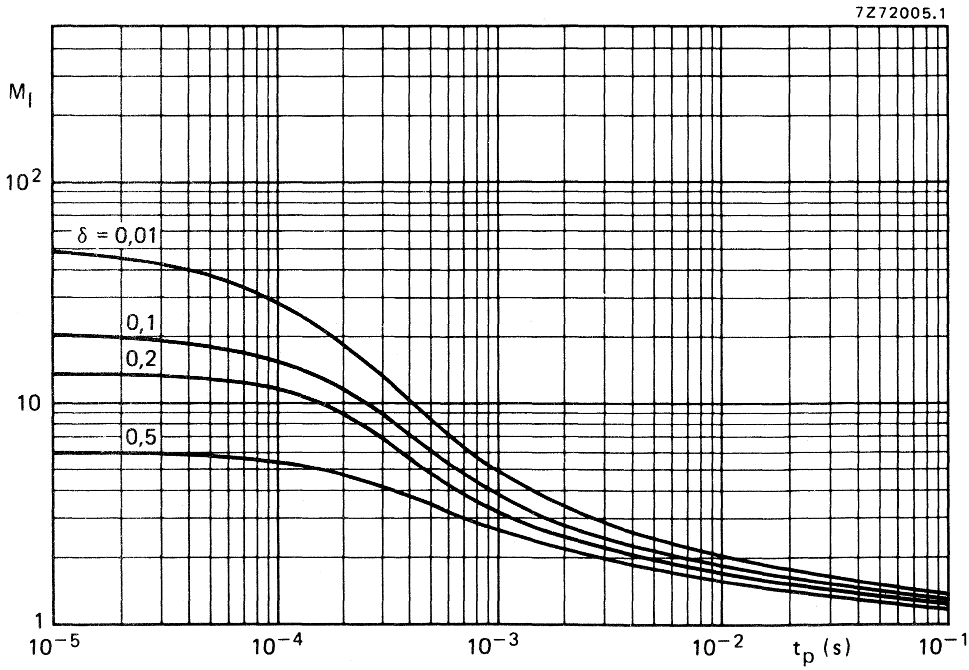


Fig. 4 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

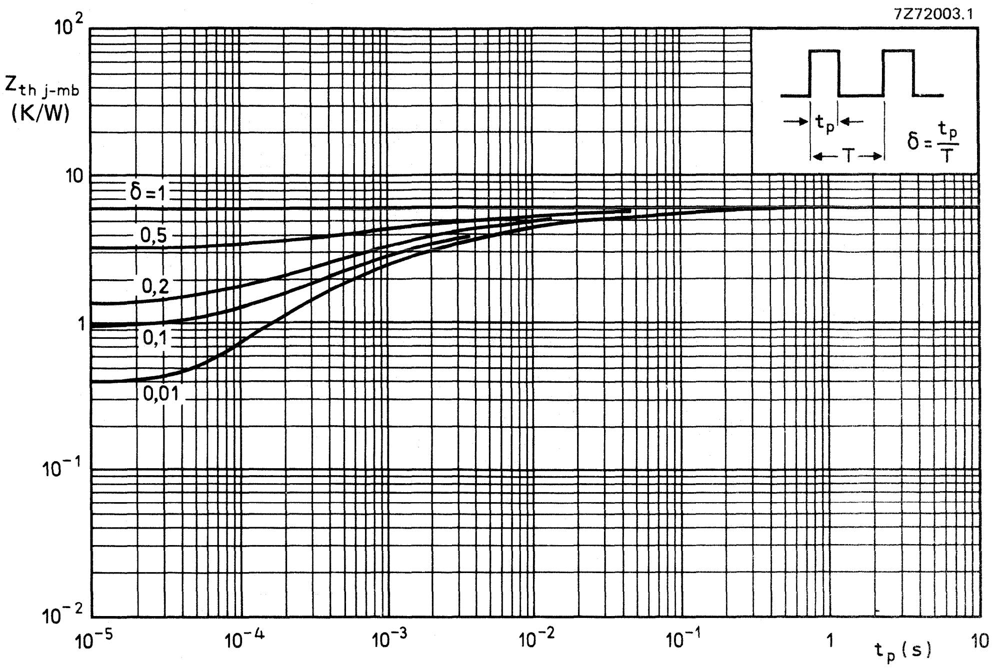


Fig. 5 Pulse power rating chart.

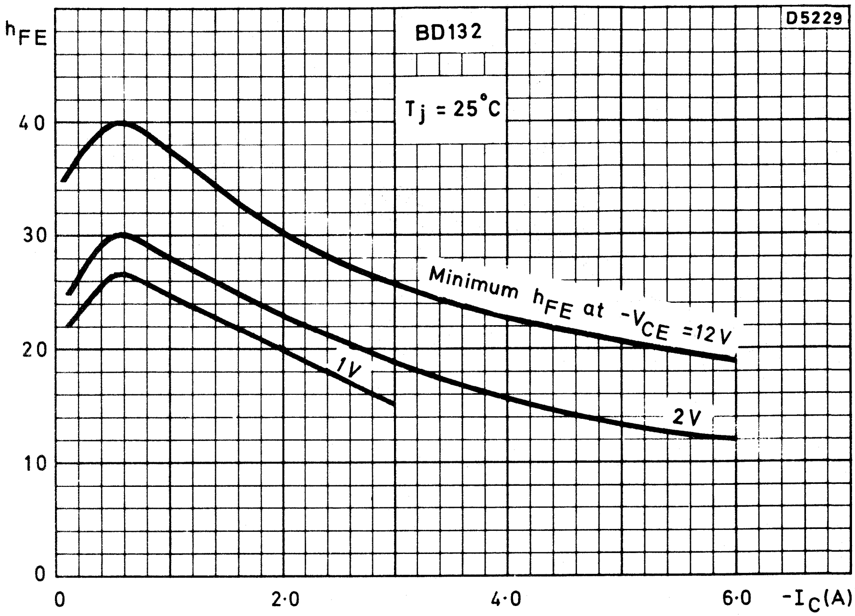


Fig. 6 D.C. current gain.

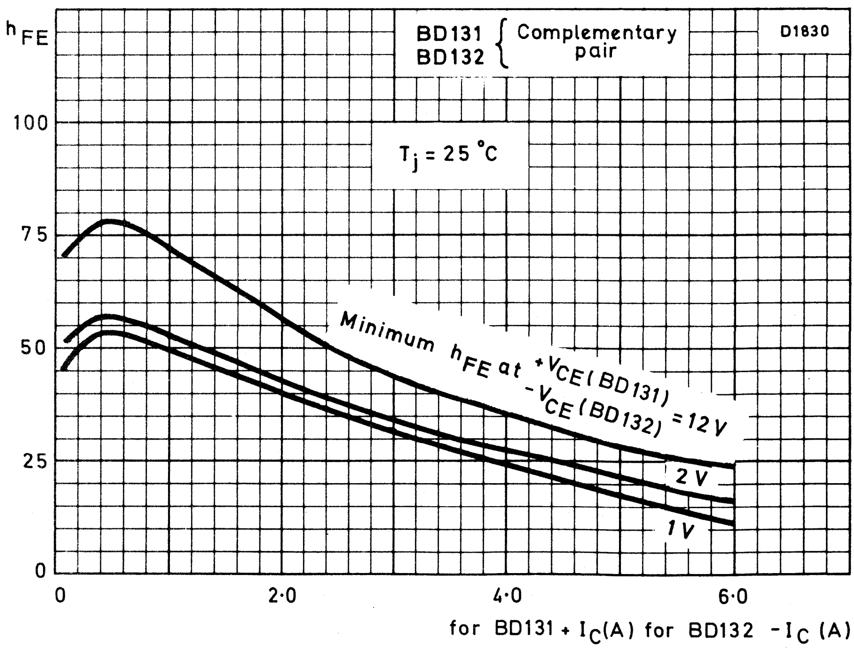


Fig. 7 D.C. current gain ratio.

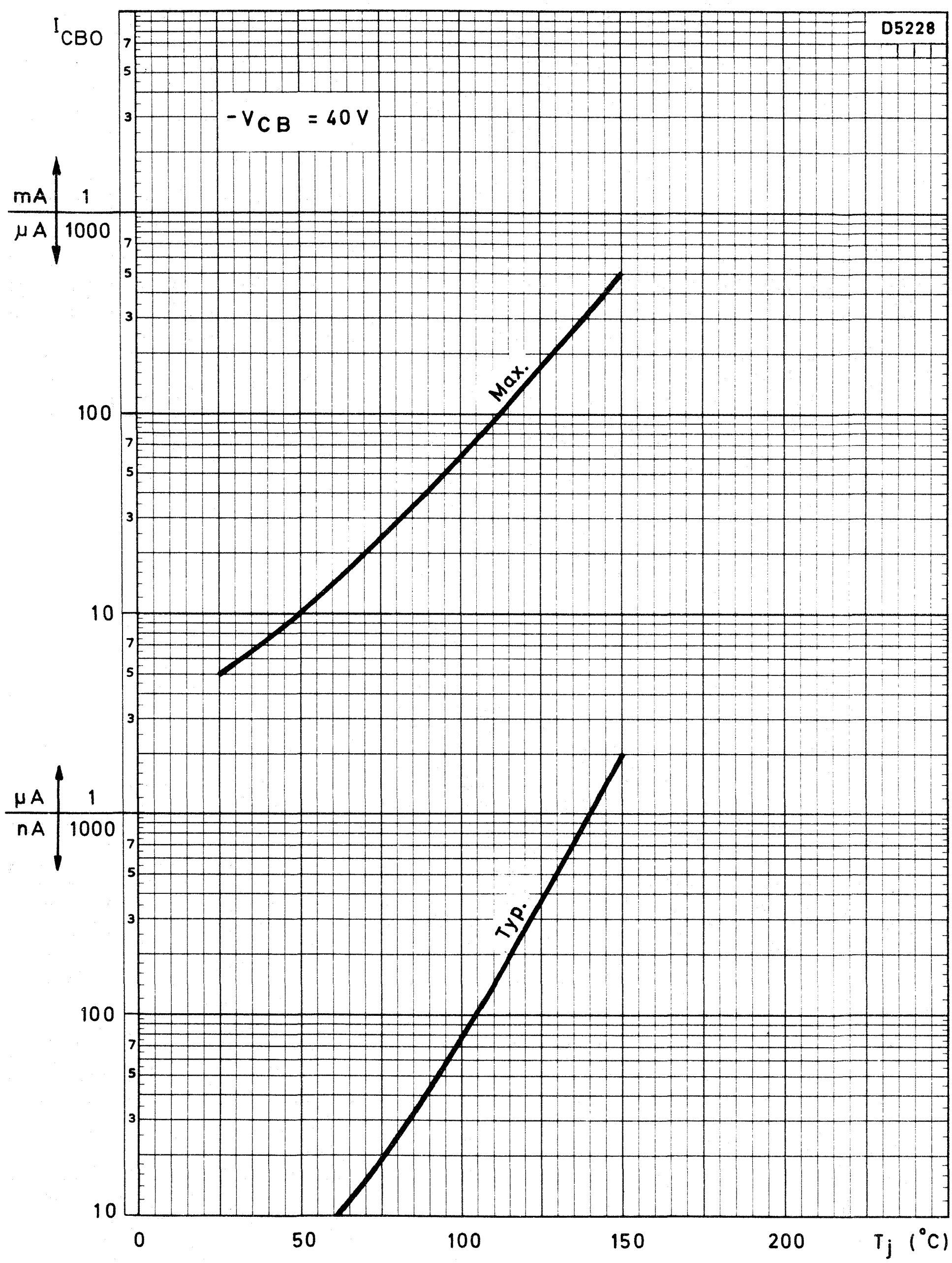


Fig. 8 Collector-base current (open emitter) as a function of the junction temperature.

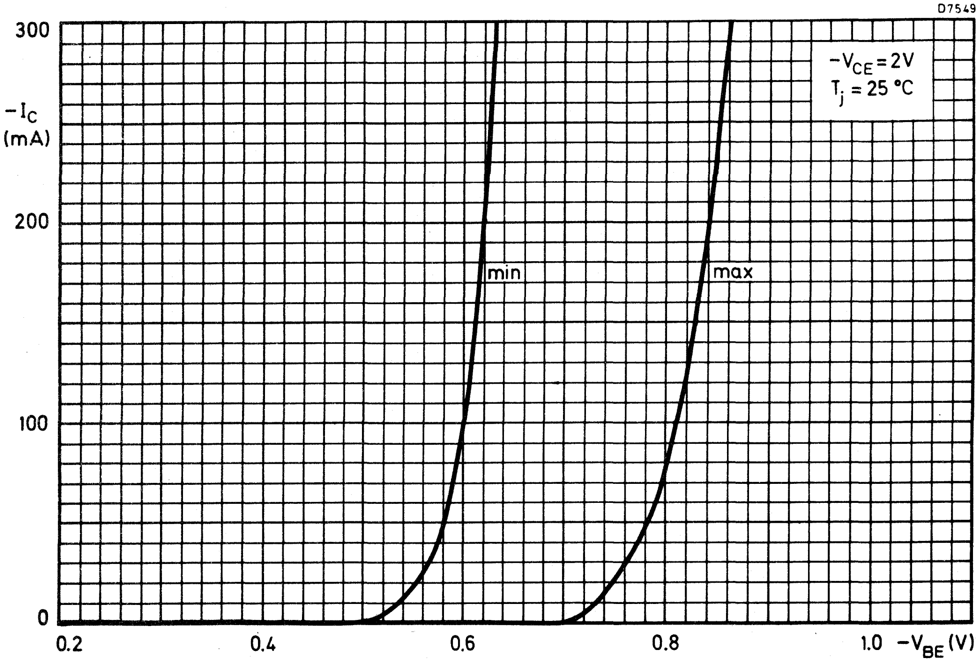

D7549
300
200
100
0
$-I_C$
(mA)
0.2
0.4
0.6
0.8
1.0 $-V_{BE}$ (V)
$-V_{CE} = 2V$
$T_j = 25\ °C$
min
max

Fig. 9.

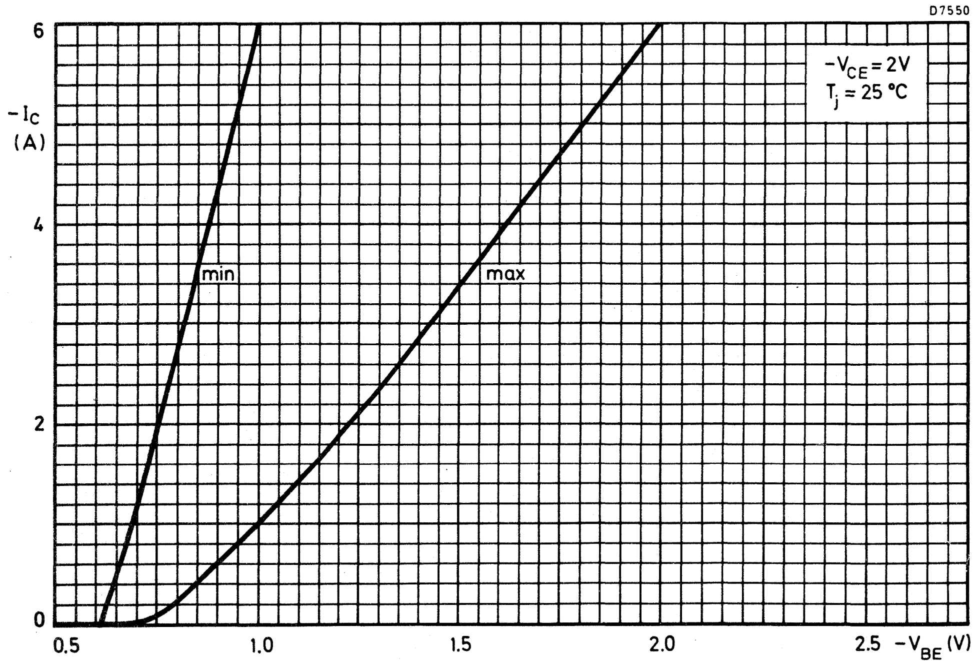

D7550
6
4
2
0
$-I_C$
(A)
0.5
1.0
1.5
2.0
2.5 $-V_{BE}$ (V)
$-V_{CE} = 2V$
$T_j = 25\ °C$
min
max

Fig. 10.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose n-p-n transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD136, BD138 and BD140 are complementary to the BD135, BD137 and BD139 respectively.

QUICK REFERENCE DATA

			BD135	BD137	BD139	
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 (d.c.)	I_C	max.	1,5	1,5	1,5	A
Collector current (peak value)	I_{CM}	max.	2,0	2,0	2,0	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	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 = 50 mA; V_{CE} = 5 V	f_T	typ.	250	250	250	MHz

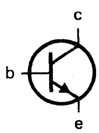
MECHANICAL DATA

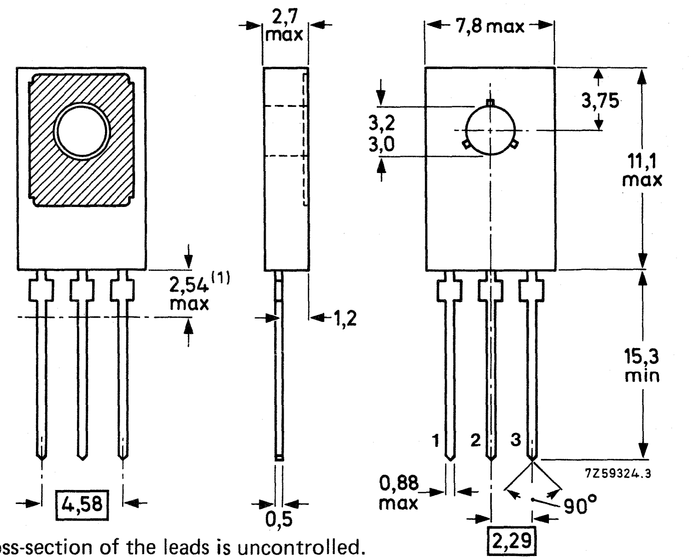
Dimensions in mm

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

Collector connected to metal part of mounting surface.

Pinning
1 = emitter
2 = collector
3 = base





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

See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD135	BD137	BD139	
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
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.	1,5	1,5	1,5	A
Collector current (peak value)	I_{CM}	max.	2,0	2,0	2,0	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.		8		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	$R_{th\ j\text{-}a}$	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	10	K/W

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 = 125 °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				
BDxxx	h_{FE}		40 to 250	
BDxxx-6	h_{FE}		40 to 100	
BDxxx-10	h_{FE}		63 to 160	
BDxxx-16	h_{FE}		100 to 250	
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	>	25	
Transition frequency at f = 35 MHz				
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250	MHz
D.C. current gain ratio of matched pairs				
BD135/BD136; BD137/BD138; BD139/BD140				
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	1,6	

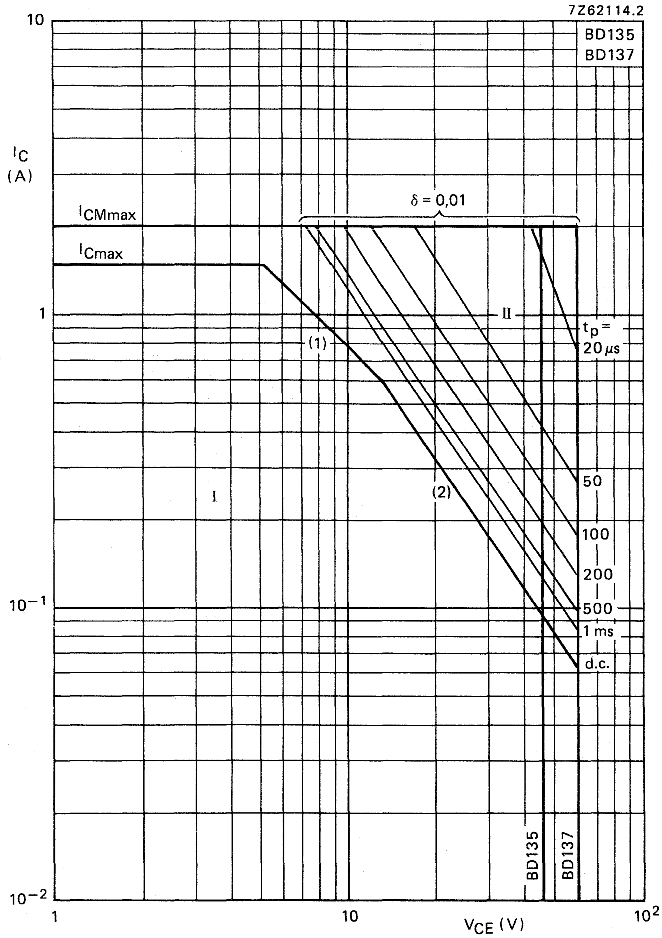


Fig. 2 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

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

(2) Second breakdown limits.

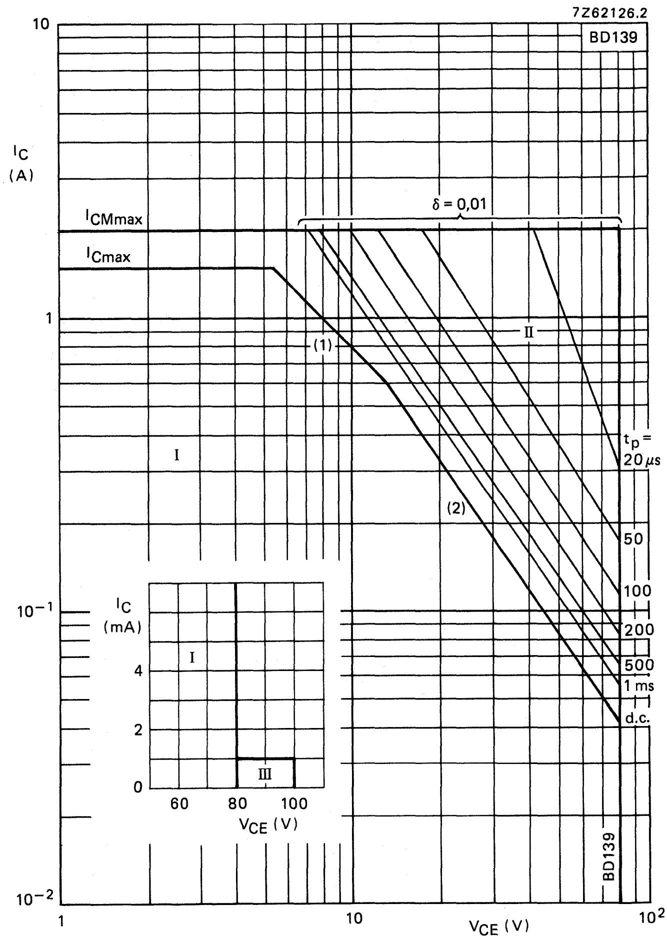


Fig. 3 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leqslant 1\ k\Omega$

(1) $P_{tot\ max}$ line
(2) Second breakdown limit

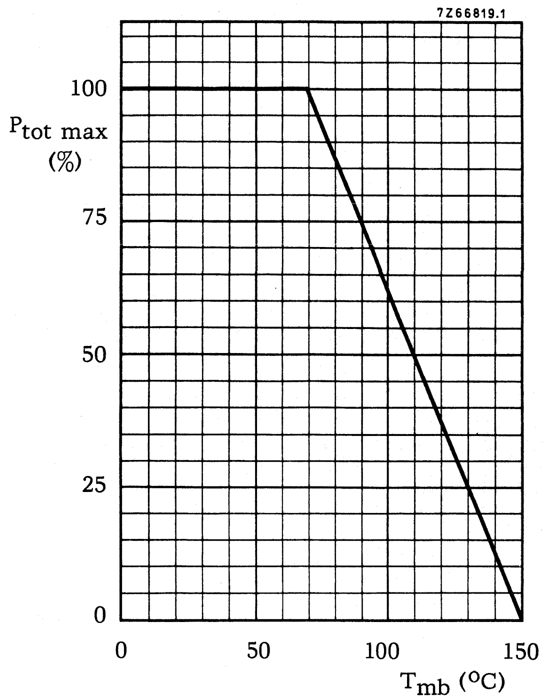

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

Fig. 4.

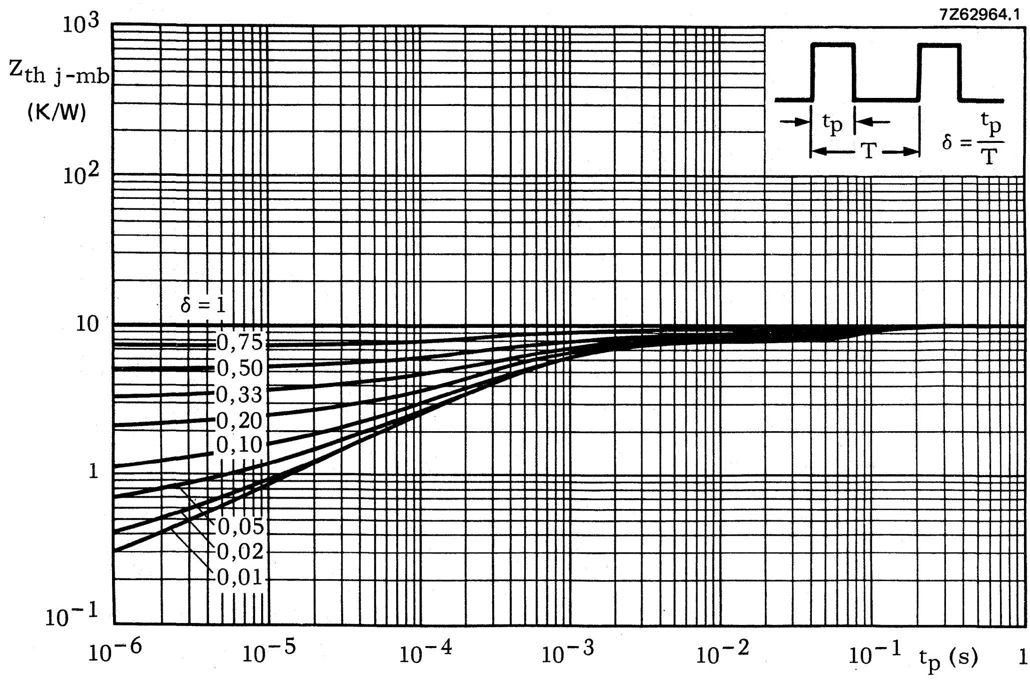

7Z62964.1
10^3
$Z_{th\ j\text{-}mb}$
(K/W)
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

Fig. 5.

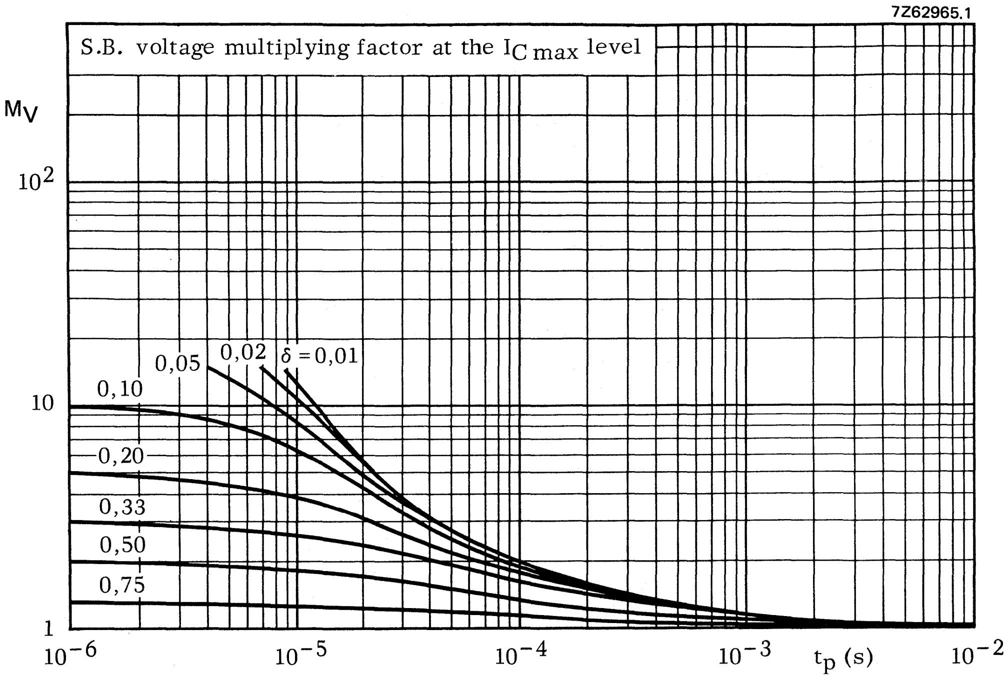

7Z62965.1
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 6.

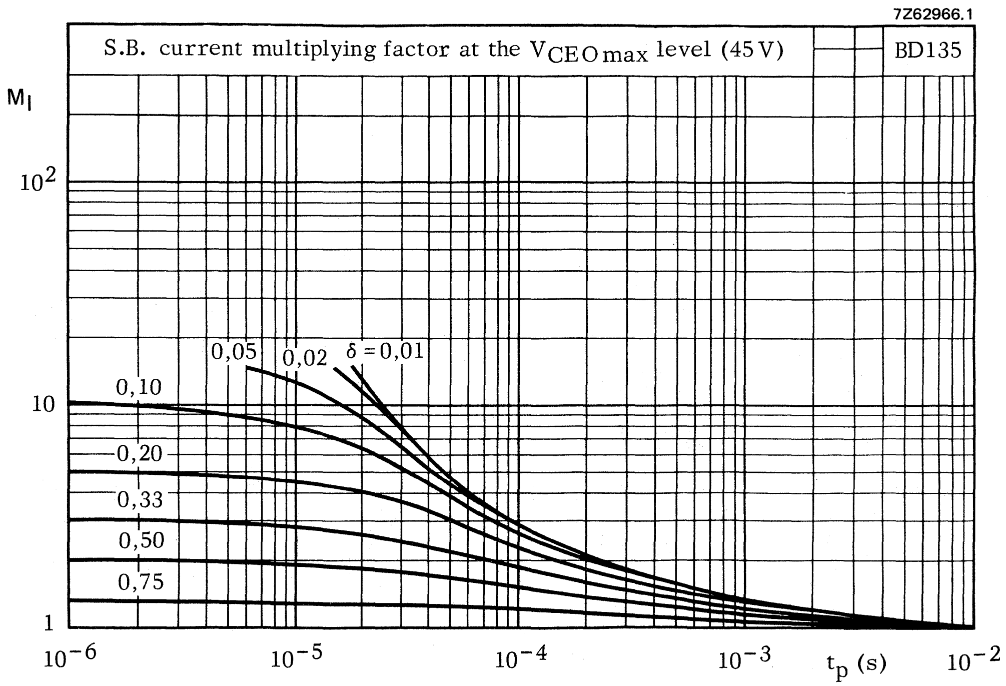

7Z62966.1
S.B. current multiplying factor at the $V_{CEO\,max}$ level (45 V)
BD135
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 7.

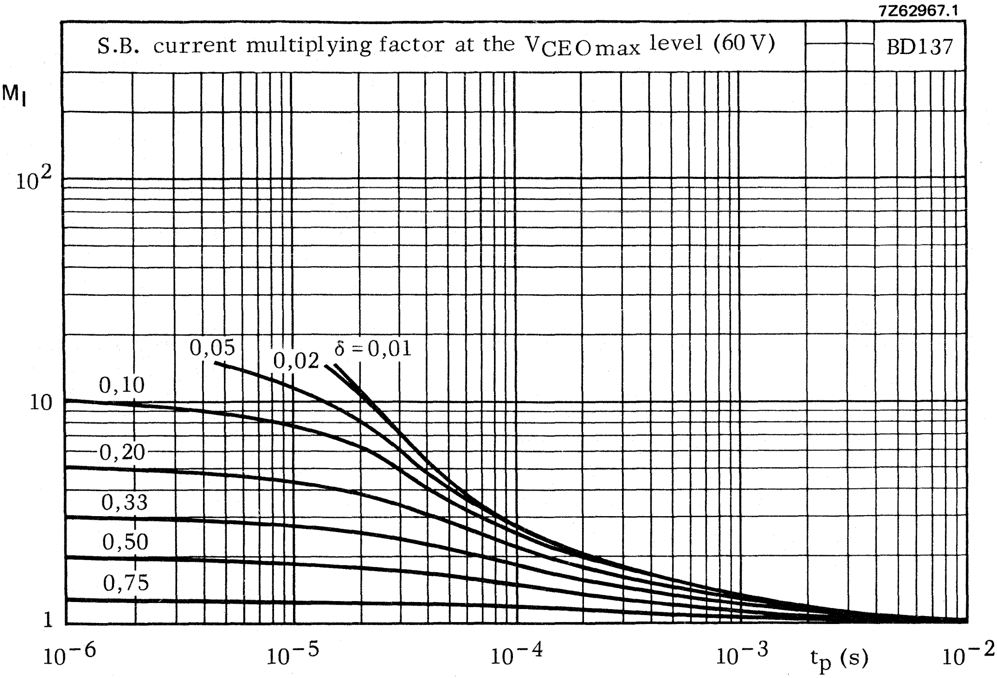

7Z62967.1
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BD137
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 8.

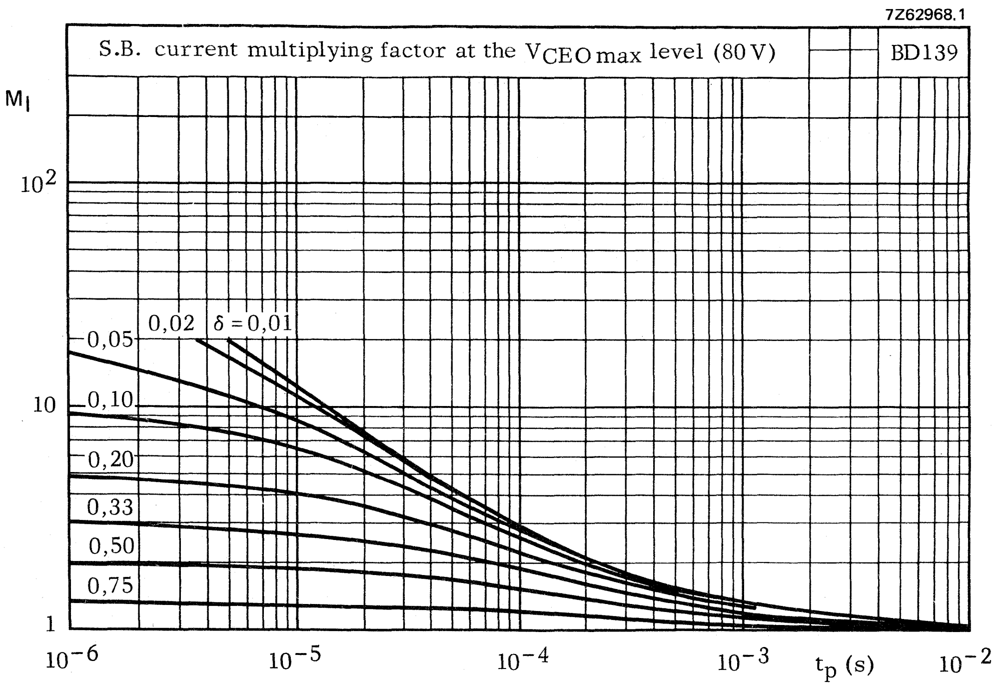

7Z62968.1
S.B. current multiplying factor at the V_{CEOmax} level (80 V)
BD139
M_I
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 9.

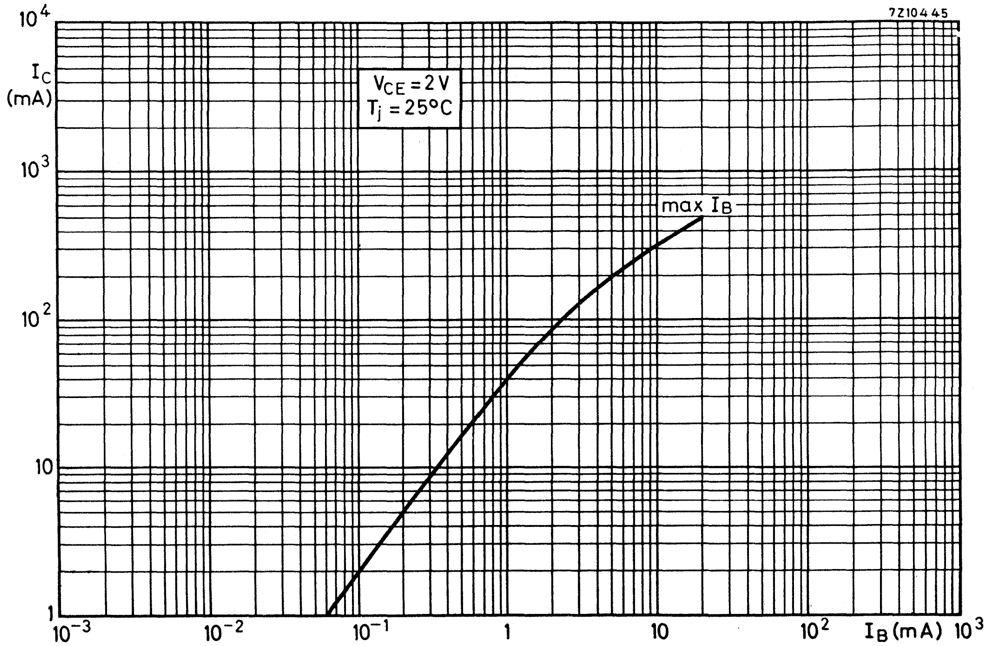

7Z10445
10^4
I_C (mA)
$V_{CE} = 2$ V
$T_j = 25$ °C
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

Fig. 10.

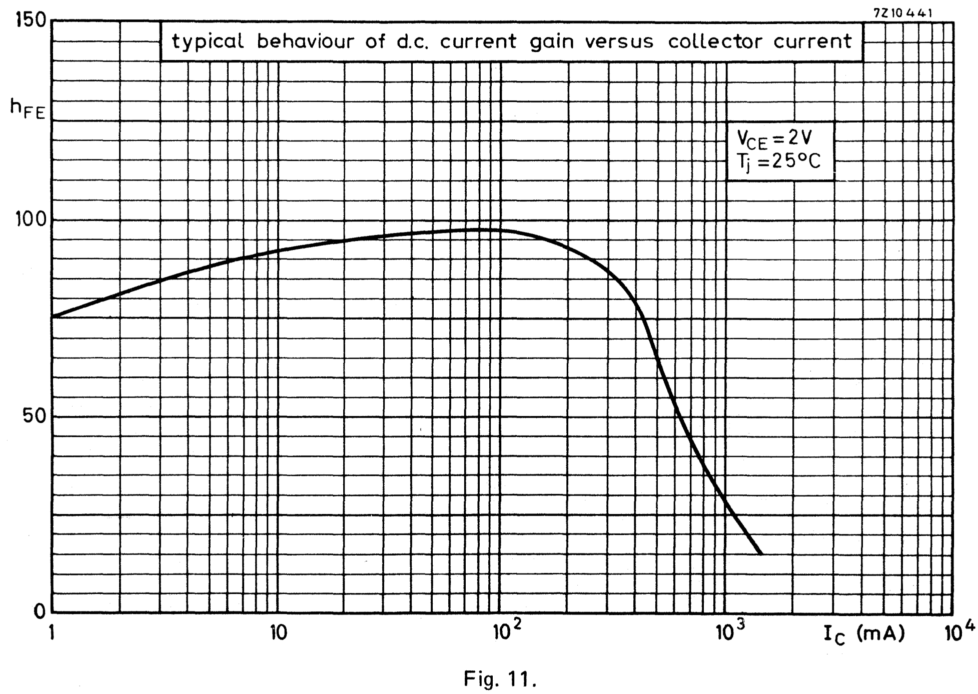

7Z10441
150
typical behaviour of d.c. current gain versus collector current
h_{FE}
$V_{CE} = 2$ V
$T_j = 25$ °C
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4

Fig. 11.

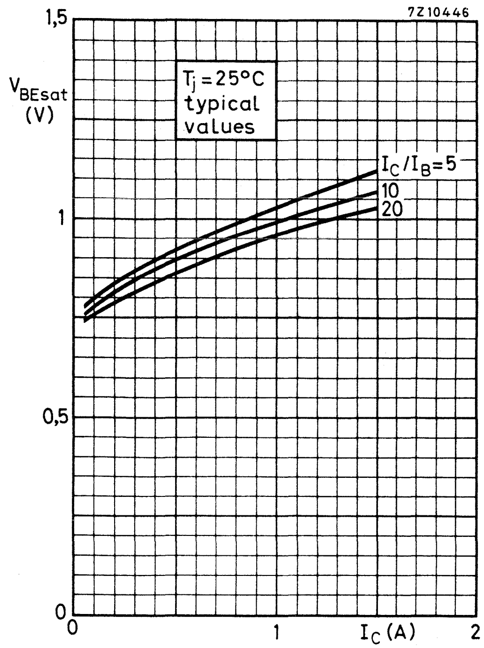


Fig. 12.

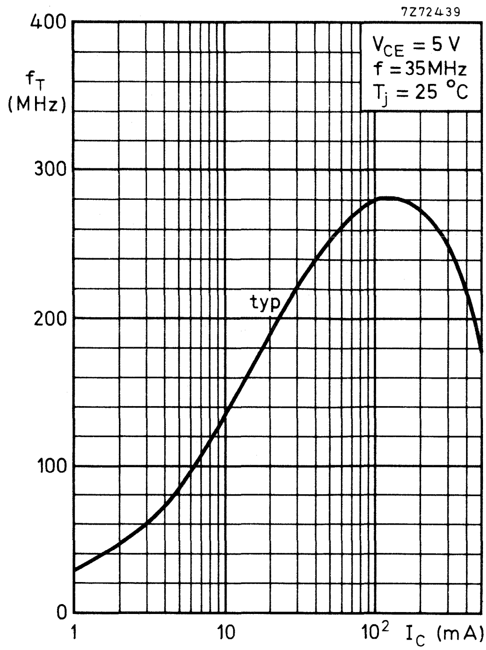


Fig. 13.

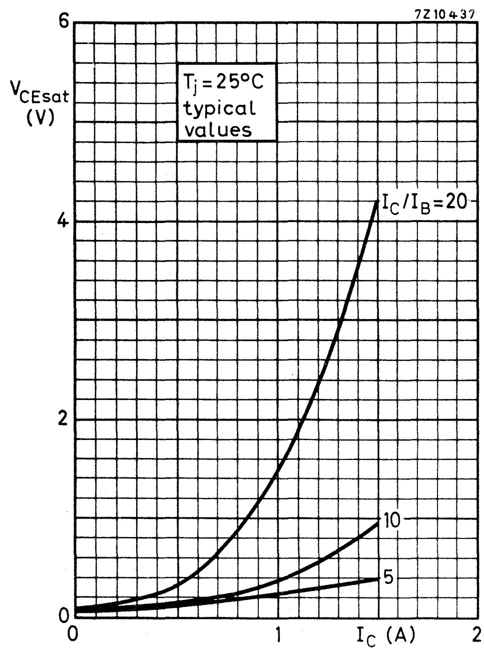


Fig. 14.

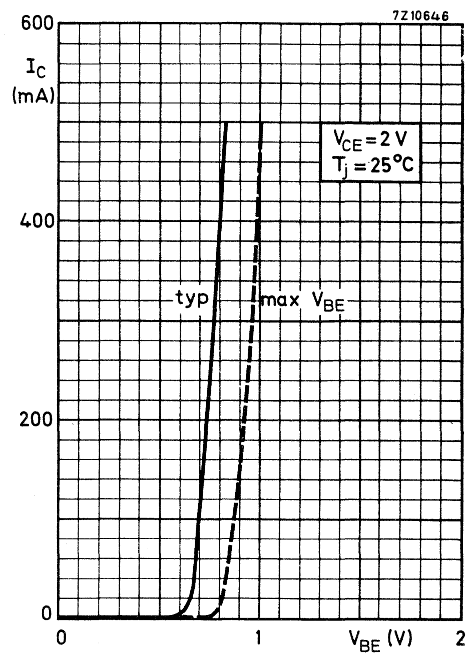


Fig. 15.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose p-n-p transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD135, BD137 and BD139 are complementary to the BD136, BD138 and BD140 respectively.

QUICK REFERENCE DATA

			BD136	BD138	BD140	
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 (d.c.)	$-I_C$	max.	1,5	1,5	1,5	A
Collector current (peak value)	$-I_{CM}$	max.	2,0	2,0	2,0	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	> <	40 250	40 250	40 250	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz

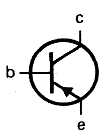
MECHANICAL DATA

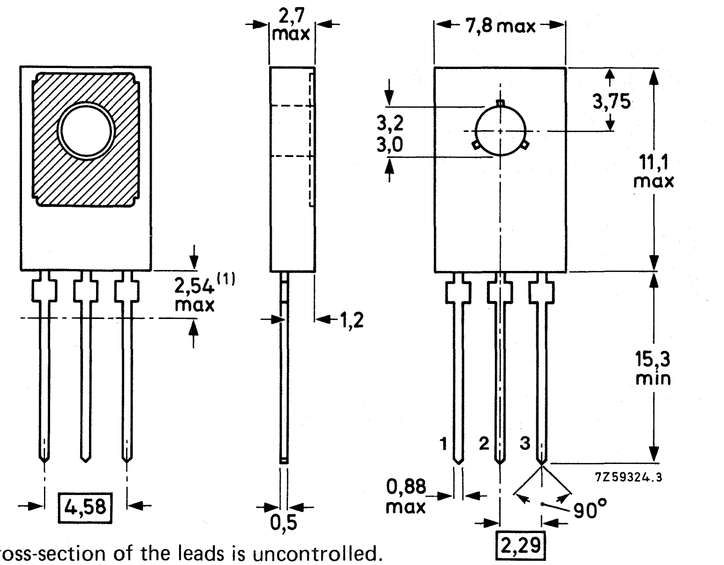
Dimensions in mm

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

Collector connected to metal part of mounting surface

Pinning
1 = emitter
2 = collector
3 = base





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

See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD136	BD138	BD140	
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
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	1,5	1,5	1,5	A
Collector current (peak value)	$-I_{CM}$	max.	2,0	2,0	2,0	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.		8		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	$R_{th\ j\text{-}a}$	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	10	K/W

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 = 125 °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	$-V_{EB}$	<	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				
BDxxx	h_{FE}		40 to 250	
BDxxx-06	h_{FE}		40 to 100	
BDxxx-10	h_{FE}		63 to 160	
BDxxx-16	h_{FE}		100 to 250	
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25	
Transition frequency at f = 35 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	MHz
D.C. current gain ratio of matched pairs				
BD135/BD136; BD137/BD138; BD139/BD140				
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	1,6	

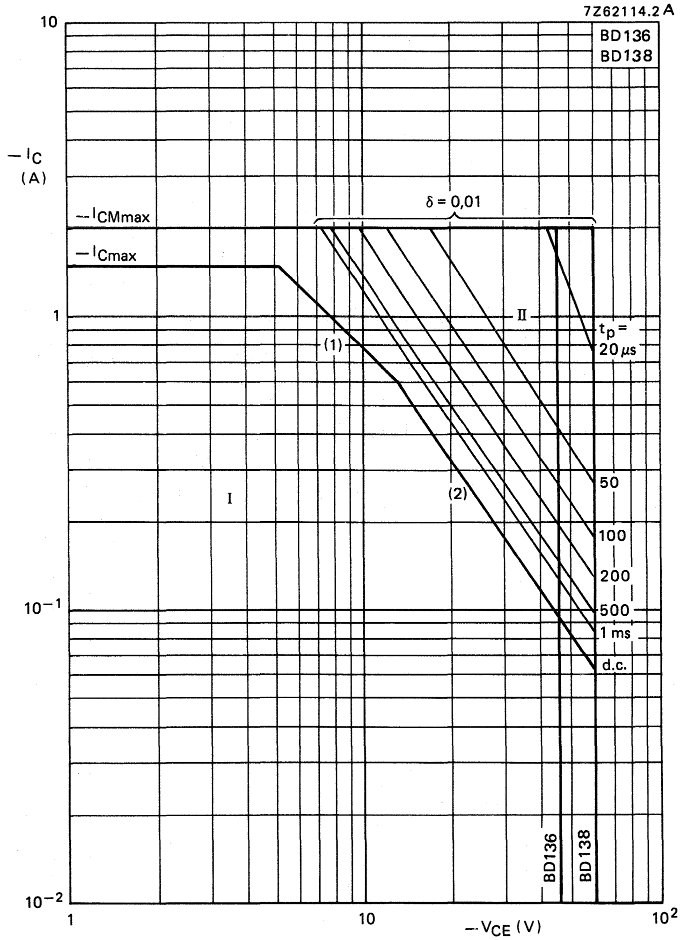


Fig. 2 Safe Operating Area with the transistor forward biased.

I   Region of permissible d.c. operation

II   Permissible extension for repetitive pulse operation

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

(2) Second breakdown limits.

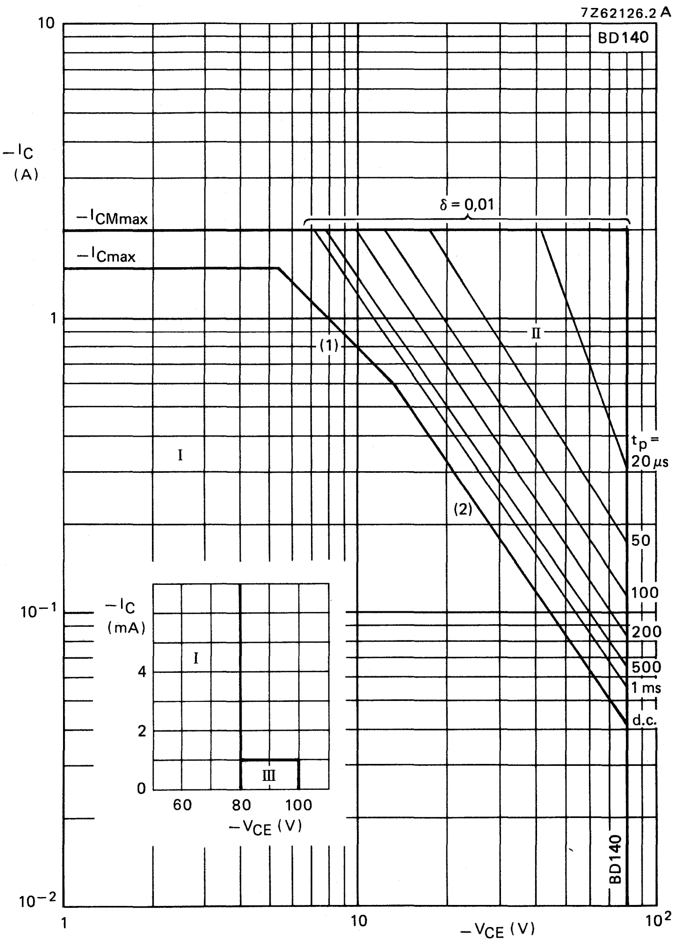


Fig. 3 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leqslant 1\ k\Omega$

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

(2) Second breakdown limits.

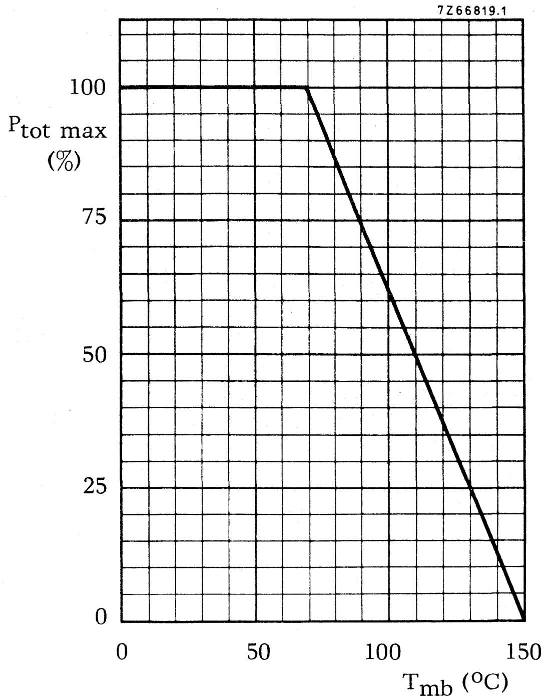

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

Fig. 4.

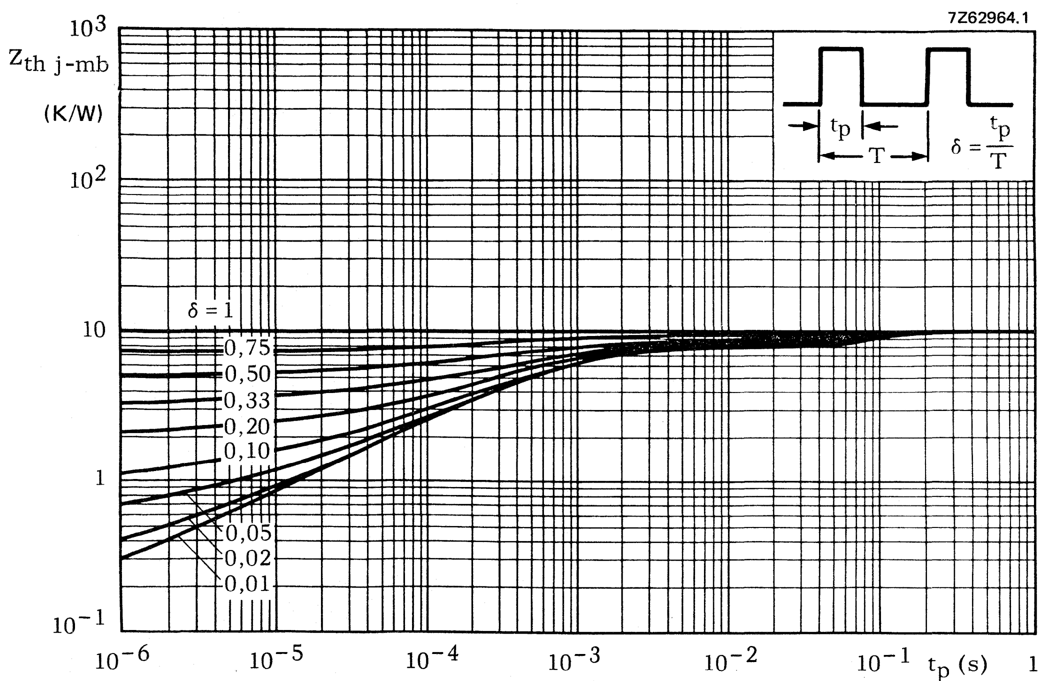

7Z62964.1
10^3
$Z_{th\ j-mb}$
(K/W)
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

Fig. 5.

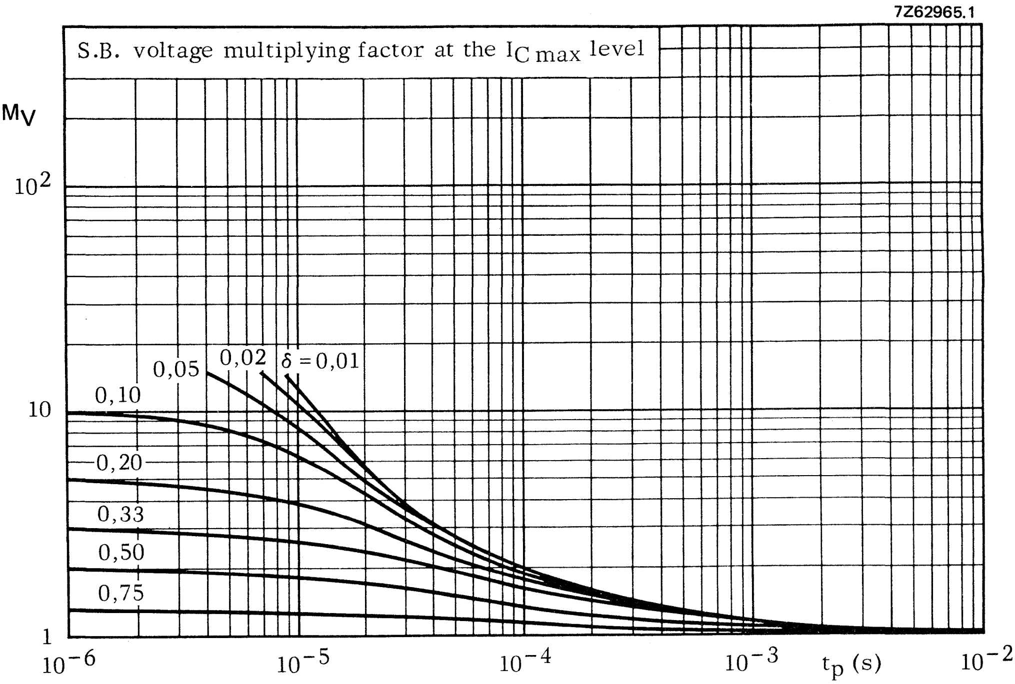

7Z62965.1
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 6.

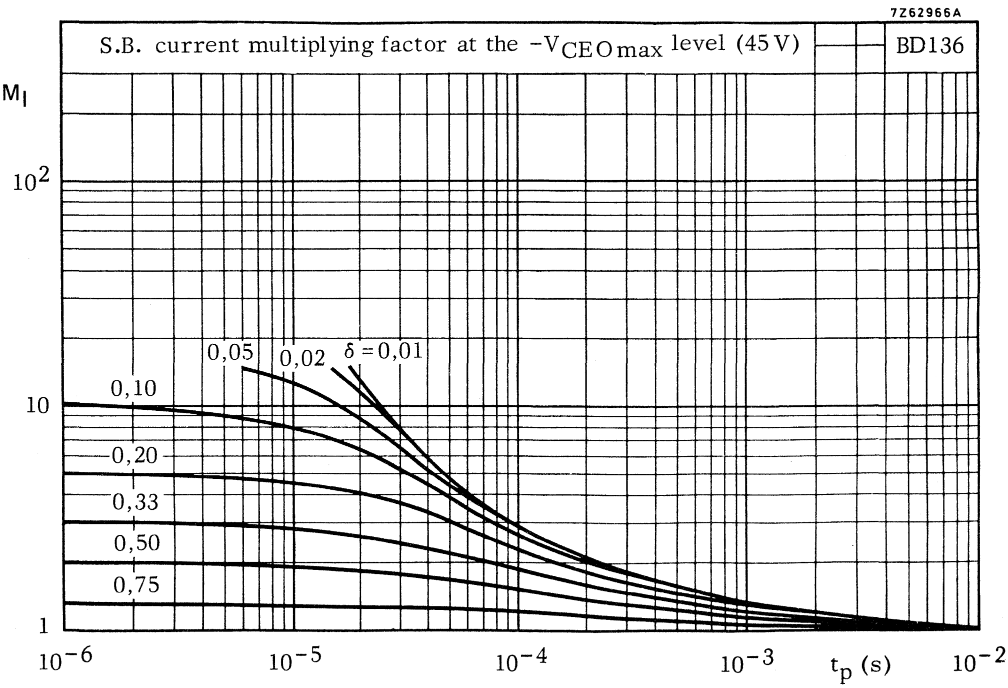

7Z62966A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (45 V)
BD136
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 7.

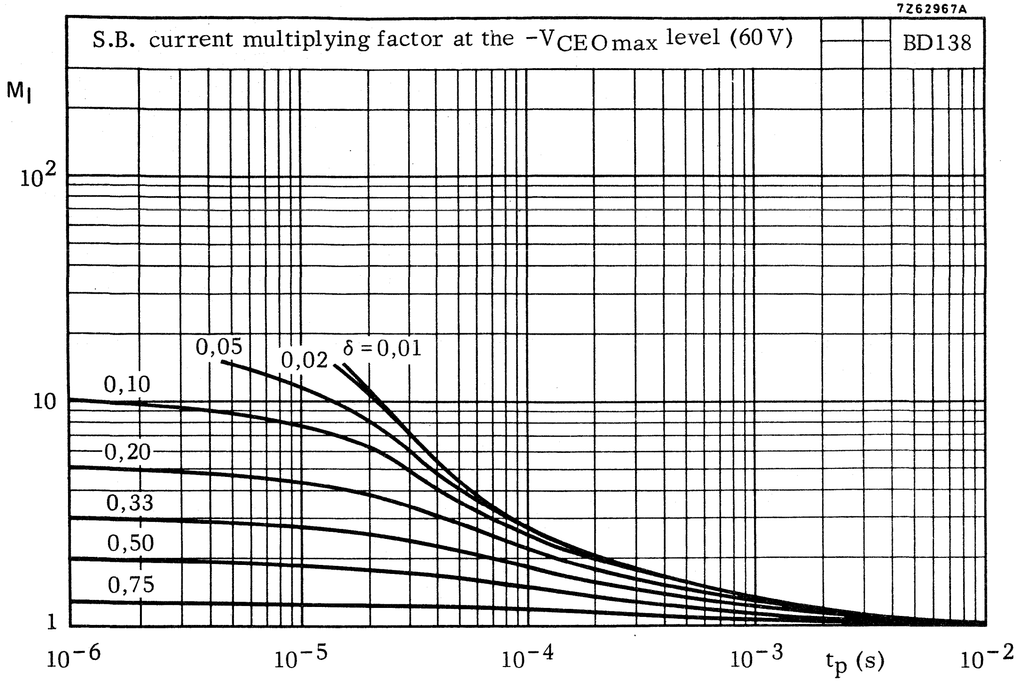

7Z62967A
S.B. current multiplying factor at the $-V_{CEO max}$ level (60 V)
BD138
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 8.

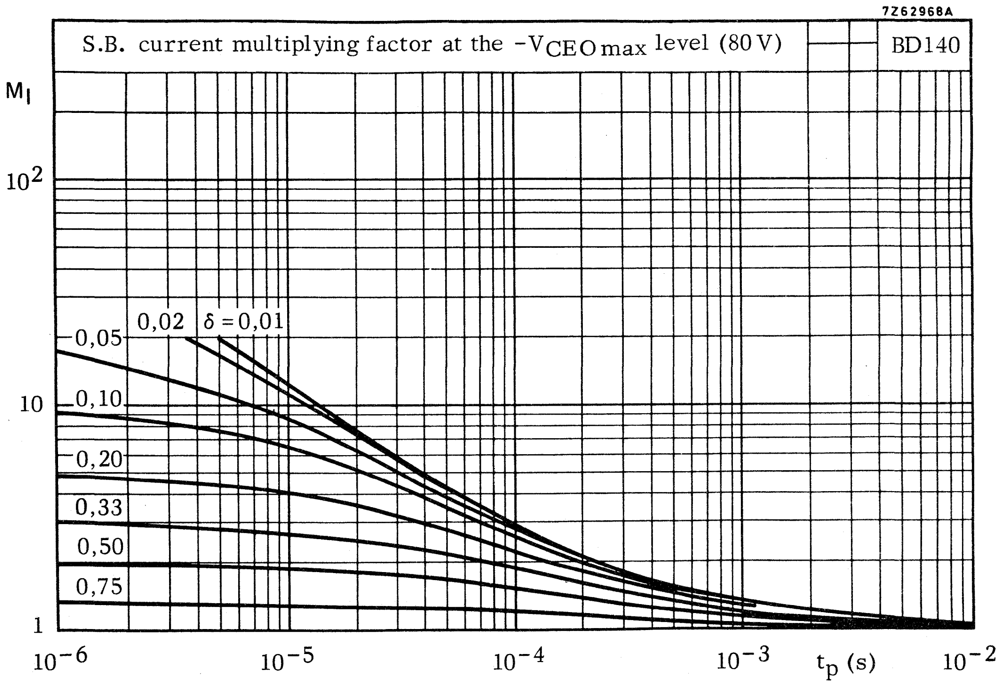

7Z62968A
S.B. current multiplying factor at the $-V_{CEO max}$ level (80 V)
BD140
M_I
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 9.

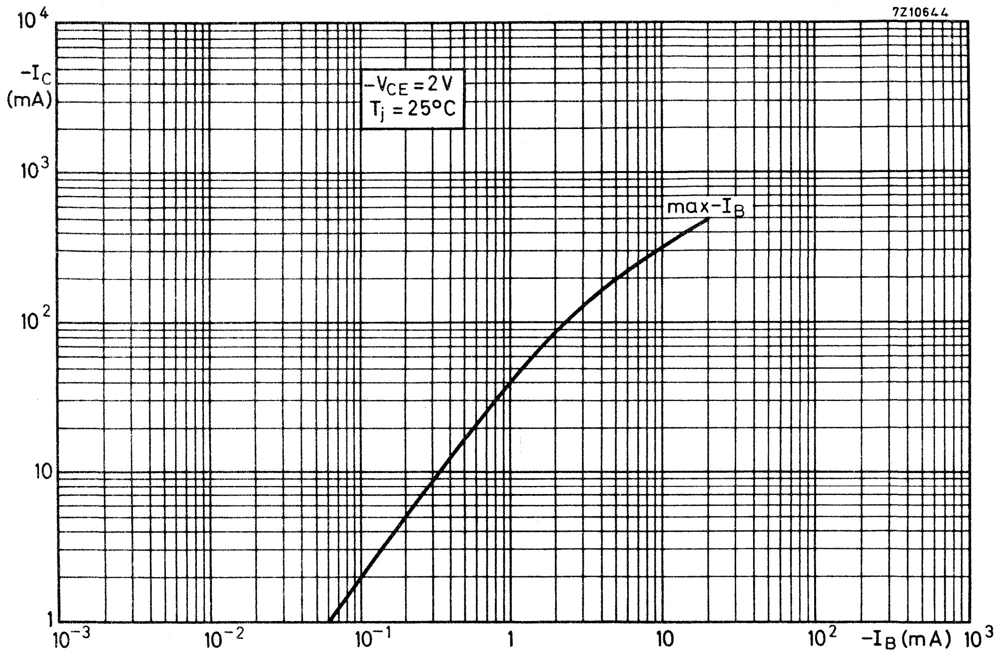

7Z10644
10^4
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$ °C
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

Fig. 10.

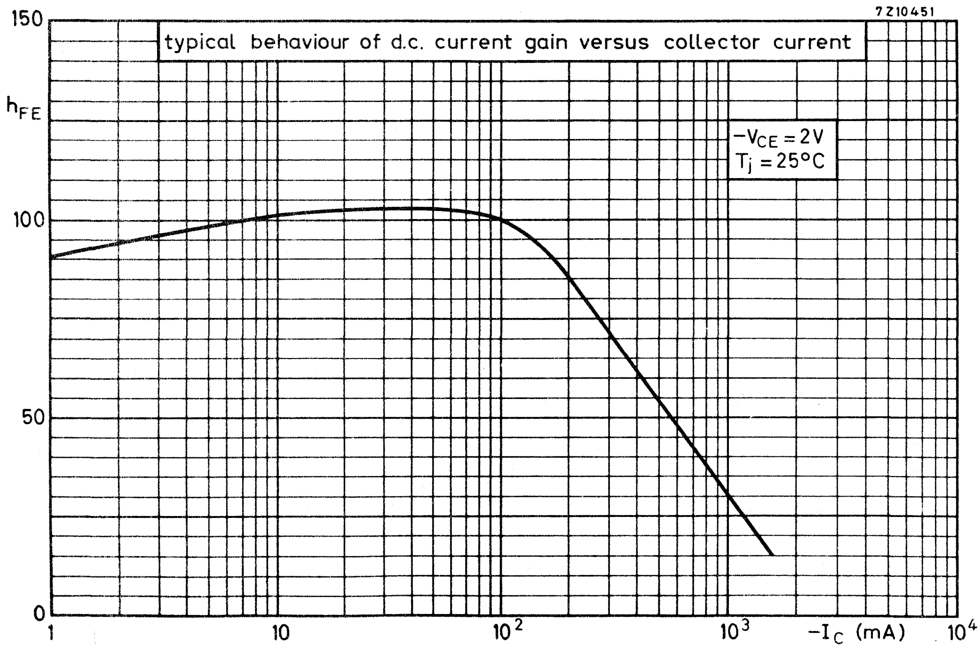

7Z10451
150
typical behaviour of d.c. current gain versus collector current
h_{FE}
$-V_{CE} = 2$ V
$T_j = 25$ °C
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 11.

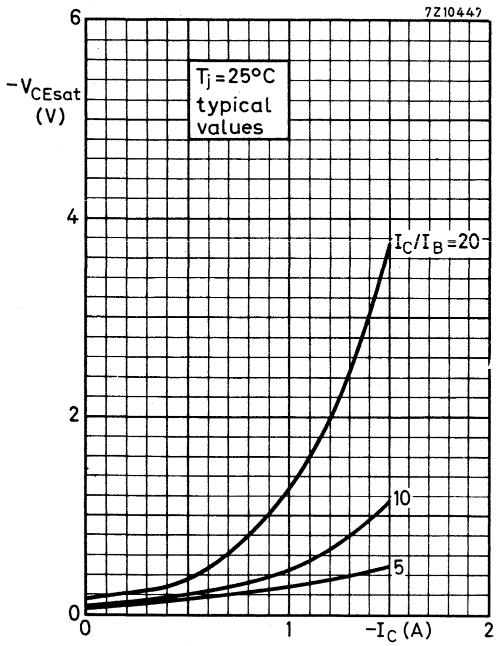


Fig. 12.

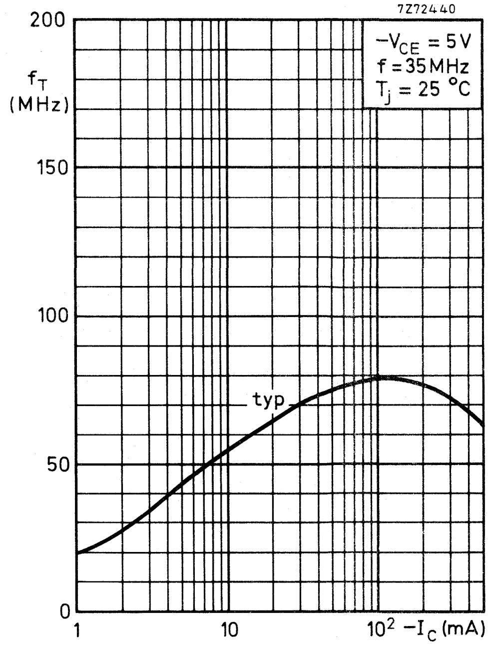


Fig. 13.

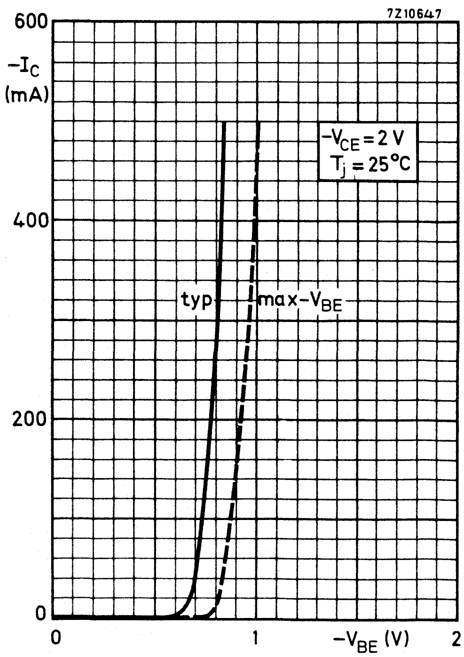


Fig. 14.

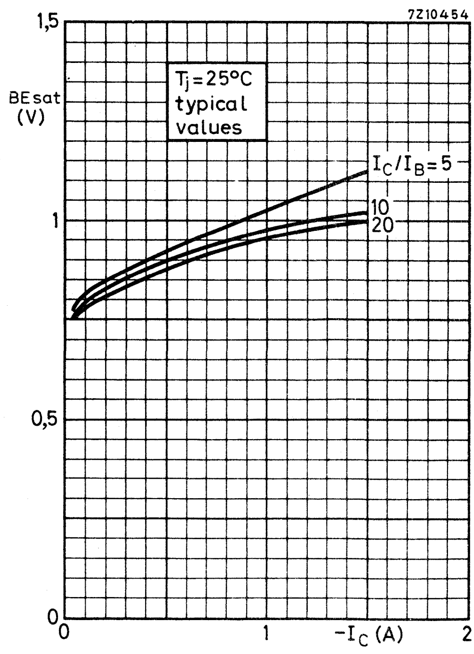


Fig. 15.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

NPN transistors in a plastic envelope. With their PNP complements BD202, BD204 and BDX78 they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

			BD201	BD203	BDX77	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector current (DC)	I_C	max.		8		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Cut-off frequency I_C = 0.3 A; V_{CE} = 3 V	f_{hfe}	min.		25		kHz

MECHANICAL DATA

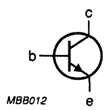
Dimensions in mm

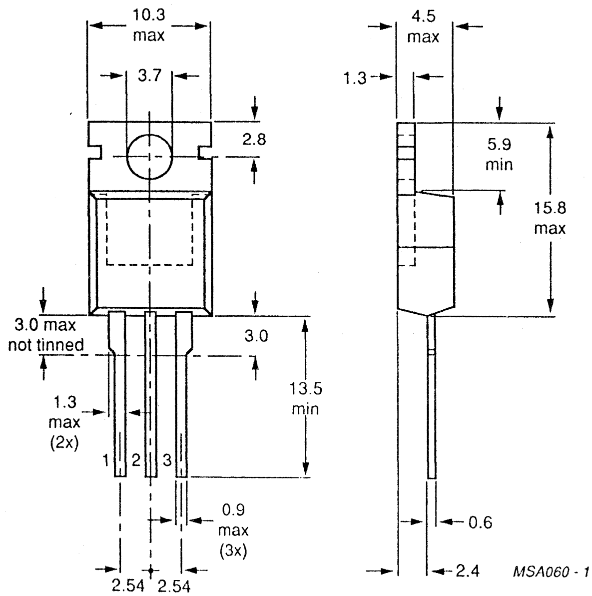
Fig.1 TO-220.

Collector connected to mounting base.

Pinning

1 = base
2 = collector
3 = emitter





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD201	BD203	BDX77	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (DC)	I_C	max.		8		A
Collector current (peak value, t_p max. 10 ms)	I_{CM}	max.		12		A
Collector current (non-repetitive peak value, t_p max. 2 ms)	I_{CSM}	max.		25		A
Base current (DC)	I_B	max.		3		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Storage temperature range	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_B = 0$; $V_{CE} = 30$ V		I_{CEO}	max.	0.2	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C		I_{CBO}	max.	1	mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V		I_{EBO}	max.	0.5	mA
Base-emitter voltage *					
$I_C = 3$ A; $V_{CE} = 2$ V		V_{BE}	max.	1.5	V
Knee voltage*					
$I_C = 3$ A; I_B = value for which $I_C = 3.3$ A at $V_{CE} = 2$ V		V_{CEK}	typ.	1	V
Saturation voltage*					
$I_C = 3$ A; $I_B = 0.3$ A		V_{CEsat}	max.	1	V
$I_C = 6$ A; $I_B = 0.6$ A		V_{CEsat}	max.	1.5	V
		V_{BEsat}	max.	2	V
DC current gain*					
$I_C = 3$ A; $V_{CE} = 2$ V	BD201	h_{FE}	min.	30	
$I_C = 2$ A; $V_{CE} = 2$ V	BD203	h_{FE}	min.	30	
$I_C = 1$ A; $V_{CE} = 2$ V	BDX77	h_{FE}	min.	30	
Cut-off frequency					
$I_C = 0.3$ A; $V_{CE} = 3$ V		f_{hfe}	min.	25	kHz

* Measured under pulse conditions: $t_p < 300\ \mu s$; $\delta = 2\%$.

Transition frequency at f = 1 MHz			
I_C = 0.3 A; V_{CE} = 3 V	f_T	min.	7 MHz
DC current gain ration of matched complementary pairs			
I_C = 1 A; V_{CE} = 2 V	h_{FE1}/h_{FE2}	max.	2.5
Forward bias second breakdown collector current			
V_{CE} = 40 V; t_p = 0.1 s; T_{amb} = 25 °C	$I_{(SB)}$	min.	1.5 A
Switching times			
I_{Con} = 2 A; I_{Bon} = $-I_{Boff}$ = 0.2 A			
turn-on time	t_{on}	max.	1 μs
turn-off time	t_{off}	max.	4 μs

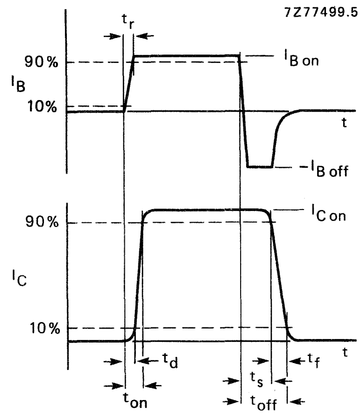


Fig.2 Switching waveforms.

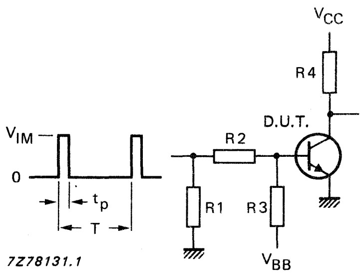


Fig.3 Switching times test circuit.

V_{IM}	= 15 V	R3	= 22 Ω
V_{CC}	= 20 V	R4	= 10 Ω
V_{BB}	= −4 V	$t_r = t_f$	⩽ 15 ns
R1	= –	t_p	= 20 μs
R2	= 33 Ω	T	= 500 μs

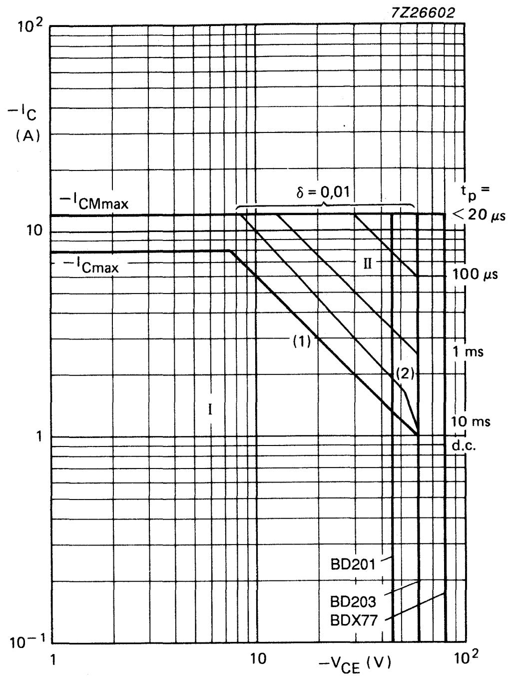


Fig.4 Safe Operating Area; $T_{mb} \leqslant 25$ °C.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits.

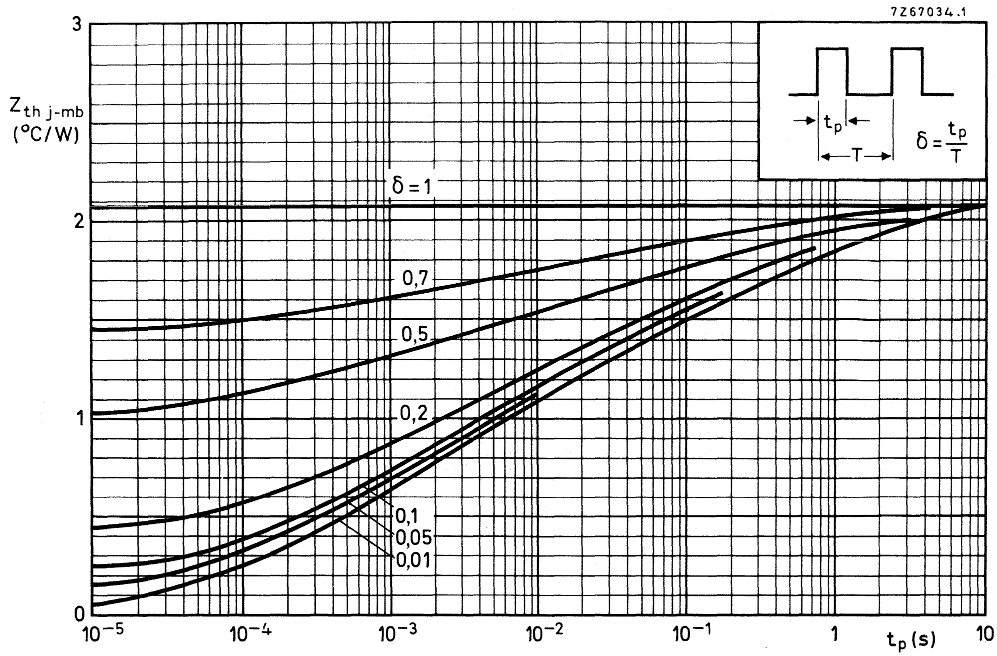


Fig.5 Pulse power rating chart.

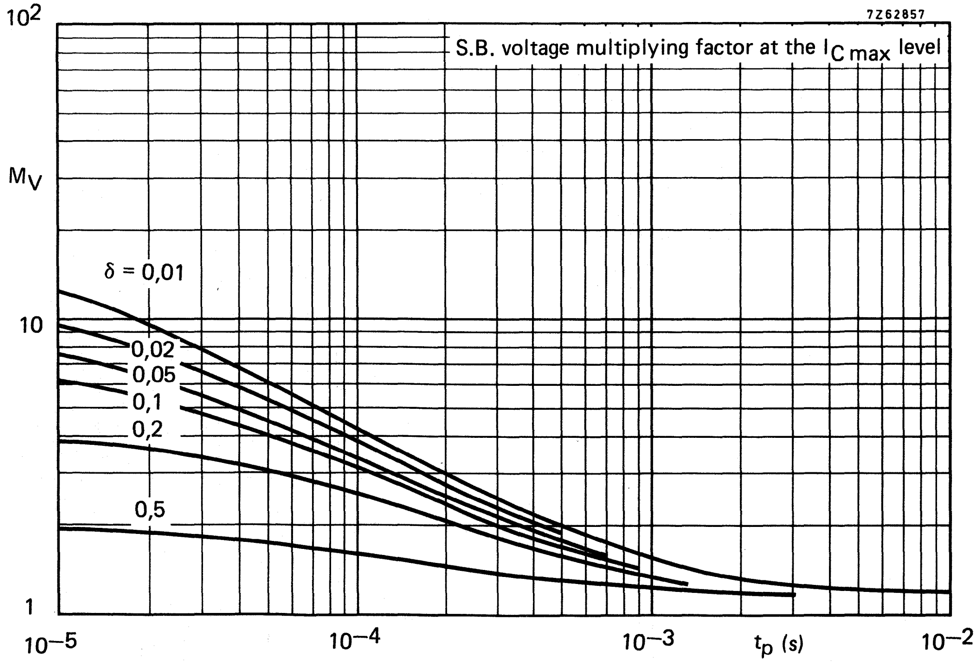


Fig.6 S.B. voltage multiplying factor at the I_{Cmax} level.

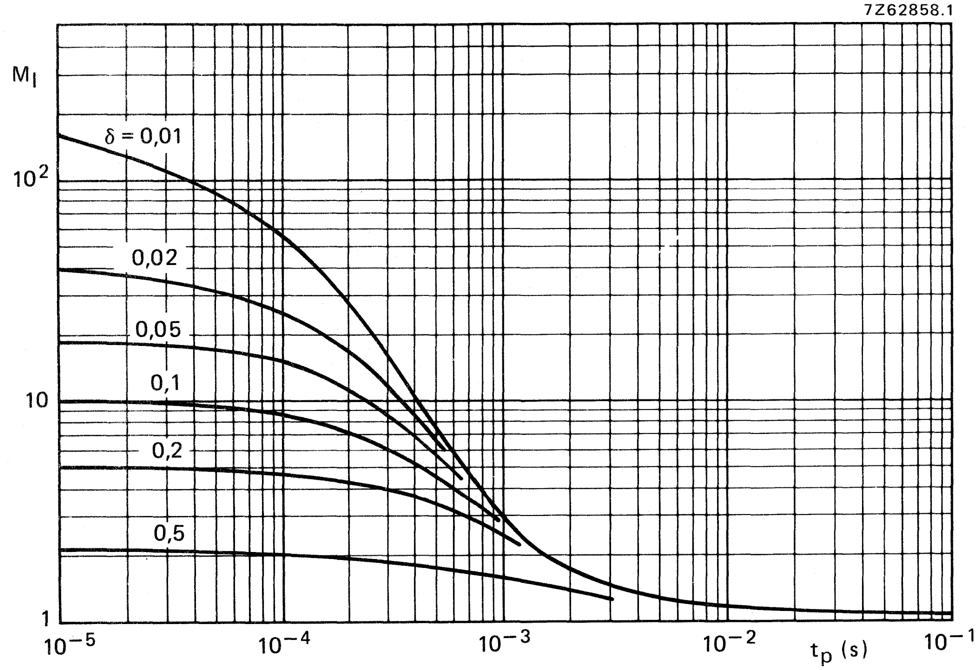


Fig.7 S.B. current multiplying factor at the V_{CEOmax} level.

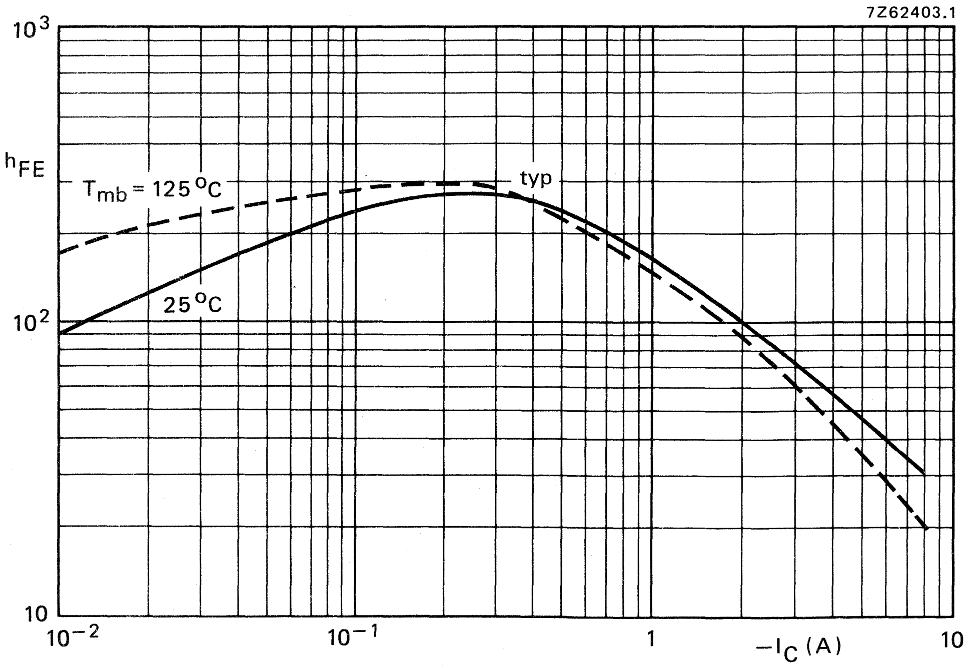


Fig.8 DC current gain. V_{CE} = 2 V.

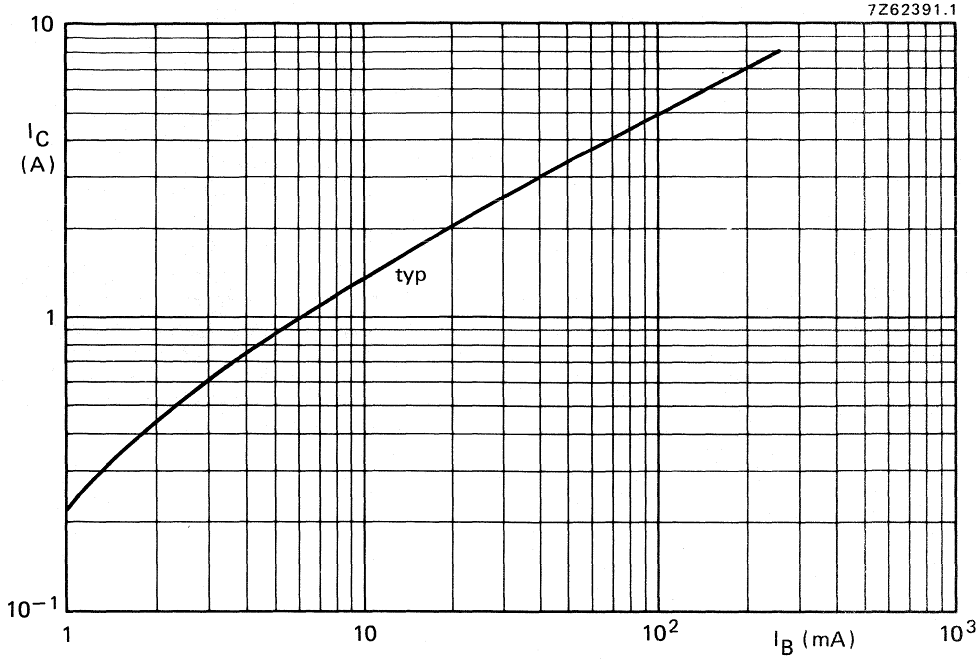


Fig. 9 Collector current as a function of base current. V_{CE} = 2 V; T_j = 25 °C.

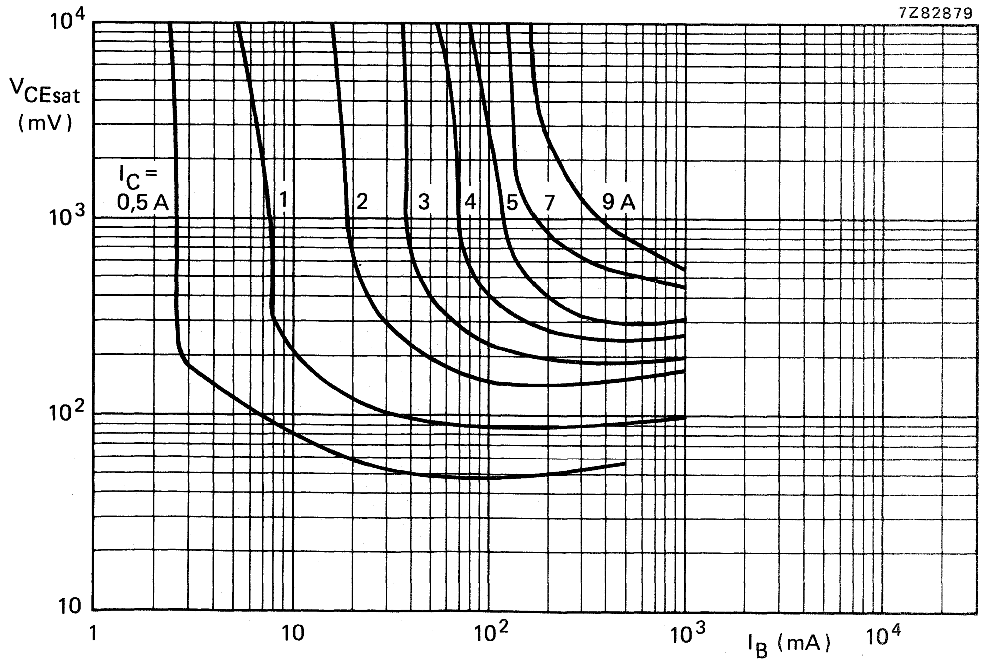


Fig.10 Typical collector-emitter saturation voltage. T_j = 25 °C.

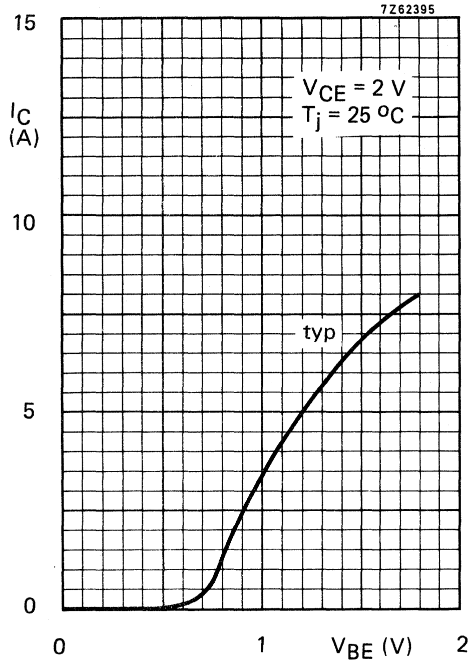


Fig.11.

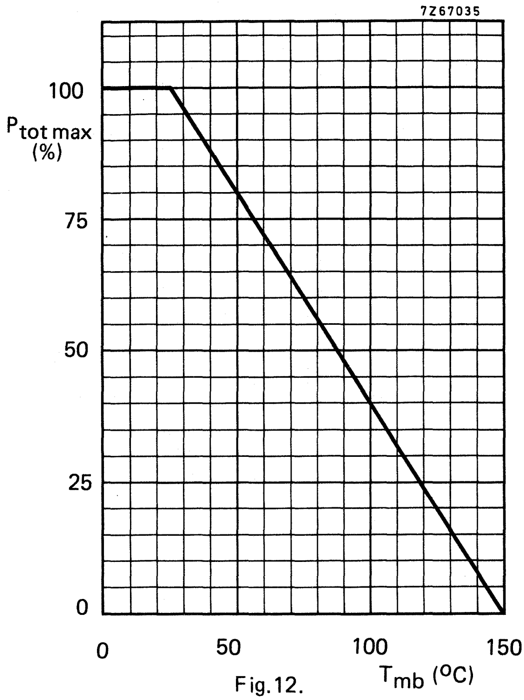


Fig.12.

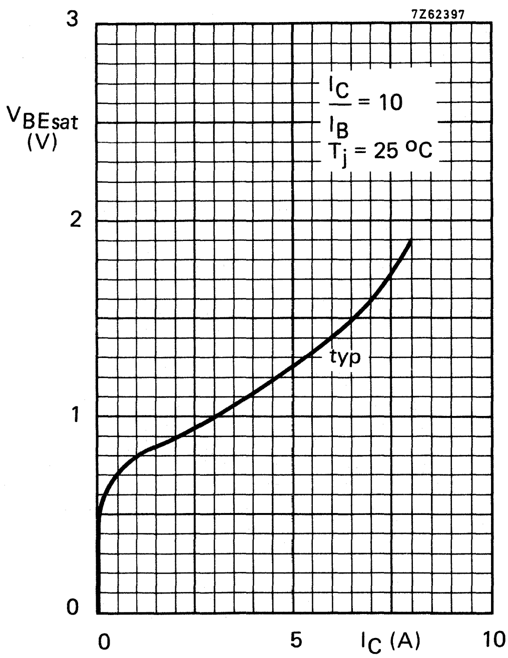


Fig.13.

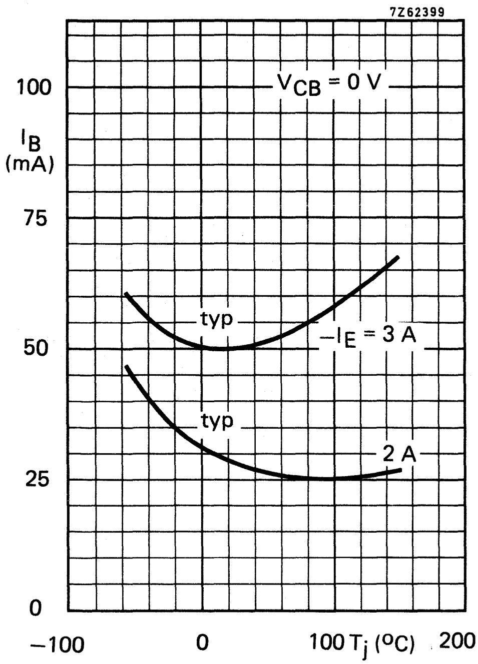


Fig.14.

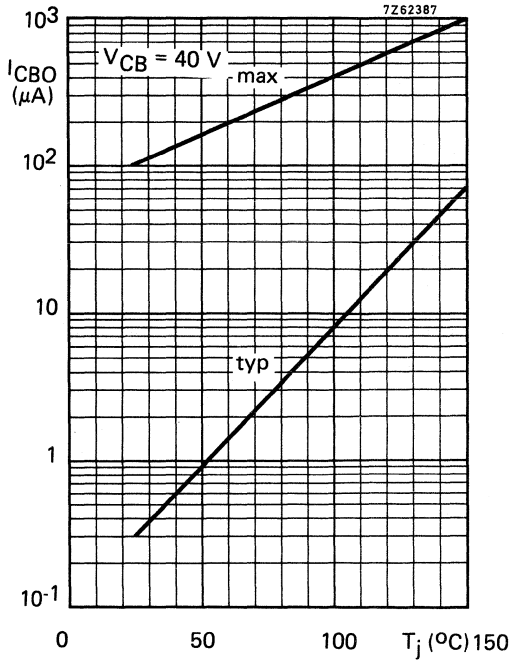


Fig.15.

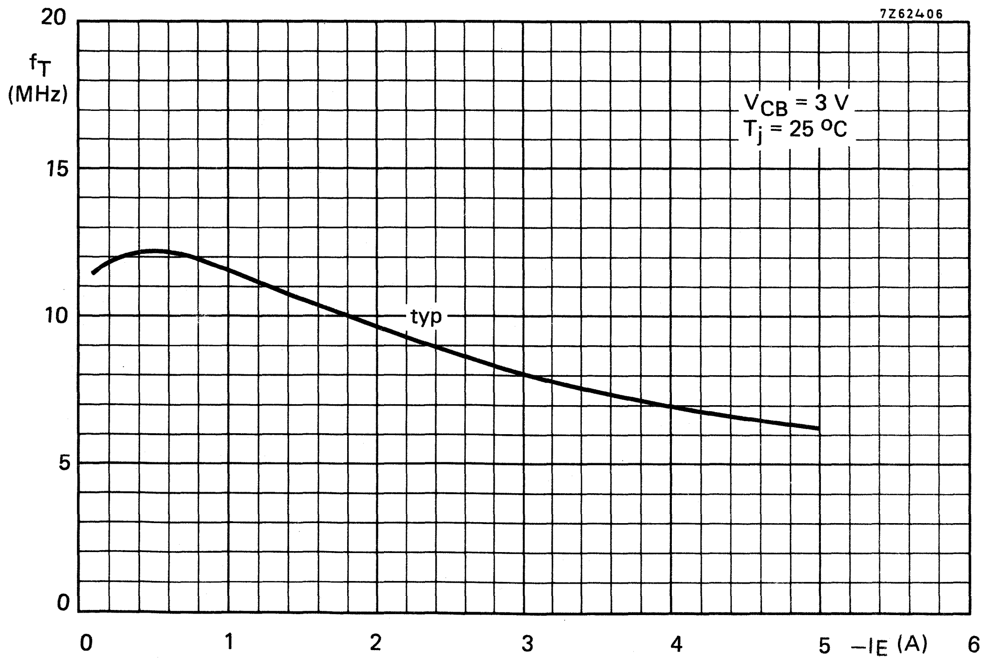


Fig.16.

SILICON EPITAXIAL POWER TRANSISTORS

NPN Silicon power transistors in a SOT186 envelope with an electrically insulated mounting base.
PNP complements are BD202F, BD204F and BDX78F.

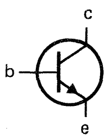
QUICK REFERENCE DATA

			BD201F	BD203F	BDX77F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current DC	I_C	max.		8		A
peak value	I_{CM}	max.		12		A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.		32		W

MECHANICAL DATA

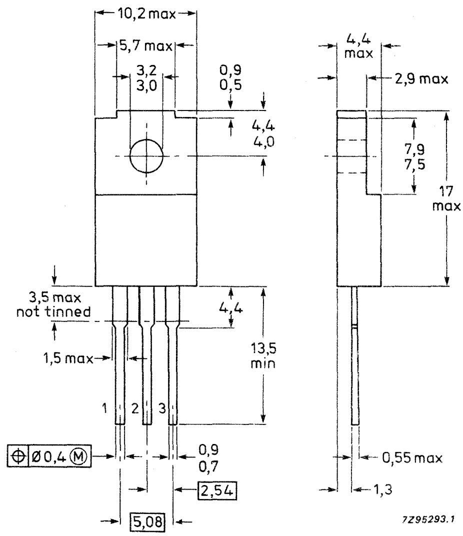
Dimensions in mm

Fig.1 SOT186.



Pinning

1 = Base
2 = Collector
3 = Emitter



RATINGS

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

			BD201F	BD203F	BDX77F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current						
DC	I_C	max.		8		A
peak value	I_{CM}	max.		12		A
Base current (DC)	I_B	max.		3		A
Total power dissipation						
up to T_h = 25 °C (note 1)	P_{tot}	max.		20		W
up to T_h = 25 °C (note 2)	P_{tot}	max.		32		W
Storage temperature	T_{stg}			−65 to 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

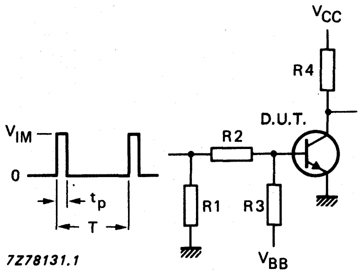
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD201F	BD203F	BDX77F	
Collector cut-off current						
I_B = 0; V_{CE} = 30 V	I_{CEO}	max.	0.2	0.2	0.2	mA
I_E = 0; V_{CB} = V_{CBO}	I_{CBO}	max.	0.1	0.1	0.1	mA
I_E = 0; V_{CB} = ½V_{CBO}; T_j = 150 °C	I_{CBO}	max.	1.0	1.0	1.0	mA
Emitter cut-off current						
I_C = 0; V_{EB} = 5 V	I_{EBO}	max.	0.5	0.5	0.5	mA
Collector-emitter breakdown voltage (note 1)						
I_C = 0.2 A; I_B = 0	$V_{(BR)CEO}$	min.	45	60	80	V
DC current gain (note 1)						
I_C = 3 A; V_{CE} = 2 V	h_{FE}	min.	30	–	–	
I_C = 2 A; V_{CE} = 2 V	h_{FE}	min.	–	30	30	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	min.	30	30	–	
Collector-emitter saturation voltage (note 1)						
I_C = 3 A; I_B = 0.3 A	V_{CEsat}	max.	1.0	1.0	1.0	V
I_C = 2 A; I_B = 0.2 A	V_{CEsat}	max.	–	–	0.6	V
I_C = 6 A; I_B = 0.6 A	V_{CEsat}	max.	1.5	1.5	1.5	V
Knee voltage (note 1)						
I_C = 3 A; I_B = value at which I_C = 3.3 A at V_{CE} = 2 V	V_{CEK}	typ.		1.0		V
Base-emitter voltage (note 1)						
I_C = 3 A; V_{CE} = 2 V	V_{BE}	max.		1.5		V
Base-emitter saturation voltage (note 1)						
I_C = 6 A; I_B = 0.6 A	V_{BEsat}	max.		2.0		V
Cut-off frequency						
I_C = 0.3 A; V_{CE} = 3 V	f_{HFE}	min.		25		kHz
Transition frequency at f = 1 MHz						
I_E = 0.3 A; V_{CB} = 3 V	f_T	min.		7.0		MHz
Forward bias second breakdown collector current						
V_{CE} = 40 V; t_p = 0.1 s	I_{SB}	min.		0.8		A
Switching times						
$I_{C\,on}$ = 2 A; $I_{B\,on}$ = $I_{B\,off}$ = 0.2 A						
turn-on time	t_{on}	max.		1.0		µs
turn-off time	t_{off}	max.		4.0		µs

Note

1. To be measured under pulsed conditions. Pulse time 300 µs, duty cycle 2%.



V_{IM}	= 15 V
V_{CC}	= 20 V
$-V_{BB}$	= 4 V
R1	= 56 Ω
R2	= 33 Ω
R3	= 22 Ω
R4	= 10 Ω
t_r	= t_f = 15 ns
t_p	= 20 μs
T	= 500 μs

Fig. 2 Switching times test circuit.

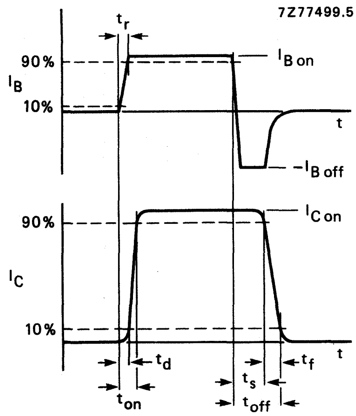
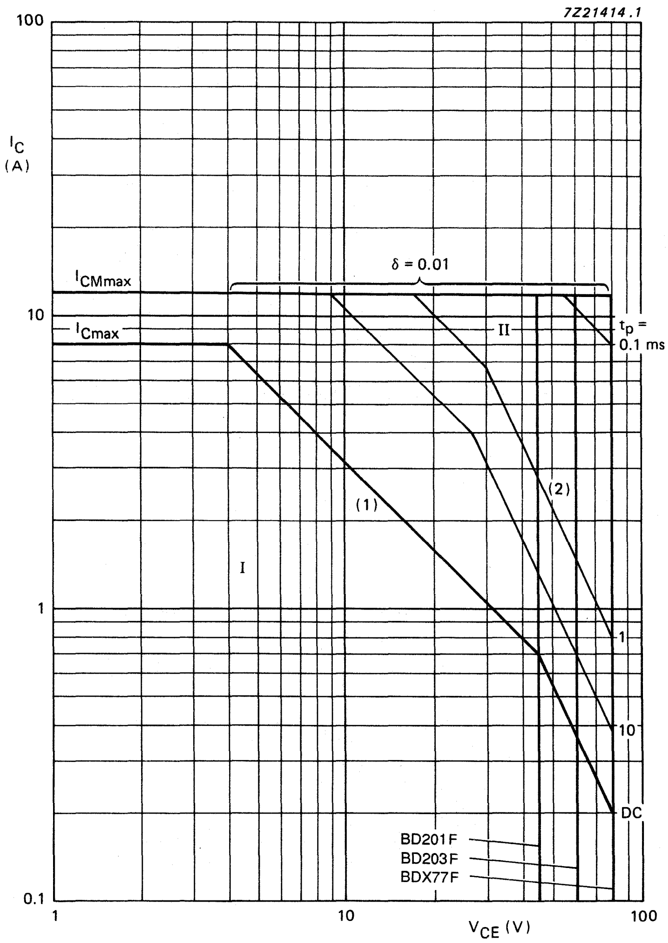


Fig. 3 Switching times waveforms.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) P_{tot} max and P_{peak} max lines.
(2) Second-breakdown limits.

Note: Mounted with heatsink compound and 30 ± 5 newtons pressure on the centre of the envelope.

Fig.4 Safe Operating Area; T_{amb} = 25 °C.

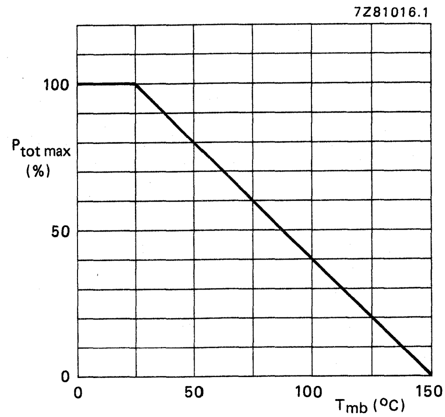


Fig. 5 Maximum power dissipation as a function of temperature.

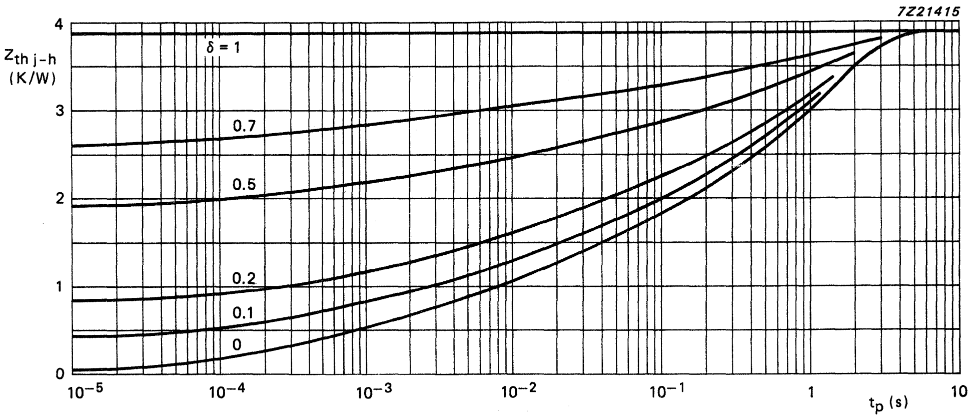


Fig. 6 Pulse power rating chart.

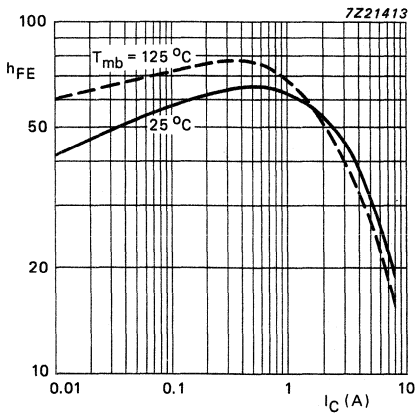


Fig. 7 Typical DC current gain curves at V_{CE} = 2 V.

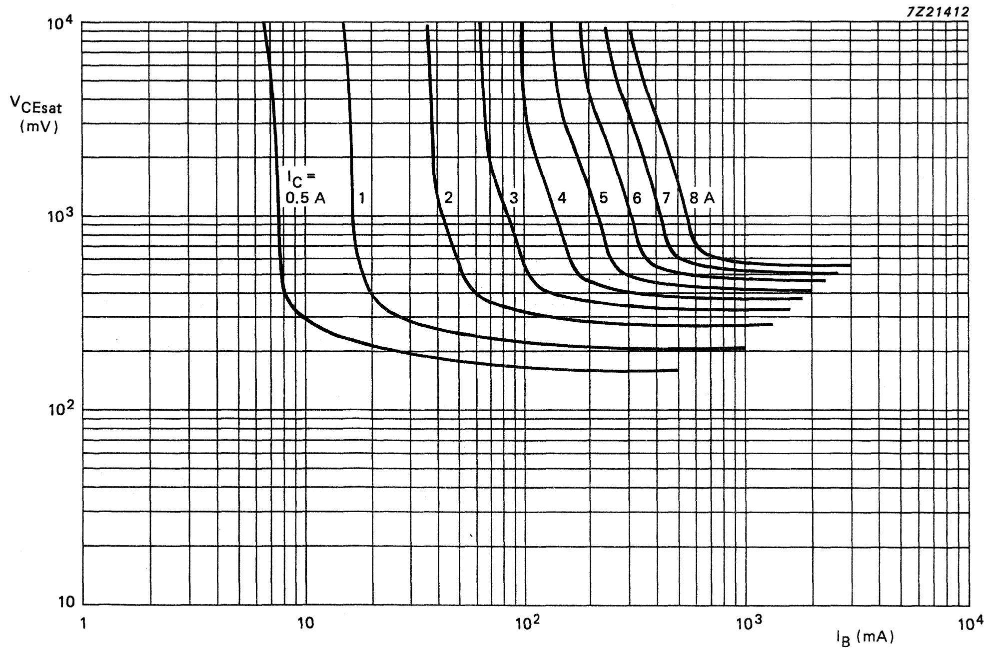


Fig. 8 Collector-emitter saturation voltage as a function of base current; typical values; T_j = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

PNP transistors in a plastic envelope. With their npn complements BD201, BD203, and BDX77, they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

			BD202	BD204	BDX78	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector current (DC)	$-I_C$	max.		8		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Cut-off frequency $-I_C$ = 0.3 A; $-V_{CE}$ = 3 V	f_{hfe}	min.		25		kHz

MECHANICAL DATA

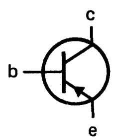
Dimensions in mm

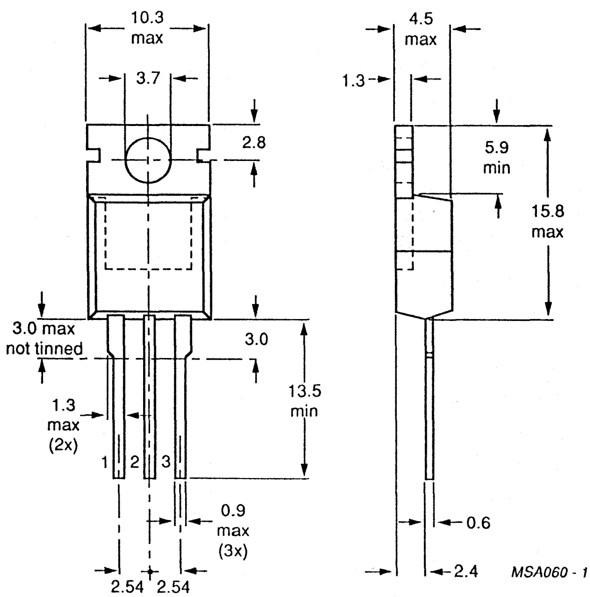
Fig.1 TO-220.

Collector connected to mounting base.

Pinning

1 = base
2 = collector
3 = emitter





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD202	BD204	BDX78	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (DC)	$-I_C$	max.		8		A
Collector current (peak value; t_p max. 10 ms)	$-I_{CM}$	max.		12		A
Collector current (non-repetitive peak value, t_p max. 2 ms)	$-I_{CSM}$	max.		25		A
Base current (DC)	$-I_B$	max.		3		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Storage temperature range	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_B = 0$; $-V_{CE} = 30$ V		$-I_{CEO}$	max.	0.2	mA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C		$-I_{CBO}$	max.	1	mA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 5$ V		$-I_{EBO}$	max.	0.5	mA
Collector-emitter breakdown voltage					
$I_C = 0.2$ A; $I_B = 0$	BD202	$-V_{(BR)CEO}$	min.	45	V
$I_C = 0.2$ A; $I_B = 0$	BD204	$-V_{(BR)CEO}$	min.	60	V
$I_C = 0.2$ A; $I_B = 0$	BDX78	$-V_{(BR)CEO}$	min.	80	V
Base-emitter voltage (note 1)					
$-I_C = 3$ A; $-V_{CE} = 2$ V		$-V_{BE}$	max.	1.5	V
Knee voltage (note 1)					
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3.3$ A at $-V_{CE} = 2$ V		$-V_{CEK}$	typ.	1	V
Saturation voltages (note 1)					
$-I_C = 3$ A; $-I_B = 0.3$ A		$-V_{CEsat}$	max.	1	V
$-I_C = 6$ A; $-I_B = 0.6$ A		$-V_{CEsat}$	max.	1.5	V
		$-V_{BEsat}$	max.	2	V
DC current gain (note 1)					
$-I_C = 3$ A; $-V_{CE} = 2$ V	BD202	h_{FE}	min.	30	
$-I_C = 2$ A; $-V_{CE} = 2$ V	BD204	h_{FE}	min.	30	
$-I_C = 1$ A; $-V_{CE} = 2$ V	BDX78	h_{FE}	min.	30	

Note

1. Measured under pulse conditions: $t_p < 300\ \mu s$; $\delta < 2\%$.

Cut-off frequency		
$-I_C = 0.3$ A; $-V_{CE} = 3$ V	f_{hfe}	min. 25 kHz
Transition frequency at f = 1 MHz		
$-I_C = 0.3$ A; $-V_{CE} = 3$ V	f_T	min. 7 MHz
DC current gain ratio of matched complementary pairs		
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE1}/h_{FE2}	max. 2.5
Forward bias second breakdown collector current		
$V_{CE} = 40$ V; $t_p = 0.1$ s	I_{SB}	min. 1.5 A
Switching times		
$-I_{Con} = 2$ A; $-I_{Bon} = I_{Boff} = 0.2$ A		
turn-on time	t_{on}	max. 1 µs
turn-off time	t_{off}	max. 2 µs

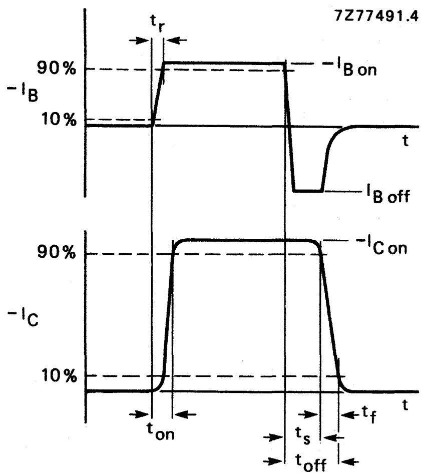


Fig. 2 Switching times waveforms.

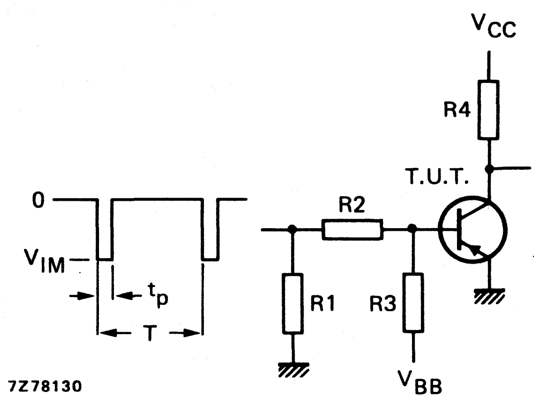
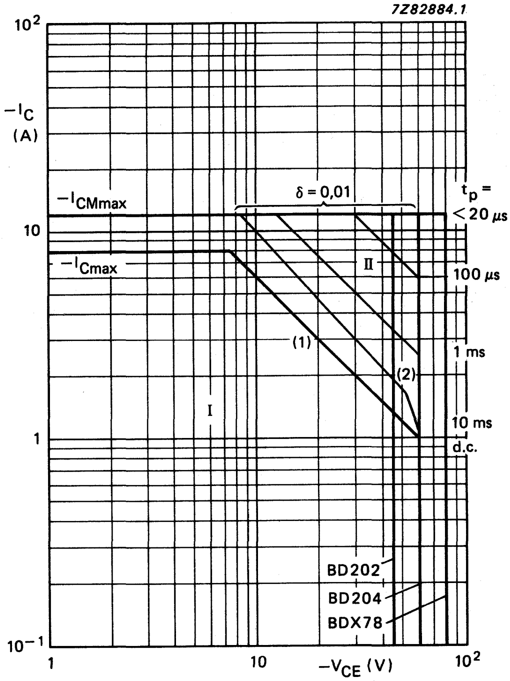


Fig. 3 Switching times test circuit.

$-V_{IM}$	= 15 V	R3	= 22 Ω
$-V_{CC}$	= 20 V	R4	= 10 Ω
$+V_{BB}$	= 4 V	$t_r = t_f$	= 15 ns
R1	= 56 Ω	t_p	= 10 µs
R2	= 33 Ω	T	= 500 µs



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

Fig.4 Safe operating area; T_{mb} = 25 °C.

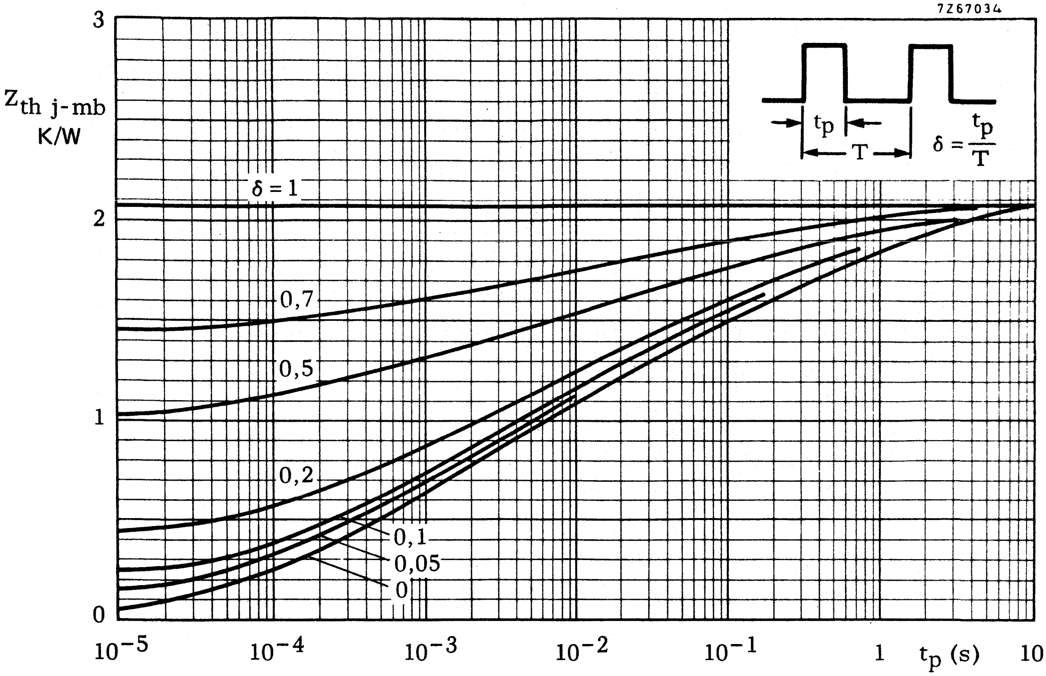


Fig. 5 Pulse power rating chart.

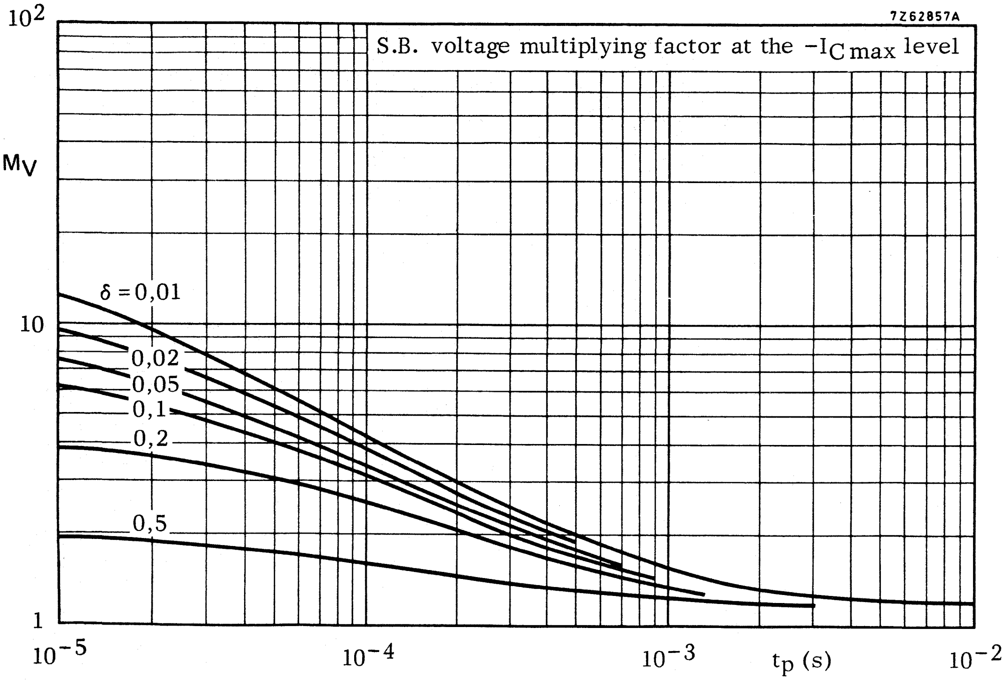


Fig. 6 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

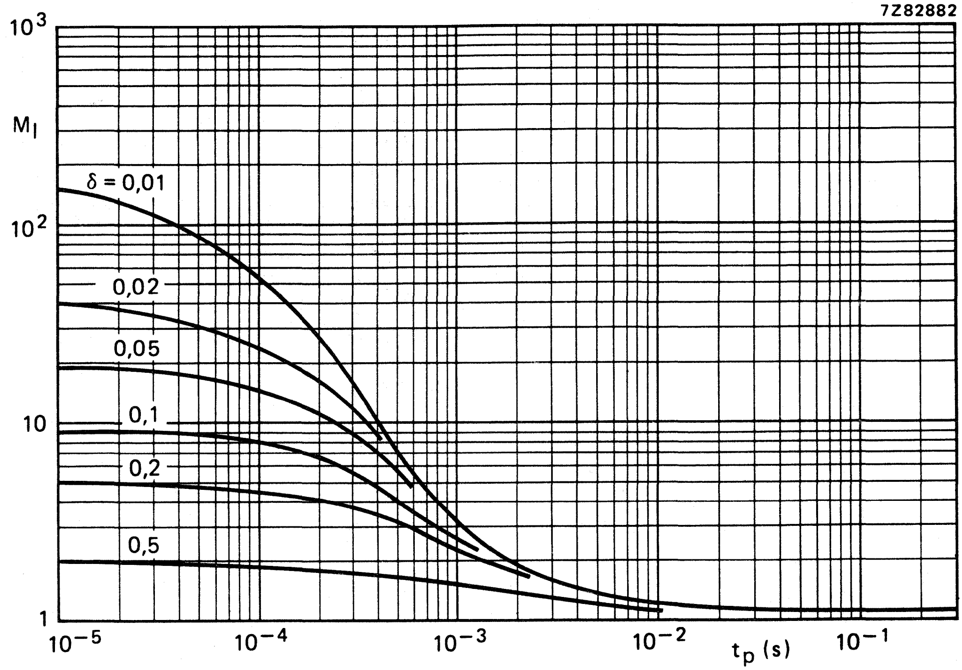


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

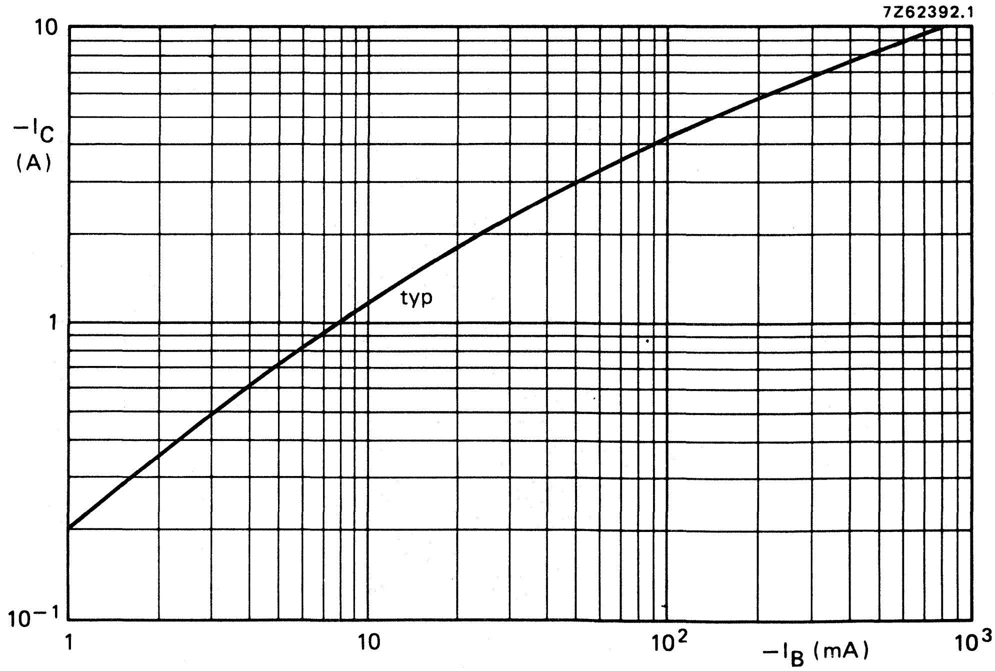


Fig. 8 Typical collector current as a function of base current. $-V_{CE}$ = 2 V; T_j = 25 °C.

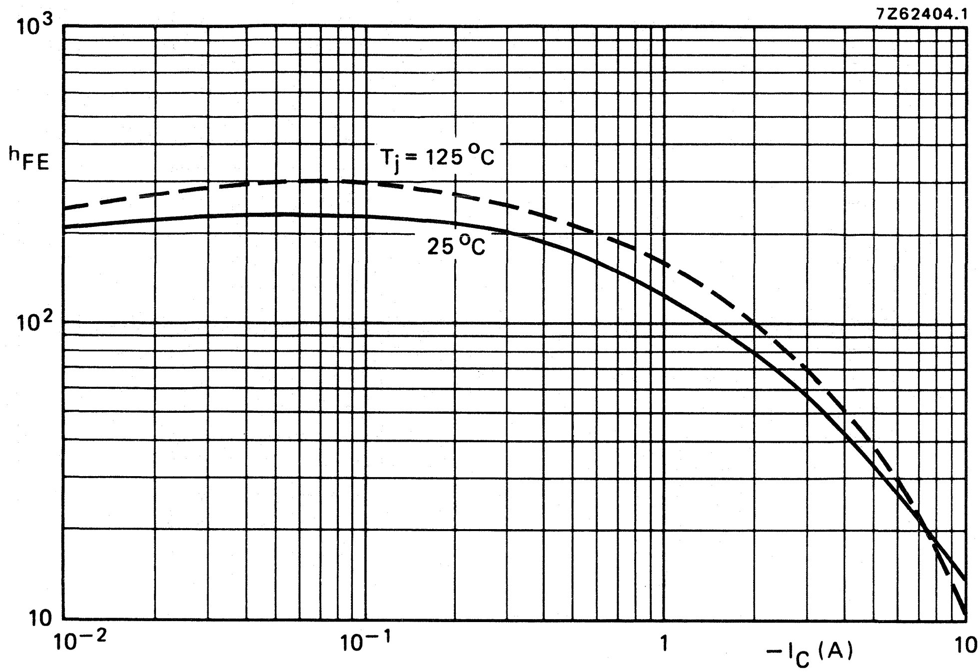


Fig. 9 Typical forward current transfer ratio at $-V_{CE} = 2$ V.

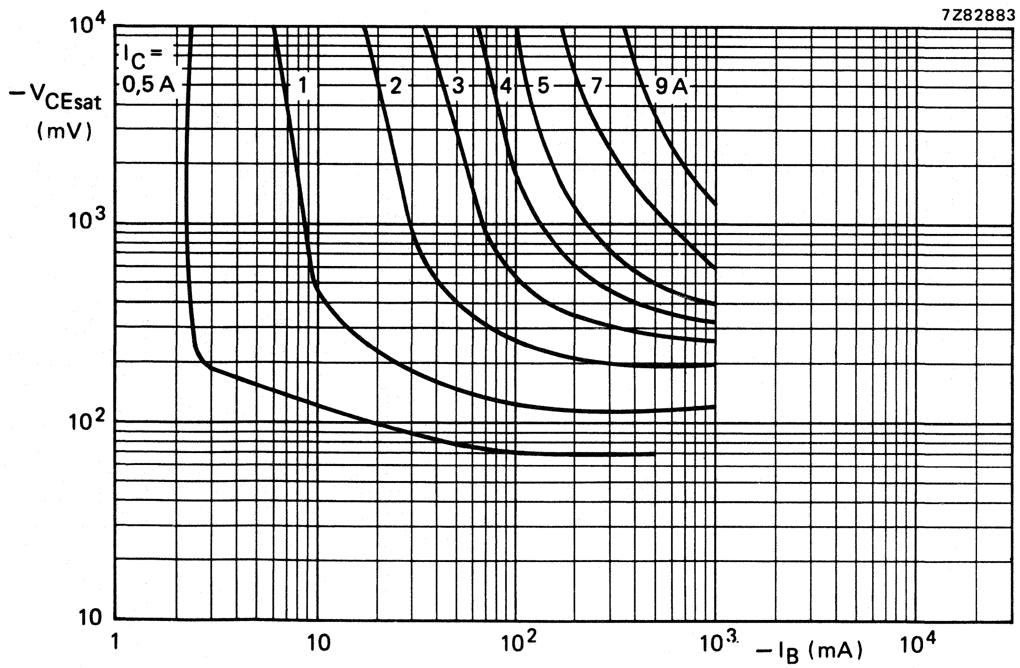


Fig. 10 Typical collector-emitter saturation voltage. $T_j = 25\ ^oC$.

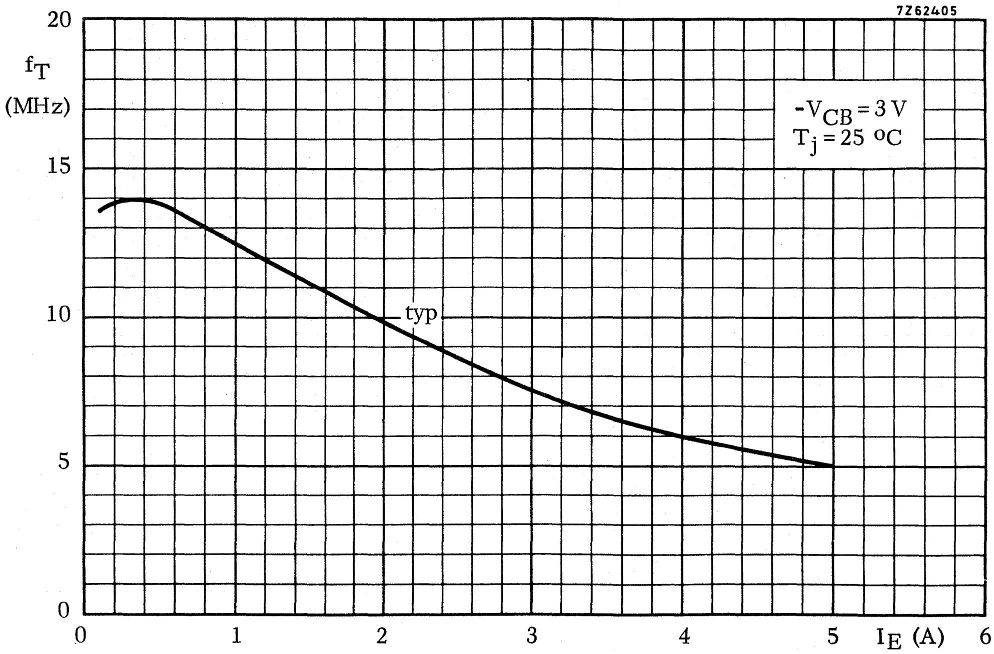


Fig. 11 Typical transition frequency.

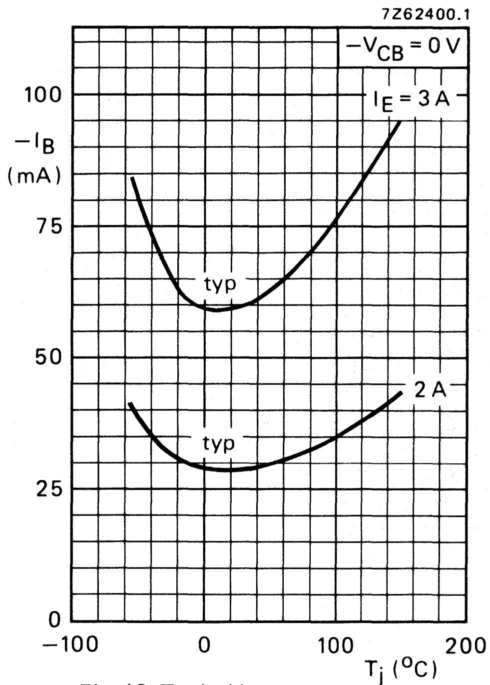


Fig. 12 Typical base current.

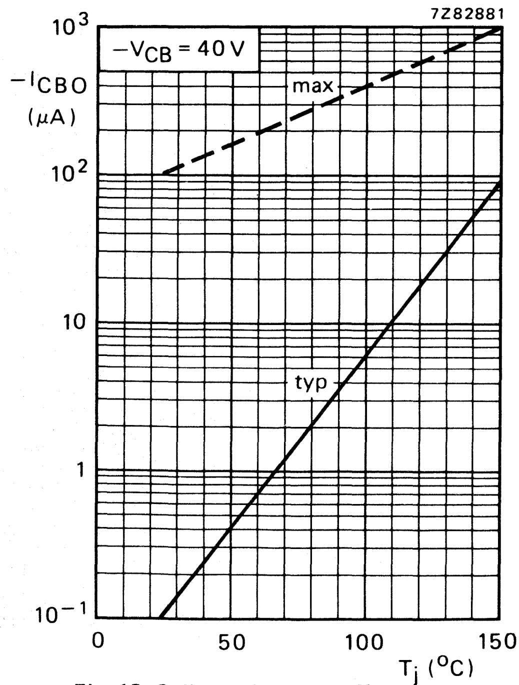


Fig. 13 Collector-base cut-off current.

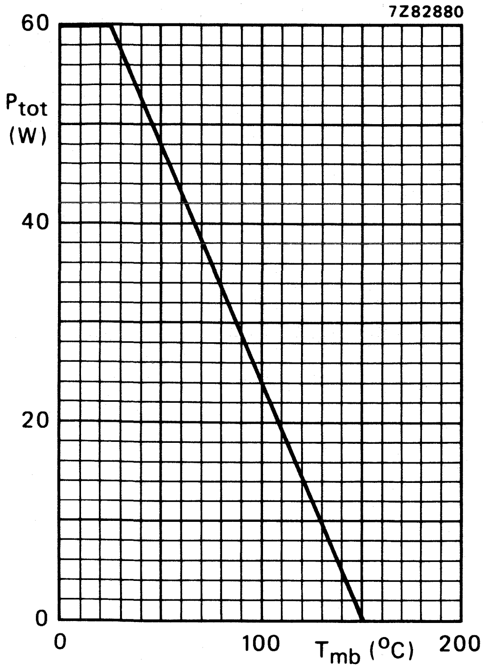


Fig. 14 Total power dissipation.

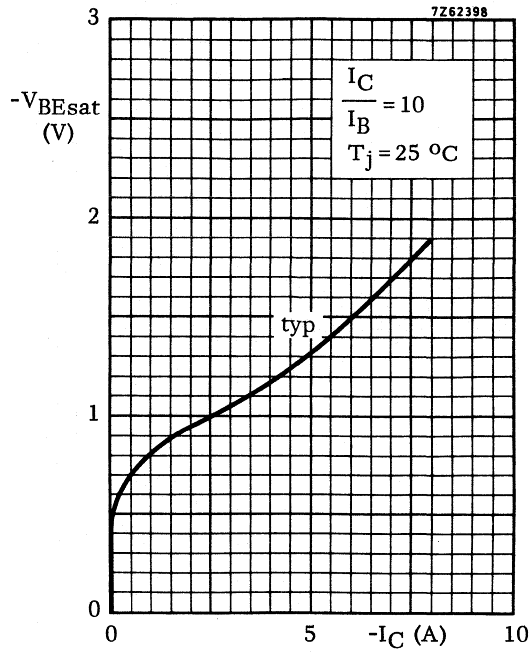


Fig. 15 Base-emitter saturation voltage.

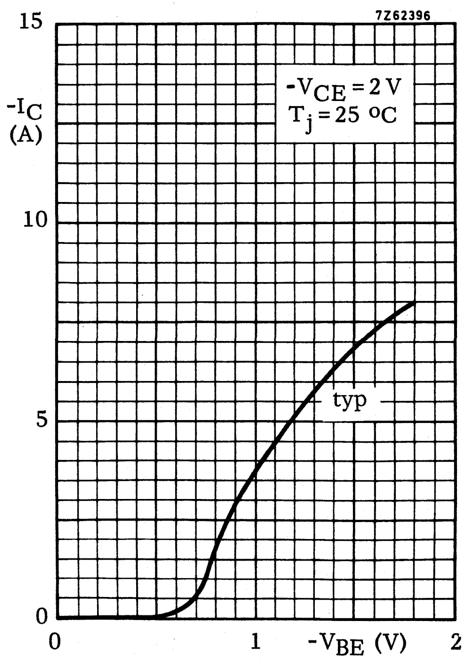


Fig. 16 Typical collector current.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon power transistors in SOT186 envelopes with an electrically insulated mounting base.
NPN complements are BD201F, BD203F and BDX77F respectively.

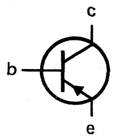
QUICK REFERENCE DATA

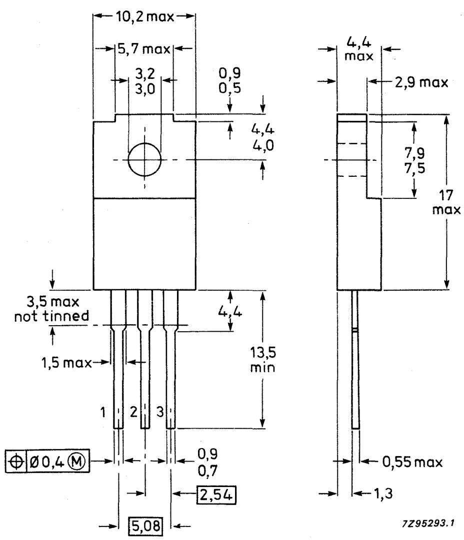
			BD202F	BD204F	BDX78F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current DC	$-I_C$	max.		8		A
peak value	$-I_{CM}$	max.		12		A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.		32		W

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT186.





Pinning

1 = Base
2 = Collector
3 = Emitter

RATINGS

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

			BD202F	BD204F	BDX78F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current						
DC	$-I_C$	max.		8		A
peak value	$-I_{CM}$	max.		12		A
Base current (DC)	$-I_B$	max.		3		A
Total power dissipation						
up to T_h = 25 °C (note 1)	P_{tot}	max.		20		W
up to T_h = 25 °C (note 2)	P_{tot}	max.		32		W
Storage temperature range	T_{stg}			−65 to 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

CHARACTERISTICS

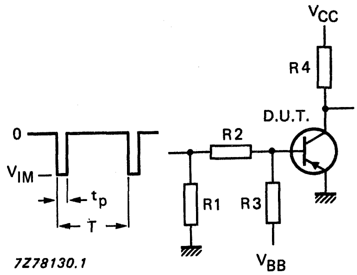
T_j = 25 °C unless otherwise specified

			BD202F	BD204F	BDX78F	
Collector cut-off current						
$I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	max.	0.2	0.2	0.2	mA
$I_E = 0; -V_{CB} = V_{CBO}$	$-I_{CBO}$	max.	0.1	0.1	0.1	mA
$I_E = 0; -V_{CB} = ½ V_{CBO}; T_j = 150$ °C	$-I_{CBO}$	max.	1.0	1.0	1.0	mA
Emitter cut-off current						
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	max.	0.5	0.5	0.5	mA
Collector-emitter breakdown voltage (note 1)						
$-I_C = 0.2$ A; $I_B = 0$	$-V_{(BR)CEO}$	min.	45	60	80	V
DC current gain (note 1)						
$-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	min.	30	—	—	
$-I_C = 2$ A; $-V_{CE} = 2$ V	h_{FE}	min.	—	30	30	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	min.	30	30	—	
Collector-emitter saturation voltage (note 1)						
$-I_C = 3$ A; $-I_B = 0.3$ A	$-V_{CEsat}$	max.	1.0	1.0	1.0	V
$-I_C = 2$ A; $-I_B = 0.2$ A	$-V_{CEsat}$	max.	—	—	0.6	V
$-I_C = 6$ A; $-I_B = 0.6$ A	$-V_{CEsat}$	max.	1.5	1.5	1.5	V

Knee voltage (note 1)				
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3.3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1.0	V
Base-emitter voltage (note 1)				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	max.	1.5	V
Base-emitter saturation voltage (note 1)				
$-I_C = 6$ A; $-I_B = 0.6$ A	$-V_{BEsat}$	max.	2.0	V
Cut-off frequency				
$-I_C = 0.3$ A; $-V_{CE} = 3$ V	f_{HFE}	min.	25	kHz
Transition frequency at f = 1 MHz				
$-I_E = 0.3$ A; $-V_{CB} = 3$ V	f_T	min.	7.0	MHz
Forward bias second breakdown collector current				
$-V_{CE} = 40$ V; $t_p = 0.1$ s	$-I_{SB}$	min.	0.8	A
Switching times				
$-I_{C\,on} = 2$ A; $-I_{B\,on} = I_{B\,off} = 0.2$ A				
turn-on time	t_{on}	max.	1.0	µs
turn-off time	t_{off}	max.	2.0	µs

Note

1. To be measured under pulsed conditions. Pulse time 300 µs, duty cycle 2%.



$-V_{IM}$	= 15 V
$-V_{CC}$	= 20 V
$+V_{BB}$	= 4 V
R1	= 56 Ω
R2	= 33 Ω
R3	= 22 Ω
R4	= 10 Ω
t_r	= t_f = 15 ns
t_p	= 20 μs
T	= 500 μs

Fig. 2 Switching times test circuit.

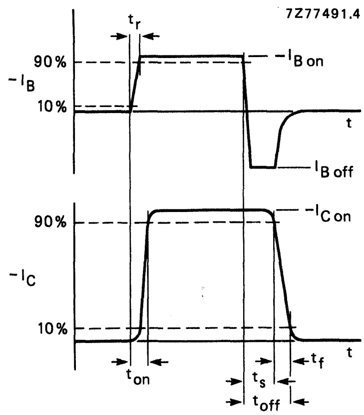
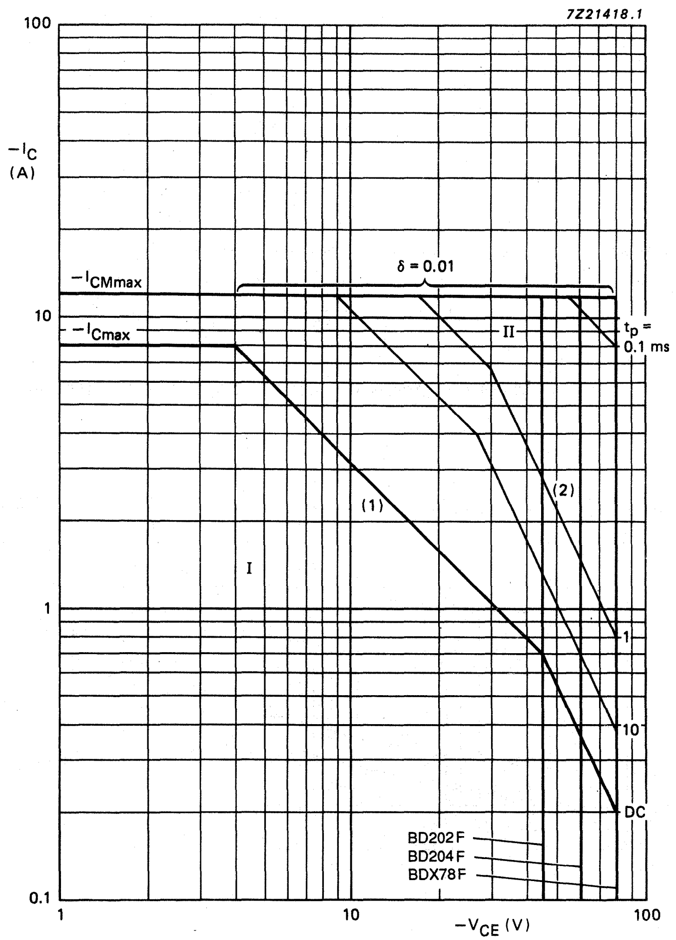


Fig. 3 Switching times waveforms.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) P_{tot} max and P_{peak} max lines.
(2) Second-breakdown limits.

Note: Mounted with heatsink compound and 30 ± 5 newtons pressure on the centre of the envelope.

Fig. 4 Safe Operating Area; T_{amb} = 25 °C.

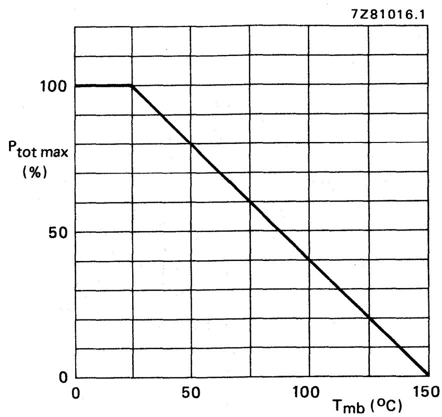


Fig. 5 Maximum power dissipation as a function of temperature.

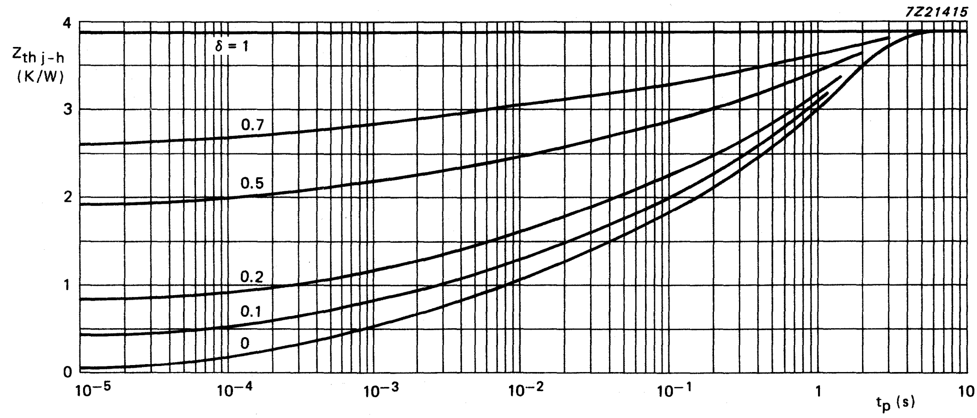


Fig. 6 Pulse power rating chart.

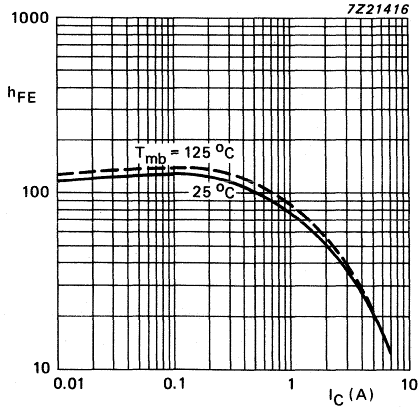


Fig. 7 Typical DC current gain curves at $-V_{CE}$ = 2 V.

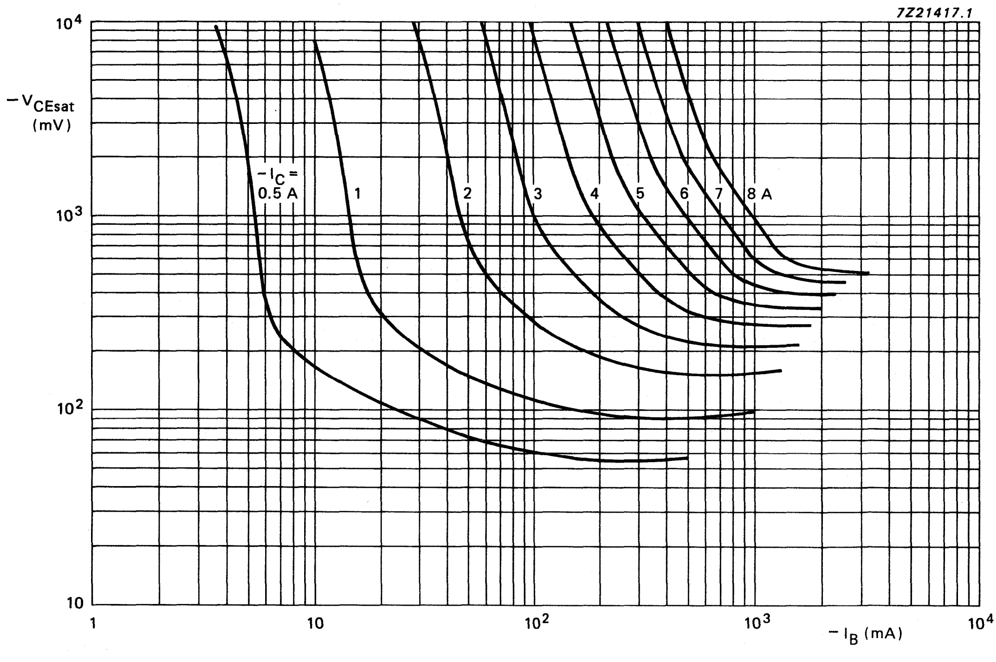


Fig. 8 Collector-emitter saturation voltage as a function of base current; typical values; T_j = 25 °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose n-p-n transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD227, BD229 and BD231.

QUICK REFERENCE DATA

			BD226	BD228	BD230	
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.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	12,5	12,5	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 to 250		
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		125		MHz

MECHANICAL DATA

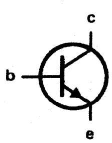
Dimensions in mm

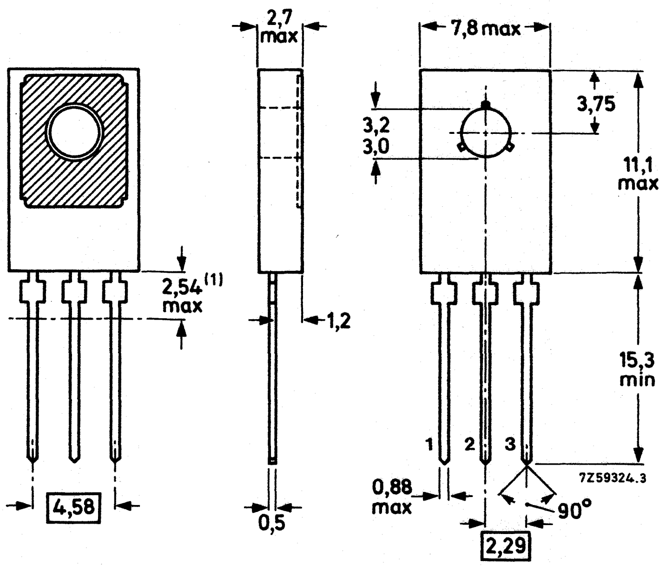
TO-126 (SOT-32)

Collector connected to metal part of mounting surface

Pinning

1 = emitter
2 = collector
3 = base





See chapters Mounting Instructions and Accessories.

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

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

			BD226	BD228	BD230	
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
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Collector current (d.c.)	I_C	max.	1,5	A
Collector current (peak value)	I_{CM}	max.	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

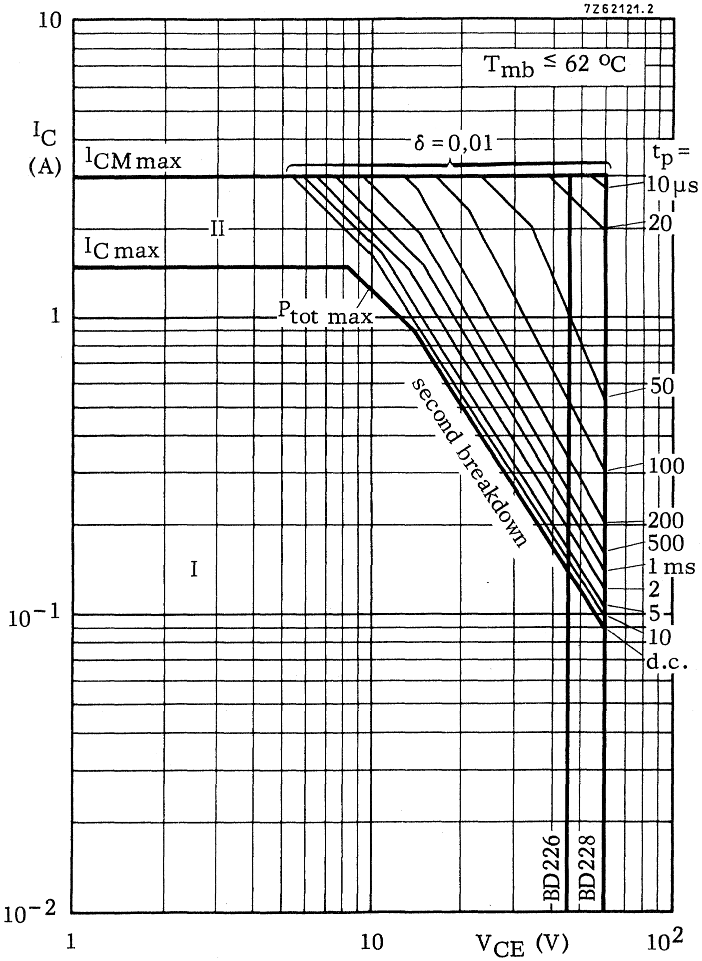
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	7	K/W

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; $T_j = 125$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA
Base-emitter voltage [1]				
$I_C = 1$ A; $V_{CE} = 2$ V	V_{BE}	<	1,3	V
Saturation voltage				
$I_C = 1$ A; $I_B = 0.1$ A	V_{CEsat}	<	0,8	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 to 250	
$I_C = 1$ A ; $V_{CE} = 2$ V	h_{FE}	>	25	
Transition frequency at f = 35 MHz				
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	125	MHz
D.C. current gain ratio of matched pairs BD226/BD227; BD228/BD229; BD230/BD231				
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ. <	1,3 1,6	

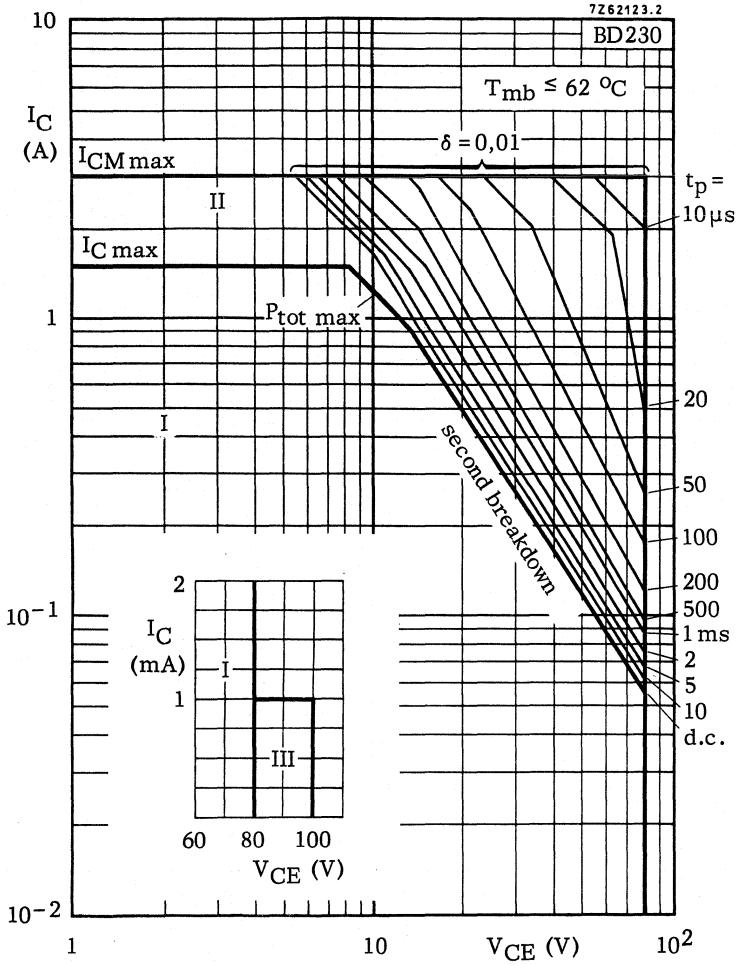
[1] V_{BE} decreases by about 2,3 mV/K with increasing temperature.



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

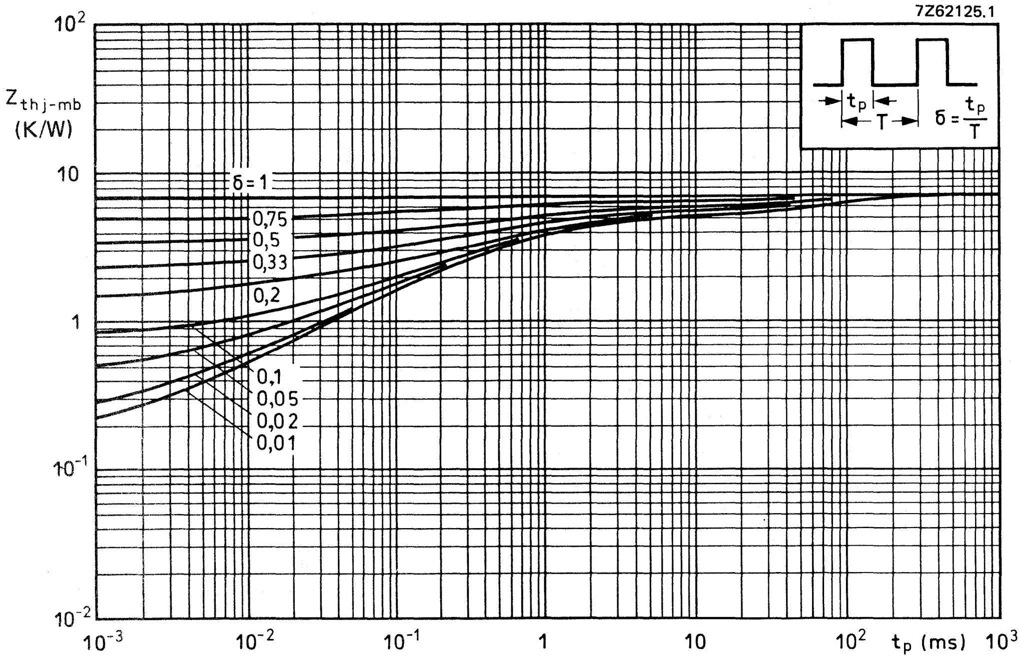


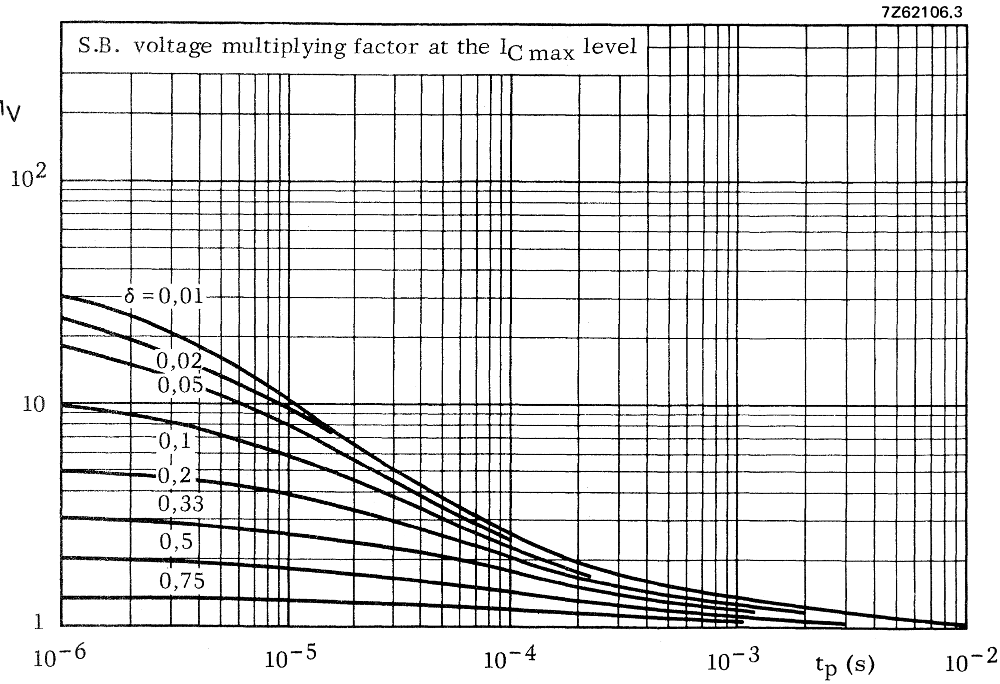
Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

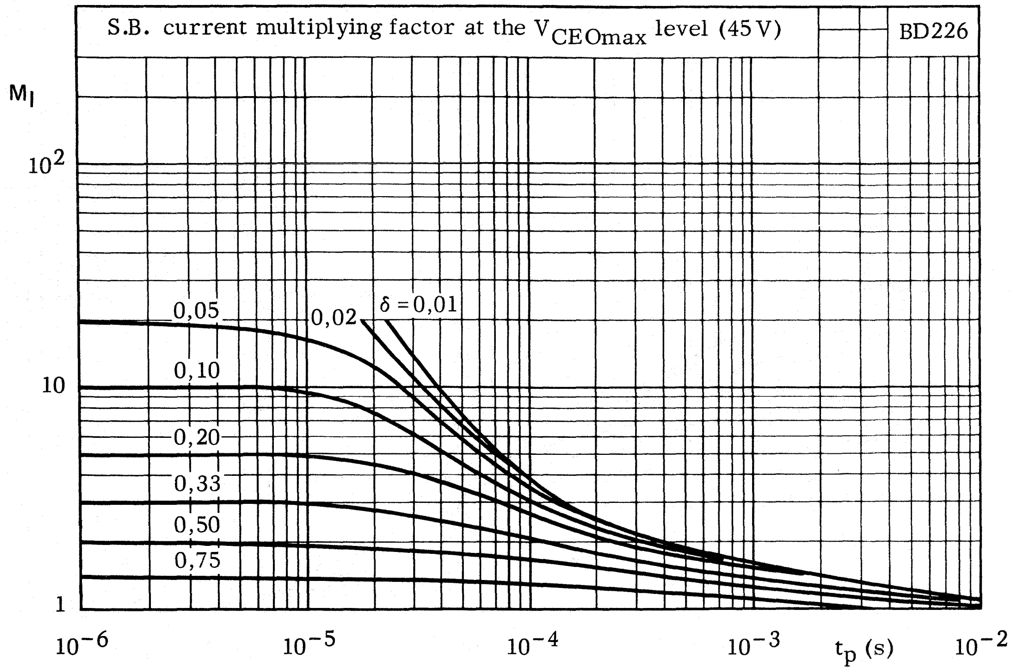
II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

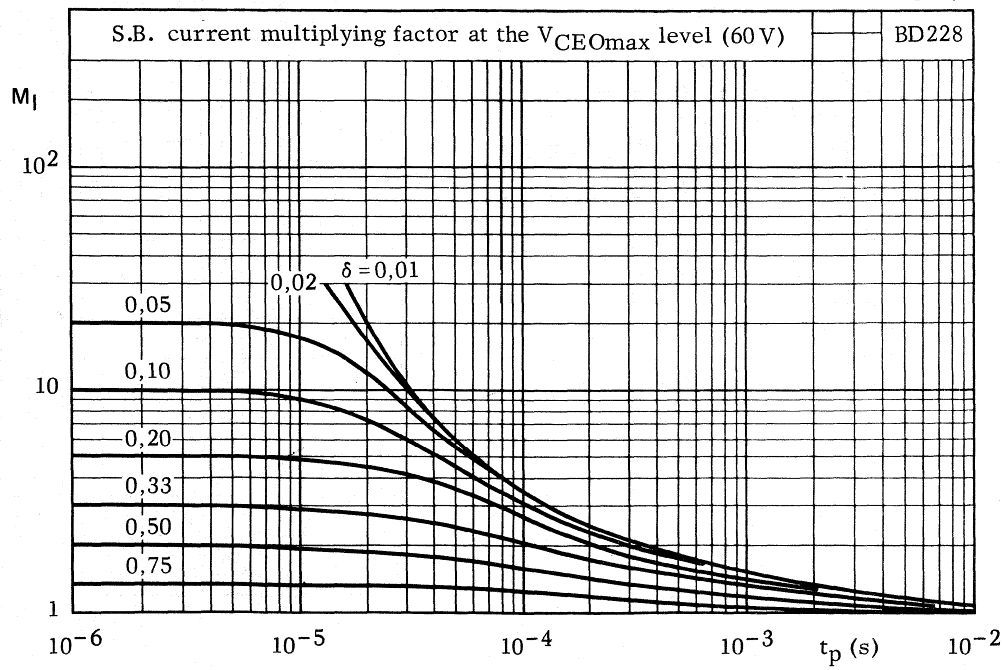

7Z62125.1
$Z_{th\,j\text{-}mb}$ (K/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
$\delta = \frac{t_p}{T}$
t_p (ms)

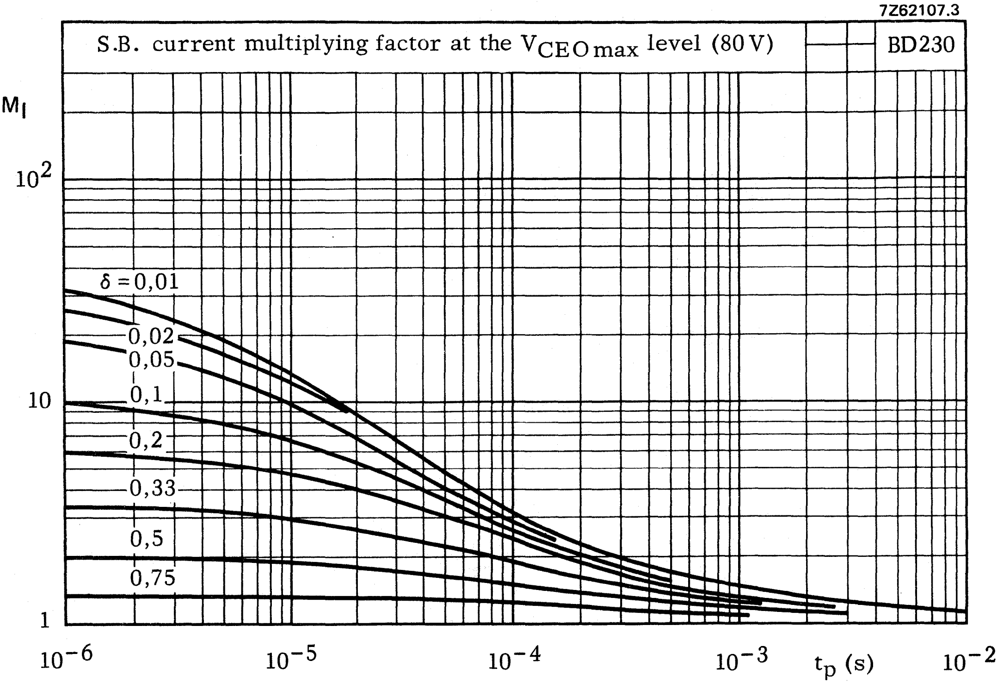

7Z62106.3
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
t_p (s)

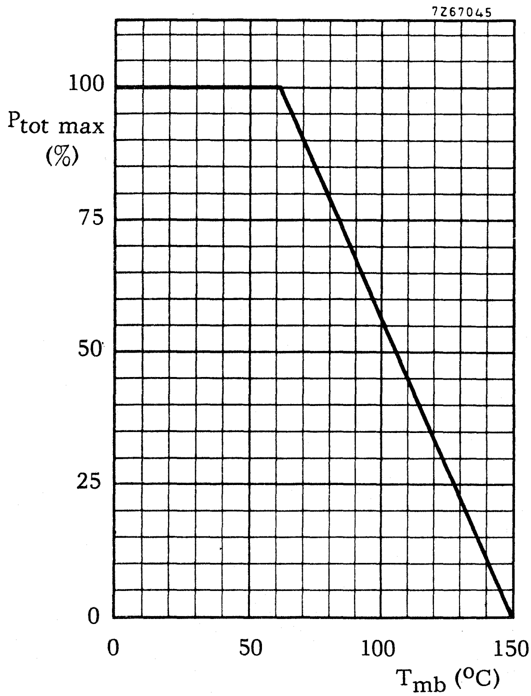
7Z62342.2

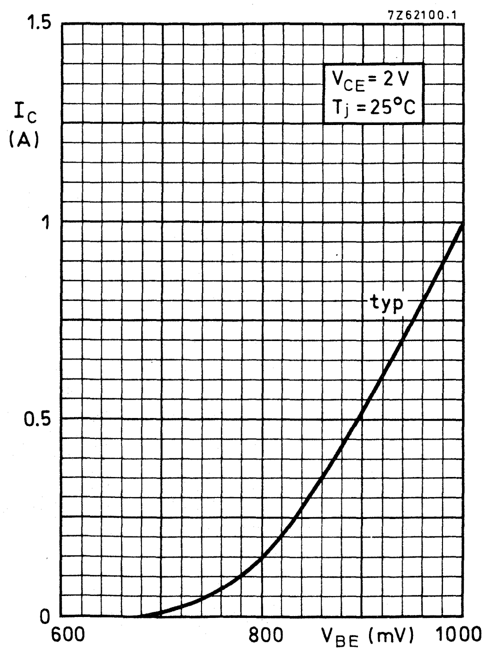


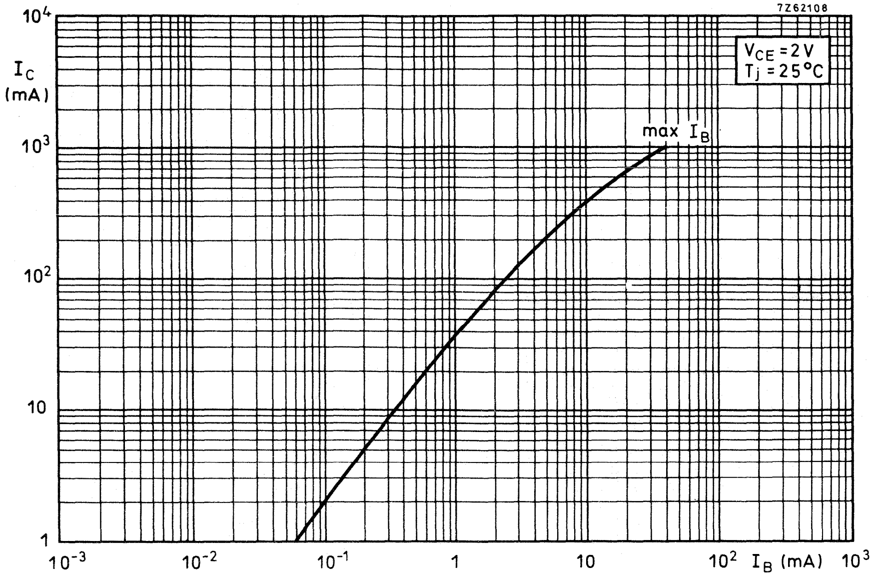
7Z62343.2

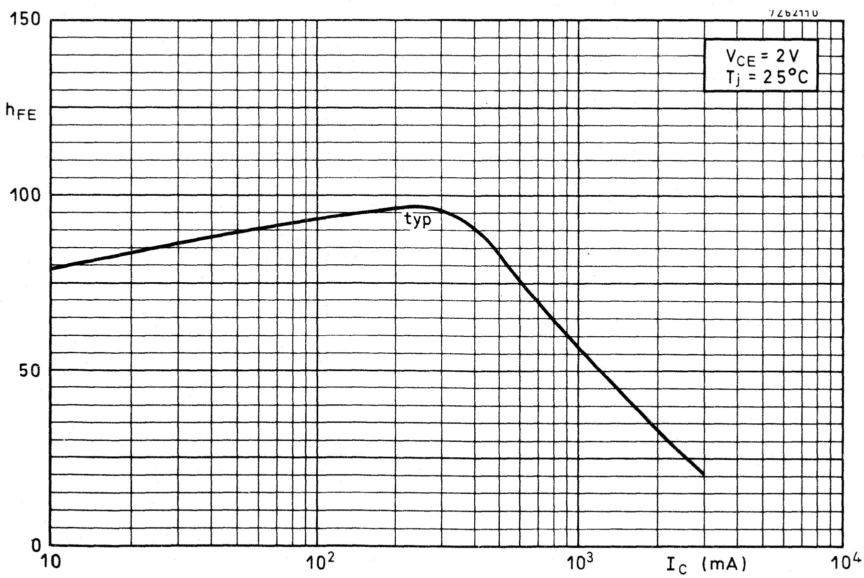


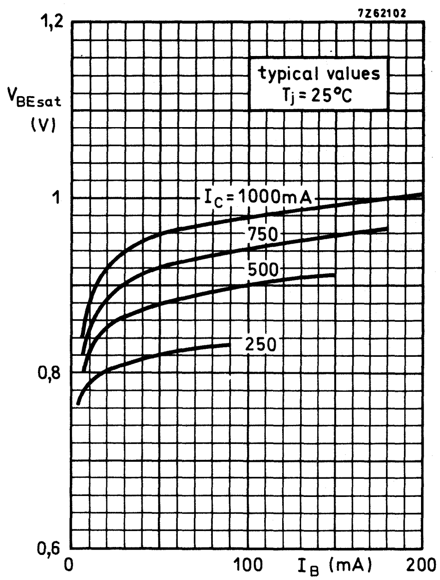

7Z62107.3
S.B. current multiplying factor at the V_CEO max level (80 V)
BD230
M_I
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^-6
10^-5
10^-4
10^-3
t_p (s)
10^-2

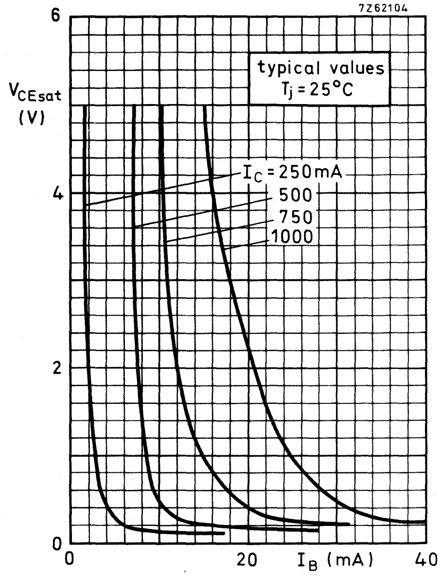

7Z67045
100
P_tot max
(%)
75
50
25
0
0
50
100
150
T_mb (°C)

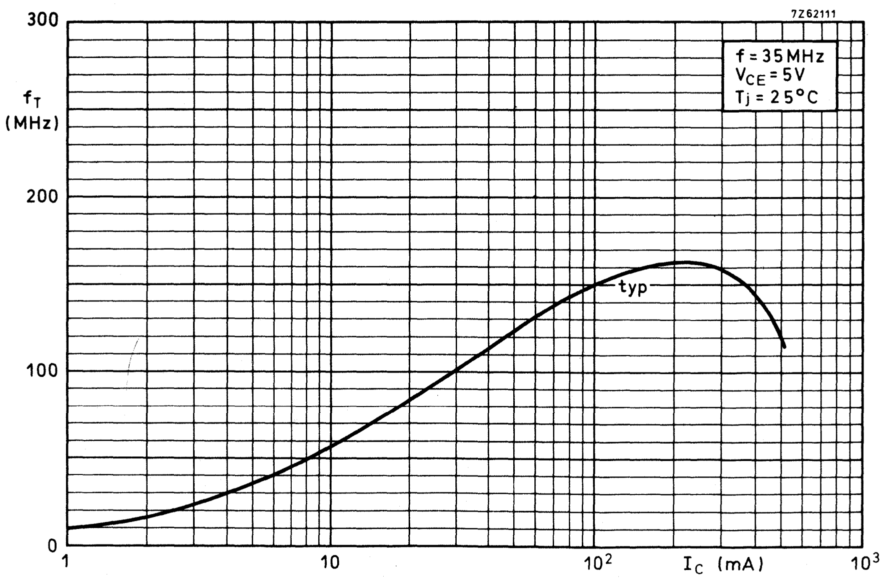

7Z62100.1
1.5
I_C
(A)
1
0.5
0
V_CE = 2 V
T_j = 25°C
typ
600
800
V_BE (mV)
1000


7Z62108
V_{CE} = 2 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


7Z62110
V_{CE} = 2 V
T_j = 25 °C
h_{FE}
150
100
50
0
typ
10
10^2
10^3
I_C (mA)
10^4


7Z62102
typical values
Tj = 25°C
V_BEsat (V)
1,2
1
0,8
0,6
I_C = 1000mA
750
500
250
0
100
I_B (mA)
200


7Z62104
typical values
Tj = 25°C
V_CEsat (V)
6
4
2
0
I_C = 250mA
500
750
1000
20
I_B (mA)
40


7Z62111
f = 35MHz
V_CE = 5V
Tj = 25°C
f_T (MHz)
300
200
100
0
typ
1
10
10^2
I_C (mA)
10^3

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose pnp transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD226, BD228 and BD230.

QUICK REFERENCE DATA

			BD227	BD229	BD231	
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.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12.5	12.5	12.5	W
Junction temperature	T_j	max.	150	150	150	°C
DC current gain						
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}			40 to 250		
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.		50		MHz

MECHANICAL DATA

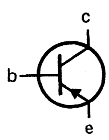
Dimensions in mm

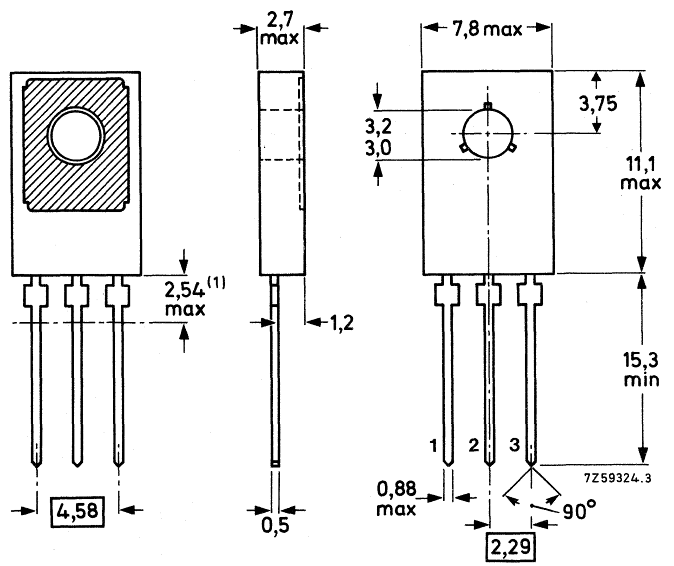
Fig. 1 TO-126 (SOT-32)

Collector connected to metal part of mounting surface.

Pinning:

1 = emitter
2 = collector
3 = base





See Mounting Instructions and Accessories

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

RATINGS

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

			BD227	BD229	BD231	
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
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (DC)	$-I_C$	max.		1.5		A
Collector current (peak value)	$-I_{CM}$	max.		3		A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.		12.5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	7	K/W

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; $T_j = 125$ °C	$-I_{CBO}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base-emitter voltage *				
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1.3	V
Saturation voltage				
$-I_C = 1$ A; $-I_B = 0.1$ A	$-V_{CEsat}$	<	0.8	V
DC current gain				
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25	
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}	<	40 to 250	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25	
Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	50	MHz
DC current gain ratio of matched pairs BD226/BD227; BD228/BD229; BD230/BD231				
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	typ.	1.3	
		<	1.6	

* $-V_{BE}$ decreases by about 2.3 mV/K with increasing temperature.

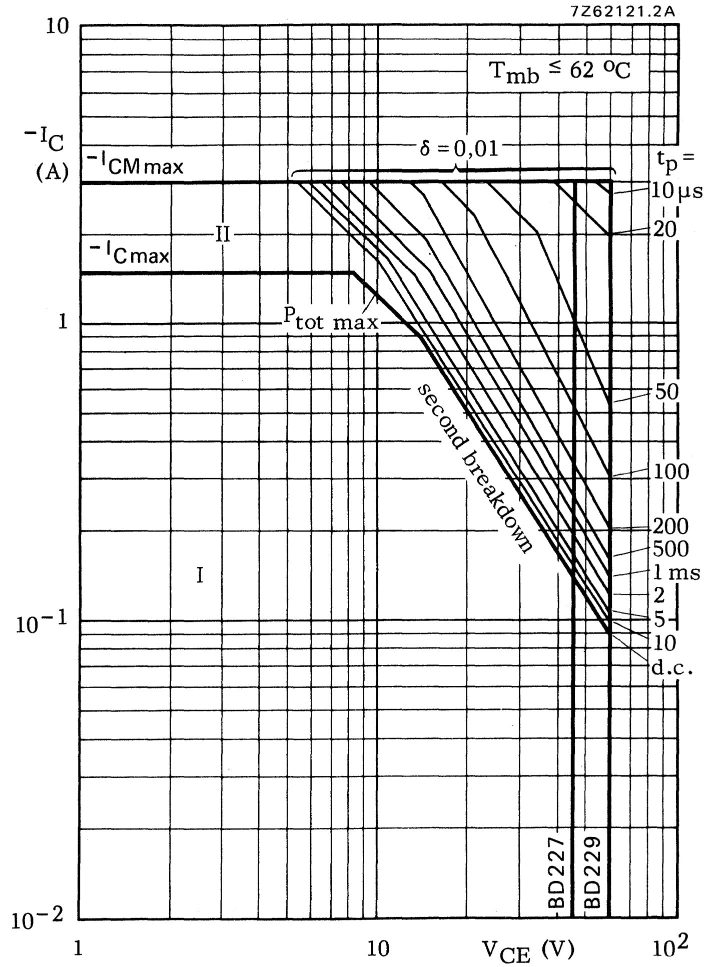


Fig. 2 Safe operating area with the transistor forward biased.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

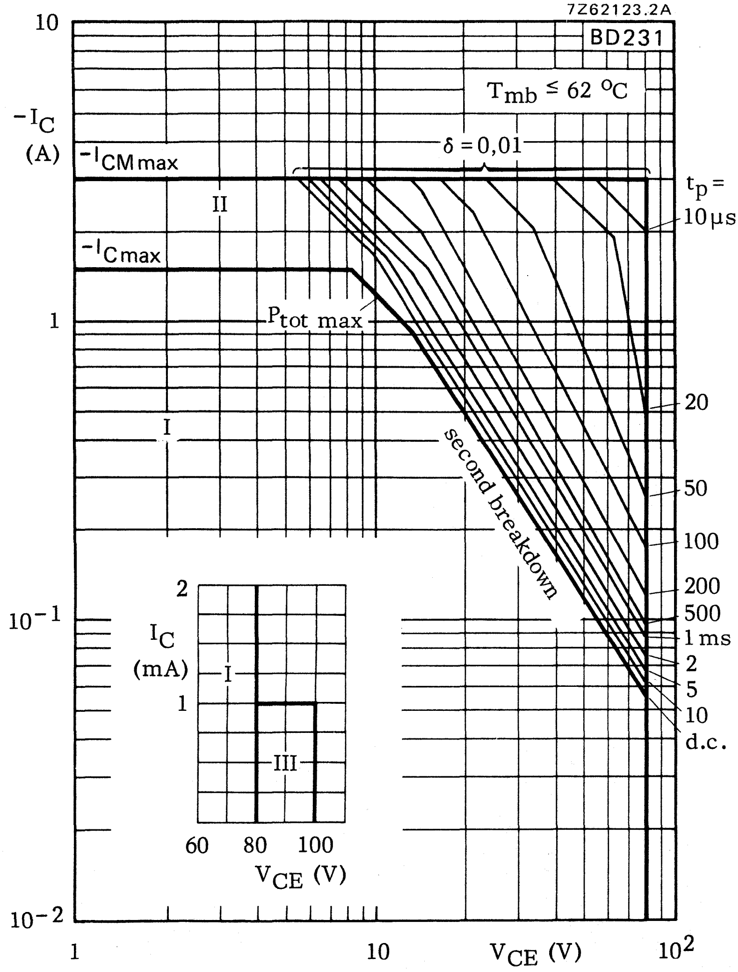


Fig. 3 Safe operating area with the transistor forward biased.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leqslant 1\ k\Omega$.

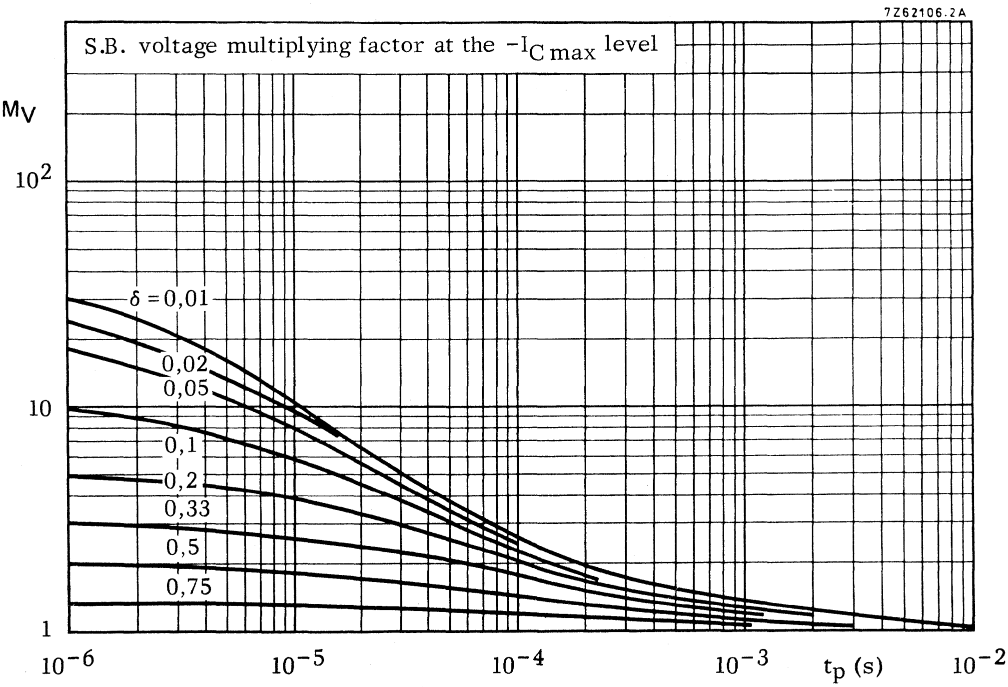

7Z62106.2A
S.B. voltage multiplying factor at the $-I_{C max}$ level
M_V
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 4.

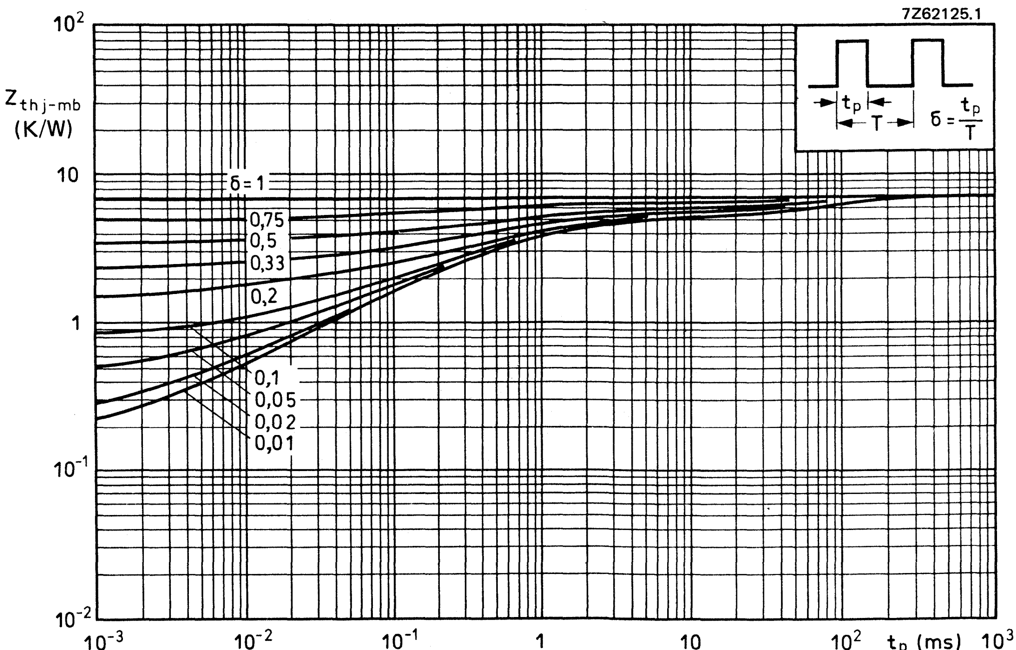

7Z62125.1
$Z_{th\,j\text{-}mb}$
(K/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

Fig. 5.

7Z62342.1A

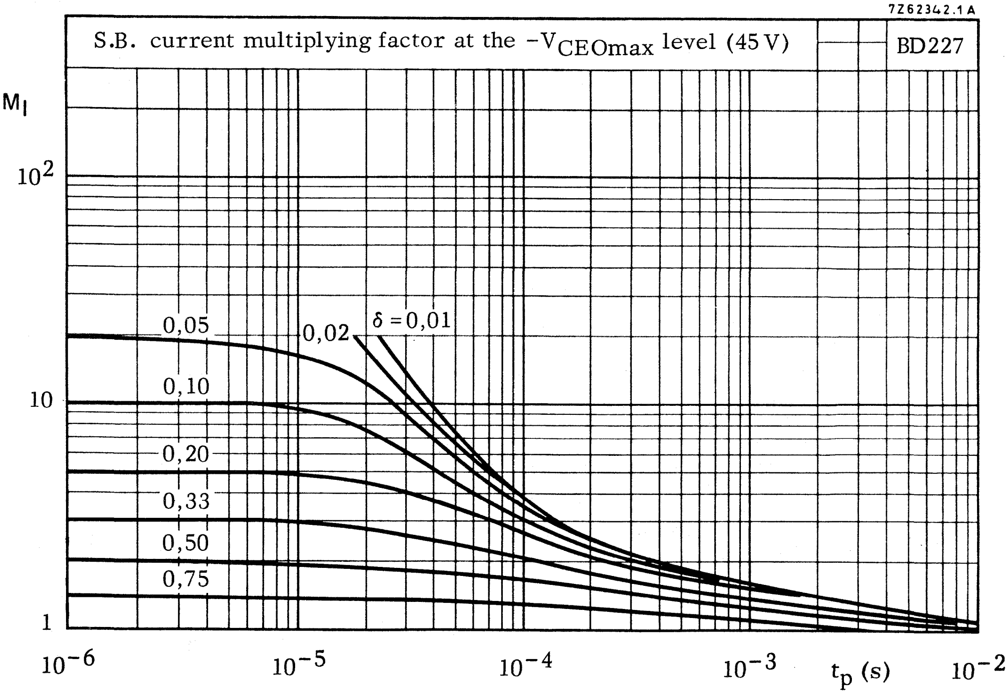


Fig. 6.

7Z62343.1A

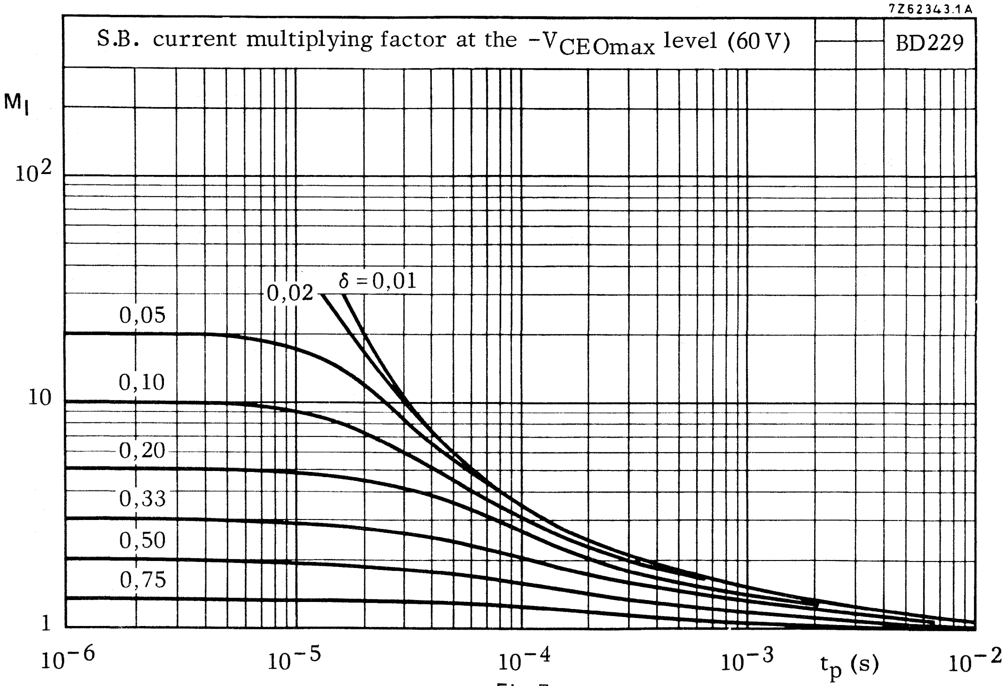


Fig. 7.

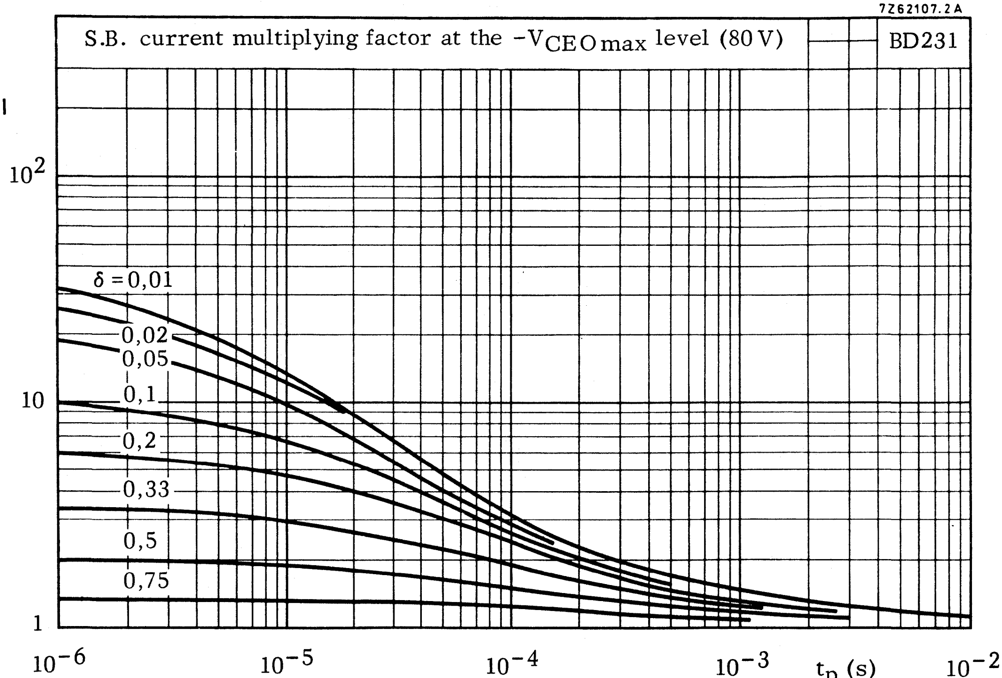


Fig. 8.

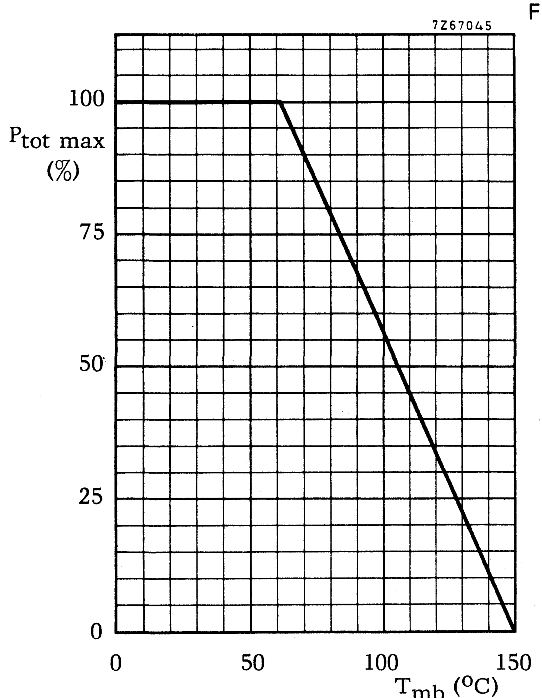


Fig. 9.

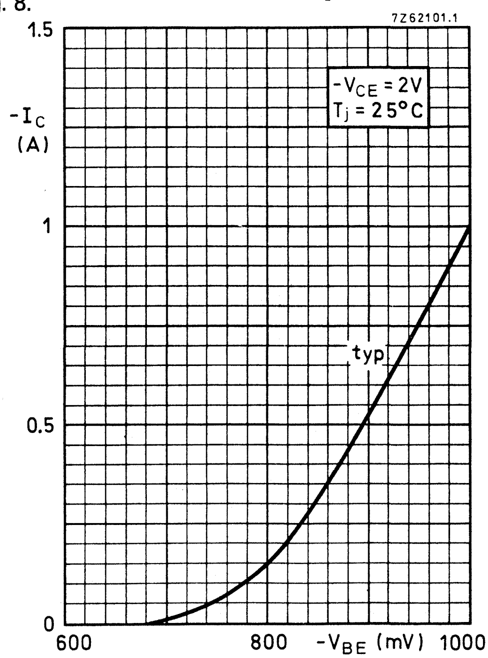


Fig. 10.

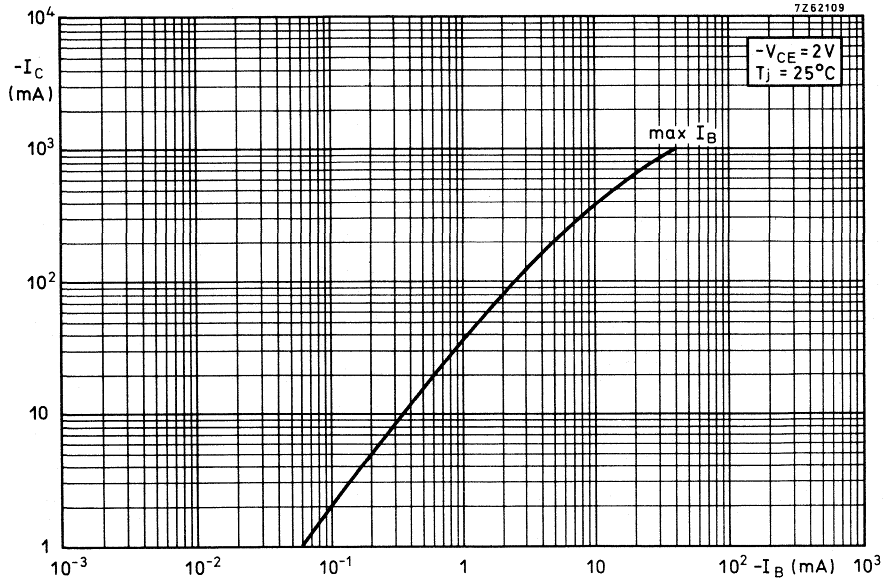

7Z62109
10^4
$-I_C$ (mA)
10^3
10^2
10
1
$-V_{CE} = 2\,V$
$T_j = 25\,°C$
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

Fig. 11.

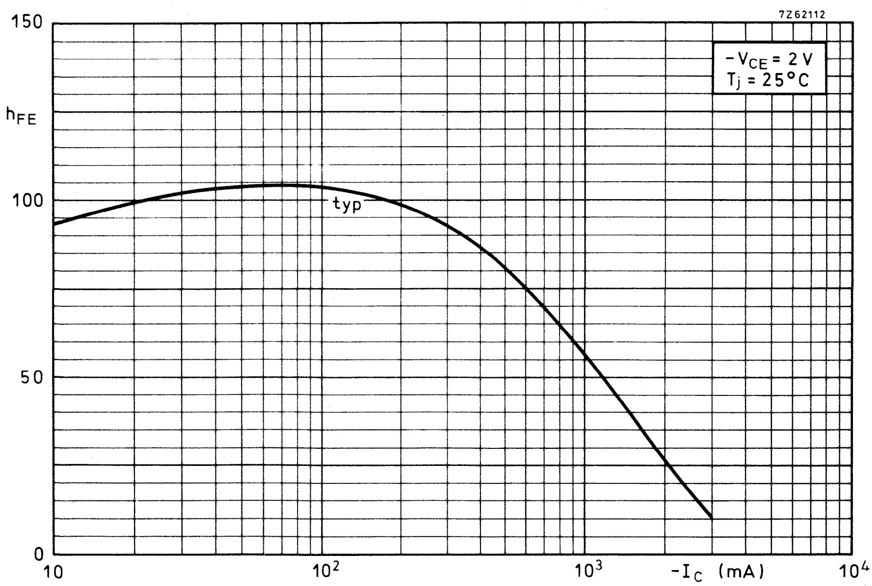

7Z62112
150
h_{FE}
100
50
0
$-V_{CE} = 2\,V$
$T_j = 25\,°C$
typ
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 12.

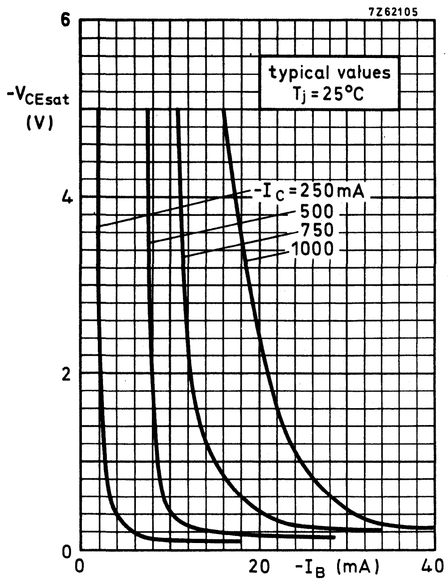


Fig. 13.

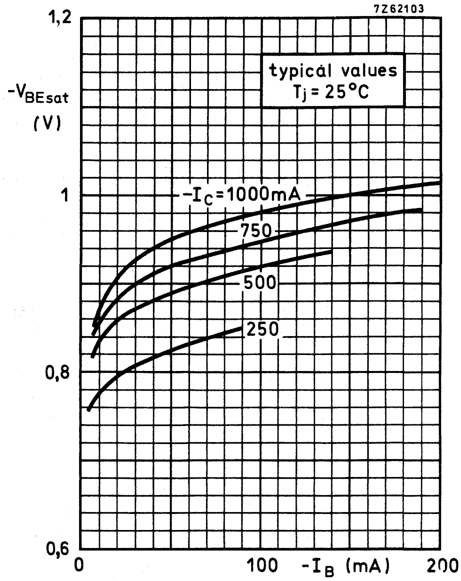


Fig. 14.

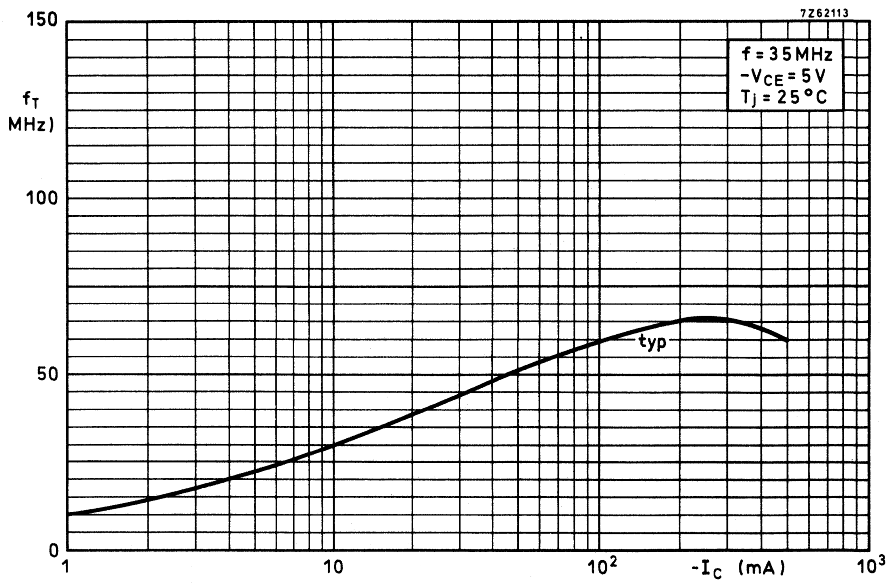


Fig. 15.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur. P-N-P complements are BD234, BD236 and BD238. Matched pairs can be supplied.

QUICK REFERENCE DATA

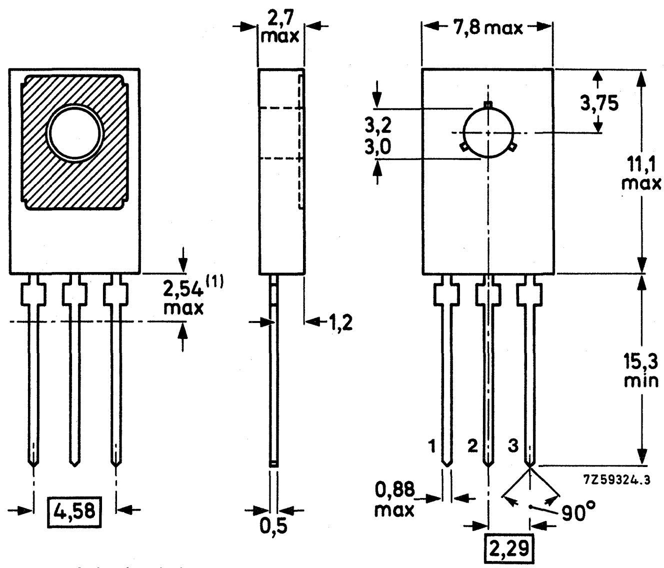
			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency I_C = 250 mA; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

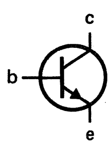
Fig. 1 TO-126 (SOT-32).

Collector connected to metal part of mounting surface



Pinning

1 = emitter
2 = collector
3 = base



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

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD233	BD235	BD237	
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
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		2		A
Collector current (peak value)	I_{CM}	max.		6		A
Base current (d.c.)	I_B	max.		0,5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		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	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

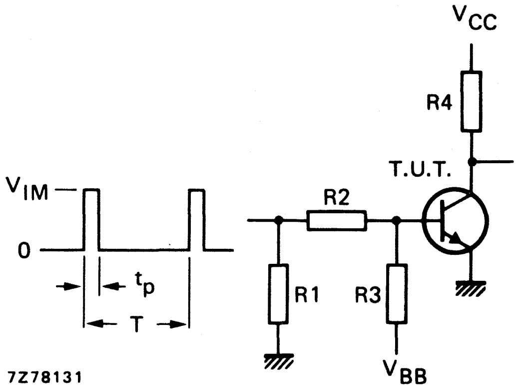
Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	50	μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	0,2	mA
Second-breakdown collector current				
V_{CE} = 40 V; t_p = 20 ms	$I_{(SB)C}$	<	0,5	A
Base-emitter voltage*				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Saturation voltage*				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
D.C. current gain*				
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified.

D.C. current gain ratio of matched complementary pairs*				
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6	
Switching times				
I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A				
turn-on time	t_{on}	typ.	0,4	μs
		<	1	μs
turn-off time	t_{off}	typ.	1,5	μs
		<	3	μs



V_{IM} = 16 V
V_{CC} = 20 V
$-V_{BB}$ = 6,4 V
R1 = 82 Ω
R2 = 82 Ω
R3 = 82 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 2 Test circuit.

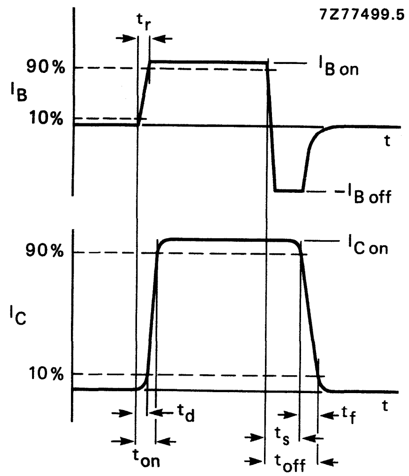


Fig. 3 Switching times waveforms.

* Measured under pulse conditions; $t_p < 300$ μs, $\delta < 2\%$.

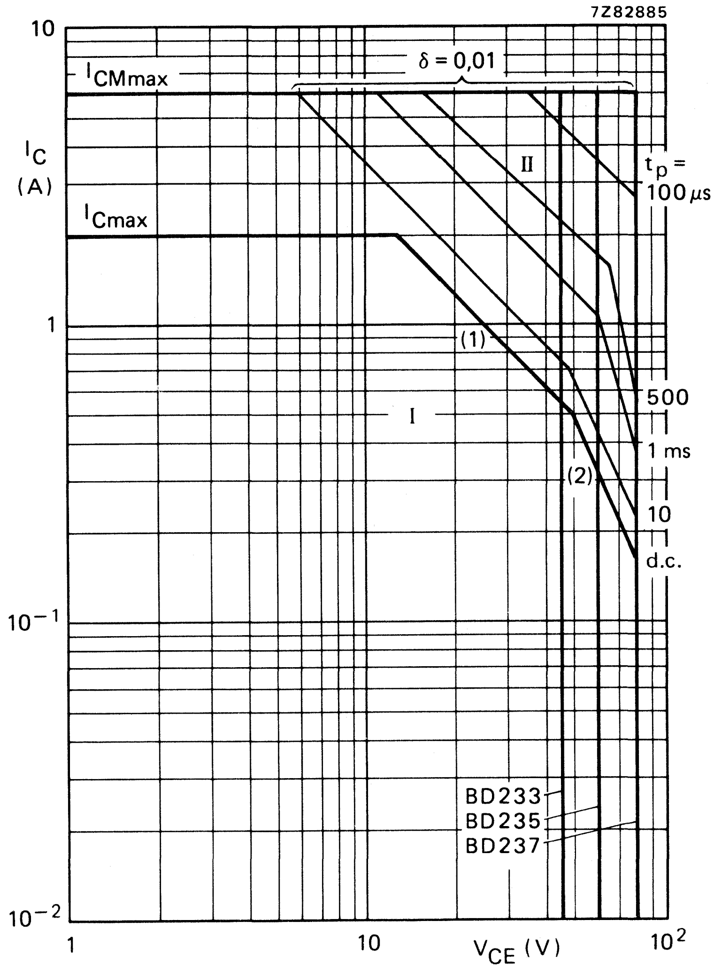


Fig. 4 Safe Operating Area with the transistor forward biased, $T_{mb} \leqslant 25\ ^{\circ}C$.

