

Low-frequency Power
transistors and
Hybrid IC Power Modules

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Philips Components



PHILIPS

**LOW-FREQUENCY POWER TRANSISTORS AND
HYBRID IC POWER MODULES**

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NOTE: For information on high-voltage and switching power transistors see Book SC06.

SELECTION GUIDE

ACCESSORIES

CLIP MOUNTING

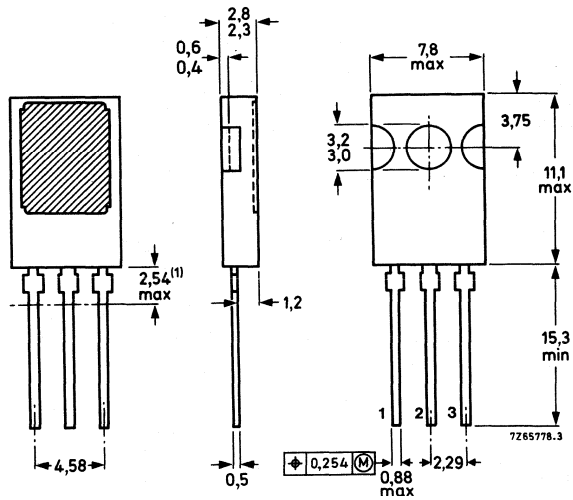
envelope	direct mounting		insulated mounting		
	clip		mica	alumina	clip
TO-126 (SOT32)	56353		56354		56353
SOT82	56353		56354		56353
TO-220 (SOT78)	56363		56369	56367	56364
SOT186	56363				
SOT93	56379		56378		56379
SOT199	56379				

SCREW MOUNTING

envelope	direct mounting		insulated mounting			
	metal washer	mounting size	mica washer	insulated bush	metal washer	mounting size
TO-126 (SOT32) up to 300 V	56326	M3	56387a	56387b	56326	M2,5
TO-220 (SOT78) up to 800 V up to 1000 V	56360a	M3	56359b 56359b	56359c 56359d	56360a 56360a	M3 M3
SOT186	56360a	M3				
SOT93	—	M4	56368a	56368b		M3
SOT199	—	M				
TO-3 (SOT3) up to 500 V	—	M4	56201d	56201j or 56261a		M3
up to 2000 V			56339	56352		M3

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

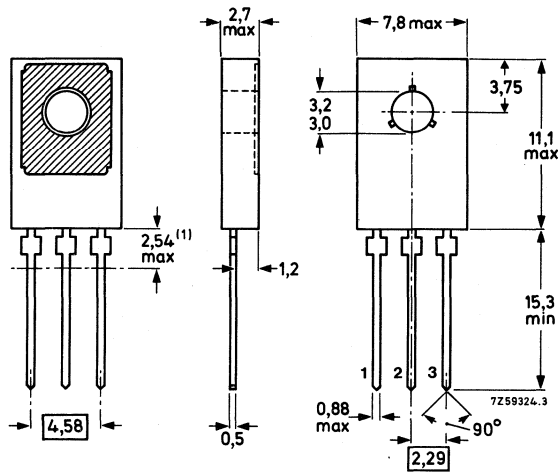
SOT82



type	polarity	I _C (A)	V _{CEO} (V)	V _{CBO} (V)	P _{tot} (W)	page
BD331	npn	6	60	60	60	215
BD332	pnp	6	60	60	60	225
BD333	npn	6	80	80	60	215
BD334	pnp	6	80	80	60	225
BD335	npn	6	100	100	60	215
BD336	pnp	6	100	100	60	225
BD337	npn	6	120	120	60	215
BD338	pnp	6	120	120	60	225

SELECTION GUIDE

TO-126



type	polarity	I _C (A)	V _{CEO} (V)	V _{CB0} (V)	P _{tot} (W)	page
BDX42	npn	1	45*	60	1.25	705
BDX45	pnp	1	45*	60	1.25	713
BDX43	npn	1	60*	80	1.25	705
BDX46	pnp	1	60*	80	1.25	713
BDX44	npn	1	80*	90	1.25	705
BDX47	pnp	1	80*	90	1.25	713
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	199

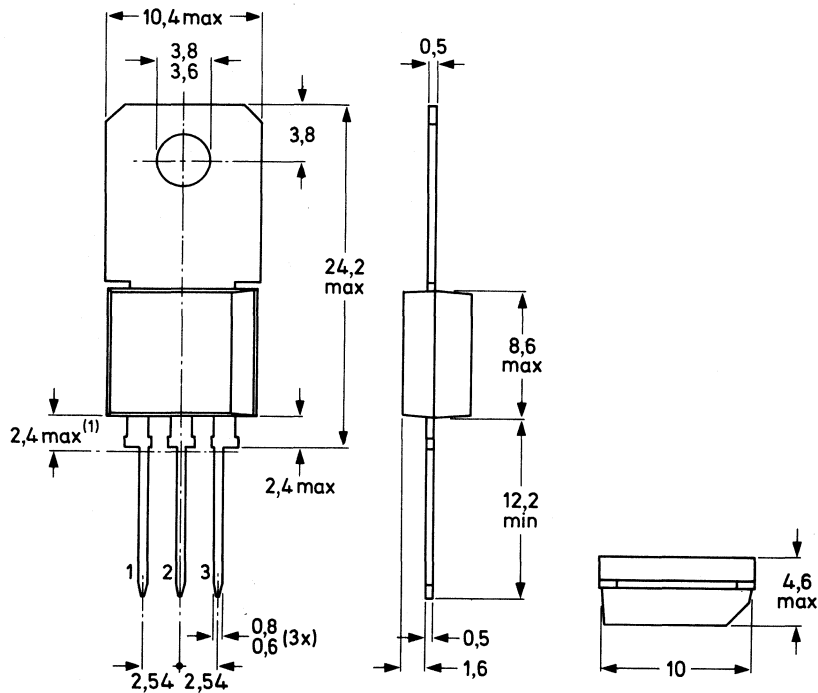
* V_{CEr}.

TO-126 (continued)

type	polarity	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	page
BD330	pnp	3	20	32	15	207
BD131	nnp	3	45	70	15	47
BD132	pnnp	3	45	45	15	57
BD433	nnp	4	22	22	36	235
BD434	pnnp	4	22	22	36	243
BD435	nnp	4	32	32	36	235
BD436	pnnp	4	32	32	36	243
BD437	nnp	4	45	45	36	235
BD438	pnnp	4	45	45	36	243
BD675	nnp	4	45	60	40	287
BD676	pnnp	4	45	45	40	297
BD677	nnp	4	60	80	40	287
BD678	pnnp	4	60	60	40	297
BD719	nnp	4	60	60	36	305
BD720	pnnp	4	60	60	36	313
BD679	nnp	4	80	100	40	287
BD680	pnnp	4	80	80	40	297
BD721	nnp	4	80	80	36	305
BD722	pnnp	4	80	80	36	313
BD681	nnp	4	100	120	40	287
BD682	pnnp	4	100	100	40	297
BD723	nnp	4	100	100	36	305
BD724	pnnp	4	100	100	36	313
BD683	nnp	4	120	140	40	287
BD684	pnnp	4	120	120	40	297
BD725	nnp	4	120	120	36	305
BD726	pnnp	4	120	120	36	313
BDX35	nnp	5	60	100	15	697
BDX36	nnp	5	60	120	15	697
BDX37	nnp	5	80	120	15	697

SELECTION GUIDE

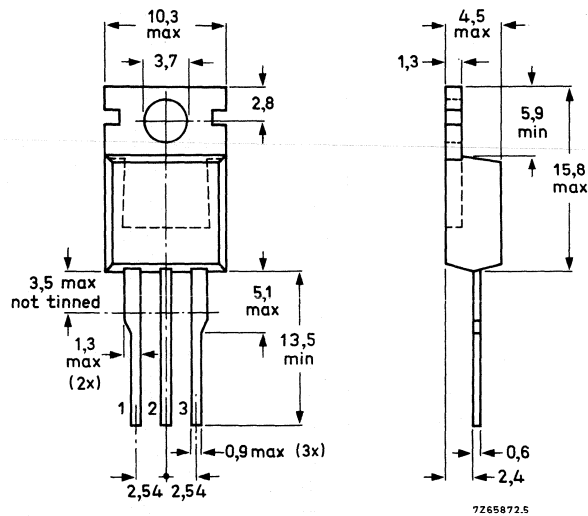
TO-202



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type	polarity	I _C (A)	V _{CEO} (V)	V _{CBO} (V)	P _{tot} (W)	page
BD825	nnp	1	45	45	8	321
BD826	pnnp	1	45	45	8	329
BD827	nnp	1	60	60	8	321
BD828	pnnp	1	60	60	8	329
BD829	nnp	1	80	100	8	321
BD830	pnnp	1	80	100	8	329
BD839	nnp	1.5	45	45	10	337
BD840	pnnp	1.5	45	45	10	345
BD841	nnp	1.5	60	60	10	337
BD842	pnnp	1.5	60	60	10	345
BD843	nnp	1.5	80	100	10	337
BD844	pnnp	1.5	80	100	10	345

TO-220



7265872.5

type	polarity	I_C (A)	V_{CE0} (V)	V_{CBO} (V)	P_{tot} (W)	page
BDT29	npn	1	40	80	30	427
BDT30	pnp	1	40	80	30	441
TIP29	npn	1	40	80	30	819
TIP30	pnp	1	40	80	30	821
BDT29A	npn	1	60	100	30	427
BDT30A	pnp	1	60	100	30	441
TIP29A	npn	1	60	100	30	819
TIP30A	pnp	1	60	100	30	821
BDT29B	npn	1	80	120	30	427
BDT30B	pnp	1	80	120	30	441
TIP29B	npn	1	80	120	30	819
TIP30B	pnp	1	80	120	30	821
BDT29C	npn	1	100	140	30	427
BDT30C	pnp	1	100	140	30	441
TIP29C	npn	1	100	140	30	819
TIP30C	pnp	1	100	140	30	821
BDT31	npn	3	40	80	40	455
BDT32	pnp	3	40	80	40	471
TIP31	npn	3	40	80	40	823
TIP32	pnp	3	40	80	40	825
BD239	npn	3	45	45	30	157
BD240	pnp	3	45	45	30	163
BD933	npn	3	45	45	30	353
BD934	pnp	3	45	45	30	367
BD239A	npn	3	60	60	30	157

SELECTION GUIDE

TO-220 (continued)

type	polarity	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	page
BD240A	pnp	3	60	60	30	163
BD935	npn	3	60	60	30	353
BD936	pnp	3	60	60	30	367
BDT31A	npn	3	60	100	40	455
BDT32A	pnp	3	60	100	40	471
TIP31A	npn	3	60	100	40	823
TIP32A	pnp	3	60	100	40	825
BD239B	npn	3	80	80	30	157
BD240B	pnp	3	80	80	30	163
BD937	npn	3	80	100	30	353
BD938	pnp	3	80	100	30	367
BDT31B	npn	3	80	120	40	455
BDT32B	pnp	3	80	120	40	471
TIP31B	npn	3	80	120	40	823
TIP32B	pnp	3	80	120	40	825
BD239C	npn	3	100	100	30	157
BD240C	pnp	3	100	100	30	163
BD939	npn	3	100	120	30	353
BD940	pnp	3	100	120	30	367
BDT31C	npn	3	100	140	40	455
BDT32C	pnp	3	100	140	40	471
TIP31C	npn	3	100	140	40	823
TIP32C	pnp	3	100	140	40	825
BD941	npn	3	120	140	30	353
BD942	pnp	3	120	140	30	367
BDT60	pnp	4	60	60	50	519
BDT61	npn	4	60	60	50	535
TIP110	npn	4	60	60	50	843
TIP115	pnp	4	60	60	50	849
BDT60A	pnp	4	80	80	50	519
BDT61A	npn	4	80	80	50	535
TIP111	npn	4	80	80	50	843
TIP116	pnp	4	80	80	50	849
BDT60B	pnp	4	100	100	50	519
BDT61B	npn	4	100	100	50	535
TIP112	npn	4	100	100	50	843
TIP117	pnp	4	100	100	50	849
BDT60C	pnp	4	120	120	50	519
BDT61C	npn	4	120	120	50	535
BD943	npn	5	22	22	40	379
BD944	pnp	5	22	22	40	393
BD945	npn	5	32	32	40	379
BD946	pnp	5	32	32	40	393
BD241	npn	5	45	45	40	169
BD242	pnp	5	45	45	40	179

TO-220 (continued)

typ	polarity	I _C (A)	V _{CEO} (V)	V _{CB0} (V)	P _{tot} (W)	page
BD947	npn	5	45	45	40	379
BD948	pnp	5	45	45	40	393
BD241A	npn	5	60	60	40	169
BD242A	pnp	5	60	60	40	179
BD949	npn	5	60	60	40	407
BD950	pnp	5	60	60	40	417
TIP120	npn	5	60	60	65	855
TIP125	pnp	5	60	60	65	861
BD241B	npn	5	80	80	40	169
BD242B	pnp	5	80	80	40	179
BD951	npn	5	80	80	40	407
BD952	pnp	5	80	80	40	417
TIP121	npn	5	80	80	65	855
TIP126	pnp	5	80	80	65	861
BD241C	npn	5	100	100	40	169
BD242C	pnp	5	100	100	40	179
BD953	npn	5	100	100	40	407
BD954	pnp	5	100	100	40	417
TIP122	npn	5	100	100	65	855
TIP127	pnp	5	100	100	65	861
BD955	npn	5	120	120	40	407
BD956	pnp	5	120	120	40	417
BDT41	npn	6	40	40	65	487
BDT42	pnp	6	40	80	65	503
TIP41	npn	6	40	80	65	839
TIP42	pnp	6	40	80	65	841
BDT41A	npn	6	60	60	65	487
BDT42A	pnp	6	60	100	65	503
TIP41A	npn	6	60	100	65	839
TIP42A	pnp	6	60	100	65	841
BDT41B	npn	6	80	80	65	487
BDT42B	pnp	6	80	120	65	503
TIP41B	npn	6	80	120	65	839
TIP42B	pnp	6	80	120	65	841
BDT41C	npn	6	100	100	65	487
BDT42C	pnp	6	100	140	65	503
TIP41C	npn	6	100	140	65	839
TIP42C	pnp	6	100	140	65	841
BD201	npn	8	45	60	60	85
BD202	pnp	8	45	60	60	103
BD243	npn	8	45	45	65	187
BD244	pnp	8	45	45	65	193
BD643	npn	8	45	60	62.5	251
BD644	pnp	8	45	45	62.5	269
BD203	npn	8	60	60	60	85

SELECTION GUIDE

TO-220 (continued)

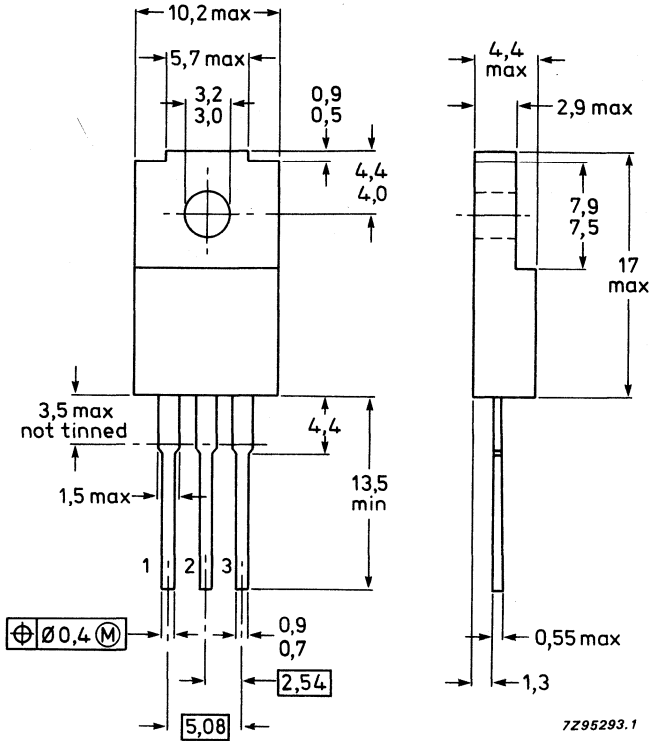
type	polarity	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	page
BD204	npn	8	60	60	60	103
BD243A	npn	8	60	60	65	187
BD244A	npn	8	60	60	65	193
BD645	npn	8	60	80	62.5	251
BD646	npn	8	60	60	62.5	269
TIP130	npn	8	60	60	70	867
TIP135	npn	8	60	60	70	873
BD243B	npn	8	80	80	65	187
BD244B	npn	8	80	80	65	193
BD647	npn	8	80	100	62.5	251
BD648	npn	8	80	80	62.5	269
BDX77	npn	8	80	100	60	85
BDX78	npn	8	80	100	60	103
TIP131	npn	8	80	80	70	867
TIP136	npn	8	80	80	70	873
BD243C	npn	8	100	100	65	187
BD244C	npn	8	100	100	65	193
BD649	npn	8	100	120	62.5	251
BD650	npn	8	100	100	62.5	269
TIP132	npn	8	100	100	70	867
TIP137	npn	8	100	100	70	873
BD651	npn	8	120	140	62.5	251
BD652	npn	8	120	120	62.5	269
BDT62	npn	10	60	60	90	553
BDT63	npn	10	60	60	90	571
BDT91	npn	10	60	60	90	637
BDT92	npn	10	60	60	90	647
TIP2955T	npn	10	60	70	75	897
TIP3055T	npn	10	60	70	75	907
BDT62A	npn	10	80	80	90	553
BDT63A	npn	10	80	80	90	571
BDT93	npn	10	80	80	90	637
BDT94	npn	10	80	80	90	647
BDT62B	npn	10	100	100	90	553
BDT63B	npn	10	100	100	90	571
BDT95	npn	10	100	100	90	637
BDT96	npn	10	100	100	90	647
BDT62C	npn	10	120	120	90	553
BDT63C	npn	10	120	120	90	571
BDT64	npn	12	60	60	125	589
BDT65	npn	12	60	60	125	605
BDT64A	npn	12	80	80	125	589
BDT65A	npn	12	80	80	125	605

TO-220 (continued)

type	polarity	I _C (A)	V _{CEO} (V)	V _{CB0} (V)	P _{tot} (W)	page
BDT64B	pnp	12	100	100	125	589
BDT65B	npn	12	100	100	125	605
BDT64C	pnp	12	120	120	125	589
BDT65C	npn	12	120	120	125	605
BDT81	npn	15	60	60	125	621
BDT82	pnp	15	60	60	125	629
BDT83	npn	15	80	80	125	621
BDT84	pnp	15	80	80	125	629
BDT85	npn	15	100	100	125	621
BDT86	pnp	15	100	100	125	629
BDT87	npn	15	120	120	125	621
BDT88	pnp	15	120	120	125	629

SELECTION GUIDE

SOT186



7295293.1

type	polarity	I _C (A)	V _{CEO} (V)	V _{CB0} (V)	P _{tot} (W)	page
BDT29F	npn	3	40	80	19	433
BDT30F	pnp	3	40	80	19	447
BDT31F	npn	3	40	80	22	463
BDT32F	pnp	3	40	80	22	479
BD933F	npn	3	45	45	19	361
BD934F	pnp	3	45	45	19	373
BD935F	npn	3	60	60	19	361
BD936F	pnp	3	60	60	19	373
BDT29AF	npn	3	60	100	19	433
BDT30AF	pnp	3	60	100	19	447
BDT31AF	npn	3	60	100	22	463
BDT32AF	pnp	3	60	100	22	479
BD937F	npn	3	80	100	19	361
BD938F	pnp	3	80	100	19	373
BDT29BF	npn	3	80	120	19	433
BDT30BF	pnp	3	80	120	19	447
BDT31BF	npn	3	80	120	22	463
BDT32BF	pnp	3	80	120	22	479
BD939F	npn	3	100	120	19	361
BD940F	pnp	3	100	120	19	373

SOT186 (continued)

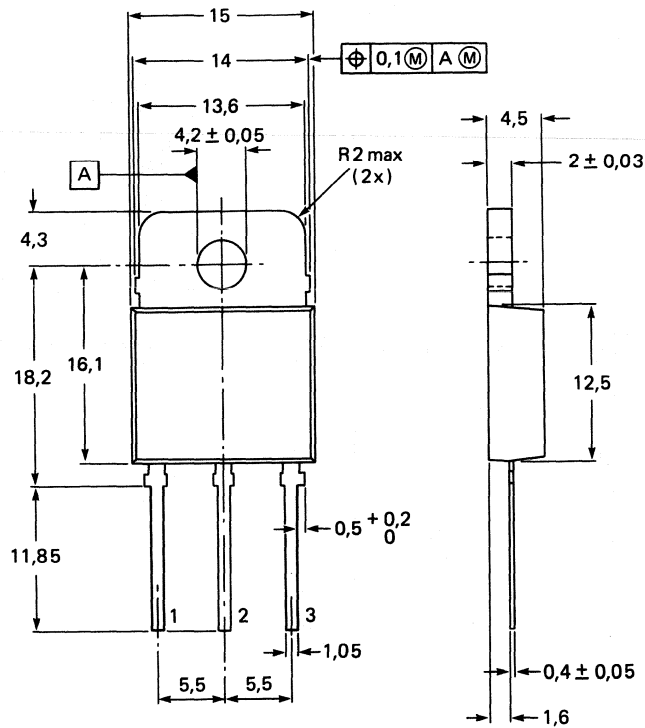
type	polarity	I _C (A)	V _{CEO} (V)	V _{CBO} (V)	P _{tot} (W)	page
BDT29CF	npn	3	100	140	19	433
BDT30CF	pnP	3	100	140	19	447
BDT31CF	npn	3	100	140	22	463
BDT32CF	pnP	3	100	140	22	479
BDT29DF	npn	3	120	160	19	433
BD941F	npn	3	120	140	19	361
BD942F	pnP	3	120	140	19	373
BDT30DF	pnP	3	120	160	19	447
BDT31DF	npn	3	120	160	22	463
BDT32DF	pnP	3	120	160	22	479
BDT60F	pnP	4	60	60	25	527
BDT61F	npn	4	60	60	25	545
BDT60AF	pnP	4	80	80	25	527
BDT61AF	npn	4	80	80	25	545
BDT60BF	pnP	4	100	100	25	527
BDT61BF	npn	4	100	100	25	545
BDT60CF	pnP	4	120	120	25	527
BDT61CF	npn	4	120	120	25	545
BD943F	npn	5	22	22	22	387
BD944F	pnP	5	22	22	22	401
BD945F	npn	5	32	32	22	387
BD946F	pnP	5	32	32	22	401
BD947F	npn	5	45	45	22	387
BD948F	pnP	5	45	45	22	401
BD949F	npn	5	60	60	22	415
BD950F	pnP	5	60	60	22	425
BD951F	npn	5	80	80	22	415
BD952F	pnP	5	80	80	22	425
BD953F	npn	5	100	100	22	415
BD954F	pnP	5	100	100	22	425
BD955F	npn	5	120	120	22	415
BD956F	pnP	5	120	120	22	425
BDT41F	npn	6	40	80	32	495
BDT42F	pnP	6	40	80	32	511
BDT41AF	npn	6	60	100	32	495
BDT42AF	pnP	6	60	100	32	511
BDT41BF	npn	6	80	120	32	495
BDT42BF	pnP	6	80	120	32	511
BDT41CF	npn	6	100	140	32	495
BDT42CF	pnP	6	100	140	32	511
BD201F	npn	8	45	60	32	95
BD202F	pnP	8	45	60	32	113
BD644F	pnP	8	45	45	20	279
BD203F	npn	8	60	60	32	95
BD204F	pnP	8	60	60	32	113

SELECTION GUIDE

SOT186 (continued)

type	polarity	I _C (A)	V _{CEO} (V)	V _{CBO} (V)	P _{tot} (W)	page
BD643F	npn	8	45	60	20	261
BD645F	npn	8	60	80	20	261
BD646F	pnP	8	60	60	20	279
BD647F	npn	8	80	100	20	261
BD648F	pnP	8	80	80	20	279
BDX77F	npn	8	80	100	32	95
BDX78F	pnP	8	80	100	32	113
BD649F	npn	8	100	120	20	261
BD650F	pnP	8	100	100	20	279
BD651F	npn	8	120	140	20	261
BD652F	pnP	8	120	120	20	279
BDT62F	pnP	10	60	60	36	563
BDT63F	npn	10	60	60	36	581
BDT91F	npn	10	60	60	32	645
BDT92F	pnP	10	60	60	32	655
BDT62AF	pnP	10	80	80	36	563
BDT63AF	npn	10	80	80	36	581
BDT93F	npn	10	80	80	32	645
BDT94F	pnP	10	80	80	32	655
BDT62BF	pnP	10	100	100	36	563
BDT63BF	npn	10	100	100	36	581
BDT95F	npn	10	100	100	32	645
BDT96F	pnP	10	100	100	32	655
BDT62CF	pnP	10	120	120	36	563
BDT63CF	npn	10	120	120	36	581
BDT64F	pnP	12	60	60	39	597
BDT65F	npn	12	60	60	39	613
BDT64AF	pnP	12	80	80	39	597
BDT65AF	npn	12	80	80	39	613
BDT64BF	pnP	12	100	100	39	597
BDT65BF	npn	12	100	100	39	613
BDT64CF	pnP	12	120	120	39	597
BDT65CF	npn	12	120	120	39	613
BDT81F	npn	15	60	60	36	627
BDT82F	pnP	15	60	60	36	635
BDT83F	npn	15	80	80	36	627
BDT84F	pnP	15	80	80	36	635
BDT85F	npn	15	100	100	36	627
BDT86F	pnP	15	100	100	36	635
BDT87F	npn	15	120	120	36	627
BDT88F	pnP	15	120	120	36	635

SOT93



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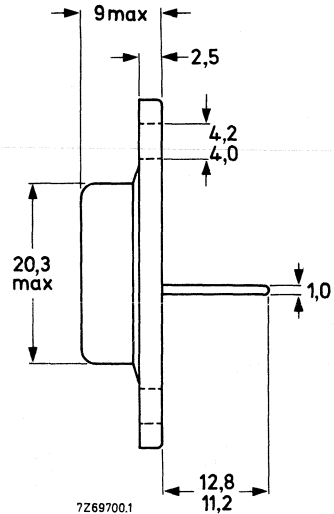
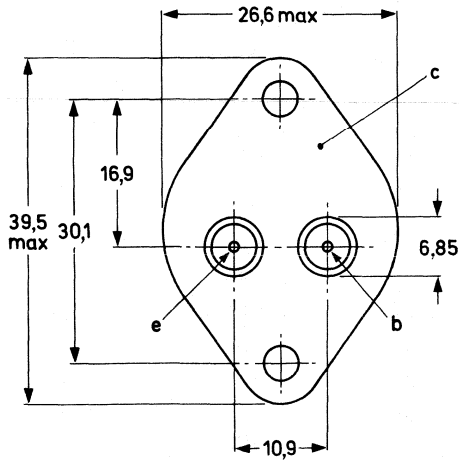
type	polarity	I_C (A)	V_{CE0} (V)	V_{CBO} (V)	P_{tot} (W)	page
TIP33	npn	10	40	80	80	827
TIP34	pnp	10	40	80	80	833
BDV91	npn	10	60	60	100	685
BDV92	pnp	10	60	60	100	691
TIP140	npn	10	60	60	125	879
TIP145	pnp	10	60	60	125	885
TIP33A	npn	10	60	100	80	827
TIP34A	pnp	10	60	100	80	833
BDV93	npn	10	80	80	100	685
BDV94	pnp	10	80	80	100	691
TIP141	npn	10	80	80	125	879
TIP146	pnp	10	80	80	125	885
TIP33B	npn	10	80	120	80	827
TIP34B	pnp	10	80	120	80	833
BDV95	npn	10	100	100	100	685
BDV96	pnp	10	100	100	100	691
TIP142	npn	10	100	100	125	879
TIP147	pnp	10	100	100	125	885
TIP33C	npn	10	100	140	80	827

SELECTION GUIDE

SOT93 (continued)

type	polarity	I_C (A)	V_{CE0} (V)	V_{CBO} (V)	P_{tot} (W)	page
TIP34C	pnP	10	100	140	80	833
BDV64	pnP	12	60	60	125	657
BDV65	npn	12	60	60	125	665
BDV64A	pnP	12	80	80	125	657
BDV65A	npn	12	80	80	125	665
BDV64B	pnP	12	100	100	125	657
BDV65B	npn	12	100	100	125	665
BDV64C	pnP	12	120	120	125	657
BDV65C	npn	12	120	120	125	665
TIP2955	pnP	15	60	100	100	891
TIP3055	npn	15	60	100	100	901
BDV66A	pnP	16	80	100	175	673
BDV67A	npn	16	80	100	200	679
BDV66B	pnP	16	100	120	175	673
BDV67B	npn	16	100	120	200	679
BDV66C	pnP	16	120	140	175	673
BDV67C	npn	16	120	140	200	679
BDV66D	pnP	16	150	160	175	673
BDV67D	npn	16	150	160	200	679

TO-3



type	polarity	I_C (A)	V_{CEO} (V)	V_{CBO} (V)	P_{tot} (W)	page
BDX62	pnp	8	60	60	90	721
BDX63	npn	8	60	80	90	731
BDX62A	pnp	8	80	80	90	721
BDX63A	npn	8	80	100	90	731
BDX62B	pnp	8	100	100	90	721
BDX63B	npn	8	100	120	90	731
BDX62C	pnp	8	120	120	90	721
BDX63C	npn	8	120	140	90	731
BDX91	npn	10	60	60	90	795
BDX92	pnp	10	60	60	90	803
BDY92	npn	10	60	80	40	811
BDX93	npn	10	80	80	90	795
BDX94	pnp	10	80	80	90	803
BDY91	npn	10	80	100	40	811
BDX95	npn	10	100	100	90	795
BDX96	pnp	10	100	100	90	803
BDY90	npn	10	100	120	40	811
BDX64	pnp	12	60	60	117	741
BDX65	npn	12	60	80	117	751
BDX64A	pnp	12	80	80	117	741
BDX65A	npn	12	80	100	117	751
BDX64B	pnp	12	100	100	117	741
BDX65B	npn	12	100	120	117	751
BDX64C	pnp	12	120	120	117	741
BDX65C	npn	12	120	140	117	751

SELECTION GUIDE

TO-3 (continued)

type	polarity	I_C (A)	V_{CE0} (V)	V_{CB0} (V)	P_{tot} (W)	page
BDX66	pnp	16	60	60	150	761
BDX67	nnp	16	60	80	150	771
BDX66A	pnnp	16	80	80	150	761
BDX67A	nnp	16	80	100	150	771
BDX66B	pnnp	16	100	100	150	761
BDX67B	nnp	16	100	120	150	771
BDX66C	pnnp	16	120	120	150	761
BDX67C	nnp	16	120	140	150	771
BDX68	pnnp	25	60	60	200	783
BDX69	nnp	25	60	80	200	787
BDX68A	pnnp	25	80	80	200	783
BDX69A	nnp	25	80	100	200	787
BDX68B	pnnp	25	100	100	200	783
BDX69B	nnp	25	100	120	200	787
BDX68C	pnnp	25	120	120	200	783
BDX69C	nnp	25	120	140	200	787

TYPE NUMBER SURVEY

TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	TO-3
56353	spring clip	TO-126/SOT82
56354	mica insulator	TO-126/SOT82
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer (brass)	TO-220
56363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT93
56368b	insulating bush (up to 800 V)	SOT93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT93
56379	spring clip	SOT93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

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

Emitter to base voltage ratings

- V_{EBmax} The maximum permissible instantaneous reverse voltage between emitter and base terminal. The emitter voltage is negative with respect to base for pnp transistor and positive with respect to base for npn types.
- $V_{EBmax} (I_C = 0)$ The maximum permissible instantaneous reverse voltage between emitter and base terminals when the collector terminal is open-circuited.

Collector to emitter voltage ratings

- V_{CEmax} The maximum permissible instantaneous voltage between collector and emitter terminals. The collector voltage is negative with respect to emitter in pnp transistors and positive with respect to emitter in npn types. This rating is very dependent on circuit conditions and collector current and it is necessary to refer to the curve of V_{CE} versus I_C for the appropriate circuit condition in order to obtain the correct rating.
- V_{CEmax} (Cut-off) The maximum permissible instantaneous voltage between collector and emitter terminals when the emitter current is reduced to zero by means of a reverse emitter base voltage, i.e. the base voltage is normally positive with respect to emitter for pnp transistor and negative with respect to emitter for npn types.

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

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

Due to the current dependency of V_{CE} it is usual to present this information as a voltage rating chart which is a curve of collector 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.

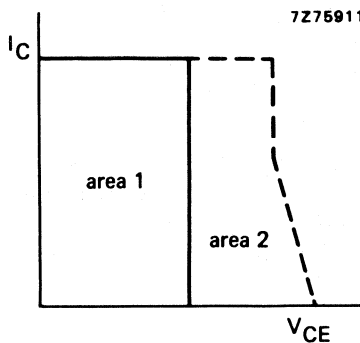


Fig. 1 Permissible operation areas.

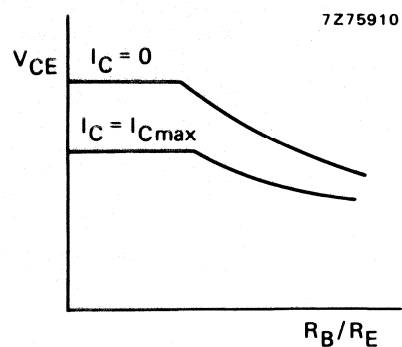


Fig. 2 Effect of collector current on permissible operation areas.

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.

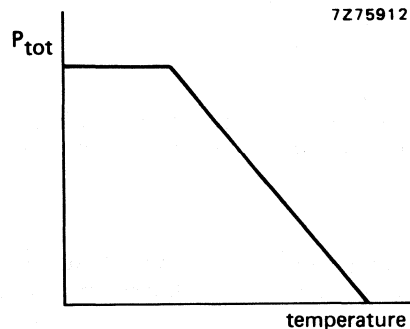


Fig. 3 Permissible total power dissipation.

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

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

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

TRANSISTOR RATINGS

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

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

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

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

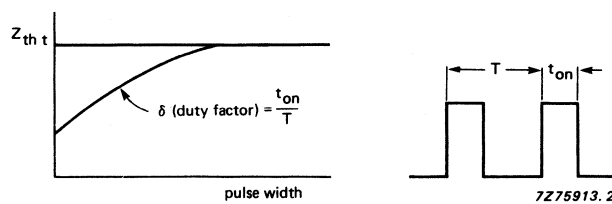


Fig. 4 Pulse power operation.

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

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

where $Z_{\text{th } t}$ and d are given in Fig. 4 and $R_{\text{th } c-a}$ is the thermal resistance between case and ambient for case rated device. For mounting base rated device, it is equal to $R_{\text{th } h} + R_{\text{th } i}$ 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 $Z_{\text{th } t}$.

Temperature ratings

$T_{j\text{max}}$	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.
$T_{j\text{max}}$ (continuous operation)	The maximum permissible continuous value.
$T_{j\text{max}}$ (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

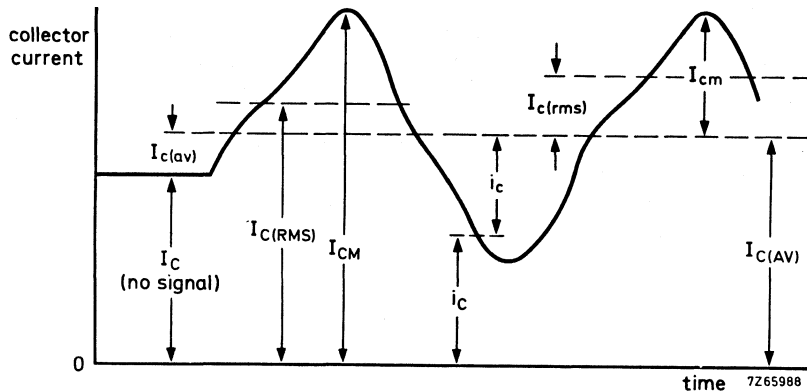
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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

TRANSISTOR SAFE OPERATING AREA (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 $R_{th\ j-mb}$ between junction and mounting base, see Fig. 1.

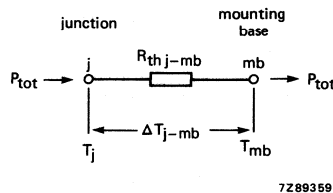


Fig. 1 Heat transport in a transistor with power dissipation constant with respect to time.

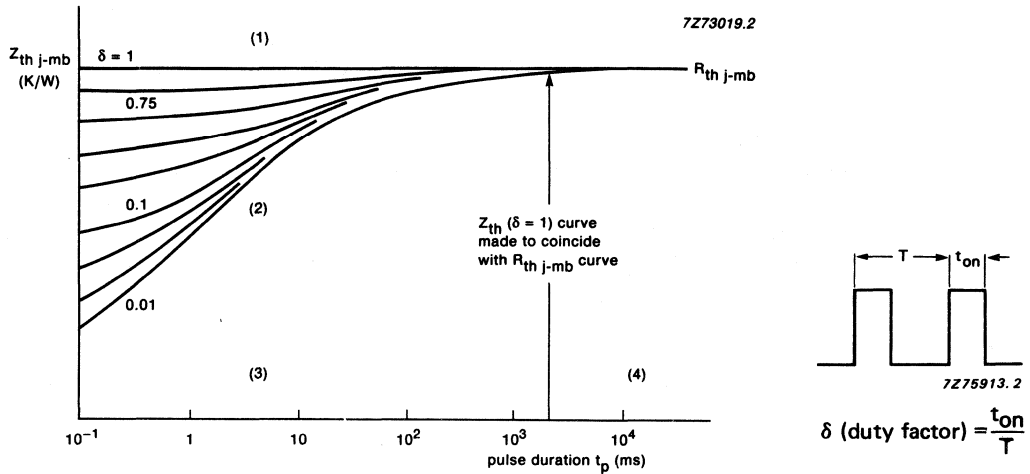
For steady-state (DC) operation the junction temperature will increase to:

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

For pulse operation the junction temperature will be:

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

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 $Z_{th\ j-mb}$ curves for a power transistor.

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

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

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);

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

For pulsed conditions;

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

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

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

For pulsed conditions

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

Again the temperature specified in a data sheet is usually $T_{\text{h}} = 25\text{ }^{\circ}\text{C}$ 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 $V_{\text{CE}} > V_{\text{CEO max}}$
- 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.

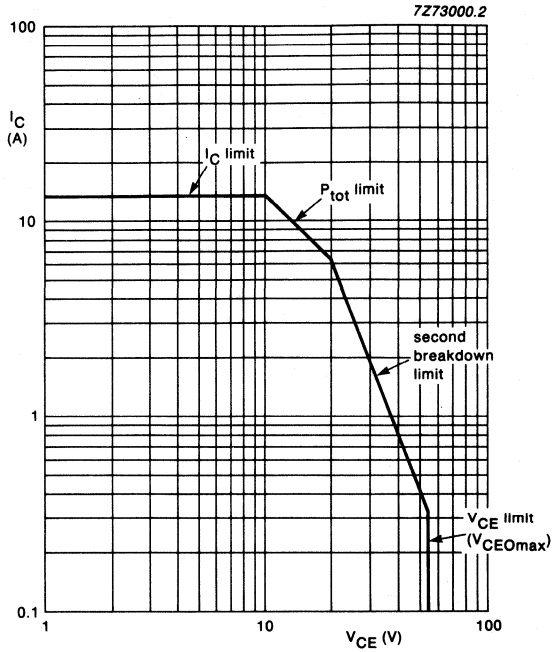
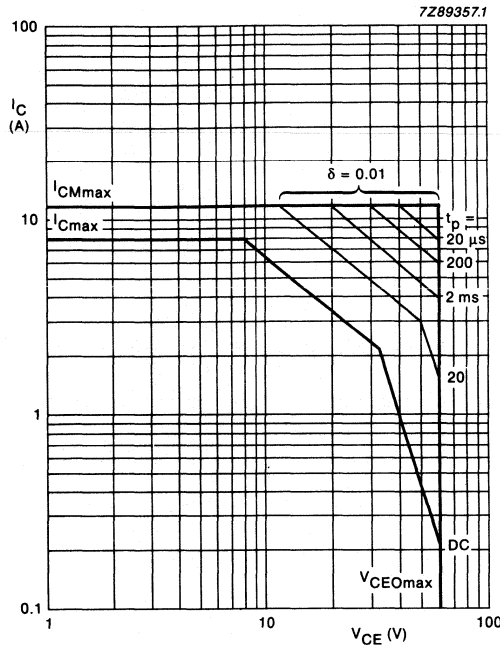


Fig. 3 A typical DC SOAR graph with boundaries defined.

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.

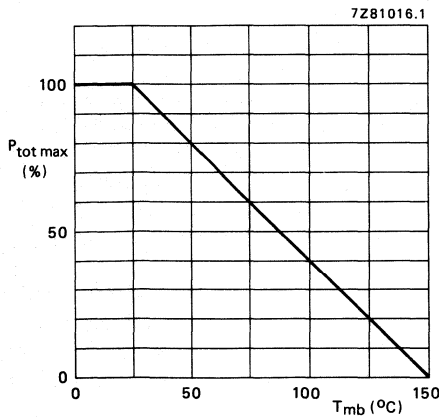
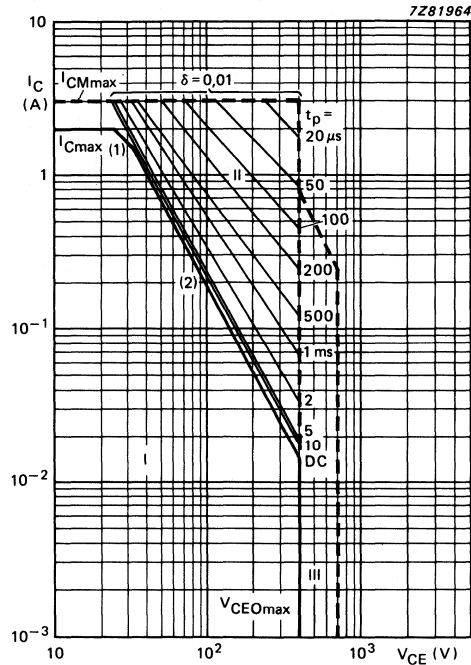


Fig. 5 Power derating curve, maximum permissible dissipation as a function of mounting base temperature.

FORWARD BIASED SAFE OPERATING AREA WITH $V_{CE} > V_{CE0max}$



- 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 $R_{BE} \leq 100 \Omega$ and $t_p \leq 6.0 \mu s$.

Fig. 6 Safe operating area at $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

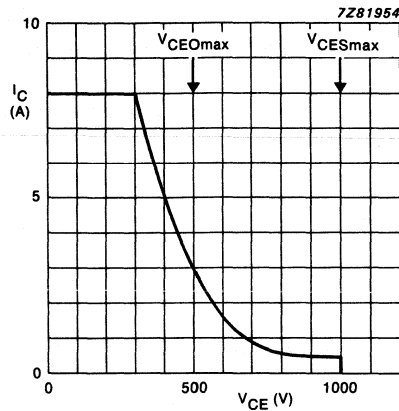
For switching power transistors in inductive load applications such as flyback converters, the collector-emitter voltage normally exceeds the rated V_{CE0max} limit in the non-inductive stage. The collector current will rise steeply at turn on while the collector-emitter voltage is still greater than V_{CE0max} . 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 $T_{mb} \leq 100^\circ\text{C}$; $V_{BE \text{ off}} = 5\text{ V}$; $I_C/I_B \geq 5$.

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 worst case average dissipation	P_{wc}

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

For direct mounted devices:

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

For fully isolated devices:

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

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

For direct mounted devices:

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

For fully isolated devices:

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

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 preferred 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 $T_{mb} = 60\text{ }^\circ\text{C}$	P_{tot}	max.	15 W
Junction temperature	T_j	max.	150 $^\circ\text{C}$
D.C. current gain	h_{FE}	>	40
$I_C = 0,5\text{ A}; V_{CE} = 12\text{ V}$			
Transition frequency at $f = 35\text{ MHz}$	f_T	>	60 MHz
$I_C = 0,25\text{ A}; V_{CE} = 5\text{ V}$			

MECHANICAL DATA

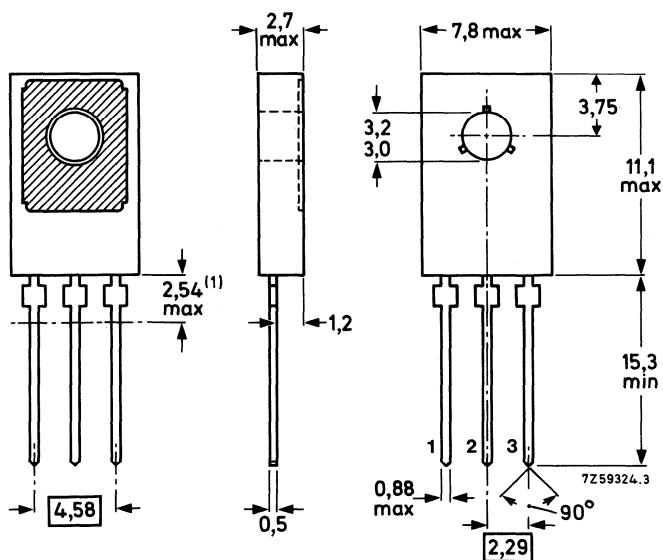
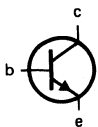
Dimensions in mm

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 $T_{mb} = 60\text{ }^{\circ}\text{C}$	P_{tot}	max.	15 W
Storage temperature	T_{stg}		-65 to + 150 $^{\circ}\text{C}$
Junction temperature	T_j	max.	150 $^{\circ}\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	6 K/W
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CHARACTERISTICS $T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified

Collector cut-off current

$I_E = 0; V_{CB} = 50\text{ V}$

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

$I_E = 0; V_{CB} = 50\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$I_{CBO} < 500\text{ }\mu\text{A}$

Emitter cut-off current

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

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

Saturation voltages

$I_C = 0,5\text{ A}; I_B = 50\text{ mA}$

$V_{CEsat} < 0,3\text{ V}$

$V_{BEsat} < 1,2\text{ V}$

$I_C = 2\text{ A}; I_B = 200\text{ mA}$

$V_{CEsat} < 0,7\text{ V}$

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

D.C. current gain

$I_C = 0,5\text{ A}; V_{CE} = 12\text{ V}$

$h_{FE} > 40$

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

$h_{FE} > 20$

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

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

$C_c < 60\text{ pF}$

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

$I_C = 0,25\text{ A}; V_{CE} = 5\text{ V}; T_{amb} = 25\text{ }^\circ\text{C}$

$f_T > 60\text{ MHz}$

D.C. current gain ratio of the complementary pairs

$I_C = 0,5\text{ A}; V_{CE} = 12\text{ V}$

$h_{FE1}/h_{FE2} < 1,2$

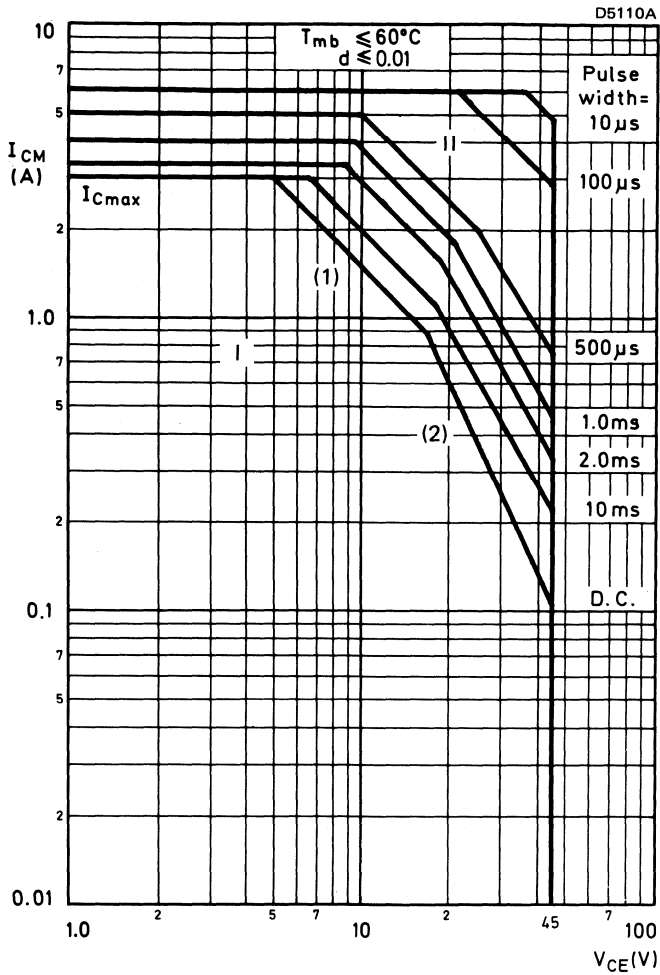


Fig. 2 Safe Operating Area with the transistor forward biased.

- 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.

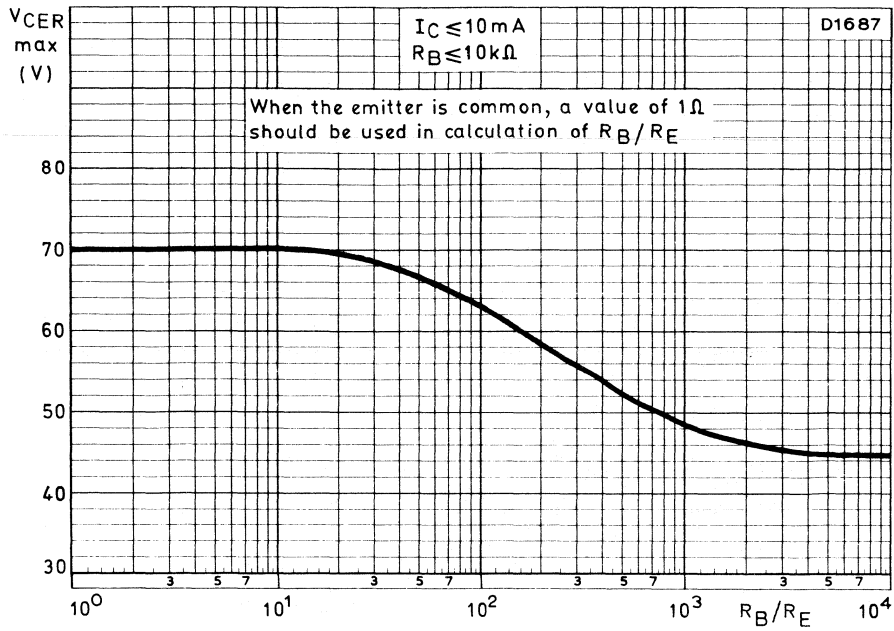


Fig. 3 Maximum allowable collector-emitter voltage as a function of base-emitter resistance.

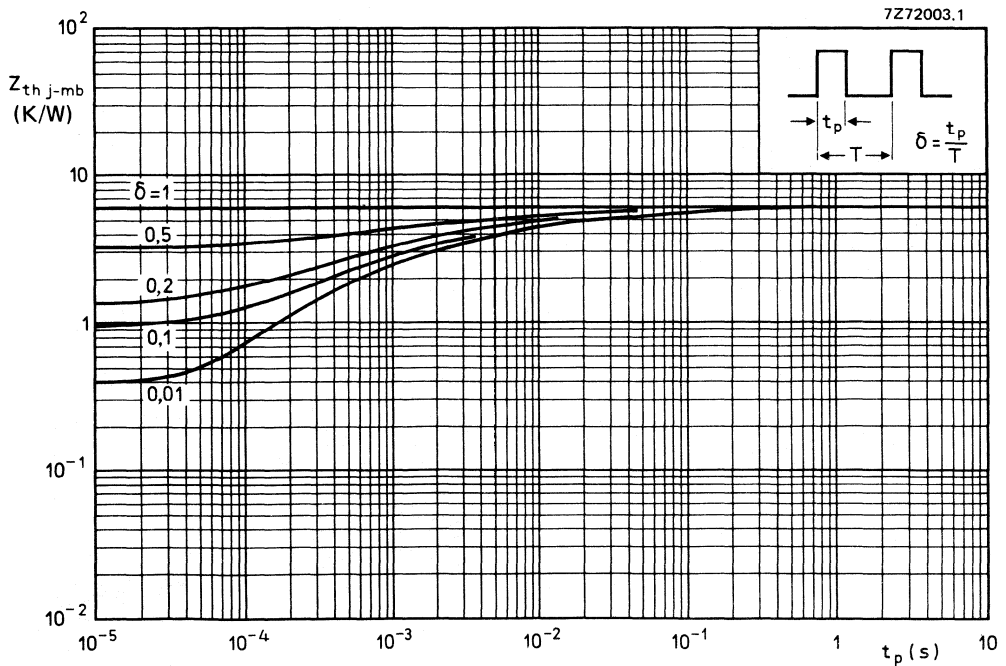


Fig. 4 Pulse power rating chart.

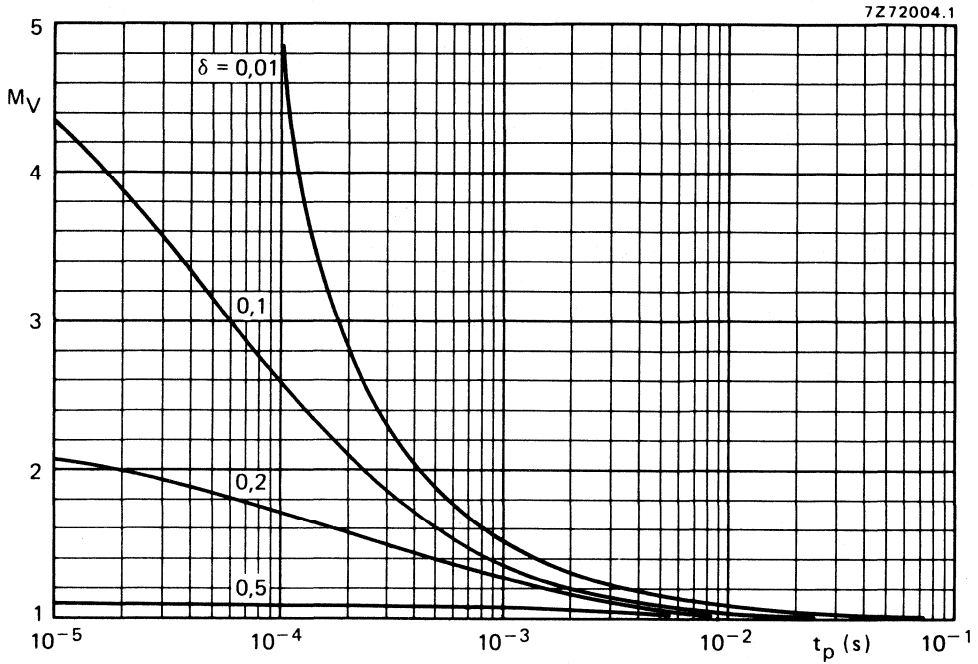


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

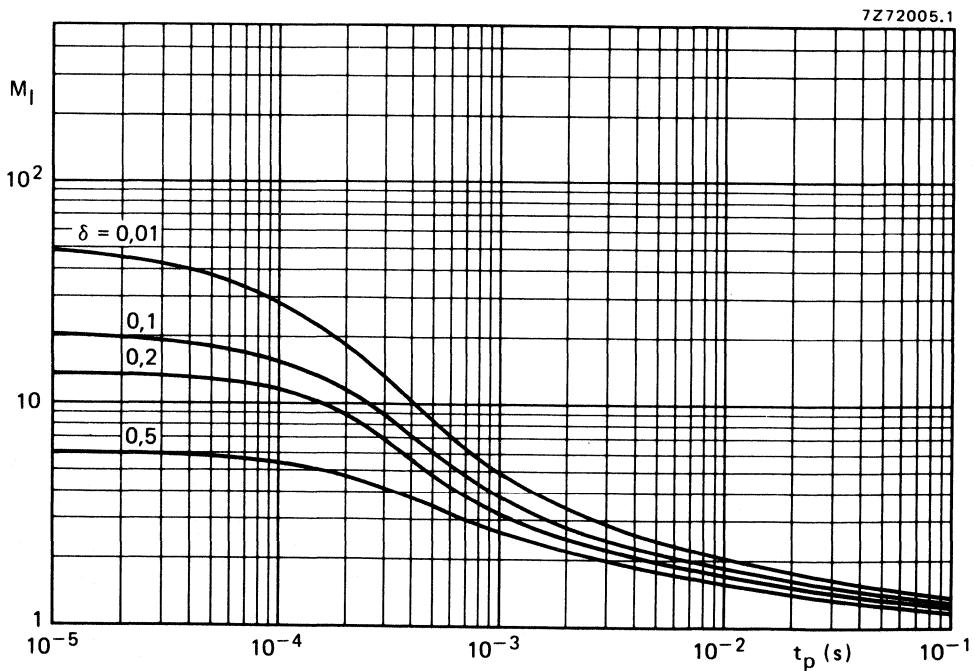


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

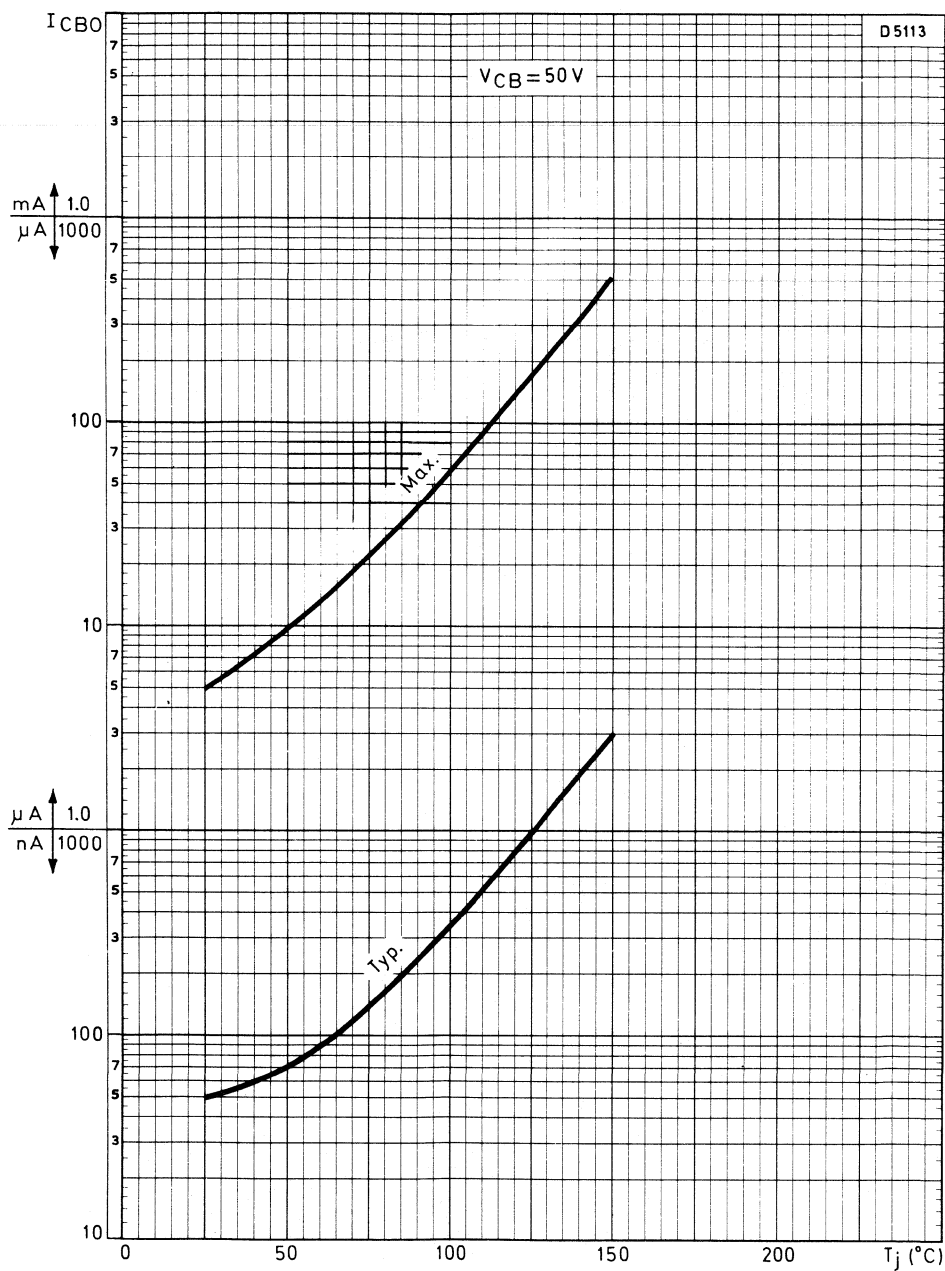


Fig. 7 Collector-base current (open emitter) as a function of the junction temperature.

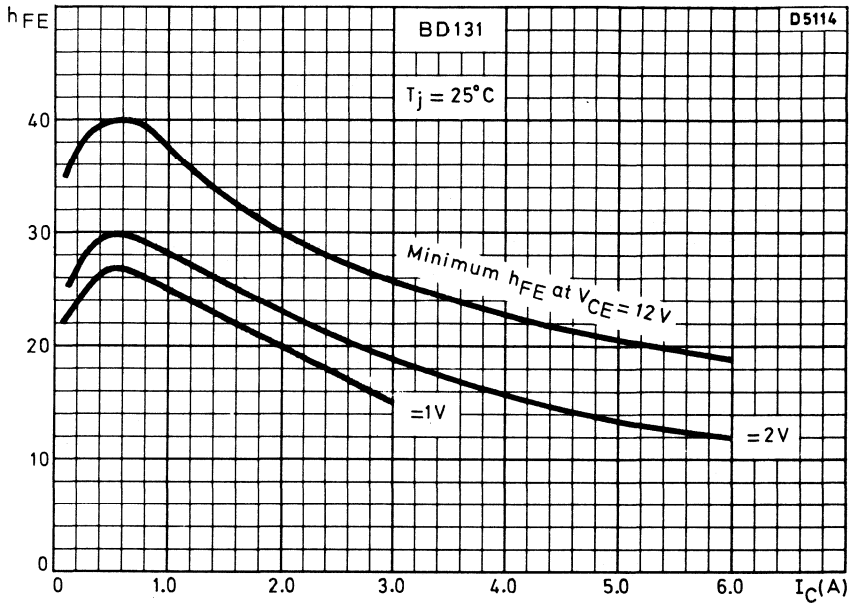


Fig. 8.

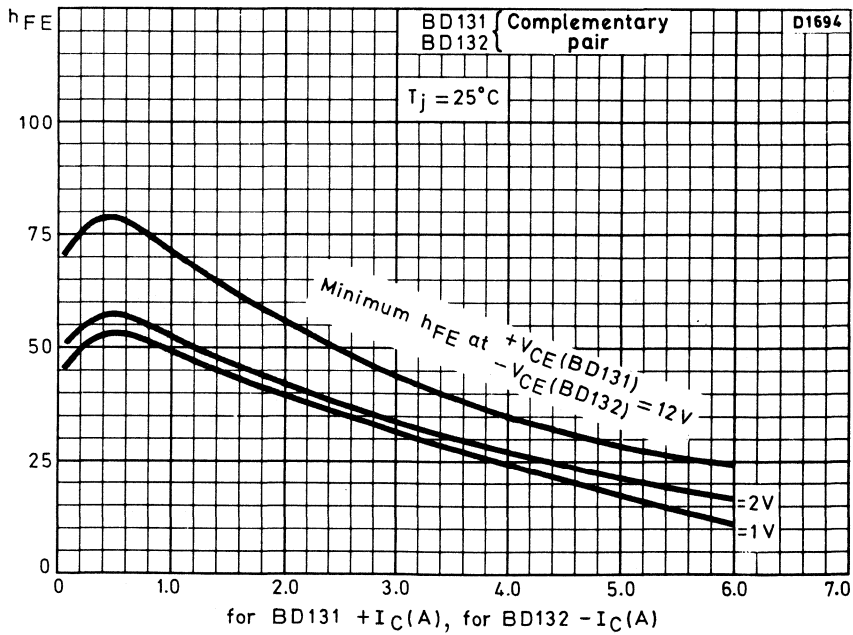


Fig. 9.

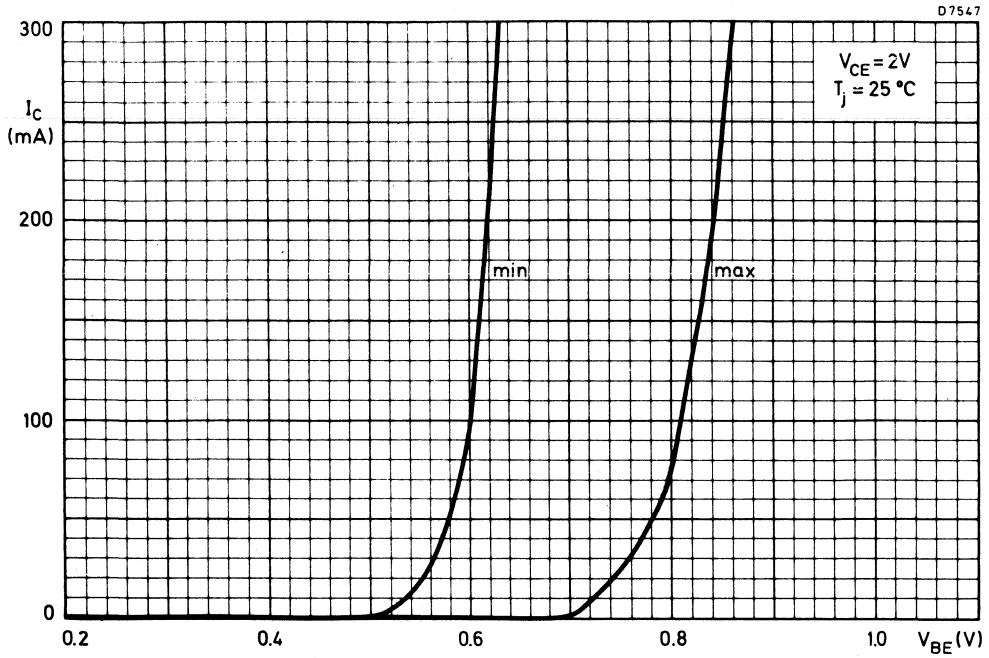


Fig. 10.

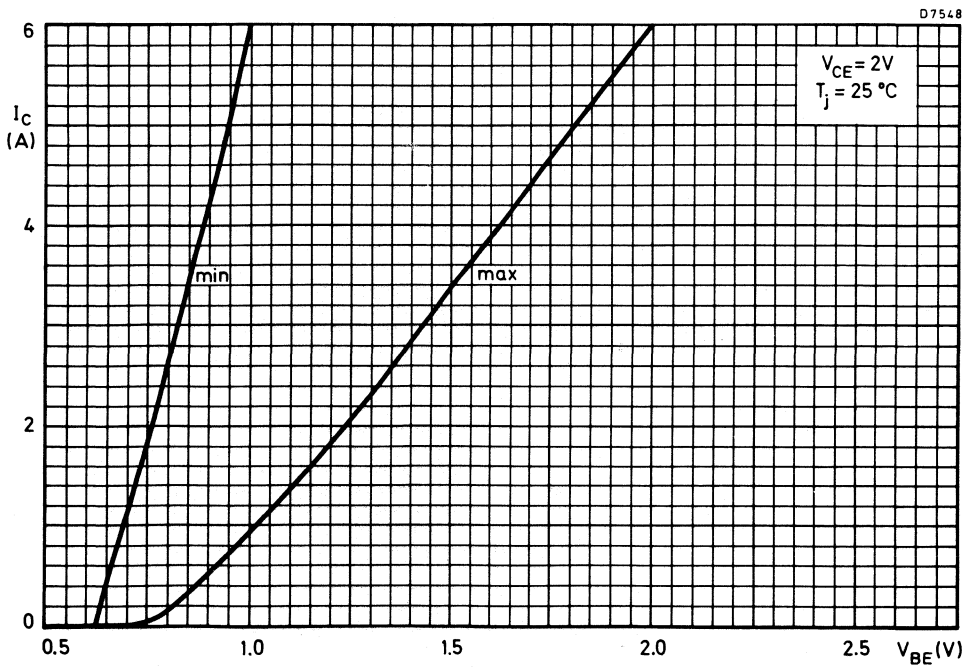


Fig. 11.

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 $T_{mb} = 60\text{ }^\circ\text{C}$	P_{tot} max.	15 W
Junction temperature	T_j max.	150 $^\circ\text{C}$
D.C. current gain	h_{FE}	> 40
Transition frequency at $f = 35\text{ MHz}$	f_T	> 60 MHz
$-I_C = 0,5\text{ A}; -V_{CE} = 12\text{ V}$		
$-I_C = 0,25\text{ A}; -V_{CE} = 5\text{ V}$		

MECHANICAL DATA

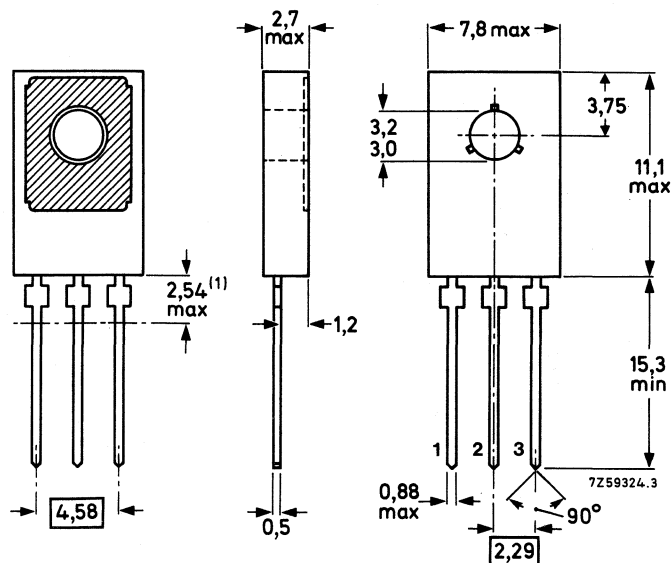
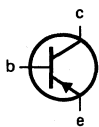
Dimensions in mm

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 $T_{mb} = 60\text{ }^{\circ}\text{C}$	P_{tot}	max.	15 W
Storage temperature	T_{stg}		-65 to $+150\text{ }^{\circ}\text{C}$
Junction temperature	T_j	max.	$150\text{ }^{\circ}\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	6 K/W
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CHARACTERISTICS $T_j = 25\text{ }^{\circ}\text{C}$ unless otherwise specified

Collector cut-off current

$I_E = 0; -V_{CB} = 40\text{ V}$	$-I_{CBO}$	<	5 μA
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$I_E = 0; -V_{CB} = 40\text{ V}; T_j = 150\text{ }^{\circ}\text{C}$	$-I_{CBO}$	<	500 μA
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Emitter cut-off current

$I_C = 0; -V_{EB} = 3\text{ V}$	$-I_{EBO}$	<	5 μA
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Saturation voltages

$-I_C = 0,5\text{ A}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	<	0,3 V
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	$-V_{BEsat}$	<	1,2 V
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$-I_C = 2\text{ A}; -I_B = 200\text{ mA}$	$-V_{CEsat}$	<	0,7 V
---	--------------	---	-------

	$-V_{BEsat}$	<	1,5 V
--	--------------	---	-------

D.C. current gain

$-I_C = 0,5\text{ A}; -V_{CE} = 12\text{ V}$	h_{FE}	>	40
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$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	20
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Transition frequency at $f = 35\text{ MHz}$

$-I_C = 0,25\text{ A}; -V_{CE} = 5\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}$	f_T	>	60 MHz
--	-------	---	--------

D.C. current gain ratio

of the complementary pairs			
$-I_C = 500\text{ mA}; -V_{CE} = 12\text{ V}$	h_{FE1}/h_{FE2}	<	1,2

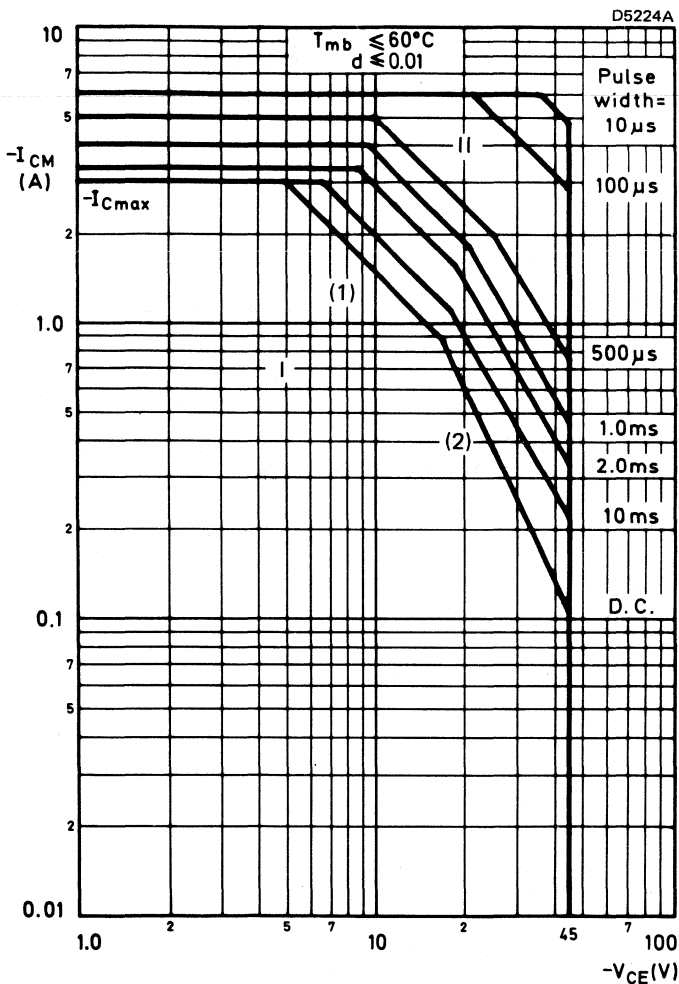


Fig. 2 Safe Operating Area with the transistor forward biased.

- 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.

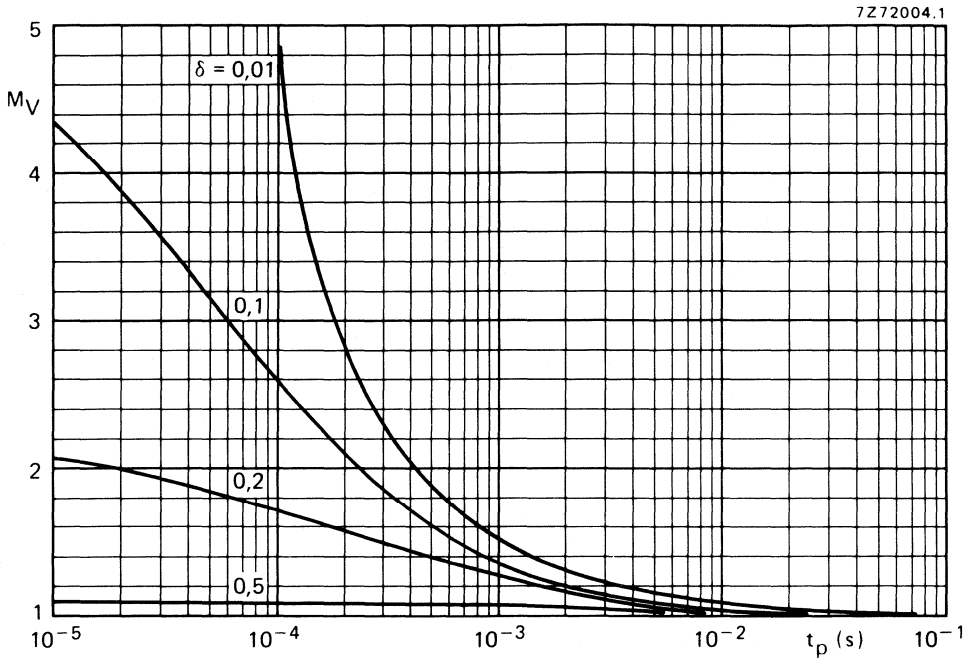


Fig. 3 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

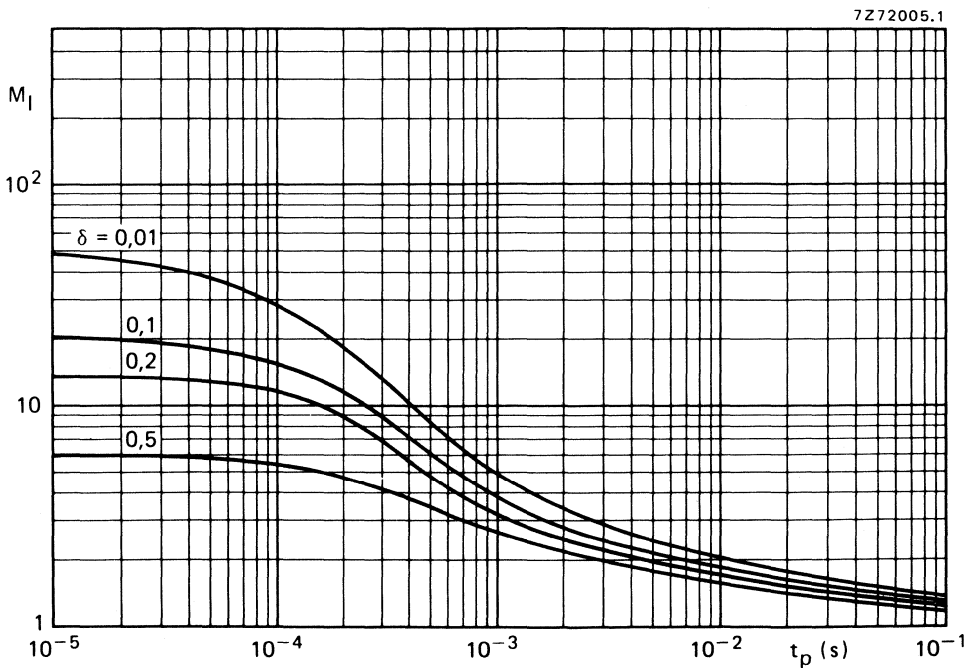


Fig. 4 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

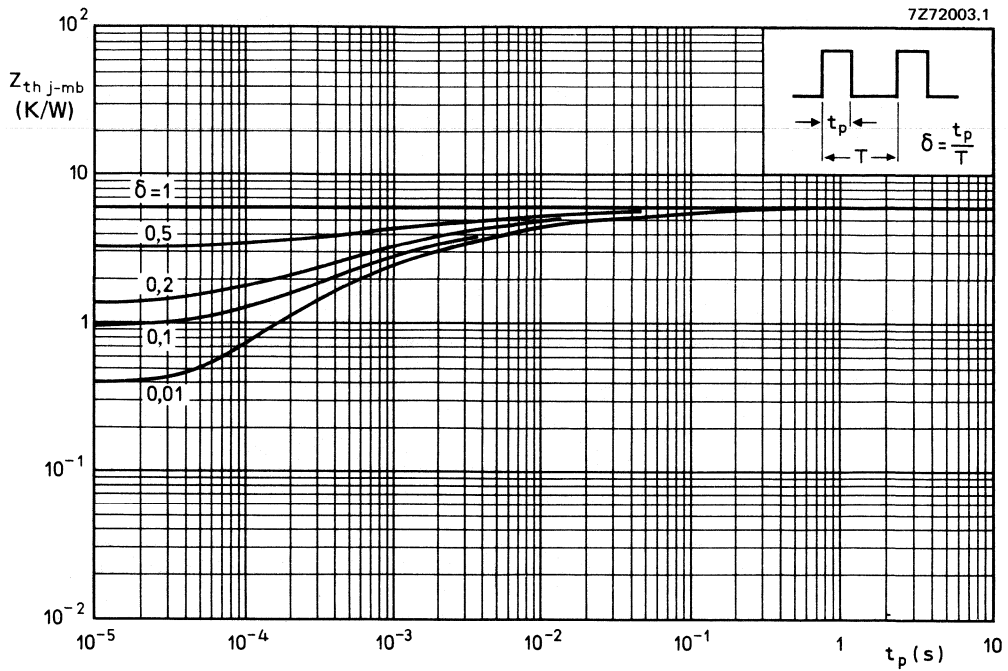


Fig. 5 Pulse power rating chart.

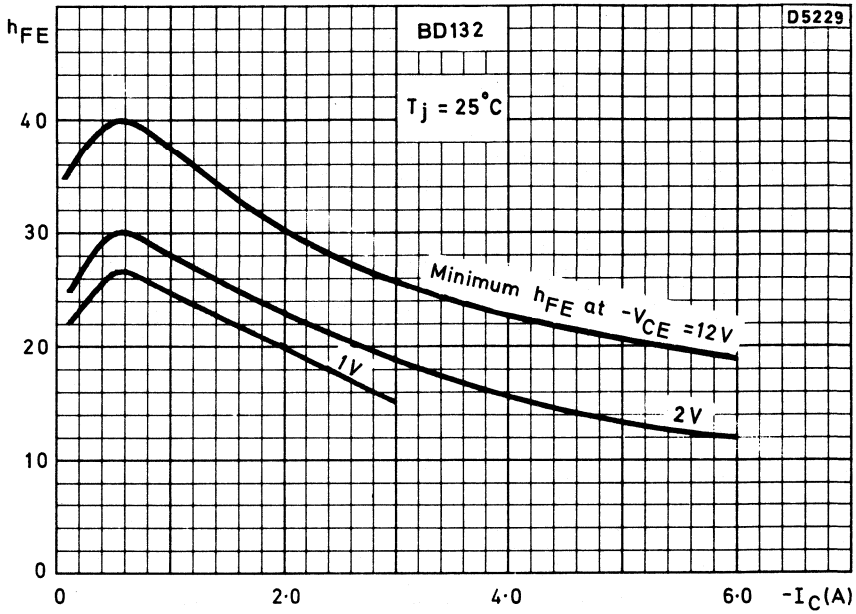


Fig. 6 D.C. current gain.

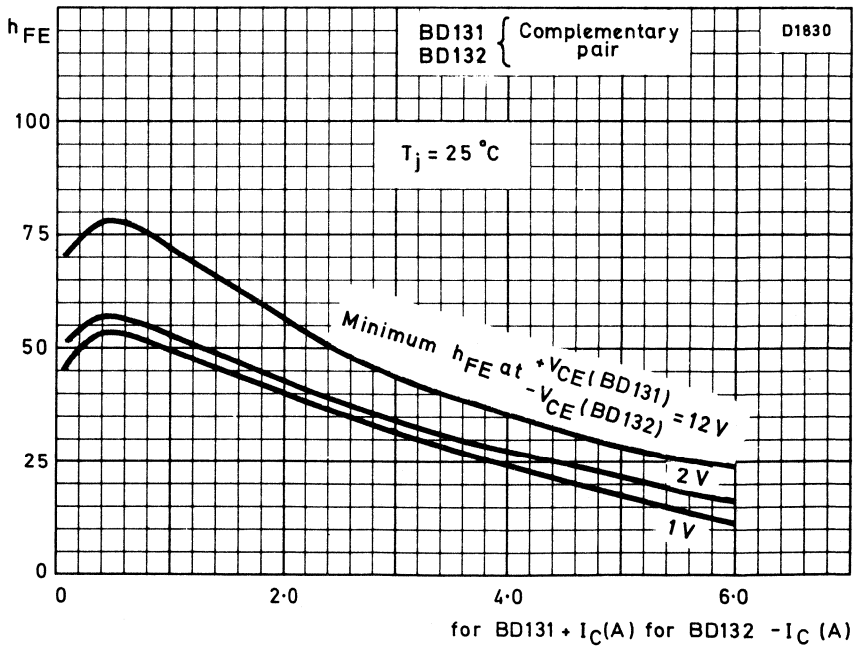


Fig. 7 D.C. current gain ratio.

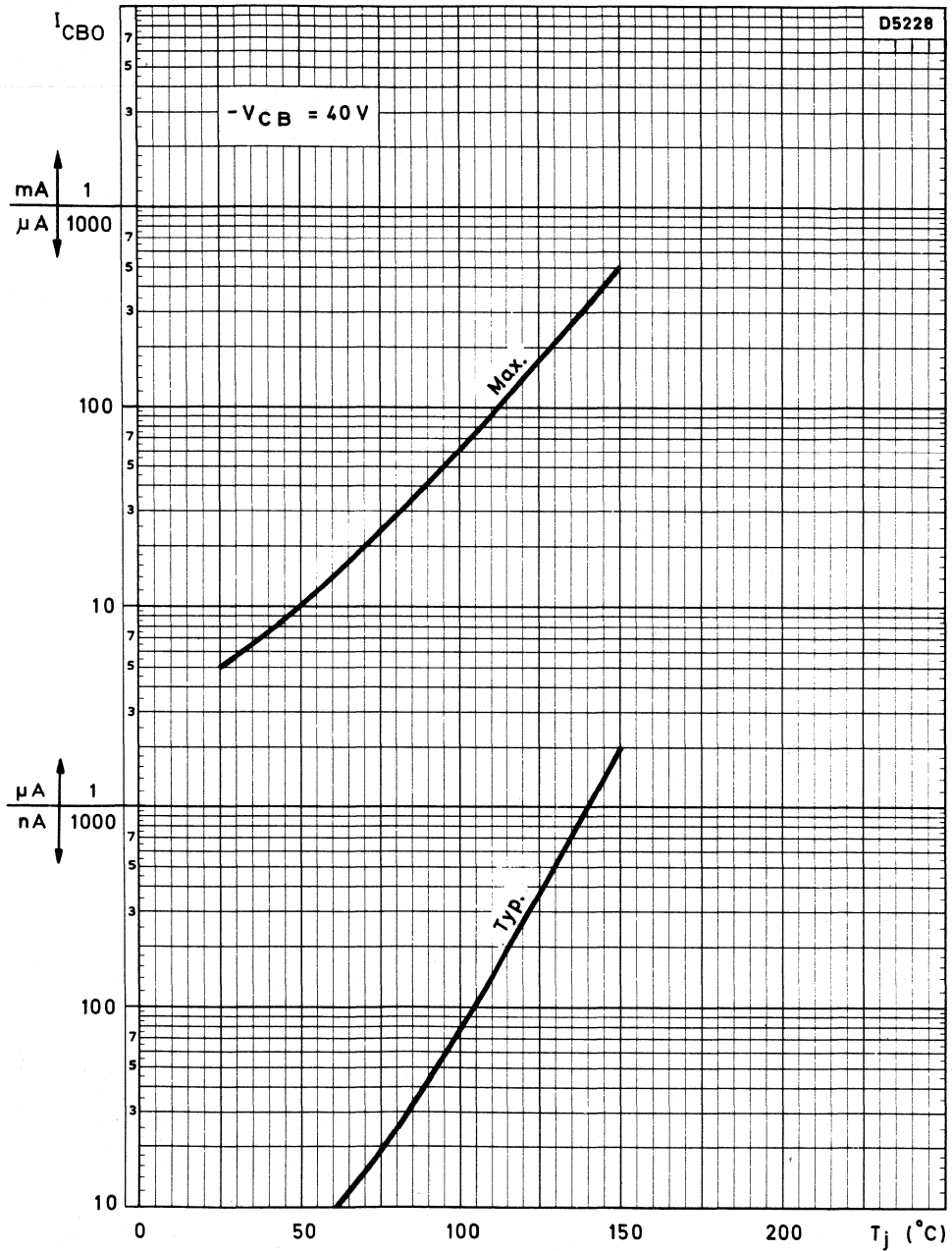


Fig. 8 Collector-base current (open emitter) as a function of the junction temperature.

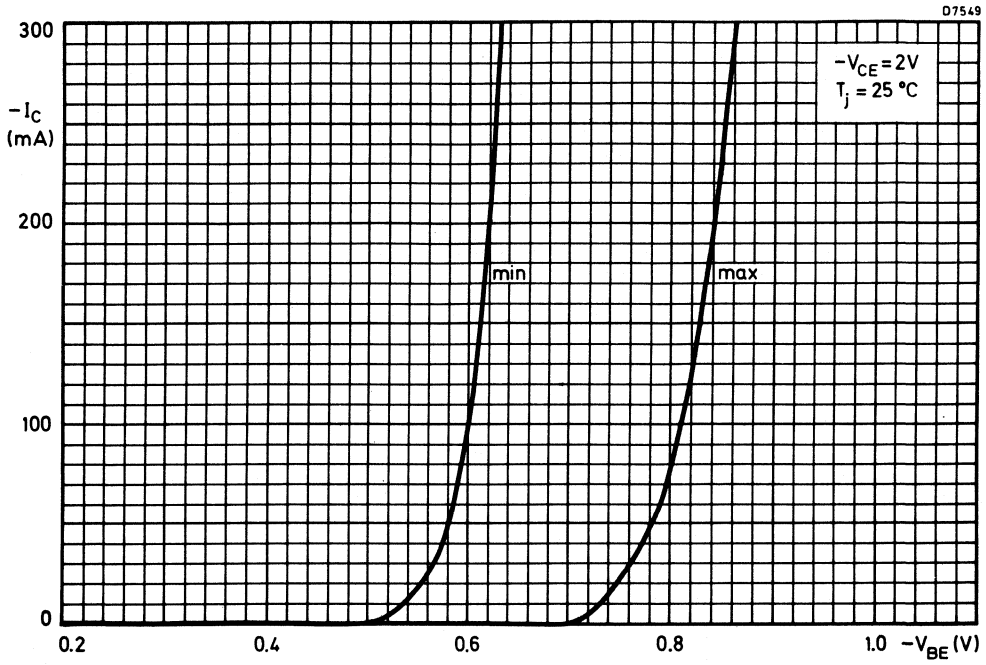


Fig. 9.

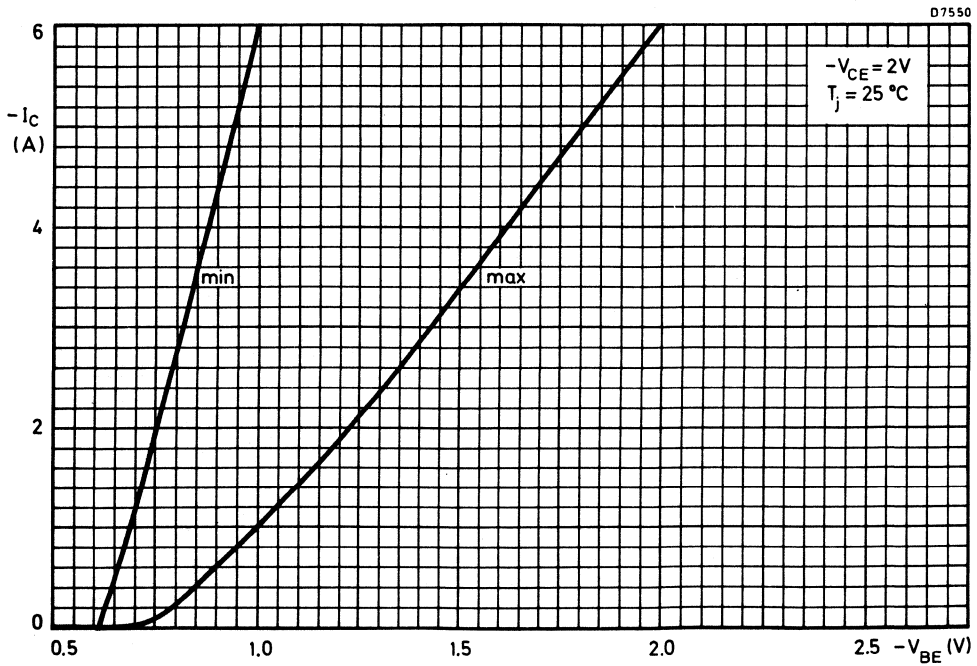


Fig. 10.

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_{CB0} max.	45	60	100 V
Collector-emitter voltage (open base)	V_{CEO} max.	45	60	80 V
Collector-emitter voltage ($R_{BE} = 1 \text{ k}\Omega$)	V_{CER} max.	45	60	100 V
Collector current (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 $T_{mb} = 70 \text{ }^\circ\text{C}$	P_{tot} max.	8	8	8 W
Junction temperature	T_j max.	150	150	150 $^\circ\text{C}$
D.C. current gain	h_{FE}	> 40	40	40
$I_C = 150 \text{ mA}; V_{CE} = 2 \text{ V}$	<	250	250	250
Transition frequency	f_T typ.	250	250	250 MHz
$I_C = 50 \text{ mA}; V_{CE} = 5 \text{ V}$				

MECHANICAL DATA

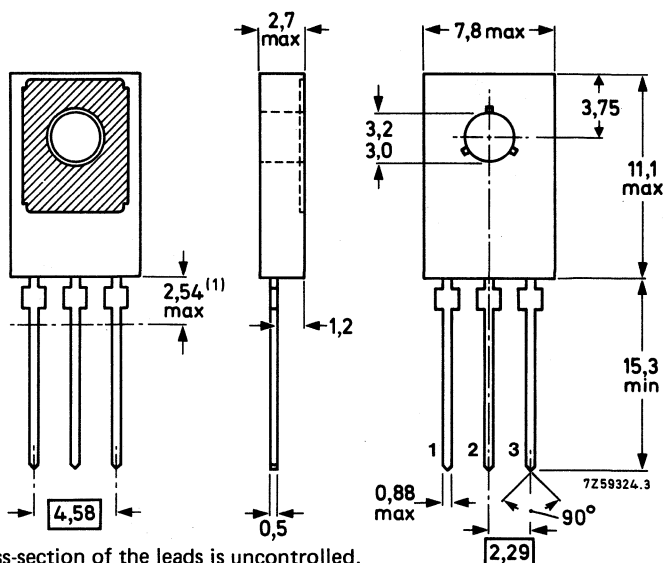
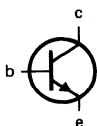
Dimensions in mm

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 ($R_{BE} = 1 \text{ k}\Omega$)	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 $T_{mb} = 70 \text{ }^\circ\text{C}$	P_{tot}	max.		8	W
Storage temperature	T_{stg}			-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

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

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

$I_E = 0; V_{CB} = 30 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$

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

Emitter cut-off current

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

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

Base-emitter voltage

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

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

Saturation voltage

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

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

D.C. current gain

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

$h_{FE} > 25$

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

BDxxx

$h_{FE} \text{ 40 to 250}$

BDxxx-6

$h_{FE} \text{ 40 to 100}$

BDxxx-10

$h_{FE} \text{ 63 to 160}$

BDxxx-16

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

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

$h_{FE} > 25$

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

$I_C = 50 \text{ mA}; V_{CE} = 5 \text{ V}$

$f_T \text{ typ. 250 MHz}$

D.C. current gain ratio of matched pairs

BD135/BD136; BD137/BD138; BD139/BD140

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

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

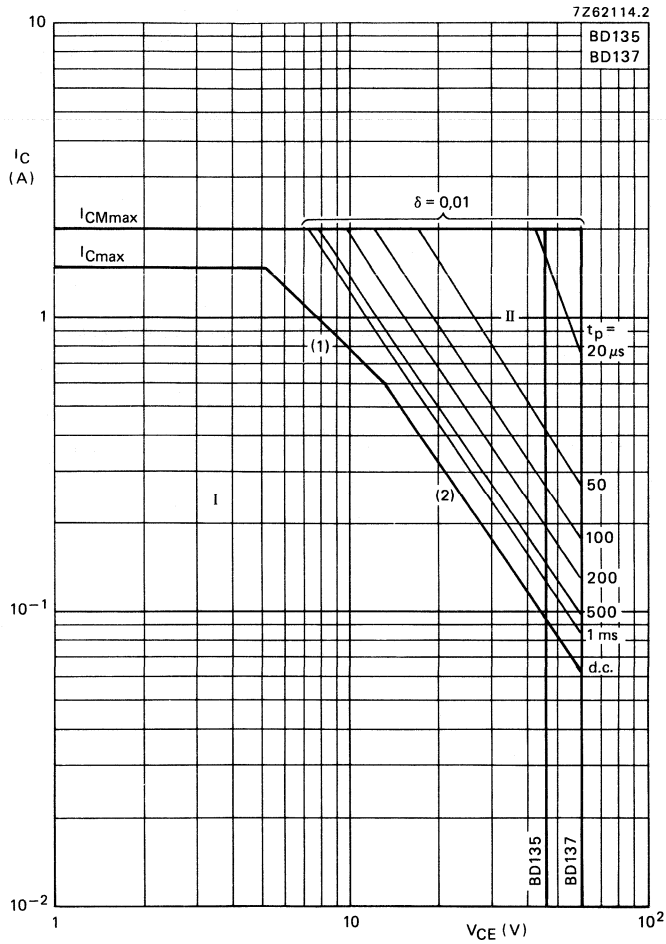


Fig. 2 Safe Operating Area with the transistor forward biased.

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

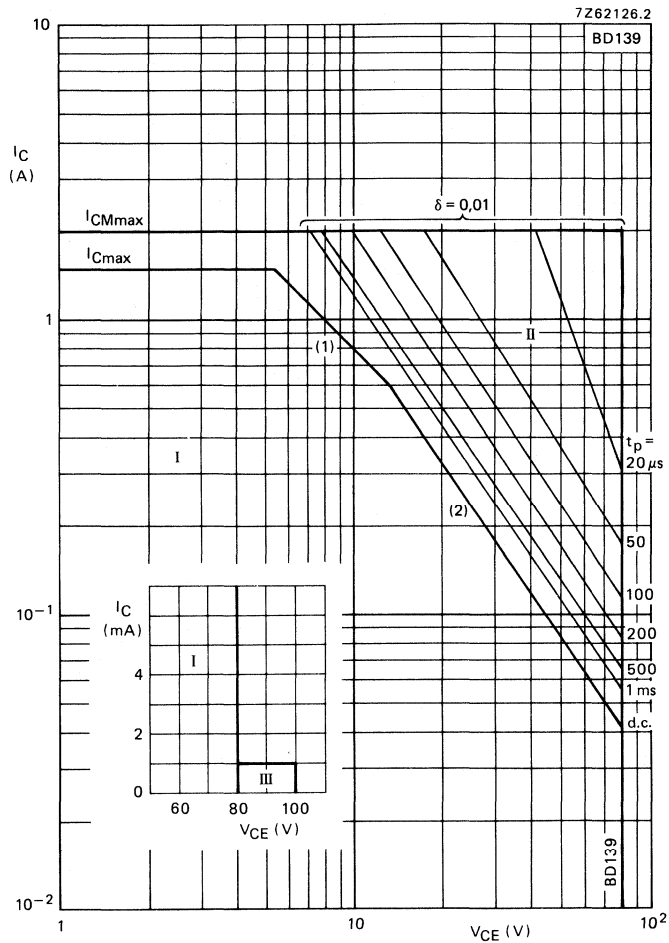


Fig. 3 Safe Operating Area with the transistor forward biased.

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

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

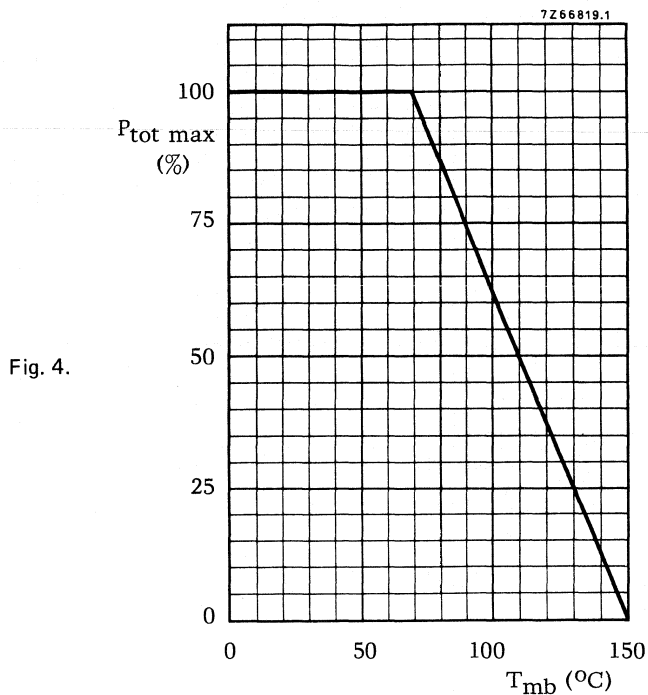


Fig. 4.

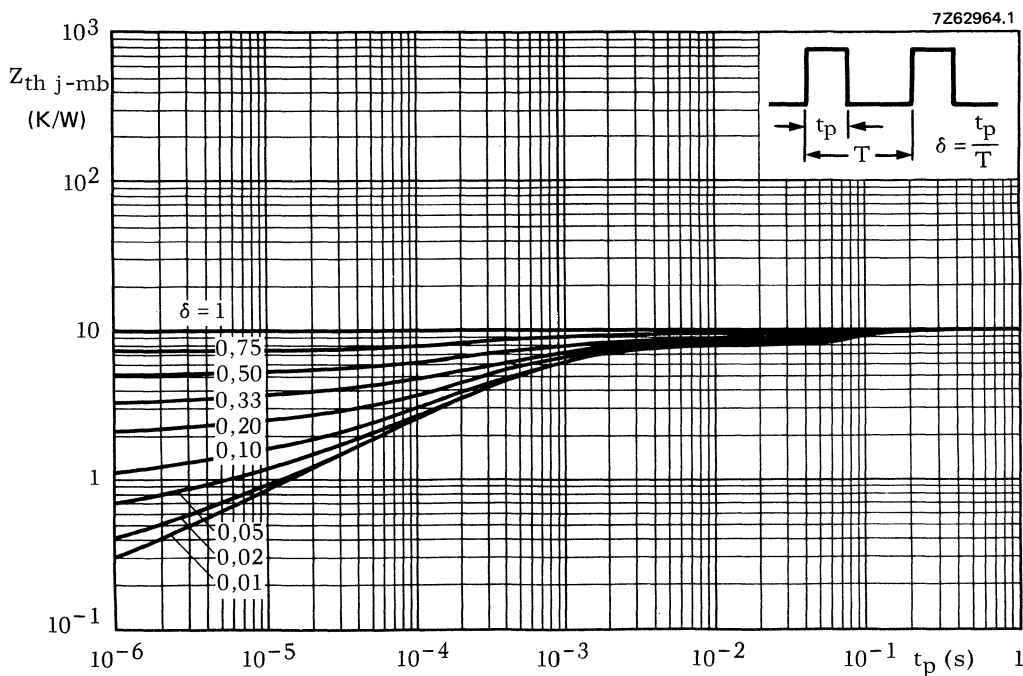


Fig. 5.

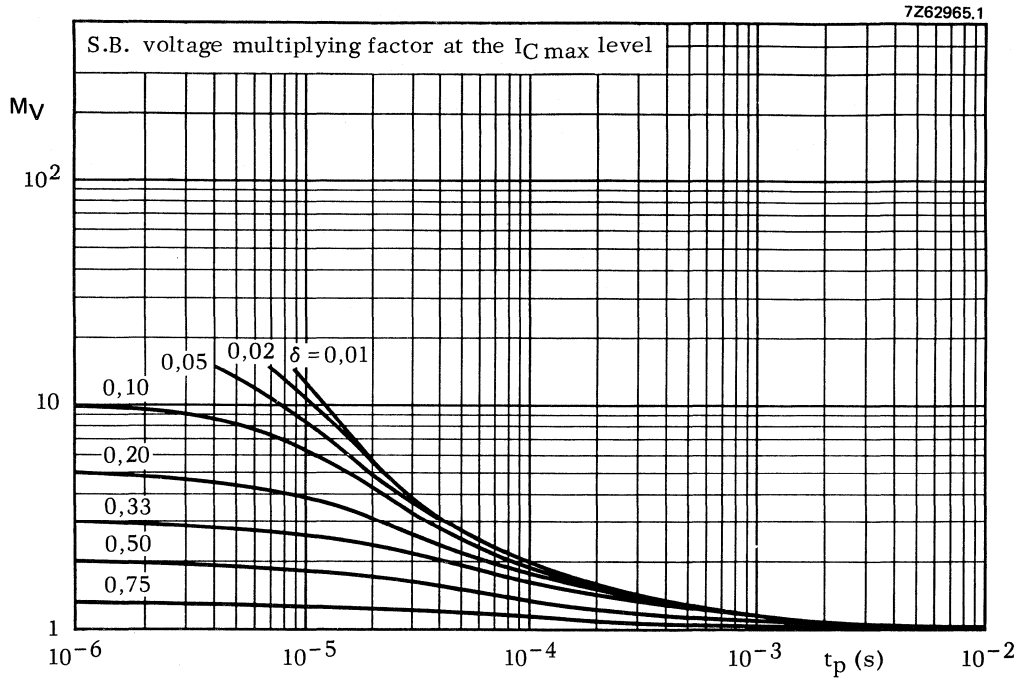


Fig. 6.

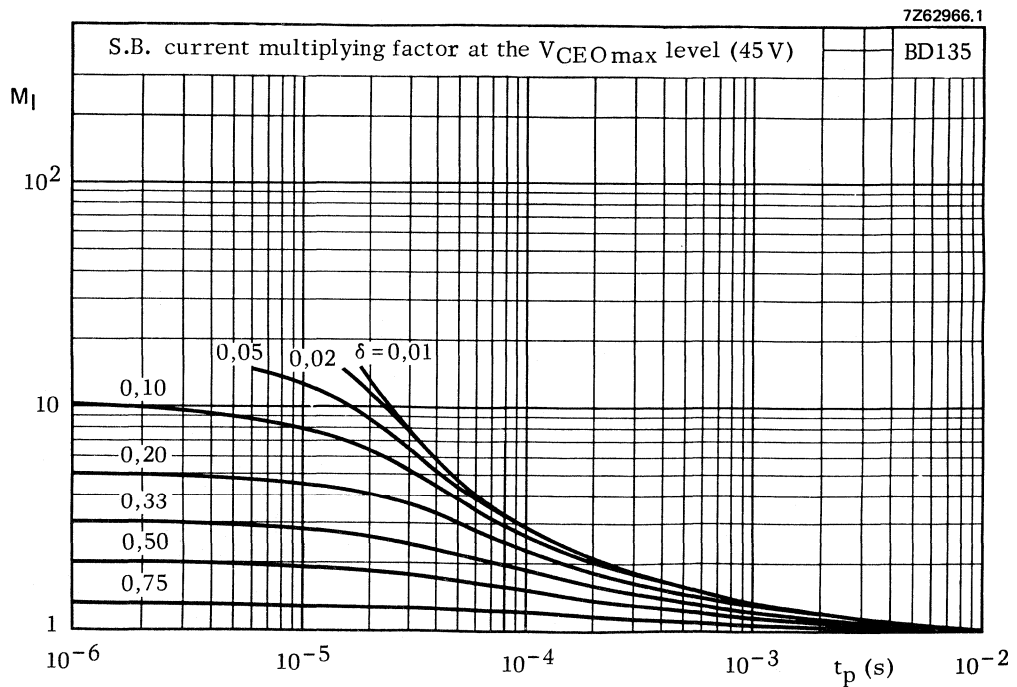
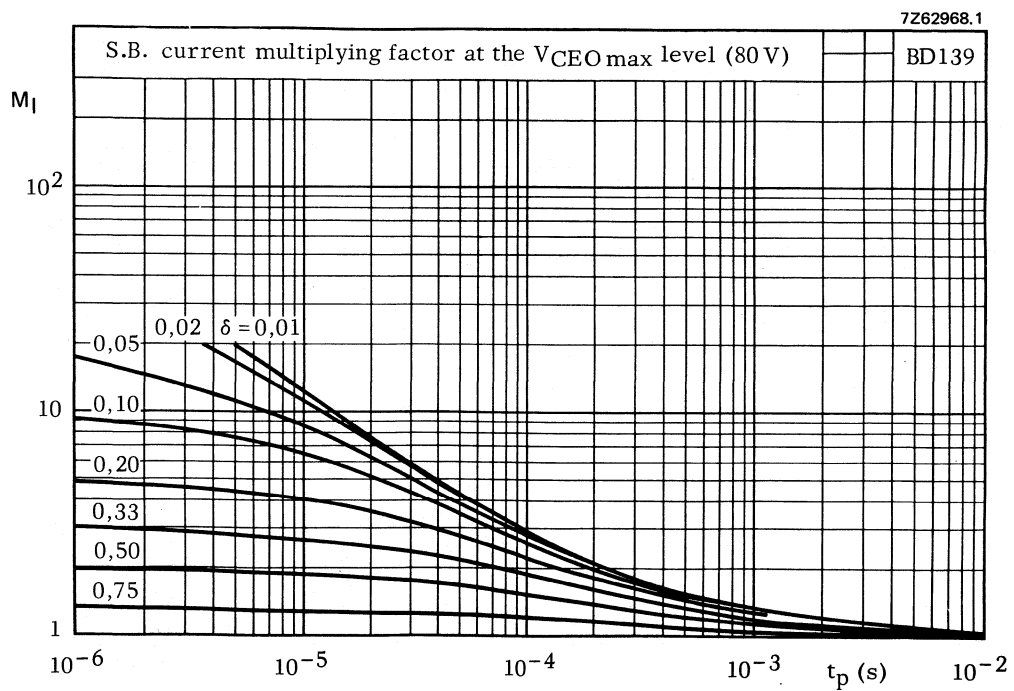
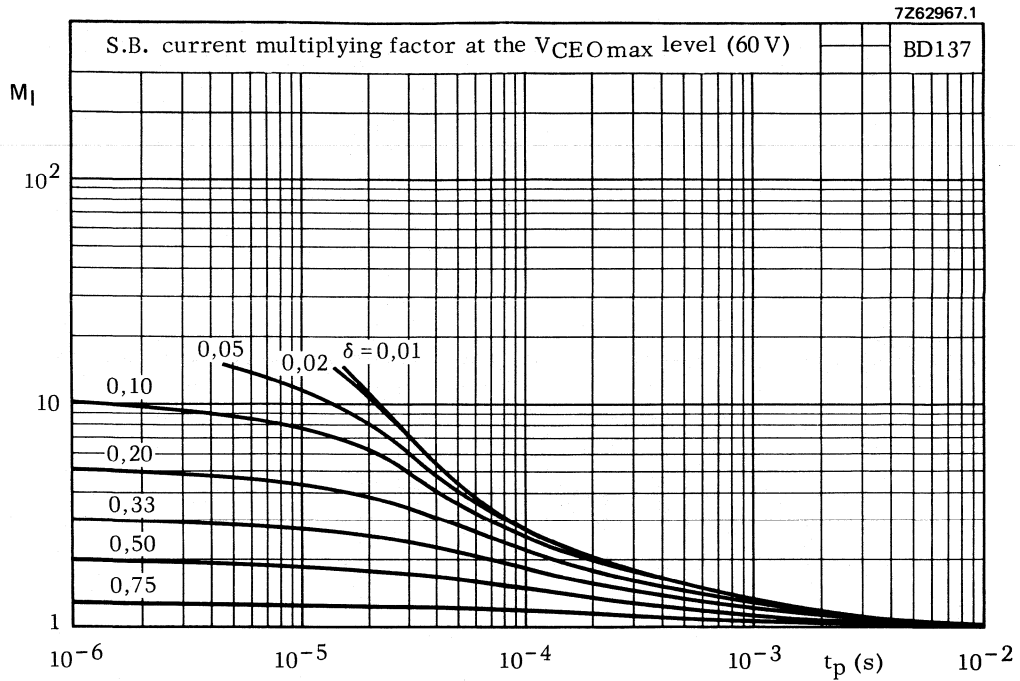


Fig. 7.



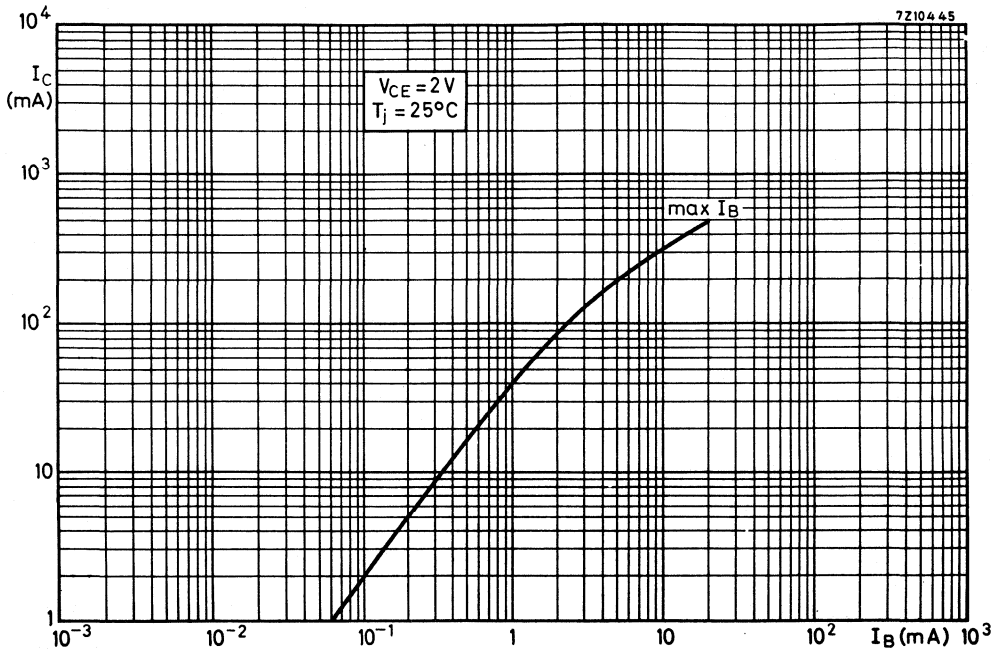


Fig. 10.

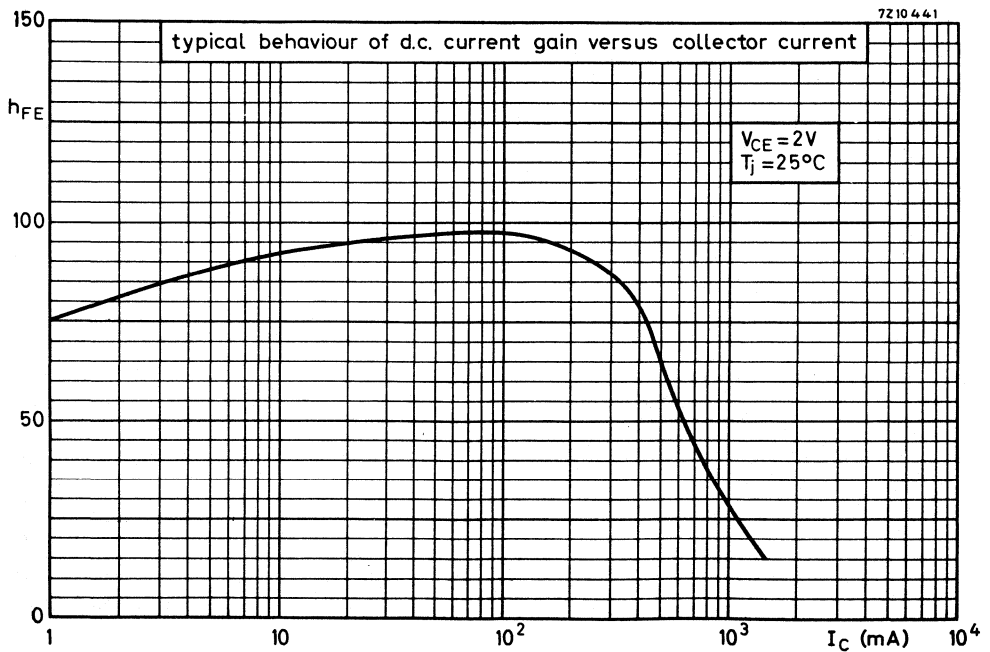


Fig. 11.

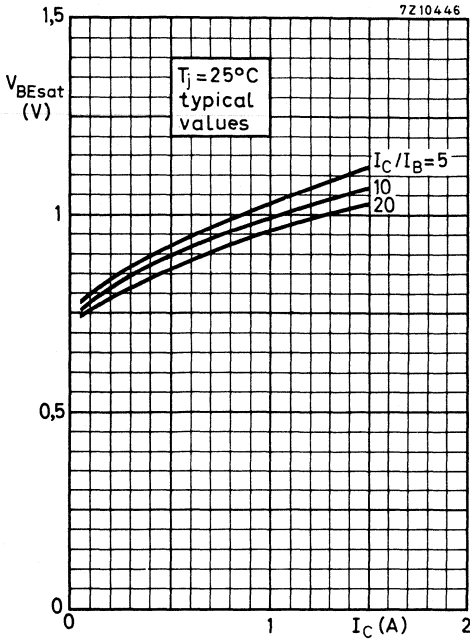


Fig. 12.

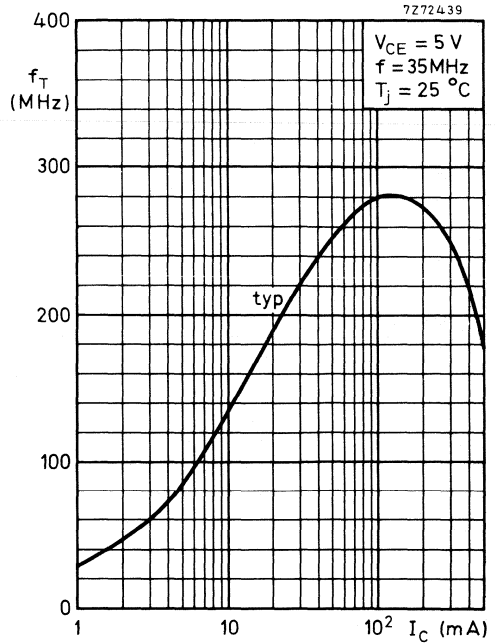


Fig. 13.

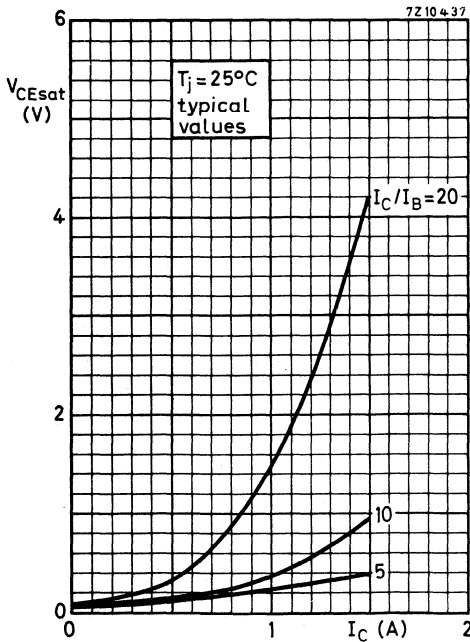


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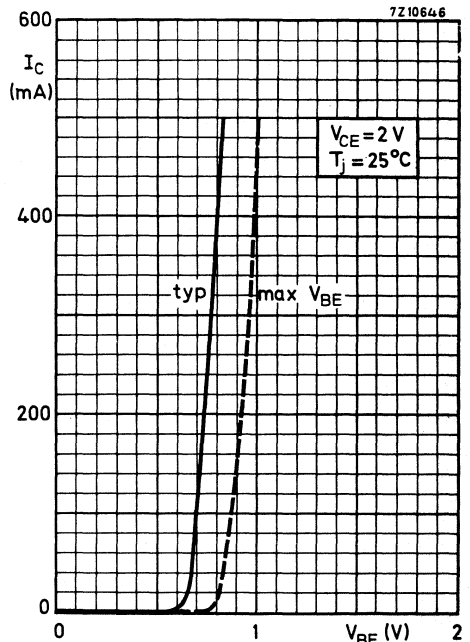


Fig. 15.

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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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 $T_{mb} = 70 \text{ }^\circ\text{C}$	P_{tot}	max.	8	8	8 W
Junction temperature	T_j	max.	150	150	150 $^\circ\text{C}$
D.C. current gain					
$-I_C = 150 \text{ mA}; -V_{CE} = 2 \text{ V}$	h_{FE}	$>$	40	40	40
		$<$	250	250	250
Transition frequency					
$-I_C = 50 \text{ mA}; -V_{CE} = 5 \text{ V}$	f_T	typ.	75	75	75 MHz

MECHANICAL DATA

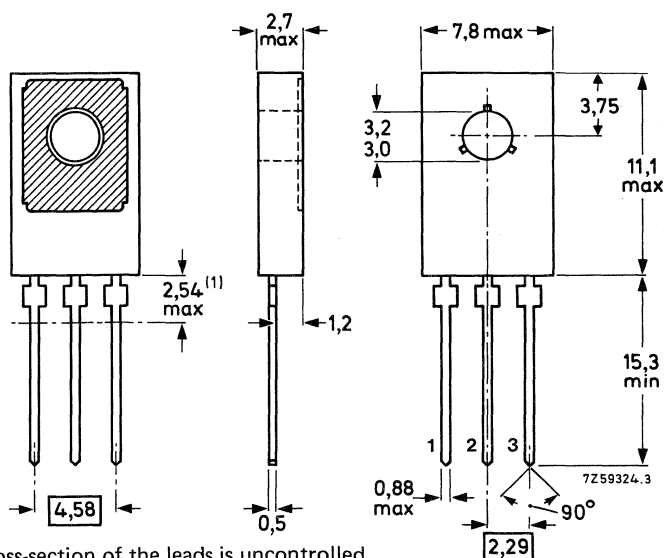
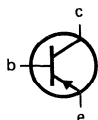
Dimensions in mm

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)	$-V_{CB0}$	max.	45	60	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80 V
Collector-emitter voltage ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	max.	45	60	100 V
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 $T_{mb} = 70 \text{ }^\circ\text{C}$	P_{tot}	max.	8		W
Storage temperature	T_{stg}		-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = 30 \text{ V}$	$-I_{CBO}$	<	100 nA
$I_E = 0; -V_{CB} = 30 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$	$-I_{CBO}$	<	10 μA

Emitter cut-off current

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

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

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

D.C. current gain

$-I_C = 5 \text{ mA}; -V_{CE} = 2 \text{ V}$	h_{FE}	>	25
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$-I_C = 150 \text{ mA}; -V_{CE} = 2 \text{ V}$

BDxxx	h_{FE}		40 to 250
-------	----------	--	-----------

BDxxx-06	h_{FE}		40 to 100
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BDxxx-10	h_{FE}		63 to 160
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BDxxx-16	h_{FE}		100 to 250
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$-I_C = 500 \text{ mA}; -V_{CE} = 2 \text{ V}$	h_{FE}	>	25
--	----------	---	----

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

$-I_C = 50 \text{ mA}; -V_{CE} = 5 \text{ V}$	f_T	typ.	75 MHz
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D.C. current gain ratio of matched pairs

BD135/BD136; BD137/BD138; BD139/BD140	h_{FE1}/h_{FE2}	typ.	1,3
---------------------------------------	-------------------	------	-----

$ I_C = 150 \text{ mA}; V_{CE} = 2 \text{ V}$	h_{FE1}/h_{FE2}	<	1,6
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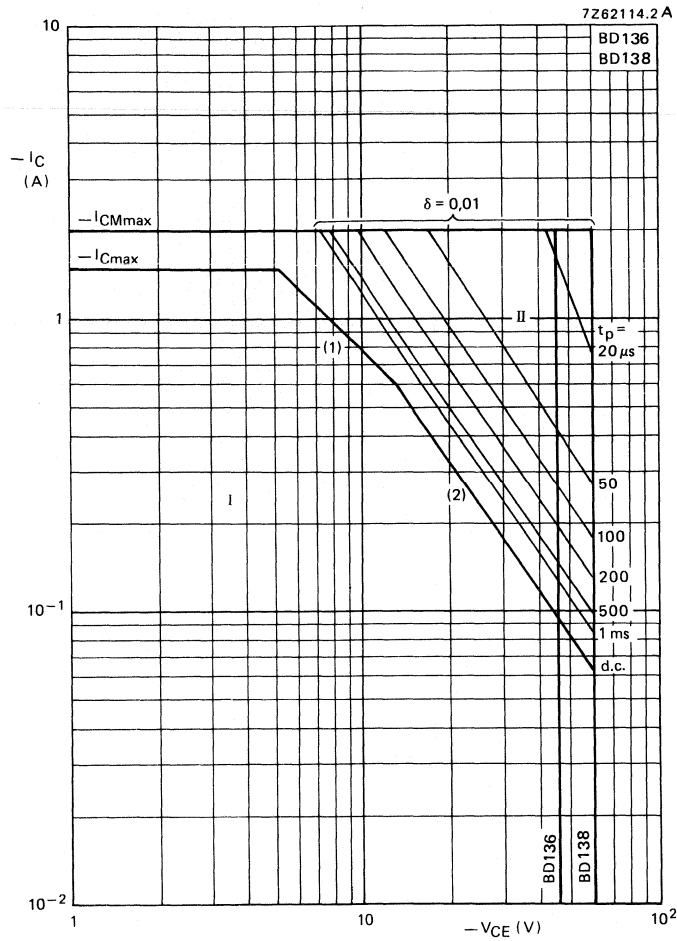


Fig. 2 Safe Operating Area with the transistor forward biased.

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

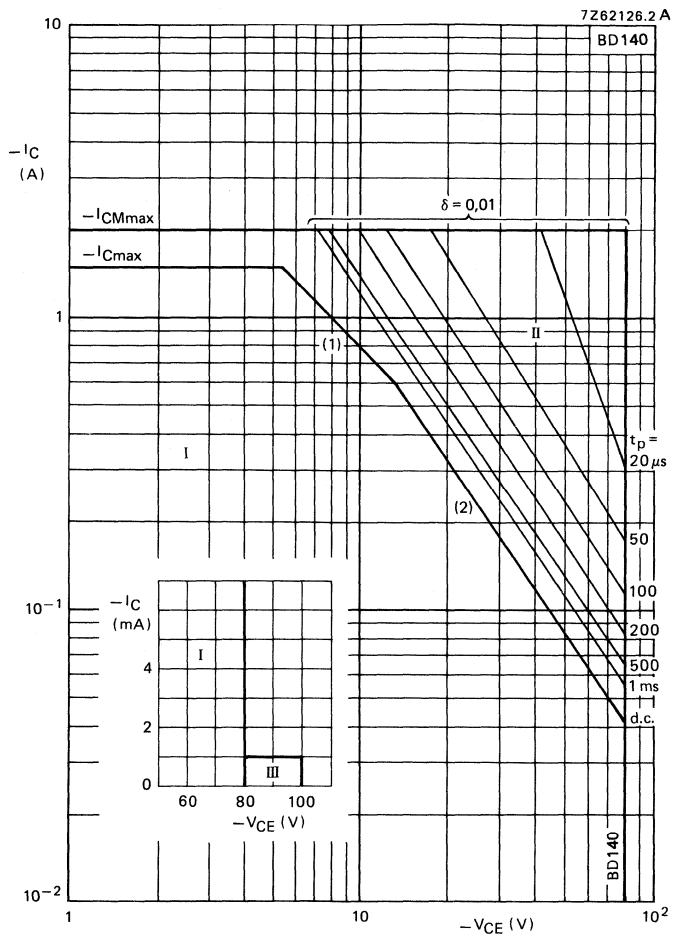


Fig. 3 Safe Operating Area with the transistor forward biased.

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

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

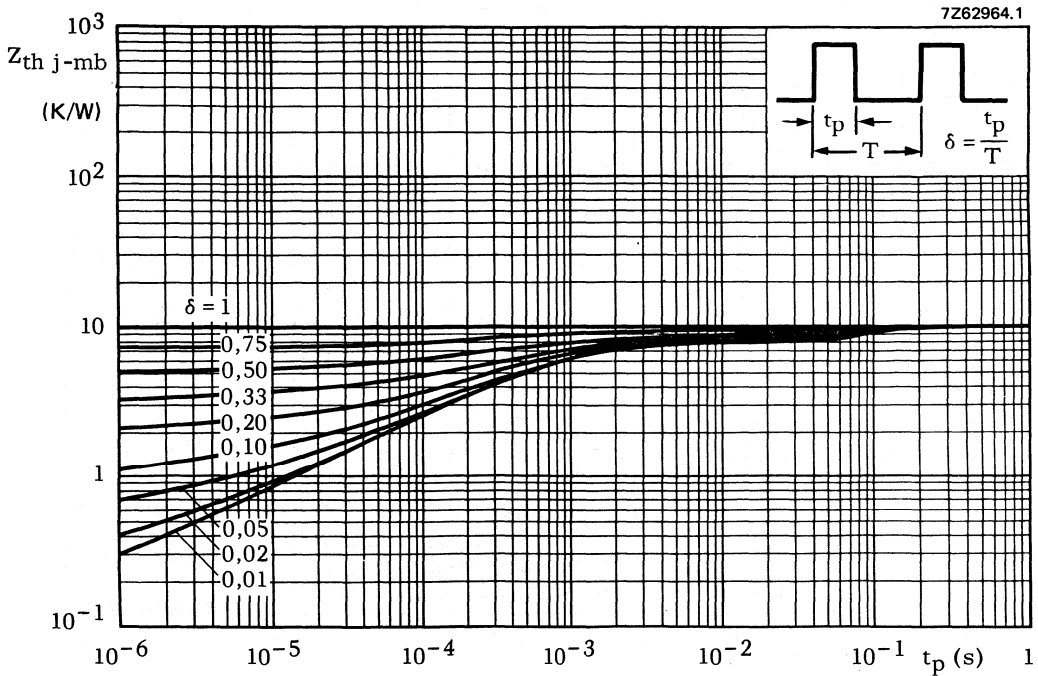
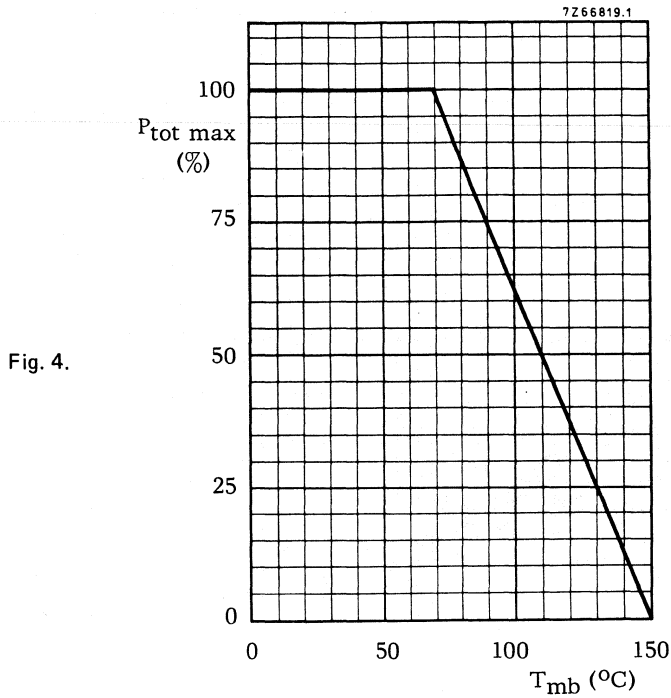


Fig. 5.

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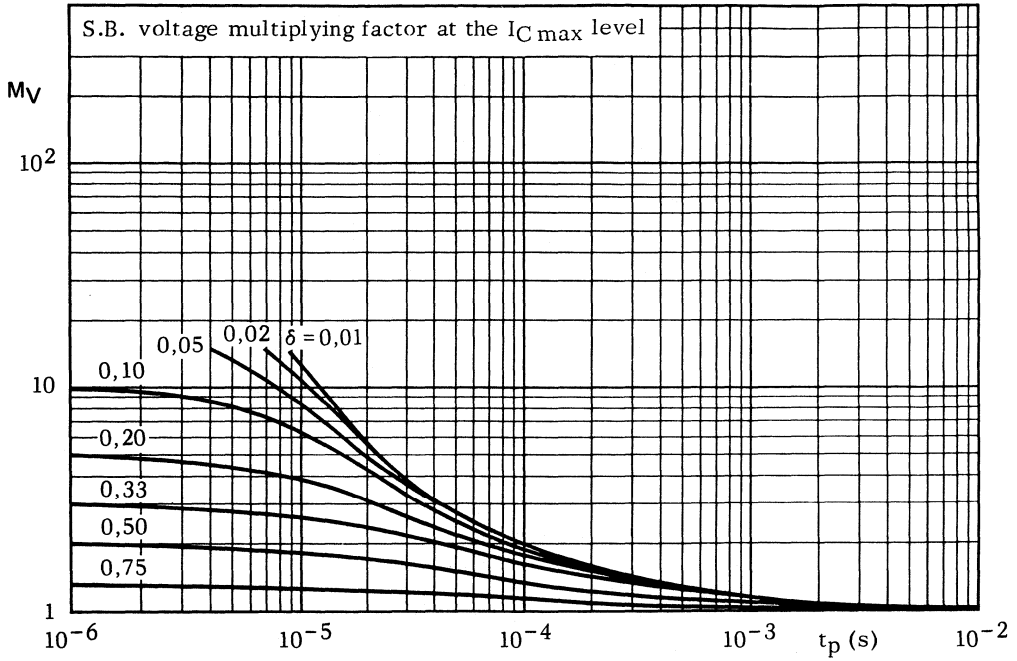


Fig. 6.

7Z62966A

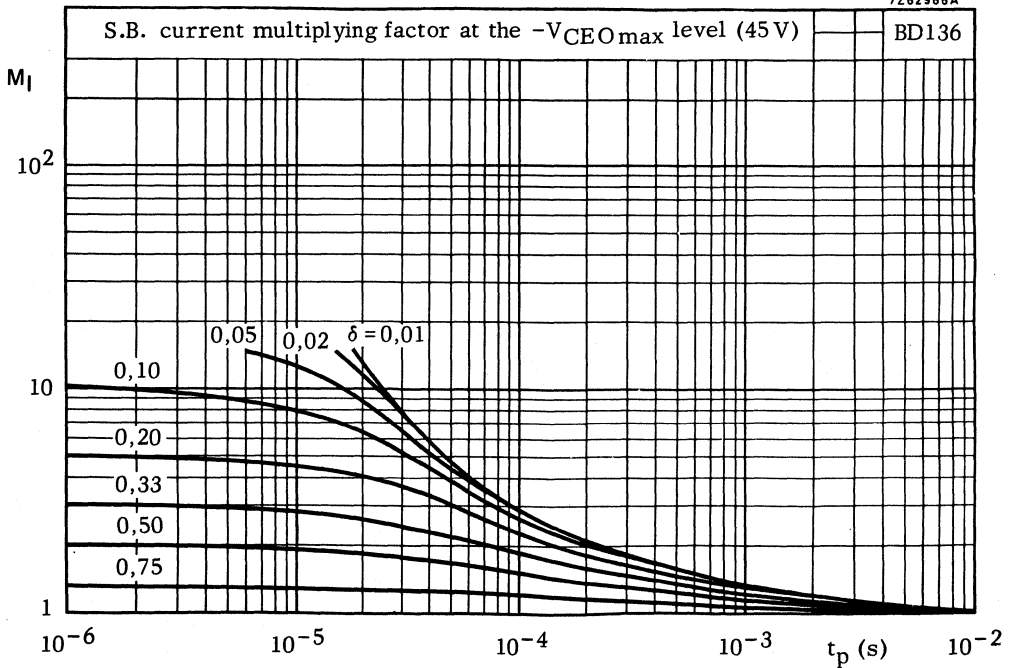
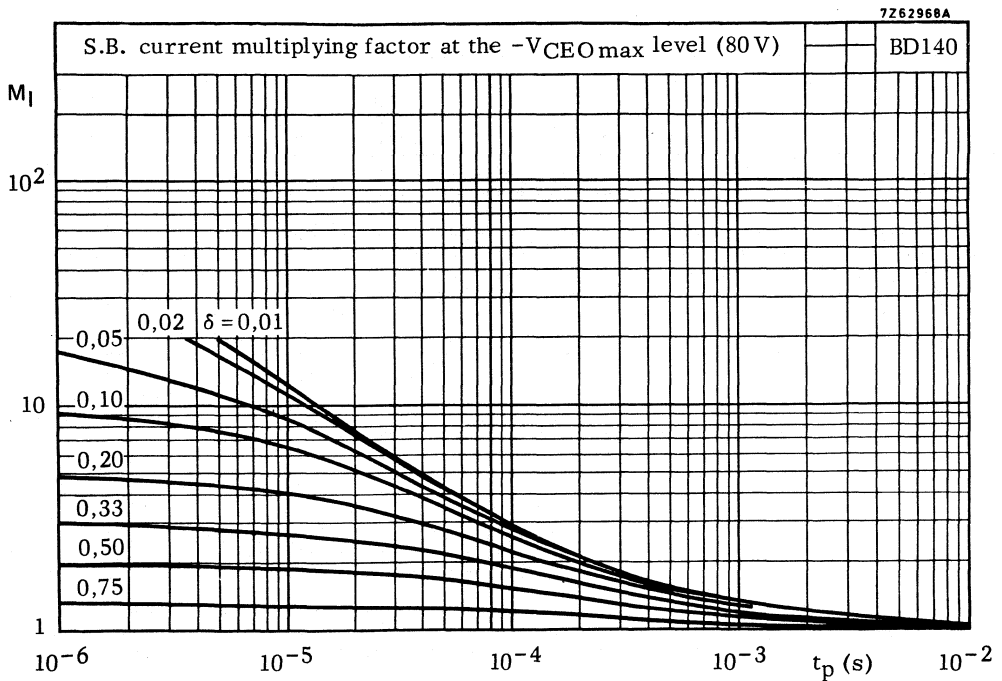
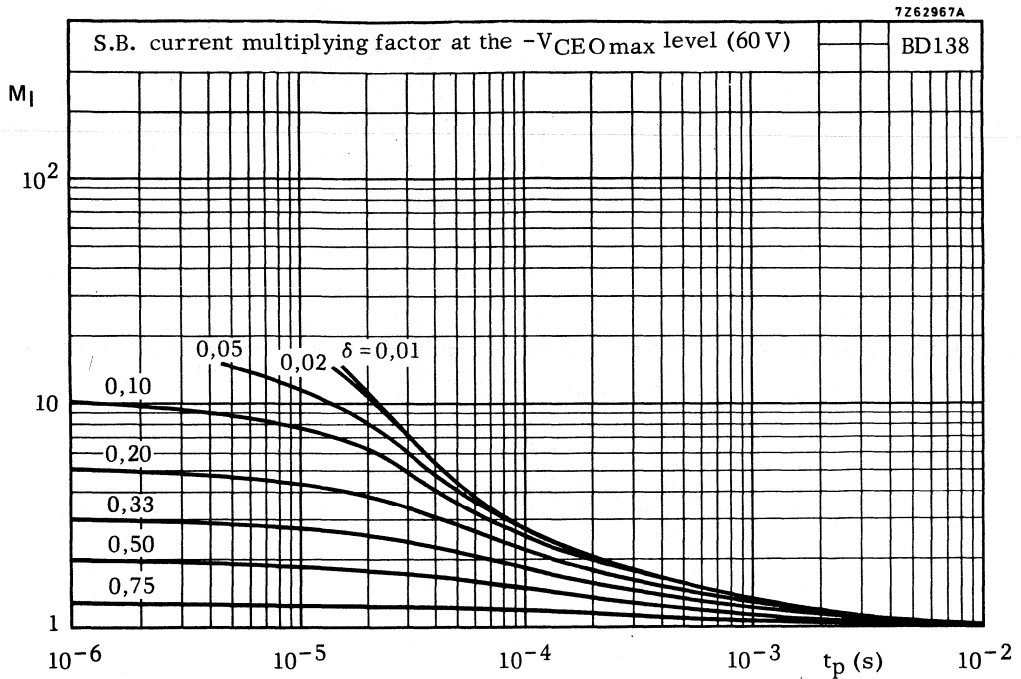


Fig. 7.



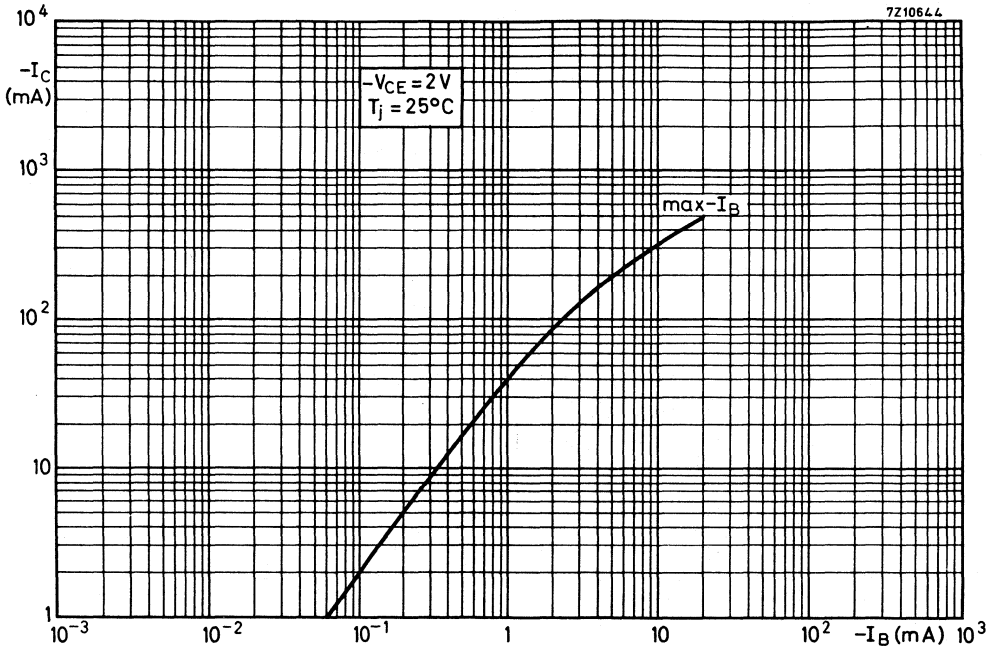


Fig. 10.

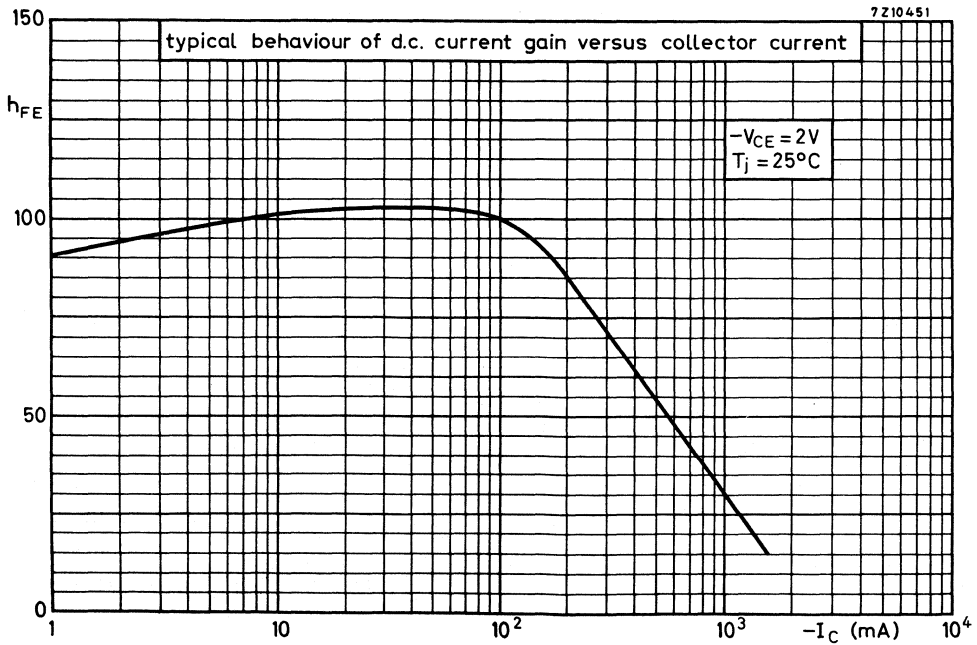


Fig. 11.

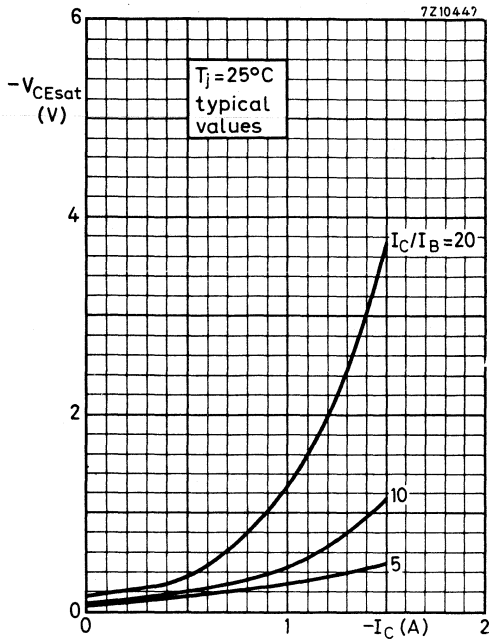


Fig. 12.

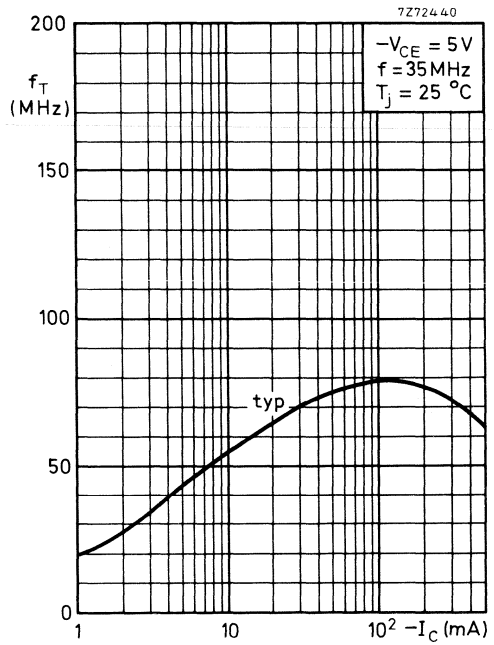


Fig. 13.

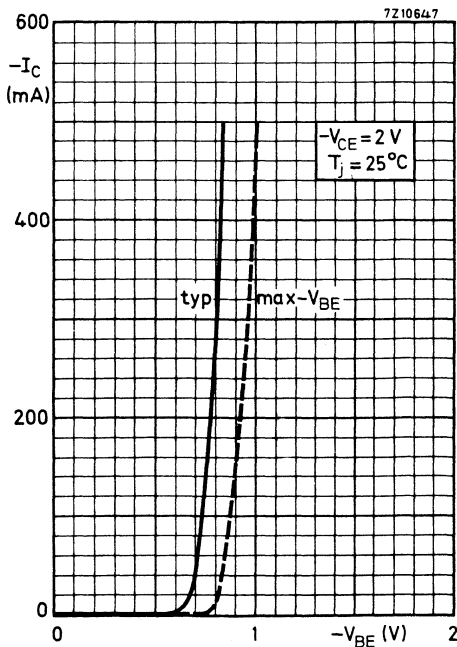


Fig. 14.

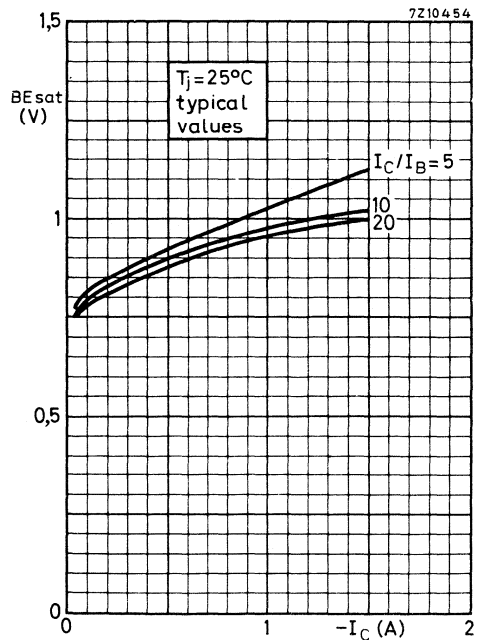


Fig. 15.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a plastic envelope. With their p-n-p 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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	60		W
Cut-off frequency $I_C = 0,3\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe}	>	25		kHz

MECHANICAL DATA

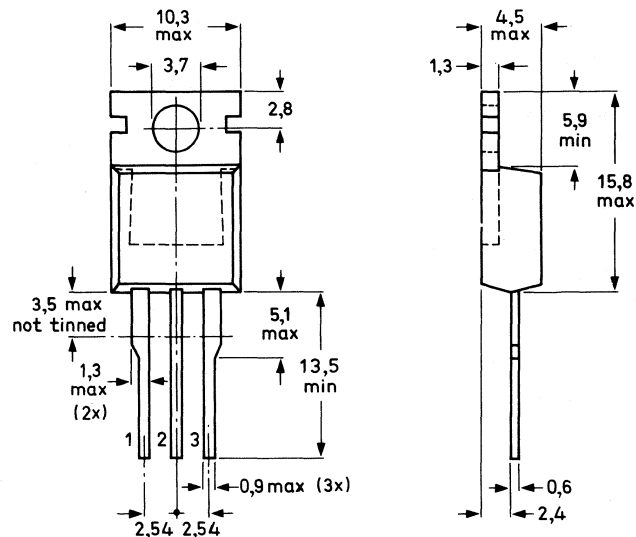
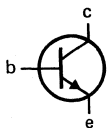
Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



7265872.5

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, $t_p \leq 10$ ms)	I_{CM}	max.		12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ 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	$R_{th\ j-mb}$	=		2,08	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		70	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current $I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<		0,2	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<		1	mA
Emitter cut-off current $I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<		0,5	mA
Base-emitter voltage* $I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<		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}	<		1	V
$I_C = 6$ A; $I_B = 0,6$ A	V_{CEsat}	<		1,5	V
	V_{BEsat}	<		2	V
D.C. current gain* BD201; $I_C = 3$ A; $V_{CE} = 2$ V	h_{FE}	>		30	
BD203; $I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>		30	
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>		30	
Cut-off frequency $I_C = 0,3$ A; $V_{CE} = 3$ V	f_{hfe}	>		25	kHz

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

Transition frequency at $f = 1 \text{ MHz}$

$I_C = 0,3 \text{ A}; V_{CE} = 3 \text{ V}$

$f_T > 7 \text{ MHz}$

D.C. current gain ratio of matched complementary pairs

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

$h_{FE1}/h_{FE2} < 2,5$

Forward bias second breakdown collector current

$V_{CE} = 40 \text{ V}; t_p = 0,1 \text{ s}; T_{amb} = 25 \text{ }^\circ\text{C}$

$I_{(SB)} > 1,5 \text{ A}$

Switching times

$I_{Con} = 2 \text{ A}; I_{B on} = -I_{B off} = 0,2 \text{ A}$

Turn-on time

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

Turn-off time

$t_{off} < 4 \text{ } \mu\text{s}$

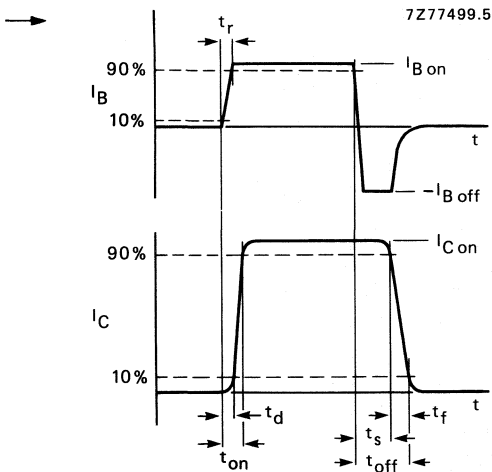


Fig. 2 Switching time waveforms.

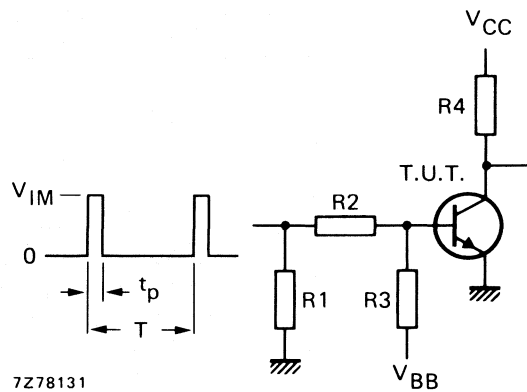


Fig. 3 Switching times test circuit.

$V_{IM} = 15 \text{ V}$	$R3 = 22 \text{ } \Omega$
$V_{CC} = 20 \text{ V}$	$R4 = 10 \text{ } \Omega$
$V_{BB} = -4 \text{ V}$	$t_r = t_f \leq 15 \text{ ns}$
$R1 = -$	$t_p = 20 \text{ } \mu\text{s}$
$R2 = 33 \text{ } \Omega$	$T = 500 \text{ } \mu\text{s}$

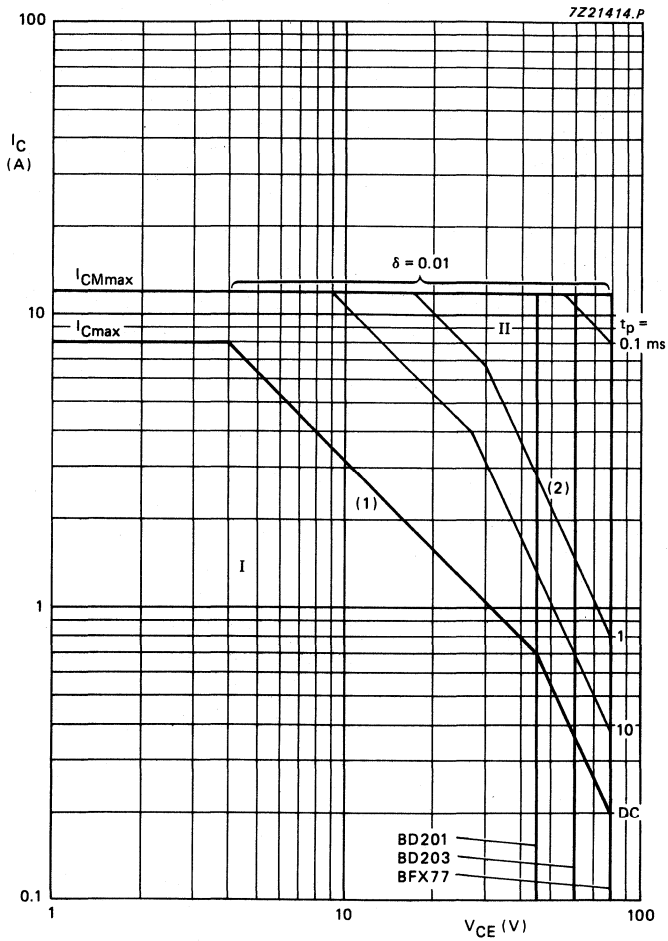


Fig. 4 Safe Operating Area, $T_{mb} \leq 25^{\circ}\text{C}$.

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

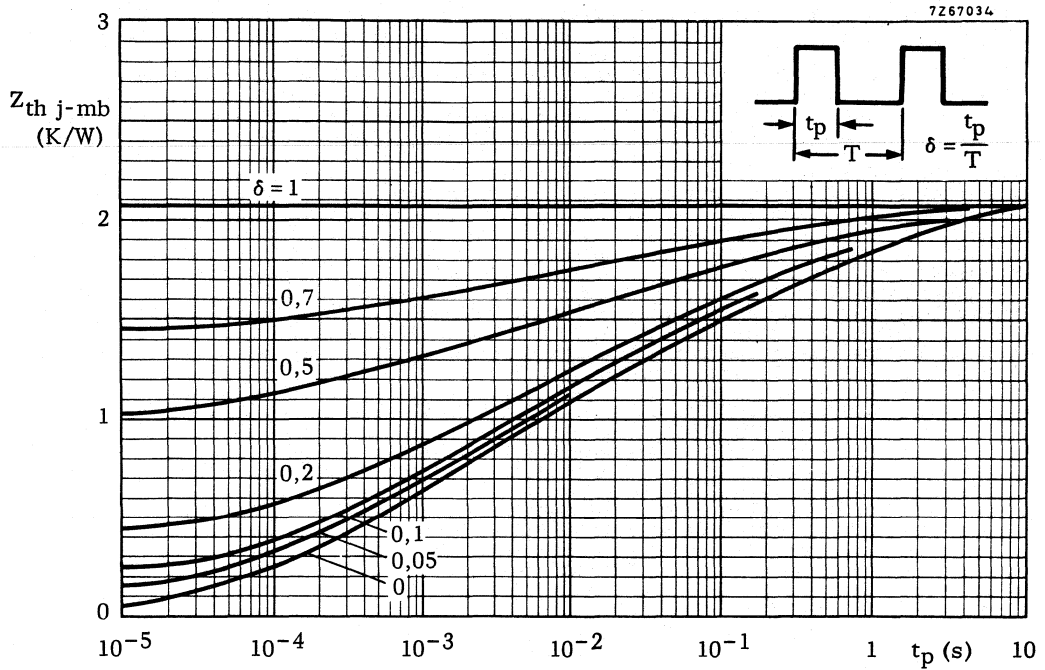


Fig. 5 Pulse power rating chart.

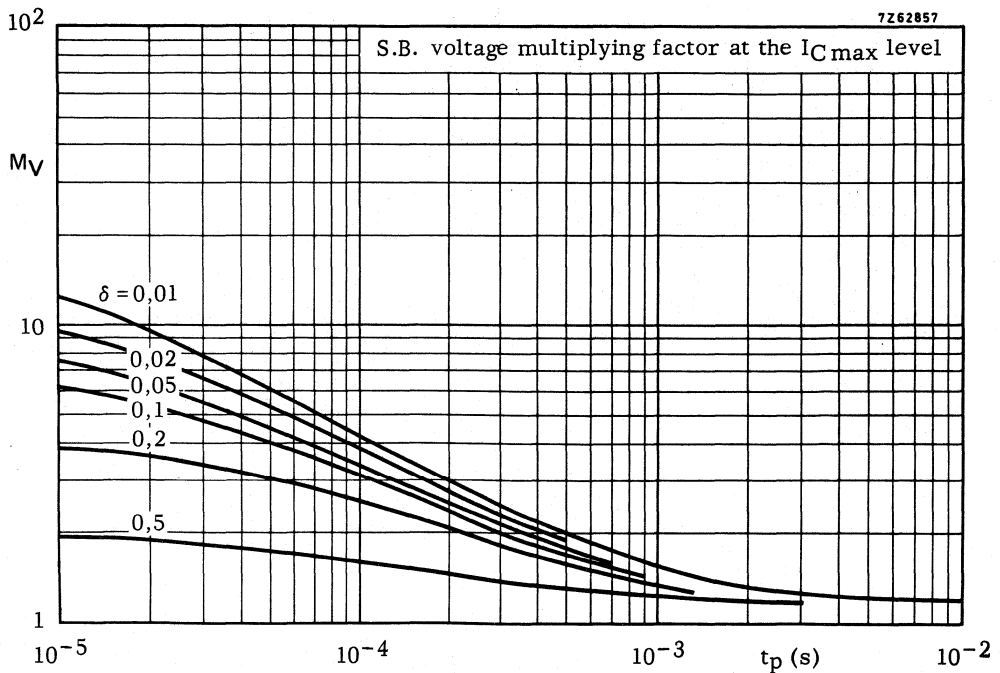


Fig. 6 S.B. voltage multiplying factor at the I_{Cmax} level.

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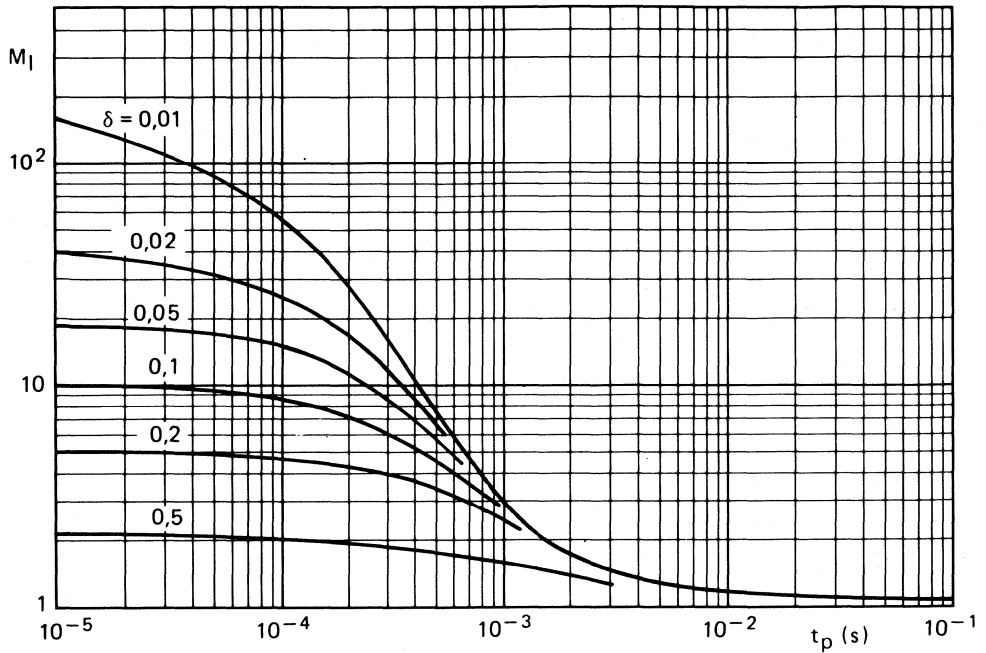


Fig. 7 S.B. current multiplying factor at the $V_{CE0 \max}$ level.

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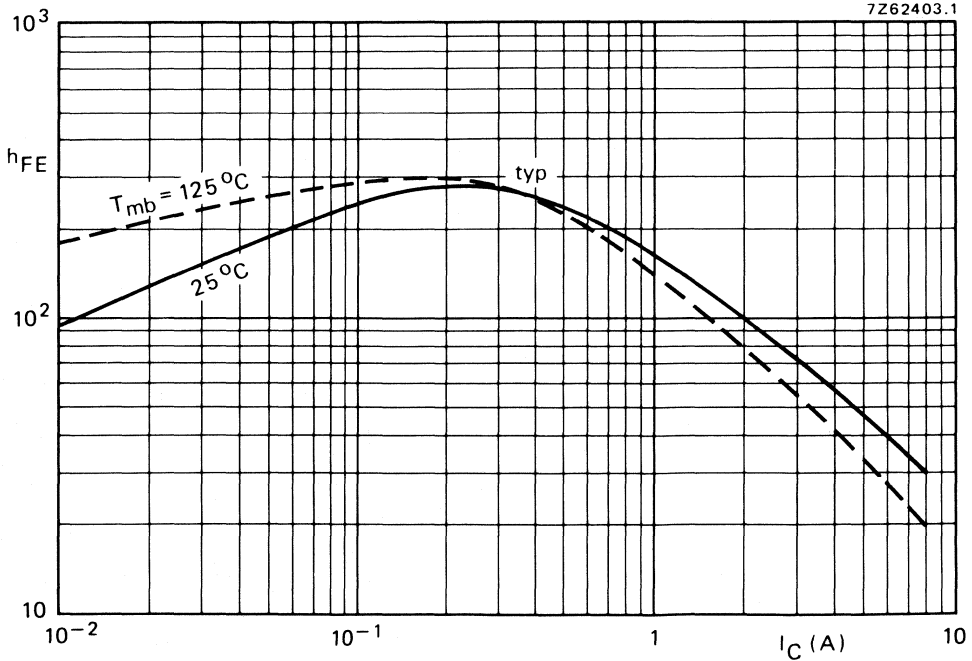


Fig. 8 D.C. current gain. $V_{CE} = 2$ V.

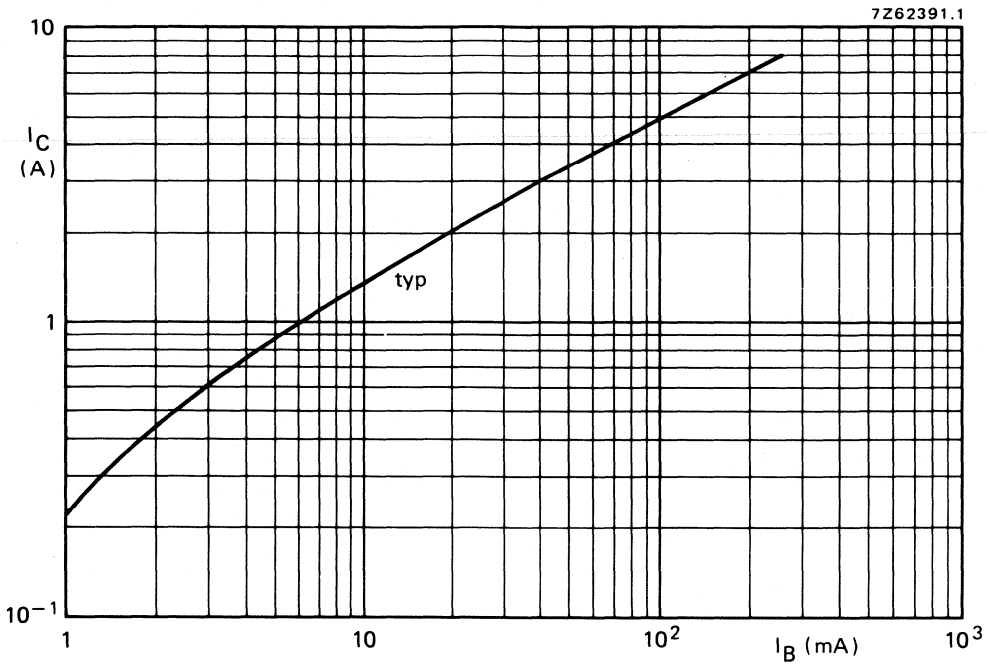


Fig. 9 Collector current as a function of base current. $V_{CE} = 2$ V; $T_j = 25$ °C.

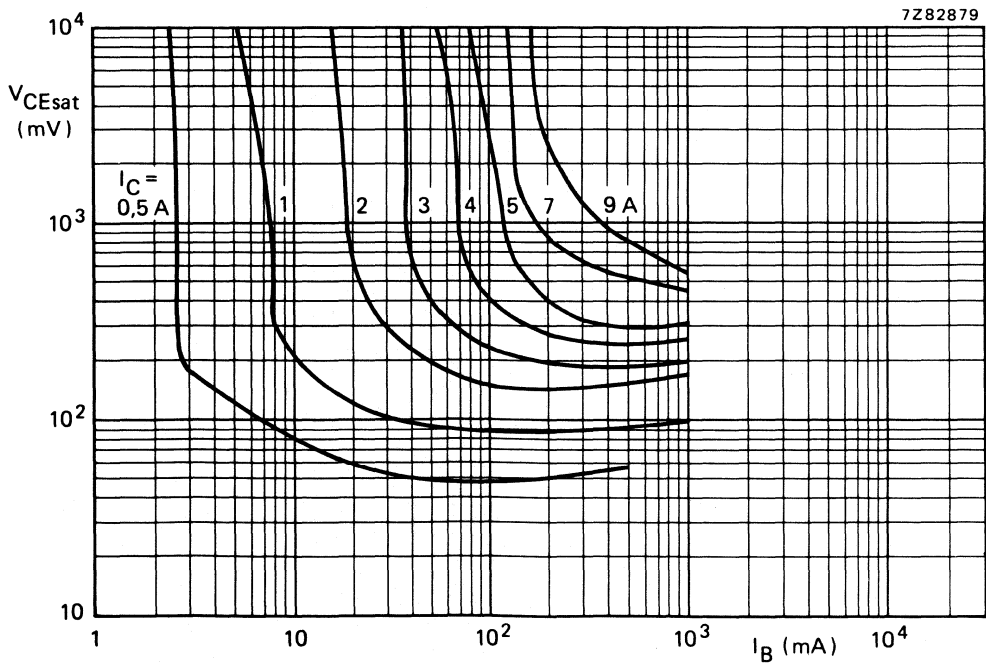


Fig. 10 Typical collector-emitter saturation voltage. $T_j = 25$ °C.

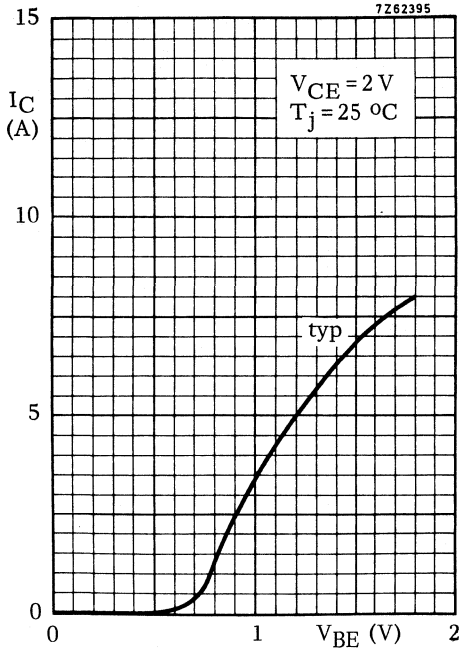


Fig. 11.

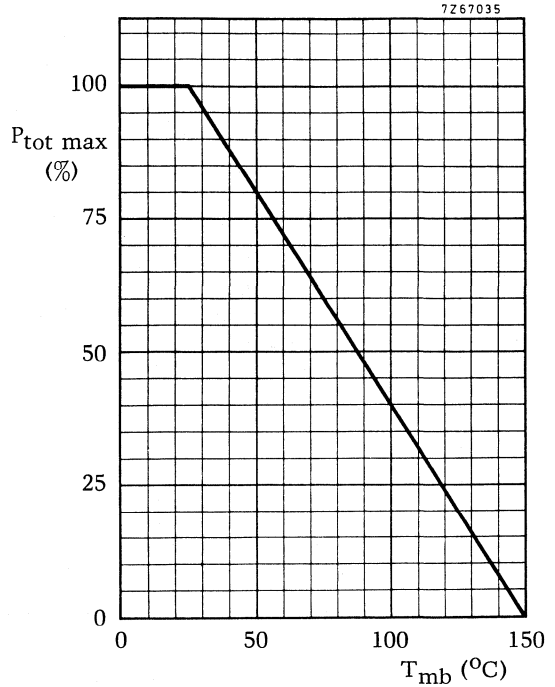


Fig. 12.

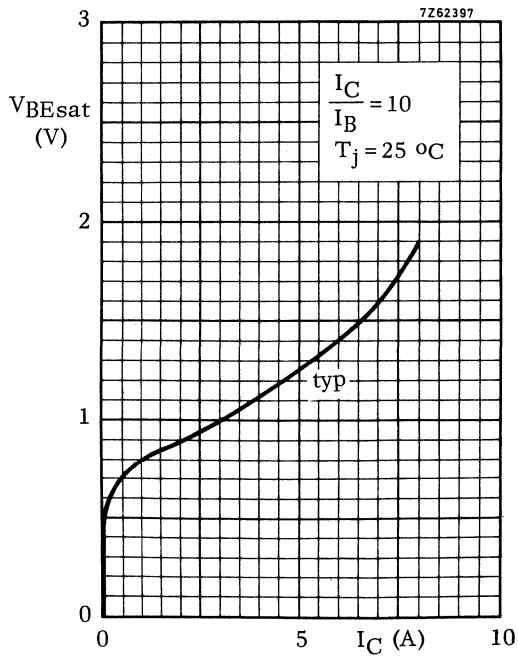


Fig. 13.

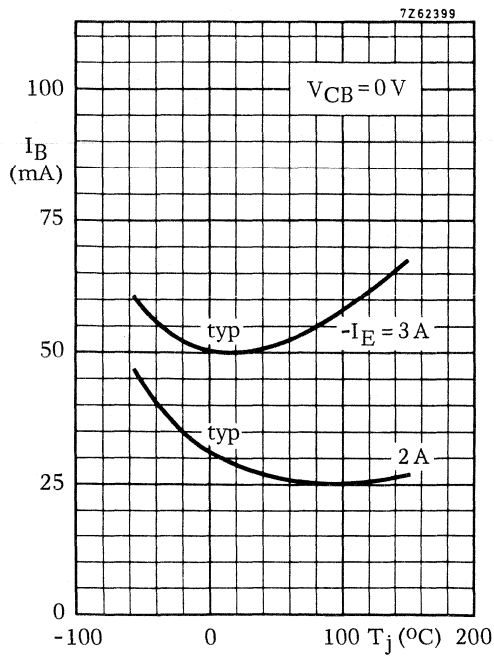


Fig. 14.

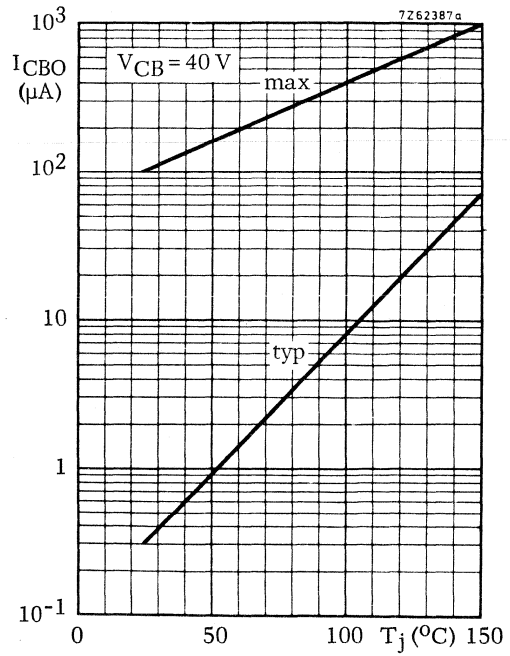


Fig. 15.

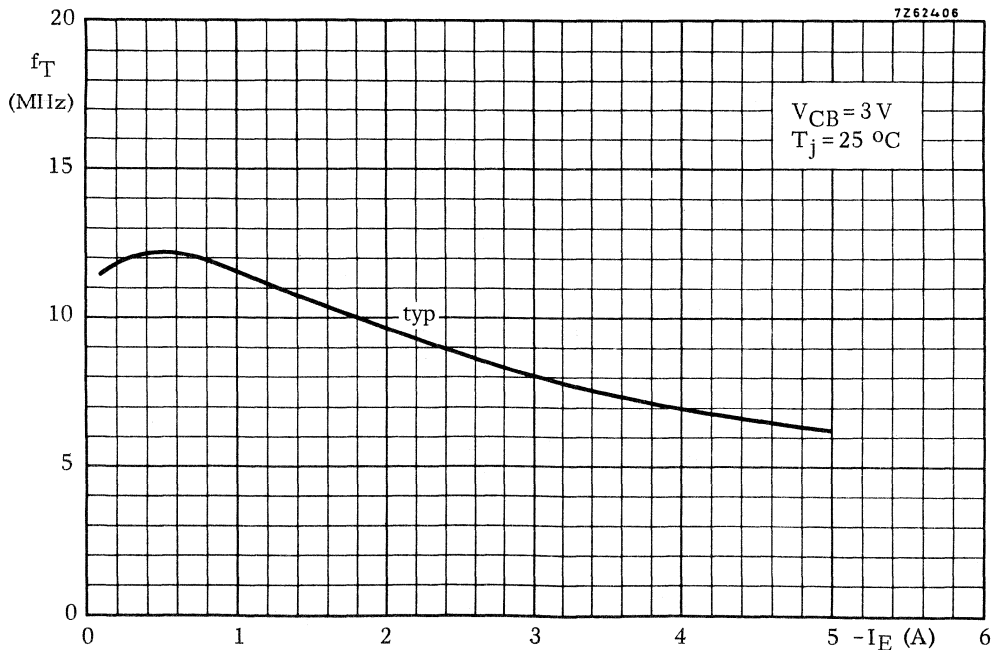


Fig. 16.

SILICON EPITAXIAL POWER TRANSISTORS

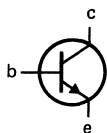
NPN Silicon power transistors in a SOT186 envelope with an electrically insulated mounting base.
PNP complements are BD202F, BD204F and BDX78F.

QUICK REFERENCE DATA

			BD201F	BD203F	BDX77F
Collector-base voltage (open emitter)	V_{CB0}	max.	60	60	100 V
Collector-emitter voltage (open base)	V_{CE0}	max.	45	60	80 V
Emitter-base voltage (open collector)	V_{EB0}	max.		5	V
Collector current DC	I_C	max.		8	A
peak value	I_{CM}	max.		12	A
Total power dissipation up to $T_h = 25\text{ }^\circ\text{C}$	P_{tot}	max.		32	W

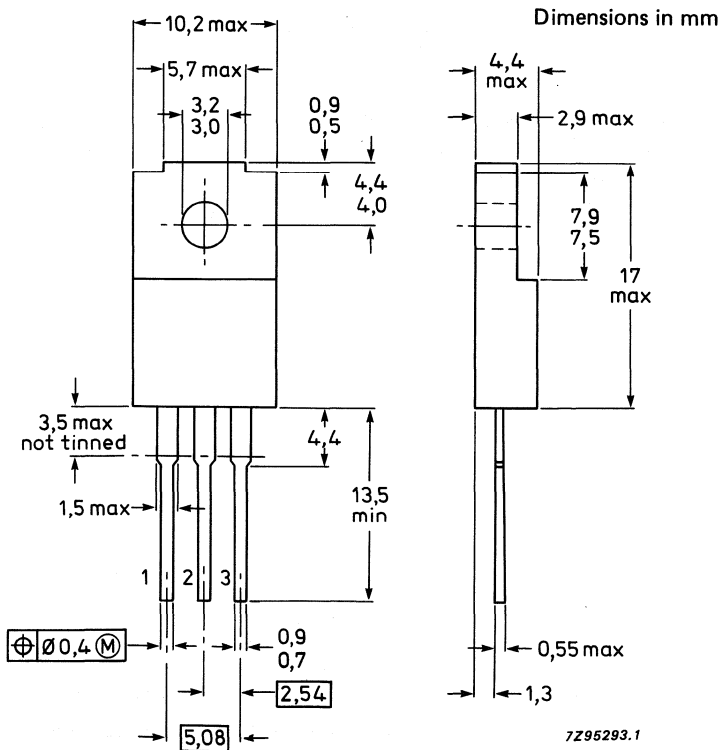
MECHANICAL DATA

Fig. 1 SOT186.



Pinning

- 1 = Base
- 2 = Collector
- 3 = Emitter



7Z95293.1

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-mb} =		1.6	K/W
From junction to external heatsink (note 1)	R _{th j-h} =		6.3	K/W
From junction to external heatsink (note 2)	R _{th j-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

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

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

Note

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

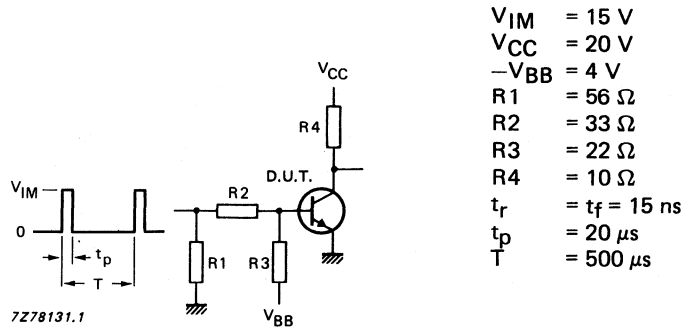


Fig. 2 Switching times test circuit.

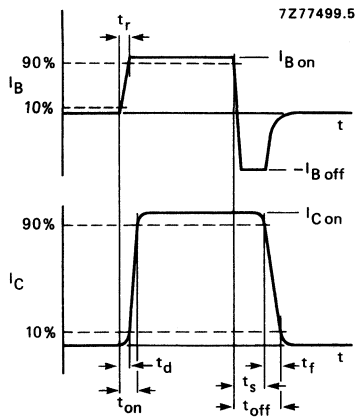
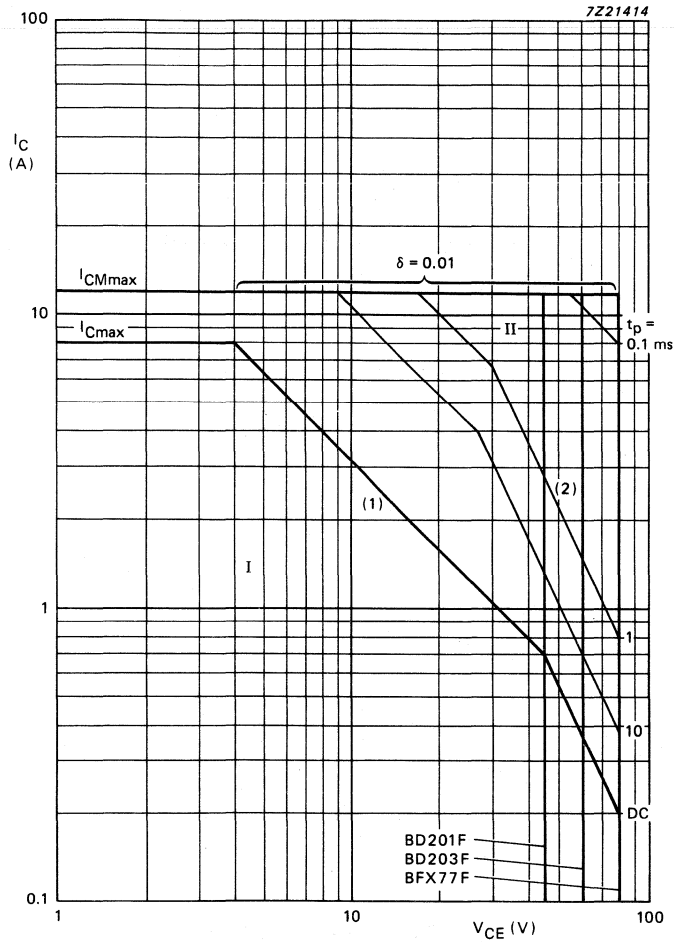


Fig. 3 Switching times waveforms.



- 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; $T_{amb} = 25 \text{ }^\circ\text{C}$.

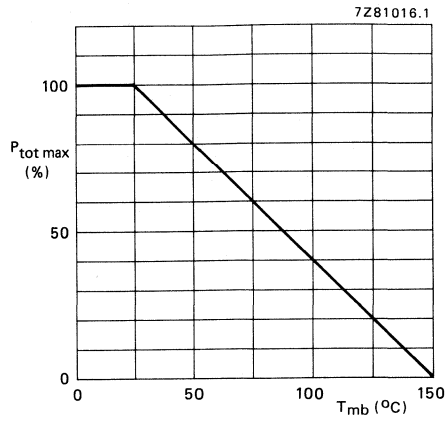


Fig. 5 Maximum power dissipation as a function of temperature.

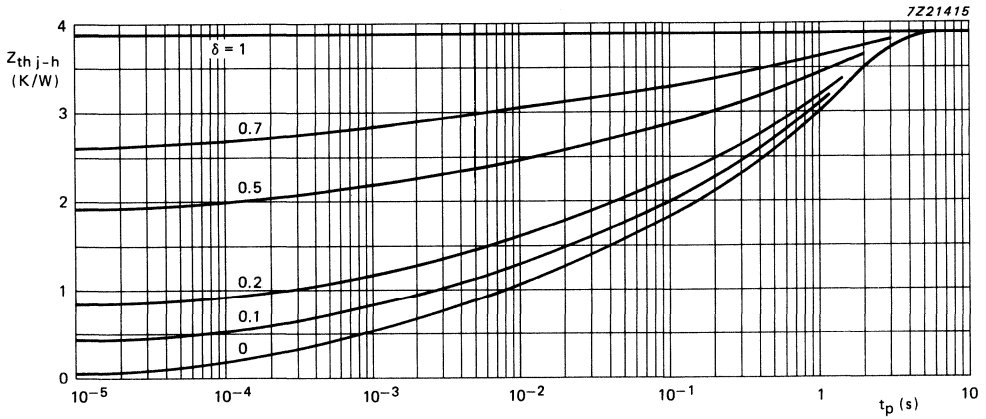


Fig. 6 Pulse power rating chart.

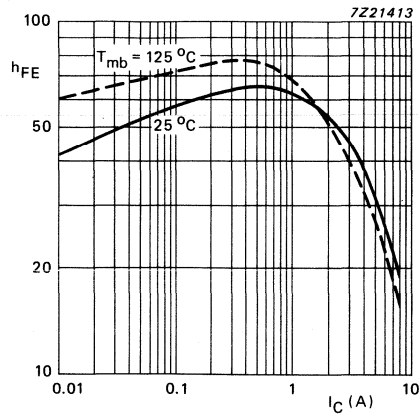


Fig. 7 Typical DC current gain curves at $V_{CE} = 2\text{ V}$.

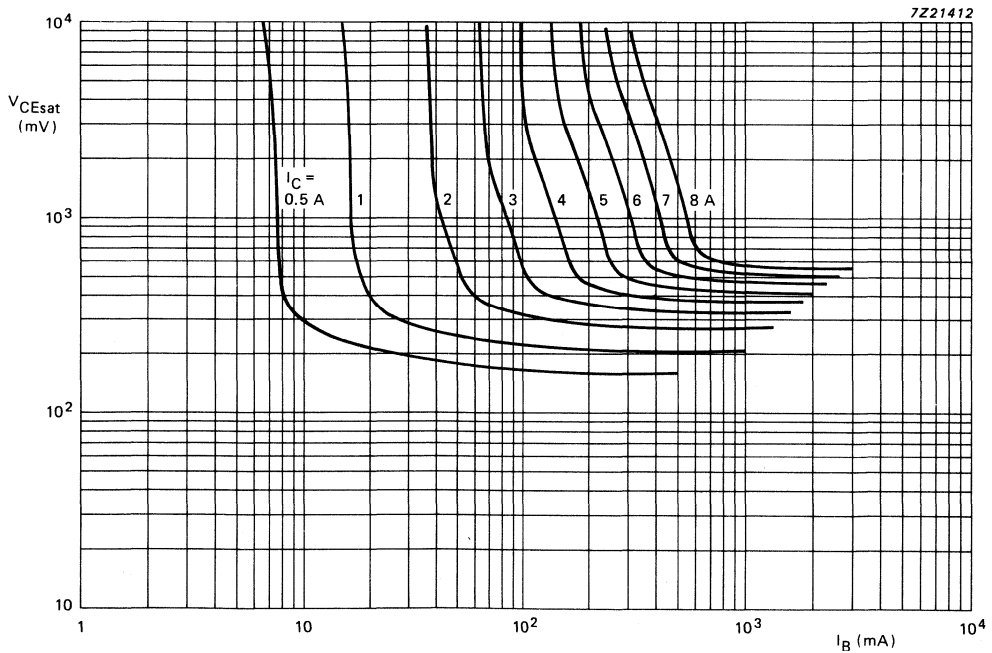


Fig. 8 Collector-emitter saturation voltage as a function of base current; typical values; $T_j = 25\text{ }^{\circ}\text{C}$.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		60	W
Cut-off frequency					
$-I_C = 0.3\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	min.		25	kHz

MECHANICAL DATA

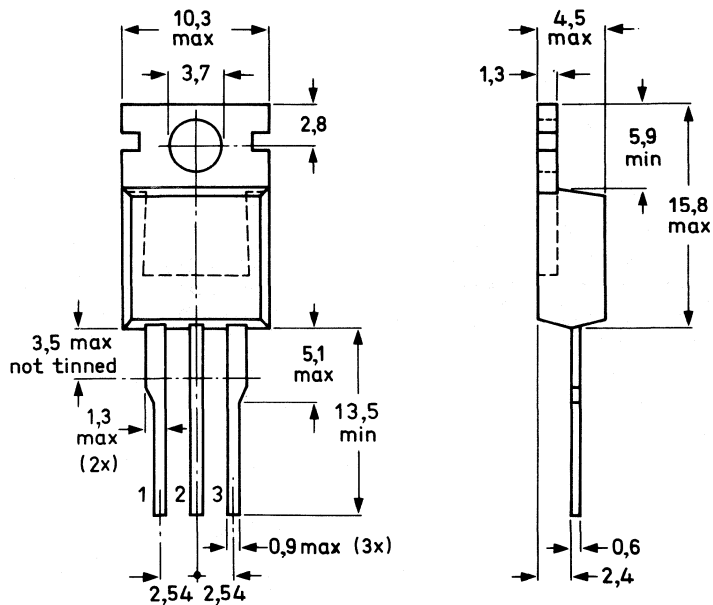
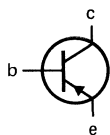
Dimensions in mm

Fig.1 TO-220.

Collector connected to mounting base.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



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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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	60	W
Storage temperature range	T_{stg}		-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

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

Note

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

Cut-off frequency

$-I_C = 0.3 \text{ A}; -V_{CE} = 3 \text{ V}$

f_{hfe} min. 25 kHz

Transition frequency at $f = 1 \text{ MHz}$

$-I_C = 0.3 \text{ A}; -V_{CE} = 3 \text{ V}$

f_T min. 7 MHz

DC current gain ratio of matched complementary pairs

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

h_{FE1}/h_{FE2} max. 2.5

Forward bias second breakdown collector current

$V_{CE} = 40 \text{ V}; t_p = 0.1 \text{ s}$

I_{SB} min. 1.5 A

Switching times

$-I_{Con} = 2 \text{ A}; -I_{Bon} = I_{Boff} = 0.2 \text{ A}$

turn-on time

t_{on} max. 1 μs

turn-off time

t_{off} max. 2 μs

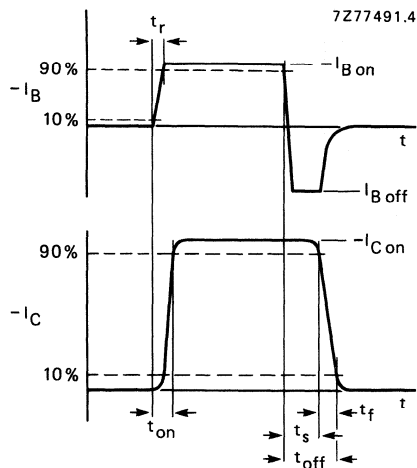


Fig. 2 Switching times waveforms.

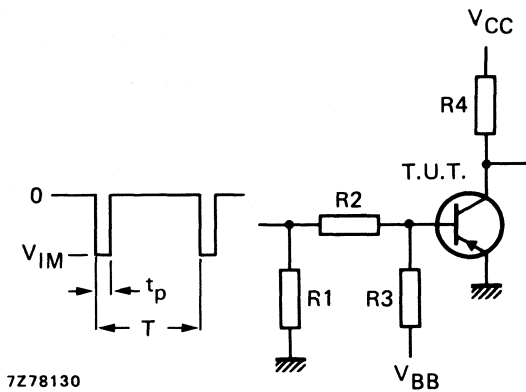
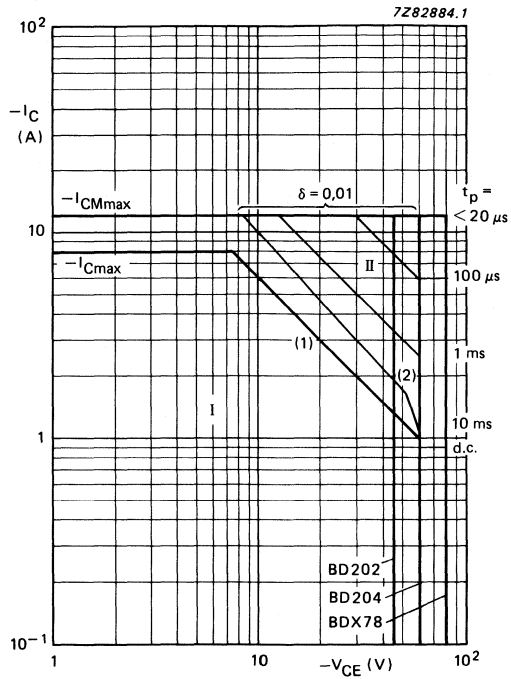


Fig. 3 Switching times test circuit.

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



- 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; $T_{mb} = 25 \text{ }^\circ\text{C}$.

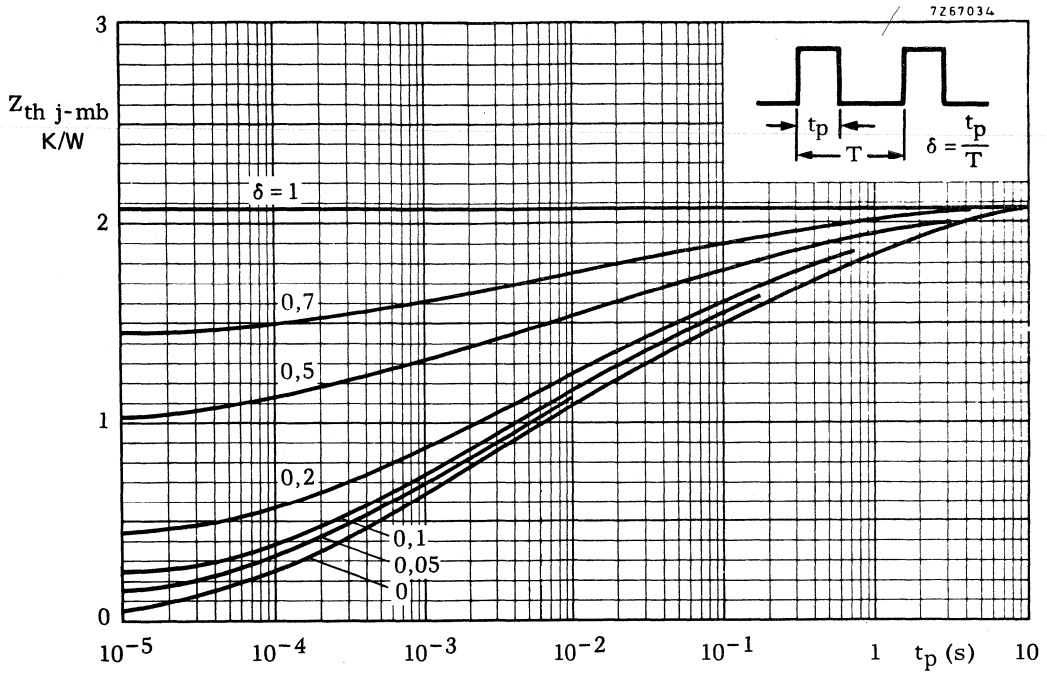


Fig. 5 Pulse power rating chart.

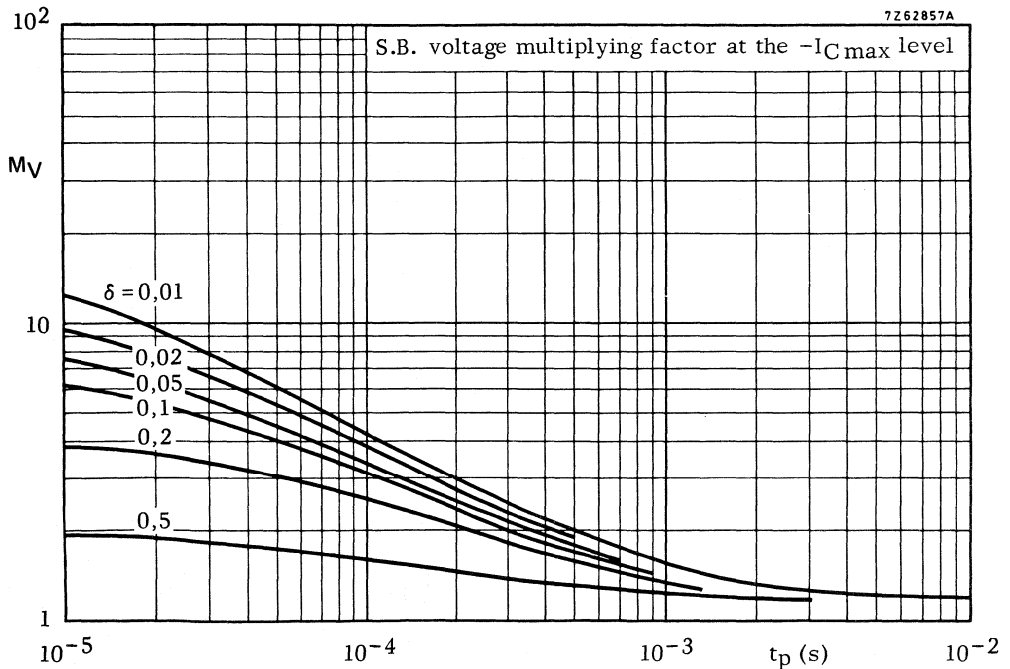


Fig. 6 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

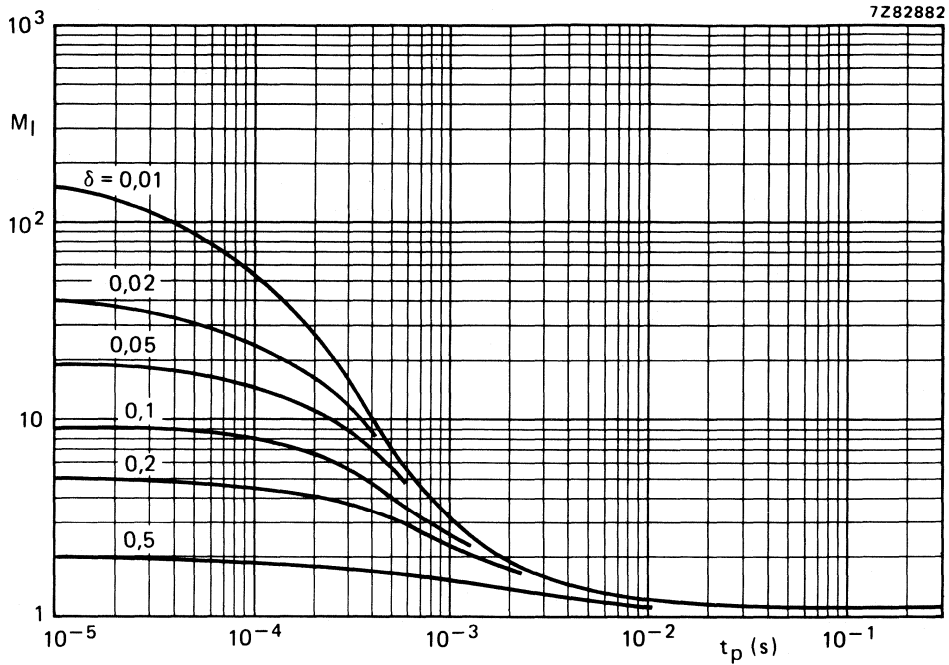


Fig. 7 S.B. current multiplying factor at the $-V_{CE0max}$ level.

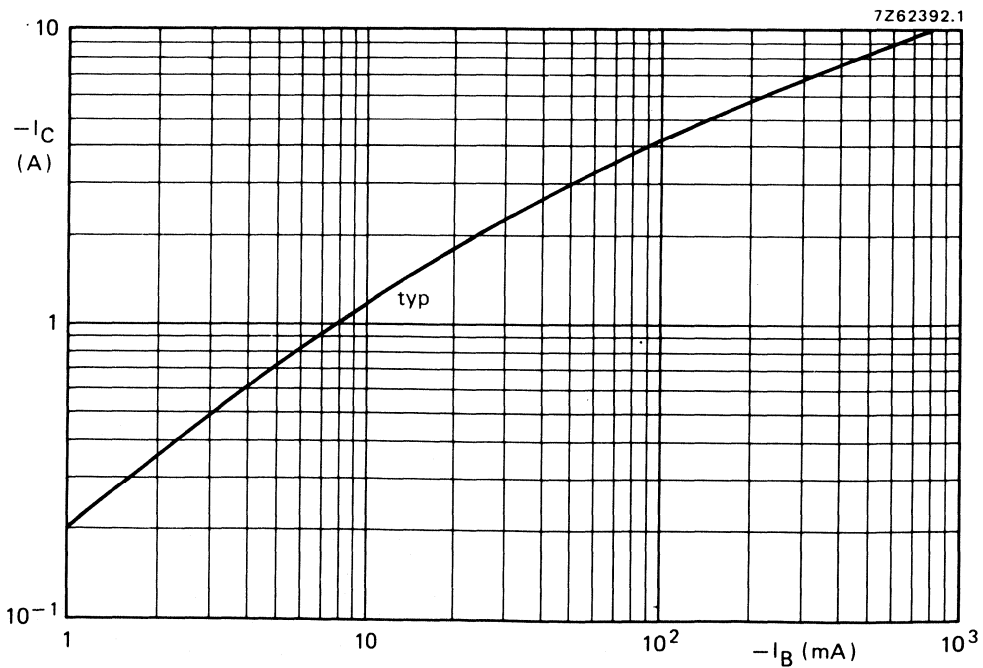


Fig. 8 Typical collector current as a function of base current. $-V_{CE} = 2$ V; $T_j = 25$ °C.

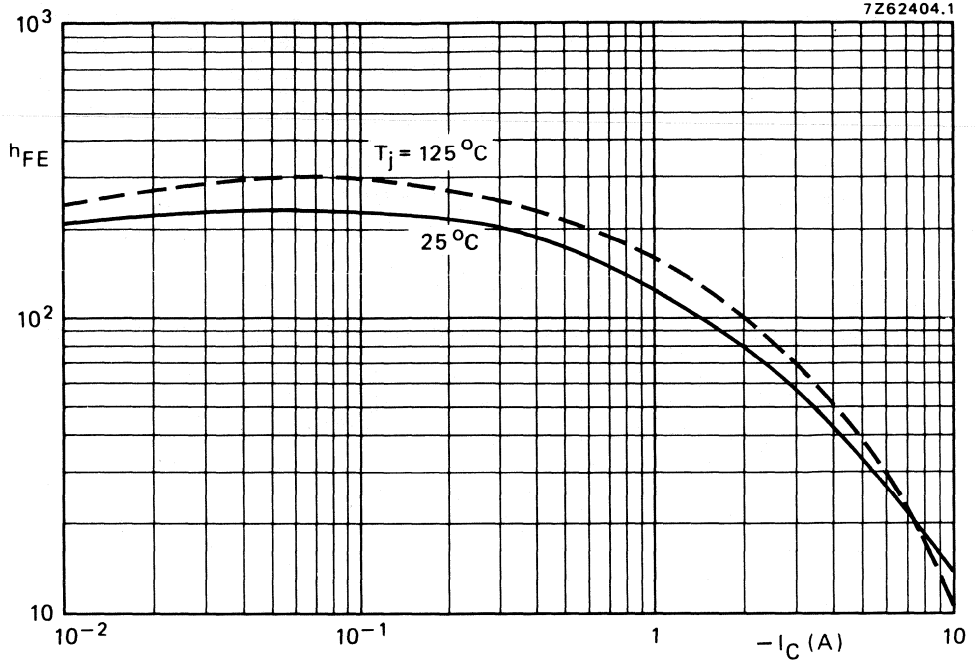


Fig. 9 Typical forward current transfer ratio at $-V_{CE} = 2$ V.

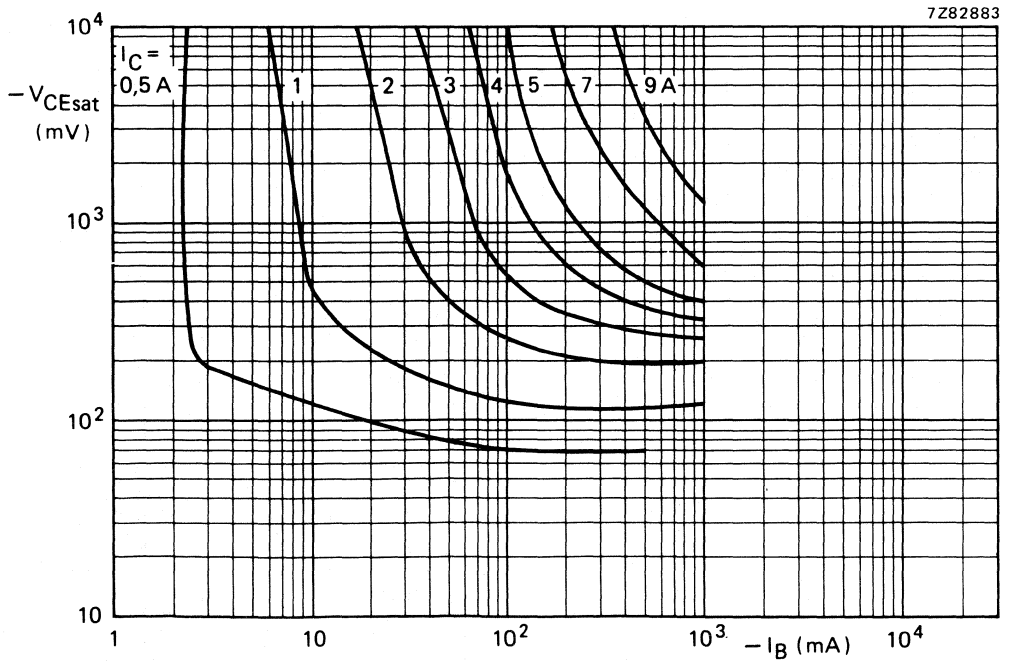


Fig. 10 Typical collector-emitter saturation voltage. $T_j = 25^\circ\text{C}$.

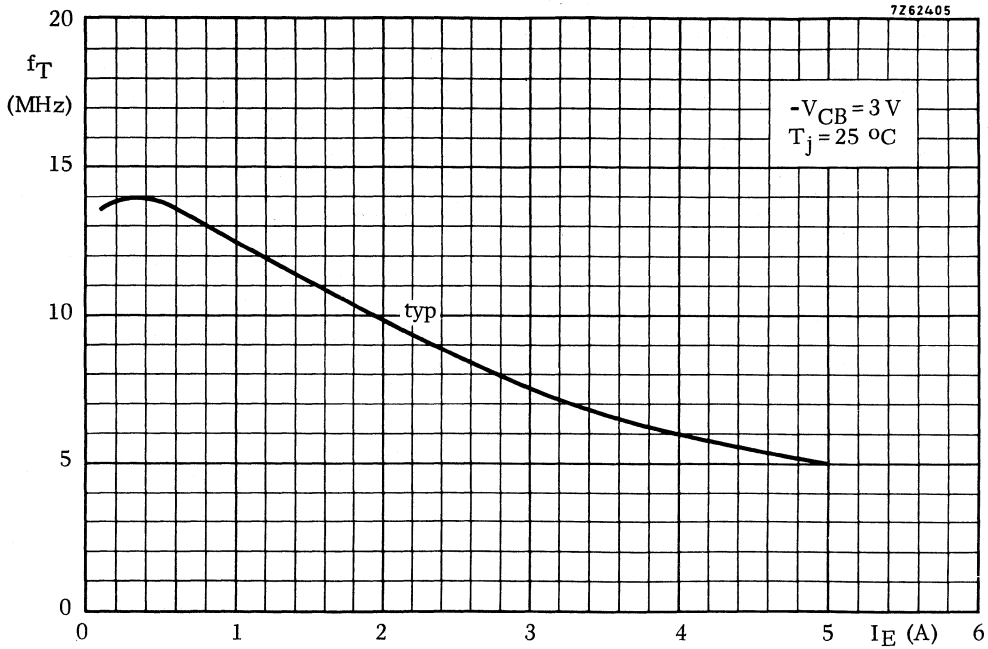


Fig. 11 Typical transition frequency.

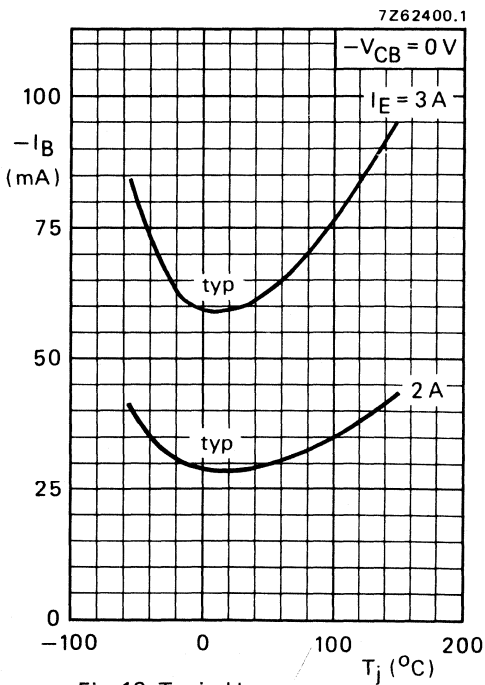


Fig. 12 Typical base current.

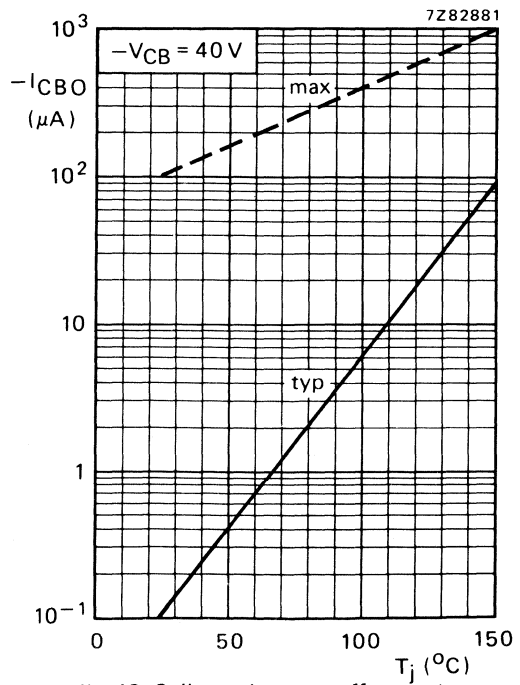


Fig. 13 Collector-base cut-off current.

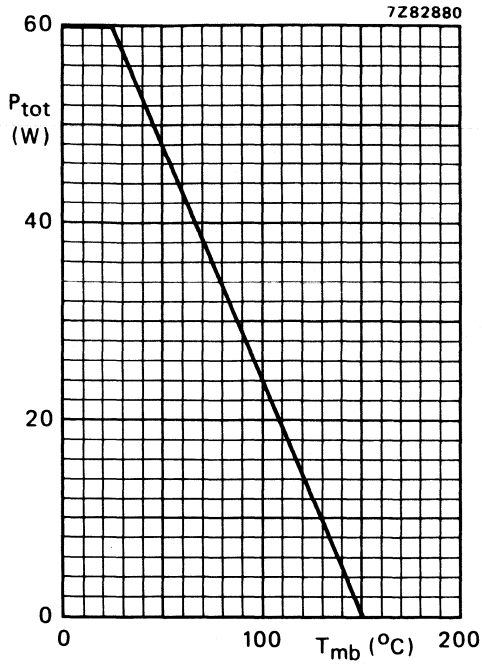


Fig. 14 Total power dissipation.

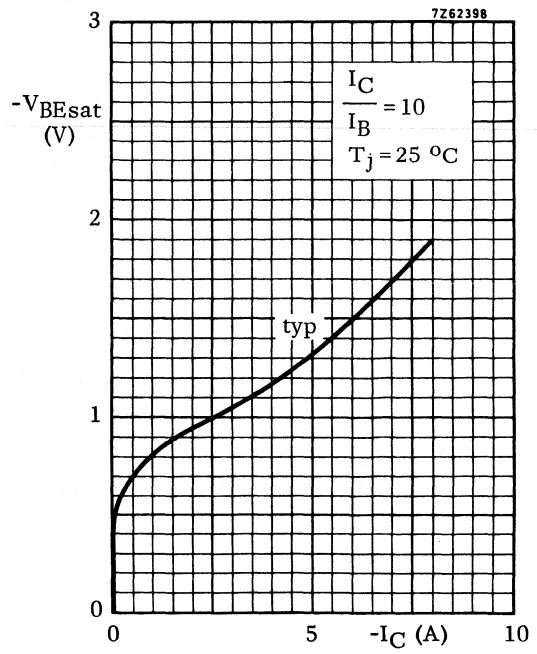


Fig. 15 Base-emitter saturation voltage.