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

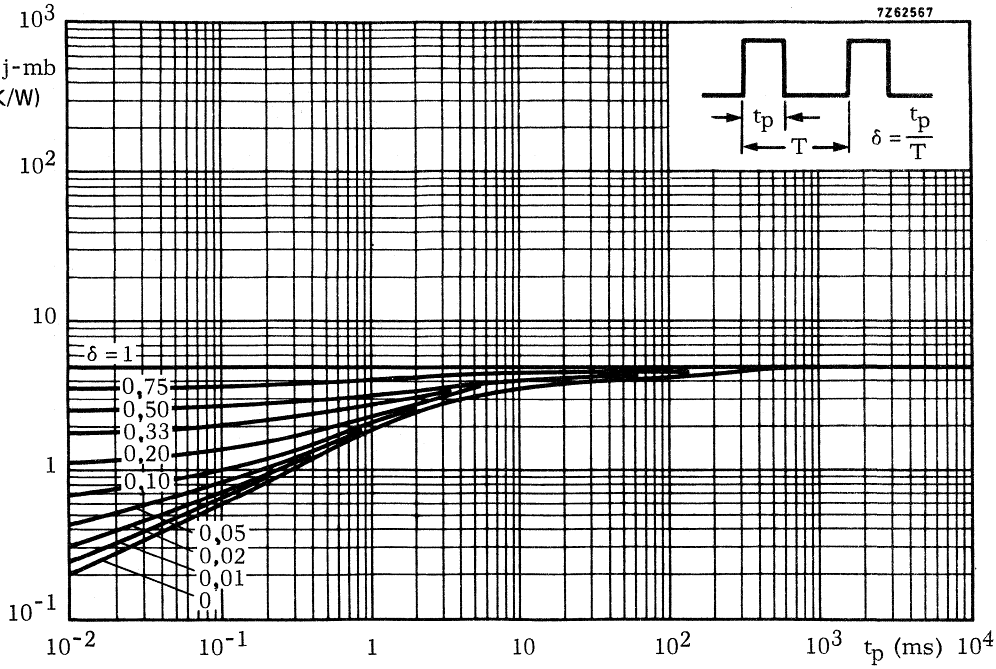
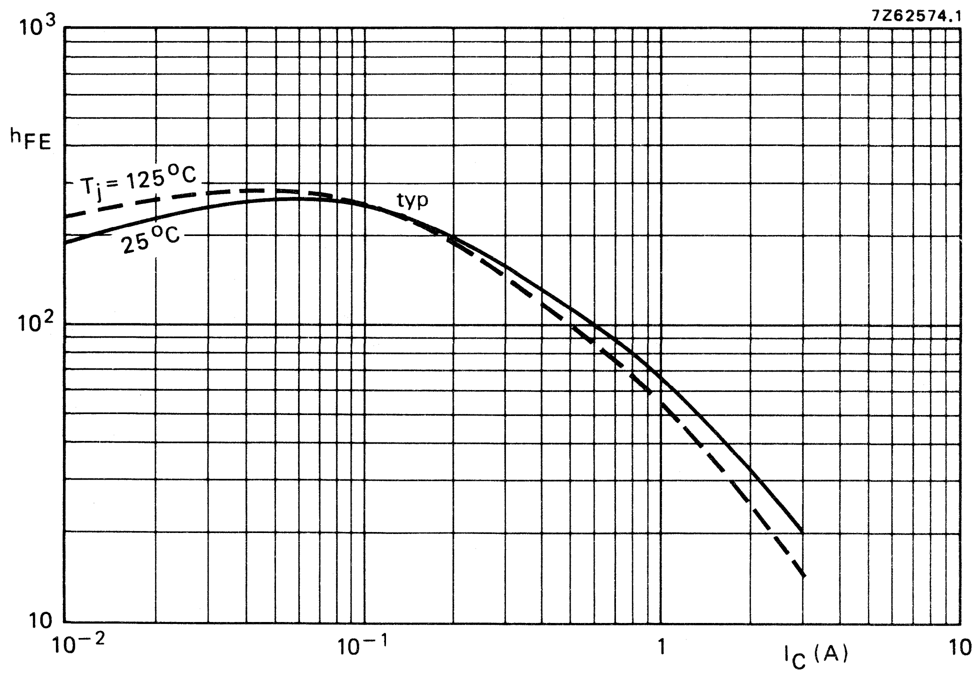


Fig. 5 Pulse power rating chart.



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

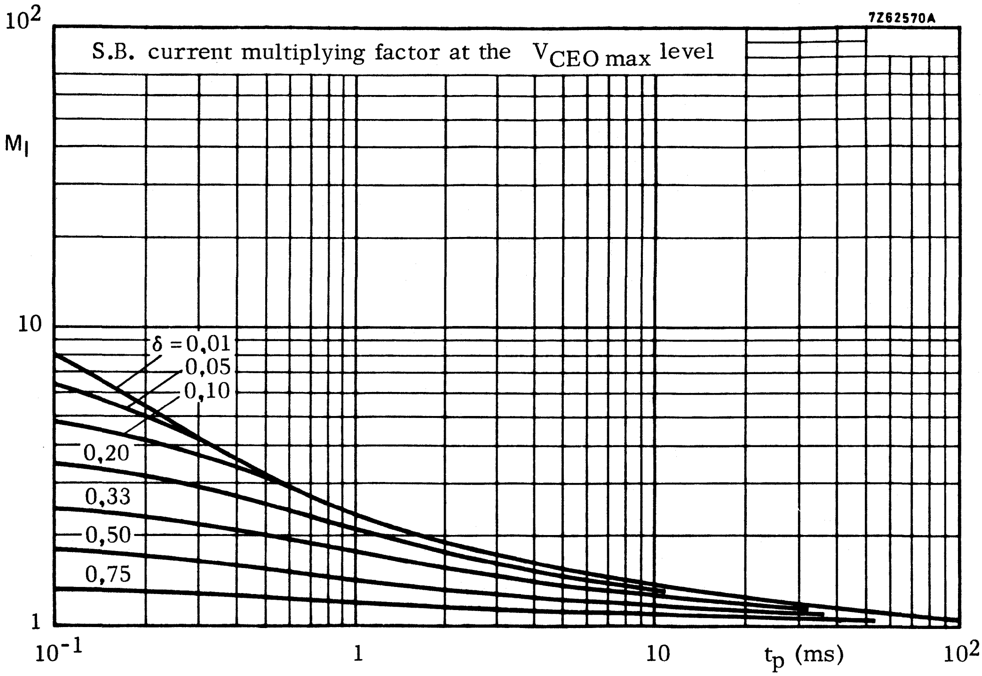


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

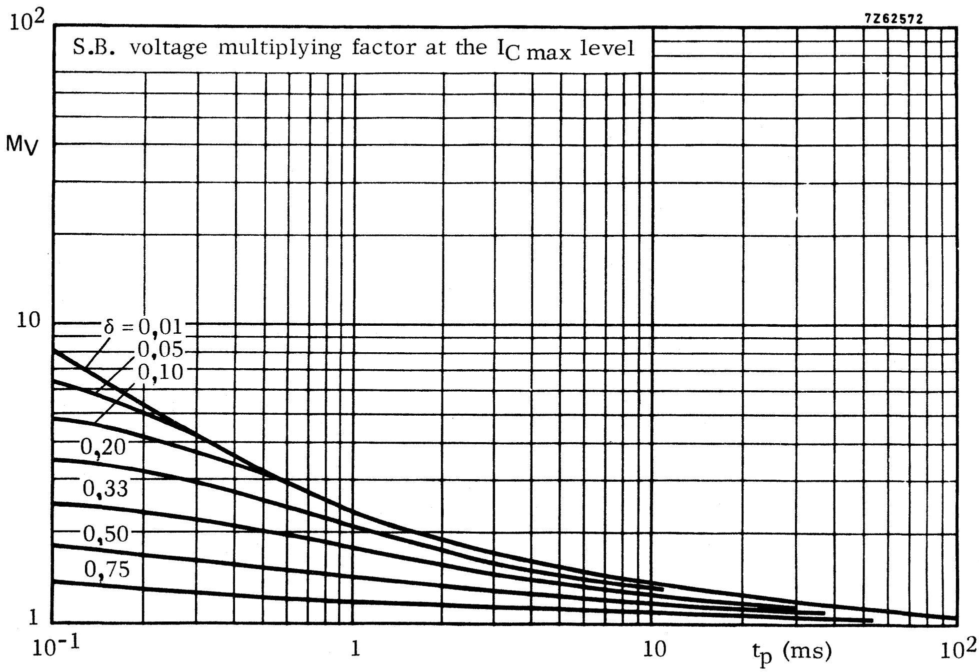


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

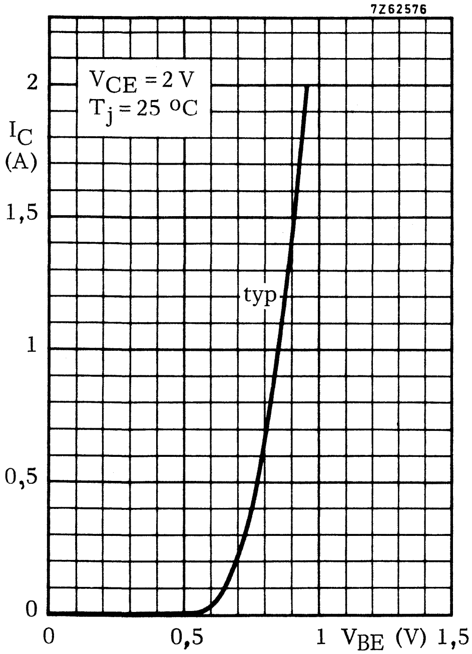

7Z62576
V_{CE} = 2 V
T_j = 25 °C
I_C
(A)
typ
2
1,5
1
0,5
0
0
0,5
1
V_{BE} (V)
1,5

Fig. 9.

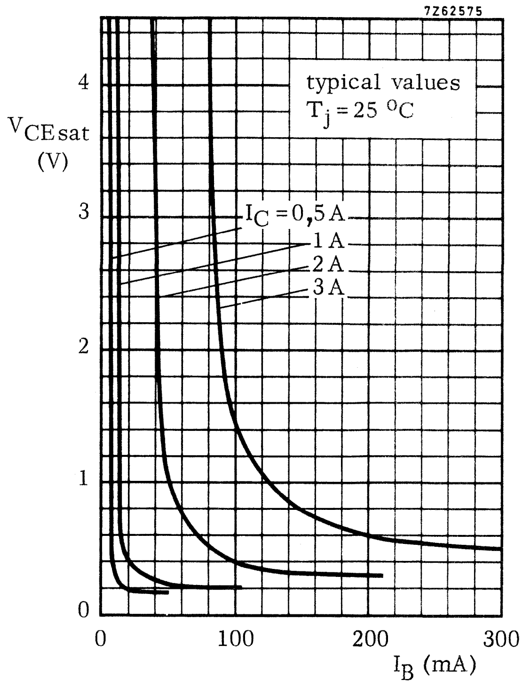

7Z62575
typical values
T_j = 25 °C
V_{CEsat}
(V)
I_C = 0,5 A
1 A
2 A
3 A
4
3
2
1
0
0
100
200
300
I_B (mA)

Fig. 10.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur. N-P-N complements are BD233, BD235 and BD237. Matched pairs can be supplied.

QUICK REFERENCE DATA

			BD234	BD236	BD238	
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 (d.c.)	$-I_C$	max.		2		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>		3		MHz

MECHANICAL DATA

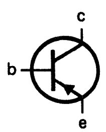
Dimensions in mm

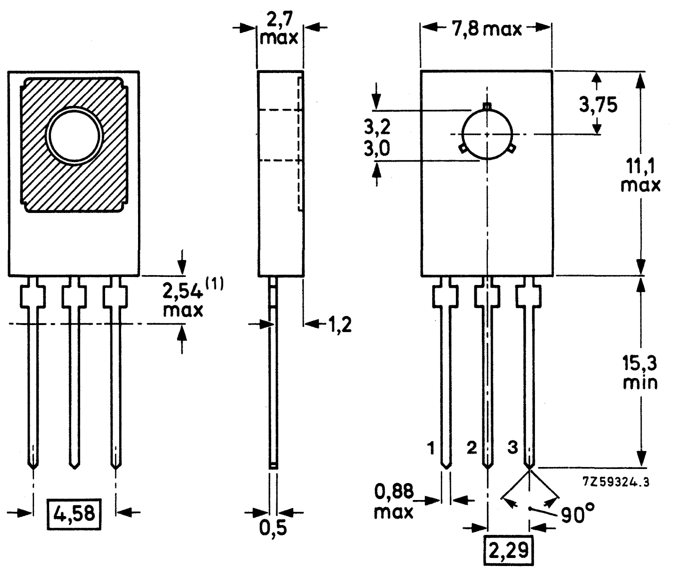
Fig. 1 TO-126 (SOT-32)

Collector connected to metal part of mounting surface

Pinning

1 = emitter
2 = collector
3 = base





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

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

			BD234	BD236	BD238	
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
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	2	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	25	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	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	K/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	50	μA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	1	mA

Emitter cut-off current

$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	0,2	mA

CHARACTERISTICS (continued)

T_j = 25 °C

Base-emitter voltage			
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	$-V_{BE}$	<	1,3 V
Saturation voltage			
$-I_C$ = 1 A; $-I_B$ = 0,1 A	$-V_{CEsat}$	<	0,6 V
D.C. current gain			
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>	25
Transition frequency at f = 1 MHz			
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>	3 MHz
D.C. current gain ratio of matched pairs BD233/BD234; BD235/BD236; BD237/BD238			
$\lvert I_C \rvert$ = 150 mA; $\lvert V_{CE} \rvert$ = 2 V	h_{FE1}/h_{FE2}	<	1,6
Switching times			
$-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A			
turn-on time	t_{on}	typ	0,3 μs
turn-off time	t_{off}	typ	0,7 μs

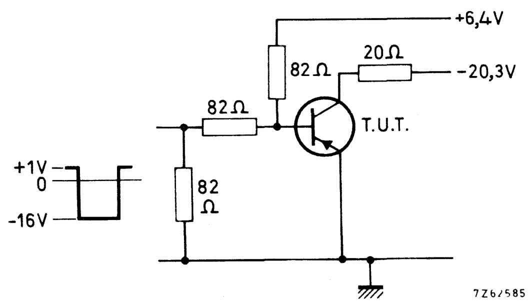


Fig. 2 Switching times test circuit.

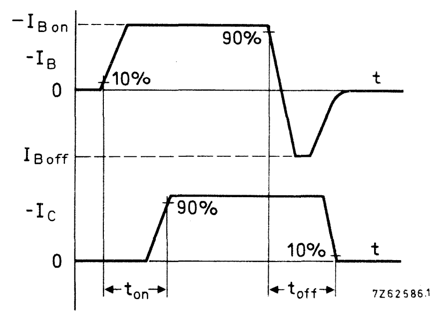


Fig. 3 Switching times waveforms.

Input pulse:

t_r = t_f = 15 ns
t_p = 10 μs
T = 500 μs

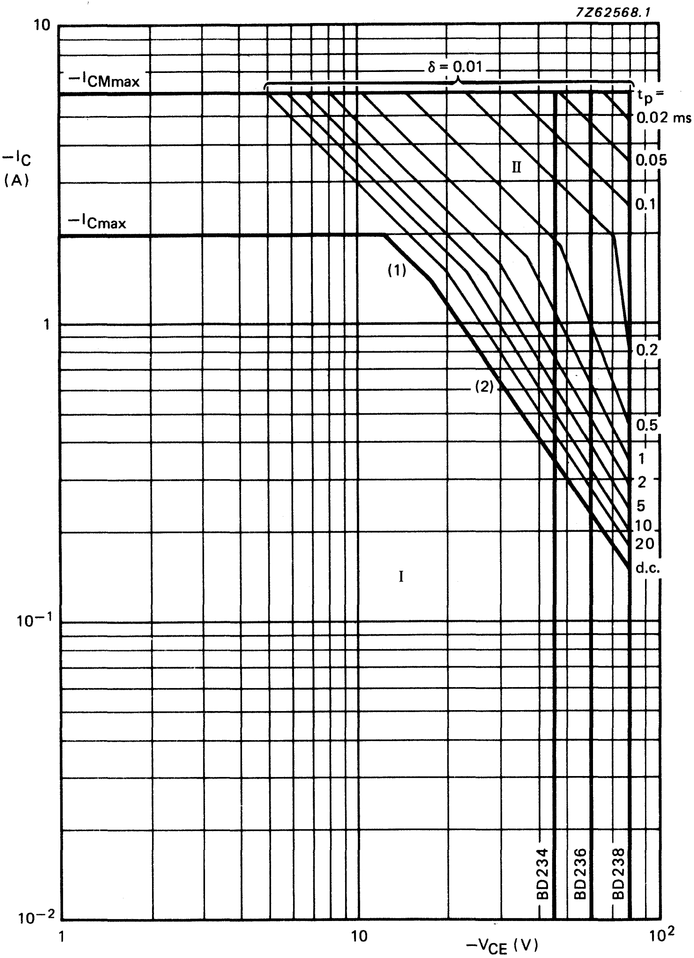


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

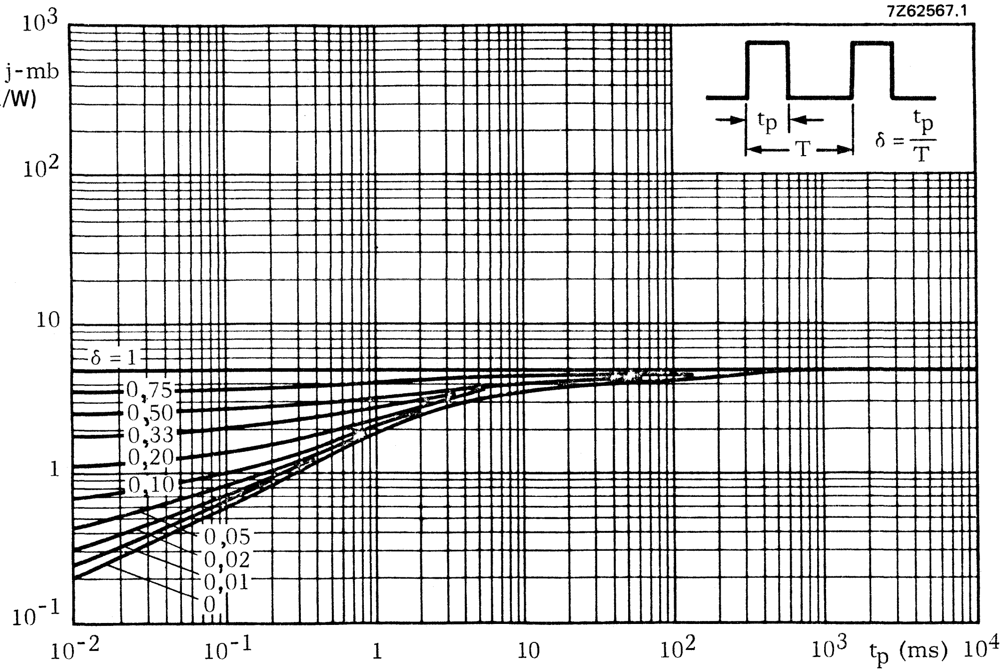

7Z62567.1
10^3
$Z_{th\ j-mb}$ (K/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 5

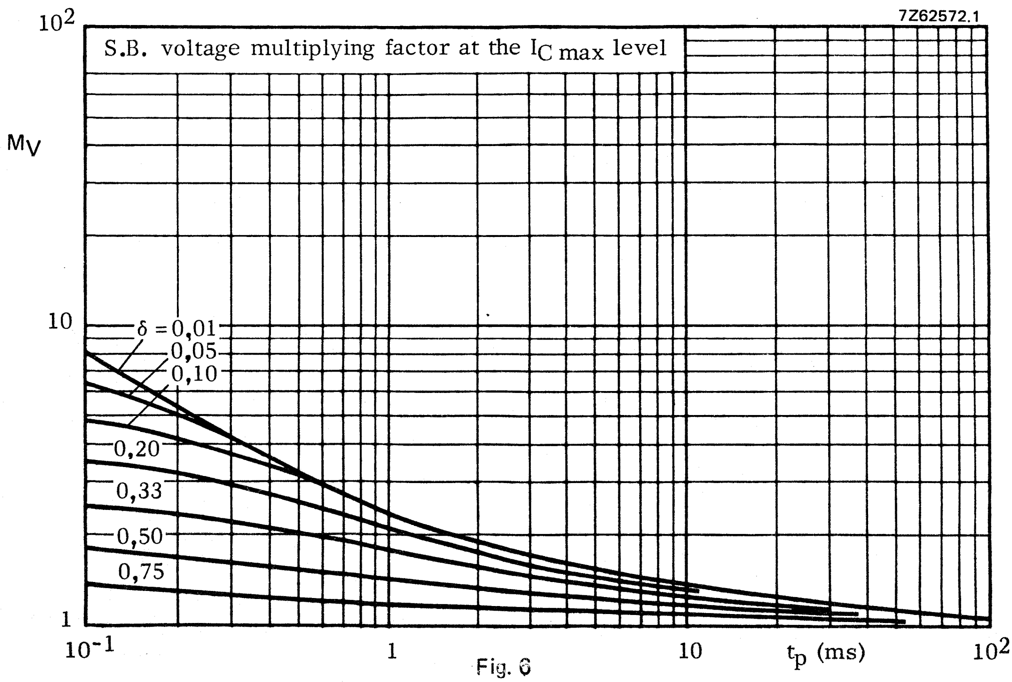

7Z62572.1
10^2
S.B. voltage multiplying factor at the $I_{C\ max}$ level
M_V
10
1
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 6

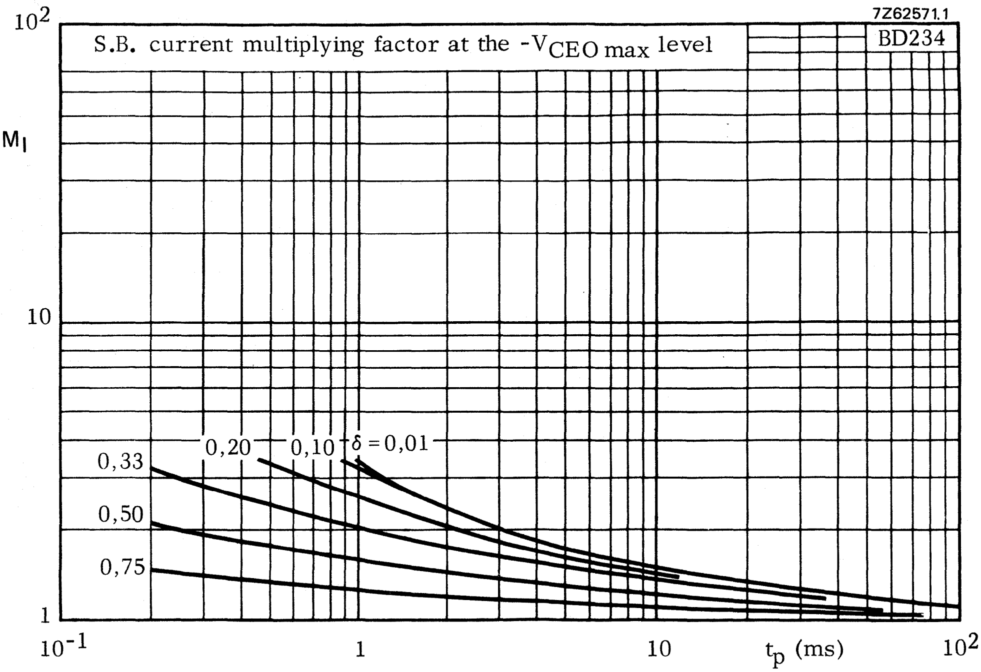

7Z62571.1
S.B. current multiplying factor at the -VCEO max level
BD234
M_I
10^2
10
1
0,33
0,20
0,10
δ = 0,01
0,50
0,75
10^-1
1
10
t_p (ms)
10^2

Fig. 7

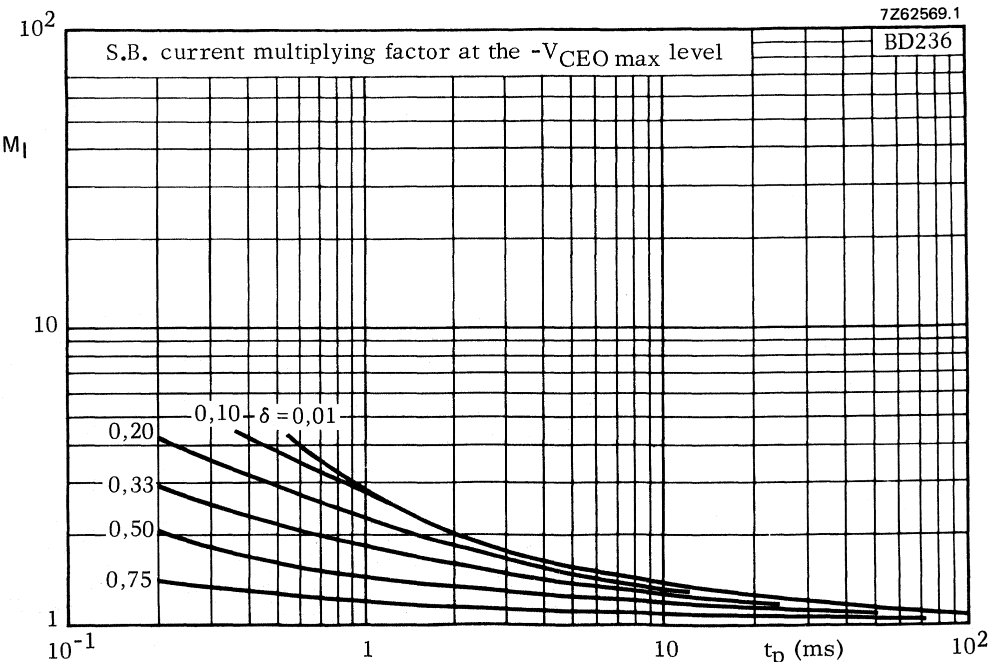

7Z62569.1
S.B. current multiplying factor at the -VCEO max level
BD236
M_I
10^2
10
1
0,10
δ = 0,01
0,20
0,33
0,50
0,75
10^-1
1
10
t_p (ms)
10^2

Fig. 8

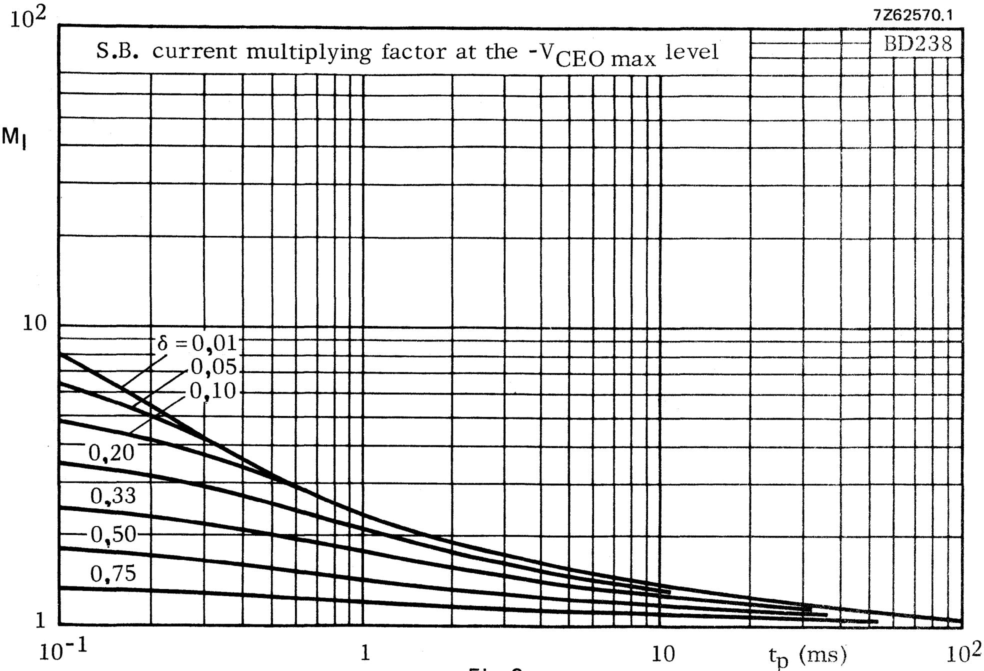


Fig. 9

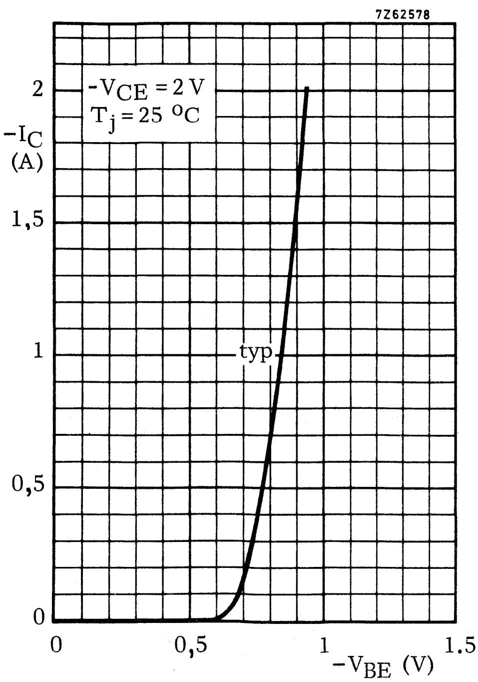


Fig. 10

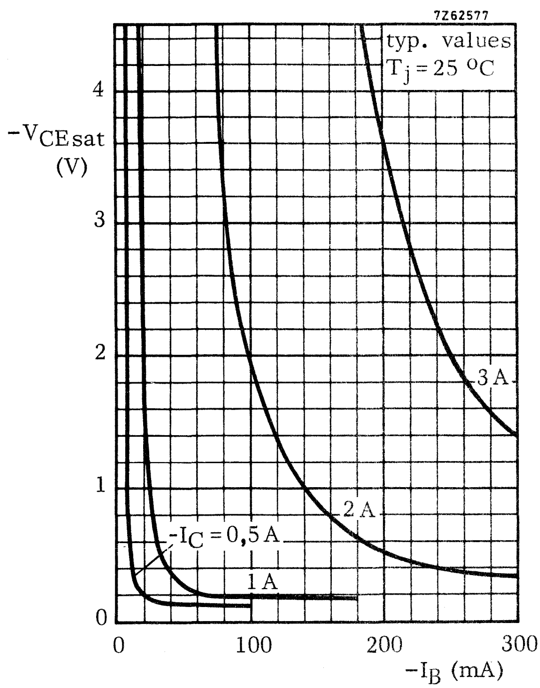


Fig. 11

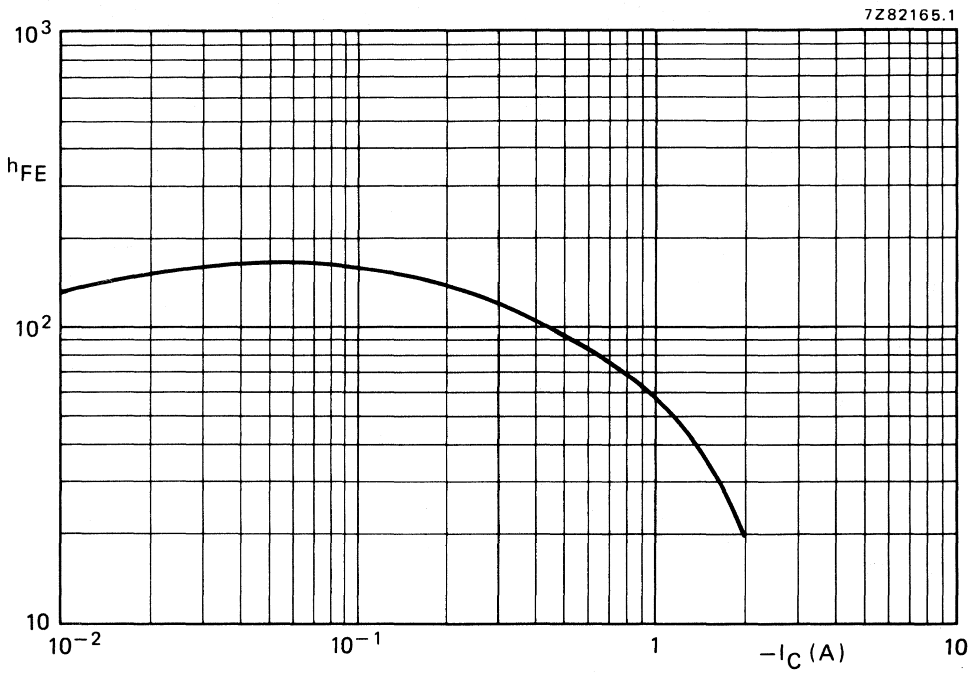


Fig. 12 Typical static forward current transfer ratio as a function of the collector current.
$-V_{CE}$ = 2 V; $T_j \leqslant 25\ ^oC$.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope intended for car-radio output stages.
P-N-P complement is BD330. Matched pairs can be supplied.

QUICK REFERENCE DATA

Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 1 V	h_{FE}		85 to 375	
Transition frequency I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	130	MHz

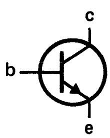
MECHANICAL DATA

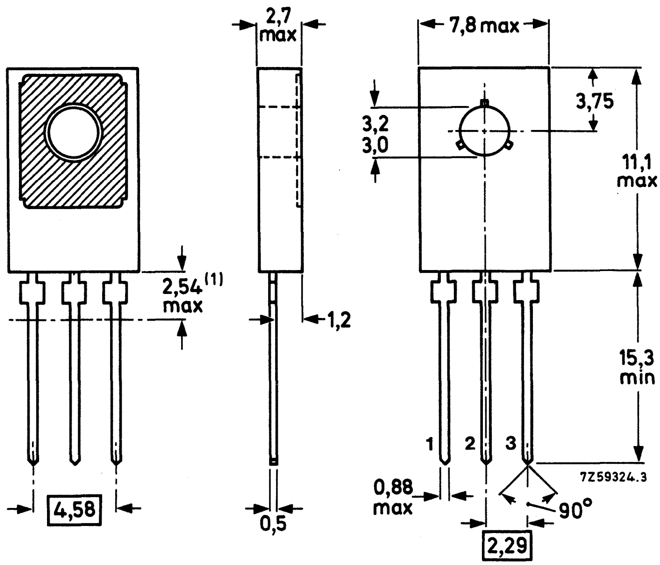
Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface

Pinning
1 = emitter
2 = collector
3 = base





See chapters Mounting Instructions and Accessories.

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

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

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	32	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.	3	A
Collector current (peak value)	I_{CM}	max.	3	A
Base current (d.c.)	I_B	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	3	A
Total power dissipation up to T_{mb} = 45 ^oC	P_{tot}	max.	15	W
Storage temperature	T_{stg}		− 65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

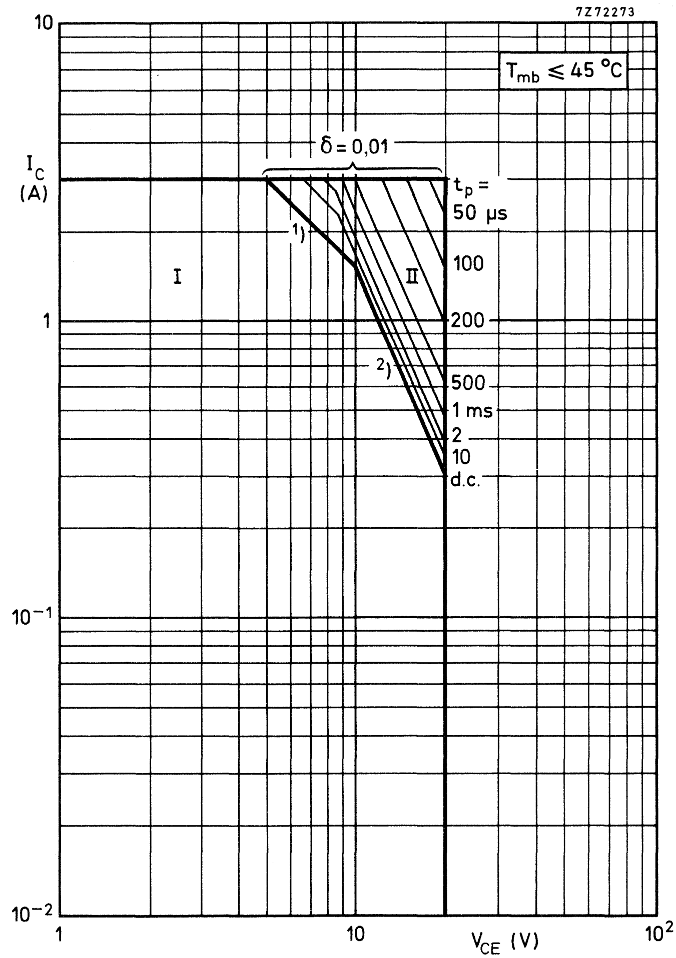
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	7	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 32$ V	I_{CBO}	<	10	μA
$I_E = 0$; $V_{CB} = 32$ 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.	0,6	V
$I_C = 2$ A; $V_{CE} = 1$ V	V_{BE}	<	1,2	V
Collector-emitter saturation voltage				
$I_C = 2$ A; $I_B = 0,2$ A	V_{CEsat}	<	0,5	V
D.C. current gain				
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	
$I_C = 0,5$ A; $V_{CE} = 1$ V	h_{FE}		85 to 375	
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	130	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\|I_C\| = 0,5$ A; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,6	

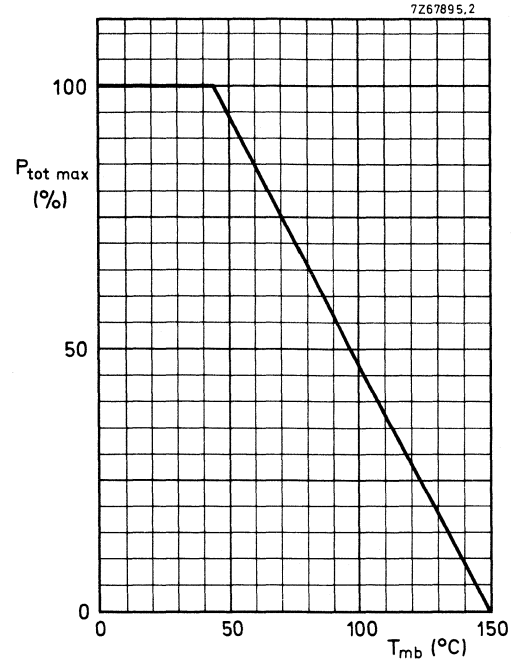


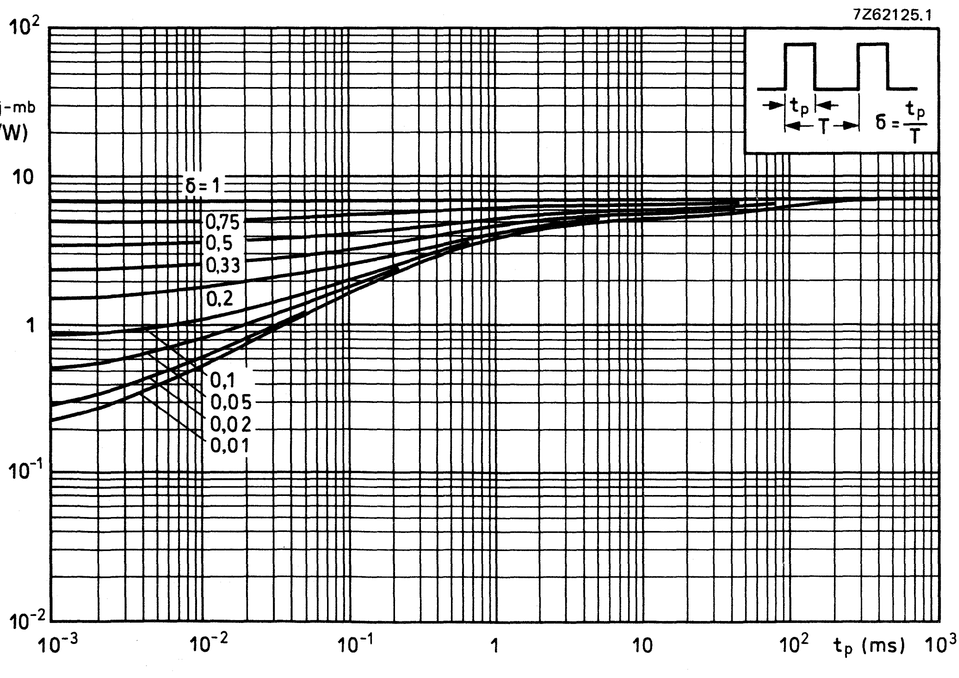
Safe Operating Area with the transistor forward biased

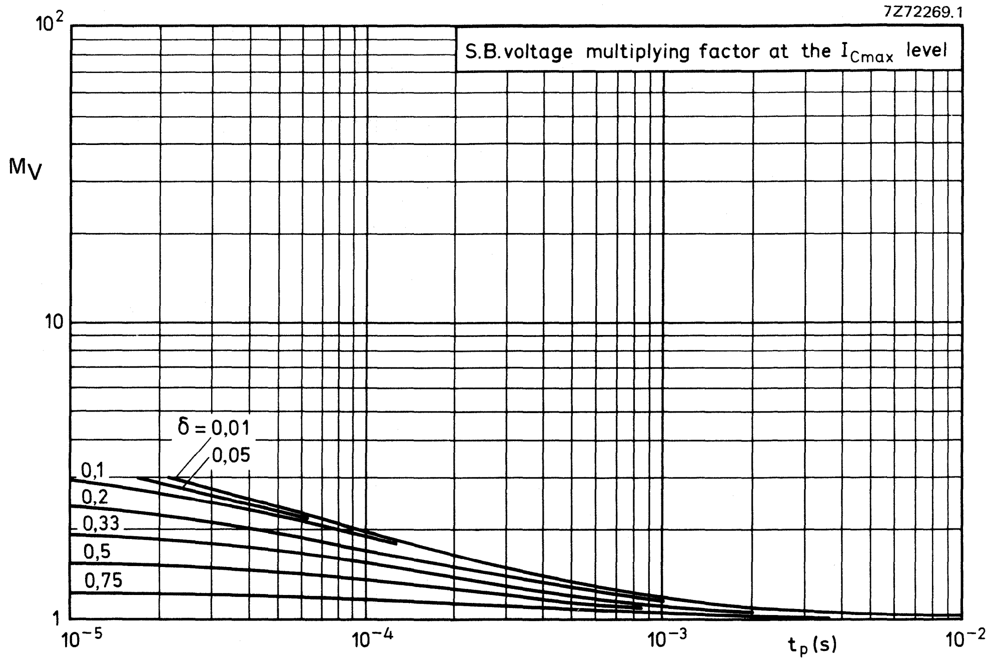
I Region of permissible d.c. operation
II Permissible extension for repetive pulse operation

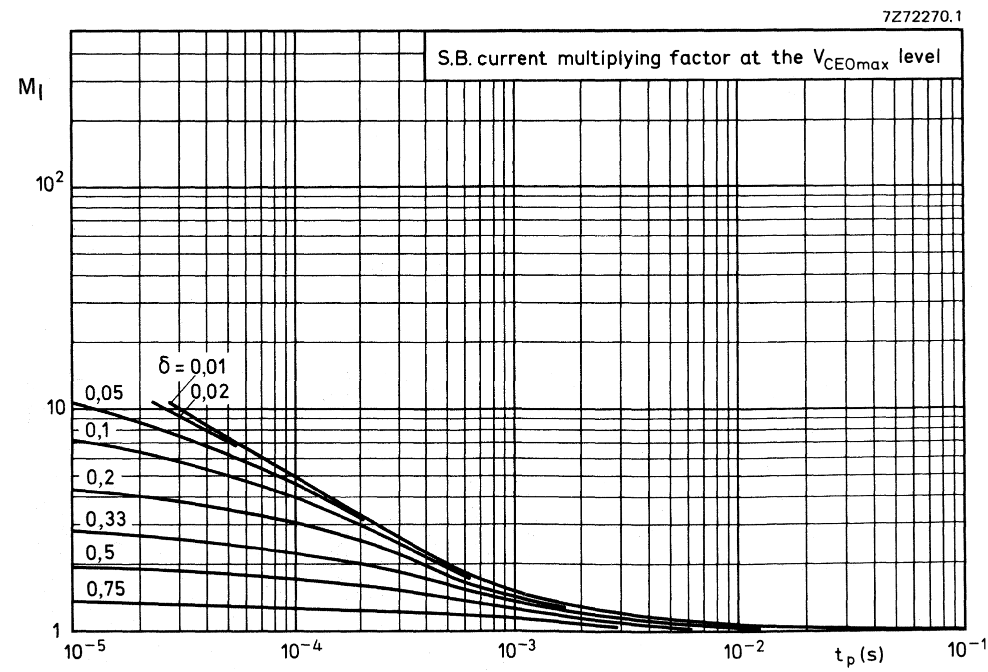
[1]) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

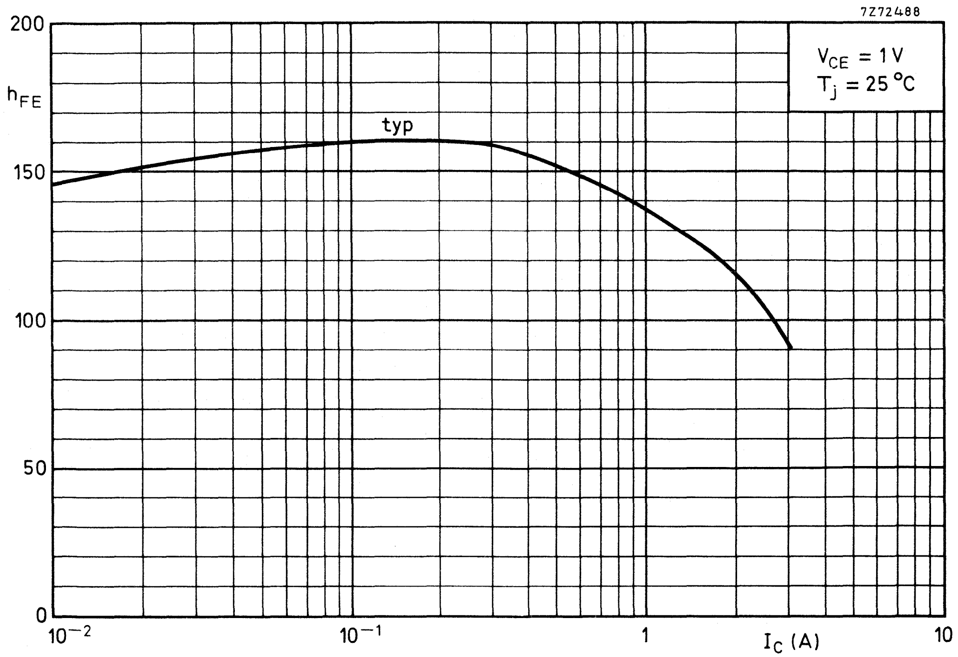
[2]) Second-breakdown limits

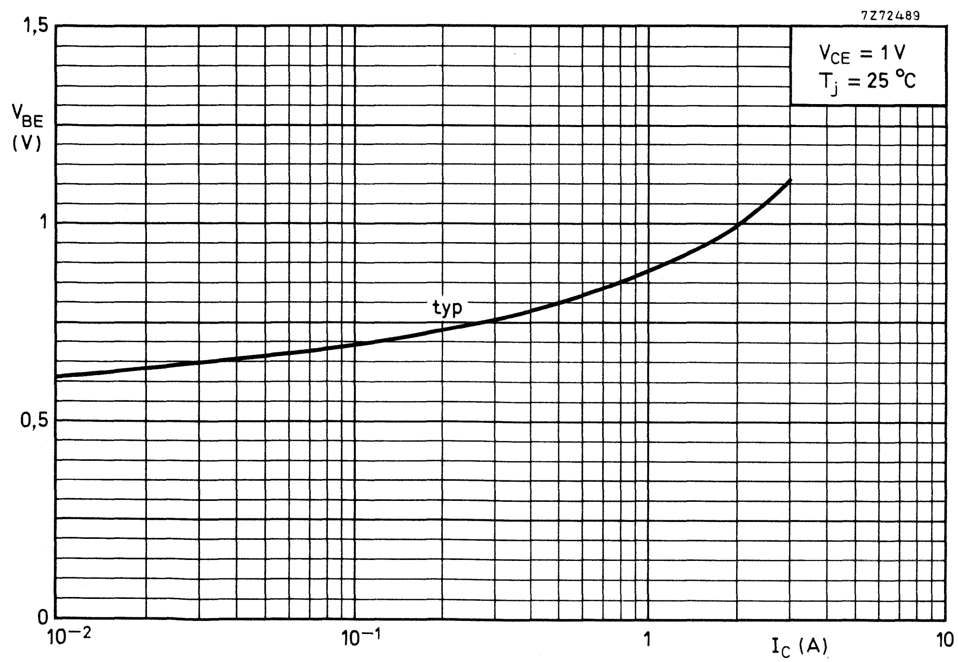

7Z67895.2
$P_{tot\ max}$ (%)
100
50
0
0
50
100
150
T_{mb} (°C)

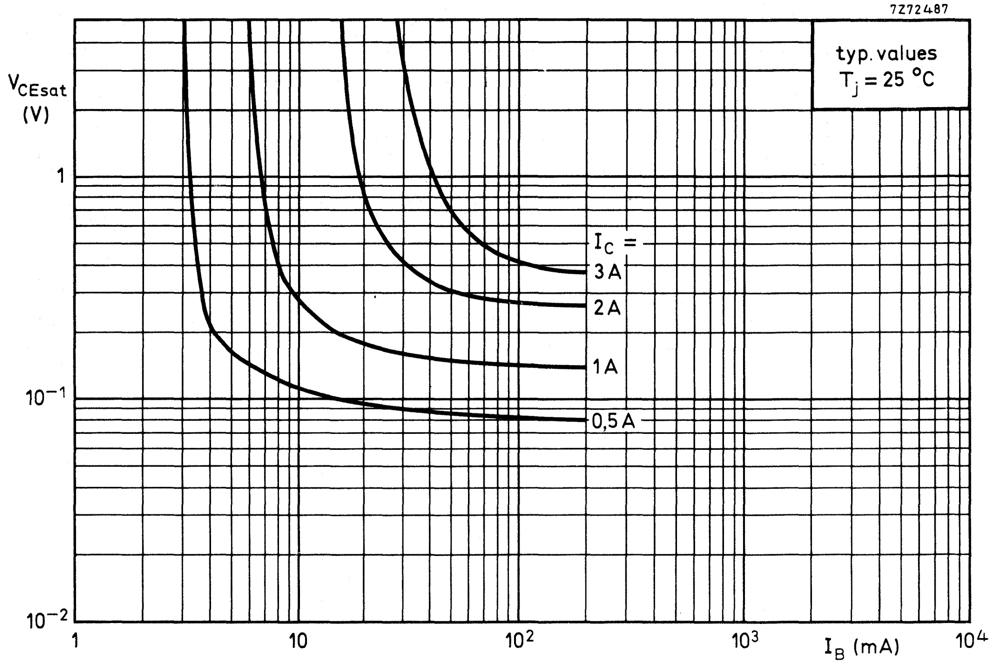

7Z62125.1
$Z_{th\ j\text{-}mb}$ (K/W)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$


7Z72269.1
S.B. voltage multiplying factor at the I_{Cmax} level
M_V
10^2
10
1
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270.1
S.B. current multiplying factor at the V_{CEOmax} level
M_I
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72488
200
150
100
50
0
h_{FE}
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
10
I_C (A)


7Z72489
1,5
1
0,5
0
V_{BE} (V)
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
10
I_C (A)


7Z72487
typ. values
$T_j = 25\ ^\circ C$
V_{CEsat} (V)
1
10^{-1}
10^{-2}
$I_C =$
3 A
2 A
1 A
0,5 A
1
10
10^2
10^3
I_B (mA)
10^4

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope intended for car-radio output stages.
N-P-N complement is BD329. Matched pairs can be supplied.

QUICK REFERENCE DATA

Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	100	MHz

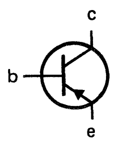
MECHANICAL DATA

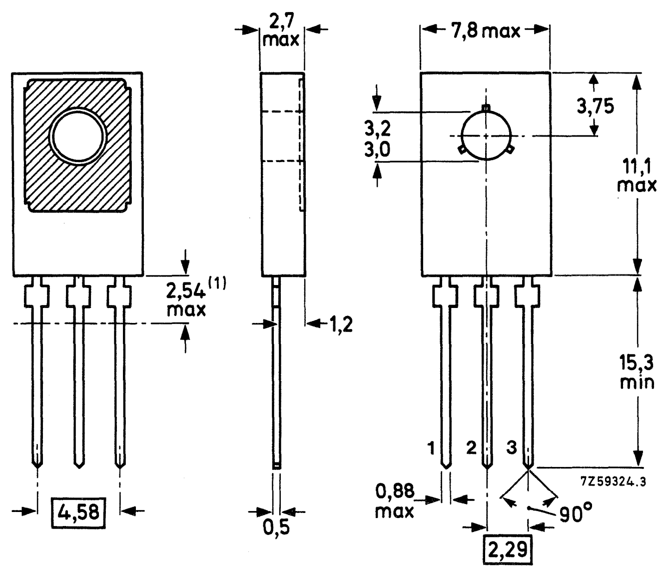
Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface

Pinning
1 = emitter
2 = collector
3 = base





See chapters Mounting Instructions and Accessories.

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

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	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.	3	A
Collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	$-I_B$	max.	1	A
Emitter current (d.c.)	I_E	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Storage temperature	T_{stg}		− 65 to +150	°C
Junction temperature	T_j	max.	150	°C

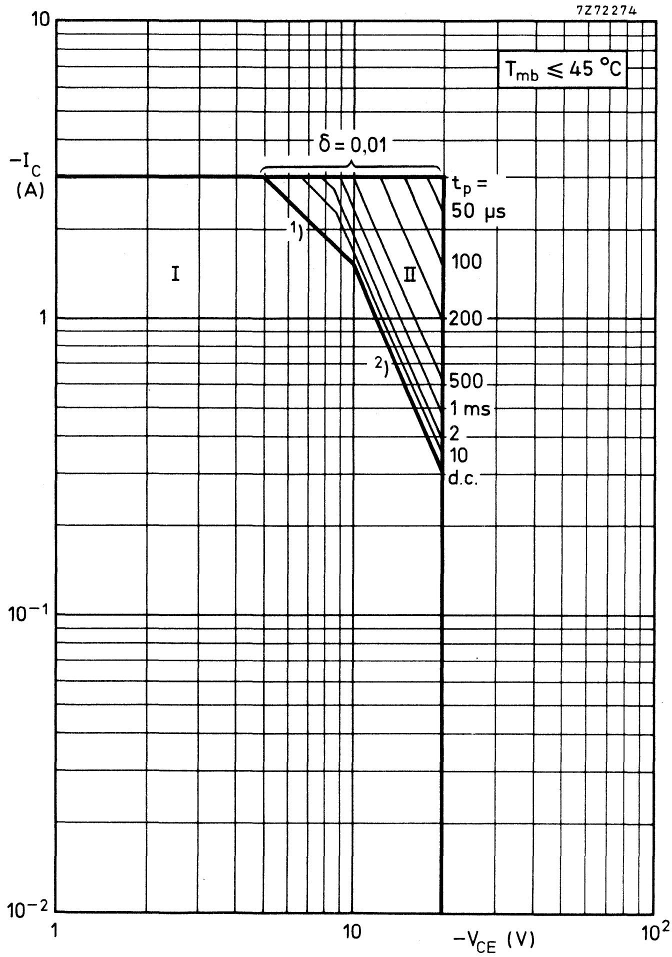
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	7	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 32$ V	$-I_{CBO}$	<	10	μA
$I_E = 0;\ -V_{CB} = 32$ V; $T_j = 150\ ^oC$	$-I_{CBO}$	<	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.	0,6	V
$-I_C = 2$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2	V
Collector-emitter saturation voltage				
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	
$-I_C = 0,5$ A; $-V_{CE} = 1$ V	h_{FE}		85 to 375	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	100	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\lvert I_C \rvert = 0,5$ A; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	<	1,6	

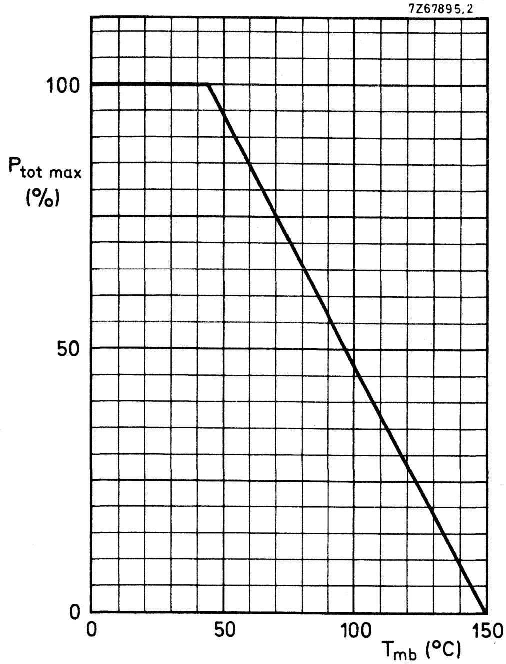


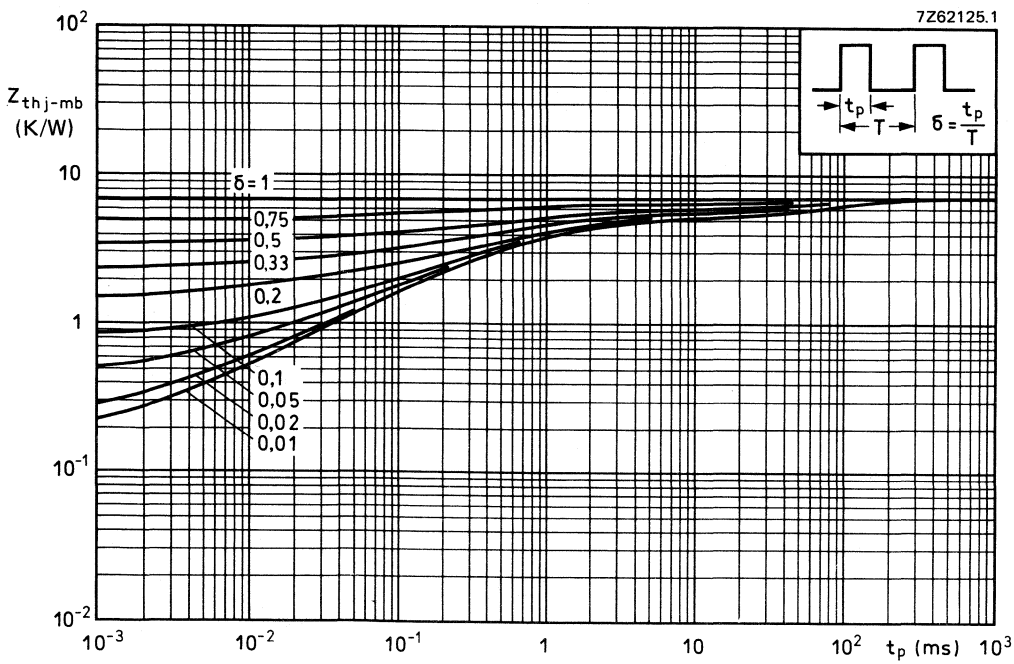
Safe Operating Area with the transistor forward biased

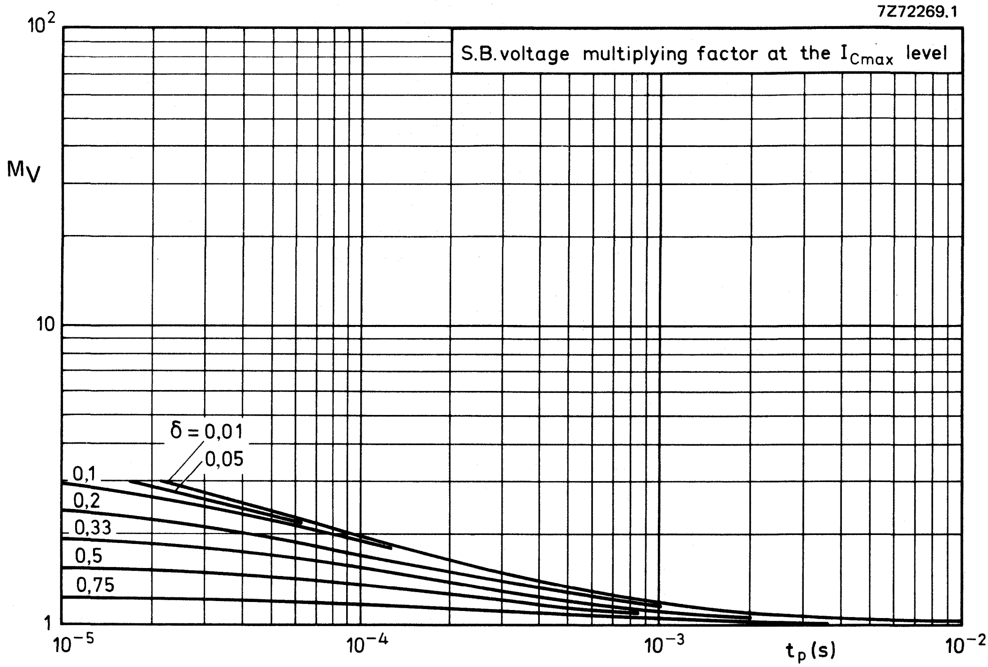
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

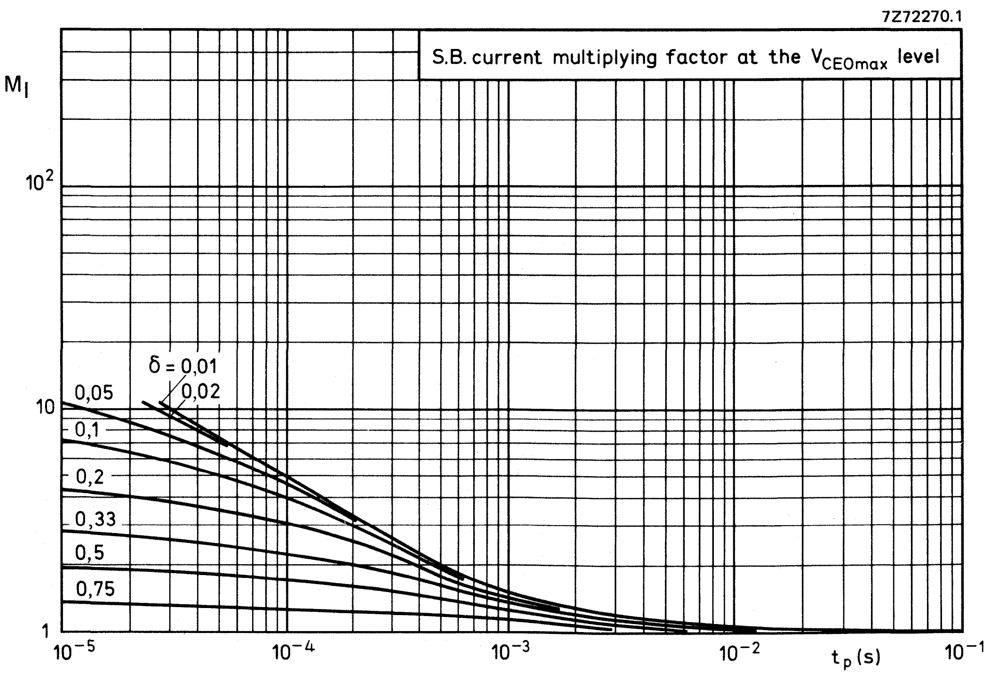
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

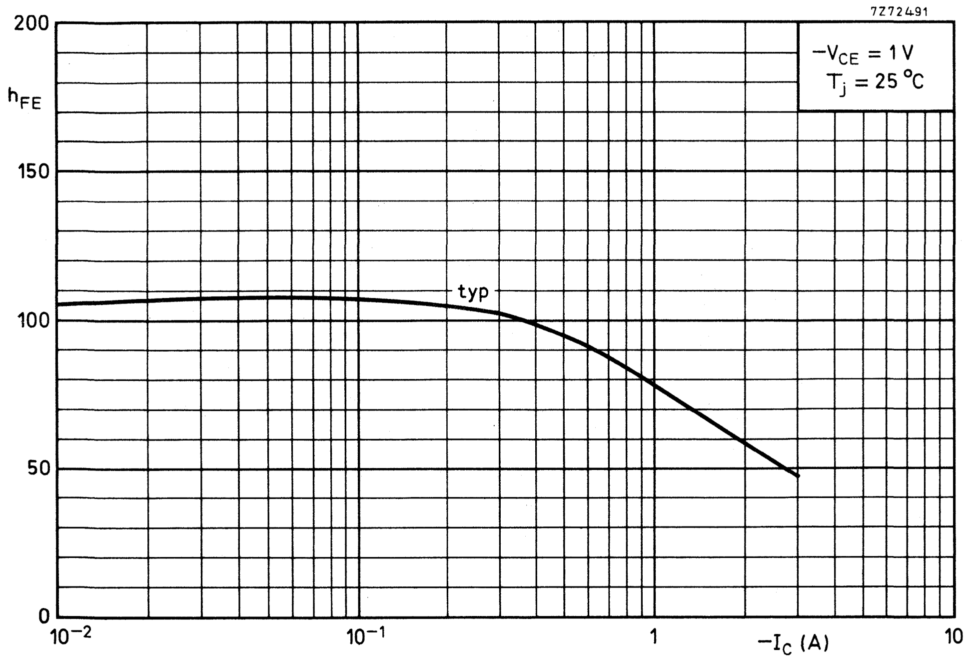
2) Second-breakdown limits

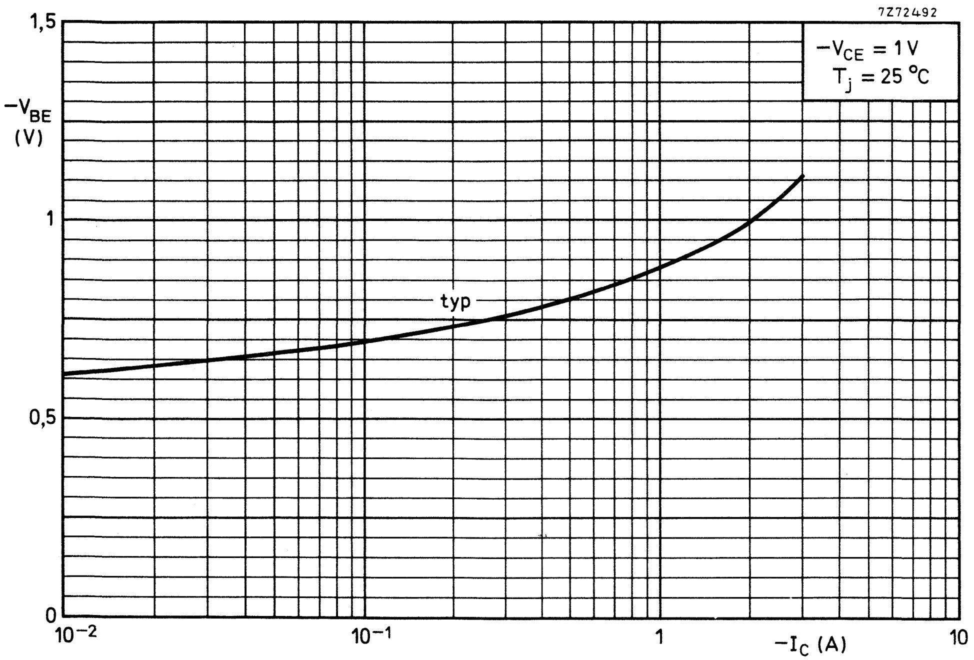

7Z67895.2
100
50
0
$P_{tot\ max}$
(%)
0
50
100
150
T_{mb} (°C)

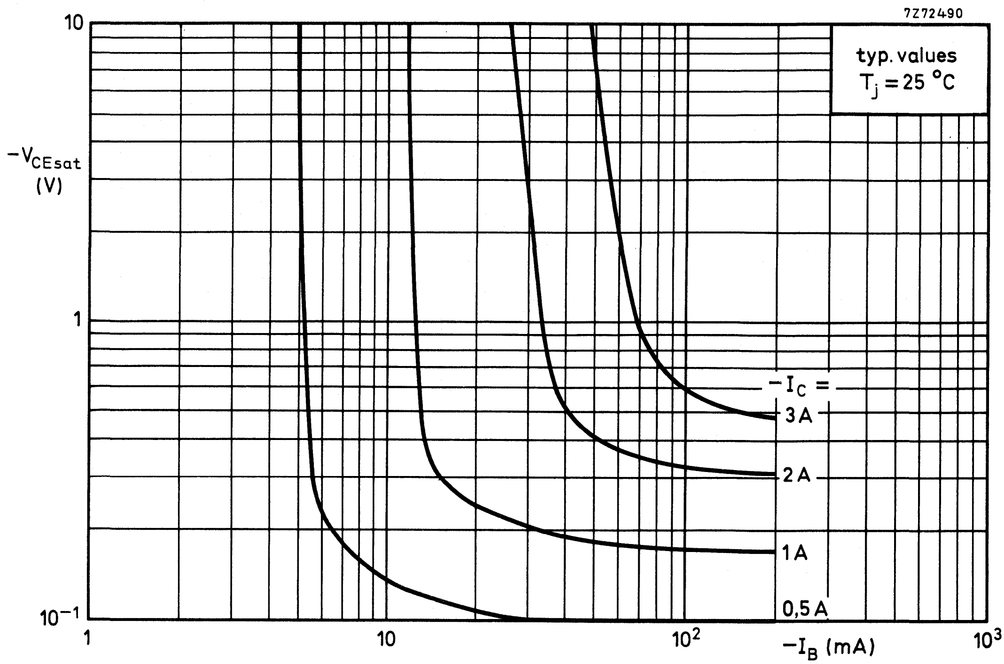

7Z62125.1
10^2
10
1
10^{-1}
10^{-2}
$Z_{th\ j\text{-}mb}$
(K/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z72269.1
S.B. voltage multiplying factor at the I_{Cmax} level
M_V
10^2
10
1
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270.1
S.B. current multiplying factor at the V_{CEOmax} level
M_I
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72491
$-V_{CE}$ = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10


7Z72492
$-V_{CE}$ = 1 V
T_j = 25 °C
$-V_{BE}$ (V)
1,5
1
0,5
0
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10


7Z72490
typ. values
$T_j = 25\ ^\circ C$
$-V_{CEsat}$ (V)
10
1
10^{-1}
1
10
10^2
10^3
$-I_B$ (mA)
$-I_C =$
3 A
2 A
1 A
0,5 A

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. P-N-P complements are BD332, BD334, BD336 and BD338.

QUICK REFERENCE DATA

			BD331	333	335	337	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector-current (d.c.)	I_C	max.	6				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>	750				

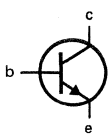
MECHANICAL DATA

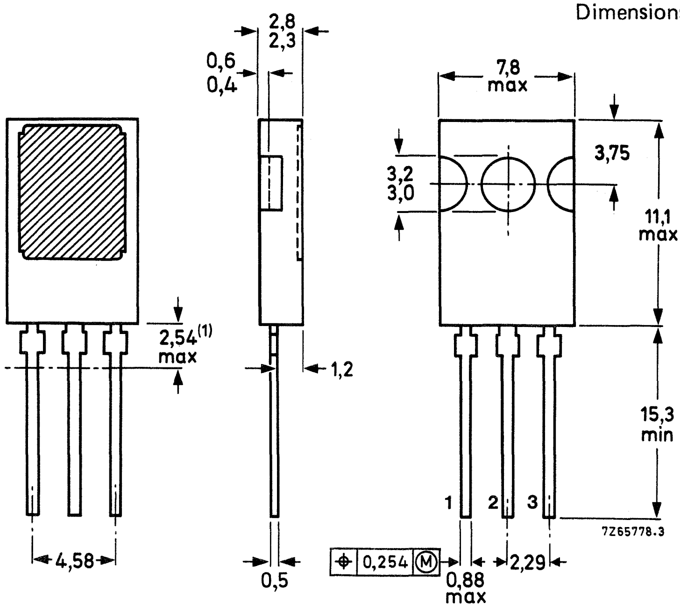
Dimensions in mm

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface

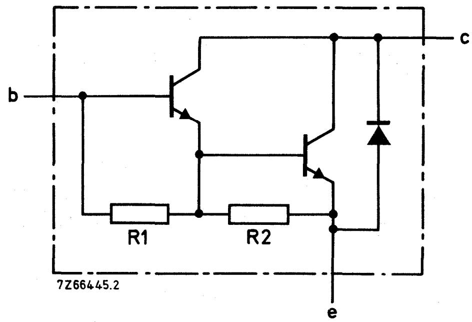
Pinning
1 = base
2 = collector
3 = emitter





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

See also chapters Mounting Instructions and Accessories.



R_1 typ. 4 kΩ
R_2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD331	333	335	337	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (d.c.)	I_C	max.	6				A
Collector current (peak value) $t_p \leqslant 10$ ms; $\delta \leqslant 0{,}1$	I_{CM}	max.	10				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60				W
Storage temperature	T_{stg}		−65 to + 150				^oC
Junction temperature *	T_j	max.	150				^oC

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	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

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current			
$I_E = 0; V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1 mA
$I_E = 0; V_{CB} = V_{CBOmax}; T_j = 150\ ^oC$	I_{CBO}	<	1 mA
$I_B = 0; V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	0,2 mA
Emitter cut-off current			
$I_C = 0; V_{EB} = 5$ V	I_{EBO}	<	5 mA
D.C. current gain *			
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1900
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	750
$I_C = 6$ A; $V_{CE} = 3$ V	h_{FE}	typ.	3000
Base-emitter voltage **			
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage			
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	<	2 V
Cut-off frequency			
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50 kHz
Turn-off breakdown energy with inductive load (see Fig. 12)			
$-I_{Boff} = 0; I_{Con} = 4,5$ A	$E_{(BR)}$	>	50 mJ
Diode forward voltage			
$I_F = 3$ A	V_F	typ.	1,8 V
D.C. current gain ratio of complementary matched pairs			
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5
Small signal current gain			
$I_C = 3$ A; $V_{CE} = 3$ V; f = 1 MHz	h_{fe}	>	10
Second-breakdown collector current			
$V_{CE} = 60$ V; $t_p = 25$ ms	$I_{(SB)}$	>	1 A
Switching times (between 10% and 90% levels)			
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 12$ mA			
Turn-on time	t_{on}	typ.	1 μs
		<	2 μs
Turn-off time	t_{off}	typ.	5 μs
		<	10 μs

* Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.

** V_{BE} decreases by about 3,8 mV/K with increasing temperature.

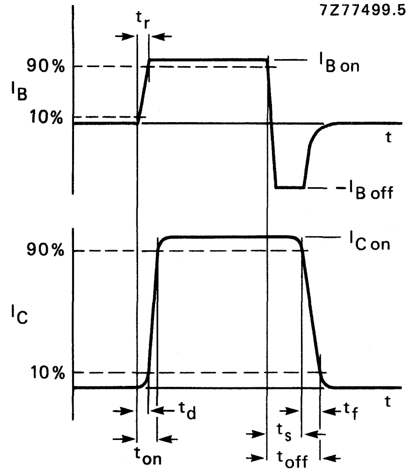
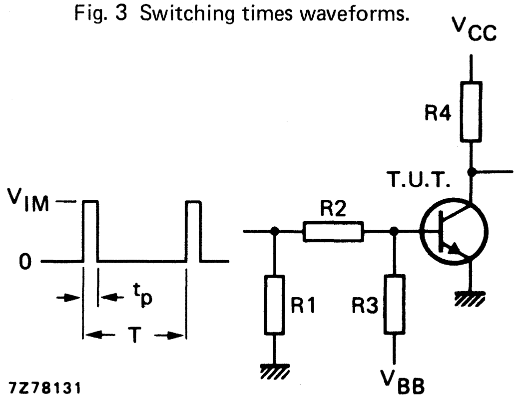
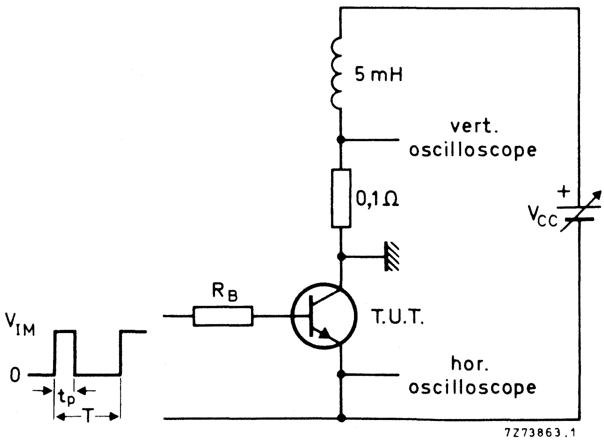


Fig. 3 Switching times waveforms.



V_{IM} = 10 V
V_{CC} = 10 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.



V_{IM} = 12 V
R_B = 270 Ω
I_C = 4,5 A
δ = 1 %
t_p = 1 ms

Fig. 5 Test circuit for turn-off breakdown energy.

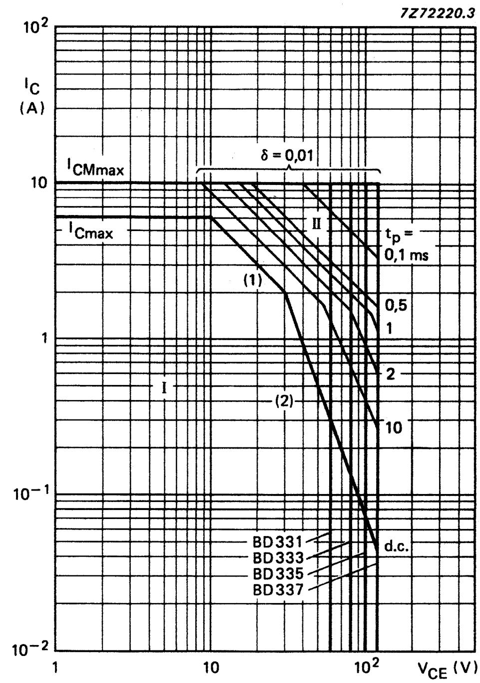


Fig. 6 Safe Operating Area, $T_{mb} \leq 25$ °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

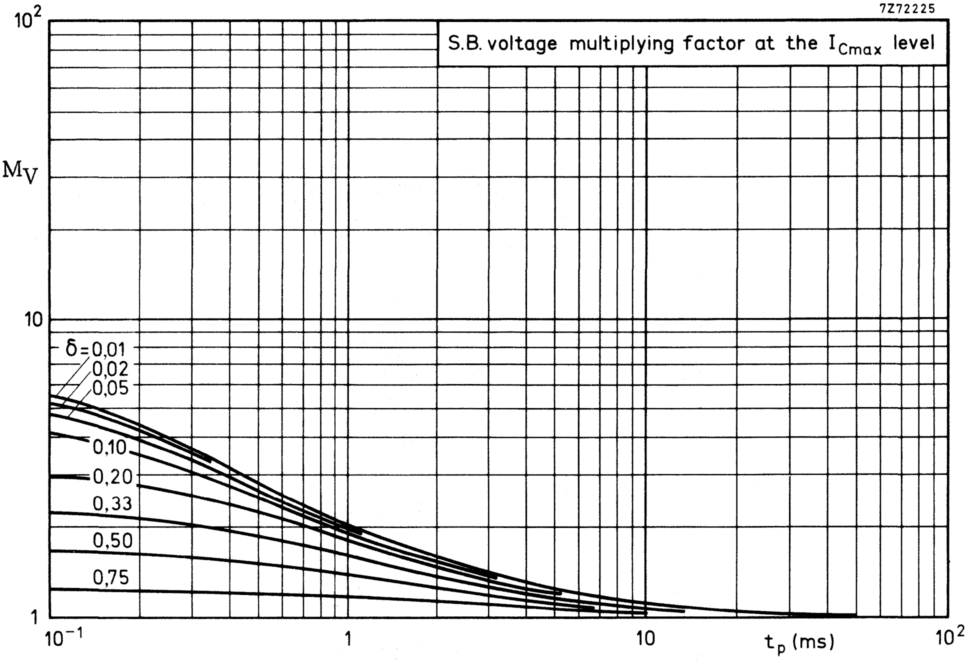


Fig. 7 Second breakdown voltage multiplying factor at I_{Cmax} level.

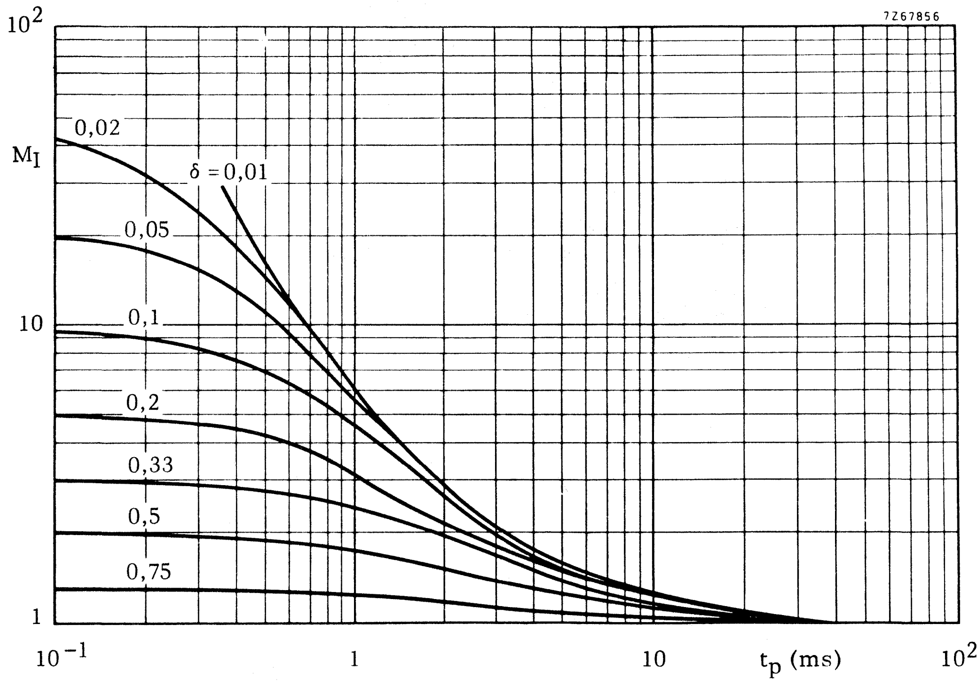


Fig. 8 Second breakdown current multiplying factor at V_{CEOmax} level.

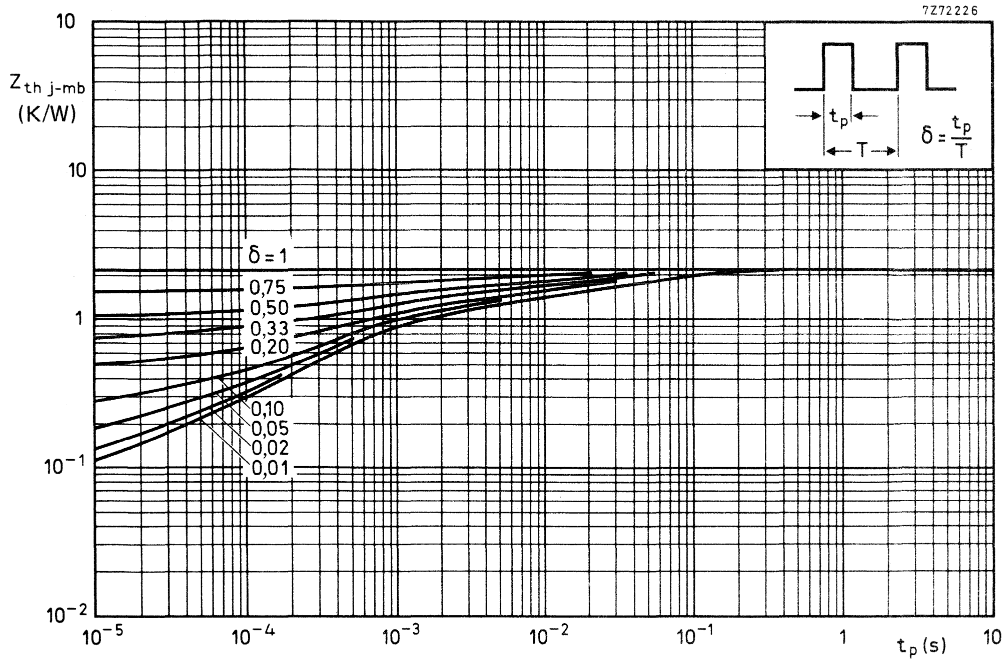


Fig. 9 Pulse power rating chart.

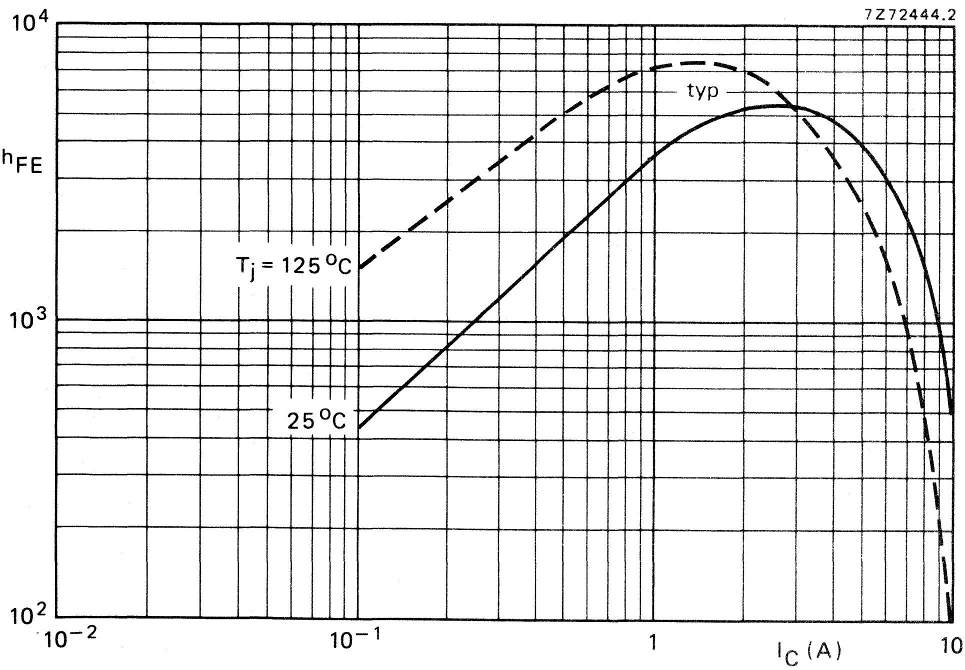


Fig. 10 D.C. current gain. V_{CE} = 3 V.

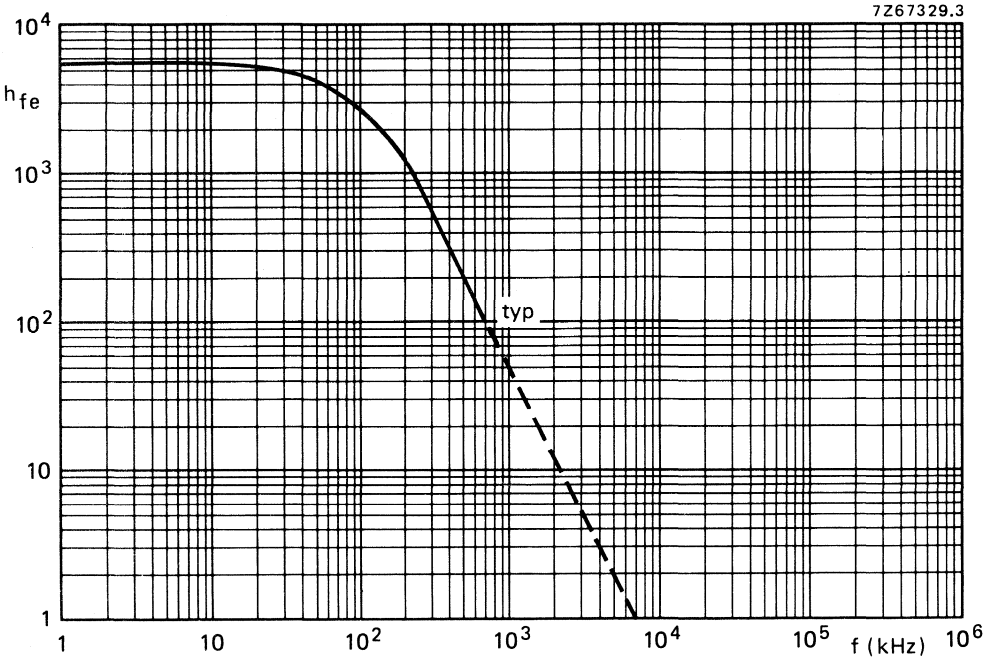


Fig. 11 Small signal current gain at I_C = 3 A; V_{CE} = 3 V.

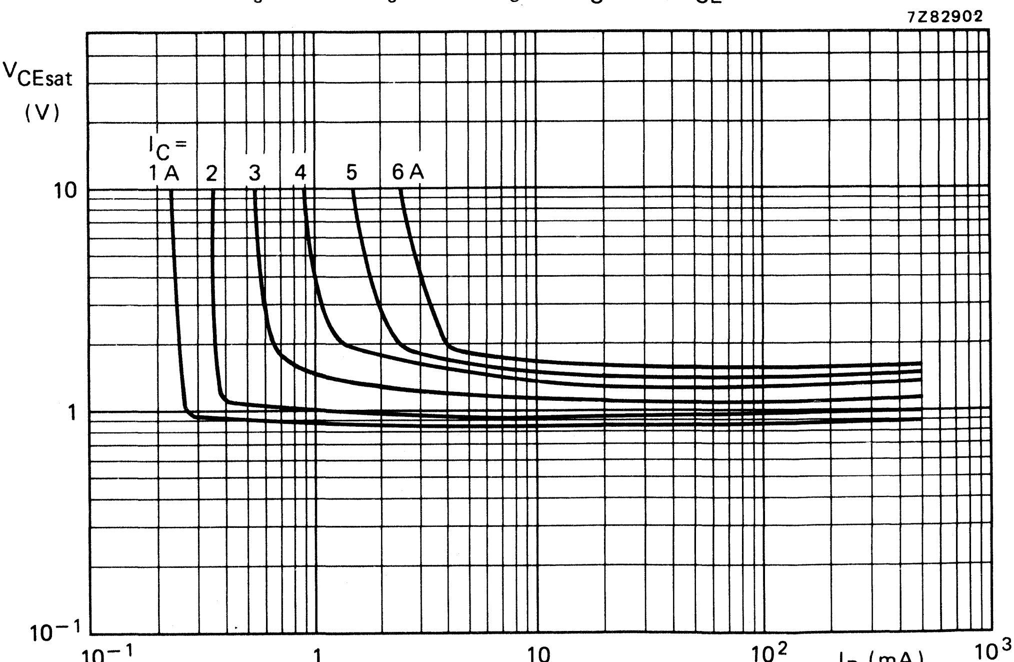


Fig. 12 Typical values collector-emitter saturation. T_j = 25 °C.

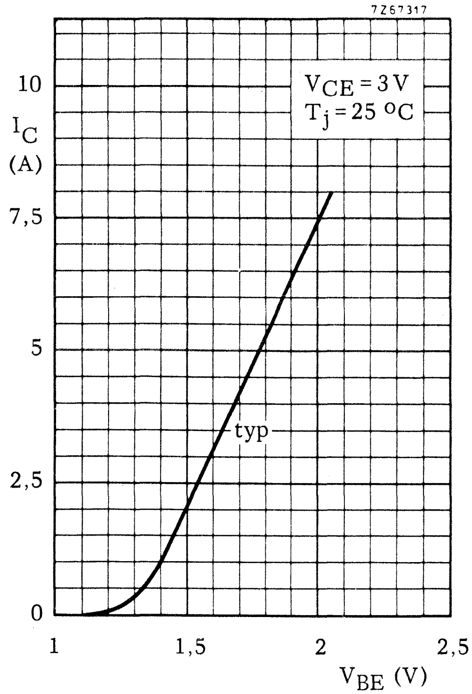


Fig. 13 Collector current.

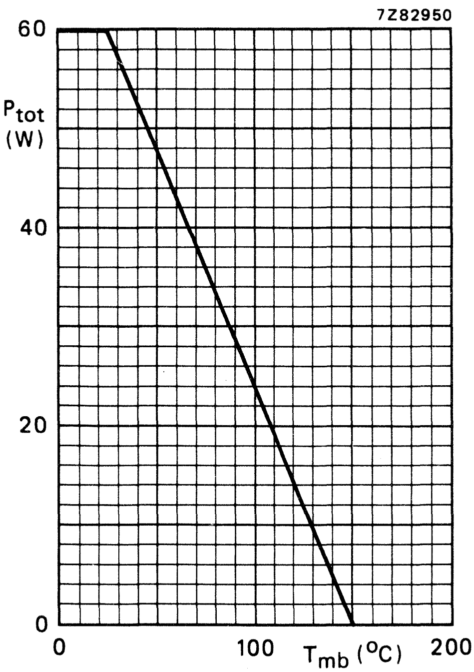


Fig. 14 Power derating curve.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. N-P-N complements are BD331, BD333, BD335 and BD337.

QUICK REFERENCE DATA

			BD332	334	336	338	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector-current (d.c.)	$-I_C$	max.	6				A
Base current (d.c.)	$-I_B$	max.	150				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>	750				

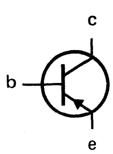
MECHANICAL DATA

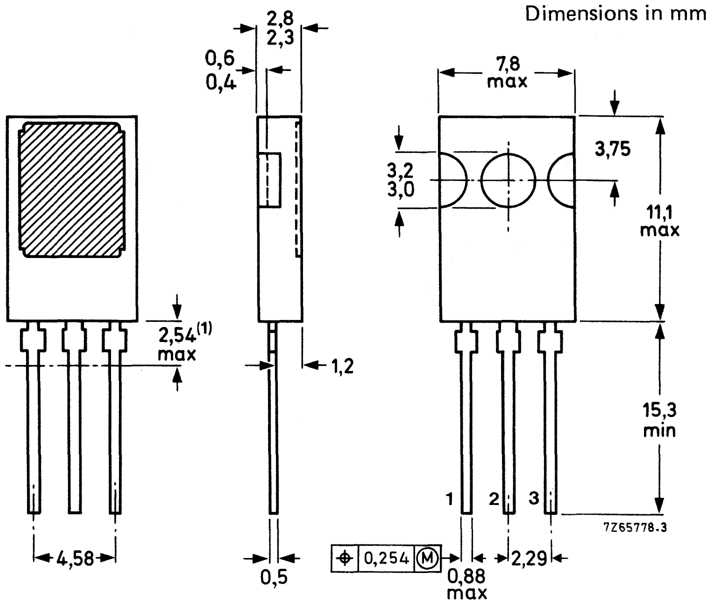
Dimensions in mm

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface.

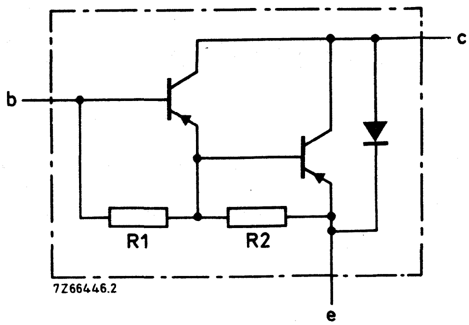
Pinning
1 = base
2 = collector
3 = emitter





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

See also chapters Mounting instructions and Accessories.



R_1 typ. 4 kΩ
R_2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD332	334	336	338	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	6				A
Collector current (peak value) $t_p \leqslant 10$ ms; $\delta \leqslant 0,1$	$-I_{CM}$	max.	10				A
Base current (d.c.)	$-I_B$	max.	150				mA
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature *	T_j	max.	150				°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	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			
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1 mA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	1 mA
$I_B = 0$; $-V_{CE} = -½\ V_{CEO}$	$-I_{CEO}$	<	0,2 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	5 mA
D.C. current gain *			
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2700
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	>	750
$-I_C$ = 6 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	400
Base-emitter voltage **			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage			
$-I_C$ = 3 A; $-I_B$ = 12 mA	$-V_{CEsat}$	<	2 V
Small signal current gain			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V; f = 1 MHz	h_{fe}	>	10
Cut-off frequency			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100 kHz
Diode, forward voltage			
I_F = 3 A	V_F	typ.	1,8 V
D.C. current gain ratio of complementary matched pairs			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	<	2,5
Second breakdown collector current non-repetitive; without heatsink			
$-V_{CE}$ = 60 V; t_p = 25 ms	$-I_{(SB)}$	>	1 A
Switching times (see Figs 3 and 4)			
$-I_{Con}$ = 3 A; $-I_{Bon} = I_{Boff}$ = 12 mA			
turn-on time	t_{on}	typ.	1 μs
		<	2 μs
turn-off time	t_{off}	typ.	5 μs
		<	10 μs

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

** V_{BE} decreases by about 3,8 mV/K with increasing temperature.

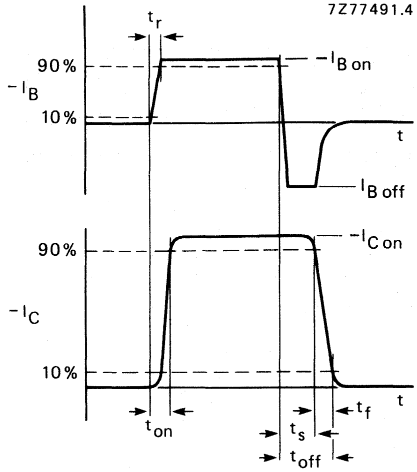
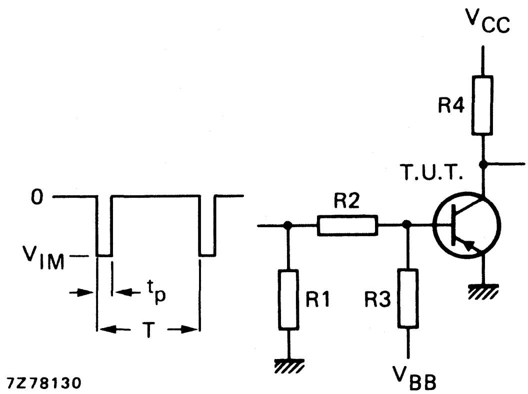


Fig. 3 Switching times waveforms.



$-V_{IM}$ = 10 V
$-V_{CC}$ = 10 V
V_{BB} = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

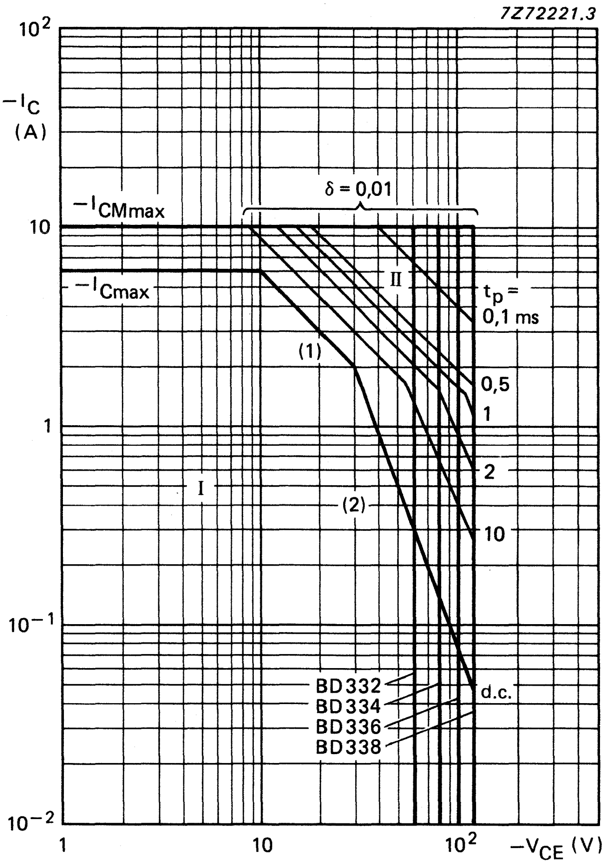


Fig. 5 Safe Operating Area with the transistor forward biased; T_{mb} = 25 °C.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second breakdown limits.

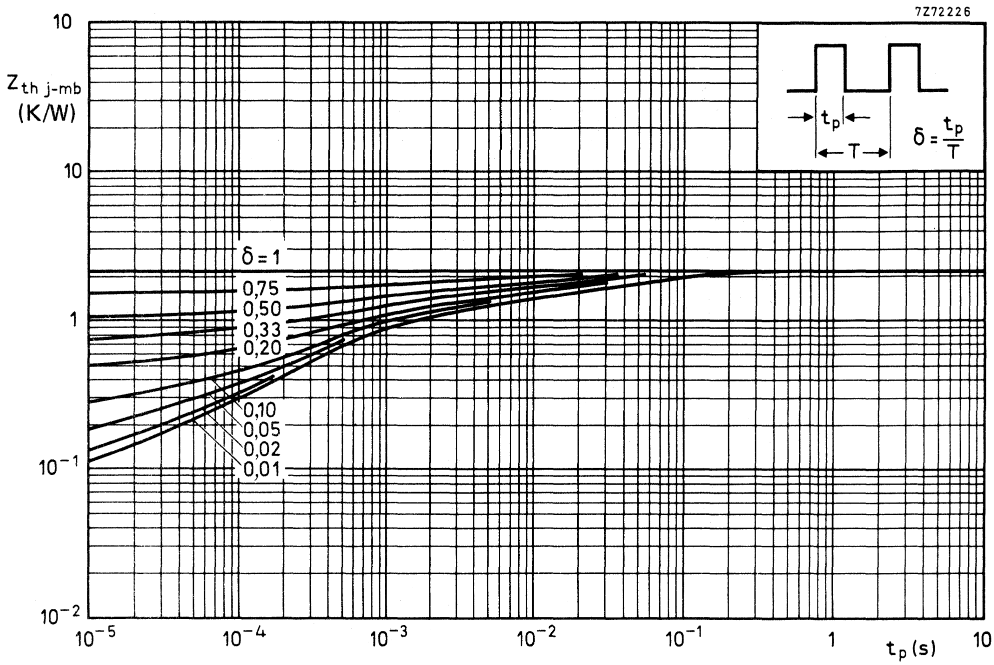


Fig. 6 Pulse power rating chart.

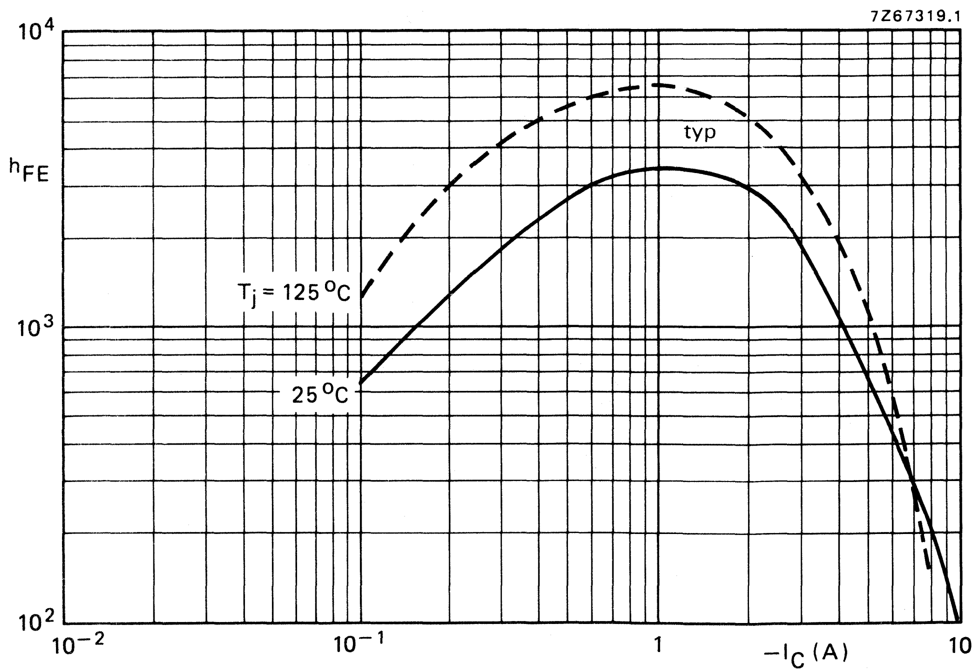


Fig. 7 D.C. current gain at $-V_{CE} = 3$ V.

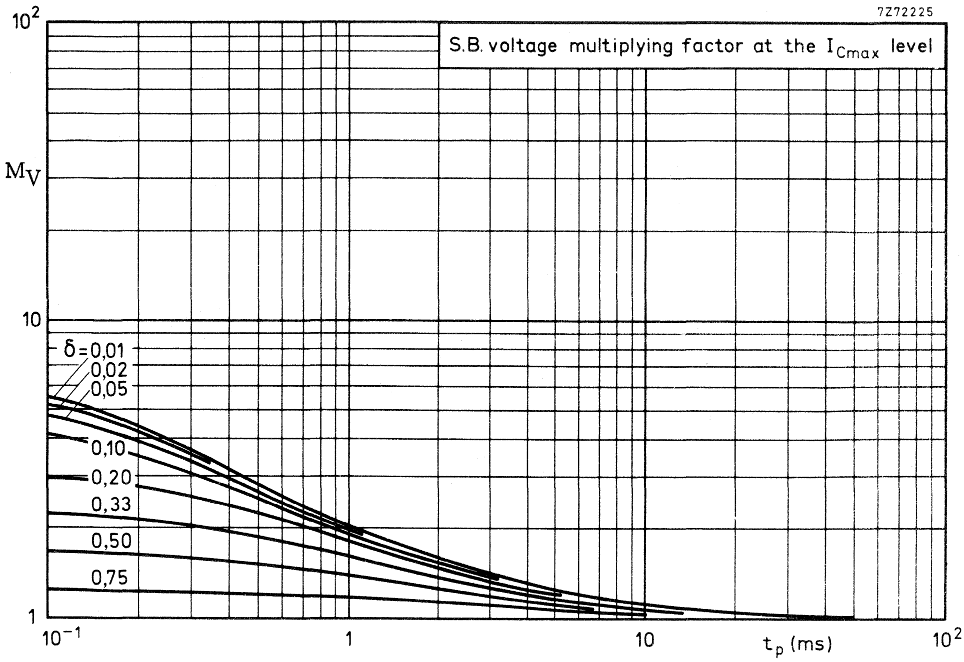


Fig. 8 Second breakdown voltage multiplying factor at the I_{Cmax} level.

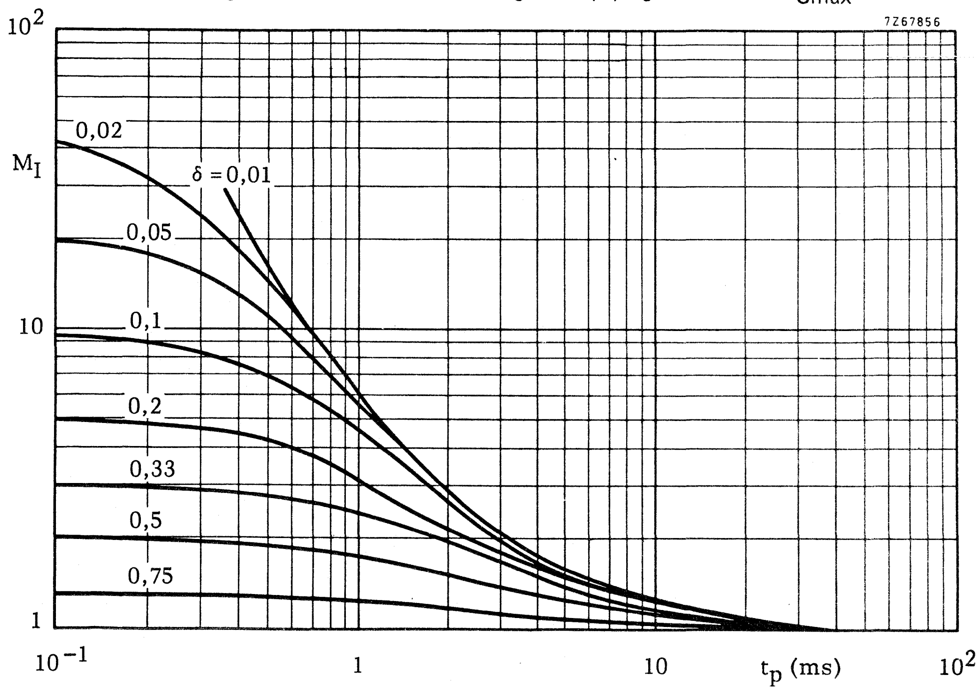


Fig. 9 Second breakdown current multiplying factor at the V_{CEOmax} level.

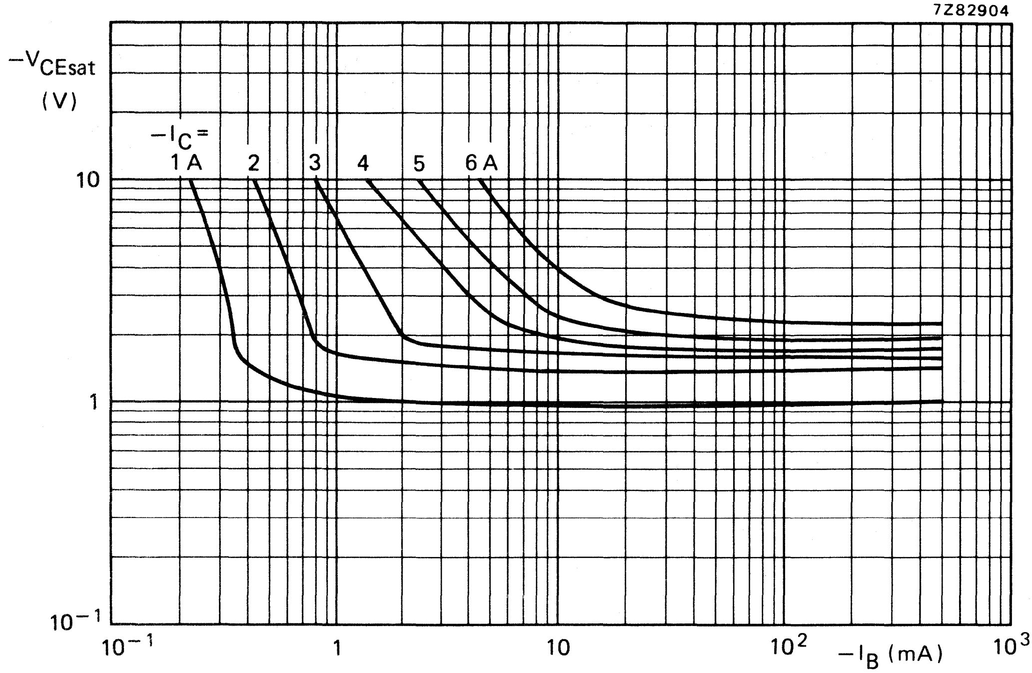


Fig. 10 Typical values collector-emitter saturation voltage. T_j = 25 °C.

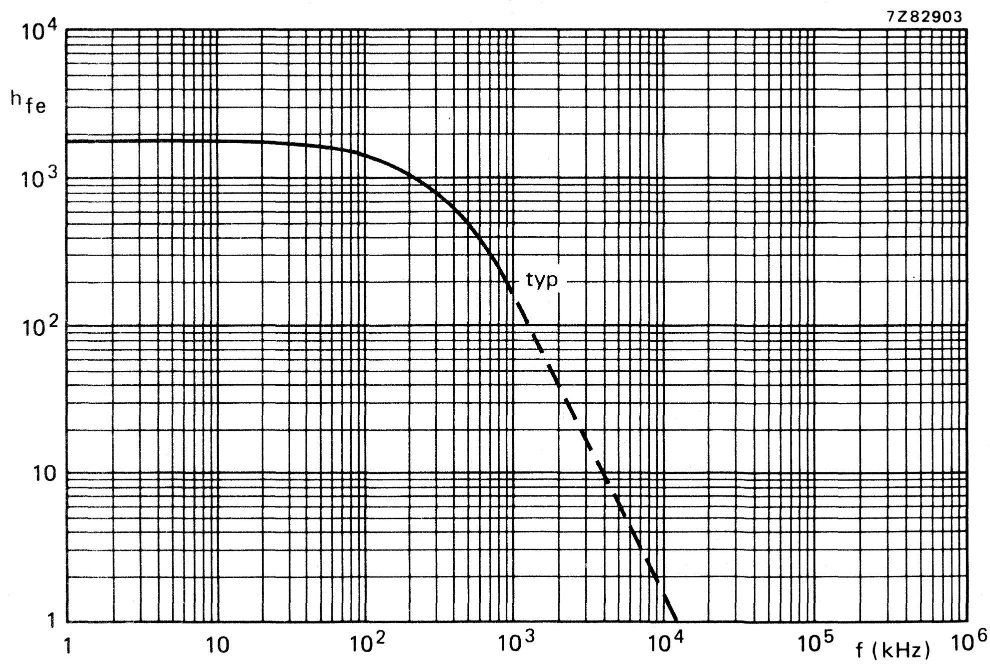


Fig. 11 Small signal current gain. $-I_C$ = 3 A; $-V_{CE}$ = 3 V.

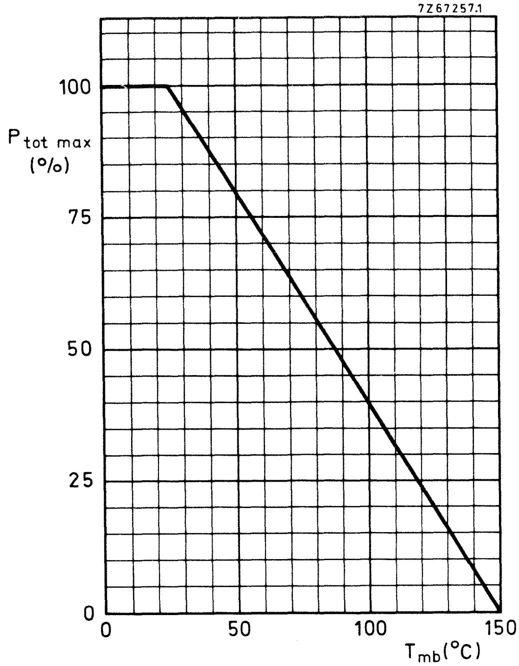


Fig. 12 Power derating curve.

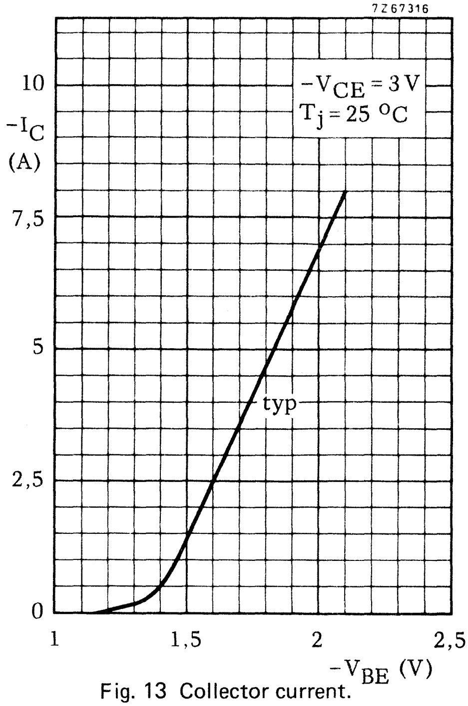


Fig. 13 Collector current.

Silicon epitaxial-base transistors BD433/435/437/439/441

DESCRIPTION

NPN transistors in a TO-126 (SOT32) plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W. The complementary pairs are BD434, BD436, BD438, BD440 and BD442 respectively.

PINNING - TO-126 (SOT32)

PIN	DESCRIPTION
1	emitter
2	collector
3	base

Collector connected to metal part of mounting surface.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CES}	collector-emitter voltage	$V_{BE} = 0$			
	BD433		–	22	V
	BD435		–	32	V
	BD437		–	45	V
	BD439		–	60	V
	BD441		–	80	V
V_{CEO}	collector-emitter voltage	open base			
	BD433		–	22	V
	BD435		–	32	V
	BD437		–	45	V
	BD439		–	60	V
	BD441		–	80	V
I_C	collector current	average value	–	4	A
I_{CM}	collector current	peak value	–	7	A
P_{tot}	total power dissipation	$T_{mb} = 25$ °C	–	36	W
h_{FE}	DC current gain	$I_C = 2$ A; $V_{CE} = 1$ V			
	BD433		50	–	
	BD435		50	–	
	BD437		40	–	
	BD439		25	–	
	BD441		15	–	
f_T	transition frequency	$I_C = 250$ mA; $V_{CE} = 1$ V	7	–	MHz

PIN CONFIGURATION

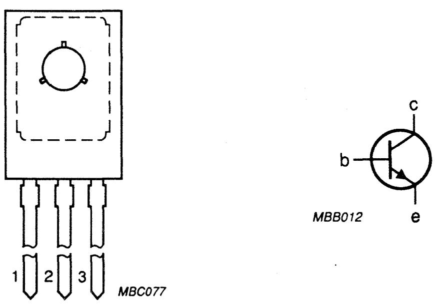


Fig.1 Simplified outline and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BD433		–	22	V
	BD435		–	32	V
	BD437		–	45	V
	BD439		–	60	V
	BD441		–	80	V
V_{CES}	collector-emitter voltage	$V_{BE} = 0$			
	BD433		–	22	V
	BD435		–	32	V
	BD437		–	45	V
	BD439		–	60	V
	BD441		–	80	V
V_{CEO}	collector-emitter voltage	open base			
	BD433		–	22	V
	BD435		–	32	V
	BD437		–	45	V
	BD439		–	60	V
	BD441		–	80	V
V_{EBO}	emitter-base voltage	open collector	–	5	V
I_C	collector current	average value	–	4	A
I_{CM}	collector current	peak value	–	7	A
I_B	base current	$T_{mb} = 25$ °C	–	1	A
P_{tot}	total power dissipation	$T_{mb} = 25$ °C	–	36	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		–	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}mb}$	from junction to mounting base		3.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	in free air	100	K/W

CHARACTERISTICS

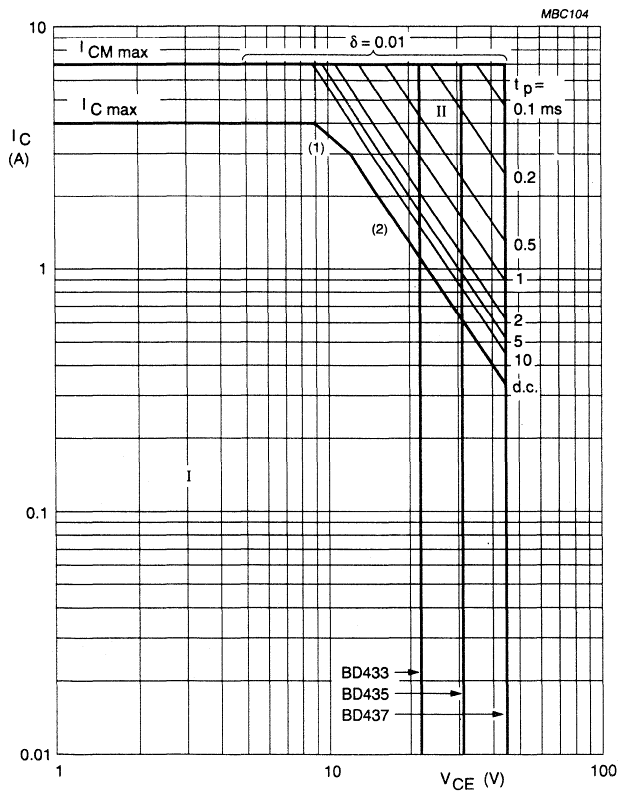
T_j = 25 °C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut off current	I_E = 0; $V_{CB} = V_{CBO\ max}$	–	–	50	μA
		I_E = 0; V_{CB} = 10 V; T_j = 150 °C	–	–	1	mA
		I_E = 0; $V_{CB} = V_{CBO\ max}$ T_j = 150 °C	–	–	1	mA
I_{EBO}	emitter cut off current	I_C = 0; V_{EB} = 5 V	–	–	0.2	mA
V_{CEK}	knee voltage	I_C = 2 A; I_B = value for which I_C = 2.2 A at V_{CE} = 1 V				
	BD433, BD435, BD437		–	–	0.8	V
V_{BE}	base-emitter voltage	I_C = 10 mA; V_{CE} = 5 V; note 1	–	580	–	mV
		I_C = 2 A; V_{CE} = 1 V; note 1				
	BD433, BD435		–	–	1.1	V
	BD439, BD441		–	–	1.5	V
		I_C = 3 A; V_{CE} = 1 V; note 1				
	BD437		–	–	1.3	V
$V_{CE\ sat}$	collector-emitter saturation voltage	I_C = 2 A; I_B = 0.2 A				
	BD433, BD435		–	–	0.5	V
	BD439, BD441		–	–	0.8	V
		I_C = 3 A; I_B = 0.3 A				
	BD437		–	–	0.7	V

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
h_{FE}	DC current gain	I_C = 10 mA; V_{CB} = 5 V				
	BD433		25	–	–	
	BD435		25	–	–	
	BD437		25	–	–	
	BD439		20	–	–	
	BD441		15	–	–	
		I_C = 500 mA; V_{CB} = 1 V				
	BD433		85	–	475	
	BD435		85	–	475	
	BD437		85	–	375	
	BD439		40	–	–	
	BD441		40	–	–	
		I_C = 2 A; V_{CB} = 1 V				
	BD433		50	–	–	
	BD435		50	–	–	
	BD437		40	–	–	
	BD439		25	–	–	
	BD441		15	–	–	
		I_C = 3 A; V_{CB} = 1 V				
	BD437		30	–	–	
f_T	transition frequency	at f = 1 MHz; I_C = 250 mA; V_{CE} = 1 V	7	–	–	MHz
h_{FE1} / h_{FE2}	DC current gain ratio of the complementary pairs	I_C = 500 mA; V_{CB} = 1 V				
	BD433/BD434		–	–	1.4	
	BD435/BD436		–	–	1.4	
	BD437/BD438		–	–	1.8	
	BD439/BD440		–	–	1.4	
	BD441/BD442		–	–	1.4	

Note

1. V_{BE} decreases by typ. 2.3 mV/K with increasing temperature.



BD433, BD435, BD437

T_{mb} = 25 °C

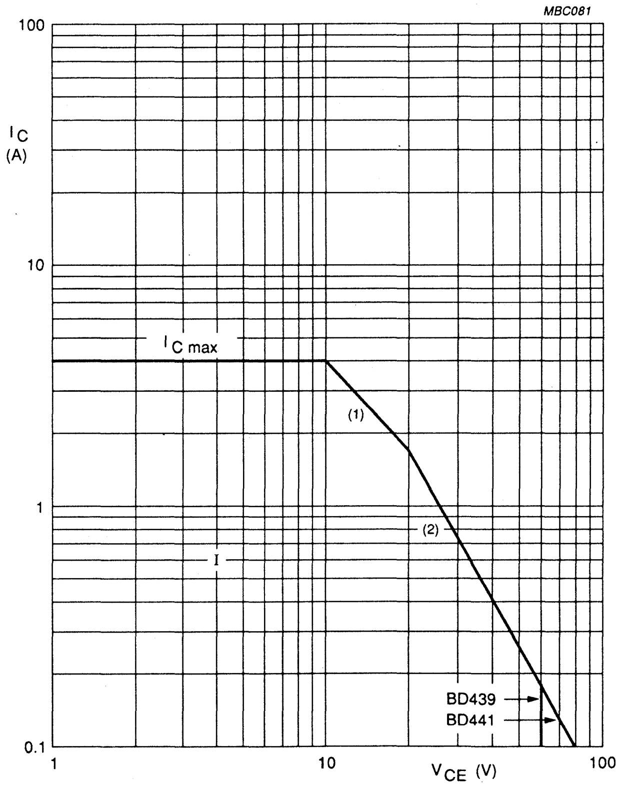
I Region of permissible DC operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

Fig.2 Safe operating area.



BD439, BD441

T_{mb} = 25 °C

I   Region of permissible DC operation.

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

(2) Second breakdown limits.

Fig.3 Safe operating area.

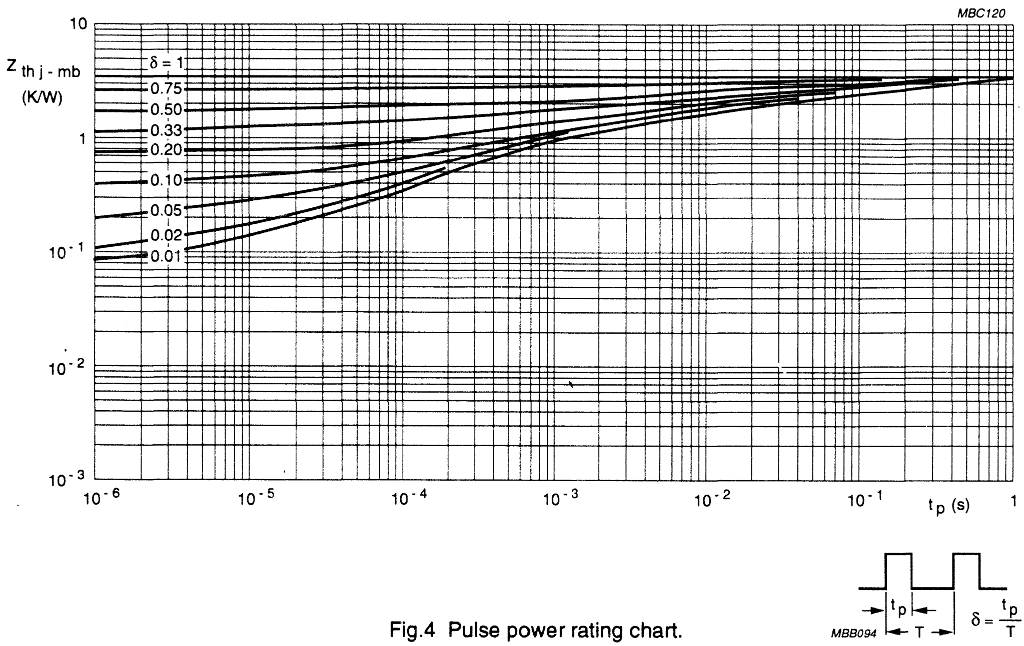
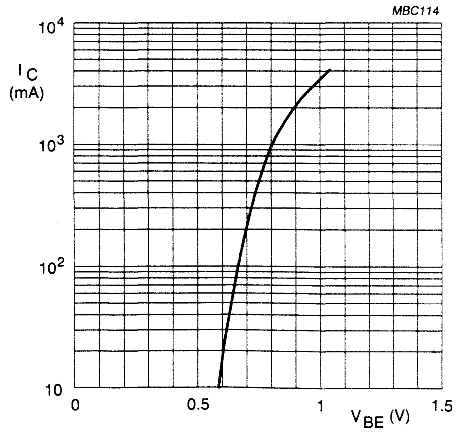
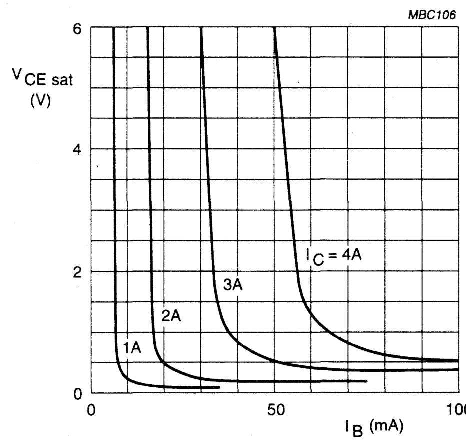


Fig.4 Pulse power rating chart.



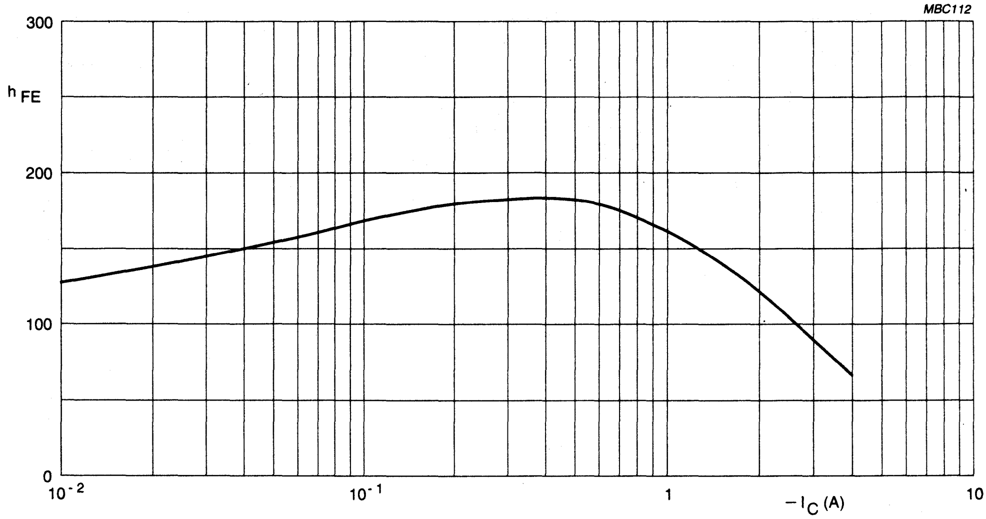
V_{CE} = 1 V; T_j = 25 °C.

Fig.5 Base-emitter voltage as a function of collector current.



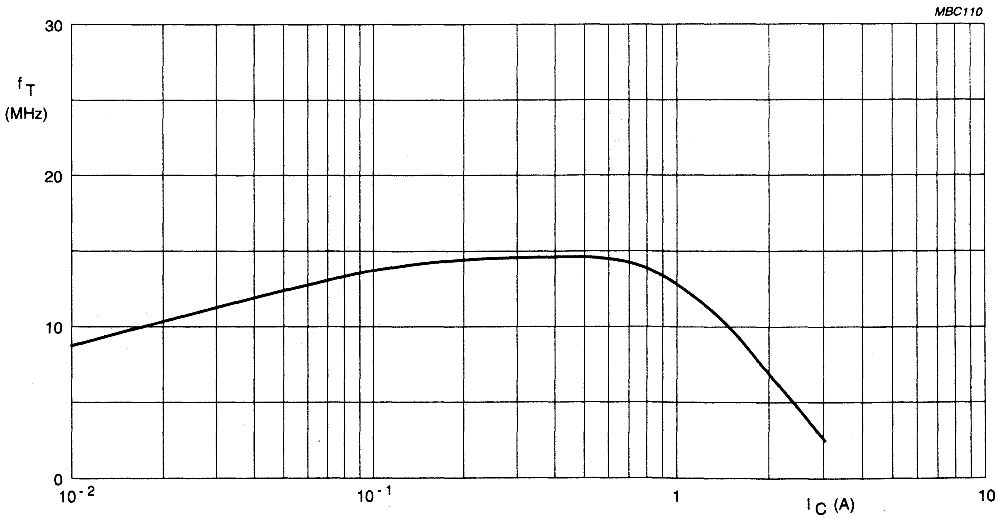
T_j = 25 °C.

Fig.6 Typical values collector-emitter saturation voltage.



V_{CE} = 1 V; T_j = 25 °C.

Fig.7 Typical values DC current gain.



f = 1 MHz; V_{CE} = 1 V; T_j = 25 °C.

Fig.8 Transition frequency.

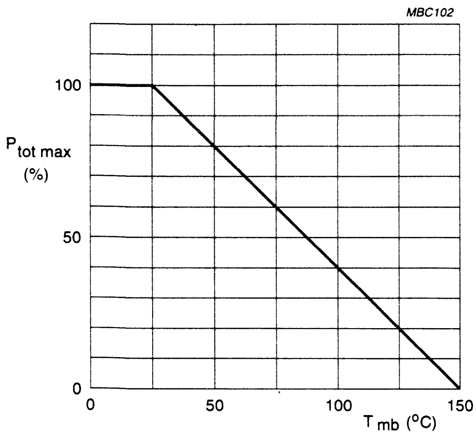
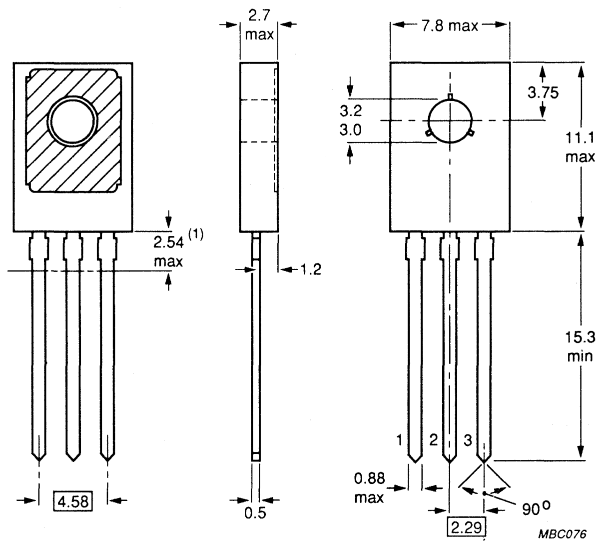


Fig.9 Power derating curve.

PACKAGE OUTLINE



Dimensions in mm

Collector connected to metal part of mounting surface

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

Fig.10 TO-126 (SOT32).

Silicon epitaxial-base transistors BD434/436/438/440/442

DESCRIPTION

PNP transistors in a TO-126 (SOT32) plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W. The complementary pairs are BD433, BD435, BD437, BD439 and BD441 respectively.

PINNING - TO-126 (SOT32)

PIN	DESCRIPTION
1	emitter
2	collector
3	base

Collector connected to metal part of mounting surface.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CES}$	collector-emitter voltage	$-V_{BE} = 0$			
	BD434		–	22	V
	BD436		–	32	V
	BD438		–	45	V
	BD440		–	60	V
	BD442		–	80	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BD434		–	22	V
	BD436		–	32	V
	BD438		–	45	V
	BD440		–	60	V
	BD442		–	80	V
$-I_C$	collector current	average value	–	4	A
$-I_{CM}$	collector current	peak value	–	7	A
P_{tot}	total power dissipation	$T_{mb} = 25$ °C	–	36	W
h_{FE}	DC current gain	$-I_C = 2$ A; $-V_{CE} = 1$ V			
	BD434		50	–	
	BD436		50	–	
	BD438		40	–	
	BD440		25	–	
	BD442		15	–	
f_T	transition frequency	$-I_C = 250$ mA; $-V_{CE} = 1$ V	7	–	MHz

PIN CONFIGURATION

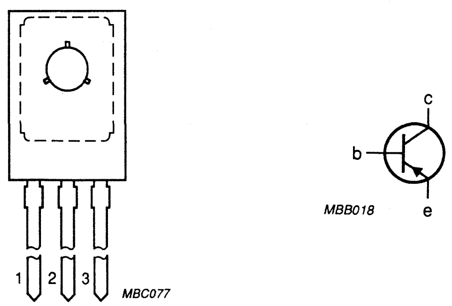


Fig.1 Simplified outline and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BD434		–	22	V
	BD436		–	32	V
	BD438		–	45	V
	BD440		–	60	V
	BD442		–	80	V
$-V_{CES}$	collector-emitter voltage	$-V_{BE} = 0$			
	BD434		–	22	V
	BD436		–	32	V
	BD438		–	45	V
	BD440		–	60	V
	BD442		–	80	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BD434		–	22	V
	BD436		–	32	V
	BD438		–	45	V
	BD440		–	60	V
	BD442		–	80	V
$-V_{EBO}$	emitter-base voltage	open collector	–	5	V
$-I_C$	collector current	average value	–	4	A
$-I_{CM}$	collector current	peak value	–	7	A
$-I_B$	base current	T_{mb} = 25 °C	–	1	A
P_{tot}	total power dissipation	T_{mb} = 25 °C	–	36	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		–	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}mb}$	from junction to mounting base		3.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	in free air	100	K/W

CHARACTERISTICS

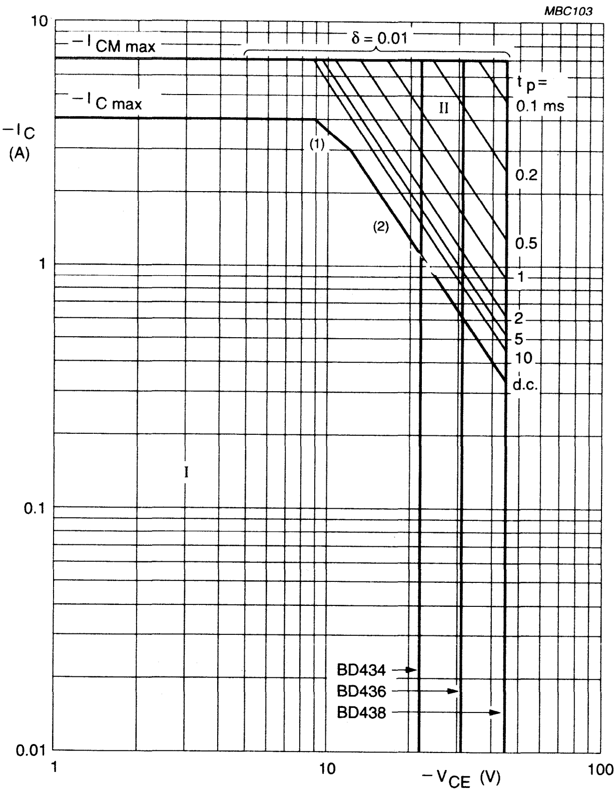
T_j = 25 °C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CBO}$	collector cut off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	–	–	50	μA
		$I_E = 0$; $-V_{CB} = 10$ V; $T_j = 150$ °C	–	–	1	mA
		$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$ $T_j = 150$ °C	–	–	1	mA
$-I_{EBO}$	emitter cut off current	$I_C = 0$; $-V_{EB} = 5$ V	–	–	0.2	mA
$-V_{CEK}$	knee voltage	$-I_C = 2$ A; $-I_B$ = value for which $-I_C = 2.2$ A at $-V_{CE} = 1$ V				
	BD434, BD436, BD438		–	–	0.8	V
$-V_{BE}$	base-emitter voltage	$-I_C = 10$ mA; $-V_{CE} = 5$ V; note 1	–	580	–	mV
		$-I_C = 2$ A; $-V_{CE} = 1$ V; note 1				
	BD434, BD436		–	–	1.1	V
	BD440, BD442		–	–	1.5	V
		$-I_C = 3$ A; $-V_{CE} = 1$ V; note 1				
	BD438		–	–	1.3	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 2$ A; $-I_B = 0.2$ A				
	BD434, BD436		–	–	0.5	V
	BD440, BD442		–	–	0.8	V
		$-I_C = 3$ A; $-I_B = 0.3$ A				
	BD438		–	–	0.7	V

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
h_{FE}	DC current gain	$-I_C = 10$ mA; $-V_{CB} = 5$ V				
	BD434		25	–	–	
	BD436		25	–	–	
	BD438		25	–	–	
	BD440		20	–	–	
	BD442		15	–	–	
		$-I_C = 500$ mA; $-V_{CB} = 1$ V				
	BD434		85	–	475	
	BD436		85	–	475	
	BD438		85	–	375	
	BD440		40	–	–	
	BD442		40	–	–	
		$-I_C = 2$ A; $-V_{CB} = 1$ V				
	BD434		50	–	–	
	BD436		50	–	–	
	BD438		40	–	–	
	BD440		25	–	–	
	BD442		15	–	–	
		$-I_C = 3$ A; $-V_{CB} = 1$ V				
	BD438		30	–	–	
f_T	transition frequency	at f = 1 MHz; $-I_C = 250$ mA; $-V_{CE} = 1$ V	7	–	–	MHz
h_{FE1} / h_{FE2}	DC current gain ratio of the complementary pairs	$-I_C = 500$ mA; $-V_{CB} = 1$ V				
	BD433/BD434		–	–	1.4	
	BD435/BD436		–	–	1.4	
	BD437/BD438		–	–	1.8	
	BD439/BD440		–	–	1.4	
	BD441/BD442		–	–	1.4	

Note

1. V_{BE} decreases by typ. 2.3 mV/K with increasing temperature.



BD434, BD436, BD438

T_{mb} = 25 °C

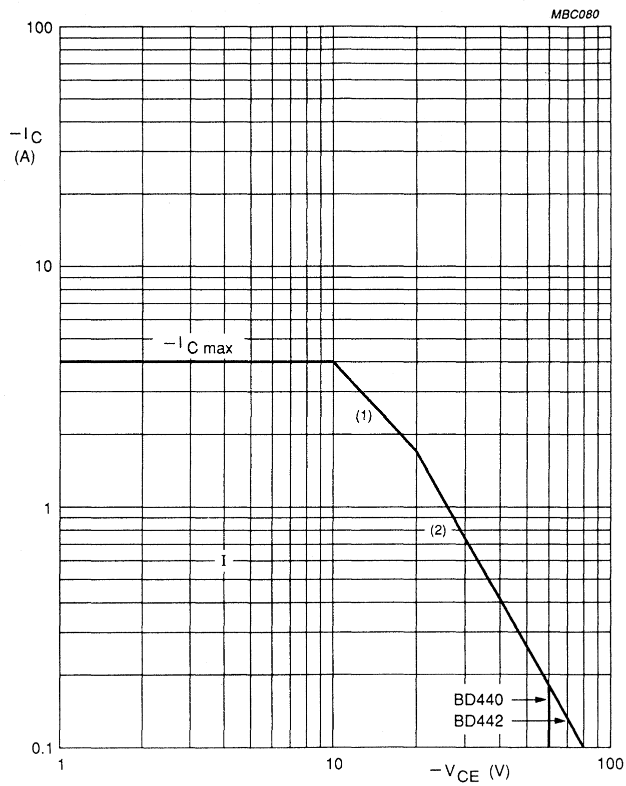
I Region of permissible DC operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

Fig.2 Safe operating area.



BD440, BD442

$T_{mb} = 25\ °C$

I Region of permissible DC operation.

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

(2) Second breakdown limits.

Fig.3 Safe operating area.

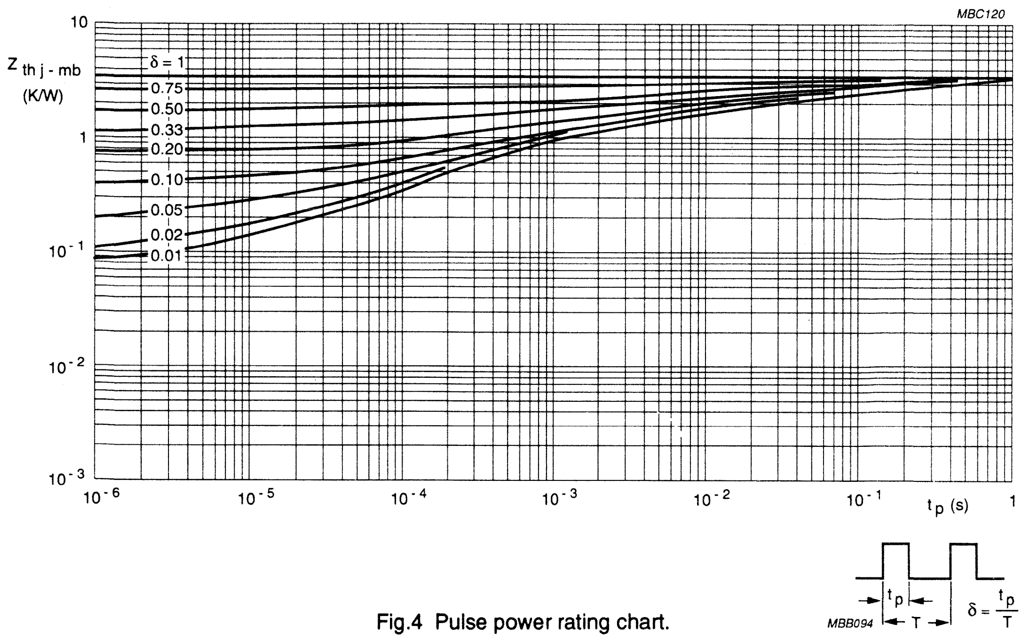
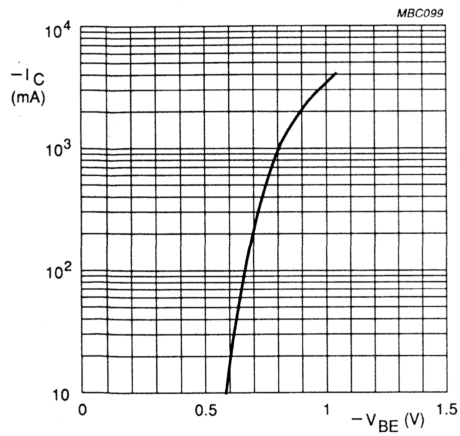
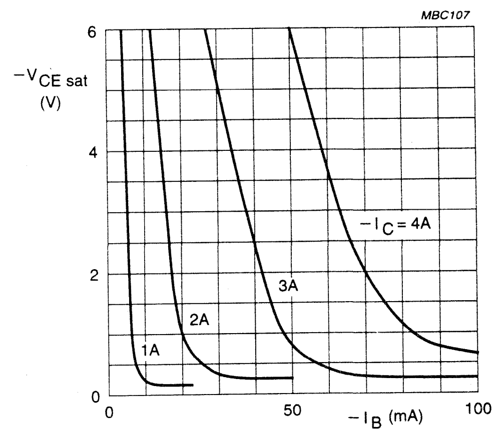


Fig.4 Pulse power rating chart.



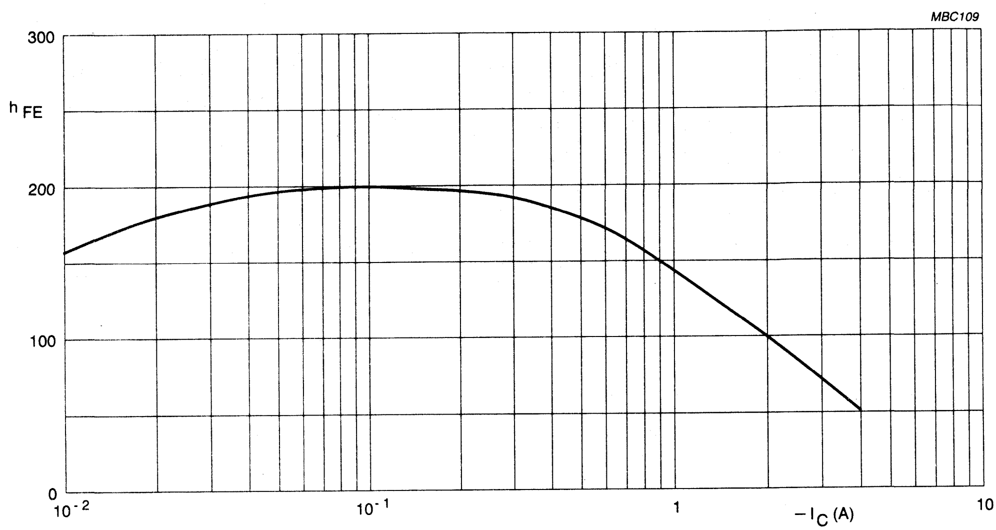
$-V_{CE} = 1$ V; $T_j = 25$ °C.

Fig.5 Base-emitter voltage as a function of collector current.



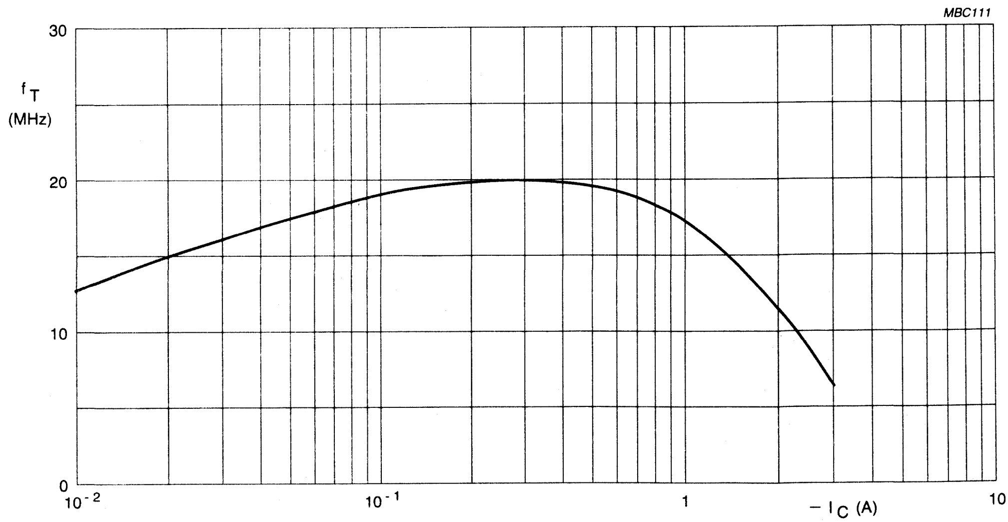
$T_j = 25$ °C

Fig.6 Typical values collector-emitter saturation voltage.



$-V_{CE} = 1$ V; $T_j = 25$ °C.

Fig.7 Typical values DC current gain.



f = 1 MHz; $-V_{CE} = 1$ V; $T_j = 25$ °C.

Fig.8 Transition frequency.

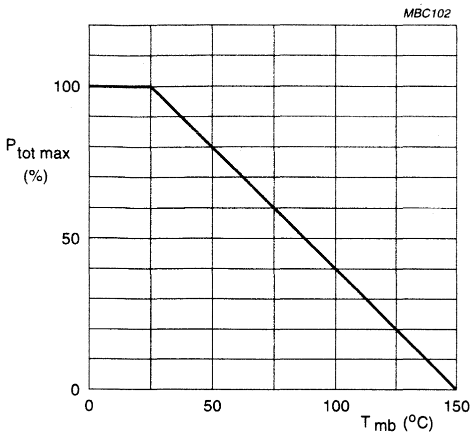
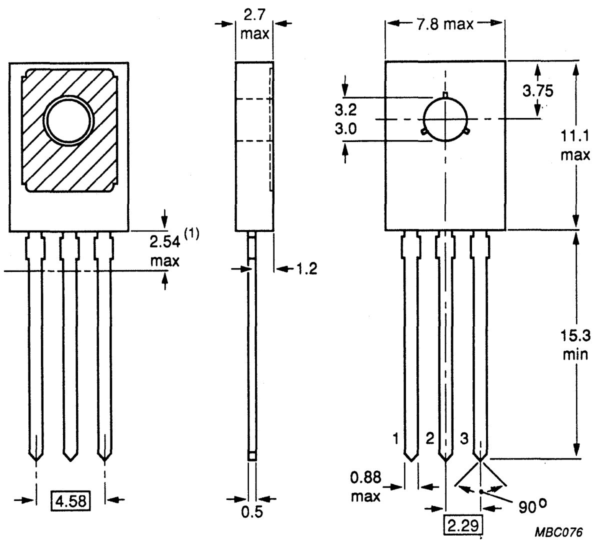


Fig.9 Power derating curve.

PACKAGE OUTLINE



Dimensions in mm

Collector connected to metal part of mounting surface

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

Fig.10 TO-126 (SOT32).

SILICON DARLINGTON POWER TRANSISTORS

NPN epitaxial-base transistors in a monolithic Darlington circuit and housed in a TO-220 envelope. They are intended for output stages in audio equipment, general amplifiers, and analogue switching applications.

PNP complements are BD644, BD646, BD648, BD650 and BD652.

QUICK REFERENCE DATA

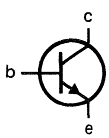
			BD643	645	647	649	651	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Collector current DC	I_C	max.			8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			62.5			W
Junction temperature	T_j	max.			150			°C
DC current gain I_C = 3 A; V_{CE} = 3 V	h_{FE}	min.	–	750	750	750	750	
I_C = 4 A; V_{CE} = 3 V	h_{FE}	min.	750	–	–	–	–	

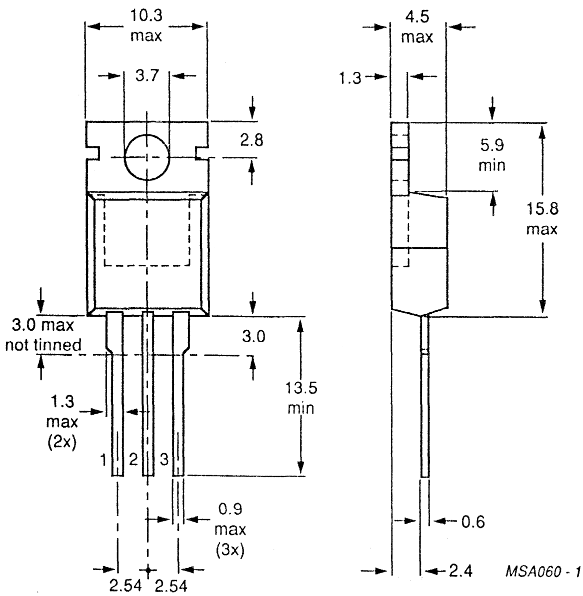
MECHANICAL DATA

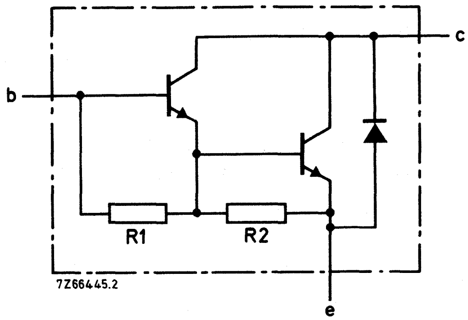
Dimensions in mm

Fig. 1 TO-220.

Pinning
1 = Base
2 = Collector
3 = Emitter







R1 typ. 4 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD643	645	647	649	651	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current DC	I_C	max.			8			A
peak value	I_{CM}	max.			12			A
Base current (DC)	I_B	max.			150			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			62.5			W
Storage temperature range	T_{stg}				−65 to + 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\,j\text{-}mb}$	max.	2.0	K/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	max.	70	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 currents				
$I_E = 0$; $V_{CB} = V_{CEO\,max}$	I_{CBO}	max.	0.1	mA
$I_E = 0$; $V_{CB} = ½ V_{CBO\,max}$; T_j = 150 °C	I_{CBO}	max.	1	mA
$I_E = 0$; $V_{CE} = ½ V_{CEO\,max}$	I_{CEO}	max.	0.2	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	max.	5	mA

			BD643	645	647	649	651	
DC current gain (see note 1)								
I_C = 0.5 A; V_{CE} = 3 V	h_{FE}	typ.	1900	1900	1900	1900	1900	
I_C = 4 A; V_{CE} = 3 V	h_{FE}	min.	750	–	–	–	–	
I_C = 3 A; V_{CE} = 3 V		min.	–	750	750	750	750	
I_C = 8 A; V_{CE} = 3 V	h_{FE}	typ.	1800	1800	1800	1800	1800	
Base-emitter voltage (see notes 1 and 2)								
I_C = 4 A; V_{CE} = 3 V	V_{BE}	max.	2.5	–	–	–	–	V
I_C = 3 A; V_{CE} = 3 V		max.	–	2.5	2.5	2.5	2.5	V
Saturation voltages (1)								
I_C = 4 A; I_B = 16 mA	V_{CEsat}	max.	2	–	–	–	–	V
I_C = 3 A; I_B = 12 mA		max.	–	2	2	2	2	V
I_C = 5 A; I_B = 50 mA	V_{CEsat}	max.	2.5	2.5	2.5	2.5	2.5	V
I_C = 5 A; I_B = 50 mA	V_{BEsat}	max.	3	3	3	3	3	V
Small signal current gain								
I_C = 4 A; V_{CE} = 3 V; f = 1 MHz	h_{fe}	min.	10	–	–	–	–	
I_C = 3 A; V_{CE} = 3 V; f = 1 MHz		min.	–	10	10	10	10	
Cut-off frequency								
I_C = 4 A; V_{CE} = 3 V	f_{hfe}	typ.	50	–	–	–	–	
I_C = 3 A; V_{CE} = 3 V		typ.	–	50	50	50	50	kHz
Second-breakdown collector current t_p = 0.1 s; non-repetitive, without heatsink								
V_{CE} = 50 V	$I_{(SB)}$	min.	1.25	–	–	–	–	A
V_{CE} = 60 V		min.	–	1.04	1.04	1.04	1.04	A
DC current gain ratio of matched pairs at V_{CE} = 3 V								
I_C = 4 A BD643/BD644	h_{FE1}/h_{FE2}	max.	2.5	–	–	–	–	
I_C = 3 A BD645/BD646		max.	–	2.5	2.5	2.5	2.5	

Diode forward voltage				
I_F = 3 A	V_F	typ.	0.9	V
Collector capacitance at f = 1 MHz				
V_{CB} = 10 V	C_c	typ.	75	pF
Turn-off breakdown energy with inductive load; I_C = 4.5 A (see Fig. 3)	$E_{(BR)}$	min.	50	mJ

(1) Measured under pulse conditions: t_p = 300 μs, $\delta \leqslant 2\%$.
(2) V_{BE} decreases by about 3.8 mV/K with increasing temperature.

Switching times (see Figs 4 and 5)

$I_C = 3$ A; $I_{Bon} = -I_{Boff} = 12$ mA

turn-on time	t_{on}	typ.	1.0 μs
		max.	2.0 μs
turn-off time	t_{off}	typ.	5.0 μs
		max.	10 μs

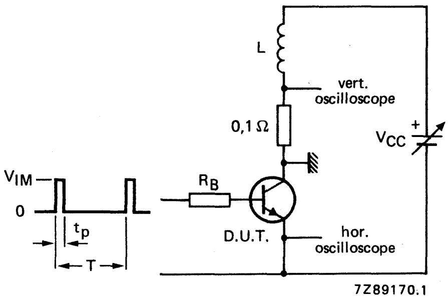


Fig. 3 Test circuit for turn-off breakdown energy; $V_{IM} = 12$ V; $R_B = 270$; $I_C = 4.5$ A; $t_p = 1$ ms; $\delta = 1\%$.

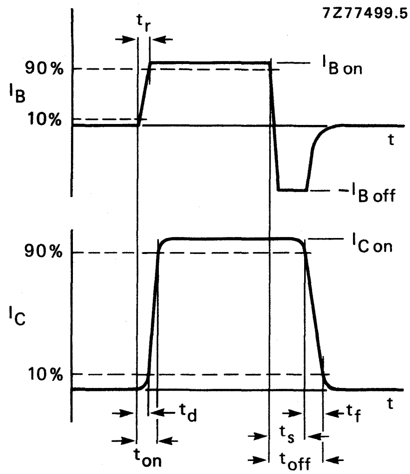
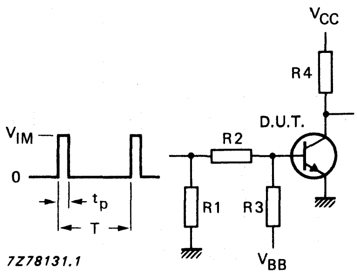


Fig. 4 Switching times waveforms.



V_{CC}	=	10 V
V_{IM}	=	10 V
$-V_{BB}$	=	4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 5 Switching times test circuit.

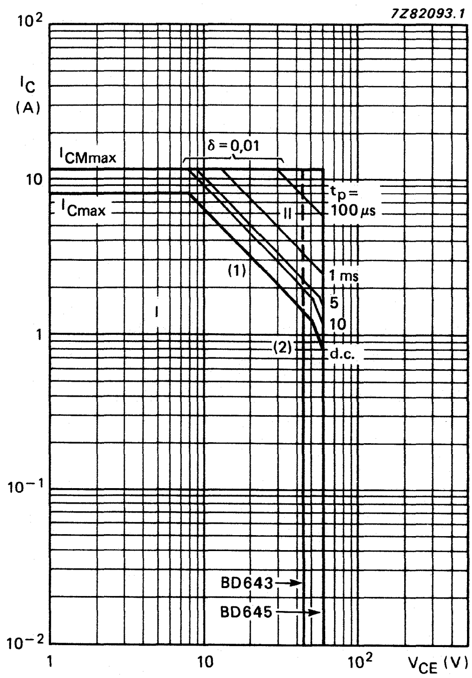


Fig. 6 **BD643; BD645** Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

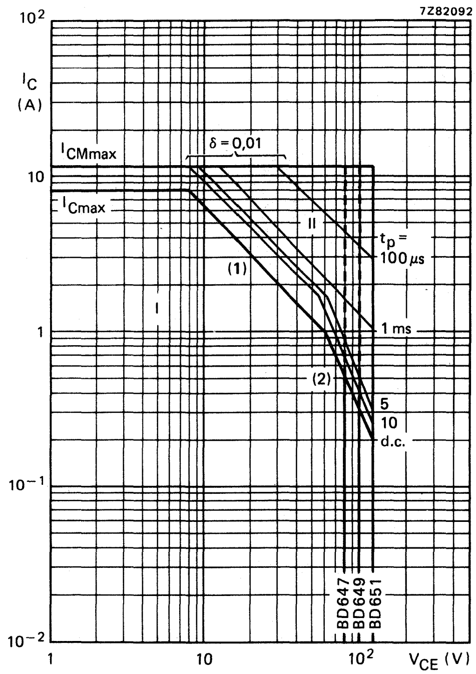


Fig. 7 **BD647, BD649, BD651** Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

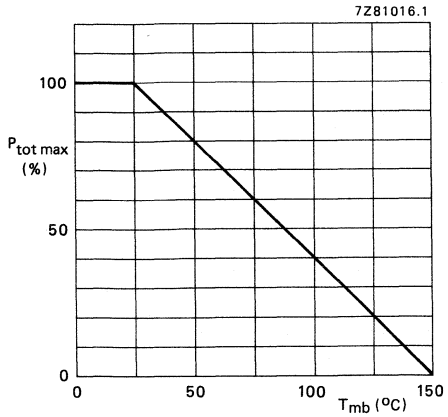


Fig. 8 Power derating curve.

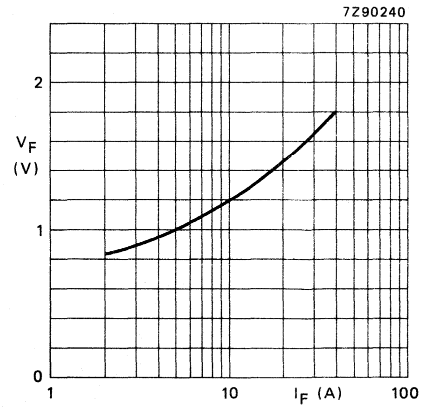


Fig. 9 Diode forward voltage versus forward current; T_j = 25 °C; typical values.

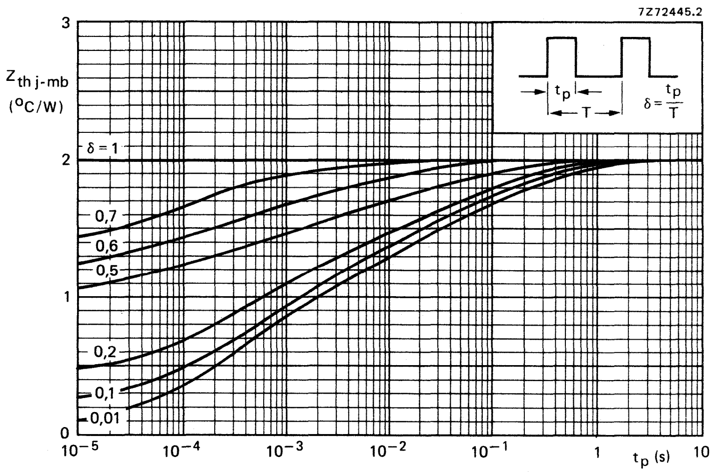


Fig. 10 Pulse power rating chart.

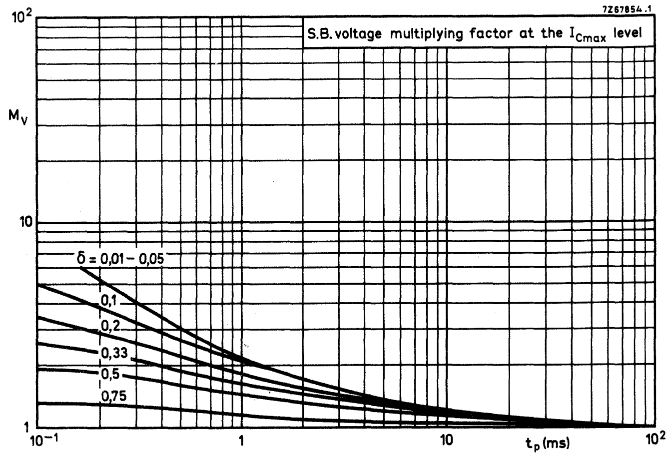


Fig. 11 Second breakdown voltage multiplying factor at the $I_{C\,max}$ level.

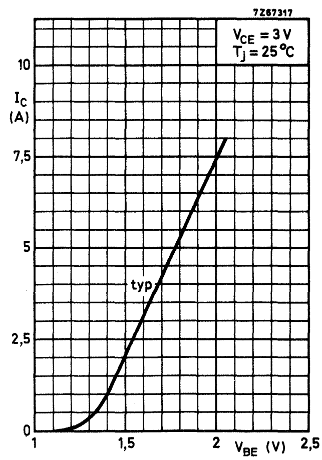


Fig. 12 Collector current as a function of base-emitter voltage; V_{CE} = 3 V; T_j = 25 °C; typical values.

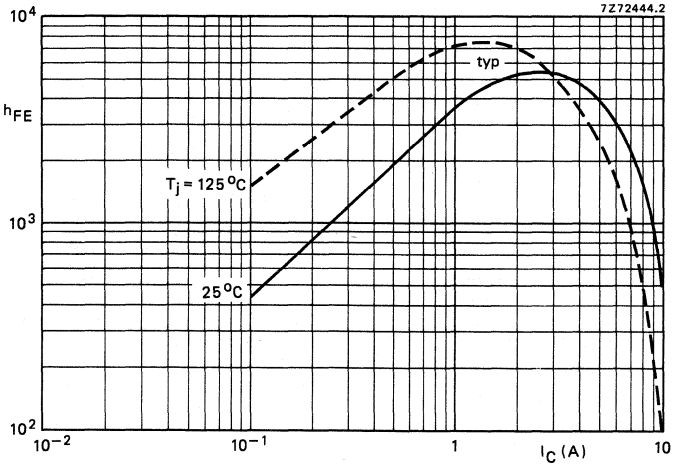


Fig. 13 DC current gain; V_{CE} = 3 V; typical values.

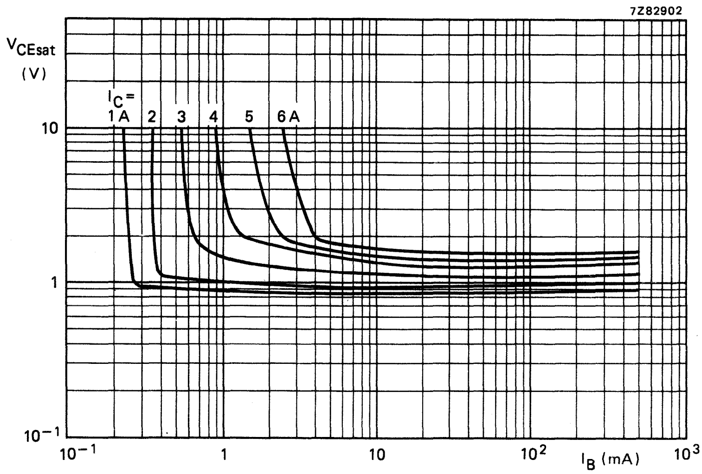


Fig. 14 Collector-emitter saturation voltage; T_j = 25 °C; typical values.

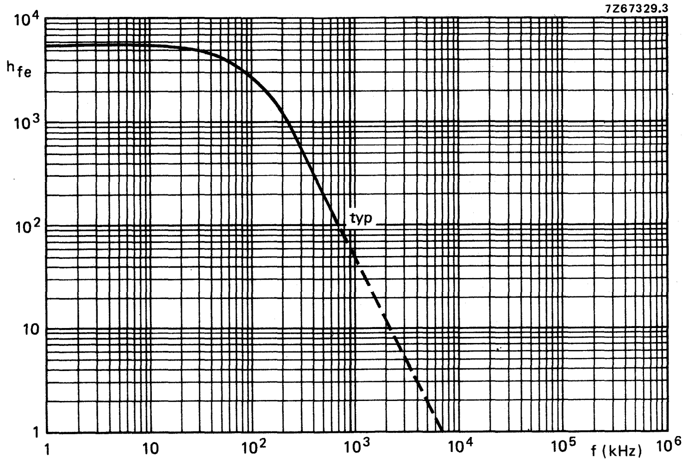


Fig. 15 Small signal current gain; I_C = 3 A; V_{CE} = 3 V; typical values.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon Darlington transistors in a SOT186 envelope with an electrically insulated mounting base.
PNP complements are BD644F, BD646F, BD648F, BD650F and BD652F.

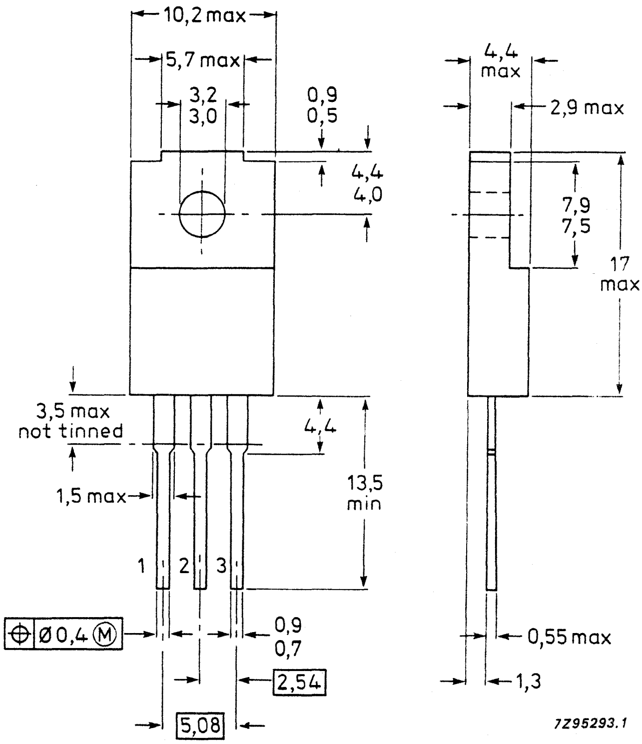
QUICK REFERENCE DATA

			BD643F	645F	647F	649F	651F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Collector current (DC)	I_C	max.			8			A
Total power dissipation at $T_h \leqslant 25\ ^oC$	P_{tot}	max.			20			W
Junction temperature	T_j	max.			150			^oC

MECHANICAL DATA

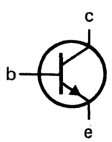
Dimensions in mm

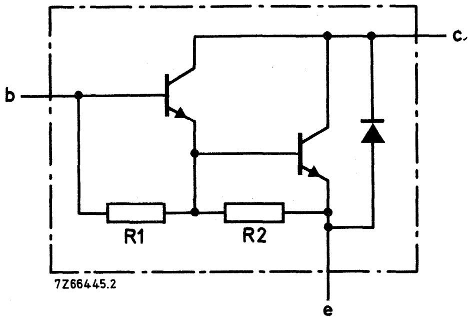
Fig.1 SOT186.



Pinning

1 = base
2 = collector
3 = emitter





R1 typ. 4 kΩ
R2 typ. 100 kΩ

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD643F	645F	647F	649F	651F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current (DC)	I_C	max.			8			A
(peak value)	I_{CM}	max.			12			A
Base current (DC)	I_B	max.			150			mA
Total power dissipation at $T_h \leq 25$ °C (note 1)	P_{tot}	max.			20			W
at $T_h \leq 25$ °C (note 2)	P_{tot}	max.			32			W
Storage temperature range	T_{stg}				−65 to + 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\text{-}jmb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{th}	max.	12	pF

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

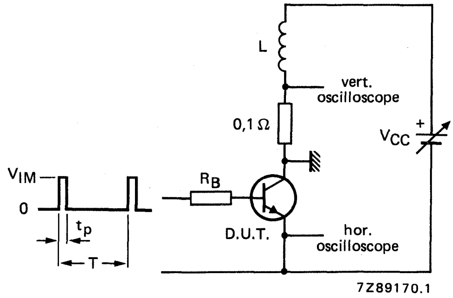
Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	max.	0.1	mA
$I_E = 0$; $V_{CB} = 1/2\ V_{CBOmax}$; $T_j = 150$ °C	I_{CBO}	max.	1	mA
$I_B = 0$; $V_{CE} = 1/2\ V_{CEOmax}$	I_{CEO}	max.	0.2	mA
Emitter cut-off current				
$V_{BE} = 5$ V; $I_C = 0$	I_{EBO}	max.	5	mA

			BD643F	645F	647F	649F	651F	
Static forward current transfer ratio (note 1)								
$I_C = 0.5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1900	1900	1900	1900	1900	
$I_C = 4$ A; $V_{CE} = 3$ V	h_{FE}	min.	750	—	—	—	—	
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	min.	—	750	750	750	750	
$I_C = 8$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1800	1800	1800	1800	1800	
Collector-emitter saturation voltage (note 1)								
$I_C = 4$ A; $I_B = 16$ mA	V_{CEsat}	max.	2	—	—	—	—	V
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	max.	—	2	2	2	2	V
$I_C = 5$ A; $I_B = 50$ mA	V_{CEsat}	max.	2.5	2.5	2.5	2.5	2.5	V
Base-emitter saturation voltage (note 1)								
$I_C = 5$ A; $I_B = 50$ mA	V_{BEsat}	max.	3	3	3	3	3	V
Base-emitter voltage (note 1)								
$I_C = 4$ A; $V_{CE} = 3$ V	V_{BE}	max.	2.5	—	—	—	—	V
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	max.	—	2.5	2.5	2.5	2.5	V
Common-emitter cut-off frequency								
$I_C = 4$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50	—	—	—	—	kHz
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	—	50	50	50	50	kHz
Small signal current gain								
$I_C = 4$ A; $V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	10	—	—	—	—	
$I_C = 3$ A; $V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	—	10	10	10	10	

Forward bias second breakdown collector current				
$V_{CE} = 50$ V; $t_p = 0.1$ s	$I_{(SB)}$	min.	0.55	A
Forward voltage				
$I_F = 3$ A	V_F	typ.	0.9	V
Switching times				
$I_C = 3$ A; $I_{B\,on} = I_{B\,off} = 12$ mA				
Turn on time	t_{on}	max.	2	μs
		typ.	1	μs
Turn off time	t_{off}	max.	10	μs
		typ.	5	μs

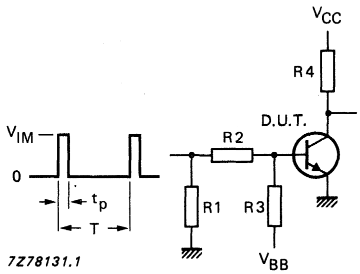
Note

1. To be measured under pulsed conditions, $t_p < 300$ μs; $\delta < 2\%$.



V_{IM} = 12 V
R_B = 270 Ω
L = 5 mH
I_{CC} = 4.5 A
δ = $t_p/T \times 100\%$

Fig. 3 Test circuit for turn-off breakdown energy.



V_{IM} = 10 V
V_{CC} = 10 V
$-V_{BB}$ = 4 V
R_1 = 56 Ω
R_2 = 410 Ω
R_3 = 560 Ω
R_4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

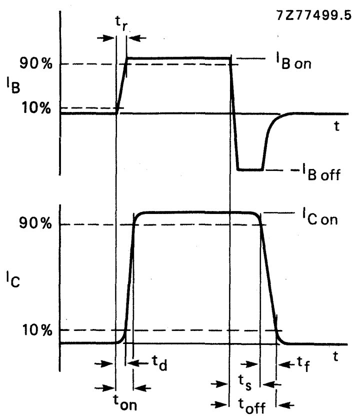
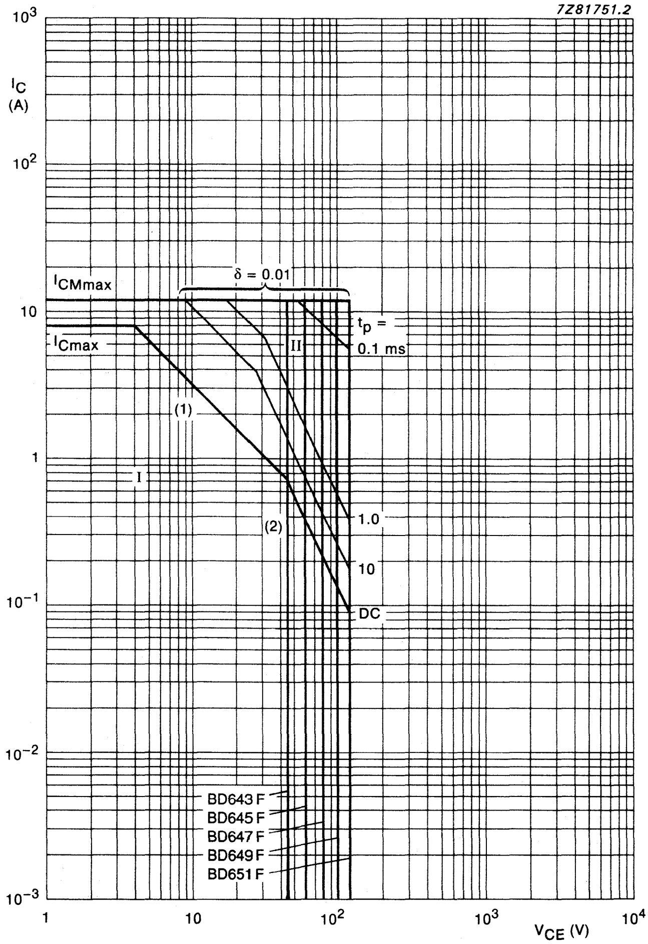


Fig. 5 Switching times waveforms.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and P_{peak} lines.
(2) Second-breakdown limits.

Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

Fig.6 Safe Operating Area; T_{amb} = 25 °C.

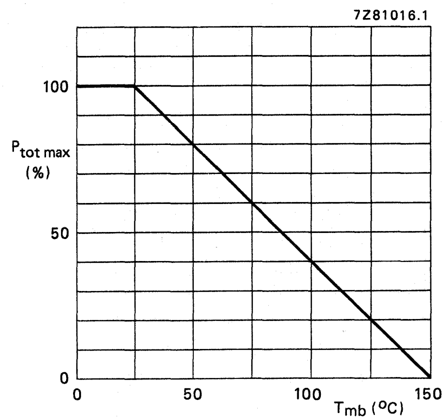


Fig. 7 Power derating curve.

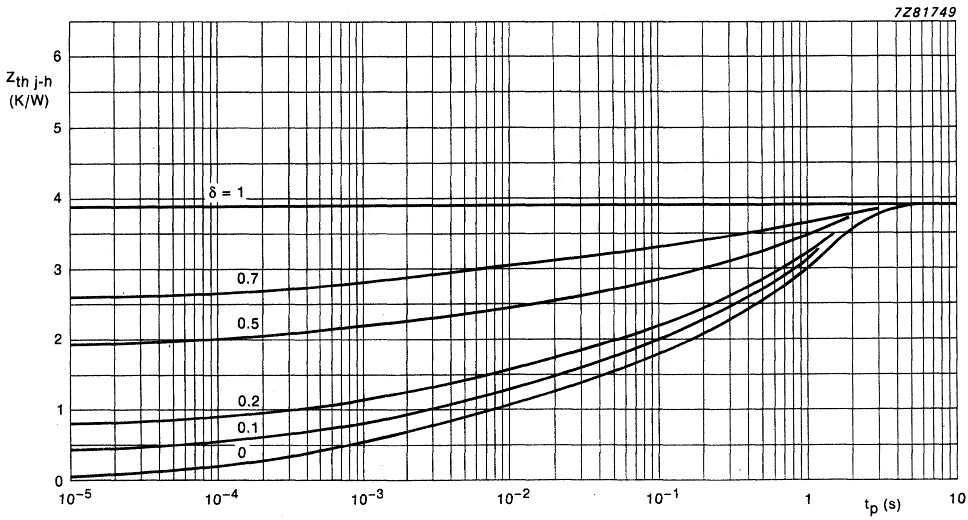


Fig. 8 Pulse power rating chart.

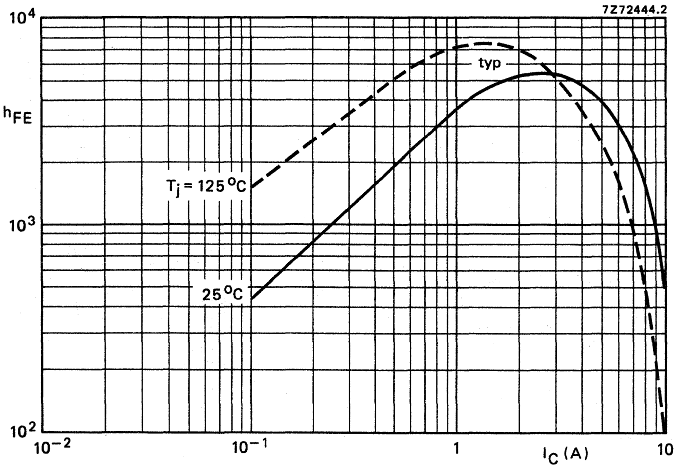


Fig. 9 Typical DC current gain curves; $V_{CE} = 3$ V.

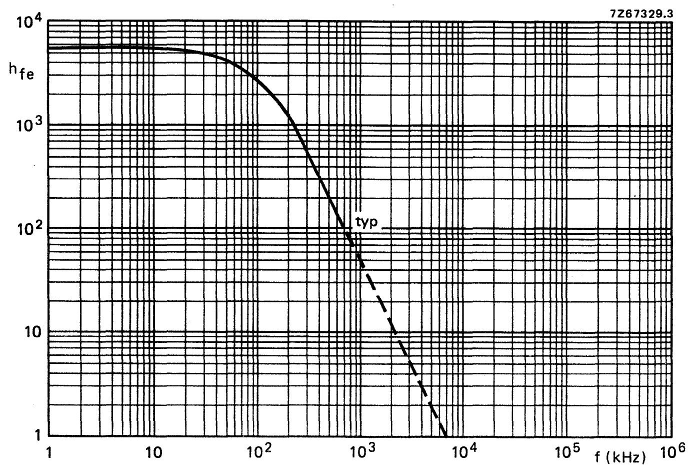


Fig. 10 Small signal current gain.

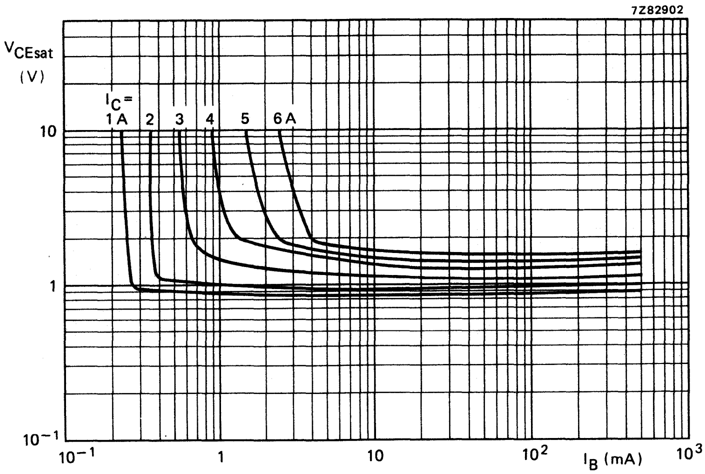


Fig. 11 Typical collector-emitter saturation voltage; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

PNP epitaxial-base transistors in a monolithic Darlington circuit. They are housed in a TO-220 envelope and intended for applications such as audio output stages, switching, and general amplifiers.

The NPN complements are BD643, BD645, BD647, BD649 and BD651.

QUICK REFERENCE DATA

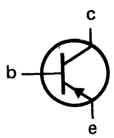
			BD644	646	648	650	652	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector current (DC)	$-I_C$	max.			8			A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.			62.5			W
Junction temperature	T_j	max.			150			°C
DC current gain $-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	min.	–	750	750	750	750	
$-I_C$ = 4 A; $-V_{CE}$ = 3 V		min.	750	–	–	–	–	

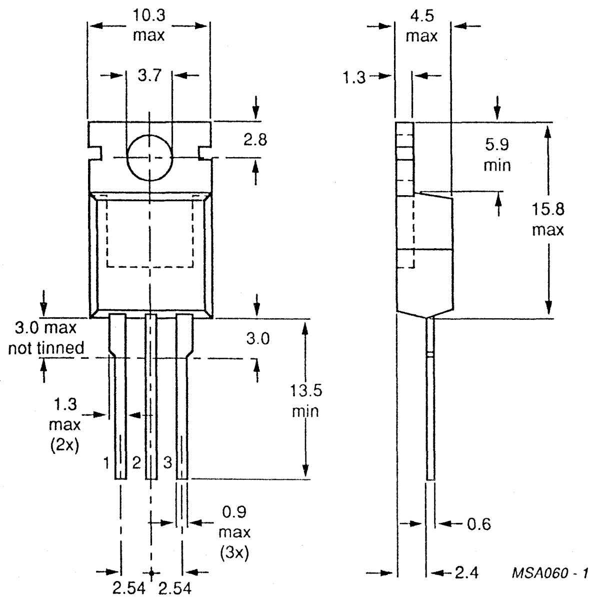
MECHANICAL DATA

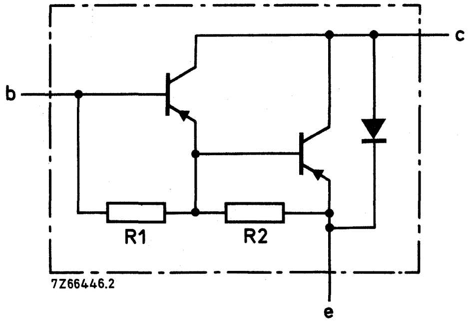
Dimensions in mm

Fig. 1 TO-220.

Pinning
1 = base
2 = collector
3 = emitter







R1 typ. 4 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD644	646	648	650	652	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
Collector current (DC)	$-I_C$	max.			8			A
Collector current (peak value)	$-I_{CM}$	max.			12			A
Base current (DC)	$-I_B$	max.			150			mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.			62.5			W
Storage temperature range	T_{stg}				−65 to +150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	2	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	max.	70	K/W

* Based on maximum junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents				
$-I_E = 0$; $-V_{CB} = -V_{CEO}$ max.	$-I_{CBO}$	max.	0.1	mA
$-I_E = 0$; $-V_{CB} = -1/2\ V_{CBO}$ max. T_j = 150 °C	$-I_{CBO}$	max.	1	mA
$-I_E = 0$; $-V_{CE} = -1/2\ V_{CEO}$ max.	$-I_{CEO}$	max.	0.2	mA
Emitter cut-off current				
$-I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	max.	5	mA

			BD644	646	648	650	652	
DC current gain (see note 1)								
$-I_C = 0.5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2700	2700	2700	2700	2700	
$-I_C = 4$ A; $-V_{CE} = 3$ V	h_{FE}	min.	750	–	–	–	–	
$-I_C = 3$ A; $-V_{CE} = 3$V	h_{FE}	min.	–	750	750	750	750	
$-I_C = 8$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	200	200	200	200	200	
Base-emitter voltage (see notes 1 and 2)								
$-I_C = 4$ A; $-V_{CE} = 3$ V	$-V_{BE}$	max.	2.5	–	–	–	–	V
$-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	max.	–	2.5	2.5	2.5	2.5	V
Saturation voltages (see note 1)								
$-I_C = 4$ A; $-I_B = 16$ mA	$-V_{CEsat}$	max.	2	–	–	–	–	V
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	max.	–	2	2	2	2	V
$-I_C = 5$ A; $-I_B = 50$ mA	$-V_{CEsat}$	max.	2.5	2.5	2.5	2.5	2.5	V
$-I_C = 5$ A; $-I_B = 50$ mA	$-V_{BEsat}$	max.	3	3	3	3	3	V
Small signal current gain; f = 1 MHz								
$-I_C = 4$ A; $-V_{CE} = 3$ V	h_{fe}	min.	10	–	–	–	–	
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{fe}	min.	–	10	10	10	10	
Cut-off frequency								
$-I_C = 4$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	100	–	–	–	–	kHz
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	–	100	100	100	100	kHz
Second-breakdown collector current $t_p = 0.1$ s; non-repetitive; without heatsink								
$-V_{CE} = 50$ V	$-I_{(SB)}$	min.	1.25	–	–	–	–	A
$-V_{CE} = 60$ V	$-I_{(SB)}$	min.	–	1.04	1.04	1.04	1.04	A
DC current gain ratio of matched pairs at $-V_{CE} = 3$ V								
$-I_C = 4$ A BD644/BD643	h_{FE1}/h_{FE2}	max.	2.5	–	–	–	–	
$-I_C = 3$A BD652/BD651	h_{FE1}/h_{FE2}	max.	–	2.5	2.5	2.5	2.5	

Diode forward voltage; $-I_F = 3$ A	$-V_F$	typ.	1.6	V
Collector capacitance at f = 1 MHz				
$-V_{CB} = 10$ V	C_c	typ.	75	pF

1. Measured under pulse conditions: $t_p = 300\ \mu s$, $\delta \leqslant 2\%$.
2. V_{BE} decreases by about 3.8 mV/K with increasing temperature.

Switching times (see Figs 3 and 4)
$-I_C = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA

turn-on time	t_{on}	typ.	1	μs
turn-off time	t_{off}	typ.	5	μs

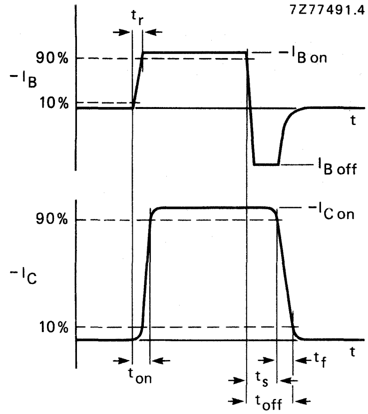
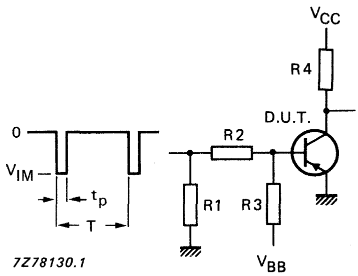


Fig. 3 Switching times waveforms.



$-V_{CC} = 10$ V
$-V_{IM} = 10$ V
$V_{BB} = 4$ V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f = 15$ ns
$t_p = 10$ μs
T = 500 μs

Fig. 4 Switching times test circuit.

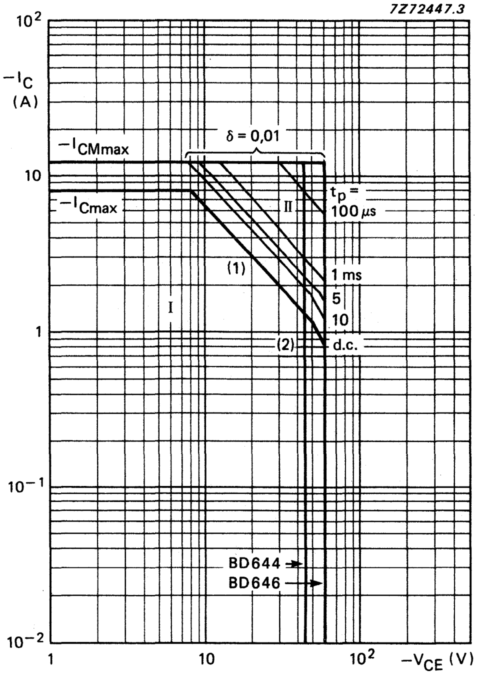


Fig. 5 **BD644; BD646** Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines
(2) Second-breakdown limits.

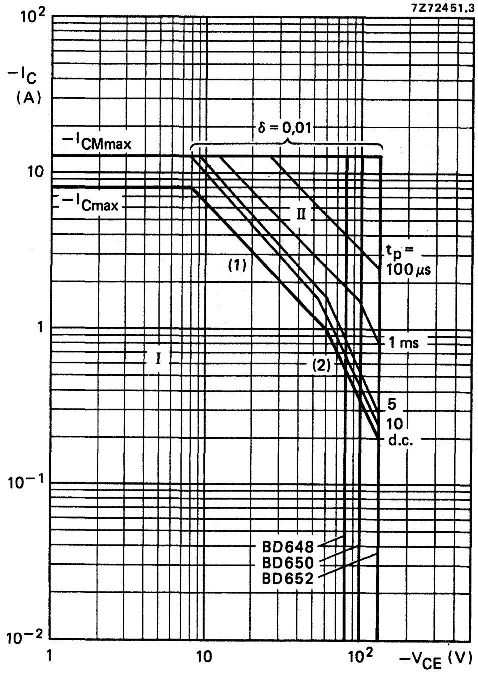


Fig. 6 **BD648, BD650, BD652** Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines
(2) Second-breakdown limits.

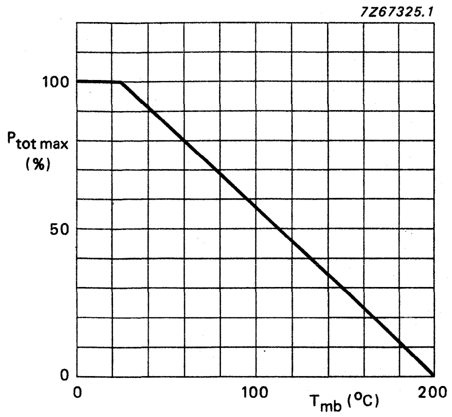


Fig. 7 Power derating curve.

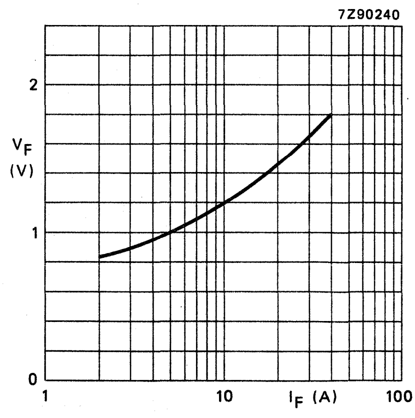


Fig. 8 Diode forward voltage versus forward current; T_j = 25 °C; typical values.

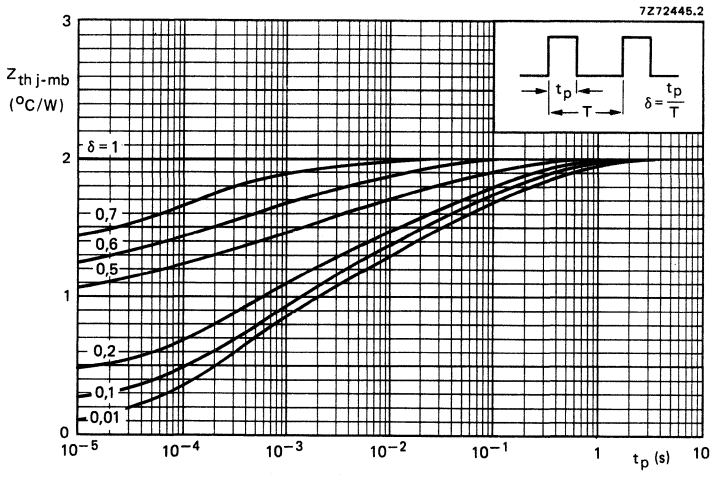


Fig. 9 Pulse power rating chart.

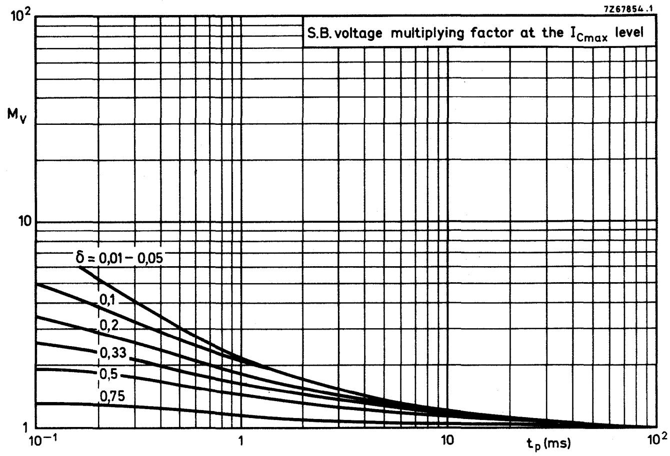


Fig. 10 Second breakdown voltage multiplying factor at the I_{Cmax} level.

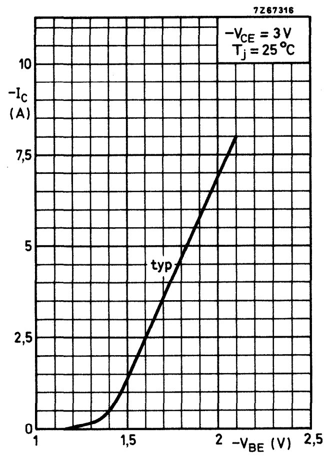


Fig. 11 Collector current versus base-emitter voltage; $-V_{CE}$ = 3 V; T_j = 25 °C; typical value.

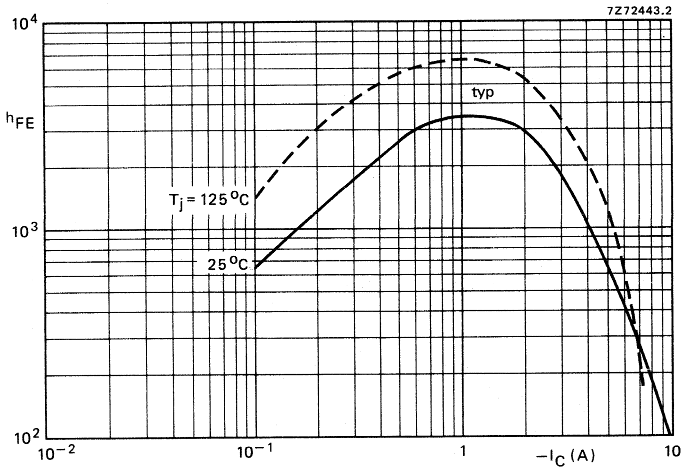


Fig. 12 DC current gain; $-V_{CE}$ = 3 V; typical values.

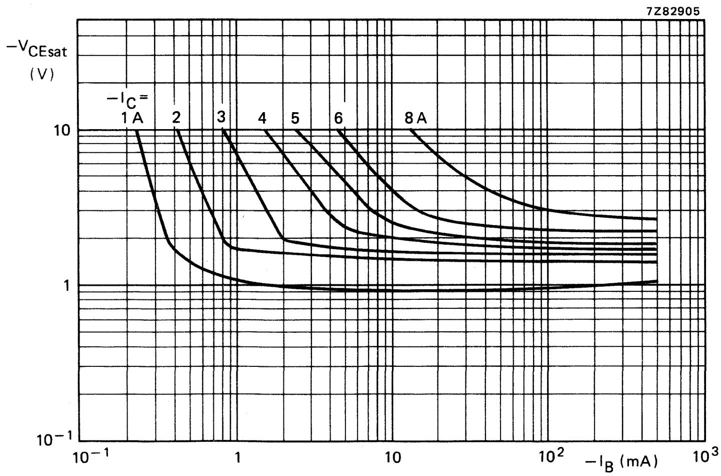


Fig. 13 Collector-emitter saturation voltage; T_j = 25 °C; typical values.

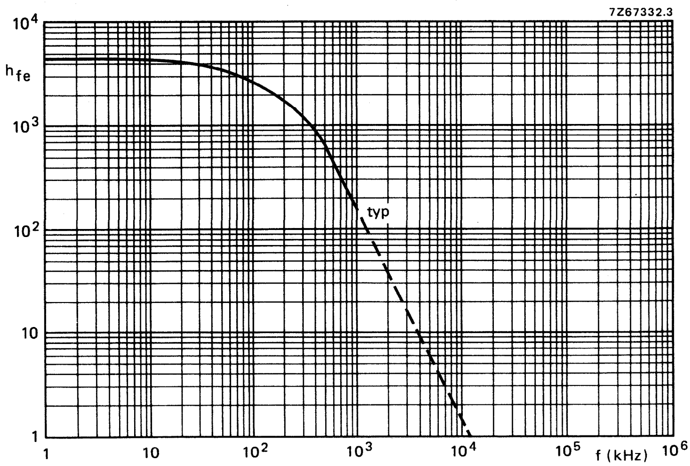


Fig. 14 Small signal current gain; $-I_C = 3$ A; $-V_{CE} = 3$ V; typical values.

SILICON DARLINGTON POWER TRANSISTORS

PNP silicon Darlington transistors in a SOT186 envelope with an electrically insulated mounting base. NPN complements are BD643F, BD645F, BD647F, BD649F and BD651F.

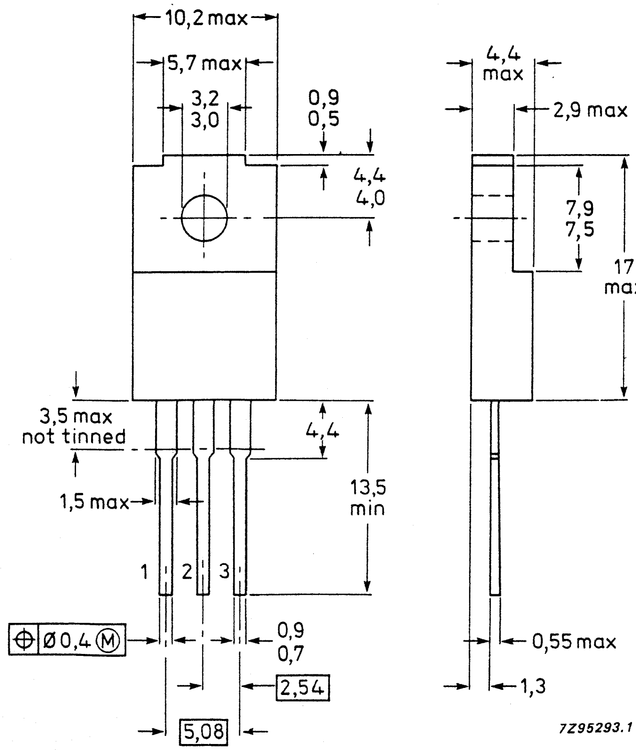
QUICK REFERENCE DATA

			BD644F	646F	648F	650F	652F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector current (DC)	$-I_C$	max.			8			A
Total power dissipation at $T_h \leq 25\ ^oC$	P_{tot}	max.			20			W
Junction temperature	T_j	max.			150			^oC

MECHANICAL DATA

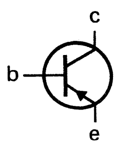
Dimensions in mm

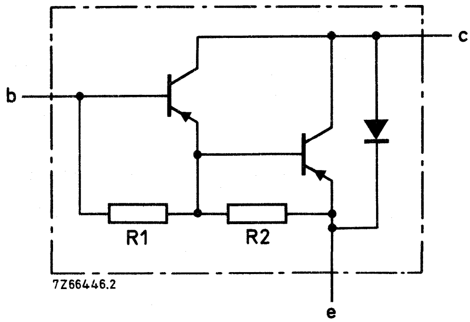
Fig.1 SOT186.



Pinning

1 = base
2 = collector
3 = emitter





R1 typ. 4 kΩ
R2 typ. 80 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD644F	646F	648F	650F	652F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
Collector current (DC)	$-I_C$	max.			8			A
(peak value)	$-I_{CM}$	max.			12			A
Base current (DC)	$-I_B$	max.			150			mA
Total power dissipation at $T_h \leq 25\ ^oC$ (note 1)	P_{tot}	max.			20			W
at $T_h \leq 25\ ^oC$ (note 2)	P_{tot}	max.			32			W
Storage temperature range	T_{stg}				−65 to + 150			^oC
Junction temperature	T_j	max.			150			^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{th}	max.	12	pF

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Emitter cut-off current				
V_{EB} = 5 V; I_C = 0	$-I_{EBO}$	max.	5	mA
Collector-emitter leakage current				
$-V_{CE} = -1/2\ V_{CEO}$; I_B = 0	$-I_{CEO}$	max.	0.2	mA
Collector cut-off current				
$-V_{CB} = -V_{CBO}$; I_E = 0	$-I_{CBO}$	max.	0.1	mA

			BD644F	646F	648F	650F	652F	
$-V_{CB}$ = 30 V; I_E = 0; T_j = 150 °C	$-I_{CBO}$	max.	1	–	–	–	–	mA
$-V_{CB}$ = 40 V; I_E = 0; T_j = 150 °C	$-I_{CBO}$	max.	–	1	–	–	–	mA
$-V_{CB}$ = 50 V; I_E = 0; T_j = 150 °C	$-I_{CBO}$	max.	–	–	1	–	–	mA
$-V_{CB}$ = 60 V; I_E = 0; T_j = 150 °C	$-I_{CBO}$	max.	–	–	–	1	–	mA
$-V_{CB}$ = 70 V; I_E = 0; T_j = 150 °C	$-I_{CBO}$	max.	–	–	–	–	1	mA
Collector-emitter leakage current								
$-V_{CE}$ = 25 V; I_B = 0	$-I_{CEO}$	max.	0.5	–	–	–	–	mA
$-V_{CE}$ = 30 V; I_B = 0	$-I_{CEO}$	max.	–	0.5	–	–	–	mA
$-V_{CE}$ = 40 V; I_B = 0	$-I_{CEO}$	max.	–	–	0.5	–	–	mA
$-V_{CE}$ = 50 V; I_B = 0	$-I_{CEO}$	max.	–	–	–	0.5	–	mA
$-V_{CE}$ = 60 V; I_B = 0	$-I_{CEO}$	max.	–	–	–	–	0.5	mA
Static forward current transfer ratio (note 1)								
$-I_C$ = 0.5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2700	2700	2700	2700	2700	
$-I_C$ = 4 A; $-V_{CE}$ = 3 V	h_{FE}	min.	750	–	–	–	–	
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	min.	–	750	750	750	750	
$-I_C$ = 8 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2000	2000	2000	2000	2000	
Collector-emitter saturation voltage (note 1)								
$-I_C$ = 4 A; $-I_B$ = 16 mA	$-V_{CEsat}$	max.	2	–	–	–	–	V
$-I_C$ = 3 A; $-I_B$ = 12 mA	$-V_{CEsat}$	max.	–	2	2	2	2	V
$-I_C$ = 5 A; $-I_B$ = 50 mA	$-V_{CEsat}$	max.	2.5	2.5	2.5	2.5	2.5	V
Base-emitter saturation voltage (note 1)								
$-I_C$ = 5 A; $-I_B$ = 50 mA	$-V_{BEsat}$	max.	3	3	3	3	3	V
Base-emitter voltage (note 1)								
$-I_C$ = 4 A; $-V_{CE}$ = 3 V	$-V_{BE}$	max.	2.5	–	–	–	–	V
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	$-V_{BE}$	max.	–	2.5	2.5	2.5	2.5	V
Common-emitter cut-off frequency								
$-I_C$ = 4 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100	–	–	–	–	kHz
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	–	100	100	100	100	kHz
Small signal current gain								
$-I_C$ = 4 A; $-V_{CE}$ = 3 V; f = 1 MHz	h_{fe}	typ.	150	–	–	–	–	
$-I_C$ = 3 A; $-V_{CE}$ = 3 V; f = 1 MHz	h_{fe}	typ.	–	150	150	150	150	

Forward bias second breakdown collector current				
$-V_{CE}$ = 50 V; t_p = 0.1 s	$-I_{(SB)}$	min.	0.55	A
Forward voltage				
I_F = 3 A	V_F	typ.	1.8	V

Note

1. To be measured under pulsed conditions, pulse time 300 μs; duty cycle 2%.

CHARACTERISTICS (continued)

Switching times

$-I_C = 3$ A; $-I_{B\,on} = -I_{B\,off} = 12$ mA

Turn on time	t_{on}	max.	2	μs
		typ.	1	μs
Turn off time	t_{off}	max.	10	μs
		typ.	5	μs

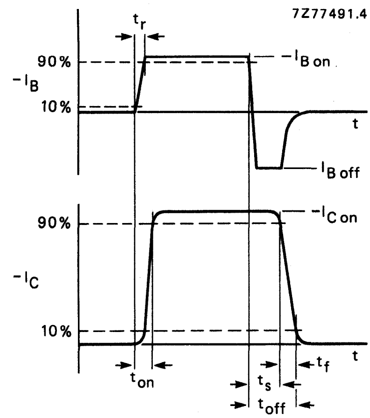
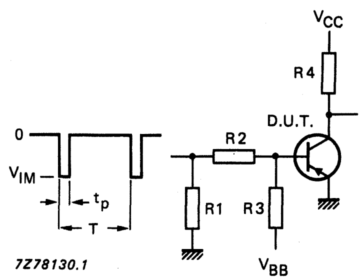
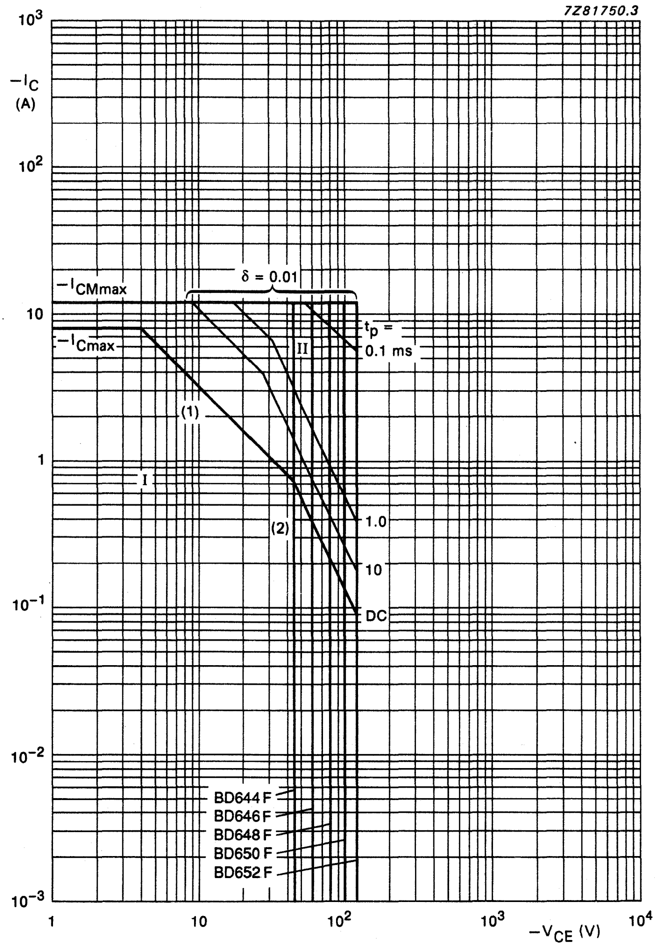


Fig. 3 Switching times waveforms.



$-V_{IM}$ = 10 V
$-V_{CC}$ = 10 V
$+V_{BB}$ = 4 V
R_1 = 56 Ω
R_2 = 410 Ω
R_3 = 560 Ω
R_4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and P_{peak} lines.
(2) Second-breakdown limits.

Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

Fig.5 Safe Operating Area; T_{amb} = 25 °C.

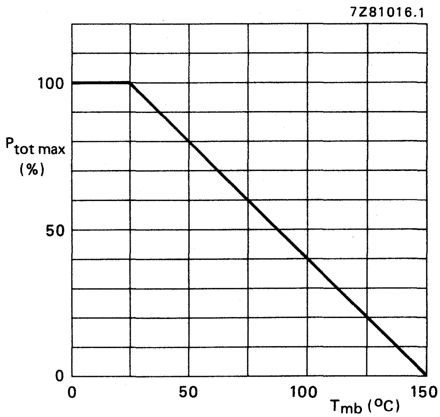


Fig. 6 Power derating curve.

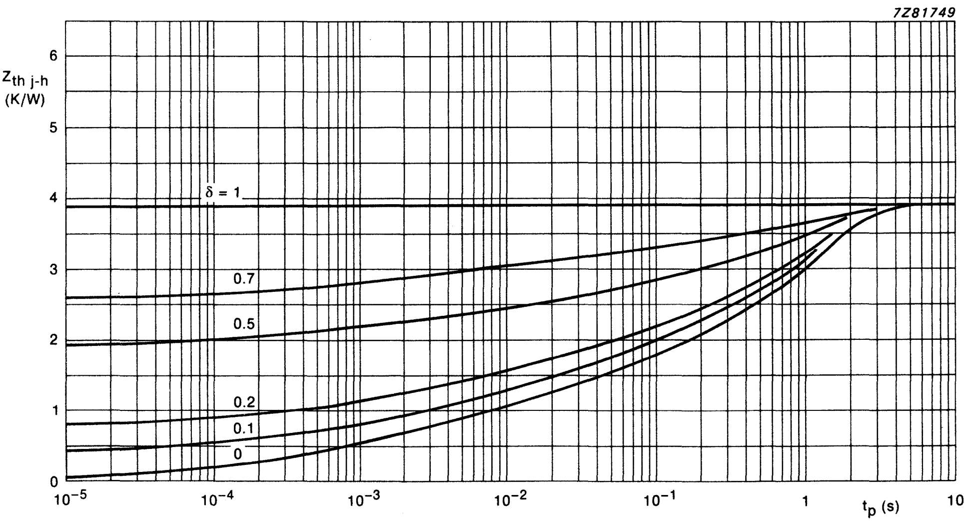


Fig. 7 Pulse power rating chart.

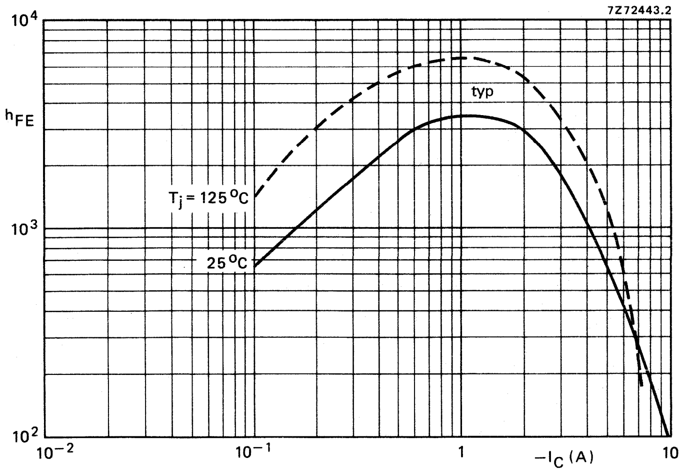


Fig. 8 Typical DC current gain curves, $-V_{CE} = 3$ V.

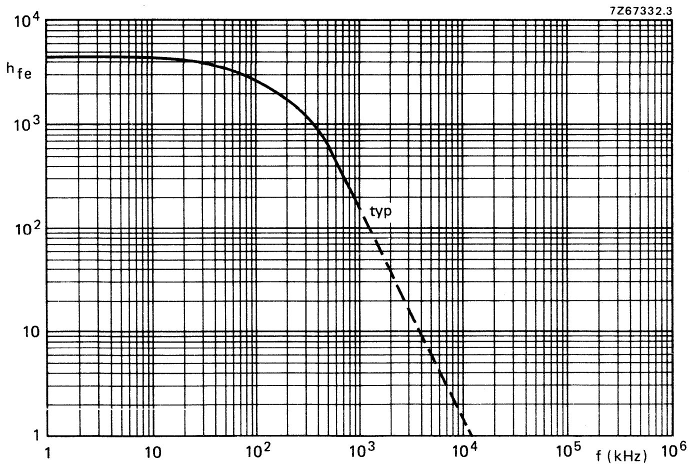


Fig. 9 Small signal current gain.

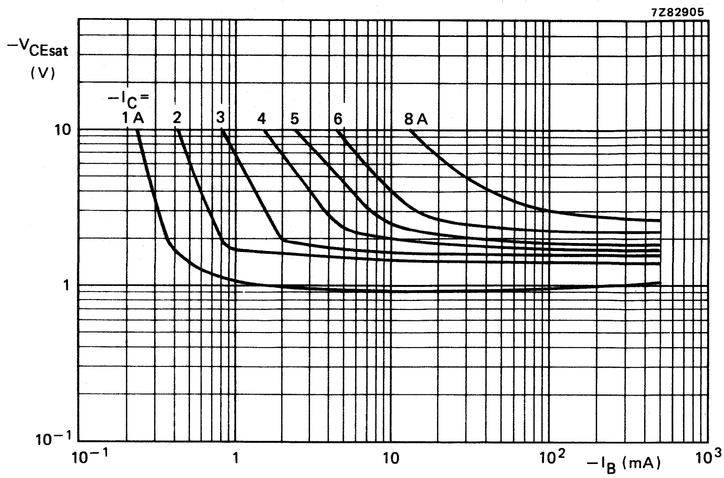


Fig. 10 Typical collector-emitter saturation voltage; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio and video applications; SOT-32 plastic envelope. P-N-P complements are BD676, BD678, BD680, BD682 and BD684.

QUICK REFERENCE DATA

			BD675	677	679	681	683	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V

Collector current (d.c.)	I_C	max.	4	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	2200	
I_C = 1,5 A; V_{CE} = 3 V	h_{FE}	>	750	
Cut-off frequency I_C = 1,5 A; V_{CE} = 3 V	f_{hfe}	typ.	60	kHz

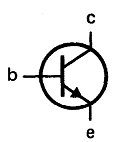
MECHANICAL DATA

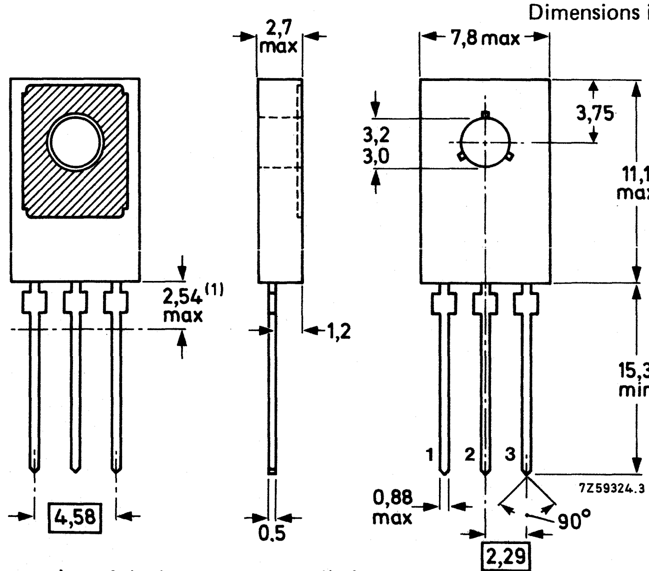
Dimensions in mm

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

Collector connected to mounting base.

Pinning
1 = emitter
2 = collector
3 = base

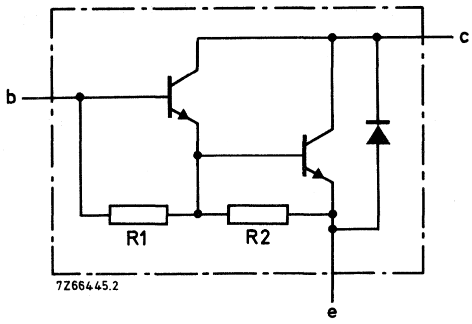




(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

CIRCUIT DIAGRAM



R_1 typ. 3 kΩ
R_2 typ. 120 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD675	677	679	681	683	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	5	V

Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (d.c.)	I_B	max.	100	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W

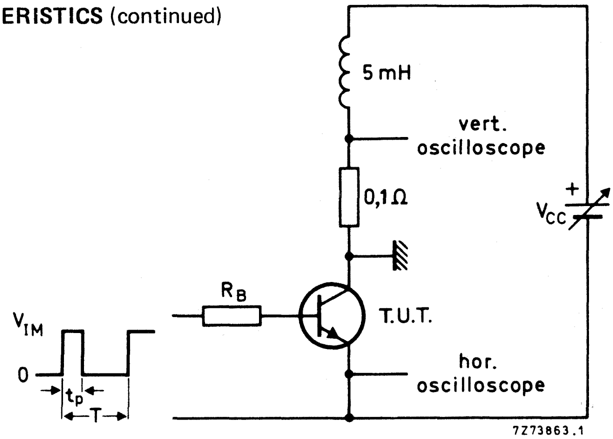
CHARACTERISTICS

T_j = 25 °C, unless otherwise specified; where I_C = 1,5 A for BD675 read I_C = 2 A.

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; T_{mb} = 150 °C	I_{CBO}	<	1 mA
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	0,2 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
D.C. current gain (note 1)			
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	2200
I_C = 1,5 A; V_{CE} = 3 V	h_{FE}	>	750
I_C = 4 A; V_{CE} = 3 V	h_{FE}	typ.	1500
Base-emitter voltage (notes 1 and 2)			
I_C = 1,5 A; V_{CE} = 3 V (BD675; I_C = 2 A)	V_{BE}	<	2,5 V
Collector-emitter saturation voltage (note 1)			
I_C = 1,5 A; I_B = 6 mA (BD675; I_C = 2 A)	V_{CEsat}	<	2,5 V
Small signal current gain			
I_C = 1,5 A; V_{CE} = 3 V; f = 1 MHz (BD675; I_C = 2 A)	h_{fe}	>	10
Cut-off frequency			
I_C = 1,5 A; V_{CE} = 3 V (BD675; I_C = 2 A)	f_{hfe}	typ.	60 kHz
Turn-off breakdown energy with inductive load			
$-I_{Boff} = 0$; I_C = 3,5 A; (Fig. 3)	$E_{(BR)}$	>	30 mJ
D.C. current gain ratio of matched complementary pairs			
I_C = 1,5 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5
Diode forward voltage			
I_F = 1,5 A (BD675; I_F = 2 A)	V_F	typ.	1,5 V
Second-breakdown collector current			
V_{CE} = 50 V; t_p = 20 ms, non rep.; without heatsink	$I_{(SB)}$	>	0,8 A
BD675; V_{CE} = 40 V; t_p = ms	$I_{(SB)}$	>	1 A
Switching times (between 10% and 90% levels)			
I_{Con} = 1,5 A; $I_{Bon} = -I_{Boff}$ = 6 mA; V_{CC} = 30 V			
Turn-on time	t_{on}	typ.	0,8 µs
		<	2 µs
Turn-off time	t_{off}	typ.	4,5 µs
		<	8 µs

Notes
1. Measured under pulse conditions: $t_p < 300$ µs; $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/K with increasing temperature.

CHARACTERISTICS (continued)



V_{IM} = 12 V
R_B = 270 Ω
I_{CC} = 3,5 A
T = 1 ms
δ = 1 %

Fig. 3 Test circuit for turn-off breakdown energy.

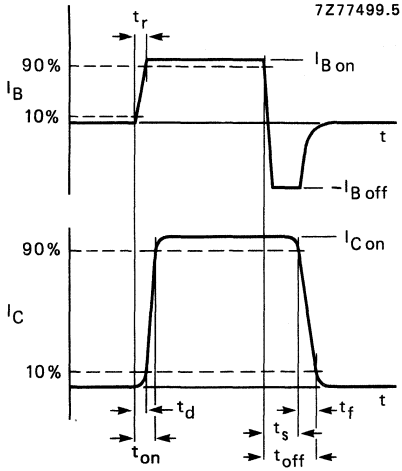
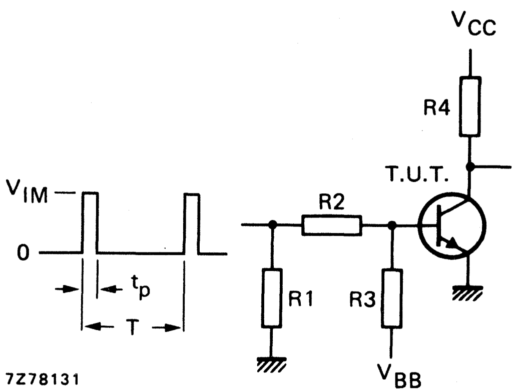


Fig. 4 Switching times waveforms.



V_{IM} = 12 V
V_{CC} = 30 V
V_{BB} = −3 V
R1 = 56 Ω
R2 = 1 kΩ
R3 = 680 Ω
R4 = 22 Ω
$t_r = t_f \leqslant 15$ ns
t_p = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

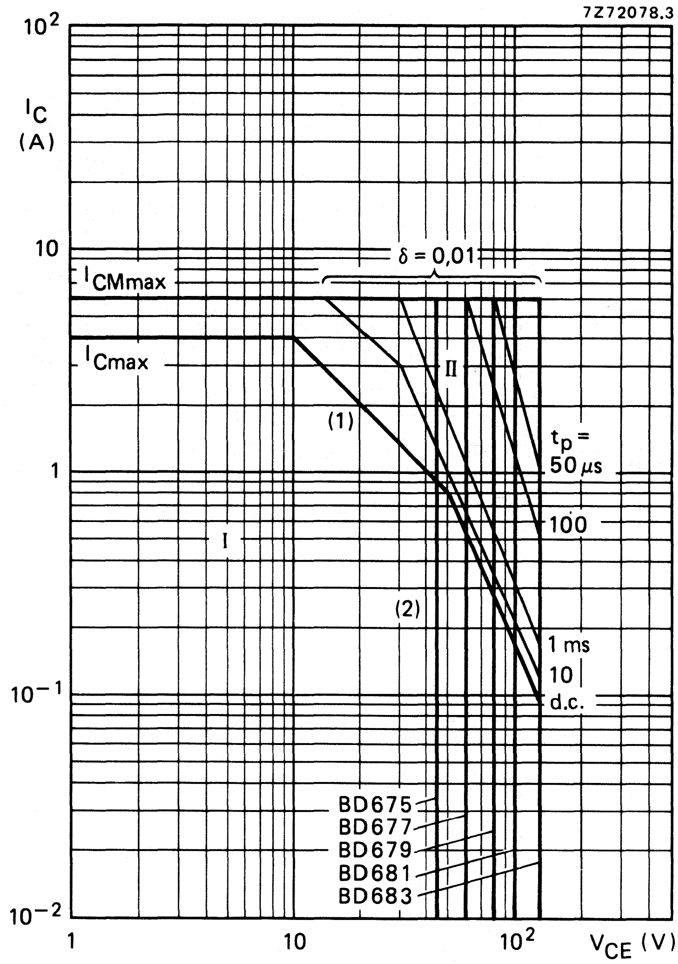


Fig. 6 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

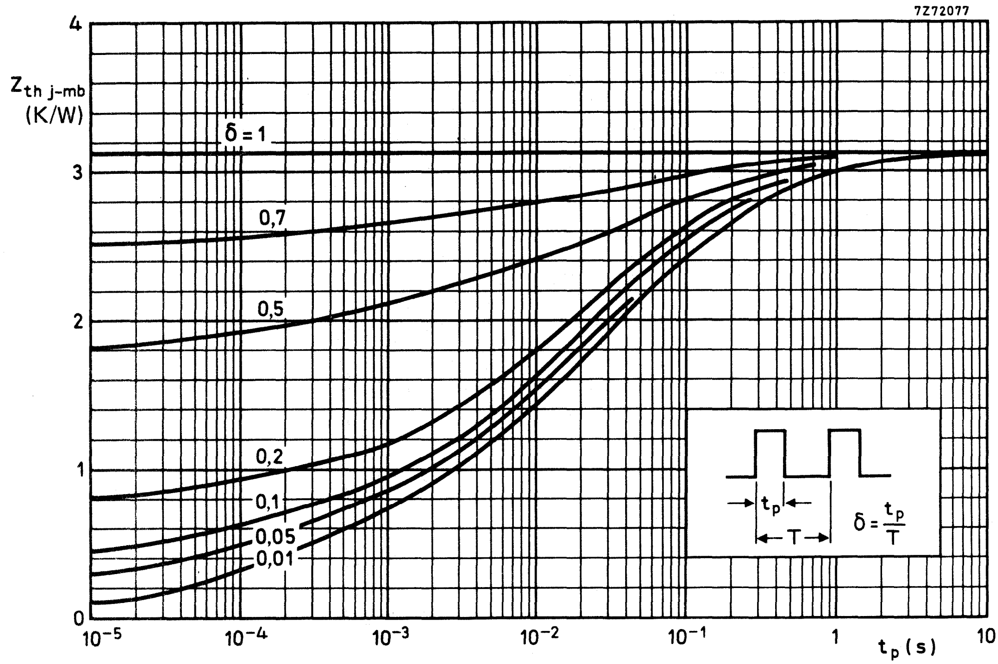


Fig. 7 Pulse power rating chart.

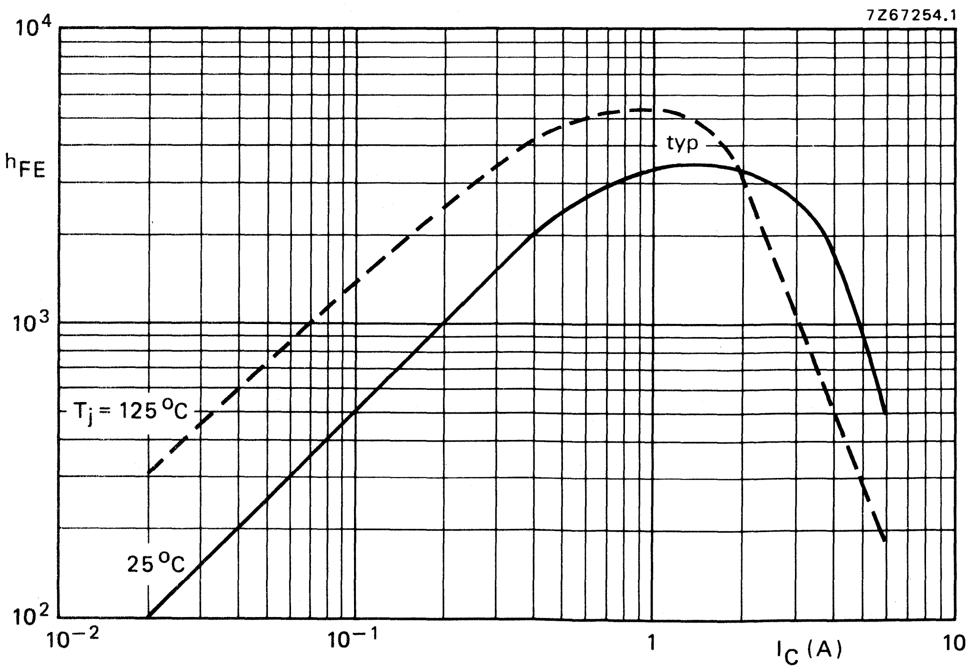


Fig. 8 D.C. current gain at V_{CE} = 3 V.

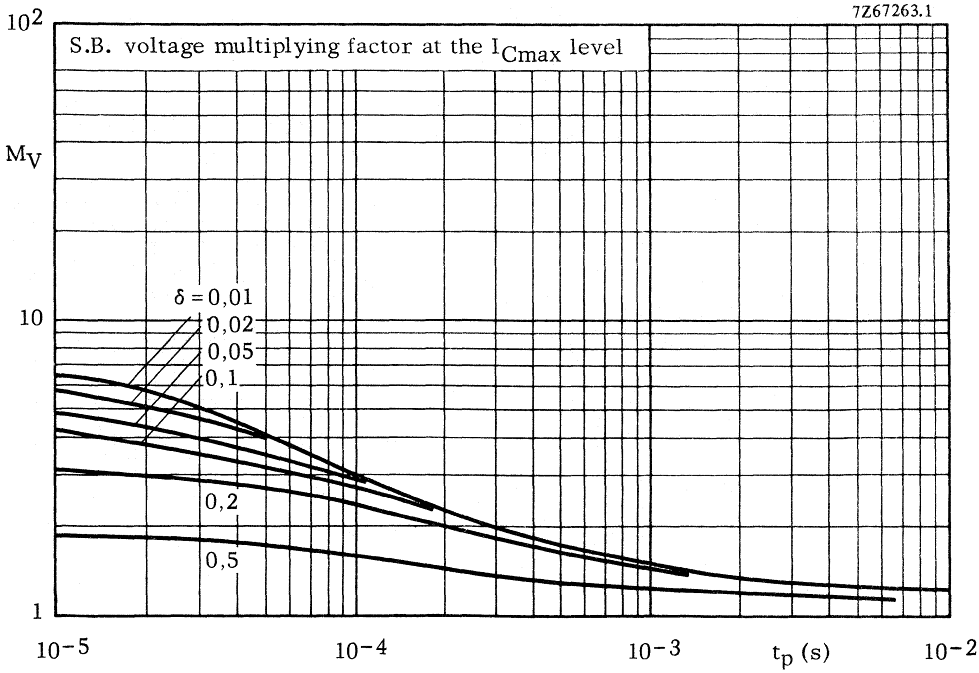


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

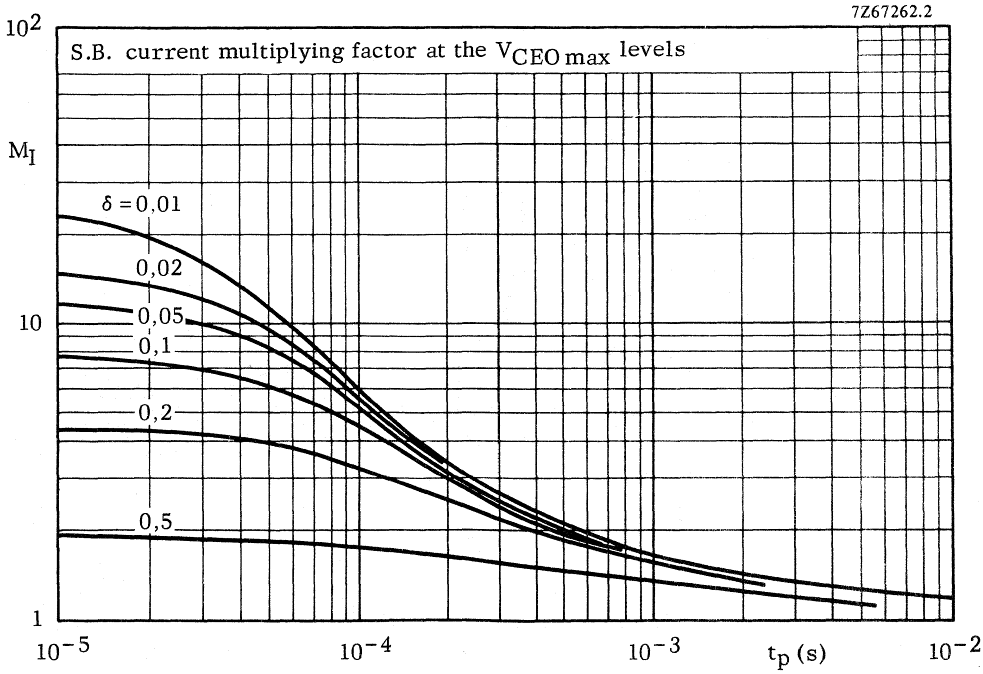


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} levels.

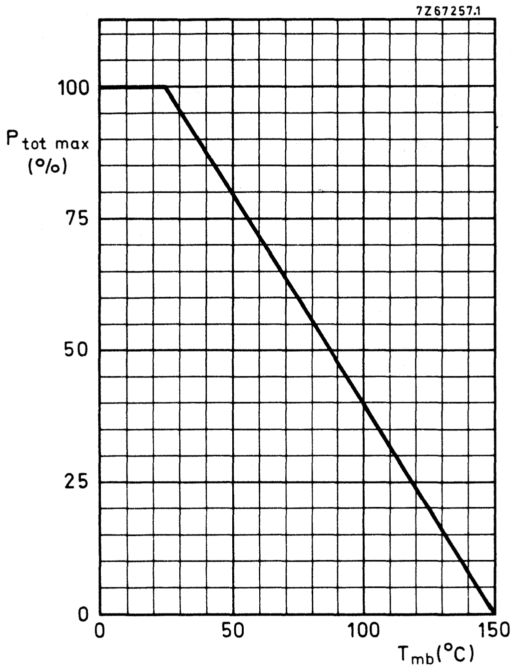


Fig. 11 Power derating curve.

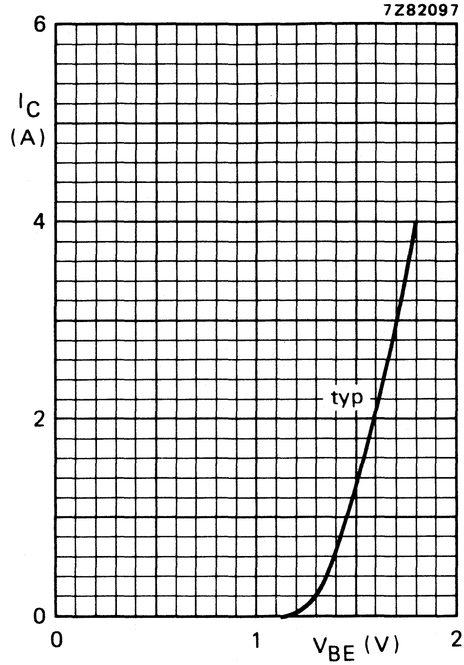


Fig. 12 Typical collector current.

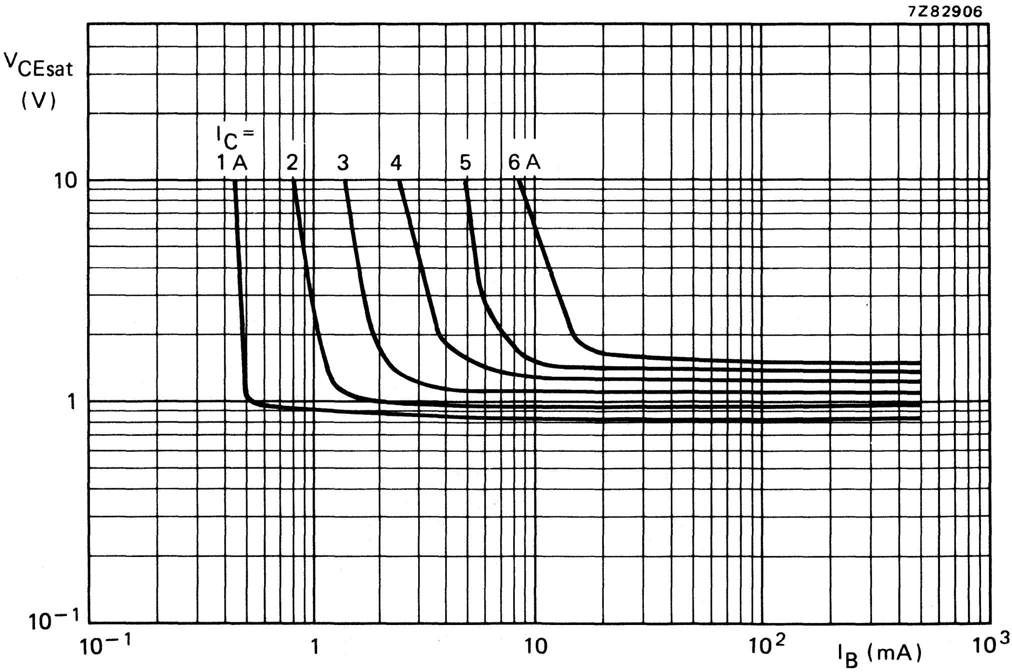


Fig. 13 Typical values collector-emitter saturation voltage. T_{mb} = 25 °C.

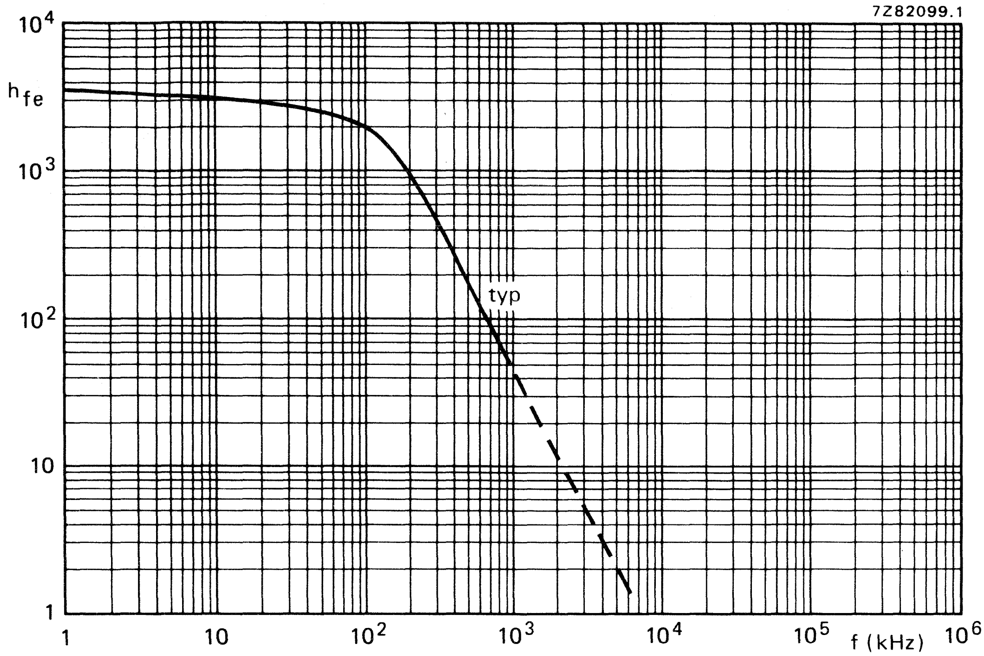


Fig. 14 Small signal current gain. I_C = 1,5 A; V_{CE} = 3 V.

Silicon Darlington power transistors — BD675A/BD677A/BD679A

DESCRIPTION

NPN epitaxial base transistors in a monolithic Darlington circuit in a TO-126 (SOT32) plastic envelope intended for audio and video applications. PNP complements are BD676A, BD678A and BD680A respectively.

PINNING - TO-126 (SOT32)

PIN	DESCRIPTION
1	emitter
2	collector
3	base

Collector connected to mounting base.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter				
	BD675A		–	–	45	V
	BD677A		–	–	60	V
	BD679A		–	–	80	V
V_{CEO}	collector-emitter voltage	open base				
	BD675A		–	–	45	V
	BD677A		–	–	60	V
	BD679A		–	–	80	V
I_C	collector current	average value	–	–	4	A
P_{tot}	total power dissipation	T_{mb} = 25 °C	–	–	40	W
T_j	junction temperature		–	–	150	°C
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 3 V	750	–	–	
f_{hfe}	cut-off frequency	I_C = 1.5 A; V_{CE} = 3 V	–	60	–	kHz

PIN CONFIGURATION

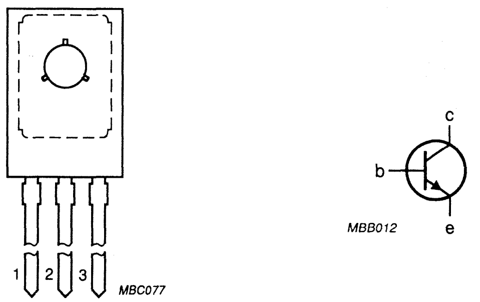
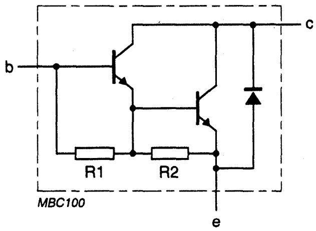


Fig.1 Simplified outline and symbol.



R1 typ. 3 kΩ
R2 typ. 120 Ω

Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BD675A		–	45	V
	BD677A		–	60	V
	BD679A		–	80	V
V_{CEO}	collector-emitter voltage	open base			
	BD675A		–	45	V
	BD677A		–	60	V
	BD679A		–	80	V
V_{EBO}	emitter-base voltage	open collector	–	5	V
I_C	collector current	average value	–	4	A
I_{CM}	collector current	peak value	–	6	A
I_B	base current		–	100	mA
P_{tot}	total power dissipation	T_{mb} = 25 °C	–	40	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		–	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}mb}$	from junction to mounting base		3.12	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	in free air	100	K/W

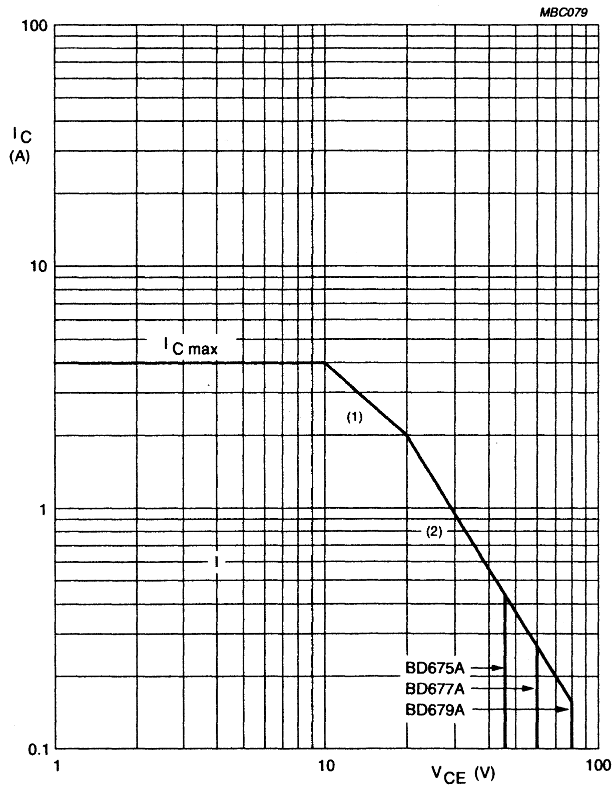
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector cut off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$	–	0.2	mA
		$I_E = 0$; $V_{CB} = 0.5\ V_{CBO\ max}$ T_{mb} = 150 °C	–	1	mA
I_{EBO}	emitter cut off current	$I_C = 0$; V_{EB} = 5 V	–	5	mA
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 3 V	750	–	
V_{BE}	base-emitter voltage	I_C = 2 A; V_{CE} = 3 V; note 1 note 2	–	2.5	V
$V_{CE\ sat}$	collector-emitter saturation voltage	I_C = 2 A; I_B = 40 mA note 1	–	2.8	V
h_{fe}	small signal current gain	I_C = 1.5 A; V_{CE} = 3 V; f = 1 MHz	10	–	

Notes

1. Measured under pulse conditions; $t_p < 300$, $\delta < 2\%$.
2. V_{BE} decreases by typ. 2.3 mV/K with increasing temperature.



T_{mb} = 25 °C

I Region of permissible DC operation.

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

(2) Second breakdown limits.

Fig.3 Safe operating area.

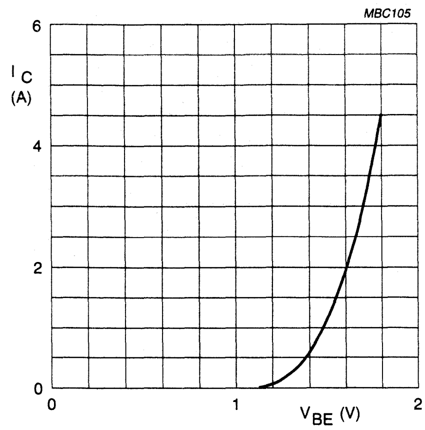
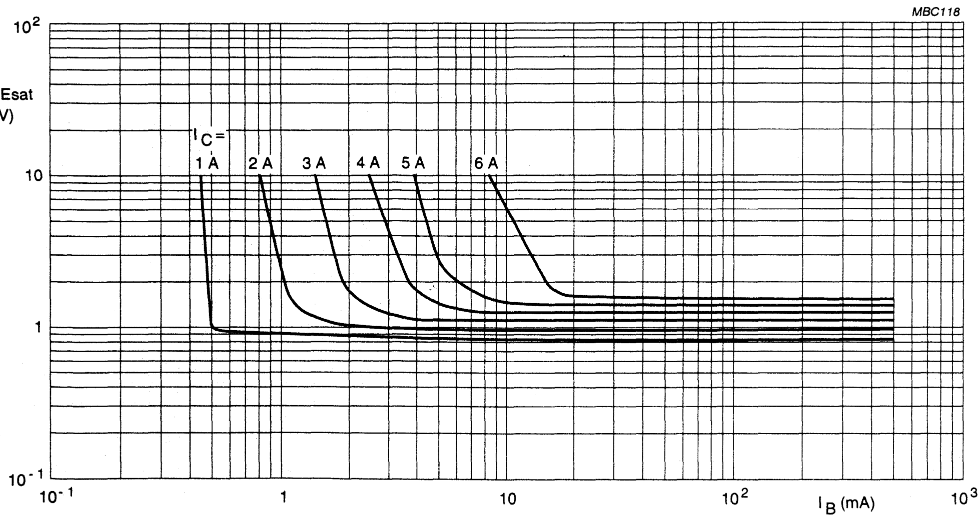
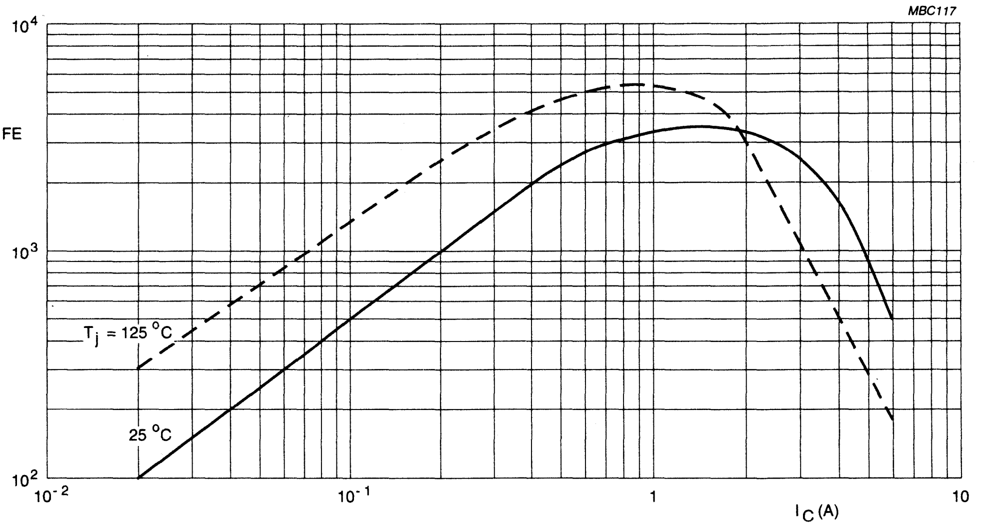


Fig.4 Base-emitter voltage as a function of collector current.



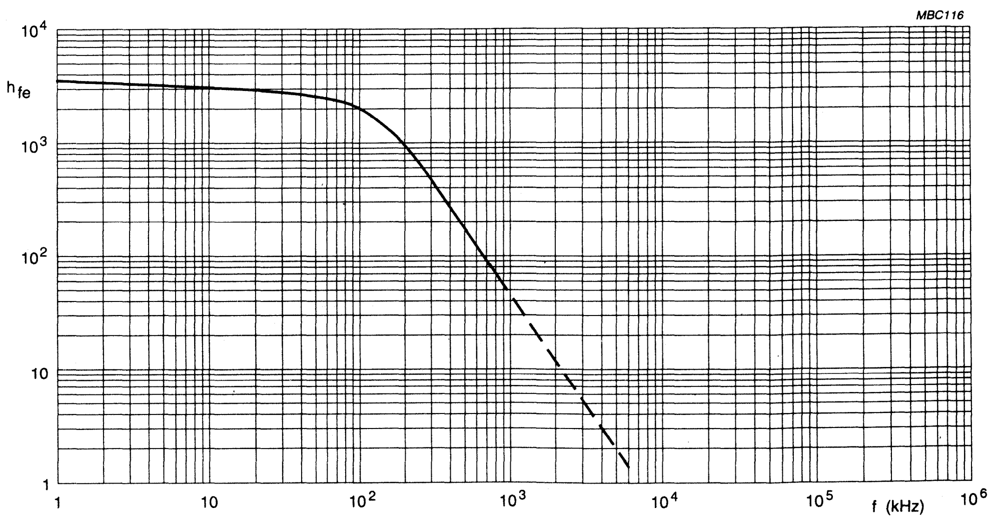
T_{mb} = 25 °C.

Fig.5 Typical values collector-emitter saturation voltage.



V_{CE} = 3 V.

Fig.6 DC current gain.



I_C = 1.5 A, V_{CE} = 3 V.

Fig.7 Typical values small signal current gain.

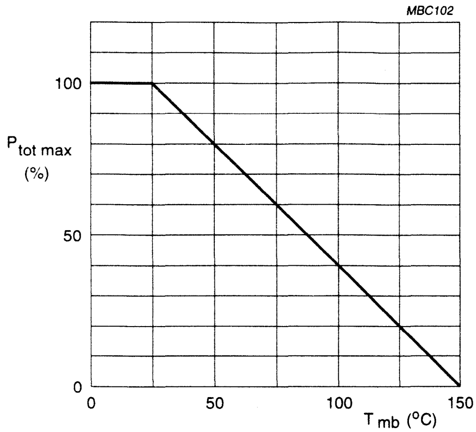
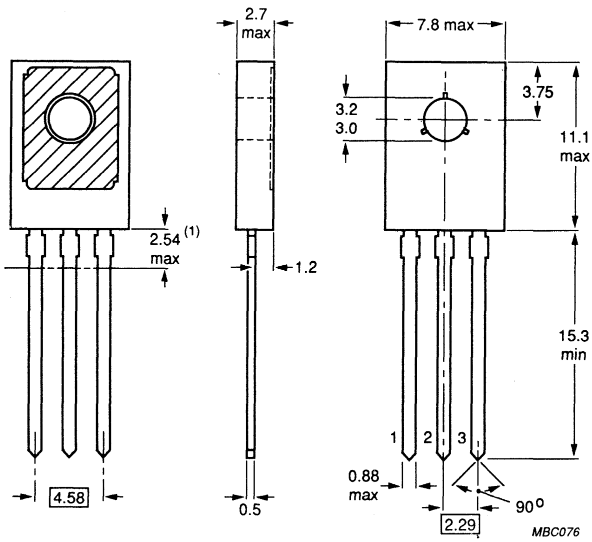


Fig.8 Power derating curve.

PACKAGE OUTLINE



Dimensions in mm

Collector connected to mounting base.

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

Fig.9 TO-126 (SOT32).

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio and video output applications; SOT-32 plastic envelope. N-P-N complements are BD675, BD677, BD679, BD681 and BD683.

QUICK REFERENCE DATA

			BD676	678	680	682	684	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector-current (d.c.)	$-I_C$	max.			4			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.			2200			
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE}	>			750			
Cut-off frequency								
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.			60			kHz

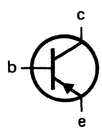
MECHANICAL DATA

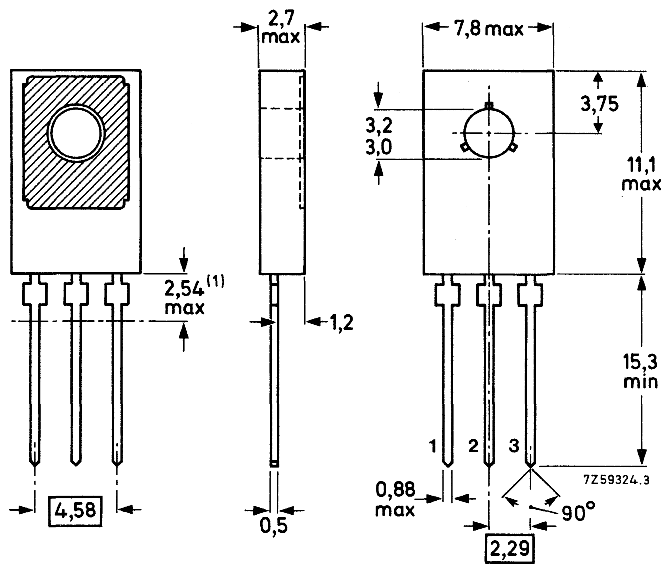
Dimensions in mm

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

Collector connected to mounting base.

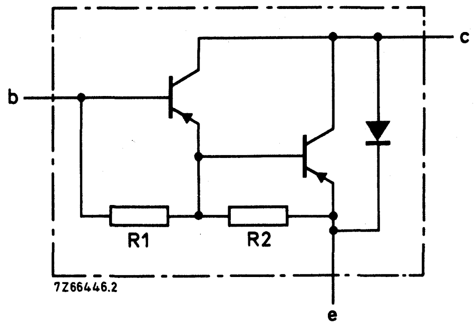
Pinning
1 = emitter
2 = collector
3 = base





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

See also chapters Mounting instructions and Accessories.



R1 typ. 3 kΩ
R2 typ. 80 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD676	678	680	682	684	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	4	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Base current (d.c.)	$-I_B$	max.	100	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified; where $-I_C$ = 1,5 A for BD676 read $-I_C$ = 2 A.

Collector cut-off current			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA
$I_E = 0; -V_{CB} = -0,6\ V_{CBOmax}; T_{mb} = 150\ ^oC$	$-I_{CBO}$	<	1 mA
$I_B = 0; -V_{CE} = -½\ V_{CEOmax}$	$-I_{CEO}$	<	0,2 mA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain (note 1)			
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2200
$-I_C = 1,5$ A; $-V_{CE} = 3$ V*	h_{FE}	>	750
$-I_C = 4$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	650
Base-emitter voltage (notes 1 and 2)			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V*	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage (note 1)			
$-I_C = 1,5$ A; $-I_B = 6$ mA*	$-V_{CEsat}$	<	2,5 V
Small-signal current gain			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V; f = 1 MHz*	h_{fe}	>	10
Cut-off frequency			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V*	f_{hfe}	typ.	60 kHz
D.C. current gain ratio of matched complementary pairs			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5
Diode, forward voltage			
$I_F = 1,5$ A*	V_F	typ.	1,5 V
Switching times (see Figs 3 and 4)			
$-I_{Con} = 1,5$ A; $-I_{Bon} = I_{Boff} = 6$ mA			
turn-on time	t_{on}	typ.	0,3 μs
		<	1,5 μs
turn-off time	t_{off}	typ.	1,5 μs
		<	5 μs
Second-breakdown collector current			
$-V_{CE} = 50$ V; $t_p = 20$ ms	$-I_{(SB)}$	>	0,8 A
for BD676 $-V_{CE} = 40$ V	$-I_{(SB)}$	>	1 A

* for BD676 condition $-I_C$ or $-I_F$ = 2 A.

Notes
1. Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/K with increasing temperature.

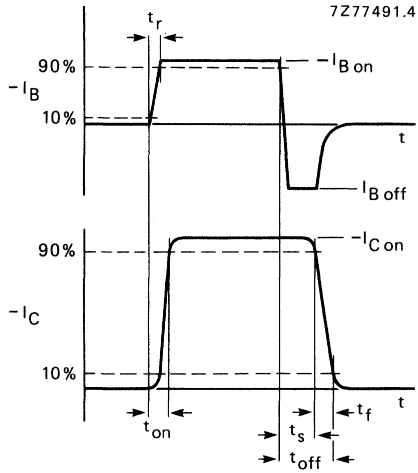
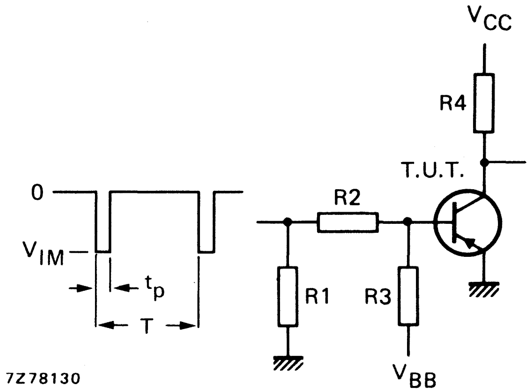


Fig. 3 Switching times waveform.



$-V_{IM}$	=	12 V
$-V_{CC}$	=	30 V
$+V_{BB}$	=	3 V
R1	=	56 Ω
R2	=	1 kΩ
R3	=	68 Ω
R4	=	22 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuits.

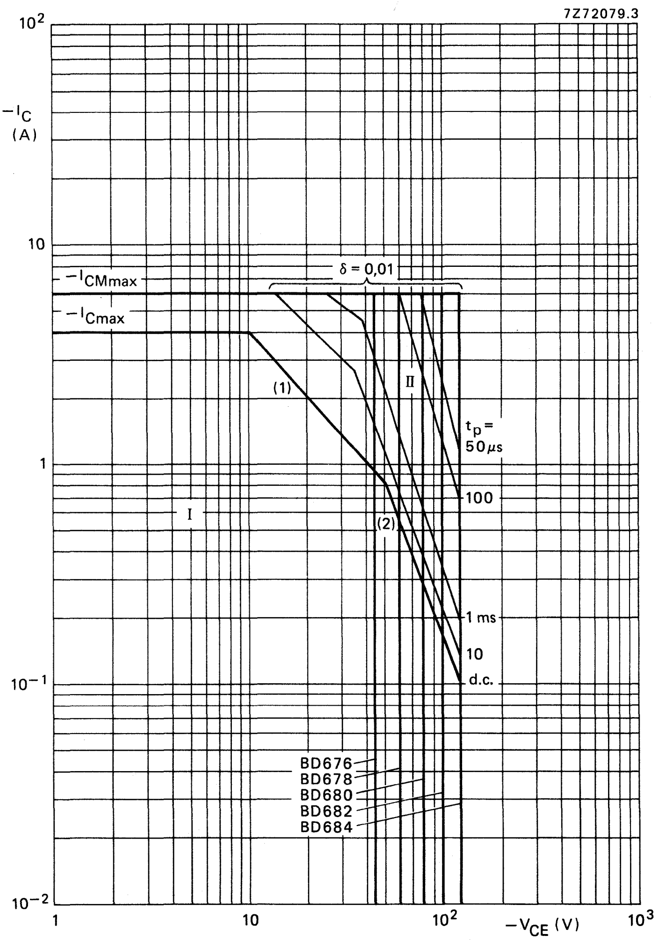


Fig. 5 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

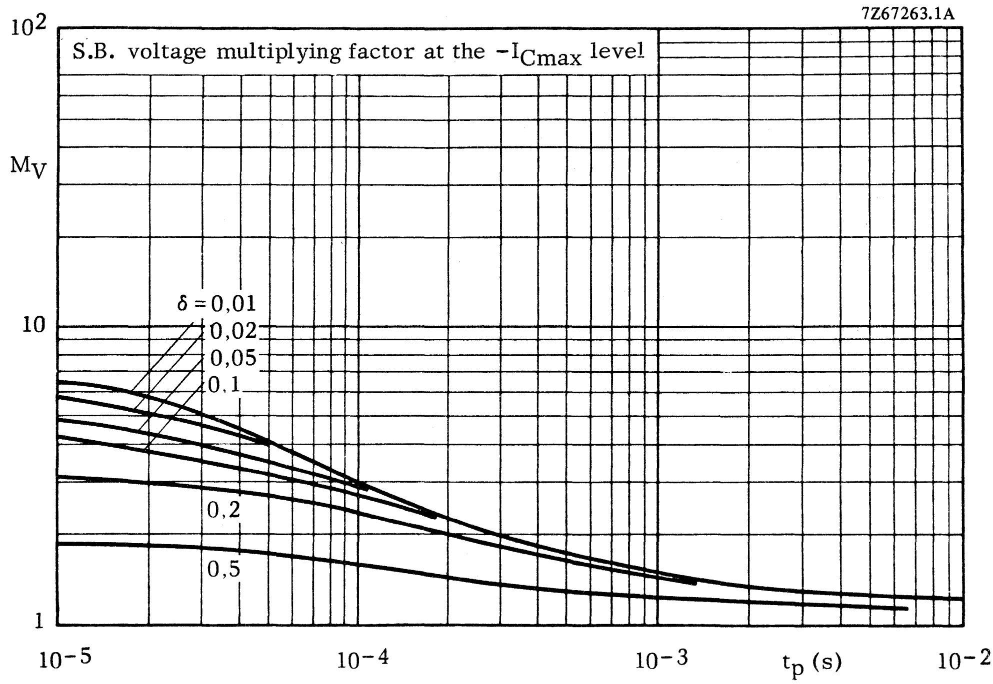


Fig. 6 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

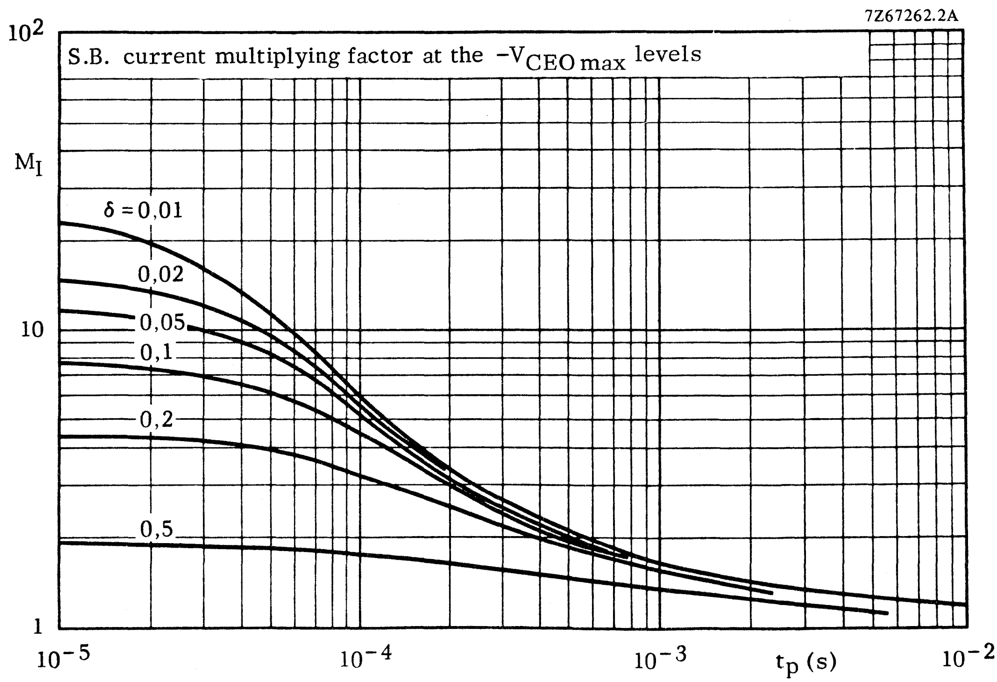


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ levels.

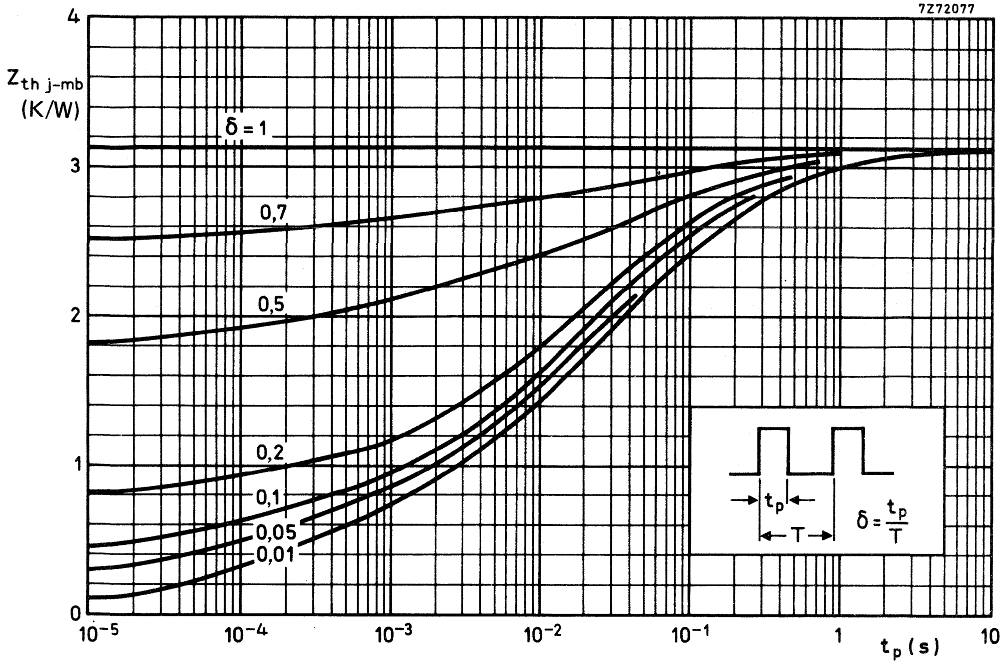


Fig. 8 Pulse power rating chart.

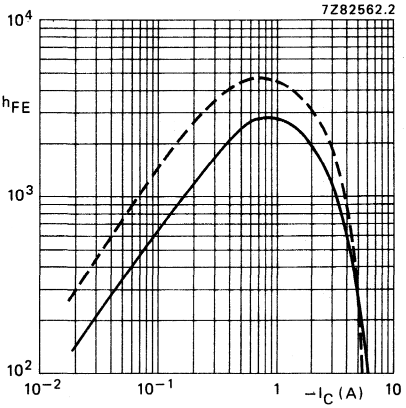


Fig. 9 D.C. current gain. $-V_{CE} = 3$ V;
——— $T_j = 25$ °C;
- - - - $T_j = 125$ °C.

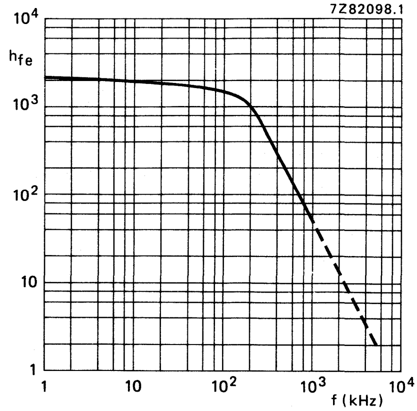


Fig. 10 Typical values small signal current gain. $-I_C = 1,5$ A; $-V_{CE} = 3$ V.

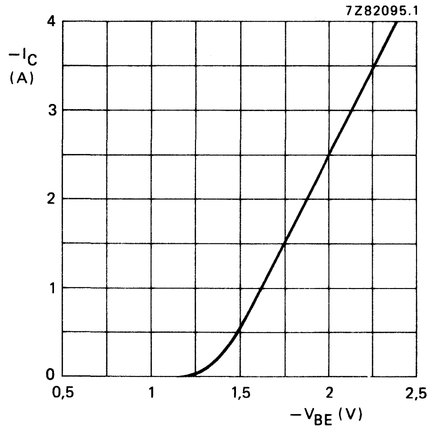


Fig. 11 Typical values; $-V_{CE} = 3$ V $T_j = 25$ °C.

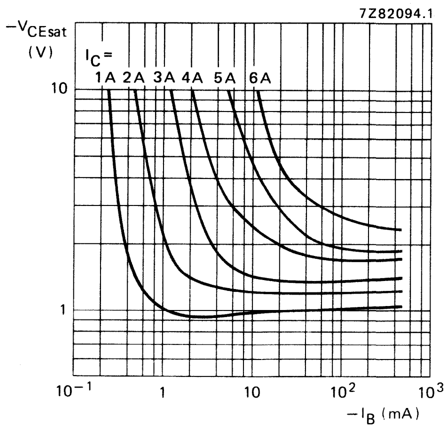


Fig. 12 Typical values collector-emitter saturation voltage as a function of base current. $T_{mb} = 25$ °C.

Silicon Darlington power transistors — BD676A/678A/680A

DESCRIPTION

PNP epitaxial base transistors in a monolithic Darlington circuit in a TO-126 (SOT32) plastic envelope intended for audio and video applications. NPN complements are BD675A, BD677A and BD679A respectively.

PINNING - TO-126 (SOT32)

PIN	DESCRIPTION
1	emitter
2	collector
3	base

Collector connected to mounting base.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter				
	BD676A		–	–	45	V
	BD678A		–	–	60	V
	BD680A		–	–	80	V
$-V_{CEO}$	collector-emitter voltage	open base				
	BD676A		–	–	45	V
	BD678A		–	–	60	V
	BD680A		–	–	80	V
$-I_C$	collector current	average value	–	–	4	A
P_{tot}	total power dissipation	T_{mb} = 25 °C	–	–	40	W
T_j	junction temperature		–	–	150	°C
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 3 V	750	–	–	
f_{hfe}	cut-off frequency	$-I_C$ = 1.5 A; $-V_{CE}$ = 3 V	–	60	–	kHz

PIN CONFIGURATION

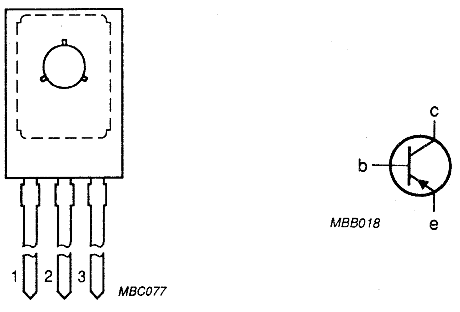
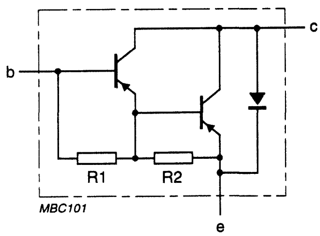


Fig.1 Simplified outline and symbol.



R1 typ. 3 kΩ

R2 typ. 80 Ω

Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BD676A		–	45	V
	BD678A		–	60	V
	BD680A		–	80	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BD676A		–	45	V
	BD678A		–	60	V
	BD680A		–	80	V
$-V_{EBO}$	emitter-base voltage	open collector	–	5	V
$-I_C$	collector current	average value	–	4	A
$-I_{CM}$	collector current	peak value	–	6	A
$-I_B$	base current		–	100	mA
P_{tot}	total power dissipation	T_{mb} = 25 °C	–	40	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		–	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}mb}$	from junction to mounting base		3.12	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	in free air	100	K/W

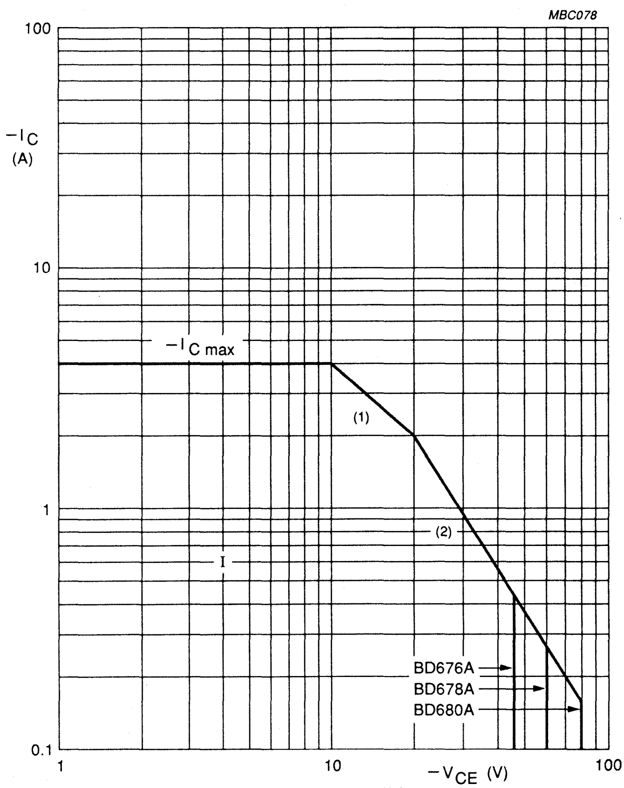
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-I_{CBO}$	collector cut off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	–	0.2	mA
		$I_E = 0$; $-V_{CB} = -0.5\ V_{CBO\ max}$ T_{mb} = 150 °C	–	1	mA
$-I_{EBO}$	emitter cut off current	$I_C = 0$; $-V_{EB}$ = 5 V	–	5	mA
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 3 V	750	–	
$-V_{BE}$	base-emitter voltage	$-I_C$ = 2 A; $-V_{CE}$ = 3 V; note 1 note 2	–	2.5	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C$ = 2 A; $-I_B$ = 40 mA note 1	–	2.8	V
h_{fe}	small signal current gain	$-I_C$ = 1.5 A; $-V_{CE}$ = 3 V; f = 1 MHz	10	–	

Notes

1. Measured under pulse conditions; t_p < 300 , δ < 2%.
2. V_{BE} decreases by typ. 2.3 mV/K with increasing temperature.



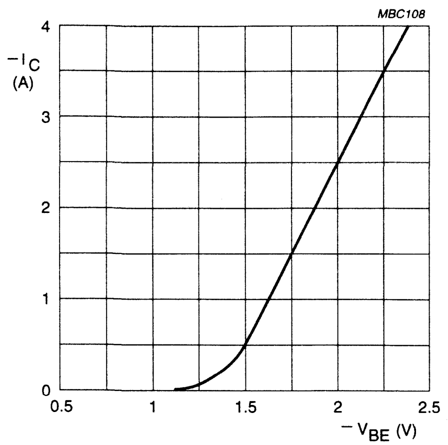
T_{mb} = 25 °C

I Region of permissible DC operation.

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

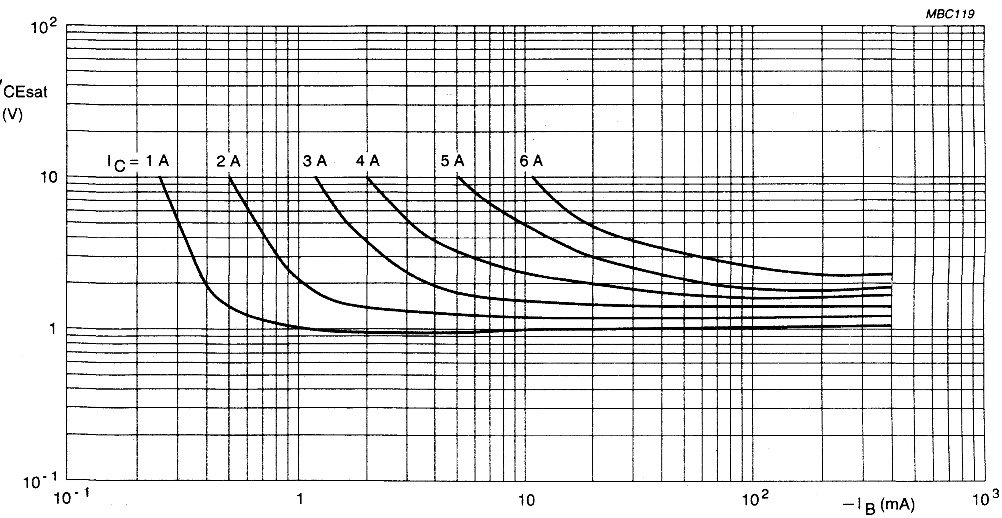
(2) Second breakdown limits.

Fig.3 Safe operating area.



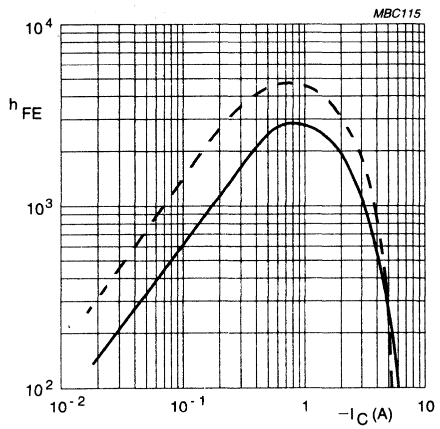
$-V_{CE}$ = 3 V, T_j = 25 °C.

Fig.4 Base-emitter voltage as a function of collector current.



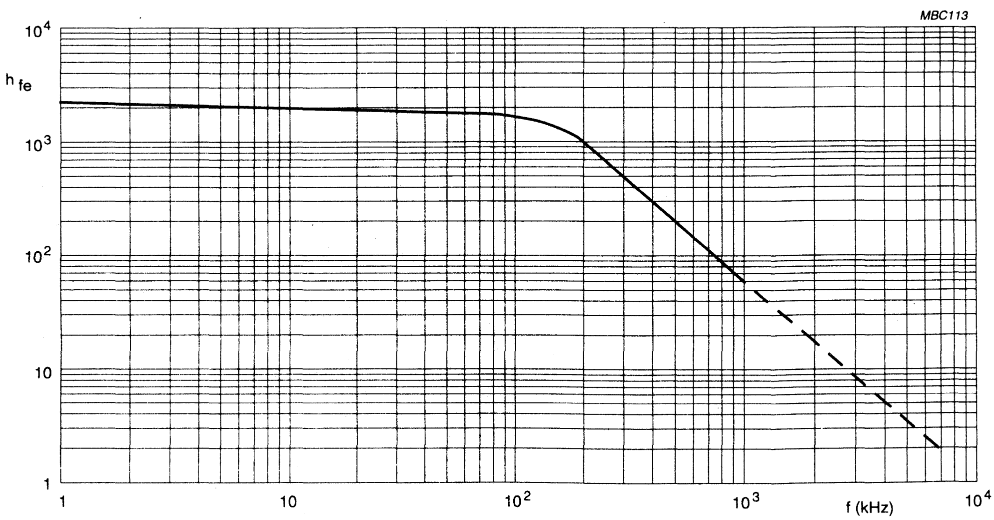
T_{mb} = 25 °C.

Fig.5 Typical values collector-emitter saturation voltage.



$-V_{CE}$ = 3 V.
Solid line = T_j = 25 °C.
Dotted line = T_j = 125 °C.

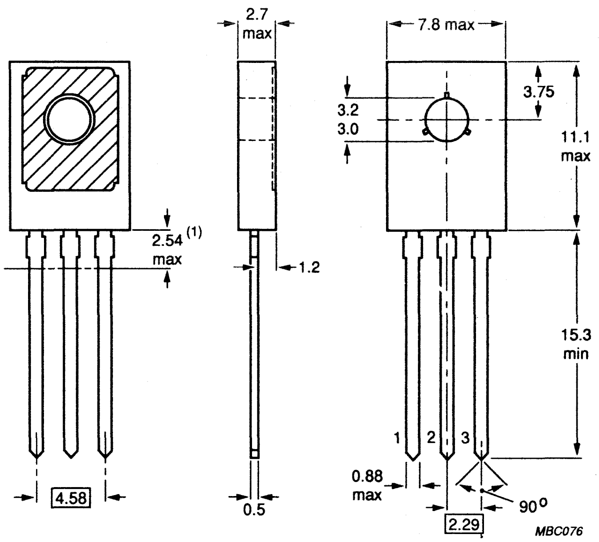
Fig.6 DC current gain.



$-I_C$ = 1.5 A, $-V_{CE}$ = 3 V.

Fig.7 Typical values small signal current gain.

PACKAGE OUTLINE



Dimensions in mm

Collector connected to mounting base.

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

Fig.8 TO-126 (SOT32).

SILICON EPITAXIAL-BASE POWER TRANSISTOR

NPN transistor in a SOT32 plastic envelope intended for use in audio output and general purpose amplifier applications. BD719 is equivalent to BD439. PNP complements are BD720; 722; 724 and BD726.

QUICK REFERENCE DATA

			BD719	BD721	BD723	BD725	
Collector-base voltage	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage	V_{EBO}	max.	5	5	5	5	V
Collector current (DC)	I_C	max.	4	4	4	4	A
(peak value)	I_{CM}	max.	7	7	7	7	A
Junction temperature	T_j	max.	150	150	150	150	°C
DC current gain							
$I_C = 2$ A; $V_{CE} = 4$ V	h_{FE}	min.	20	20	20	20	
Transition frequency							
$I_C = 500$ mA; $V_{CE} = 4$ V	f_T	min.	3	3	3	3	MHz

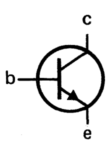
MECHANICAL DATA

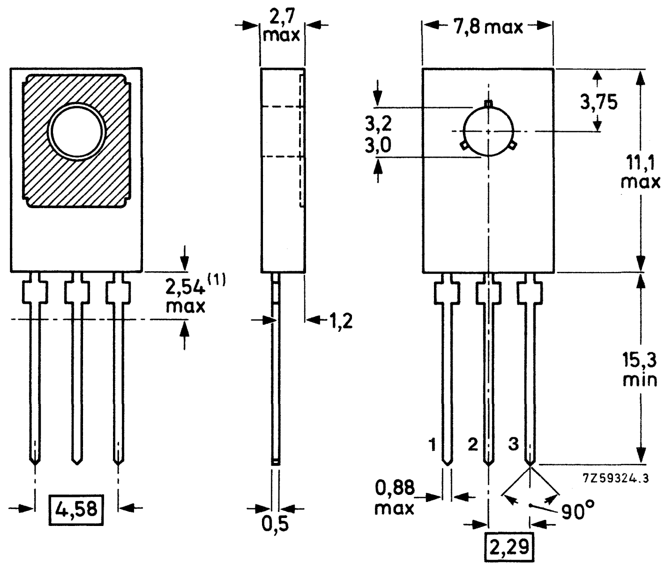
Dimensions in mm

Fig. 1 TO- 126 (SOT32).

Collector connected to metal part of mounting surface

Pinning
1 = emitter
2 = collector
3 = base





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

RATINGS

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

			BD719	BD721	BD723	BD725	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage	V_{EBO}	max.	5	5	5	5	V
Collector current							
DC value	I_C	max.	4				A
peak value	I_{CM}	max.	7				A
Base current (DC)	I_B	max.	1				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36				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	$R_{th\,j\text{-}a}$	max.	100	K/W
From junction to mounting base	$R_{th\,j\text{-}mb}$	max.	3.5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD719	BD721	BD723	BD725	
Collector cut-off current							
$I_E = 0$; $V_{CB} = V_{CBO}$	I_{CBO}	max.	50	50	50	50	μA
$I_E = 0$; $V_{CB} = ½ V_{CBO}$; T_j = 150 °C	I_{CBO}	max.	1	1	1	1	mA
$I_B = 0$; $V_{CE} = ½ V_{CEO}$	I_{CEO}	max.	0.1	0.1	0.1	0.1	mA
Emitter cut-off current							
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	max.	0.2	0.2	0.2	0.2	mA
DC current gain (1)							
I_C = 500 mA; V_{CE} = 4 V	h_{FE}	min.	40	40	40	40	
I_C = 2 A; V_{CE} = 4 V	h_{FE}	min.	20	20	20	20	
Base-emitter voltage (1) (2)							
I_C = 2 A; V_{CE} = 4 V	V_{BE}	max.	1.4	1.4	1.4	1.4	V
Collector-emitter saturation voltage (1)							
I_C = 2 A; I_B = 0.2 A	V_{CEsat}	max.	1	1	1	1	V

(1) t_p = 300 μs; $\delta \leqslant 2\%$.
(2) V_{BE} decreases by approximately 2.3 mV/K with increasing temperature.

			BD719	BD721	BD723	BD725	
Transition frequency at f = 1 MHz							
$I_C = 0.5$ A; $V_{CE} = 4$ V	f_T	min.	3	3	3	3	MHz
Switching times							
$I_{Con} = 1$ A;							
$I_{Bon} = -I_{Boff} = 0.1$ A							
Turn-on time	t_{on}	typ.	0.3	0.3	0.3	0.3	μs
Turn-off time	t_{off}	typ.	1.5	1.5	1.5	1.5	μs

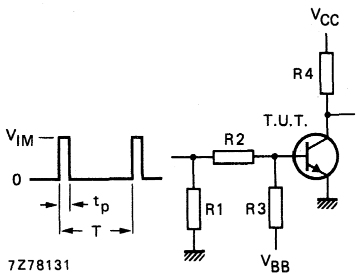


Fig. 2 Test circuit.

V_{IM} = 30 V
V_{CC} = 20 V
$-V_{BB}$ = 3.5 V
R1 = 82 Ω
R2 = 150 Ω
R3 = 39 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

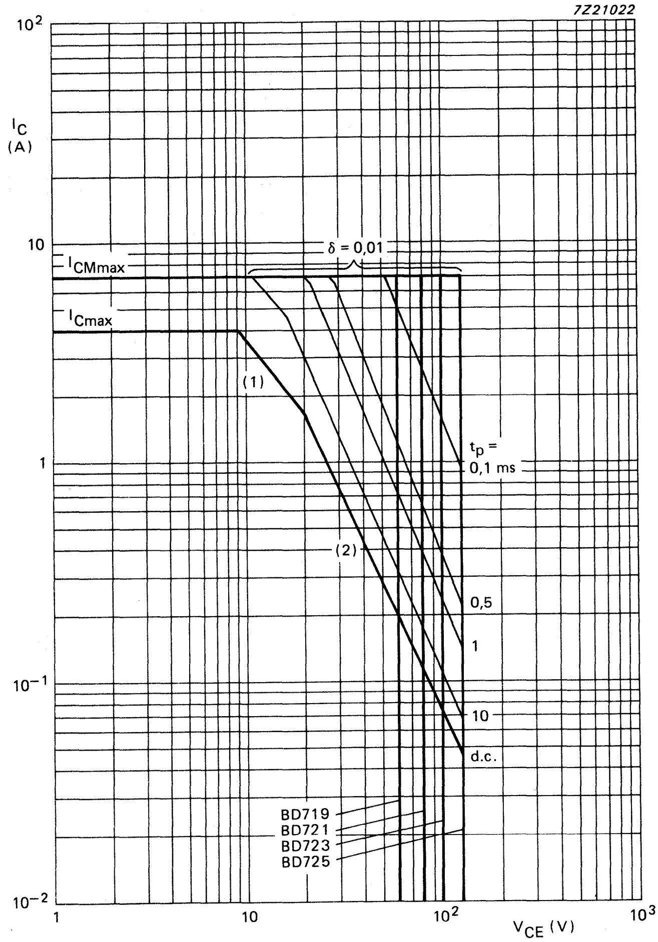


Fig. 3 Safe Operating Area, T_{mb} = 25 °C.

(1) $P_{tot\,max}$ line.
(2) Second-breakdown limits.

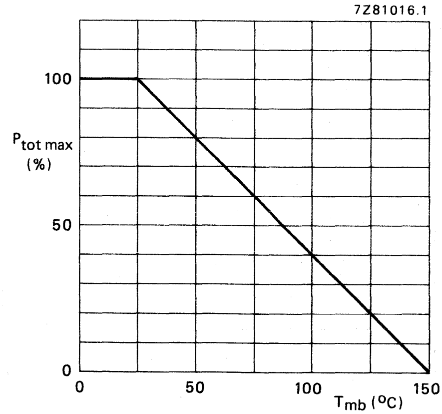


Fig. 4 Power derating curve.

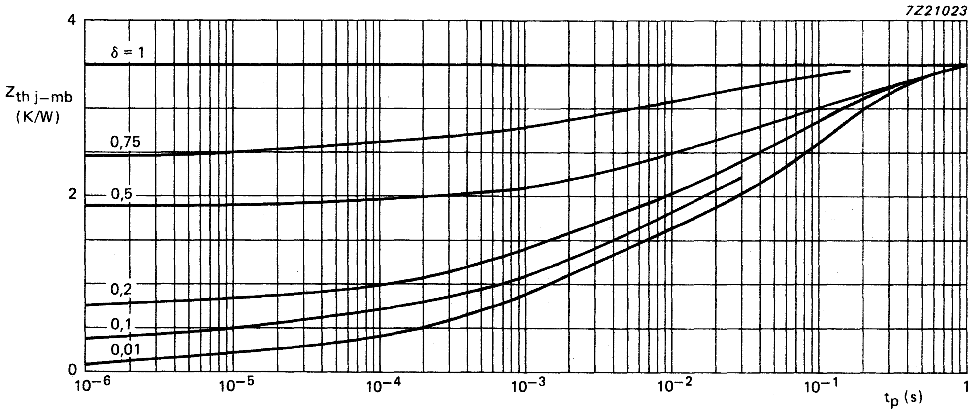


Fig. 5 Pulse power rating chart.

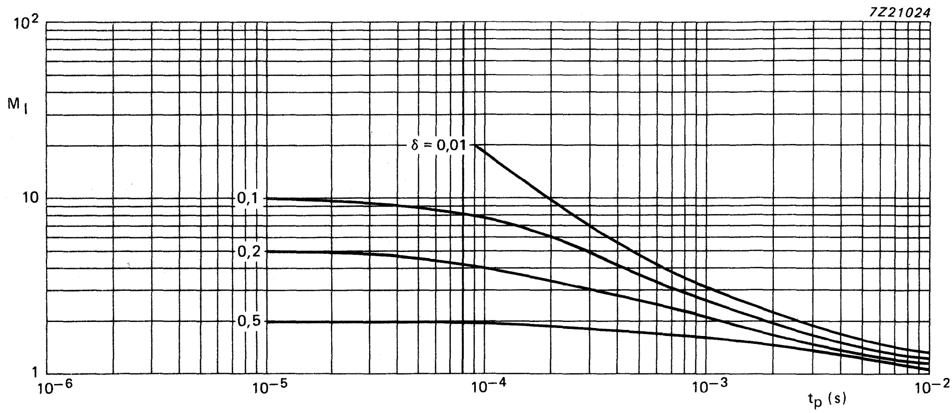


Fig. 6 Second breakdown current multiplying factor at $V_{CEO\,max}$ level.

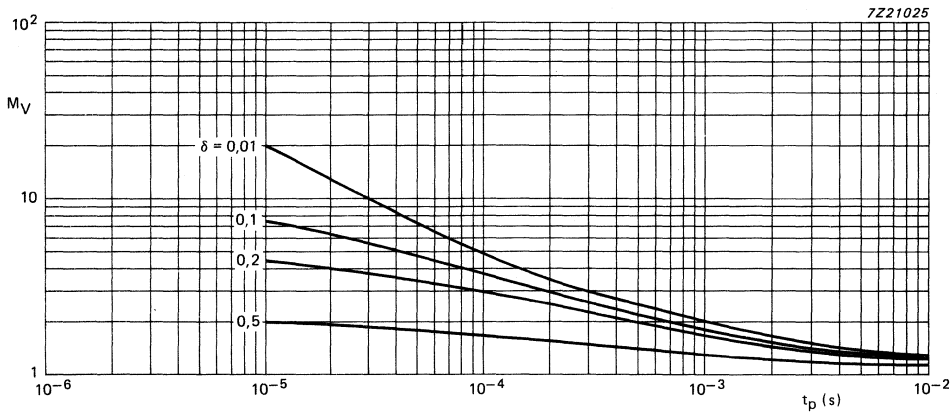


Fig. 7 Second breakdown voltage multiplying factor at $I_{C\,max}$ level.

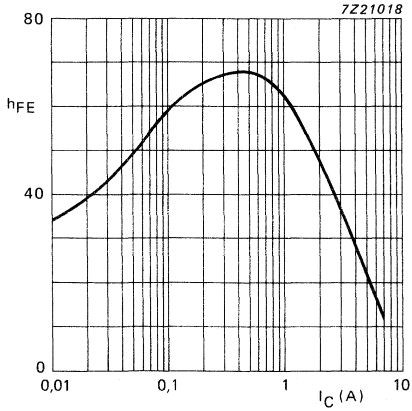


Fig. 8 Typical DC current gain. T_j = 25 °C; V_{CE} = 4 V.

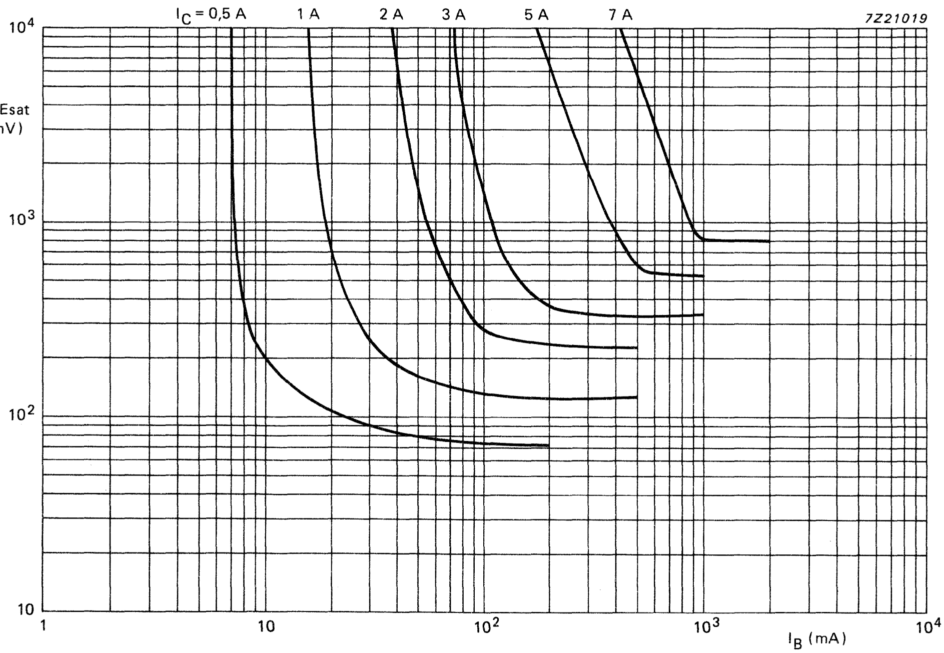


Fig. 9 Typical values collector-emitter saturation. T_j = 25 °C.

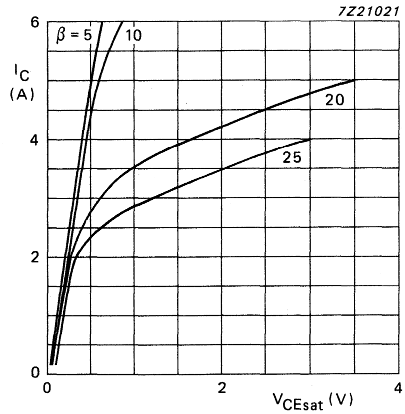


Fig. 10 Typical collector-emitter saturation voltage versus collector current (h_{FE} constant). T_j = 25 °C.

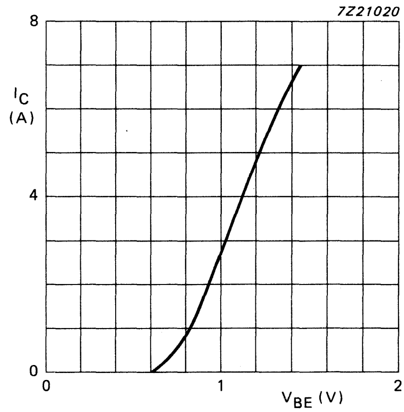


Fig. 11 Collector current. V_{CE} = 4 V; T_j = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

PNP transistor in a SOT32 plastic envelope intended for use in audio output and general purpose amplifier applications. BD720 is equivalent to BD440. NPN complements are BD719; 721; 723 and BD724.

QUICK REFERENCE DATA

			BD720	BD722	BD724	BD726	
Collector-base voltage	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (DC)	$-I_C$	max.	4	4	4	4	A
(peak value)	$-I_{CM}$	max.	7	7	7	7	A
Junction temperature	T_j	max.	150	150	150	150	°C
DC current gain $I_C = -2$ A; $V_{CE} = -4$ V	h_{FE}	min.	20	20	20	20	
Transition frequency $I_C = -0{,}5$ A; $V_{CE} = -4$ V	f_T	min.	3	3	3	3	MHz

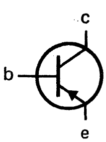
MECHANICAL DATA

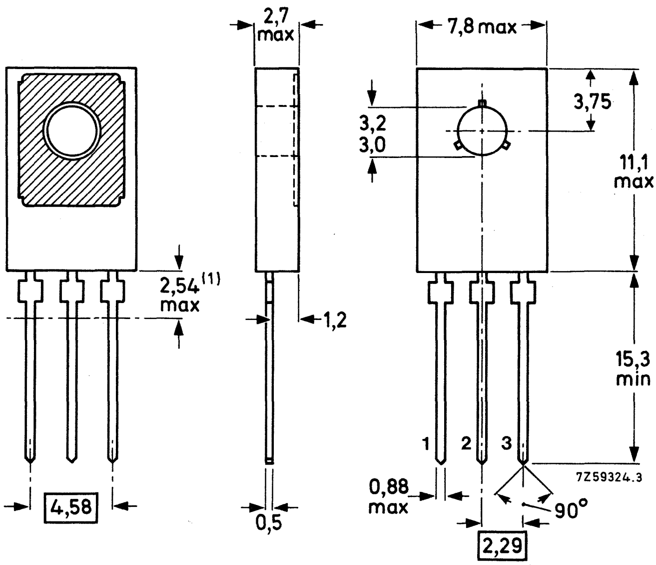
Dimensions in mm

Fig. 1 TO-126 (SOT32).

Collector connected to metal part of mounting surface

Pinning
1 = emitter
2 = collector
3 = base





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

RATINGS

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

			BD720	BD722	BD724	BD726	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	5	5	V

Collector current				
DC value	$-I_C$	max.	4	A
peak value	$-I_{CM}$	max.	7	A
Base current (DC)	$-I_B$	max.	1	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	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	$R_{th\,j\text{-}a}$	max.	100	K/W
From junction to mounting base	$R_{th\,j\text{-}mb}$	max.	3.5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD720	BD722	BD724	BD726	
Collector cut-off current							
$I_E = 0; -V_{CB} = -V_{CBO}$	$-I_{CBO}$	max.	50	50	50	50	µA
$I_E = 0; -V_{CB} = -½\,V_{CBO}$; T_j = 150 °C;	$-I_{CBO}$	max.	1	1	1	1	mA
$I_B = 0; -V_{CE} = -½\,V_{CEO}$	$-I_{CEO}$	max.	0.1	0.1	0.1	0.1	mA
Emitter cut-off current							
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	max.	0.2	0.2	0.2	0.2	mA
DC current gain (1)							
$-I_C = 0.5$ A; $-V_{CE} = 4$ V	h_{FE}	min.	40	40	40	40	
$-I_C = 2$ A; $-V_{CE} = 4$ V	h_{FE}	min.	20	20	20	20	
Base-emitter voltage (1) (2)							
$-I_C = 2$ A; $-V_{CE} = 4$ V	$-V_{BE}$	max.	1.4	1.4	1.4	1.4	V
Collector-emitter saturation voltage (1)							
$-I_C = 2$ A; $-I_B = 0.2$ A	$-V_{CEsat}$	max.	1	1	1	1	V

(1) t_p = 300 µs; $\delta \leqslant 2\%$.
(2) V_{BE} decreases by about 2.3 mV/K with increasing temperature.

			BD720	BD722	BD724	BD726	
Transition frequency at f = 1 MHz							
$-I_C$ = 0.5 A; $-V_{CE}$ = 4 V	f_t	min.	3	3	3	3	MHz
Switching times							
$-I_{Con}$ = 1 A;							
$-I_{Bon}$ = I_{Boff} = 0.1 A							
Turn-on time	t_{on}	typ.	0.1	0.1	0.1	0.1	μs
Turn-off time	t_{off}	typ.	0.4	0.4	0.4	0.4	μs

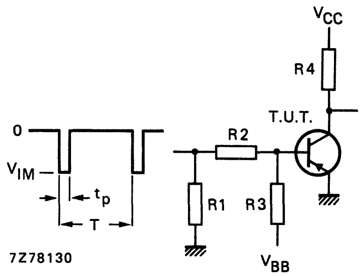


Fig. 2 Switching times test circuit.

$-V_{IM}$ = 30 V
$-V_{CC}$ = 20 V
$+V_{BB}$ = 3.5 V
R1 = 82 Ω
R2 = 150 Ω
R3 = 39 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

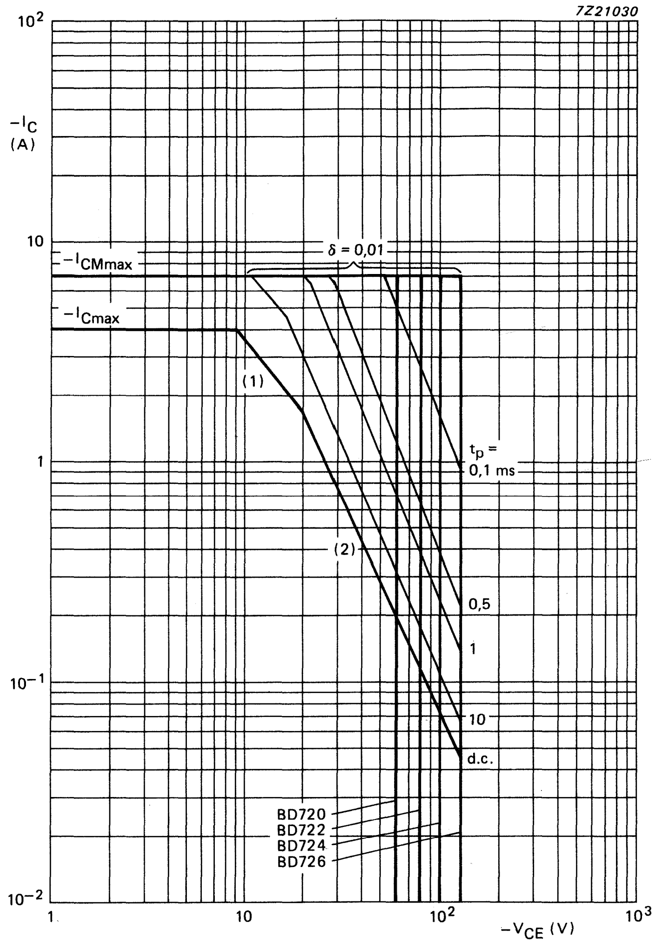


Fig. 3 Safe Operating Area, T_{mb} = 25 °C.

(1) $P_{tot\,max}$ line.
(2) Second-breakdown limits.

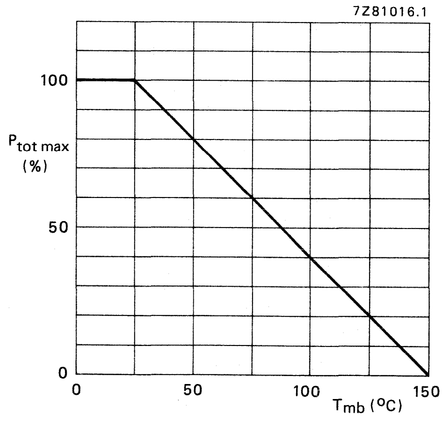


Fig. 4 Power derating curve.

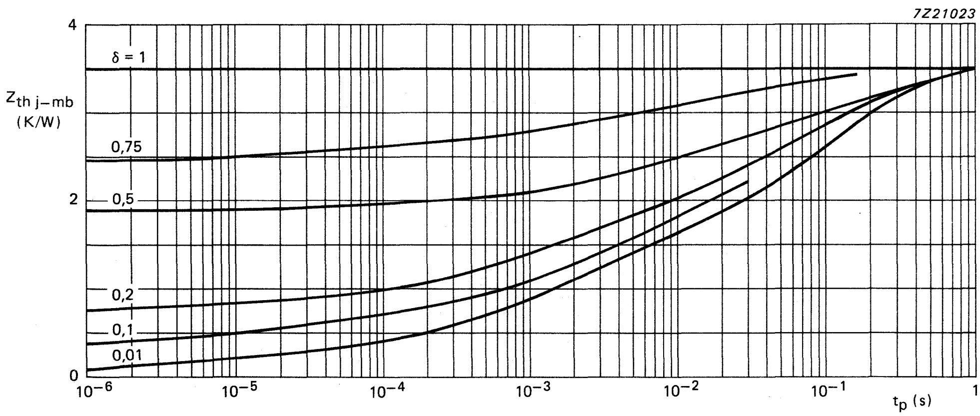


Fig. 5 Pulse power rating chart.

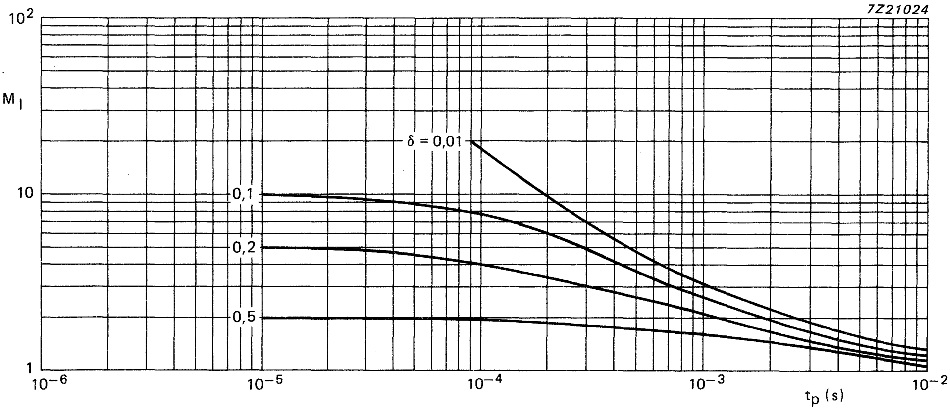


Fig. 6 Second breakdown current multiplying factor at $V_{CEO\,max}$ level.

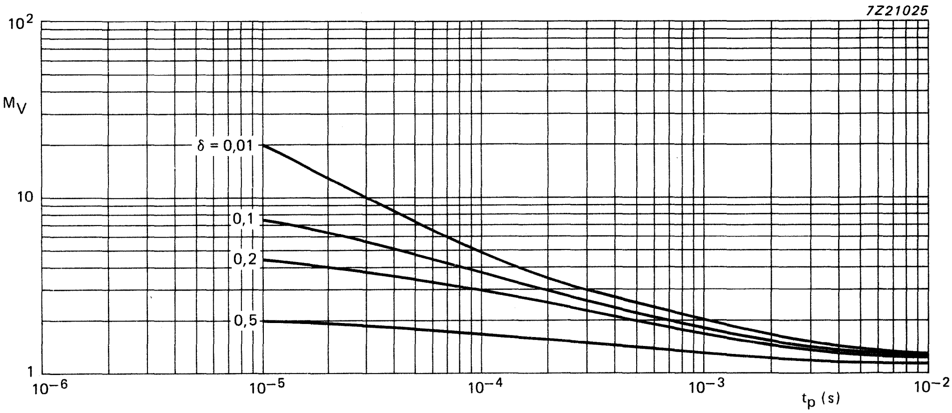


Fig. 7 Second breakdown voltage multiplying factor at $I_{C\,max}$ level.

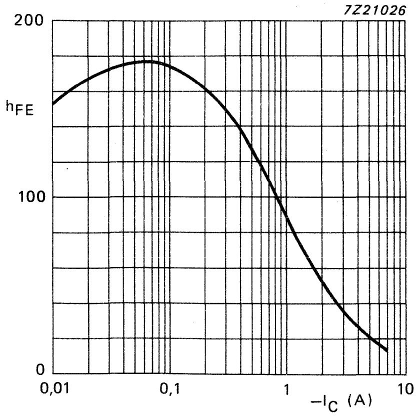


Fig. 8 Typical DC current gain. T_j = 25 °C; V_{CE} = 4 V.

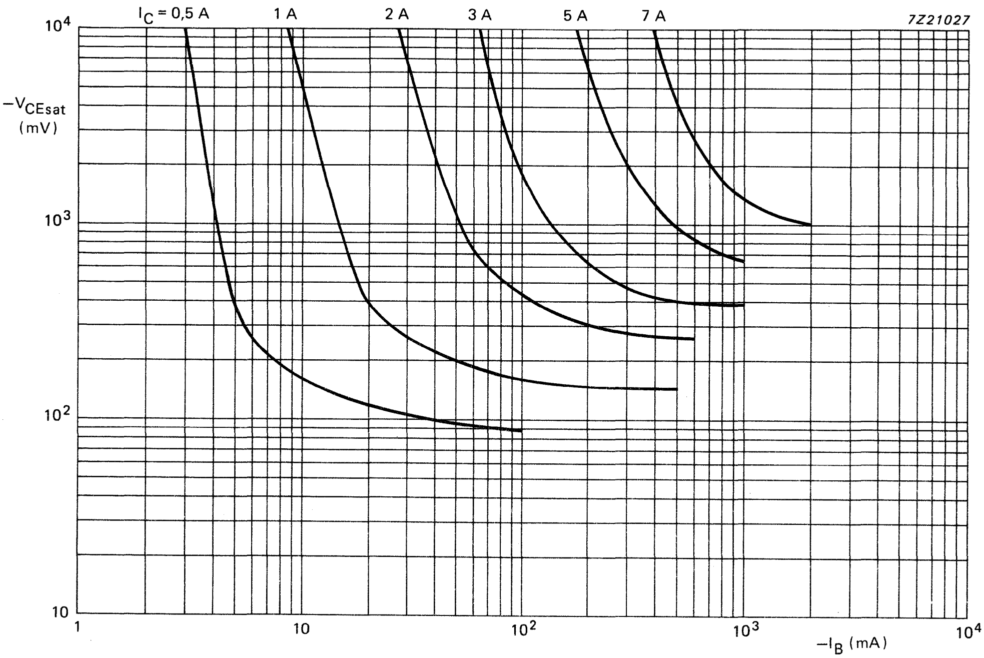


Fig. 9 Typical values collector-emitter saturation. T_j = 25 °C.

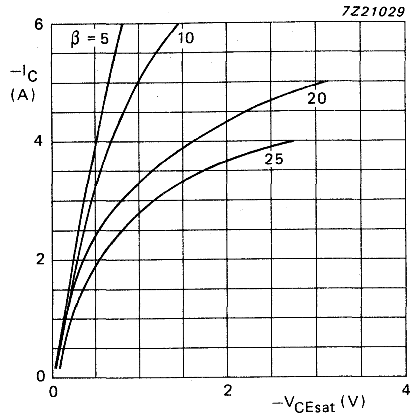


Fig. 10 Typical collector-emitter saturation voltage versus collector current (h_{FE} constant). T_j = 25 °C.

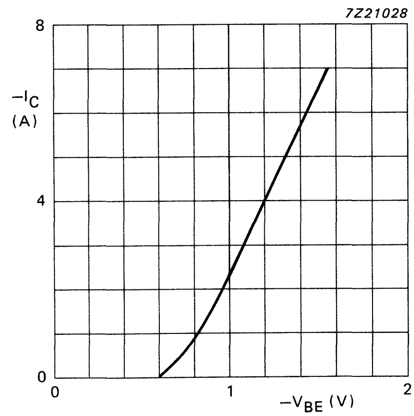


Fig. 11 Collector current. V_{CE} = 4 V; T_j = 25 °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose N-P-N transistors, in TO-202 plastic envelopes, recommended for driver-stages in hi-fi amplifiers and television circuits.

P-N-P complements are BD826, BD828 and BD830. Matched pairs can be supplied.

QUICK REFERENCE DATA

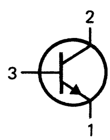
			BD825	BD827	BD829	
Collector-base voltage	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		1,5		A
Total power dissipation						
at T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
at T_{mb} = 50 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 150 mA; V_{CE} = 2 V	h_{FE}			40 to 250		
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		250		MHz

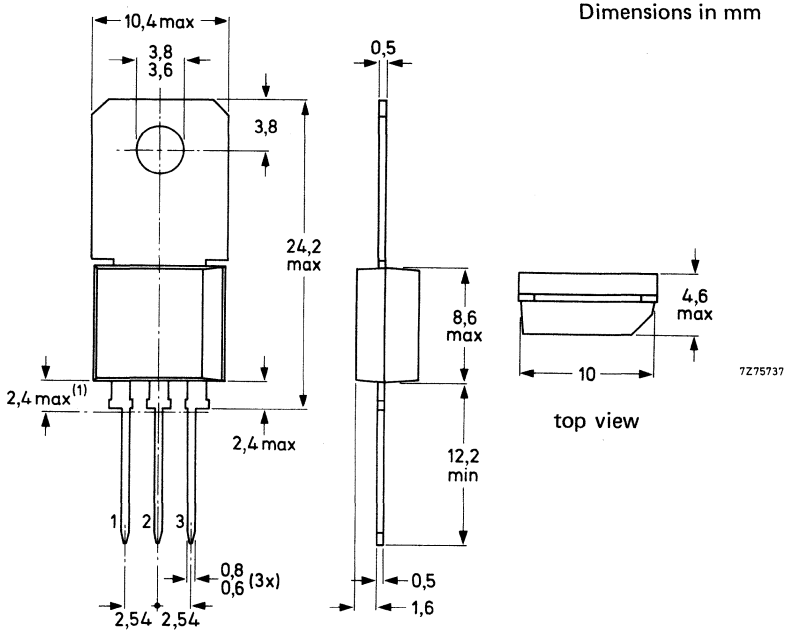
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD825	BD827	BD829	
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 (d.c.)	I_C	max.		1,0		A
Collector current (peak)	I_{CM}	max.		1,5		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 50 °C	P_{tot}	max.		8		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	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents			
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	100 nA
I_E = 0; V_{CB} = 30 V; T_j = 125 °C	I_{CBO}	<	10 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10 μA
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 to 250
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	>	25
Collector-emitter saturation voltage			
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5 V
Base-emitter voltage			
I_C = 500 mA; V_{CE} = 2 V	V_{BE}	<	1 V
Transition frequency at f = 35 MHz			
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250 MHz
D.C. current gain ratio of matched complementary pairs			
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	typ.	1,3
		<	1,6

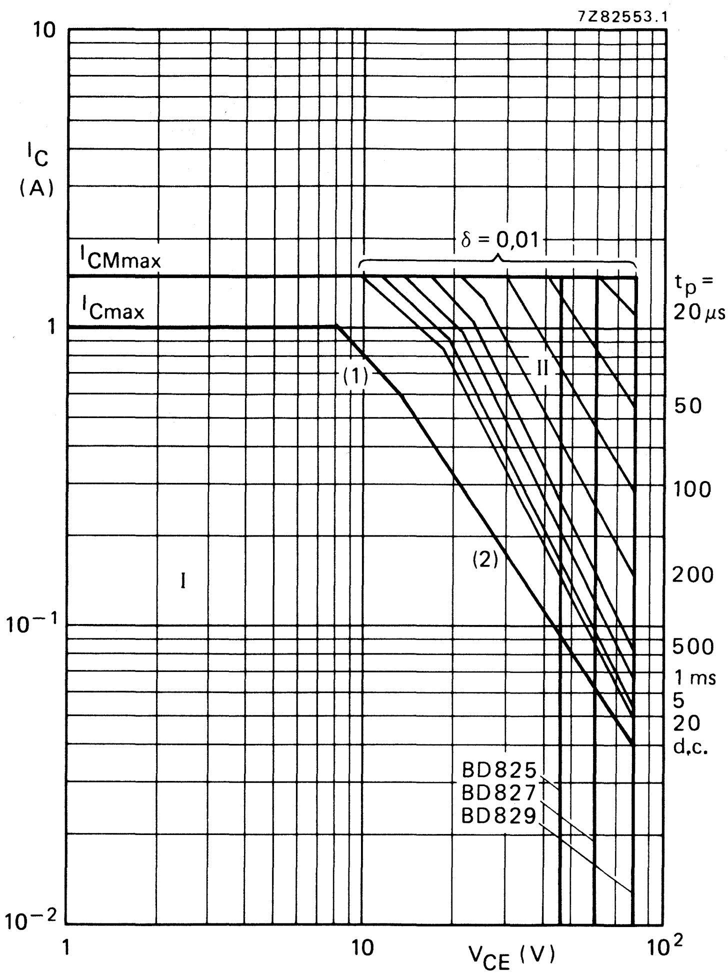


Fig. 2 Safe Operating Area, $T_{mb} \leqslant 25$ °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

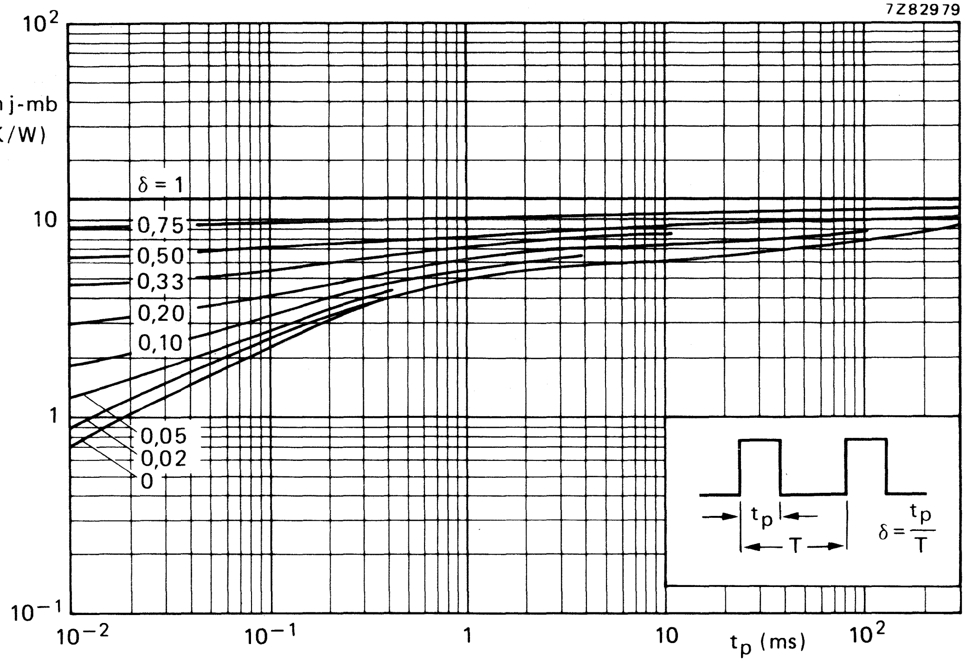


Fig. 3 Pulse power rating chart.

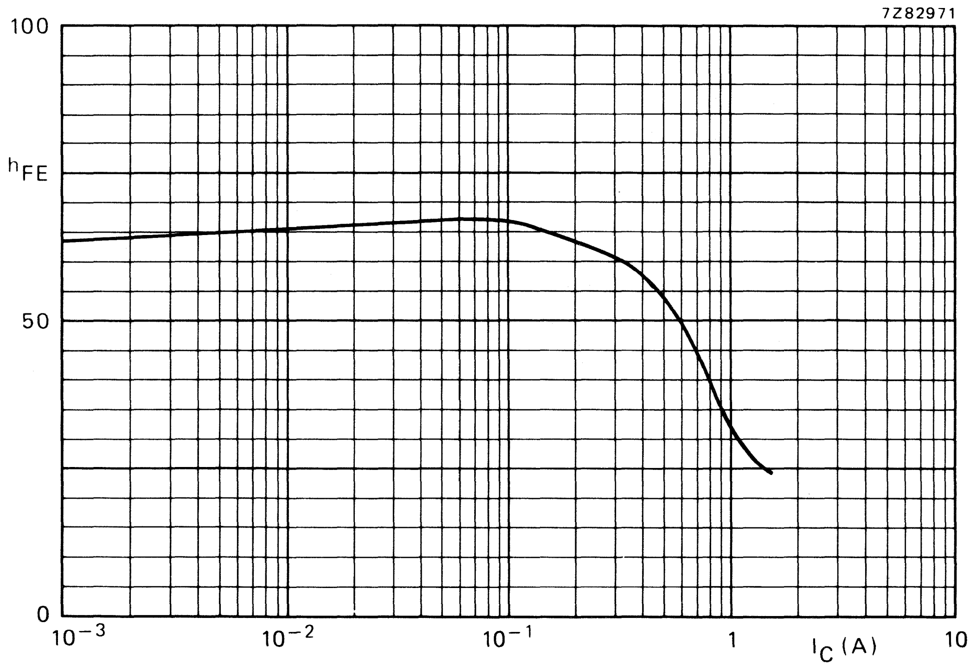


Fig. 4 Typical values d.c. current gain. $V_{CE} = 2$ V; $T_{amb} = 25$ °C.

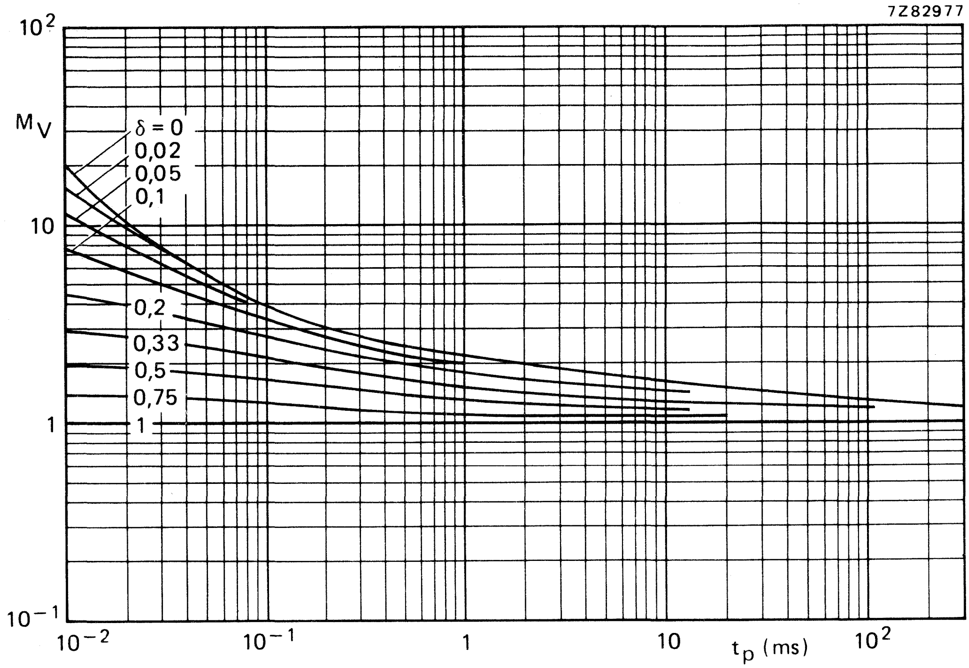


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

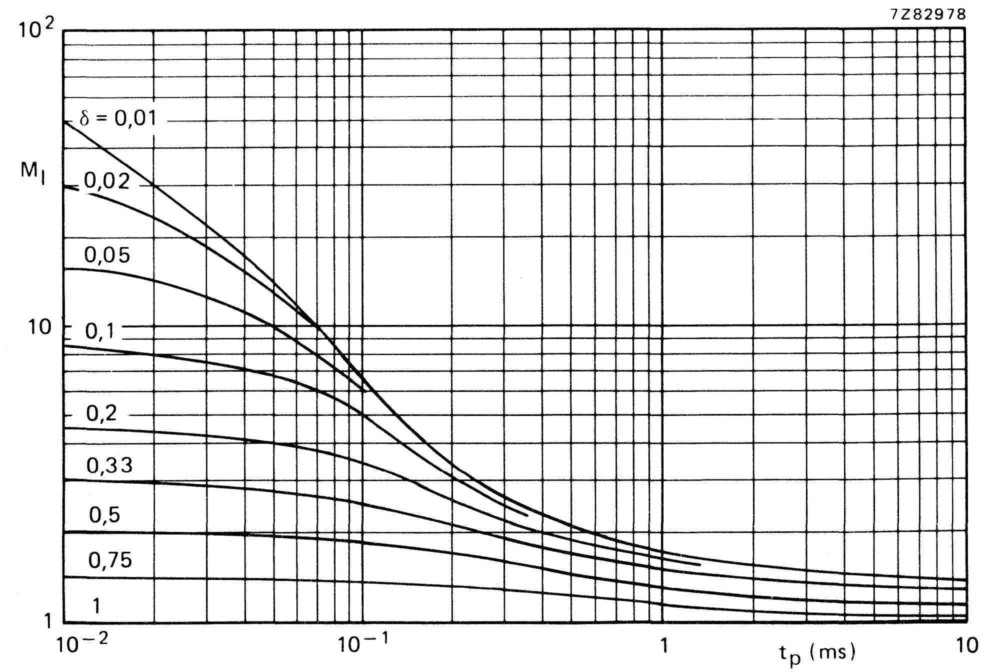


Fig. 6 S.B. current multiplying factor at V_{CEOmax} level.

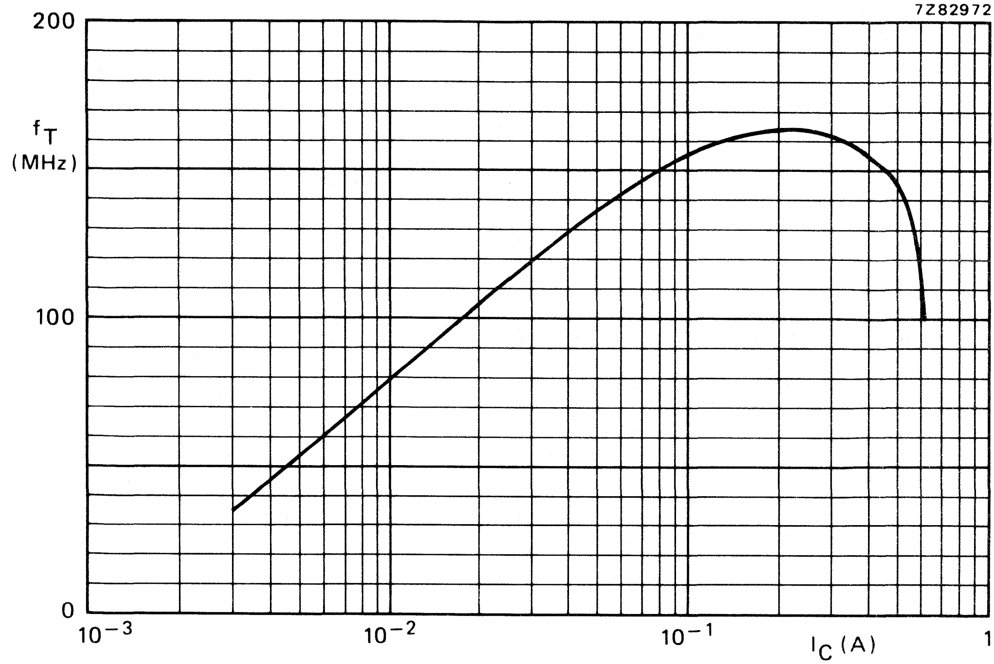


Fig. 7 Typical values transition frequency. V_{CE} = 5 V; f = 35 MHz; T_{amb} = 25 °C.

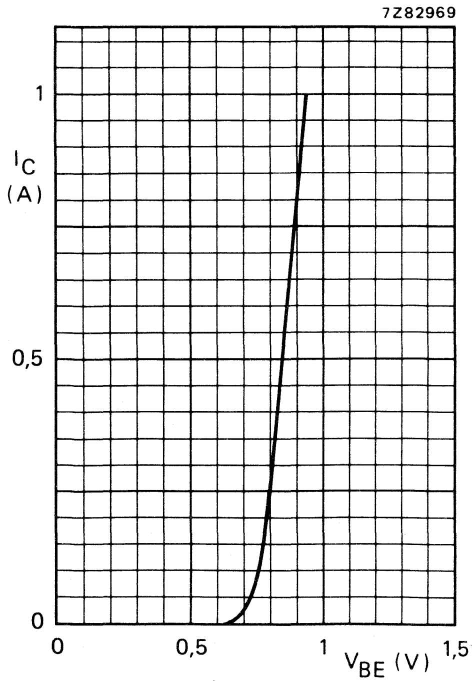


Fig. 8 Typical values. V_{CE} = 2 V; T_{amb} = 25 °C.

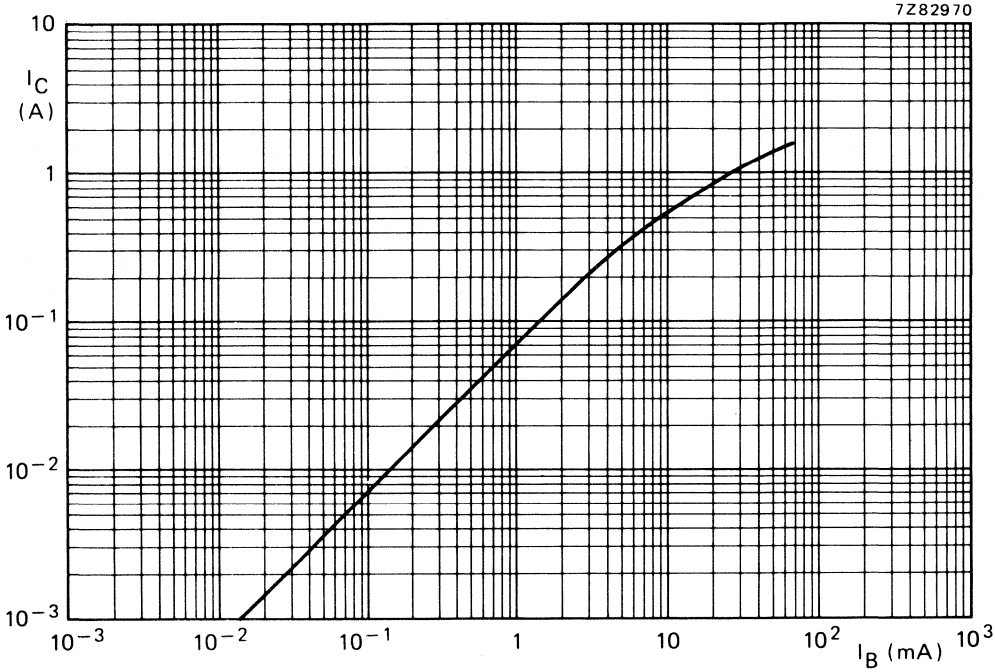


Fig. 9 Typical values at V_{CE} = 2 V; T_{amb} = 25 °C:

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose P-N-P transistors, in TO-202 plastic envelopes, recommended for driver stages in hi-fi amplifiers and television circuits.

N-P-N complements are BD825, BD827 and BD829. Matched pairs can be supplied.

QUICK REFERENCE DATA

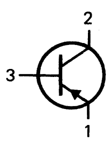
			BD826	BD828	BD830	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		1,5		A
Total power dissipation						
at T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
at T_{mb} = 50 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}			40 to 250		
Transition frequency						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.		75		MHz

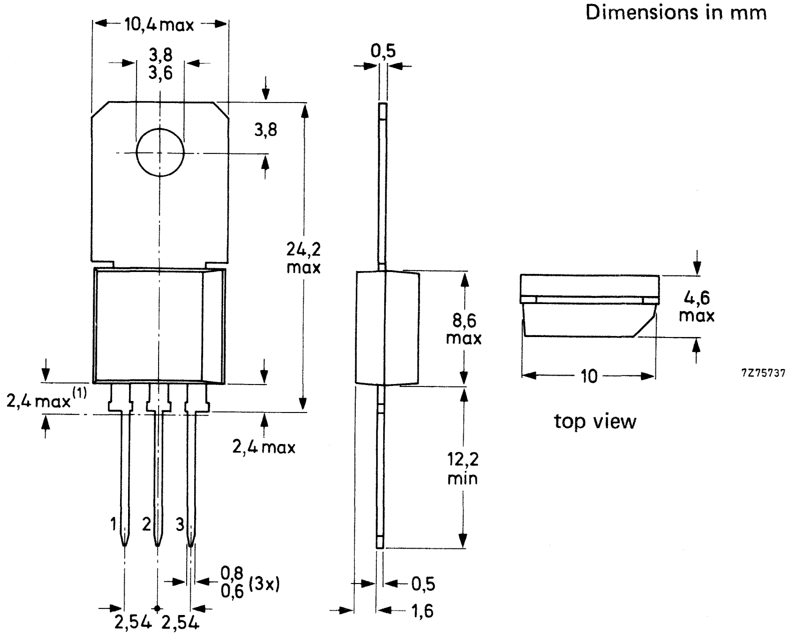
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD826	BD828	BD830	
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
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
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.	2			W
T_{mb} = 50 °C	P_{tot}	max.	8			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	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

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; $T_j = 125$ °C	$-I_{CBO}$	<	10	μA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
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 to 250	
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25	
Collector-emitter saturation voltage				
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,5	V
Base-emitter voltage				
$-I_C = 500$ mA; $-V_{CE} = 2$ V	$-V_{BE}$	<	1	V
Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	75	MHz
D.C. current gain ratio of matched complementary pairs				
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ. <	1,3 1,6	

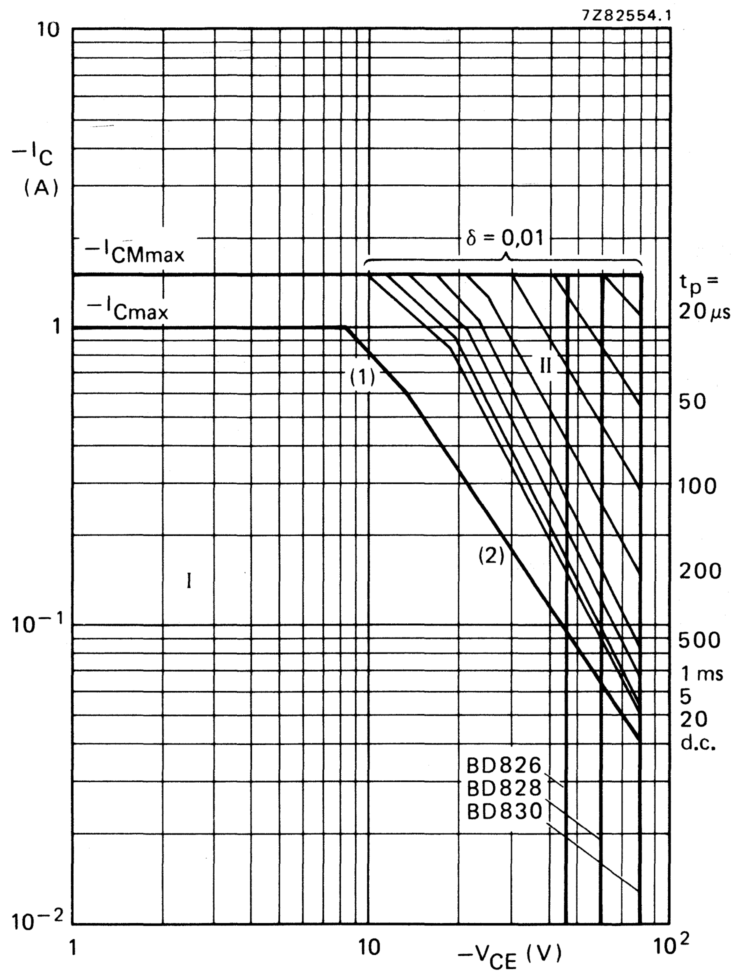


Fig. 2 Safe Operating Area, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetition pulse operation.

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

(2) Second-breakdown limits.

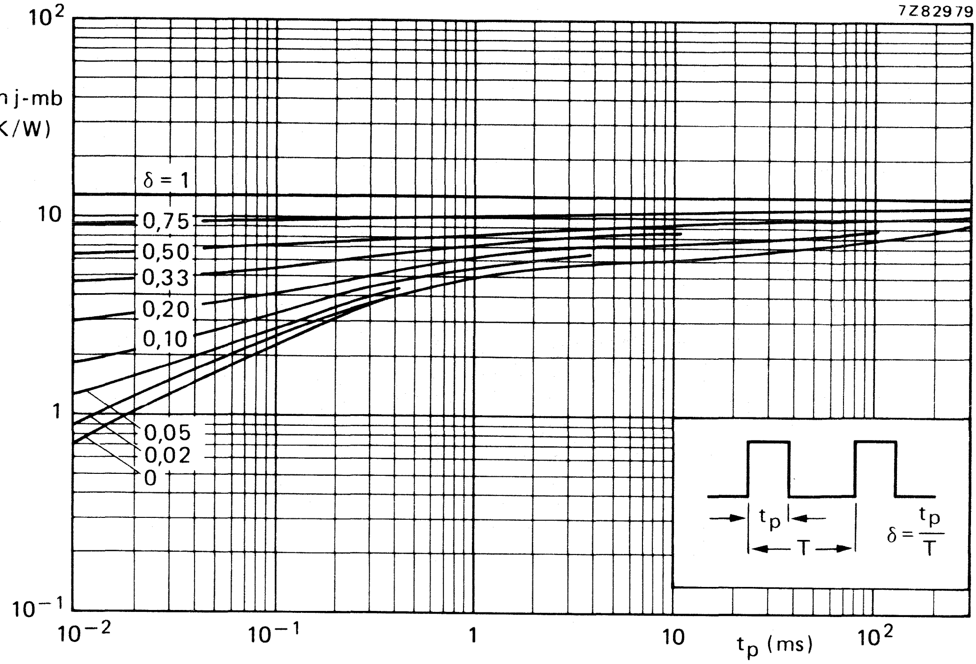


Fig. 3 Pulse power rating chart.

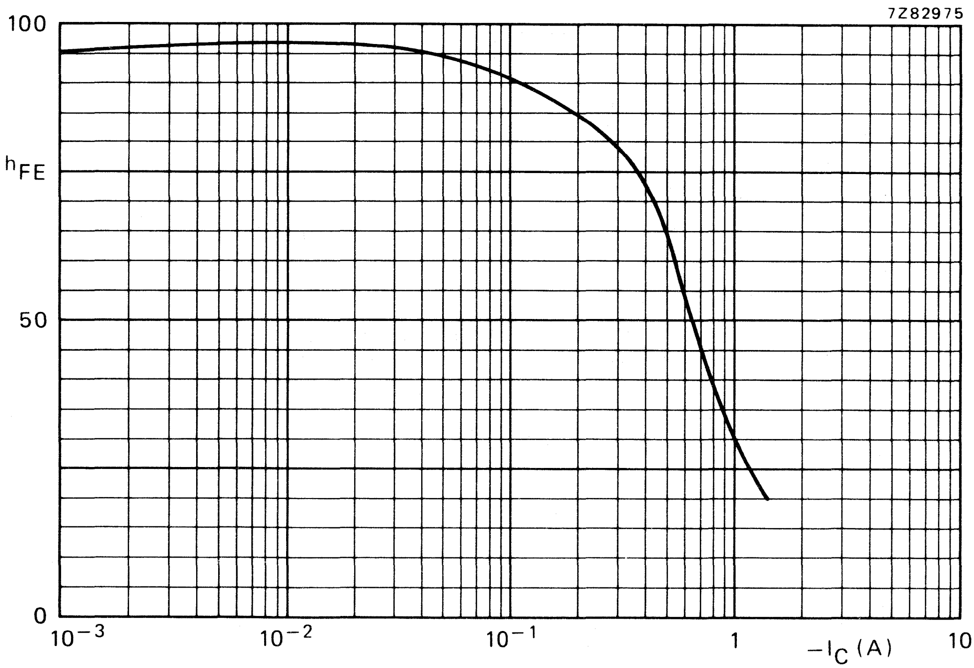


Fig. 4 Typical values d.c. current gain. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

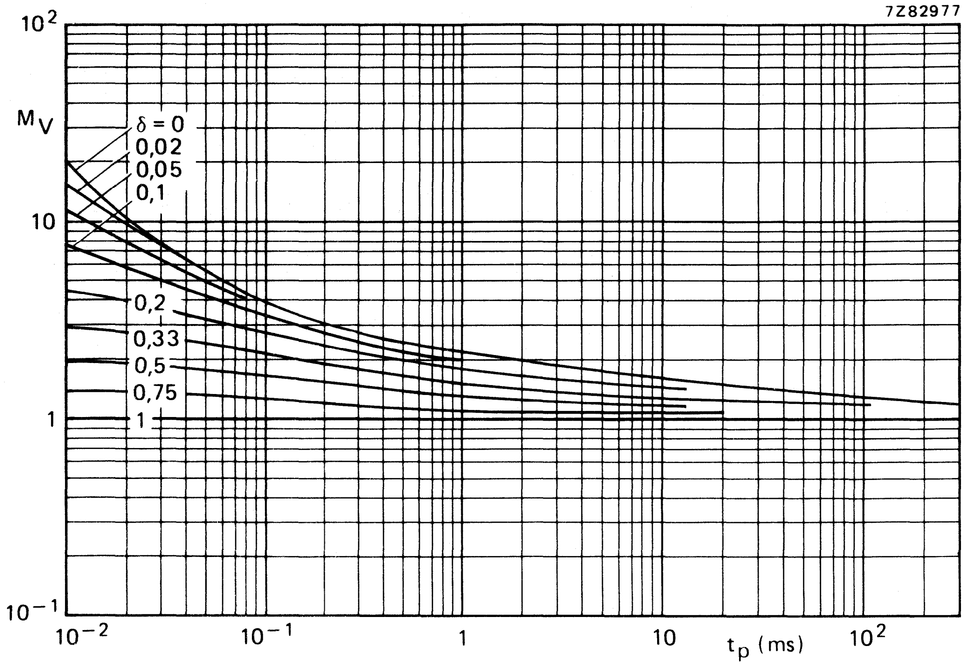


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

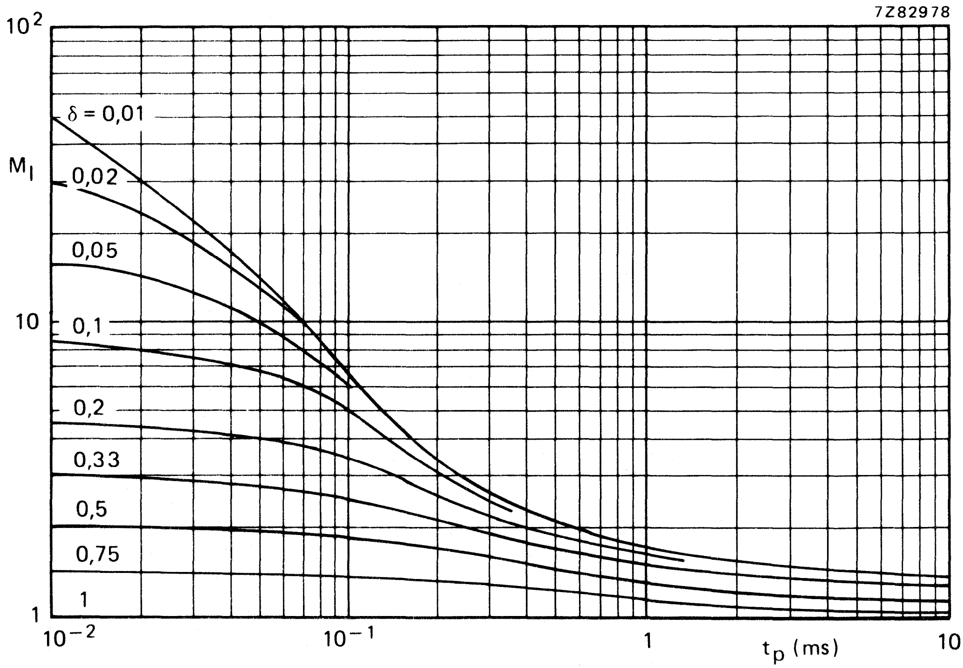


Fig. 6 S.B. current multiplying factor at V_{CEOmax} level.

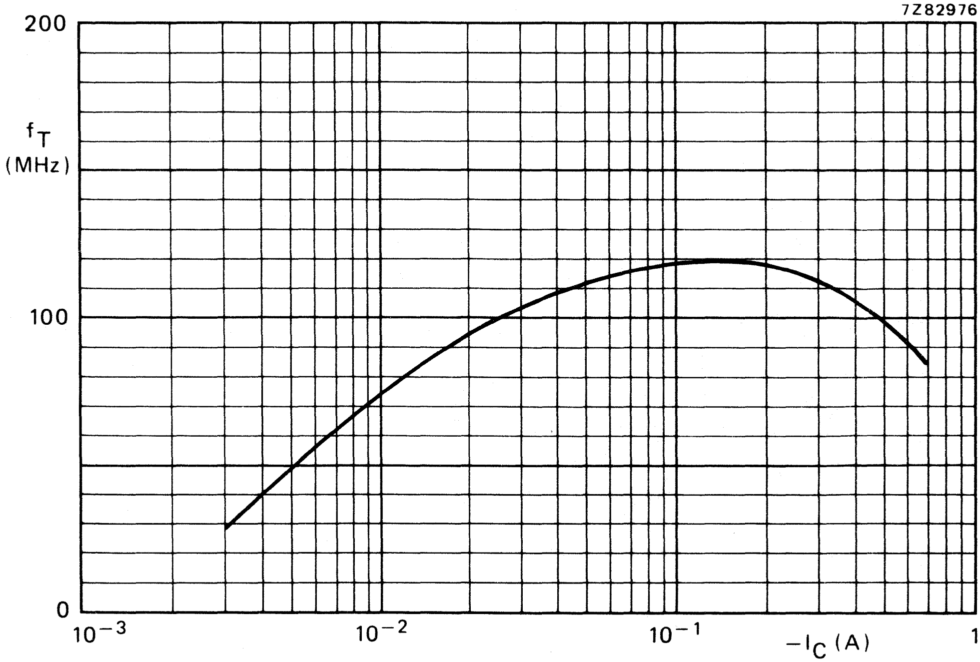


Fig. 7 Typical values transition frequency at $-V_{CE}$ = 5 V; f = 35 MHz; T_{amb} = 25 °C.

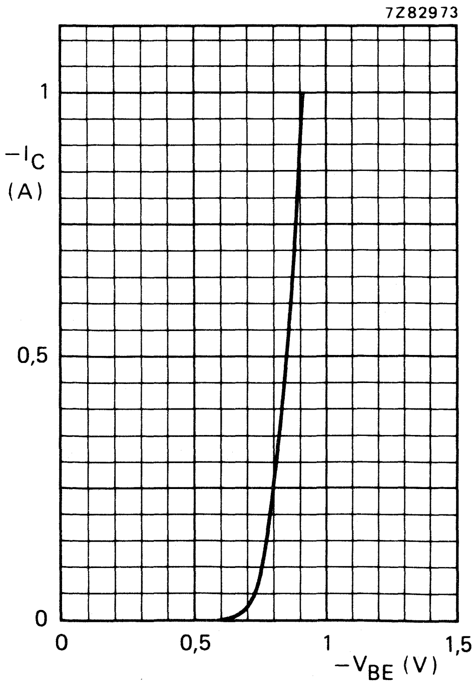


Fig. 8 Typical values. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

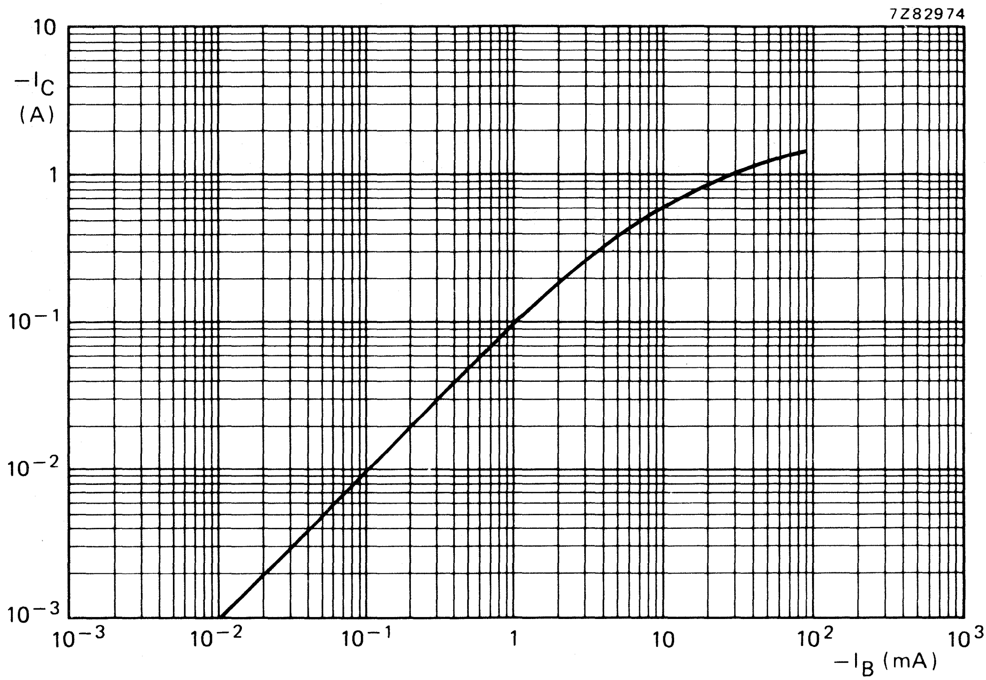


Fig. 9 Typical values at $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N silicon transistors, in a plastic TO-202 envelope, recommended for use in television circuits and audio applications.
P-N-P complements are BD840, BD842 and BD844.

QUICK REFERENCE DATA

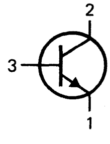
			BD839	BD841	BD843	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency at f = 35 MHz						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		125		MHz

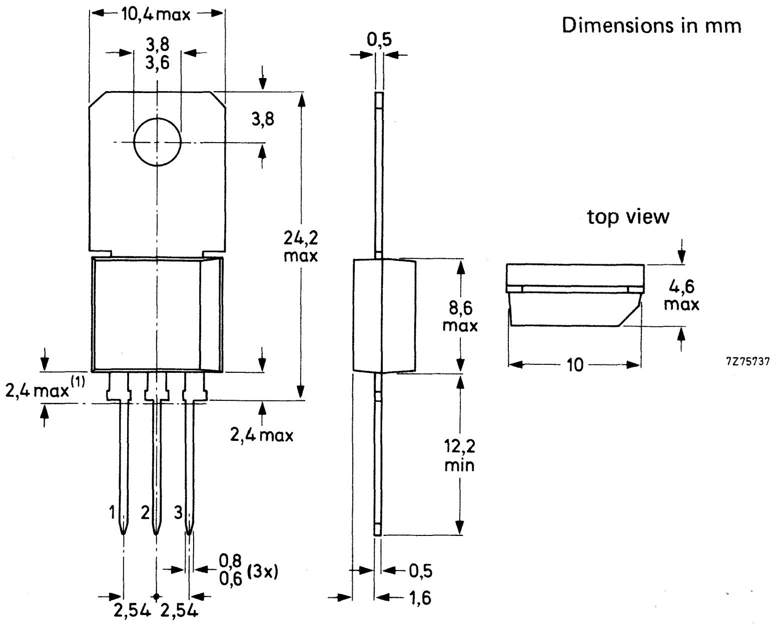
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD839	BD841	BD843	
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
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		1,5		A
Collector current (peak value)	I_{CM}	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		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	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

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 = 125 °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 = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3 V
Collector-emitter saturation voltage			
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,8 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 to 250
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	125 MHz
D.C. current gain ratio of BD839/BD840, BD841/BD842, BD843/BD844		typ.	1,3
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6

* V_{BE} decreases by about 2,3 mV/K with increasing temperature.

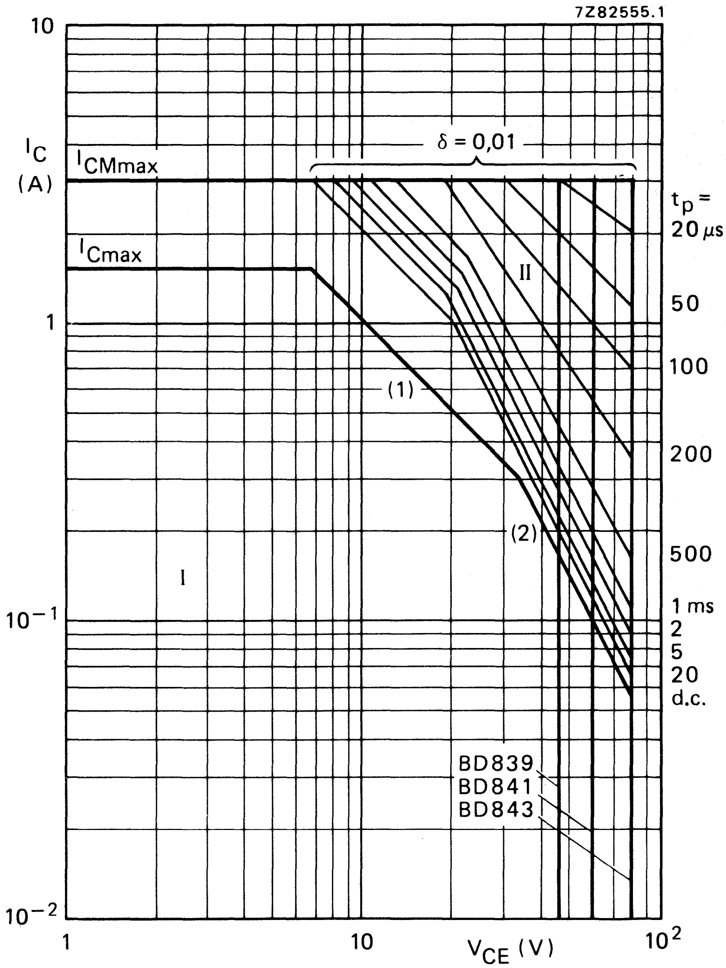


Fig. 2 Safe Operating Area, $T_{mb} \leqslant 25\ ^{o}C$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

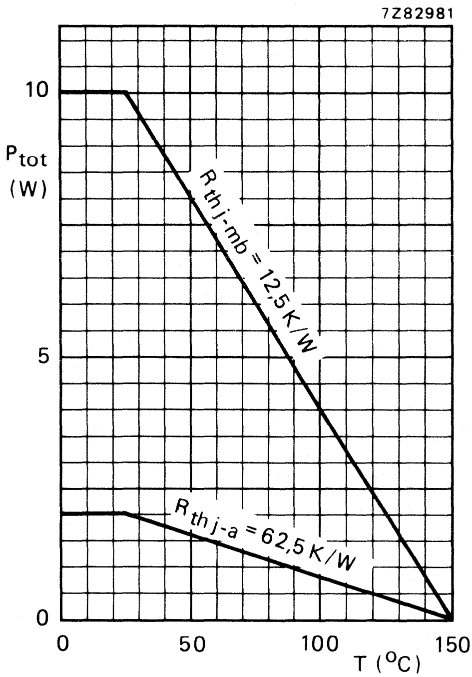


Fig. 3 Power derating curve.

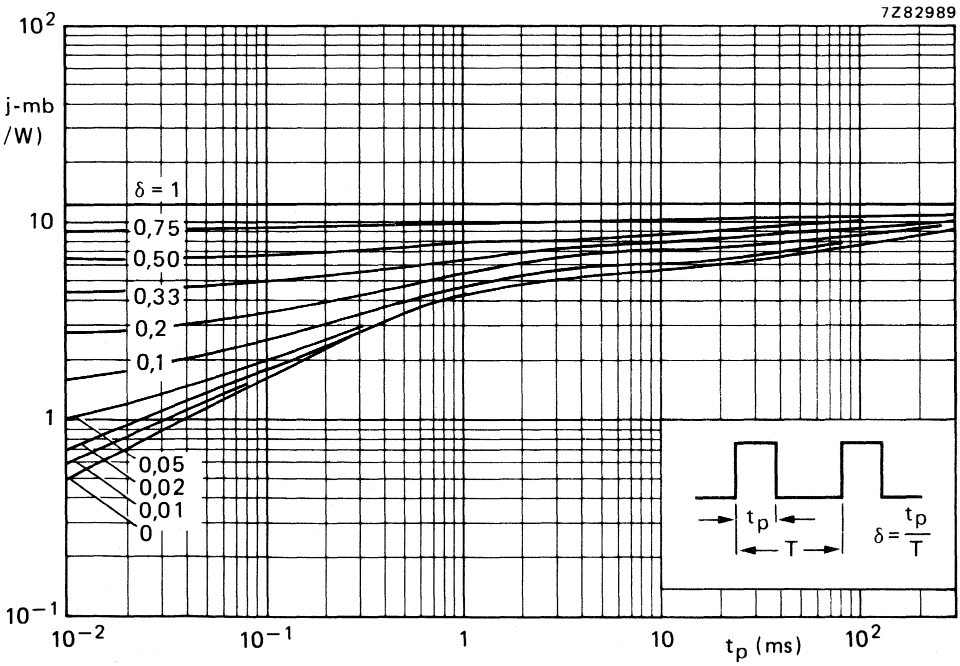


Fig. 4 Pulse power rating chart.

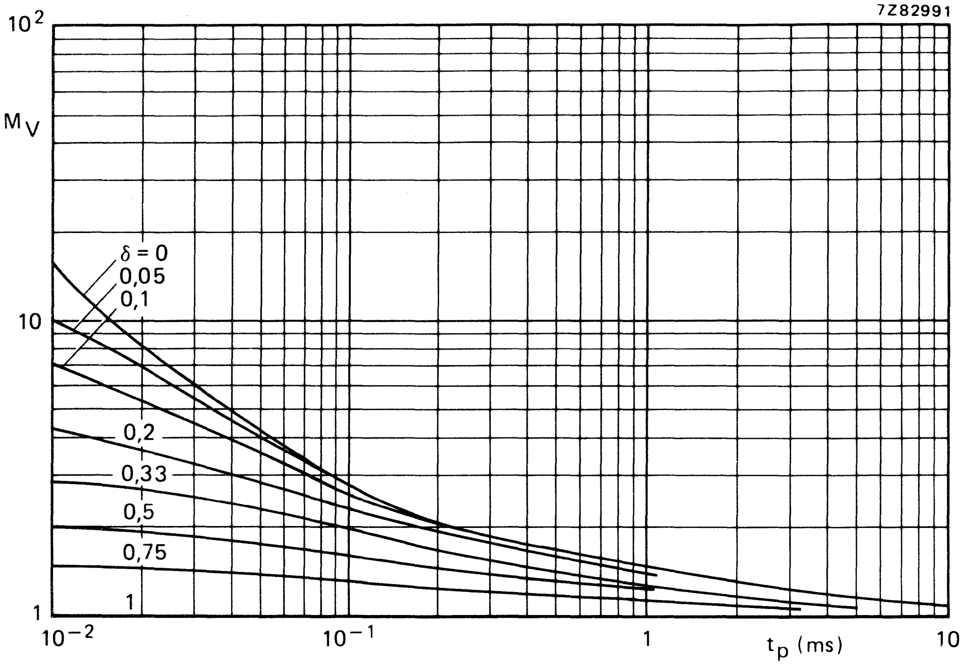


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

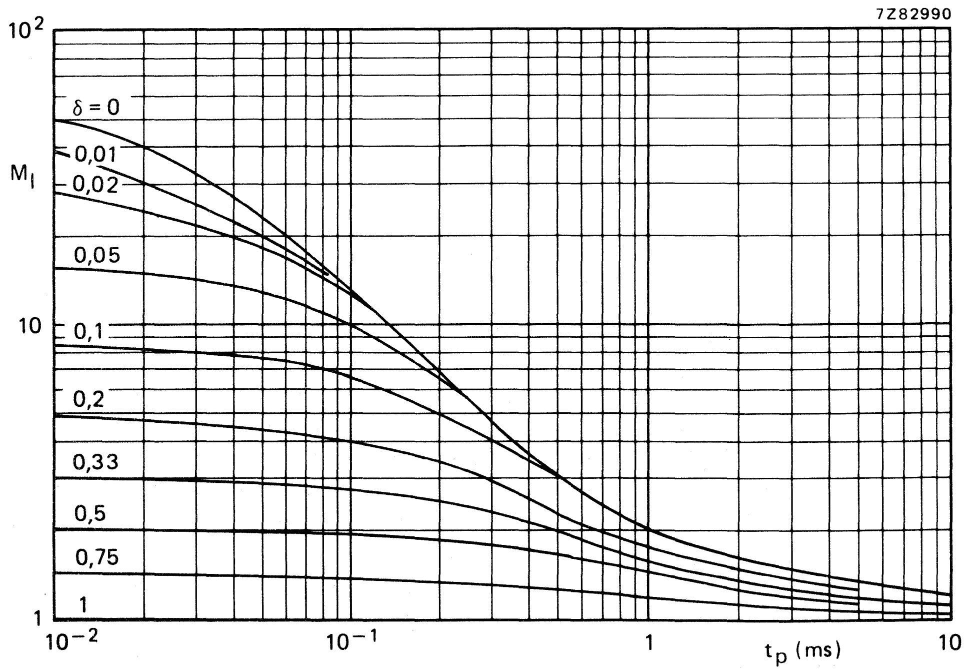


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

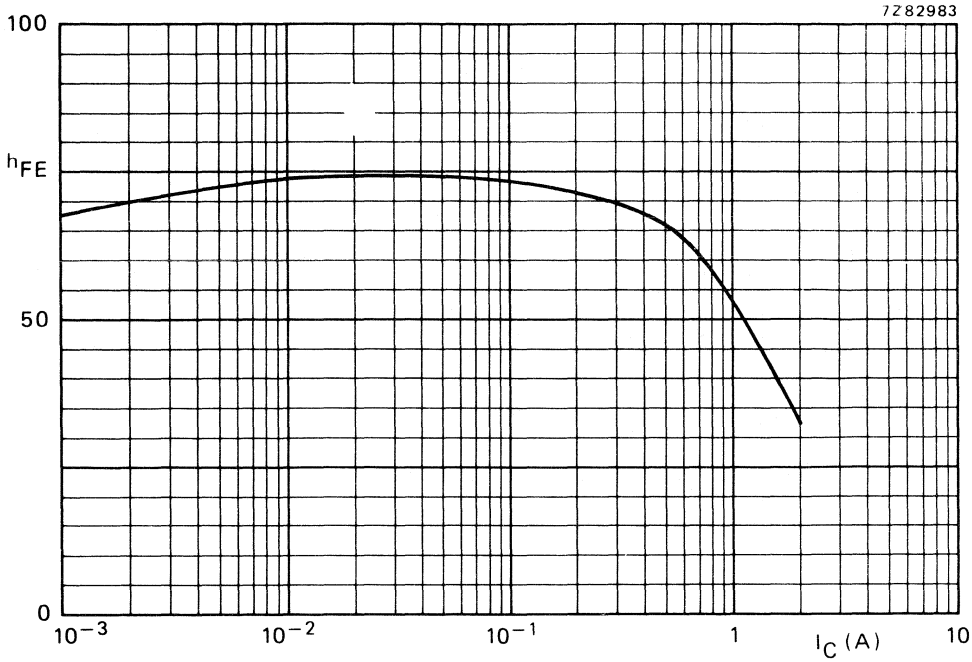


Fig. 7 Typical values d.c. current gain. V_{CE} = 2 V; T_{amb} = 25 °C.

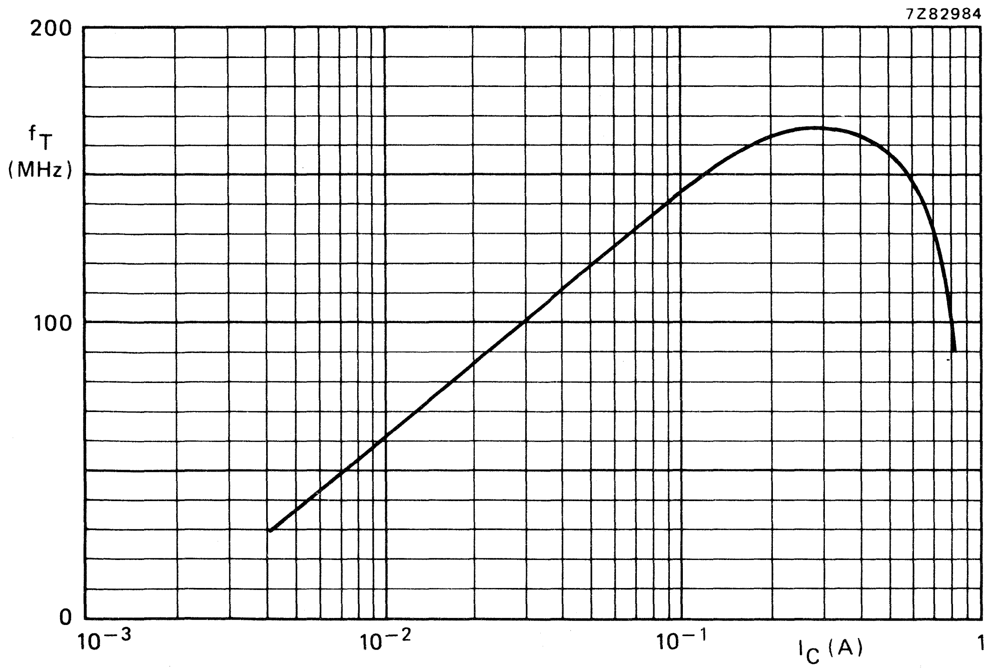


Fig. 8 Typical values transition frequency. V_{CE} = 5 V; T_{amb} = 25 °C; f = 35 MHz.

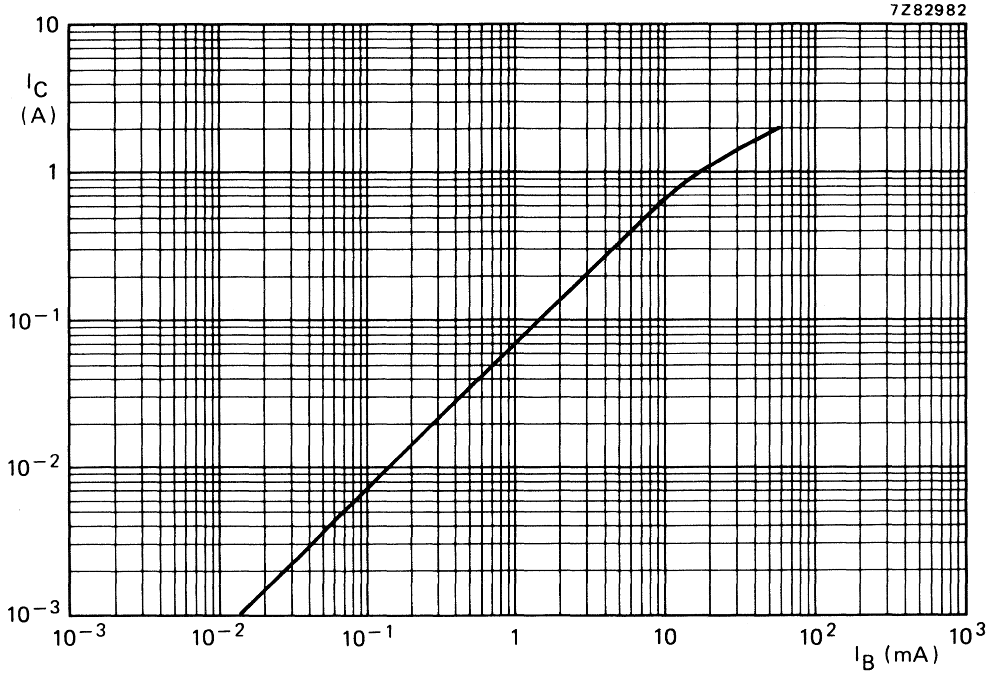


Fig. 9 Typical values at V_{CE} = 2 V; T_{amb} = 25 °C.

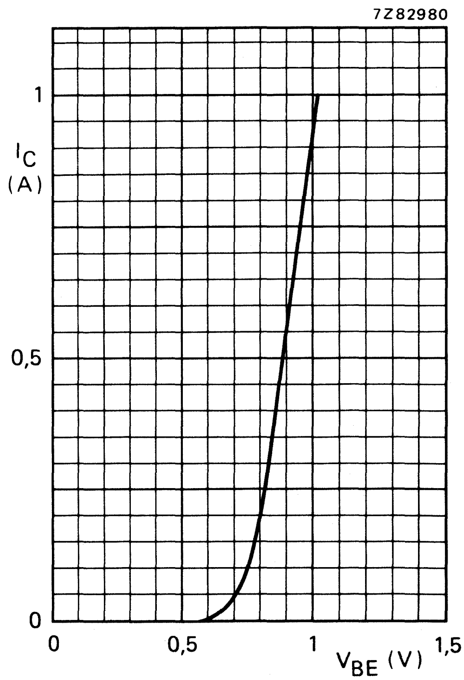


Fig. 10 Typical values. V_{CE} = 2 V; T_{amb} = 25 °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

P-N-P silicon transistors, in a plastic TO-202 envelope, recommended for use in television circuits and audio applications.
N-P-N complements are BD839, BD841 and BD843.

QUICK REFERENCE DATA

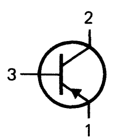
			BD840	BD842	BD844	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	5	V
Collector current (peak value)	$-I_{CM}$	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency at f = 35 MHz	f_T	typ.		50		MHz

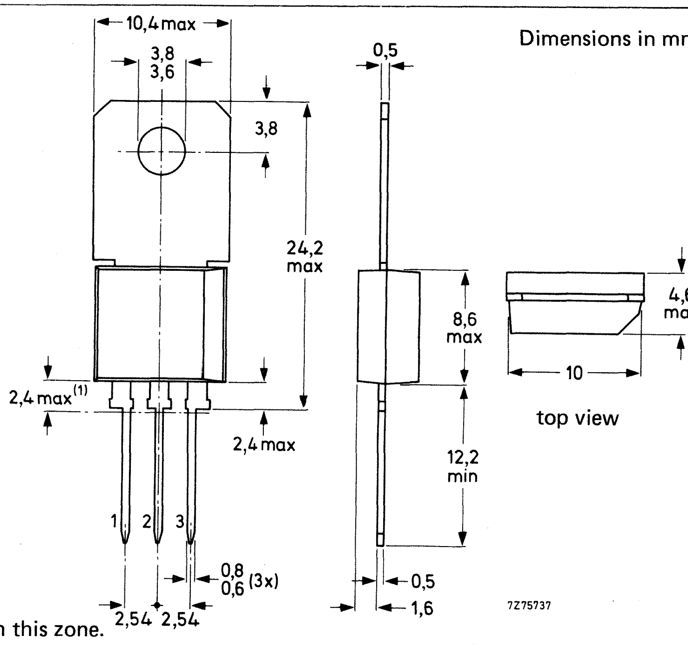
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD840	BD842	BD844	
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
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		1,5		A
Collector current (peak value)	$-I_{CM}$	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		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	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

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; $T_j = 125$ °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base-emitter voltage*			
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3 V
Collector-emitter saturation voltage			
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,8 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 to 250
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	50 MHz
D.C. current gain ratio			
of BD839/BD840, BD841/BD842, BD843/BD844		typ.	1,3
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	<	1,6

* V_{BE} decreases by about 2,3 mV/K with increasing temperature.

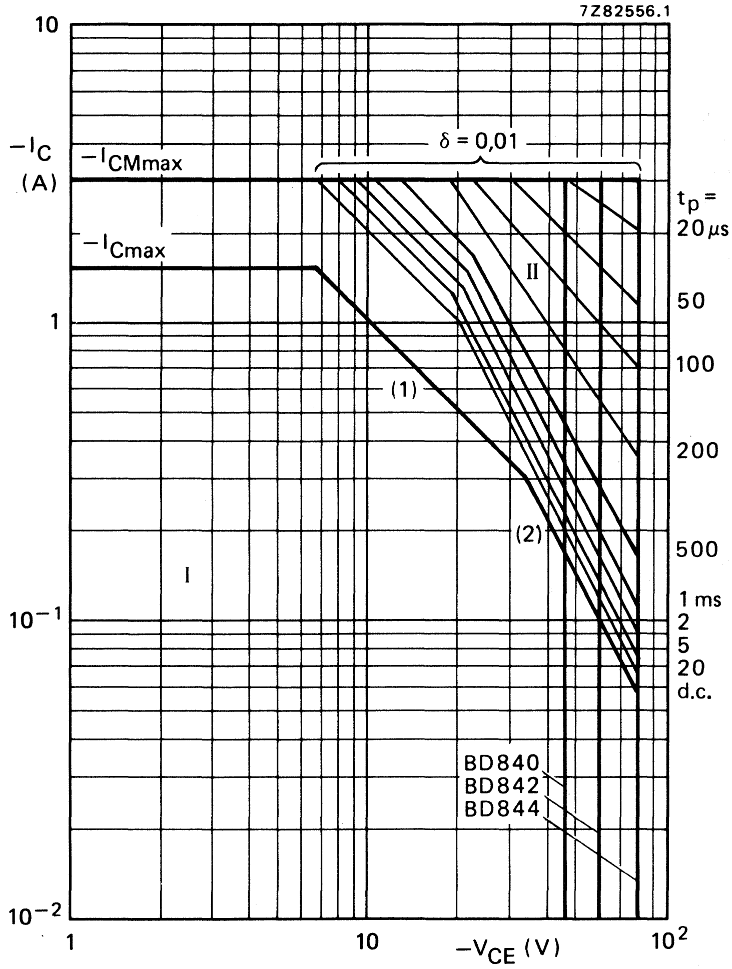


Fig. 2 Safe Operating Area, $T_{mb} \leqslant 25\ ^{o}C$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

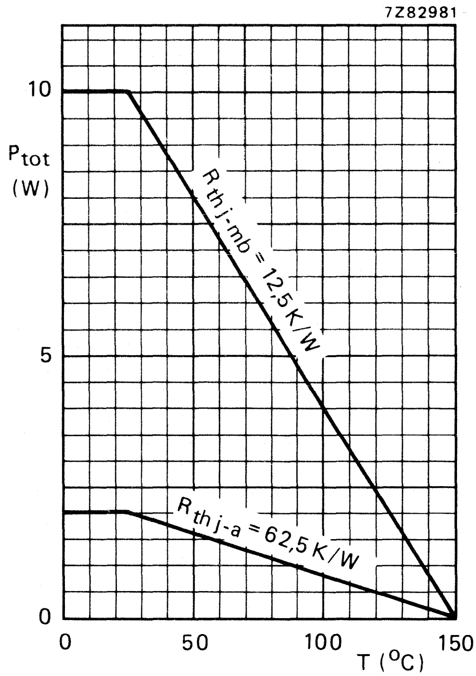


Fig. 3 Power derating curve.

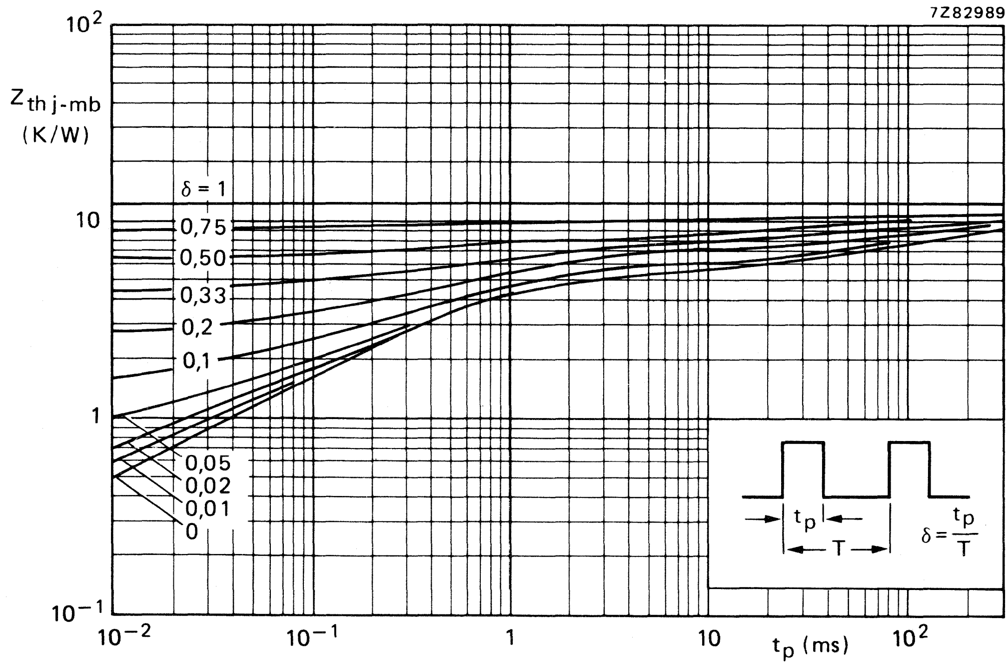


Fig. 4 Pulse power rating chart.

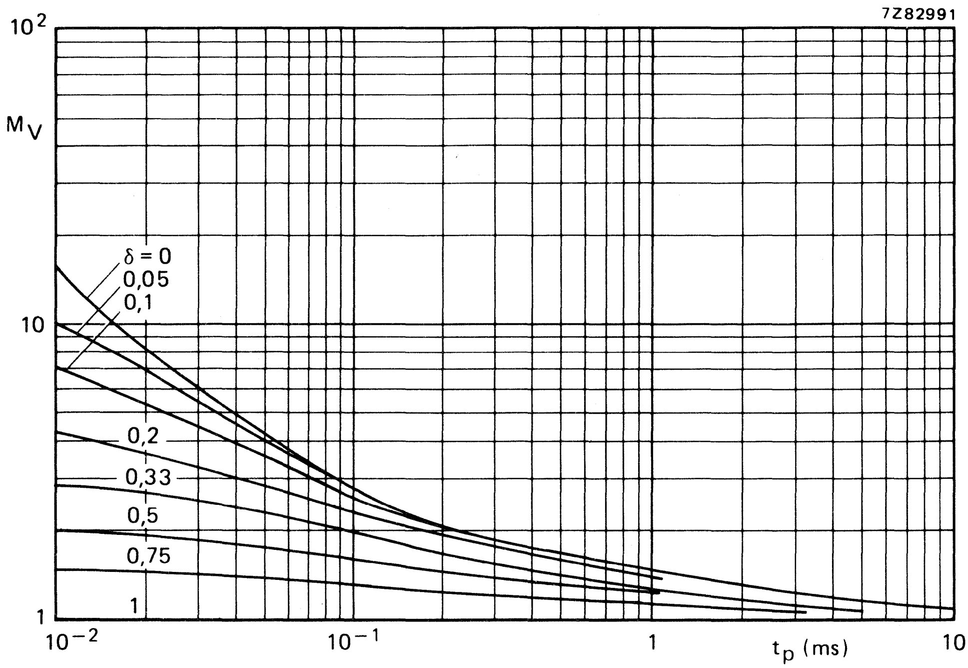


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

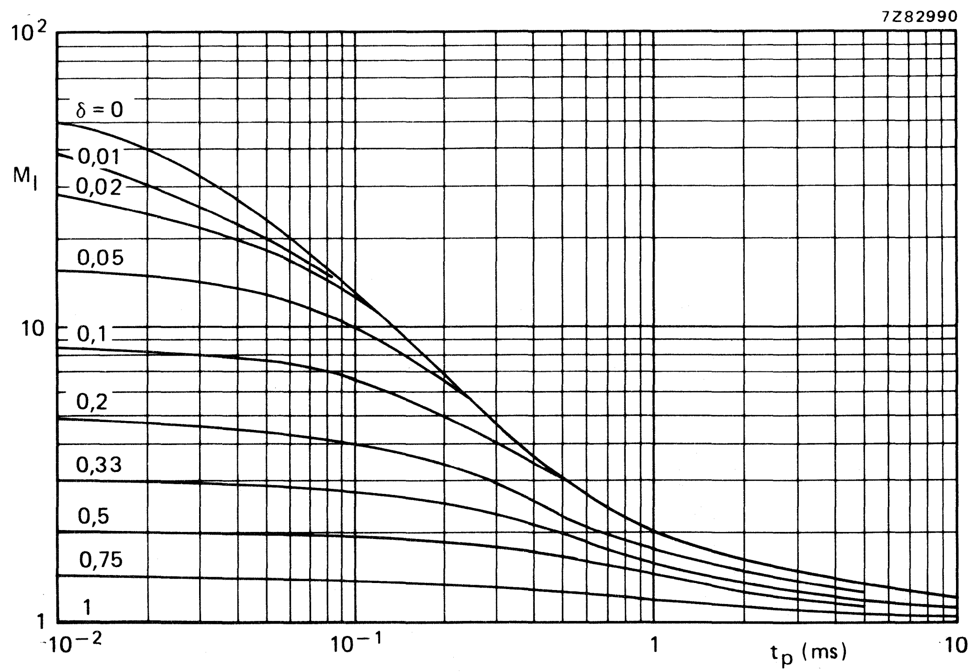


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

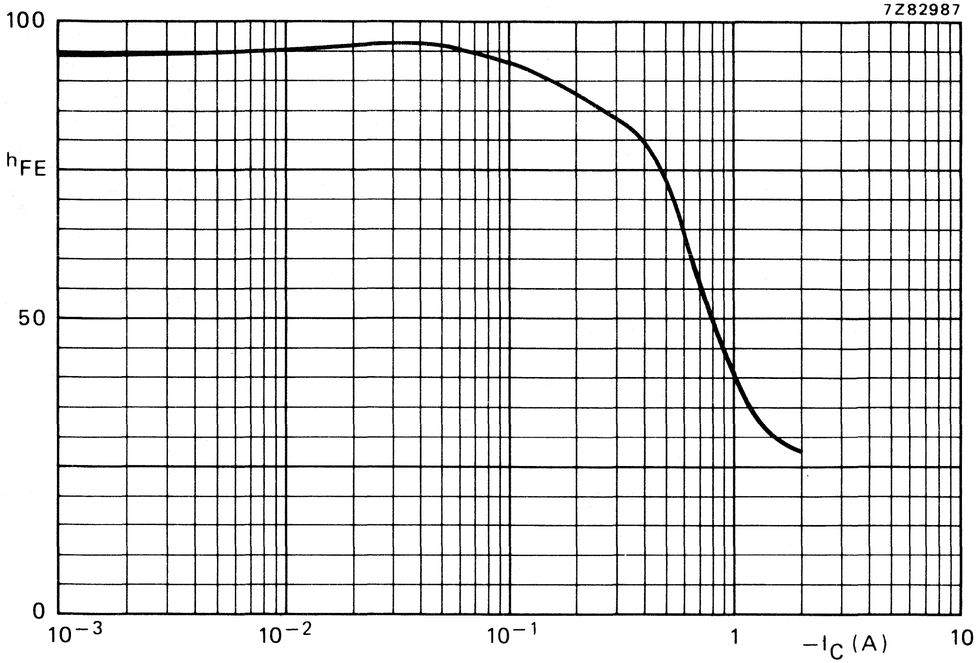


Fig. 7 Typical values d.c. current gain. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

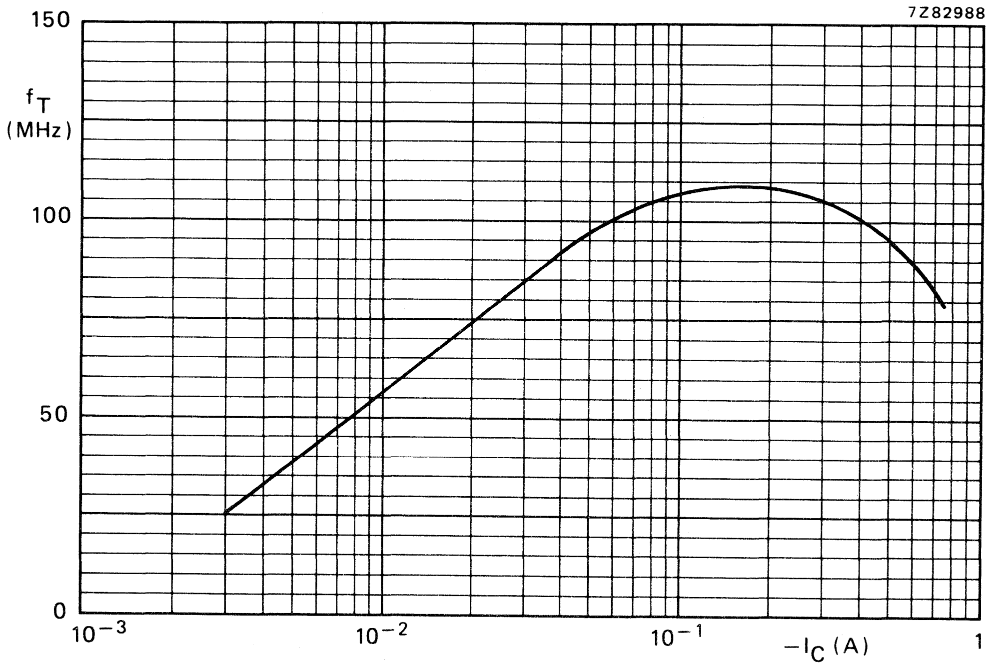


Fig. 8 Typical values transition frequency. $-V_{CE}$ = 5 V; f = 35 MHz; T_{amb} = 25 °C.

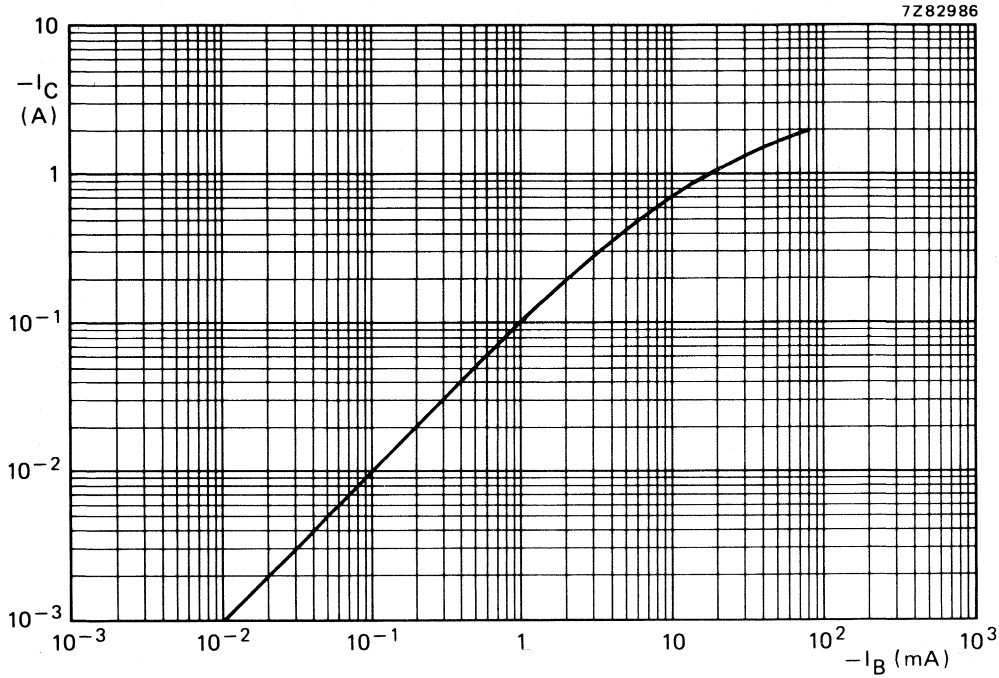


Fig. 9 Typical values at $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

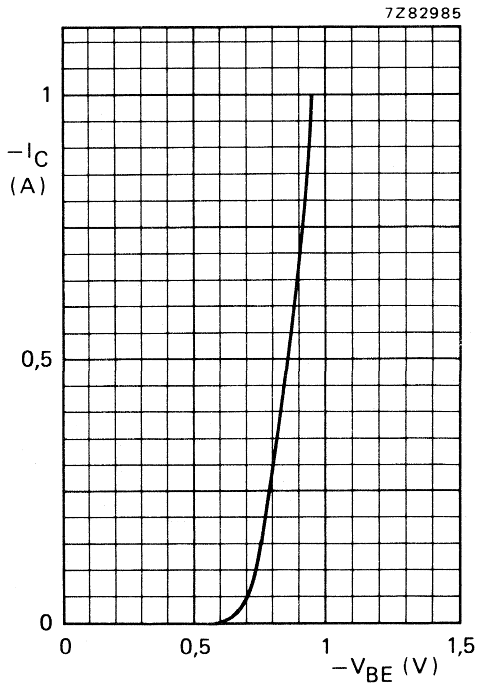


Fig. 10 Typical values. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.
P-N-P complements are BD934; 936; 938; 940 and 942.

QUICK REFERENCE DATA

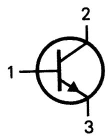
			BD933	935	937	939	941	
Collector-base voltage	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	100	120	V
Collector current (d.c.)	I_C	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
I_C = 150 mA; V_{CE} = 2 V	h_{FE}				40 to 250			
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>			25			
Transition frequency								
I_C = 250 mA; V_{CE} = 10 V	f_T	>			3			MHz

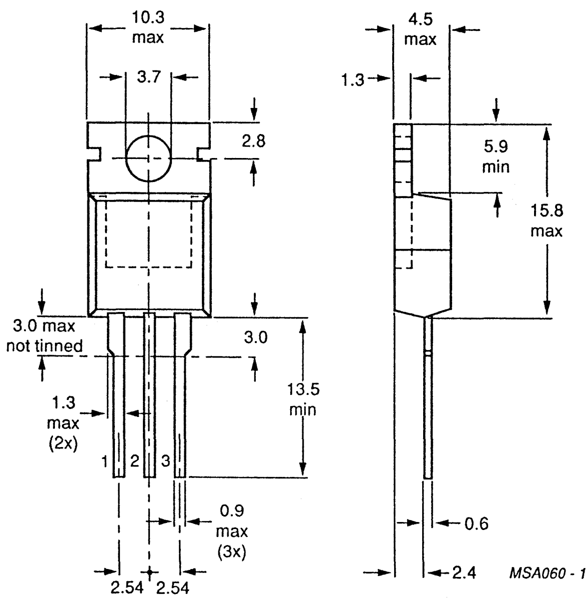
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD933	935	937	939	941	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V

Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	7	A
Base current (d.c.)	I_B	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30	W
Storage temperature	T_{stg}		–65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	50	μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	1	mA
$I_E = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	0,1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	0,2	mA
D.C. current gain *				
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	
Base-emitter voltage **				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Collector-emitter saturation voltage *				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz
Switching times				
I_{Con} = 1 A; $I_{Bon} = -I_{Boff}$ = 0,1 A turn-on time	t_{on}	typ	0,4	μs
		<	1	μs
Turn-off time	t_{off}	typ.	1,5	μs
		<	3	μs
Second-breakdown collector current				
V_{CE} = 40 V; t_p = 0,1 s; non-repetitive	$I_{(SB)}$	>	0,75	A

* Measured under pulse conditions: $t_p \leqslant 300$ μs; $\delta < 2\%$.

** V_{BE} decreases by about 2,3 mV/K with increasing temperature.

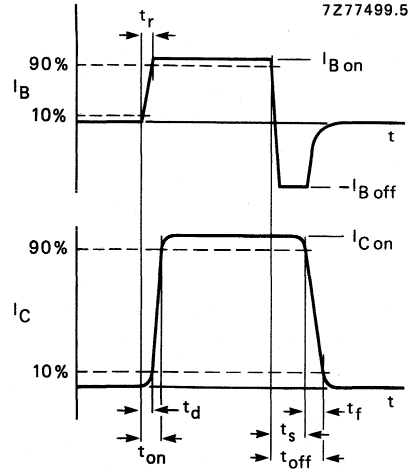
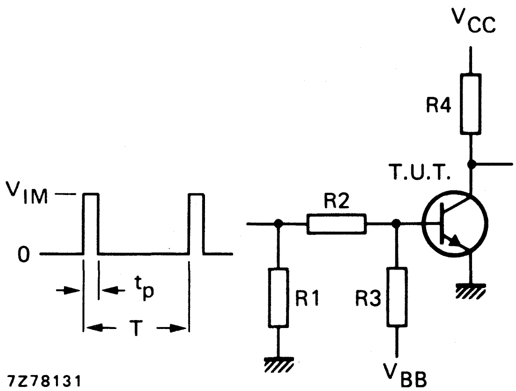


Fig. 2 Switching times waveforms.



V_{CC}	=	20 V
V_{IM}	=	16 V
$-V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

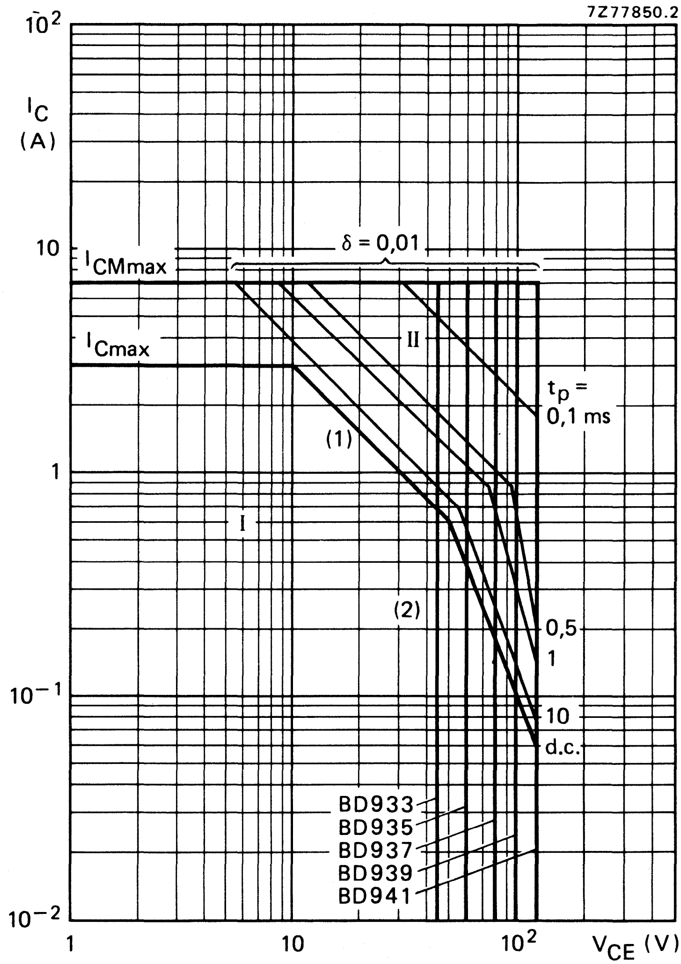


Fig. 4 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

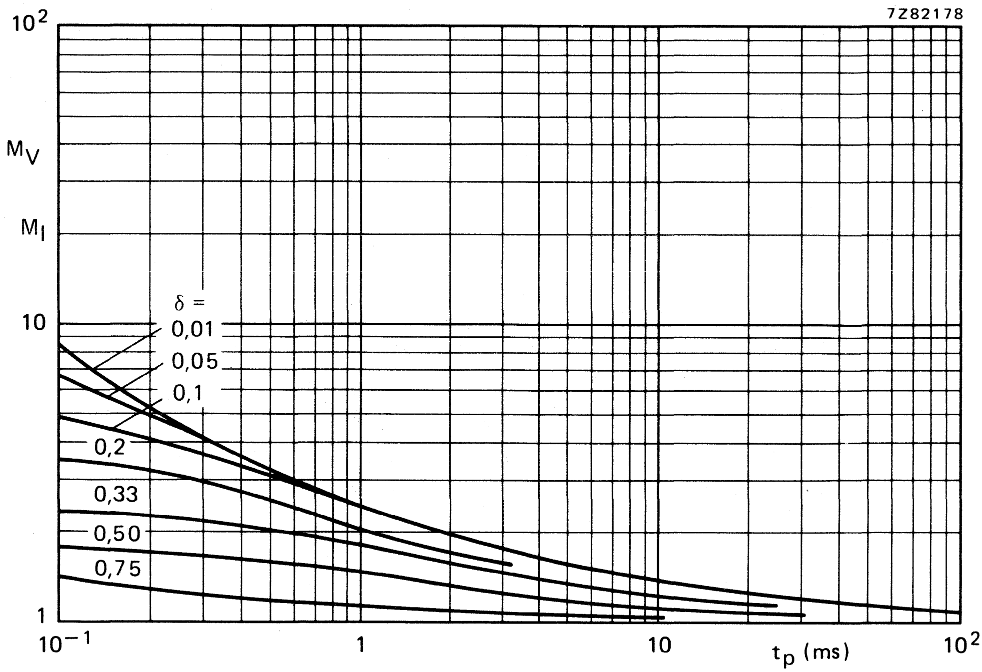


Fig. 5 Second-breakdown voltage multiplying factor at the I_{Cmax} level and second-breakdown current multiplying factor at the V_{CEOmax} level.

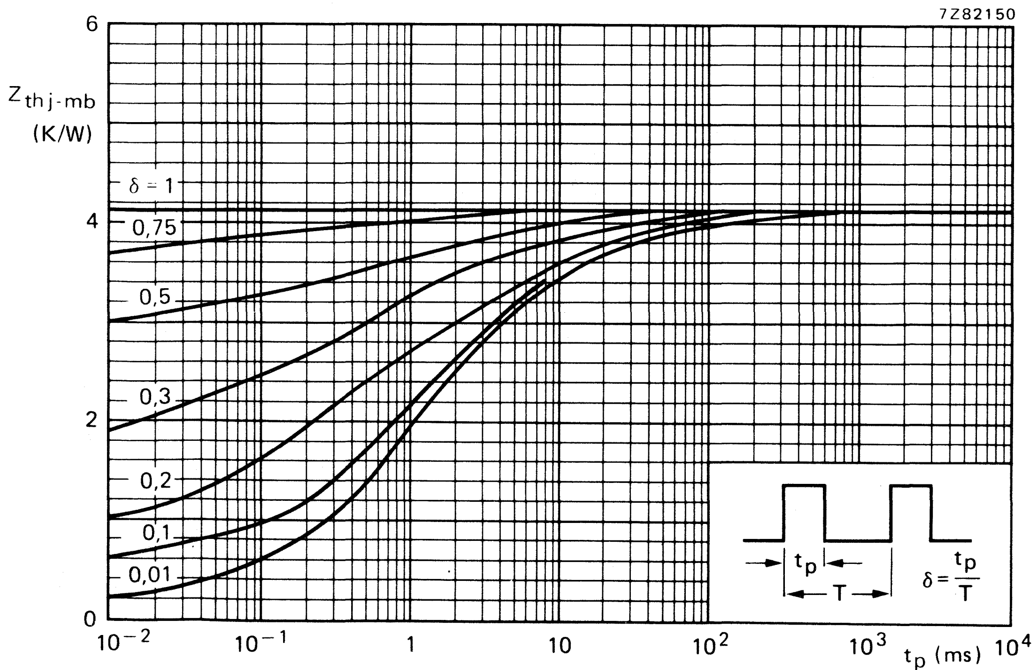


Fig. 6 Pulse power rating chart.

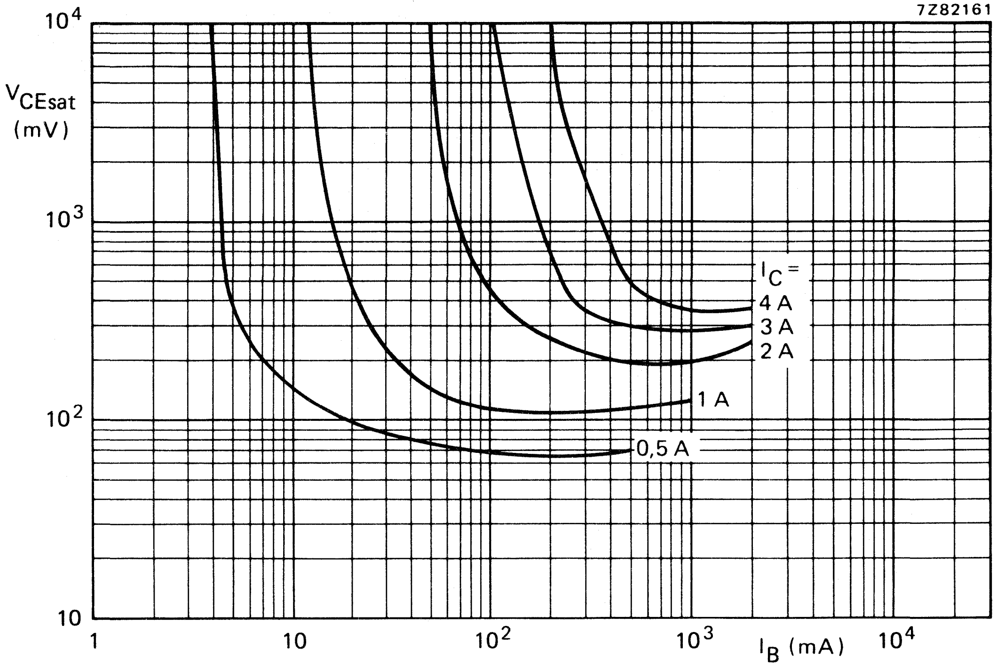


Fig. 7 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

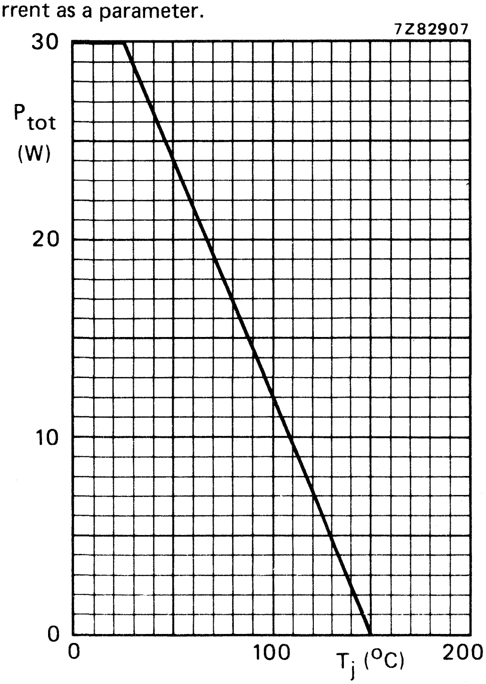


Fig. 8 Power derating curve.

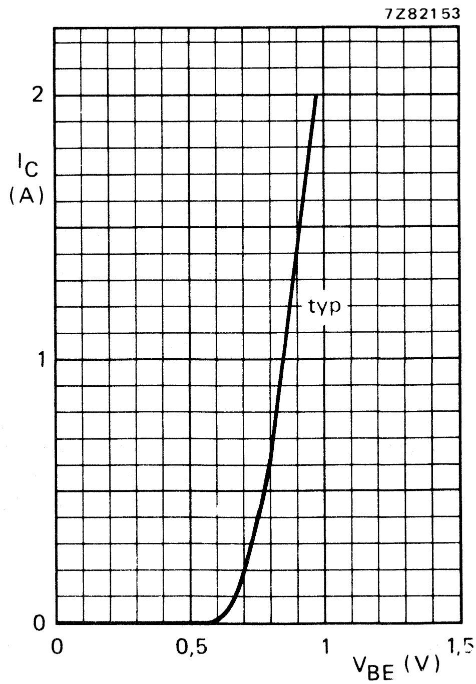


Fig. 9 V_{CE} = 2 V; T_j = 25 °C.

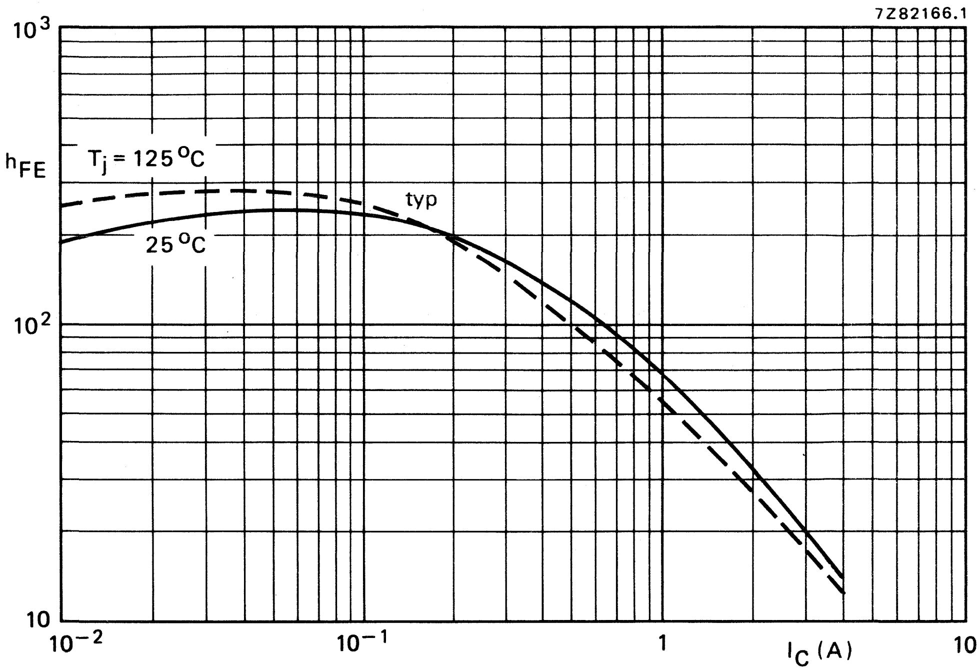


Fig. 10 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 2$ V

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon power transistor in a SOT186 envelope with an electrically insulated mounting base, intended for use in audio output stages and for general purpose amplifier applications.

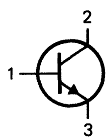
PNP complements are BD934F, BD936F, BD938F, BD940F and BD942F.

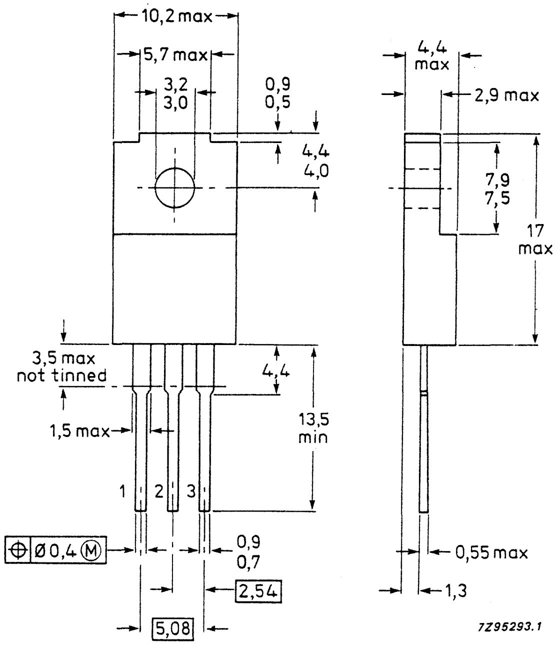
QUICK REFERENCE DATA

			BD933F	935F	937F	939F	941F	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current d.c.	I_C	max.			3			A
Collector current peak value	I_{CM}	max.			7			A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.			19			W
D.C. current gain I_C = 1 A; V_{CE} = 2 V	h_{FE}	min.			25			
Transition frequency at f = 1 MHz I_C = 250 mA; V_{CE} = 10 V	f_T	min.			3			MHz

Fig.1 SOT186.

Dimensions in mm





RATINGS

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

			BD933F	935F	937F	939F	941F	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current d.c.	I_C	max.			3			A
peak value	I_{CM}	max.			7			A
Base current (d.c.)	I_B	max.			0,5			A
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.			14			W
up to T_h = 25 °C (2)	P_{tot}	max.			19			W
Storage temperature	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	9,17	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	6,67	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	55	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value (3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

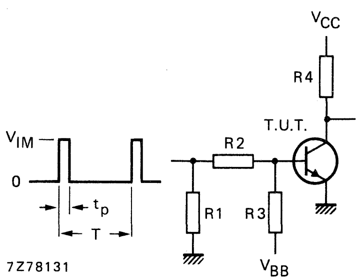
(2) Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

(3) Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure p_{amb} = 1013 mbar.

CHARACTERISTICS

T_h = 25 °C unless otherwise specified

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_h = 150 °C	I_{CBO}	<	3	mA
$I_E = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
D.C. current gain (1)				
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	40 to 250		
Base-emitter voltage (1)+(2)				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Collector-emitter saturation voltage (1)				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz
Second-breakdown collector current				
V_{CE} = 40 V; t_p = 1 s; non-repetitive, without heatsink	I_{SB}	>	475	mA
Switching times				
I_C = 1 A; $I_{Bon} = -I_{Boff}$ = 0,1 A				
turn-on time	t_{on}	typ.	0,4	µs
		<	1	µs
turn-off time	t_{off}	typ.	1,5	µs
		<	3	µs



V_{CC} = 20 V
V_{IM} = 16 V
$-V_{BB}$ = 6,4 V
R1 = 82 Ω
R2 = 82 Ω
R3 = 82 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 µs
T = 500 µs

Fig. 2 Switching times test circuit.

(1) Measured under pulse conditions: t_p = 300 µs; δ = 0,02.
(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.

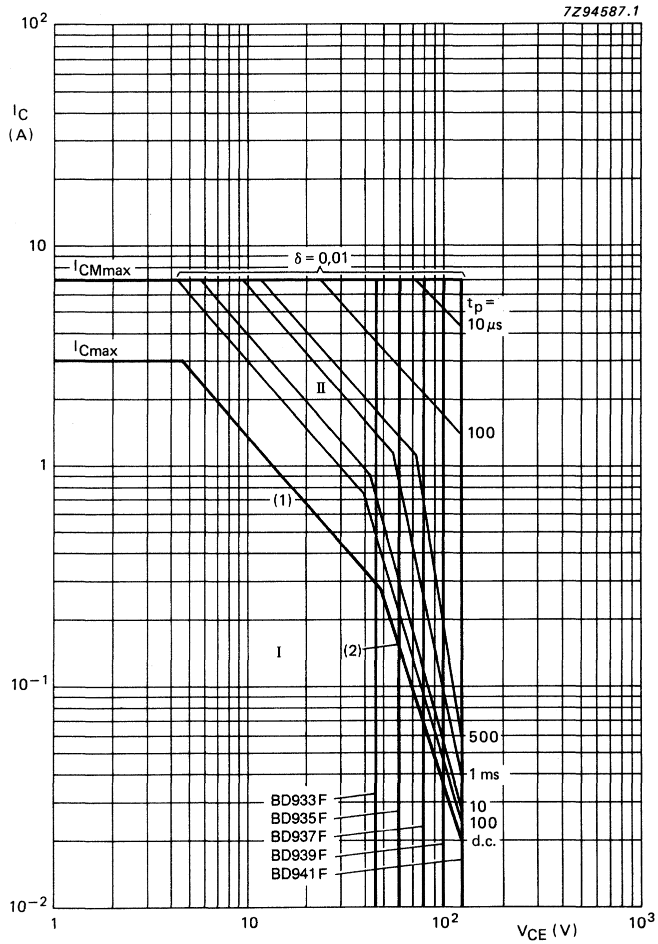


Fig. 4 Safe Operating Area, T_{amb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *without* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

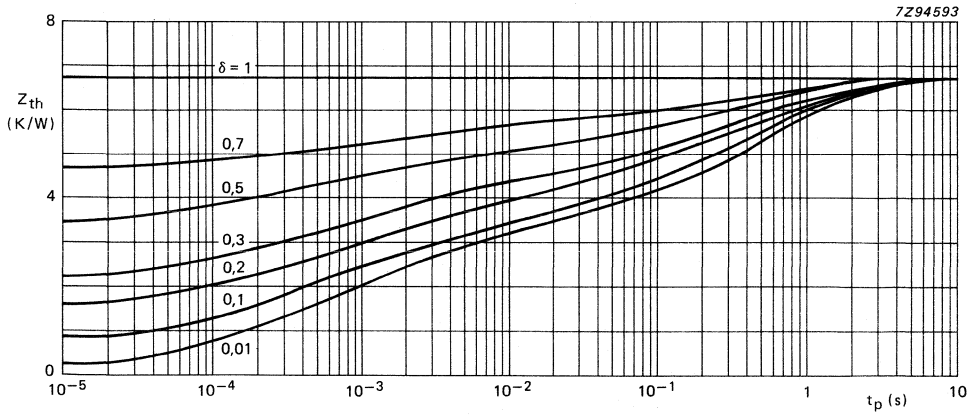


Fig. 5 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

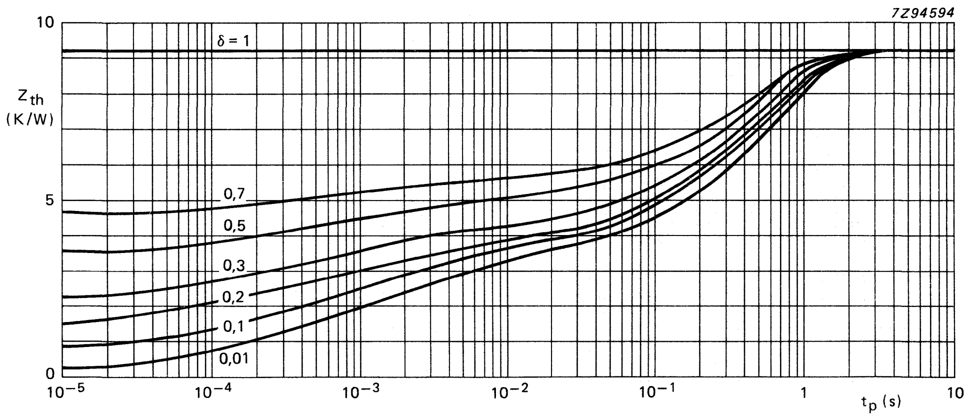


Fig. 6 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

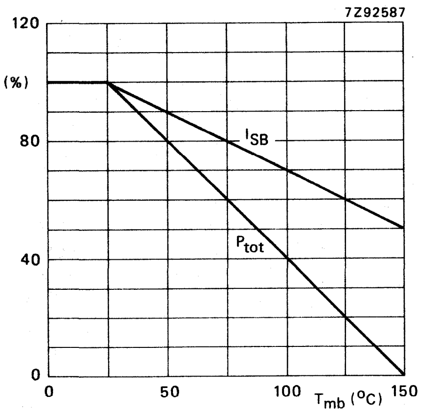


Fig. 7 Total power dissipation and second-breakdown current derating curve.

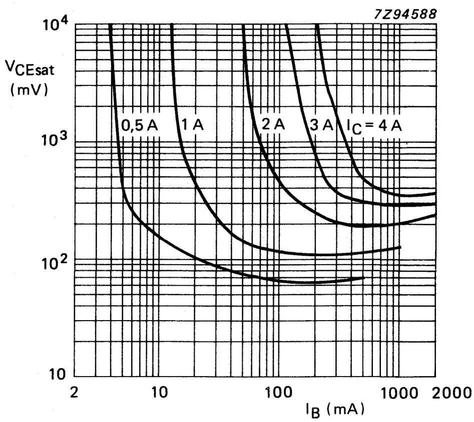


Fig. 8 Collector-emitter saturation voltage; typical values.

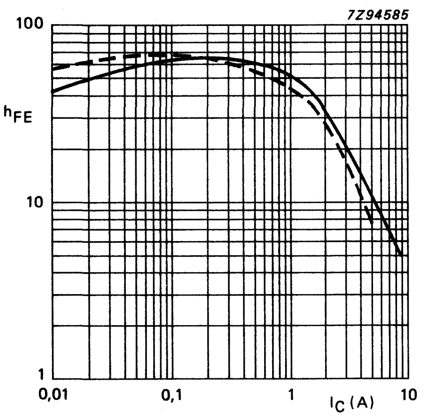


Fig. 9 D.C. current gain; V_{CE} = 2 V; typical values;
—— T_j = 25 °C; – – – – T_j = 125 °C.

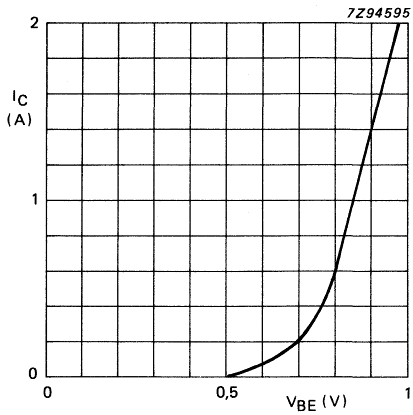


Fig. 10 V_{CE} = 2 V; typical values.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.
N-P-N complements are BD933; 935; 937; 939 and 941.

QUICK REFERENCE DATA

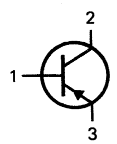
			BD934	936	938	940	942	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}				40 to 250			
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>			25			
Transition frequency								
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>			3			MHz

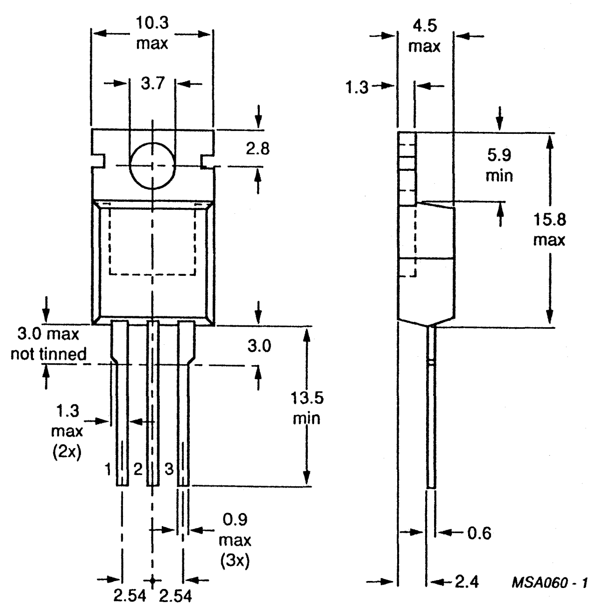
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD934	936	938	940	942	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V

Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Collector current (d.c.)	$-I_C$	max.	3	A
Collector current (peak value)	$-I_{CM}$	max.	7	A
Base current (d.c.)	$-I_B$	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$-I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	50	μA
$-I_E = 0; -V_{CB} = -V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	1	mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	0,1	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	0,2	mA
D.C. current gain (note 1)				
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250	
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>	25	
Base-emitter voltage (notes 1 and 2)				
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	$-V_{BE}$	<	1,3	V
Collector-emitter saturation voltage (note 1)				
$-I_C$ = 1 A; $-I_B$ = 0,1 A	$-V_{CEsat}$	<	0,6	V
Transition frequency at f = 1 MHz				
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>	3	MHz
Switching times				
$-I_{Con}$ = 1 A; $-I_{Bon} = I_{Boff}$ = 0,1 A				
turn-on time	t_{on}	typ.	0,2	μs
		<	0,6	μs
turn-off time	t_{off}	typ.	0,7	μs
		<	2,4	μs

Notes
1. Measured under pulse conditions: $t_p \leq 300$ μs; $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 2,3 mV/K with increasing temperature.

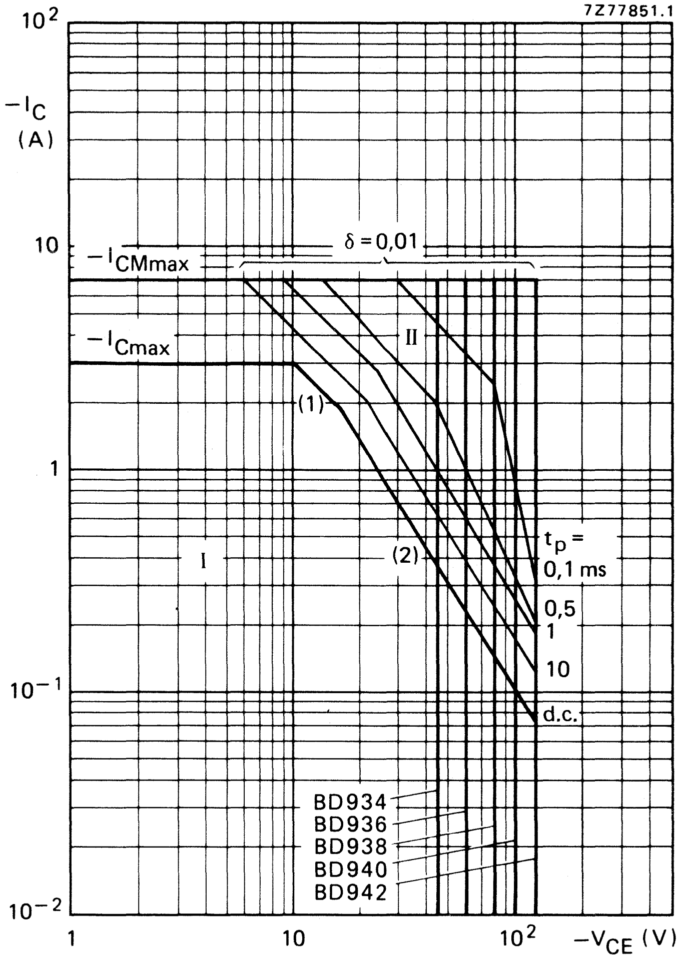


Fig. 2 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

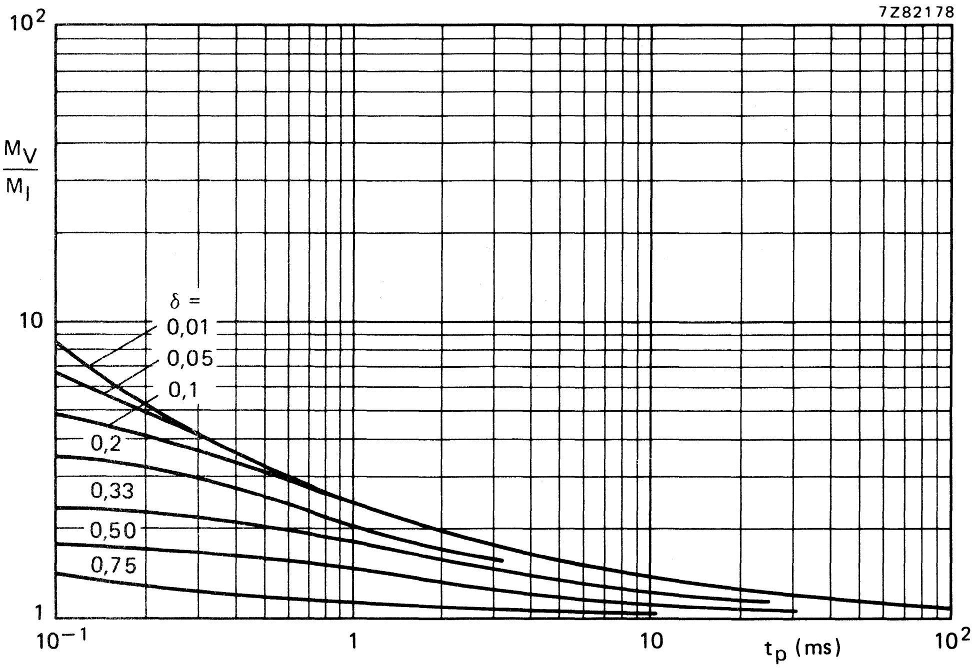


Fig. 3 Second breakdown voltage multiplying factor at the I_{Cmax} level and second breakdown current multiplying factor at the V_{CEOmax} level.

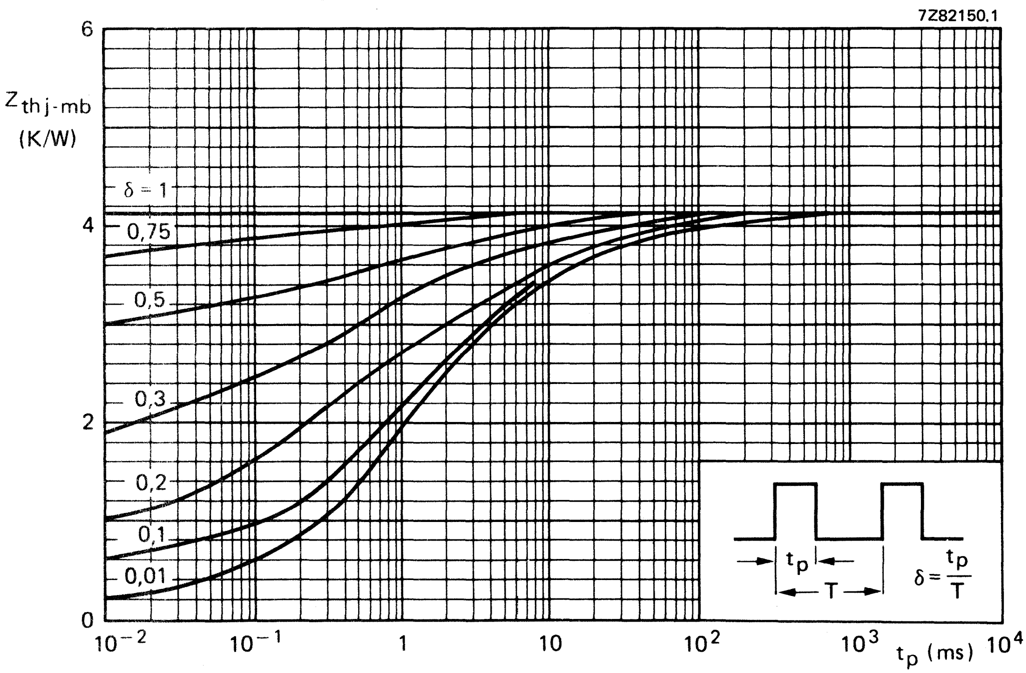


Fig. 4 Pulse power rating chart.