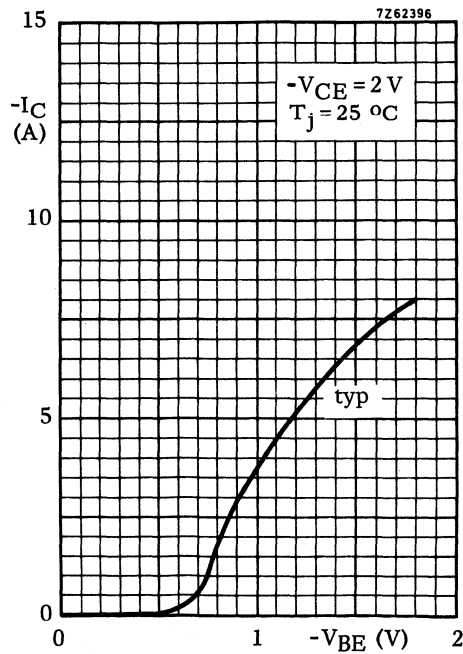


Fig. 16 Typical collector current.

SILICON EPITAXIAL POWER TRANSISTORS

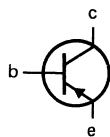
PNP silicon power transistors in SOT186 envelopes with an electrically insulated mounting base.
NPN complements are BD201F, BD203F and BDX77F respectively.

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 $T_h = 25^\circ\text{C}$	P_{tot} max.		32	W

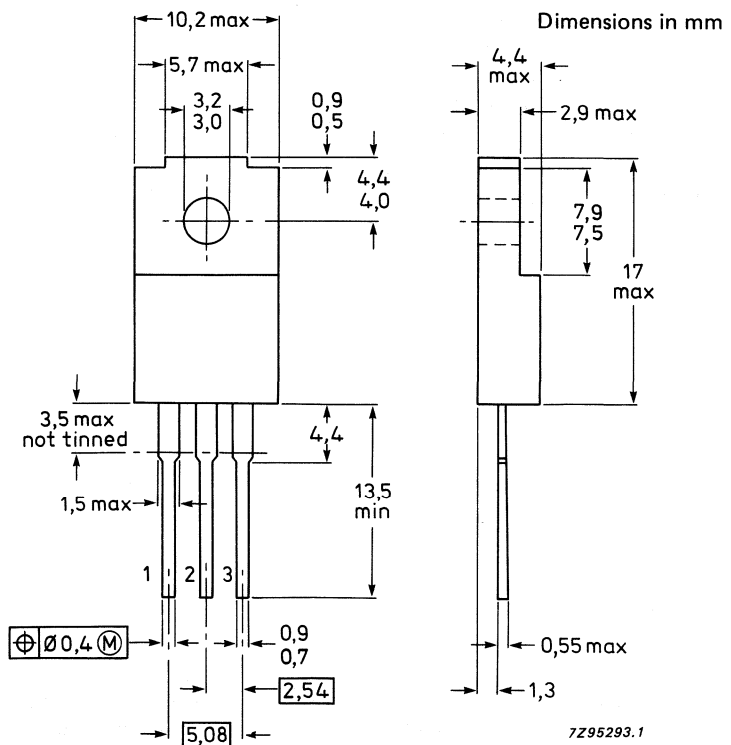
MECHANICAL DATA

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)	$-V_{CB0}$	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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.	20		W
up to $T_h = 25\text{ }^\circ\text{C}$ (note 2)		max.	32		W
Storage temperature range	T_{stg}		-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

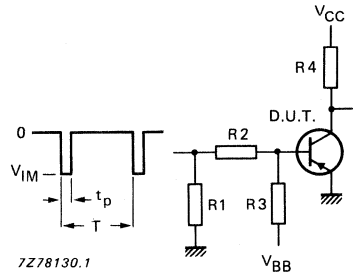
CHARACTERISTICS

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

		BD202F	BD204F	BDX78F
Collector cut-off current				
$I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	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
$I_E = 0; -V_{CB} = \frac{1}{2} V_{CBO}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	max. 1.0	1.0	1.0 mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	max. 0.5	0.5	0.5 mA
Collector-emitter breakdown voltage (note 1)				
$-I_C = 0.2\text{ A}; I_B = 0$	$-V_{(BR)CEO}$	min. 45	60	80 V
DC current gain (note 1)				
$-I_C = 3\text{ A}; -V_{CE} = 2\text{ V}$	hFE	min. 30	—	—
$-I_C = 2\text{ A}; -V_{CE} = 2\text{ V}$	hFE	min. —	30	30
$-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$	hFE	min. 30	30	—
Collector-emitter saturation voltage (note 1)				
$-I_C = 3\text{ A}; -I_B = 0.3\text{ A}$	$-V_{CEsat}$	max. 1.0	1.0	1.0 V
$-I_C = 2\text{ A}; -I_B = 0.2\text{ A}$	$-V_{CEsat}$	max. —	—	0.6 V
$-I_C = 6\text{ A}; -I_B = 0.6\text{ A}$	$-V_{CEsat}$	max. 1.5	1.5	1.5 V
Knee voltage (note 1)				
$-I_C = 3\text{ A}; -I_B = \text{value at which}$				
$-I_C = 3.3\text{ A at } -V_{CE} = 2\text{ V}$	$-V_{CEK}$	typ.	1.0	V
Base-emitter voltage (note 1)				
$-I_C = 3\text{ A}; -V_{CE} = 2\text{ V}$	$-V_{BE}$	max.	1.5	V
Base-emitter saturation voltage (note 1)				
$-I_C = 6\text{ A}; -I_B = 0.6\text{ A}$	$-V_{BEsat}$	max.	2.0	V
Cut-off frequency				
$-I_C = 0.3\text{ A}; -V_{CE} = 3\text{ V}$	f _{HFE}	min.	25	kHz
Transition frequency at f = 1 MHz				
$-I_E = 0.3\text{ A}; -V_{CB} = 3\text{ V}$	f _T	min.	7.0	MHz
Forward bias second breakdown collector current				
$-V_{CE} = 40\text{ V}; t_p = 0.1\text{ s}$	$-I_{SB}$	min.	0.8	A
Switching times				
$-I_{C\text{ on}} = 2\text{ A}; -I_{B\text{ on}} = I_{B\text{ off}} = 0.2\text{ A}$				
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%.



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

Fig. 2 Switching times test circuit.

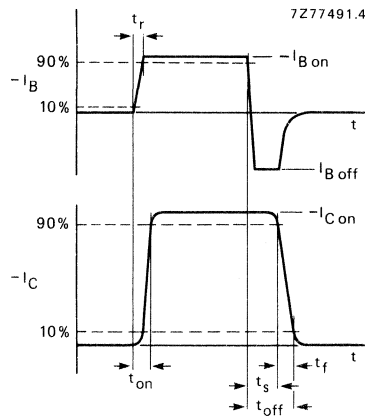
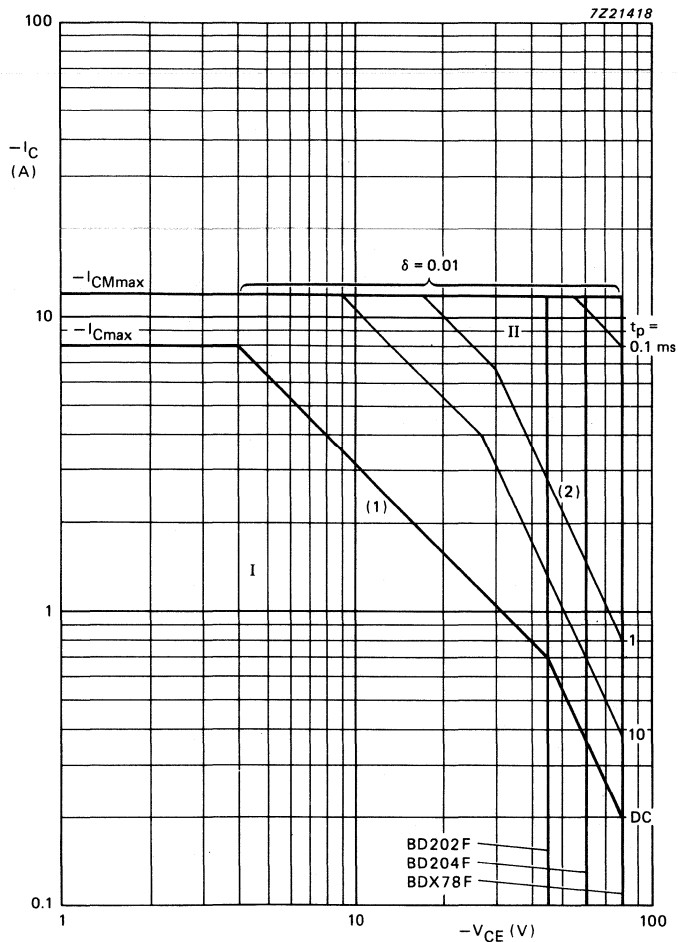


Fig. 3 Switching times waveforms.



- 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; $T_{amb} = 25^\circ\text{C}$.

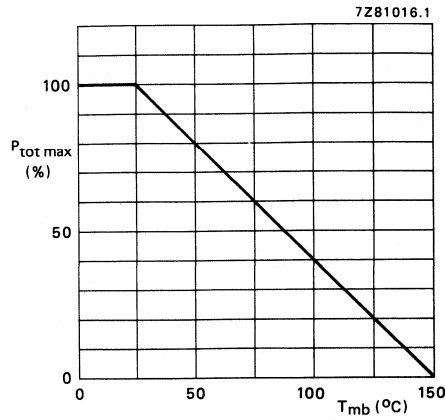


Fig. 5 Maximum power dissipation as a function of temperature.

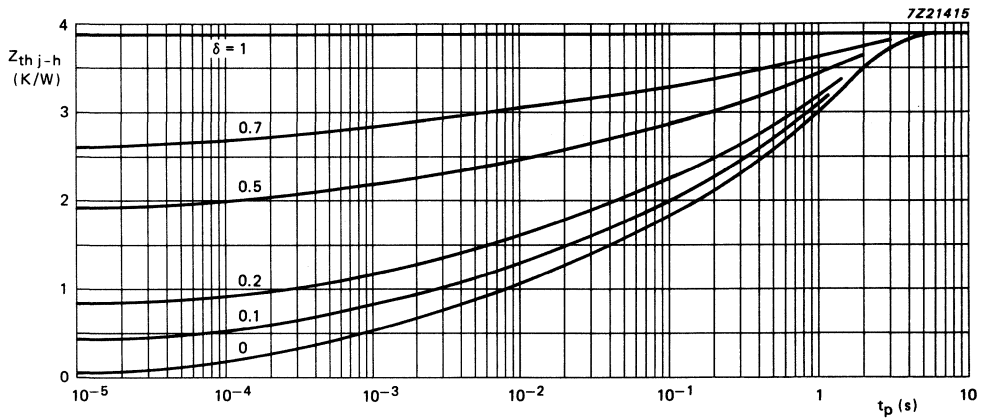


Fig. 6 Pulse power rating chart.

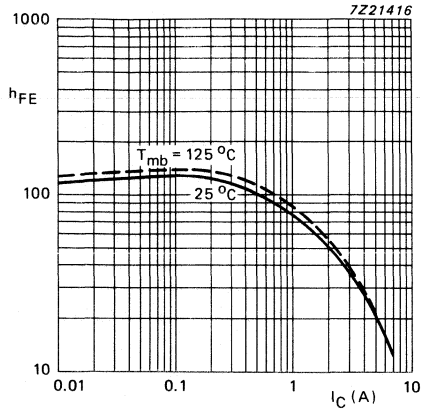


Fig. 7 Typical DC current gain curves at $-V_{CE} = 2 \text{ V}$.

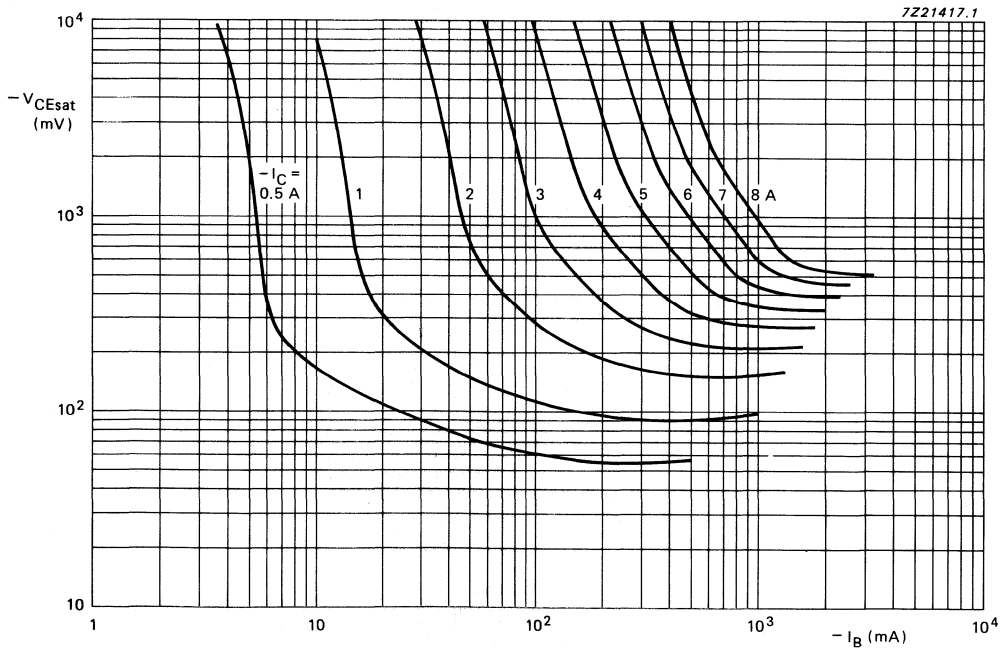


Fig. 8 Collector-emitter saturation voltage as a function of base current; typical values; $T_j = 25 \text{ }^\circ\text{C}$.

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 ($R_{BE} = 1\text{ k}\Omega$)	V_{CER}	max. 45	60	100 V
Collector current (peak value)	I_{CM}	max. 3	3	3 A
Total power dissipation up to $T_{mb} = 62\text{ }^\circ\text{C}$	P_{tot}	max. 12,5	12,5	12,5 W
Junction temperature	T_j	max. 150	150	150 $^\circ\text{C}$
D. C. current gain	h_{FE}	40 to 250		
$I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$	h_{FE}	> 25		
$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	> 25		
Transition frequency	f_T	typ.	125	MHz
$I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$	f_T	typ.	125	MHz

MECHANICAL DATA

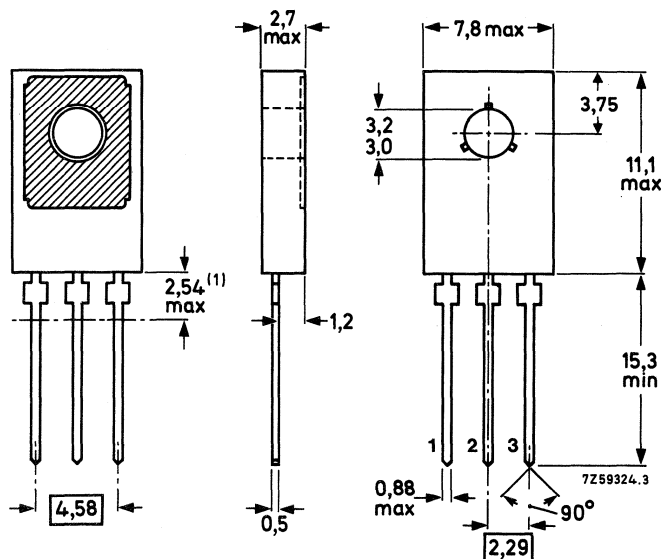
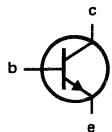
Dimensions in mm

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 ($R_{BE} = 1 \text{ k}\Omega$)	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 $T_{mb} = 62 \text{ }^\circ\text{C}$	P_{tot}	max.		12,5		W
Storage temperature	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$
THERMAL RESISTANCE						
From junction to ambient in free air	$R_{th \text{ j-a}}$	=		100		K/W
From junction to mounting base	$R_{th \text{ j-mb}}$	=		7		K/W

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 30\text{ V}$	I_{CBO}	<	100	nA
$I_E = 0; V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$	I_{CBO}	<	10	μA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	10	μA
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Base-emitter voltage ¹⁾

$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$	V_{BE}	<	1,3	V
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Saturation voltage

$I_C = 1\text{ A}; I_B = 0.1\text{ A}$	V_{CEsat}	<	0,8	V
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D. C. current gain

$I_C = 5\text{ mA}; V_{CE} = 2\text{ V}$	h_{FE}	>	25	
$I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$	h_{FE}		40 to 250	
$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	>	25	

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

$I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$	f_T	typ.	125	MHz
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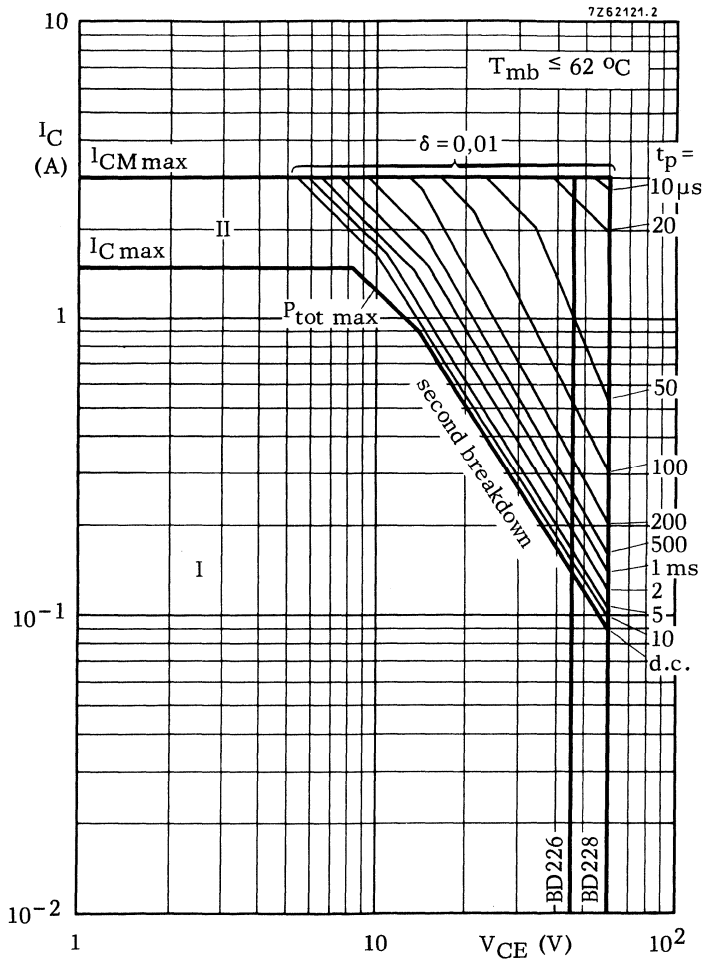
D. C. current gain ratio of
matched pairs

BD226/BD227; BD228/BD229;

BD230/BD231

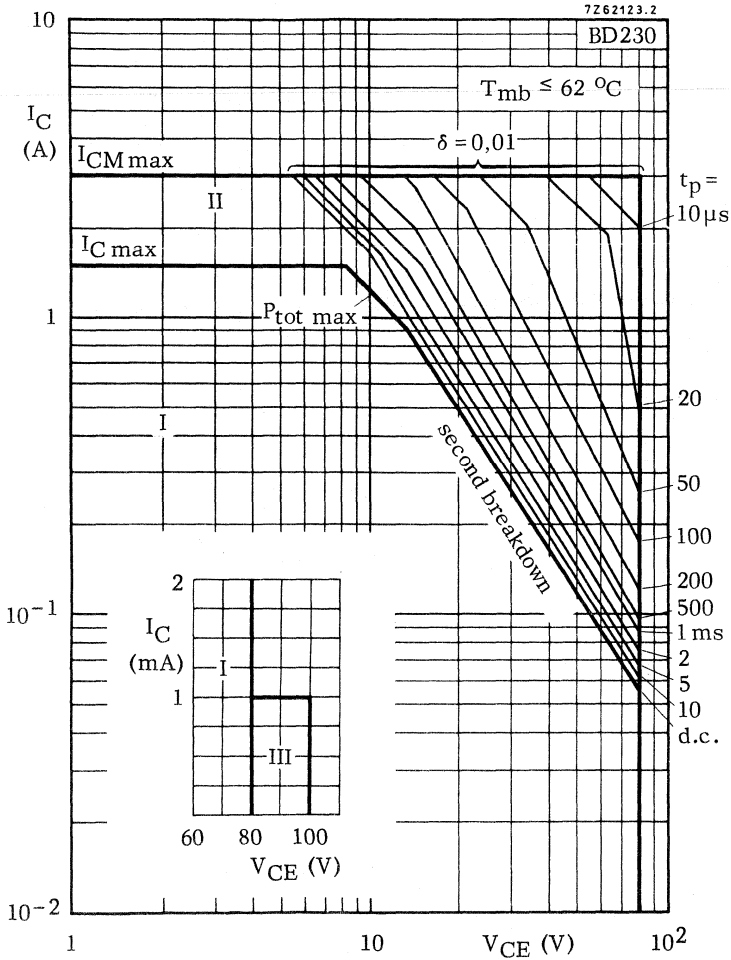
$ I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$	h_{FE1}/h_{FE2}	typ. <	1,3 1,6	
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¹⁾ V_{BE} decreases by about 2,3 mV/K with increasing temperature.



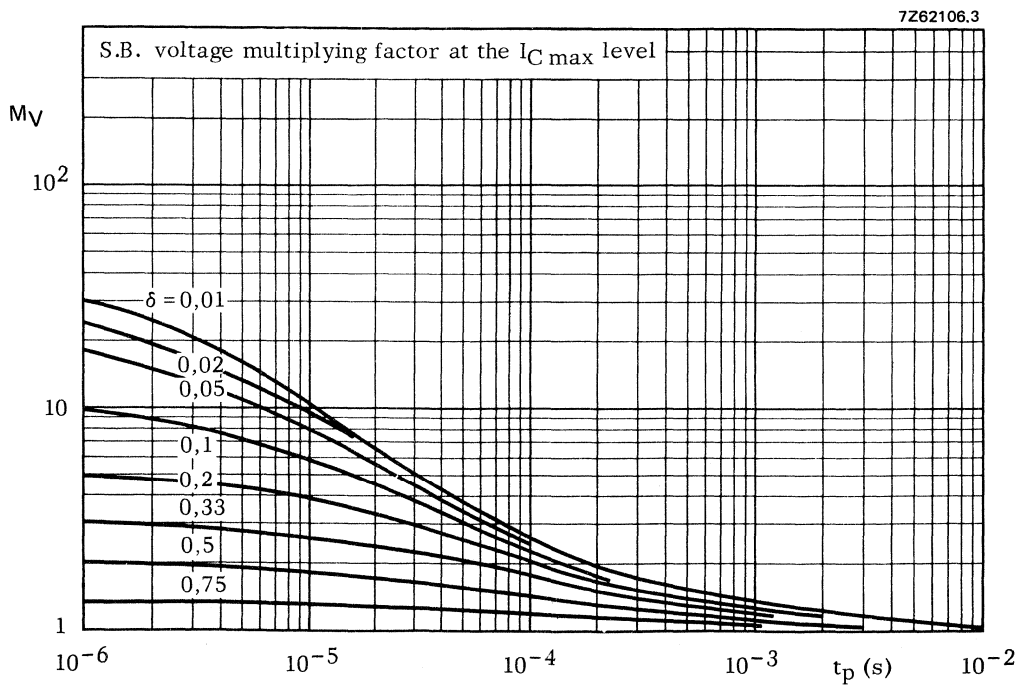
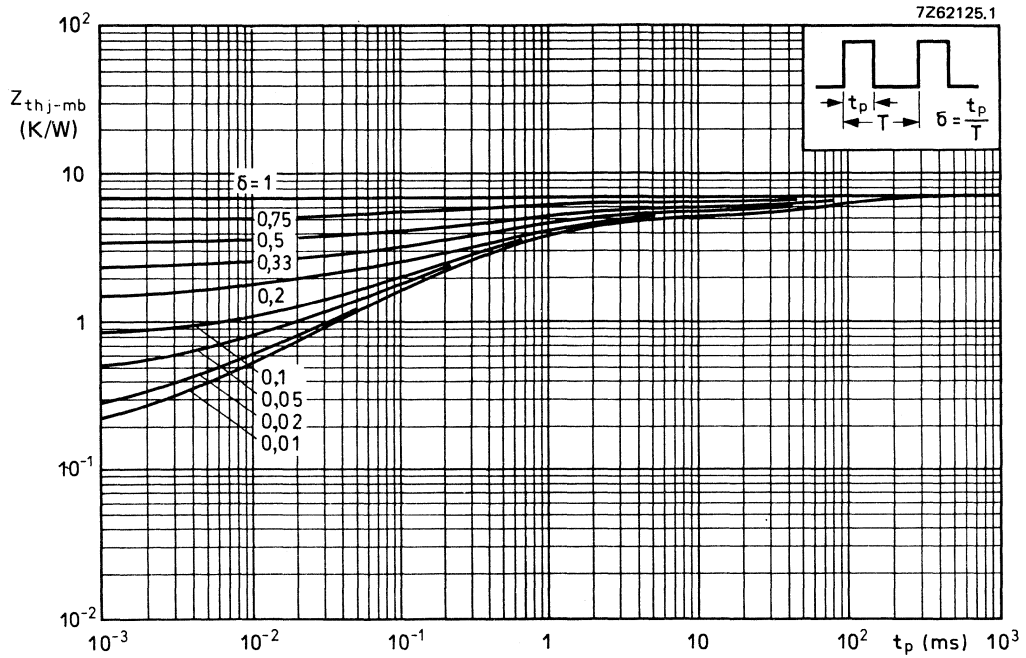
Safe Operating Area with the transistor forward biased

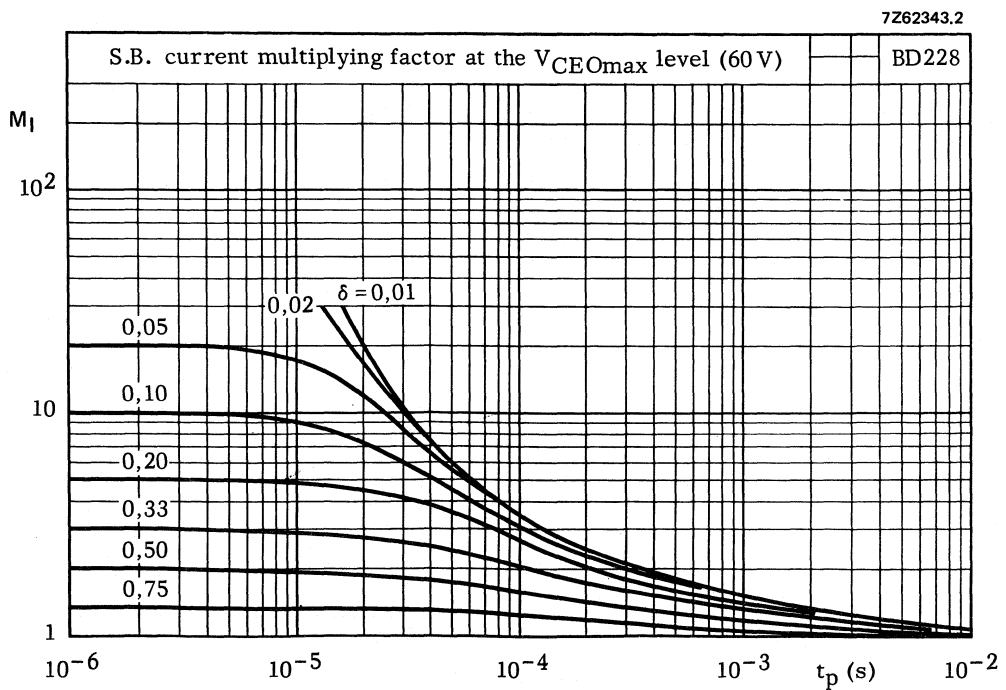
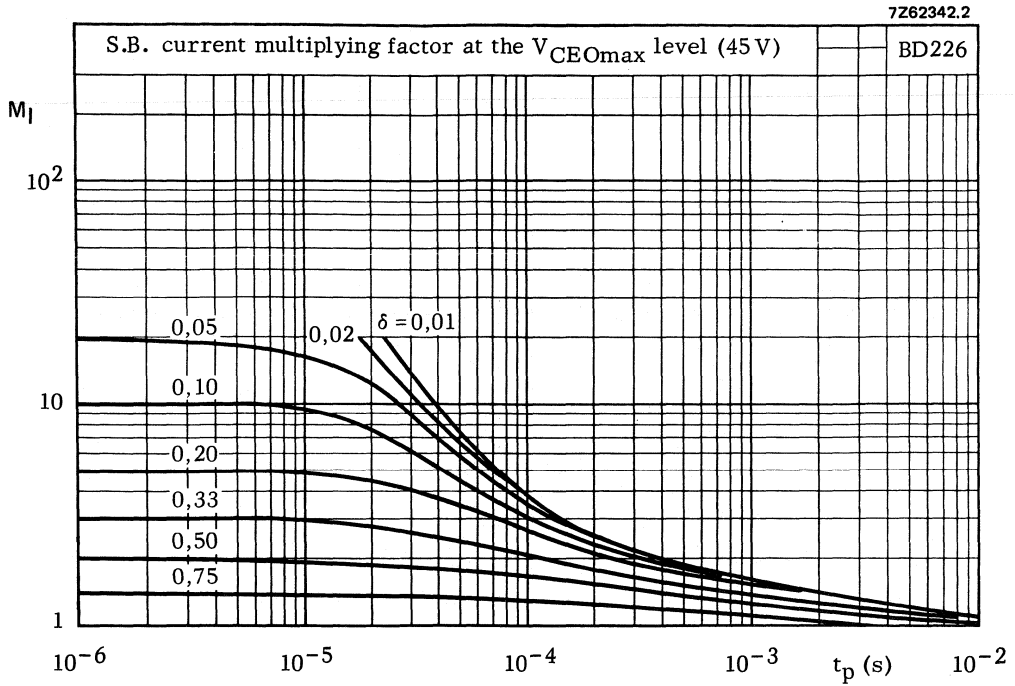
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation

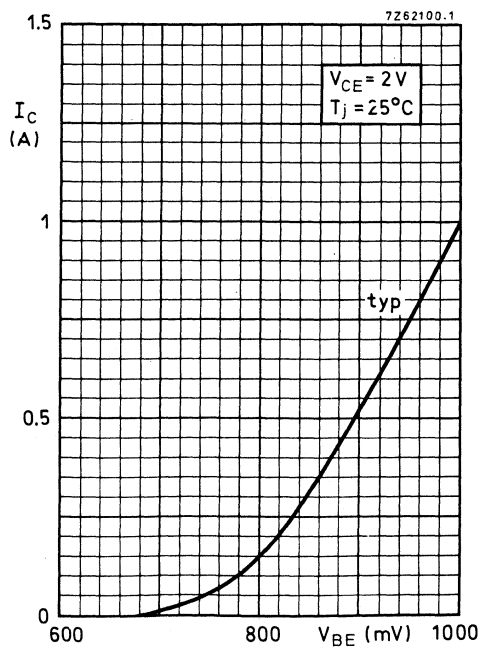
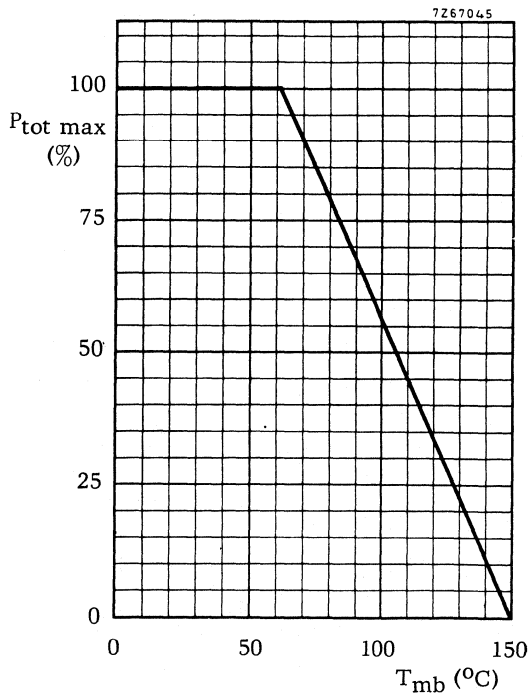
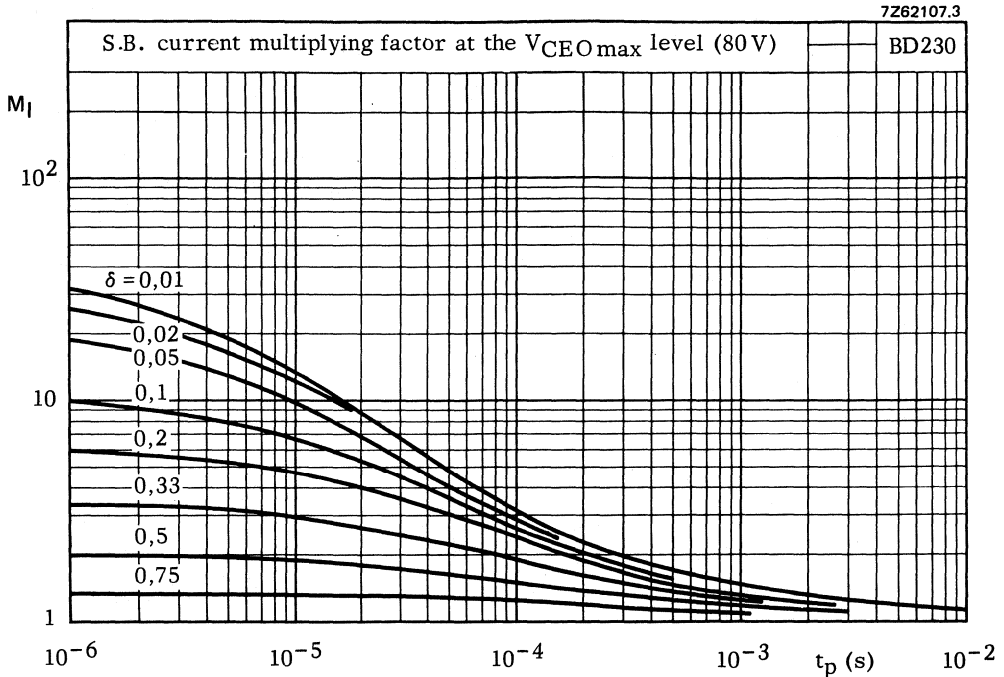


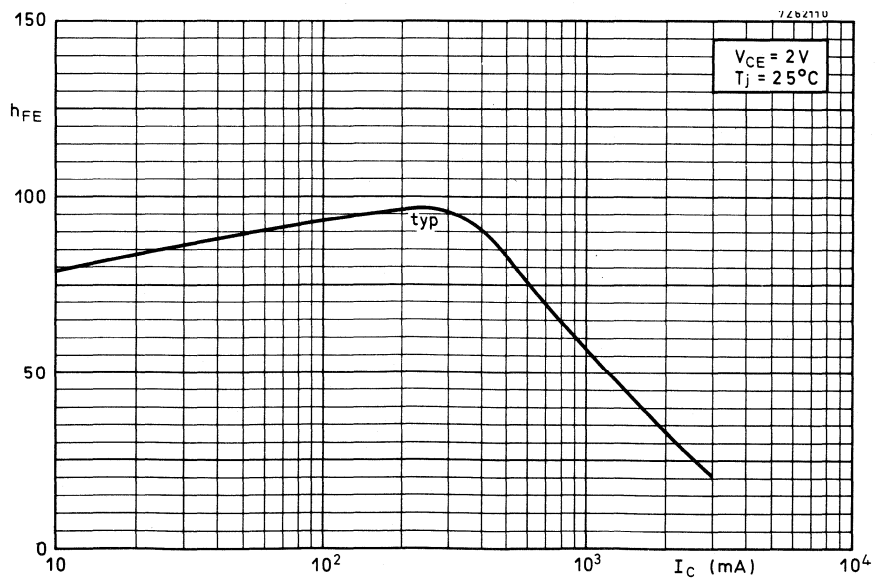
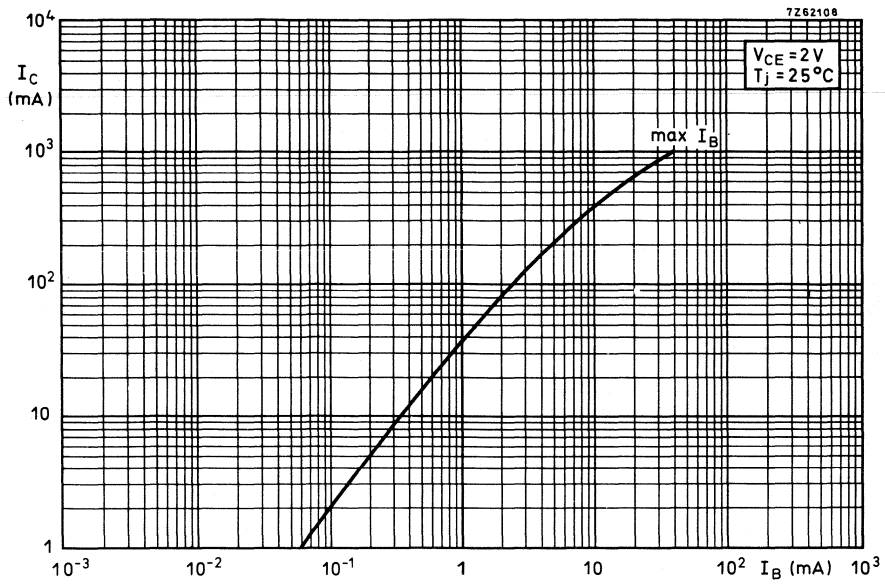
Safe Operating Area with the transistor forward biased

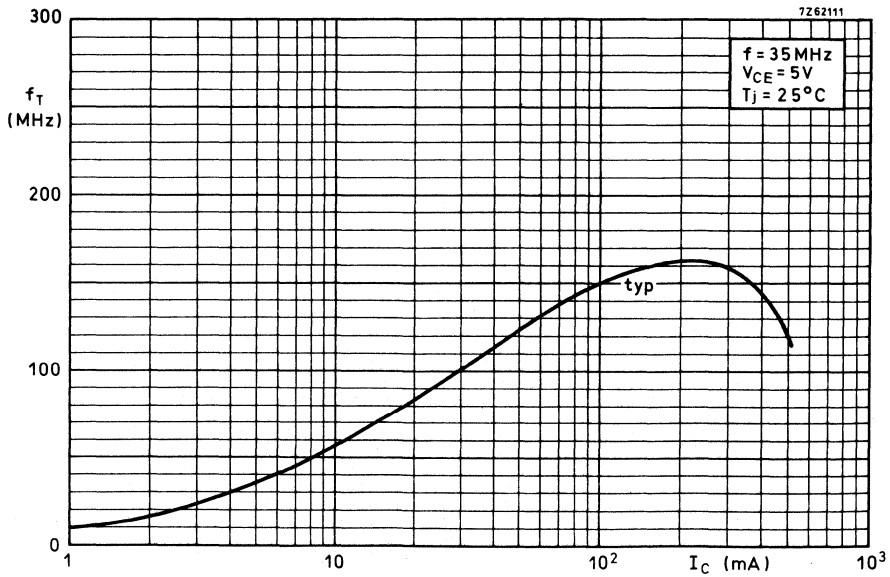
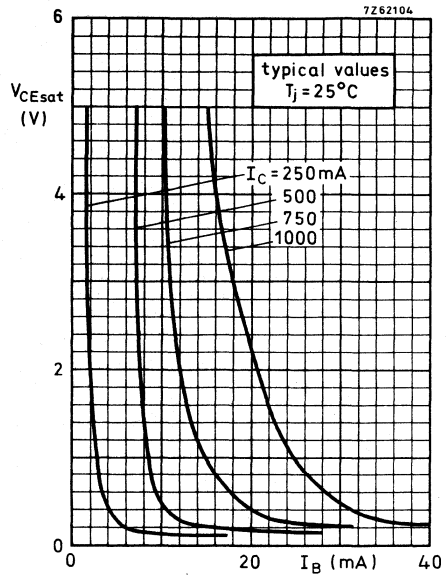
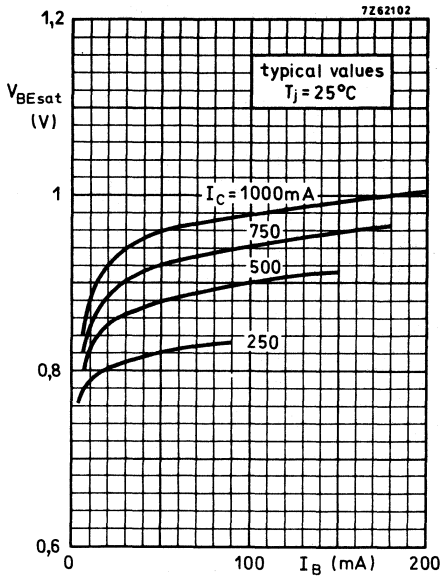
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1 \text{ k}\Omega$











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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$ max.	45	60	100 V
Collector current (peak value)	$-I_{CM}$ max.	3	3	3 A
Total power dissipation up to $T_{mb} = 62 \text{ }^\circ\text{C}$	P_{tot} max.	12.5	12.5	12.5 W
Junction temperature	T_j max.	150	150	150 $^\circ\text{C}$
DC current gain		40 to 250		
$-I_C = 150 \text{ mA}; -V_{CE} = 2 \text{ V}$	h_{FE}	40 to 250		
$-I_C = 1 \text{ A}; -V_{CE} = 2 \text{ V}$	h_{FE}	> 25		
Transition frequency		50		
$-I_C = 50 \text{ mA}; -V_{CE} = 5 \text{ V}$	f_T typ.	50 MHz		

MECHANICAL DATA

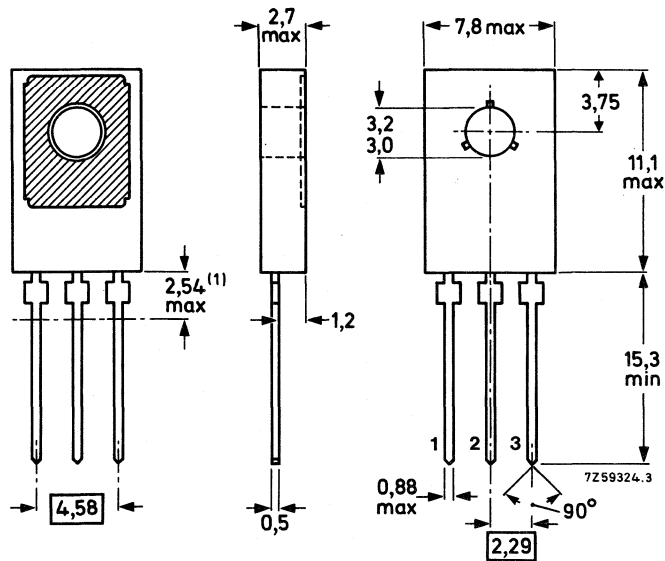
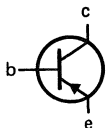
Dimensions in mm

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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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 $T_{mb} = 62 \text{ }^\circ\text{C}$	P_{tot}	max.		12.5	W
Storage temperature	T_{stg}		-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; -V_{CB} = 30\text{ V}$ $-I_{CBO} < 100\text{ nA}$ $I_E = 0; -V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$ $-I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

Base-emitter voltage *

 $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$ $-V_{BE} < 1.3\text{ V}$

Saturation voltage

 $-I_C = 1\text{ A}; -I_B = 0.1\text{ A}$ $-V_{CEsat} < 0.8\text{ V}$

DC current gain

 $-I_C = 5\text{ mA}; -V_{CE} = 2\text{ V}$ $h_{FE} > 25$ $-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$ $h_{FE} < 40\text{ to }250$ $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$ $h_{FE} > 25$ Transition frequency at $f = 35\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 5\text{ V}$ $f_T \text{ typ. } 50\text{ MHz}$

DC current gain ratio of matched pairs

BD226/BD227; BD228/BD229;

BD230/BD231

 $|I_C| = 150\text{ mA}; |V_{CE}| = 2\text{ V}$ $h_{FE1}/h_{FE2} \text{ typ. } 1.3$
 < 1.6 * $-V_{BE}$ decreases by about 2.3 mV/K with increasing temperature.

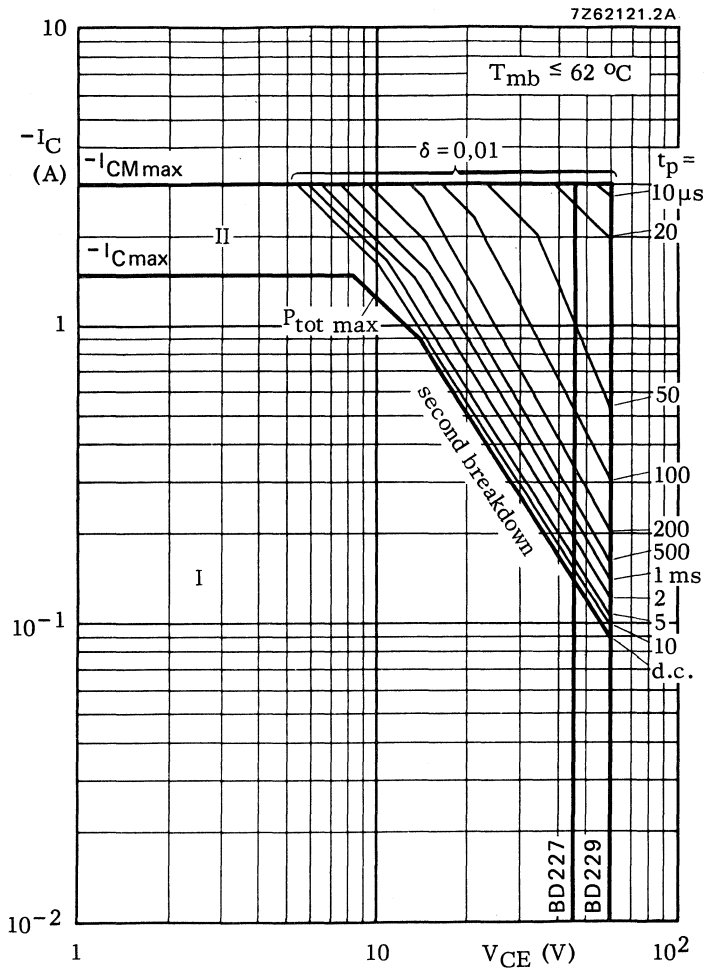


Fig. 2 Safe operating area with the transistor forward biased.

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

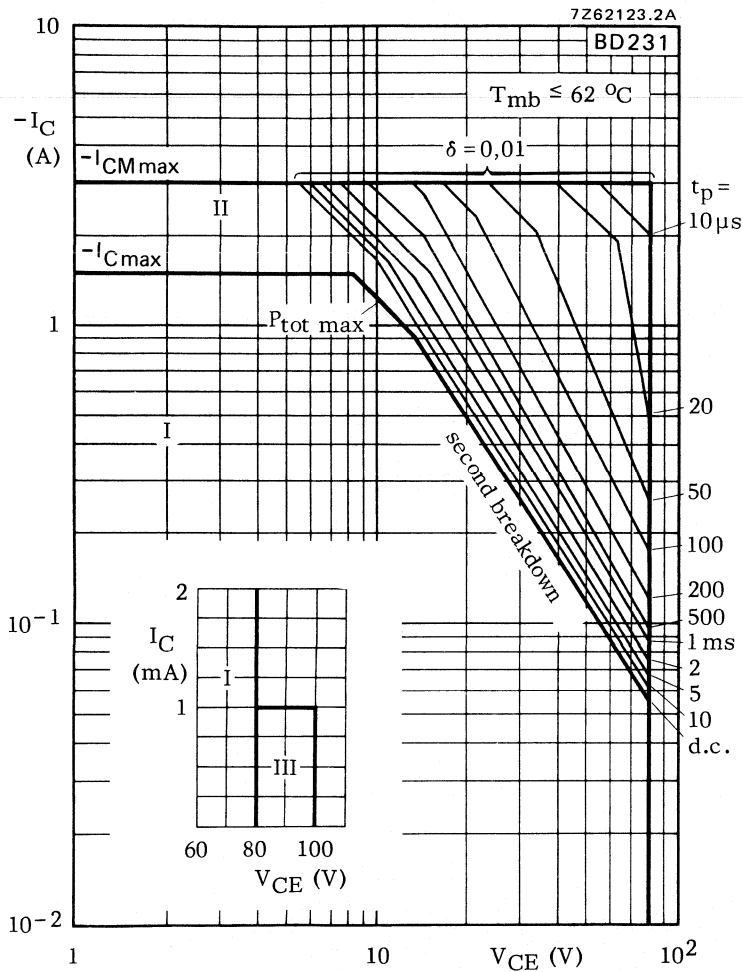


Fig. 3 Safe operating area with the transistor forward biased.

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

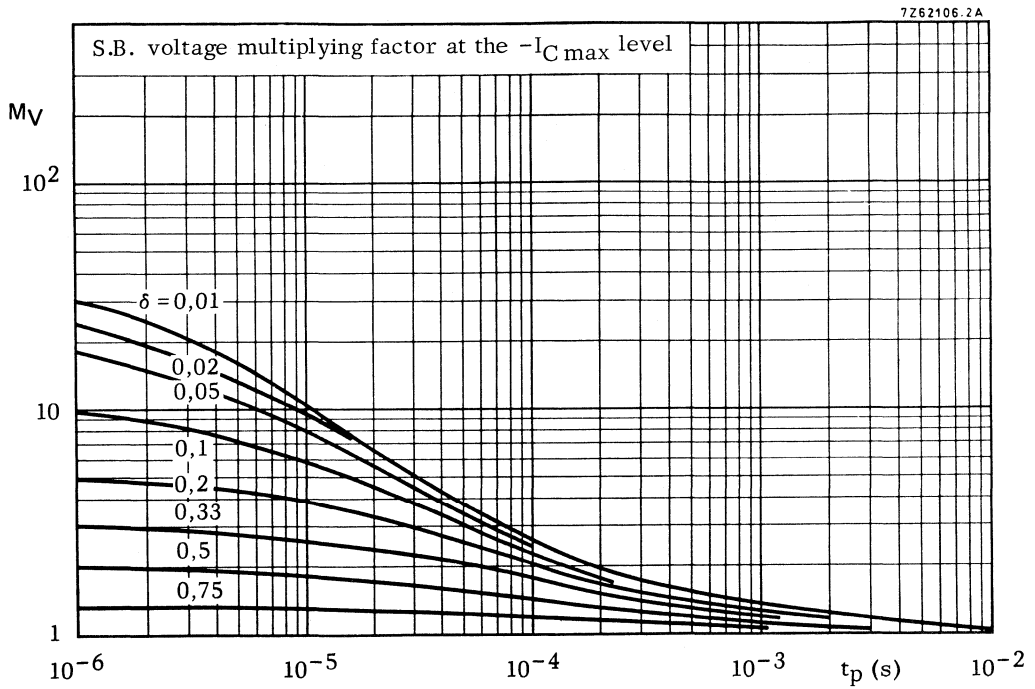


Fig. 4.

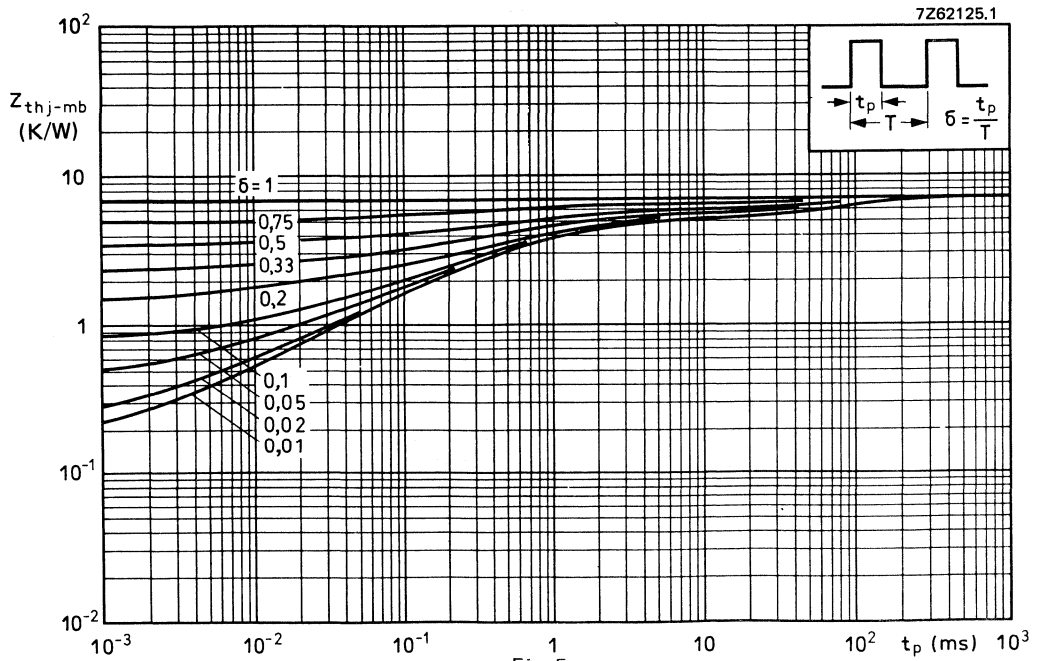


Fig. 5.

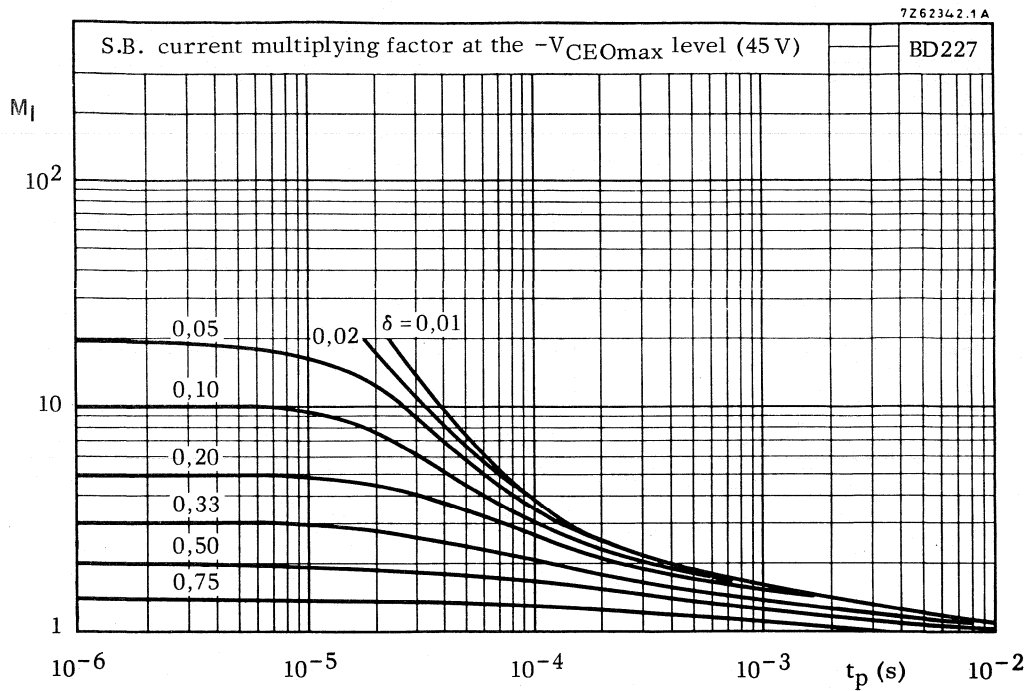


Fig. 6.

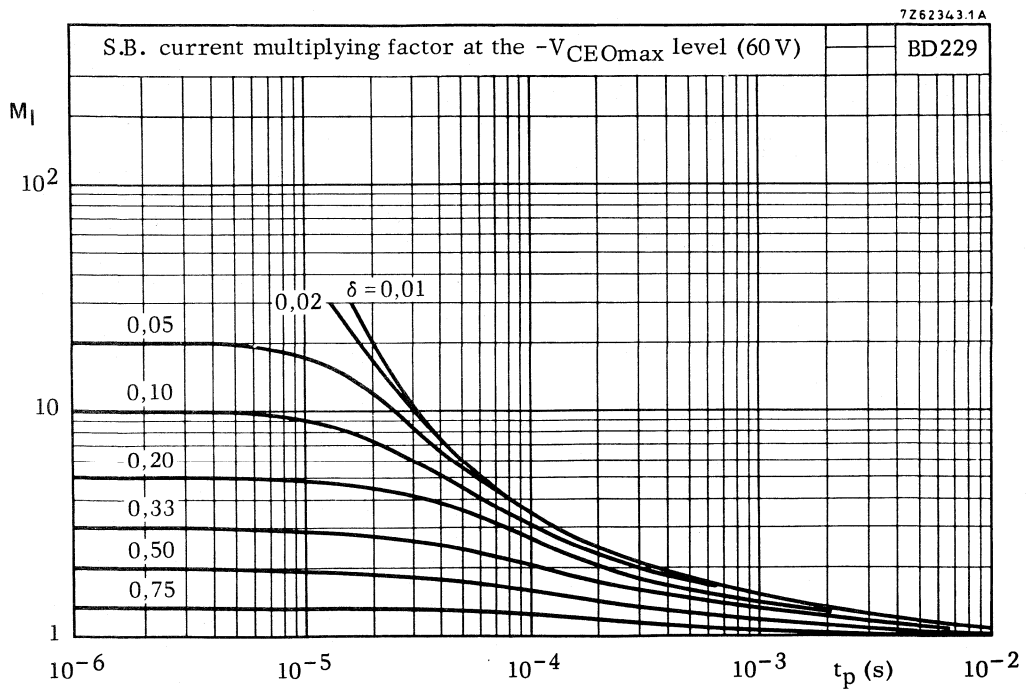


Fig. 7.

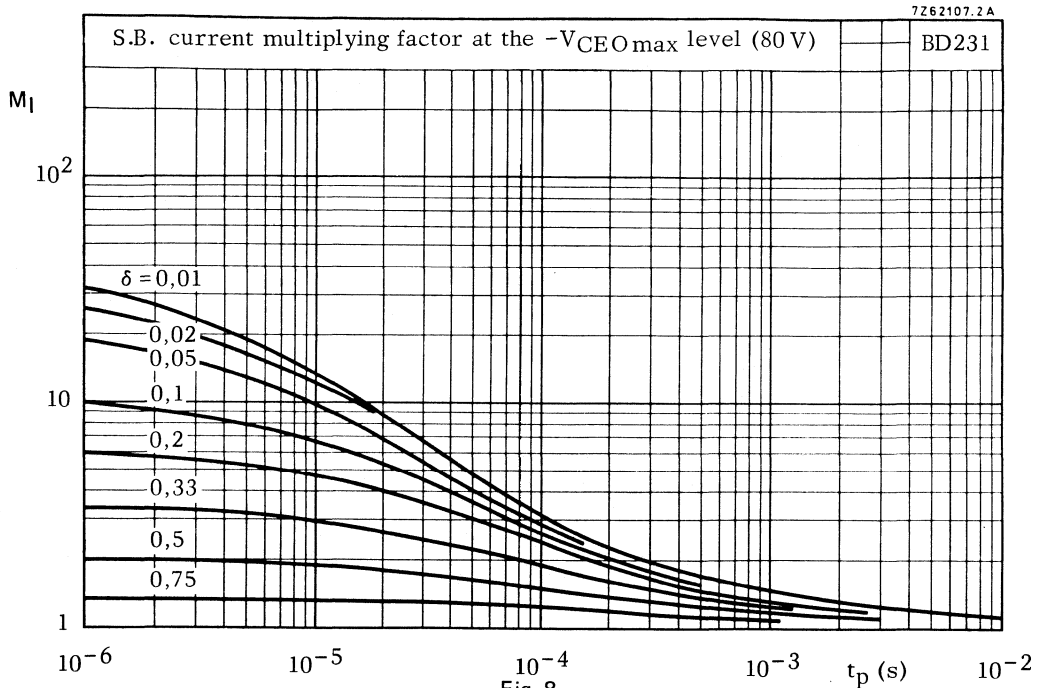


Fig. 8.

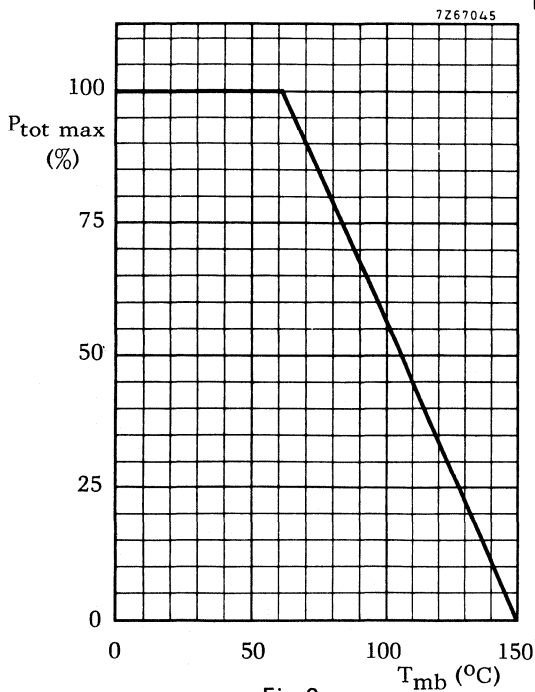


Fig. 9.

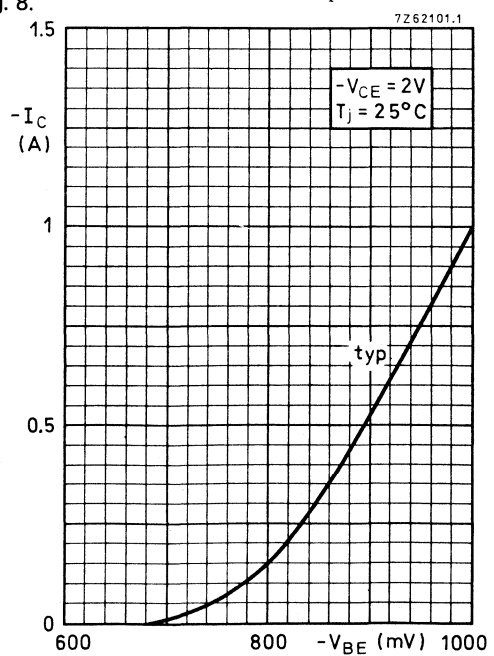


Fig. 10.

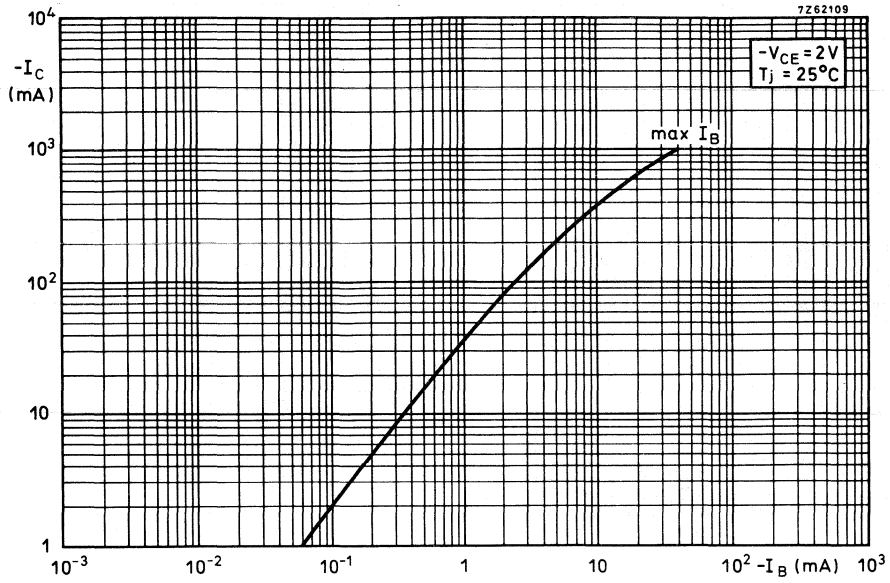


Fig. 11.

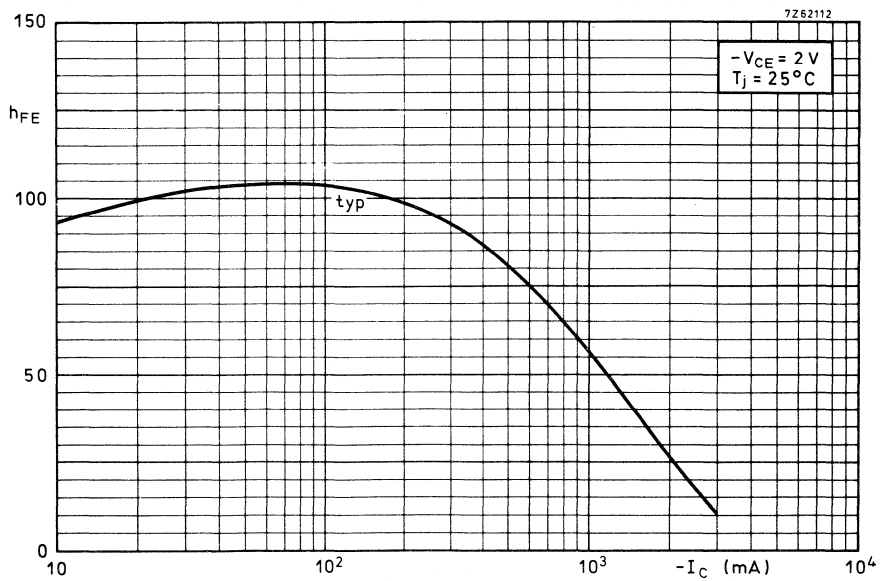


Fig. 12.

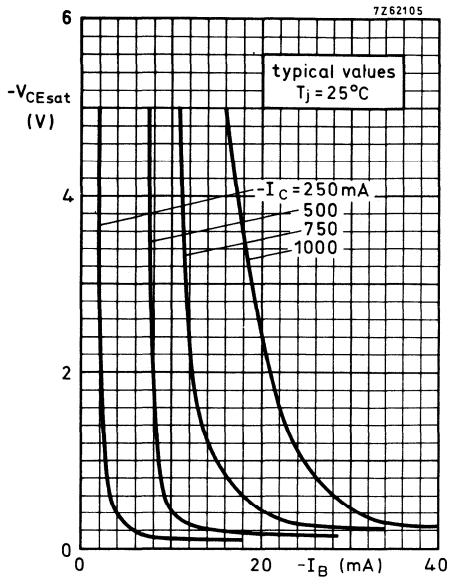


Fig. 13.

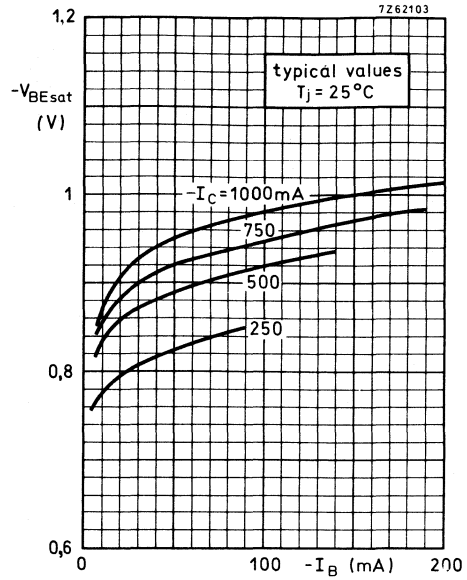


Fig. 14.

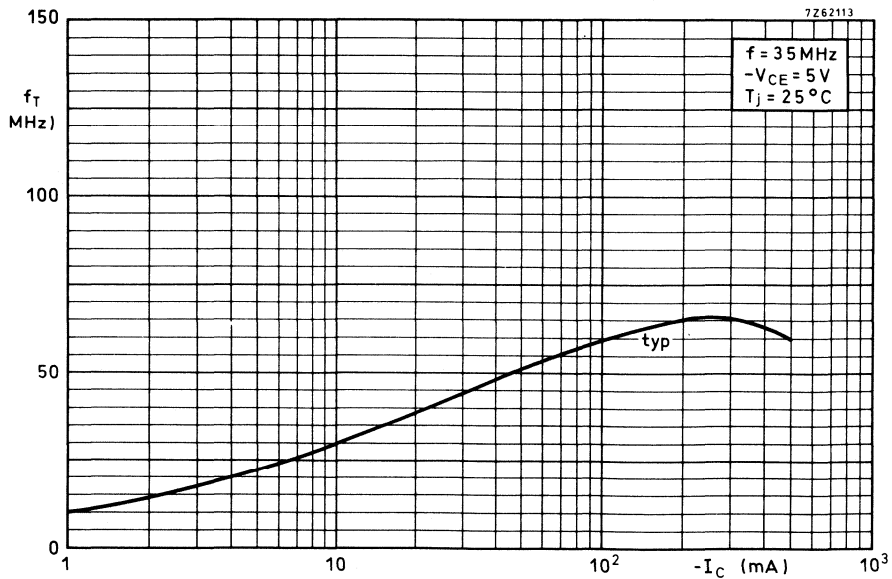


Fig. 15.

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 ($R_{BE} = 1 \text{ k}\Omega$)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		$^\circ\text{C}$
D.C. current gain	h_{FE}	>		25		
$I_C = 1 \text{ A}; V_{CE} = 2 \text{ V}$						
Transition frequency	f_T	>		3		MHz
$I_C = 250 \text{ mA}; V_{CE} = 10 \text{ V}$						

MECHANICAL DATA

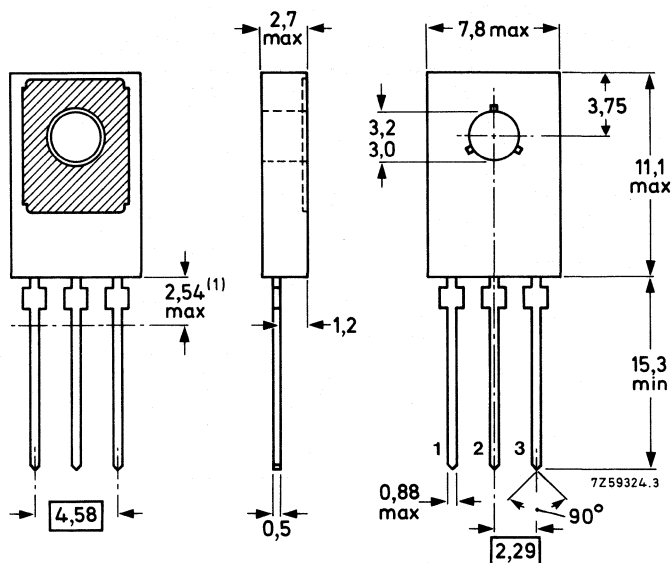
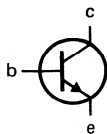
Dimensions in mm

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 ($R_{BE} = 1\text{ k}\Omega$)	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		25		W
Storage temperature	T_{stg}		-65 to + 150			$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=		100		K/W
From junction to mounting base	$R_{th\ j-mb}$	=		5		K/W

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CBOmax}$ $I_{CBO} <$ 50 μA

$I_E = 0; V_{CB} = V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$ $I_{CBO} <$ 1 mA

Emitter cut-off current

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

Second-breakdown collector current

$V_{CE} = 40\text{ V}; t_p = 20\text{ ms}$ $I_{(SB)C} <$ 0,5 A

Base-emitter voltage*

$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$ $V_{BE} <$ 1,3 V

Saturation voltage*

$I_C = 1\text{ A}; I_B = 0,1\text{ A}$ $V_{CEsat} <$ 0,6 V

D.C. current gain*

$I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$ h_{FE} 40 to 250

$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$ $h_{FE} >$ 25

Transition frequency at $f = 1\text{ MHz}$

$I_C = 250\text{ mA}; V_{CE} = 10\text{ V}$ $f_T >$ 3 MHz

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

CHARACTERISTICS (continued)

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

D.C. current gain ratio of matched complementary pairs*

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

$h_{FE1}/h_{FE2} < 1,6$

Switching times

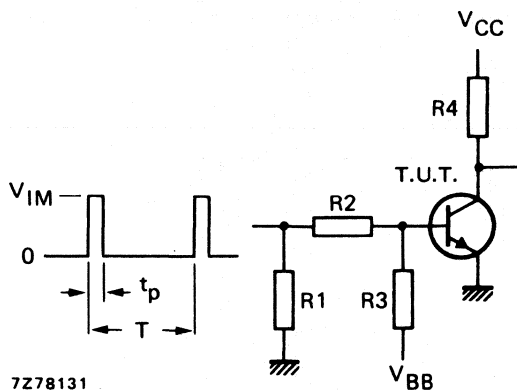
$I_{Con} = 1\text{ A}; I_{Bon} = -I_{Boff} = 0,1\text{ A}$

turn-on time

t_{on} typ. $0,4\text{ }\mu\text{s}$
< $1\text{ }\mu\text{s}$

turn-off time

t_{off} typ. $1,5\text{ }\mu\text{s}$
< $3\text{ }\mu\text{s}$



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

Fig. 2 Test circuit.

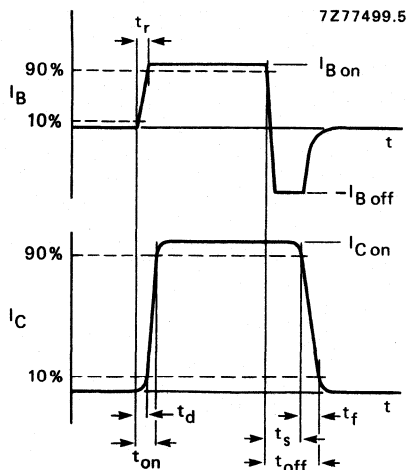


Fig. 3 Switching times waveforms.

* Measured under pulse conditions; $t_p < 300\text{ }\mu\text{s}$, $\delta < 2\%$.

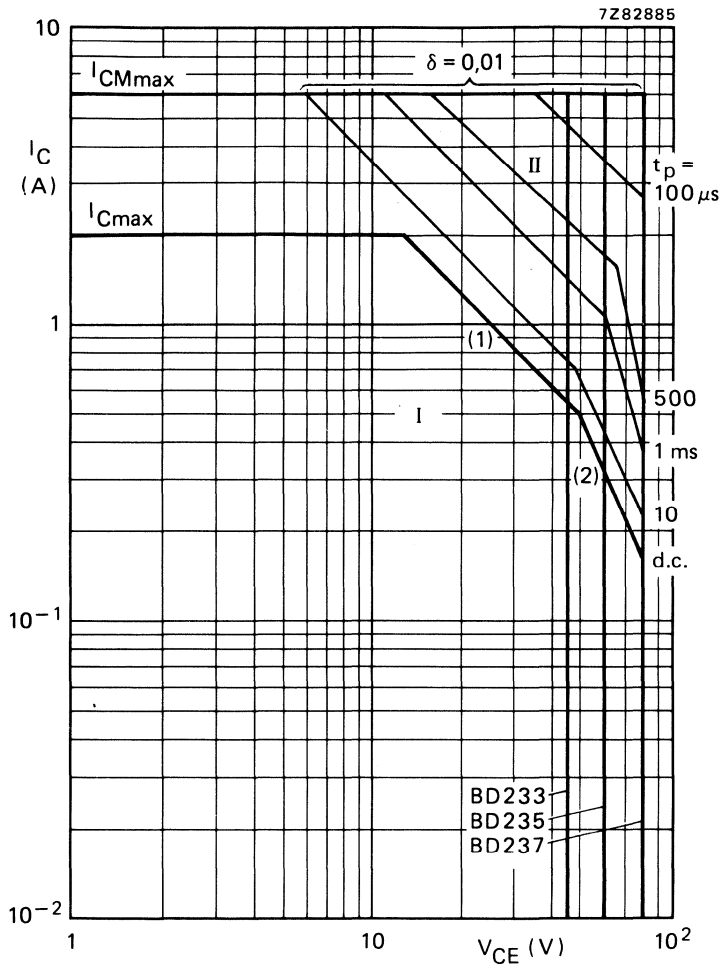


Fig. 4 Safe Operating Area with the transistor forward biased, $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

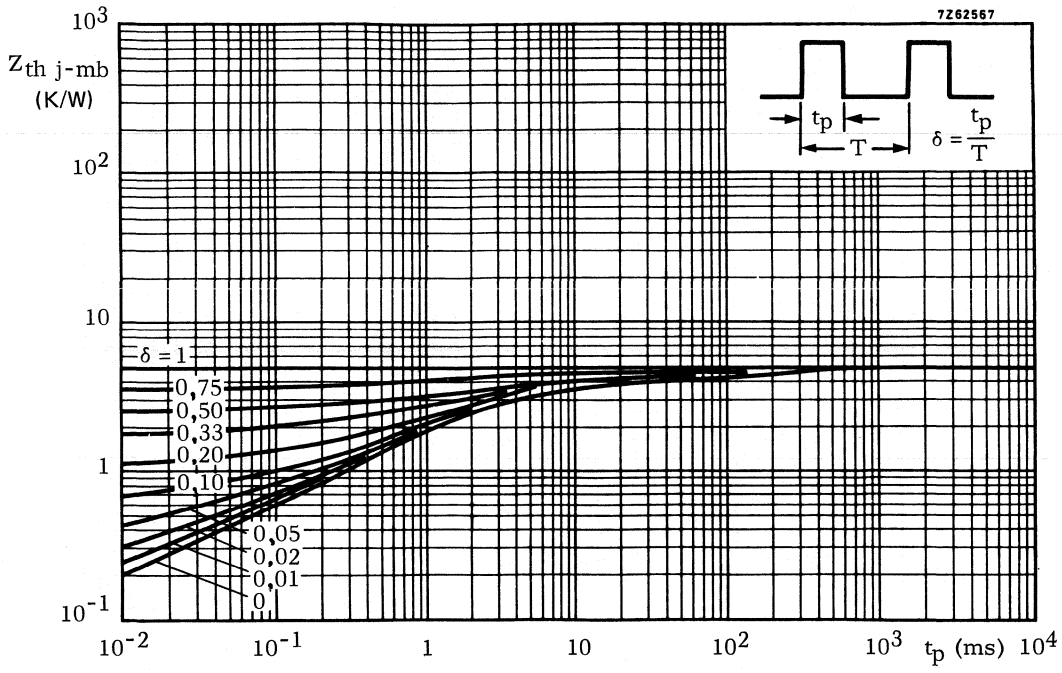
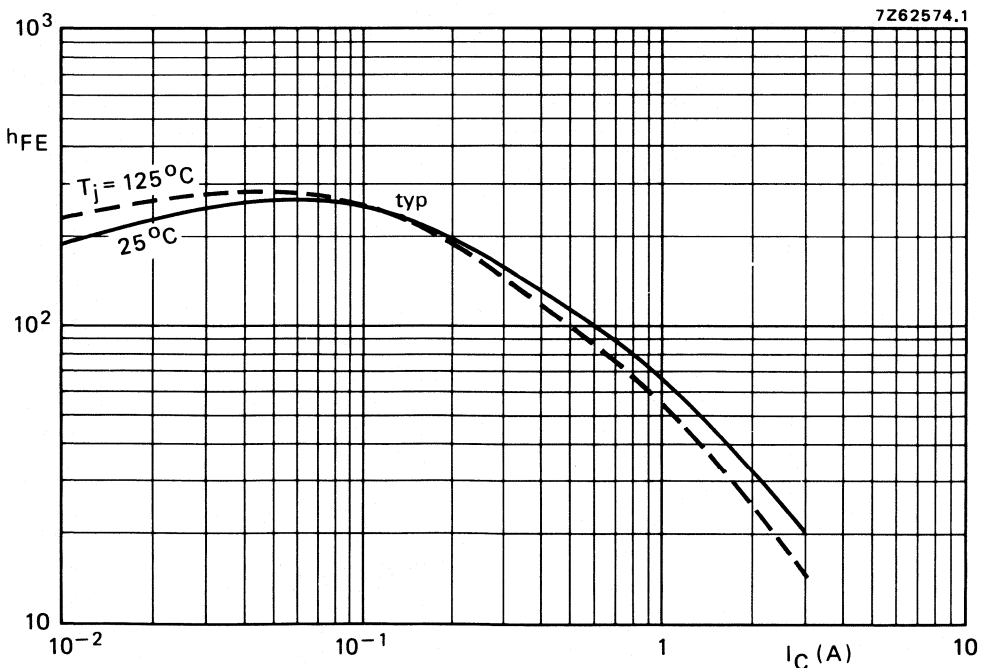


Fig. 5 Pulse power rating chart.



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

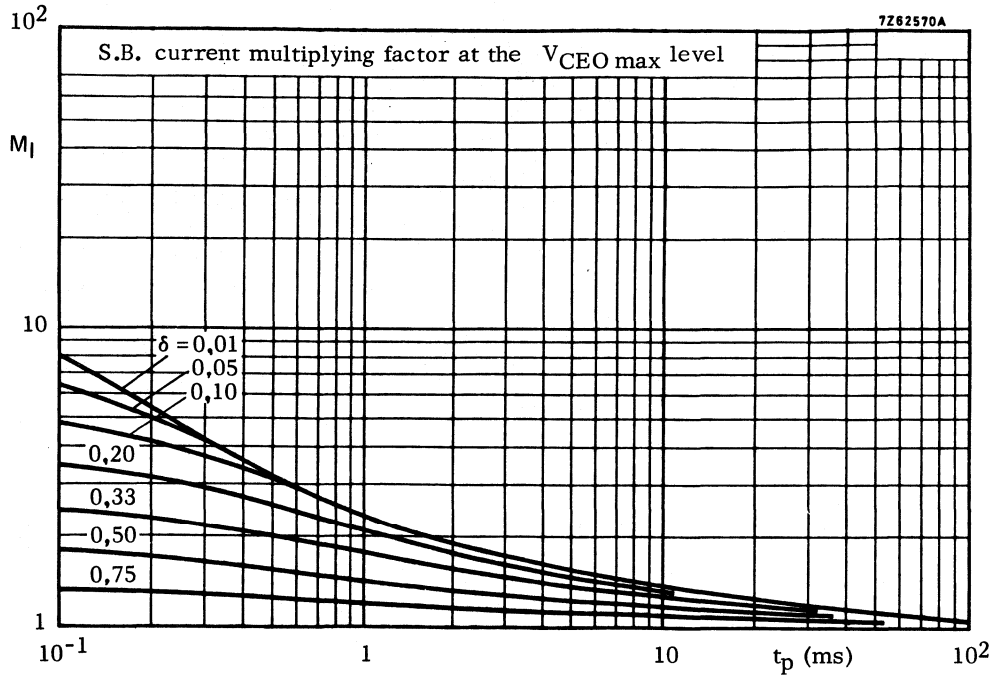


Fig. 7 S.B. current multiplying factor at the $V_{CE0\max}$ level.

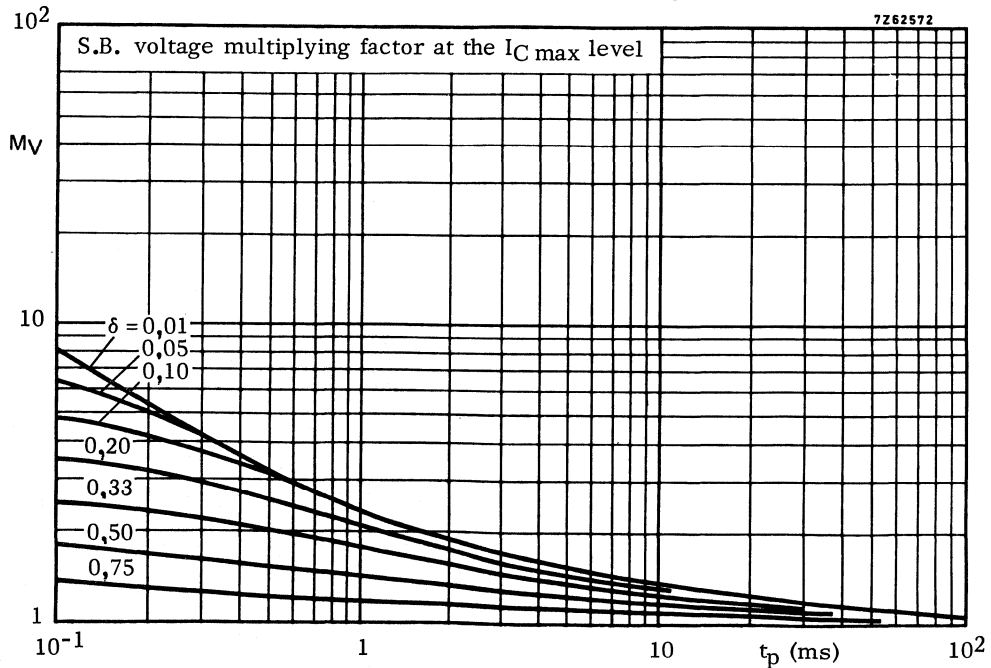


Fig. 8 S.B. voltage multiplying factor at the $I_{C\max}$ level.

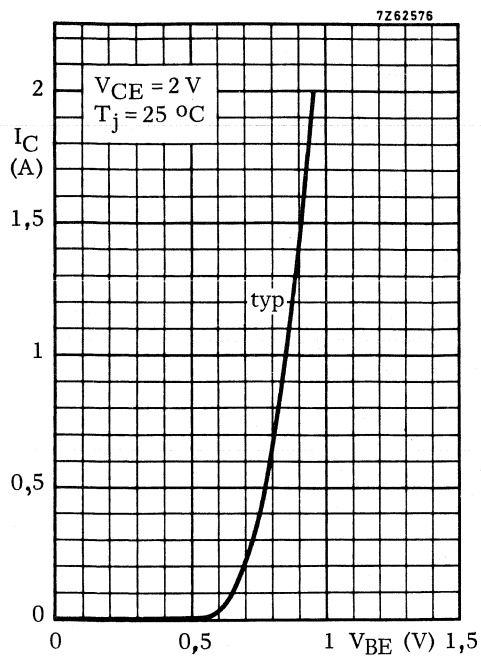


Fig. 9.

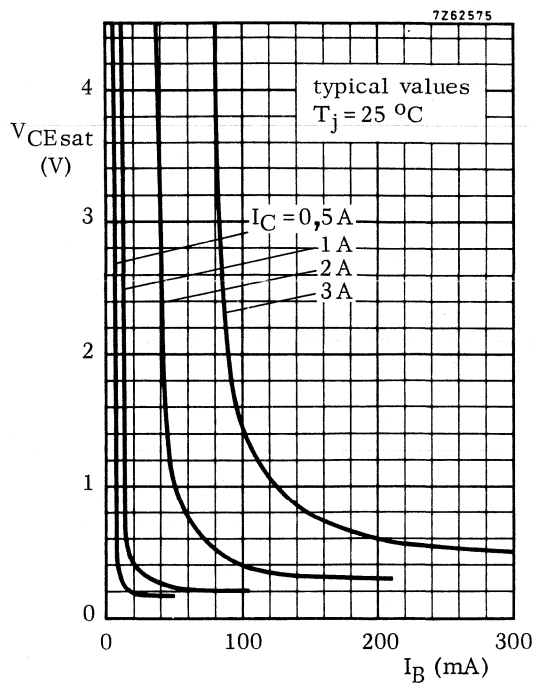


Fig. 10.

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 ($R_{BE} = 1\text{ k}\Omega$)	$-V_{CER}$	max. 45	60	100	V
Collector current (d.c.)	$-I_C$	max.	2		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	25		W
Junction temperature	T_j	max.	150		$^\circ\text{C}$
D.C. current gain $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$	h_{FE}	>	25		
Transition frequency $-I_C = 250\text{ mA}; -V_{CE} = 10\text{ V}$	f_T	>	3		MHz

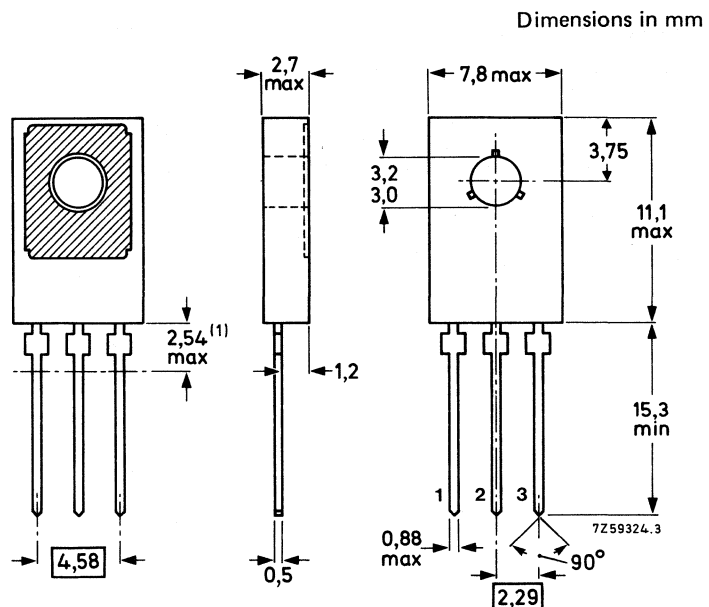
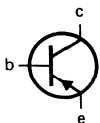
MECHANICAL DATA

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.

**BD234; BD236;
BD238**

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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	25			W
--	-----------	------	----	--	--	---

Storage temperature	T_{stg}		-65 to +150			$^\circ\text{C}$
---------------------	-----------	--	-------------	--	--	------------------

Junction temperature	T_j	max.	150			$^\circ\text{C}$
----------------------	-------	------	-----	--	--	------------------

THERMAL RESISTANCE

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

From junction to mounting base	$R_{th \text{ j-mb}}$	=	5			K/W
--------------------------------	-----------------------	---	---	--	--	-----

CHARACTERISTICS

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

Collector cut-off current

→ $I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	50			μA
------------------------------------	------------	---	----	--	--	---------------

→ $I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150 \text{ }^\circ\text{C}$	$-I_{CBO}$	<	1			mA
--	------------	---	---	--	--	----

Emitter cut-off current

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

CHARACTERISTICS (continued)

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

Base-emitter voltage

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

$-V_{BE} < 1,3\text{ V}$

Saturation voltage

$-I_C = 1\text{ A}; -I_B = 0,1\text{ A}$

$-V_{CEsat} < 0,6\text{ V}$

D.C. current gain

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

$h_{FE} \quad 40\text{ to }250$

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

$h_{FE} > 25$

Transition frequency at $f = 1\text{ MHz}$

$-I_C = 250\text{ mA}; -V_{CE} = 10\text{ V}$

$f_T > 3\text{ MHz}$

D.C. current gain ratio of matched pairs

BD233/BD234; BD235/BD236; BD237/BD238

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

$h_{FE1}/h_{FE2} < 1,6$

Switching times

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

turn-on time

$t_{on} \quad \text{typ} \quad 0,3\text{ }\mu\text{s}$

turn-off time

$t_{off} \quad \text{typ} \quad 0,7\text{ }\mu\text{s}$

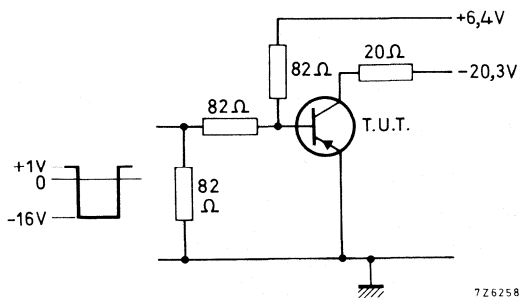


Fig. 2 Switching times test circuit

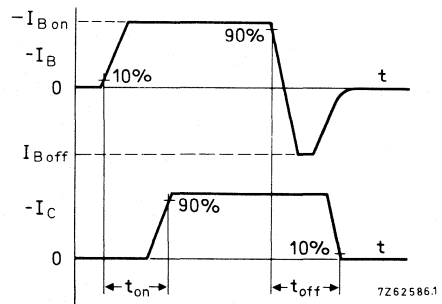


Fig. 3 Switching times waveforms.

Input pulse:

$t_r = t_f = 15\text{ ns}$

$t_p = 10\text{ }\mu\text{s}$

$T = 500\text{ }\mu\text{s}$

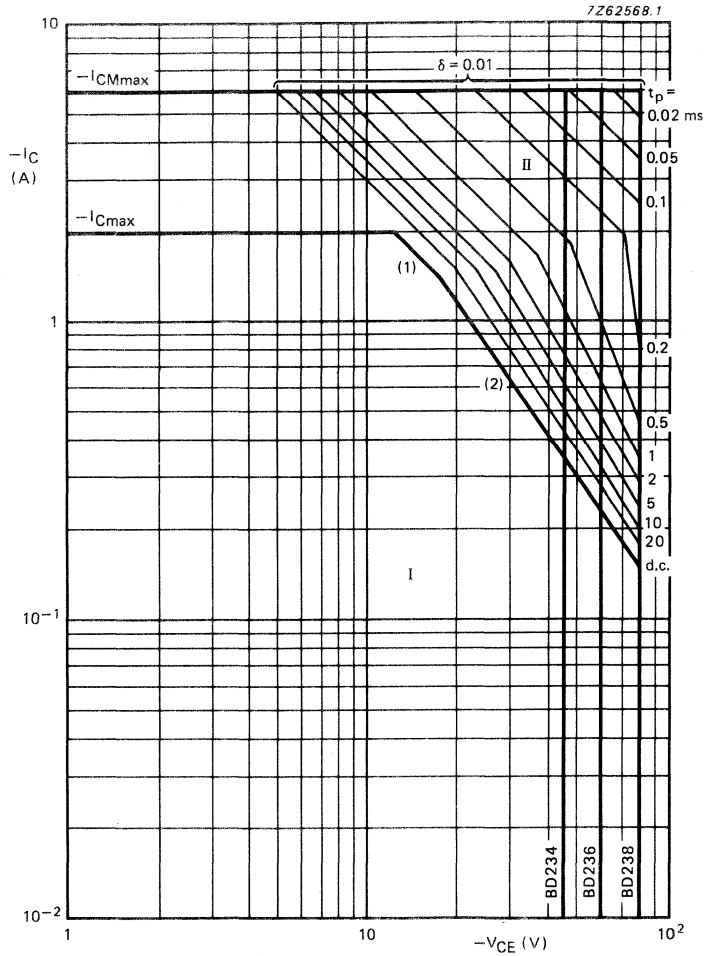


Fig. 4 Safe Operating Area; $T_{mb} = 25^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

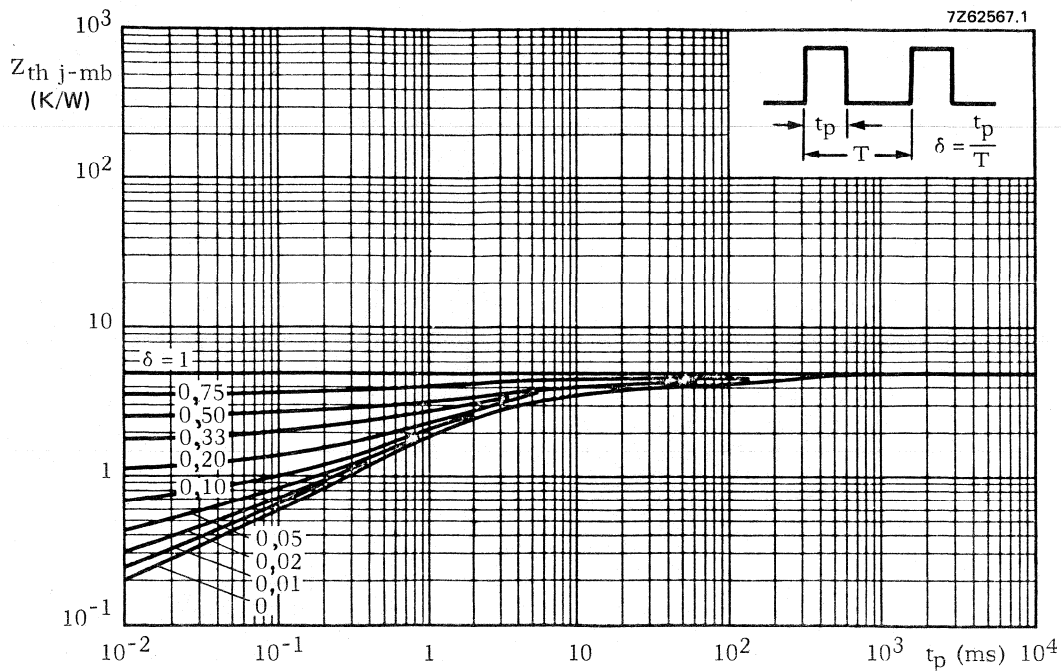


Fig. 5

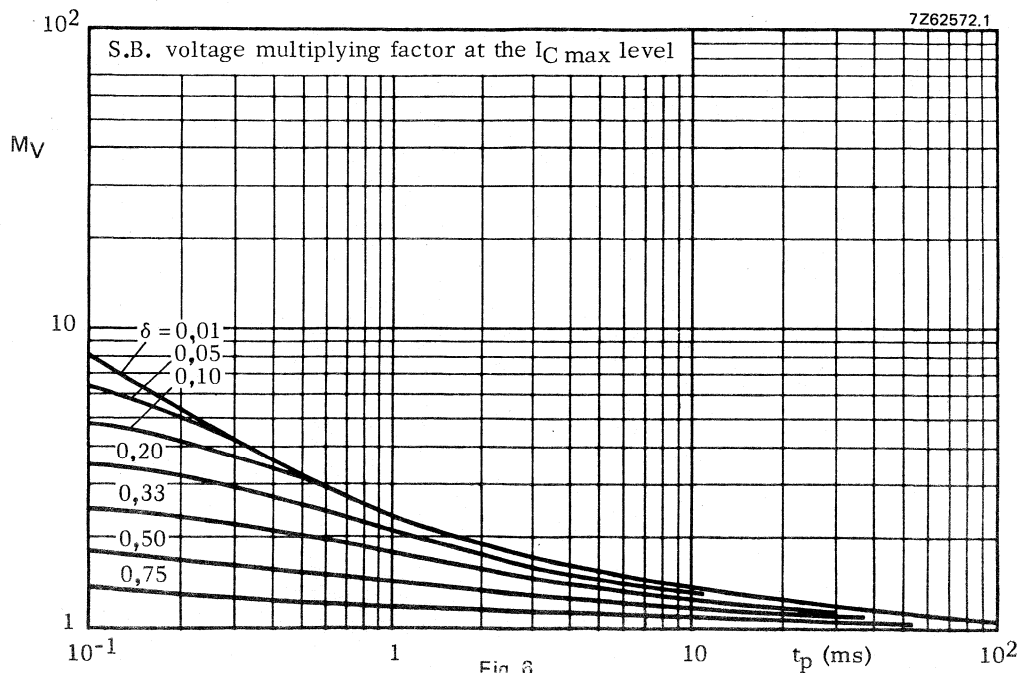
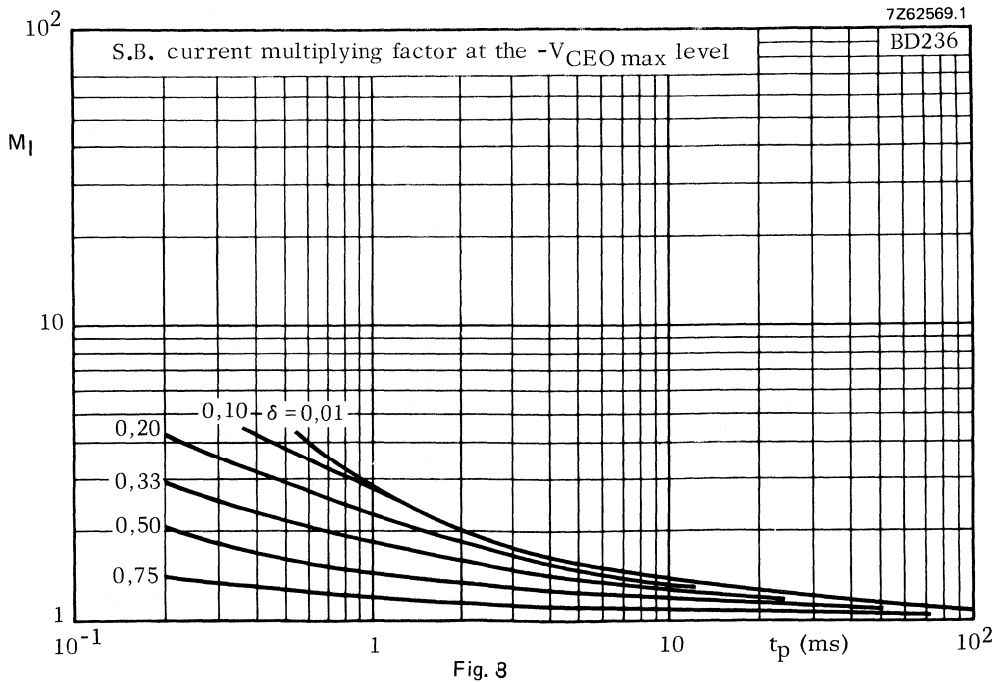
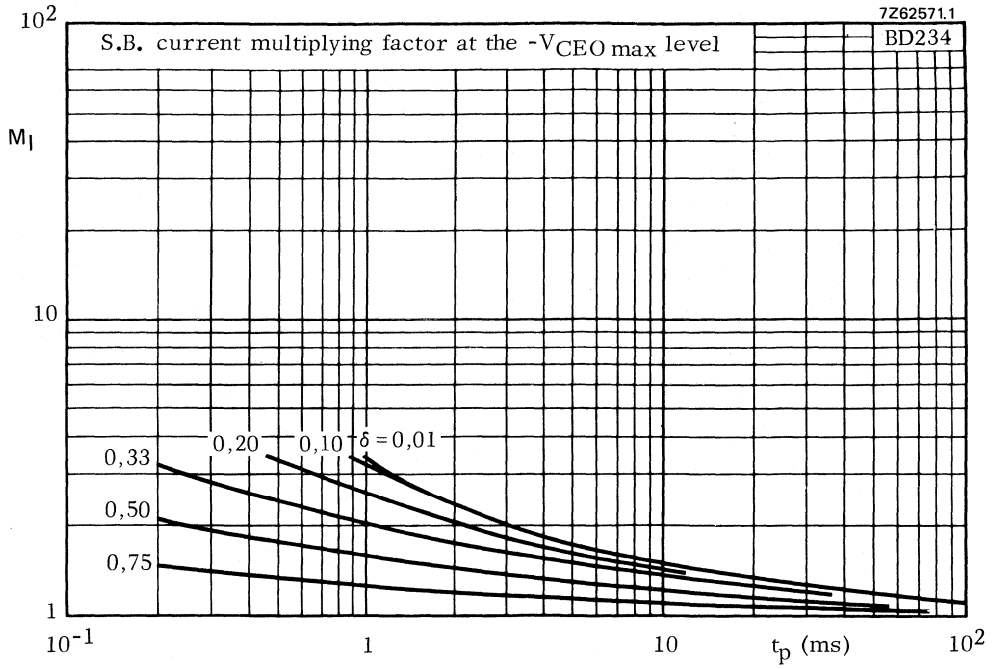


Fig. 6



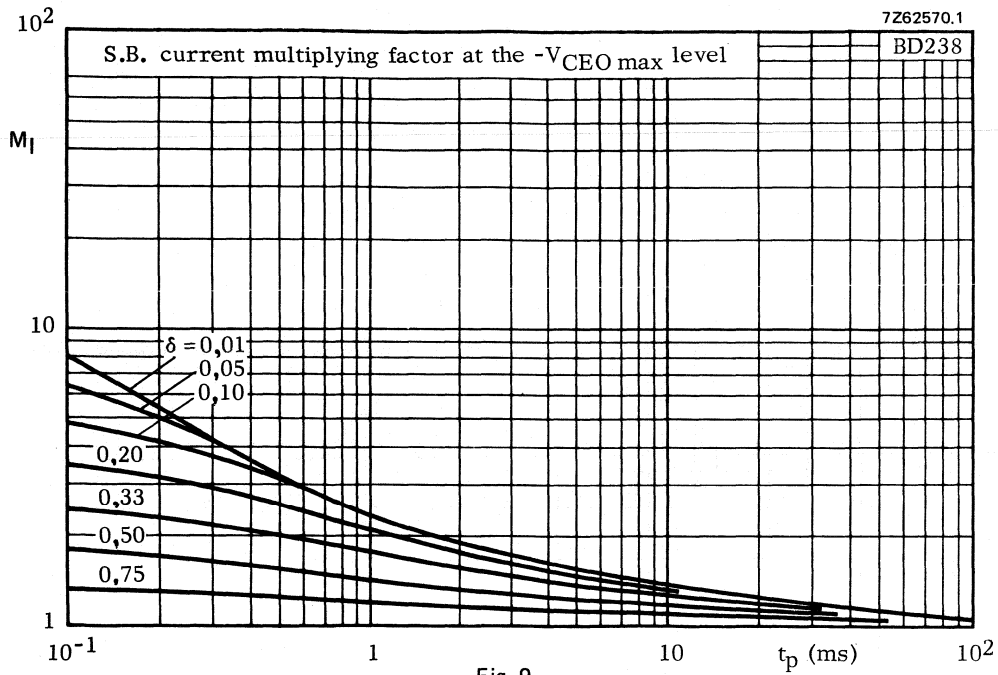


Fig. 9

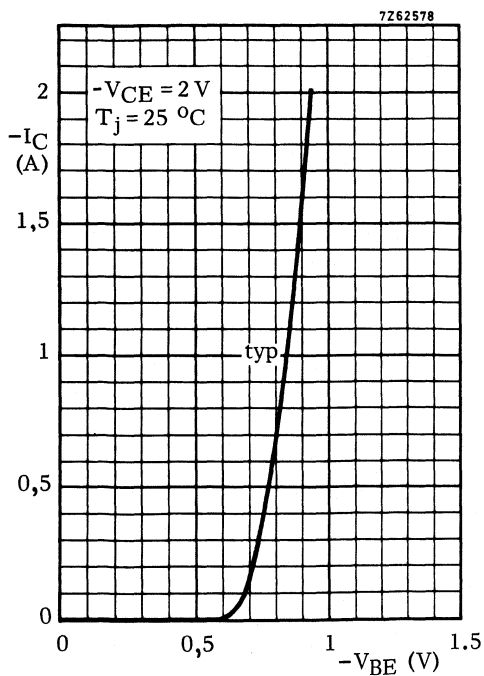


Fig. 10

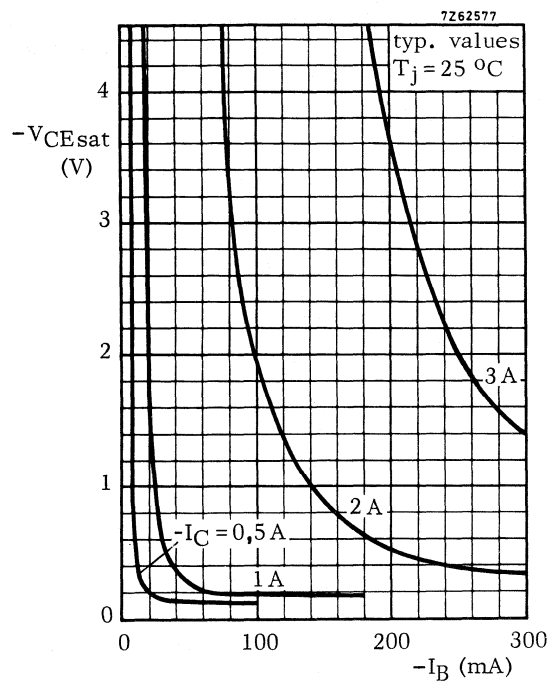


Fig. 11

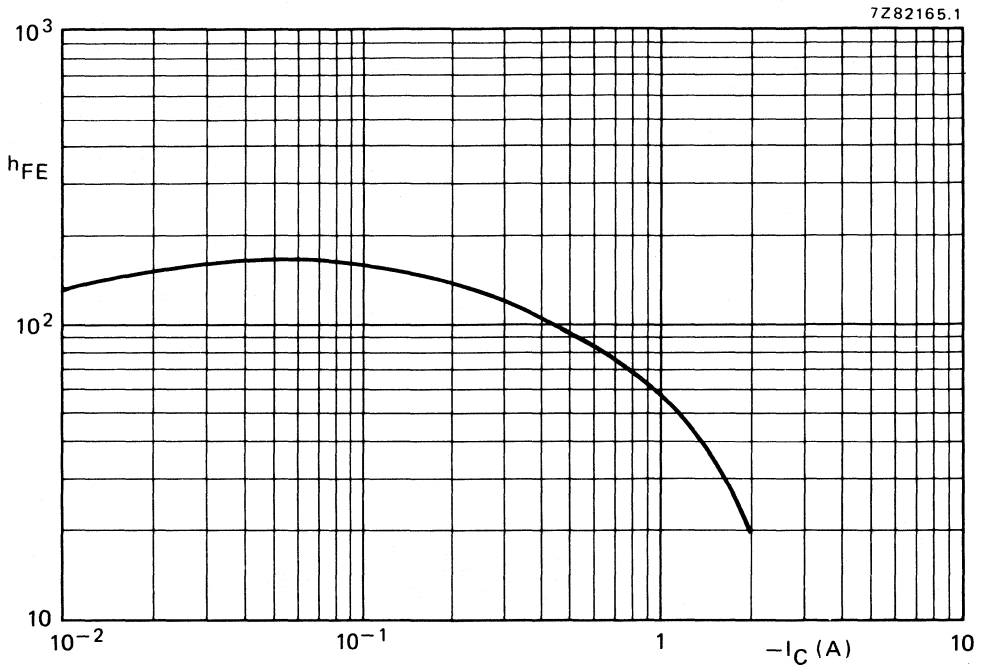


Fig. 12 Typical static forward current transfer ratio as a function of the collector current.
 $-V_{CE} = 2 \text{ V}; T_j \leq 25 \text{ }^\circ\text{C}.$

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in audio output stages, general amplifier and high-speed switching applications. P-N-P complements are BD240; 240A; 240B and BD240C.

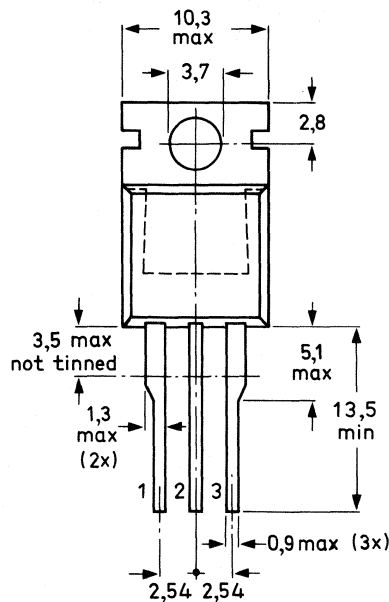
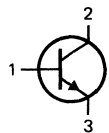
QUICK REFERENCE DATA

		BD239	A	B	C
Collector-base voltage	V_{CBO} max.	45	60	80	100 V
Collector-emitter voltage	V_{CEO} max.	45	60	80	100 V
Collector current (d.c.)	I_C max.		3		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		30		W
Junction temperature	T_j max.		150		$^\circ\text{C}$
D.C. current gain $I_C = 1\text{ A}, V_{CE} = 4\text{ V}$	$h_{FE} >$		15		
Transition frequency at $f = 1\text{ MHz}$ $I_C = 200\text{ mA}, V_{CE} = 10\text{ V}$	$f_T >$		3		MHz

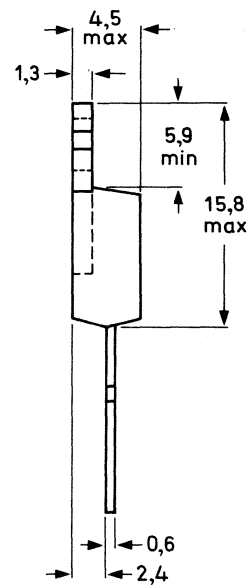
MECHANICAL DATA

Fig. 1 TO-220AB

Collector connected to mounting base



Dimensions in mm



7265872.5

See also chapters Mounting instructions and Accessories.

RATINGS

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

		BD239	A	B	C	
Collector-base voltage (open emitter)	V_{CB0}	max.	45	60	80	100 V
Collector-emitter voltage (open base)	V_{CE0}	max.	45	60	80	100 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max.	55	70	90	115 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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.		30		W
Storage temperature	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

		BD239; A	BD239B; C	
→ Collector cut-off current				
$I_B = 0; V_{CE} = 30 \text{ V}$	I_{CEO}	< 0,1	-	mA
$I_B = 0; V_{CE} = 60 \text{ V}$	I_{CEO}	< -	0,1	mA
$V_{BE} = 0; V_{CE} = V_{CE0max}$	I_{CES}	<	0,2	mA
→ Emitter cut-off current				
$I_C = 0; V_{EB} = 5 \text{ V}$	I_{EBO}	<	0,2	mA
D.C. current gain*				
$I_C = 200 \text{ mA}; V_{CE} = 4 \text{ V}$	h_{FE}	>	40	
$I_C = 1 \text{ A}; V_{CE} = 4 \text{ V}$	h_{FE}	>	15	
Base-emitter voltage**				
$I_C = 1 \text{ A}; V_{CE} = 4 \text{ V}$	V_{BE}	<	1,3	V
Collector-emitter saturation voltage*				
$I_C = 1 \text{ A}; I_B = 0,2 \text{ A}$	V_{CEsat}	<	0,6	V
Turn-off breakdown energy				
$L = 20 \text{ mH}; I_{CC} = 1,8 \text{ A}$	$E_{(BR)}$	>	32	mJ

* Measured under pulse conditions; $t_p \leq 300 \mu\text{s}$, $\delta \leq 0,02$.

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

Transition frequency at $f = 1 \text{ MHz}$

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

$f_T > 3 \text{ MHz}$

Switching times

(between 10% and 90% levels)

$I_{Con} = 0,2 \text{ A}; I_{B on} = -I_{B off} = 20 \text{ mA}$

Turn-on time

t_{on} typ. $0,3 \mu\text{s}$

Turn-off time

t_{off} typ. $0,8 \mu\text{s}$

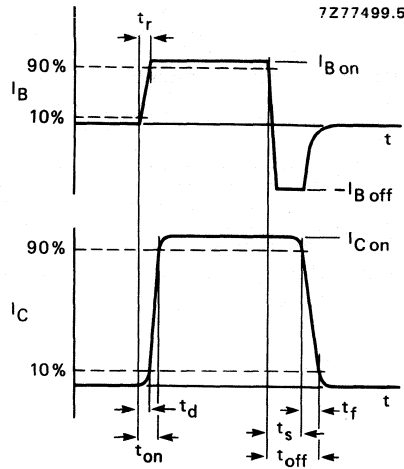
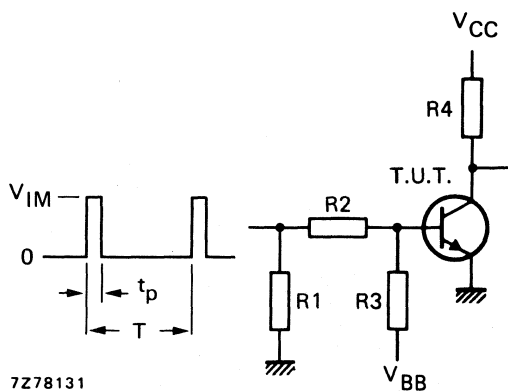


Fig. 2 Switching times waveforms.



- $V_{IM} = 40 \text{ V}$
- $V_{CC} = 30 \text{ V}$
- $-V_{BB} = 4,4 \text{ V}$
- $R1 = 51 \Omega$
- $R2 = 1000 \Omega$
- $R3 = 300 \Omega$
- $R4 = 150 \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

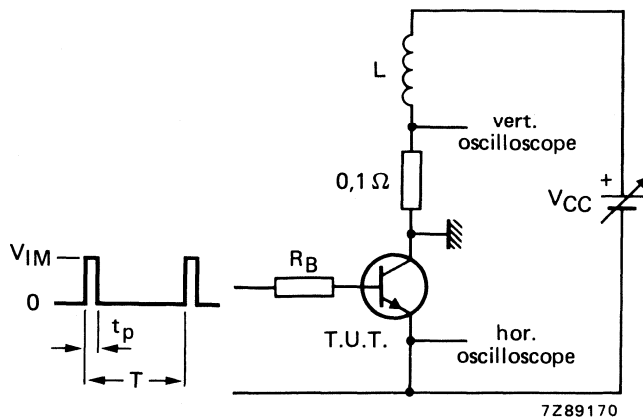


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = 12 \text{ V}$; $R_B = 270 \Omega$; $I_{CC} = 1,8 \text{ A}$; $t_p = 1 \text{ ms}$; $\delta = 0,01$.

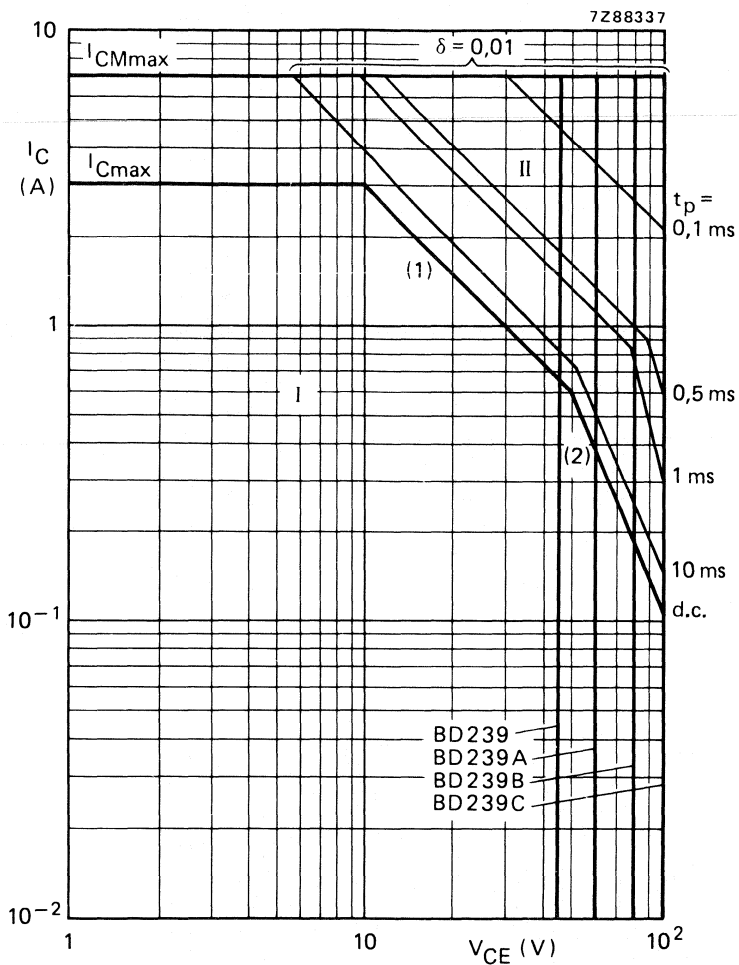


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

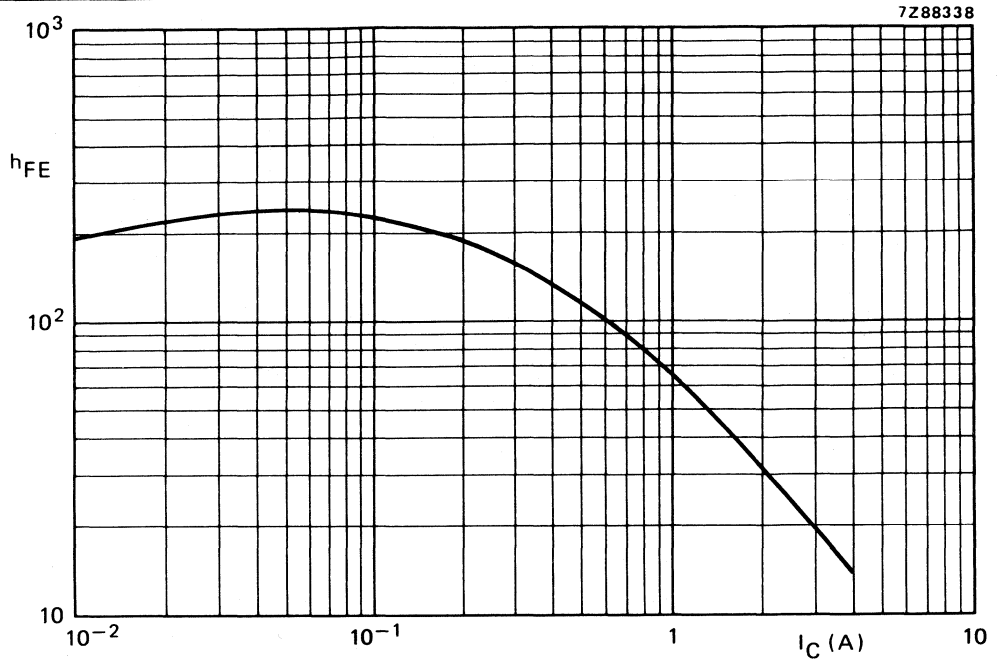


Fig. 6 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4$ V, $T_j = 25$ °C.

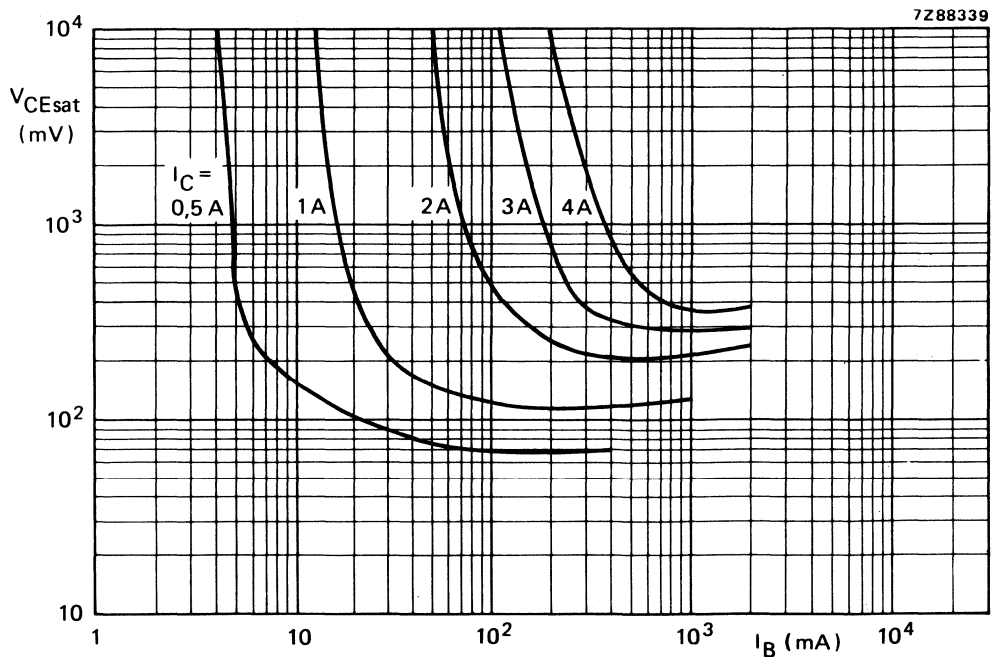


Fig. 7 Typical values collector-emitter saturation voltage at $T_j = 25$ °C.

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 BD239; 239A; 239B; and BD239C.

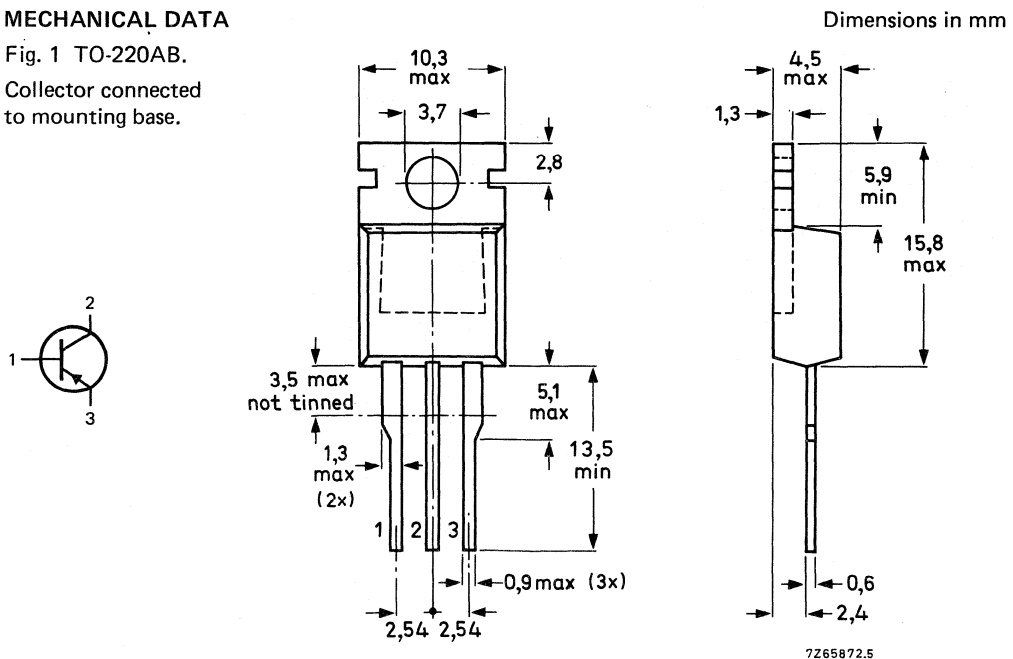
QUICK REFERENCE DATA

		BD240	A	B	C
Collector-base voltage	$-V_{CBO}$ max.	45	60	80	100 V
Collector-emitter voltage	$-V_{CEO}$ max.	45	60	80	100 V
Collector current (d.c.)	$-I_C$ max.			3	A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			30	W
Junction temperature	T_j max.			150	$^\circ\text{C}$
D.C. current gain					
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	$h_{FE} >$			15	
Transition frequency					
$-I_C = 200\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T >$			3	MHz

MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BD240	A	B	C
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	45	60	80	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	45	60	80	100 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	$-V_{CER}$ max.	55	70	90	115 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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	30			W
Storage temperature	T_{stg}	-65 to + 150			$^\circ\text{C}$
Junction temperature	T_j max.	150			$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

		BD240A	BD240B; C
→ Collector cut-off current			
$-I_B = 0; -V_{CE} = 30 \text{ V}$	$-I_{CEO} <$	0,1	— mA
$-I_B = 0; -V_{CE} = 60 \text{ V}$	$-I_{CEO} <$	—	0,1 mA
$-V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES} <$	0,2	mA
→ Emitter cut-off current			
$I_C = 0; -V_{EB} = 5 \text{ V}$	$-I_{EBO} <$	0,2	mA
D.C. current gain *			
$-I_C = 200 \text{ mA}; -V_{CE} = 4 \text{ V}$	$h_{FE} >$	40	
$-I_C = 1 \text{ A}; -V_{CE} = 4 \text{ V}$	$h_{FE} >$	15	
Base-emitter voltage *			
$-I_C = 1 \text{ A}; -V_{CE} = 4 \text{ V}$	$-V_{BE} <$	1,3	V
Collector-emitter saturation voltage *			
$-I_C = 1 \text{ A}; -I_B = 0,2 \text{ A}$	$-V_{CEsat} <$	0,6	V
Turn off breakdown energy			
$L = 20 \text{ mH}; -I_{CC} = 1,22 \text{ A}$	$E(BR) >$	15	mJ

* Measured under pulse conditions: $t_p \leq 300 \mu\text{s}; \delta < 0,02$.

Transition frequency at $f = 1 \text{ MHz}$

$-I_C = 200 \text{ mA}; -V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

$-I_{Con} = 0,2 \text{ A}; -I_{Bon} = I_{Boff} = 20 \text{ mA}$

turn-on time

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

turn-off time

t_{off} typ. $0,4 \mu\text{s}$

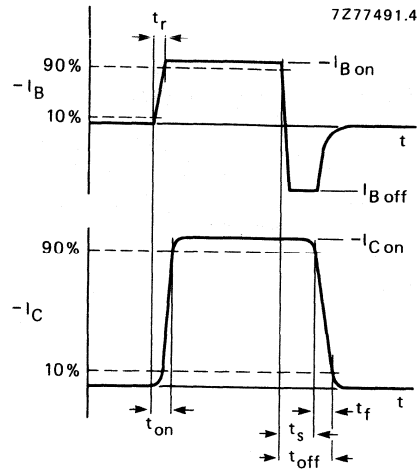


Fig. 2 Switching times waveforms.

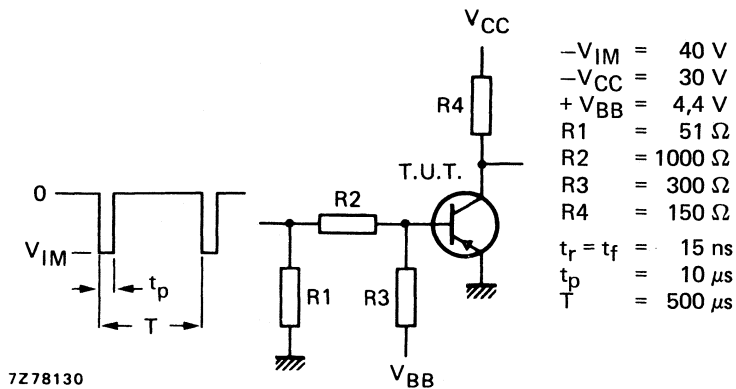


Fig. 3 Switching times test circuit.

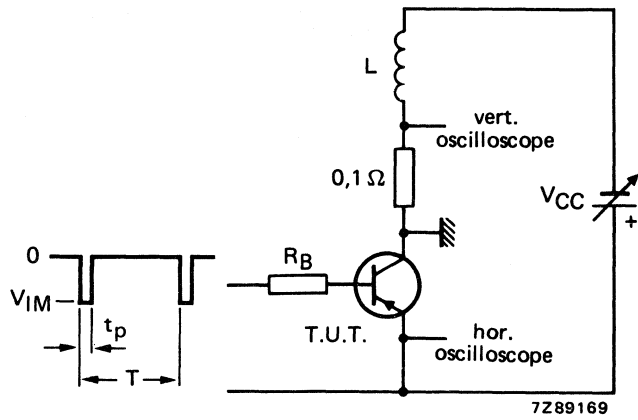


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = -12$ V; $R_B = 270$ Ω ; $-I_{CC} = 1,22$ A; $t_p = 1$ ms; $\delta = 0,01$.

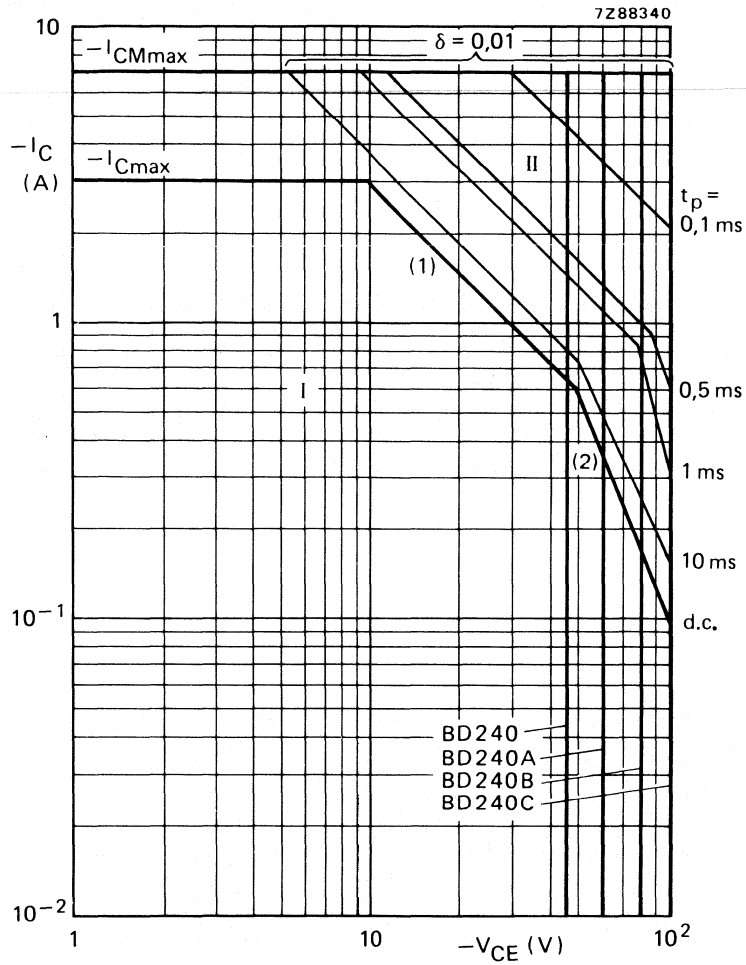


Fig. 5 Safe Operating ARea; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

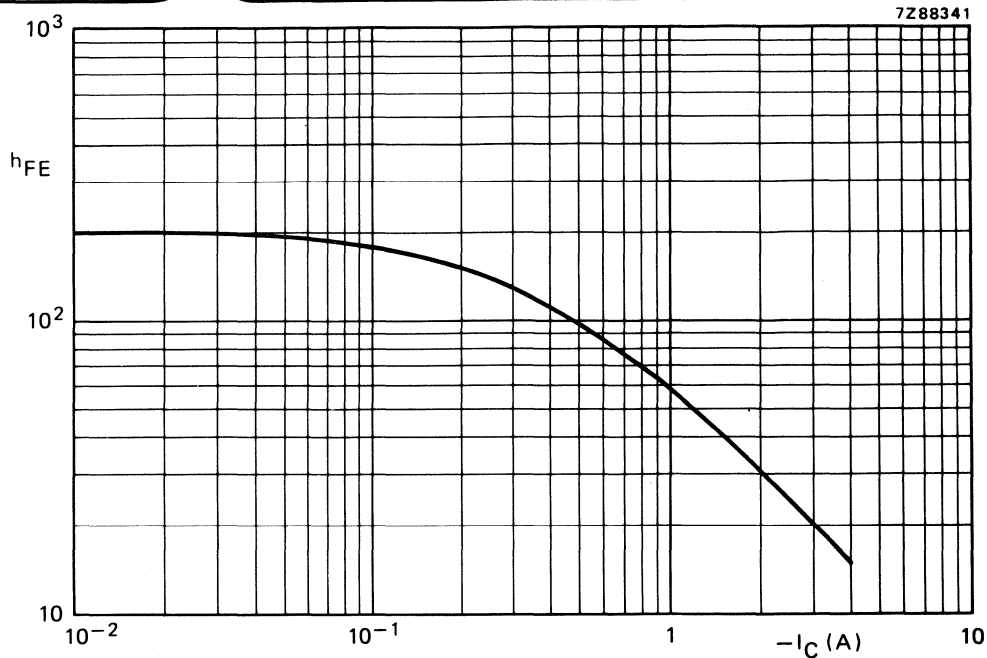


Fig. 6 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 4$ V, $T_j = 25$ °C.

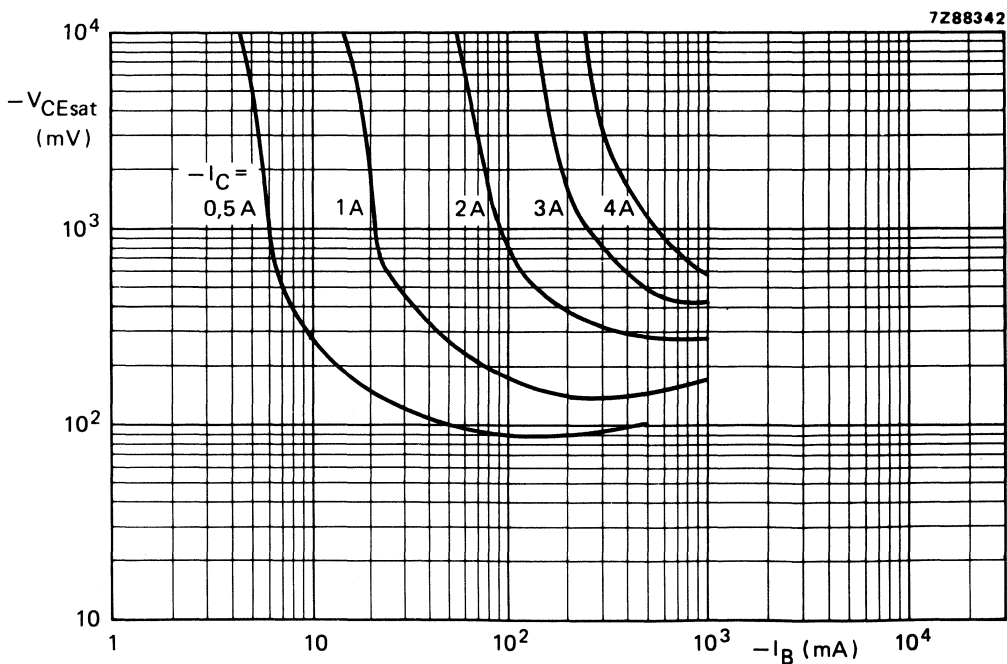


Fig. 7 Typical values collector-emitter saturation voltage at $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in audio output stages, general amplifier and high-speed switching applications. P-N-P complements are BD242; 242A; 242B; and 242C.

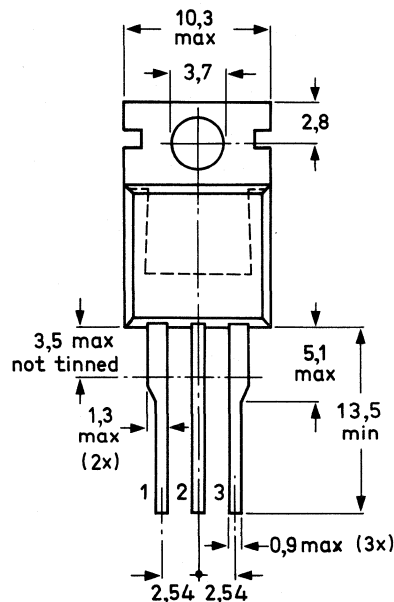
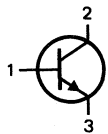
QUICK REFERENCE DATA

		BD241	A	B	C
Collector-base voltage	V_{CBO}	max. 45	60	80	100 V
Collector-emitter voltage	V_{CEO}	max. 45	60	80	100 V
Collector current (d.c.)	I_C	max.	5		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	40		W
Junction temperature	T_j	max.	150		$^\circ\text{C}$
D.C. current gain $I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	25		
Transition frequency at $f = 1\text{ MHz}$ $I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$	f_T	>	3		MHz

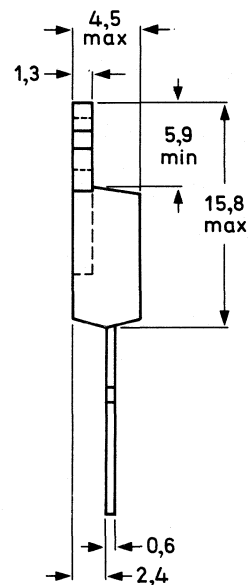
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



Dimensions in mm



7265872.5

See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD241	A	B	C
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	100 V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max.	55	70	90	115 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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.		40		W
Storage temperature	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	3, 12	K/W
From junction to ambient in free air	R_{thj-a}	=	70	K/W

CHARACTERISTICS

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

			BD241; A	BD241B; C
→ Collector cut-off current				
$I_B = 0; V_{CE} = 30 \text{ V}$	I_{CEO}	<	0,1	mA
$I_B = 0; V_{CE} = 60 \text{ V}$	I_{CEO}	<	—	0,1 mA
$V_{BE} = 0; V_{CE} = V_{CEOmax}$	I_{CES}	<	0,2 mA	
→ Emitter cut-off current				
$I_C = 0; V_{EB} = 5 \text{ V}$	I_{EBO}	<		1 mA
D.C. current gain*				
$I_C = 1 \text{ A}; V_{CE} = 4 \text{ V}$	h_{FE}	>		25
$I_C = 3 \text{ A}; V_{CE} = 4 \text{ V}$	h_{FE}	>		10
Base-emitter voltage**				
$I_C = 3 \text{ A}; V_{CE} = 4 \text{ V}$	V_{BE}	<		1,8 V
Collector-emitter saturation voltage*				
$I_C = 3 \text{ A}; I_B = 0,6 \text{ A}$	V_{CEsat}	<		1,2 V
Small-signal current gain				
$I_C = 0,5 \text{ A}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$	$ h_{fe} $	>		20
Turn off breakdown energy				
$L = 20 \text{ mH}; I_C = 1,8 \text{ A}$	$E_{(BR)}$	>		32 mJ

* Measured under pulse conditions: $t_p \leq 300 \mu\text{s}; \delta < 0,02$.

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

Transition frequency at $f = 1 \text{ MHz}$

$I_C = 0,5 \text{ A}; V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

(between 10% and 90% levels)

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

Turn-on time

t_{on} typ. $0,3 \mu\text{s}$

Turn-off time

t_{off} typ. $1 \mu\text{s}$

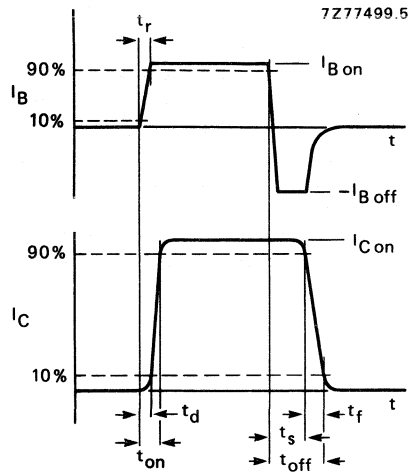


Fig. 2 Switching times waveforms.

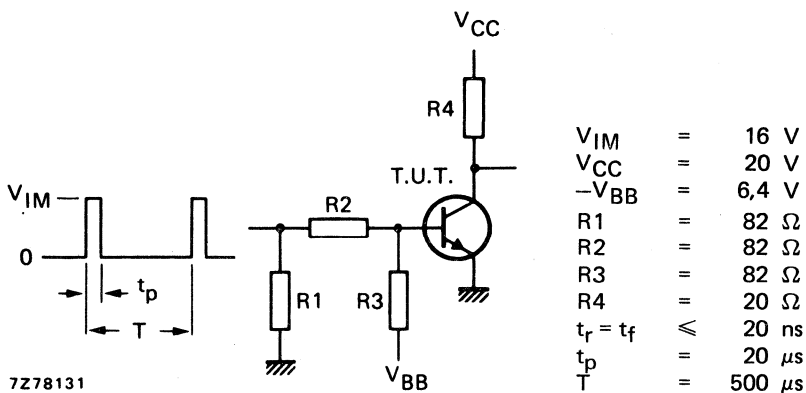


Fig. 3 Switching times test circuit.

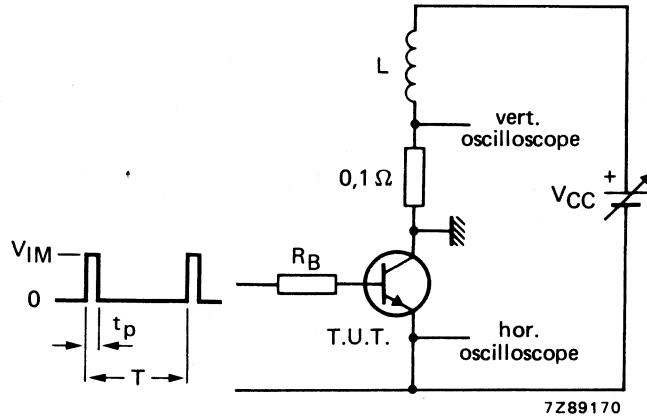


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = 12\text{ V}$; $R_B = 270\ \Omega$; $I_{CC} = 1,8\text{ A}$; $t_p = 1\text{ ms}$; $\delta = 0,01$.

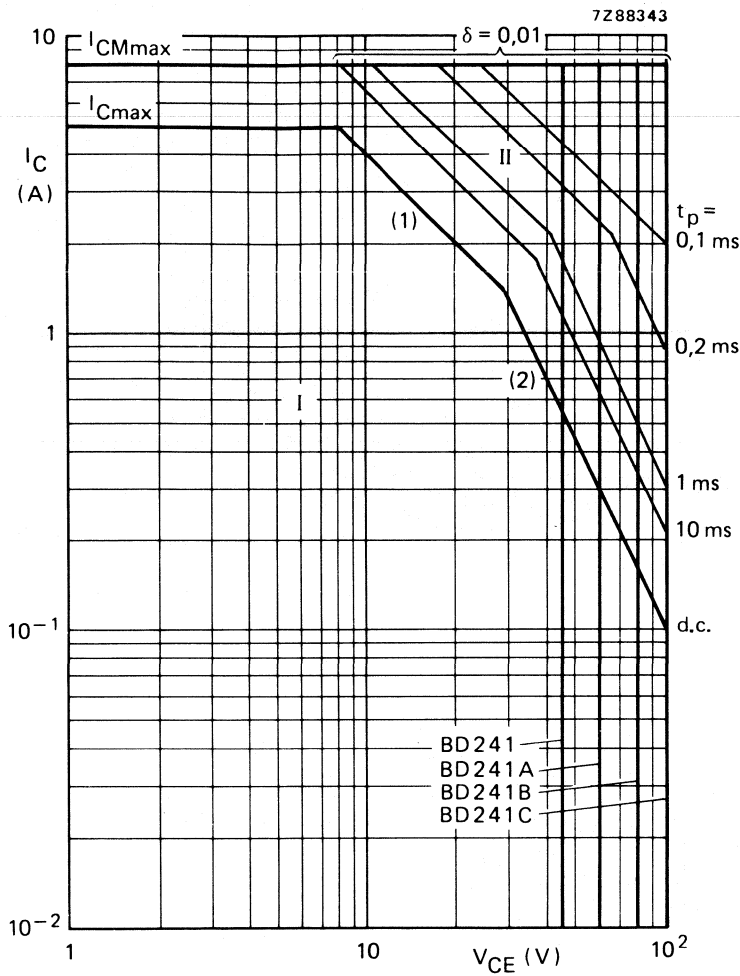


Fig. 5 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

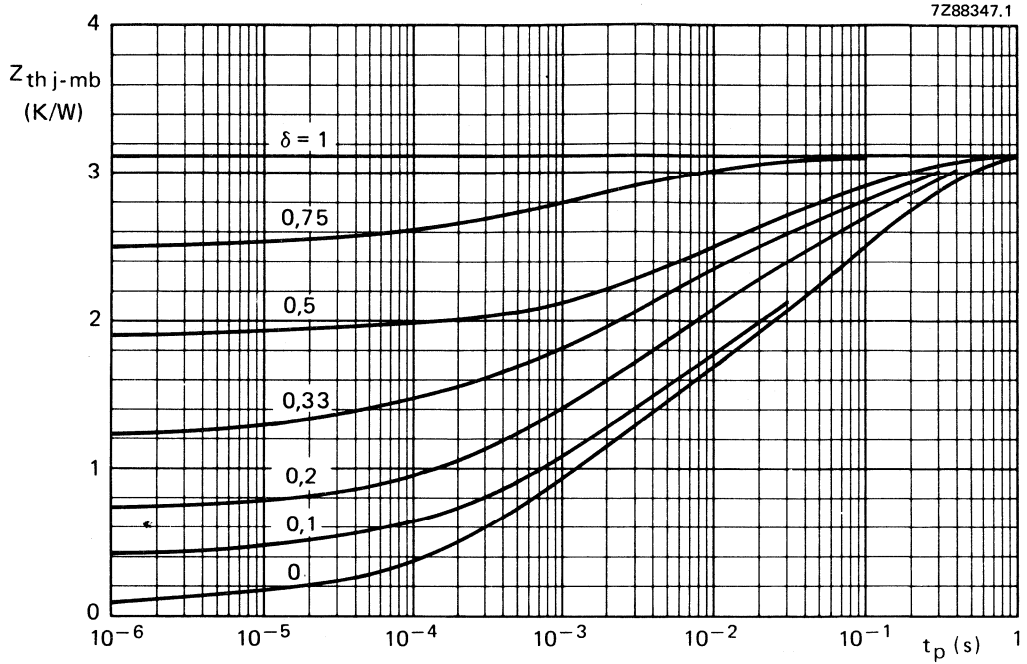


Fig. 6 Power pulse rating chart.

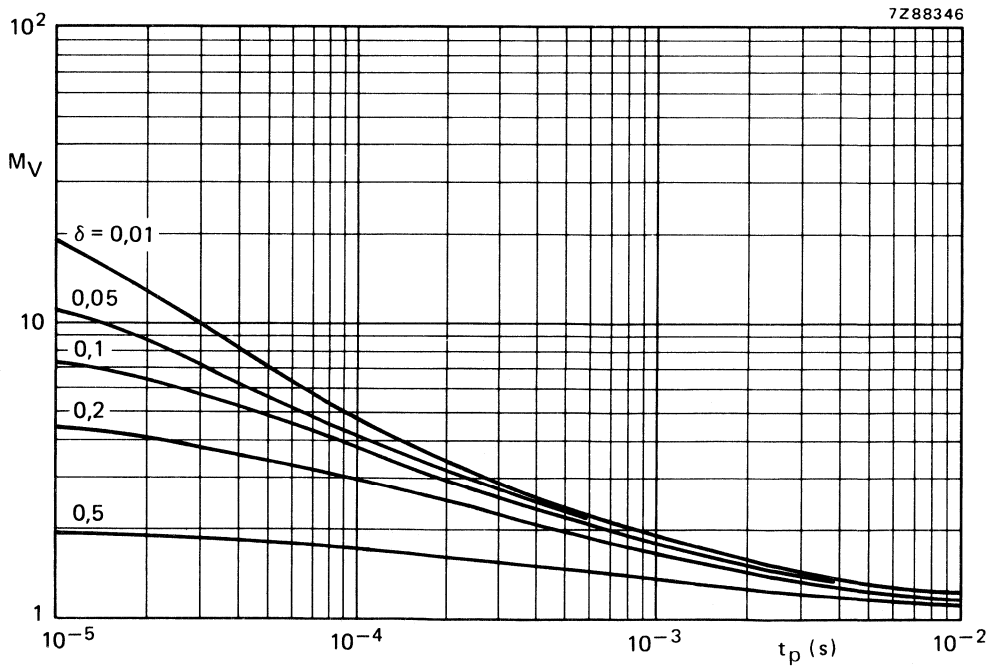
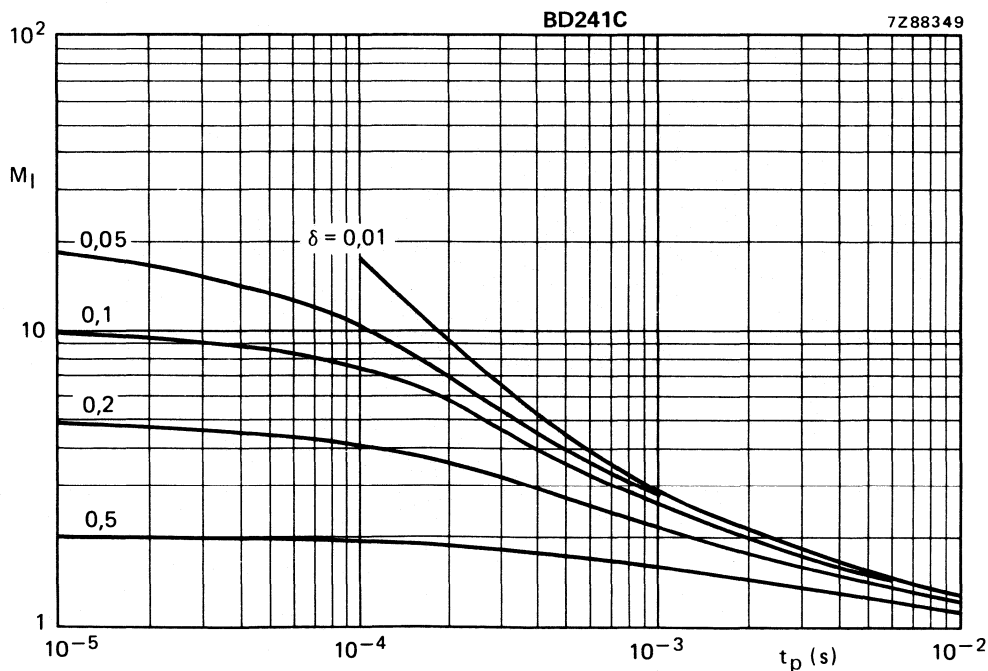
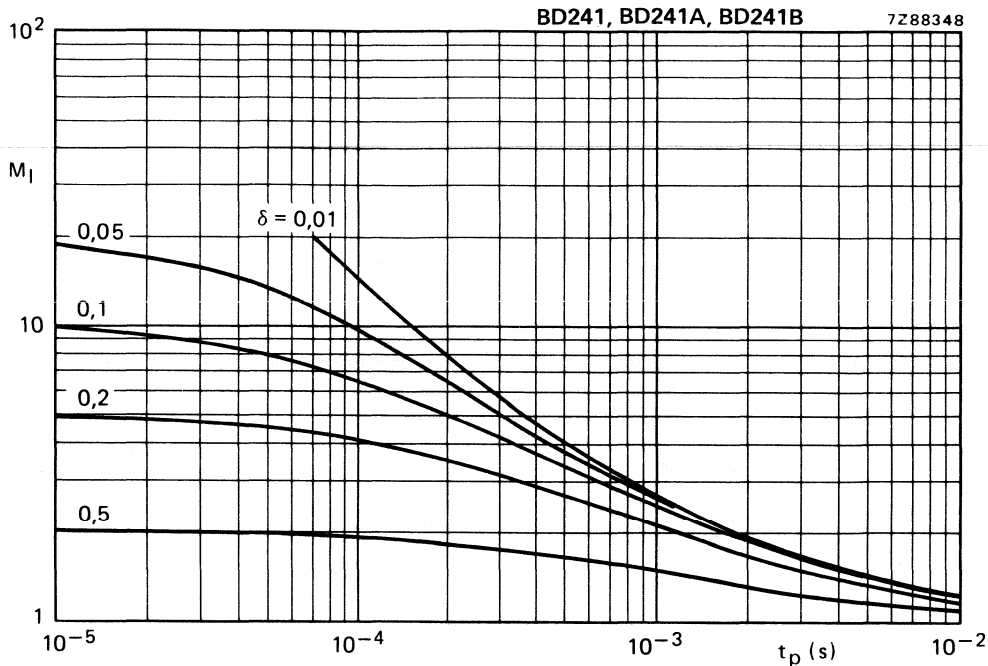


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.



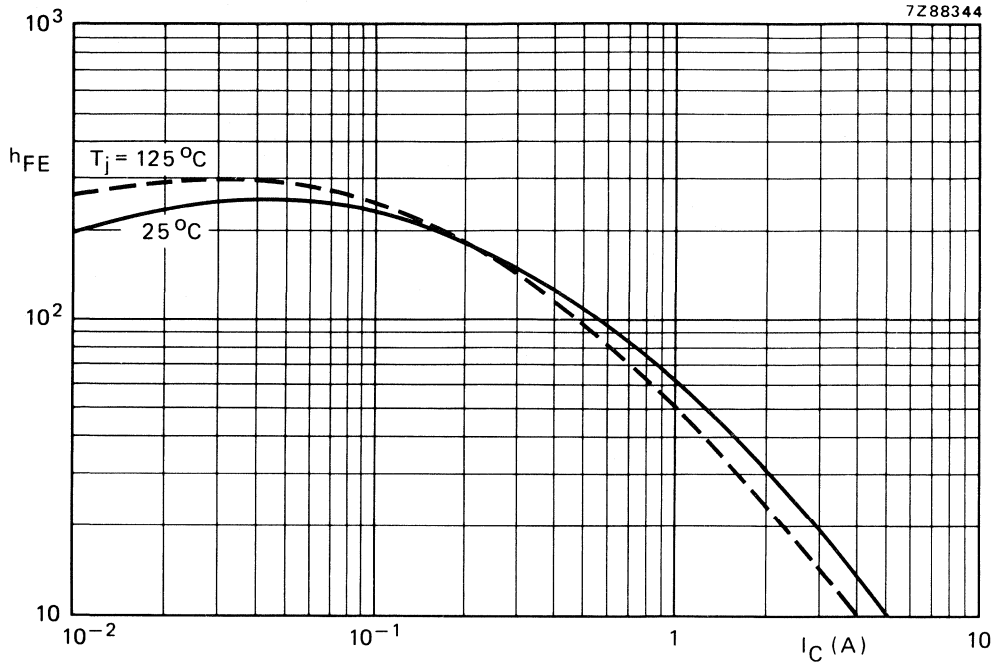


Fig. 10 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4$ V.

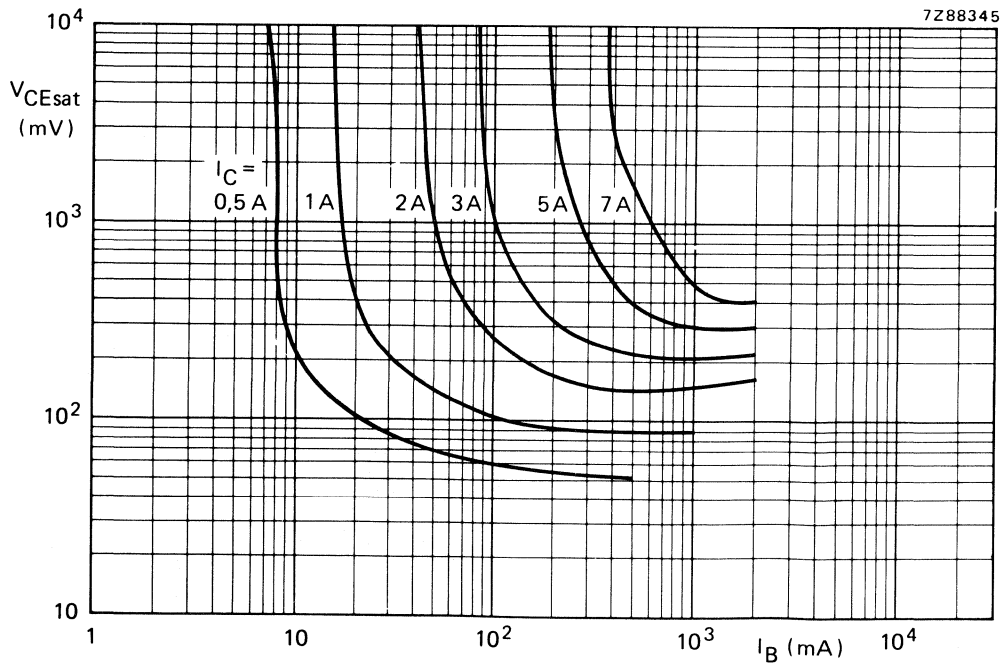


Fig. 11 Typical values collector-emitter saturation voltage at $T_j = 25^\circ\text{C}$.

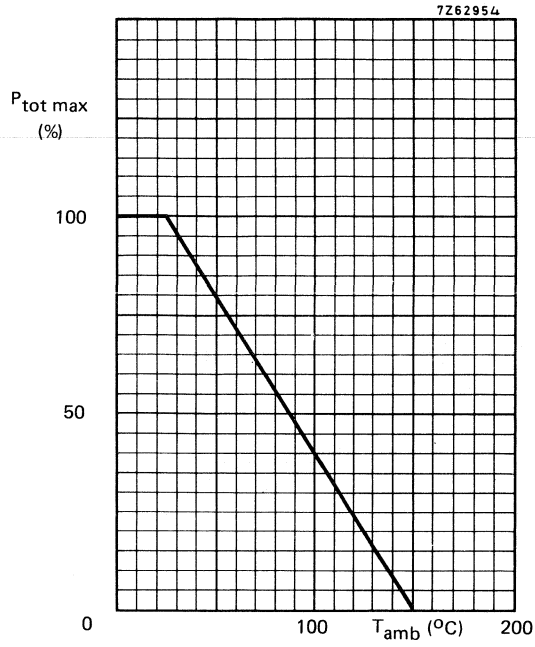


Fig. 12 Power derating curve.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in audio output stages, general amplifier and high-speed switching applications. N-P-N complements are BD241; 241A; 241B and BD241C.

QUICK REFERENCE DATA

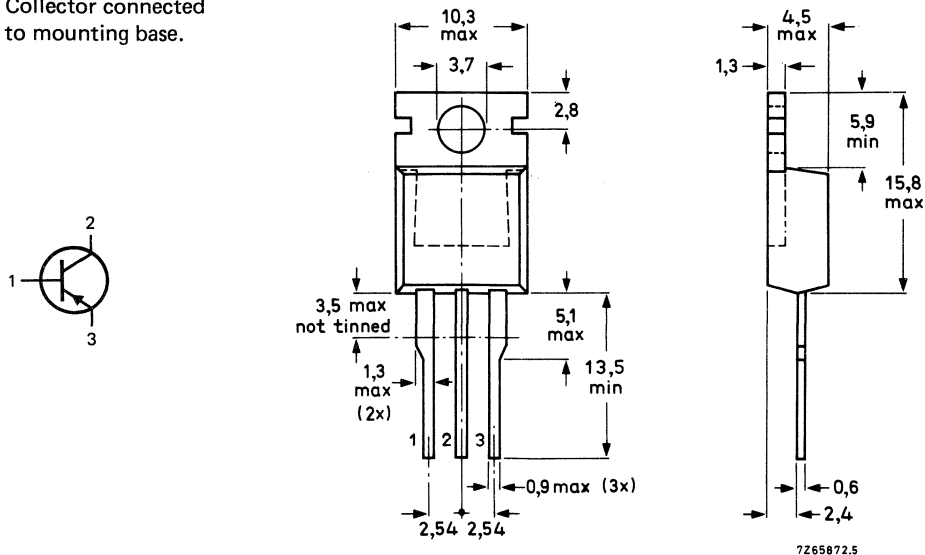
		BD242	A	B	C	
Collector-base voltage	$-V_{CBO}$ max.	45	60	80	100	V
Collector-emitter voltage	$-V_{CEO}$ max.	45	60	80	100	V
Collector current (d.c.)	$-I_C$ max.			5	A	
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			40	W	
Junction temperature	T_j max.			150	$^\circ\text{C}$	
D.C. current gain	h_{FE} >			25		
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$						
Transition frequency	f_T >			3	MHz	
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$						

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD242	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	$-V_{CER}$	max.	55	70	90	115	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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.			40		W
Storage temperature	T_{stg}		-65 to + 150				$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

			BD242; A	BD242B; C	
→ Collector cut-off current					
$-I_B = 0; -V_{CE} = 30 \text{ V}$	$-I_{CEO}$	<	0,1	—	mA
$-I_B = 0; -V_{CE} = 60 \text{ V}$	$-I_{CEO}$	<	—	0,1	mA
$-V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<		0,2	mA
→ Emitter cut-off current					
$I_C = 0; -V_{EB} = 5 \text{ V}$	$-I_{EBO}$	<		0,2	mA
D.C. current gain *					
$-I_C = 1 \text{ A}; -V_{CE} = 4 \text{ V}$	h_{FE}	>		25	
$-I_C = 3 \text{ A}; -V_{CE} = 4 \text{ V}$	h_{FE}	>		10	
Base-emitter voltage *					
$-I_C = 3 \text{ A}; -V_{CE} = 4 \text{ V}$	$-V_{BE}$	<		1,8	V
Collector-emitter saturation voltage *					
$-I_C = 3 \text{ A}; -I_B = 0,6 \text{ A}$	$-V_{CEsat}$	<		1,2	V
Small-signal current gain					
$-I_C = 0,5 \text{ A}; -V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$	$ h_{fe} $	>		20	
Turn off breakdown energy					
$L = 20 \text{ mH}; -I_{CC} = 1,22 \text{ A}$	$E_{(BR)}$	>		15	mJ

* Measured under pulse conditions: $t_p \leq 300 \mu\text{s}; \delta < 0,02$.

Transition frequency at $f = 1 \text{ MHz}$
 $-I_C = 500 \text{ mA}; -V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

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

turn-on time

$t_{on} \text{ typ. } 0,3 \mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 1 \mu\text{s}$

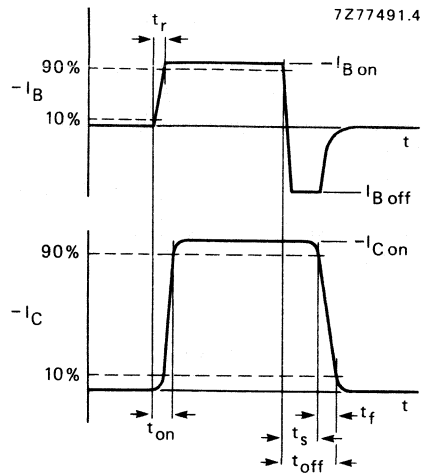


Fig. 2 Switching times waveforms.

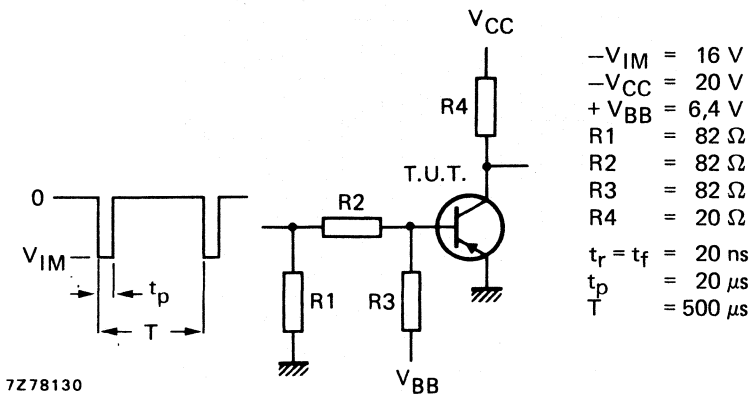


Fig. 3 Switching times test circuit.

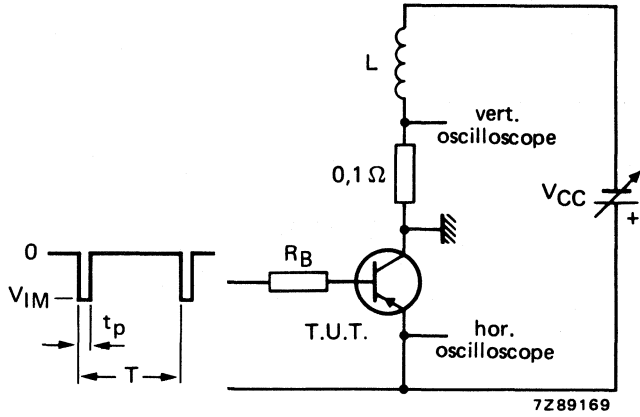


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = -12 \text{ V}$; $R_B = 270 \text{ } \Omega$; $-I_{CC} = 1,22 \text{ A}$; $t_p = 1 \text{ ms}$; $\delta = 0,01$.

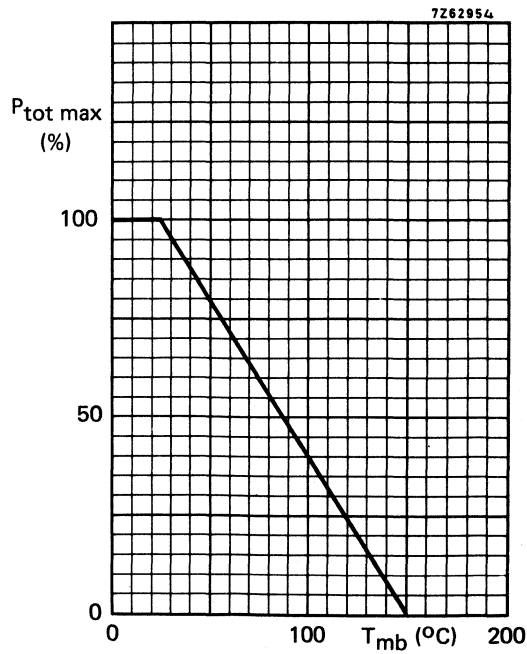


Fig. 4a Power derating curve.

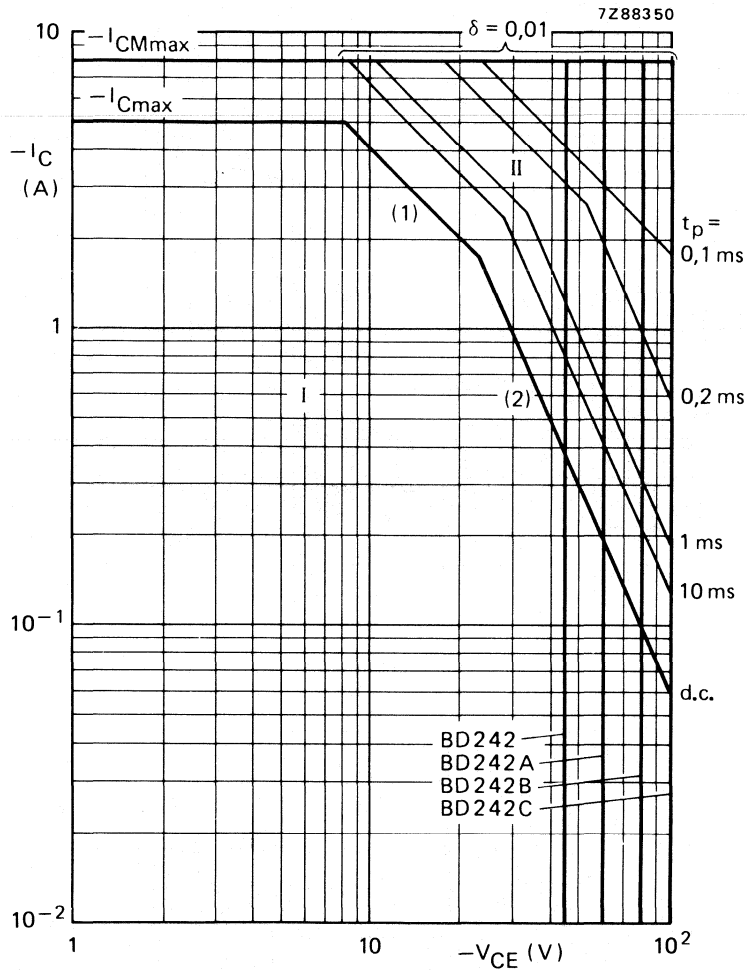


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

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

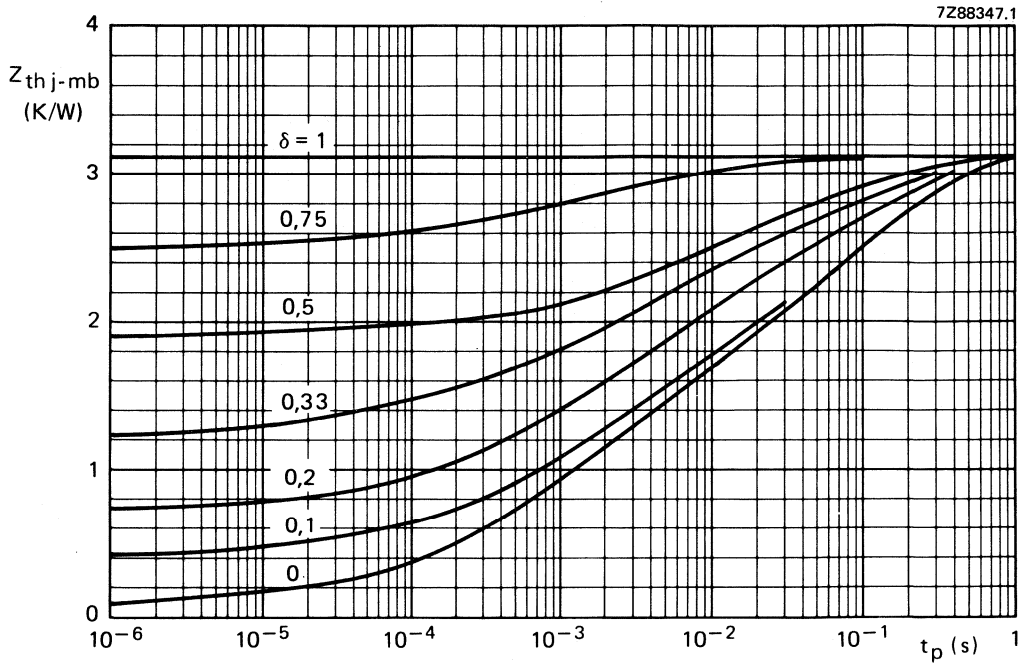


Fig. 6 Power pulse rating chart.

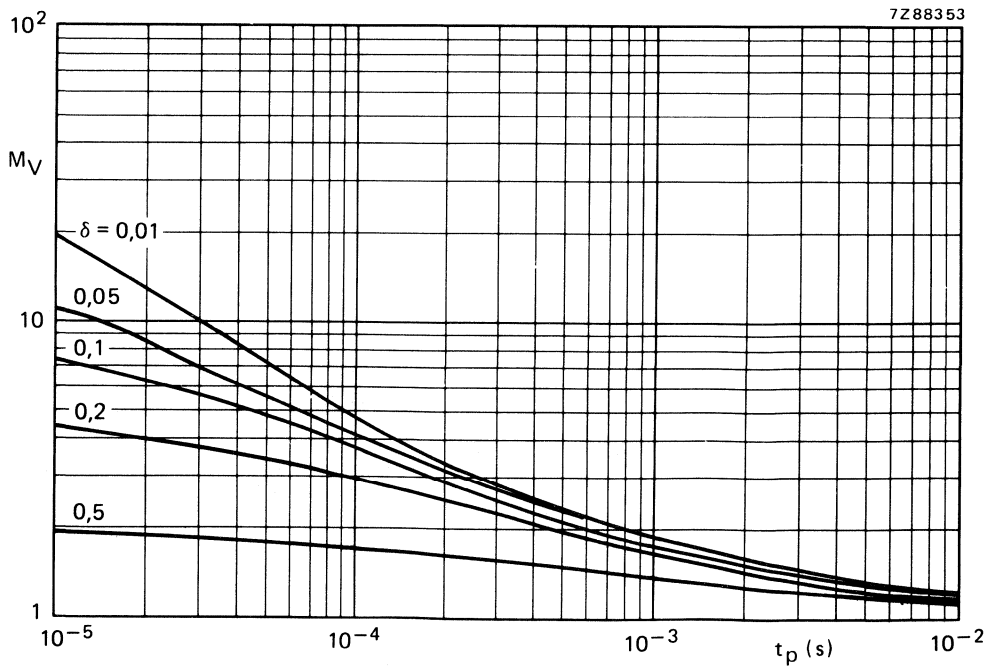


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

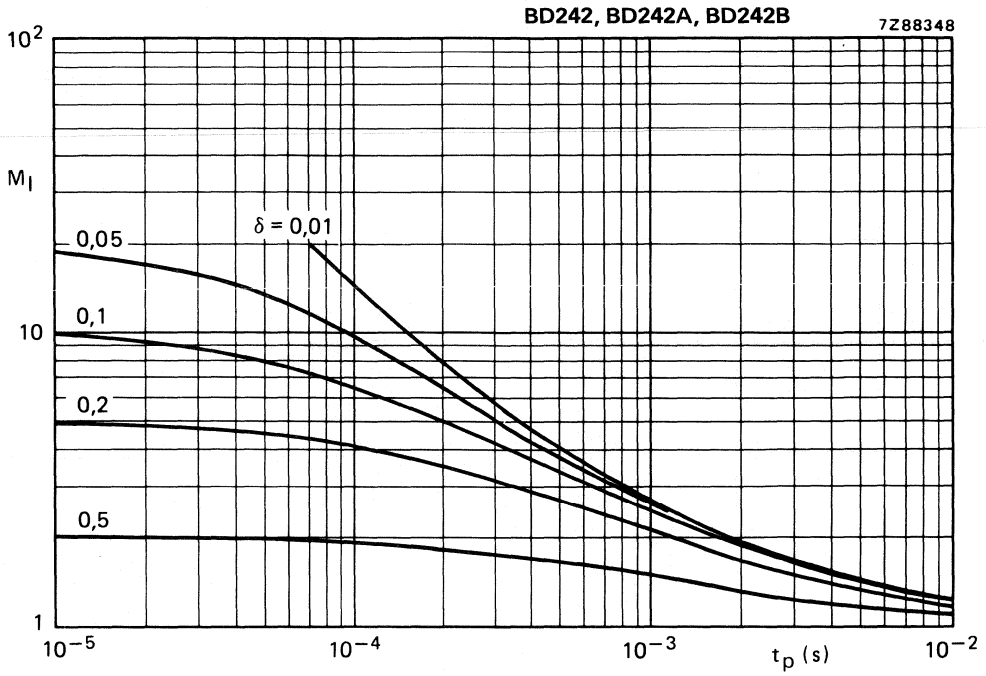


Fig. 8 S.B. current multiplying factor at the V_{CE0max} level.

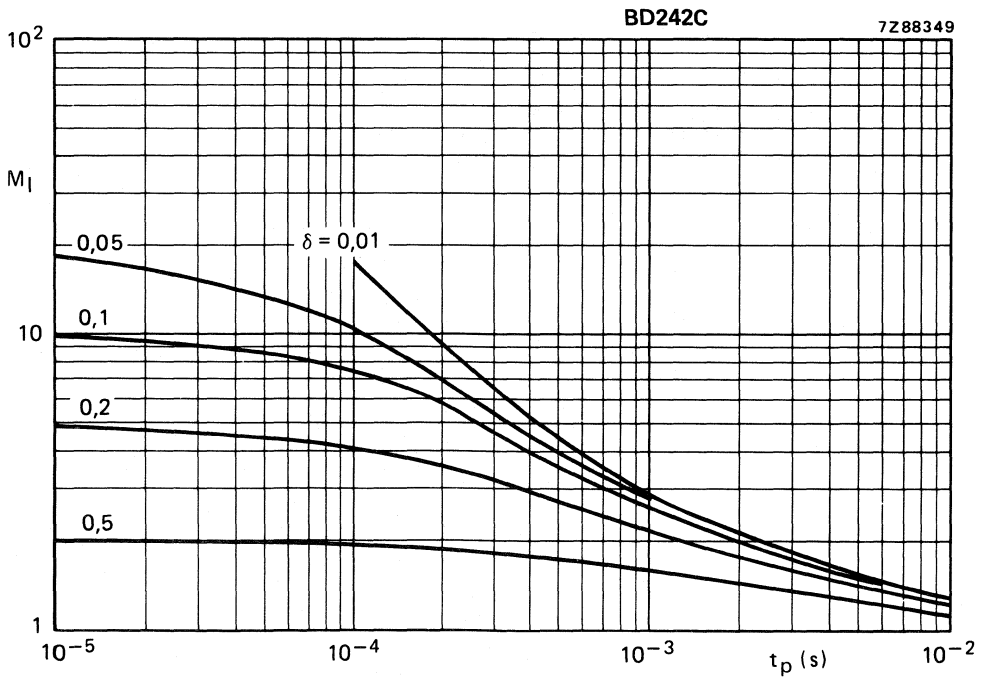


Fig. 9 S.B. current multiplying factor at the V_{CE0max} level.

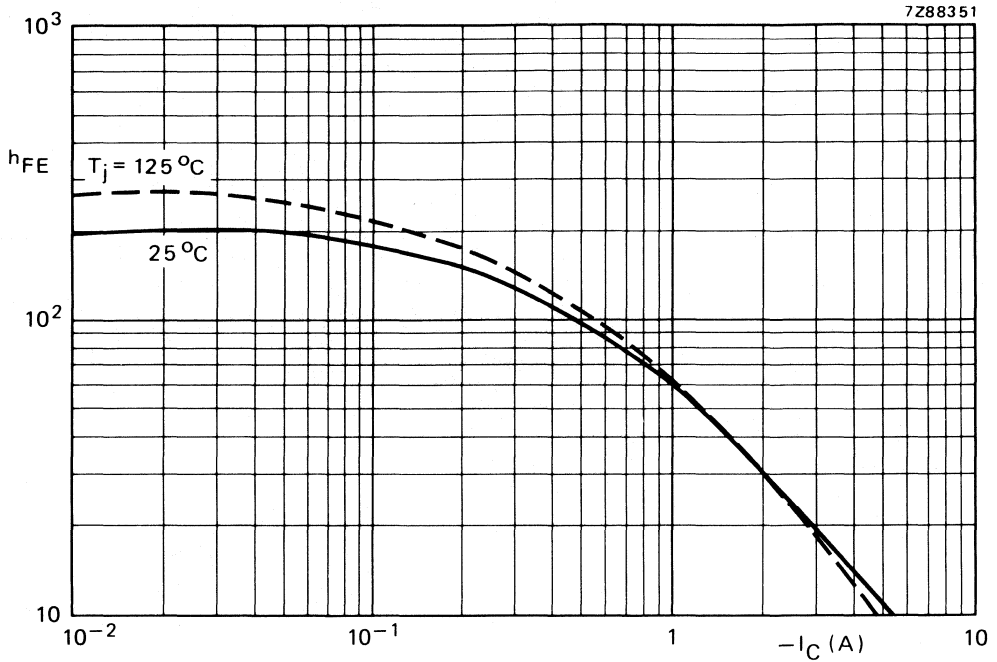


Fig. 10 Typical static forward current transfer ratio as a function of the collector current; $-V_{CE} = 4\text{ V}$.

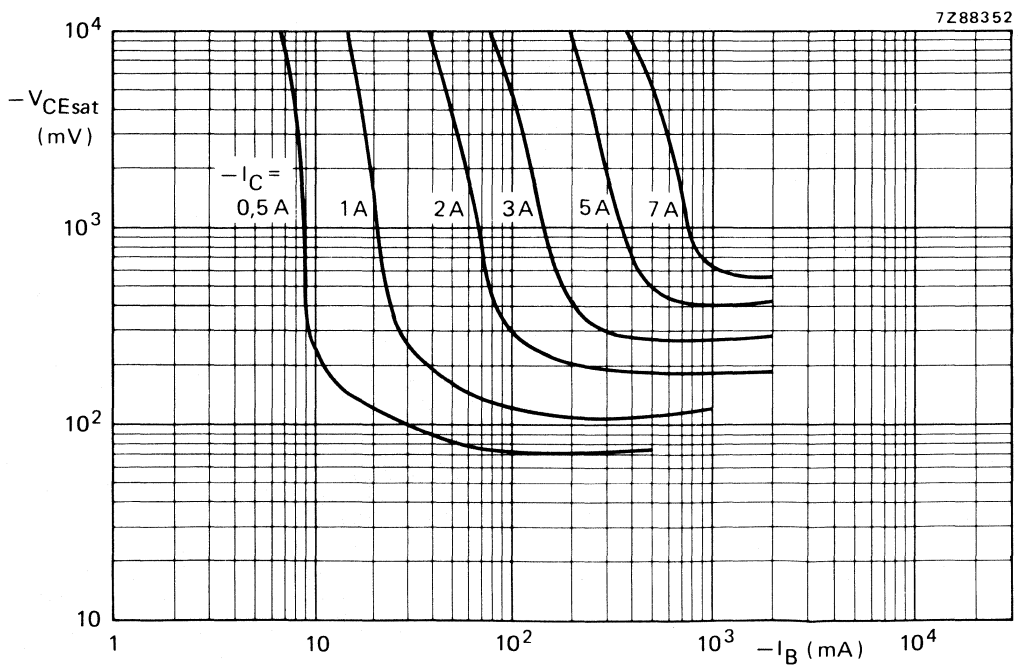


Fig. 11 Typical values collector-emitter saturation voltage at $T_j = 25^\circ\text{C}$.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in general amplifier and switching applications. P-N-P complements are BD244; 244A; 244B; and BD244C.

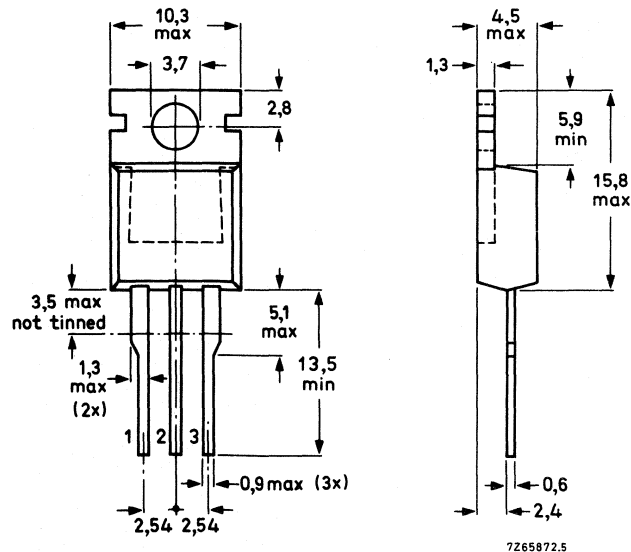
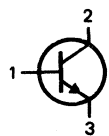
QUICK REFERENCE DATA

		BD243			
		A	B	C	
Collector-base voltage	V_{CBO}	max. 45	60	80	100 V
Collector-emitter voltage	V_{CEO}	max. 45	60	80	100 V
Collector current (d.c.)	I_C	max. 8			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max. 65			W
Junction temperature	T_j	max. 150			$^\circ\text{C}$
D.C. current gain	h_{FE}	>			15
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$					
Transition frequency at $f = 1\text{ MHz}$	f_T	>			3 MHz
$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$					

MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BD243	A	B	C
Collector-base voltage (open emitter)	V_{CBO}	max. 45	60	80	100 V
Collector-emitter voltage (open base)	V_{CEO}	max. 45	60	80	100 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max. 55	70	90	115 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5		V
Collector current (d.c.)	I_C	max.	8		A
Collector current (peak value)	I_{CM}	max.	12		A
Base-current (d.c.)	I_B	max.	3		A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	65		W
Storage temperature	T_{stg}		-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	1,92	K/W
From junction to ambient in free air	R_{thj-a}	=	70	K/W

CHARACTERISTICS

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

		BD243; A	BD243B; C
→ Collector cut-off current $I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	< 0,2	— mA
$I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO}	< —	0,2 mA
$V_{BE} = 0; V_{CE} = V_{CEOmax}$	I_{CES}	< 0,4	mA
→ Emitter cut-off current $I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	< 0,5	mA
D.C. current gain* $I_C = 300\text{ mA}; V_{CE} = 4\text{ V}$	h_{FE}	> 30	
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	> 15	
Base-emitter voltage** $I_C = 6\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	< 2	V
Collector-emitter saturation voltage* $I_C = 6\text{ A}; I_B = 1\text{ A}$	V_{CEsat}	< 1,5	V
Turn off breakdown energy $L = 20\text{ mH}; I_{CC} = 2,5\text{ A}$	$E_{(BR)}$	> 62,5	mJ

* Measured under pulse conditions: $t_p \leq 300\mu\text{s}; \delta < 0,02$.

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

Transition frequency at $f = 1 \text{ MHz}$

$I_C = 0,5 \text{ A}; V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

(between 10% and 90% levels)

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

Turn-on time

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

Turn-off time

t_{off} typ. $2 \mu\text{s}$

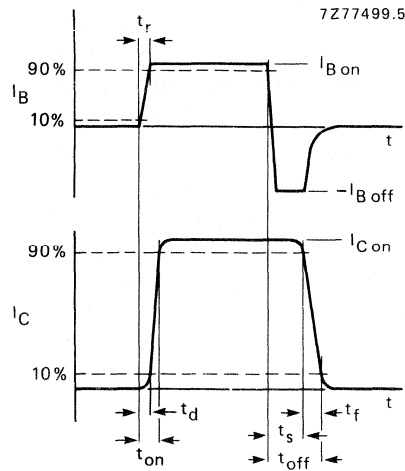


Fig. 2 Switching times waveforms.

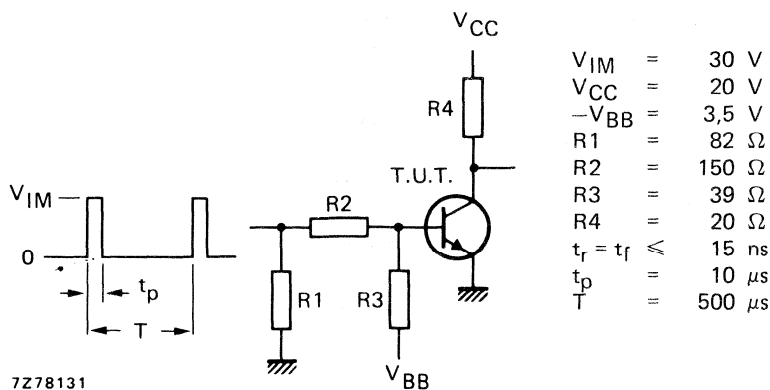


Fig. 3 Switching times test circuit.

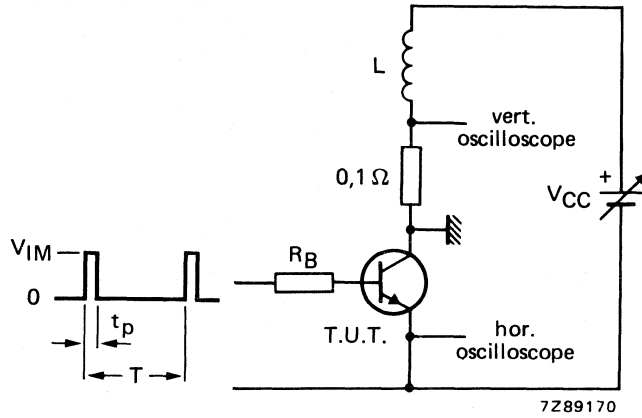


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = 12\text{ V}$; $R_B = 270\ \Omega$; $I_{CC} = 2,5\text{ A}$; $t_p = 1\text{ ms}$; $\delta = 0,01$.

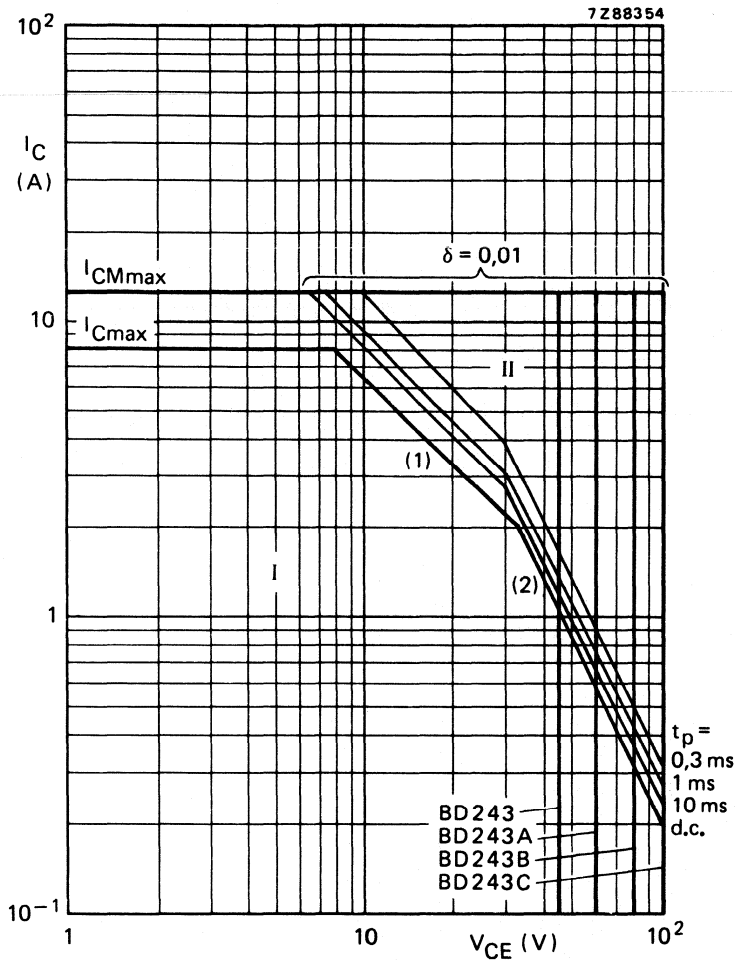


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^\circ\text{C}$.

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

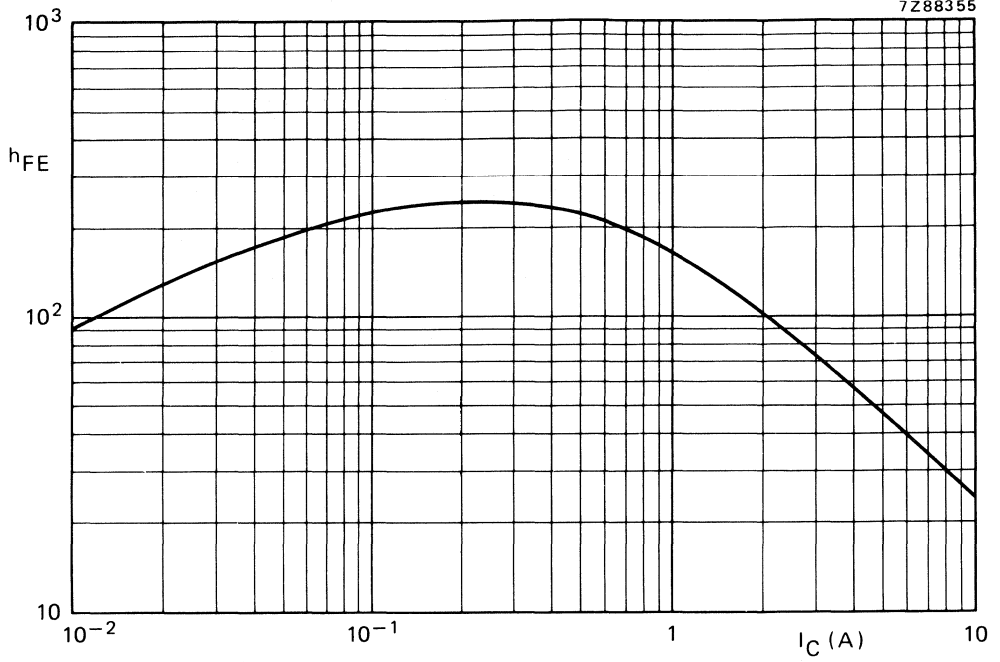


Fig. 6 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4$ V, $T_j = 25$ °C.

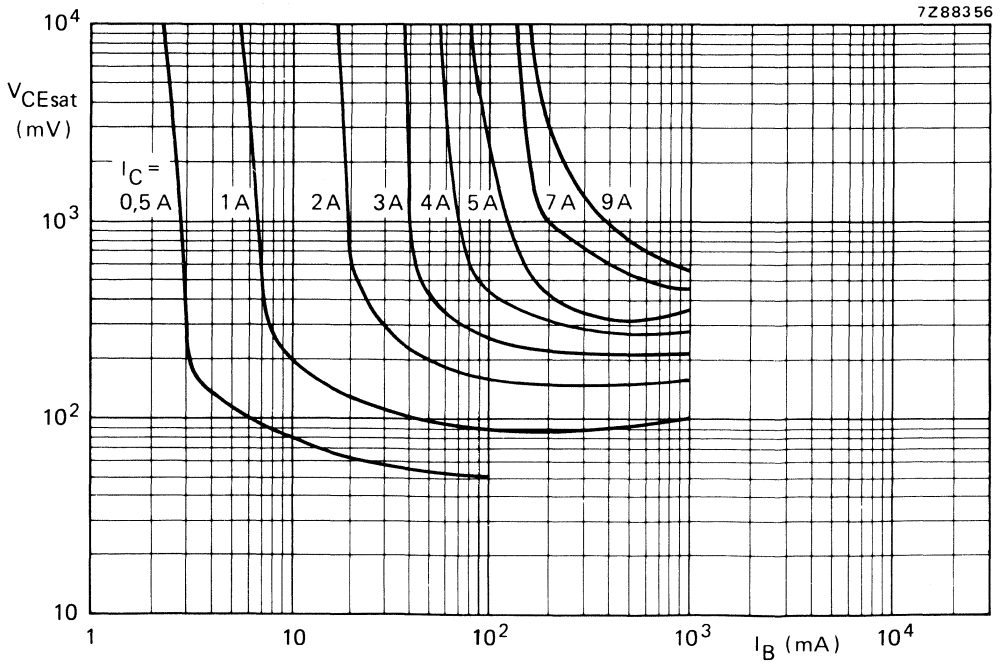


Fig. 7 Typical values collector-emitter saturation voltage at $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in general amplifier and switching applications. N-P-N complements are BD243; 243A; 243B; and BD243C.

QUICK REFERENCE DATA

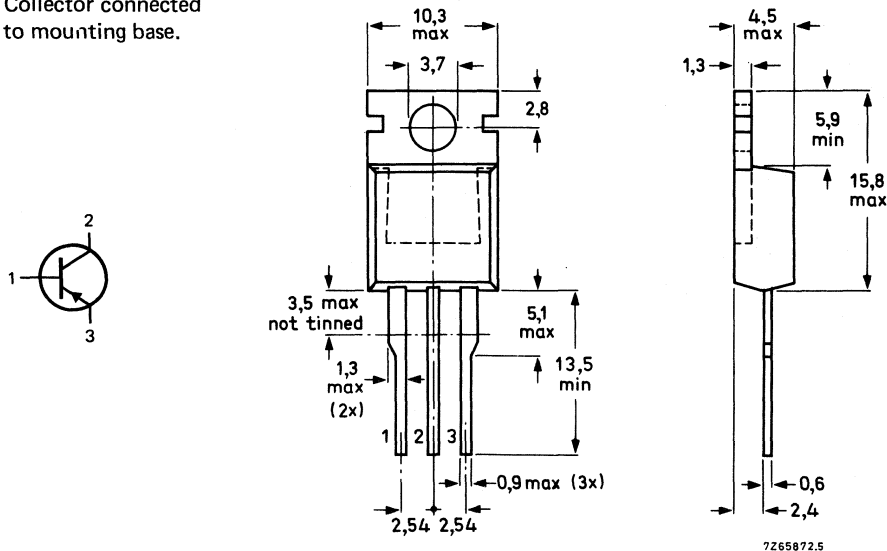
		BD244	A	B	C
Collector-base voltage	$-V_{CBO}$ max.	45	60	80	100 V
Collector-emitter voltage	$-V_{CEO}$ max.	45	60	80	100 V
Collector current (d.c.)	$-I_C$ max.	8		A	
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot} max.	65		W	
Junction temperature	T_j max.	150		$^\circ\text{C}$	
D.C. current gain	$h_{FE} >$	15			
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$					
Transition frequency	$f_T >$	3		MHz	
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$					

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD244	A	B	C
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	$-V_{CER}$	max.	55	70	90	115 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5	V
Collector current (d.c.)	$-I_C$	max.			8	A
Collector current (peak value)	$-I_{CM}$	max.			12	A
Base current (d.c.)	$-I_B$	max.			3	A
Total power dissipation up to $T_{mb} = 25^\circ C$	P_{tot}	max.			65	W
Storage temperature	T_{stg}				-65 to +150	$^\circ C$
Junction temperature	T_j	max.			150	$^\circ C$

THERMAL RESISTANCE

From junction to mounting base	$R_{th j-mb}$	=		1,92		K/W
From junction to ambient in free air	$R_{th j-a}$	=		70		K/W

CHARACTERISTICS

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

			BD244; A	BD244B; 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	
Base-emitter voltage *					
$-I_C = 6 A; -V_{CE} = 4 V$	$-V_{BE}$	<		2	V
Collector-emitter saturation voltage *					
$-I_C = 6 A; -I_B = 1 A$	$-V_{CEsat}$	<		1,5	V
Turn off breakdown energy					
$L = 20 mH; -I_{CC} = 2,5 A$	$E(BR)$	>		62,5	mJ

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

Transition frequency at $f = 1 \text{ MHz}$

$-I_C = 500 \text{ mA}; -V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

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

turn-on time

$t_{on} \text{ typ. } 0,4 \mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 0,7 \mu\text{s}$

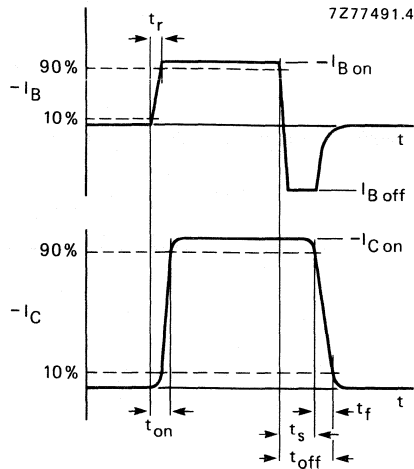


Fig. 2 Switching times waveforms.

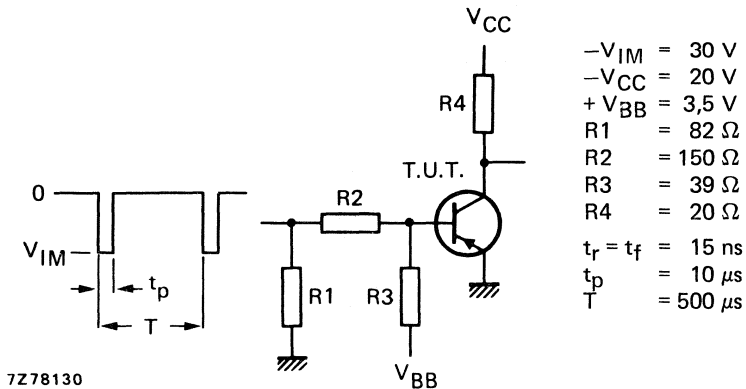


Fig. 3 Switching times test circuit.

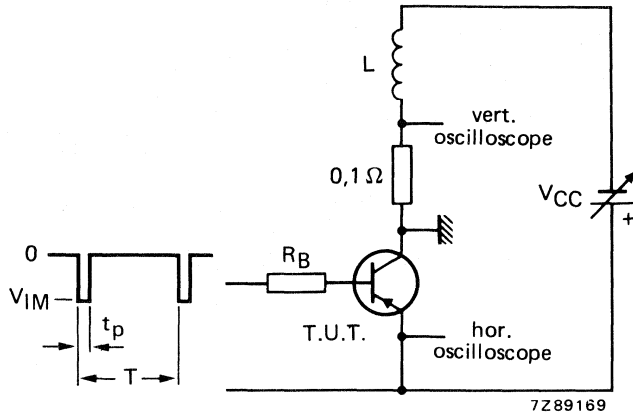


Fig. 4 Test circuit for turn-off breakdown energy.
 $V_{IM} = -12$ V; $R_B = 270$ Ω ; $-I_{CC} = 2,5$ A; $t_p = 1$ ms; $\delta = 0,01$.

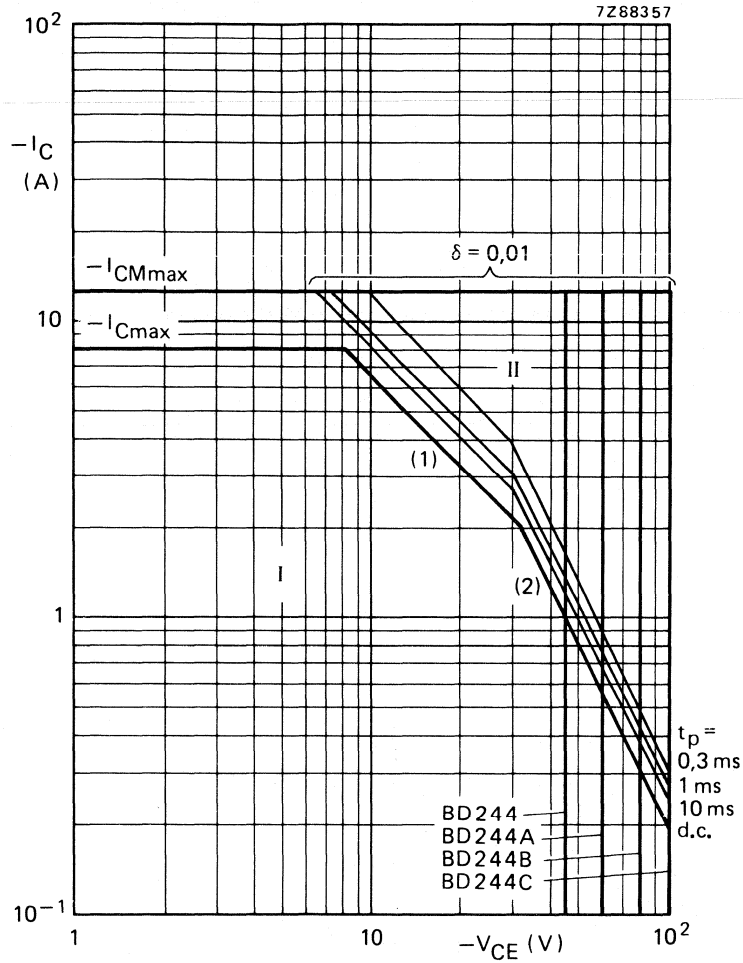


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

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

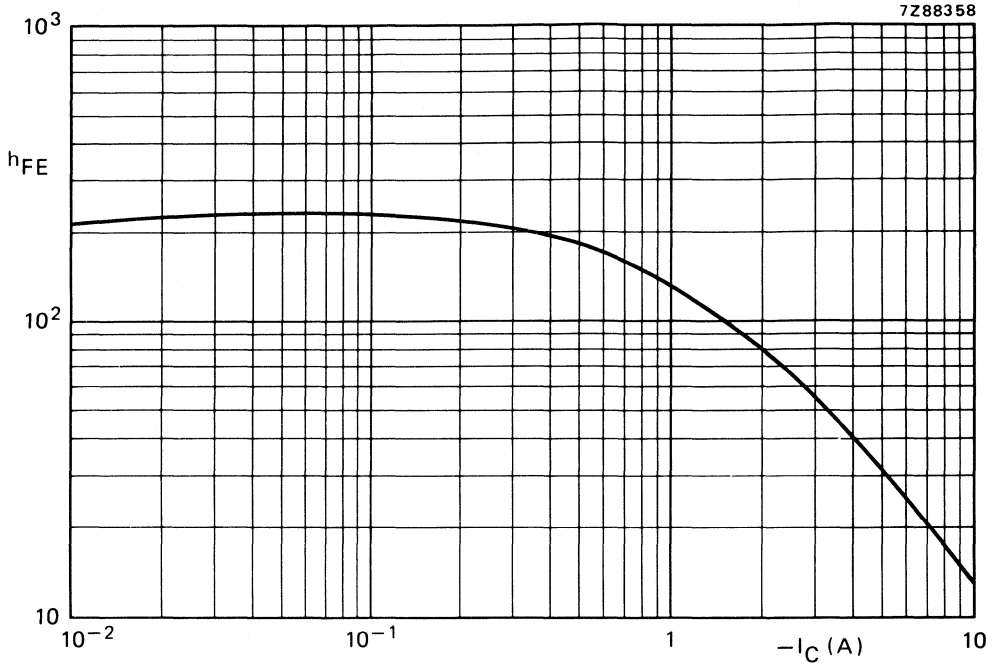


Fig. 6 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 4$ V, $T_j = 25$ °C.

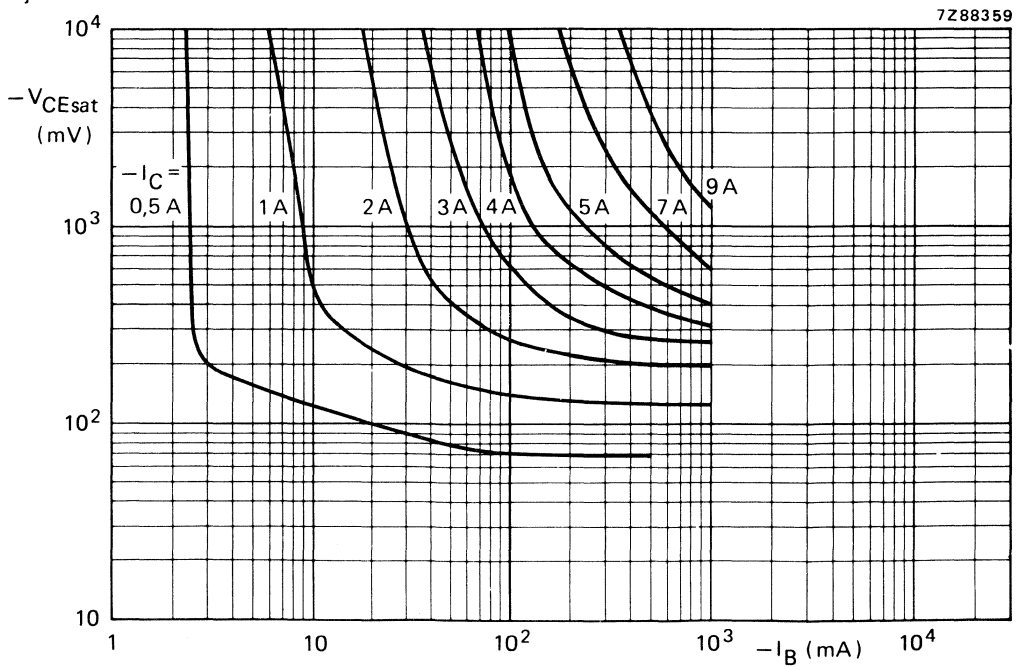


Fig. 7 Typical values collector-emitter saturation voltage at $T_j = 25$ °C.

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 $T_{mb} = 45\text{ }^{\circ}\text{C}$	P_{tot}	max.	15 W
Junction temperature	T_j	max.	150* $^{\circ}\text{C}$
D.C. current gain $I_C = 0,5\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}		85 to 375
Transition frequency $I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$	f_T	typ.	130 MHz

MECHANICAL DATA

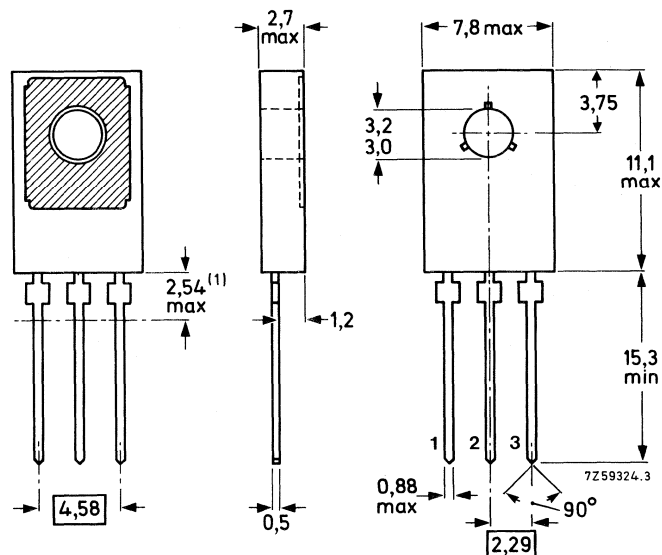
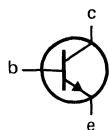
Dimensions in mm

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 $T_{mb} = 45\text{ }^\circ\text{C}$	P_{tot}	max.	15 W
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Storage temperature	T_{stg}	- 65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.	150 $^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 32\text{ V}$	I_{CBO}	<	10	μA
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$I_E = 0; V_{CB} = 32\text{ V}; T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	<	1	mA
--	-----------	---	---	----

Emitter cut-off current

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

Base-emitter voltage

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$	V_{BE}	typ.	0,6	V
---	----------	------	-----	---

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

Collector-emitter saturation voltage

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

D. C. current gain

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$	h_{FE}	>	50	
---	----------	---	----	--

$I_C = 0,5\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}		85 to 375	
---	----------	--	-----------	--

$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	>	40	
---	----------	---	----	--

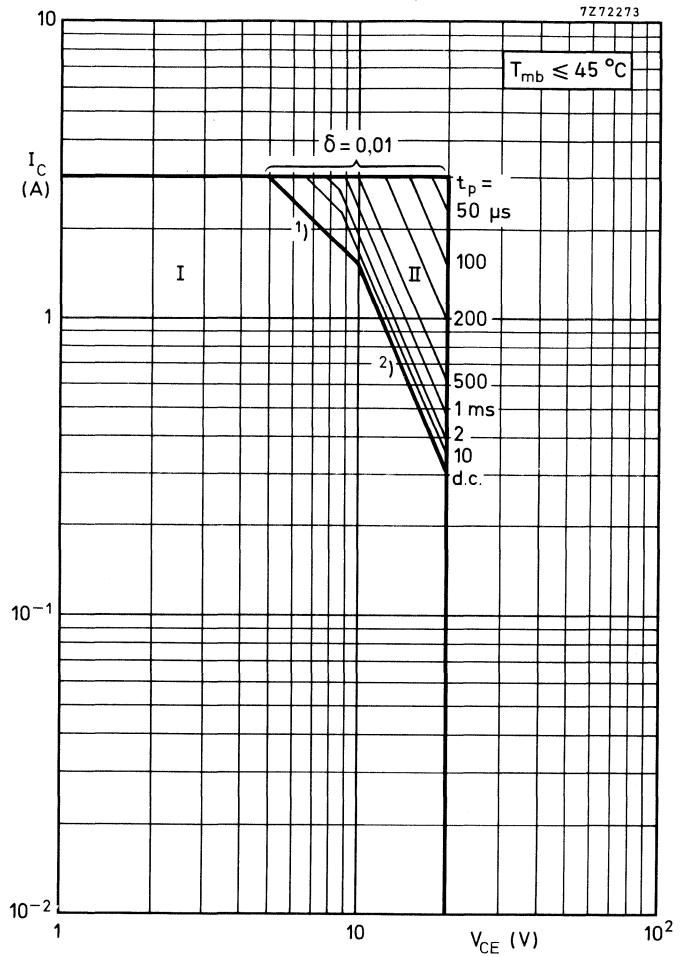
Transition frequency at $f = 35\text{ MHz}$

$I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$	f_T	typ.	130	MHz
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D. C. current gain ratio of matched pairs

BD329/BD330

$ I_C = 0,5\text{ A}; V_{CE} = 1\text{ V}$	h_{FE1}/h_{FE2}	<	1,6	
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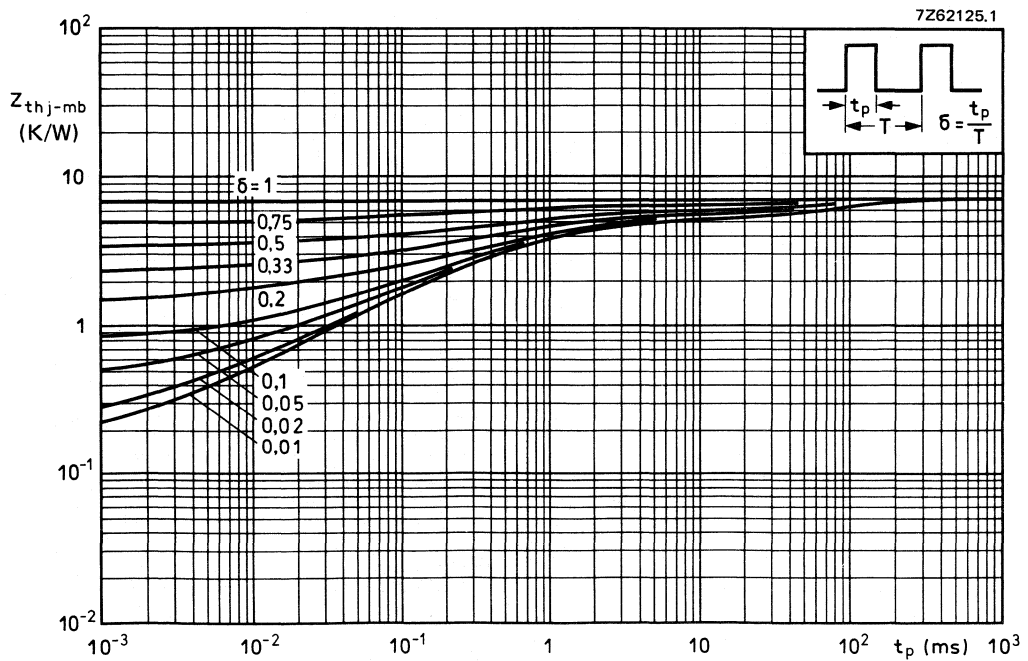
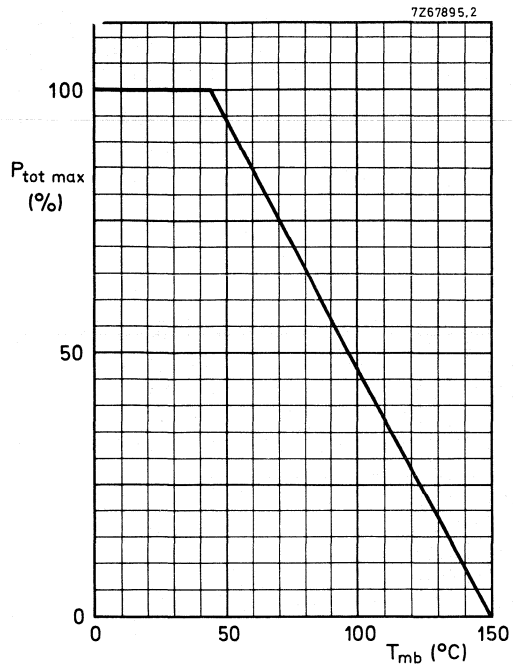
Safe Operating Area with the transistor forward biased

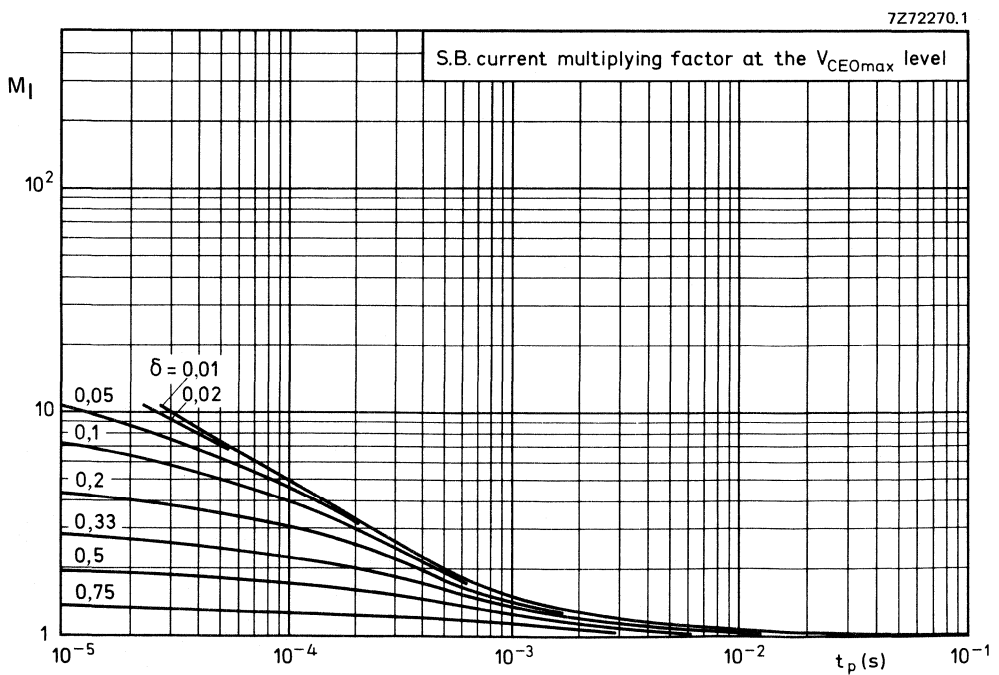
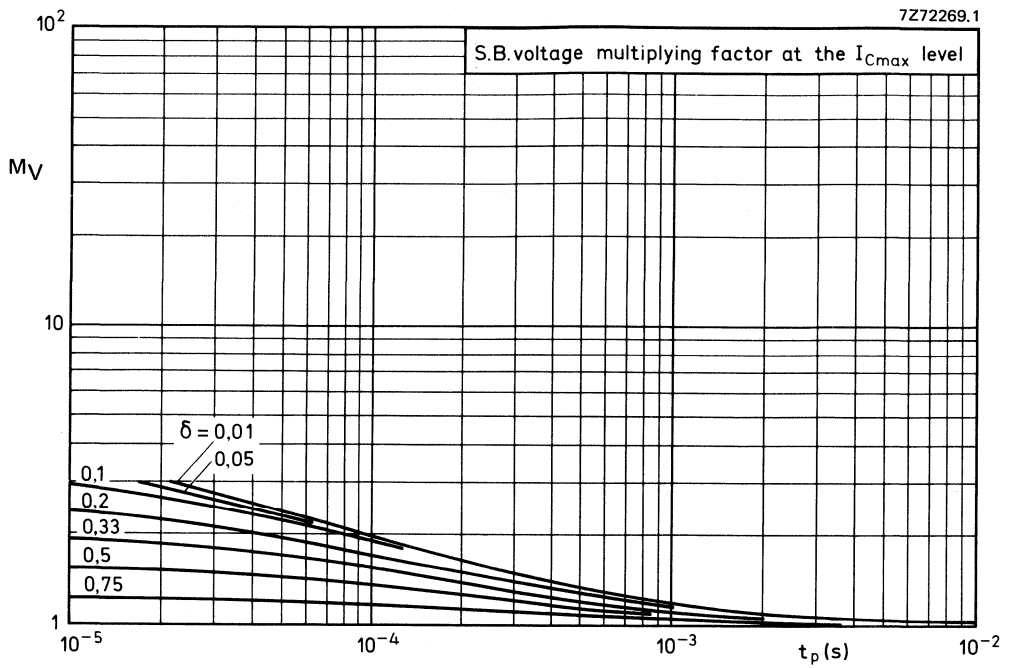
I Region of permissible d.c. operation

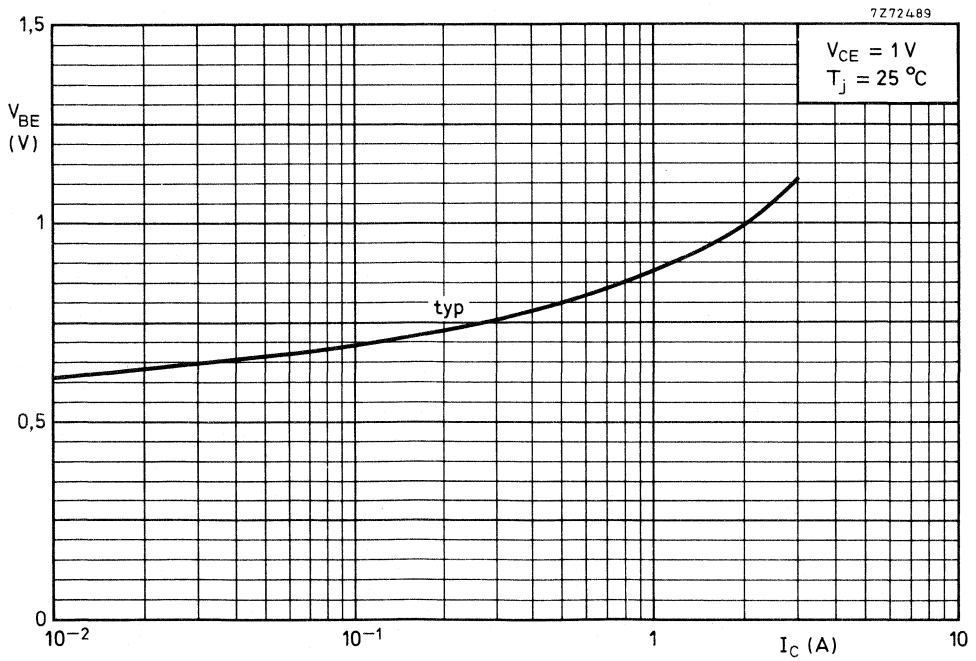
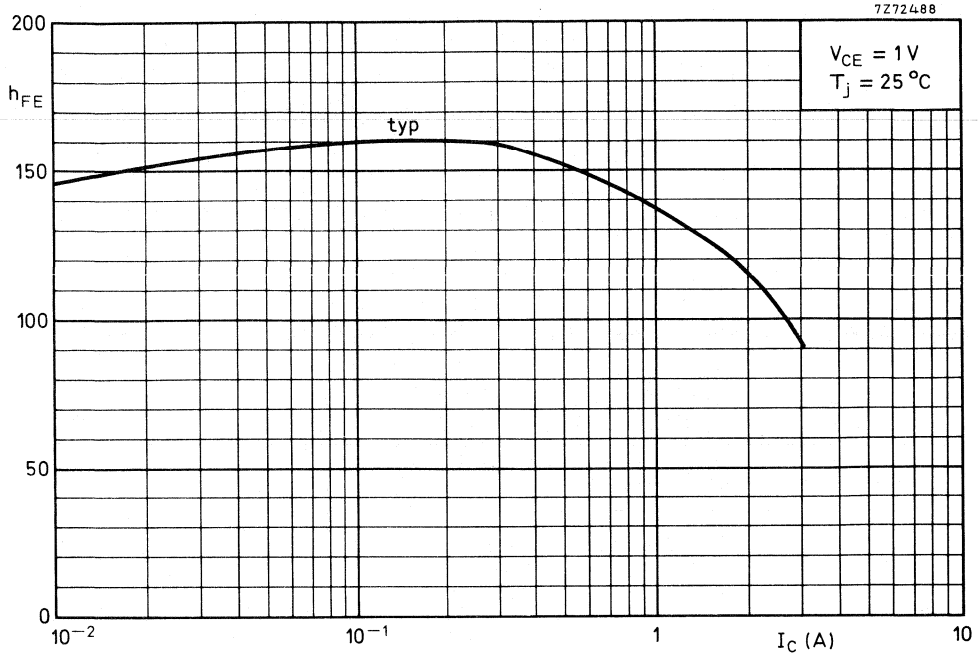
II Permissible extension for repetitive pulse operation

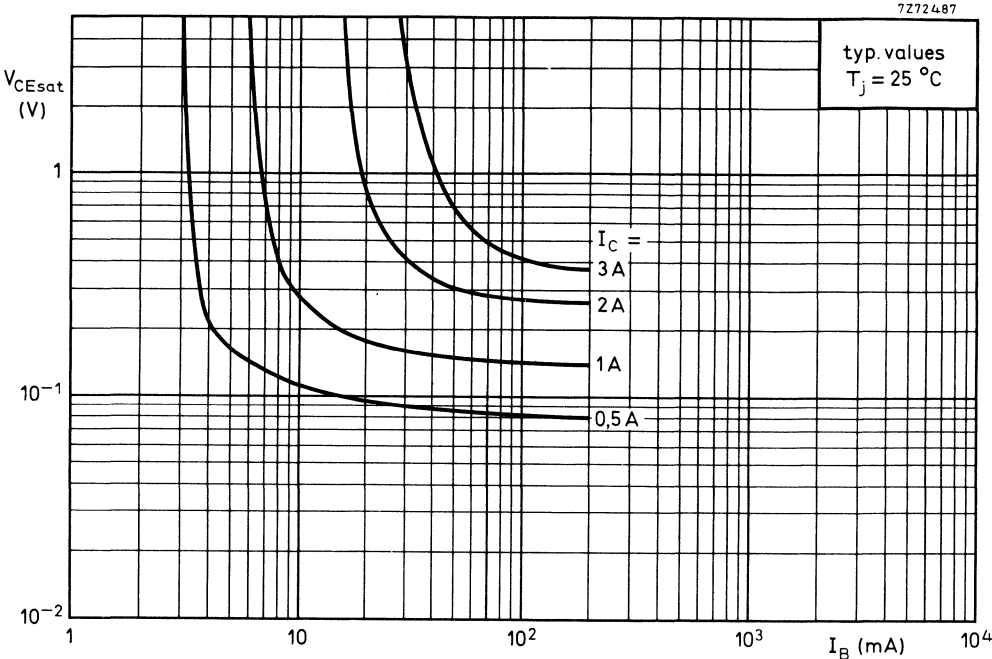
1) P_{tot} max and P_{peak} max lines.

2) Second-breakdown limits









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 $T_{mb} = 45\text{ }^{\circ}\text{C}$	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	$^{\circ}\text{C}$
D.C. current gain $-I_C = 0,5\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}		85 to 375	
Transition frequency $-I_C = 50\text{ mA}; -V_{CE} = 5\text{ V}$	f_T	typ.	100	MHz

MECHANICAL DATA

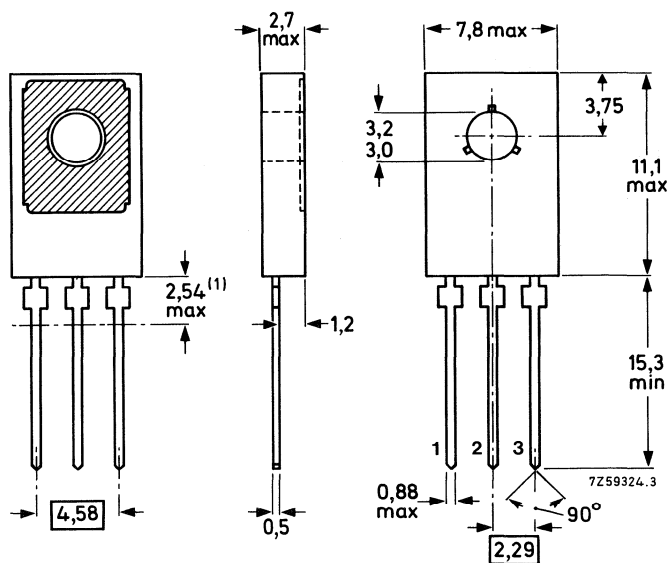
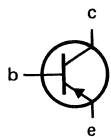
Dimensions in mm

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 $T_{mb} = 45^\circ\text{C}$	P_{tot}	max.	15 W
---	-----------	------	------

Storage temperature	T_{stg}	- 65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.	150 $^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = 32\text{ V}$

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

$I_E = 0; -V_{CB} = 32\text{ V}; T_j = 150\text{ }^\circ\text{C}$

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

Emitter cut-off current

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

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

Base-emitter voltage

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

$-V_{BE} \text{ typ. } 0,6\text{ V}$

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

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

Collector-emitter saturation voltage

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

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

D. C. current gain

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

$h_{FE} > 50$

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

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

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

$h_{FE} > 40$

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

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

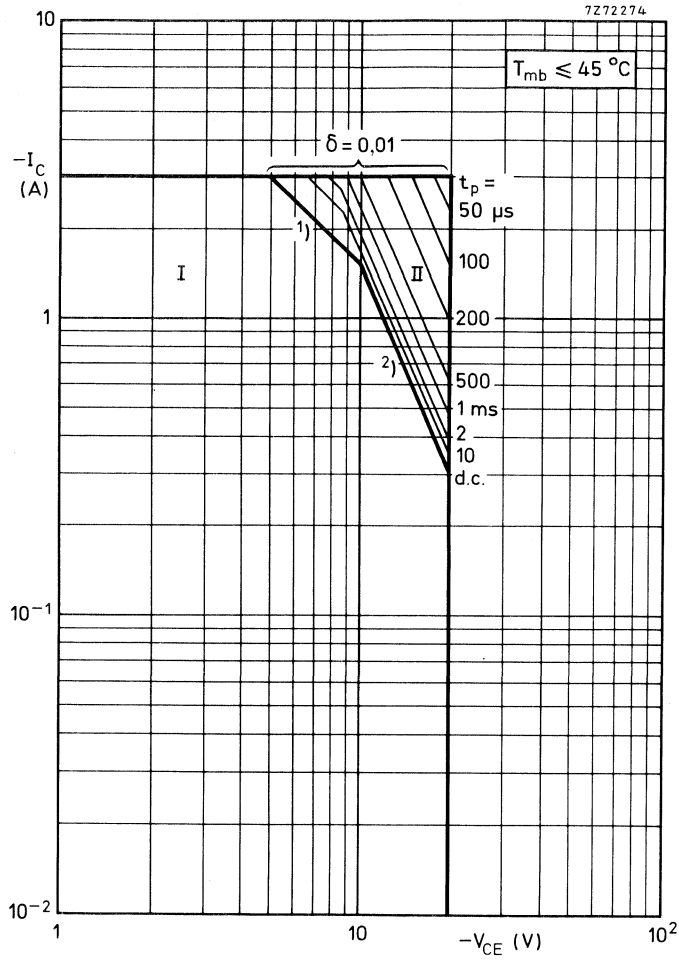
$f_T \text{ typ. } 100\text{ MHz}$

D. C. current gain ratio of
matched pairs

BD329/BD330

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

$h_{FE1}/h_{FE2} < 1,6$

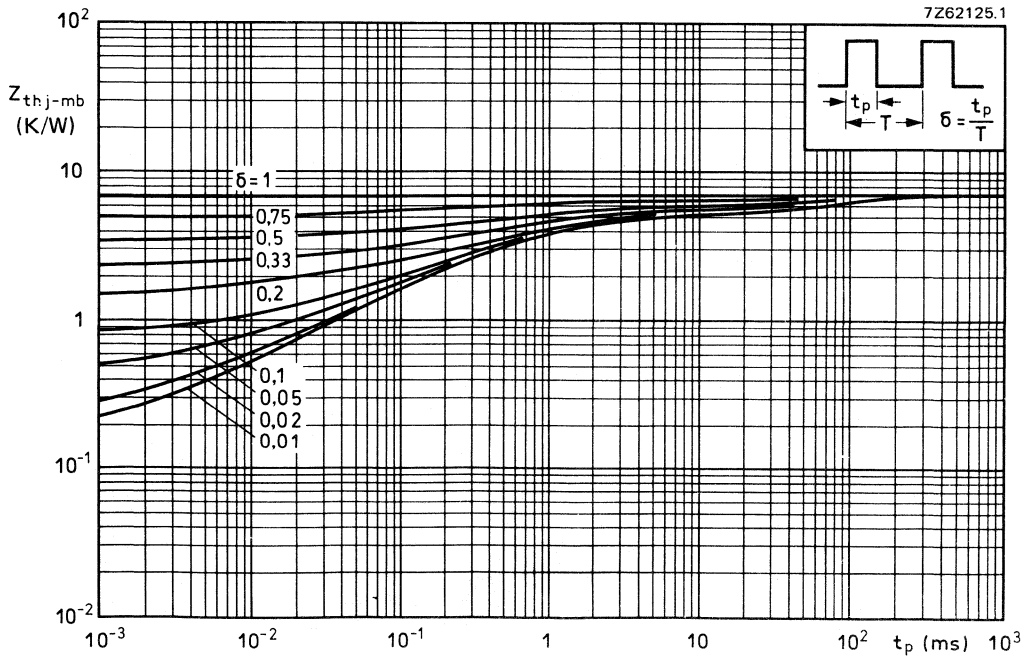
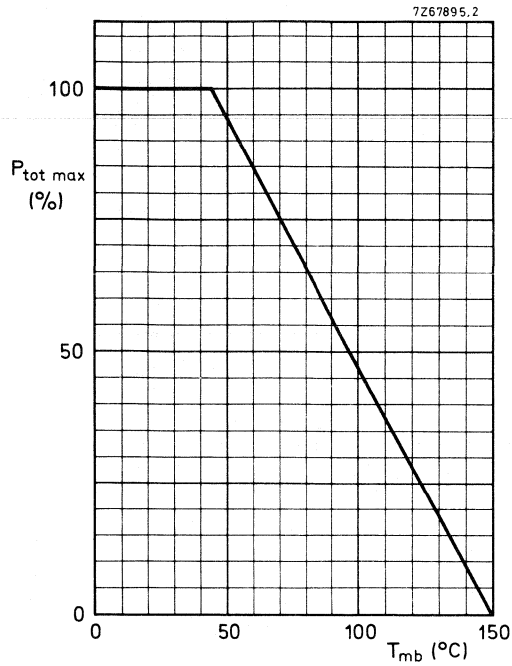


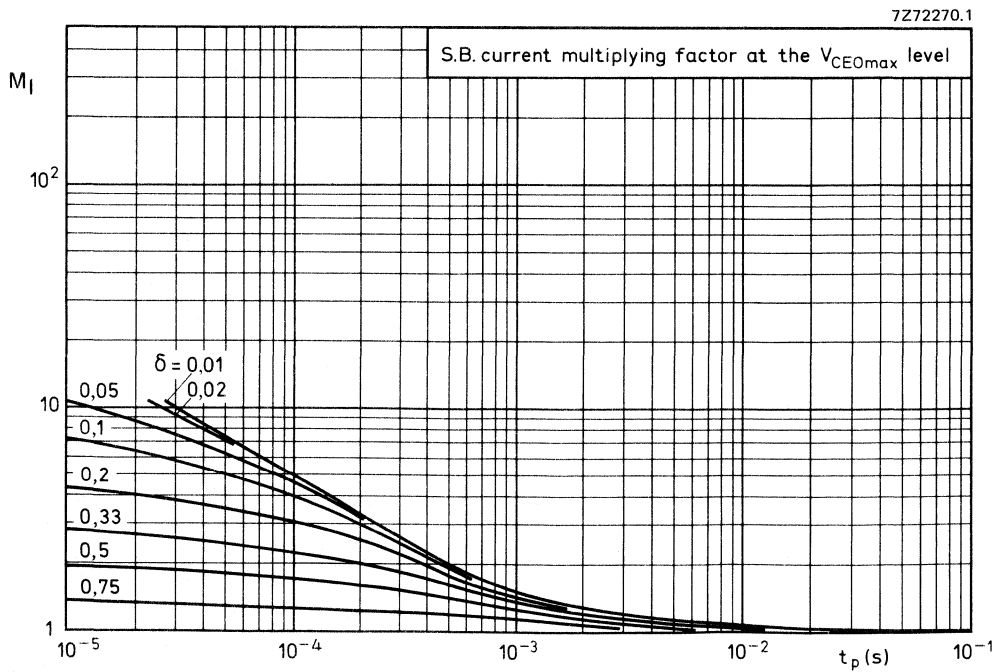
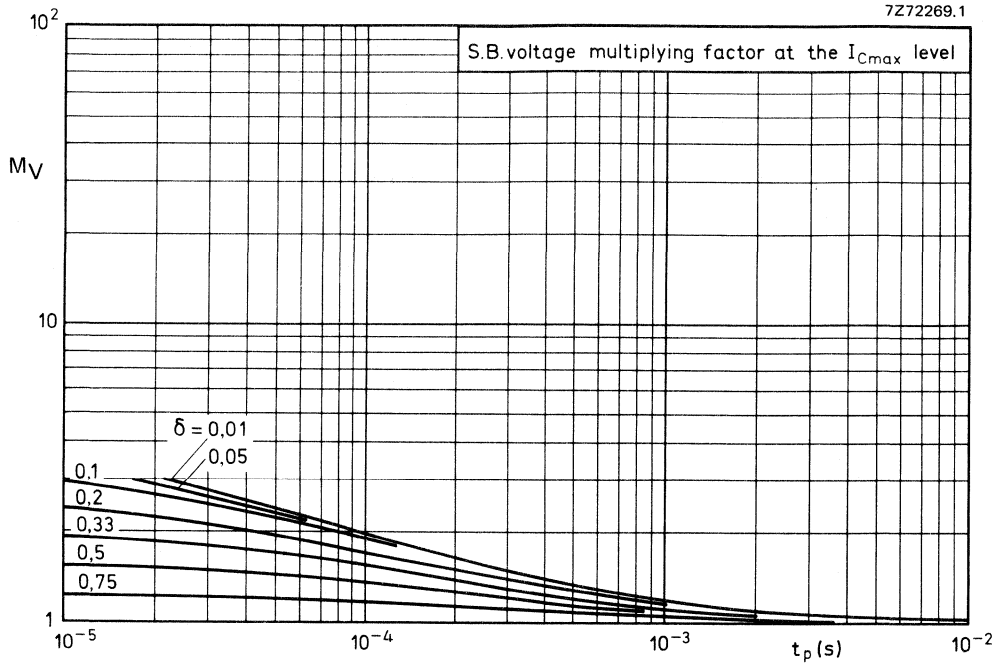
Safe Operating Area with the transistor forward biased

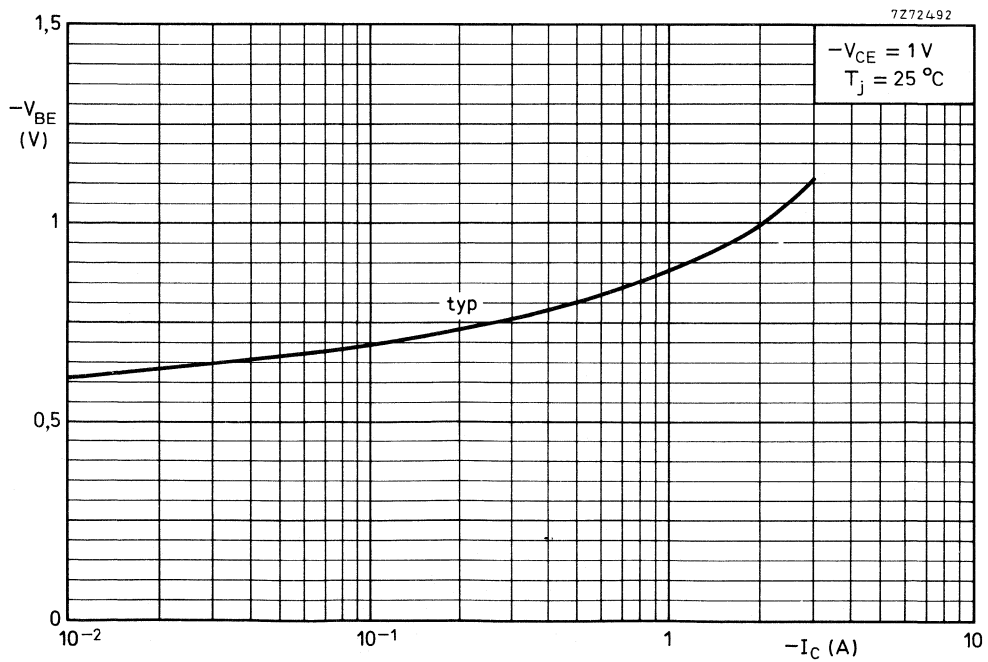
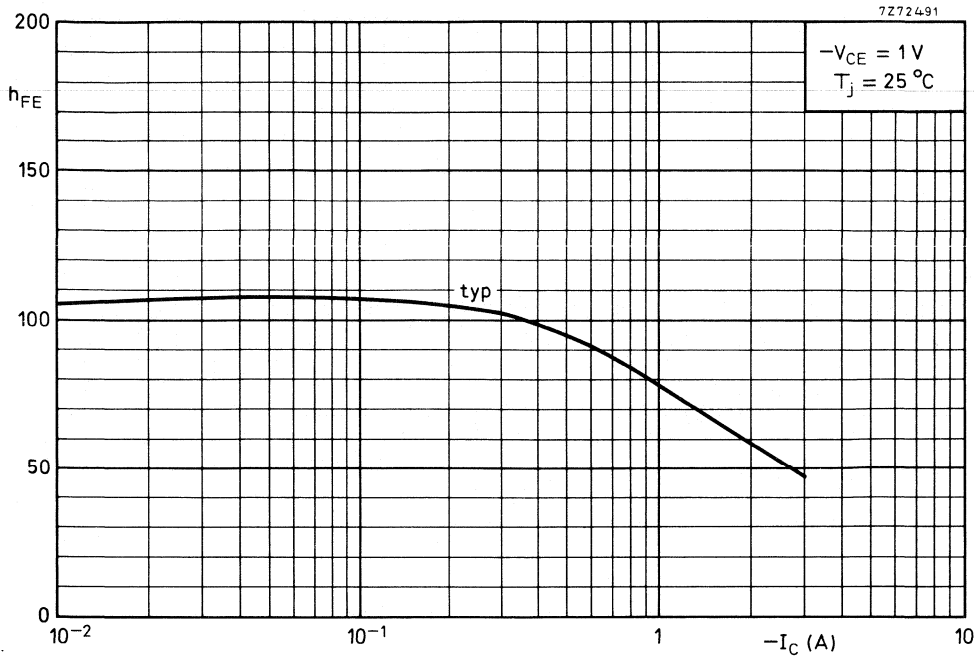
- I Region of permissible d. c. operation
- II Permissible extension for repetitive pulse operation

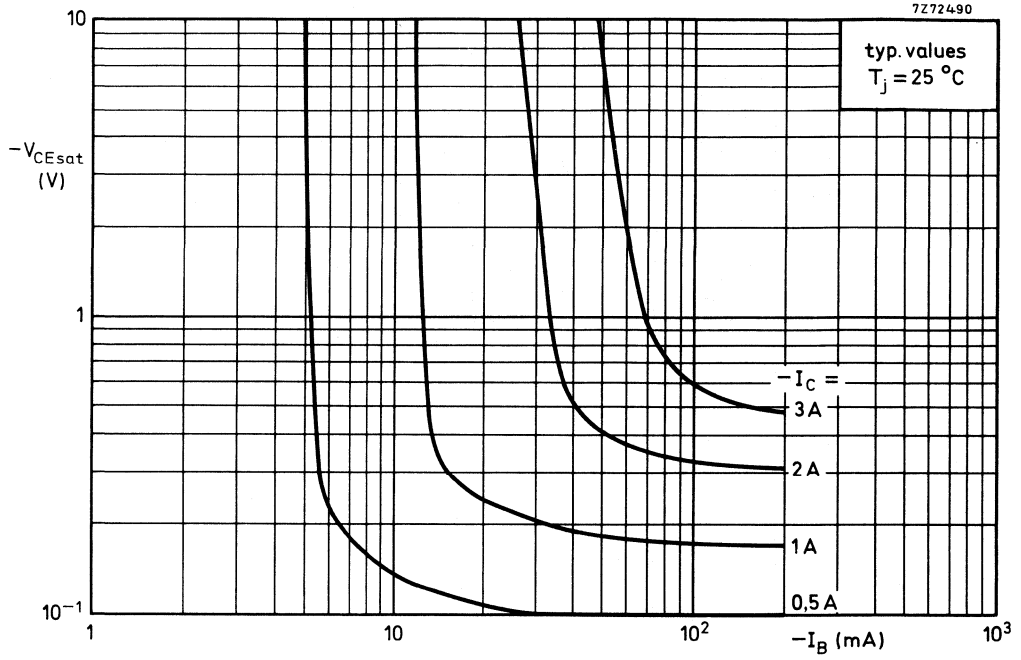
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

2) Second-breakdown limits









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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		60		W
Junction temperature	T_j	max.		150		$^\circ\text{C}$
D.C. current gain $I_C = 3,0\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	>		750		

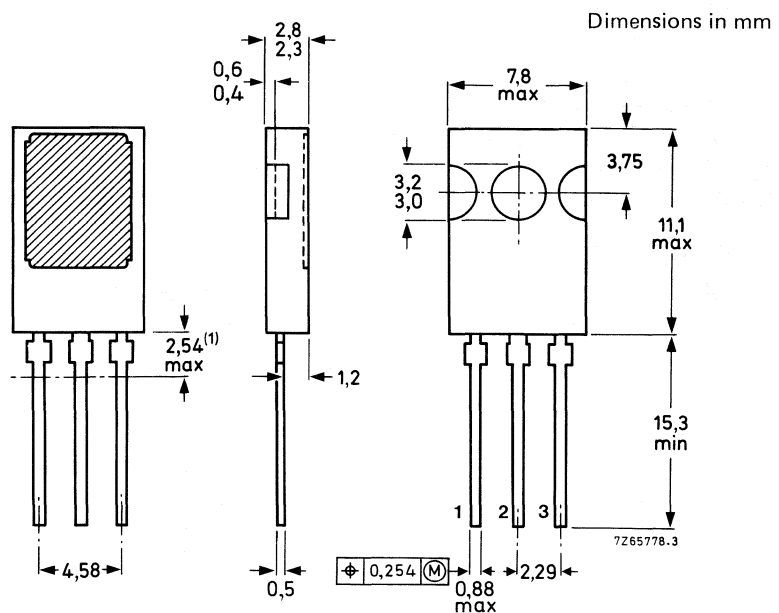
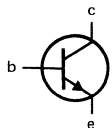
MECHANICAL DATA

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface

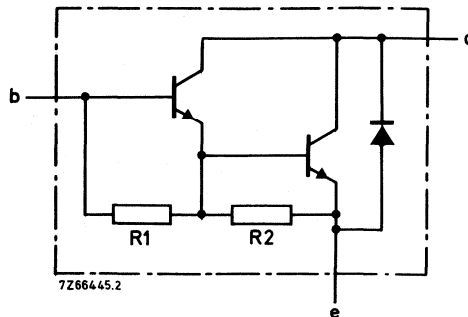
Pinning

- 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.



R₁ typ. 4 kΩ
R₂ 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 ≤ 10 ms; δ ≤ 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-mb}	=	2,08			K/W
From junction to ambient in free air	R _{th j-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

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0max}$

$I_{CBO} < 0,1\text{ mA} \leftarrow$

$I_E = 0; V_{CB} = V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$

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

$I_B = 0; V_{CE} = \frac{1}{2} V_{CE0max}$

$I_{CEO} < 0,2\text{ mA} \leftarrow$

Emitter cut-off current

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

$I_{EBO} < 5\text{ mA}$

D.C. current gain *

$I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 1900$

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 750$

$I_C = 6\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 3000$

Base-emitter voltage **

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage

$I_C = 3\text{ A}; I_B = 12\text{ mA}$

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

Cut-off frequency

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 50\text{ kHz}$

Turn-off breakdown energy with inductive load (see Fig. 12)

$-I_{Boff} = 0; I_{Con} = 4,5\text{ A}$

$E(BR) > 50\text{ mJ}$

Diode forward voltage

$I_F = 3\text{ A}$

$V_F \text{ typ. } 1,8\text{ V}$

D.C. current gain ratio of complementary
matched pairs

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE1}/h_{FE2} < 2,5$

Small signal current gain

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

$h_{fe} > 10 \leftarrow$

Second-breakdown collector current

$V_{CE} = 60\text{ V}; t_p = 25\text{ ms}$

$I(SB) > 1\text{ A}$

Switching times

(between 10% and 90% levels)

$I_{Con} = 3\text{ A}; I_{Bon} = -I_{Boff} = 12\text{ mA}$

Turn-on time

$t_{on} \text{ typ. } 1\text{ } \mu\text{s}$
 $< 2\text{ } \mu\text{s}$

Turn-off time

$t_{off} \text{ typ. } 5\text{ } \mu\text{s}$
 $< 10\text{ } \mu\text{s}$

* Measured under pulse conditions: $t_p < 300\text{ } \mu\text{s}$, $\delta < 2\%$.** V_{BE} decreases by about $3,8\text{ mV/K}$ with increasing temperature.

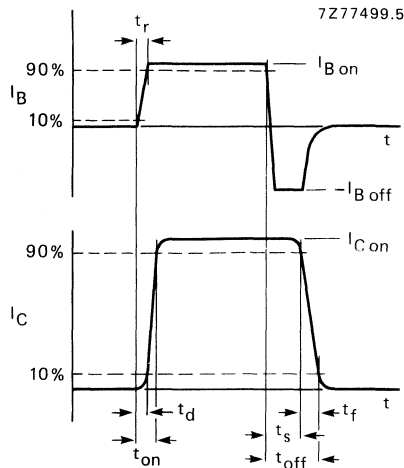
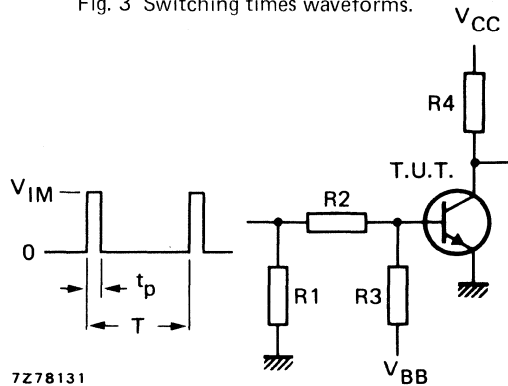
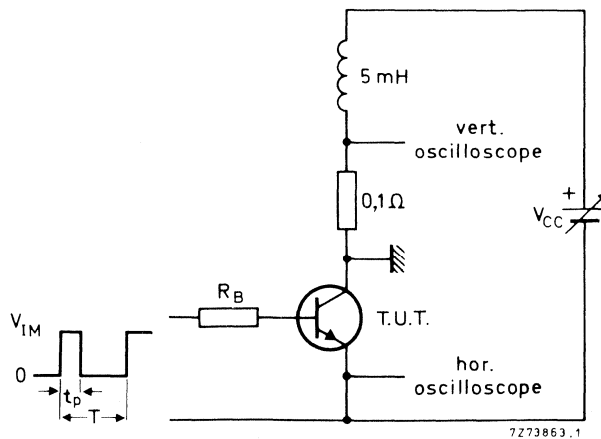


Fig. 3 Switching times waveforms.



- $V_{IM} = 10 \text{ V}$
- $V_{CC} = 10 \text{ V}$
- $-V_{BB} = 4 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 410 \Omega$
- $R3 = 560 \Omega$
- $R4 = 3 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.



- $V_{IM} = 12 \text{ V}$
- $R_B = 270 \Omega$
- $I_C = 4.5 \text{ A}$
- $\delta = 1 \%$
- $t_p = 1 \text{ ms}$

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

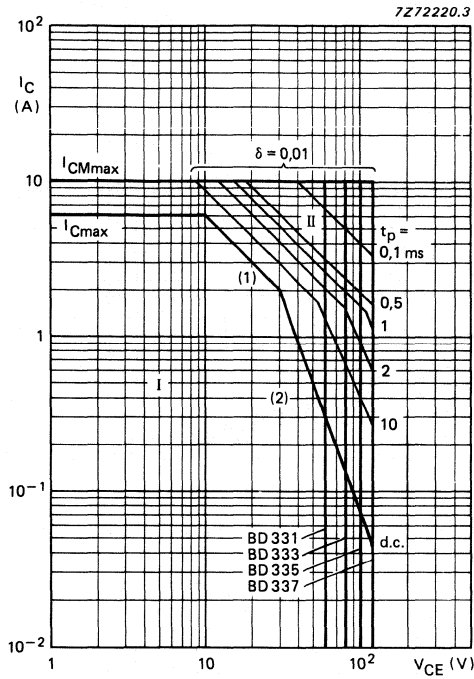


Fig. 6 Safe Operating Area, $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

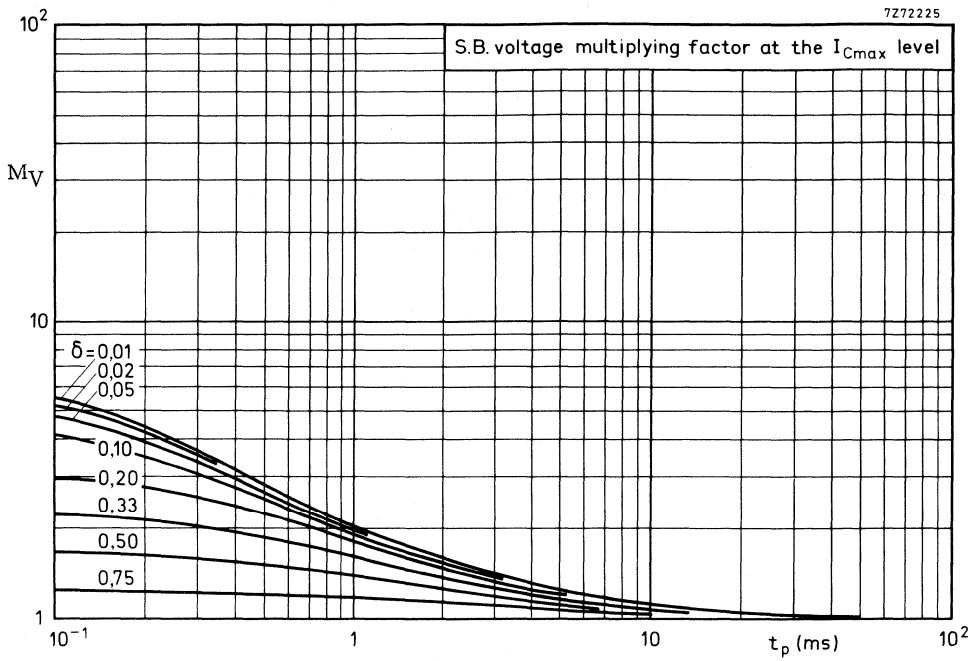


Fig. 7 Second breakdown voltage multiplying factor at I_{Cmax} level.

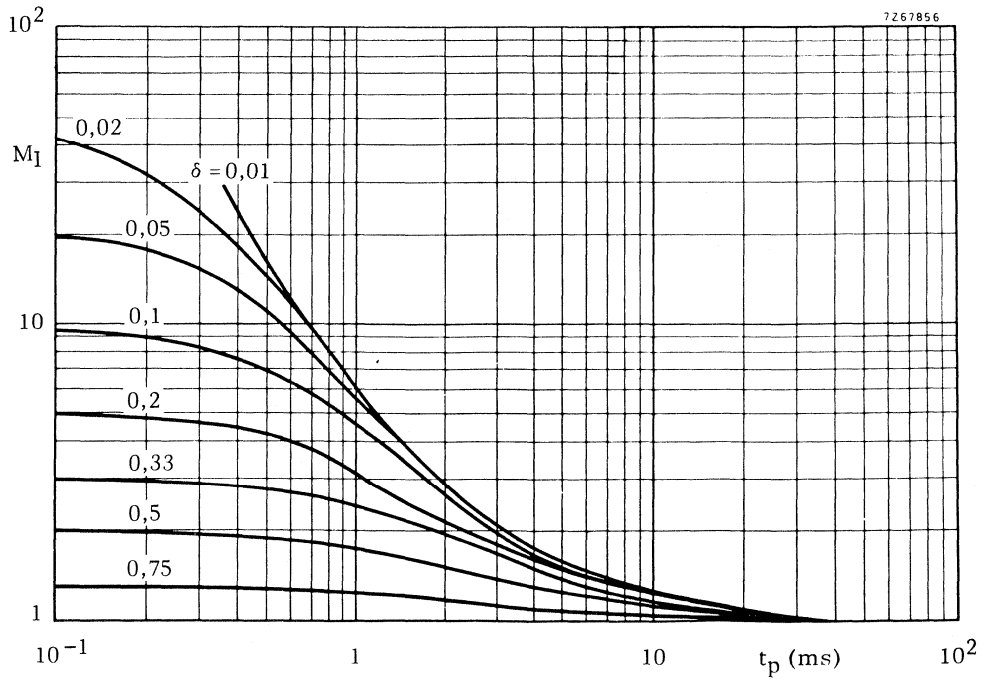


Fig. 8 Second breakdown current multiplying factor at V_{CE0max} level.

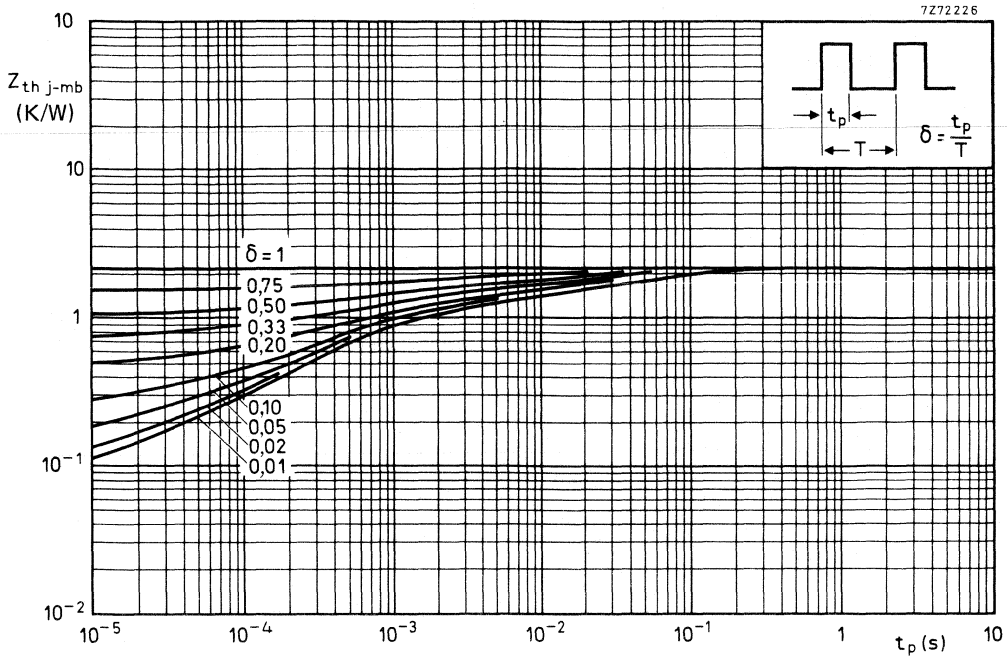


Fig. 9 Pulse power rating chart.

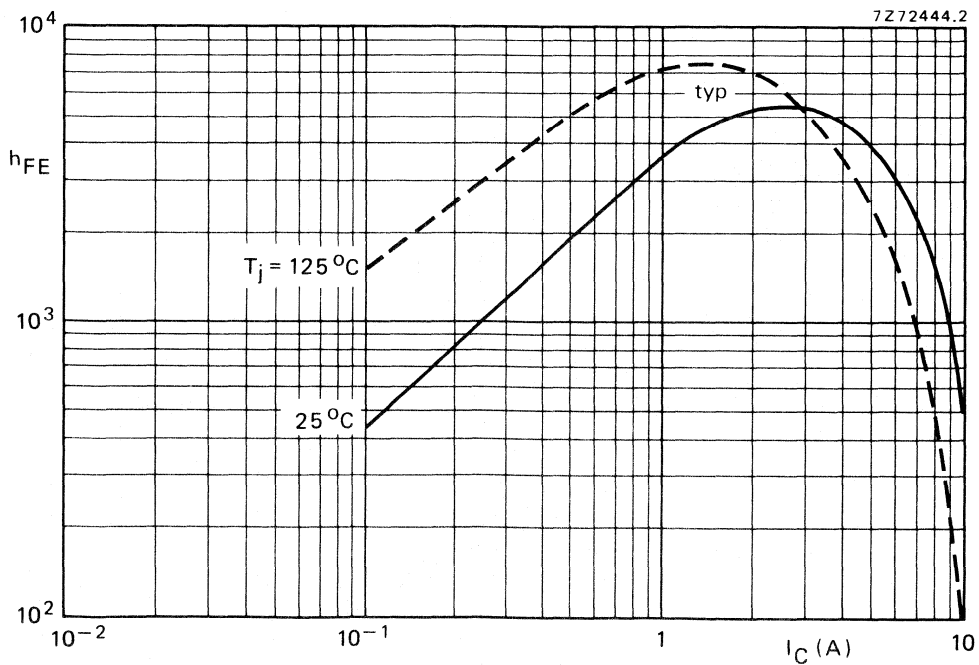


Fig. 10 D.C. current gain. $V_{CE} = 3\text{ V}$.

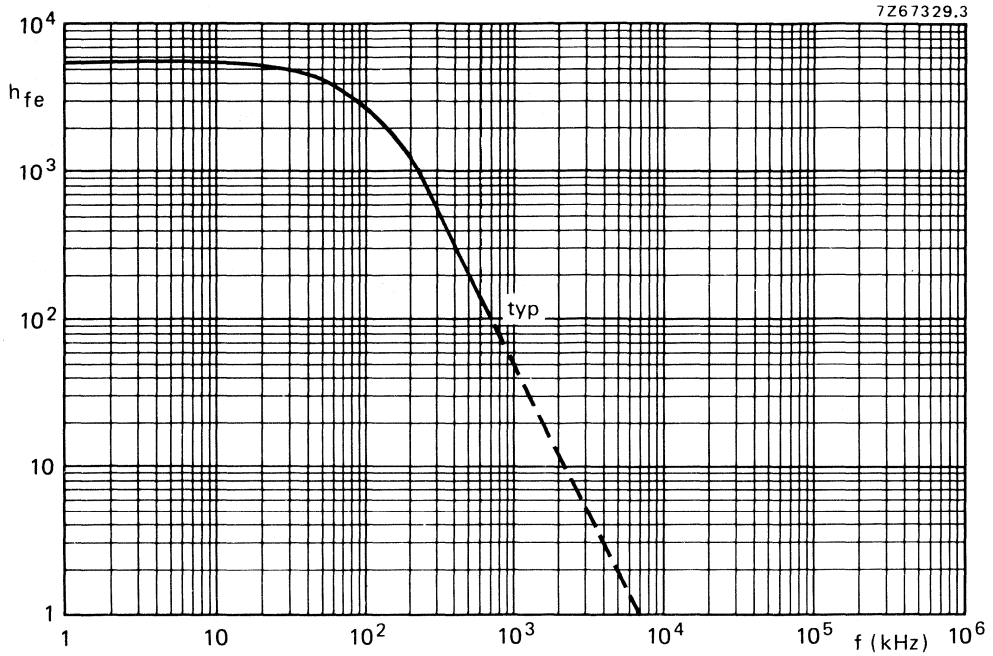


Fig. 11 Small signal current gain at $I_C = 3 \text{ A}$; $V_{CE} = 3 \text{ V}$.

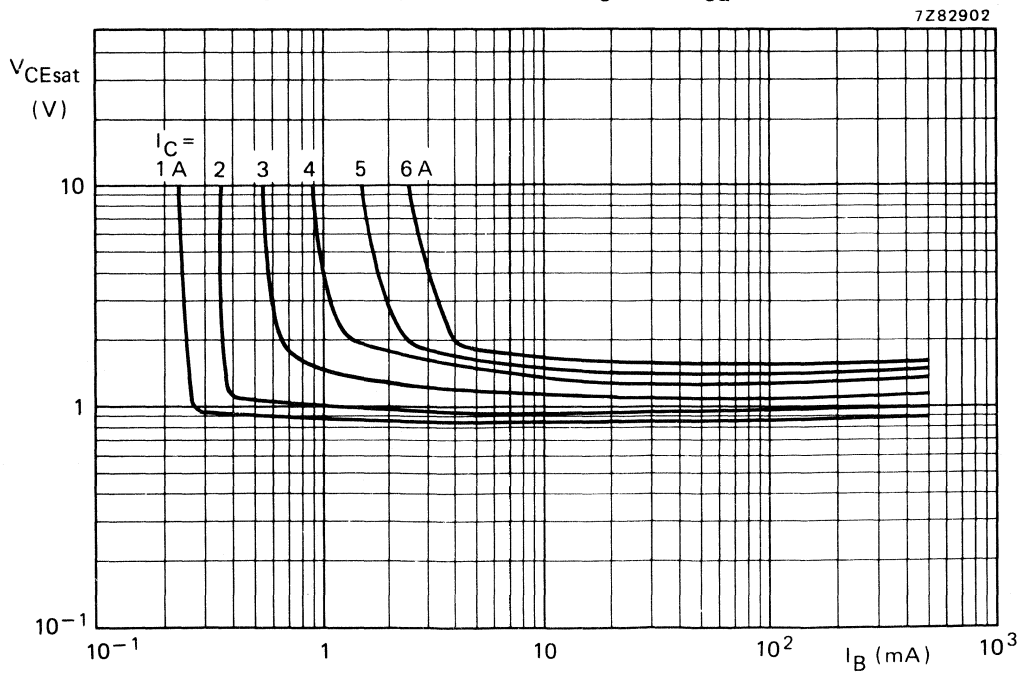


Fig. 12 Typical values collector-emitter saturation. $T_j = 25 \text{ }^\circ\text{C}$.

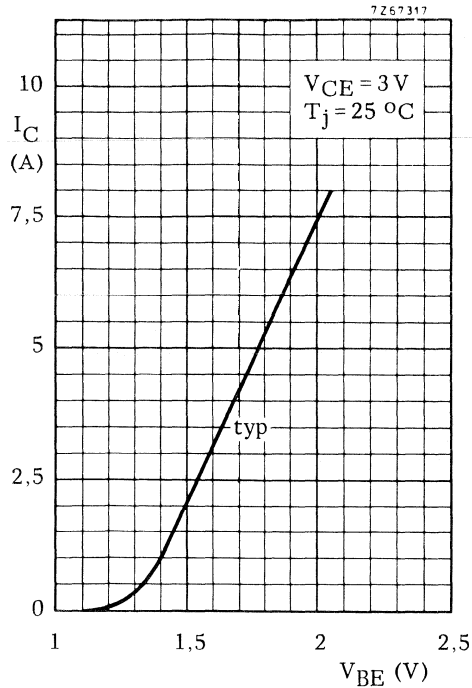


Fig. 13 Collector current.

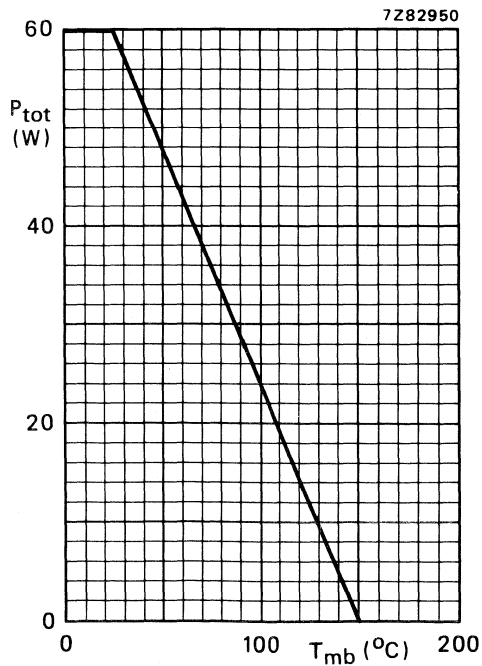


Fig. 14 Power derating curve.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	60		W	
Junction temperature	T_j	max.	150		$^\circ\text{C}$	
D.C. current gain $-I_C = 3,0\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	>	750			

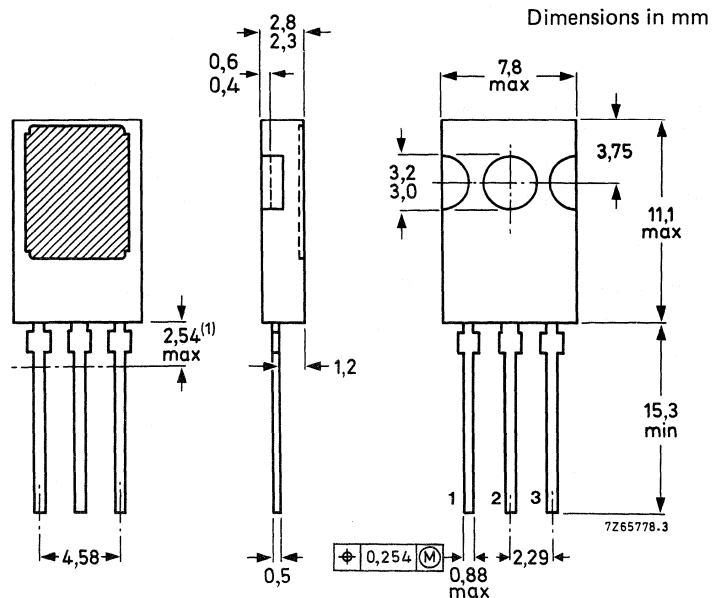
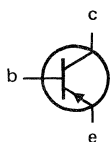
MECHANICAL DATA

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface.

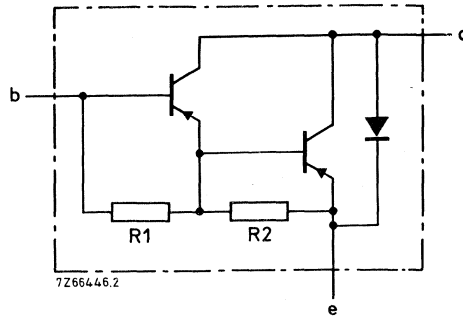
Pinning

- 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.



R₁ typ. 4 kΩ
R₂ 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 _{CB0}	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 ≤ 10 ms; δ ≤ 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-mb}	=	2,08	K/W
From junction to ambient in free air	R _{th j-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

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

Collector cut-off current

 $I_E = 0; -V_{CB} = -V_{CB0max}$ $-I_{CBO} < 0,1\text{ mA}$ ← $I_E = 0; -V_{CB} = -V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$ $-I_{CBO} < 1\text{ mA}$ ← $I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEO}$ $-I_{CEO} < 0,2\text{ mA}$ ←

Emitter cut-off current

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

D.C. current gain *

 $-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 2700 $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ $h_{FE} > 750$ $-I_C = 6\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 400

Base-emitter voltage **

 $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ $-V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage

 $-I_C = 3\text{ A}; -I_B = 12\text{ mA}$ $-V_{CEsat} < 2\text{ V}$

Small signal current gain

 $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ $h_{fe} > 10$ ←

Cut-off frequency

 $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ f_{hfe} typ. 100 kHz

Diode, forward voltage

 $I_F = 3\text{ A}$ V_F typ. 1,8 VD.C. current gain ratio of
complementary matched pairs $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ $h_{FE1}/h_{FE2} < 2,5$

Second breakdown collector current

non-repetitive; without heatsink
 $-V_{CE} = 60\text{ V}; t_p = 25\text{ ms}$ $-I_{(SB)} > 1\text{ A}$

Switching times (see Figs 3 and 4)

 $-I_{Con} = 3\text{ A}; -I_{Bon} = I_{Boff} = 12\text{ mA}$
turn-on time t_{on} typ. 1 μs $< 2\text{ } \mu\text{s}$ turn-off time t_{off} typ. 5 μs $< 10\text{ } \mu\text{s}$ * Measured under pulse conditions: $t_p < 300\text{ } \mu\text{s}$, $\delta < 2\%$.** V_{BE} decreases by about 3,8 mV/K with increasing temperature.

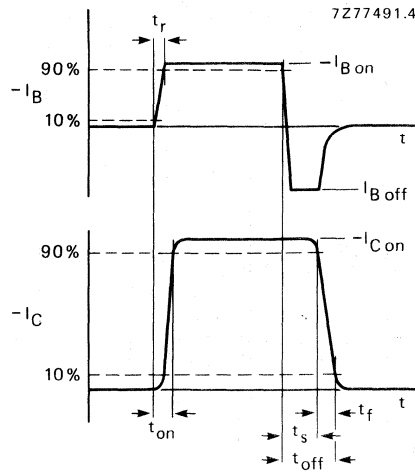
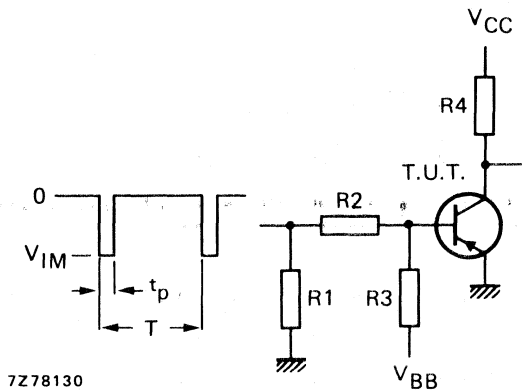


Fig. 3 Switching times waveforms.



- $-V_{IM} = 10 \text{ V}$
- $-V_{CC} = 10 \text{ V}$
- $V_{BB} = 4 \text{ V}$
- $R1 = 56 \ \Omega$
- $R2 = 410 \ \Omega$
- $R3 = 560 \ \Omega$
- $R4 = 3 \ \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \ \mu\text{s}$
- $T = 500 \ \mu\text{s}$

Fig. 4 Switching times test circuit.

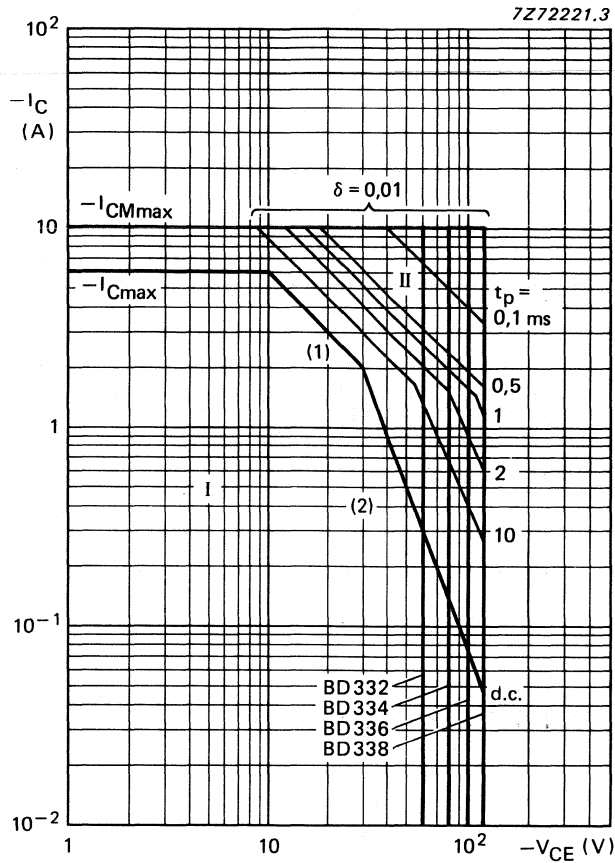


Fig. 5 Safe Operating Area with the transistor forward biased; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

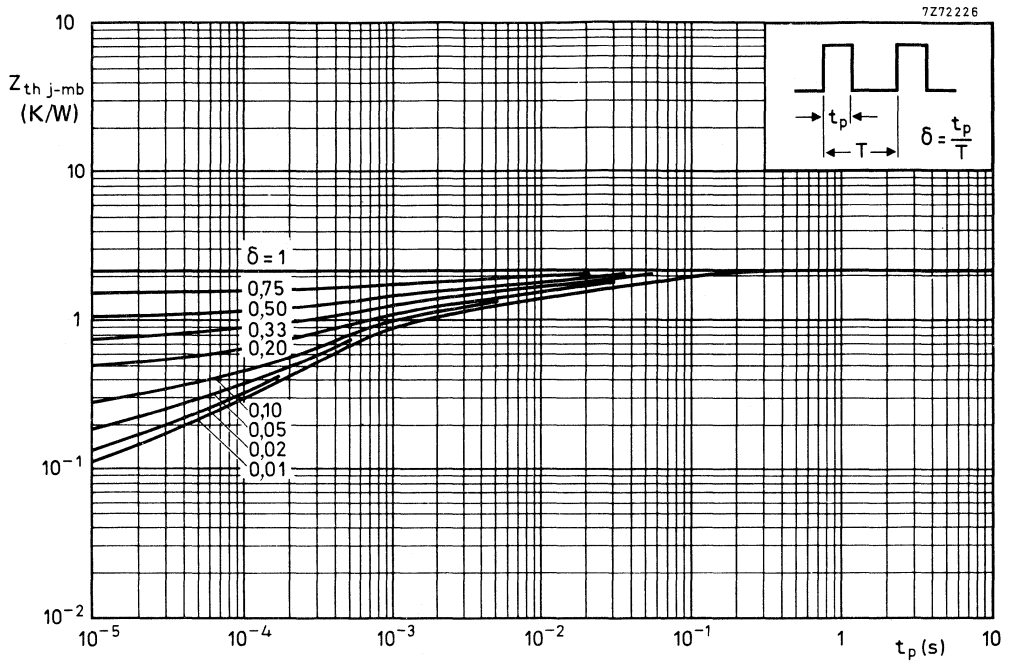


Fig. 6 Pulse power rating chart.

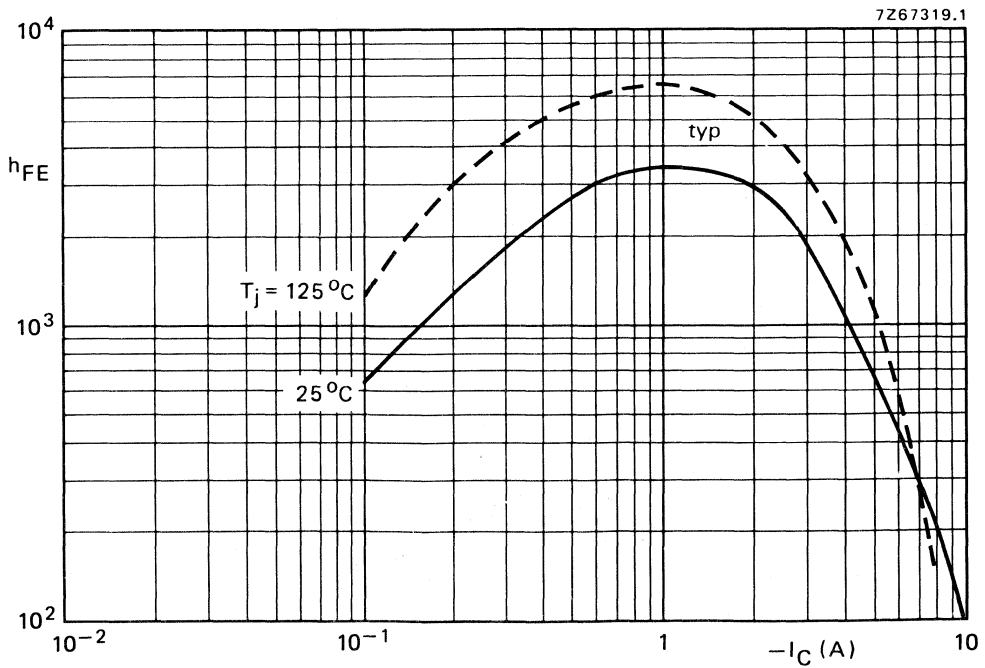


Fig. 7 D.C. current gain at $-V_{CE} = 3\text{ V}$.

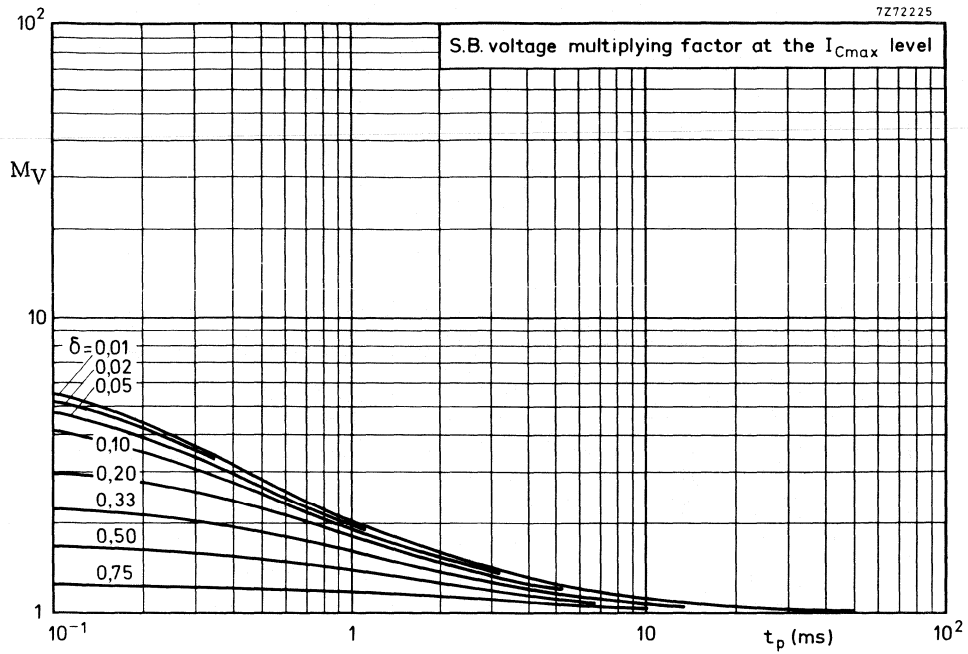


Fig. 8 Second breakdown voltage multiplying factor at the I_{Cmax} level.

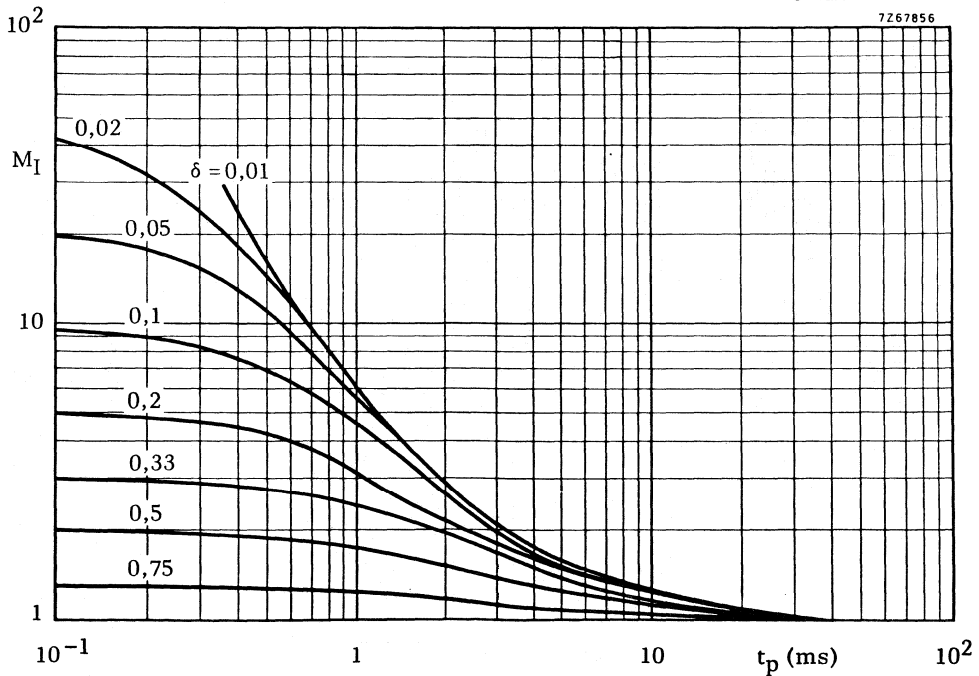


Fig. 9 Second breakdown current multiplying factor at the V_{CEOmax} level.

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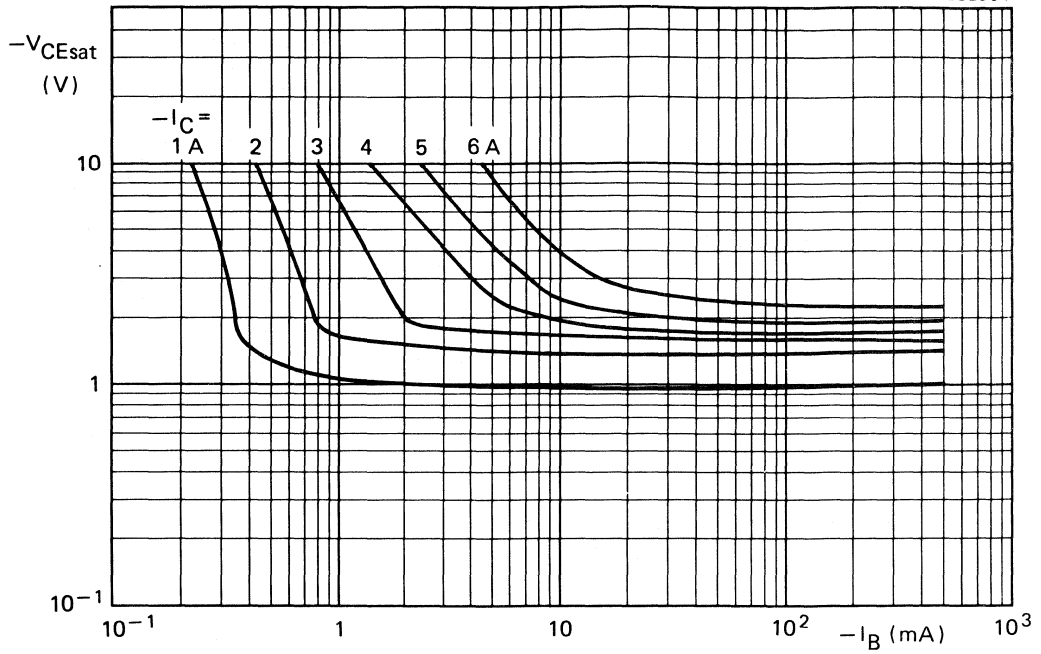


Fig. 10 Typical values collector-emitter saturation voltage. $T_j = 25^\circ\text{C}$.

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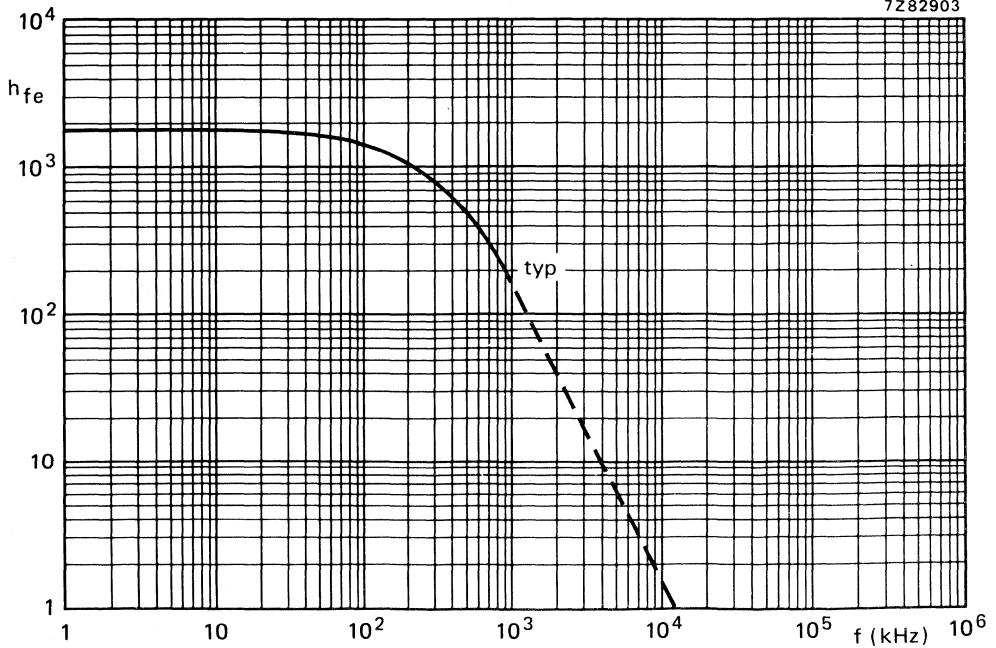


Fig. 11 Small signal current gain. $-I_C = 3\text{ A}$; $-V_{CE} = 3\text{ V}$.

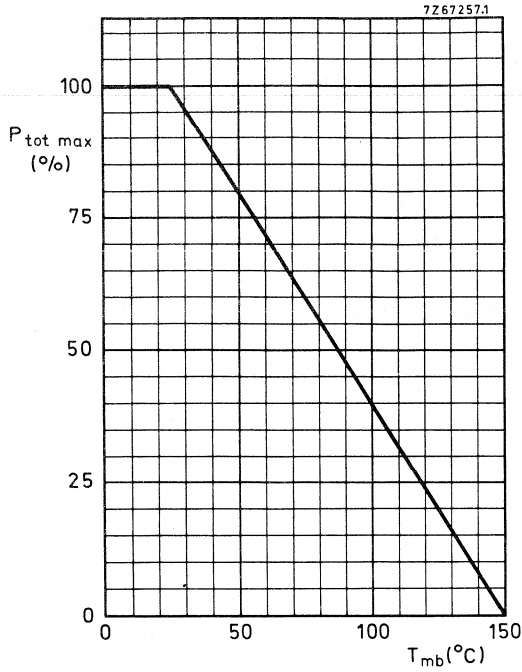


Fig. 12 Power derating curve.

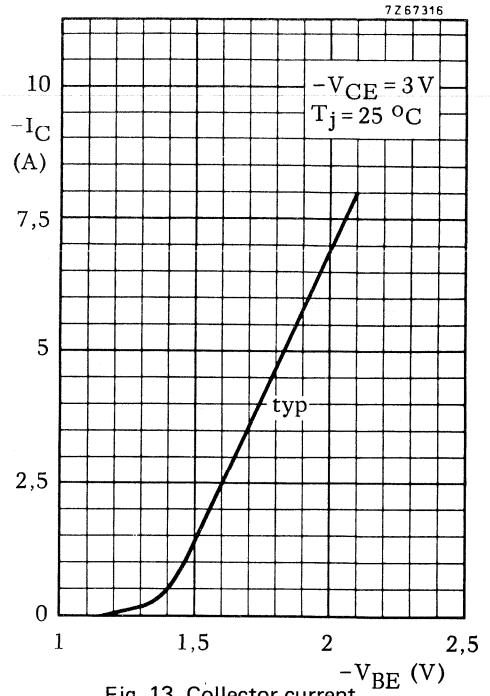


Fig. 13 Collector current.

SILICON EPITAXIAL-BASE TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.

The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

QUICK REFERENCE DATA

		BD433	BD435	BD437	
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES} max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO} max.	22	32	45	V
Collector current (peak value)	I_{CM} max.	7	7	7	A
Collector current (d.c.)	I_C max.	4	4	4	A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	36	36	36	W
D.C. current gain					
$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	$h_{FE} >$	50	50	40	
Transition frequency					
$I_C = 250\text{ mA}; V_{CE} = 1\text{ V}$	$f_T >$	7	7	7	

MECHANICAL DATA

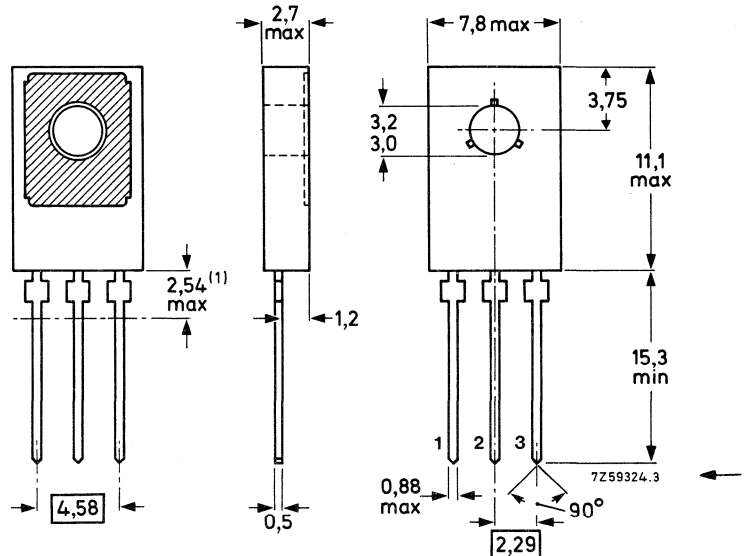
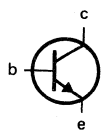
Dimensions in mm

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)

			BD433	BD435	BD437	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	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	5	5	V
Collector current (d. c.)	I_C	max.		4		A
Collector current (peak value)	I_{CM}	max.		7		A
Base current (d. c.)	I_B	max.		1		A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		36		W
Storage temperature	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$
THERMAL RESISTANCE						
From junction to mounting base	$R_{th\ j-mb}$	=		3,5		K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		100		K/W

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0max}$	I_{CBO}	<	50	μA	←
$I_E = 0; V_{CB} = 10\text{ V}; T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	<	1	mA	
$I_E = 0; V_{CB} = V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	<	1	mA	←

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	0,2	mA	←
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Knee voltage

			BD433	BD435	BD437	
$I_C = 2\text{ A}; I_B = \text{value for which}$ $I_C = 2,2\text{ A at } V_{CE} = 1\text{ V}$	V_{CEK}	<	0,8	0,8	0,8	V

Base-emitter voltage ¹⁾

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	V_{BE}	typ.	580	580	580	mV
$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	V_{BE}	<	1,1	1,1	-	V
$I_C = 3\text{ A}; V_{CE} = 1\text{ V}$	V_{BE}	<	-	-	1,3	V

Collector-emitter saturation voltage

$I_C = 2\text{ A}; I_B = 0,2\text{ A}$	V_{CEsat}	<	0,5	0,5	-	V
$I_C = 3\text{ A}; I_B = 0,3\text{ A}$	V_{CEsat}	<	-	-	0,7	V

D. C. current gain

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	h_{FE}	>	25	25	25
$I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$	h_{FE}	>	85	85	85
$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	<	475	475	375
$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	>	50	50	40
$I_C = 3\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	>	-	-	30

Transition frequency at $f = 1\text{ MHz}$

$I_C = 250\text{ mA}; V_{CE} = 1\text{ V}$	f_T	>	7		MHz
--	-------	---	---	--	--------------

D. C. current gain ratio of the complementary pairs

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

BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<	1,4
BD437/BD438	h_{FE1}/h_{FE2}	<	1,8

1) V_{BE} decreases by typ. 2, 3 mV/K with increasing temperature.

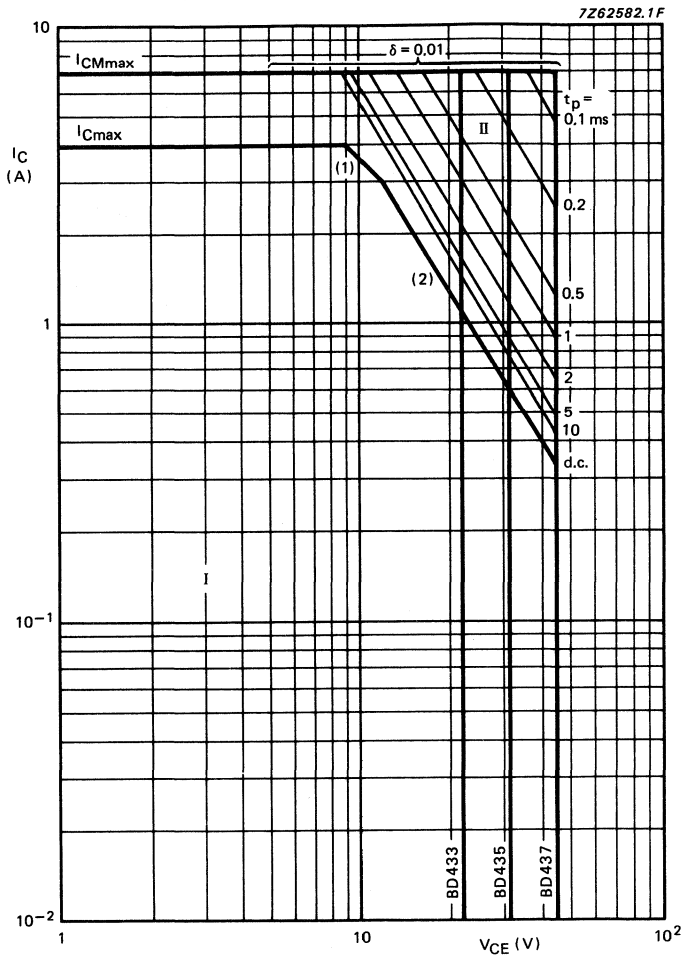
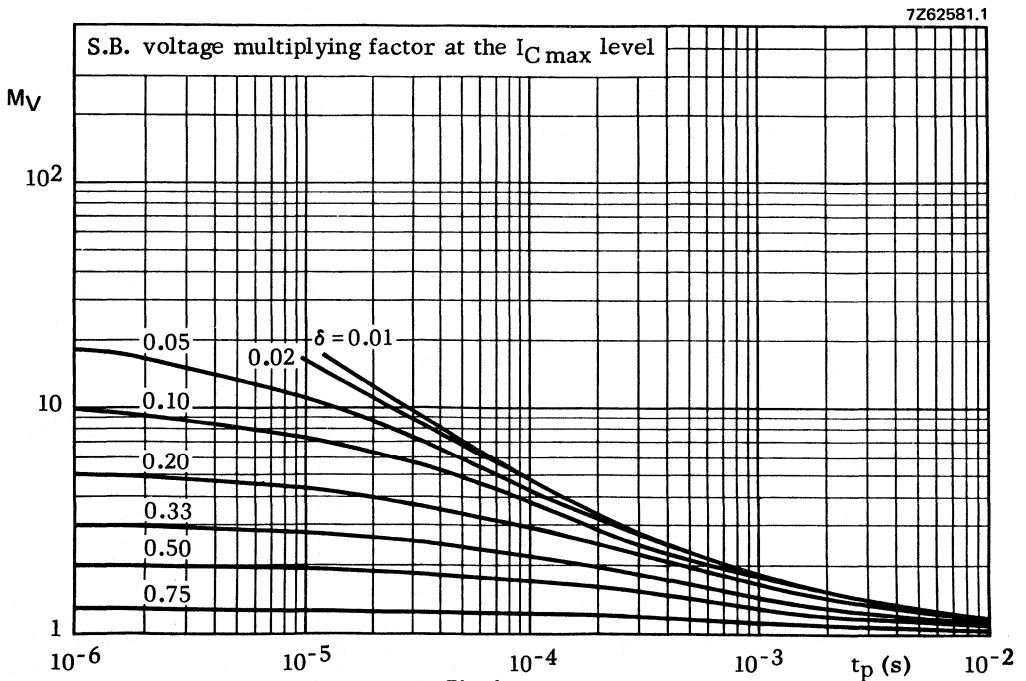
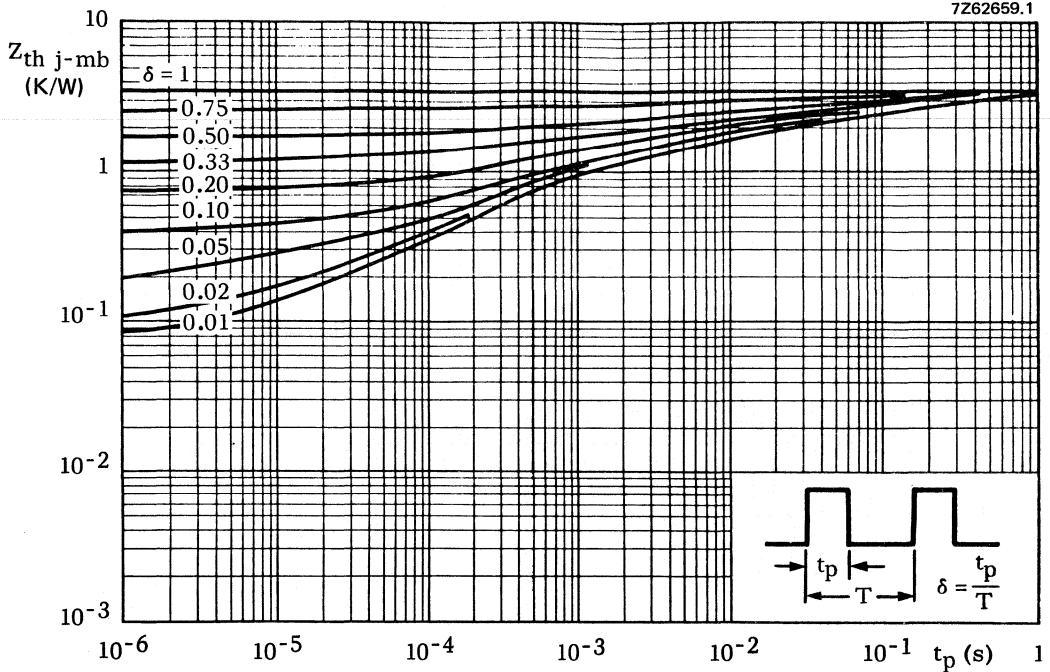


Fig. 2 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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



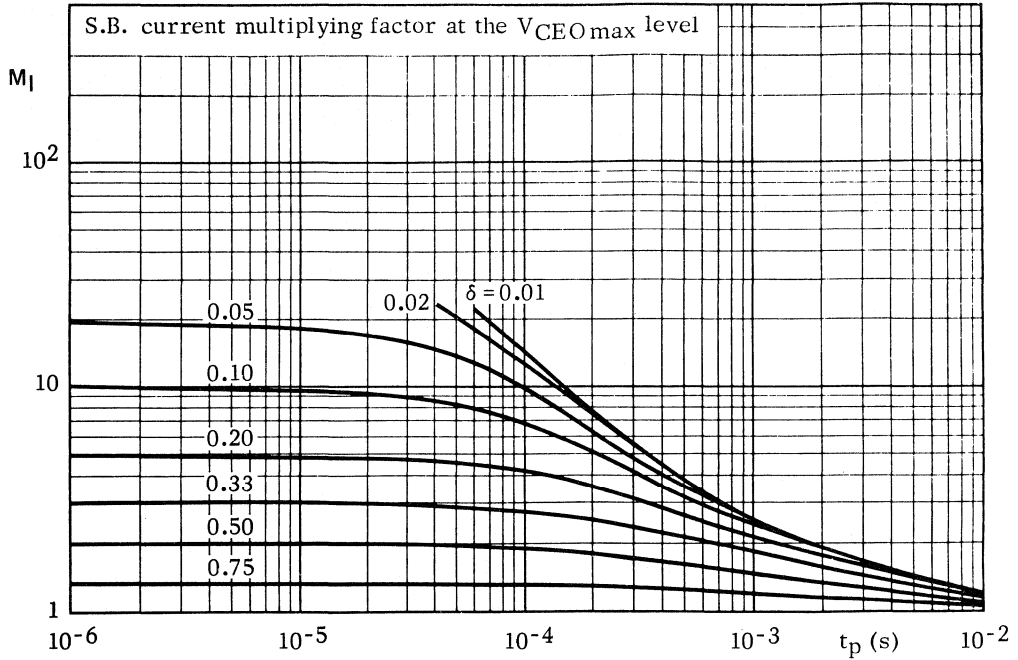


Fig. 5

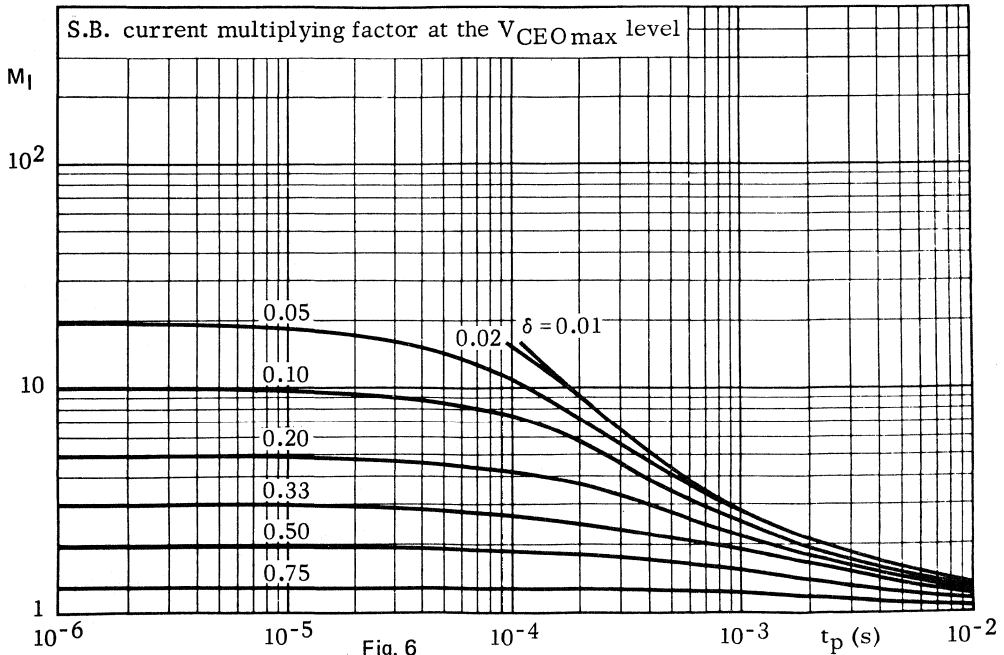


Fig. 6

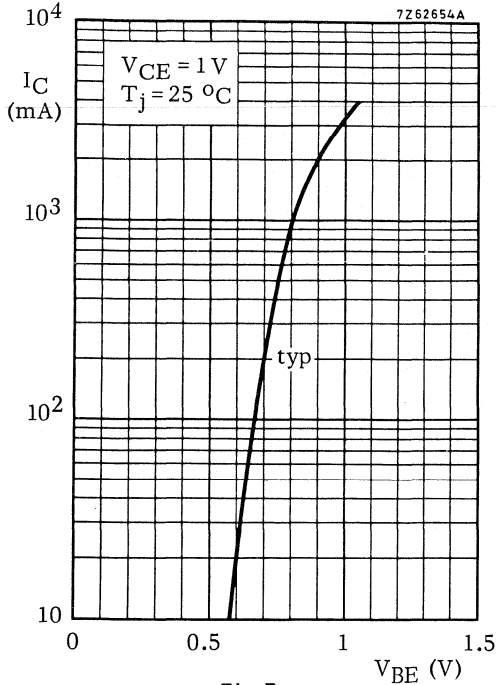


Fig. 7

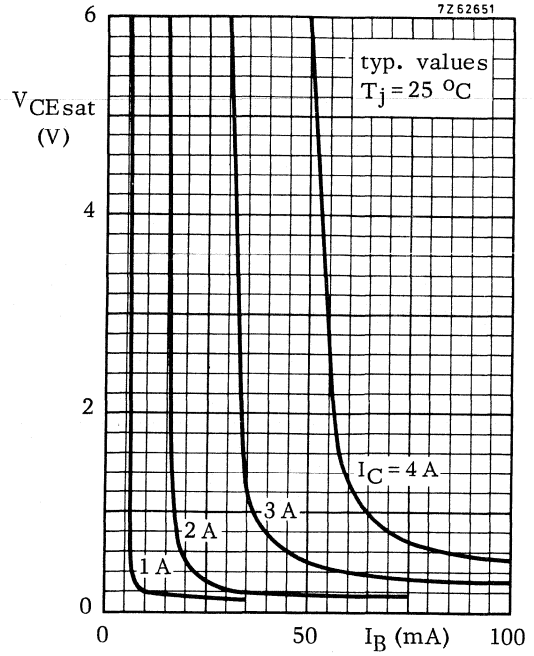


Fig. 8

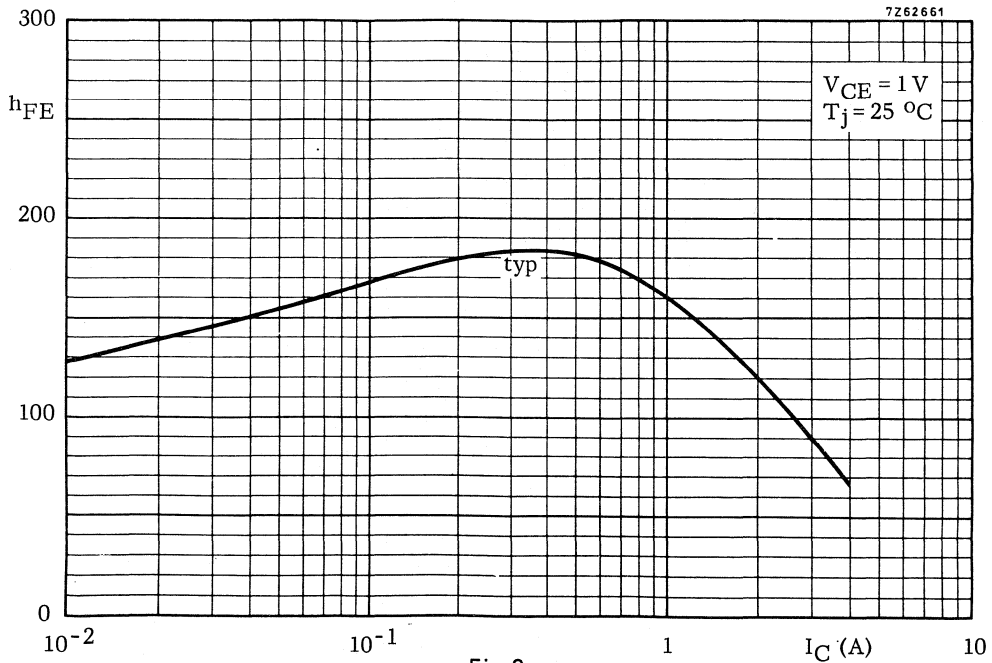


Fig. 9

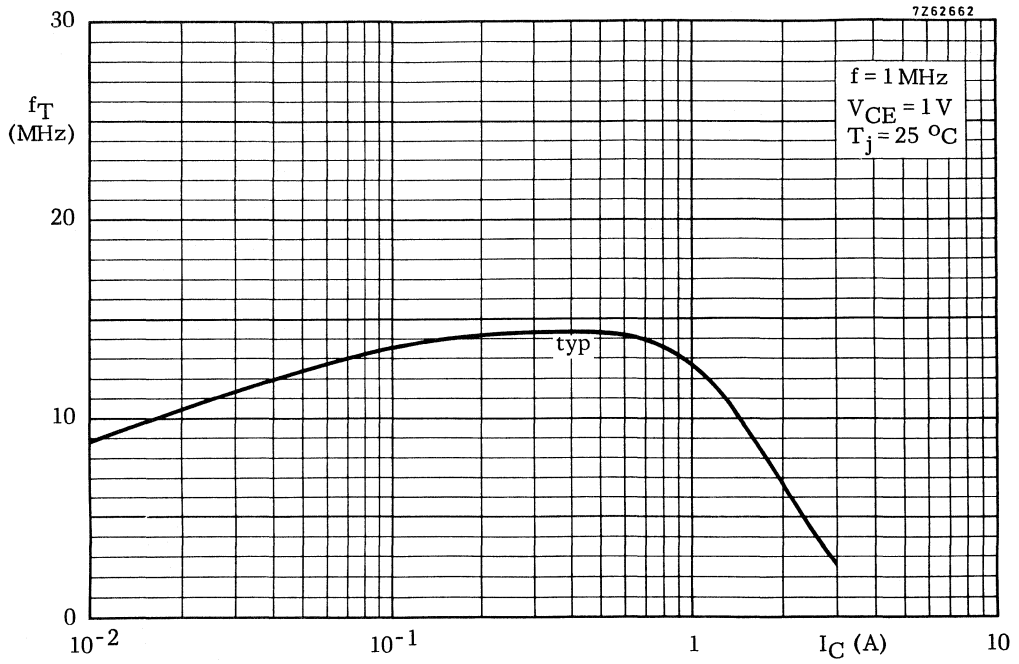


Fig. 11

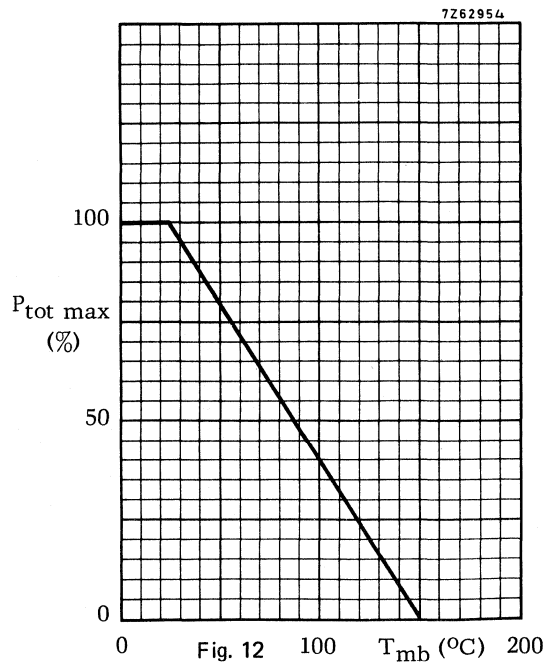


Fig. 12

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.

The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

QUICK REFERENCE DATA

		BD434	BD436	BD438	
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$ max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	22	32	45	V
Collector current (d.c.)	$-I_C$ max.	4	4	4	A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	36	36	36	W
D.C. current gain					
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE} >	50	50	40	
Transition frequency					
$-I_C = 250\text{ mA}; -V_{CE} = 1\text{ V}$	f_T >	7	7	7	MHz

MECHANICAL DATA

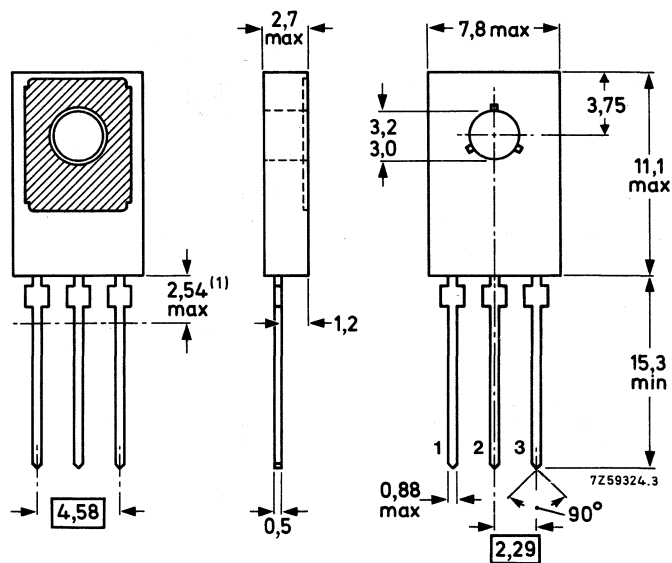
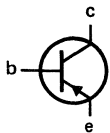
Dimensions in mm

Fig. 1 TO -126 (SOT-32)

Collector connected to metal part of mounting surface

Pinning

- 1 = emitter
- 2 = collector
- 3 = base



See 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)

		BD434	BD436	BD438	
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 22	32	45	V
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$	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	5	5	V
Collector current (d. c.)	$-I_C$	max.	4		A
Collector current (peak value)	$-I_{CM}$	max.	7		A
Base current (d. c.)	$-I_B$	max.	1		A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	36		W
Storage temperature	T_{stg}		-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$
THERMAL RESISTANCE					
From junction to mounting base	$R_{th\ j-mb}$	=	3, 5		K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100		K/W

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0max}$	$-I_{CBO}$	<	50	μA	←
$I_E = 0; -V_{CB} = 10\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1	mA	
$I_E = 0; -V_{CB} = -V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1	mA	←

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	0,2	mA	←
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Knee voltage

			BD434	BD436	BD438	
$-I_C = 2\text{ A}; -I_B = \text{value for which}$ $-I_C = 2,2\text{ A at } -V_{CE} = 1\text{ V}$	$-V_{CEK}$	<	0,8	0,8	0,8	V

Base-emitter voltage ¹⁾

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$-V_{BE}$	typ.	580	580	580	mV
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	1,1	1,1	-	V
$-I_C = 3\text{ A}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	-	-	1,3	V

Collector-emitter saturation voltage

$-I_C = 2\text{ A}; -I_B = 0,2\text{ A}$	$-V_{CEsat}$	<	0,5	0,5	-	V
$-I_C = 3\text{ A}; -I_B = 0,3\text{ A}$	$-V_{CEsat}$	<	-	-	0,7	V

D. C. current gain

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	h_{FE}	>	25	25	25	
$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	h_{FE}	>	85	85	85	
		<	475	475	375	
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	50	50	40	
$-I_C = 3\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	-	-	30	

Transition frequency at $f = 1\text{ MHz}$

$-I_C = 250\text{ mA}; -V_{CE} = 1\text{ V}$	f_T	>	7			MHz
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D. C. current gain ratio of the complementary pairs

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

BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<	1,4			
BD437/BD438	h_{FE1}/h_{FE2}	<	1,8			

¹⁾ $-V_{BE}$ decreases by typ. 2,3 mV/K with increasing temperature.

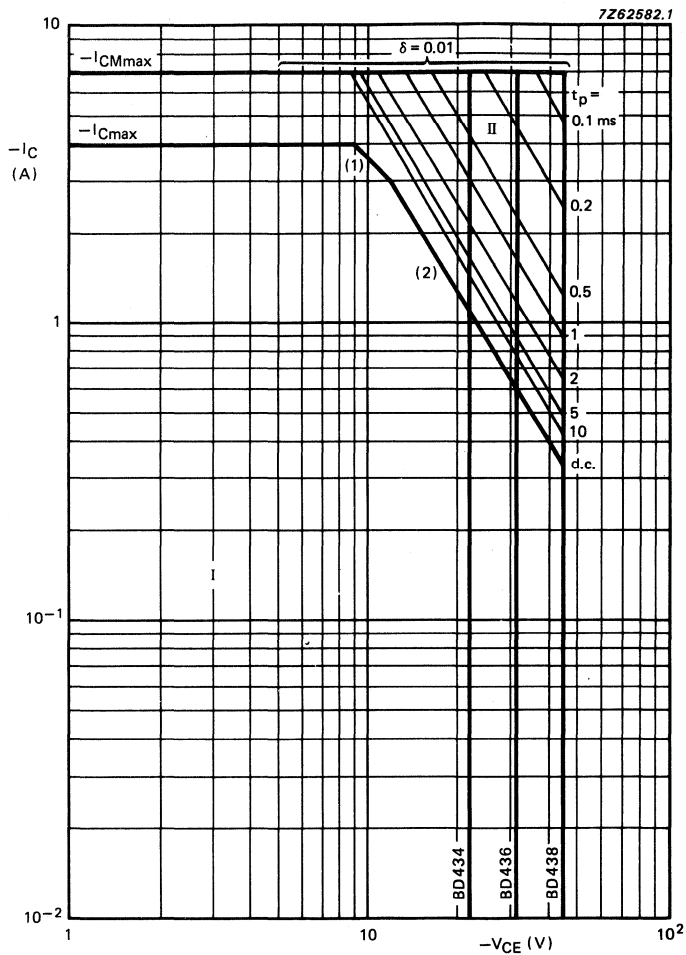


Fig. 2 Safe Operating Area; $T_{mb} = 25^{\circ}\text{C}$.

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

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

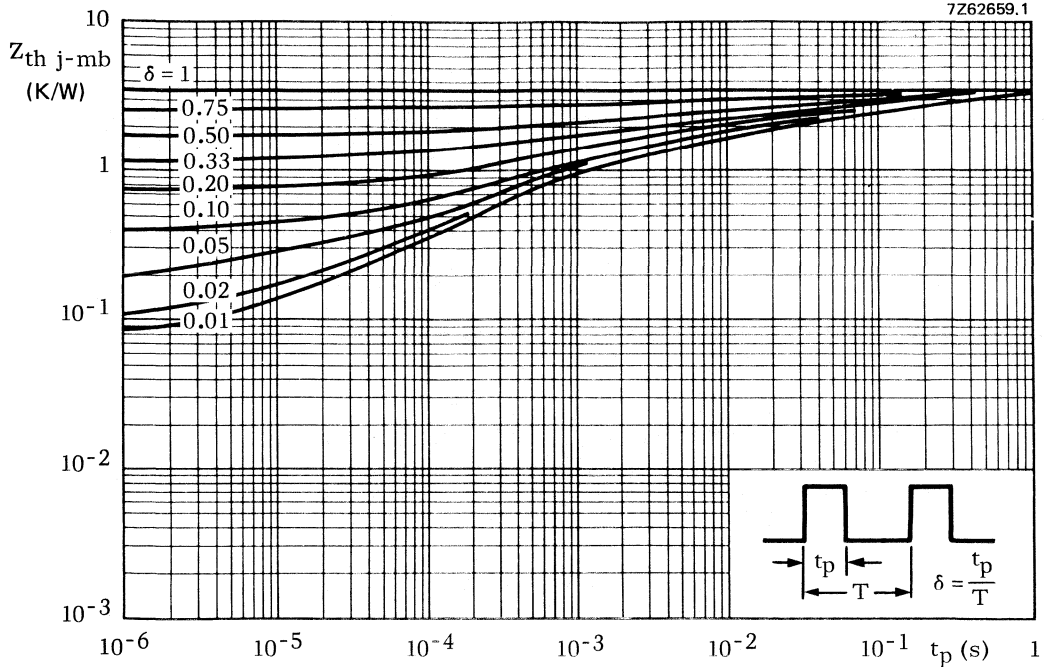


Fig 3

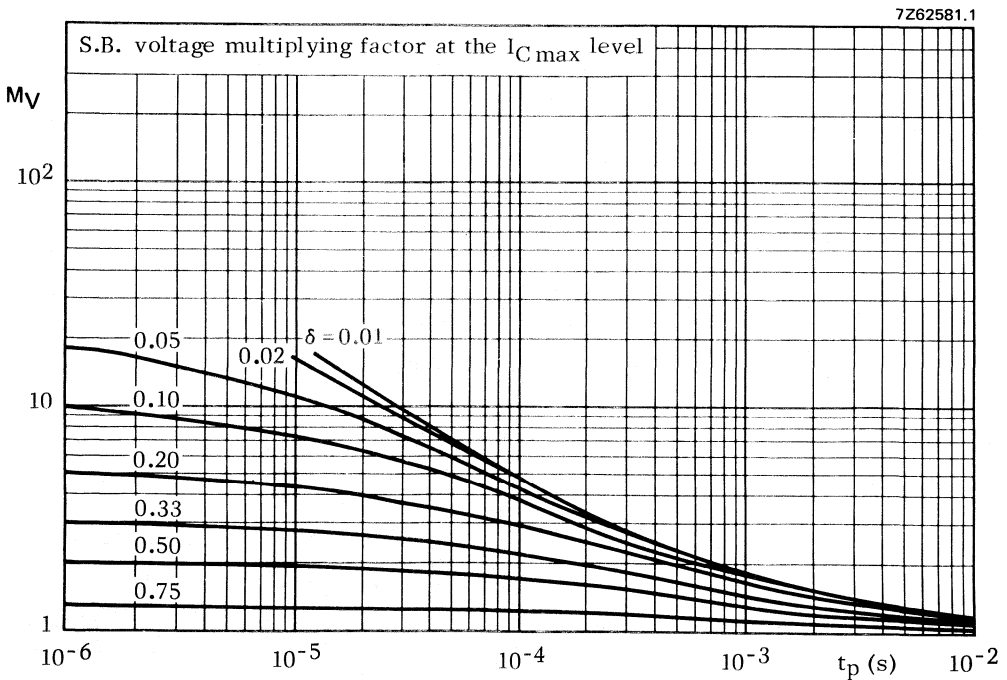


Fig 4

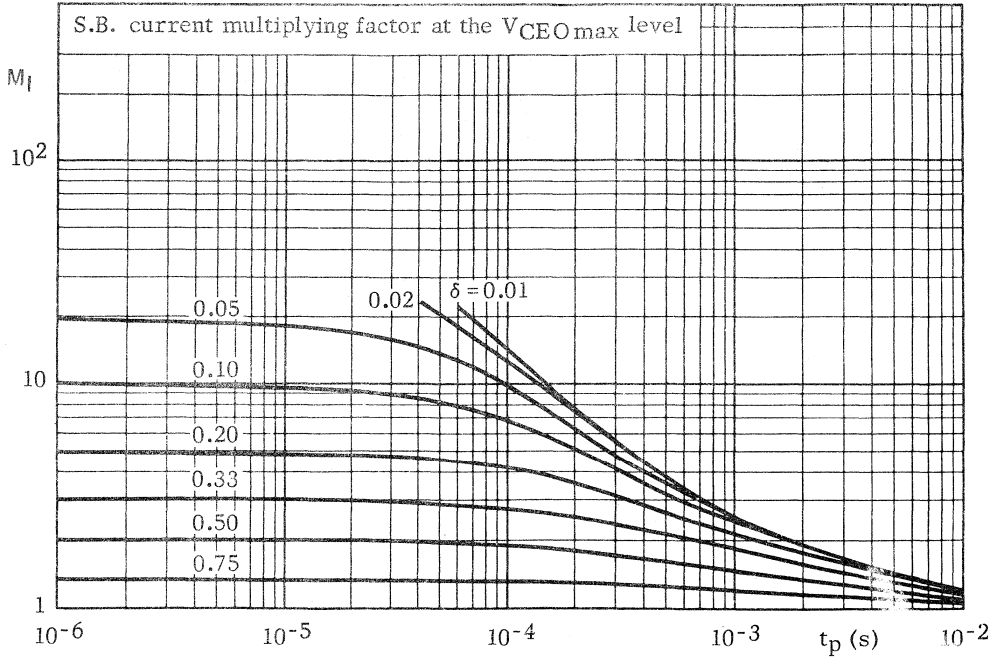


Fig 5

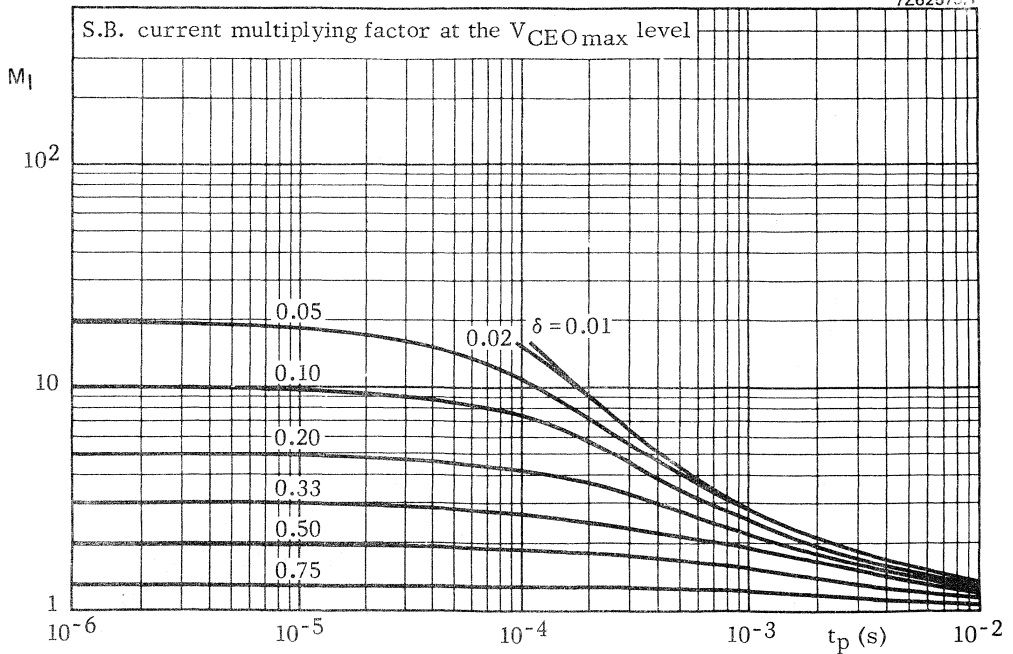
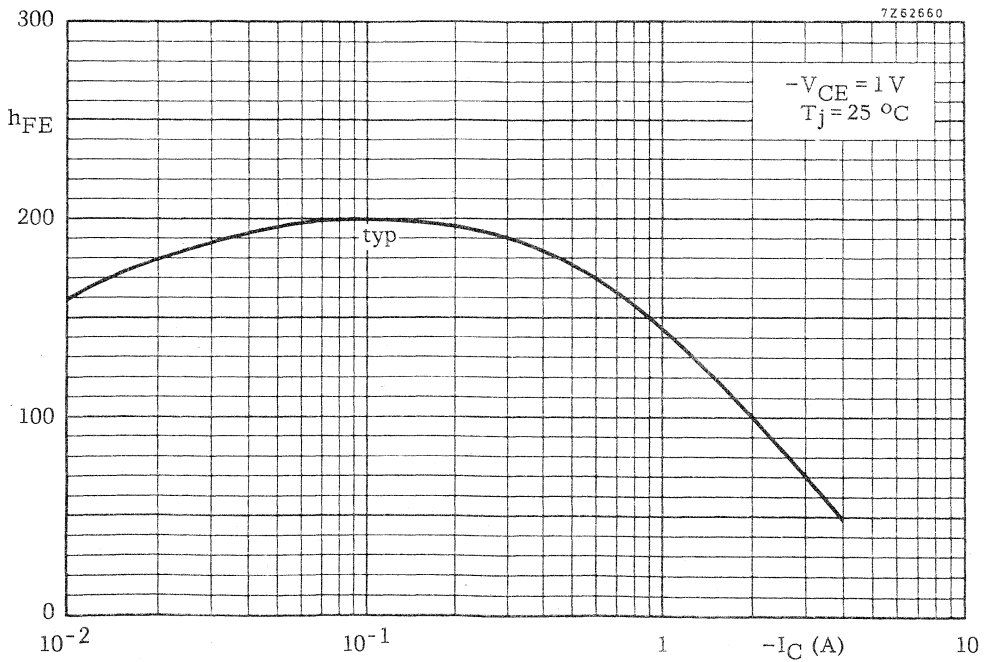
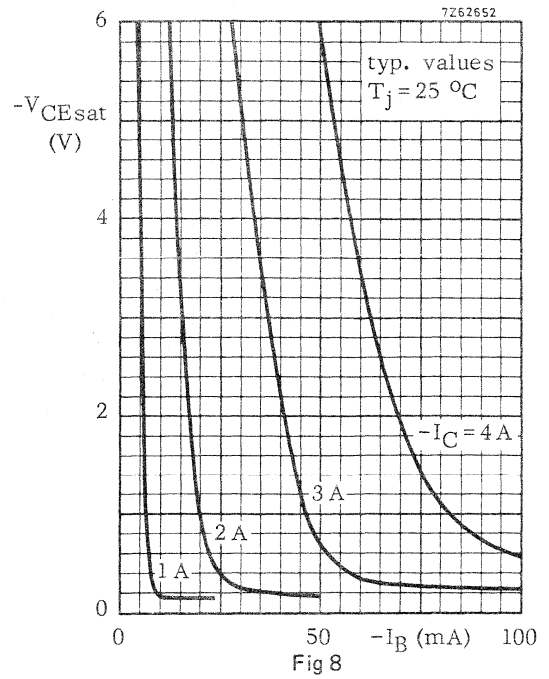
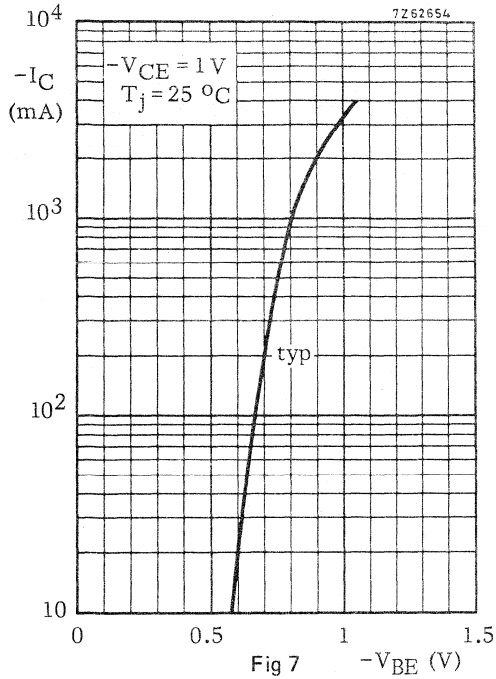


Fig 6



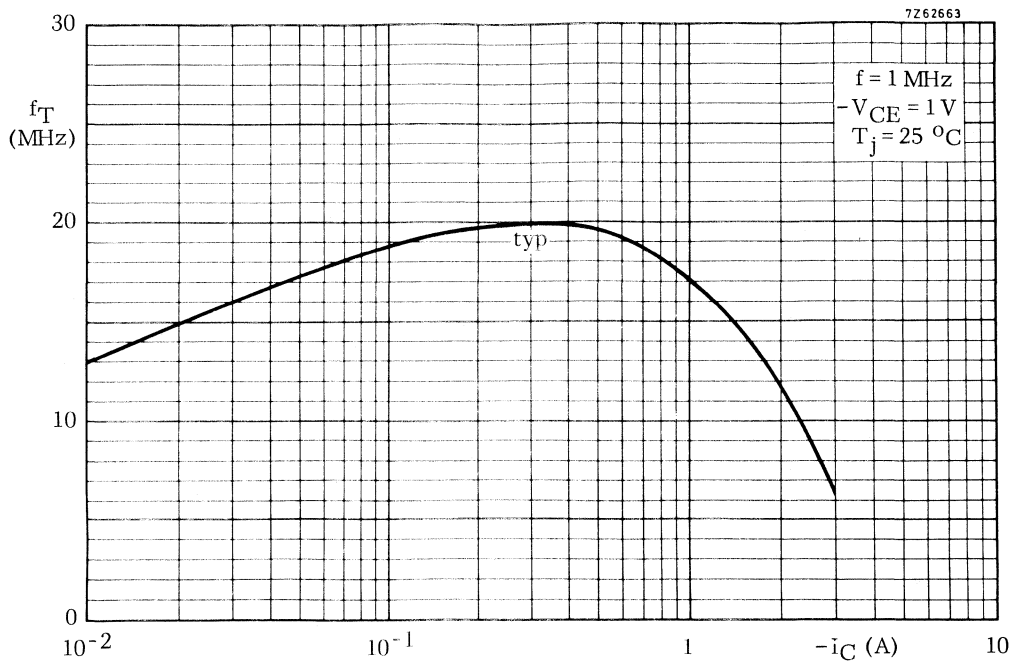


Fig 10

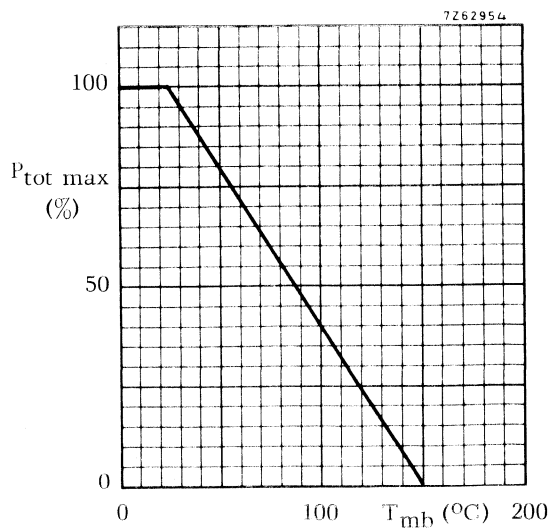


Fig 11

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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		62.5		W
Junction temperature	T_j	max.		150		$^\circ\text{C}$
DC current gain $I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ $I_C = 4\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	min. — min. 750	750 —	750 —	750 —	750 —

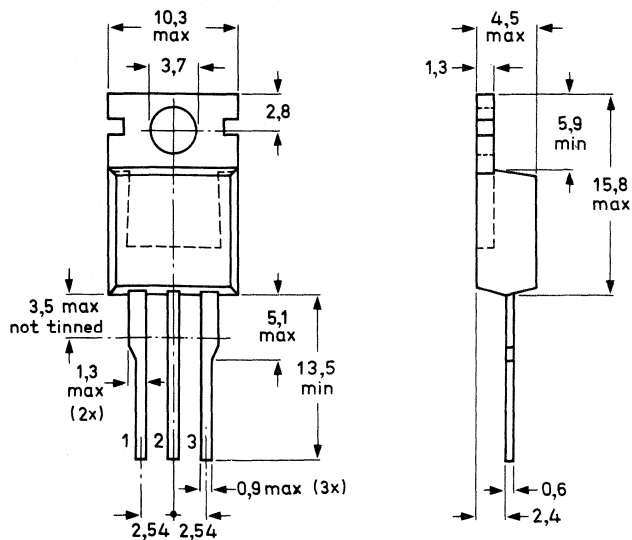
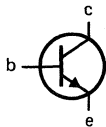
MECHANICAL DATA

Dimensions in mm

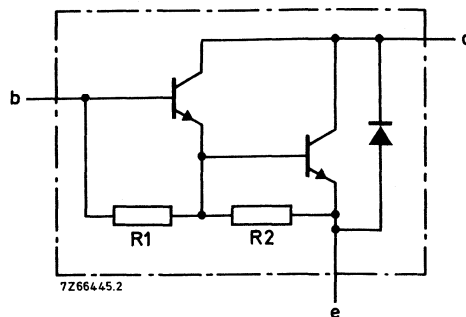
Fig. 1 TO-220AB.

Pinning

- 1 = Base
- 2 = Collector
- 3 = Emitter



7265872.5



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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		62.5		W
Storage temperature range	T_{stg}			-55 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE*

From junction to mounting base	R_{thj-mb}	max.		2.0		K/W
From junction to ambient in free air	R_{thj-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

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

Collector cut-off currents

 $I_E = 0; V_{CB} = V_{CEO\text{ max}}$ I_{CBO} max. 0.1 mA $I_E = 0; V_{CB} = \frac{1}{2} V_{CBO\text{ max}};$ $T_j = 150\text{ }^\circ\text{C}$ I_{CBO} max. 1 mA $I_E = 0; V_{CE} = \frac{1}{2} V_{CEO\text{ max}}$ I_{CEO} max. 0.2 mA

Emitter cut-off current

 $I_C = 0; V_{EB} = 5\text{ V}$ I_{EBO} max. 5 mA

DC current gain (see note 1)

 $I_C = 0.5\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} typ. 1900 $I_C = 4\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} min. 750 $I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} min. 750 $I_C = 8\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} typ. 1800

Base-emitter voltage (see notes 1 and 2)

 $I_C = 4\text{ A}; V_{CE} = 3\text{ V}$ V_{BE} max. 2.5 V $I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ V_{BE} max. 2.5 V

Saturation voltages (1)

 $I_C = 4\text{ A}; I_B = 16\text{ mA}$ V_{CEsat} max. 2 V $I_C = 3\text{ A}; I_B = 12\text{ mA}$ V_{CEsat} max. 2 V $I_C = 5\text{ A}; I_B = 50\text{ mA}$ V_{CEsat} max. 2.5 V $I_C = 5\text{ A}; I_B = 50\text{ mA}$ V_{BEsat} max. 3 V

Small signal current gain

 $I_C = 4\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ h_{fe} min. 10 $I_C = 3\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ h_{fe} min. 10

Cut-off frequency

 $I_C = 4\text{ A}; V_{CE} = 3\text{ V}$ f_{hfe} typ. 50 kHz $I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ f_{hfe} typ. 50 kHz

Second-breakdown collector current

 $t_p = 0.1\text{ s};$ non-repetitive,

without heatsink

 $V_{CE} = 50\text{ V}$ $I_{(SB)}$ min. 1.25 A $V_{CE} = 60\text{ V}$ $I_{(SB)}$ min. 1.04 A

DC current gain ratio of matched

pairs at $V_{CE} = 3\text{ V}$ $I_C = 4\text{ A}$

BD643/BD644

 h_{FE1}/h_{FE2} max. 2.5 $I_C = 3\text{ A}$

BD645/BD646

 h_{FE1}/h_{FE2} max. 2.5

Diode forward voltage

 $I_F = 3\text{ A}$ V_F typ. 0.9 VCollector capacitance at $f = 1\text{ MHz}$ $V_{CB} = 10\text{ V}$ C_c typ. 75 pF

Turn-off breakdown energy with

inductive load; $I_C = 4.5\text{ A}$ $E_{(BR)}$ min. 50 mJ

(see Fig. 3)

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

Switching times (see Figs 4 and 5)

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

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

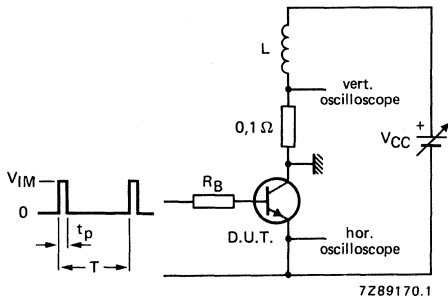


Fig. 3 Test circuit for turn-off breakdown energy; $V_{IM} = 12 \text{ V}$; $R_B = 270$; $I_C = 4.5 \text{ A}$; $t_p = 1 \text{ ms}$; $\delta = 1\%$.

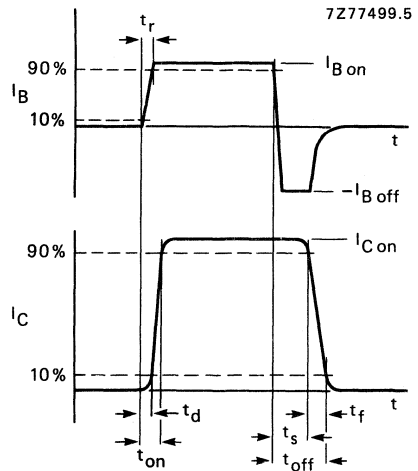
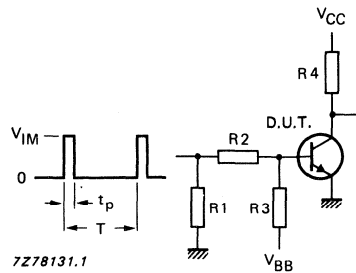


Fig. 4 Switching times waveforms.



V_{CC}	=	10 V
V_{IM}	=	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. 5 Switching times test circuit.

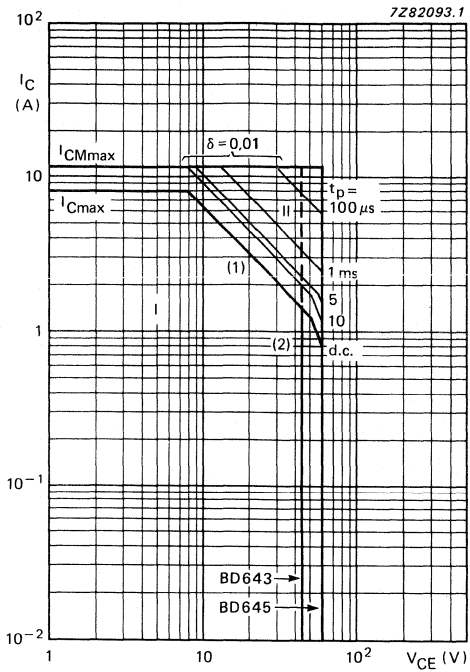


Fig. 6 **BD643; BD645** Safe Operating Area, $T_{mb} = 25^\circ C$.

- 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.

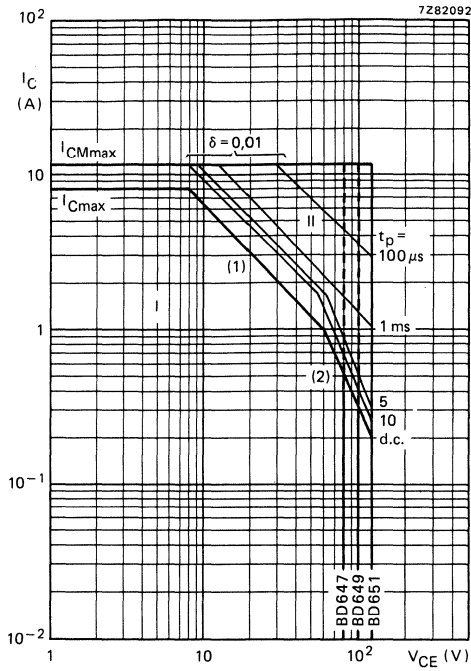


Fig. 7 BD647, BD649, BD651 Safe Operating Area, $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

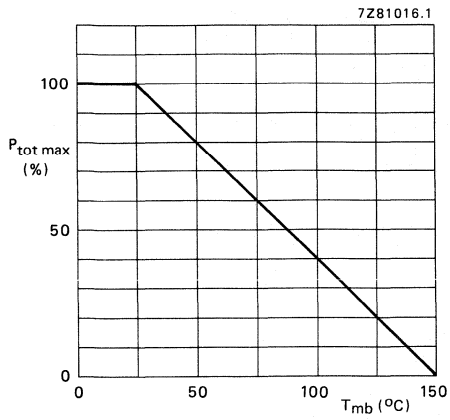


Fig. 8 Power derating curve.

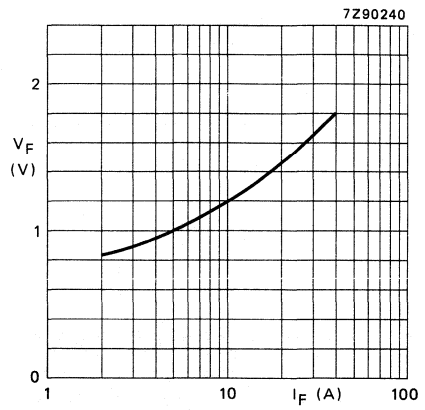


Fig. 9 Diode forward voltage versus forward current; $T_j = 25$ °C; typical values.

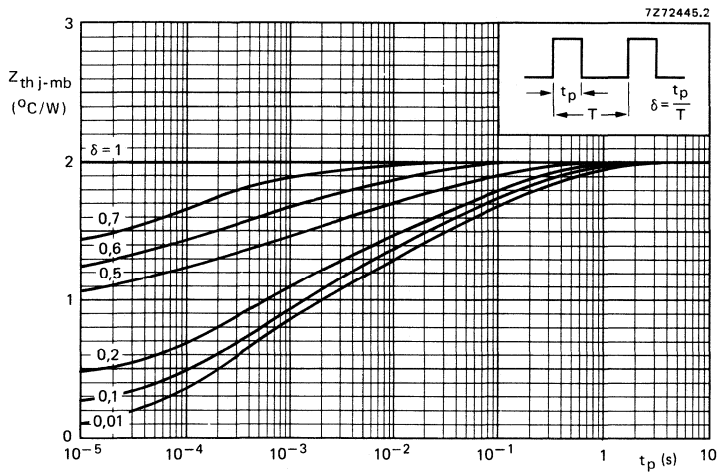


Fig. 10 Pulse power rating chart.

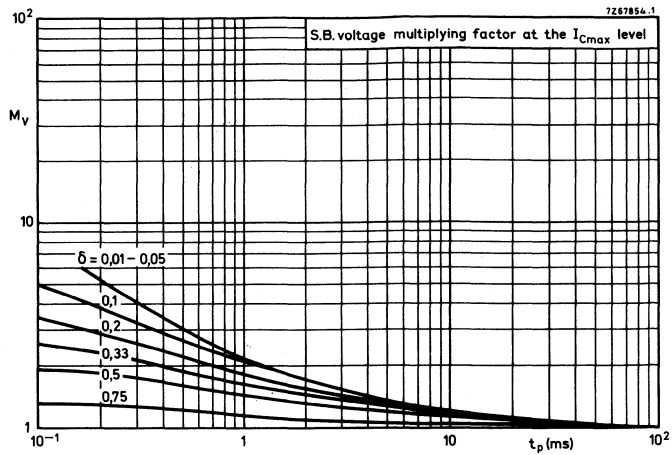


Fig. 11 Second breakdown voltage multiplying factor at the I_{Cmax} level.

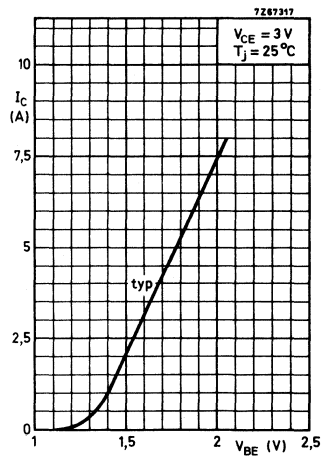


Fig. 12 Collector current as a function of base-emitter voltage;
 $V_{CE} = 3V$; $T_j = 25^\circ C$; typical values.

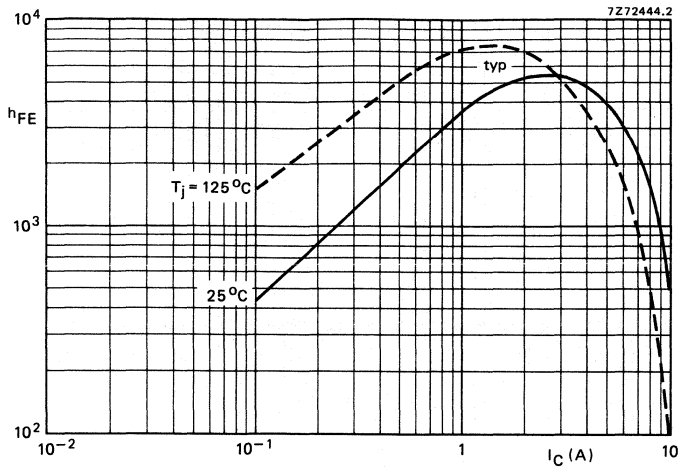


Fig. 13 DC current gain; $V_{CE} = 3\text{ V}$; typical values.

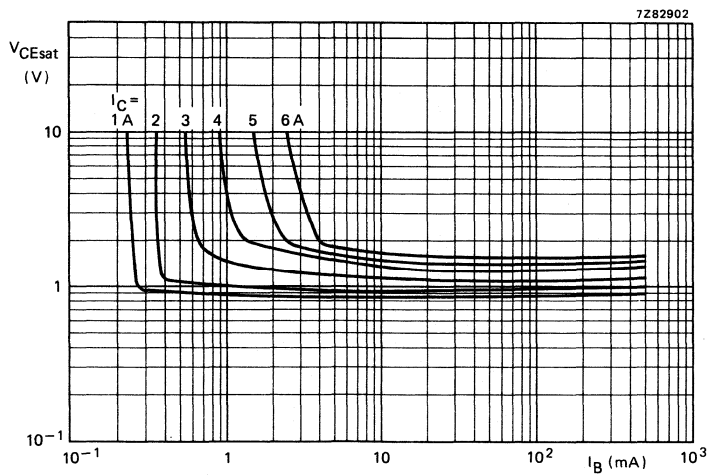


Fig. 14 Collector-emitter saturation voltage; $T_j = 25^\circ\text{C}$; typical values.

BD643; BD645;
BD647; BD649;
BD651

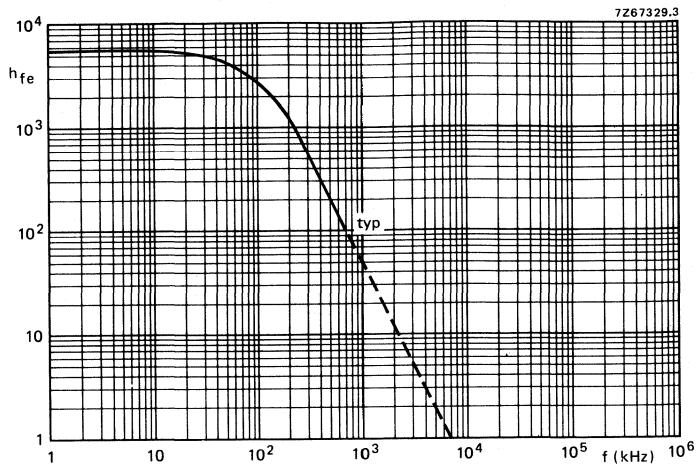


Fig. 15 Small signal current gain; $I_C = 3\text{ A}$; $V_{CE} = 3\text{ V}$; typical values.

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

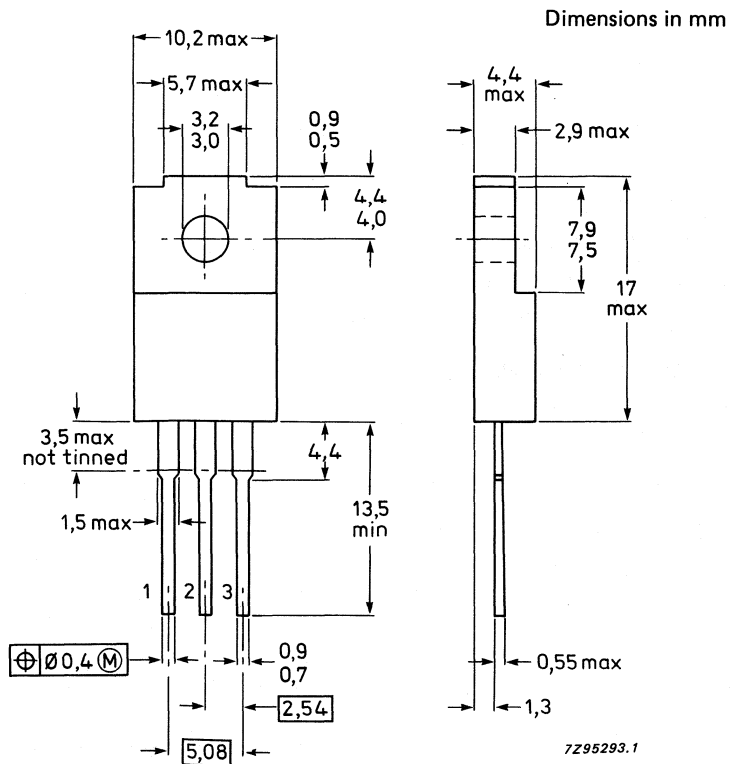
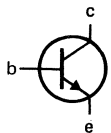
		BD643F	645F	647F	649F	651F
Collector-base voltage (open emitter)	V_{CBO} max.	60	80	100	120	140 V
Collector-emitter voltage (open base)	V_{CEO} max.	45	60	80	100	120 V
Collector current (DC)	I_C max.	8			A	
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot} max.	20			W	
Junction temperature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

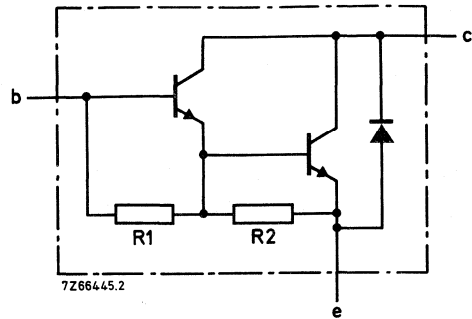
MECHANICAL DATA

Fig. 1 SOT186.

Pinning

- 1 = emitter
- 2 = collector
- 3 = base





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) (peak value)	I_C max.			8		A
	I_{CM} max.			12		A
Base current (DC)	I_B max.			150		mA
Total power dissipation at $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot} max.			20		W
at $T_h \leq 25^\circ\text{C}$ (note 2)	P_{tot} max.			32		W
Storage temperature range	T_{stg}		-65 to +150			$^\circ\text{C}$
Junction temperature	T_j max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Collector cut-off currents

 $I_E = 0; V_{CB} = V_{CE0max}$ I_{CBO} max. 0.1 mA $I_E = 0; V_{CB} = 1/2 V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$ I_{CBO} max. 1 mA $I_B = 0; V_{CE} = 1/2 V_{CE0max}$ I_{CEO} max. 0.2 mA

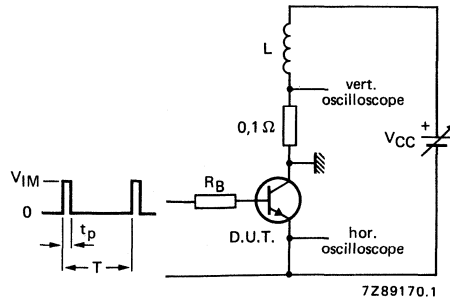
Emitter cut-off current

 $V_{BE} = 5\text{ V}; I_C = 0$ I_{EBO} max. 5 mA

			BD643F	645F	647F	649F	651F
Static forward current transfer ratio (note 1)							
$I_C = 0.5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	1900	1900	1900	1900	1900
$I_C = 4\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	min.	750	—	—	—	—
$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	min.	—	750	750	750	750
$I_C = 8\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	1800	1800	1800	1800	1800
Collector-emitter saturation voltage (note 1)							
$I_C = 4\text{ A}; I_B = 16\text{ mA}$	V_{CEsat}	max.	2	—	—	—	— V
$I_C = 3\text{ A}; I_B = 12\text{ mA}$	V_{CEsat}	max.	—	2	2	2	2 V
$I_C = 5\text{ A}; I_B = 50\text{ mA}$	V_{CEsat}	max.	2.5	2.5	2.5	2.5	2.5 V
Base-emitter saturation voltage (note 1)							
$I_C = 5\text{ A}; I_B = 50\text{ mA}$	V_{BEsat}	max.	3	3	3	3	3 V
Base-emitter voltage (note 1)							
$I_C = 4\text{ A}; V_{CE} = 3\text{ V}$	V_{BE}	max.	2.5	—	—	—	— V
$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$	V_{BE}	max.	—	2.5	2.5	2.5	2.5 V
Common-emitter cut-off frequency							
$I_C = 4\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe}	typ.	50	—	—	—	— kHz
$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe}	typ.	—	50	50	50	50 kHz
Small signal current gain							
$I_C = 4\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$	h_{fe}	typ.	10	—	—	—	—
$I_C = 3\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$	h_{fe}	typ.	—	10	10	10	10
Forward bias second breakdown collector current							
$V_{CE} = 50\text{ V}; t_p = 0.1\text{ s}$	$I_{(SB)}$	min.			0.55		A
Forward voltage							
$I_F = 3\text{ A}$	V_F	typ.			0.9		V
Switching times							
$I_C = 3\text{ A}; I_{B\text{ on}} = I_{B\text{ off}} = 12\text{ mA}$							
Turn on time	t_{on}	max.			2		μs
		typ.			1		μs
Turn off time	t_{off}	max.			10		μs
		typ.			5		μs

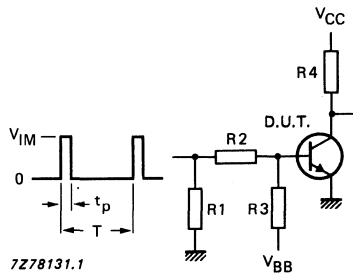
Note

1. To be measured under pulsed conditions, $t_p < 300\text{ }\mu\text{s}$; $\delta < 2\%$.



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

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



$V_{IM} = 10 \text{ V}$
 $V_{CC} = 10 \text{ V}$
 $-V_{BB} = 4 \text{ V}$
 $R_1 = 56 \Omega$
 $R_2 = 410 \Omega$
 $R_3 = 560 \Omega$
 $R_4 = 3 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.

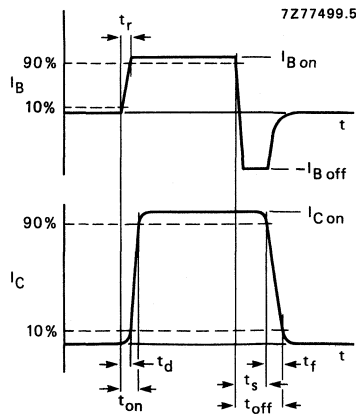
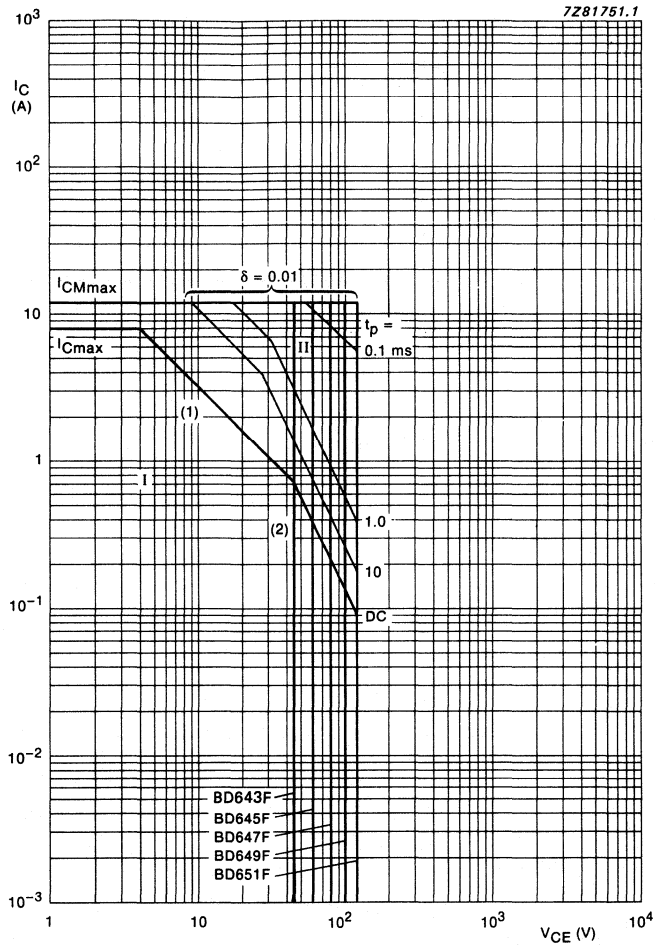


Fig. 5 Switching times waveforms.



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

- (1) $P_{tot \text{ max}}$ 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; $T_{amb} = 25 \text{ }^\circ\text{C}$.

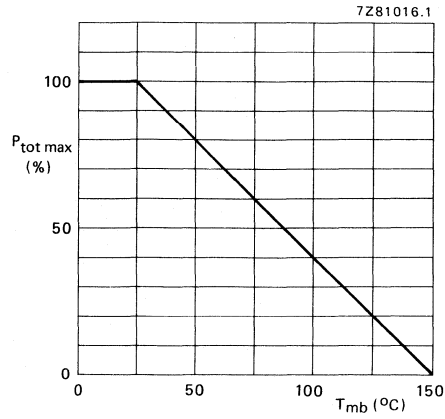


Fig. 7 Power derating curve.

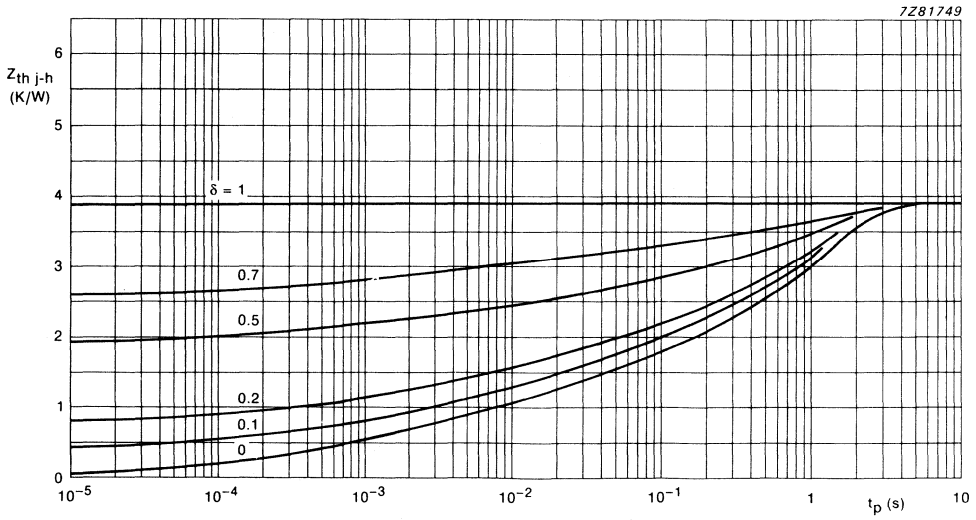


Fig. 8 Pulse power rating chart.

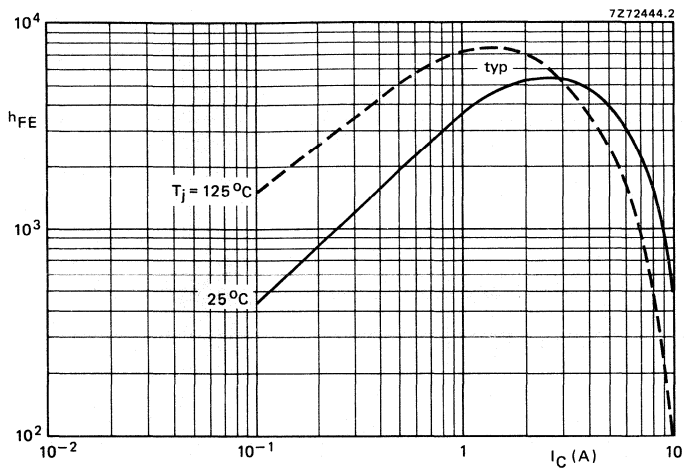


Fig. 9 Typical DC current gain curves; V_{CE} = 3 V.

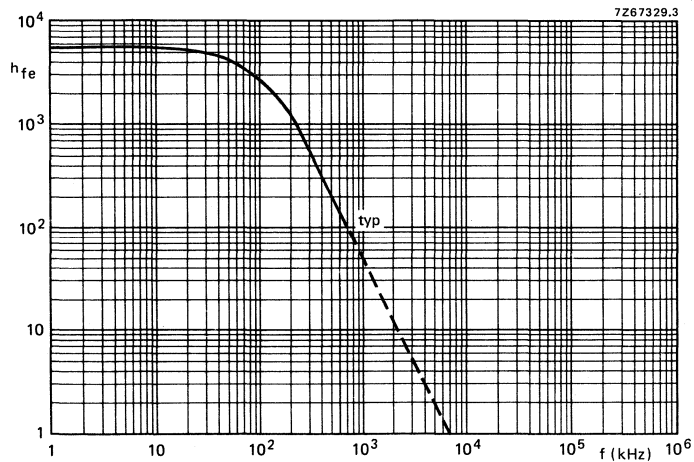


Fig. 10 Small signal current gain.

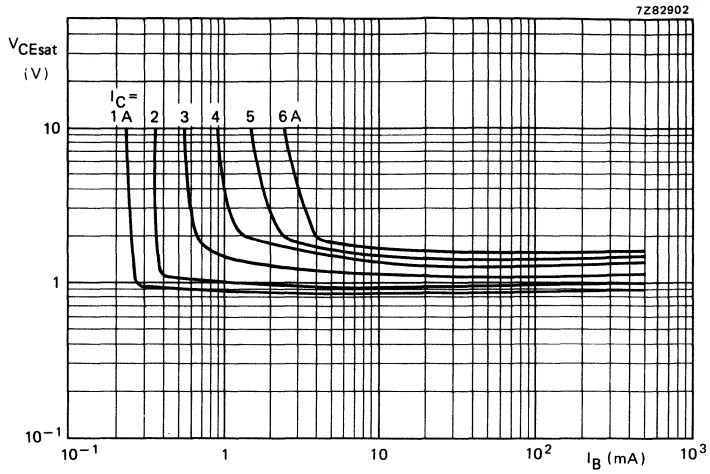


Fig. 11 Typical collector-emitter saturation voltage; $T_j = 25^\circ\text{C}$.

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 BD644, BD646, BD648, BD650 and BD652.

QUICK REFERENCE DATA

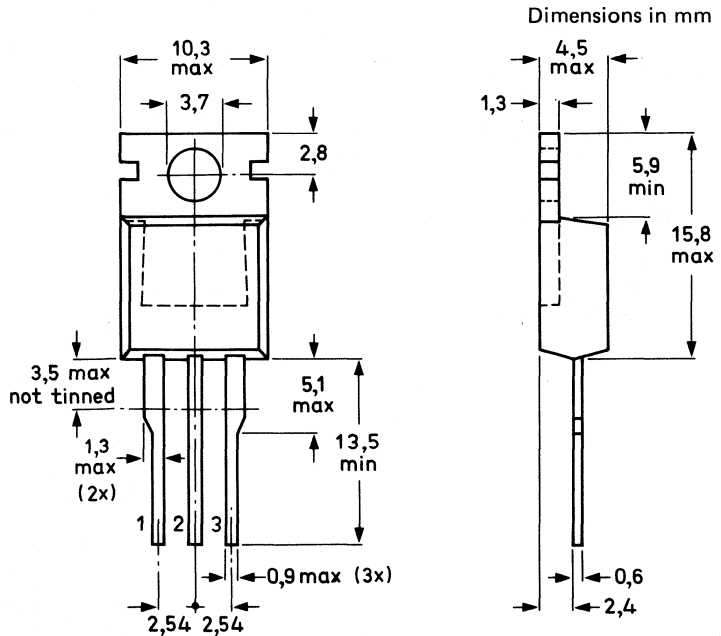
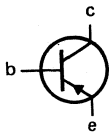
		BD644	646	648	650	652
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	45	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	45	60	80	100	120 V
Collector current (DC)	$-I_C$ max.			8		A
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	P_{tot} max.			62.5		W
Junction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

MECHANICAL DATA

Fig. 1 TO-220AB

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



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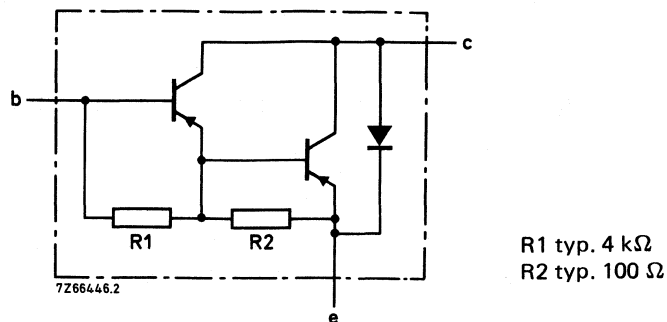


Fig. 2 Circuit diagram.

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 $T_{amb} = 25^\circ\text{C}$	P_{tot}	max.			62.5		W
Storage temperature range	T_{stg}			-55 to +150			$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE *

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

 $T_j = 25^\circ\text{C}$ 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. $T_j = 150^\circ\text{C}$	$-I_{CBO}$	max.	1			mA
$-I_E = 0; -V_{CE} = -1/2 V_{CEO}$ max.	$-I_{CEO}$	max.	0.2			mA
Emitter cut-off current						
$-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	max.	5			mA

			BD644	646	648	650	652
DC current gain (see note 1)							
$-I_C = 0.5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	2700	2700	2700	2700	2700
$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	min.	750	—	—	—	—
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	min.	—	750	750	750	750
$-I_C = 8\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	2000	2000	2000	2000	2000
Base-emitter voltage (see notes 1 and 2)							
$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$	$-V_{BE}$	max.	2.5	—	—	—	— V
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	$-V_{BE}$	max.	—	2.5	2.5	2.5	2.5 V
Saturation voltages (see note 1)							
$-I_C = 4\text{ A}; -I_B = 16\text{ mA}$	$-V_{CEsat}$	max.	2	—	—	—	— V
$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$	$-V_{CEsat}$	max.	—	2	2	2	2 V
$-I_C = 5\text{ A}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	max.	2.5	2.5	2.5	2.5	2.5 V
$-I_C = 5\text{ A}; -I_B = 50\text{ mA}$	$-V_{BEsat}$	max.	3	3	3	3	3 V
Small signal current gain; $f = 1\text{ MHz}$							
$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$	h_{fe}	min.	10	—	—	—	—
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{fe}	min.	—	10	10	10	10
Cut-off frequency							
$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	typ.	100	—	—	—	— kHz
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	typ.	—	100	100	100	100 kHz
Second-breakdown collector current $t_p = 0.1\text{ s}$; non-repetitive; without heatsink							
$-V_{CE} = 50\text{ V}$	$-I_{(SB)}$	min.	1.25	—	—	—	— A
$-V_{CE} = 60\text{ V}$	$-I_{(SB)}$	min.	—	1.04	1.04	1.04	1.04 A
DC current gain ratio of matched pairs at $-V_{CE} = 3\text{ V}$							
$-I_C = 4\text{ A BD644/BD643}$	h_{FE1}/h_{FE2}	max.	2.5	—	—	—	—
$-I_C = 3\text{ A BD652/BD651}$	h_{FE1}/h_{FE2}	max.	—	2.5	2.5	2.5	2.5
Diode forward voltage; $-I_F = 3\text{ A}$	$-V_F$	typ.	1.6			V	
Collector capacitance at $f = 1\text{ MHz}$ $-V_{CB} = 10\text{ V}$	C_C	typ.	75			pF	

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

Switching times (see Figs 3 and 4)

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

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

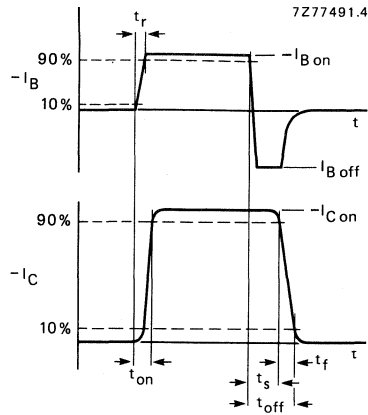


Fig. 3 Switching times waveforms.

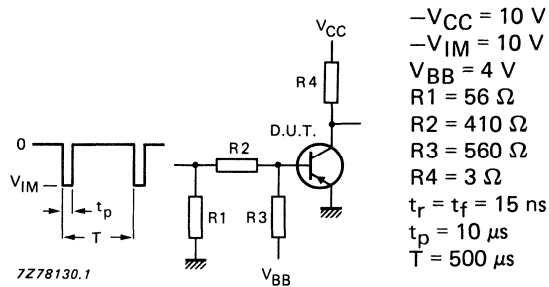


Fig. 4 Switching times test circuit.

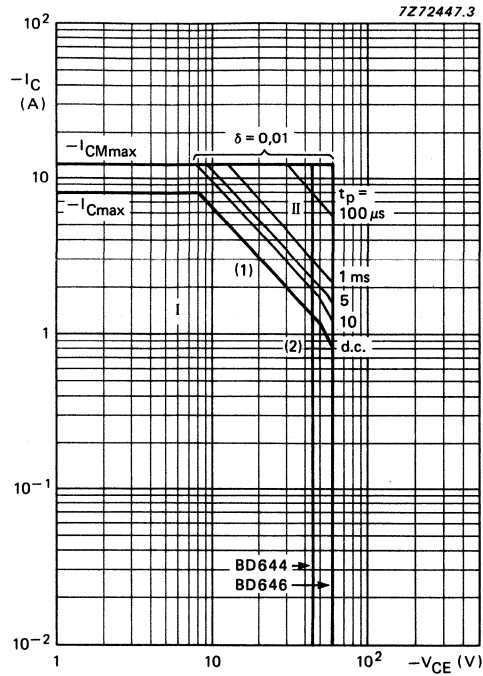


Fig. 5 **BD644; BD646** Safe Operating Area, $T_{mb} = 25^\circ C$.

- 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.

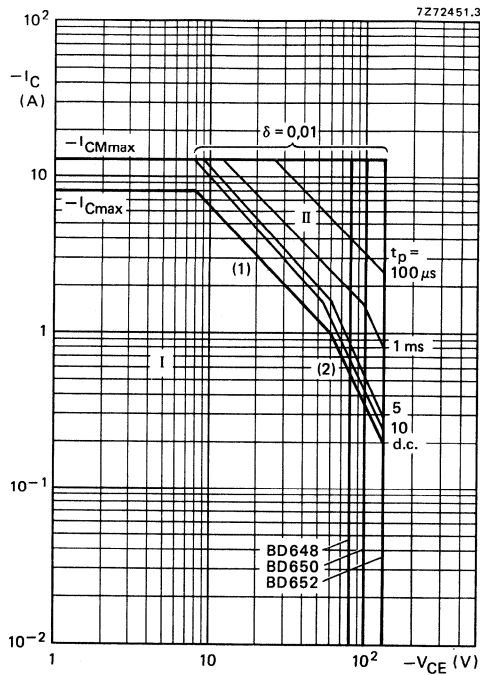


Fig. 6 **BD648, BD650, BD652** Safe Operating Area, $T_{mb} = 25^\circ C$.

- 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.

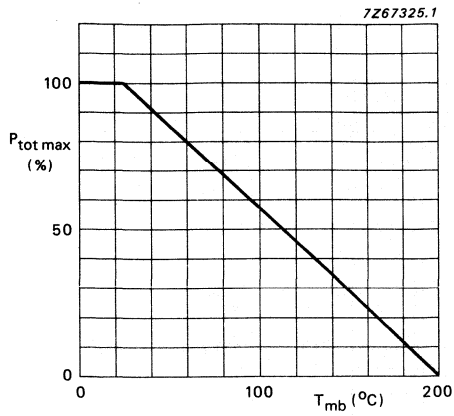


Fig. 7 Power derating curve.

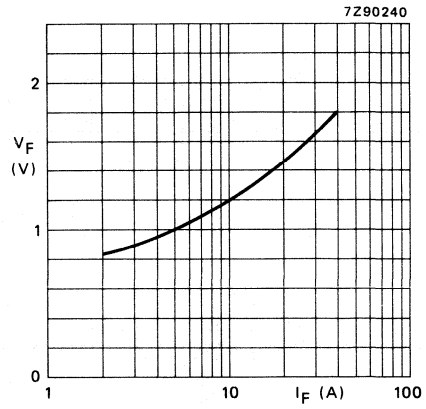


Fig. 8 Diode forward voltage versus forward current;
 $T_j = 25^\circ\text{C}$; typical values.

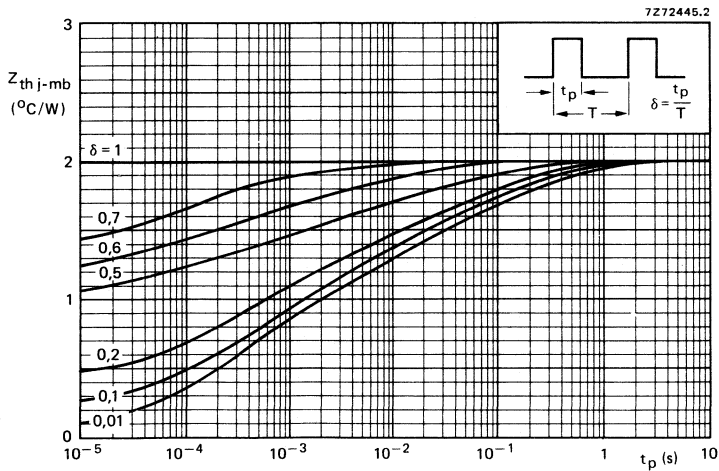


Fig. 9 Pulse power rating chart.

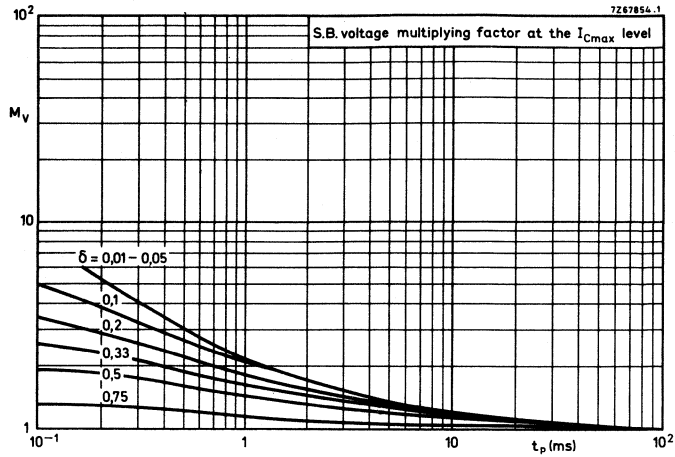


Fig. 10 Second breakdown voltage multiplying factor at the I_{Cmax} level.

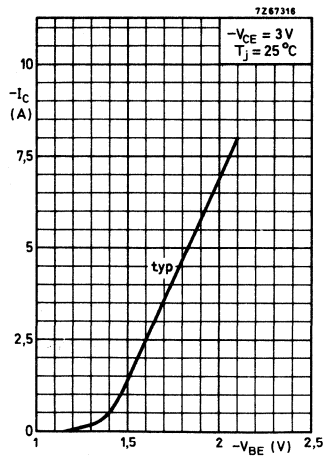


Fig. 11 Collector current versus base-emitter voltage; $-V_{CE} = 3V$; $T_j = 25^\circ C$; typical value.

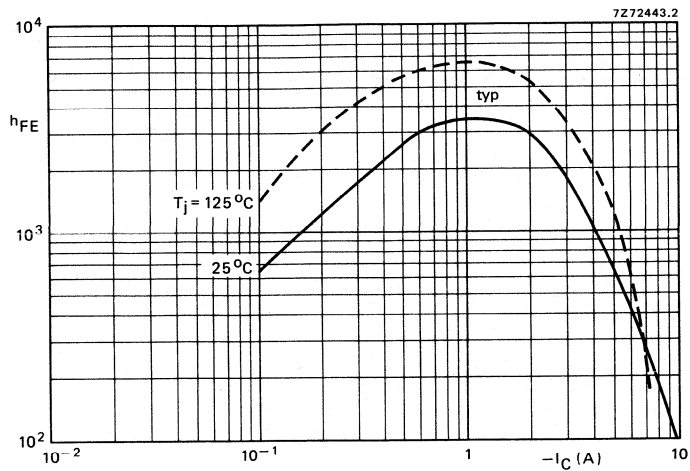


Fig. 12 DC current gain; $-V_{CE} = 3\text{ V}$; typical values.

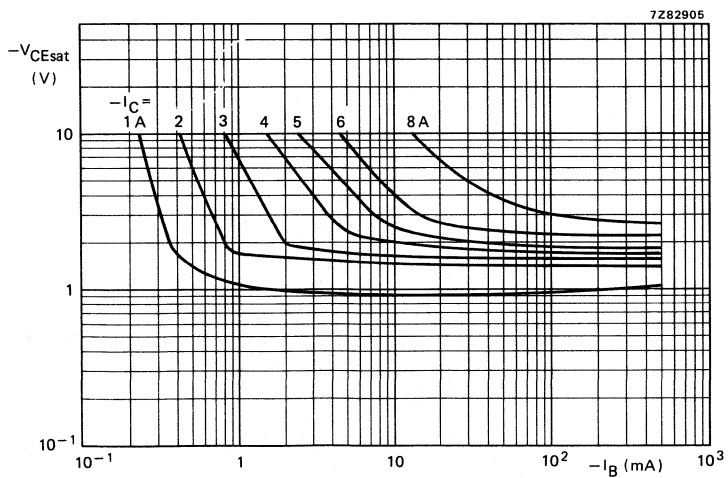


Fig. 13 Collector-emitter saturation voltage; T_j = 25 °C; typical values.

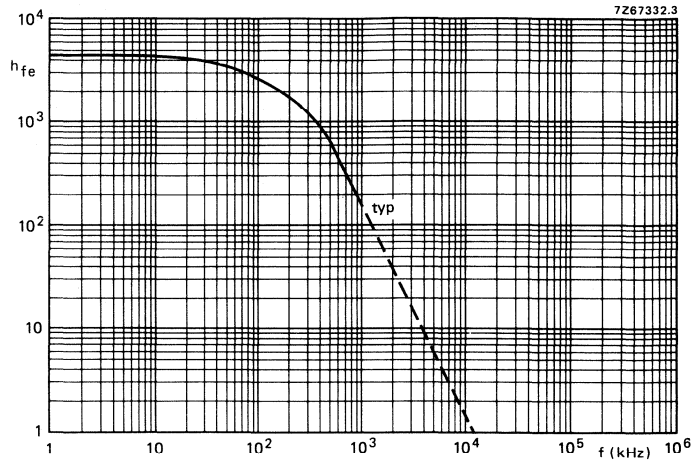


Fig. 14 Small signal current gain; $-I_C = 3$ A; $-V_{CE} = 3$ V; typical values.

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 $T_h \leq 25^\circ\text{C}$	P_{tot}	max.	20				W
Junction temperature	T_j	max.	150				$^\circ\text{C}$

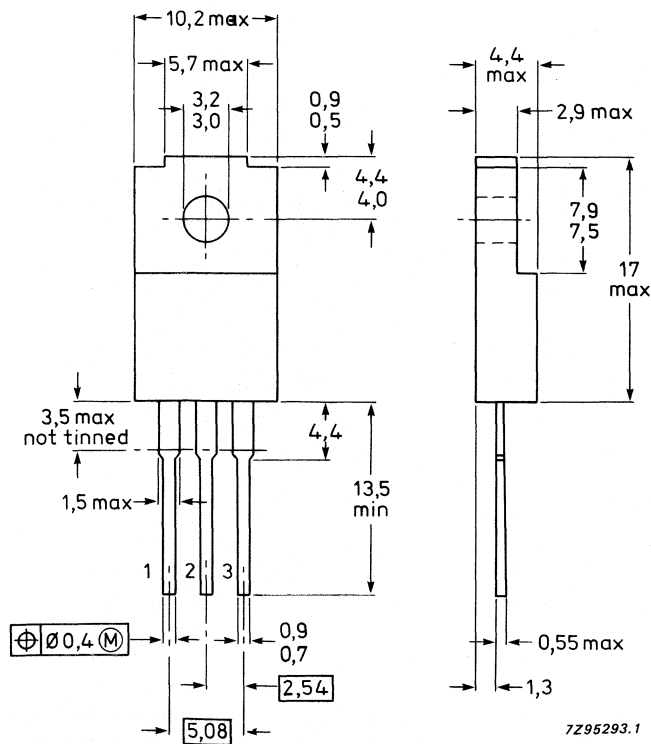
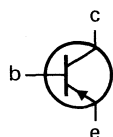
MECHANICAL DATA

Dimensions in mm

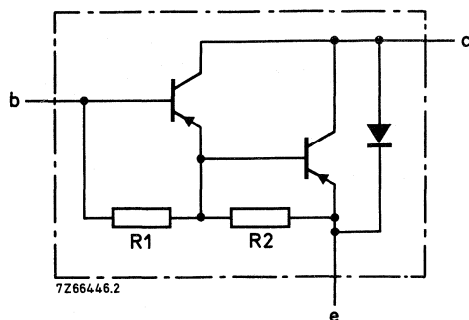
Fig. 1 SOT186.

Pinning

- 1 = emitter
- 2 = collector
- 3 = base



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R1 typ. 4 k Ω
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) (peak value)	$-I_C$ max.			8		A
	$-I_{CM}$ max.			12		A
Base current (DC)	$-I_B$ max.			150		mA
Total power dissipation at $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot} max.			20		W
	P_{tot} max.			32		W
Storage temperature range	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Emitter cut-off current

 $V_{EB} = 5\text{ V}; I_C = 0$ $-I_{EBO}$ 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
$-V_{CB} = 30\text{ V}$	$-I_{CBO}$	max.	1	—	—	—	— mA
$-V_{CB} = 40\text{ V}$	$-I_{CBO}$	max.	—	1	—	—	— mA
$-V_{CB} = 50\text{ V}$	$-I_{CBO}$	max.	—	—	1	—	— mA
$-V_{CB} = 60\text{ V}$	$-I_{CBO}$	max.	—	—	—	1	— mA
$-V_{CB} = 70\text{ V}$	$-I_{CBO}$	max.	—	—	—	—	1 mA

$I_E = 0; T_j = 150^\circ\text{C}$

Collector-emitter leakage current

 $-V_{CE} = 25\text{ V}; I_B = 0$ $-I_{CEO}$ max. 0.5 mA $-V_{CE} = 30\text{ V}; I_B = 0$ $-I_{CEO}$ max. — 0.5 mA $-V_{CE} = 40\text{ V}; I_B = 0$ $-I_{CEO}$ max. — — 0.5 mA $-V_{CE} = 50\text{ V}; I_B = 0$ $-I_{CEO}$ max. — — — 0.5 mA $-V_{CE} = 60\text{ V}; I_B = 0$ $-I_{CEO}$ max. — — — 0.5 mA

Static forward current transfer ratio (note 1)

 $-I_C = 0.5\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 2700 2700 2700 2700 2700 $-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} min. 750 — — — — $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} min. — 750 750 750 750 $-I_C = 8\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 2000 2000 2000 2000 2000

Collector-emitter saturation voltage (note 1)

 $-I_C = 4\text{ A}; -I_B = 16\text{ mA}$ $-V_{CEsat}$ max. 2 — — — — V $-I_C = 3\text{ A}; -I_B = 12\text{ mA}$ $-V_{CEsat}$ max. — 2 2 2 2 V $-I_C = 5\text{ A}; -I_B = 50\text{ mA}$ $-V_{CEsat}$ max. 2.5 2.5 2.5 2.5 2.5 V

Base-emitter saturation voltage (note 1)

 $-I_C = 5\text{ A}; -I_B = 50\text{ mA}$ $-V_{BEsat}$ max. 3 3 3 3 3 V

Base-emitter voltage (note 1)

 $-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$ $-V_{BE}$ max. 2.5 — — — — V $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ $-V_{BE}$ max. — 2.5 2.5 2.5 2.5 V

Common-emitter cut-off frequency

 $-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$ f_{hfe} typ. 100 — — — — kHz $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$ f_{hfe} typ. — 100 100 100 100 kHz

Small signal current gain

 $-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ h_{fe} typ. 150 — — — — $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ h_{fe} typ. — 150 150 150 150

Forward bias second breakdown

collector current

 $-V_{CE} = 50\text{ V}; t_p = 0.1\text{ s}$ $-I_{(SB)}$ min. 0.55 A

Forward voltage

 $I_F = 3\text{ A}$ 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

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

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

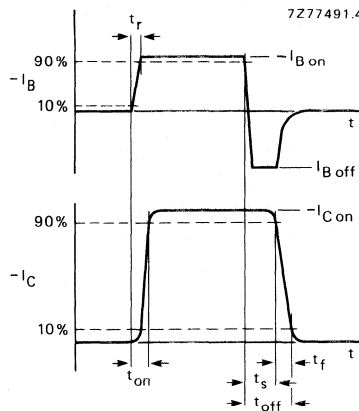


Fig. 3 Switching times waveforms.

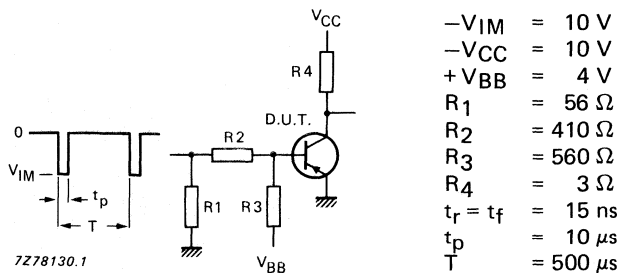
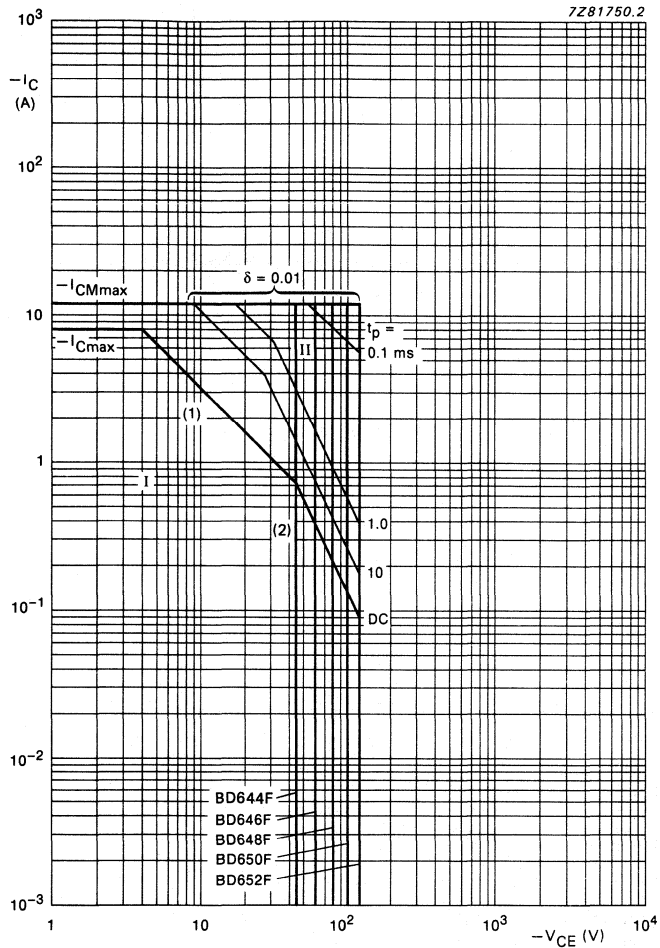


Fig. 4 Switching times test circuit.



- I Region of permissible DC operation.
- II Permissible extension for repetitive pulse operation.
- (1) $P_{tot \text{ max}}$ 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; $T_{amb} = 25 \text{ }^\circ\text{C}$.

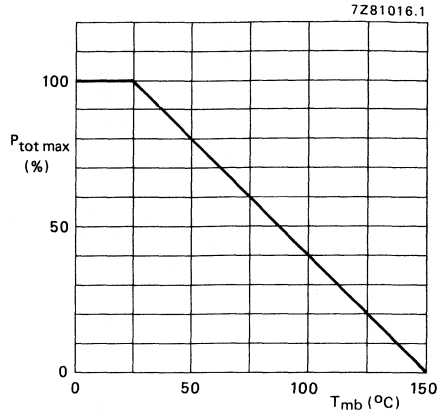


Fig. 6 Power derating curve.

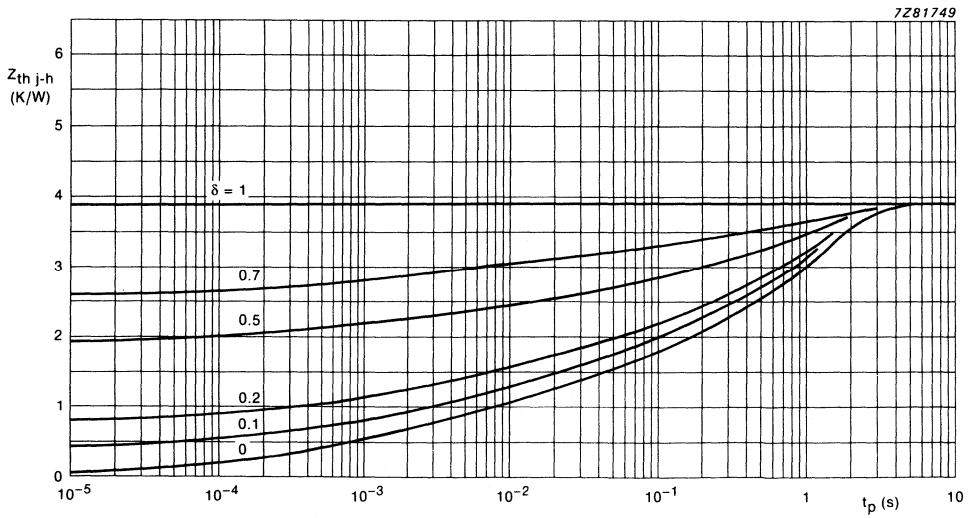


Fig. 7 Pulse power rating chart.

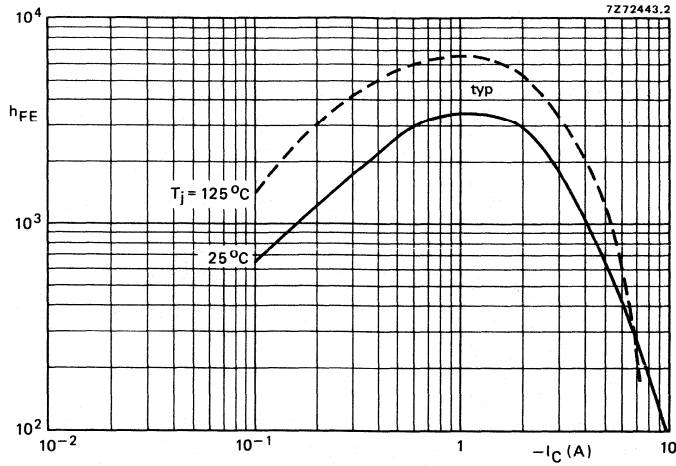


Fig. 8 Typical DC current gain curves, $-V_{CE} = 3$ V.

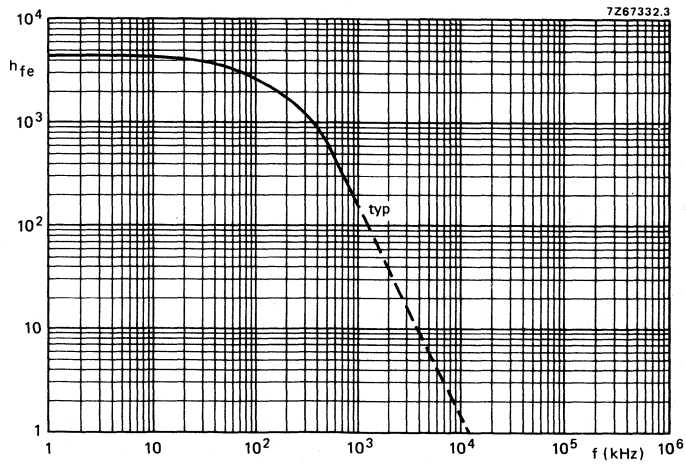


Fig. 9 Small signal current gain.

BD644F; 646F;
BD648F; 650F;
BD652F

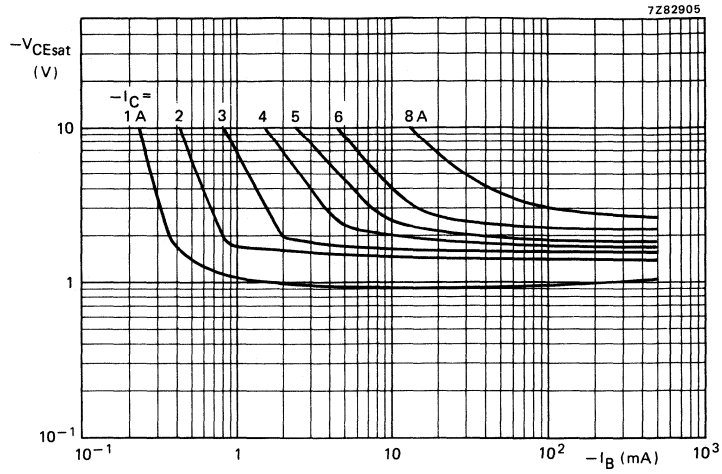


Fig. 10 Typical collector-emitter saturation voltage; $T_j = 25^\circ\text{C}$.

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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	40			W	
Junction temperature	T_j	max.	150			$^\circ\text{C}$	
D.C. current gain			2200				
$I_C = 0,5 \text{ A}; V_{CE} = 3 \text{ V}$	h_{FE}	typ.	750				
$I_C = 1,5 \text{ A}; V_{CE} = 3 \text{ V}$	h_{FE}	>					
Cut-off frequency			60			kHz	
$I_C = 1,5 \text{ A}; V_{CE} = 3 \text{ V}$	f_{hfe}	typ.					

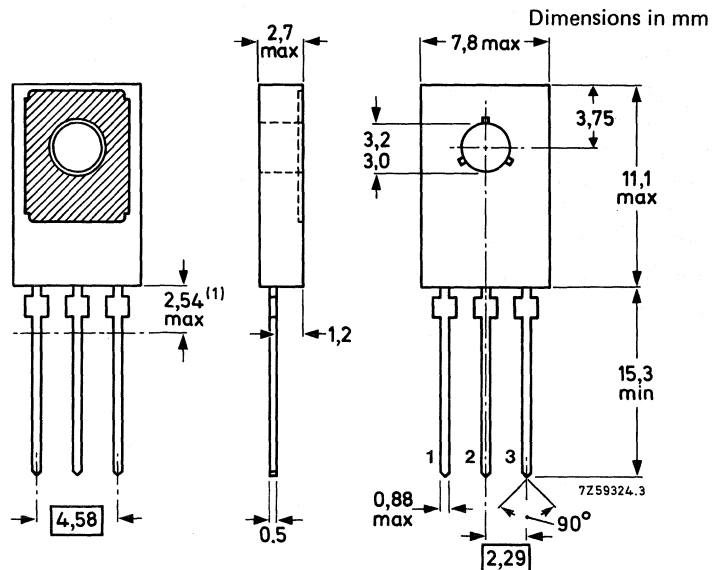
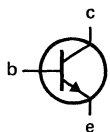
MECHANICAL DATA

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

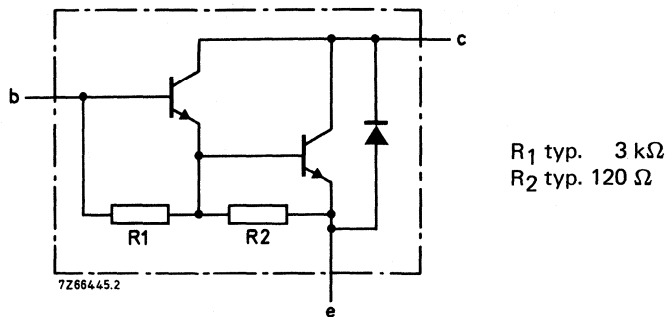


Fig. 2 Darlington circuit diagram.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			40			W
Storage temperature	T_{stg}				-65 to +150			$^\circ\text{C}$
Junction temperature	T_j	max.			150			$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_j = 25\text{ }^\circ\text{C}$, unless otherwise specified; where $I_C = 1,5\text{ A}$ for BD675 read $I_C = 2\text{ A}$.

Collector cut-off current

$I_E = 0; V_{CB} = V_{CE0max}$	I_{CBO}	<	0,2 mA	
$I_E = 0; V_{CB} = \frac{1}{2} V_{CB0max}; T_{mb} = 150\text{ }^\circ\text{C}$	I_{CBO}	<	1 mA	←
$I_B = 0; V_{CE} = \frac{1}{2} V_{CE0max}$	I_{CEO}	<	0,2 mA	←

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	5 mA
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D.C. current gain (note 1)

$I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	2200
$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	>	750
$I_C = 4\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	1500

Base-emitter voltage (notes 1 and 2)

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$ (BD675; $I_C = 2\text{ A}$)	V_{BE}	<	2,5 V
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Collector-emitter saturation voltage (note 1)

$I_C = 1,5\text{ A}; I_B = 6\text{ mA}$ (BD675; $I_C = 2\text{ A}$)	V_{CEsat}	<	2,5 V
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Small signal current gain

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$ (BD675; $I_C = 2\text{ A}$)	h_{fe}	>	10
--	----------	---	----

Cut-off frequency

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$ (BD675; $I_C = 2\text{ A}$)	f_{hfe}	typ.	60 kHz
--	-----------	------	--------

Turn-off breakdown energy with inductive load

$-I_{Boff} = 0; I_C = 3,5\text{ A}$; (Fig. 3)	$E(BR)$	>	30 mJ
--	---------	---	-------

D.C. current gain ratio of matched complementary pairs

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE1}/h_{FE2}	<	2,5
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Diode forward voltage

$I_F = 1,5\text{ A}$ (BD675; $I_F = 2\text{ A}$)	V_F	typ.	1,5 V
---	-------	------	-------

Second-breakdown collector current

$V_{CE} = 50\text{ V}; t_p = 20\text{ ms}$, non rep.; without heatsink	$I_{(SB)}$	>	0,8 A
BD675; $V_{CE} = 40\text{ V}; t_p = \text{ms}$	$I_{(SB)}$	>	1 A

Switching times

(between 10% and 90% levels)

$I_{Con} = 1,5\text{ A}; I_{Bon} = -I_{Boff} = 6\text{ mA}; V_{CC} = 30\text{ V}$

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: $t_p < 300\text{ } \mu\text{s}$; $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/K with increasing temperature.

CHARACTERISTICS (continued)

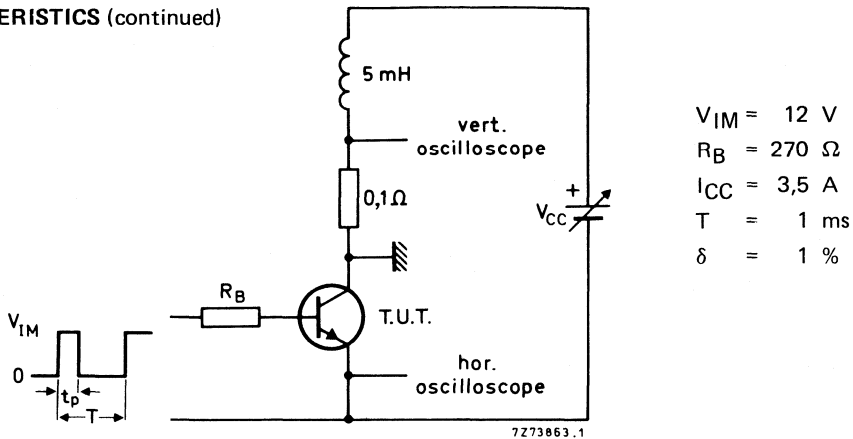


Fig. 3 Test circuit for turn-off breakdown energy.

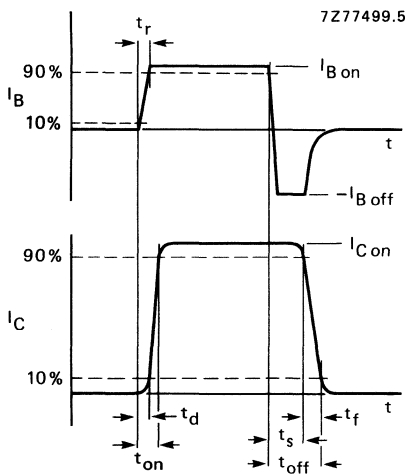


Fig. 4 Switching times waveforms.

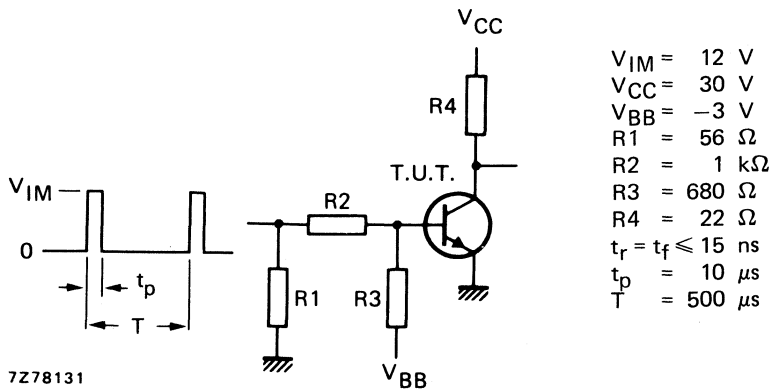


Fig. 5 Switching times test circuit.

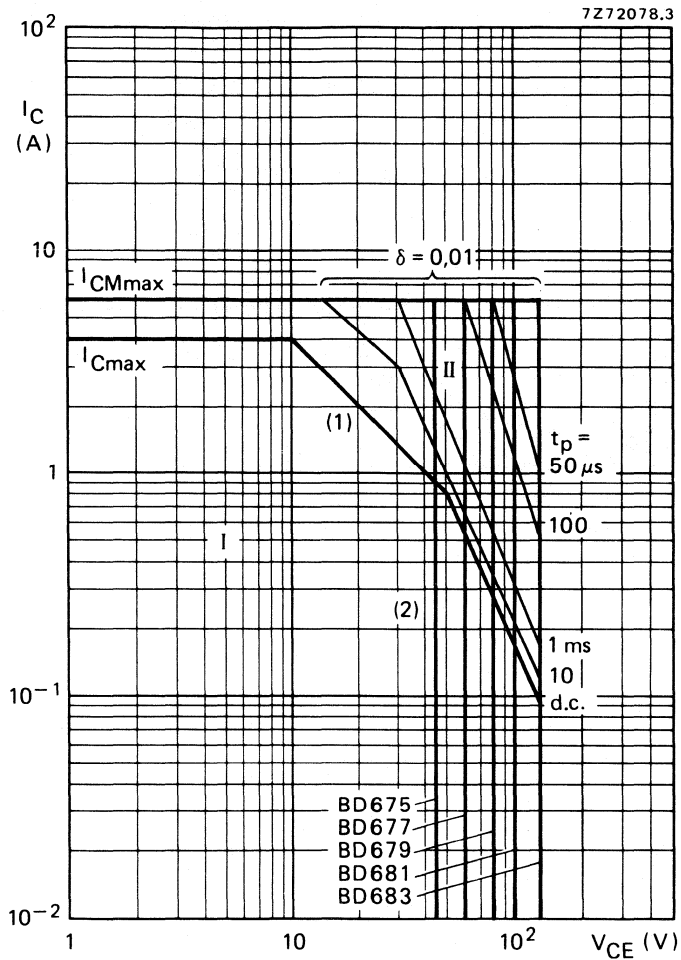


Fig. 6 Safe Operating Area. $T_{mb} = 25\text{ }^\circ\text{C}$.

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

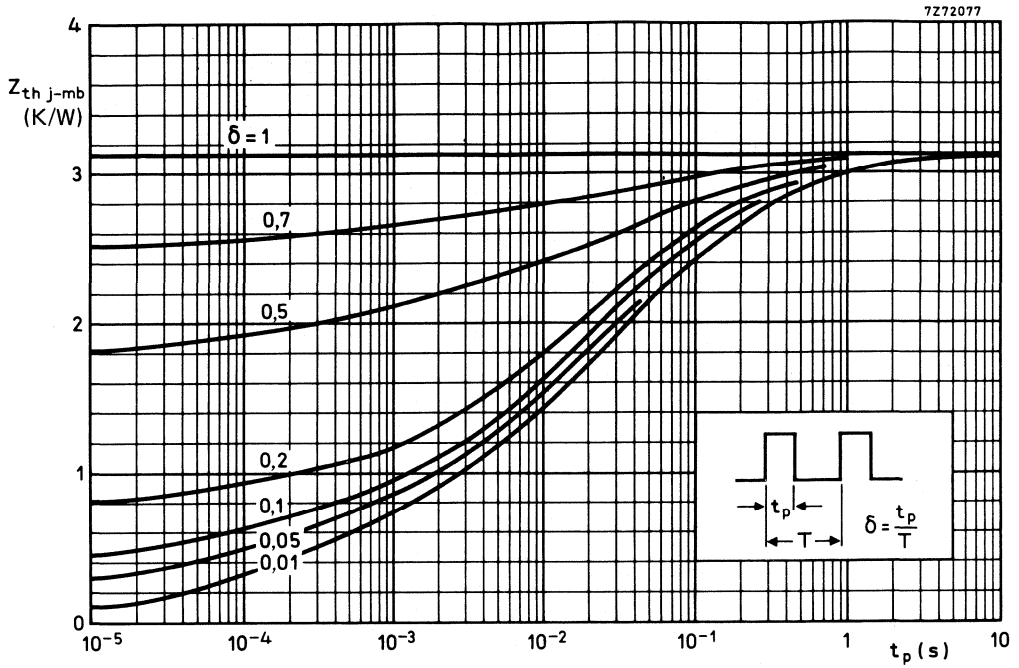


Fig. 7 Pulse power rating chart.

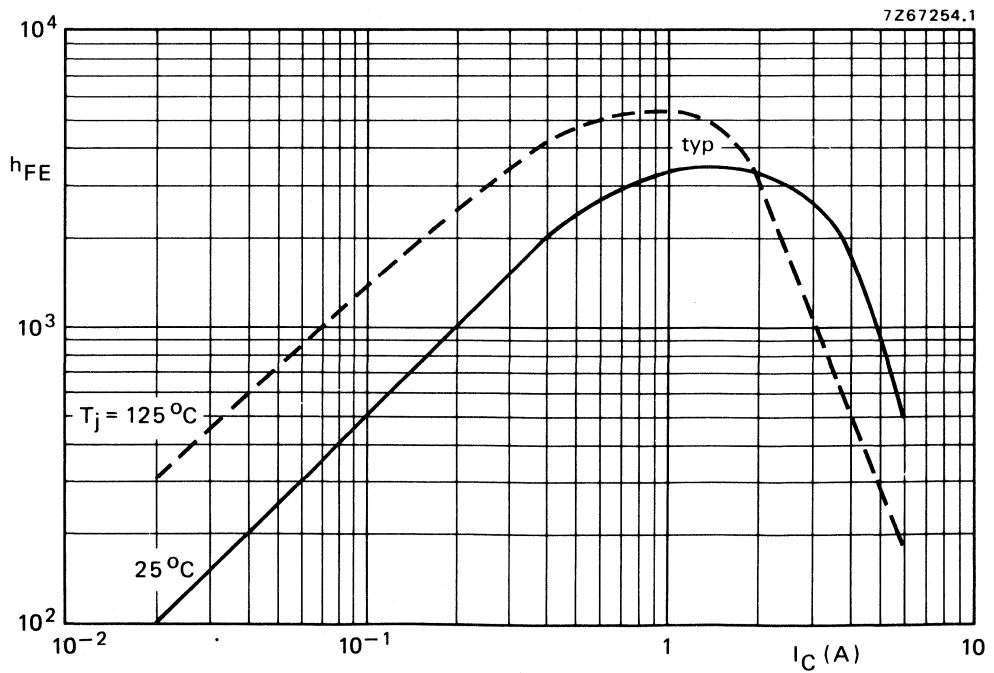


Fig. 8 D.C. current gain at $V_{CE} = 3$ V.

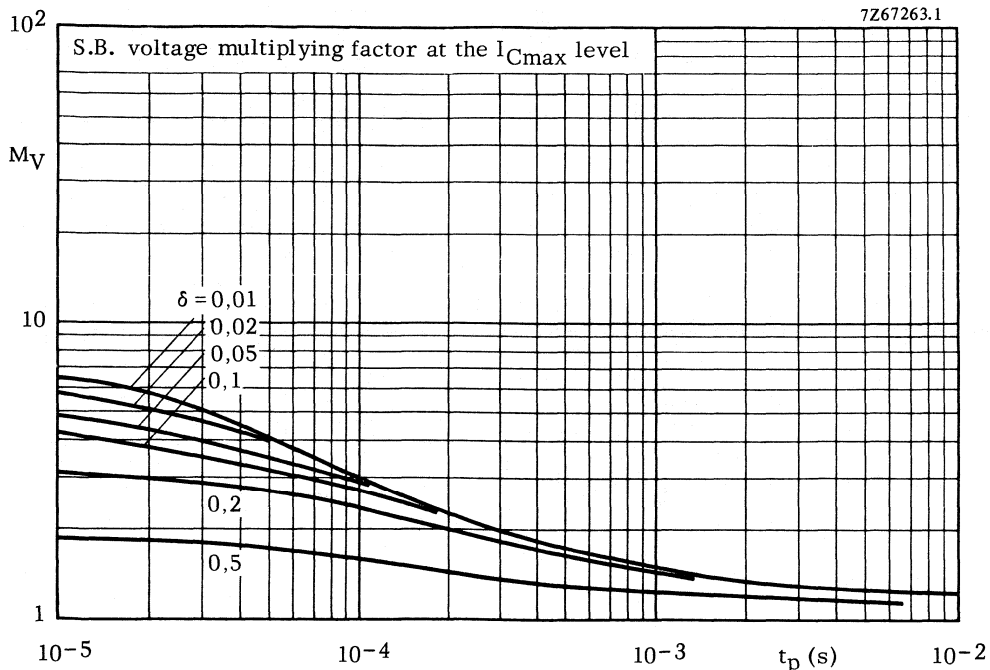


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

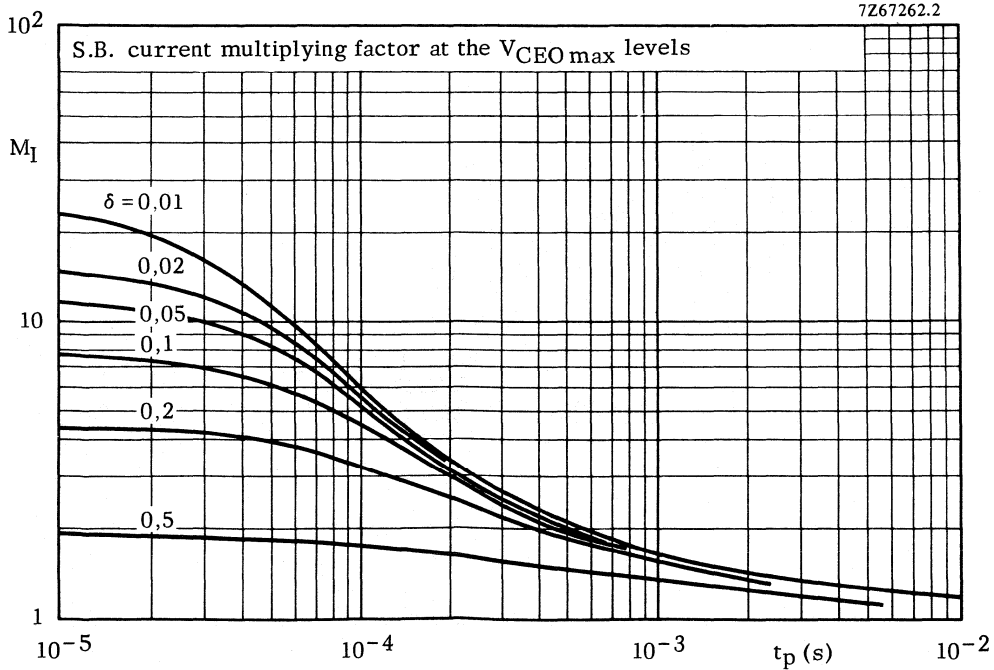


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} levels.

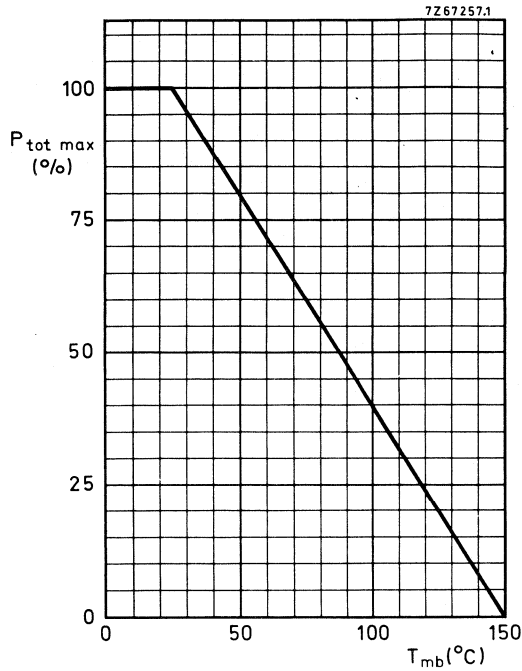


Fig. 11 Power derating curve.

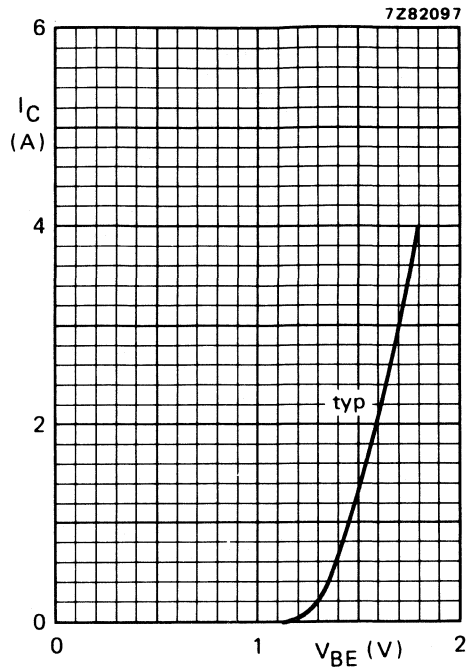


Fig. 12 Typical collector current.

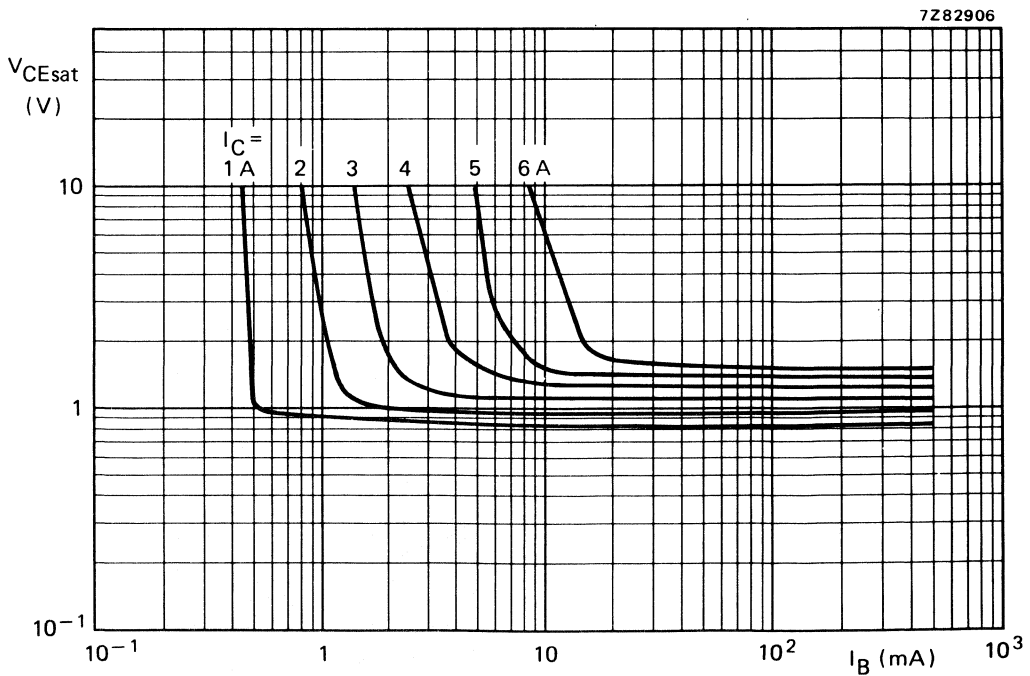


Fig. 13 Typical values collector-emitter saturation voltage. $T_{mb} = 25^\circ C$.