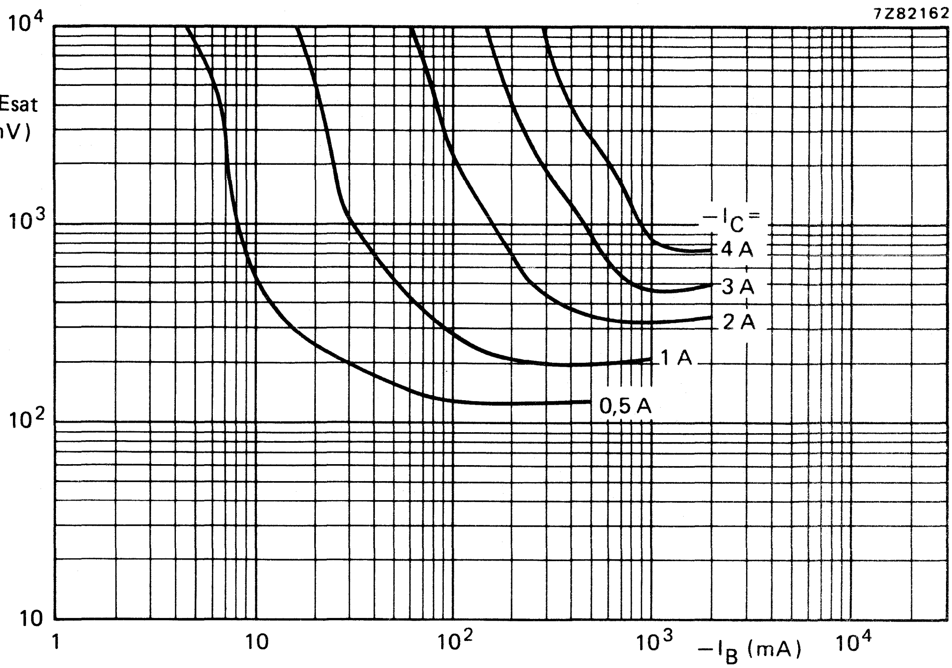


Fig. 5 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

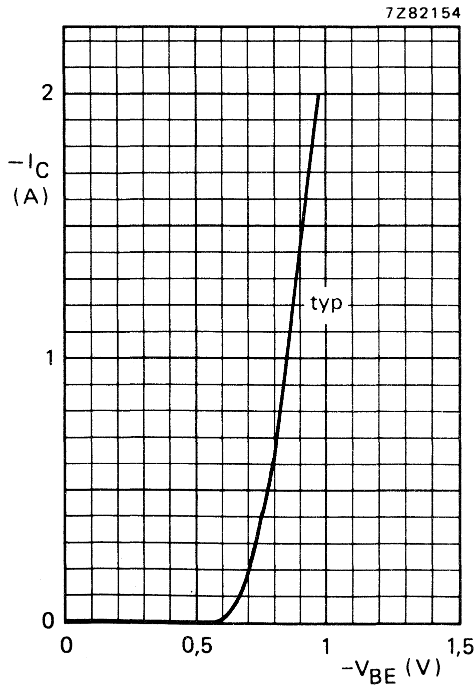


Fig. 6 Typical collector current as a function of base-emitter voltage. $-V_{CE}$ = 2 V; T_j = 25 °C.

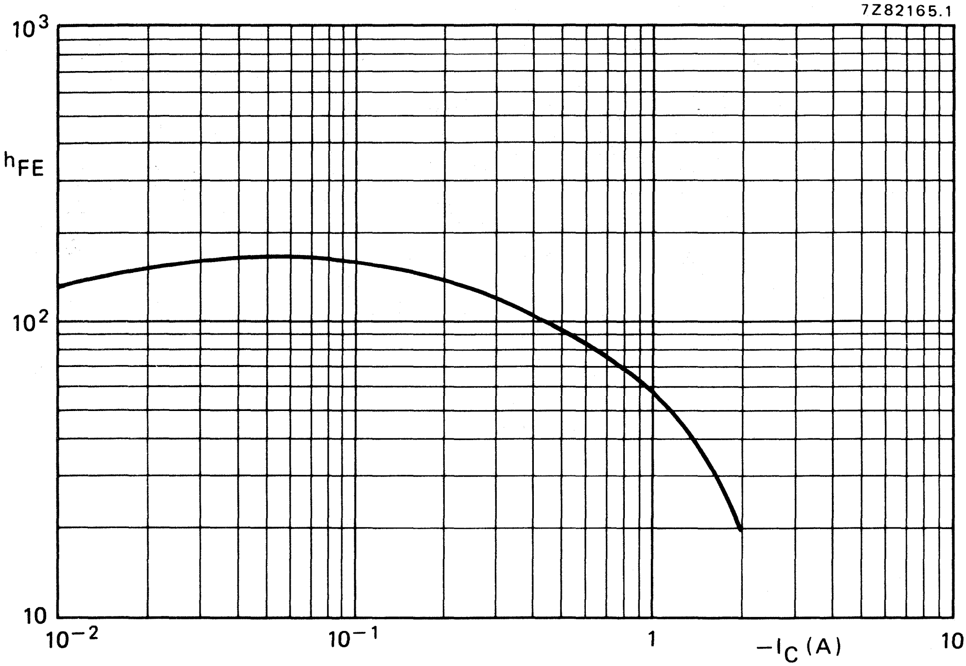


Fig. 7 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 2$ V; $T_j \leqslant 25$ °C.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon power transistor in a SOT186 envelope with an electrically insulated mounting base, intended for use in audio output stages and for general purpose amplifier applications.

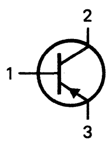
NPN complements are BD933F, BD935F, BD937F, BD939F and BD941F.

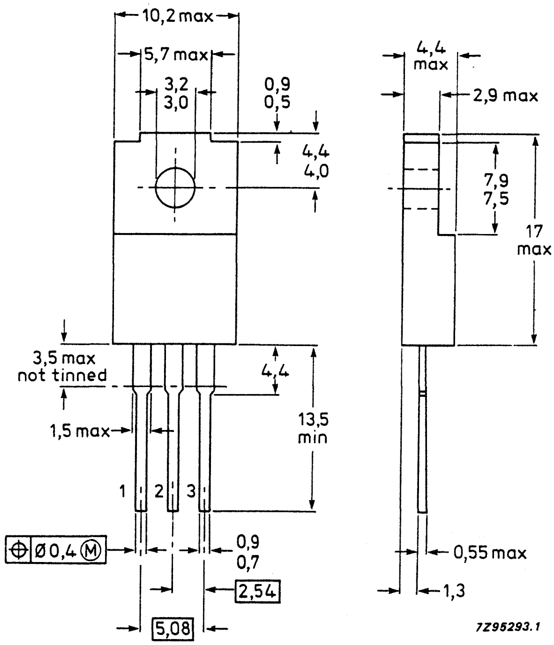
QUICK REFERENCE DATA

			BD934F	936F	938F	940F	942F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
Collector current d.c.	$-I_C$	max.			3			A
peak value	$-I_{CM}$	max.			7			A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.			19			W
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	min.			25			
Transition frequency at f = 1 MHz $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	min.			3			MHz

Fig.1 SOT186.

Dimensions in mm





RATINGS

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

			BD934F	936F	938F	940F	942F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
Collector current d.c.	$-I_C$	max.			3			A
peak value	$-I_{CM}$	max.			7			A
Base current (d.c.)	$-I_B$	max.			0,5			A
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.			14			W
up to T_h = 25 °C (2)	P_{tot}	max.			19			W
Storage temperature	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	9,17	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	6,67	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	55	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value (3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 Newton pressure on centre of envelope.

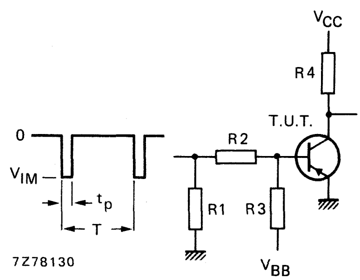
(2) Mounted with heatsink compound and 30 ± 5 Newton pressure on centre of envelope.

(3) Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure p_{amb} = 1013 mbar.

CHARACTERISTICS

T_h = 25 °C unless otherwise specified

Collector cut-off currents				
$-I_E = 0; -V_{CB} = V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$-I_E = 0; -V_{CB} = V_{CBOmax}; T_h = 150\ ^oC$	$-I_{CBO}$	<	3	mA
$-I_E = 0; -V_{CE} = V_{CEOmax}$	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$-I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA
D.C. current gain (1)				
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25	
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}	40 to 250		
Base-emitter voltage (1)+(2)				
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3	V
Collector-emitter saturation voltage (1)				
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,6	V
Transition frequency at f = 1 MHz				
$-I_C = 250$ mA; $-V_{CE} = 10$ V	f_T	>	3	MHz
Second-breakdown collector current				
$-V_{CE} = 40$ V; $t_p = 1$ s; non-repetitive, without heatsink	$-I_{SB}$	>	475	mA
Switching times				
$-I_C = 1$ A; $-I_{Bon} = +I_{Boff} = 0,1$ A				
turn-on time	t_{on}	typ.	0,2	μs
		<	0,6	μs
turn-off time	t_{off}	typ.	0,7	μs
		<	2,4	μs



$-V_{CC}$ = 20 V
$-V_{IM}$ = 16 V
$+V_{BB}$ = 6,4 V
R1 = 82 Ω
R2 = 82 Ω
R3 = 82 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 2 Switching times test circuit.

(1) Measured under pulse conditions: $t_p = 300$ μs; δ = 0,02.
(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.

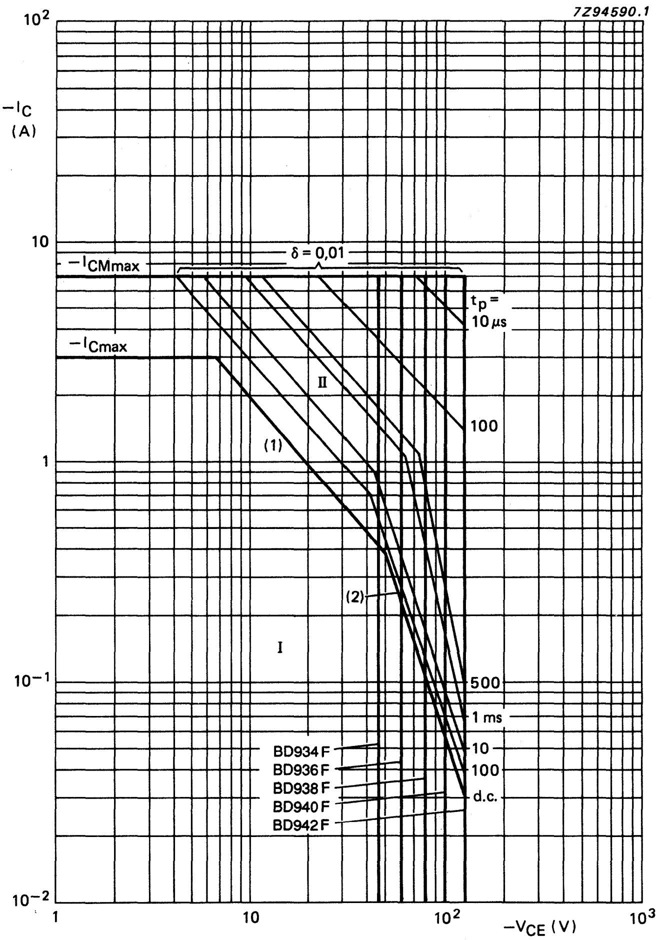


Fig. 3 Safe Operating Area, T_{amb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *with* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

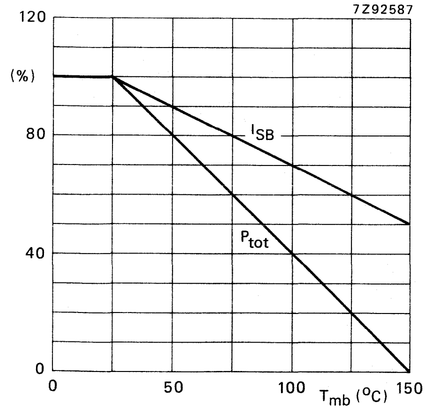


Fig. 7 Total power dissipation and second-breakdown current derating curve.

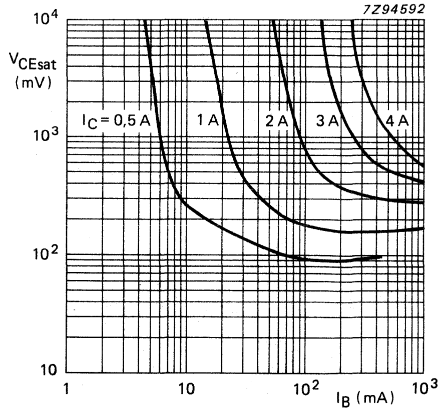


Fig. 8 Collector-emitter saturation voltage; typical values.

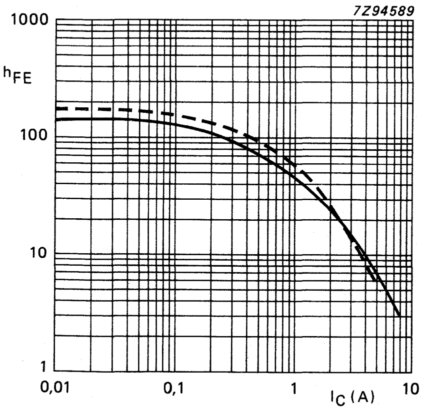


Fig. 9 D.C. current gain; $-V_{CE}$ = 2 V; typical values;
—— T_j = 25 °C; – – – – T_j = 125 °C.

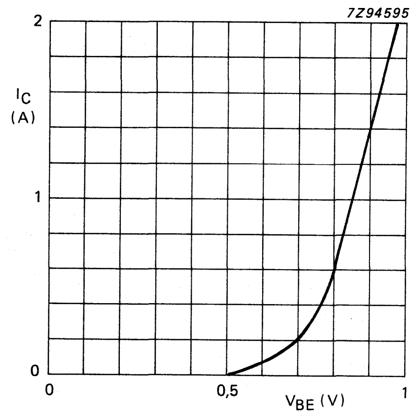


Fig. 10 $-V_{CE}$ = 2 V; typical values.

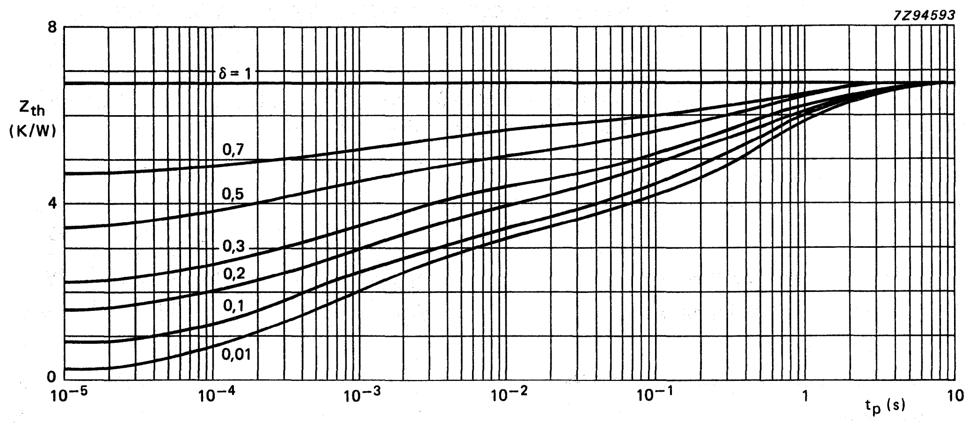


Fig. 5 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

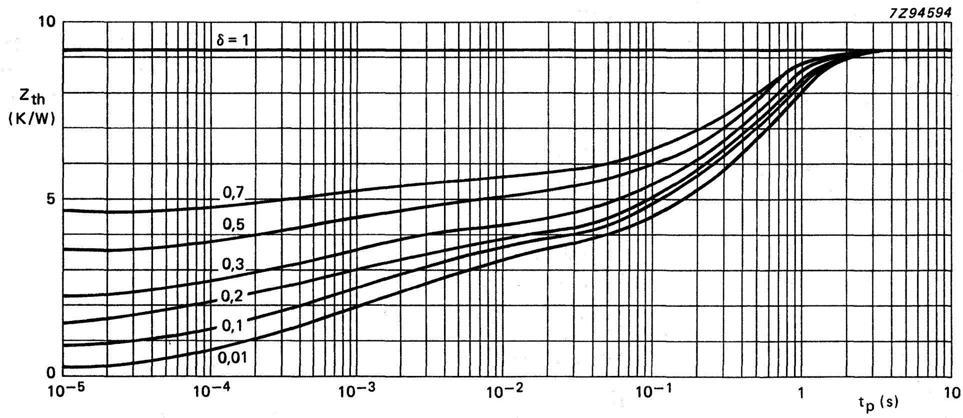


Fig. 6 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in audio output stages and general purpose amplifier applications. P-N-P complements are BD944; 946 and 948.

QUICK REFERENCE DATA

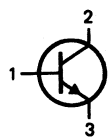
			BD943	945	947	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Collector current (d.c.)	I_C	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		25		
I_C = 500 mA; V_{CE} = 1 V	h_{FE}			85 to 475		
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
Transition frequency at f = 1 MHz						
I_C = 250 mA; V_{CE} = 1 V	f_T	>		3		MHz

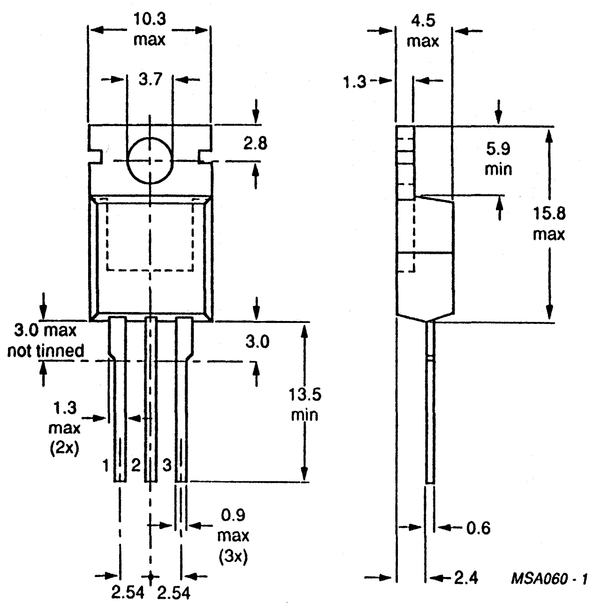
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD943	945	947	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value)	I_{CM}	max.		8		A
Base current (d.c.)	I_B	max.		1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD943	945	947	
Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		50		μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<		1		mA
$I_B = 0$; V_{CE} = 15 V; BD943 / 20 V; BD945 / 25 V; BD947	I_{CEO}	<		0.1		mA
Emitter cut-off current						
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<		0.2		mA
D.C. current gain (note 1)						
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		25		
I_C = 500 mA; V_{CE} = 1 V	h_{FE}			85 to 475		
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
I_C = 3 A; V_{CE} = 1 V	h_{FE}	>	–	–	30	
Base-emitter voltage (notes 1 and 2)						
I_C = 2 A; V_{CE} = 1 V	V_{BE}	<	1,1	1,1	–	V
I_C = 3 A; V_{CE} = 1 V	V_{BE}	<	–	–	1,3	V
Collector-emitter saturation voltage (note 1)						
I_C = 2 A; I_B = 0,2 A	V_{CEsat}	<	0,5	0,5	–	V
I_C = 3 A; I_B = 0,3 A	V_{CEsat}	<	–	–	0,7	V

Notes
1. Measured under pulse conditions; $t_p \leq 300$ μs; $\delta < 2\%$.
2. V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Knee voltage*			
I_C = 2 A; I_B value for which I_C = 2,2 A and V_{CE} = 1 V	V_{CEK}	<	0,8 V
Transition frequency at f = 1 MHz			
I_C = 250 mA; V_{CE} = 1 V	f_T	>	3 MHz

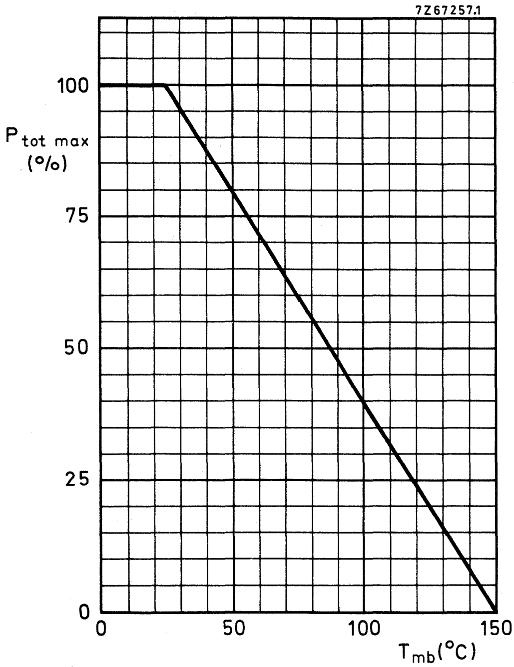


Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

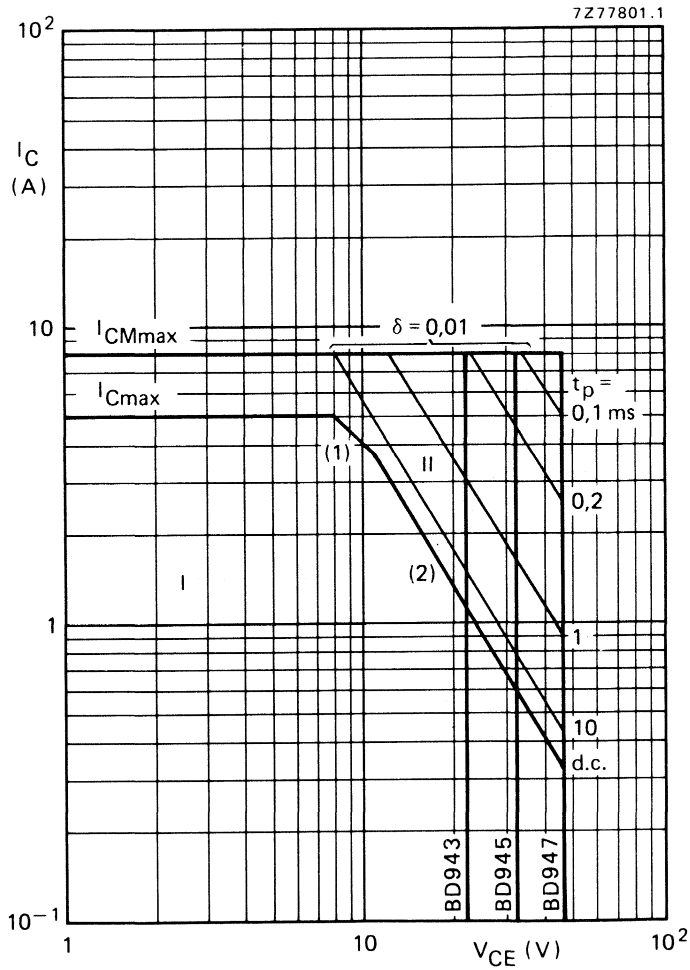


Fig. 3 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

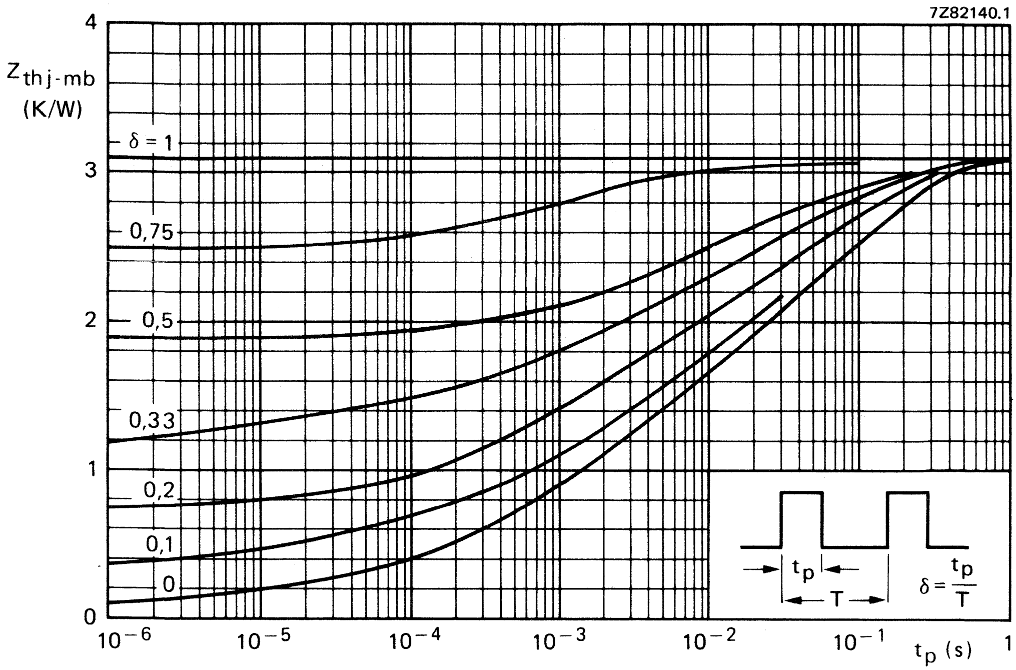


Fig. 4 Pulse power rating chart.

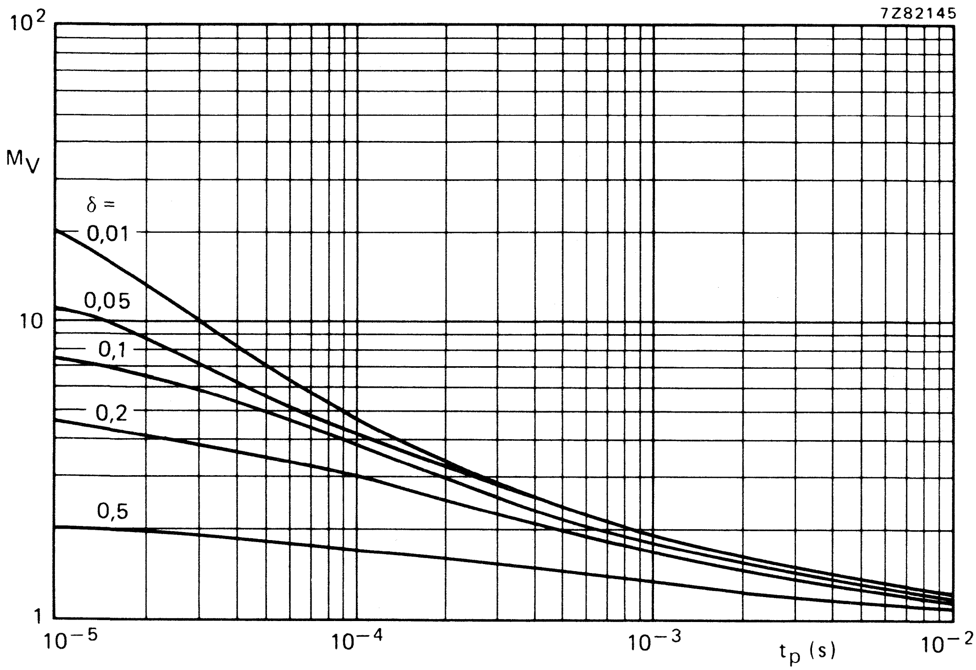


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

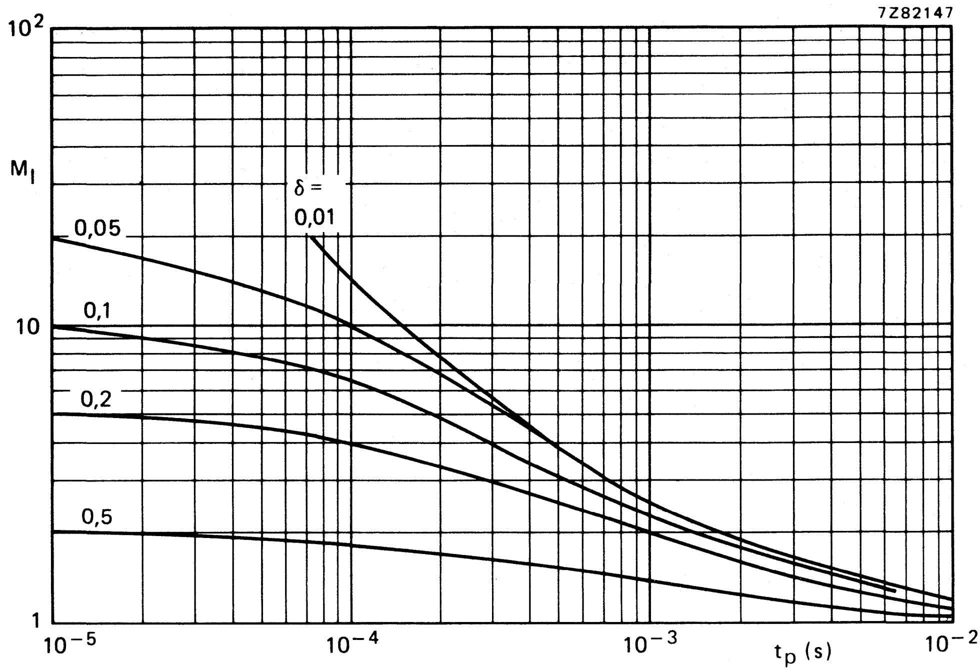


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level for BD943 and BD945.

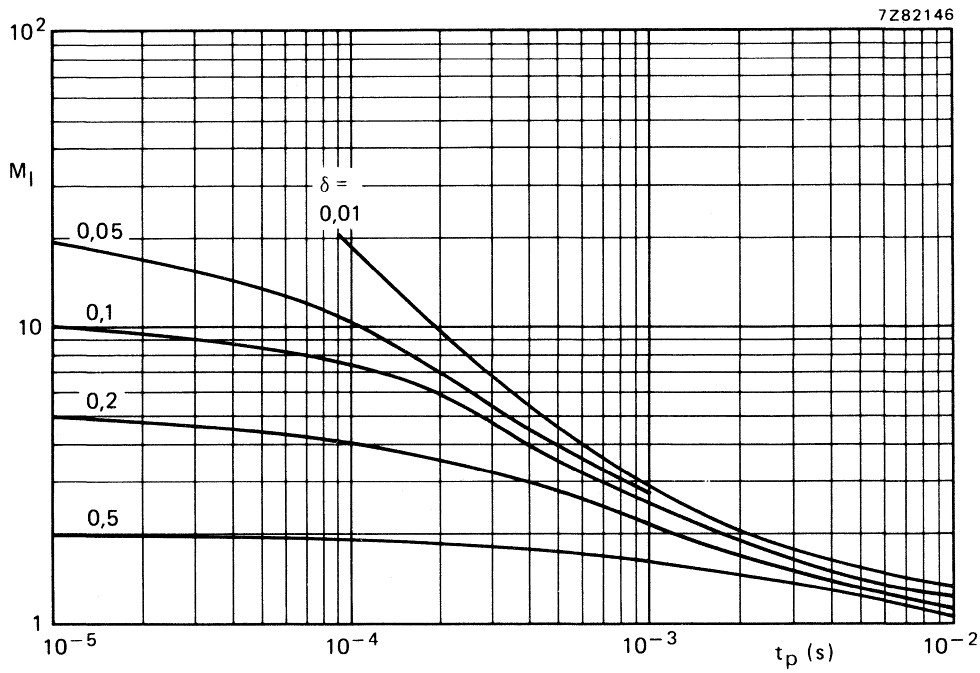


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level for BD947.

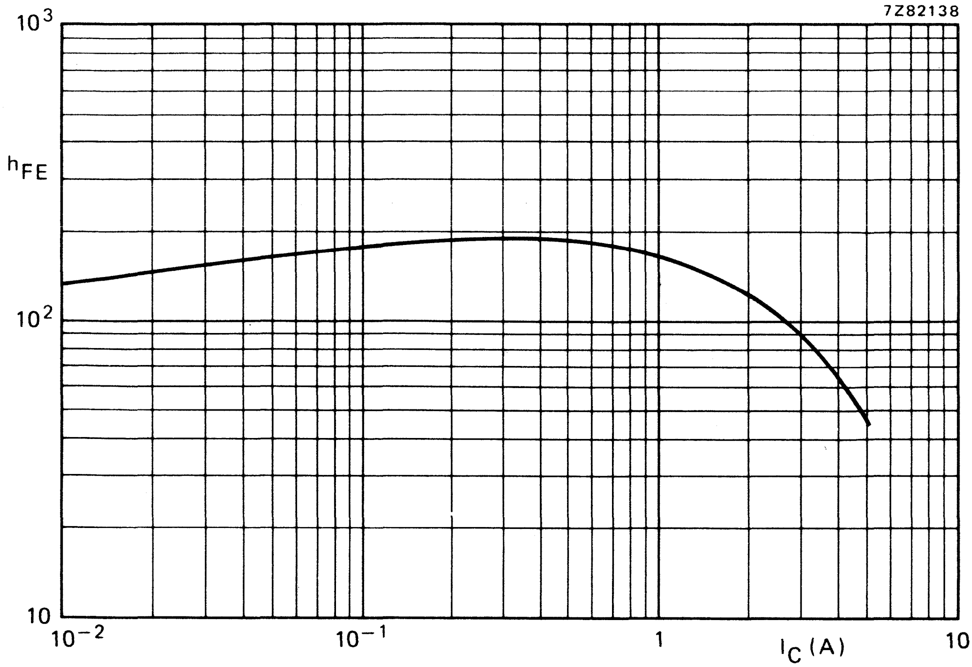


Fig. 8 Typical d.c. current gain at V_{CE} = 1 V; T_j = 25 °C.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

PNP complements are BD944F, BD946F and BD948F.

QUICK REFERENCE DATA

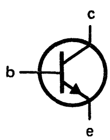
			BD943F	945F	947F	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
DC collector current	I_C	max.		5		A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.		22		W

MECHANICAL DATA

Dimensions in mm

Pinning

1 = base
2 = collector
3 = emitter



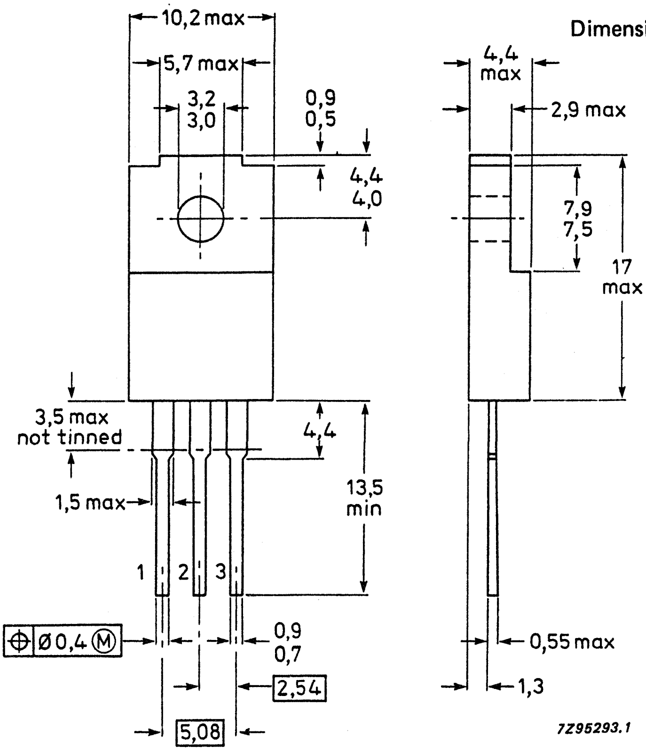


Fig.1 SOT186.

RATINGS

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

			BD943F	945F	947F	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
DC collector current	I_C	max.		5		A
Peak collector current	I_{CM}	max.		8		A
Base current	I_B	max.		1		A
Total power dissipation						
up to T_h = 25 °C (note 1)	P_{tot}	max.		15		W
up to T_h = 25 °C (note 2)	P_{tot}	max.		22		W
Storage temperature range	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	2.93	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	7.93	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.43	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $V_{CB} = V_{CBOmax}$		I_{CBO}	max.	50	μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C		I_{CBO}	max.	1	mA
$I_B = 0$; V_{CE} = 15 V	BD943F	I_{CEO}	max.	0.1	mA
$I_B = 0$; V_{CE} = 20 V	BD945F	I_{CEO}	max.	0.1	mA
$I_B = 0$; V_{CE} = 25 V	BD947F	I_{CEO}	max.	0.1	mA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 5 V		I_{EBO}	max.	0.2	mA

Notes

1. Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.

			BD943F	945F	947F	
DC current gain (note 1)						
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	min.	25	25	25	
I_C = 500 mA; V_{CE} = 1 V	h_{FE}	min.	85	85	85	
		max.	475	475	475	
I_C = 2 A; V_{CE} = 1 V	h_{FE}	min.	50	50	40	
I_C = 3 A; V_{CE} = 1 V	h_{FE}	min.	—	—	30	
Base-emitter voltage (notes 1 and 2)						
I_C = 2 A; V_{CE} = 1 V	V_{BE}	max.	1.1	1.1	—	V
I_C = 3 A; V_{CE} = 1 V	V_{BE}	max.	—	—	1.3	V
Collector-emitter saturation voltage (note 1)						
I_C = 2 A; I_B = 0.2 A	V_{CEsat}	max.	0.5	0.5	—	V
I_C = 3 A; I_B = 0.3 A	V_{CEsat}	max.	—	—	0.7	V
Knee voltage (note 1)						
I_C = 2 A; I_B = 20 mA	V_{CEK}	max.		0.8		V
Transition frequency at f = 1 MHz						
I_C = 250 mA; V_{CE} = 1 V	f_T	min.		3		MHz

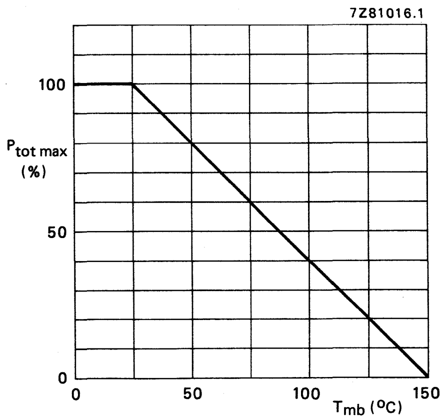
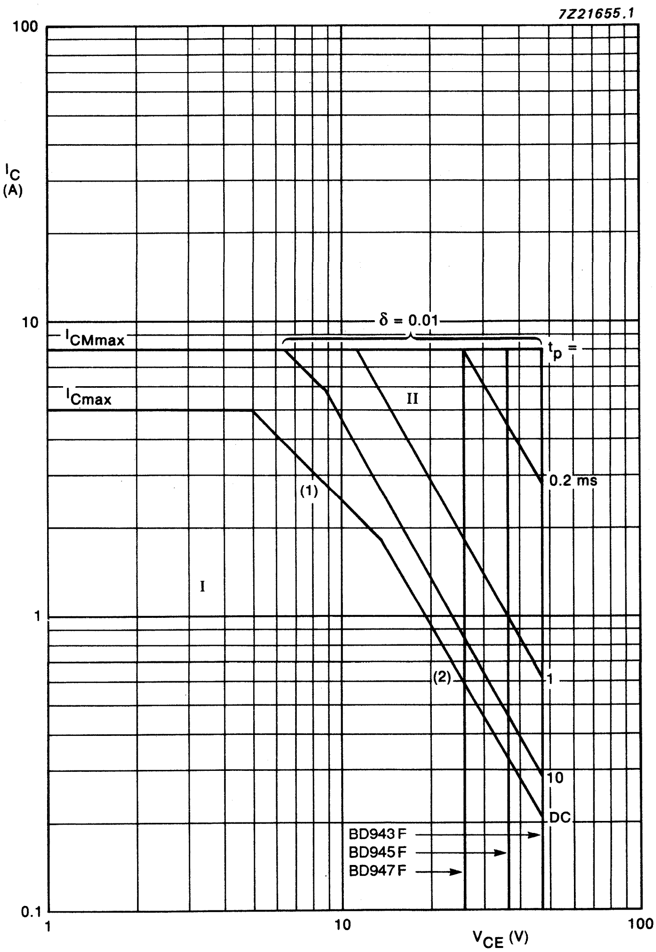


Fig. 2 Power derating curve.

Notes

1. Measured under pulse conditions; $t_p \leq 300\ \mu s$; $\delta < 2\%$.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits.

Fig. 3 Safe Operating Area, T_{mb} = 25 °C.

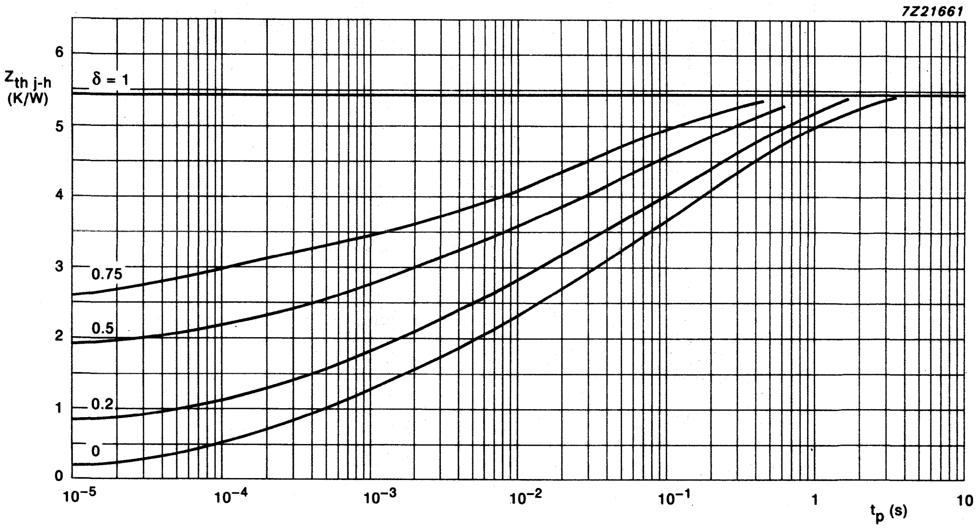


Fig. 4 Pulse power rating chart.

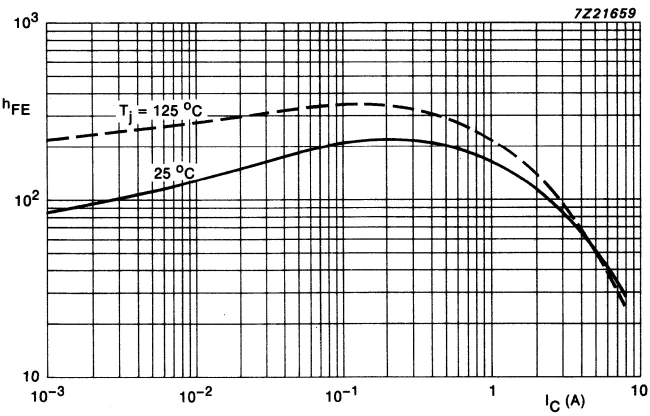


Fig. 5 DC current gain; V_{CE} = 1 V; typical values.

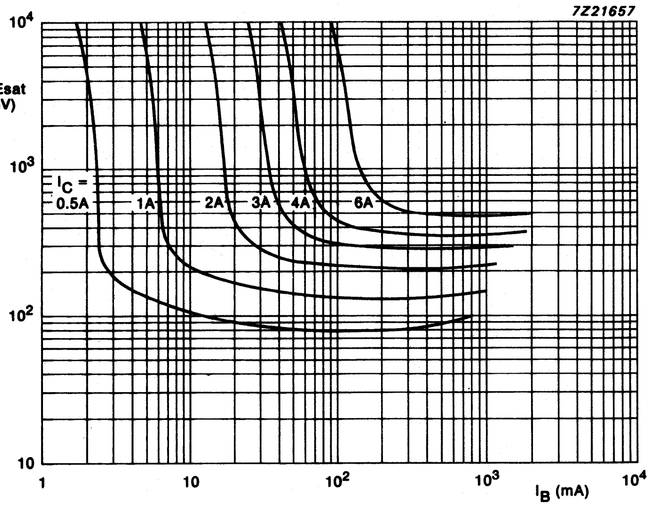


Fig.6 Collector-emitter saturation voltage as a function of base current T_h = 25°C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in audio output stages and general purpose amplifiers. N-P-N complements are BD943; 945 and 947.

QUICK REFERENCE DATA

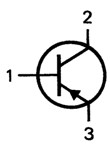
			BD944	946	948	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (d.c.)	$-I_C$	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>		25		
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}			85 to 475		
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	50	50	40	
Transition frequency at f = 1 MHz						
$-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	>		3		MHz

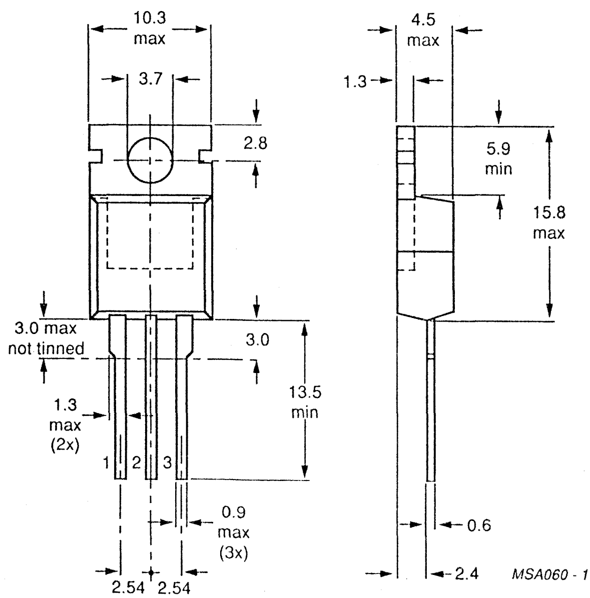
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD944	946	948	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current (d.c.)	$-I_C$	max.		5		A
Collector current (peak value)	$-I_{CM}$	max.		8		A
Base current (d.c.)	$-I_B$	max.		1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD944	946	948	
Collector cut-off current						
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<		50		μA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<		1		mA
$I_B = 0; -V_{CE} = 15$ V; BD944 $-V_{CE} = 20$ V; BD946 $-V_{CE} = 25$ V; BD948	$-I_{CEO}$	<		0,1		mA
Emitter cut-off current						
$-I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<		0,2		mA
D.C. current gain (note 1)						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>		25		
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}			85 to 475		
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	50	50	40	
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	h_{FE}	>	–	–	30	
Base-emitter voltage (notes 1 and 2)						
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	$-V_{BE}$	<	1,1	1,1	–	V
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	$-V_{BE}$	<	–	–	1,3	V
Collector-emitter saturation voltage (note 1)						
$-I_C$ = 2 A; $-I_B$ = 0,2 A	$-V_{CEsat}$	<	0,5	0,5	–	V
$-I_C$ = 3 A; $-I_B$ = 0,3 A	$-V_{CEsat}$	<	–	–	0,7	V

Notes

1. Measured under pulse conditions; $t_p \leq 300$ μs; $\delta < 2\%$.
2. V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Knee voltage *			
$-I_C$ = 2 A; $-I_B$ = value for which			
$-I_C$ = 2,2 A and $-V_{CE}$ = 1 V	$-V_{CEK}$	<	0,8 V
Transition frequency at f = 1 MHz			
$-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	>	3 MHz

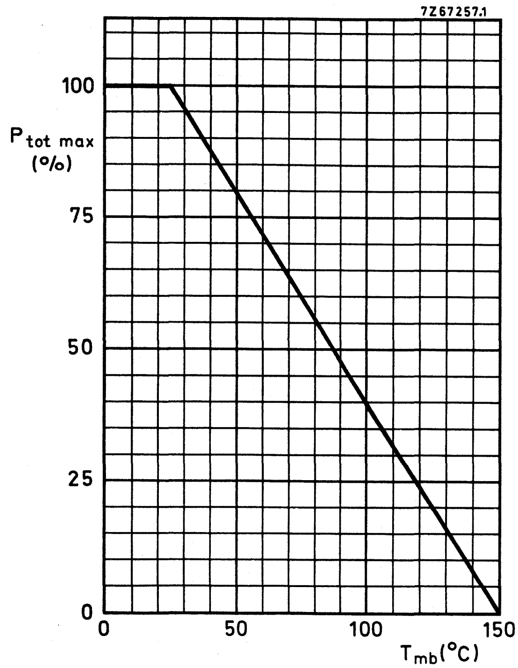


Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

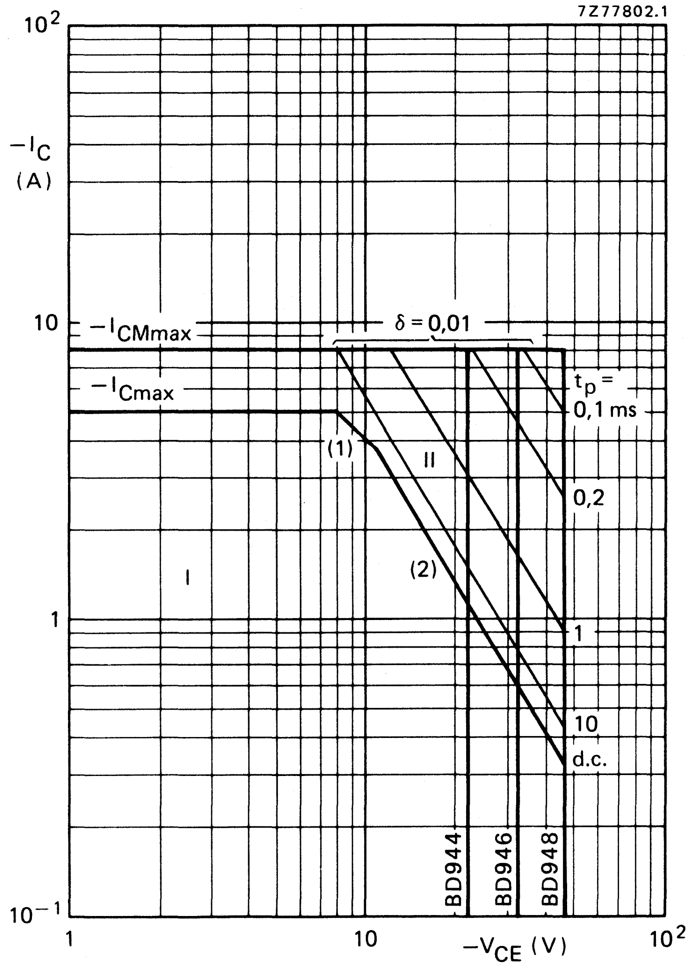


Fig. 3 Safe Operating Area, $T_{mb} = 25\ ^oC$.

I Region of permissible d.c operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

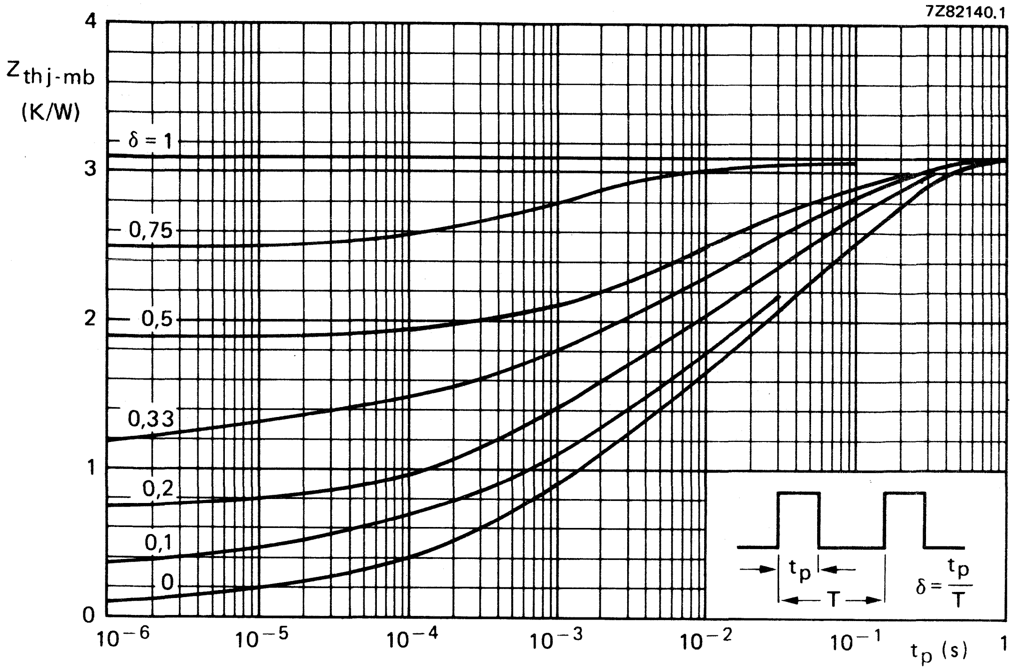


Fig. 4 Pulse power rating chart.

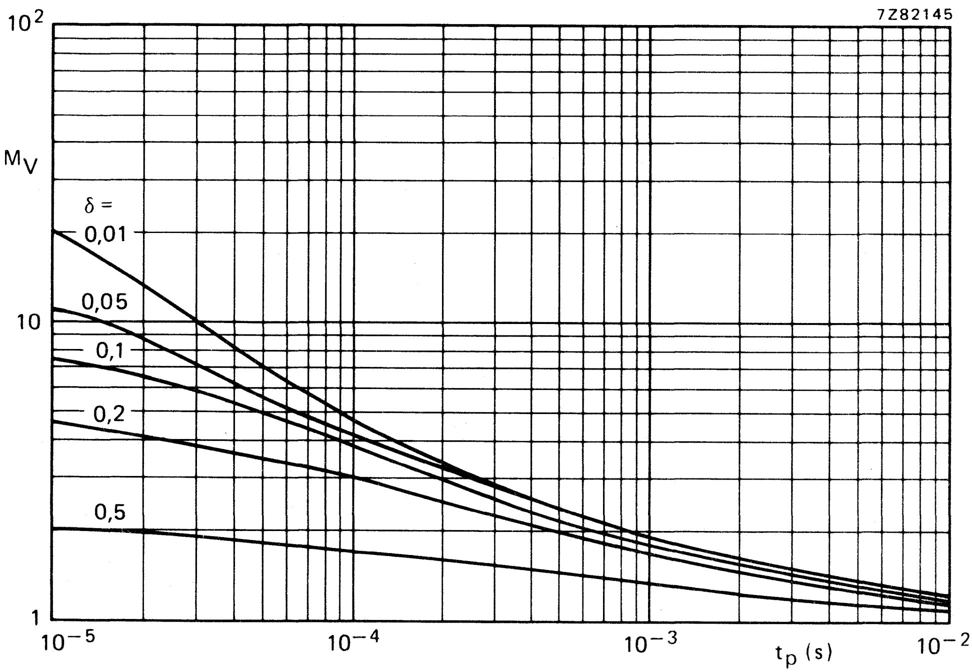


Fig. 5 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

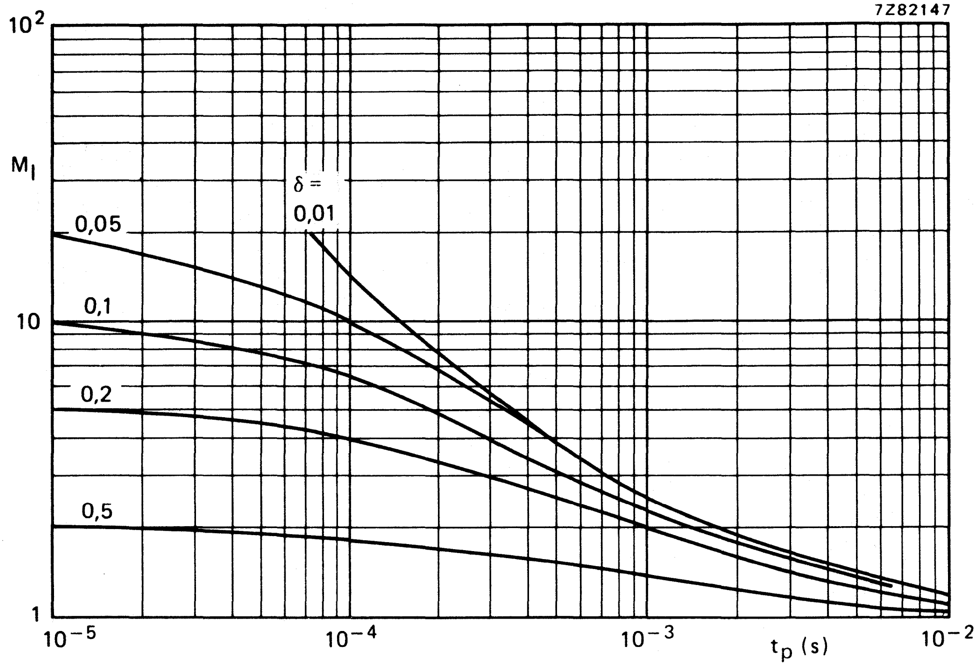


Fig. 6 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD944/946.

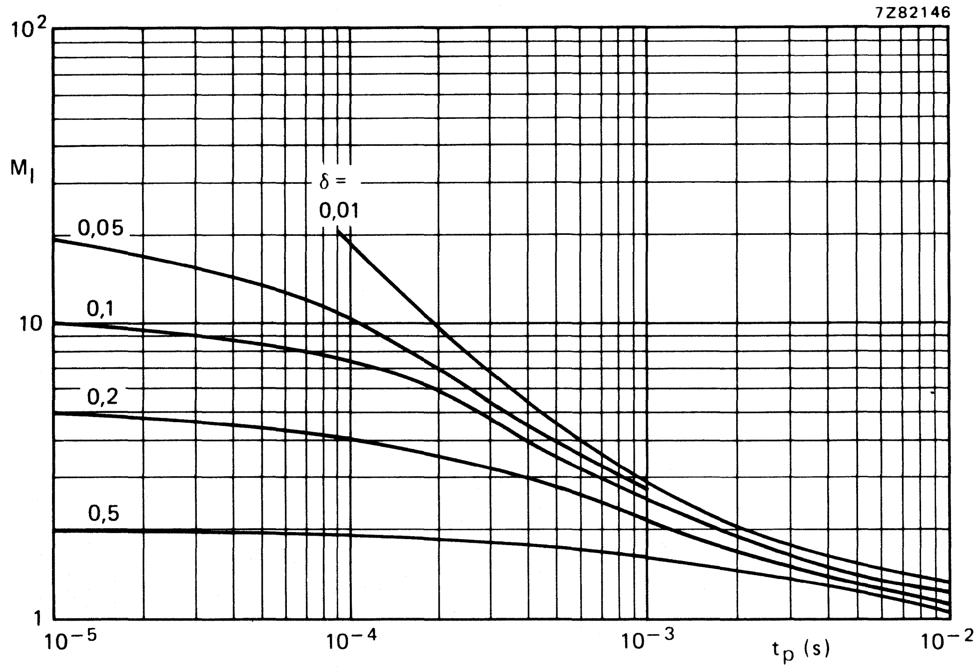


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD948.

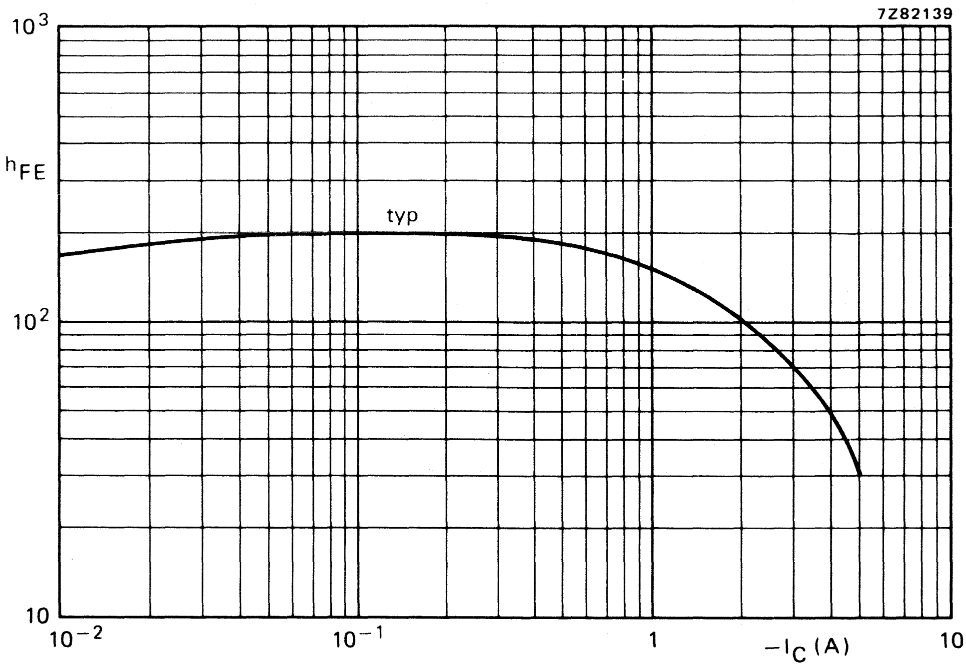


Fig. 8 Typical d.c. current gain at $-V_{CE}$ = 1 V; T_j = 25 °C.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon epitaxial power transistors each in a SOT186 envelope with an electrically insulated mounting base.

NPN complements are BD943F, BD945F and BD947F.

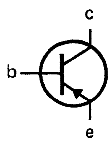
QUICK REFERENCE DATA

			BD944F	BD946F	BD948F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current (DC)	$-I_C$	max.		5		A
Total power dissipation up to $T_h = 25\ ^oC$	P_{tot}	max.		22		W

MECHANICAL DATA

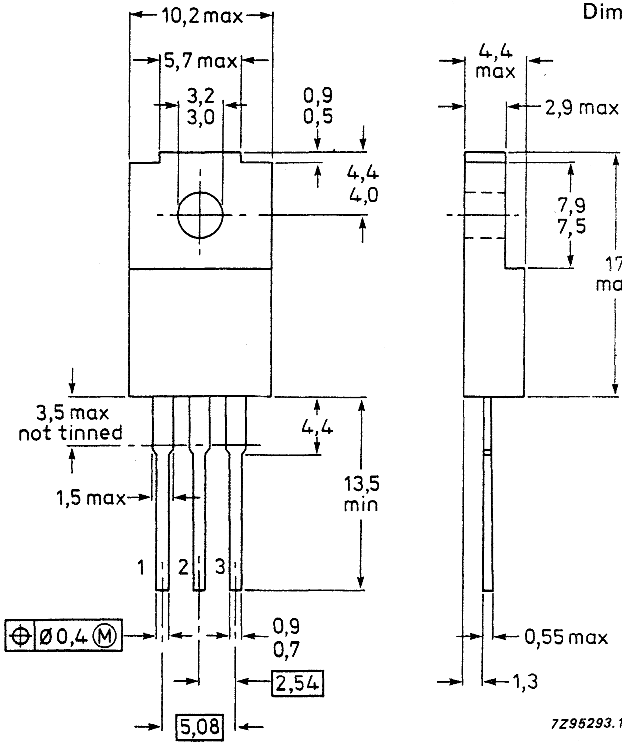
Dimensions in mm

Fig.1 SOT186.



Pinning

1 = base
2 = collector
3 = emitter



RATINGS

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

			BD944F	BD946F	BD948F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current						
DC	$-I_C$	max.		5		A
peak value	$-I_{CM}$	max.		8		A
Base current	$-I_B$	max.		1		A
Total power dissipation						
up to T_h = 25 °C (note 1)	P_{tot}	max.		15		W
up to T_h = 25 °C (note 2)	P_{tot}	max.		22		W
Storage temperature range	T_{stg}			−65 to 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	2.93	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	7.93	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.43	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	max.	50	μA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	max.	1	mA
$I_B = 0; -V_{CE} = 15$ V; BD944F $-V_{CE} = 20$ V; BD946F $-V_{CE} = 25$ V; BD948F	$-I_{CEO}$	max.	0.1	mA
Emitter cut-off current				
$-I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	max.	0.2	mA

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

			BD944F	946F	948F	
DC current gain (note 1)						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	min.	25	25	25	
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	min.	85	85	85	
		max.	475	475	475	
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	min.	50	50	40	
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	h_{FE}	min.	—	—	30	
Base-emitter voltage (note 1 and 2)						
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	$-V_{BE}$	max.	1.1	1.1	—	V
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	$-V_{BE}$	max.	—	—	1.3	V
Collector-emitter saturation voltage (note 1)						
$-I_C$ = 2 A; $-I_B$ = 0.2 A	$-V_{CEsat}$	max.	0.5	0.5	—	V
$-I_C$ = 3 A; $-I_B$ = 0.3 A	$-V_{CEsat}$	max.	—	—	0.7	V
Knee voltage (1)						
$-I_C$ = 2 A; $-I_B$ = value when						
$-I_C$ = 2.2 A; $-V_{CE}$ = 1 V	$-V_{CEK}$	max.		0.8		V
Transition frequency at f = 1 MHz						
$-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	min.		3		MHz

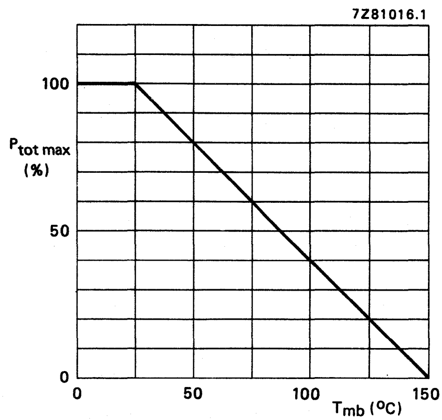
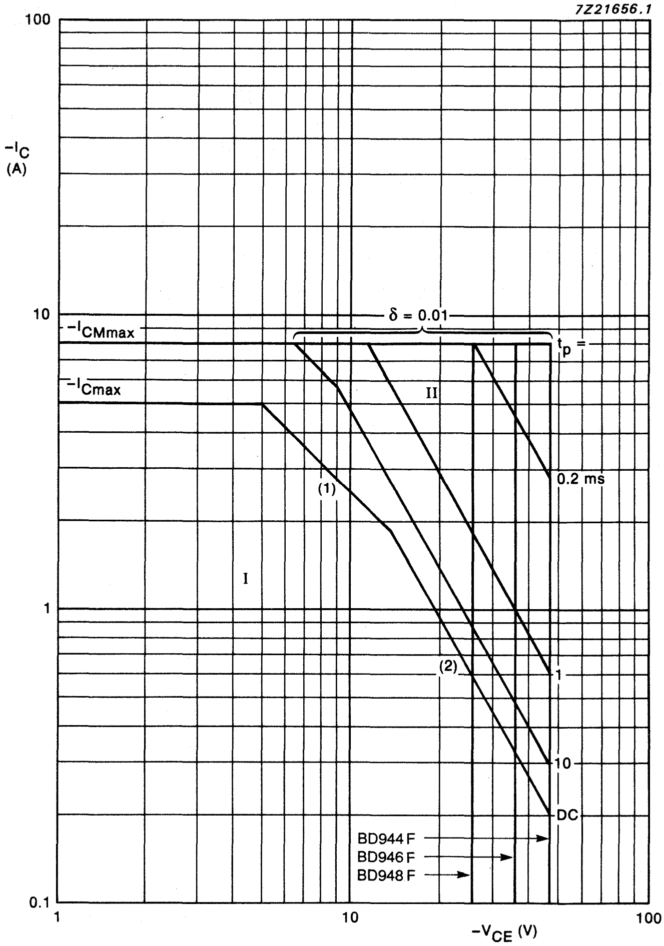


Fig.2 Power derating curve.

Notes

1. Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Fig.3 Safe Operating Area, $T_{mb} = 25\ ^{o}C$.

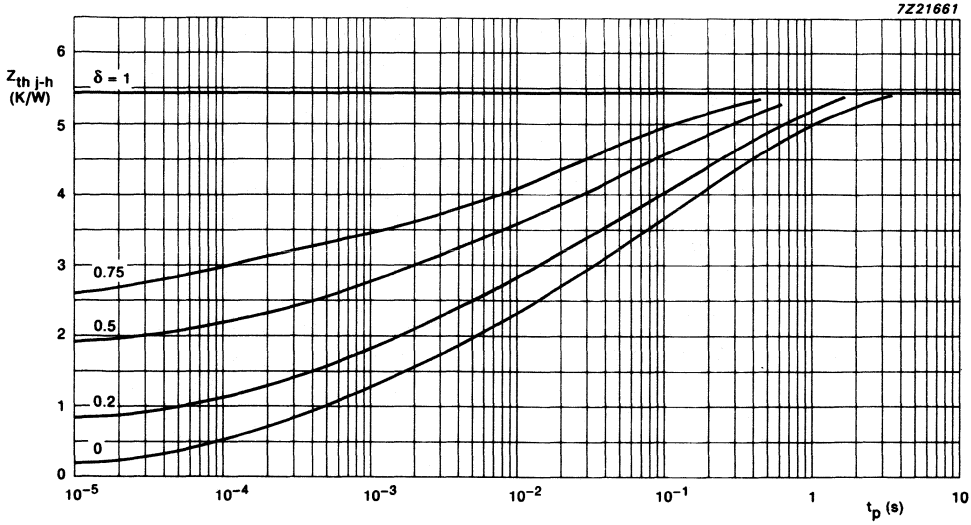


Fig.4 Pulse power rating chart.

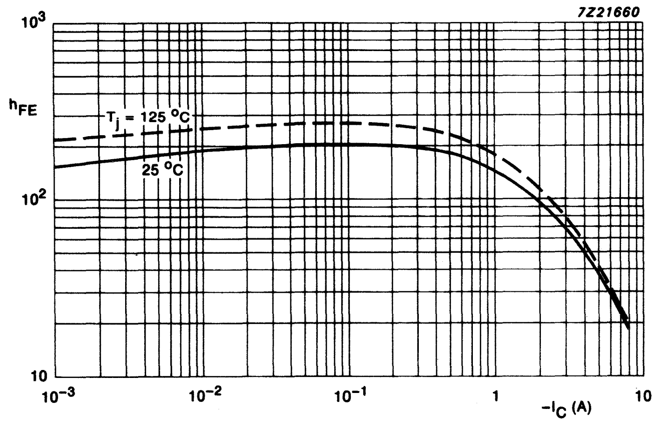


Fig.5 DC current gain; $-V_{CE}$ = 1 V; typical values.

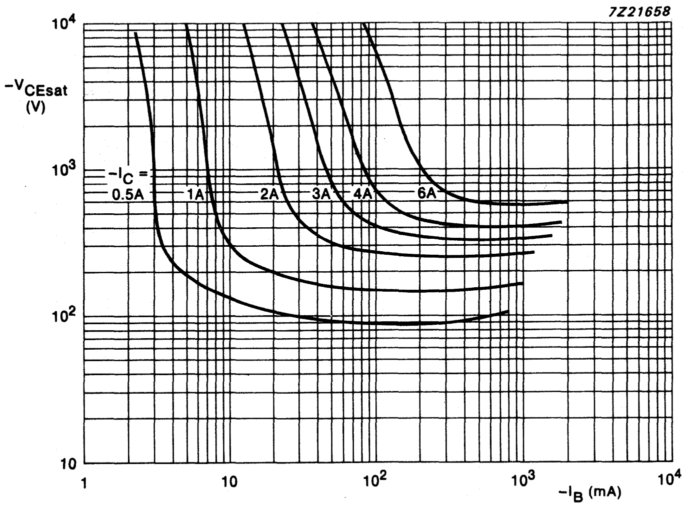


Fig.6 Collector-emitter saturation voltage as a function of base current; T_h = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in a plastic TO-220 envelope. With their p-n-p complements BD950; 952; 954 and 956 they are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

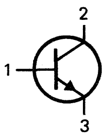
			BD949	BD951	BD953	BD955	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.		5			A
Collector current (peak value)	I_{CM}	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 0,5 A; V_{CE} = 4 V	h_{FE}	>		40			
I_C = 2 A; V_{CE} = 4 V	h_{FE}	>		20			

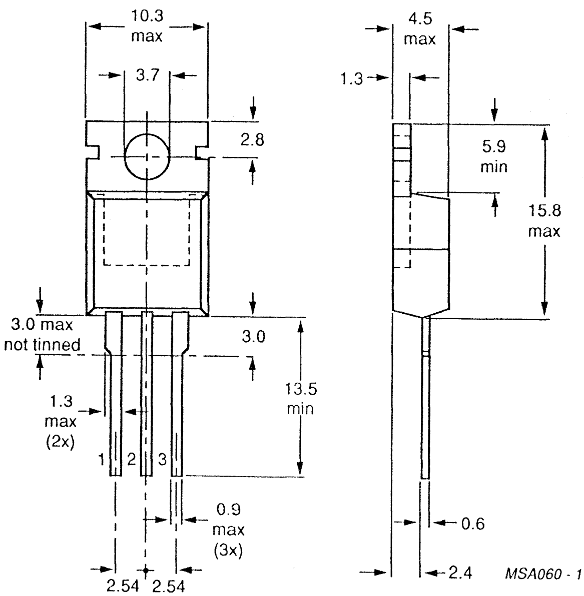
MECHANICAL DATA

Fig. 1 TO-220.

Dimensions in mm

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD949	951	953	955	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	5				A
Collector current (peak value)	I_{CM}	max.	8				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBO\,max}$	I_{CBO}	<	50	μA
$I_E = 0$; V_{CB} = ½ $V_{CBO\,max}$; T_j = 150 °C	I_{CBO}	<	1	mA
$I_B = 0$; V_{CE} = ½ $V_{CEO\,max}$	I_{CEO}	<	0,1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	0,2	mA
D.C. current gain (note 1)				
I_C = 0,5 A; V_{CE} = 4 V	h_{FE}	>	40	
I_C = 2 A; V_{CE} = 4 V	h_{FE}	>	20	
Base-emitter voltage (notes 1 and 2)				
I_C = 2 A; V_{CE} = 4 V	V_{BE}	<	1,4	V
Collector-emitter saturation voltage (note 1)				
I_C = 2 A; I_B = 0,2 A	V_{CEsat}	<	1	V
Transition frequency at f = 1 MHz				
I_C = 0,5 A; V_{CE} = 4 V	f_T	>	3	MHz

(1) Measured under pulse conditions: $t_p \leqslant 300\ \mu s$, $\delta < 2\%$.
(2) V_{EB} decreases by about 2,3 mV/K with increasing temperature.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1,5 μs

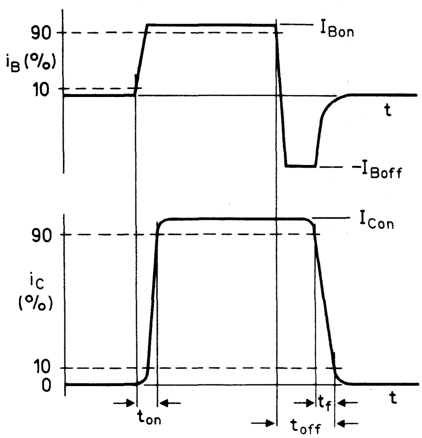
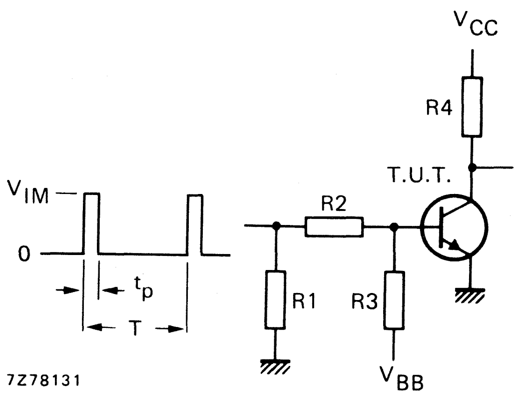


Fig. 2 Switching times waveforms.



V_{IM} = 30 V
V_{CC} = 20 V
V_{BB} = −3,5 V
R1 = 82 Ω
R2 = 150 Ω
R3 = 39 Ω
R4 = 20 Ω
$t_r = t_f$ ≤ 15 ns
t_p = 10 μs
T = 500 μs

Fig. 3 Switching times test circuit.

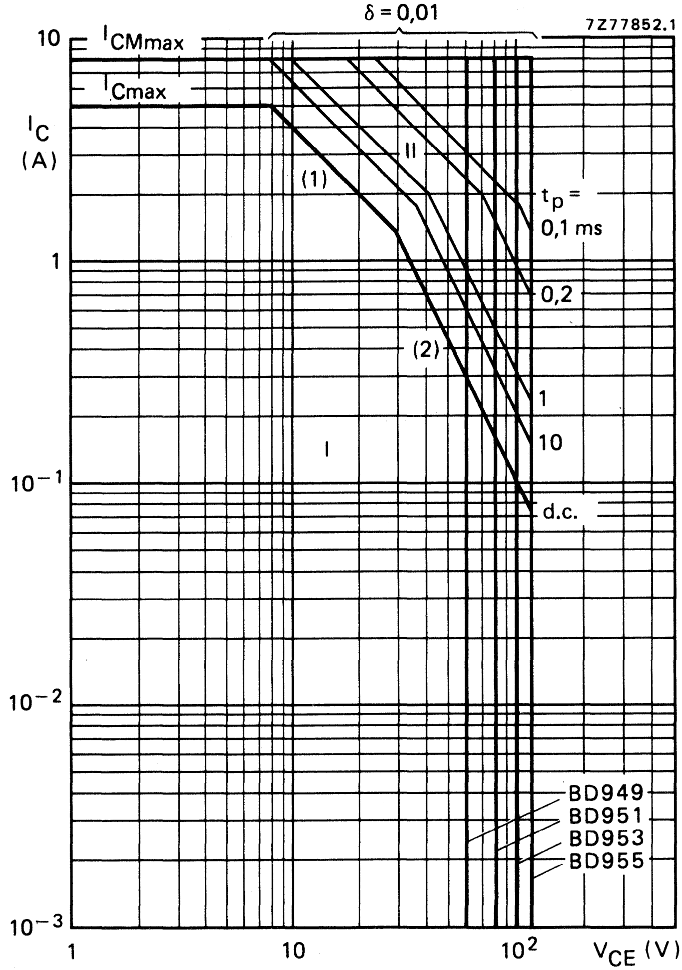


Fig. 4 Safe Operating Area, $T_{mb} \leqslant 25\ ^oC$.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

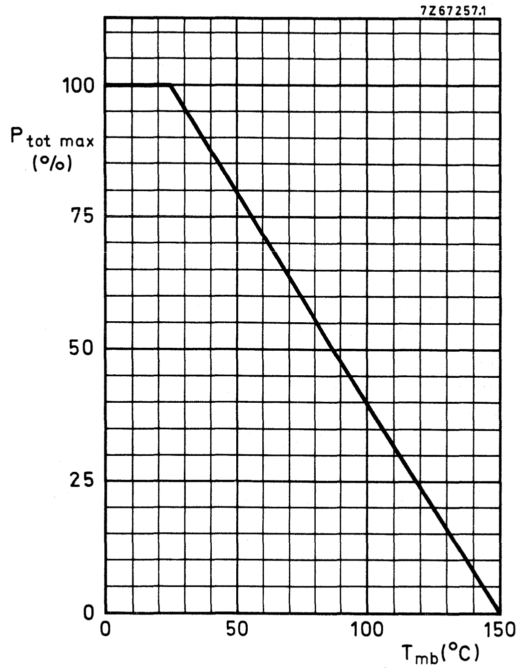


Fig. 5 Power derating curve.

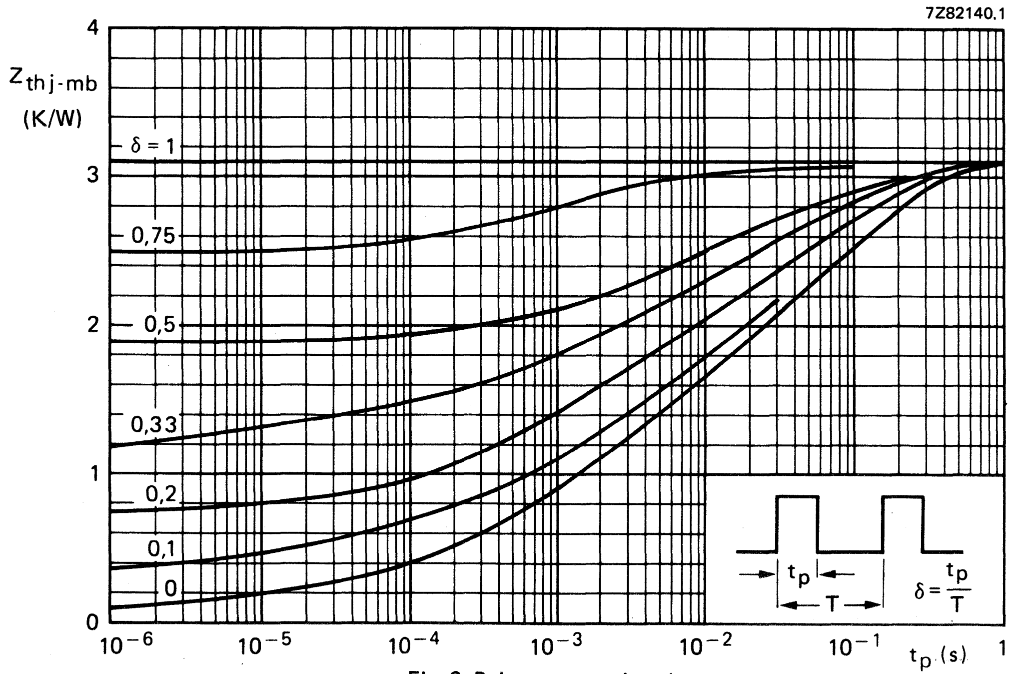


Fig. 6 Pulse power rating chart.

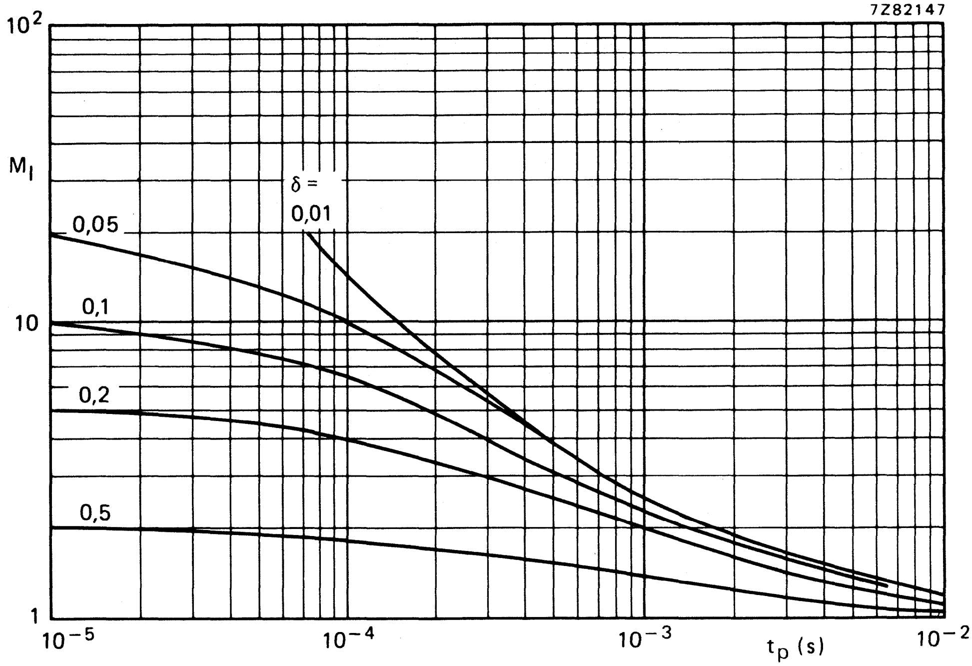


Fig. 7 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD949/951.

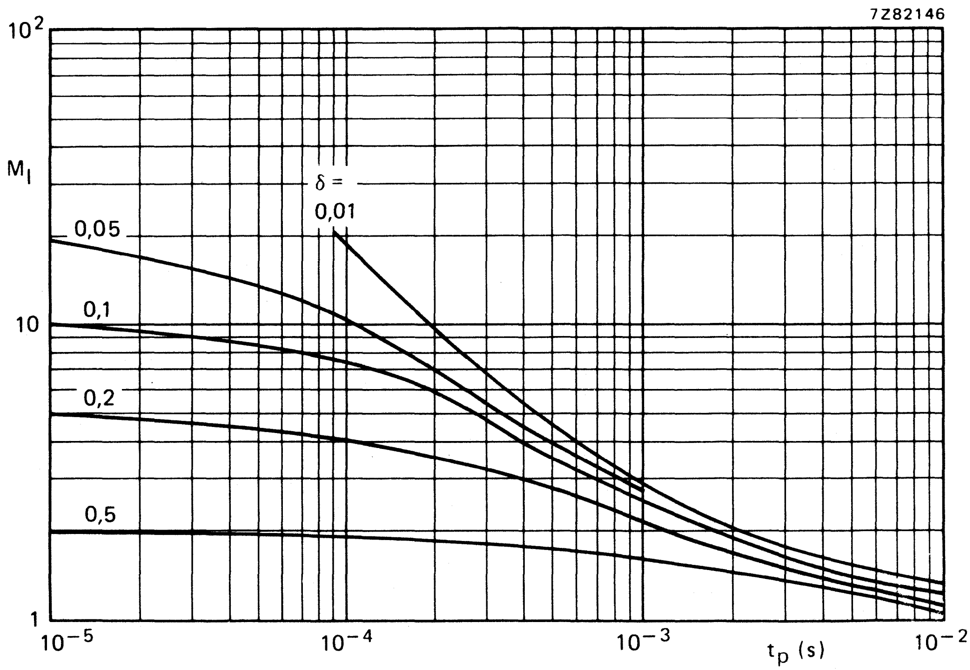


Fig. 8 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD953/955.

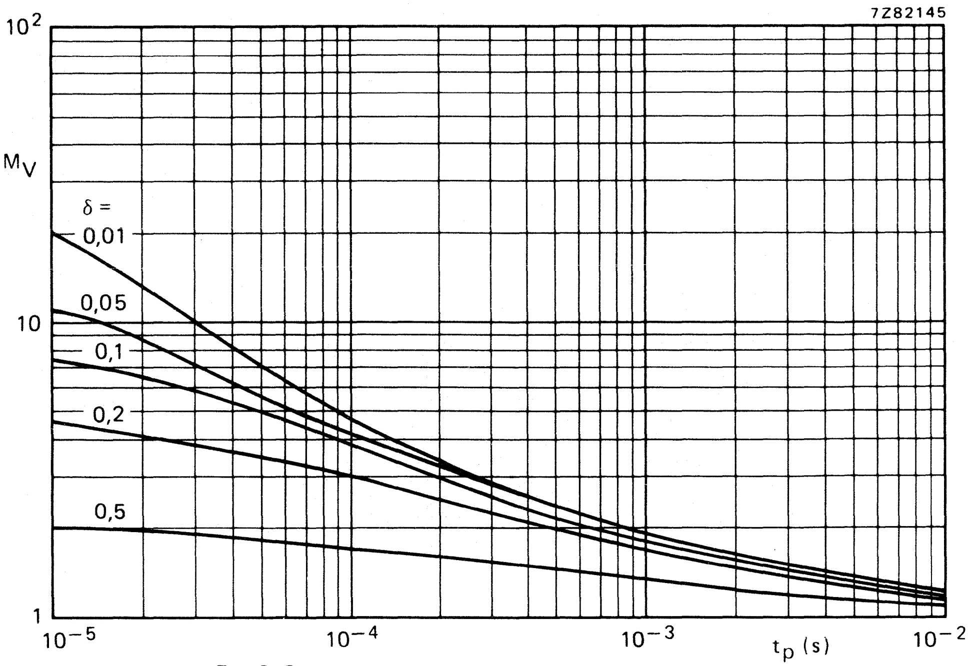


Fig. 9 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

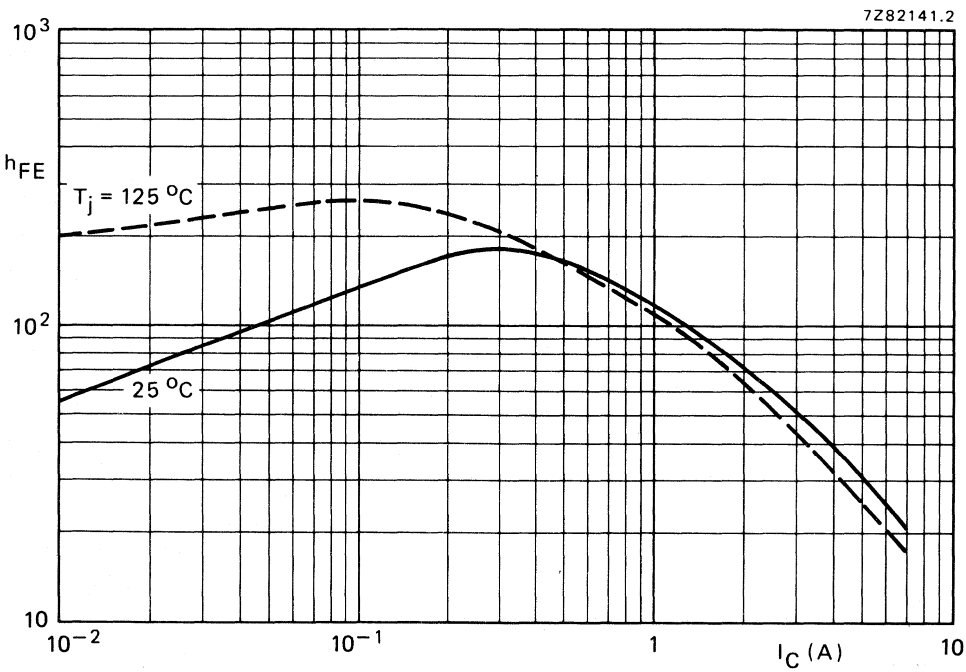


Fig. 10 Typical d.c. current gain at V_{CE} = 4 V.

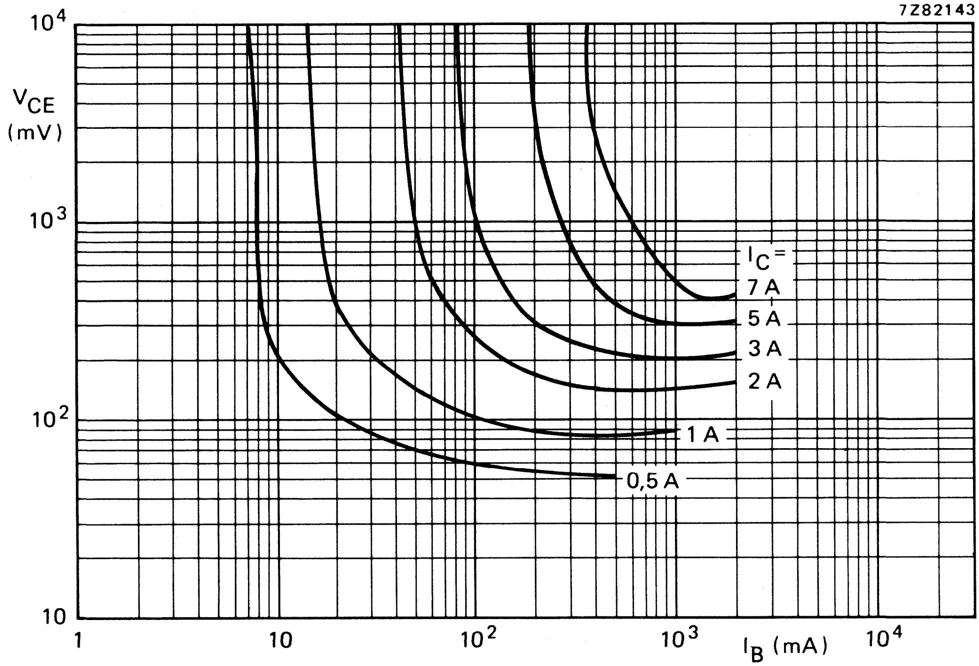


Fig. 11 Collector-emitter voltage as a function of base current.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon power transistors each in a SOT186 envelope with an electrically insulated mounting base. PNP complements are BD950F, BD952F, BD954F and BD956F.

QUICK REFERENCE DATA

			BD949F	951F	953F	955F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (DC)	I_C	max.	5				A
peak value	I_{CM}	max.	8				A
Total power dissipation at $T_h \leqslant 25$ °C	P_{tot}	max.	22				W
DC current gain $I_C = 2$ A; $V_{CE} = 4$ V	h_{FE}	typ.	20				

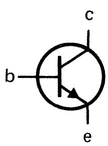
MECHANICAL DATA

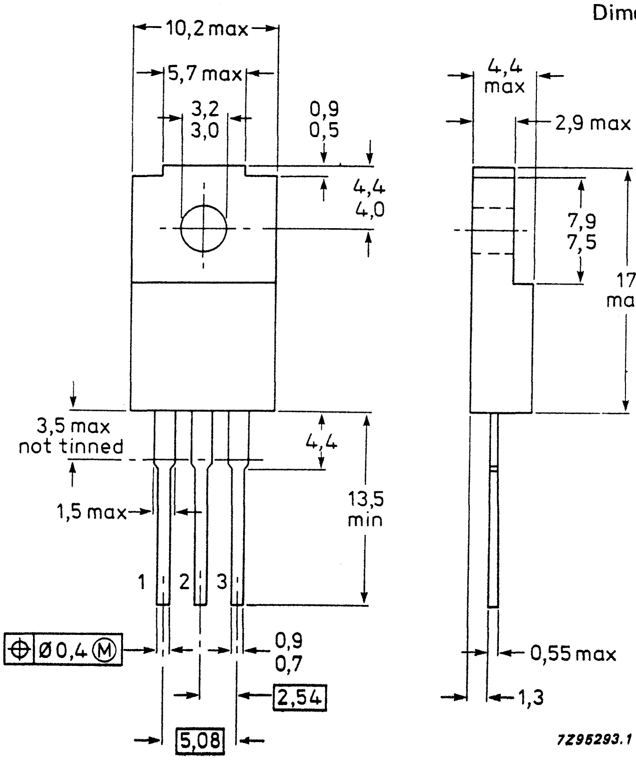
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BD949F	951F	953F	955F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (DC)	I_C	max.	5				A
peak value	I_{CM}	max.	8				A
Base current (DC)	I_B	max.	5				A
Total power dissipation at $T_h \leq 25\ ^oC$ (note 1)	P_{tot}	max.	15				W
at $T_h \leq 25\ ^oC$ (note 2)	P_{tot}	max.	22				W
Storage temperature range	T_{stg}		−65 to 150				^oC
Junction temperature	T_j	max.	150				^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	3.12	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	8.12	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.62	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $I_C = 2\ A; I_B = 0.2\ A$	V_{CEsat}	max.	1	V
DC current gain $I_C = 2\ A; V_{CE} = 4\ V$	h_{FE}	typ.	20	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-220 envelope. With their n-p-n complements BD949; 951; 953 and 955 they are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

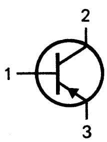
			BD950	952	954	956	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		5			A
Collector current (peak value)	$-I_{CM}$	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
$-I_C$ = 0,5 A; $-V_{CE}$ = 4 V	h_{FE}	>		40			
$-I_C$ = 2 A; $-V_{CE}$ = 4 V	h_{FE}	>		20			

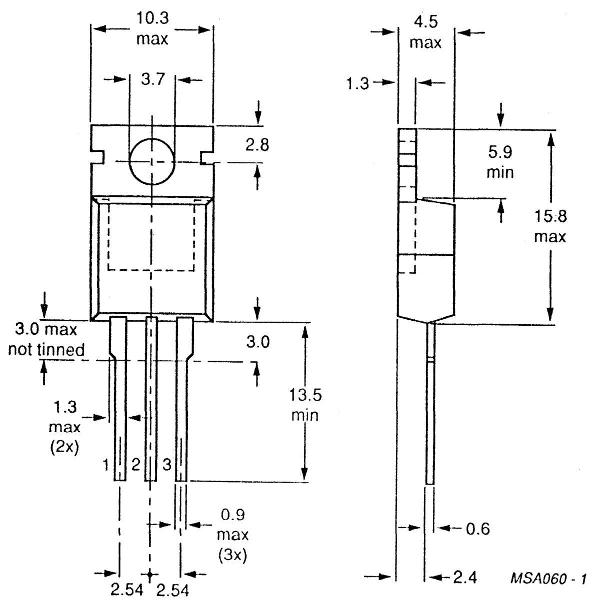
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD950	952	954	956	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	5				A
Collector current (peak value)	$-I_{CM}$	max.	8				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBO\,max}$	$-I_{CBO}$	<	50	μA
$I_E = 0$; $-V_{CB} = -½\ V_{CBO\,max}$; T_j = 150 °C	$-I_{CBO}$	<	1	mA
$I_B = 0$; $-V_{CE} = -½\ V_{CEO\,max}$	$-I_{CEO}$	<	0,1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	0,2	mA
D.C. current gain (note 1)				
$-I_C = 0,5$ A; $-V_{CE} = 4$ V	h_{FE}	>	40	
$-I_C = 2$ A; $-V_{CE} = 4$ V	h_{FE}	>	20	
Base-emitter voltage (notes 1 and 2)				
$-I_C = 2$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,4	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	1	V
Transition frequency at f = 1 MHz				
$-I_C = 0,5$ A; $-V_{CE} = 4$ V	f_T	>	3	MHz

(1) Measured under pulse conditions: $t_p \leqslant 300\ \mu s$, $\delta < 2\%$.
(2) V_{EB} decreases by about 2,3 mV/K with increasing temperature.

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels) $I_{Con} = 1$ A; $-I_{Bon} = I_{Boff} = 0{,}1$ A			
Turn-on time	t_{on}	typ.	0,1 μs
Turn-off time	t_{off}	typ.	0,4 μs

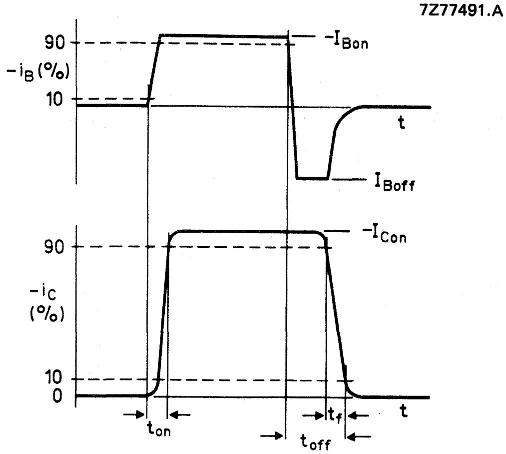
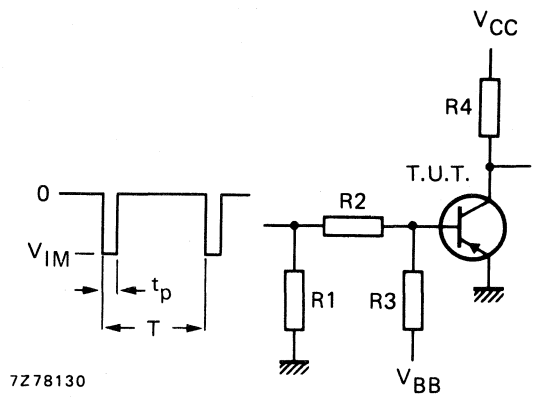


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	30 V
$-V_{CC}$	=	20 V
V_{BB}	=	3,5 V
R1	=	82 Ω
R2	=	150 Ω
R3	=	39 Ω
R4	=	20 Ω
$t_r = t_f \leqslant$		15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

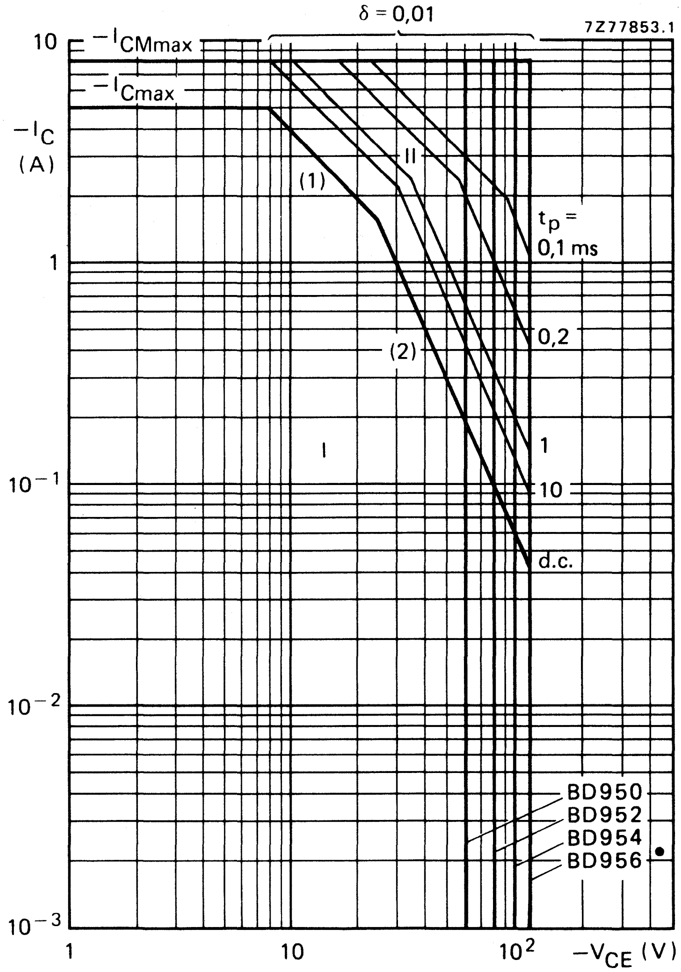


Fig. 4 Safe Operating Area, $T_{mb} \leqslant 25\ ^{o}C$.

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

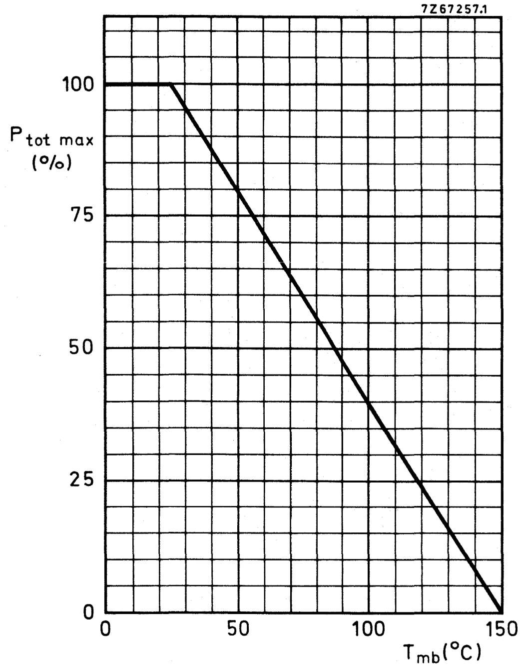


Fig. 5 Power derating curve.

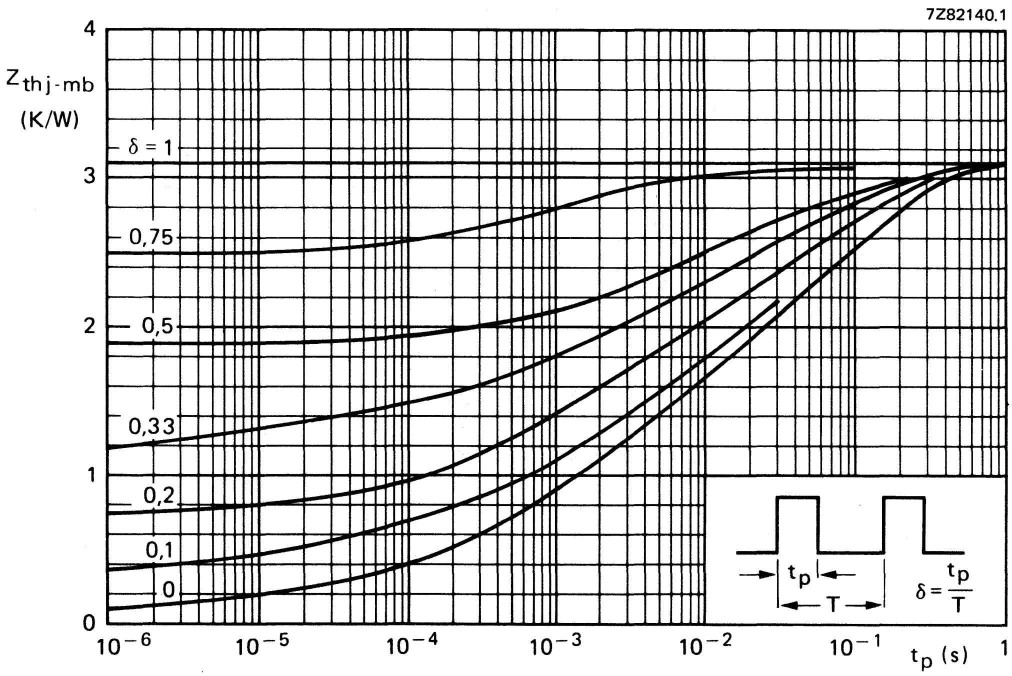


Fig. 6 Pulse power rating chart.

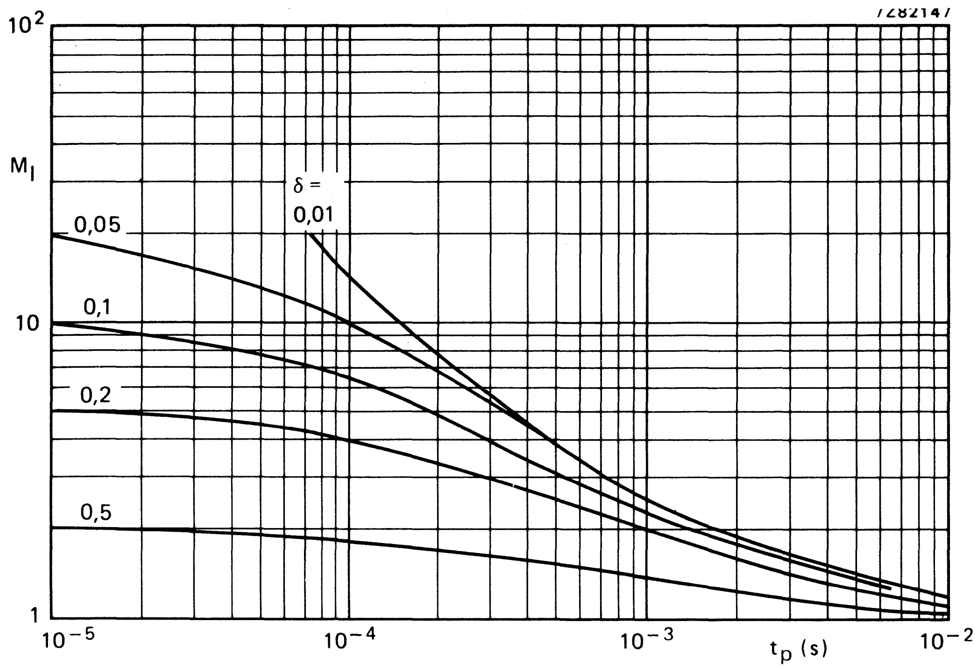


Fig. 7 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD950 and BD952.

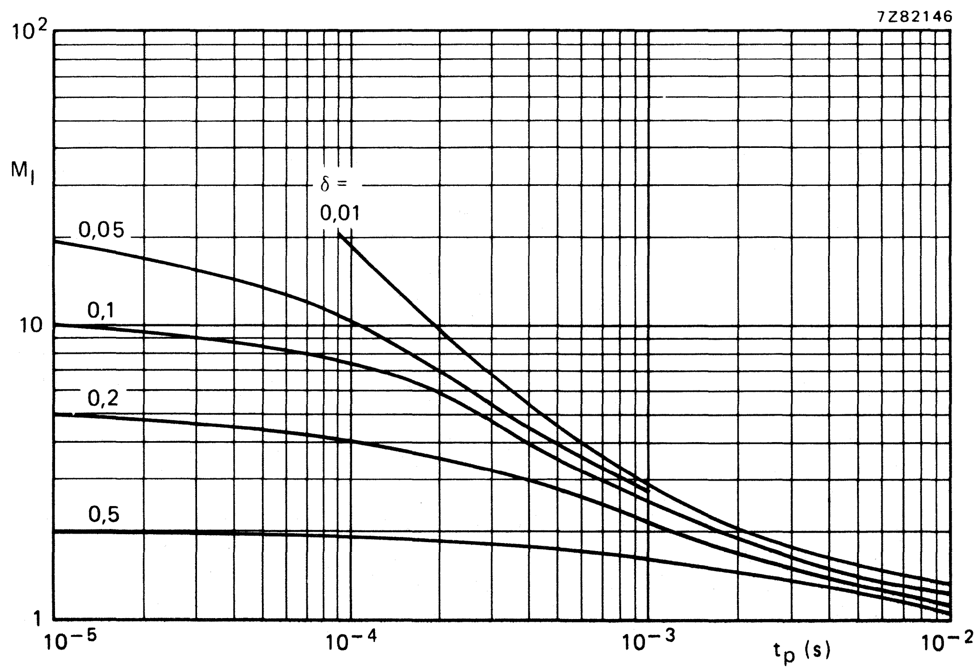


Fig. 8 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD954 and BD956.

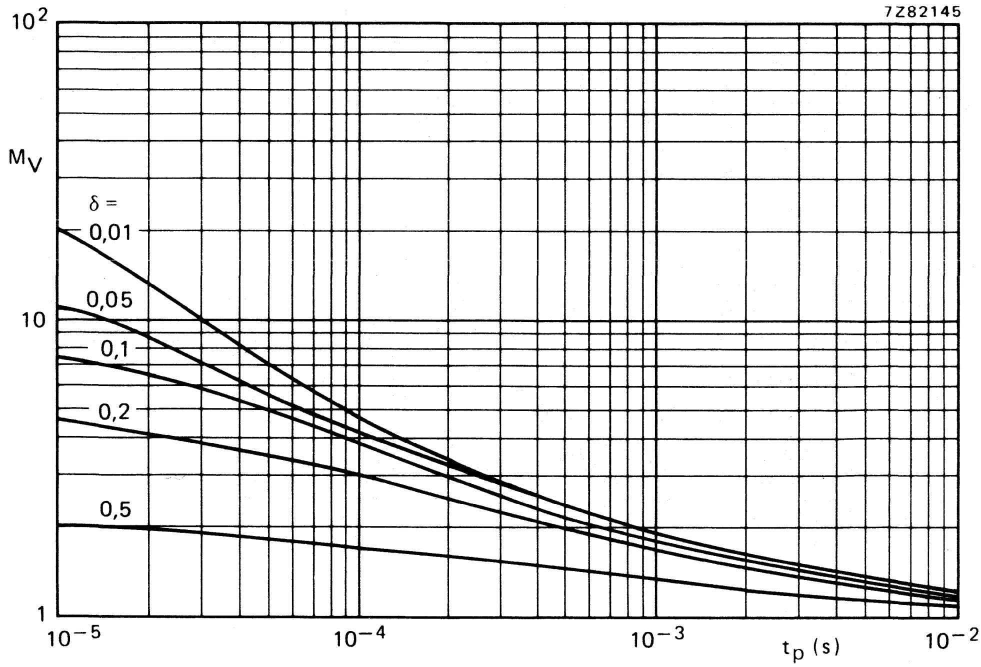


Fig. 9 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

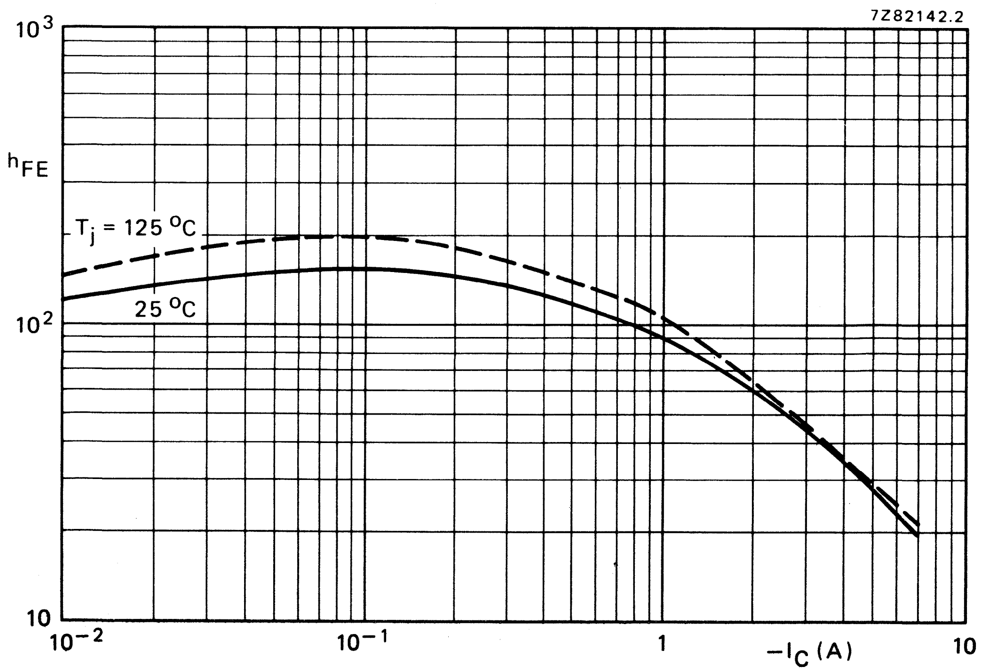


Fig. 10 Typical d.c. current gain at $-V_{CE}$ = 4 V.

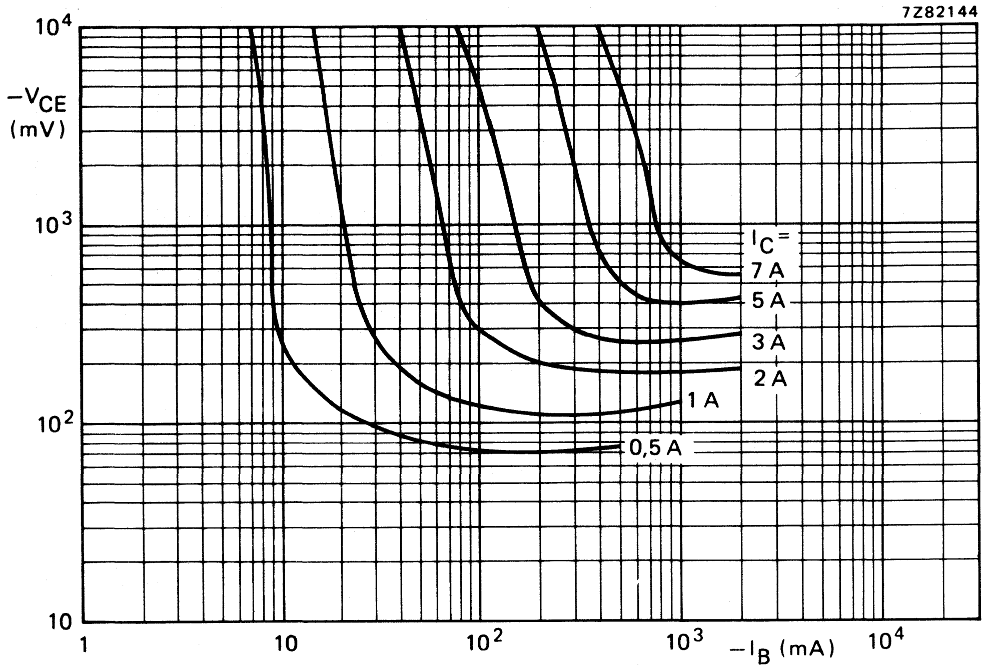


Fig. 11 Collector-emitter voltage as a function of base current.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon power transistors each in a SOT186 envelope with an electrically insulated mounting base.
NPN complements are BD949F, BD951F, BD953F and BD955F.

QUICK REFERENCE DATA

			BD950F	952F	954F	956F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (DC)	$-I_C$	max.	5				A
peak value	$-I_{CM}$	max.	8				A
Total power dissipation at $T_h \leq 25\,^oC$	P_{tot}	max.	22				W
DC current gain $-I_C = 2$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	20				

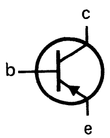
MECHANICAL DATA

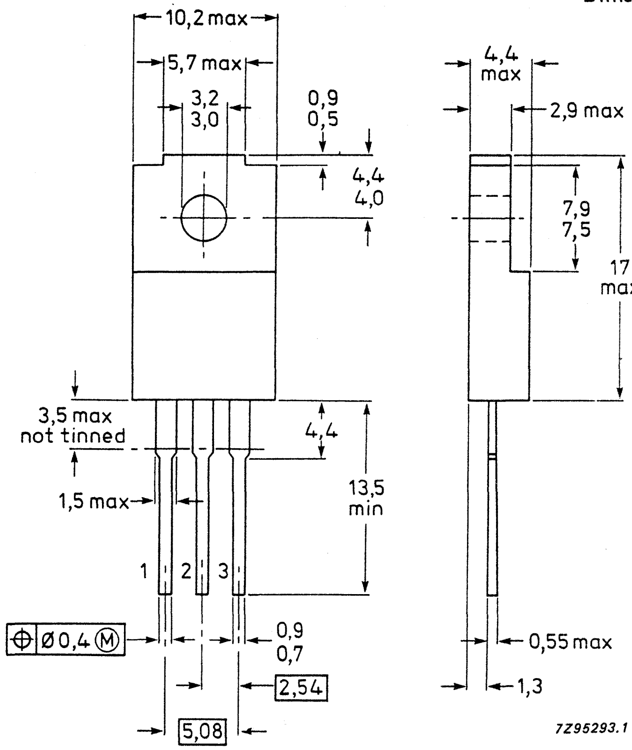
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BD950F	952F	954F	956F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (DC)	$-I_C$	max.	5				A
peak value	$-I_{CM}$	max.	8				A
Base current (DC)	$-I_B$	max.	5				A
Total power dissipation at $T_h \leq 25\ ^oC$ (note 1)	P_{tot}	max.	15				W
at $T_h \leq 25\ ^oC$ (note 2)	P_{tot}	max.	22				W
Storage temperature range	T_{stg}		−65 to 150				^oC
Junction temperature	T_j	max.	150				^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	3.12	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	8.12	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.62	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $-I_C = 2$ A; $-I_B = 0.2$ A	V_{CEsat}	max.	1	V
DC current gain $-I_C = 2$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	20	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS60/60A/60B/60C

PNP silicon Darlington power transistors

DESCRIPTION

PNP silicon power transistors in a monolithic Darlington circuit in a miniature SMD envelope (SOT223) intended for switching applications. NPN complements are BDS61/61A/61B/61C.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

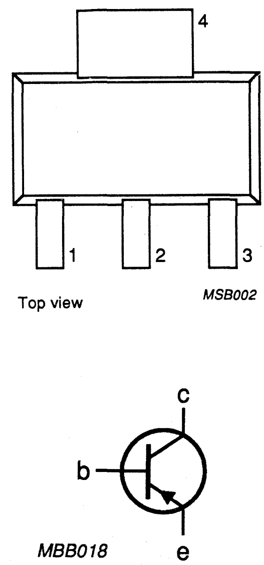


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS60		-	60	V
	BDS60A		-	80	V
	BDS60B		-	100	V
	BDS60C		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS60		-	60	V
	BDS60A		-	80	V
	BDS60B		-	100	V
	BDS60C		-	120	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	6	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 0.5 V $-V_{CE}$ = 3 V;	2200	-	

Note

1. Mounted on PCB.

PNP silicon Darlington power transistors BDS60/60A/60B/60C

R1 typ. 3 kΩ
R2 typ. 80 Ω

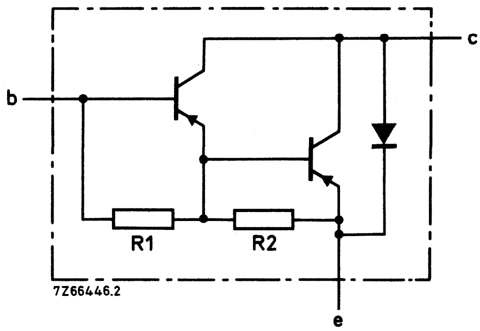


Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS60		-	60	V
	BDS60A		-	80	V
	BDS60B		-	100	V
	BDS60C		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS60		-	60	V
	BDS60A		-	80	V
	BDS60B		-	100	V
	BDS60C		-	120	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	6	A
$-I_B$	base current		-	100	mA
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

PNP silicon Darlington power transistors BDS60/60A/60B/60C

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

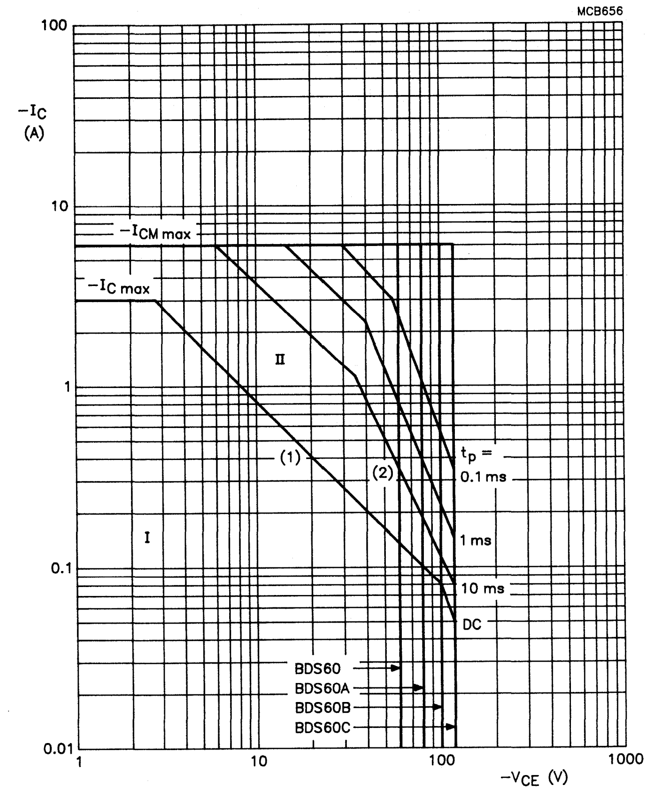
SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CEO}$	collector cut-off current	$-I_B = 0$; $V_{CE} = 1/2\ V_{CEO\ max}$	-	-	0.2	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CEO\ max}$	-	-	0.2	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\ max}$; $T_j = 150$ °C	-	-	0.5	mA
$-I_{EBO}$	emitter cut-off current	$-I_C = 0$; $-V_{EB} = 5$ V	-	-	5	mA
$-V_{BE}$	base-emitter voltage	$-I_C = 1.5$ A; $-V_{CE} = 3$ V; note 1	-	-	**2.5**	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 1.5$ A; $-I_B = 6$ mA; note 1	-	-	**2.5**	V
h_{FE}	DC current gain	$-I_C = 0.5$ A; $-V_{CE} = 3$ V note 1	-	2200	-	
h_{FE}	DC current gain	$-I_C = 1.5$ A; $-V_{CE} = 3$ V; note 1	**750**	-	-	
h_{FE}	DC current gain	$-I_C = 3$ A; $-V_{CE} = 3$ V; note 1	-	500	-	
V_F	diode forward voltage	$I_F = 3$ A	-	2.1	-	V
f_{hfe}	cut-off frequency	$-I_C = 1.5$ A; $-V_{CE} = 3$ V	-	25	-	kHz
h_{fe}	small signal current gain	f = 1 MHz; $-I_C = 1.5$ A; $-V_{CE} = 3$ V	10	-	-	
t_{on}	switching times turn-on time	$-I_{C\ on} = 1.5$ A; $-I_{B\ on} = I_{Boff} = 6$ A; $-V_{CC} = 30$ V	-	0.3	1.5	µs
t_{off}	switching times turn-off time		-	1.5	5	µs

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.

PNP silicon Darlington power transistors

BDS60/60A/60B/60C



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

Fig.3 Safe operating area; T_{tab} = 25 °C.

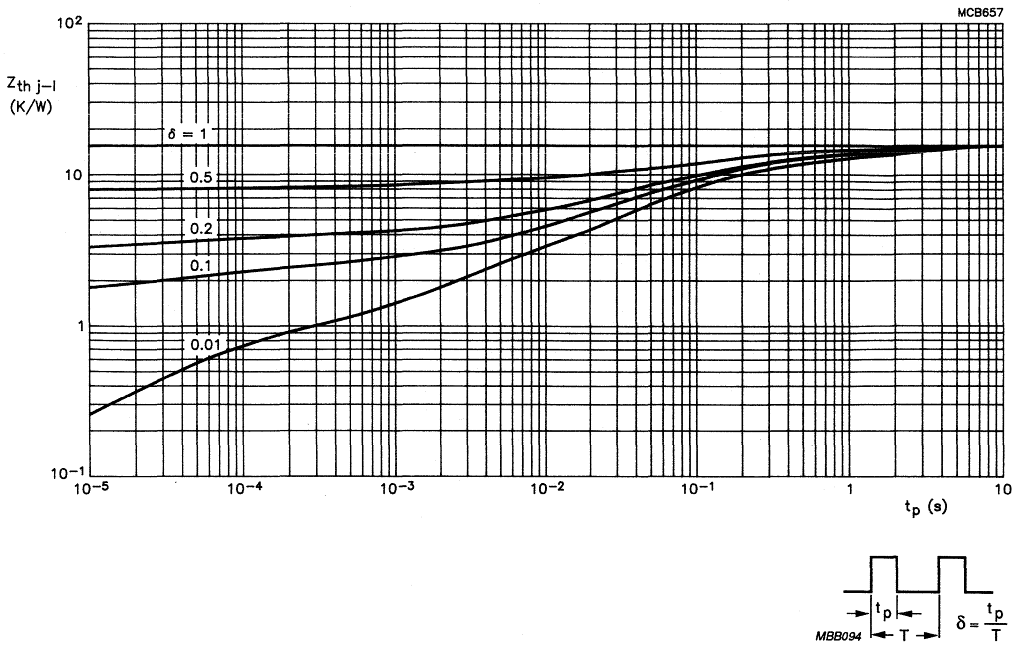


Fig.4 Pulse power rating chart.

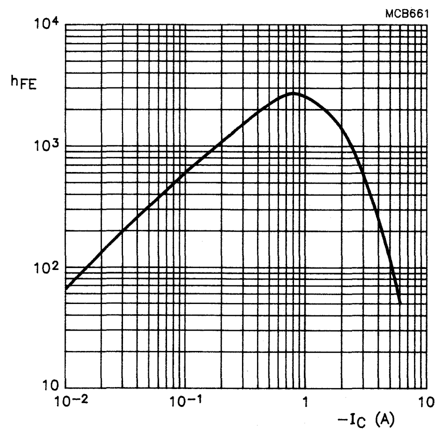


Fig.5 Typical DC current gain; $-V_{CE}$ = 3 V; T_{tab} = 25 °C.

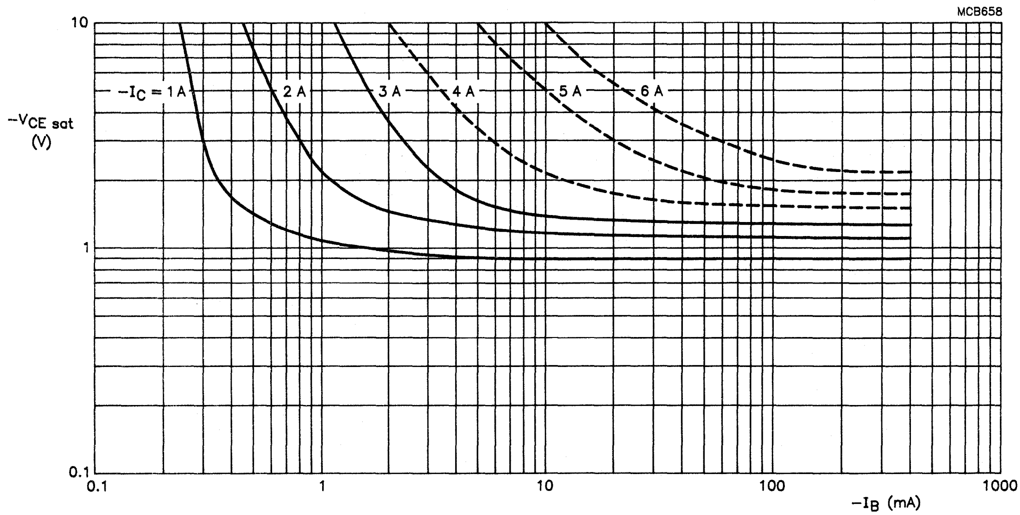


Fig.6 Typical values of collector-emitter saturation voltage at T_{tab} = 25 °C.

PACKAGE OUTLINE

Dimensions in mm

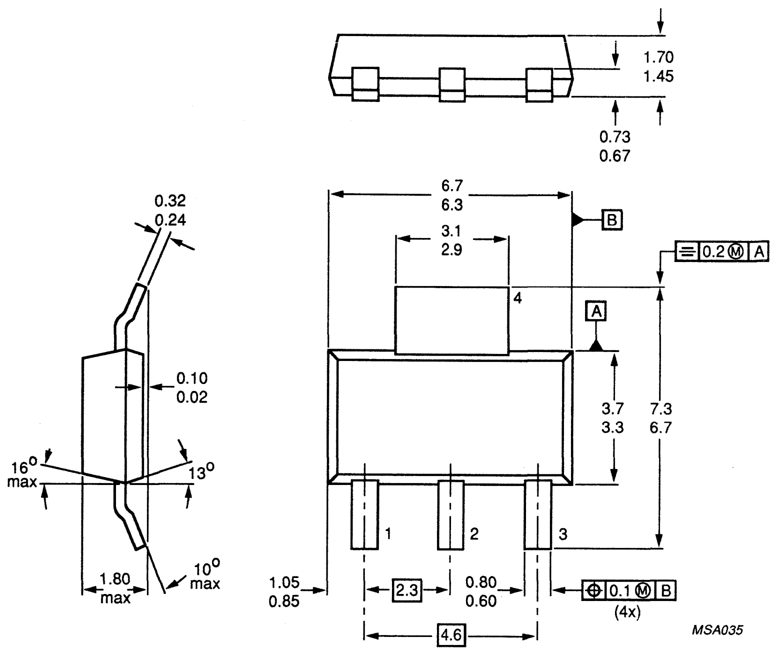


Fig.7 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS61/61A/61B/61C

NPN silicon Darlington power transistors

DESCRIPTION

NPN silicon power transistors in a monolithic Darlington circuit in a miniature SMD envelope (SOT223) intended for switching applications. PNP complements are BDS60/60A/60B/60C.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

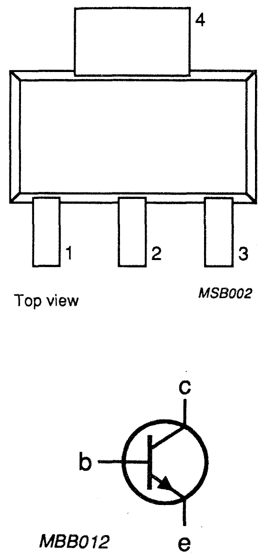


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS61		-	60	V
	BDS61A		-	80	V
	BDS61B		-	100	V
	BDS61C		-	120	V
V_{CEO}	collector-emitter voltage	open base			
	BDS61		-	60	V
	BDS61A		-	80	V
	BDS61B		-	100	V
	BDS61C		-	120	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	6	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 0.5 V $-V_{CE}$ = 3 V;	1150	-	

Note

1. Mounted on PCB.

NPN silicon Darlington power transistors

BDS61/61A/61B/61C

R1 typ. 3 kΩ
R2 typ. 120 Ω

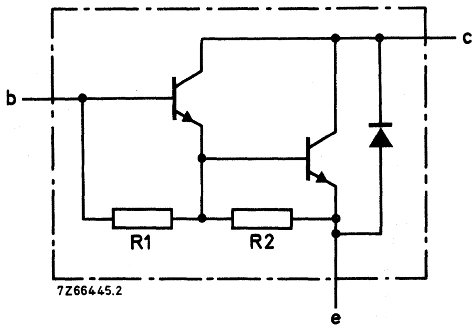


Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS61		-	60	V
	BDS61A		-	80	V
	BDS61B		-	100	V
	BDS61C		-	120	V
V_{CEO}	collector-emitter voltage	open base			
	BDS61		-	60	V
	BDS61A		-	80	V
	BDS61B		-	100	V
	BDS61C		-	120	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	6	A
I_B	base current		-	100	mA
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

NPN silicon Darlington power transistors BDS61/61A/61B/61C

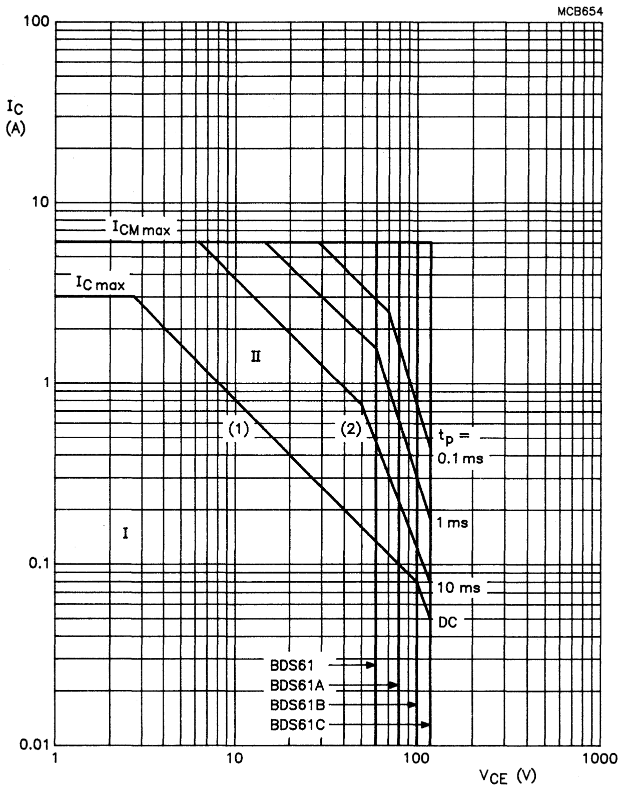
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CEO}	collector cut-off current	$I_B = 0$; $V_{CE} = 1/2\ V_{CEO\,max}$	-	-	0.2	mA
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\,max}$ $T_j = 150$ °C	-	-	0.5	mA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	-	-	5	mA
V_{BE}	base-emitter voltage	$I_C = 1.5$ A; $-V_{CE} = 3$ V; note 1	-	-	2.5	V
$V_{CE\,sat}$	collector-emitter saturation voltage	$I_C = 1.5$ A; $I_B = 6$ mA; note 1	-	-	2.5	V
h_{FE}	DC current gain	$I_C = 0.5$ A; $V_{CE} = 3$ V note 1	-	1150	-	
h_{FE}	DC current gain	$I_C = 1.5$ A; $V_{CE} = 3$ V; note 1	750	-	-	
h_{FE}	DC current gain	$I_C = 3$ A; $V_{CE} = 3$ V; note 1	-	1800	-	
V_F	diode forward voltage	$I_F = 3$ A	-	2.6	-	V
f_{hfe}	cut-off frequency	$I_C = 1.5$ A; $-V_{CE} = 3$ V	-	25	-	kHz
h_{fe}	small signal current gain	f = 1 MHz; $I_C = 1.5$ A; $V_{CE} = 3$ V	10	-	-	
t_{on}	switching times turn-on time	$I_{C\,on} = 1.5$ A; $I_{B\,on} = -I_{Boff} = 6$ A; $V_{CC} = 30$ V	-	0.8	2	µs
t_{off}	switching times turn-off time		-	4.5	8	µs

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.



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

Fig.3 Safe operating area; T_{tab} = 25 °C.

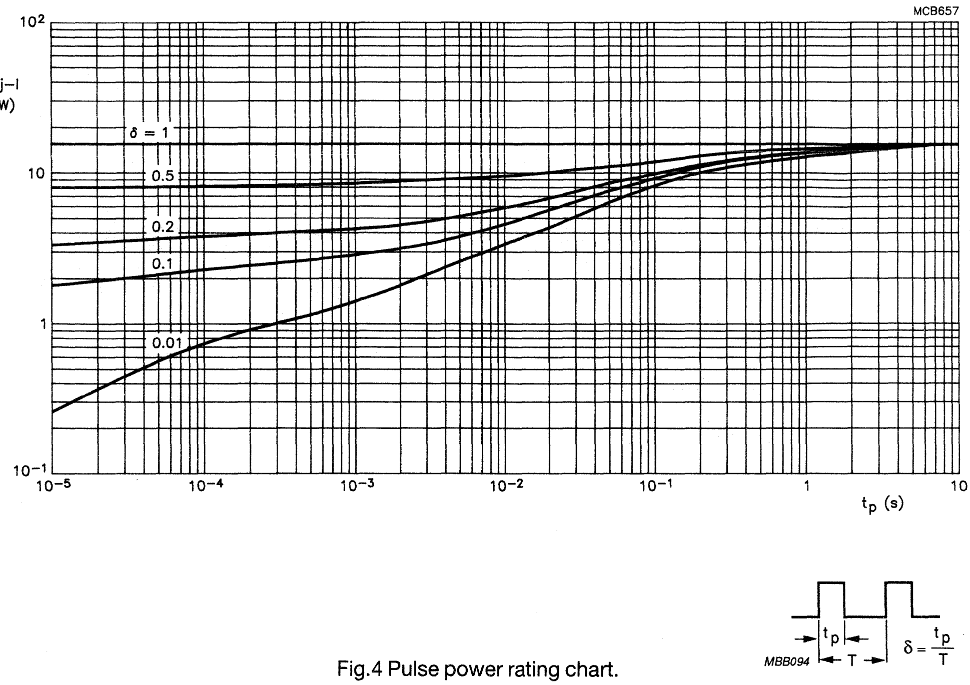


Fig.4 Pulse power rating chart.

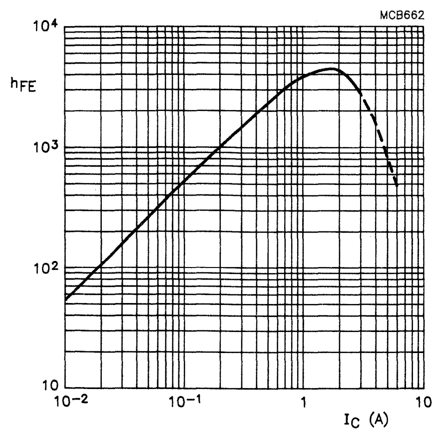


Fig.5 Typical DC current gain; V_{CE} = 3 V; T_{tab} = 25 °C.

NPN silicon Darlington power transistors BDS61/61A/61B/61C

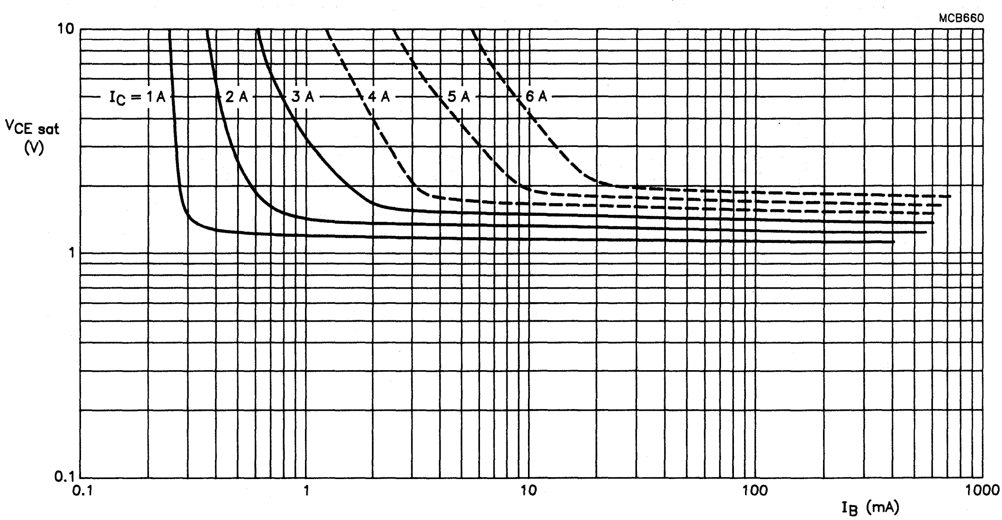


Fig.6 Typical values of collector-emitter saturation voltage at T_{tab} = 25 °C.

PACKAGE OUTLINE

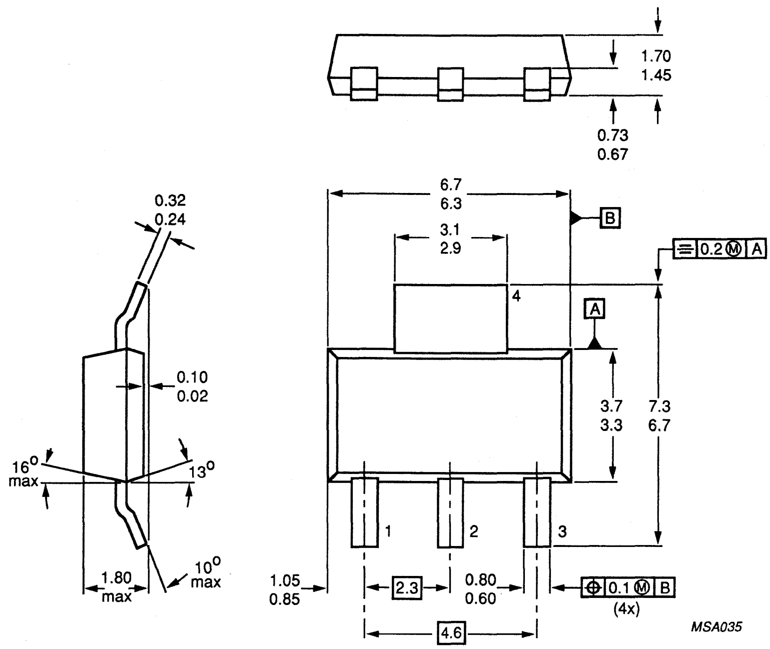


Fig.7 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS201/203/77

NPN silicon epitaxial base power transistors

DESCRIPTION

NPN silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. PNP complements are BDS202/204/78.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

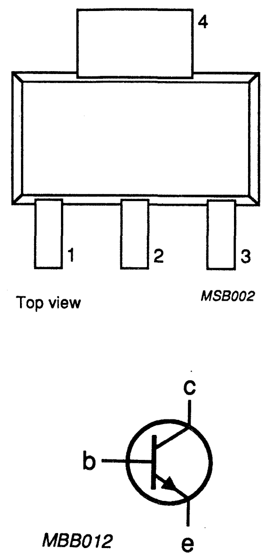


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS201		-	60	V
	BDS203		-	60	V
	BDS77		-	100	V
V_{CEO}	collector-emitter voltage	open base			
	BDS201		-	45	V
	BDS203		-	60	V
	BDS77		-	80	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
f_{hfe}	cut-off frequency	I_C = 0.3 V; V_{CE} = 3 V;	25	-	kHz

Note

1. Mounted on PCB

NPN silicon epitaxial base power transistors BDS201/203/77

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS201		-	60	V
	BDS203		-	60	V
	BDS77		-	100	V
V_{CEO}	collector-emitter voltage	open base			
	BDS201		-	45	V
	BDS203		-	60	V
	BDS77		-	80	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
I_B	base current		-	1	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

NPN silicon epitaxial base power transistors BDS201/203/77

CHARACTERISTICS

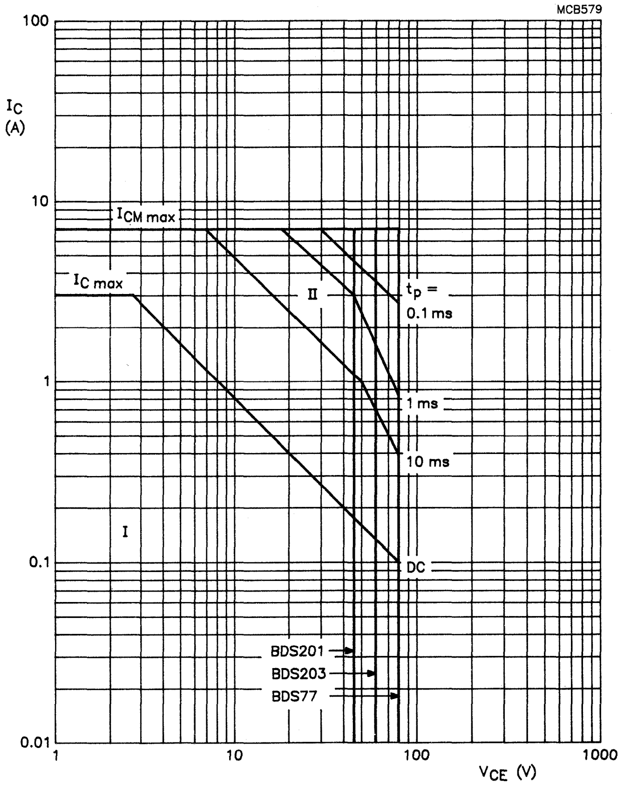
T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{(BR)CEO}$	collector-emitter breakdown voltage BDS201 BDS203 BDS77	I_B = 0; I_C =200 mA	 - - -	 - - -	 45 60 80	 V V V
I_{CEO}	collector cut-off current	I_B = 0; V_{CE} = 30 V	-	-	0.2	mA
I_{CBO}	collector cut-off current	I_E = 0; V_{CE} = 40 V; T_j = 150 °C	-	-	1	mA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = 5 V	-	-	0.5	mA
V_{BE}	base-emitter voltage	I_C = 3 A; $-V_{CE}$ = 2 V; note 1	-	-	1.5	V
$V_{CE\ sat}$	collector-emitter saturation voltage	I_C = 3 A; I_B = 0.3 A; note 1	-	-	1	V
$V_{CE\ sat}$	collector-emitter saturation voltage	I_C = 6 A; I_B = 0.6 A; note 1	-	-	1.8	V
$V_{BE\ sat}$	collector-emitter saturation voltage	I_C = 6 A; I_B = 0.6 A; note 1	-	-	2.1	V
h_{FE}	DC current gain	I_C = 3 A; V_{CE} = 2 V; note 1 (BDS201)	30	-	-	
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 2 V; note 1 (BDS203/77)	30	-	-	
f_T	transition frequency	f = 1 MHz; I_C = 0.3 A; $-V_{CE}$ = 3 V	7	-	-	MHz
f_{hfe}	cut-off frequency	I_C = 0.3 A; $-V_{CE}$ = 3 V	25	-	-	kHz
t_{on}	switching times turn-on time	$I_{C\ on}$ = 2 A; $I_{B\ on} = -I_{B\ off}$ = 0.2 A; V_{CC} = 20 V	-	-	1	µs
t_{off}	switching times turn-off time		-	-	3	µs

Note

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.

NPN silicon epitaxial base power transistors BDS201/203/77



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig.2 Safe operating area; T_{tab} = 25 °C.

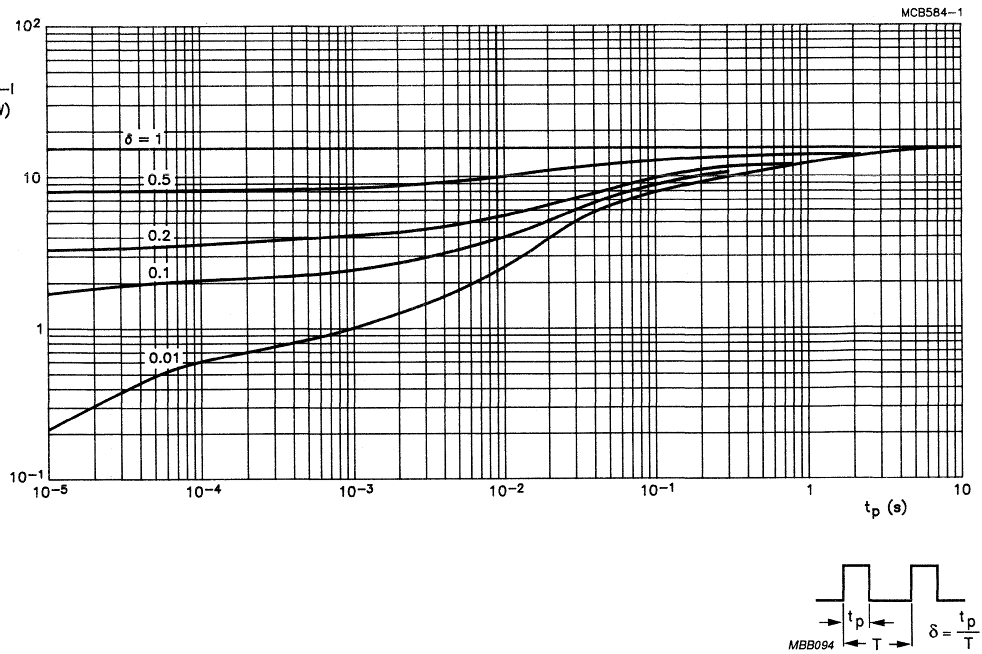


Fig.3 Pulse power rating chart.

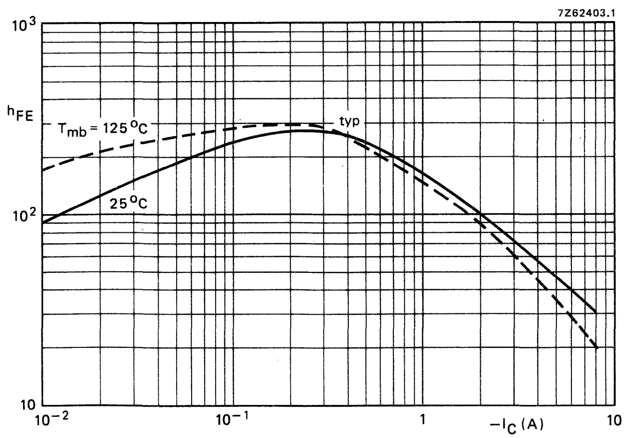


Fig.4 DC current gain; V_{CE} = 2 V.

NPN silicon epitaxial base power transistors BDS201/203/77

PACKAGE OUTLINE

Dimensions in mm

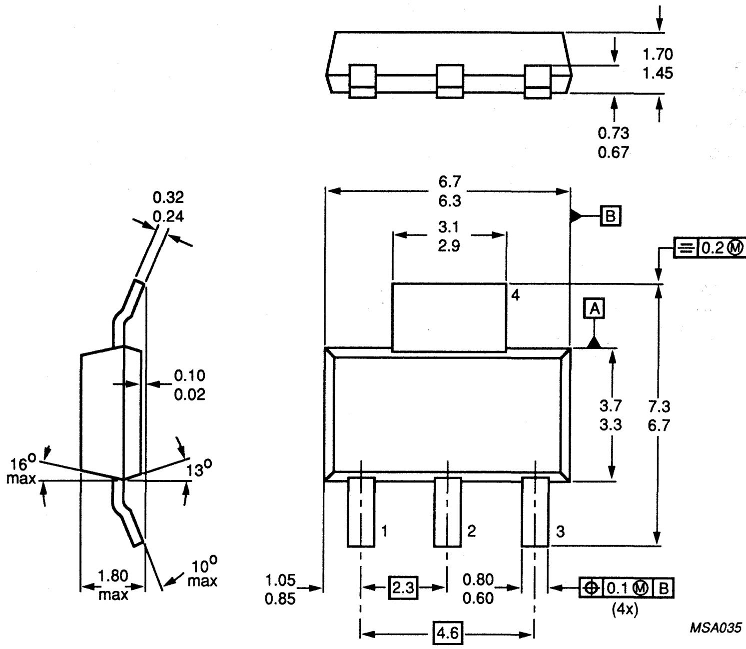


Fig.5 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS202/204/78

PNP silicon epitaxial base power transistors

DESCRIPTION

PNP silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. NPN complements are BDS201/203/77.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

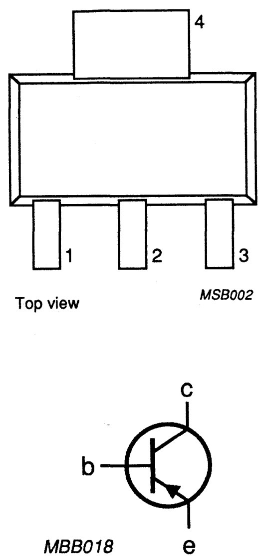


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS202		-	60	V
	BDS204		-	60	V
	BDS78		-	100	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS202		-	45	V
	BDS204		-	60	V
	BDS78		-	80	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
f_{hfe}	cut-off frequency	I_C = 0.3 V V_{CE} = 3 V;	25	-	kHz

Note

1. Mounted on PCB

PNP silicon epitaxial base power transistors BDS202/204/78

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS202		-	60	V
	BDS204		-	60	V
	BDS78		-	100	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS202		-	45	V
	BDS204		-	60	V
	BDS78		-	80	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
$-I_B$	base current		-	1	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

PNP silicon epitaxial base power transistors BDS202/204/78

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

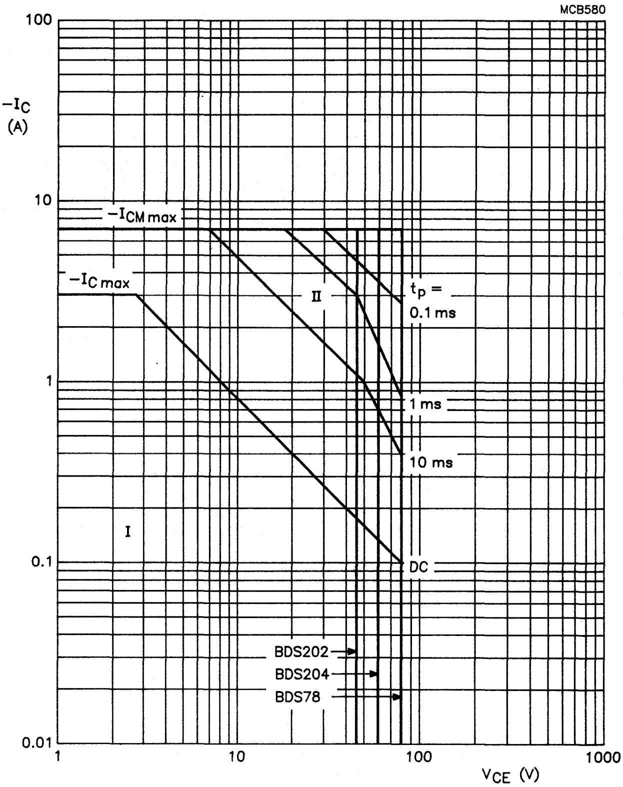
SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{(BR)CEO}$	collector-emitter breakdown voltage	I_B = 0; $-I_C$ =200 mA	45	-	60	V
$-I_{CEO}$	collector cut-off current	I_B = 0; $-V_{CE}$ = 30 V	-	-	0.2	mA
$-I_{CBO}$	collector cut-off current	I_E = 0; $-V_{CE}$ = 40 V; T_j = 150 °C	-	-	1	mA
$-I_{EBO}$	emitter cut-off current	I_C = 0; $-V_{EB}$ = 5 V	-	-	0.5	mA
$-V_{BE}$	base-emitter voltage	$-I_C$ = 3 A; $-V_{CE}$ = 2 V; note 1	-	-	1.5	V
$-V_{CE\,sat}$	collector-emitter saturation voltage	$-I_C$ = 3 A; $-I_B$ = 0.3 A; note 1	-	-	1	V
$-V_{CE\,sat}$	collector-emitter saturation voltage	$-I_C$ = 6 A; $-I_B$ = 0.6 A; note 1	-	-	1.8	V
$-V_{BE\,sat}$	collector-emitter saturation voltage	$-I_C$ = 6 A; $-I_B$ = 0.6 A; note 1	-	-	2.1	V
h_{FE}	DC current gain	$-I_C$ = 3 A; $-V_{CE}$ = 2 V note 1	30	-	-	
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 2 V; note 1	30	-	-	
f_T	transition frequency	f = 1 MHz; $-I_C$ = 0.3 A; $-V_{CE}$ = 3 V	7	-	-	MHz
f_{hfe}	cut-off frequency	$-I_C$ = 0.3 A; $-V_{CE}$ = 3 V	25	-	-	kHz
t_{on}	switching times turn-on time	$-I_{C\,on}$ = 2 A; $-I_{B\,on}$ = $I_{B\,off}$ = 0.2 A; V_{CC} = 20 V	-	-	1	µs
t_{off}	switching times turn-off time		-	-	3	µs

Note

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.

PNP silicon epitaxial base power transistors

BDS202/204/78



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig.2 Safe operating area; T_{tab} = 25 °C.

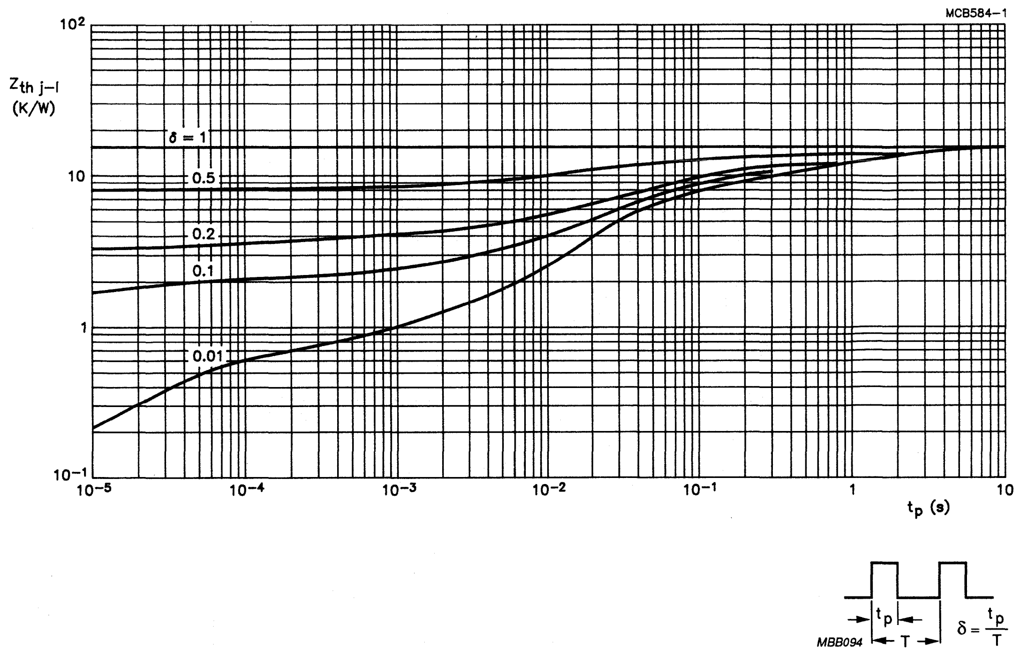


Fig.3 Pulse power rating chart.

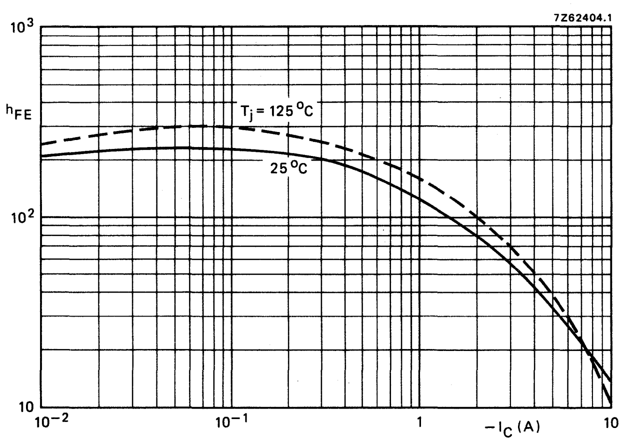


Fig.4 DC current gain; $-V_{CE}$ = 2 V.

PNP silicon epitaxial base power transistors BDS202/204/78

PACKAGE OUTLINE

Dimensions in mm

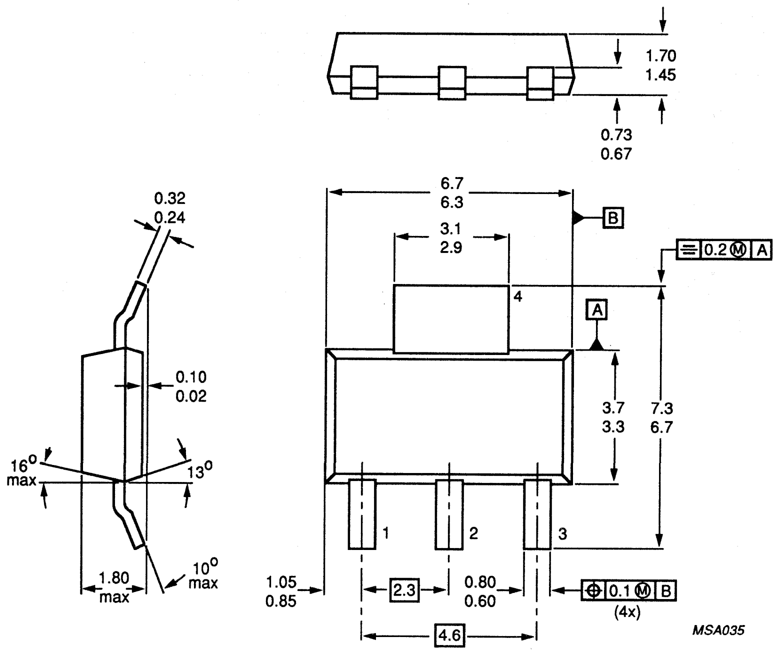


Fig.5 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS643/645/647/649/651
NPN silicon Darlington power transistors

DESCRIPTION

NPN epitaxial base transistors in a monolithic Darlington circuit in SOT223, intended for general purpose and switching applications. PNP complements are BDS644/646/648/650/652.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

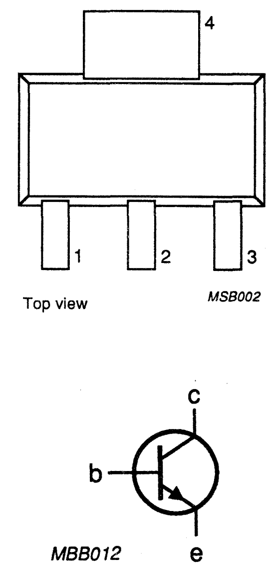


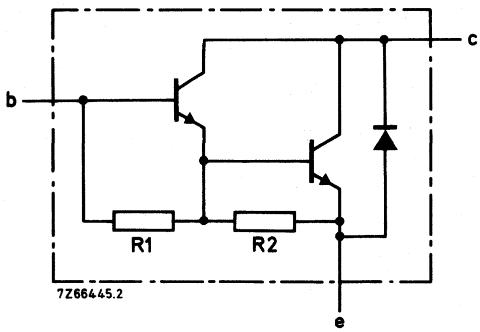
Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS643		-	60	V
	BDS645		-	80	V
	BDS647		-	100	V
	BDS649		-	120	V
	BDS651		-	140	V
V_{CEO}	collector-emitter voltage	open base			
	BDS643		-	45	V
	BDS645		-	60	V
	BDS647		-	80	V
	BDS649		-	100	V
	BDS651		-	120	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	I_C = 3 mA; V_{CE} = 3 V;	1000		

Note

1. Mounted on PCB



R1 typ. 4 kΩ

R2 typ. 100 Ω

Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS643		-	60	V
	BDS645		-	80	V
	BDS647		-	100	V
	BDS649		-	120	V
	BDS651		-	140	V
V_{CEO}	collector-emitter voltage	open base			
	BDS643		-	45	V
	BDS645		-	60	V
	BDS647		-	80	V
	BDS649		-	100	V
	BDS651		-	120	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
I_B	base current		-	150	mA
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

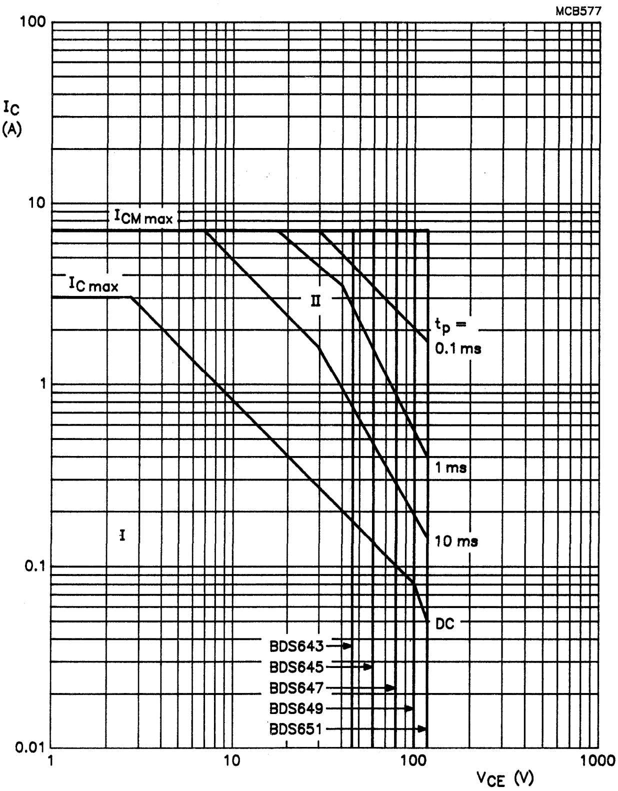
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CEO}	collector cut-off current	I_B = 0; V_{CE} = 1/2 $V_{CEO\ max}$	-	-	0.2	mA
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = $V_{CEO\ max}$	-		0.1	mA
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = 1/2 $V_{CBO\ max}$; T_j = 150 °C	-	-	1	mA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = 5 V	-	-	5	mA
V_{BE}	base-emitter voltage	I_C = 3 A; V_{CE} = 3 V; note 1	-	-	2.5	V
$V_{CE\ sat}$	saturation voltage	I_C = 3 A; I_B = 12 mA; note 1	-	-	2	V
$V_{CE\ sat}$	saturation voltage	I_C = 5 A; I_B = 50 mA note 1	-	-	2.5	V
$V_{BE\ sat}$	saturation voltage	I_C = 5 A; I_B = 50 mA; note 1	-	-	3	V
h_{FE}	DC current gain	I_C = 0.5 A; V_{CE} = 3 V note 1	-	2000	-	
h_{FE}	DC current gain	I_C = 3 A; V_{CE} = 3 V; note 1	1000	-	-	
V_F	diode forward voltage	I_F = 3 A	-	1.8	-	V
f_{hfe}	cut-off frequency	I_C = 3 A; V_{CE} = 3 V	-	50	-	kHz
h_{fe}	small signal current gain	f = 1 MHz; I_C = 3 A; V_{CE} = 3 V	10	-	-	
C_c	collector capacitance	f = 1 MHz; V_{CB} = 10 V	-	75	-	pF
t_{on}	switching times turn-on time	$I_{C\ on}$ = 3 A; $I_{B\ on}$ = $I_{B\ off}$ = 12 mA	-	-	2	µs
t_{off}	switching times turn-off time		-	-	10	µs

Note

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig. 3 Safe operating area; T_{tab} = 25 °C.

NPN silicon Darlington power transistors BDS643/645/647/649/651

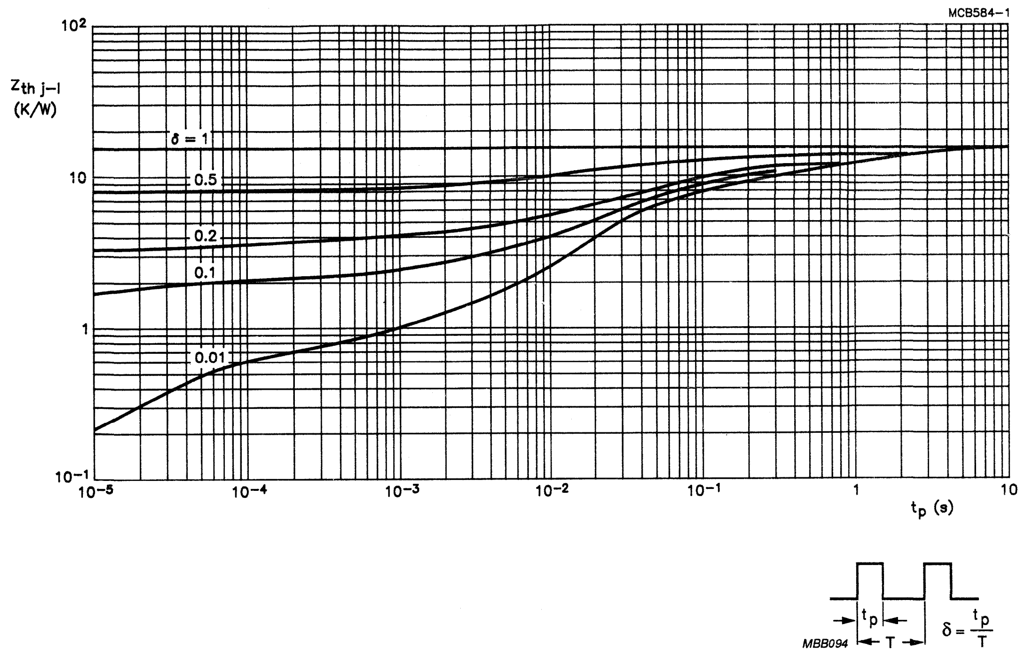


Fig.4 Pulse power rating chart.

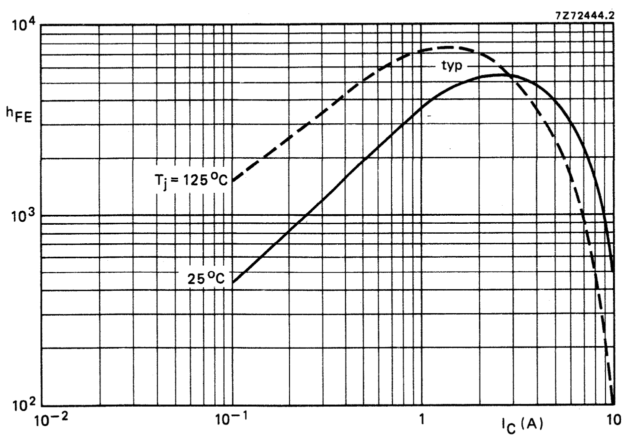


Fig.5 DC current gain; V_{CE} = 3 V; typical values.

PACKAGE OUTLINE

Dimensions in mm.

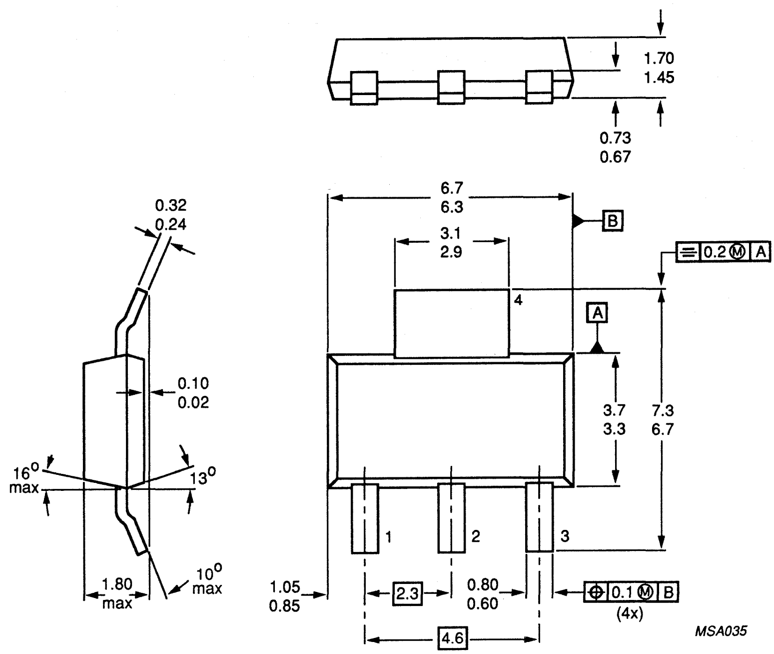


Fig.6 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS644/646/648/650/652

PNP silicon Darlington power transistors

DESCRIPTION

PNP silicon epitaxial base transistors in a monolithic Darlington circuit in a miniature SMD envelope (SOT223), intended for general purpose and switching applications. NPN complements are BDS643/645/647/649/651.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

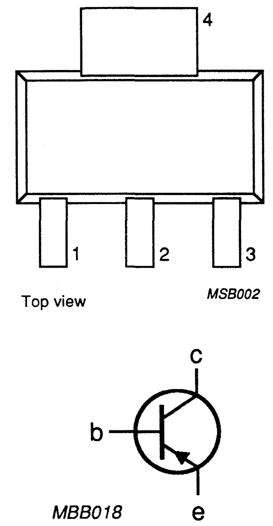


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS644		-	45	V
	BDS646		-	60	V
	BDS648		-	80	V
	BDS650		-	100	V
	BDS652		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS644		-	45	V
	BDS646		-	60	V
	BDS648		-	80	V
	BDS650		-	100	V
	BDS652		-	120	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 3 mA; $-V_{CE}$ = 3 V;	1000		

Note

1. Mounted on PCB

PNP silicon Darlington power transistors BDS644/646/648/650/652

R1 typ. 4 Ω
R2 typ. 100 Ω

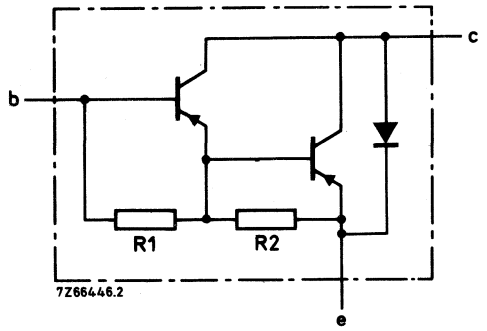


Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS644		-	45	V
	BDS646		-	60	V
	BDS648		-	80	V
	BDS650		-	100	V
	BDS652		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS644		-	45	V
	BDS646		-	60	V
	BDS648		-	80	V
	BDS650		-	100	V
	BDS652		-	120	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
$-I_B$	base current		-	150	mA
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

CHARACTERISTICS

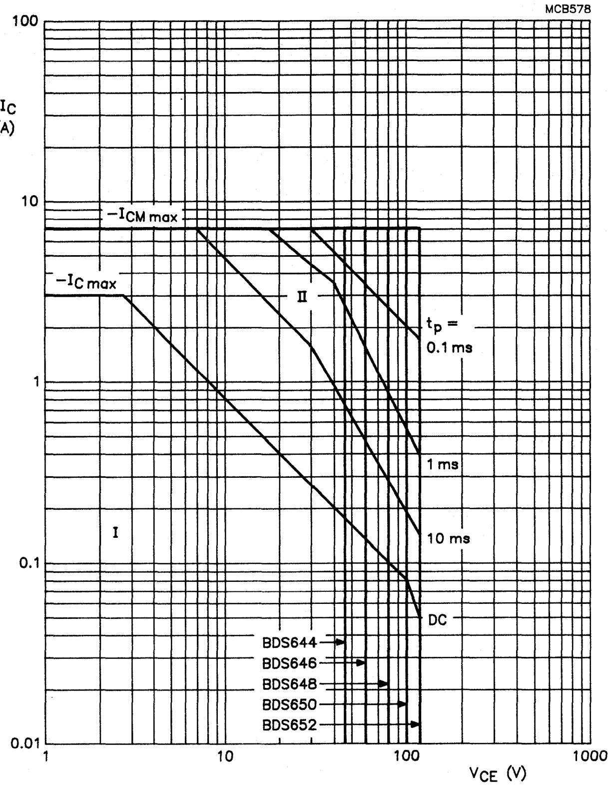
T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CEO}$	collector cut-off current	$-I_B = 0$; $-V_{CE} = 1/2\ V_{CEO\ max}$	-	-	0.2	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CEO\ max}$	-		0.1	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = 1/2\ V_{CBO\ max}$; $T_j = 150$ °C	-	-	1	mA
$-I_{EBO}$	emitter cut-off current	$-I_C = 0$; $-V_{EB} = 5$ V	-	-	5	mA
$-V_{BE}$	base-emitter voltage	$-I_C = 3$ A; $-V_{CE} = 3$ V; note 1	-	-	2.5	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 3$ A; $-I_B = 12$ mA; note 1	-	-	2	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 5$ A; $-I_B = 50$ mA note 1	-	-	2.5	V
$-V_{BE\ sat}$	base-emitter saturation voltage	$-I_C = 5$ A; $-I_B = 50$ mA; note 1	-	-	3	V
h_{FE}	DC current gain	$-I_C = 0.5$ A; $-V_{CE} = 3$ V note 1	-	2000	-	
h_{FE}	DC current gain	$-I_C = 3$ A; $-V_{CE} = 3$ V; note 1	1000	-	-	
V_F	diode forward voltage	$I_F = 3$ A	-	1.2	-	V
f_{hfe}	cut-off frequency	$-I_C = 3$ A; $-V_{CE} = 3$ V	-	100	-	kHz
h_{fe}	small signal current gain	f = 1 MHz; $-I_C = 3$ A; $-V_{CE} = 3$ V;	10	-	-	
C_c	collector capacitance	f = 1 MHz; $-V_{CB} = 10$ V	-	75	-	pF
t_{on}	switching times turn-on time	$-I_{C\ on} = 3$ A; $-I_{B\ on} = I_{B\ off} = 12$ mA; $-V_{CC} = 10$ V	-	-	2	µs
t_{off}	switching times turn-off time		-	-	10	µs

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.

PNP silicon Darlington power transistors BDS644/646/648/650/652



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig.3 Safe operating area; T_{tab} = 25 °C.

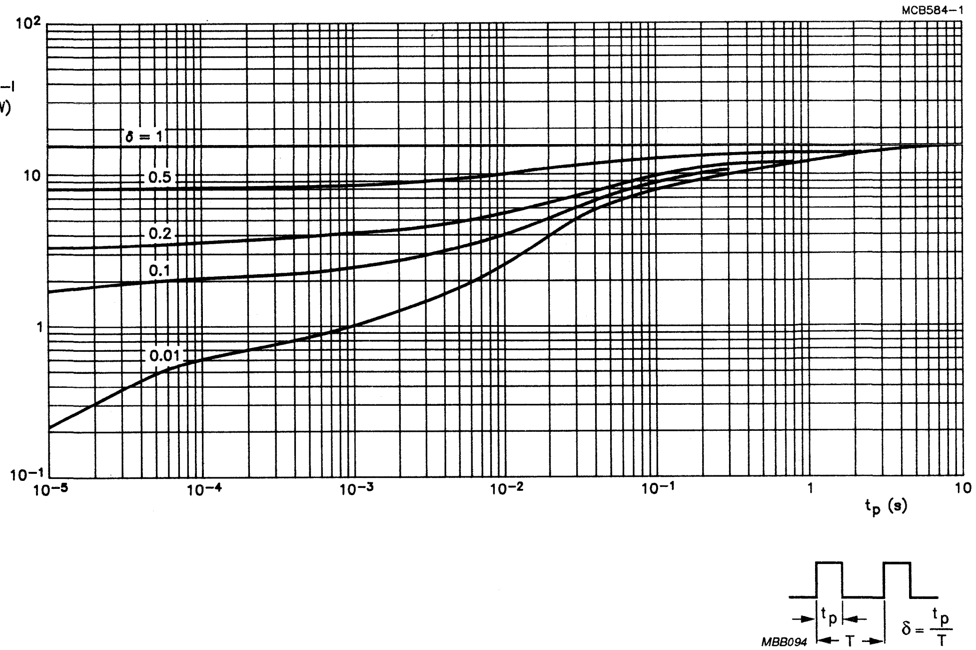


Fig.4 Pulse power rating chart.

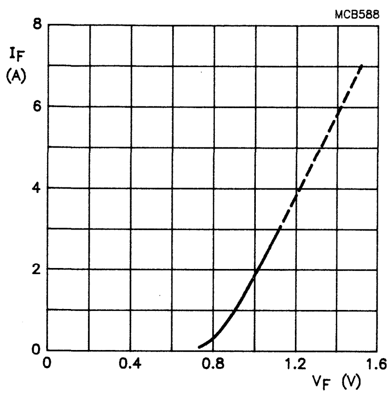


Fig.5 Diode forward current as a function of forward voltage; T_{tab} = 25 °C; typical values.

PNP silicon Darlington power transistors BDS644/646/648/650/652

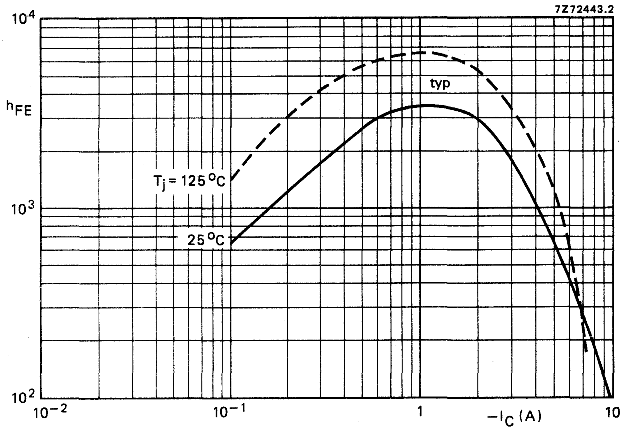


Fig.6 DC current gain; $-V_{CE}$ = 3 V; typical values.

PACKAGE OUTLINE

Dimensions in mm

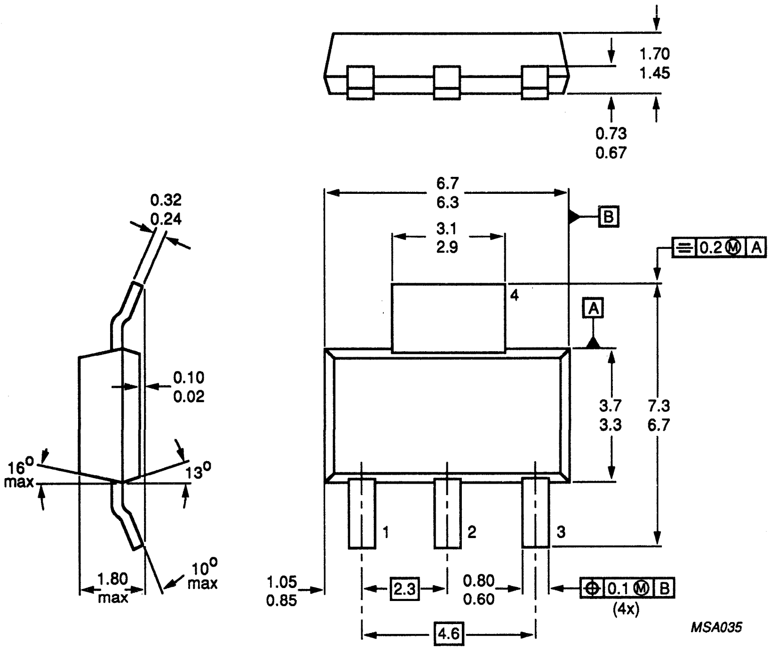


Fig.7 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS933/935/937/939/941
NPN silicon epitaxial base power transistors

DESCRIPTION

NPN silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. PNP complements are BDS934/936/938/940/942.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

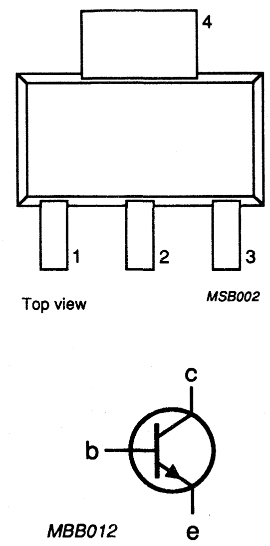


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS933		-	45	V
	BDS935		-	60	V
	BDS937		-	100	V
	BDS939		-	120	V
	BDS941		-	140	V
V_{CEO}	collector-emitter voltage	open base			
	BDS933		-	45	V
	BDS935		-	60	V
	BDS937		-	80	V
	BDS939		-	100	V
	BDS941		-	120	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	6	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	I_C = 150 mA; V_{CE} = 2 V;	40	250	
h_{FE}	DC current gain	I_C = 1 A; V_{CE} = 2 V;	25	-	
f_T	transition frequency	I_C = 250 mA; V_{CE} = 10 V	3	-	MHz

Note

1. Mounted on PCB

NPN silicon epitaxial base power transistors

BDS933/935/937/939/941

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS933		-	45	V
	BDS935		-	60	V
	BDS937		-	100	V
	BDS939		-	120	V
	BDS941		-	140	V
V_{CEO}	collector-emitter voltage	open base			
	BDS933		-	45	V
	BDS935		-	60	V
	BDS937		-	80	V
	BDS939		-	100	V
	BDS941		-	120	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	6	A
I_B	base current		-	0.5	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

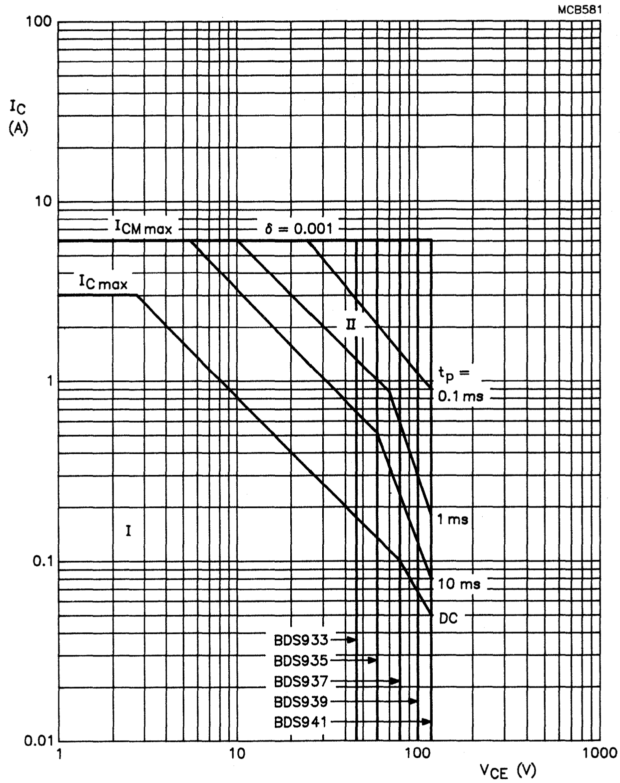
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$	-	-	50	µA
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$; $T_j = 150$ °C	-	-	1	mA
I_{CEO}	collector cut-off current	$I_B = 0$; $V_{CE} = V_{CEO\ max}$	-	-	0.1	mA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	-	-	0.2	mA
V_{BE}	base-emitter voltage	$I_C = 1$ A; $V_{CE} = 2$ V; note 1	-	-	1.3	V
$V_{CE\ sat}$	collector-emitter saturation voltage	$I_C = 1$ A; $I_B = 0.1$ A	-	-	0.6	V
h_{FE}	DC current gain	$I_C = 150$ mA; $V_{CE} = 2$ V note 1	40	-	250	
h_{FE}	DC current gain	$I_C = 1$ A; $V_{CE} = 2$ V; note 1	25	-	-	
f_T	transition frequency	f = 1 MHz; $I_C = 250$ mA; $V_{CE} = 10$ V	3	-	-	MHz
t_{on}	switching times turn-on time	$I_{C\ on} = 1$ A; $I_{B\ on} = -I_{B\ off} = 0.1$ A	-	0.4	1	µs
t_{off}	switching times turn-off time		-	1.5	3	µs

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig.2 Safe operating area; T_{tab} = 25 °C.

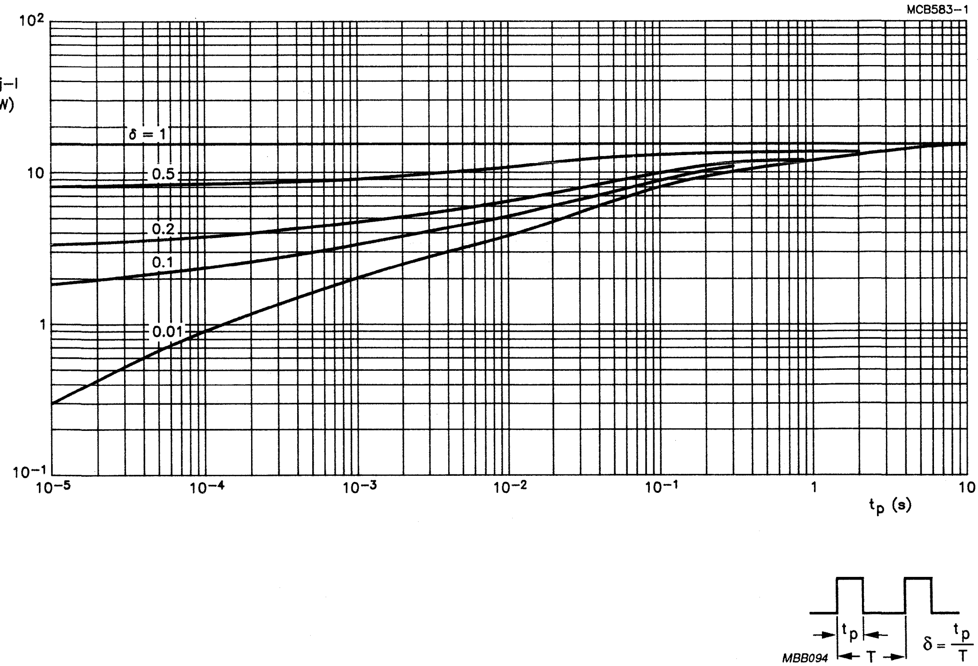


Fig.3 Pulse power rating chart.

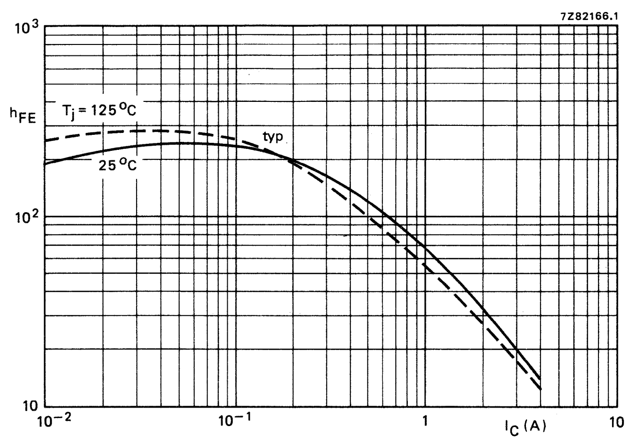


Fig.4 Typical DC current gain; V_{CE} = 2 V.

PACKAGE OUTLINE

Dimensions in mm

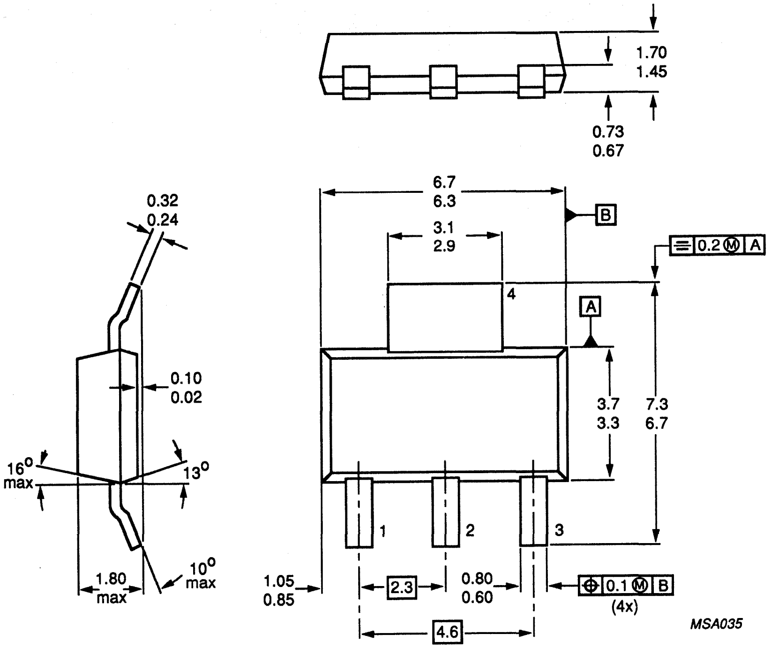


Fig.5 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS934/936/938/940/942

PNP silicon epitaxial base power transistors

DESCRIPTION

PNP silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. NPN complements are BDS933/935/937/939/941.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

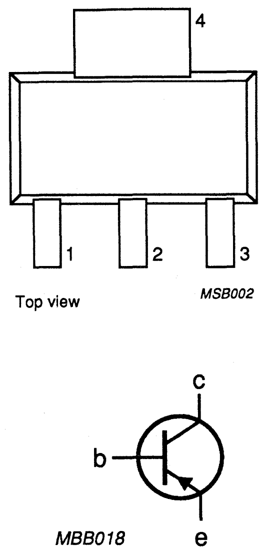


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage BDS934 BDS936 BDS938 BDS940 BDS942	open emitter	 - - - - -	 45 60 100 120 140	 V V V V V
$-V_{CEO}$	collector-emitter voltage BDS934 BDS936 BDS938 BDS940 BDS942	open base	 - - - - -	 45 60 80 100 120	 V V V V V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	6	A
P_{tot}	total power dissipation	T_{tab} = 25 °C note 1	- -	8 1.5	W W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	40	250	
h_{FE}	DC current gain	$-I_C$ = 1 A; $-V_{CE}$ = 2 V	25	-	
f_T	transition frequency	$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	3	-	MHz

Note

1. When mounted on PCB

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS934		-	45	V
	BDS936		-	60	V
	BDS938		-	100	V
	BDS940		-	120	V
	BDS942		-	140	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS934		-	45	V
	BDS936		-	60	V
	BDS938		-	80	V
	BDS940		-	100	V
	BDS942		-	120	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	6	A
$-I_B$	base current		-	0.5	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

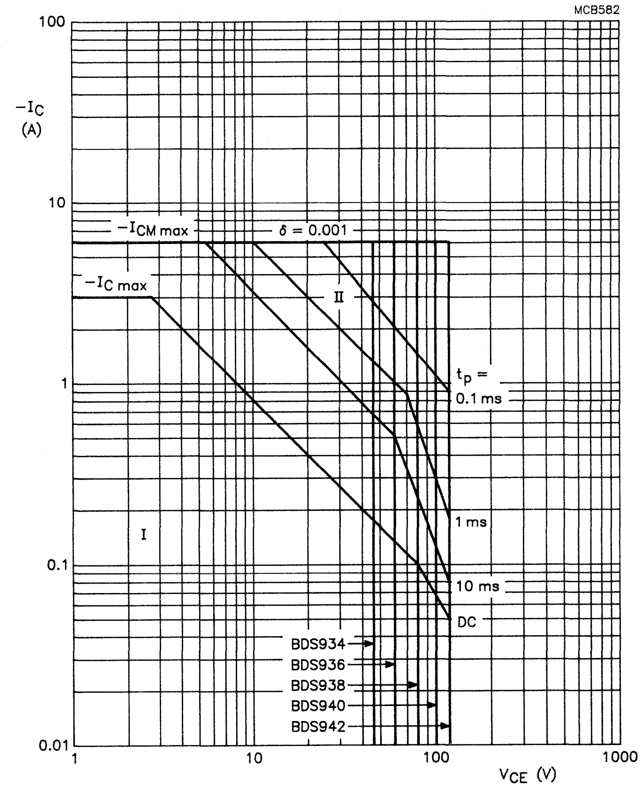
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	-	-	50	μA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$; T_j = 150 °C	-	-	1	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE} = -V_{CEO\ max}$	-	-	0.1	mA
$-I_{EBO}$	emitter cut-off current	$-I_C = 0$; $-V_{EB}$ = 5 V	-	-	0.2	mA
$-V_{BE}$	base-emitter voltage	$-I_C$ = 1 A; $-V_{CE}$ = 2 V; note 1	-	-	1.3	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C$ = 1 A; $-I_B$ = 0.1 A	-	-	0.6	V
h_{FE}	DC current gain	$-I_C$ = 150 mA; $-V_{CE}$ = 2 V note 1	40	-	250	
h_{FE}	DC current gain	$-I_C$ = 1 A; $-V_{CE}$ = 2 V; note 1	25	-	-	
f_T	transition frequency	f = 1 MHz; $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	3	-	-	MHz
t_{on}	switching times turn-on time	$-I_{C\ on}$ = 1 A; $I_{B\ on} = I_{B\ off}$ = 0.1 A	-	0.2	0.6	μs
t_{off}	switching times	turn-off time	-	0.7	2.4	μs

Note

1. Measured under pulse conditions: t_p < 300 μs, duty cycle < 2%.



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.

Fig.2 Safe operating area; T_{tab} = 25 °C.

PNP silicon epitaxial base power transistors

BDS934/936/938/940/942

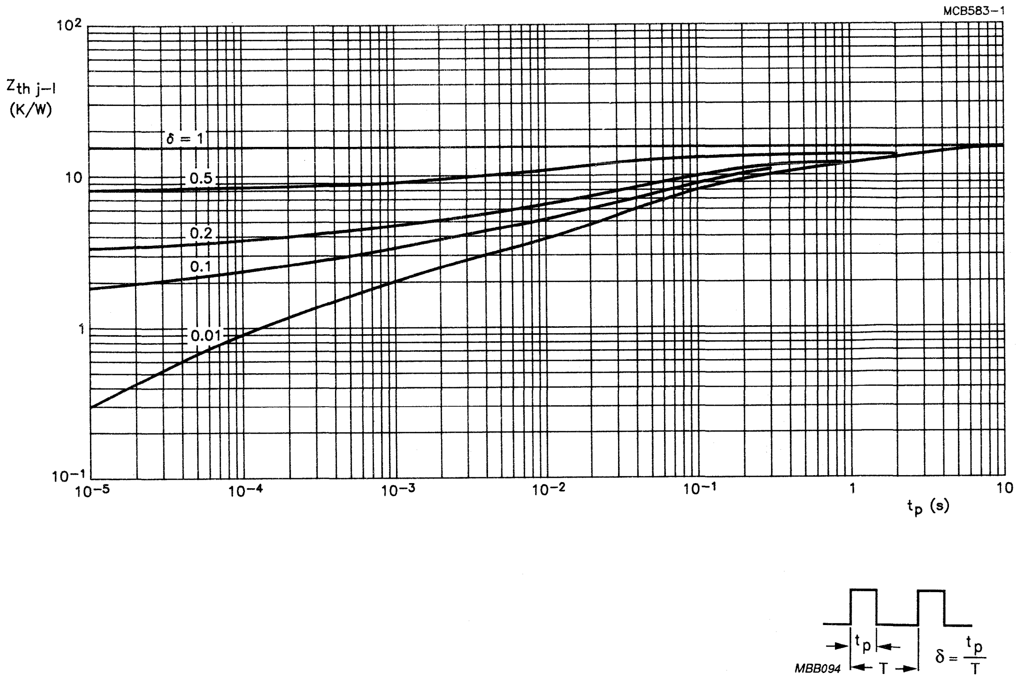


Fig.3 Pulse power rating chart.

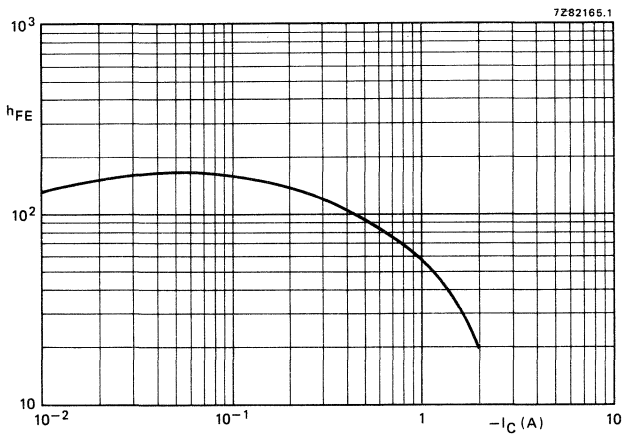
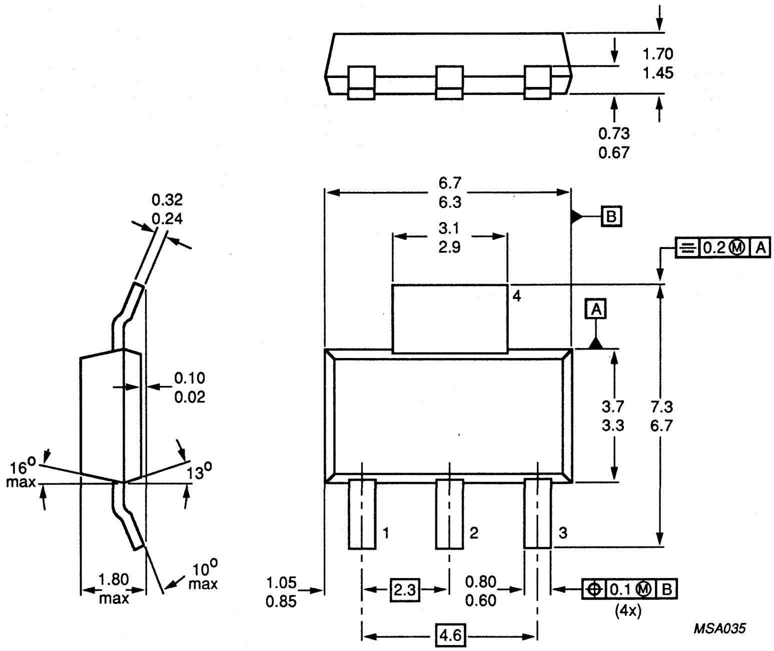


Fig.4 Typical static forward current transfer ratio as a function of the collector current; $-V_{CE} = 2$ V; $T_j \leq 25$ °C.

PACKAGE OUTLINE



Dimensions in mm

Fig.5 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS943/945/947

NPN silicon epitaxial base power transistors

DESCRIPTION

NPN silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. PNP complements are BDS944/946/948.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

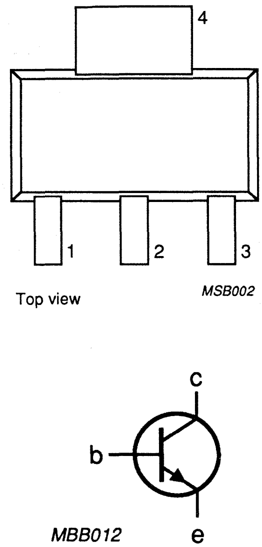


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS943		-	22	V
	BDS945		-	32	V
	BDS947		-	45	V
V_{CEO}	collector-emitter voltage	open base			
	BDS943		-	22	V
	BDS945		-	32	V
	BDS947		-	45	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	I_C = 10 mA; V_{CE} = 5 V	25	-	
h_{FE}	DC current gain	I_C = 500 mA; V_{CE} = 1 V	85	475	
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 1 V			
	BDS943		50	-	
	BDS945		50	-	
	BDS947		40	-	

Note

1. Mounted on PCB.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS943		-	22	V
	BDS945		-	32	V
	BDS947		-	45	V
V_{CEO}	collector-emitter voltage	open base			
	BDS943		-	22	V
	BDS945		-	32	V
	BDS947		-	45	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
I_B	base current		-	1	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

NPN silicon epitaxial base power transistors BDS943/945/947

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

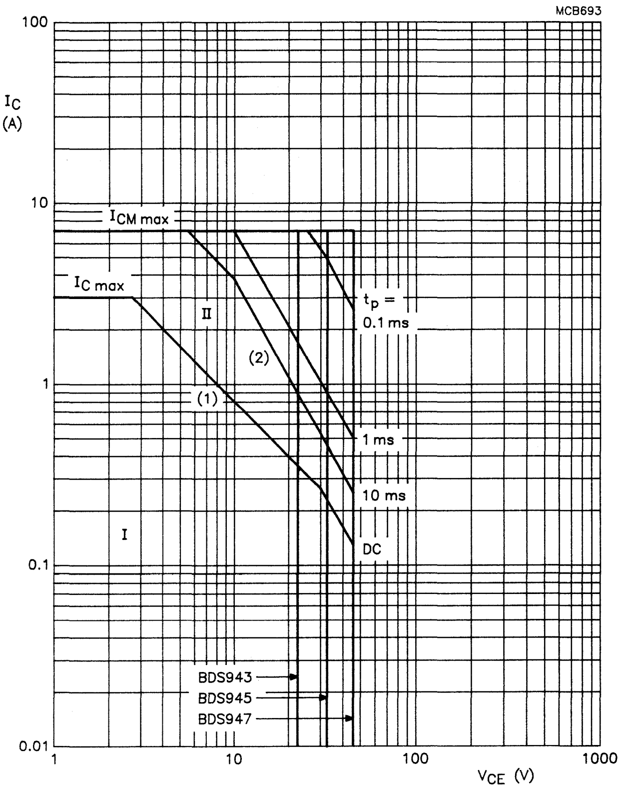
SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = $V_{CBO\ max}$	-	50	µA
I_{CEO}	collector cut-off current	I_B = 0; V_{CE} = 15 V (BDS943)	-	0.1	mA
I_{CEO}	collector cut-off current	I_B = 0; V_{CE} = 20 V (BDS945)	-	0.1	mA
I_{CEO}	collector cut-off current	I_B = 0; V_{CE} = 25 V (BDS947)	-	0.1	mA
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = $V_{CBO\ max}$; T_j = 150 °C	-	1	mA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = 5 V	-	0.2	mA
V_{BE}	base-emitter voltage	I_C = 2 A; V_{CE} = 1 V; note 1	-	1.2	V
$V_{CE\ sat}$	collector-emitter saturation voltage	I_C = 2 A; I_B = 0.2 A; note 1	-	0.5	V
h_{FE}	DC current gain	I_C = 10 mA; V_{CE} = 5 V note 1	25	-	
h_{FE}	DC current gain	I_C = 500 mA; V_{CE} = 1 V; note 1	85	475	
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 1 V; note 1 (BDS943/945)	50	-	
h_{FE}	DC current gain	I_C = 250 mA; V_{CE} = 1 V; note 1 (BDS947)	40	-	
f_T	transition frequency	f = 1 MHz; I_C = 250 mA; V_{CE} = 1 V	3	-	MHz

Note

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.

NPN silicon epitaxial base power transistors

BDS943/945/947



1. Region of permissible DC operation.
2. Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second breakdown limits.

Fig.2 Safe operating area; T_{tab} = 25 °C.

NPN silicon epitaxial base power transistors

BDS943/945/947

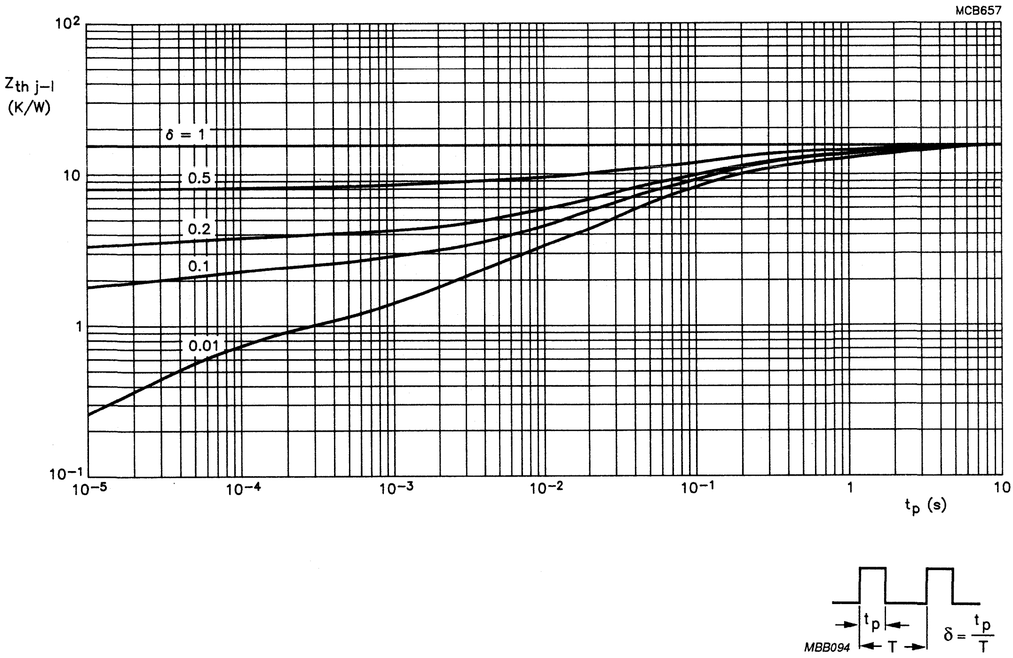


Fig.3 Pulse power rating chart.

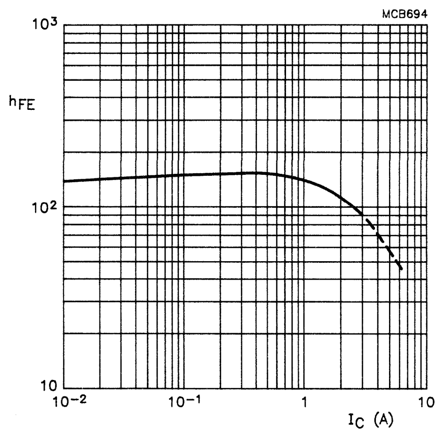


Fig.4 Typical DC current gain; V_{CE} = 1 V; T_{tab} = 25 °C.

NPN silicon epitaxial base power transistors BDS943/945/947

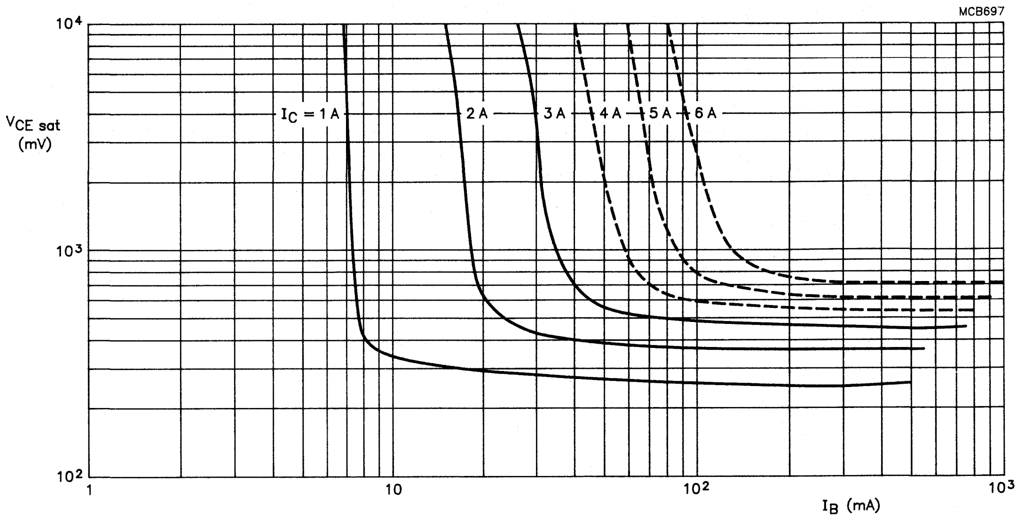


Fig.5 Typical values of collector-emitter saturation voltage at T_{tab} = 25 °C.