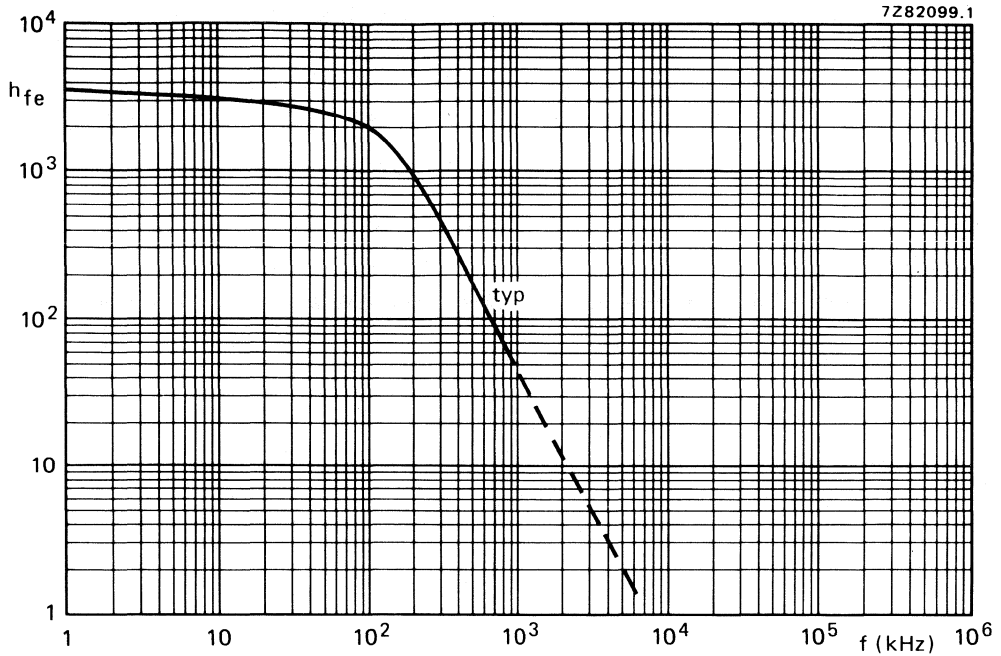


Fig. 14 Small signal current gain. $I_C = 1,5 \text{ A}$; $V_{CE} = 3 \text{ V}$.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			40	W	
Junction temperature	T_j max.			150	$^\circ\text{C}$	
D.C. current gain				2200		
$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} typ.			750		
$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} >					
Cut-off frequency				60	kHz	
$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe} typ.					

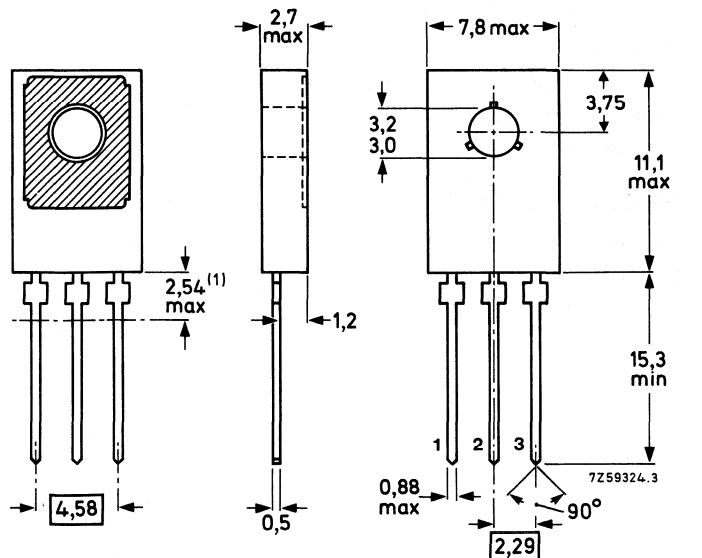
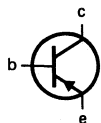
MECHANICAL DATA

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

Collector connected to mounting base.

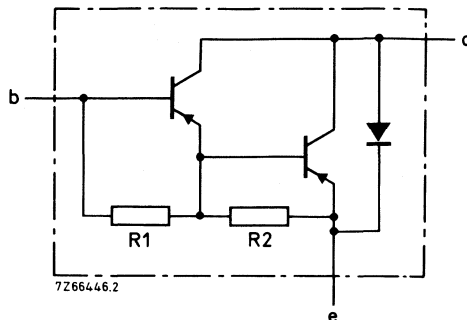
Pinning

- 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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			40	W	
Storage temperature	T_{stg}				-65 to +150	$^\circ\text{C}$	
Junction temperature	T_j	max.			150	$^\circ\text{C}$	

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified; where $-I_C = 1,5\text{ A}$ for BD676 read $-I_C = 2\text{ A}$.

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA	
$I_E = 0; -V_{CB} = -0,6 V_{CBOmax}; T_{mb} = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1 mA	←
$I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEOmax}$	$-I_{CEO}$	<	0,2 mA	←

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	5 mA
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D.C. current gain (note 1)

$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	2200
$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}^*$	h_{FE}	>	750
$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	650

Base-emitter voltage (notes 1 and 2)

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}^*$	$-V_{BE}$	<	2,5 V
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Collector-emitter saturation voltage (note 1)

$-I_C = 1,5\text{ A}; -I_B = 6\text{ mA}^*$	$-V_{CEsat}$	<	2,5 V
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Small-signal current gain

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}^*$	h_{fe}	>	10
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Cut-off frequency

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}^*$	f_{hfe}	typ.	60 kHz
---	-----------	------	--------

D.C. current gain ratio of matched complementary pairs

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE1}/h_{FE2}	<	2,5
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Diode, forward voltage

$I_F = 1,5\text{ A}^*$	V_F	typ.	1,5 V
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Switching times (see Figs 3 and 4)

$-I_{Con} = 1,5\text{ A}; -I_{Bon} = I_{Boff} = 6\text{ mA}$			
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

$-V_{CE} = 50\text{ V}; t_p = 20\text{ ms}$	$-I_{(SB)}$	>	0,8 A
for BD676 $-V_{CE} = 40\text{ V}$	$-I_{(SB)}$	>	1 A

* for BD676 condition $-I_C$ or $-I_F = 2\text{ A}$.

Notes

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

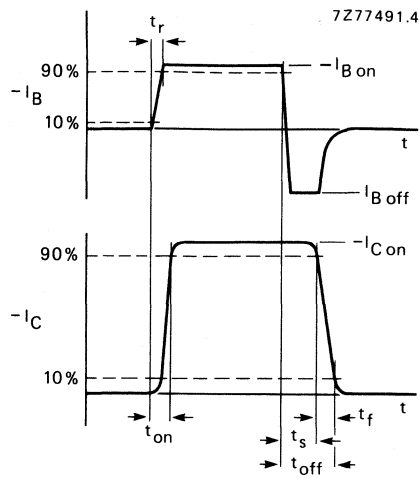


Fig. 3 Switching times waveform.

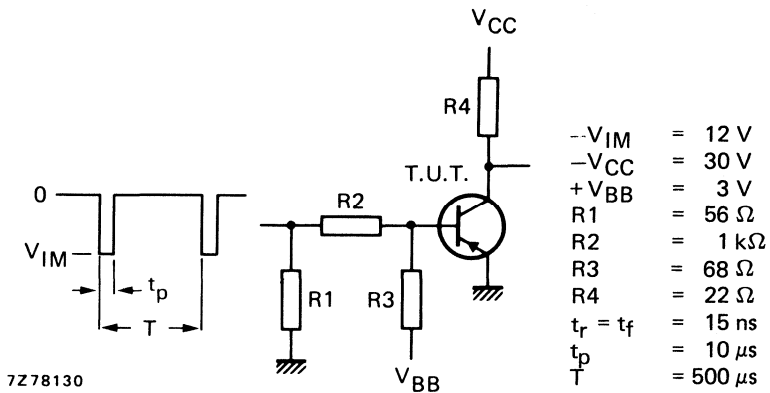


Fig. 4 Switching times test circuits.

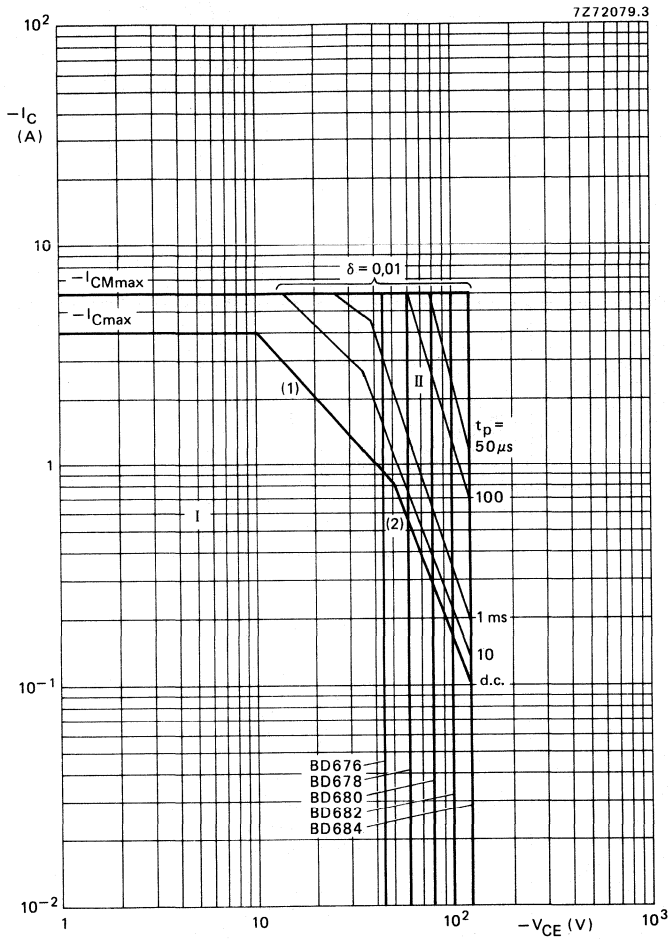


Fig. 5 Safe Operating Area. $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

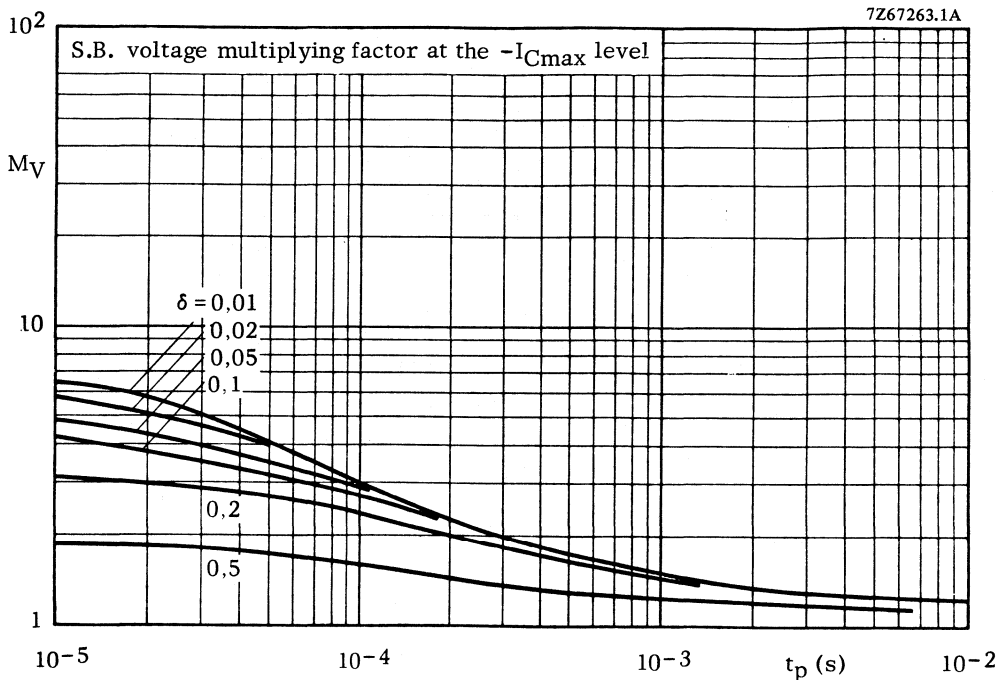


Fig. 6 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

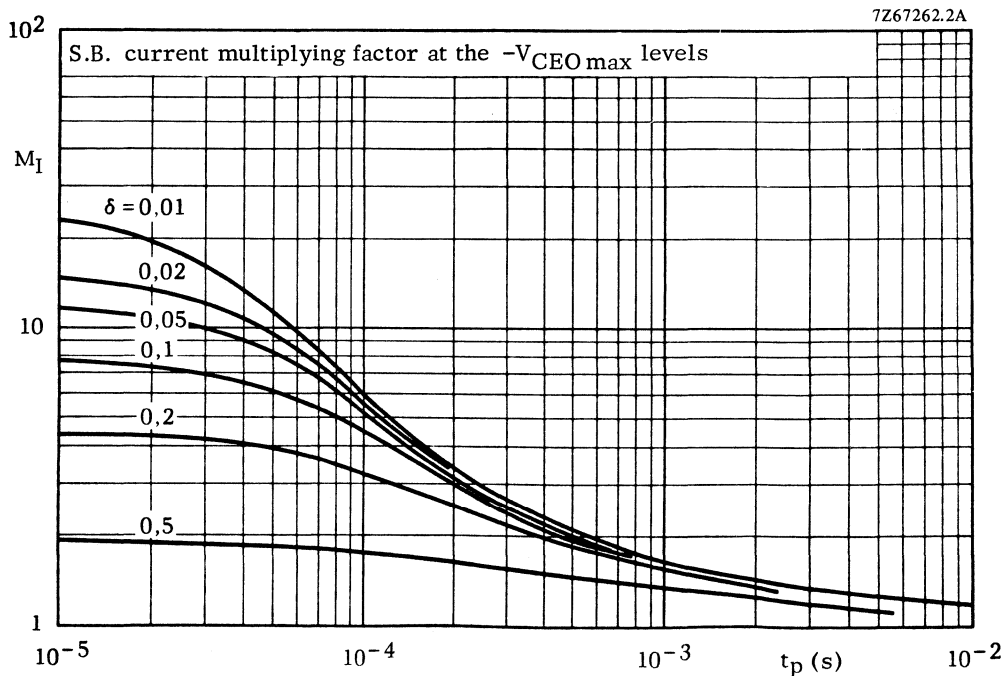


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ levels.

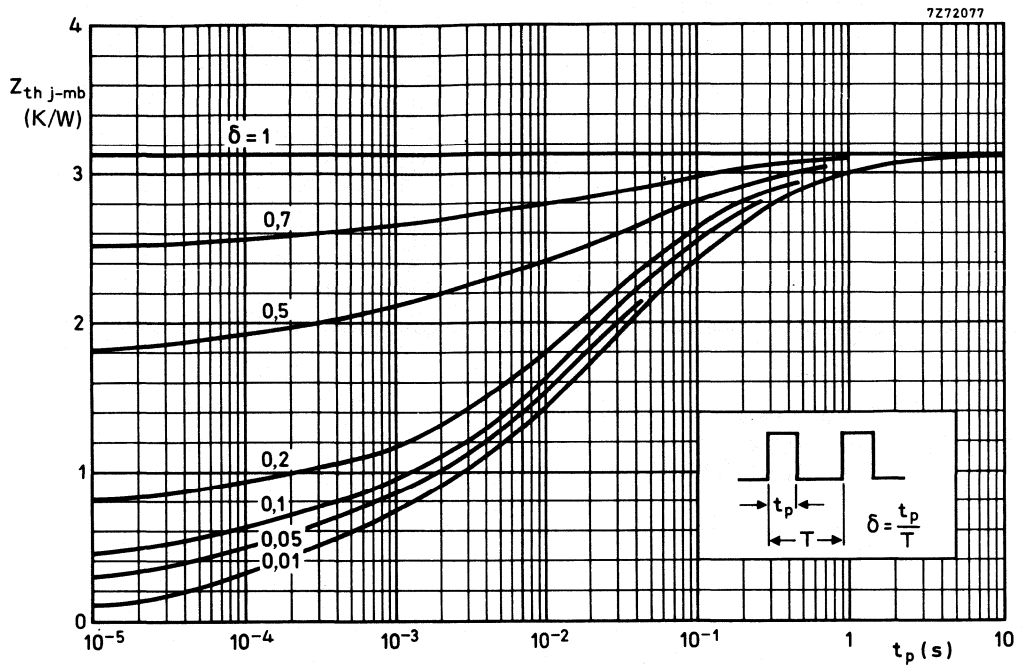


Fig. 8 Pulse power rating chart.

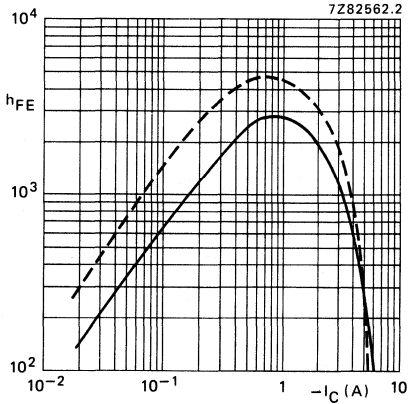


Fig. 9 D.C. current gain. $-V_{CE} = 3$ V;
 ——— $T_j = 25^\circ\text{C}$;
 - - - - $T_j = 125^\circ\text{C}$.

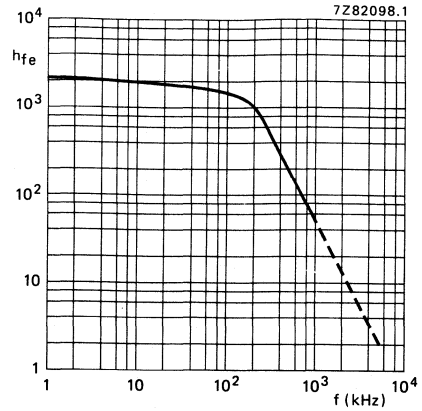


Fig. 10 Typical values small signal current gain. $-I_C = 1,5$ A;
 $-V_{CE} = 3$ V.

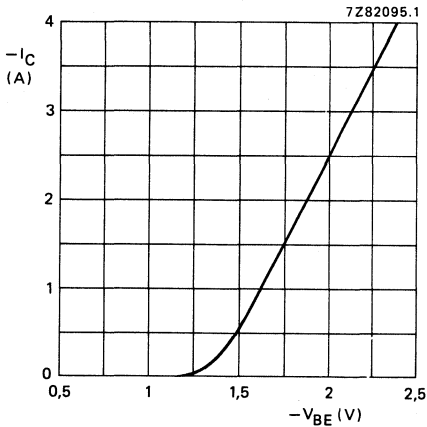


Fig. 11 Typical values; $-V_{CE} = 3$ V
 $T_j = 25^\circ\text{C}$.

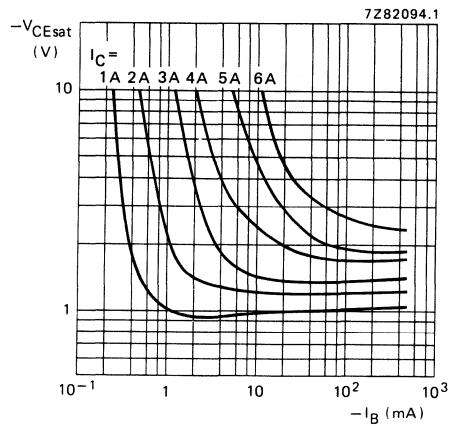


Fig. 12 Typical values collector-emitter saturation voltage as a function of base current. $T_{mb} = 25^\circ\text{C}$.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope intended for use in audio output and general purpose amplifier applications. P-N-P 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 (d.c.) (peak value)	I_C I_{CM}	max.	4 7	4 7	4 7	4 7 A
Junction temperature	T_j	max.	150	150	150	150 °C
D.C. current gain $I_C = 2 \text{ A}; V_{CE} = 4 \text{ V}$	h_{FE}	min.	20	20	20	20
Transition frequency $I_C = 500 \text{ mA}; V_{CE} = 4 \text{ V}$	f_T	min.	3	3	3	3 MHz

MECHANICAL DATA

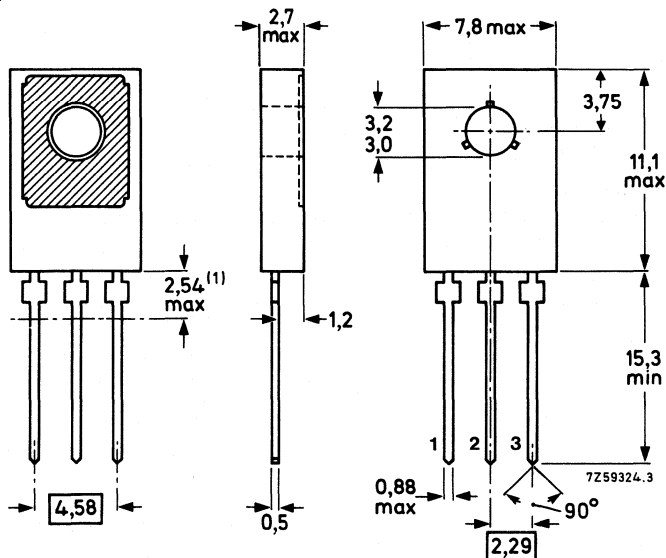
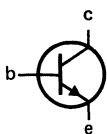
Dimensions in mm

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 d.c. value	I_C	max.		4		A
peak value	I_{CM}	max.		7		A
Base current (d.c.)	I_B	max.		1		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		36		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	max.		100		K/W
From junction to mounting base	$R_{th\ j-mb}$	max.		3,5		K/W

CHARACTERISTICS

$T_j = 25\text{ }^\circ\text{C}$ 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
$I_E = 0; V_{CB} = \frac{1}{2} V_{CBO}$	I_{CBO}	max.	1	1	1	1 mA
$T_j = 150\text{ }^\circ\text{C}$						
$I_B = 0; V_{CE} = \frac{1}{2} V_{CEO}$	I_{CEO}	max.	0,1	0,1	0,1	0,1 mA
→ Emitter cut-off current						
$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	max.	0,2	0,2	0,2	0,2 mA
D.C. current gain (1)						
$I_C = 500\text{ mA}; V_{CE} = 4\text{ V}$	h_{FE}	min.	40	40	40	40
$I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	min.	20	20	20	20
Base-emitter voltage (1) (2)						
$I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	max.	1,4	1,4	1,4	1,4 V
Collector-emitter saturation voltage (1)						
$I_C = 2\text{ A}; I_B = 0,2\text{ A}$	V_{CEsat}	max.	1	1	1	1 V

(1) $t_p = 300\text{ }\mu\text{s}; \delta \leq 2\%$.

(2) V_{BE} decreases by approximately 2,3 mV/K with increasing temperature.

Transition frequency at $f = 1 \text{ MHz}$

$I_C = 0,5 \text{ A}; V_{CE} = 4 \text{ V}$

		BD719	BD721	BD723	BD725
f_T	min.	3	3	3	3 MHz

Switching times

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

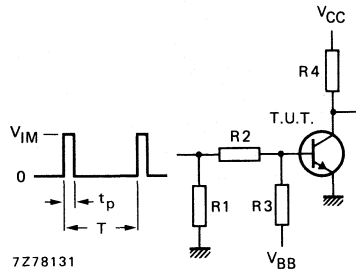
$I_{Bon} = -I_{Boff} = 0,1 \text{ A}$

Turn-on time

t_{on}	typ.	0,3	0,3	0,3	0,3 μs
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Turn-off time

t_{off}	typ.	1,5	1,5	1,5	1,5 μs
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7Z78131

Fig. 2 Test circuit.

$V_{IM} = 30 \text{ V}$

$V_{CC} = 20 \text{ V}$

$-V_{BB} = 3,5 \text{ V}$

$R1 = 82 \Omega$

$R2 = 150 \Omega$

$R3 = 39 \Omega$

$R4 = 20 \Omega$

$t_r = t_f = 15 \text{ ns}$

$t_p = 10 \mu\text{s}$

$T = 500 \mu\text{s}$

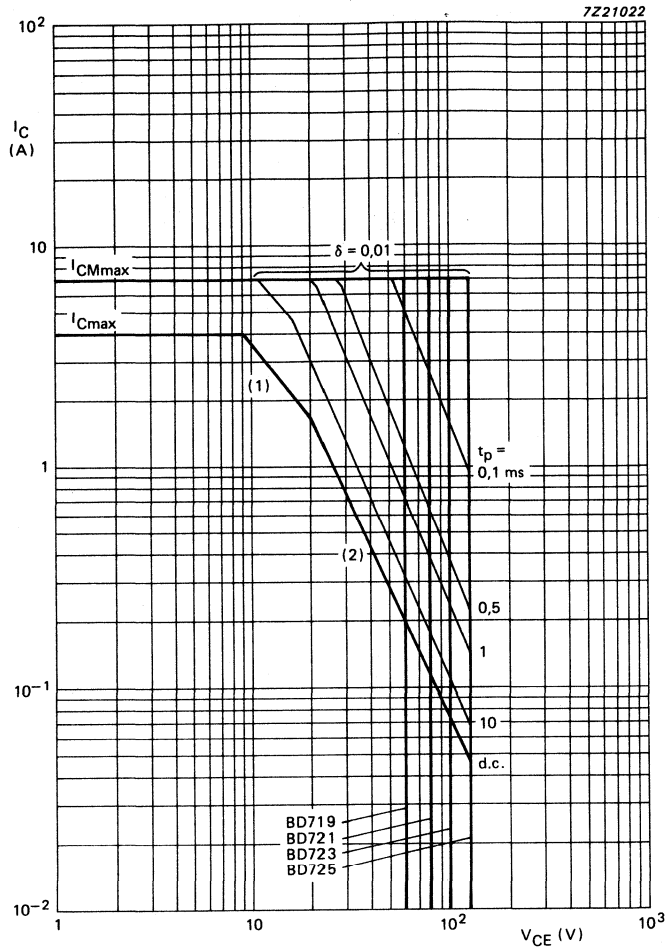


Fig. 3 Safe Operating Area, $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

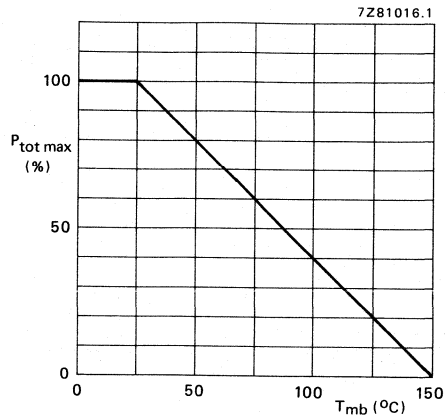


Fig. 4 Power derating curve.

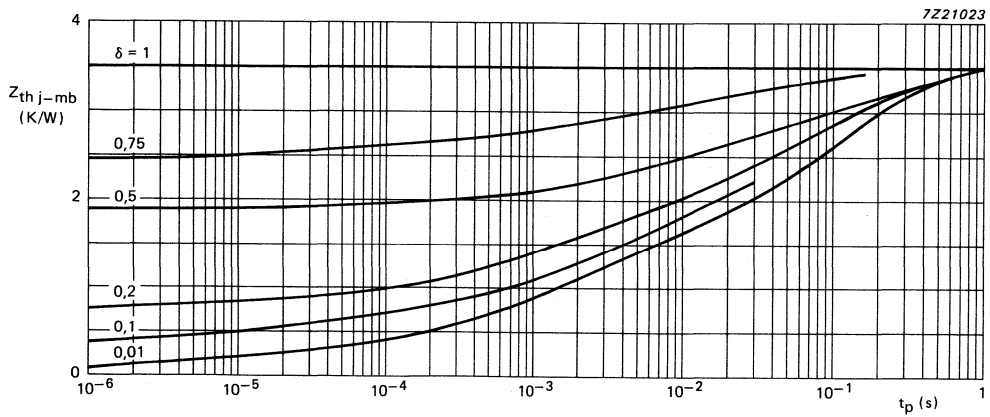


Fig. 5 Pulse power rating chart.

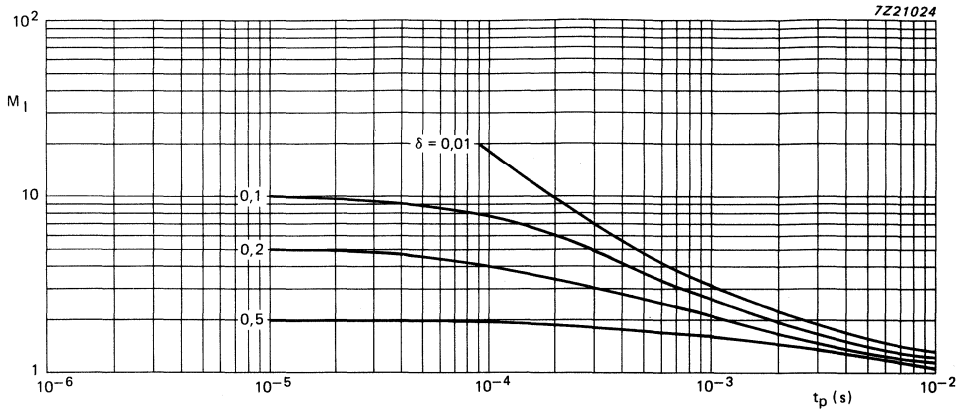


Fig. 6 Second breakdown current multiplying factor at V_{CE0} max level.

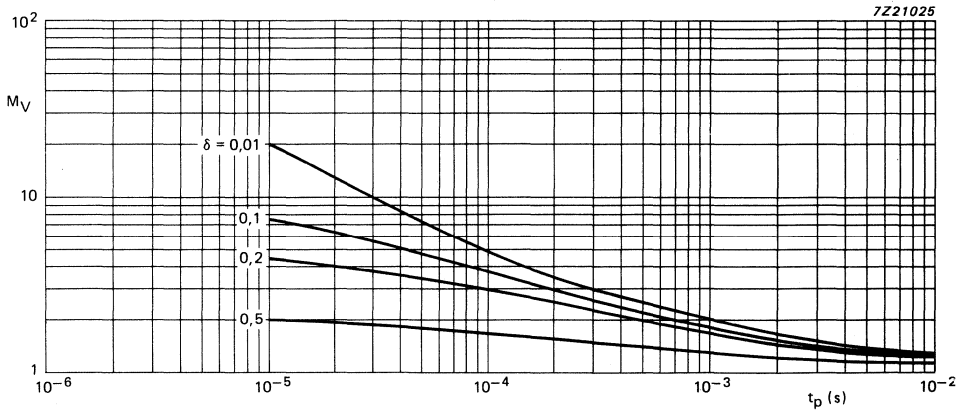


Fig. 7 Second breakdown voltage multiplying factor at I_{C} max level.

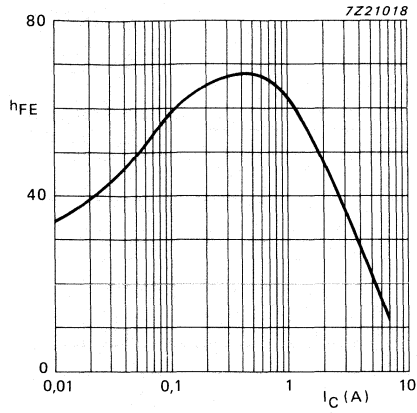


Fig. 8 Typical D.C. current gain. $T_j = 25^\circ\text{C}$; $V_{CE} = 4$ V.

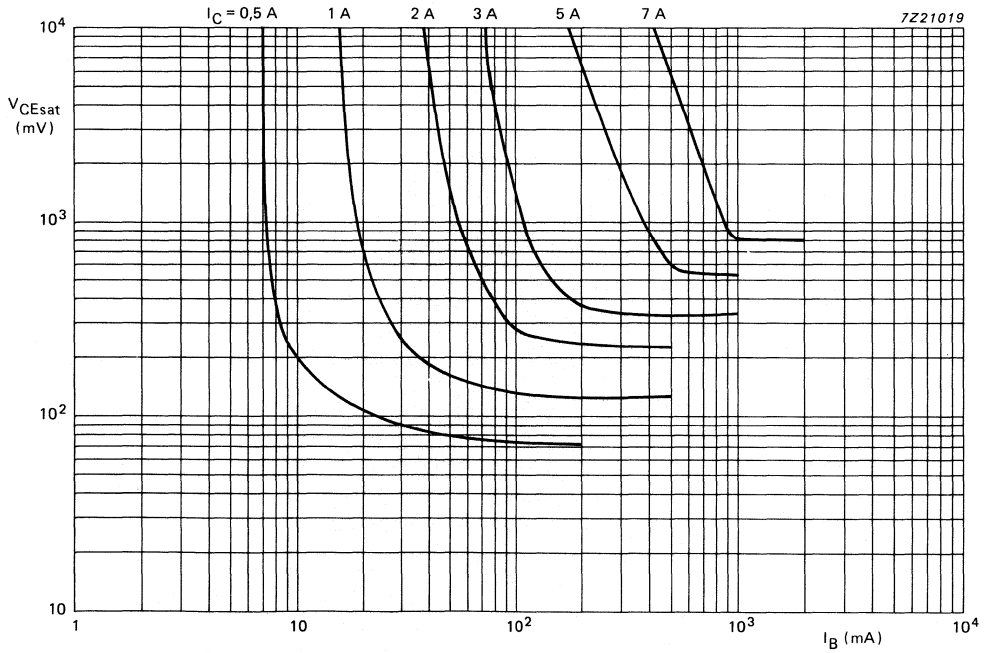


Fig. 9 Typical values collector-emitter saturation. $T_j = 25^\circ\text{C}$.

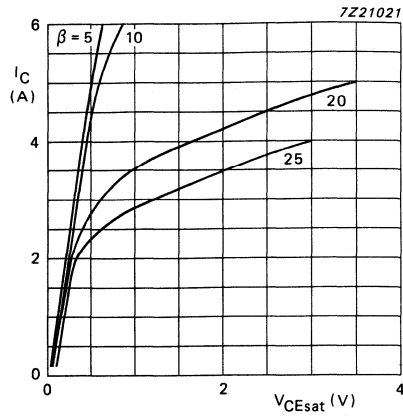


Fig. 10 Typical collector-emitter saturation voltage versus collector current (h_{FE} constant). $T_j = 25^\circ\text{C}$.

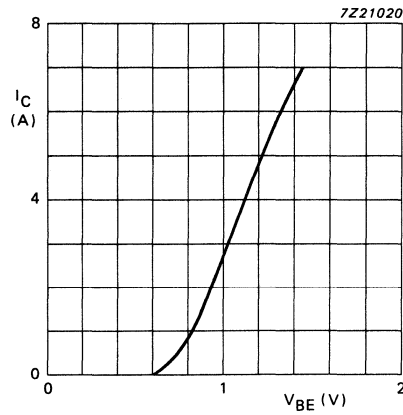


Fig. 11 Collector current. $V_{CE} = 4\text{ V}$; $T_j = 25^\circ\text{C}$.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

PNP transistor in a SOT-32 plastic envelope intended for use in audio output and general purpose amplifier applications. NPN complements are BD719; 721; 723 and BD724.

QUICK REFERENCE DATA

			BD720	BD722	BD724	BD726
Collector-base voltage	$-V_{CB0}$	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 (d.c.) (peak value)	$-I_C$	max.	4	4	4	4 A
	$-I_{CM}$	max.	7	7	7	7 A
Junction temperature	T_j	max.	150	150	150	150 °C
D.C. 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

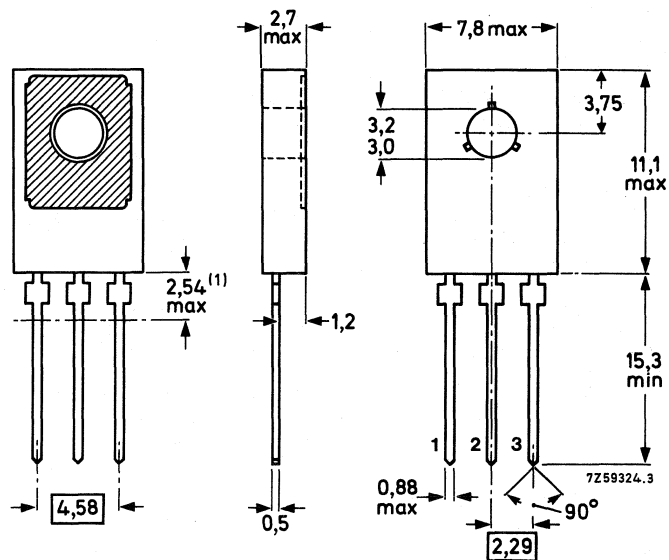
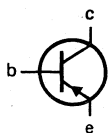
Dimensions in mm

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						
d.c. value	$-I_C$	max.		4		A
peak value	$-I_{CM}$	max.		7		A
Base current (d.c.)	$-I_B$	max.		1		A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		36		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to ambient in free air	R_{thj-a}	max.		100		K/W
From junction to mounting base	R_{thj-mb}	max.		3,5		K/W

CHARACTERISTICS

$T_j = 25^\circ\text{C}$ 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 mA
$I_E = 0; -V_{CB} = -\frac{1}{2} V_{CBO}$	$-I_{CBO}$	max.	1	1	1	1 mA
$T_j = 150^\circ\text{C};$						
$I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEO}$	$-I_{CEO}$	max.	0,1	0,1	0,1	0,1 mA
→ Emitter cut-off current						
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	max.	0,2	0,2	0,2	0,2 mA
D.C. current gain (1)						
$-I_C = 0,5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.	40	40	40	40
$-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.	20	20	20	20
Base-emitter voltage (1) (2)						
$-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	max.	1,4	1,4	1,4	1,4 V
Collector-emitter saturation voltage (1)						
$-I_C = 2\text{ A}; -I_B = 0,2\text{ A}$	$-V_{CEsat}$	max.	1	1	1	1 V

(1) $t_p = 300\ \mu\text{s}; \delta \leq 2\%$.

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

Transition frequency at $f = 1 \text{ MHz}$

$-I_C = 0,5 \text{ A}; -V_{CE} = 4 \text{ V}$

	BD720	BD722	BD724	BD726
f_t min.	3	3	3	3 MHz

Switching times

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

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

Turn-on time

t_{on} typ.	0,1	0,1	0,1	0,1 μs
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Turn-off time

t_{off} typ.	0,4	0,4	0,4	0,4 μs
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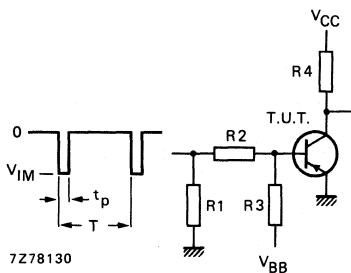


Fig. 2 Switching times test circuit.

$-V_{IM} = 30 \text{ V}$
 $-V_{CC} = 20 \text{ V}$
 $+V_{BB} = 3,5 \text{ V}$
 $R1 = 82 \Omega$
 $R2 = 150 \Omega$
 $R3 = 39 \Omega$
 $R4 = 20 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

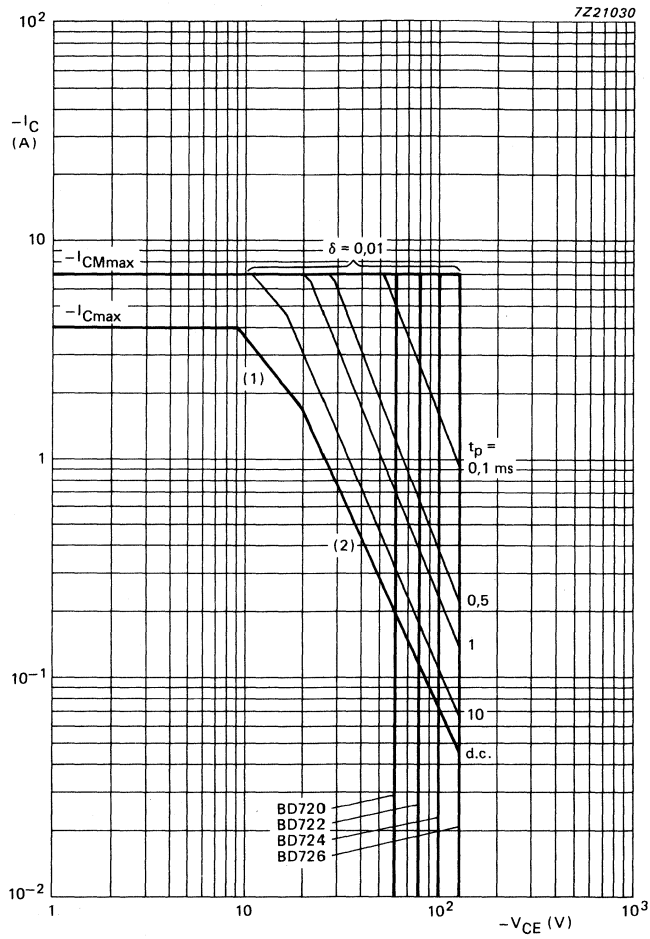


Fig. 3 Safe Operating Area, $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

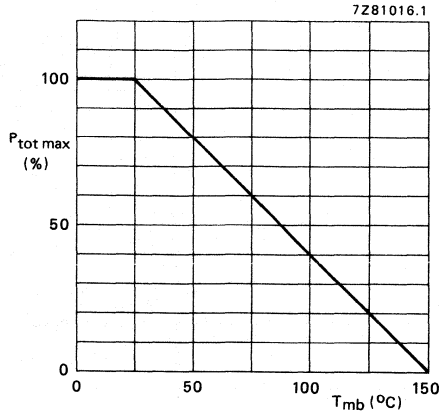


Fig. 4 Power derating curve.

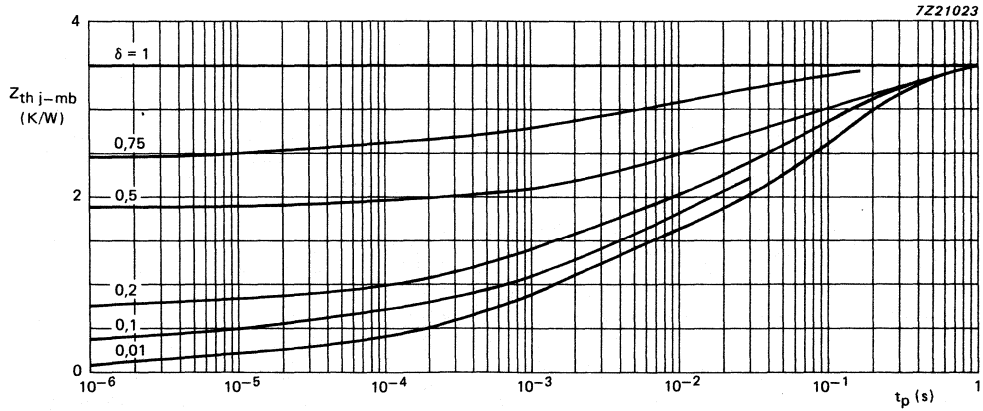


Fig. 5 Pulse power rating chart.

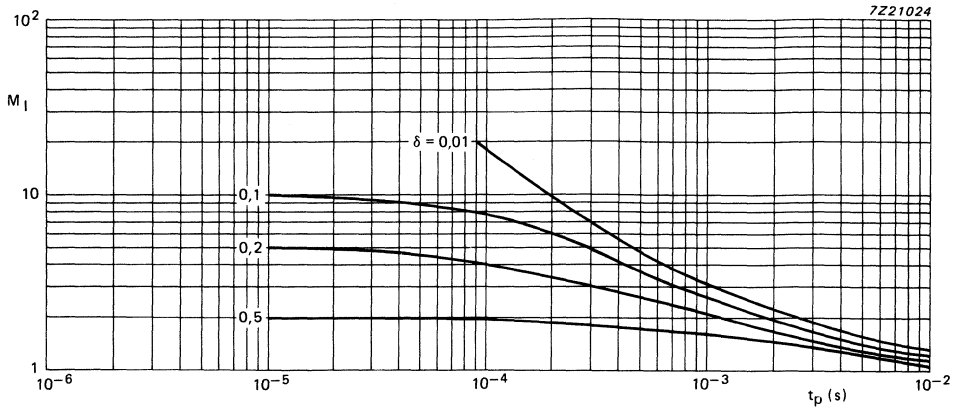


Fig. 6 Second breakdown current multiplying factor at V_{CE0} max level.

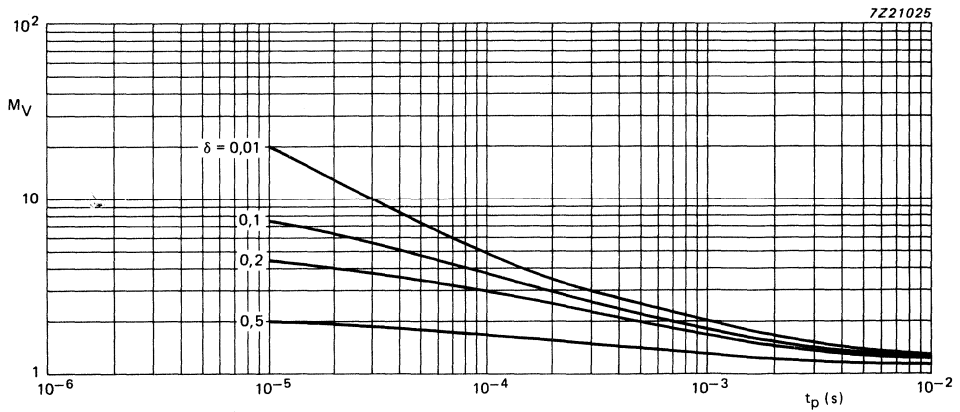


Fig. 7 Second breakdown voltage multiplying factor at I_C max level.

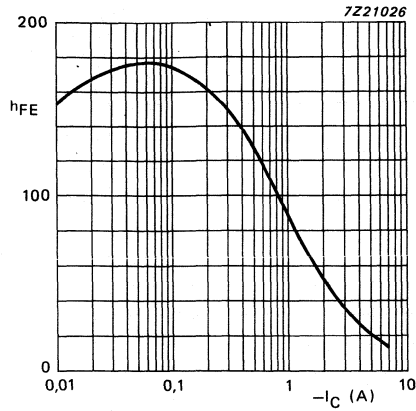


Fig. 8 Typical D.C. current gain. $T_j = 25\text{ }^\circ\text{C}$; $V_{CE} = 4\text{ V}$.

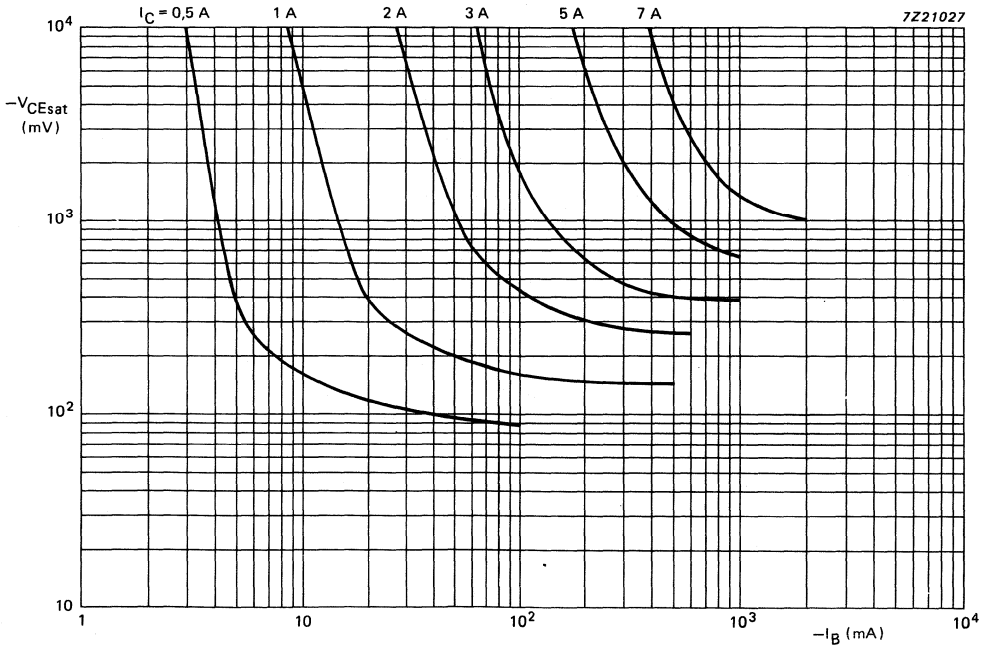


Fig. 9 Typical values collector-emitter saturation. $T_j = 25\text{ }^\circ\text{C}$.

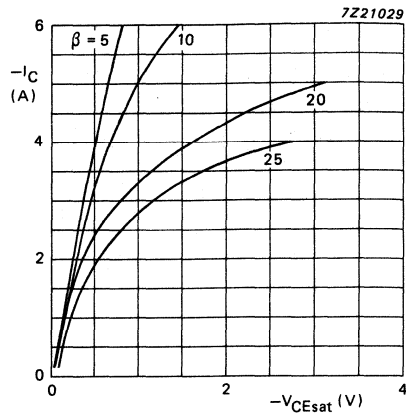


Fig. 10 Typical collector-emitter saturation voltage versus collector current (h_{FE} constant). $T_j = 25^\circ\text{C}$.

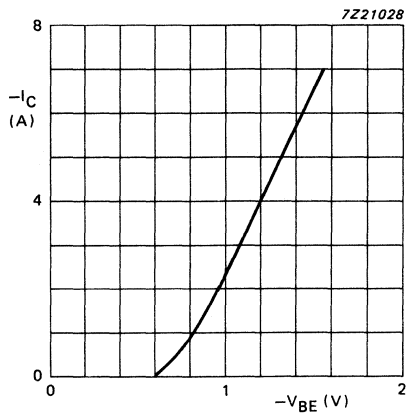


Fig. 11 Collector current. $V_{CE} = 4\text{ V}$; $T_j = 25^\circ\text{C}$.

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.

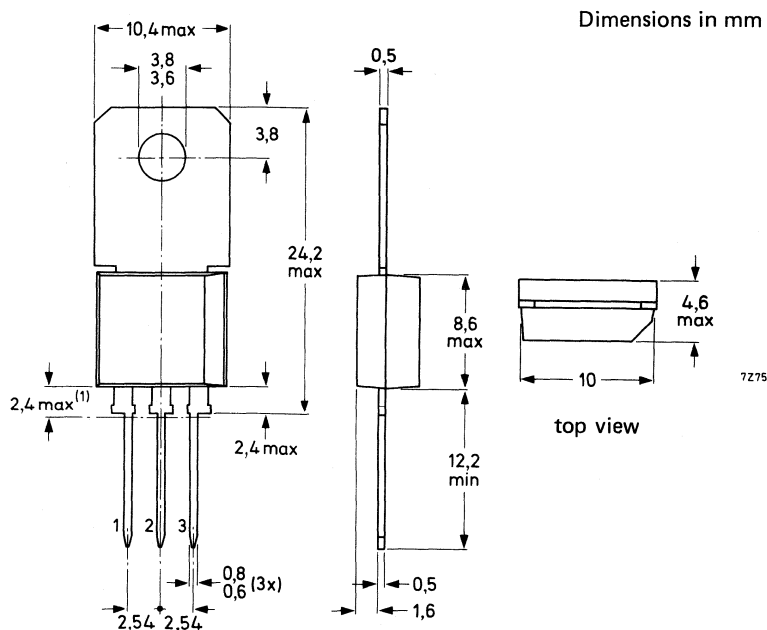
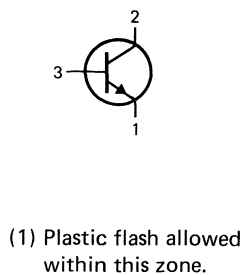
QUICK REFERENCE DATA

		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 ($R_{BE} = 1 \text{ k}\Omega$)	V_{CER}	max. 45	60	100 V
Collector current (peak value)	I_{CM}	max. 1,5		A
Total power dissipation at $T_{amb} = 25 \text{ }^\circ\text{C}$ (free air) at $T_{mb} = 50 \text{ }^\circ\text{C}$	P_{tot}	max. 2		W
	P_{tot}	max. 8		W
Junction temperature	T_j	max. 150		$^\circ\text{C}$
D.C. current gain $I_C = 150 \text{ mA}; V_{CE} = 2 \text{ V}$	h_{FE}	40 to 250		
Transition frequency $I_C = 50 \text{ mA}; V_{CE} = 5 \text{ V}$	f_T	typ. 250	MHz	

MECHANICAL DATA

Fig. 1 TO-202.

Collector connected to mounting base



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 ($R_{BE} = 1\text{ k}\Omega$)	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						
$T_{amb} = 25\text{ }^\circ\text{C}$ (free air)	P_{tot}	max.		2		W
$T_{mb} = 50\text{ }^\circ\text{C}$	P_{tot}	max.		8		W
Storage temperature	T_{stg}		-65 to + 150			$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off currents

 $I_E = 0; V_{CB} = 30\text{ V}$ $I_{CBO} < 100\text{ nA}$ $I_E = 0; V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$ $I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

D.C. current gain

 $I_C = 5\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} > 25$ $I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} 40\text{ to }250$ $I_C = 500\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} > 25$

Collector-emitter saturation voltage

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

Base-emitter voltage

 $I_C = 500\text{ mA}; V_{CE} = 2\text{ V}$ $V_{BE} < 1\text{ V}$ Transition frequency at $f = 35\text{ MHz}$ $I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$ $f_T \text{ typ. } 250\text{ MHz}$

D.C. current gain ratio of matched complementary pairs

 $|I_C| = 150\text{ mA}; |V_{CE}| = 2\text{ V}$ $h_{FE1}/h_{FE2} \text{ typ. } 1,3$
 $< 1,6$

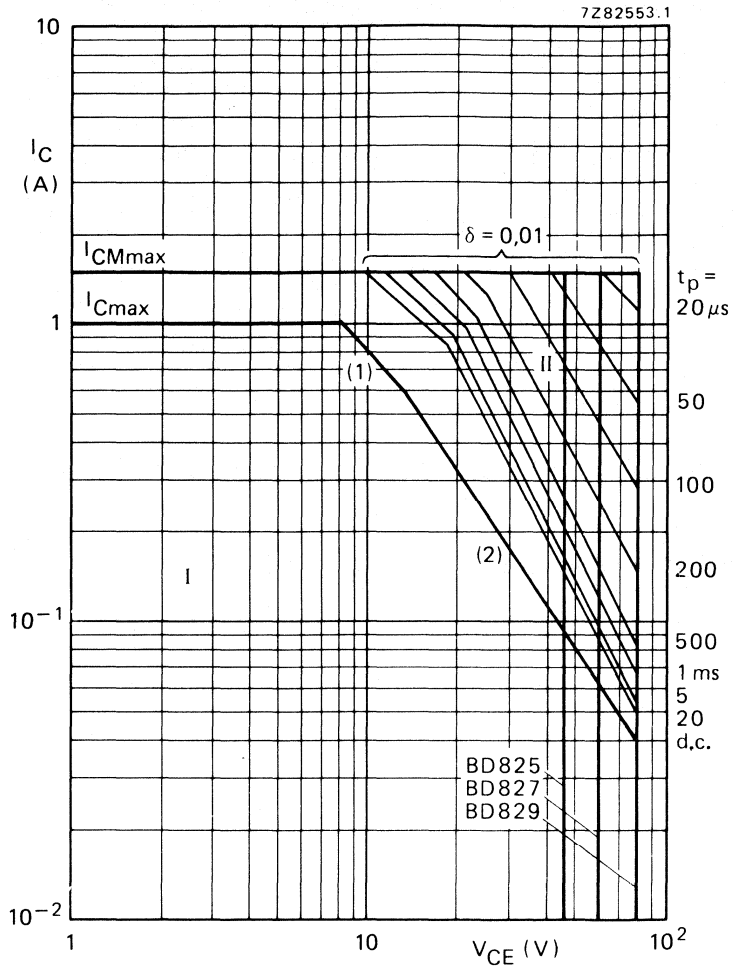
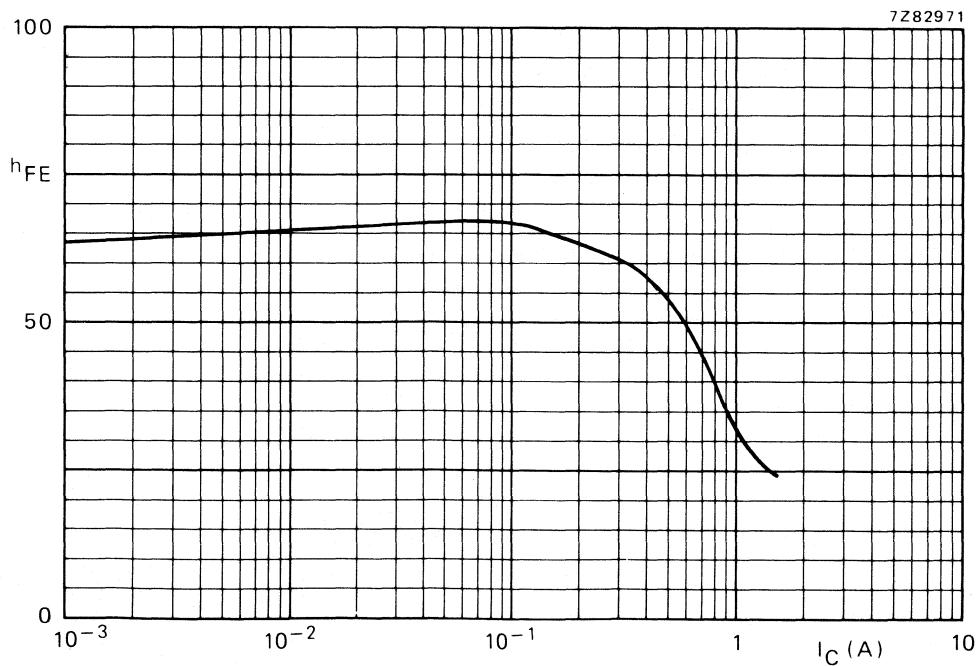
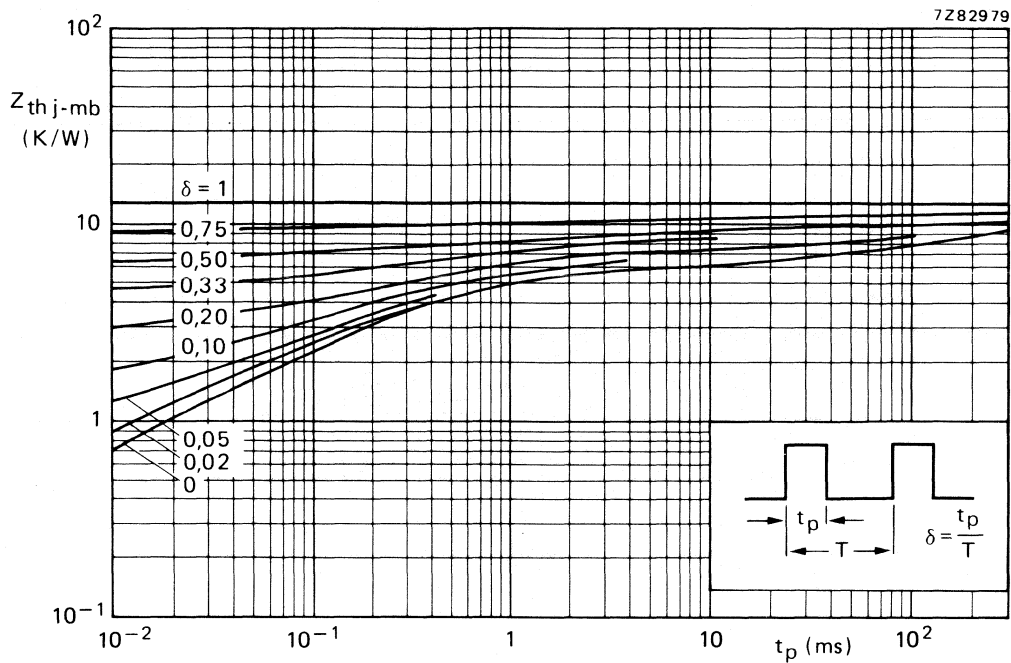


Fig. 2 Safe Operating Area. $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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



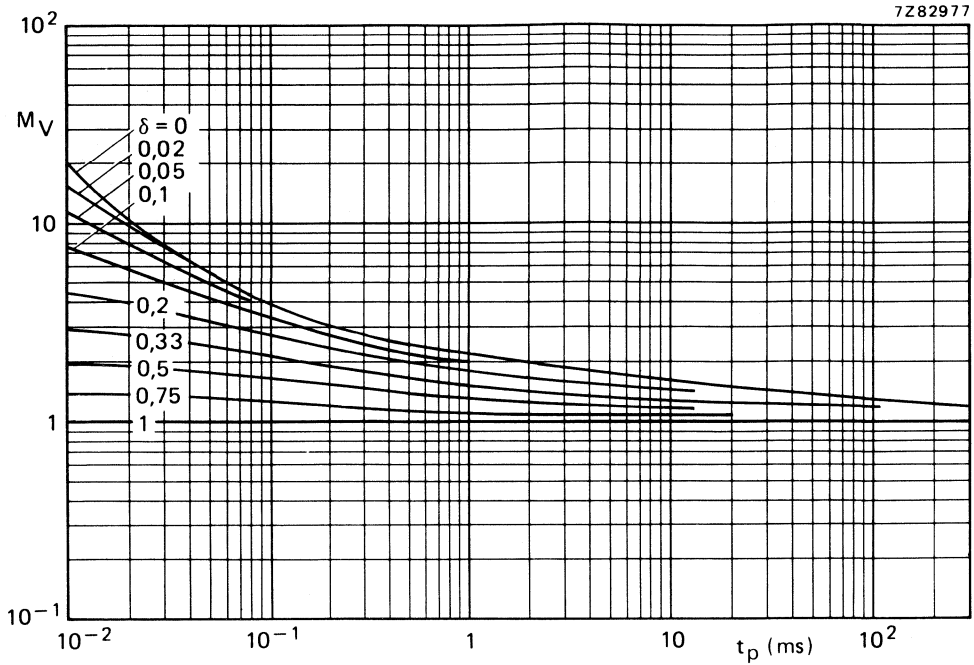


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

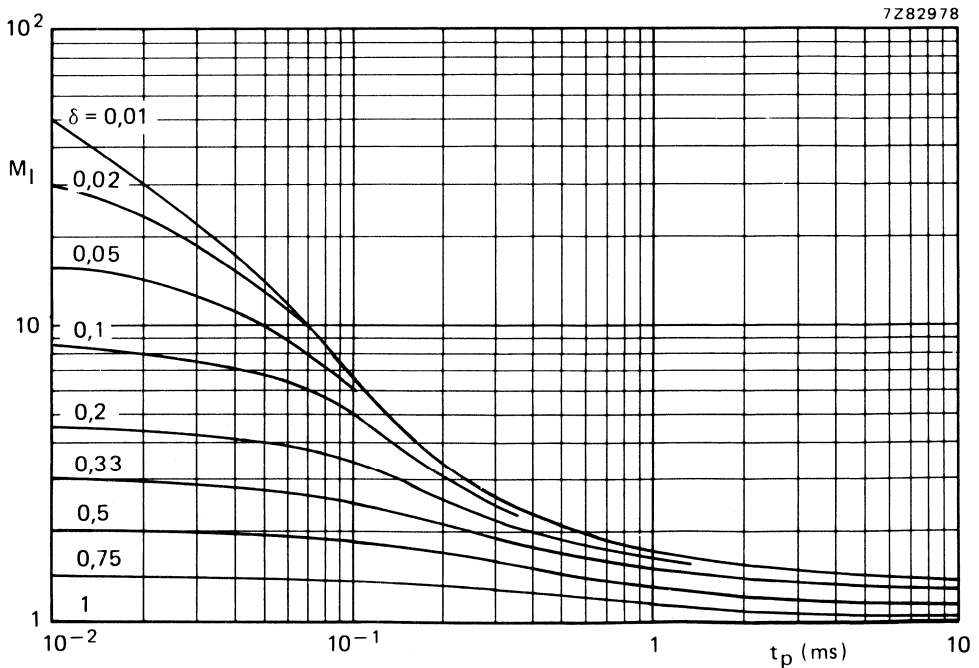


Fig. 6 S.B. current multiplying factor at V_{CE0max} level.

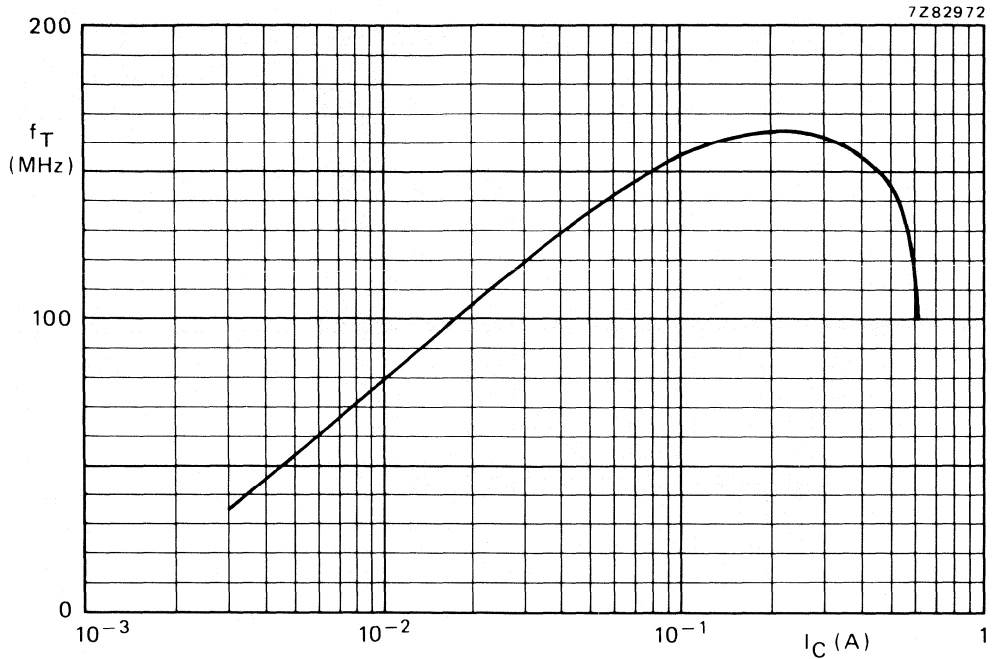


Fig. 7 Typical values transition frequency. $V_{CE} = 5 \text{ V}$; $f = 35 \text{ MHz}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

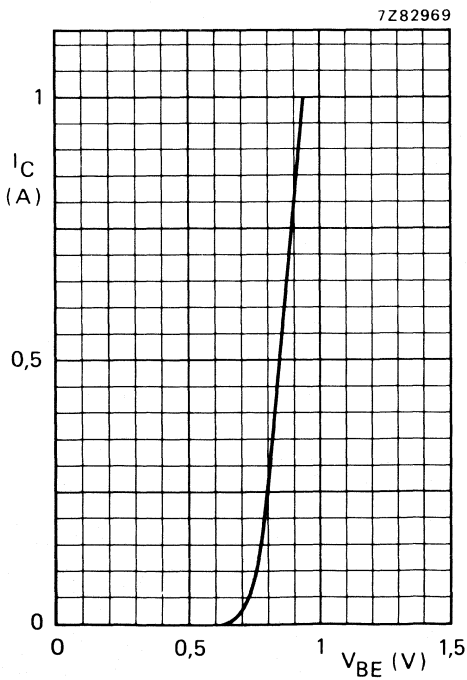


Fig. 8 Typical values. $V_{CE} = 2 \text{ V}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

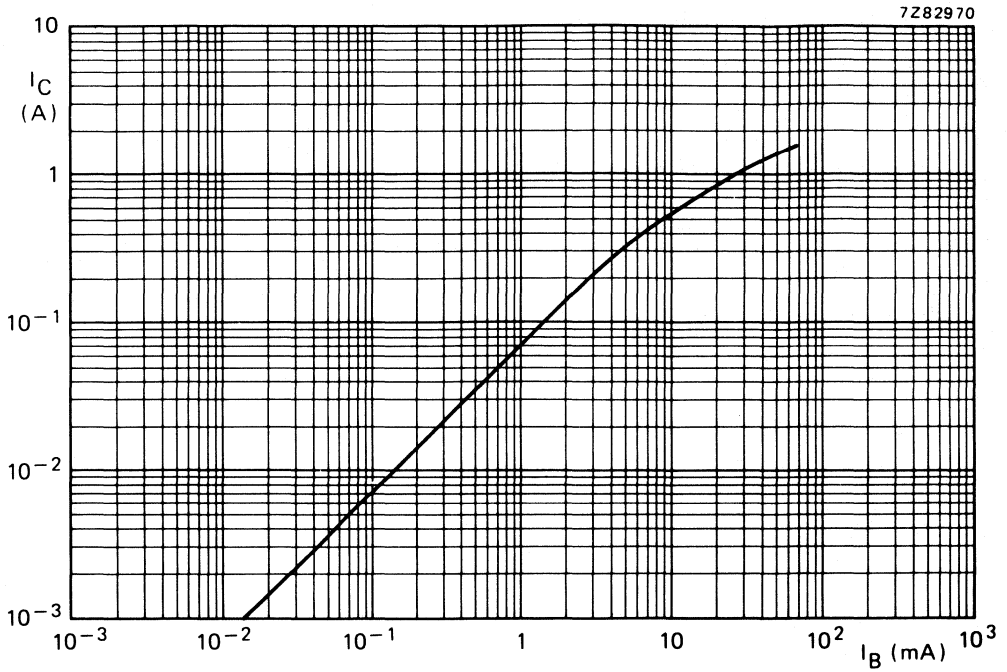


Fig. 9 Typical values at $V_{CE} = 2\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$:

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.

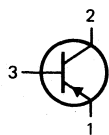
QUICK REFERENCE DATA

			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 $T_{amb} = 25\text{ }^{\circ}\text{C}$ (free air)	P_{tot}	max.		2	W
at $T_{mb} = 50\text{ }^{\circ}\text{C}$	P_{tot}	max.		8	W
Junction temperature	T_j	max.		150	$^{\circ}\text{C}$
D.C. current gain					
$-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$	h_{FE}			40 to 250	
Transition frequency					
$-I_C = 50\text{ mA}; -V_{CE} = 5\text{ V}$	f_T	typ.		75	MHz

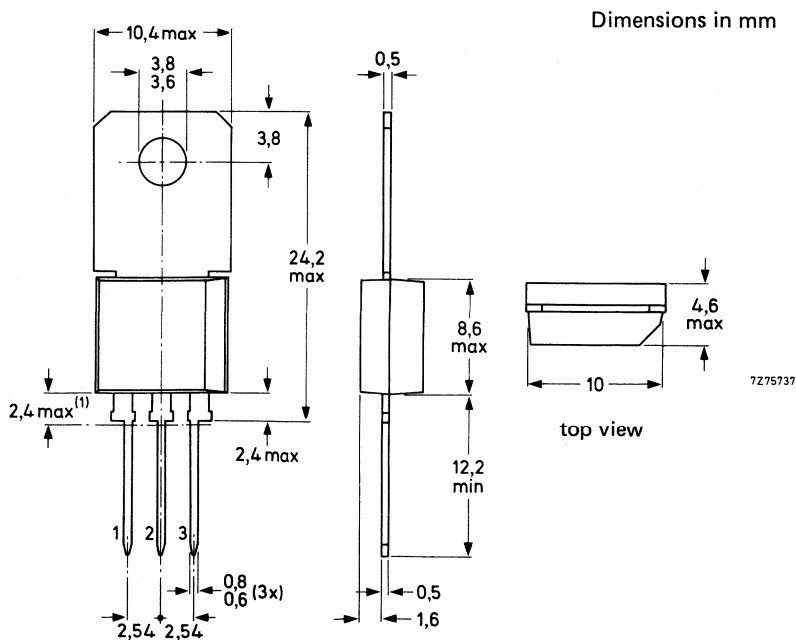
MECHANICAL DATA

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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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						
$T_{amb} = 25 \text{ }^\circ\text{C}$ (free air)	P_{tot}	max.		2		W
$T_{mb} = 50 \text{ }^\circ\text{C}$	P_{tot}	max.		8		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Collector cut-off current

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

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

$I_E = 0; -V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$

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

Emitter cut-off current

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

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

D.C. current gain

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

$h_{FE} > 25$

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

$h_{FE} \quad 40\text{ to }250$

$-I_C = 500\text{ mA}; -V_{CE} = 2\text{ V}$

$h_{FE} > 25$

Collector-emitter saturation voltage

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

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

Base-emitter voltage

$-I_C = 500\text{ mA}; -V_{CE} = 2\text{ V}$

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

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

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

$f_T \quad \text{typ.} \quad 75\text{ MHz}$

D.C. current gain ratio of matched complementary pairs

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

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

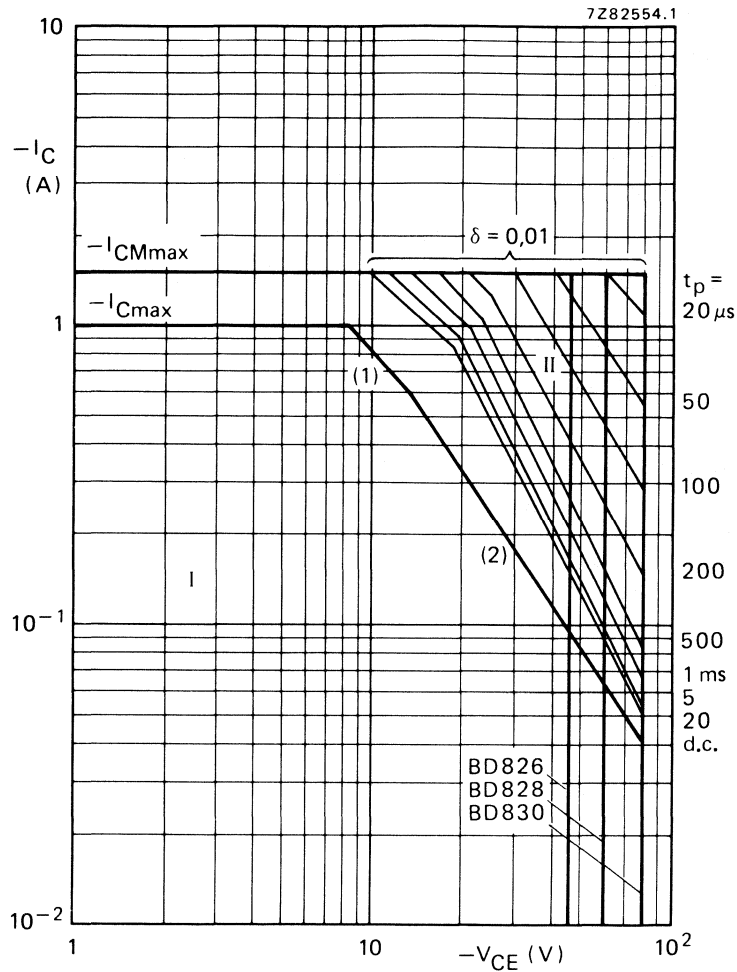


Fig. 2 Safe Operating Area, $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

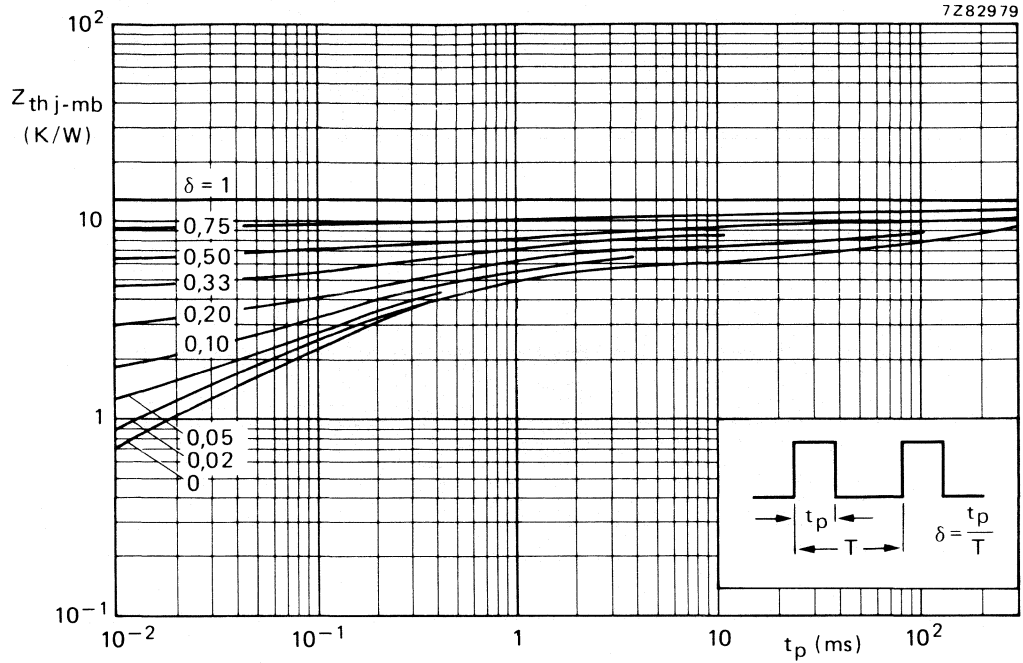


Fig. 3 Pulse power rating chart.

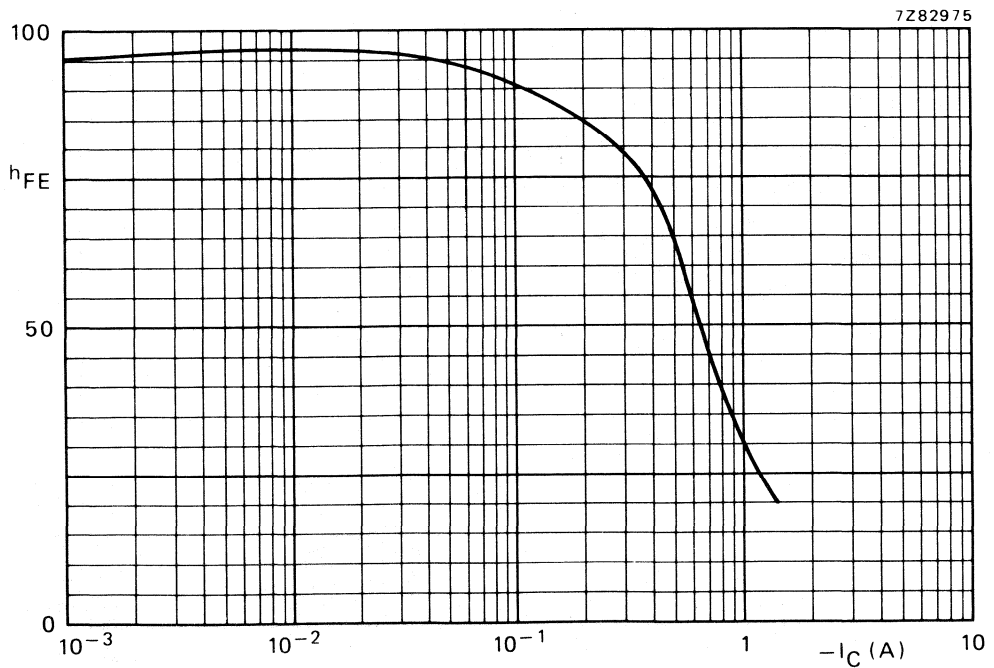


Fig. 4 Typical values d.c. current gain. $-V_{CE} = 2 \text{ V}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

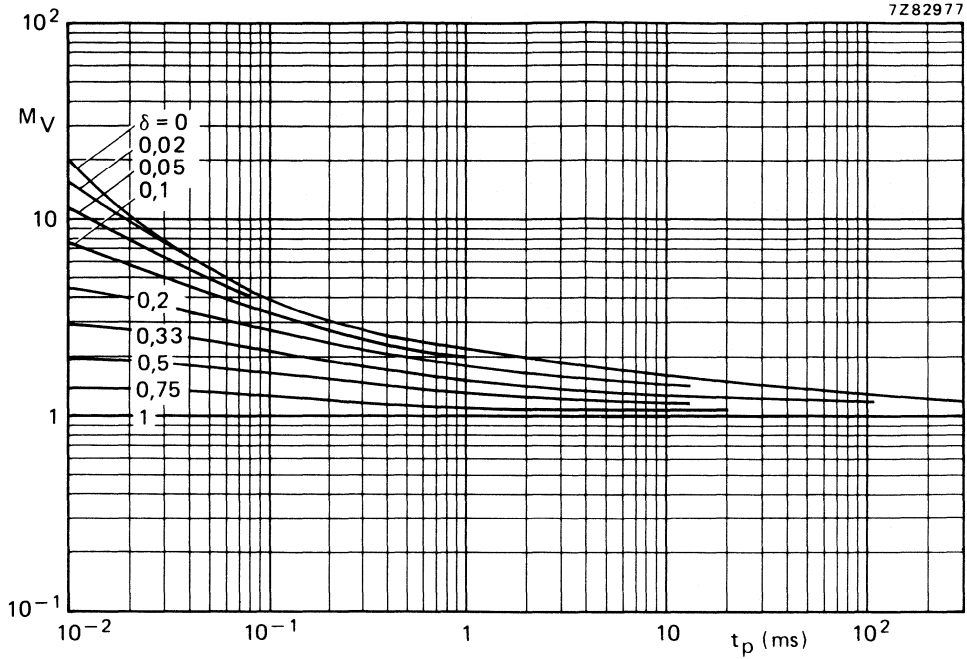


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

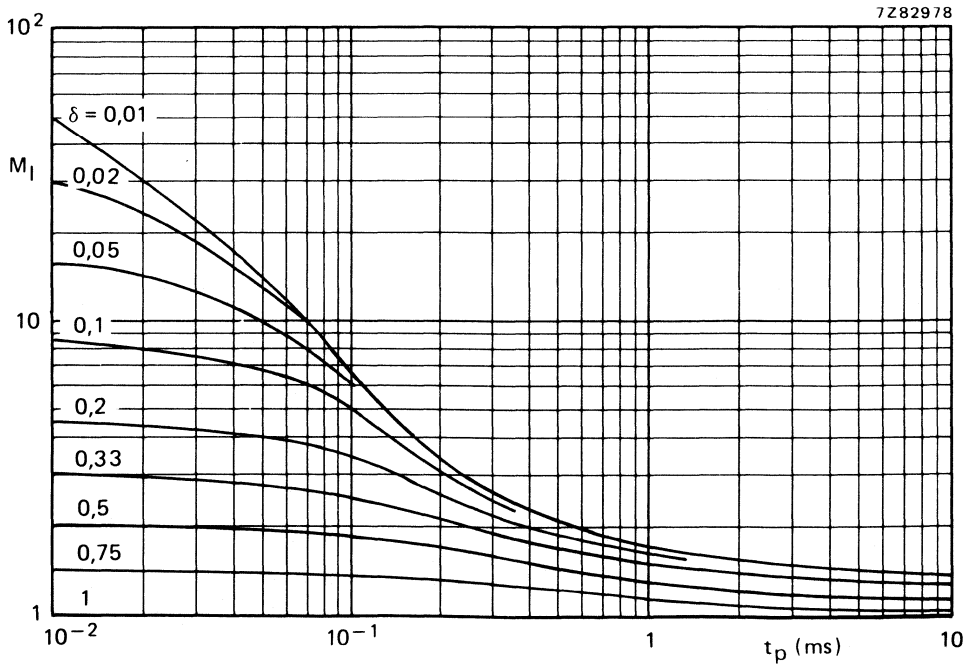


Fig. 6 S.B. current multiplying factor at V_{CE0max} level.

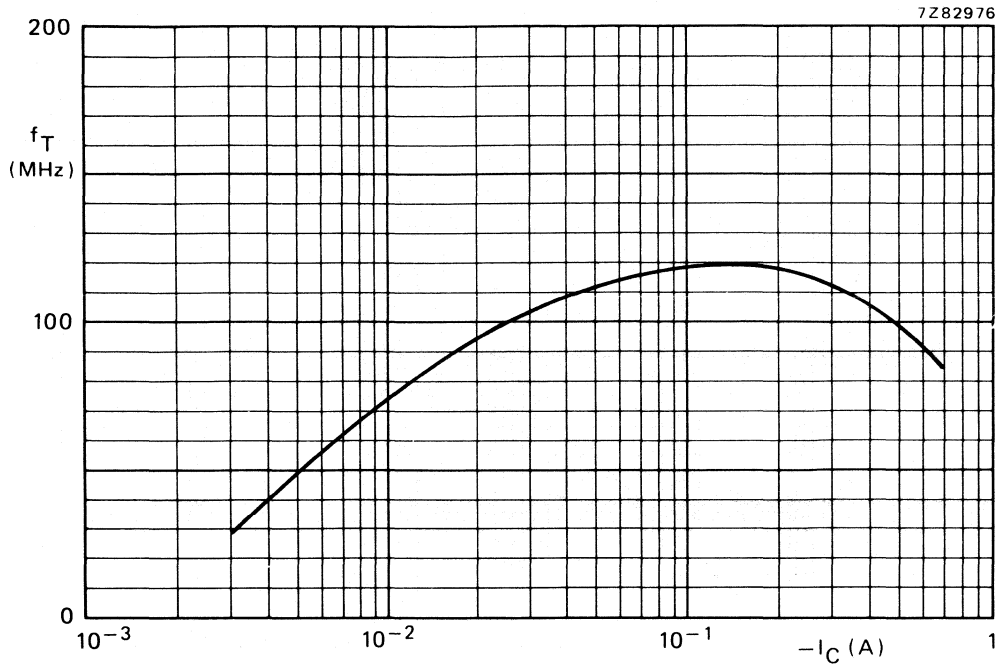


Fig. 7 Typical values transition frequency at $-V_{CE} = 5$ V; $f = 35$ MHz; $T_{amb} = 25$ °C.

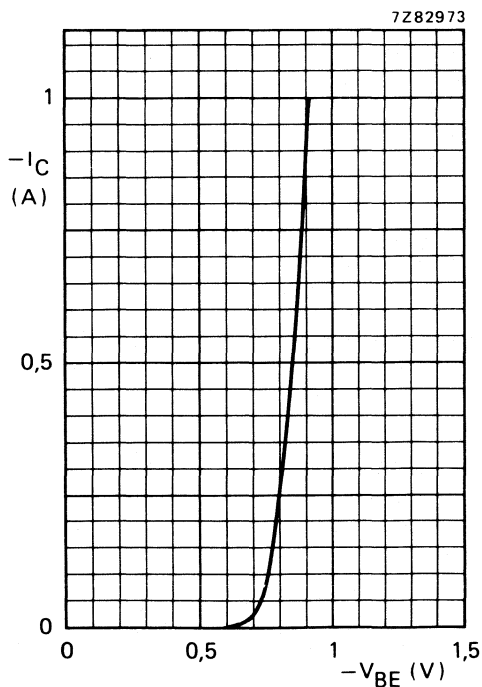


Fig. 8 Typical values. $-V_{CE} = 2$ V; $T_{amb} = 25$ °C.

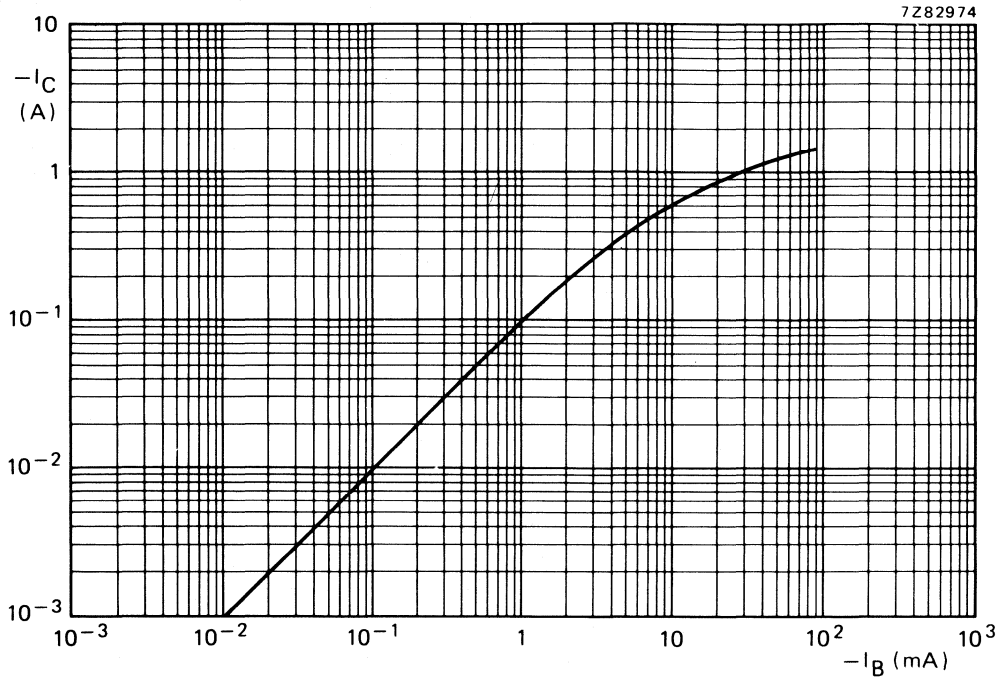


Fig. 9 Typical values at $-V_{CE} = 2 \text{ V}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

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.

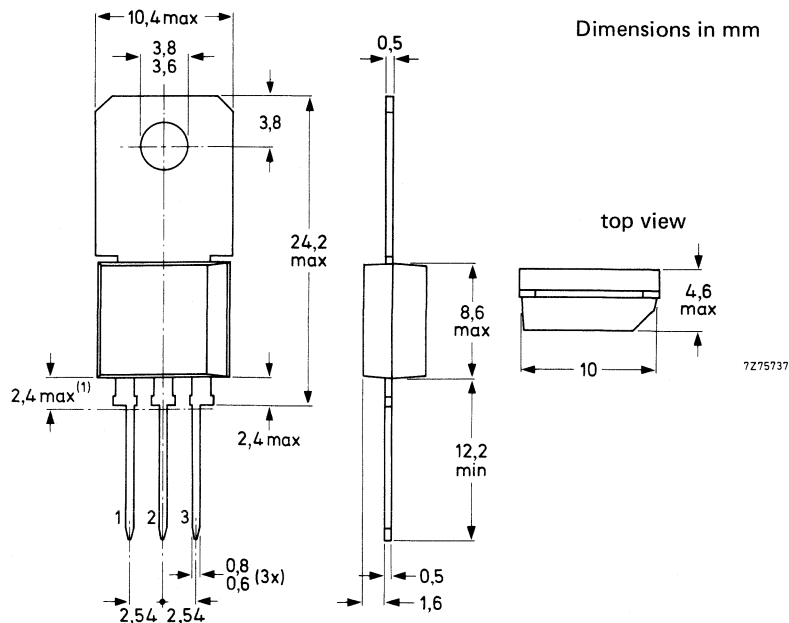
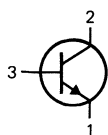
QUICK REFERENCE DATA

		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 ($R_{BE} = 1 \text{ k}\Omega$)	V_{CER}	max. 45	60	100	V
Collector current (peak value)	I_{CM}	max. 3			A
Total power dissipation					
$T_{amb} = 25 \text{ }^\circ\text{C}$ (free air)	P_{tot}	max. 2			W
$T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max. 10			W
Junction temperature	T_j	max. 150			$^\circ\text{C}$
D.C. current gain					
$I_C = 1 \text{ A}; V_{CE} = 2 \text{ V}$	h_{FE}	>			25
Transition frequency at $f = 35 \text{ MHz}$					
$I_C = 50 \text{ mA}; V_{CE} = 5 \text{ V}$	f_T	typ. 5	125		MHz

MECHANICAL DATA

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 ($R_{BE} = 1\text{ k}\Omega$)	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					
$T_{amb} = 25\text{ }^\circ\text{C}$ (free air)	P_{tot}	max.	2		W
$T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	10		W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Collector cut-off current

 $I_E = 0; V_{CB} = 30\text{ V}$ $I_{CBO} < 100\text{ nA}$ $I_E = 0; V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$ $I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

Base-emitter voltage*

 $I_C = 1\text{ A}; V_{CE} = 2\text{ V}$ $V_{BE} < 1,3\text{ V}$

Collector-emitter saturation voltage

 $I_C = 1\text{ A}; I_B = 0,1\text{ A}$ $V_{CEsat} < 0,8\text{ V}$

D.C. current gain

 $I_C = 5\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} > 25$ $I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} 40\text{ to }250$ $I_C = 1\text{ A}; V_{CE} = 2\text{ V}$ $h_{FE} > 25$ Transition frequency at $f = 35\text{ MHz}$ $I_C = 50\text{ mA}; V_{CE} = 5\text{ V}$ f_T typ. 125 MHz

D.C. current gain ratio of

BD839/BD840, BD841/BD842, BD843/BD844

 $|I_C| = 150\text{ mA}; |V_{CE}| = 2\text{ V}$ h_{FE1}/h_{FE2} typ. 1,3 $< 1,6$ * V_{BE} decreases by about 2,3 mV/K with increasing temperature.

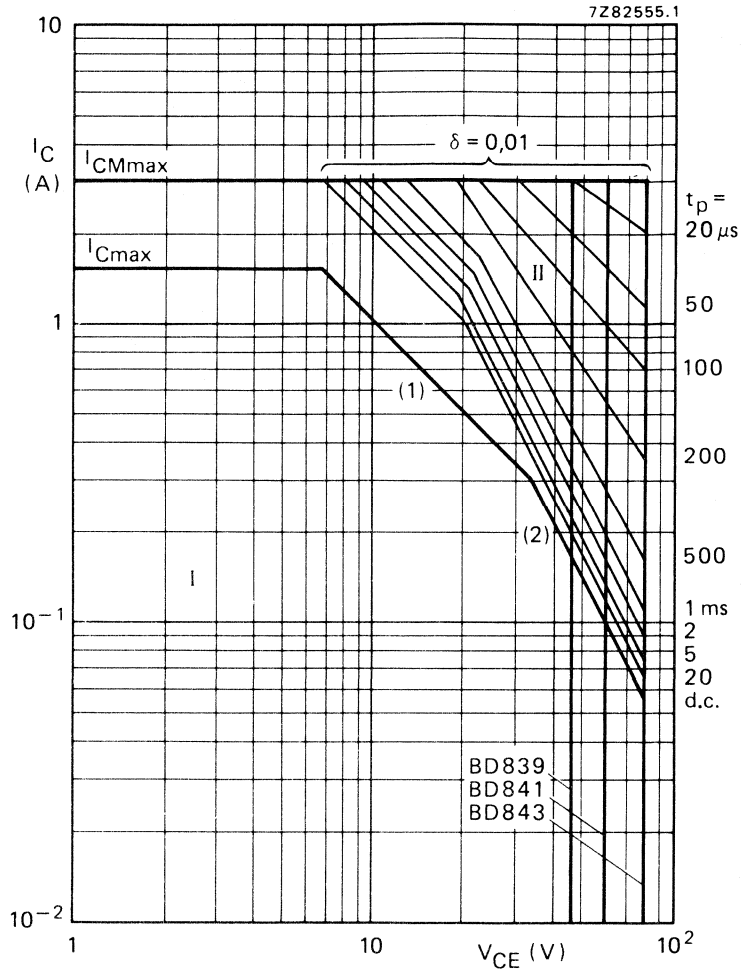


Fig. 2 Safe Operating Area, $T_{mb} \leq 25^\circ C$.

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.

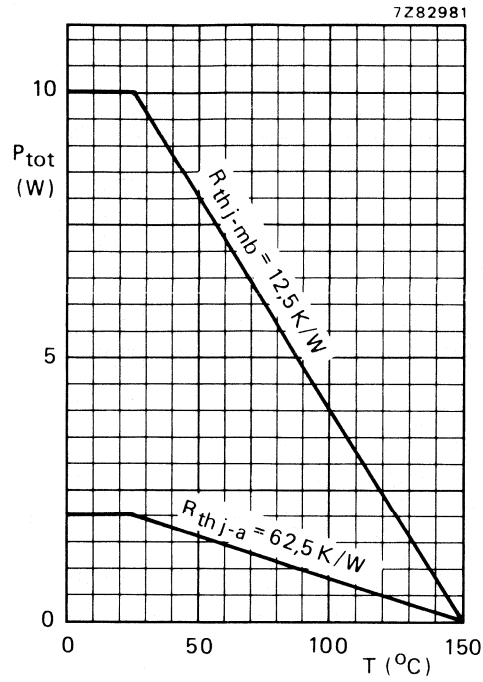


Fig. 3 Power derating curve.

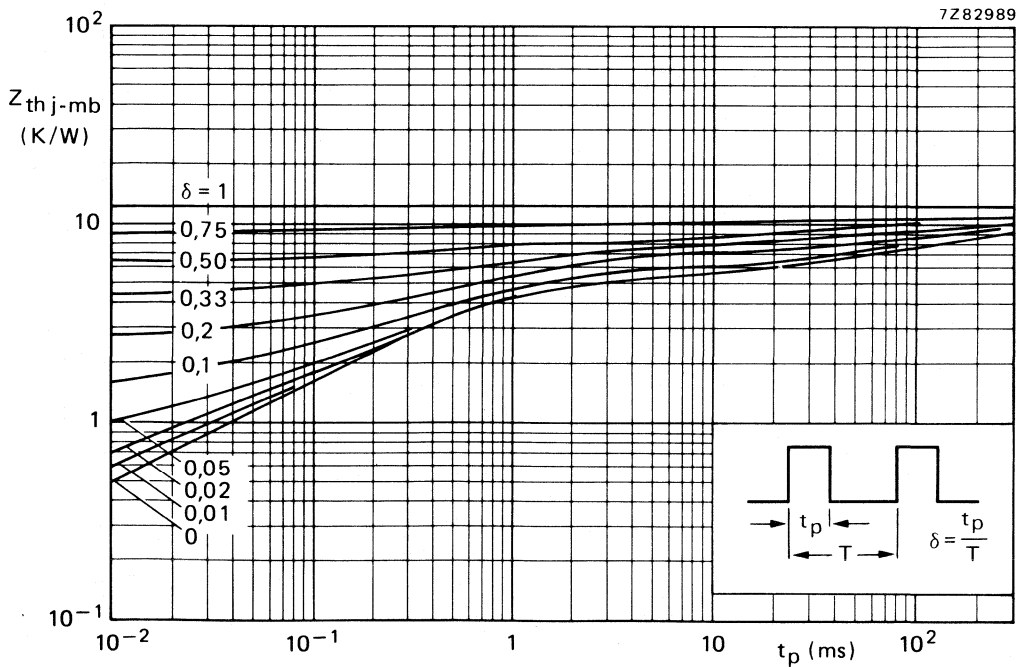


Fig. 4 Pulse power rating chart.

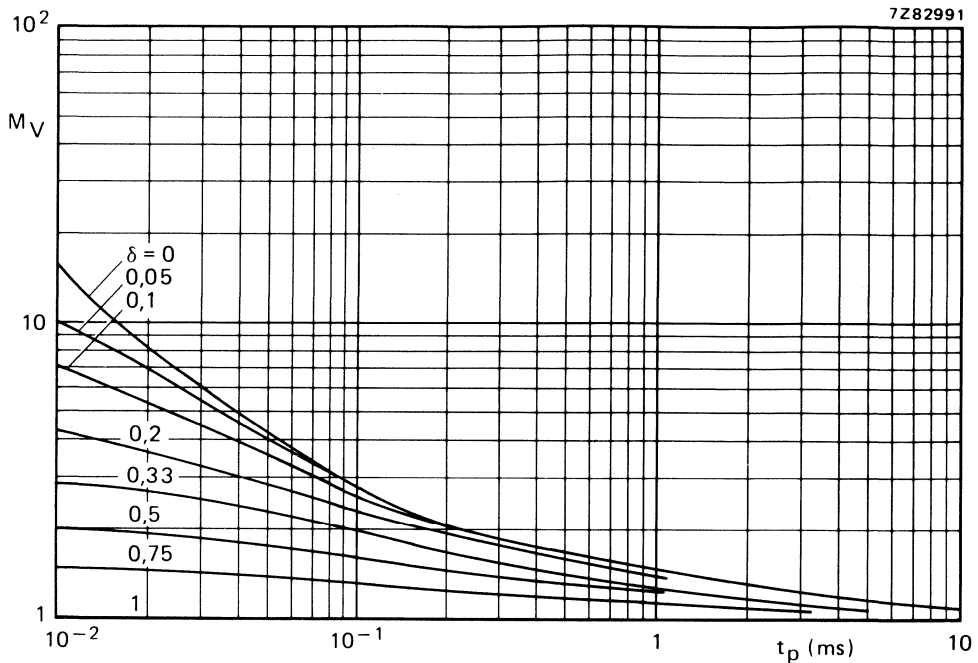


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

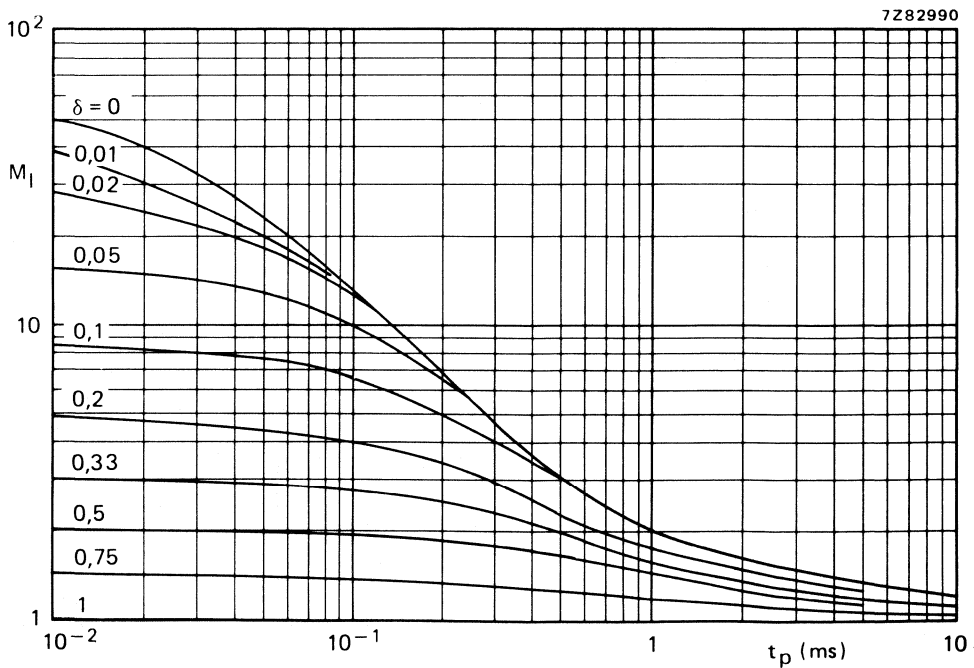


Fig. 6 S.B. current multiplying factor at the V_{CEmax} level.

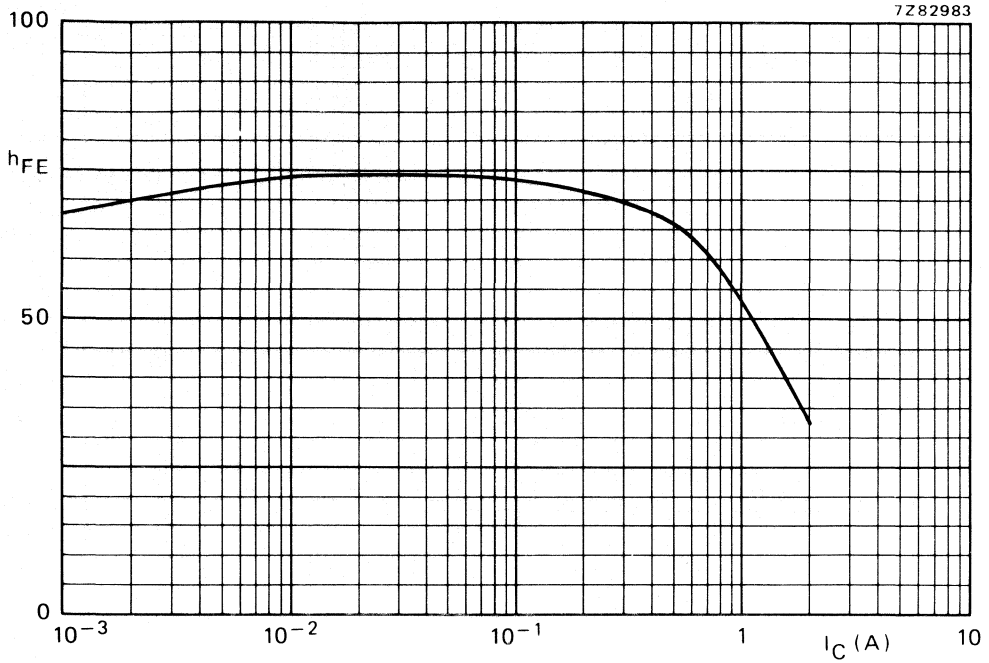


Fig. 7 Typical values d.c. current gain. $V_{CE} = 2\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.

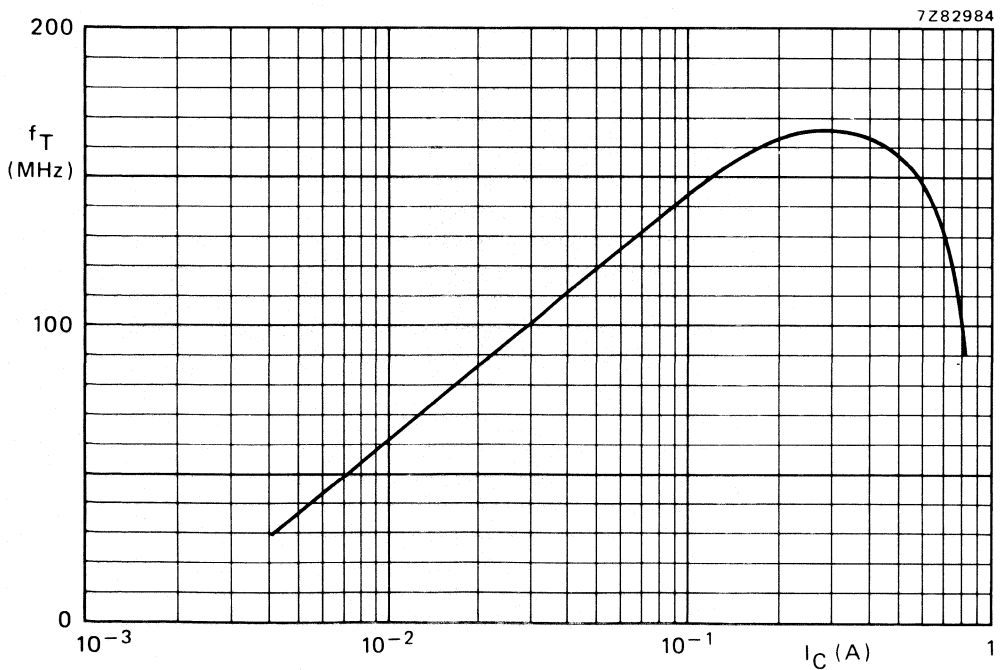


Fig. 8 Typical values transition frequency. $V_{CE} = 5\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$; $f = 35\text{ MHz}$.

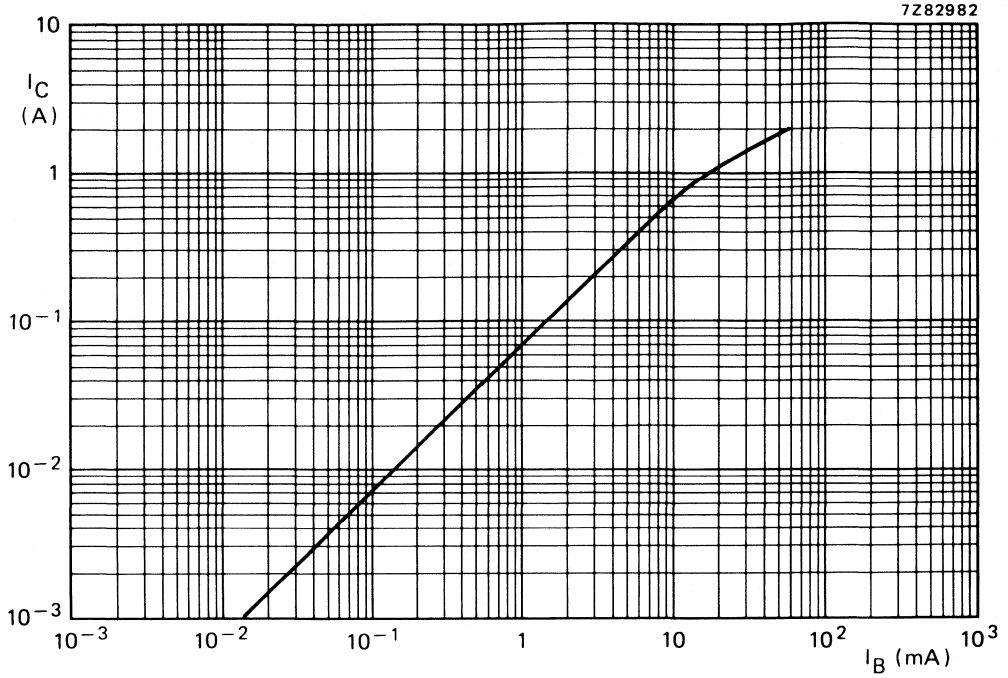


Fig. 9 Typical values at $V_{CE} = 2\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

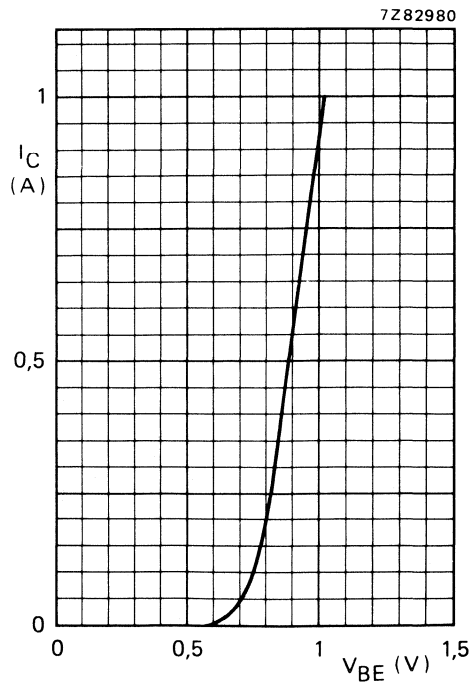


Fig. 10 Typical values. $V_{CE} = 2\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

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.

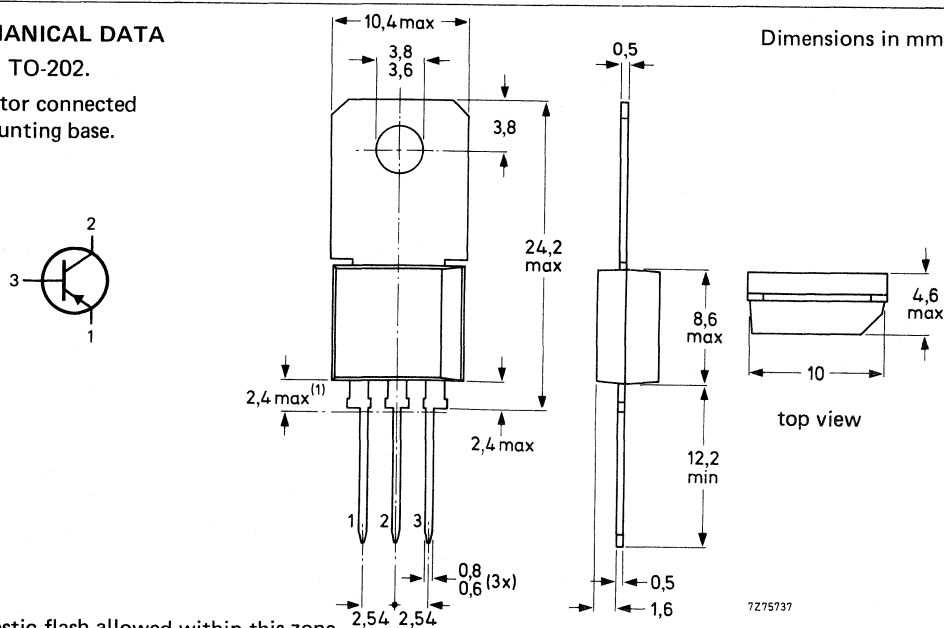
QUICK REFERENCE DATA

		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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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					
$T_{amb} = 25 \text{ }^\circ\text{C}$ (free air)	P_{tot}	max.	2	W	
$T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	10	W	
Junction temperature	T_j	max.	150	$^\circ\text{C}$	
D.C. current gain					
$-I_C = 1 \text{ A}; -V_{CE} = 2 \text{ V}$	h_{FE}	>	25		
Transition frequency at $f = 35 \text{ MHz}$	f_T	typ.	50	MHz	

MECHANICAL DATA

Fig. 1 TO-202.

Collector connected to mounting base.



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 ($R_{BE} = 1 \text{ k}\Omega$)	$-V_{CER}$	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					
$T_{amb} = 25 \text{ }^\circ\text{C}$ (free air)	P_{tot}	max.	2		W
$T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	10		W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Collector cut-off current

 $I_E = 0; -V_{CB} = 30\text{ V}$ $-I_{CBO} < 100\text{ nA}$ $I_E = 0; -V_{CB} = 30\text{ V}; T_j = 125\text{ }^\circ\text{C}$ $-I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

Base-emitter voltage*

 $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$ $-V_{BE} < 1,3\text{ V}$

Collector-emitter saturation voltage

 $-I_C = 1\text{ A}; -I_B = 0,1\text{ A}$ $-V_{CEsat} < 0,8\text{ V}$

D.C. current gain

 $-I_C = 5\text{ mA}; -V_{CE} = 2\text{ V}$ $h_{FE} > 25$ $-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$ $h_{FE} 40\text{ to }250$ $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$ $h_{FE} > 25$ Transition frequency at $f = 35\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 5\text{ V}$ $f_T \text{ typ. } 50\text{ MHz}$

D.C. current gain ratio

of BD839/BD840, BD841/BD842, BD843/BD844

 $|I_C| = 150\text{ mA}; |V_{CE}| = 2\text{ V}$ $h_{FE1}/h_{FE2} \text{ typ. } 1,3$
 $< 1,6$ * V_{BE} decreases by about $2,3\text{ mV/K}$ with increasing temperature.

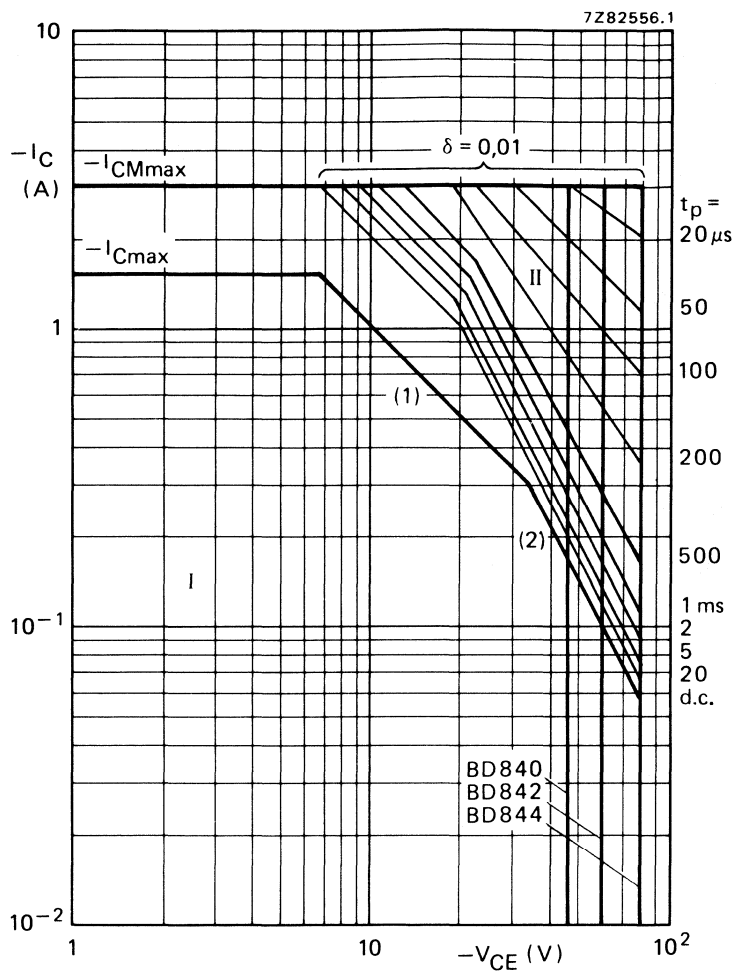


Fig. 2 Safe Operating Area, $T_{mb} \leq 25^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

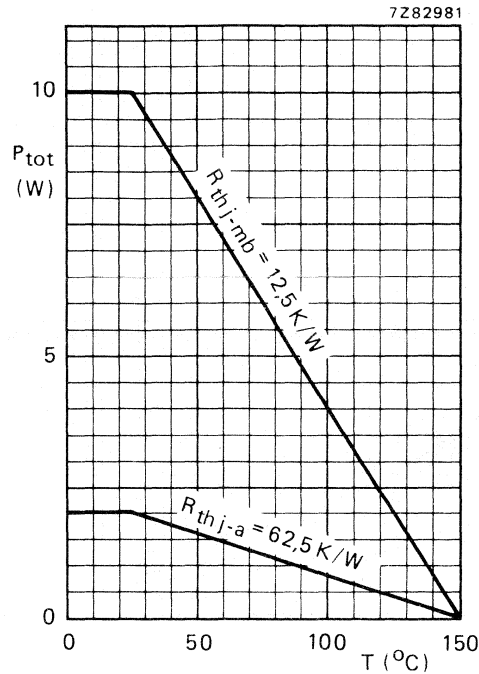


Fig. 3 Power derating curve.

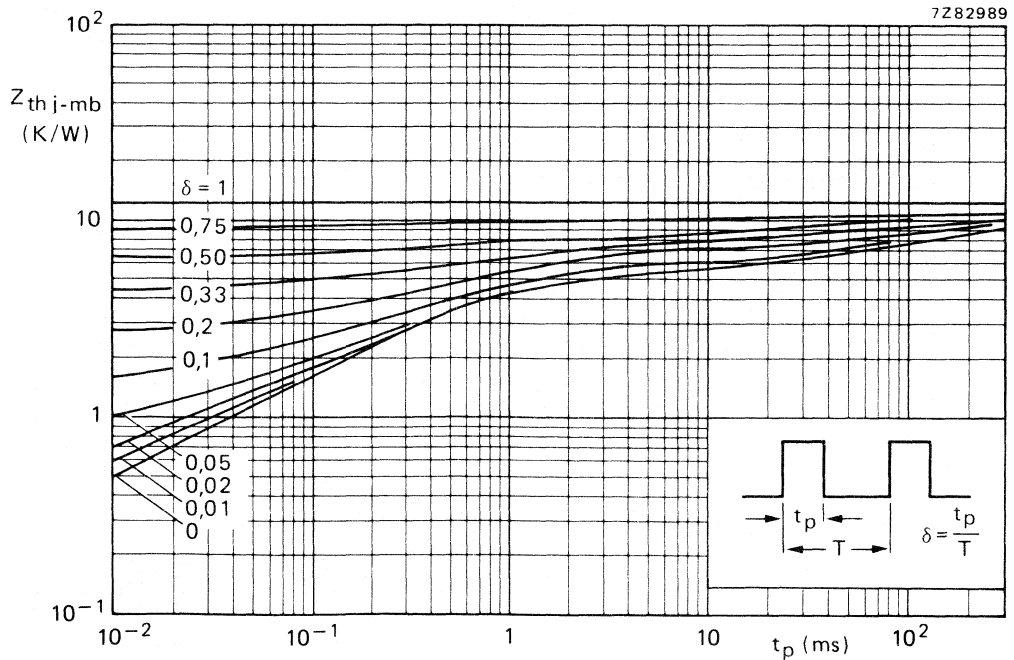


Fig. 4 Pulse power rating chart.

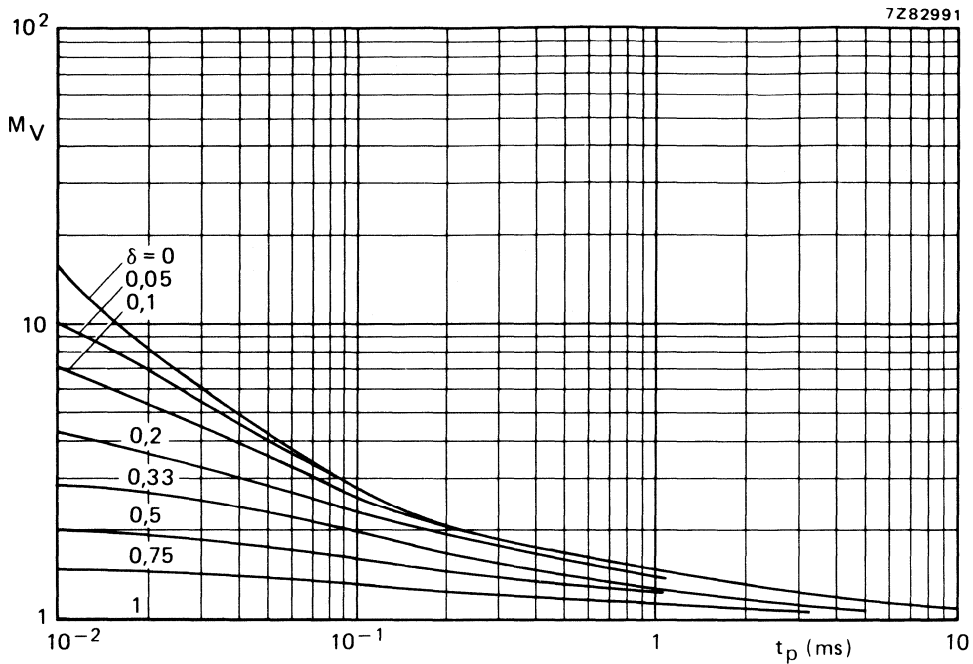


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

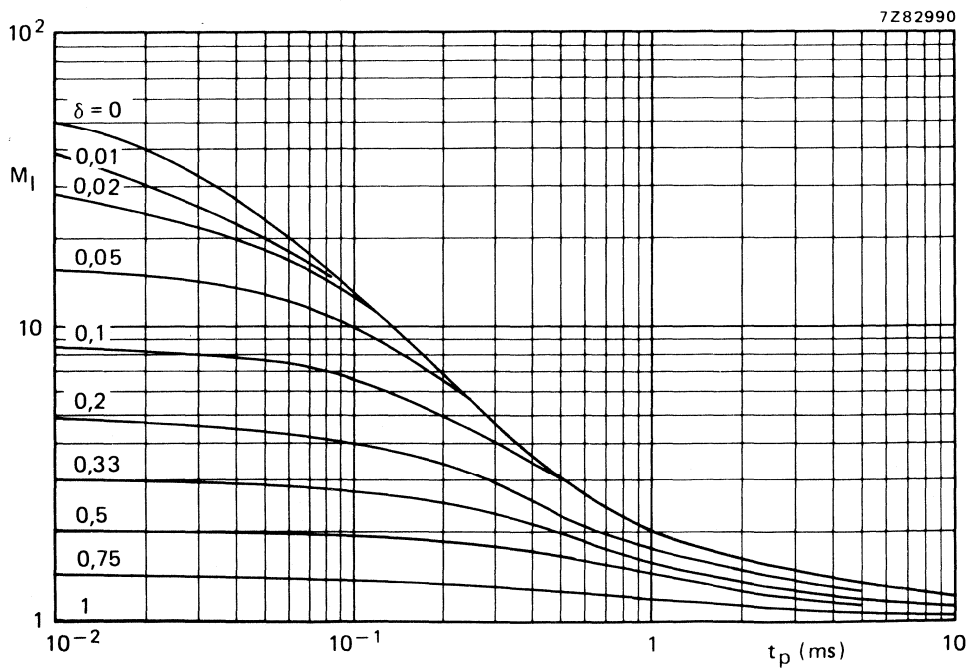


Fig. 6 S.B. current multiplying factor at the V_{CE0max} level.

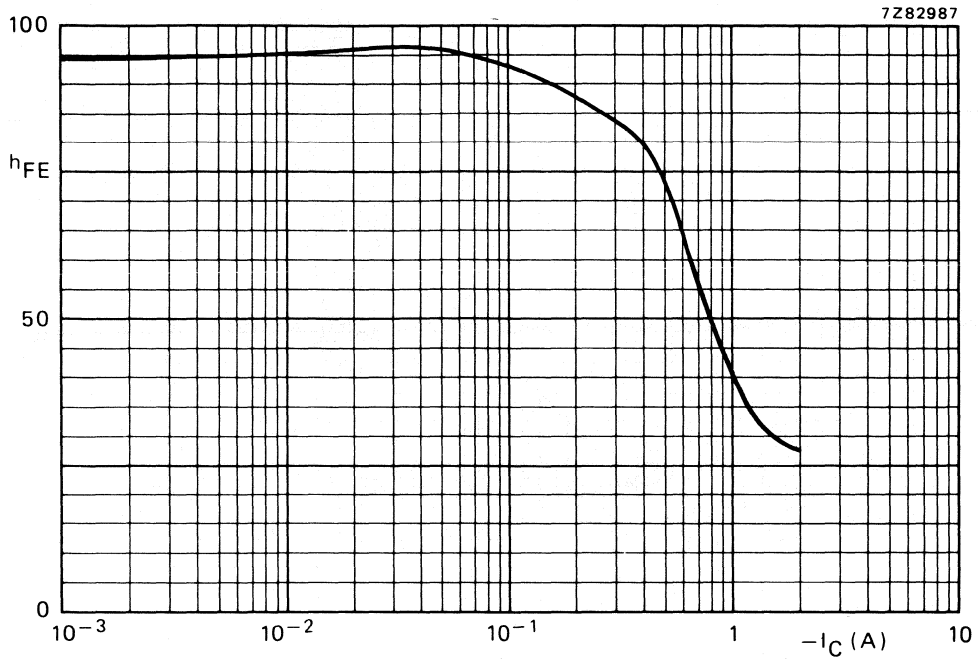


Fig. 7 Typical values d.c. current gain. $-V_{CE} = 2 \text{ V}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

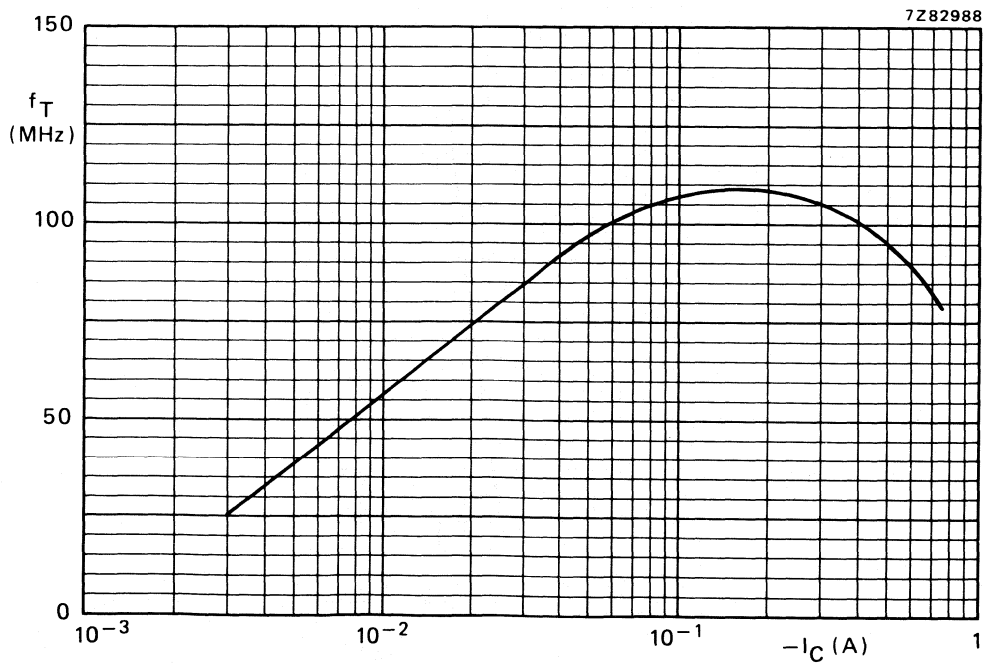


Fig. 8 Typical values transition frequency. $-V_{CE} = 5 \text{ V}$; $f = 35 \text{ MHz}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

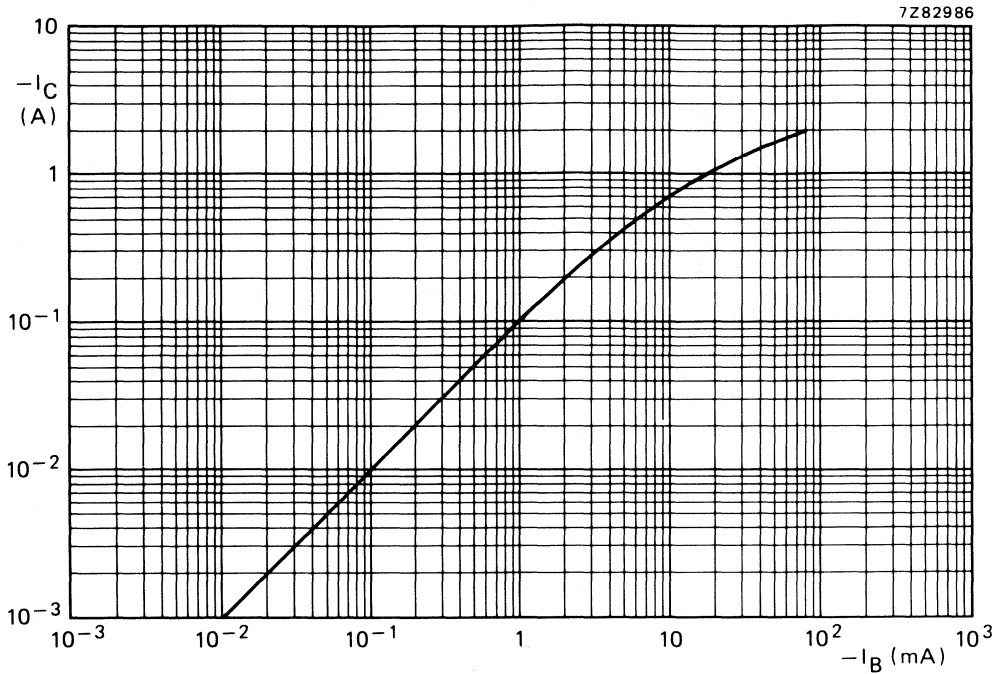


Fig. 9 Typical values at $-V_{CE} = 2$ V; $T_{amb} = 25$ °C.

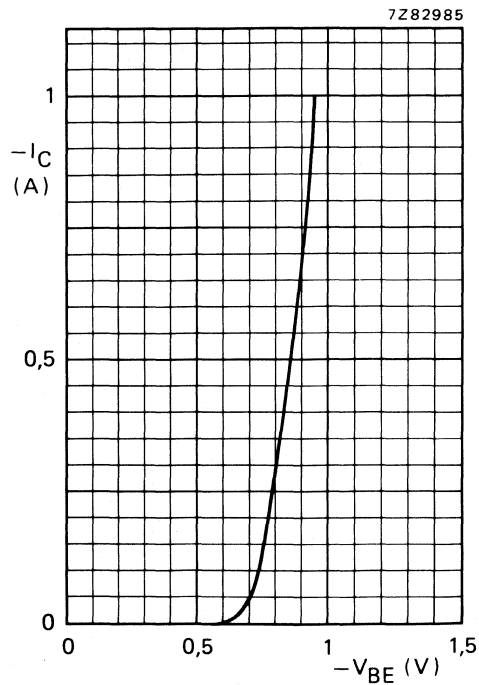


Fig. 10 Typical values. $-V_{CE} = 2$ V; $T_{amb} = 25$ °C.

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

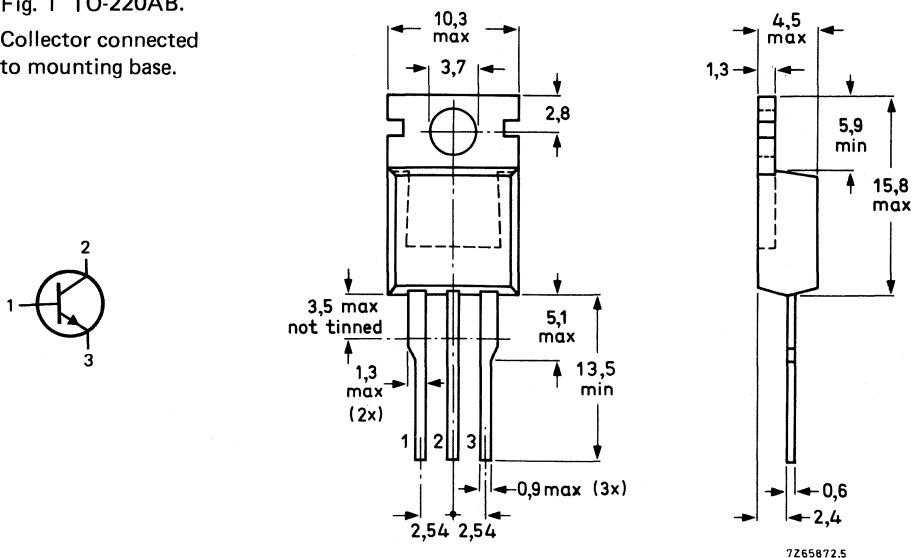
		BD933	935	937	939	941
Collector-base voltage	V_{CBO} max.	45	60	100	120	140 V
Collector-emitter voltage	V_{CEO} max.	45	60	80	100	120 V
Collector current (d.c.)	I_C max.			3		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			30		W
Junction temperature	T_j max.			150	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

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			30			W	
Storage temperature	T_{stg}		-65 to + 150						$^\circ\text{C}$
Junction temperature	T_j	max.			150			$^\circ\text{C}$	

THERMAL RESISTANCE

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

CHARACTERISTICS

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

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

* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}$; $\delta < 2\%$.

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

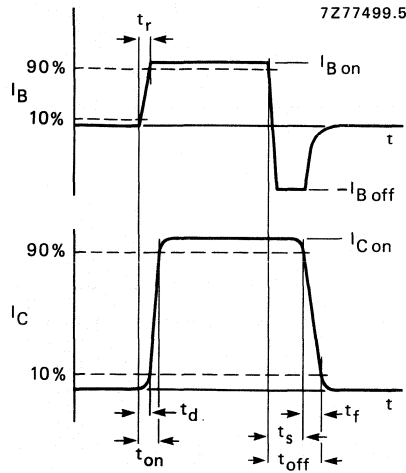


Fig. 2 Switching times waveforms.

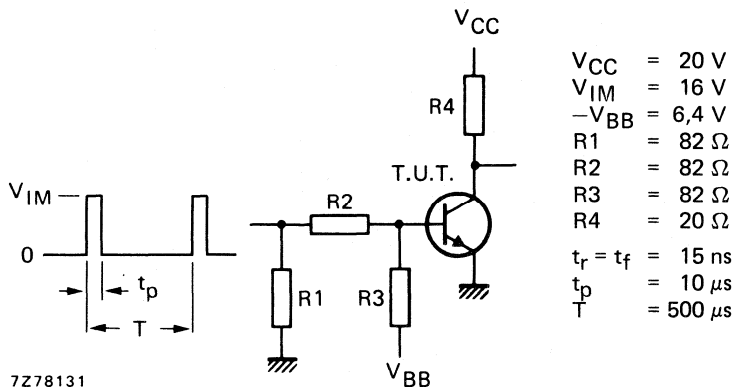


Fig. 3 Switching times test circuit.

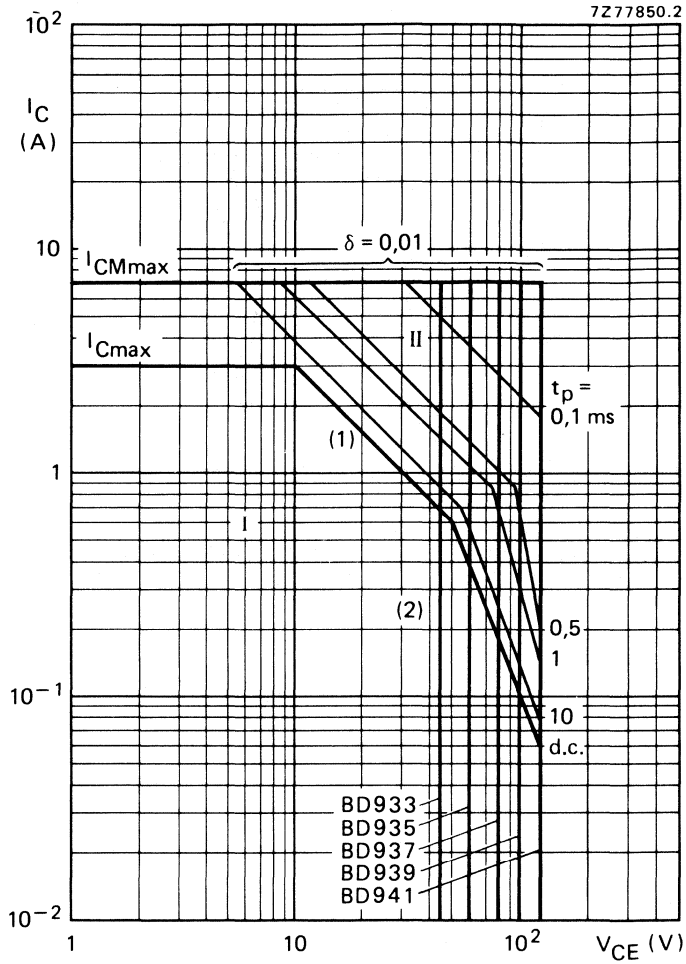


Fig. 4 Safe Operating Area; $T_{mb} = 25^{\circ}\text{C}$.

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

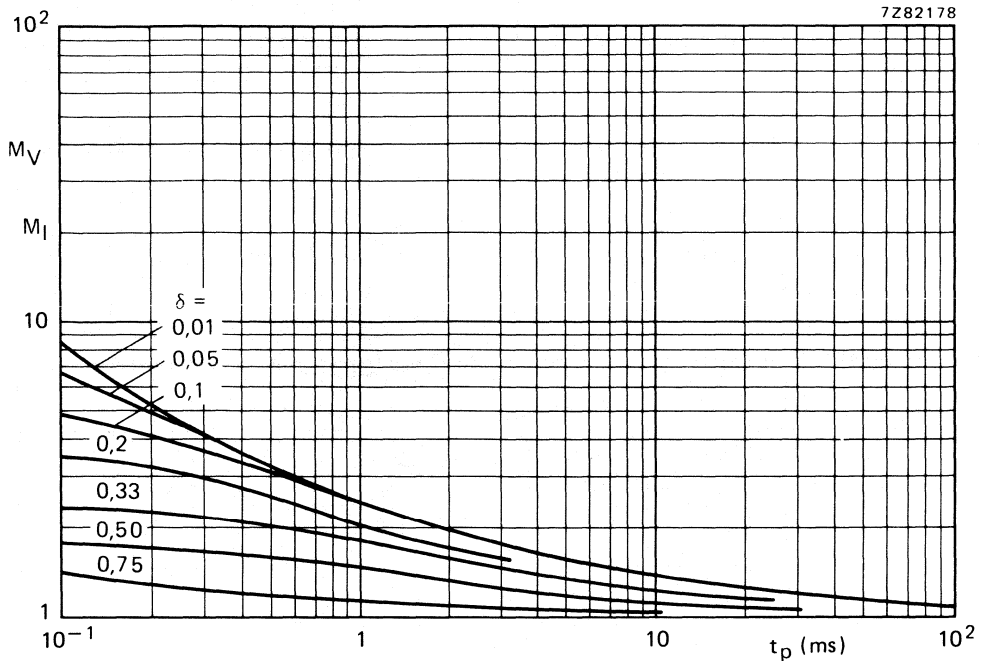


Fig. 5 Second-breakdown voltage multiplying factor at the I_{Cmax} level and second-breakdown current multiplying factor at the V_{CE0max} level.

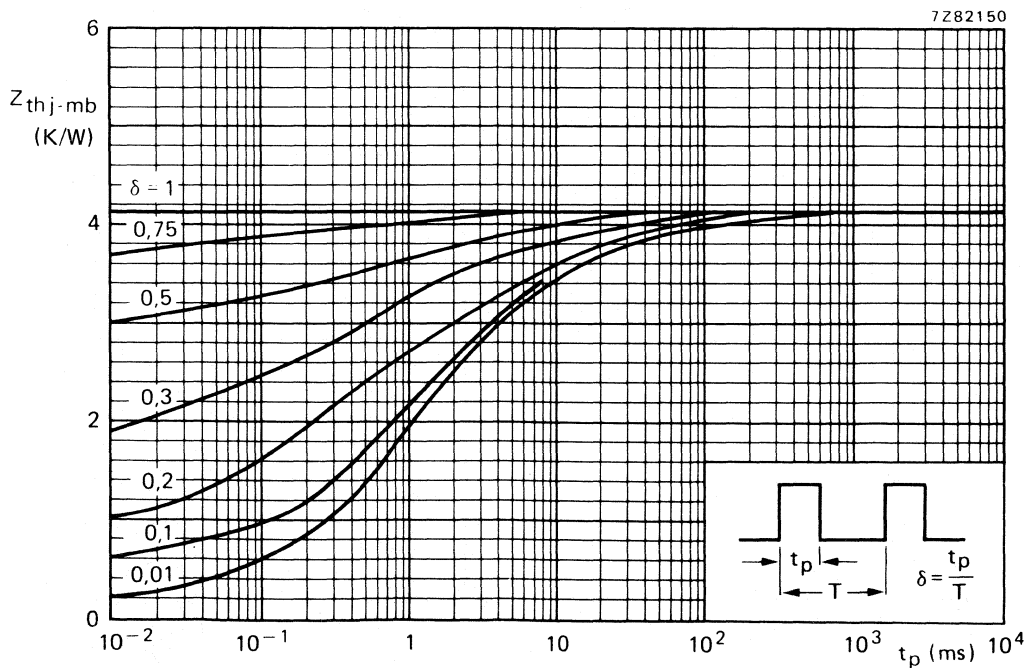


Fig. 6 Pulse power rating chart.

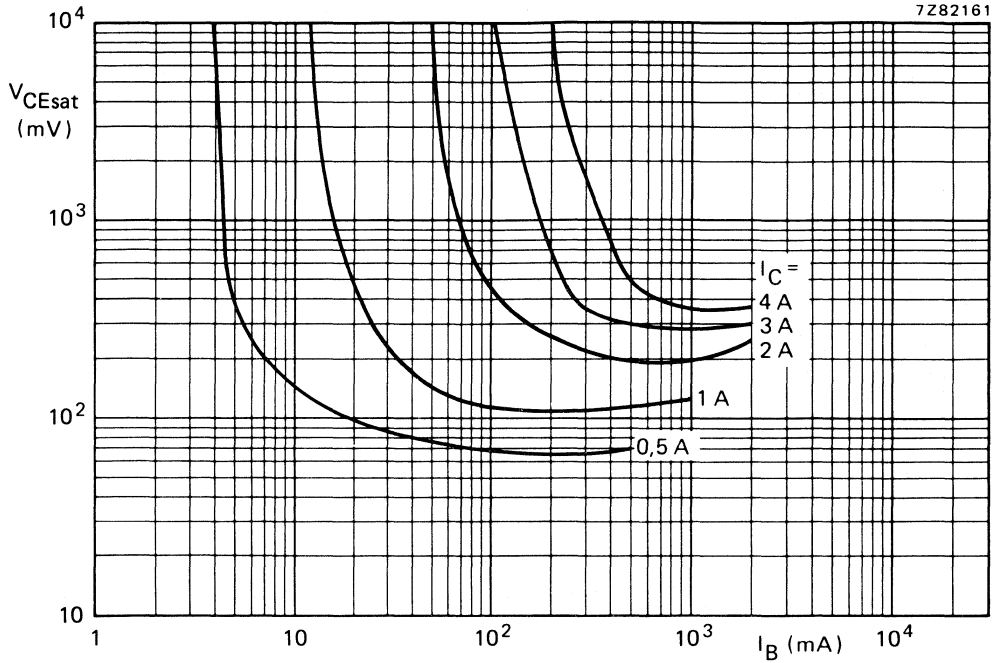


Fig. 7 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

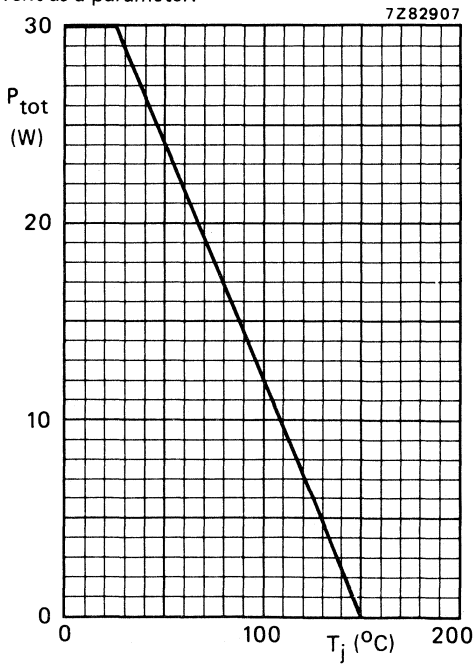


Fig. 8 Power derating curve.

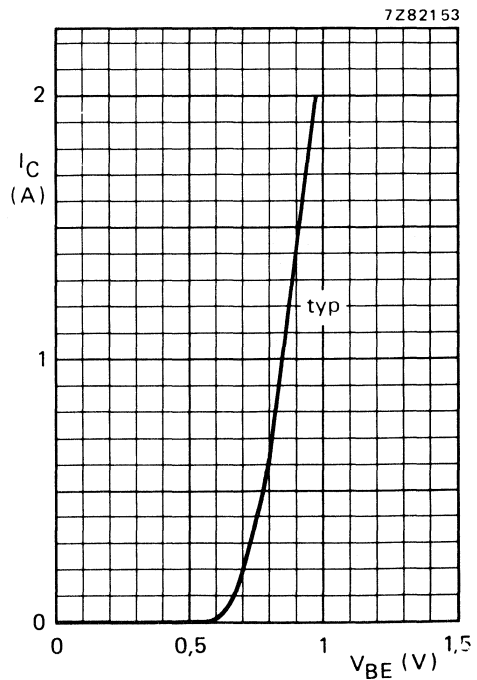


Fig. 9 $V_{CE} = 2 V$; $T_j = 25 ^{\circ}C$.

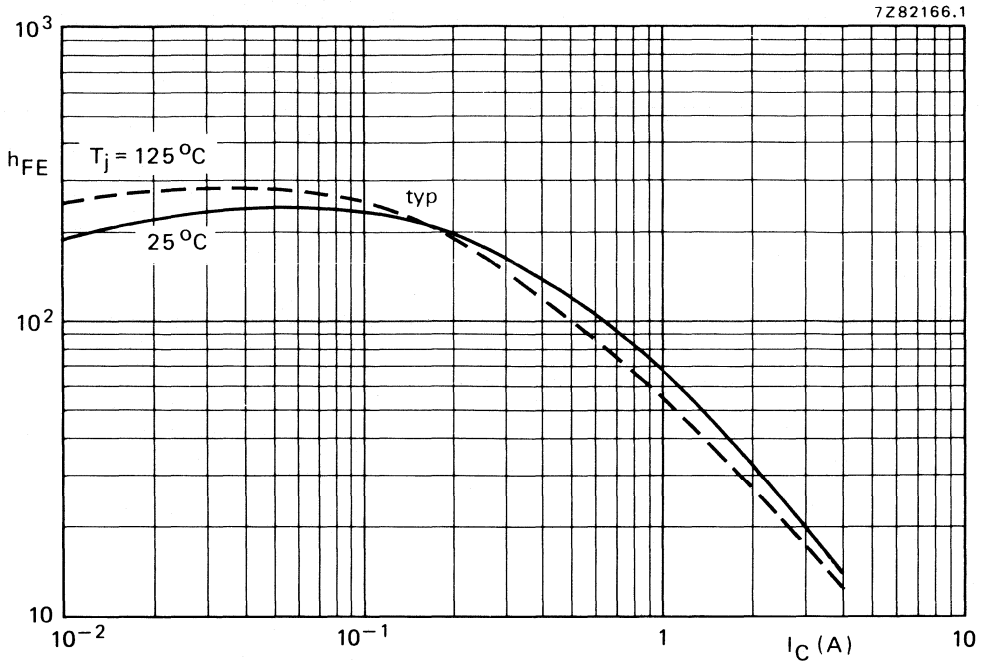


Fig. 10 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 2\text{ V}$

SILICON EPITAXIAL POWER TRANSISTORS

N-P-N silicon power transistor in a SOT-186 envelope with an electrically insulated mounting base, intended for use in audio output stages and for general purpose amplifier applications.

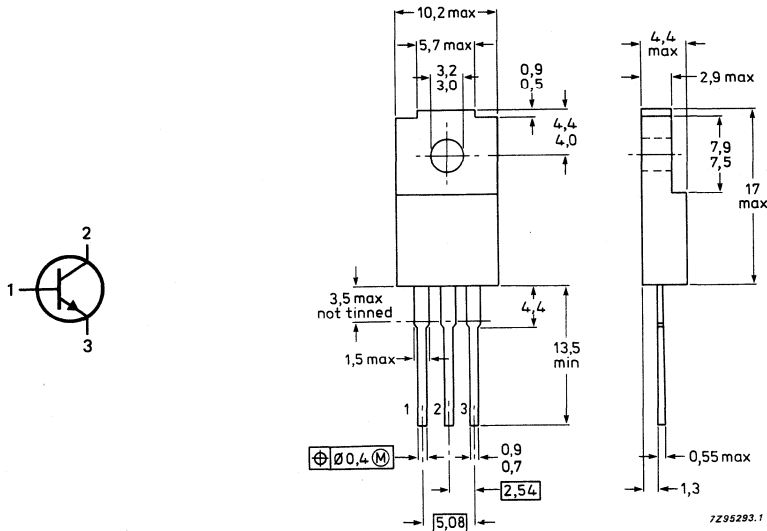
P-N-P complements are BD934F, BD936F, BD938F, BD940F and BD942F.

QUICK REFERENCE DATA

			BD933F	935F	937F	939F	941F	
Collector-base voltage (open emitter)	V_{CB0}	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 $T_h = 25^\circ\text{C}$	P_{tot}	max.			19			W
D.C. current gain $I_C = 1\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	min.			25			
Transition frequency at $f = 1\text{ MHz}$ $I_C = 250\text{ mA}; V_{CE} = 10\text{ V}$	f_T	min.			3			MHz

Fig. 1 SOT-186.

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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.			14			W	
up to $T_h = 25\text{ }^\circ\text{C}$ (2)	P_{tot}	max.			19			W	
Storage temperature	T_{stg}				-65 to 150			$^\circ\text{C}$	
Junction temperature	T_j	max.			150			$^\circ\text{C}$	

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=			4,17			K/W
From junction to external heatsink (1)	$R_{th\ j-h}$	=			9,17			K/W
From junction to external heatsink (2)	$R_{th\ j-h}$	=			6,67			K/W
From junction to ambient	$R_{th\ j-a}$	=			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-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 $T_h = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure $p_{amb} = 1013\text{ mbar}$.

CHARACTERISTICS

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

Collector cut-off currents

$I_E = 0; V_{CB} = V_{CB0max}$
 $I_E = 0; V_{CB} = V_{CB0max}; T_h = 150\text{ }^\circ\text{C}$
 $I_E = 0; V_{CE} = V_{CE0max}$

$I_{CBO} < 0,1\text{ mA}$
 $I_{CBO} < 3\text{ mA}$
 $I_{CEO} < 0,5\text{ mA}$

Emitter cut-off current

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

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

D.C. current gain (1)

$I_C = 1\text{ A}; V_{CE} = 2\text{ V}$
 $I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$

$h_{FE} > 25$
 $h_{FE} 40\text{ to }250$

Base-emitter voltage (1)+(2)

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

$V_{BE} < 1,3\text{ V}$

Collector-emitter saturation voltage (1)

$I_C = 1\text{ A}; I_B = 0,1\text{ A}$

$V_{CEsat} < 0,6\text{ V}$

Transition frequency at $f = 1\text{ MHz}$

$I_C = 250\text{ mA}; V_{CE} = 10\text{ V}$

$f_T > 3\text{ MHz}$

Second-breakdown collector current

$V_{CE} = 40\text{ V}; t_p = 1\text{ s};$
 non-repetitive, without heatsink

$I_{SB} > 475\text{ mA}$

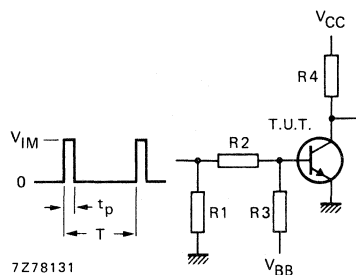
Switching times

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

turn-on time

turn-off time

t_{on} typ. $0,4\text{ }\mu\text{s}$
 $< 1\text{ }\mu\text{s}$
 t_{off} typ. $1,5\text{ }\mu\text{s}$
 $< 3\text{ }\mu\text{s}$



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

Fig. 2 Switching times test circuit.

(1) Measured under pulse conditions: $t_p = 300\text{ }\mu\text{s}; \delta = 0,02$.

(2) V_{BE} decreases by about $2,3\text{ mV/K}$ with increasing temperature.

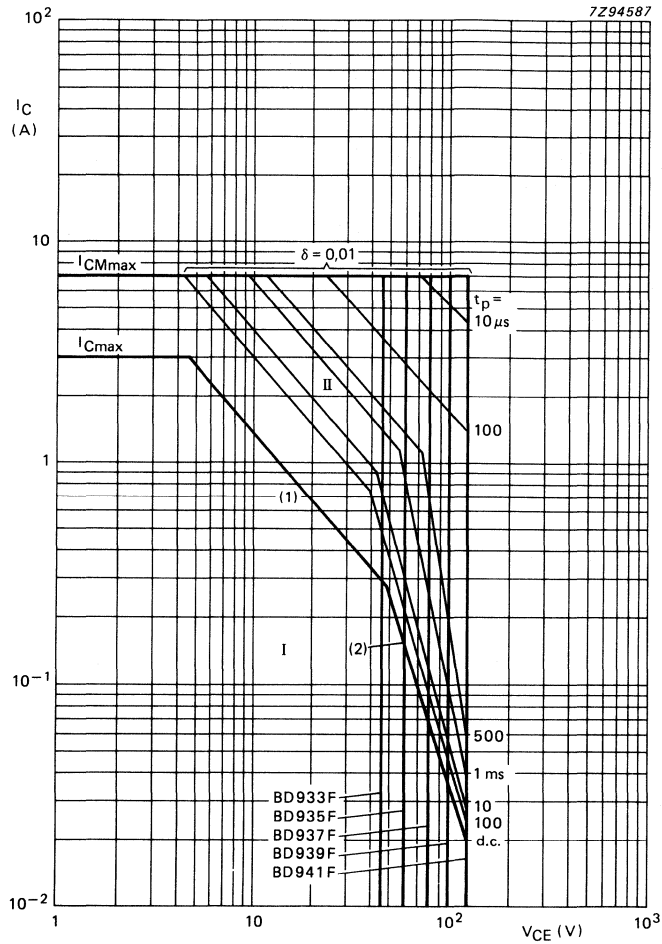


Fig. 4 Safe Operating Area, $T_{amb} = 25\text{ }^{\circ}\text{C}$.

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

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

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

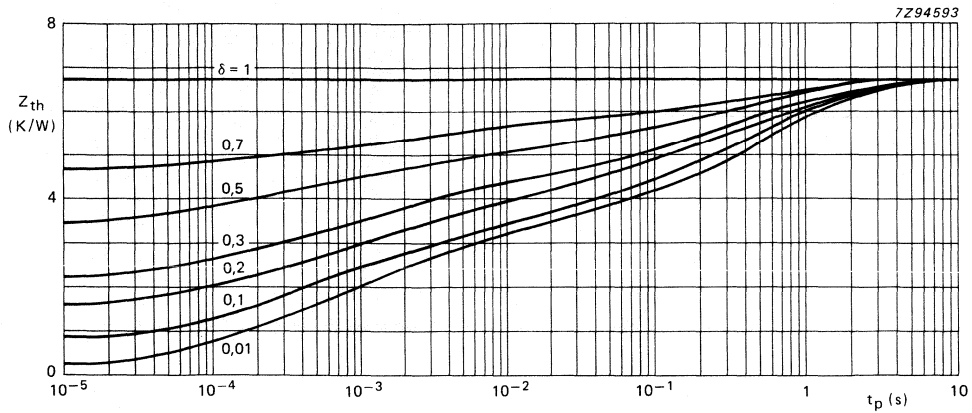


Fig. 5 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

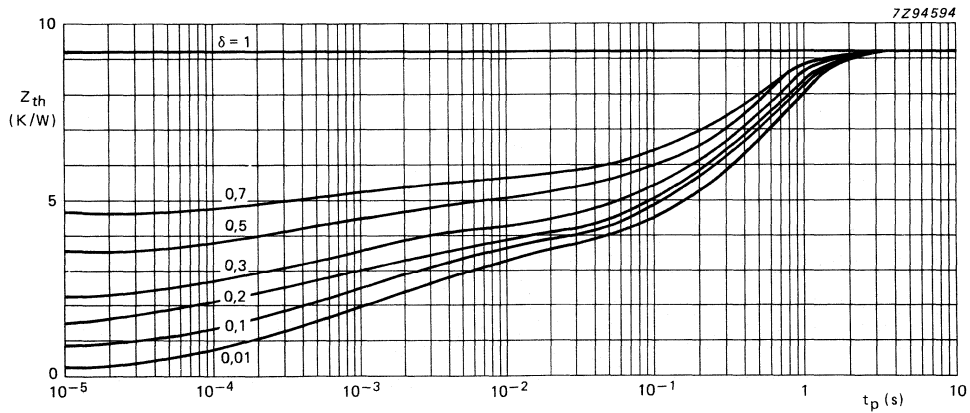


Fig. 6 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

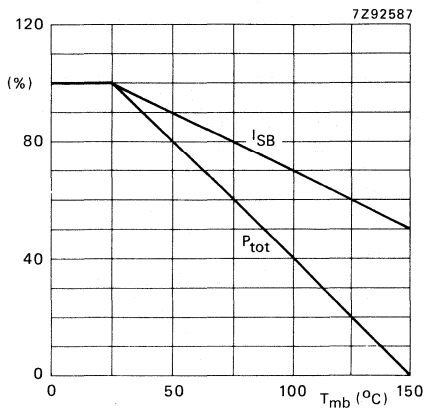


Fig. 7 Total power dissipation and second-breakdown current derating curve.

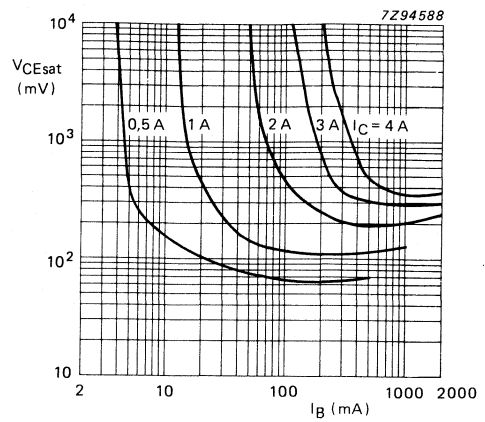


Fig. 8 Collector-emitter saturation voltage; typical values.

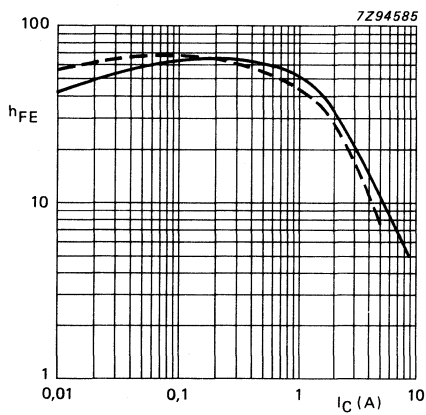


Fig. 9 D.C. current gain; $V_{CE} = 2\text{ V}$; typical values;
 — $T_j = 25\text{ °C}$; - - - $T_j = 125\text{ °C}$.

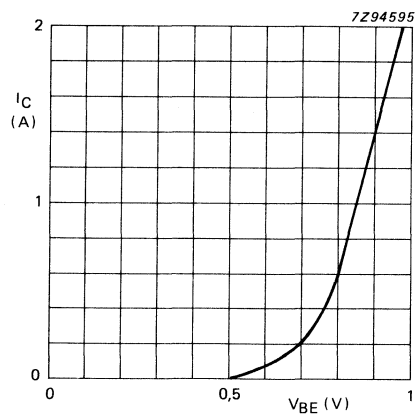


Fig. 10 $V_{CE} = 2\text{ V}$; typical values.

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

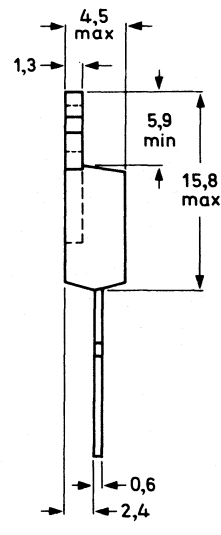
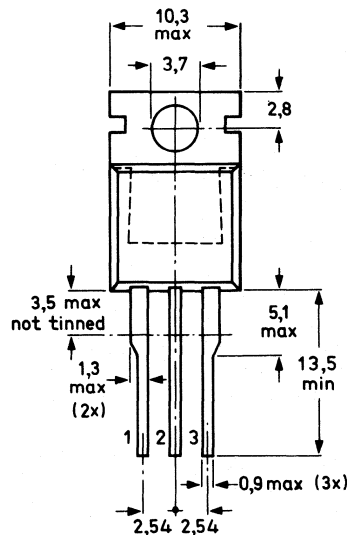
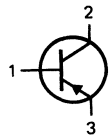
		BD934	936	938	940	942
Collector-base voltage	$-V_{CBO}$ max.	45	60	100	120	140 V
Collector-emitter voltage	$-V_{CEO}$ max.	45	60	80	100	120 V
Collector current (d.c.)	$-I_C$ max.			3		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			30		W
Junction temperature	T_j max.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

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



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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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			30			W
Storage temperature	T_{stg}		-65 to + 150					$^\circ\text{C}$
Junction temperature	T_j	max.			150			$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

→ Collector cut-off current								
$-I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<			50			μA
$-I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<			1			mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<			0,1			mA
→ Emitter cut-off current								
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<			0,2			mA
D.C. current gain (note 1)								
$-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$	h_{FE}				40 to 250			
$-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$	h_{FE}	>			25			
Base-emitter voltage (notes 1 and 2)								
$-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$	$-V_{BE}$	<			1,3			V
Collector-emitter saturation voltage (note 1)								
$-I_C = 1\text{ A}; -I_B = 0,1\text{ A}$	$-V_{CEsat}$	<			0,6			V
Transition frequency at $f = 1\text{ MHz}$								
$-I_C = 250\text{ mA}; -V_{CE} = 10\text{ V}$	f_T	>			3			MHz
Switching times								
$-I_{Con} = 1\text{ A}; -I_{Bon} = I_{Boff} = 0,1\text{ A}$								
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: $t_p \leq 300\text{ }\mu\text{s}$; $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 2,3 mV/K with increasing temperature.

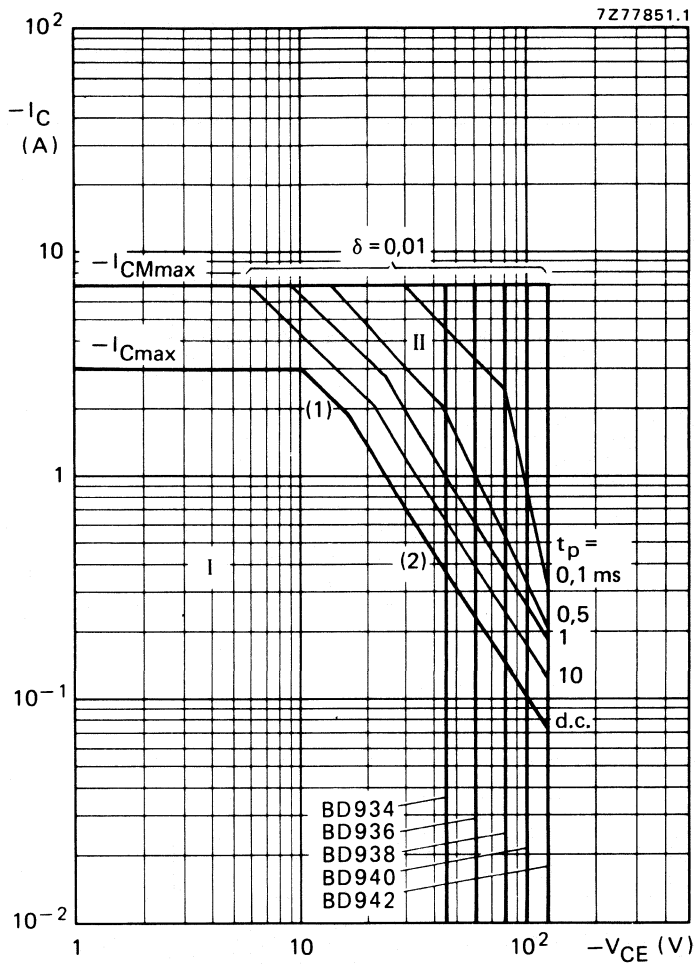


Fig. 2 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

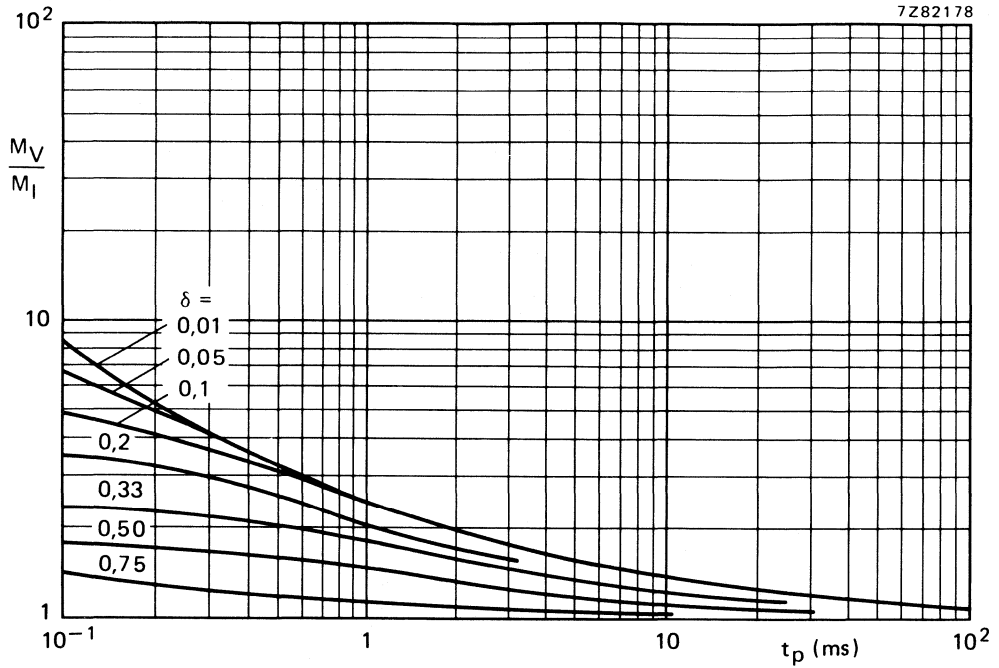


Fig. 3 Second breakdown voltage multiplying factor at the I_{Cmax} level and second breakdown current multiplying factor at the V_{CE0max} level.

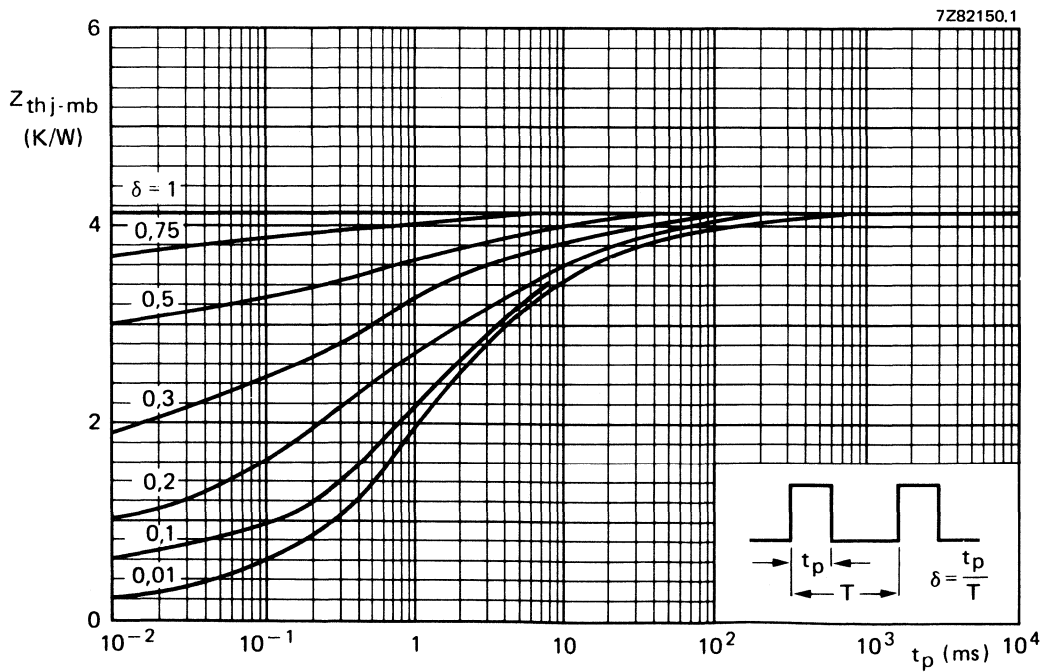


Fig. 4 Pulse power rating chart.

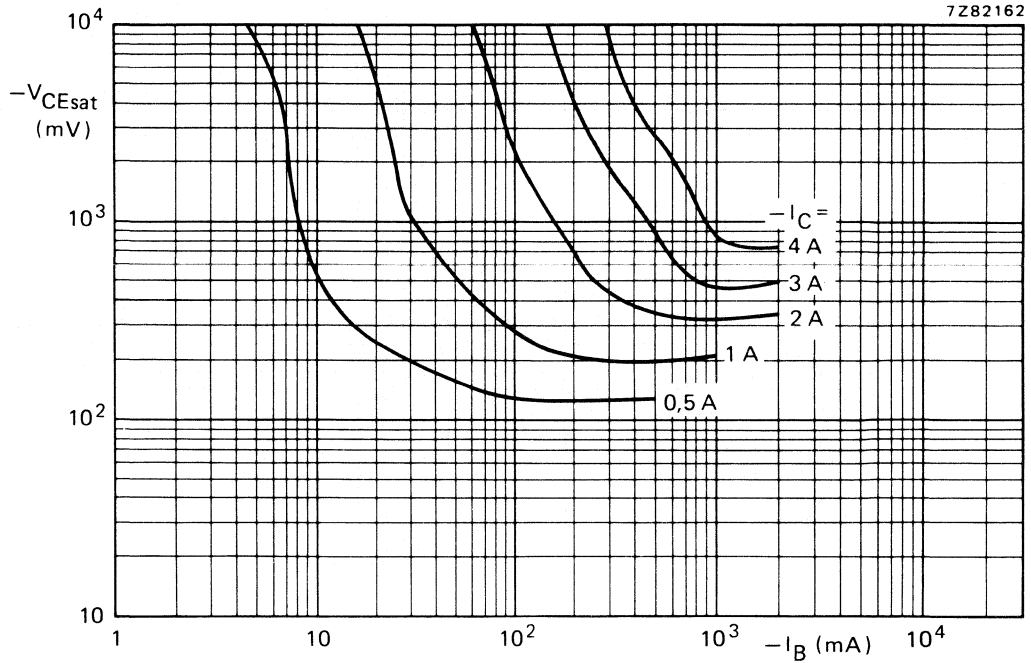


Fig. 5 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

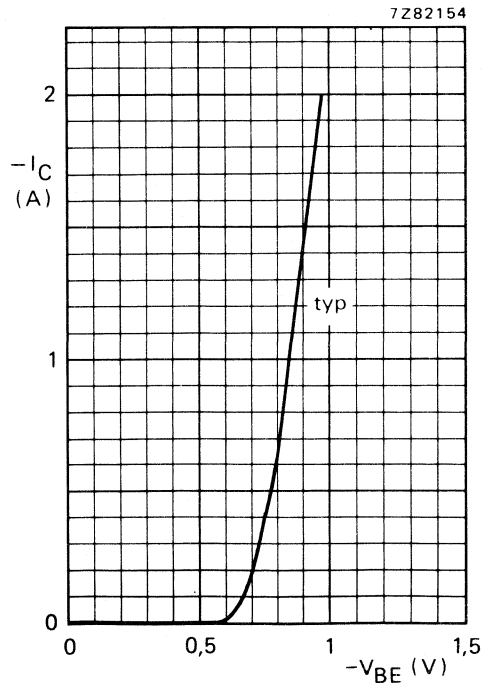


Fig. 6 Typical collector current as a function of base-emitter voltage. $-V_{CE} = 2$ V; $T_j = 25$ °C.

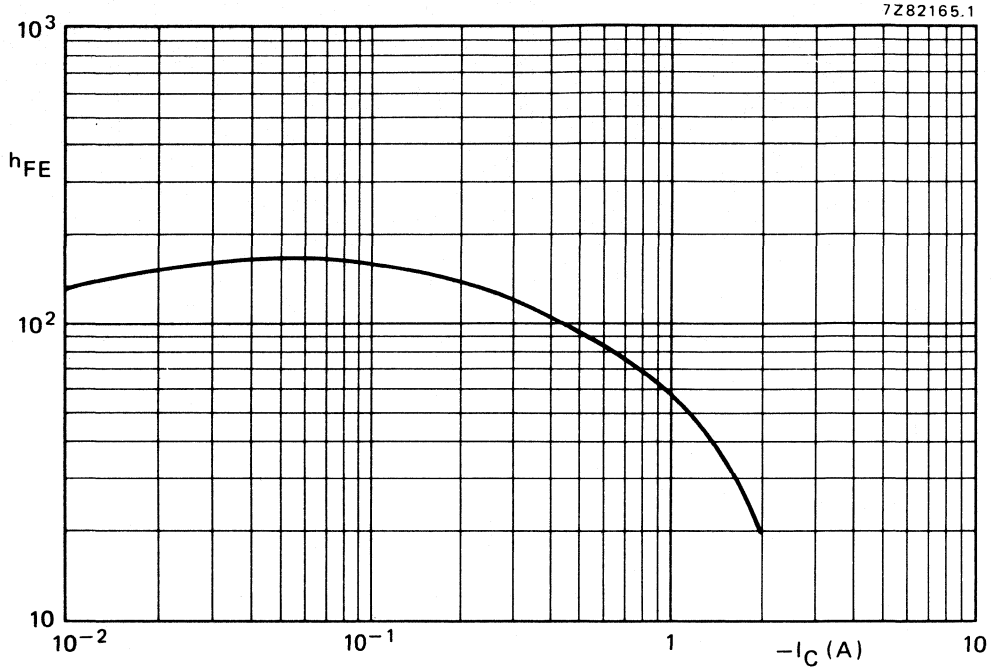


Fig. 7 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 2$ V;
 $T_j \leq 25$ °C.

SILICON EPITAXIAL POWER TRANSISTORS

P-N-P silicon power transistor in a SOT-186 envelope with an electrically insulated mounting base, intended for use in audio output stages and for general purpose amplifier applications.

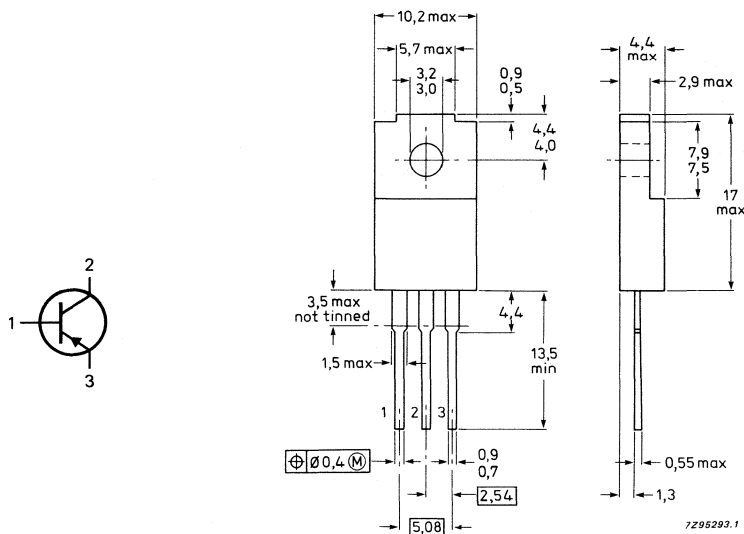
N-P-N complements are BD933F, BD935F, BD937F, BD939F and BD941F.

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 $T_h = 25\text{ }^\circ\text{C}$	P_{tot}	max.			19		W
D.C. current gain $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$	h_{FE}	min.			25		
Transition frequency at $f = 1\text{ MHz}$ $-I_C = 250\text{ mA}; -V_{CE} = 10\text{ V}$	f_T	min.			3		MHz

Fig. 1 SOT-186.

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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.		14			W
up to $T_h = 25\text{ }^\circ\text{C}$ (2)	P_{tot}	max.		19			W
Storage temperature	T_{stg}			-65 to 150			$^\circ\text{C}$
Junction temperature	T_j	max.		150			$^\circ\text{C}$

THERMAL RESISTANCE

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

INSULATION

Voltage allowed between all terminals
and external heatsink,
peak value (3)

V_{insul}	max.		1000				V
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Insulation capacitance between
collector and external heatsink

C_{c-h}	typ.		12				pF
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(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 $T_h = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure
 $P_{amb} = 1013\text{ mbar}$.

CHARACTERISTICS

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

Collector cut-off currents

- $-I_E = 0; -V_{CB} = V_{CB0max}$
- $-I_E = 0; -V_{CB} = V_{CB0max}; T_h = 150\text{ }^\circ\text{C}$
- $-I_E = 0; -V_{CE} = V_{CEOmax}$

$-I_{CBO}$	<	0,1 mA
$-I_{CBO}$	<	3 mA
$-I_{CEO}$	<	0,5 mA

Emitter cut-off current

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

$-I_{EBO}$	<	1 mA
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D.C. current gain (1)

- $-I_C = 1\text{ A}; -V_{CE} = 2\text{ V}$
- $-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$

h_{FE}	>	25
h_{FE}		40 to 250

Base-emitter voltage (1)+(2)

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

$-V_{BE}$	<	1,3 V
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Collector-emitter saturation voltage (1)

- $-I_C = 1\text{ A}; -I_B = 0,1\text{ A}$

$-V_{CEsat}$	<	0,6 V
--------------	---	-------

Transition frequency at $f = 1\text{ MHz}$

- $-I_C = 250\text{ mA}; -V_{CE} = 10\text{ V}$

f_T	>	3 MHz
-------	---	-------

Second-breakdown collector current

- $-V_{CE} = 40\text{ V}; t_p = 1\text{ s};$
non-repetitive, without heatsink

$-I_{SB}$	>	475 mA
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Switching times

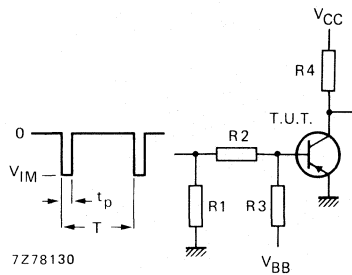
- $-I_C = 1\text{ A}; -I_{Bon} = +I_{Boff} = 0,1\text{ A}$

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: $t_p = 300\text{ } \mu\text{s}; \delta = 0,02$.

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

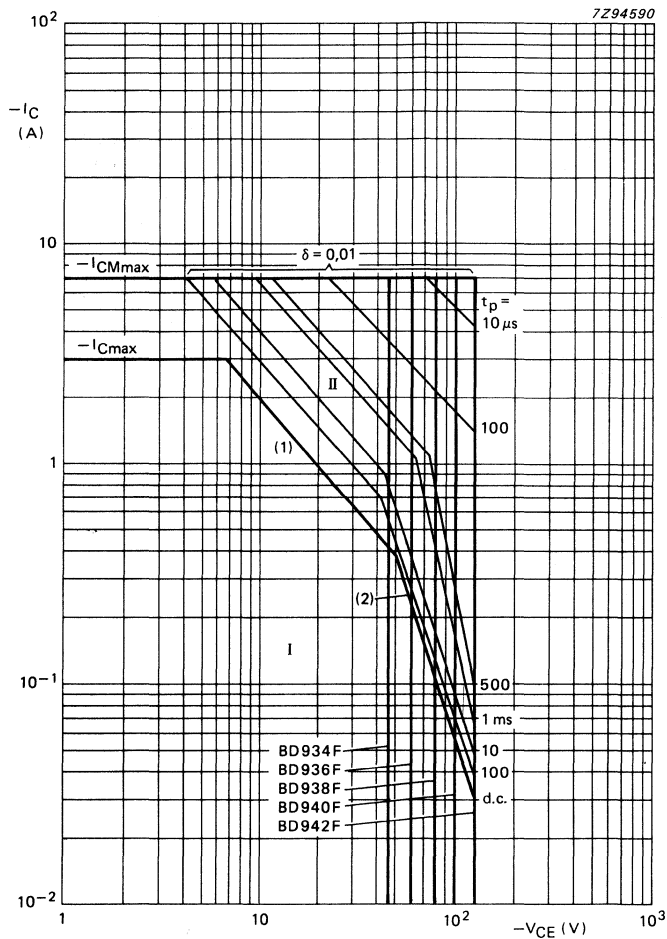


Fig. 3 Safe Operating Area, $T_{amb} = 25^\circ C$.

- 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.

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

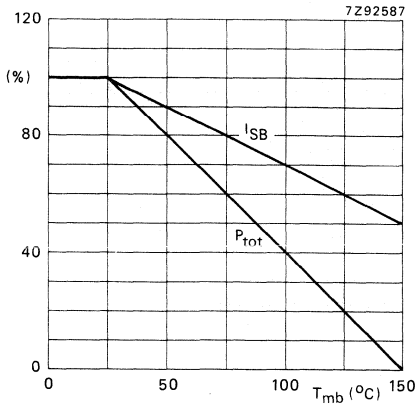


Fig. 7 Total power dissipation and second-breakdown current derating curve.

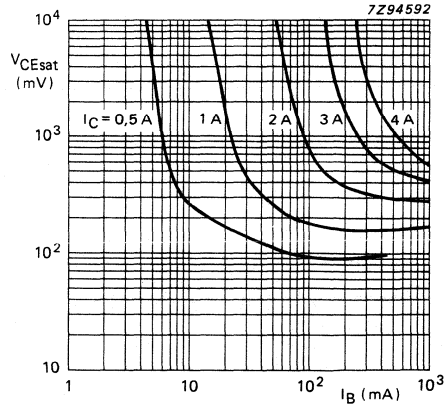


Fig. 8 Collector-emitter saturation voltage; typical values.

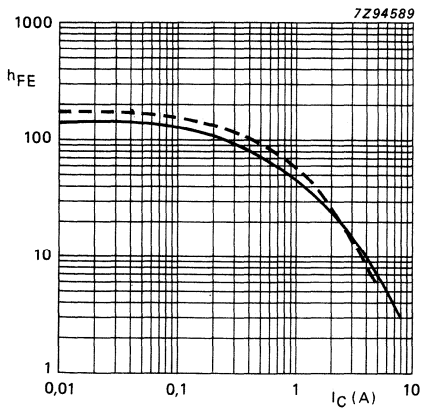


Fig. 9 D.C. current gain; $-V_{CE} = 2\text{ V}$; typical values;
— $T_j = 25\text{ }^\circ\text{C}$; - - - $T_j = 125\text{ }^\circ\text{C}$.

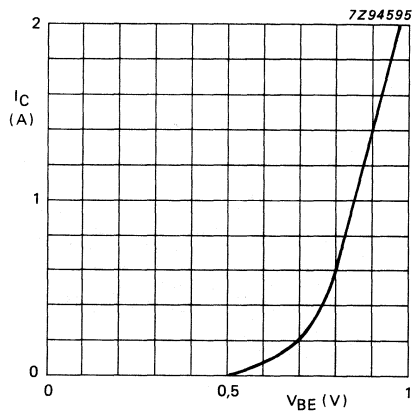


Fig. 10 $-V_{CE} = 2\text{ V}$; typical values.

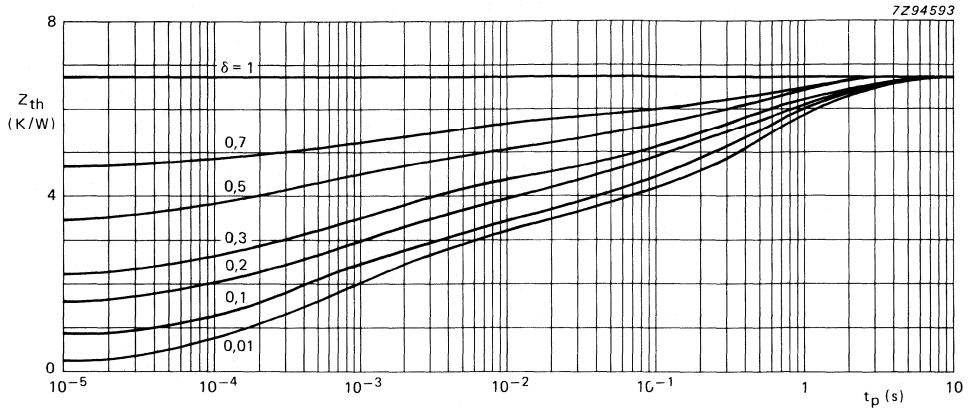


Fig. 5 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

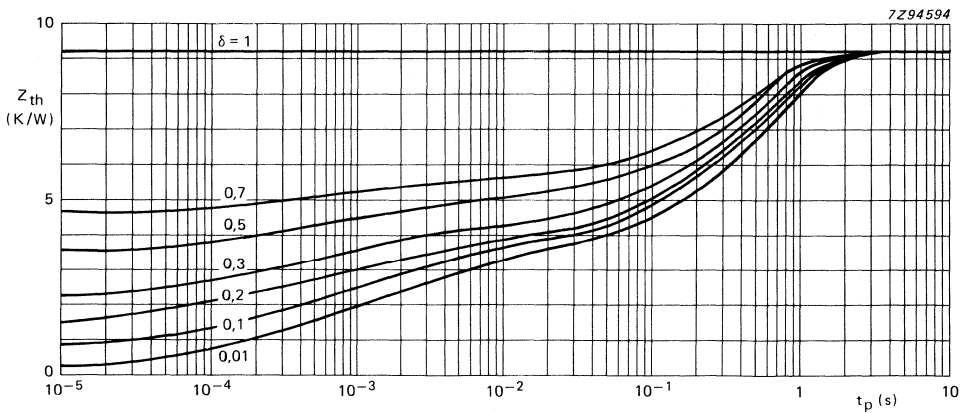


Fig. 6 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

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

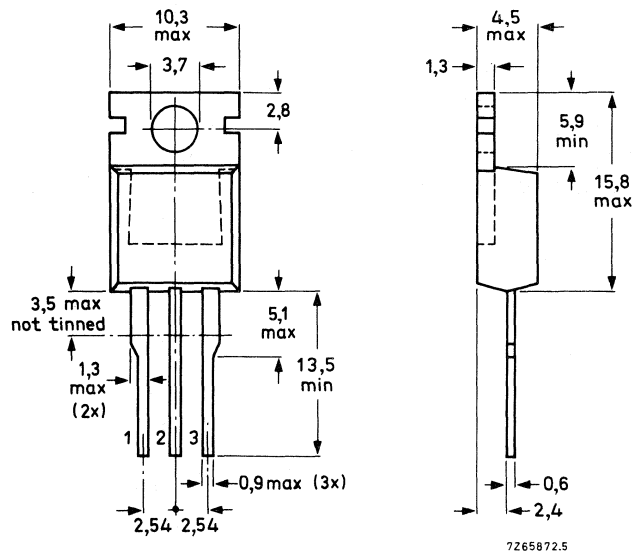
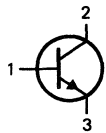
		BD943	945	947
Collector-base voltage (open emitter)	V_{CBO} max.	22	32	45 V
Collector-emitter voltage (open base)	V_{CEO} max.	22	32	45 V
Collector current (d.c.)	I_C max.		5	A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		40	W
Junction temperature	T_j max.		150	$^\circ\text{C}$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

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

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_{CB0}	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		40	W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0max}$	I_{CB0}	<		0,1	mA
$I_E = 0; V_{CB} = V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$ 15 V; BD943	I_{CB0}	<		3	mA
$I_B = 0; V_{CE} = 20\text{ V};$ BD945 25 V; BD947	I_{CEO}	<		0,5	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<		1	mA
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D.C. current gain (note 1)

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	h_{FE}	>		25	
$I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$	h_{FE}			85 to 475	
$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	>	50	50	40
$I_C = 3\text{ A}; V_{CE} = 1\text{ V}$	h_{FE}	>	-	-	30

Base-emitter voltage (notes 1 and 2)

$I_C = 2\text{ A}; V_{CE} = 1\text{ V}$	V_{BE}	<	1,1	1,1	- V
$I_C = 3\text{ A}; V_{CE} = 1\text{ V}$	V_{BE}	<	-	-	1,3 V

Collector-emitter saturation voltage (note 1)

$I_C = 2\text{ A}; I_B = 0,2\text{ A}$	V_{CEsat}	<	0,5	0,5	- V
$I_C = 3\text{ A}; I_B = 0,3\text{ A}$	V_{CEsat}	<	-	-	0,7 V

Notes

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

Knee voltage*

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

$I_C = 2,2 \text{ A}$ and $V_{CE} = 1 \text{ V}$

Transition frequency at $f = 1 \text{ MHz}$

$I_C = 250 \text{ mA}$; $V_{CE} = 1 \text{ V}$

$V_{CEK} < 0,8 \text{ V}$

$f_T > 3 \text{ MHz}$

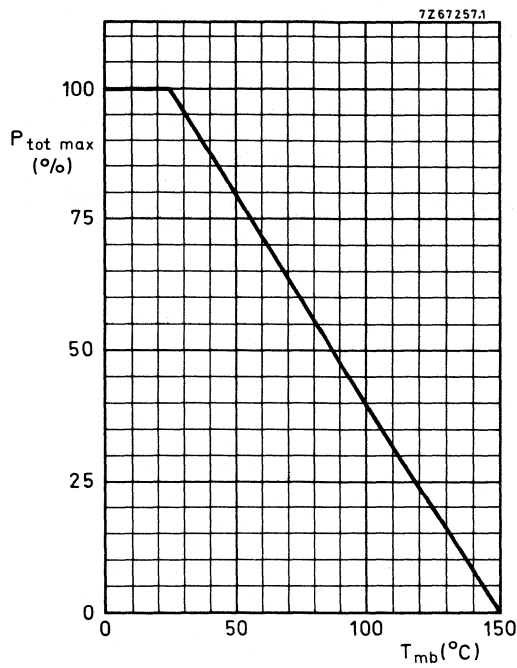


Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leq 300 \mu\text{s}$; $\delta < 2\%$.

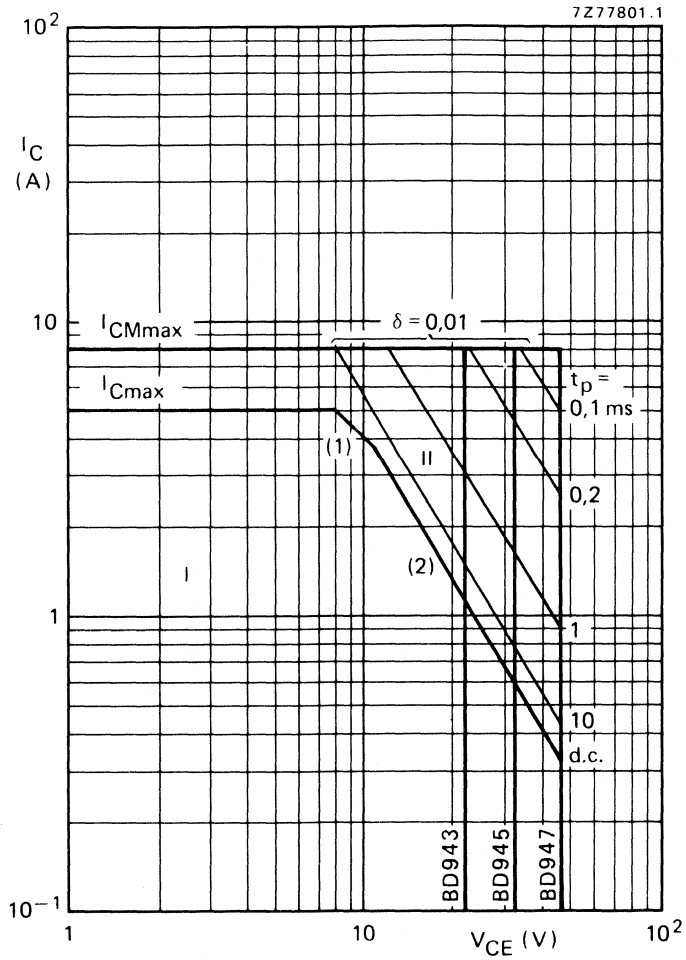


Fig. 3 Safe Operating ARea, $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

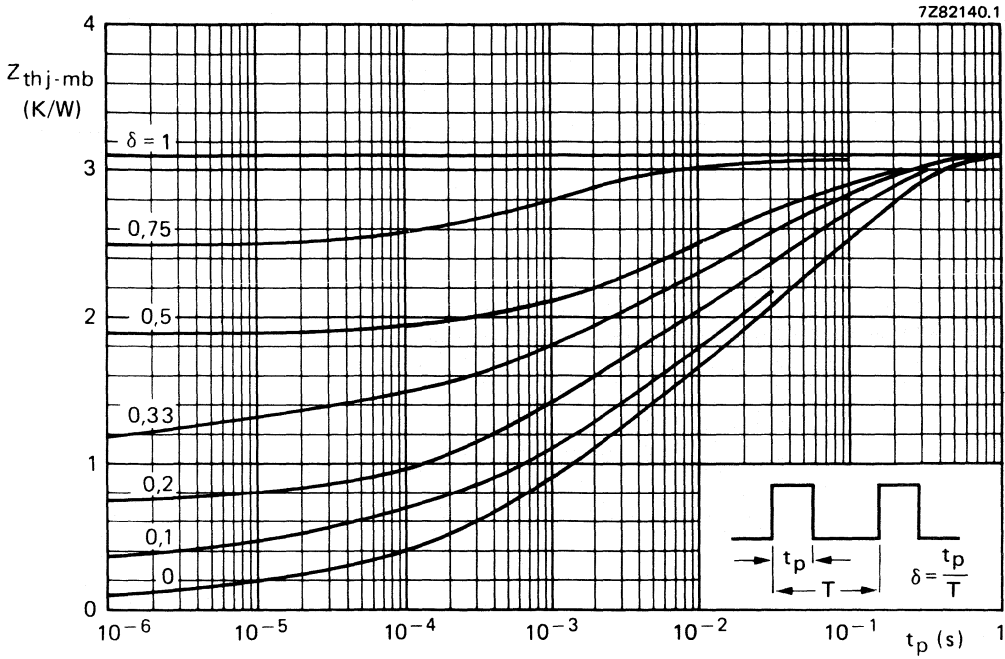


Fig. 4 Pulse power rating chart.

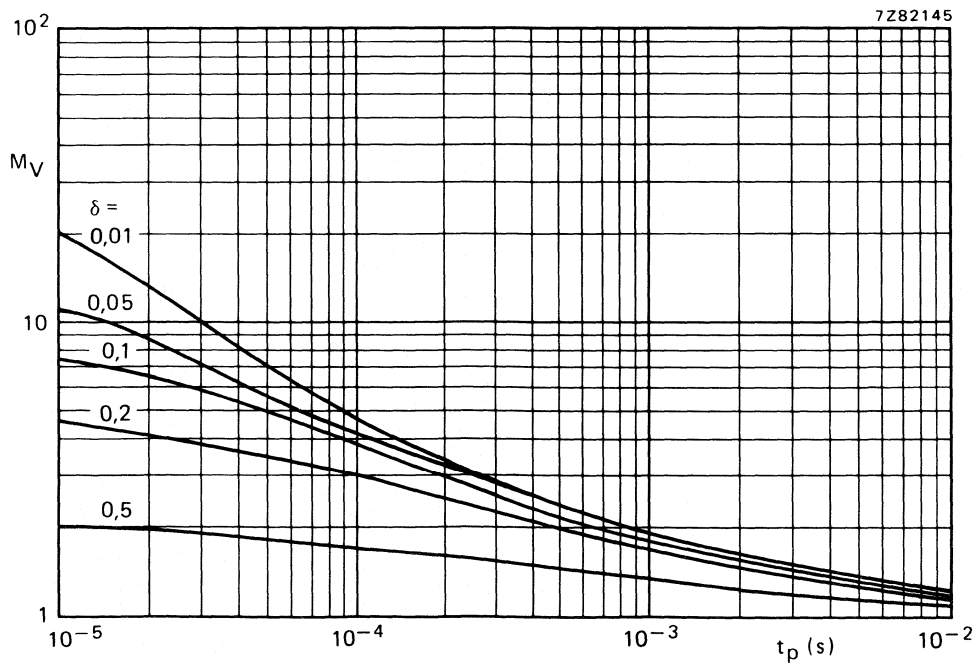


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

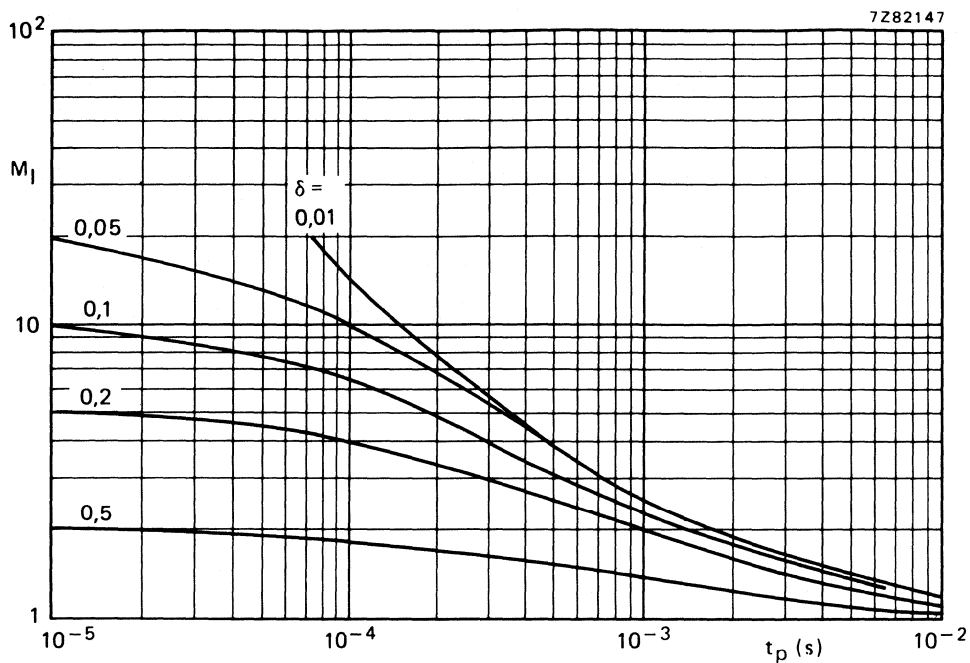


Fig. 6 S.B. current multiplying factor at the V_{CE0max} level for BD943 and BD945.

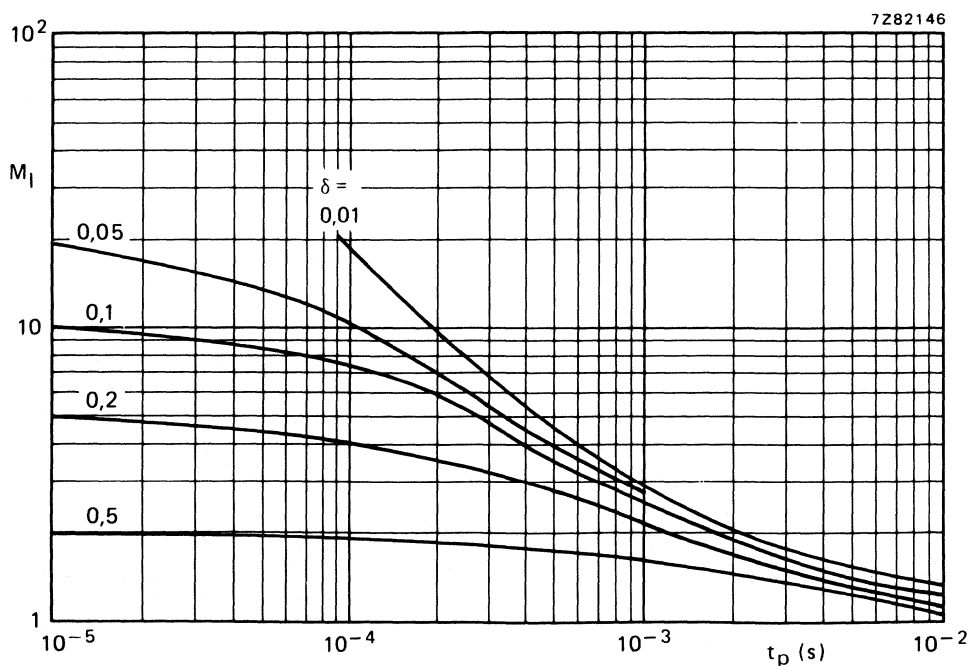


Fig. 7 S.B. current multiplying factor at the V_{CE0max} level for BD947.

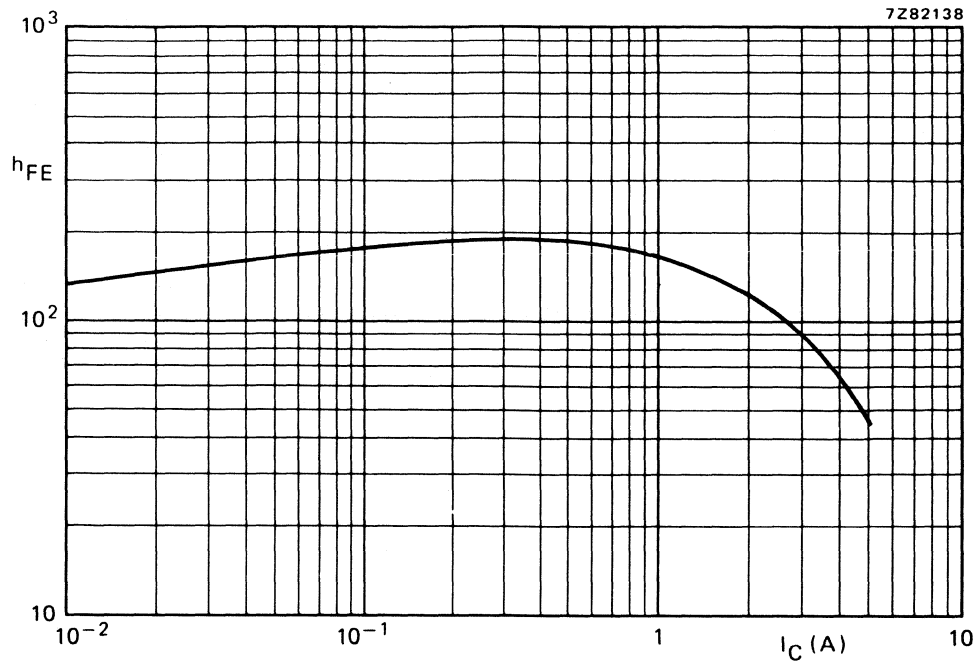


Fig. 8 Typical d.c. current gain at $V_{CE} = 1\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$.

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 $T_h = 25^\circ\text{C}$	P_{tot}	max.		22		W

MECHANICAL DATA

Pinning

- 1 = base
- 2 = collector
- 3 = emitter

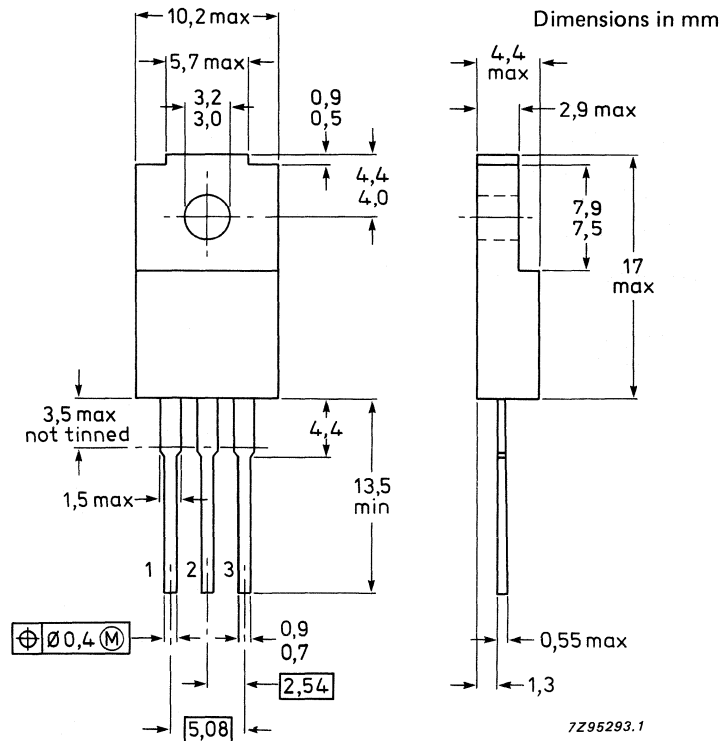
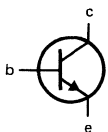


Fig. 1 SOT186.

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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.		15		W
up to $T_h = 25\text{ }^\circ\text{C}$ (note 2)	P_{tot}	max.		22		W
Storage temperature range	T_{stg}		-65 to + 150			$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

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

INSULATION

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

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

Collector cut-off current						
$I_E = 0; V_{CB} = V_{CBOmax}$	I_{CBO}	max.		50		μA
$I_E = 0; V_{CB} = V_{CBOmax};$ $T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	max.		1		mA
$I_B = 0; V_{CE} = 15\text{ V}$	BD943F	I_{CEO}	max.	0.1		mA
$I_B = 0; V_{CE} = 20\text{ V}$	BD945F	I_{CEO}	max.	0.1		mA
$I_B = 0; V_{CE} = 25\text{ V}$	BD947F	I_{CEO}	max.	0.1		mA
Emitter cut-off current						
$I_C = 0; V_{EB} = 5\text{ V}$	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)					
$I_C = 10 \text{ mA}; V_{CE} = 5 \text{ V}$	h_{FE} min.	25	25	25	
$I_C = 500 \text{ mA}; V_{CE} = 1 \text{ V}$	h_{FE} min.	85	85	85	
	h_{FE} max.	475	475	475	
$I_C = 2 \text{ A}; V_{CE} = 1 \text{ V}$	h_{FE} min.	50	50	40	
$I_C = 3 \text{ A}; V_{CE} = 1 \text{ V}$	h_{FE} min.	—	—	30	
Base-emitter voltage (notes 1 and 2)					
$I_C = 2 \text{ A}; V_{CE} = 1 \text{ V}$	V_{BE} max.	1.1	1.1	—	V
$I_C = 3 \text{ A}; V_{CE} = 1 \text{ V}$	V_{BE} max.	—	—	1.3	V
Collector-emitter saturation voltage (note 1)					
$I_C = 2 \text{ A}; I_B = 0.2 \text{ A}$	V_{CEsat} max.	0.5	0.5	—	V
$I_C = 3 \text{ A}; I_B = 0.3 \text{ A}$	V_{CEsat} max.	—	—	0.7	V
Knee voltage (note 1)					
$I_C = 2 \text{ A}; I_B = 20 \text{ mA}$	V_{CEK} max.		0.8		V
Transition frequency at $f = 1 \text{ MHz}$					
$I_C = 250 \text{ mA}; V_{CE} = 1 \text{ V}$	f_T min.		3		MHz

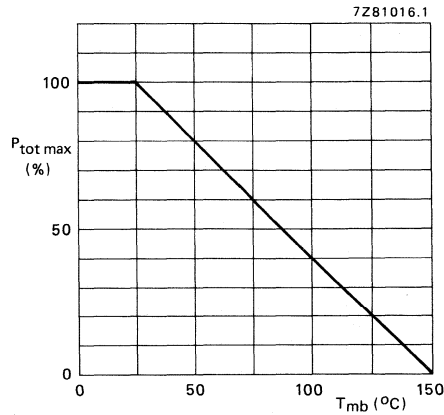
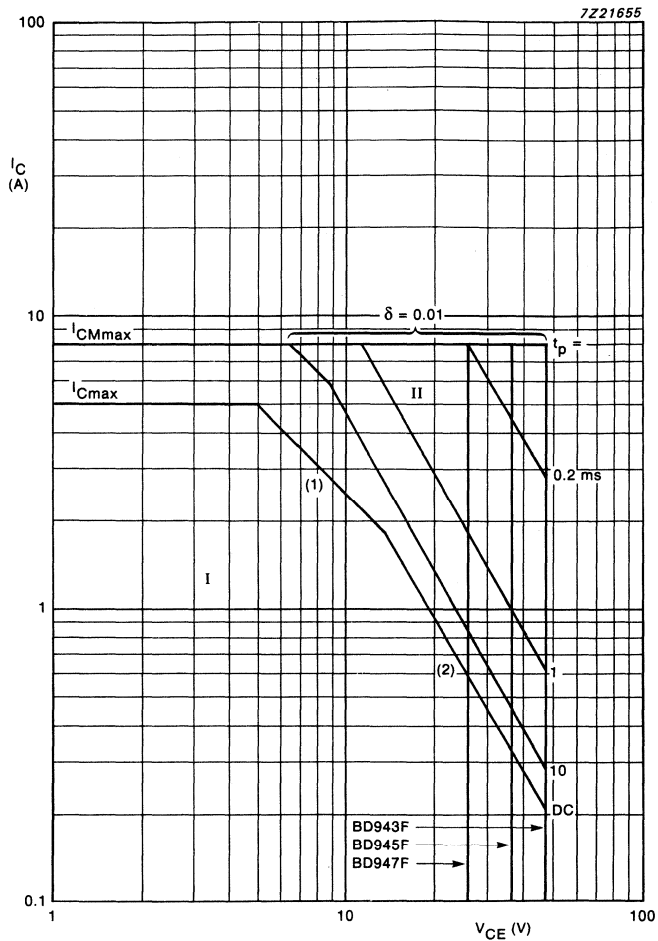


Fig. 2 Power derating curve.

Notes

1. Measured under pulse conditions; $t_p \leq 300 \mu\text{s}$; $\delta < 2\%$.
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) $P_{tot \text{ max}}$ and $P_{peak \text{ max}}$ lines.
- (2) Second-breakdown limits.

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

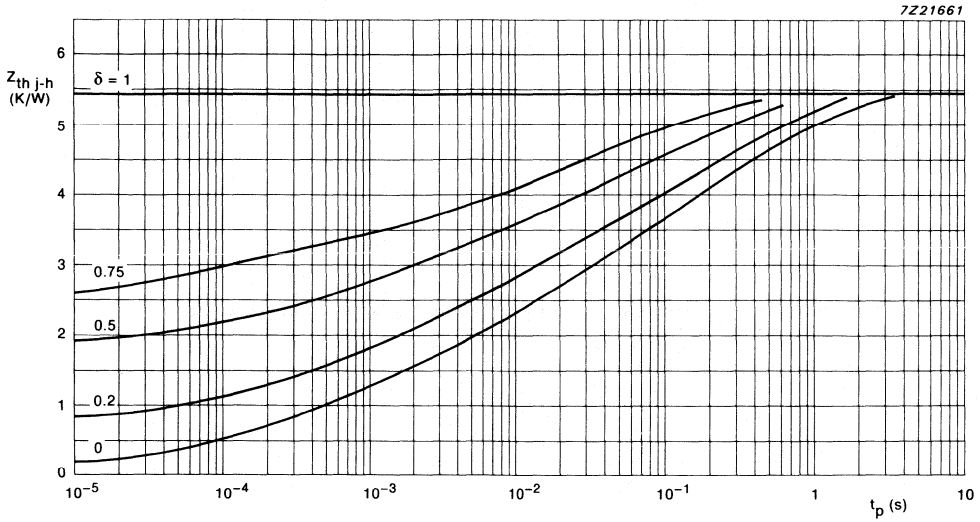


Fig. 4 Pulse power rating chart.

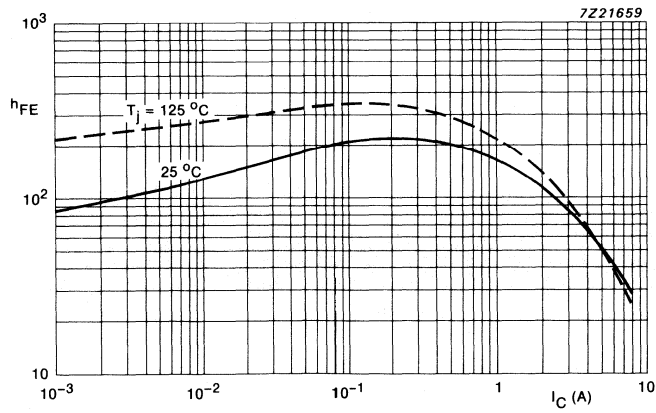


Fig. 5 DC current gain; $V_{CE} = 1$ V; typical values.

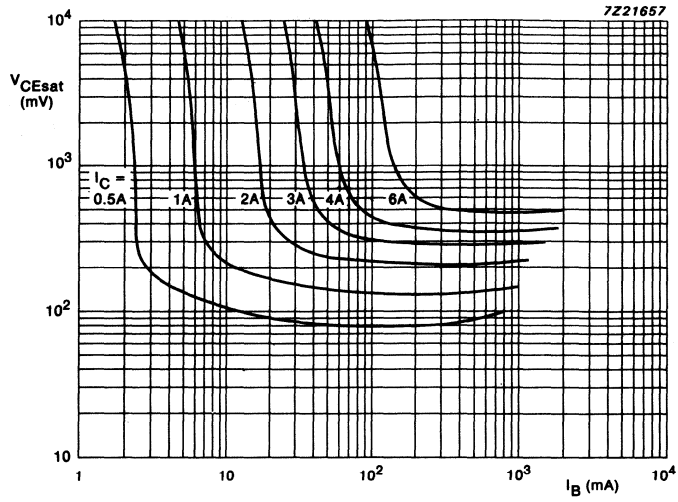


Fig.6 Collector-emitter saturation voltage as a function of base current $T_h = 25^\circ C$.

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.

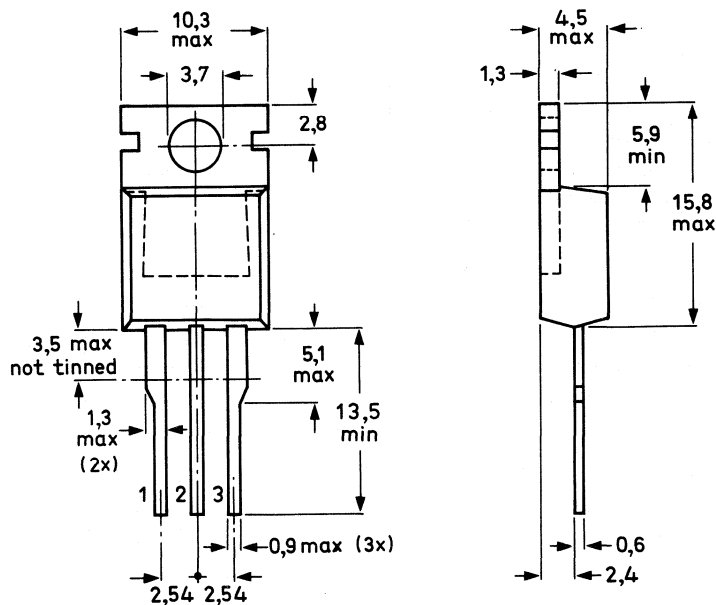
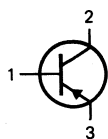
QUICK REFERENCE DATA

			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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		40	W
Junction temperature	T_j	max.		150	$^\circ\text{C}$
D.C. current gain				25	
$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	h_{FE}	>		85 to 475	
$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	h_{FE}				
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	50	50	40
Transition frequency at $f = 1\text{ MHz}$				3	MHz
$-I_C = 250\text{ mA}; -V_{CE} = 1\text{ V}$	f_T	>			

MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



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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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		40	W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

→ Collector cut-off current					
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<		50	μA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<		1	mA
$I_B = 0; -V_{CE} = 15\text{ V}; \text{BD944}$ $-V_{CE} = 20\text{ V}; \text{BD946}$ $-V_{CE} = 25\text{ V}; \text{BD948}$	$-I_{CEO}$	<		0,1	mA
→ Emitter cut-off current					
$-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<		0,2	mA
D.C. current gain (note 1)					
$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	h_{FE}	>		25	
$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	h_{FE}			85 to 475	
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	50	50	40
$-I_C = 3\text{ A}; -V_{CE} = 1\text{ V}$	h_{FE}	>	-	-	30
Base-emitter voltage (notes 1 and 2)					
$-I_C = 2\text{ A}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	1,1	1,1	- V
$-I_C = 3\text{ A}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	-	-	1,3 V
Collector-emitter saturation voltage (note 1)					
$-I_C = 2\text{ A}; -I_B = 0,2\text{ A}$	$-V_{CEsat}$	<	0,5	0,5	- V
$-I_C = 3\text{ A}; -I_B = 0,3\text{ V}$	$-V_{CEsat}$	<	-	-	0,7 V

Notes

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

Knee voltage *

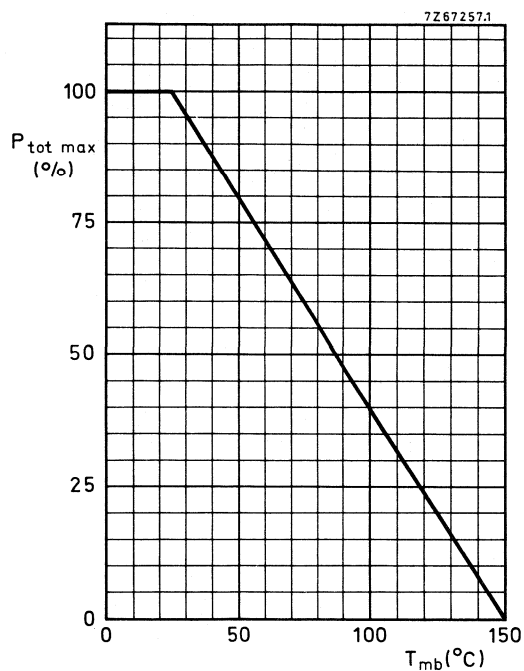
 $-I_C = 2 \text{ A}; -I_B = \text{value for which}$ $-I_C = 2,2 \text{ A and } -V_{CE} = 1 \text{ V}$ Transition frequency at $f = 1 \text{ MHz}$ $-I_C = 250 \text{ mA}; -V_{CE} = 1 \text{ V}$ $-V_{CEK} < 0,8 \text{ V}$ $f_T > 3 \text{ MHz}$ 

Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leq 300 \mu\text{s}; \delta < 2\%$.

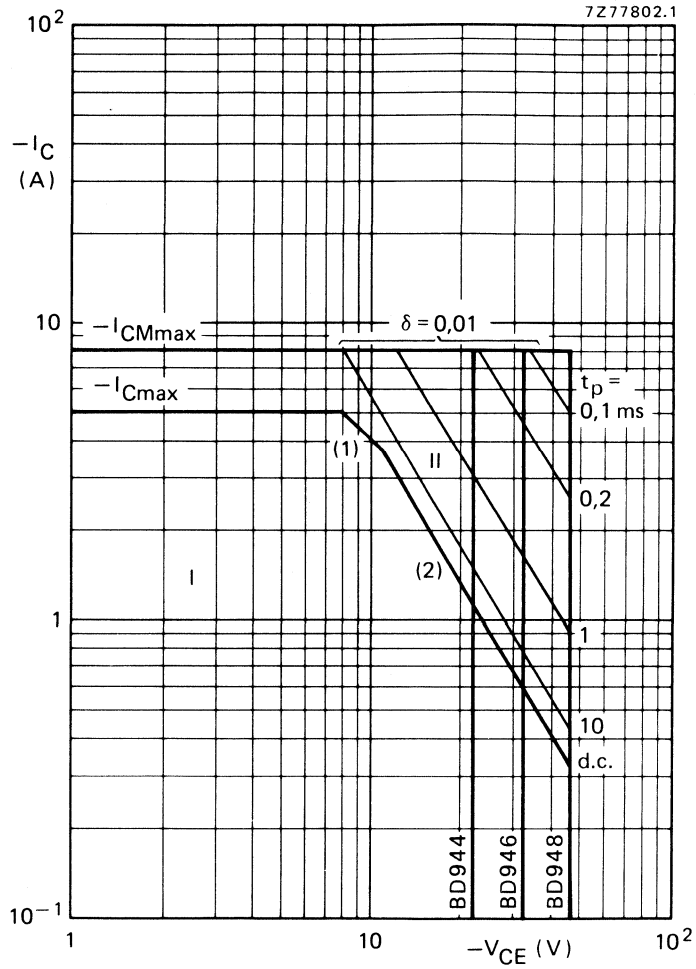


Fig. 3 Safe Operating Area, $T_{mb} = 25^\circ\text{C}$.

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

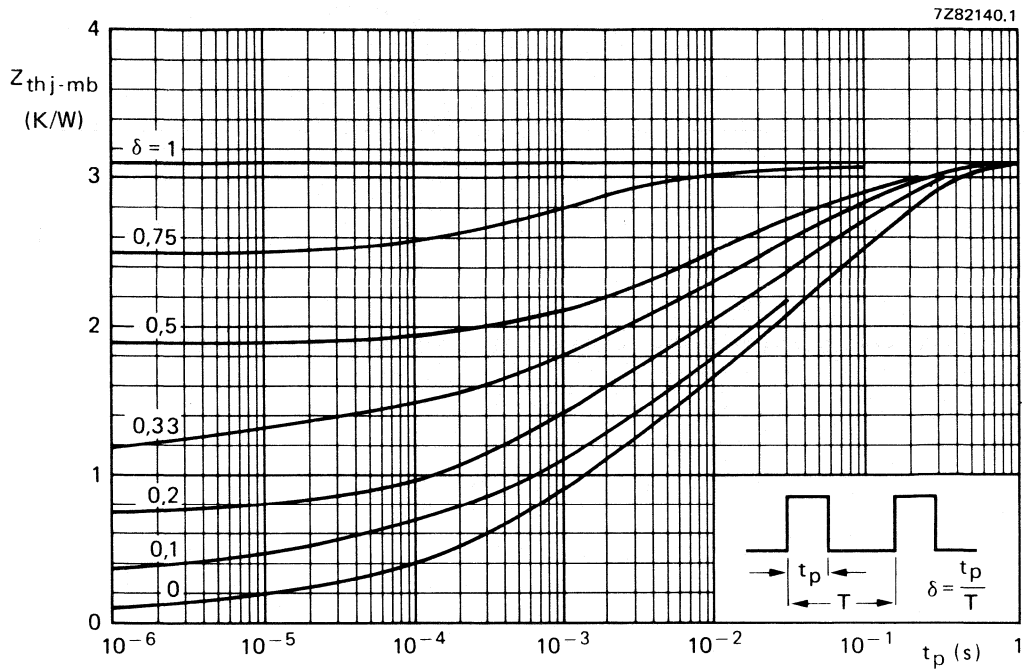


Fig. 4 Pulse power rating chart.

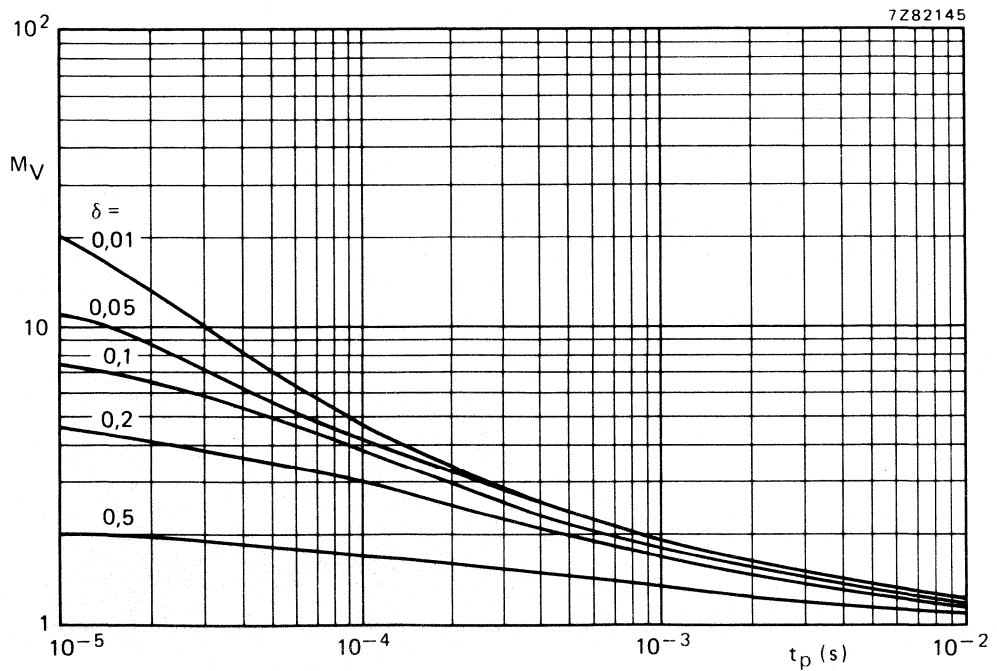


Fig. 5 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

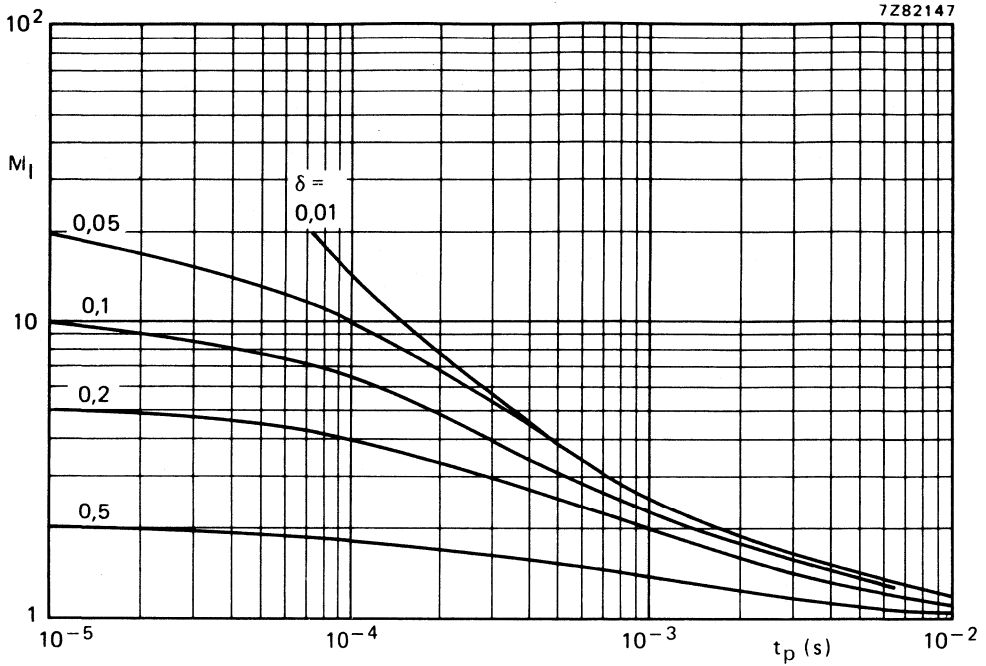


Fig. 6 S.B. current multiplying factor at the $-V_{CEmax}$ level for BD944/946.

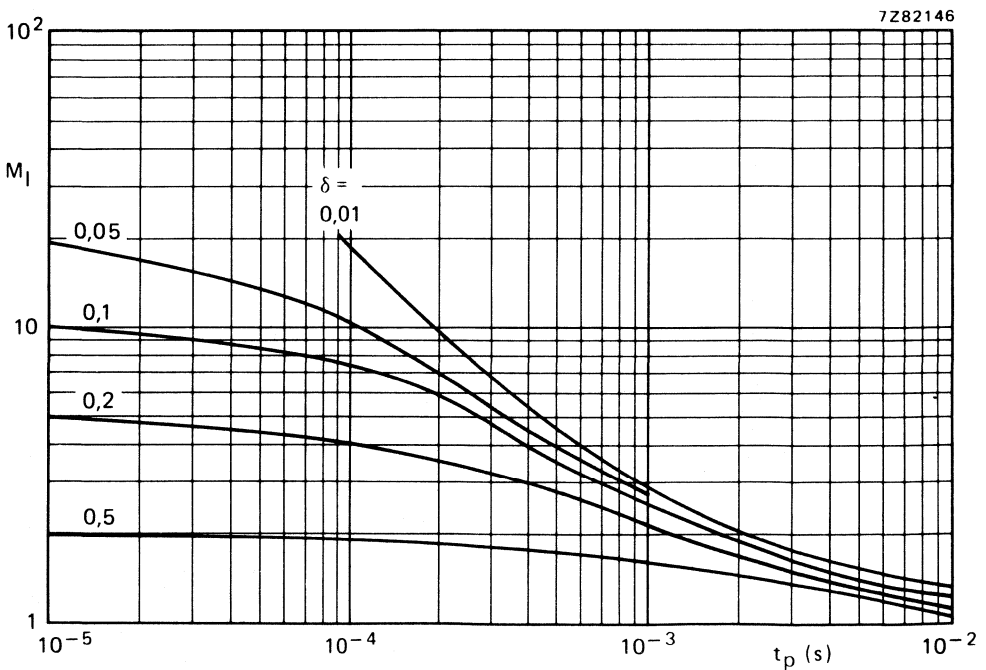


Fig. 7 S.B. current multiplying factor at the $-V_{CEmax}$ level for BD948.

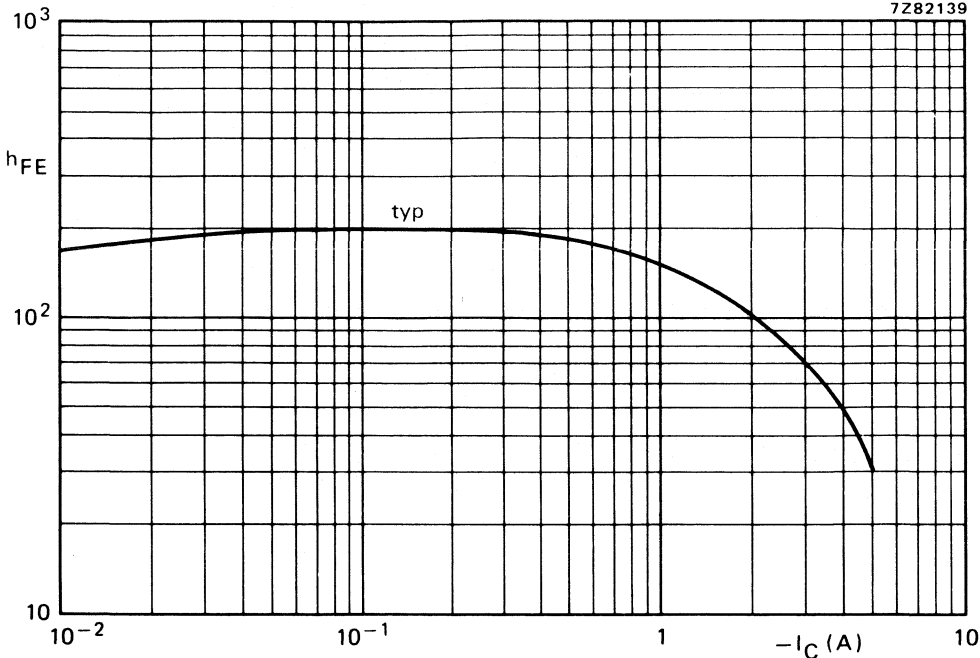


Fig. 8 Typical d.c. current gain at $-V_{CE} = 1$ V; $T_j = 25$ °C.

SILICON EPITAXIAL POWER TRANSISTORS

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

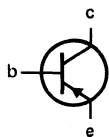
NPN complements are BD943F, BD945F and BD947F.

QUICK REFERENCE DATA

			BD944F	BD946F	BD948F
Collector-base voltage (open emitter)	$-V_{CB0}$	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 $T_H = 25\text{ }^\circ\text{C}$	P_{tot}	max.		22	W

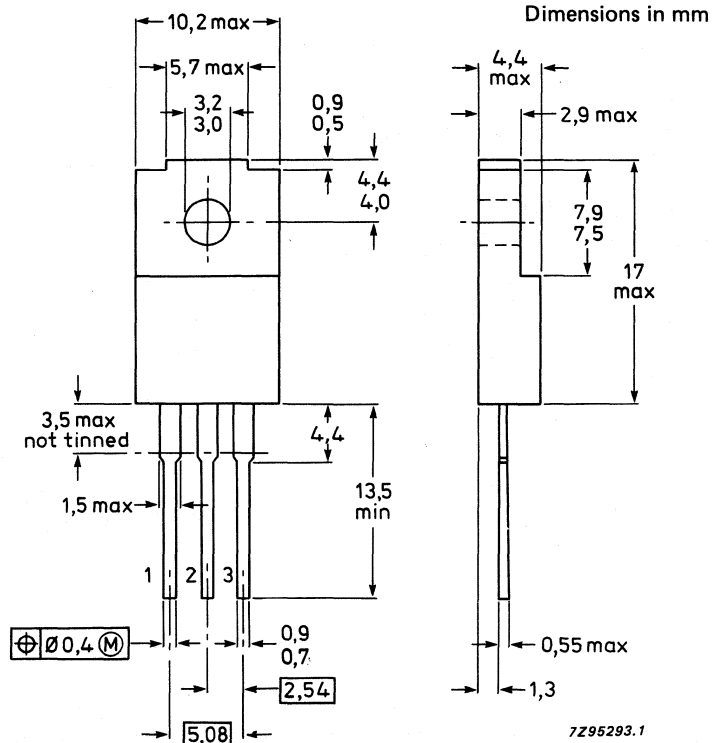
MECHANICAL DATA

Fig.1 SOT186.



Pinning

- 1 = base
- 2 = collector
- 3 = emitter



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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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.		15	W
up to $T_h = 25\text{ }^\circ\text{C}$ (note 2)		max.		22	W
Storage temperature range	T_{stg}			-65 to 150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

INSULATION

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

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

Collector cut-off current $I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	max.		50	μA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	max.		1	mA
$I_B = 0; -V_{CE} = 15\text{ V}; \text{BD944F}$					
$-V_{CE} = 20\text{ V}; \text{BD946F}$	$-I_{CEO}$	max.		0.1	mA
$-V_{CE} = 25\text{ V}; \text{BD948F}$					
Emitter cut-off current $-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	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)					
$-I_C = 10 \text{ mA}; -V_{CE} = 5 \text{ V}$	h_{FE}	min.	25	25	25
$-I_C = 500 \text{ mA}; -V_{CE} = 1 \text{ V}$	h_{FE}	min.	85	85	85
$-I_C = 2 \text{ A}; -V_{CE} = 1 \text{ V}$	h_{FE}	max.	475	475	475
$-I_C = 3 \text{ A}; -V_{CE} = 1 \text{ V}$	h_{FE}	min.	50	50	40
	h_{FE}	min.	—	—	30
Base-emitter voltage (note 1 and 2)					
$-I_C = 2 \text{ A}; -V_{CE} = 1 \text{ V}$	$-V_{BE}$	max.	1.1	1.1	— V
$-I_C = 3 \text{ A}; -V_{CE} = 1 \text{ V}$	$-V_{BE}$	max.	—	—	1.3 V
Collector-emitter saturation voltage (note 1)					
$-I_C = 2 \text{ A}; -I_B = 0.2 \text{ A}$	$-V_{CEsat}$	max.	0.5	0.5	— V
$-I_C = 3 \text{ A}; -I_B = 0.3 \text{ A}$	$-V_{CEsat}$	max.	—	—	0.7 V
Knee voltage (1)					
$-I_C = 2 \text{ A}; -I_B = \text{value when}$					
$-I_C = 2.2 \text{ A}; -V_{CE} = 1 \text{ V}$	$-V_{CEK}$	max.		0.8	V
Transition frequency at $f = 1 \text{ MHz}$					
$-I_C = 250 \text{ mA}; -V_{CE} = 1 \text{ V}$	f_T	min.		3	MHz

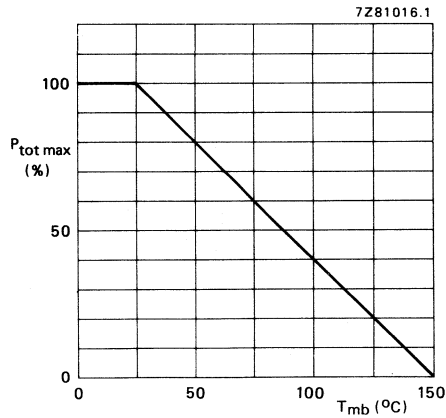
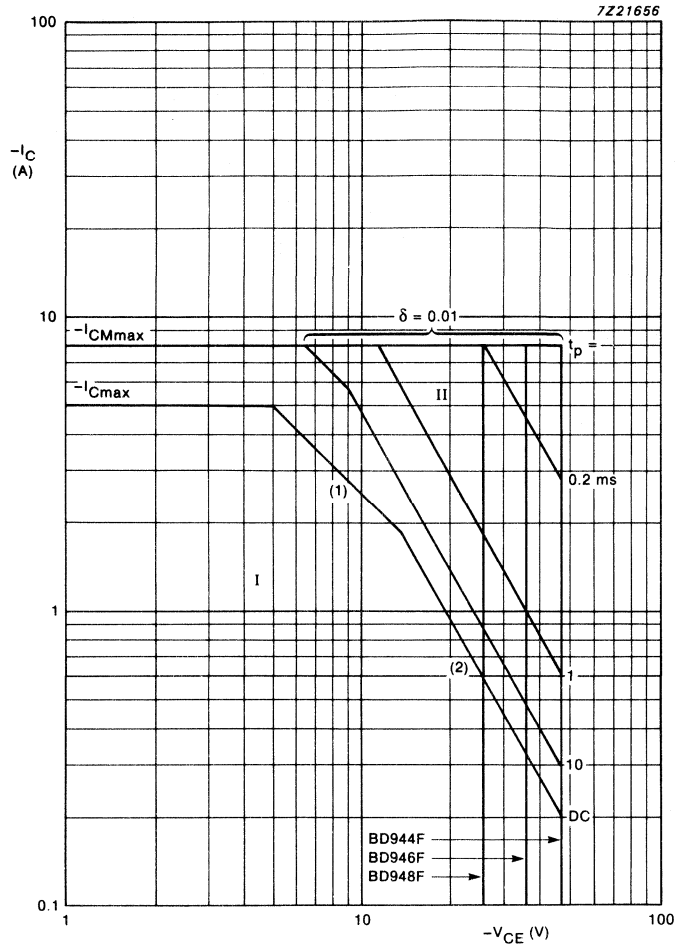


Fig.2 Power derating curve.

Notes

1. Measured under pulse conditions; $t_p \leq 300 \mu\text{s}$; $\delta < 2\%$.
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, $T_{mb} = 25\ ^\circ\text{C}$.

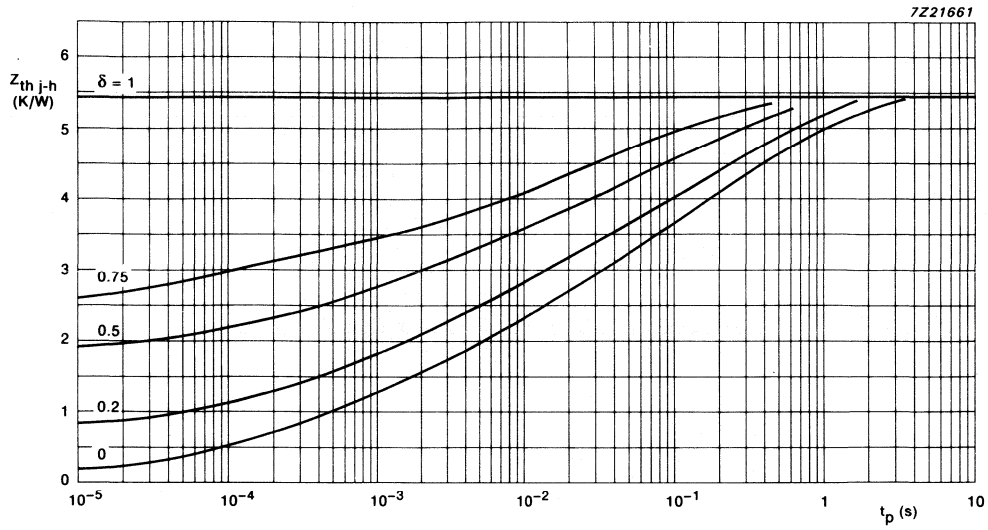


Fig.4 Pulse power rating chart.

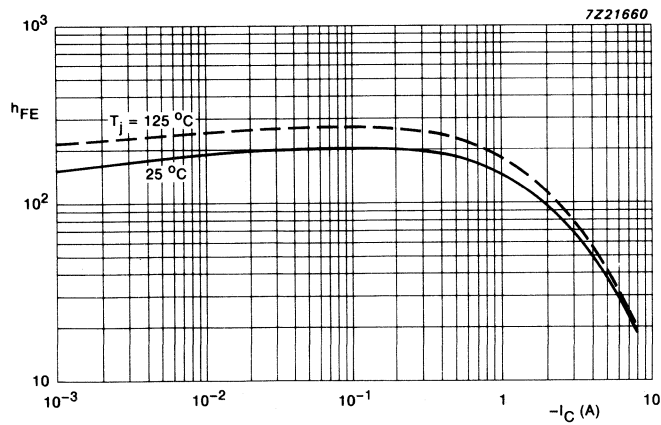


Fig.5 DC current gain; $-V_{CE} = 1$ V; typical values.

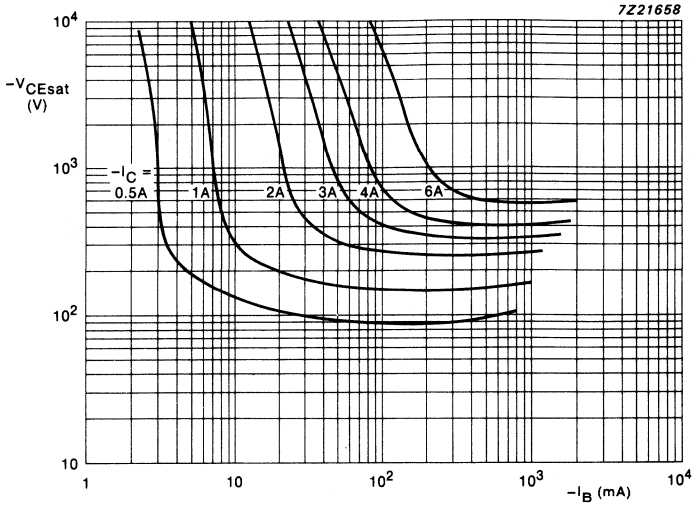


Fig.6 Collector-emitter saturation voltage
as a function of base current; $T_h = 25^\circ C$.

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.

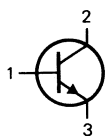
QUICK REFERENCE DATA

		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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	40		W
Junction temperature	T_j	max.	150		$^\circ\text{C}$
D.C. current gain					
$I_C = 0,5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	40		
$I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	20		

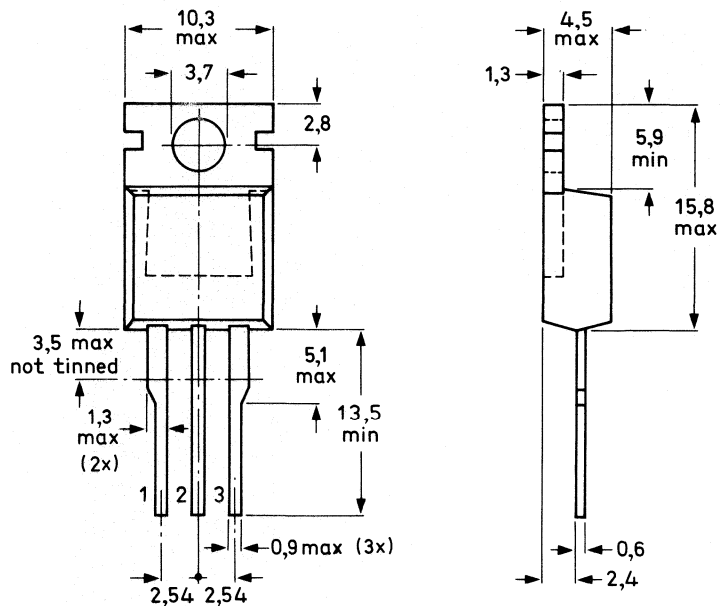
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters
Mounting instructions
and Accessories.



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RATINGS

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

		BD949	951	953	955
Collector-base voltage (open emitter)	V_{CB0} 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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			40	W
Storage temperature	T_{stg}			-65 to 150	$^\circ\text{C}$
Junction temperature	T_j max.			150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

→ Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0\ max}$	I_{CBO} <		50		μA
$I_E = 0; V_{CB} = \frac{1}{2} V_{CB0\ max}; T_j = 150\text{ }^\circ\text{C}$	I_{CBO} <		1		mA
$I_B = 0; V_{CE} = \frac{1}{2} V_{CEO\ max}$	I_{CEO} <		0,1		mA

→ Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO} <		0,2		mA
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D.C. current gain (note 1)

$I_C = 0,5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE} >		40		
$I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	h_{FE} >		20		

Base-emitter voltage (notes 1 and 2)

$I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	V_{BE} <		1,4		V
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Collector-emitter saturation voltage (note 1)

$I_C = 2\text{ A}; I_B = 0,2\text{ A}$	V_{CEsat} <		1		V
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Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,5\text{ A}; V_{CE} = 4\text{ V}$	f_T >		3		MHz
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(1) Measured under pulse conditions: $t_p \leq 300\ \mu\text{s}$, $\delta < 2\%$.

(2) V_{EB} decreases by about 2,3 mV/K with increasing temperature.

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

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

Turn-on time

Turn-off time

t_{on} typ. 0,3 μs
 t_{off} typ. 1,5 μs

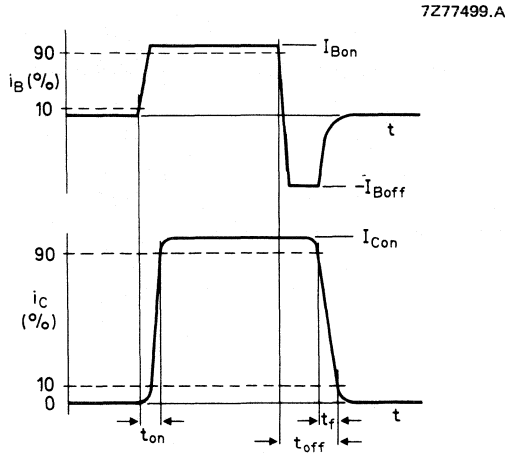
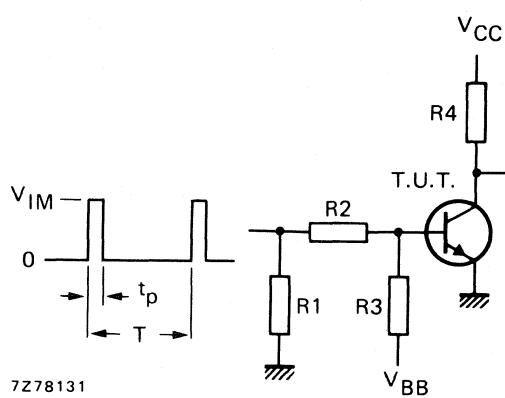


Fig. 2 Switching times waveforms.



$V_{IM} = 30\text{ V}$
 $V_{CC} = 20\text{ V}$
 $V_{BB} = -3,5\text{ V}$
 $R1 = 82\ \Omega$
 $R2 = 150\ \Omega$
 $R3 = 39\ \Omega$
 $R4 = 20\ \Omega$
 $t_r = t_f \leq 15\text{ ns}$
 $t_p = 10\ \mu\text{s}$
 $T = 500\ \mu\text{s}$

Fig. 3 Switching times test circuit.

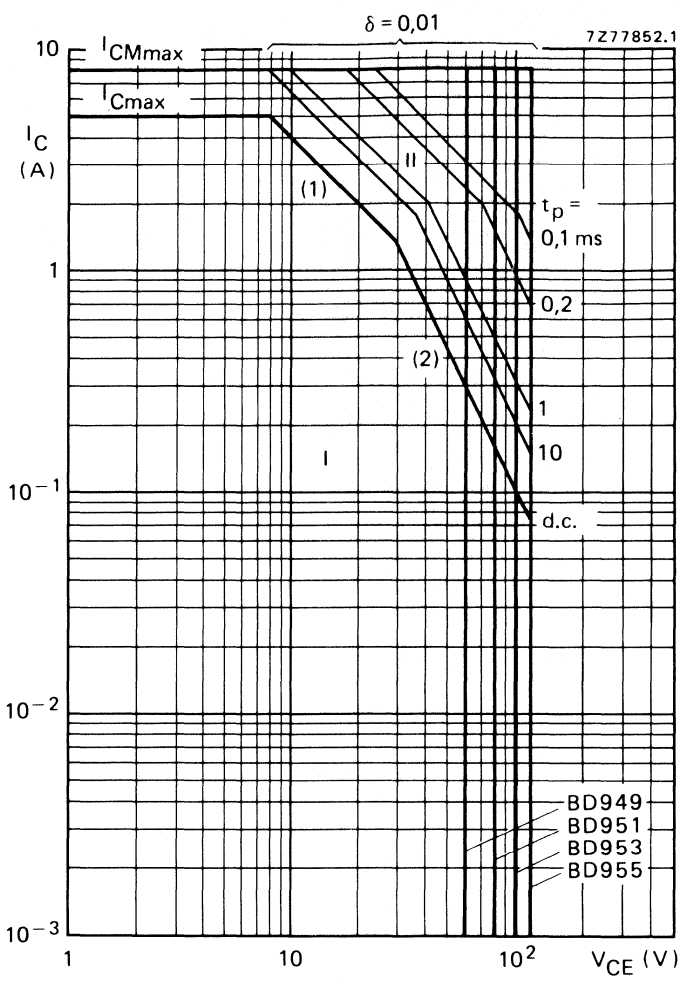


Fig. 4 Safe Operating ARea; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

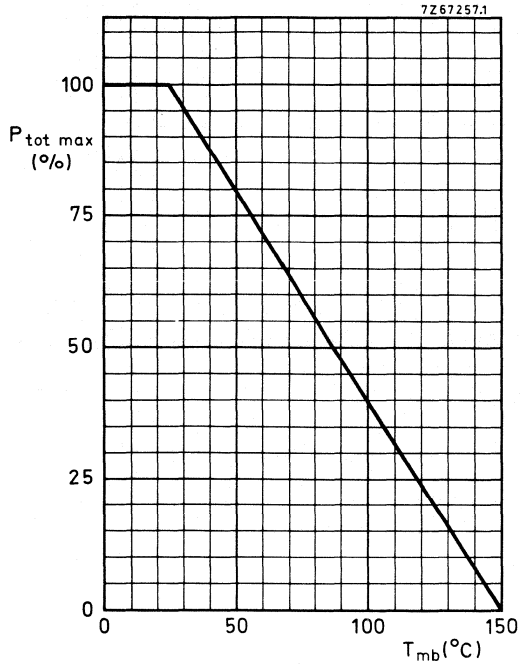


Fig. 5 Power derating curve.

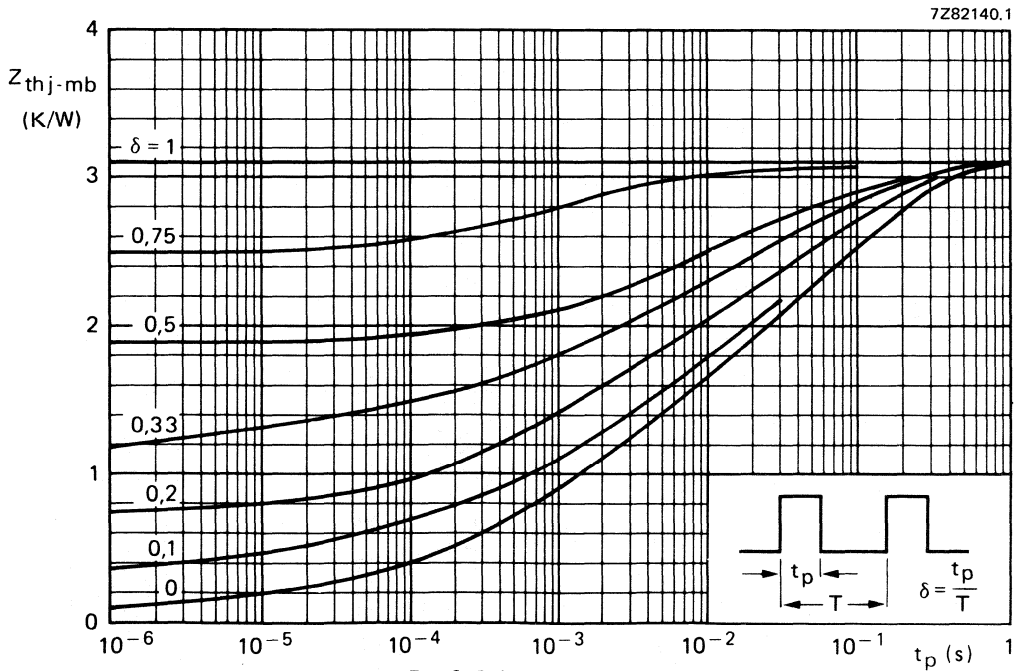


Fig. 6 Pulse power rating chart.

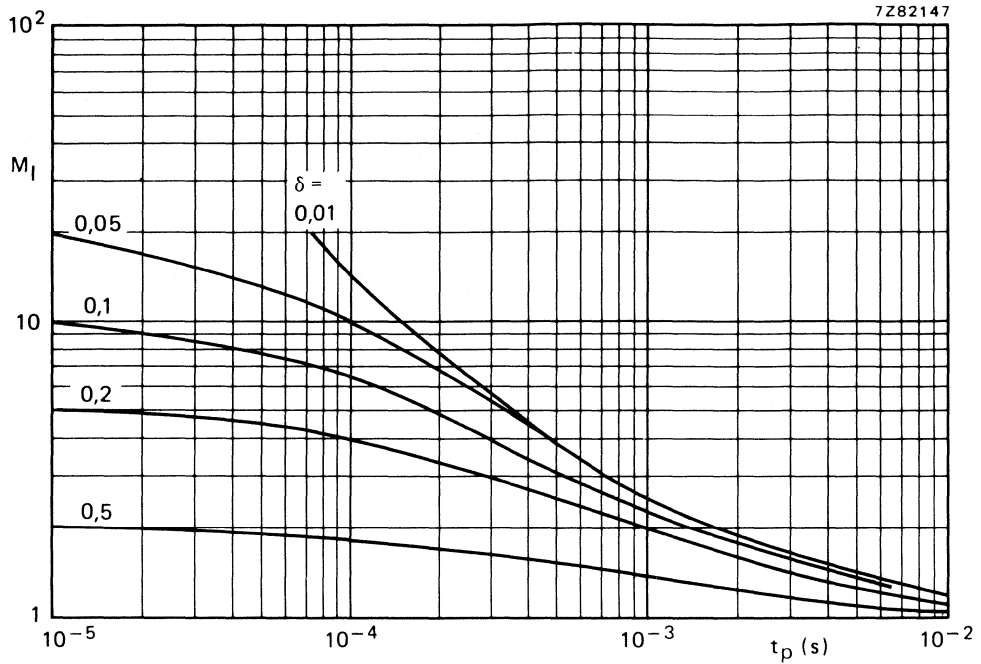


Fig. 7 S.B. current multiplying factor at the $V_{CE0 \max}$ level for BD949/951.

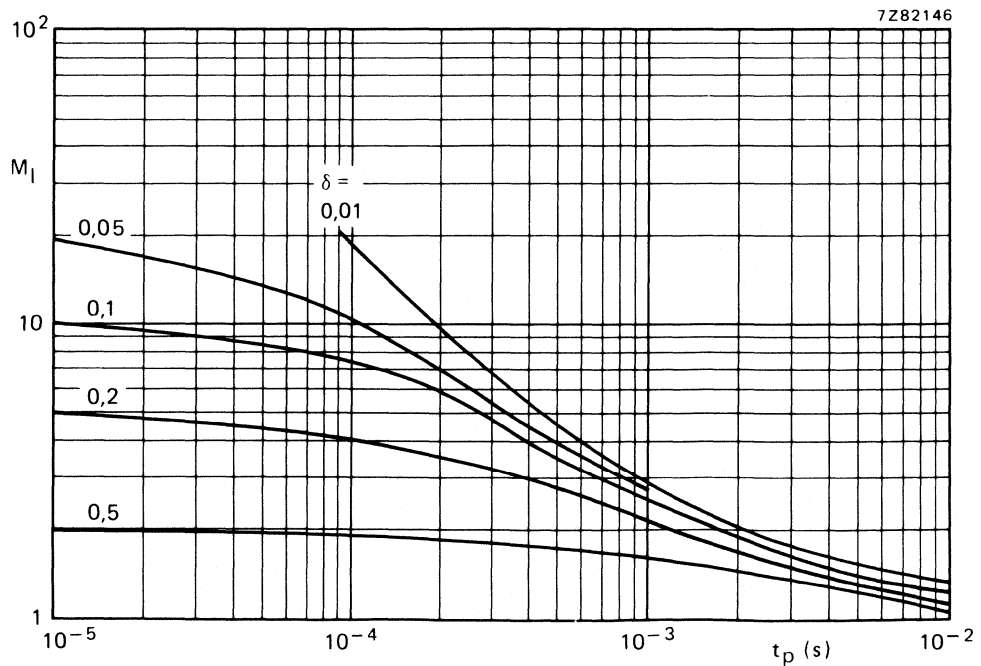


Fig. 8 S.B. current multiplying factor at the $V_{CE0 \max}$ level for BD953/955.

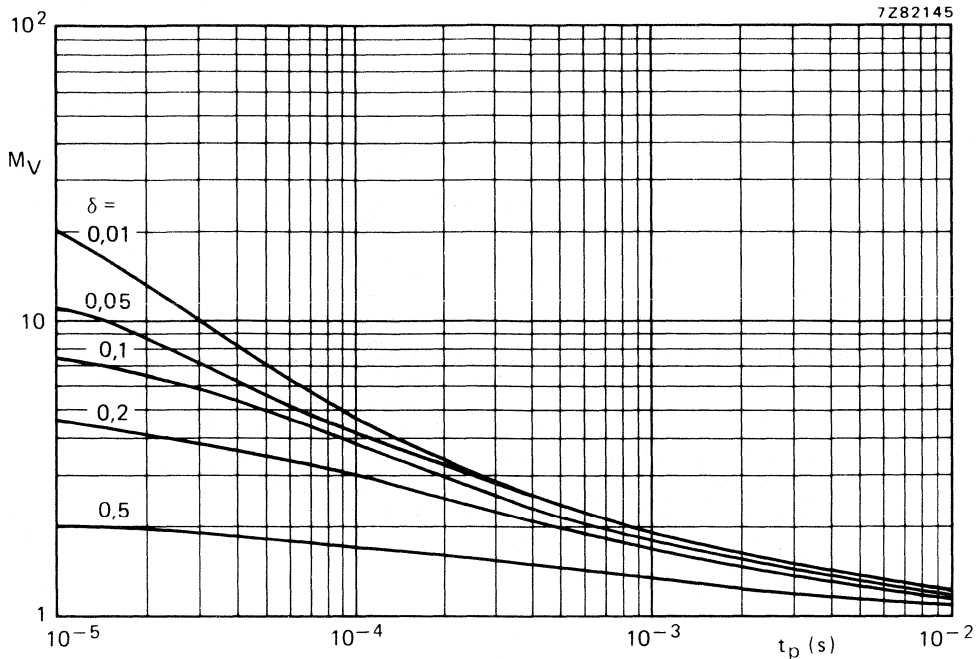


Fig. 9 S.B. voltage multiplying factor at the I_C max level.

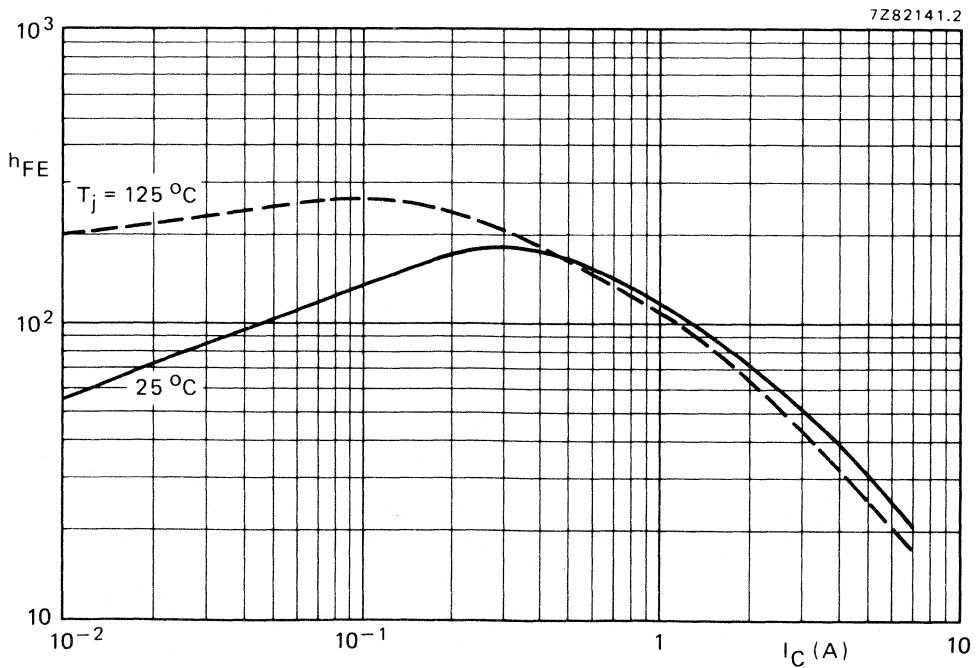


Fig. 10 Typical d.c. current gain at $V_{CE} = 4$ V.

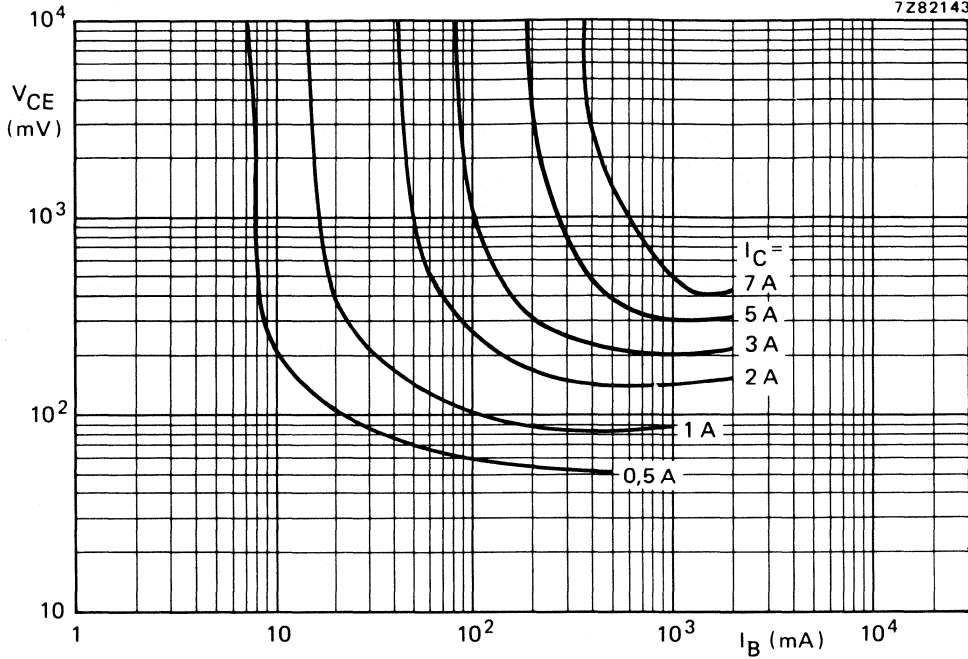


Fig. 11 Collector-emitter voltage as a function of base current.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

BD949F;951F;
BD953F;955F

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

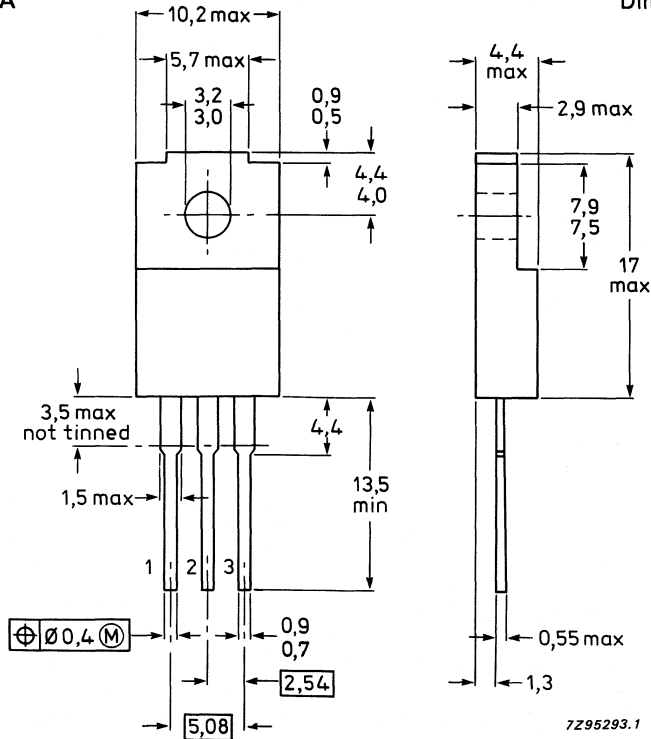
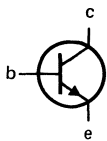
		BD949F	951F	953F	955F	
Collector-base voltage (open emitter)	V_{CBO}	max. 60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max. 60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5			V
Collector current (DC) peak value	I_C	max.	5			A
	I_{CM}	max.	8			A
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot}	max.	22			W
DC current gain $I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	typ.	20			

MECHANICAL DATA

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) peak value	I_C	max.		5			A
	I_{CM}	max.		8			A
Base current (DC)	I_B	max.		5			A
Total power dissipation at $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.		15			W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.		22			W
Storage temperature range	T_{stg}			-65 to 150			$^\circ\text{C}$
Junction temperature	T_j	max.		150			$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	R_{thj-mb}	=		3.12			K/W
From junction to external heatsink (note 1)	R_{thj-h}	=		8.12			K/W
From junction to external heatsink (note 2)	R_{thj-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 $I_C = 2\text{ A}; I_B = 0.2\text{ A}$	V_{CEsat}	max.		1			V
DC current gain $I_C = 2\text{ A}; V_{CE} = 4\text{ V}$	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

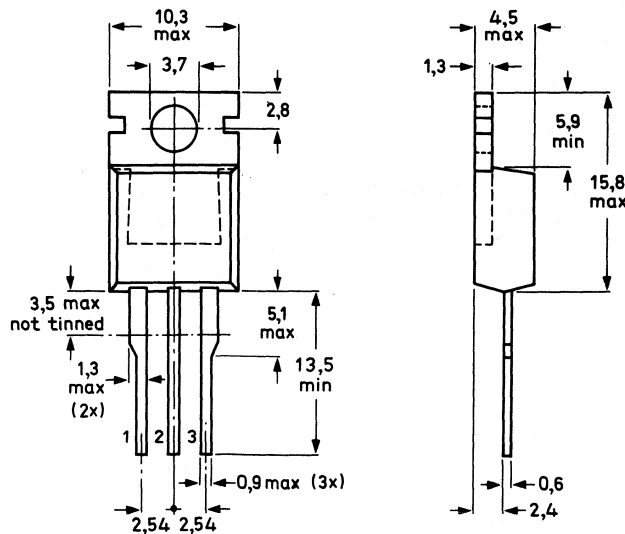
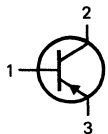
		BD950	952	954	956
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	80	100	120 V
Collector current (d.c.)	$-I_C$ max.		5		A
Collector current (peak value)	$-I_{CM}$ max.		8		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		40		W
Junction temperature	T_j max.		150		$^\circ\text{C}$
D.C. current gain					
$-I_C = 0,5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	40		
$-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	20		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



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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)	$-V_{CB0}$	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	40		W
Storage temperature	T_{stg}		-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

→ Collector cut-off current					
$I_E = 0; -V_{CB} = -V_{CB0\ max}$	$-I_{CBO}$	<	50		μA
$I_E = 0; -V_{CB} = -\frac{1}{2} V_{CB0\ max}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1		mA
$I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEO\ max}$	$-I_{CEO}$	<	0,1		mA
→ Emitter cut-off current					
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	0,2		mA
D.C. current gain (note 1)					
$-I_C = 0,5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	40		
$-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	20		
Base-emitter voltage (notes 1 and 2)					
$-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<	1,4		V
Collector-emitter saturation voltage (note 1)					
$-I_C = 2\text{ A}; -I_B = 0,2\text{ A}$	$-V_{CEsat}$	<	1		V
Transition frequency at $f = 1\text{ MHz}$					
$-I_C = 0,5\text{ A}; -V_{CE} = 4\text{ V}$	f_T	>	3		MHz

(1) Measured under pulse conditions: $t_p \leq 300\ \mu\text{s}$, $\delta < 2\%$.

(2) V_{EB} decreases by about 2,3 mV/K with increasing temperature.

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

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

Turn-on time

Turn-off time

t_{on} typ. 0,1 μs
 t_{off} typ. 0,4 μs

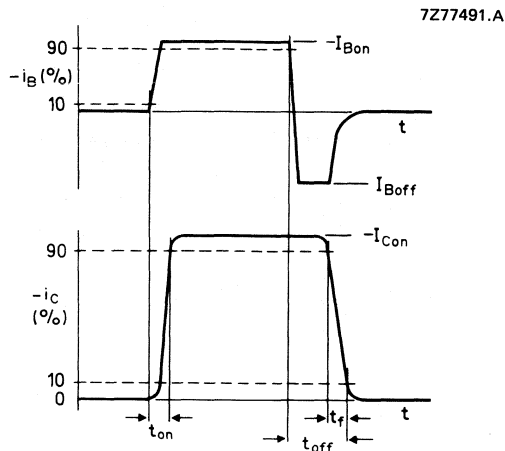
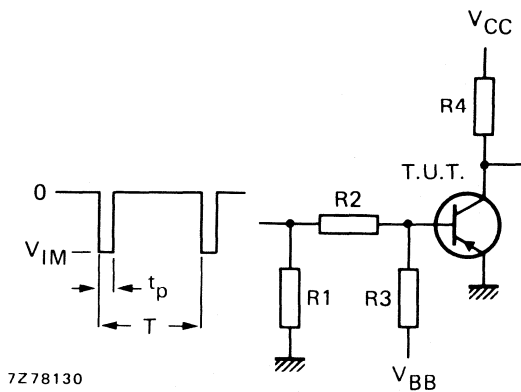


Fig. 2 Switching times waveforms.



$-V_{IM} = 30 \text{ V}$
 $-V_{CC} = 20 \text{ V}$
 $V_{BB} = 3,5 \text{ V}$
 $R1 = 82 \Omega$
 $R2 = 150 \Omega$
 $R3 = 39 \Omega$
 $R4 = 20 \Omega$
 $t_r = t_f \leq 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

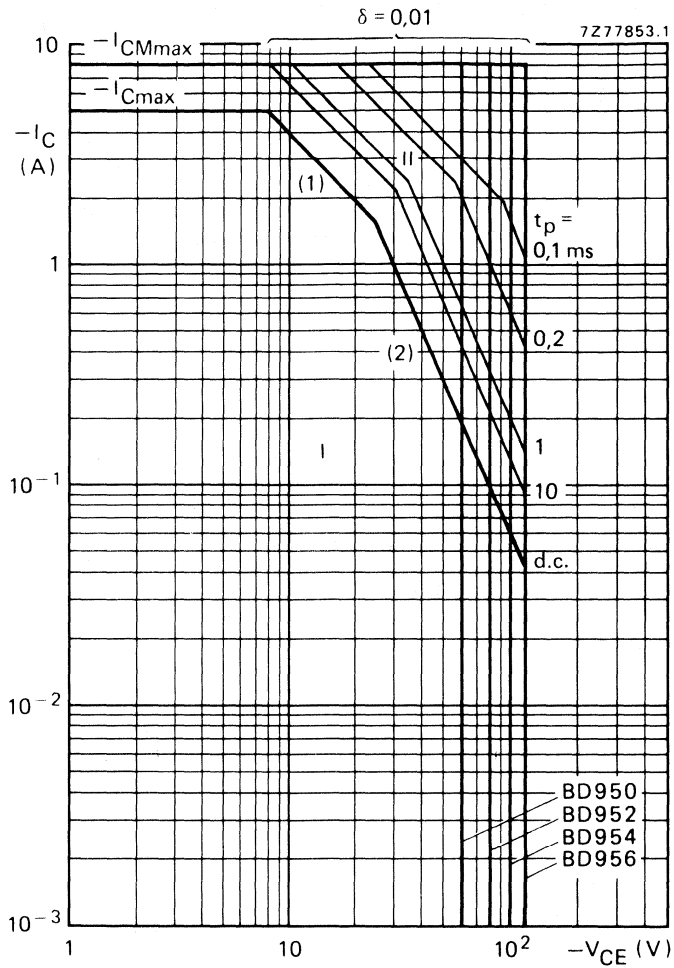


Fig. 4 Safe Operating Area; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

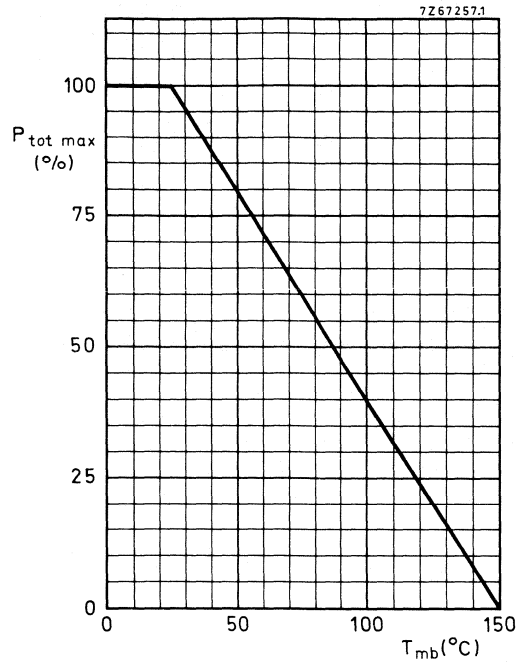


Fig. 5 Power derating curve.

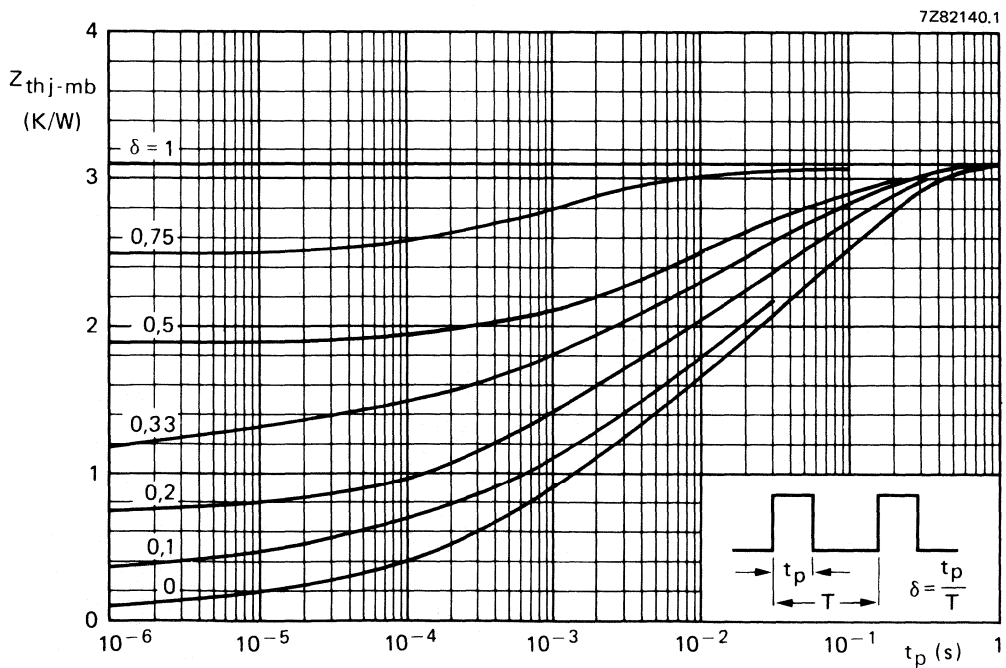


Fig. 6 Pulse power rating chart.

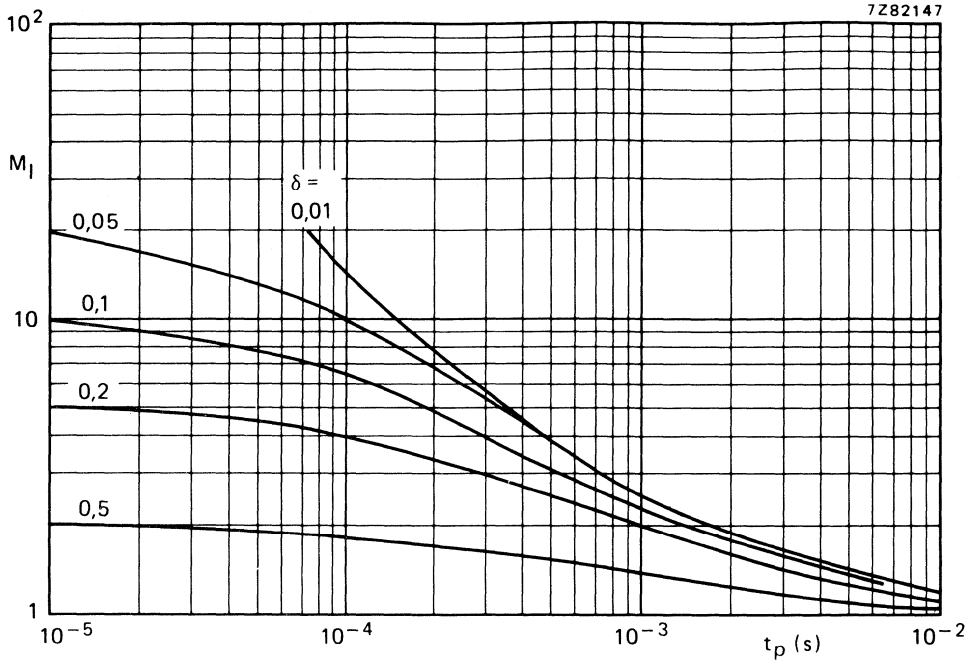


Fig. 7 S.B. current multiplying factor at the $-V_{CEO \max}$ level for BD950 and BD952.

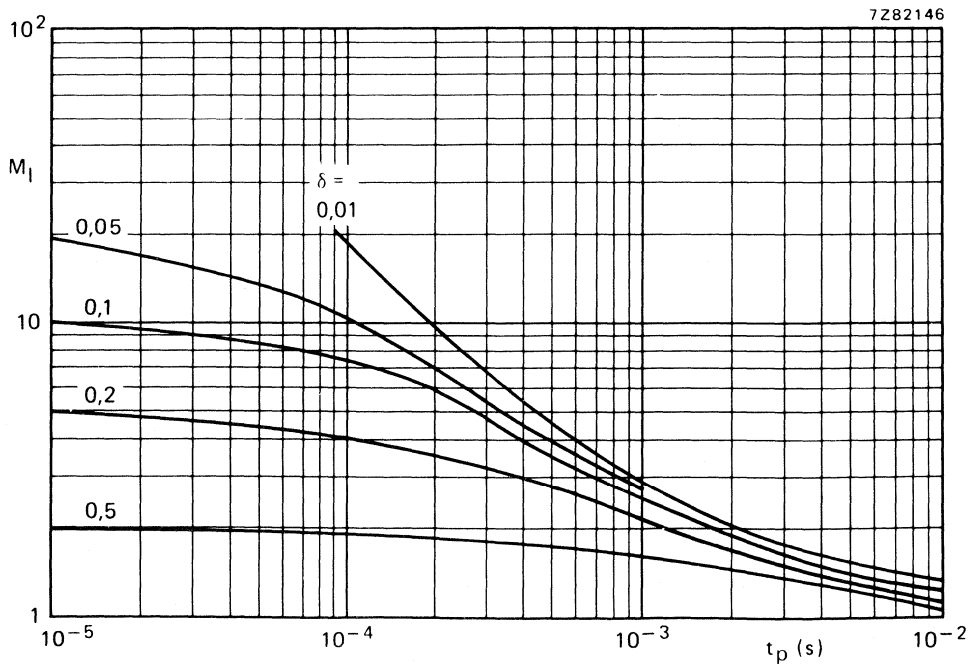


Fig. 8 S.B. current multiplying factor at the $-V_{CEO \max}$ level for BD954 and BD956.

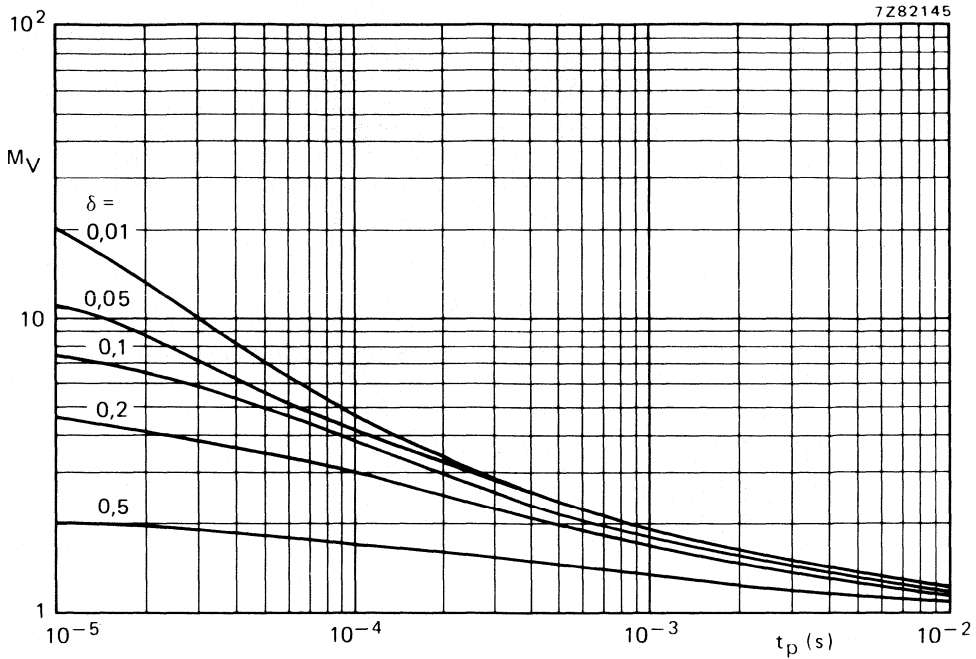


Fig. 9 S.B. voltage multiplying factor at the $-I_{C \max}$ level.

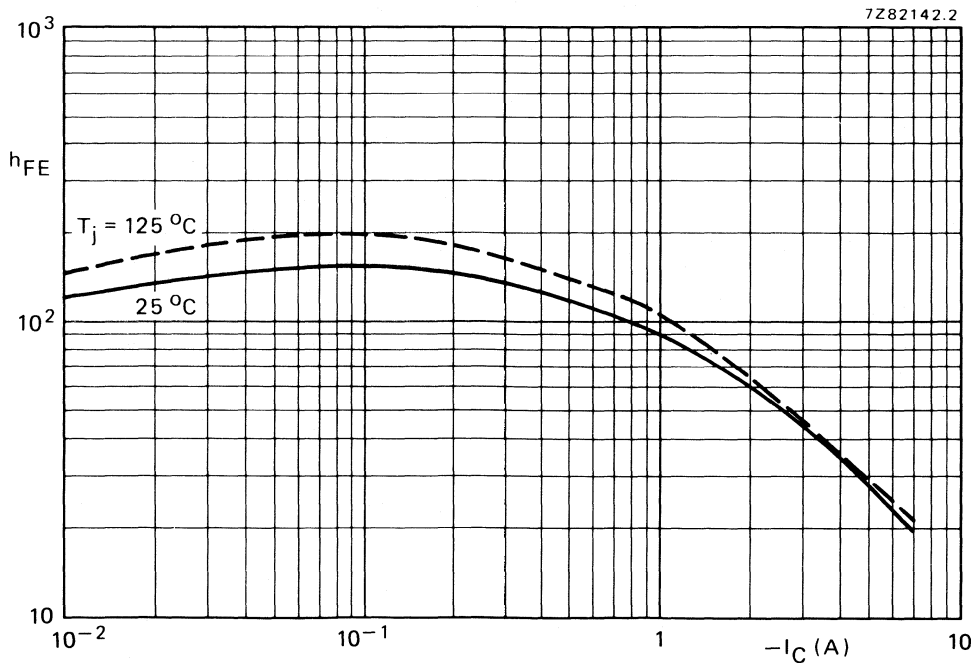


Fig. 10 Typical d.c. current gain at $-V_{CE} = 4$ V.

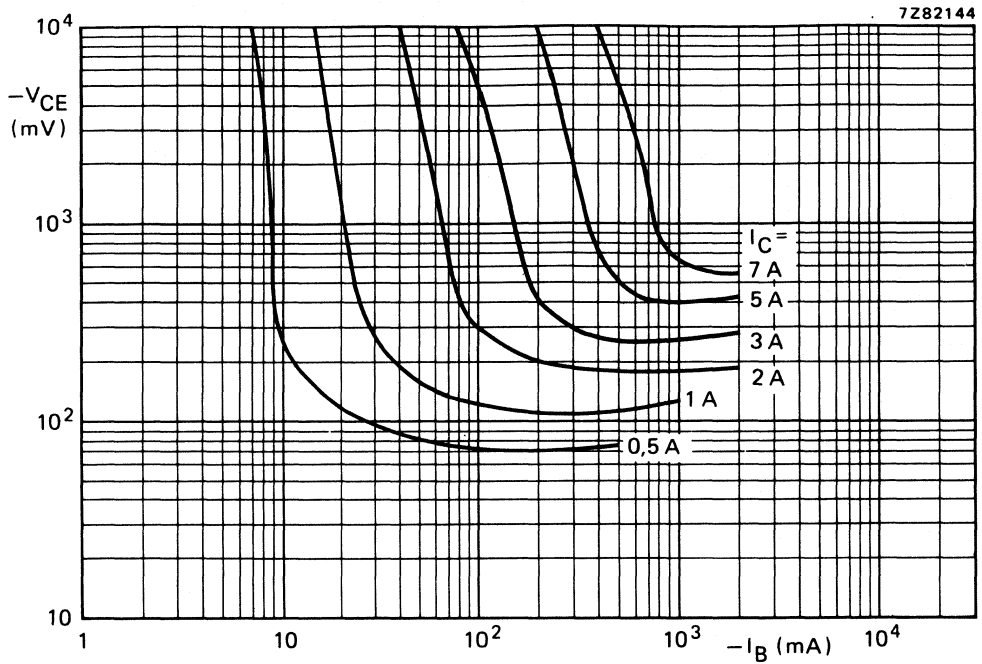


Fig. 11 Collector-emitter voltage as a function of base current.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

BD950F;952F;
BD954F;956F

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) peak value	$-I_C$ max.		5		A
	$-I_{CM}$ max.		8		A
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot} max.		22		W
DC current gain $-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE} typ.		20		

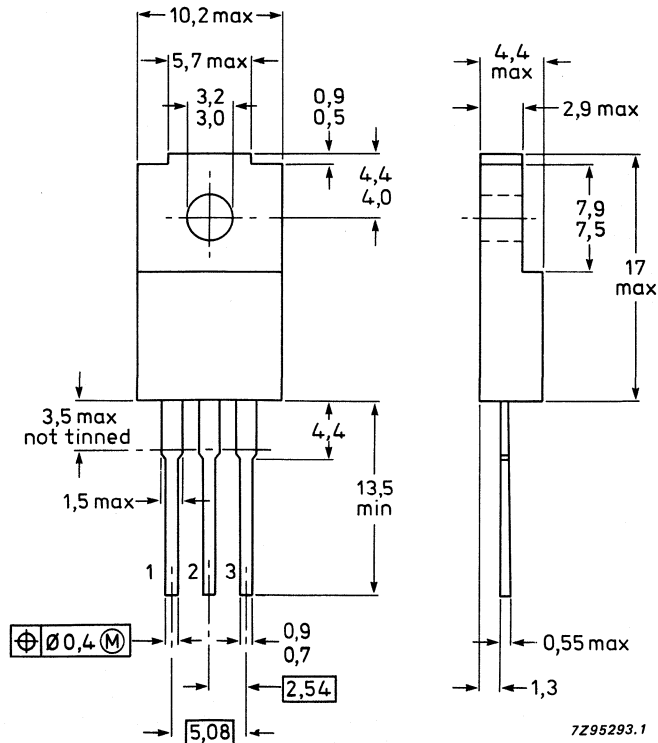
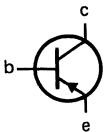
MECHANICAL DATA

Dimensions in mm

Fig.1 SOT186.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



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**BD950F;952F;
BD954F;956F**

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) peak value	$-I_C$ $-I_{CM}$	max.			5 8		A A
Base current (DC)	$-I_B$	max.			5		A
Total power dissipation at $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.			15		W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.			22		W
Storage temperature range	T_{stg}				-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=			3.12		K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=			8.12		K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=			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 $-I_C = 2\text{ A}; -I_B = 0.2\text{ A}$	V_{CEsat}	max.			1		V
DC current gain $-I_C = 2\text{ A}; -V_{CE} = 4\text{ V}$	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

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 BDT30 series.
The TIP29 series is an equivalent type.

QUICK REFERENCE DATA

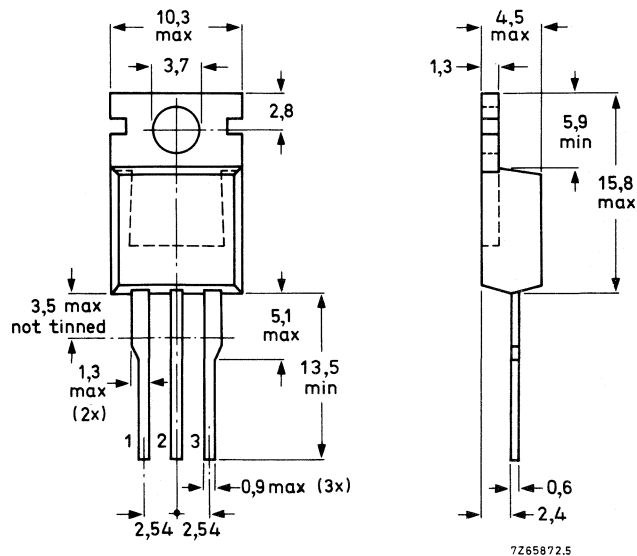
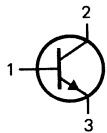
		BDT29	A	B	C
Collector-base voltage	V_{CBO} max.	80	100	120	140 V
Collector-emitter voltage	V_{CEO} max.	40	60	80	100 V
Collector current (d.c.)	I_C max.	1			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	30			W
Junction temperature	T_j max.	150			$^\circ\text{C}$
D.C. current gain	h_{FE} >	40			
$I_C = 200\text{ mA}; V_{CE} = 4\text{ V}$	h_{FE}	15 to 75			
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$					
Transition frequency at $f = 1\text{ MHz}$	f_T >	3			MHz
$I_C = 200\text{ mA}; V_{CE} = 10\text{ V}$					

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

BDT29; 29A BDT29B; 29C

RATINGS

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

			BDT29	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 $T_{mb} = 25\text{ °C}$	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	$R_{th\ j-mb}$	=		4,17		K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		70		K/W

CHARACTERISTICS

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

			BDT29; A	BDT29B; C			
→ Collector cut-off current							
→ $I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	<	0,1	—	mA		
→ $I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO}	<	—	0,1	mA		
$V_{BE} = 0; V_{CE} = V_{CEOmax}$	I_{CES}	<	0,2		mA		
Emitter cut-off current							
→ $I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	0,2		mA		
D.C. current gain*							
$I_C = 200\text{ mA}; V_{CE} = 4\text{ V}$	h_{FE}	>	40				
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	15 to 75				
Base-emitter voltage**							
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	<	1,3		V		
Collector-emitter saturation voltage*							
$I_C = 1\text{ A}; I_B = 0,125\text{ A}$	V_{CEsat}	<	0,7		V		
Collector-emitter breakdown voltage*							
$I_B = 0; I_C = 30\text{ mA}$	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current gain							
$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$ h_{fe} $	>	20				
Turn off breakdown energy							
$L = 20\text{ mH}; I_{CC} = 1,8\text{ A}$	$E_{(BR)}$	>	32		mJ		

* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}$; $\delta < 2\%$.

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

Transition frequency at $f = 1 \text{ MHz}$

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

$f_T > 3 \text{ MHz}$

Switching times

(between 10% and 90% levels)

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

Turn-on time

t_{on} typ. $0,3 \mu\text{s}$

Turn-off time

t_{off} typ. $1 \mu\text{s}$

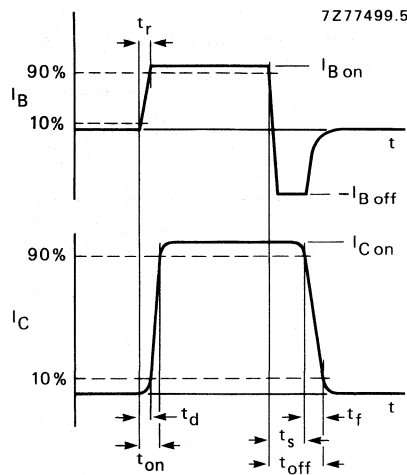


Fig. 2 Switching times waveforms.

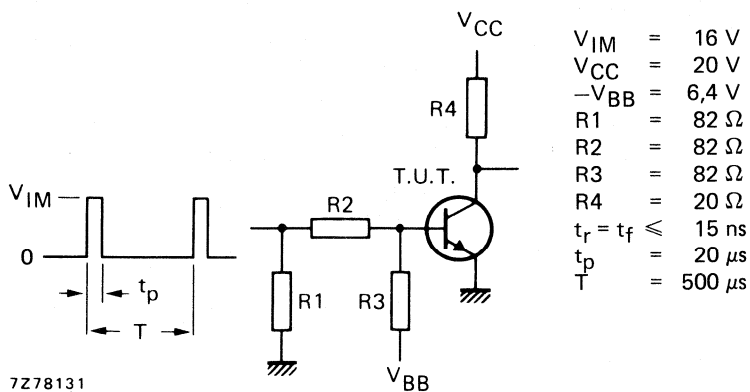


Fig. 3 Switching times test circuit.

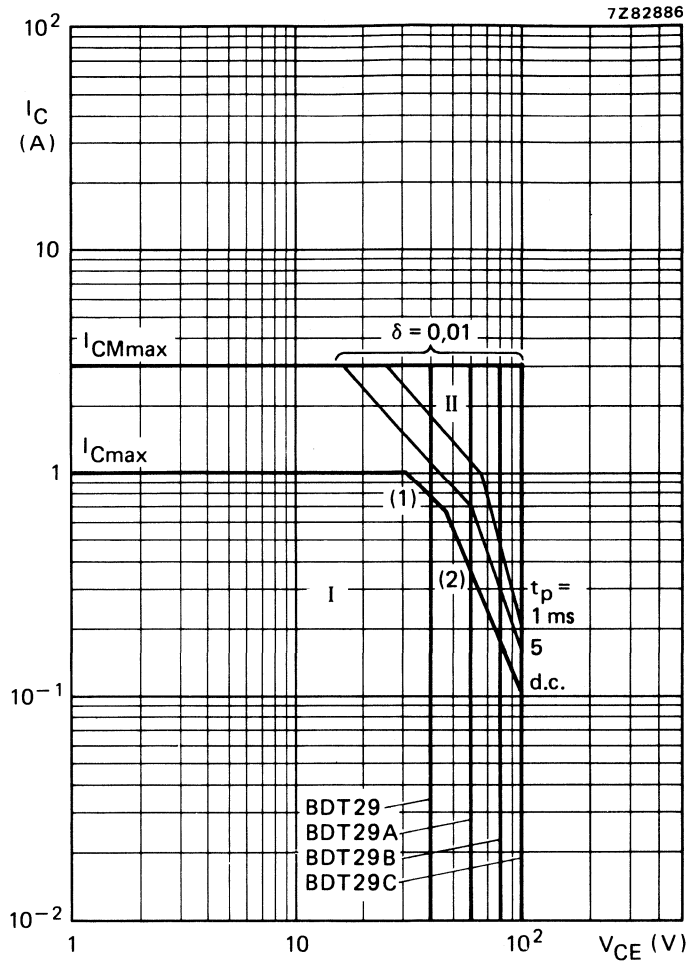


Fig. 4 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

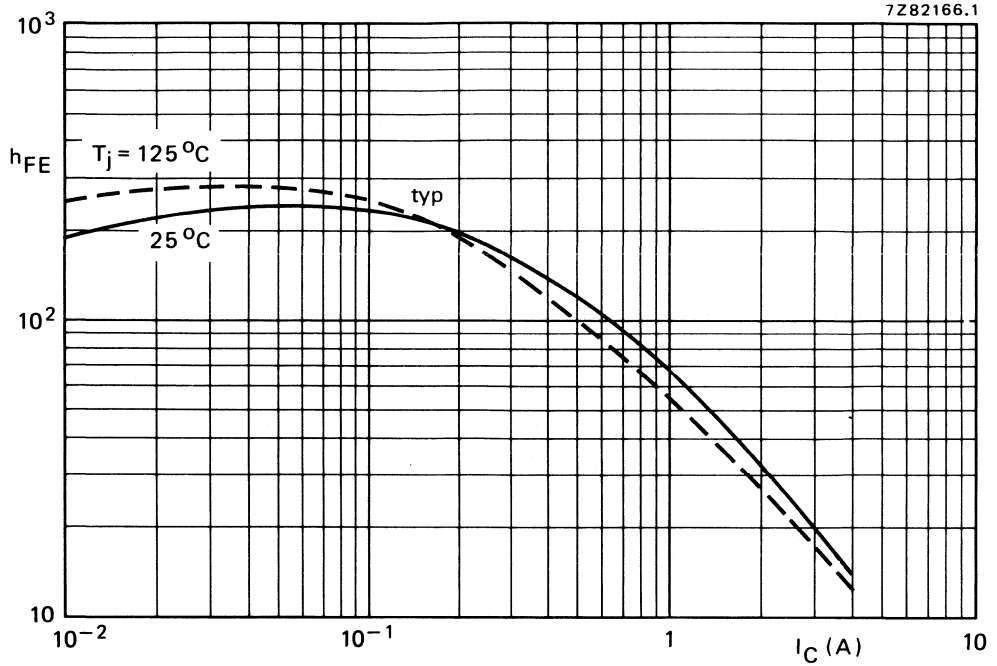


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4\text{ V}$.

SILICON EPITAXIAL POWER TRANSISTORS

N-P-N silicon power transistors in a SOT-186 envelope with an electrically insulated mounting base, intended for use in audio output stages, general purpose amplifier and high-speed switching applications.

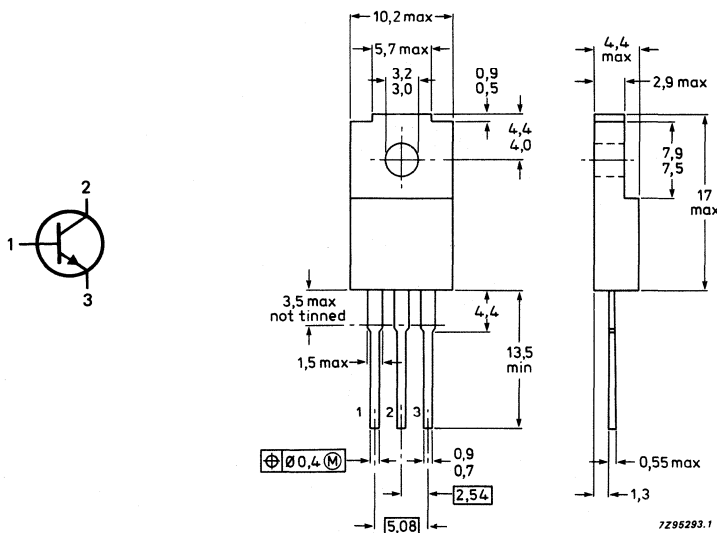
P-N-P complements are BDT30F, BDT30AF, BDT30BF, BDT30CF and BDT30DF.

QUICK REFERENCE DATA

		BDT29F	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 A
	peak value	I_{CM} max.	7	7	7	7 A
Total power dissipation up to $T_h = 25^\circ\text{C}$	P_{tot} max.	19	19	19	19	19 W
D.C. current gain $I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	15 to 75				
Transition frequency at $f = 1\text{ MHz}$ $I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$	f_T min.	3			MHz	

Fig. 1 SOT-186.

Dimensions in mm



BDT29F
BDT29AF; 29BF
BDT29CF; 29DF

RATINGS

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

		BDT29F	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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.			14		W
up to $T_h = 25\text{ }^\circ\text{C}$ (2)	P_{tot}	max.			19		W
Storage temperature	T_{stg}				-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

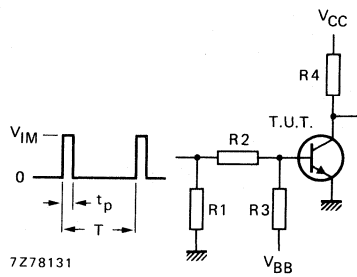
(3) Heatsink temperature $T_h = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure $P_{amb} = 1013\text{ mbar}$.

CHARACTERISTICS

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

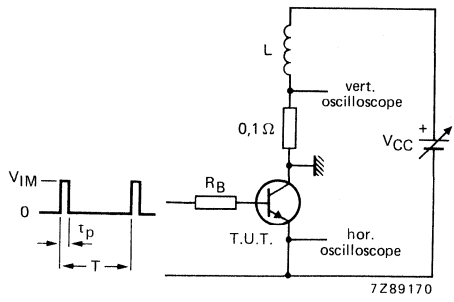
		BDT29F	29AF	29BF	29CF	29DF	
Collector cut-off currents							
$I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	< 0,1	0,1	—	—	—	mA ←
$I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO}	< —	—	0,1	0,1	—	mA ←
$I_B = 0; V_{CE} = 90\text{ V}$	I_{CEO}	< —	—	—	—	0,1	mA ←
$V_{BE} = 0; V_{CE} = V_{CBO\text{ max}}$	I_{CES}	< 0,2	0,2	0,2	0,2	0,2	mA
Emitter cut-off current							
$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	< 0,2	0,2	0,2	0,2	0,2	mA ←
Collector-emitter breakdown voltages (1)							
$I_B = 0; I_C = 30\text{ mA}$	$V_{(BR)CEO}$	> 40	60	80	100	120	V
D.C. current gain (1)							
$I_C = 0,2\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		40			
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		15 to 75			
Base-emitter voltages (1)+(2)							
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	<		1,3			
Collector-emitter saturation voltage (1)							
$I_C = 1\text{ A}; I_B = 0,125\text{ A}$	V_{CEsat}	<		0,7			V
Transition frequency at $f = 1\text{ MHz}$							
$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$	f_T	>		3			MHz
Small-signal current gain							
$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$							
at 1 kHz	h_{fe}	>		20			
at 1 MHz	h_{fe}	>		3			
Turn-off breakdown energy with inductive load (see Fig. 3)							
$I_C = 1,8\text{ A}; L = 20\text{ mH}$	$E_{(BR)}$	>		32			mJ
Switching times (see Fig. 2)							
$I_C = 1\text{ A}; I_{Bon} = -I_{Boff} = 0,1\text{ A}$							
turn-on time	t_{on}	typ.		0,3			μs
turn-off time	t_{off}	typ.		1			μs

(1) Measured under pulse conditions: $t_p = 300\text{ }\mu\text{s}$; $\delta = 2\%$.(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.



- $V_{CC} = 20 \text{ V}$
- $V_{IM} = 16 \text{ V}$
- $-V_{BB} = 6,4 \text{ V}$
- $R_1 = 82 \Omega$
- $R_2 = 82 \Omega$
- $R_3 = 82 \Omega$
- $R_4 = 20 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 20 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 2 Switching times test circuit.



- $V_{IM} = 12 \text{ V}$
- $R_B = 270 \Omega$
- $L = 20 \text{ mH}$
- $I_C = 1,8 \text{ A}$
- $t_p = 1 \text{ ms}$
- $\delta = 1 \%$

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

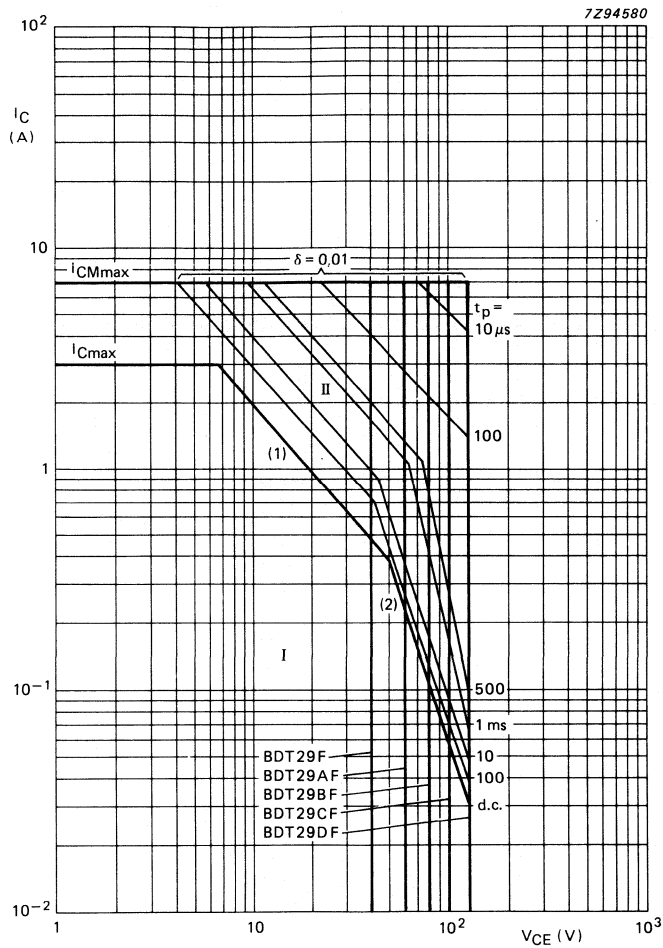


Fig. 4 Safe Operating Area, $T_{amb} = 25^\circ C$.

- 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.

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

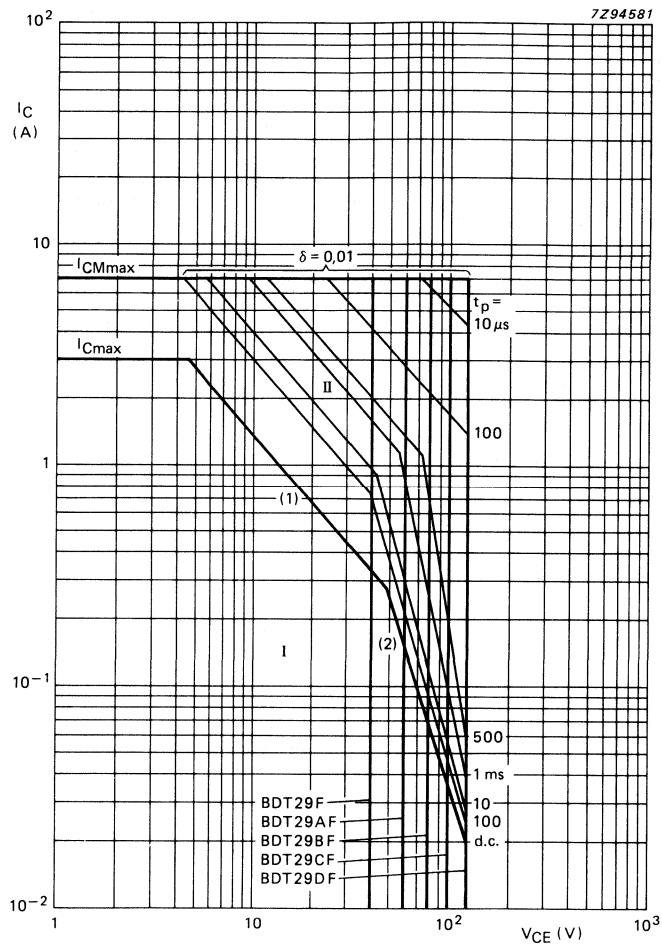


Fig. 5 Safe Operating Area, $T_{amb} = 25^\circ C$

- 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.

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

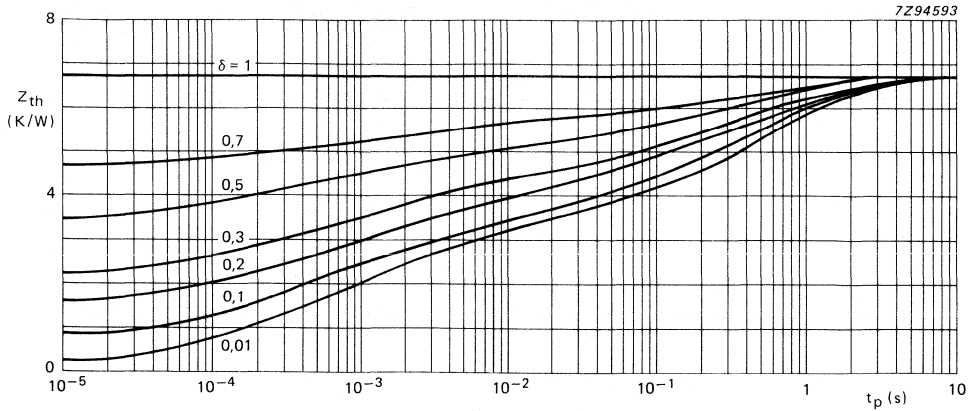


Fig. 6 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

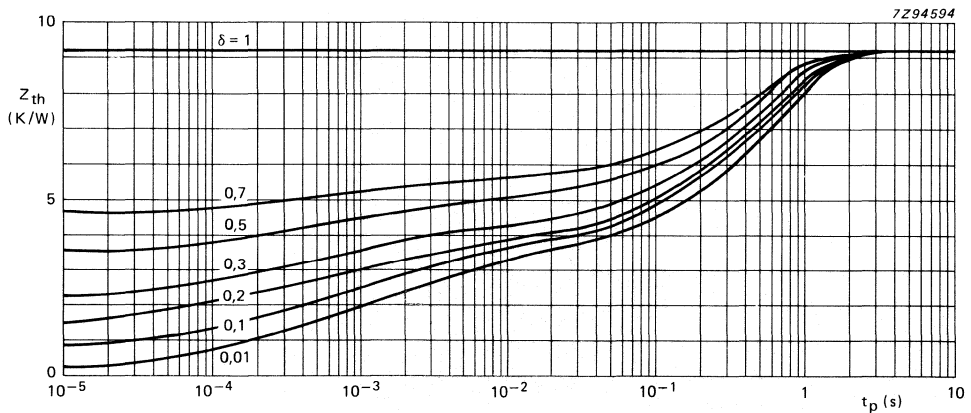


Fig. 7 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

BDT29F
BDT29AF; 29BF
BDT29CF; 29DF

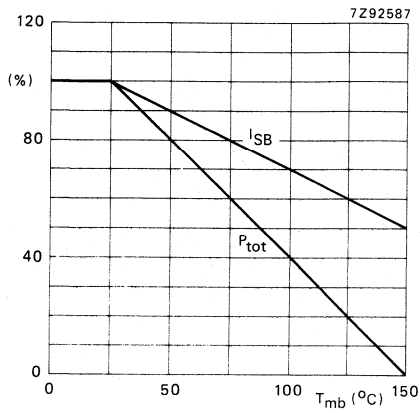


Fig. 8 Total power dissipation and second-breakdown current derating curve.

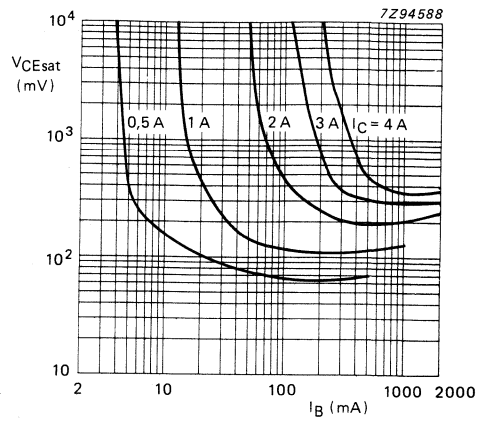


Fig. 9 Collector-emitter saturation voltage; typical values.

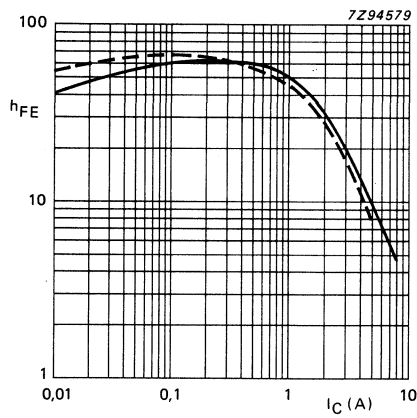


Fig. 10 D.C. current gain; $V_{CE} = 4 \text{ V}$; typical values;
— $T_j = 25 \text{ }^\circ\text{C}$; - - - $T_j = 125 \text{ }^\circ\text{C}$.

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. The TIP30 series is an equivalent type.

P-N-P complements are BDT29 series.

QUICK REFERENCE DATA

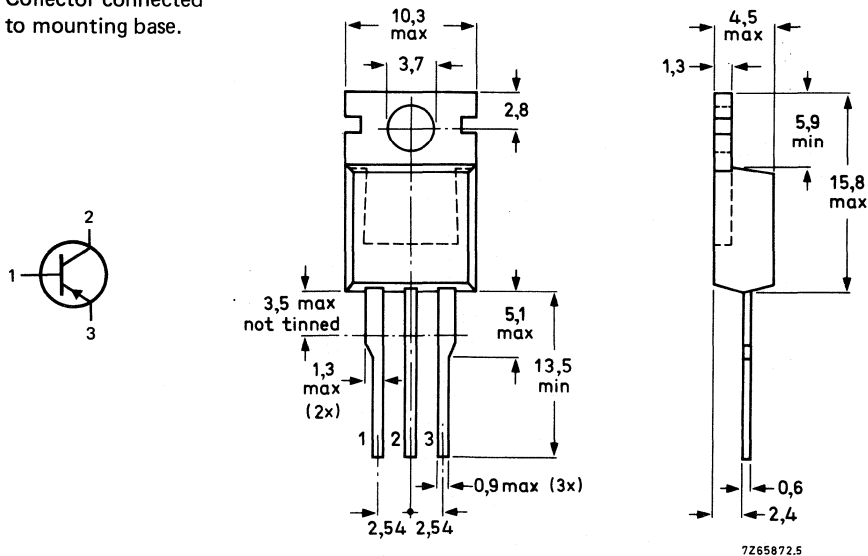
		BDT30			
		A	B	C	
Collector-base voltage	$-V_{CBO}$ max.	80	100	120	140 V
Collector-emitter voltage	$-V_{CEO}$ max.	40	60	80	100 V
Collector current (d.c.)	$-I_C$ max.	1			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	30			W
Junction temperature	T_j max.	150			$^\circ\text{C}$
D.C. current gain	h_{FE}	15 to 75			
Transition frequency	f_T >	3			MHz
		$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$			
		$-I_C = 200\text{ mA}; -V_{CE} = 10\text{ V}$			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT30	A	B	C	
→ Collector-base voltage (open emitter)	$-V_{CB0}$	max.	80	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CE0}$	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	30				W
Storage temperature	T_{stg}		-65 to +150				$^\circ\text{C}$
Junction temperature	T_j	max.	150				$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

			BDT30;A	BDT30B;C		
→ Collector cut-off current						
→ $-I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	<	0,1	—	mA	
→ $-I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	<	—	0,1	mA	
$-V_{BE} = 0; -V_{CE} = -V_{CE0max}$	$-I_{CES}$	<	0,2		mA	
→ Emitter cut-off current						
→ $I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	0,2		mA	
D.C. current gain*						
$-I_C = 200\text{ mA}; -V_{CE} = 4\text{ V}$	h_{FE}	>	40			
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}		15 to 75			
Base-emitter voltage*						
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<	1,3		V	
Collector-emitter saturation voltage*						
$-I_C = 1\text{ A}; -I_B = 0,125\text{ A}$	$-V_{CEsat}$	<	0,7		V	
Collector-emitter breakdown voltage*						
$I_B = 0; -I_C = 30\text{ mA}$	$-V_{(BR)CEO}$	>	BDT30	A	B	C
			40	60	80	100
Small-signal current gain						
$-I_C = 0,2\text{ A}; -V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$ h_{fe} $	>	20			
Turn off breakdown energy						
$L = 20\text{ mH}; I_{CC} = 1,22\text{ A}$	$E_{(BR)}$	>	15			mJ

* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}; \delta < 2\%$.

Transition frequency at $f = 1 \text{ MHz}$
 $-I_C = 200 \text{ mA}; -V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times

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

turn-on time

t_{on} typ. $0,3 \mu\text{s}$

turn-off time

t_{off} typ. $1 \mu\text{s}$

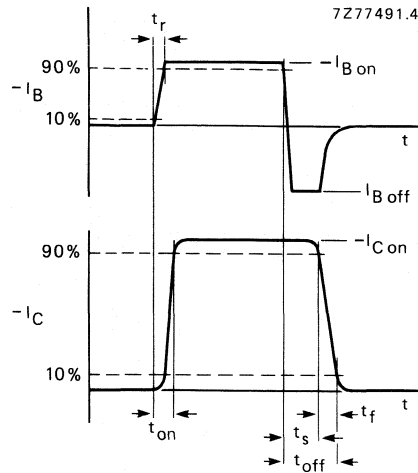


Fig. 2 Switching times waveforms.

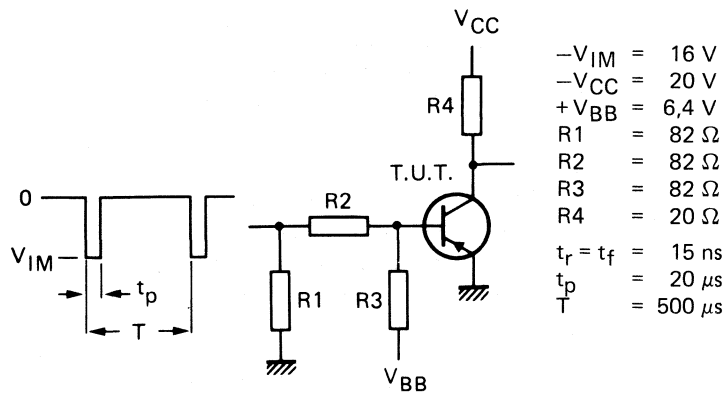


Fig. 3 Switching times test circuit.

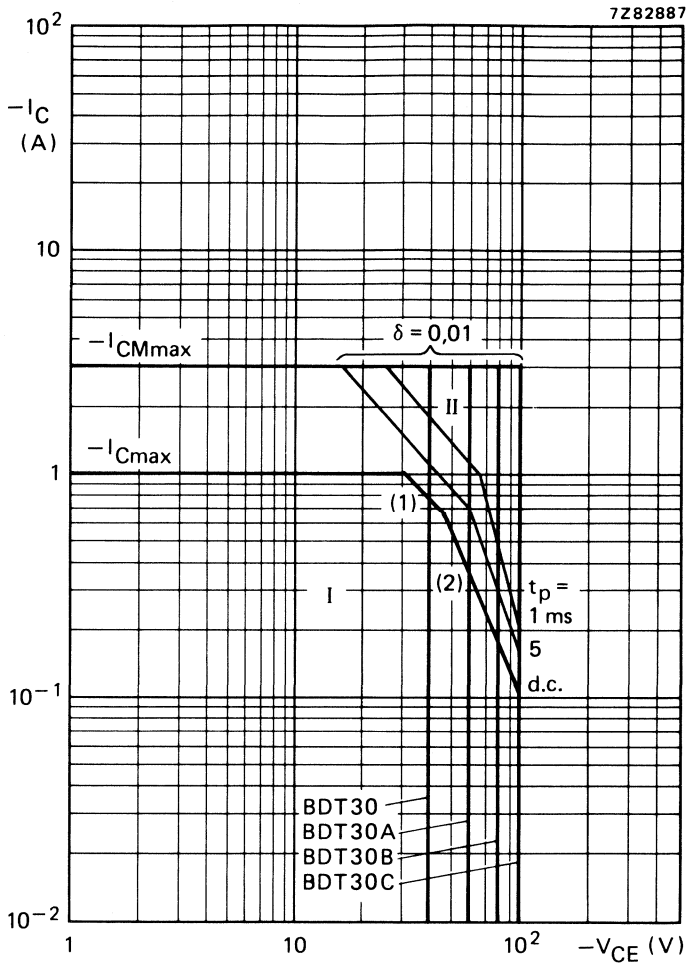


Fig. 4 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

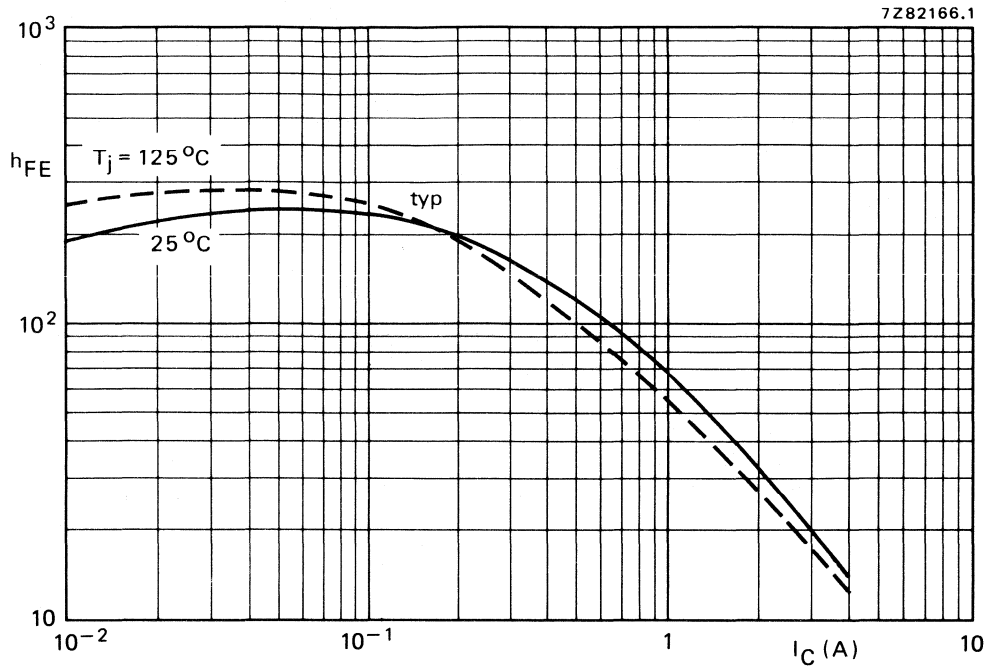


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 4$ V.

SILICON EPITAXIAL POWER TRANSISTORS

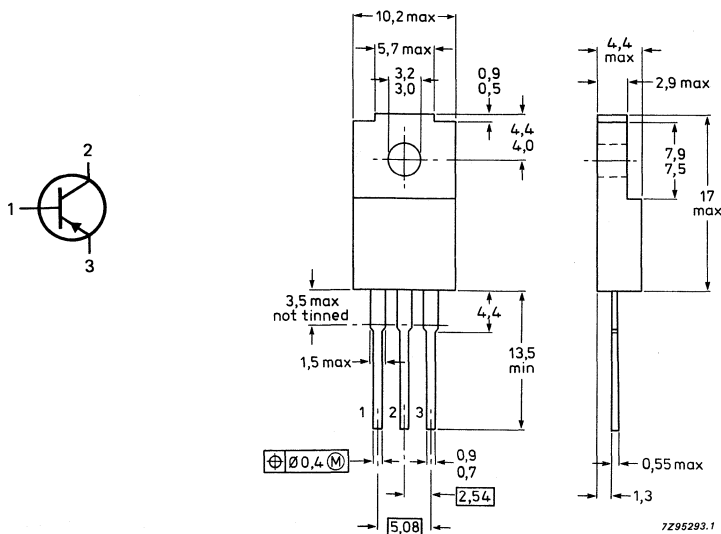
P-N-P silicon power transistor in a SOT-186 envelope with an electrically insulated mounting base, for use in audio output stages and for general purpose amplifier and high-speed switching applications. N-P-N complements are BDT29F, BDT29AF, BDT29BF, BDT29CF and BDT29DF.

QUICK REFERENCE DATA

		BDT30F	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 $T_h = 25^\circ\text{C}$	P_{tot} max.	19	19	19	19	19 W
D.C. current gain $-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	15 to 75				
Transition frequency at $f = 1\text{ MHz}$ $-I_C = 0,2\text{ A}; -V_{CE} = 10\text{ V}$	f_T min.	3			MHz	

Fig. 1 SOT-186.

Dimensions in mm



RATINGS

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

		BDT30F 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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.			14			W
up to $T_h = 25\text{ }^\circ\text{C}$ (2)	P_{tot}	max.			19			W
Storage temperature	T_{stg}				-65 to 150			$^\circ\text{C}$
Junction temperature	T_j	max.			150			$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	R_{thj-mb}	=			4,17			K/W
From junction to external heatsink (1)	R_{thj-h}	=			9,17			K/W
From junction to external heatsink (2)	R_{thj-h}	=			6,67			K/W
From junction to ambient	R_{thj-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-h}	typ.			12			pF

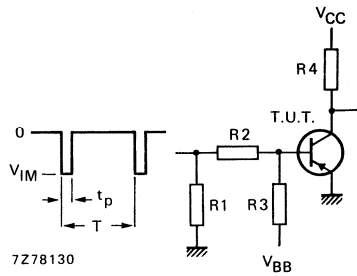
- (1) Mounted without heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
- (2) Mounted with heatsink compound and 30 ± 5 newtons pressure on centre of envelope.
- (3) Heatsink temperature $T_h = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure $P_{amb} = 1013$ mbar.

CHARACTERISTICS

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

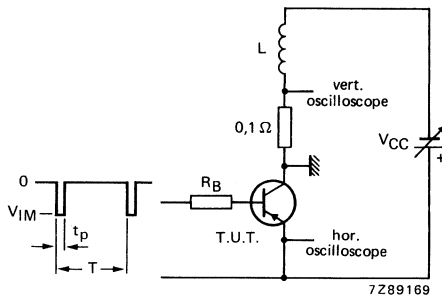
		BST30F	30AF	30BF	30CF	30DF	
Collector cut-off currents							
$-I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	< 0,1	0,1	—	—	—	mA ←
$-I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	< —	—	0,1	0,1	—	mA ←
$-I_B = 0; -V_{CE} = 90\text{ V}$	$-I_{CEO}$	< —	—	—	—	0,1	mA ←
$-V_{BE} = 0; -V_{CE} = V_{CBOmax}$	$-I_{CES}$	< 0,2	0,2	0,2	0,2	0,2	mA
Emitter-cut-off current							
$-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	< 0,2	0,2	0,2	0,2	0,2	mA ←
Collector-emitter breakdown voltages (1)							
$-I_B = 0; -I_C = 30\text{ mA}$	$-V_{(BR)CEO}$	> 40	60	80	100	120	V
D.C. current gain (1)							
$-I_C = 0,2\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>		40			
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>		15 to 75			
Base-emitter voltage (1)+(2)							
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<		1,3			V
Collector-emitter saturation voltage (1)							
$-I_C = 1\text{ A}; -I_B = 0,125\text{ A}$	$-V_{CEsat}$	<		0,7			V
Transition frequency at $f = 1\text{ MHz}$							
$-I_C = 0,2\text{ A}; -V_{CE} = 10\text{ V}$	f_T	>		3			MHz
Small-signal current gain							
$-I_C = 0,2\text{ A}; -V_{CE} = 10\text{ V}$							
at 1 kHz	h_{fe}	>		20			
at 1 MHz	h_{fe}	>		3			
Turn-off breakdown energy with inductive load (see Fig. 3)							
$-I_C = 1,8\text{ A}; L = 20\text{ mH}$	$E_{(BR)}$	>		32			mJ
Switching times (see Fig. 2)							
$-I_C = 1\text{ A}; -I_{Bon} = + I_{Boff} = 0,1\text{ A}$							
turn-on time	t_{on}	typ.		0,3			μs
turn-off time	t_{off}	typ.		1			μs

(1) Measured under pulse conditions: $t_p = 300\text{ }\mu\text{s}$; $\delta = 2\%$.(2) V_{BE} decreases by about 2,3 mV/K with increasing temperature.



$-V_{CC} = 20 \text{ V}$
 $-V_{IM} = 16 \text{ V}$
 $+V_{BB} = 6,4 \text{ V}$
 $R1 = 82 \Omega$
 $R2 = 82 \Omega$
 $R3 = 82 \Omega$
 $R4 = 20 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 20 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 2 Switching times test circuit.



$-V_{IM} = 12 \text{ V}$
 $R_B = 270 \Omega$
 $L = 20 \text{ mH}$
 $-I_C = 1,8 \text{ A}$
 $t_p = 1 \text{ ms}$
 $\delta = 1 \%$

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

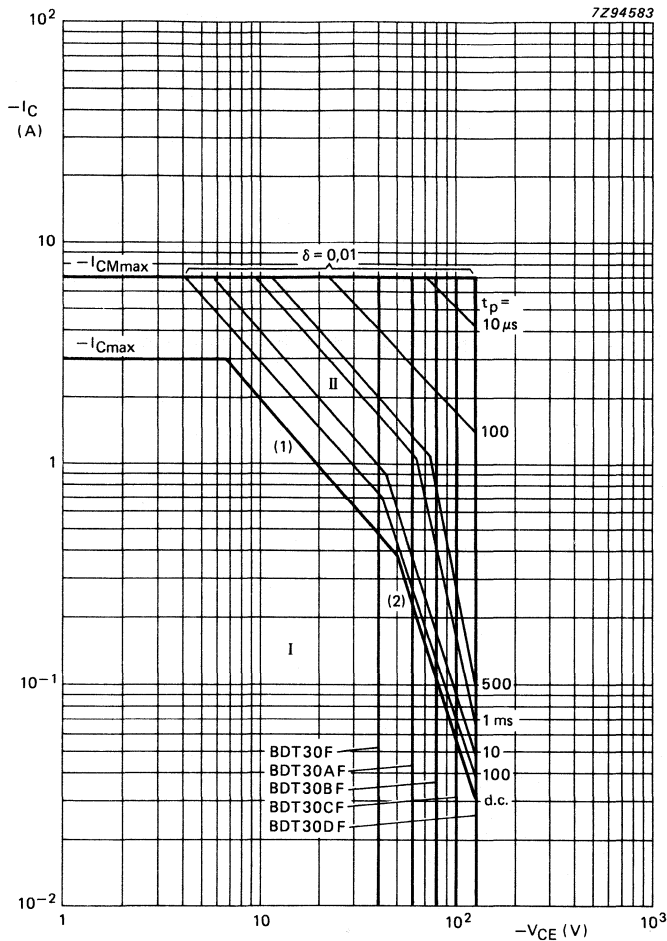


Fig. 4 Safe Operating Area, $T_{amb} = 25\text{ }^{\circ}\text{C}$.

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

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

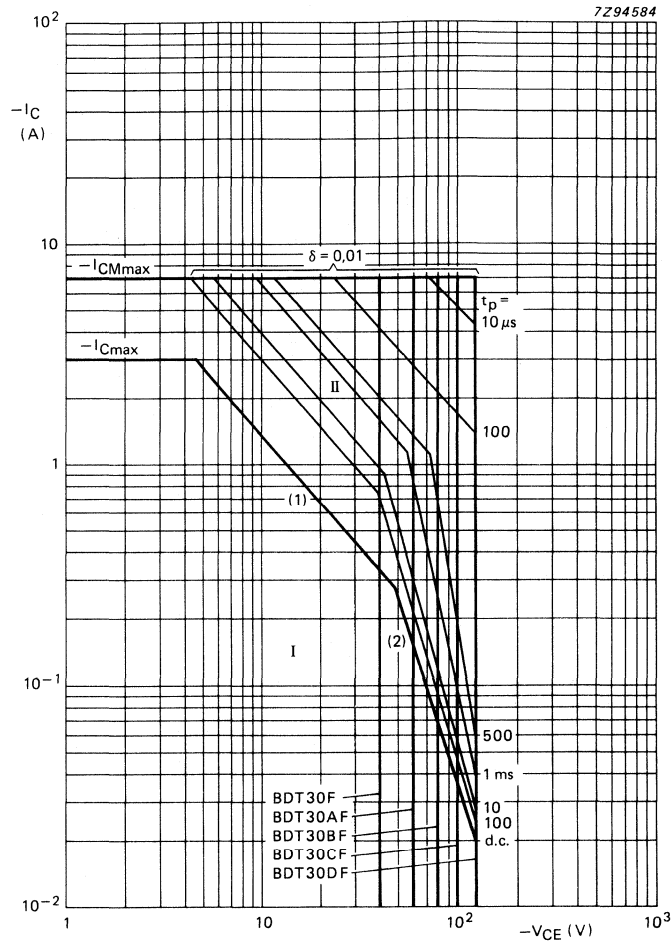


Fig. 5 Safe Operating Area, $T_{amb} = 25^{\circ}\text{C}$.

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

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

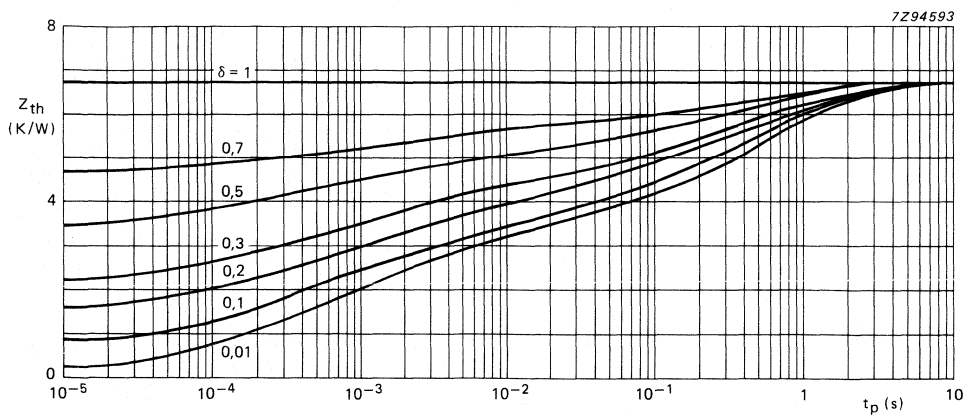


Fig. 6 Pulse power rating chart; mounted *with* heatsink compound and 30 ± 5 Newton pressure on the envelope.

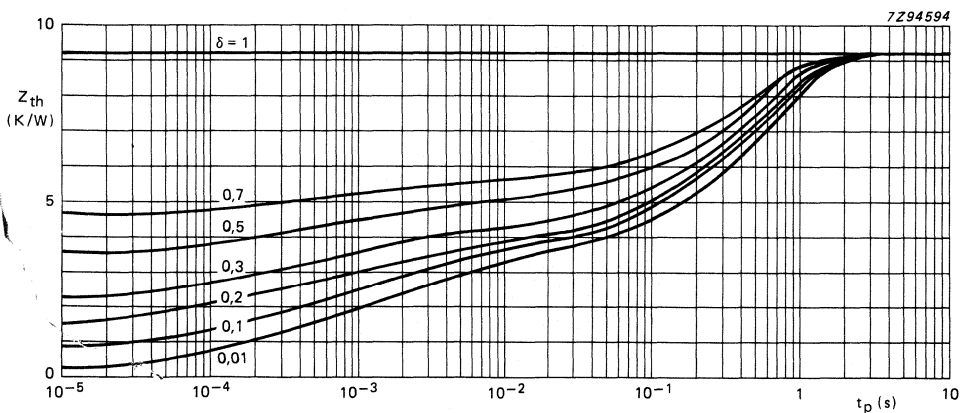


Fig. 7 Pulse power rating chart; mounted *without* heatsink compound and 30 ± 5 Newton pressure on the envelope.

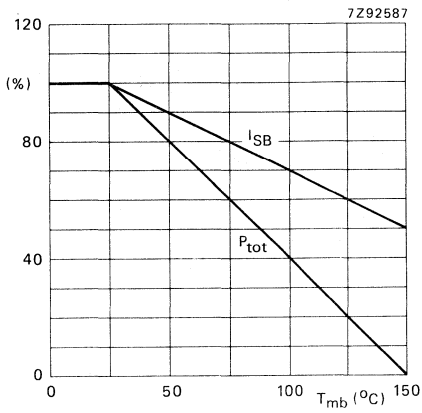


Fig. 8 Total power dissipation and second-breakdown current derating curve.

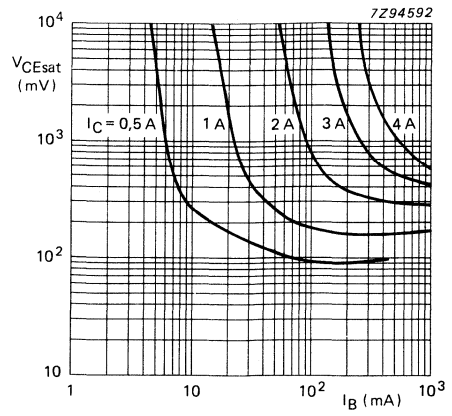


Fig. 9 Collector-emitter saturation voltage; typical values.

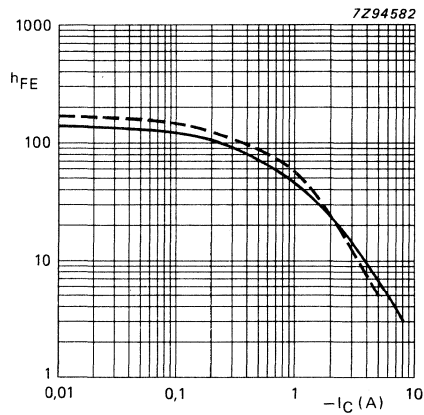


Fig. 10 D.C. current gain; $-V_{CE} = 4 \text{ V}$; typical values;
 — $T_j = 25 \text{ }^\circ\text{C}$; - - - $T_j = 125 \text{ }^\circ\text{C}$.

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. The TIP31 series is an equivalent type. P-N-P complements are BDT32 series. ←

QUICK REFERENCE DATA

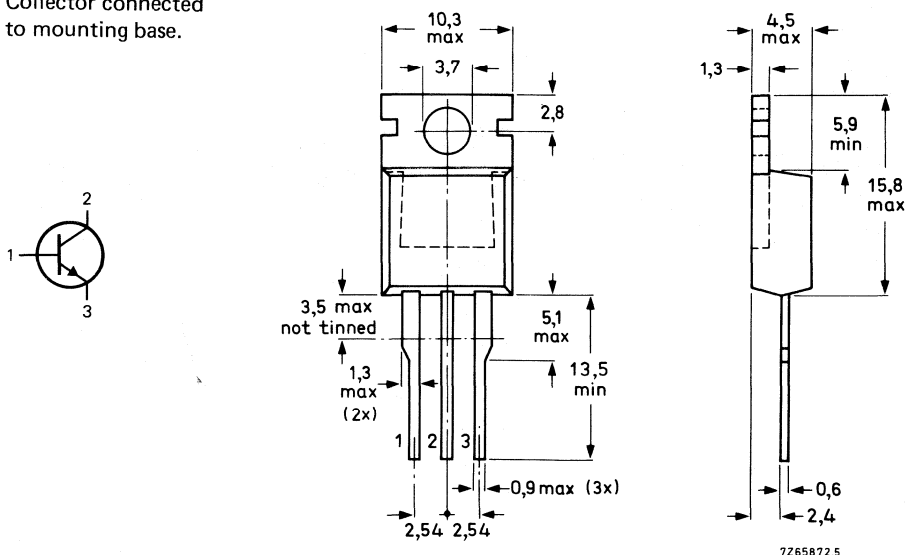
		BDT31	A	B	C
Collector-base voltage (open emitter)	V_{CBO}	max. 80	100	120	140 V
Collector-emitter voltage (open base)	V_{CEO}	max. 40	60	80	100 V
Collector current (d.c.)	I_C	max.		3	A
Collector current (peak value)	I_{CM}	max.		5	A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		40	W
Junction temperature	T_j	max.		150	$^\circ\text{C}$
D.C. current gain				25	
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		25	
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}			10 to 50	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

		BDT31	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			40	W
Storage temperature	T_{stg}			-65 to +150	$^\circ\text{C}$
Junction temperature	T_j max.			150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

		BDT31; A	BDT31B; C
→ Collector cut-off current	$I_B = 0; V_{CE} = 30\text{ V}$	0,1	— mA
→ $I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO} <	—	0,1 mA
$V_{BE} = 0; V_{CE} = V_{CEOmax}$	I_{CES} <	0,2	mA
→ Emitter cut-off current	$I_C = 0; V_{EB} = 5\text{ V}$		0,2 mA
D.C. current gain *	$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$		25
	$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$		10 to 50
Base-emitter voltage * **	$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$		1,8 V
Collector-emitter saturation voltage *	$I_C = 3\text{ A}; I_B = 0,375\text{ A}$		1,2 V
Collector-emitter breakdown voltage *	$I_B = 0; I_C = 30\text{ mA}$	40	60 80 100 V
Small-signal current transfer ratio	$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$		20
	$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}; f = 1\text{ MHz}$		3
Turn-off breakdown energy	$L = 20\text{ mH}; I_{CC} = 1,8\text{ A}$		32 mJ

* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}$; $\delta \leq 2\%$.

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

Switching times

(between 10% and 90% levels)

$I_{C on} = 1 \text{ A}; I_{B on} = -I_{B off} = 0,1 \text{ A}$

Turn-on time

Turn-off time

t_{on}	typ.	0,3 μs
t_{off}	typ.	1 μs

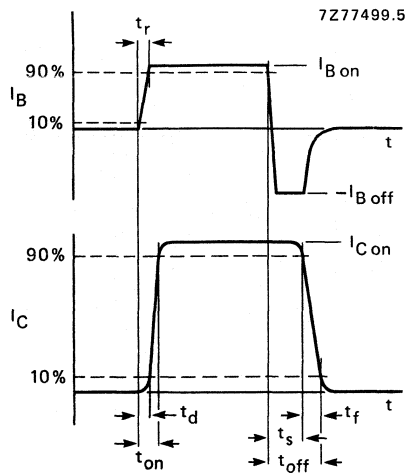


Fig. 2 Switching times waveforms.

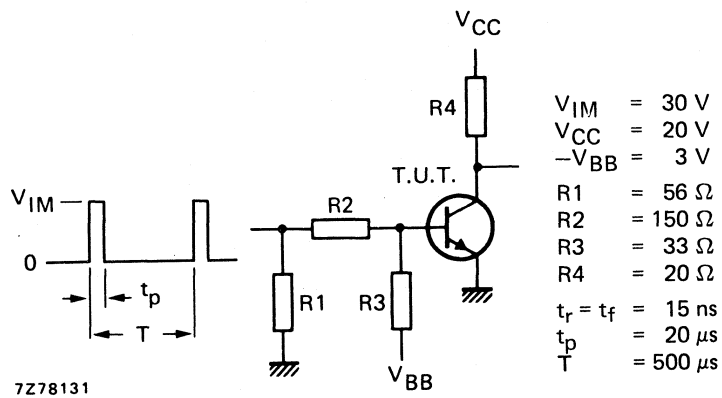


Fig. 3 Switching times test circuit.

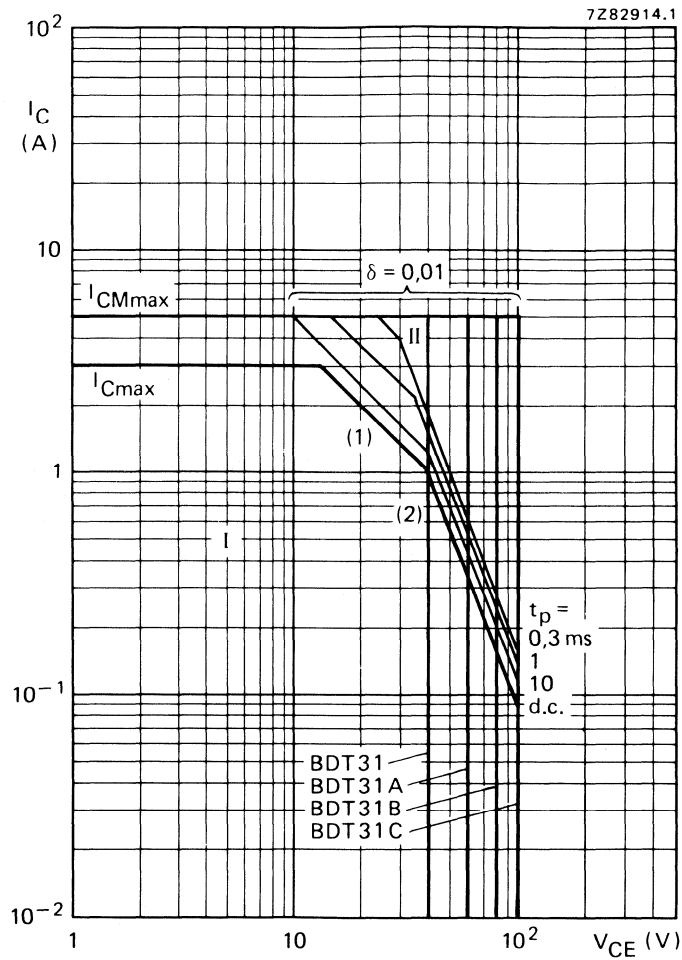


Fig. 4 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

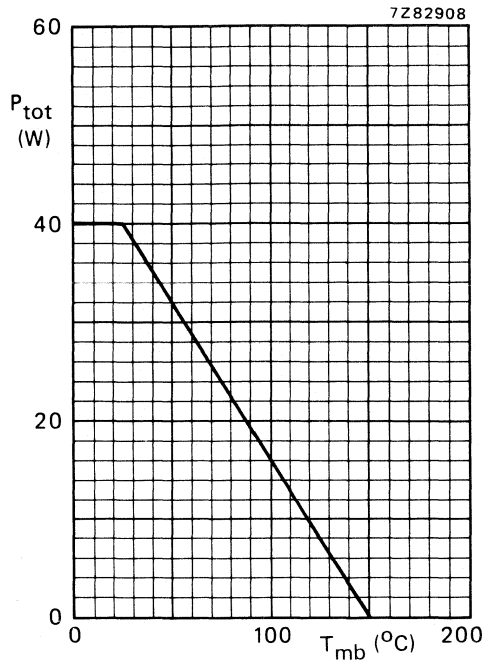


Fig. 5 Power derating curve.

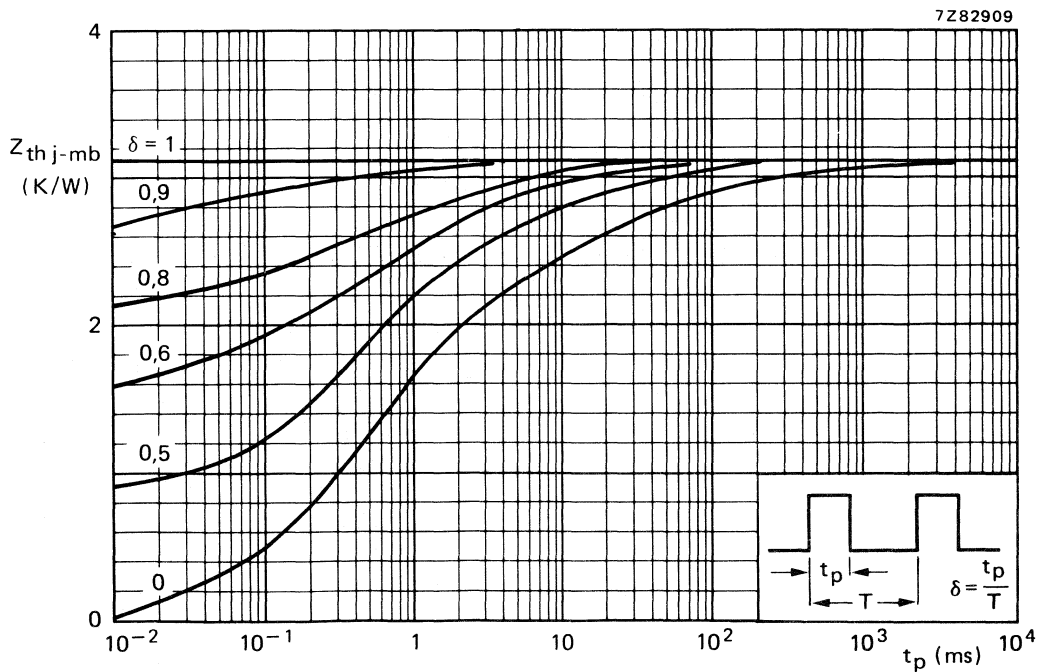


Fig. 6 Pulse power rating chart.

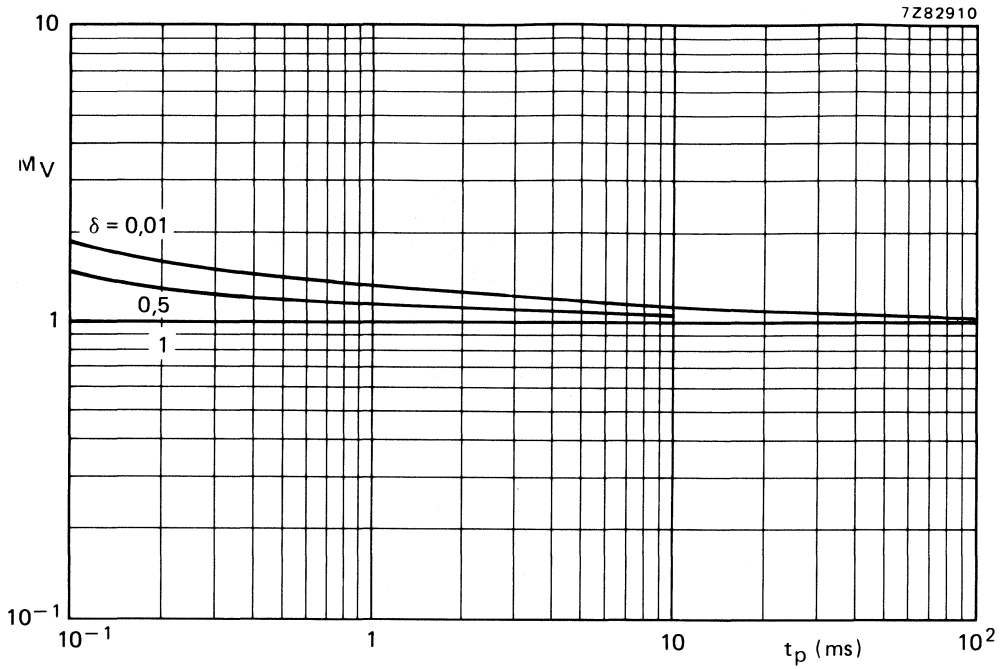


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

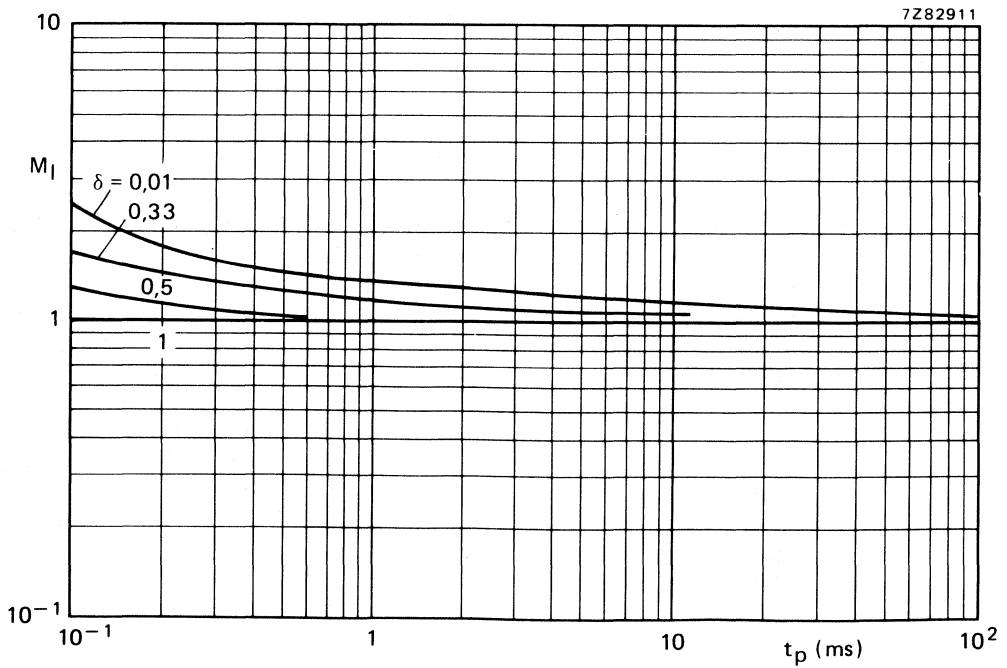


Fig. 8 S.B. current multiplying factor at the V_{CE0max} level.

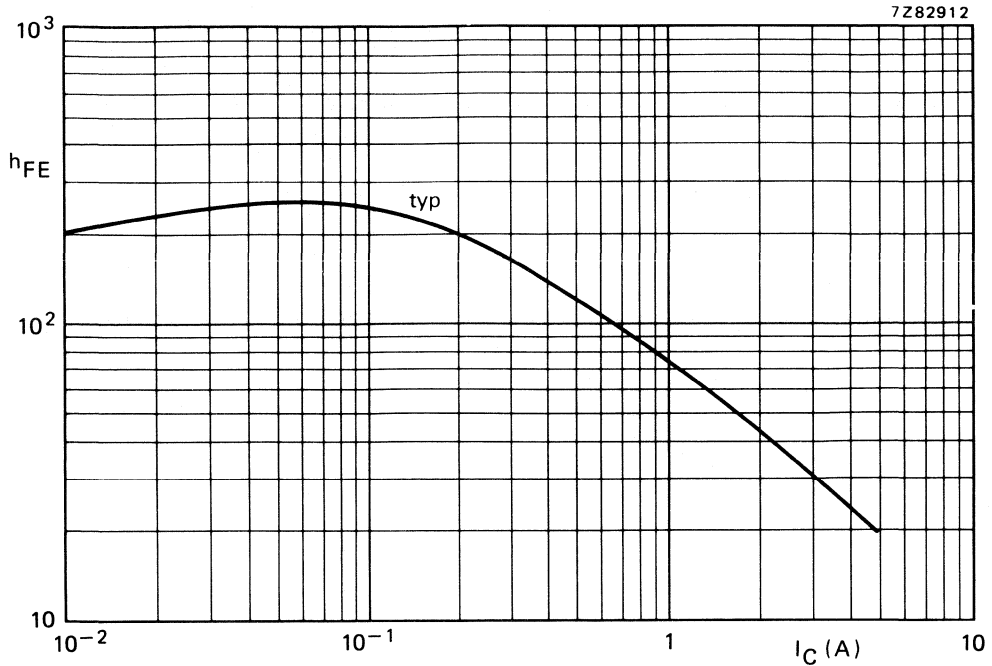


Fig. 9 Typical values d.c. current gain at $V_{CE} = 4$ V.

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 BDT32F, BDT32AF, BDT32BF, BDT32CF, and BDT32DF.

QUICK REFERENCE DATA

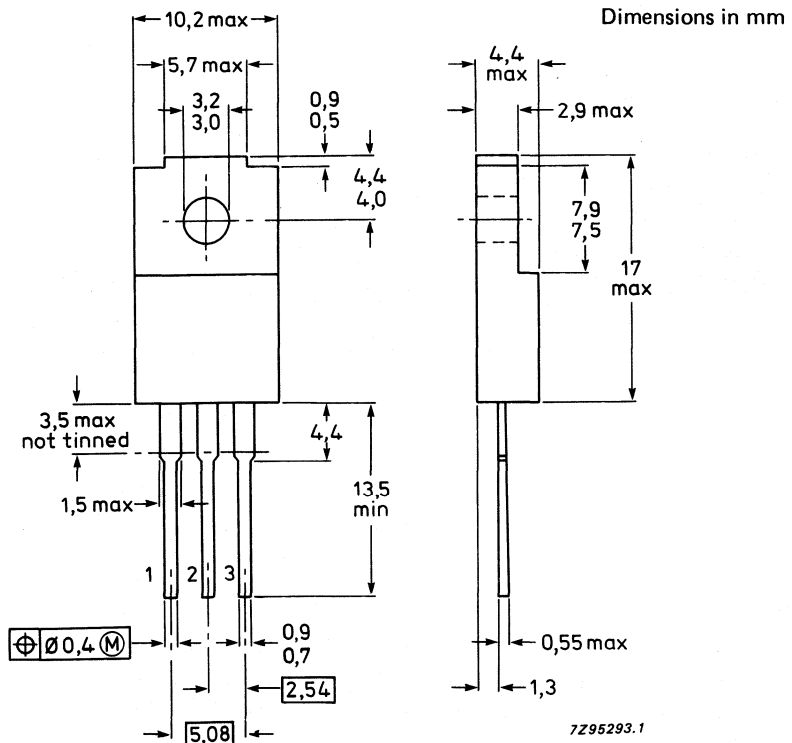
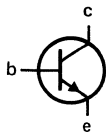
			BDT31F	31AF	31BF	31CF	31DF
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	160 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	120 V
Emitter-base voltage (open collector)	V_{EBO}	max.			5		V
DC collector current	I_C	max.			3		A
Peak collector current	I_{CM}	max.			5		A
DC current gain							
$I_C = 3 \text{ A}; V_{CE} = 4 \text{ V}$	h_{FE}	min.			10		
Small-signal current gain at $f = 1 \text{ MHz}$							
$I_C = 0.5 \text{ A}; V_{CE} = 10 \text{ V}$	h_{fe}	min.			3		

MECHANICAL DATA

Fig.1 SOT186.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



7295293.1

RATINGS

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

			BDT31F	31AF	31BF	31CF	31DF
Collector-base voltage (open emitter)	V_{CB0}	max.	80	100	120	140	160 V
Collector-emitter voltage (open base)	V_{CE0}	max.	40	60	80	100	120 V
Emitter-base voltage (open collector)	V_{EB0}	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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.			15		W
up to $T_h = 25\text{ }^\circ\text{C}$ (note 2)	P_{tot}	max.			22		W
Storage temperature range	T_{stg}				-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=			3.12		K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=			8.12		K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=			5.62		K/W
From junction to ambient	$R_{th\ j-a}$	=			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-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 $T_h = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure $P_{amb} = 1013\text{ mbar}$.

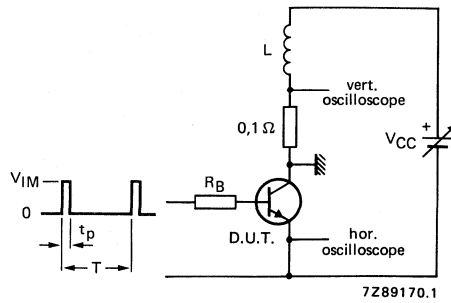
CHARACTERISTICS

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

			BDT31F	31AF	31BF	31CF	31DF
Collector cut-off current							
$I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	max.	0.1	0.1	—	—	— mA
$I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO}	max.	—	—	0.1	0.1	— mA
$I_B = 0; V_{CE} = 90\text{ V}$	I_{CEO}	max.	—	—	—	—	0.1 mA
$V_{BE} = 0; V_{CE} = V_{CB0max}$	I_{CES}	max.	0.2	0.2	0.2	0.2	0.2 mA
Emitter cut-off current							
$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	max.	0.2	0.2	0.2	0.2	0.2 mA
DC current gain (note 1)							
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	min.	25	25	25	25	25
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	min.	10	10	10	10	5
	h_{FE}	max.	50	50	50	50	—
Collector-emitter breakdown voltage (note 1)							
$I_B = 0; I_C = 30\text{ mA}$	$V_{(BR)CEO}$	min.	40	60	80	100	120 V
Collector-emitter saturation voltage (note 1)							
$I_C = 3\text{ A}; I_B = 375\text{ mA}$	V_{CEsat}	max.	1.2	1.2	1.2	1.2	— V
$I_C = 3\text{ A}; I_B = 750\text{ mA}$	V_{CEsat}	max.	—	—	—	—	2.5 V
Base-emitter voltages (notes 1 and 2)							
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	max.			1.8		V
Small-signal current gain							
$I_C = 0.5\text{ A}; V_{CE} = 10\text{ V}$	h_{fe}	min.			20		
at 1 kHz	h_{fe}	min.			3		
at 1 MHz							
Turn-off breakdown energy with inductive load (see Fig.3)							
$I_C = 1.8\text{ A}; L = 20\text{ mH}$	$E_{(BR)}$	min.			32		mJ
Switching times (see Fig.2)							
$I_C = 1\text{ A}; I_{B\text{ on}} = -I_{B\text{ off}} = 0.1\text{ A}$							
turn-on time	t_{on}	typ.			0.3		μs
turn-off time	t_{off}	typ.			1		μs

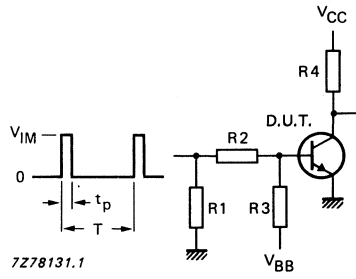
Notes

1. Measured under pulse conditions: $t_p = 300\text{ }\mu\text{s}$; $\delta = 2\%$.
2. V_{BE} decreases by about 2.3 mV/K with increasing temperature.



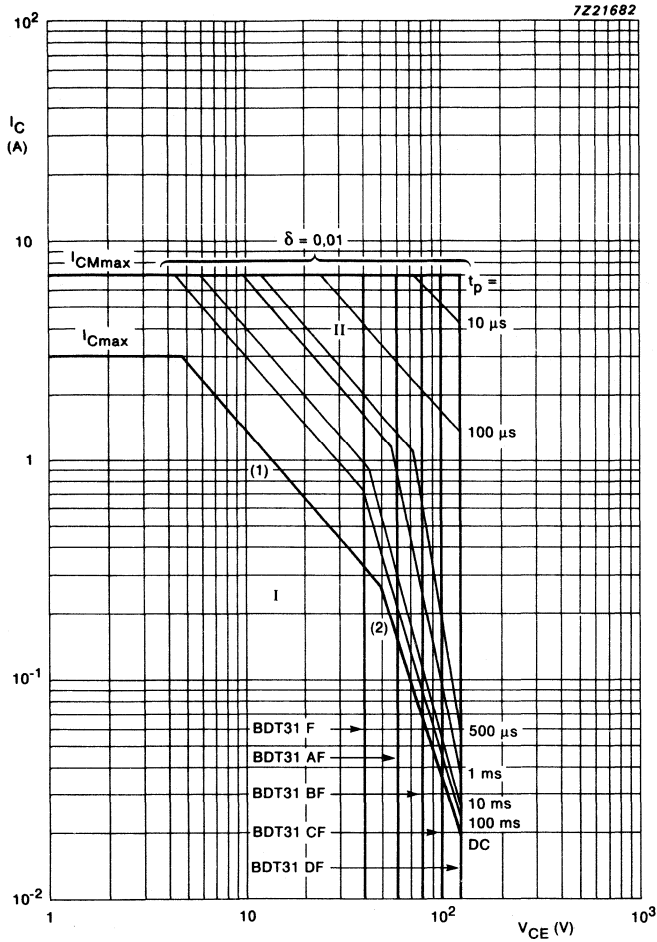
$V_{CC} = 20 \text{ V}$
 $V_{IM} = 30 \text{ V}$
 $-V_{BB} = 3 \text{ V}$
 $R_1 = 56 \Omega$
 $R_2 = 150 \Omega$
 $R_3 = 33 \Omega$
 $R_4 = 20 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 20 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig.2 Switching times test circuit.



$V_{IM} = 12 \text{ V}$
 $R_B = 270 \Omega$
 $L = 20 \text{ mH}$
 $I_C = 1.8 \text{ A}$
 $t_p = 1 \text{ ms}$
 $\delta = 1 \%$

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, $T_{amb} = 25^\circ\text{C}$.

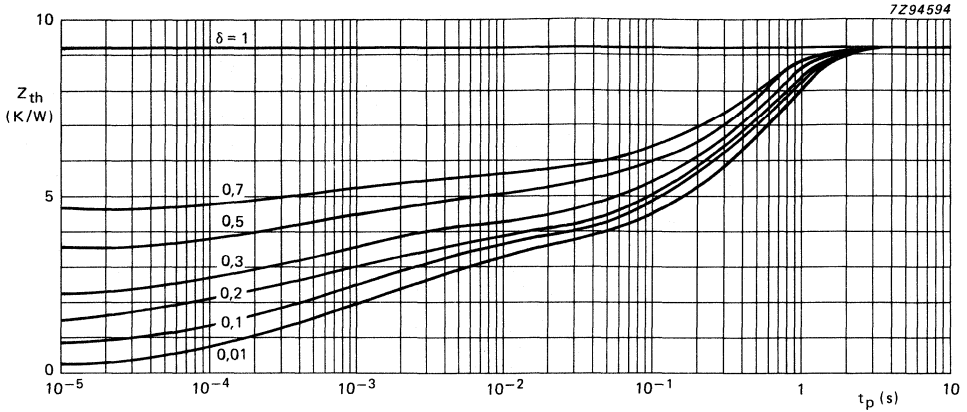


Fig.5 Pulse power rating chart; mounted without heatsink compound and 30 ± 5 newtons pressure on the envelope.

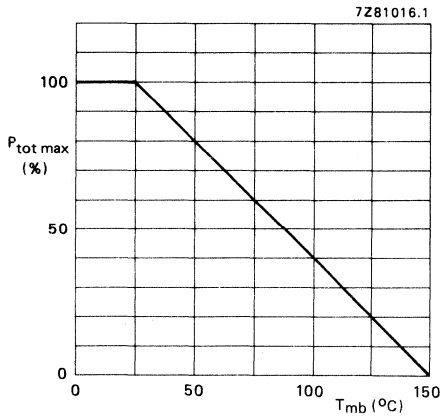


Fig.6 Total power dissipation.

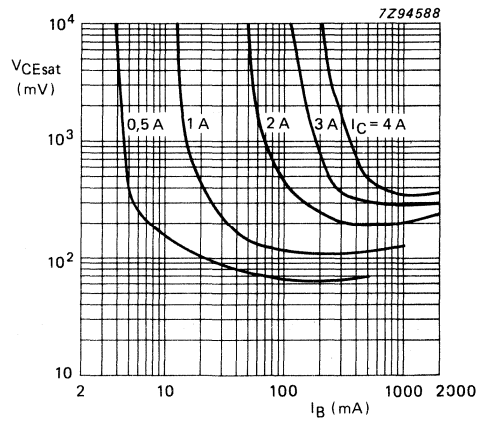


Fig.7 Typical collector-emitter saturation voltage; $T_j = 25^\circ\text{C}$.

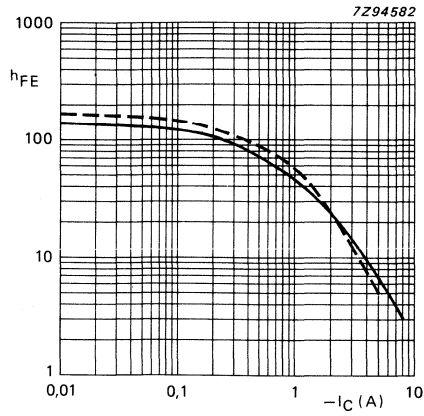


Fig.8 Typical DC current gain; $V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-220 envelope. They are intended for use in a wide range of power amplifiers and for switching applications. The TIP32 series is an equivalent type. P-N-P complements are BDT31 series.

QUICK REFERENCE DATA

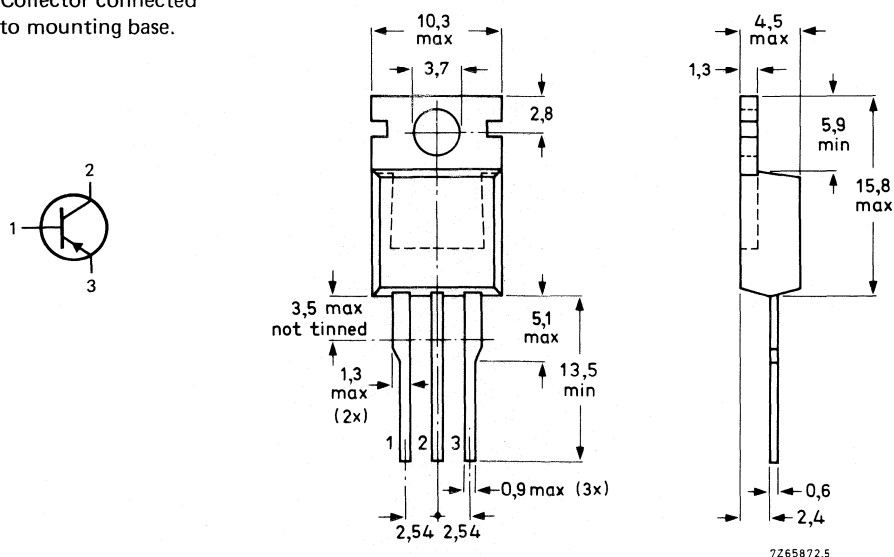
		BDT32				A	B	C
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	V	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V	
Collector current (d.c.)	$-I_C$	max.	3			A		
Collector current (peak value)	$-I_{CM}$	max.	5			A		
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	40			W		
Junction temperature	T_j	max.	150			$^\circ\text{C}$		
D.C. current gain						25		
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>				10 to 50		
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}							

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

BDT32; A BDT32B; C

RATINGS

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

		BDT32				
		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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max. 40				W
Storage temperature	T_{stg}	-65 to 150				$^\circ\text{C}$
Junction temperature	T_j	max. 150				$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

		BDT32; A		B; C			
→ Collector cut-off current							
$I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	<	0,1		mA		
$I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	<			0,1 mA		
$V_{EB} = 0; -V_{CE} = -V_{CEO}$	$-I_{CES}$	<	0,2		mA		
→ Emitter cut-off current							
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	0,2		mA		
D.C. current gain *							
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	25				
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	10 to 50				
Base-emitter voltage * **							
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<	1,8		V		
Collector-emitter saturation voltage							
$-I_C = 3\text{ A}; -I_B = 0,375\text{ A}$	$-V_{CEsat}$	<	1,2		V		
Collector-emitter breakdown voltage *							
$I_B = 0; -I_C = 30\text{ mA}$	$-V_{(BR)CEO}$	>	40	60	80	100	V
Small signal current transfer ratio							
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$ h_{fe} $	>		20			
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}; f = 1\text{ MHz}$	$ h_{fe} $	>		3			
Turn-off breakdown energy							
$L = 20\text{ mH}; I_{CC} = 1,22\text{ A}$	$E_{(BR)}$	>		15		mJ	

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

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

Switching times

(between 10% and 90% levels)

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

Turn-on time

Turn-off time

t_{on} typ. $0,3 \mu\text{s}$
 t_{off} typ. $1 \mu\text{s}$

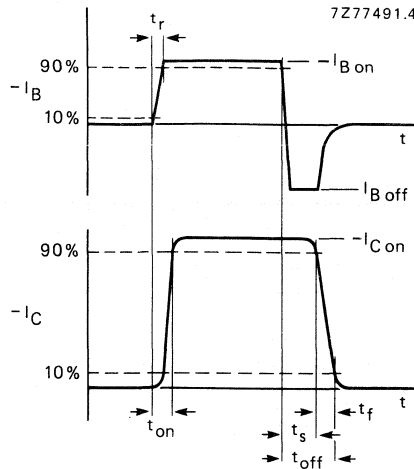
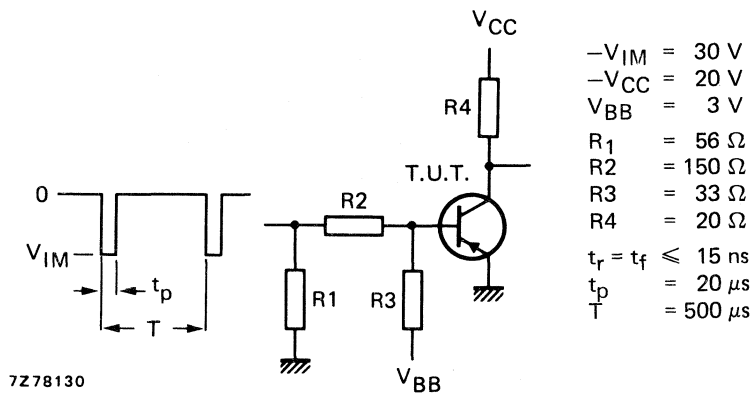


Fig. 2 Switching times waveforms.



- $-V_{IM} = 30 \text{ V}$
- $-V_{CC} = 20 \text{ V}$
- $V_{BB} = 3 \text{ V}$
- $R_1 = 56 \Omega$
- $R_2 = 150 \Omega$
- $R_3 = 33 \Omega$
- $R_4 = 20 \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 20 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

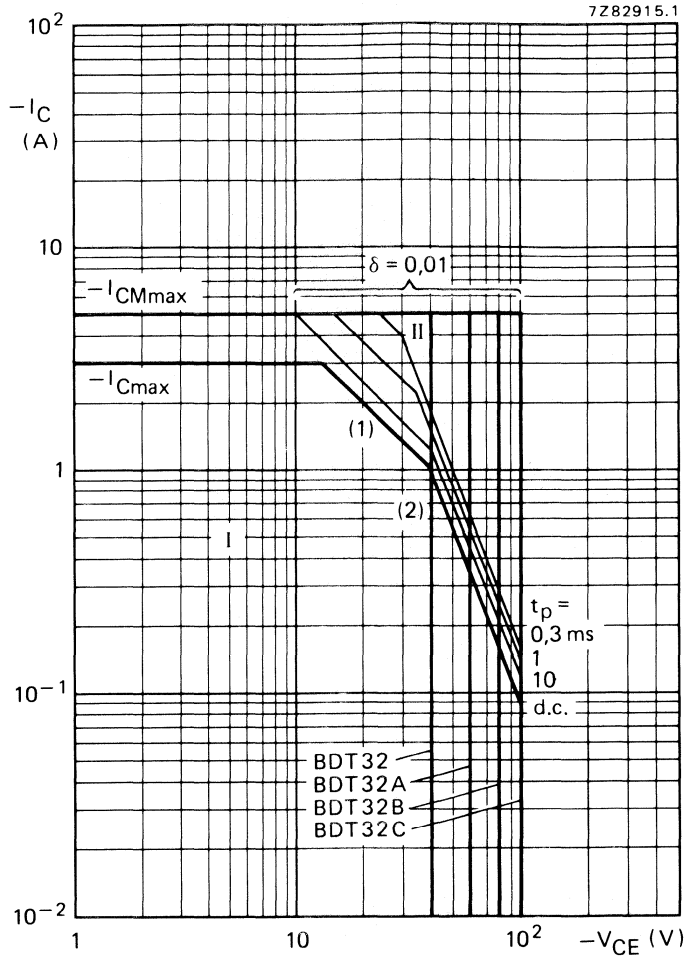


Fig. 4 Safe Operating Area; $T_{mb} \leq 25\ ^\circ C$.

- 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.

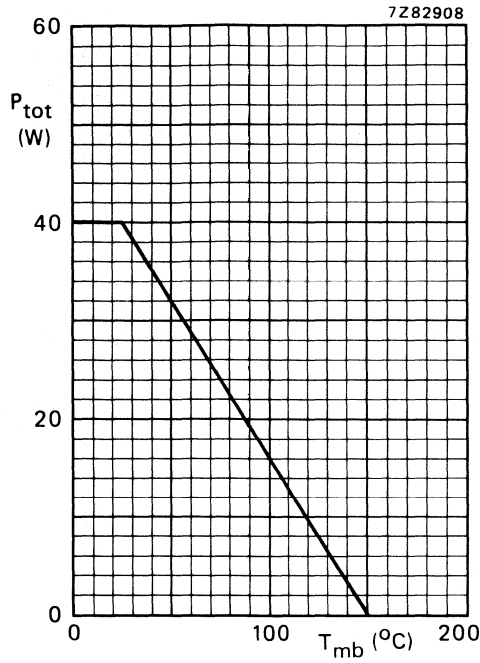


Fig. 5 Power derating curve.

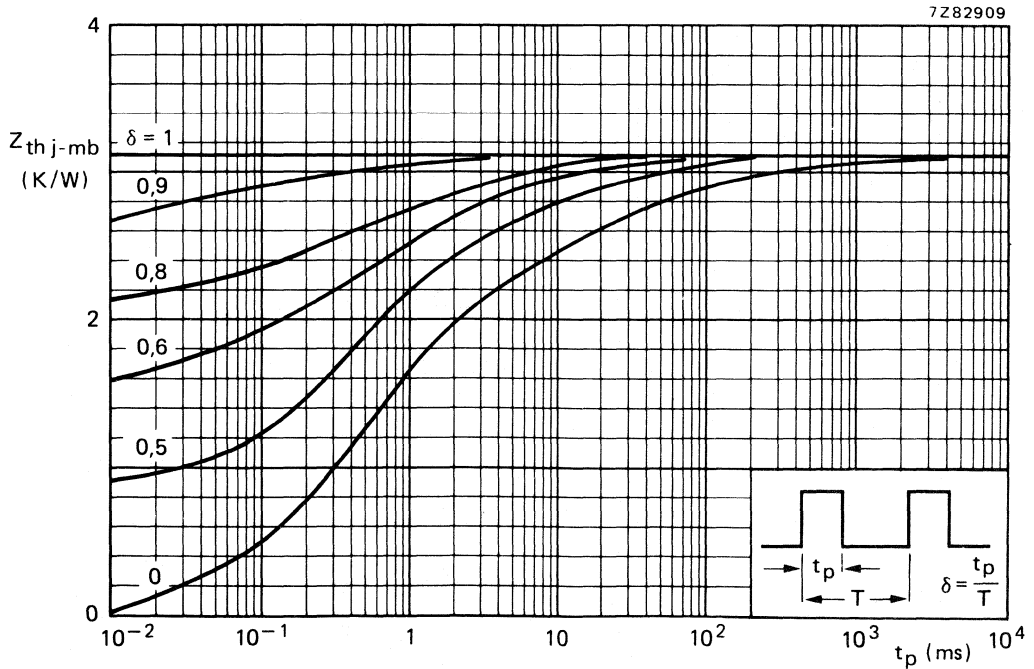


Fig. 6 Pulse power rating chart.

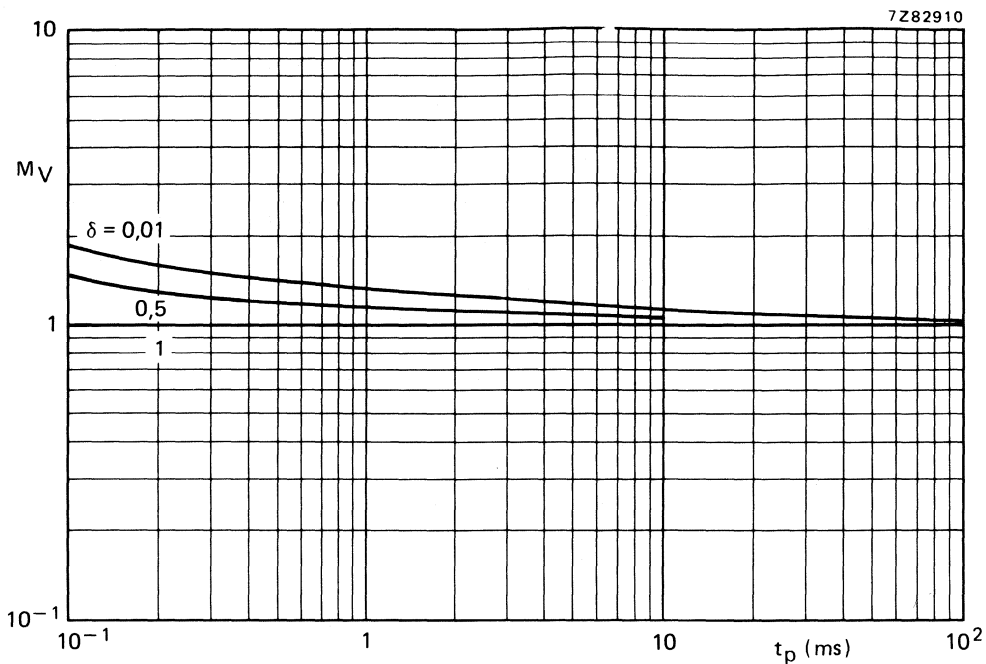


Fig. 7 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

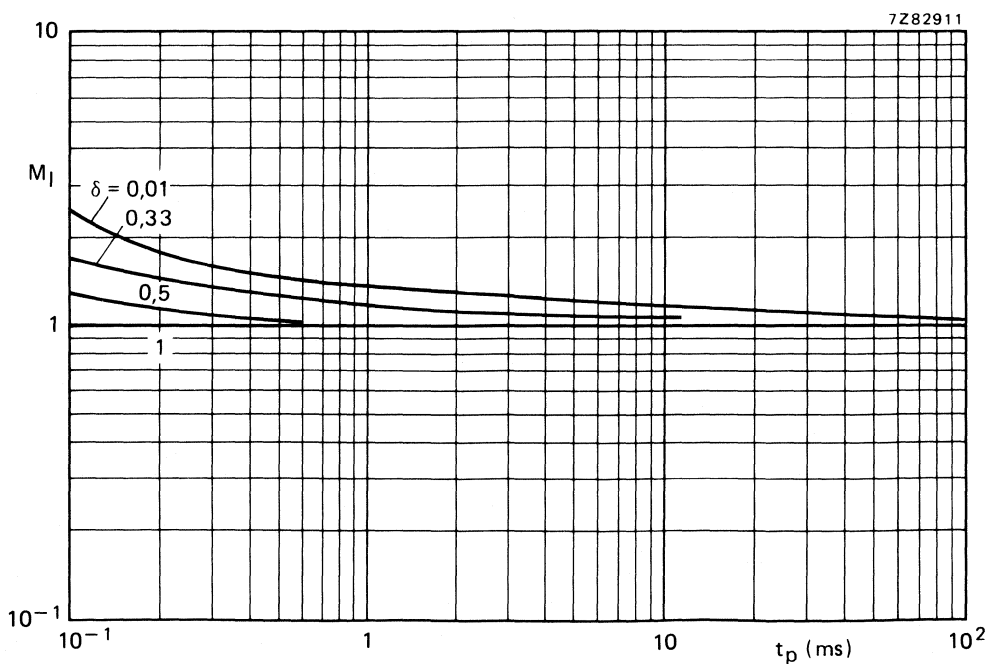


Fig. 8 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

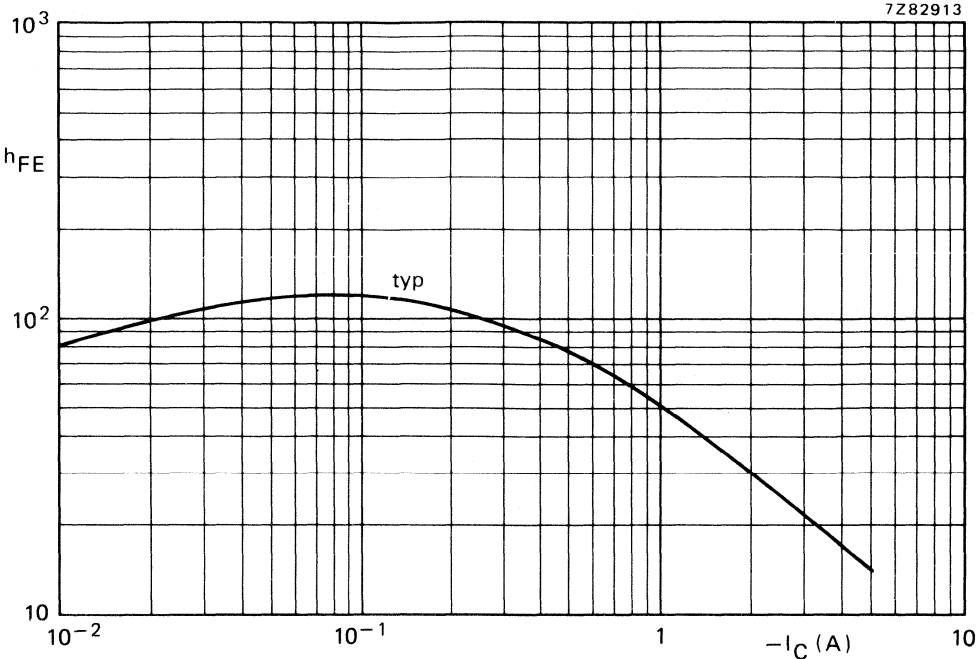


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V; $T_j = 25$ °C.

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 BDT31F, BDT31AF, BDT31BF, BDT31CF, and BDT31DF.

QUICK REFERENCE DATA

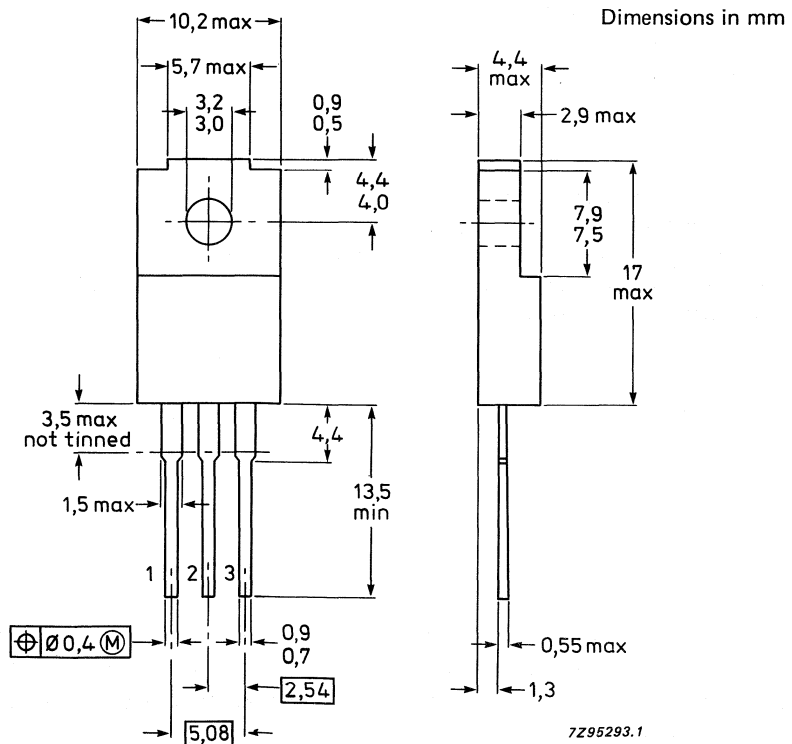
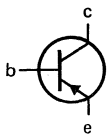
			BDT32F	32AF	32BF	32CF	32DF
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140	160 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	120 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			5		V
DC collector current	$-I_C$	max.			3		A
Peak collector current	$-I_{CM}$	max.			7		A
DC current gain							
$-I_C = 3 \text{ A}; -V_{CE} = 4 \text{ V}$	h_{FE}	min.			10		
Small-signal current gain at $f = 1 \text{ MHz}$							
$-I_C = 0.5 \text{ A}; -V_{CE} = 10 \text{ V}$	h_{fe}	min.			3		

MECHANICAL DATA

Fig.1 SOT186.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



RATINGS

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

			BDT32F	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 $T_H = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.			15		W
up to $T_H = 25\text{ }^\circ\text{C}$ (note 2)	P_{tot}	max.			22		W
Storage temperature range	T_{stg}				-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=			3.12		K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=			8.12		K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=			5.62		K/W
From junction to ambient	$R_{th\ j-a}$	=			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-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 $T_H = 25\text{ }^\circ\text{C}$; relative humidity $R_H \leq 75\%$; atmospheric pressure $P_{amb} = 1013\text{ mbar}$.

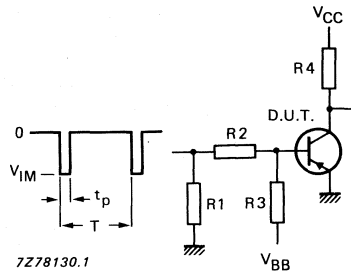
CHARACTERISTICS

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

			BDT32F	32AF	32BF	32CF	32DF
Collector cut-off current							
$-I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	max.	0.1	0.1	—	—	— mA
$-I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	max.	—	—	0.1	0.1	— mA
$-I_B = 0; -V_{CE} = 90\text{ V}$	$-I_{CEO}$	max.	—	—	—	—	0.1 mA
$-V_{BE} = 0; -V_{CE} = -V_{CB0max}$	$-I_{CES}$	max.	0.2	0.2	0.2	0.2	0.2 mA
Emitter cut-off current							
$-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	max.	0.2	0.2	0.2	0.2	0.2 mA
DC current gain (1)							
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.	25	25	25	25	25
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.	10	10	10	10	5
		max.	50	50	50	50	—
Collector-emitter breakdown voltage (note 1)							
$-I_B = 0; -I_C = 30\text{ mA}$	$-V_{(BR)CEO}$	min.	40	60	80	100	120 V
Collector-emitter saturation voltage (note 1)							
$-I_C = 3\text{ A}; -I_B = 375\text{ mA}$	$-V_{CEsat}$	max.	1.2	1.2	1.2	1.2	— V
$-I_C = 3\text{ A}; -I_B = 750\text{ mA}$		max.	—	—	—	—	2.5 V
Base-emitter voltages (notes 1 and 2)							
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	max.			1.8		V
Small-signal current gain							
$-I_C = 0.5\text{ A}; -V_{CE} = 10\text{ V}$							
at 1 kHz	h_{fe}	min.			20		
at 1 MHz		min.			3		
Turn-off breakdown energy with inductive load (see Fig.3)							
$-I_C = 1.8\text{ A}; L = 20\text{ mH}$	$E_{(BR)}$	min.			32		mJ
Switching times (see Fig.2)							
$-I_C = 1\text{ A}; -I_{B\text{ on}} = +I_{B\text{ off}} = 0.1\text{ A}$							
turn-on time	t_{on}	typ.			0.3		μs
turn-off time	t_{off}	typ.			1		μs

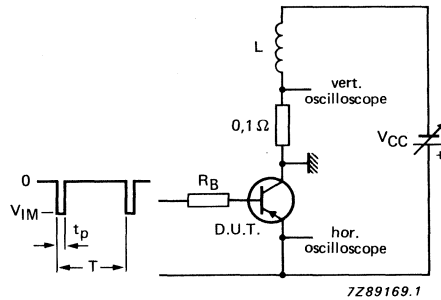
Notes

- Measured under pulse conditions: $t_p = 300\text{ }\mu\text{s}$; $\delta = 2\%$.
- V_{BE} decreases by about 2.3 mV/K with increasing temperature.



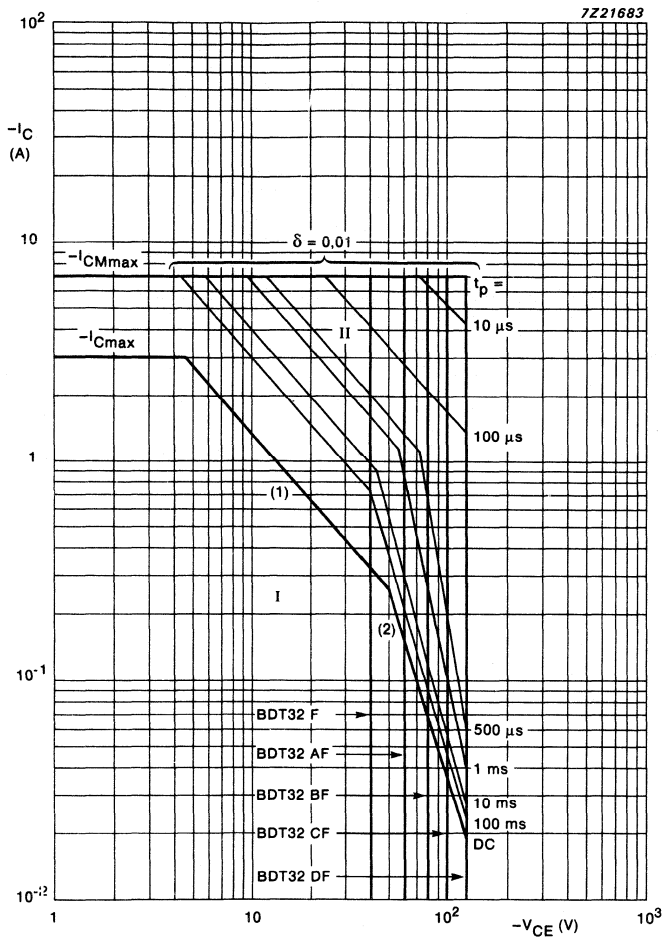
- $-V_{CC} = 20 \text{ V}$
- $-V_{IM} = 30 \text{ V}$
- $+V_{BB} = 3 \text{ V}$
- $R_1 = 56 \ \Omega$
- $R_2 = 150 \ \Omega$
- $R_3 = 33 \ \Omega$
- $R_4 = 20 \ \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 20 \ \mu\text{s}$
- $T = 500 \ \mu\text{s}$

Fig.2 Switching times test circuit.



- $-V_{IM} = 12 \text{ V}$
- $R_B = 270 \ \Omega$
- $L = 20 \text{ mH}$
- $-I_C = 1.8 \text{ A}$
- $t_p = 1 \text{ ms}$
- $\delta = 1 \%$

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, $T_{amb} = 25\ ^\circ\text{C}$.

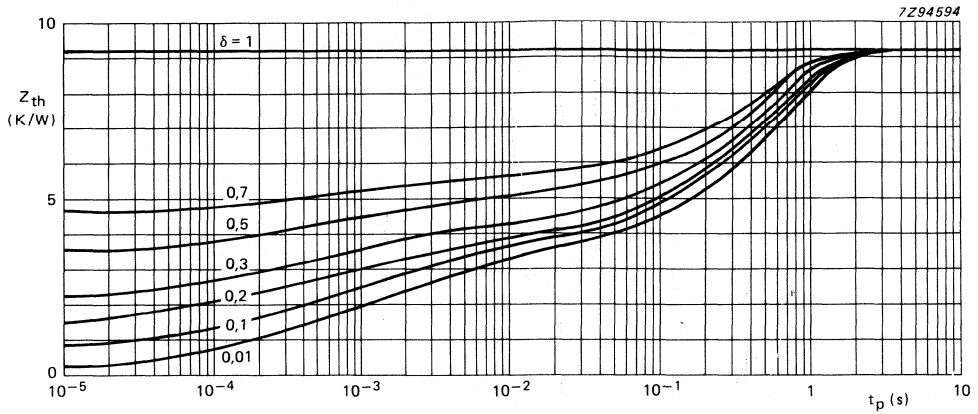


Fig.5 Pulse power rating chart; mounted **without** heatsink compound and 30 ± 5 Newton pressure on the envelope.

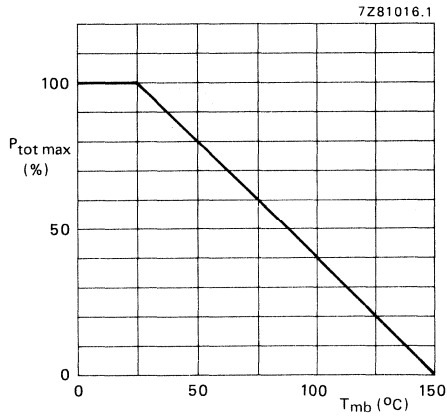


Fig.6 Total power dissipation.

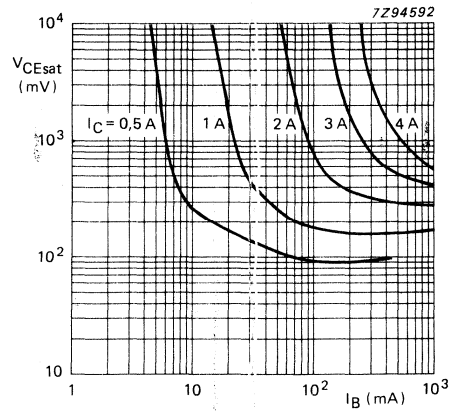


Fig.7 Typical collector-emitter saturation voltage; $T_j = 25 \text{ }^\circ\text{C}$.

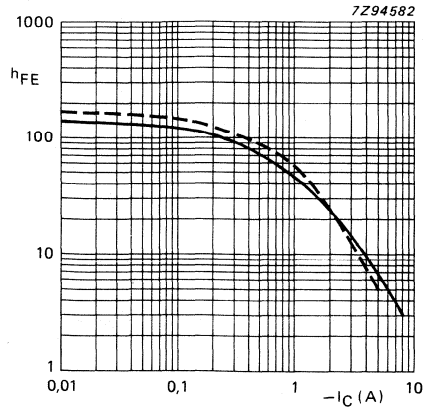


Fig.8 Typical DC current gain; $-V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in general purpose amplifier and switching applications. The TIP41 series is an equivalent type. P-N-P complements are BDT42 series.

QUICK REFERENCE DATA

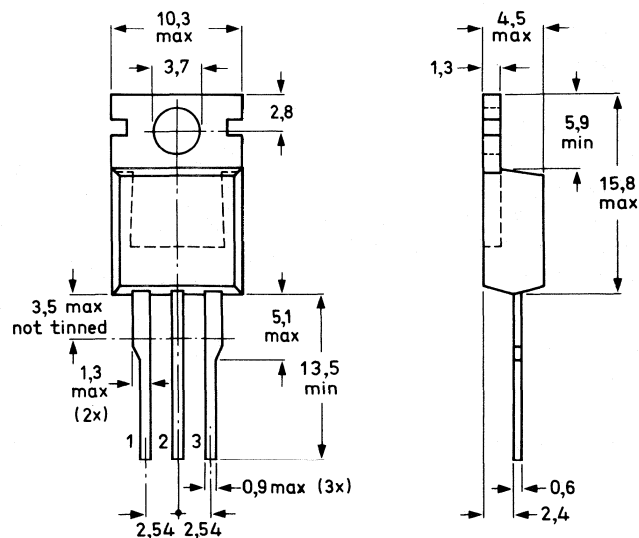
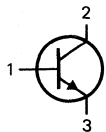
		BDT41			
		A	B	C	
Collector-base voltage (open emitter)	V_{CBO} max.	80	100	120	140 V
Collector-emitter voltage (open base)	V_{CEO} max.	40	60	80	100 V
Collector current (d.c.)	I_C max.	6		A	
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	65		W	
Junction temperature	T_j max.	150		$^\circ\text{C}$	
D.C. current gain $I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	15 to 75			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT41	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	65				W
Storage temperature	T_{stg}		-65 to + 150				$^\circ\text{C}$
Junction temperature	T_j	max.	150				$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,92			K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70			K/W

CHARACTERISTICS

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

			BDT41;A	B;C			
→ Collector cut-off current							
→ $I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	<	0,2	-	mA		
→ $I_B = 0; V_{CE} = 60\text{ V}$	I_{CEO}	<	-	0,2	mA		
$V_{BE} = 0; V_{CE} = V_{CEOmax}$	I_{CES}	<	0,4		mA		
→ Emitter cut-off current							
→ $I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	0,5		mA		
D.C. current gain*							
$I_C = 0,3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	30				
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	15 to 75				
Base-emitter voltage**							
$I_C = 6\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	<	2		V		
Collector-emitter saturation voltage*							
$I_C = 6\text{ A}; I_B = 0,6\text{ A}$	V_{CEsat}	<	1,5		V		
Collector-emitter breakdown voltage*							
$I_B = 0; I_C = 30\text{ mA}$	$V_{(BR)CEO}$	>	BDT41	A	B	C	
			40	60	80	100	V
Small-signal current transfer ratio							
$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$ h_{fe} $	>	20				
Transition frequency at $f = 1\text{ MHz}$							
$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_T	>	3				MHz

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

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

Turn-off breakdown energy with inductive load (Fig. 4)

$-I_{Boff} = 0; I_{CC} = 2,5 \text{ A}$

$E(BR) > 62,5 \text{ mJ}$

Switching times

(between 10% and 90% levels)

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

Turn-on time

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

Turn-off time

t_{off} typ. $1 \mu\text{s}$

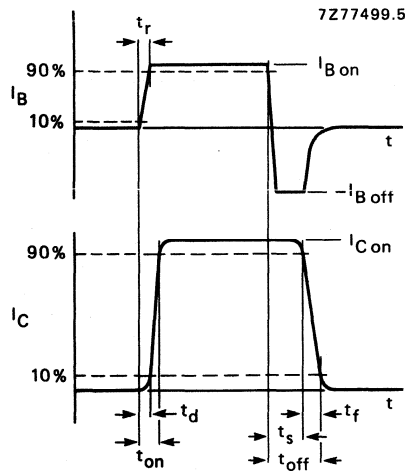


Fig. 2 Switching times waveforms.

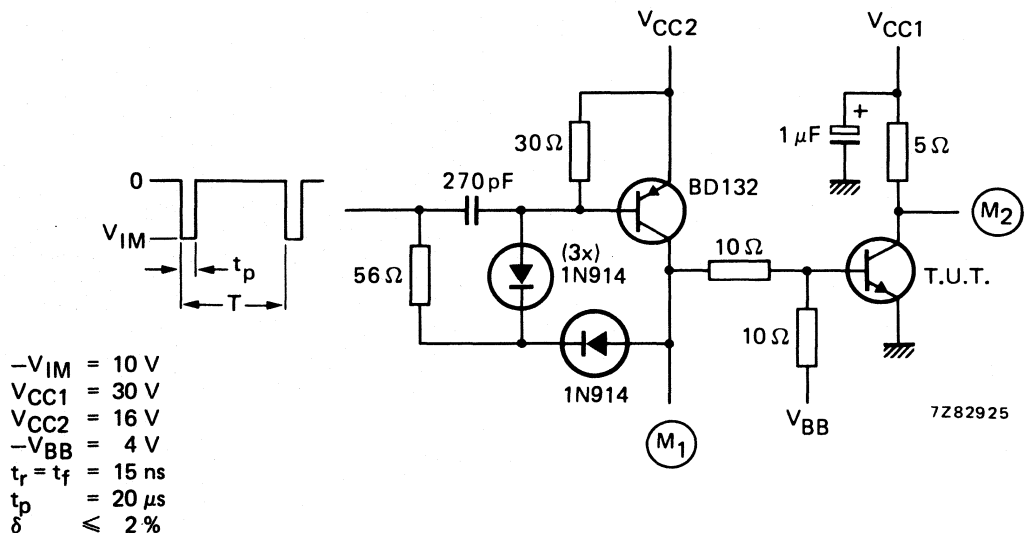


Fig. 3 Switching times test circuit.
Adjust V_{CC2} so that the input to $M_1 = 14 \text{ V}$.

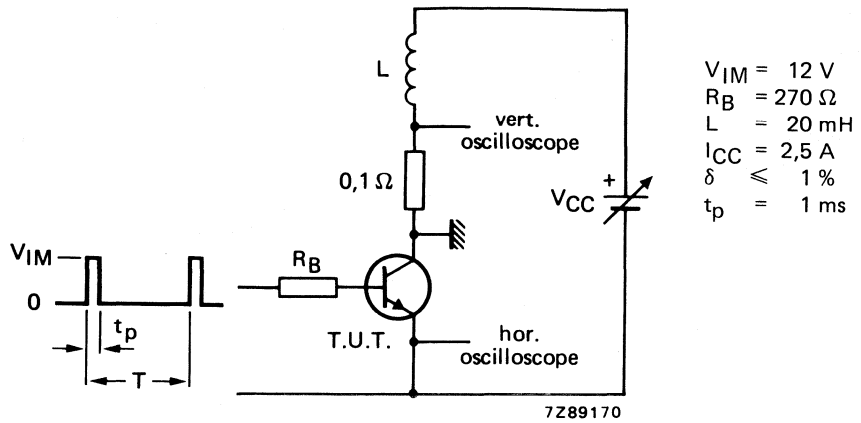


Fig. 4 Test circuit for turn-off breakdown energy.

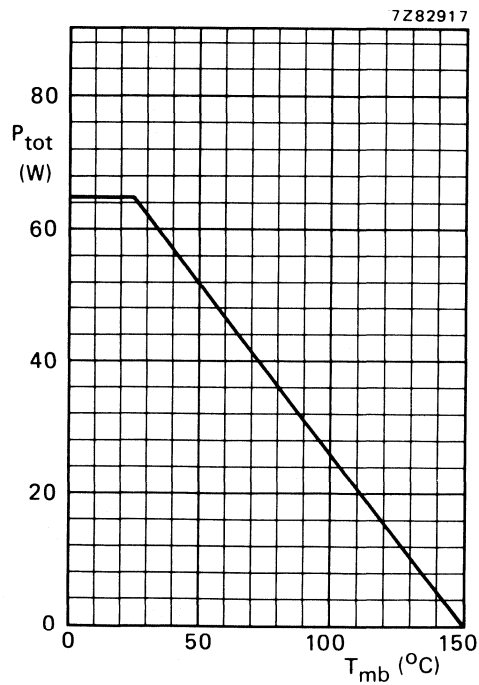


Fig. 5 Power derating curve.

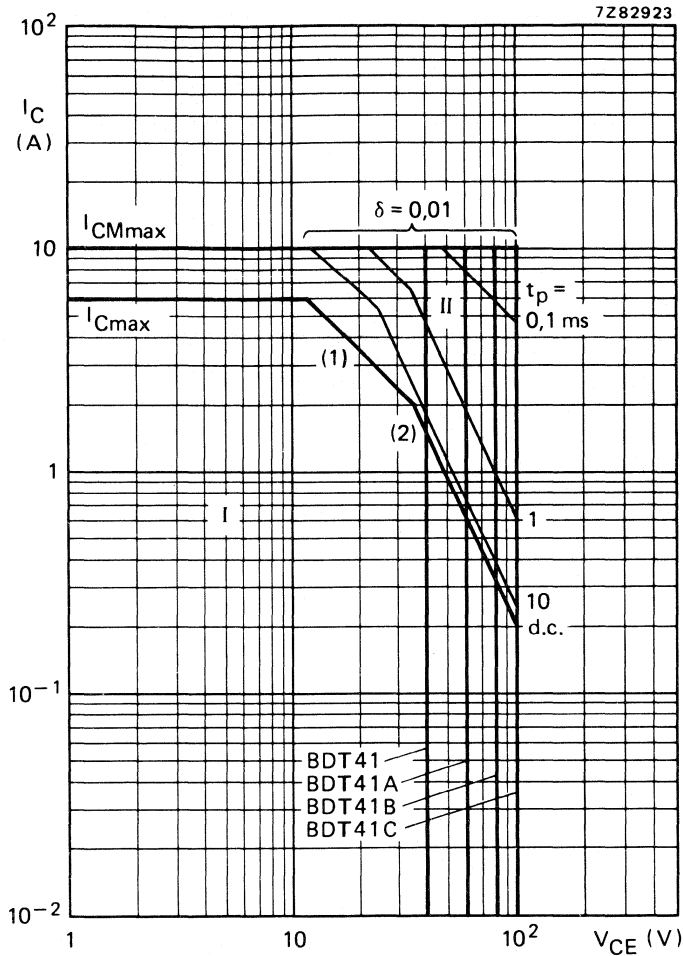


Fig. 6 Safe Operating Area, $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

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

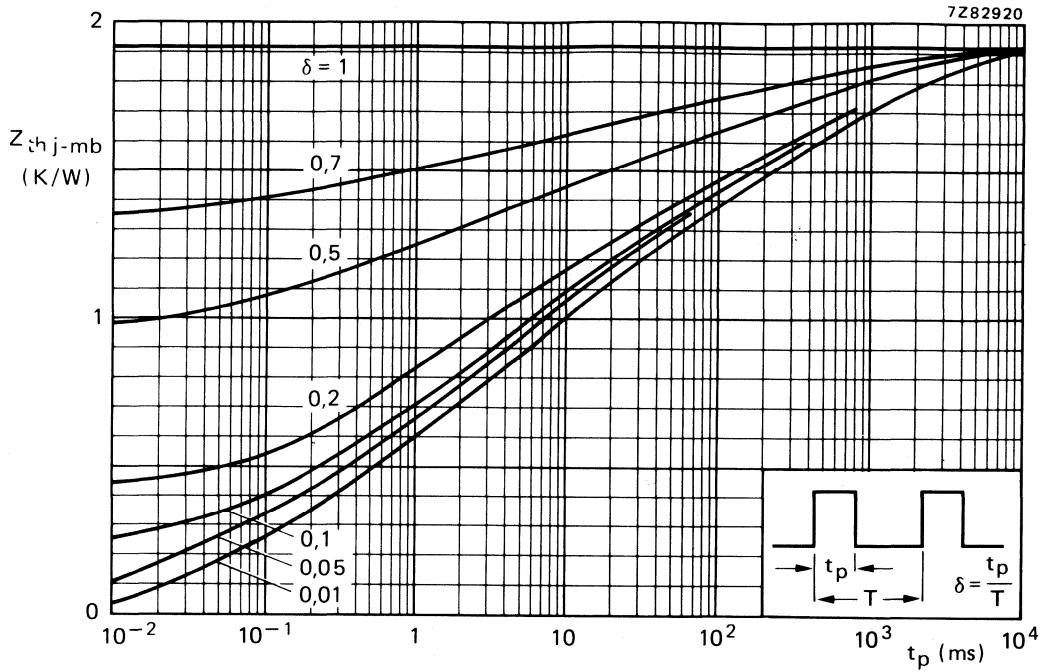


Fig. 7 Pulse power rating chart.

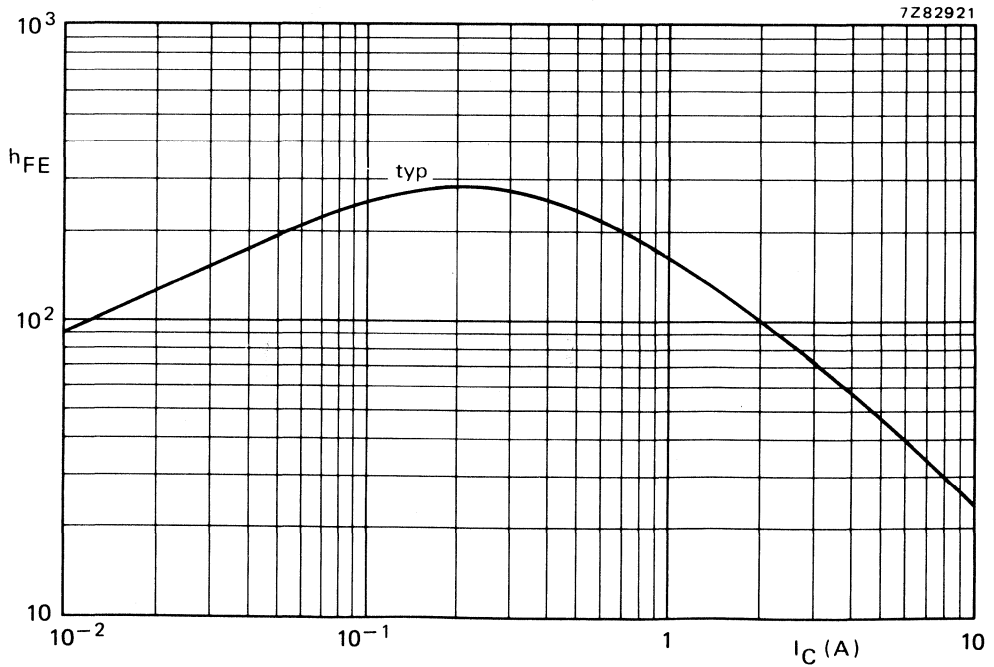


Fig. 8 D.C. current gain at $V_{CE} = 4 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

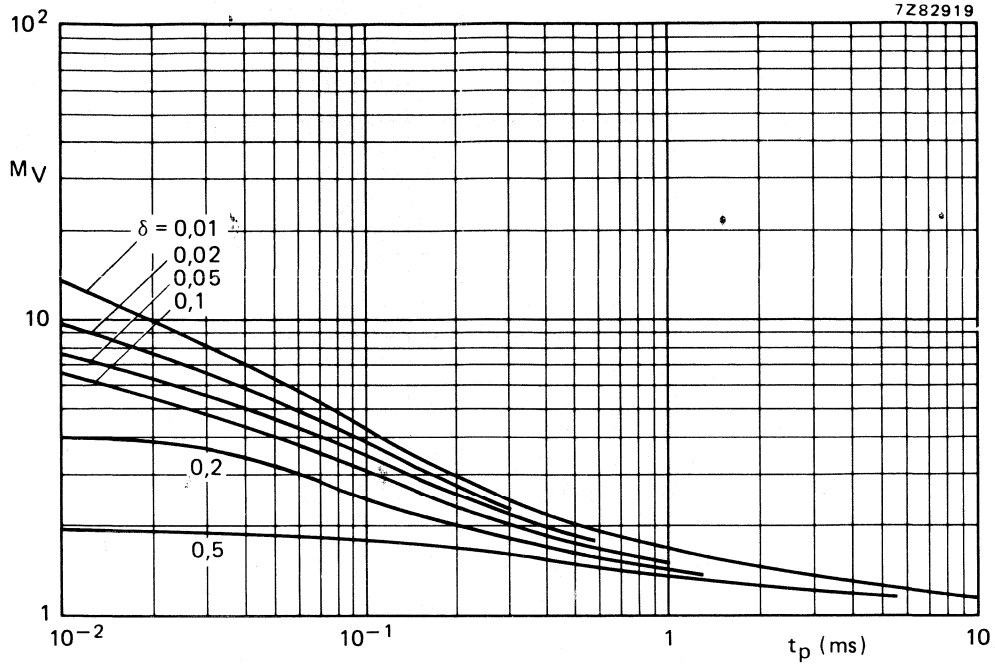


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

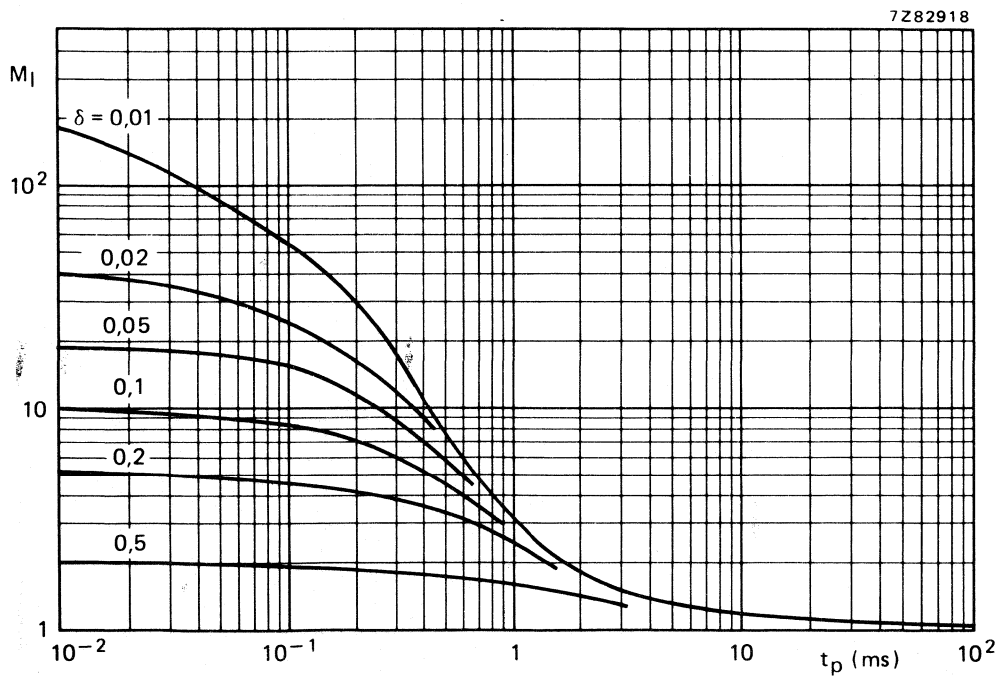


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

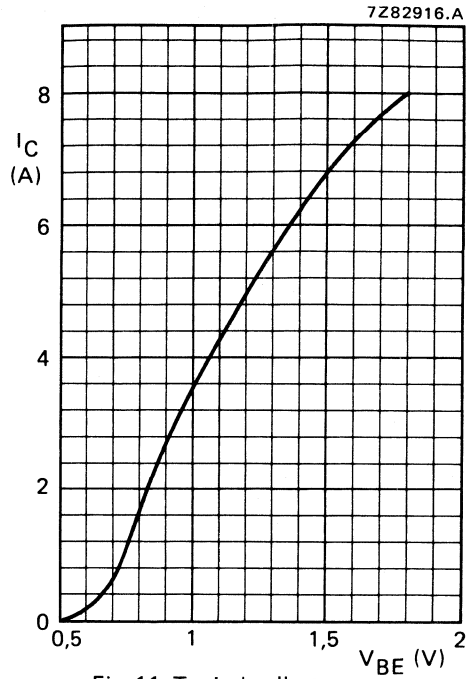


Fig. 11 Typical collector current.
 $V_{CE} = 4 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

SILICON EPITAXIAL POWER TRANSISTORS

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

PNP complements are BDT42F, BDT42AF, BDT42BF, and BDT42CF.

QUICK REFERENCE DATA

		BDT41F	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 $T_h = 25\text{ }^\circ\text{C}$	P_{tot}	max.		32	W
Junction temperature	T_j	max.		150	$^\circ\text{C}$
DC current gain	h_{FE}	min.		15	
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$		max.		75	

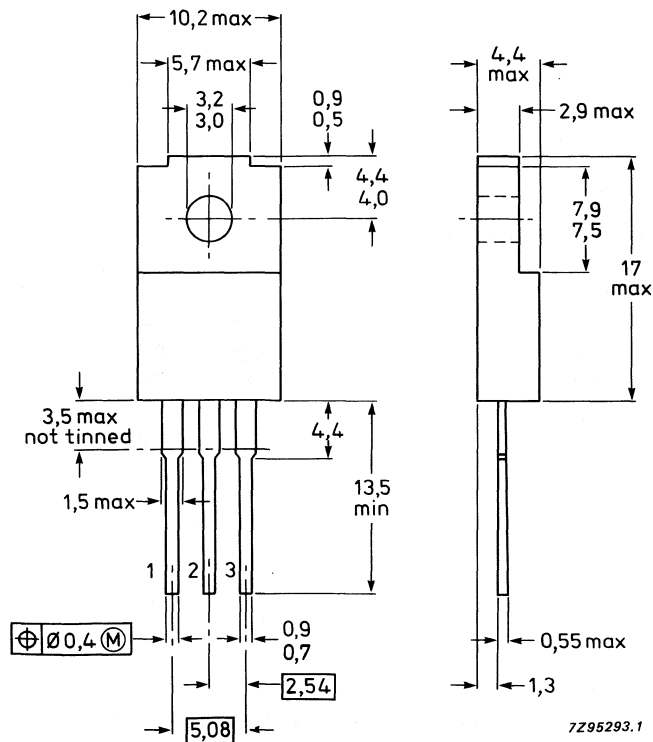
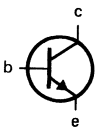
MECHANICAL DATA

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)

			BDT41F	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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.			20		W
up to $T_h = 25\text{ }^\circ\text{C}$ (note 2)	P_{tot}	max.			32		W
Storage temperature range	T_{stg}				-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

INSULATION

Voltage allowed between all terminals and external heatsink, peak value

Isolation capacitance from collector to external heatsink

V_{insul}	max.			1000			V
C_{th}	typ.			12			pF

CHARACTERISTICS

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

			BDT41F	AF	BF	CF	
Collector cut-off currents $I_B = 0; V_{CE} = 30\text{ V}$	I_{CEO}	max.	0.2	0.2	—	—	mA
$I_B = 0; V_{CE} = 60\text{ V}$	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 $I_C = 0; V_{EB} = 5\text{ V}$	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)

$I_C = 0.3 \text{ A}; V_{CE} = 4 \text{ V}$

h_{FE} min. 30

$I_C = 3 \text{ A}; V_{CE} = 4 \text{ V}$

h_{FE} min. 15
max. 75

Base-emitter voltage (note 2)

$I_C = 6 \text{ A}; V_{CE} = 4 \text{ V}$

V_{BE} max. 2 V

Collector-emitter saturation voltage (note 1)

$I_C = 6 \text{ A}; I_B = 0.6 \text{ A}$

V_{CEsat} max. 1.5 V

Collector-emitter breakdown voltage (note 1)

$I_C = 30 \text{ mA}; I_B = 0$

		BDT41F	AF	BF	CF
$V_{(BR)CEO}$	max.	40	60	80	100 V

Small-signal current transfer ratio

$I_C = 0.5 \text{ A}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$

$|h_{fe}|$ min. 20

Transition frequency

$I_C = 0.5 \text{ A}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$

f_T min. 3 MHz

Turn-off breakdown energy with inductive load (Fig.4)

$I_{Boff} = 0; I_{CC} = 2.5 \text{ V}$

$E_{(BR)}$ min. 62.5 mJ

Switching times (Figs 2 and 3) (between 10% and 90% levels)

$I_{Con} = 6 \text{ A}; I_{Bon} = -I_{Boff} = 0.6 \text{ A}$

turn-on time t_{on} typ. 0.6 μs

turn-off time

t_{off} typ. 1 μs

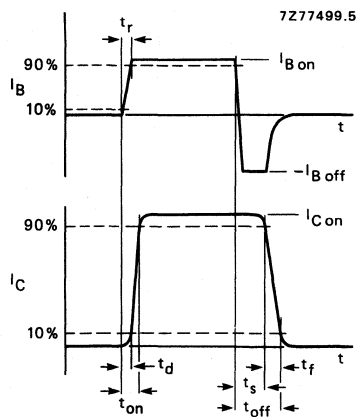


Fig.2 Switching times waveform.