PACKAGE OUTLINE

Dimensions in mm

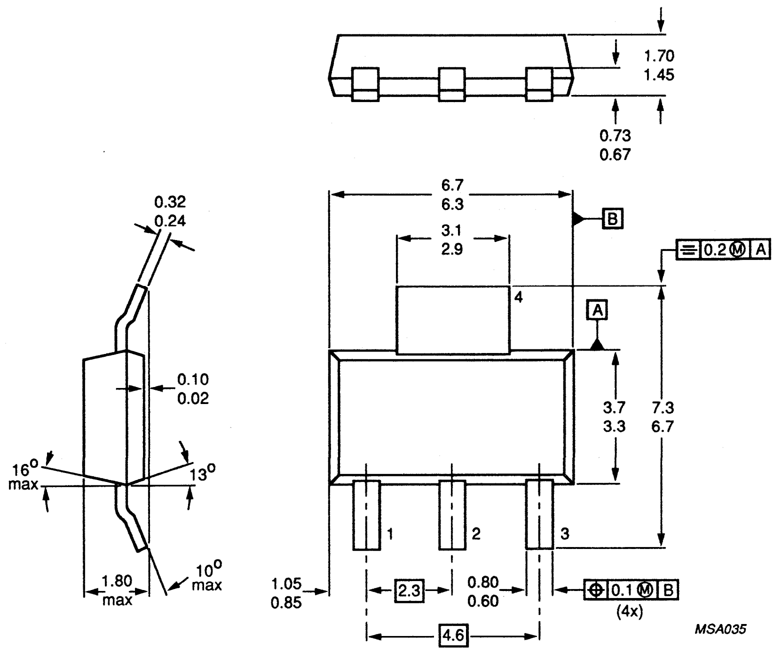


Fig.6 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS944/946/948

PNP silicon epitaxial base power transistors

DESCRIPTION

PNP silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. NPN complements are BDS943/945/947.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

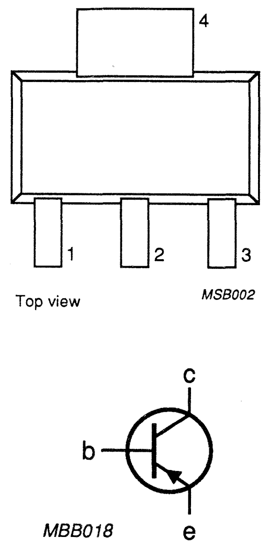


Fig. 1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage BDS944 BDS946 BDS948	open emitter	 - - -	 22 32 45	 V V V
$-V_{CEO}$	collector-emitter voltage BDS944 BDS946 BDS948	open base	 - - -	 22 32 45	 V V V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C note 1	- -	8 1.5	W W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	25	-	
h_{FE}	DC current gain	$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	85	475	
h_{FE}	DC current gain BDS944 BDS946 BDS948	$-I_C$ = 2 A; $-V_{CE}$ = 1 V	 50 50 40	 - - -	

Note

1. Mounted on PCB.

PNP silicon epitaxial base power transistors BDS944/946/948

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS944		-	22	V
	BDS946		-	32	V
	BDS948		-	45	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS944		-	22	V
	BDS946		-	32	V
	BDS948		-	45	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
$-I_B$	base current		-	1	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

CHARACTERISTICS

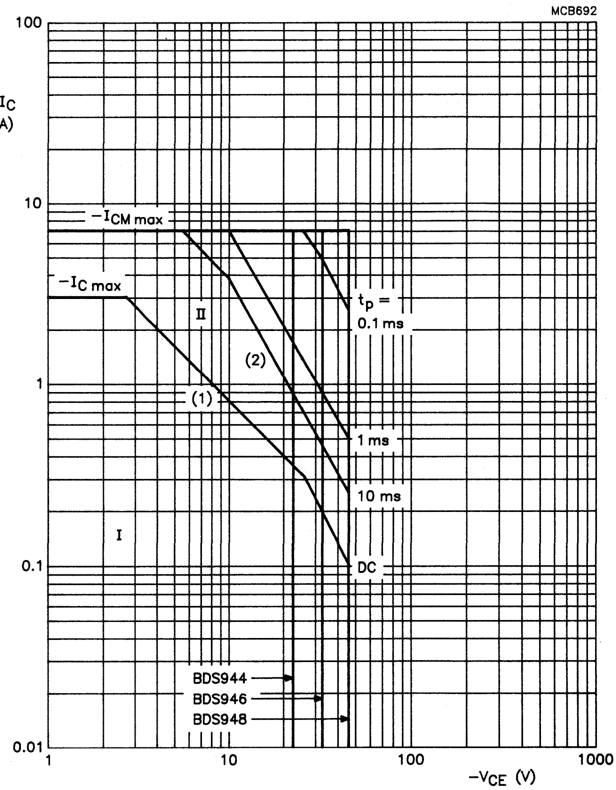
T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	-	50	µA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE}$ = 15 V (BDS944)	-	0.1	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE}$ = 20 V (BDS946)	-	0.1	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE}$ = 25 V (BDS948)	-	0.1	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$; T_j = 150 °C	-	1	mA
$-I_{EBO}$	emitter cut-off current	$I_C = 0$; $-V_{EB}$ = 5 V	-	0.2	mA
$-V_{BE}$	base-emitter voltage	$-I_C$ = 2 A; $-V_{CE}$ = 1 V; note 1	-	1.2	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C$ = 2 A; $-I_B$ = 0.2 A; note 1	-	0.5	V
h_{FE}	DC current gain	$-I_C$ = 10 mA; $-V_{CE}$ = 5 V note 1	25	-	
h_{FE}	DC current gain	$-I_C$ = 500 mA; $-V_{CE}$ = 1 V; note 1	85	475	
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 1 V; note 1 (BDS944/946)	50	-	
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 1 V; note 1 (BDS948)	40	-	
f_T	transition frequency	f = 1 MHz; $-I_C$ = 250 mA; $-V_{CE}$ = 1 V	3	-	MHz

Note

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.

PNP silicon epitaxial base power transistors BDS944/946/948



1. Region of permissible DC operation.
2. Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second breakdown limits.

Fig.2 Safe operating area; T_{tab} = 25 °C.

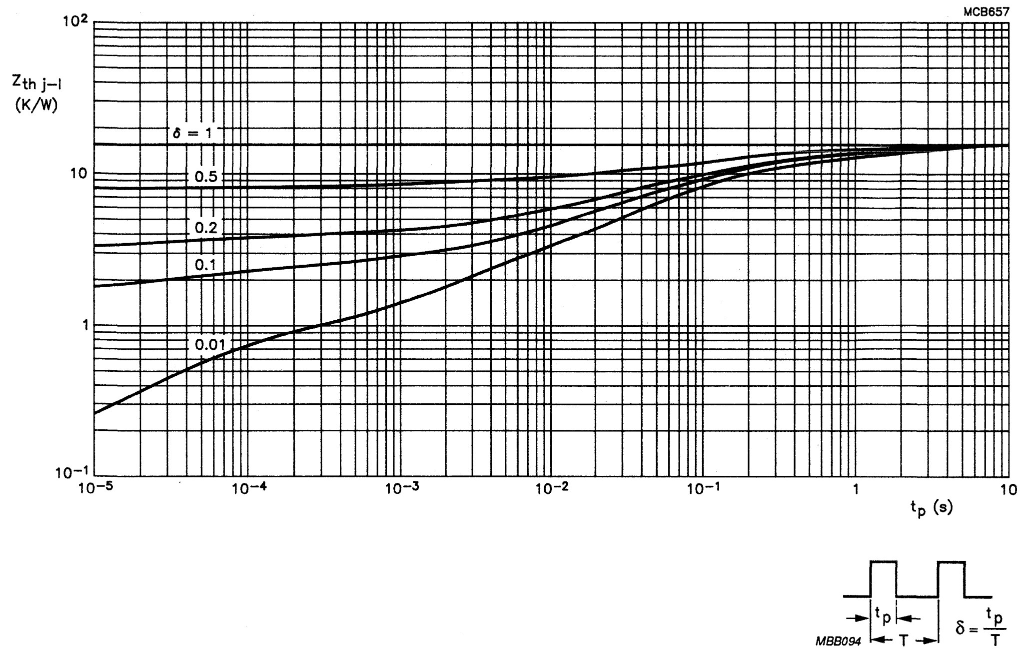


Fig.3 Pulse power rating chart.

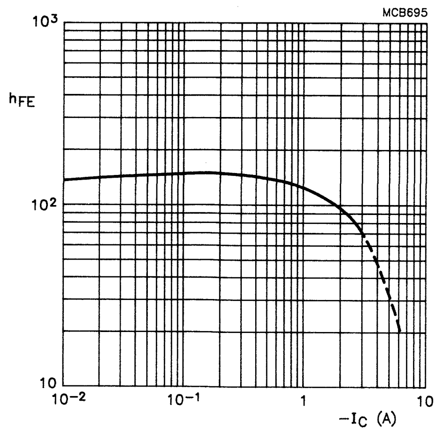


Fig.4 Typical DC current gain; V_{CE} = 1 V; T_{tab} = 25 °C.

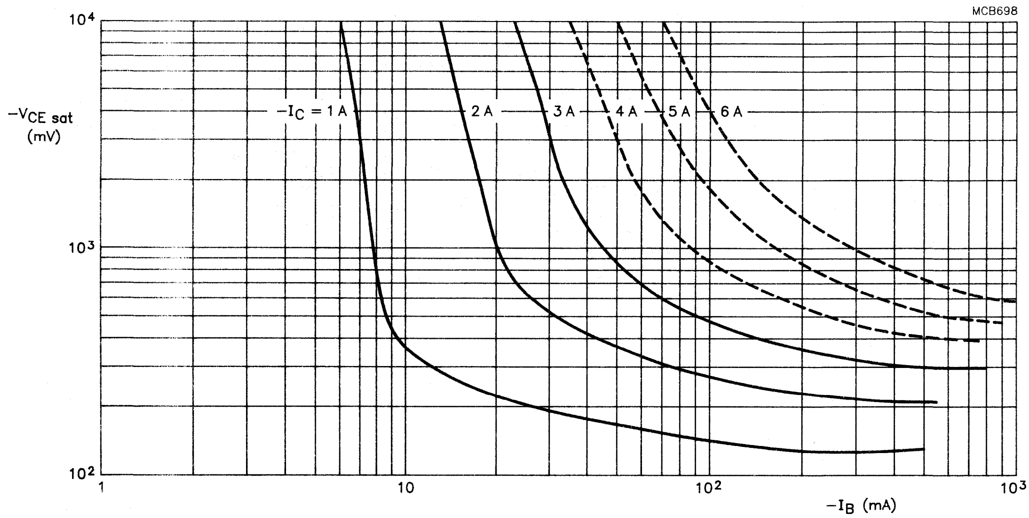


Fig.5 Typical values of collector-emitter saturation voltage at $T_{tab} = 25$ °C.

PACKAGE OUTLINE

Dimensions in mm

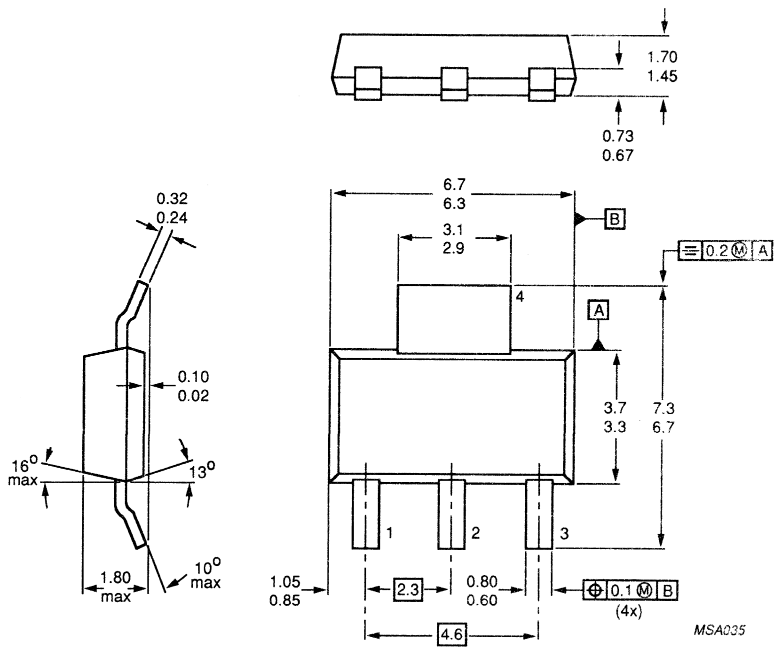


Fig.6 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS949/951/953/955
NPN silicon epitaxial base power transistors

DESCRIPTION

NPN silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. PNP complements are BDS950/952/954/956.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

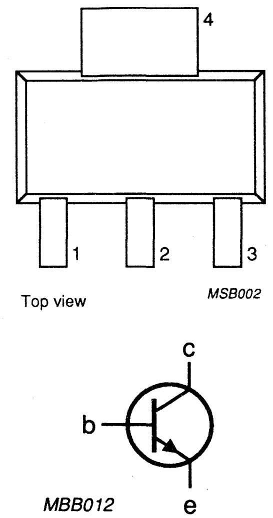


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS949		-	60	V
	BDS951		-	80	V
	BDS953		-	100	V
	BDS955		-	120	V
V_{CEO}	collector-emitter voltage	open base			
	BDS949		-	60	V
	BDS951		-	80	V
	BDS953		-	100	V
	BDS955		-	120	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	I_C = 0.5 A; V_{CE} = 4 V	40	-	
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 4 V	20	-	

Note

1. Mounted on PCB.

NPN silicon epitaxial base power transistors BDS949/951/953/955

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDS949		-	60	V
	BDS951		-	80	V
	BDS953		-	100	V
	BDS955		-	120	V
V_{CEO}	collector-emitter voltage	open base			
	BDS949		-	60	V
	BDS951		-	80	V
	BDS953		-	100	V
	BDS955		-	120	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	3	A
I_{CM}	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}t}$	from junction to tab		15.5	K/W
$R_{th\ j\text{-}a}$	from junction to ambient	on PCB	83.3	K/W

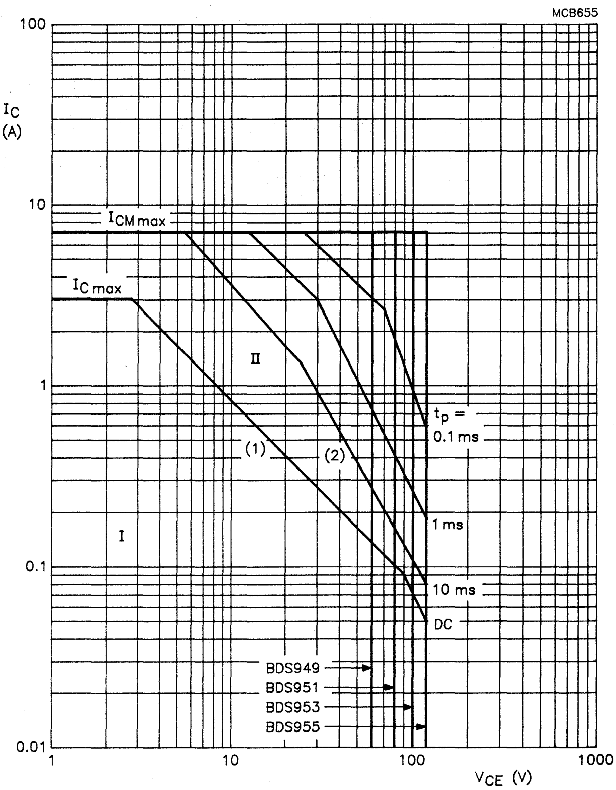
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$	-	50	μA
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\ max}$; T_j = 150 °C	-	1	mA
I_{CEO}	collector cut-off current	$I_B = 0$; $V_{CE} = 1/2\ V_{CEO\ max}$	-	0.1	mA
I_{EBO}	emitter cut-off current	$I_C = 0$; V_{EB} = 5 V	-	0.2	mA
V_{BE}	base-emitter voltage	I_C = 2 A; V_{CE} = 4 V; note 1	-	1.4	V
$V_{CE\ sat}$	collector-emitter stauration voltage	I_C = 2 A; I_B = 0.2 A; note 1	-	1	V
h_{FE}	DC current gain	I_C = 500 mA; V_{CE} = 4 V; note 1	40	-	
h_{FE}	DC current gain	I_C = 2 A; V_{CE} = 4 V; note 1	20	-	
f_T	transition frequency	f = 1 MHz; I_C = 500 mA; V_{CE} = 4 V	3	-	MHz

Note

1. Measured under pulse conditions: t_p < 300 μs, duty cycle < 2%.



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

Fig.2 Safe operating area; T_{tab} = 25 °C.

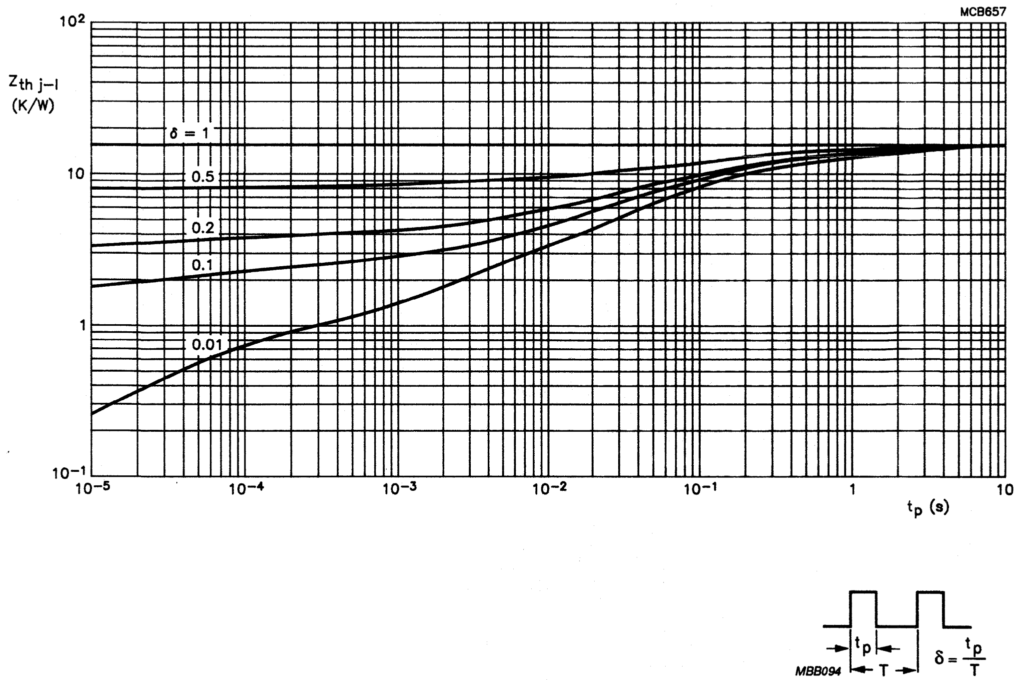


Fig.3 Pulse power rating chart.

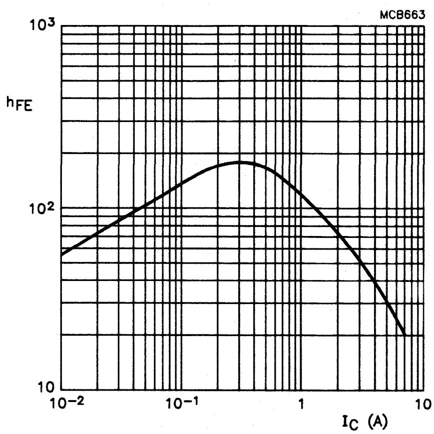


Fig.4 Typical DC current gain; V_{CE} = 4 V; T_{tab} = 25 °C.

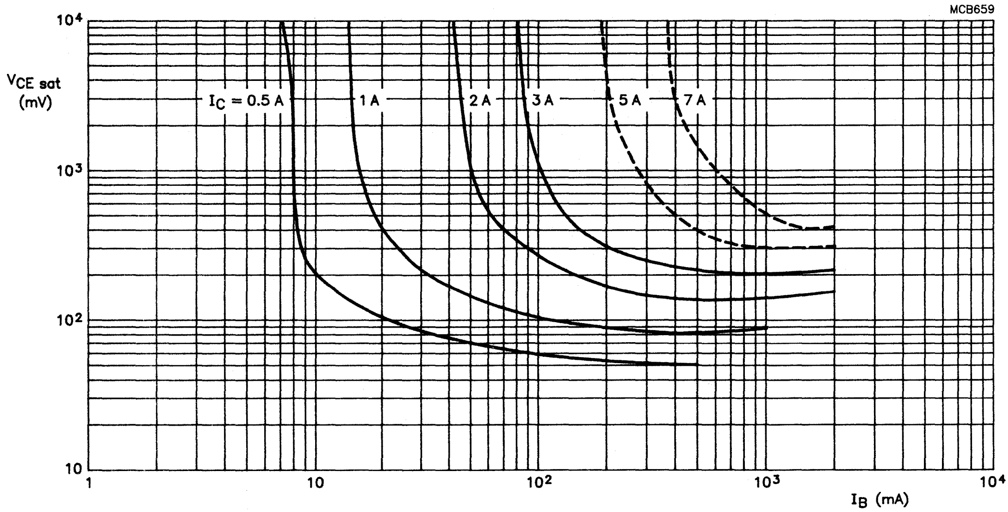


Fig.5 Typical values of collector-emitter saturation voltage at T_{tab} = 25 °C.

PACKAGE OUTLINE

Dimensions in mm

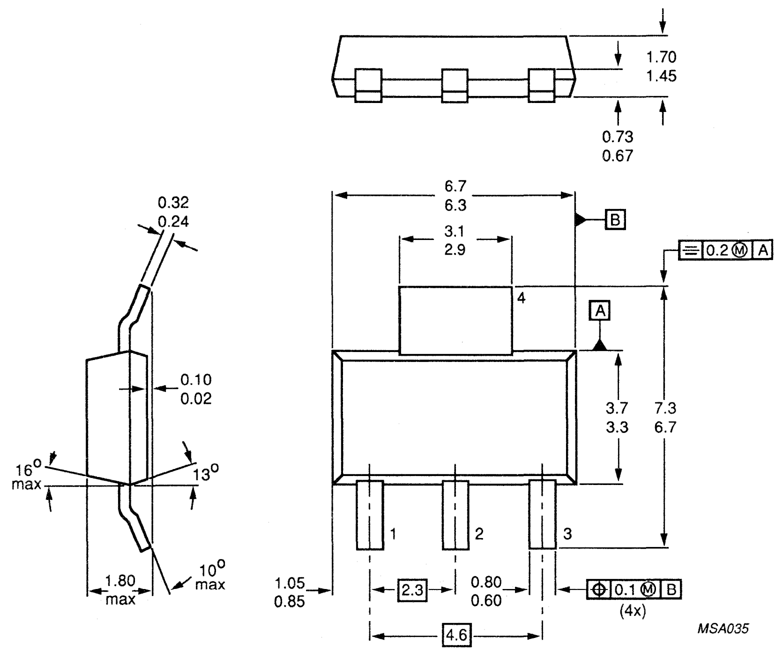


Fig.6 SOT223.

Philips Components

Data sheet	
status	Product specification
date of issue	April 1991

BDS950/952/954/956

PNP silicon epitaxial base power transistors

DESCRIPTION

PNP silicon epitaxial base transistors in a miniature SMD envelope (SOT223) intended for general purpose and switching applications. NPN complements are BDS949/951/953/955.

PINNING - SOT223

PIN	DESCRIPTION
1	base
2	collector
3	emitter
4	collector

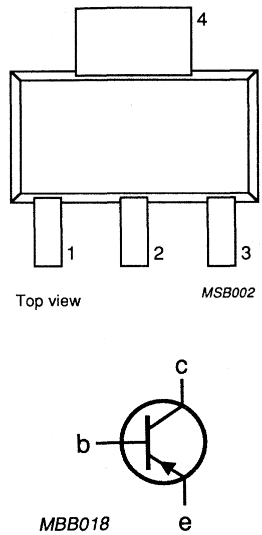


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS950		-	60	V
	BDS952		-	80	V
	BDS954		-	100	V
	BDS956		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS950		-	60	V
	BDS952		-	80	V
	BDS954		-	100	V
	BDS956		-	120	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
		note 1	-	1.5	W
T_j	junction temperature		-	150	°C
h_{FE}	DC current gain	$-I_C$ = 0.5 A; $-V_{CE}$ = 4 V	40	-	
h_{FE}	DC current gain	$-I_C$ = 2 A; $-V_{CE}$ = 4 V	20	-	

Note

1. Mounted on PCB.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDS950		-	60	V
	BDS952		-	80	V
	BDS954		-	100	V
	BDS956		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDS950		-	60	V
	BDS952		-	80	V
	BDS954		-	100	V
	BDS956		-	120	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	3	A
$-I_{CM}$	collector current	peak value	-	7	A
P_{tot}	total power dissipation	T_{tab} = 25 °C	-	8	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j-t}$	from junction to tab		15.5	K/W
$R_{th\ j-a}$	from junction to ambient	on PCB	83.3	K/W

PNP silicon epitaxial base power transistors BDS950/952/954/956

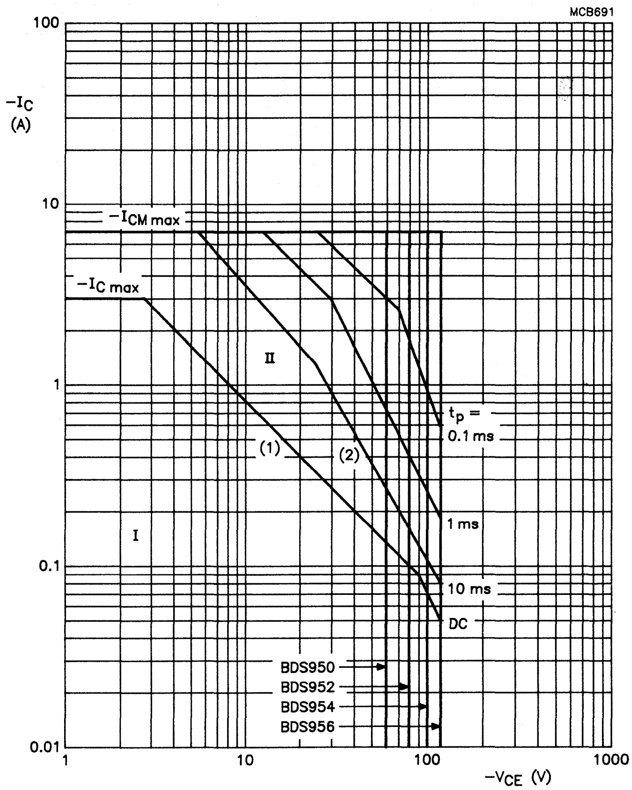
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	-	50	µA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\ max}$; $T_j = 150$ °C	-	1	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $V_{CE} = 1/2\ V_{CEO\ max}$	-	0.1	mA
$-I_{EBO}$	emitter cut-off current	$I_C = 0$; $-V_{EB} = 5$ V	-	0.2	mA
$-V_{BE}$	base-emitter voltage	$-I_C = 2$ A; $-V_{CE} = 4$ V; note 1	-	1.4	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 2$ A; $-I_B = 0.2$ A; note 1	-	1	V
h_{FE}	DC current gain	$-I_C = 500$ mA; $-V_{CE} = 4$ V note 1	40	-	
h_{FE}	DC current gain	$-I_C = 2$ A; $-V_{CE} = 4$ V; note 1	20	-	
f_T	transition frequency	f = 1 MHz; $-I_C = 500$ mA; $-V_{CE} = 4$ V	3	-	MHz

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.



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

Fig.2 Safe operating area; T_{tab} = 25 °C.

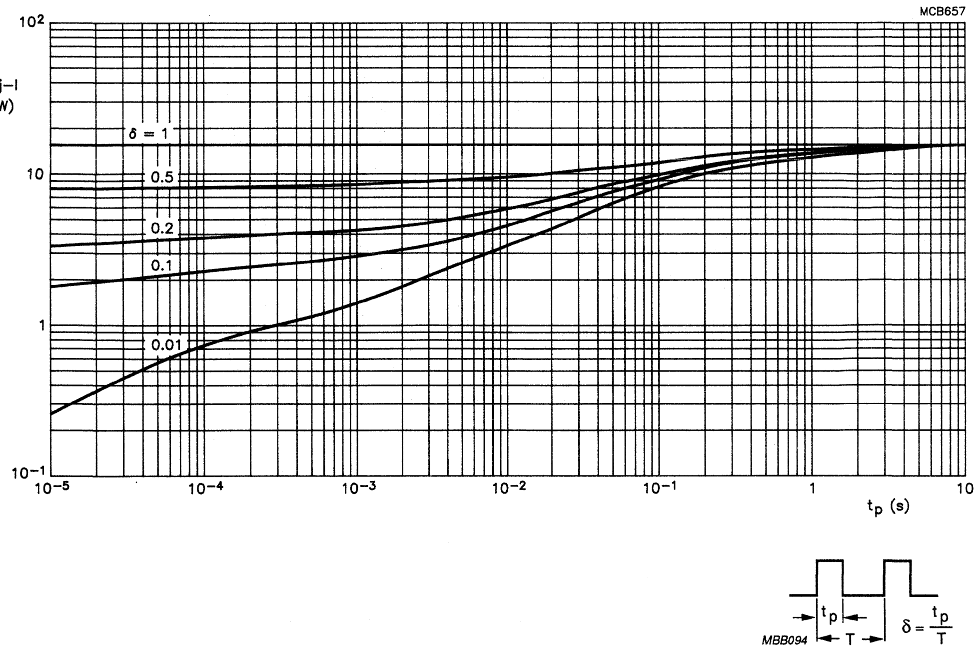


Fig.3 Pulse power rating chart.

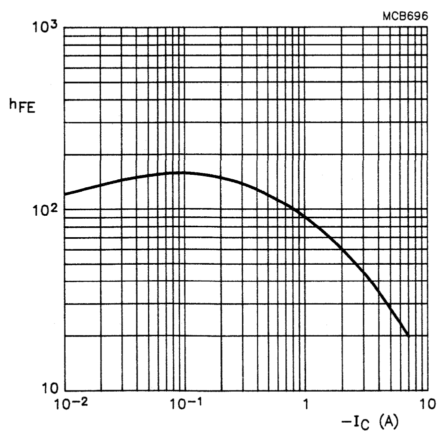


Fig.4 Typical DC current gain; V_{CE} = 4 V; T_{tab} = 25 °C.

PNP silicon epitaxial base power transistors BDS950/952/954/956

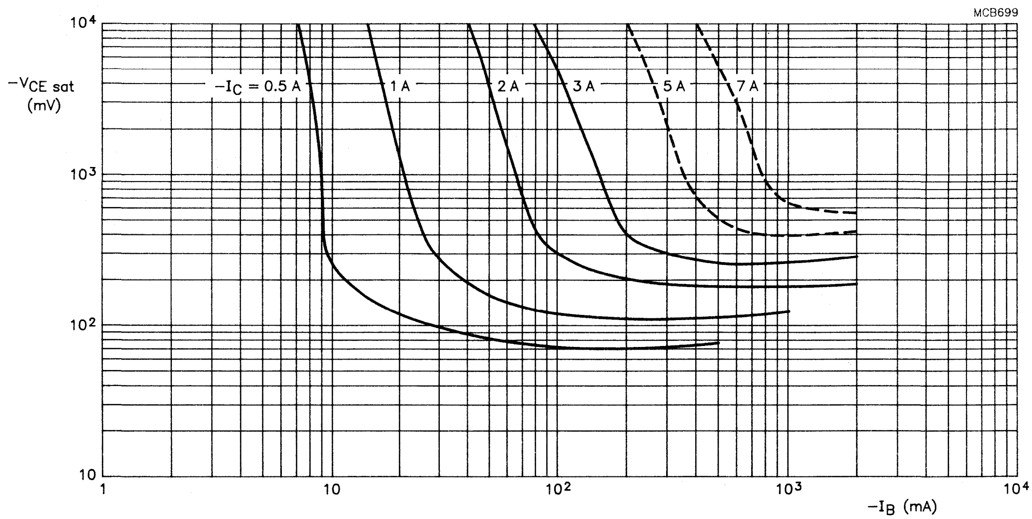


Fig.5 Typical values of collector-emitter saturation voltage at $T_{tab} = 25$ °C.

PNP silicon epitaxial base power transistors BDS950/952/954/956

PACKAGE OUTLINE

Dimensions in mm

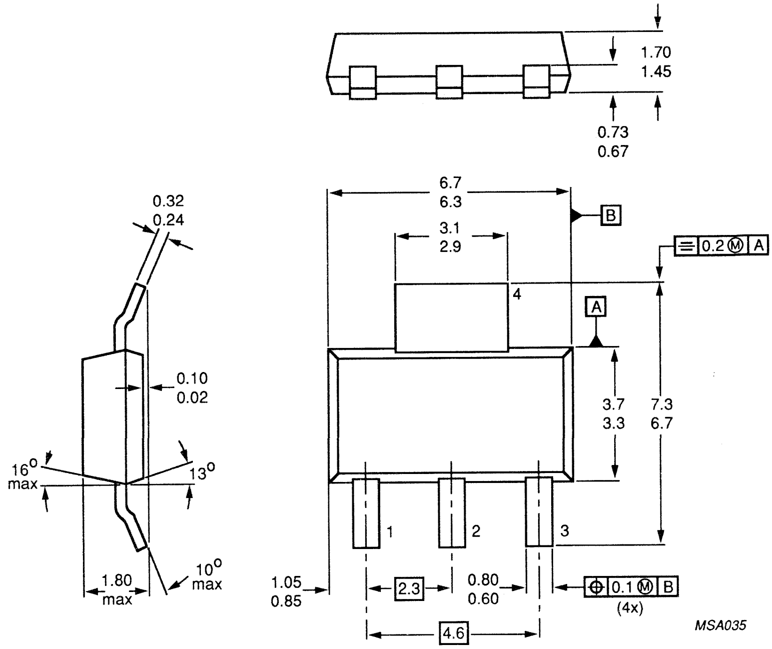


Fig.6 SOT223.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P silicon power transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier applications.
N-P-N complements are BDT61, BDT61A, BDT61B and BDT61C.

QUICK REFERENCE DATA

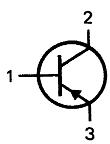
			BDT60	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		4			A
Collector current (peak value)	$-I_{CM}$	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50			W
Junction temperature	T_j	max.		150			°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		2200			

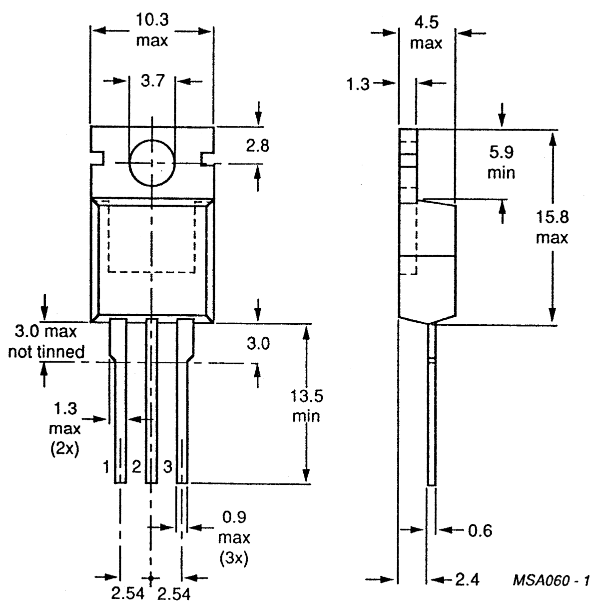
MECHANICAL DATA

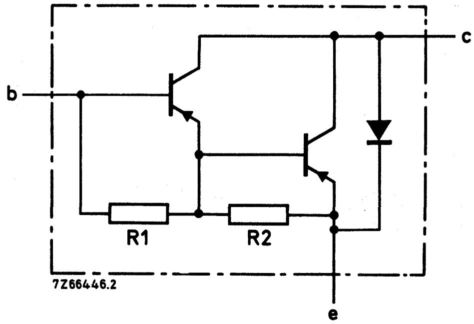
Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.







R1 typ. 6 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT60	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	4				A
Collector current (peak value)	$-I_{CM}$	max.	6				A
Reverse diode current	$I_R = I_C$	max.	4				A
Base current (d.c.)	$-I_B$	max.	100				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	50				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature*	T_j	max.	150				°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	2,5	K/W
From junction to ambient (in free air)	$R_{th\,j\text{-}a}$	=	70	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			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	⩽	0,2 mA
$I_E = 0; -V_{CB} = -½V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	⩽	1 mA
$I_B = 0; -V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	⩽	0,2 mA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	⩽	5 mA
Forward bias second-breakdown collector current			
$-V_{CE} = 50$ V; t = 0,1 s; non-repetitive (without heatsink); $T_{amb} = 25$ °C	$-I_{(SB)}$	⩾	1 A
D.C. current gain*			
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2200
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	h_{FE}	⩾	750
$-I_C =$ 4 A; $-V_{CE} = 3$ V	h_{FE}	typ.	270
Base-emitter voltage			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	$-V_{BE}$	⩽	2,5 V
Collector-emitter saturation voltage*			
$-I_C = 1,5$ A; $-I_B = 6$ mA	$-V_{CEsat}$	⩽	2,5 V
Cut-off frequency			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	f_{hfe}	⩾	25 kHz
Small-signal current gain at f = 1 MHz			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	h_{fe}	⩾	10
Diode, forward voltage			
$I_F = 1,5$ A	V_F	<	2 V

Switching times
(between 10% and 90% levels)
$-I_{Con} = 1,5$ A; $-I_{Bon} = I_{Boff} = 6$ mA; $-V_{CC} = 30$ V

turn-on time	t_{on}	typ.	0,3 μs
		<	1,5 μs
turn-off time	t_{off}	typ.	1,5 μs
		<	5 μs

* Measured under pulse conditions; $t_p < 300$ μs; $\delta < 2\%$.

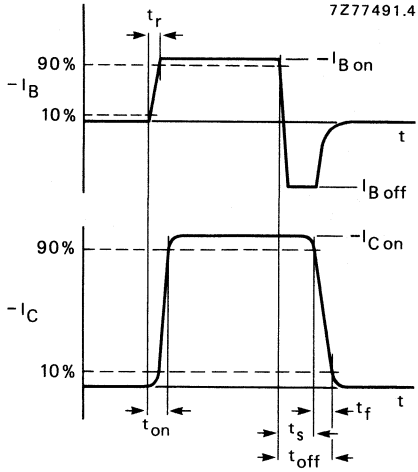


Fig. 3 Switching times waveforms.

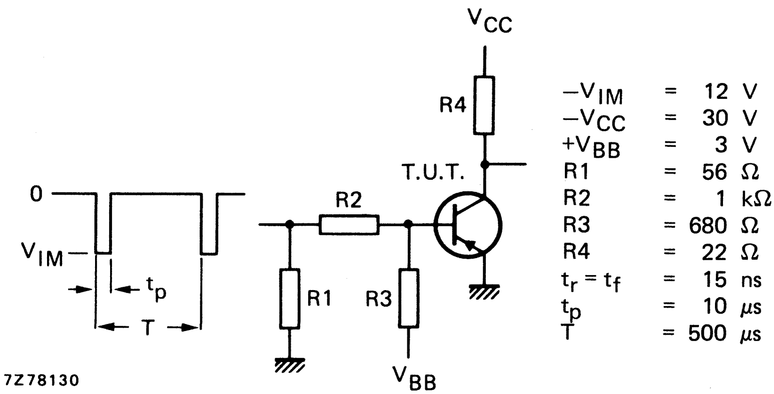


Fig. 4 Switching times test circuit.

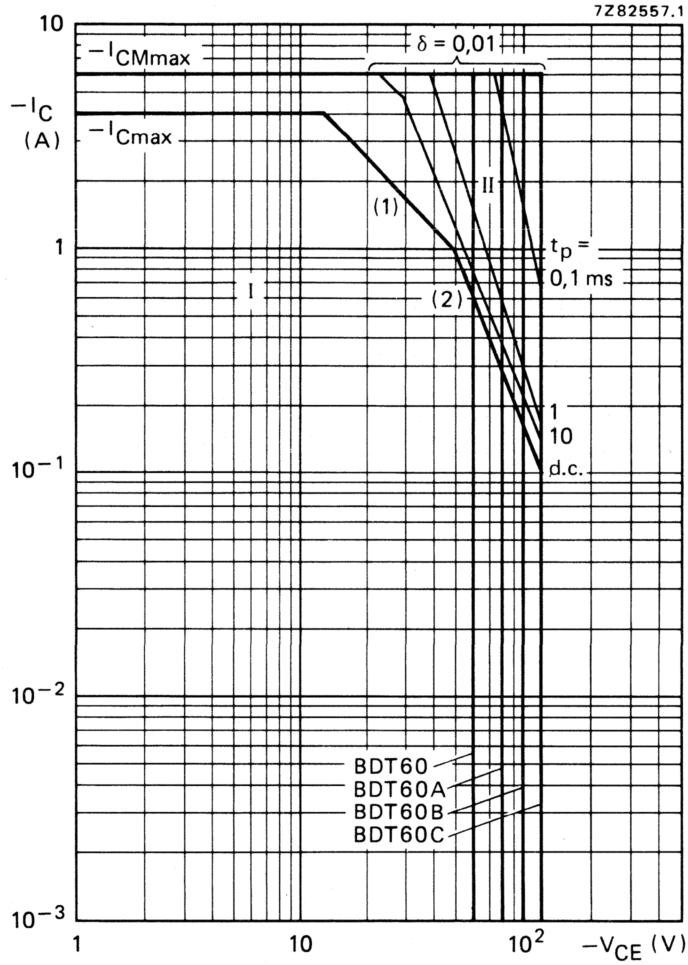


Fig. 5 Safe Operating Area, T_{mb} = 25 °C.

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

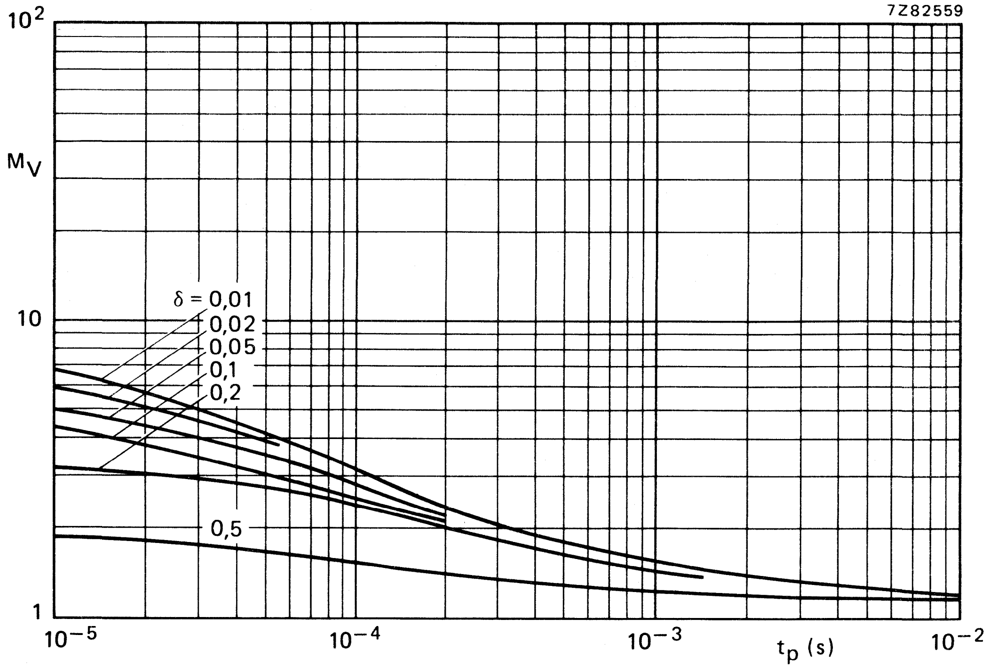


Fig. 6 Second-breakdown voltage multiplying factor at the $I_{C\,max}$ level.

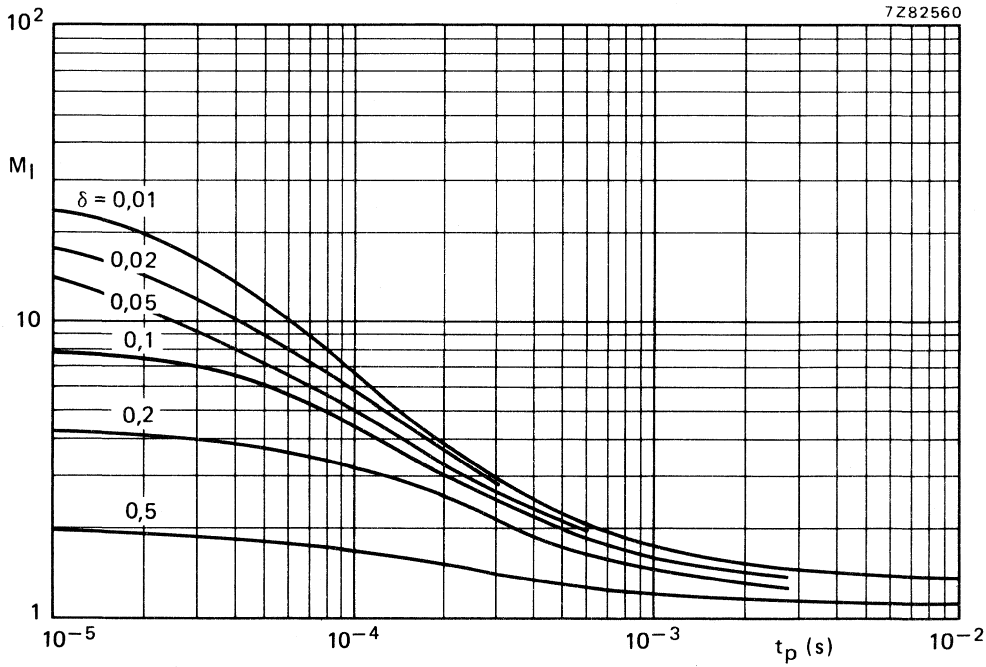


Fig. 7 Second-breakdown current multiplying factor at the $V_{CEO\,max}$ level.

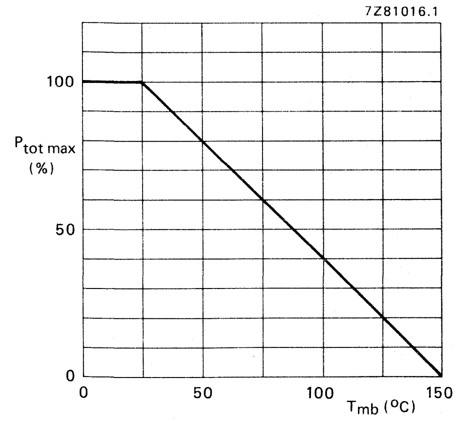


Fig. 8 Power derating curve.

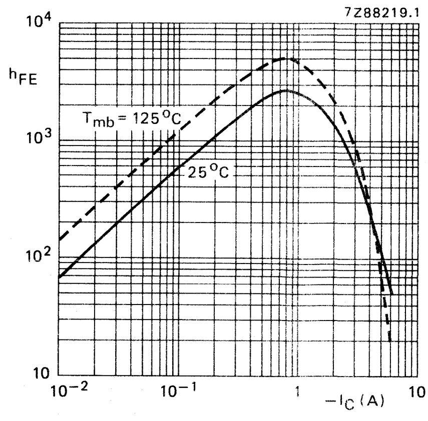


Fig. 9 Typical d.c. current gain. $-V_{CE}$ = 3 V.

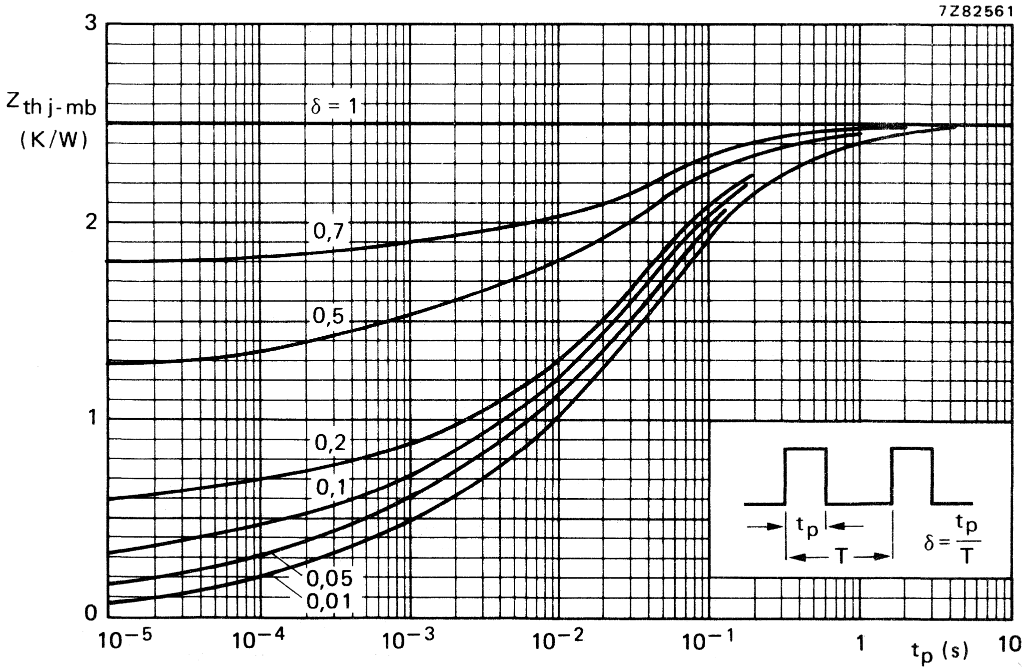


Fig. 10 Pulse power rating chart.

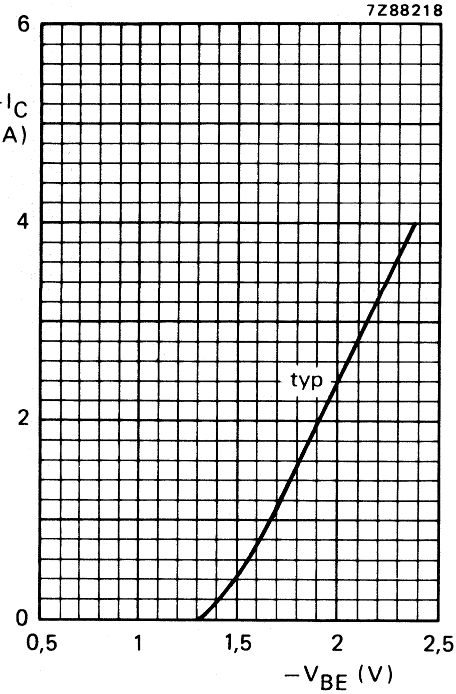


Fig. 11 $-V_{CE}$ = 3 V; T_j = 25 °C.

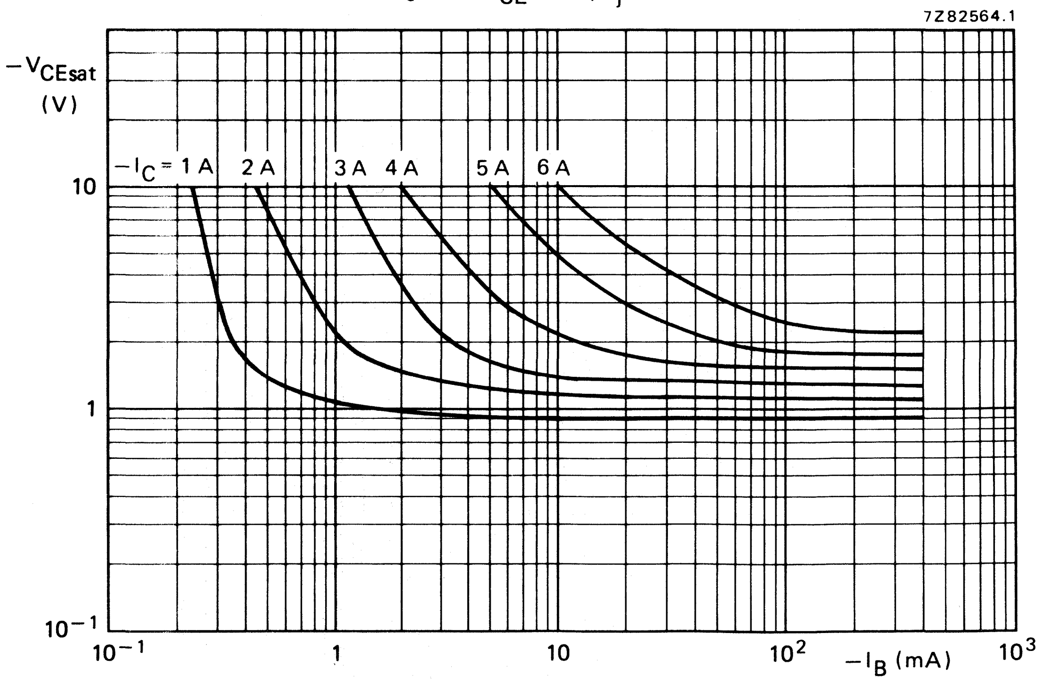


Fig. 12 Typical values collector-emitter saturation voltage at T_{mb} = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

PNP silicon power transistors in a monolithic Darlington circuit and housed in a SOT186 envelope with an electrically insulated mounting base.

They are recommended for applications such as audio output stages and general purpose amplifiers.

NPN complements are BDT61F, BDT61AF, BDT61BF and BDT61CF.

QUICK REFERENCE DATA

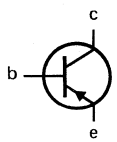
			BDT60F	60AF	60BF	60CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current							
DC	$-I_C$	max.		4			A
peak value	$-I_{CM}$	max.		6			A
Total power dissipation up to $T_h = 25\ ^oC$	P_{tot}	max.		25			W
DC current gain							
$-I_C = 0.5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.		2000			

MECHANICAL DATA

Dimensions in mm

Pinning:

1 = base
2 = collector
3 = emitter



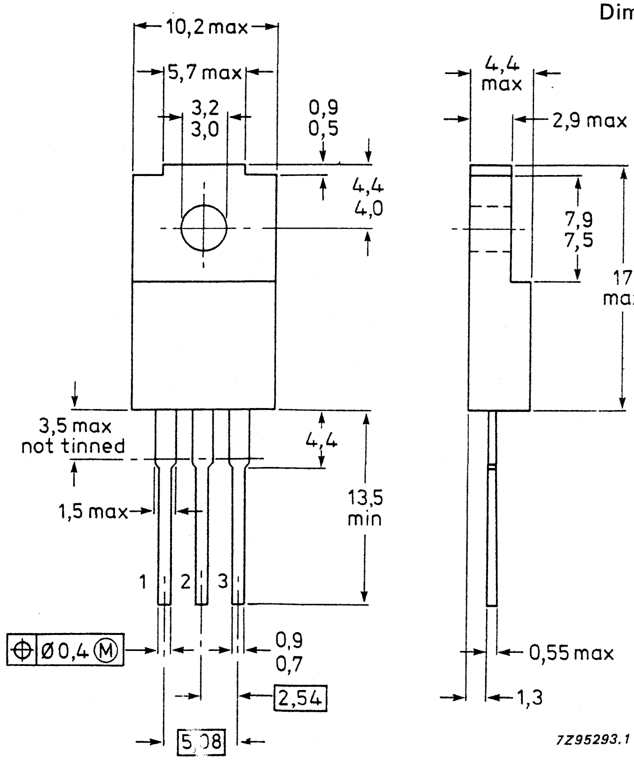
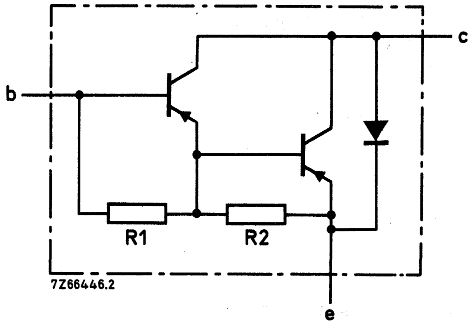


Fig.1 SOT186.



R1	typ.	6 kΩ
R2	typ.	100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT60F	60AF	60BF	60CF	
Collector-base voltage (open collector)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5			V
Collector current DC	$-I_C$	max.		4			A
peak value	$-I_{CM}$	max.		6			A
Reverse diode current	I_R	max.		4			A
Base current (DC)	$-I_B$	max.		100			mA
Total power dissipation up to T_h = 25 °C*	P_{tot}	max.		17			W
up to T_h = 25 °C**	P_{tot}	max.		25			W
Storage temperature range	T_{stg}			−65 to 150			°C
Junction temperature	T_j	max.		150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\,j\text{-}mb}$	=	2.7	K/W
From junction to external heatsink*	$R_{th\,j\text{-}h}$	=	5	K/W
From junction to external heatsink**	$R_{th\,j\text{-}h}$	=	7.35	K/W

* Mounted without heatsink compound and 30 ± 5 newtons pressure on centre envelope.
** Mounted with heatsink compound and 30 ± 5 newtons pressure on centre envelope.

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000 V
Isolation capacitor from collector to external heatsink	C_{th}	typ.	12 pF

CHARACTERISTICS

T_h = 25 °C unless otherwise specified

Collector cut-off currents			
$-I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	max.	0.2 mA
$-I_E = 0$; $-V_{CB} = -½\ V_{CBO\,max}$; $T_j = 150$ °C	$-I_{CBO}$	max.	1 mA
$-I_B = 0$; $-V_{CE} = -½\ V_{CEO\,max}$	$-I_{CEO}$	max.	0.2 mA
Emitter cut-off current			
$-I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	max.	5 mA
Forward bias second breakdown collector current $V_{CE} = 50$ V			
$t_p = 0.1$ s; non-repetitive	$-I_{(SB)}$	min.	0.5 A
DC current gain*			
$-I_C = 0.5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2000
$-I_C = 1.5$ A; $-V_{CE} = 3$ V	h_{FE}	min.	750
$-I_C = 4$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	250
Base-emitter voltage*	$-V_{BE}$	max.	2.5 V
Collector-emitter saturation voltage*			
$-I_C = 1.5$ A; $-I_B = 6$ mA	$-V_{CEsat}$	max.	2.5 V
Cut-off frequency			
$-I_C = 1.5$ A; $-V_{CE} = 3$ V	f_{hfe}	min.	25 KHz
Small-signal current gain at f = 1 MHz			
$-I_C = 1.5$ A; $-V_{CE} = 3$ V	h_{fe}	min.	10
Diode forward voltage			
$I_F = 1.5$ A	V_F	max.	2 V
$I_F = 4$ A	V_F	typ.	2.1 V

* Measured under pulse conditions: t_p max. 300 μs; δ max. 2%.

CHARACTERISTICS (continued)

Switching times (see Fig. 3)

$-I_{C\,on} = 1.5$ A; $-I_{B\,on} = +I_{B\,off} = 6$ A

turn-on time	t_{on}	typ.	0.3 μs
		max.	1.5 μs
turn-off time	t_{off}	typ.	1.5 μs
		max.	5 μs

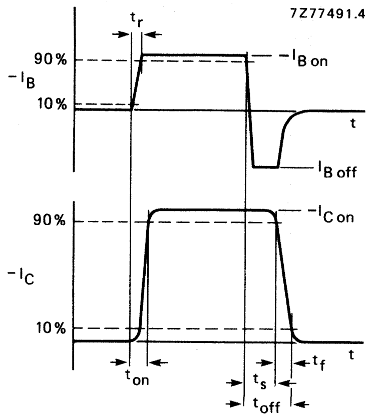
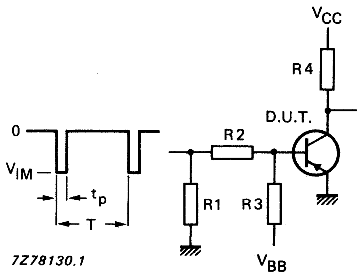


Fig. 3 Switching times waveforms.



$-V_{CC}$	=	30 V
$-V_{IM}$	=	12 V
$+V_{BB}$	=	3 V
R1	=	56 Ω
R2	=	1 kΩ
R3	=	680 Ω
R4	=	22 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

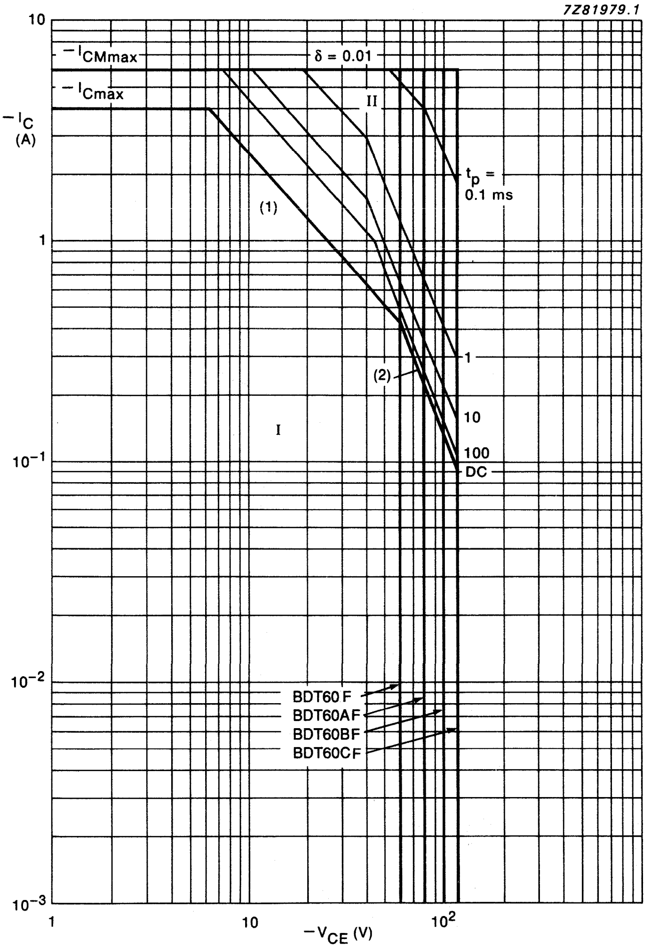


Fig. 5 Safe Operating Area, $T_h = 25\ ^oC$.

I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

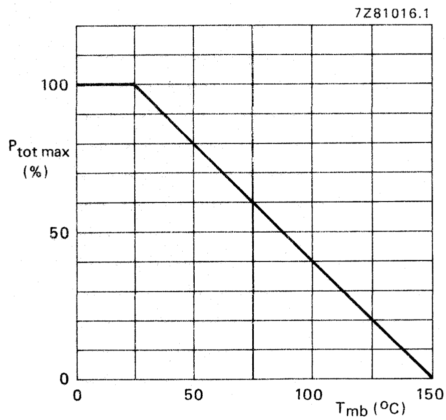


Fig. 6 Total power dissipation.

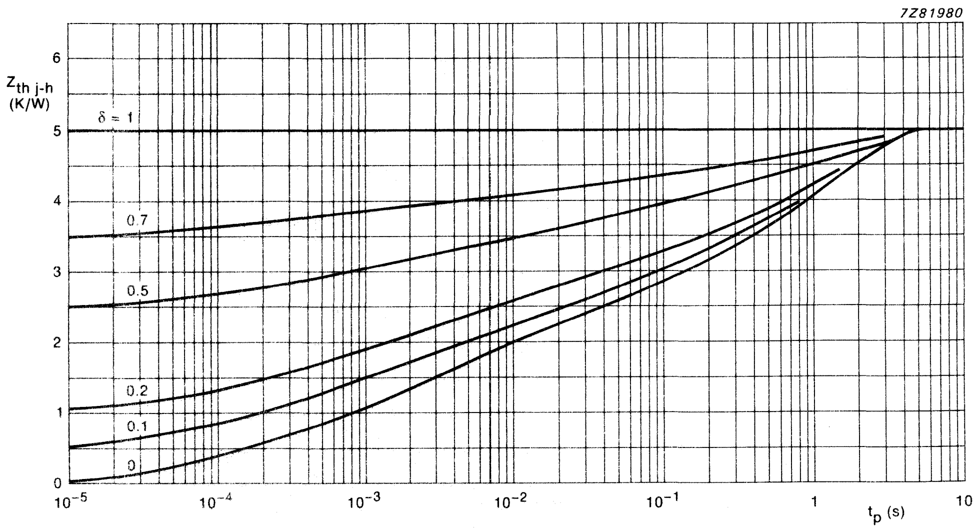


Fig. 7 Pulse power rating chart.

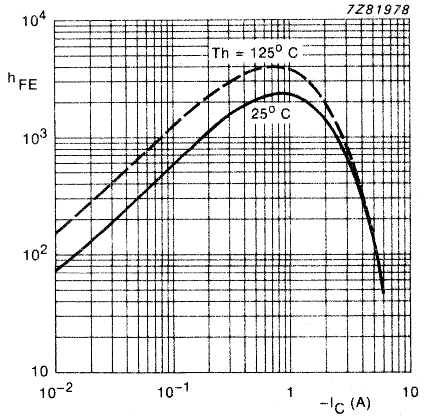


Fig. 8 DC current gain; $-V_{CE}$ = 3 V; typical values.

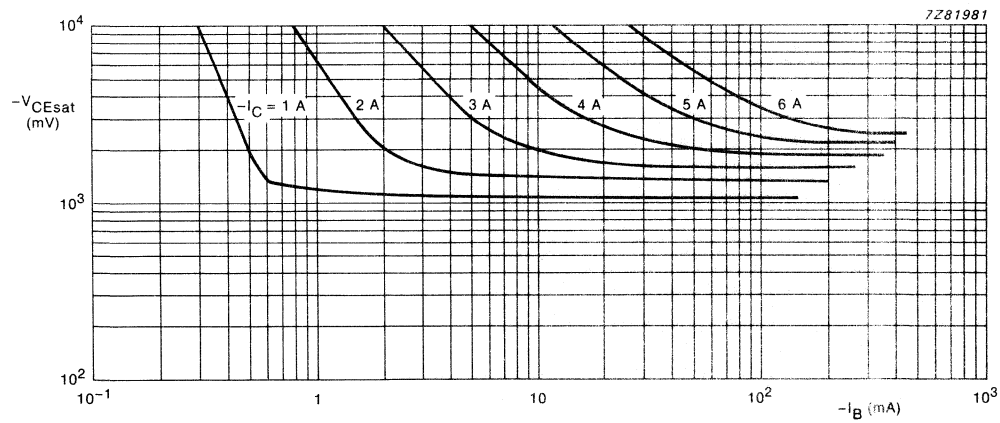


Fig. 9 Collector-emitter saturation voltage; T_h = 25 °C; typical values.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N silicon power transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier applications.

P-N-P complements are BDT60, 60A, 60B and 60C.

QUICK REFERENCE DATA

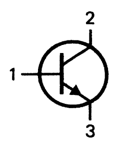
			BDT61	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.		4			A
Collector current (peak value)	I_{CM}	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50			W
Junction temperature	T_j	max.		150			°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1150			

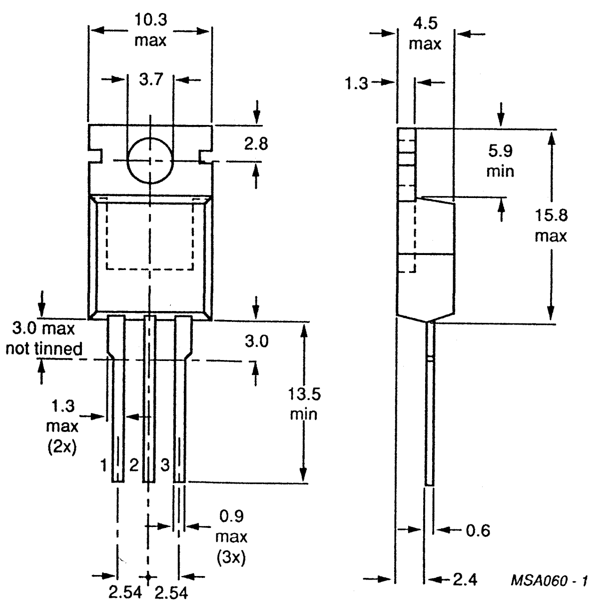
MECHANICAL DATA

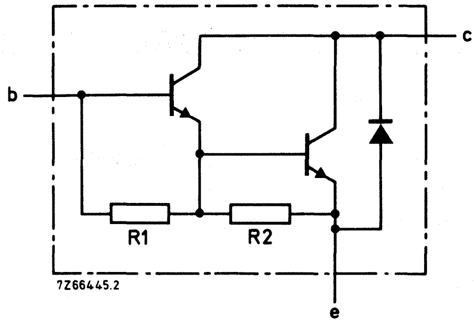
Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.







R1 typ. 6 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT61	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V

Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	6	A
Reverse diode current	$I_R = -I_C$	max.	4	A
Base current (d.c.)	I_B	max.	100	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	50	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature *	T_j	max.	150	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	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

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	$\leqslant$	0,2 mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	$\leqslant$	0,5 mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	$\leqslant$	0,2 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	$\leqslant$	5 mA
Forward-bias second-breakdown collector current			
$V_{CE} = 50$ V; t = 0,1 s; non-repetitive (without heatsink); $T_{amb} = 25\ ^oC$	$I_{(SB)}$	$\geqslant$	1 A
D.C. current gain *			
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1150
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{FE}	$\geqslant$	750
$I_C = 4$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1000
Base-emitter voltage *			
$I_C = 1,5$ A; $V_{CE} = 3$ V	V_{BE}	$\leqslant$	2,5 V
Collector-emitter saturation voltage *			
$I_C = 1,5$ A; $I_B = 6$ mA	V_{CEsat}	$\leqslant$	2,5 V
Turn-off breakdown energy with inductive load (Fig. 3)			
$-I_{Boff} = 0$; L = 5 mH; $I_{CC} = 3,2$ A	$E_{(BR)}$	$\geqslant$	25 mJ
Small-signal current gain at f = 1 MHz			
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{fe}	$\geqslant$	10
Cut-off frequency			
$I_C = 1,5$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	25 kHz

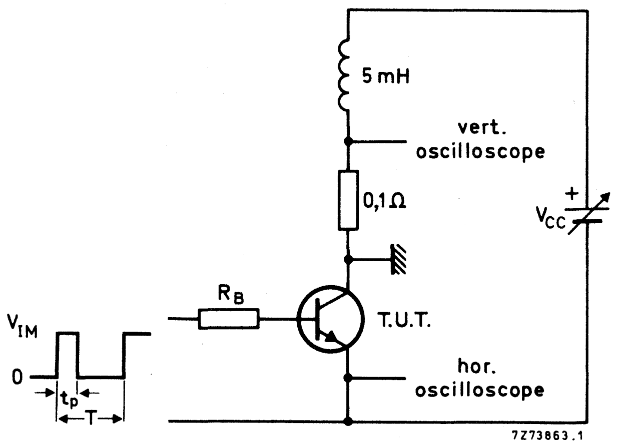


Fig. 3 Turn-off breakdown energy with inductive load.

$V_{IM} = 12$ V; $R_B = 270\ \Omega$; $\delta = \frac{t_p}{T} \times 100\% = 1\%$; $I_{CC} = 3,2$ A.

* Measured under pulse conditions; $t_n < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Diode, forward voltage			
I_F = 1,5 A	V_F	<	2 V
I_F = 4 A	V_F	typ.	2,1 V
Switching times (between 10% and 90% levels)			
I_{Con} = 1,5 A; $I_{Bon} = -I_{Boff}$ = 6 mA			
turn-on time	t_{on}	typ.	0,8 μs
		<	2 μs
turn-off time	t_{off}	typ.	4,5 μs
		<	8 μs

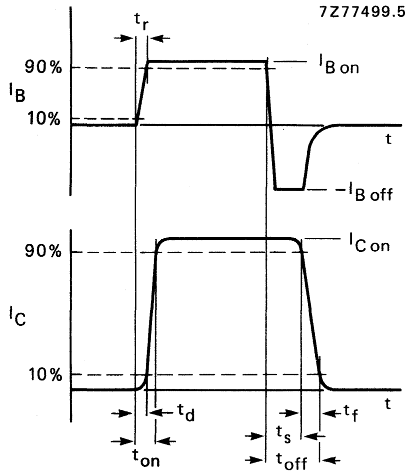


Fig. 4 Switching times waveforms.

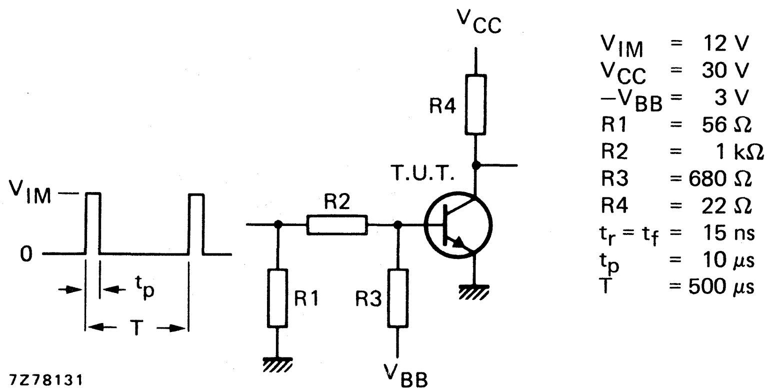


Fig. 5 Switching times test circuit.

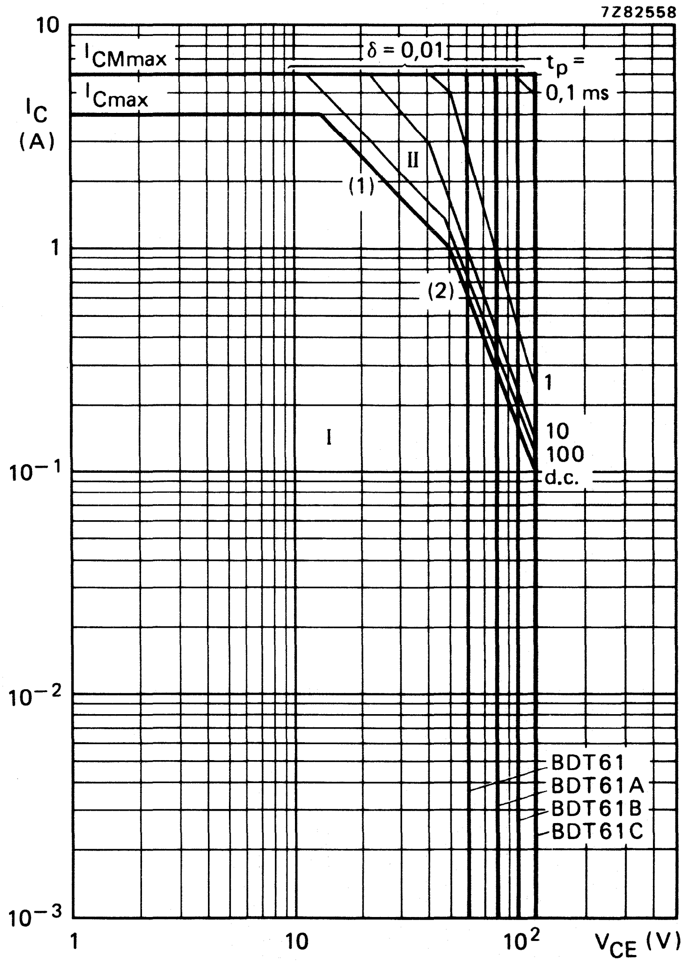


Fig. 6 Safe Operating Area, T_{mb} = 25 °C.

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

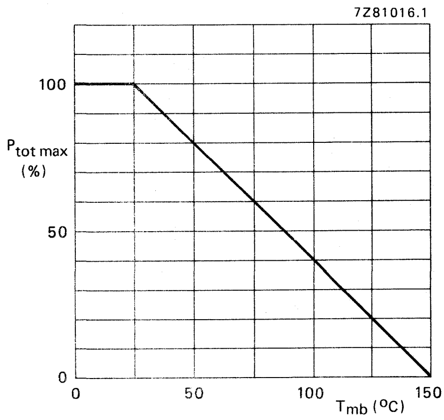


Fig. 7 Power derating curve.

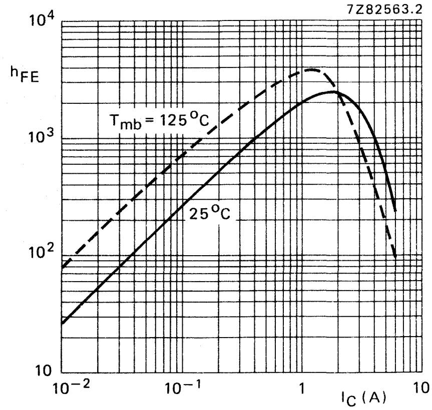


Fig. 8 Typical d.c. current gain. V_{CE} = 3 V.

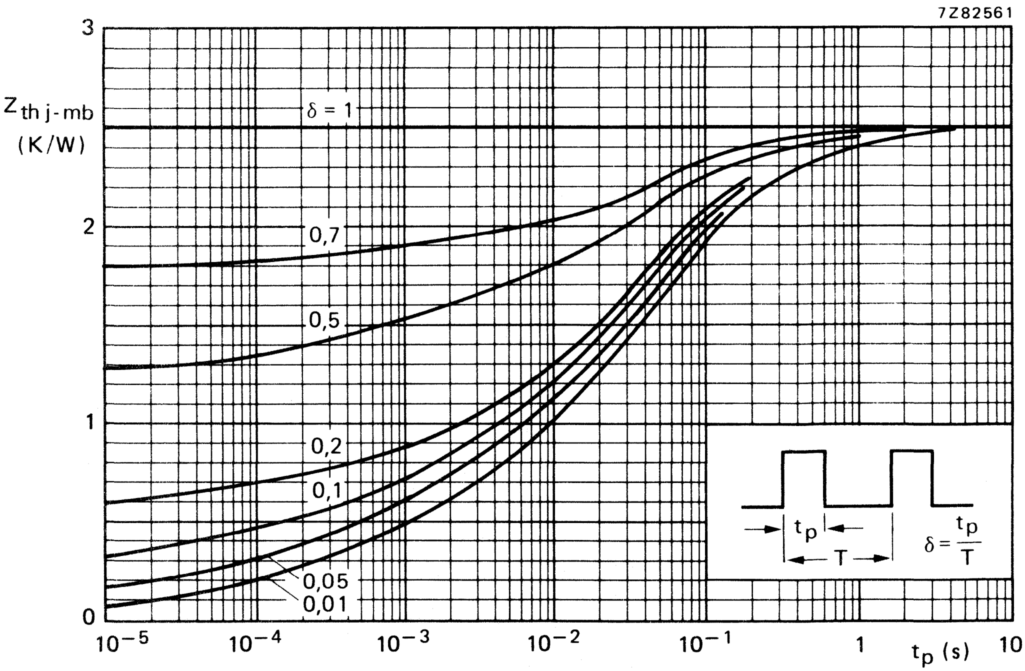


Fig. 9 Pulse power rating chart.

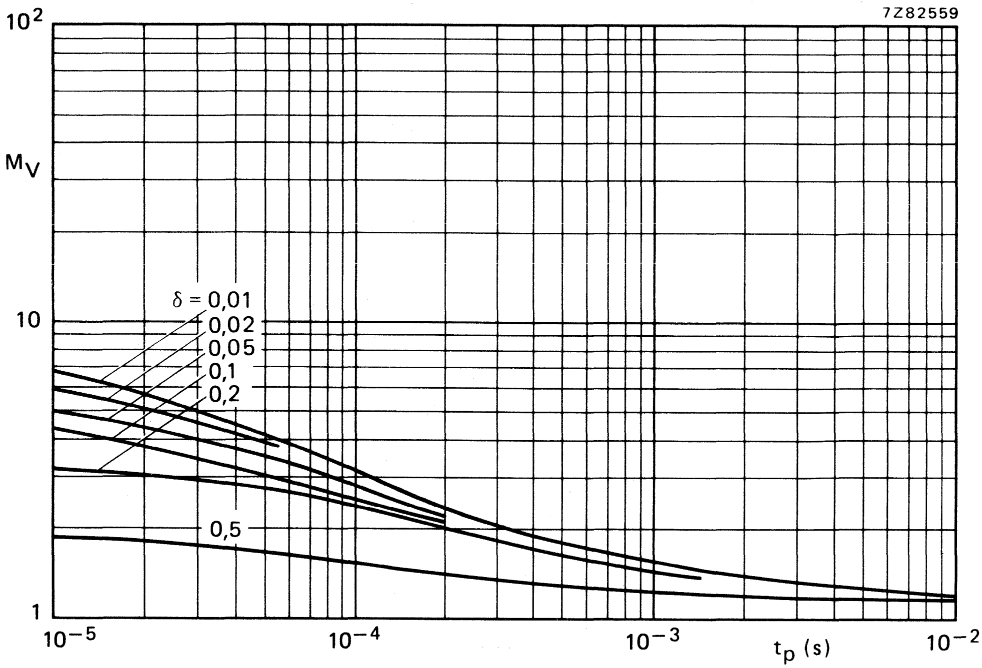


Fig. 10 Second breakdown voltage multiplying factor at the I_{Cmax} level.

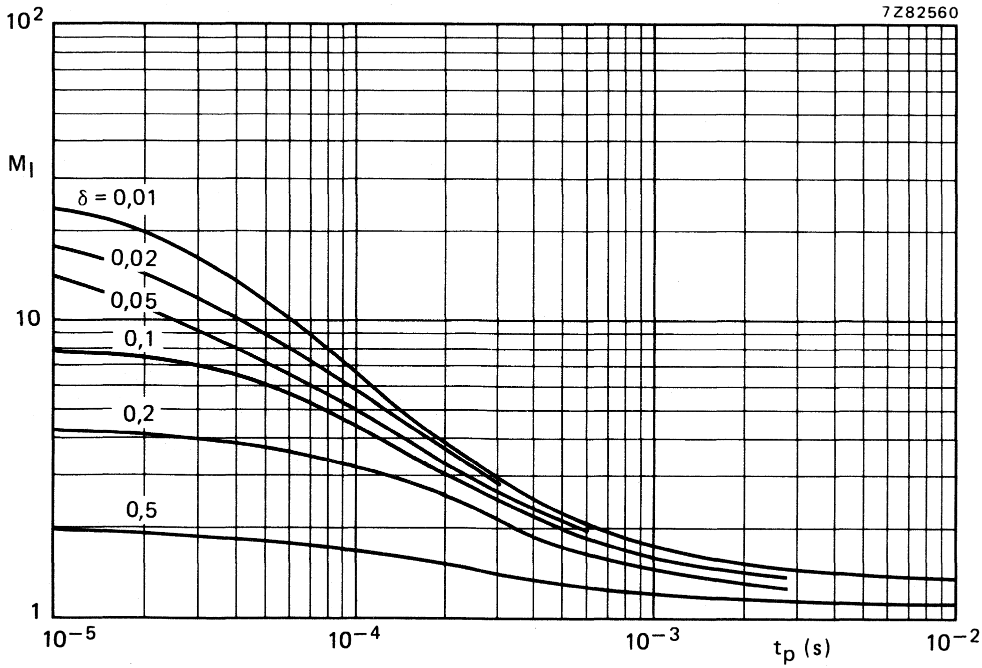


Fig. 11 Second breakdown current multiplying factor at the V_{CEOmax} level.

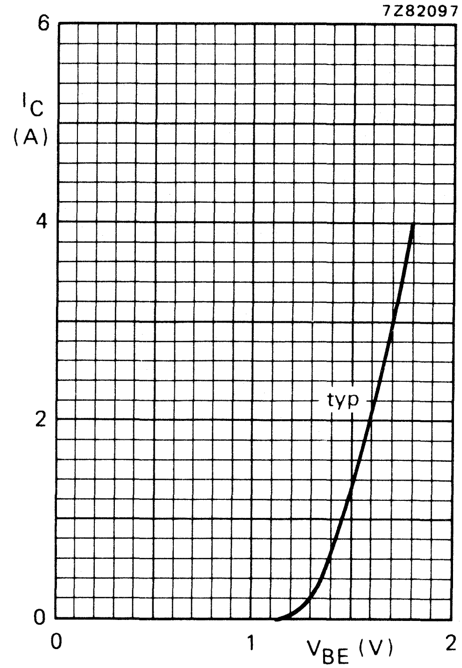


Fig. 12 V_{CE} = 3 V; T_j = 25 °C.

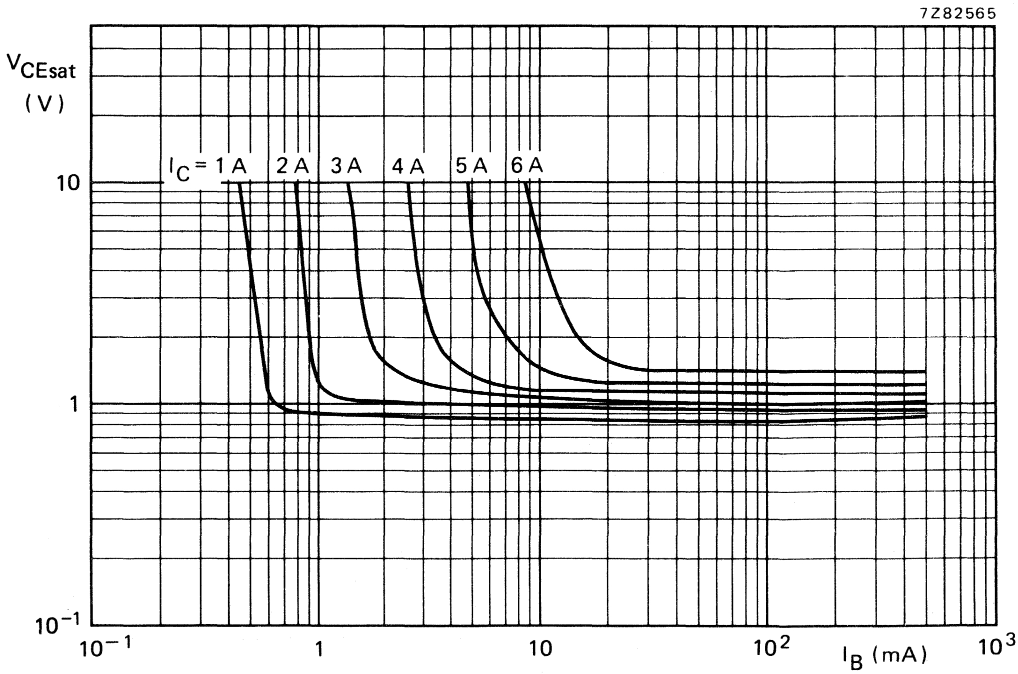


Fig. 13 Typical values collector-emitter saturation voltage at T_{mb} = 25 °C.

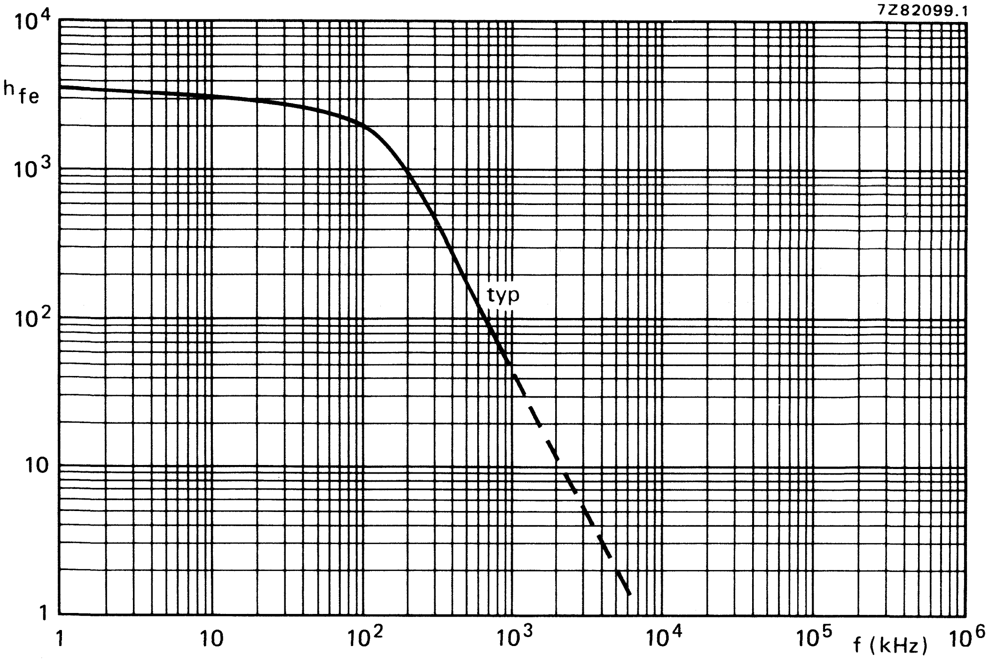


Fig. 14 Small signal current gain. I_C = 1,5 A; V_{CE} = 3 V; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon power transistors in a monolithic Darlington circuit and housed in a SOT186 envelope with an electrically insulated mounting base.

They are recommended for applications such as audio output stages and general purpose amplifiers.

PNP complements are BDT60F, BDT60AF, BDT60BF and BDT60CF.

QUICK REFERENCE DATA

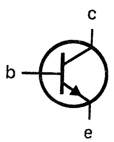
			BDT61F	61AF	61BF	61CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current							
DC	I_C	max.		4			A
peak value	I_{CM}			6			A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.		25			W
DC current gain							
I_C = 0.5 A; V_{CE} = 3 V	h_{FE}	typ.		2000			

MECHANICAL DATA

Dimensions in mm

Pinning

1 = base
2 = collector
3 = emitter



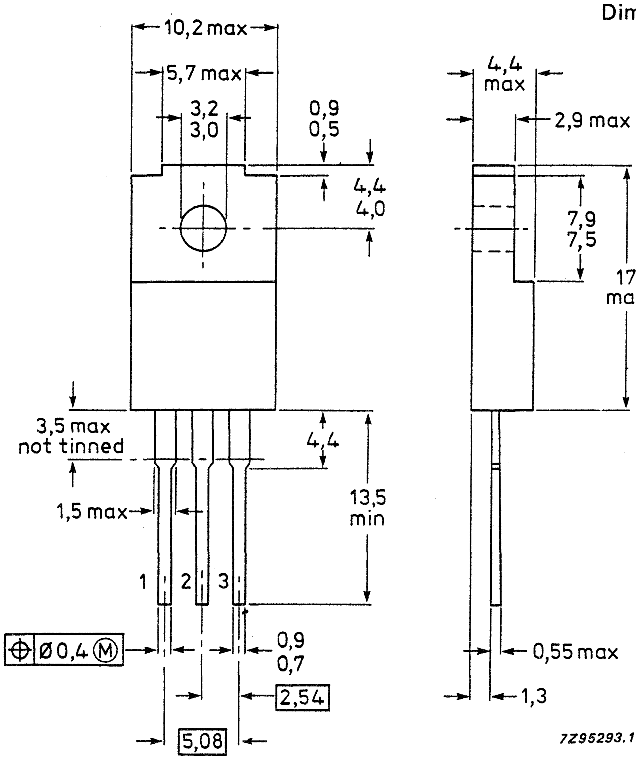
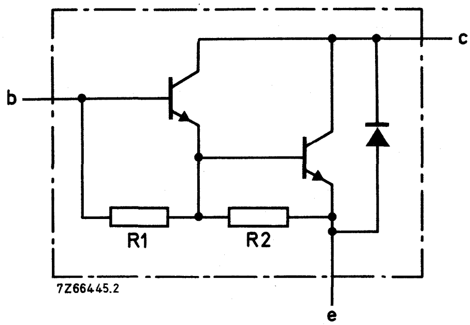


Fig.1 SOT186.



R1 typ. 3500 Ω
R2 typ. 150 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT61F	61AF	61BF	61CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5			V
Collector current DC	I_C	max.		4			A
peak value	I_{CM}	max.		6			A
Reverse diode current	I_R	max.		4			A
Base current (DC)	I_B	max.		100			mA
Total power dissipation up to T_h = 25 °C*	P_{tot}	max.		17			W
up to T_h = 25 °C**	P_{tot}	max.		25			W
Storage temperature range	T_{stg}			−65 to 150			°C
Junction temperature	T_j	max.		150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\,j\text{-}mb}$	=	2.7	K/W
From junction to external heatsink**	$R_{th\,j\text{-}h}$	=	5	K/W
From junction to external heatsink*	$R_{th\,j\text{-}h}$	=	7.35	K/W

* Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.
** Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000 V
Isolation capacitor from collector to external heatsink	C_{th}	typ.	12 pF

CHARACTERISTICS

$T_h = 25\ ^oC$ unless otherwise specified

Collector cut-off currents			
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	max.	0.2 mA
$I_E = 0$; $T_j = 150\ ^oC$ $V_{CB} = ½\ V_{CBO\,max}$	I_{CBO}	max.	1 mA
$I_B = 0$ $V_{CE} = ½\ V_{CEO\,max}$	I_{CEO}	max.	0.2 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	max.	5 mA
Forward bias second breakdown collector current $V_{CE} = 50$ V $t_p = 0.1$ s; non-repetitive	$I_{(SB)}$	min.	0.5 A
DC current gain*			
$I_C = 0.5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	2000
$I_C = 1.5$ A; $V_{CE} = 3$ V	h_{FE}	min.	750
$I_C = 4$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1000
Base-emitter voltage*	V_{BE}	max.	2.5 V
Collector-emitter saturation voltage*			
$I_C = 1.5$ A; $I_B = 6$ mA	V_{CEsat}	max.	2.5 V
Cut-off frequency			
$I_C = 1.5$ A; $V_{CE} = 3$ V	f_{hfe}	min.	25 KHz
Small-signal current gain at f = 1 MHz			
$I_C = 1.5$ A; $V_{CE} = 3$ V	h_{fe}	min.	10
Diode forward voltage			
$I_F = 1.5$ A	V_F	max.	2 V
$I_F = 4$ A	V_F	typ.	2.1 V

* Measured under pulse conditions: t_p max. 300 μs; δ max. 2%.

CHARACTERISTICS (continued)

Switching times (see Fig. 3)

$I_{C\,on}$ = 1.5 A; $I_{B\,on}$ = $-I_{B\,off}$ = 6 mA

turn-on time	t_{on}	typ.	0.8 μs
		max.	2 μs
turn-off time	t_{off}	typ.	4.5 μs
		max.	8 μs

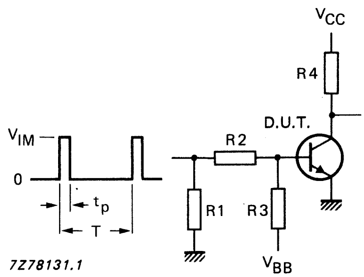
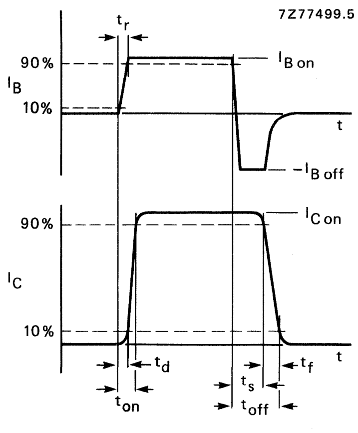
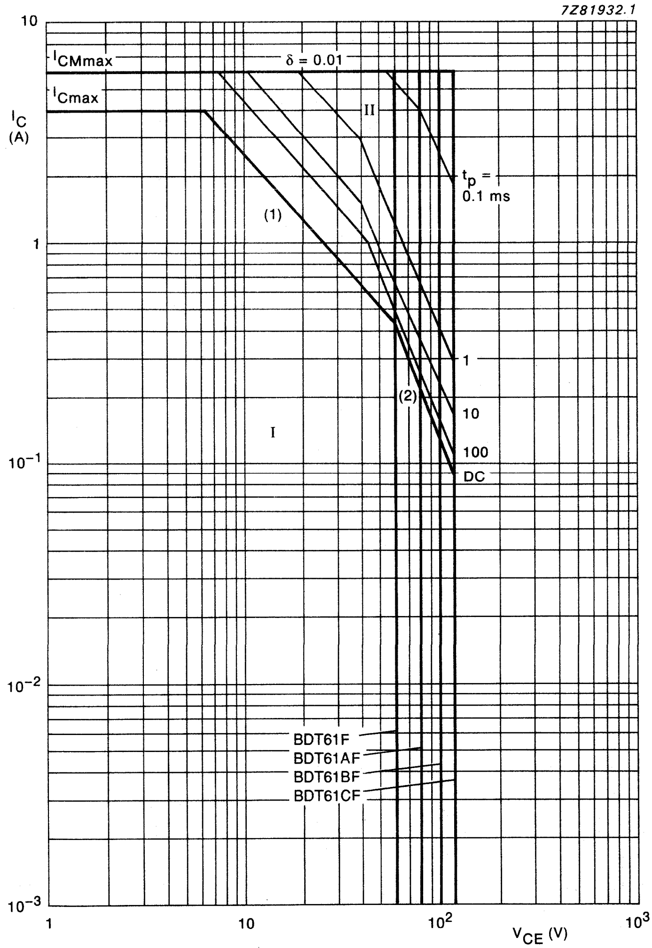


Fig. 3 Switching times waveforms.



V_{CC}	=	30 V
V_{IM}	=	12 V
$-V_{BB}$	=	3 V
R1	=	56 Ω
R2	=	1 kΩ
R3	=	680 Ω
R4	=	22 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Fig. 5 Safe Operating Area, T_h = 25 °C.

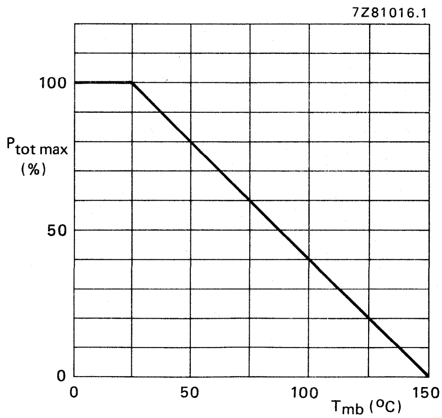


Fig. 6 Total power dissipation.

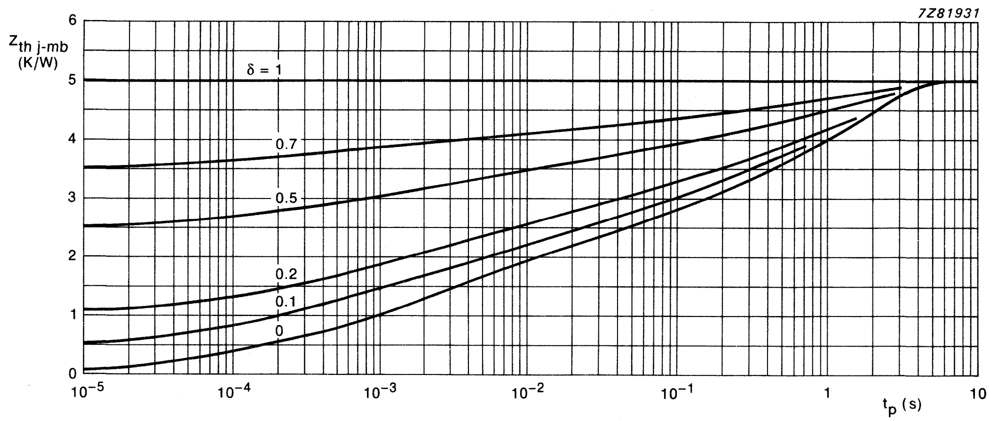


Fig. 7 Pulse power rating chart.

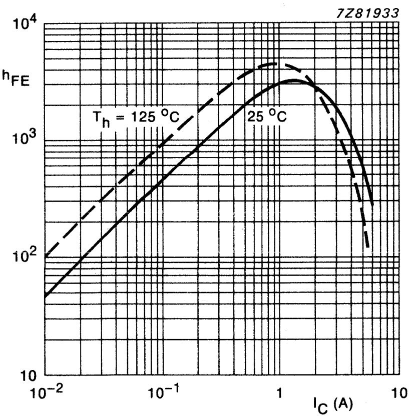


Fig. 8 DC current gain; V_{CE} = 3 V; typical values.

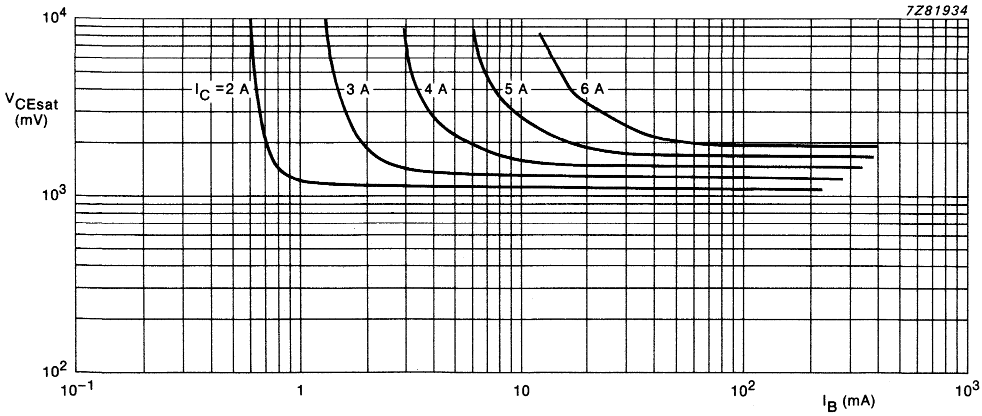


Fig. 9 Collector-emitter saturation voltage; T_h = 25 °C; typical values.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220 plastic envelope. N-P-N complements are BDT63, BDT63A, BDT63B and BDT63C.

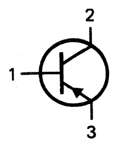
QUICK REFERENCE DATA

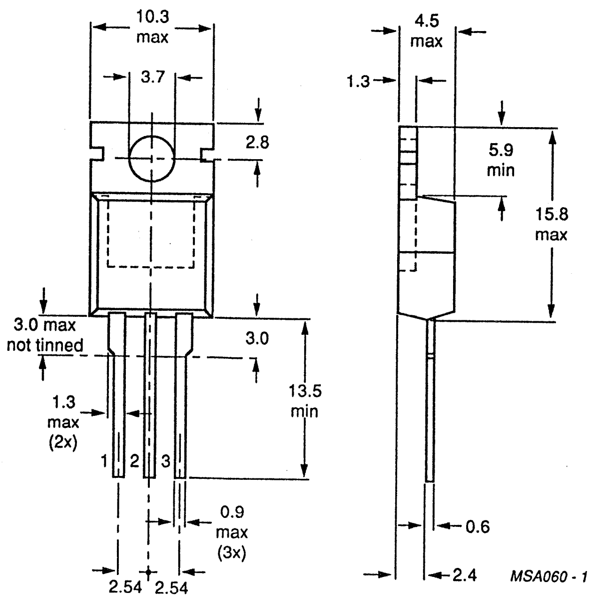
			BDT62	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.			10		A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	$-I_{CM}$	max.			15		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			90		W
Junction temperature	T_j	max.			150		°C
D.C. current gain $-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	>			1000		

MECHANICAL DATA

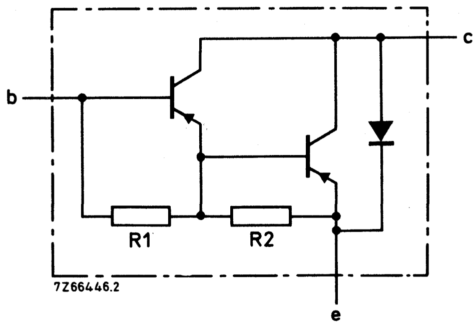
Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.



R1 typ. 4 kΩ
R2 typ. 60 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT62	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	10				A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	$-I_{CM}$	max.	15				A
Base current (d.c.)	$-I_B$	max.	250				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature*	T_j	max.	150				°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,39	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

* Base 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				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2	mA
$I_E = 0$; $-V_{CB} = -½V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	0,2	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	5	mA
Forward bias second-breakdown collector current				
$-V_{CE}$ = 40 V; t = 0,1 s; non-repetitive (without heatsink)				
BDT62	$I_{(SB)}$	>	0,45	A
BDT62A, B and C	$I_{(SB)}$	>	1,4	A
D.C. current gain*				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	>	1000	
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	200	
Base-emitter voltage*				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage*				
$-I_C$ = 3 A; $-I_B$ = 12 mA	$-V_{CEsat}$	<	2	V
$-I_C$ = 8 A; $-I_B$ = 80 mA	$-V_{CEsat}$	<	2,5	V
Cut-off frequency				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100	kHz
Collector capacitance				
$-V_{CB}$ = 10 V; f = 1 MHz	C_{ob}	typ.	100	pF
D.C. current gain ratio of matched complementary pairs				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	<	2,5	
Small-signal current gain at f = 1 MHz				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{fe}	>	10	

* Measured under pulse conditions; $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Diode, forward voltage			
$I_F = 3$ A	V_F	<	2 V
Switching times (between 10% and 90% levels) $-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA			
turn-on time	t_{on}	typ.	0,5 μs
		<	1,5 μs
turn-off time	t_{off}	typ.	2,5 μs
		<	5 μs

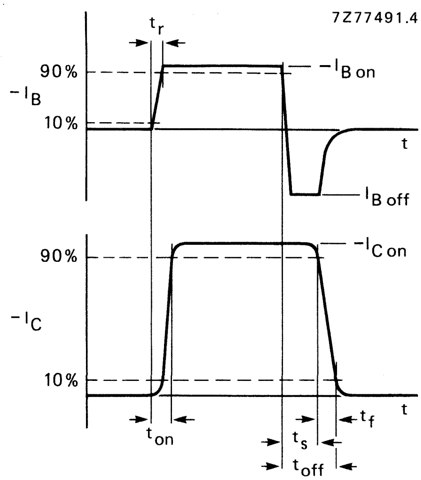


Fig. 3 Switching times waveforms.

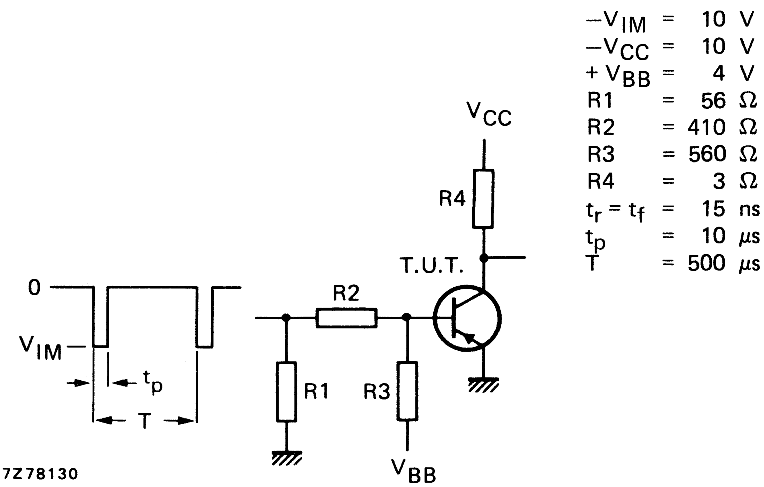


Fig. 4 Switching times test circuit.

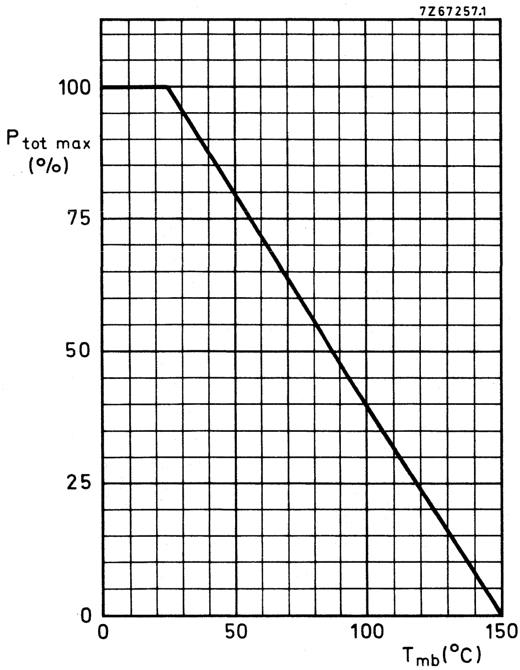


Fig. 5 Power derating curve.

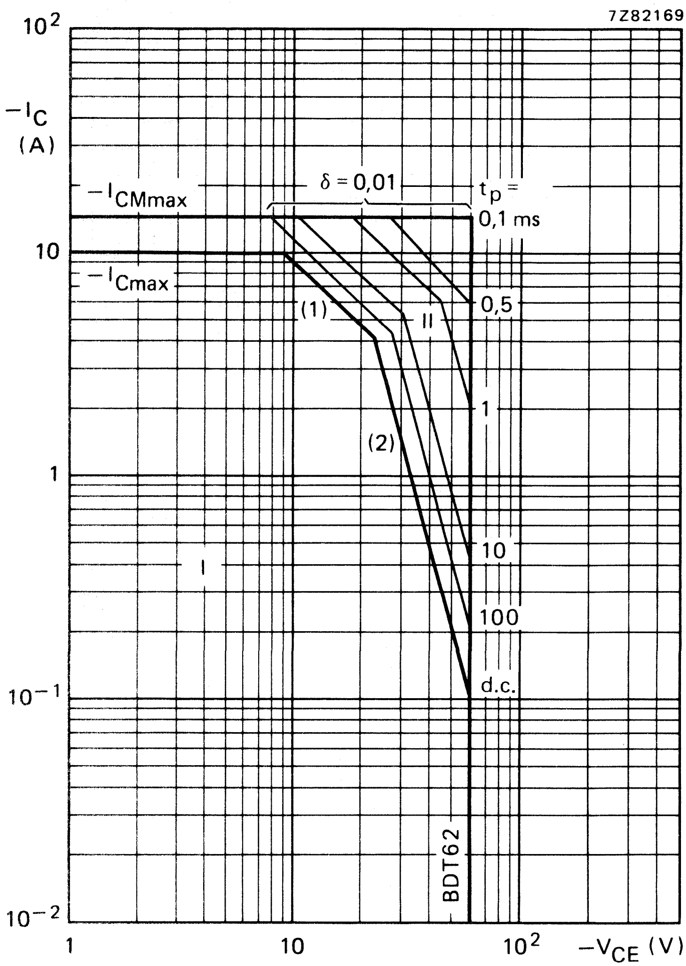


Fig. 6 Safe Operating Area BDT62; $T_{mb} = 25\ ^oC$.

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

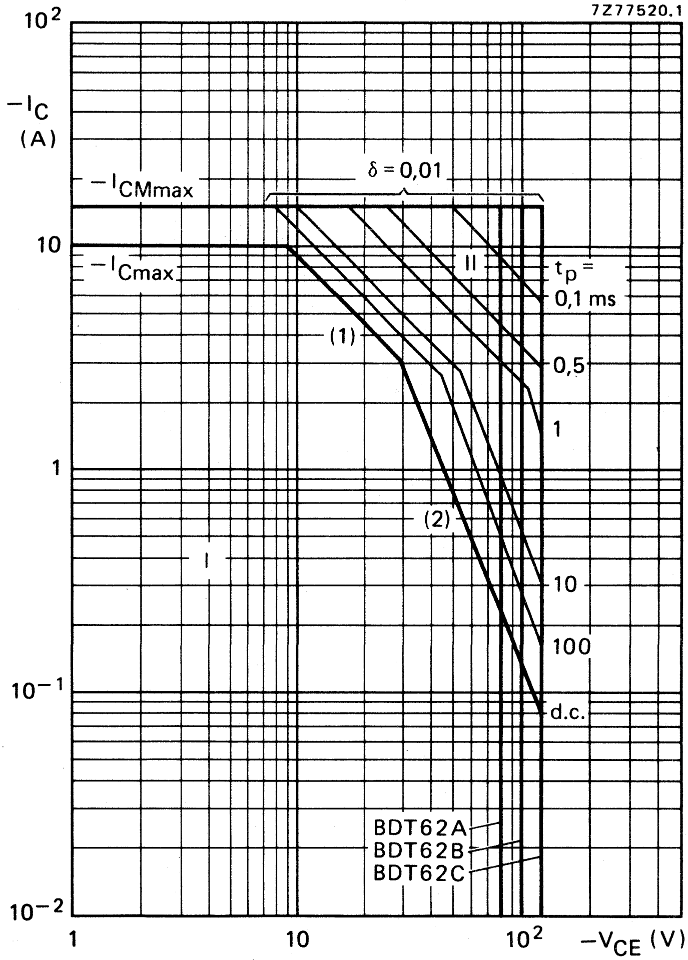


Fig. 7 Safe Operating Area BDT62A; 62B and 62C; T_{mb} = 25 °C.

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

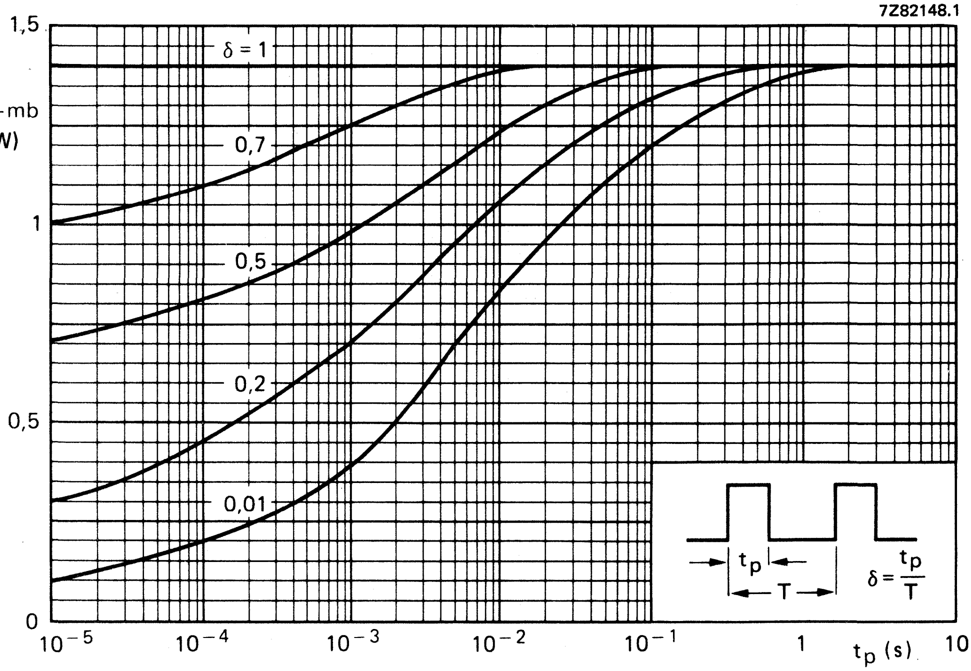


Fig. 8 Pulse power rating chart.

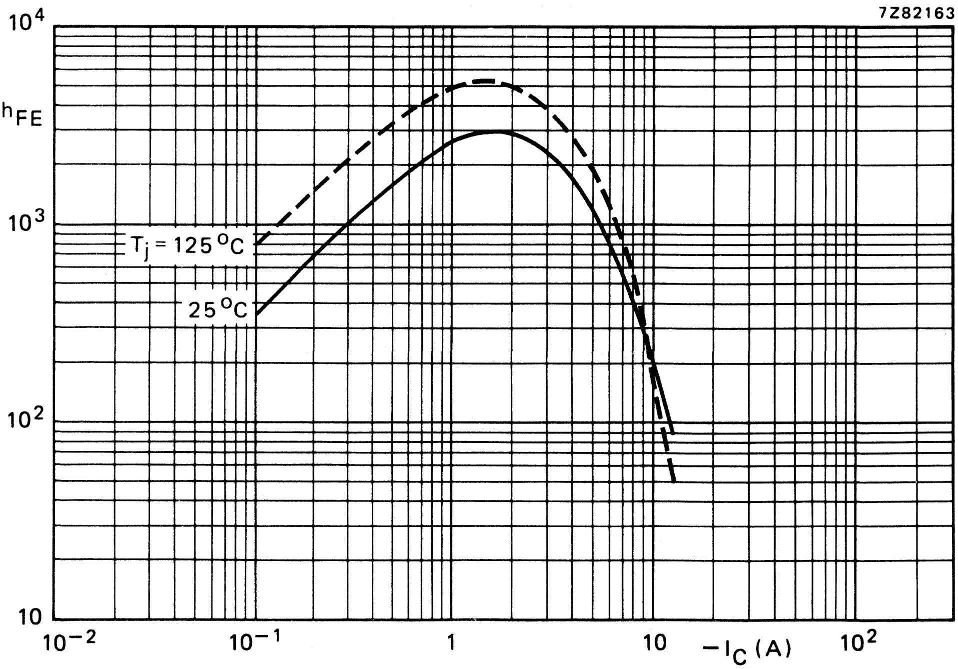


Fig. 9 Typical d.c. current gain at $-V_{CE} = 3$ V.

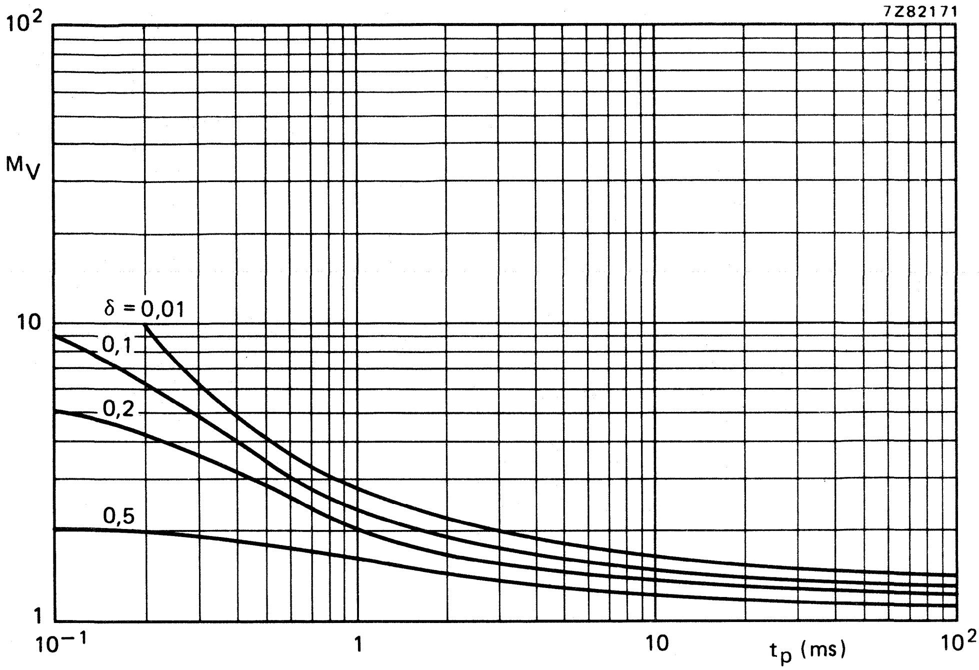


Fig. 10 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

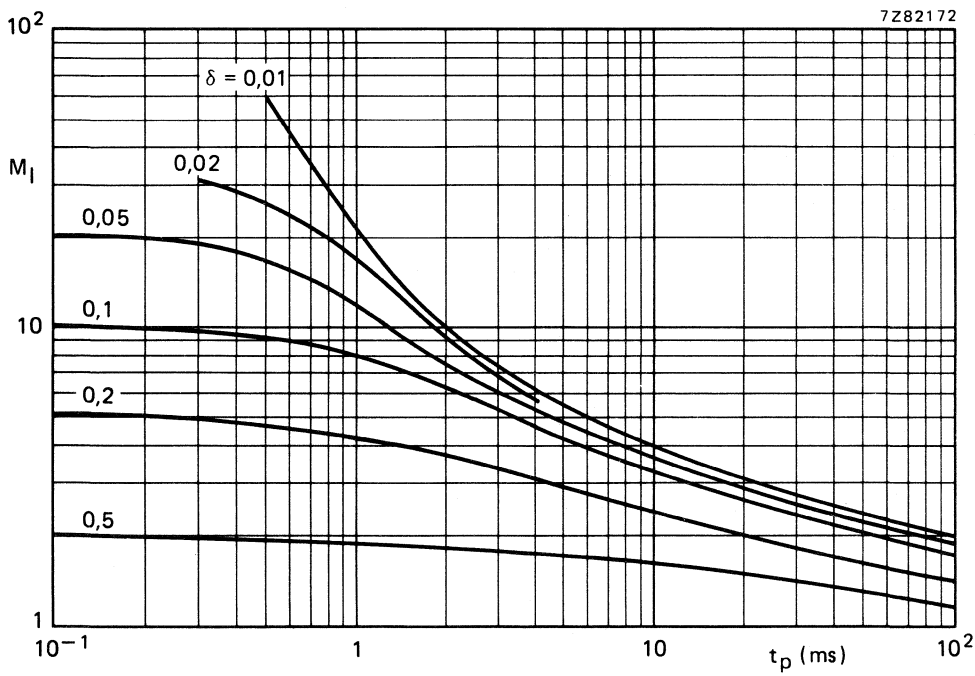


Fig. 11 S.B. current multiplying factor at the $V_{CEO\,max}$ level.

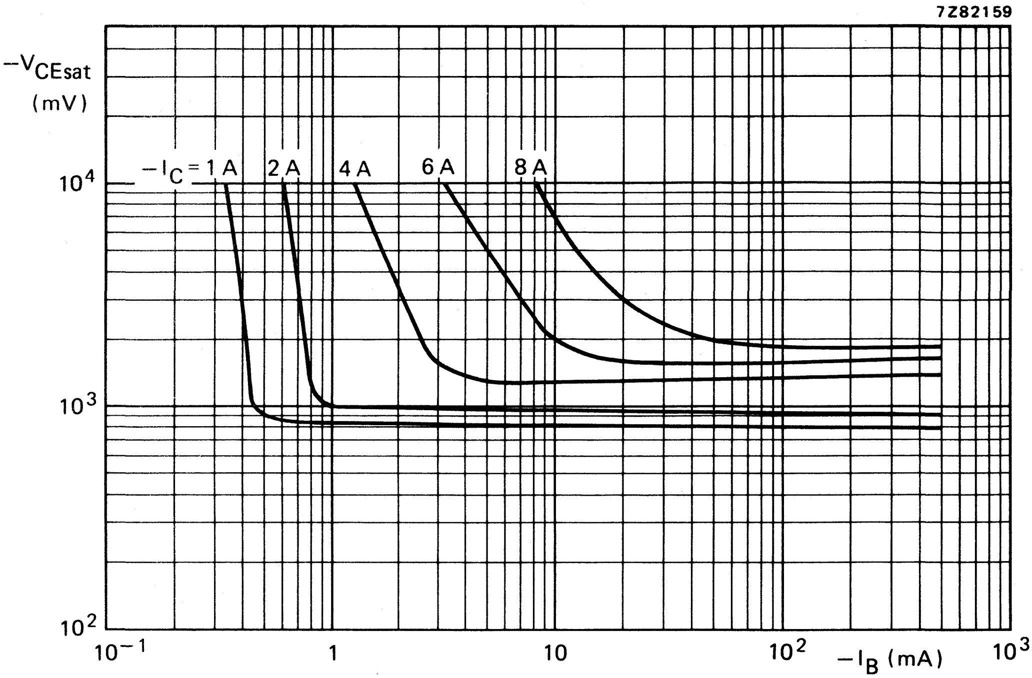


Fig. 12 Typical collector-emitter saturation voltage.

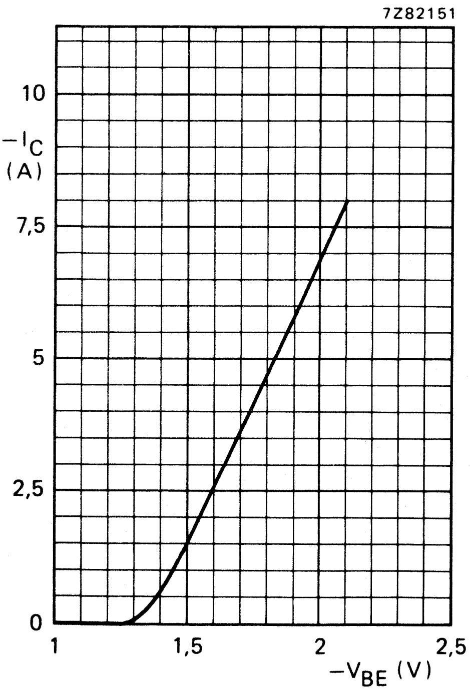


Fig. 13 Typical base emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

PNP silicon darlington power transistors in a SOT186 envelope with an electrically insulated mounting base. The devices are designed for audio output stages and general amplifier and switching applications. NPN complements are BDT63F, BDT63AF, BDT63BF and BDT63CF.

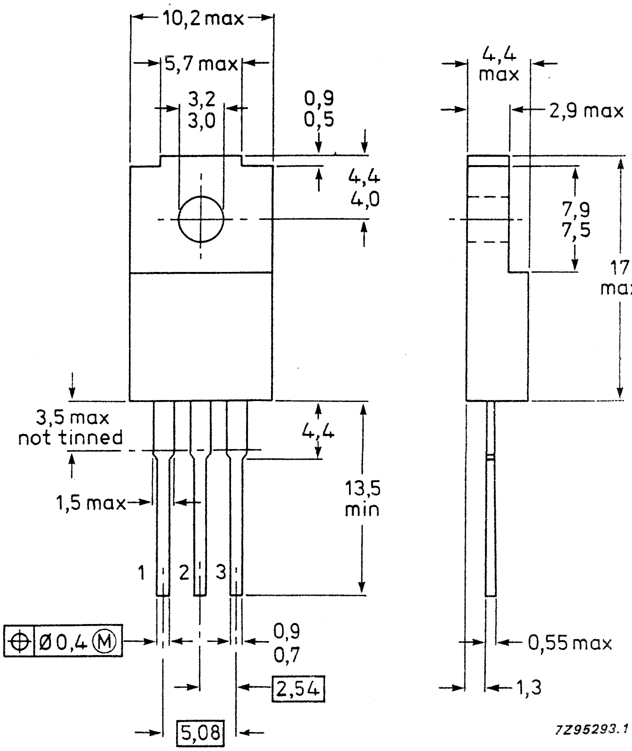
QUICK REFERENCE DATA

			BDT62F	62AF	62BF	62CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current DC	$-I_C$	max.	10				A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.	36				W
Junction temperature	T_j	max.	150				°C
DC current gain $-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	min.	1000				

MECHANICAL DATA

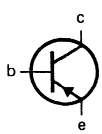
Dimensions in mm

Fig.1 SOT186.



Pinning:

1 = Base
2 = Collector
3 = Emitter



RATINGS

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

			BDT62F	62AF	62BF	62CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5.0				V
Collector current DC	$-I_C$	max.	10				A
peak value	$-I_{CM}$	max.	15				A
Base current (DC)	$-I_B$	max.	250				mA
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.	21				W
up to T_h = 25 °C (2)	P_{tot}	max.	36				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

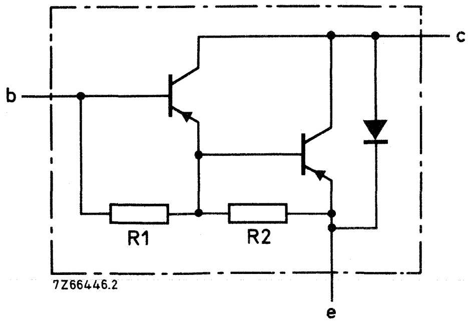
From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.17	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	5.95	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	3.47	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Insulation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.



R1 typ. 4 kΩ
R2 typ. 60 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	max.	0.2	mA
$I_E = 0$; T_j = 150 °C; $-V_{CB} = -1/2\ V_{CBOmax}$	$-I_{CBO}$	max.	2.0	mA
$I_B = 0$; $-V_{CE} = -1/2\ V_{CEOmax}$	$-I_{CEO}$	max.	0.5	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	max.	5.0	mA
Forward bias second-breakdown collector current				
$-V_{CE}$ = 40 V; t = 0.1 s; non-repetitive (without heatsink)	$I_{(SB)}$	min.	0.9	A
DC current gain (3)				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	min.	1000	
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	150	
Base-emitter voltage (3)				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	$-V_{BE}$	max.	2.5	V
Collector-emitter saturation voltage (3)				
$-I_C$ = 3 A; $-I_B$ = 12 mA	$-V_{CEsat}$	max.	2.0	V
$-I_C$ = 8 A; $-I_B$ = 80 mA	$-V_{CEsat}$	max.	2.5	V
Cut-off frequency				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100	kHz
Collector capacitance				
$-V_{CB}$ = 10 V; f = 1 MHz	C_c	typ.	100	pF
Small-signal current gain at f = 1 MHz				
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{fe}	min.	10	
Diode, forward voltage				
I_F = 3 A	V_F	max.	2.0	V

(3) Measured under pulse conditions; $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
$-I_{Con}$ = 3 A;
$-I_{Bon} = I_{Boff}$ = 12 mA

Turn-on time	t_{on}	typ.	0.5	μs
		max.	1.5	μs
Turn-off time	t_{off}	typ.	2.5	μs
		max.	5.0	μs

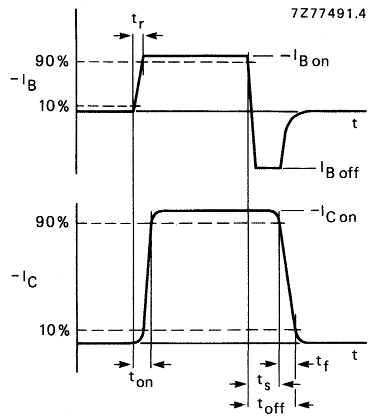
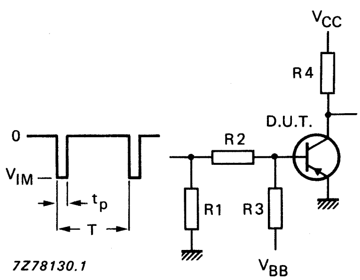


Fig. 3 Switching times waveforms.



$-V_{IM}$	= 10 V
$-V_{CC}$	= 10 V
$+V_{BB}$	= 4.0 V
R1	= 56 Ω
R2	= 410 Ω
R3	= 560 Ω
R4	= 3.0 Ω
$t_r = t_f$	= 15 ns
t_p	= 10 μs
T	= 500 μs

Fig. 4 Switching times test circuit.

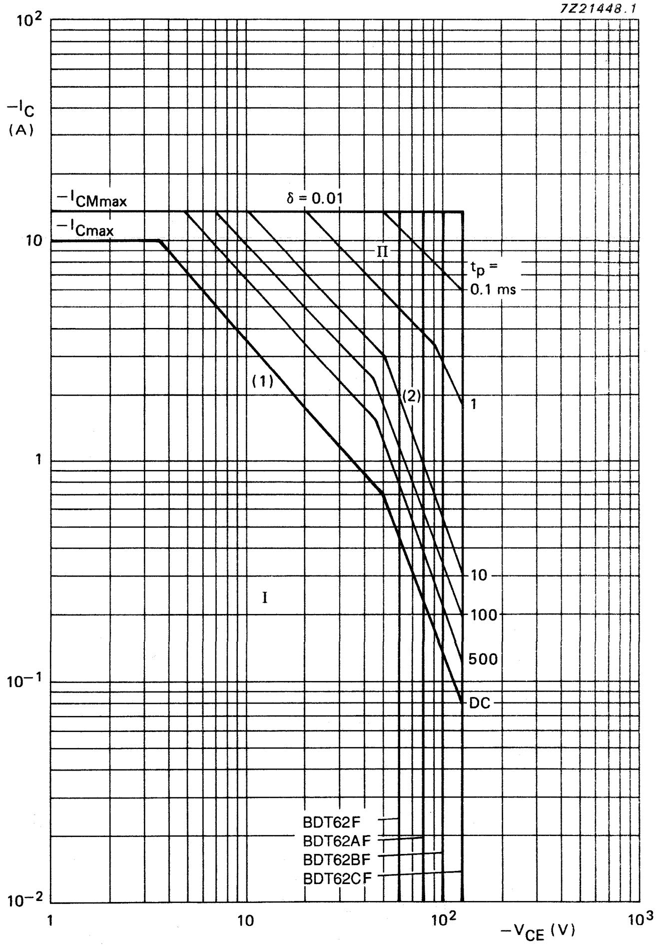


Fig. 5 Safe Operating Area; $T_h = 25$ °C.

I Region of permissible DC operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

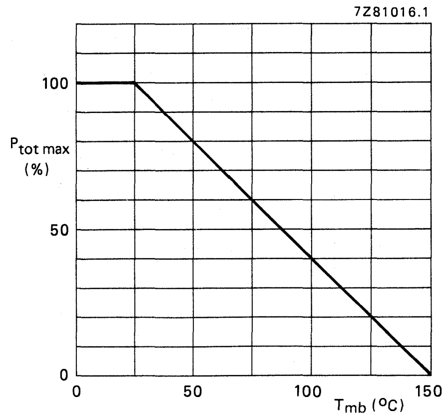


Fig. 6 Power derating curve.

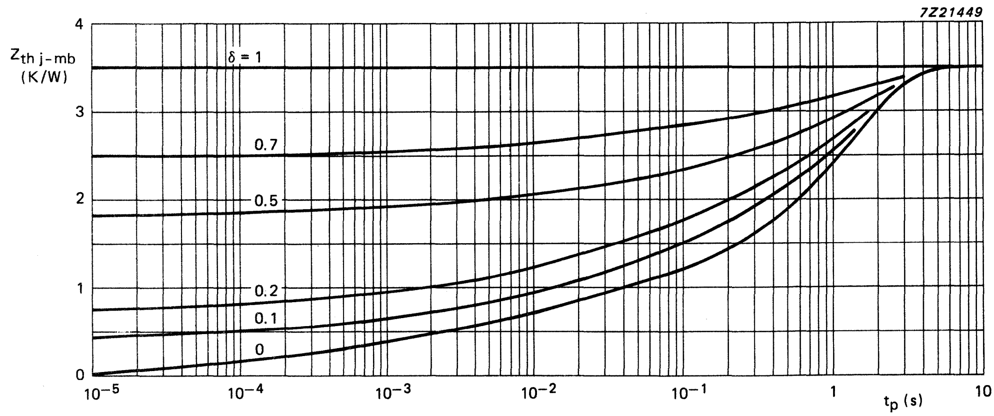


Fig. 7 Pulse power rating chart.

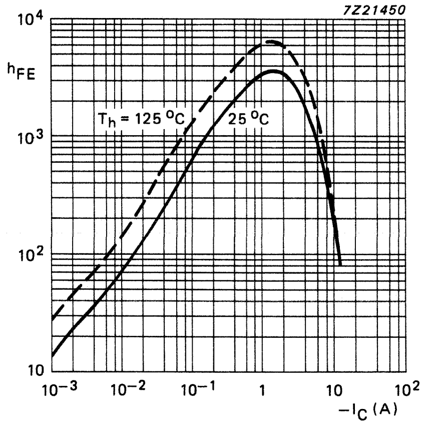


Fig. 8 Typical DC current gain at $-V_{CE} = 3$ V.

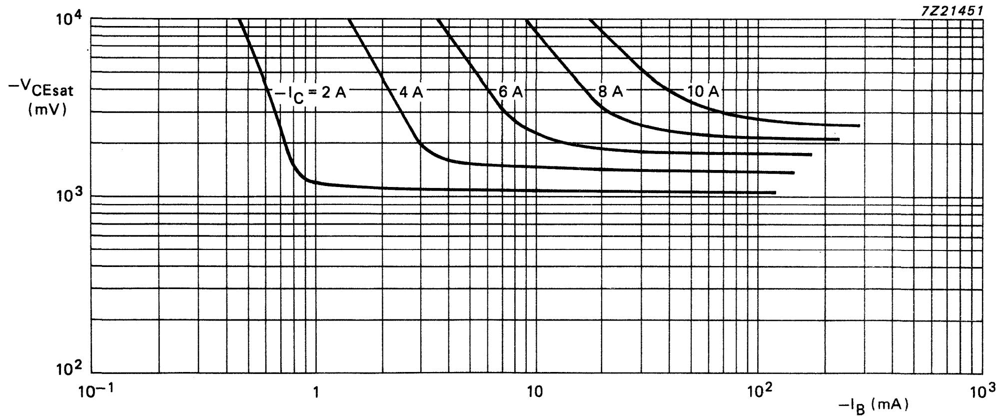


Fig. 9 Typical collector-emitter saturation voltage; $T_h = 25\,^oC$.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. P-N-P complements are BDT62, BDT62A; BDT62B and BDT62C.

QUICK REFERENCE DATA

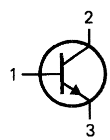
			BDT63	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.	10				A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	I_{CM}	max.	15				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	1000				

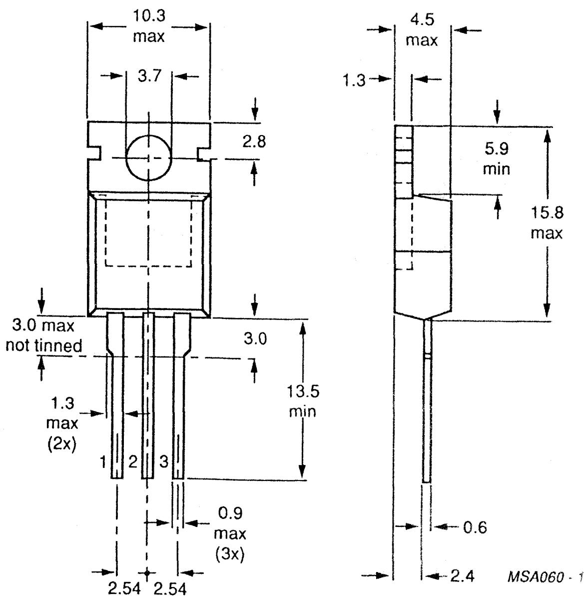
MECHANICAL DATA

Dimensions in mm

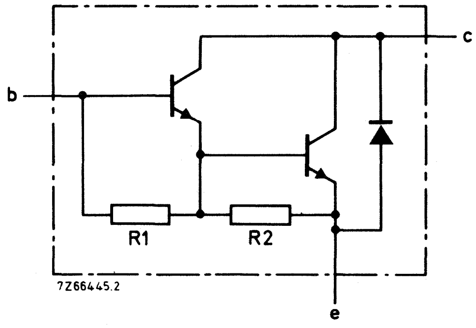
Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.



R1 typ. 8 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT63	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	10				A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	I_{CM}	max.	15				A
Base current (d.c.)	I_B	max.	250				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature*	T_j	max.	150				°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,39	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	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			
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	0,2 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
Forward-bias second-breakdown collector current			
V_{CE} = 60 V; t = 0,1 s; non-repetitive (without heatsink)	$I_{(SB)}$	>	1,5 A
D.C. current gain*			
I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	1000
I_C = 10 A; V_{CE} = 3 V	h_{FE}	typ.	3000
Base-emitter voltage*			
I_C = 3 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage*			
I_C = 3 A; I_B = 12 mA	V_{CEsat}	<	2 V
I_C = 8 A; I_B = 80 mA	V_{CEsat}	<	2,5 V
Diode, forward voltage			
I_F = 3 A	V_F	<	2,5 V
Turn-off breakdown energy with inductive load (Fig. 6)			
$-I_{Boff} = 0$; L = 5 mH	$E_{(BR)}$	>	100 mJ
Small-signal current gain at f = 1 MHz			
I_C = 3 A; V_{CE} = 3 V	h_{fe}	>	10
Cut-off frequency			
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	50 kHz
Collector capacitance			
V_{CB} = 10 V; f = 1 MHz	C_{ob}	typ.	100 pF
D.C. current gain ratio of matched complementary pairs			
I_C = 3 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5

* Measured under pulse conditions; $t_n < 300$ µs; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 12 mA

turn-on time	t_{on}	typ.	1 μs
		<	2,5 μs
turn-off time	t_{off}	typ.	5 μs
		<	10 μs

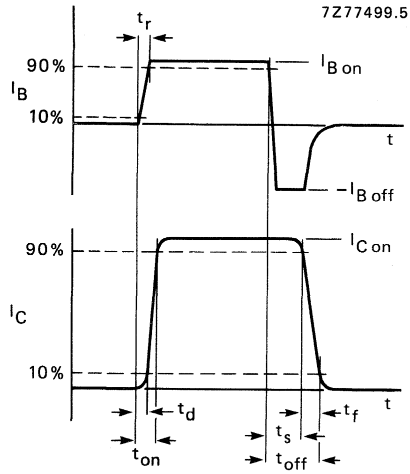


Fig. 3 Switching times waveforms.

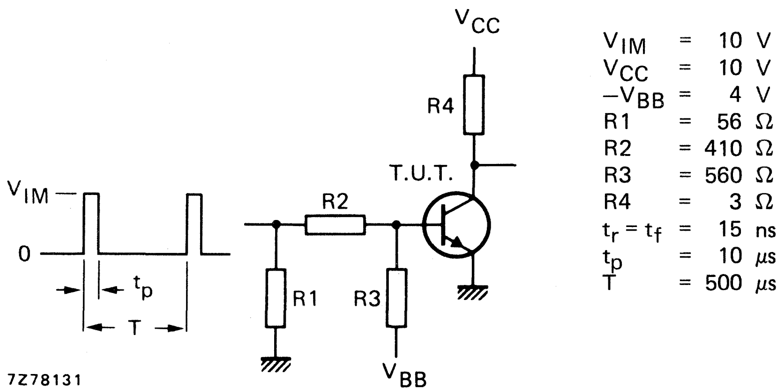


Fig. 4 Switching times test circuit.

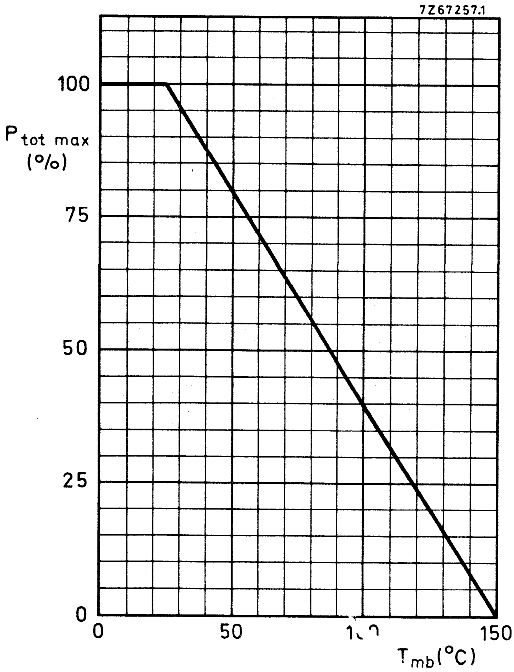


Fig. 5 Power derating curve.

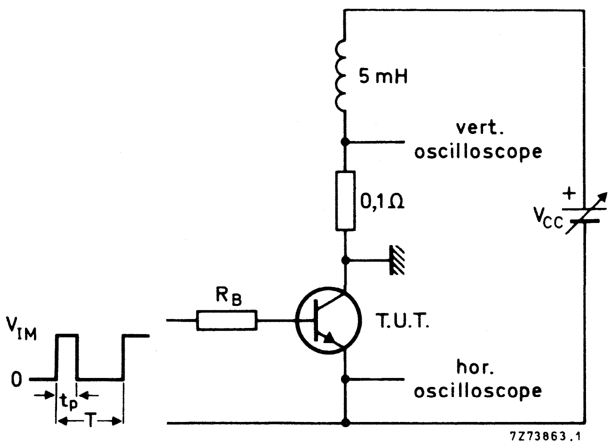


Fig. 6 Turn-off breakdown energy with inductive load.
V_{IM} = 12 V; R_B = 270 Ω; $\delta = \frac{t_p}{T} \times 100\% = 1\%$; I_{CC} = 6,3 A.

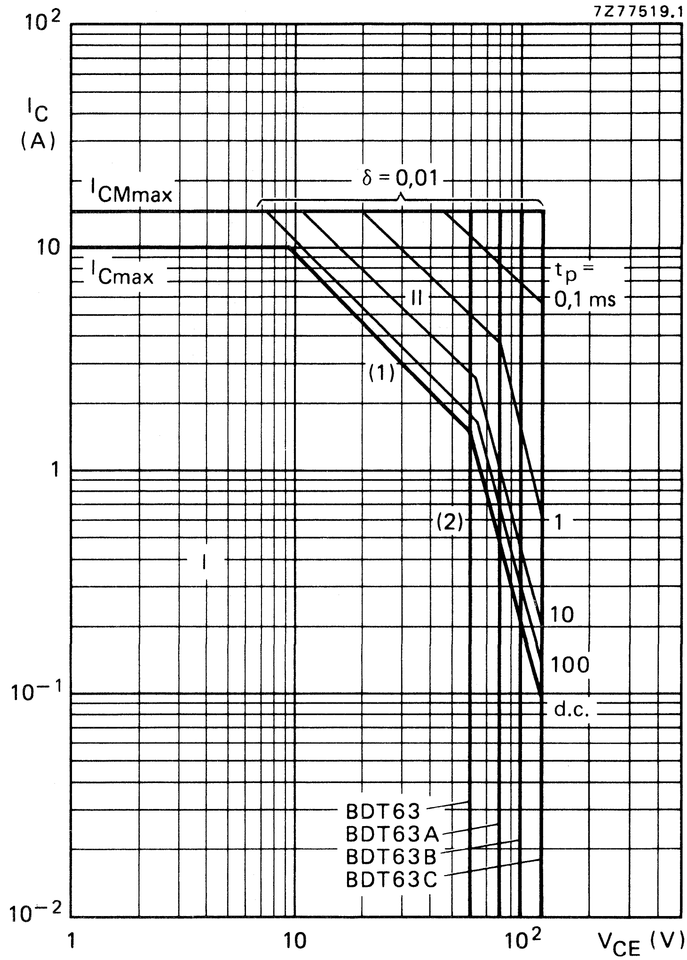


Fig. 7 Safe Operating Area, T_{mb} = 25 °C.

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

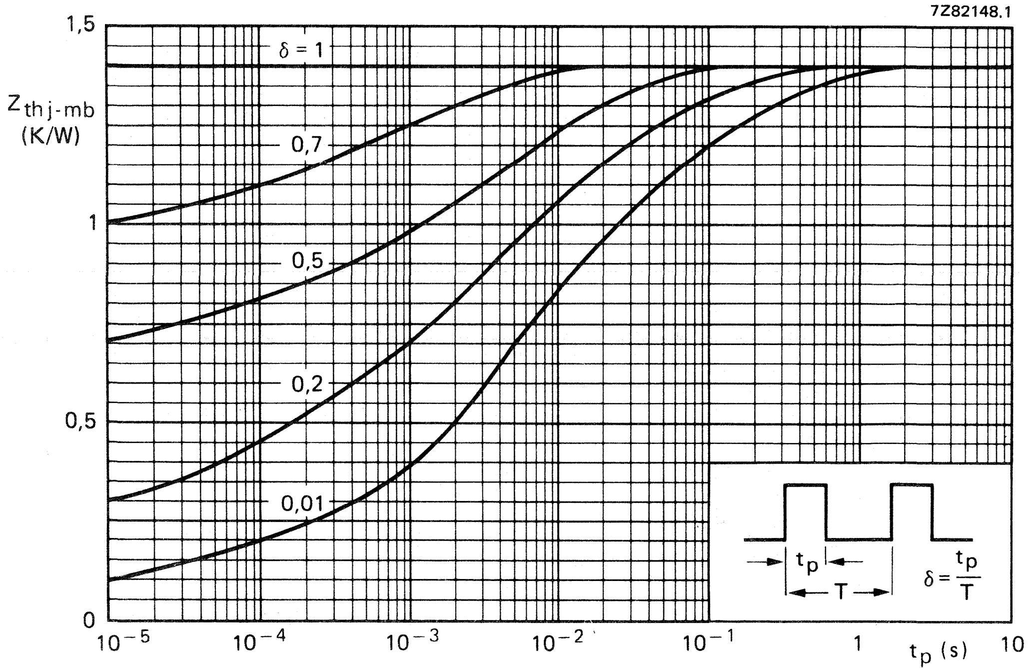


Fig. 8 Pulse power rating chart.

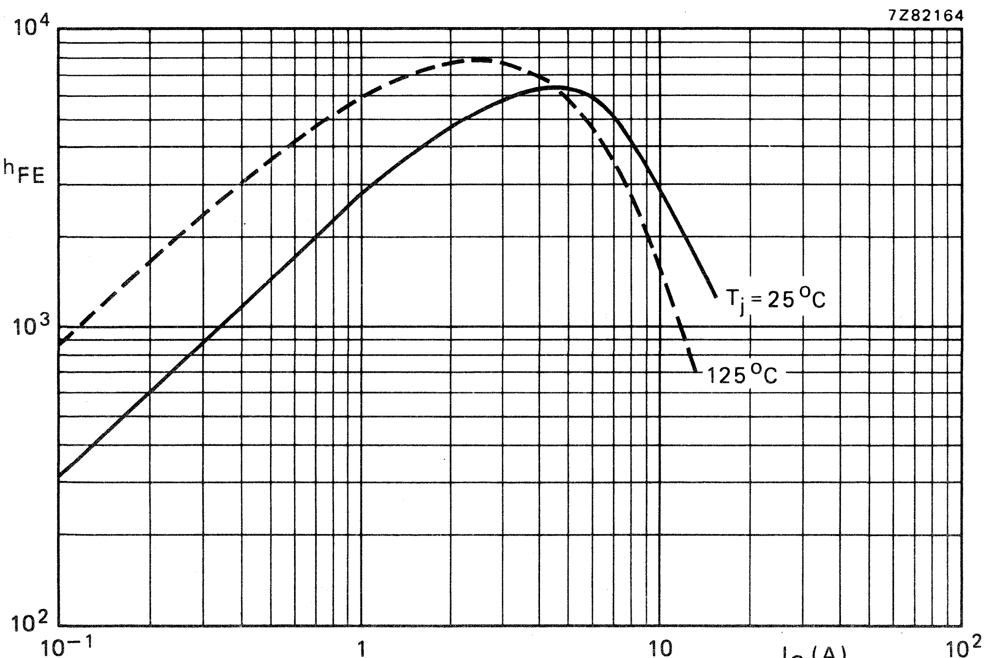


Fig. 9 Typical d.c. current gain at V_{CE} = 3 V.

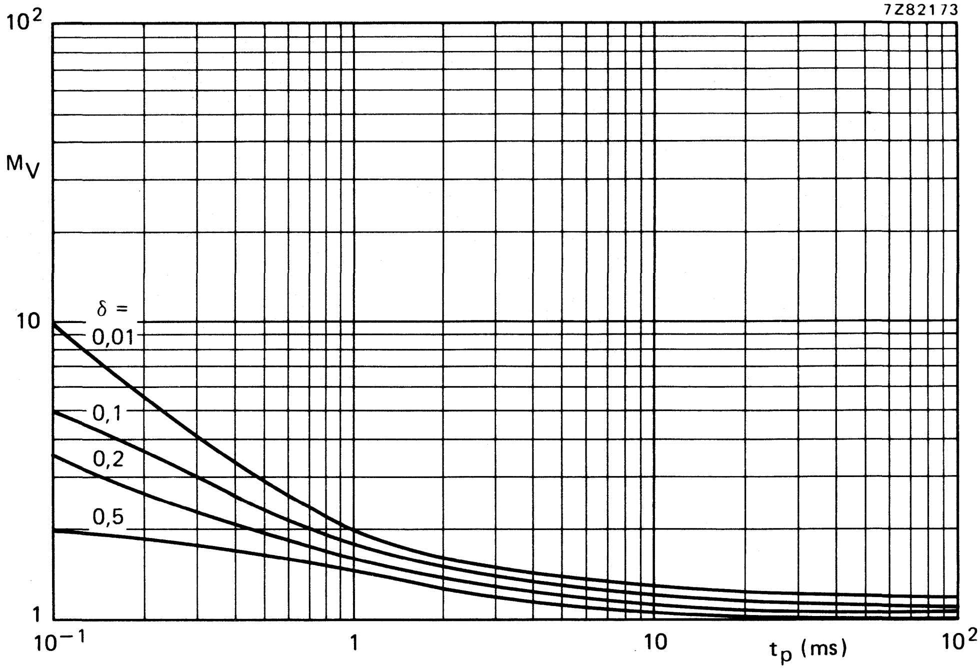


Fig. 10 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

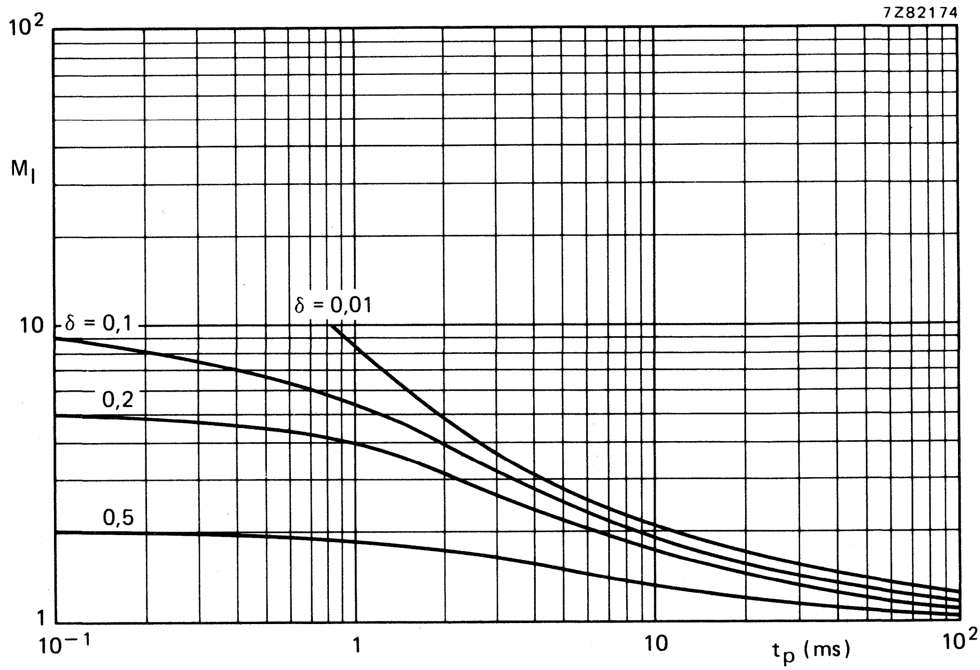


Fig. 11 S.B. current multiplying factor at V_{CEO} level = 60 V and 100 V.

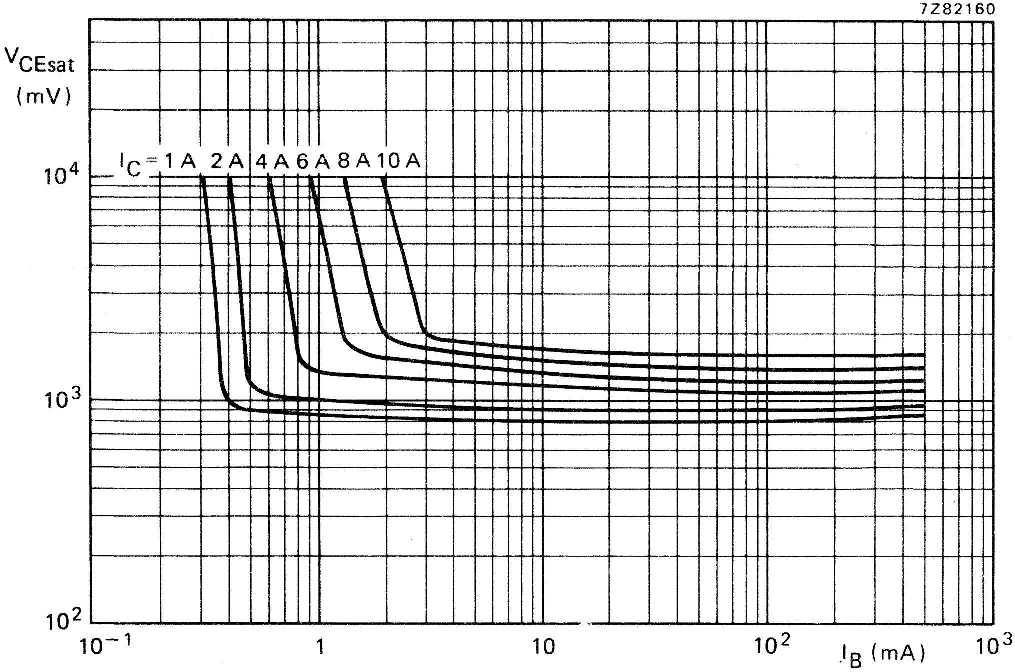


Fig. 12 Typical collector-emitter saturation voltage.

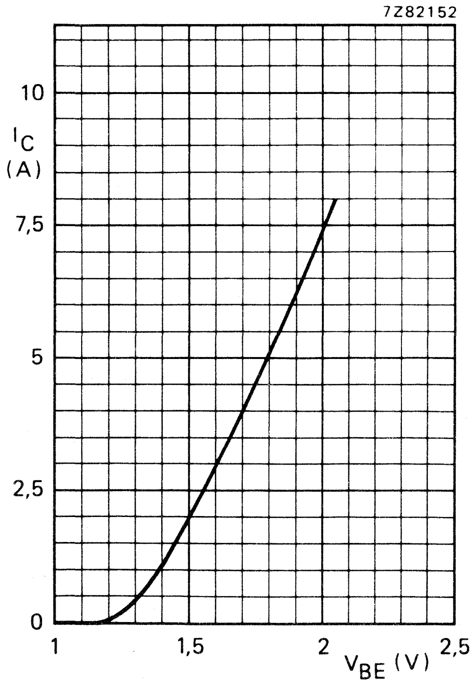


Fig. 13 Typical base-emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon darlington power transistors in a SOT186 envelope with an electrically insulated mounting base. The devices are designed for audio output stages and general amplifier and switching applications. PNP complements are BDT62F, BDT62AF, BDT62BF and BDT62CF.

QUICK REFERENCE DATA

			BDT63F	63AF	63BF	63CF	
Collector-base voltage	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage	V_{CEO}	max.	60	80	100	120	V
Collector current DC	I_C	max.	10				A
Total power dissipation up to $T_h = 25\ ^oC$	P_{tot}	max.	36				W
Junction temperature	T_j	max.	150				^oC
DC current gain $I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	min.	1000				

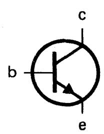
MECHANICAL DATA

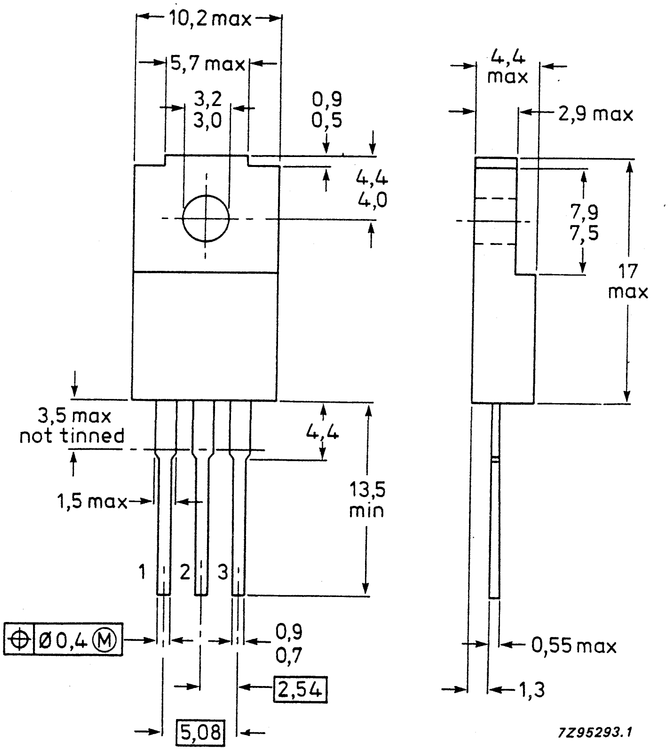
Dimensions in mm

Fig.1 SOT186.

Pinning:

1 = Base
2 = Collector
3 = Emitter





RATINGS

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

			BDT63F	63AF	63BF	63CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5.0				V
Collector current DC	I_C	max.	10				A
peak value	I_{CM}	max.	15				A
Base current (DC)	I_B	max.	250				mA
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.	21				W
up to T_h = 25 °C (2)	P_{tot}	max.	36				W
Storage temperature range	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

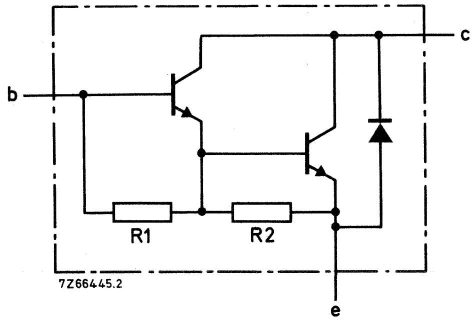
From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.17	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	5.95	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	3.47	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Insulation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.



R1 typ. 8 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	max.	0.2	mA
$I_E = 0$; $V_{CB} = 1/2\ V_{CBOmax}$; $T_j = 150$ °C	I_{CBO}	max.	2.0	mA
$I_B = 0$; $V_{CE} = 1/2\ V_{CEOmax}$	I_{CEO}	max.	0.5	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	max.	5.0	mA
Forward-bias second breakdown collector current				
$V_{CE} = 40$ V; t = 0.1 s; non-repetitive (without heatsink)	$I_{(SB)}$	min.	0.9	A
DC current gain (3)				
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	min.	1000	
$I_C = 10$ A; $V_{CE} = 3$ V	h_{FE}	typ.	800	
Base-emitter voltage (3)				
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	max.	2.5	V
Collector-emitter saturation voltage (3)				
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	max.	2.0	V
$I_C = 8$ A; $I_B = 80$ mA	V_{CEsat}	max.	2.5	V
Diode, forward voltage				
$I_F = 3$ A	V_F	max.	2.5	V
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; L = 5 mH	$E_{(BR)}$	min.	100	mJ
Small-signal current gain at f = 1 MHz				
$I_C = 3$ A; $V_{CE} = 3$ V	h_{fe}	min.	10	
Cut-off frequency				
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50	kHz
Collector capacitance				
$V_{CB} = 10$ V; f = 1 MHz	C_c	typ.	100	pF

(3) Measured under pulse conditions; $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
I_{Con} = 3 A;
$I_{Bon} = -I_{Boff}$ = 12 mA

Turn-on time	t_{on}	typ.	1.0	μs
		max.	2.5	μs
Turn-off time	t_{off}	typ.	5.0	μs
		max.	10	μs

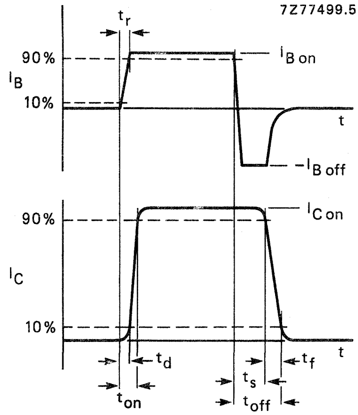
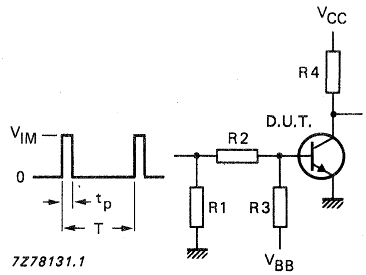


Fig. 3 Switching times waveforms.



V_{IM} = 10 V
V_{CC} = 10 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

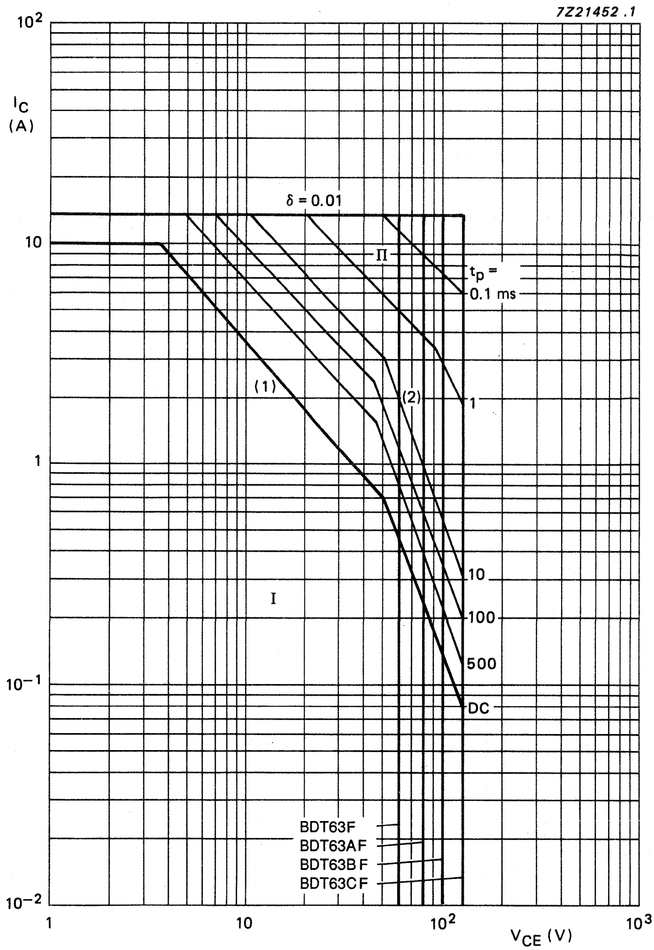


Fig. 5 Safe Operating Area; $T_{MB} \leqslant 25\ ^{o}C$.

1 Region of permissible DC operation.

11 Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

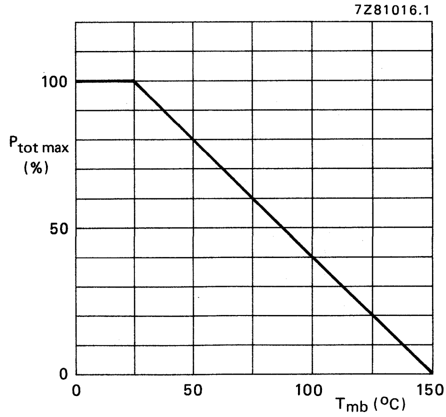


Fig. 6 Power derating curve.

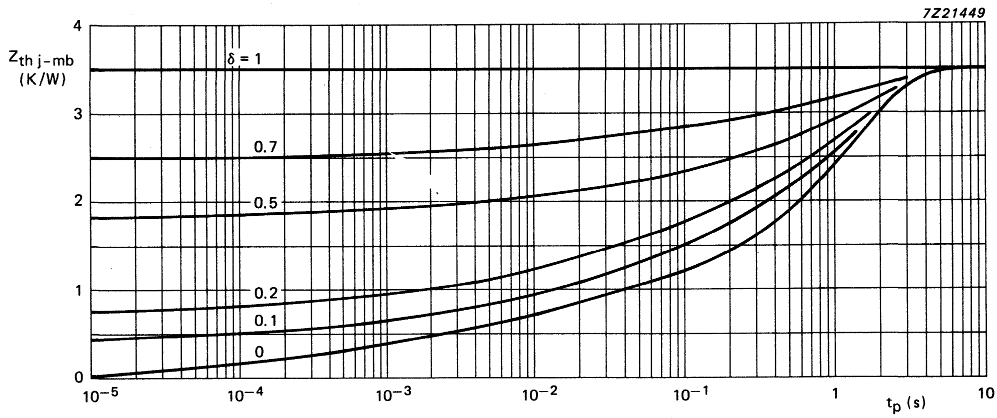


Fig. 7 Pulse power rating chart.

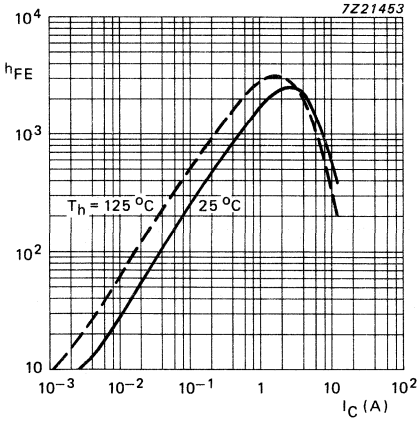


Fig. 8 Typical DC current gain at V_{CE} = 3 V.

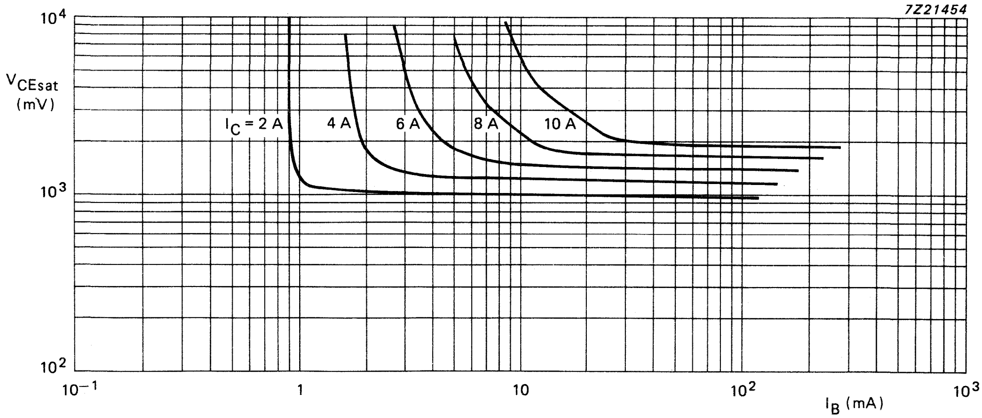


Fig. 9 Typical collector-emitter saturation voltage; T_h = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

PNP epitaxial base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220 plastic envelope. NPN complements are BDT65, BDT65A, BDT65B and BDT65C.

QUICK REFERENCE DATA

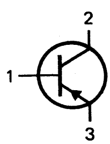
			BDT64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	12				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>	1000				

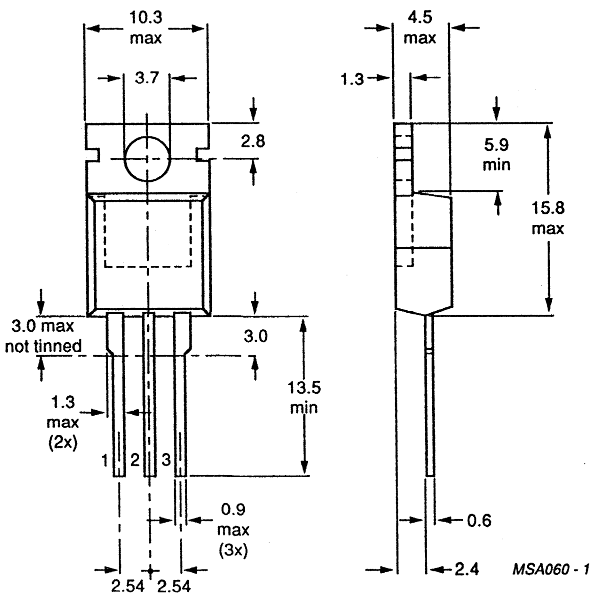
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

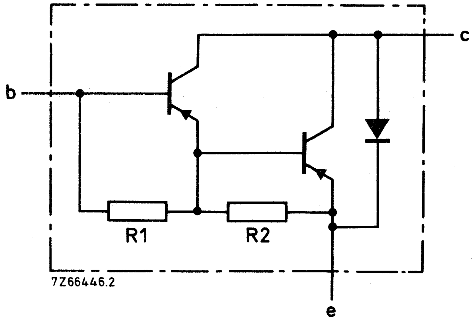


Fig. 2 Circuit diagram. R1 typ. 3 kΩ; R2 typ. 45 Ω.

RATINGS

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

			BDT64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	12				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Base current (d.c.)	$-I_B$	max.	500				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current			
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$	$-I_{CBO}$	<	0,4 mA
$I_E = 0$; $-V_{CB} = -½\ V_{CBOmax}$; $T_j = 150\ ^oC$	$-I_{CBO}$	<	2 mA
$I_B = 0$; $-V_{CE} = -½\ V_{CEOmax}$	$-I_{CEO}$	<	0,2 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain*			
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	1500
$-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	>	1000
$-I_C = 12$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	750
Base-emitter voltage			
$-I_C = 5$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage*			
$-I_C = 5$ A; $-I_B = 20$ mA	$-V_{CEsat}$	<	2 V
$-I_C = 10$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	3 V
Diode, forward voltage			
$I_F = 5$ A	V_F	<	2 V
$I_F = 12$ A	V_F	typ.	2 V
Collector capacitance at f = 1 MHz			
$-V_{CB} = 10$ V; $I_E = I_e = 0$	C_c	typ.	200 pF
Second breakdown collector current			
non-repetitive; without heatsink			
$-V_{CE} = 60$ V; $t_p = 0,1$ s	$-I_{SB}$	>	2 A
Switching times (see Figs 3 and 4)			
$-I_{Con} = 5$ A; $-I_{Bon} = I_{Boff} = 20$ mA			
$-V_{CC} = 30$ V			
turn-on time	t_{on}	typ.	0,5 μs
		<	2 μs
turn-off time	t_{off}	typ.	2,5 μs
		<	5 μs
Small-signal current gain			
$-I_C = 5$ A; $-V_{CE} = 3$ V; f = 1 MHz	h_{fe}	>	10

* Measured under pulse conditions: $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

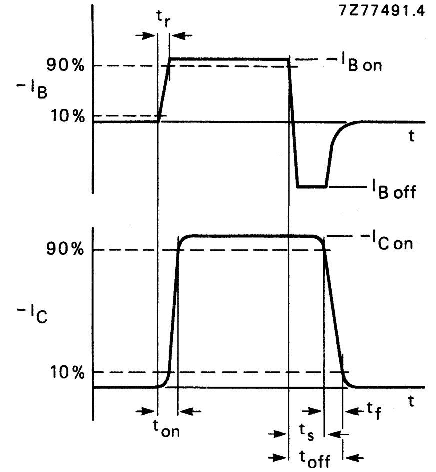
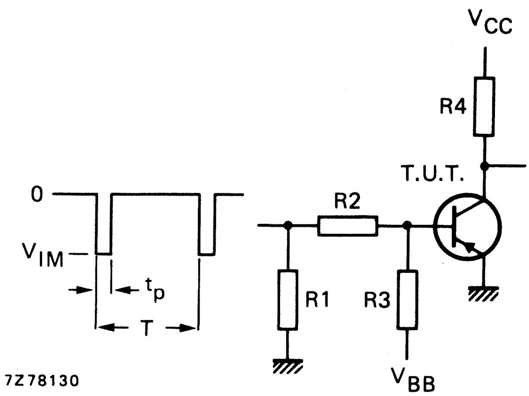


Fig. 3 Switching times waveforms.



$-V_{IM}$ = 15 V
$-V_{CC}$ = 30 V
V_{BB} = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 6 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

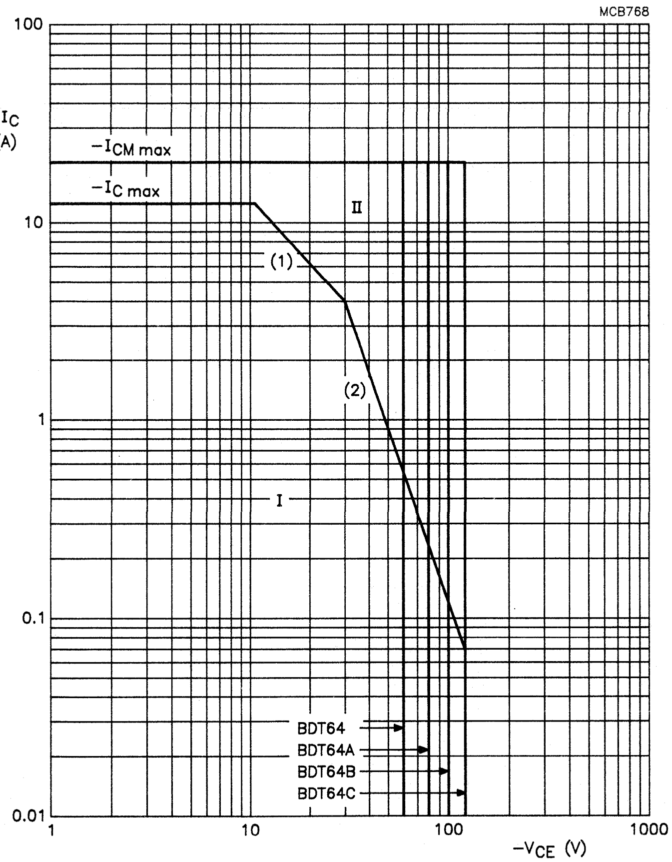


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

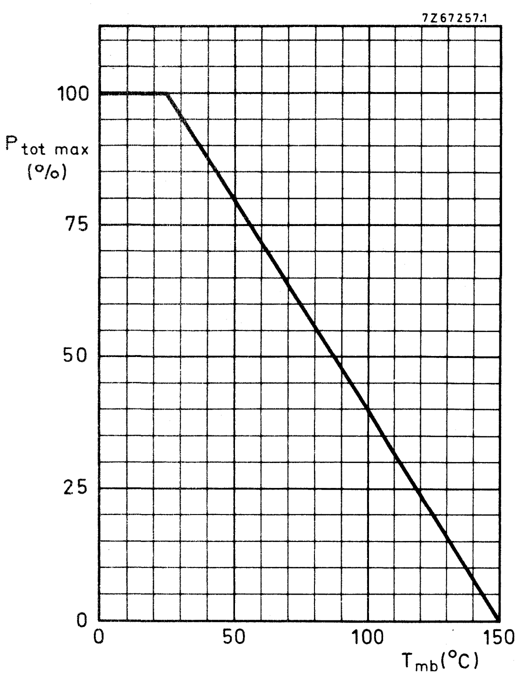


Fig. 6 Power derating curve.

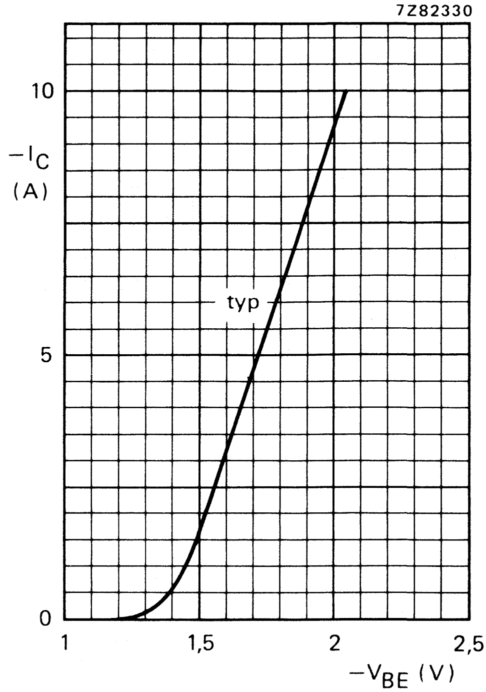


Fig. 7 $-V_{CE}$ = 3 V; T_{amb} = 25 °C.

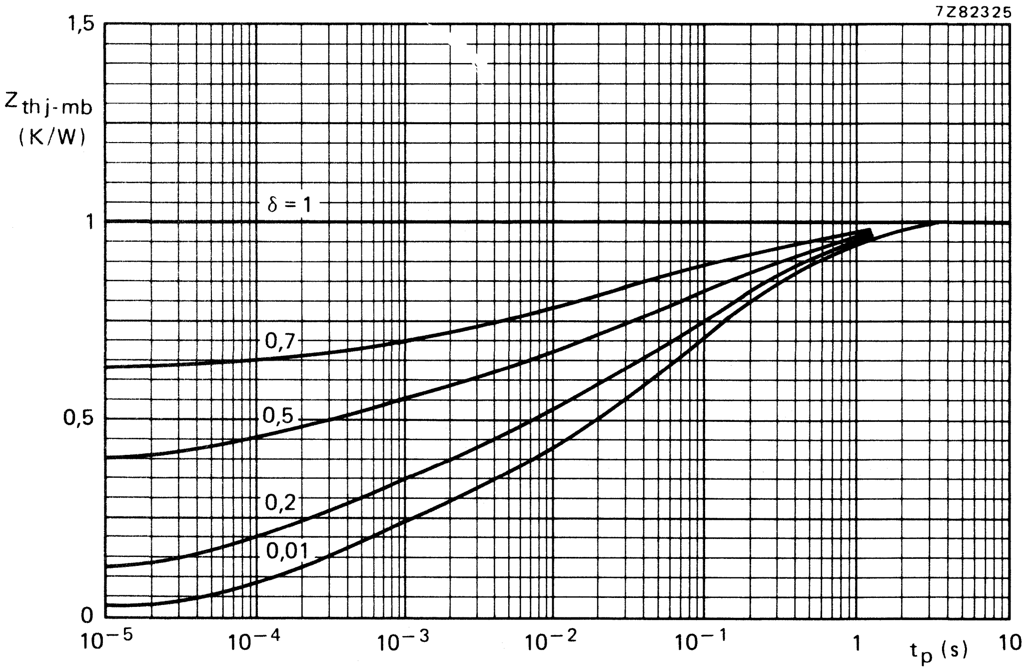


Fig. 8 Pulse power rating chart.

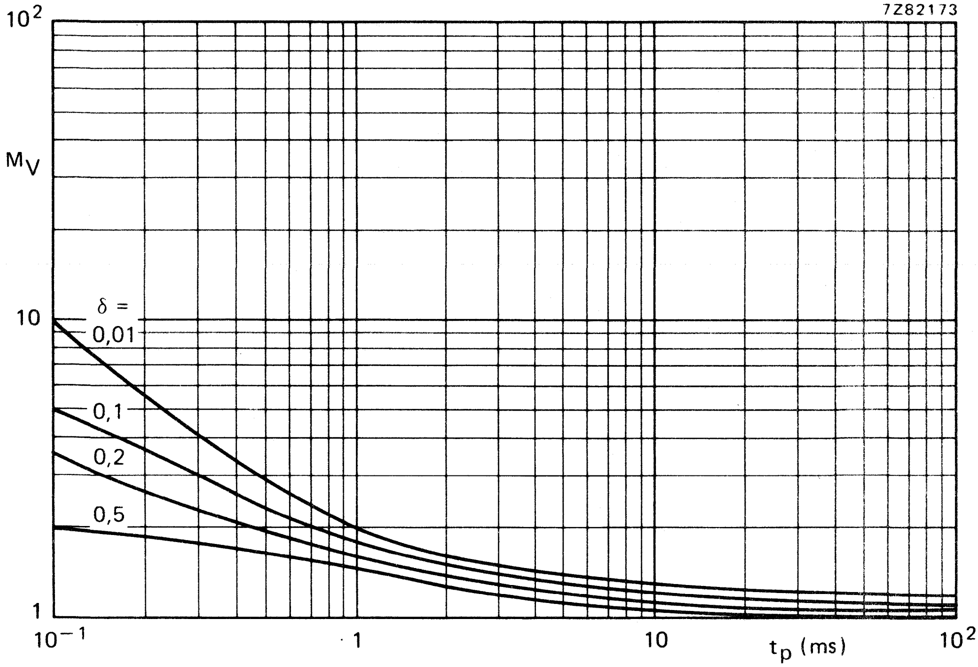


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

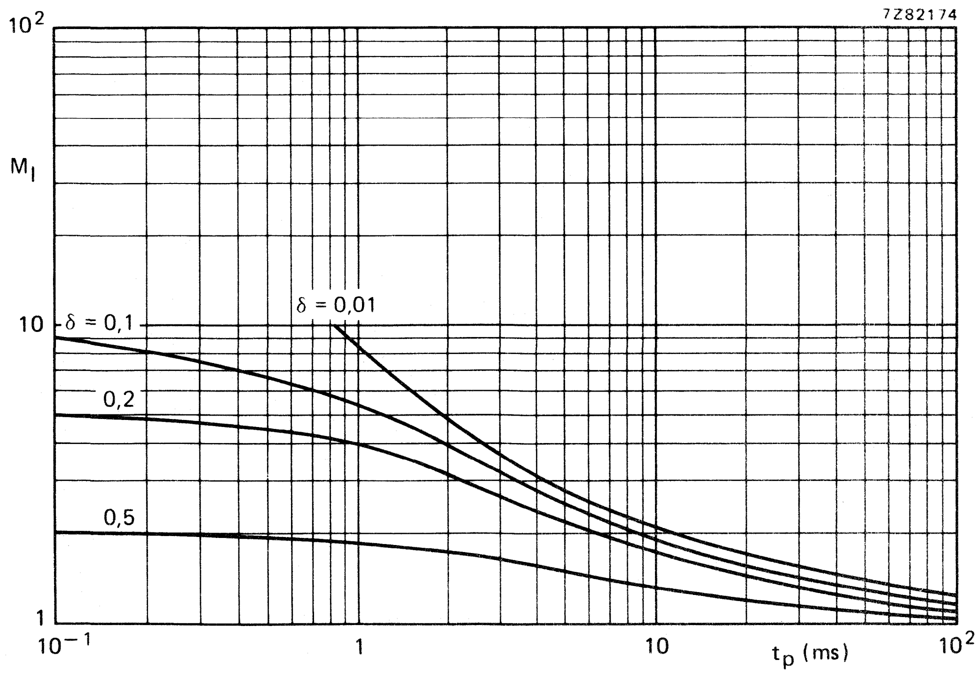


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

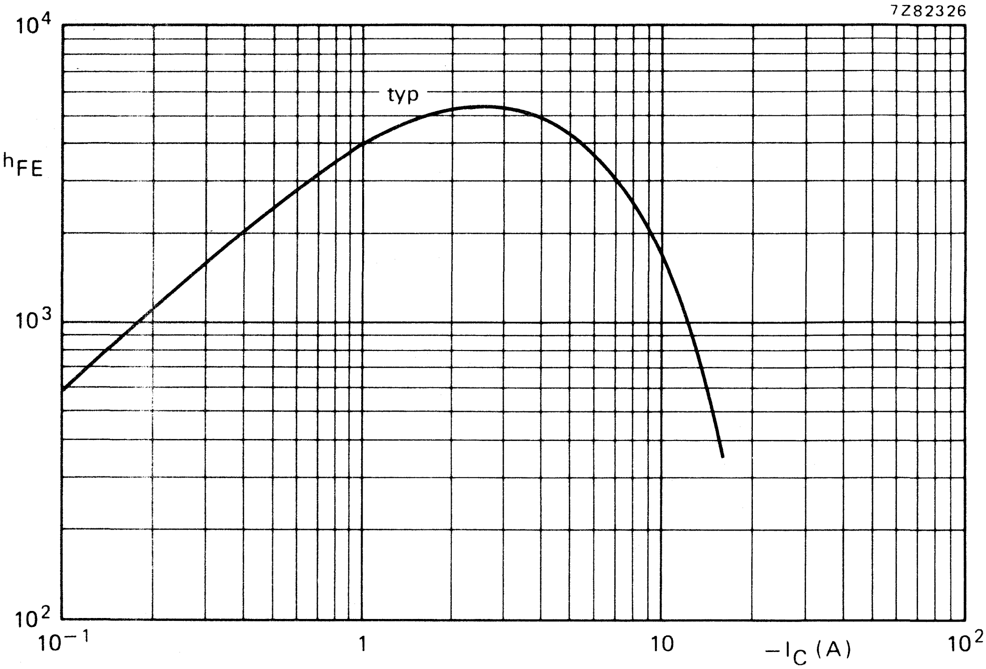


Fig. 11 D.C. current gain. $-V_{CE}$ = 3 V; T_j = 25 °C.

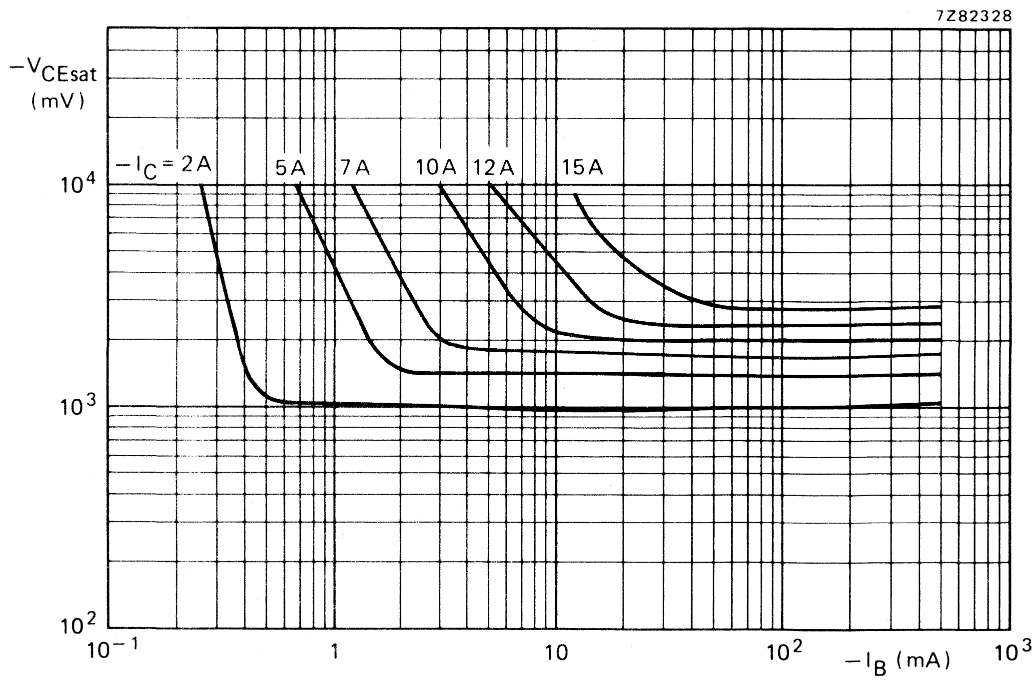


Fig. 12 Typical collector-emitter saturation voltages.

SILICON DARLINGTON POWER TRANSISTORS

PNP Silicon Darlington power transistors in a SOT186 envelope with an electrically insulated mounting base. The devices are designed for audio output stages and general amplifier and switching applications. NPN complements are BDT65F, BDT65AF, BDT65BF and BDT65CF.

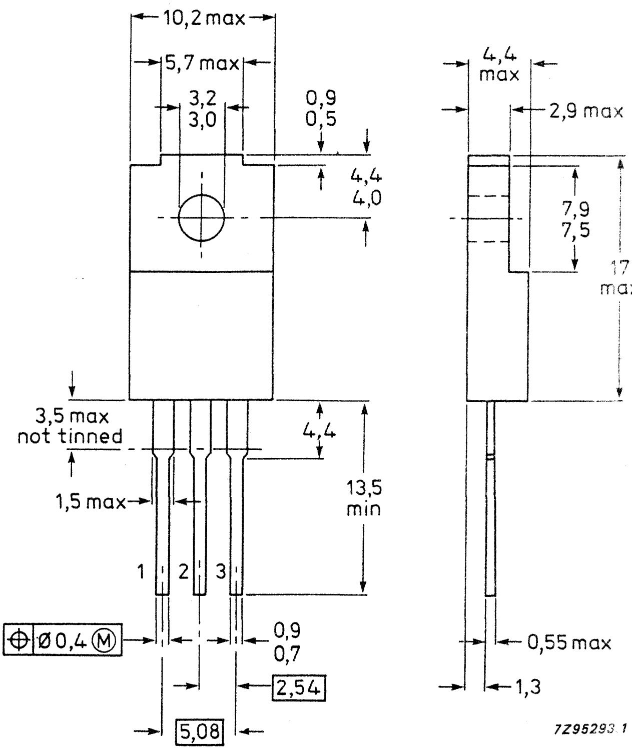
QUICK REFERENCE DATA

			BDT64F	64AF	64BF	64CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current DC	$-I_C$	max.	12				A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.	39				W
Junction temperature	T_j	max.	150				°C
DC current gain $-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	min.	1000				

MECHANICAL DATA

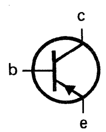
Dimensions in mm

Fig.1 SOT186.



Pinning:

1 = Base
2 = Collector
3 = Emitter



RATINGS

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

			BDT64F	64AF	64BF	64CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5.0				V
Collector current DC	$-I_C$	max.	12				A
peak value	$-I_{CM}$	max.	20				A
Base current (DC)	$-I_B$	max.	500				mA
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.	22				W
up to T_h = 25 °C (2)	P_{tot}	max.	39				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

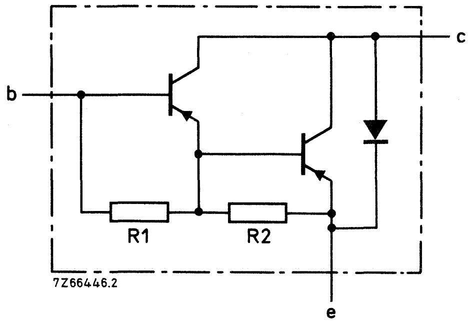
From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	0.9	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	5.7	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	3.2	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Insulation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.



R1 typ. 3 kΩ
R2 typ. 45 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	max.	0.4	mA
$I_E = 0; T_j = 150\ ^oC;$ $-V_{CB} = -1/2\ V_{CBOmax}$	$-I_{CBO}$	max.	2.0	mA
$I_B = 0;$ $-V_{CE} = -1/2\ V_{CEOmax}$	$-I_{CEO}$	max.	1.0	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	max.	5.0	mA
DC current gain (3)				
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	4000	
$-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	min.	1000	
$-I_C = 12$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	800	
Base-emitter voltage (3)				
$-I_C = 5$ A; $-V_{CE} = 4$ V	$-V_{BE}$	max.	2.5	V
Collector-emitter saturation voltage (3)				
$-I_C = 5$ A; $-I_B = 20$ mA	$-V_{CEsat}$	max.	2.0	V
$-I_C = 10$ A; $-I_B = 100$ mA	$-V_{CEsat}$	max.	3.0	V
Diode, forward voltage				
$I_F = 5$ A	V_F	max.	2.0	V
Collector capacitance at f = 1 MHz				
$-V_{CB} = 10$ V; $I_E = I_C = 0$	C_c	typ.	200	pF
Second-breakdown collector current				
non-repetitive; without heatsink				
$-V_{CE} = 60$ V; $t_p = 0.1$ s	$-I_{(SB)}$	min.	0.65	A
Switching times				
$-I_{Con} = 5$ A; $-I_{Bon} = I_{Boff} = 20$ mA; $-V_{CC} = 30$ V				
Turn-on time	t_{on}	typ.	0.5	μs
		max.	2.0	μs
Turn-off time	t_{off}	typ.	2.5	μs
		max.	5.0	μs
Small-signal current gain at f = 1 MHz				
$-I_C = 5$ A; $-V_{CE} = 3$ V	h_{fe}	min.	10	

(3) Measured under pulse conditions; $t_p < 300$ μs; $\delta < 2\%$.

CHARACTERISTICS (continued)

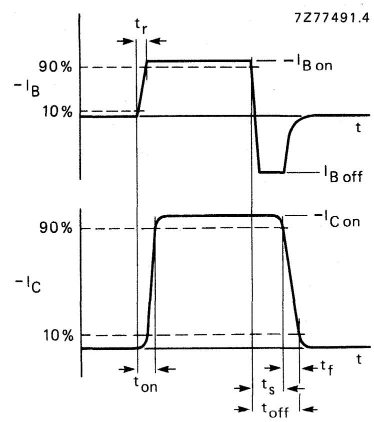
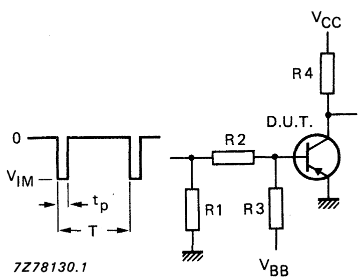


Fig. 3 Switching times waveforms.



$-V_{IM}$ = 15 V
$-V_{CC}$ = 30 V
$+V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 6 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

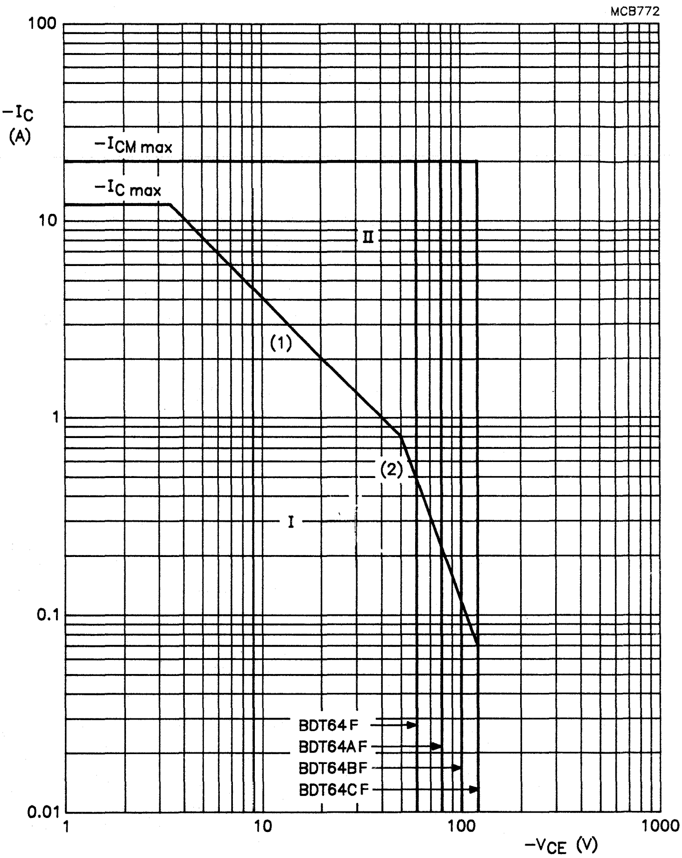


Fig. 5 Safe Operating Area; T_h = 25 °C.

(I) Region of permissible DC operation.

(II) Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

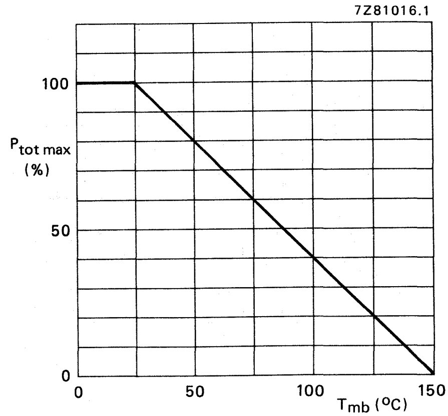


Fig. 6 Power derating curve.

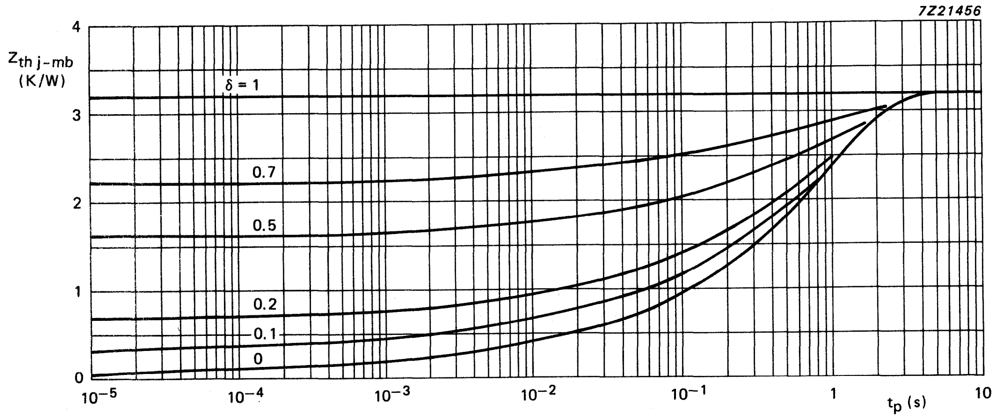


Fig. 7 Pulse power rating chart.

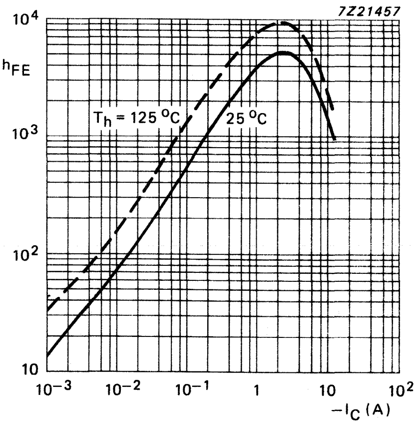


Fig. 8 Typical DC current gain as a function of collector current; $-V_{CE}$ = 4 V; T_j = 25 °C.

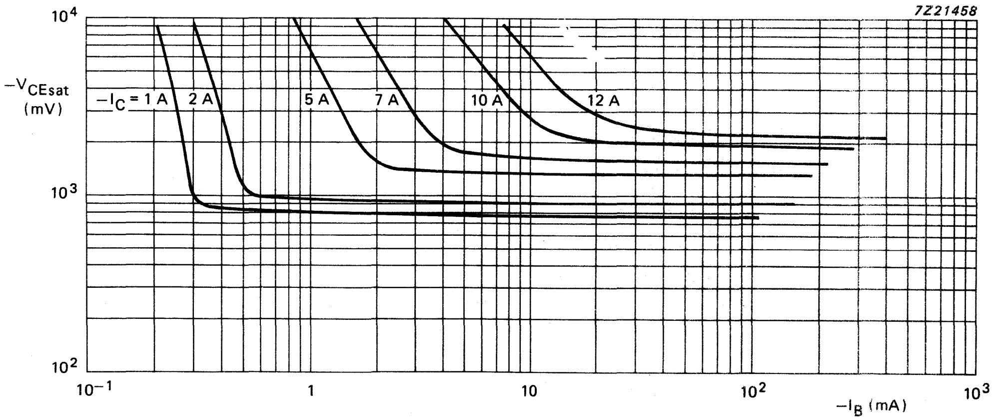


Fig. 9 Typical collector-emitter saturation voltages; T_h = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

NPN epitaxial base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220 plastic envelope. PNP complements are BDT64; BDT64A; BDT64B and BDT64C.

QUICK REFERENCE DATA

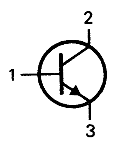
			BDT65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (d.c.)	I_C	max.	12				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000				

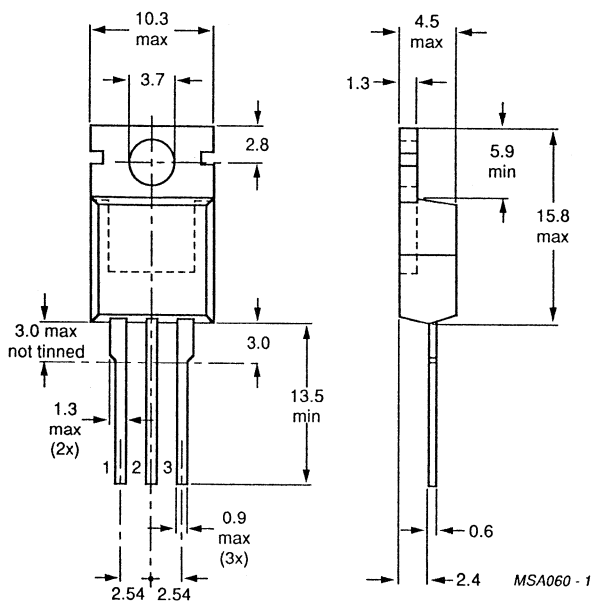
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

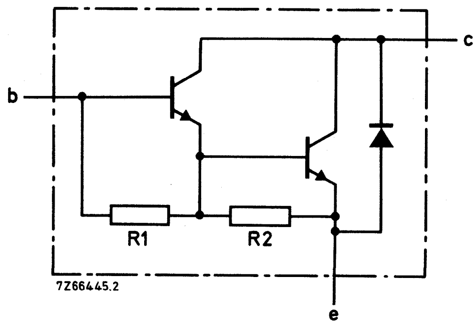


Fig. 2 Circuit diagram. R1 typ. 5 kΩ; R2 typ. 80 Ω.

RATINGS

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

			BDT65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	500	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current			
$V_{CB} = V_{CBOmax}$; $I_E = 0$	I_{CBO}	<	0,4 mA
$V_{CB} = ½V_{CBOmax}$; $I_E = 0$; $T_j = 150\ ^oC$	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	0,2 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5 mA
D.C. current gain*			
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}	typ.	1500
$I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	>	1000
$I_C = 12$ A; $V_{CE} = 4$ V	h_{FE}	typ.	1000
Base-emitter voltage			
$I_C = 5$ A; $V_{CE} = 4$ V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage*			
$I_C = 5$ A; $I_B = 20$ mA	V_{CEsat}	<	2 V
$I_C = 10$ A; $I_B = 100$ mA	V_{CEsat}	<	3 V
Diode, forward voltage			
$I_F = 5$ A	V_F	<	2 V
$I_F = 12$ A	V_F	typ.	2 V
Collector capacitance at f = 1 MHz			
$V_{CB} = 10$ V; $I_E = I_e = 0$	C_c	typ.	200 pF
Second-breakdown collector current non-repetitive; without heatsink			
$V_{CE} = 60$ V; $t_p = 0,1$ s	I_{SB}	>	2 A
Turn-off breakdown energy with inductive load;			
$-I_{Boff} = 0$; $I_{CM} = 6,3$ A; L = 5 mH (see Fig. 3)	$E_{(BR)}$	>	100 mJ
Switching times (see Figs 4 and 5)			
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 20$ mA			
turn-on time	t_{on}	typ.	1 μs
		<	2,5 μs
turn-off time	t_{off}	typ.	6,0 μs
		<	10 μs
Small-signal current gain			
$I_C = 5$ A; $V_{CE} = 3$ V; f = 1 MHz	h_{fe}	>	10

* Measured under pulse conditions $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

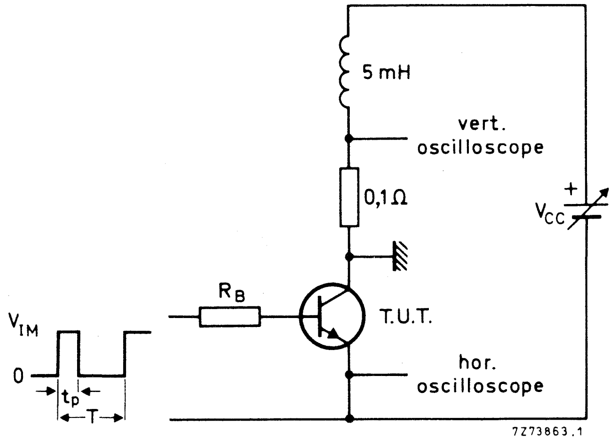


Fig. 3 Test circuit for turn-off breakdown energy.
V_{IM} = 12 V; R_B = 270 Ω;
t_p = 1 ms; δ = 1%.

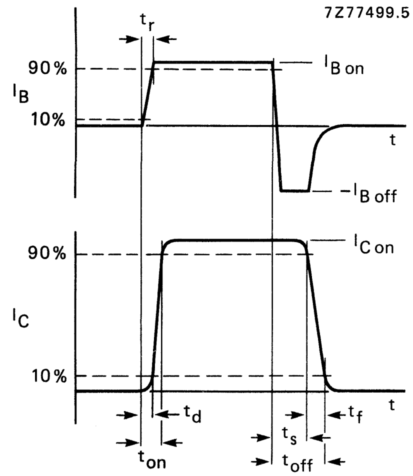
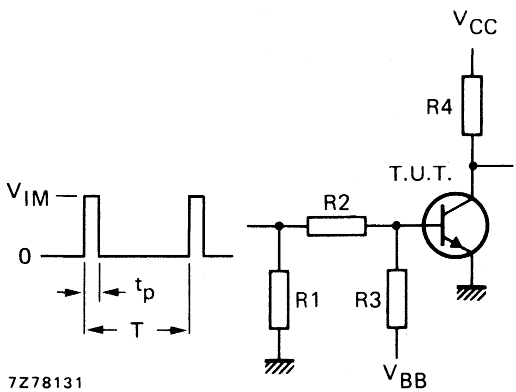


Fig. 4 Switching times waveforms.



V_{CC} = 30 V
V_{IM} = 15 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 6 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

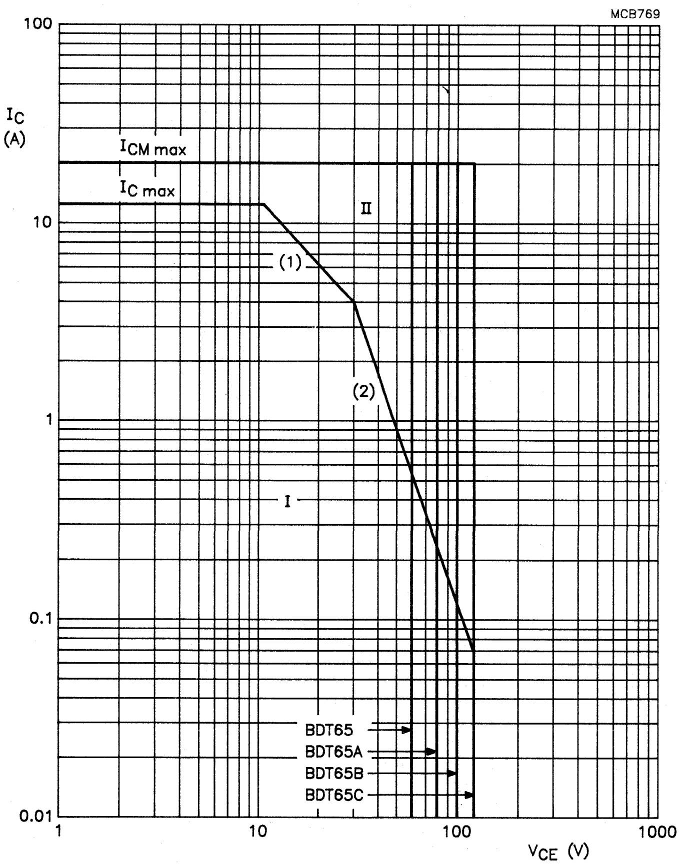


Fig. 6 Safe Operating Area; T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

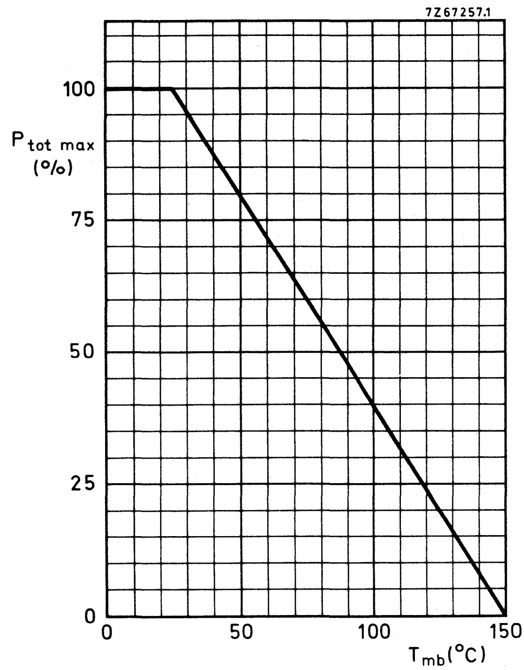


Fig. 7 Power derating curve.

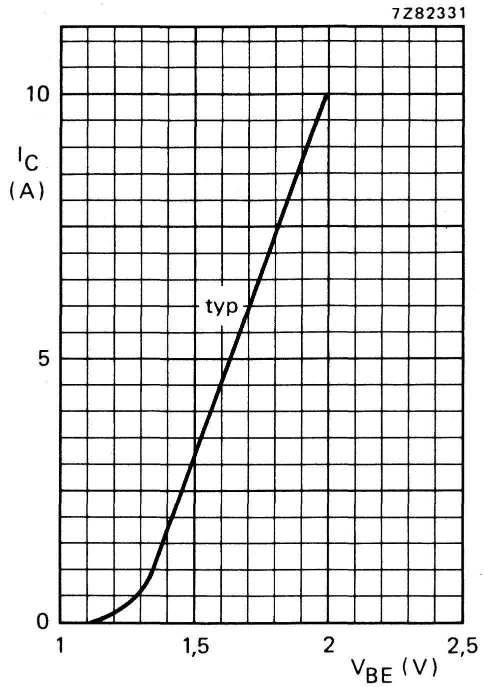


Fig. 8 Base-emitter voltage as a function of collector current. V_{CE} = 3 V; T_{amb} = 25 °C.

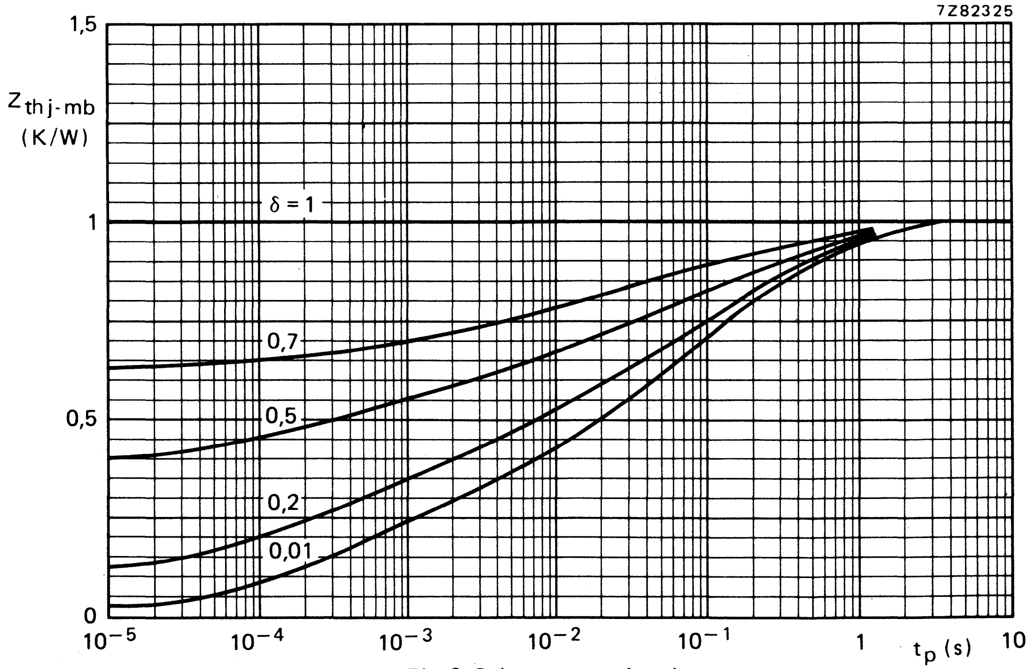


Fig. 9 Pulse power rating chart.