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.

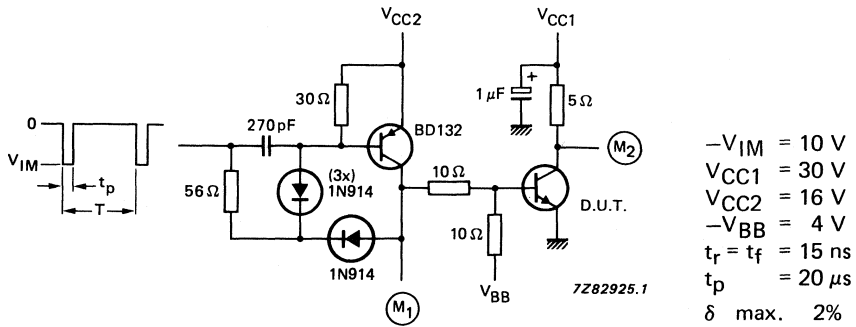


Fig.3 Switching times test circuit.
Adjust V_{CC2} to give $M_1 = 14 \text{ V}$.

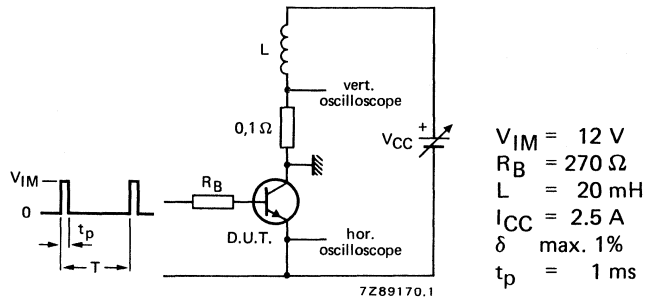
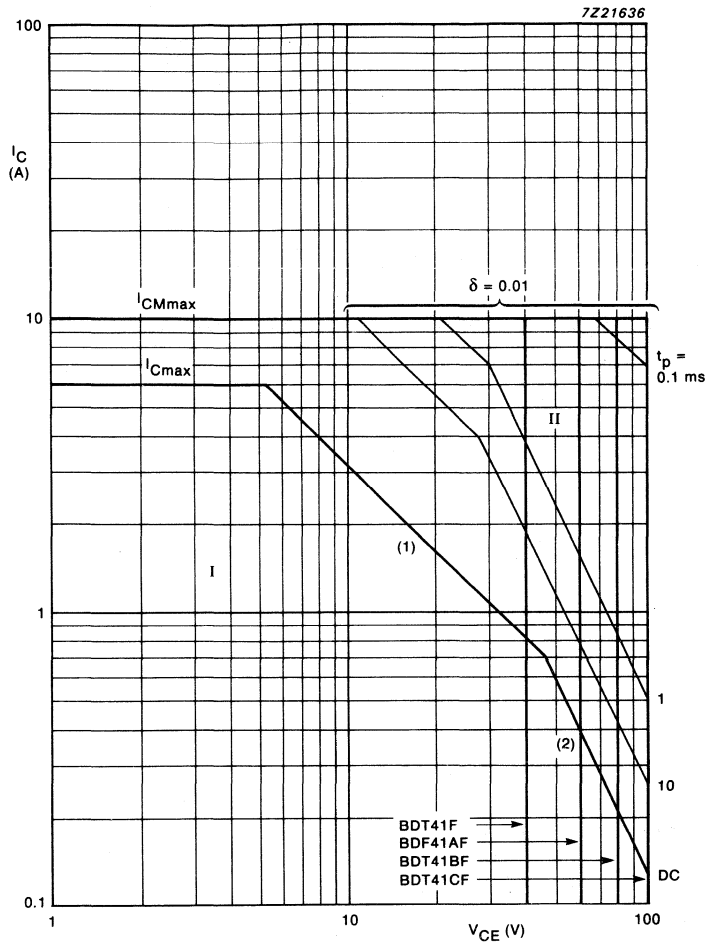


Fig.4 Test circuit for turn-off breakdown energy.



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

Fig.5 Safe operating area, $T_{mb} = 25^\circ\text{C}$.

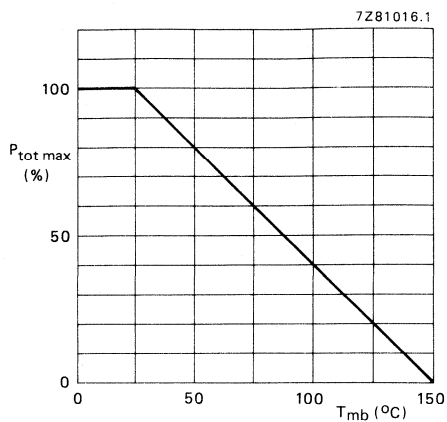


Fig.6 Total power dissipation.

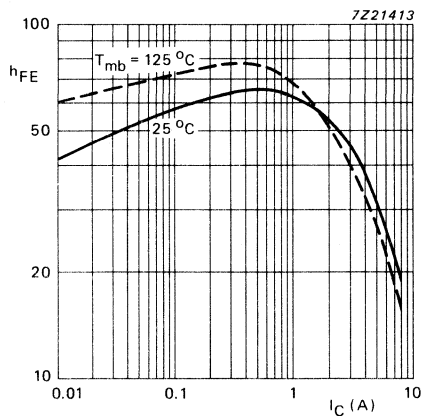


Fig.7 DC current gain; $V_{CE} = 4$ V; typical values.

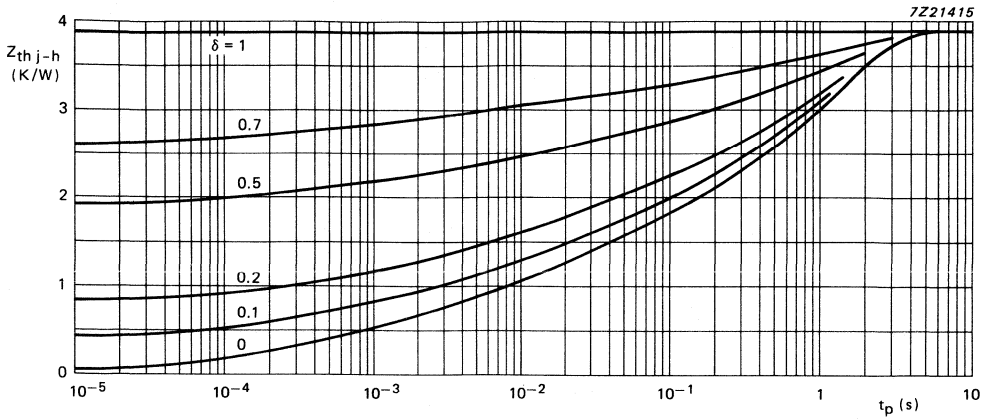


Fig.8 Pulse power rating chart.

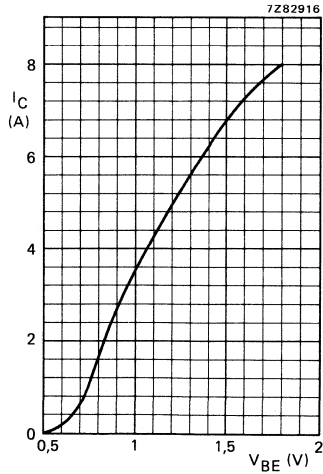


Fig.9 Typical collector current.
 $V_{CE} = 4\text{ V}; T_j = 25\text{ }^\circ\text{C}.$

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in general output stages of amplifier circuits and switching applications. The TIP42 series is an equivalent type. P-N-P complements are BDT41 series.

QUICK REFERENCE DATA

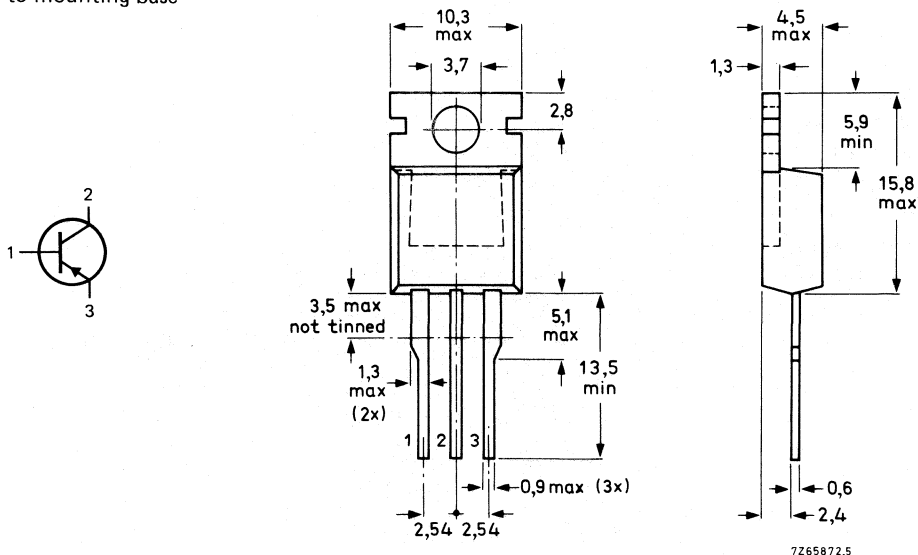
		BDT42				A	B	C
Collector-base voltage	$-V_{CBO}$	max.	80	100	120	140	V	
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100	V	
Collector current (d.c.)	$-I_C$	max.	6			A		
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	65			W		
Junction temperature	T_j	max.	150			$^\circ\text{C}$		
D.C. current gain $-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}		15 to 75					

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base



See also chapters Mounting Instructions and Accessories.

BDT42;A BDT42B;C

RATINGS

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

		BDT42				
		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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max. 65				W
Storage temperature	T_{stg}	-65 to +150				$^\circ\text{C}$
Junction temperature	T_j	max. 150				$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70	K/W

CHARACTERISTICS

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

		BDT42;A		B;C			
→ Collector cut-off current							
$I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	<	0,2	—	mA		
$I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	<	—	0,2	mA		
$V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	0,4		mA		
→ Emitter cut-off current							
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	0,5		mA		
D.C. current gain*							
$-I_C = 300\text{ mA}; -V_{CE} = 4\text{ V}$	h_{FE}	>	30				
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	15 to 75				
Base-emitter voltage**							
$-I_C = 6\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<	2		V		
Collector-emitter saturation voltage*							
$-I_C = 6\text{ A}; -I_B = 0,6\text{ A}$	$-V_{CEsat}$	<	1,5		V		
Collector-emitter breakdown voltage*							
$I_B = 0; -I_C = 30\text{ mA}$	$-V_{(BR)CEO}$	>	40	60	80	100	V
Transition frequency at $f = 1\text{ MHz}$							
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$	f_T	>	3			MHz	
Small signal current transfer ratio							
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$ h_{fe} $	>	20				

* Measured under pulse conditions: $t_p \leq 300\ \mu\text{s}$; $\delta < 2\%$.

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

Turn-off breakdown energy with inductive load (Fig. 4)

$I_{B\text{off}} = 0; -I_{CC} = 2,5 \text{ A}$

$E_{(BR)} > 62,5 \text{ mJ}$

Switching times

$-I_{C\text{on}} = 6 \text{ A}; -I_{B\text{on}} = I_{B\text{off}} = 0,6 \text{ A}$

turn-on time

t_{on} typ. $0,4 \mu\text{s}$

turn-off time

t_{off} typ. $0,7 \mu\text{s}$

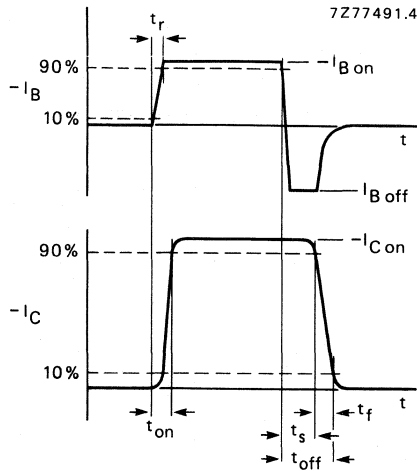
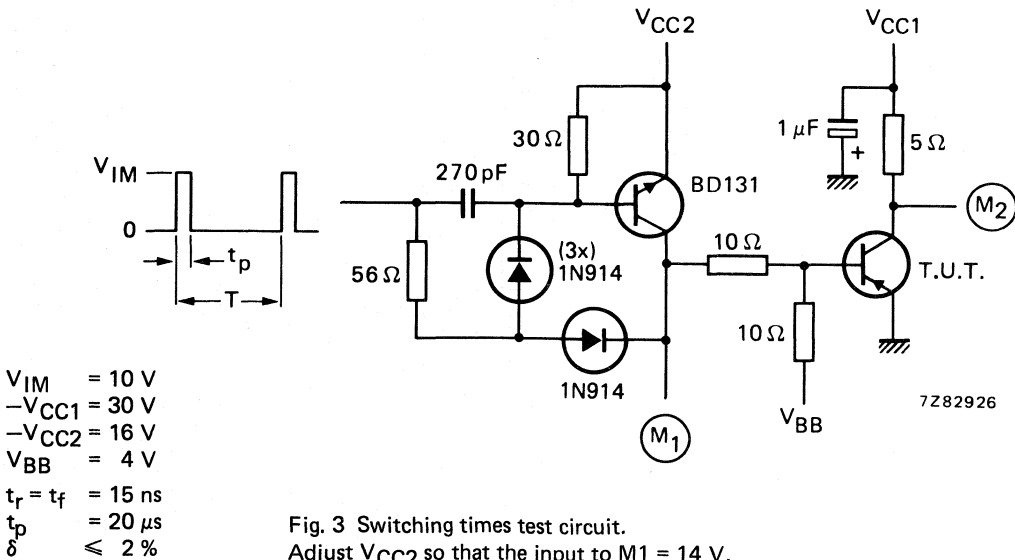


Fig. 2 Switching times waveforms.



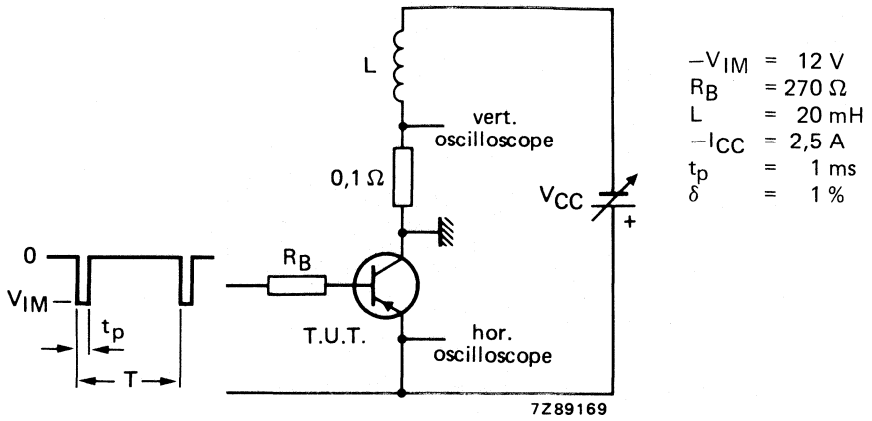


Fig. 4 Test circuit for turn-off breakdown energy.

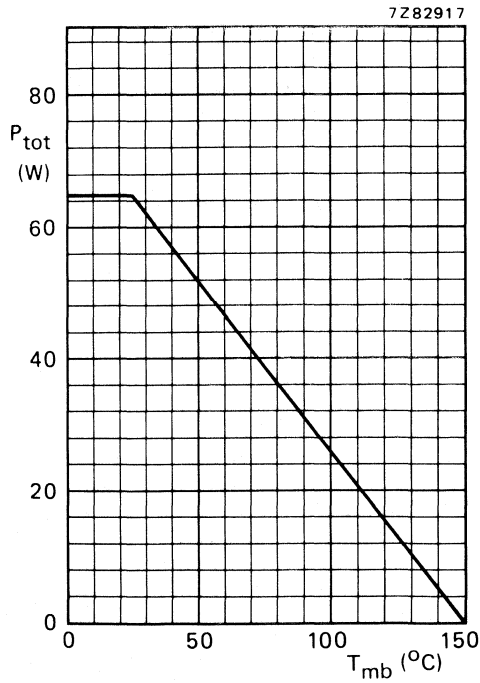


Fig. 5 Power derating curve.

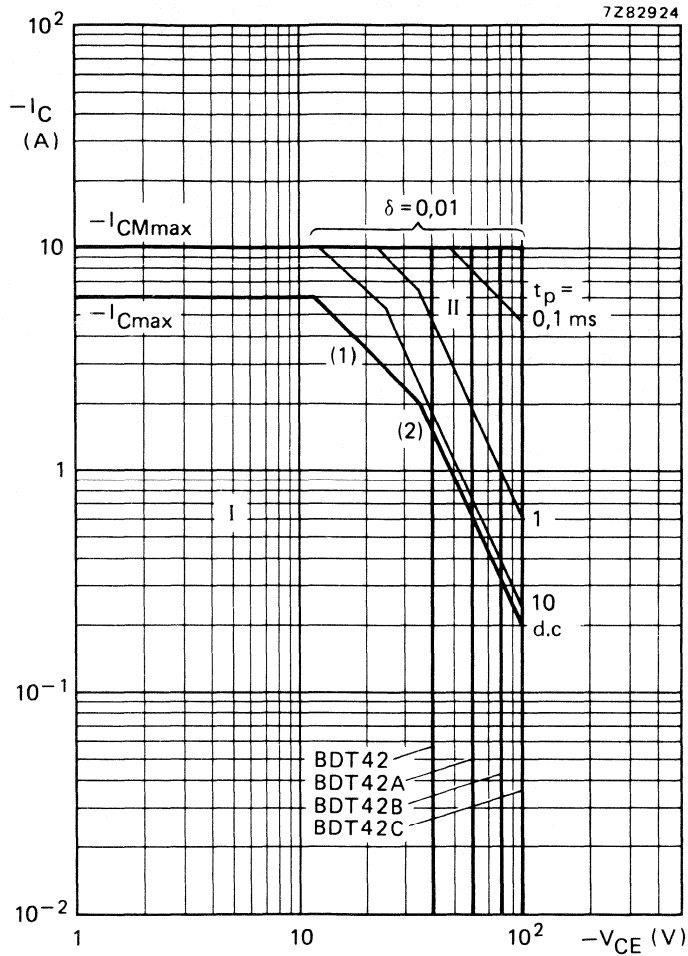


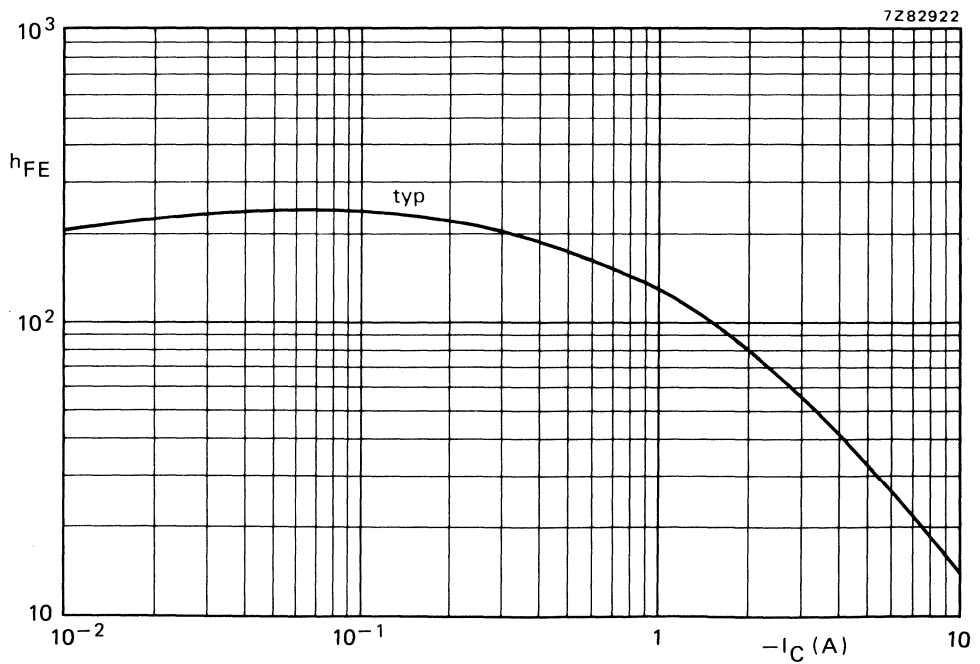
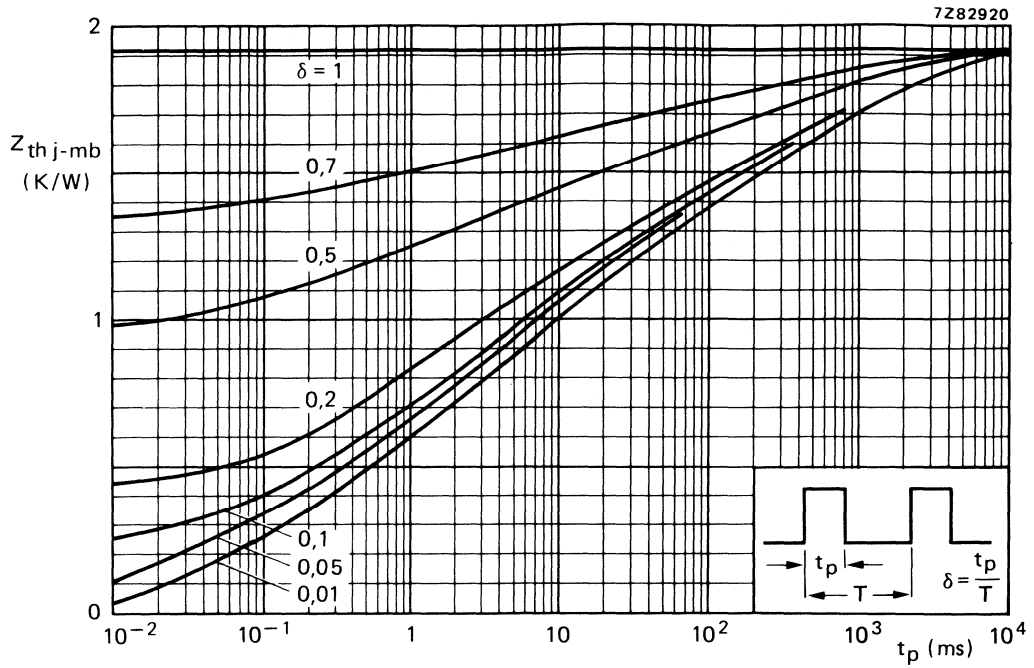
Fig. 6 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(3) Second-breakdown limits.



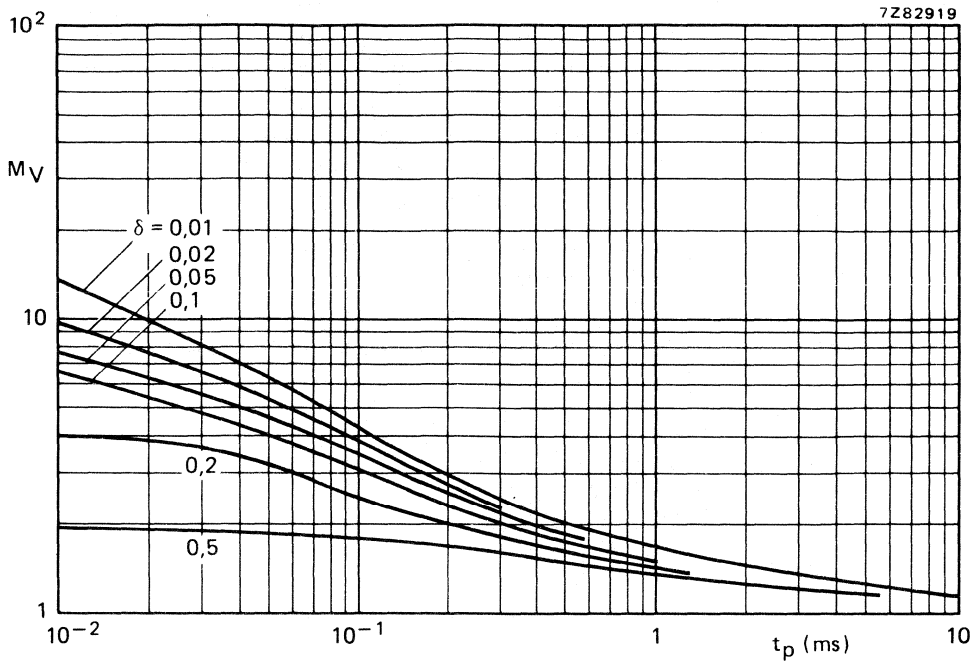


Fig. 9 Second breakdown voltage multiplying factor at the I_{Cmax} level.

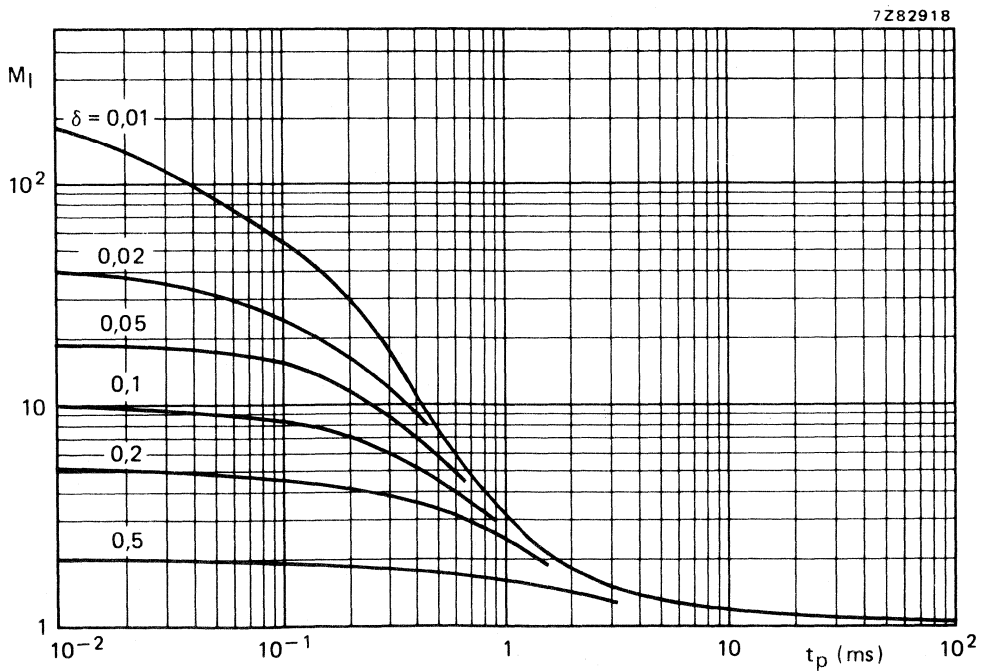


Fig. 10 Second breakdown current multiplying factor at the V_{CE0max} level.

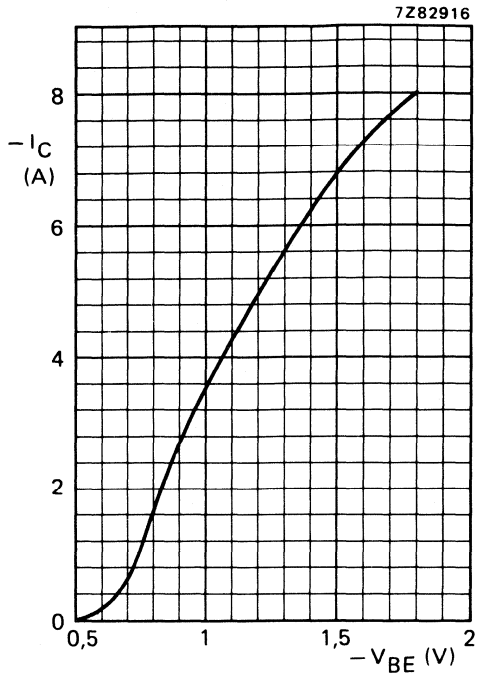


Fig. 11 Typical collector current.
 $-V_{CE} = 4 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

SILICON EPITAXIAL POWER TRANSISTORS

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

NPN complements are BDT41F, BDT41AF, BDT41BF, and BDT41CF.

QUICK REFERENCE DATA

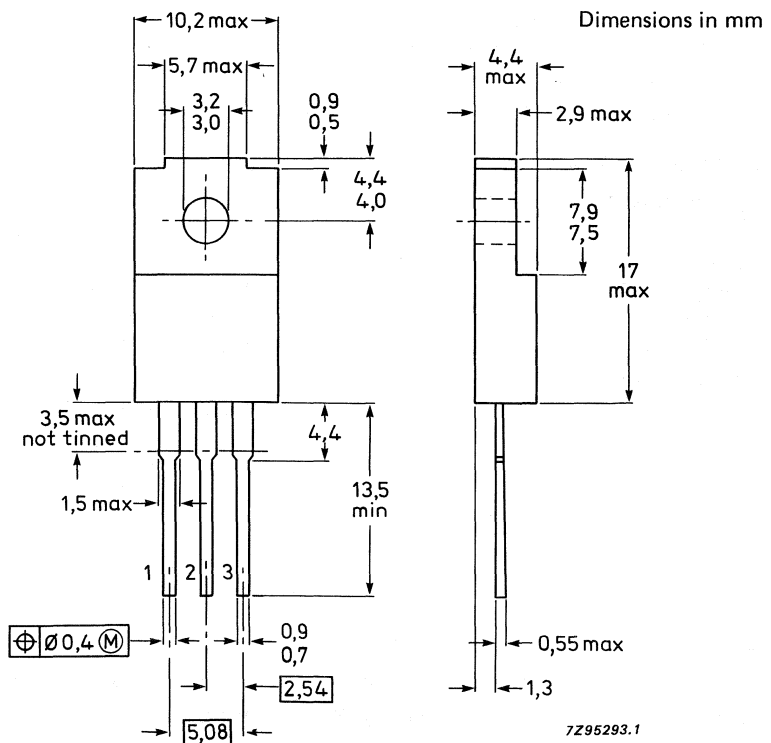
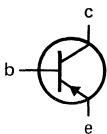
		BDT42F AF BF CF				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	100	120	140 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100 V
DC collector current	$-I_C$	max.			6	A
Peak collector current	I_{CM}	max.			10	A
Total power dissipation up to $T_H = 25^\circ\text{C}$	P_{tot}	max.			32	W
Junction temperature	T_j	max.			150	$^\circ\text{C}$
DC current gain	h_{FE}	min.			15	
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$		max.			75	

MECHANICAL DATA

Fig.1 SOT186.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



7295293.1

RATINGS

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

			BDT42F	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 $T_h = 25\text{ }^\circ\text{C}$ (note 1)	P_{tot}	max.			20		W
op to $T_h = 25\text{ }^\circ\text{C}$ (note 2)	P_{tot}	max.			32		W
Storage temperature range	T_{stg}				-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.			150		$^\circ\text{C}$

THERMAL RESISTANCE

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

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

			BDT42F	AF	BF	CF	
Collector cut-off currents							
$-I_B = 0; -V_{CE} = 30\text{ V}$	$-I_{CEO}$	max.	0.2	0.2	-	-	mA
$-I_B = 0; -V_{CE} = 60\text{ V}$	$-I_{CEO}$	max.	-	-	0.2	0.2	mA
$-V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	max.			0.4		mA
Emitter cut-off current							
$-I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	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)				
$-I_C = 0.3 \text{ A}; -V_{CE} = 4 \text{ V}$	h_{FE}		30	
$-I_C = 3 \text{ A}; -V_{CE} = 4 \text{ V}$	h_{FE}	min.	15	
		max.	75	
Base-emitter voltage (note 2)				
$-I_C = 6 \text{ A}; -V_{CE} = 4 \text{ V}$	$-V_{BE}$	max.	2	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 6 \text{ A}; -I_B = 0.6 \text{ A}$	$-V_{CEsat}$	max.	1.5	V
Collector-emitter breakdown voltage (note 1)				
$-I_C = 30 \text{ mA}; -I_B = 0$	$-V_{(BR)CEO}$	max.		
			BDT42F	AF
			40	60
			80	100
				V
Small-signal current transfer ratio				
$-I_C = 0.5 \text{ A}; -V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$	h_{fe}	min.	20	
Transition frequency				
$-I_C = 0.5 \text{ A}; -V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$	f_T	min.	3	MHz
Turn-off breakdown energy with inductive load (Fig.4)				
$-I_{B \text{ off}} = 0; -I_{CC} = 2.5 \text{ V}$	$E(BR)$	min.	62.5	mJ
Switching times (Figs 2 and 3)				
(between 10% and 90% levels)				
$-I_{C \text{ on}} = 6 \text{ A}; -I_{B \text{ on}} = I_{B \text{ off}} = 0.6 \text{ A}$				
turn-on time	t_{on}	typ.	0.6	μs
turn-off time	t_{off}	typ.	1	μs

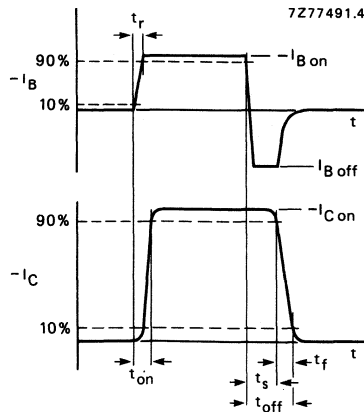


Fig.2 Switching times waveform.

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.

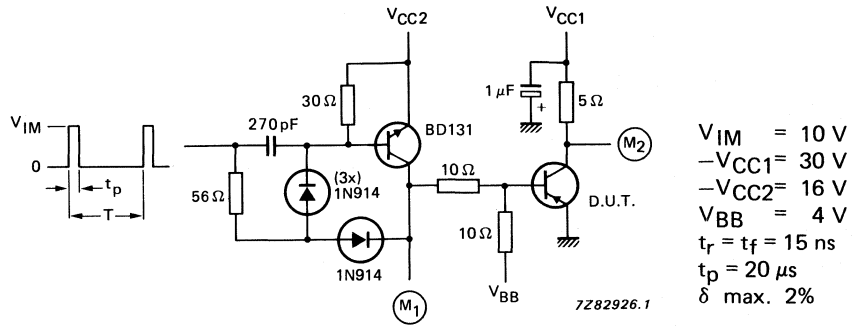


Fig.3 Switching times test circuit.
Adjust V_{CC2} to give $M_1 = 14 \text{ V}$.

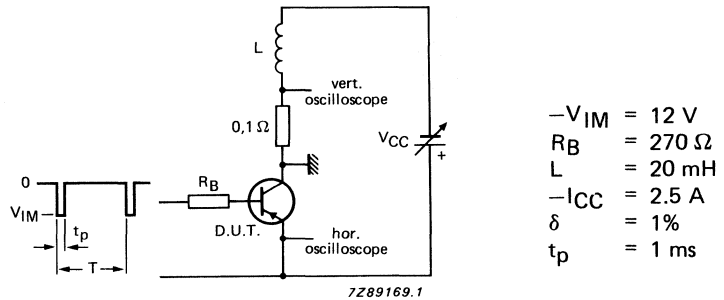
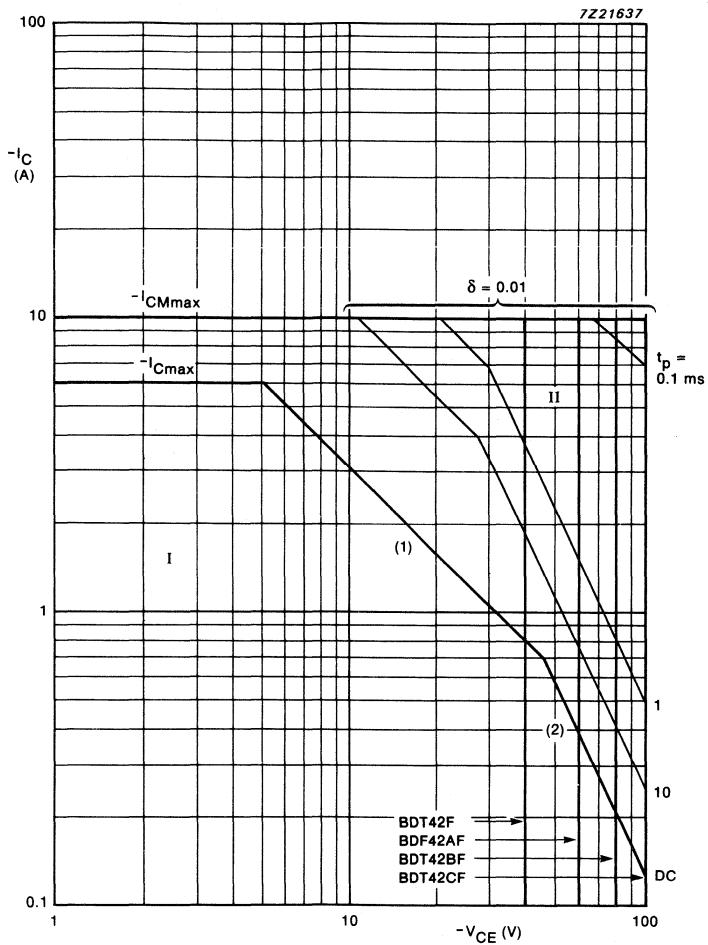


Fig.4 Test circuit for turn-off breakdown energy.



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

Fig.5 Safe operating area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

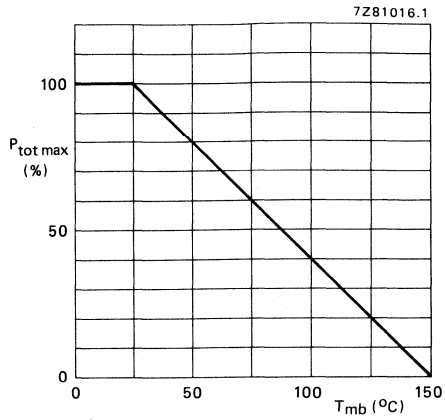


Fig.6 Total power dissipation.

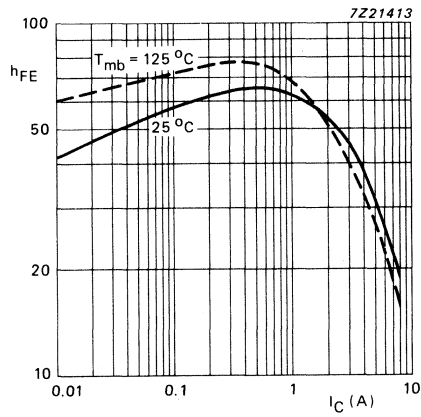


Fig.7 DC current gain; $-V_{\text{CE}} = 4 \text{ V}$; typical values.

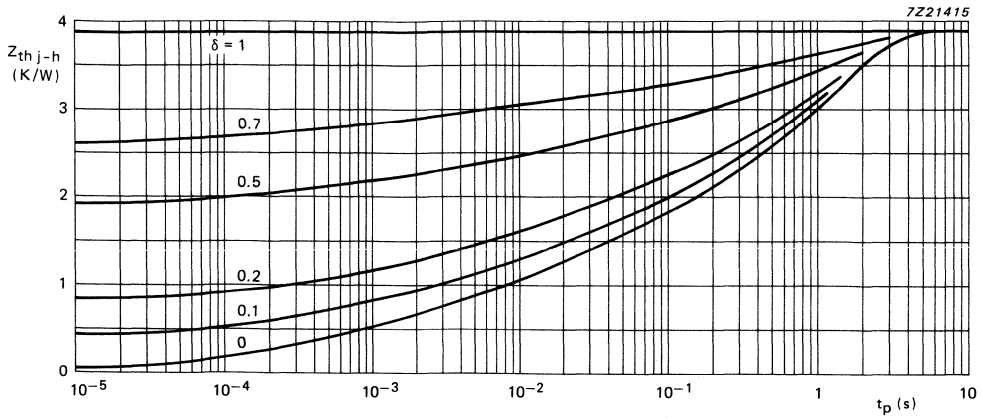


Fig.8 Pulse power rating chart.

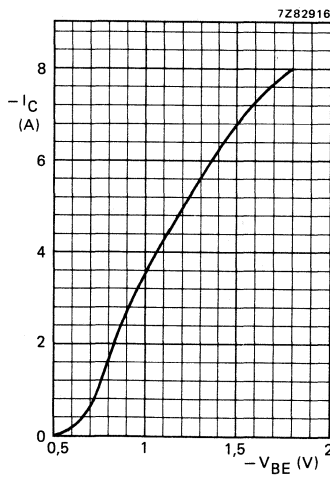


Fig.9 Typical collector current; $-V_{CE} = 4\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$.

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.

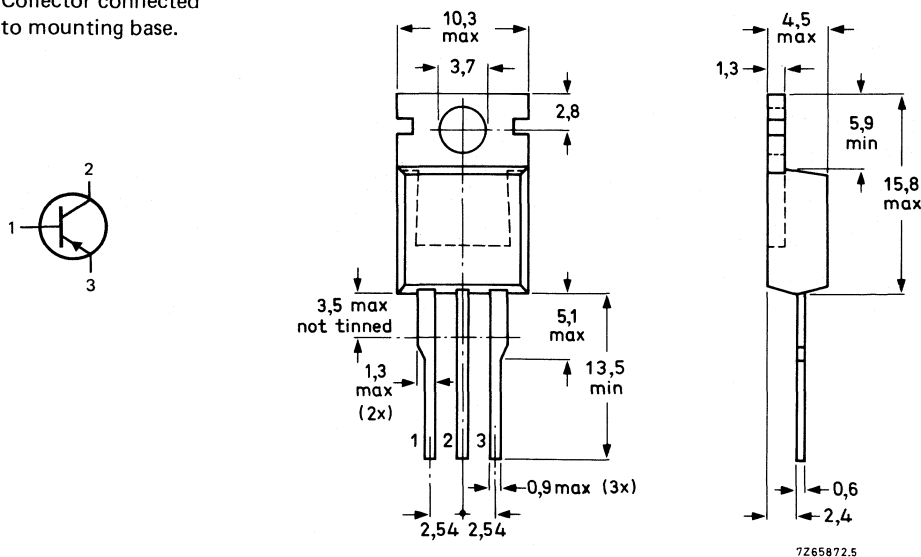
QUICK REFERENCE DATA

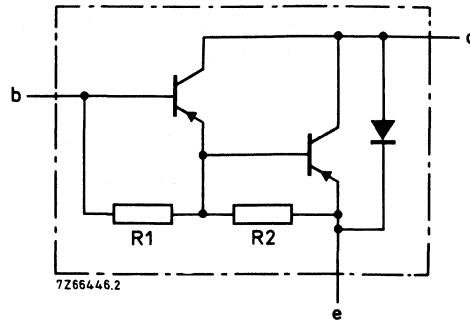
		BDT60	A	B	C
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	80	100	120 V
Collector current (d.c.)	$-I_C$ max.		4		A
Collector current (peak value)	$-I_{CM}$ max.		6		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		50		W
Junction temperature	T_j max.		150		$^\circ\text{C}$
D.C. current gain $-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} typ.		2200		

MECHANICAL DATA

Fig. 1 TO-220AB.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.			50	W
Storage temperature	T_{stg}			-65 to +150	$^\circ\text{C}$
Junction temperature*	T_j max.			150	$^\circ\text{C}$

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$ =		2,5	K/W
From junction to ambient (in free air)	$R_{th\ j-a}$ =		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

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0max}$

$-I_{CBO} \leq 0,2\text{ mA}$

$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$

$-I_{CBO} \leq 1\text{ mA}$ ←

$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CE0max}$

$-I_{CEO} \leq 0,2\text{ mA}$ ←

Emitter cut-off current

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

$-I_{EBO} \leq 5\text{ mA}$

Forward bias second-breakdown collector current

$-V_{CE} = 50\text{ V}; t = 0,1\text{ s}; \text{non-repetitive}$

$(\text{without heatsink}); T_{amb} = 25\text{ }^\circ\text{C}$

$-I_{(SB)} \geq 1\text{ A}$

D.C. current gain*

$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 2200$

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \geq 750$

$-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 270$

Base-emitter voltage

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$

$-V_{BE} \leq 2,5\text{ V}$

Collector-emitter saturation voltage*

$-I_C = 1,5\text{ A}; -I_B = 6\text{ mA}$

$-V_{CEsat} \leq 2,5\text{ V}$

Cut-off frequency

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$

$f_{hfe} \geq 25\text{ kHz}$

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

$-I_C = 1,5\text{ A}; -V_{CE} = 3\text{ V}$

$h_{fe} \geq 10$

Diode, forward voltage

$I_F = 1,5\text{ A}$

$V_F < 2\text{ V}$

$I_F = 4\text{ A}$

$V_F \text{ typ. } 2,1\text{ V}$

Switching times

(between 10% and 90% levels)

$-I_{Con} = 1,5\text{ A}; -I_{Bon} = I_{Boff} = 6\text{ mA}; -V_{CC} = 30\text{ V}$

turn-on time

$t_{on} \text{ typ. } 0,3\text{ }\mu\text{s}$
 $t_{on} < 1,5\text{ }\mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 1,5\text{ }\mu\text{s}$
 $t_{off} < 5\text{ }\mu\text{s}$

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

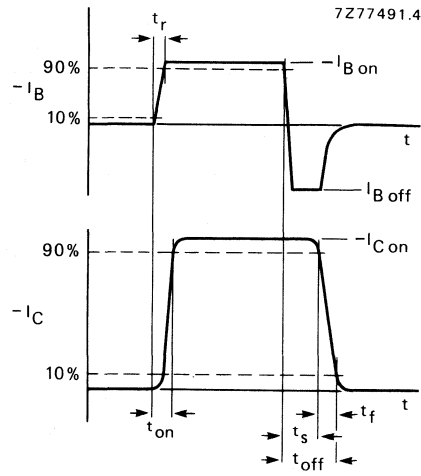


Fig. 3 Switching times waveforms.

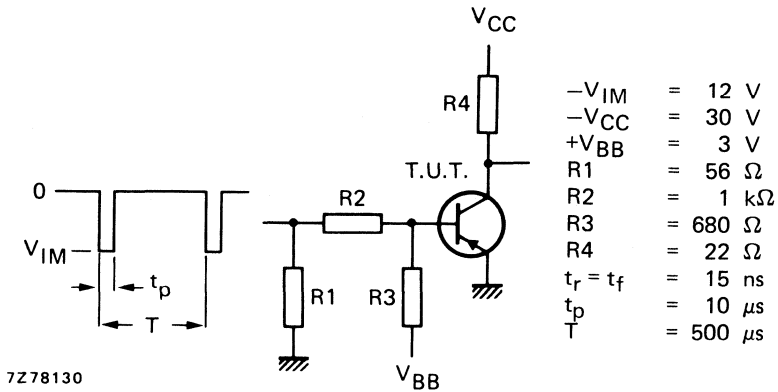


Fig. 4 Switching times test circuit.

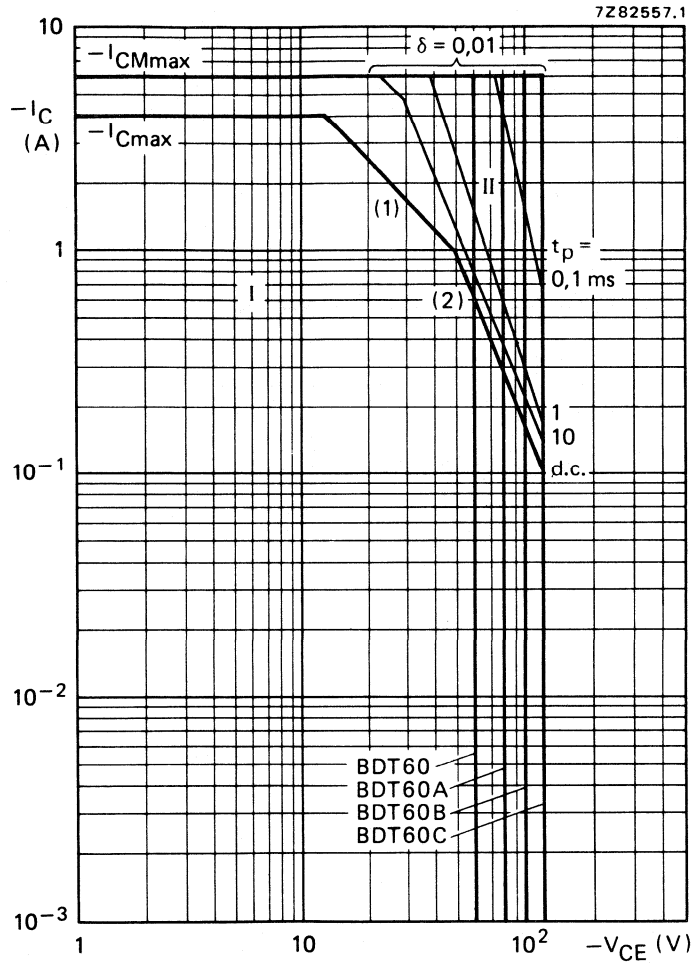


Fig. 5 Safe Operating Area; $T_{mb} = 25$ °C.

- 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.

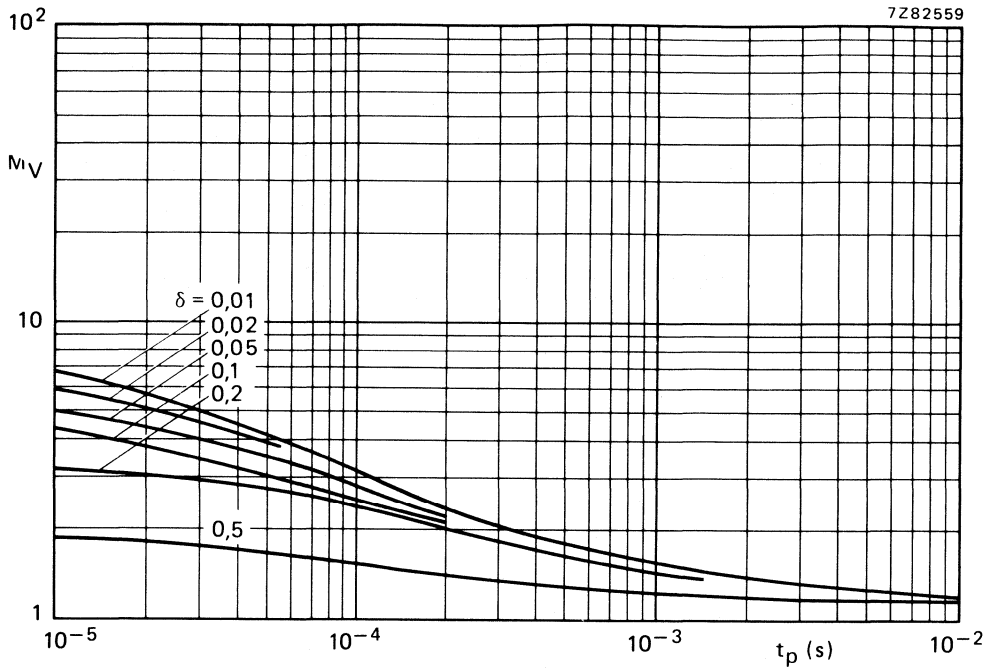


Fig. 6 Second-breakdown voltage multiplying factor at the $I_{C \max}$ level.

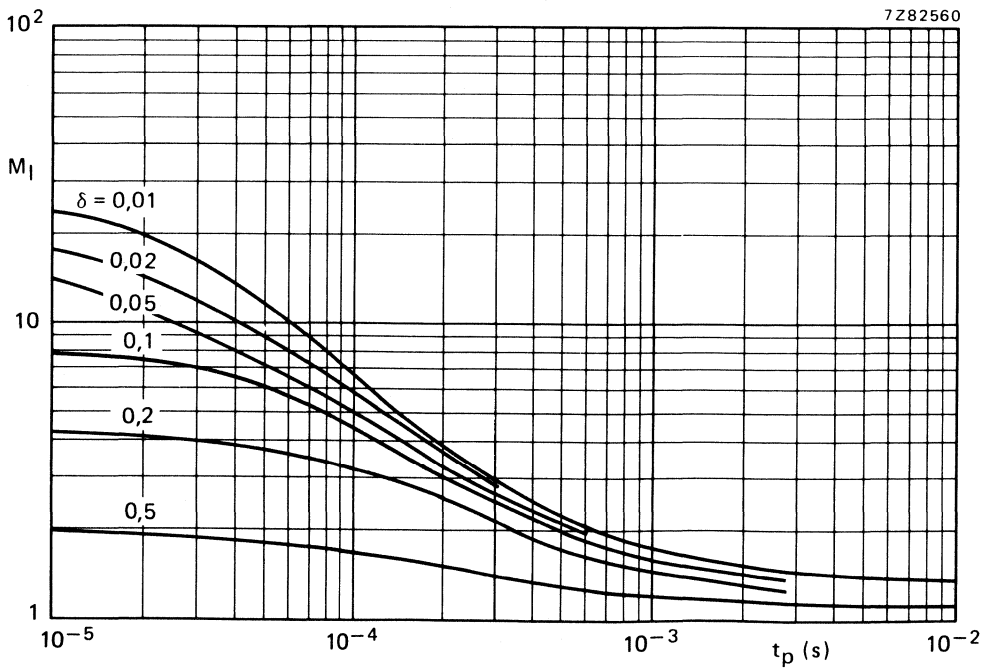


Fig. 7 Second-breakdown current multiplying factor at the $V_{CE0 \max}$ level.

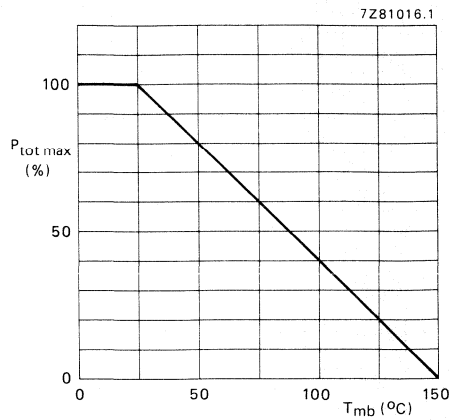


Fig. 8 Power derating curve.

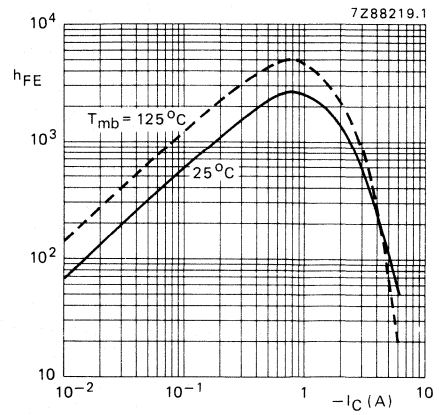


Fig. 9 Typical d.c. current gain. $-V_{CE} = 3\ V$.

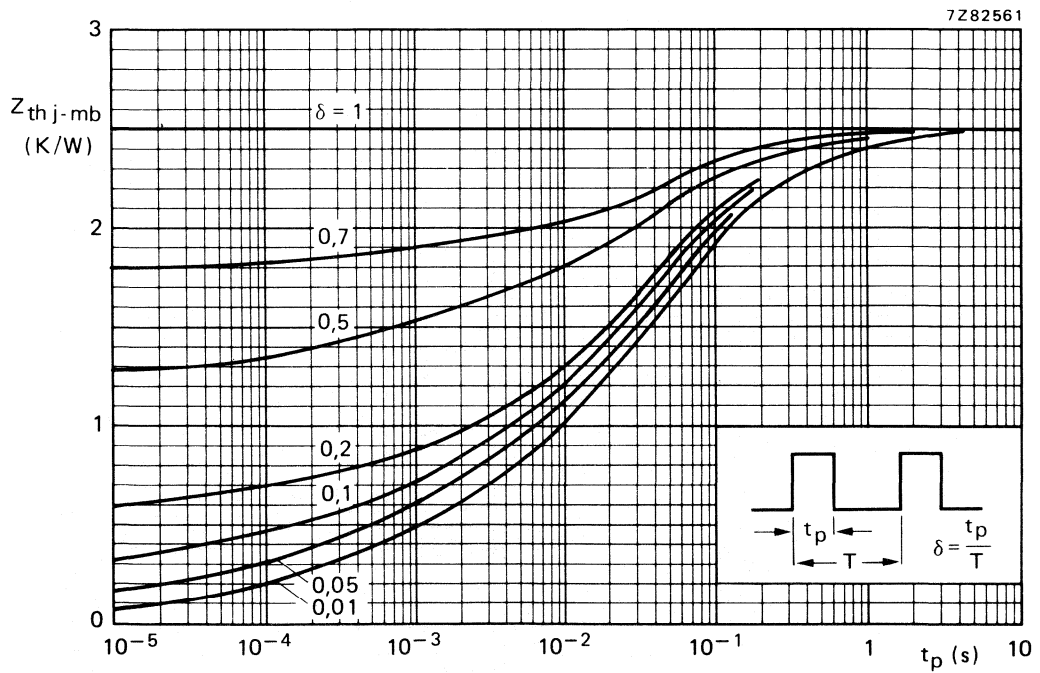


Fig. 10 Pulse power rating chart.

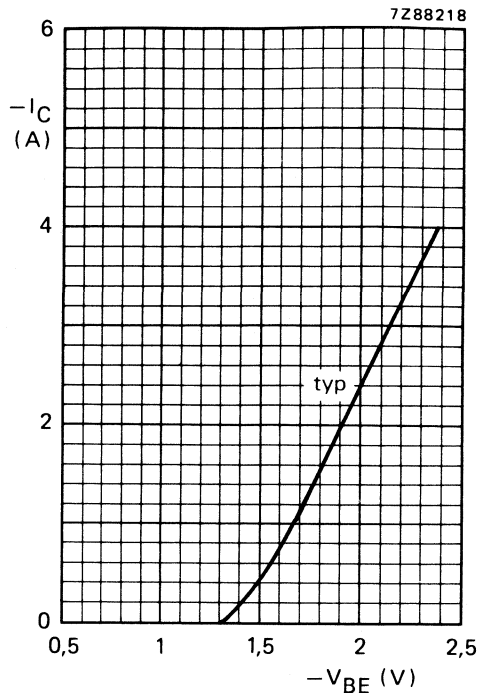


Fig. 11 $-V_{CE} = 3 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

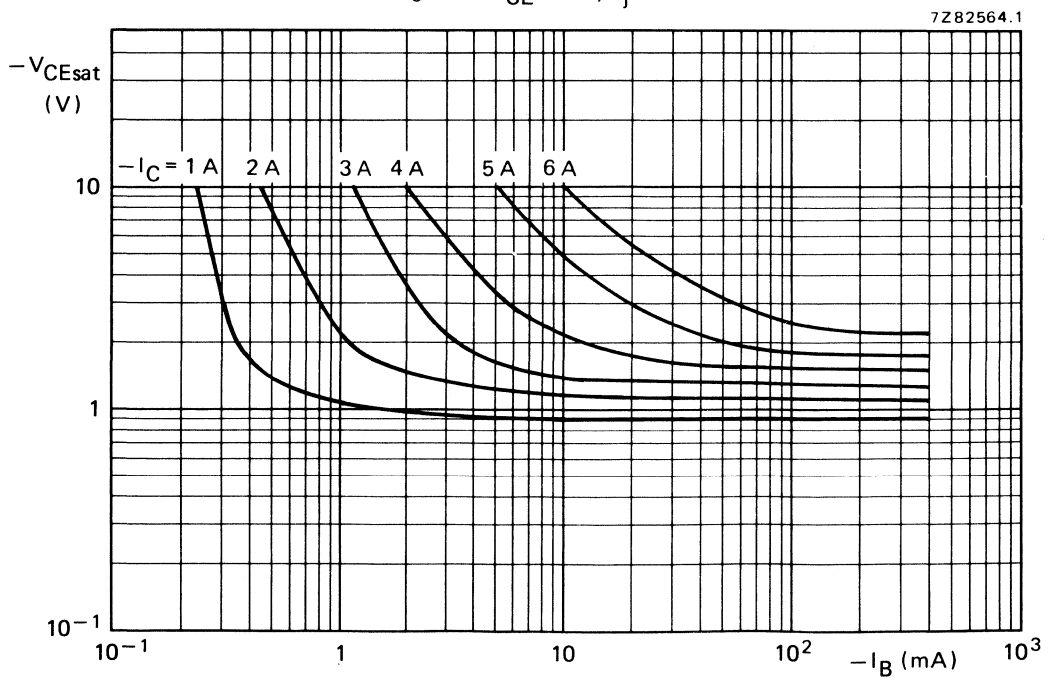


Fig. 12 Typical values collector-emitter saturation voltage at $T_{mb} = 25 \text{ }^\circ\text{C}.$

SILICON DARLINGTON POWER TRANSISTORS

PNP silicon power transistors in a monolithic Darlington circuit and housed in a SOT-186 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 $T_h = 25\text{ }^\circ\text{C}$	P_{tot}	max.	25		W
DC current gain					
$-I_C = 0.5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	2000		

MECHANICAL DATA

Dimensions in mm

Pinning:

- 1 = base
- 2 = collector
- 3 = emitter

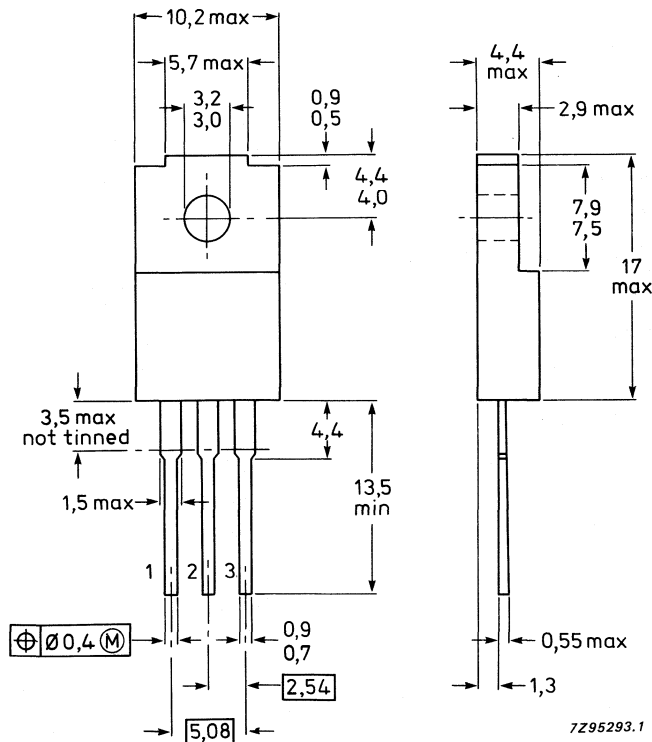
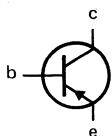
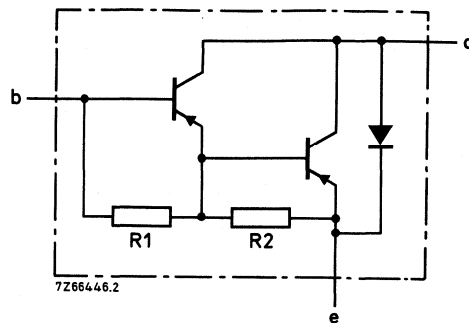


Fig. 1 SOT-186.

**BDT60F; 60AF
BDT60BF; 60CF**



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 $T_h = 25\text{ }^\circ\text{C}^*$	P_{tot}	max.	17		W
up to $T_h = 25\text{ }^\circ\text{C}^{**}$		max.	25		W
Storage temperature range	T_{stg}		-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	R_{thj-mb}	=	2.7		K/W
From junction to external heatsink*	R_{thj-h}	=	5		K/W
From junction to external heatsink**	R_{thj-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.

INSULATIONVoltage allowed between all terminals
and external heatsink, peak value V_{insul} max. 1000 VIsolation capacitor from collector
to external heatsink C_{th} typ. 12 pF**CHARACTERISTICS** $T_h = 25\text{ }^\circ\text{C}$ unless otherwise specified

Collector cut-off currents

 $-I_E = 0; -V_{CB} = 30\text{ V}$ $-I_{CBO}$ max. 0.2 mA $-I_E = 0; -V_{CB} = -\frac{1}{2} V_{CBO} \text{ max}; T_j = 150\text{ }^\circ\text{C}$ $-I_{CBO}$ max. 1 mA $-I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEO} \text{ max}$ $-I_{CEO}$ max. 0.2 mA

Emitter cut-off current

 $-I_C = 0; -V_{EB} = 5\text{ V}$ $-I_{EBO}$ max. 5 mA

Forward bias second breakdown

collector current $V_{CE} = 50\text{ V}$ $t_p = 0.1\text{ s}$; non-repetitive $-I_{(SB)}$ min. 0.5 A

DC current gain*

 $-I_C = 0.5\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 2000 $-I_C = 1.5\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} min. 750 $-I_C = 4\text{ A}; -V_{CE} = 3\text{ V}$ h_{FE} typ. 250

Base-emitter voltage*

 $-V_{BE}$ max. 2.5 V

Collector-emitter saturation voltage*

 $-I_C = 1.5\text{ A}; -I_B = 6\text{ mA}$ $-V_{CEsat}$ max. 2.5 V

Cut-off frequency

 $-I_C = 1.5\text{ A}; -V_{CE} = 3\text{ V}$ f_{hfe} min. 25 KHzSmall-signal current gain at $f = 1\text{ MHz}$ $-I_C = 1.5\text{ A}; -V_{CE} = 3\text{ V}$ h_{fe} min. 10

Diode forward voltage

 $I_F = 1.5\text{ A}$ V_F max. 2 V $I_F = 4\text{ A}$ 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)

$-I_{C\text{ on}} = 1.5\text{ A}; -I_{B\text{ on}} = +I_{B\text{ off}} = 6\text{ A}$

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

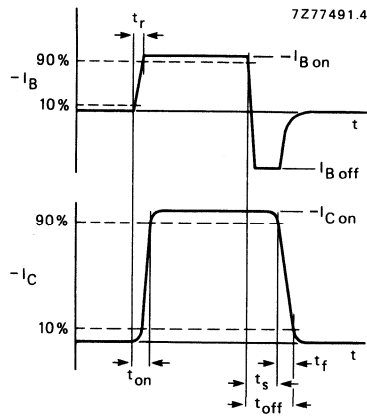
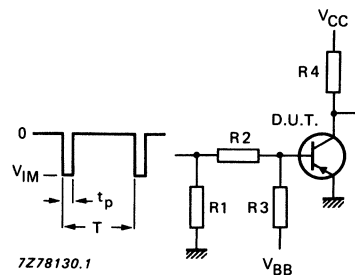


Fig. 3 Switching times waveforms.



- $-V_{CC} = 30\text{ V}$
- $-V_{IM} = 12\text{ V}$
- $+V_{BB} = 3\text{ V}$
- $R_1 = 56\ \Omega$
- $R_2 = 1\text{ k}\Omega$
- $R_3 = 680\ \Omega$
- $R_4 = 22\ \Omega$
- $t_r = t_f = 15\text{ ns}$
- $t_p = 10\ \mu\text{s}$
- $T = 500\ \mu\text{s}$

Fig. 4 Switching times test circuit.

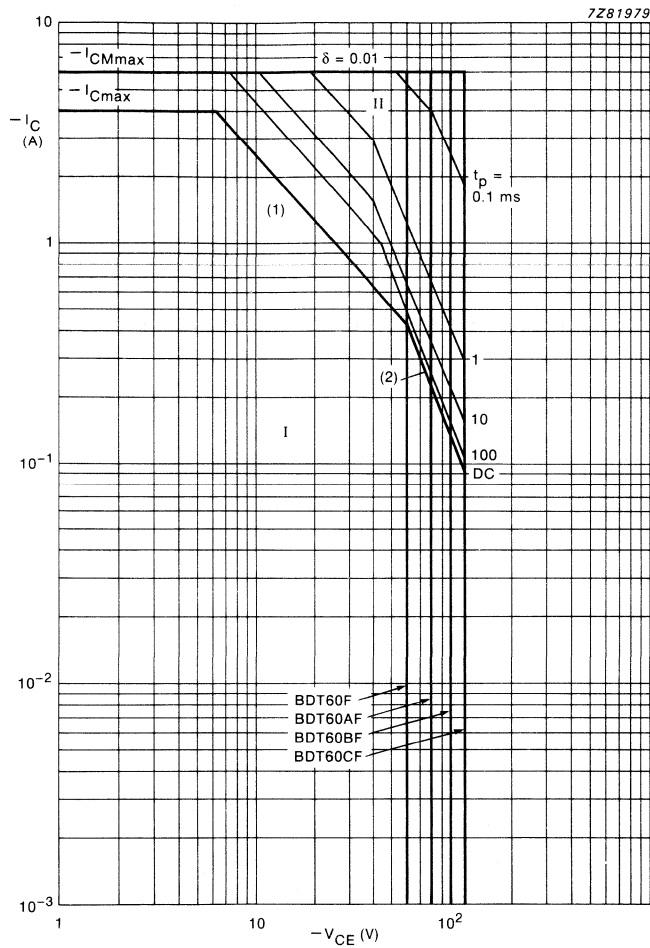


Fig. 5 Safe Operating Area, $T_h = 25\text{ }^\circ\text{C}$.

- 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.

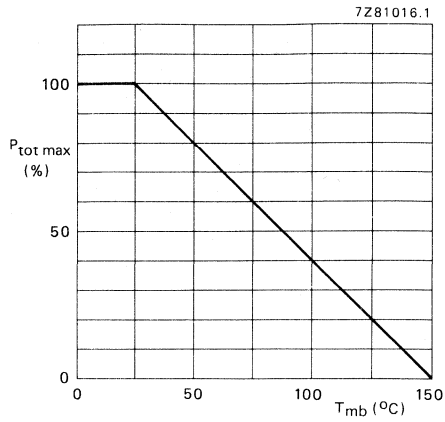


Fig. 6 Total power dissipation.

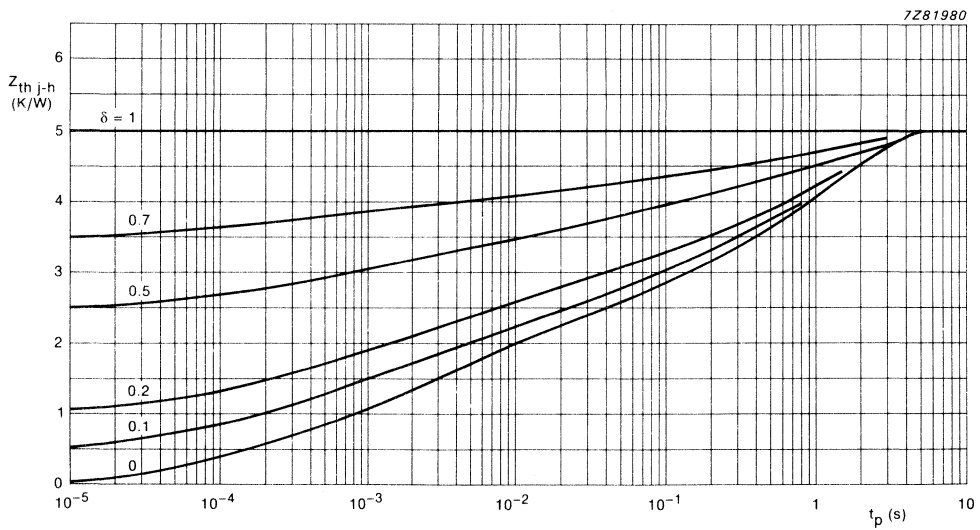


Fig. 7 Pulse power rating chart.

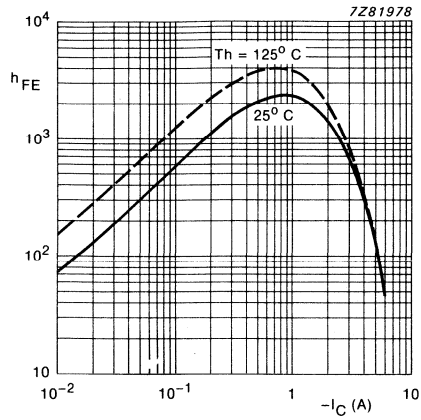


Fig. 8 DC current gain; $-V_{CE} = 3\text{ V}$; typical values.

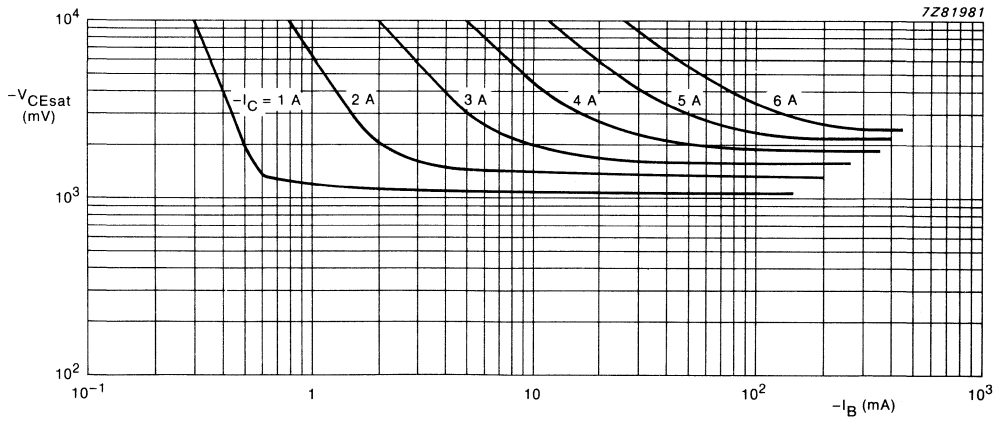


Fig. 9 Collector-emitter saturation voltage; $T_h = 25^\circ\text{C}$; typical values.

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.

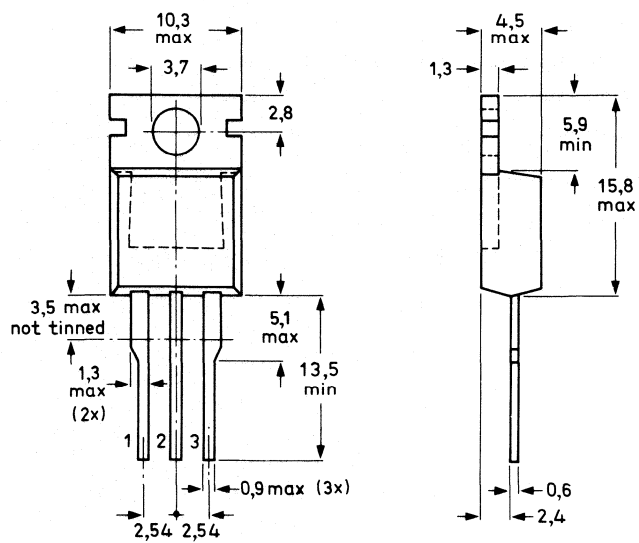
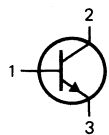
QUICK REFERENCE DATA

			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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			50	W
Junction temperature	T_j	max.			150	$^\circ\text{C}$
D.C. current gain $I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.			1150	

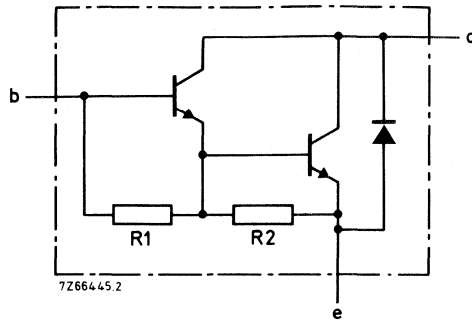
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



7265872.5



R1 typ. 6 k Ω
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_{CB0}	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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		50		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature *	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j-mb}$	=		2,5		K/W
From junction to ambient (in free air)	$R_{th\ j-a}$	=		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

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0\text{max}}$

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0\text{max}}; T_j = 150\text{ }^\circ\text{C}$

$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0\text{max}}$

$I_{CBO} \leq 0,2\text{ mA}$

$I_{CBO} \leq 0,5\text{ mA} \leftarrow$

$I_{CEO} \leq 0,2\text{ mA} \leftarrow$

Emitter cut-off current

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

$I_{EBO} \leq 5\text{ mA}$

Forward-bias second-breakdown collector current

$V_{CE} = 50\text{ V}; t = 0,1\text{ s}; \text{non-repetitive}$

$(\text{without heatsink}); T_{\text{amb}} = 25\text{ }^\circ\text{C}$

$I_{(SB)} \geq 1\text{ A}$

D.C. current gain *

$I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 1150 \leftarrow$

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \geq 750 \leftarrow$

$I_C = 4\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 1000 \leftarrow$

Base-emitter voltage *

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} \leq 2,5\text{ V}$

Collector-emitter saturation voltage *

$I_C = 1,5\text{ A}; I_B = 6\text{ mA}$

$V_{CE\text{sat}} \leq 2,5\text{ V}$

Turn-off breakdown energy with inductive load (Fig. 3)

$-I_{B\text{off}} = 0; L = 5\text{ mH}; I_{CC} = 3,2\text{ A}$

$E_{(BR)} \geq 25\text{ mJ}$

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

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$

$h_{fe} \geq 10$

Cut-off frequency

$I_C = 1,5\text{ A}; V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 25\text{ kHz}$

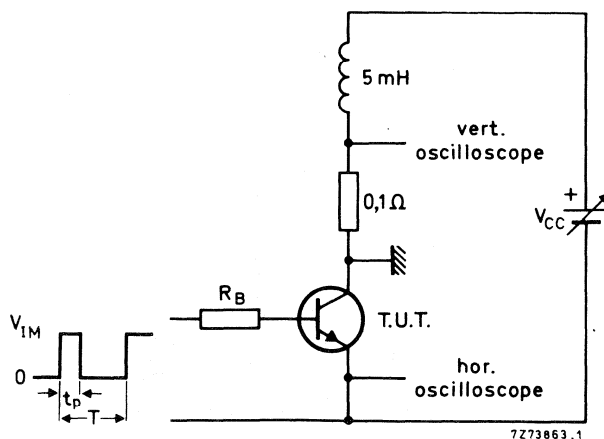


Fig. 3 Turn-off breakdown energy with inductive load.

$$V_{IM} = 12\text{ V}; R_B = 270\ \Omega; \delta = \frac{t_p}{T} \times 100\% = 1\%; I_{CC} = 3,2\text{ A}.$$

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

CHARACTERISTICS (continued)

Diode, forward voltage

$I_F = 1,5 \text{ A}$

$I_F = 4 \text{ A}$

$V_F < 2 \text{ V}$
 $V_F \text{ typ. } 2,1 \text{ V}$

Switching times

(between 10% and 90% levels)

$I_{Con} = 1,5 \text{ A}; I_{Bon} = -I_{Boff} = 6 \text{ mA}$

turn-on time

$t_{on} \text{ typ. } 0,8 \mu\text{s}$
 $< 2 \mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 4,5 \mu\text{s}$
 $< 8 \mu\text{s}$

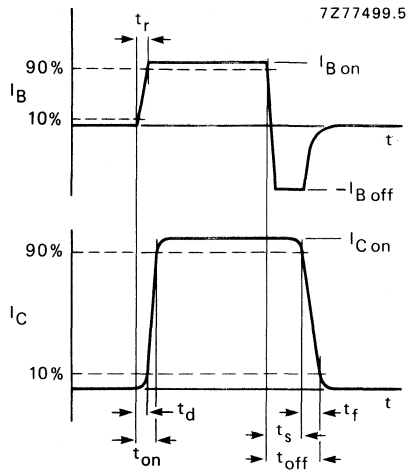
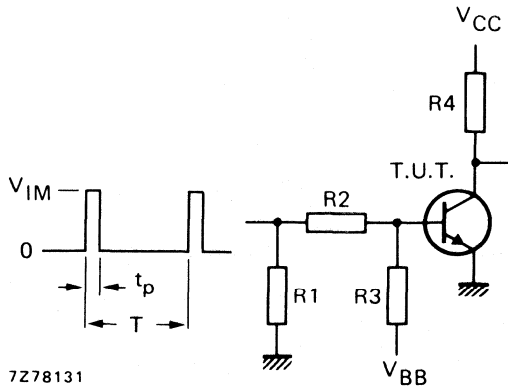


Fig. 4 Switching times waveforms.



- $V_{IM} = 12 \text{ V}$
- $V_{CC} = 30 \text{ V}$
- $-V_{BB} = 3 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 1 \text{ k}\Omega$
- $R3 = 680 \Omega$
- $R4 = 22 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 5 Switching times test circuit.

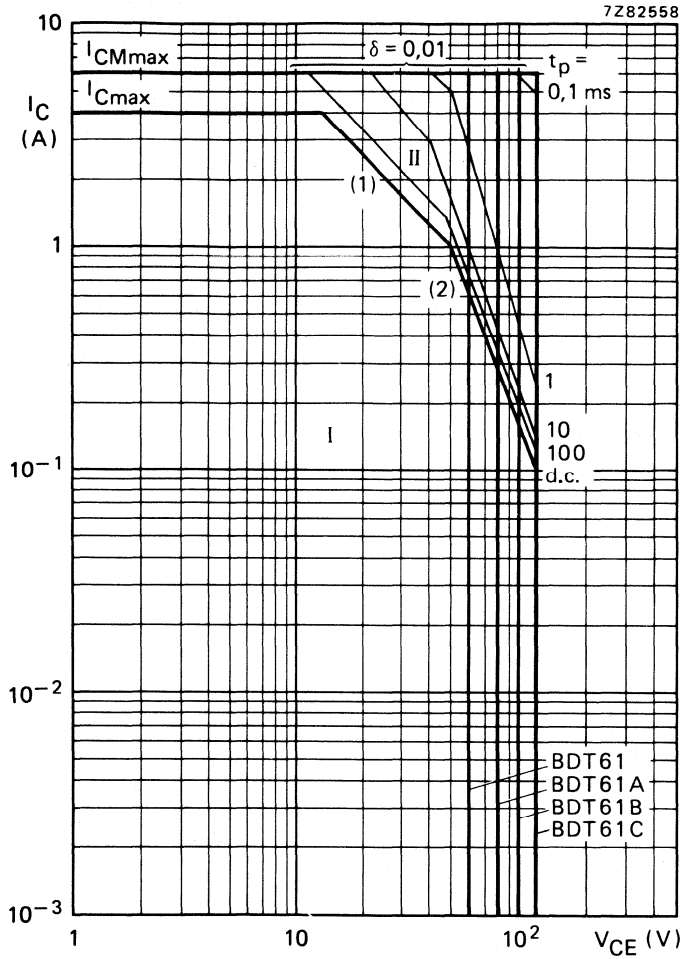


Fig. 6 Safe Operating Area; $T_{mb} = 25$ °C.

- 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.

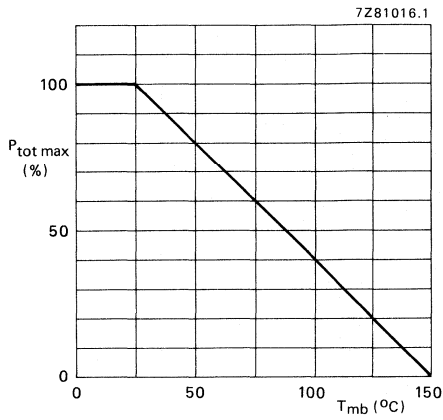


Fig. 7 Power derating curve.

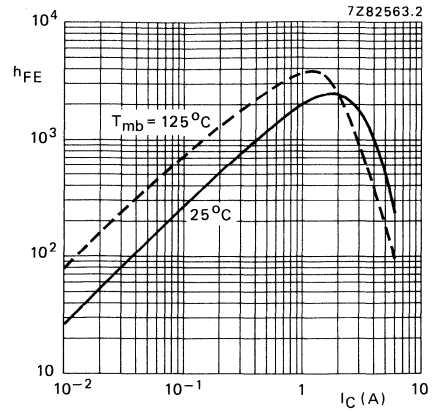


Fig. 8 Typical d.c. current gain. $V_{CE} = 3\ V$.

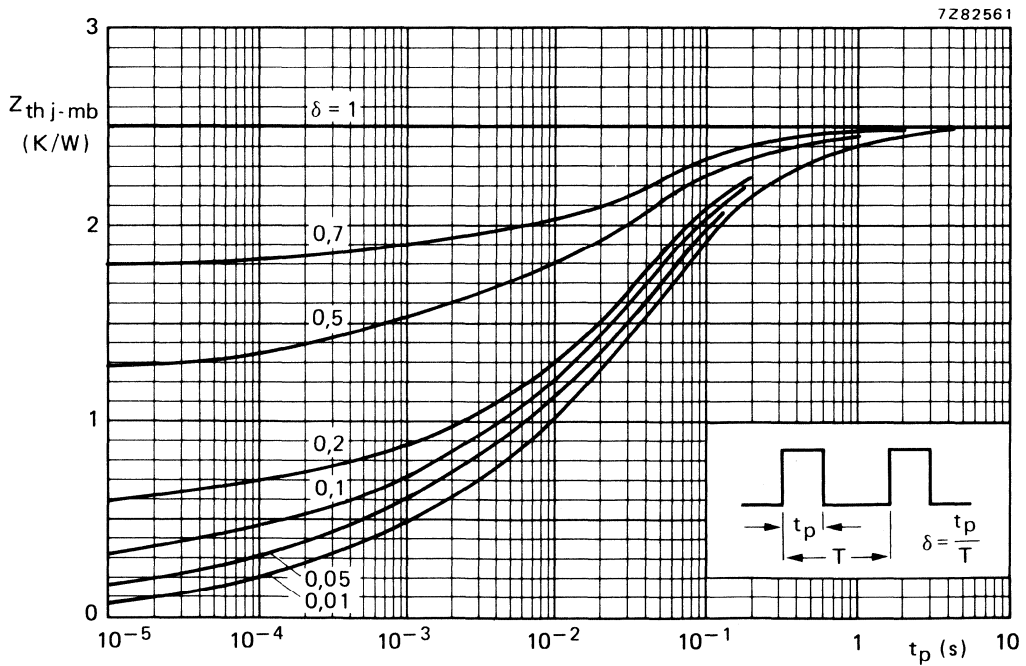


Fig. 9 Pulse power rating chart.

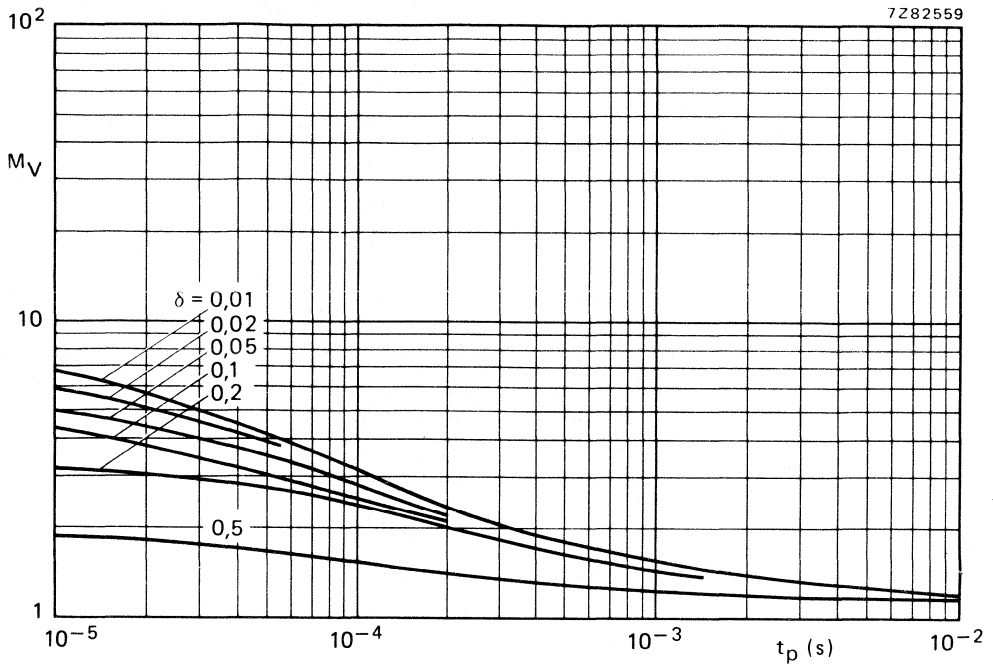


Fig. 10 Second breakdown voltage multiplying factor at the I_{Cmax} level.

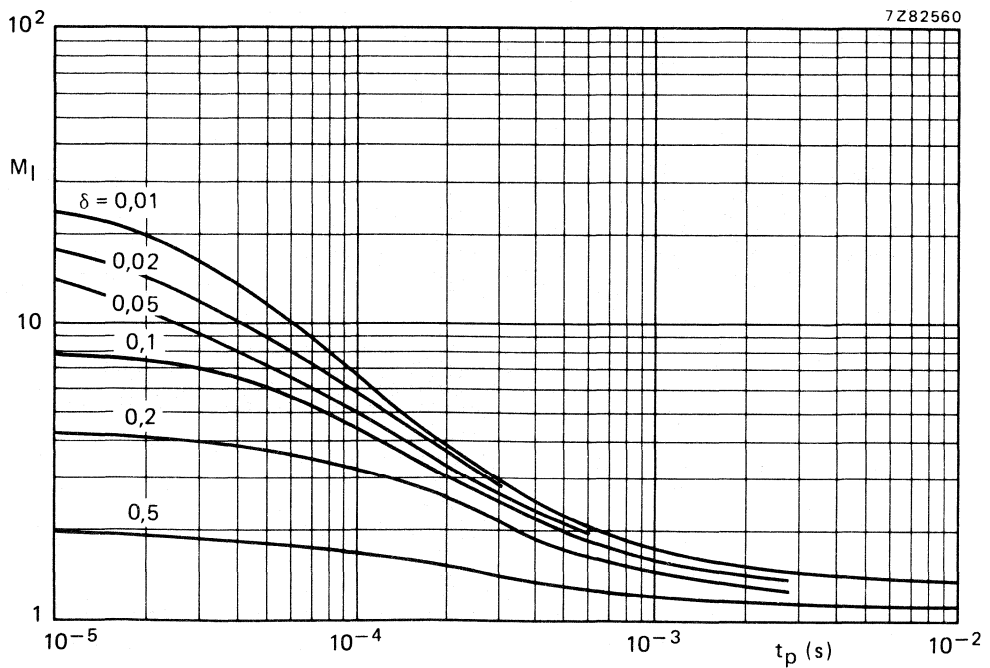


Fig. 11 Second breakdown current multiplying factor at the V_{CE0max} level.

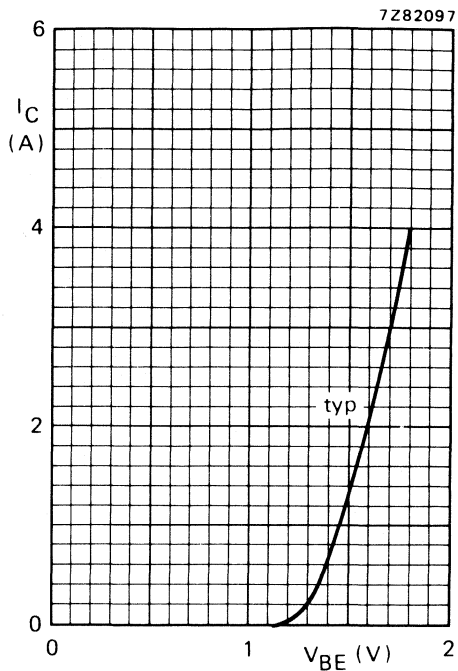


Fig. 12 $V_{CE} = 3\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$.

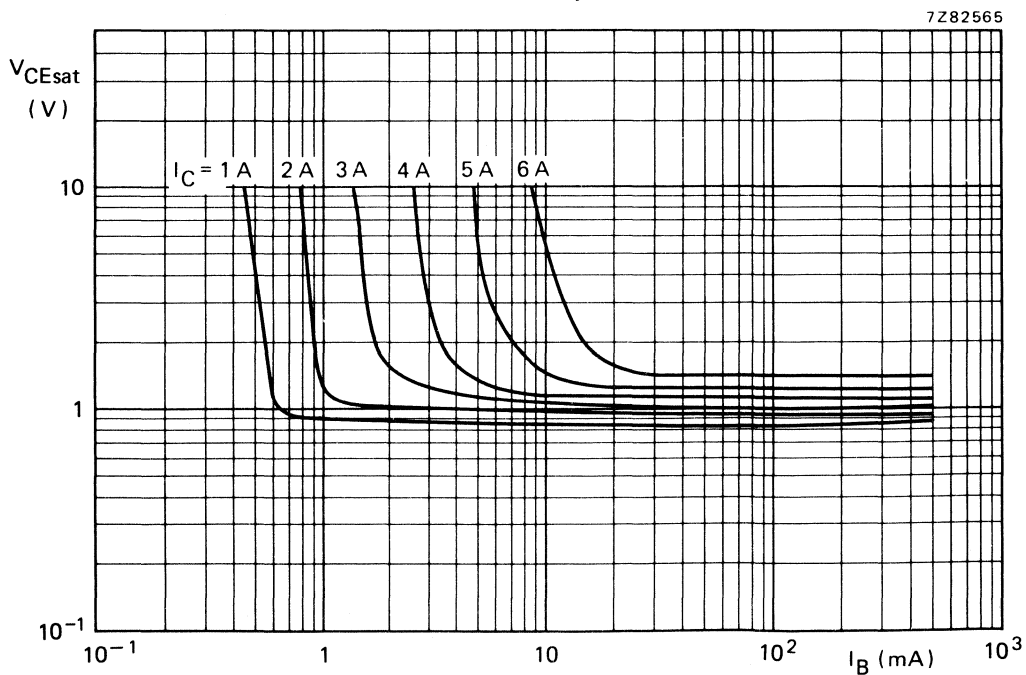


Fig. 13 Typical values collector-emitter saturation voltage at $T_{mb} = 25\text{ }^\circ\text{C}$.

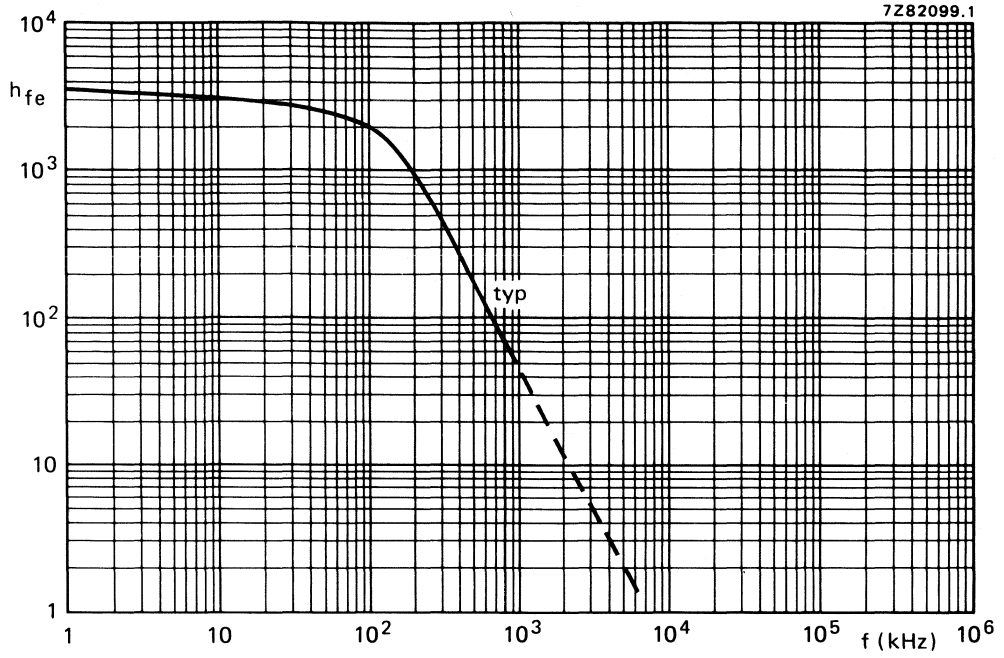


Fig. 14 Small signal current gain. $I_C = 1,5 \text{ A}$; $V_{CE} = 3 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

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 $T_h = 25\text{ }^\circ\text{C}$	P_{tot}	max.	25		W
DC current gain					
$I_C = 0.5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	2000		

MECHANICAL DATA

Dimensions in mm

Pinning

- 1 = base
- 2 = collector
- 3 = emitter

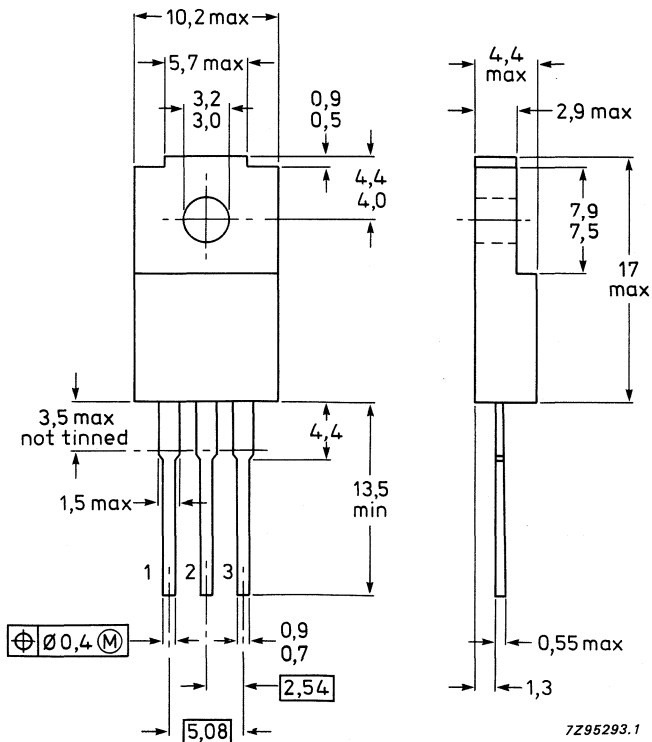
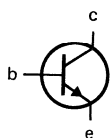
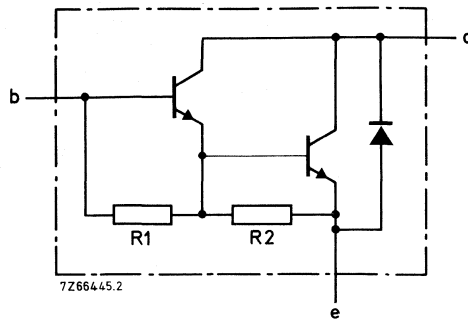


Fig. 1 SOT186.



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 $T_h = 25^\circ\text{C}^*$	P_{tot}	max.	17		W
up to $T_h = 25^\circ\text{C}^{**}$		max.	25		W
Storage temperature range	T_{stg}		-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	R_{thj-mb}	=	2.7		K/W
From junction to external heatsink**	R_{thj-h}	=	5		K/W
From junction to external heatsink*	R_{thj-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.

INSULATIONVoltage allowed between all terminals
and external heatsink, peak value V_{insul} max. 1000 VIsolation capacitor from collector
to external heatsink C_{th} typ. 12 pF**CHARACTERISTICS** $T_h = 25\text{ }^\circ\text{C}$ unless otherwise specified

Collector cut-off currents

 $I_E = 0; V_{CB} = 30\text{ V}$ I_{CBO} max. 0.2 mA $I_E = 0; T_j = 150\text{ }^\circ\text{C}$ $V_{CB} = \frac{1}{2} V_{CBO\text{ max}}$ I_{CBO} max. 1 mA $I_B = 0$ $V_{CE} = \frac{1}{2} V_{CEO\text{ max}}$ I_{CEO} max. 0.2 mA

Emitter cut-off current

 $I_C = 0; V_{EB} = 5\text{ V}$ I_{EBO} max. 5 mAForward bias second breakdown
collector current $V_{CE} = 50\text{ V}$
 $t_p = 0.1\text{ s}$; non-repetitive $I_{(SB)}$ min. 0.5 A

DC current gain*

 $I_C = 0.5\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} typ. 2000 $I_C = 1.5\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} min. 750 $I_C = 4\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} typ. 1000

Base-emitter voltage*

 V_{BE} max. 2.5 V

Collector-emitter saturation voltage*

 $I_C = 1.5\text{ A}; I_B = 6\text{ mA}$ V_{CEsat} max. 2.5 V

Cut-off frequency

 $I_C = 1.5\text{ A}; V_{CE} = 3\text{ V}$ f_{hfe} min. 25 KHzSmall-signal current gain at $f = 1\text{ MHz}$ $I_C = 1.5\text{ A}; V_{CE} = 3\text{ V}$ h_{fe} min. 10

Diode forward voltage

 $I_F = 1.5\text{ A}$ V_F max. 2 V $I_F = 4\text{ A}$ 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

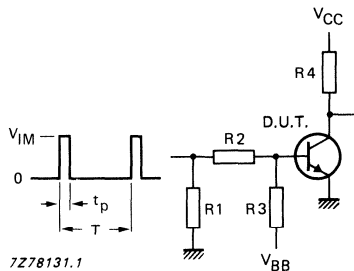


Fig. 3 Switching times waveforms.

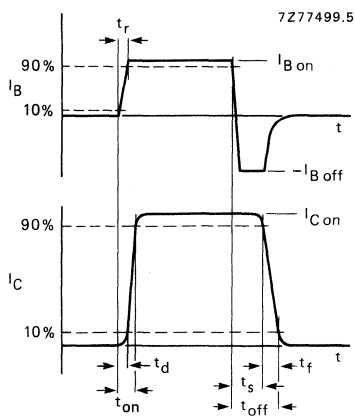
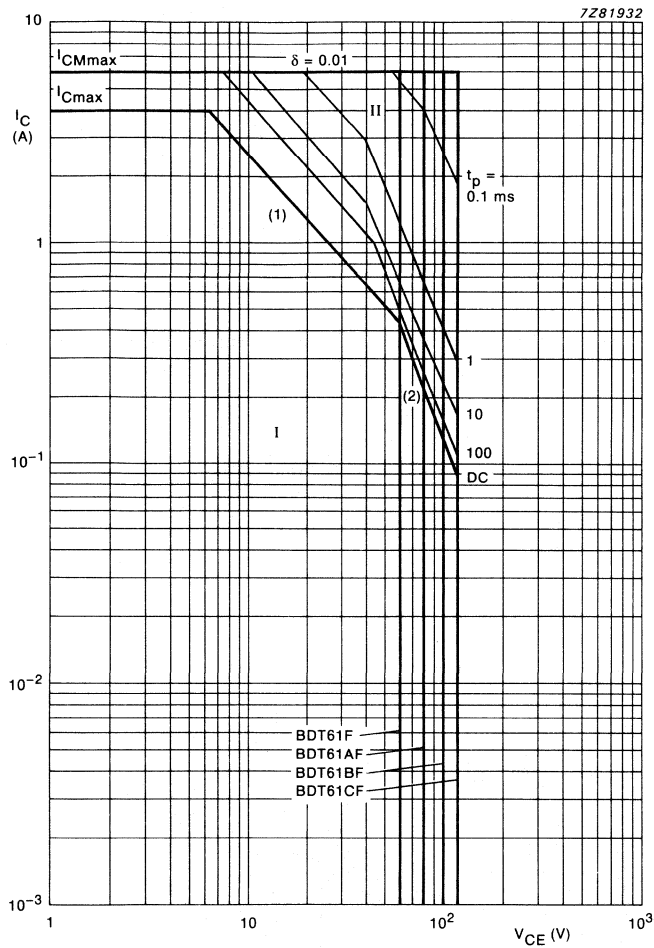


Fig. 4 Switching times test circuit.



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

Fig. 5 Safe Operating Area, $T_h = 25 \text{ }^\circ\text{C}$.

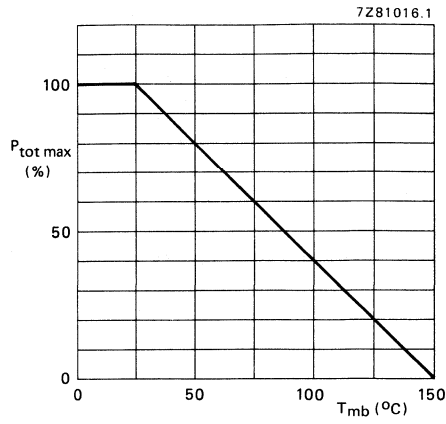


Fig. 6 Total power dissipation.

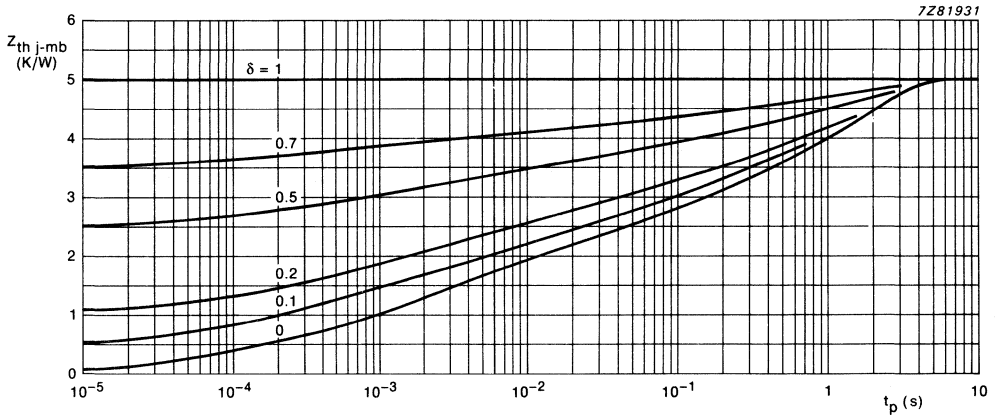


Fig. 7 Pulse power rating chart.

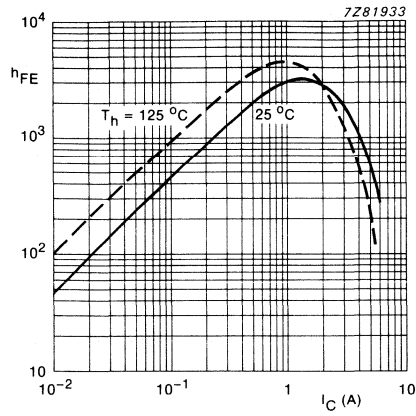


Fig. 8 DC current gain; $V_{CE} = 3\text{ V}$; typical values.

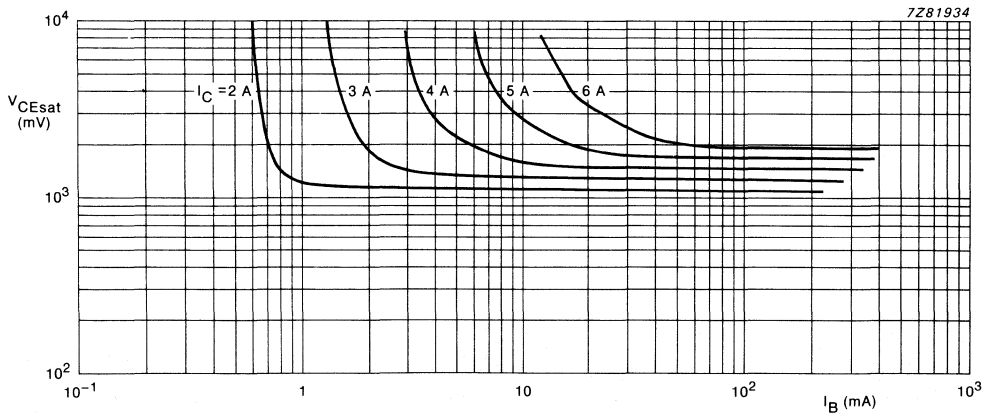


Fig. 9 Collector-emitter saturation voltage; $T_h = 25\text{ }^\circ\text{C}$; typical values.

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.

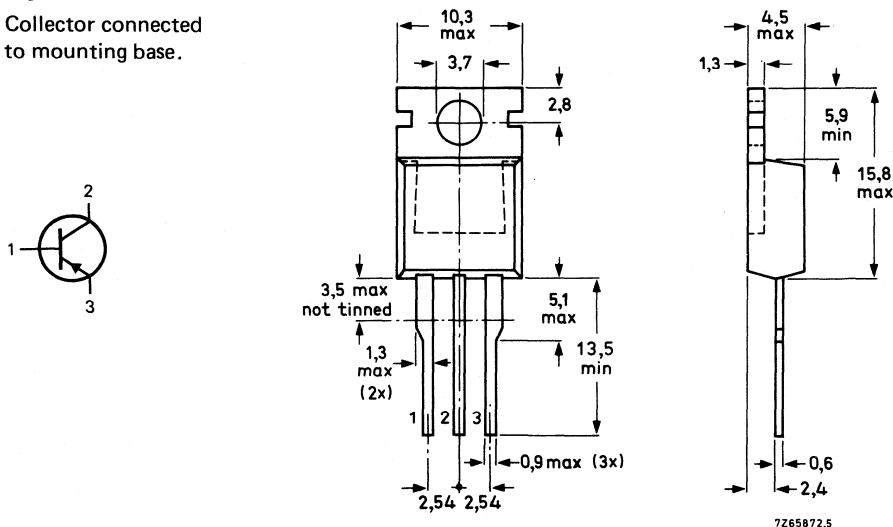
QUICK REFERENCE DATA

		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)	$-I_{CM}$ max.		15		A
$t_p = 0,3$ ms; $\delta = 10\%$					
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	h_{FE}	>		1000	
$-I_C = 3$ A; $-V_{CE} = 3$ V					

MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters
Mounting instructions
and Accessories.

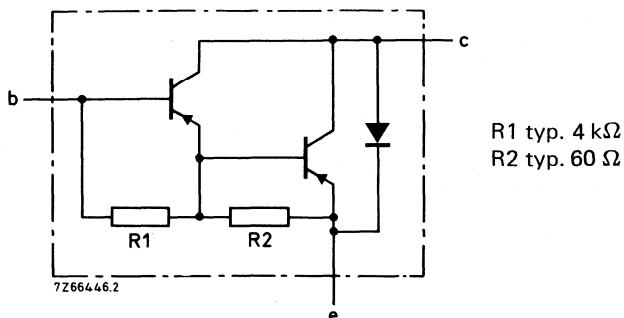


Fig. 2 Circuit diagram.

RATINGS

Limiting values in accordance with the Absolute Maximum System (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; $\delta = 10\%$	$-I_{CM}$ 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	$R_{th\ j-mb}$ =	1,39	K/W
From junction to ambient (in free air)	$R_{th\ j-a}$ =	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 $T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified.

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CBOmax}$

$-I_{CBO} < 0,2\text{ mA}$

$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$

$-I_{CBO} < 2\text{ mA}$

$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEOmax}$

$-I_{CEO} < 0,2\text{ mA}$ ←

Emitter cut-off current

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

$-I_{EBO} < 5\text{ mA}$

Forward bias second-breakdown collector current

$-V_{CE} = 40\text{ V}; t = 0,1\text{ s}; \text{non-repetitive}$

(without heatsink)

BDT62

$I_{(SB)} > 0,45\text{ A}$

BDT62A, B and C

$I_{(SB)} > 1,4\text{ A}$

D.C. current gain*

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 200$

Base-emitter voltage*

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$-V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage*

$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$

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

$-I_C = 8\text{ A}; -I_B = 80\text{ mA}$

$-V_{CEsat} < 2,5\text{ V}$

Cut-off frequency

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 100\text{ kHz}$

Collector capacitance

$-V_{CB} = 10\text{ V}; f = 1\text{ MHz}$

$C_{ob} \text{ typ. } 100\text{ pF}$

D.C. current gain ratio of matched complementary pairs

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE1}/h_{FE2} < 2,5$

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

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$

$h_{fe} > 10$

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

CHARACTERISTICS (continued)

Diode, forward voltage

$I_F = 3 \text{ A}$

$V_F < 2 \text{ V}$

Switching times

(between 10% and 90% levels)

$-I_{Con} = 3 \text{ A}; -I_{Bon} = I_{Boff} = 12 \text{ mA}$

turn-on time

$t_{on} \text{ typ. } 0,5 \mu\text{s}$
 $< 1,5 \mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 2,5 \mu\text{s}$
 $< 5 \mu\text{s}$

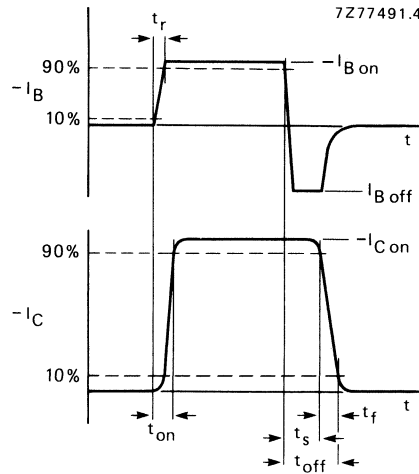
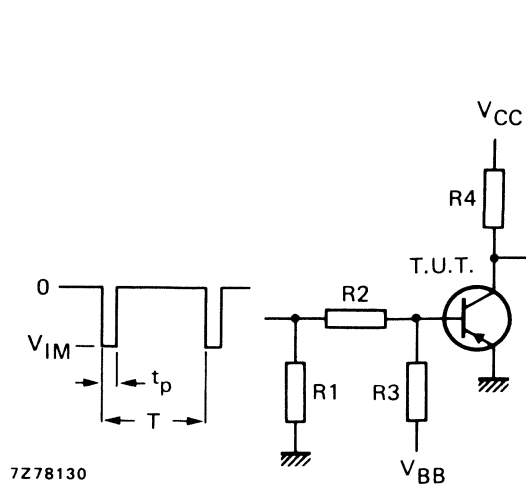


Fig. 3 Switching times waveforms.



- $-V_{IM} = 10 \text{ V}$
- $-V_{CC} = 10 \text{ V}$
- $+V_{BB} = 4 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 410 \Omega$
- $R3 = 560 \Omega$
- $R4 = 3 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.

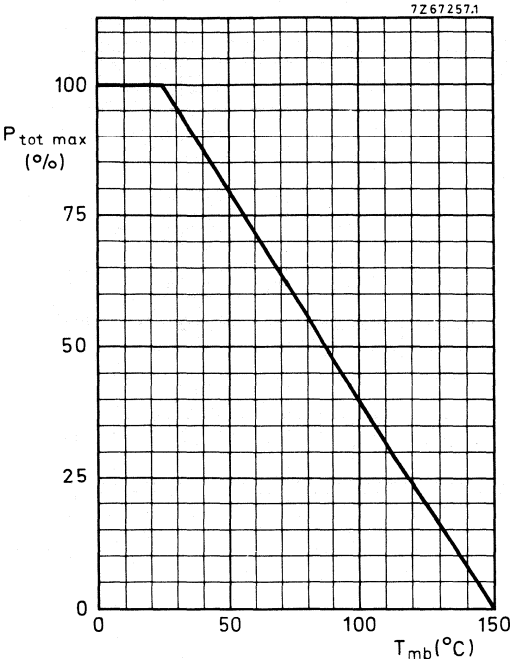


Fig. 5 Power derating curve.

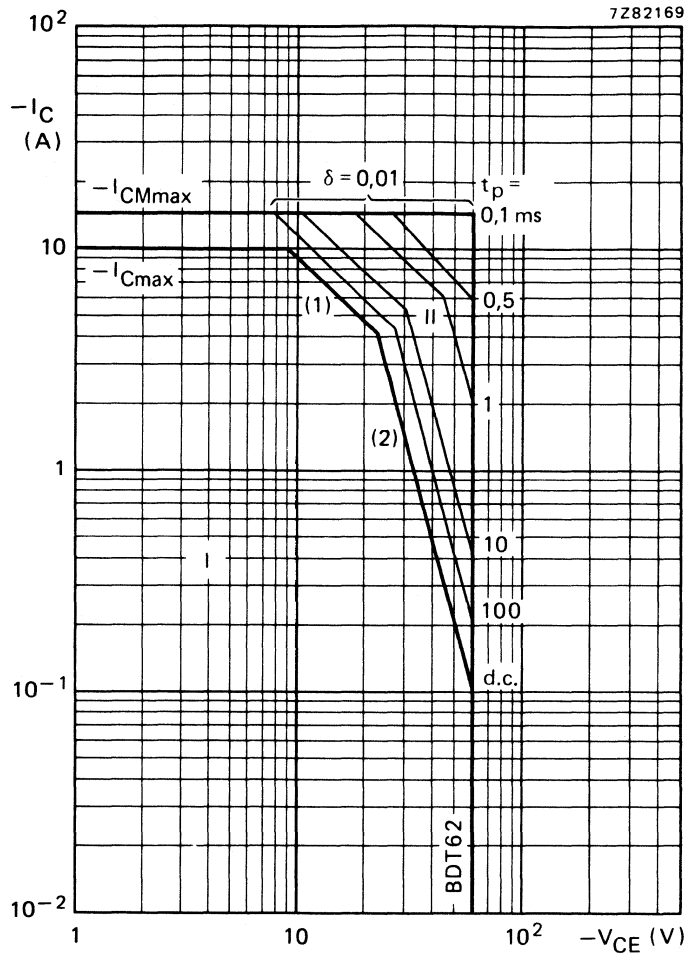


Fig. 6 Safe Operating ARea BDT62; $T_{mb} = 25$ °C.

- 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.

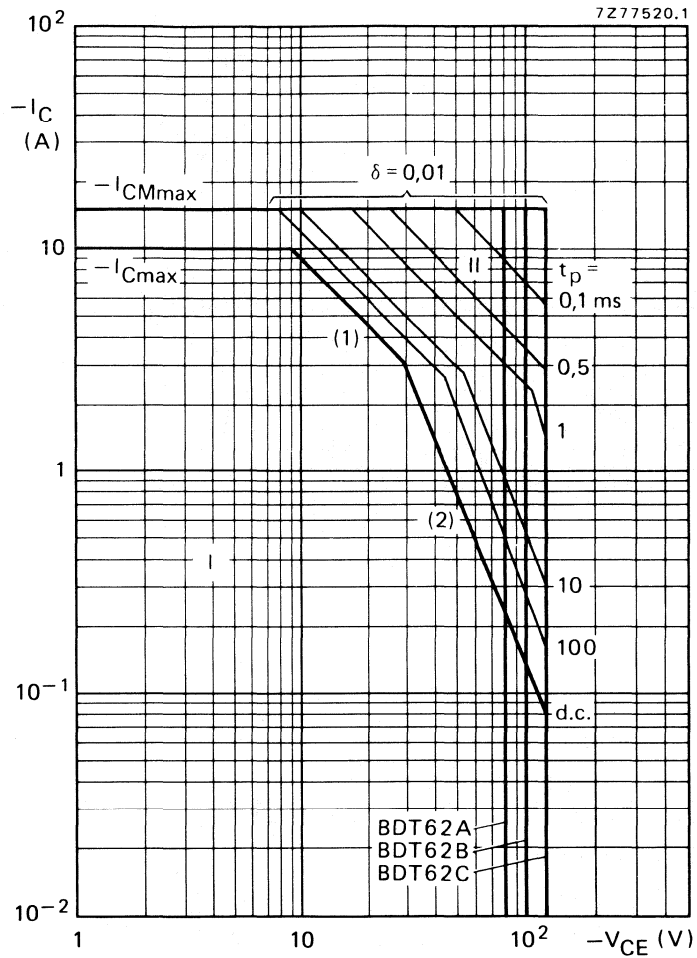


Fig. 7 Safe Operating Area BDT62A; 62B and 62C; $T_{mb} = 25^\circ\text{C}$.

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

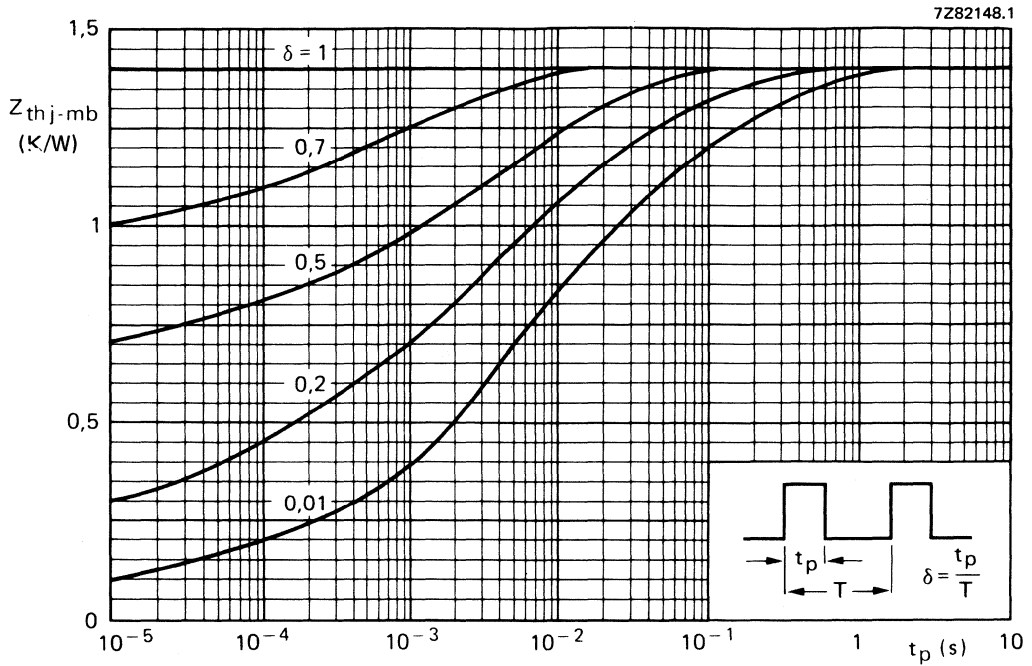


Fig. 8 Pulse power rating chart.

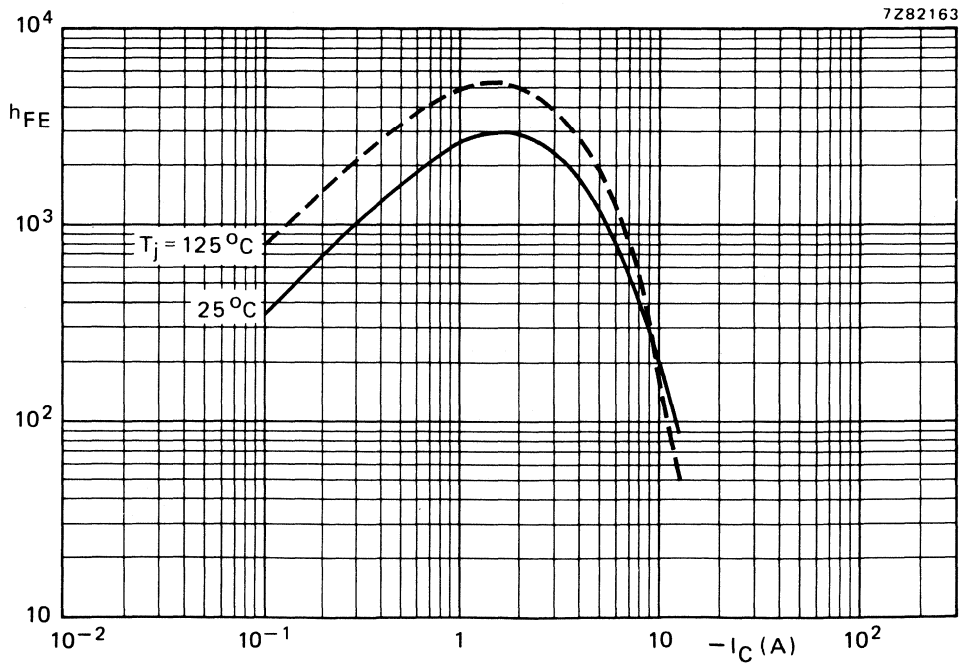


Fig. 9 Typical d.c. current gain at $-V_{CE} = 3$ V.

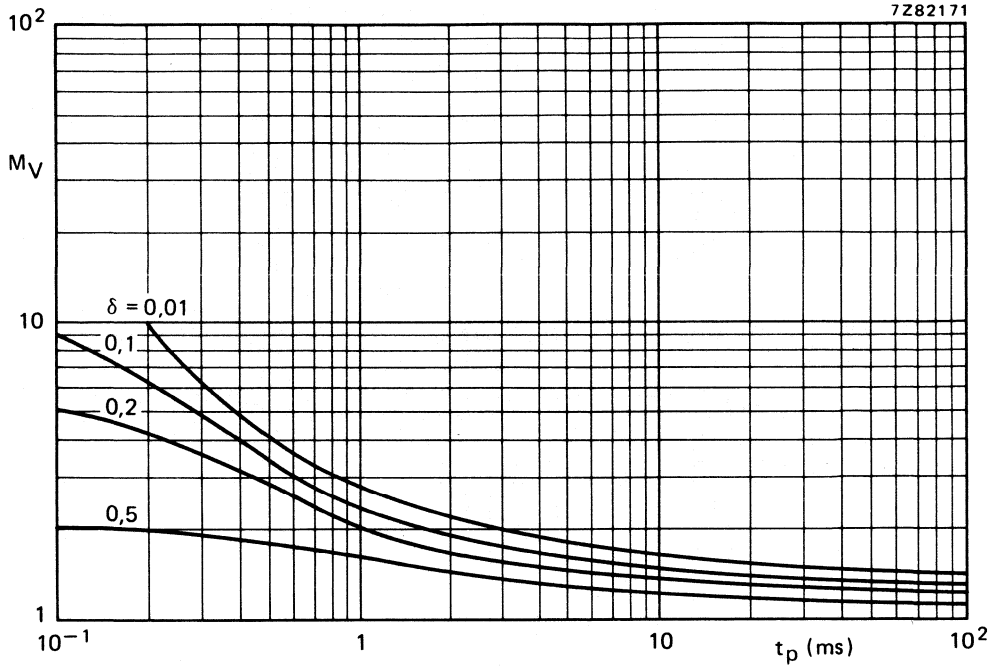


Fig. 10 S.B. voltage multiplying factor at the I_C max level.

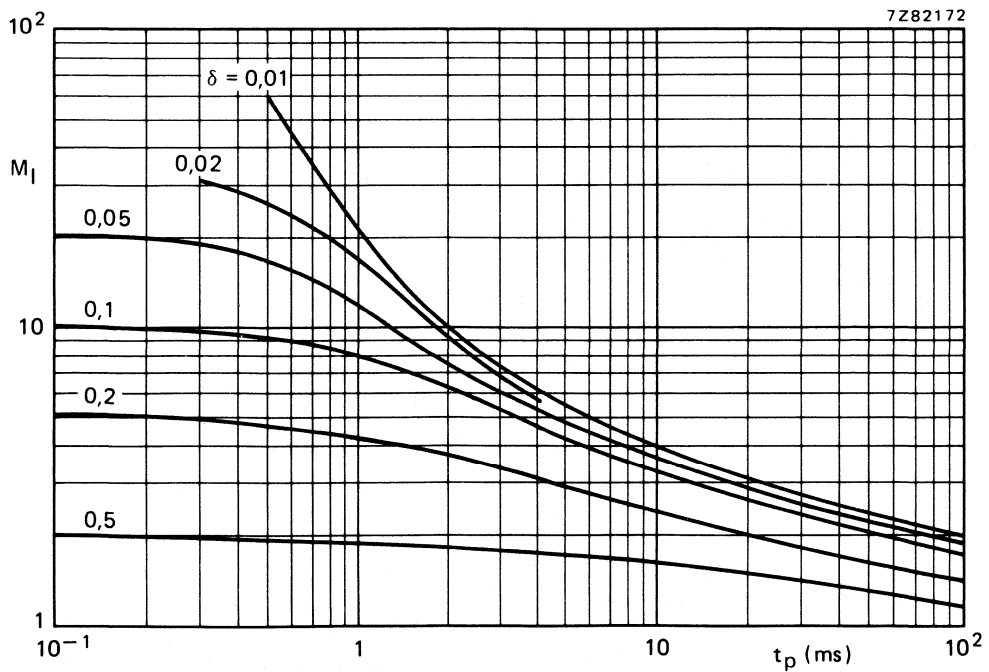


Fig. 11 S.B. current multiplying factor at the V_{CEO} max level.

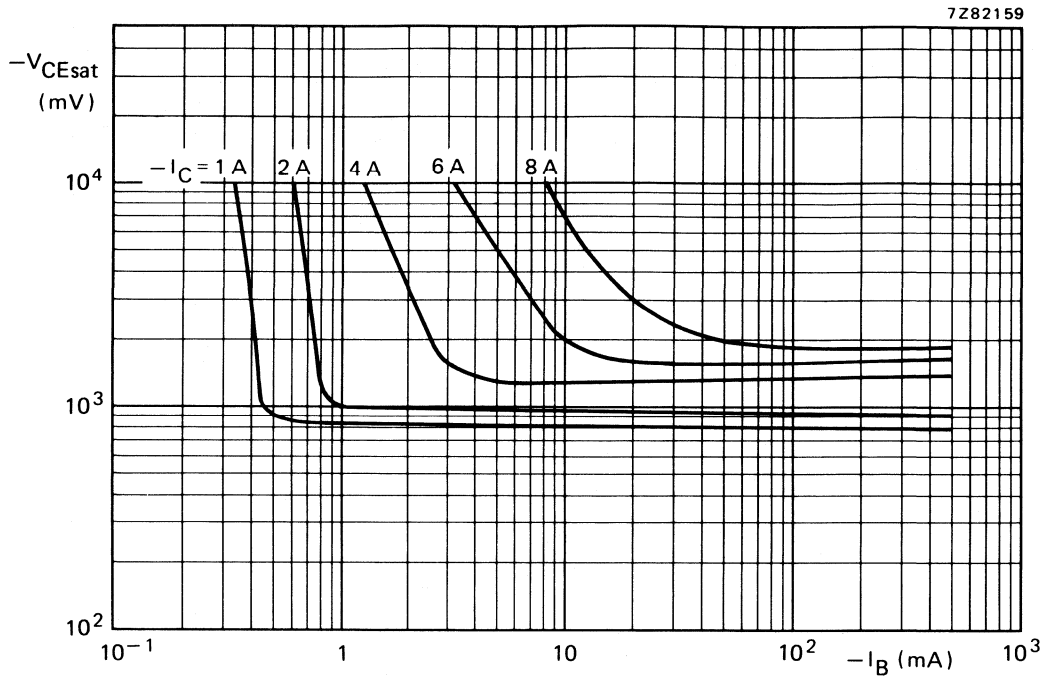


Fig. 12 Typical collector-emitter saturation voltage.

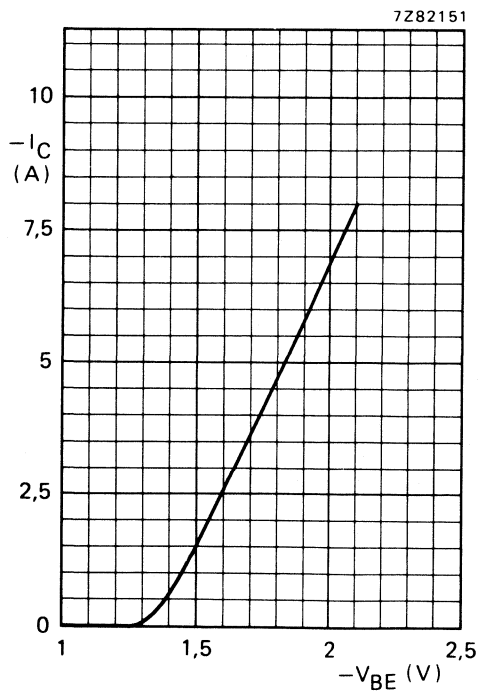


Fig. 13 Typical base emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

PNP silicon darlington power transistors in a SOT-186 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)	$-V_{CB0}$	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 $T_h = 25^\circ\text{C}$	P_{tot}	max.			36	W
Junction temperature	T_j	max.			150	$^\circ\text{C}$
DC current gain						
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	min.			1000	

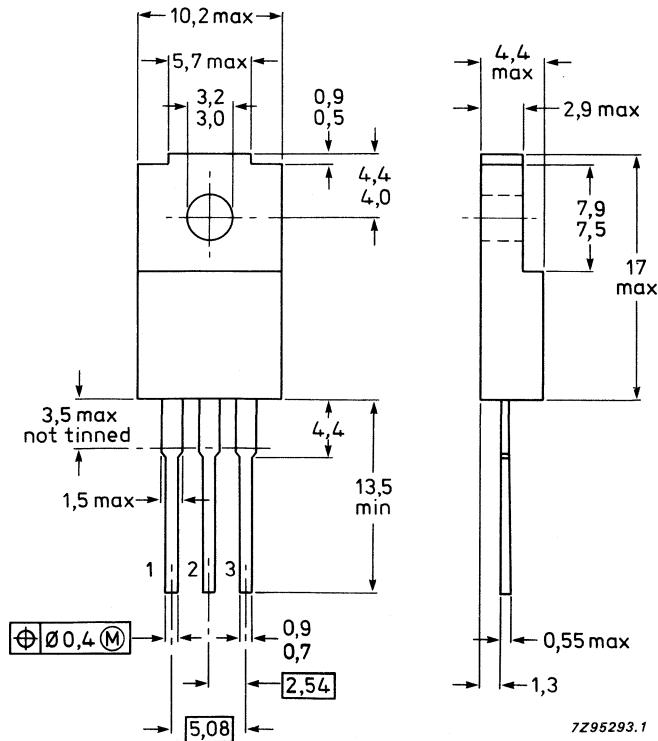
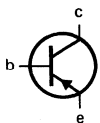
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-186.

Pinning:

- 1 = Base
- 2 = Collector
- 3 = Emitter



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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 $T_h = 25^\circ\text{C}$ (1)	P_{tot}	max.	21			W
up to $T_h = 25^\circ\text{C}$ (2)		max.	36			W
Storage temperature	T_{stg}		-65 to 150			$^\circ\text{C}$
Junction temperature	T_j	max.	150			$^\circ\text{C}$

THERMAL RESISTANCE

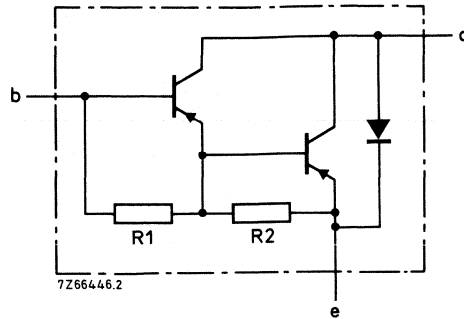
From junction to internal heatsink	$R_{th\ j-mb}$	=	1.17			K/W
From junction to external heatsink (1)	$R_{th\ j-h}$	=	5.95			K/W
From junction to external heatsink (2)	$R_{th\ j-h}$	=	3.47			K/W

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 k Ω
R2 typ. 60 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0\text{max}}$	$-I_{CBO}$	max.	0.2	mA
$I_E = 0; T_j = 150\text{ }^\circ\text{C};$ $-V_{CB} = -1/2 V_{CB0\text{max}}$	$-I_{CBO}$	max.	2.0	mA
$I_B = 0; -V_{CE} = -1/2 V_{CE0\text{max}}$	$-I_{CEO}$	max.	0.5	mA

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	max.	5.0	mA
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Forward bias second-breakdown
collector current

$-V_{CE} = 40\text{ V}; t = 0.1\text{ s};$ non-repetitive (without heatsink)	$I_{(SB)}$	min.	0.9	A
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DC current gain (3)

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	min.	1000	
$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	150	

Base-emitter voltage (3)

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	$-V_{BE}$	max.	2.5	V
---	-----------	------	-----	---

Collector-emitter saturation voltage (3)

$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$	$-V_{CE\text{sat}}$	max.	2.0	V
$-I_C = 8\text{ A}; -I_B = 80\text{ mA}$	$-V_{CE\text{sat}}$	max.	2.5	V

Cut-off frequency

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	typ.	100	kHz
---	-----------	------	-----	-----

Collector capacitance

$-V_{CB} = 10\text{ V}; f = 1\text{ MHz}$	C_c	typ.	100	pF
---	-------	------	-----	----

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

$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{fe}	min.	10	
---	----------	------	----	--

Diode, forward voltage

$I_F = 3\text{ A}$	V_F	max.	2.0	V
--------------------	-------	------	-----	---

(3) Measured under pulse conditions; $t_p < 300\text{ }\mu\text{s}$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

$-I_{Con} = 3 \text{ A}$;

$-I_{Bon} = I_{Boff} = 12 \text{ mA}$

Turn-on time

t_{on}	typ.	0.5	μs
	max.	1.5	μs
Turn-off time	typ.	2.5	μs
	max.	5.0	μs

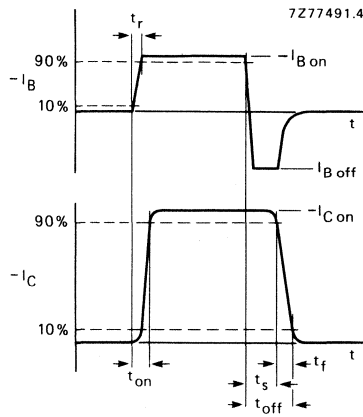
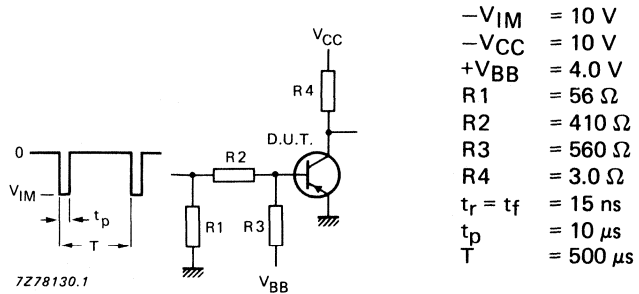


Fig. 3 Switching times waveforms.



- $-V_{IM} = 10 \text{ V}$
- $-V_{CC} = 10 \text{ V}$
- $+V_{BB} = 4.0 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 410 \Omega$
- $R3 = 560 \Omega$
- $R4 = 3.0 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.

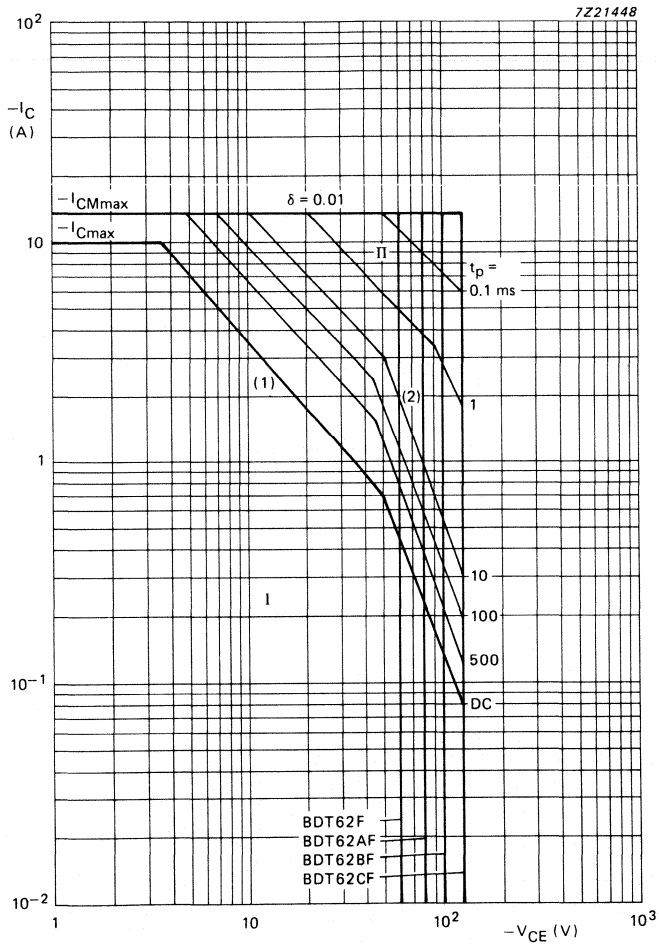


Fig. 5 Safe Operating Area; $T_h = 25^\circ\text{C}$.

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

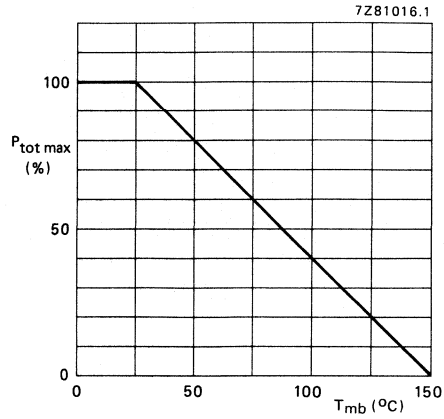


Fig. 6 Power derating curve.

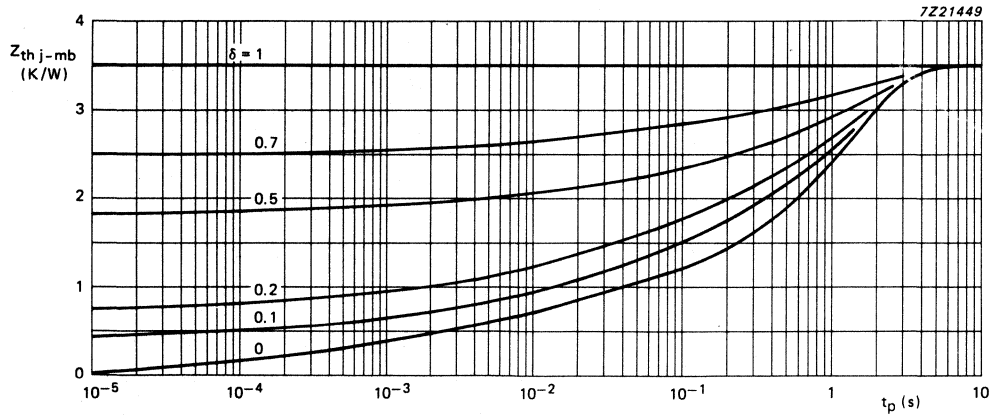


Fig. 7 Pulse power rating chart.

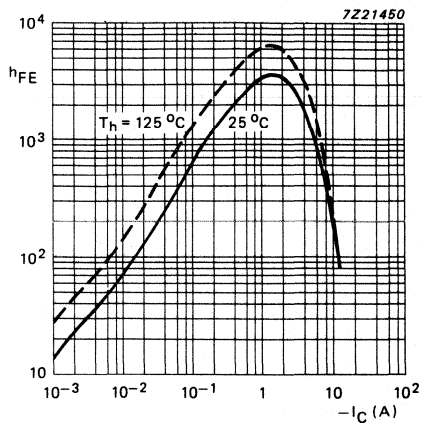


Fig. 8 Typical DC current gain at $-V_{CE} = 3\text{ V}$.

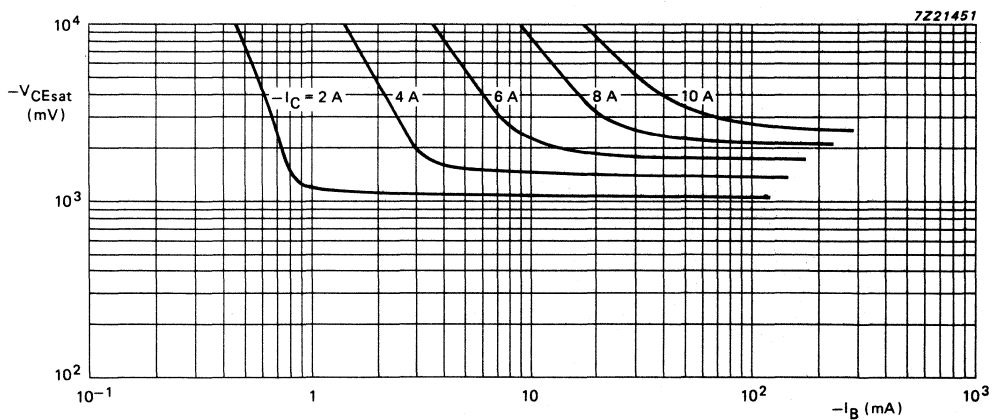


Fig. 9 Typical collector-emitter saturation voltage; $T_h = 25\text{ }^\circ\text{C}$.

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 BDT62, BDT62A; BDT62B and BDT62C.

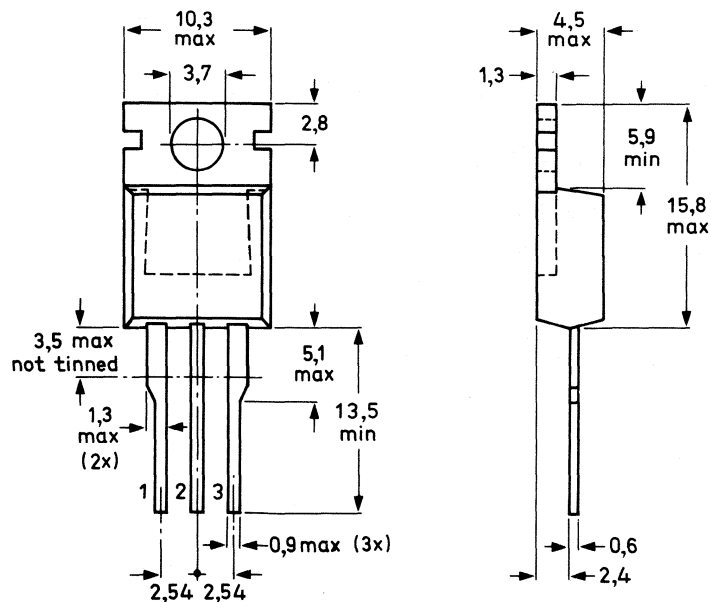
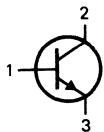
QUICK REFERENCE DATA

		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; $\delta = 10\%$	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-220AB.

Collector connected to mounting base.



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See also chapters
Mounting instructions
and Accessories.

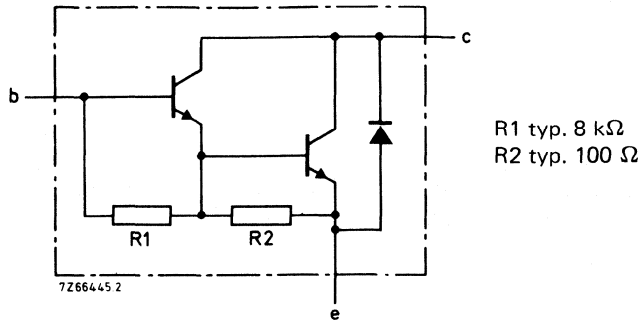


Fig. 2 Circuit diagram.

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) $t_p = 0,3 \text{ ms}; \delta = 10\%$	I_{CM}	max.	15				A
Base current (d.c.)	I_B	max.	250				mA
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	90				W
Storage temperature	T_{stg}		-65 to + 150				$^\circ\text{C}$
Junction temperature*	T_j	max.	150				$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	$R_{th j-mb}$	=	1,39			K/W
From junction to ambient (in free air)	$R_{th j-a}$	=	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 $T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified.

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0\max}$

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0\max}; T_j = 150\text{ }^\circ\text{C}$

$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0\max}$

$I_{CBO} < 0,2\text{ mA}$

$I_{CBO} < 2\text{ mA}$

$I_{CEO} < 0,2\text{ mA}$ ←

Emitter cut-off current

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

$I_{EBO} < 5\text{ mA}$

Forward-bias second breakdown collector current

$V_{CE} = 60\text{ V}; t = 0,1\text{ s}; \text{non-repetitive}$

(without heatsink)

$I_{(SB)} > 1,5\text{ A}$

D.C. current gain*

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$h_{FE} \text{ typ. } 3000$

Base-emitter voltage*

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage*

$I_C = 3\text{ A}; I_B = 12\text{ mA}$

$I_C = 8\text{ A}; I_B = 80\text{ mA}$

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

$V_{CEsat} < 2,5\text{ V}$

Diode, forward voltage

$I_F = 3\text{ A}$

$V_F < 2\text{ V}$

Turn-off breakdown energy with inductive load (Fig. 6)

$-I_{B\text{off}} = 0; L = 5\text{ mH}$

$E_{(BR)} > 100\text{ mJ}$

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

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$h_{fe} > 10$

Cut-off frequency

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 50\text{ kHz}$

Collector capacitance

$V_{CB} = 10\text{ V}; f = 1\text{ MHz}$

$C_{ob} \text{ typ. } 100\text{ pF}$

D.C. current gain ratio of matched

complementary pairs

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE1}/h_{FE2} < 2,5$

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

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

$I_{Con} = 3 \text{ A}; I_{Bon} = -I_{Boff} = 12 \text{ mA}$

turn-on time

t_{on} typ. $1 \mu\text{s}$
 < $2,5 \mu\text{s}$

turn-off time

t_{off} typ. $5 \mu\text{s}$
 < $10 \mu\text{s}$

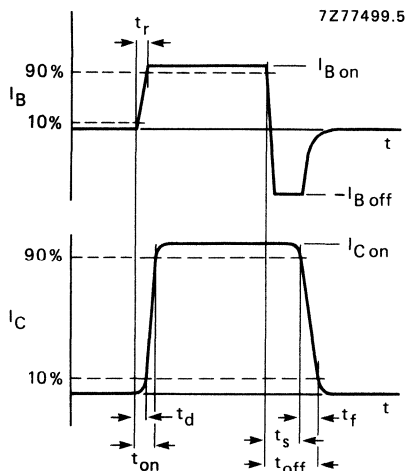
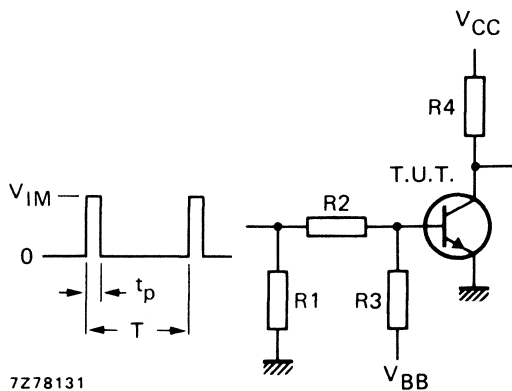


Fig. 3 Switching times waveforms.



$V_{IM} = 10 \text{ V}$
 $V_{CC} = 10 \text{ V}$
 $-V_{BB} = 4 \text{ V}$
 $R1 = 56 \Omega$
 $R2 = 410 \Omega$
 $R3 = 560 \Omega$
 $R4 = 3 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.

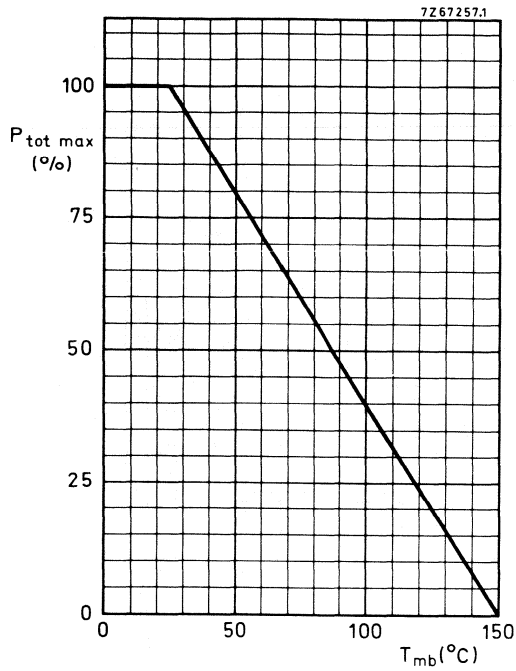


Fig. 5 Power derating curve.

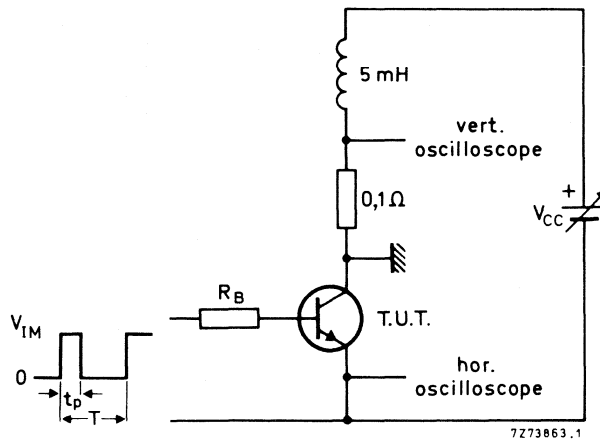


Fig. 6 Turn-off breakdown energy with inductive load.

$V_{IM} = 12\text{ V}; R_B = 270\ \Omega; \delta = \frac{t_p}{T} \times 100\% = 1\%; I_{CC} = 6,3\text{ A.}$

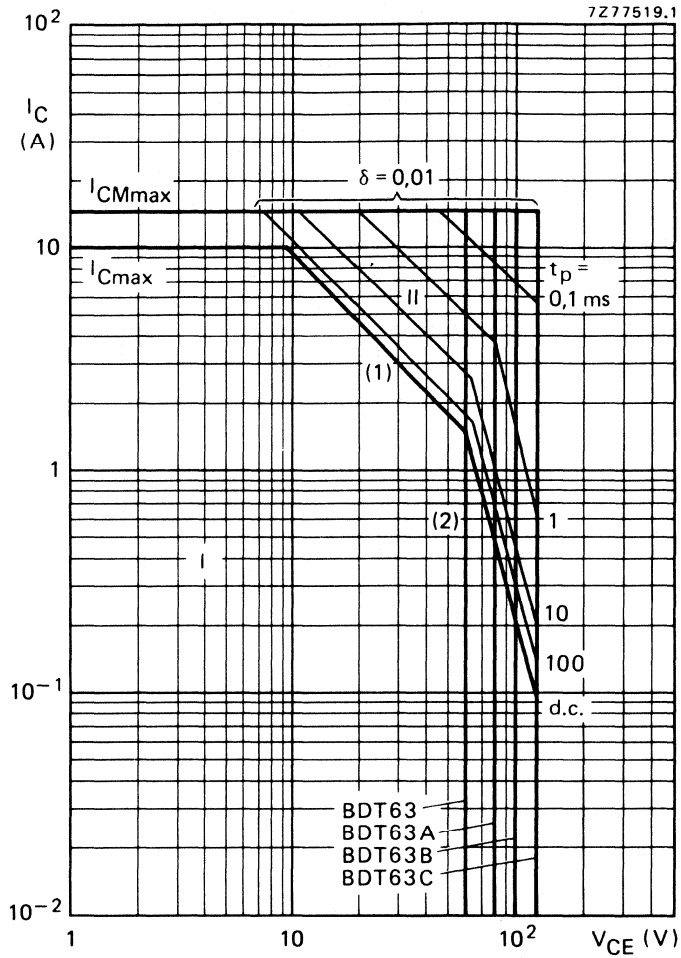


Fig. 7 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

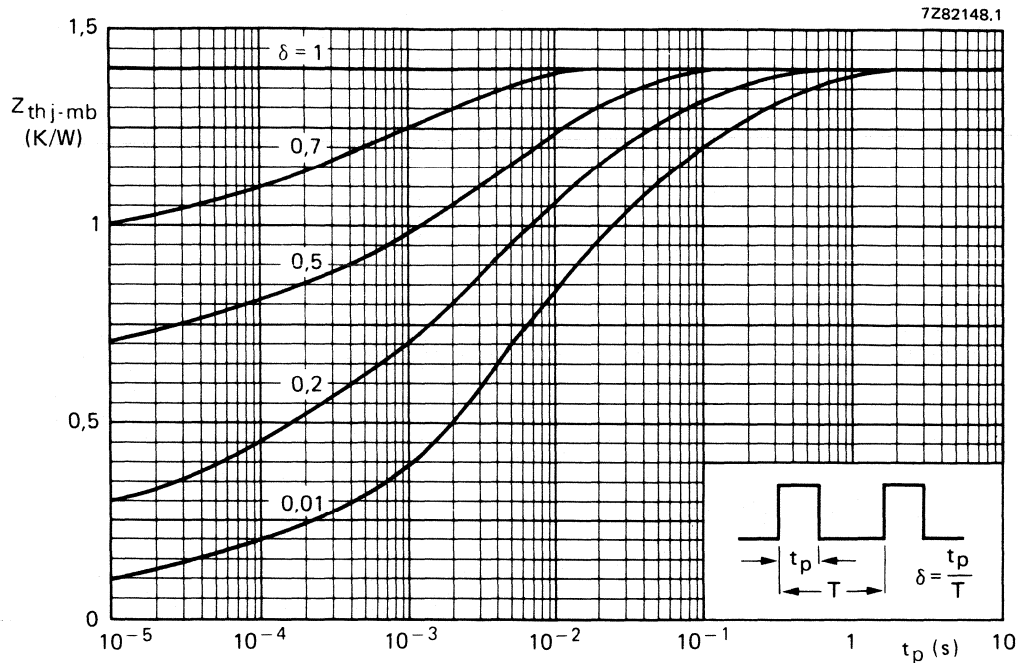


Fig. 8 Pulse power rating chart.

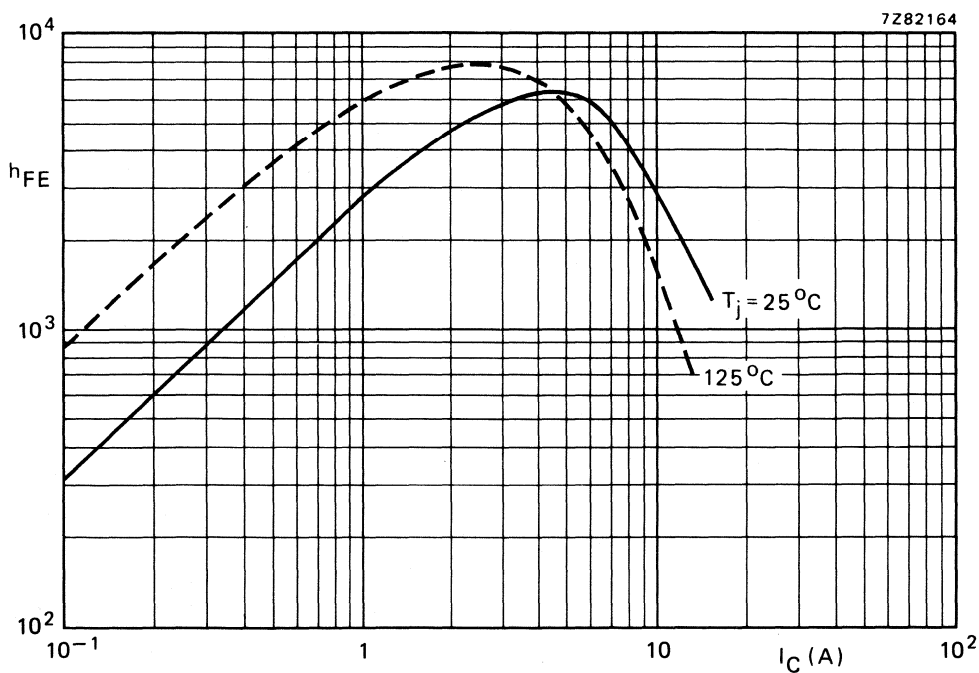


Fig. 9 Typical d.c. current gain at $V_{CE} = 3$ V.

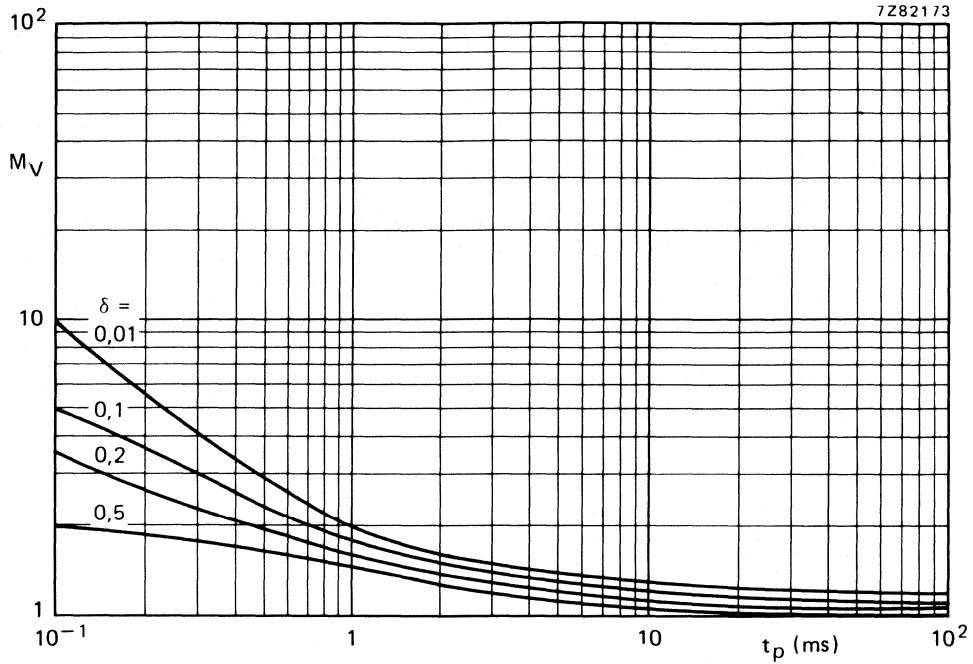


Fig. 10 S.B. voltage multiplying factor at the I_C max level.

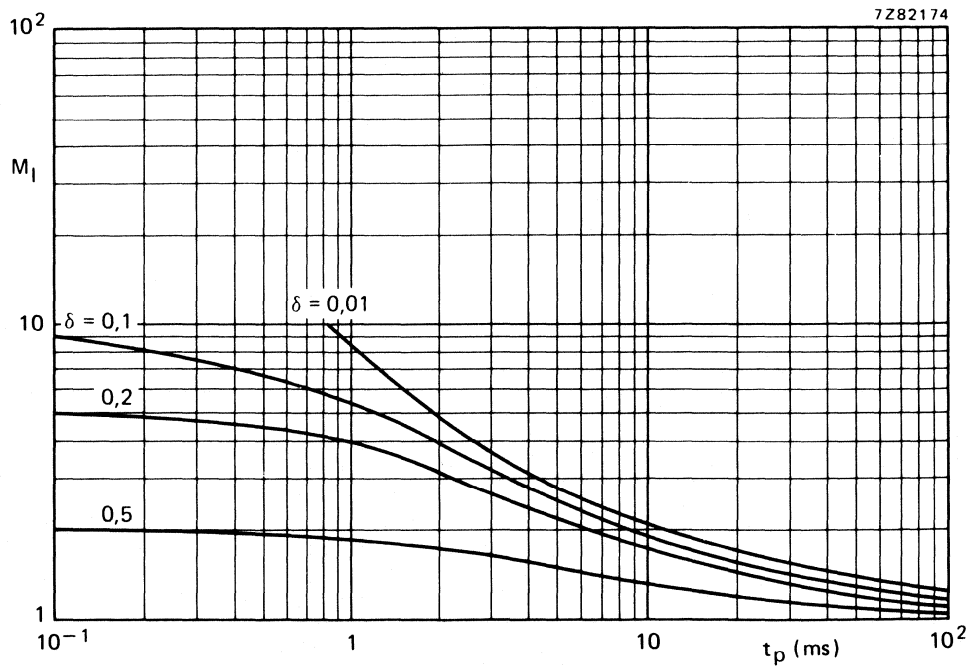


Fig. 11 S.B. current multiplying factor at V_{CE0} level = 60 V and 100 V.

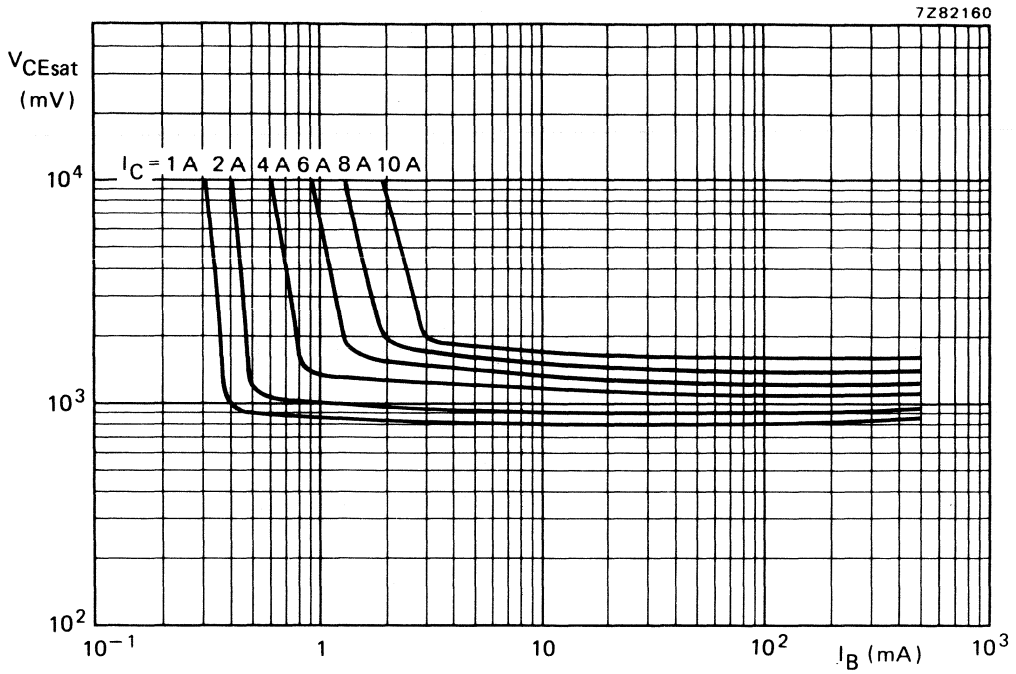


Fig. 12 Typical collector-emitter saturation voltage.

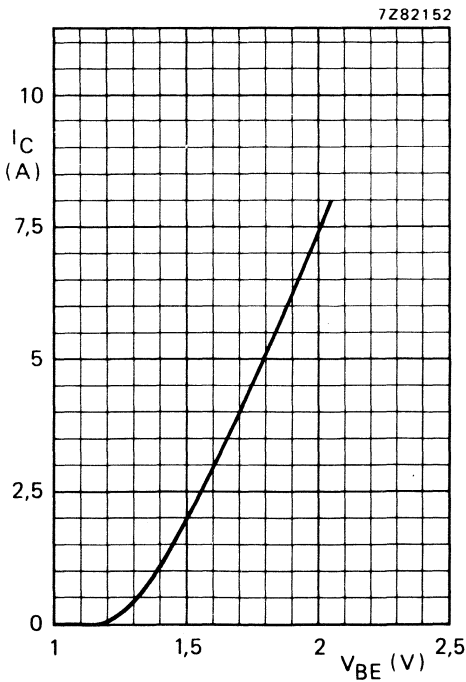


Fig. 13 Typical base-emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon darlington power transistors in a SOT-186 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.

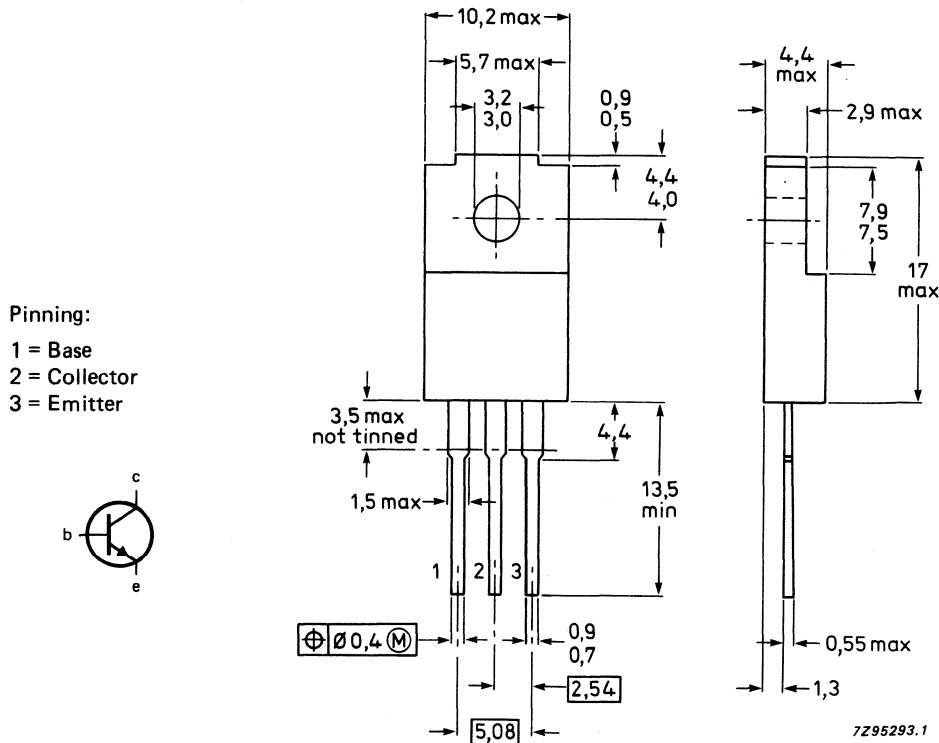
QUICK REFERENCE DATA

		BDT63F 63AF 63BF 63CF				
Collector-base voltage	V_{CB0}	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 $T_h = 25^\circ\text{C}$	P_{tot}	max.	36		W	
Junction temperature	T_j	max.	150		$^\circ\text{C}$	
DC current gain $I_C = 3\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	min.	1000			

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-186.



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)		max.		36		W
Storage temperature range	T _{stg}			-65 to 150		°C
Junction temperature	T _j	max.		150		°C

THERMAL RESISTANCE

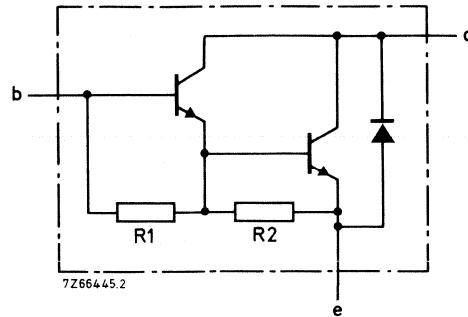
From junction to internal heatsink	R _{th j-mb}	=		1.17		K/W
From junction to internal heatsink (1)	R _{th j-h}	=		5.95		K/W
From junction to internal heatsink (2)	R _{th j-h}	=		3.47		K/W

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 k Ω
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0max}$ I_{CBO} max. 0.2 mA

$I_E = 0; V_{CB} = 1/2 V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$ I_{CBO} max. 2.0 mA

$I_B = 0; V_{CE} = 1/2 V_{CE0max}$ I_{CEO} max. 0.5 mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$ I_{EBO} max. 5.0 mA

Forward-bias second breakdown
collector current

$V_{CE} = 40\text{ V}; t = 0.1\text{ s};$
non-repetitive (without heatsink) $I_{(SB)}$ min. 0.9 A

DC current gain (3)

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} min. 1000

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$ h_{FE} typ. 800

Base-emitter voltage (3)

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ V_{BE} max. 2.5 V

Collector-emitter saturation voltage (3)

$I_C = 3\text{ A}; I_B = 12\text{ mA}$ V_{CEsat} max. 2.0 V

$I_C = 8\text{ A}; I_B = 80\text{ mA}$ V_{CEsat} max. 2.5 V

Diode, forward voltage

$I_F = 3\text{ A}$ V_F max. 2.0 V

Turn-off breakdown energy with
inductive load

$-I_{Boff} = 0; L = 5\text{ mH}$ $E_{(BR)}$ min. 100 mJ

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

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ h_{fe} min. 10

Cut-off frequency

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$ f_{hfe} typ. 50 kHz

Collector capacitance

$V_{CB} = 10\text{ V}; f = 1\text{ MHz}$ C_c typ. 100 pF

(3) Measured under pulse conditions; $t_p < 300\text{ }\mu\text{s}$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)

$I_{C on} = 3 A$;

$I_{B on} = -I_{B off} = 12 mA$

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

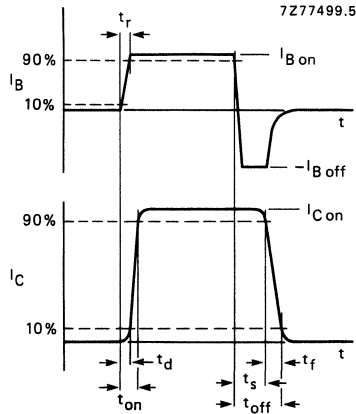
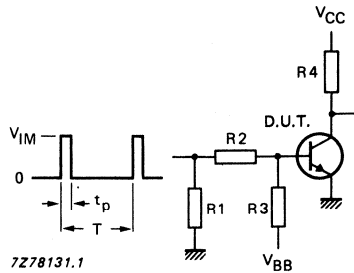


Fig. 3 Switching times waveforms.



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

Fig. 4 Switching times test circuit.

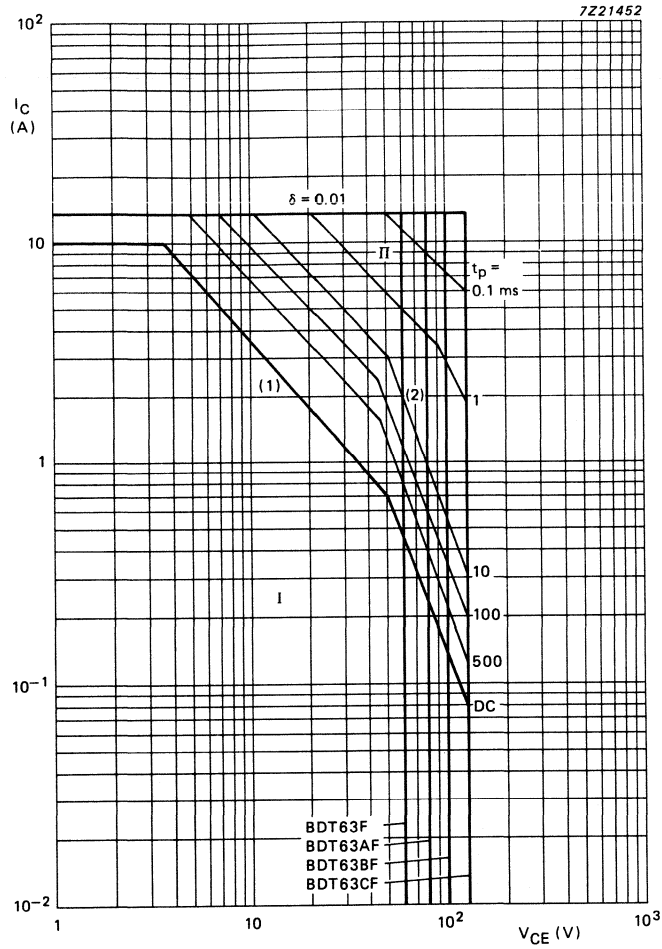


Fig. 5 Safe Operating Area; $T_{MB} \leq 25 \text{ }^\circ\text{C}$.

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

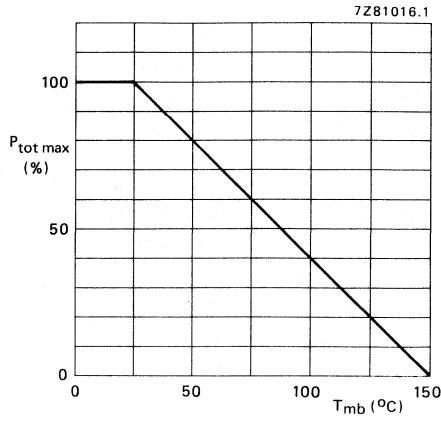


Fig. 6 Power derating curve.

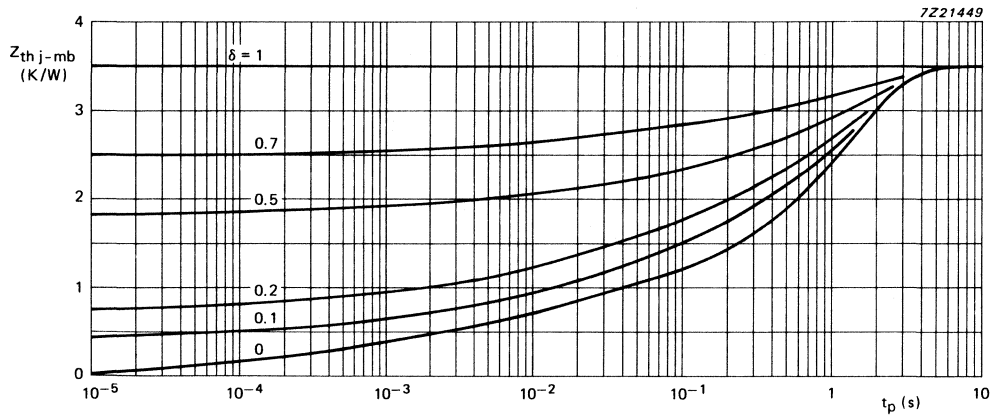


Fig. 7 Pulse power rating chart.

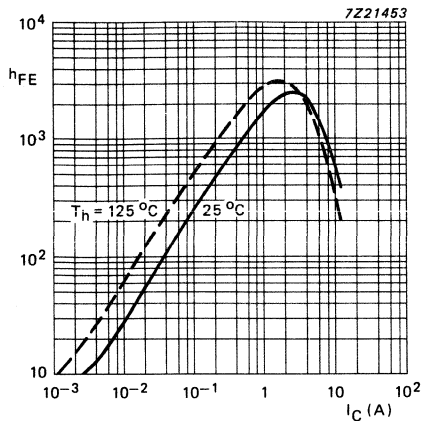


Fig. 8 Typical DC current gain at $V_{CE} = 3\text{ V}$.

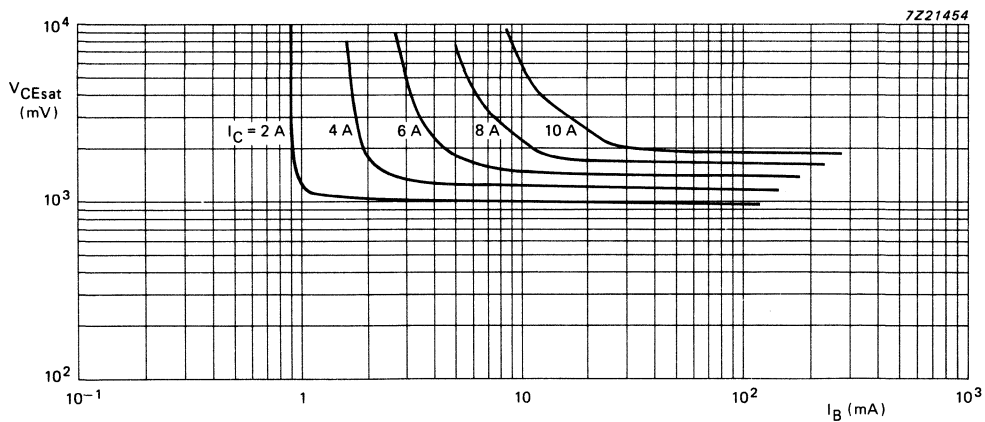


Fig. 9 Typical collector-emitter saturation voltage; $T_h = 25\text{ }^\circ\text{C}$.

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-220 plastic envelope. N-P-N complements are BDT65, BDT65A, BDT65B and BDT65C.

QUICK REFERENCE DATA

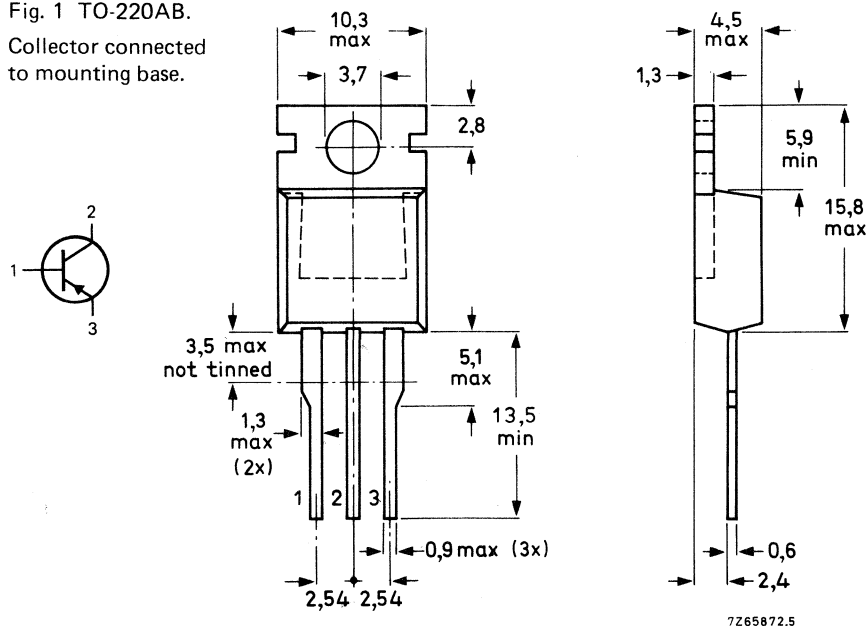
		BDT64	64A	64B	64C
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 60	80	100	120 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max. 5	5	5	5 V
Collector current (d.c.)	$-I_C$	max.	12		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125		W
Junction temperature	T_j	max.	150		$^\circ\text{C}$
D.C. current gain $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>	1000		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

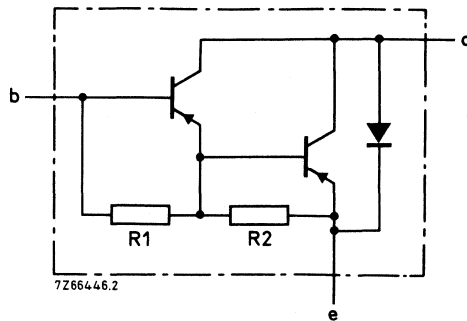


Fig. 2 Circuit diagram. R1 typ. 3 k Ω ; R2 typ. 45 Ω .

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125			W
Storage temperature	T_{stg}		-65 to + 150			$^\circ\text{C}$
Junction temperature	T_j	max.	150			$^\circ\text{C}$

THERMAL RESISTANCE

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

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

Collector cut-off current

$$-V_{CB} = -V_{CB0max}; I_E = 0$$

$$I_E = 0; -V_{CB} = -\frac{1}{2} V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$$

$$I_B = 0; -V_{CE} = -\frac{1}{2} V_{CE0max}$$

$$-I_{CBO} < 0,4\text{ mA}$$

$$-I_{CBO} < 2\text{ mA}$$

$$-I_{CEO} < 0,2\text{ mA} \leftarrow$$

Emitter cut-off current

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

$$-I_{EBO} < 5\text{ mA}$$

D.C. current gain*

$$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$$

$$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$$

$$-I_C = 12\text{ A}; -V_{CE} = 4\text{ V}$$

$$h_{FE} \text{ typ. } 1500$$

$$h_{FE} > 1000$$

$$h_{FE} \text{ typ. } 750$$

Base-emitter voltage

$$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$$

$$-V_{BE} < 2,5\text{ V}$$

Collector-emitter saturation voltage*

$$-I_C = 5\text{ A}; -I_B = 20\text{ mA}$$

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

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

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

Diode, forward voltage

$$I_F = 5\text{ A}$$

$$I_F = 12\text{ A}$$

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

$$V_F \text{ typ. } 2\text{ V}$$

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

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

$$C_c \text{ typ. } 200\text{ pF}$$

Second breakdown collector current

non-repetitive; without heatsink

$$-V_{CE} = 60\text{ V}; t_p = 0,1\text{ s}$$

$$-I_{SB} > 2\text{ A}$$

Switching times (see Figs 3 and 4)

$$-I_{Con} = 5\text{ A}; -I_{Bon} = I_{Boff} = 20\text{ mA}$$

$$-V_{CC} = 30\text{ V}$$

turn-on time

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

$$t_{on} < 2\text{ }\mu\text{s}$$

turn-off time

$$t_{off} \text{ typ. } 2,5\text{ }\mu\text{s}$$

$$t_{off} < 5\text{ }\mu\text{s}$$

Small-signal current gain

$$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$$

$$h_{fe} > 10$$

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

CHARACTERISTICS (continued)

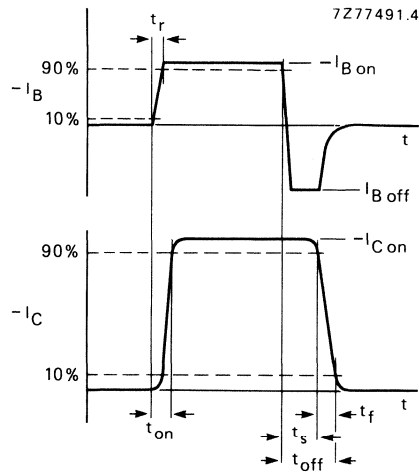


Fig. 3 Switching times waveforms.

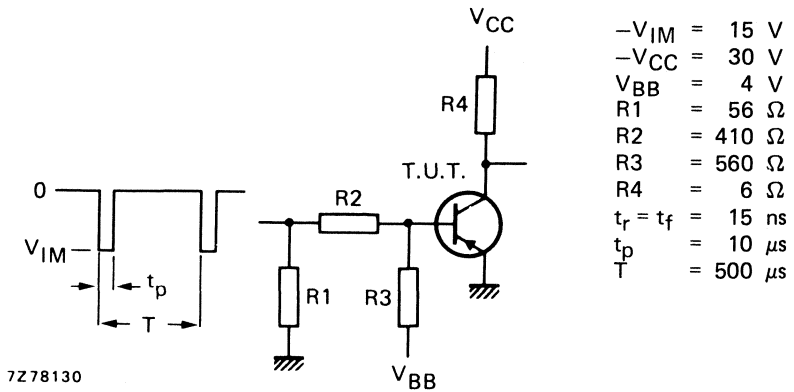


Fig. 4 Switching times test circuit.

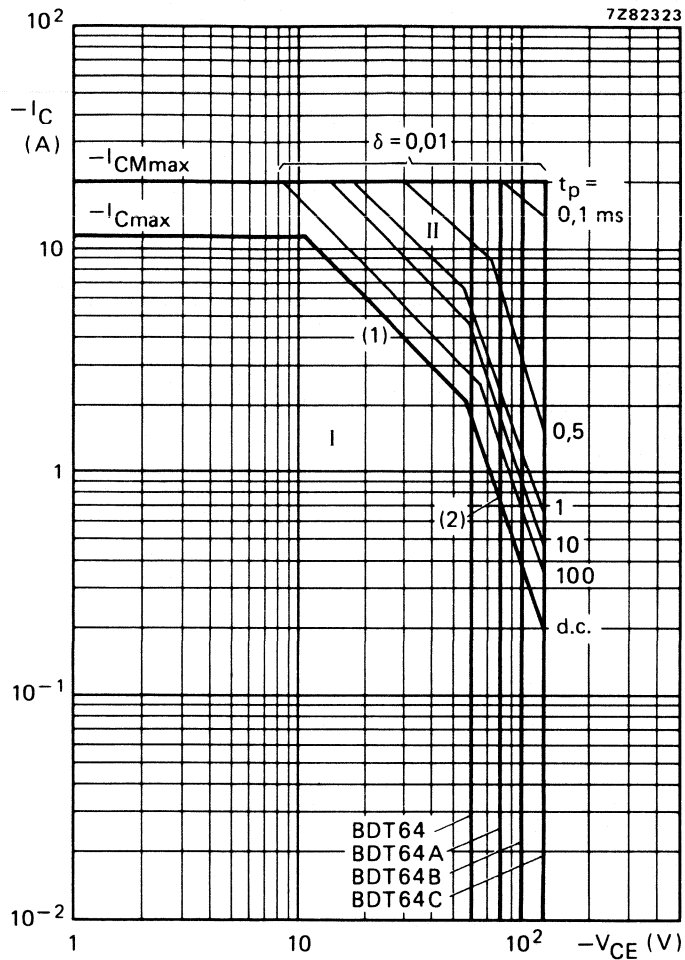


Fig. 5 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

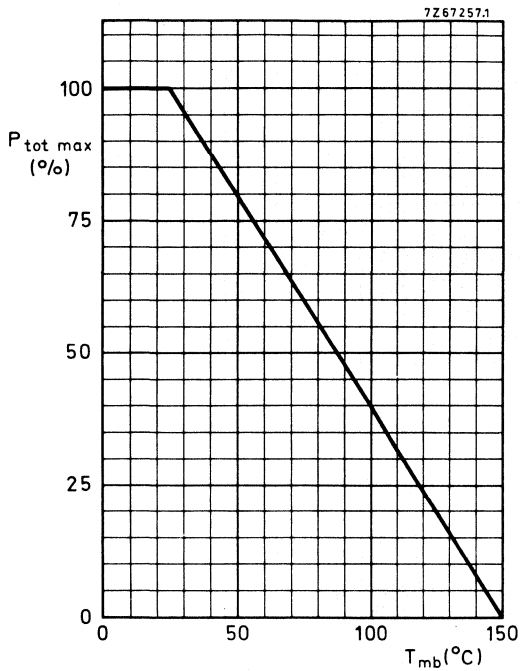


Fig. 6 Power derating curve.

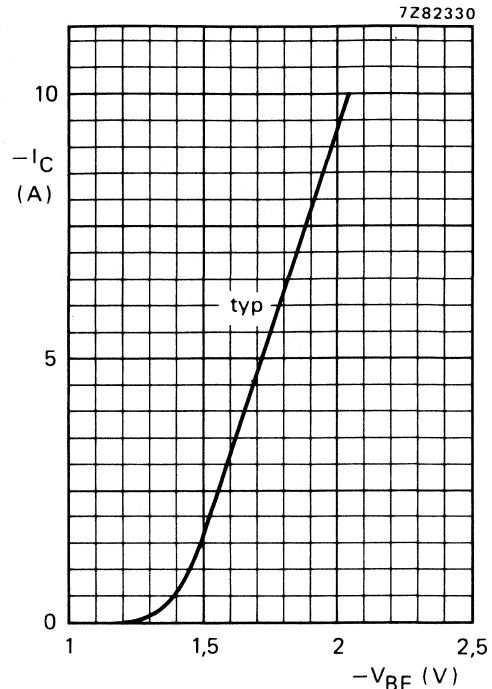


Fig. 7 $-V_{CE} = 3\ V$; $T_{amb} = 25\ ^\circ C$.

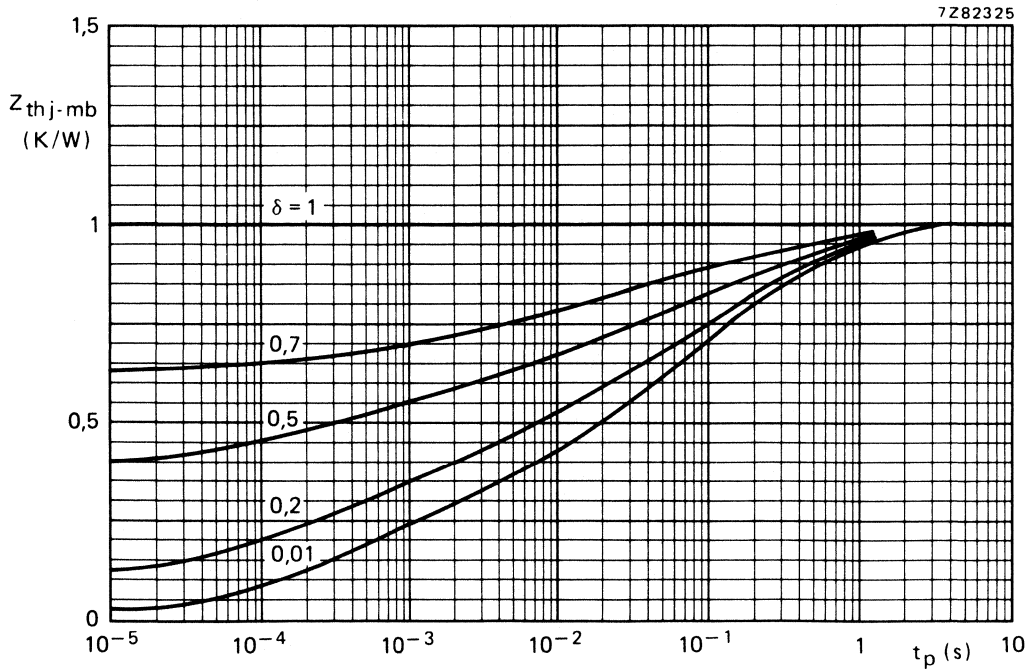


Fig. 8 Pulse power rating chart.

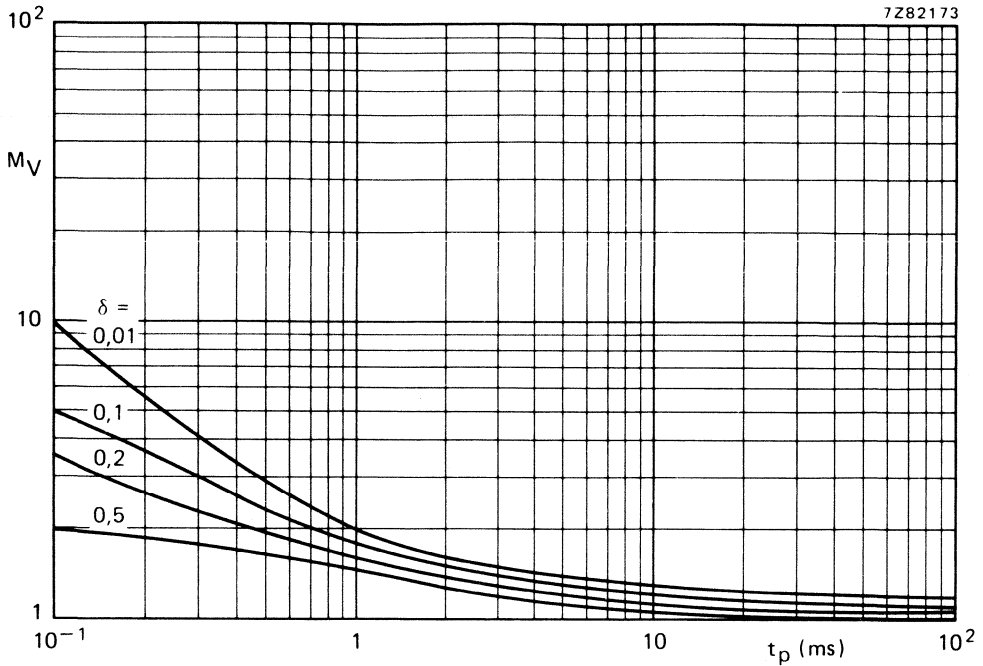


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

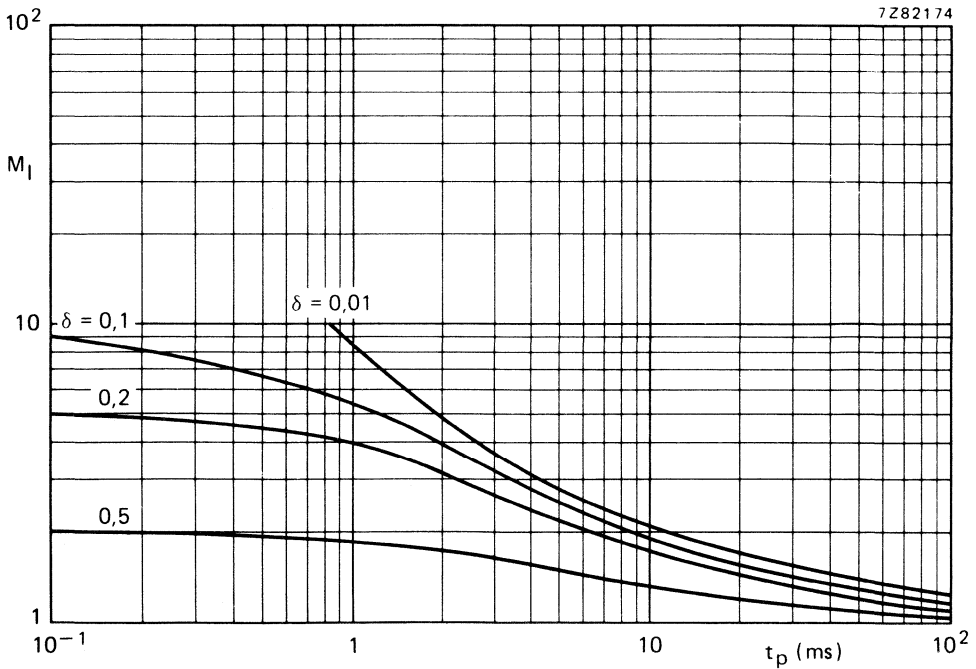


Fig. 10 S.B. current multiplying factor at the V_{CE0max} level.

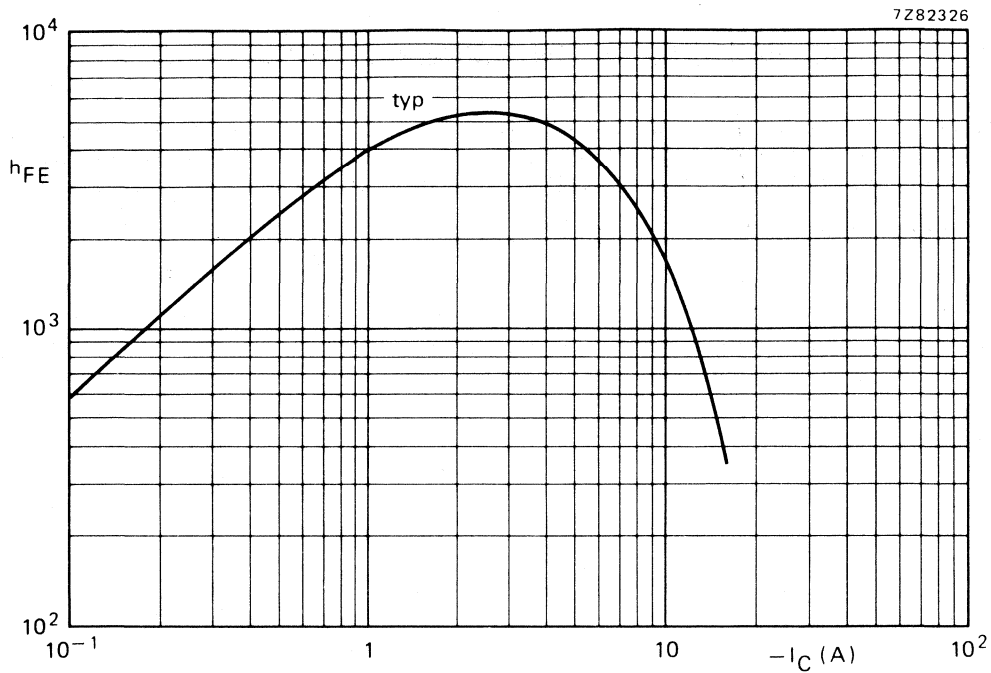


Fig. 11 D.C. current gain. $-V_{CE} = 3$ V; $T_j = 25$ °C.

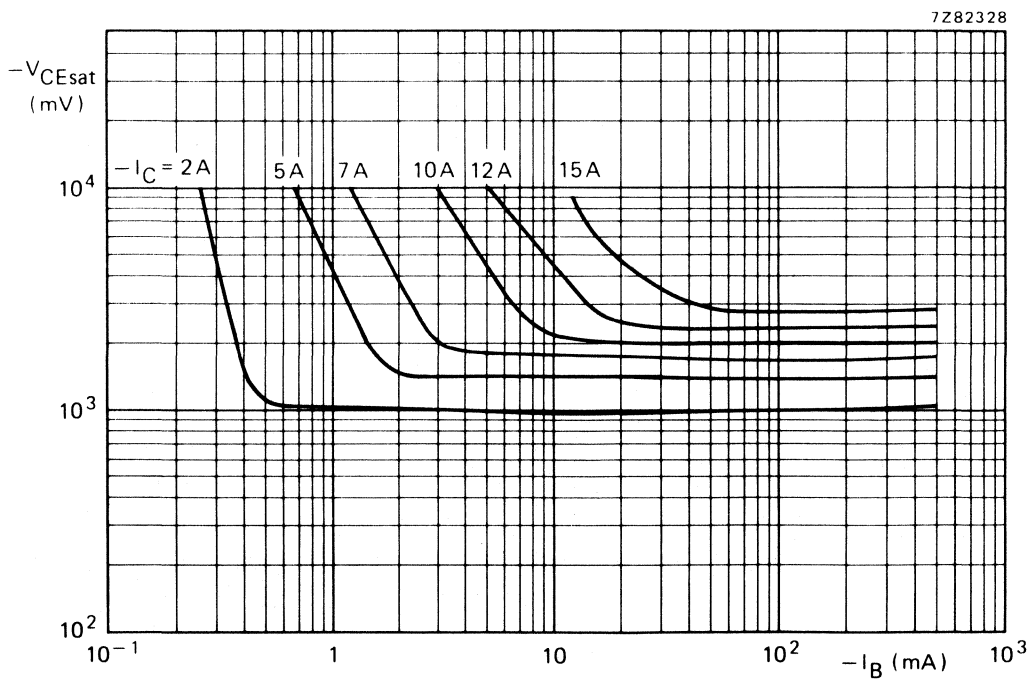


Fig. 12 Typical collector-emitter saturation voltages.

SILICON DARLINGTON POWER TRANSISTORS

PNP Silicon Darlington power transistors in a SOT-186 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.

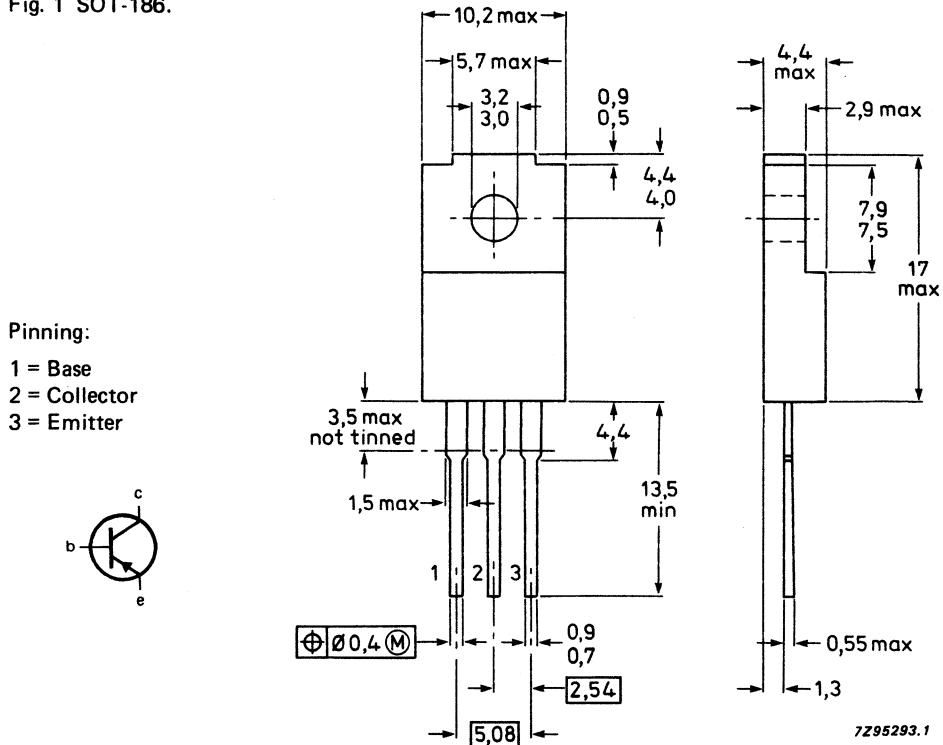
QUICK REFERENCE DATA

			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 $T_h = 25^\circ\text{C}$	P_{tot}	max.			39	W
Junction temperature	T_j	max.			150	$^\circ\text{C}$
DC current gain $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.			1000	

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-186.



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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.	22		W	
up to $T_h = 25\text{ }^\circ\text{C}$ (2)		max.	39		W	
Storage temperature	T_{stg}		-65 to 150		$^\circ\text{C}$	
Junction temperature	T_j	max.	150		$^\circ\text{C}$	

THERMAL RESISTANCE

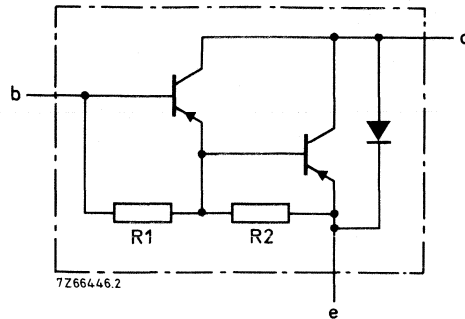
From junction to internal heatsink	$R_{th\ j-mb}$	=	0.9		K/W	
From junction to external heatsink (1)	$R_{th\ j-h}$	=	5.7		K/W	
From junction to external heatsink (2)	$R_{th\ j-h}$	=	3.2		K/W	

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

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0max}$ $-I_{CBO}$ max. 0.4 mA

$I_E = 0; T_j = 150\text{ }^\circ\text{C}; -V_{CB} = -1/2 V_{CB0max}$ $-I_{CBO}$ max. 2.0 mA

$I_B = 0; -V_{CE} = -1/2 V_{CE0max}$ $-I_{CEO}$ max. 1.0 mA

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$ $-I_{EBO}$ max. 5.0 mA

DC current gain (3)

$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$ h_{FE} typ. 4000

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$ h_{FE} min. 1000

$-I_C = 12\text{ A}; -V_{CE} = 4\text{ V}$ h_{FE} typ. 800

Base-emitter voltage (3)

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$ $-V_{BE}$ max. 2.5 V

Collector-emitter saturation voltage (3)

$-I_C = 5\text{ A}; -I_B = 20\text{ mA}$ $-V_{CEsat}$ max. 2.0 V

$-I_C = 10\text{ A}; -I_B = 100\text{ mA}$ $-V_{CEsat}$ max. 3.0 V

Diode, forward voltage

$I_F = 5\text{ A}$ V_F max. 2.0 V

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

$-V_{CB} = 10\text{ V}; I_E = I_C = 0$ C_c typ. 200 pF

Second-breakdown collector current
non-repetitive; without heatsink

$-V_{CE} = 60\text{ V}; t_p = 0.1\text{ s}$ $-I_{(SB)}$ min. 0.65 A

Switching times

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

$-I_{Bon} = I_{Boff} = 20\text{ mA}$

$-V_{CC} = 30\text{ V}$

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 $f = 1\text{ MHz}$

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$ h_{fe} min. 10

(3) Measured under pulse conditions; $t_p < 300\text{ }\mu\text{s}$; $\delta < 2\%$.

CHARACTERISTICS (continued)

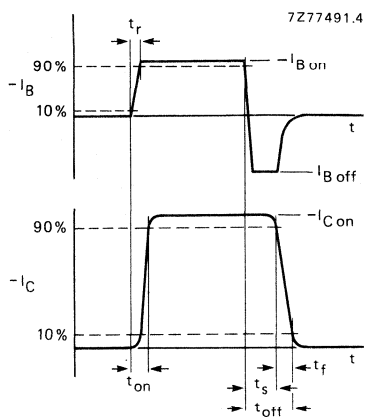


Fig. 3 Switching times waveforms.

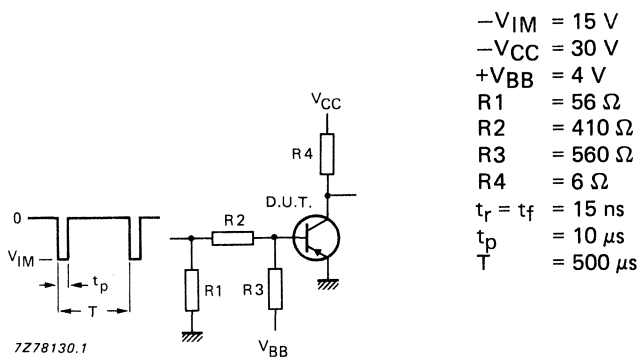


Fig. 4 Switching times test circuit.

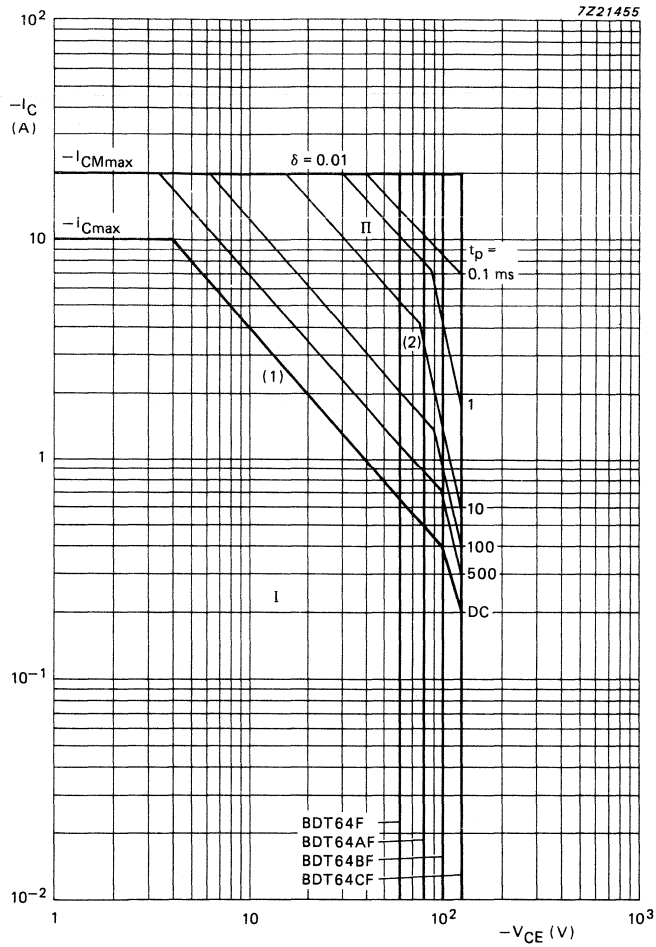


Fig. 5 Safe Operating Area; $T_h = 25^\circ\text{C}$.

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

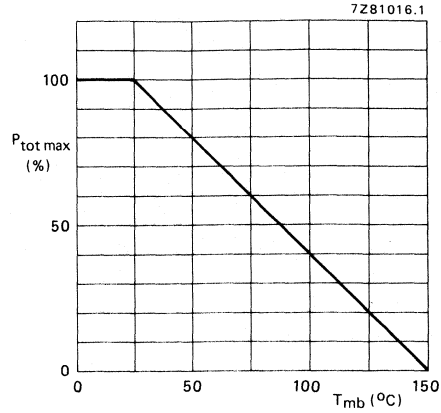


Fig. 6 Power derating curve.

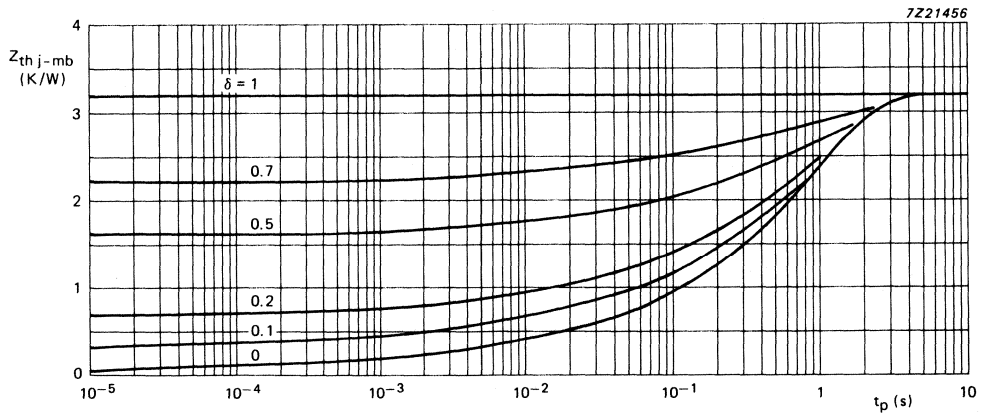


Fig. 7 Pulse power rating chart.

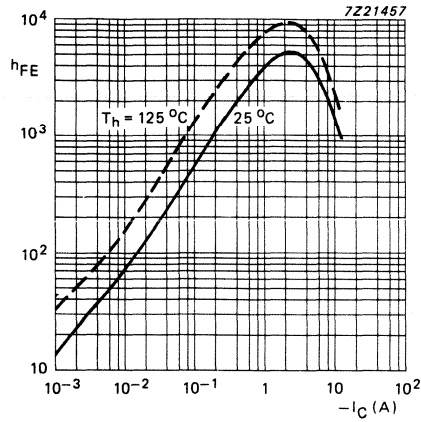


Fig. 8 Typical DC current gain as a function of collector current; $-V_{CE} = 4\text{ V}$; $T_j = 25^\circ\text{C}$.

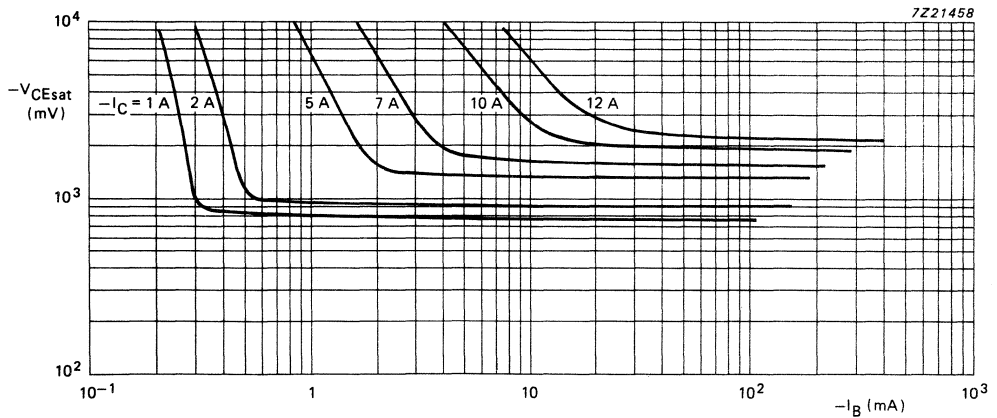


Fig. 9 Typical collector-emitter saturation voltages; $T_h = 25^\circ\text{C}$.

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-220 plastic envelope. P-N-P complements are BDT64; BDT64A; BDT64B and BDT64C.

QUICK REFERENCE DATA

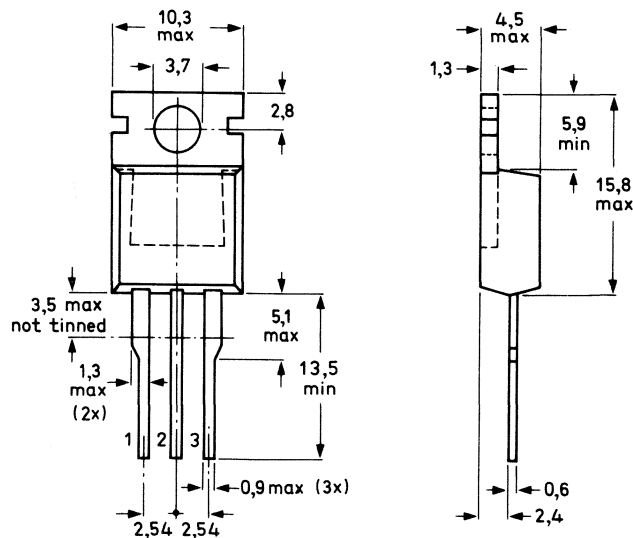
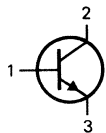
		BDT65	65A	65B	65C
Collector-base voltage (open emitter)	V_{CBO} max.	60	80	100	120 V
Collector-emitter voltage (open base)	V_{CEO} max.	60	80	100	120 V
Emitter-base voltage (open collector)	V_{EBO} max.	5	5	5	5 V
Collector current (d.c.)	I_C max.	12			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	125			W
Junction temperature	T_j max.	150			$^\circ\text{C}$
D.C. current gain $I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	$h_{FE} >$	1000			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

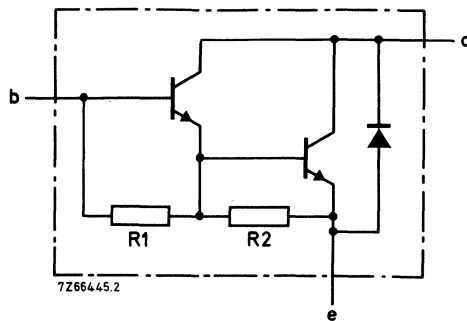


Fig. 2 Circuit diagram. R1 typ. 5 k Ω ; R2 typ. 80 Ω .

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		125		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb} =$		1		K/W
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CHARACTERISTICS $T_j = 25\text{ }^\circ\text{C}$, unless otherwise specified

Collector cut-off current

$$V_{CB} = V_{CB0max}; I_E = 0$$

$$V_{CB} = \frac{1}{2}V_{CB0max}; I_E = 0; T_j = 150\text{ }^\circ\text{C}$$

$$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0max}$$

$$I_{CBO} < 0,4\text{ mA}$$

$$I_{CBO} < 2\text{ mA}$$

$$I_{CEO} < 0,2\text{ mA} \leftarrow$$

Emitter cut-off current

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

$$I_{EBO} < 5\text{ mA}$$

D.C. current gain*

$$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$$

$$h_{FE} \text{ typ. } 1500$$

$$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$$

$$h_{FE} > 1000$$

$$I_C = 12\text{ A}; V_{CE} = 4\text{ V}$$

$$h_{FE} \text{ typ. } 1000$$

Base-emitter voltage

$$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$$

$$V_{BE} < 2,5\text{ V}$$

Collector-emitter saturation voltage*

$$I_C = 5\text{ A}; I_B = 20\text{ mA}$$

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

$$I_C = 10\text{ A}; I_B = 100\text{ mA}$$

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

Diode, forward voltage

$$I_F = 5\text{ A}$$

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

$$I_F = 12\text{ A}$$

$$V_F \text{ typ. } 2\text{ V}$$

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

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

$$C_c \text{ typ. } 200\text{ pF}$$

Second-breakdown collector current

non-repetitive; without heatsink

$$V_{CE} = 60\text{ V}; t_p = 0,1\text{ s}$$

$$I_{SB} > 2\text{ A}$$

Turn-off breakdown energy with inductive load;

$$-I_{Boff} = 0; I_{CM} = 6,3\text{ A}$$

$$L = 5\text{ mH (see Fig. 3)}$$

$$E(BR) > 100\text{ mJ}$$

Switching times (see Figs 4 and 5)

$$I_{Con} = 5\text{ A}; I_{Bon} = -I_{Boff} = 20\text{ mA}$$

turn-on time

$$t_{on} \text{ typ. } 1\text{ }\mu\text{s}$$

$$< 2,5\text{ }\mu\text{s}$$

turn-off time

$$t_{off} \text{ typ. } 6,0\text{ }\mu\text{s}$$

$$< 10\text{ }\mu\text{s}$$

Small-signal current gain

$$I_C = 5\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$$

$$h_{fe} > 10$$

* Measured under pulse conditions $t_p \leq 300\text{ }\mu\text{s}$; $\delta < 2\%$.

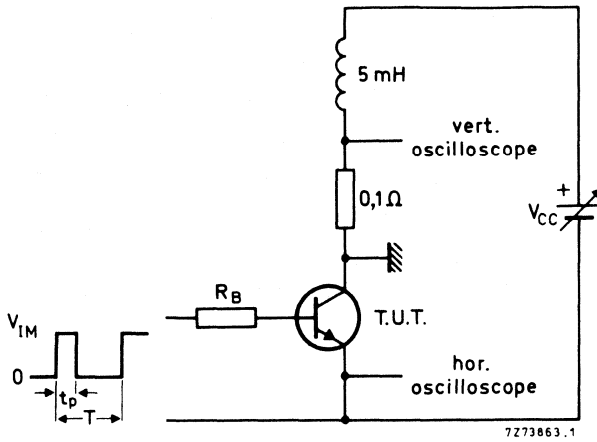


Fig. 3 Test circuit for turn-off breakdown energy.
 $V_{IM} = 12 \text{ V}$; $R_B = 270 \Omega$;
 $t_p = 1 \text{ ms}$; $\delta = 1\%$.

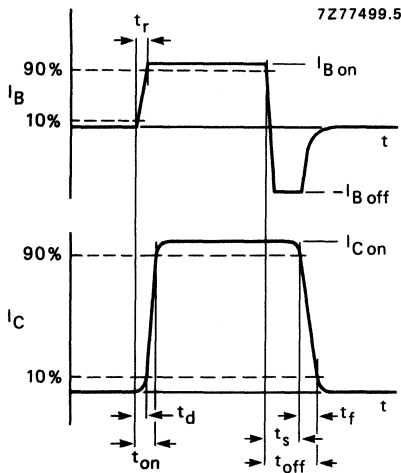
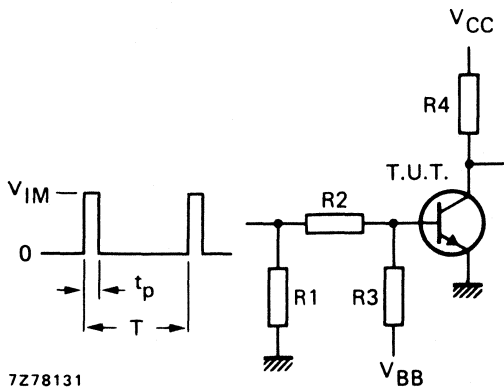


Fig. 4 Switching times waveforms.



$V_{CC} = 30 \text{ V}$
 $V_{IM} = 15 \text{ V}$
 $-V_{BB} = 4 \text{ V}$
 $R_1 = 56 \Omega$
 $R_2 = 410 \Omega$
 $R_3 = 560 \Omega$
 $R_4 = 6 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 5 Switching times test circuit.

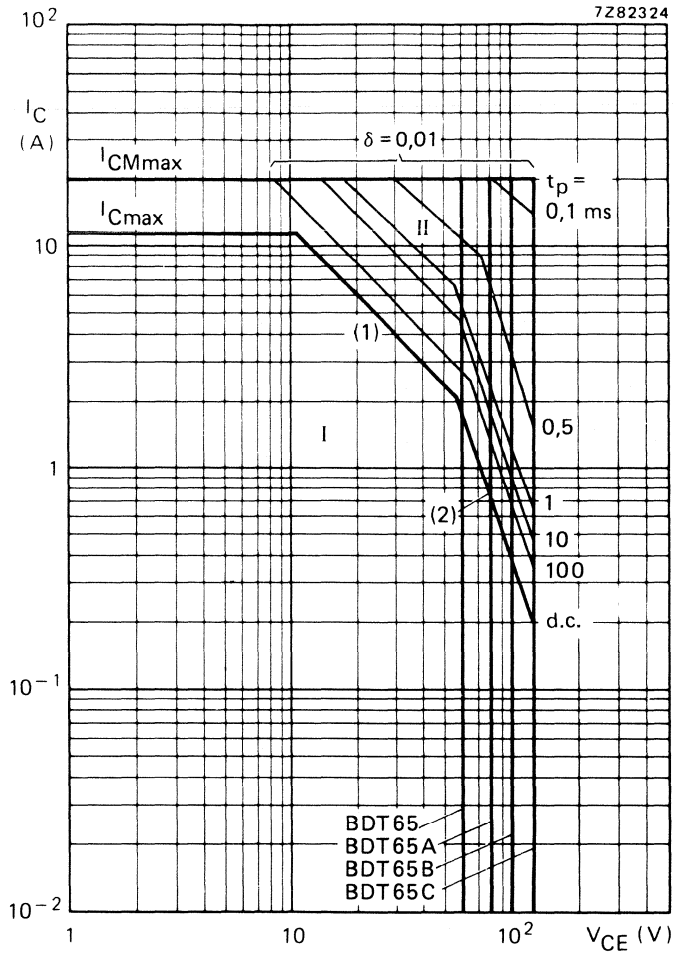


Fig. 6 Safe Operating Area; $T_{mb} = 25 \text{ }^\circ\text{C}$.

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

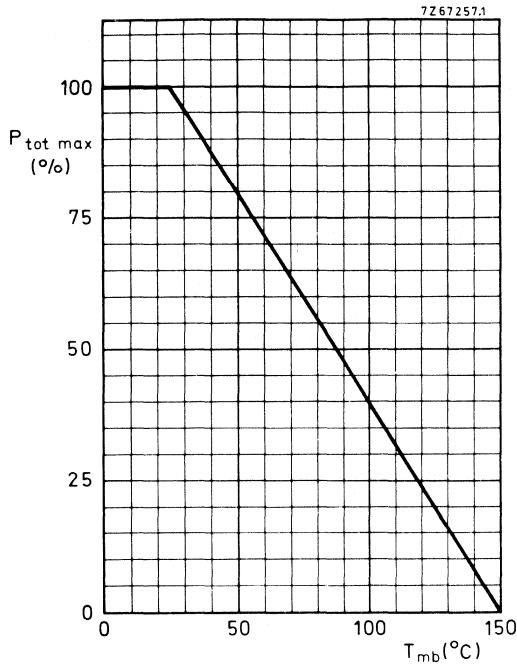


Fig. 7 Power derating curve.

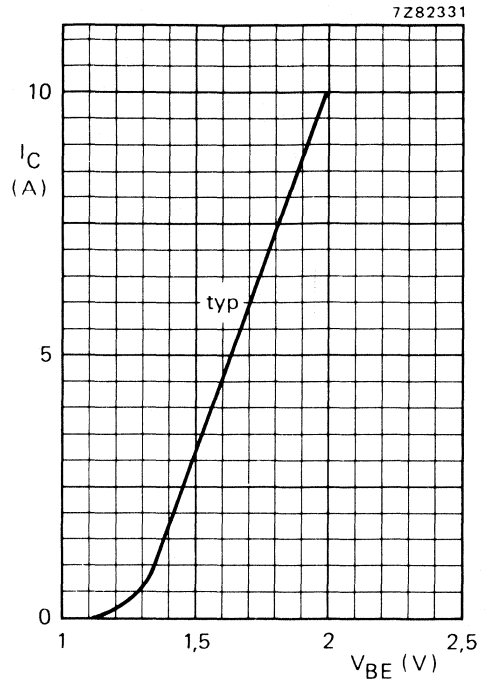


Fig. 8 Base-emitter voltage as a function of collector current. $V_{CE} = 3\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

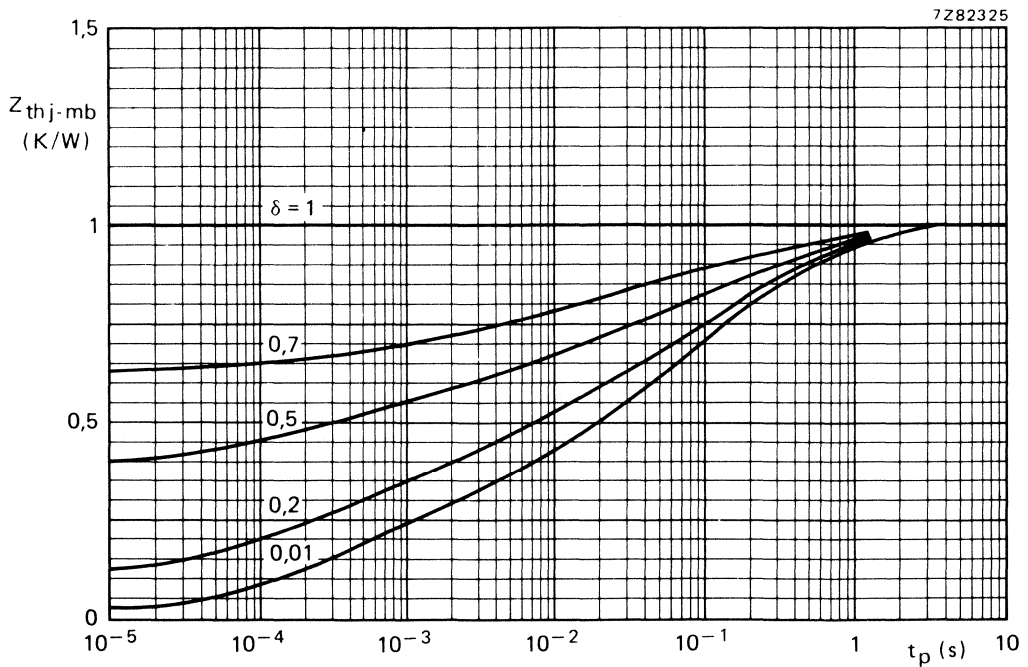


Fig. 9 Pulse power rating chart.

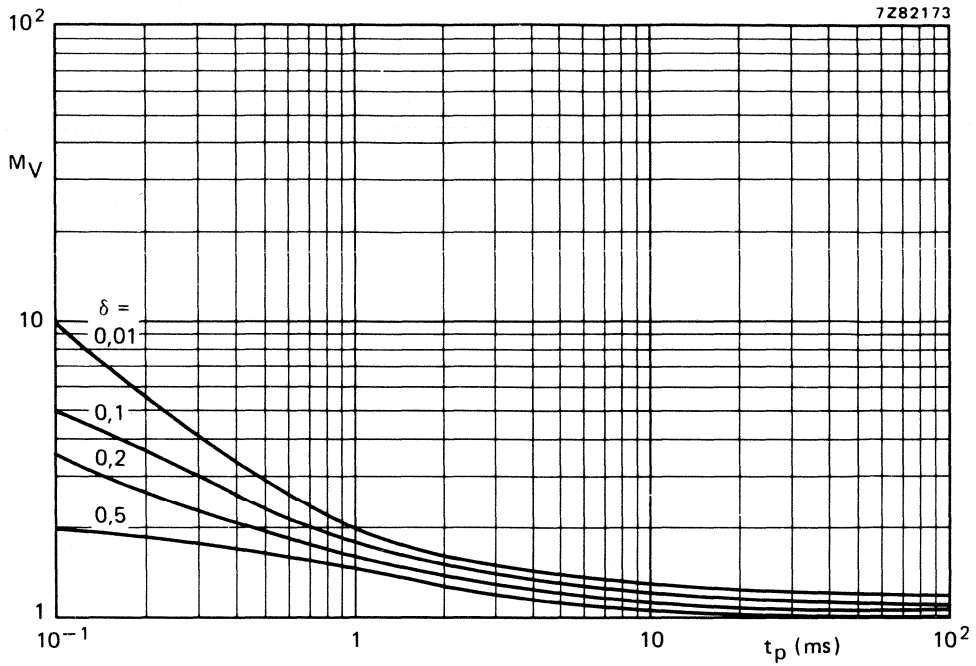


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

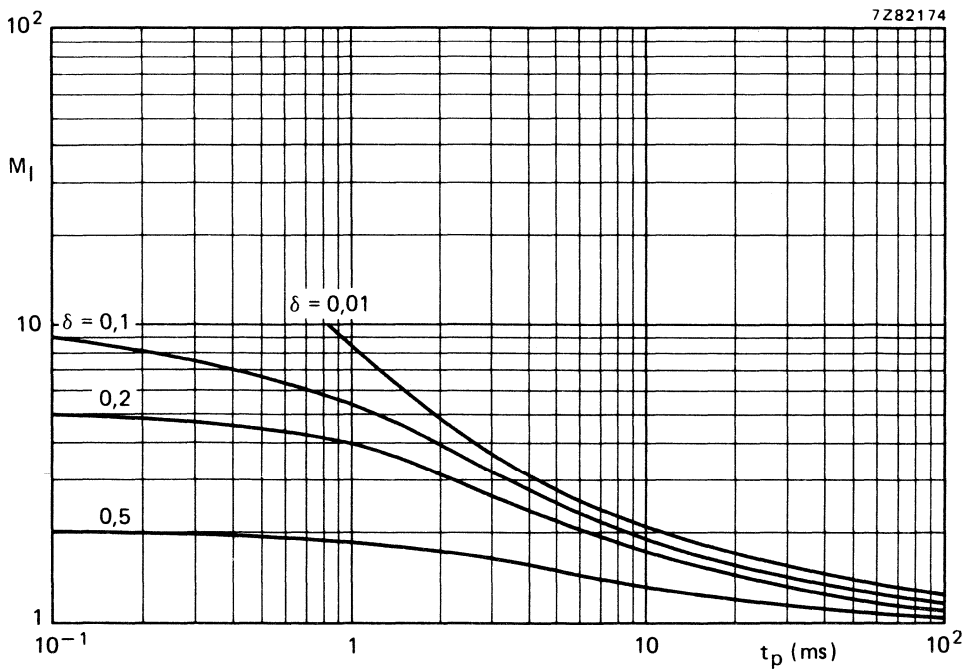


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

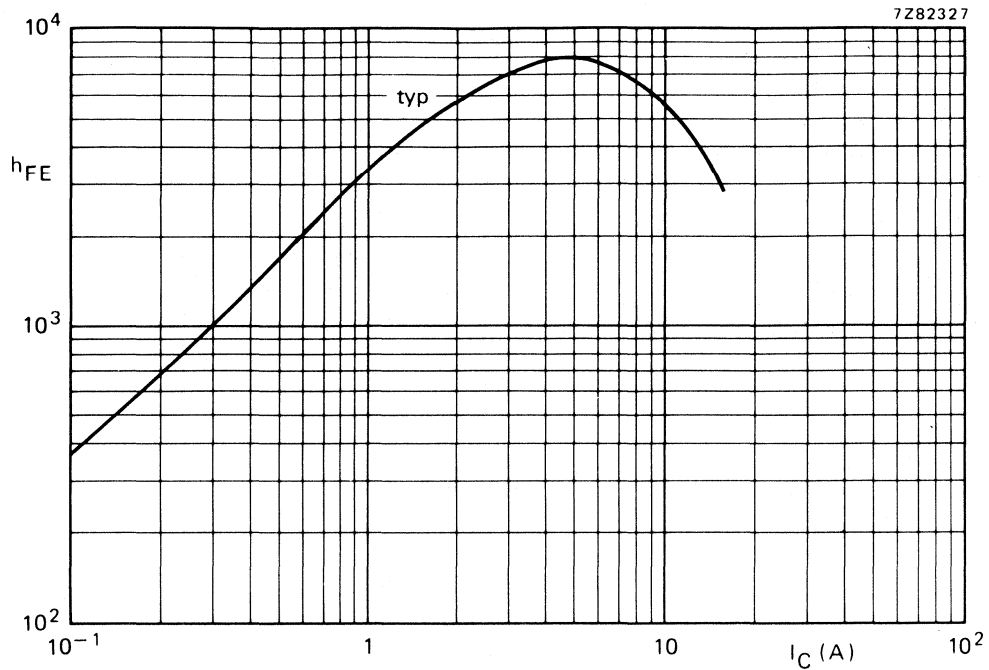


Fig. 12 Typical d.c. current gain as a function of collector current; $V_{CE} = 3\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$.

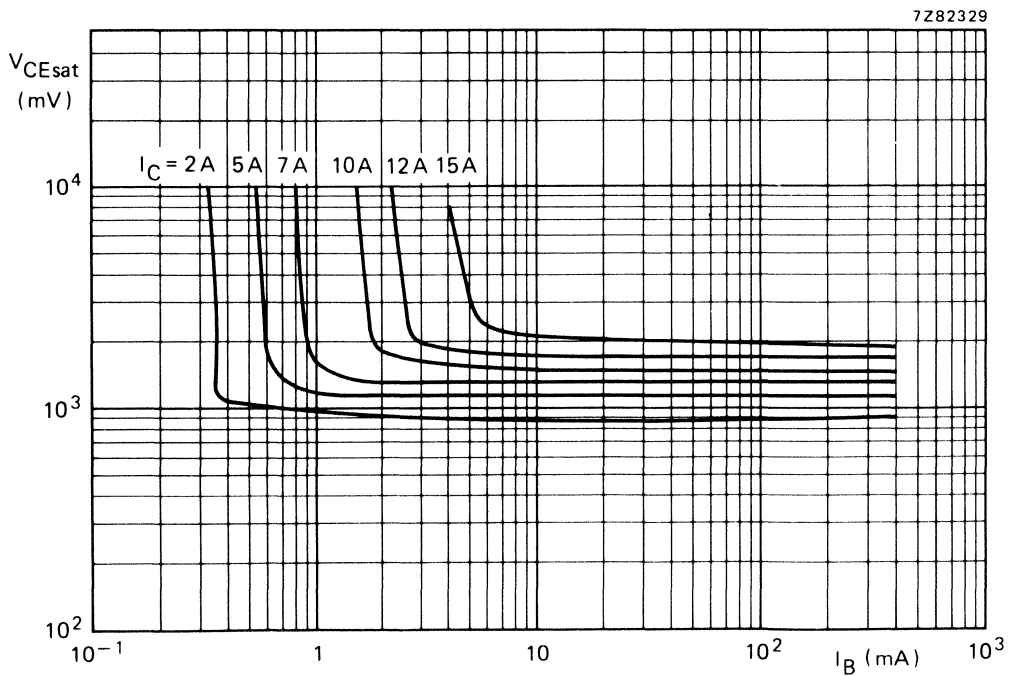


Fig. 13 Typical collector-emitter saturation voltages.

SILICON DARLINGTON POWER TRANSISTORS

NPN silicon darlington power transistors in a SOT-186 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 $T_H = 25\text{ }^\circ\text{C}$	P_{tot}	max.			39	W
Junction temperature	T_j	max.			150	$^\circ\text{C}$
DC current gain	h_{FE}	min.			1000	

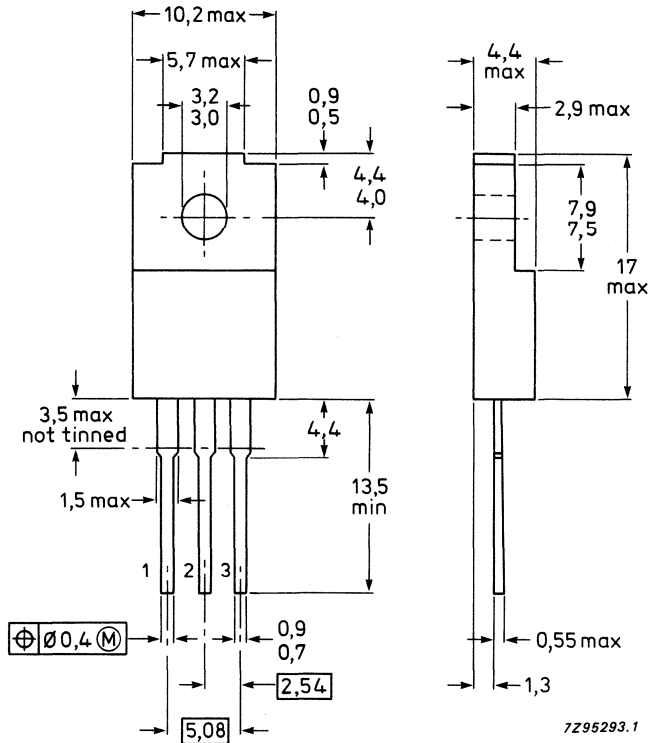
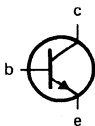
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-186.

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 $T_h = 25\text{ }^\circ\text{C}$ (1)	P_{tot}	max.		22		W
up to $T_h = 25\text{ }^\circ\text{C}$ (2)		max.		39		W
Storage temperature	T_{stg}			-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

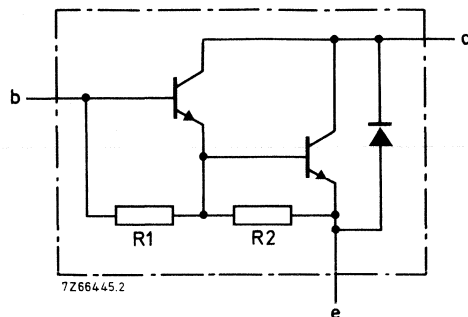
From junction to internal heatsink	$R_{th\ j-mb}$	=		0.9		K/W
From junction to internal heatsink (1)	$R_{th\ j-h}$	=		5.7		K/W
From junction to internal heatsink (2)	$R_{th\ j-h}$	=		3.2		K/W

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 k Ω
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0\text{max}}$	I_{CBO}	max.	0.4	mA
$I_E = 0; T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	max.	2.0	mA
$V_{CB} = 1/2 V_{CB0\text{max}};$ $I_B = 0; V_{CE} = 1/2 V_{CE0\text{max}}$	I_{CEO}	max.	1.0	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	max.	5.0	mA
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DC current gain (3)

$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	typ.	1500	
$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	min.	1000	
$I_C = 12\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	typ.	1500	

Base-emitter voltage

$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	max.	2.5	V
---	----------	------	-----	---

Collector-emitter saturation voltage (3)

$I_C = 5\text{ A}; I_B = 20\text{ mA}$	$V_{CE\text{sat}}$	max.	2.0	V
$I_C = 10\text{ A}; I_B = 100\text{ mA}$	$V_{CE\text{sat}}$	max.	3.0	V

Diode, forward voltage

$I_F = 5\text{ A}$	V_F	max.	2.0	V
--------------------	-------	------	-----	---

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

$V_{CB} = 10\text{ V}; I_E = I_C = 0$	C_c	typ.	200	pF
---------------------------------------	-------	------	-----	----

Second-breakdown collector current
non-repetitive; without heatsink

$V_{CE} = 60\text{ V}; t_p = 0.1\text{ s}$	$I_{(SB)}$	min.	0.65	A
--	------------	------	------	---

Turn-off breakdown energy with
inductive load;

$-I_{\text{Boff}} = 0; I_{CM} = 6.3\text{ A}; L = 5\text{ mH}$	$E_{(BR)}$	min.	100	mJ
--	------------	------	-----	----

Switching times

$I_{\text{Con}} = 5\text{ A}; I_{\text{Bon}} = -I_{\text{Boff}} = 20\text{ mA}$				
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 $f = 1\text{ MHz}$

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	h_{fe}	min.	10	
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(3) Measured under pulse conditions; $t_p \leq 300\text{ }\mu\text{s}$; $\delta < 2\%$.

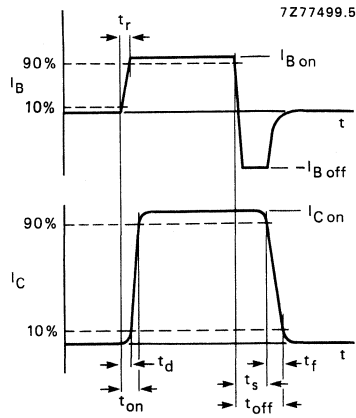
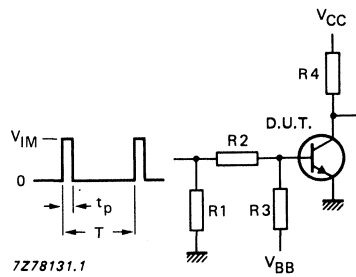


Fig. 3 Switching times waveforms.



- $V_{IM} = 15 \text{ V}$
- $V_{CC} = 30 \text{ V}$
- $-V_{BB} = 4 \text{ V}$
- $R1 = 56 \ \Omega$
- $R2 = 410 \ \Omega$
- $R3 = 560 \ \Omega$
- $R4 = 6 \ \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \ \mu\text{s}$
- $T = 500 \ \mu\text{s}$

Fig. 4 Switching times test circuit.

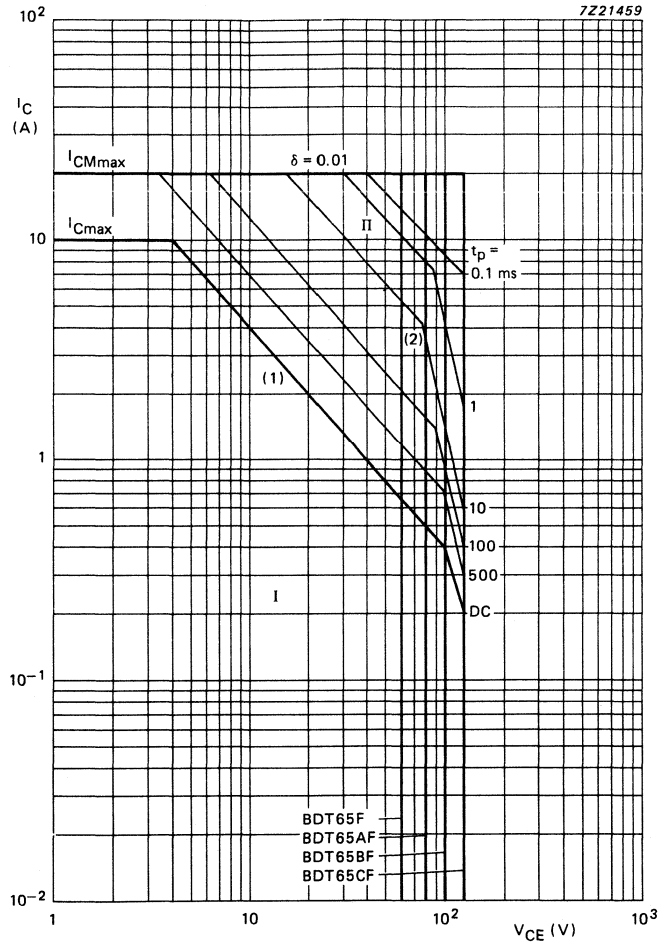


Fig. 5 Safe Operating Area; $T_h = 25\text{ }^\circ\text{C}$.

- 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.

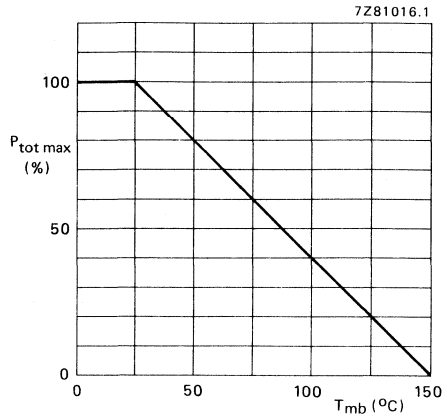


Fig. 6 Power derating curve.

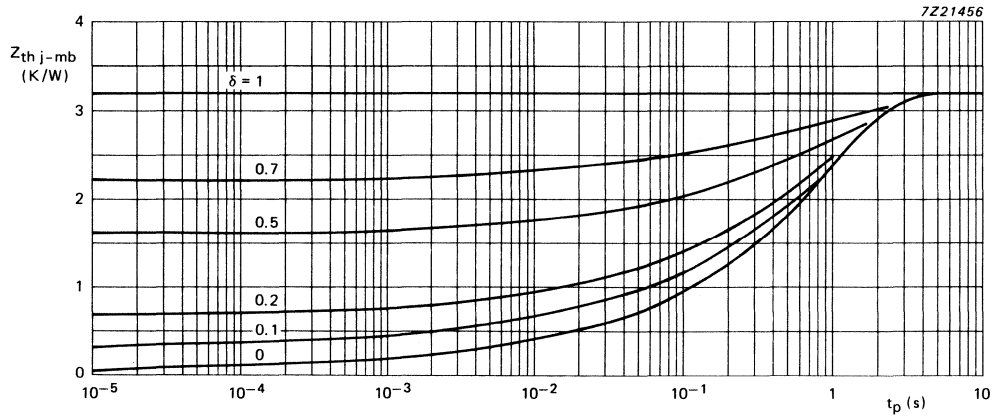


Fig. 7 Pulse power rating chart.

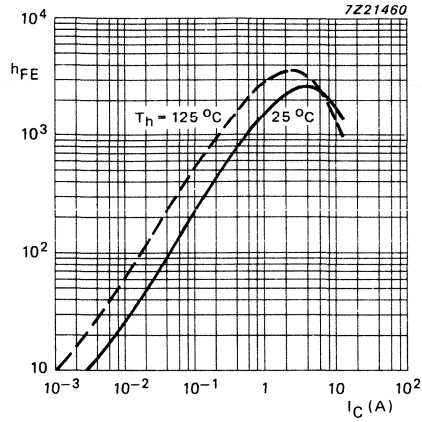


Fig. 8 Typical DC current gain as a function of collector current; $V_{CE} = 4 \text{ V}$.

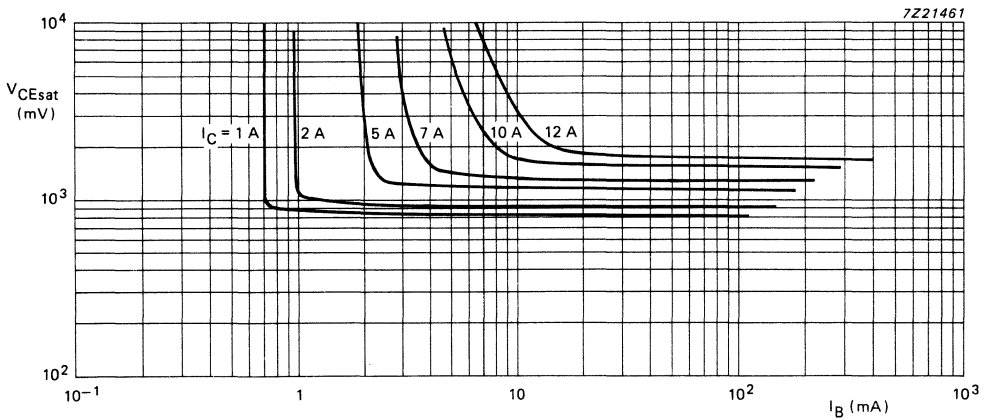


Fig. 9 Typical collector-emitter saturation voltages; $T_{mb} = 25 \text{ }^\circ\text{C}$.

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.

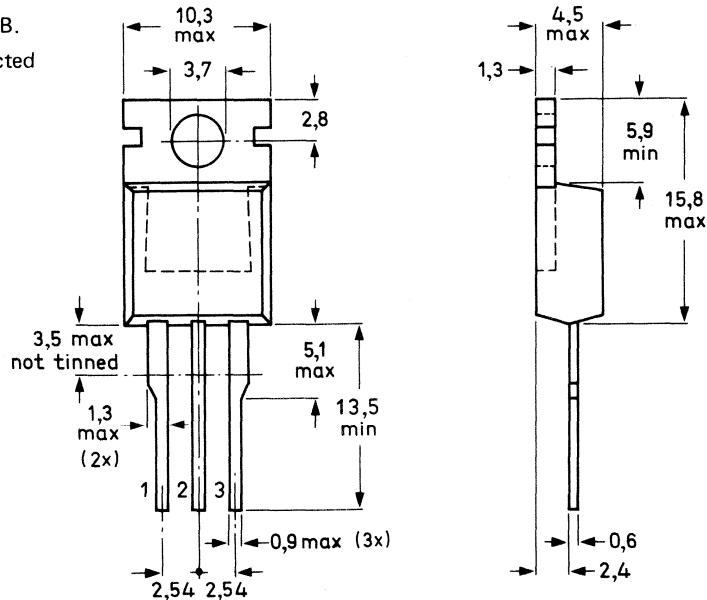
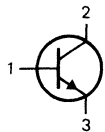
QUICK REFERENCE DATA

			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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125			W
Junction temperature	T_j	max.	150			$^\circ\text{C}$
D.C. current gain $I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	min.	40			

MECHANICAL DATA

Fig. 1 TO-220AB.

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_{CB0}	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			125	W
Storage temperature	T_{stg}			-65 to +150		$^\circ\text{C}$
Junction temperature	T_j	max.			150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=			1	K/W
From junction to ambient	$R_{th\ j-a}$	=			70	K/W

CHARACTERISTICS

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

Collector cut-off current						
→	$I_E = 0; V_{CB} = V_{CB0max}$	I_{CBO}	<		0,2	mA
	$V_{BE} = 0; V_{CE} = 0,8 V_{CB0max}$	I_{CES}	<		1	mA
Emitter cut-off current						
→	$I_C = 0; V_{EB} = 7\text{ V}$	I_{EBO}	<		0,1	mA
D.C. current gain*						
→	$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	h_{FE}	>		40	
→	$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		40	
Collector-emitter saturation voltage*						
	$I_C = 5\text{ A}; I_B = 0,5\text{ A}$	V_{CEsat}	<		1	V*
	$I_C = 7\text{ A}; I_B = 0,7\text{ A}$	V_{CEsat}	<		1,6	V*
Base-emitter voltage*						
	$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	<		1,5	V*
Transition frequency at $f = 1\text{ MHz}$						
	$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_T	typ.		10	MHz
Second breakdown collector current						
	$V_{CE} = 50\text{ V}; t_p = 100\text{ ms}$	I_{SB}	>		2,5	A

* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 2\%$.

Switching times (see Fig. 2)

$$I_C = 7 \text{ A}; I_{B1} = -I_{B2} = 0,7 \text{ A}$$

$$t_{on} \leq 1 \mu\text{s}$$

$$t_{off} \leq 2 \mu\text{s}$$

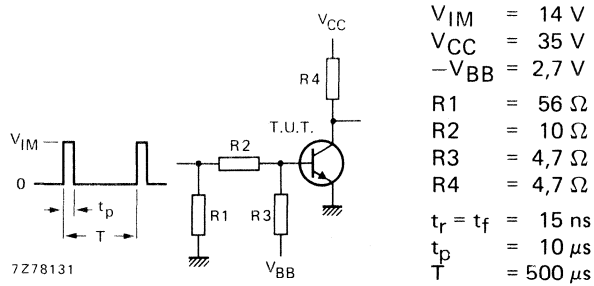


Fig. 2 Switching times test circuit.

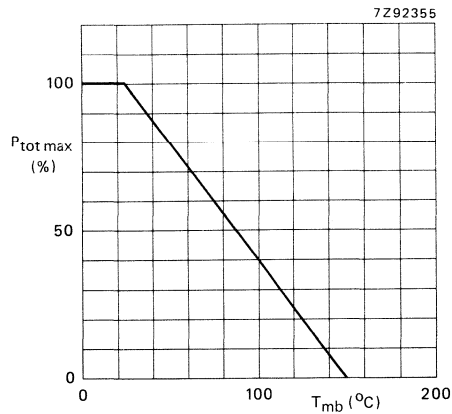


Fig. 3 Power derating curve.

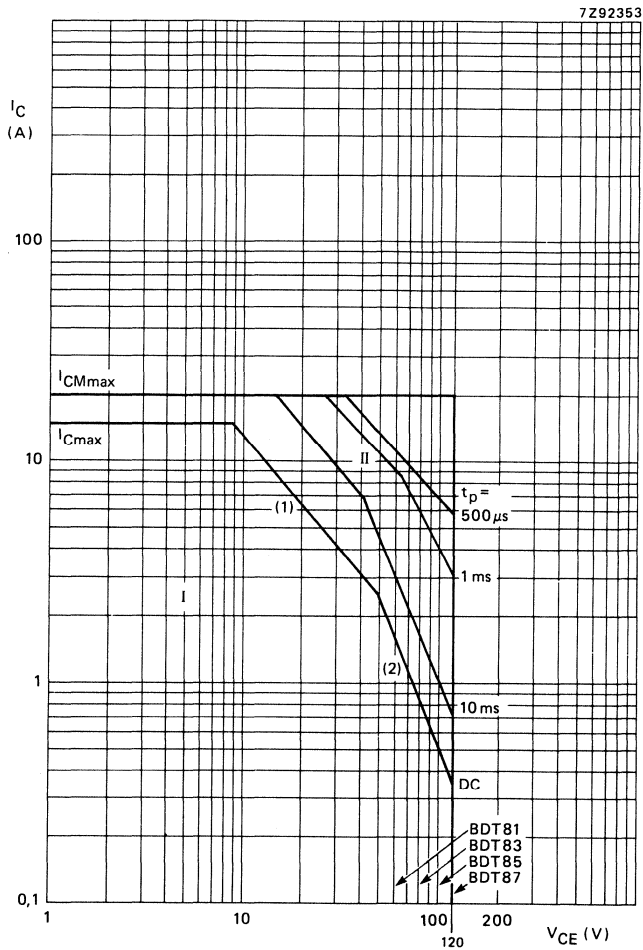


Fig. 4 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$; $\delta = 0,01$.

- 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.

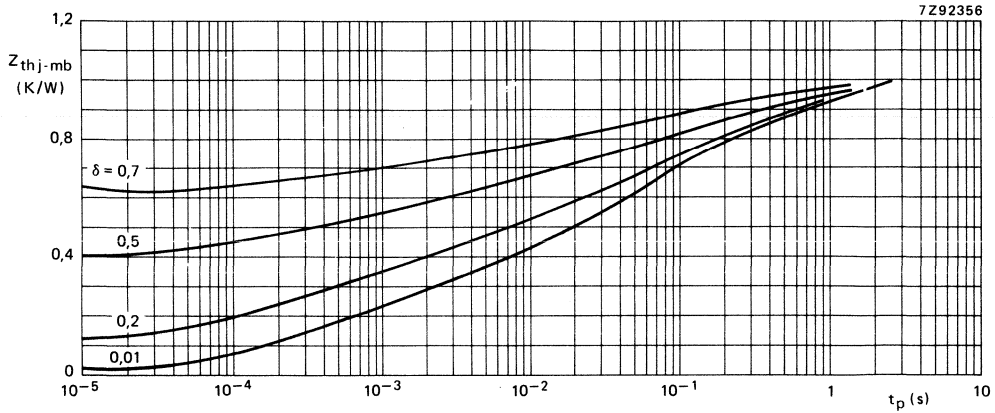


Fig. 5 Pulse power rating chart.

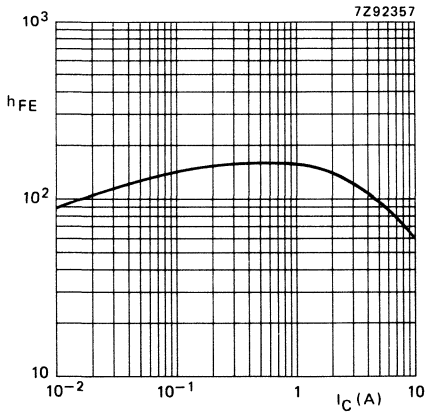


Fig. 6 Typical d.c. current gain;
 $T_{amb} = 25\text{ }^{\circ}\text{C}$; $V_{CE} = 4\text{ V}$.

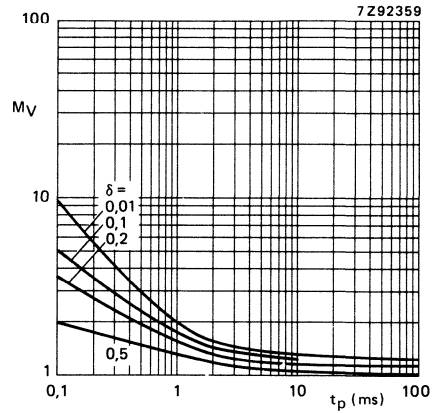


Fig. 7 Second-breakdown voltage multiplying factor at I_{Cmax} level.

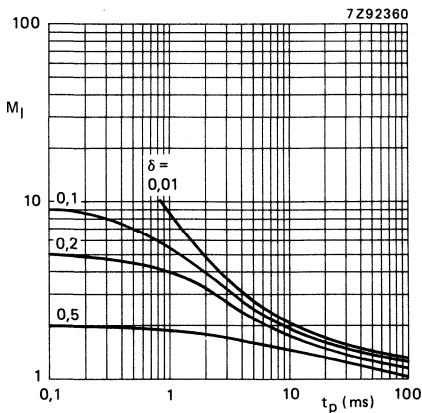


Fig. 8 Second-breakdown current multiplying factor at the V_{CEmax} level.

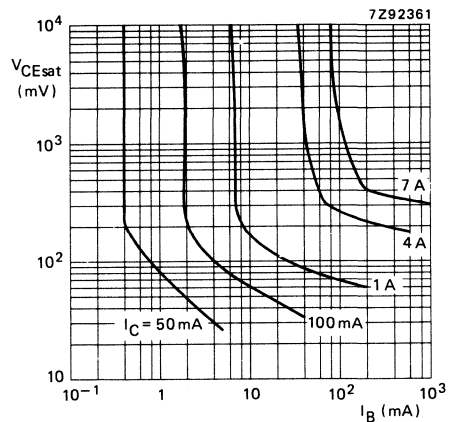


Fig. 9 Typical values collector-emitter saturation voltage.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

BDT81F; BDT83F
BDT85F; BDT87F

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_{CB0}	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_{EB0}	max.			7	V
DC collector current	I_C	max.			15	A
Peak collector current	I_{CM}	max.			20	A
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot}	max.			36	W
DC current gain $I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	typ.			40	

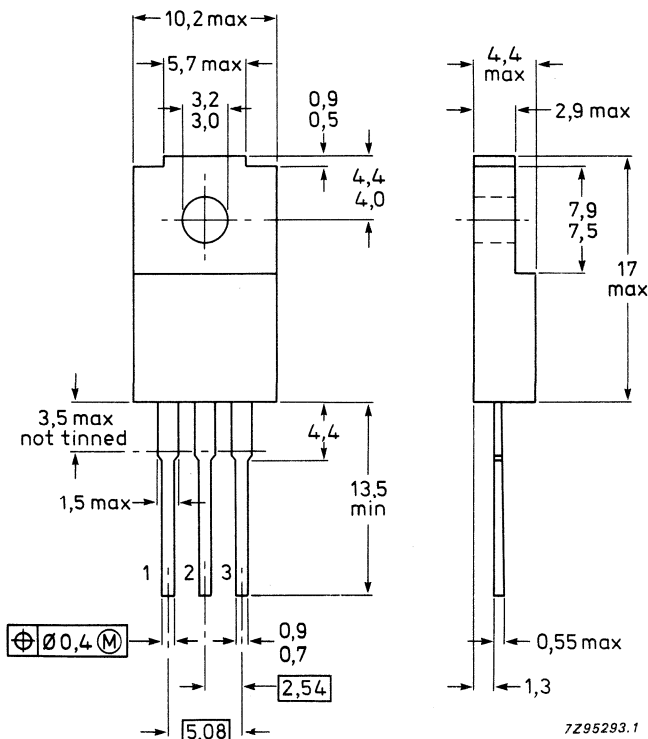
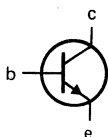
MECHANICAL DATA

Dimensions in mm

Fig.1 SOT186.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



7Z95293.1

RATINGS

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

			BDT81F	83F	85F	87F
Collector-base voltage (open emitter)	V_{CB0}	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 $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.		21		W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.		36		W
Storage temperature range	T_{stg}			-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=		1		K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=		6		K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=		3.5		K/W

INSULATION

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

Collector-emitter saturation voltage $I_C = 5\text{ A}; I_B = 0.5\text{ A}$	V_{CEsat}	max.		1.0		V
$I_C = 7\text{ A}; I_B = 0.7\text{ A}$		max.		1.6		V
DC current gain $I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	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.

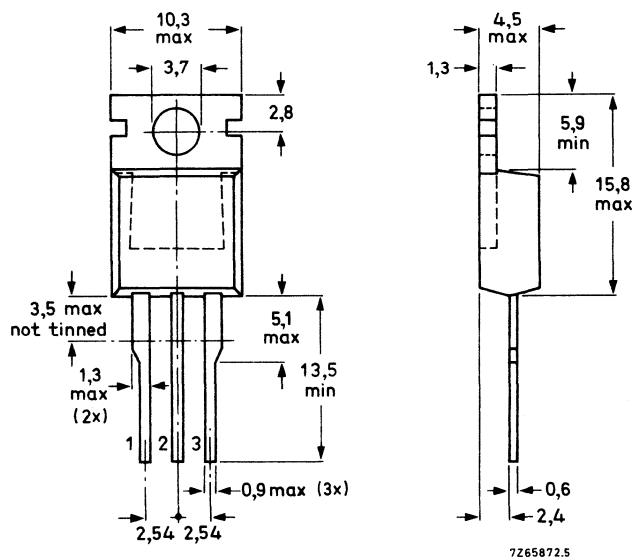
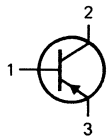
QUICK REFERENCE DATA

			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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125			W
Junction temperature	T_j	max.	150			$^\circ\text{C}$
D.C. current gain $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	min.	40			

MECHANICAL DATA

Fig. 1 TO-220AB.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			125	W
Storage temperature	T_{stg}				-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.			150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	max.			1	K/W
From junction to ambient	$R_{th\ j-a}$	max.			70	K/W

CHARACTERISTICS

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

→ $-I_C = 0; -V_{EB} = 7\text{ V}$	$-I_{EBO}$	<			0.1	mA
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D.C. current gain*

→ $-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$	h_{FE}	>			40	
→ $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>			40	

Collector-emitter saturation voltage*

$-I_C = 5\text{ A}; -I_B = 0,5\text{ A}$	$-V_{CEsat}$	<			1	V*
$-I_C = 7\text{ A}; -I_B = 0,7\text{ A}$	$-V_{CEsat}$	<			1,6	V*

Base-emitter voltage*

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<			1,5	V*
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Transition frequency at $f = 1\text{ MHz}$

$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}$	f_T	typ.			20	MHz
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Second breakdown collector current

$-V_{CE} = 50\text{ V}; t_p = 100\text{ ms}$ (non-repetitive without heatsink)	$-I_{SB}$	>			2,5	A
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* Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 2\%$.

Switching times (see Fig. 2)

$$-I_C = 7 \text{ A}; -I_{B1} = I_{B2} = 0,7 \text{ A}$$

$$t_{on} \leq 1 \mu\text{s}$$

$$t_{off} \leq 2 \mu\text{s}$$

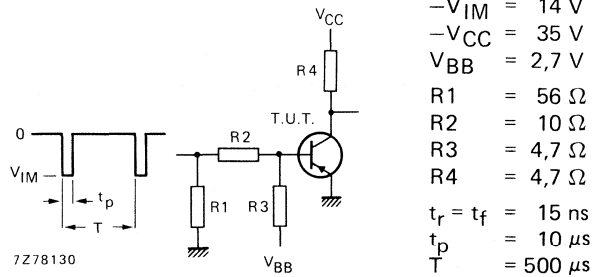


Fig. 2 Switching times test circuit.

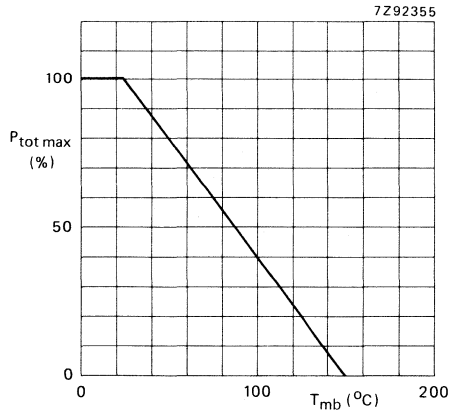


Fig. 3 Power derating curve.

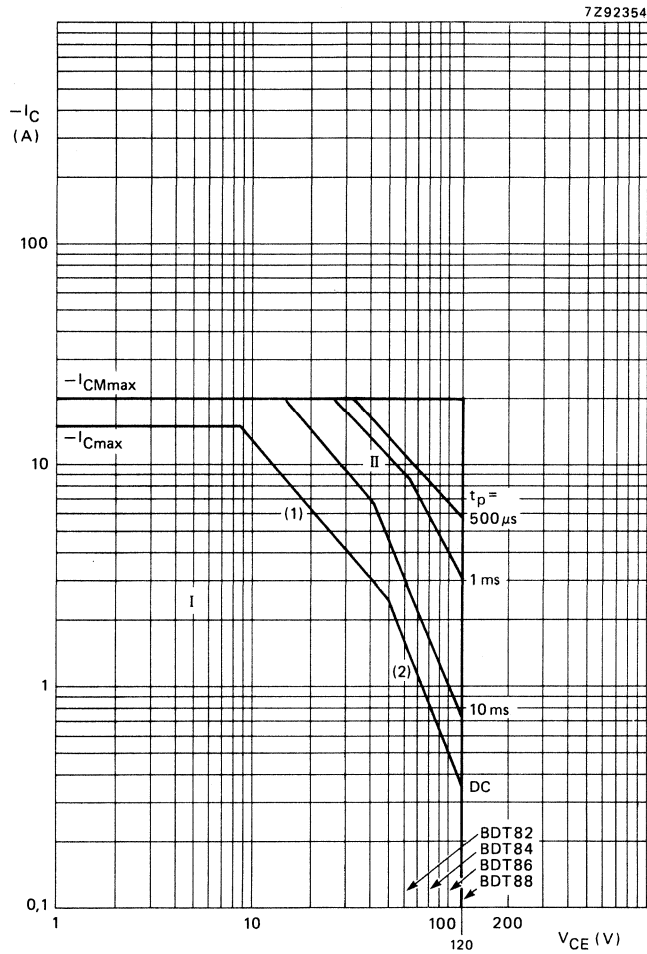


Fig. 4 Safe Operating Area; $T_{mb} = 25\ ^\circ C$; $\delta = 0,01$.

- 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.

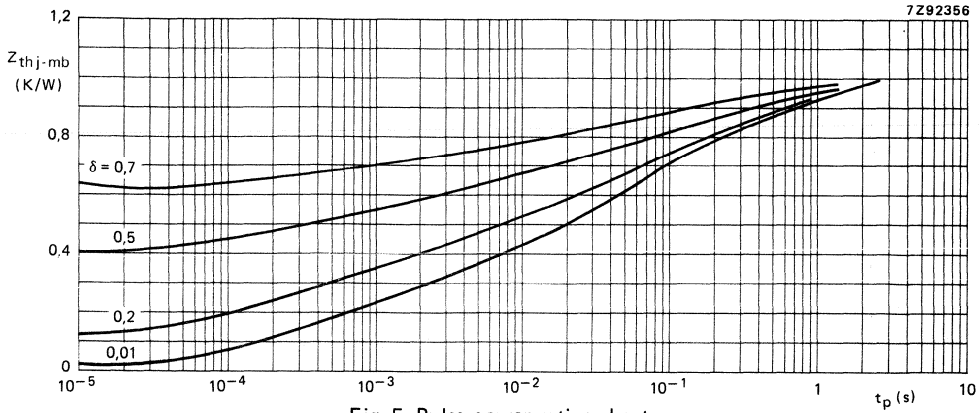


Fig. 5 Pulse power rating chart.

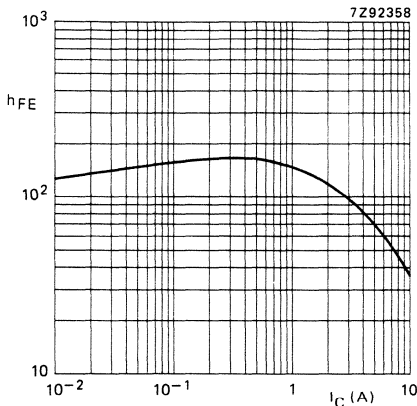


Fig. 6 Typical d.c. current gain;
 $T_{amb} = 25^{\circ}C$; $-V_{CE} = 4 V$.

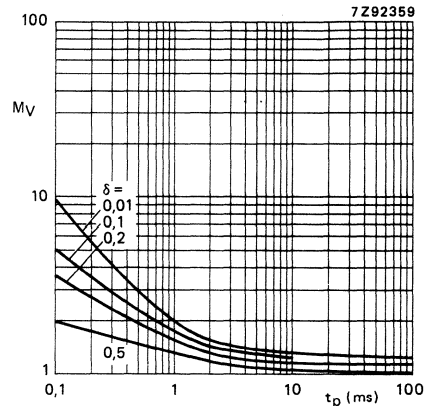


Fig. 7 Second-breakdown voltage multiplying factor at I_{Cmax} level.

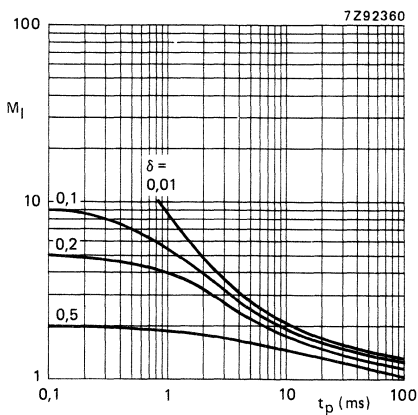


Fig. 8 Second-breakdown current multiplying factor at V_{CEmax} level.

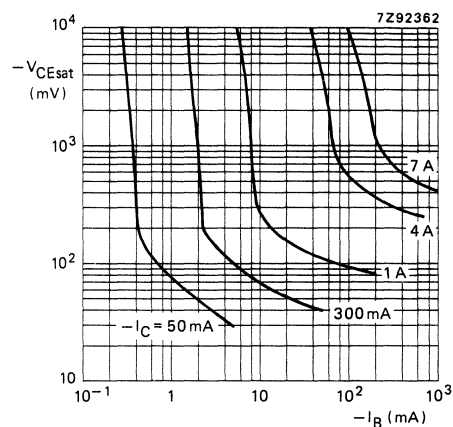


Fig. 9 Typical values collector-emitter saturation voltage.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

BDT82F; BDT84F
BDT86F; BDT88F

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

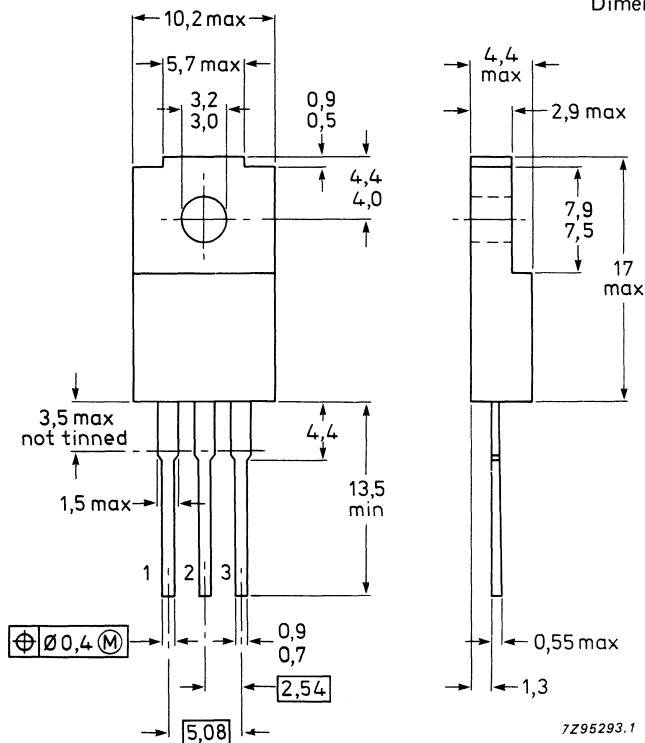
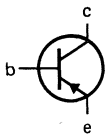
			BDT82F	84F	86F	88F
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.			7	V
DC collector current	$-I_C$	max.			15	A
Peak collector current	$-I_{CM}$	max.			20	A
Total power dissipation at $T_H \leq 25^\circ\text{C}$	P_{tot}	max.			36	W
DC current gain $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	typ.			40	

MECHANICAL DATA

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 $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.		21		W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.		36		W
Storage temperature range	T_{stg}			-65 to 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=		1		K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=		6		K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=		3.5		K/W

INSULATION

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

Collector-emitter saturation voltage $-I_C = 5\text{ A}; -I_B = 0.5\text{ A}$	$-V_{CEsat}$	max.		1.0		V
$-I_C = 7\text{ A}; -I_B = 0.7\text{ A}$		max.		1.6		V
DC current gain $-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	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.

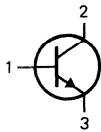
QUICK REFERENCE DATA

		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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	90	W
Junction temperature	T_j	max.	150	$^\circ\text{C}$
D.C. current gain			20 to 200	
$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}			
$I_C = 10\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	5	
Transition frequency			4	MHz
$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_T	>		

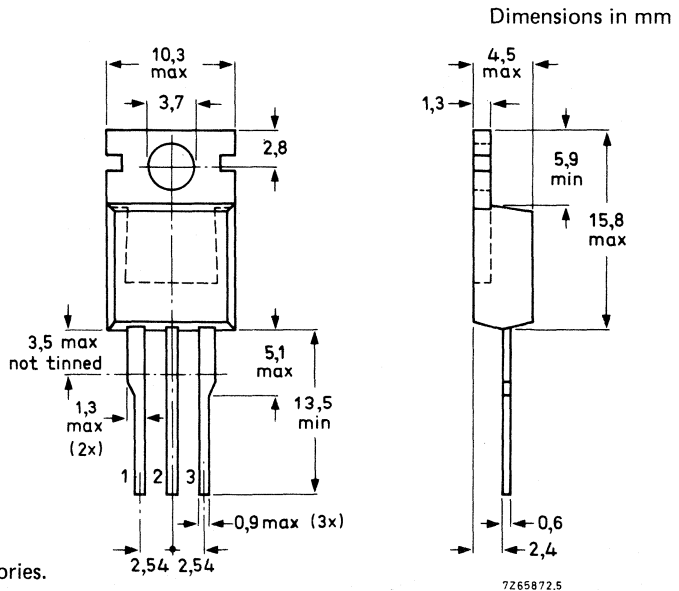
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	90	W
Storage temperature	T_{stg}		-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,4	K/W
From junction to ambient (in free air)	$R_{th\ j-a}$	=	70	K/W

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0; V_{CB} = \frac{1}{2}V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	I_{CBO}	<	5	mA
$I_B = 0; V_{CE} = V_{CEOmax}$	I_{CEO}	<	1	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 7\text{ V}$	I_{EBO}	<	1	mA
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D.C. current gain (note 1)

$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}		20 to 200	
$I_C = 10\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>	5	

Base-emitter voltage (notes 1 and 2)

$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$	V_{BE}	<	1,6	V
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Collector-emitter saturation voltage (note 1)

$I_C = 4\text{ A}; I_B = 0,4\text{ A}$	V_{CEsat}	<	1	V
$I_C = 10\text{ A}; I_B = 3,3\text{ A}$	V_{CEsat}	<	3	V

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_T	>	4	MHz
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Cut-off frequency

$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_{hfe}	>	20	kHz
--	-----------	---	----	-----

Notes

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

Second-breakdown collector current

$V_{CE} = 60 \text{ V}; t_p = 0,1 \text{ s}$

$I_{(SB)} > 1,5 \text{ A}$

Switching times

(between 10% and 90% levels)

$I_{Con} = 4 \text{ A}; I_{Bon} = -I_{Boff} = 0,4 \text{ A}$

Turn-on time

$t_{on} \begin{matrix} \text{typ.} & 0,5 \mu\text{s} \\ < & 1 \mu\text{s} \end{matrix}$

Turn-off time

$t_{off} \begin{matrix} \text{typ.} & 2 \mu\text{s} \\ < & 4 \mu\text{s} \end{matrix}$

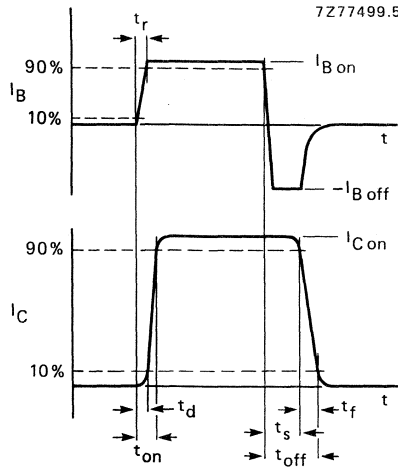


Fig. 2 Switching times waveforms.

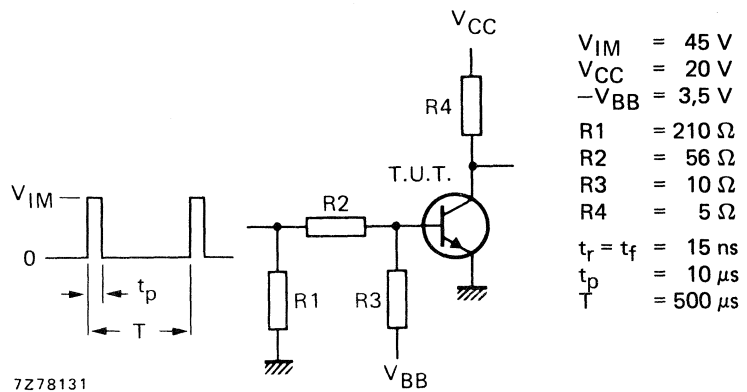


Fig. 3 Switching times test circuit.

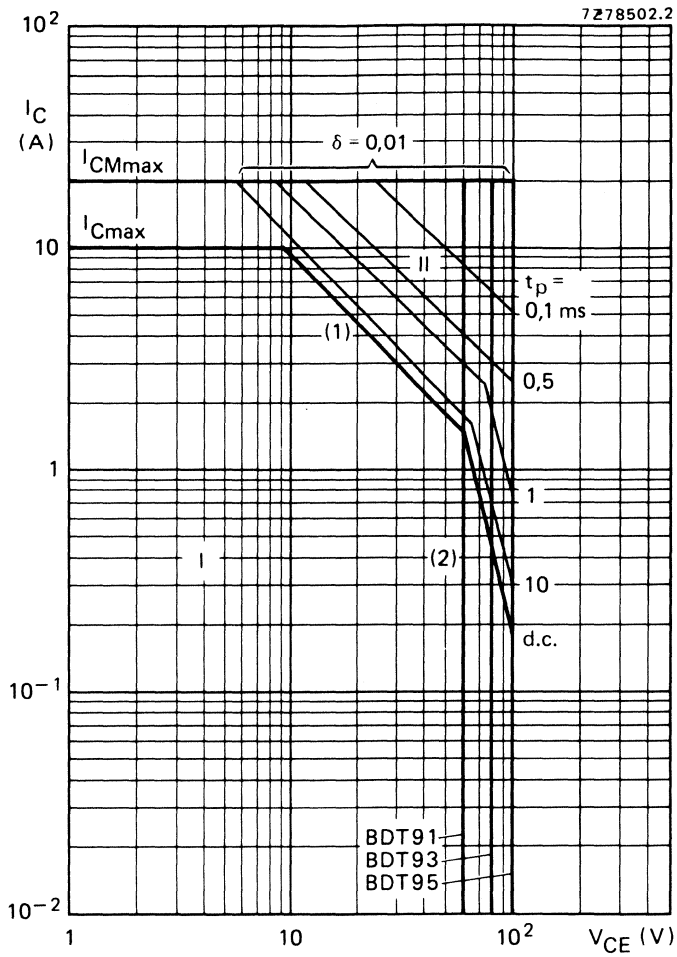


Fig. 4 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

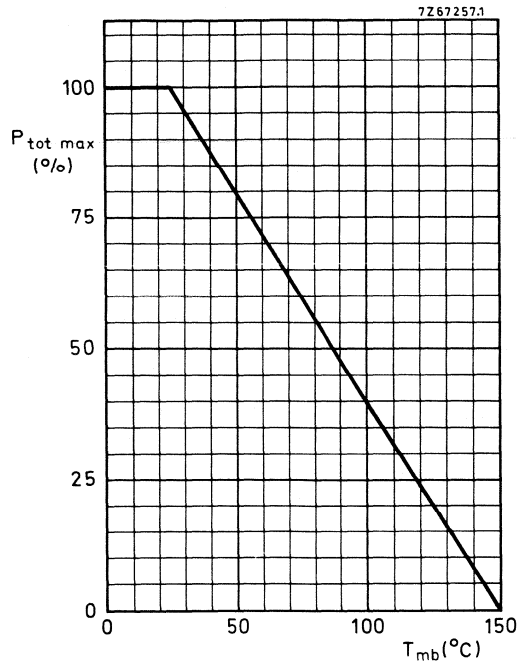


Fig. 5 Power derating curve.

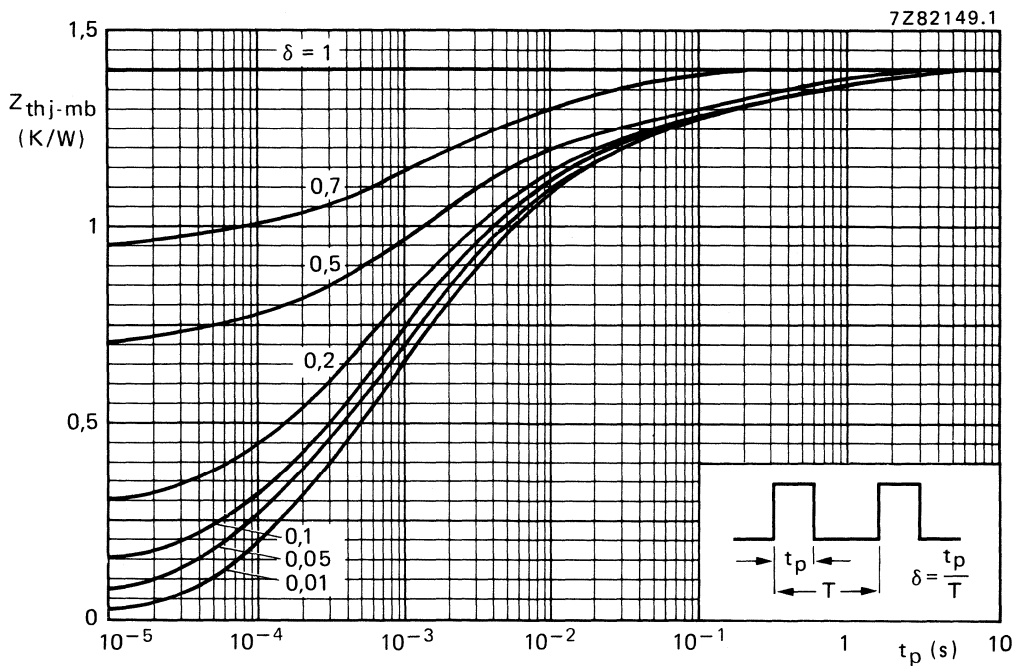


Fig. 6 Pulse power rating chart.

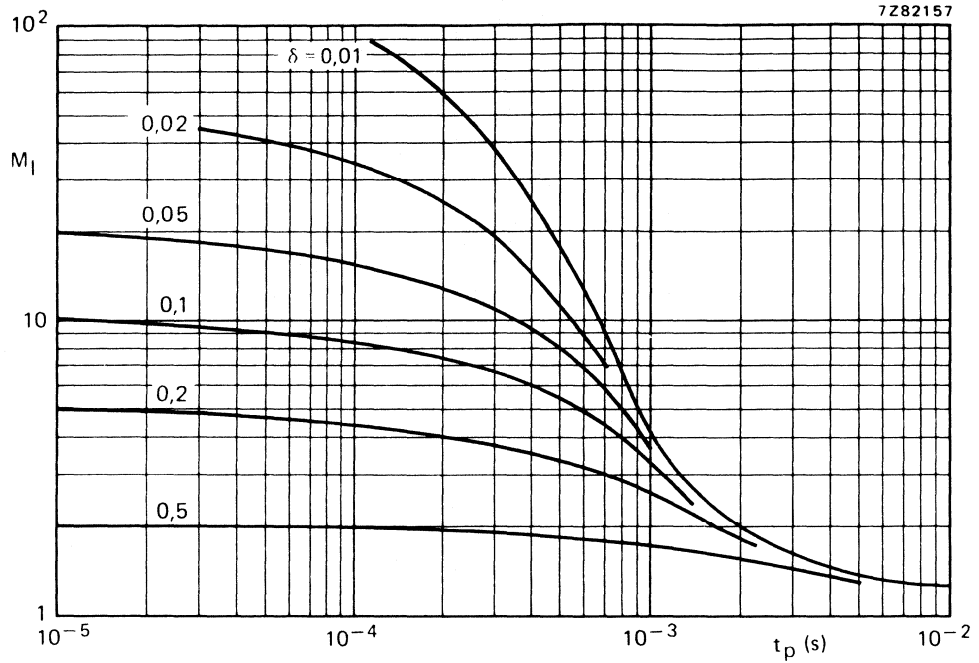


Fig. 7 S.B. current multiplying factor at the V_{CE0max} level.

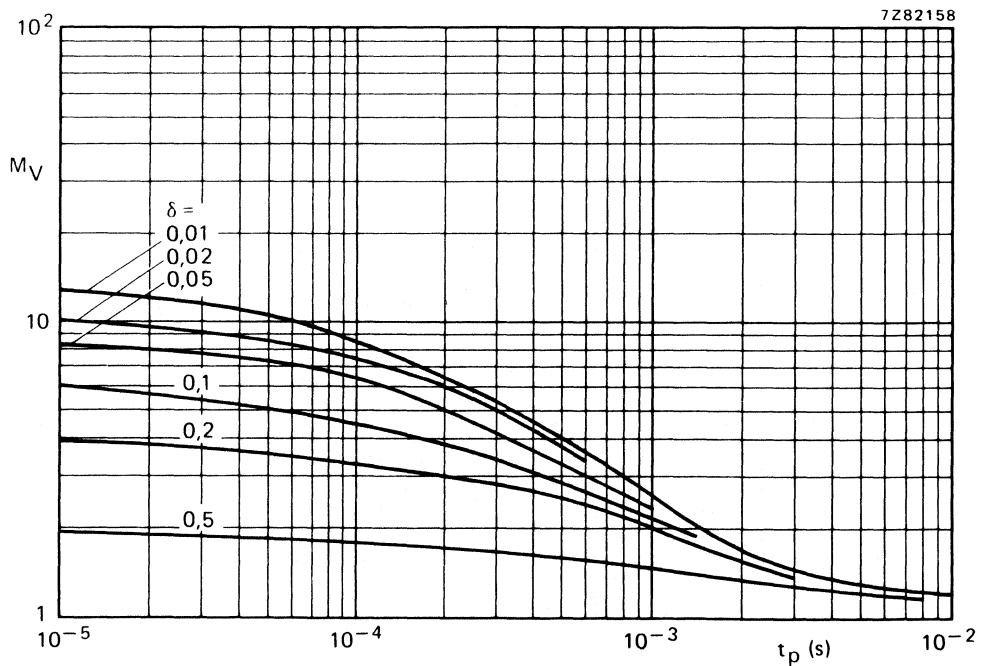


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

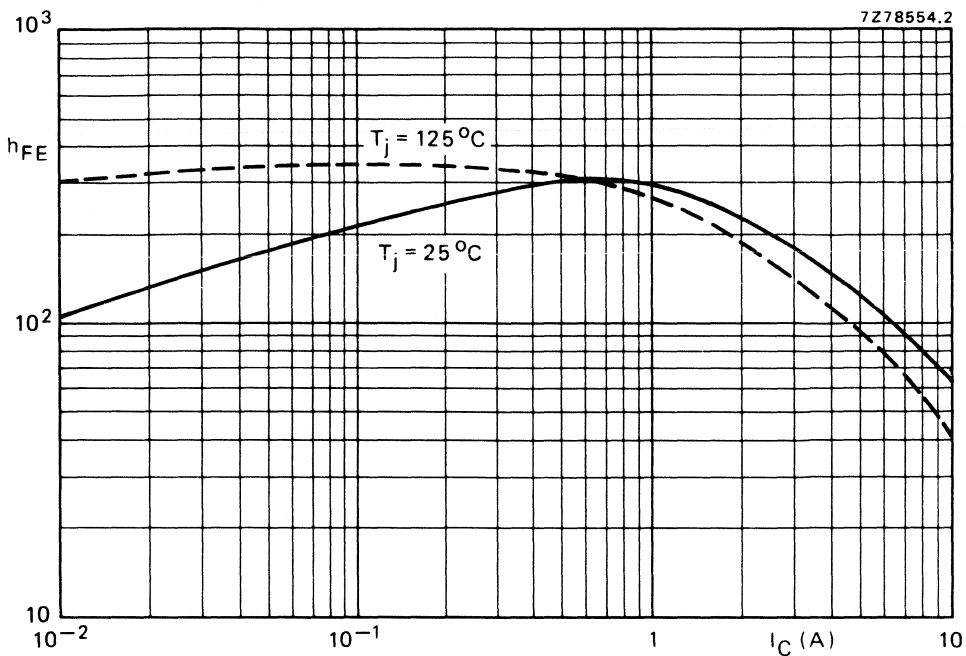


Fig. 9 Typical d.c. current gain at $V_{CE} = 4$ V.

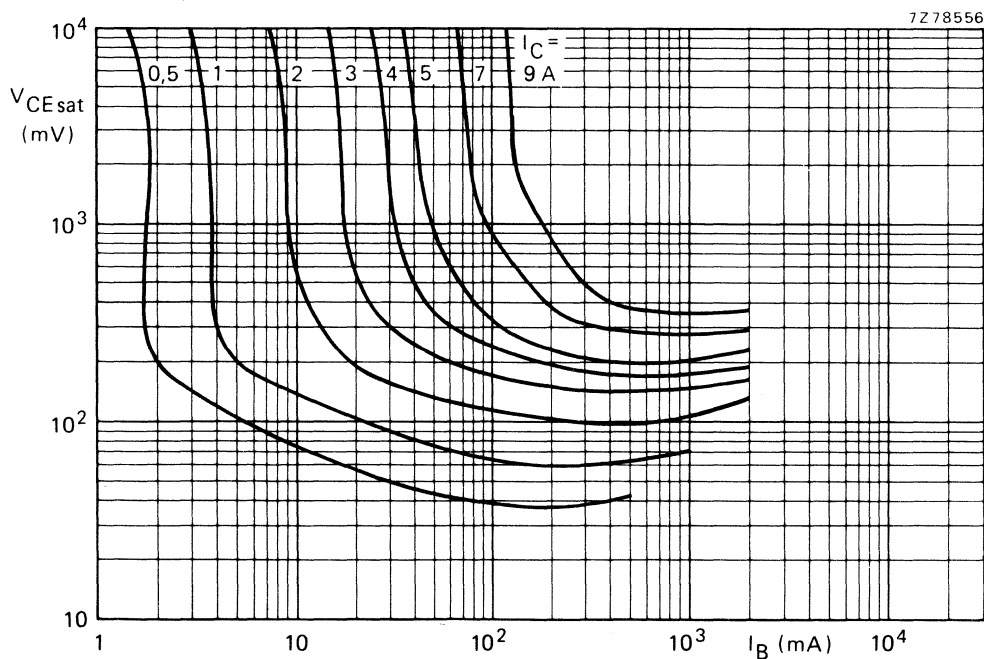


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25^\circ\text{C}$.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

**BDT91F; BDT93F;
BDT95F**

SILICON EPITAXIAL POWER TRANSISTORS

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

PNP complements are BDT92F, BDT94F, and BDT96F.

QUICK REFERENCE DATA

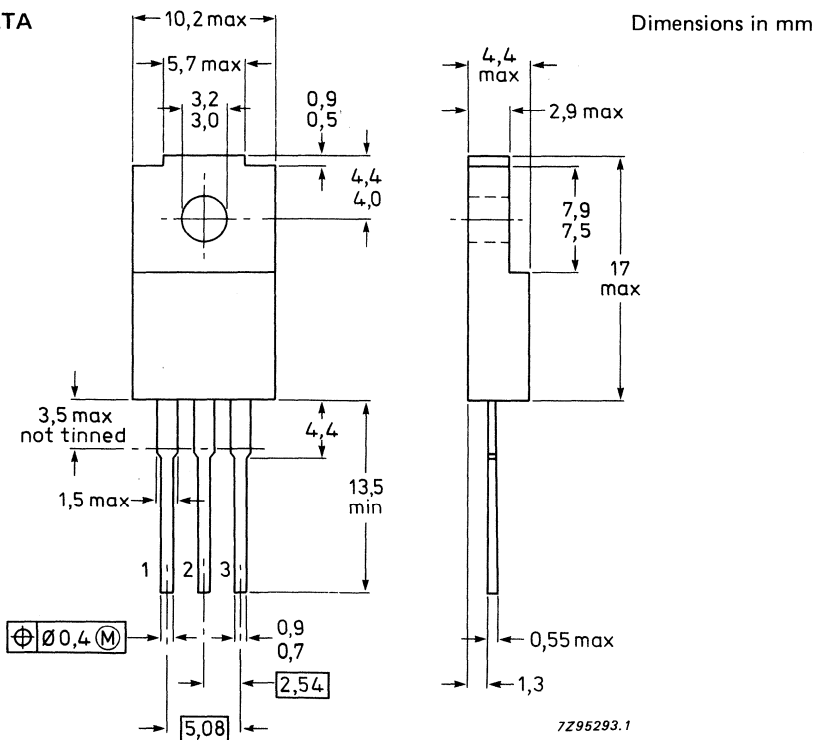
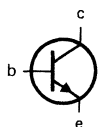
		BDT91F 93F 95F			
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100 V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100 V
Emitter-base voltage (open collector)	V_{EBO}	max.		7	V
DC collector current	I_C	max.		10	A
Peak collector current	I_{CM}	max.		20	A
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot}	max.		32	W
DC current gain	h_{FE}	min.		20	
$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$		max.		200	

MECHANICAL DATA

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 $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.		20	W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.		32	W
Storage temperature range	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=		1.4	K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=		6.4	K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=		3.9	K/W

INSULATION

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

Collector-emitter saturation voltage $I_C = 4\text{ A}; I_B = 0.4\text{ A}$	V_{CEsat}	max.		1	V
$I_C = 10\text{ A}; I_B = 3.3\text{ A}$		max.		3	V
DC current gain $I_C = 4\text{ A}; V_{CE} = 4\text{ V}$	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.

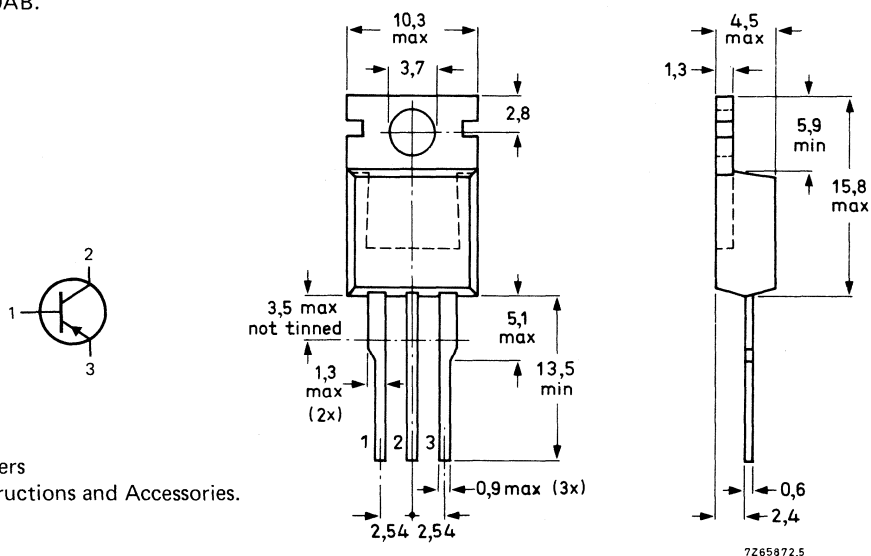
QUICK REFERENCE DATA

		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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	90	W
Junction temperature	T_j	max.	150	$^\circ\text{C}$
D.C. current gain			20 to 200	
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}		5	
$-I_C = 10\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>		
Transition frequency			4	MHz
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}$	f_T	>		

MECHANICAL DATA

Fig. 1 TO-220AB.

Dimensions in mm



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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		90	W
Storage temperature	T_{stg}			-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=		1,4	K/W
From junction to ambient (in free air)	$R_{th\ j-a}$	=		70	K/W

CHARACTERISTICS

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

→ Collector cut-off current					
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<		0,1	mA
$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<		1	mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<		0,2	mA
→ Emitter cut-off current					
$I_C = 0; -V_{EB} = 7\text{ V}$	$-I_{EBO}$	<		0,1	mA
D.C. current gain (note 1)					
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}			20 to 200	
$-I_C = 10\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>		5	
Base-emitter voltage (notes 1 and 2)					
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE}$	<		1,6	V
Collector-emitter saturation voltage (note 1)					
$-I_C = 4\text{ A}; -I_B = 0,4\text{ A}$	$-V_{CEsat}$	<		1	V
$-I_C = 10\text{ A}; -I_B = 3,3\text{ A}$	$-V_{CEsat}$	<		3	V
Transition frequency at $f = 1\text{ MHz}$					
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}$	f_T	>		4	MHz
Cut-off frequency					
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}$	f_{hfe}	>		20	kHz
D.C. current gain ratio of matched pairs					
BDT91/92; $-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE1}/h_{FE2}	<		2,5	

Notes

1. Measured under pulse conditions: $t_p \leq 300\text{ }\mu\text{s}$; $\delta \leq 2\%$.

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

Second-breakdown collector current

$-V_{CE} = 60 \text{ V}; t_p = 0,1 \text{ s}$

$-I_{(SB)} > 1,5 \text{ A}$

Switching times

(between 10% and 90% levels)

$-I_{Con} = 4 \text{ A}; -I_{Bon} = +I_{Boff} = 0,4 \text{ A}$

Turn-on time

$t_{on} \begin{matrix} \text{typ.} & 0,5 \mu\text{s} \\ < & 1,5 \mu\text{s} \end{matrix}$

Turn-off time

$t_{off} \begin{matrix} \text{typ.} & 1 \mu\text{s} \\ < & 3 \mu\text{s} \end{matrix}$

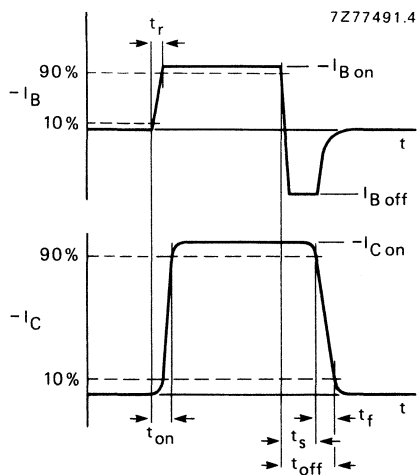
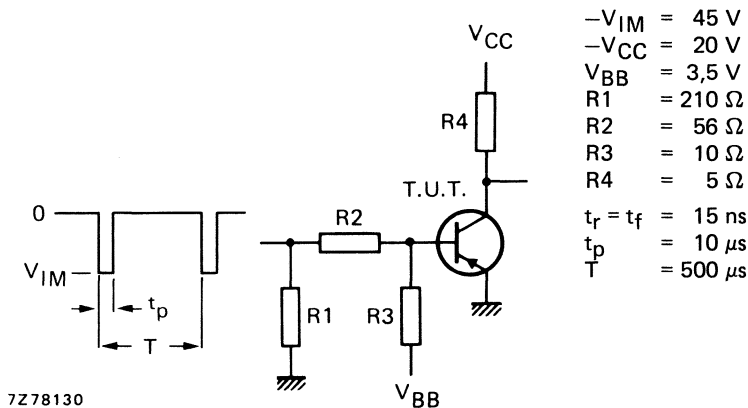


Fig. 2 Switching times waveforms.



- $-V_{IM} = 45 \text{ V}$
- $-V_{CC} = 20 \text{ V}$
- $V_{BB} = 3,5 \text{ V}$
- $R1 = 210 \Omega$
- $R2 = 56 \Omega$
- $R3 = 10 \Omega$
- $R4 = 5 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

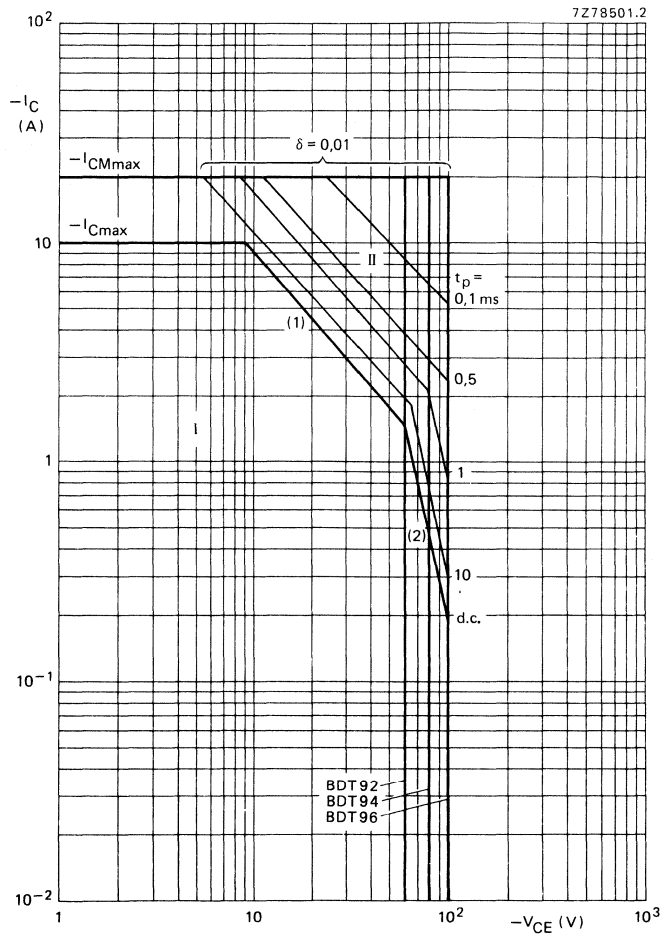


Fig. 4 Safe Operating ARea; $T_{mb} = 25^{\circ}\text{C}$.

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

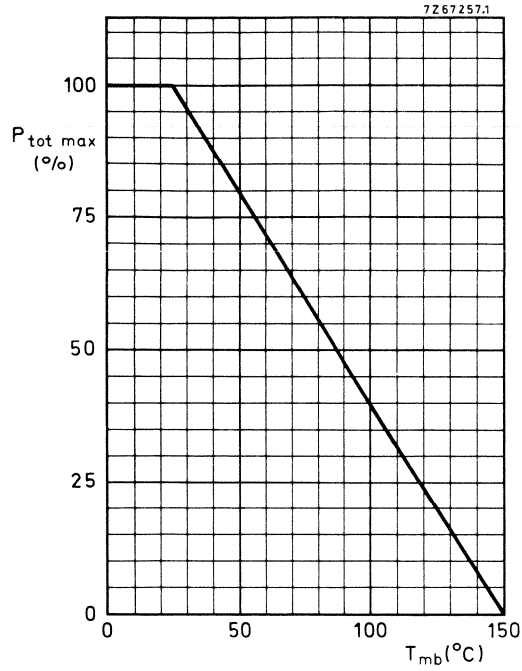


Fig. 5 Power derating curve.

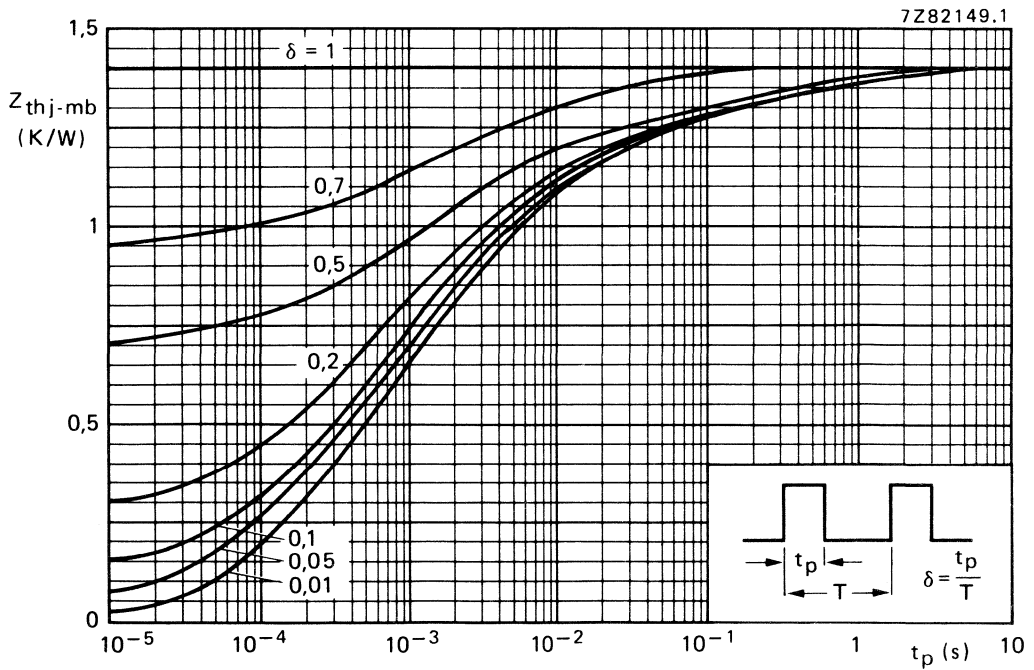


Fig. 6 Pulse power rating chart.

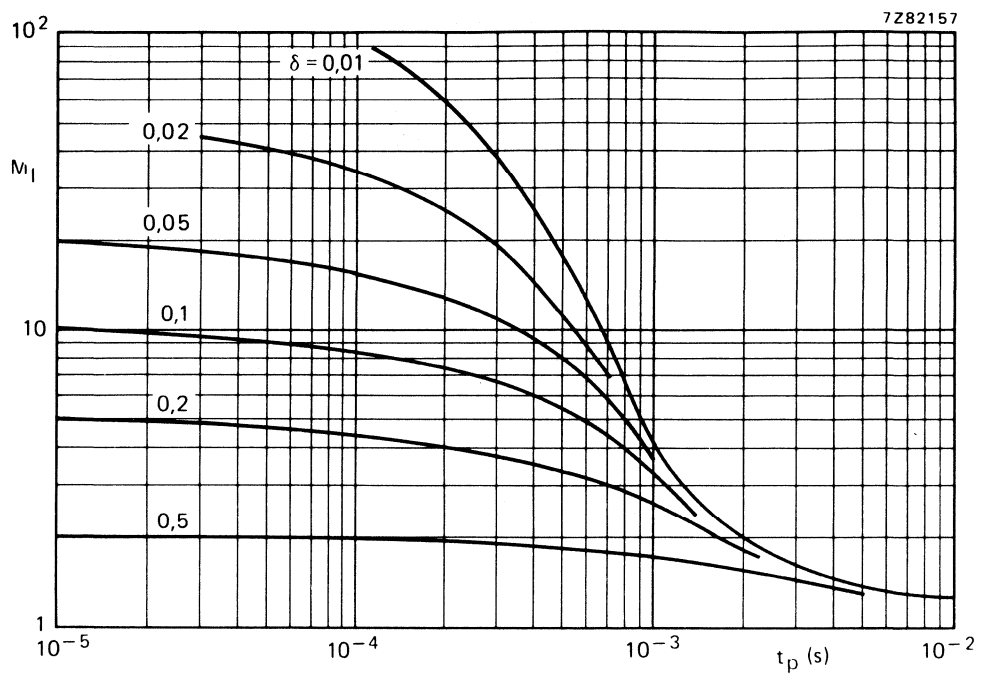


Fig. 7 S.B. current multiplying factor at the V_{CE0max} level.

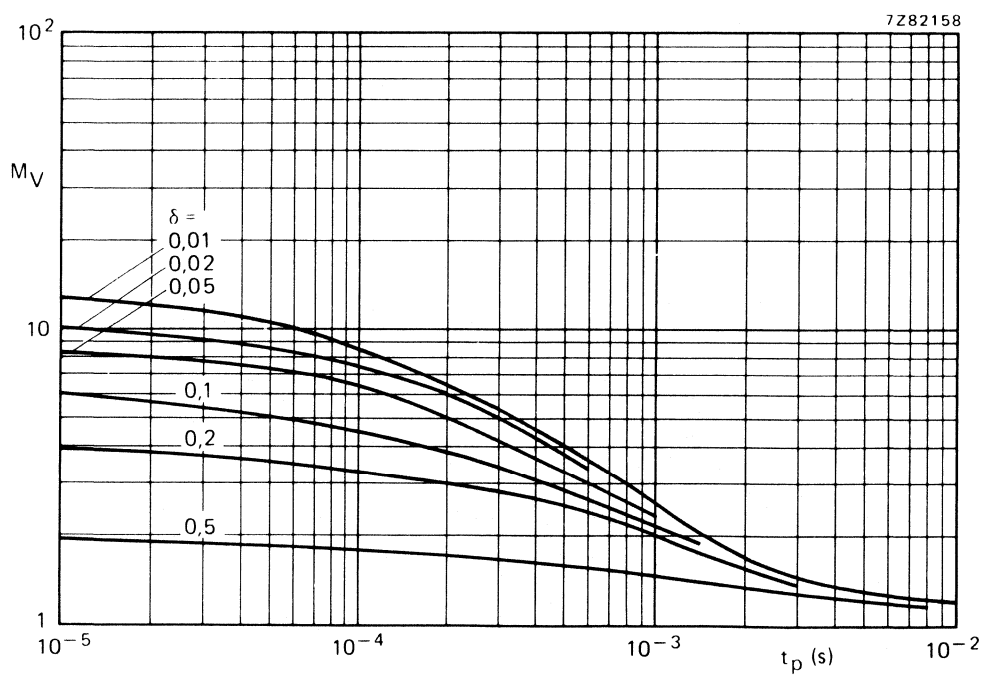


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

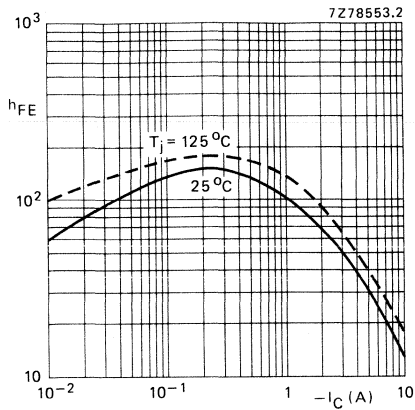


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V.

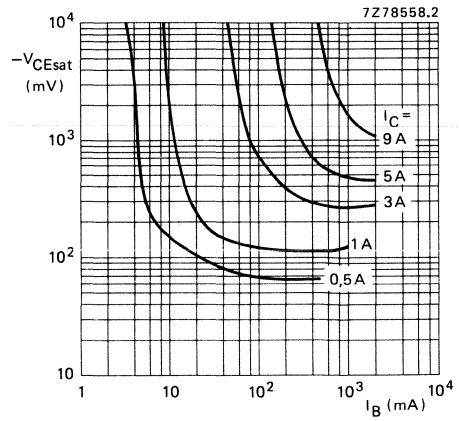


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25^\circ\text{C}$.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

BDT92F; BDT94F;
BDT96F

SILICON EPITAXIAL POWER TRANSISTORS

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

NPN complements are BDT91F, BDT93F, and BDT95F.

QUICK REFERENCE DATA

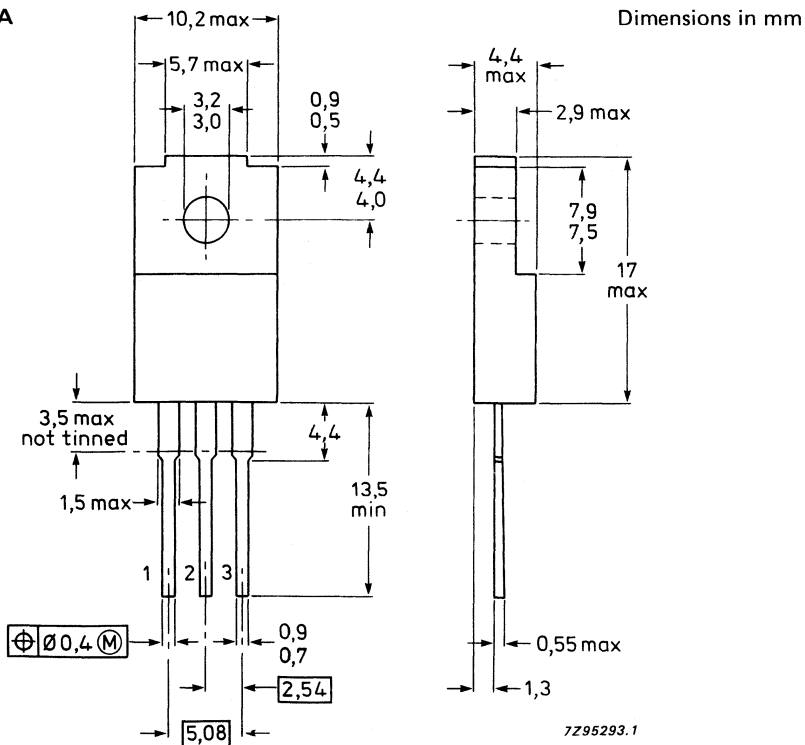
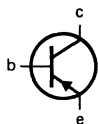
			BDT92F	94F	96F
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7	V
DC collector current	$-I_C$	max.		10	A
Peak collector current	$-I_{CM}$	max.		20	A
Total power dissipation at $T_h \leq 25^\circ\text{C}$	P_{tot}	max.		32	W
DC current gain		min.		20	
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	max.		200	

MECHANICAL DATA

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 $T_h \leq 25^\circ\text{C}$ (note 1)	P_{tot}	max.		20	W
at $T_h \leq 25^\circ\text{C}$ (note 2)		max.		32	W
Storage temperature range	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to internal heatsink	$R_{th\ j-mb}$	=		1.4	K/W
From junction to external heatsink (note 1)	$R_{th\ j-h}$	=		6.4	K/W
From junction to external heatsink (note 2)	$R_{th\ j-h}$	=		3.9	K/W

INSULATION

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

Collector-emitter saturation voltage					
$-I_C = 4\text{ A}; -I_B = 0.4\text{ A}$	$-V_{CEsat}$	max.		1	V
$-I_C = 10\text{ A}; -I_B = 3.3\text{ A}$		max.		3	V
DC current gain					
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125		W	
Junction temperature	T_j	max.	150		$^\circ\text{C}$	
DC current gain			1000			
$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>				
Cut-off frequency			100			
$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$	f_{hfe}	typ.			kHz	

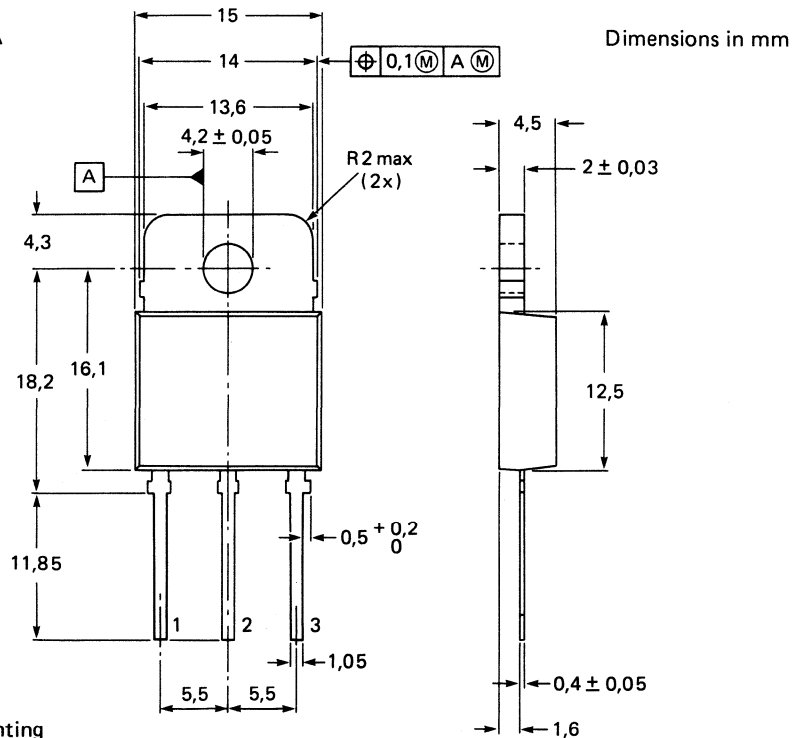
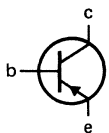
MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



See also chapters Mounting instructions and Accessories.

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CIRCUIT DIAGRAM

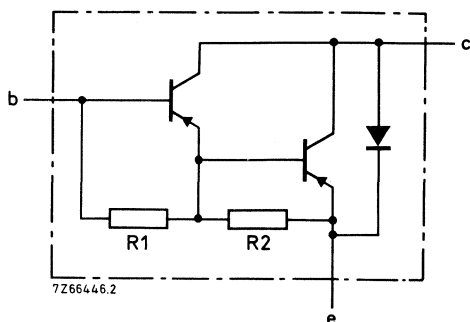


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		125		W
Storage temperature	T_{stg}			-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.		150		$^\circ\text{C}^*$

THERMAL RESISTANCE

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

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

Collector cut-off currents

$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	400	μA
$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	2	mA
$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEOmax}$	$-I_{CEO}$	<	0,2	mA

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	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 $T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified.

D.C. current gain*

$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$

h_{FE} typ. 1500

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$

h_{FE} > 1000

$-I_C = 10\text{ A}; -V_{CE} = 4\text{ V}$

h_{FE} typ. 1000

Base-emitter voltage*

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$

$-V_{BE}$ < 2,5 V**

Collector-emitter saturation voltage*

$-I_C = 5\text{ A}; -I_B = 20\text{ mA}$

$-V_{CEsat}$ < 2 V

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

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

C_C typ. 200 pF

Cut-off frequency

$-I_C = 5\text{ A}; -V_{CE} = 4\text{ V}$

f_{hfe} typ. 100 kHz

Diode, forward voltage

$I_F = 5\text{ A}$

V_F typ. 1,8 V

$I_F = 12\text{ A}$

V_F typ. 2 V

Switching times (see also Fig. 4)

$-I_{Con} = 5\text{ A}; -I_{Bon} = I_{Boff} = 20\text{ mA}; V_{CC} = -16\text{ V}$

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

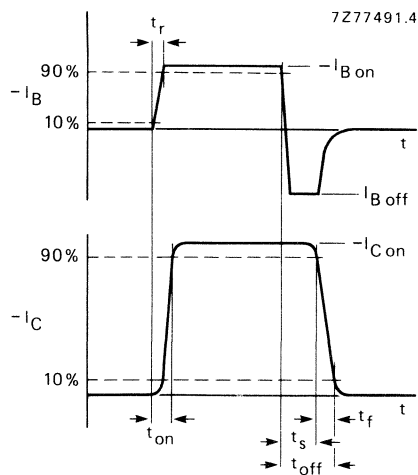


Fig. 3 Waveforms.

* Measured under pulse conditions: $t_p < 300\text{ }\mu\text{s}$; $\delta < 2\%$.** $-V_{BE}$ decreases by about 3,6 mV/K with increasing temperature.

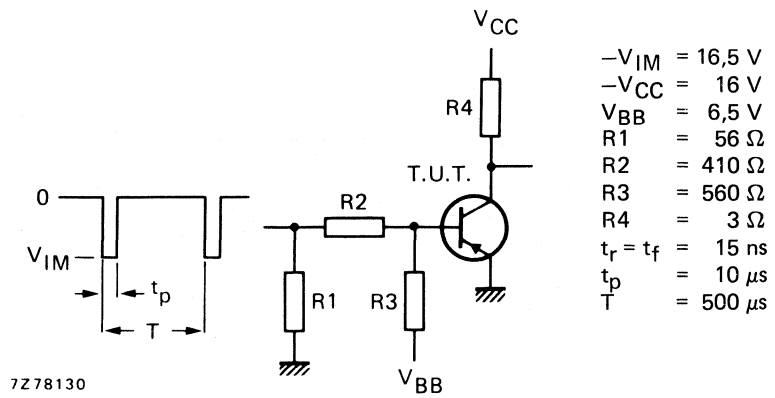


Fig. 4 Switching times test circuit.

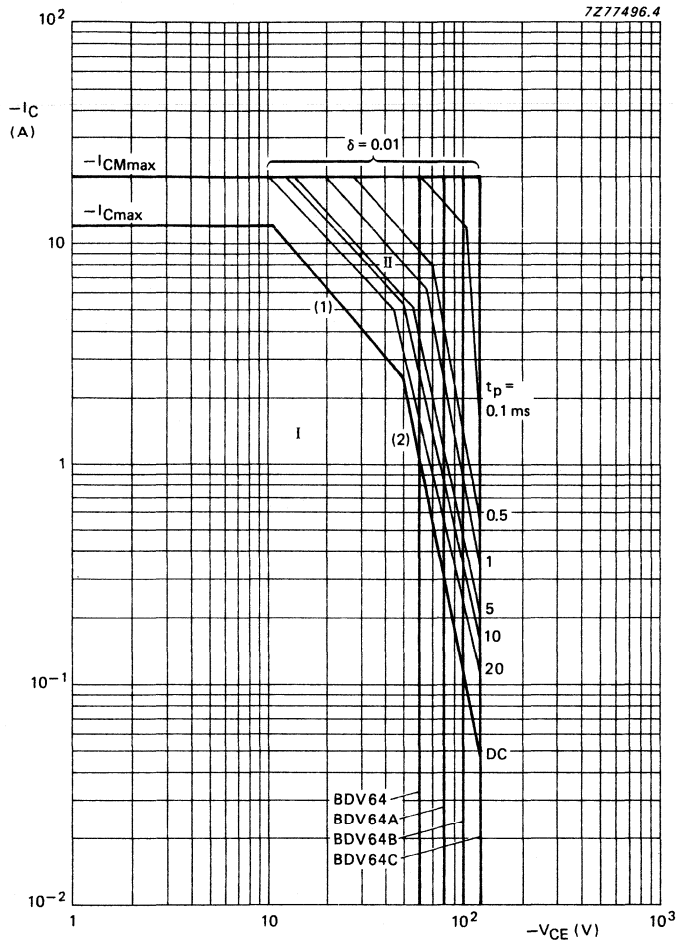


Fig. 5 Safe Operating Area; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

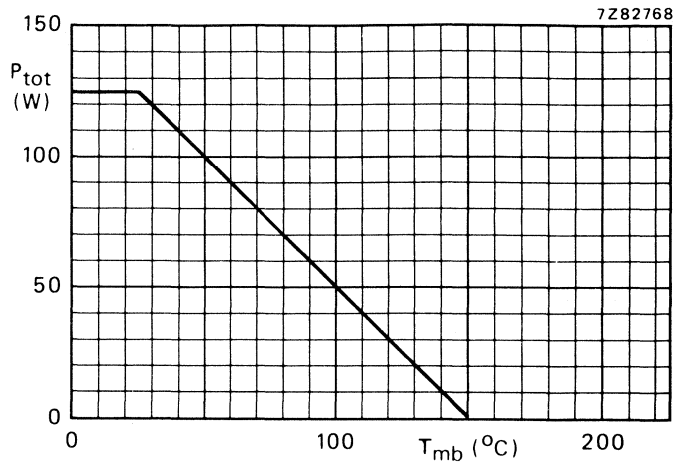


Fig. 6 Power derating curve.

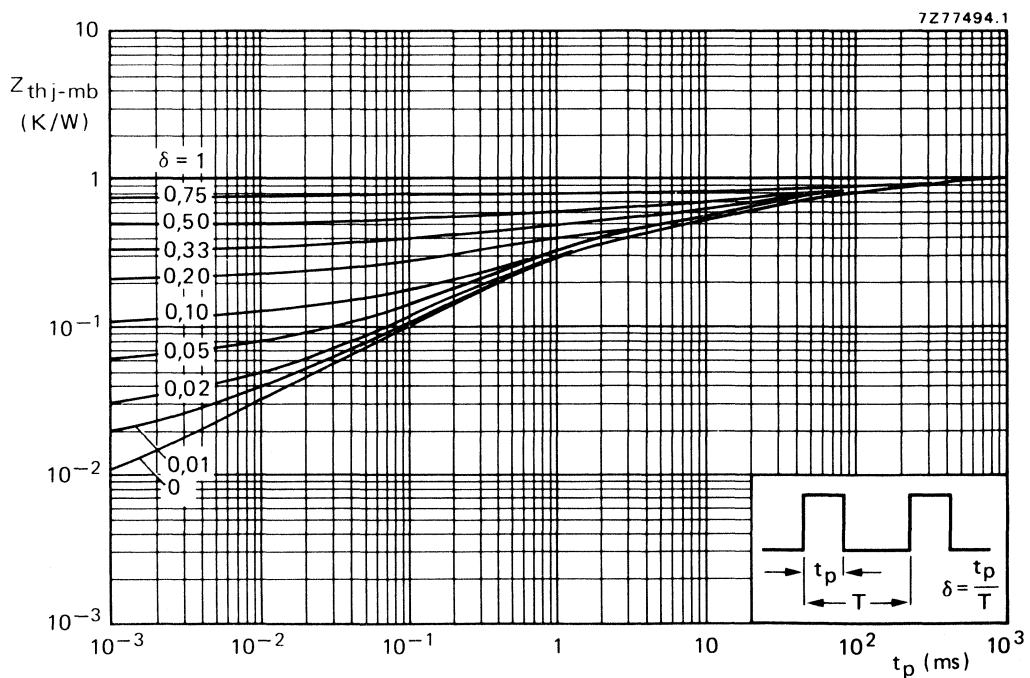


Fig. 7 Pulse power rating chart.

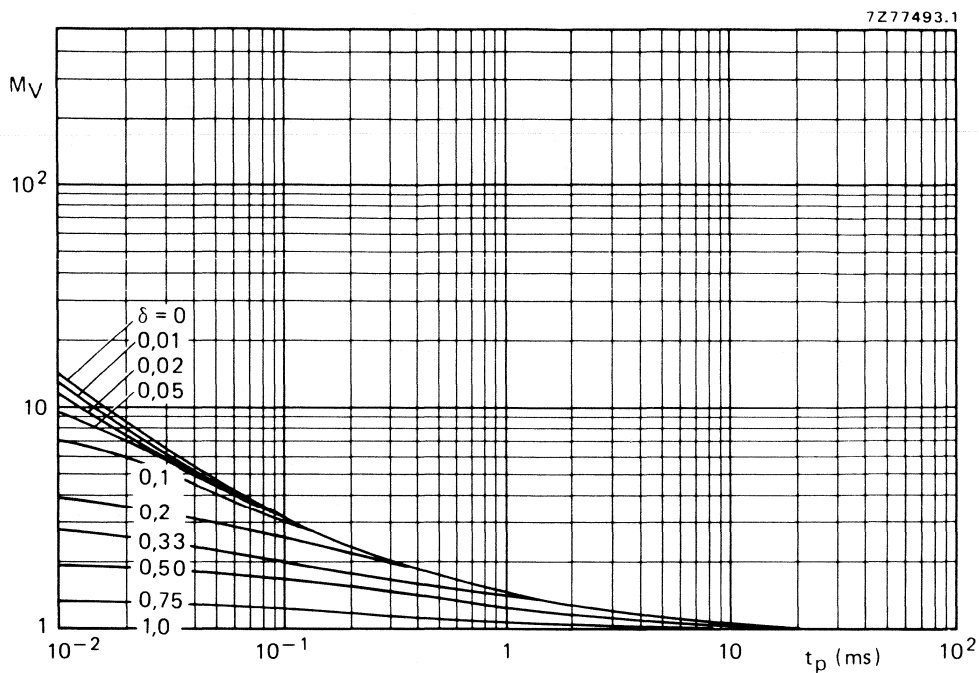


Fig. 8 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

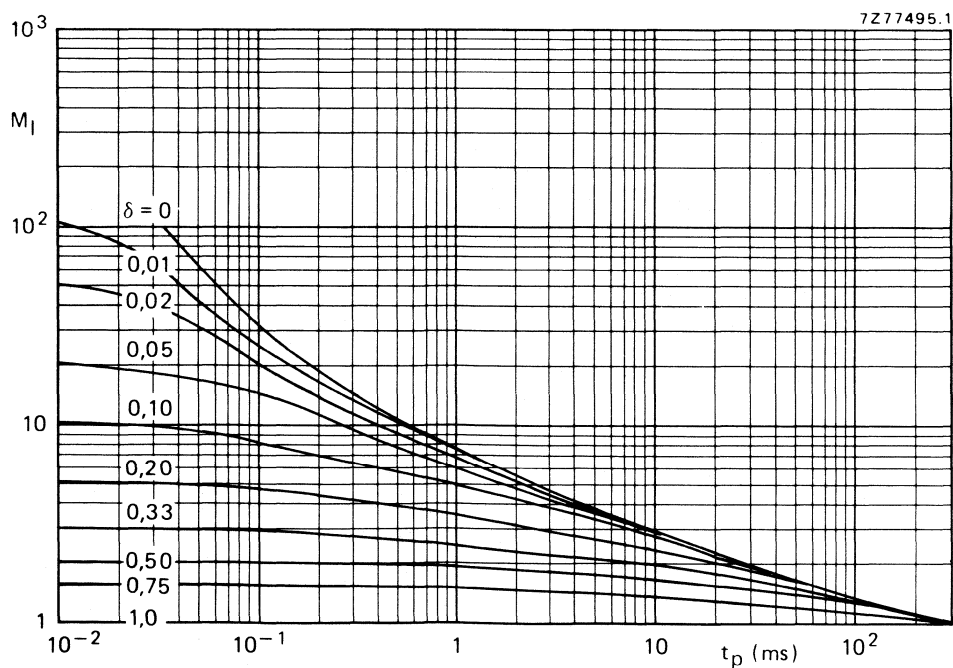


Fig. 9 S.B. current multiplying factor at the $-V_{CE0max}$ level (100 V).

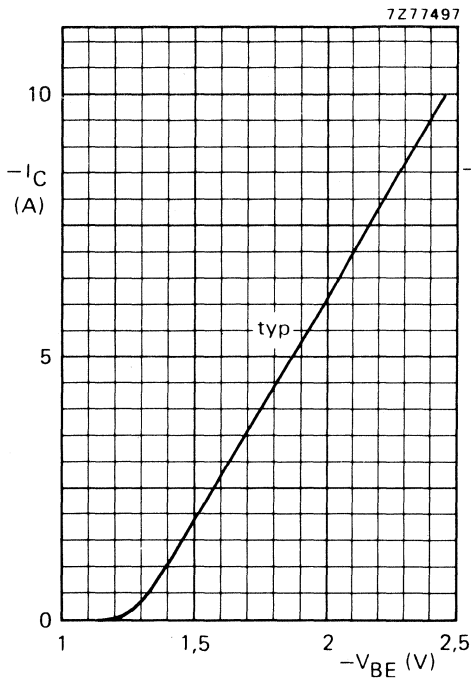


Fig. 10 $-V_{CE} = 4 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

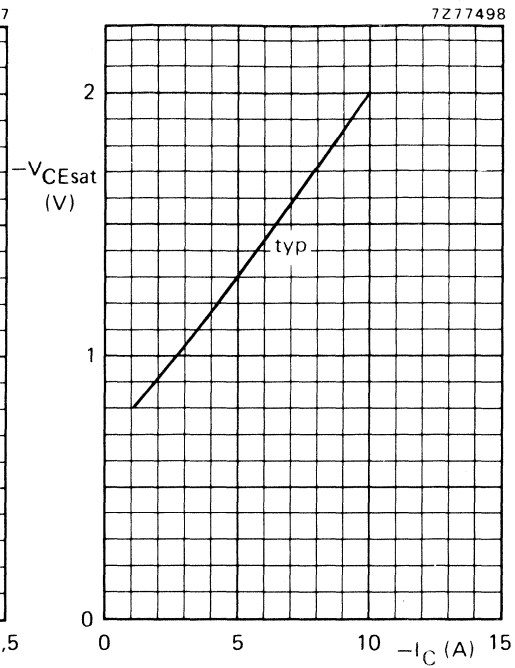


Fig. 11 $-I_C/I_B = 250$; $T_j = 25 \text{ }^\circ\text{C}$.

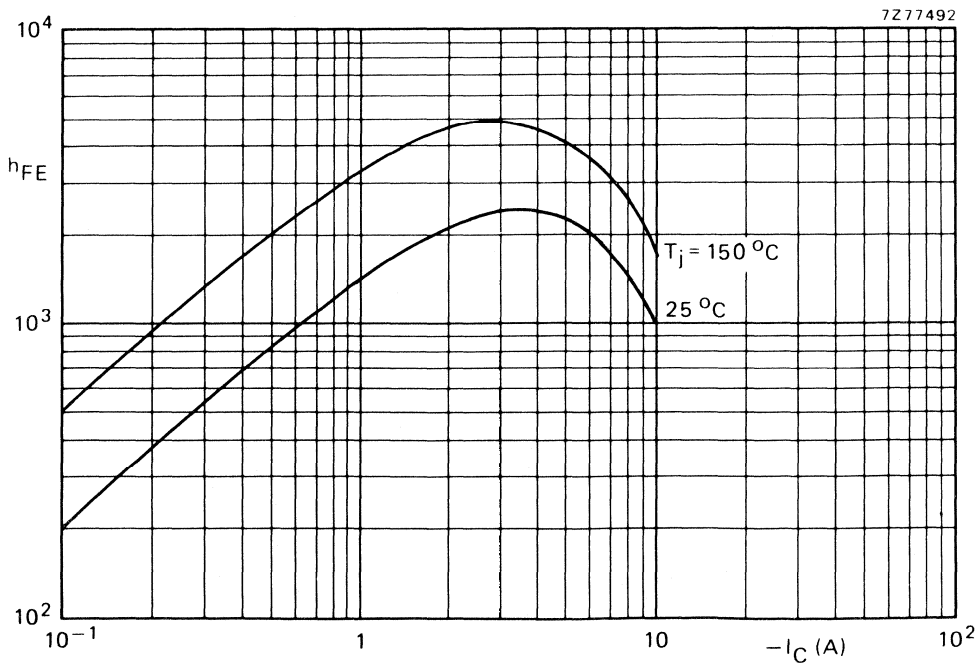


Fig. 12 Typical values; $-V_{CE} = 4 \text{ V}$.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. P-N-P 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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		125		W
Junction temperature	T_j	max.		150		$^\circ\text{C}$
D.C. current gain						
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	typ.		1500		
$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		1000		
Cut-off frequency						
$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$	f_{hfe}	typ.		70		kHz

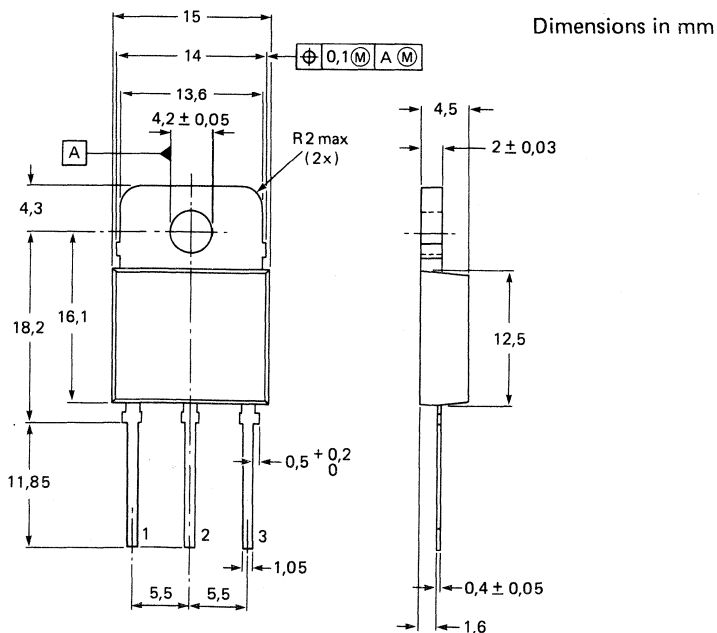
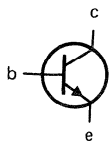
MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting-base.

Pinning:

- 1 = base
- 2 = collector
- 3 = emitter



See also chapters Mounting instructions and Accessories.

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CIRCUIT DIAGRAM

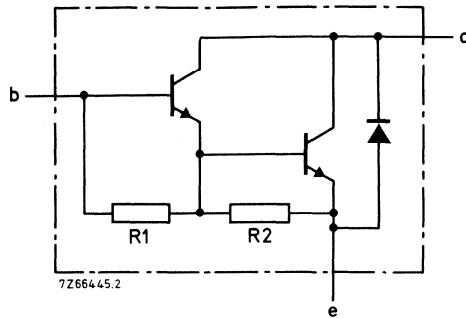


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

		BDV65	A	B	C
Collector-base voltage (open emitter)	V_{CB0} 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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		125		W
Storage temperature	T_{stg}		-65 to +150		$^\circ\text{C}$
Junction temperature	T_j max.		150		$^\circ\text{C}^*$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off currents

$I_E = 0; V_{CB} = V_{CB0max}$ $I_{CB0} <$ 400 μA

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$ $I_{CB0} <$ 2 mA

$I_B = 0; V_{CE} = \frac{1}{2}V_{CEOmax}$ $I_{CEO} <$ 0,2 mA

Emitter cut-off current

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

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

D.C. current gain*

$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$

$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$

$I_C = 10\text{ A}; V_{CE} = 4\text{ V}$

h_{FE} typ. 1500

h_{FE} > 1000

h_{FE} typ. 1750

Base-emitter voltage*

$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$

$V_{BE} < 2,5\text{ V}^{**}$

Collector-emitter saturation voltage*

$I_C = 5\text{ A}; I_B = 20\text{ mA}$

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

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

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

C_C typ. 150 pF

Cut-off frequency

$I_C = 5\text{ A}; V_{CE} = 4\text{ V}$

f_{hfe} typ. 70 kHz

Diode, forward voltage

$I_F = 5\text{ A}$

$I_F = 12\text{ A}$

V_F typ. 1,2 V

V_F typ. 2 V

Switching times (see also Fig. 4)

$I_{Con} = 5\text{ A}; I_{B on} = -I_{B off} = 20\text{ mA}; V_{CC} = 16\text{ V}$

Turn-on time

t_{on} typ. 1 μs

Fall time

t_f typ. 3 μs

Turn-off time

t_{off} typ. 6 μs

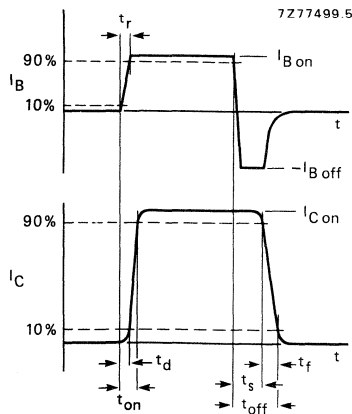


Fig. 3 Waveforms showing $t_{on}; t_s + t_f = t_{off}$.

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

** V_{BE} decreases by about 3,6 mV/K with increasing temperature.

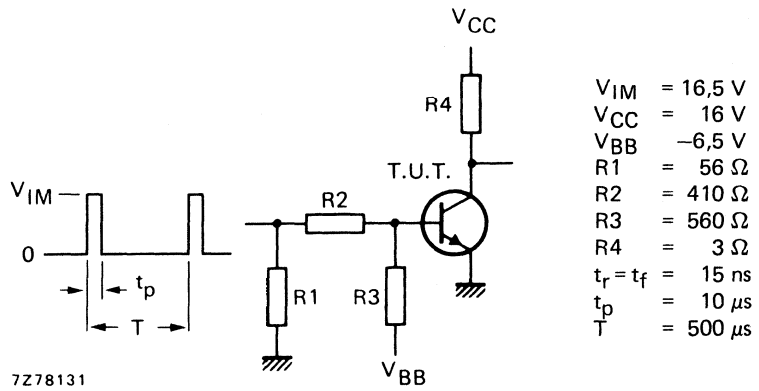


Fig. 4 Switching times test circuit.

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

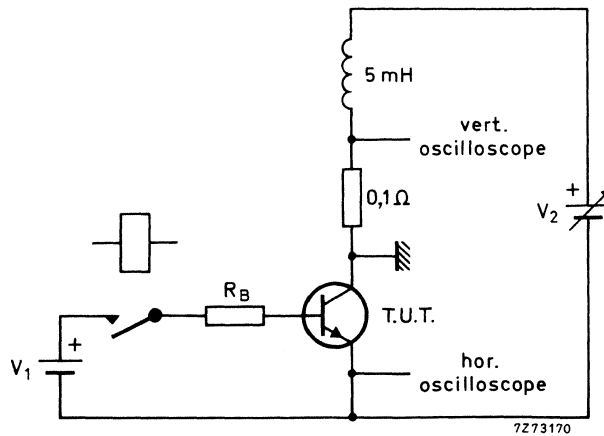


Fig. 5 Test circuit; $V_1 = 12$ V; $R_B = 270$ Ω .

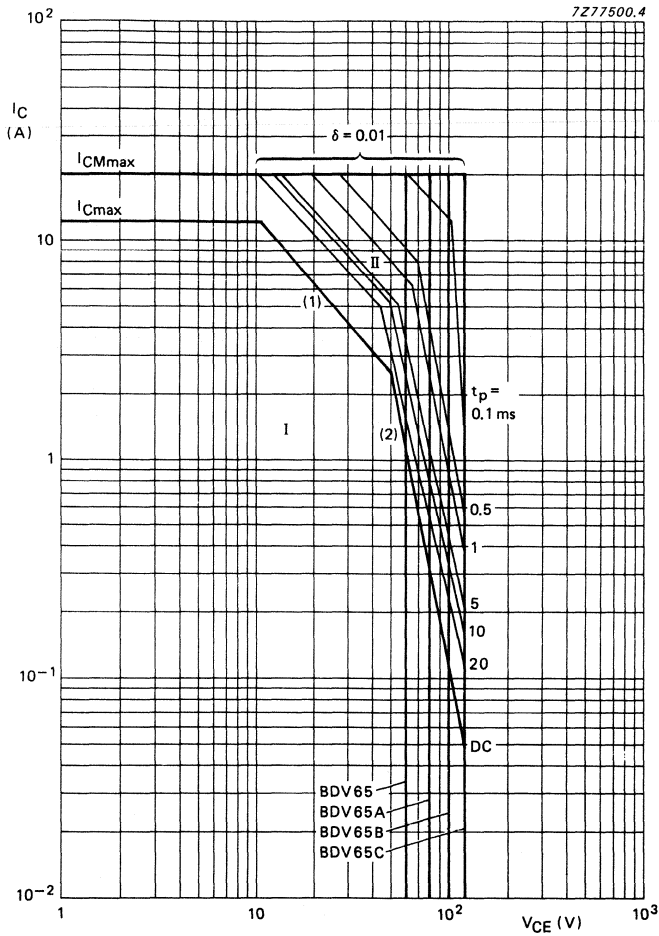


Fig. 6 Safe Operating Area; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

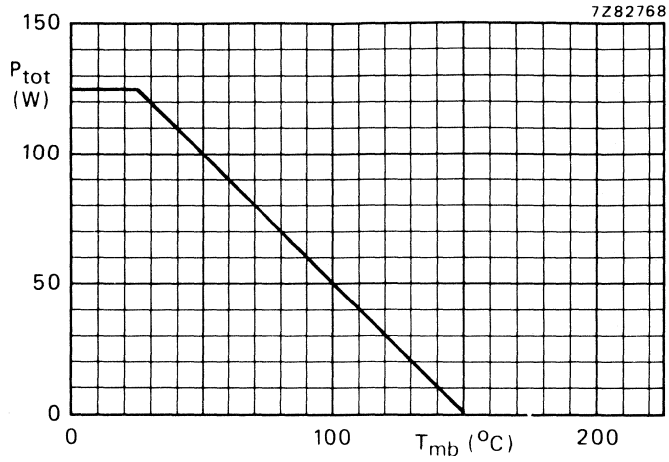


Fig. 7 Power derating curve.

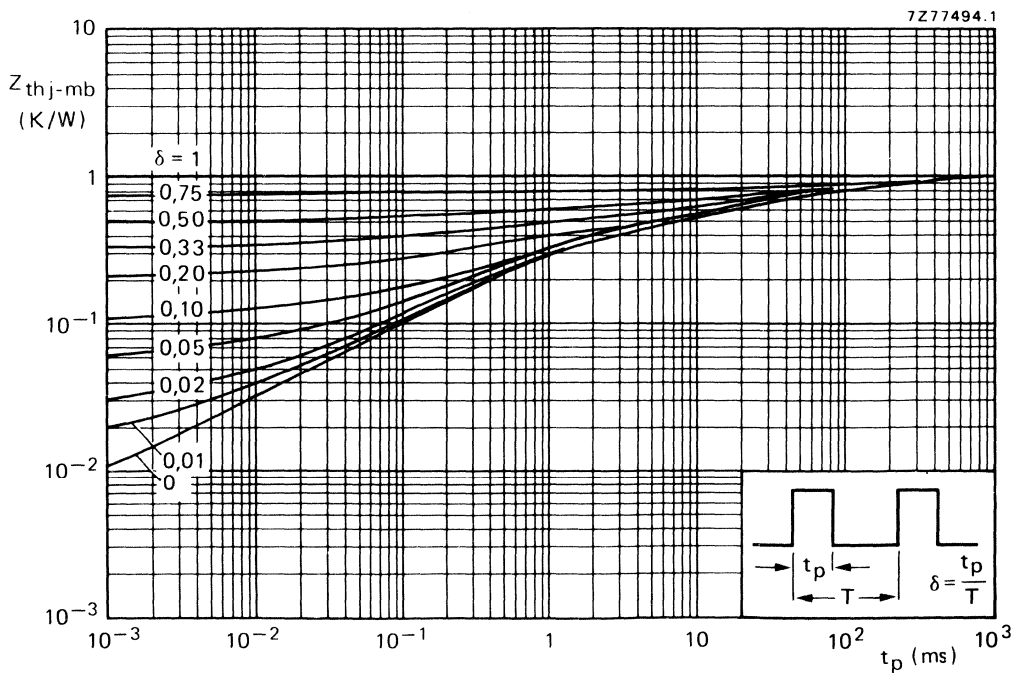


Fig. 8 Pulse power rating chart.

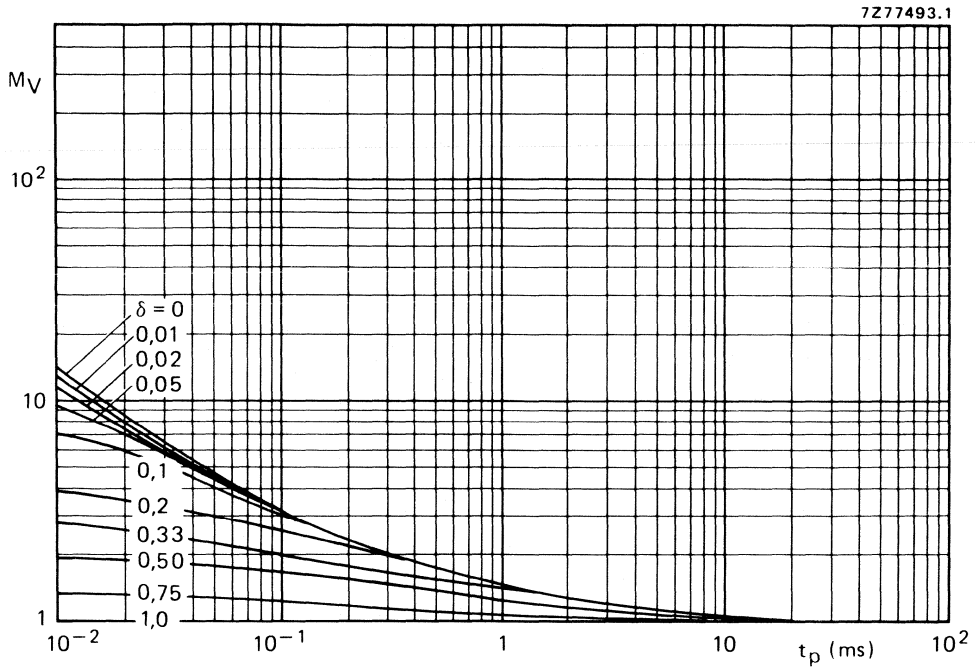


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

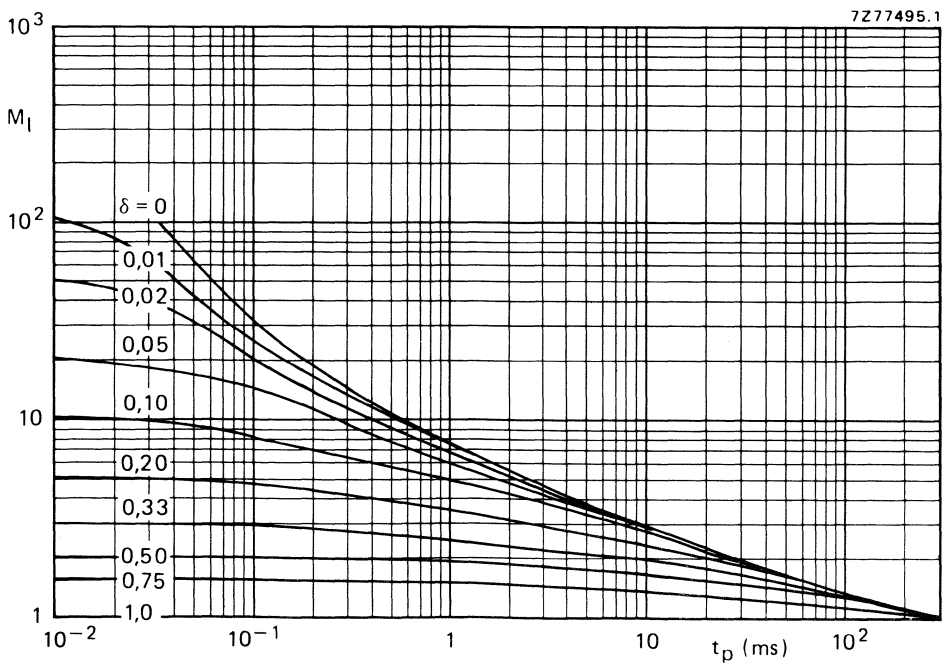


Fig. 10 S.B. current multiplying factor at the V_{CE0max} level (100 V).

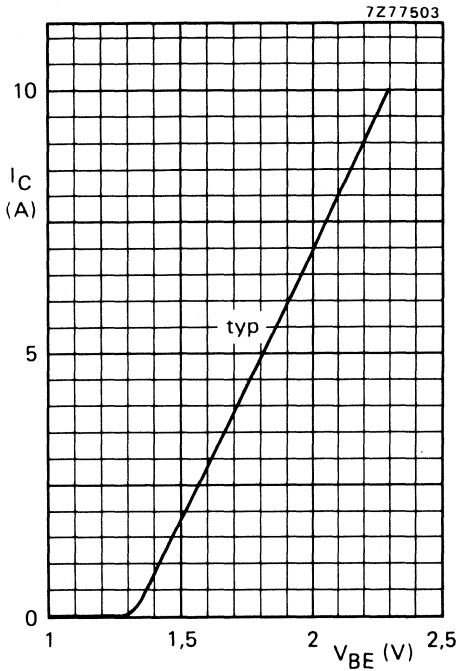


Fig. 11 $V_{CE} = 4 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

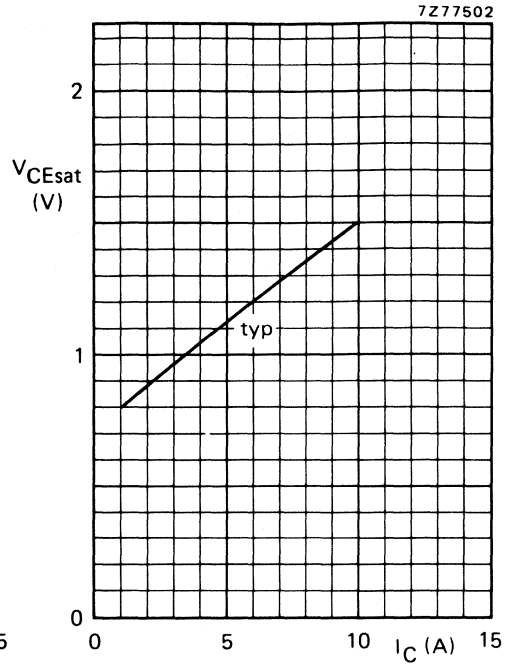


Fig. 12 $I_C/I_B = 250$; $T_j = 25 \text{ }^\circ\text{C}$.

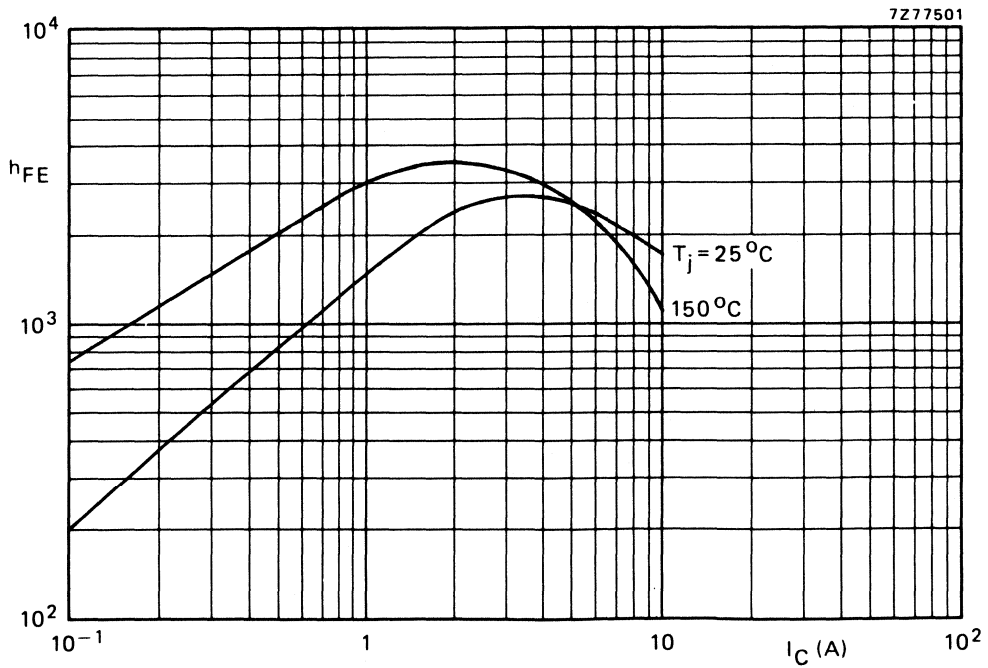


Fig. 13 Typical values; $V_{CE} = 4 \text{ V}$.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		175		W
Junction temperature	T_j max.		150		$^\circ\text{C}$
D.C. current gain					
$-I_C = 1\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} typ.		3000		
$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} >		1000		
Cut-off frequency					
$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe} typ.		60		kHz

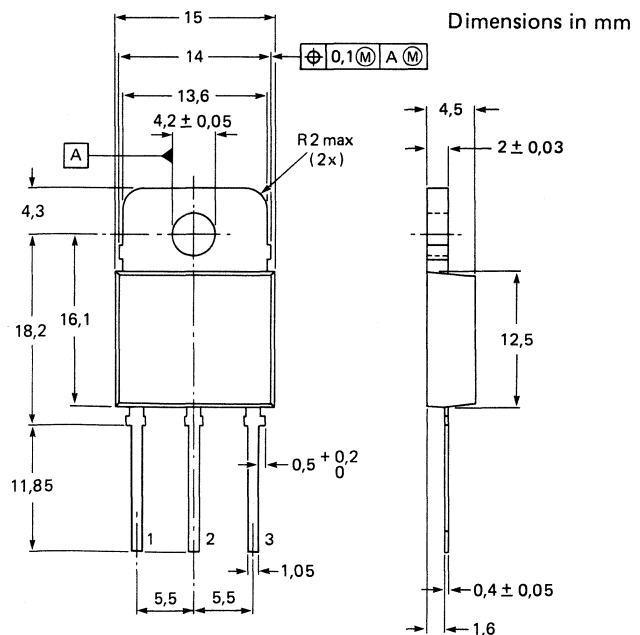
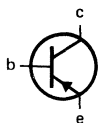
MECHANICAL DATA

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

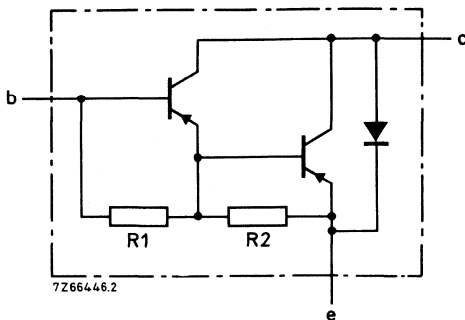


Fig. 2.
R1 typical 3 kΩ
R2 typical 80 Ω

RATINGS

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

		BDV66A				B	C	D
Collector-base voltage (open emitter)	$-V_{CB0}$	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 $T_{mb} = 25\text{ °C}$	P_{tot}	max.		175		W		
Storage temperature	T_{stg}		-65 to +150			°C		
Junction temperature*	T_j	max.		150		°C		

THERMAL RESISTANCE

From junction to mounting base* $R_{th\ j-mb} =$ 0,625 K/W

CHARACTERISTICS

$T_j = 25\text{ °C}$ unless otherwise specified.

Collector cut-off currents

$I_E = 0; -V_{CB} = -V_{CB0max}$ $-I_{CBO} <$ 1 mA

$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CB0max}; T_j = 150\text{ °C}$ $-I_{CBO} <$ 4 mA

$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEOmax}$ $-I_{CEO} <$ 1 mA

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$ $-I_{EBO} <$ 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*			
$-I_C = 1 \text{ A}; -V_{CE} = 3 \text{ V}$	h_{FE}	typ.	3000
$-I_C = 10 \text{ A}; -V_{CE} = 3 \text{ V}$	h_{FE}	>	1000
$-I_C = 16 \text{ A}; -V_{CE} = 3 \text{ V}$	h_{FE}	typ.	1000
Base-emitter voltage**			
$-I_C = 10 \text{ A}; -V_{CE} = 3 \text{ V}$	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage*			
$-I_C = 10 \text{ A}; -I_B = 40 \text{ mA}$	$-V_{CEsat}$	<	2 V
Collector capacitance at $f = 1 \text{ MHz}$			
$I_E = I_e = 0; -V_{CB} = 10 \text{ V}$	C_C	typ.	300 pF
Cut-off frequency			
$-I_C = 5 \text{ A}; -V_{CE} = 3 \text{ V}$	f_{hfe}	typ.	60 kHz
Diode, forward voltage			
$I_F = 10 \text{ A}$	V_F	<	3 V
D.C. current gain ratio of matched complementary pairs			
$-I_C = 10 \text{ A}; -V_{CE} = 3 \text{ V}$	h_{FE1}/h_{FE2}	<	2,5
Small-signal current gain			
$-I_C = 5 \text{ A}; -V_{CE} = 3 \text{ V}; f = 1 \text{ MHz}$	h_{fe}	typ.	40
Switching times			
$-I_{Con} = 10 \text{ A}; -I_{Bon} = I_{Boff} = 40 \text{ mA}; V_{CC} = -12 \text{ V}$			
Turn-on time	t_{on}	typ.	1 μs
Turn-off time	t_{off}	typ.	3,5 μs

* Measured under pulse conditions: $t_p < 300 \mu\text{s}$; $\delta < 2\%$.** $-V_{BE}$ decreases by about 3,6 mV/K with increasing temperature.

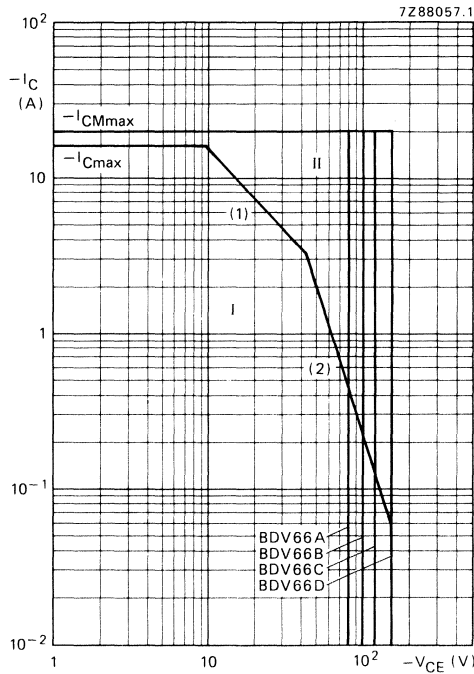


Fig. 3 Safe Operating Area; $T_{mb} \leq 25^\circ\text{C}$.

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

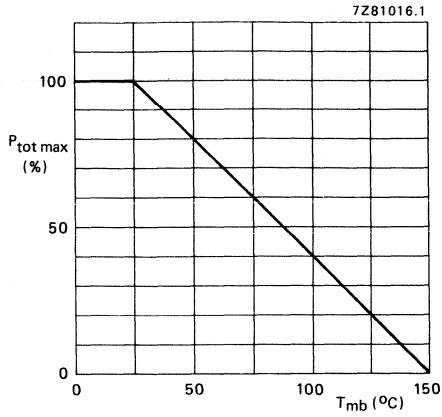


Fig. 4 Power derating curve.

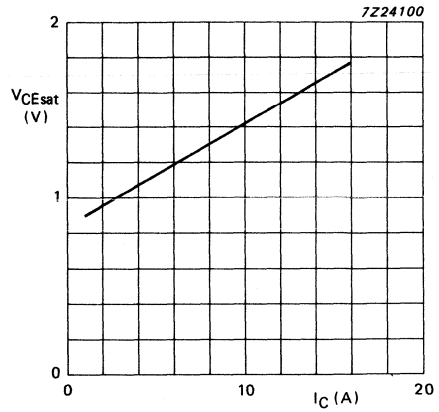


Fig. 5 Typical collector-emitter saturation voltage $-I_C/-I_B = 250$; $T_{mb} = 25$ °C.

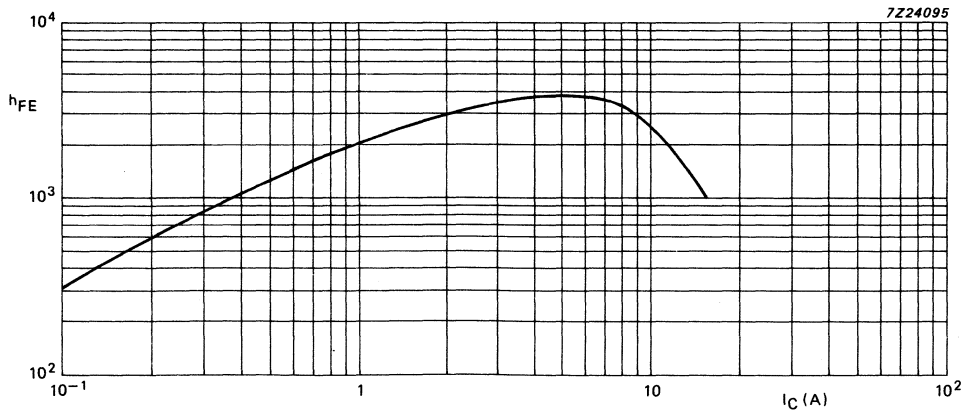


Fig. 6 Typical DC current gain $-V_{CE} = 3$ V; $T_j = 25$ °C.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.			200		W	
Junction temperature	T_j	max.			150		$^\circ\text{C}$	
D.C. current gain								
$I_C = 1\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.			3000			
$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	>			1000			
Cut-off frequency								
$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe}	typ.			60		kHz	

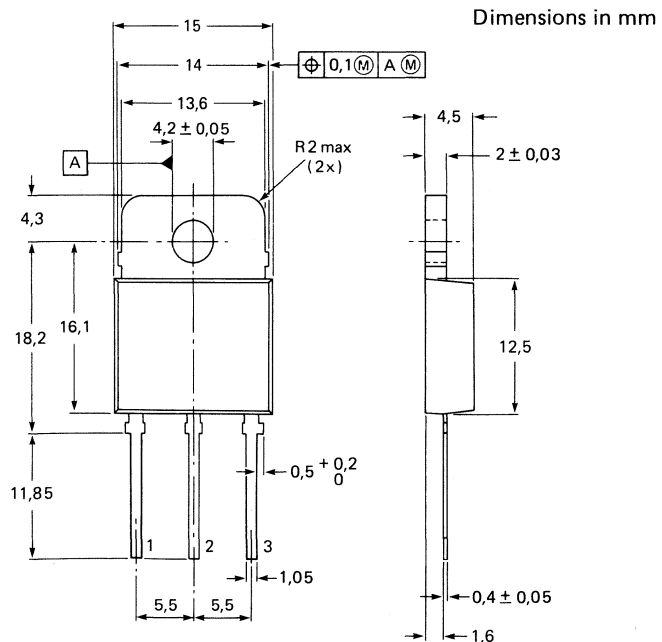
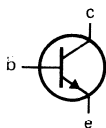
MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting-base.

Pinning:

- 1 = base
- 2 = collector
- 3 = emitter



See also chapters Mounting instructions and Accessories.

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CIRCUIT DIAGRAM

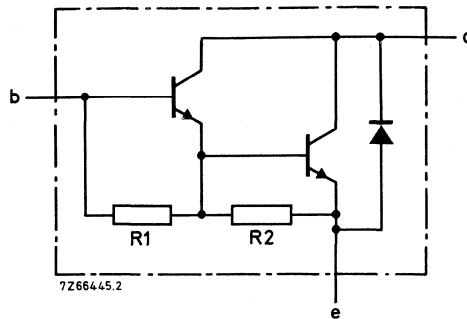


Fig. 2.
R1 typical 3 kΩ
R2 typical 80 Ω

RATINGS

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

		BDV67A				
		B	C	D		
Collector-base voltage (open emitter)	V_{CB0}	max.	100	120	140	160 V
Collector-emitter voltage (open base)	V_{CE0}	max.	80	100	120	150 V
Emitter-base voltage (open collector)	V_{EB0}	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		200		W
Storage temperature	T_{stg}		-65 to + 150			$^\circ\text{C}$
Junction temperature*	T_j	max.		150		$^\circ\text{C}$

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	0,625	K/W
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CHARACTERISTICS

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

Collector cut-off currents

$I_E = 0; V_{CB} = V_{CB0max}$	I_{CB0}	<	1	mA
$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0max}; T_j = 150\text{ }^\circ\text{C}$	I_{CB0}	<	4	mA
$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0max}$	I_{CE0}	<	1	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	5	mA
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

D.C. current gain*

$I_C = 1 \text{ A}; V_{CE} = 3 \text{ V}$

h_{FE} typ. 3000

$I_C = 10 \text{ A}; V_{CE} = 3 \text{ V}$

h_{FE} > 1000

$I_C = 16 \text{ A}; V_{CE} = 3 \text{ V}$

h_{FE} typ. 1000

Base-emitter voltage**

$I_C = 10 \text{ A}; V_{CE} = 3 \text{ V}$

V_{BE} < 2,5 V

Collector-emitter saturation voltage*

$I_C = 10 \text{ A}; I_B = 40 \text{ mA}$

V_{CEsat} < 2 V

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

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

C_c typ. 300 pF

Cut-off frequency

$I_C = 5 \text{ A}; V_{CE} = 3 \text{ V}$

f_{hfe} typ. 60 kHz

Diode, forward voltage

$I_F = 10 \text{ A}$

V_F < 3 V

D.C. current gain ratio of matched complementary pairs

$I_C = 10 \text{ A}; V_{CE} = 3 \text{ V}$

h_{FE1}/h_{FE2} < 2,5

Small-signal current gain

$I_C = 5 \text{ A}; V_{CE} = 3 \text{ V}; f = 1 \text{ MHz}$

h_{fe} typ. 40

Turn-off breakdown energy with inductive load (see also Fig. 3).

$I_{Con} = 6,3 \text{ A}; -I_{Boff} = 0; t_p = 1 \text{ ms}; T = 100 \text{ ms}$

$E(BR)$ > 150 mJ

Switching times

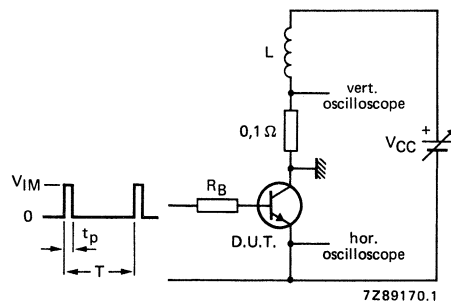
$I_{Con} = 10 \text{ A}; I_{Bon} = -I_{Boff} = 40 \text{ mA}; V_{CC} = 12 \text{ V}$

Turn-on time

t_{on} typ. 1 μs

Turn-off time

t_{off} typ. 3,5 μs

Fig. 3 Test circuit; $V_1 = 12 \text{ V}$; $R_B = 270 \Omega$.* Measured under pulse conditions: $t_p < 300 \mu\text{s}$; $\delta < 2\%$.** V_{BE} decreases by about 3,6 mV/K with increasing temperature.

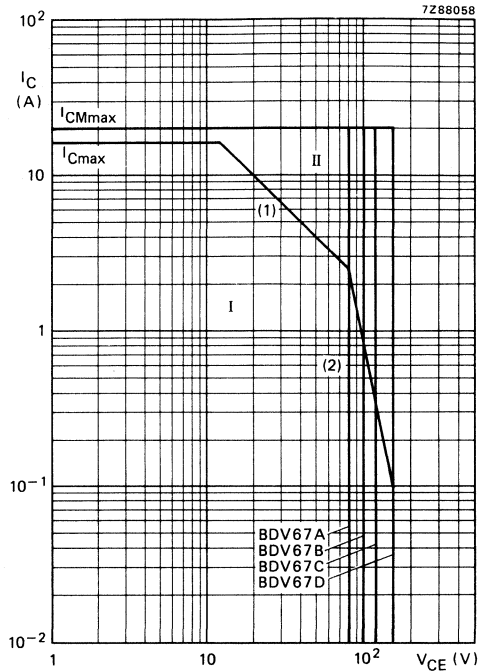


Fig. 4 Safe Operating Area; $T_{mb} \leq 25^\circ C$.

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

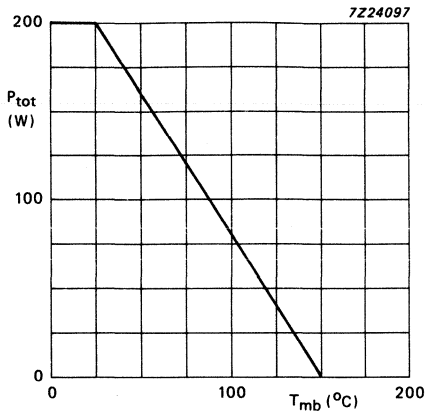


Fig. 5 Power derating curve.

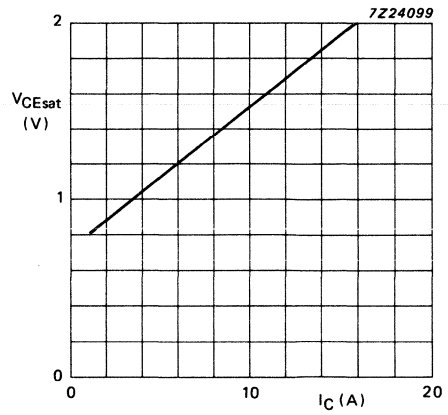


Fig. 6 Typical collector-emitter saturation voltage at $T_{mb} = 25^\circ\text{C}$; $I_C/I_B = 250$.

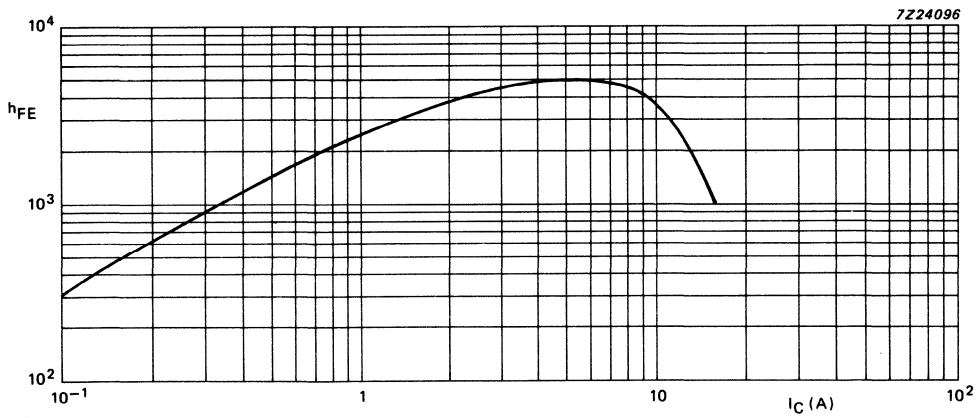


Fig. 7 Typical DC current gain at $V_{CE} = 3\text{ V}$.

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_{CB0}	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 $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.		100	W
Junction temperature	T_j	max.		150	$^\circ\text{C}$
D.C. current gain	h_{FE}	>		20	
$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$					
Transition frequency	f_T	>		3	MHz
$I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$					

MECHANICAL DATA

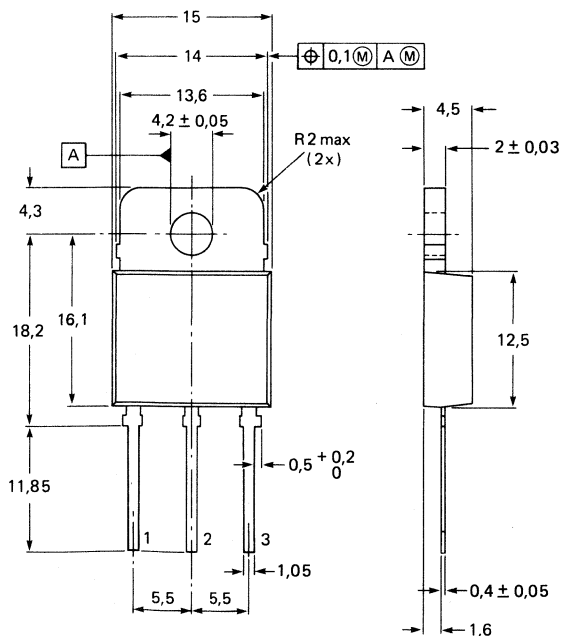
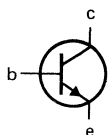
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



See chapters Mounting instructions SOT-93 and Accessories.

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RATINGS

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

			BDV91	BDV93	BDV95
Collector-base voltage (open emitter)	V_{CB0}	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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		100	W
Storage temperature	T_{stg}			-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=		1,25	K/W
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CHARACTERISTICS

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

Collector cut-off currents

$I_E = 0; V_{CB} = V_{CB0\ max}$

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0\ max}; T_j = 150\text{ }^\circ\text{C}$

$I_B = 0; V_{CE} = V_{CEO\ max}$

I_{CB0}	<	0,1	mA
I_{CB0}	<	1	mA
I_{CEO}	<	0,2	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 7\text{ V}$

I_{EBO}	<	0,1	mA
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D.C. current gain

$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$

$I_C = 10\text{ A}; V_{CE} = 4\text{ V}$

h_{FE}	>	20	
h_{FE}	>	5	

Collector-emitter saturation voltage

$I_C = 4\text{ A}; I_B = 0,4\text{ A}$

$I_C = 10\text{ A}; I_B = 3,3\text{ A}$

$V_{CE\ sat}$	<	1	V
$V_{CE\ sat}$	<	3	V

Base-emitter saturation voltage

$I_C = 4\text{ A}; I_B = 0,4\text{ A}$

$V_{BE\ sat}$	<	1,6	V
---------------	---	-----	---

Base-emitter voltage

$I_C = 4\text{ A}; V_{CE} = 4\text{ V}$

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

CHARACTERISTICS (continued)

Transition frequency

$I_C = 0,5 \text{ A}; V_{CE} = 10 \text{ V}$

$f_T > 3 \text{ MHz}$

Switching times (between 10% and 90% levels)

$I_{Con} = 4 \text{ A}; I_{Bon} = -I_{Boff} = 0,4 \text{ A}; V_{CC} = 30 \text{ V}$

Turn-on time

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

Turn-off time

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

Fall time

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

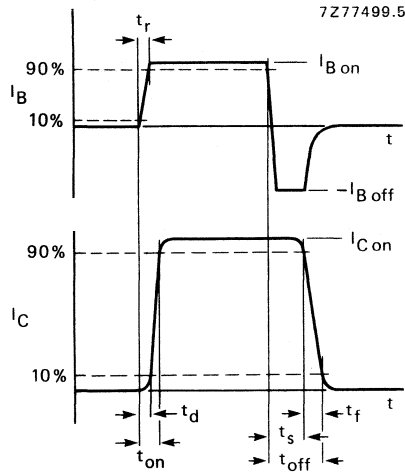


Fig. 2 Switching times waveforms.

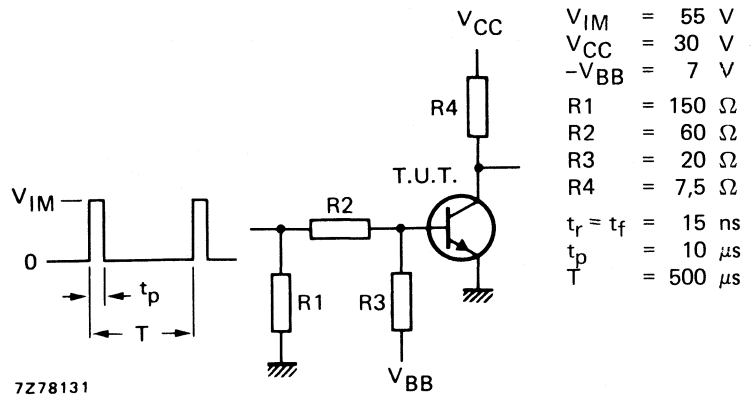


Fig. 3 Switching times test circuit.

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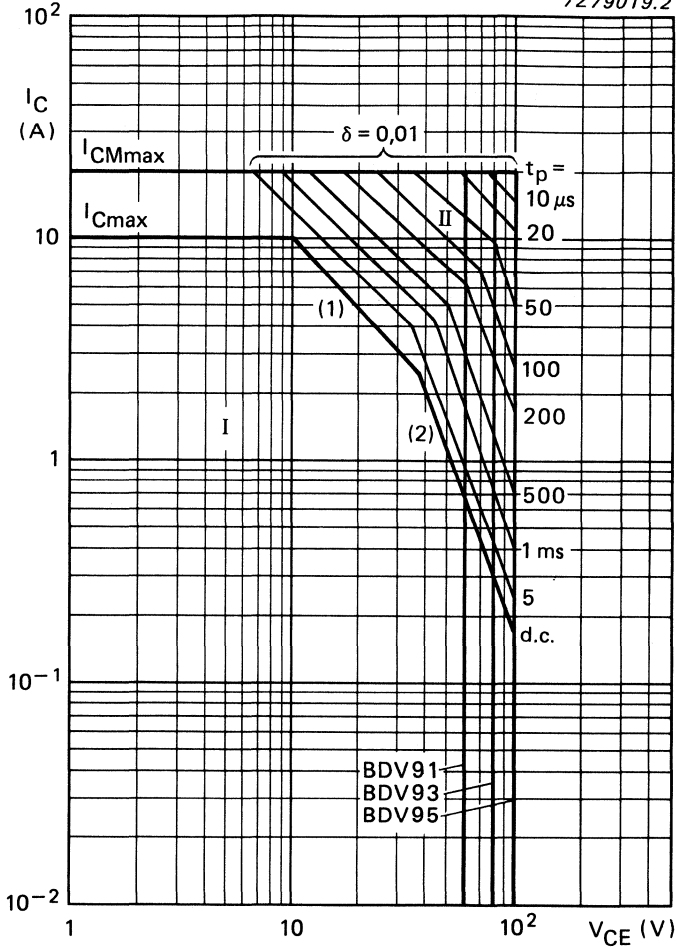


Fig. 4 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

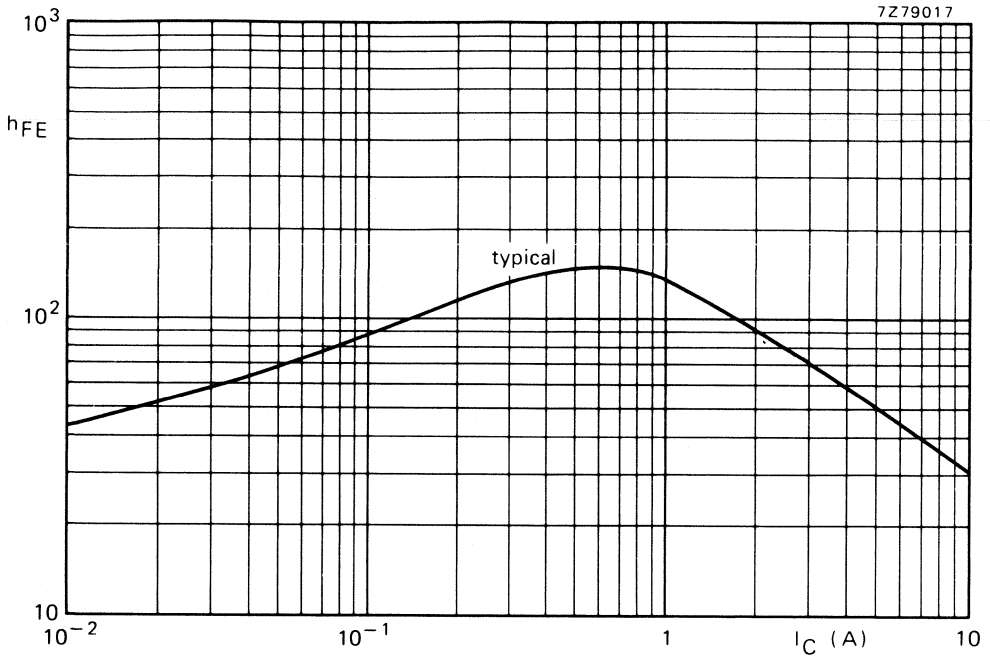


Fig. 5 $V_{CE} = 4$ V; $T_j = 25$ °C.

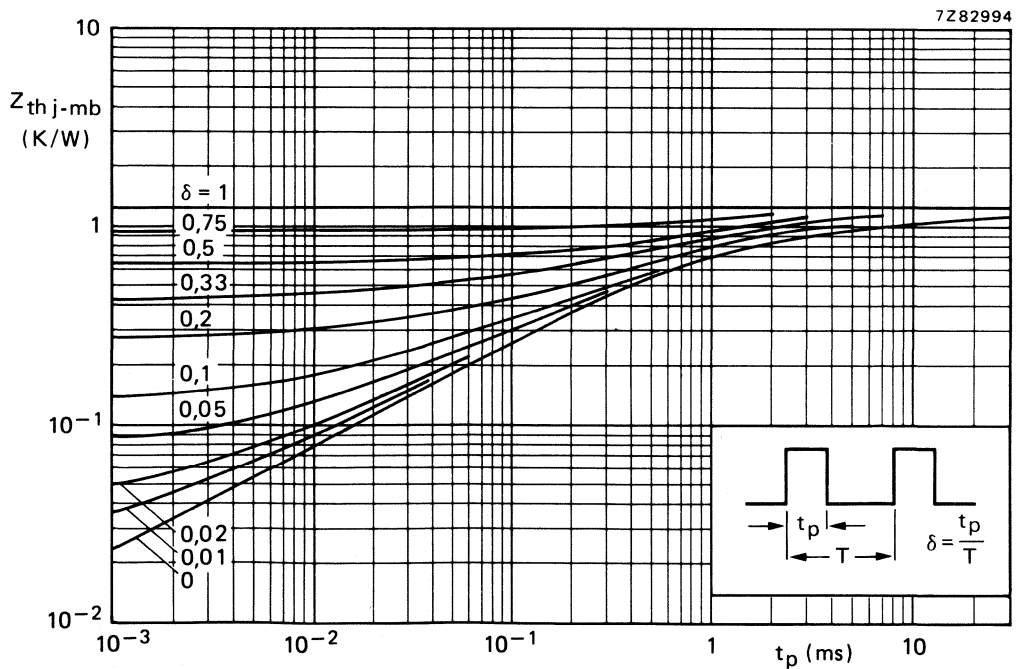


Fig. 6 Pulse power rating chart.

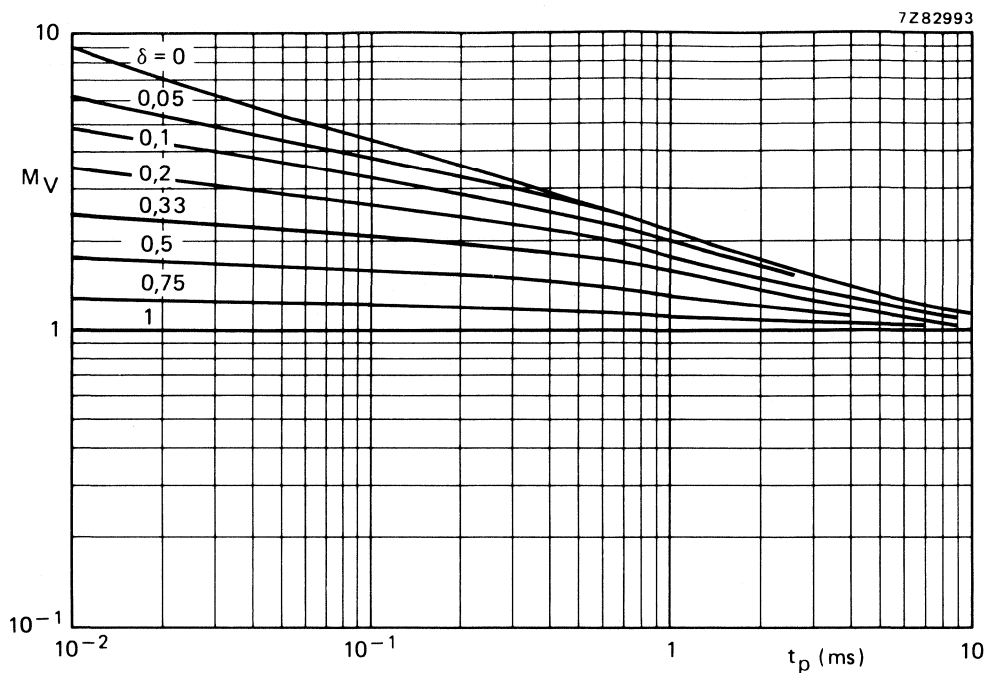


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

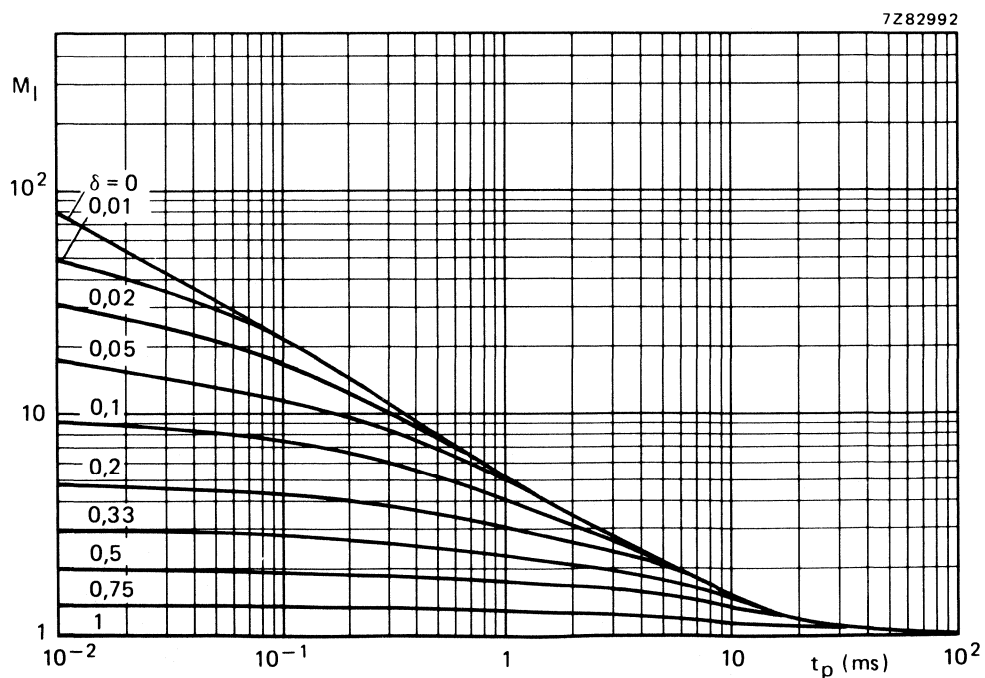


Fig. 8 Second-breakdown current multiplying factor at the V_{CE0max} level.

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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.		100	W
Junction temperature	T_j max.		150	$^\circ\text{C}$
D.C. current gain				
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	$h_{FE} >$		20	
Transition frequency				
$-I_C = 0,5\text{ A}; -V_{CE} = 10\text{ V}$	$f_T >$		4	MHz

MECHANICAL DATA

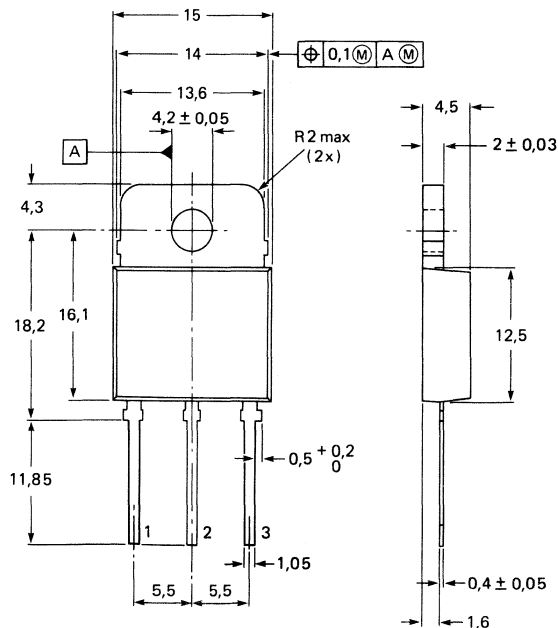
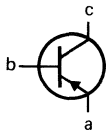
Dimensions in mm

Fig. 1 SOT-93.

Collector connect
to mounting base

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



See chapters Mounting instructions
SOT-93 and Accessories.

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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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	100		W
Storage temperature	T_{stg}	-65 to +150		$^\circ\text{C}$
Junction temperature	T_j max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb} =$	1,25	K/W
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CHARACTERISTICS

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

→ Collector cut-off currents				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO} <$	0,1	mA	
$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CBOmax}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO} <$	1	mA	
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO} <$	0,2	mA	
→ Emitter cut-off current				
$I_C = 0; -V_{EB} = 7\text{ V}$	$-I_{EBO} <$	0,1	mA	
D.C. current gain				
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	$h_{FE} >$	20		
$-I_C = 10\text{ A}; -V_{CE} = 4\text{ V}$	$h_{FE} >$	5		
Collector-emitter saturation voltage				
$-I_C = 4\text{ A}; -I_B = 0,4\text{ A}$	$-V_{CEsat} <$	1	V	
$-I_C = 10\text{ A}; -I_B = 3,3\text{ A}$	$-V_{CEsat} <$	3	V	
Base-emitter saturation voltage				
$-I_C = 4\text{ A}; -I_B = 0,4\text{ A}$	$-V_{BEsat} <$	1,6	V	
Base-emitter voltage				
$-I_C = 4\text{ A}; -V_{CE} = 4\text{ V}$	$-V_{BE} <$	1,6	V	

CHARACTERISTICS (continued)

Transition frequency

$-I_C = 0,5 \text{ A}; -V_{CE} = 10 \text{ V}$

$f_T > 4 \text{ MHz}$

Switching times (between 10% and 90% levels)

$-I_{Con} = 4 \text{ A}; -I_{Bon} = I_{Boff} = 0,4 \text{ A}; -V_{CC} = 30 \text{ V}$

Turn-on time

$t_{on} \text{ typ. } 0,3 \mu\text{s}$

Turn-off time

$t_{off} \text{ typ. } 0,7 \mu\text{s}$

Fall time

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

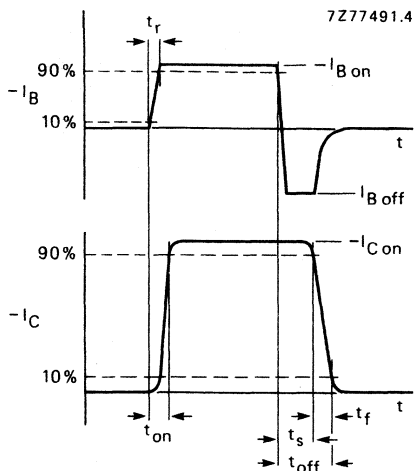
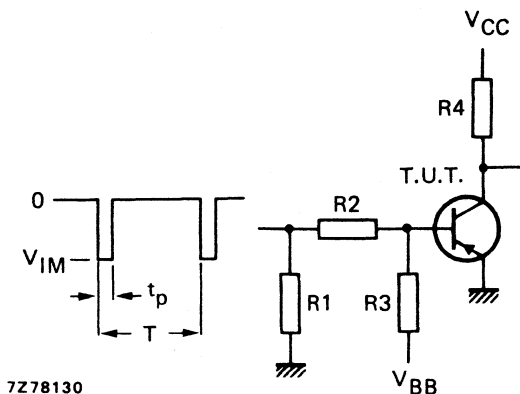


Fig. 2 Switching times waveforms.



- $-V_{IM} = 55 \text{ V}$
- $-V_{CC} = 30 \text{ V}$
- $V_{BB} = 7 \text{ V}$
- $R1 = 150 \Omega$
- $R2 = 60 \Omega$
- $R3 = 20 \Omega$
- $R4 = 7,5 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

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Fig. 3 Switching times test circuit.

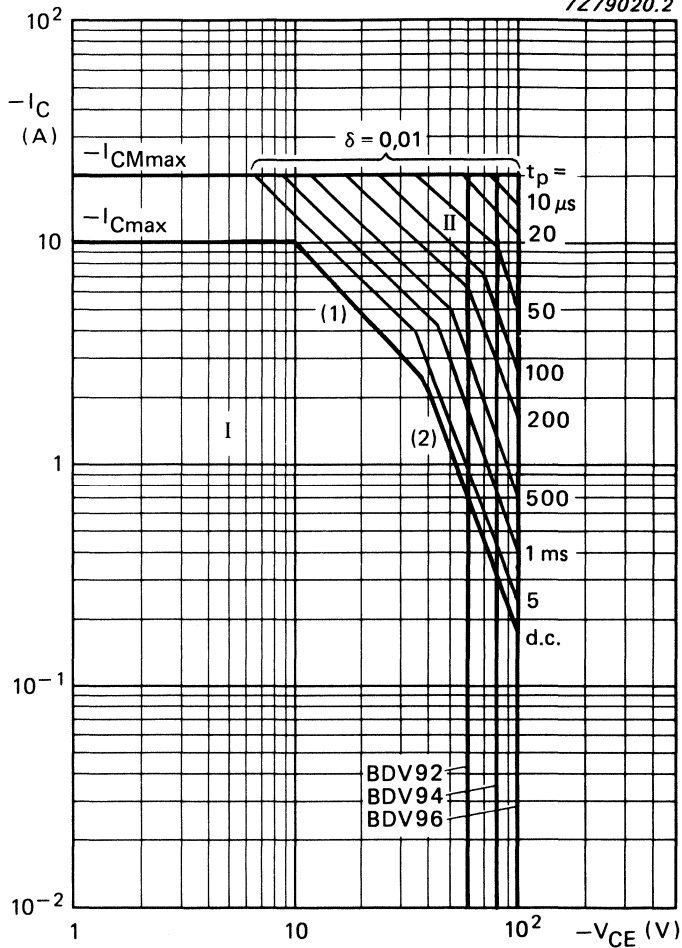


Fig. 4 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

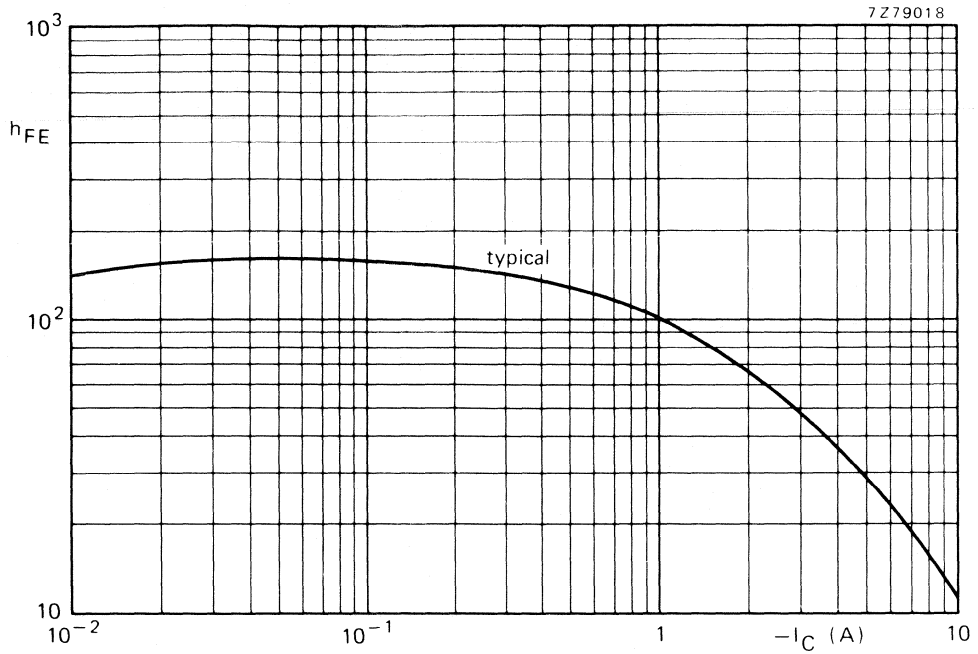


Fig. 5 $-V_{CE} = 4 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

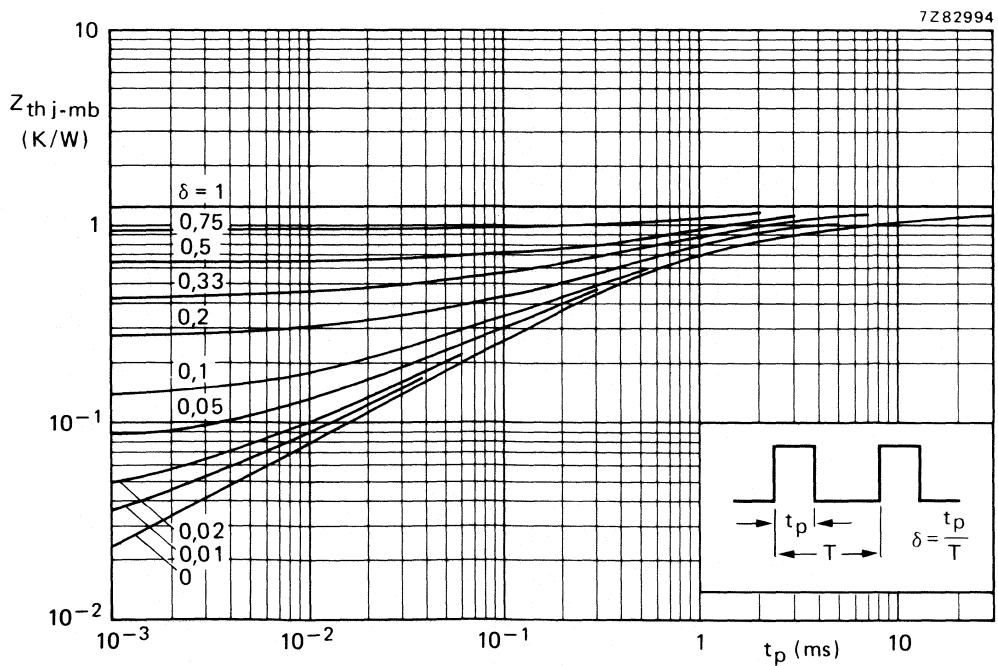


Fig. 6 Pulse power rating chart.

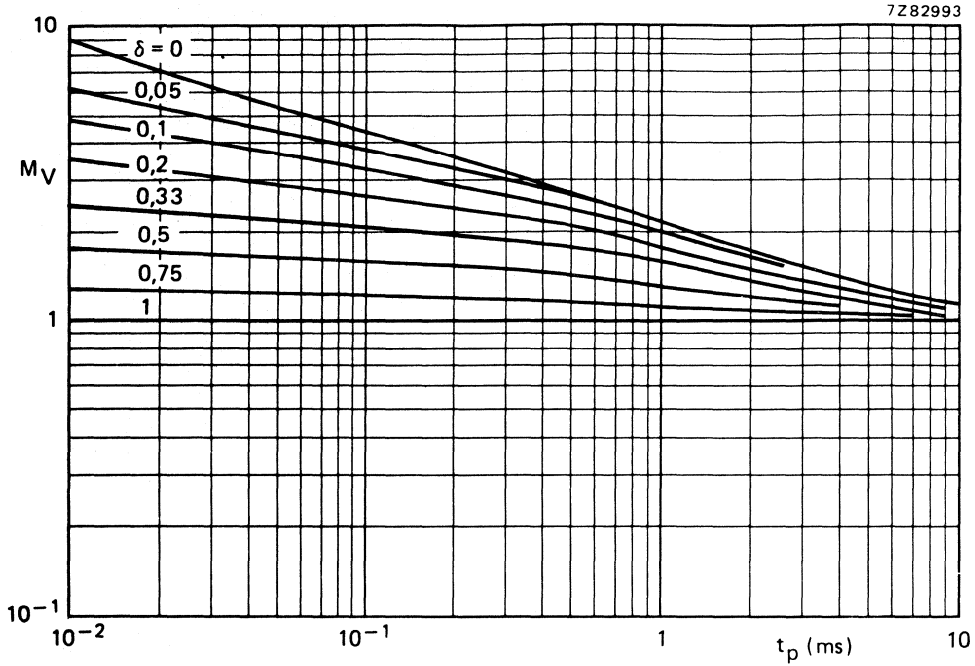


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

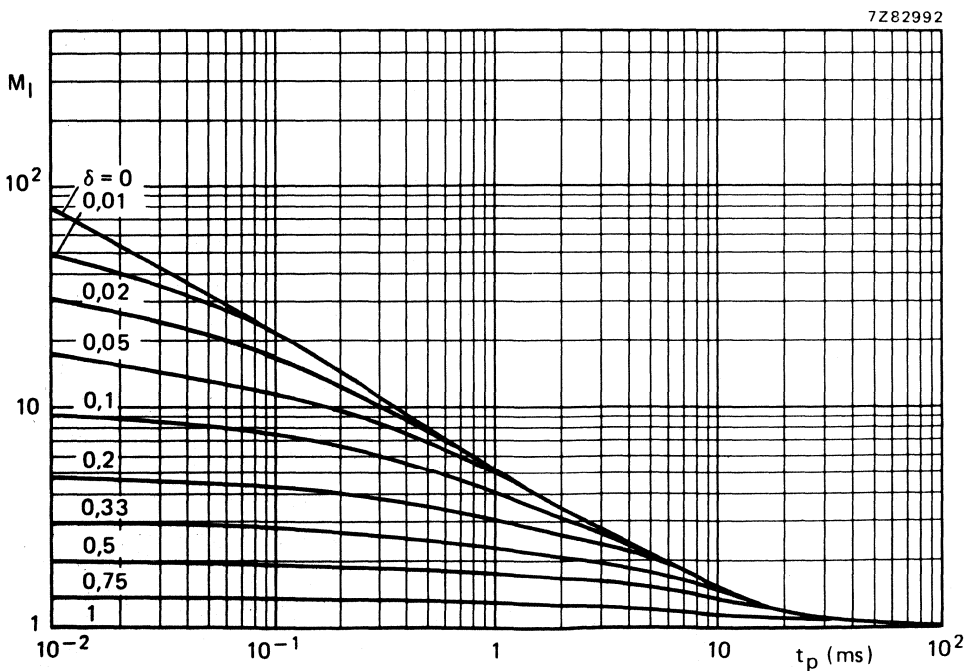


Fig. 8 Second-breakdown current multiplying factor at the V_{CE0max} level.

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 $T_{mb} = 75^\circ\text{C}$	P_{tot}	max.	15	15	15 W
D.C. current gain $I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	h_{FE}	>	45	45	45
Collector-emitter saturation voltage $I_C = 5\text{ A}; I_B = 0,5\text{ A}$	V_{CEsat}	<	0,9	0,7	0,9 V
Turn-off time $I_{Con} = 5\text{ A}; I_{Bon} = -I_{Boff} = 0,5\text{ A}$	t_{off}	typ.	350	350	350 ns

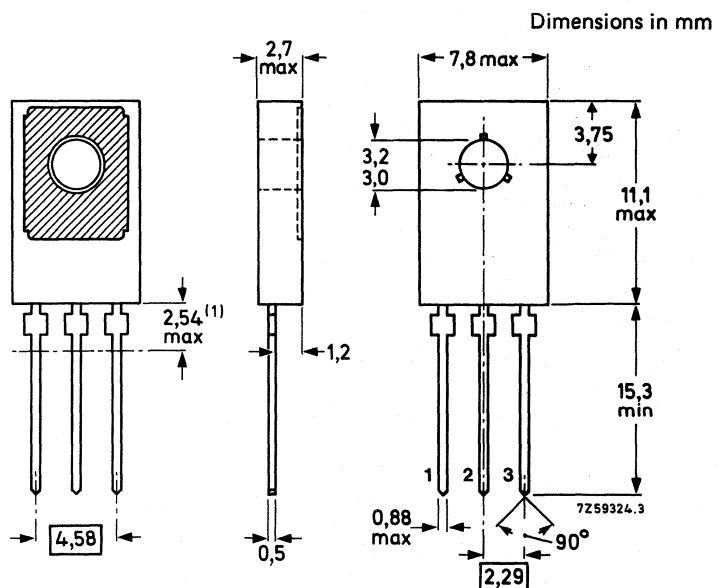
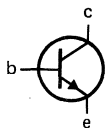
MECHANICAL DATA

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 $T_{mb} = 75\text{ }^\circ\text{C}$	P_{tot}	max.		15	W
up to $T_{amb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		1,25	W
Storage temperature	T_{stg}			-65 to + 150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$
THERMAL RESISTANCE					
From junction to mounting base	$R_{th\ j-mb}$	=		5	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		100	K/W

CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; V_{CB} = 80\text{ V}$ BDX35 $I_{CBO} < 10\text{ }\mu\text{A}$ $I_E = 0; V_{CB} = 80\text{ V}; T_j = 100\text{ }^\circ\text{C}$ BDX35 $I_{CBO} < 50\text{ }\mu\text{A}$ $I_E = 0; V_{CB} = 100\text{ V}$ BDX36/37 $I_{CBO} < 10\text{ }\mu\text{A}$ $I_E = 0; V_{CB} = 100\text{ V}; T_j = 100\text{ }^\circ\text{C}$ BDX36/37 $I_{CBO} < 50\text{ }\mu\text{A}$

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$ I_{EBO} typ. 5 nA
 $I_{EBO} < 10\text{ }\mu\text{A}$ $I_C = 0; V_{EB} = 5\text{ V}$ $I_{EBO} < 1\text{ mA}$

D.C. current gain

 $I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$ BDX35/36 h_{FE} 45 to 450BDX37 h_{FE} typ. 130 h_{FE} typ. 80

Collector-emitter saturation voltage

 $I_C = 5\text{ A}; I_B = 0,5\text{ A}$ BDX35/37 $V_{CEsat} < 0,9\text{ V}$ BDX36 $V_{CEsat} < 0,7\text{ V}$ $I_C = 7\text{ A}; I_B = 0,7\text{ A}$ BDX35/37 $V_{CEsat} < 1,2\text{ V}$ $I_C = 10\text{ A}; I_B = 1\text{ A}$ BDX36 $V_{CEsat} < 1,5\text{ V}$

Base-emitter saturation voltage

 $I_C = 5\text{ A}; I_B = 0,5\text{ A}$ BDX35/37 $V_{BEsat} < 1,6\text{ V}$ $I_C = 7\text{ A}; I_B = 0,7\text{ A}$ BDX35/37 $V_{BEsat} < 1,9\text{ V}$ ← $I_C = 10\text{ A}; I_B = 1\text{ A}$ BDX36 $V_{BEsat} < 2,5\text{ V}$ ←Collector capacitance at $f = 1\text{ MHz}$ $I_E = I_e = 0; V_{CB} = 10\text{ V}$ C_c typ. 40 pF
 $C_c < 60\text{ pF}$ Transition frequency at $f = 35\text{ MHz}$ $I_C = 0,5\text{ A}; V_{CE} = 5\text{ V}; T_{amb} = 25\text{ }^\circ\text{C}$ f_T typ. 100 MHz

Switching times

(between 10% and 90% levels)

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

turn-on time

 t_{on} typ. 0,06 μs
 $t_{on} < 0,1\text{ }\mu\text{s}$

turn-off time

 t_{off} typ. 0,6 μs
 $t_{off} < 0,8\text{ }\mu\text{s}$ $I_{Con} = 2\text{ A}; I_{Bon} = -I_{Boff} = 0,2\text{ A}$

turn-on time

 $t_{on} < 80\text{ ns}$

turn-off time

 t_{off} typ. 0,45 μs
 $t_{off} < 0,7\text{ }\mu\text{s}$ $I_{Con} = 5\text{ A}; I_{Bon} = -I_{Boff} = 0,5\text{ A}$

turn-on time

 t_{on} typ. 180 ns
 $t_{on} < 300\text{ ns}$

turn-off time

 t_{off} typ. 320 ns
 $t_{off} < 500\text{ ns}$

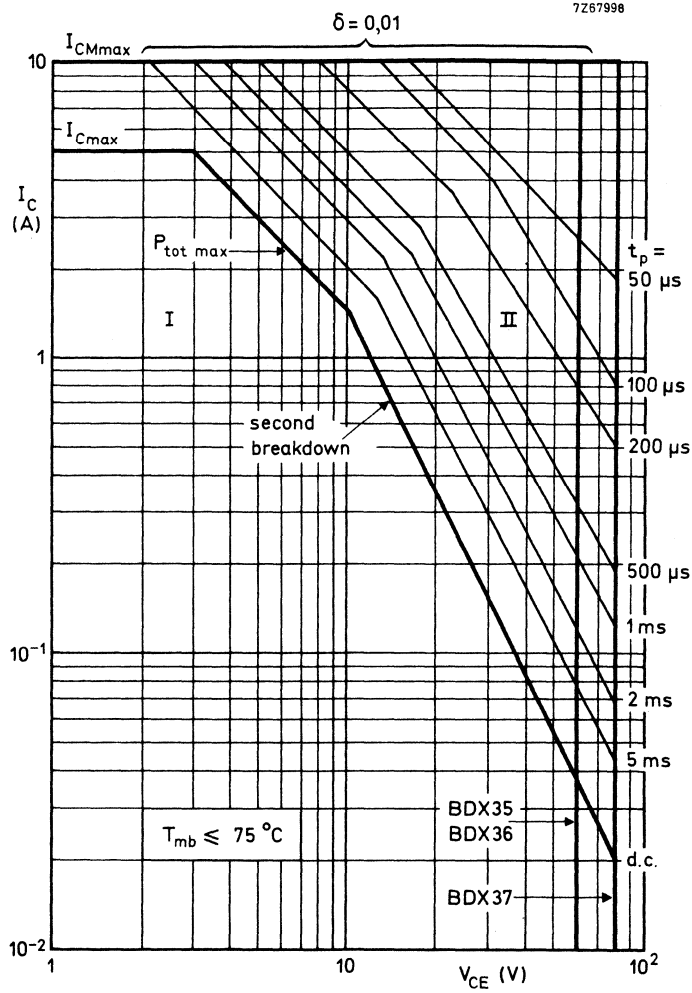


Fig. 2 Safe Operating Area with the transistor forward biased.

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

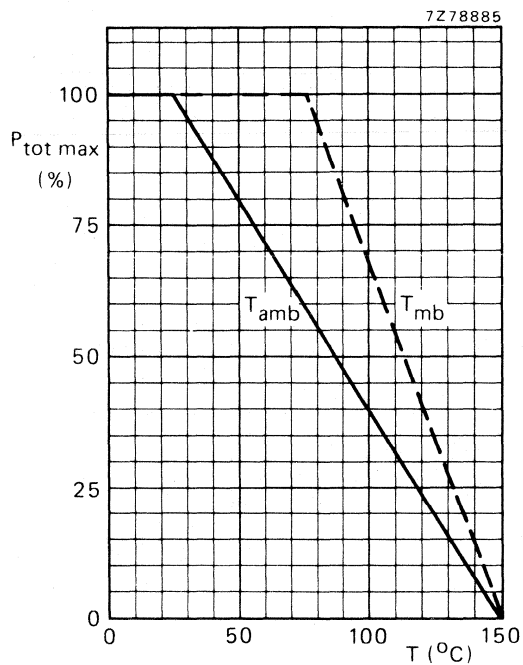


Fig. 3 Power derating curve.

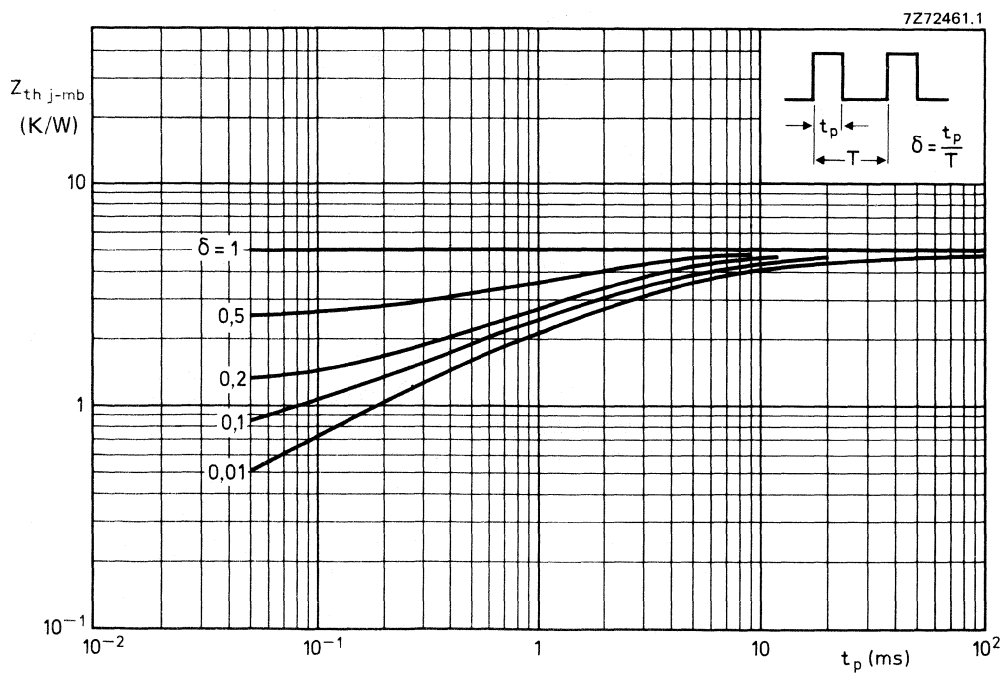


Fig. 4 Pulse power rating chart.

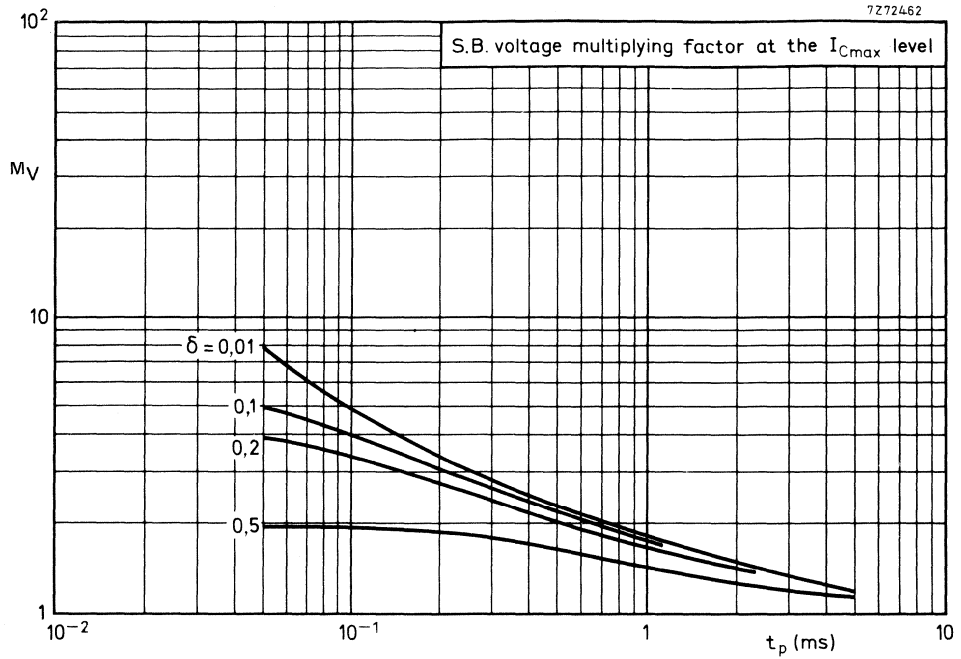


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

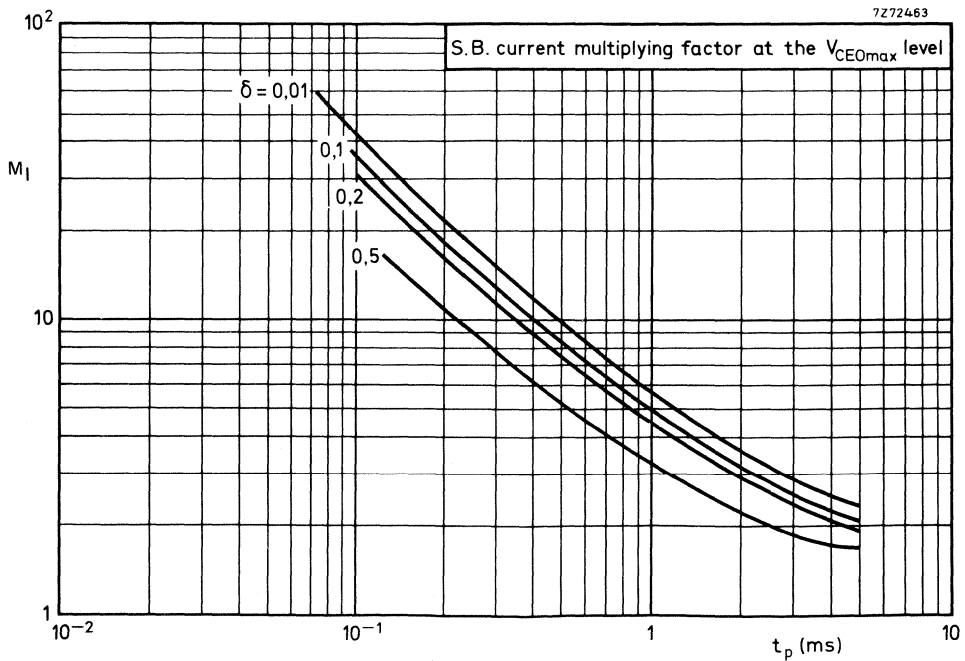


Fig. 6 S.B. current multiplying factor at the V_{CE0max} level.