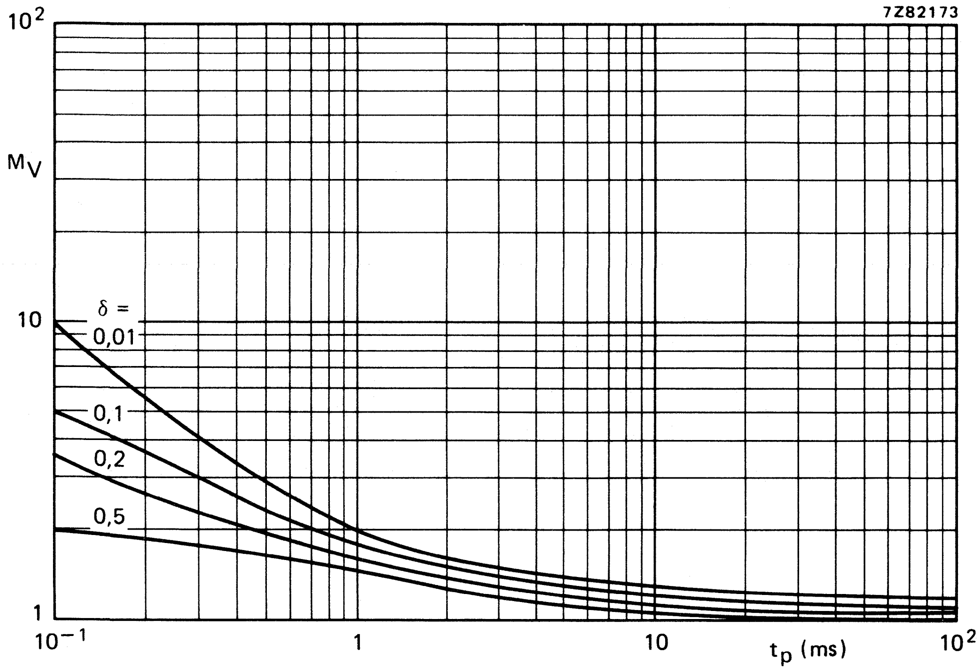


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

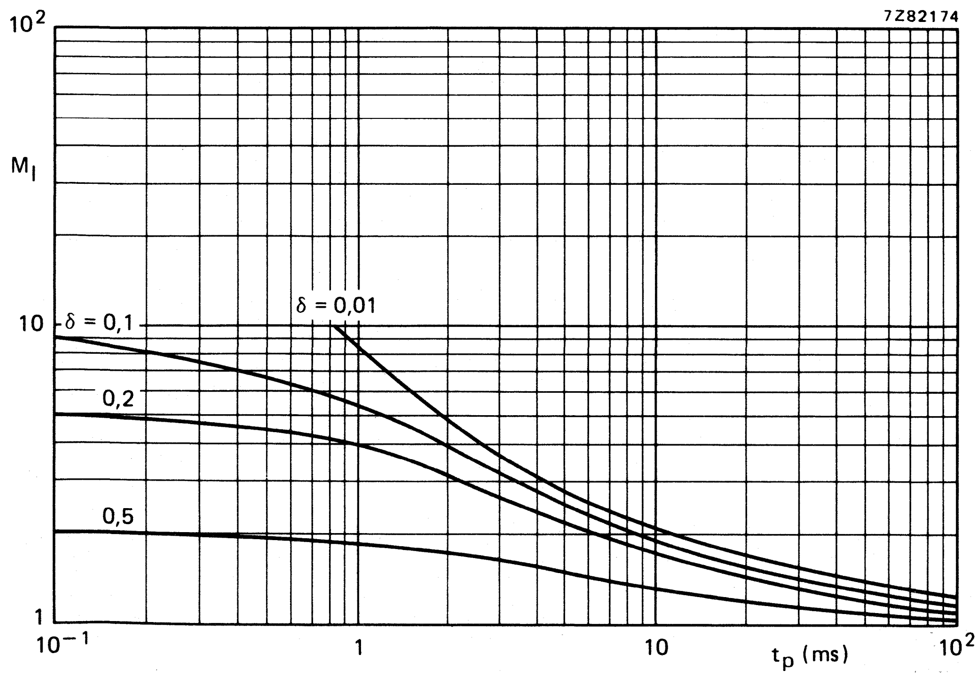


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

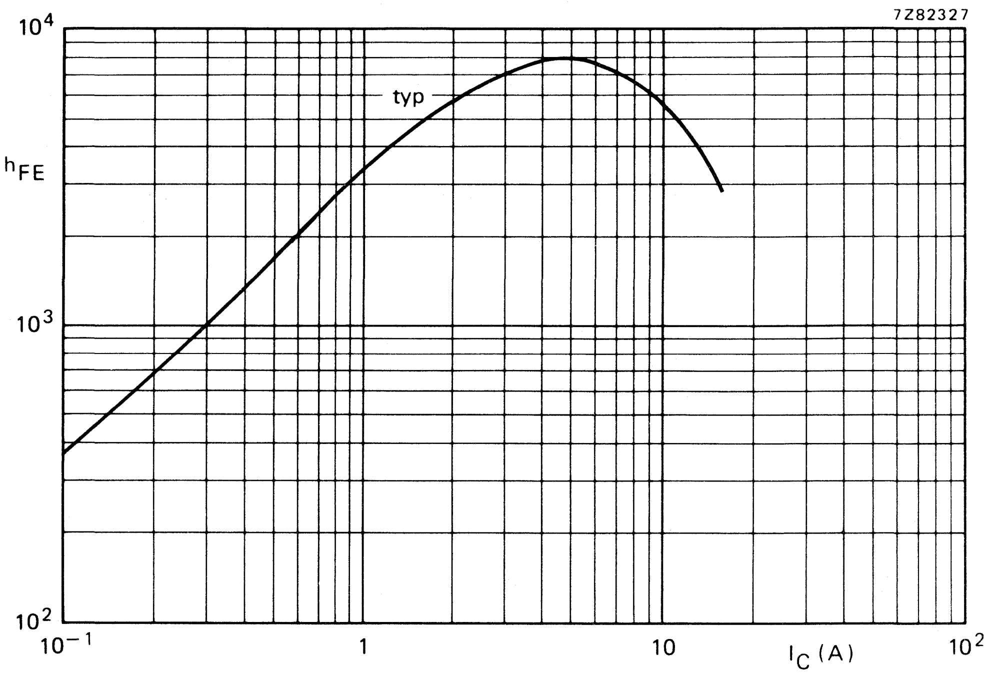


Fig. 12 Typical d.c. current gain as a function of collector current; V_{CE} = 3 V; T_j = 25 °C.

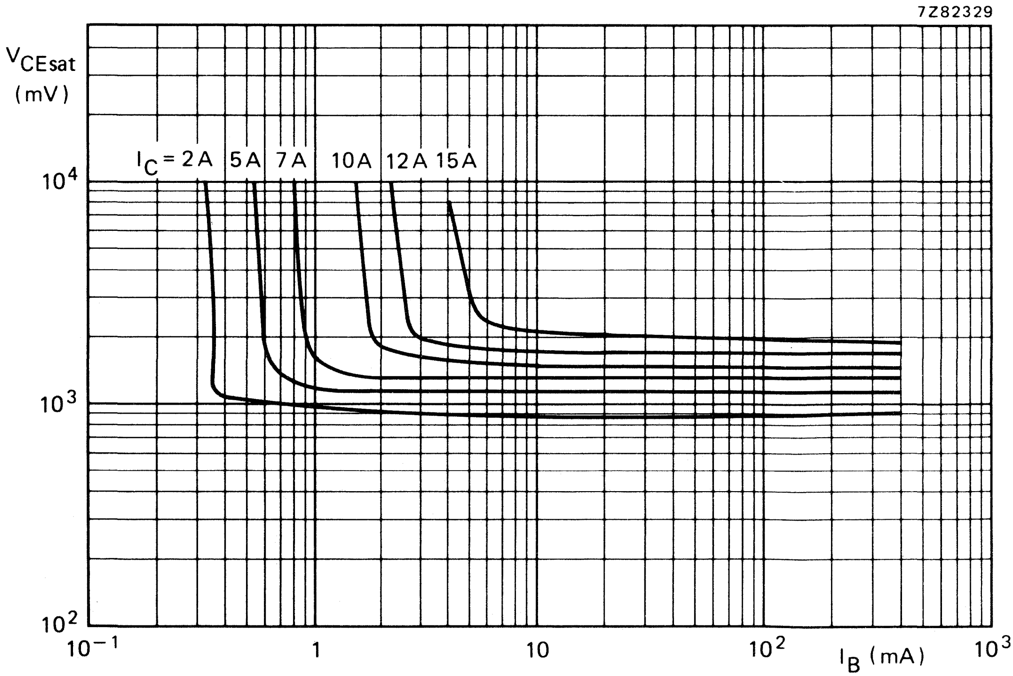


Fig. 13 Typical collector-emitter saturation voltages.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon darlington power transistors in a SOT186 envelope with an electrically insulated mounting base. The devices are designed for audio output stages and general amplifier and switching applications. PNP complements are BDT64F, BDT64AF, BDT64BF and BDT64CF.

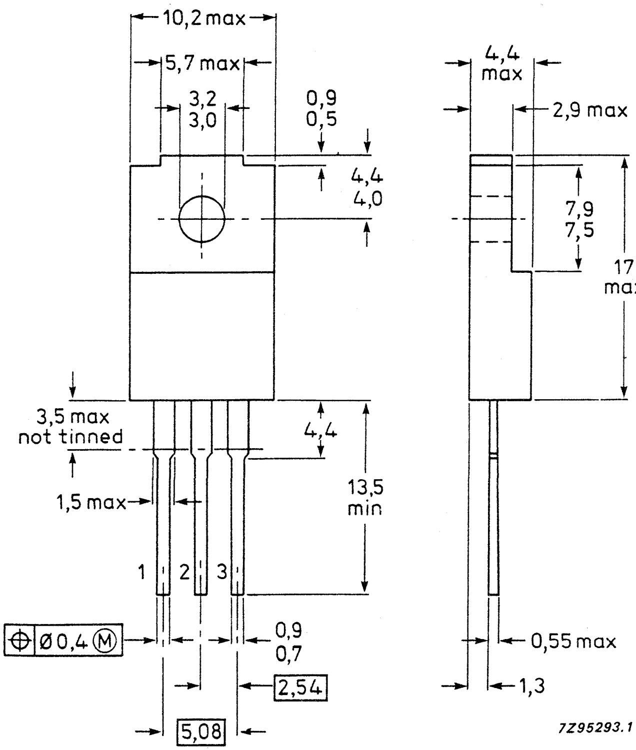
QUICK REFERENCE DATA

			BDT65F	65AF	65BF	65CF	
Collector-base voltage	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage	V_{CEO}	max.	60	80	100	120	V
Collector current DC	I_C	max.		12			A
Total power dissipation up to $T_h = 25\ ^oC$	P_{tot}	max.		39			W
Junction temperature	T_j	max.		150			^oC
DC current gain	h_{FE}	min.		1000			

MECHANICAL DATA

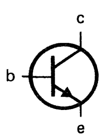
Dimensions in mm

Fig.1 SOT186.



Pinning:

1 = base
2 = collector
3 = emitter



RATINGS

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

			BDT65F	65AF	65BF	65CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5.0				V
Collector current DC	I_C	max.	12				A
peak value	I_{CM}	max.	20				A
Base current (DC)	I_B	max.	500				mA
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.	22				W
up to T_h = 25 °C (2)	P_{tot}	max.	39				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

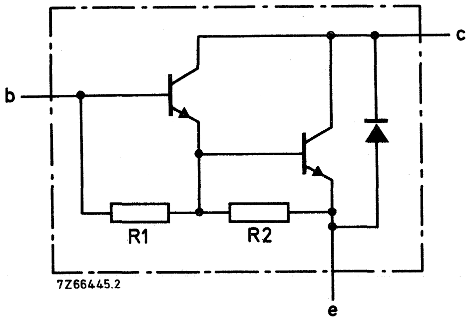
From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	0.9	K/W
From junction to internal heatsink (1)	$R_{th\ j\text{-}h}$	=	5.7	K/W
From junction to internal heatsink (2)	$R_{th\ j\text{-}h}$	=	3.2	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Insulation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.



R1 typ. 5 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	max.	0.4	mA
$I_E = 0$; $T_j = 150$ °C $V_{CB} = 1/2\ V_{CBOmax}$;	I_{CBO}	max.	2.0	mA
$I_B = 0$; $V_{CE} = 1/2\ V_{CEOmax}$	I_{CEO}	max.	1.0	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	max.	5.0	mA
DC current gain (3)				
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}	typ.	1500	
$I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	min.	1000	
$I_C = 12$ A; $V_{CE} = 4$ V	h_{FE}	typ.	1500	
Base-emitter voltage				
$I_C = 5$ A; $V_{CE} = 4$ V	V_{BE}	max.	2.5	V
Collector-emitter saturation voltage (3)				
$I_C = 5$ A; $I_B = 20$ mA	V_{CEsat}	max.	2.0	V
$I_C = 10$ A; $I_B = 100$ mA	V_{CEsat}	max.	3.0	V
Diode, forward voltage				
$I_F = 5$ A	V_F	max.	2.0	V
Collector capacitance at f = 1 MHz				
$V_{CB} = 10$ V; $I_E = I_C = 0$	C_c	typ.	200	pF
Second-breakdown collector current non-repetitive; without heatsink				
$V_{CE} = 60$ V; $t_p = 0.1$ s	$I_{(SB)}$	min.	0.65	A
Turn-off breakdown energy with inductive load;				
$-I_{Boff} = 0$; $I_{CM} = 6.3$ A; L = 5 mH	$E_{(BR)}$	min.	100	mJ
Switching times				
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 20$ mA				
Turn-on time	t_{on}	typ.	1.0	μs
		max.	2.5	μs
Turn-off time	t_{off}	typ.	6.0	μs
		max.	10	μs
Small-signal current gain at f = 1 MHz				
$I_C = 5$ A; $V_{CE} = 3$ V	h_{fe}	min.	10	

(3) Measured under pulse conditions; $t_p \leqslant 300$ μs; $\delta < 2\%$.

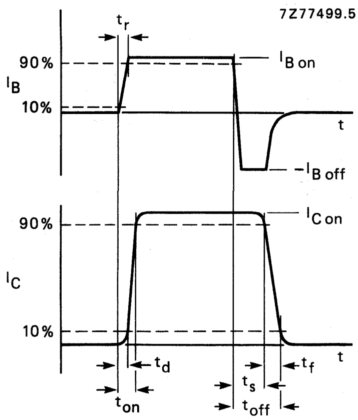
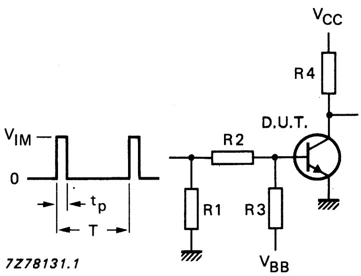


Fig. 3 Switching times waveforms.



V_{IM} = 15 V
V_{CC} = 30 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 6 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

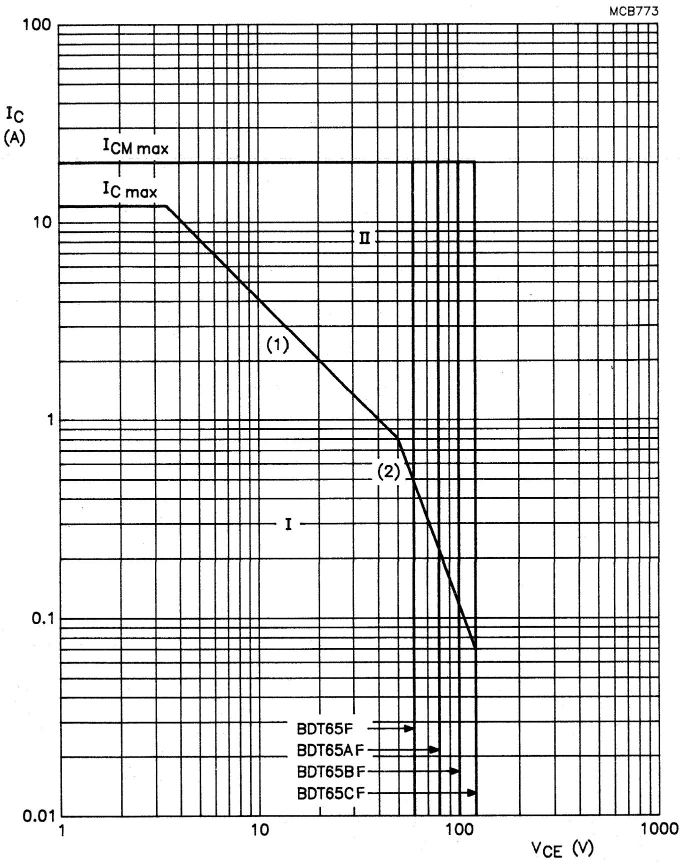


Fig. 5 Safe Operating Area; T_h = 25 °C.

I Region of permissible DC operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

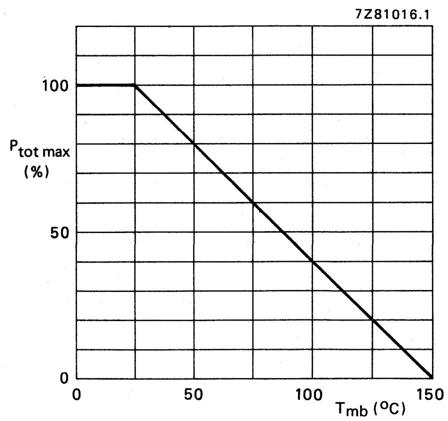


Fig. 6 Power derating curve.

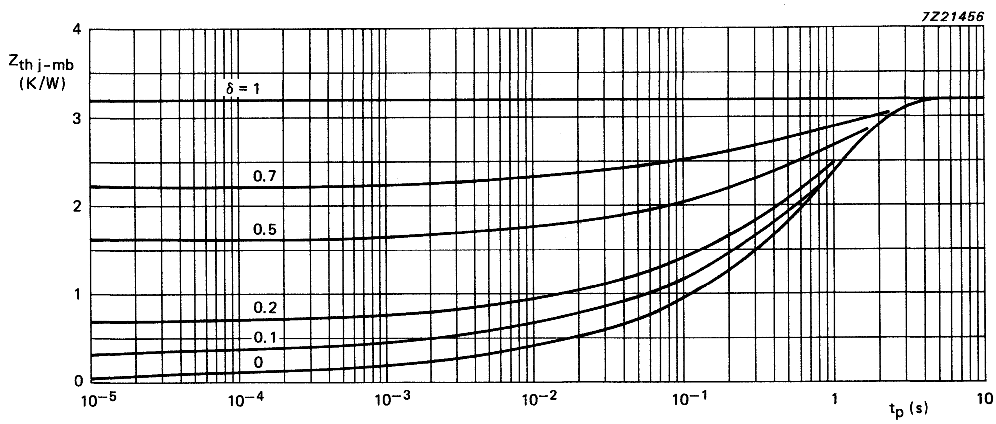


Fig. 7 Pulse power rating chart.

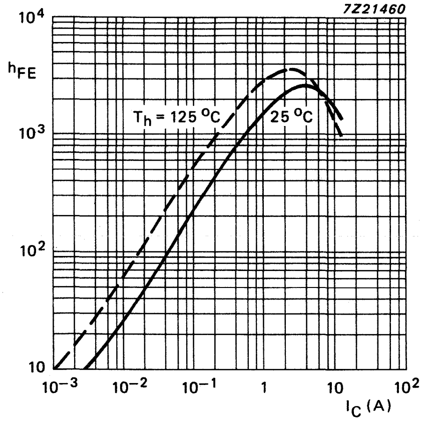


Fig. 8 Typical DC current gain as a function of collector current; V_{CE} = 4 V.

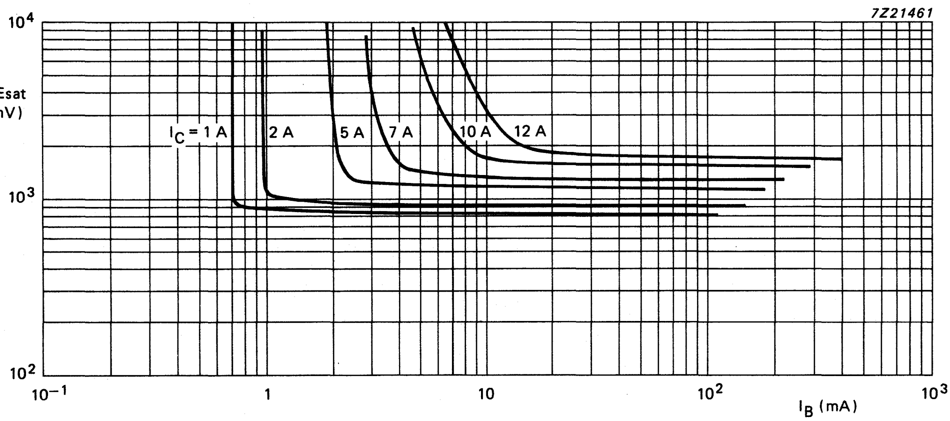


Fig. 9 Typical collector-emitter saturation voltages; T_{mb} = 25 °C.

SILICON POWER TRANSISTORS

N-P-N epitaxial base transistors in a TO-220 plastic envelope, designed for use in audio output stages and general amplifier and switching applications.

P-N-P complements are BDT82, BDT84, BDT86 and BDT88.

QUICK REFERENCE DATA

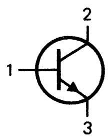
			BDT81	BDT83	BDT85	BDT87	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	7	V
Collector current (d.c.)	I_C	max.	15				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				^oC
D.C. current gain $I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	min.	40				

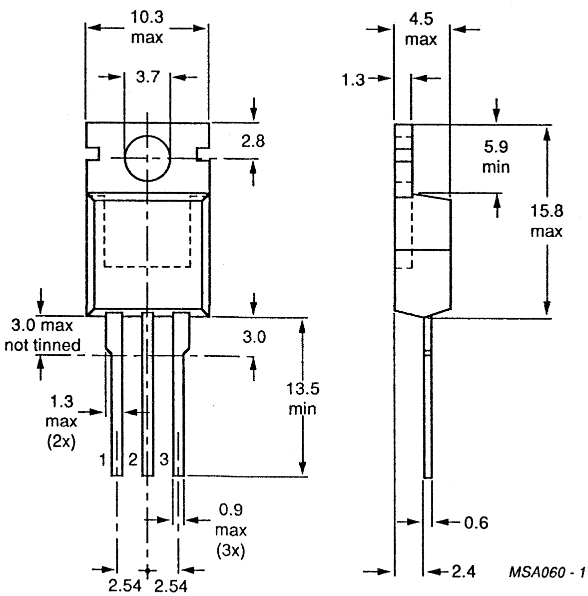
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to case.





See also chapters Mounting instructions and Accessories

RATINGS

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

			BDT81	BDT83	BDT85	BDT87	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	7	V
Collector current (d.c.)	I_C	max.	15				A
Collector current (peak value)	I_{CM}	max.	20				A
Base current (d.c.)	I_B	max.	4				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2	mA
$V_{BE} = 0$; $V_{CE} = 0{,}8\ V_{CBOmax}$	I_{CES}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 7$ V	I_{EBO}	<	0,1	mA
D.C. current gain*				
$I_C = 50$ mA; $V_{CE} = 10$ V	h_{FE}	>	40	
$I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	>	40	
Collector-emitter saturation voltage*				
$I_C = 5$ A; $I_B = 0{,}5$ A	V_{CEsat}	<	1	V*
$I_C = 7$ A; $I_B = 0{,}7$ A	V_{CEsat}	<	1,6	V*
Base-emitter voltage*				
$I_C = 5$ A; $V_{CE} = 4$ V	V_{BE}	<	1,5	V*
Transition frequency at f = 1 MHz				
$I_C = 0{,}5$ A; $V_{CE} = 10$ V	f_T	typ.	10	MHz
Second breakdown collector current				
$V_{CE} = 50$ V; $t_p = 100$ ms	I_{SB}	>	2,5	A

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.

Switching times (see Fig. 2)

$I_C = 7$ A; $I_{B1} = -I_{B2} = 0,7$ A

	t_{on}	≤	1 μs
	t_{off}	≤	2 μs

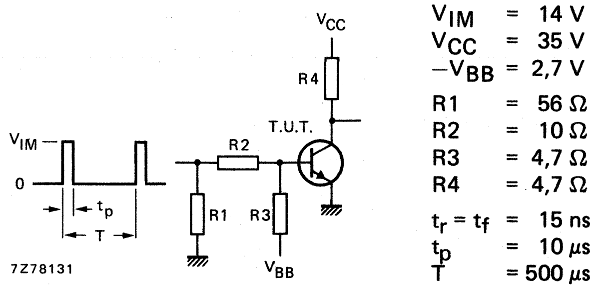


Fig. 2 Switching times test circuit.

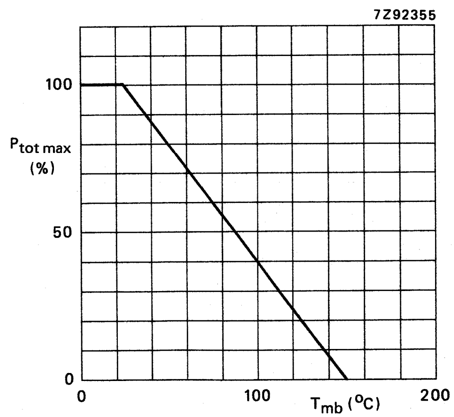


Fig. 3 Power derating curve.

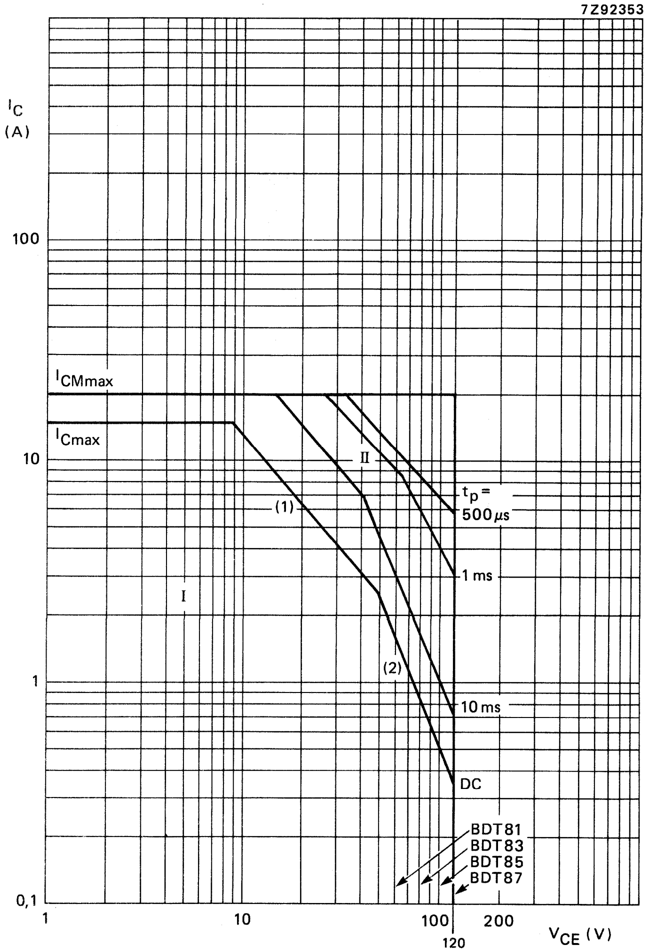


Fig. 4 Safe Operating Area, T_{mb} = 25 °C; δ = 0,01.

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

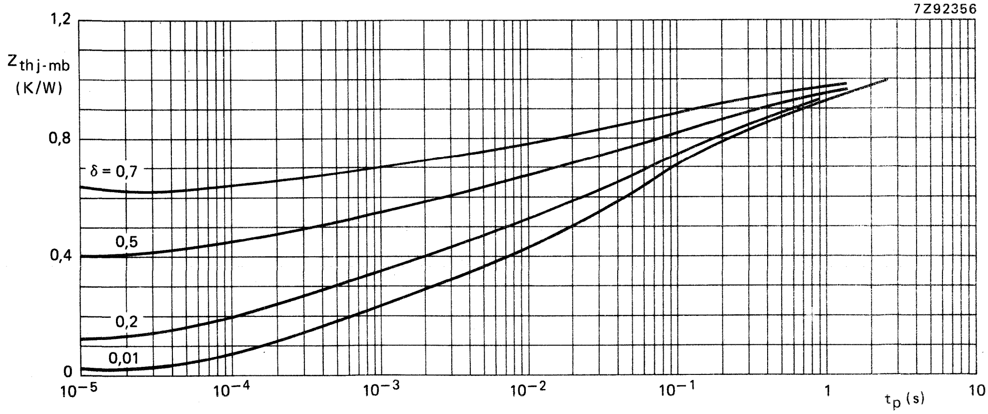


Fig. 5 Pulse power rating chart.

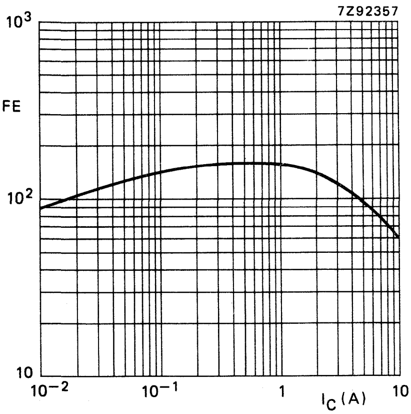


Fig. 6 Typical d.c. current gain; T_{amb} = 25 °C; V_{CE} = 4 V.

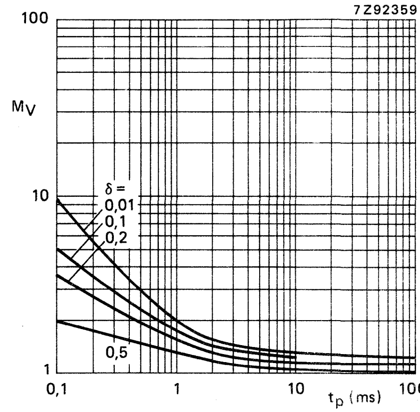


Fig. 7 Second-breakdown voltage multiplying factor at I_{Cmax} level.

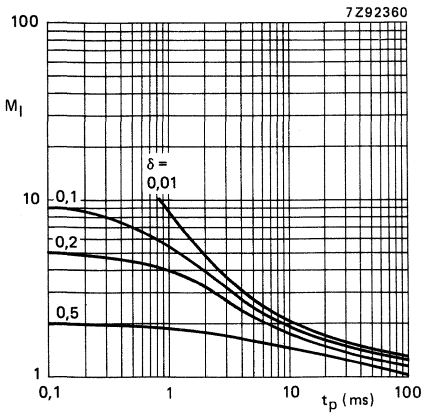


Fig. 8 Second-breakdown current multiplying factor at the V_{CEOmax} level.

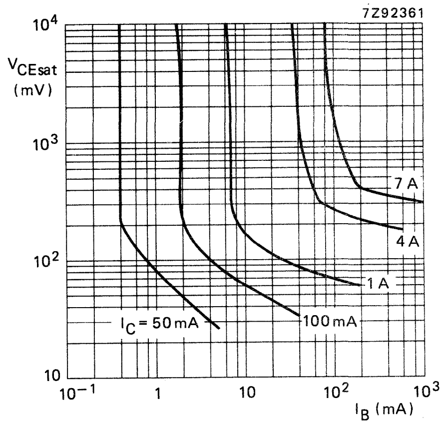


Fig. 9 Typical values collector-emitter saturation voltage.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

PNP complements are BDT82F, BDT84F, BDT86F and BDT88F.

QUICK REFERENCE DATA

			BDT81F	83F	85F	87F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7			V
DC collector current	I_C	max.		15			A
Peak collector current	I_{CM}	max.		20			A
Total power dissipation at $T_h \leq 25\ ^oC$	P_{tot}	max.		36			W
DC current gain $I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	typ.		40			

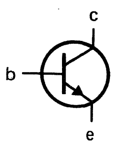
MECHANICAL DATA

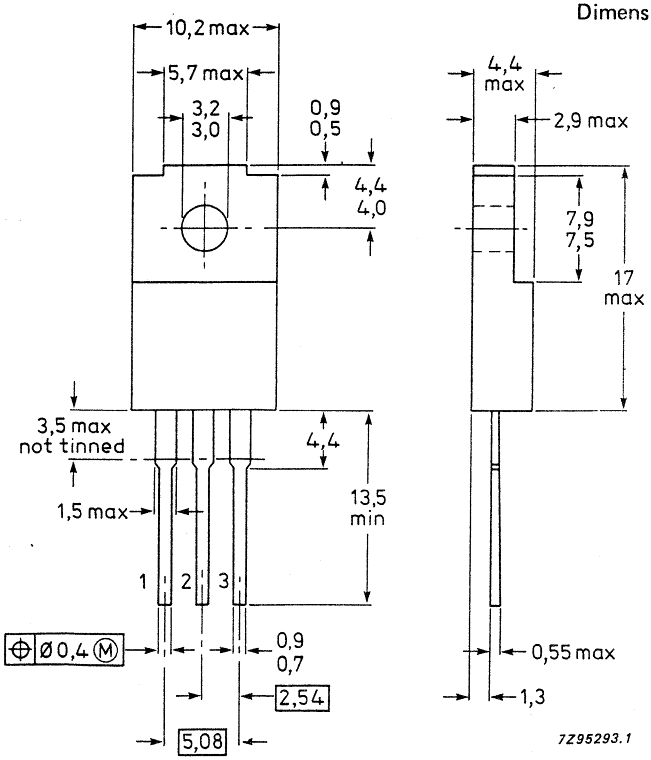
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BDT81F	83F	85F	87F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7			V
DC collector current	I_C	max.		15			A
Peak collector current	I_{CM}	max.		20			A
DC base current	I_B	max.		4			A
Total power dissipation at $T_h \leqslant 25\ ^oC$ (note 1)	P_{tot}	max.		21			W
at $T_h \leqslant 25\ ^oC$ (note 2)	P_{tot}	max.		36			W
Storage temperature range	T_{stg}			−65 to 150			^oC
Junction temperature	T_j	max.		150			^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.5	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $I_C = 5$ A; $I_B = 0.5$ A	V_{CEsat}	max.	1.0	V
$I_C = 7$ A; $I_B = 0.7$ A	V_{CEsat}	max.	1.6	V
DC current gain $I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	typ.	40	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

SILICON POWER TRANSISTORS

P-N-P epitaxial base transistors in a TO-220 plastic envelope, designed for use in audio output stages and general amplifier and switching applications.

N-P-N complements are BDT81, BDT83, BDT85 and BDT87.

QUICK REFERENCE DATA

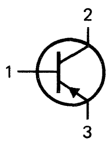
			BDT82	BDT84	BDT86	BDT88	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	7	7	7	7	V
Collector current (d.c.)	$-I_C$	max.	15				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	min.	40				

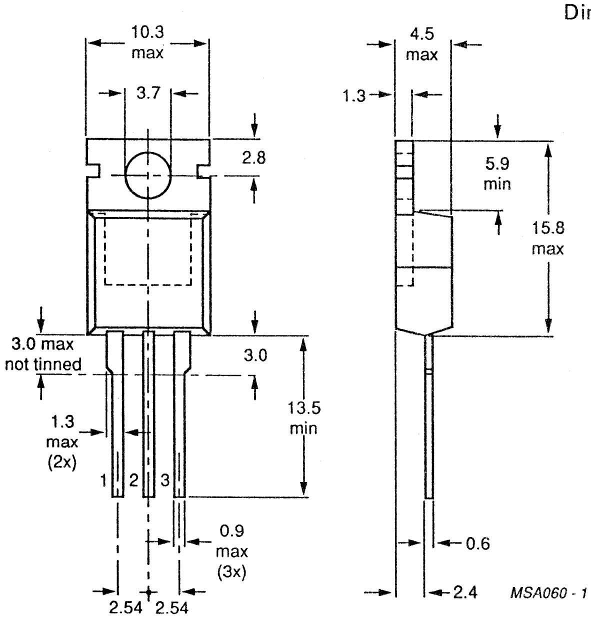
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to case.





See also chapters Mounting instructions and Accessories

RATINGS

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

			BDT82	BDT84	BDT86	BDT88	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	7	7	7	7	V
Collector current (d.c.)	$-I_C$	max.	15				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Base current (d.c.)	$-I_B$	max.	4				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	1	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	max.	70	K/W

CHARACTERISTICS

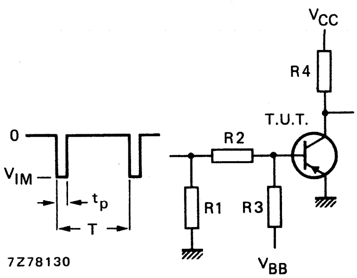
T_j = 25 °C unless otherwise specified

Collector cut-off current				
$-I_E = 0$; $-V_{CB} = V_{CBOmax}$	$-I_{CBO}$	<	0.2	mA
$-V_{BE} = 0$; $-V_{CE} = 0,8\ V_{CBOmax}$	$-V_{CES}$	<	1	mA
Emitter cut-off current				
$-I_C = 0$; $-V_{EB} = 7$ V	$-I_{EBO}$	<	0.1	mA
D.C. current gain*				
$-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	40	
$-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	>	40	
Collector-emitter saturation voltage*				
$-I_C = 5$ A; $-I_B = 0,5$ A	$-V_{CEsat}$	<	1	V*
$-I_C = 7$ A; $-I_B = 0,7$ A	$-V_{CEsat}$	<	1,6	V*
Base-emitter voltage*				
$-I_C = 5$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,5	V*
Transition frequency at f = 1 MHz				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	typ.	20	MHz
Second breakdown collector current				
$-V_{CE} = 50$ V; $t_p = 100$ ms (non-repetitive without heatsink)	$-I_{SB}$	>	2,5	A

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.

Switching times (see Fig. 2)
$-I_C = 7$ A; $-I_{B1} = I_{B2} = 0,7$ A

t_{on}	≤	1 μs
t_{off}	≤	2 μs



$-V_{IM}$	=	14 V
$-V_{CC}$	=	35 V
V_{BB}	=	2,7 V
R1	=	56 Ω
R2	=	10 Ω
R3	=	4,7 Ω
R4	=	4,7 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 2 Switching times test circuit.

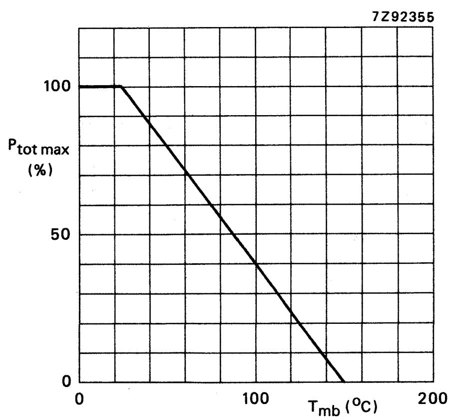


Fig. 3 Power derating curve.

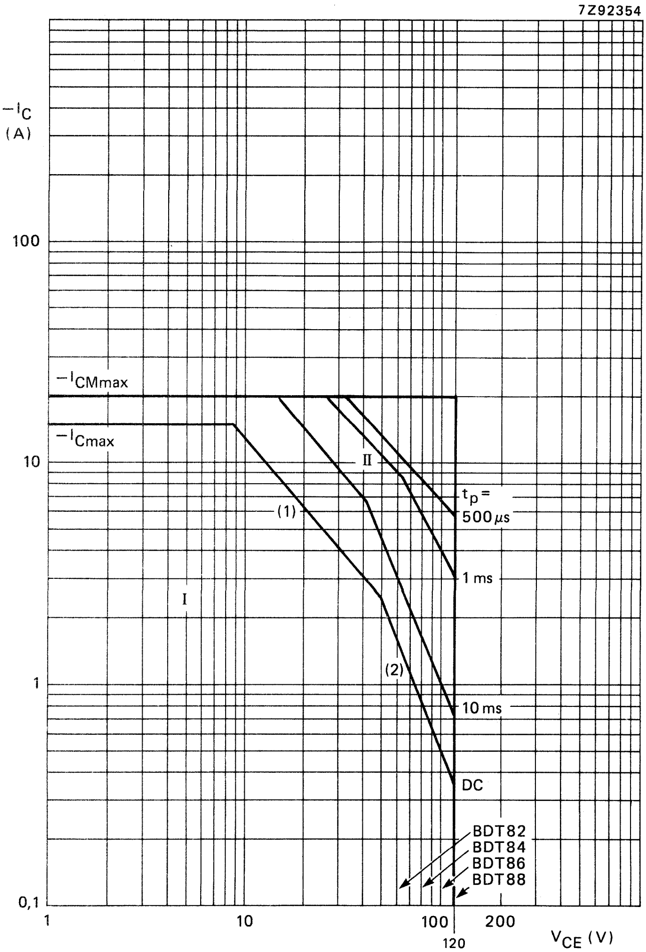


Fig. 4 Safe Operating Area, T_{mb} = 25 °C; δ = 0,01.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

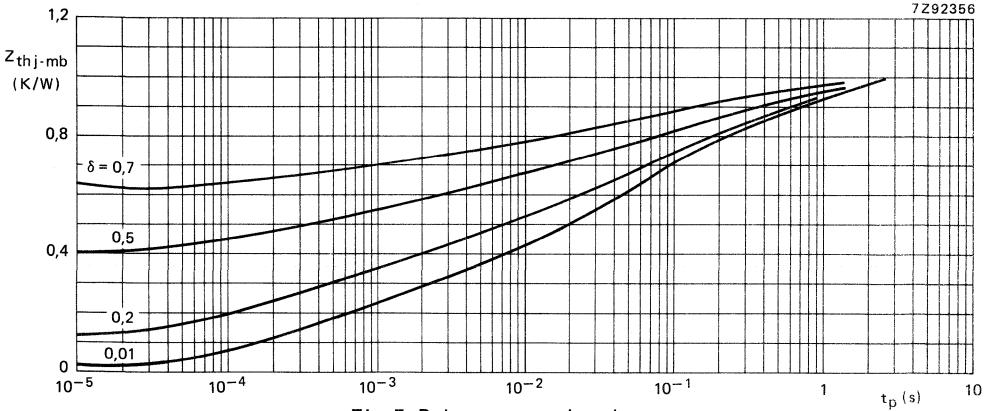


Fig. 5 Pulse power rating chart.

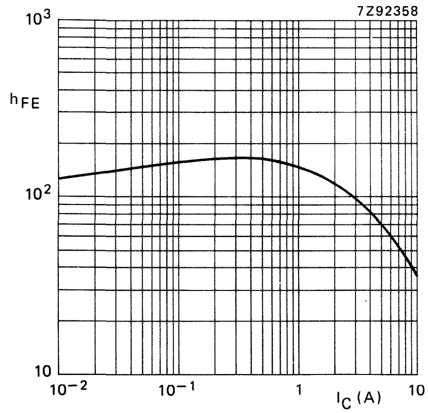


Fig. 6 Typical d.c. current gain; T_{amb} = 25 °C; $-V_{CE}$ = 4 V.

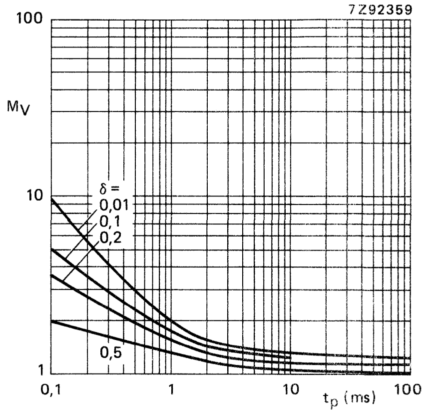


Fig. 7 Second-breakdown voltage multiplying factor at I_{Cmax} level.

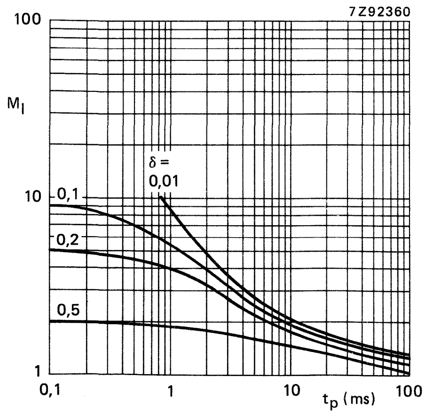


Fig. 8 Second-breakdown current multiplying factor at V_{CEOmax} level.

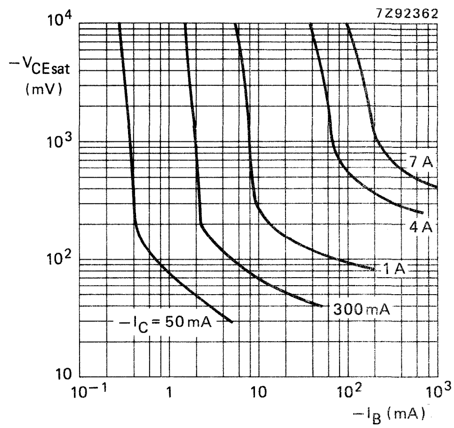


Fig. 9 Typical values collector-emitter saturation voltage.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

NPN complements are BDT81F, BDT83F, BDT85F and BDT87F.

QUICK REFERENCE DATA

			BDT82F	84F	86F	88F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7			V
DC collector current	$-I_C$	max.		15			A
Peak collector current	$-I_{CM}$	max.		20			A
Total power dissipation at $T_h \leqslant 25\ ^oC$	P_{tot}	max.		36			W
DC current gain $-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	typ.		40			

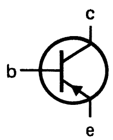
MECHANICAL DATA

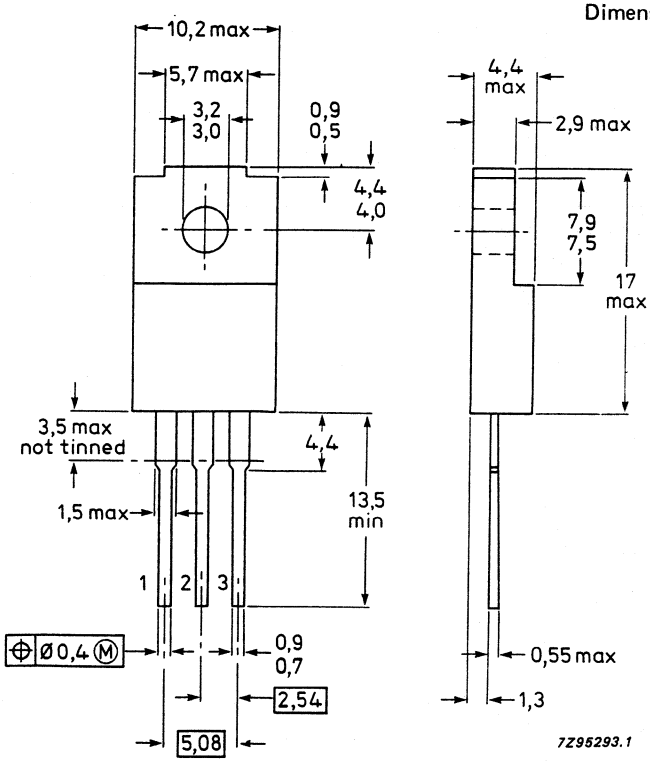
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BDT82F	84F	86F	88F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7			V
DC collector current	$-I_C$	max.		15			A
Peak collector current	$-I_{CM}$	max.		20			A
DC base current	$-I_B$	max.		4			A
Total power dissipation at $T_h \leq 25\ ^oC$ (note 1)	P_{tot}	max.		21			W
at $T_h \leq 25\ ^oC$ (note 2)	P_{tot}	max.		36			W
Storage temperature range	T_{stg}			−65 to 150			^oC
Junction temperature	T_j	max.		150			^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.5	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $-I_C = 5$ A; $-I_B = 0.5$ A	$-V_{CEsat}$	max.	1.0	V
$-I_C = 7$ A; $-I_B = 0.7$ A	$-V_{CEsat}$	max.	1.6	V
DC current gain $-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	40	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound 30 ± 5 newtons pressure on centre of envelope.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications.
P-N-P complements are BDT92, BDT94 and BDT96.

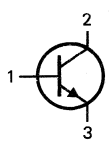
QUICK REFERENCE DATA

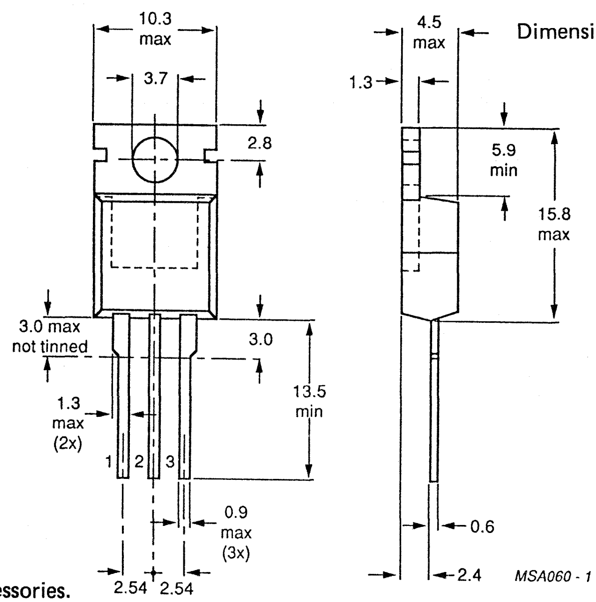
			BDT91	BDT93	BDT95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		90		W
Junction temperature	T_j	max.		150		^oC
D.C. current gain						
$I_C = 4$ A; $V_{CE} = 4$ V	h_{FE}			20 to 200		
$I_C = 10$ A; $V_{CE} = 4$ V	h_{FE}	>		5		
Transition frequency						
$I_C = 0{,}5$ A; $V_{CE} = 10$ V	f_T	>		4		MHz

MECHANICAL DATA

Fig. 1 TO-220.

Collector connected to mounting base.





Dimensions in mm

See also chapters
Mounting instructions and Accessories.

RATINGS

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

			BDT91	BDT93	BDT95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7		V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		4		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,4	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °V	I_{CBO}	<	5	mA
$I_B = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 7 V	I_{EBO}	<	1	mA
D.C. current gain (note 1)				
I_C = 4 A; V_{CE} = 4 V	h_{FE}		20 to 200	
I_C = 10 A; V_{CE} = 4 V	h_{FE}	>	5	
Base-emitter voltage (notes 1 and 2)				
I_C = 4 A; V_{CE} = 4 V	V_{BE}	<	1,6	V
Collector-emitter saturation voltage (note 1)				
I_C = 4 A; I_B = 0,4 A	V_{CEsat}	<	1	V
I_C = 10 A; I_B = 3,3 A	V_{CEsat}	<	3	V
Transition frequency at f = 1 MHz				
I_C = 0,5 A; V_{CE} = 10 V	f_T	>	4	MHz
Cut-off frequency				
I_C = 0,5 A; V_{CE} = 10 V	f_{hfe}	>	20	kHz

Notes
1. Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.
2. V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Second-breakdown collector current			
V_{CE} = 60 V; t_p = 0,1 s	$I_{(SB)}$	>	1,5 A
Switching times (between 10% and 90% levels)			
I_{Con} = 4 A; I_{Bon} = $-I_{Boff}$ = 0,4 A			
Turn-on time	t_{on}	typ.	0,5 μs
		<	1 μs
Turn-off time	t_{off}	typ.	2 μs
		<	4 μs

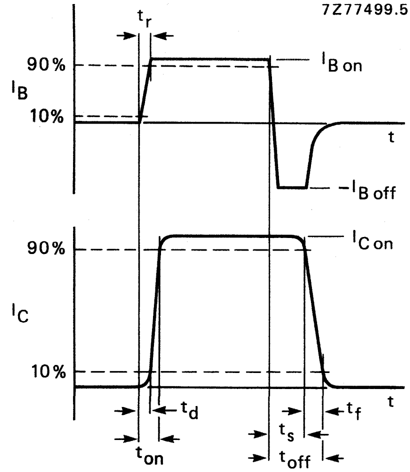


Fig. 2 Switching times waveforms.

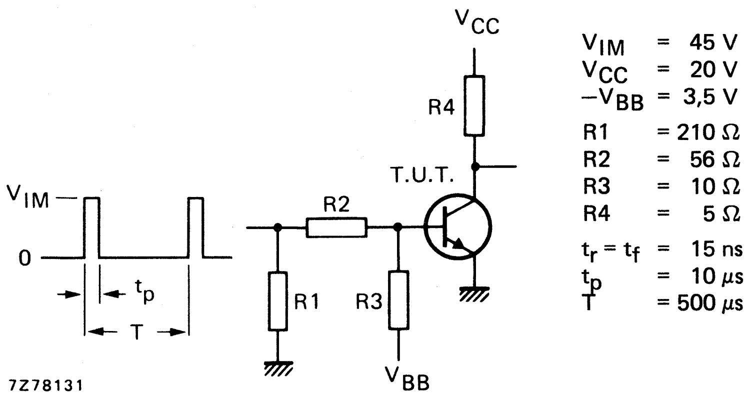


Fig. 3 Switching times test circuit.

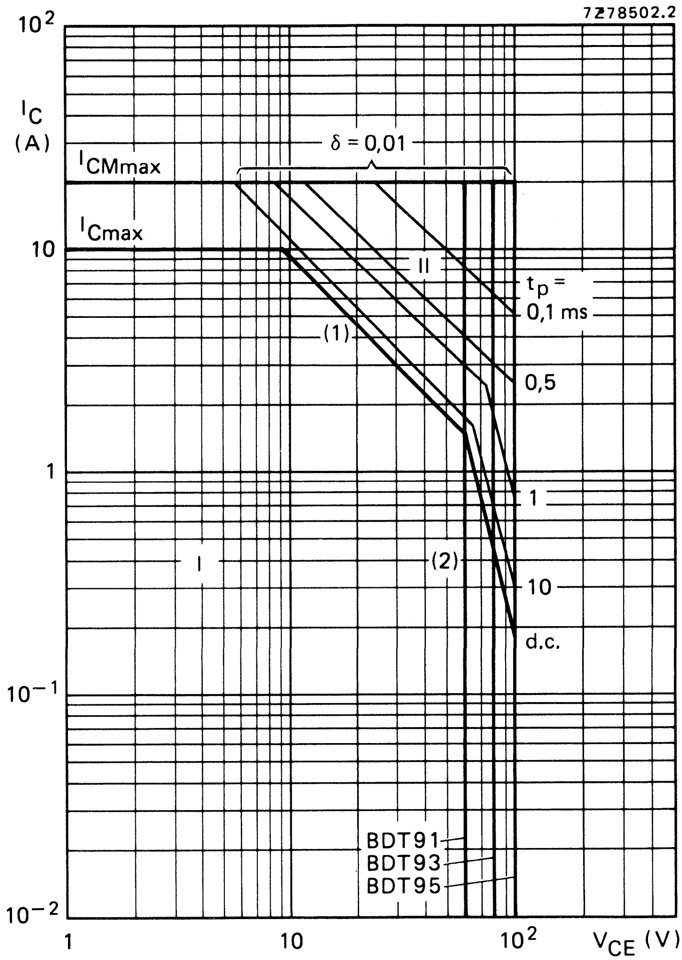


Fig. 4 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

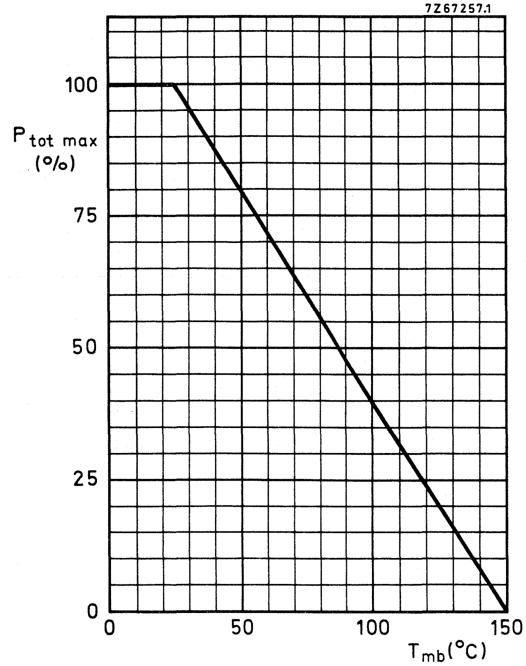


Fig. 5 Power derating curve.

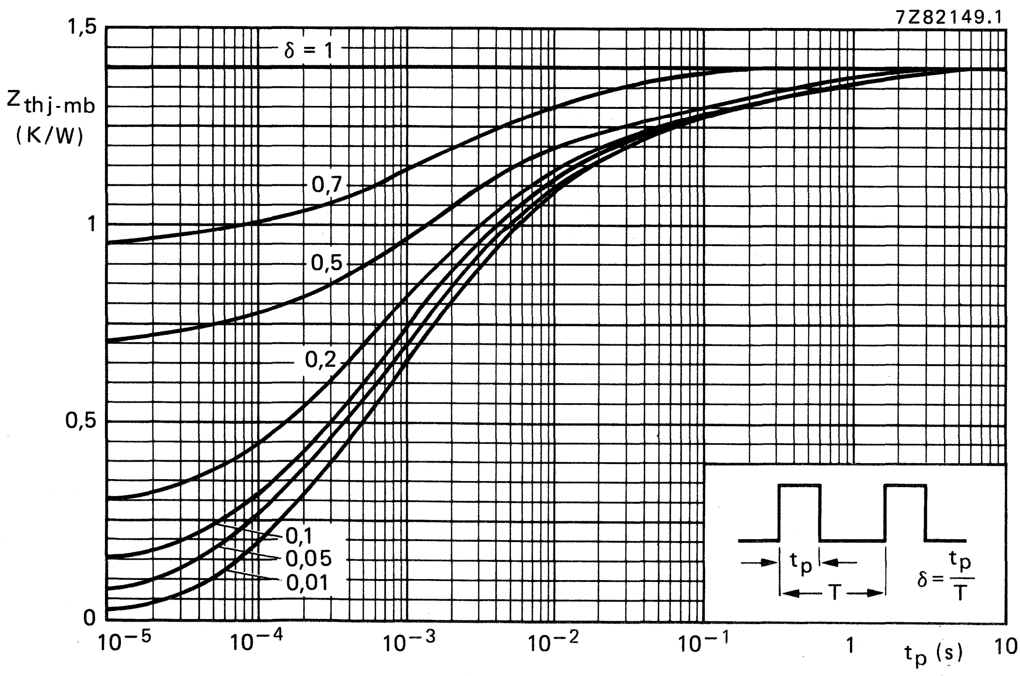


Fig. 6 Pulse power rating chart.

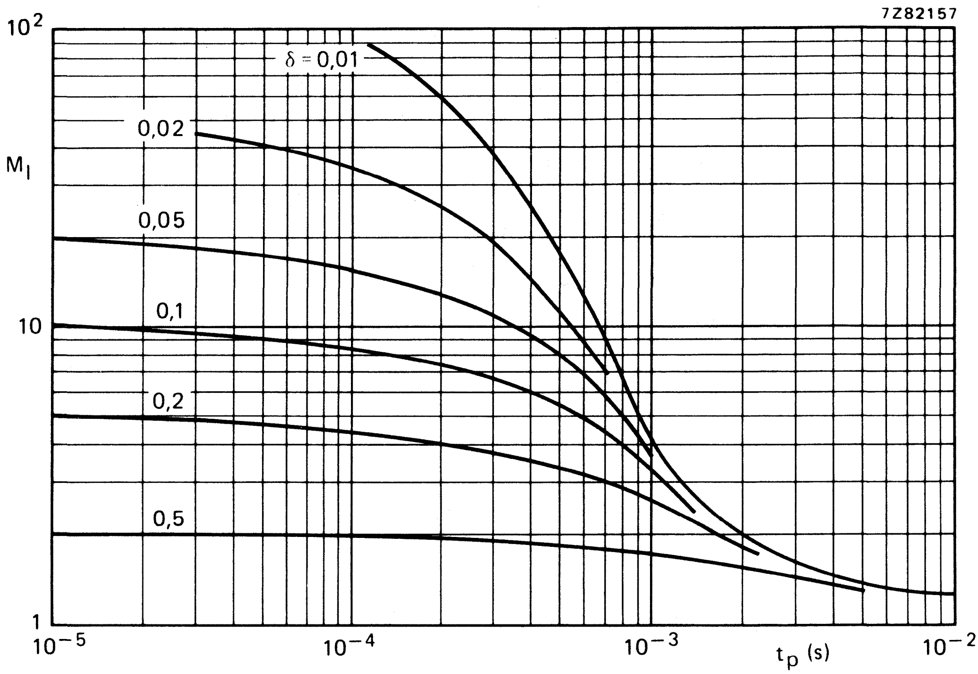


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

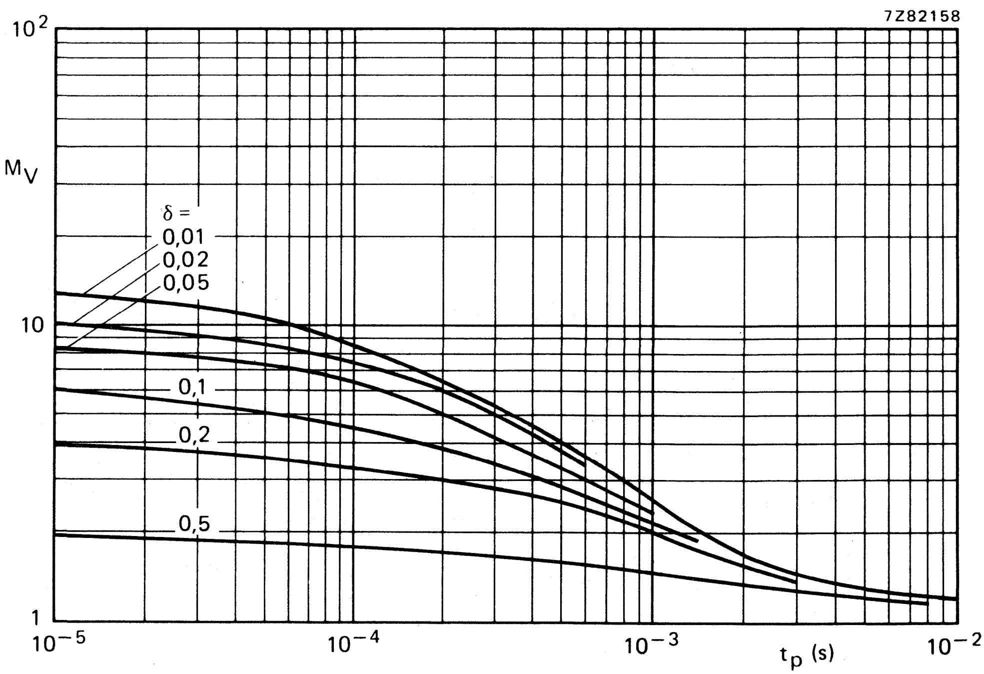


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

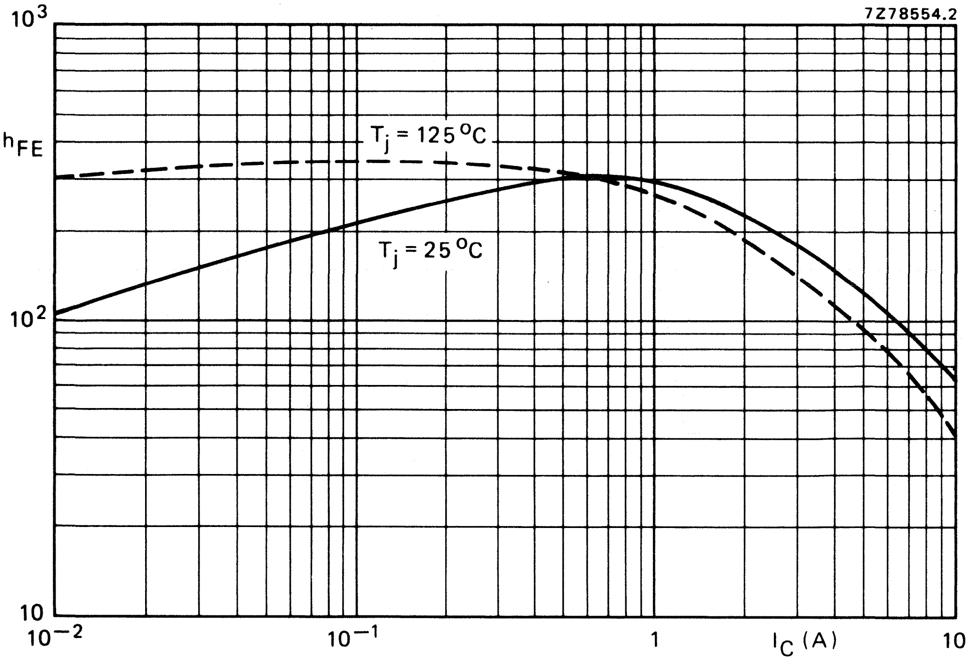


Fig. 9 Typical d.c. current gain at $V_{CE} = 4$ V.

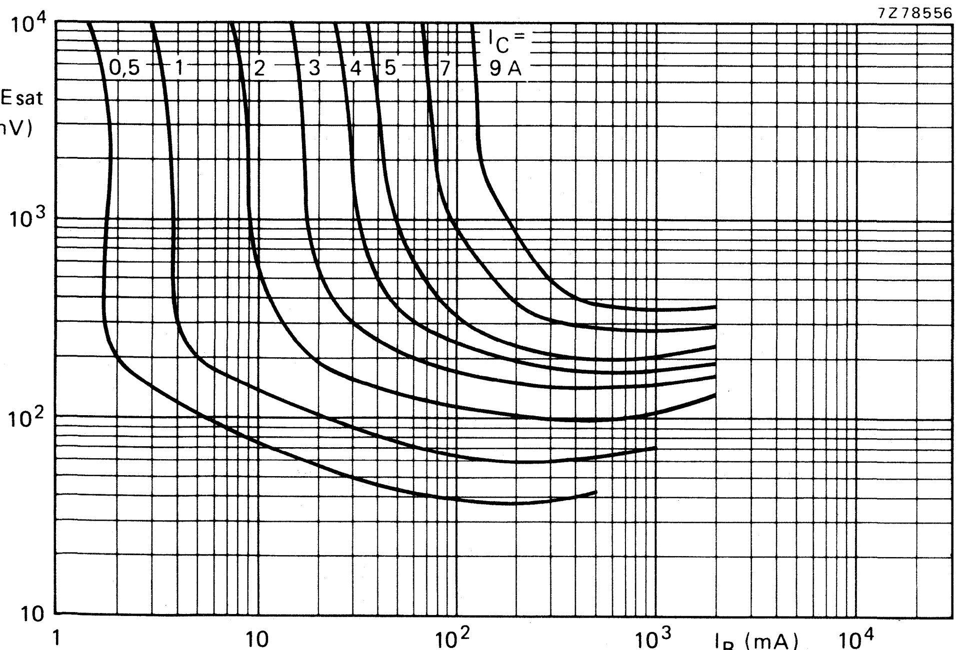


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25\ ^oC$.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

PNP complements are BDT92F, BDT94Fand BDT96F.

QUICK REFERENCE DATA

			BDT91F	93F	95F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7		V
DC collector current	I_C	max.		10		A
Peak collector current	I_{CM}	max.		20		A
Total power dissipation at $T_h \leqslant 25\ ^oC$	P_{tot}	max.		32		W
DC current gain $I_C = 4$ A; $V_{CE} = 4$ V	h_{FE}	min.		20		
		max.		200		

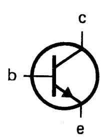
MECHANICAL DATA

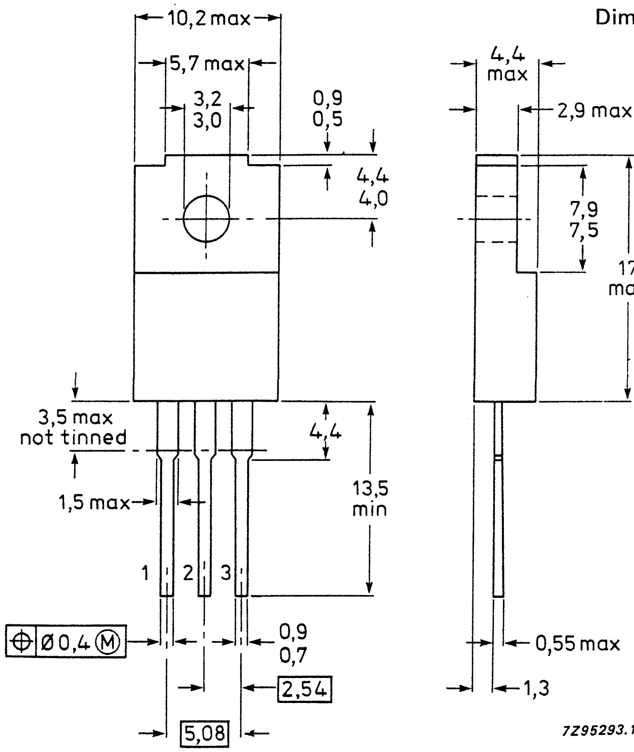
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BDT91F	93F	95F	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7		V
DC collector current	I_C	max.		10		A
Peak collector current	I_{CM}	max.		20		A
Base current	I_B	max.		4		A
Total power dissipation at $T_h \leq 25\ ^oC$ (note 1)	P_{tot}	max.		20		W
at $T_h \leq 25\ ^oC$ (note 2)	P_{tot}	max.		32		W
Storage temperature range	T_{stg}			−65 to + 150		^oC
Junction temperature	T_j	max.		150		^oC

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.4	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.4	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $I_C = 4\ A$; $I_B = 0.4\ A$	V_{CEsat}	max.	1	V
$I_C = 10\ A$; $I_B = 3.3\ A$	V_{CEsat}	max.	3	V
DC current gain $I_C = 4\ A$; $V_{CE} = 4\ V$	h_{FE}	min.	20	
		max.	200	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications.
N-P-N complements are BDT91, BDT93 and BDT95.

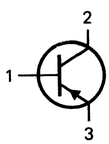
QUICK REFERENCE DATA

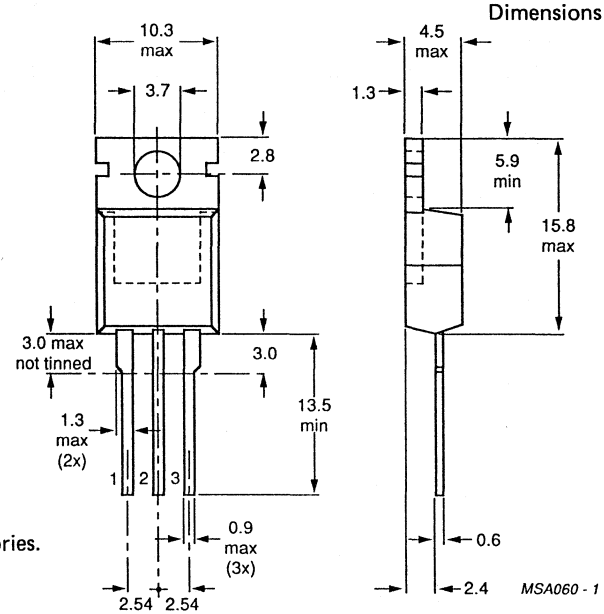
			BDT92	BDT94	BDT96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 4 A; $-V_{CE}$ = 4 V	h_{FE}			20 to 200		
$-I_C$ = 10 A; $-V_{CE}$ = 4 V	h_{FE}	>		5		
Transition frequency						
$-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>		4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.





See also chapters
Mounting instructions and Accessories.

RATINGS

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

			BDT92	BDT94	BDT96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7		V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Base current (d.c.)	$-I_B$	max.		4		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,4	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0; -V_{CB} = -½V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	1	mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	0,2	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 7$ V	$-I_{EBO}$	<	0,1	mA
D.C. current gain (note 1)				
$-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}		20 to 200	
$-I_C = 10$ A; $-V_{CE} = 4$ V	h_{FE}	>	5	
Base-emitter voltage (notes 1 and 2)				
$-I_C = 4$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,6	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 4$ A; $-I_B = 0,4$ A	$-V_{CEsat}$	<	1	V
$-I_C = 10$ A; $-I_B = 3,3$ A	$-V_{CEsat}$	<	3	V
Transition frequency at f = 1 MHz				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	>	4	MHz
Cut-off frequency				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_{hfe}	>	20	kHz
D.C. current gain ratio of matched pairs				
BDT91/92; $-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5	

Notes
1. Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta \leq 2\%$.
2. V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Second-breakdown collector current $-V_{CE}$ = 60 V; t_p = 0,1 s	$-I_{(SB)}$	>	1,5 A
Switching times (between 10% and 90% levels) $-I_{Con}$ = 4 A; $-I_{Bon}$ = + I_{Boff} = 0,4 A			
Turn-on time	t_{on}	typ.	0,5 μs
		<	1,5 μs
Turn-off time	t_{off}	typ.	1 μs
		<	3 μs

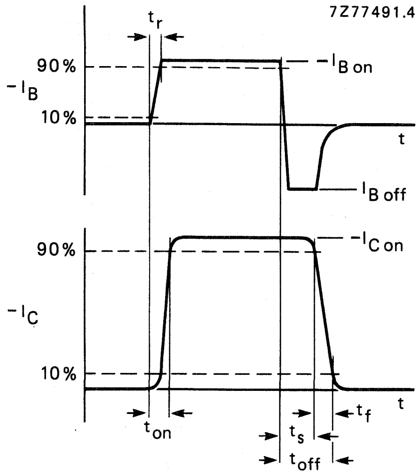
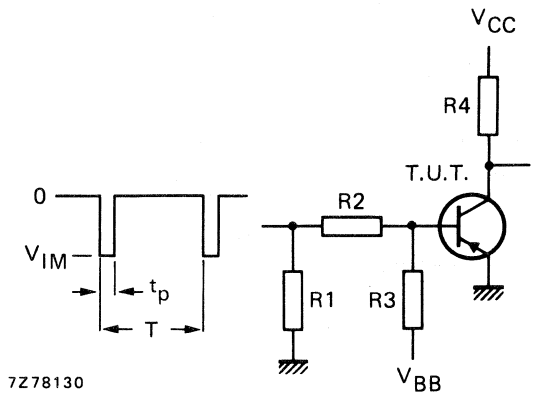


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	45 V
$-V_{CC}$	=	20 V
V_{BB}	=	3,5 V
R1	=	210 Ω
R2	=	56 Ω
R3	=	10 Ω
R4	=	5 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

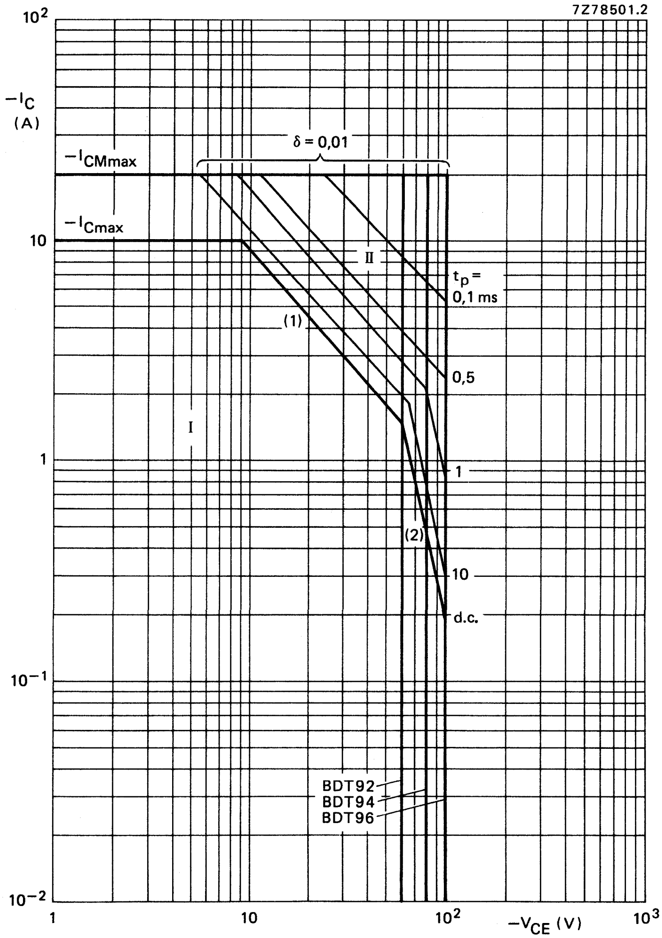


Fig. 4 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits

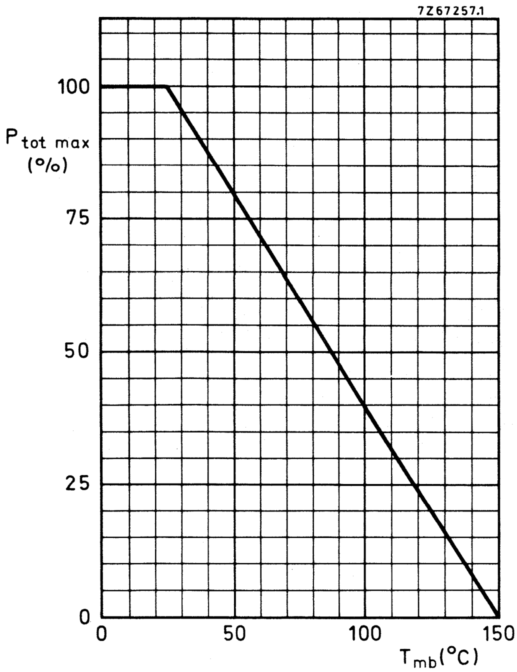


Fig. 5 Power derating curve.

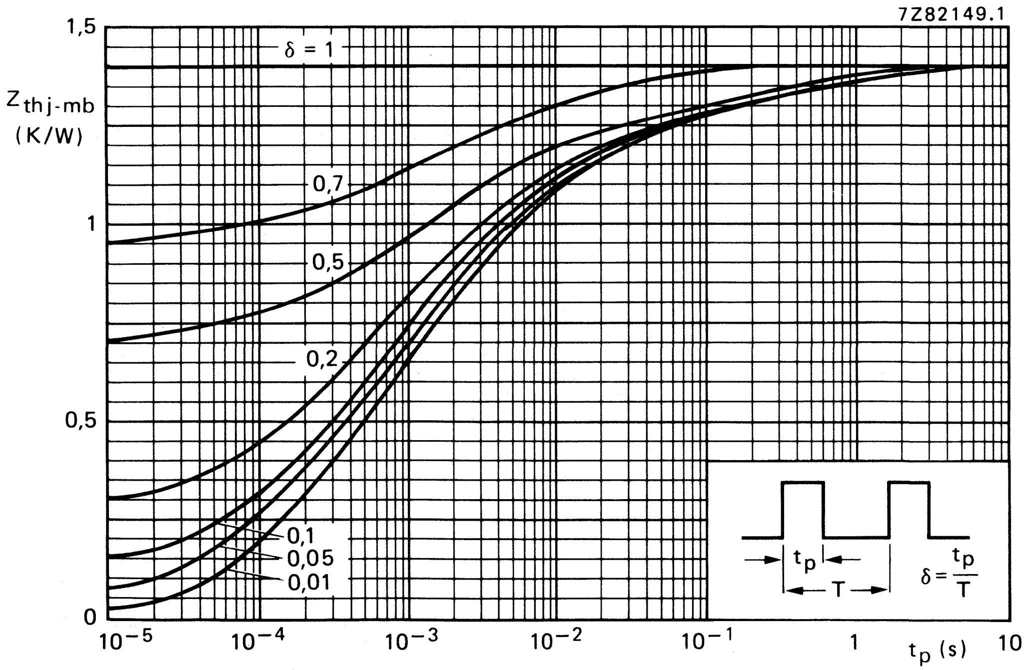


Fig. 6 Pulse power rating chart.

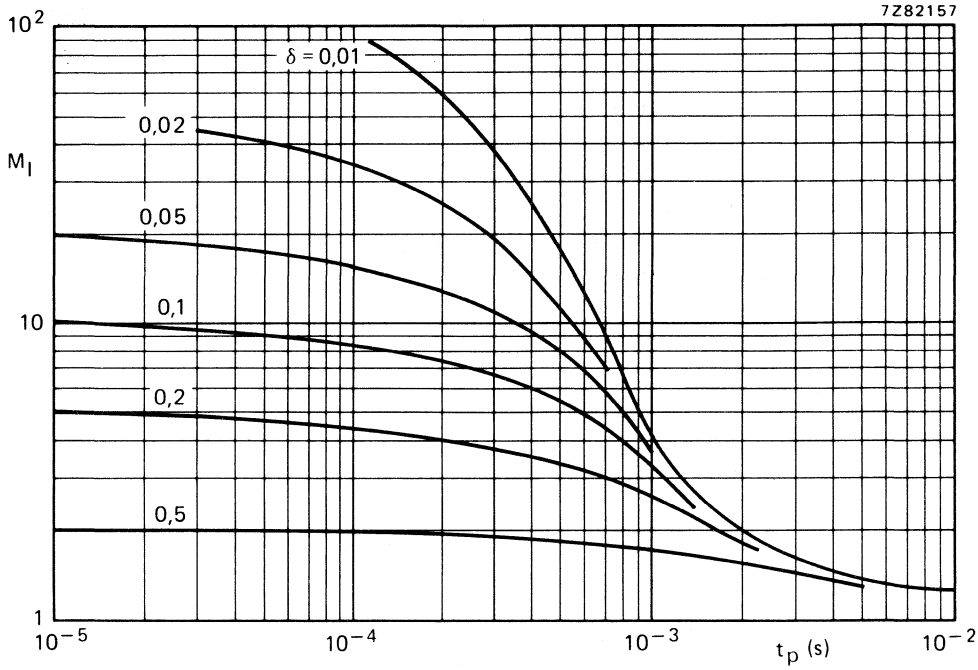


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

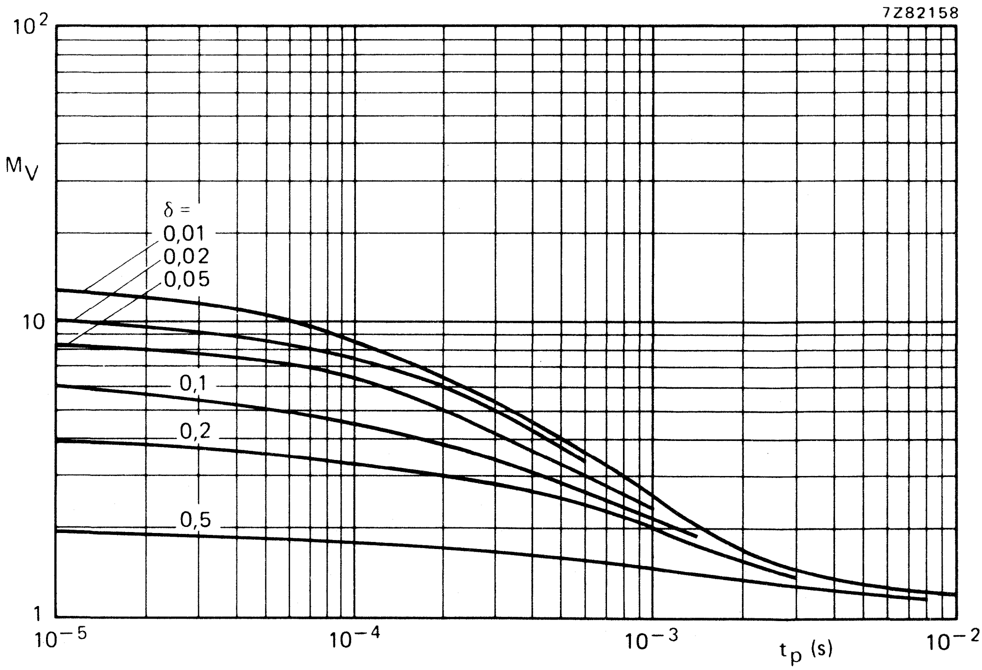


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

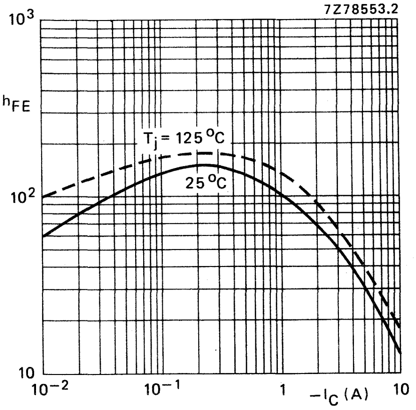


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V.

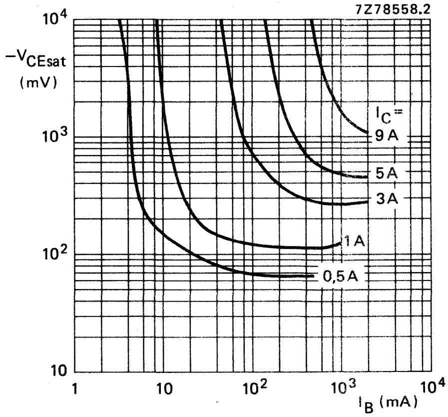


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25\ ^oC$.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

NPN complements are BDT91F, BDT93Fand BDT95F.

QUICK REFERENCE DATA

			BDT92F	94F	96F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7		V
DC collector current	$-I_C$	max.		10		A
Peak collector current	$-I_{CM}$	max.		20		A
Total power dissipation at $T_h \leqslant 25\ ^oC$	P_{tot}	max.		32		W
DC current gain $-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}	min.		20		
		max.		200		

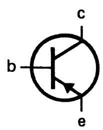
MECHANICAL DATA

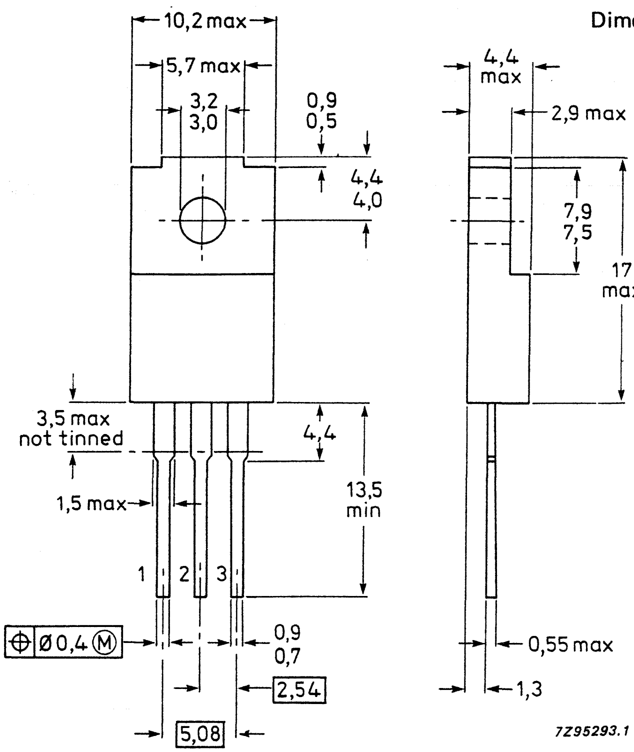
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			BDT92F	94F	96F	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7		V
DC collector current	$-I_C$	max.		10		A
Peak collector current	$-I_{CM}$	max.		20		A
Base current	$-I_B$	max.		4		A
Total power dissipation at $T_h \leqslant 25$ °C (note 1)	P_{tot}	max.		20		W
at $T_h \leqslant 25$ °C (note 2)	P_{tot}	max.		32		W
Storage temperature range	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.4	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.4	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink (peak value)	V_{insul}	max.	1000	V

CHARACTERISTICS

Collector-emitter saturation voltage $-I_C = 4$ A; $-I_B = 0.4$ A	$-V_{CEsat}$	max.	1	V
$-I_C = 10$ A; $-I_B = 3.3$ A	$-V_{CEsat}$	max.	3	V
DC current gain $-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}	min.	20	
		max.	200	

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. N-P-N complements are BDV65, 65A, 65B and 65C.

QUICK REFERENCE DATA

			BDV64	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		12			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125			W
Junction temperature	T_j	max.		150			°C
DC current gain $-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>		1000			
Cut-off frequency $-I_C$ = 5 A; $-V_{CE}$ = 4 V	f_{hfe}	typ.		100			kHz

MECHANICAL DATA

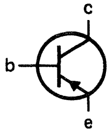
Dimensions in mm

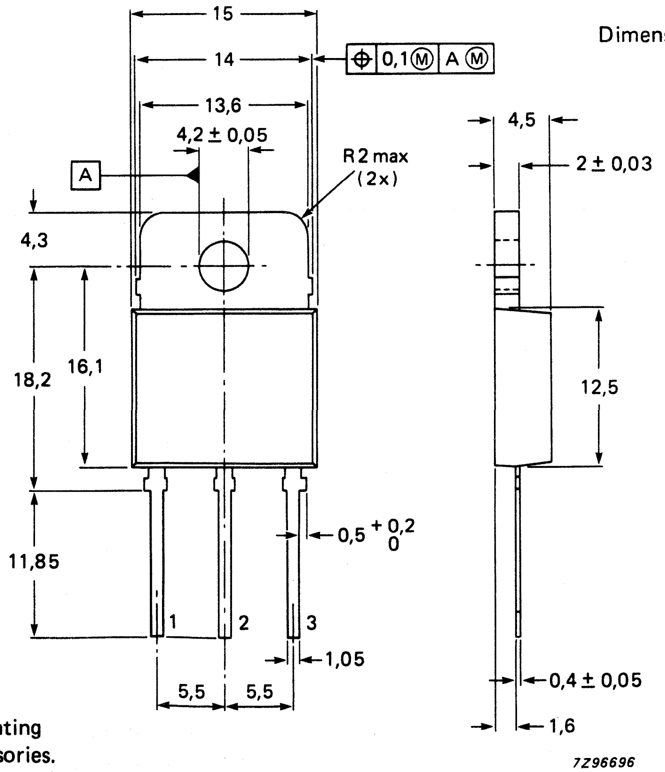
Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning

1 = base
2 = collector
3 = emitter





See also chapters Mounting instructions and Accessories.

CIRCUIT DIAGRAM

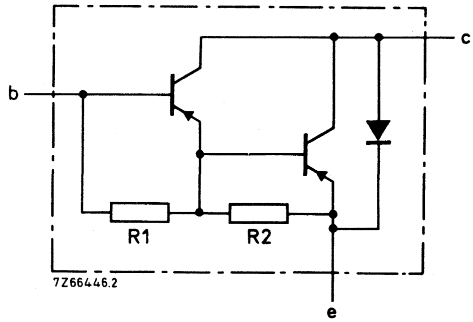


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV64	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	12	A
Collector current (peak value)	$-I_{CM}$	max.	20	A
Base current (d.c.)	$-I_B$	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C*

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	400	μA
$I_E = 0; -V_{CB} = -½V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	2	mA
$I_B = 0; -V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	0,2	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA

* 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.

D.C. current gain*			
$-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}	typ.	1500
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>	1000
$-I_C$ = 10 A; $-V_{CE}$ = 4 V	h_{FE}	typ.	1000
Base-emitter voltage*			
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	$-V_{BE}$	<	2,5 V**
Collector-emitter saturation voltage*			
$-I_C$ = 5 A; $-I_B$ = 20 mA	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	200 pF
Cut-off frequency			
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	f_{hfe}	typ.	100 kHz
Diode, forward voltage			
I_F = 5 A	V_F	typ.	1,8 V
I_F = 12 A	V_F	typ.	2 V
Switching times (see also Fig. 4)			
$-I_{Con}$ = 5 A; $-I_{Bon} = I_{Boff}$ = 20 mA; V_{CC} = −16 V			
Turn-on time	t_{on}	typ.	0,5 μs
Fall time	t_f	typ.	1,0 μs
Turn-off time	t_{off}	typ.	2,0 μs

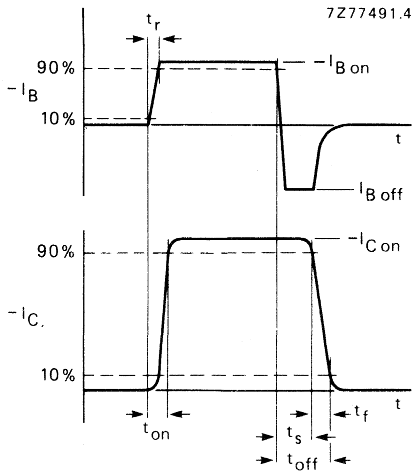
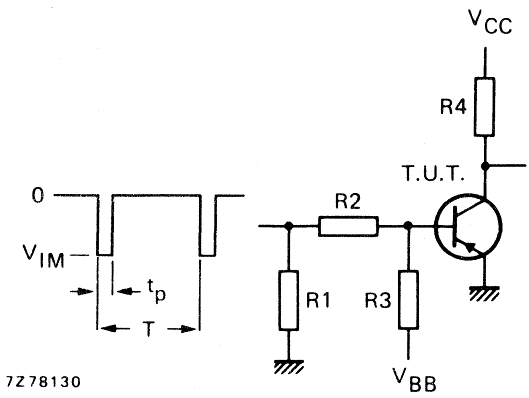


Fig. 3 Waveforms.

* Measured under pulse conditions: t_p < 300 μs; δ < 2%.
**$-V_{BE}$ decreases by about 3,6 mV/K with increasing temperature.



$-V_{IM}$	= 16,5 V
$-V_{CC}$	= 16 V
V_{BB}	= 6,5 V
R1	= 56 Ω
R2	= 410 Ω
R3	= 560 Ω
R4	= 3 Ω
$t_r = t_f$	= 15 ns
t_p	= 10 μs
T	= 500 μs

Fig. 4 Switching times test circuit.

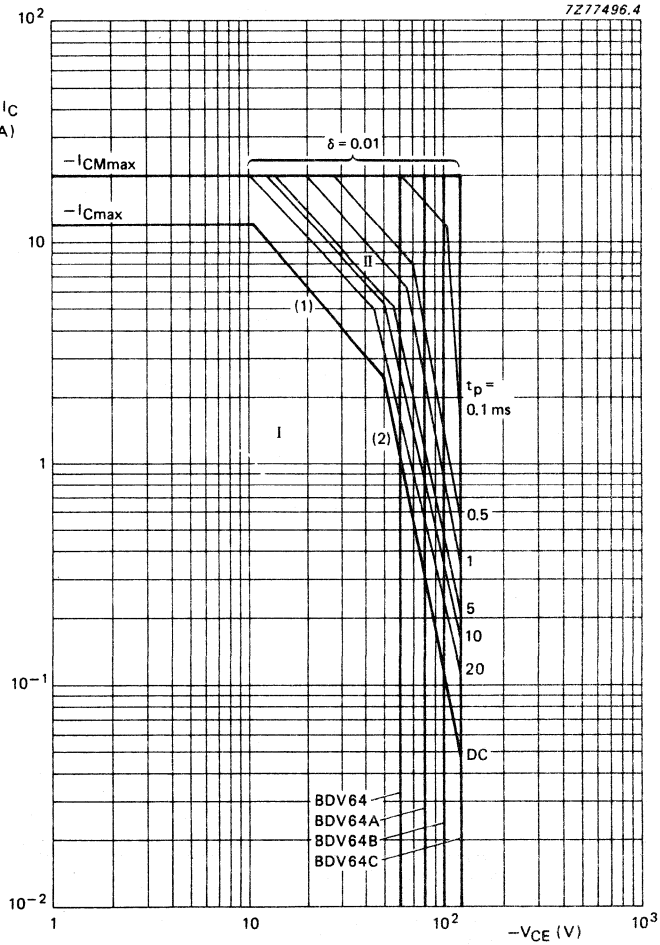


Fig. 5 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

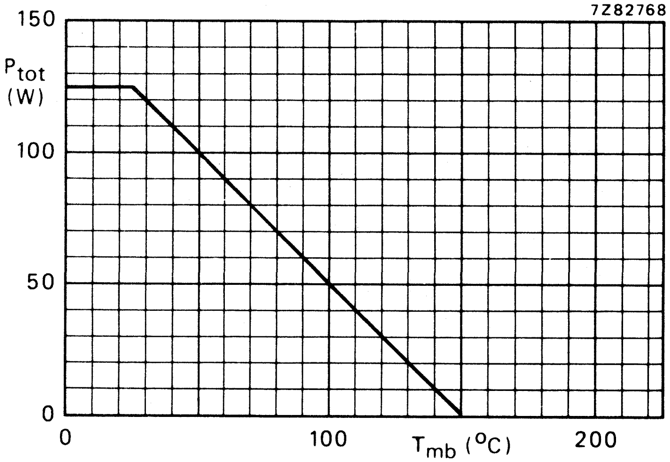


Fig. 6 Power derating curve.

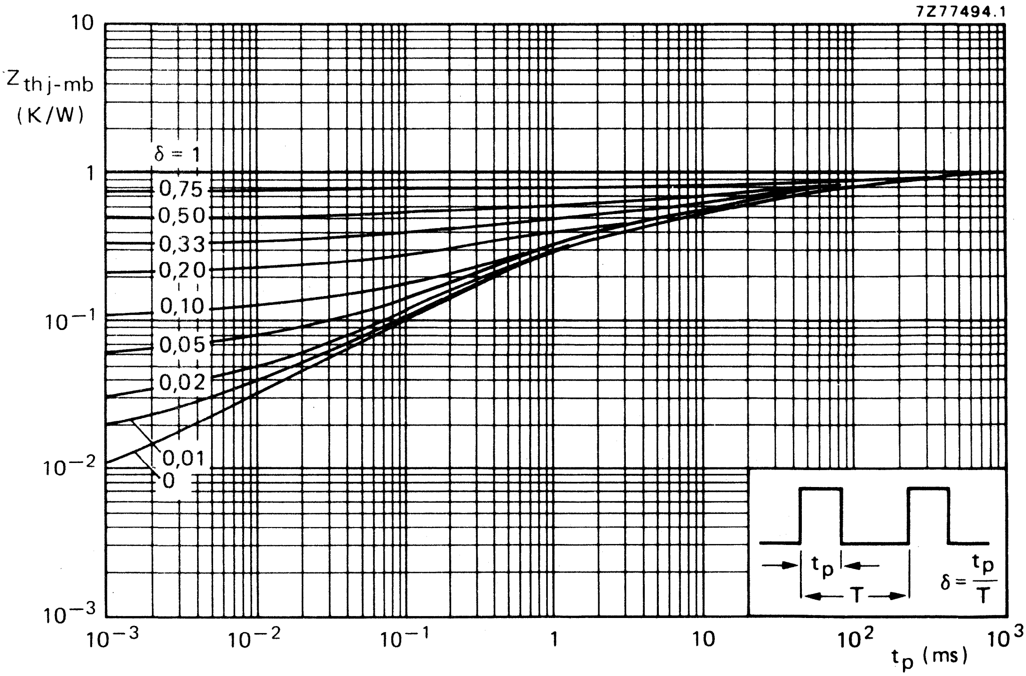


Fig. 7 Pulse power rating chart.

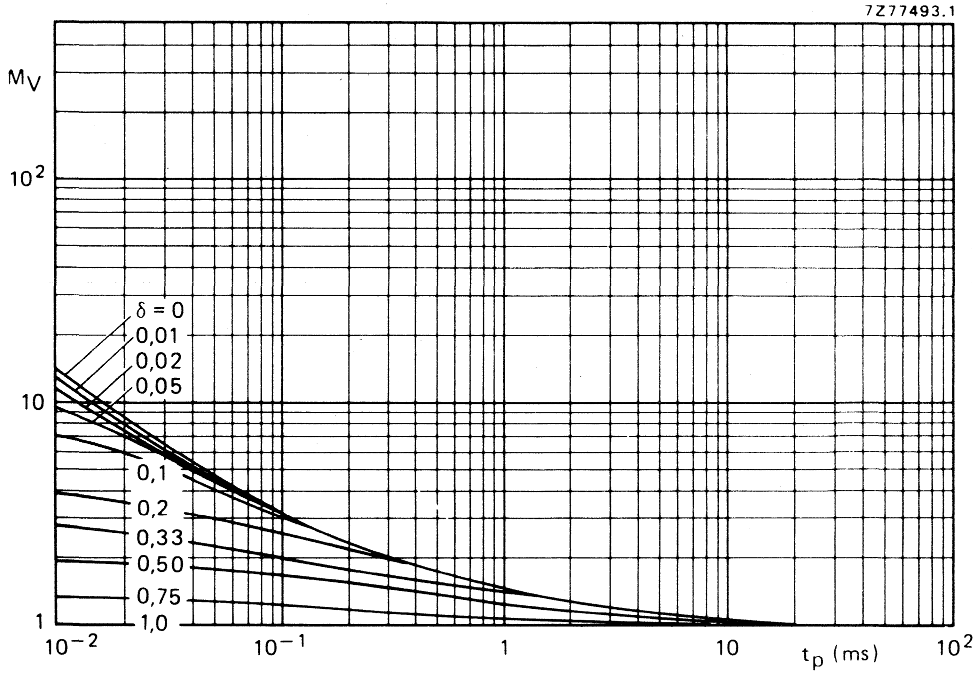


Fig. 8 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

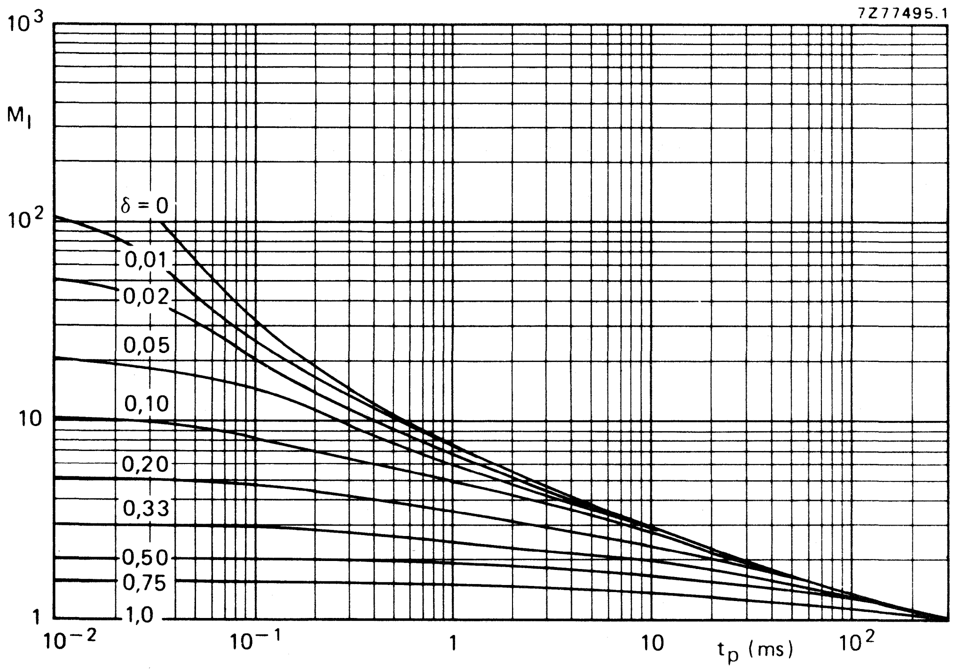


Fig. 9 S.B. current multiplying factor at the $-V_{CEOmax}$ level (100 V).

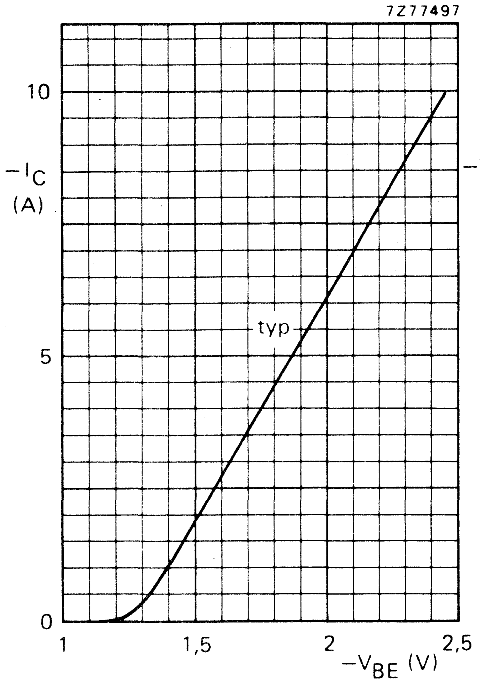


Fig. 10 $-V_{CE}$ = 4 V; T_j = 25 °C.

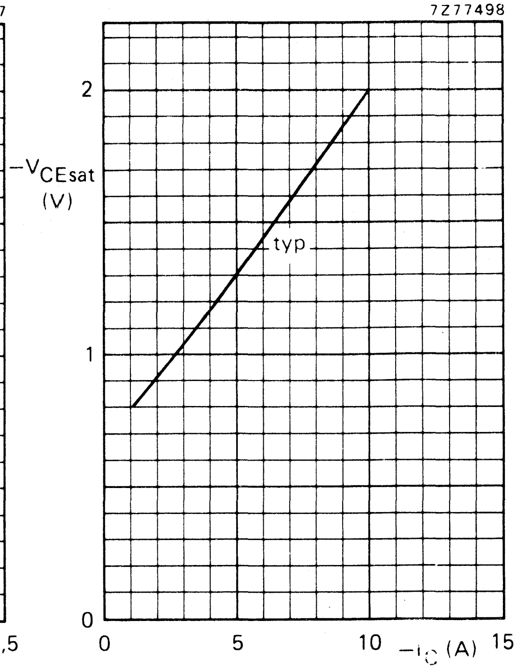


Fig. 11 $-I_C/I_B$ = 250; T_j = 25 °C.

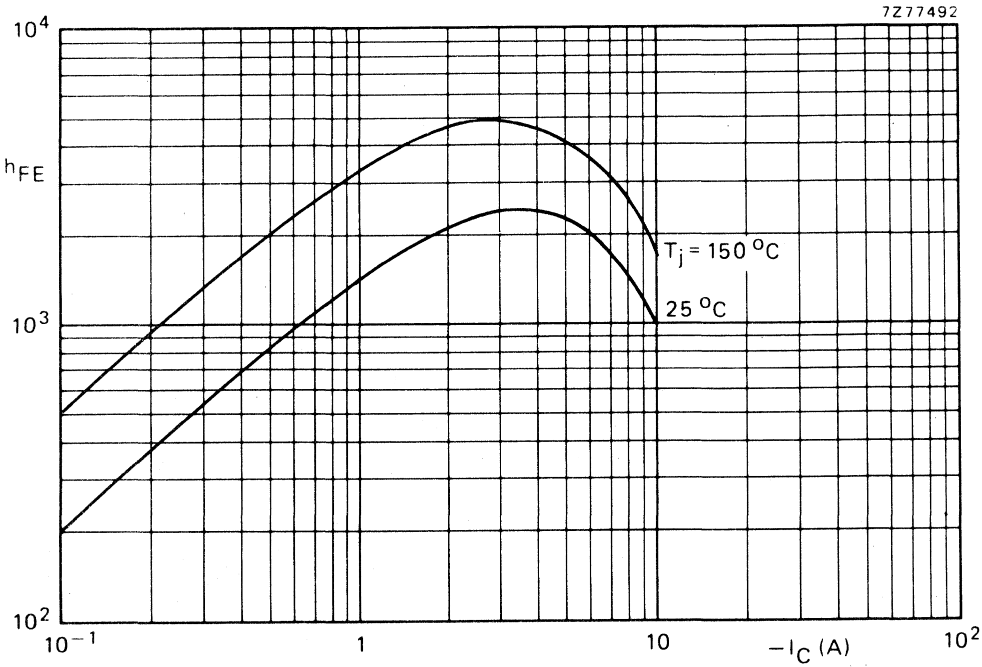


Fig. 12 Typical values; $-V_{CE}$ = 4 V.

Philips Components

Data sheet	
status	Product specification
date of issue	December 1990

BDV64F/64AF/64BF/64CF
PNP silicon Darlington power transistors

DESCRIPTION

PNP epitaxial base transistors in a monolithic Darlington circuit for audio output stages and general amplifier and switching applications. NPN complements are BDV65F/65AF/65BF/65CF.

PINNING - SOT199

PIN	DESCRIPTION
1	base
2	collector
3	emitter

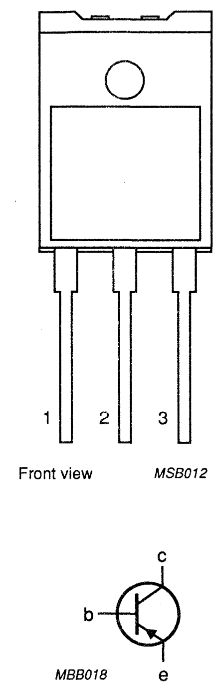
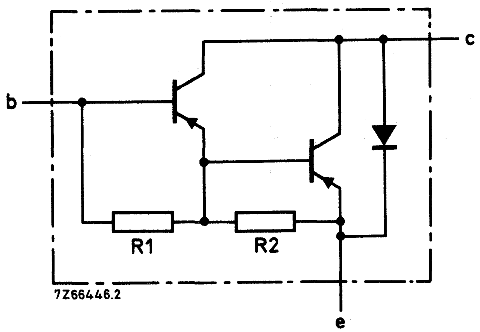


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter				
	BDV64F		-	-	60	V
	BDV64AF		-	-	80	V
	BDV64BF		-	-	100	V
	BDV64CF		-	-	120	V
$-V_{CEO}$	collector-emitter voltage	open base				
	BDV64F		-	-	60	V
	BDV64AF		-	-	80	V
	BDV64BF		-	-	100	V
	BDV64CF		-	-	120	V
$-I_C$	collector current	average value	-	-	12	A
P_{tot}	total power dissipation	$T_h = 25$ °C	-	-	50	W
T_j	junction temperature		-	-	150	°C
h_{FE}	DC current gain	$-I_C = 5$ A; $-V_{CE} = 4$ V	1000	-	-	
f_{hfe}	cut-off frequency	$-I_C = 5$ A; $-V_{CE} = 4$ V	-	100	-	kHz

PNP silicon Darlington power transistors BDV64F/64AF/64BF/64CF



R1 typ. 5 Ω
R2 typ. 80 Ω

Fig.2 Darlington circuit diagram.

PNP silicon Darlington power transistors BDV64F/64AF/64BF/64CF

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDV64F		-	60	V
	BDV64AF		-	80	V
	BDV64BF		-	100	V
	BDV64CF		-	120	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDV64F		-	60	V
	BDV64AF		-	80	V
	BDV64BF		-	100	V
	BDV64CF		-	120	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	12	A
$-I_{CM}$	collector current	peak value	-	20	A
$-I_B$	base current		-	0.5	A
P_{tot}	total power dissipation	T_h = 25 °C			
		note 1	-	50	W
		note 2	-	31	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j-h}$	from junction to external heatsink	note 1	2.5	K/W
$R_{th\ j-h}$	from junction to external heatsink	note 2	4.0	K/W
$R_{th\ j-h}$	from junction to internal heatsink		1	K/W

Notes

1. Mounted with heatsink compound and 30 ± 5 N pressure on centre of envelope.
2. Mounted without heatsink compound and 30 ± 5 N pressure on centre of envelope.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	-	-	400	µA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = 1/2\ -V_{CBO\ max}$; $T_j = 150$ °C	-	-	2	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE} = 1/2\ -V_{CEO\ max}$	-	-	0.2	mA
$-I_{EBO}$	emitter cut-off current	$I_C = 0$; $-V_{EB} = 5$ V	-	-	5	mA
h_{FE}	DC current gain	$-I_C = 1$ A; $-V_{CE} = 4$ V; note 1	-	1500	-	
h_{FE}	DC current gain	$-I_C = 5$ A; $-V_{CE} = 4$ V; note 1	1000	-	-	
h_{FE}	DC current gain	$-I_C = 10$ A; $-V_{CE} = 4$ V; note 1	-	1000	-	
$-V_{BE}$	base-emitter voltage	$-I_C = 5$ A; $-V_{CE} = 4$ V; notes 1 and 2	-	-	2.5	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C = 5$ A; $-I_B = 20$ mA; note 1	-	-	2	V
C_c	collector capacitance	f = 1 MHz; $I_E = i_e = 0$; $-V_{CB} = 10$ V	-	200	-	pF
f_{hfe}	cut-off frequency	$-I_C = 5$ A; $-V_{CE} = 4$ V	-	100	-	kHz
V_F	diode forward voltage	$I_F = 5$ A; $I_F = 12$ A	- -	1.8 2	- -	V V
t_{on}	switching times turn-on time	$-I_{C\ on} = 1.5$ A; $-I_{B\ on} = I_{B\ off} = 20$ mA; $-V_{CC} = 16$ V	-	0.5	-	µs
t_f	switching times fall time		-	1	-	µs
t_{off}	switching times turn-off time		-	2	-	µs

Note

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.
2. $-V_{BE}$ decreases by about 3.6 mV/K with increasing temperature.

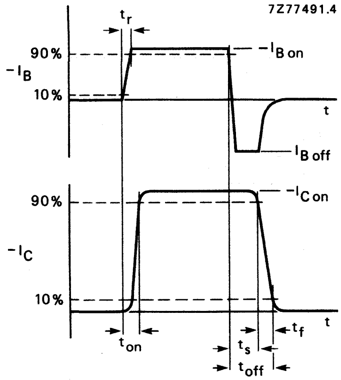
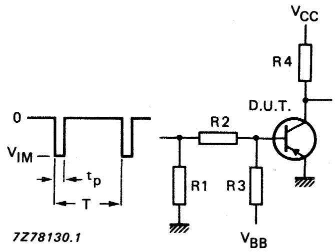
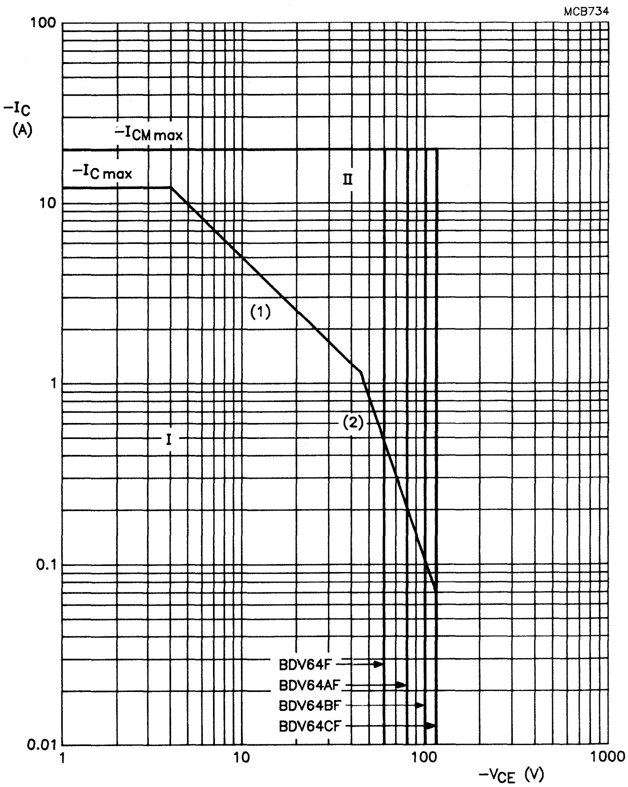


Fig.3 Switching times waveforms.



$-V_{IM}$	=	16.5	V
$-V_{CC}$	=	16	V
V_{BB}	=	6.5	V
R1	=	56	Ω
R2	=	410	Ω
R3	=	560	Ω
R4	=	3	Ω
$t_r = t_f$	=	15	ns
t_p	=	10	µs
T	=	500	µs

Fig.4 Switching times test circuit.



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

Fig.5 Safe operating area; T_h = 25 °C;

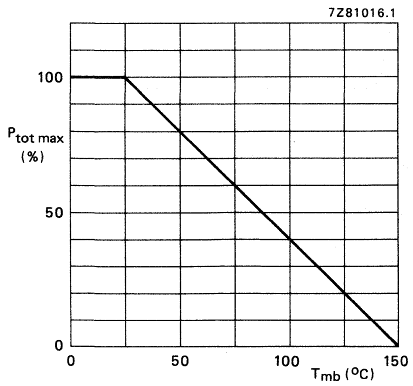


Fig.6 Power derating curve.

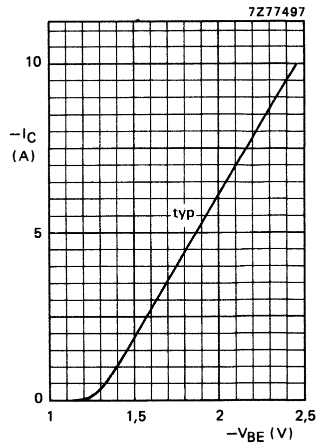


Fig.7 Collector current as a function of base-emitter voltage; $-V_{CE} = 4$ V; $T_j = 25°C$.

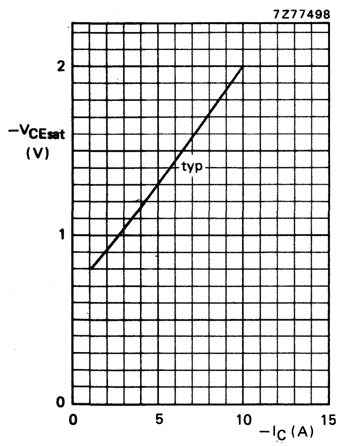


Fig.8 Collector-emitter saturation voltage as a function of collector current; $-I_C/I_B = 250$; $T_j = 25°C$.

PNP silicon Darlington power transistors BDV64F/64AF/64BF/64CF

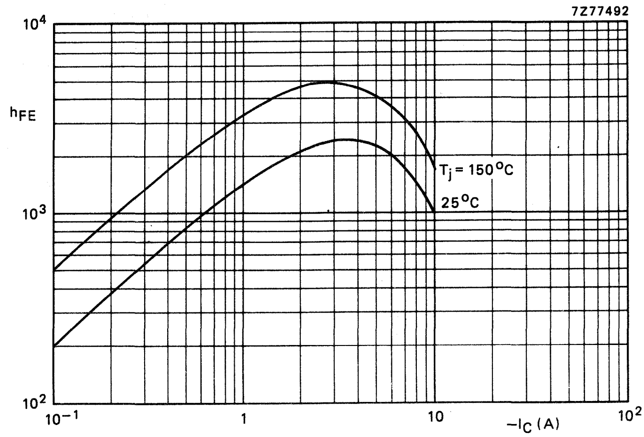


Fig.9 DC current gain; $-V_{CE}$ = 4 V; typical values.

PACKAGE OUTLINE

Dimensions in mm

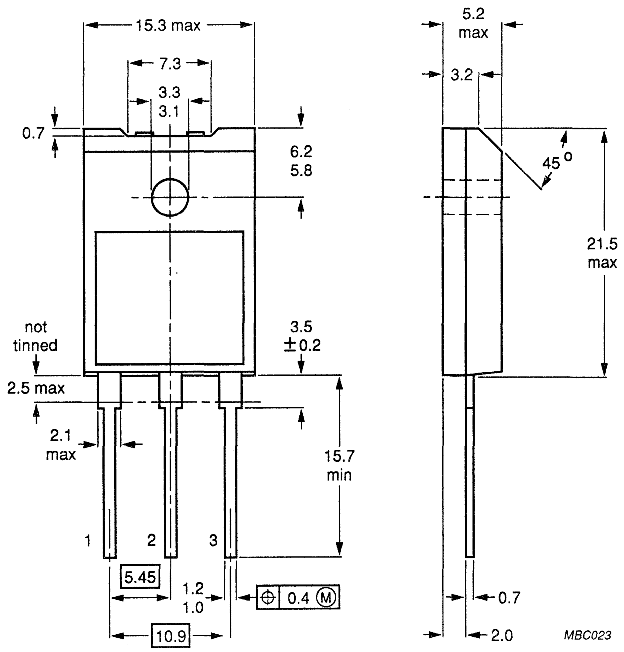


Fig.10 SOT199.

SILICON DARLINGTON POWER TRANSISTORS

NPN epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. PNP complements are BDV64, 64B and 64C.

QUICK REFERENCE DATA

			BDV65	A	B	C	
Collector-base voltage (open emitter	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (DC)	I_C	max.		12			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 1 A; V_{CE} = 4 V	h_{FE}	typ.		1500			
I_C = 5 A; V_{CE} = 4 V	h_{FE}	>		1000			
Cut-off frequency							
I_C = 5 A; V_{CE} = 4 V	f_{hfe}	typ.		70			kHz

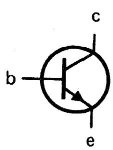
MECHANICAL DATA

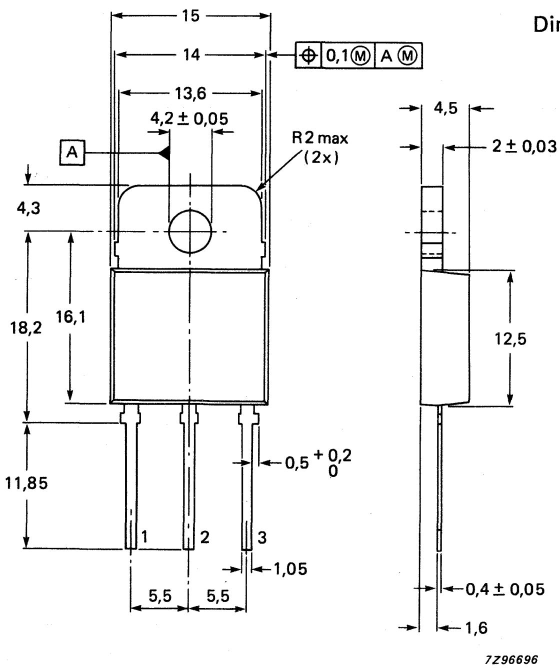
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting-base.

Pinning:
1 = base
2 = collector
3 = emitter





See also chapters Mounting instructions and Accessories.

CIRCUIT DIAGRAM

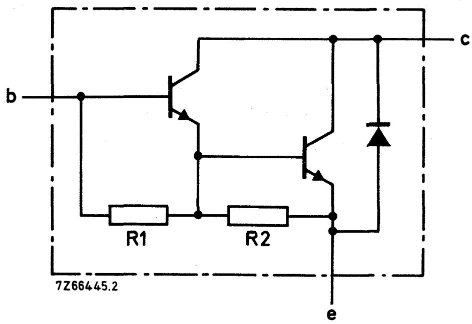


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV65	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C*

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	400	μA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	0,2	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5	mA

* 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.

D.C. current gain*			
I_C = 1 A; V_{CE} = 4 V	h_{FE}	typ.	1500
I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000
I_C = 10 A; V_{CE} = 4 V	h_{FE}	typ.	1750
Base-emitter voltage*			
I_C = 5 A; V_{CE} = 4 V	V_{BE}	<	2,5 V**
Collector-emitter saturation voltage*			
I_C = 5 A; I_B = 20 mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	150 pF
Cut-off frequency			
I_C = 5 A; V_{CE} = 4 V	f_{hfe}	typ.	70 kHz
Diode, forward voltage			
I_F = 5 A	V_F	typ.	1,2 V
I_F = 12 A	V_F	typ.	2 V
Switching times (see also Fig. 4)			
I_{Con} = 5 A; $I_{Bon} = -I_{Boff}$ = 20 mA; V_{CC} = 16 V			
Turn-on time	t_{on}	typ.	1 μs
Fall time	t_f	typ.	3 μs
Turn-off time	t_{off}	typ.	6 μs

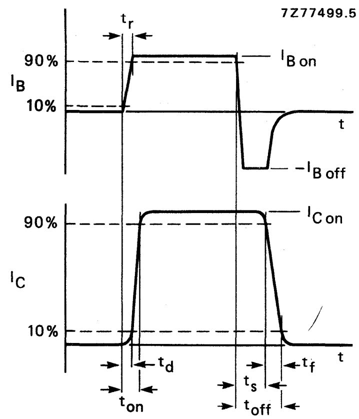


Fig. 3 Waveforms showing t_{on}; $t_s + t_f = t_{off}$.

* Measured under pulse conditions: $t_p < 300$ μs; $\delta < 2\%$.
** V_{BE} decreases by about 3,6 mV/K with increasing temperature.

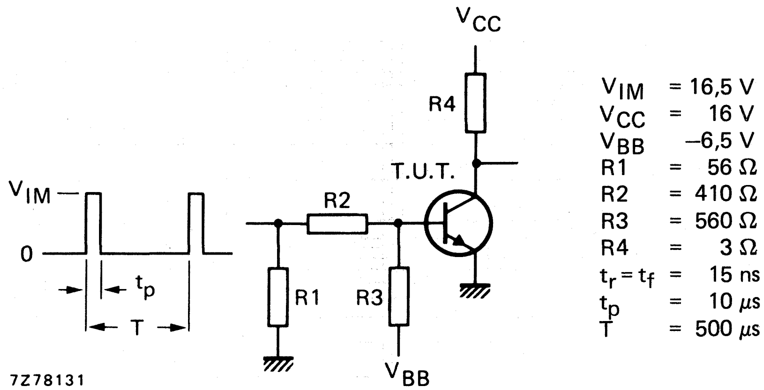


Fig. 4 Switching times test circuit.

Turn-off breakdown energy with inductive load (see also Fig. 5).

I_{Con} = 6,3 A; $-I_{Boff}$ = 0; t_p = 1 ms; T = 100 ms	$E_{(BR)}$	>	100 mJ

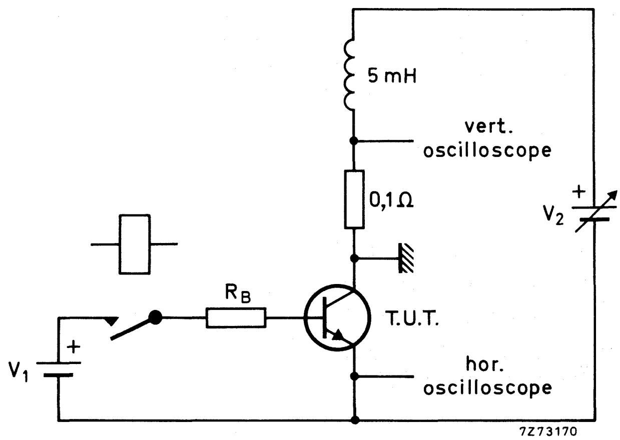


Fig. 5 Test circuit; V_1 = 12 V; R_B = 270 Ω.

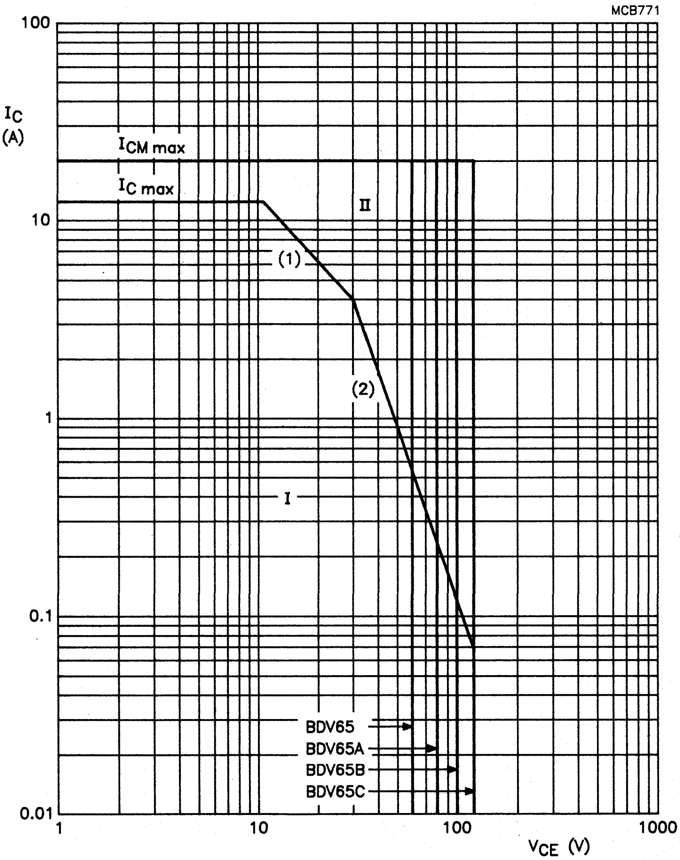


Fig. 6 Safe Operating Area; $T_{mb} \leq 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

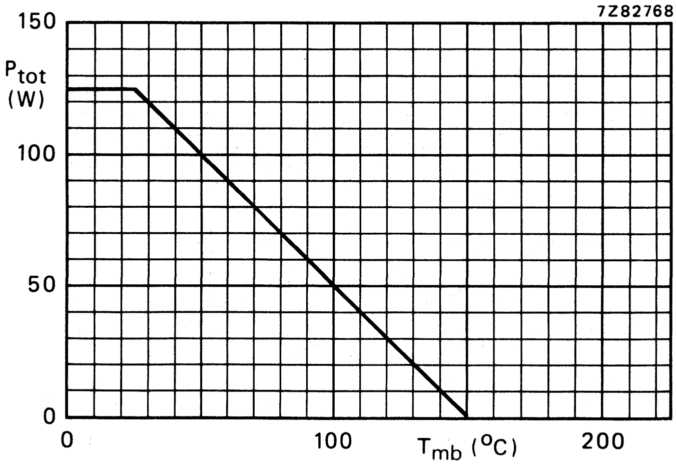


Fig. 7 Power derating curve.

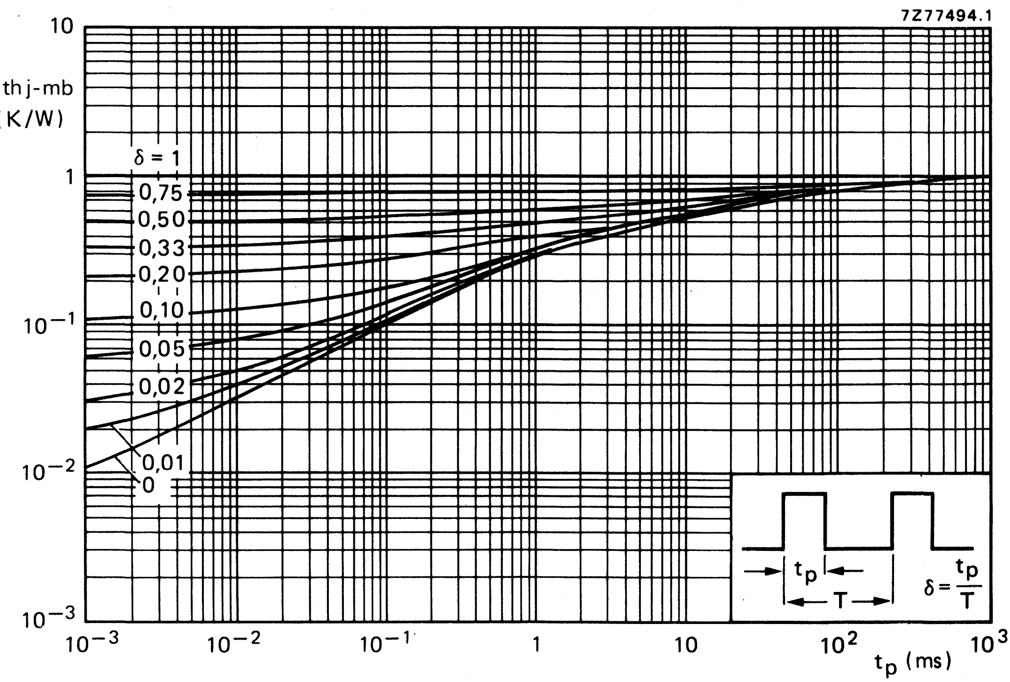


Fig. 8 Pulse power rating chart.

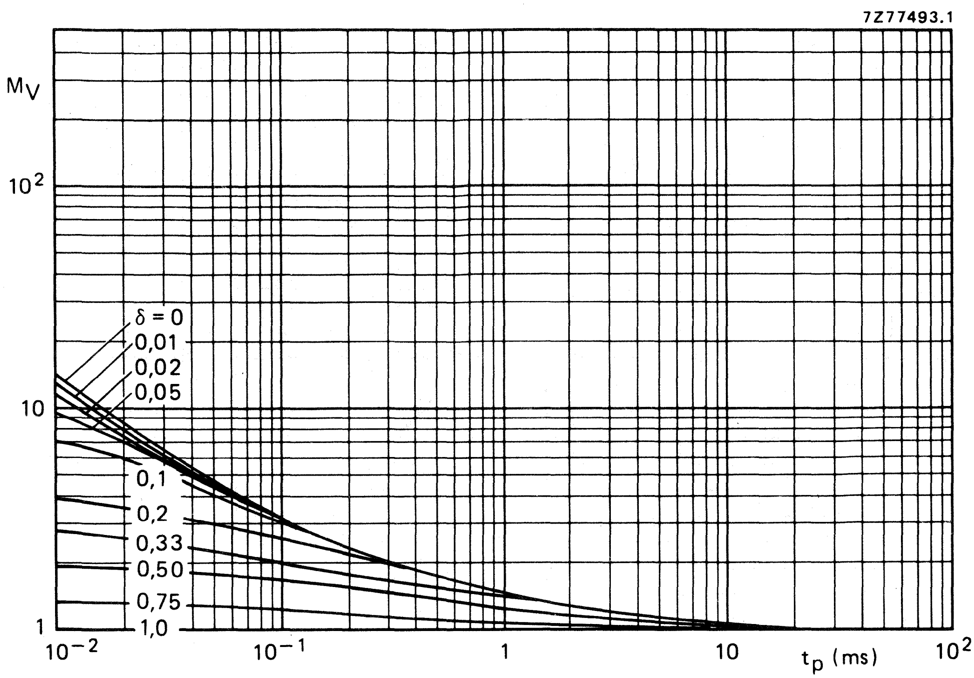


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

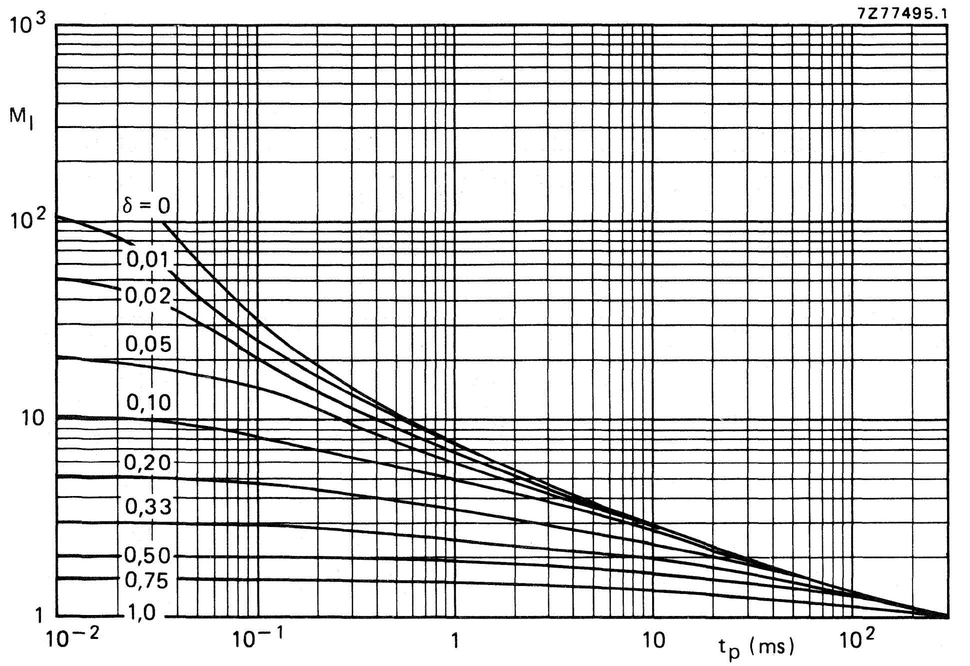


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level (100 V).

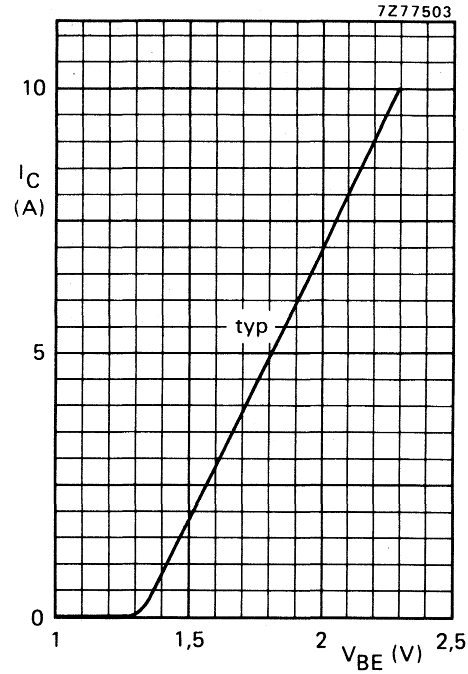


Fig. 11 V_{CE} = 4 V; T_j = 25 °C.

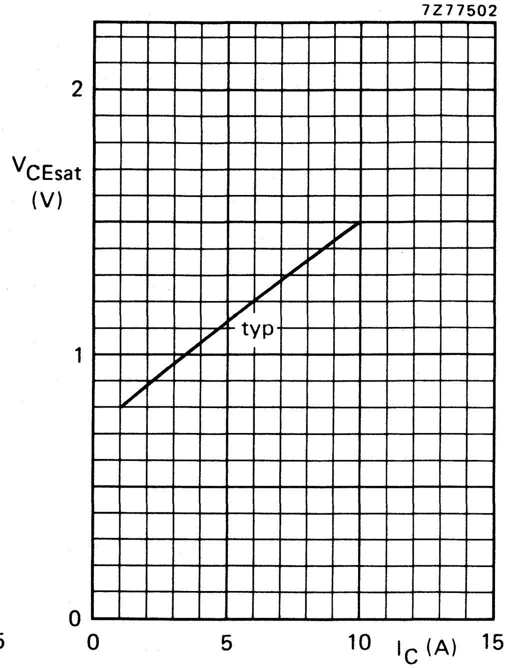


Fig. 12 I_C/I_B = 250; T_j = 25 °C.

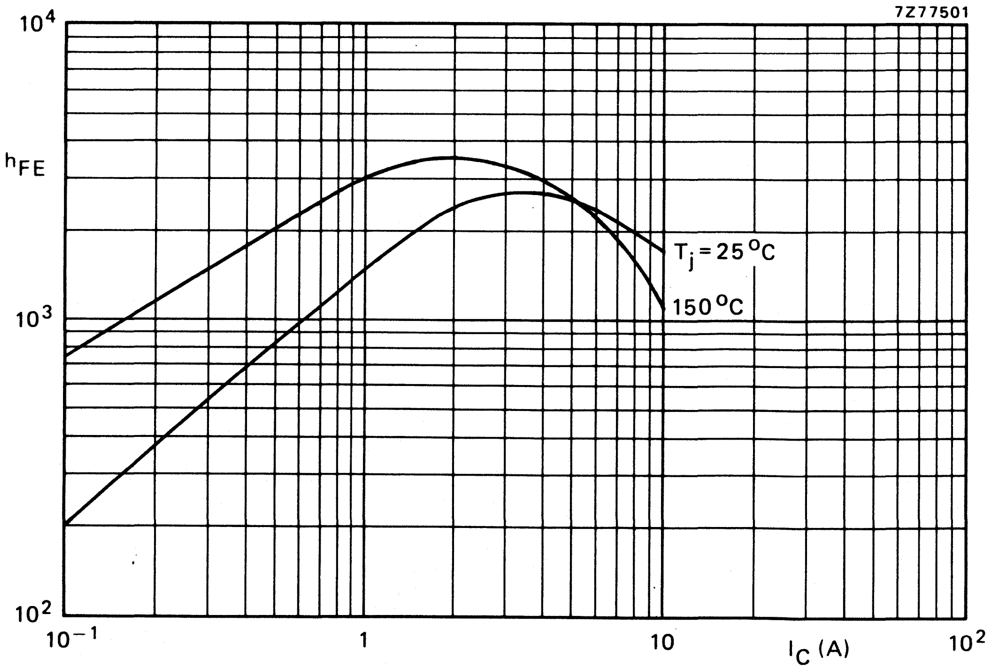


Fig. 13 Typical values; V_{CE} = 4 V.

Philips Components

Data sheet	
status	Product specification
date of issue	December 1990

BDV65F/65AF/65BF/65CF

NPN silicon Darlington power transistors

DESCRIPTION

NPN epitaxial base transistors in a monolithic Darlington circuit for audio output stages and general amplifier and switching applications. PNP complements are BDV64F/64AF/64BF/64CF.

PINNING - SOT199

PIN	DESCRIPTION
1	base
2	collector
3	emitter

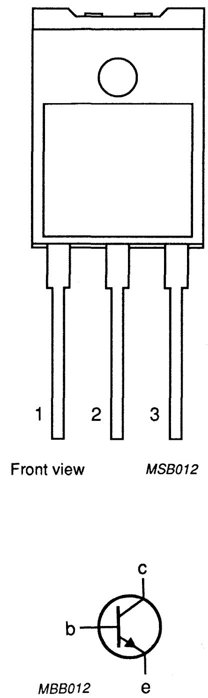
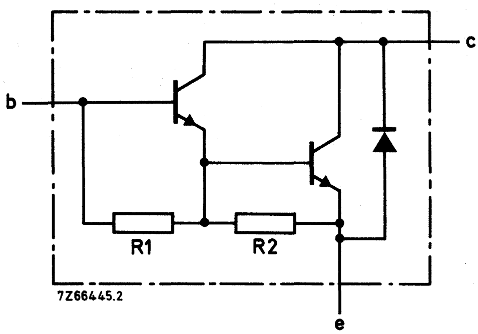


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter				
	BDV65F		-	-	60	V
	BDV65AF		-	-	80	V
	BDV65BF		-	-	100	V
	BDV65CF		-	-	120	V
V_{CEO}	collector-emitter voltage	open base				
	BDV65F		-	-	60	V
	BDV65AF		-	-	80	V
	BDV65BF		-	-	100	V
	BDV65CF		-	-	120	V
I_C	collector current	average value	-	-	12	A
P_{tot}	total power dissipation	T_h = 25 °C	-	-	50	W
T_j	junction temperature		-	-	150	°C
h_{FE}	DC current gain	I_C = 1 A; V_{CE} = 4 V	-	1500	-	
h_{FE}	DC current gain	I_C = 5 A; V_{CE} = 4 V	1000	-	-	
f_{hfe}	cut-off frequency	I_C = 5 A; V_{CE} = 4 V	-	70	-	kHz



R1 typ. 5 Ω
R2 typ. 80 Ω

Fig.2 Darlington circuit diagram.

NPN silicon Darlington power transistors BDV65F/65AF/65BF/65CF

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDV65F		-	60	V
	BDV65AF		-	80	V
	BDV65BF		-	100	V
	BDV65CF		-	120	V
V_{CEO}	collector-emitter voltage	open base			
	BDV65F		-	60	V
	BDV65AF		-	80	V
	BDV65BF		-	100	V
	BDV65CF		-	120	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	12	A
I_{CM}	collector current	peak value	-	20	A
I_B	base current		-	0.5	A
P_{tot}	total power dissipation	T_h = 25 °C			
		note 1	-	50	W
		note 2	-	31	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 1	2.5	K/W
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 2	4	K/W
$R_{th\ j\text{-}h}$	from junction to internal heatsink		1	K/W

Notes

1. Mounted with heatsink compound and 30 ± 5 N pressure on centre of envelope.
2. Mounted without heatsink compound and 30 ± 5 N pressure on centre of envelope.

NPN silicon Darlington power transistors BDV65F/65AF/65BF/65CF

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$	-	-	400	µA
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\ max}$; $T_j = 150$ °C	-	-	2	mA
I_{CEO}	collector cut-off current	$I_B = 0$; $V_{CE} = 1/2\ V_{CEO\ max}$	-	-	0.2	mA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	-	-	5	mA
h_{FE}	DC current gain	$I_C = 1$ A; $V_{CE} = 4$ V; note 1	-	1500	-	
h_{FE}	DC current gain	$I_C = 5$ A; $V_{CE} = 4$ V; note 1	1000	-	-	
h_{FE}	DC current gain	$I_C = 10$ A; $V_{CE} = 4$ V; note 1	-	1750	-	
V_{BE}	base-emitter voltage	$I_C = 5$ A; $V_{CE} = 4$ V; notes 1 and 2	-	-	2.5	V
$V_{CE\ sat}$	collector-emitter saturation voltage	$I_C = 5$ A; $I_B = 20$ mA; note 1	-	-	2	V
C_c	collector capacitance	f = 1 MHz; $I_E = i_e = 0$; $V_{CB} = 10$ V	-	150	-	pF
f_{hfe}	cut-off frequency	$I_C = 5$ A; $V_{CE} = 4$ V	-	70	-	kHz
V_F	diode forward voltage	$I_F = 5$ A; $I_F = 12$ A	- -	1.2 2	- -	V V
t_{on}	switching times turn-on time	$I_{C\ on} = 5$ A; $I_{B\ on} = I_{B\ off} = 20$ mA; $V_{CC} = 16$ V	-	1	-	µs
t_f	switching times fall time		-	3	-	µs
t_{off}	switching times turn-off time		-	6	-	µs

Notes

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.
2. V_{BE} decreases by about 3.6 mV/K with increasing temperature.

NPN silicon Darlington power transistors | BDV65F/65AF/65BF/65CF

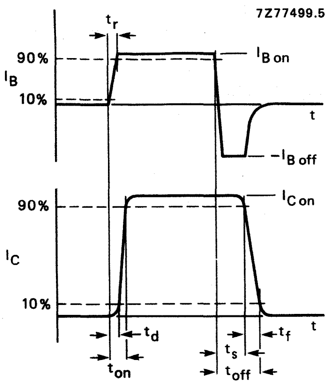
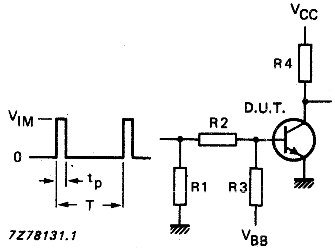


Fig.3 Switching times waveforms.



V_{IM}	=	16.5	V
V_{CC}	=	16	V
V_{BB}	=	−6.5	V
R1	=	56	Ω
R2	=	410	Ω
R3	=	560	Ω
R4	=	3	Ω
$t_r = t_f$	=	15	ns
t_p	=	10	µs
T	=	500	µs

Turn-off breakdown energy with inductive load.
$I_{C\,on}$ = 6.3 A; $-I_{B\,off}$ = 0; t_p = 1 ms; T = 100 ms; $E_{(BR)}$ > 100 mJ.

Fig.4 Switching times test circuit.

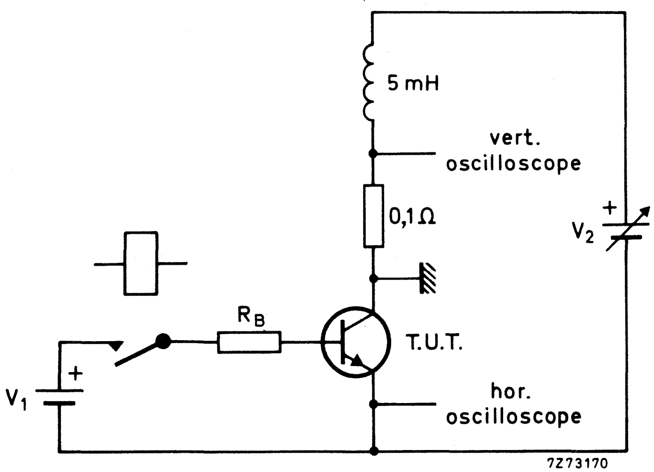
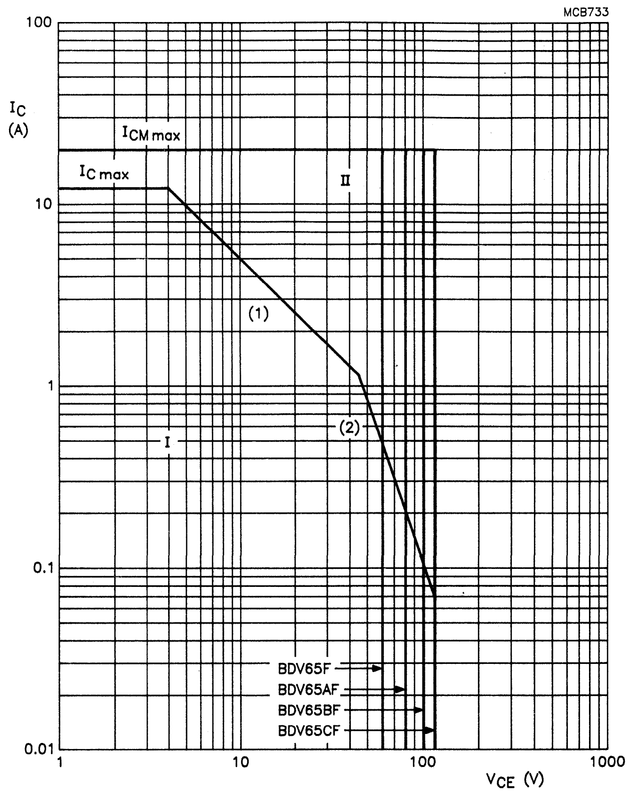


Fig.5 Test circuit; V_1 = 12 V; R_B = 270 Ω.

NPN silicon Darlington power transistors BDV65F/65AF/65BF/65CF



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

Fig.6 Safe operating area; T_h = 25 °C;

NPN silicon Darlington power transistors BDV65F/65AF/65BF/65CF

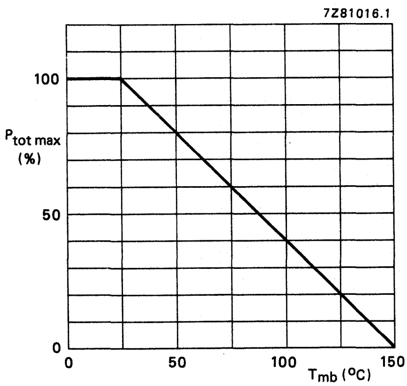


Fig.7 Power derating curve.

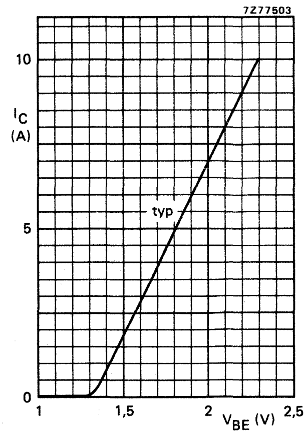


Fig.8 Collector current as a function of base-emitter voltage; V_{CE} = 4 V; T_j = 25 °C.

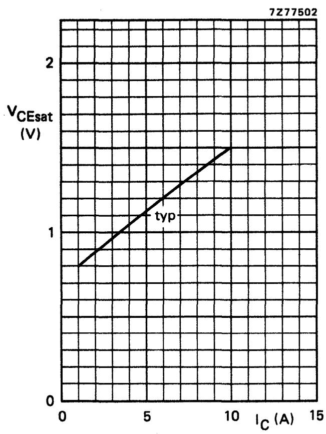


Fig.9 Collector-emitter saturation voltage as a function of collector current; I_C/I_B = 250; T_j = 25°C.

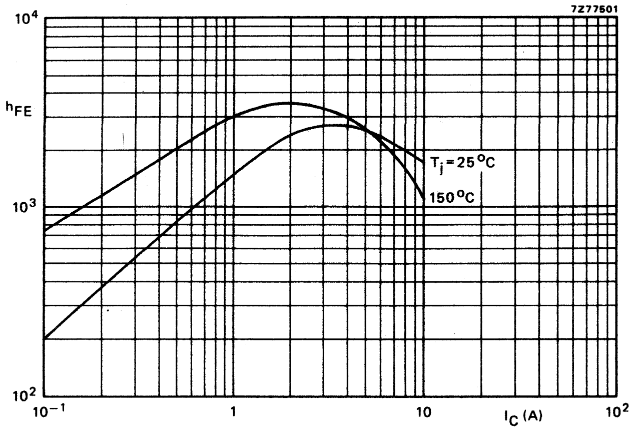


Fig.10 DC current gain; V_{CE} = 4 V; typical values.

PACKAGE OUTLINE

Dimensions in mm

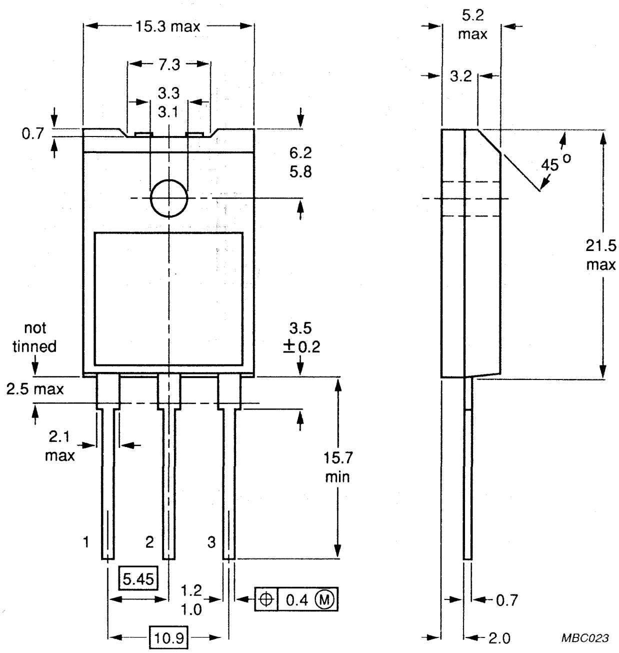


Fig.11 SOT199.

DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base Darlington transistors for audio output stages and general amplifier and switching applications. N-P-N complements are BDV67A; B; C and D. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

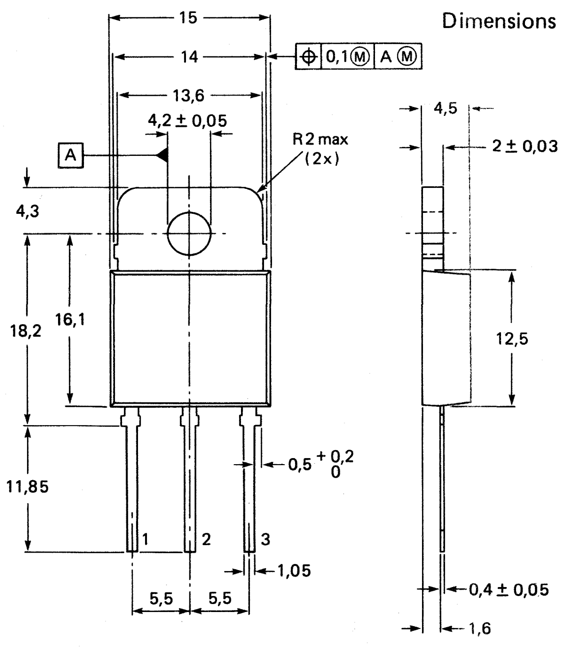
			BDV66A	B	C	D	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80	100	120	150	V
Collector current (d.c.)	$-I_C$	max.	16				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	175				W
Junction temperature	T_j	max.	150				°C
D.C. current gain							
$-I_C$ = 1 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	3000				
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE}	>	1000				
Cut-off frequency							
$-I_C$ = 5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	60				kHz

MECHANICAL DATA

Fig. 1 SOT-93

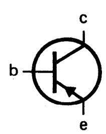
Dimensions in mm

Collector connected to mounting base.



Pinning

1 = base
2 = collector
3 = emitter



See also chapters Mounting instructions and Accessories.

CIRCUIT DIAGRAM

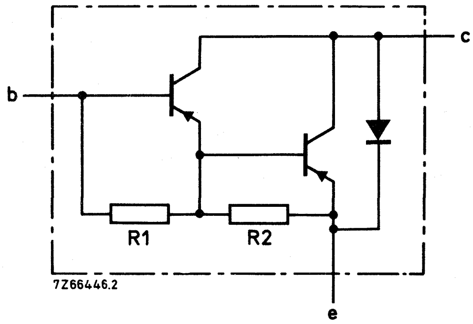


Fig. 2.
R1 typical 3 kΩ
R2 typical 80 Ω

RATINGS

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

			BDV66A	B	C	D	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80	100	120	150	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	16				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Base current (d.c.)	$-I_B$	max.	0,5				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	175				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature*	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base*	$R_{th\ j\text{-}mb}$	=	0,625	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	1	mA
$I_E = 0; -V_{CB} = -½V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	4	mA
$I_B = 0; -V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA

* 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.

D.C. current gain*			
$-I_C$ = 1 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	3000
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE}	>	1000
$-I_C$ = 16 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	1000
Base-emitter voltage**			
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage*			
$-I_C$ = 10 A; $-I_B$ = 40 mA	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	300 pF
Cut-off frequency			
$-I_C$ = 5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	60 kHz
Diode, forward voltage			
I_F = 10 A	V_F	<	3 V
D.C. current gain ratio of matched complementary pairs			
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	<	2,5
Small-signal current gain			
$-I_C$ = 5 A; $-V_{CE}$ = 3 V; f = 1 MHz	h_{fe}	typ.	40
Switching times			
$-I_{Con}$ = 10 A; $-I_{Bon} = I_{Boff}$ = 40 mA; V_{CC} = −12 V			
Turn-on time	t_{on}	typ.	1 μs
Turn-off time	t_{off}	typ.	3,5 μs

* Measured under pulse conditions: $t_p < 300$ μs; $\delta < 2\%$.
** $-V_{BE}$ decreases by about 3,6 mV/K with increasing temperature.

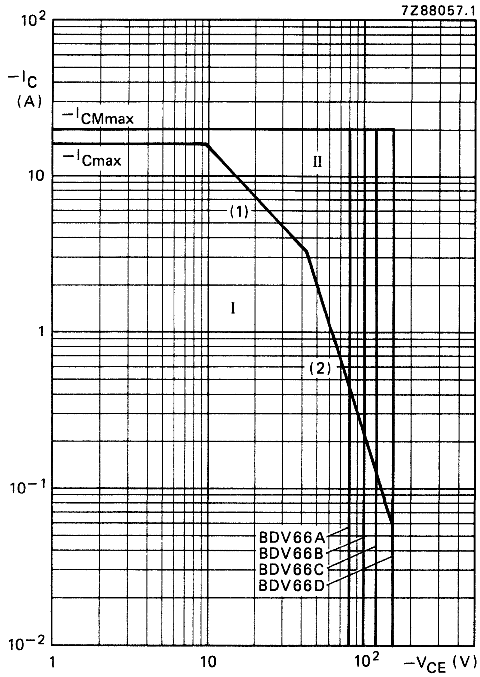


Fig. 3 Safe Operating Area; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

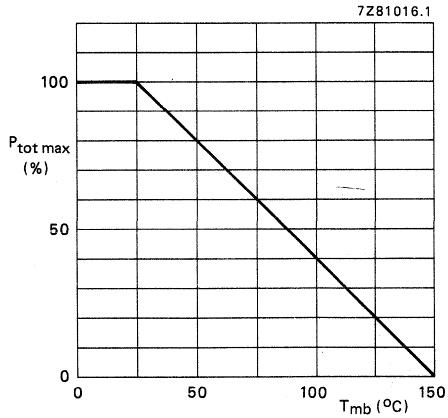


Fig. 4 Power derating curve.

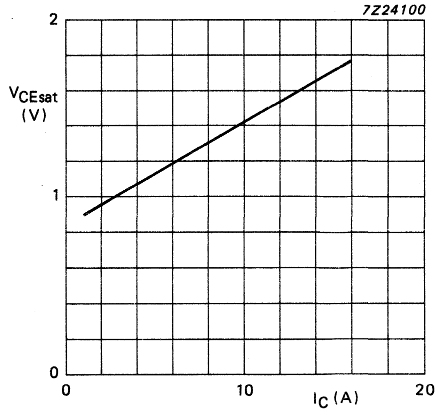


Fig. 5 Typical collector-emitter saturation voltage $-I_C/-I_B = 250$; $T_{mb} = 25\ ^oC$.

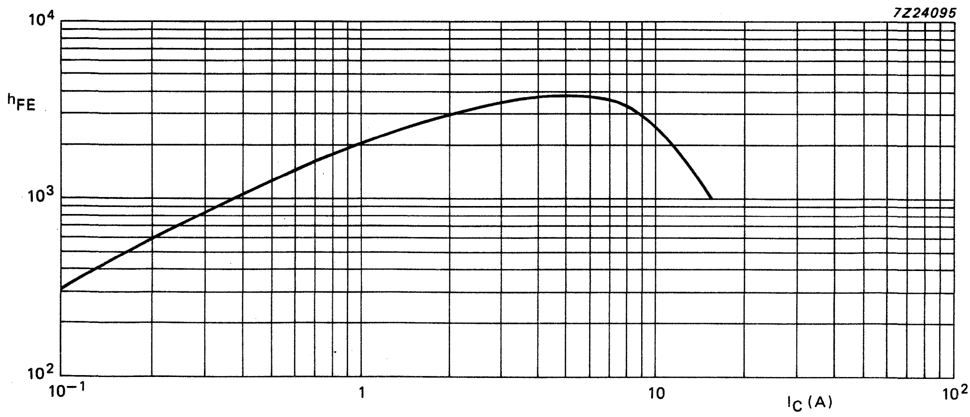


Fig. 6 Typical DC current gain $-V_{CE} = 3$ V; $T_j = 25\ ^oC$.

Philips Components

Data sheet	
status	Product specification
date of issue	December 1990

BDV66AF/66BF/66CF/66DF

PNP Darlington power transistors

DESCRIPTION

PNP epitaxial base Darlington transistors for audio output stages and general amplifier and switching applications. NPN complements are BDV67AF/67BF/67CF/67DF. Matched complementary pairs can be supplied.

PINNING - SOT199

PIN	DESCRIPTION
1	base
2	collector
3	emitter

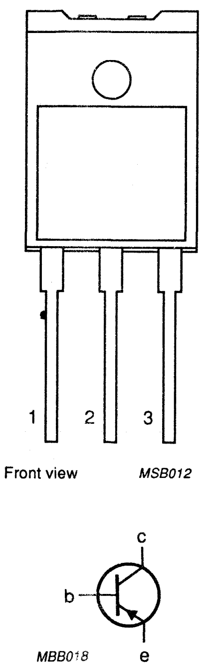
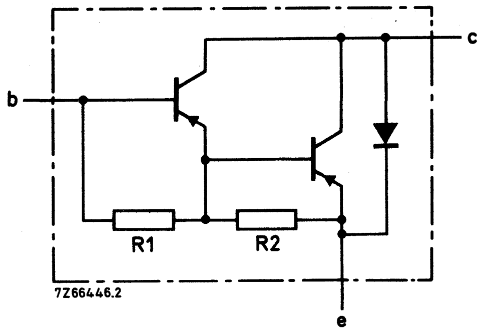


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter				
	BDV66AF		-	-	100	V
	BDV66BF		-	-	120	V
	BDV66CF		-	-	140	V
	BDV66DF		-	-	160	V
$-V_{CEO}$	collector-emitter voltage	open base				
	BDV66AF		-	-	80	V
	BDV66BF		-	-	100	V
	BDV66CF		-	-	120	V
	BDV66DF		-	-	150	V
$-I_C$	collector current	average value	-	-	16	A
$-I_{CM}$	collector current	peak value	-	-	20	A
P_{tot}	total power dissipation	T_h = 25 °C	-	-	60	W
T_j	junction temperature		-	-	150	°C
h_{FE}	DC current gain	$-I_C$ = 1 A; $-V_{CE}$ = 3 V	-	3000	-	
h_{FE}	DC current gain	$-I_C$ = 10 A; $-V_{CE}$ = 3 V	1000	-	-	
f_{hfe}	cut-off frequency	$-I_C$ = 5 A; $-V_{CE}$ = 3 V	-	60	-	kHz

PNP Darlington power transistors BDV66AF/66BF/66CF/66DF



R1 typ. 3 Ω
R2 typ. 80 Ω

Fig.2 Darlington circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{CBO}$	collector-base voltage	open emitter			
	BDV66AF		-	100	V
	BDV66BF		-	120	V
	BDV66CF		-	140	V
	BDV66DF		-	160	V
$-V_{CEO}$	collector-emitter voltage	open base			
	BDV66AF		-	80	V
	BDV66BF		-	100	V
	BDV66CF		-	120	V
	BDV66DF		-	150	V
$-V_{EBO}$	emitter-base voltage	open collector	-	5	V
$-I_C$	collector current	average value	-	16	A
$-I_{CM}$	collector current	peak value	-	20	A
$-I_B$	base current		-	0.5	A
P_{tot}	total power dissipation	T_h = 25 °C			
		note 1	-	60	W
		note 2	-	35	W
T_{stg}	storage temperature range		−65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 1	2.08	K/W
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 2	3.57	K/W
$R_{th\ j\text{-}h}$	from junction to internal heatsink		0.625	K/W

Notes

1. Mounted with heatsink compound and 30 ± 5 N pressure on centre of envelope.
2. Mounted without heatsink compound and 30 ± 5 N pressure on centre of envelope.

CHARACTERISTICS

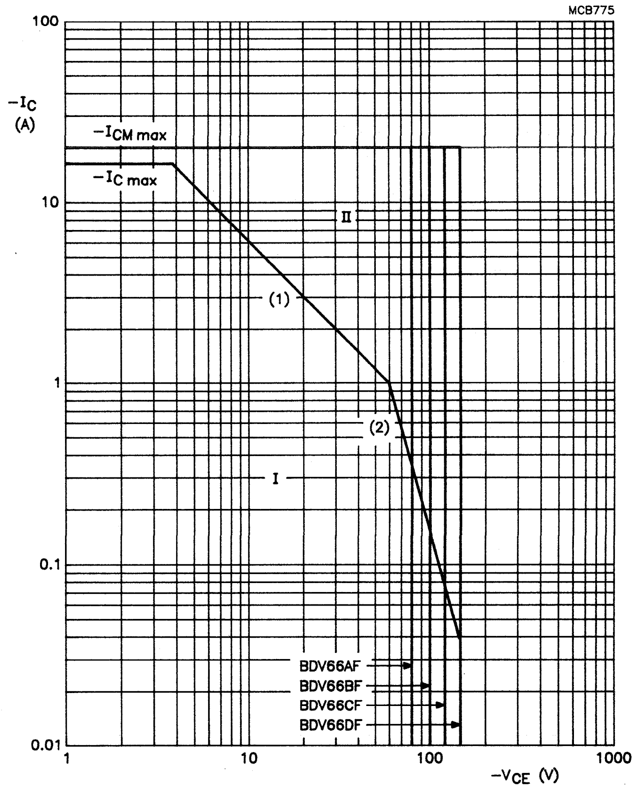
T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -V_{CBO\ max}$	-	-	1	mA
$-I_{CBO}$	collector cut-off current	$I_E = 0$; $-V_{CB} = -1/2\ V_{CBO\ max}$; T_j = 150 °C	-	-	4	mA
$-I_{CEO}$	collector cut-off current	$I_B = 0$; $-V_{CE} = -1/2\ V_{CEO\ max}$	-	-	1	mA
$-I_{EBO}$	emitter cut-off current	$I_C = 0$; $-V_{EB}$ = 5 V	-	-	5	mA
h_{FE}	DC current gain	$-I_C$ = 1 A; $-V_{CE}$ = 3 V; note 1	-	3000	-	
h_{FE}	DC current gain	$-I_C$ = 10 A; $-V_{CE}$ = 3 V; note 1	1000	-	-	
h_{FE}	DC current gain	$-I_C$ = 16 A; $-V_{CE}$ = 3 V; note 1	-	1000	-	
$-V_{BE}$	base-emitter voltage	$-I_C$ = 10 A; $-V_{CE}$ = 3 V; note 2	-	-	2.5	V
$-V_{CE\ sat}$	collector-emitter saturation voltage	$-I_C$ = 10 A; $-I_B$ = 40 mA; note 1	-	-	2	V
C_c	collector capacitance	f = 1 MHz; $I_E = i_e = 0$; $-V_{CB}$ = 10 V	-	300	-	pF
f_{hfe}	cut-off frequency	$-I_C$ = 5 A; $-V_{CE}$ = 3 V	-	60	-	kHz
$-V_F$	diode forward voltage	I_F = 10 A	-	-	3	V
h_{FE1}/h_{FE2}	DC current gain ratio of matched complementary pairs	$-I_C$ = 10 A; $-V_{CE}$ = 3 V	-	-	2.5	
h_{fe}	small-signal current gain	f = 1 MHz; $-I_C$ = 5 A; $-V_{CE}$ = 3 V	-	40	-	
t_{on}	switching times turn-on time	$-I_{C\ on}$ = 10 A; $-I_{B\ on} = I_{B\ off}$ = 40 mA; $-V_{CC}$ = 12 V	-	1	-	µs
t_{off}	switching times turn-off time		-	3.5	-	µs

Notes

1. Measured under pulse conditions: t_p < 300 µs, duty cycle < 2%.
2. $-V_{BE}$ decreases by about 3.6 mV/K with increasing temperature.

PNP Darlington power transistors BDV66AF/66BF/66CF/66DF



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ line.
(2) Second breakdown limits.

Fig.3 Safe operating area; T_h = 25 °C;

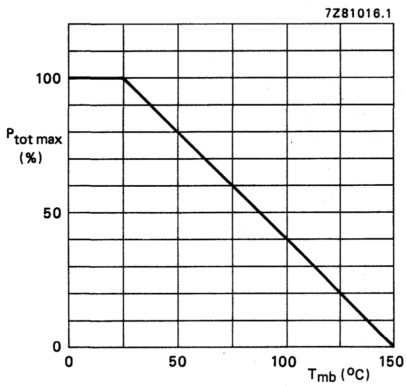


Fig.4 Power derating curve.

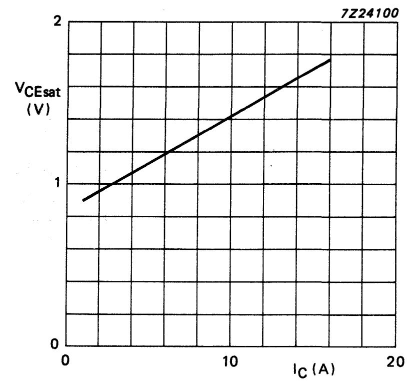


Fig.5 Collector-emitter saturation voltage as a function of collector current; $-I_C/-I_B = 250$; $T_h = 25$ °C.

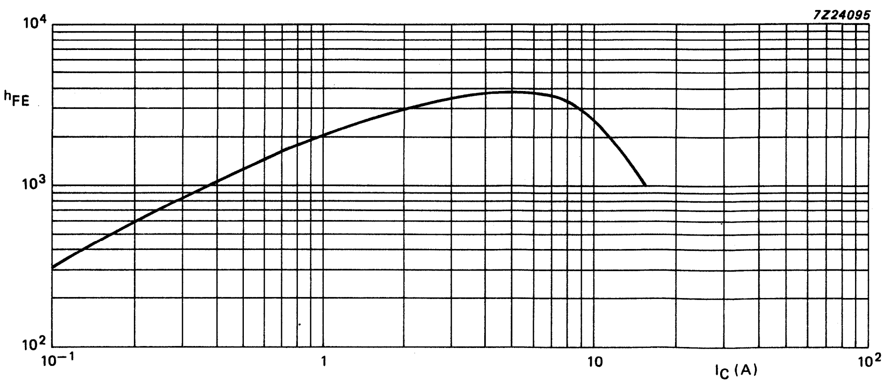


Fig.6 DC current gain; $-V_{CE} = 3$ V; $T_j = 25$ °C; typical values.

PACKAGE OUTLINE

Dimensions in mm

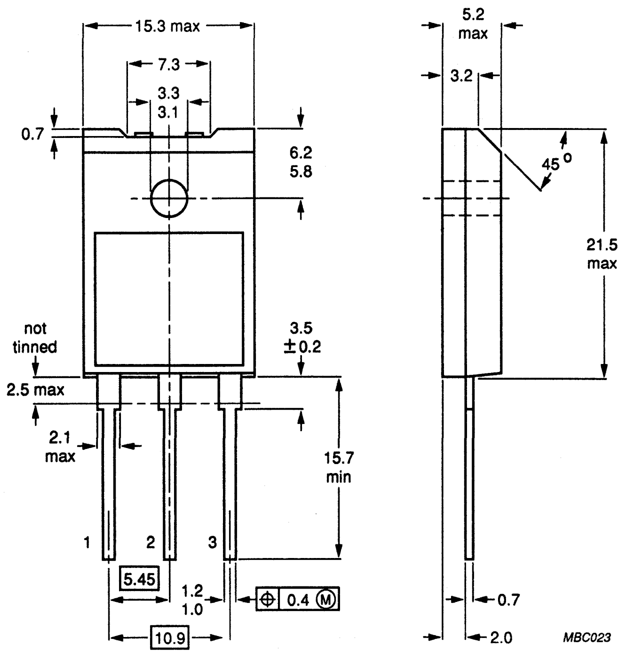


Fig.7 SOT199.

DARLINGTON POWER TRANSISTORS

NPN epitaxial base Darlington transistors for audio output stages and general amplifier and switching applications. PNP complements are BDV66A, B, C and D. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

			BDV67A	B	C	D	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	100	120	150	V
Collector current (DC)	I_C	max.		16			A
Collector current (peak value)	I_{CM}	max.		20			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		200			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.		3000			
I_C = 10 A; V_{CE} = 3 V	h_{FE}	>		1000			
Cut-off frequency							
I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.		60			kHz

MECHANICAL DATA

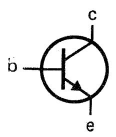
Dimensions in mm

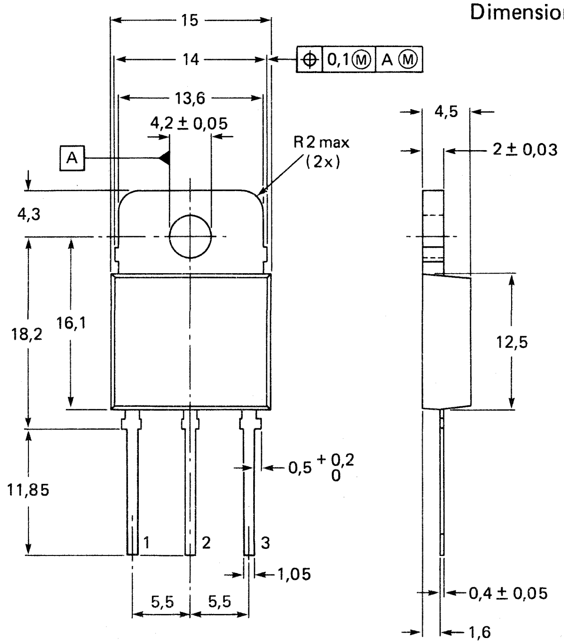
Fig. 1 SOT-93.

Collector connected to mounting-base.

Pinning:

1 = base
2 = collector
3 = emitter





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See also chapters Mounting instructions and Accessories.

CIRCUIT DIAGRAM

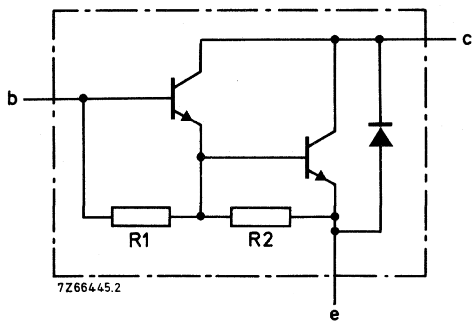


Fig. 2.
R1 typical 3 kΩ
R2 typical 80 Ω

RATINGS

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

			BDV67A	B	C	D	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	100	120	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	16	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	200	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature*	T_j	max.	150	°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0,625	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	1	mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	4	mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5	mA

* 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.

D.C. current gain*			
I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.	3000
I_C = 10 A; V_{CE} = 3 V	h_{FE}	>	1000
I_C = 16 A; V_{CE} = 3 V	h_{FE}	typ.	1000
Base-emitter voltage**			
I_C = 10 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage*			
I_C = 10 A; I_B = 40 mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	300 pF
Cut-off frequency			
I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.	60 kHz
Diode, forward voltage			
I_F = 10 A	V_F	<	3 V
D.C. current gain ratio of matched complementary pairs			
I_C = 10 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5
Small-signal current gain			
I_C = 5 A; V_{CE} = 3 V; f = 1 MHz	h_{fe}	typ.	40
Turn-off breakdown energy with inductive load (see also Fig. 3).			
I_{Con} = 6,3 A; $-I_{Boff}$ = 0; t_p = 1 ms; T = 100 ms	$E_{(BR)}$	>	150 mJ
Switching times			
I_{Con} = 10 A; $I_{Bon} = -I_{Boff}$ = 40 mA; V_{CC} = 12 V			
Turn-on time	t_{on}	typ.	1 μs
Turn-off time	t_{off}	typ.	3,5 μs

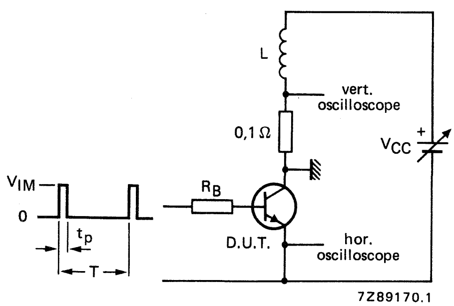


Fig. 3 Test circuit; V_1 = 12 V; R_B = 270 Ω.

* Measured under pulse conditions: t_p < 300 μs; δ < 2%.
** V_{BE} decreases by about 3,6 mV/K with increasing temperature.

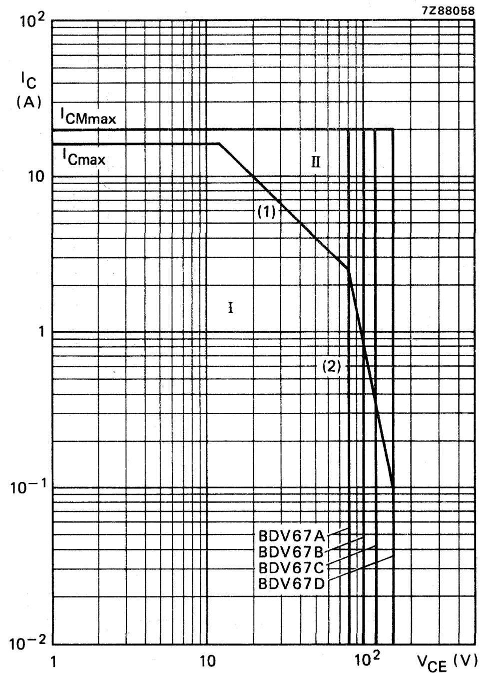


Fig. 4 Safe Operating Area; $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible DC operation.
II Permissible extension for repetitive operation.

(1) $P_{tot\ max}$ line.
(2) Second breakdown limits.

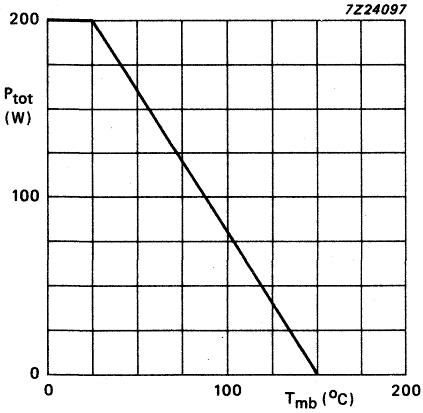


Fig. 5 Power derating curve.

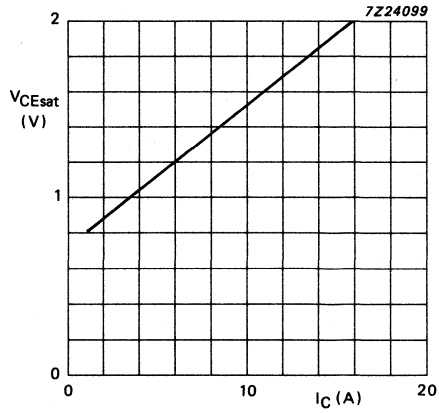


Fig. 6 Typical collector-emitter saturation voltage at T_{mb} = 25 °C; I_C/I_B = 250.

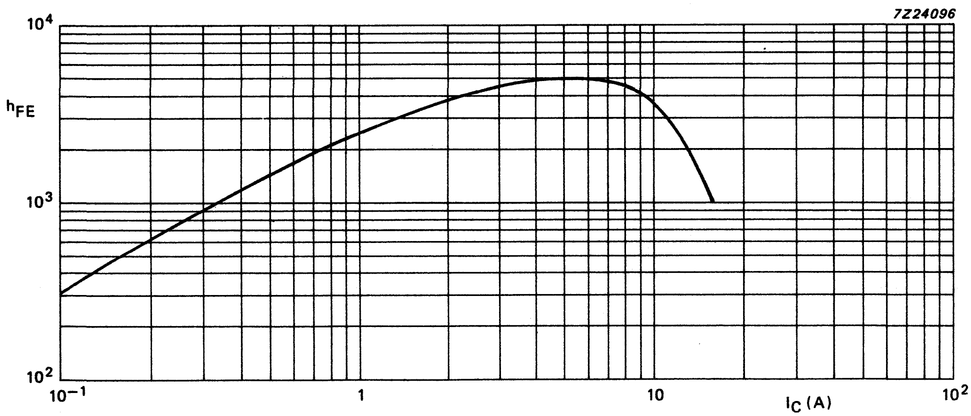


Fig. 7 Typical DC current gain at V_{CE} = 3 V.

Philips Components

Data sheet	
status	Product specification
date of issue	December 1990

BDV67AF/67BF/67CF/67DF

NPN Darlington power transistors

DESCRIPTION

NPN epitaxial base Darlington transistors for audio output stages and general amplifier and switching applications. PNP complements are BDV66AF/66BF/66CF/66DF. Matched complementary pairs can be supplied.

PINNING - SOT199

PIN	DESCRIPTION
1	base
2	collector
3	emitter

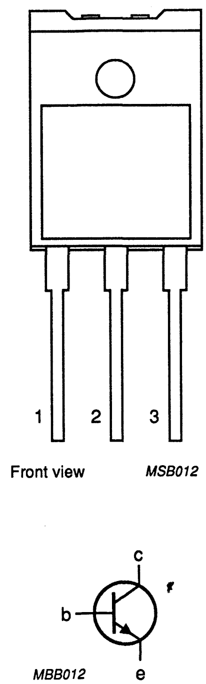
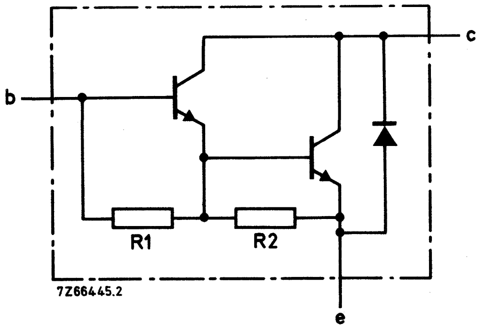


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter				
	BDV67AF		-	-	100	V
	BDV67BF		-	-	120	V
	BDV67CF		-	-	140	V
	BDV67DF		-	-	160	V
V_{CEO}	collector-emitter voltage	open base				
	BDV67AF		-	-	80	V
	BDV67BF		-	-	100	V
	BDV67CF		-	-	120	V
	BDV67DF		-	-	150	V
I_C	collector current	average value	-	-	16	A
I_{CM}	collector current	peak value	-	-	20	A
P_{tot}	total power dissipation	$T_h = 25$ °C	-	-	60	W
T_j	junction temperature		-	-	150	°C
h_{FE}	DC current gain	$I_C = 1$ A; $V_{CE} = 3$ V	-	3000	-	
h_{FE}	DC current gain	$I_C = 10$ A; $V_{CE} = 3$ V	1000	-	-	
f_{hfe}	cut-off frequency	$I_C = 5$ A; $V_{CE} = 3$ V	-	60	-	kHz

NPN Darlington power transistors BDV67AF/67BF/67CF/67DF



R1 typ. 3 Ω
R2 typ. 80 Ω

Fig.2 Darlington circuit diagram.

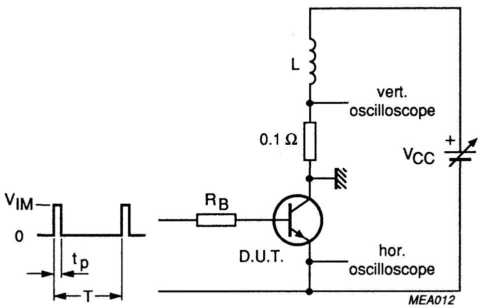


Fig.3 Test circuit; V_1 = 12 V; R_B = 270 Ω.

NPN Darlington power transistors BDV67AF/67BF/67CF/67DF

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BDV67AF		-	100	V
	BDV67BF		-	120	V
	BDV67CF		-	140	V
	BDV67DF		-	160	V
V_{CEO}	collector-emitter voltage	open base			
	BDV67AF		-	80	V
	BDV67BF		-	100	V
	BDV67CF		-	120	V
	BDV67DF		-	150	V
V_{EBO}	emitter-base voltage	open collector	-	5	V
I_C	collector current	average value	-	16	A
I_{CM}	collector current	peak value	-	20	A
I_B	base current		-	0.5	A
P_{tot}	total power dissipation	T_h = 25 °C			
		note 1	-	60	W
		note 2	-	35	W
T_{stg}	storage temperature range		–65	+150	°C
T_j	junction temperature		-	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 1	2.08	K/W
$R_{th\ j\text{-}h}$	from junction to external heatsink	note 2	3.57	K/W
$R_{th\ j\text{-}h}$	from junction to internal heatsink		0.625	K/W

Notes

1. Mounted with heatsink compound and 30 ± 5 N pressure on centre of envelope.
2. Mounted without heatsink compound and 30 ± 5 N pressure on centre of envelope.

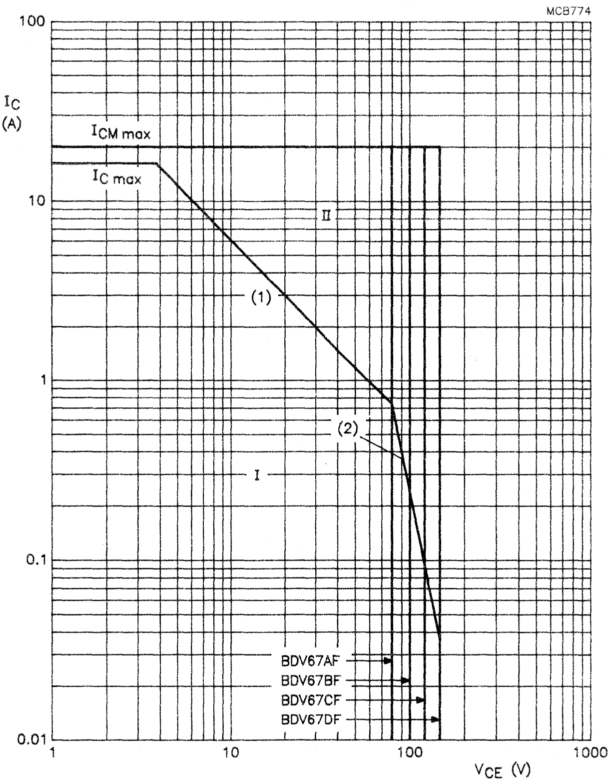
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = V_{CBO\ max}$	-	-	1	mA
I_{CBO}	collector cut-off current	$I_E = 0$; $V_{CB} = 1/2\ V_{CBO\ max}$; $T_j = 150$ °C	-	-	4	mA
I_{CEO}	collector cut-off current	$I_B = 0$; $V_{CE} = 1/2\ V_{CEO\ max}$	-	-	1	mA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	-	-	5	mA
h_{FE}	DC current gain	$I_C = 1$ A; $V_{CE} = 3$ V; note 1	-	3000	-	
h_{FE}	DC current gain	$I_C = 10$ A; $V_{CE} = 3$ V; note 1	1000	-	-	
h_{FE}	DC current gain	$I_C = 16$ A; $V_{CE} = 3$ V; note 1	-	1000	-	
V_{BE}	base-emitter voltage	$I_C = 10$ A; $V_{CE} = 3$ V; note 2	-	-	2.5	V
$V_{CE\ sat}$	collector-emitter saturation voltage	$I_C = 10$ A; $I_B = 40$ mA; note 1	-	-	2	V
C_c	collector capacitance	f = 1 MHz; $I_E = i_e = 0$; $V_{CB} = 10$ V	-	300	-	pF
f_{hfe}	cut-off frequency	$I_C = 5$ A; $V_{CE} = 3$ V	-	60	-	kHz
V_F	diode forward voltage	$I_F = 10$ A	-	-	3	V
h_{FE1}/ h_{FE2}	DC current gain ratio of matched complementary pairs	$I_C = 10$ A; $V_{CE} = 3$ V	-	-	2.5	
h_{fe}	small-signal current gain	f = 1 MHz; $I_C = 5$ A; $V_{CE} = 3$ V	-	40	-	
$E_{(BR)}$	turn-off breakdown energy with inductive load	$I_{Con} = 6.3$ A; $-I_{B\ off} = 0$; $t_p = 1$ ms; t = 100 ms	150	-	-	mJ
t_{on}	switching times turn-on time	$I_{C\ on} = 10$ A; $I_{B\ on} = -I_{B\ off} = 40$ mA; $V_{CC} = 12$ V	-	1	-	µs
t_{off}	switching times turn-off time		-	3.5	-	µs

Notes

1. Measured under pulse conditions: $t_p < 300$ µs, duty cycle < 2%.
2. V_{BE} decreases by about 3.6 mV/K with increasing temperature.



I. Region of permissible DC operation.
II. Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ line.
(2) Second breakdown limits.

Fig.4 Safe operating area; T_h = 25 °C;

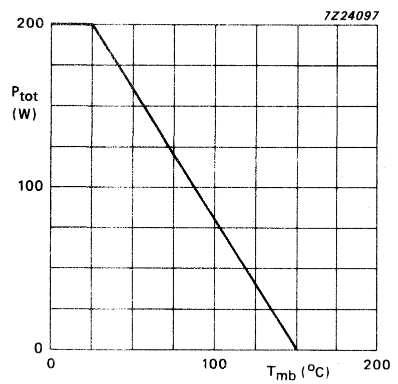


Fig.5 Power derating curve.

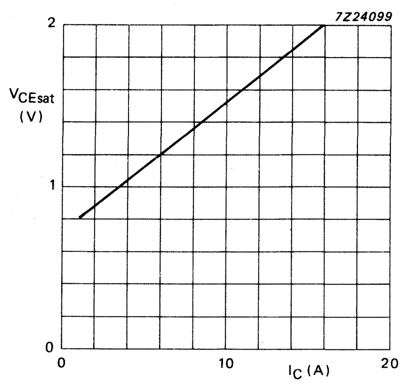


Fig.6 Collector-emitter saturation voltage as a function of collector current; $I_C/I_B = 250$; $T_h = 25$ °C.

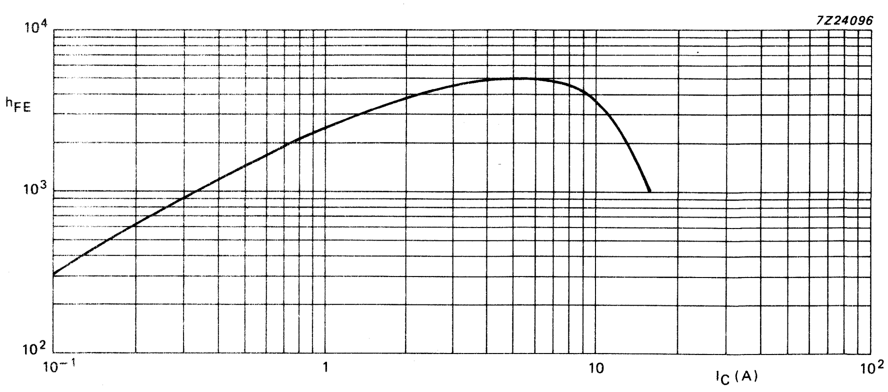


Fig.7 DC current gain; $V_{CE} = 3$ V; $T_j = 25$ °C; typical values.

NPN Darlington power transistors BDV67AF/67BF/67CF/67DF

PACKAGE OUTLINE

Dimensions in mm

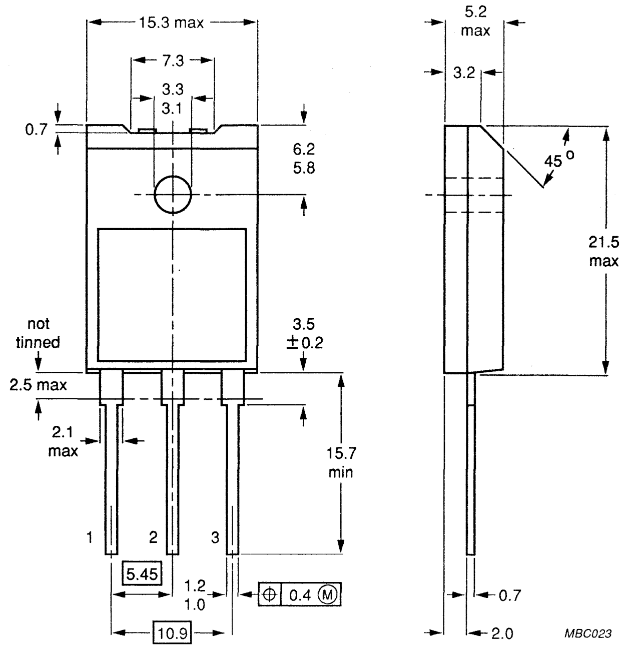


Fig.8 SOT199.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N epitaxial base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications.

P-N-P complements are BDV92, BDV94 and BDV96.

QUICK REFERENCE DATA

			BDV91	BDV93	BDV95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		10		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}	>		20		
Transition frequency I_C = 0,5 A; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

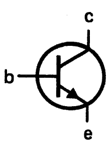
Dimensions in mm

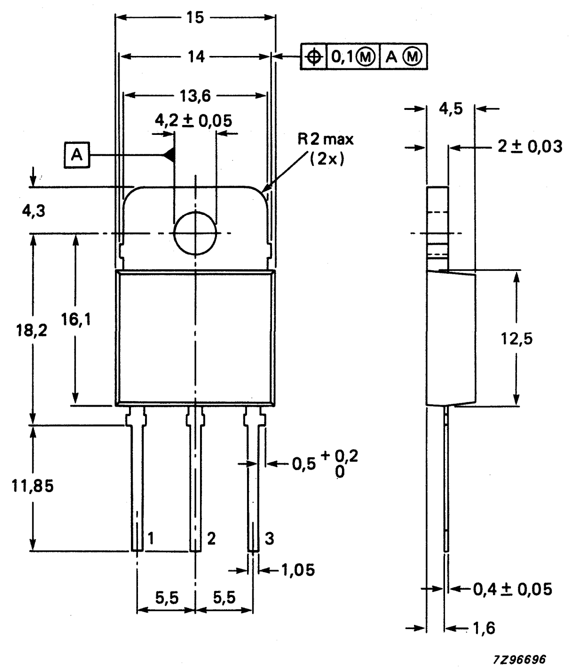
Fig. 1 SOT-93.

Collector connected to mounting base

Pinning

1 = base
2 = collector
3 = emitter





See chapters Mounting instructions SOT-93 and Accessories.

RATINGS

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

			BDV91	BDV93	BDV95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		7		A
Emitter current (d.c.)	I_E	max.		14		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBO\,max}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½V_{CBO\,max}$; T_j = 150 °C	I_{CBO}	<	1	mA
$I_B = 0$; $V_{CE} = V_{CEO\,max}$	I_{CEO}	<	0,2	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 7 V	I_{EBO}	<	0,1	mA
D.C. current gain				
I_C = 4 A; V_{CE} = 4 V	h_{FE}	>	20	
I_C = 10 A; V_{CE} = 4 V	h_{FE}	>	5	
Collector-emitter saturation voltage				
I_C = 4 A; I_B = 0,4 A	$V_{CE\,sat}$	<	1	V
I_C = 10 A; I_B = 3,3 A	$V_{CE\,sat}$	<	3	V
Base-emitter saturation voltage				
I_C = 4 A; I_B = 0,4 A	$V_{BE\,sat}$	<	1,6	V
Base-emitter voltage				
I_C = 4 A; V_{CE} = 4 V	V_{BE}	<	1,6	V

CHARACTERISTICS (continued)

Transition frequency			
I_C = 0,5 A; V_{CE} = 10 V	f_T	>	3 MHz
Switching times (between 10% and 90% levels)			
I_{Con} = 4 A; I_{Bon} = $-I_{Boff}$ = 0,4 A; V_{CC} = 30 V			
Turn-on time	t_{on}	typ.	0,5 μs
Turn-off time	t_{off}	typ.	2,0 μs
Fall time	t_f	typ.	0,7 μs

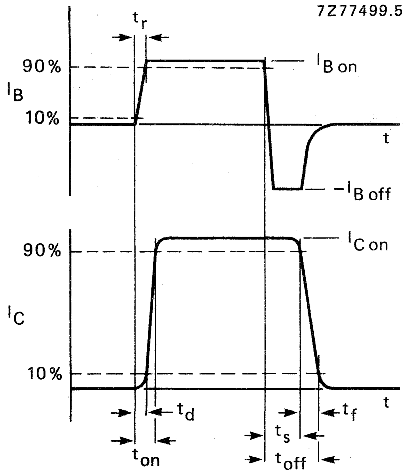
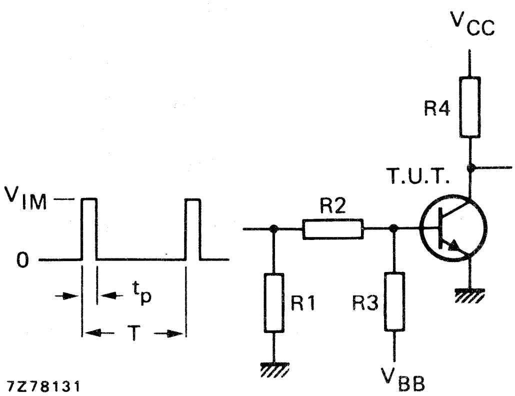


Fig. 2 Switching times waveforms.



V_{IM}	=	55 V
V_{CC}	=	30 V
$-V_{BB}$	=	7 V
R1	=	150 Ω
R2	=	60 Ω
R3	=	20 Ω
R4	=	7,5 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

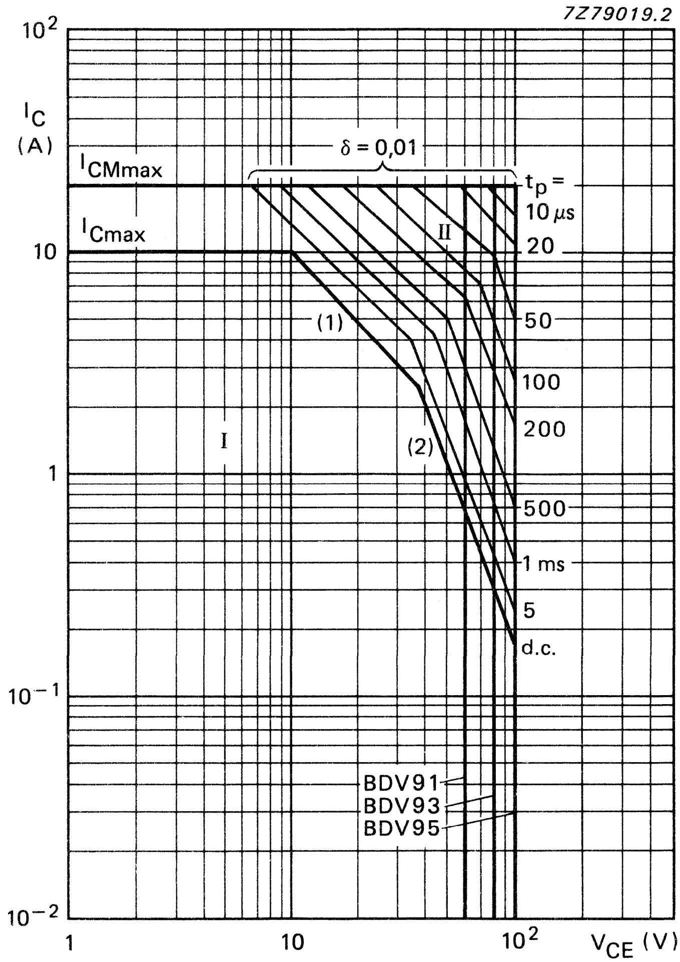


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

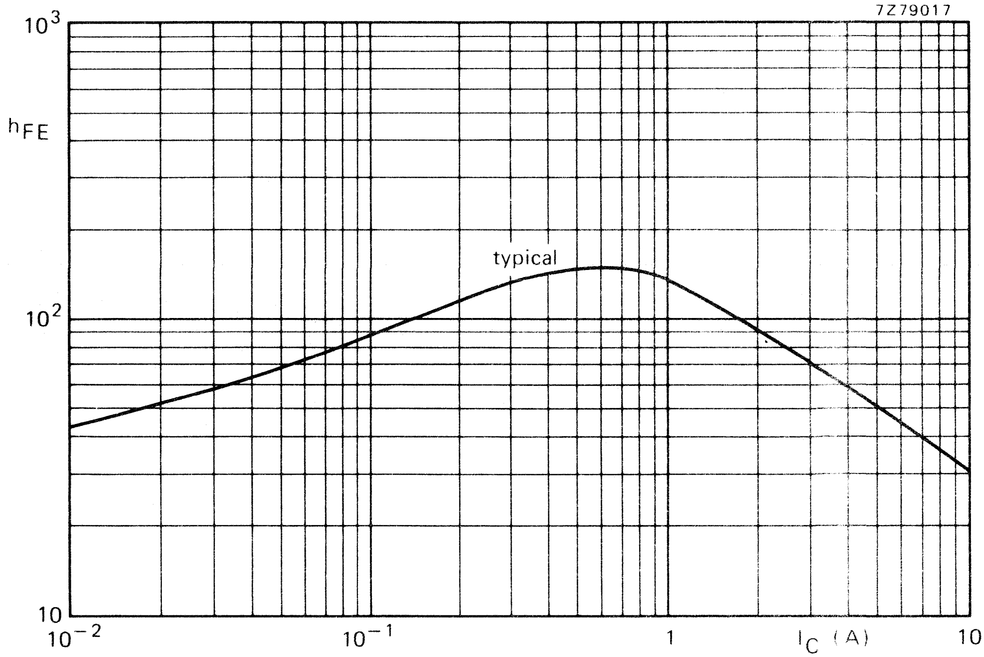


Fig. 5 V_{CE} = 4 V; T_j = 25 °C.

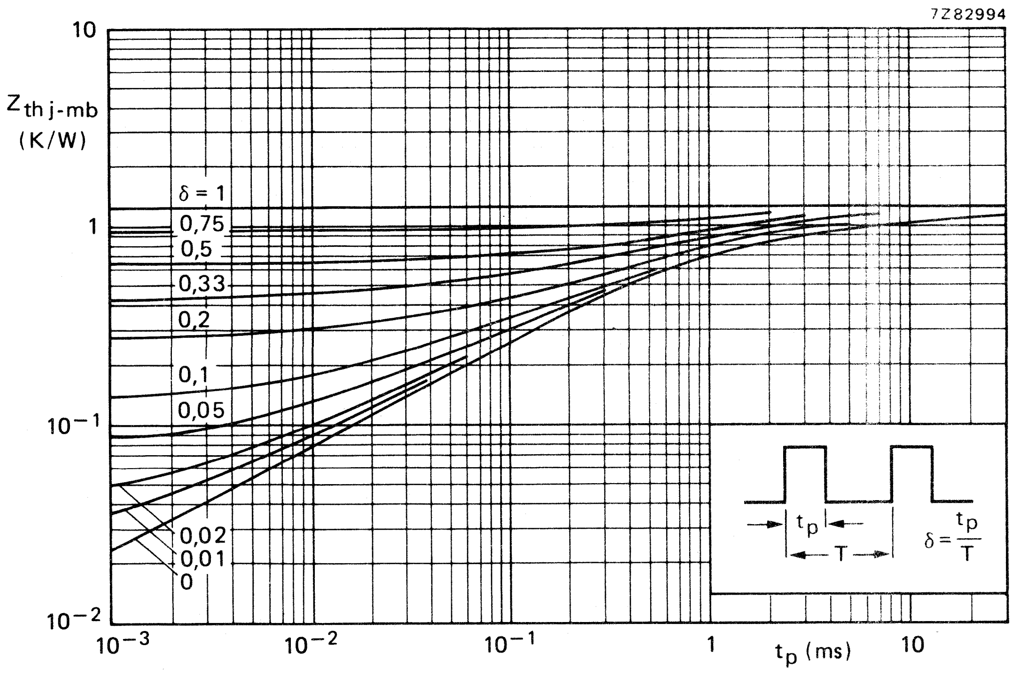


Fig. 6 Pulse power rating chart.

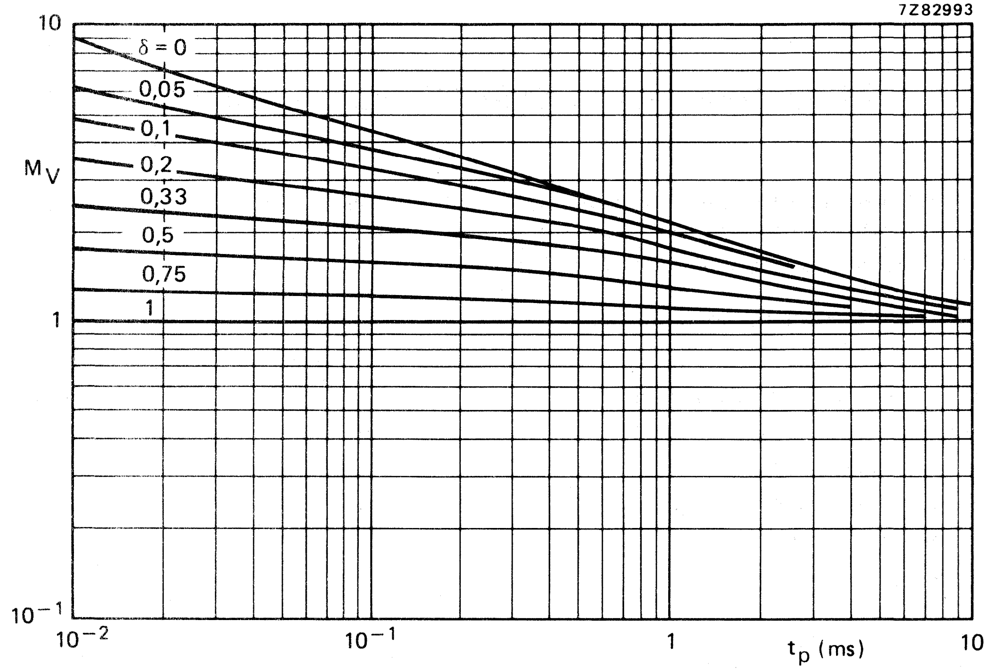


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

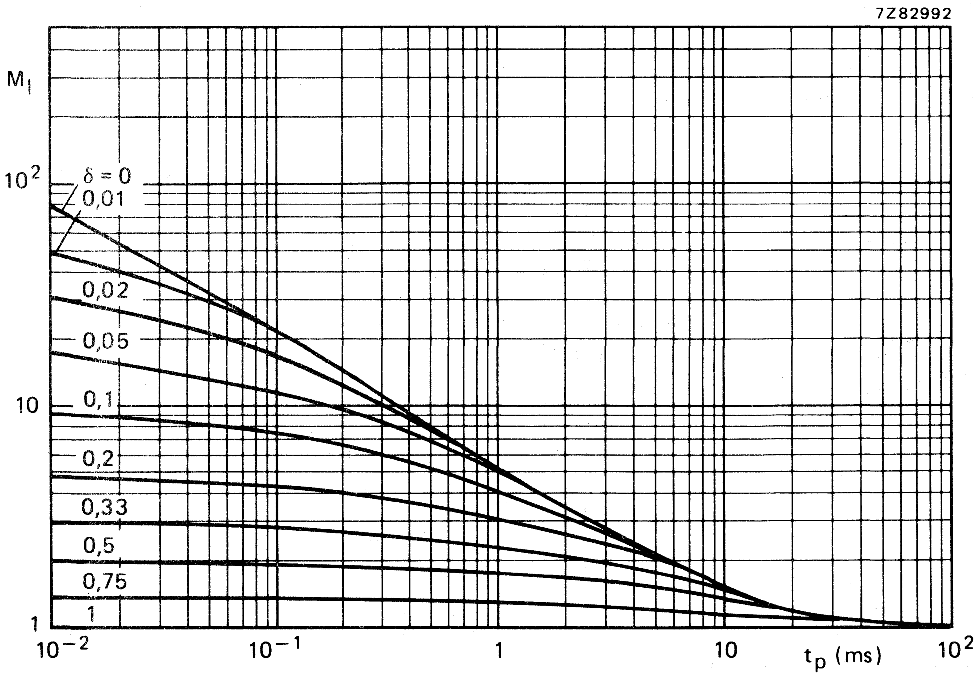


Fig. 8 Second-breakdown current multiplying factor at the V_{CEOmax} level.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P epitaxial base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications.

N-P-N complements are BDV91, BDV93 and BDV95.

QUICK REFERENCE DATA

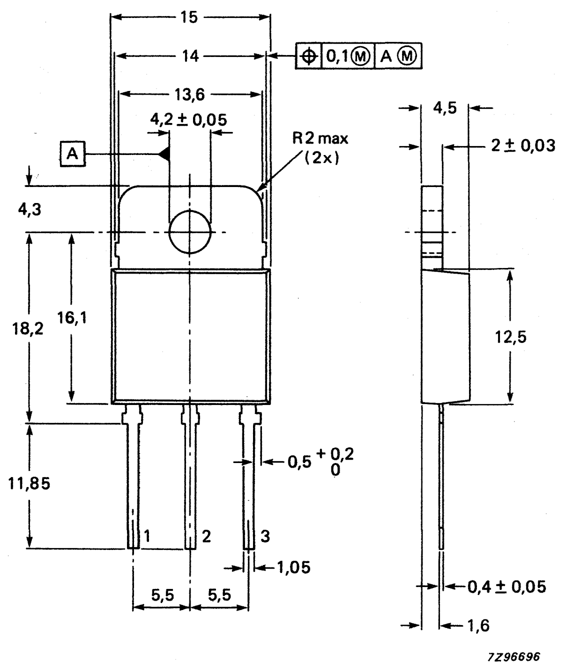
			BDV92	BDV94	BDV96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		10		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 4 A; $-V_{CE}$ = 4 V	h_{FE}	>		20		
Transition frequency $-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>		4		MHz

MECHANICAL DATA

Dimensions in mm

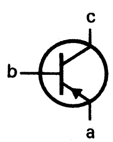
Fig. 1 SOT-93.

Collector connected to mounting base



Pinning

1 = base
2 = collector
3 = emitter



See chapters Mounting instructions SOT-93 and Accessories.

RATINGS

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

			BDV92	BDV94	BDV96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	7	7	7	V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Base current (d.c.)	$-I_B$	max.		7		A
Emitter current (d.c.)	$-I_E$	max.		14		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0; -V_{CB} = -½V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	1	mA
$I_B = 0; -V_{CE} = -V_{CEO\,max}$	$-I_{CEO}$	<	0,2	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 7$ V	$-I_{EBO}$	<	0,1	mA
D.C. current gain				
$-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}	>	20	
$-I_C = 10$ A; $-V_{CE} = 4$ V	h_{FE}	>	5	
Collector-emitter saturation voltage				
$-I_C = 4$ A; $-I_B = 0,4$ A	$-V_{CEsat}$	<	1	V
$-I_C = 10$ A; $-I_B = 3,3$ A	$-V_{CEsat}$	<	3	V
Base-emitter saturation voltage				
$-I_C = 4$ A; $-I_B = 0,4$ A	$-V_{BEsat}$	<	1,6	V
Base-emitter voltage				
$-I_C = 4$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,6	V

CHARACTERISTICS (continued)

Transition frequency			
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	>	4 MHz
Switching times (between 10% and 90% levels)			
$-I_{Con} = 4$ A; $-I_{Bon} = I_{Boff} = 0,4$ A; $-V_{CC} = 30$ V			
Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	0,7 μs
Fall time	t_f	typ.	0,3 μs

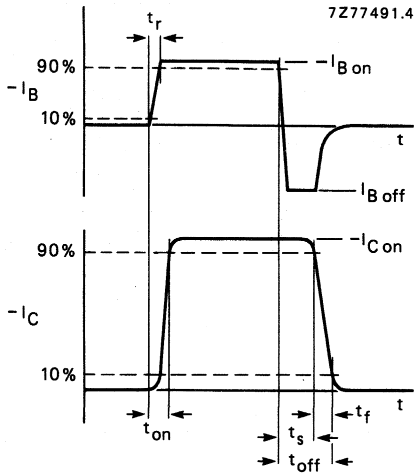
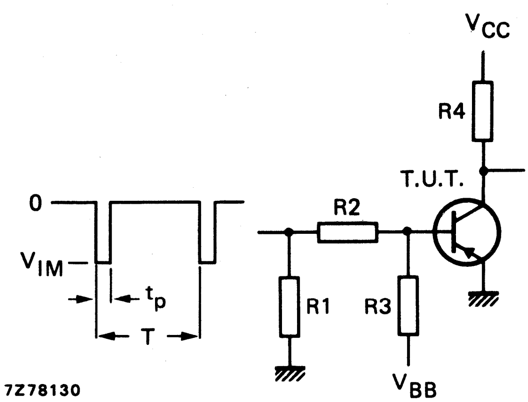


Fig. 2 Switching times waveforms.



$-V_{IM}$ = 55 V
$-V_{CC}$ = 30 V
V_{BB} = 7 V
R1 = 150 Ω
R2 = 60 Ω
R3 = 20 Ω
R4 = 7,5 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 3 Switching times test circuit.

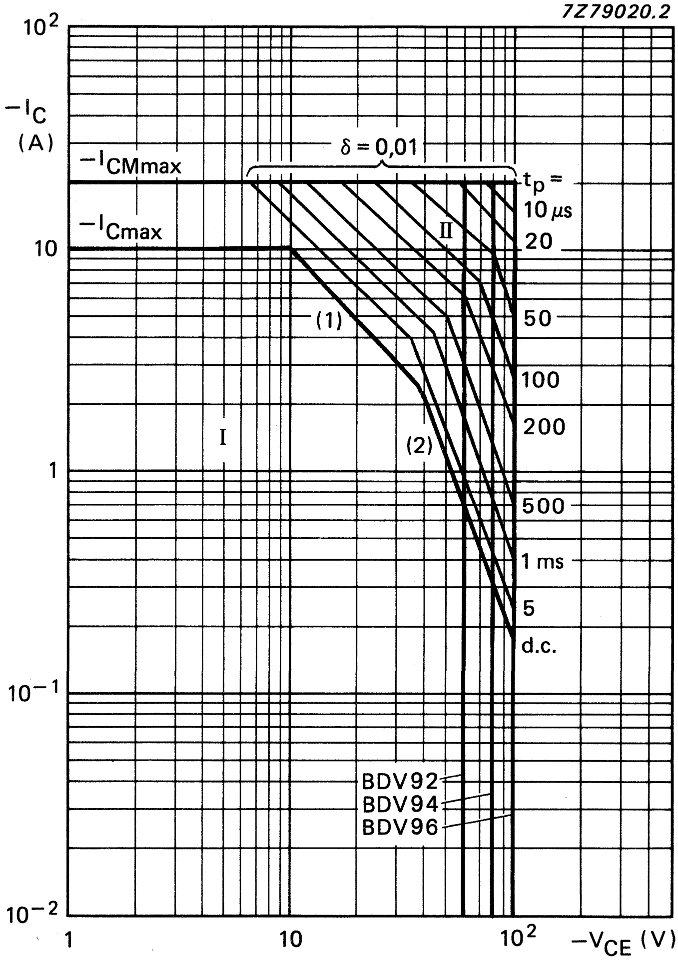


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

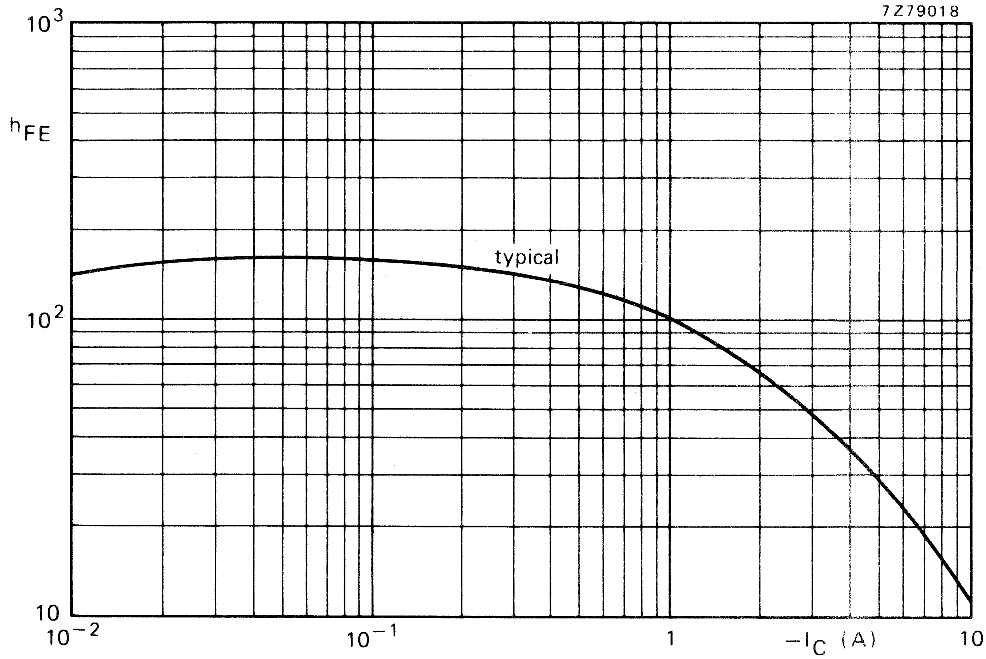


Fig. 5 $-V_{CE}$ = 4 V; T_j = 25 °C.

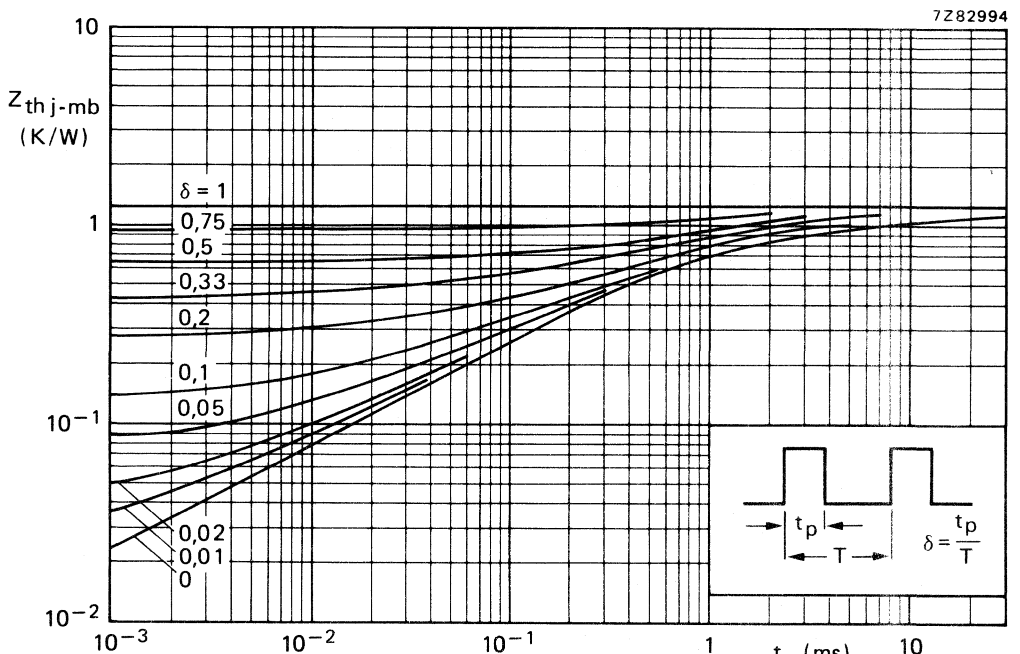


Fig. 6 Pulse power rating chart.

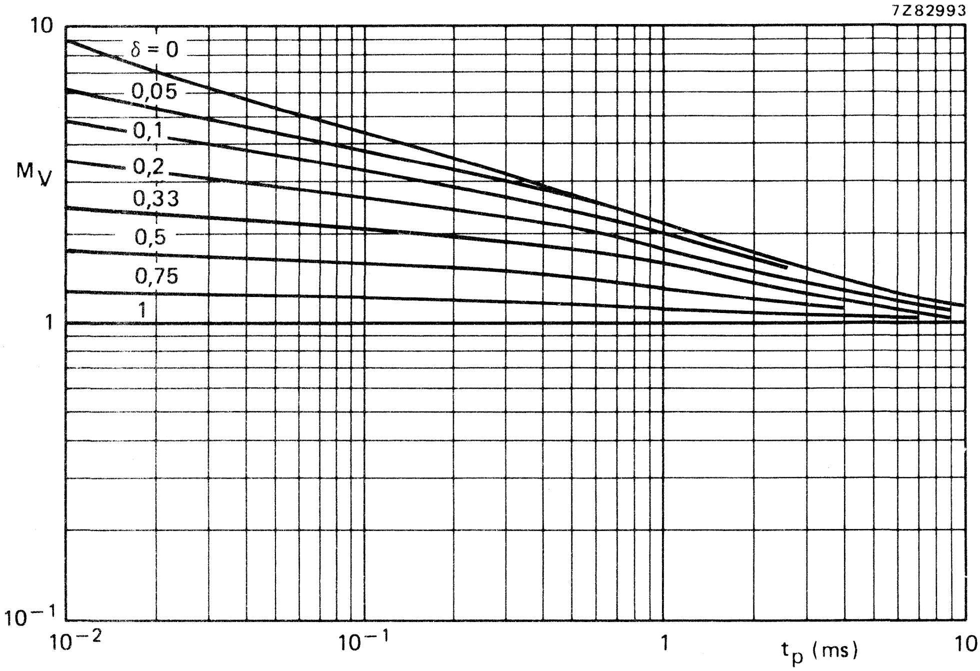


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

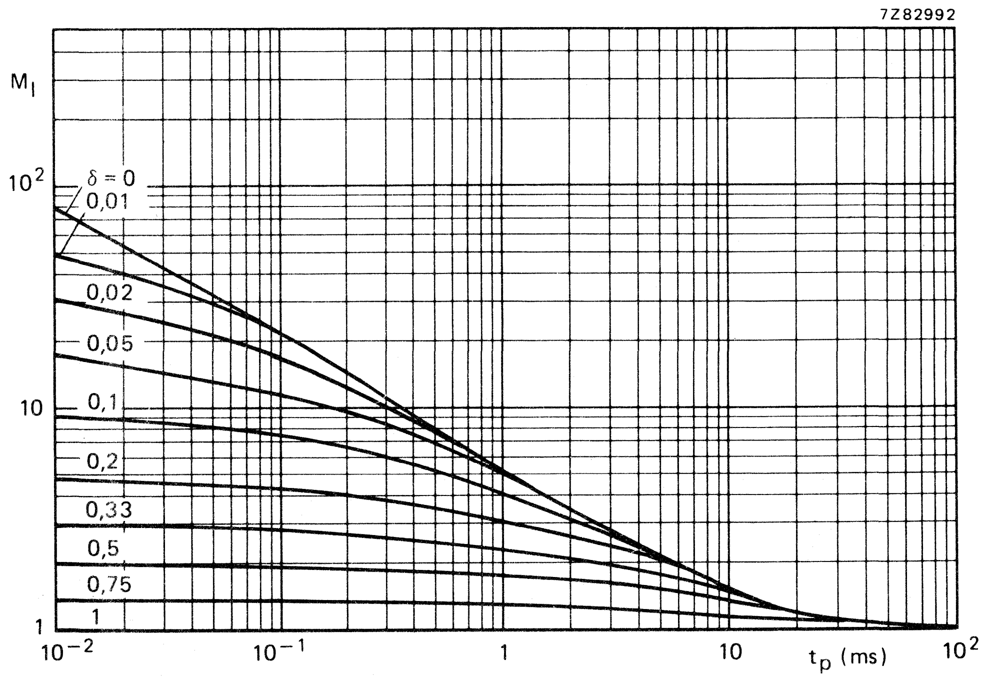


Fig. 8 Second-breakdown current multiplying factor at the V_{CEOmax} level.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N transistors in TO-126 plastic envelopes intended for high current switching applications, e.g. inverters, and switching regulator circuits.

QUICK REFERENCE DATA

			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V
Collector current (d.c.)	I_C	max.	5	5	5	A
Collector current (peak value)	I_{CM}	max.	10	10	10	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	15	15	15	W
D.C. current gain I_C = 0,5 A; V_{CE} = 10 V	h_{FE}	>	45	45	45	
Collector-emitter saturation voltage I_C = 5 A; I_B = 0,5 A	V_{CEsat}	<	0,9	0,7	0,9	V
Turn-off time I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 0,5 A	t_{off}	typ.	350	350	350	ns

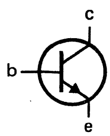
MECHANICAL DATA

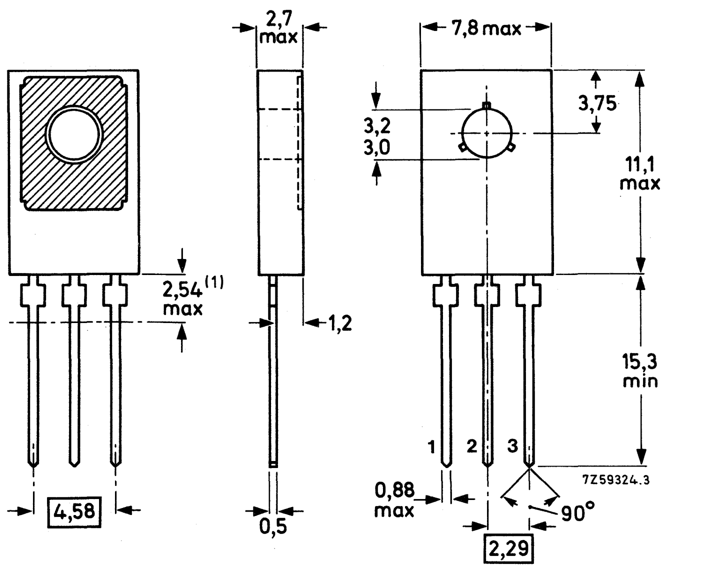
Dimensions in mm

Fig. 1 TO-126 (SOT-32)

Collector connected to the metal part of the mounting surface

Pinning
1 = emitter
2 = collector
3 = base





(1) Within this region the cross-section of the leads is uncontrolled.
See also chapters Mounting instructions and Accessories.

RATINGS

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

Voltages			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	120	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V

Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	5	A
Collector current (peak value)	I_{CM}	max.	10	A
Base current (d.c.)	I_B	max.	1	A
Base current (peak value)	I_{BM}	max.	2	A
Reverse base current (peak value)	$-I_{BM}$	max.	2	A
Total power dissipation				
up to T_{mb} = 75 °C	P_{tot}	max.	15	W
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 80$ V	BDX35	I_{CBO}	<	10 μA
$I_E = 0$; $V_{CB} = 80$ V; $T_j = 100$ °C	BDX35	I_{CBO}	<	50 μA
$I_E = 0$; $V_{CB} = 100$ V	BDX36/37	I_{CBO}	<	10 μA
$I_E = 0$; $V_{CB} = 100$ V; $T_j = 100$ °C	BDX36/37	I_{CBO}	<	50 μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V		I_{EBO}	typ.	5 nA
			<	10 μA
$I_C = 0$; $V_{EB} = 5$ V		I_{EBO}	<	1 mA
D.C. current gain		h_{FE}		45 to 450
$I_C = 0,5$ A; $V_{CE} = 10$ V	BDX35/36	h_{FE}	typ.	130
	BDX37	h_{FE}	typ.	80
Collector-emitter saturation voltage				
$I_C = 5$ A; $I_B = 0,5$ A	BDX35/37	V_{CEsat}	<	0,9 V
	BDX36	V_{CEsat}	<	0,7 V
$I_C = 7$ A; $I_B = 0,7$ A	BDX35/37	V_{CEsat}	<	1,2 V
$I_C = 10$ A; $I_B = 1$ A	BDX36	V_{CEsat}	<	1,5 V
Base-emitter saturation voltage				
$I_C = 5$ A; $I_B = 0,5$ A		V_{BEsat}	<	1,6 V
$I_C = 7$ A; $I_B = 0,7$ A	BDX35/37	V_{BEsat}	<	2,0 V
$I_C = 10$ A; $I_B = 1$ A	BDX36	V_{BEsat}	<	2,5 V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V		C_c	typ.	40 pF
			<	60 pF
Transition frequency at f = 35 MHz				
$I_C = 0,5$ A; $V_{CE} = 5$ V; $T_{amb} = 25$ °C		f_T	typ.	100 MHz
Switching times (between 10% and 90% levels)				
$I_{Con} = 1$ A; $I_{Bon} = -I_{Boff} = 0,1$ A				
turn-on time		t_{on}	typ.	0,06 μs
			<	0,1 μs
turn-off time		t_{off}	typ.	0,6 μs
			<	0,8 μs
$I_{Con} = 2$ A; $I_{Bon} = -I_{Boff} = 0,2$ A				
turn-on time		t_{on}	<	80 ns
turn-off time		t_{off}	typ.	0,45 μs
			<	0,7 μs
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 0,5$ A				
turn-on time		t_{on}	typ.	180 ns
			<	300 ns
turn-off time		t_{off}	typ.	320 ns
			<	500 ns

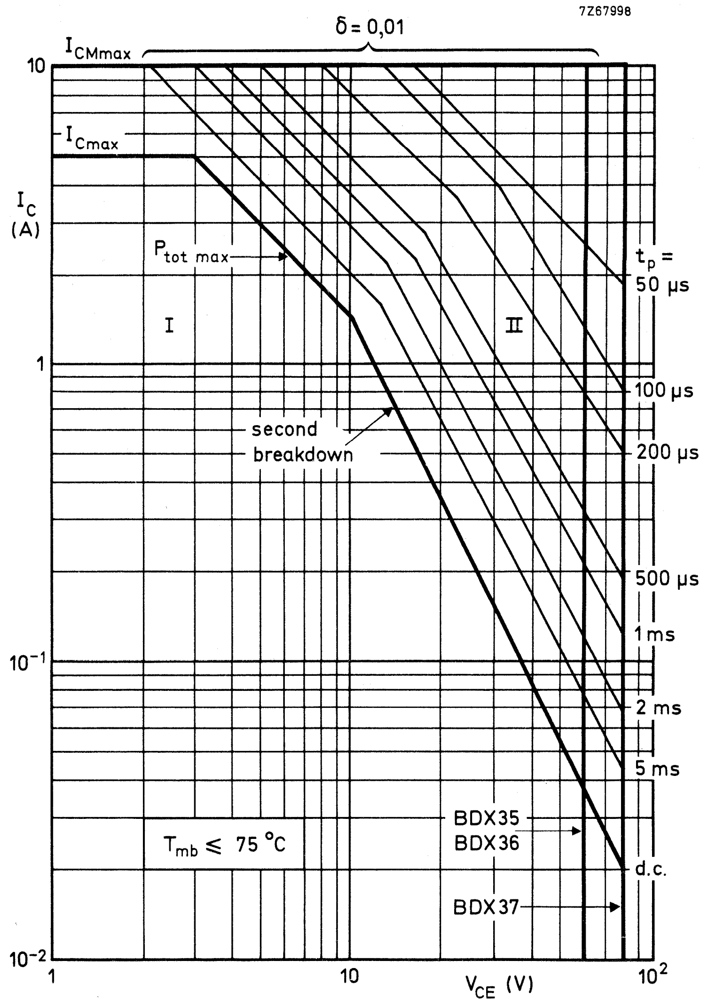


Fig. 2 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

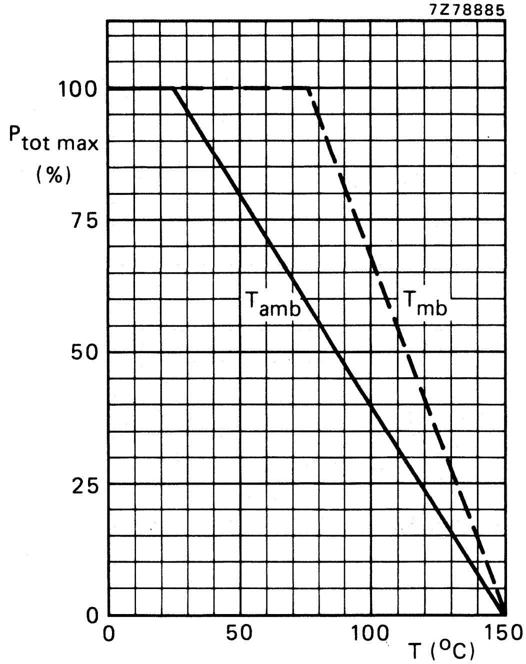


Fig. 3 Power derating curve.

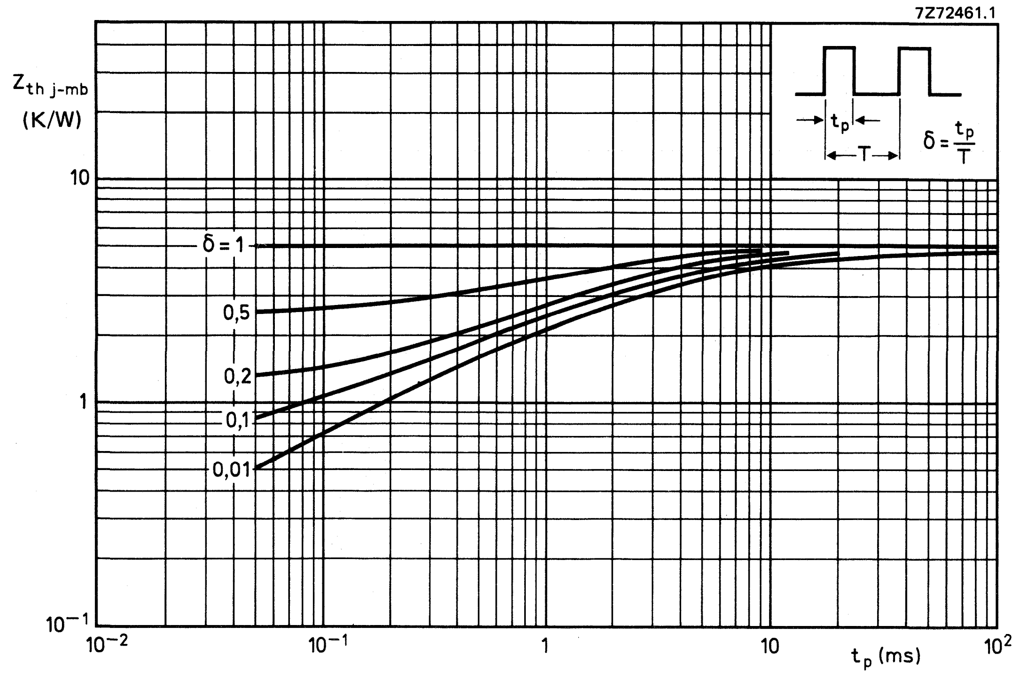


Fig. 4 Pulse power rating chart.

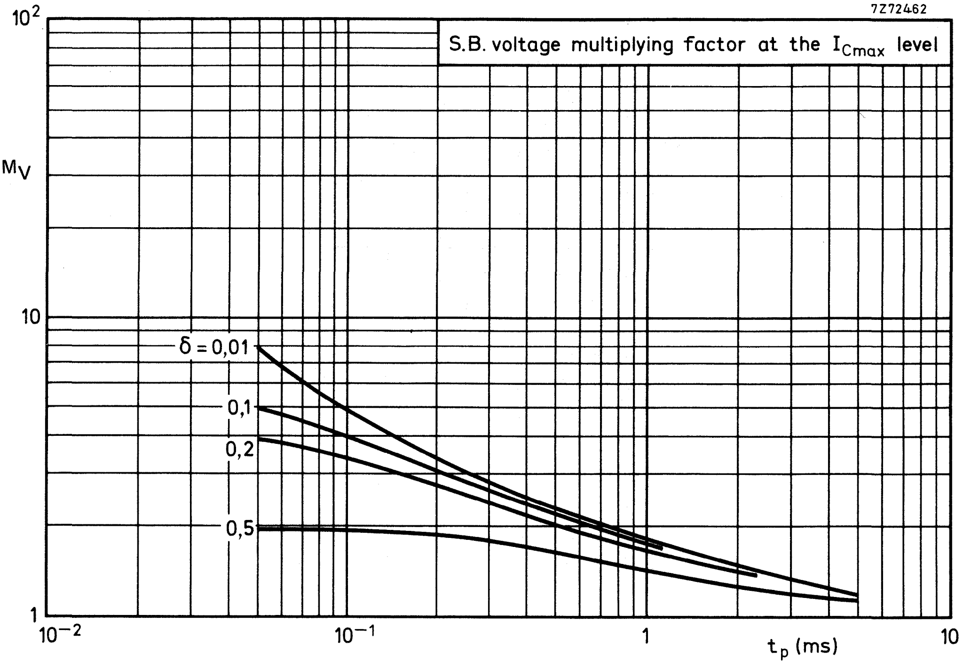


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

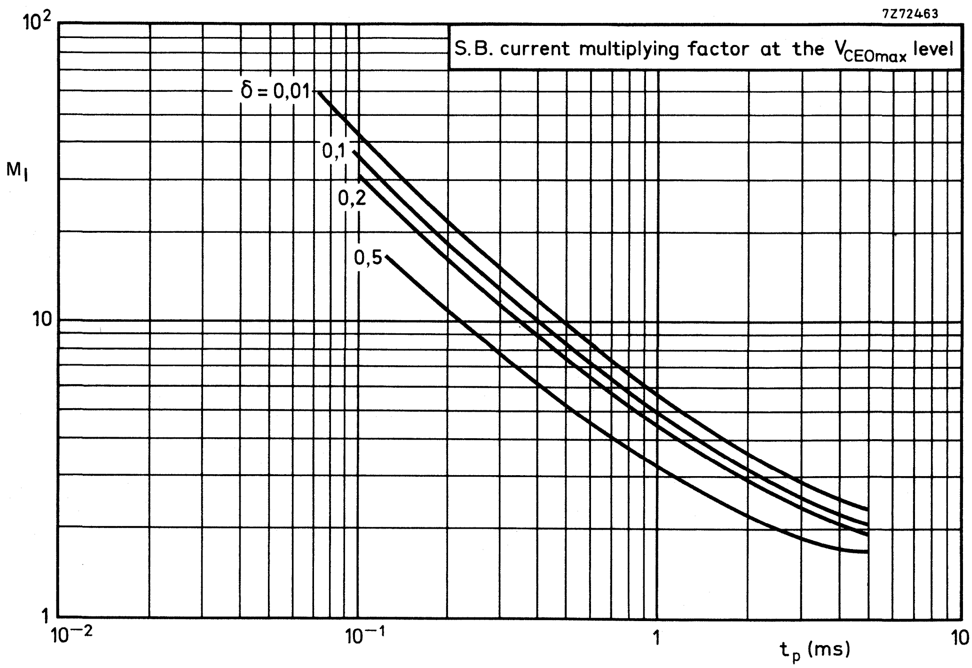


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

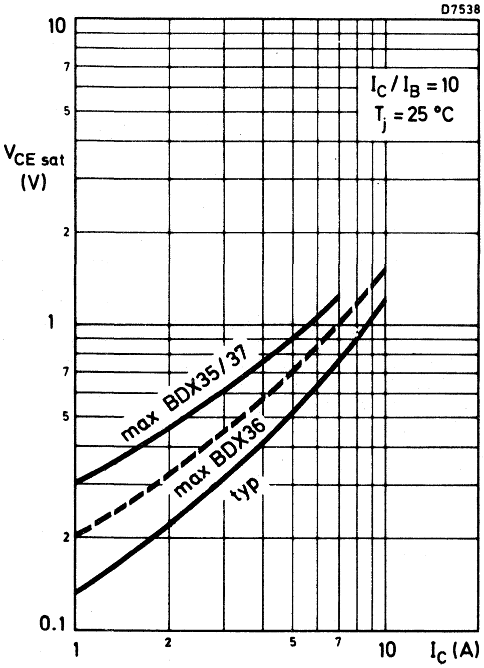


Fig. 7 Collector-emitter saturation voltage as a function of the collector current.

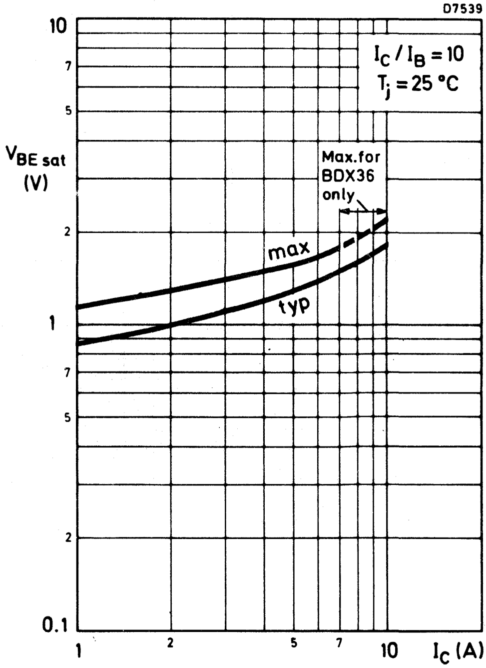


Fig. 8 Base-emitter saturation voltage as a function of the collector current.

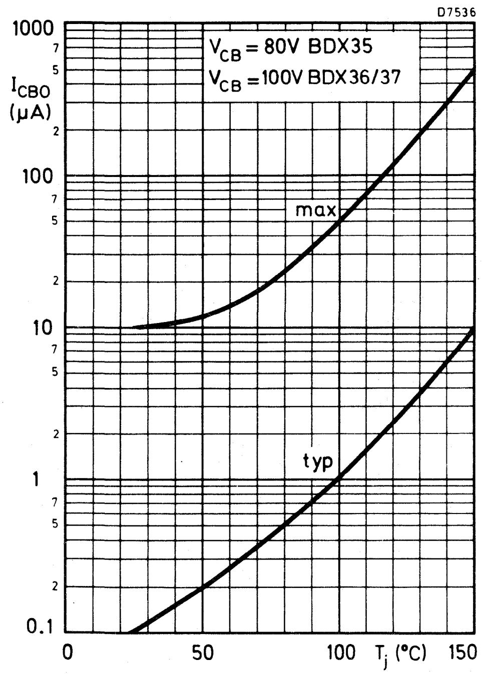


Fig. 9 Collector-base current with an open emitter as a function of junction temperature.

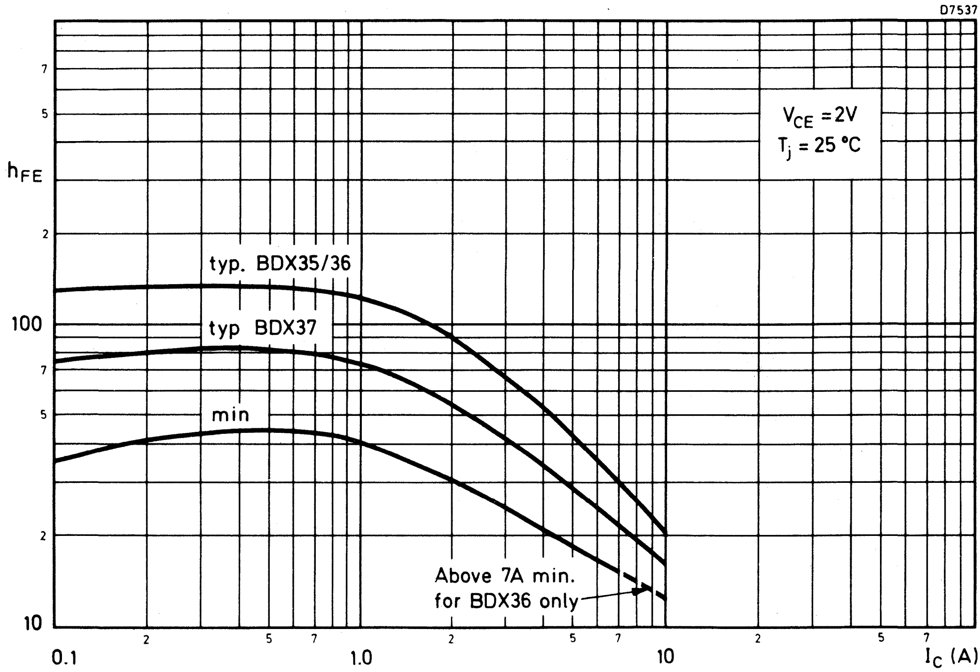


Fig. 10 D.C. current gain as a function of collector current.

N-P-N SILICON PLANAR DARLINGTON TRANSISTORS

Silicon n-p-n planar Darlington transistors for industrial switching applications, e.g. print hammer, solenoid, relay and lamp driving. Encapsulated in a TO-126 plastic envelope with collector connected to the heatsink.
P-N-P complements are BDX45, BDX46 and BDX47 respectively.

QUICK REFERENCE DATA

			BDX42	BDX43	BDX44	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	V
Collector-emitter voltage	V_{CER}	max.	45	60	80	V
Collector current	I_C	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
D.C. current gain						
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>	2000	2000	2000	
Collector-emitter saturation voltage						
I_C = 1 A; I_B = 1 mA	V_{CEsat}	<	–	1,6	–	V
I_C = 1 A; I_B = 4 mA	V_{CEsat}	<	1,6	–	1,6	V
Turn-off time						
I_C = 500 mA; $I_{Bon} = -I_{Boff}$ = 0,5 mA	t_{off}	typ.	1500	1500	1500	ns

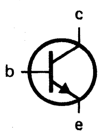
MECHANICAL DATA

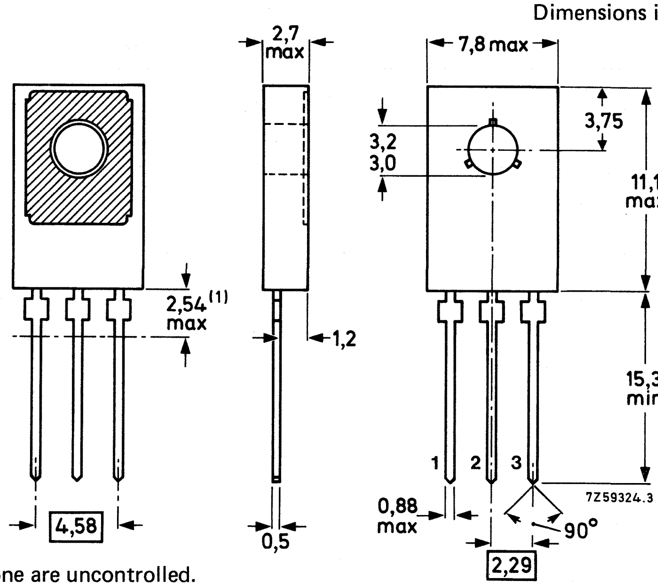
Dimensions in mm

Fig. 1 TO-126.

Collector connected to the metal part of mounting surface.

Pinning
1 = emitter
2 = collector
3 = base





(1) Dimensions within this zone are uncontrolled.

See also chapters Mounting Instructions and Accessories.

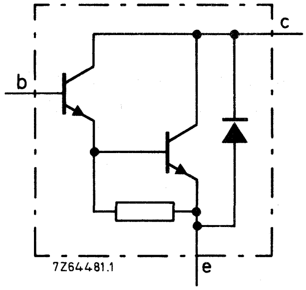


Fig. 2 Circuit diagram.

RATINGS

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

			BDX42	BDX43	BDX44	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	90	V
Collector-emitter voltage *	V_{CER}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		1		A
Collector current (peak)	I_{CM}	max.		2		A
Base current (d.c.)	I_B	max.		0,1		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		1,25		W
up to T_{mb} = 100 °C	P_{tot}	max.		5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

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

* External R_{BE} not to exceed value shown in Fig. 12.

** 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				
V_{BE} = 0; V_{CE} = 45 V	BDX42	I_{CES}	<	10 μA
V_{BE} = 0; V_{CE} = 60 V	BDX43	I_{CES}	<	10 μA
V_{BE} = 0; V_{CE} = 80 V	BDX44	I_{CES}	<	10 μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V		I_{EBO}	<	10 μA
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
Collector-emitter saturation voltage				
I_C = 500 mA; I_B = 0,5 mA		V_{CEsat}	<	1,3 V
I_C = 1 A; I_B = 1 mA	BDX43	V_{CEsat}	<	1,6 V
I_C = 1 A; I_B = 4 mA	BDX42, 44	V_{CEsat}	<	1,6 V
I_C = 500 mA; I_B = 0,5 mA; T_j = 150 °C		V_{CEsat}	<	1,3 V
I_C = 1 A; I_B = 1 mA; T_j = 150 °C	BDX43	V_{CEsat}	<	1,8 V
I_C = 1 A; I_B = 4 mA; T_j = 150 °C	BDX42, 44	V_{CEsat}	<	1,6 V
Base-emitter saturation voltage				
I_C = 500 mA; I_B = 0,5 mA		V_{BEsat}	<	1,9 V
I_C = 1 A; I_B = 1 mA	BDX43	V_{BEsat}	<	2,2 V
I_C = 1 A; I_B = 4 mA	BDX42, 44	V_{BEsat}	<	2,2 V
Small signal current gain				
I_C = 500 mA; V_{CE} = 5 V; f = 35 MHz		h_{fe}	typ.	10
Switching times (see also Fig. 3 and Fig. 4)				
I_C = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns
I_C = 1 A; I_{Bon} = $-I_{Boff}$ = 1 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns

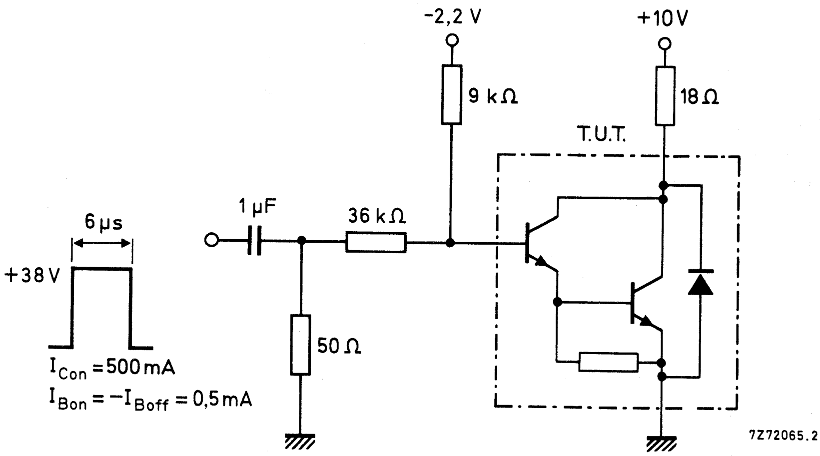


Fig. 3 Test circuit for 500 mA switching.

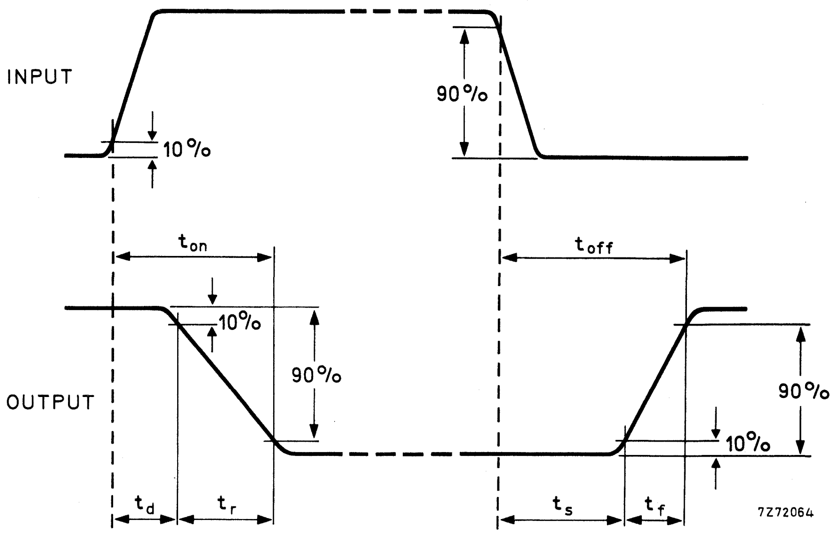


Fig. 4 Switching waveforms.

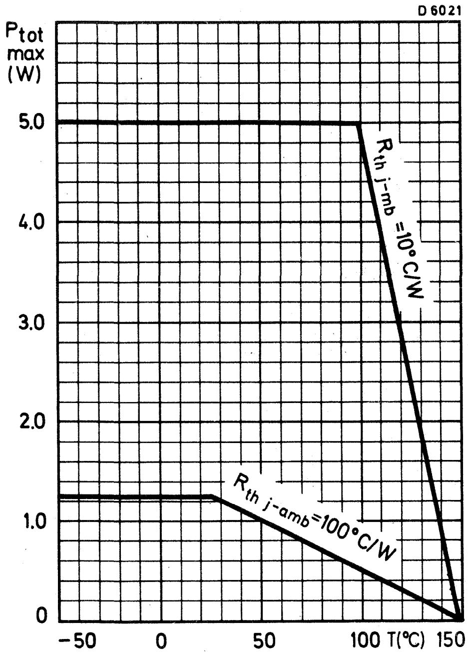


Fig. 5.

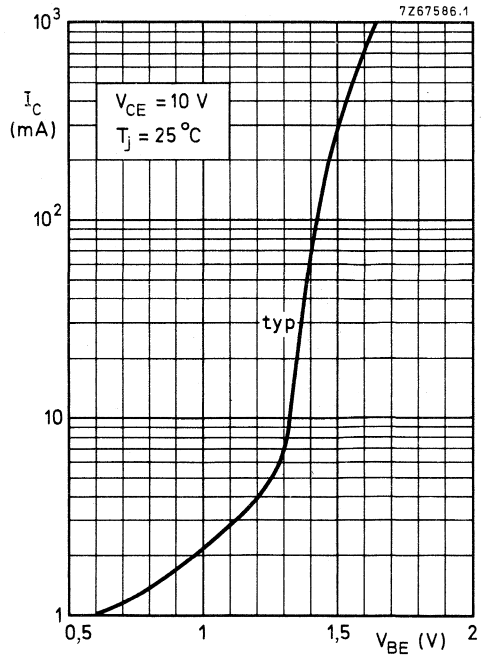


Fig. 6.

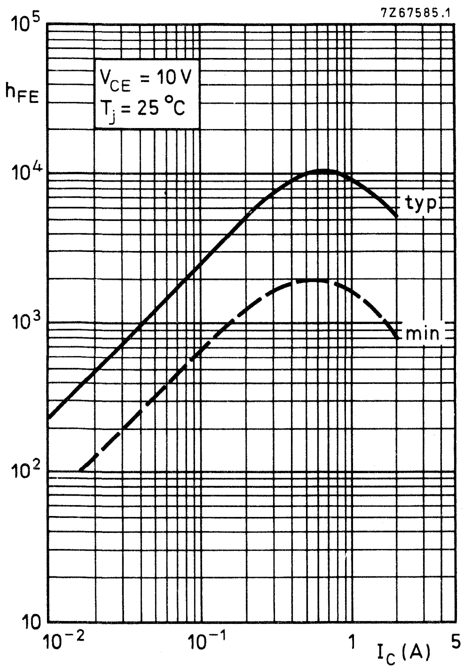


Fig. 7.

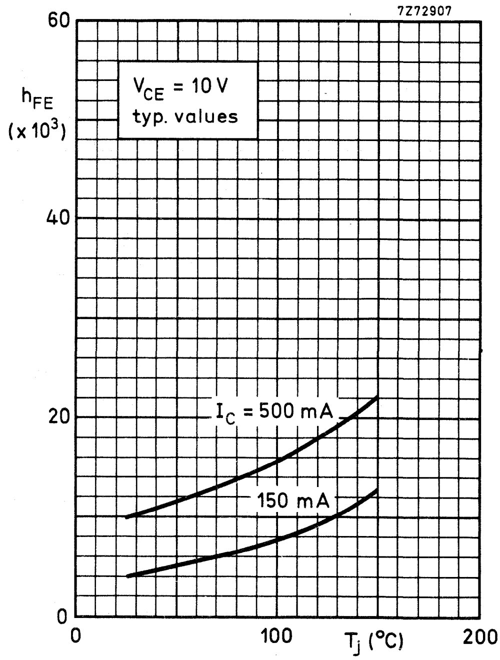


Fig. 8.

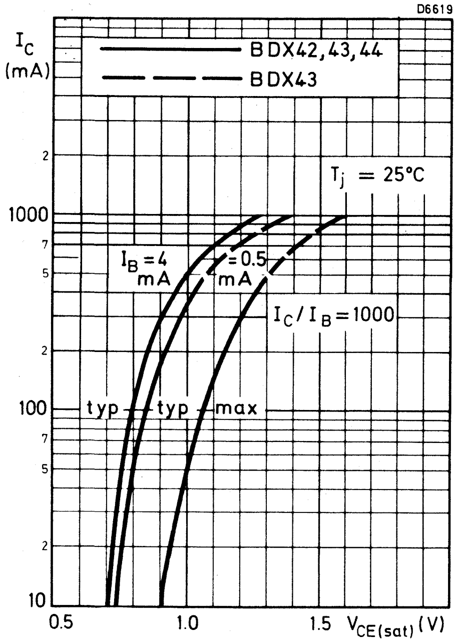


Fig. 9.

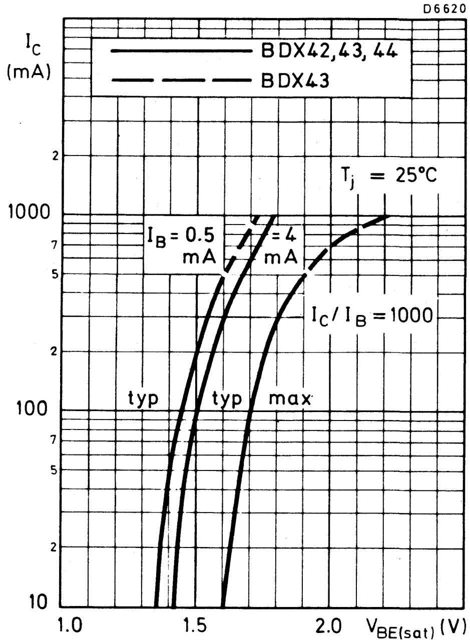


Fig. 10.

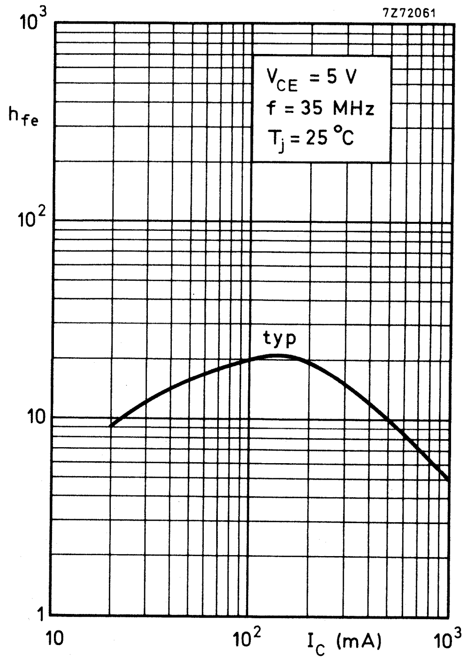


Fig. 11.

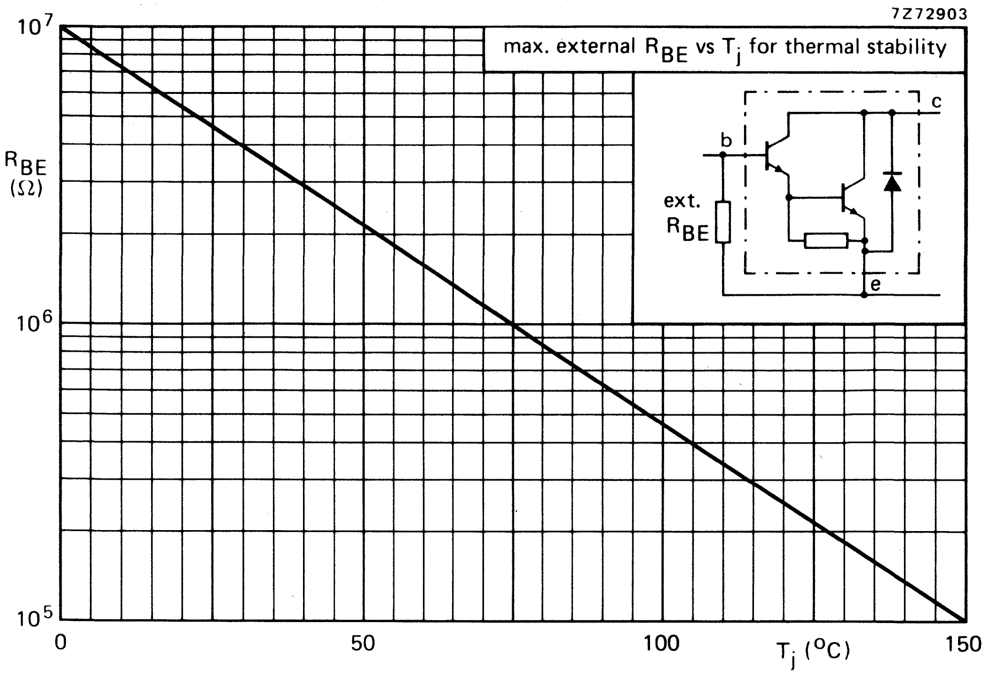

7Z72903
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
0
50
100
150
T_j (^oC)
c
b
e
ext.
R_{BE}

Fig. 12.

P-N-P SILICON PLANAR DARLINGTON TRANSISTORS

Silicon p-n-p planar Darlington transistors for industrial switching applications, e.g. print hammer, solenoid, relay and lamp driving. Encapsulated in a TO-126 plastic envelope with collector connected to the heatsink.
N-P-N complements are BDX42, BDX43 and BDX44 respectively.

QUICK REFERENCE DATA

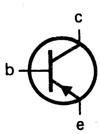
			BDX45	BDX46	BDX47	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage	$-V_{CER}$	max.	45	60	80	V
Collector current	$-I_C$	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
D.C. current gain						
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	2000	2000	2000	
Collector-emitter saturation voltage						
$-I_C$ = 1 A; $-I_B$ = 1 mA	$-V_{CEsat}$	<	–	1,6	–	V
$-I_C$ = 1 A; $-I_B$ = 4 mA	$-V_{CEsat}$	<	1,6	–	1,6	V
Turn-off time						
$-I_C$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 0,5 mA	t_{off}	typ.	1500	1500	1500	ns

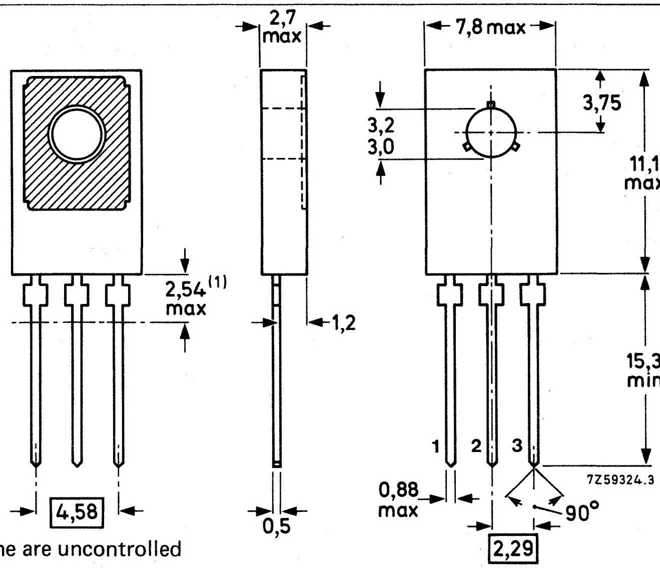
MECHANICAL DATA

Fig. 1 TO-126.

Collector connected to the metal part of mounting surface.

Pinning
1 = emitter
2 = collector
3 = base





(1) Dimensions within this zone are uncontrolled

See also chapters Mounting Instructions and Accessories.

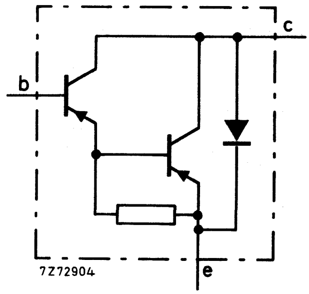


Fig. 2 Circuit diagram.

RATINGS

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

			BDX45	BDX46	BDX47	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	90	V
Collector-emitter voltage *	$-V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current (d.c.)	$-I_C$	max.		1		A
Collector current (peak)	$-I_{CM}$	max.		2		A
Base current (d.c.)	$-I_B$	max.		0,1		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		1,25		W
up to T_{mb} = 100 °C	P_{tot}	max.		5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature**	T_j	max.		150		°C

THERMAL RESISTANCE **

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

* External R_{BE} not to exceed value shown in Fig. 12.

** 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				
V_{BE} = 0; $-V_{CE}$ = 45 V	BDX45	$-I_{CES}$	<	10 μA
V_{BE} = 0; $-V_{CE}$ = 60 V	BDX46	$-I_{CES}$	<	10 μA
V_{BE} = 0; $-V_{CE}$ = 80 V	BDX47	$-I_{CES}$	<	10 μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V		$-I_{EBO}$	<	10 μA
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
Collector-emitter saturation voltage				
$-I_C$ = 500 mA; $-I_B$ = 0,5 mA		$-V_{CEsat}$	<	1,3 V
$-I_C$ = 1 A; $-I_B$ = 1 mA	BDX46	$-V_{CEsat}$	<	1,6 V
$-I_C$ = 1 A; $-I_B$ = 4 mA	BDX45, 47	$-V_{CEsat}$	<	1,6 V
$-I_C$ = 500 mA; $-I_B$ = 0,5 mA; T_j = 150 °C		$-V_{CEsat}$	<	1,3 V
$-I_C$ = 1 A; $-I_B$ = 1 mA; T_j = 150 °C	BDX46	$-V_{CEsat}$	<	1,8 V
$-I_C$ = 1 A; $-I_B$ = 4 mA; T_j = 150 °C	BDX45, 47	$-V_{CEsat}$	<	1,6 V
Base-emitter saturation voltage				
$-I_C$ = 500 mA; $-I_B$ = 0,5 mA		$-V_{BEsat}$	<	1,9 V
$-I_C$ = 1 A; $-I_B$ = 1 mA	BDX46	$-V_{BEsat}$	<	2,2 V
$-I_C$ = 1 A; $-I_B$ = 4 mA	BDX45, 47	$-V_{BEsat}$	<	2,2 V
Small signal current gain				
$-I_C$ = 500 mA; $-V_{CE}$ = 5 V, f = 35 MHz		h_{fe}	typ.	10
Switching times (see also Fig. 3 and Fig. 4)				
$-I_C$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 0,5 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns
$-I_C$ = 1 A; $-I_{Bon}$ = I_{Boff} = 1 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns

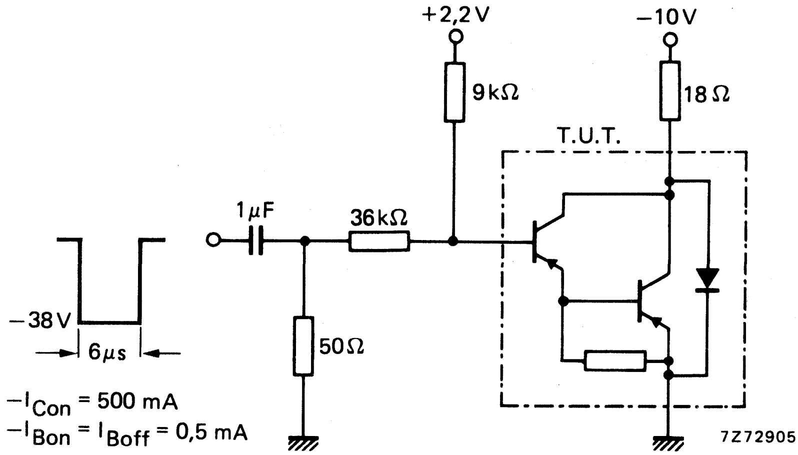


Fig. 3 Test circuit for 500 mA switching.

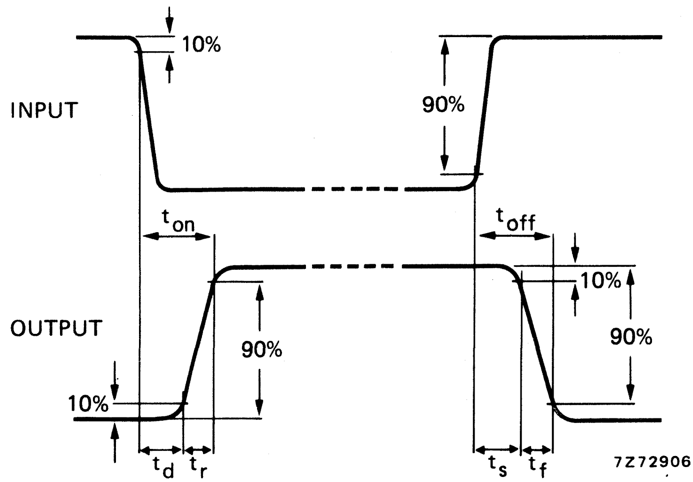


Fig. 4 Switching waveforms.

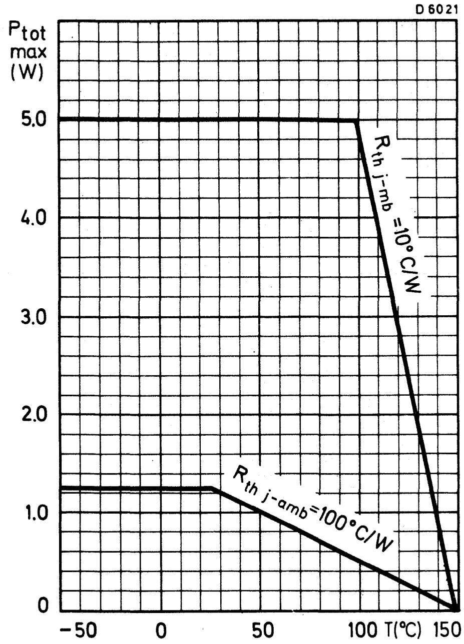


Fig. 5.

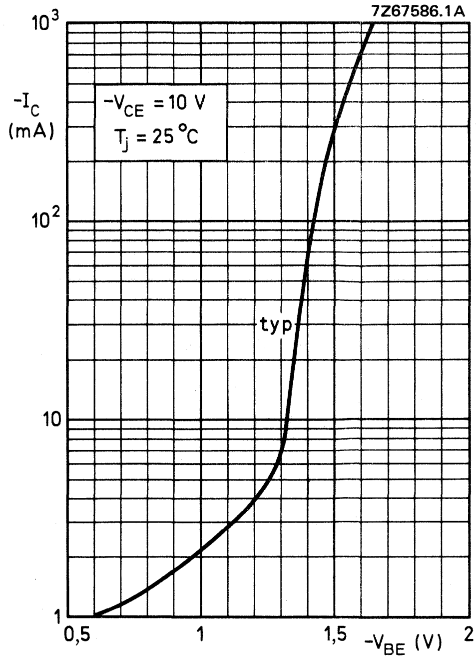


Fig. 6.

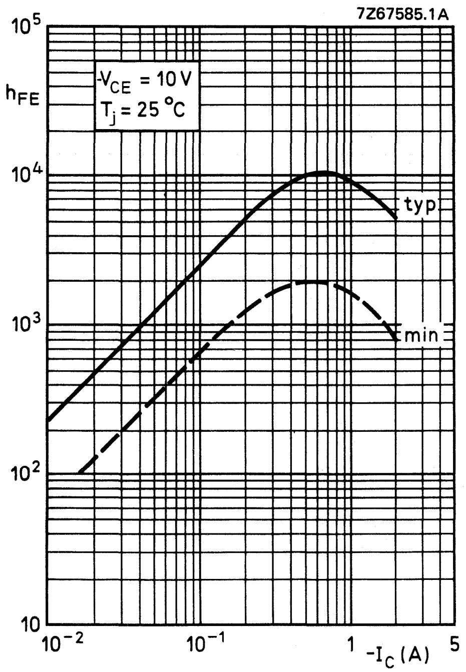


Fig. 7.

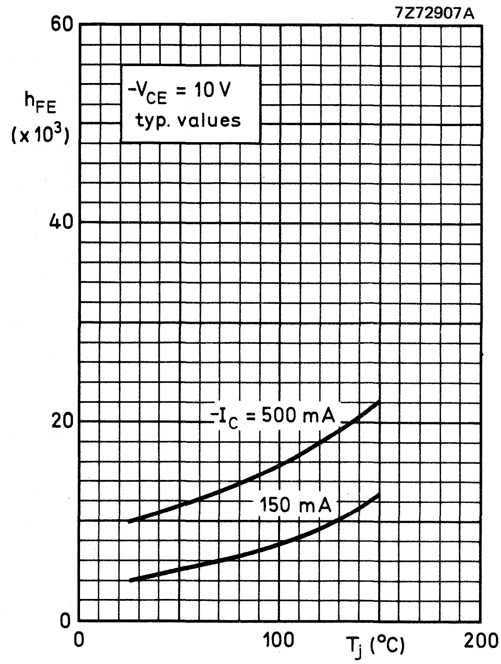


Fig. 8.

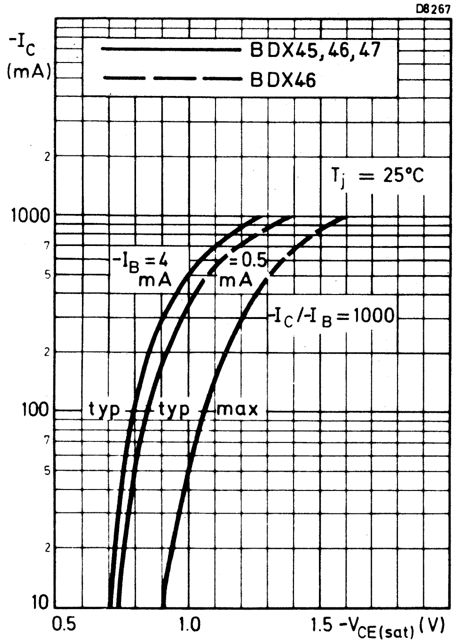


Fig. 9.

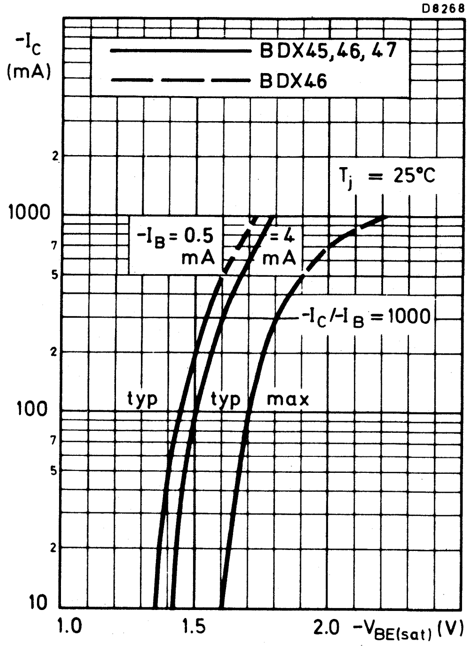


Fig. 10.

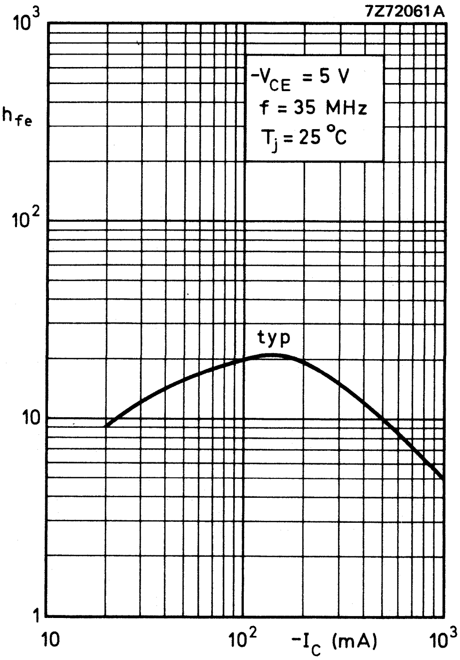


Fig. 11.

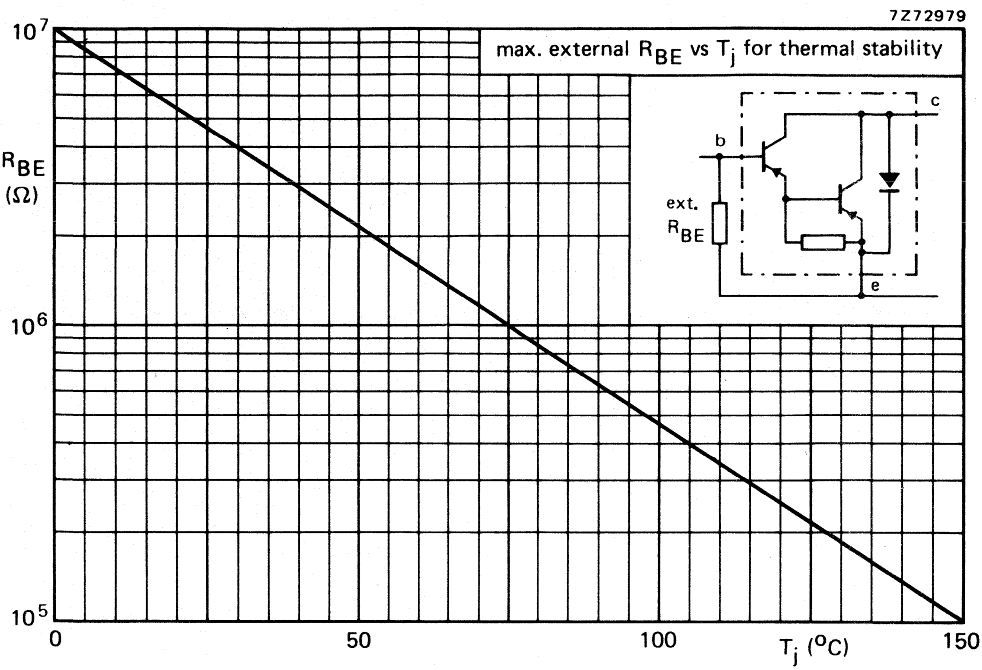

7Z72979
max. external R_{BE} vs T_j for thermal stability
10^7
R_{BE}
(Ω)
10^6
10^5
0
50
100
150
T_j (°C)
c
b
ext.
R_{BE}
e

Fig. 12.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

N-P-N transistor in a plastic envelope, intended for industrial amplifier and switching applications.
P-N-P complement is BDX78.

QUICK REFERENCE DATA

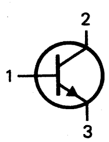
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector current (DC)	I_C	max.	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	30	
Cut-off frequency I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25	kHz

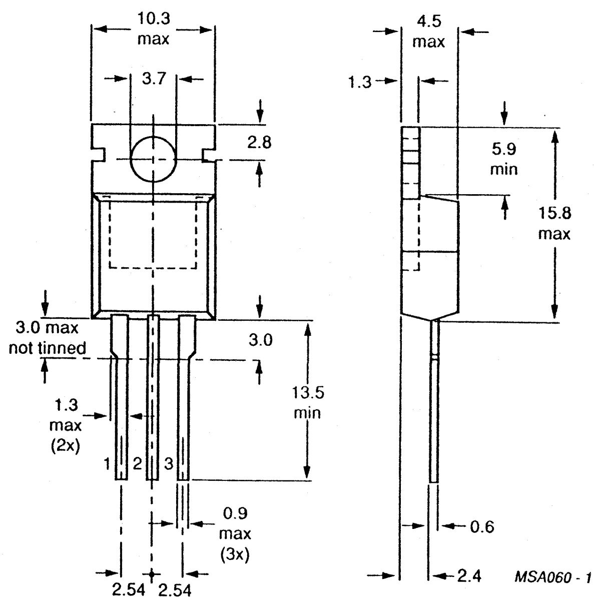
MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base





For more information see BD201/BD203/BDX77 data

SILICON EPITAXIAL-BASE POWER TRANSISTOR

P-N-P transistor in a plastic envelope, intended for industrial amplifier and switching applications.
N-P-N complement BDX77.

QUICK REFERENCE DATA

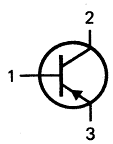
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80 V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100 V
Collector current (DC)	$-I_C$	max.	8 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60 W
D.C. current gain $-I_C$ = 2 A; $-V_{CE}$ = 2 V	h_{FE}	>	30
Cut-off frequency $-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25 kHz

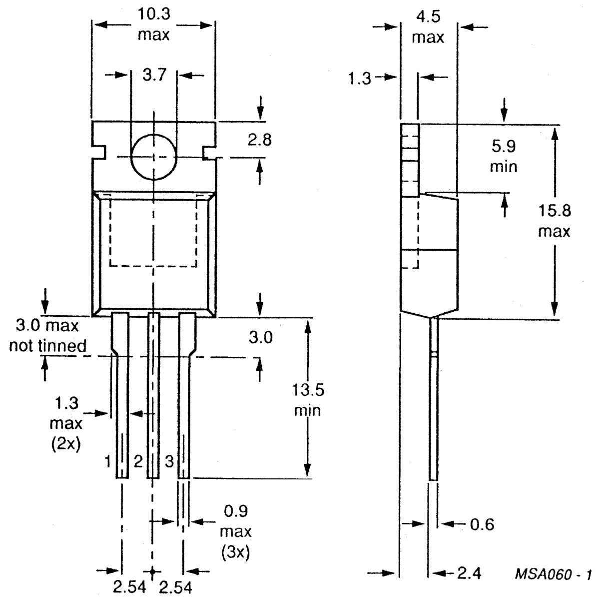
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220

Collector connected to mounting base





For more information see BD202/BD204/BDX78 data

SILICON EPITAXIAL BASE POWER TRANSISTORS

NPN silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur. PNP complements are TIP30 series.

QUICK REFERENCE DATA

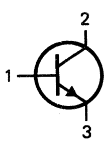
			TIP29	A	B	C	
Collector-base voltage	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.		1			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		30			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 200 mA; V_{CE} = 4 V	h_{FE}	>		40			
I_C = 1 A; V_{CE} = 4 V	h_{FE}			15 to 75			
Transition frequency at f = 1 MHz							
I_C = 200 mA; V_{CE} = 10 V	f_T	>		3			MHz

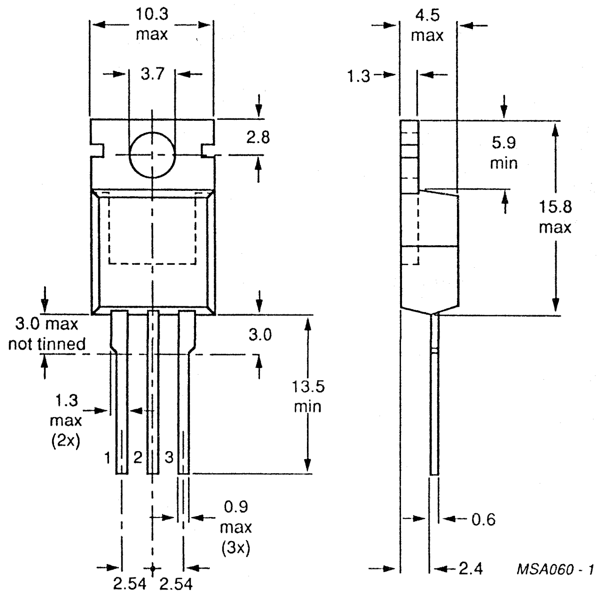
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP29	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	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.	3				A
Base current (d.c.)	I_B	max.	0,4				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP29;A	TIP29B;C	
Collector cut-off current					
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,1	—	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	<	—	0,1	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	<	0,2		mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	0,2		mA
D.C. current gain*					
$I_C = 200$ mA; $V_{CE} = 4$ V	h_{FE}	>	40		
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage**					
$I_C = 1$ A; $V_{CE} = 4$ V	V_{BE}	<	1,3		V
Collector-emitter saturation voltage*					
$I_C = 1$ A; $I_B = 0,125$ A	V_{CEsat}	<	0,7		V

			TIP29	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current gain							
$I_C = 0,2$ A; $V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
Turn off breakdown energy							
L = 20 mH; $I_{CC} = 1,8$ A	$E_{(BR)}$	>	32				mJ

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.
** V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Transition frequency at f = 1 MHz I_C = 0,2 A; V_{CE} = 10 V	f_T	>	3 MHz
Switching times (between 10% and 90% levels) I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A			
Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

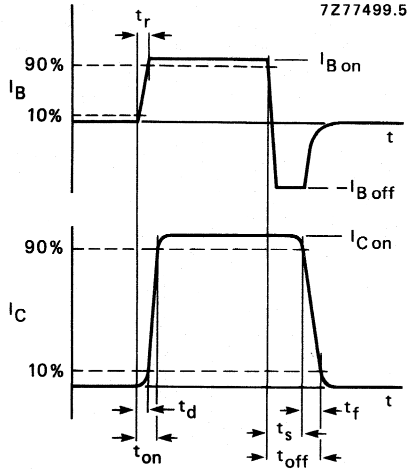


Fig. 2 Switching times waveforms.

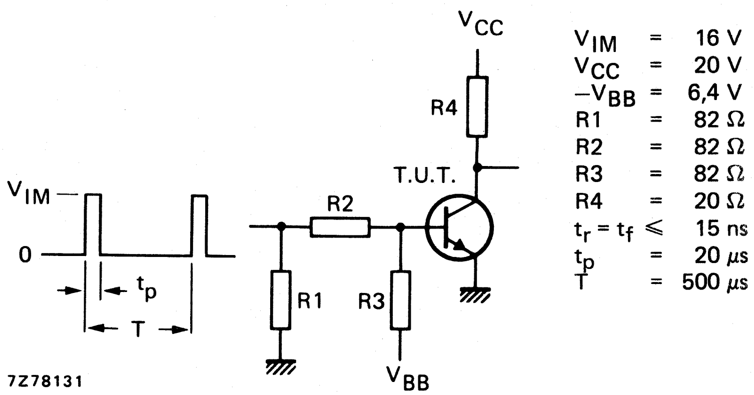


Fig. 3 Switching times test circuit.

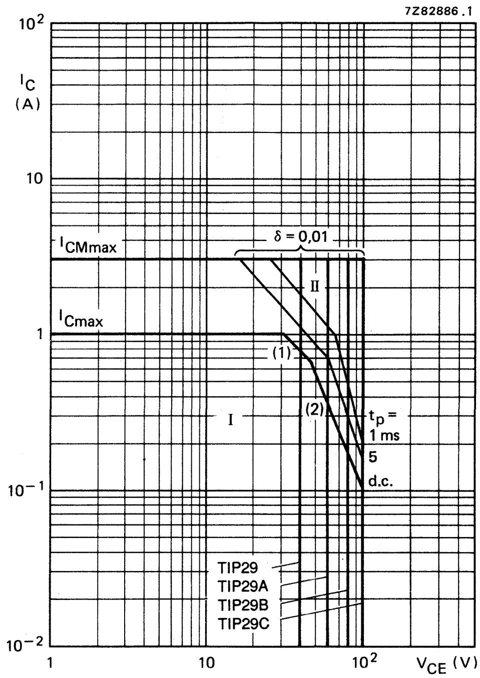


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

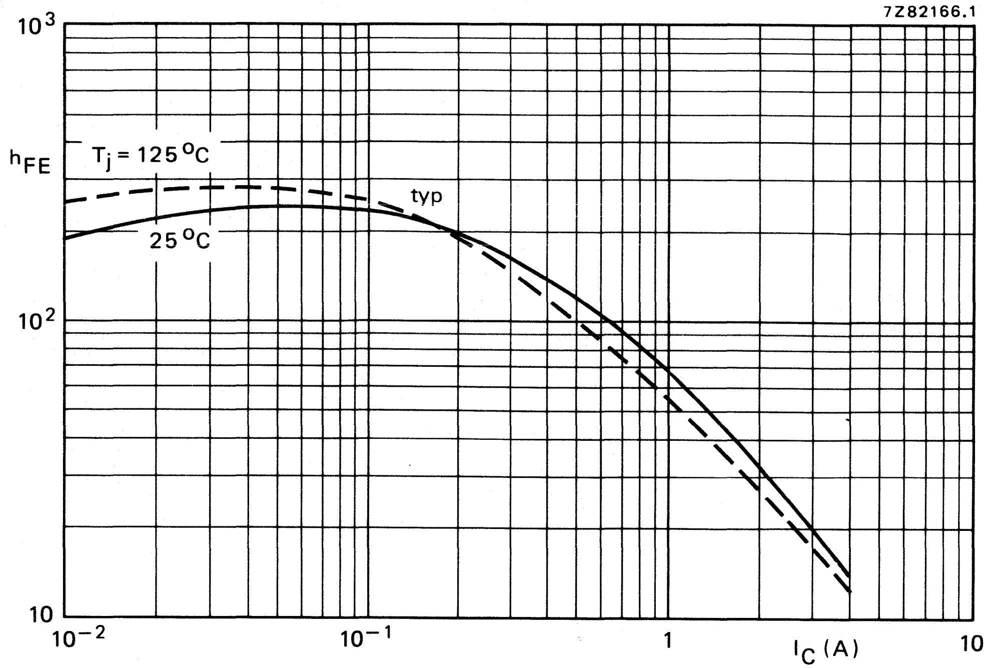


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4$ V.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon power transistors in a SOT186 envelope with an electrically insulated mounting base, intended for use in audio output stages, general purpose amplifier and high-speed switching applications.

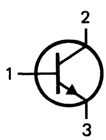
PNP complements are TIP30F, TIP30AF, TIP30BF, TIP30CF and TIP30DF.

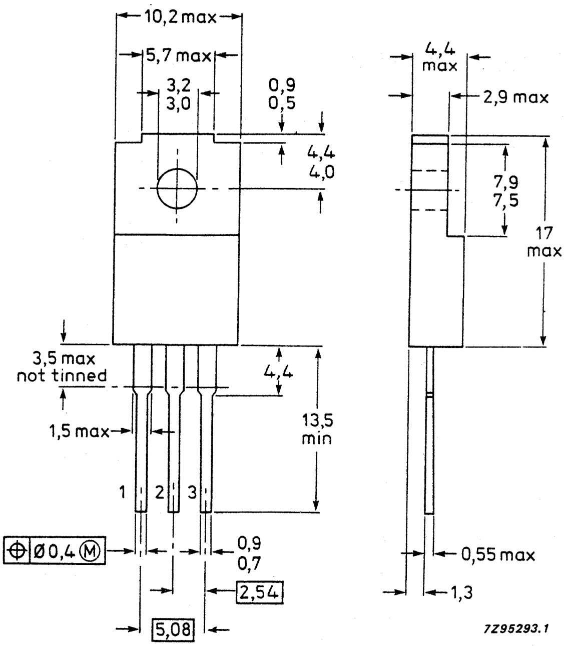
QUICK REFERENCE DATA

			TIP29F	29AF	29BF	29CF	29DF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	5	V
Collector current d.c.	I_C	max.	3	3	3	3	3	A
peak value	I_{CM}	max.	7	7	7	7	7	A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.	19	19	19	19	19	W
D.C. current gain I_C = 1 A; V_{CE} = 4 V	h_{FE}				15 to 75			
Transition frequency at f = 1 MHz I_C = 0,2 A; V_{CE} = 10 V	f_T	min.			3			MHz

Fig.1 SOT186.

Dimensions in mm





RATINGS

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

			TIP29F	29AF	29BF	29CF	29DF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current d.c.	I_C	max.			3			A
peak value	I_{CM}	max.			7			A
Base current (d.c.)	I_B	max.			0,4			A
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.			14			W
up to T_h = 25 °C (2)	P_{tot}	max.			19			W
Storage temperature	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to external heatsink (1)	$R_{th\ j\text{-}h}$	=	9,17	K/W
From junction to external heatsink (2)	$R_{th\ j\text{-}h}$	=	6,67	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	55	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value (3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newtons pressure on centre envelope.

(2) Mounted with heatsink compound and 30 ± 5 newtons pressure on centre envelope.

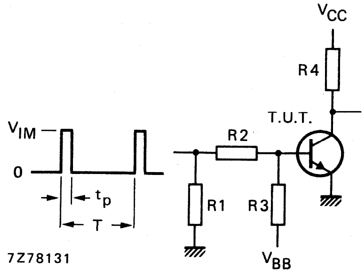
(3) Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure p_{amb} = 1013 mbar.

CHARACTERISTICS

T_h = 25 °C unless otherwise specified

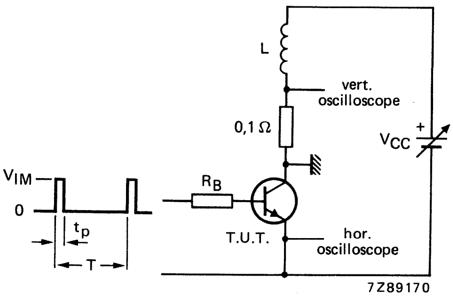
			TIP29F	29AF	29BF	29CF	29DF	
Collector cut-off currents								
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,1	0,1	—	—	—	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	<	—	—	0,1	0,1	—	mA
$I_B = 0$; $V_{CE} = 90$ V	I_{CEO}	<	—	—	—	—	0,1	mA
$V_{BE} = 0$; $V_{CE} = V_{CBO\,max}$	I_{CES}	<	0,2	0,2	0,2	0,2	0,2	mA
Emitter cut-off current								
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	0,2	0,2	0,2	0,2	0,2	mA
Collector-emitter breakdown voltages (1)								
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	40	60	80	100	120	V
D.C. current gain (1)								
$I_C = 0,2$ A; $V_{CE} = 4$ V	h_{FE}	>			40			
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}				15 to 75			
Base-emitter voltages (1)+(2)								
$I_C = 1$ A; $V_{CE} = 4$ V	V_{BE}	<			1,3			
Collector-emitter saturation voltage (1)								
$I_C = 1$ A; $I_B = 0,125$ A	V_{CEsat}	<			0,7			V
Transition frequency at f = 1 MHz								
$I_C = 0,2$ A; $V_{CE} = 10$ V	f_T	>			3			MHz
Small-signal current gain								
$I_C = 0,2$ A; $V_{CE} = 10$ V								
at 1 kHz	h_{fe}	>			20			
at 1 MHz	h_{fe}	>			3			
Turn-off breakdown energy with inductive load (see Fig. 3)								
$I_C = 1,8$ A; L = 20 mH	$E_{(BR)}$	>			32			mJ
Switching times (see Fig. 2)								
$I_C = 1$ A; $I_{Bon} = -I_{Boff} = 0,1$ A								
turn-on time	t_{on}	typ.			0,3			µs
turn-off time	t_{off}	typ.			1			µs

(1) Measured under pulse conditions: t_p = 300 µs; δ = 2%.
(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.



V_{CC} = 20 V
V_{IM} = 16 V
$-V_{BB}$ = 6,4 V
R1 = 82 Ω
R2 = 82 Ω
R3 = 82 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 20 μs
T = 500 μs

Fig. 2 Switching times test circuit.



V_{IM} = 12 V
R_B = 270 Ω
L = 20 mH
I_C = 1,8 A
t_p = 1 ms
δ = 1 %

Fig. 3 Test circuit for turn-off breakdown energy.

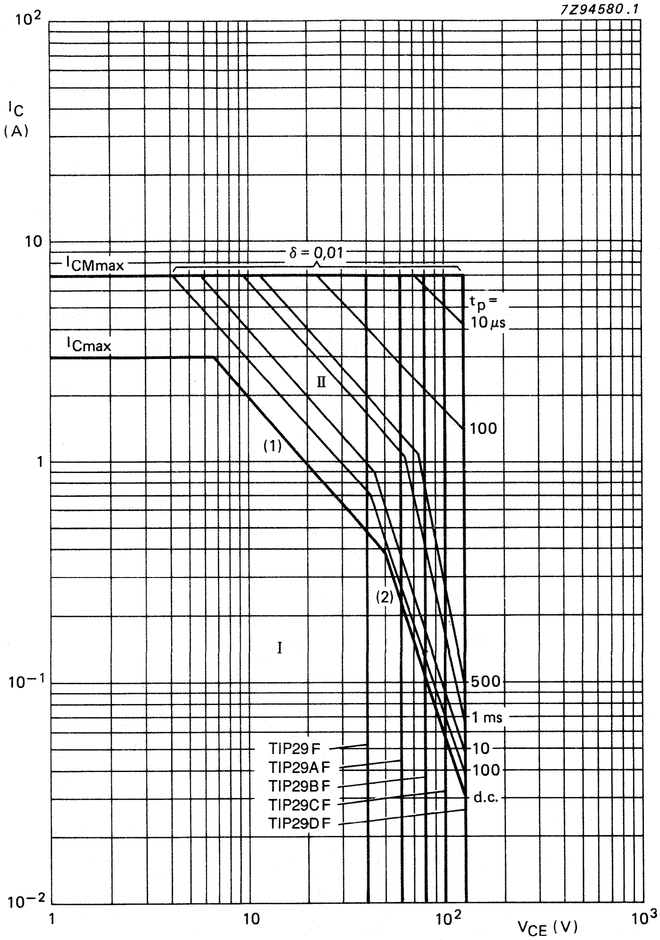


Fig. 4 Safe Operating Area, T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *with* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

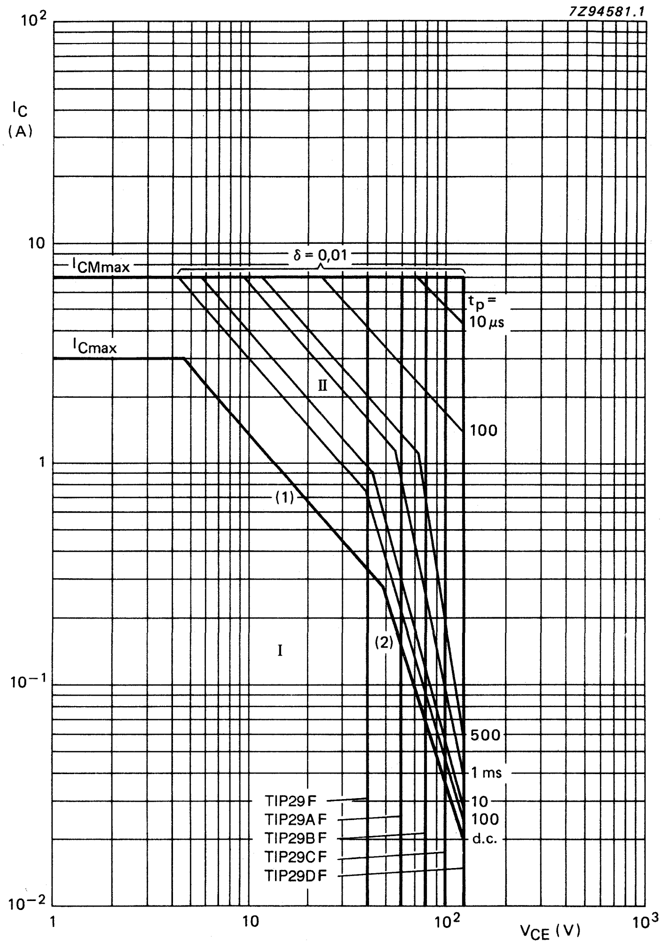


Fig. 5 Safe Operating Area, T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *without* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

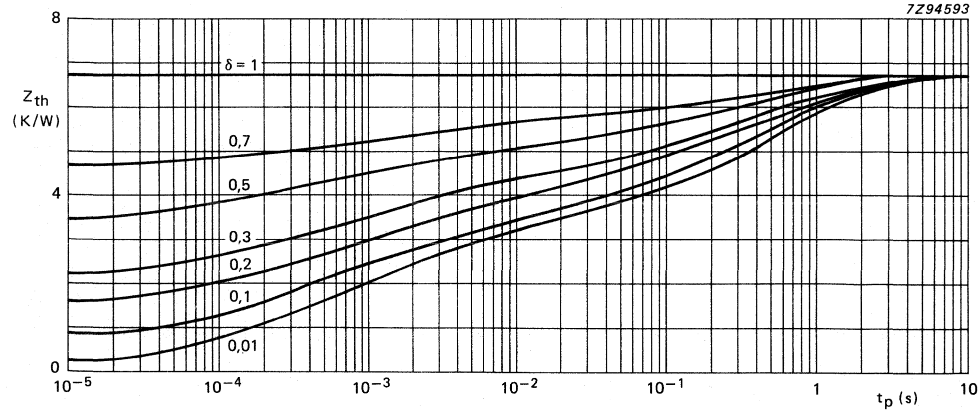


Fig. 6 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

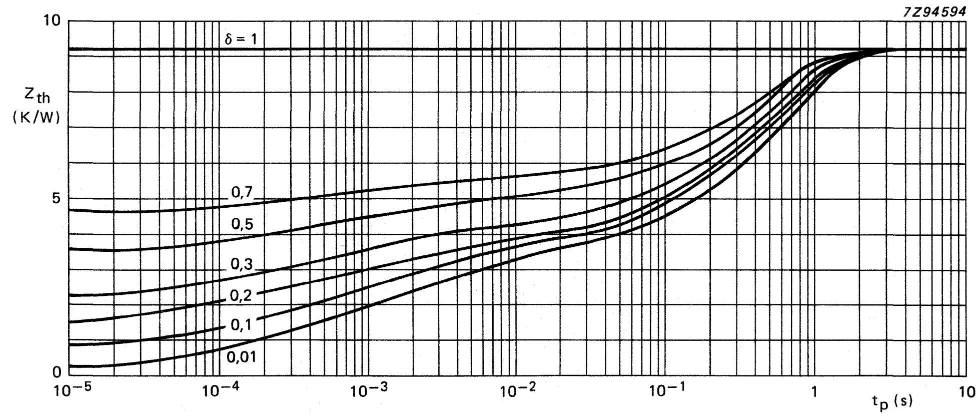


Fig. 7 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

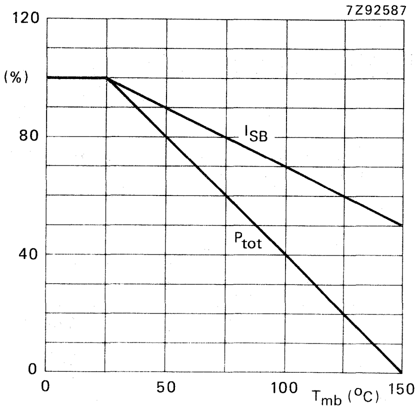


Fig. 8 Total power dissipation and second-breakdown current derating curve.

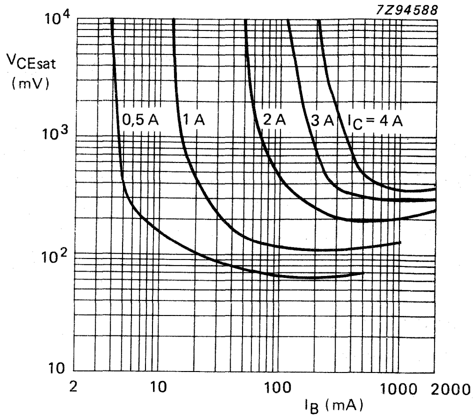


Fig. 9 Collector-emitter saturation voltage; typical values.

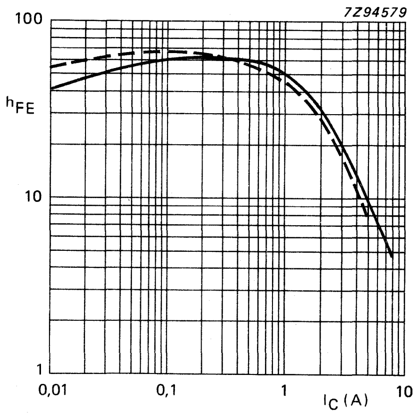


Fig. 10 D.C. current gain; V_{CE} = 4 V; typical values;
—— T_j = 25 °C; – – – – T_j = 125 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

PNP silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur. NPN complements are TIP29 series.

QUICK REFERENCE DATA

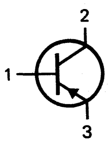
			TIP30	A	B	C	
Collector-base voltage	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.	1				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}		15 to 75				
Transition frequency $-I_C$ = 200 mA; $-V_{CE}$ = 10 V	f_T	>	3				MHz

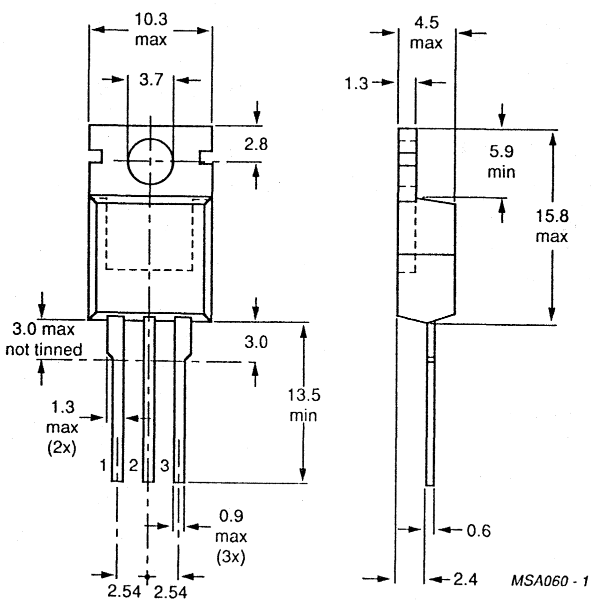
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP30	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	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.	3				A
Base current (d.c.)	$-I_B$	max.	0,4				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Storage temperature	T_{stg}		−65 to +150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP30;A	TIP30B;C	
Collector cut-off current					
$-I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	0,1	–	mA
$-I_B = 0; -V_{CE} = 60$ V	$-I_{CEO}$	<	–	0,1	mA
$-V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	0,2		mA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5$V	$-I_{EBO}$	<	0,2		mA
D.C. current gain*					
$-I_C = 200$ mA; $-V_{CE} = 4$ V	h_{FE}	>	40		
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage*					
$-I_C = 1$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,3		V
Collector-emitter saturation voltage*					
$-I_C = 1$ A; $-I_B = 0{,}125$ A	$-V_{CEsat}$	<	0,7		V

			TIP30	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0; -I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	
Small-signal current gain							
$-I_C = 0{,}2$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
Turn off breakdown energy							
L = 20 mH; $I_{CC} = 1{,}22$ A	$E_{(BR)}$	>	15				mJ

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

Transition frequency at f = 1 MHz $-I_C$ = 200 mA; $-V_{CE}$ = 10 V	f_T	>	3 MHz
Switching times $-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A			
turn-on time	t_{on}	typ.	0,3 μs
turn-off time	t_{off}	typ.	1 μs

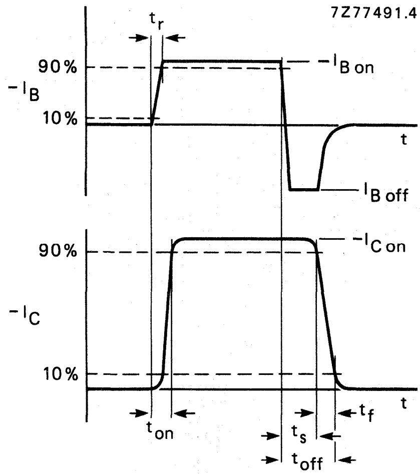
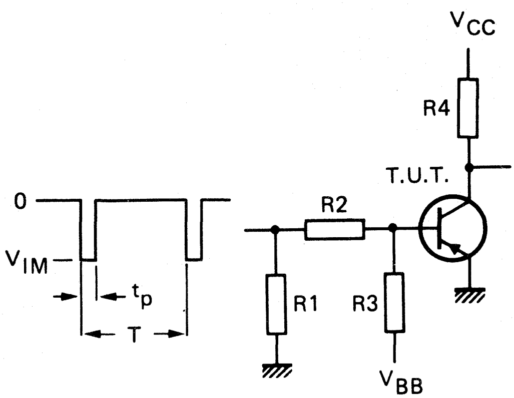


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	16 V
$-V_{CC}$	=	20 V
$+V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	=	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

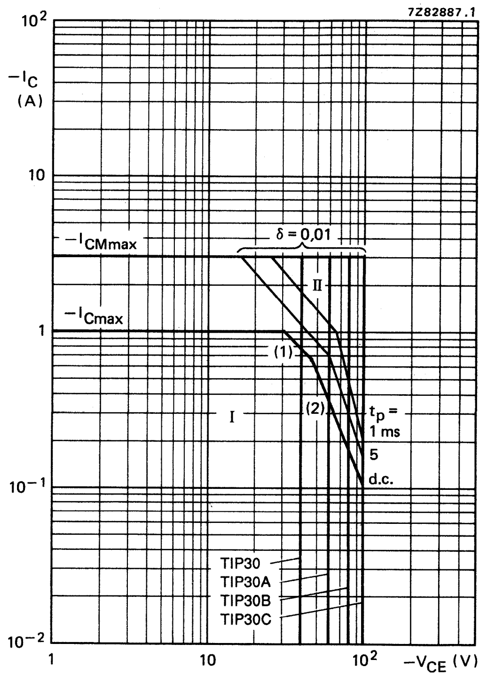


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

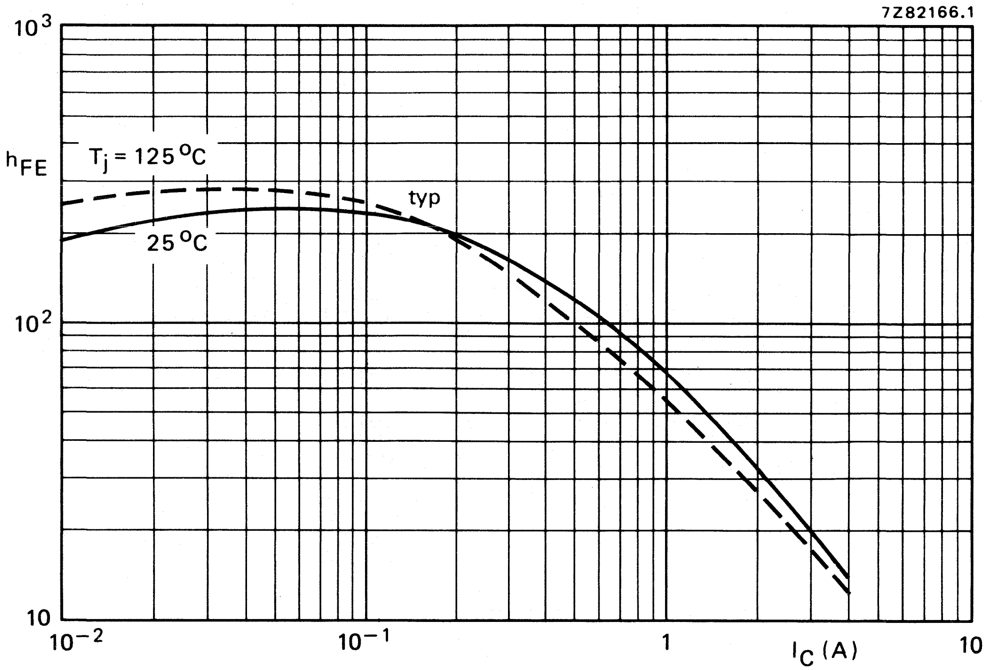


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 4$ V.

SILICON EPITAXIAL POWER TRANSISTORS

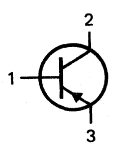
PNP silicon power transistor in a SOT186 envelope with an electrically insulated mounting base, for use in audio output stages and for general purpose amplifier and high-speed switching applications.

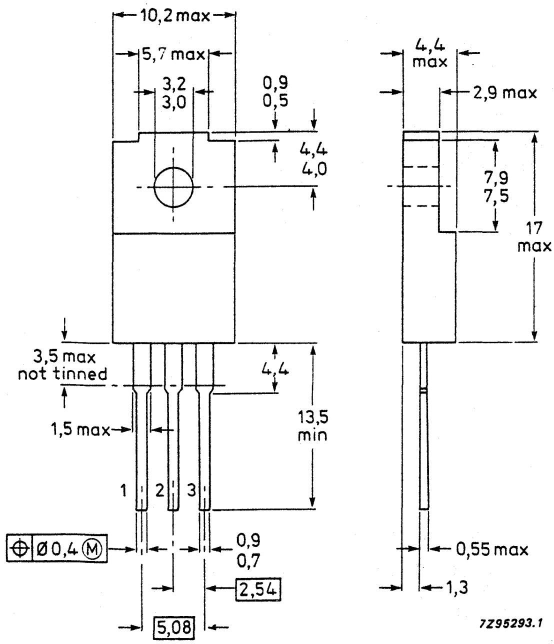
NPN complements are TIP29F, TIP29AF, TIP29BF, TIP29CF and TIP29DF.

QUICK REFERENCE DATA

			TIP30F	30AF	30BF	30CF	30DF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	5	V
Collector current d.c.	$-I_C$	max.	3	3	3	3	3	A
peak value	$-I_{CM}$	max.	7	7	7	7	7	A
Total power dissipation up to T_h = 25 °C	P_{tot}	max.	19	19	19	19	19	W
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}		15 to 75					
Transition frequency at f = 1 MHz $-I_C$ = 0,2 A; $-V_{CE}$ = 10 V	f_T	min.	3					MHz

Fig.1 SOT186. Dimensions in mm





RATINGS

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

			TIP30F	30AF	30BF	30CF	30DF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
Collector current d.c.	$-I_C$	max.			3			A
peak value	$-I_{CM}$	max.			7			A
Base current (d.c.)	$-I_B$	max.			0,4			A
Total power dissipation up to T_h = 25 °C (1)	P_{tot}	max.			14			W
up to T_h = 25 °C (2)	P_{tot}	max.			19			W
Storage temperature	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\,j\text{-}mb}$	=	4,17	K/W
From junction to external heatsink (1)	$R_{th\,j\text{-}h}$	=	9,17	K/W
From junction to external heatsink (2)	$R_{th\,j\text{-}h}$	=	6,67	K/W
From junction to ambient	$R_{th\,j\text{-}a}$	=	55	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value (3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

(1) Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

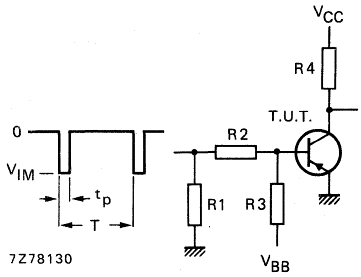
(3) Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure p_{amb} = 1013 mbar.

CHARACTERISTICS

T_h = 25 °C unless otherwise specified

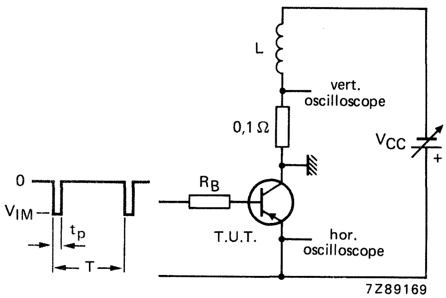
			TIP30F	30AF	30BF	30CF	30DF	
Collector cut-off currents								
$-I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	0,1	0,1	–	–	–	mA
$-I_B = 0; -V_{CE} = 60$ V	$-I_{CEO}$	<	–	–	0,1	0,1	–	mA
$-I_B = 0; -V_{CE} = 90$ V	$-I_{CEO}$	<	–	–	–	–	0,1	mA
$-V_{BE} = 0; -V_{CE} = V_{CBOmax}$	$-I_{CES}$	<	0,2	0,2	0,2	0,2	0,2	mA
Emitter-cut-off current								
$-I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	0,2	0,2	0,2	0,2	0,2	mA
Collector-emitter breakdown voltages (1)								
$-I_B = 0; -I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	120	V
D.C. current gain (1)								
$-I_C = 0,2$ A; $-V_{CE} = 4$ V	h_{FE}	>			40			
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}				15 to 75			
Base-emitter voltage (1)+(2)								
$-I_C = 1$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<			1,3			V
Collector-emitter saturation voltage (1)								
$-I_C = 1$ A; $-I_B = 0,125$ A	$-V_{CEsat}$	<			0,7			V
Transition frequency at f = 1 MHz								
$-I_C = 0,2$ A; $-V_{CE} = 10$ V	f_T	>			3			MHz
Small-signal current gain								
$-I_C = 0,2$ A; $-V_{CE} = 10$ V								
at 1 kHz	h_{fe}	>			20			
at 1 MHz	h_{fe}	>			3			
Turn-off breakdown energy with inductive load (see Fig. 3)								
$-I_C = 1,8$ A; L = 20 mH	$E_{(BR)}$	>			32			mJ
Switching times (see Fig. 2)								
$-I_C = 1$ A; $-I_{Bon} = +I_{Boff} = 0,1$ A								
turn-on time	t_{on}	typ.			0,3			µs
turn-off time	t_{off}	typ.			1			µs

(1) Measured under pulse conditions: $t_p = 300$ µs; $\delta = 2\%$.
(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.



$-V_{CC}$	=	20 V
$-V_{IM}$	=	16 V
$+V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	=	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 2 Switching times test circuit.



$-V_{IM}$	=	12 V
R_B	=	270 Ω
L	=	20 mH
$-I_C$	=	1,8 A
t_p	=	1 ms
δ	=	1 %

Fig. 3 Test circuit for turn-off breakdown energy.

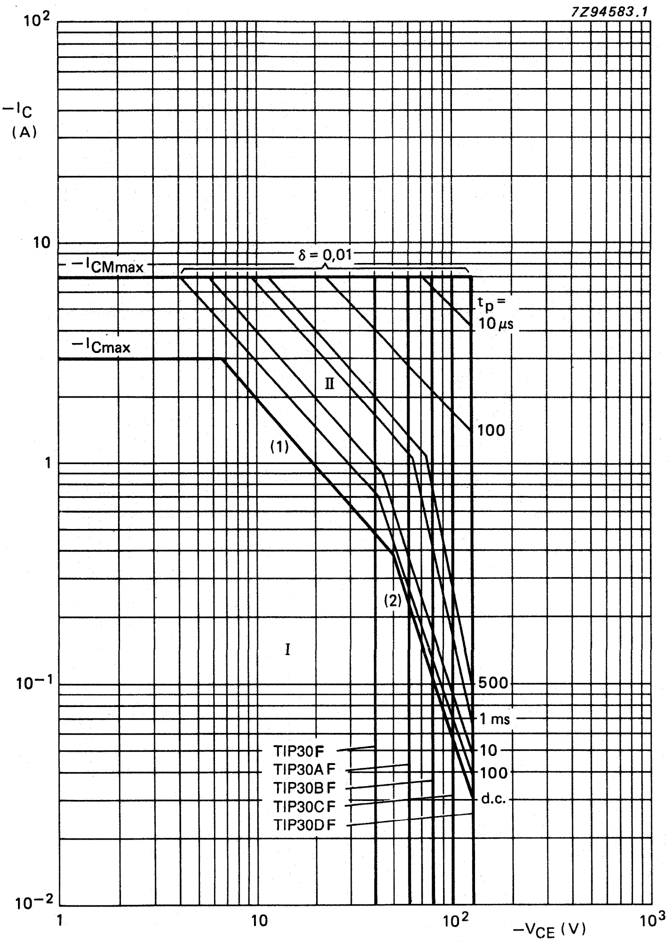


Fig. 4 Safe Operating Area, T_{amb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *with* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

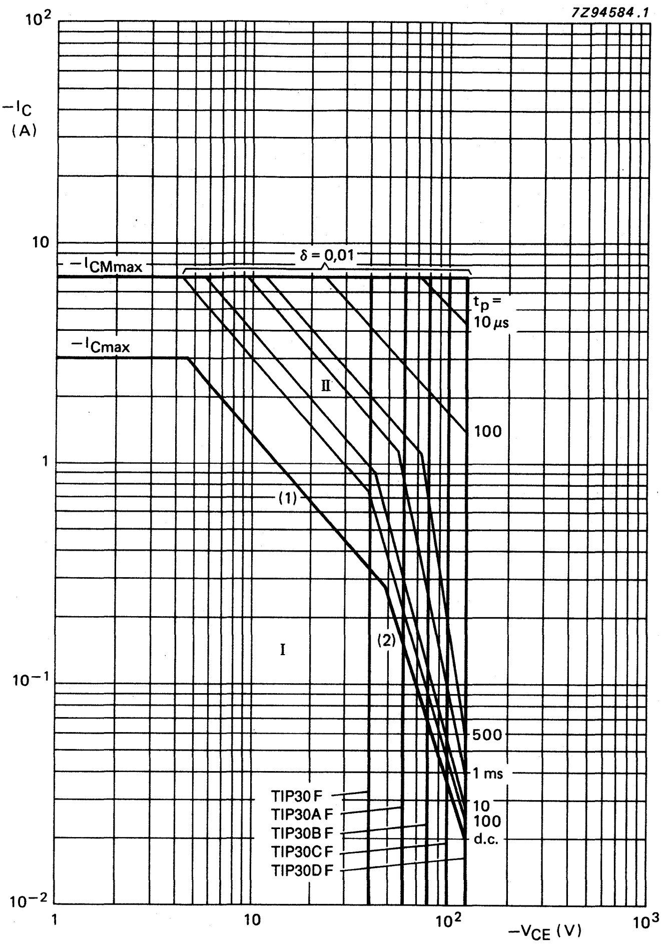


Fig. 5 Safe Operating Area, T_{amb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Mounted *without* heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

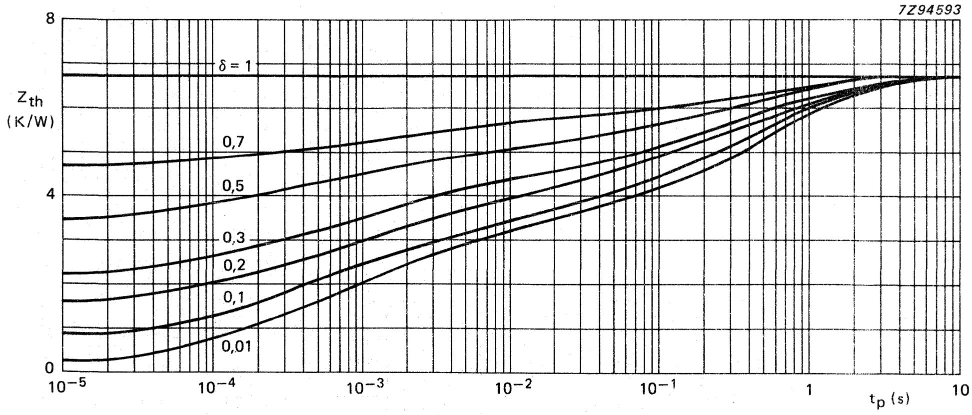


Fig. 6 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

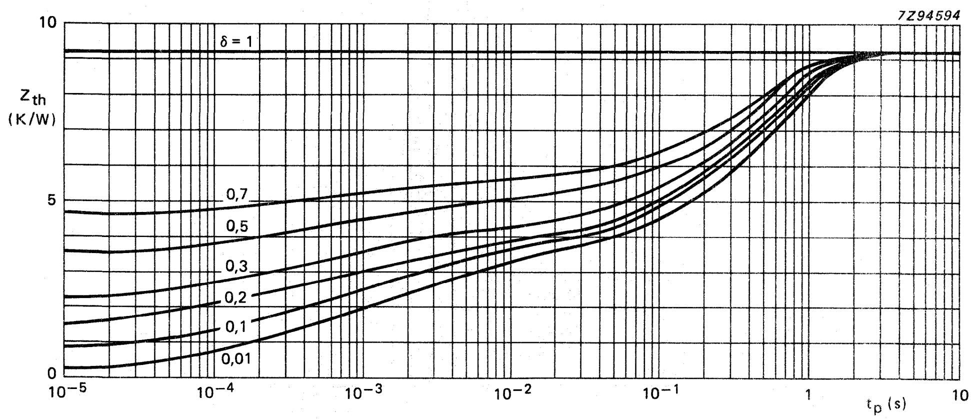


Fig. 7 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

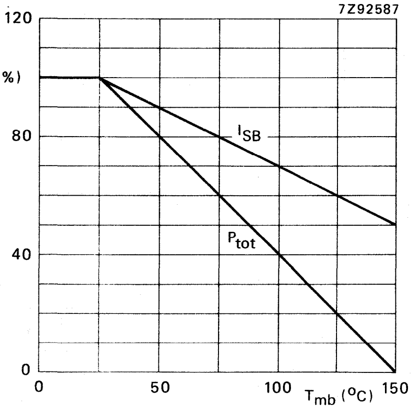


Fig. 8 Total power dissipation and second-breakdown current derating curve.

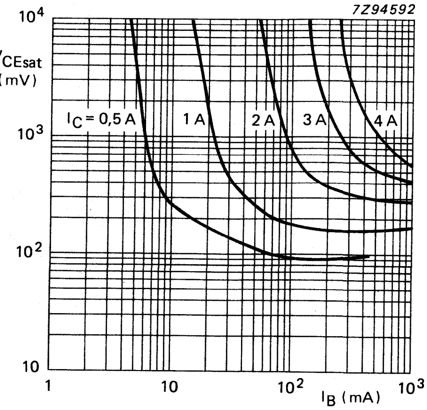


Fig. 9 Collector-emitter saturation voltage; typical values.

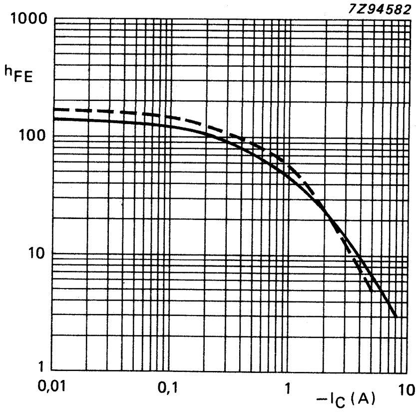


Fig. 10 D.C. current gain; $-V_{CE}$ = 4 V; typical values;
—— T_j = 25 °C; – – – – T_j = 125 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

NPN transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications. PNP complements are TIP32 series.

QUICK REFERENCE DATA

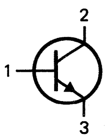
			TIP31	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.		3			A
Collector current (peak value)	I_{CM}	max.		5			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 1 A; V_{CE} = 4 V	h_{FE}	>		25			
I_C = 3 A; V_{CE} = 4 V	h_{FE}			10 to 50			

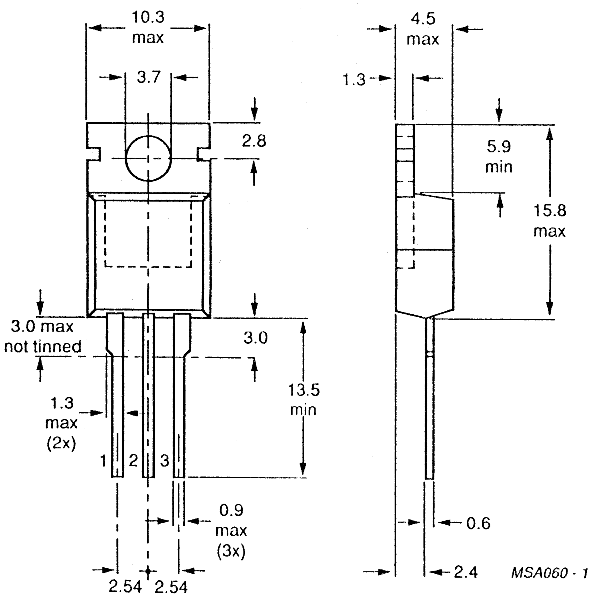
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP31	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	3				A
Collector current (peak value)	I_{CM}	max.	5				A
Base current (d.c.)	I_B	max.	1				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP31;A	TIP31B;C	
Collector cut-off current					
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,1	–	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	<	–	0,1	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	<	0,2		mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	0,2		mA
D.C. current gain *					
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}	>	25		
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}		10 to 50		
Base-emitter voltage * **					
$I_C = 3$ A; $V_{CE} = 4$ V	V_{BE}	<	1,8		V
Collector-emitter saturation voltage *					
$I_C = 3$ A; $I_B = 0,375$ A	V_{CEsat}	<	1,2		V

			TIP31	A	B	C	
Collector-emitter breakdown voltage *							
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current transfer ratio							
$I_C = 0,5$ A; $V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
$I_C = 0,5$ A; $V_{CE} = 10$ V; f = 1 MHz	$\|h_{fe}\|$	>	3				
Turn-off breakdown energy							
L = 20 mH; $I_{CC} = 1,8$ A	$E_{(BR)}$	>	32				mJ

* Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta \leq 2\%$.

** V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Switching times
(between 10% and 90% levels)
I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

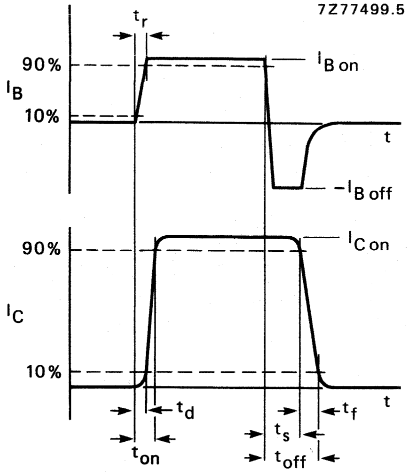


Fig. 2 Switching times waveforms.

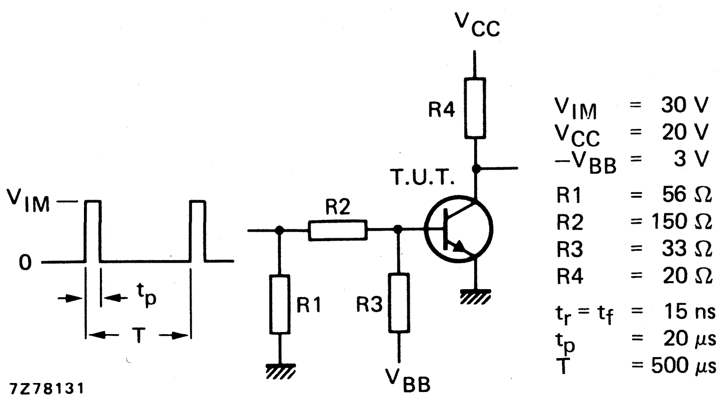


Fig. 3 Switching times test circuit.

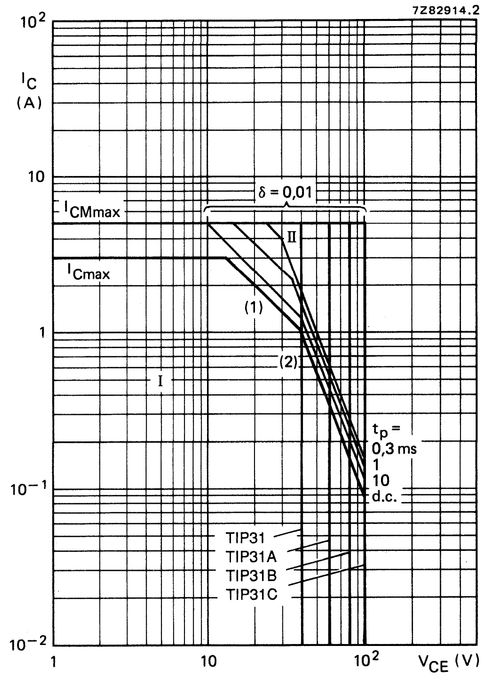


Fig. 4 Safe Operating Area; $T_{mb} = 25$ °C.

I   Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

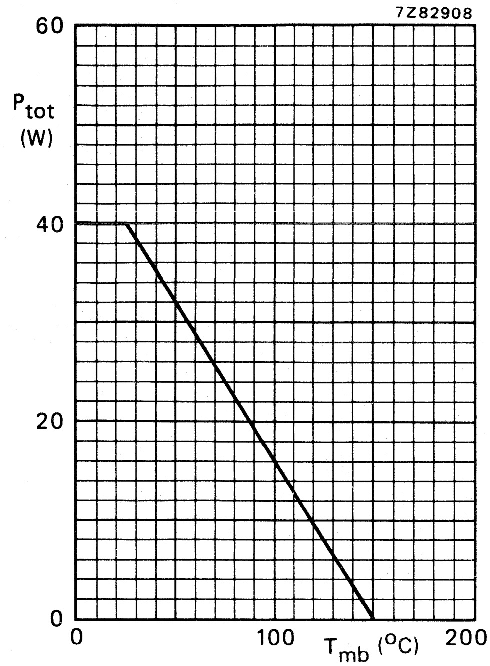


Fig. 5 Power derating curve.

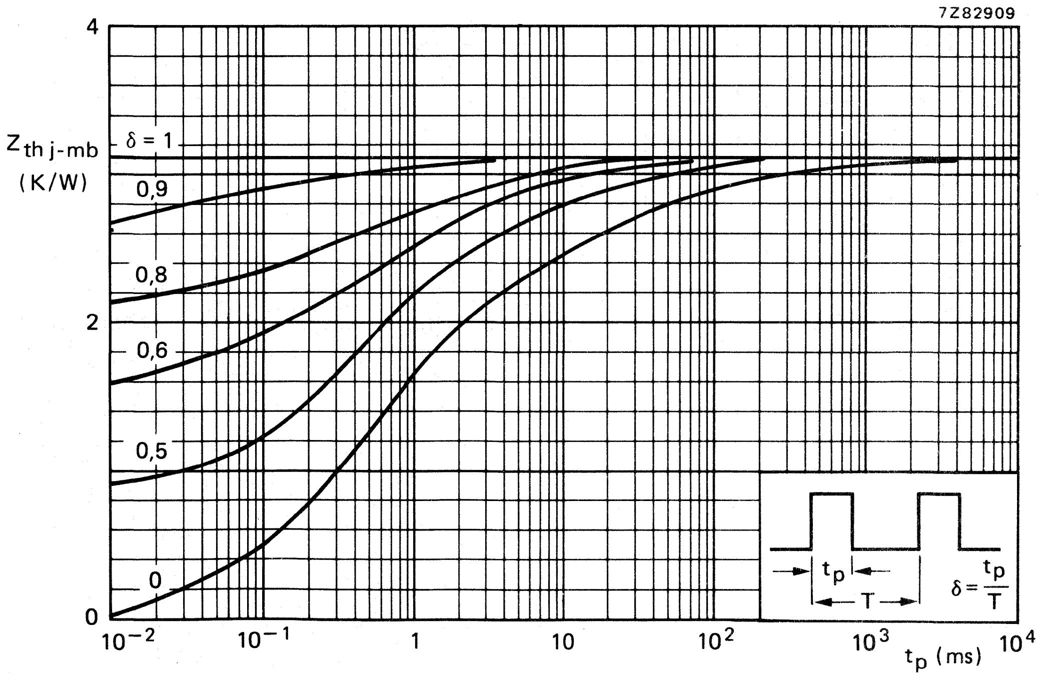


Fig. 6 Pulse power rating chart.

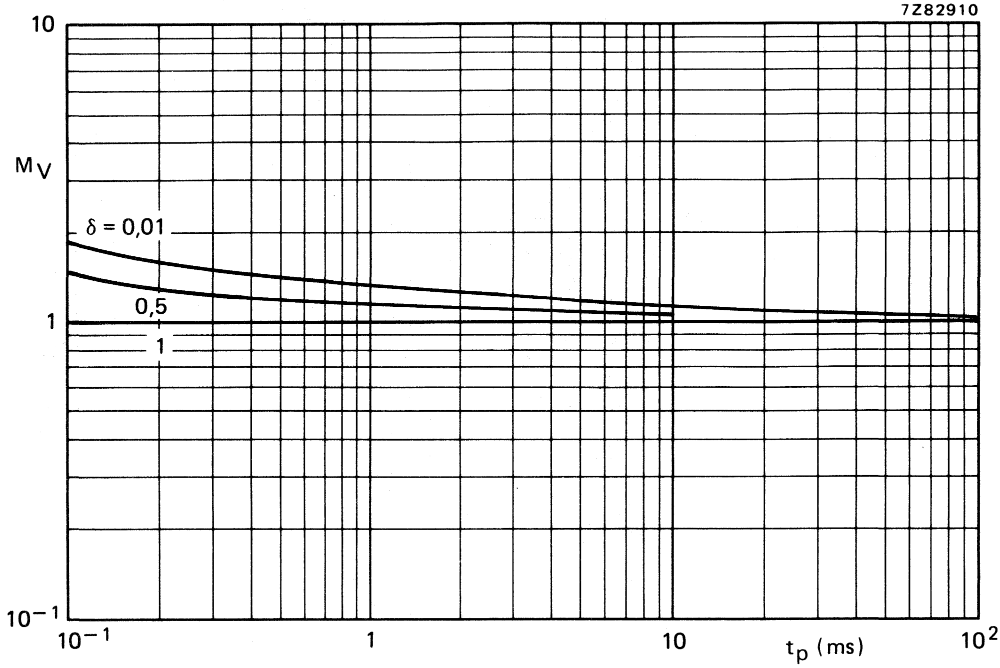


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

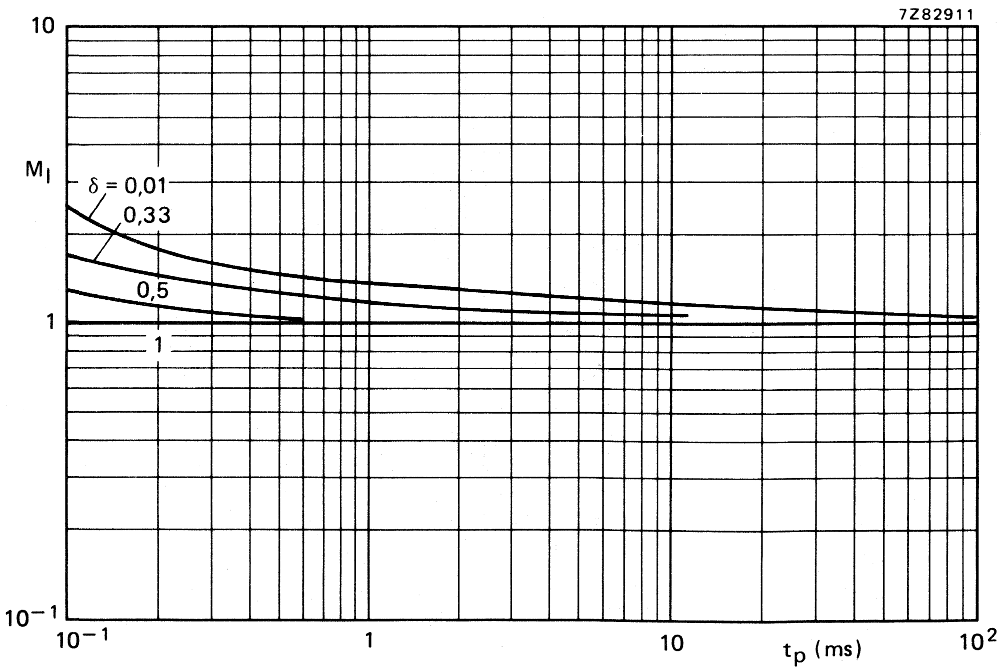


Fig. 8 S.B. current multiplying factor at the V_{CEOmax} level.

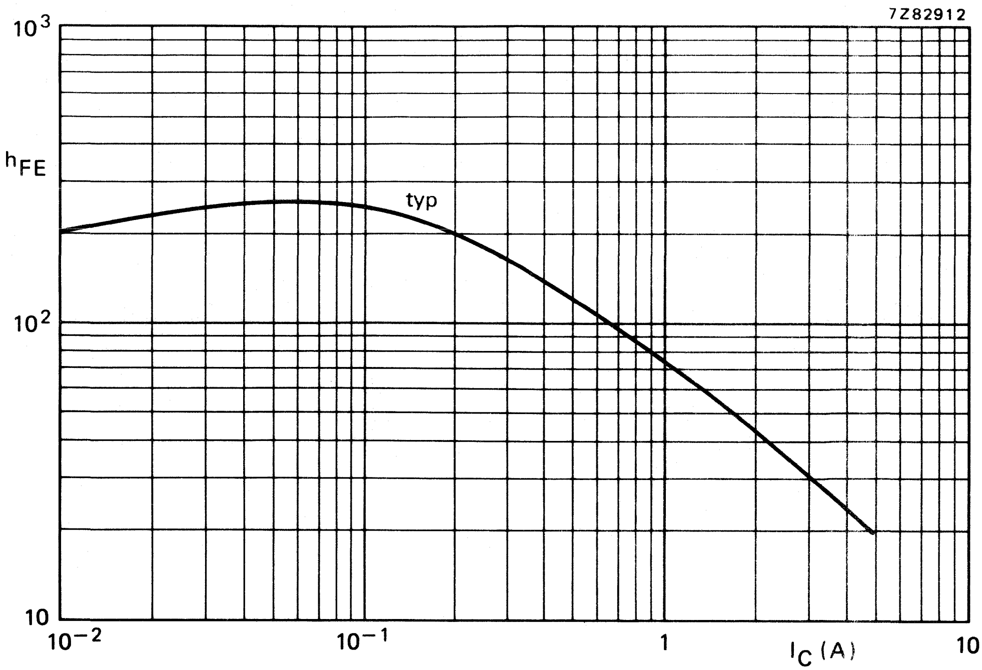


Fig. 9 Typical values d.c. current gain at V_{CE} = 4 V.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon power transistors in a SOT186 envelope with an electrically insulated mounting base.

They are intended for use in audio amplifier output stages, general purpose amplifiers, and high-speed switching applications.

PNP complements are TIP32F, TIP32AF, TIP32BF, TIP32CF and TIP32DF.

QUICK REFERENCE DATA

			TIP31F	31AF	31BF	31CF	31DF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
DC collector current	I_C	max.			3			A
Peak collector current	I_{CM}	max.			5			A
DC current gain $I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}	min.			10			
Small-signal current gain at f = 1 MHz $I_C = 0.5$ A; $V_{CE} = 10$ V	h_{fe}	min.			3			

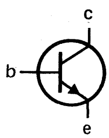
MECHANICAL DATA

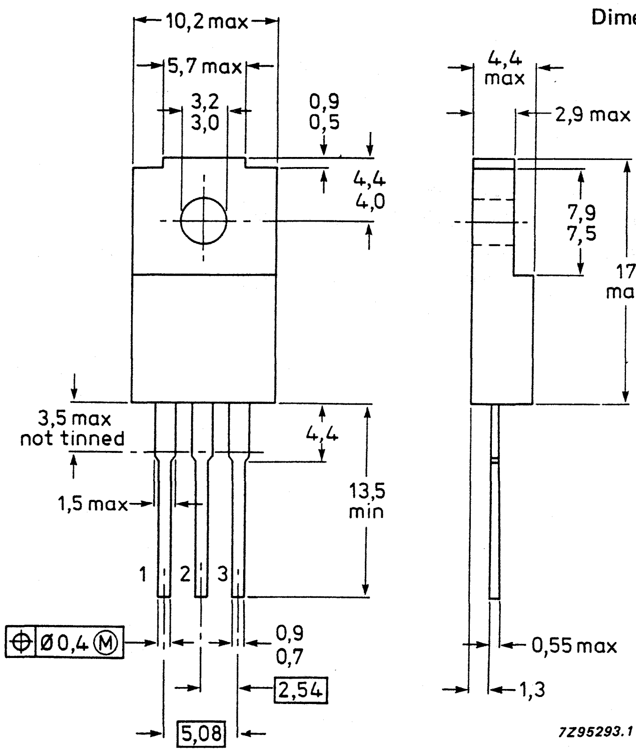
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			TIP31F	31AF	31BF	31CF	31DF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
DC collector current	I_C	max.			3			A
Peak collector current	I_{CM}	max.			5			A
DC base current	I_B	max.			1			A
Total power dissipation up to T_h = 25 °C (note 1)	P_{tot}	max.			15			W
up to T_h = 25 °C (note 2)	P_{tot}	max.			22			W
Storage temperature range	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	3.12	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	8.12	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.62	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	55	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value (note 3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
3. Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure P_{amb} = 1013 mbar.

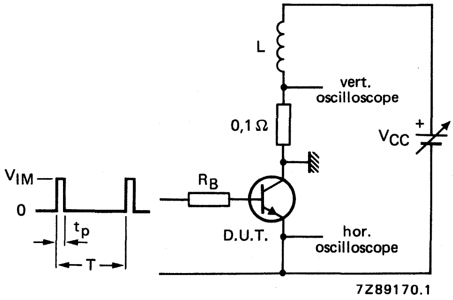
CHARACTERISTICS

T_h = 25 °C unless otherwise specified

			TIP31F	31AF	31BF	31CF	31DF	
Collector cut-off current								
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	max.	0.1	0.1	–	–	–	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	max.	–	–	0.1	0.1	–	mA
$I_B = 0$; $V_{CE} = 90$ V	I_{CEO}	max.	–	–	–	–	0.1	mA
$V_{BE} = 0$; $V_{CE} = V_{CBOmax}$	I_{CES}	max.	0.2	0.2	0.2	0.2	0.2	mA
Emitter cut-off current								
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	max.	0.2	0.2	0.2	0.2	0.2	mA
DC current gain (note 1)								
$I_C = 1$ A; $V_{CE} = 4$ V	h_{FE}	min.	25	25	25	25	25	
$I_C = 3$ A, $V_{CE} = 4$ V	h_{FE}	min.	10	10	10	10	5	
		max.	50	50	50	50	–	
Collector-emitter breakdown voltage (note 1)								
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	min.	40	60	80	100	120	V
Collector-emitter saturation voltage (note 1)								
$I_C = 3$ A; $I_B = 375$ mA	V_{CEsat}	max.	1.2	1.2	1.2	1.2	–	V
$I_C = 3$ A, $I_B = 750$ mA	V_{CEsat}	max.	–	–	–	–	2.5	V
Base-emitter voltages (notes 1 and 2)								
$I_C = 3$ A; $V_{CE} = 4$ V	V_{BE}	max.			1.8			V
Small-signal current gain								
$I_C = 0.5$ A; $V_{CE} = 10$ V								
at 1 kHz	h_{fe}	min.			20			
at 1 MHz	h_{fe}	min.			3			
Turn-off breakdown energy with inductive load (see Fig.3)								
$I_C = 1.8$ A; $L = 20$ mH	$E_{(BR)}$	min.			32			mJ
Switching times (see Fig.2)								
$I_C = 1$ A; $I_{B\,on} = -I_{B\,off} = 0.1$ A								
turn-on time	t_{on}	typ.			0.3			μs
turn-off time	t_{off}	typ.			1			μs

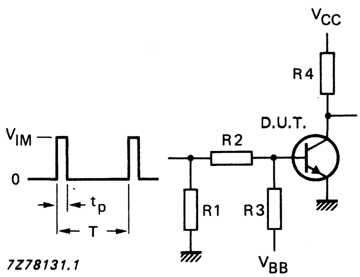
Notes

1. Measured under pulse conditions: $t_p = 300$ μs; $\delta = 2\%$.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



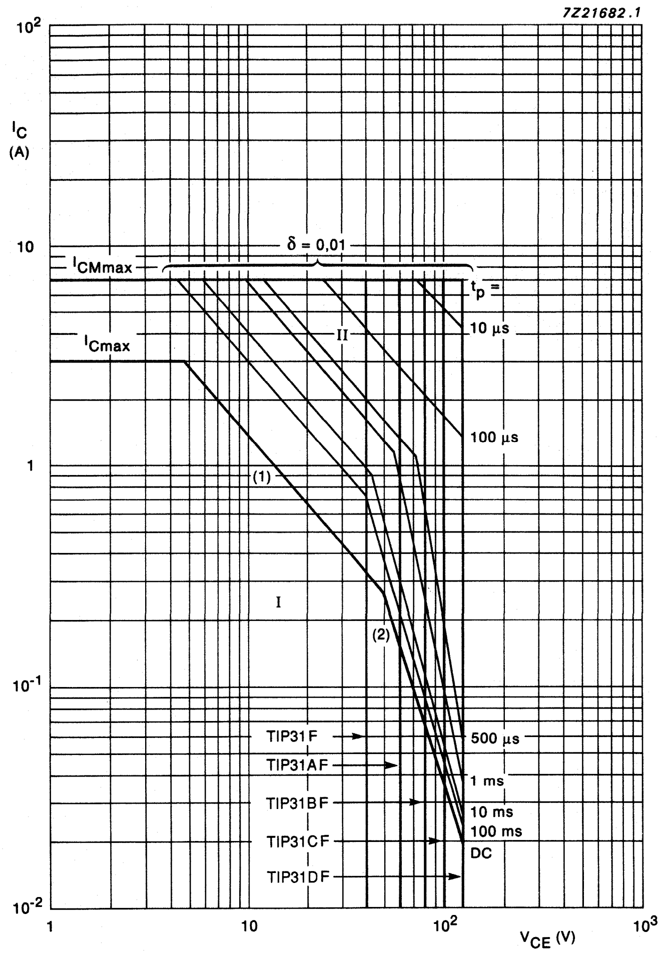
V_{CC} = 20 V
V_{IM} = 30 V
$-V_{BB}$ = 3 V
R_1 = 56 Ω
R_2 = 150 Ω
R_3 = 33 Ω
R_4 = 20 Ω
t_r = t_f = 15 ns
t_p = 20 μs
T = 500 μs

Fig.2 Switching times test circuit.



V_{IM} = 12 V
R_B = 270 Ω
L = 20 mH
I_C = 1.8 A
t_p = 1 ms
δ = 1 %

Fig.3 Test circuit for turn-off breakdown energy.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits.

Mounted without heatsink compound and 30 ± 5 newtons pressure on the centre of the envelope.

Fig.4 Safe Operating Area, T_{amb} = 25 °C.

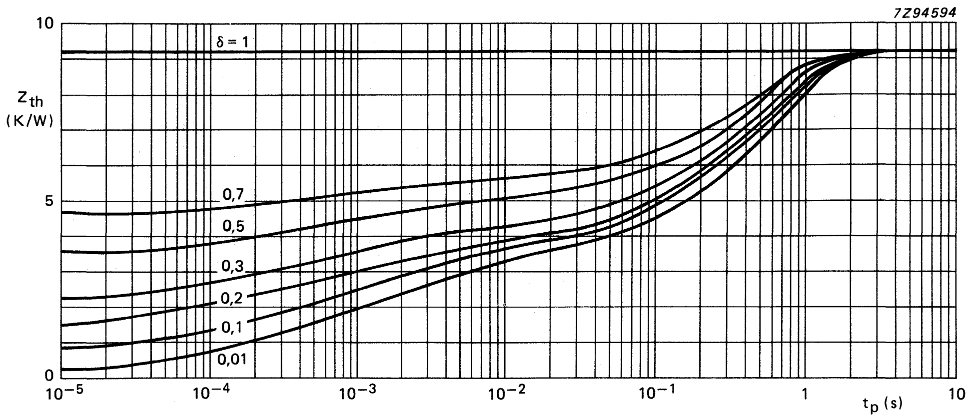


Fig.5 Pulse power rating chart; mounted without heatsink compound and 30 ± 5 newtons pressure on the envelope.

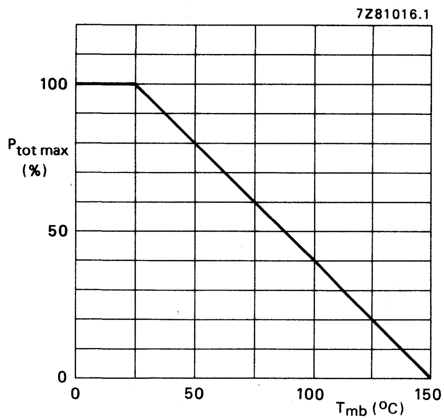


Fig.6 Total power dissipation.

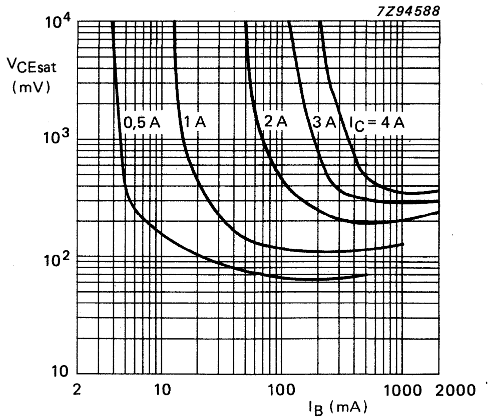


Fig.7 Typical collector-emitter saturation voltage; T_j = 25 °C.

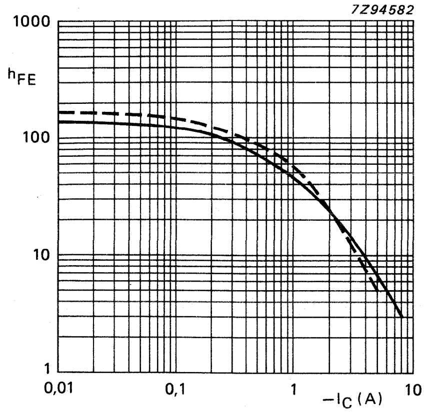


Fig.8 Typical DC current gain; V_{CE} = 4 V; T_j = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

PNP transistors in a plastic TO-220 envelope. They are intended for use in a wide range of power amplifiers and for switching applications. NPN complements are TIP31 series.

QUICK REFERENCE DATA

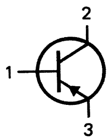
			TIP32	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		3			A
Collector current (peak value)	$-I_{CM}$	max.		5			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
$-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}	>		25			
$-I_C$ = 3 A; $-V_{CE}$ = 4 V	h_{FE}			10 to 50			

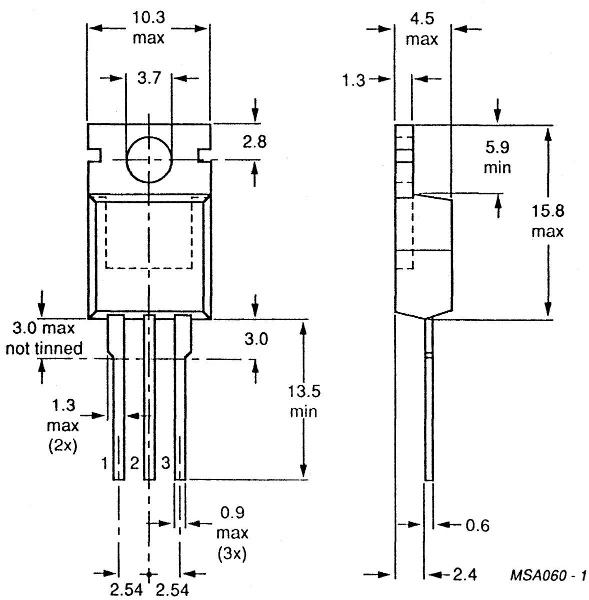
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP32	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	3				A
Collector current (peak value)	$-I_{CM}$	max.	5				A
Base current	$-I_B$	max.	1				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP32;A	TIP32B;C	
Collector cut-off current					
$I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	0,1		mA
$I_B = 0; -V_{CE} = 60$ V	$-I_{CEO}$	<		0,1	mA
$V_{EB} = 0; -V_{CE} = -V_{CEO}$	$-I_{CES}$	<	0,2		mA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	0,2		mA
D.C. current gain *					
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	>	25		
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}		10 to 50		
Base-emitter voltage * **					
$-I_C = 3$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,8		V
Collector-emitter saturation voltage					
$-I_C = 3$ A; $-I_B = 0,375$ A	$-V_{CEsat}$	<	1,2		V

			TIP32	A	B	C	
Collector-emitter breakdown voltage *							
$I_B = 0; -I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	V
Small signal current transfer ratio							
$-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 MHz	$\|h_{fe}\|$	>	3				
Turn-off breakdown energy							
L = 20 mH; $I_{CC} = 1,22$ A	$E_{(BR)}$	>	15				mJ

* Measured under pulse conditions: $t_p \leq 300\ \mu s$, $\delta < 2\%$.
** V_{EB} decreases by about 2,3 mV/K with increasing temperature.

Switching times
(between 10% and 90% levels)
$-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

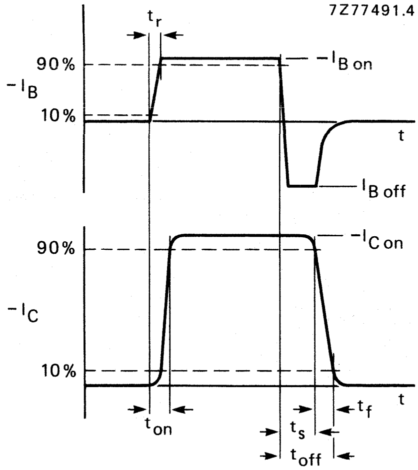
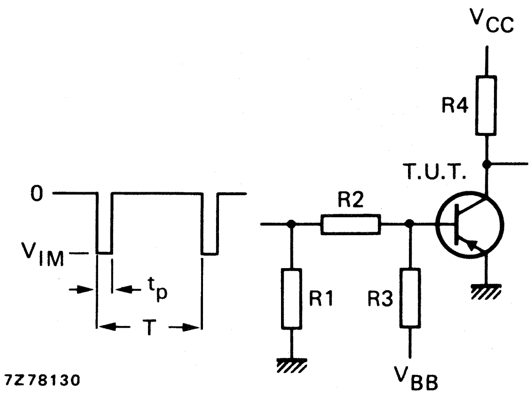


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	30 V
$-V_{CC}$	=	20 V
V_{BB}	=	3 V
R_1	=	56 Ω
R2	=	150 Ω
R3	=	33 Ω
R4	=	20 Ω
$t_r = t_f$	$\leqslant$	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

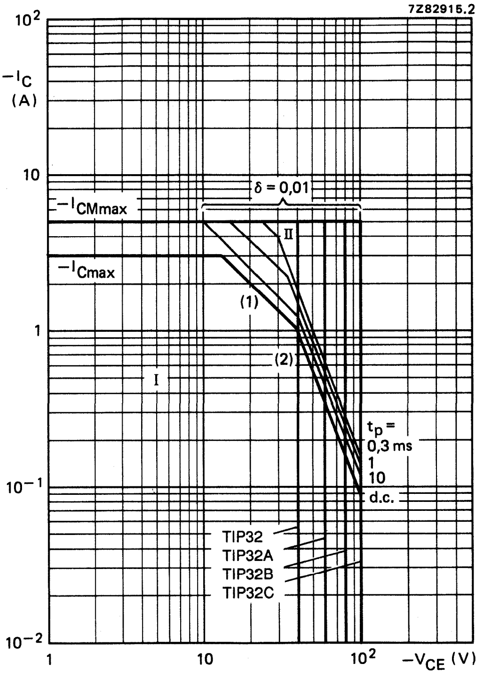


Fig. 4 Safe Operating Area. $T_{mb} \leqslant 25\ ^{o}C$.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

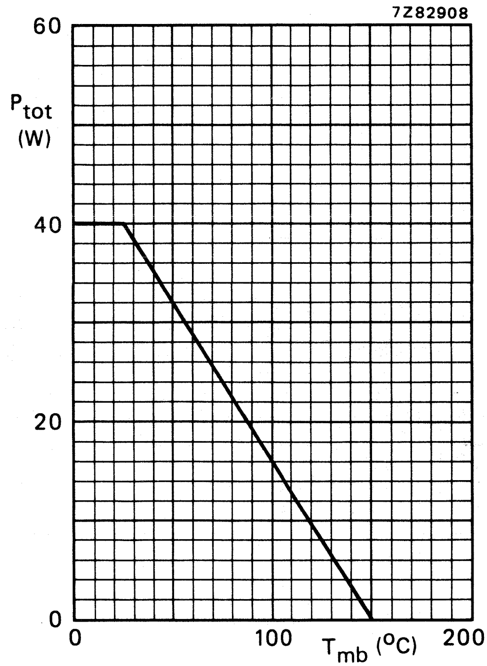


Fig. 5 Power derating curve.

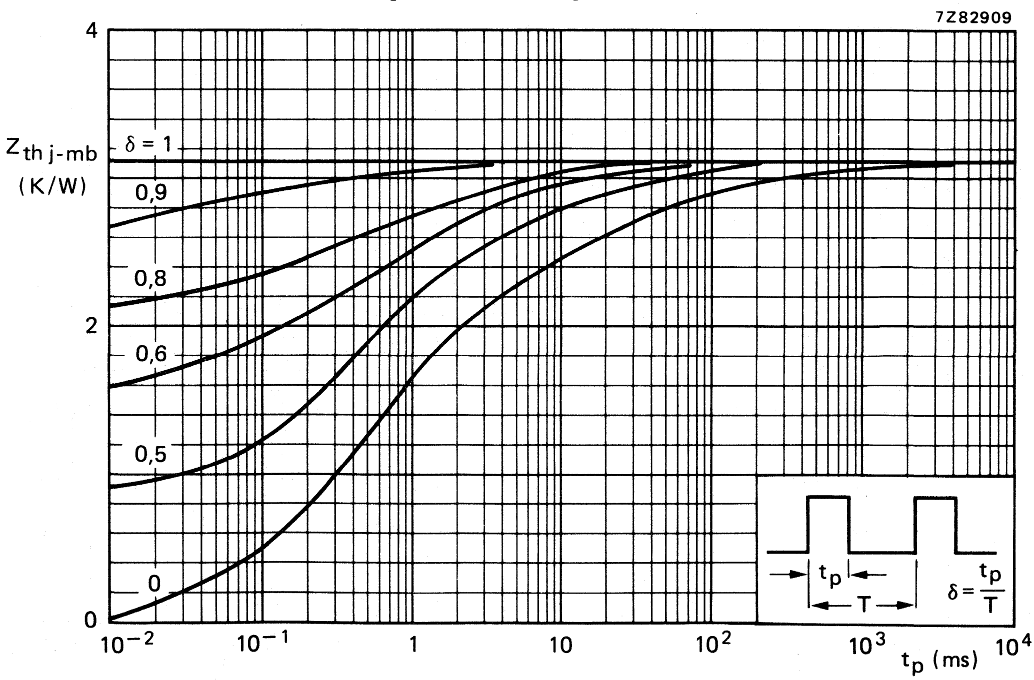


Fig. 6 Pulse power rating chart.

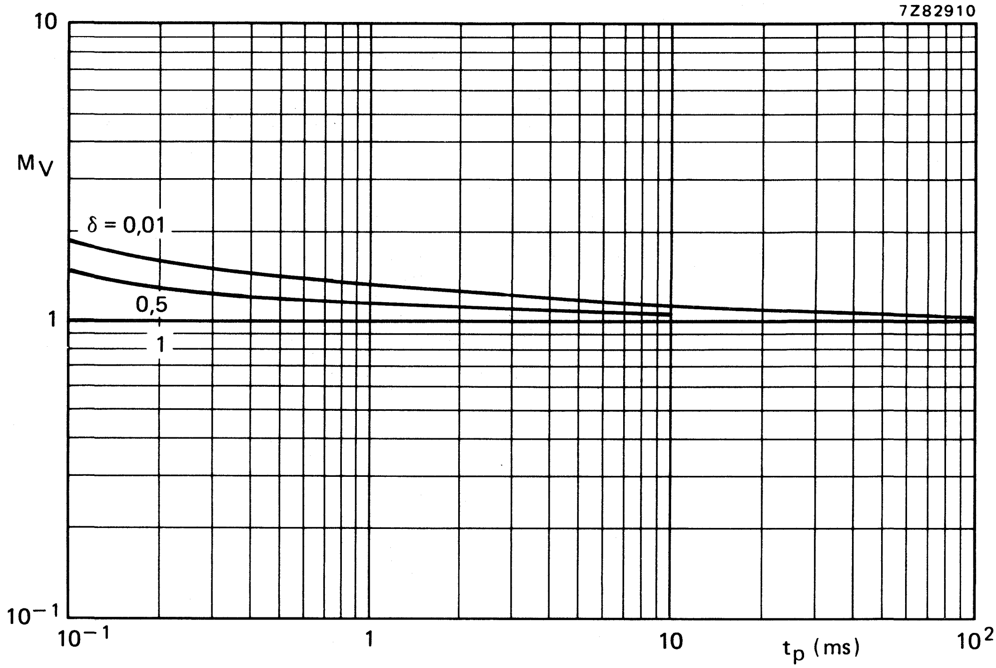


Fig. 7 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

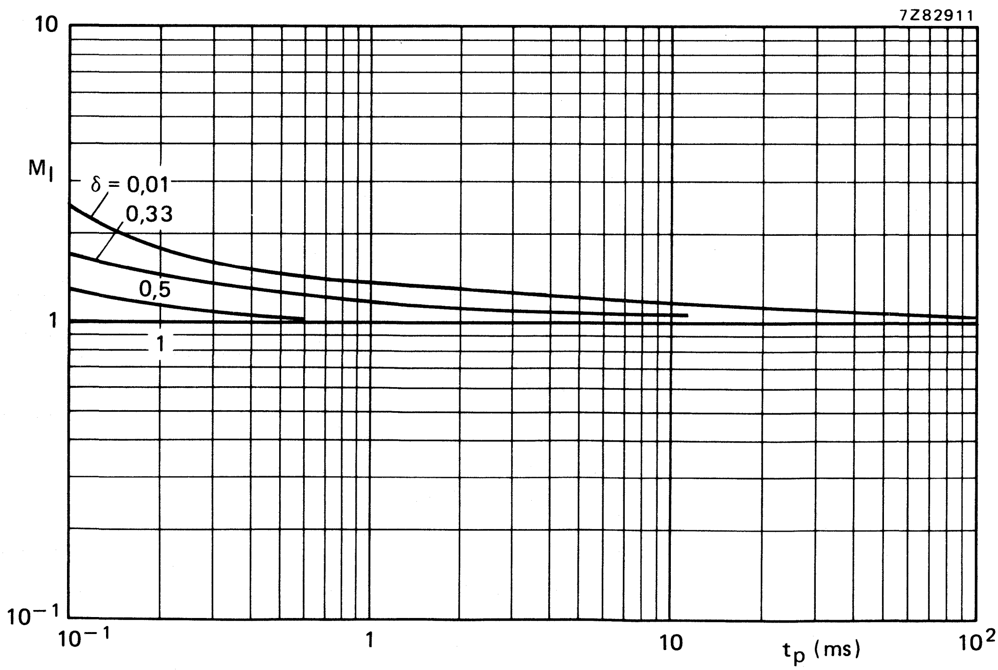


Fig. 8 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

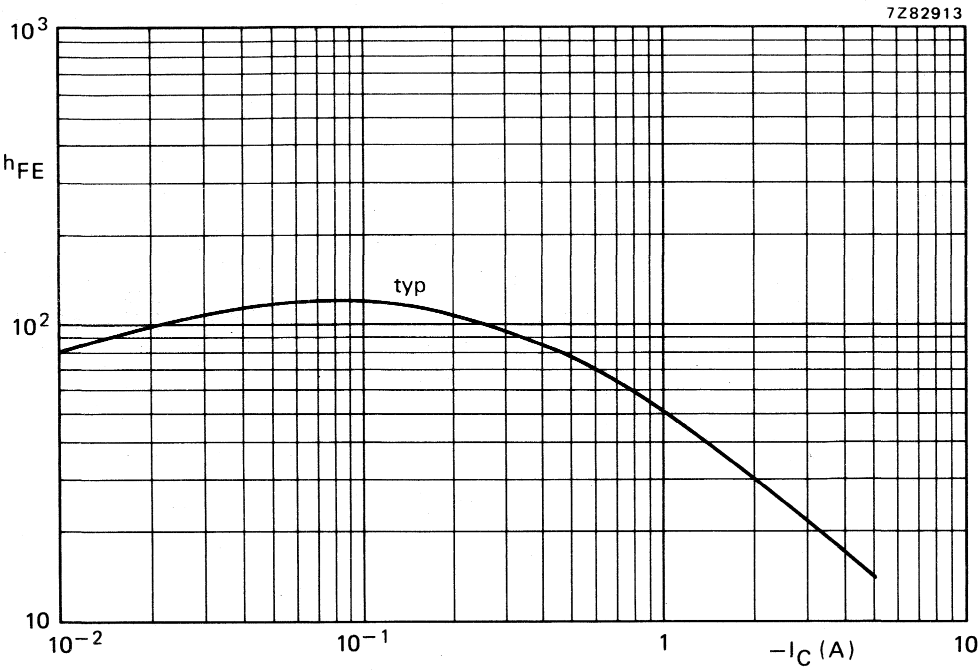


Fig. 9 Typical d.c. current gain at $-V_{CE}$ = 4 V; T_j = 25 °C.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon power transistors, each in a SOT186 envelope with an electrically insulated mounting base. They are intended for use in audio amplifier output stages, general purpose amplifiers, and high-speed switching applications.

NPN complements are TIP31F, TIP31AF, TIP31BF, TIP31CF and TIP31DF.

QUICK REFERENCE DATA

			TIP32F	32AF	32BF	32CF	32DF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
DC collector current	$-I_C$	max.			3			A
Peak collector current	$-I_{CM}$	max.			7			A
DC current gain								
$-I_C = 3$ A; $-V_{CE} = 4$V	h_{FE}	min.			10			
Small-signal current gain at f = 1 MHz								
$-I_C = 0.5$ A; $-V_{CE} = 10$ V	h_{fe}	min.			3			

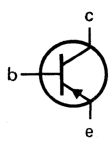
MECHANICAL DATA

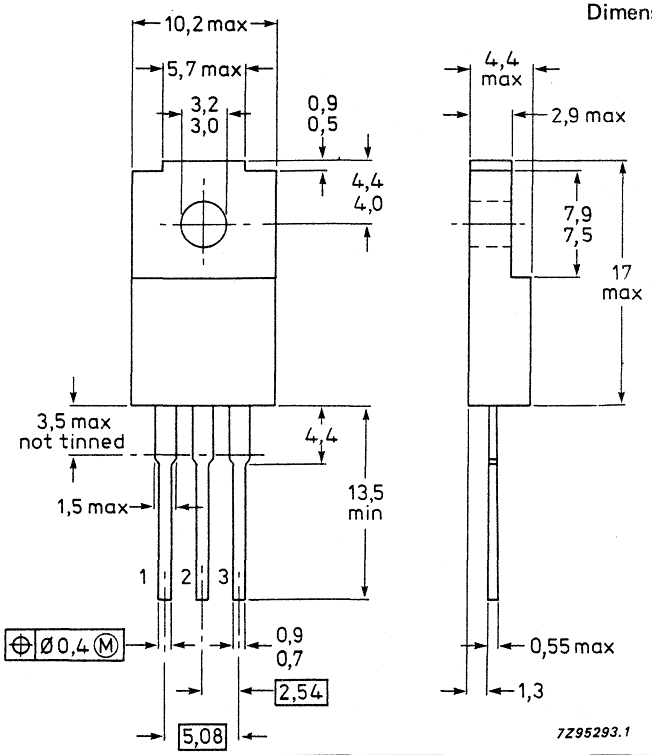
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			TIP32F	32AF	32BF	32CF	32DF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	160	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5			V
DC collector current	$-I_C$	max.			3			A
Peak collector current	$-I_{CM}$	max.			7			A
DC base current	$-I_B$	max.			1			A
Total power dissipation up to T_h = 25 °C (note 1)	P_{tot}	max.			15			W
up to T_h = 25 °C (note 2)	P_{tot}	max.			22			W
Storage temperature range	T_{stg}				−65 to 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	3.12	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	8.12	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	5.62	K/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	55	K/W

INSULATION

Peak voltage allowed between all terminals and external heatsink (note 3)	V_{insul}	max.	1000	V
Insulation capacitance between collector and external heatsink	$C_{c\text{-}h}$	typ.	12	pF

Notes

(1) Mounted without heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(2) Mounted with heatsink compound and 30 ± 5 newton pressure on centre of envelope.

(3) Heatsink temperature T_h = 25 °C; relative humidity $R_H \leqslant 75\%$; atmospheric pressure P_{amb} = 1013 mbar.

CHARACTERISTICS

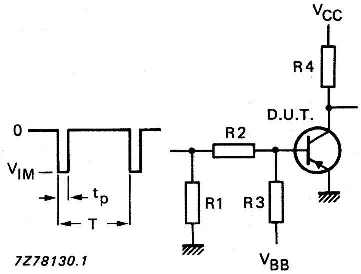
T_h = 25 °C unless otherwise specified

			TIP32F	32AF	32BF	32CF	32DF	
Collector cut-off current								
$-I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	max.	0.1	0.1	–	–	–	mA
$-I_B = 0$; $-V_{CE} = 60$ V	$-I_{CEO}$	max.	–	–	0.1	0.1	–	mA
$-I_B = 0$; $-V_{CE} = 90$ V	$-I_{CEO}$	max.	–	–	–	–	0.1	mA
$-V_{BE} = 0$; $-V_{CE} = -V_{CBOmax}$	$-I_{CES}$	max.	0.2	0.2	0.2	0.2	0.2	mA
Emitter cut-off current								
$-I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	max.	0.2	0.2	0.2	0.2	0.2	mA
DC current gain (1)								
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	min.	25	25	25	25	25	
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}	min.	10	10	10	10	5	
		max.	50	50	50	50	–	
Collector-emitter breakdown voltage (note 1)								
$-I_B = 0$; $-I_C = 30$ mA	$-V_{(BR)CEO}$	min.	40	60	80	100	120	V
Collector-emitter saturation voltage (note 1)								
$-I_C = 3$ A; $-I_B = 375$ mA	$-V_{CEsat}$	max.	1.2	1.2	1.2	1.2	–	V
$-I_C = 3$ A; $-I_B = 750$ mA	$-V_{CEsat}$	max.	–	–	–	–	2.5	V
Base-emitter voltages (notes 1 and 2)								
$-I_C = 3$ A; $-V_{CE} = 4$ V	$-V_{BE}$	max.			1.8			V
Small-signal current gain								
$-I_C = 0.5$ A; $-V_{CE} = 10$ V								
at 1 kHz	h_{fe}	min.			20			
at 1 MHz	h_{fe}	min.			3			
Turn-off breakdown energy with inductive load (see Fig.3)								
$-I_C = 1.8$ A; L = 20 mH	$E_{(BR)}$	min.			32			mJ
Switching times (see Fig.2)								
$-I_C = 1$ A; $-I_{B\,on} = +I_{B\,off} = 0.1$ A								
turn-on time	t_{on}	typ.			0.3			μs
turn-off time	t_{off}	typ.			1			μs

Notes

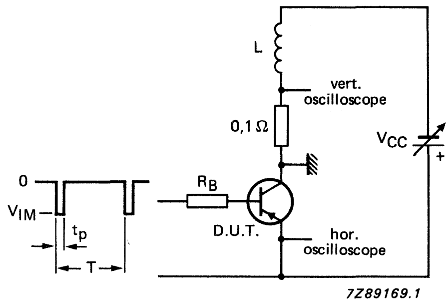
(1) Measured under pulse conditions: $t_p = 300$ μs; $\delta = 2\%$.

(2) V_{BE} decreases by about 2.3 mV/K with increasing temperature.



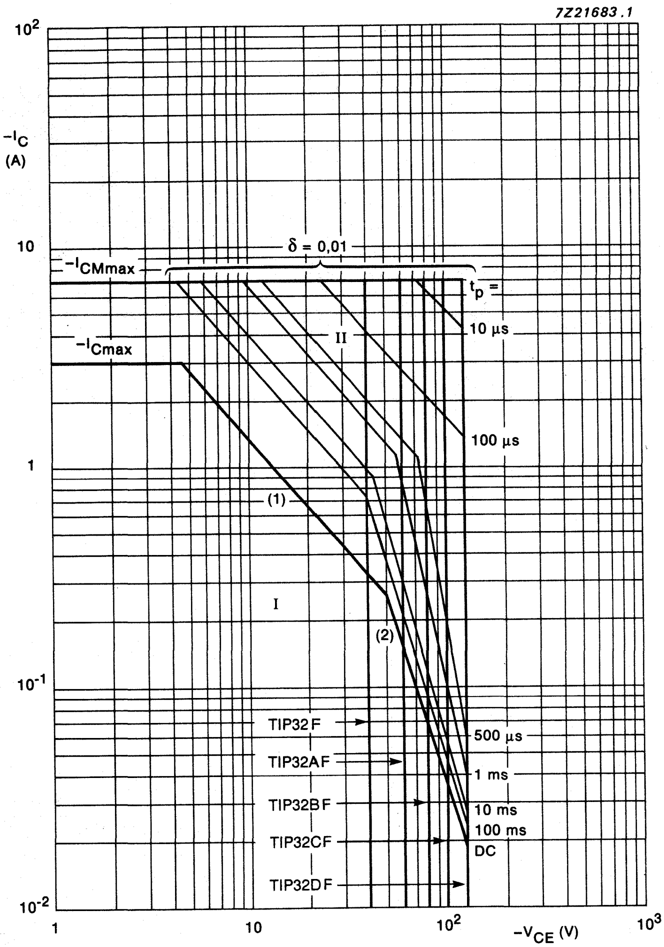
$-V_{CC}$ = 20 V
$-V_{IM}$ = 30 V
$+V_{BB}$ = 3 V
R_1 = 56 Ω
R_2 = 150 Ω
R_3 = 33 Ω
R_4 = 20 Ω
t_r = t_f = 15 ns
t_p = 20 μs
T = 500 μs

Fig.2 Switching times test circuit.



$-V_{IM}$ = 12 V
R_B = 270 Ω
L = 20 mH
$-I_C$ = 1.8 A
t_p = 1 ms
δ = 1 %

Fig.3 Test circuit for turn-off breakdown energy.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits.

Mounted **without** heatsink compound and 30 ± 5 Newton pressure on the centre of the envelope.

Fig.4 Safe Operating Area, T_{amb} = 25 °C.

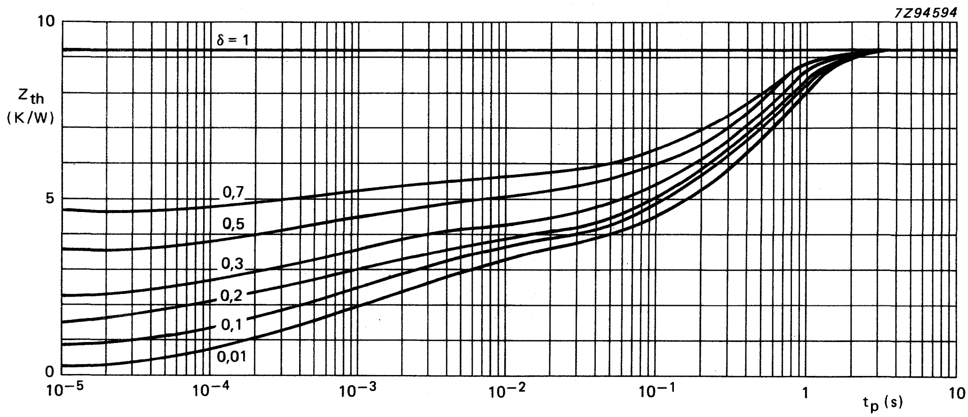


Fig.5 Pulse power rating chart; mounted **without** heatsink compound and 30 ± 5 Newton pressure on the envelope.

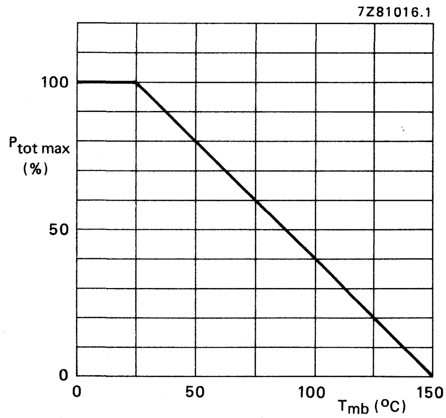


Fig.6 Total power dissipation.

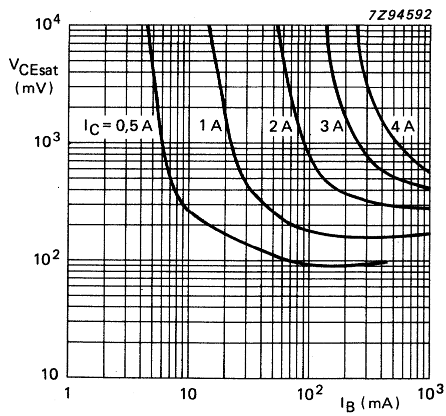


Fig.7 Typical collector-emitter saturation voltage; T_j = 25 °C.

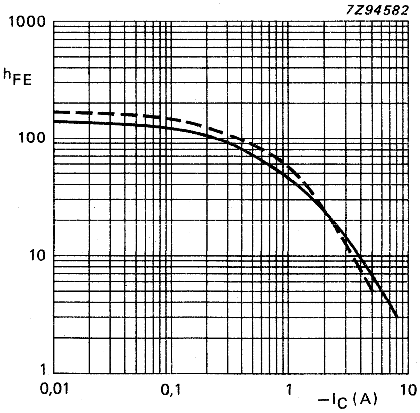


Fig.8 Typical DC current gain; $-V_{CE}$ = 4 V; T_j = 25 °C.

SILICON POWER TRANSISTORS

N-P-N epitaxial-base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications. P-N-P complements are TIP34, TIP34A, TIP34B and TIP34C.

QUICK REFERENCE DATA

			TIP33	33A	33B	33C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.	10				A
Collector current (peak value); $t_p \leqslant 0,3$ ms	I_{CM}	max.	15				A
Power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	80				W
D.C. current gain							
$V_{CE} = 4$ V; $I_C = 3$ A	h_{FE}		20 to 100				
Collector-emitter saturation voltage							
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	1				V

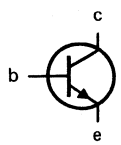
MECHANICAL DATA

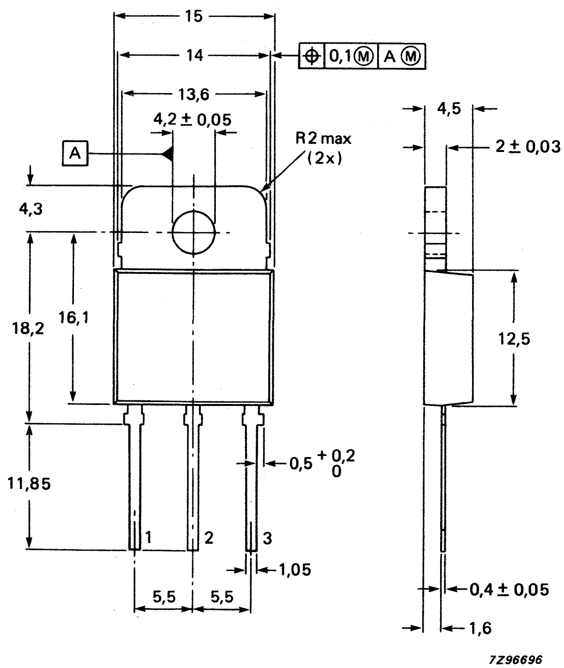
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:
1 = base
2 = collector
3 = emitter





RATINGS

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

			TIP33	33A	33B	33C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	10	A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max.	15	A
Base current (d.c.)	I_B	max.	3	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	80	W
Total power dissipation in free air	P_{tot}	max.	3,5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

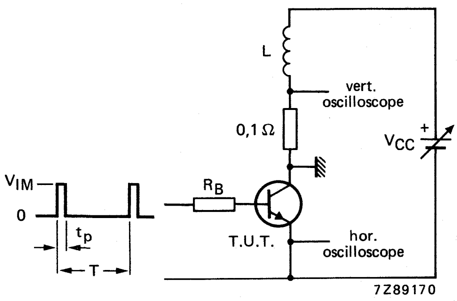
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,56	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	35,7	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

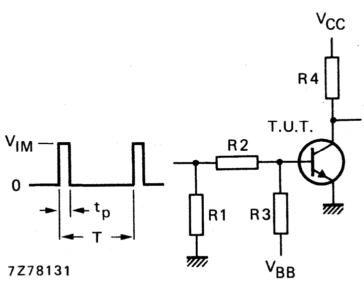
Collector cut-off currents					
$V_{CE} = V_{CBOmax}$; $V_{BE} = 0$		I_{CES}	<	0,4	mA
V_{CE} = 30 V; I_B = 0	TIP33	I_{CEO}	<	0,2	mA
	TIP33A	I_{CEO}	<	0,2	mA
V_{CE} = 60 V; I_B = 0	TIP33B	I_{CEO}	<	0,2	mA
	TIP33C	I_{CEO}	<	0,2	mA
Emitter cut-off current					
V_{EB} = 5 V; I_C = 0		I_{EBO}	<	0,1	mA
Collector-emitter sustaining voltage					
I_C = 30 mA; I_B = 0	TIP33	$V_{CEOsust}$	>	40	V
	TIP33A	$V_{CEOsust}$	>	60	V
	TIP33B	$V_{CEOsust}$	>	80	V
	TIP33C	$V_{CEOsust}$	>	100	V
D.C. current gain					
V_{CE} = 4 V; I_C = 1 A		h_{FE}	>	40	
V_{CE} = 4 V; I_C = 3 A		h_{FE}		20 to 100	
Base-emitter voltage					
V_{CE} = 4 V; I_C = 3 A		V_{BE}	<	1,6	V
V_{CE} = 4 V; I_C = 10 A		V_{BE}	<	3	V

Collector-emitter saturation voltage				
$I_C = 3$ A; $I_B = 0{,}3$ A	V_{CEsat}	<	1	V
$I_C = 10$ A; $I_B = 2{,}5$ A	V_{CEsat}	<	4	V
Small-signal current gain				
$V_{CE} = 10$ V; $I_C = 0{,}5$ A; f = 1 kHz	h_{fe}	>	20	
Transition frequency				
$V_{CE} = 10$ V; $I_C = 0{,}5$ A; f = 1 MHz	f_T	>	3	MHz
Turn-off breakdown energy (see Fig. 2)				
L = 20 mH; $I_C = 2{,}5$ A	$E_{(BR)}$	>	62,5	mJ
Switching times (see Figs 3 and 4)				
$I_C = 6$ A; $I_{Bon} = -I_{Boff} = 0{,}6$ A; $V_{CC} = 30$ V				
turn-on time	t_{on}	typ.	0,6	µs
turn-off time	t_{off}	typ.	1,7	µs



V_{IM} = 12 V
R_B = 270 Ω
L = 20 mH
I_{CC} = 2,5 A
δ ⩽ 1 %
t_p = 1 ms

Fig. 2 Test circuit for turn-off breakdown energy.



V_{IM} = 47 V
V_{CC} = 30 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 39 Ω
R3 = 10 Ω
R4 = 5 Ω
$t_r = t_f$ = 15 ns
t_p = 10 µs
T = 500 µs

Fig. 3 Switching times test circuit.

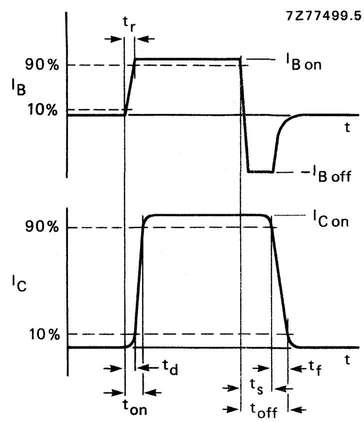


Fig. 4 Switching times waveforms.

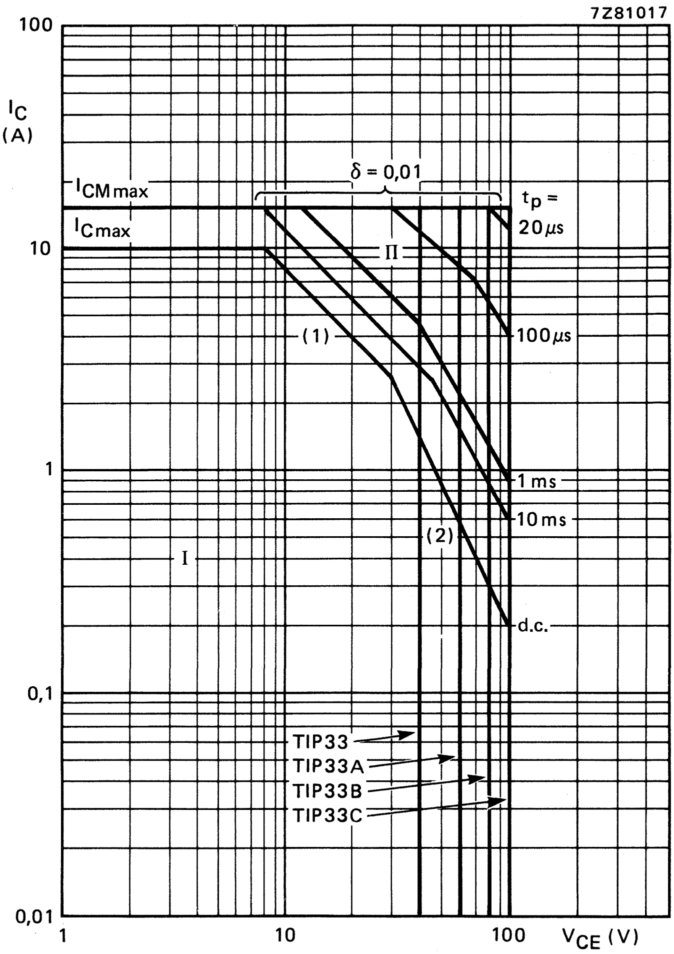


Fig. 5 Safe Operating Area at $T_{mb} \leqslant 25\ ^{o}C$.

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

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.
(2) Second-breakdown limits.

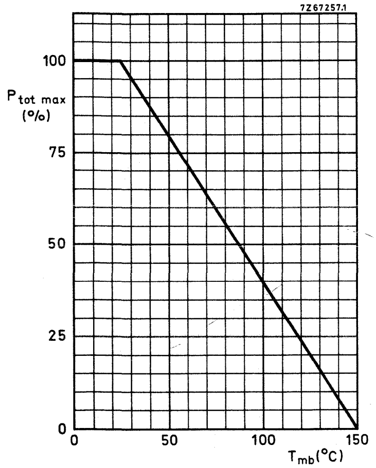


Fig. 6 Power derating curve.

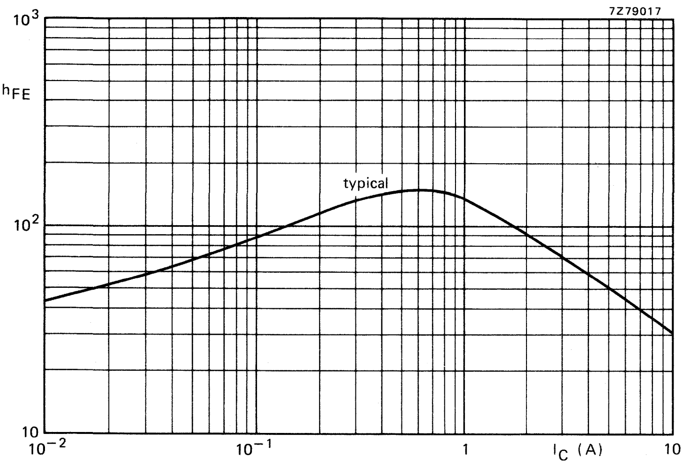


Fig. 7 V_{CE} = 4 V; T_j = 25 °C.

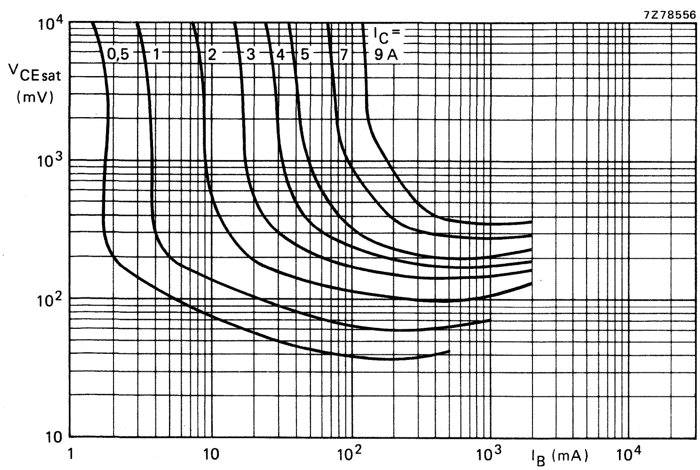


Fig. 8 Typical collector-emitter saturation voltage; T_j = 25 °C.

SILICON POWER TRANSISTORS

P-N-P epitaxial-base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications. N-P-N complements are TIP33, TIP33A, TIP33B and TIP33C.

QUICK REFERENCE DATA

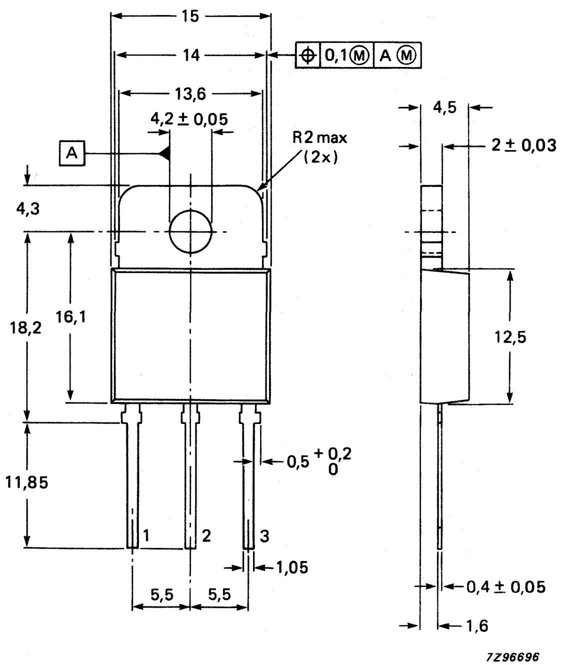
			TIP34	34A	34B	34C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.	10				A
Collector current (peak value); $t_p \leq 0{,}3$ ms	$-I_{CM}$	max.	15				A
Power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	80				W
D.C. current gain							
$-V_{CE}$ = 4 V; $-I_C$ = 3 A	h_{FE}		20 to 100				
Collector-emitter saturation voltage							
$-I_C$ = 3 A; $-I_B$ = 0,3 A	$-V_{CEsat}$	<	1				V

MECHANICAL DATA

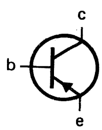
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



Pinning:
1 = base
2 = collector
3 = emitter



RATINGS

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

			TIP34	34A	34B	34C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	10	A
Collector current (peak value); $t_p \leqslant 0,3$ ms	$-I_{CM}$	max.	15	A
Base current (d.c.)	$-I_B$	max.	3	A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	80	W
Total power dissipation in free air	P_{tot}	max.	3,5	W
Storage temperature	T_{stg}		−65 to + 150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

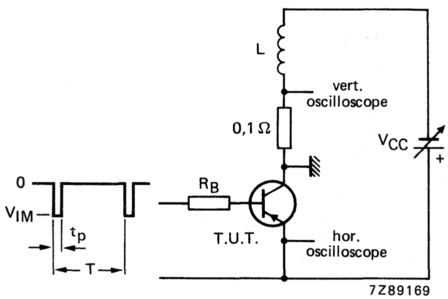
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,56	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	35,7	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

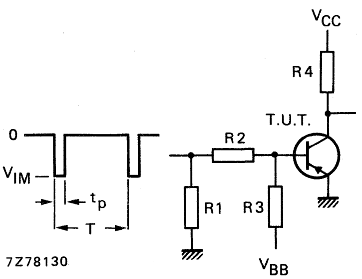
Collector cut-off currents					
$-V_{CE} = -V_{CBOmax}$; $V_{BE} = 0$		$-I_{CES}$	<	0,4	mA
$-V_{CE} = 30$ V; $I_B = 0$	TIP34	$-I_{CEO}$	<	0,2	mA
	TIP34A	$-I_{CEO}$	<	0,2	mA
$-V_{CE} = 60$ V; $I_B = 0$	TIP34B	$-I_{CEO}$	<	0,2	mA
	TIP34C	$-I_{CEO}$	<	0,2	mA
Emitter cut-off current					
$-V_{EB} = 5$ V; $I_C = 0$		$-I_{EBO}$	<	0,1	mA
Collector-emitter sustaining voltage					
$-I_C = 30$ mA; $I_B = 0$	TIP34	$-V_{CEOsust}$	>	40	V
	TIP34A	$-V_{CEOsust}$	>	60	V
	TIP34B	$-V_{CEOsust}$	>	80	V
	TIP34C	$-V_{CEOsust}$	>	100	V
D.C. current gain					
$-V_{CE} = 4$ V; $-I_C = 1$ A		h_{FE}	>	40	
$-V_{CE} = 4$ V; $-I_C = 3$ A		h_{FE}		20 to 100	
Base-emitter voltage					
$-V_{CE} = 4$ V; $-I_C = 3$ A		$-V_{BE}$	<	1,6	V
$-V_{CE} = 4$ V; $-I_C = 10$ A		$-V_{BE}$	<	3	V

Collector-emitter saturation voltage				
$-I_C = 3$ A; $-I_B = 0{,}3$ A	$-V_{CEsat}$	<	1	V
$-I_C = 10$ A; $-I_B = 2{,}5$ A	$-V_{CEsat}$	<	4	V
Small-signal current gain				
$-V_{CE} = 10$ V; $-I_C = 0{,}5$ A; f = 1 kHz	h_{fe}	>	20	
Transition frequency				
$-V_{CE} = 10$ V; $-I_C = 0{,}5$ A; f = 1 MHz	f_T	>	3	MHz
Turn-off breakdown energy (see Fig. 2)				
L = 20 mH; $-I_C = 2{,}5$ A	$E_{(BR)}$	>	62,5	mJ
Switching times (see Figs 3 and 4)				
$-I_C = 6$ A; $-I_{Bon} = +I_{Boff} = 0{,}6$ A; $-V_{CC} = 30$ V				
turn-on time	t_{on}	typ.	0,4	μs
turn-off time	t_{off}	typ.	0,7	μs



$-V_{IM}$ = 12 V
R_B = 270 Ω
L = 20 mH
$-I_{CC}$ = 2,5 A
t_p = 1 ms
δ = 1 %

Fig. 2 Test circuit for turn-off breakdown energy.



$-V_{IM}$ = 47 V
$-V_{CC}$ = 30 V
V_{BB} = 4 V
R1 = 56 Ω
R2 = 39 Ω
R3 = 10 Ω
R4 = 5 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 3 Switching times test circuit.

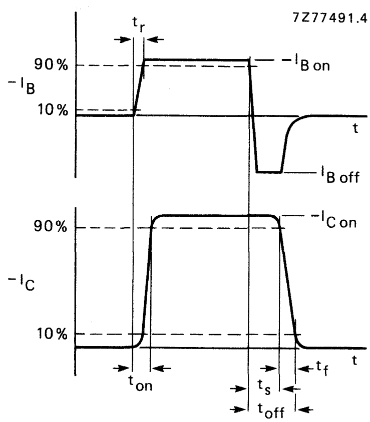


Fig. 4 Switching times waveforms.

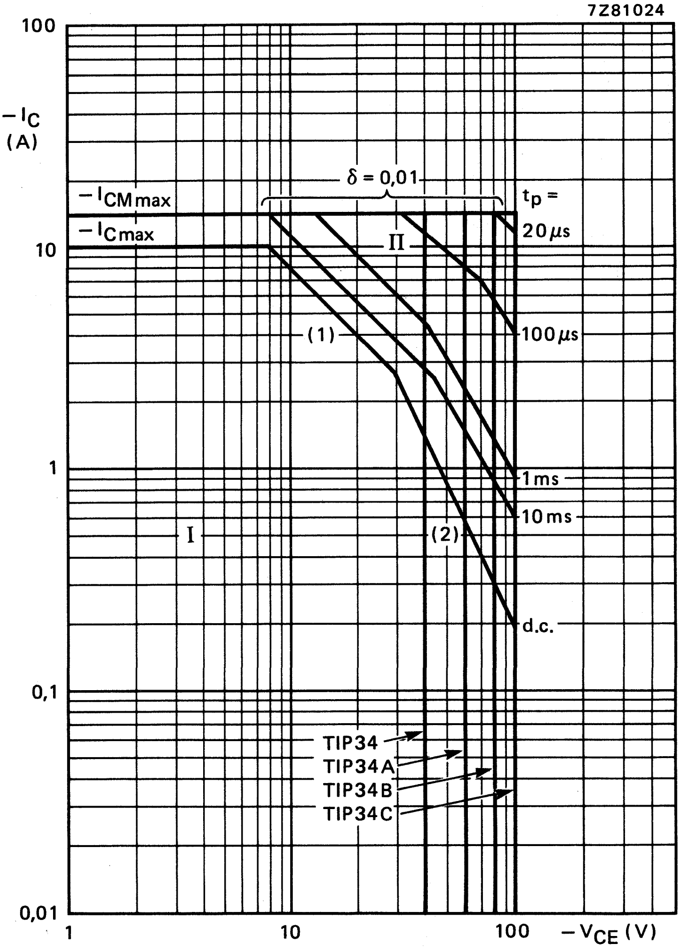


Fig. 5 Safe Operating Area at T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.
(2) Second breakdown limits.

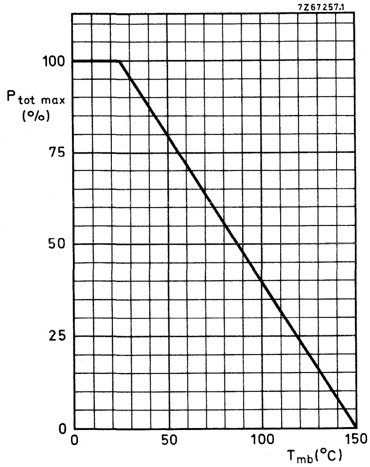


Fig. 6 Power derating curve.

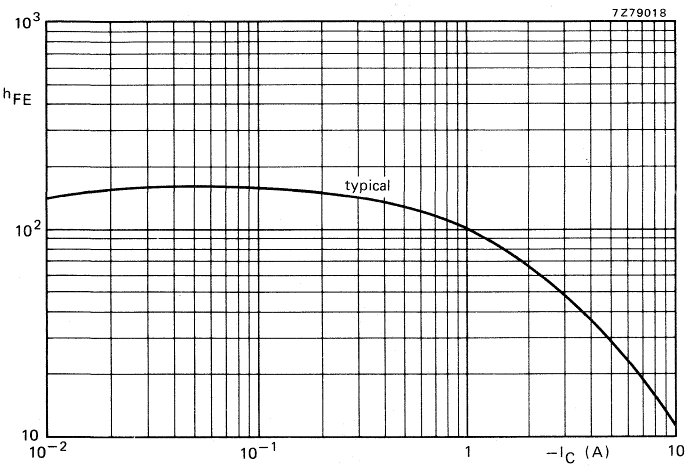


Fig. 7 $-V_{CE} = 4$ V; $T_j = 25$ °C.

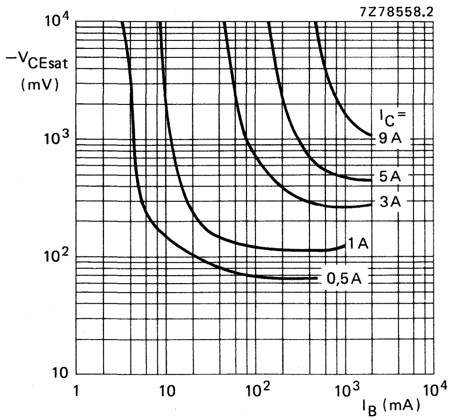


Fig. 8 Typical collector-emitter saturation voltage. $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

NPN silicon transistors in a plastic envelope intended for use in general purpose amplifier and switching applications. PNP complements are TIP42 series.

QUICK REFERENCE DATA

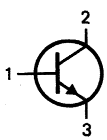
			TIP41	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.	6				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 3 A; V_{CE} = 4 V	h_{FE}		15 to 75				

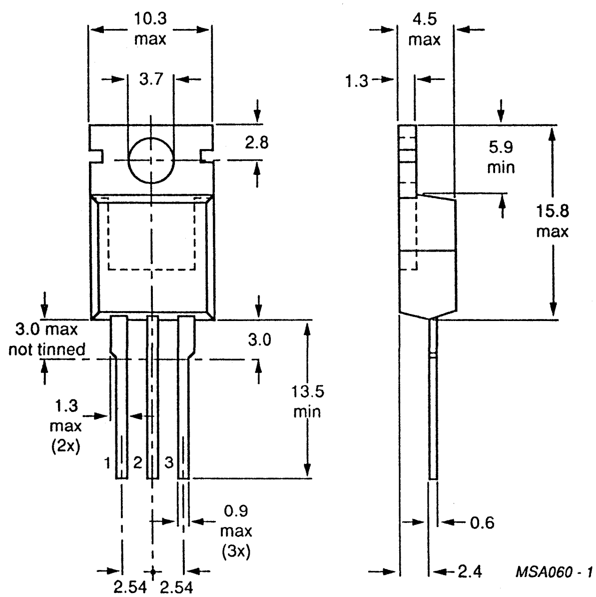
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP41	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	6				A
Collector current (peak value)	I_{CM}	max.	10				A
Base current (d.c.)	I_B	max.	3				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP41;A	B;C	
Collector cut-off current					
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,2	−	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	<	−	0,2	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	<	0,4		mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	0,5		mA
D.C. current gain*					
$I_C = 0{,}3$ A; $V_{CE} = 4$ V	h_{FE}	>	30		
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage**					
$I_C = 6$ A; $V_{CE} = 4$ V	V_{BE}	<	2		V
Collector-emitter saturation voltage*					
$I_C = 6$ A; $I_B = 0{,}6$ A	V_{CEsat}	<	1,5		V

			TIP41	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current transfer ratio							
$I_C = 0{,}5$ A; $V_{CE} = 10$ V; f = 1 kHz	$\lvert h_{fe}\rvert$	>	20				
Transition frequency at f = 1 MHz							
$I_C = 0{,}5$ A; $V_{CE} = 10$ V	f_T	>	3				MHz

* Measured under pulse conditions: $t_p \leq 300$ μs, $\delta < 2\%$.
** V_{BE} decreases by about 2,3 mV/K with increasing temperature.

Turn-off breakdown energy with inductive load (Fig. 4)			
$-I_{Boff} = 0$; $I_{CC} = 2{,}5$ A	$E_{(BR)}$	>	62,5 mJ
Switching times			
(between 10% and 90% levels)			
$I_{Con} = 6$ A; $I_{Bon} = -I_{Boff} = 0{,}6$ A			
Turn-on time	t_{on}	typ.	0,6 μs
Turn-off time	t_{off}	typ.	1 μs

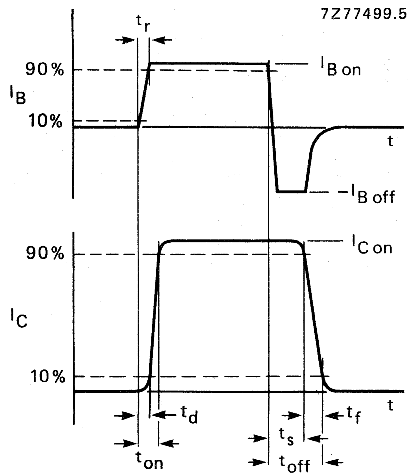
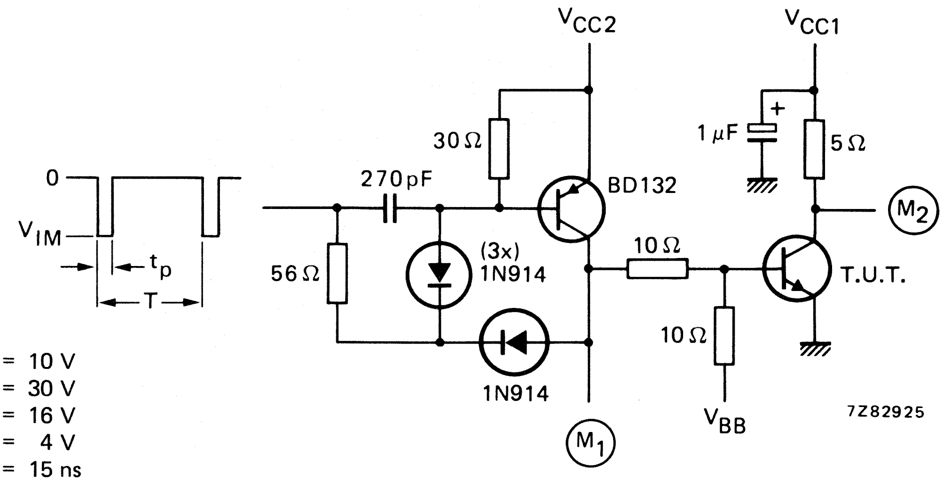


Fig. 2 Switching times waveforms.



$-V_{IM}$ = 10 V
V_{CC1} = 30 V
V_{CC2} = 16 V
$-V_{BB}$ = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 μs
δ ⩽ 2 %

Fig. 3 Switching times test circuit.
Adjust V_{CC2} so that the input to M_1 = 14 V.

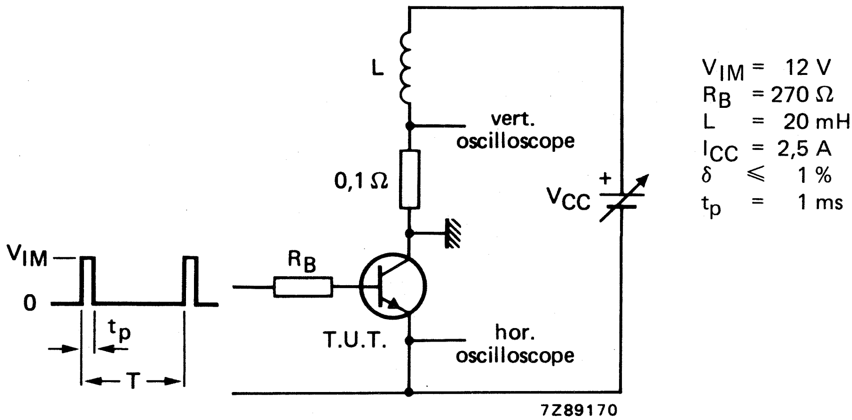


Fig. 4 Test circuit for turn-off breakdown energy.

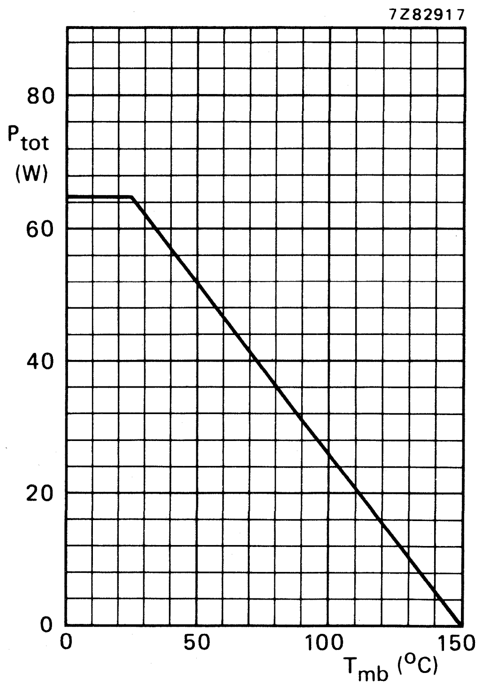


Fig. 5 Power derating curve.

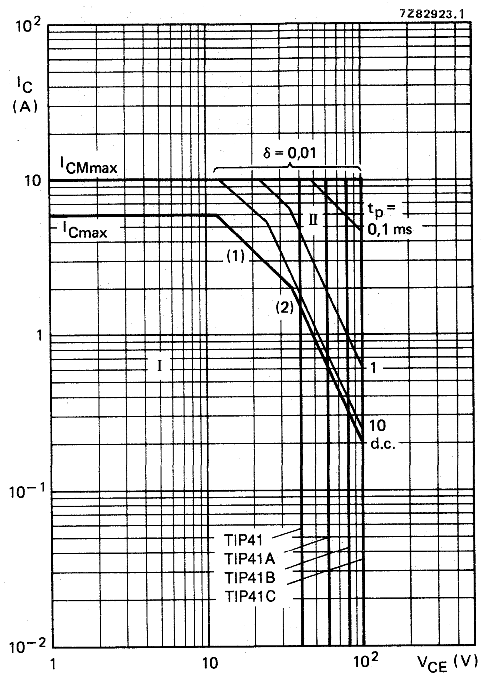


Fig. 6 Safe Operating Area, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

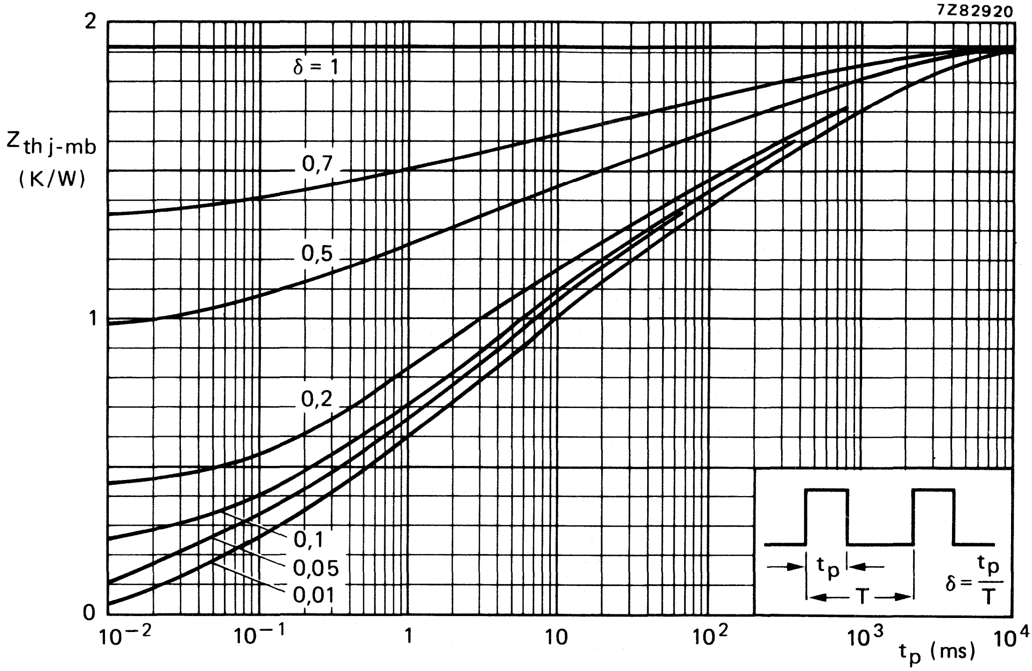


Fig. 7 Pulse power rating chart.

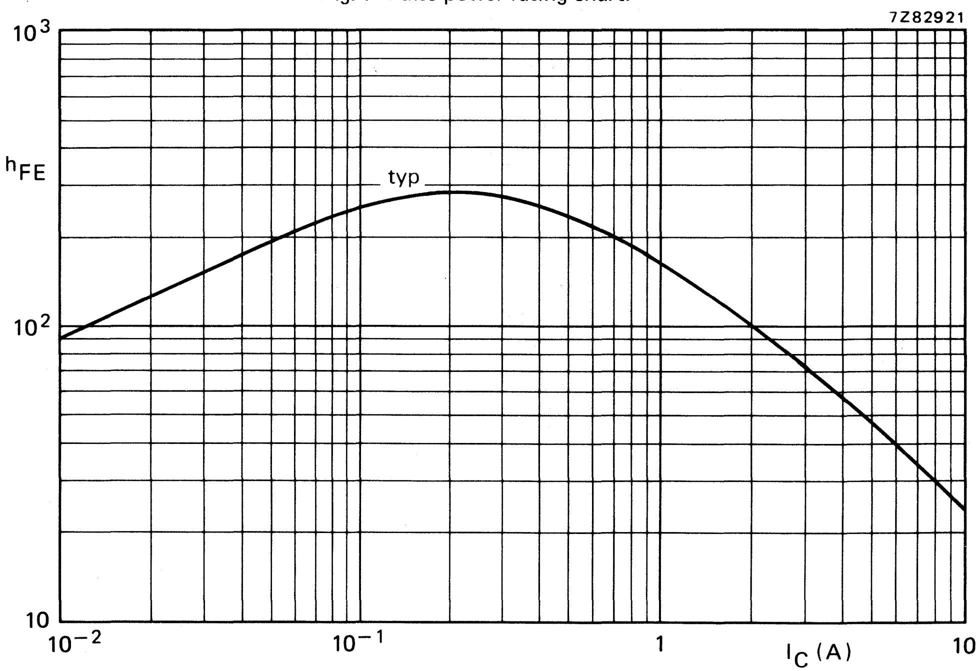


Fig. 8 D.C. current gain at V_{CE} = 4 V; T_j = 25 °C.

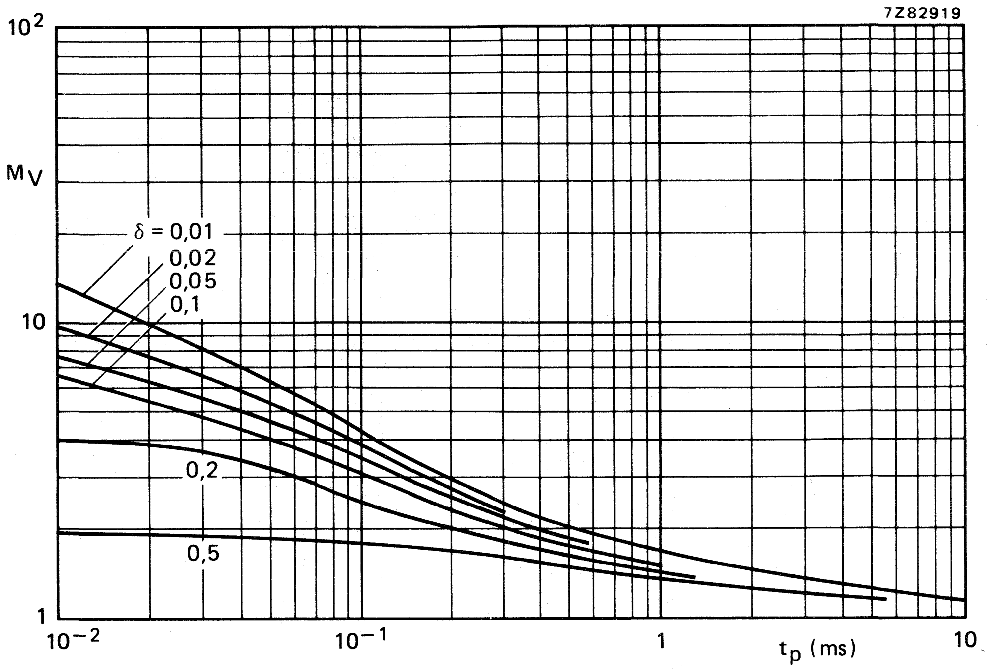


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

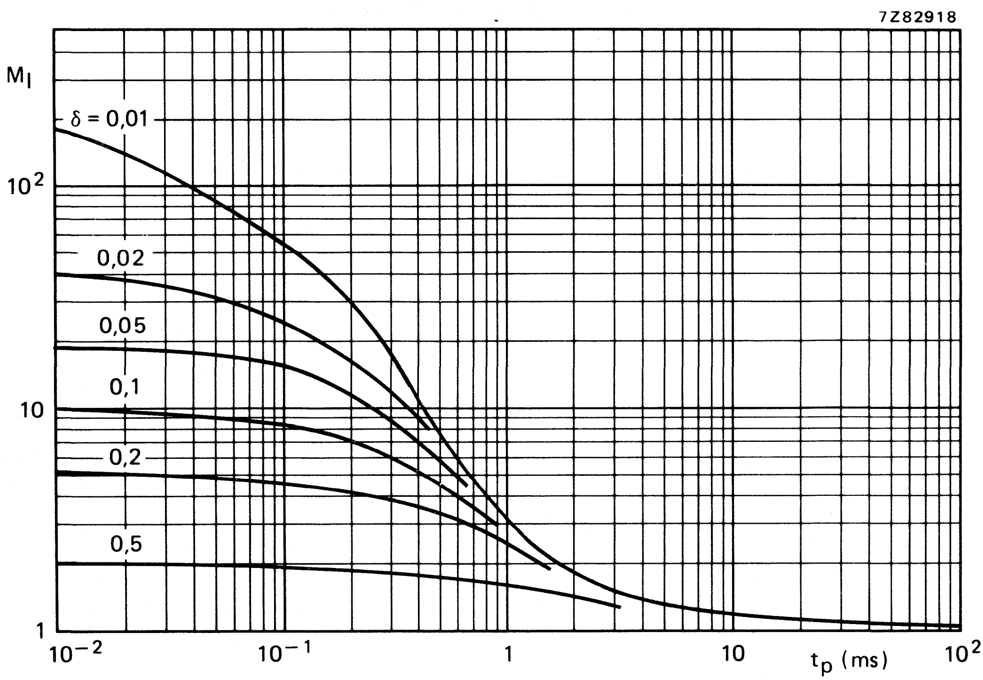


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

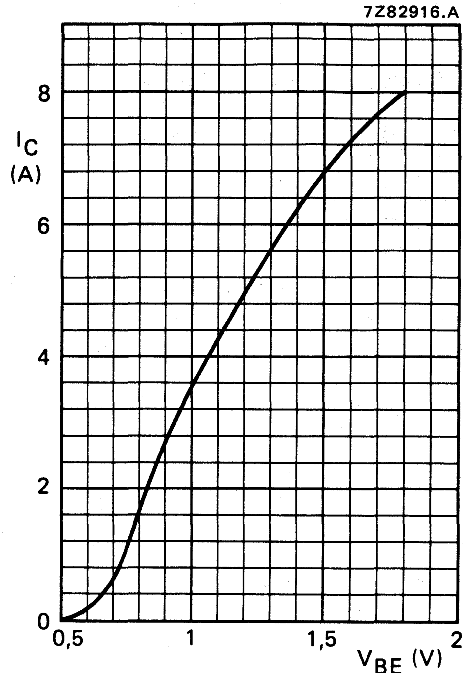


Fig. 11 Typical collector current.
V_{CE} = 4 V; T_j = 25 °C.

SILICON EPITAXIAL POWER TRANSISTORS

NPN silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

PNP complements are TIP42F, TIP42AF, TIP42BF and TIP42CF.

QUICK REFERENCE DATA

			TIP41F	AF	BF	CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
DC collector current	I_C	max.		6			A
Peak collector current	I_{CM}	max.		10			A
Total power dissipation up to $T_h = 25\,^oC$	P_{tot}	max.		32			W
Junction temperature	T_j	max.		150			^oC
DC current gain $I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}	min.		15			
		max.		75			

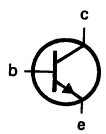
MECHANICAL DATA

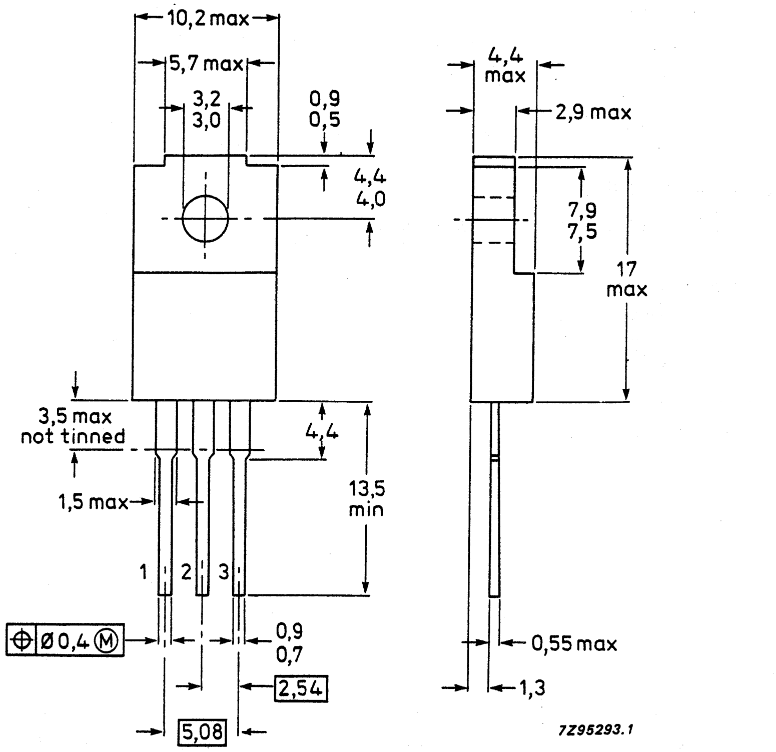
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			TIP41F	AF	BF	CF	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5			V
DC collector current	I_C	max.		6			A
Peak collector current	I_{CM}	max.		10			A
DC base current	I_B	max.		3			A
Total power dissipation							
up to T_h = 25 °C (note 1)	P_{tot}	max.		20			W
up to T_h = 25 °C (note 2)	P_{tot}	max.		32			W
Storage temperature range	T_{stg}			−65 to + 150			°C
Junction temperature	T_j	max.		150			°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{th}	typ.	12	pF

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP41F	AF	BF	CF	
Collector cut-off currents							
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	max.	0.2	0.2	–	–	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	max.	–	–	0.2	0.2	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	max.		0.4			mA
Emitter cut-off current							
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	max.		0.5			mA

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

DC current gain (note 1)							
I_C = 0.3 A; V_{CE} = 4 V	h_{FE}	min.	30				
I_C = 3 A; V_{CE} = 4 V	h_{FE}	min. max.	15 75				
Base-emitter voltage (note 2)							
I_C = 6 A; V_{CE} = 4 V	V_{BE}	max.	2				V
Collector-emitter saturation voltage (note 1)							
I_C = 6 A; I_B = 0.6 A	V_{CEsat}	max.	1.5				V
			TIP41F	AF	BF	CF	
Collector-emitter breakdown voltage (note 1)							
I_C = 30 mA; I_B = 0	$V_{(BR)CEO}$	max.	40	60	80	100	V
Small-signal current transfer ratio							
I_C = 0.5 A; V_{CE} = 10 V; f = 1 kHz	$\|h_{fe}\|$	min.	20				
Transition frequency							
I_C = 0.5 A; V_{CE} = 10 V; f = 1 kHz	f_T	min.	3				MHz
Turn-off breakdown energy with inductive load (Fig.4)							
I_{Boff} = 0; I_{CC} = 2.5 V	$E_{(BR)}$	min.	62.5				mJ
Switching times (Figs 2 and 3) (between 10% and 90% levels)							
I_{Con} = 6 A; I_{Bon} = $-I_{Boff}$ = 0.6 A							
turn-on time	t_{on}	typ.	0.6				μs
turn-off time	t_{off}	typ.	1				μs

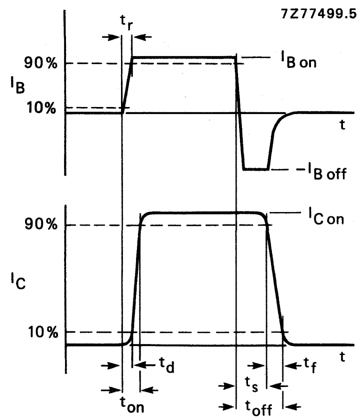
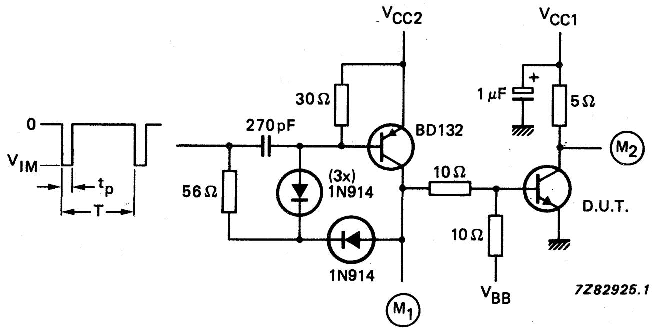


Fig.2 Switching times waveform.

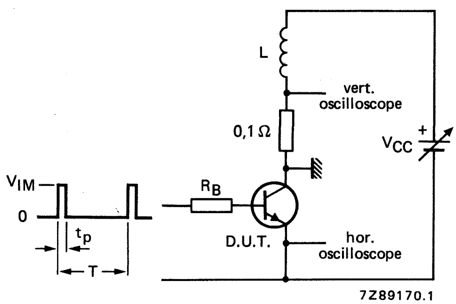
Notes

1. Measured under pulse conditions: t_p max. 300 μs; δ max. 2%.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



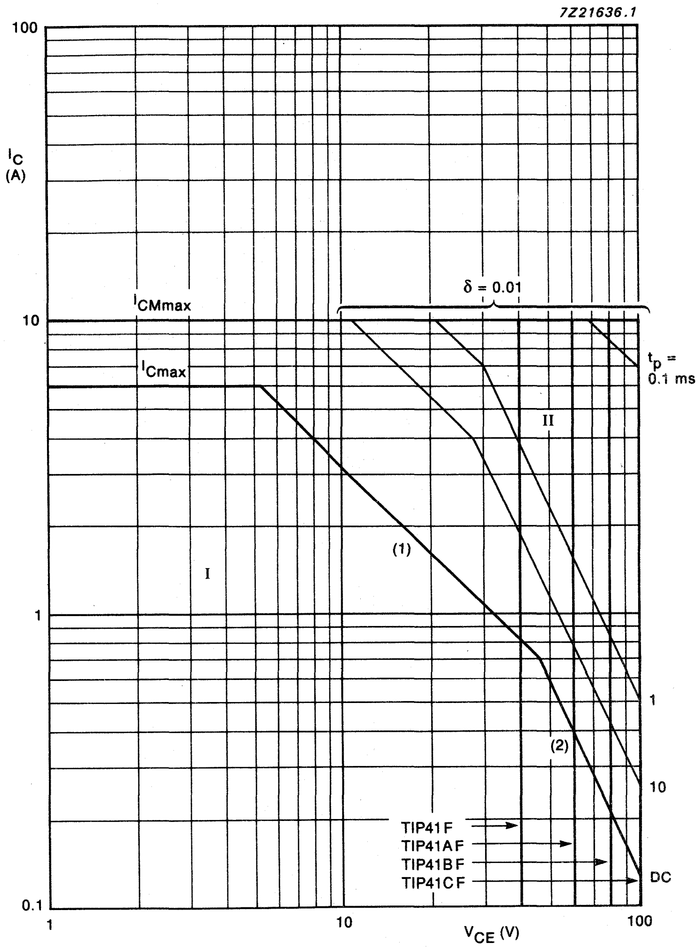
$-V_{IM}$ = 10 V
V_{CC1} = 30 V
V_{CC2} = 16 V
$-V_{BB}$ = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 µs
δ max. 2%

Fig.3 Switching times test circuit.
Adjust V_{CC2} to give M_1 = 14 V.



V_{IM} = 12 V
R_B = 270 Ω
L = 20 mH
I_{CC} = 2.5 A
δ max. 1%
t_p = 1 ms

Fig.4 Test circuit for turn-off breakdown energy.



I   Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits.

Fig.5 Safe Operating Area, T_{mb} = 25 °C.

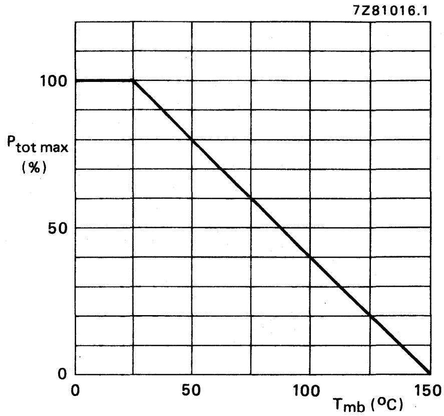


Fig.6 Total power dissipation.

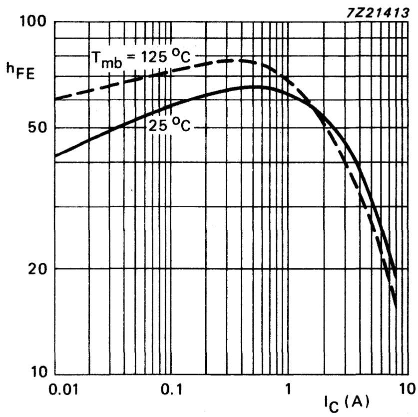


Fig.7 DC current gain; V_{CE} = 4 V; typical values.

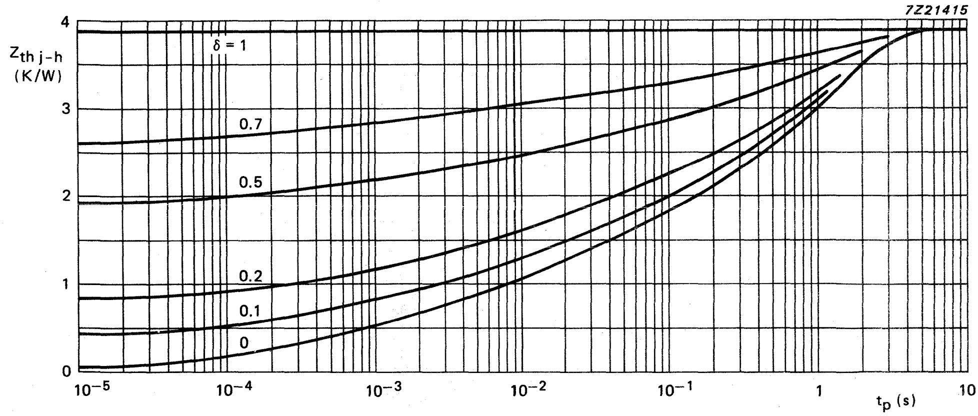


Fig.8 Pulse power rating chart.

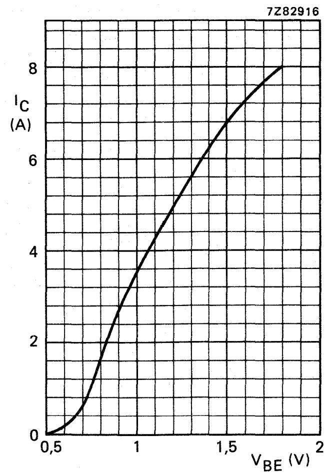


Fig.9 Typical collector current.
V_{CE} = 4 V; T_j = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

PNP silicon transistors in a plastic envelope intended for use in general output stages of amplifier circuits and switching applications. NPN complements are TIP41 series.

QUICK REFERENCE DATA

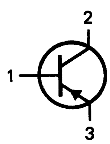
			TIP42	A	B	C	
Collector-base voltage	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.	6				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 3 A; $-V_{CE}$ = 4 V	h_{FE}		15 to 75				

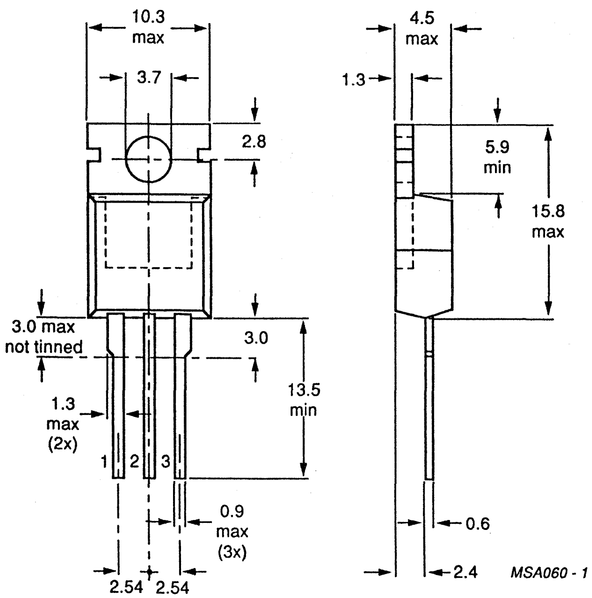
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base





See also chapters Mounting Instructions and Accessories.

RATINGS

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

			TIP42	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	6				A
Collector current (peak value)	$-I_{CM}$	max.	10				A
Base current (d.c.)	$-I_B$	max.	3				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	65				W
Storage temperature	T_{stg}		−65 to + 150				^oC
Junction temperature	T_j	max.	150				^oC

THERMAL RESISTANCE

From junction to mouting base	$R_{th\ j-mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			TIP42;A	B;C	
Collector cut-off current					
$I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	0,2	–	mA
$I_B = 0; -V_{CE} = 60$ V	$-I_{CEO}$	<	–	0,2	mA
$V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	0,4		mA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	0,5		mA
D.C. current gain*					
$-I_C = 300$ mA; $-V_{CE} = 4$ V	h_{FE}	>	30		
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage**					
$-I_C = 6$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	2		V
Collector-emitter saturation voltage*					
$-I_C = 6$ A; $-I_B = 0,6$ A	$-V_{CEsat}$	<	1,5		V

			TIP42	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0; -I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	V
Transition frequency at f = 1 MHz							
$-I_C = 500$ mA; $-V_{CE} = 10$ V	f_T	>	3				MHz
Small signal current transfer ratio							
$-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.
** V_{EB} decreases by about 2,3 mV/K with increasing temperature.

Turn-off breakdown energy with inductive load (Fig. 4)

$I_{Boff} = 0$; $-I_{CC} = 2{,}5$ A	$E_{(BR)}$	>	62,5 mJ
Switching times			
$-I_{Con} = 6$ A; $-I_{Bon} = I_{Boff} = 0{,}6$ A			
turn-on time	t_{on}	typ.	0,4 μs
turn-off time	t_{off}	typ.	0,7 μs

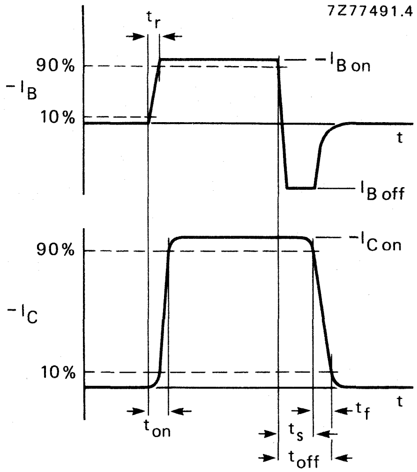
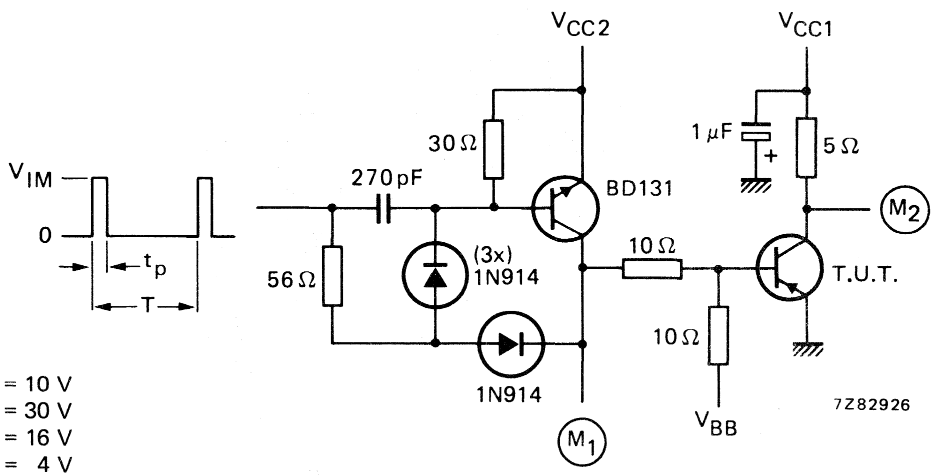


Fig. 2 Switching times waveforms.



V_{IM} = 10 V
$-V_{CC1}$ = 30 V
$-V_{CC2}$ = 16 V
V_{BB} = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 μs
δ ⩽ 2 %

Fig. 3 Switching times test circuit.
Adjust V_{CC2} so that the input to M1 = 14 V.

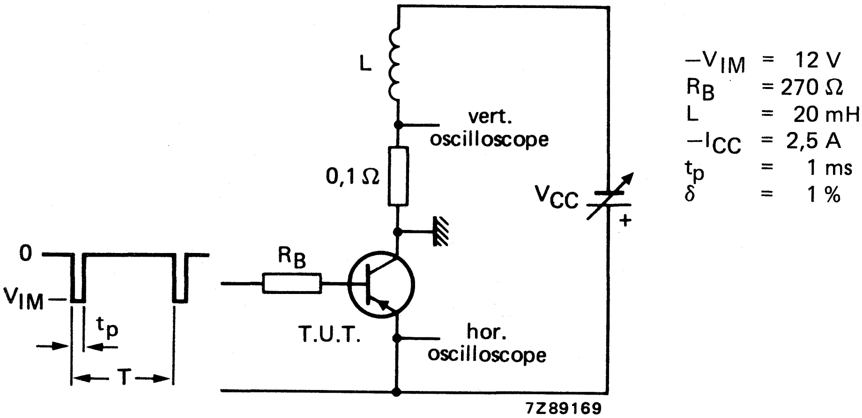


Fig. 4 Test circuit for turn-off breakdown energy.

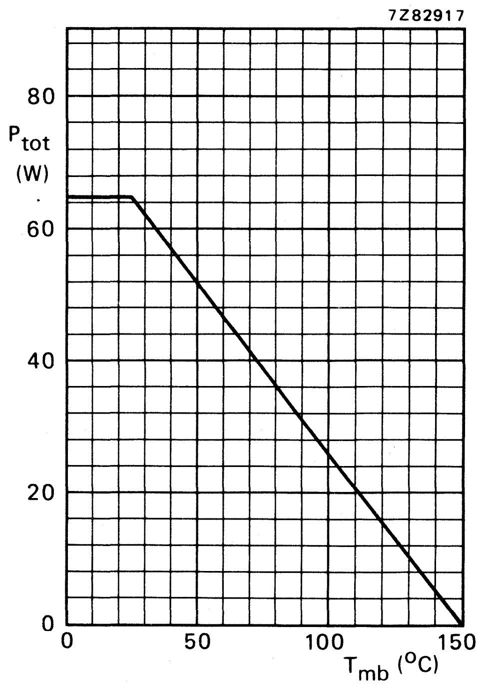


Fig. 5 Power derating curve.

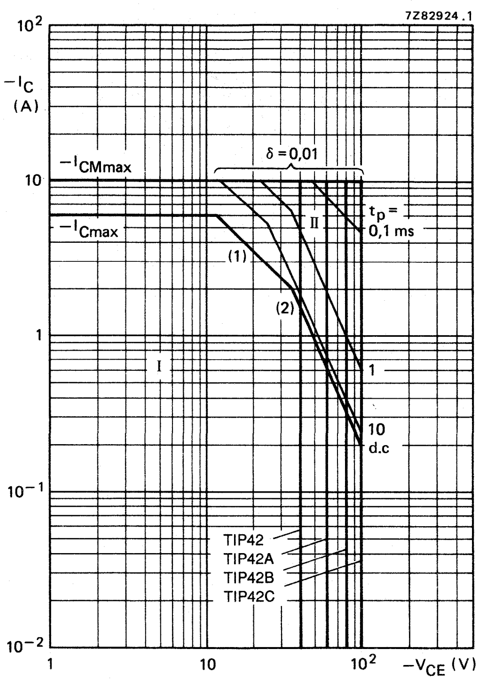


Fig. 6 Safe Operating Area; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(3) Second-breakdown limits.

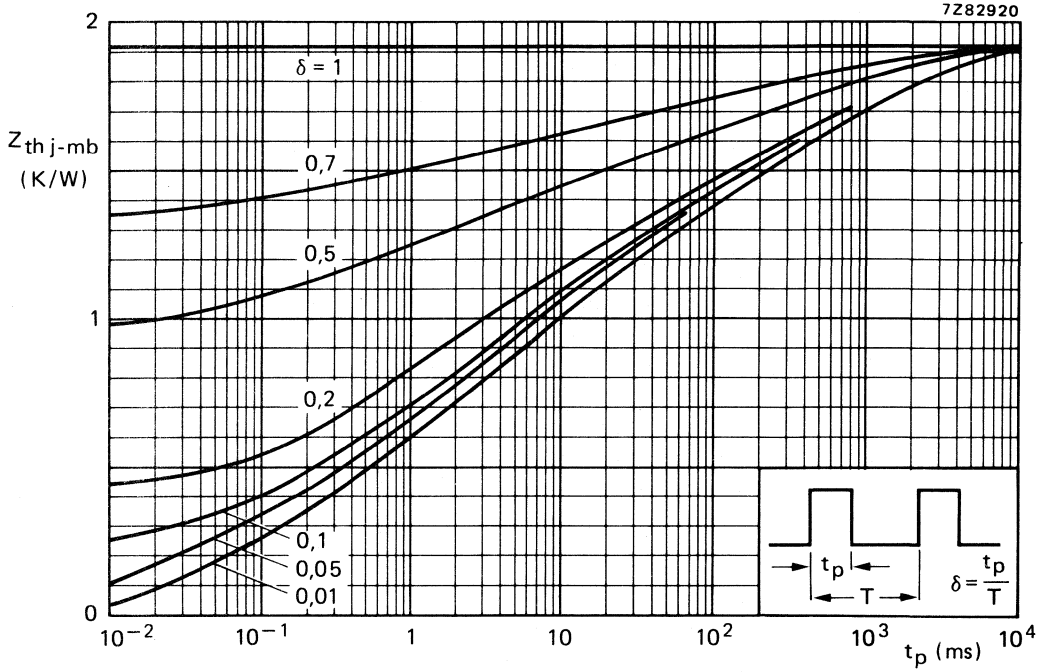


Fig. 7 Pulse power rating chart.

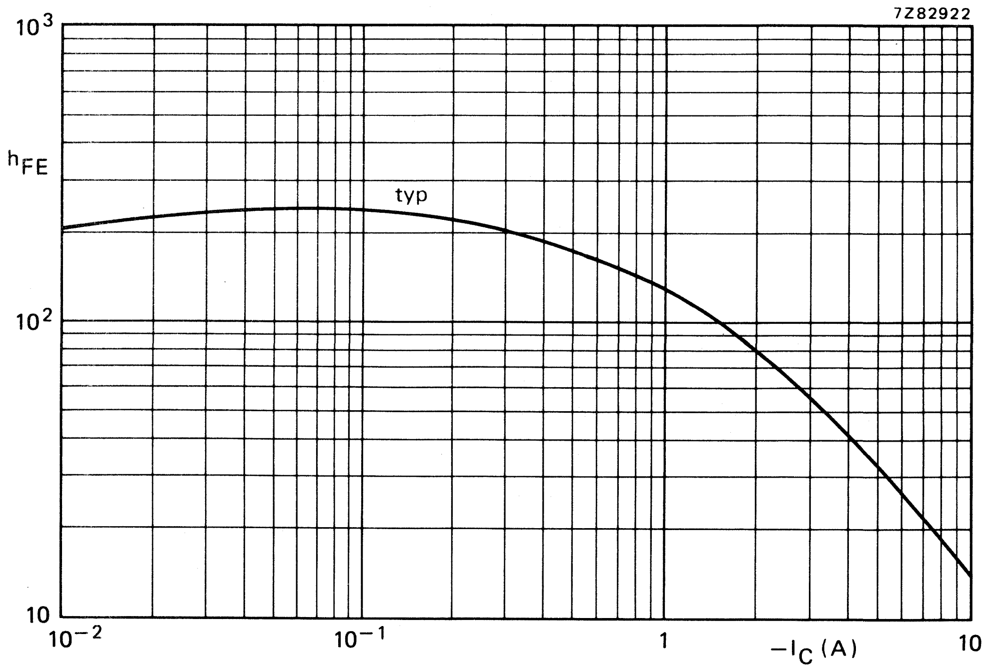


Fig. 8 Typical values d.c. current gain. $-V_{CE}$ = 4 V; T_j = 25 °C.

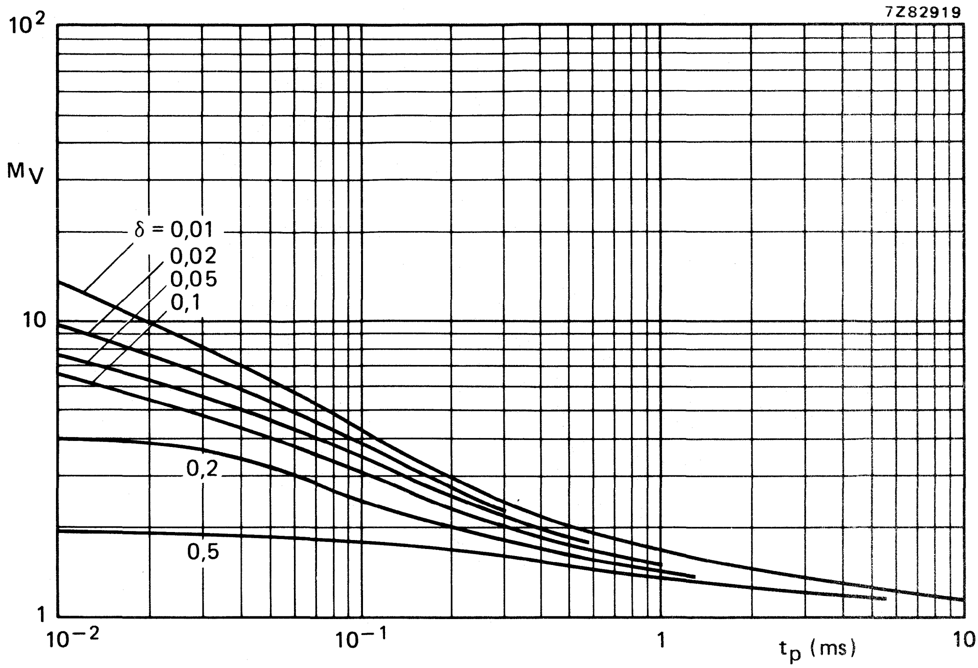


Fig. 9 Second breakdown voltage multiplying factor at the I_{Cmax} level.

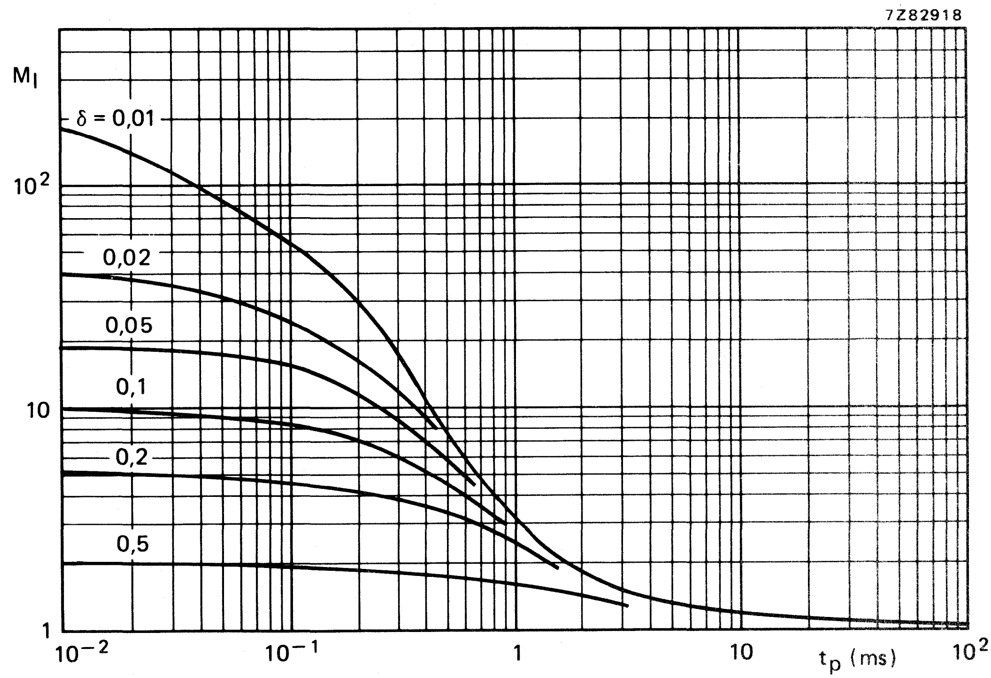


Fig. 10 Second breakdown current multiplying factor at the V_{CEOmax} level.

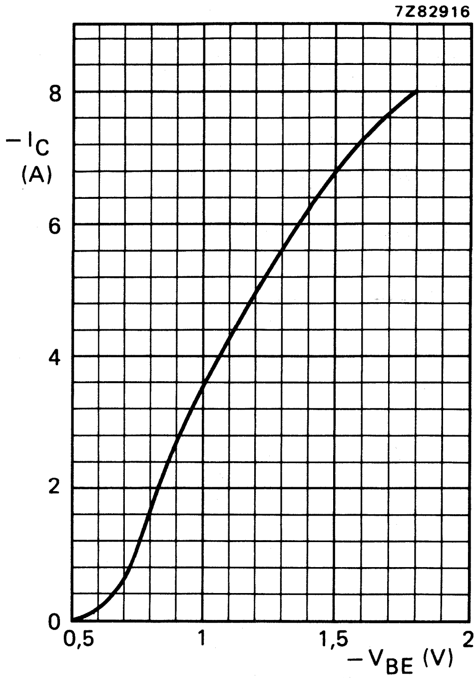


Fig. 11 Typical collector current.
$-V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON EPITAXIAL POWER TRANSISTORS

PNP silicon epitaxial power transistors, each in a SOT186 envelope with an electrically insulated mounting base.

NPN complements are TIP41F, TIP41AF, TIP41BF and TIP41CF.

QUICK REFERENCE DATA

			TIP42F	AF	BF	CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
DC collector current	$-I_C$	max.			6		A
Peak collector current	I_{CM}	max.			10		A
Total power dissipation up to $T_h = 25\ ^oC$	P_{tot}	max.			32		W
Junction temperature	T_j	max.			150		^oC
DC current gain $-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}	min.			15		
		max.			75		

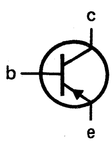
MECHANICAL DATA

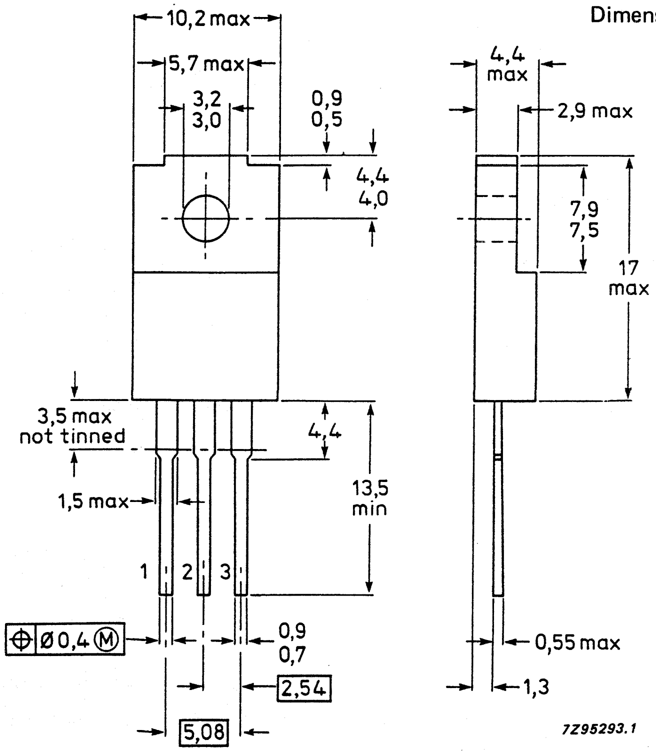
Dimensions in mm

Fig.1 SOT186.

Pinning

1 = base
2 = collector
3 = emitter





RATINGS

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

			TIP42F	AF	BF	CF	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
DC collector current	$-I_C$	max.	6				A
Peak collector current	$-I_{CM}$	max.	10				A
DC base current	$-I_B$	max.	3				A
Total power dissipation up to T_h = 25 °C (note 1)	P_{tot}	max.	20				W
Total power dissipation up to T_h = 25 °C (note 2)	P_{tot}	max.	32				W
Storage temperature range	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j\text{-}mb}$	=	1.6	K/W
From junction to external heatsink (note 1)	$R_{th\ j\text{-}h}$	=	6.3	K/W
From junction to external heatsink (note 2)	$R_{th\ j\text{-}h}$	=	3.9	K/W

INSULATION

Voltage allowed between all terminals and external heatsink, peak value	V_{insul}	max.	1000	V
Isolation capacitance from collector to external heatsink	C_{isol}	typ.	12	pF

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			TIP42F	AF	BF	CF	
Collector cut-off currents							
$-I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	max.	0.2	0.2	—	—	mA
$-I_B = 0$; $-V_{CE} = 60$ V	$-I_{CEO}$	max.	—	—	0.2	0.2	mA
$-V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	max.	0.4				mA
Emitter cut-off current							
$-I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	max.	0.5				mA

Notes

1. Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
2. Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.

Parameter	Symbol		Value	Unit
DC current gain (note 1)				
$-I_C = 0.3$ A; $-V_{CE} = 4$ V	h_{FE}		30	
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}	min.	15	
		max.	75	
Base-emitter voltage (note 2)				
$-I_C = 6$ A; $-V_{CE} = 4$ V	$-V_{BE}$	max.	2	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 6$ A; $-I_B = 0.6$ A	$-V_{CEsat}$	max.	1.5	V
Collector-emitter breakdown voltage (note 1)			TIP42F: 40; AF: 60; BF: 80; CF: 100	
$-I_C = 30$ mA; $-I_B = 0$	$-V_{(BR)CEO}$	max.	40 / 60 / 80 / 100	V
Small-signal current transfer ratio				
$-I_C = 0.5$ A; $-V_{CE} = 10$ V; f = 1 kHz	h_{fe}	min.	20	
Transition frequency				
$-I_C = 0.5$ A; $-V_{CE} = 10$ V; f = 1 kHz	f_T	min.	3	MHz
Turn-off breakdown energy with inductive load (Fig.4)				
$-I_{B\,off} = 0$; $-I_{CC} = 2.5$ V	$E_{(BR)}$	min.	62.5	mJ
Switching times (Figs 2 and 3) (between 10% and 90% levels)				
$-I_{C\,on} = 6$ A; $-I_{B\,on} = I_{B\,off} = 0.6$ A				
turn-on time	t_{on}	typ.	0.6	μs
turn-off time	t_{off}	typ.	1	μs

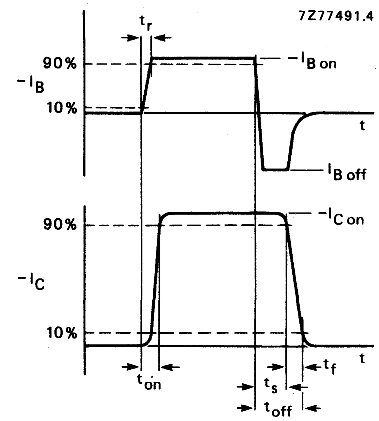
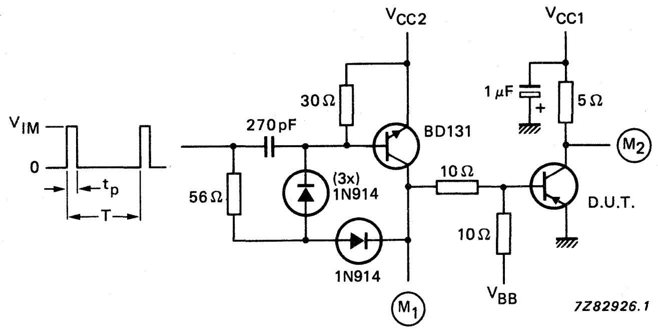


Fig.2 Switching times waveform.

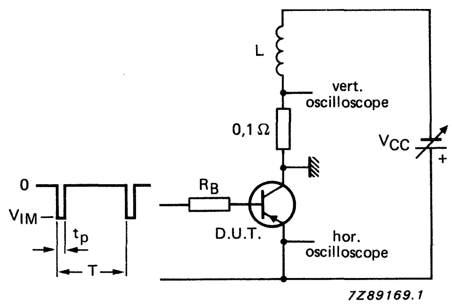
Notes

1. Measured under pulse conditions: t_p max. 300 μs; δ max. 2%.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



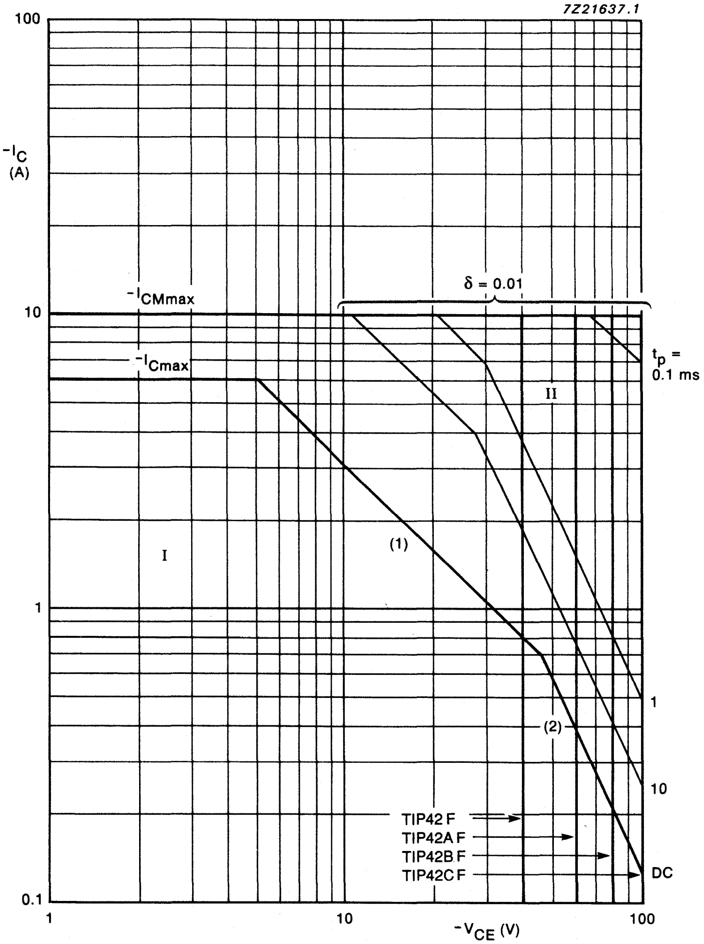
V_{IM} = 10 V
$-V_{CC1}$ = 30 V
$-V_{CC2}$ = 16 V
V_{BB} = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 μs
δ max. 2%

Fig.3 Switching times test circuit.
Adjust V_{CC2} to give M_1 = 14 V.



$-V_{IM}$ = 12 V
R_B = 270 Ω
L = 20 mH
$-I_{CC}$ = 2.5 A
δ = 1%
t_p = 1 ms

Fig.4 Test circuit for turn-off breakdown energy.



I Region of permissible DC operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines
(2) Second-breakdown limits.

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

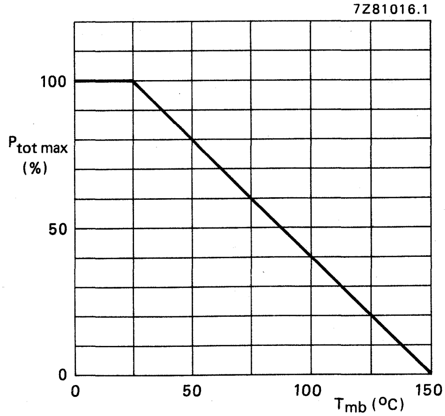


Fig.6 Total power dissipation.

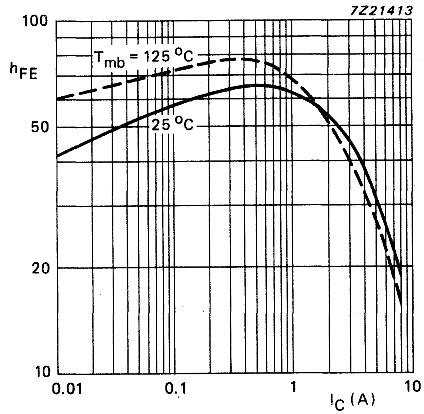


Fig.7 DC current gain; $-V_{CE}$ = 4 V; typical values.

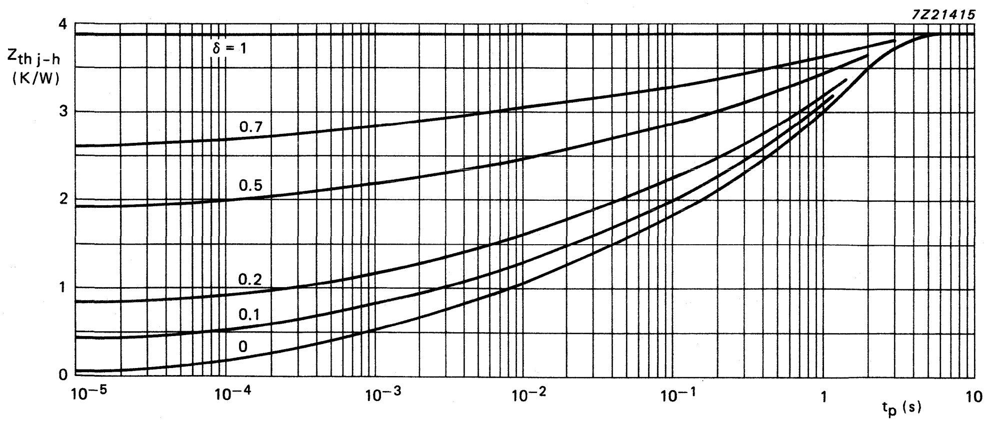


Fig.8 Pulse power rating chart.

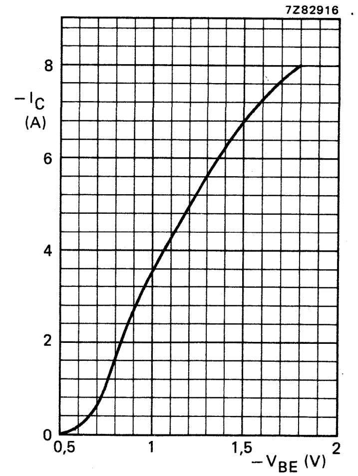


Fig.9 Typical collector current; $-V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220AB plastic envelope. P-N-P complements are TIP115, TIP116 and TIP117.

QUICK REFERENCE DATA

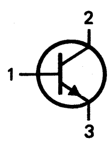
			TIP110	TIP111	TIP112	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		4		A
Collector current (peak value); $t_p \leqslant 0{,}3$ ms	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50		W
D.C. current gain						
V_{CE} = 4 V; I_C = 2 A	h_{FE}	>		500		
Collector-emitter saturation voltage						
I_C = 2 A; I_B = 8 mA	V_{CEsat}	<		2,5		V

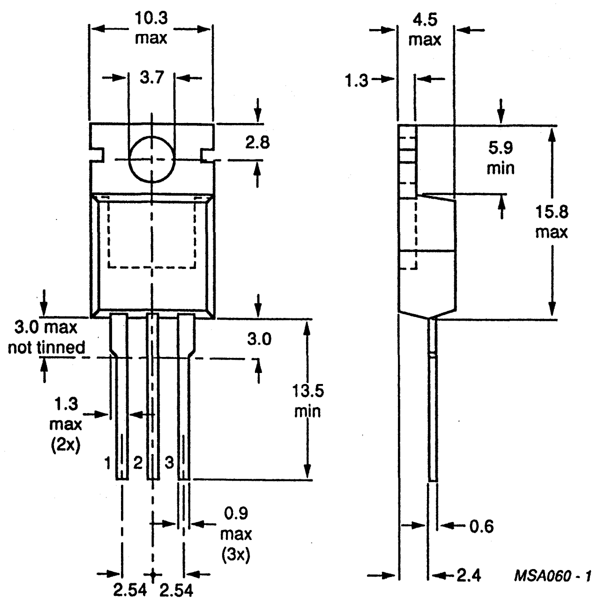
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





CIRCUIT DIAGRAM

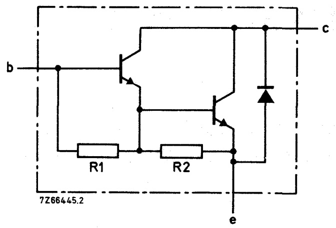


Fig. 2.
R1 typ. 6 kΩ
R2 typ. 100 Ω

RATINGS

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

			TIP110	TIP111	TIP112	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		4		A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max.		6		A
Base current (d.c.)	I_B	max.		50		mA
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		50		W
Total power dissipation in free air	P_{tot}	max.		2		W
Storage temperature	T_{stg}			−65 to + 150		^oC
Junction temperature	T_j	max.		150		^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$V_{CB} = V_{CBOmax}$; $I_E = 0$		I_{CBO}	<	0,2	mA
$V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		I_{CEO}	<	0,2	mA
Emitter cut-off current					
V_{EB} = 5 V; $I_C = 0$		I_{EBO}	<	5	mA
Collector-emitter sustaining voltage					
I_C = 30 mA; $I_B = 0$	TIP110	$V_{CEOsust}$	>	60	V
	TIP111	$V_{CEOsust}$	>	80	V
	TIP112	$V_{CEOsust}$	>	100	V
D.C. current gain					
V_{CE} = 4 V; I_C = 1 A		h_{FE}	>	1000	
V_{CE} = 4 V; I_C = 2 A		h_{FE}	>	500	
Base-emitter voltage					
V_{CE} = 4 V; I_C = 2 A		V_{BE}	<	2,8	V
Collector-emitter saturation voltage					
I_C = 2 A; I_B = 8 mA		V_{CEsat}	<	2,5	V
Switching times					
I_C = 2 A; $I_{Bon} = -I_{Boff}$ = 8 mA; V_{CC} = 30 V					
turn-on time		t_{on}	typ.	2,6	µs
turn-off time		t_{off}	typ.	4,5	µs

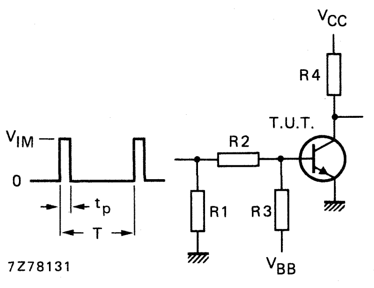


Fig. 3 Switching times test circuit with resistive load.

V_{IM} = 12 V	R1 = 56 Ω	$t_r = t_f$ = 15 ns
V_{CC} = 30 V	R2 = 750 Ω	t_p = 10 µs
$-V_{BB}$ = 5 V	R3 = 910 Ω	T = 500 µs
	R4 = 15 Ω	

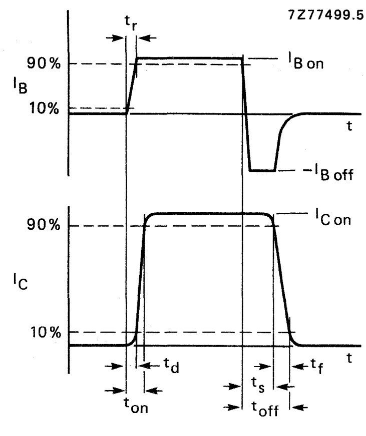


Fig. 4 Switching times waveforms.

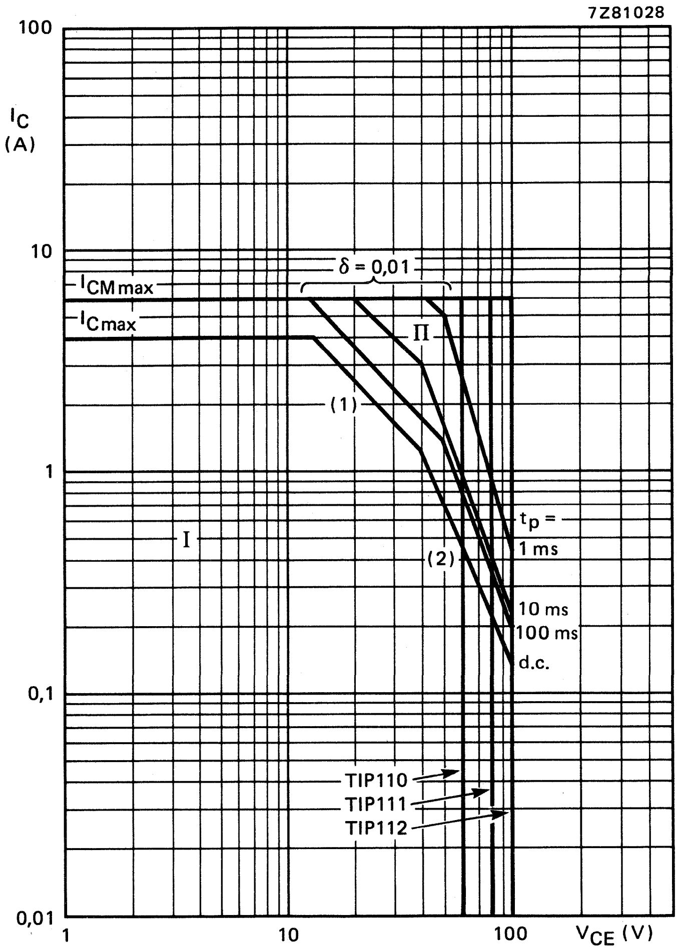


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

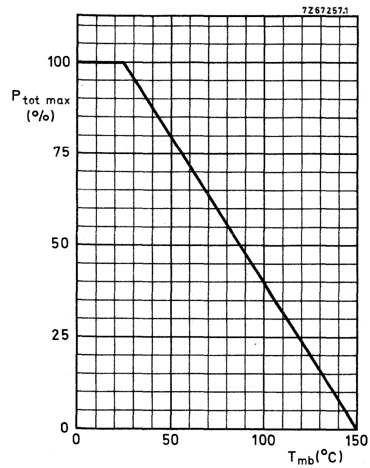


Fig. 6 Power derating curve.

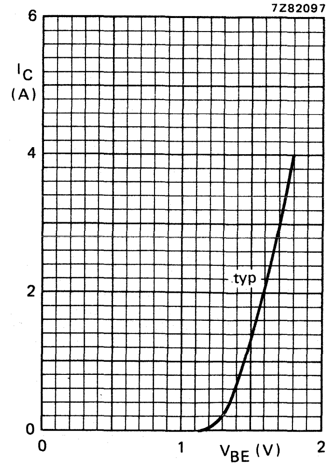


Fig. 7 V_{CE} = 4 V; T_j = 25 °C.

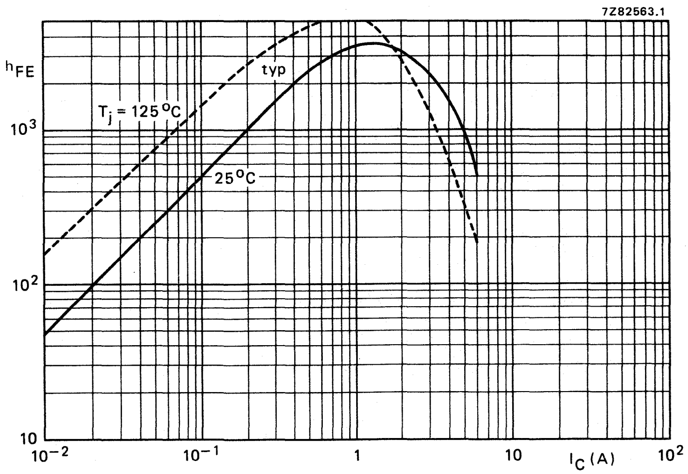


Fig. 8 Typical d.c. current gain; V_{CE} = 4 V.

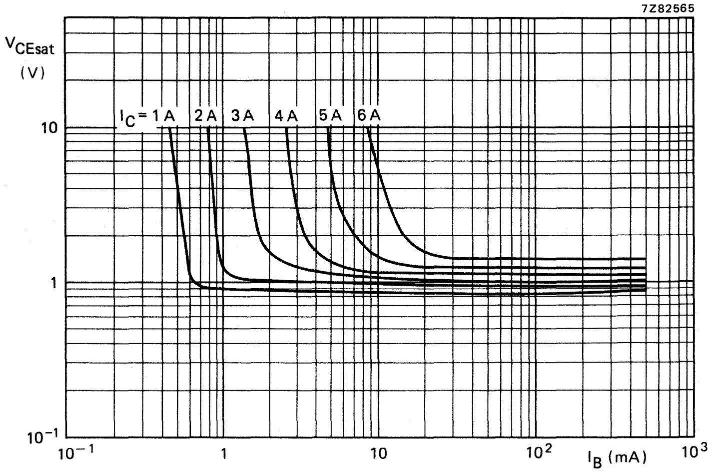


Fig. 9 Typical values; $T_j = 25\ ^oC$.

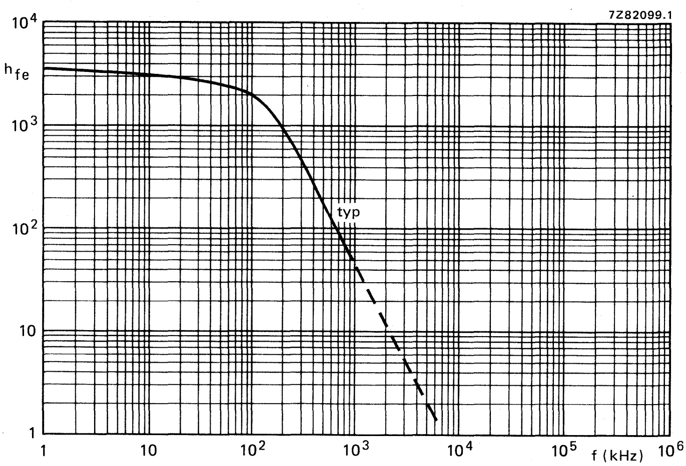


Fig. 10 Small-signal current gain; $I_C = 1{,}5$ A; $V_{CE} = 4$ V; $T_j = 25\ ^oC$.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220AB plastic envelope. N-P-N complements are TIP110, TIP111 and TIP112.

QUICK REFERENCE DATA

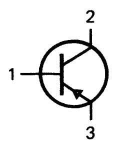
			TIP115	TIP116	TIP117	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		4		A
Collector current (peak value); $t_p \leq 0{,}3$ ms	$-I_{CM}$	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50		W
D.C. current gain						
$-V_{CE}$ = 4 V; $-I_B$ = 2 A	h_{FE}	>		500		
Collector-emitter saturation voltage						
$-I_C$ = 2 A; $-I_B$ = 8 mA	$-V_{CEsat}$	<		2,5		V

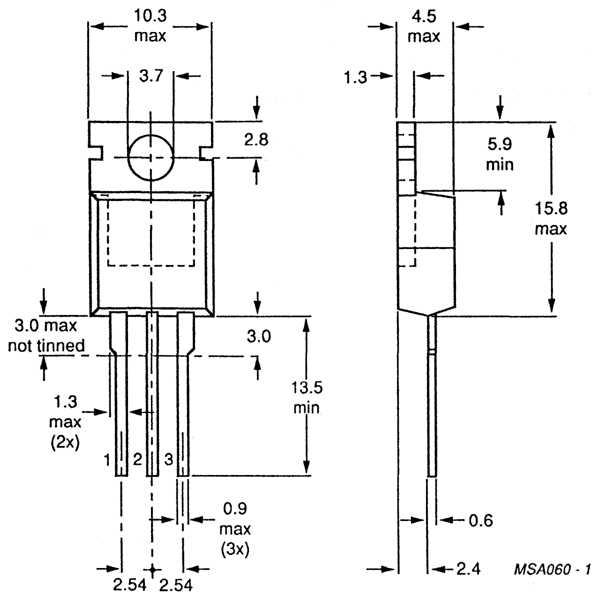
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





CIRCUIT DIAGRAM

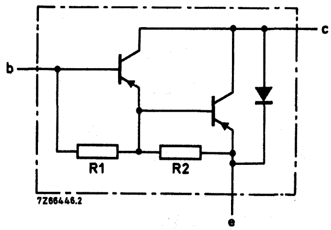


Fig. 2.
R1 typ. 6 kΩ
R2 typ. 100 Ω

RATINGS

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

			TIP115	TIP116	TIP117	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	4	A
Collector current (peak value); $t_p \leq 0,3$ ms	$-I_{CM}$	max.	6	A
Base current (d.c.)	$-I_B$	max.	50	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	50	W
Total power dissipation in free air	P_{tot}	max.	2	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$		$-I_{CBO}$	<	0,2	mA
$-V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		$-I_{CEO}$	<	0,2	mA
Emitter cut-off current					
$-V_{EB} = 5$ V; $I_C = 0$		$-I_{EBO}$	<	5	mA
Collector-emitter sustaining voltage					
$-I_C = 30$ mA; $I_B = 0$	TIP115	$-V_{CEOsust}$	>	60	V
	TIP116	$-V_{CEOsust}$	>	80	V
	TIP117	$-V_{CEOsust}$	>	100	V
D.C. current gain					
$-V_{CE} = 4$ V; $-I_C = 1$ A		h_{FE}	>	1000	
$-V_{CE} = 4$ V; $-I_C = 2$ A		h_{FE}	>	500	
Base-emitter voltage					
$-V_{CE} = 4$ V; $-I_C = 2$ A		$-V_{BE}$	<	2,8	V
Collector-emitter saturation voltage					
$-I_C = 2$ A; $-I_B = 8$ mA		$-V_{CEsat}$	<	2,5	V
Switching times					
$-I_C = 2$ A; $-I_{Bon} = +I_{Boff} = 8$ mA; $-V_{CC} = 30$ V					
turn-on time		t_{on}	typ.	2,6	μs
turn-off time		t_{off}	typ.	4,5	μs

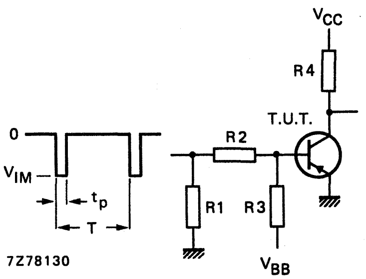


Fig. 3 Switching times test circuit.

$-V_{IM} = 12$ V　R1 = 56 Ω　$t_r = t_f = 15$ ns
$-V_{CC} = 30$ V　R2 = 750 Ω　$t_p = 10$ μs
$+V_{BB} = 5$ V　R3 = 910 Ω　T = 500 μs
R4 = 15 Ω

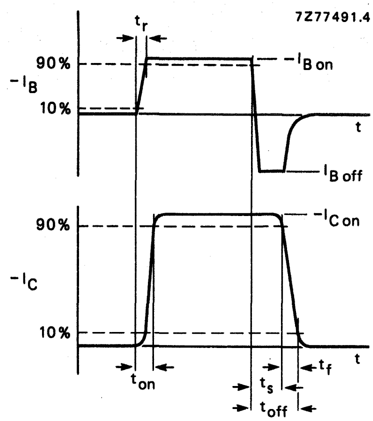


Fig. 4 Switching times waveforms.

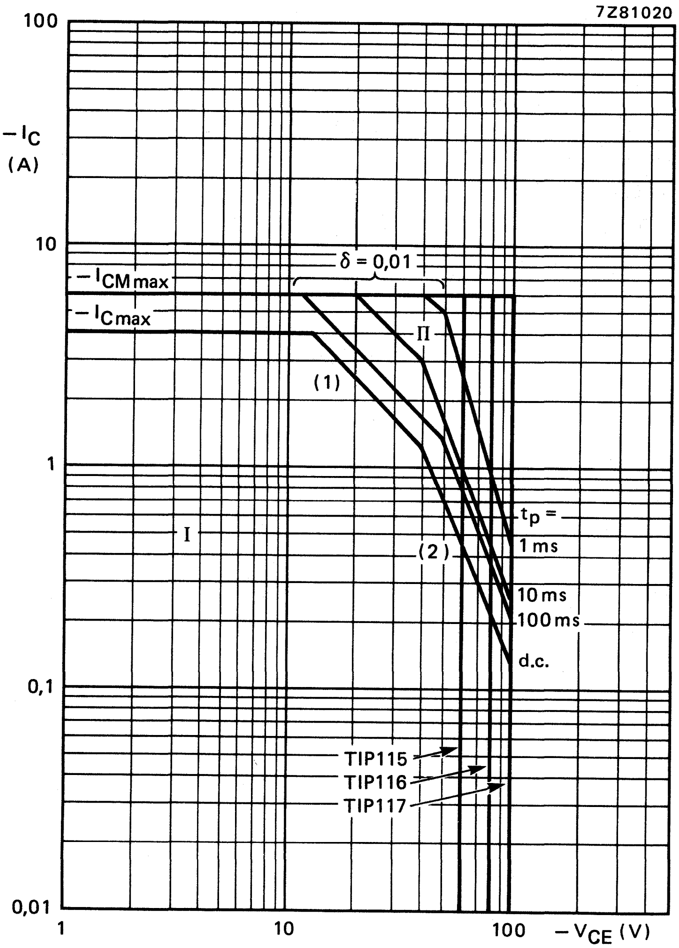


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

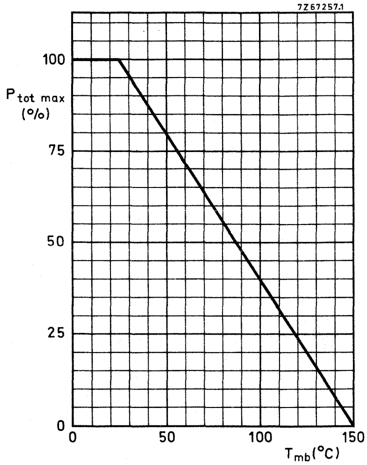


Fig. 6 Power derating curve.

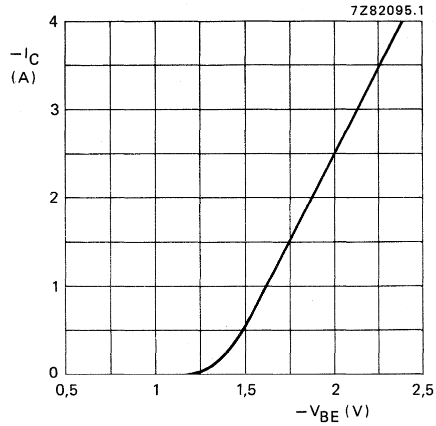


Fig. 7 $-V_{CE}$ = 4 V; T_j = 25 °C; typical values.

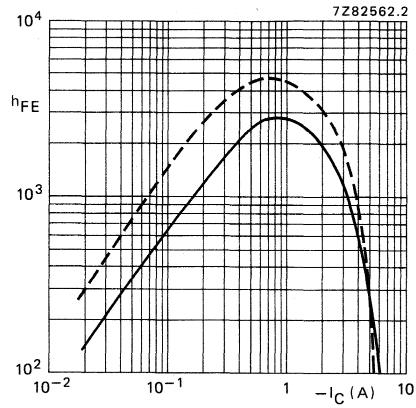


Fig. 8 Typical d.c. current gain; $-V_{CE}$ = 4 V; —— T_j = 25 °C; – – – – T_j = 125 °C.

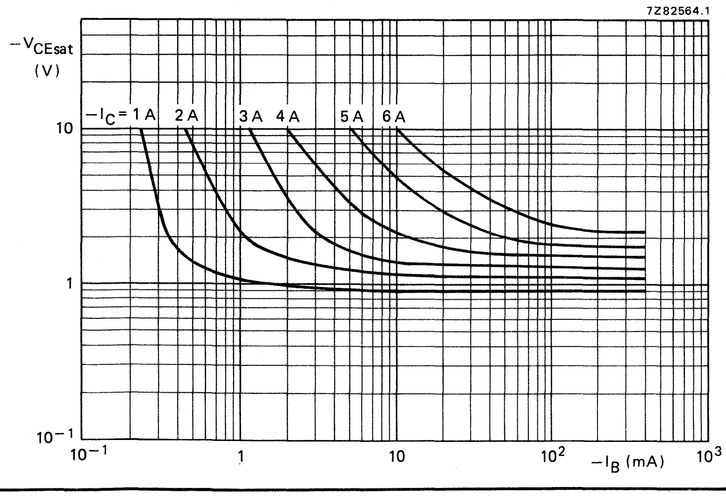


Fig. 9 Typical collector-emitter saturation voltage at T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220 plastic envelope. P-N-P complements are TIP125, TIP126 and TIP127.

QUICK REFERENCE DATA

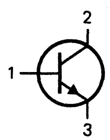
			TIP120	TIP121	TIP122	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max.		8		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		65		W
D.C. current gain						
V_{CE} = 3 V; I_C = 3 A	h_{FE}	>		1000		
Collector-emitter saturation voltage						
I_C = 3 A; I_B = 12 mA	V_{CEsat}	<		2,0		V

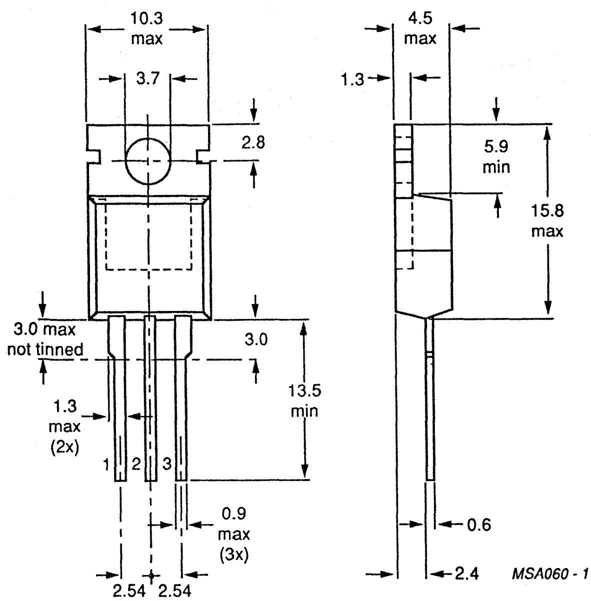
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





CIRCUIT DIAGRAM

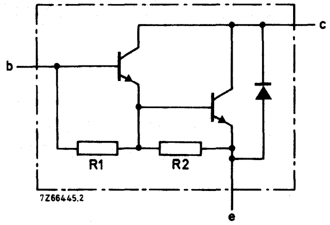


Fig. 2.
R1 typ. 4 kΩ
R2 typ. 100 Ω

RATINGS

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

			TIP120	TIP121	TIP122	
Collector-base voltage (I_E = 0)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (I_B = 0)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (I_C = 0)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value); $t_p \leqslant$ 0,3 ms	I_{CM}	max.		8		A
Base current (d.c.)	I_B	max.		0,1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		65		W
Total power dissipation in free air	P_{tot}	max.		2		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$V_{CB} = V_{CBOmax}$; $I_E = 0$		I_{CBO}	<	0,1	mA
$V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		I_{CEO}	<	0,2	mA
Emitter cut-off current					
V_{EB} = 5 V; I_C = 0		I_{EBO}	<	5,0	mA
Collector-emitter sustaining voltage					
I_C = 30 mA; I_B = 0	TIP120	$V_{CEOsust}$	>	60	V
	TIP121	$V_{CEOsust}$	>	80	V
	TIP122	$V_{CEOsust}$	>	100	V
D.C. current gain					
V_{CE} = 3 V; I_C = 0,5 A		h_{FE}	>	1000	
V_{CE} = 3 V; I_C = 3 A		h_{FE}	>	1000	
Base-emitter voltage					
V_{CE} = 3 V; I_C = 3 A		V_{BE}	<	2,5	V
Collector-emitter saturation voltage					
I_C = 3 A; I_B = 12 mA		V_{CEsat}	<	2,0	V
I_C = 5 A; I_B = 20 mA		V_{CEsat}	<	4,0	V
Switching times					
I_C = 3 A; $I_{Bon} = -I_{Boff}$ = 12 mA;					
V_{CC} = 30 V					
turn-on time		t_{on}	typ.	1,5	μs
turn-off time		t_{off}	typ.	8,5	μs

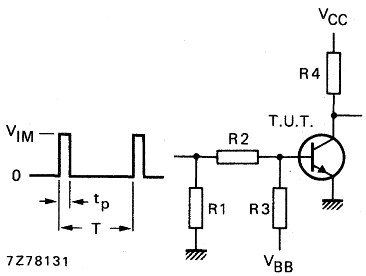


Fig. 3 Switching times test circuit.

V_{CC} = 30 V	R1 = 56 Ω	$t_r = t_f$ = 15 ns
V_{IM} = 10 V	R2 = 410 Ω	t_p = 10 μs
$-V_{BB}$ = 5 V	R3 = 560 Ω	T = 500 μs
	R4 = 10 Ω	

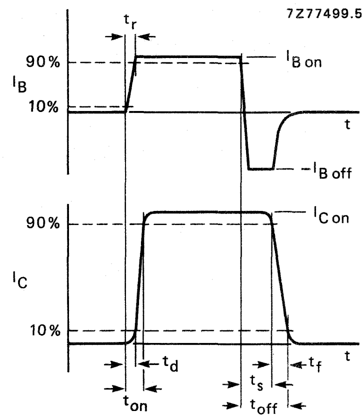


Fig. 4 Switching times waveforms.

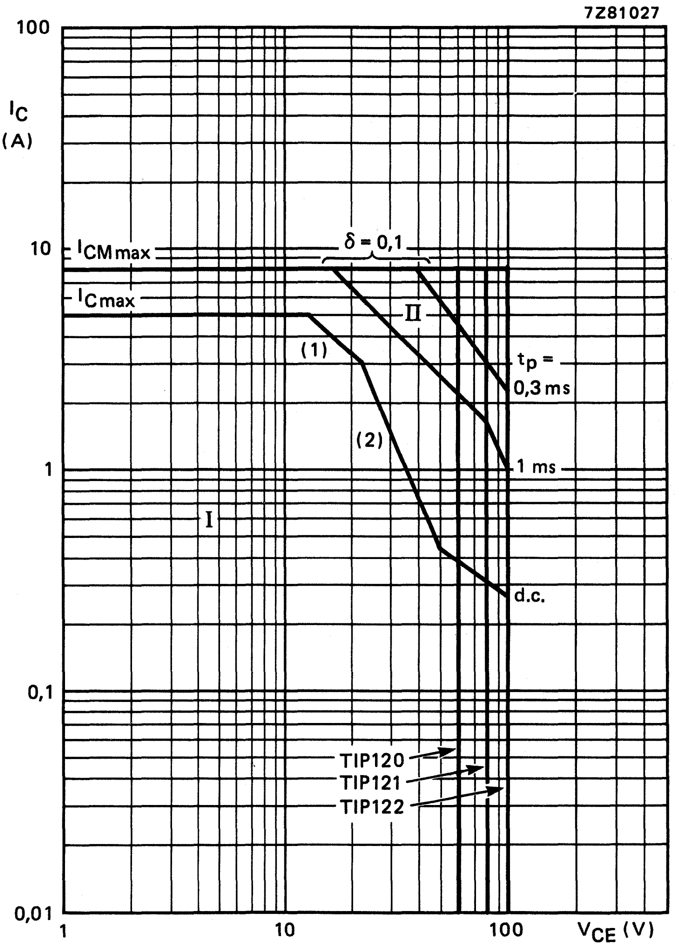


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

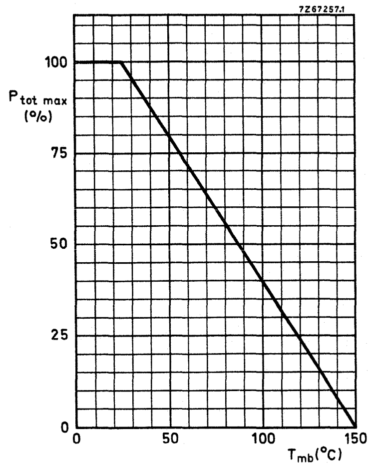


Fig. 6 Power derating curve.

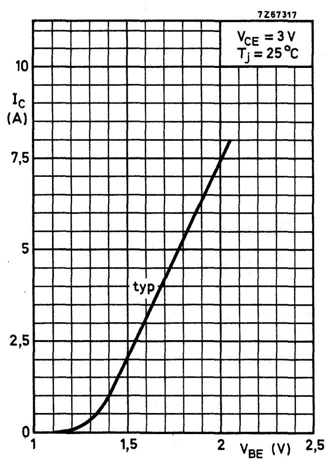


Fig. 7.

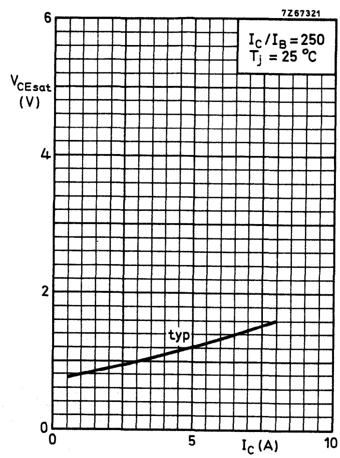


Fig. 8.

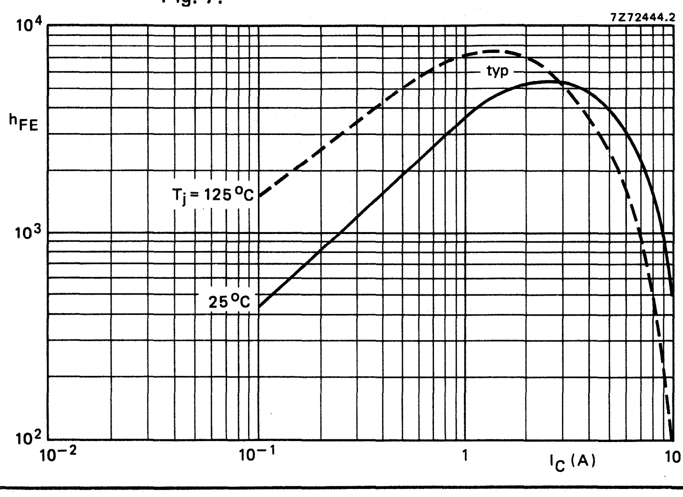


Fig. 9 Typical d.c. current gain; V_{CE} = 3 V.

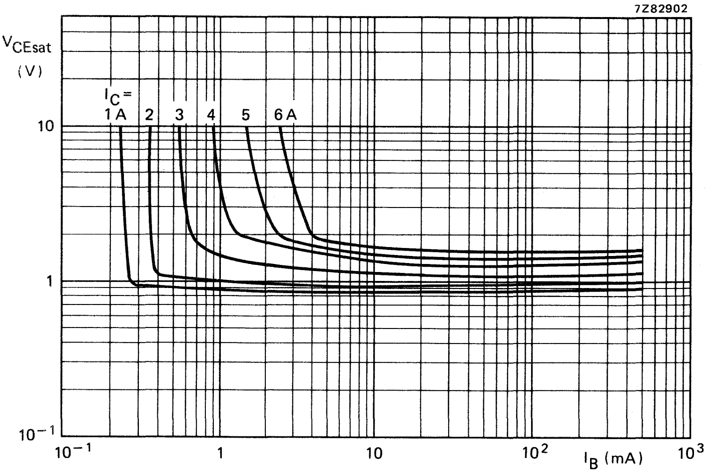


Fig. 10 Typical values; T_j = 25 °C.

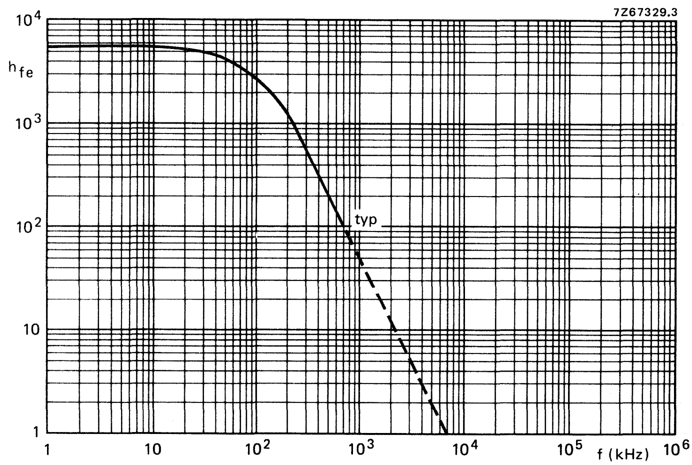


Fig. 11 Small signal current gain at I_C = 3 A; V_{CE} = 3 V; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220 plastic envelope. N-P-N complements are TIP120, TIP121 and TIP122.

QUICK REFERENCE DATA

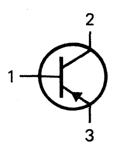
			TIP125	TIP126	TIP127	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		5		A
Collector current (peak value; $t_p \leq 0{,}3$ ms)	$-I_{CM}$	max.		8		A
Total power dissipation up to $T_{mb} = 25\ ^{o}C$	P_{tot}	max.		65		W
D.C. current gain						
$-V_{CE} = 3$ V; $-I_C = 3$ A	h_{FE}	>		1000		
Collector-emitter saturation voltage						
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<		2,0		V

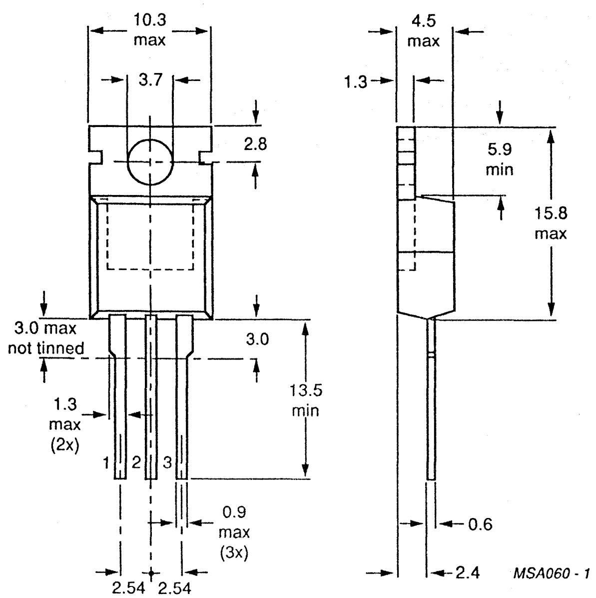
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





CIRCUIT DIAGRAM

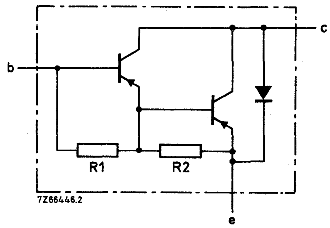


Fig. 2.
R1 typ. 4 kΩ
R2 typ. 80 Ω

RATINGS

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

			TIP125	TIP126	TIP127	
Collector-base voltage (I_E = 0)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (I_B = 0)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (I_C = 0)	$-V_{EBO}$	max.		5		V
Collector current (d.c.)	$-I_C$	max.		5		A
Collector current (peak value); $t_p \leq 0,3$ ms	$-I_{CM}$	max.		8		A
Base current (d.c.)	$-I_B$	max.		0,1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		65		W
Total power dissipation in free air	P_{tot}	max.		2		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$V_{CB} = V_{CBOmax}$; $I_E = 0$		$-I_{CBO}$	<	0,1	mA
$V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		$-I_{CEO}$	<	0,2	mA
Emitter cut-off current					
$-V_{EB} = 5$ V; $I_C = 0$		$-I_{EBO}$	<	5,0	mA
Collector-emitter sustaining voltage					
$-I_C = 30$ mA; $I_B = 0$	TIP125	$-V_{CEOsust}$	>	60	V
	TIP126	$-V_{CEOsust}$	>	80	V
	TIP127	$-V_{CEOsust}$	>	100	V
D.C. current gain					
$-V_{CE} = 3$ V; $-I_C = 0{,}5$ A		h_{FE}	>	1000	
$-V_{CE} = 3$ V; $-I_C = 3$ A		h_{FE}	>	1000	
Base-emitter voltage					
$-V_{CE} = 3$ V; $-I_C = 3$ A		$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage					
$-I_C = 3$ A; $-I_B = 12$ mA		$-V_{CEsat}$	<	2,0	V
$-I_C = 5$ A; $-I_B = 20$ mA		$-V_{CEsat}$	<	4,0	V
Switching times					
$-I_C = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA;					
$-V_{CC} = 30$ V					
turn-on time		t_{on}	typ.	1,5	µs
turn-off time		t_{off}	typ.	8,5	µs

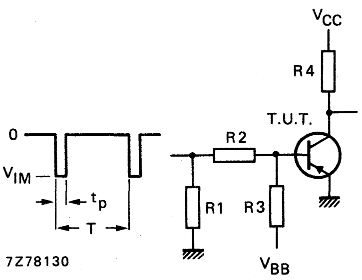


Fig. 3 Switching times test circuit.

$-V_{IM} = 10$ V	R1 = 56 Ω	$t_r = t_f = 15$ ns
$-V_{CC} = 30$ V	R2 = 410 Ω	$t_p = 10$ µs
$+V_{BB} = 5$ V	R3 = 560 Ω	T = 500 µs
	R4 = 10 Ω	

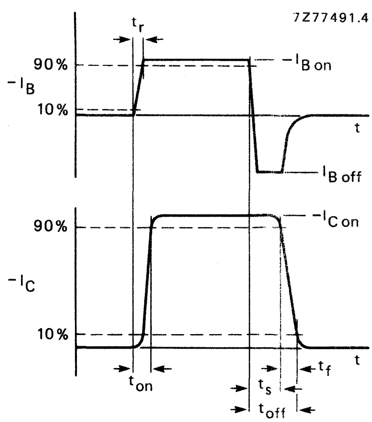


Fig. 4 Switching times waveforms.

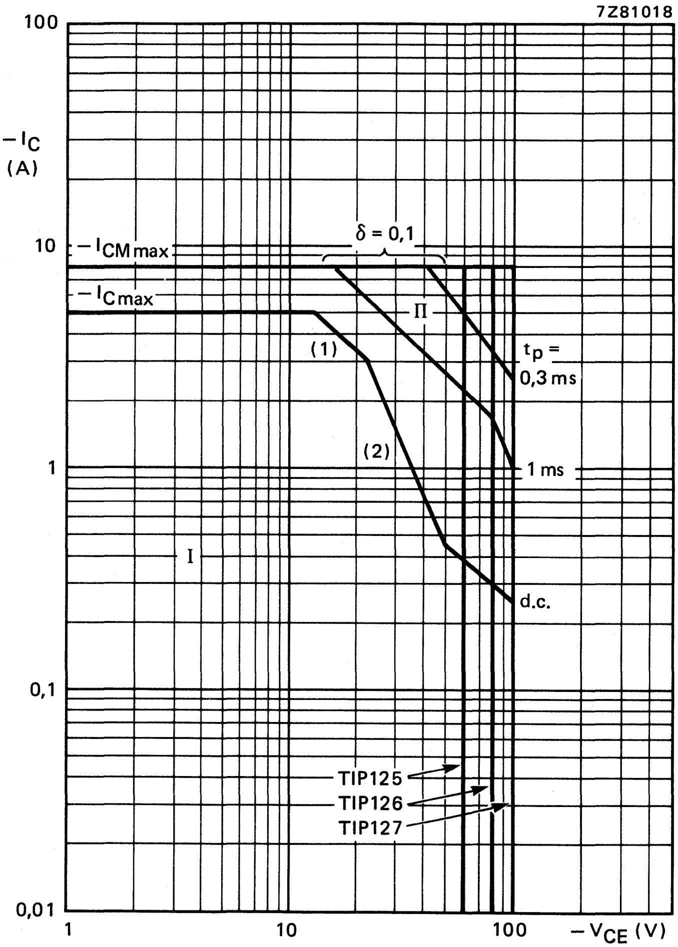


Fig. 5 Safe Operating Area at T_{mb} = 25 °C.

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

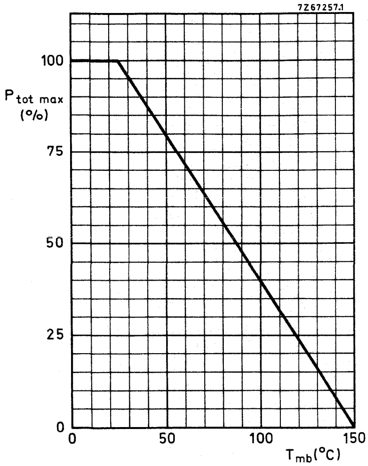


Fig. 6 Power derating curve.

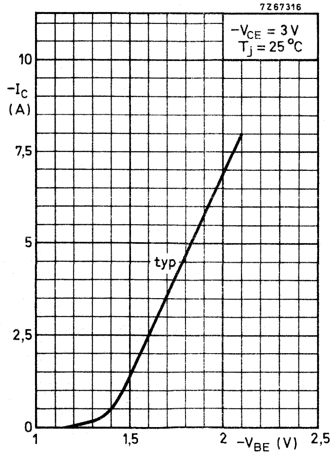


Fig. 7.

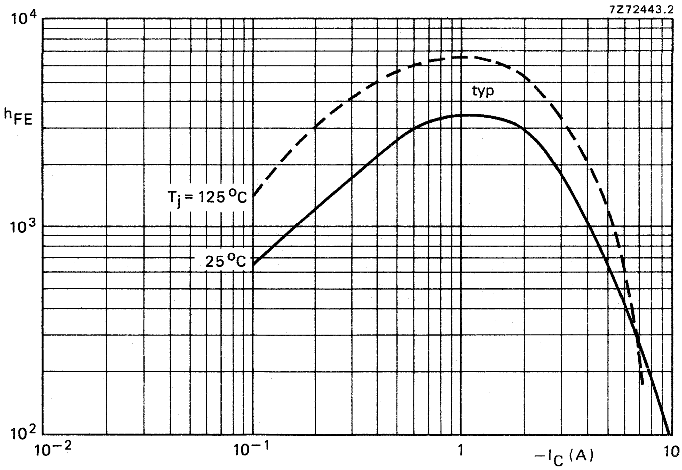


Fig. 8 D.C. current gain at $-V_{CE}$ = 3 V.

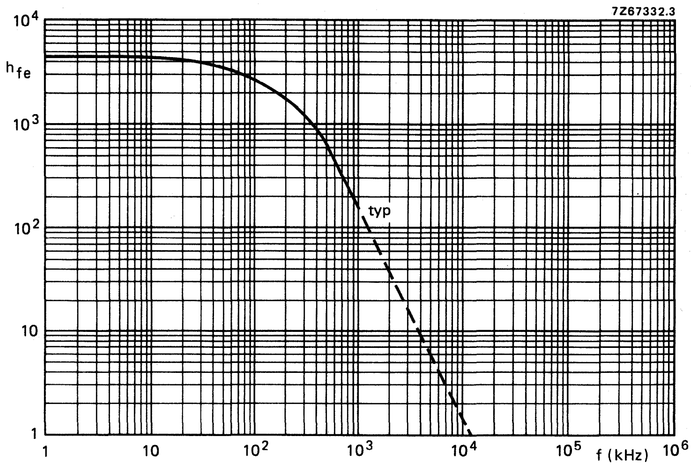


Fig. 9 Small-signal current gain at $-I_C = 3$ A; $-V_{CE} = 3$ V; $T_j = 25$ °C.

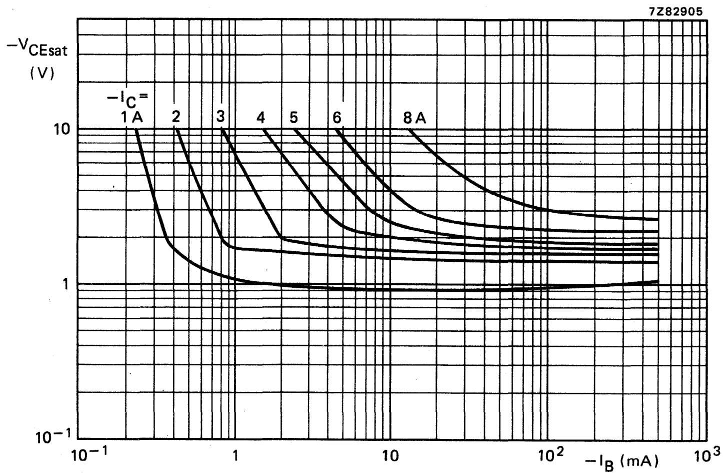


Fig. 10 Typical collector-emitter saturation voltage at $T_j = 25$ °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220AB plastic envelope. P-N-P equivalents are TIP135, TIP136 and TIP137.

QUICK REFERENCE DATA

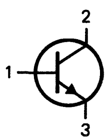
			TIP130	TIP131	TIP132	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		8		A
Collector current (peak value); $t_p \leqslant$ 0,3 ms	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		70		W
D.C. current gain						
V_{CE} = 4 V; I_C = 4 A	h_{FE}			1000 to 15 000		
Collector-emitter saturation voltage						
I_C = 4 A; I_B = 16 mA	V_{CEsat}	<		2		V

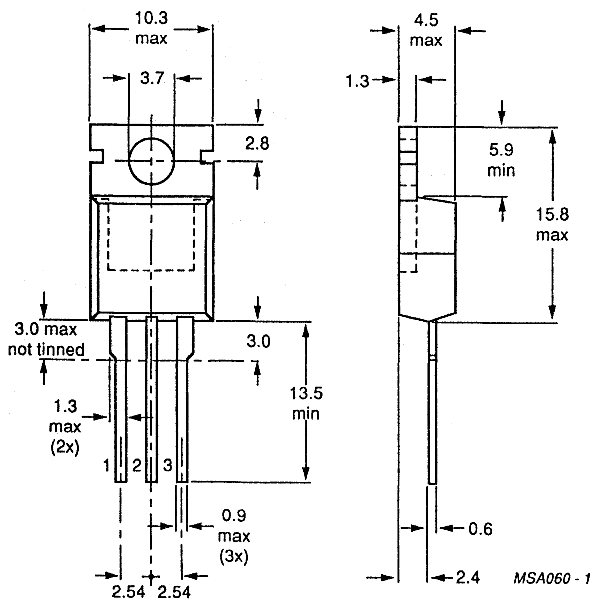
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





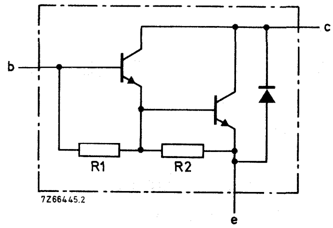


Fig. 2.
R1 typ. 8 kΩ
R2 typ. 100 kΩ

RATINGS

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

			TIP130	TIP131	TIP132	
Collector-base voltage ($I_E = 0$)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage ($I_B = 0$)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage ($I_C = 0$)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		8		A
Collector current (peak value); $t_p \leq 0{,}3$ ms	I_{CM}	max.		12		A
Base current (d.c.)	I_B	max.		0,3		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		70		W
Total power dissipation in free air	P_{tot}	max.		2		W
Storage temperature	T_{stg}			−65 to + 150		^oC
Junction temperature	T_j	max.		150		^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,79	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off currents					
$V_{CB} = V_{CBOmax}$; $I_E = 0$		I_{CBO}	<	0,2	mA
$V_{CB} = V_{CBOmax}$; $I_E = 0$; $T_j = 100\ ^oC$		I_{CBO}	<	1	mA
$V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		I_{CEO}	<	0,5	mA
Emitter cut-off current					
$V_{EB} = 5\ V$; $I_C = 0$		I_{EBO}	<	5	mA
Collector-emitter sustaining voltage					
$I_C = 30\ mA$; $I_B = 0$	TIP130	$V_{CEOsust}$	>	60	V
	TIP131	$V_{CEOsust}$	>	80	V
	TIP132	$V_{CEOsust}$	>	100	V
D.C. current gain					
$V_{CE} = 4\ V$; $I_C = 1\ A$		h_{FE}	>	500	
$V_{CE} = 4\ V$; $I_C = 4\ A$		h_{FE}		1000 to 15 000	
Base-emitter voltage					
$V_{CE} = 4\ V$; $I_C = 4\ A$		V_{BE}	<	2,5	V
Collector-emitter saturation voltage					
$I_C = 4\ A$; $I_B = 16\ mA$		V_{CEsat}	<	2	V
$I_C = 6\ A$; $I_B = 30\ mA$		V_{CEsat}	<	3	V
Collector-base capacitance					
$V_{CB} = 10\ V$; $I_E = 0$		C_{ob}	<	200	pF
Switching times					
$I_C = 3\ A$; $I_{Bon} = -I_{Boff} = 12\ mA$					
$V_{CC} = 10\ V$					
turn-on time		t_{on}	typ.	1	μs
turn-off time		t_{off}	typ.	5	μs

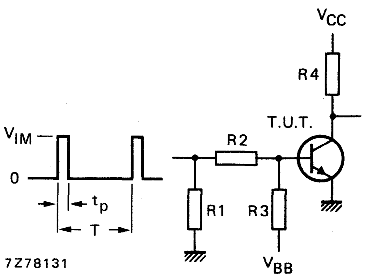


Fig. 3 Switching times test circuit with resistive load.

$V_{IM} = 10\ V$	$R1 = 56\ \Omega$	$t_r = t_f = 15\ ns$
$V_{CC} = 10\ V$	$R2 = 410\ \Omega$	$t_p = 10\ \mu s$
$-V_{BB} = 4\ V$	$R3 = 560\ \Omega$	$T = 500\ \mu s$
	$R4 = 3\ \Omega$	

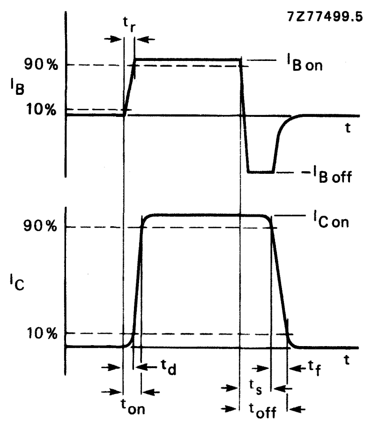


Fig. 4 Switching times waveforms.

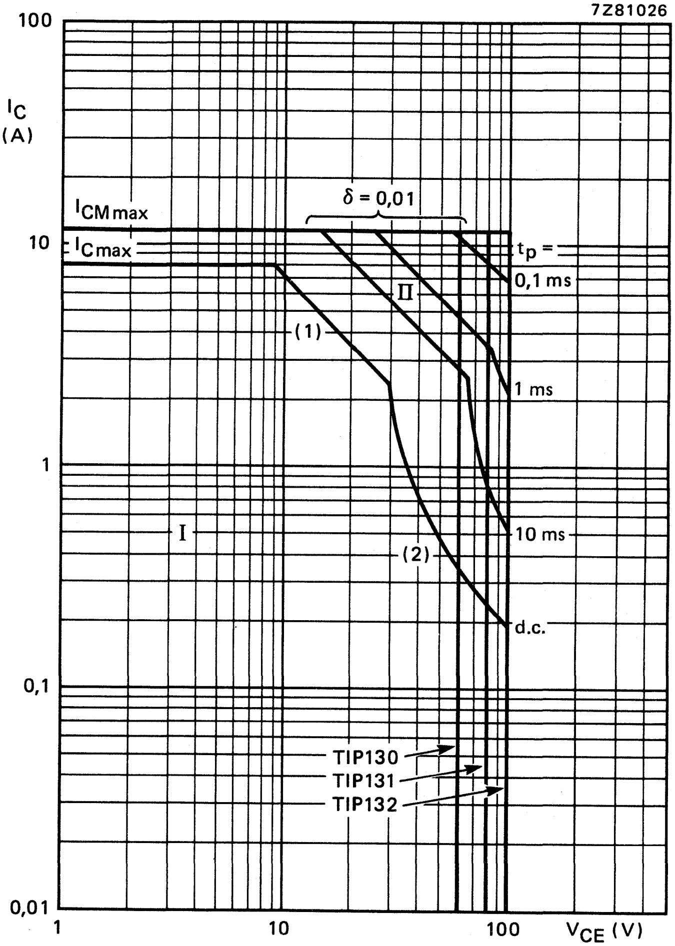


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

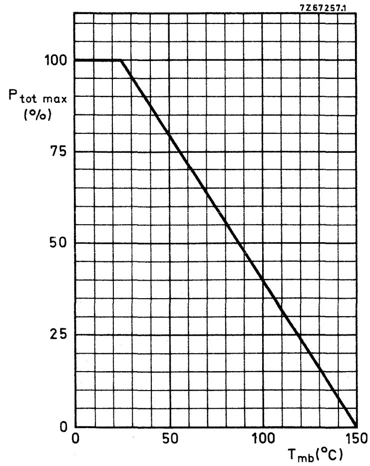


Fig. 6 Power derating curve.

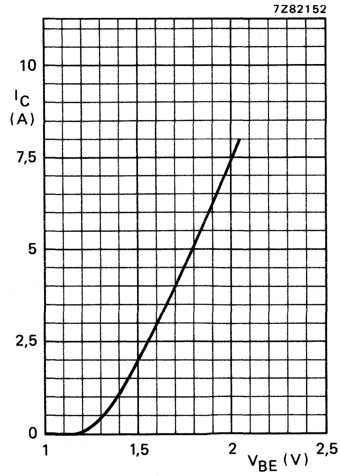


Fig. 7 Typical values; $V_{CE} = 4$ V; $T_j = 25$ °C.

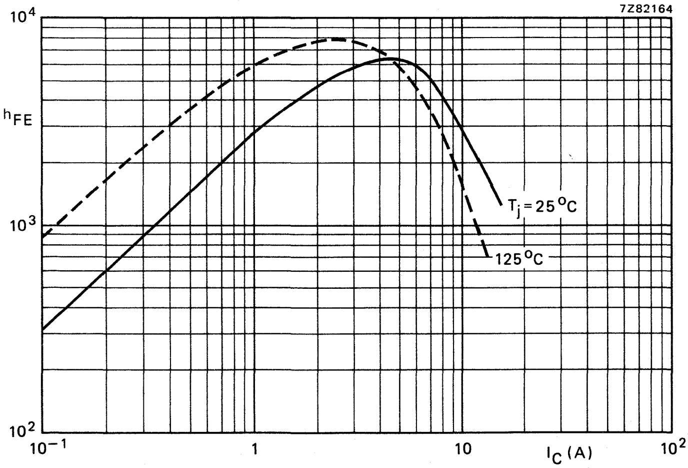


Fig. 8 Typical d.c. current gain at $V_{CE} = 4$ V.

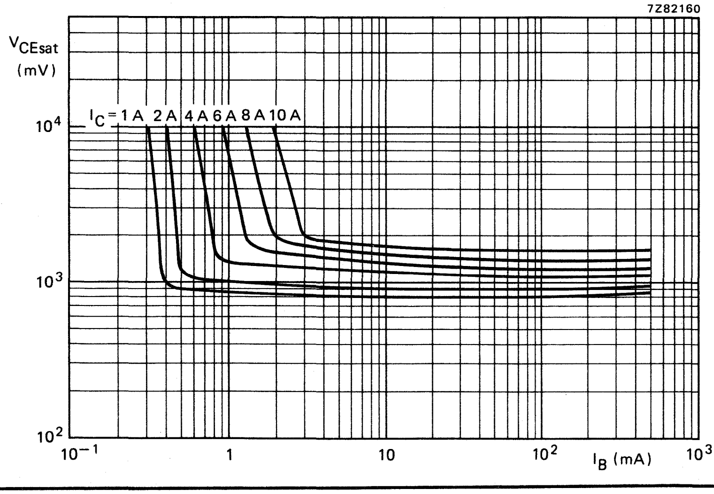


Fig. 9 Typical values; $T_j = 25$ °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220AB plastic envelope. N-P-N equivalents are TIP130, TIP131 and TIP132.

QUICK REFERENCE DATA

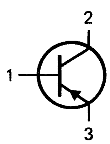
			TIP135	TIP136	TIP137	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		8		A
Collector current (peak value); $t_p \leqslant 0,3$ ms	$-I_{CM}$	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		70		W
D.C. current gain						
$-V_{CE} = 4$ V; $-I_C = 4$ A	h_{FE}			1000 to 15 000		
Collector-emitter saturation voltage						
$-I_C = 4$ A; $-I_B = 16$ mA	$-V_{CEsat}$	<		2		V

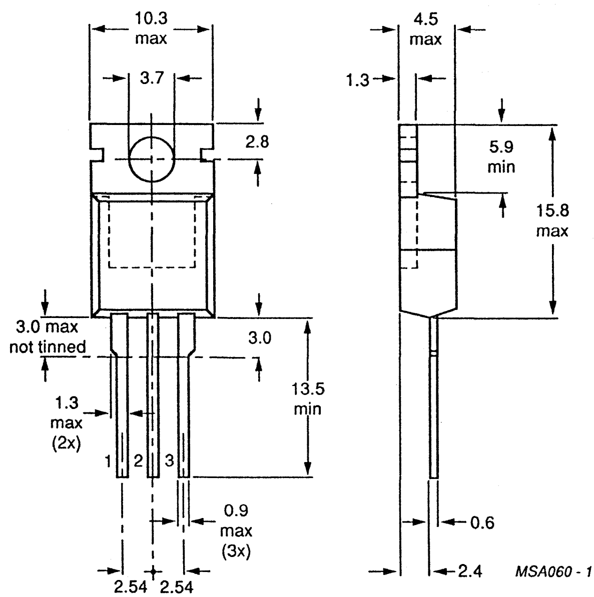
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





CIRCUIT DIAGRAM

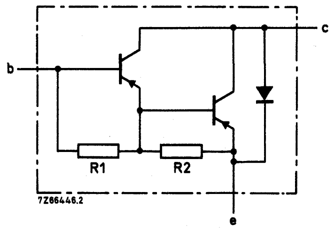


Fig. 2.
R1 typ. 4 kΩ
R2 typ. 60 Ω

RATINGS

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

			TIP135	TIP136	TIP137	
Collector-base voltage (I_E = 0)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (I_B = 0)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (I_C = 0)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		8		A
Collector current (peak value); $t_p \leq 0{,}3$ ms	$-I_{CM}$	max.		12		A
Base current (d.c.)	$-I_B$	max.		0,3		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		70		W
Total power dissipation in free air	P_{tot}	max.		2		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1,79	K/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	62,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$		$-I_{CBO}$	<	0,2	mA
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$; T_j = 100 °C		$-I_{CBO}$	<	1	mA
$-V_{CE} = -1/2\ V_{CEOmax}$; $I_B = 0$		$-I_{CEO}$	<	0,5	mA
Emitter cut-off current					
$-V_{EB}$ = 5 V; $I_C = 0$		$-I_{EBO}$	<	5	mA
Collector-emitter sustaining voltage					
$-I_C$ = 30 mA; $I_B = 0$	TIP135	$-V_{CEOsust}$	>	60	V
	TIP136	$-V_{CEOsust}$	>	80	V
	TIP137	$-V_{CEOsust}$	>	100	V
D.C. current gain					
$-V_{CE}$ = 4 V; $-I_C$ = 1 A		h_{FE}	>	500	
$-V_{CE}$ = 4 V; $-I_C$ = 4 A		h_{FE}		1000 to 15 000	
Base-emitter voltage					
$-V_{CE}$ = 4 V; $-I_C$ = 4 A		$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage					
$-I_C$ = 4 A; $-I_B$ = 16 mA		$-V_{CEsat}$	<	2	V
$-I_C$ = 6 A; $-I_B$ = 30 mA		$-V_{CEsat}$	<	3	V
Collector-base capacitance					
$-V_{CB}$ = 10 V; $I_E = 0$		C_{ob}	<	200	pF
Switching times					
$-I_C$ = 3 A; $-I_{Bon} = +I_{Boff}$ = 12 mA					
$-V_{CC}$ = 10 V					
turn-on time		t_{on}	typ.	0,5	µs
turn-off time		t_{off}	typ.	2,5	µs

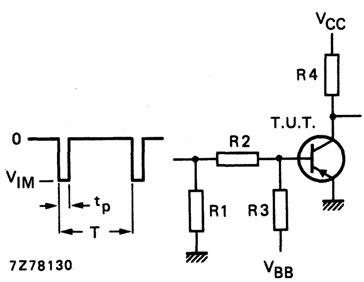


Fig. 3 Switching times test circuit.

$-V_{IM}$ = 10 V	R1 = 56 Ω	$t_r = t_f$ = 15 ns
$-V_{CC}$ = 10 V	R2 = 410 Ω	t_p = 10 µs
$+V_{BB}$ = 4 V	R3 = 560 Ω	T = 500 µs
	R4 = 3 Ω	

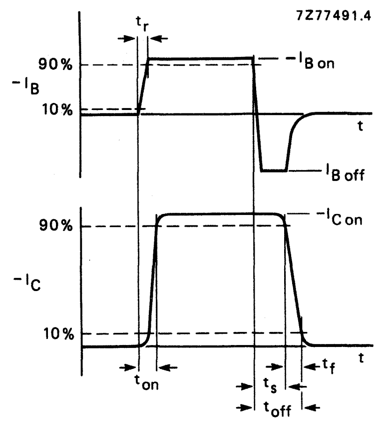


Fig. 4 Switching times waveforms.

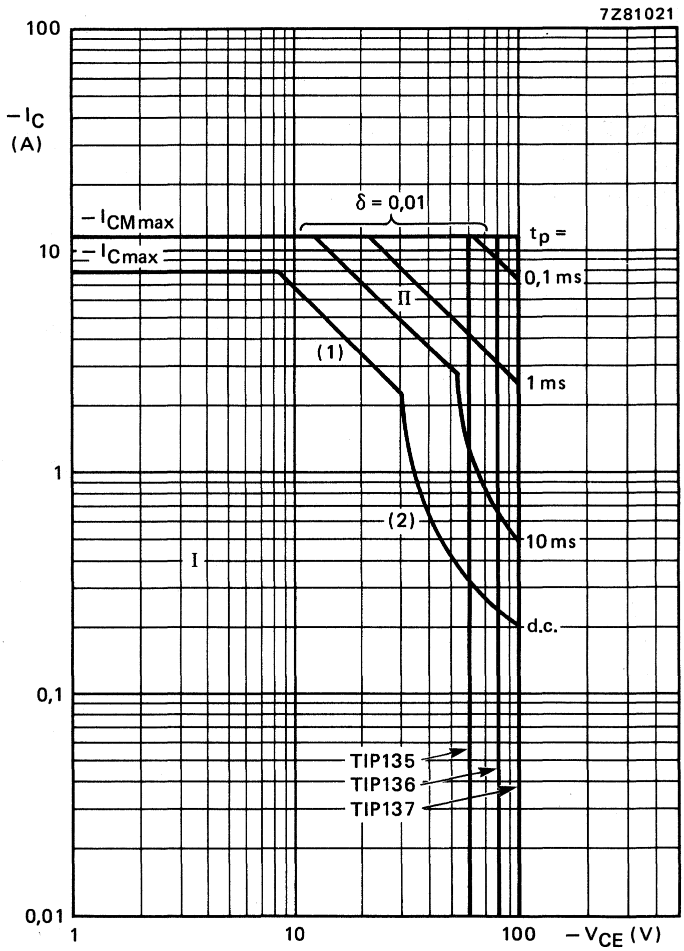


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

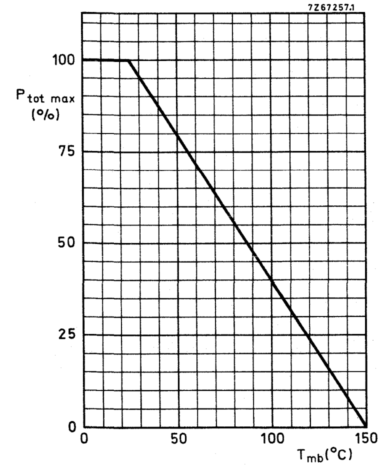


Fig. 6 Power derating curve.

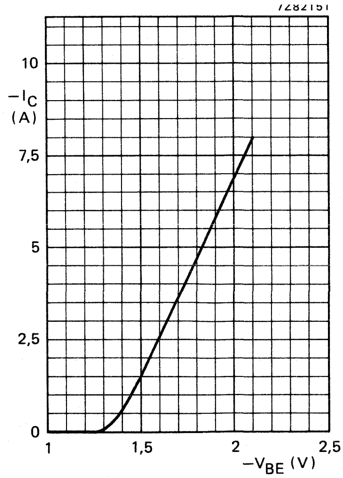


Fig. 7 Typical values; $-V_{CE}$ = 4 V; T_j = 25 °C.

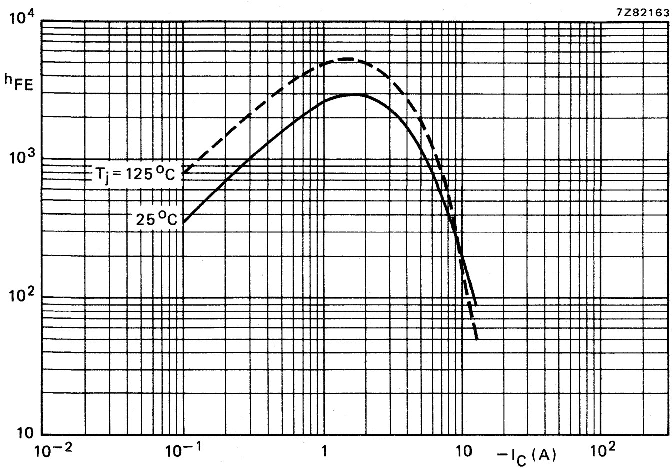


Fig. 8 Typical d.c. current gain at $-V_{CE}$ = 4 V.

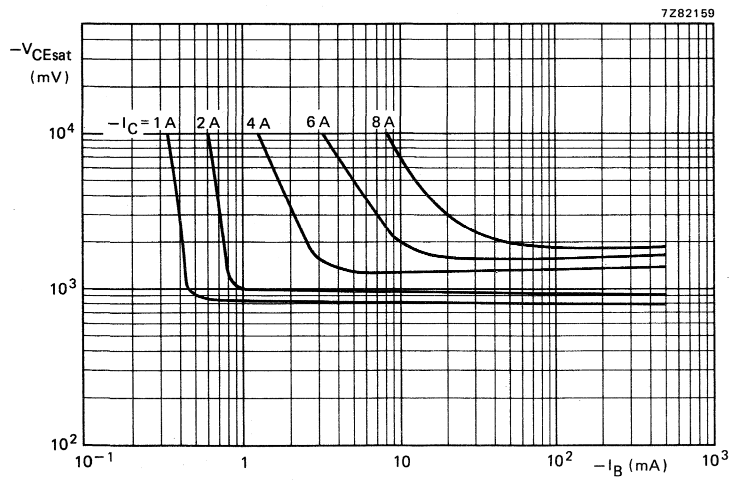


Fig. 9 Typical collector-emitter saturation voltage; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. SOT-93 plastic envelope. P-N-P complements are TIP145, TIP146 and TIP147.

QUICK REFERENCE DATA

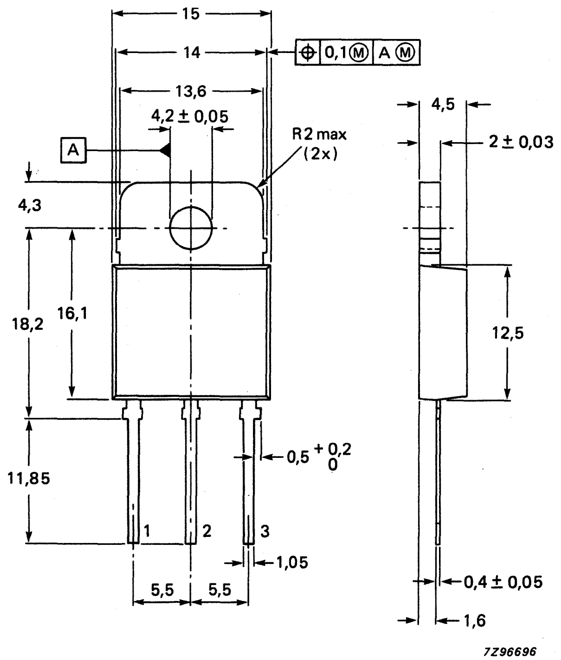
			TIP140	TIP141	TIP142	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max.		15		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125		W
D.C. current gain						
V_{CE} = 4 V; I_C = 5 A	h_{FE}	>		1000		
Collector-emitter saturation voltage						
I_C = 5 A; I_B = 10 mA	V_{CEsat}	<		2,0		V

MECHANICAL DATA

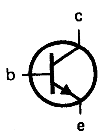
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



Pinning:
1 = base
2 = collector
3 = emitter



CIRCUIT DIAGRAM

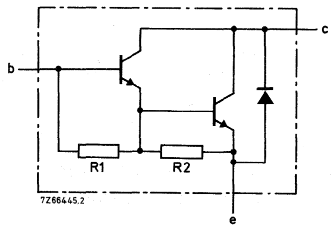


Fig. 2.
R1 typ. 5 kΩ
R2 typ. 80 Ω

RATINGS

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

			TIP140	TIP141	TIP142	
Collector-base voltage (I_E = 0)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (I_B = 0)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (I_C = 0)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value); $t_p \leqslant 0,3$ ms	I_{CM}	max.		15		A
Base current (d.c.)	I_B	max.		0,5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125		W
Total power dissipation in free air	P_{tot}	max.		3,5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	35,7	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off currents					
$V_{CB} = V_{CBOmax}$; $I_E = 0$		I_{CBO}	<	0,4	mA
$V_{CE} = 1/2\ V_{CEOmax}$; $I_B = 0$		I_{CEO}	<	0,2	mA
Emitter cut-off current					
$V_{EB} = 5$ V; $I_C = 0$		I_{EBO}	<	5	mA
Collector-emitter sustaining voltage					
$I_C = 30$ mA; $I_B = 0$	TIP140	$V_{CEOsust}$	>	60	V
	TIP141	$V_{CEOsust}$	>	80	V
	TIP142	$V_{CEOsust}$	>	100	V
D.C. current gain					
$V_{CE} = 4$ V; $I_C = 5$ A		h_{FE}	>	1000	
$V_{CE} = 4$ V; $I_C = 10$ A		h_{FE}	>	500	
Base-emitter voltage					
$V_{CE} = 4$ V; $I_C = 10$ A		V_{BE}	<	3	V
Collector-emitter saturation voltage					
$I_C = 5$ A; $I_B = 10$ mA		V_{CEsat}	<	2	V
$I_C = 10$ A; $I_B = 40$ mA		V_{CEsat}	<	3	V
Switching times (see Figs 3 and 4)					
$I_C = 10$ A; $I_{Bon} = -I_{Boff} = 40$ mA					
$V_{CC} = 30$ V					
turn-on time		t_{on}	typ.	0,9	μs
turn-off time		t_{off}	typ.	11	μs

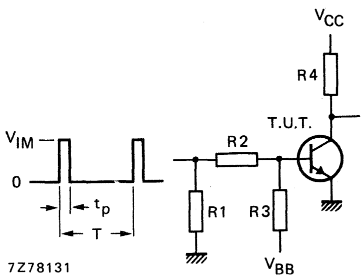


Fig. 3 Switching times test circuit.

$V_{IM} = 33$ V	R1 = 56 Ω	$t_r = t_f = 15$ ns
$V_{CC} = 30$ V	R2 = 410 Ω	$t_p = 10$ μs
$V_{BB} = -4,2$ V	R3 = 150 Ω	T = 500 μs
	R4 = 3 Ω	

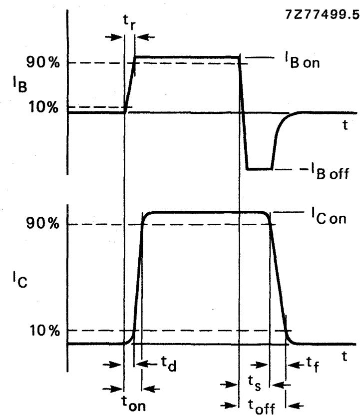


Fig. 4 Waveforms showing t_{on}; $t_s + t_f = t_{off}$.

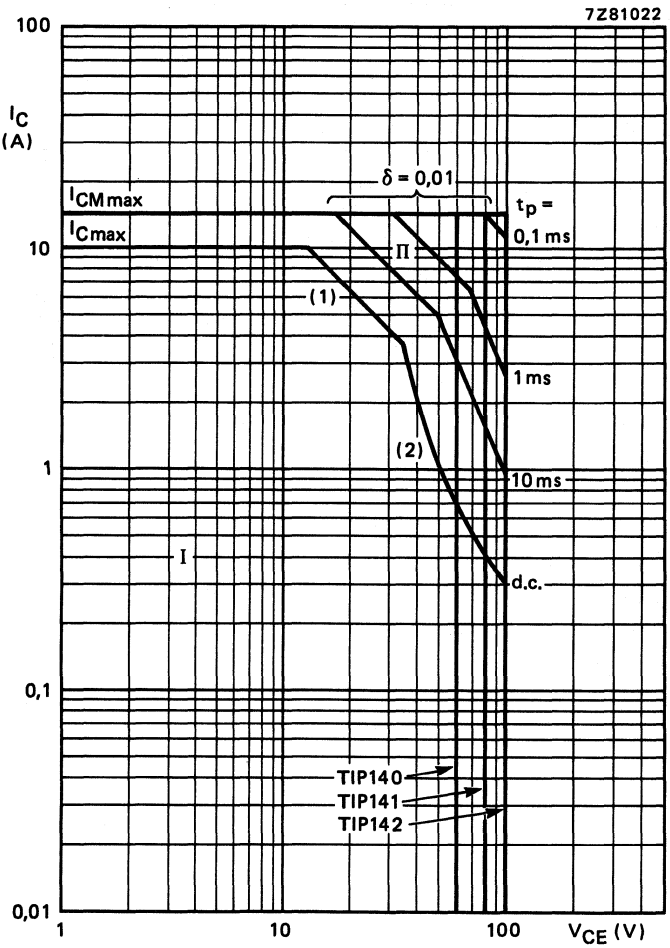


Fig. 5 Safe Operating Area; $T_{mb} \leqslant 25\ ^{o}C$.

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

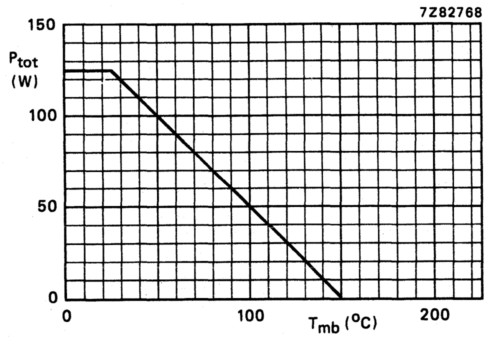


Fig. 6 Power derating curve.

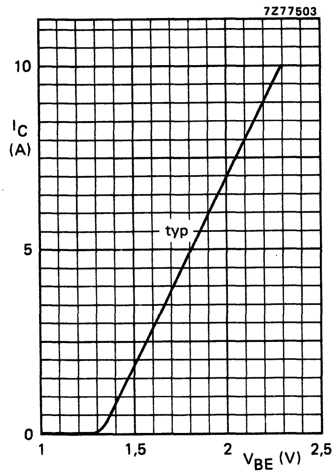


Fig. 7 $V_{CE} = 4$ V; $T_j = 25$ °C.

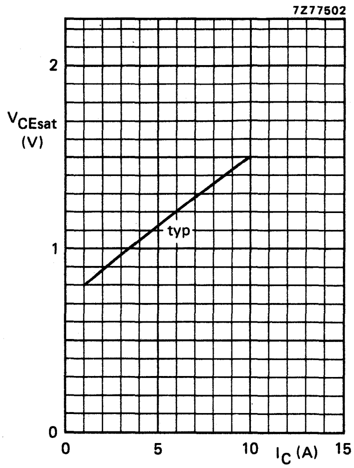


Fig. 8 $I_C/I_B = 250$; $T_j = 25$ °C.

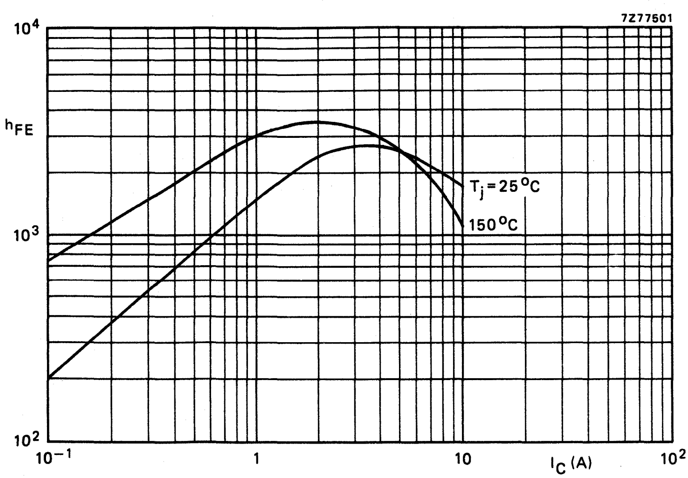


Fig. 9 Typical values; $V_{CE} = 4$ V.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. SOT-93 plastic envelope. N-P-N complements are TIP140, TIP141 and TIP142.

QUICK REFERENCE DATA

			TIP145	TIP146	TIP147	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value); $t_p \leq 0,3$ ms	$-I_{CM}$	max.		15		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		125		W
D.C. current gain						
$-V_{CE} = 4$ V; $-I_C = 5$ A	h_{FE}	>		1000		
Collector-emitter saturation voltage						
$-I_C = 5$ A; $-I_B = 10$ mA	$-V_{CEsat}$	<		2,0		V

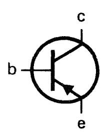
MECHANICAL DATA

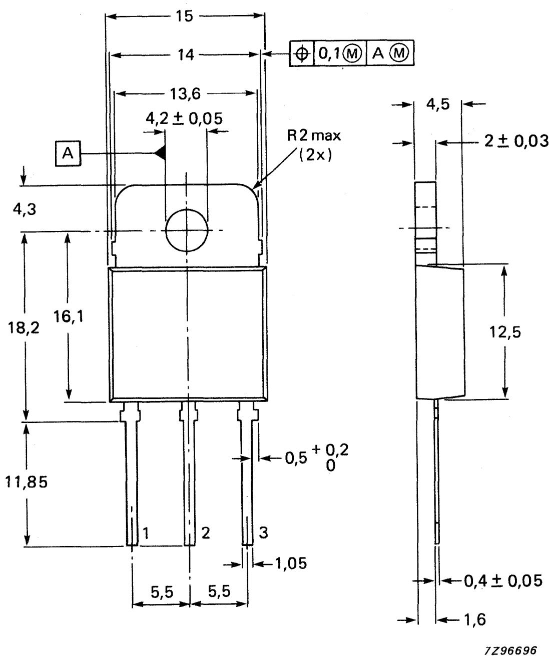
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:
1 = base
2 = collector
3 = emitter





CIRCUIT DIAGRAM

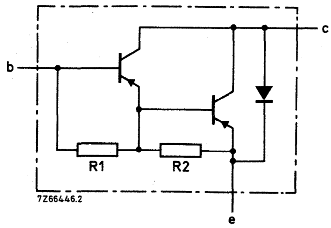


Fig. 2.
R1 typ. 5 kΩ
R2 typ. 80 Ω

RATINGS

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

			TIP145	TIP146	TIP147	
Collector-base voltage ($I_E = 0$)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage ($I_B = 0$)	$-V_{CEO}$	max.	60	80	100	V

Emitter-base voltage ($I_C = 0$)	$-V_{EBO}$	max.	5	V
Collector current (d.c.)	$-I_C$	max.	10	A
Collector current (peak value); $t_p \leqslant 0,3$ ms	$-I_{CM}$	max.	15	A
Base current (d.c.)	$-I_B$	max.	0,5	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	125	W
Total power dissipation up to $T_{amb} = 25$ °C	P_{tot}	max.	3,5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1	K/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	35,7	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents					
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$		$-I_{CBO}$	<	0,4	mA
$-V_{CE}$ = 1/2 V_{CEOmax}; $I_B = 0$		$-I_{CEO}$	<	0,2	mA
Emitter cut-off current					
$-V_{EB}$ = 5 V; $I_C = 0$		$-I_{EBO}$	<	5	mA
Collector-emitter sustaining voltage					
$-I_C$ = 30 mA; $I_B = 0$	TIP145	$-V_{CEOsust}$	>	60	V
	TIP146	$-V_{CEOsust}$	>	80	V
	TIP147	$-V_{CEOsust}$	>	100	V
D.C. current gain					
$-V_{CE}$ = 4 V; $-I_C$ = 5 A		h_{FE}	>	1000	
$-V_{CE}$ = 4 V; $-I_C$ = 10 A		h_{FE}	>	500	
Base-emitter voltage					
$-V_{CE}$ = 4 V; $-I_C$ = 10 A		$-V_{BE}$	<	3	V
Collector-emitter saturation voltage					
$-I_C$ = 5 A; $-I_B$ = 10 mA		$-V_{CEsat}$	<	2	V
$-I_C$ = 10 A; $-I_B$ = 40 mA		$-V_{CEsat}$	<	3	V
Switching times (see Figs 3 and 4)					
$-I_C$ = 10 A; $-I_{Bon} = I_{Boff}$ = 40 mA					
$-V_{CC}$ = 30 V					
turn-on time		t_{on}	typ.	0,9	μs
turn-off time		t_{off}	typ.	11	μs

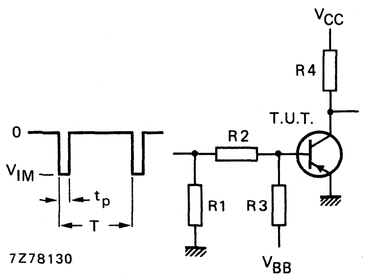


Fig. 3 Switching times test circuit.

$-V_{IM}$ = 33 V; $-V_{CC}$ = 30 V; V_{BB} = 4,2 V

R1 = 56 Ω; R2 = 410 Ω; R3 = 150 Ω; R4 = 3 Ω

$t_r = t_f$ = 15 ns; t_p = 10 μs; T = 500 μs

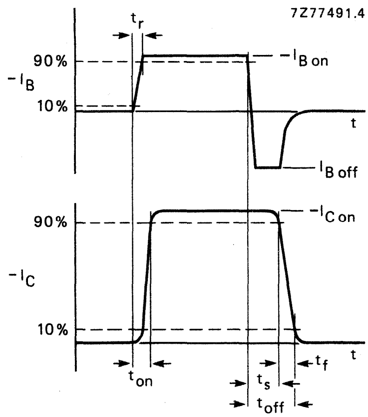


Fig. 4 Switching times waveforms.

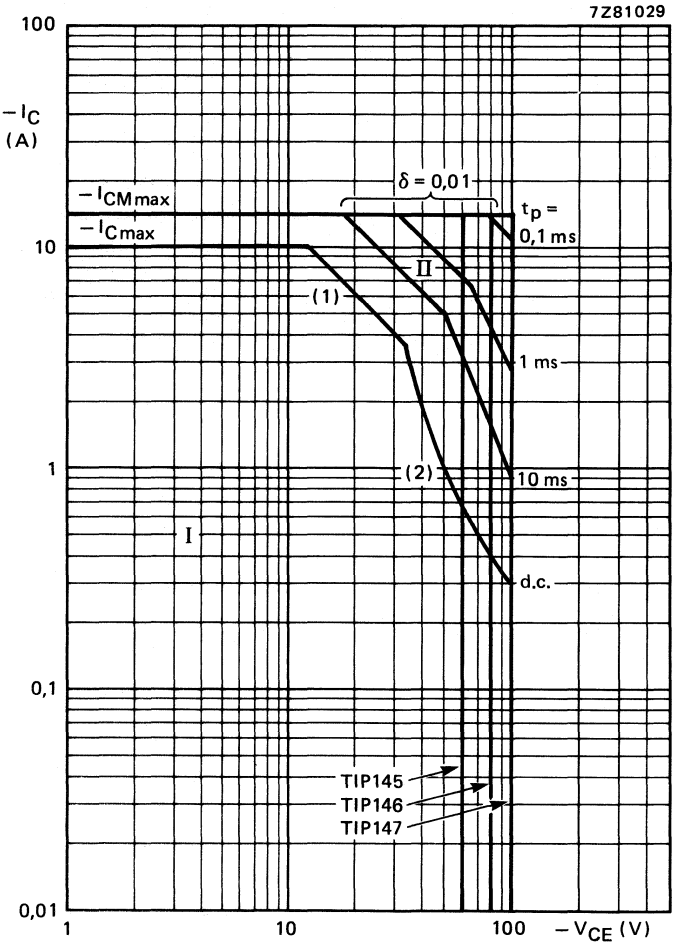


Fig. 5 Safe Operating Area; $T_{mb} \leqslant 25\ ^{o}C$.

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

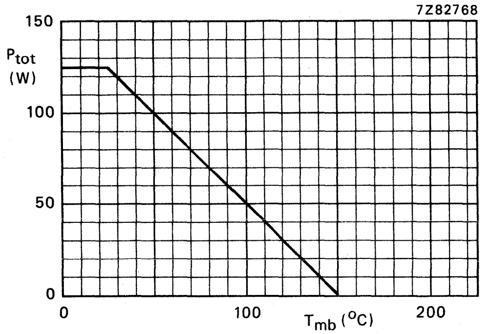


Fig. 6 Power derating curve.

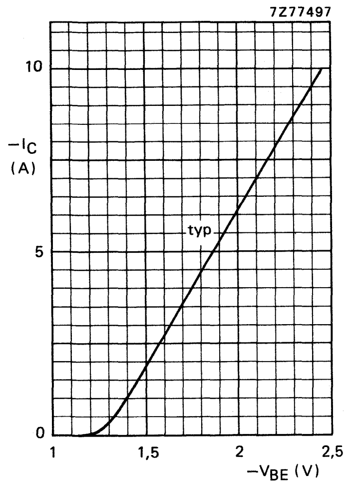


Fig. 7 $-V_{CE} = 4$ V; $T_j = 25$ °C.

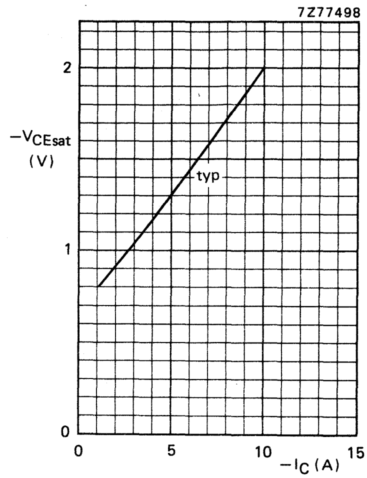


Fig. 8 $-I_C/I_B = 250$; $T_j = 25$ °C.

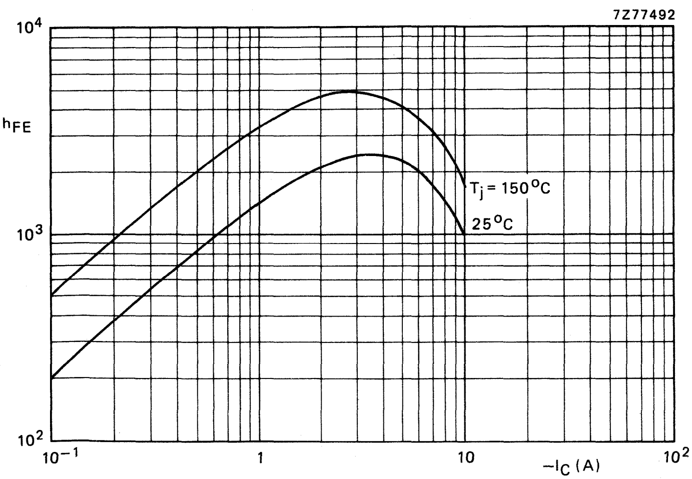


Fig. 9 Typical values; $-V_{CE} = 4$ V.

SILICON POWER TRANSISTOR

P-N-P epitaxial-base power transistor in a plastic SOT-93 envelope, for use in audio output stages and general amplifier and switching applications. N-P-N complement is TIP3055.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100 V
Collector-emitter voltage ($R_{BE} \leqslant 100\ \Omega$)	$-V_{CER}$	max.	70 V
Collector current (d.c.)	$-I_C$	max.	15 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100 W
D.C. current gain			
$-V_{CE}$ = 4 V; $-I_C$ = 4 A	h_{FE}		20 – 70
Collector-emitter saturation voltage			
$-I_C$ = 4 A; $-I_B$ = 0,4 A	$-V_{CEsat}$	<	1,1 V
Transition frequency			
$-V_{CE}$ = 10 V; $-I_C$ = 0,5 A; f = 1 MHz	f_T	>	3 MHz

MECHANICAL DATA

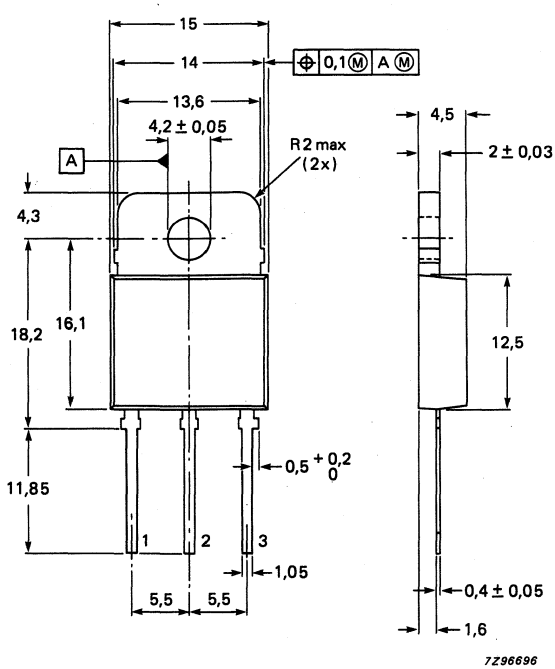
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning

1 = base
2 = collector
3 = emitter



RATINGS

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

Collector-base voltage (I_E = 0)	$-V_{CBO}$	max.	100 V
Collector-emitter voltage ($R_{BE} \leq 100\ \Omega$)	$-V_{CER}$	max.	70 V
Collector-emitter voltage (I_B = 0)	$-V_{CEO}$	max.	60 V
Emitter-base voltage (I_C = 0)	$-V_{EBO}$	max.	7 V
Collector current (d.c.)	$-I_C$	max.	15 A
Base current (d.c.)	$-I_B$	max.	7 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100 W
Total power dissipation in free air	P_{tot}	max.	3,5 W
Storage temperature	T_{stg}	−65 to + 150 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,25 K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	35,7 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents			
$-V_{CE}$ = 100 V; + V_{BE} = 1,5 V	$-I_{CEX}$	<	5 mA
$-V_{CE}$ = 30 V; I_B = 0	$-I_{CEO}$	<	0,7 mA
Emitter cut-off current			
$-V_{EB}$ = 7 V; I_C = 0	$-I_{EBO}$	<	5 mA
Collector-emitter sustaining voltage			
$-I_C$ = 30 mA; I_B = 0	$-V_{CEOsust}$	>	60 V
D.C. current gain			
$-V_{CE}$ = 4 V; $-I_C$ = 4 A	h_{FE}		20 – 70
$-V_{CE}$ = 4 V; $-I_C$ = 10 A	h_{FE}	>	5
Base-emitter voltage			
$-V_{CE}$ = 4 V; $-I_C$ = 4 A	$-V_{BE}$	<	1,8 V
Collector-emitter saturation voltage			
$-I_C$ = 4 A; $-I_B$ = 0,4 A	$-V_{CEsat}$	<	1,1 V
$-I_C$ = 10 A; $-I_B$ = 3,3 A	$-V_{CEsat}$	<	3,0 V
Small-signal current gain			
$-V_{CE}$ = 10 V; $-I_C$ = 0,5 A; f = 1 kHz	h_{fe}	>	20
Transition frequency			
$-V_{CE}$ = 10 V; $-I_C$ = 0,5 A; f = 1 MHz	f_T	>	3 MHz

Unclamped inductive load energy			
$L = 20$ mH; $-I_C = 2,5$ A	$E_{(BR)}$	<	62,5 mJ
Switching times			
$-I_C = 6$ A; $-I_{Bon} = I_{Boff} = 0,6$ A; $-V_{CC} = 30$ V			
turn-on time	t_{on}	typ.	0,4 μs
turn-off time	t_{off}	typ.	0,7 μs

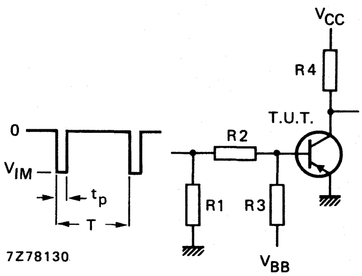


Fig. 2 Switching times test circuit.

$-V_{CC}$ = 30 V
$-V_{IM}$ = 24 V
V_{BB} = 4 V
R1 = 56 Ω
R2 = 24 Ω
R3 = 10 Ω
R4 = 5 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

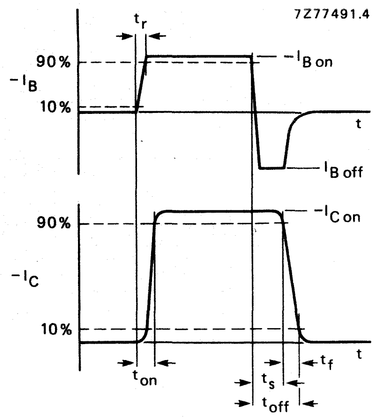


Fig. 3 Switching times waveforms.

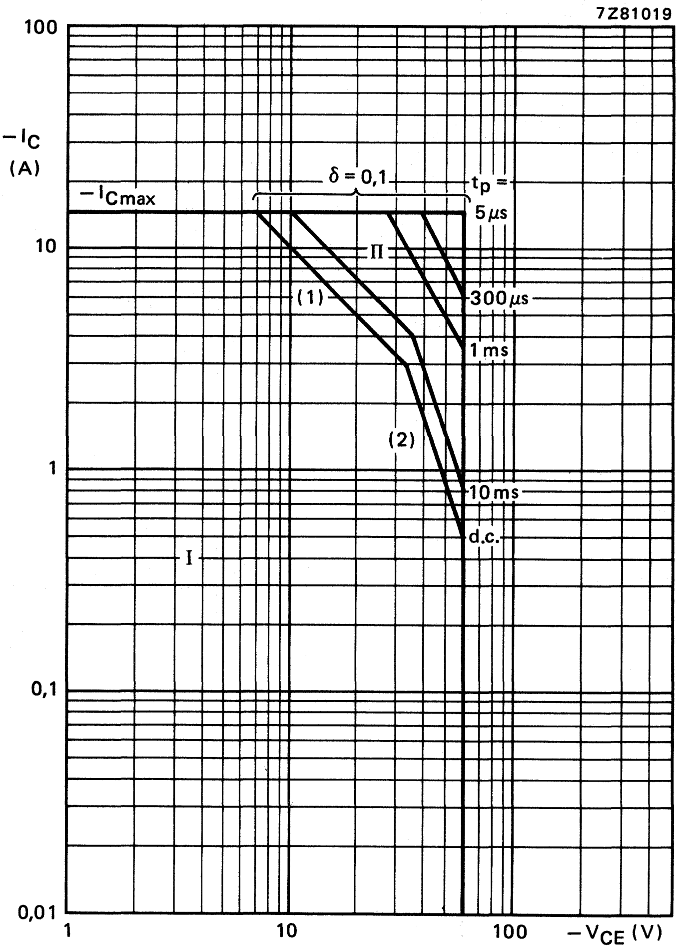


Fig. 4 Safe Operating Area; T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second breakdown limits.

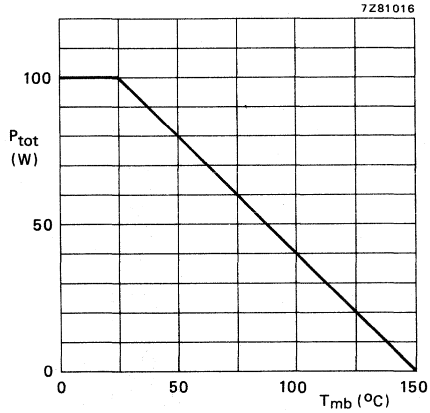


Fig. 5 Power derating curve.

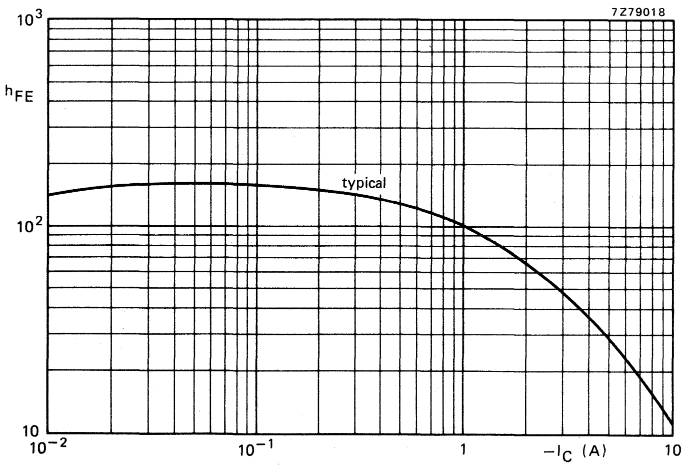


Fig. 6 $-V_{CE} = 4$ V; $T_j = 25$ °C

SILICON EPITAXIAL-BASE POWER TRANSISTOR

P-N-P transistor in a plastic envelope. With its n-p-n complement TIP3055T they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

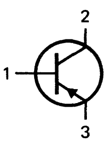
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60 V
Collector current (d.c.)	$-I_C$	max.	10 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	75 W
Transition frequency at f = 1 MHz $-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>	2 MHz

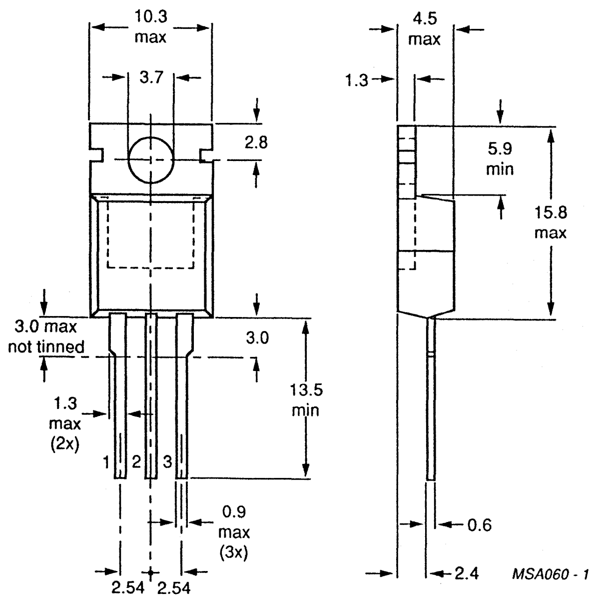
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	70 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.	10 A
Collector current (peak value, $t_p \leq 10$ ms)	$-I_{CM}$	max.	12 A
Base current (d.c.)	$-I_B$	max.	4 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	75 W
Storage temperature	T_{stg}		−65 to + 175 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,67 K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	0,2 mA
$I_E = 0$; $-V_{CB} = 70$ V	$-I_{CBO}$	<	0,1 mA
$I_E = 0$; $-V_{CB} = 70$ V; T_j = 150 °C	$-I_{CBO}$	<	1 mA
$V_{BE} = 1,5$ V; $-V_{CB} = 70$ V	$-I_{CEX}$	<	1 mA
$V_{BE} = 1,5$ V; $-V_{CB} = 70$ V; T_j = 150 °C	$-I_{CEX}$	<	5 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	0,5 mA
Saturation voltages*			
$-I_C = 4$ A; $-I_B = 0,4$ A	$-V_{CEsat}$	<	0,8 V
	$-V_{BEsat}$	<	1,8 V
$-I_C = 10$ A; $-I_B = 3,3$ A	$-V_{CEsat}$	<	4 V
Base-emitter voltage*			
$-I_C = 4$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,8 V
D.C. current gain*			
$-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}		20 to 70
$-I_C = 10$ A; $-V_{CE} = 4$ V	h_{FE}	>	5
Transition frequency at f = 1 MHz			
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	>	2 MHz

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

Switching times

$-I_{Con} = 2$ A; $I_{Bon} = I_{Boff} = 0{,}2$ A

turn-on time	t_{on}	<	1 μs
turn-off time	t_{off}	<	2 μs

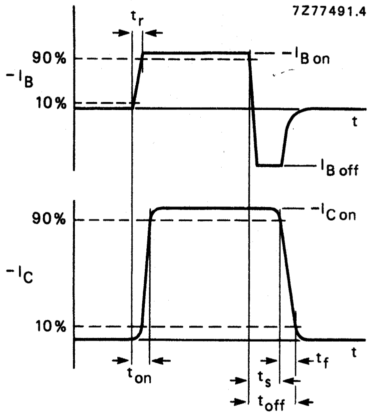


Fig. 2 Switching times waveforms.

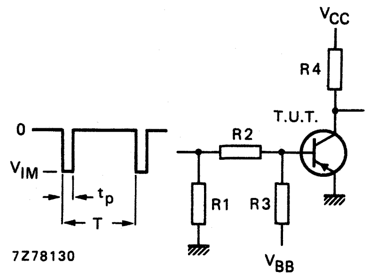


Fig. 3 Switching times test circuit.

$-V_{IM}$	= 15 V	R3	= 22 Ω
$-V_{CC}$	= 20 V	R4	= 10 Ω
$+V_{BB}$	= 4 V	$t_r = t_f$ =	15 ns
R1	= 56 Ω	t_p	= 10 μs
R2	= 33 Ω	T	= 500 μs

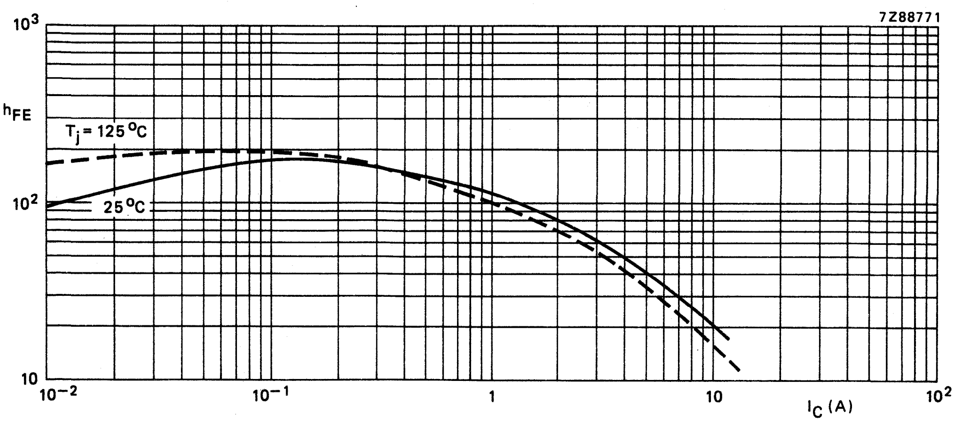


Fig. 4 Typical values d.c. current gain at $-V_{CE} = 2$ V.

DEVELOPMENT DATA

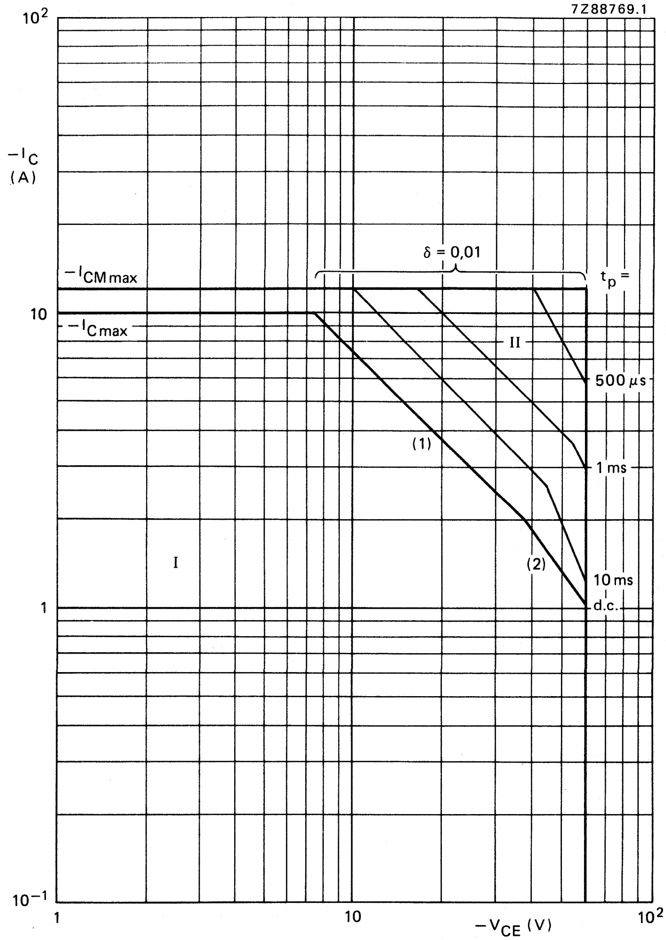


Fig. 5 Safe Operating Area; T_{mb} = 25 °C.

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

SILICON POWER TRANSISTOR

N-P-N epitaxial-base power transistor in a plastic SOT-93 envelope for use in audio output stages and general amplifier and switching applications. P-N-P complement is TIP2955.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage ($R_{BE} \leqslant 100\ \Omega$)	V_{CER}	max.	70	V
Collector current (d.c.)	I_C	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100	W
D.C. current gain				
V_{CE} = 4 V; I_C = 4 A	h_{FE}		20 to 70	
Collector-emitter saturation voltage				
I_C = 4 A; I_B = 0,4 A	V_{CEsat}	<	1,1	V
Transition frequency				
V_{CE} = 10 V; I_C = 0,5 A; f = 1 MHz	f_T	>	3	MHz

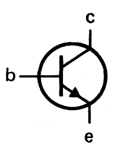
MECHANICAL DATA

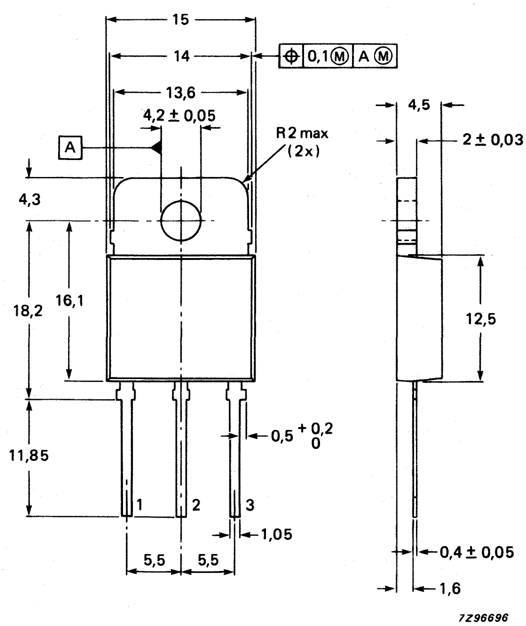
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning
1 = base
2 = collector
3 = emitter





RATINGS

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

Collector-base voltage ($I_E = 0$)	V_{CBO}	max.	100 V
Collector-emitter voltage ($R_{BE} \leqslant 100\ \Omega$)	V_{CER}	max.	70 V
Collector-emitter voltage ($I_B = 0$)	V_{CEO}	max.	60 V
Emitter-base voltage ($I_C = 0$)	V_{EBO}	max.	7 V
Collector current (d.c.)	I_C	max.	15 A
Base current (d.c.)	I_B	max.	7 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100 W
Total power dissipation in free air	P_{tot}	max.	3,5 W
Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,25 K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	35,7 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents			
V_{CE} = 100 V; $-V_{BE}$ = 1,5 V	I_{CEX}	<	5 mA
V_{CE} = 30 V; I_B = 0	I_{CEO}	<	0,7 mA
Emitter cut-off current			
V_{EB} = 7 V; I_C = 0	I_{EBO}	<	5 mA
Collector-emitter sustaining voltage			
I_C = 30 mA; I_B = 0	$V_{CEOsust}$	>	60 V
D.C. current gain			
V_{CE} = 4 V; I_C = 4 A	h_{FE}		20 to 70
V_{CE} = 4 V; I_C = 10 A	h_{FE}	>	5
Base-emitter voltage			
V_{CE} = 4 V; I_C = 4 A	V_{BE}	<	1,8 V
Collector-emitter saturation voltage			
I_C = 4 A; I_B = 0,4 A	V_{CEsat}	<	1,1 V
I_C = 10 A; I_B = 3,3 A	V_{CEsat}	<	3,0 V
Small-signal current gain			
V_{CE} = 10 V; I_C = 0,5 A; f = 1 kHz	h_{fe}	>	20
Transition frequency			
V_{CE} = 10 V; I_C = 0,5 A; f = 1 MHz	f_T	>	3 MHz

Unclamped inductive load energy			
$L = 20$ mH; $I_C = 2{,}5$ A	$E_{(BR)}$	>	62,5 mJ
Switching times (see Figs 2 and 3)			
$I_C = 6$ A; $I_{Bon} = -I_{Boff} = 0{,}6$ A; $V_{CC} = 30$ V			
turn-on time	t_{on}	typ.	0,6 μs
turn-off time	t_{off}	typ.	1,0 μs

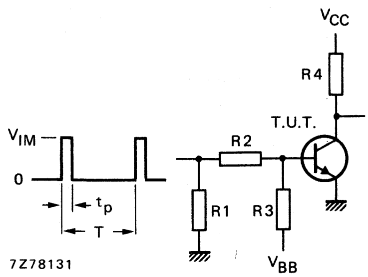


Fig. 2 Switching times test circuit.

V_{CC} = 30 V
V_{IM} = 24 V
V_{BB} = −4 V
R1 = 56 Ω
R2 = 24 Ω
R3 = 10 Ω
R4 = 5 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

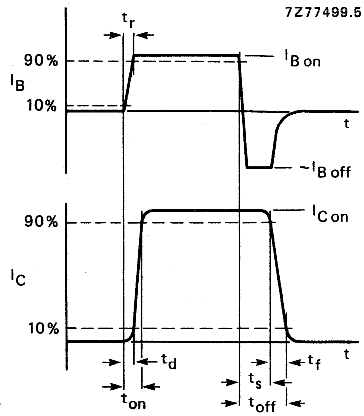


Fig. 3 Switching times waveforms.

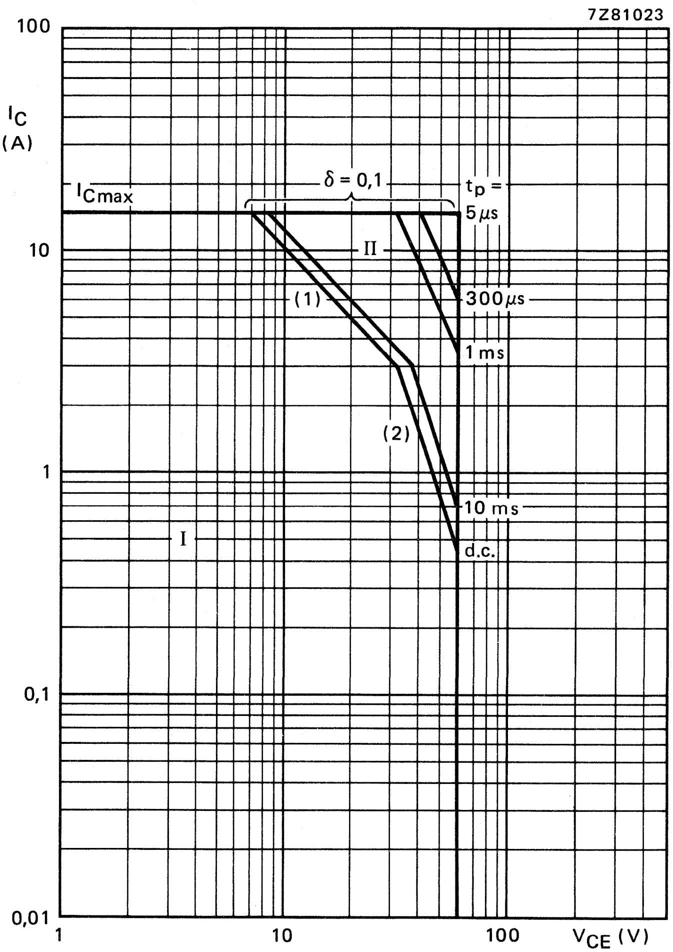


Fig. 4 Safe Operating Area ; T_{mb} = 25 °C.

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

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second breakdown limits

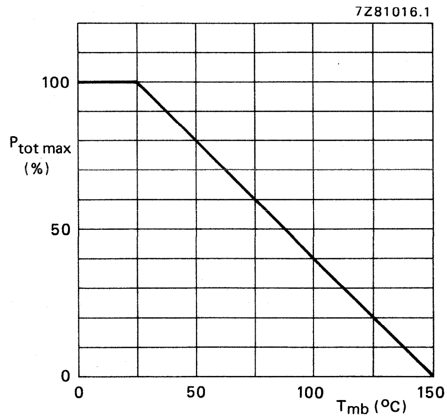


Fig. 5 Power derating curve.

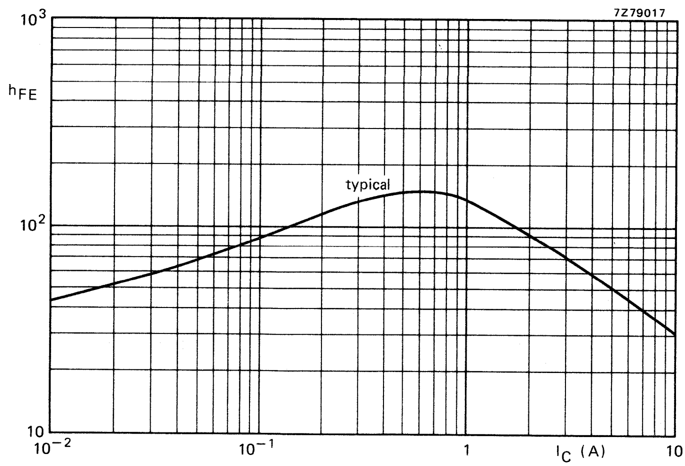


Fig. 6 V_{CE} = 4 V; T_j = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

N-P-N transistor in a plastic envelope. With its p-n-p complement TIP2955T they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

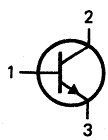
Collector-emitter voltage (open base)	V_{CEO}	max.	60 V
Collector current (d.c.)	I_C	max.	10 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	75 W
Transition frequency at f = 1 MHz I_C = 0,5 A; V_{CE} = 10 V	f_T	>	2 MHz

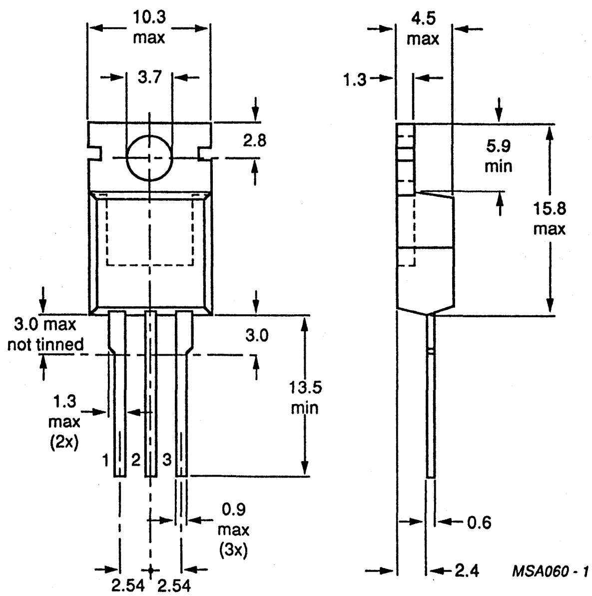
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	70 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.	10 A
Collector current (peak value, $t_p \leq 10$ ms)	I_{CM}	max.	12 A
Base current (d.c.)	I_B	max.	4 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	75 W
Storage temperature	T_{stg}	−65 to + 175 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,67 K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,2 mA
$I_E = 0$; $V_{CB} = 70$ V	I_{CBO}	<	0,1 mA
$I_E = 0$; $V_{CB} = 70$ V; $T_j = 150$ °C	I_{CBO}	<	1 mA
$V_{CE} = 70$ V; $V_{BE} = -1,5$ V	I_{CEX}	<	1 mA
$V_{CE} = 70$ V; $V_{BE} = -1,5$ V; $T_j = 150$ °C	I_{CEX}	<	5 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	0,5 mA
Base-emitter voltage*			
$I_C = 4$ A; $V_{CE} = 4$ V	V_{BE}	<	1,8 V
Saturation voltage*			
$I_C = 4$ A; $I_B = 0,4$ A	V_{CEsat}	<	0,8 V
	V_{BEsat}	<	1,8 V
$I_C = 10$ A; $I_B = 3,3$ A	V_{CEsat}	<	4 V
D.C. current gain*			
$I_C = 4$ A; $V_{CE} = 4$ V	h_{FE}		20 to 70
$I_C = 10$ A; $V_{CE} = 4$ V	h_{FE}	>	5
Transition frequency at f = 1 MHz			
$I_C = 0,5$ A; $V_{CE} = 10$ V	f_T	>	2 MHz

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

Switching times

$I_{Con} = 2$ A; $I_{Bon} = -I_{Boff} = 0{,}2$ A

Turn-on time	t_{on}	<	1 μs
Turn-off time	t_{off}	<	4 μs

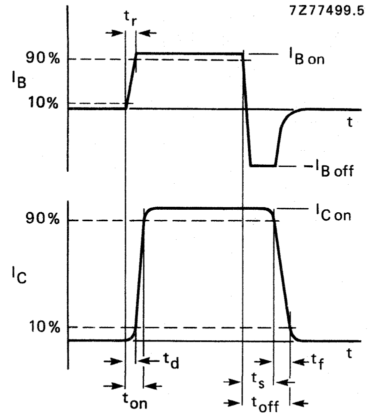


Fig. 2 Switching time waveforms.

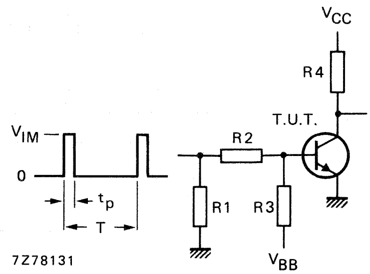


Fig. 3 Switching times test circuit.

$V_{IM} = 15$ V	R3	=	22 Ω
$V_{CC} = 20$ V	R4	=	10 Ω
$V_{BB} = -4$ V	$t_r = t_f \leqslant$		15 ns
R1 = none	t_p		20 μs
R2 = 33 Ω	T	=	500 μs

DEVELOPMENT DATA

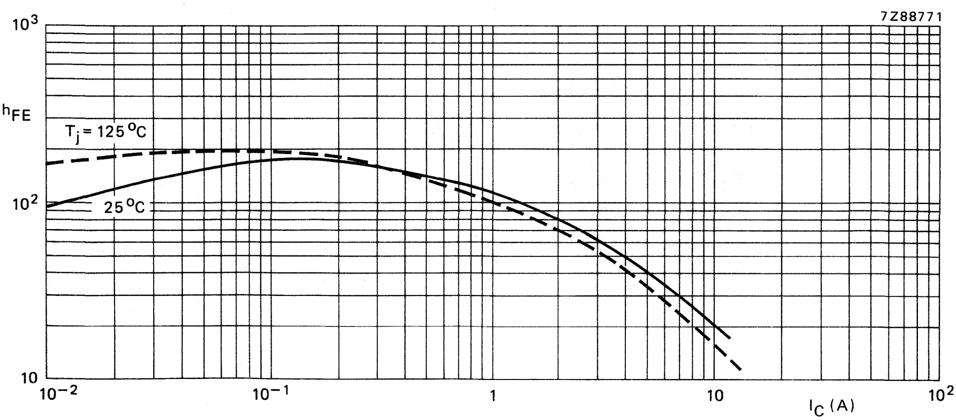


Fig. 4 Typical values d.c. current gain at $V_{CE} = 2$ V.

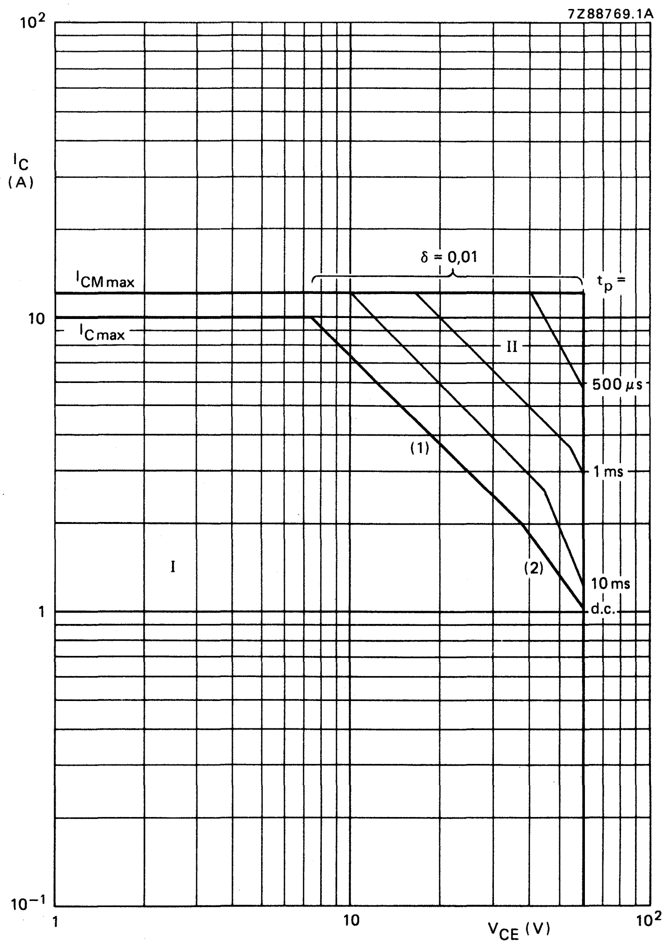


Fig. 5 Safe Operating Area , $T_{mb} \leqslant 25\ ^oC$.

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

HYBRID MODULES

Hybrid integrated circuit hi-fi audio power amplifiers

OM961/OM991

DESCRIPTION

The OM961 and OM991 are thin film hybrid integrated circuit hi-fi audio amplifiers for sinusoidal output power up to 60 W and 120 W respectively. The modules offer maximum design possibilities regarding amplification, ripple rejection, stability for complex loads etc. The amplifiers have built in short-circuit protection (SOAR protected) and are specially designed for low transient and harmonic distortion. All built in resistors are dynamically adjusted for optimum performance over a wide temperature range.

PIN CONFIGURATION

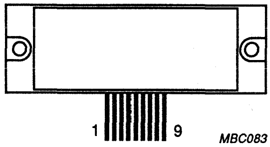


Fig.1 Simplified outline.

PINNING

PIN	DESCRIPTION
1	supply (–)
2	ground
3	output
4	output
5	driver supply (–)
6	non inverting input
7	inverting input
8	boot strap
9	supply (+)

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	UNIT
P_o	sinusoidal output power OM961	$d_{tot} < 0.2\%$; f = 20 Hz to 20 kHz; $R_L = 4\ \Omega$; $V_S = \pm31$ V	60	–	W
		$d_{tot} < 0.2\%$; f = 20 Hz to 20 kHz; $R_L = 8\ \Omega$; $V_S = \pm35$ V	60	–	W
	sinusoidal output power OM991	$d_{tot} < 0.2\%$; f = 20 Hz to 20 kHz; $R_L = 4\ \Omega$; $V_S = \pm45$ V	60	–	W
		$d_{tot} < 0.2\%$; f = 20 Hz to 20 kHz; $R_L = 8\ \Omega$; $V_S = \pm50$ V	60	–	W
d_{tot}	total harmonic distortion	$P_o = 1$ W; f = 1 kHz	–	0.02	%

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_S	symmetrical supply voltage			
	OM961	–	±45	V
	OM991	–	±50	V
T_{stg}	storage temperature range	–30	100	°C
T_{mb}	mounting base operating temperature range	–	95	°C

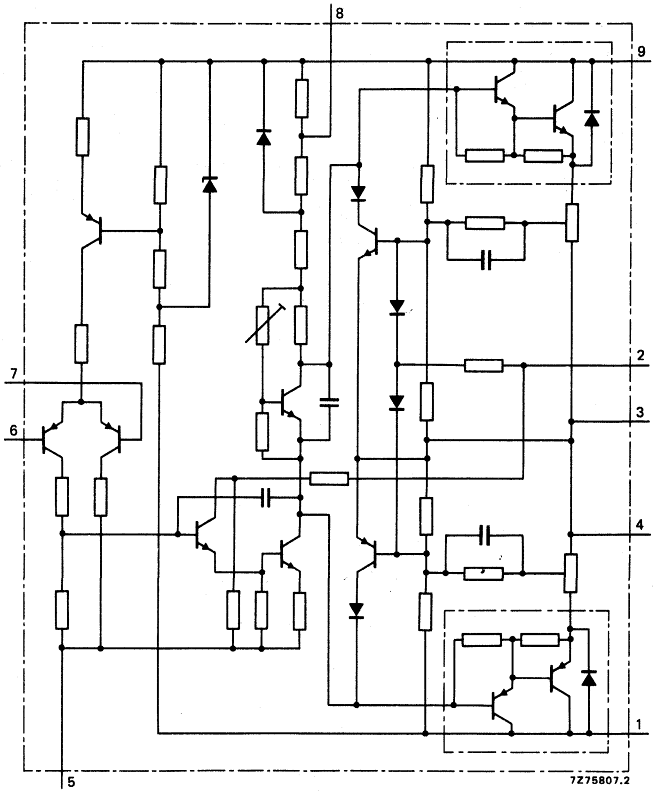


Fig.2 Circuit diagram.

CHARACTERISTICS

Measured in circuit shown in Fig.3; T_{mb} = 25 °C.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_S	symmetrical supply voltage					
	OM961		±31	–	±35	V
	OM991		±40	–	±45	V
I_{tot}	total supply current	zero signal	–	100	–	mA
P_o	sinusoidal output power OM961	d_{tot} < 0.2%; f = 20 Hz to 20 kHz; R_L = 4 Ω; note 1 note 2	60	–	–	W
		d_{tot} < 0.2%; f = 20 Hz to 20 kHz; R_L = 8 Ω note 2	–	–	60	W
	sinusoidal output power OM991	d_{tot} < 0.2%; f = 20 Hz to 20 kHz; R_L = 4 Ω	120	–	–	W
		d_{tot} < 0.2%; f = 20 Hz to 20 kHz; R_L = 8 Ω	–	–	90	W
	clipping level	d_{tot} = 0.7%; f = 1 kHz; R_L = 4 Ω				
	OM961		–	75	–	W
	OM991		100	–	135	W
d_{tot}	total harmonic distortion	P_o = 1 W; f = 1 kHz	–	0.02	–	%
d_{im}	intermodulation distortion	f_1 = 250 Hz; f_2 = 8 kHz amplitude ratio V_{f1}/V_{f2} = 4/1				
		P_o = 1 W	–	0.05	–	%
		P_o = rated value	–	0.1	–	%
V_i	input sensitivity	P_o = rated value				
	OM961		1	–	1.4	V
	OM991		1.4	–	1.7	V
R_i	input impedance	determined by input circuitry	–	10	–	kΩ
G_o	open loop gain		–	80	–	dB

Notes

1. Federal trade commission U.S.A.
2. P_o is stated as rated value.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
G_c	closed loop gain		–	24	–	dB
f	frequency response	P_o = rated value –10 dB (–1 dB)	30	–	40000	Hz
f_p	power bandwidth	–3 dB	20	–	40000	Hz
S/N	signal to noise ratio	wide band; P_o = 50 mW; unweighted	–	75	–	dB
		A-curve; P_o = 50 mW; weighted	–	87	–	dB
V_{off}	DC output offset voltage		–	±20	–	mV
RR	ripple rejection		65	–	–	dB
Z_o	output impedance		–	0.05	–	Ω

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	NOM.	UNIT
$R_{th\ h\text{-}a}$	from heatsink to ambient	heatsink length a = 50 mm (note 1)	1.0	K/W
$R_{th\ h\text{-}a}$	from heatsink to ambient	heatsink length a = 75 mm (note 1)	0.7	K/W
$R_{th\ h\text{-}a}$	from heatsink to ambient	heatsink length a = 100 mm (note 1)	0.6	K/W
$R_{th\ h\text{-}a}$	from heatsink to ambient	heatsink length a = 150 mm (note 1)	0.4	K/W
$R_{th\ mb\text{-}h}$	from mounting base to heatsink	using heatsink compound	0.2	K/W

Note

1. See Fig.5

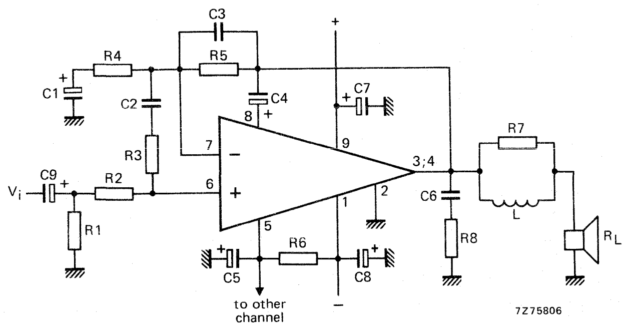


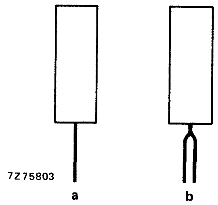
Fig.3 Example of an amplifier with external components.

List of components

COMPONENT	DESCRIPTION	VALUE
R1	0.25 W resistor	10 kΩ
R2	0.25 W resistor	4.7 kΩ
R3	0.25 W resistor	300 Ω
R4	0.25 W resistor	680 Ω
R5	0.25 W resistor	10 kΩ
R6	0.5 W resistor	22 Ω
R7	0.25 W resistor	2.2 Ω
R8	0.5 W resistor	10 Ω
C1	10 V capacitor	47 μF
C2	capacitor (10%)	270 pF
C3	capacitor (10%)	120 pF
C4	100 V capacitor	100 μF
C5	63 V capacitor	470 μF
C6	100 V capacitor	100 nF
C7	63 V capacitor	10 μF
C8	63 V capacitor	10 μF
C9	63 V capacitor	1 μF
L	inductor	4 μH
R_L	load resistance	4 or 8 Ω

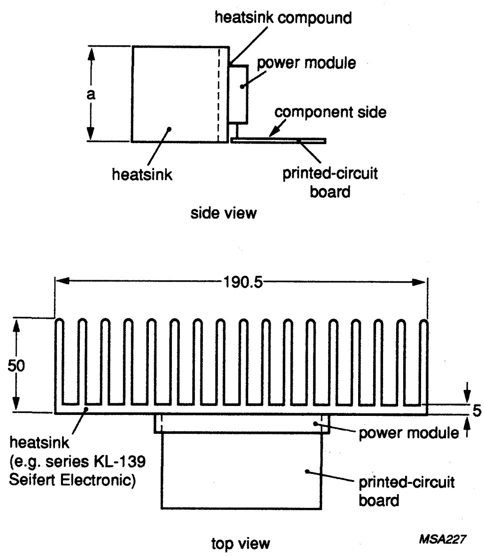
MOUNTING RECOMMENDATIONS

The modules are delivered with SIL (single in-line) leads but may also be bent to ZIL (zig-zag in-line) configuration.



A. Single in-line (SIL) leads.
B. Zig-zag in-line (ZIL) leads.

Fig.4 Lead configuration.



Dimensions in mm

Fig.5 Example of a heatsink to be used for the module.

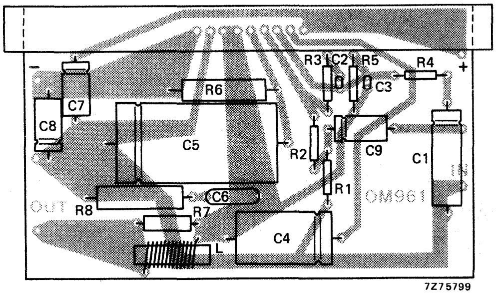


Fig.6 Component side of SIL version showing component layout.

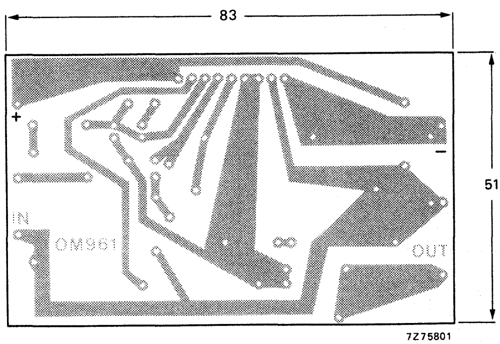
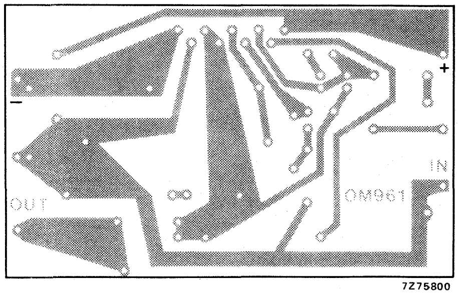


Fig.7 Track side of SIL version.



For component layout see Fig.6.

Fig.8 Component side of ZIL version.

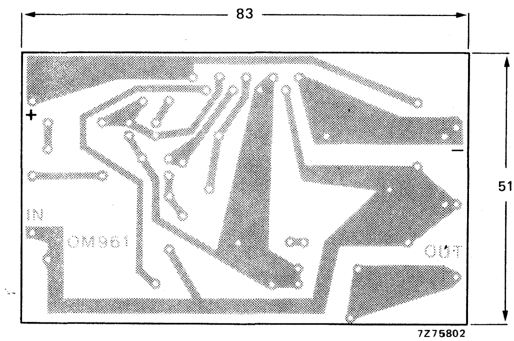
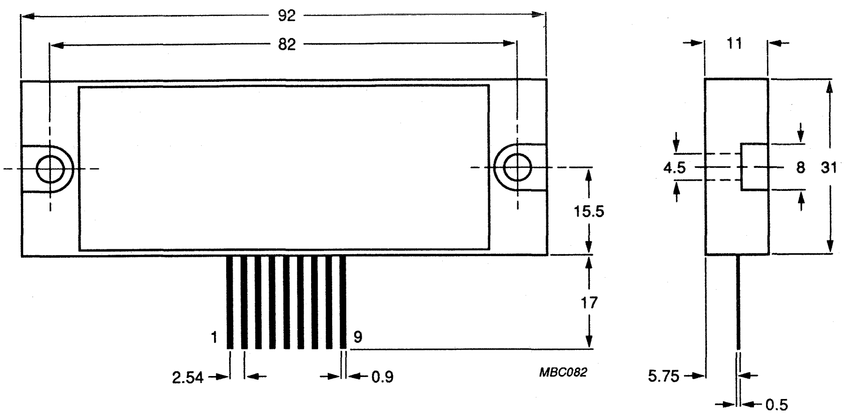


Fig.9 Track side of ZIL version.

PACKAGE OUTLINE



Dimensions in mm.

Fig.10 Encapsulation.

ACCESSORIES

CLIP MOUNTING

ENVELOPE	DIRECT MOUNTING	INSULATED MOUNTING		
	CLIP	MICA	ALUMINA	CLIP
TO-126 (SOT32)	56353	56354		56353
SOT82	56353	56354		56353
TO-220 (SOT78)	56363	56369	56367	56364
SOT186	56363			
SOT93	56379	56378		56379
SOT199	56379			

SCREW MOUNTING

ENVELOPE	DIRECT MOUNTING		INSULATED MOUNTING			
	METAL WASHER	MOUNTING SIZE	MICA WASHER	INSULATED BUSH	METAL WASHER	MOUNTING SIZE
TO-126 (SOT32)	56326	M3				
up to 300 V			56387a	56387b	56326	M2.5
TO-220 (SOT78)	56360a	M3				
up to 800 V			56359b	56359c	56360a	M3
up to 1000 V			56359b	56359d	56360a	M3
SOT186	56360a	M3				
SOT93		M4	56368a	56368b		M3
SOT199		M4				

The accessories included in this section can be supplied on request. Details of their use can be found in the chapter entitled 'Mounting Instructions'.

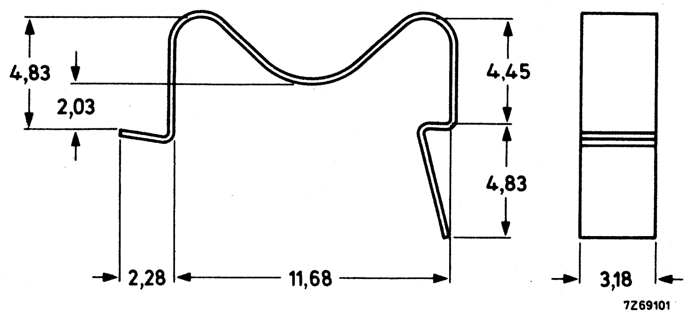
Mounting TO-126 and SOT82 envelopes.

56353 CLIP
for TO-126 and SOT82 envelopes

MECHANICAL DATA

Material: high carbon spring steel

Dimensions in mm

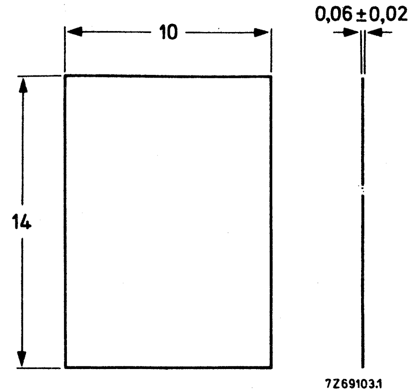


Spring clip suitable for heatsink of 1,5 to 2 mm.

56354 MICA INSULATOR
for TO-126 and SOT82 envelopes

MECHANICAL DATA

Dimensions in mm



Mounting of TO-126 envelopes

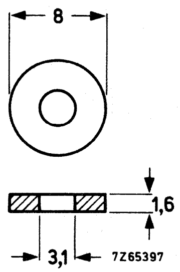
56326 WASHER

for direct mounting of TO-126 envelopes

MECHANICAL DATA

Dimensions in mm

Material: brass, nickel plated

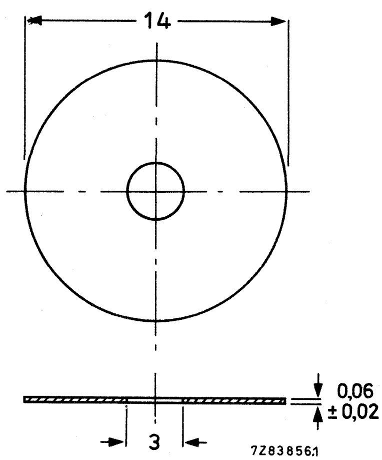


56387a MICA WASHER

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Dimensions in mm



Mounting of TO-126 envelopes

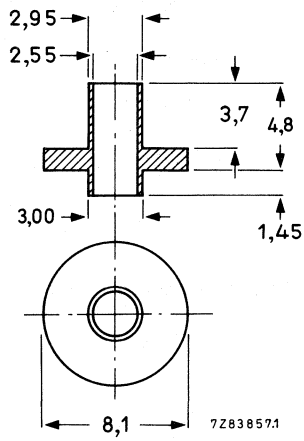
56387b INSULATING BUSH

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature T_{max} 150 °C

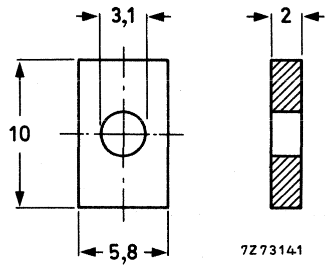
56360a RECTANGULAR WASHER

For direct and insulated mounting.

MECHANICAL DATA

Dimensions in mm

Material: brass; nickel plated.



56363 SPRING CLIP

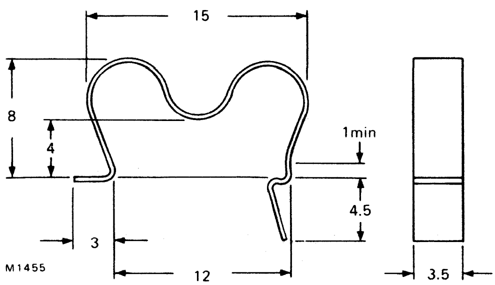
For direct mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 2.0 mm.

Recommended force
of clip on device
is 20 N (2 kgf).



56364 SPRING CLIP

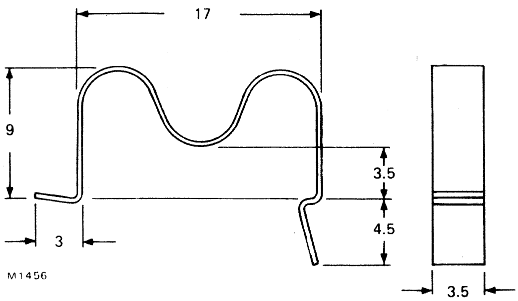
For insulated mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 1.5 mm.

Recommended force
of clip on device
is 20 N (2 kgf).



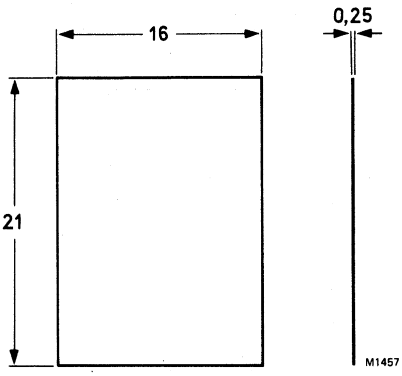
To be used in conjunction with insulators **56367** or **56369**

56367 ALUMINA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm

Material: 96-alumina.

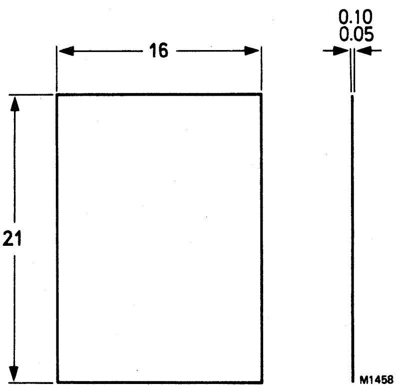


*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

56369 MICA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm

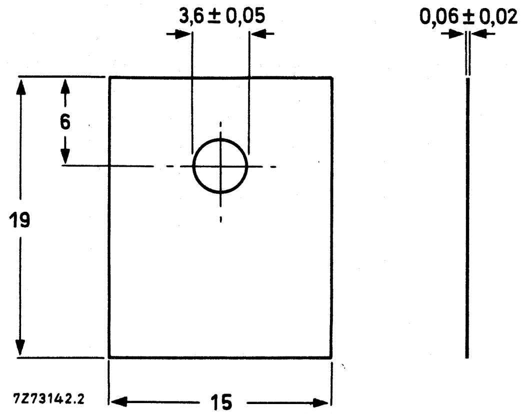


Mounting TO-220 envelopes

56359b MICAWASHER

for TO-220 envelopes (up to 1000 V)

Dimensions in mm



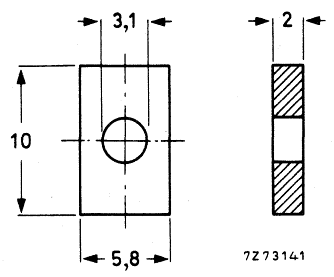
56360a RECTANGULAR WASHER

for direct and insulated mounting of TO-220 envelopes

MECHANICAL DATA

Material: brass; nickel plated.

Dimensions in mm



Mounting TO-220 envelopes

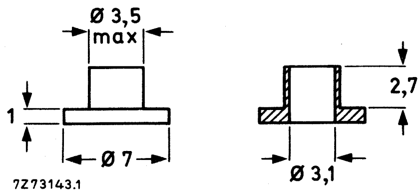
56359c INSULATING BUSH

for TO-220 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

56359d RECTANGULAR INSULATING BUSH

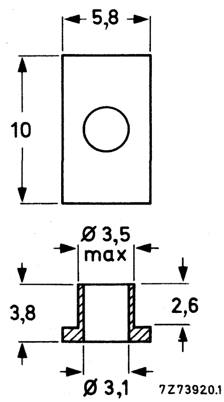
for TO-220 envelopes (up to 1000 V)

MECHANICAL DATA

Dimensions in mm

TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C



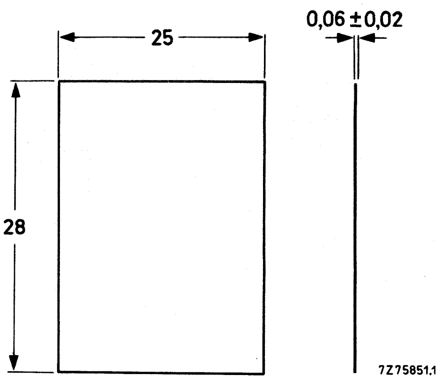
Clip mounting of SOT93 envelopes.

56378 MICA INSULATOR

for SOT93 clip mounting (up to 1500 V)

MECHANICAL DATA

Dimensions in mm



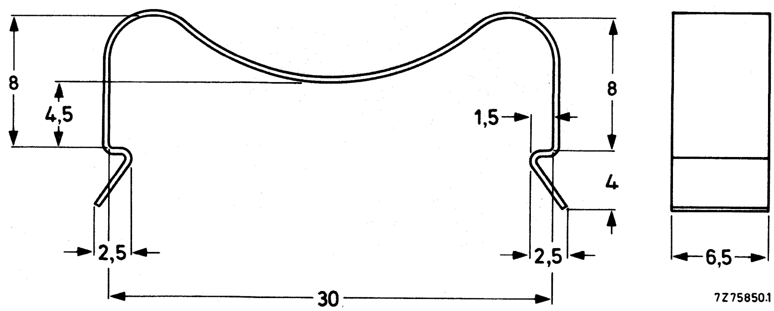
56379 SPRING CLIP

for direct and insulated mounting of SOT93 envelopes

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness 0,4 ± 0,04.



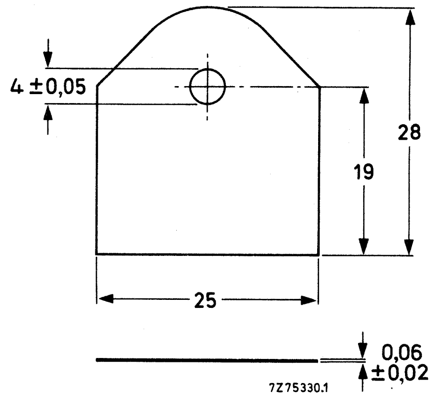
Screw mounting of SOT93 envelopes.

56368a MICA INSULATOR

for insulated screw mounting of SOT93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



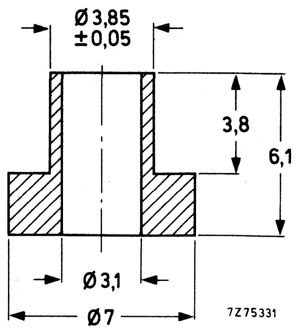
56368b INSULATING BUSH

for insulated screw mounting of SOT93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

MOUNTING INSTRUCTIONS

MOUNTING INSTRUCTIONS
FOR TO-126 AND SOT-82 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the devices to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Heatsink requirements

Minimum thickness: 2 mm.
Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred and should also be perpendicular to the plane of the heatsink, within 10^o tolerance for M2,5 thread and within 2^o tolerance for M3 thread. If the hole in the heatsink is threaded, it should be counter-sunk and free of burrs.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting (TO-126 and SOT-82)

   Mounting by means of spring clip offers:

   a. A good thermal contact under the crystal area.
   b. Safe insulation for mains and high voltage operation

2. M2,5 and M3 screw mounting. (TO-126 only).

   The spacing washer should be inserted between screw head and body.

   Mounting torque for screw mounting:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

   N.B. when the driven nut or screw is in direct contact with a toothed lock washer the torques are as follows:

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

3. Body mounting (SOT-82).

   A SOT-82 envelope can be adhesive mounted or soldered into a hybrid circuit.
   For soldering a copper plate or an anodized aluminium plate with copper layer is recommended.
   When adhesive mounting is applied also a ceramic substrate may be used.

Thermal data

From mounting base to heatsink

	$R_{th\ mb\text{-}h}$ (K/W)			
	clip mounting		screw mounting	
	direct	insulated	direct	insulated
TO-126, with heatsink compound	1,0	3,0	0,5	3,0
TO-126, without heatsink compound	3,0	6,0	1,0	6,0
SOT-82, with heatsink compound	0,4	2,0	–	–
SOT-82, without heatsink compound	2,0	5,0	–	–

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Lead soldering

For devices with a maximum junction temperature ⩽ 150 °C.

a. Dip or wave soldering
   Temperature ⩽ 260 °C at a distance from the body > 5 mm and for a total contact time with soldering bath or waves < 7 s.
b. Hand soldering
   Temperature at a distance from the body > 3 mm for a total contact time < 5 s is < 275 °C or < 250 °C for a total contact time of < 10 s.

The body of the device must be kept clear of anything with a temperature > 200 °C.
Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)
62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.
Maximum soldering temperature ⩽ 200 °C (tab-temperature).
Soldering cycle duration including pre-heating ⩽ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ⩽ 165 °C at a duration ⩽ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56353

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (see Fig. 3).

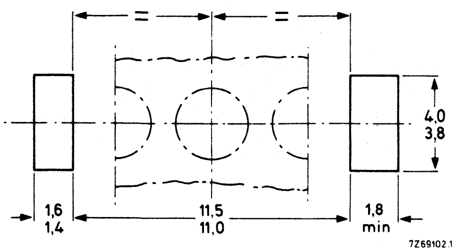


Fig. 1 Heatsink requirements.

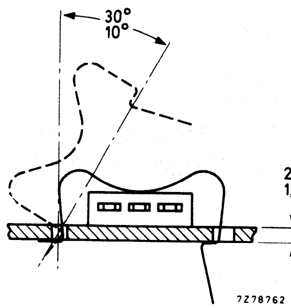


Fig. 2 Mounting spring clip.

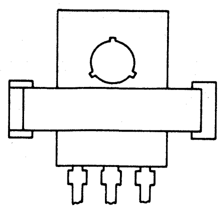


Fig. 3 Position of transistor (top view).

Insulated mounting with clip 56353 and mica 56354 (up to 1000 V insulation)

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 4 and 5).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (Fig. 6). Ensure that the device is centred on the mica insulator to prevent creepage.

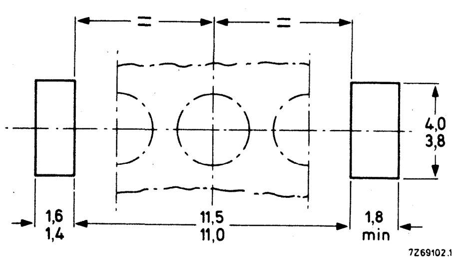


Fig. 4 Heatsink requirements.

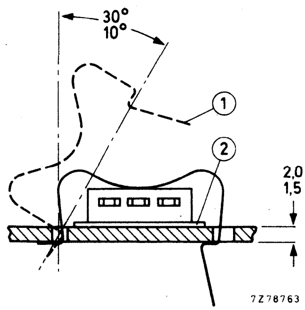


Fig. 5 Mounting.
(1) spring clip 56353.
(2) insulator 56354.

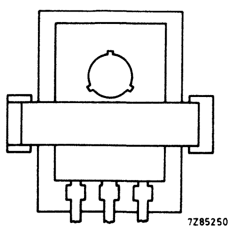


Fig. 6 Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

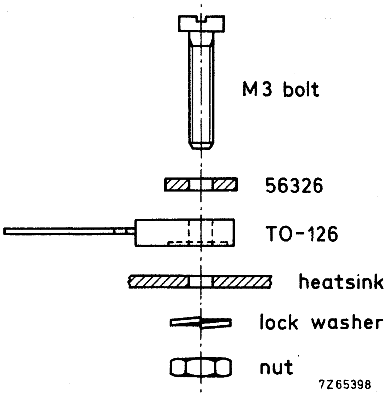


Fig. 7 Assembly through heatsink with nut.

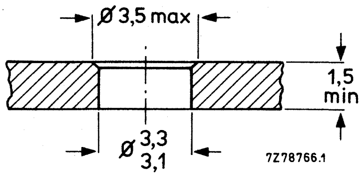


Fig. 8 Heatsink requirements.

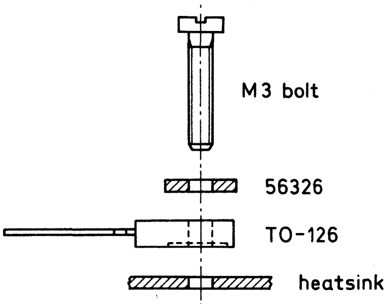


Fig. 9 Assembly into tapped heatsink.

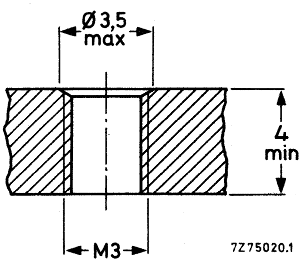


Fig. 10 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56326, 56387a and 56387b (up to 300 V)

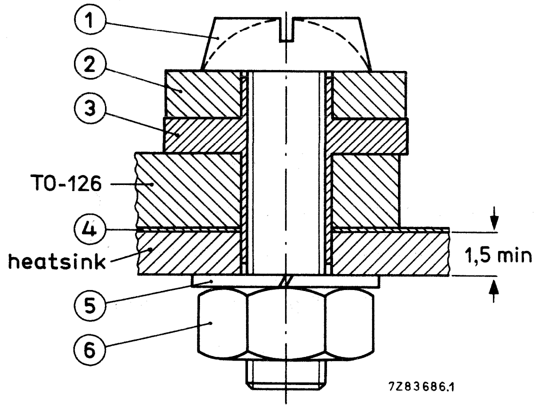


Fig. 15 Assembly through heatsink with nut.

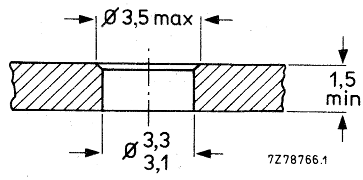


Fig. 16 Heatsink requirements.

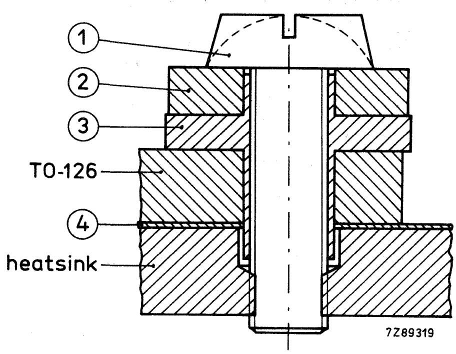


Fig. 17 Assembly with tapped heatsink.

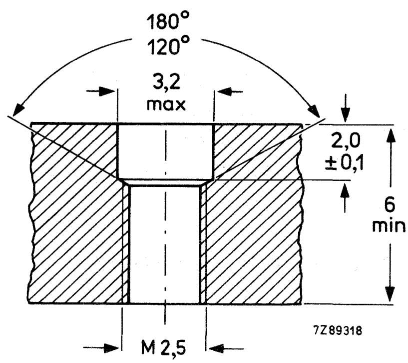


Fig. 18 Heatsink requirements.

Legend

1 M2,5 screw
2 metal washer 56326
3 insulating bush 56387b
4 mica washer 56387 a
5 lock washer
6 M2,5 nut

MOUNTING INSTRUCTIONS FOR TO-220 AND SOT-186 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting

   Mounting with a spring clip gives:

   a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. Safe insulation for mains operation.

2. M3 screw mounting

   It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

   Mounting torque for screw mounting:

   (For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

From mounting base to heatsink			clip mounting	screw mounting	
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	K/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	K/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leqslant 175$ °C, soldering temperature $T_{sld\ max} = 275$ °C.
Devices with $T_{j\ max} \leqslant 110$ °C, soldering temperature $T_{sld\ max} = 240$ °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)
62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.
Maximum soldering temperature ⩽ 200 °C (tab-temperature).
Soldering cycle duration including pre-heating ⩽ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ⩽ 165 °C at a duration ⩽ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the transistor on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

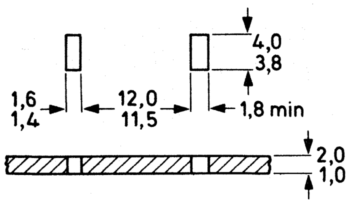


Fig. 1 Heatsink requirements.

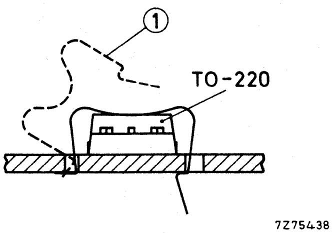


Fig. 2 Mounting.
(1) spring clip 56363.

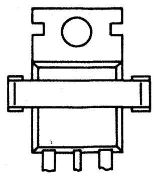


Fig. 2a Position of transistor (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Apply heatsink compound to the bottom of both transistor and insulator, then place the transistor with the insulator on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.

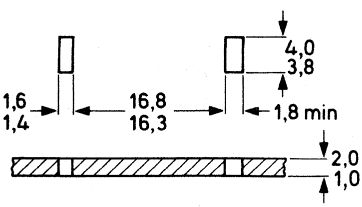


Fig. 3 Heatsink requirements.

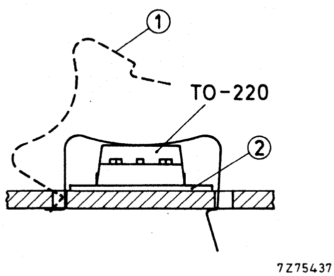


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

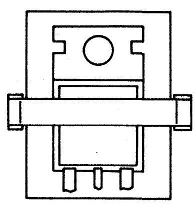


Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

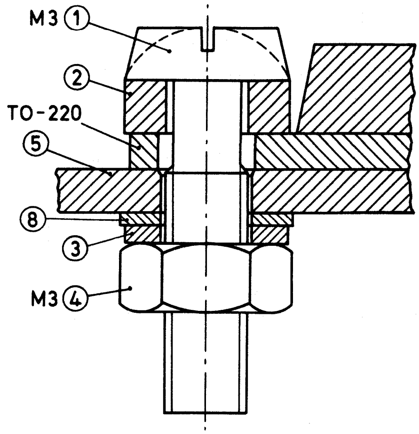


Fig. 5 Assembly.

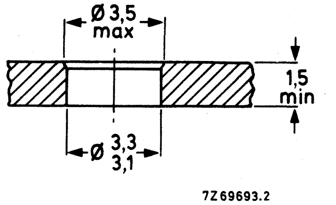


Fig. 6 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer (56360a).
(3) lock washer.
(4) M3 nut.
(5) heatsink.
(8) plain washer.

- *into tapped heatsink*

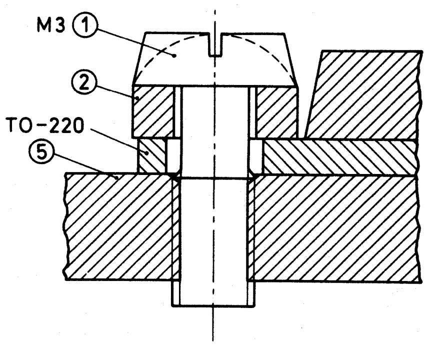


Fig. 7 Assembly.

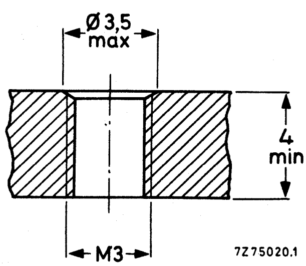


Fig. 8 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer 56360a.
(5) heatsink.

Insulated mounting with screw and spacing washer
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

- *through heatsink with nut*

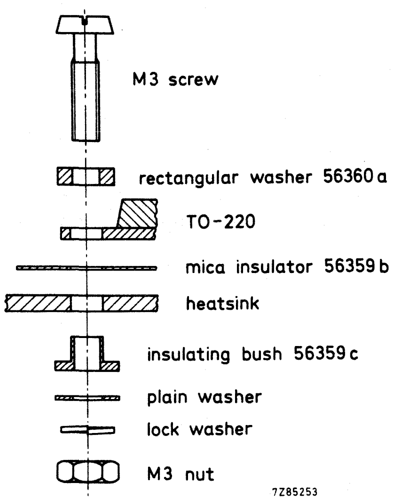


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

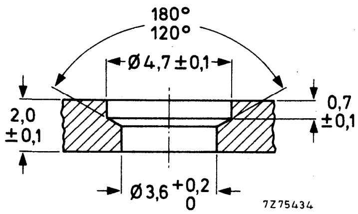


Fig. 10 Heatsink requirements for 500 V insulation.

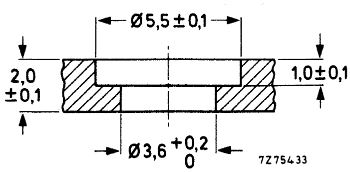


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

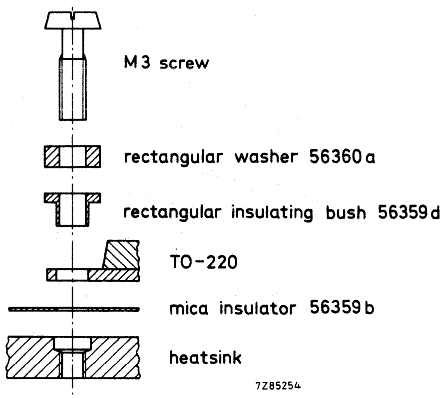


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

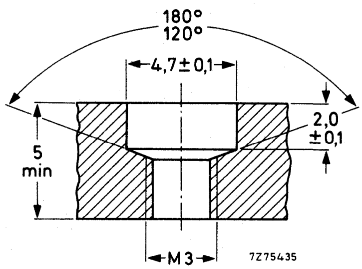


Fig. 13 Heatsink requirements for 500 V insulation.

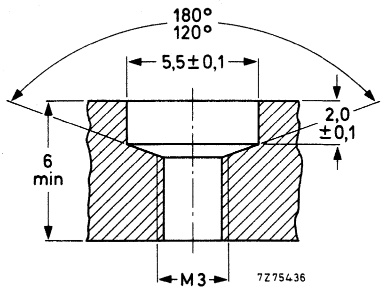


Fig. 14 Heatsink requirements for 1000 V insulation.

Mounting instructions

SOT93; SOT199

GENERAL DATA AND INSTRUCTIONS

General rules

1. Fasten the device to the heatsink before soldering the leads.
2. Avoid stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Mounting methods

CLIP MOUNTING

Mounting with a spring clip gives:

a) A good thermal contact under the crystal area.

b) Safe insulation for mains operation.

MOUNTING TORQUES

For M3 screw (insulated mounting):

Minimum torque for good heat transfer is 0.4 Nm.

Maximum torque to avoid damaging the device is 0.6 Nm.

For M4 screw (direct mounting only):

Minimum torque for good heat transfer is 0.4 Nm.

Maximum torque to avoid damaging the device is 1.0 Nm.

The M4 screw head should not touch the plastic part of the envelope.

RIVET MOUNTING NON-INSULATED

The device should not be pop-rivetted to the heatsink. It is permissible to press-rivet SOT93 providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled.

This method is NOT recommended for F packs because it will damage the plastic encapsulation.

Heatsink requirements

Flatness in the mounting area: 0.02 mm maximum per 10 mm.
Mounting holes must be deburred, for further information see clip and screw mounting instructions.

Heatsink compound

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a metallic oxide compound between the contact surfaces. Values given are of thermal resistance using this type of compound. Dow Corning 340 Heat sink compound is recommended. For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting instructions

SOT93; SOT199

Thermal data for heatsink mounting methods (SOT93 only)

Typical figures, for exact figures see data for each device type.

$R_{th\ mb\text{-}h}$	**Thermal resistance from mounting base to heatsink**	**K/W**	
Mounting method		**clip**	**screw**
direct with heatsink compound		0.3	0.3
direct without heatsink compound		1.5	0.8
with heatsink compound and 0.05 mm maximum mica insulator		0.8	0.8
without heatsink compound and 0.05 mm maximum mica insulator		3.0	2.2

Mica washers are generally not required when mounting the SOT199 F-Pack outline.

Soldering

Recommendations for devices with a maximum junction temperature rating < 175 °C:

DIP OR WAVE SOLDERING

Maximum permissible solder temperature is 260 °C at a distance from the body of > 5 mm and for a total contact time with soldering bath or waves of < 7 s.

HAND SOLDERING

Maximum permissible temperature is 275 °C at a distance from the body of > 3 mm and for a total contact time with the soldering iron of < 5 s.

The body of the device must not touch anything with a temperature > 200 °C.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Lead bending

Maximum permissible tensile force on the body for 5 seconds is 20 N.

The leads can be bent, twisted or straightened. To keep forces within the above mentioned limits the leads should always be clamped rigidly near the body during bending. This is also to prevent damage to the seal of the leads within the plastic body.

Leads can be bent as near to the body as required, but adequate length should always be allowed for clamping. This is a minimum of 1.75 mm from the body to the start of a bend radius.

The internal radius of bend should never be less than the thickness of the lead. A minimum radius of at least 1.5 x lead thickness is preferred. See figure 1 Surface cracks in the dip tin coating on the lead are common when a radius less than 1.5 x lead thickness is used. Although exposing the copper material, these cracks do not affect the mechanical strength of the lead. Lead forming by Philips is available as an option on all products supplied in these outlines.

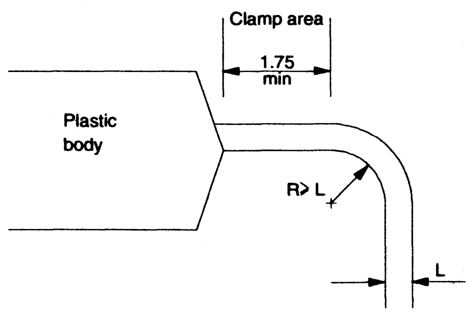


Fig 1. Minimum lead bend radius.

Additional guidelines

It is recommended that where a device is rigidly secured to a heatsink which is in turn rigidly secured to a PCB, that a bend is put in the leads to act as an expansion loop. This will prevent differential expansion of the mounting parts transferring stress to the soldering joint, as shown in figure 2 below. This is only necessary where the device is mounted so rigidly that expansion forces are transmitted through the assembly.

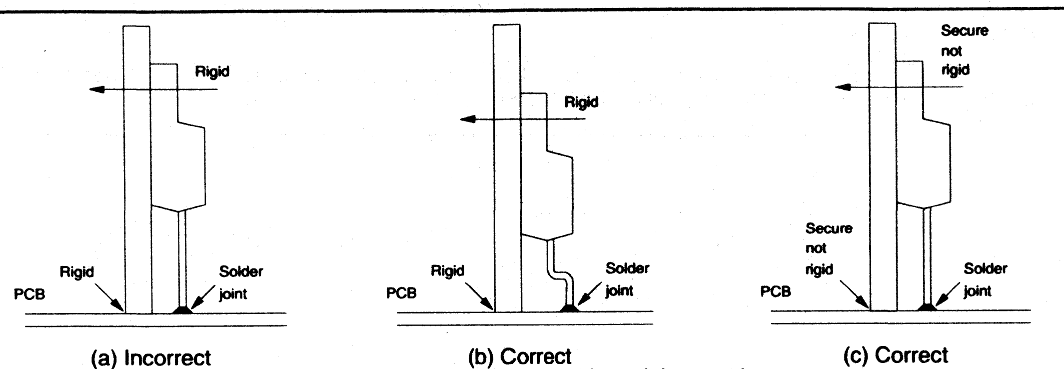


Fig 2. Printed circuit board and heatsink mounting.

Mounting instructions

SOT93; SOT199

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical. See figures 3 and 4.
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. See figure 5.

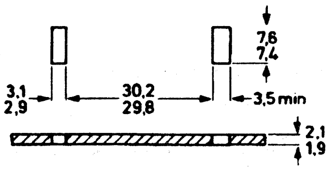


Fig 3. Heatsink requirements

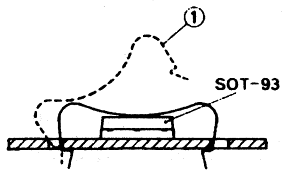


Fig 4. Mounting
(1) spring clip 56379

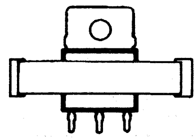


Fig 5. Position of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical. See figures 6, 7 and 8.
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. There should be a minimum of 3 mm distance between the device and the edge of the insulator for adequate creepage distance.

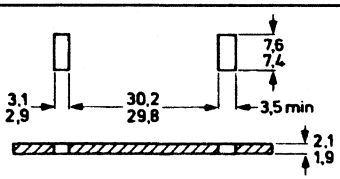


Fig 6. Heatsink requirements

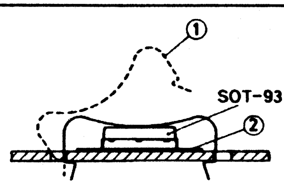


Fig 7. Mounting
(1) spring clip 56379
(2) insulator 56378

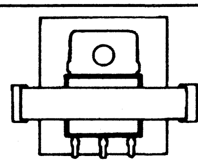


Fig 8. Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting through heatsink with nut

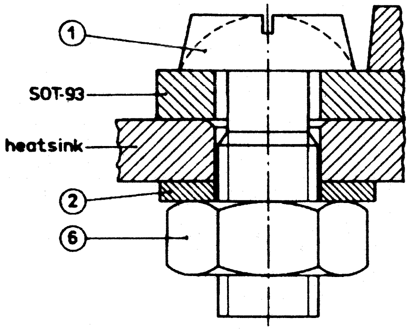


Fig 9. Assembly

(1) M4 screw
(2) plain washer
(6) M4 nut.

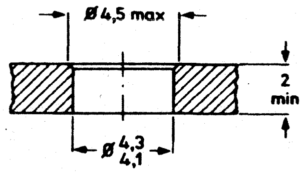


Fig 10. Heatsink requirements

When screw mounting the SOT93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended with a plain washer between aluminium heatsink and spring washer.

Mounting instructions

Insulated screw mounting upto 800V isolation

Axial deviation requirements must be adhered.

THROUGH HEATSINK WITH NUT

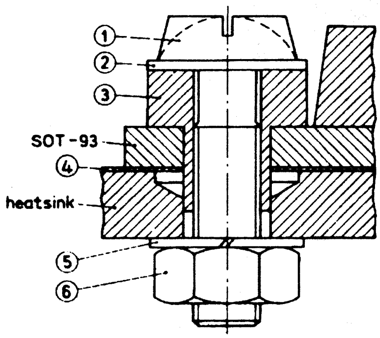


Fig 11. Assembly
(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer
(6) M3 nut

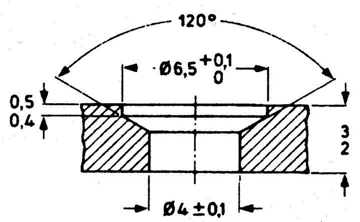


Fig 12. Heatsink requirements up to 800V.

INTO TAPPED HEATSINK

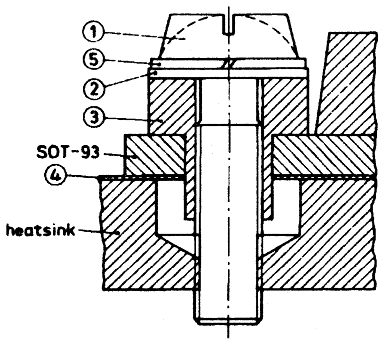


Fig 13. Assembly
(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer

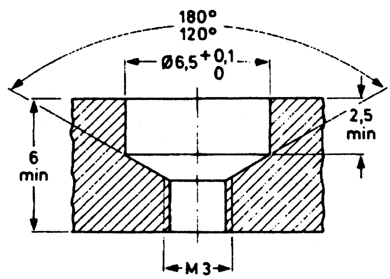


Fig 14. Heatsink requirements up to 800V

Insulated screw mounting with insert nut; up to 500V

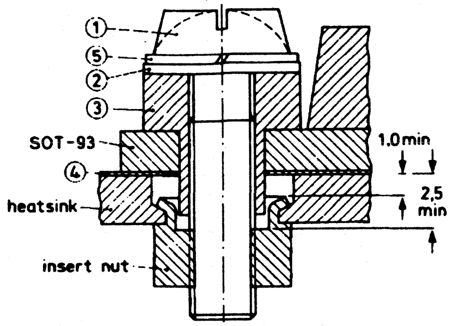


Fig 15. Assembly and heatsink requirements for 500V insulation. See also figures 9 and 10.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer

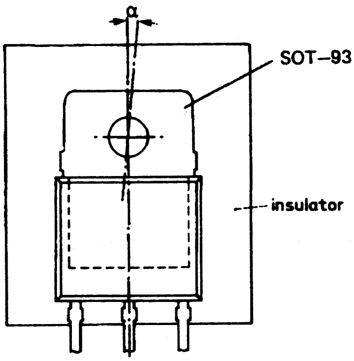


Fig 16. Mica insulator
The axial deviation (α) between package and mica should not exceed 5°

DATA HANDBOOK SYSTEM

Data handbook system

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- DISPLAY COMPONENTS;
- PASSIVE COMPONENTS;
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Catalogues are available for selected product ranges (some catalogues are also on floppy discs).

For more information about data handbooks, catalogues and subscriptions, contact one of the organizations listed on the back cover of this handbook. Product specialists are at your service and enquiries are answered promptly.

INTEGRATED CIRCUITS

IC01	Radio, Audio and Associated Systems Bipolar, MOS
IC02	Video and Associated Systems Bipolar, MOS
IC03	ICs for Telecom Subscriber Sets, Cordless, Mobile and Cellular Telephones, Radio Pagers
IC04	HE4000B Logic Family CMOS
IC05	Advanced Low-power Schottky (ALS) Logic Series
IC06	High-speed CMOS; 74HC/HCT/HCU Logic Family
IC07	Advanced CMOS Logic (ACL)
IC07 supplement: Additional ACL data	

INTEGRATED CIRCUITS (continued)

IC08	10/100k ECL Logic/Memory/PLD
IC09	TTL Logic Series
IC10	Memories MOS, TTL, ECL
IC11	Linear Products
IC12	I²C-bus-compatable ICs
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC15 supplement: Additional FAST data	
IC16	CMOS Integrated Circuits for Clocks and Watches
IC17	ICs for Telecom ISDN
IC18	Microprocessors and Peripherals
IC19	Data Communication Products
IC20	8051-based 8-bit Microcontrollers
IC23	Advanced BiCMOS Interface Logic

DISCRETE SEMICONDUCTORS

SC01	Diodes
SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small Signal Transistors
SC05	Low-frequency Power Transistors and Hybrid IC Power Modules
SC06	High-voltage and Switching Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors
SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC12	Optocouplers
SC13	PowerMOS Transistors
SC14	Wideband Transistors and Wideband Hybrid IC Modules
SC15	Microwave Transistors
SC17	Semiconductor Sensors

Data handbook system

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