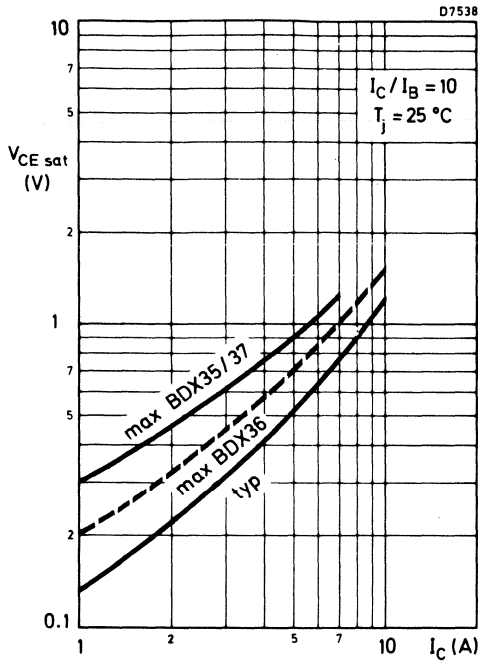


Fig. 7 Collector-emitter saturation voltage as a function of the collector current.

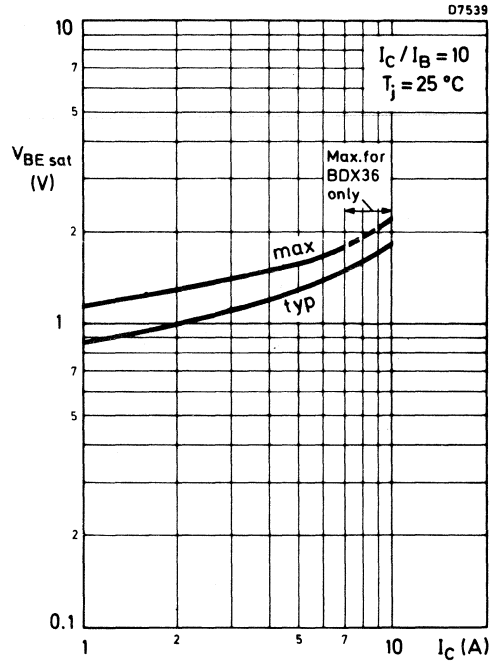


Fig. 8 Base-emitter saturation voltage as a function of the collector current.

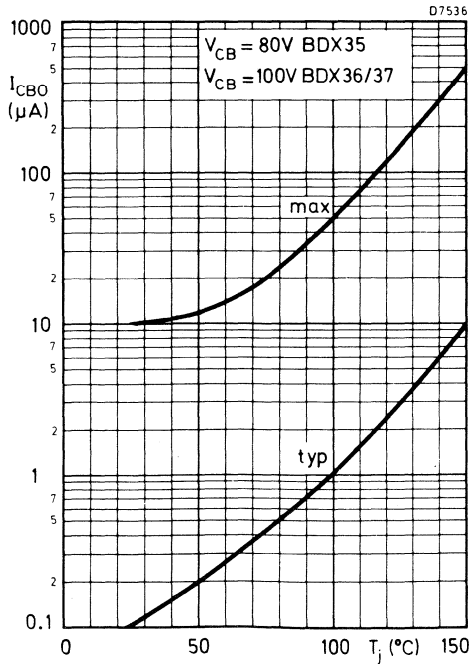


Fig. 9 Collector-base current with an open emitter as a function of junction temperature.

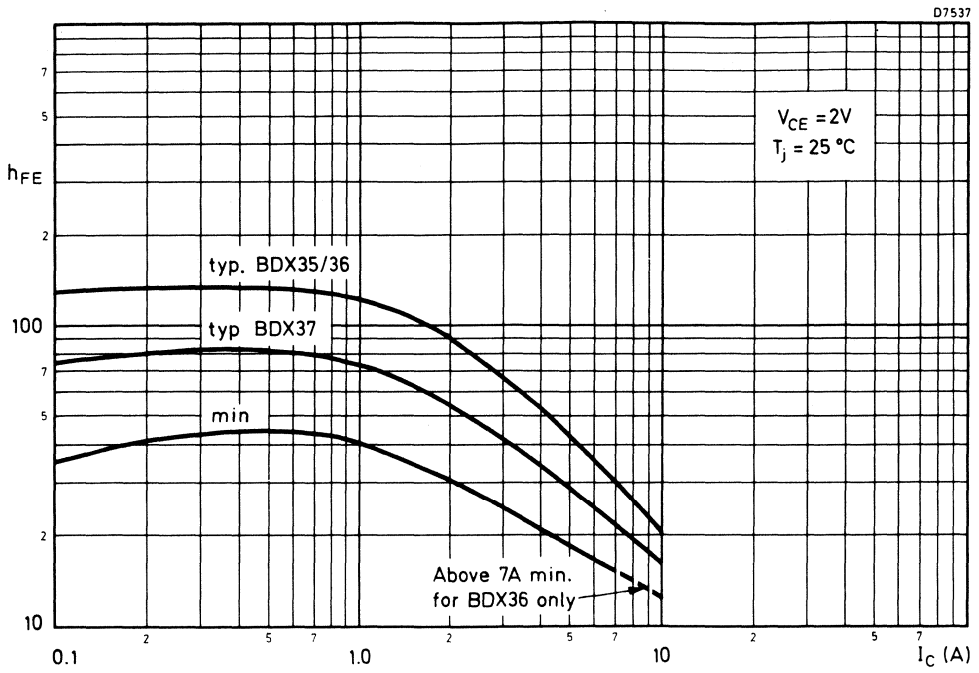


Fig. 10 D.C. current gain as a function of collector current.

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 $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{mb} = 100\text{ }^\circ\text{C}$	P_{tot} max.	1,25	1,25	1,25 W
	P_{tot} max.	5	5	5 W
D.C. current gain $I_C = 500\text{ mA}$; $V_{CE} = 10\text{ V}$	h_{FE} >	2000	2000	2000
Collector-emitter saturation voltage $I_C = 1\text{ A}$; $I_B = 1\text{ mA}$ $I_C = 1\text{ A}$; $I_B = 4\text{ mA}$	V_{CEsat} <	—	1,6	— V
	V_{CEsat} <	1,6	—	1,6 V
Turn-off time $I_C = 500\text{ mA}$; $I_{Bon} = -I_{Boff} = 0,5\text{ mA}$	t_{off} typ.	1500	1500	1500 ns

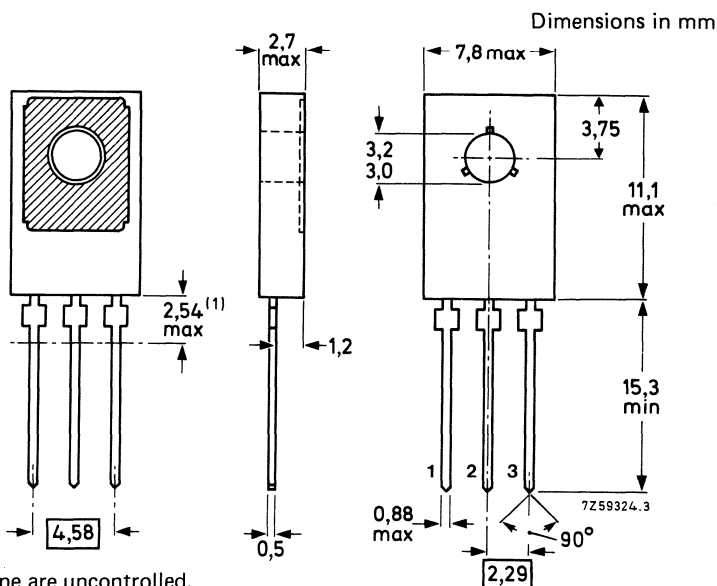
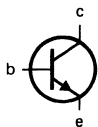
MECHANICAL DATA

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.

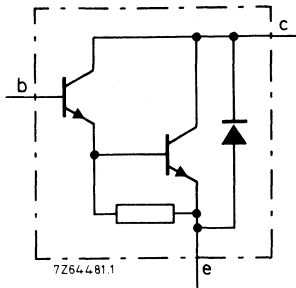


Fig. 2 Circuit diagram.

RATINGS

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

			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 $T_{amb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		1,25	W
up to $T_{mb} = 100\text{ }^\circ\text{C}$	P_{tot}	max.		5	W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature **	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE **

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

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

Collector cut-off current

 $V_{BE} = 0; V_{CE} = 45\text{ V}$ BDX42 $I_{CES} < 10\text{ }\mu\text{A}$ $V_{BE} = 0; V_{CE} = 60\text{ V}$ BDX43 $I_{CES} < 10\text{ }\mu\text{A}$ $V_{BE} = 0; V_{CE} = 80\text{ V}$ BDX44 $I_{CES} < 10\text{ }\mu\text{A}$

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$ $I_{EBO} < 10\text{ }\mu\text{A}$

D.C. current gain

 $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$ $h_{FE} > 1000$ $I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$ $h_{FE} > 2000$

Collector-emitter saturation voltage

 $I_C = 500\text{ mA}; I_B = 0,5\text{ mA}$ $V_{CEsat} < 1,3\text{ V}$ $I_C = 1\text{ A}; I_B = 1\text{ mA}$ BDX43 $V_{CEsat} < 1,6\text{ V}$ $I_C = 1\text{ A}; I_B = 4\text{ mA}$ BDX42, 44 $V_{CEsat} < 1,6\text{ V}$ $I_C = 500\text{ mA}; I_B = 0,5\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ $V_{CEsat} < 1,3\text{ V}$ $I_C = 1\text{ A}; I_B = 1\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ BDX43 $V_{CEsat} < 1,8\text{ V}$ $I_C = 1\text{ A}; I_B = 4\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ BDX42, 44 $V_{CEsat} < 1,6\text{ V}$

Base-emitter saturation voltage

 $I_C = 500\text{ mA}; I_B = 0,5\text{ mA}$ $V_{BEsat} < 1,9\text{ V}$ $I_C = 1\text{ A}; I_B = 1\text{ mA}$ BDX43 $V_{BEsat} < 2,2\text{ V}$ $I_C = 1\text{ A}; I_B = 4\text{ mA}$ BDX42, 44 $V_{BEsat} < 2,2\text{ V}$

Small signal current gain

 $I_C = 500\text{ mA}; V_{CE} = 5\text{ V}; f = 35\text{ MHz}$ h_{fe} typ. 10

Switching times (see also Fig. 3 and Fig. 4)

 $I_C = 500\text{ mA}; I_{Bon} = -I_{Boff} = 0,5\text{ mA}$

Turn-on time

 t_{on} typ. 400 ns

Turn-off time

 t_{off} typ. 1500 ns $I_C = 1\text{ A}; I_{Bon} = -I_{Boff} = 1\text{ mA}$

Turn-on time

 t_{on} typ. 400 ns

Turn-off time

 t_{off} typ. 1500 ns

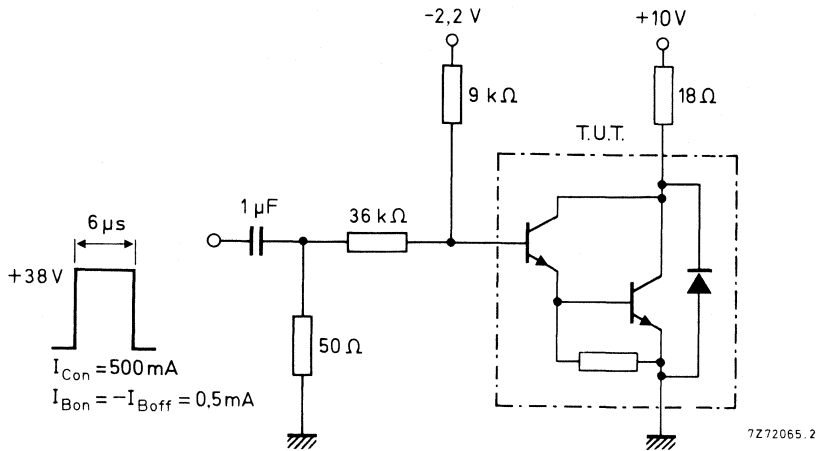


Fig. 3 Test circuit for 500 mA switching.

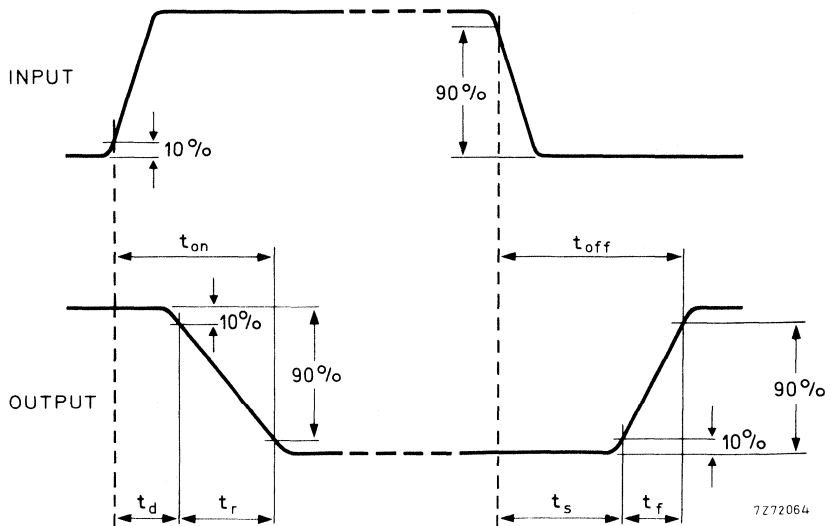


Fig. 4 Switching waveforms.

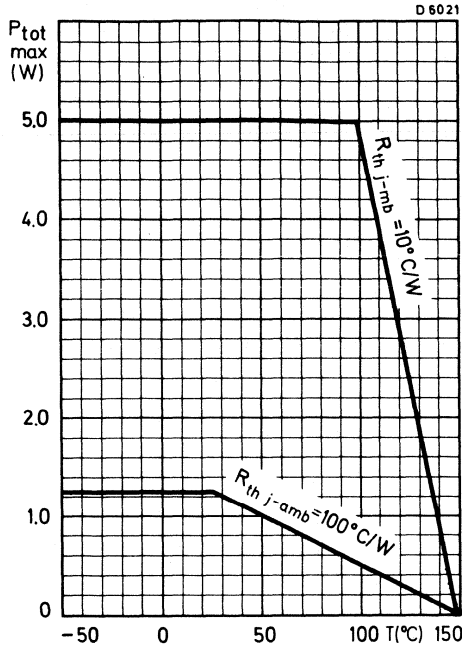


Fig. 5.

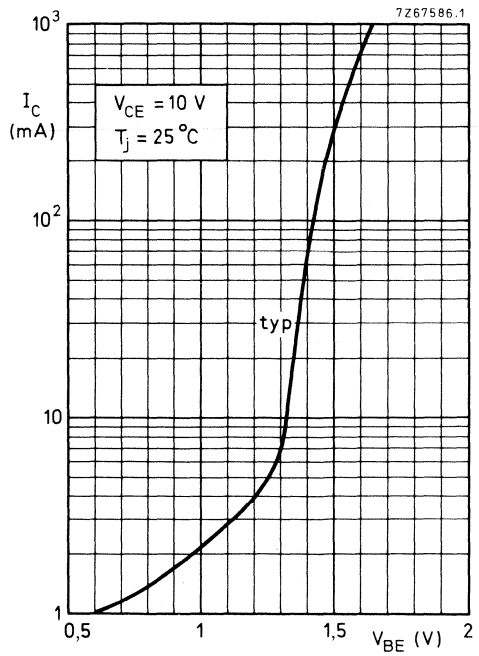


Fig. 6.

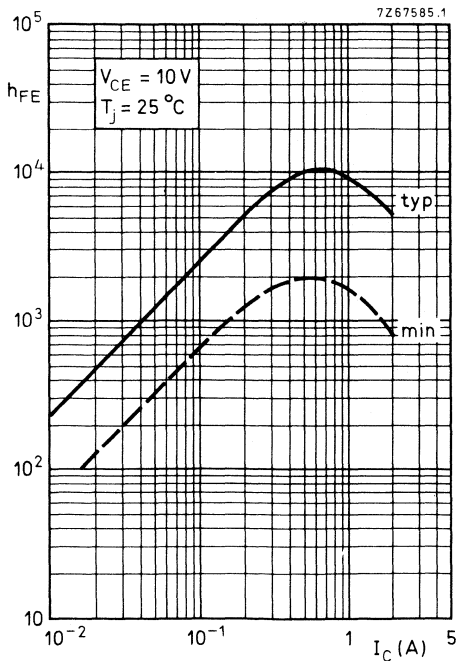


Fig. 7.

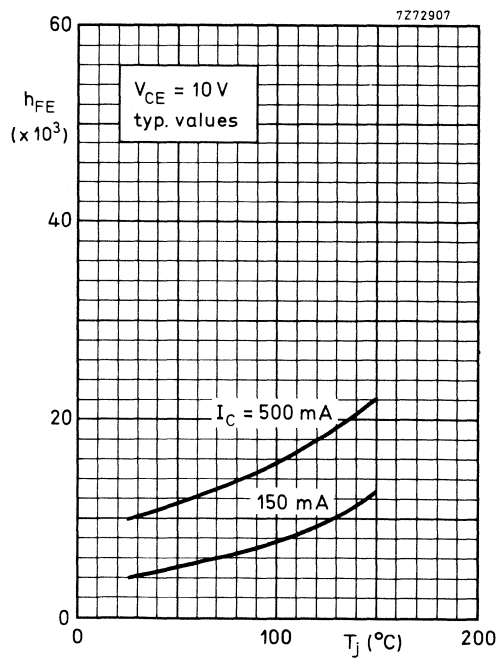


Fig. 8.

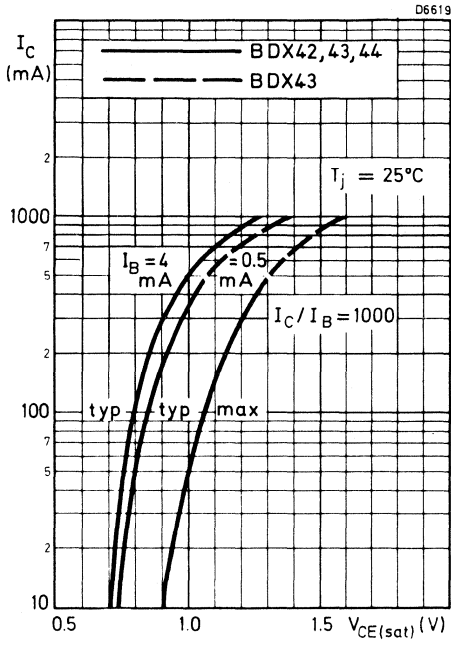


Fig. 9.

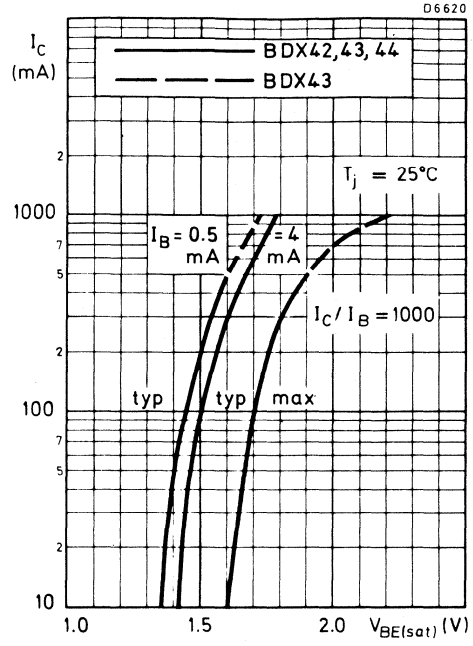


Fig. 10.

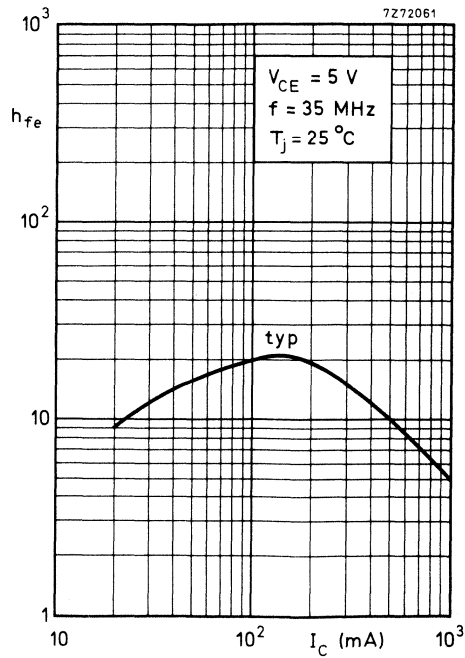


Fig. 11.

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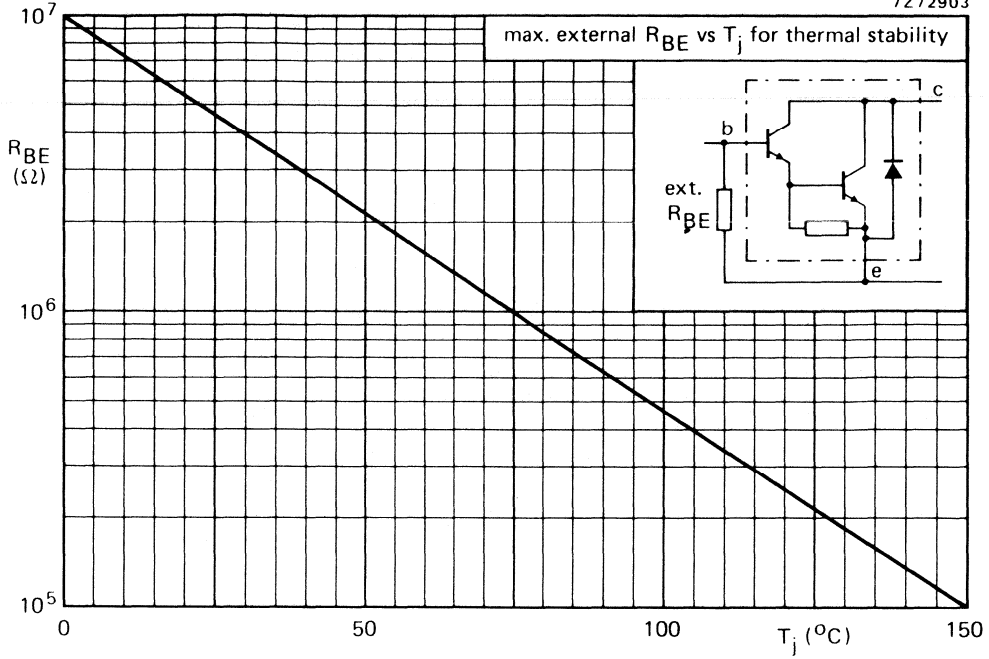


Fig. 12.

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	P_{tot}	up to $T_{amb} = 25\text{ }^\circ\text{C}$	max.	1,25	1,25	1,25 W
		up to $T_{mb} = 100\text{ }^\circ\text{C}$	max.	5	5	5 W
D.C. current gain	h_{FE}	>	2000	2000	2000	
Collector-emitter saturation voltage	$-V_{CEsat}$	$-I_C = 1\text{ A}; -I_B = 1\text{ mA}$	<	—	1,6	— V
		$-I_C = 1\text{ A}; -I_B = 4\text{ mA}$	<	1,6	—	1,6 V
Turn-off time	t_{off}	typ.	1500	1500	1500 ns	
$-I_C = 500\text{ mA}; -I_{Bon} = I_{Boff} = 0,5\text{ mA}$						

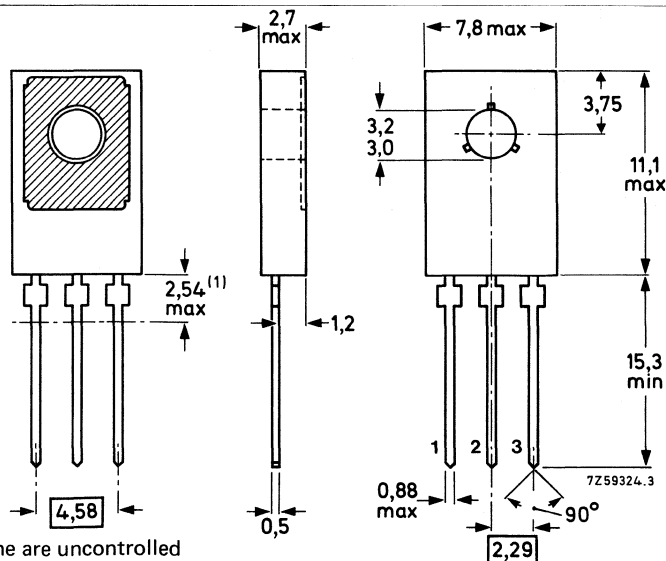
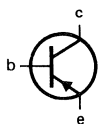
MECHANICAL DATA

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.

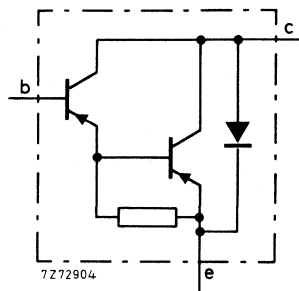


Fig. 2 Circuit diagram.

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 $T_{amb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.		1,25	W
up to $T_{mb} = 100\text{ }^{\circ}\text{C}$	P_{tot}	max.		5	W
Storage temperature	T_{stg}		-65 to + 150		$^{\circ}\text{C}$
Junction temperature **	T_j	max.		150	$^{\circ}\text{C}$

THERMAL RESISTANCE **

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

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

Collector cut-off current

 $V_{BE} = 0; -V_{CE} = 45\text{ V}$ BDX45 $-I_{CES} < 10\text{ }\mu\text{A}$ $V_{BE} = 0; -V_{CE} = 60\text{ V}$ BDX46 $-I_{CES} < 10\text{ }\mu\text{A}$ $V_{BE} = 0; -V_{CE} = 80\text{ V}$ BDX47 $-I_{CES} < 10\text{ }\mu\text{A}$

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$ $-I_{EBO} < 10\text{ }\mu\text{A}$

D.C. current gain

 $-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$ $h_{FE} > 1000$ $-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$ $h_{FE} > 2000$

Collector-emitter saturation voltage

 $-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}$ $-V_{CEsat} < 1,3\text{ V}$ $-I_C = 1\text{ A}; -I_B = 1\text{ mA}$ BDX46 $-V_{CEsat} < 1,6\text{ V}$ $-I_C = 1\text{ A}; -I_B = 4\text{ mA}$ BDX45, 47 $-V_{CEsat} < 1,6\text{ V}$ $-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ $-V_{CEsat} < 1,3\text{ V}$ $-I_C = 1\text{ A}; -I_B = 1\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ BDX46 $-V_{CEsat} < 1,8\text{ V}$ $-I_C = 1\text{ A}; -I_B = 4\text{ mA}; T_j = 150\text{ }^\circ\text{C}$ BDX45, 47 $-V_{CEsat} < 1,6\text{ V}$

Base-emitter saturation voltage

 $-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}$ $-V_{BEsat} < 1,9\text{ V}$ $-I_C = 1\text{ A}; -I_B = 1\text{ mA}$ BDX46 $-V_{BEsat} < 2,2\text{ V}$ $-I_C = 1\text{ A}; -I_B = 4\text{ mA}$ BDX45, 47 $-V_{BEsat} < 2,2\text{ V}$

Small signal current gain

 $-I_C = 500\text{ mA}; -V_{CE} = 5\text{ V}; f = 35\text{ MHz}$ h_{fe} typ. 10

Switching times (see also Fig. 3 and Fig. 4)

 $-I_C = 500\text{ mA}; -I_{Bon} = I_{Boff} = 0,5\text{ mA}$

Turn-on time

 t_{on} typ. 400 ns

Turn-off time

 t_{off} typ. 1500 ns $-I_C = 1\text{ A}; -I_{Bon} = I_{Boff} = 1\text{ mA}$

Turn-on time

 t_{on} typ. 400 ns

Turn-off time

 t_{off} typ. 1500 ns

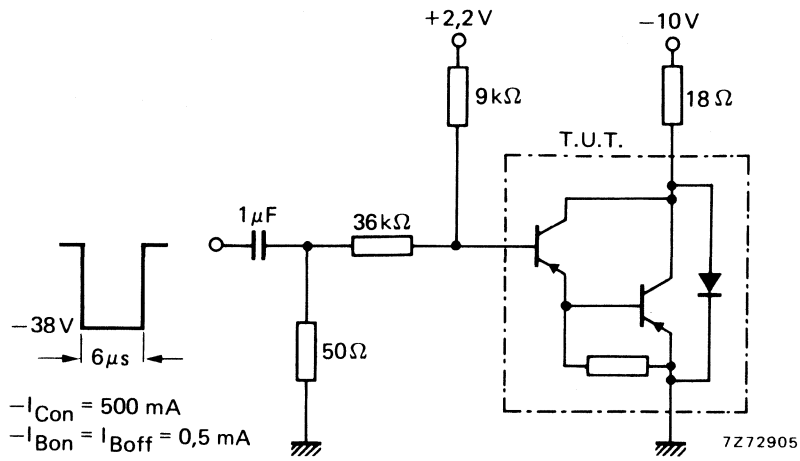


Fig. 3 Test circuit for 500 mA switching.

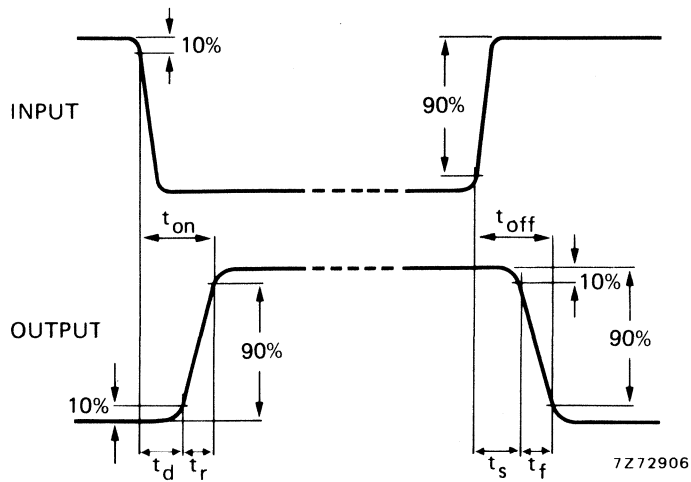


Fig. 4 Switching waveforms.

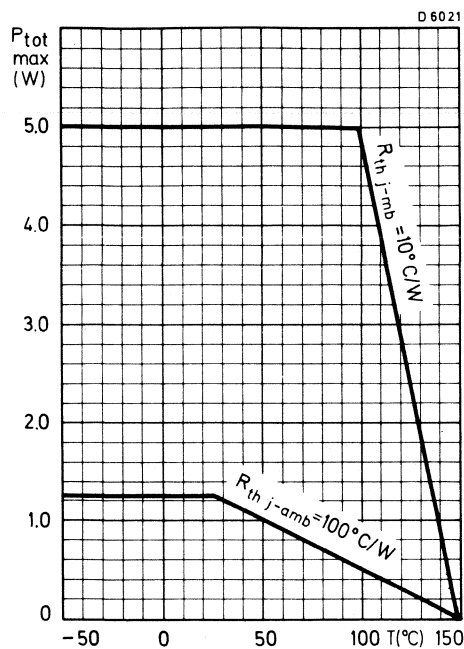


Fig. 5.

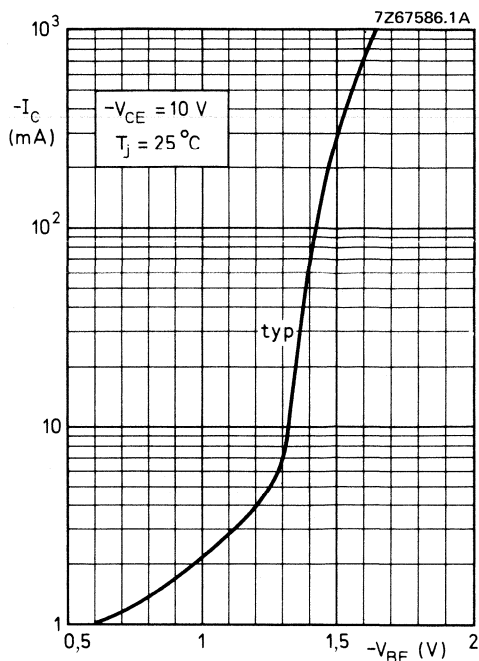


Fig. 6.

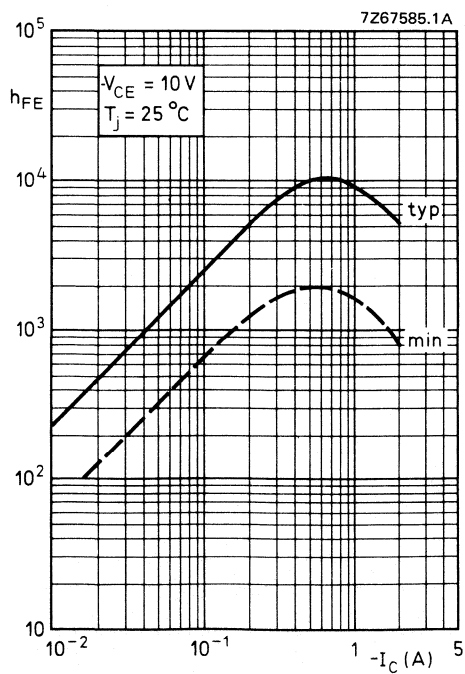


Fig. 7.

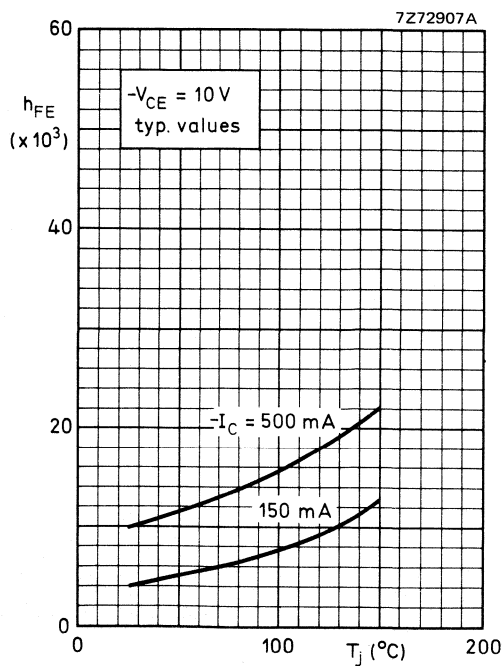


Fig. 8.

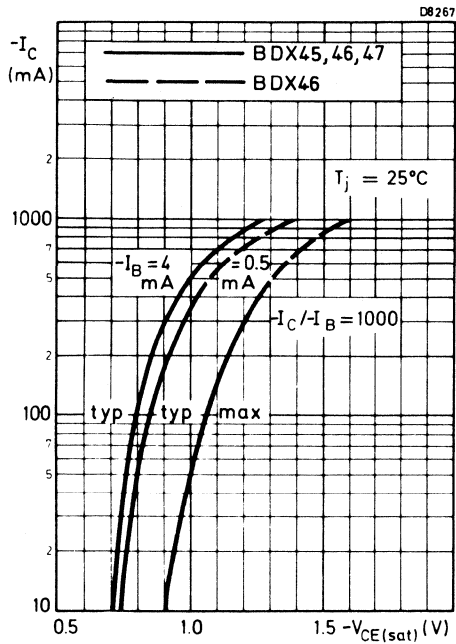


Fig. 9.

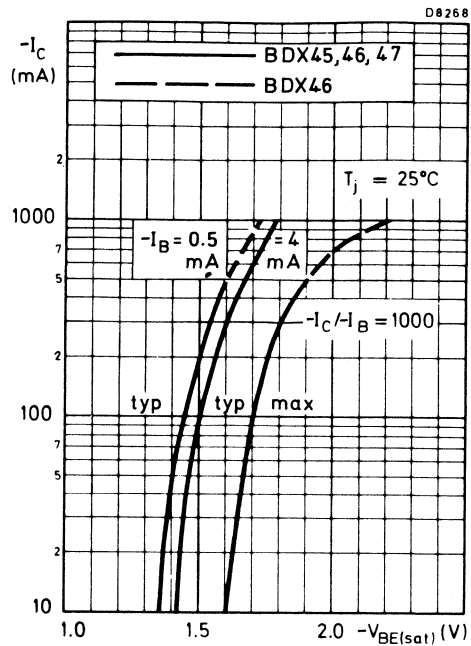


Fig. 10.

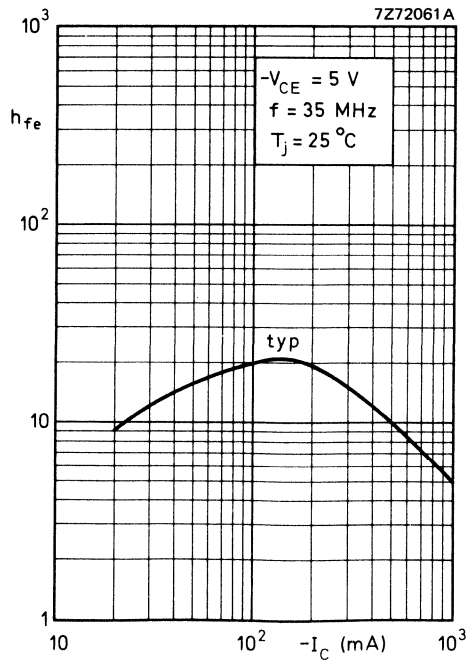


Fig. 11.

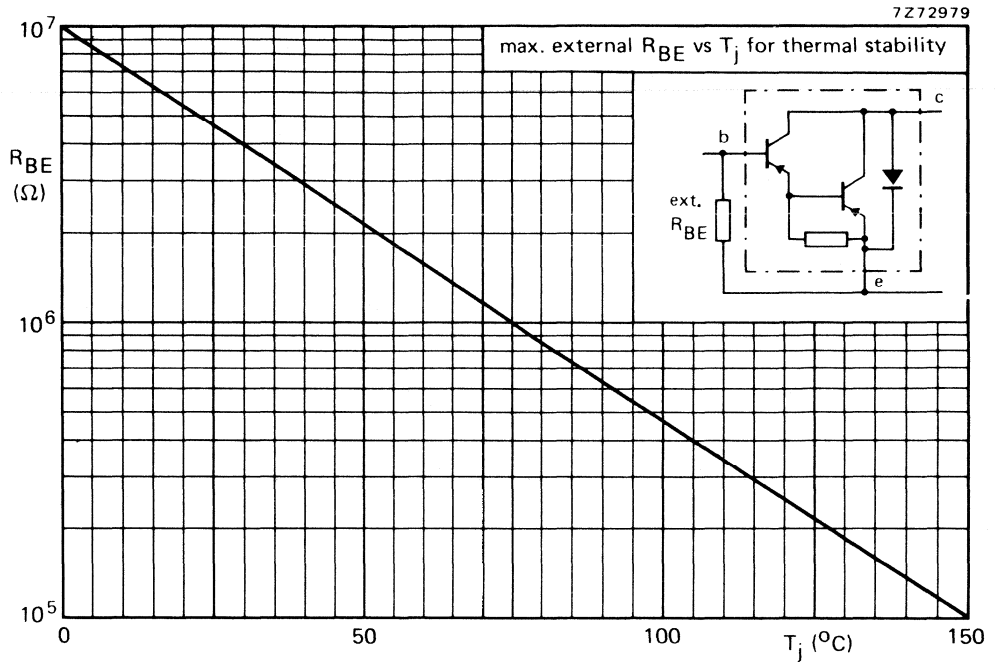


Fig. 12.

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-3 envelope, N-P-N complements are BDX63, BDX63A, BDX63B and BDX63C.

QUICK REFERENCE DATA

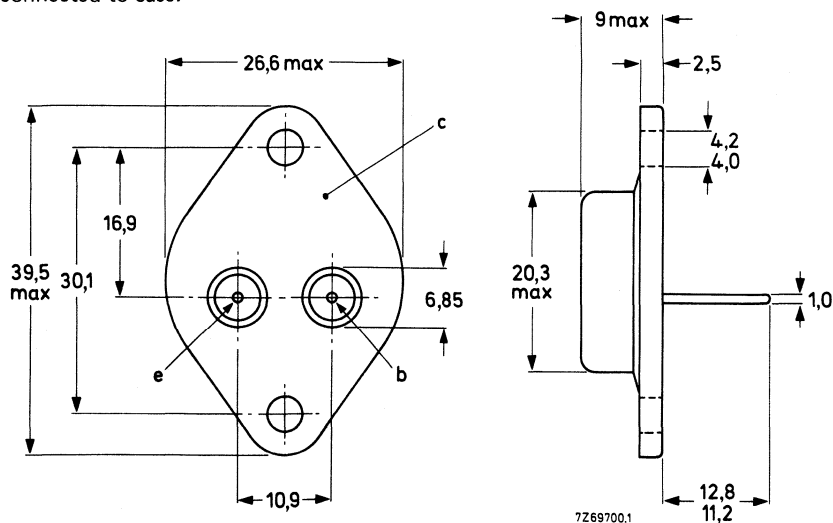
		BDX62	62A	62B	62C
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	80	100	120 V
Collector current (peak value)	$-I_{CM}$ max.	12			A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot} max.	90			W
Junction temperature	T_j max.	200			$^{\circ}\text{C}$
D.C. current gain					
$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} typ.	1500			
$-I_C = 3,0\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} >	1000			
Cut-off frequency					
$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe} typ.	100			kHz

MECHANICAL DATA

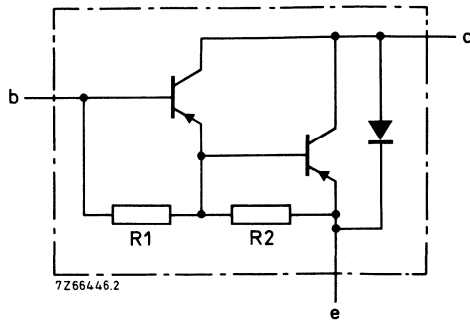
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.



R₁ typ. 6 kΩ
R₂ typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX62	62A	62B	62C
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.			8	A
Collector current (peak value)	-I _{CM}	max.			12	A
Base current (d.c.)	-I _B	max.			150	mA
Total power dissipation up to T _{mb} = 25 °C	P _{tot}	max.			90	W
Storage temperature	T _{stg}				-65 to +200	°C
Junction temperature*	T _j	max.			200	°C

THERMAL RESISTANCE*

From junction to mounting base	R _{th j-mb} =		1,94	K/W
--------------------------------	------------------------	--	------	-----

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

CHARACTERISTICS

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

Collector cut-off current

$$I_E = 0; -V_{CB} = -V_{CB0\text{max}}$$

$$-I_{CBO} < 0,2\text{ mA}$$

$$I_E = 0; -V_{CB} = 40\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX62}$$

$$I_E = 0; -V_{CB} = 50\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX62A}$$

$$I_E = 0; -V_{CB} = 60\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX62B}$$

$$I_E = 0; -V_{CB} = 70\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX62C}$$

$$-I_{CBO} < 2\text{ mA}$$

$$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEO}$$

$$-I_{CEO} < 0,2\text{ mA} \leftarrow$$

Emitter cut-off current

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

$$-I_{EBO} < 5\text{ mA}$$

D.C. current gain (note 1)

$$-I_C = 0,5\text{ A}; -V_{CE} = 3\text{ V}$$

$$h_{FE} \text{ typ. } 1500$$

$$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$$

$$h_{FE} > 1000$$

$$-I_C = 8\text{ A}; -V_{CE} = 3\text{ V}$$

$$h_{FE} \text{ typ. } 750$$

Base-emitter voltage (notes 1 and 2)

$$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$$

$$-V_{BE} < 2,5\text{ V}$$

Collector-emitter saturation voltage (note 1)

$$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$$

$$-V_{CE\text{sat}} < 2\text{ V}$$

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

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

$$C_c \text{ typ. } 100\text{ pF}$$

Cut-off frequency

$$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}$$

$$f_{hfe} \text{ typ. } 100\text{ kHz}$$

Small-signal current gain

$$-I_C = 3\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$$

$$h_{fe} \text{ typ. } 100$$

Notes

1. Measured under pulse conditions: $t_p < 300\text{ }\mu\text{s}$, $\delta < 2\%$.

2. $-V_{BE}$ decreases by about $3,6\text{ mV/K}$ with increasing temperature.

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

$-I_{Con} = 3 \text{ A}; -I_{Bon} = I_{Boff} = 12 \text{ mA}$

turn-on time

turn-off time

t_{on} typ. $0,5 \mu\text{s}$
 t_{off} typ. $2,5 \mu\text{s}$

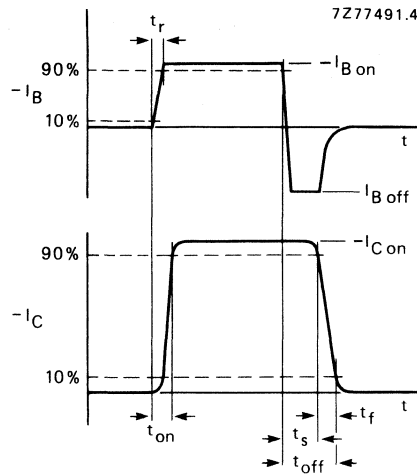


Fig. 3 Switching times waveforms.

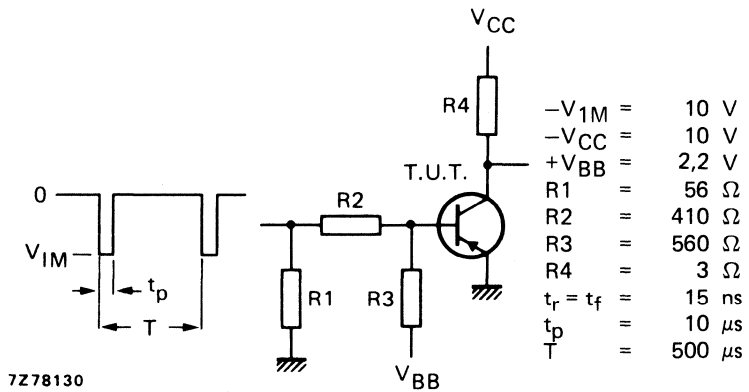


Fig. 4 Switching times test circuit.

Diode forward voltage
 $I_F = 3 \text{ A}$

V_F typ. $1,8 \text{ V}$

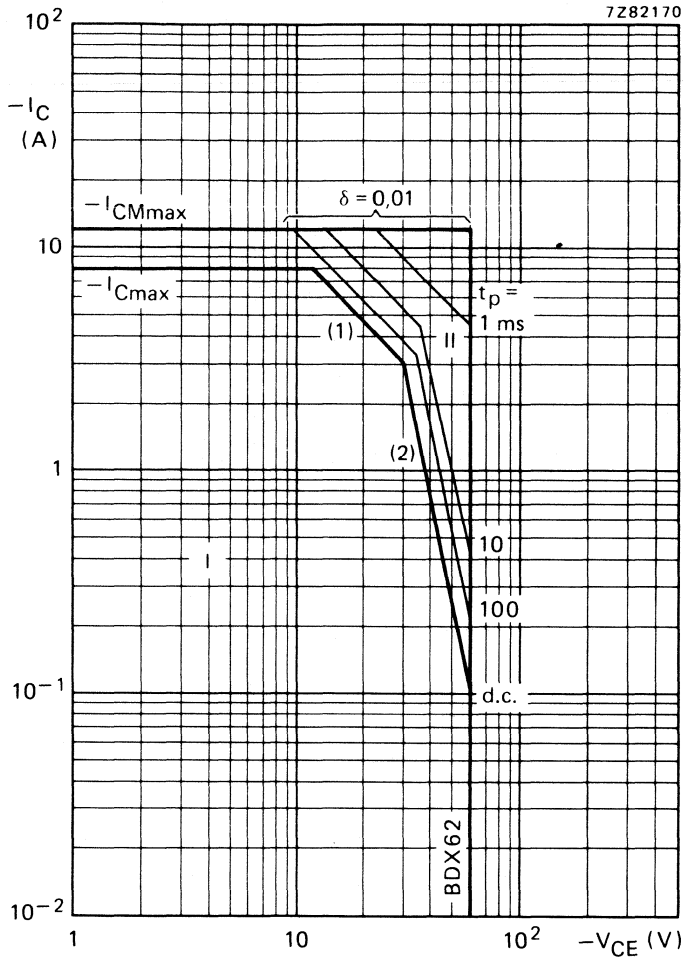


Fig. 5 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

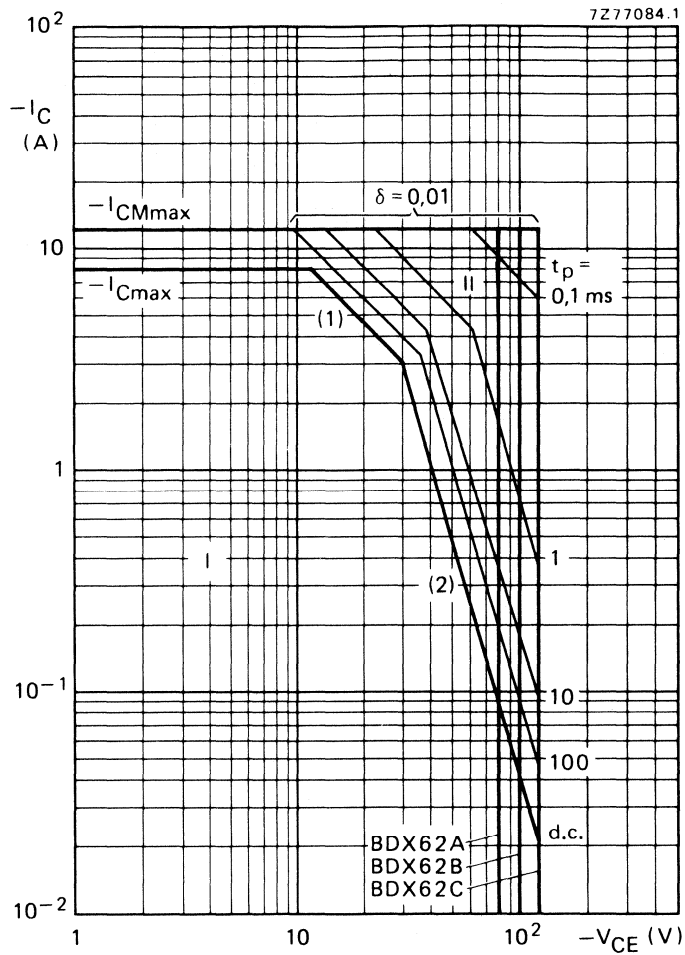


Fig. 6 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

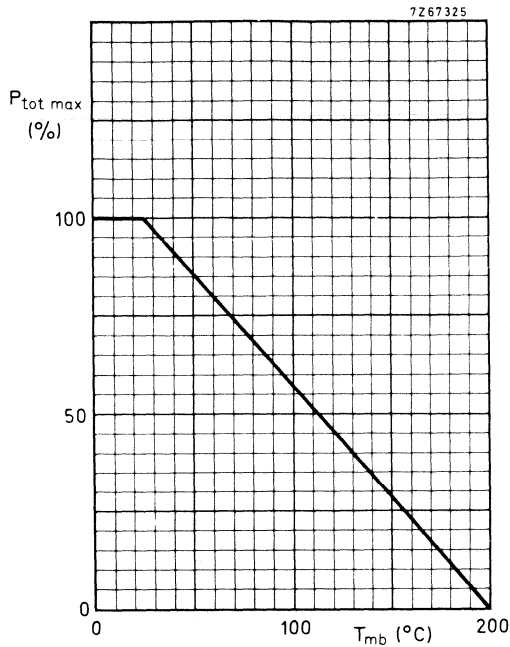


Fig. 7 Power derating curve.

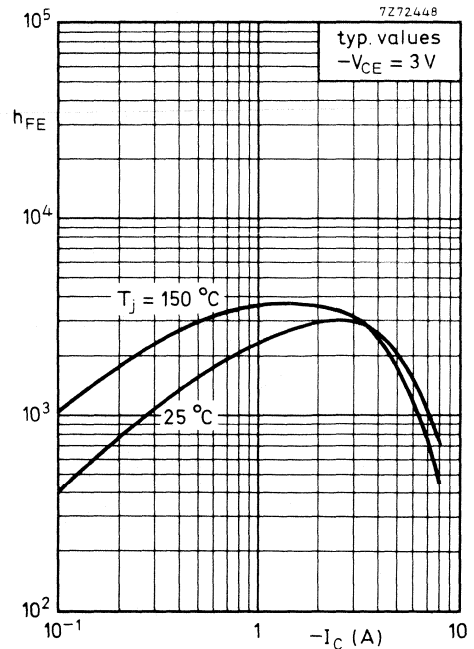


Fig. 8 D.C. current gain.

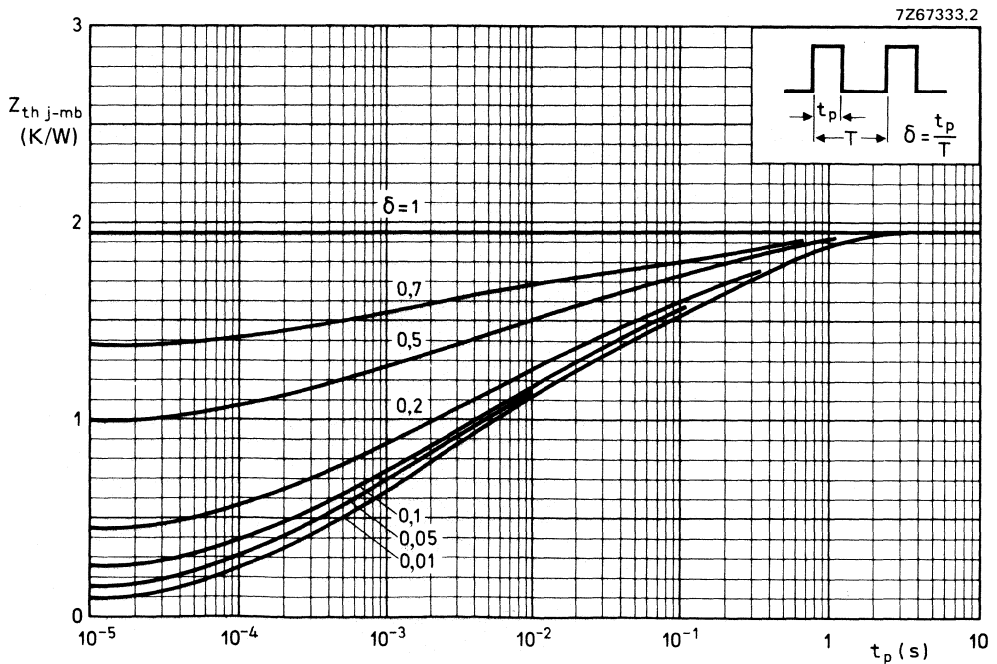


Fig. 9 Pulse power rating chart.

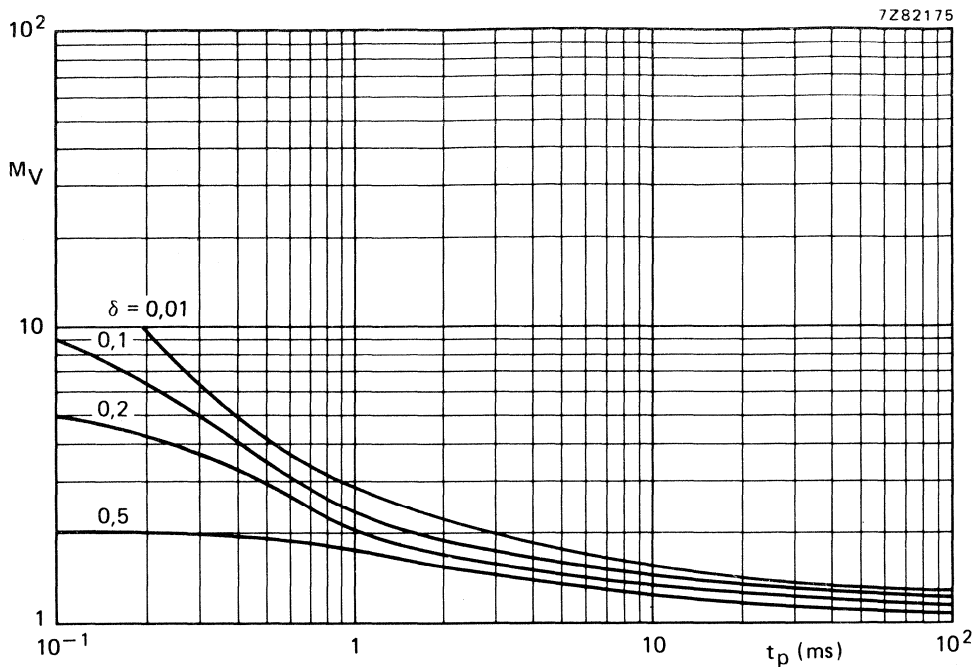


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

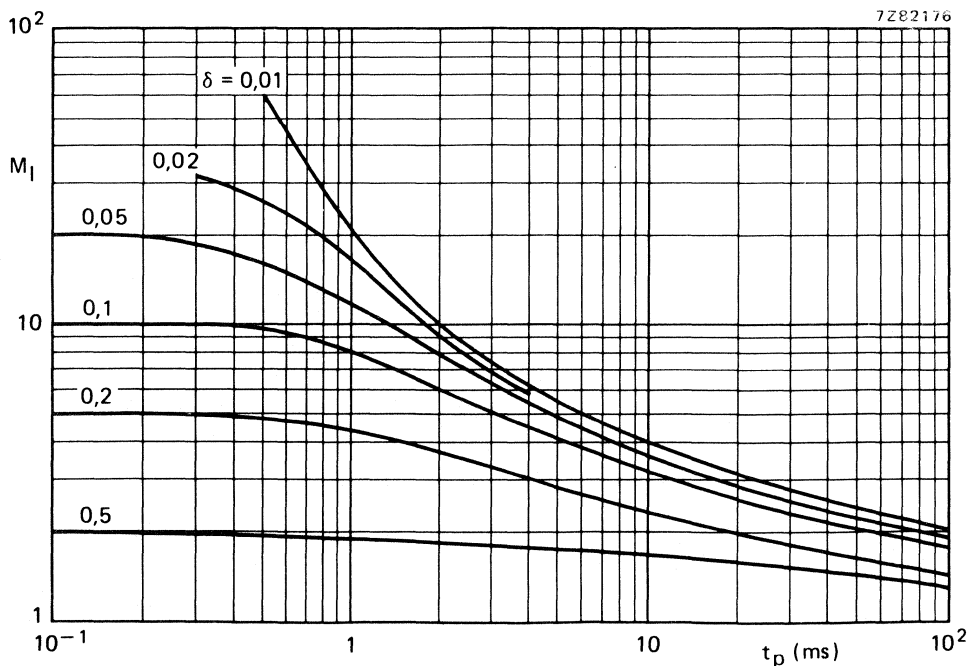


Fig. 11 S.B. current multiplying factor at the V_{CE0} 100 V and 60 V level.

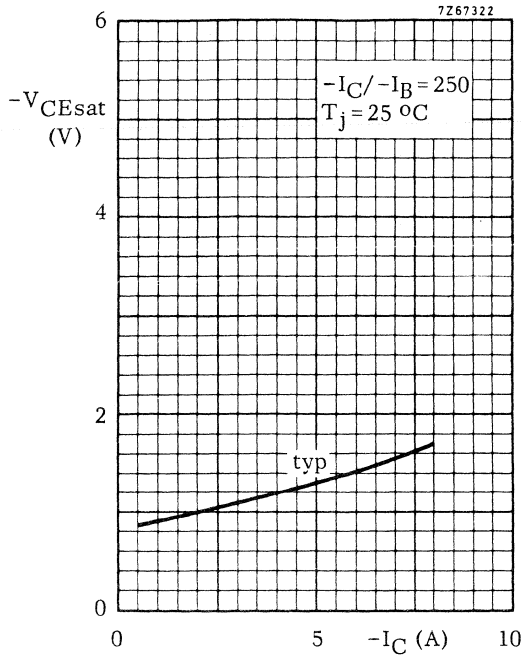


Fig. 12.

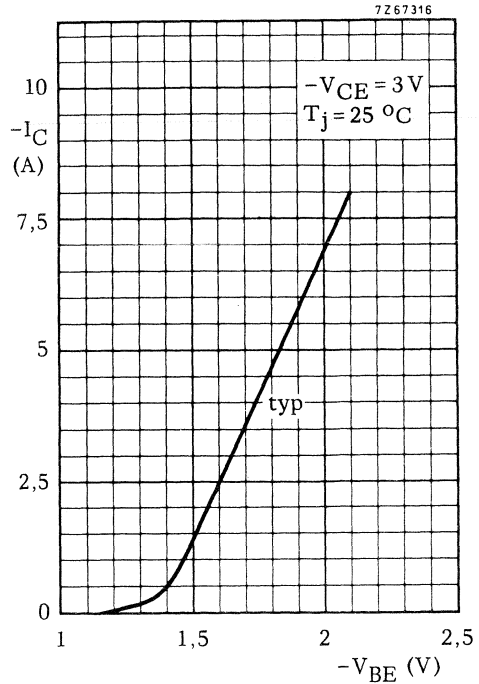


Fig. 13.

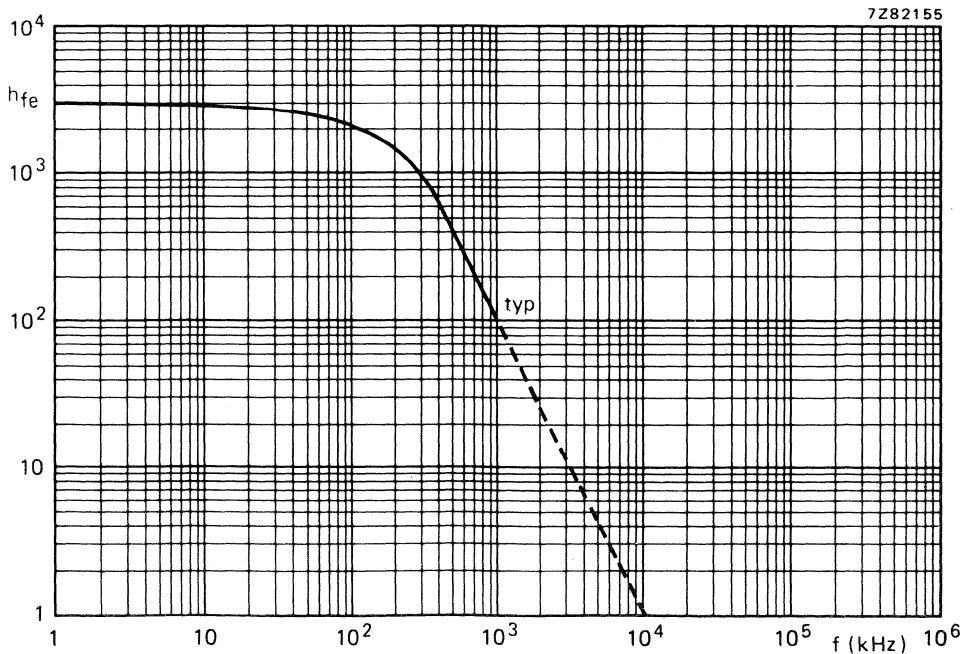


Fig. 14 Small signal current gain at $-I_C = 3\text{ A}$; $-V_{CE} = 3\text{ V}$.

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-3 envelope, P-N-P complements are BDX62, BDX62A, BDX62B and BDX62C.

QUICK REFERENCE DATA

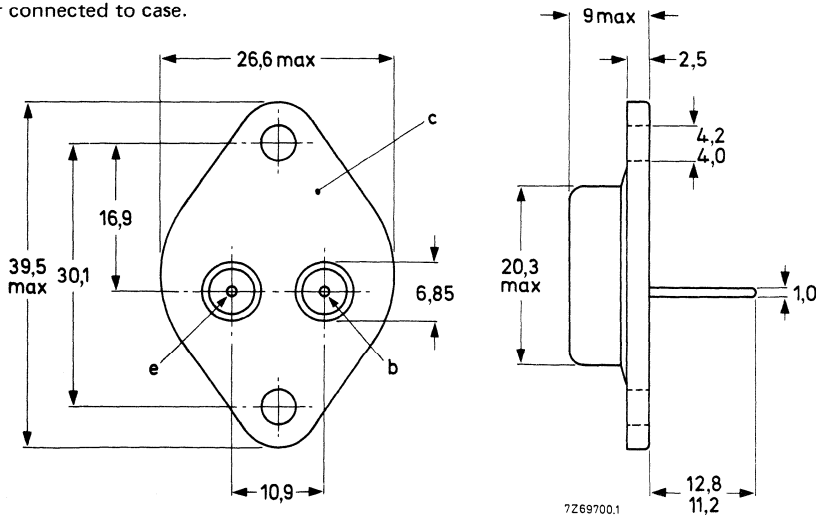
			BDX63	63A	63B	63C
Collector-base voltage (open emitter)	V_{CB0}	max.	80	100	120	140 V
Collector-emitter voltage (open base)	V_{CE0}	max.	60	80	100	120 V
Collector current (peak value)	I_{CM}	max.	12			A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.	90			W
Junction temperature	T_j	max.	200			$^{\circ}\text{C}$
D.C. current gain						
$I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	typ.	2500			
$I_C = 3,0\text{ A}; V_{CE} = 3\text{ V}$	h_{FE}	>	1000			
Cut-off frequency						
$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe}	typ.	100			kHz

MECHANICAL DATA

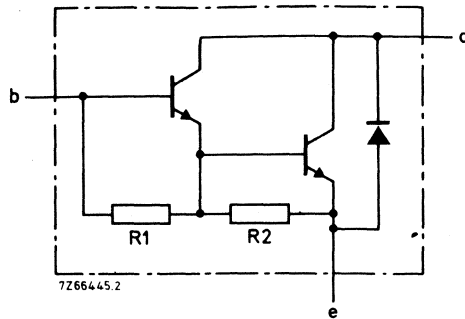
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories.



R1 typ. 8 k Ω
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX63	63A	63B	63C
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140 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.			8	A
Collector current (peak value)	I_{CM}	max.			12	A
Base current (d.c.)	I_B	max.			150	mA
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.			90	W
Storage temperature	T_{stg}			-65 to +200		$^\circ\text{C}$
Junction temperature*	T_j	max.			200	$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j-mb} =$		1,94	K/W
--------------------------------	------------------	--	------	-----

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CE0max}$

$I_{CBO} < 0,2\text{ mA}$

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0max}; T_j = 200\text{ }^\circ\text{C}$

$I_{CBO} < 2\text{ mA}$

$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0max}$

$I_{CEO} < 0,2\text{ mA}$ ←

Emitter cut-off current

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

$I_{EBO} < 5\text{ mA}$

D.C. current gain (note 1)

$I_C = 0,5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 2500$

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$I_C = 8\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 2600$

Base-emitter voltage (notes 1 and 2)

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage (note 1)

$I_C = 3\text{ A}; I_B = 12\text{ mA}$

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

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

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

$C_c \text{ typ. } 100\text{ pF}$

Cut-off frequency

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 100\text{ kHz}$

Turn-off breakdown energy with inductive load (Fig. 4)

$-I_{Boff} = 0; I_{Con} = 4,5\text{ A}; t_p = 1\text{ ms};$

$T = 100\text{ ms}$

$E_{(BR)} > 50\text{ mJ}$

Small signal current gain

$I_C = 3\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

$h_{fe} \text{ typ. } 100$

Diode, forward voltage

$I_F = 3\text{ A}$

$V_F \text{ typ. } 1,2\text{ V}$

Notes

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

CHARACTERISTICS (continued)

Switching times

(between 10% and 90% levels)

$I_{C\text{on}} = 3 \text{ A}; I_{B\text{on}} = -I_{B\text{off}} = 12 \text{ mA}$

turn-on time

turn-off time

$t_{\text{on typ.}} = 0,5 \mu\text{s}$
 $t_{\text{off typ.}} = 5 \mu\text{s}$

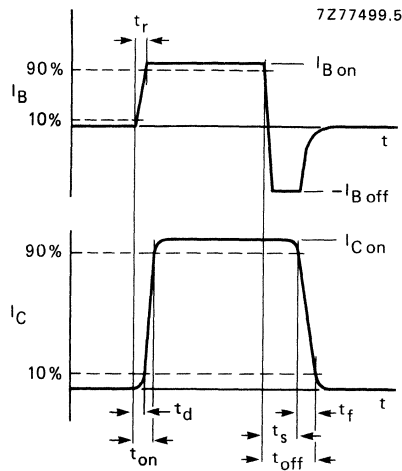


Fig. 3 Switching time waveforms.

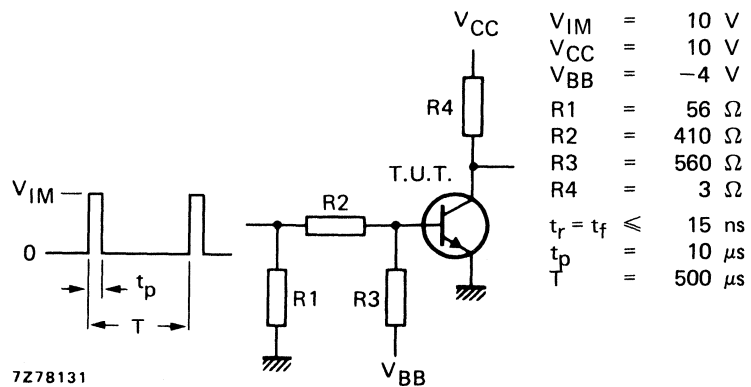


Fig. 4 Switching times test circuit.

Diode, forward voltage
 $I_F = 3 \text{ A}$

V_F typ. 1,2 V

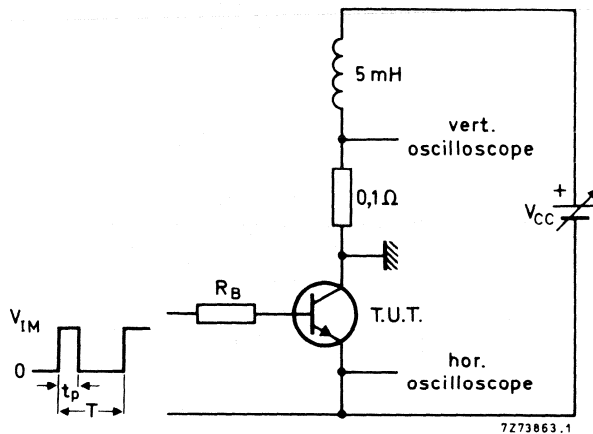


Fig. 5 Test circuit for turn-off breakdown energy.
 $V_{IM} = 12 \text{ V}$; $R_B = 270 \Omega$; $I_{CC} = 4,5 \text{ A}$; $t_p = 1 \text{ ms}$; $\delta = 1\%$.

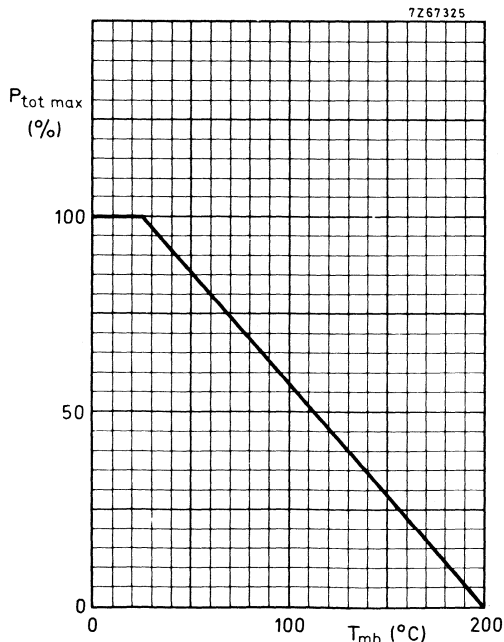


Fig. 6 Power derating curve.

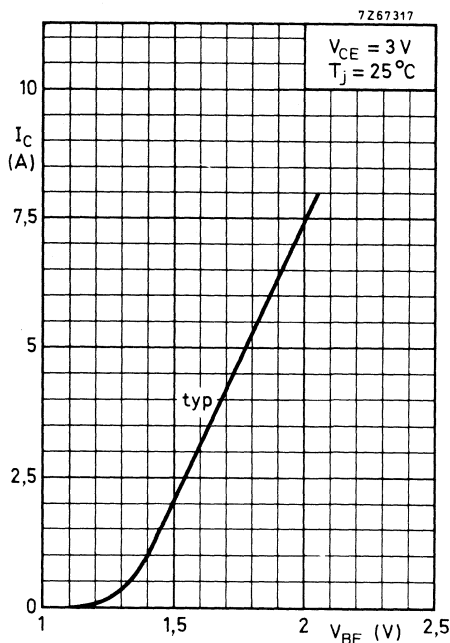


Fig. 7.

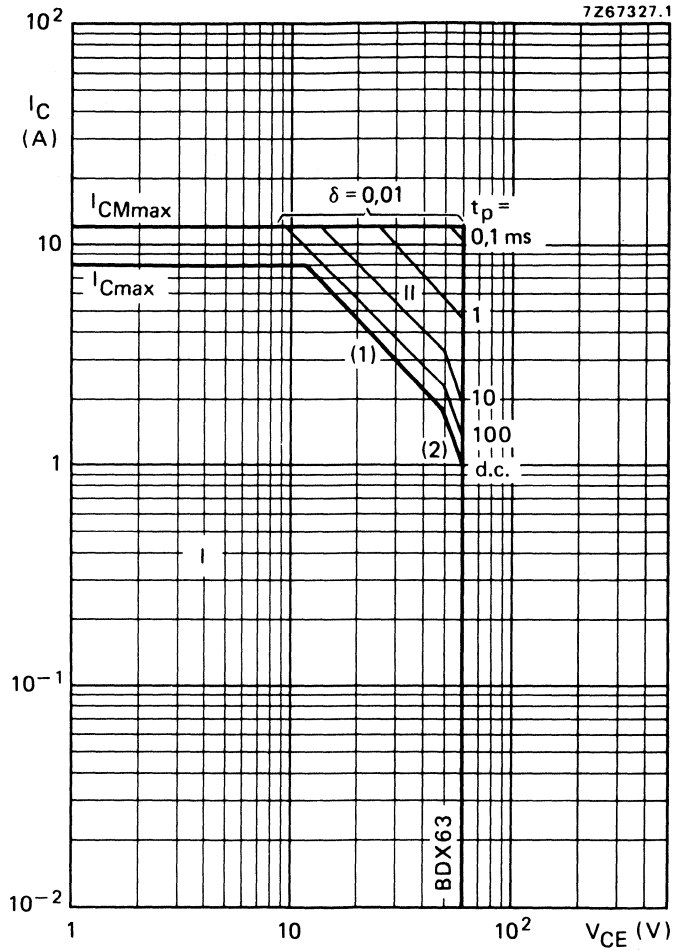


Fig. 8 Safe Operating Area, $T_{mb} \leq 25^\circ\text{C}$.

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

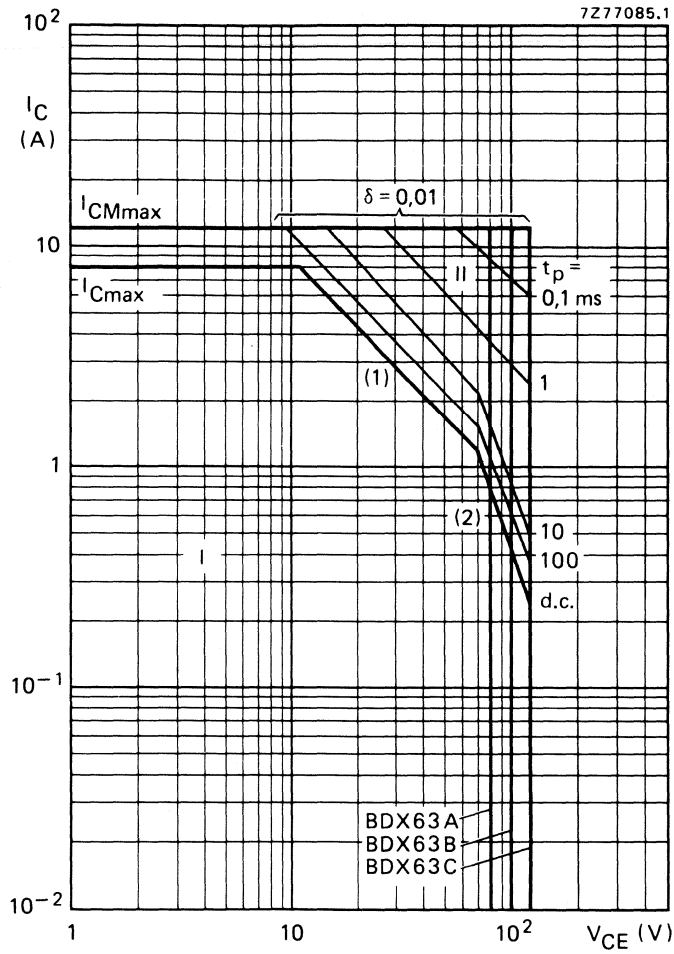
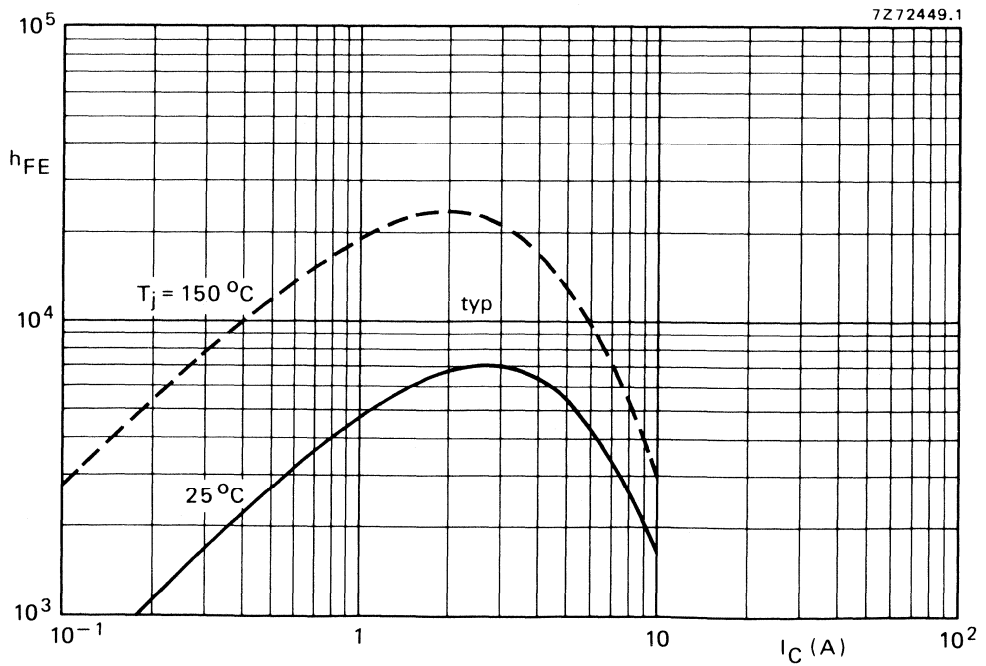
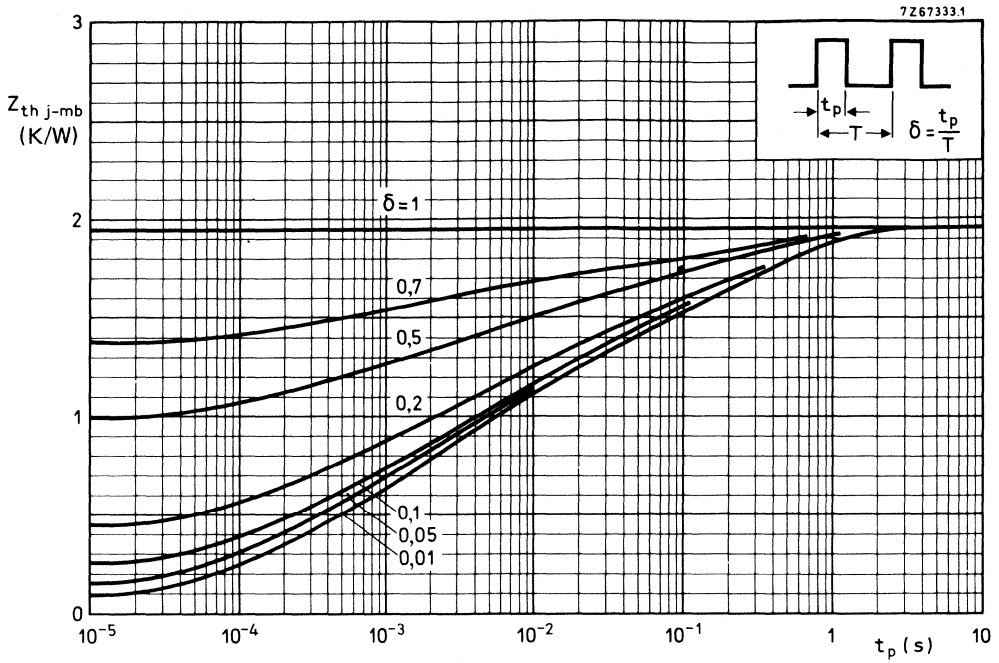


Fig. 9 Safe Operating Area, $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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



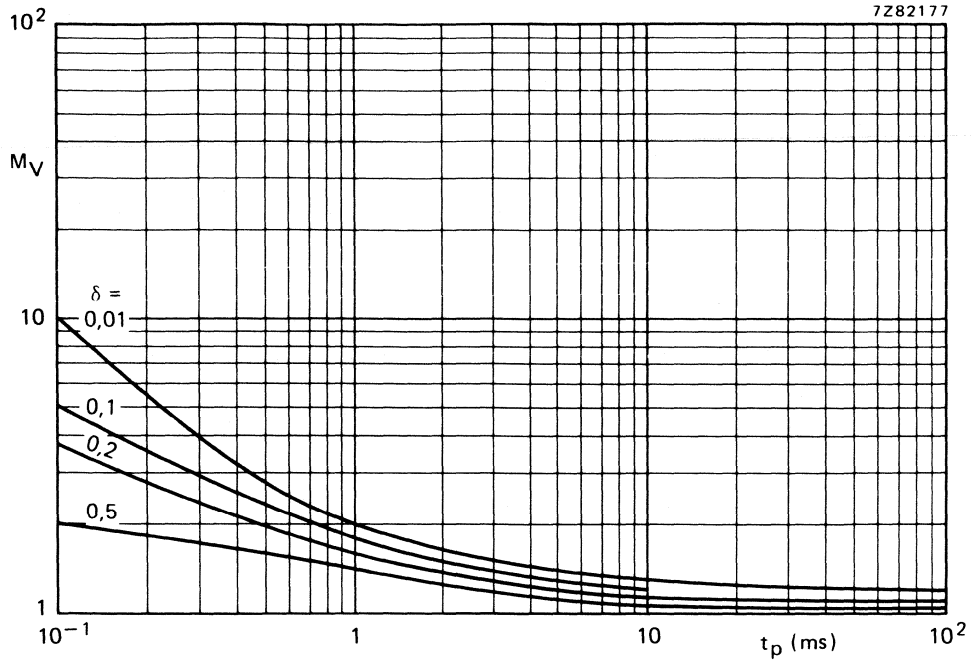


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

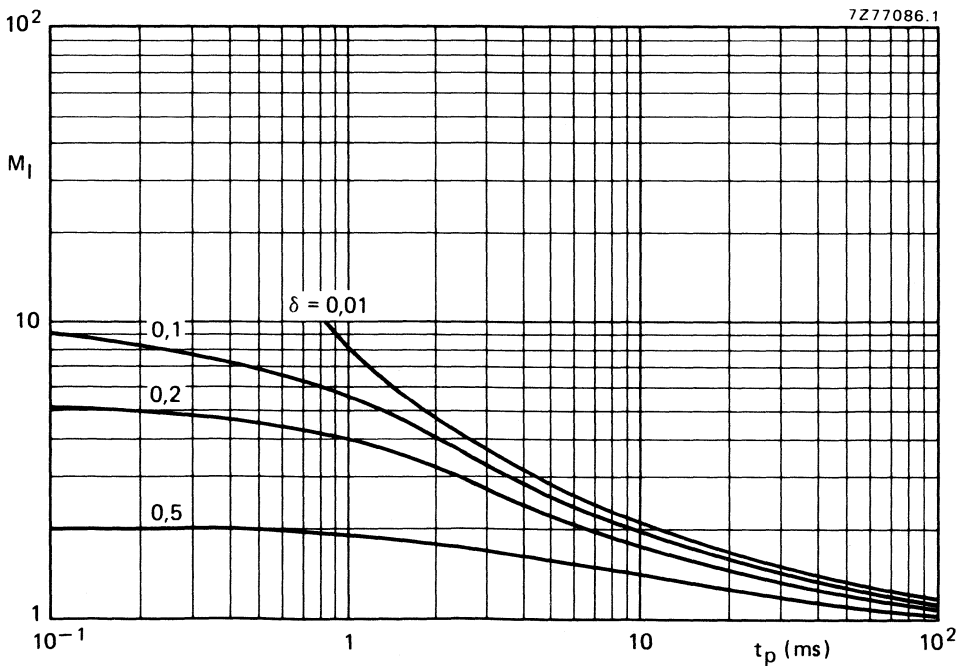


Fig. 13 S.B. current multiplying factor at the V_{CEO} 100 V and 60 V level.

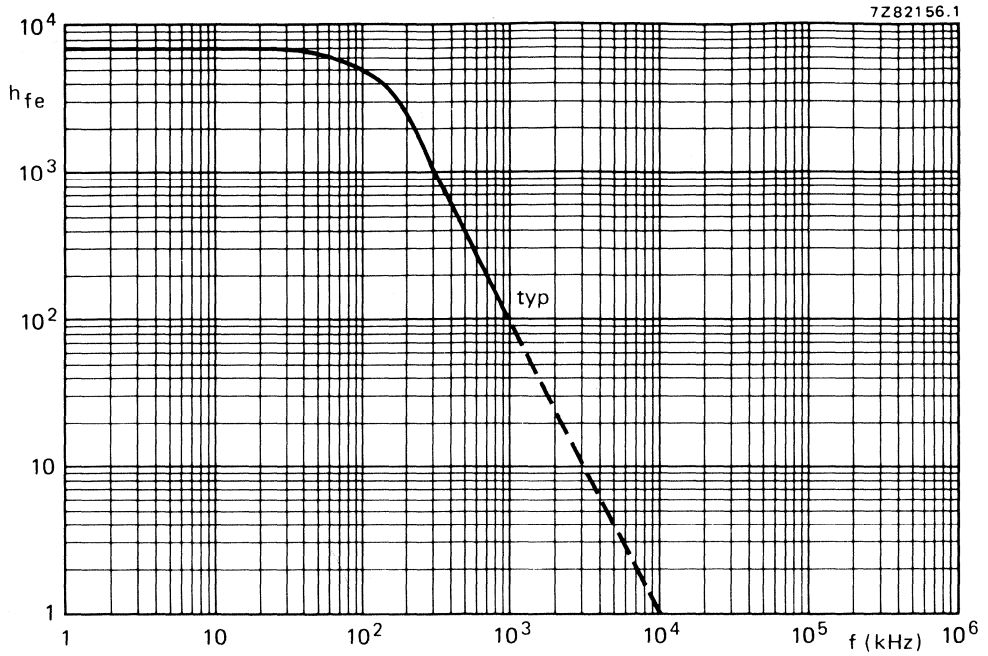


Fig. 14 Small-signal current gain at $I_C = 3$ A; $V_{CE} = 3$ V.

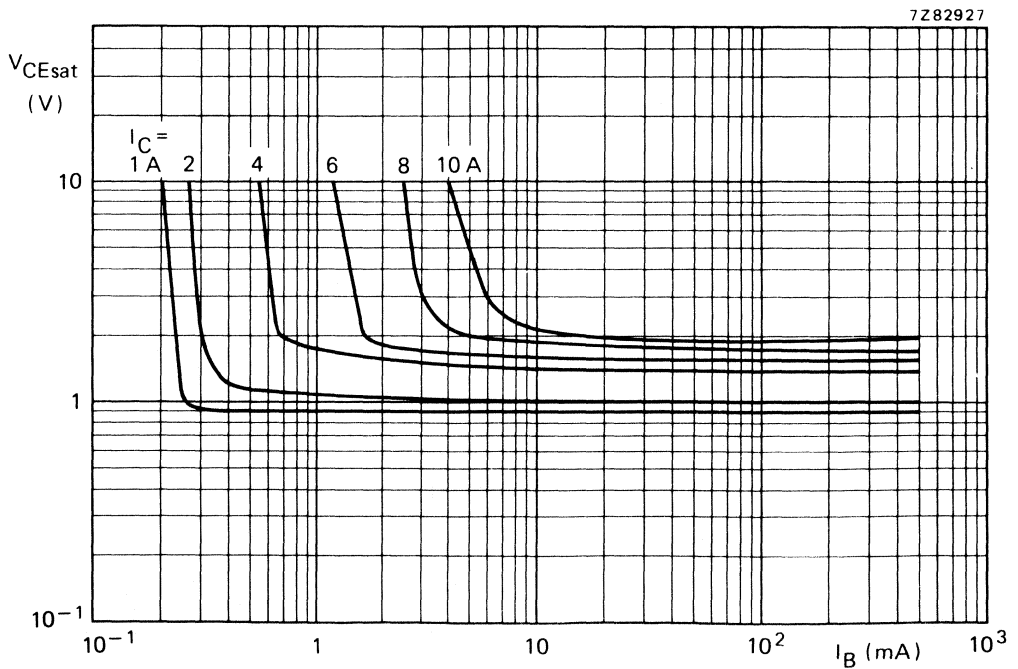


Fig. 15 Typical values collector-emitter saturation voltage at $T_j = 25$ °C.

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-3 envelope. N-P-N complements are BDX65, BDX65A, BDX65B and BDX65C.

QUICK REFERENCE DATA

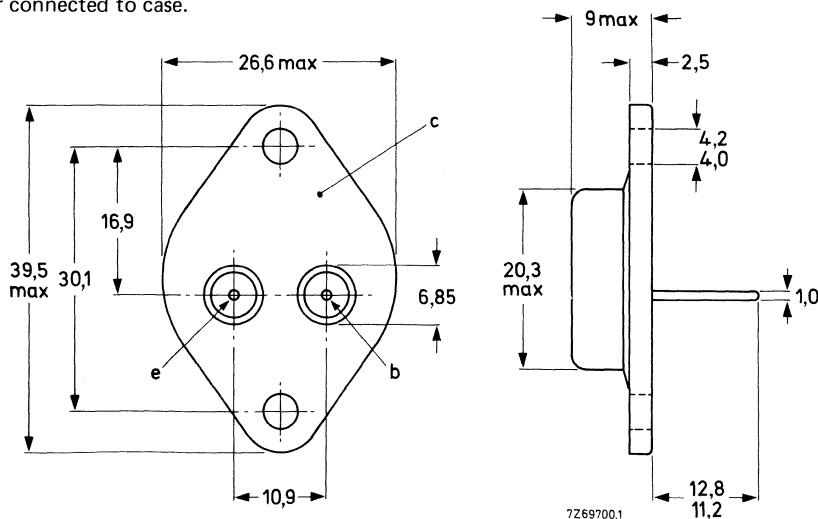
			BDX64	64A	64B	64C
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120 V
Collector current (peak value)	$-I_{CM}$	max.	16			A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.	117			W
Junction temperature	T_j	max.	200			$^{\circ}\text{C}$
D.C. current gain						
$-I_C = 1\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	1500			
$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	>	1000			
Cut-off frequency						
$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	typ.	80			kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

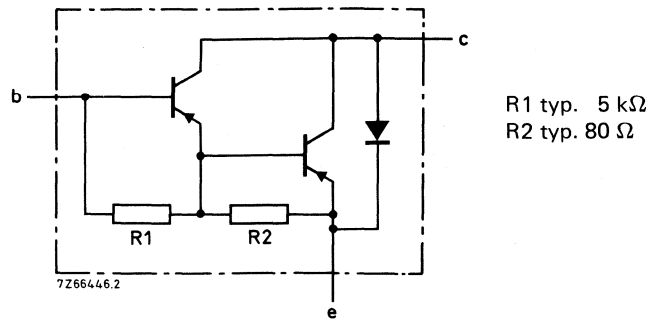


Fig. 2 Circuit diagram.

RATINGS

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

			BDX64	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.		16		A
Base current (d.c.)	$-I_B$	max.		200		mA
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		117		W
Storage temperature	T_{stg}			-65 to + 200		$^\circ\text{C}$
Junction temperature*	T_j	max.		200		$^\circ\text{C}$

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	1,5	K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CBOmax}$

$-I_{CBO} < 0,4\text{ mA}$

$I_E = 0; -V_{CB} = 40\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX64}$

$I_E = 0; -V_{CB} = 50\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX64A}$

$I_E = 0; -V_{CB} = 60\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX64B}$

$I_E = 0; -V_{CB} = 70\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX64C}$

$-I_{CBO} < 3\text{ mA}$

$I_B = 0; -V_{CE} = -\frac{1}{2} V_{CEOmax}$

$-I_{CEO} < 0,2\text{ mA}$

Emitter cut-off current

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

$-I_{EBO} < 5\text{ mA}$

D.C. current gain (note 1)

$-I_C = 1\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 1500$

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$-I_C = 12\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 750$

Base-emitter voltage (notes 1 and 2)

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$

$-V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage (note 1)

$-I_C = 5\text{ A}; -I_B = 20\text{ mA}$

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

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

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

$C_c \text{ typ. } 200\text{ pF}$

Cut-off frequency

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 80\text{ kHz}$

Small-signal current gain

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

$h_{fe} \text{ typ. } 30$

Notes

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

CHARACTERISTICS (continued)

Diode, forward voltage

$I_F = 5 \text{ A}$

$V_F < 1,8 \text{ V}$

Switching times

(between 10% and 90% levels)

$-I_{Con} = 5 \text{ A}; -I_{Bon} = I_{Boff} = 20 \text{ mA}$

turn-on time

t_{on} typ. $1 \mu\text{s}$

turn-off time

t_{off} typ. $2,5 \mu\text{s}$

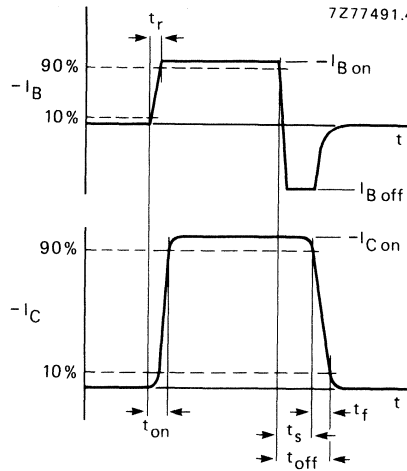
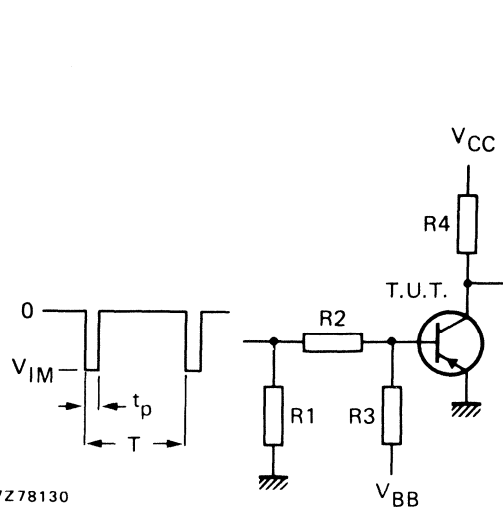


Fig. 3 Switching times waveforms.



- $-V_{IM} = 16,5 \text{ V}$
- $-V_{CC} = 16 \text{ V}$
- $+V_{BB} = 6,5 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 410 \Omega$
- $R3 = 560 \Omega$
- $R4 = 3 \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 4 Switching times test circuit.

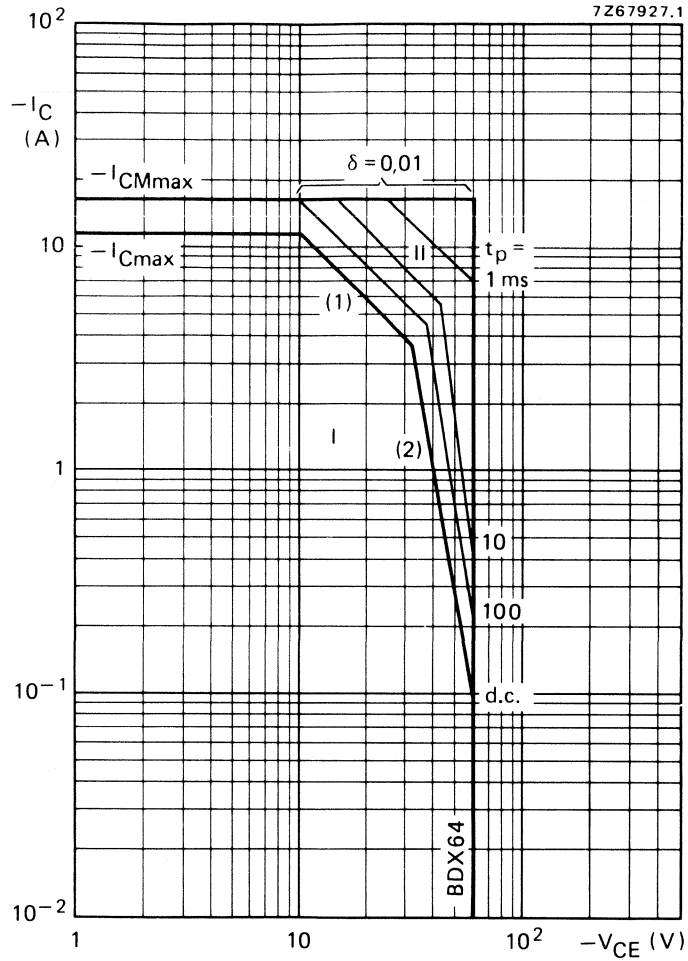


Fig. 5 Safe Operating Area; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

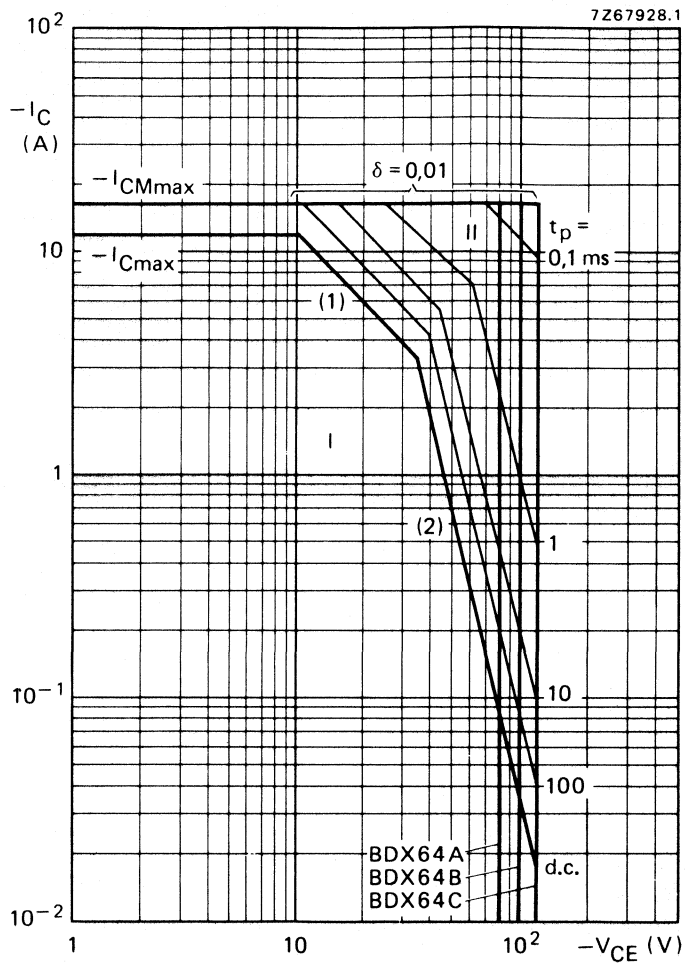


Fig. 6 Safe Operating Area; $T_{mb} \leq 25^\circ\text{C}$.

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

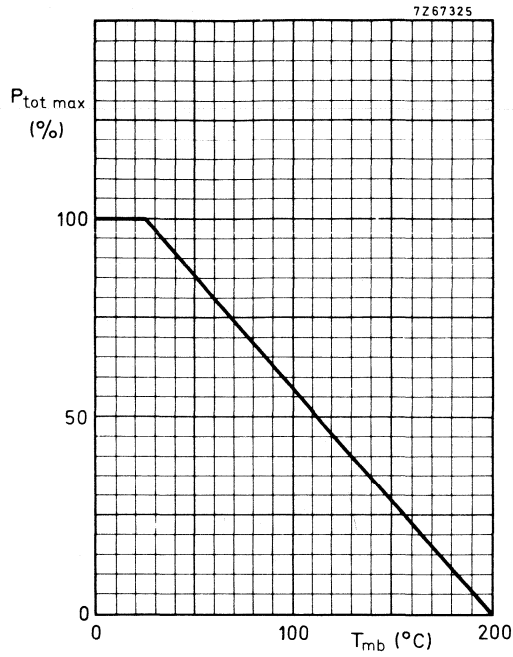


Fig. 7 Power derating curve.

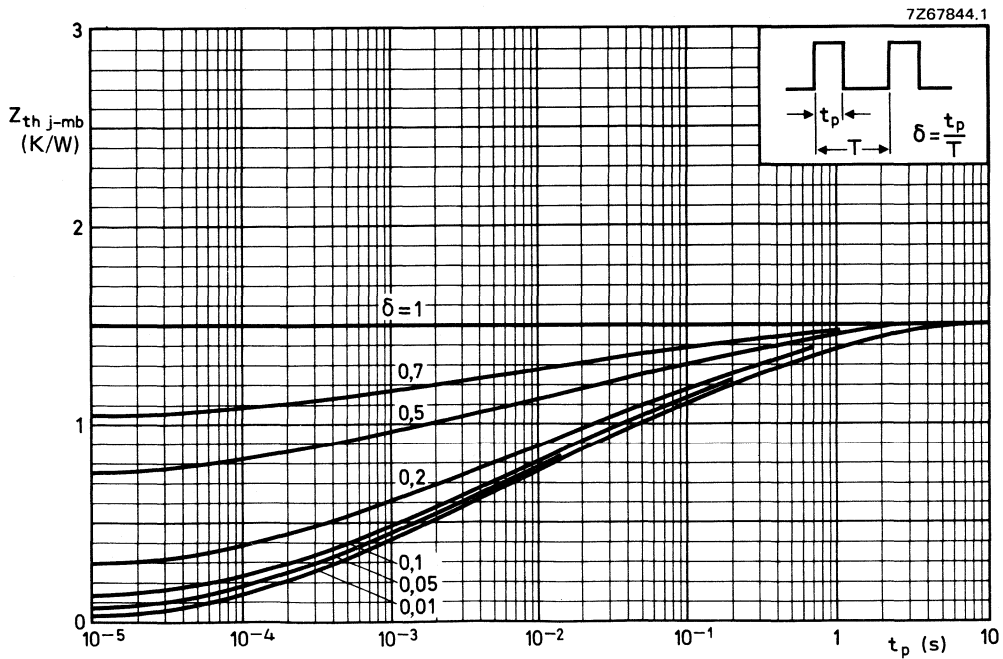


Fig. 8 Pulse power rating chart.

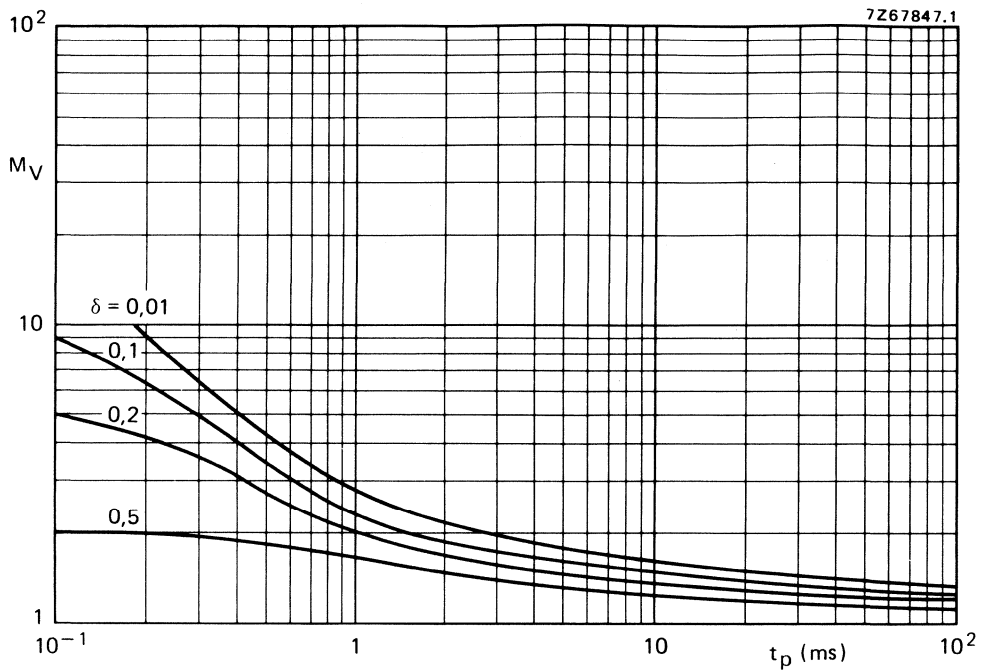


Fig. 9 S.B. voltage multiplying factor at the $-I_{C \max}$ level.

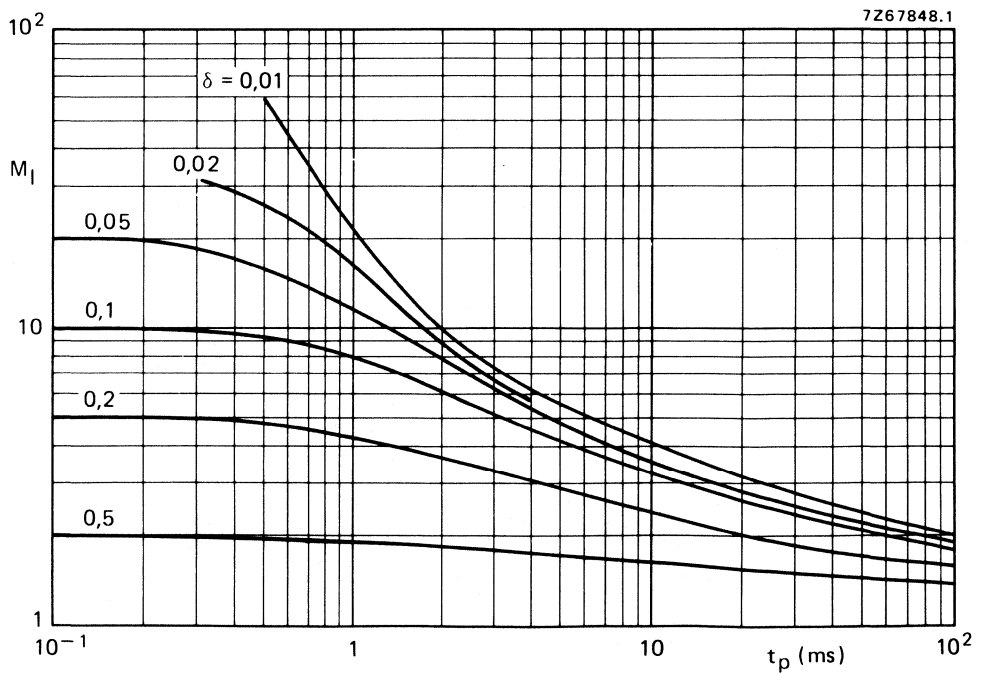


Fig. 10 S.B. current multiplying factor at $-V_{CEO}$ 100 V and 60 V level.

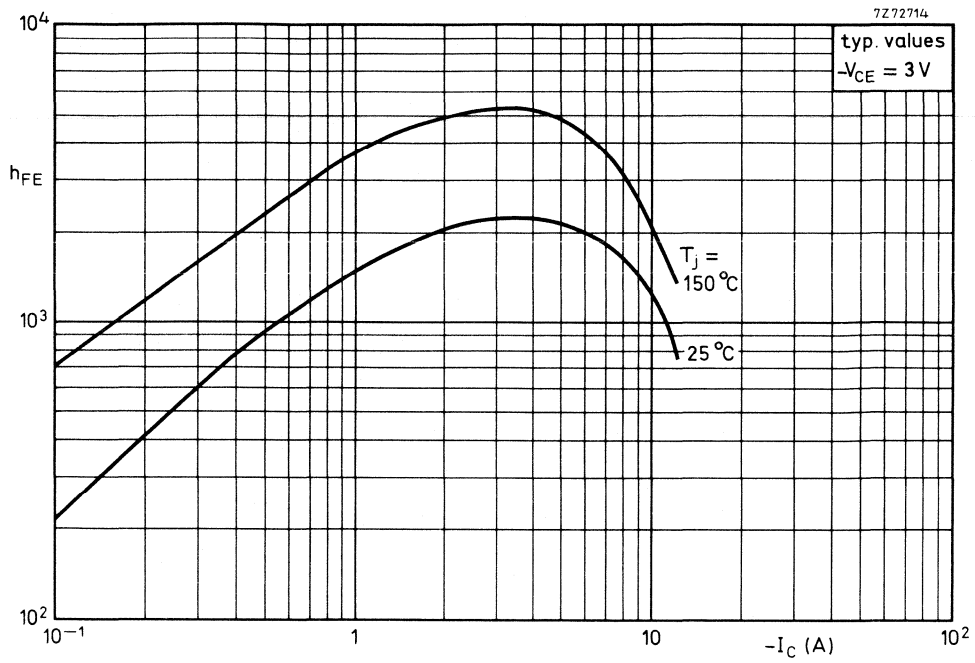


Fig. 11 D.C. current gain.

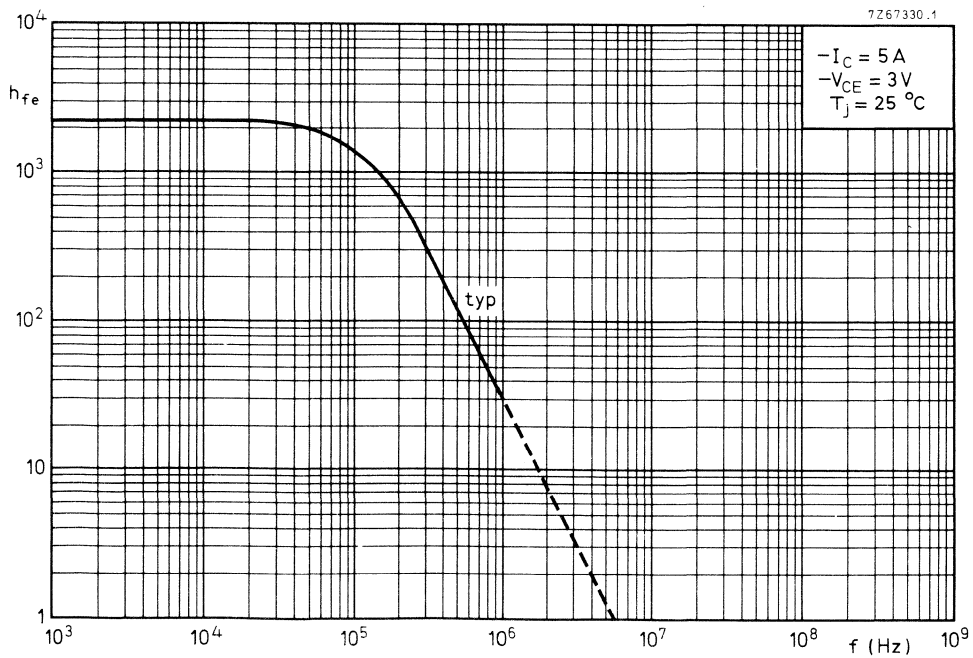


Fig. 12 Small-signal current gain.

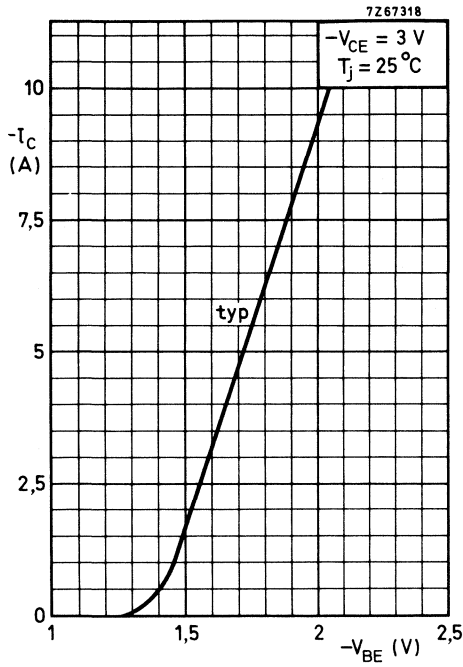


Fig. 13 Typical collector current.

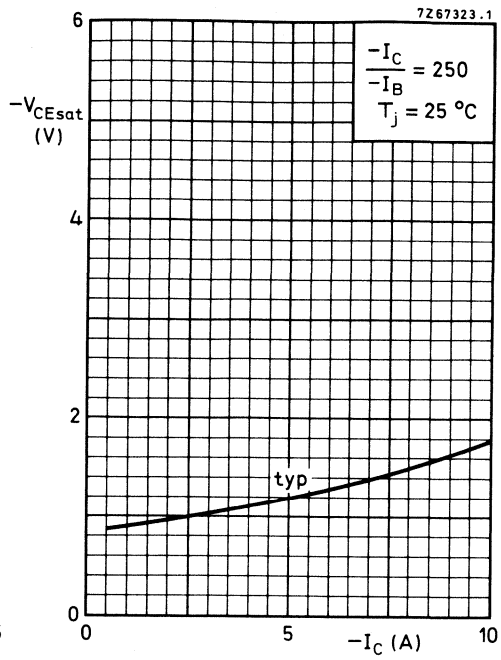


Fig. 14 Typical collector-emitter saturation voltage.

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-3 envelope. P-N-P complements are BDX64, BDX64A, BDX64B and BDX64C.

QUICK REFERENCE DATA

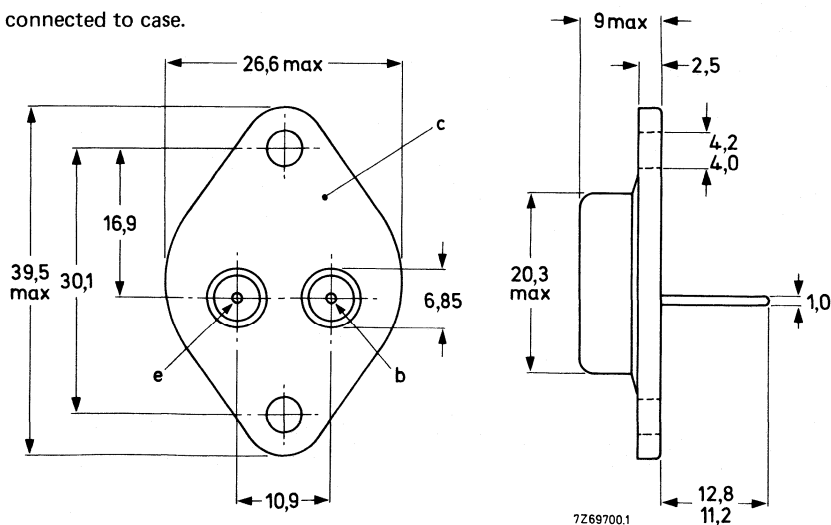
		BDX65	65A	65B	65C
Collector-base voltage (open emitter)	V_{CB0} max.	80	100	120	140 V
Collector-emitter voltage (open base)	V_{CE0} max.	60	80	100	120 V
Collector current (peak value)	I_{CM} max.	16			A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot} max.	117			W
Junction temperature	T_j max.	200			$^{\circ}\text{C}$
D.C. current gain $I_C = 1\text{ A}; V_{CE} = 3\text{ V}$	h_{FE} typ.	3300			
$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE} >	1000			
Cut-off frequency $I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe} typ.	50			kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

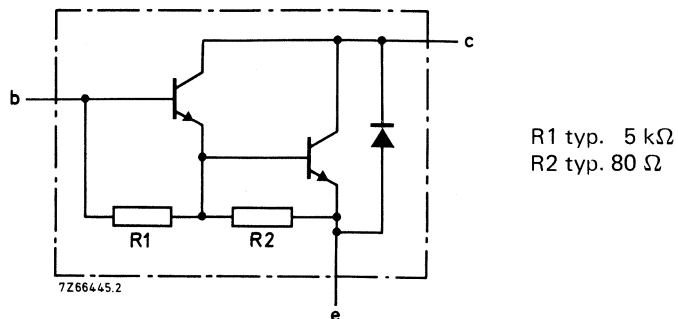


Fig. 2 Circuit diagram.

RATINGS

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

			BDX65	65A	65B	65C
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140 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.		16		A
Base current (d.c.)	I_B	max.		200		mA
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		117		W
Storage temperature	T_{stg}			-65 to +200		$^\circ\text{C}$
Junction temperature*	T_j	max.		200		$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j-mb}$	=		1,5		K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CE0max}$

$I_{CBO} < 0,4\text{ mA}$

$I_E = 0; V_{CB} = \frac{1}{2} V_{CBOmax}; T_j = 200\text{ }^\circ\text{C}$

$I_{CBO} < 3\text{ mA}$

$I_B = 0; V_{CE} = \frac{1}{2} V_{CE0max}$

$I_{CEO} < 0,2\text{ mA}$ ←

Emitter cut-off current

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

$I_{EBO} < 5\text{ mA}$

D.C. current gain (note 1)

$I_C = 1\text{ A}; V_{CE} = 3\text{ V}$

h_{FE} typ. 3300

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$I_C = 12\text{ A}; V_{CE} = 3\text{ V}$

h_{FE} typ. 3700

Base-emitter voltage (notes 1 and 2)

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage (note 1)

$I_C = 5\text{ A}; I_B = 20\text{ mA}$

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

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

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

C_c typ. 200 pF

Cut-off frequency

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$

f_{hfe} typ. 50 kHz

Turn-off breakdown energy with inductive load (Fig. 5)

$-I_{Boff} = 0; I_{CC} = 6,3\text{ A}$

$E_{(BR)} > 100\text{ mJ}$

Notes

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

CHARACTERISTICS (continued)

Diode, forward voltage

$I_F = 5 \text{ A}$

V_F typ. 1,2 V

Switching times

(between 10% and 90% levels)

$I_{C\text{on}} = 5 \text{ A}; I_{B\text{on}} = -I_{B\text{off}} = 20 \text{ mA}$

Turn-on time

t_{on} typ. 1 μs

Turn-off time

t_{off} typ. 6 μs

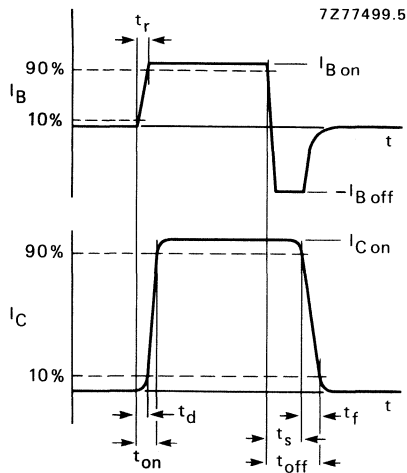
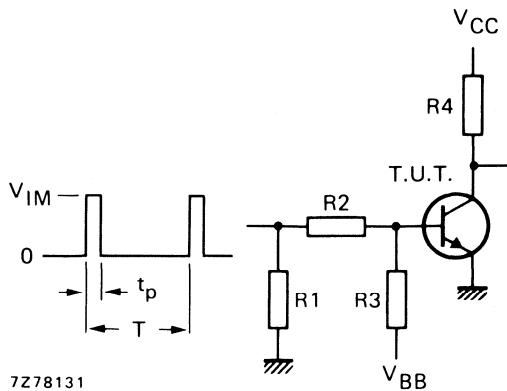


Fig. 3 Switching times waveforms.



- $V_{IM} = 15 \text{ V}$
- $V_{CC} = 15 \text{ V}$
- $-V_{BB} = 4 \text{ V}$
- $R1 = 56 \ \Omega$
- $R2 = 410 \ \Omega$
- $R3 = 560 \ \Omega$
- $R4 = 3 \ \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 10 \ \mu\text{s}$
- $T = 500 \ \mu\text{s}$

Fig. 4 Switching times test circuit.

CHARACTERISTICS (continued)

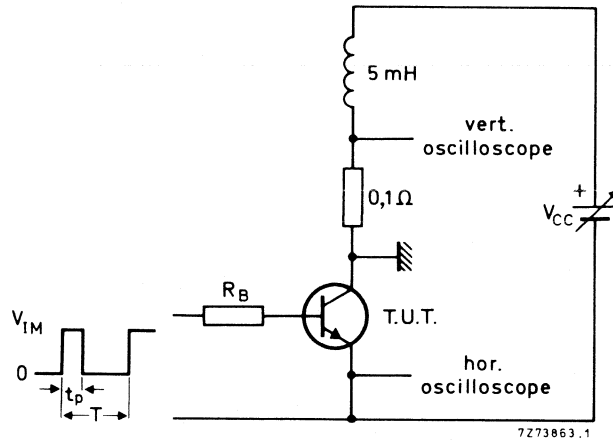


Fig. 5 Test circuit for turn-off breakdown energy. $V_{IM} = 12 \text{ V}$; $R_B = 270 \Omega$; $I_{CC} = 6,3 \text{ A}$; $\delta = 1\%$.

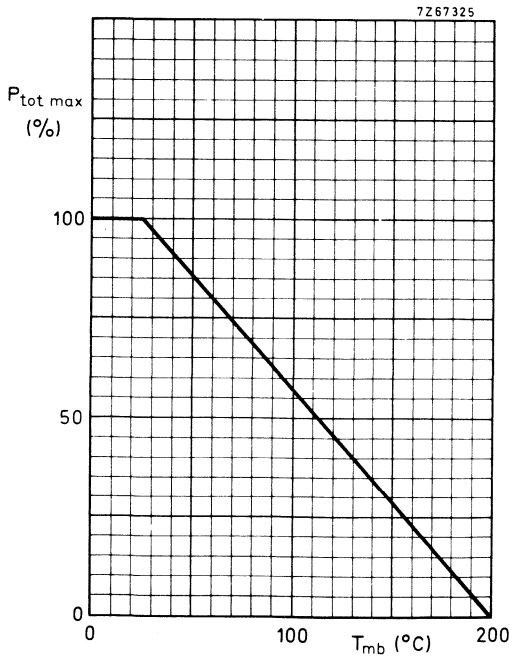


Fig. 6 Power derating curve.

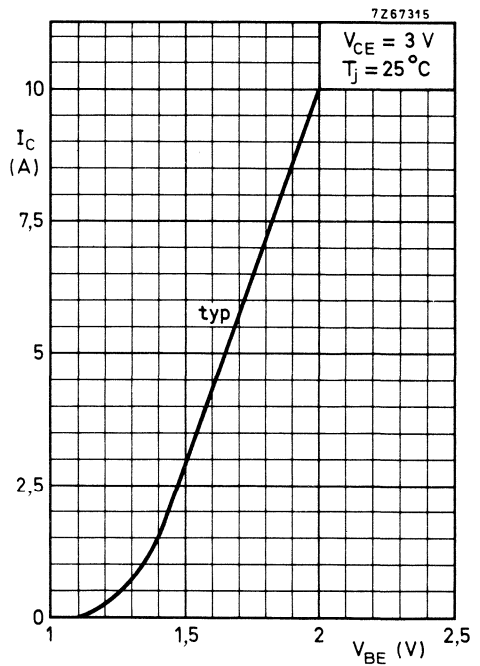


Fig. 7 Typical collector current.

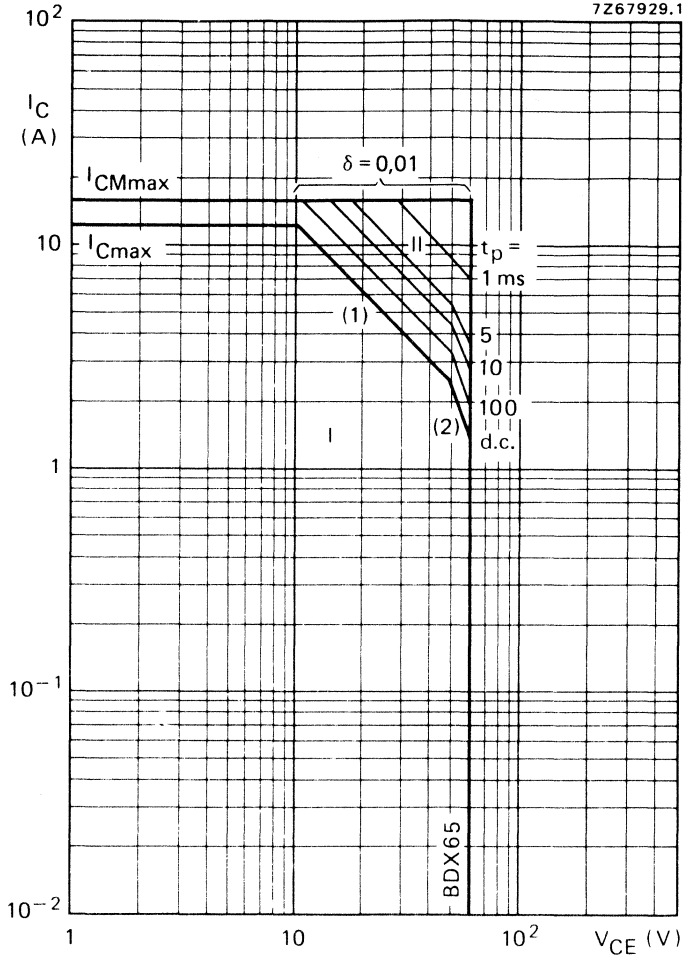


Fig. 8 Safe Operating ARea at $T_{mb} \leq 25 \text{ }^\circ\text{C}$ of BDX65.
 I Region of permissible d.c. operation.
 II Permissible extension for repetitive pulse operation.
 (1) $P_{tot \text{ max}}$ and $P_{tot \text{ peak max}}$ lines.
 (2) Second-breakdown limits.

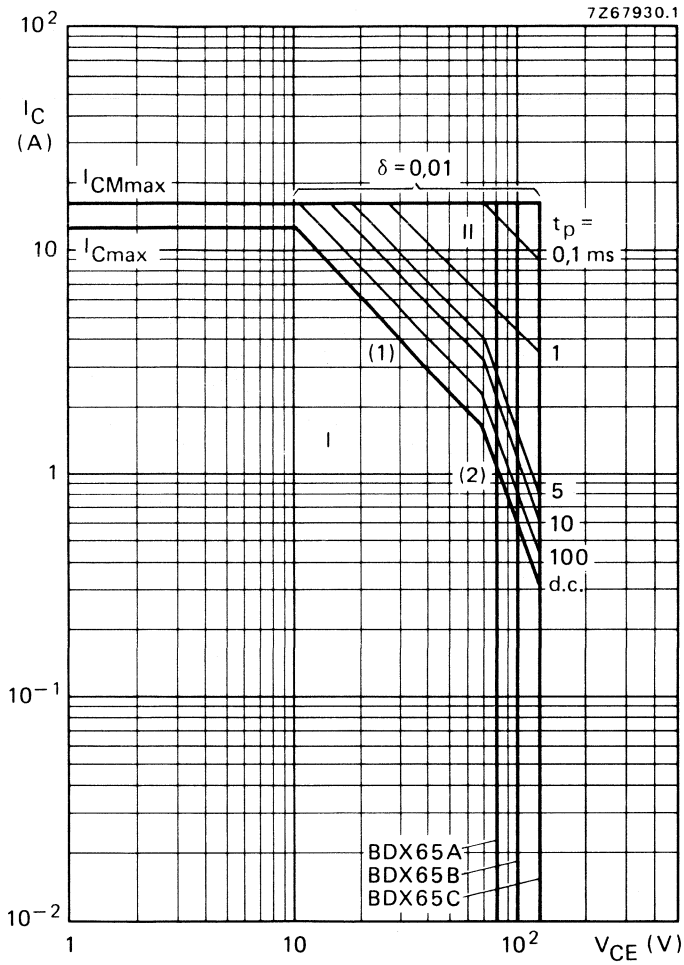


Fig. 9 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second-breakdown limits.

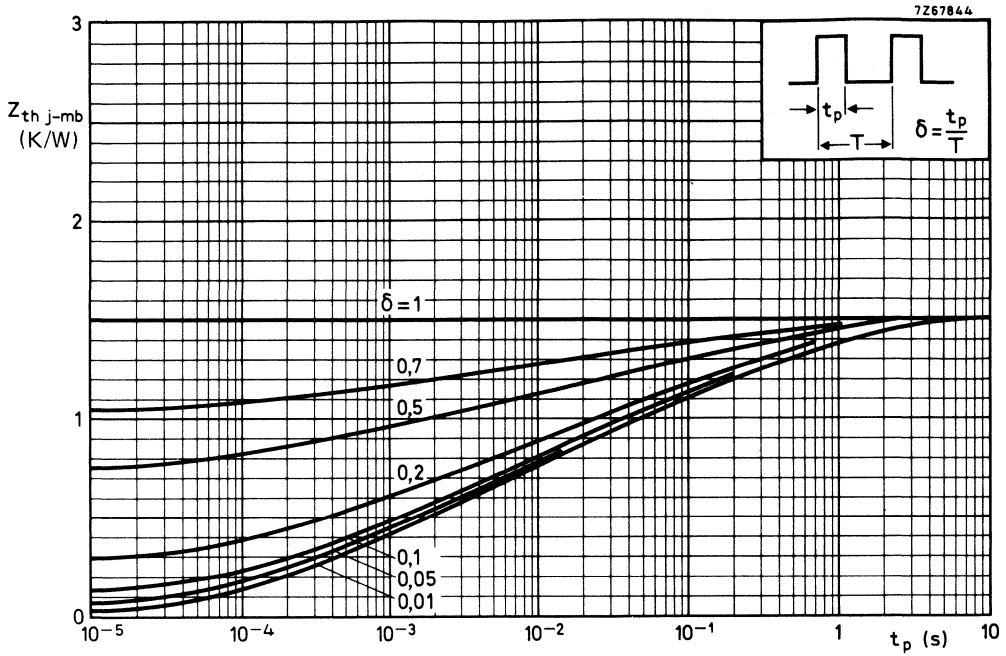


Fig. 10 Pulse power rating chart.

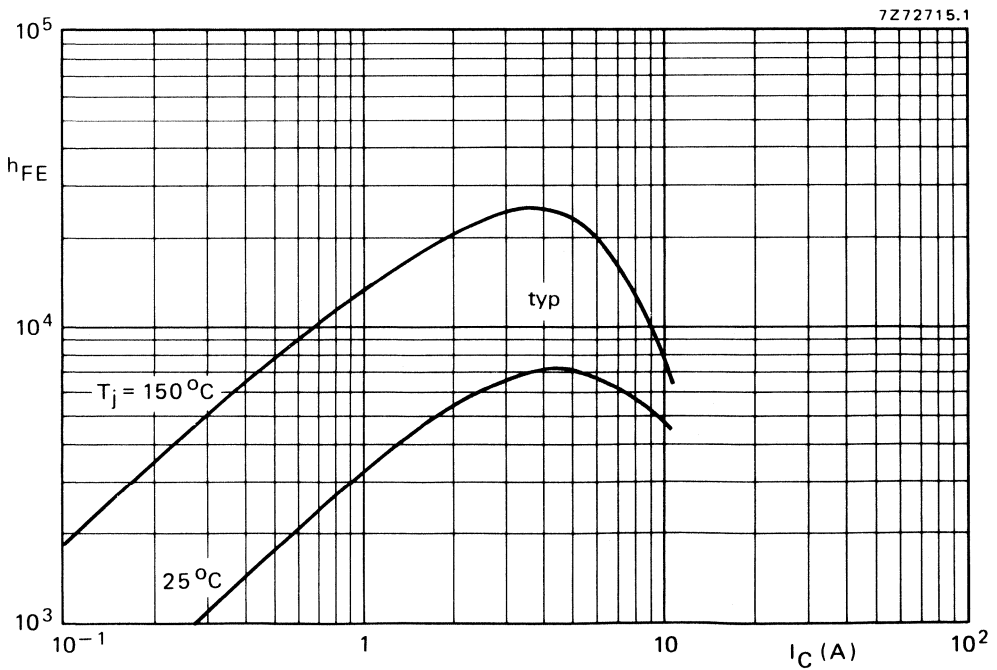


Fig. 11 Typical d.c. current gain at $V_{CE} = 3\ V$.

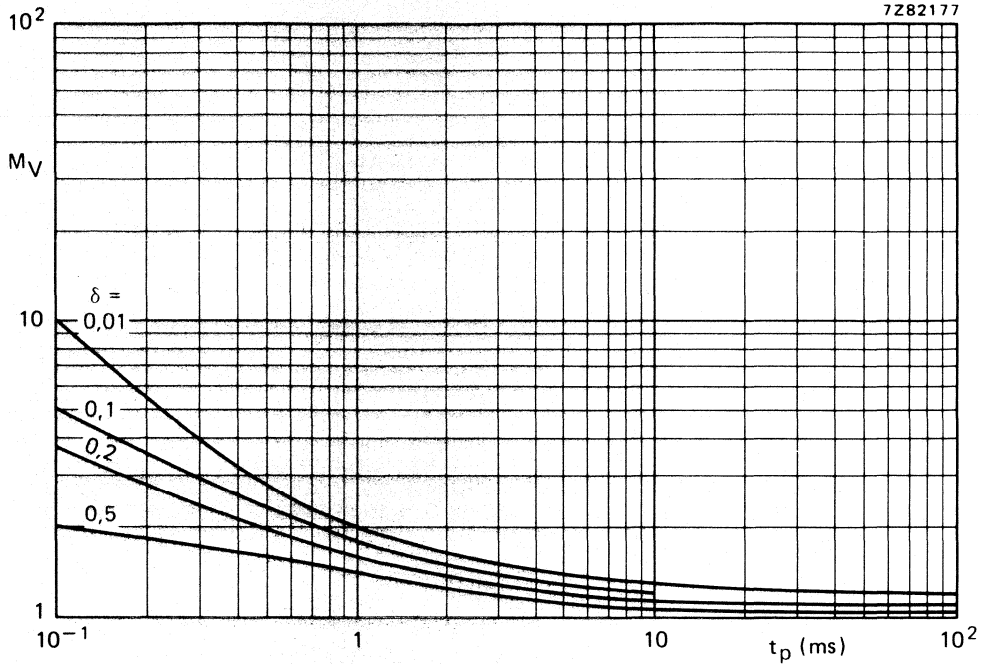


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

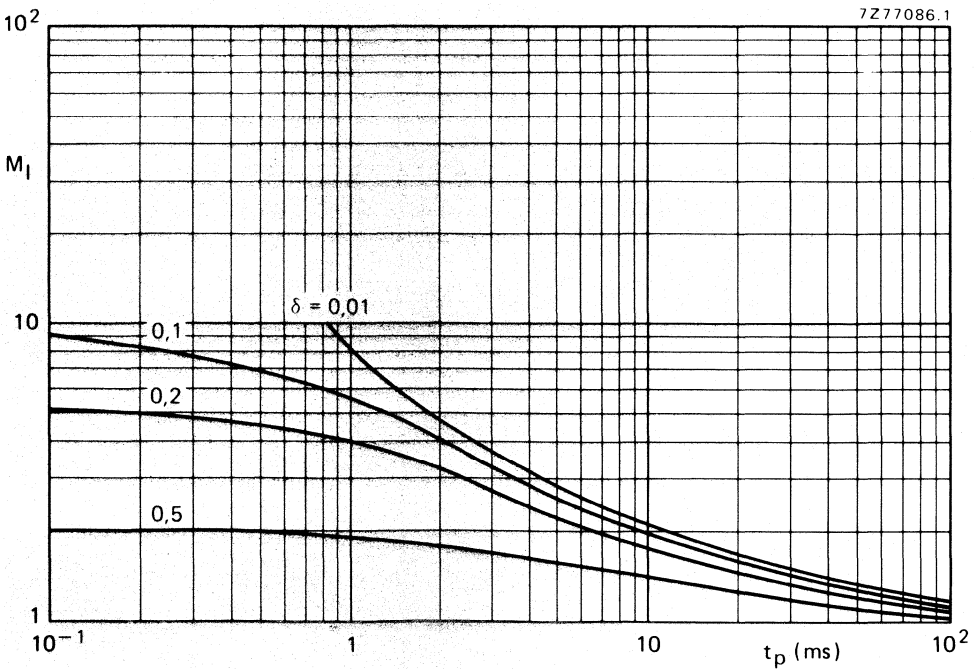


Fig. 13 S.B. current multiplying factor at V_{CE0} 100 V and 60 V level.

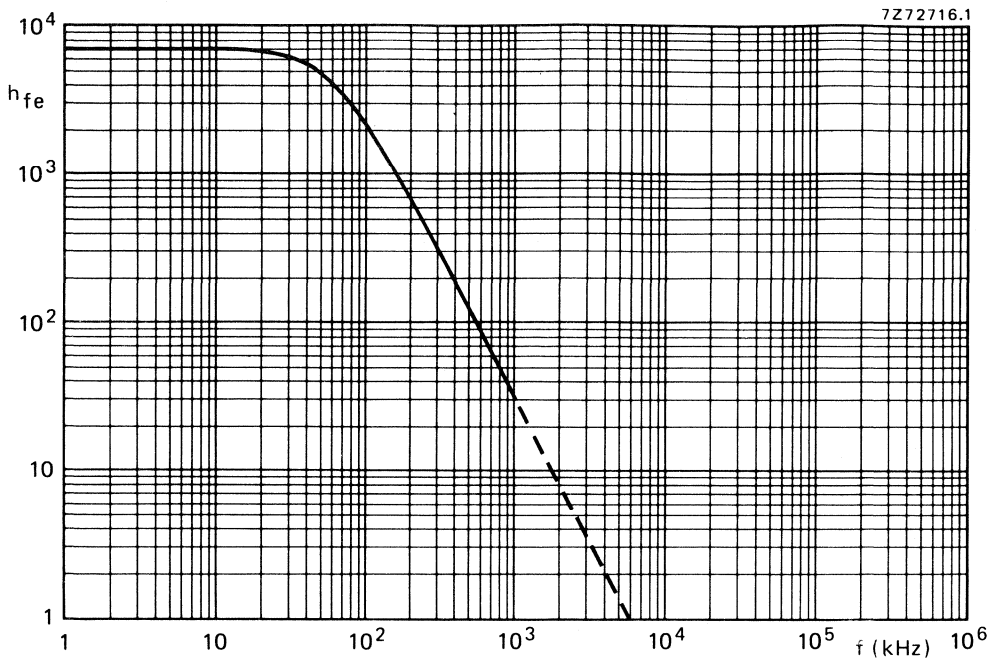


Fig. 14 Typical small-signal current gain, $I_C = 5 \text{ A}$; $V_{CE} = 3 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

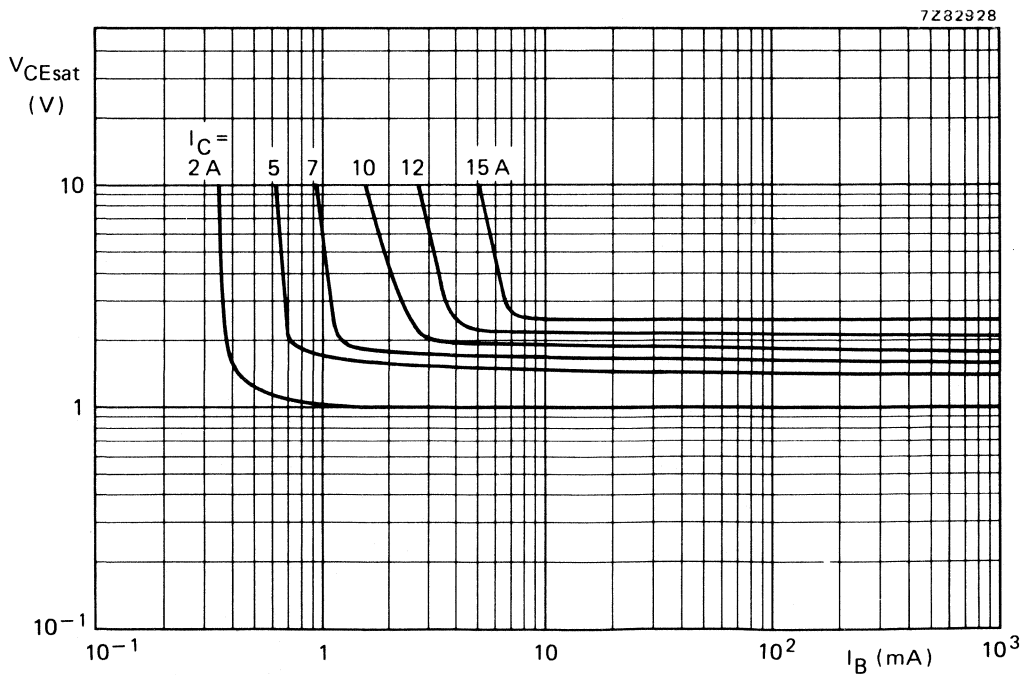


Fig. 15 Typical values collector-emitter saturation voltage. $T_{amb} = 25 \text{ }^\circ\text{C}$.

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-3 envelope. N-P-N complements are BDX67, BDX67A, BDX67B and BDX67C.

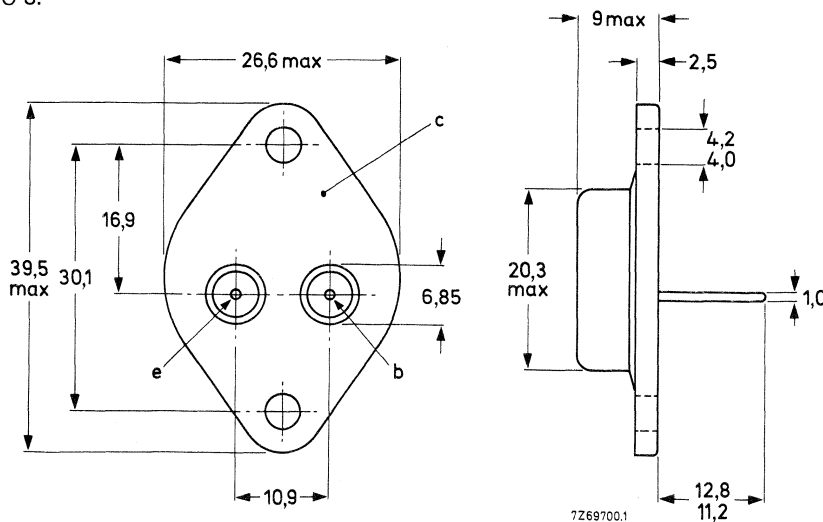
QUICK REFERENCE DATA

			BDX66	66A	66B	66C
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 (peak value)	$-I_{CM}$	max.	20			A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.	150			W
Junction temperature	T_j	max.	200			$^{\circ}\text{C}$
D.C. current gain						
$-I_C = 1\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	typ.	2000			
$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE}	>	1000			
Cut-off frequency						
$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe}	typ.	60			kHz

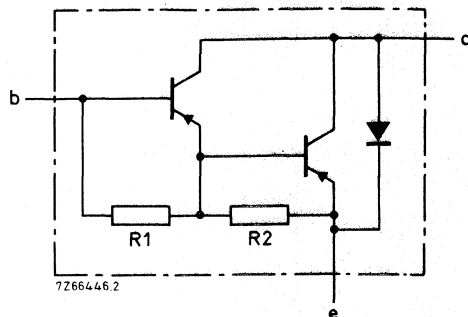
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.



See also chapters Mounting instructions and Accessories.



R1 typ. 3 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

		BDX66	66A	66B	66C
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.	16		A
Collector current (peak value)	$-I_{CM}$	max.	20		A
Base current	$-I_B$	max.	250		mA
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	150		W
Storage temperature	T_{stg}		-65 to +200		$^\circ\text{C}$
Junction temperature*	T_j	max.	200		$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	R_{thj-mb}	=	1,17	K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = -V_{CB0max}$

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

$I_E = 0; -V_{CB} = 40\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX66}$

$I_E = 0; -V_{CB} = 50\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX66A}$

$I_E = 0; -V_{CB} = 60\text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX66B}$

$I_E = 0; -V_{CB} = 70\text{ V}; T_j = 20\text{ }^\circ\text{C}; \text{BDX66C}$

$-I_{CBO} < 5\text{ mA}$

$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEOmax}$

$-I_{CEO} < 1\text{ mA}$

Emitter cut-off current

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

$-I_{EBO} < 5\text{ mA}$

D.C. current gain *

$-I_C = 1\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 2000$

$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$-I_C = 16\text{ A}; -V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 1000$

Base-emitter voltage *

$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$

$-V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage *

$-I_C = 10\text{ A}; -I_B = 40\text{ mA}$

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

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

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

$C_C \text{ typ. } 300\text{ pF}$

Cut-off frequency

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 60\text{ kHz}$

Small-signal current gain

$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

$h_{fe} \text{ typ. } 50$

Diode, forward voltage

$I_F = 10\text{ A}$

$V_F \text{ typ. } 2\text{ V}$

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

CHARACTERISTICS (continued)

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

Switching times

(between 10% and 90% levels)

$-I_{Con} = 10\text{ A}$; $-I_{B on} = I_{B off} = 40\text{ mA}$

turn-on time

turn-off time

t_{on}	typ.	1 μs
t_{off}	typ.	3,5 μs

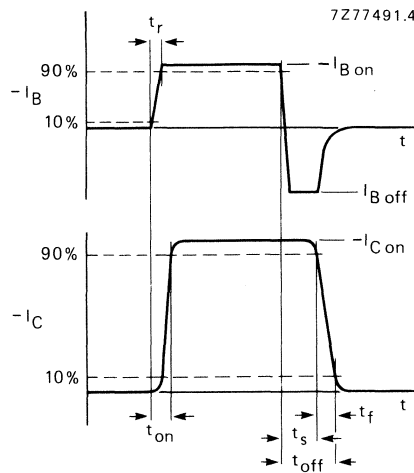


Fig. 3 Switching times waveforms.

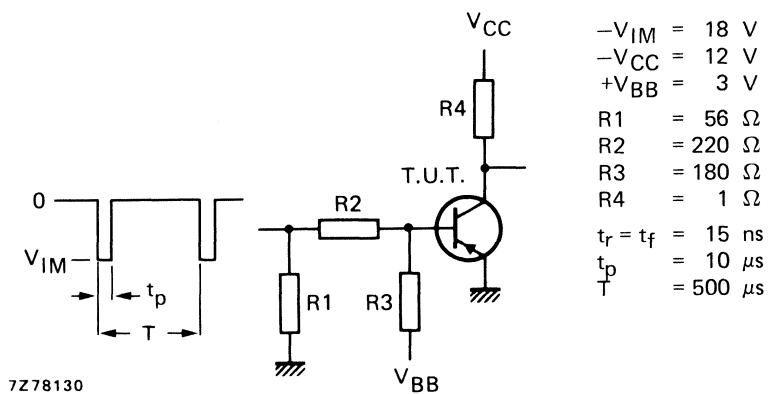


Fig. 4 Switching times test circuit.

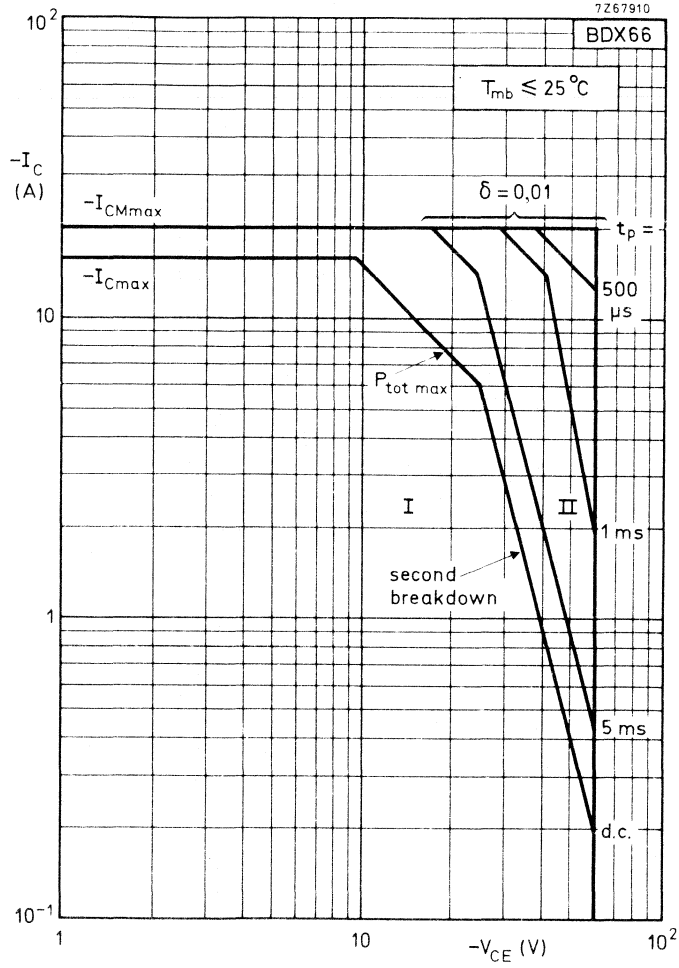


Fig. 5 Safe Operating Area with the transistor forward biased.

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

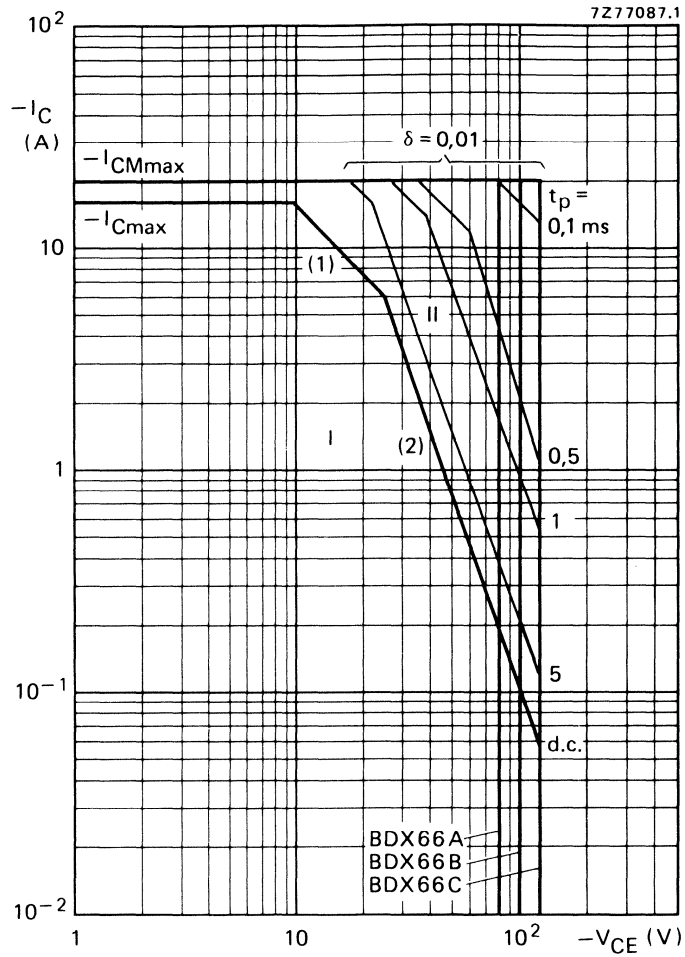


Fig. 6 Safe Operating Area.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

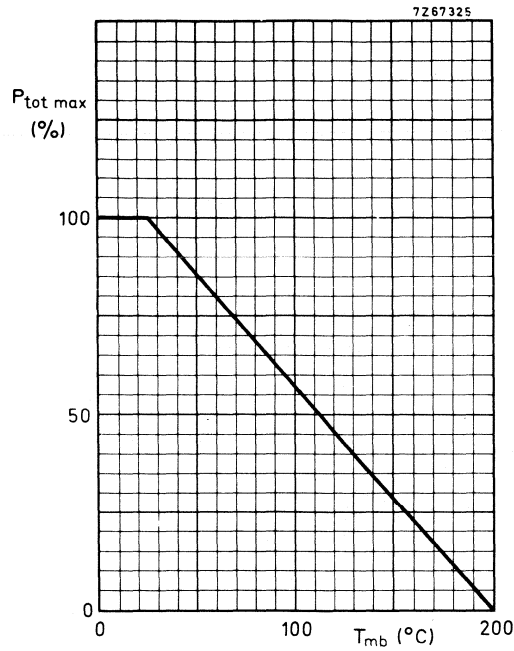


Fig. 7 Power derating curve.

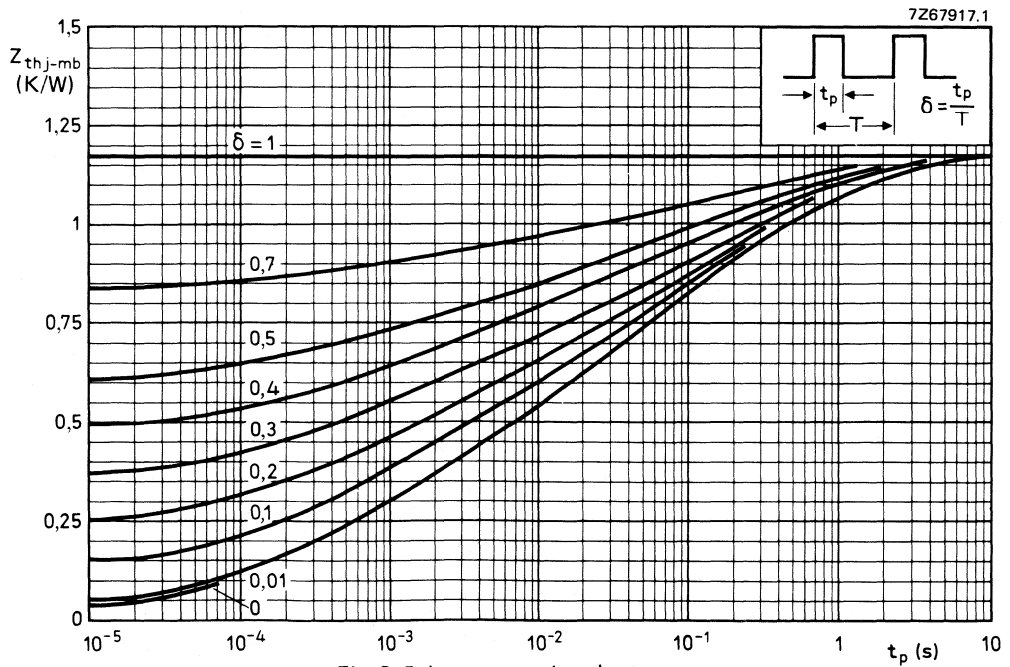


Fig. 8 Pulse power rating chart.

7277090

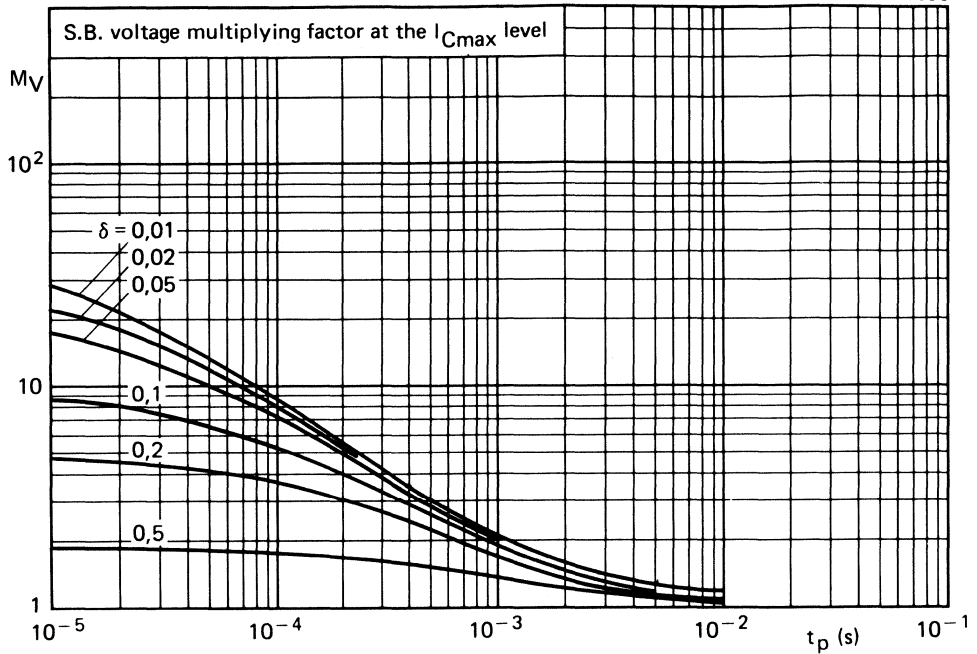


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

7277089

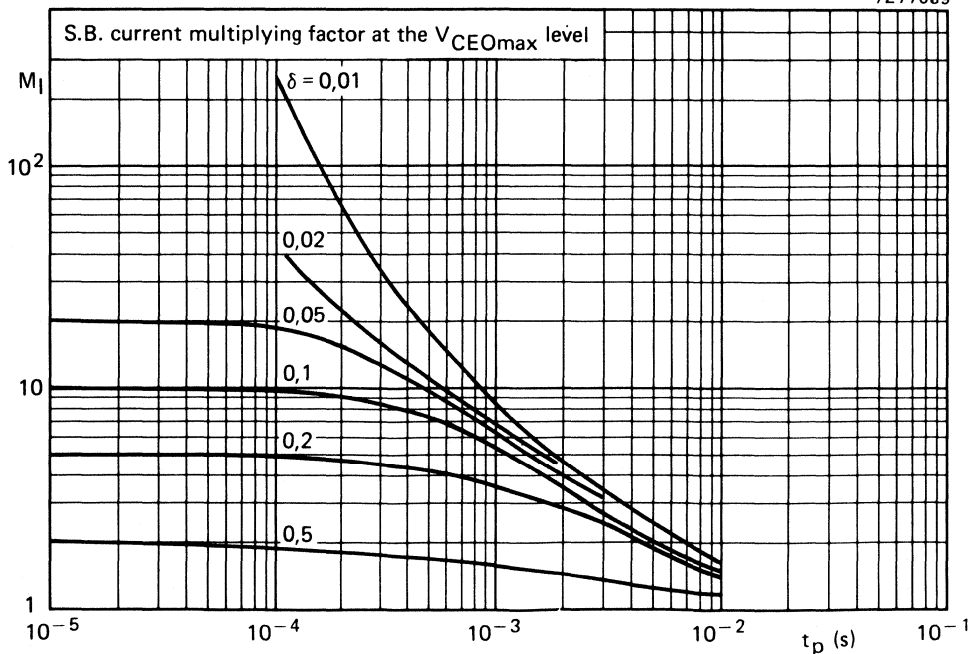


Fig. 10 S.B. current multiplying factor at the V_{CE0max} level.

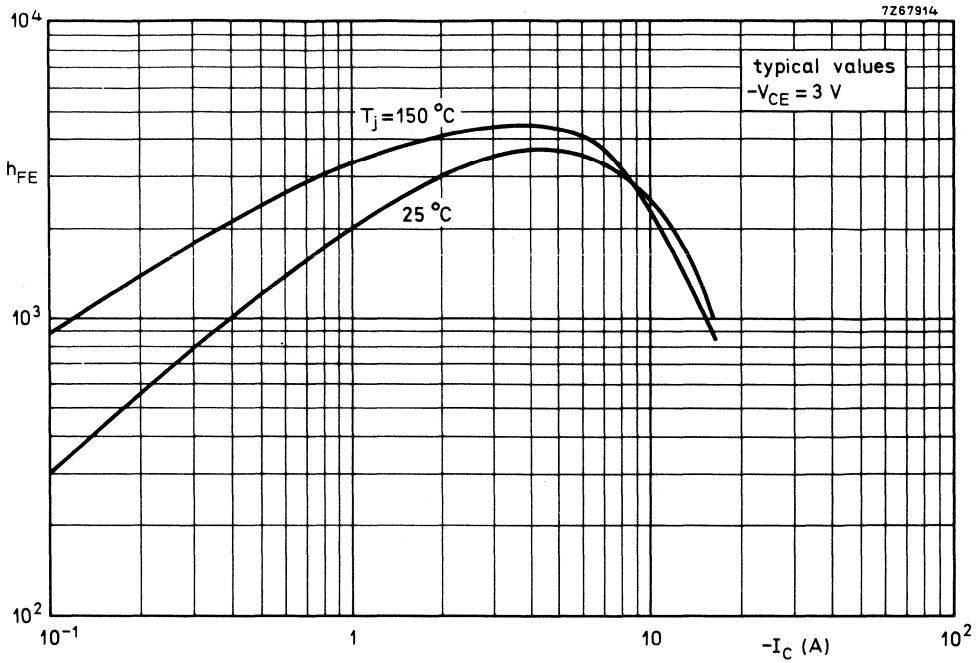


Fig. 11 D.C. current gain.

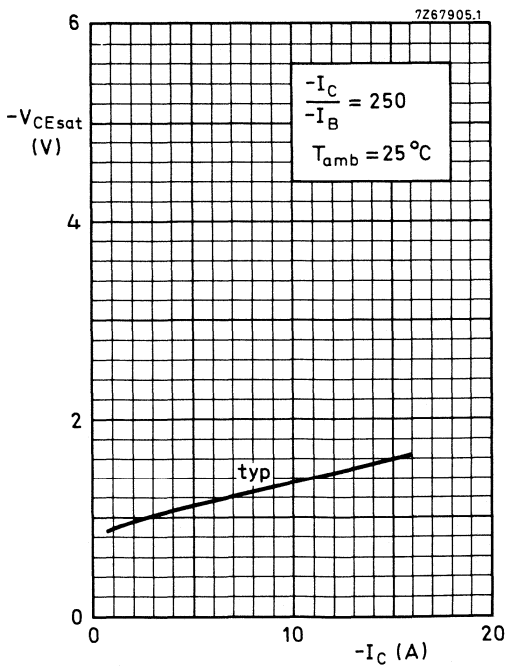


Fig. 12 Collector-emitter saturation voltage.

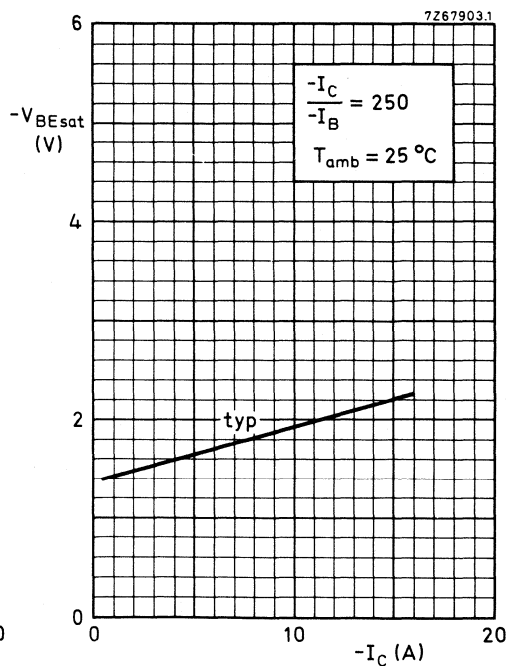


Fig. 13 Base-emitter saturation voltage.

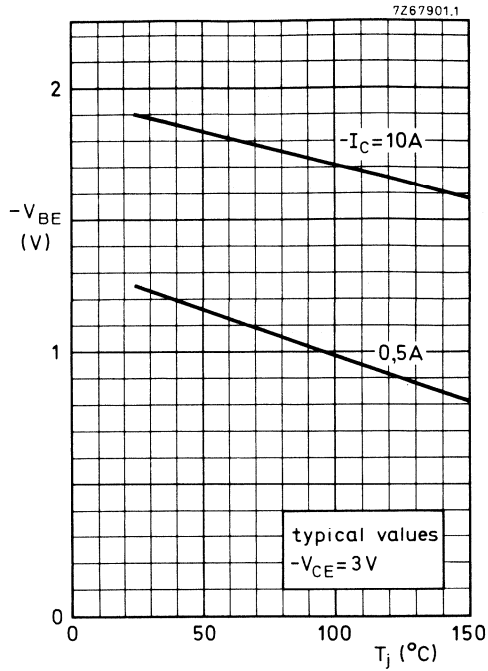


Fig. 14 Typical base-emitter voltage.

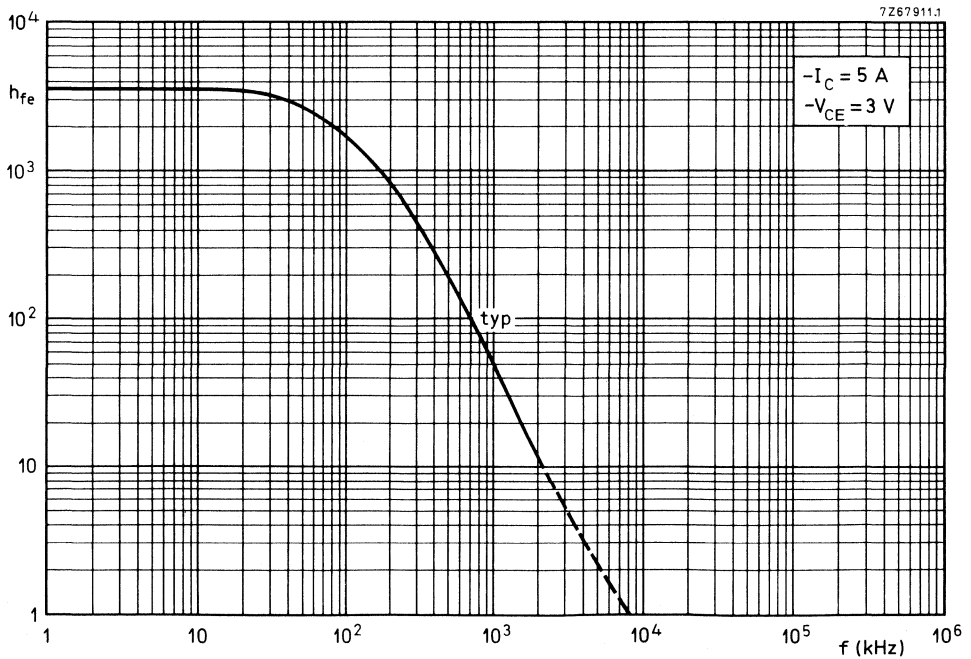


Fig. 15 Small-signal current gain.

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-3 envelope. P-N-P complements are BDX66, BDX66A, BDX66B and BDX66C.

QUICK REFERENCE DATA

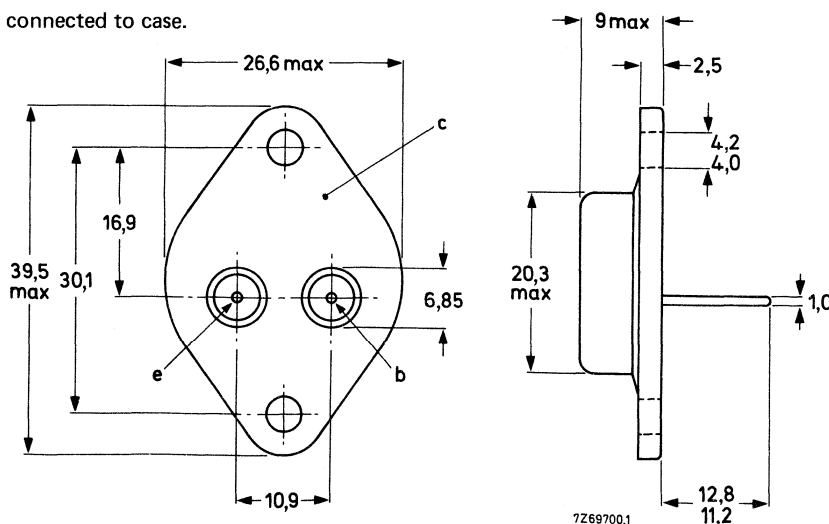
		BDX67	67A	67B	67C
Collector-base voltage (open emitter)	V_{CBO} max.	80	100	120	140 V
Collector-emitter voltage (open base)	V_{CEO} max.	60	80	100	120 V
Collector current (peak value)	I_{CM} max.	20		A	
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot} max.	150		W	
Junction temperature	T_j max.	200		$^{\circ}\text{C}$	
D.C. current gain $I_C = 1\text{ A}; V_{CE} = 3\text{ V}$	h_{FE} typ.	5200			
$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$	h_{FE} >	1000			
Cut-off frequency $I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe} typ.	50		kHz	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories.

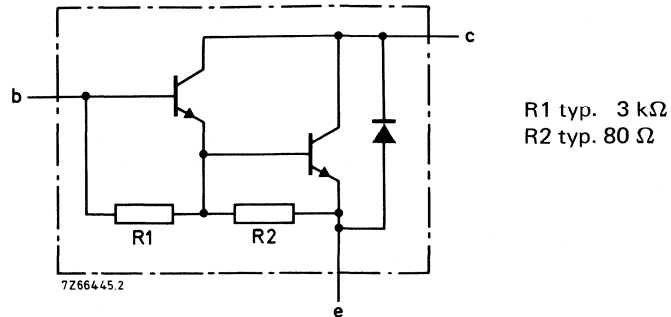


Fig. 2 Circuit diagram.

RATINGS

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

			BDX67	67A	67B	67C
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140 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.		16		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		250		mA
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		150		W
Storage temperature	T_{stg}			-65 to +200		$^\circ\text{C}$
Junction temperature *	T_j	max.		200		$^\circ\text{C}$
THERMAL RESISTANCE *						
From junction to mounting base	$R_{th\ j-mb}$	=		1,17		K/W

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CE0max}$

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

$I_E = 0; V_{CB} = \frac{1}{2} V_{CB0max}; T_j = 200\text{ }^\circ\text{C}$

$I_{CBO} < 5\text{ mA}$

$I_B = 0; V_{CE} = \frac{1}{2} V_{CE0max}$

$I_{CEO} < 1\text{ mA}$ ←

Emitter-cut-off current

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

$I_{EBO} < 5\text{ mA}$

D.C. current gain *

$I_C = 1\text{ A}; V_{CE} = 3\text{ V}$

h_{FE} typ. 5200

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$I_C = 16\text{ A}; V_{CE} = 3\text{ V}$

h_{FE} typ. 4000

Base-emitter voltage *

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage *

$I_C = 10\text{ A}; I_B = 40\text{ mA}$

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

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

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

C_c typ. 300 pF

Cut-off frequency

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$

f_{hfe} typ. 50 kHz

Turn-off breakdown energy with inductive load

$-I_{Boff} = 0; I_{CC} = 7,8\text{ A};$ see Fig. 5

$E_{(BR)} > 150\text{ mJ}$

Small-signal current gain

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

h_{fe} typ. 20

Diode, forward voltage

$I_F = 10\text{ A}$

V_F typ. 2,5 V

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

CHARACTERISTICS (continued)

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

Switching times

(between 10% and 90% levels)

$I_{Con} = 10\text{ A}$; $I_{B on} = -I_{B off} = 40\text{ mA}$;

turn-on time

turn-off time

t_{on}	typ.	1 μs
t_{off}	typ.	3,5 μs

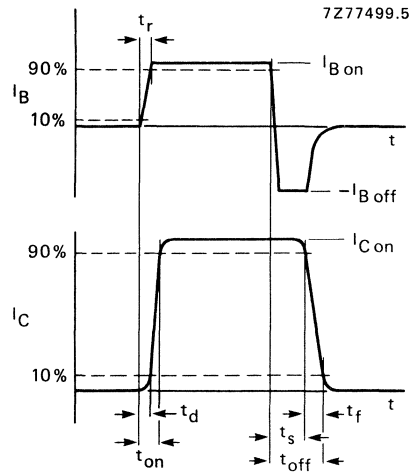


Fig. 3 Switching times waveforms.

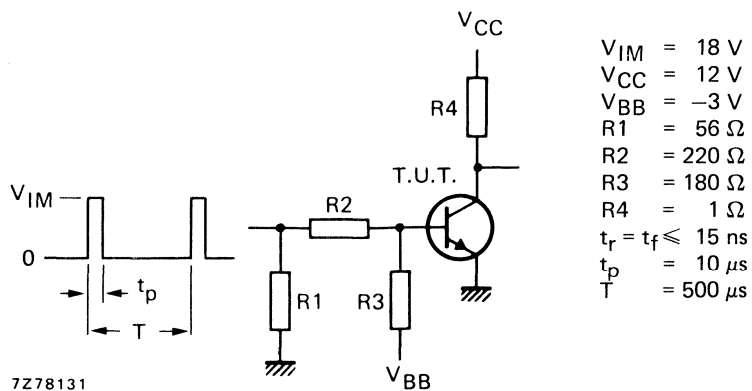


Fig. 4 Switching times test circuit.

CHARACTERISTICS (continued)

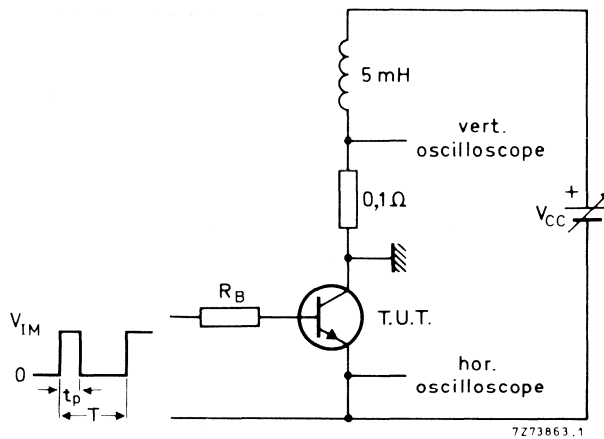


Fig. 5 Test circuit for turn-off breakdown energy. $V_{IM} = 12$ V; $R_B = 270$ Ω ; $I_{CC} = 7,8$ A; $t_p = 1$ ms; $\delta = 1\%$.

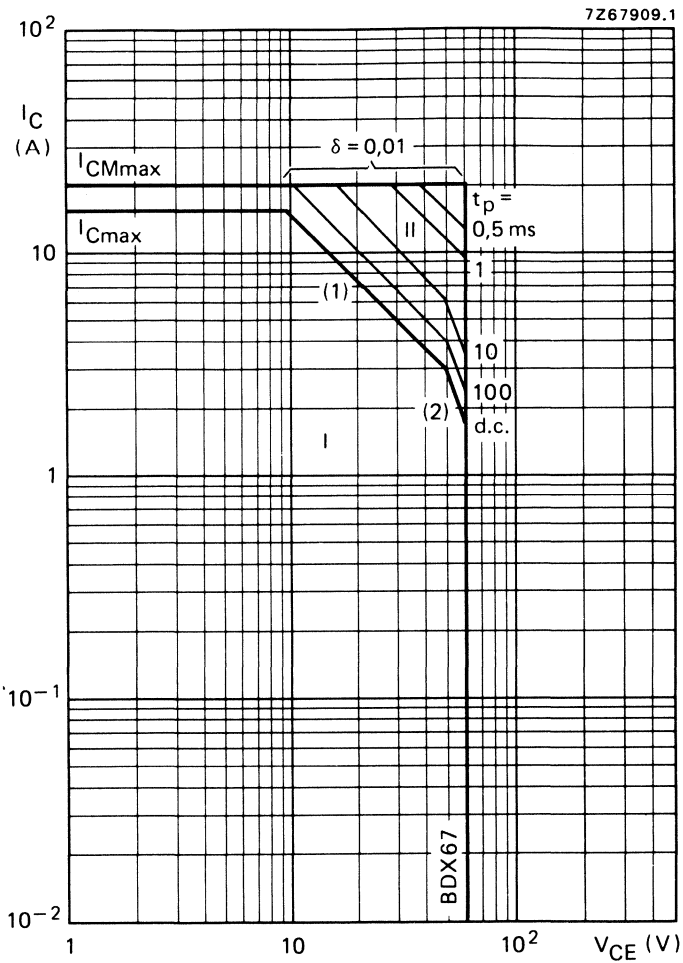


Fig. 6 Safe Operating Area at $T_{mb} = 25\text{ }^{\circ}\text{C}$ of BDX67.

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.

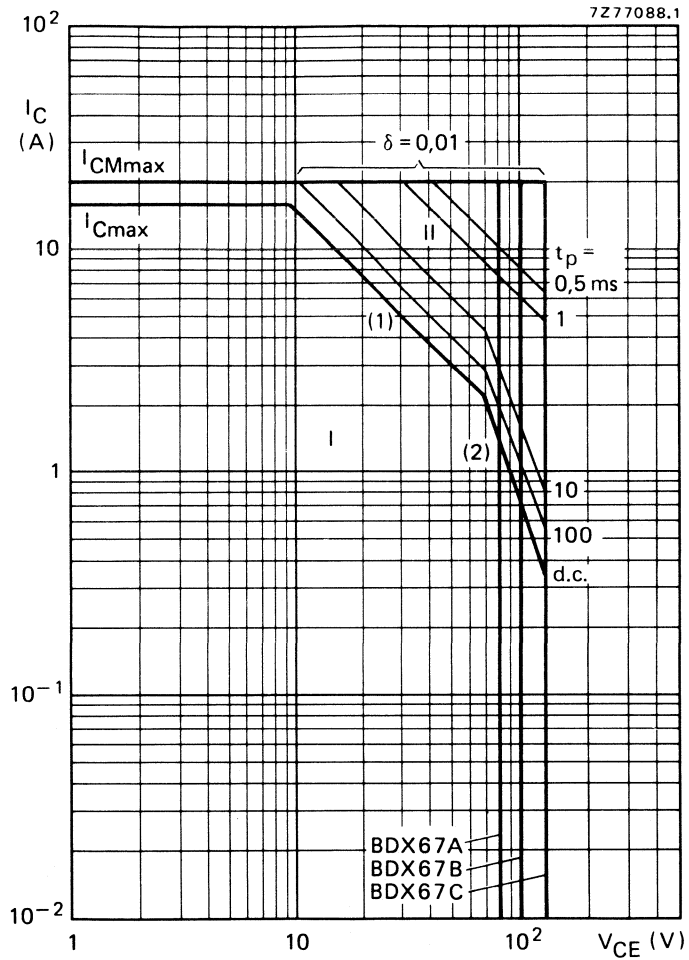


Fig. 7 Safe Operating Area at $T_{mb} = 25\text{ }^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

(2) Second breakdown limits.

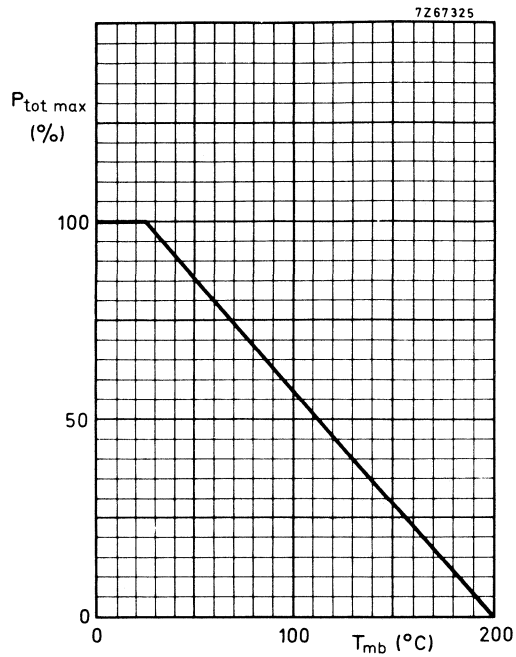


Fig. 8 Power derating curve.

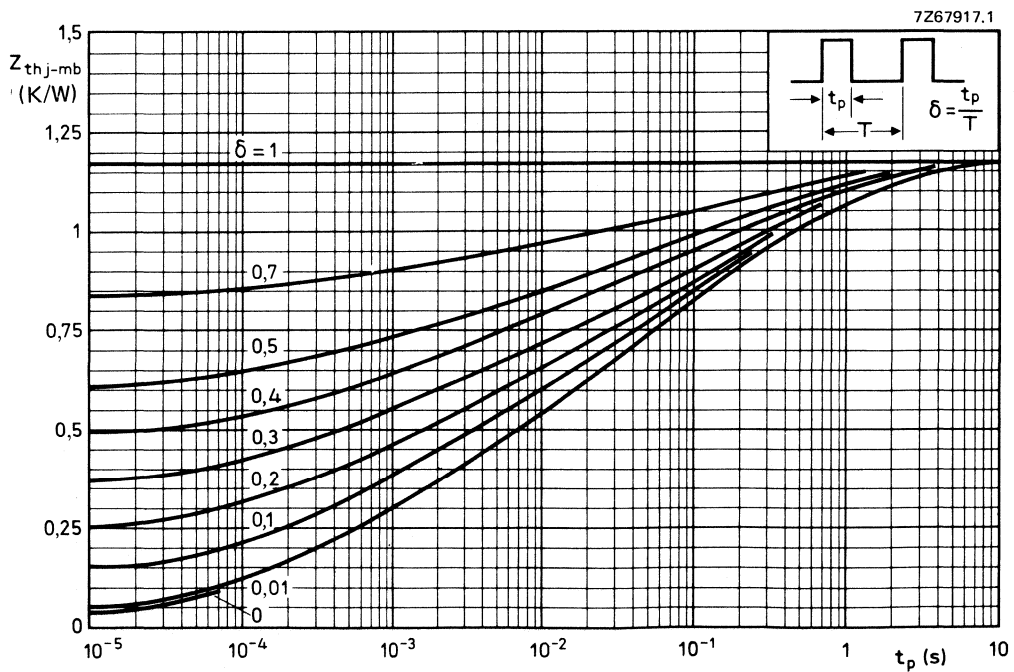


Fig. 9 Pulse power rating chart.

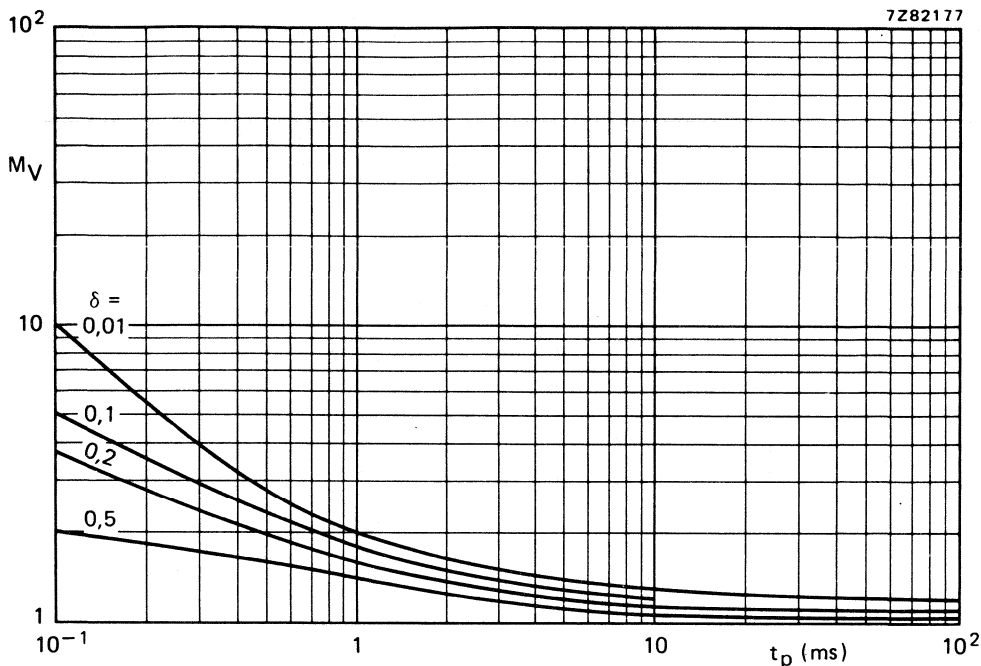


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

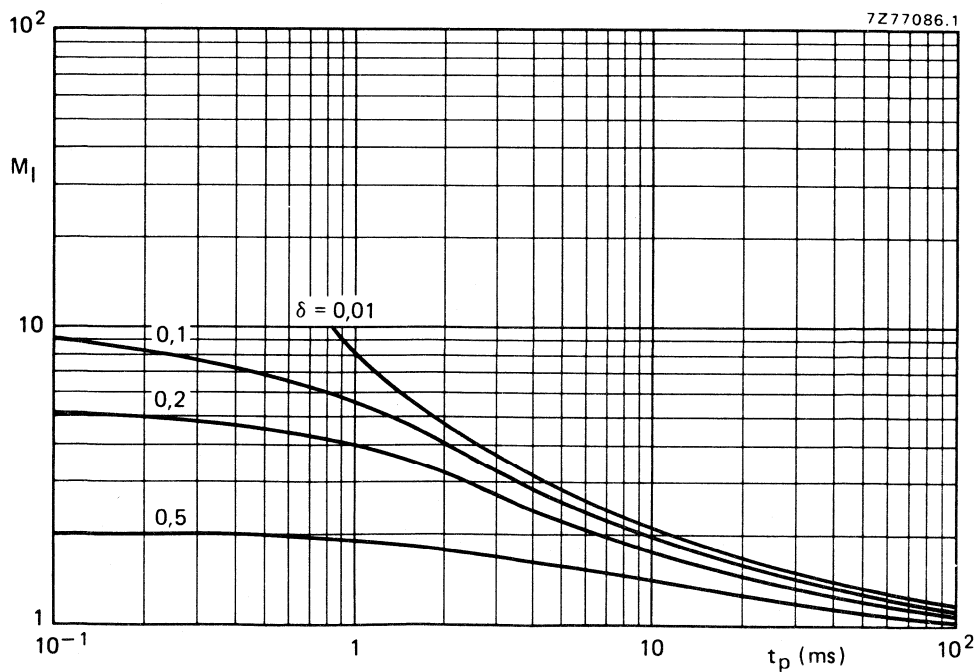


Fig. 11 S.B. current multiplying factor at the V_{CE0max} level.

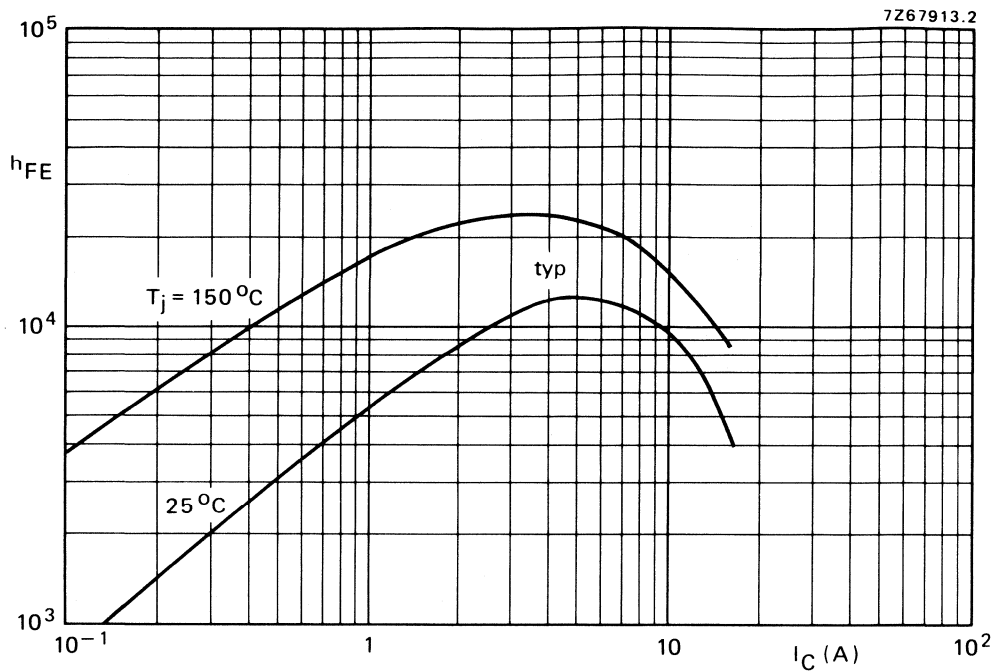


Fig. 12 D.C. current gain.

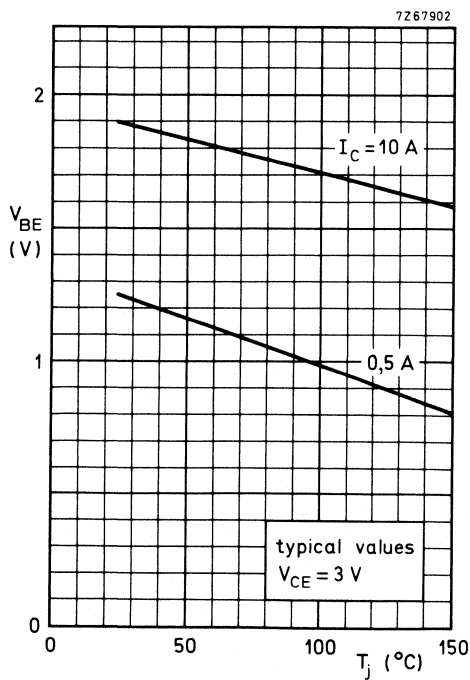


Fig. 13 Typical base-emitter voltage.

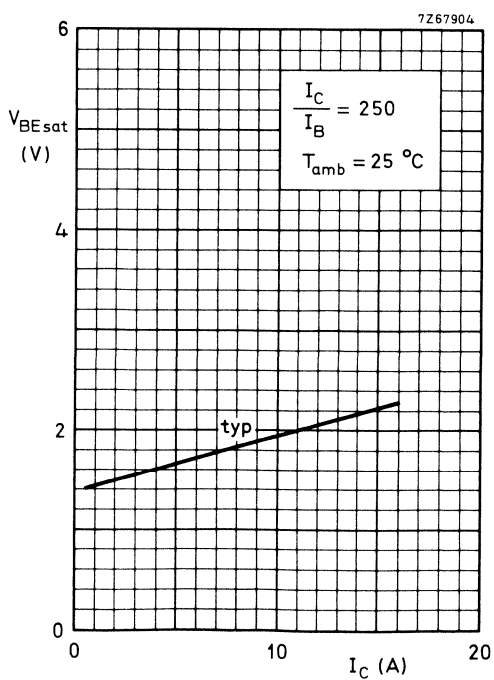


Fig. 14 Base-emitter saturation voltage.

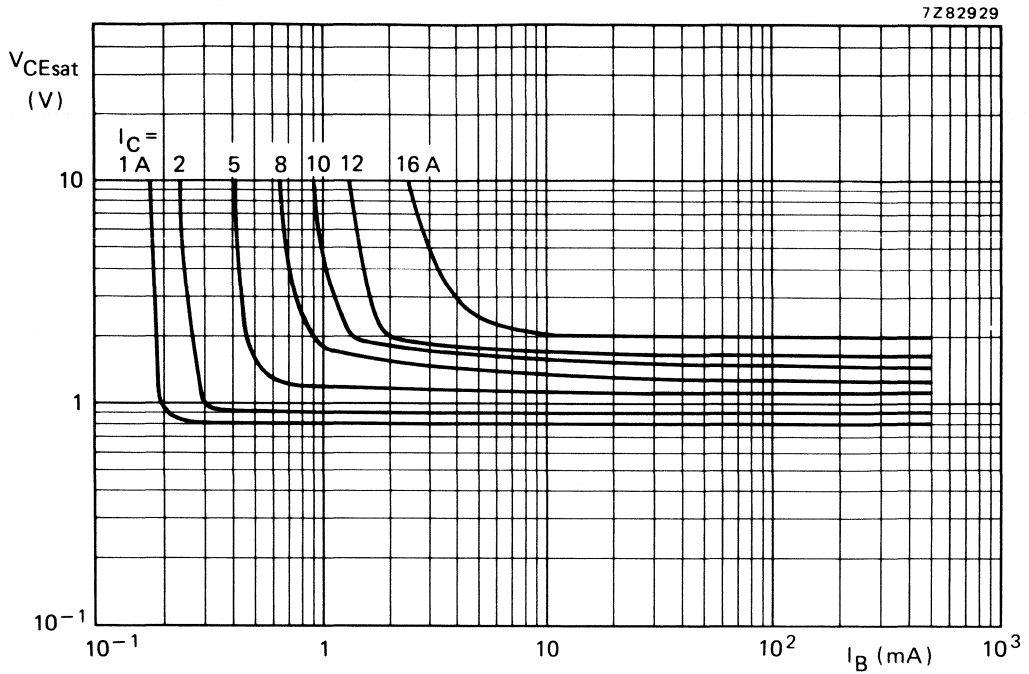


Fig. 15 Typical values collector-emitter saturation voltage at $T_j = 25^\circ\text{C}$.

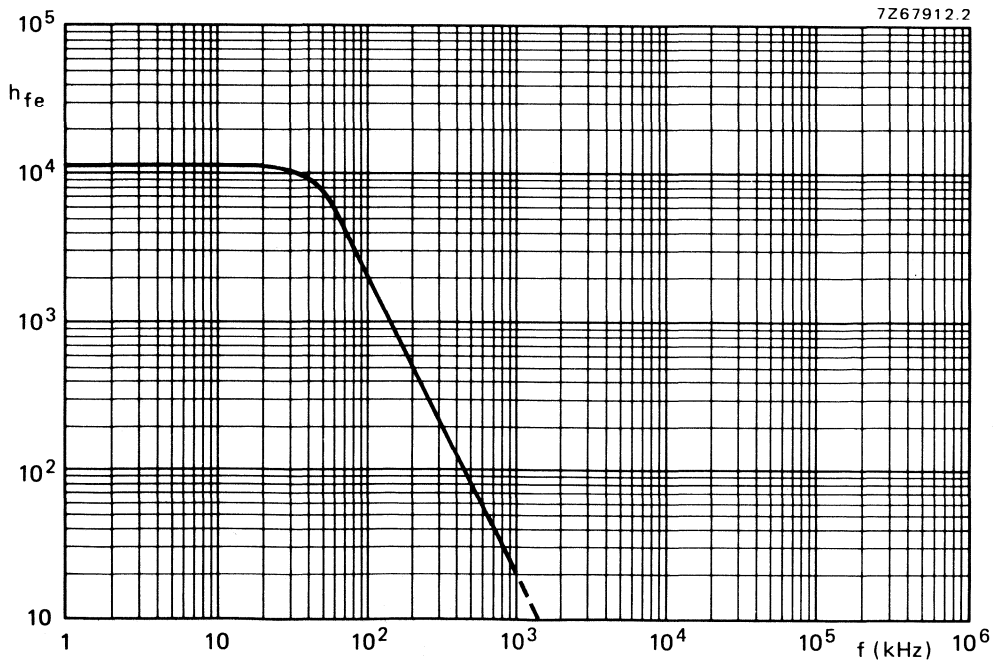


Fig. 16 Small-signal current gain, $I_C = 5\text{ A}$; $V_{CE} = 3\text{ V}$.

DARLINGTON POWER TRANSISTORS

P-N-P Darlington's for audio output stages and general amplifier and switching applications. In a TO-3 envelope. N-P-N complements are BDX69, BDX69A, BDX69B and BDX69C.

QUICK REFERENCE DATA

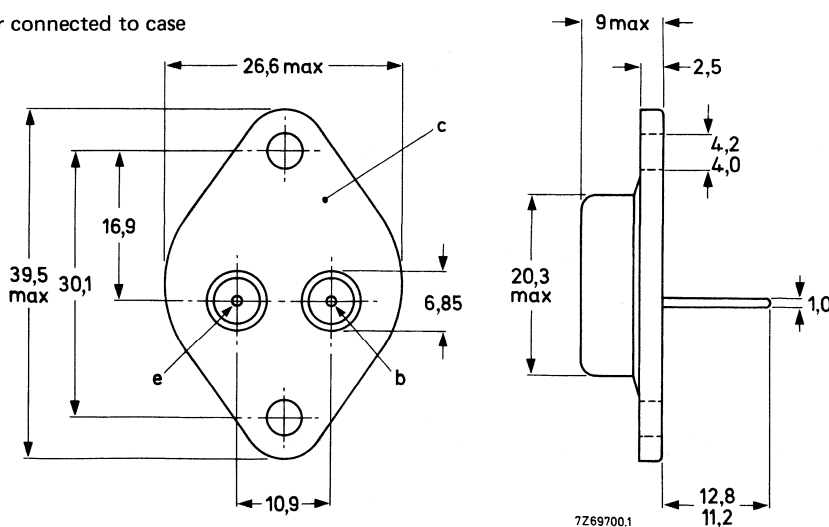
		BDX68	68A	68B	68C	
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$ max.	40				A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot} max.	200				W
Junction temperature	T_j max.	200				$^{\circ}\text{C}$
D.C. current gain						
$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} typ.	3000				
$-I_C = 20\text{ A}; -V_{CE} = 3\text{ V}$	h_{FE} >	1000				
Cut-off frequency						
$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}$	f_{hfe} typ.	60				kHz

MECHANICAL DATA

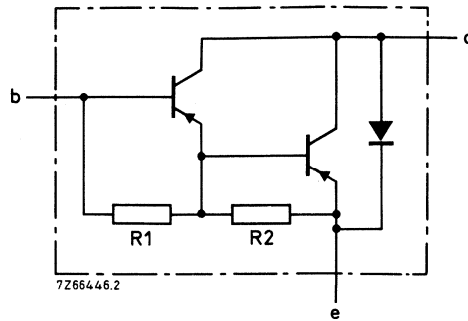
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case



See also chapters Mounting instructions and Accessories.



R1 typ. 1,5 kΩ
R2 typ. 40 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX68	68A	68B	68C	
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.	25				A
Collector current (peak value)	$-I_{CM}$	max.	40				A
Base current	$-I_B$	max.	500				mA
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	200				W
Storage temperature	T_{stg}		-65 to +200				$^\circ\text{C}$
Junction temperature*	T_j	max.	200				$^\circ\text{C}$

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	0,875			K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current

$$I_E = 0; -V_{CB} = -V_{CB0\max} \quad -I_{CBO} < 2\text{ mA}$$

$$I_E = 0; -V_{CB} = -\frac{1}{2}V_{CB0\max}; T_j = 200\text{ }^\circ\text{C} \quad -I_{CBO} < 10\text{ mA}$$

$$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CE0\max} \quad -I_{CEO} < 6\text{ mA}$$

Emitter cut-off current

$$I_C = 0; -V_{EB} = 5\text{ V} \quad -I_{EBO} < 10\text{ mA}$$

D.C. current gain*

$$-I_C = 5\text{ A}; -V_{CE} = 3\text{ V} \quad h_{FE} \text{ typ. } 3000$$

$$-I_C = 20\text{ A}; -V_{CE} = 3\text{ V} \quad h_{FE} > 1000$$

$$-I_C = 30\text{ A}; -V_{CE} = 3\text{ V} \quad h_{FE} \text{ typ. } 1000$$

Base-emitter voltage*

$$-I_C = 20\text{ A}; -V_{CE} = 3\text{ V} \quad -V_{BE} < 2,5\text{ V}$$

Collector-emitter saturation voltage*

$$-I_C = 20\text{ A}; -I_B = 80\text{ mA} \quad -V_{CE\text{sat}} < 2\text{ V}$$

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

$$I_E = I_e = 0; -V_{CB} = 10\text{ V} \quad C_c \text{ typ. } 600\text{ pF}$$

Cut-off frequency

$$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V} \quad f_{hfe} \text{ typ. } 60\text{ kHz}$$

Small-signal current gain

$$-I_C = 10\text{ A}; -V_{CE} = 3\text{ V}; f = 1\text{ MHz} \quad h_{fe} \text{ typ. } 20$$

Diode, forward voltage

$$I_F = 20\text{ A} \quad V_F \text{ typ. } 2,0\text{ V}$$

Switching times

(between 10% and 90% levels)

$$-I_{C\text{on}} = 20\text{ A}; -I_{B\text{on}} = I_{B\text{off}} = 80\text{ mA} \quad \text{turn-on time} \quad t_{\text{on}} \text{ typ. } 1\text{ }\mu\text{s}$$

$$\text{turn-off time} \quad t_{\text{off}} \text{ typ. } 3,5\text{ }\mu\text{s}$$

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

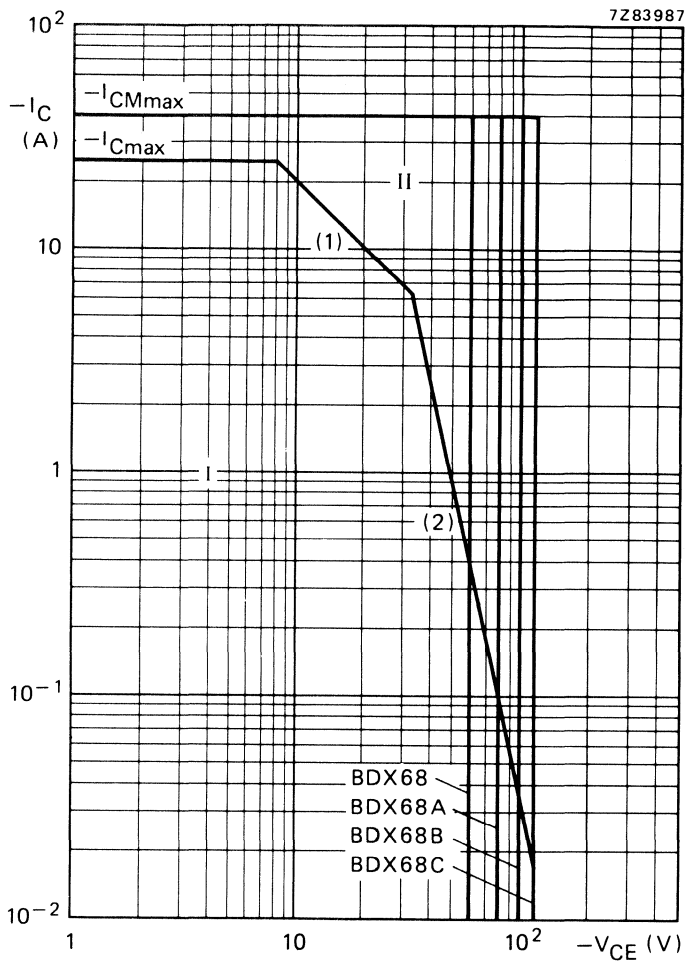


Fig. 3 Safe Operating Area.

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

DARLINGTON POWER TRANSISTORS

N-P-N Darlington transistors for audio output stages and general amplifier and switching applications. In TO-3 envelope. P-N-P complements are BDX68, BDX68A, BDX68B and BDX68C.

QUICK REFERENCE DATA

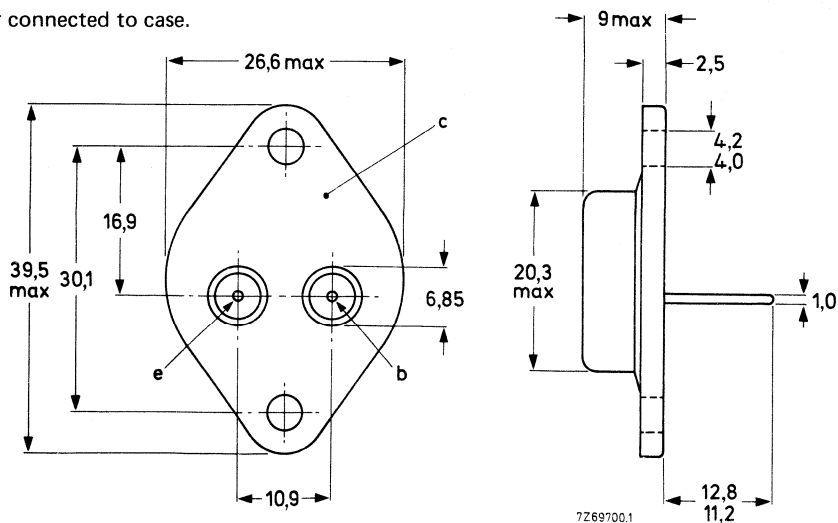
		BDX69	69A	69B	69C	
Collector-base voltage (open emitter)	V_{CBO} max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO} max.	60	80	100	120	V
Collector current (peak value)	I_{CM} max.	40				A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot} max.	200				W
Junction temperature	T_j max.	200				$^{\circ}\text{C}$
D.C. current gain						
$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$	h_{FE} typ.	3000				
$I_C = 20\text{ A}; V_{CE} = 3\text{ V}$	$h_{FE} >$	1000				
Cut-off frequency						
$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$	f_{hfe} typ.	50				kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO.3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories in l.f. power transistor handbook.

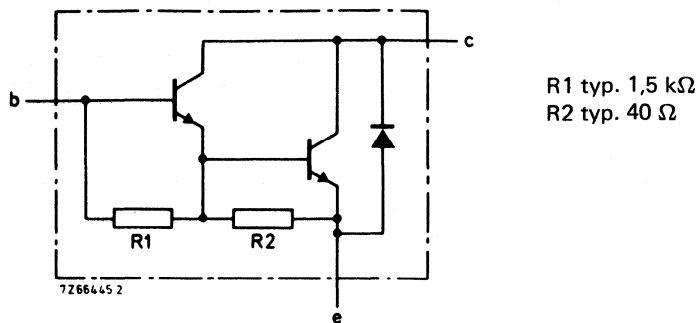


Fig. 2 Circuit diagram.

RATINGS

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

		BDX69	69A	69B	69C		
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	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.	25				A
Collector current (peak value)	I_{CM}	max.	40				A
Base current (d.c.)	I_B	max.	500				mA
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	200				W
Storage temperature	T_{stg}		-65 to + 200				$^\circ\text{C}$
Junction temperature*	T_j	max.	200				$^\circ\text{C}$

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j-mb}$	=	0,875	K/W
--------------------------------	----------------	---	-------	-----

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CB0\max}$

$I_{CBO} < 2\text{ mA}$

$I_E = 0; V_{CB} = \frac{1}{2}V_{CB0\max}; T_j = 200\text{ }^\circ\text{C}$

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

$I_B = 0; V_{CE} = \frac{1}{2}V_{CE0\max}$

$I_{CEO} < 6\text{ mA}$

Emitter cut-off current

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

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

D.C. current gain*

$I_C = 5\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 3000$

$I_C = 20\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} > 1000$

$I_C = 30\text{ A}; V_{CE} = 3\text{ V}$

$h_{FE} \text{ typ. } 4000$

Base-emitter voltage*

$I_C = 20\text{ A}; V_{CE} = 3\text{ V}$

$V_{BE} < 2,5\text{ V}$

Collector-emitter saturation voltage*

$I_C = 20\text{ A}; I_B = 80\text{ mA}$

$V_{CE\text{sat}} < 2\text{ V}$

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

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

$C_c \text{ typ. } 600\text{ pF}$

Cut-off frequency

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}$

$f_{hfe} \text{ typ. } 50\text{ kHz}$

Small-signal current gain

$I_C = 10\text{ A}; V_{CE} = 3\text{ V}; f = 1\text{ MHz}$

$h_{fe} \text{ typ. } 20$

Diode, forward voltage

$I_F = 20\text{ A}$

$V_F \text{ typ. } 2,5\text{ V}$

Switching times

(between 10% and 90% levels)

$I_{Con} = 20\text{ A}; I_{Bon} = -I_{Boff} = 80\text{ mA}$

turn-on time

$t_{on} \text{ typ. } 1\text{ }\mu\text{s}$

turn-off time

$t_{off} \text{ typ. } 3,5\text{ }\mu\text{s}$

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

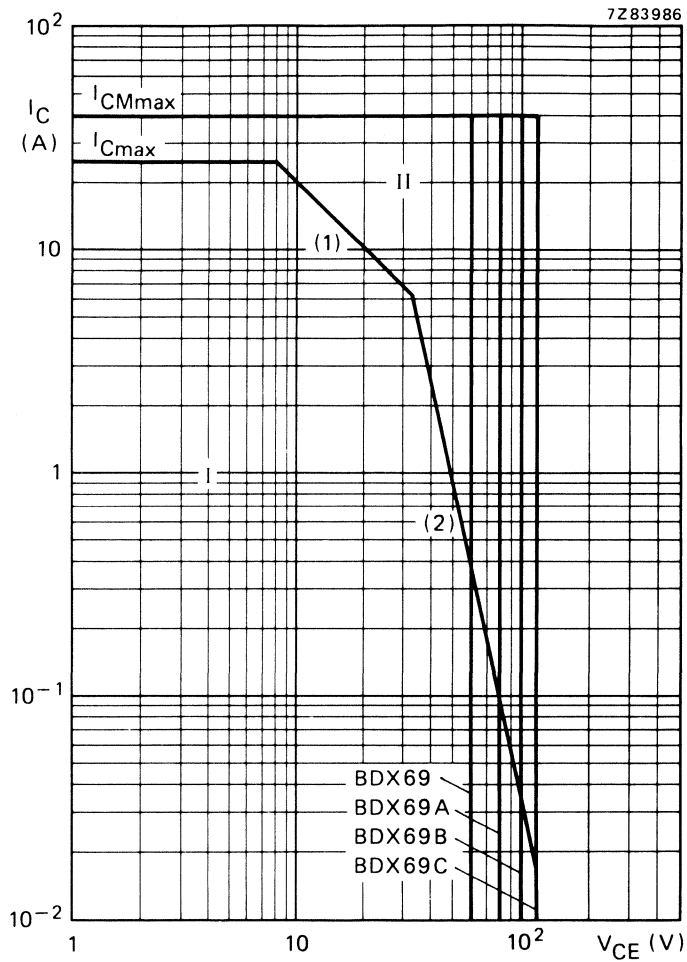


Fig. 3 Safe Operating ARea at $T_{mb} = 25\text{ }^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) P_{tot} max line.

(2) Second breakdown limits.

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

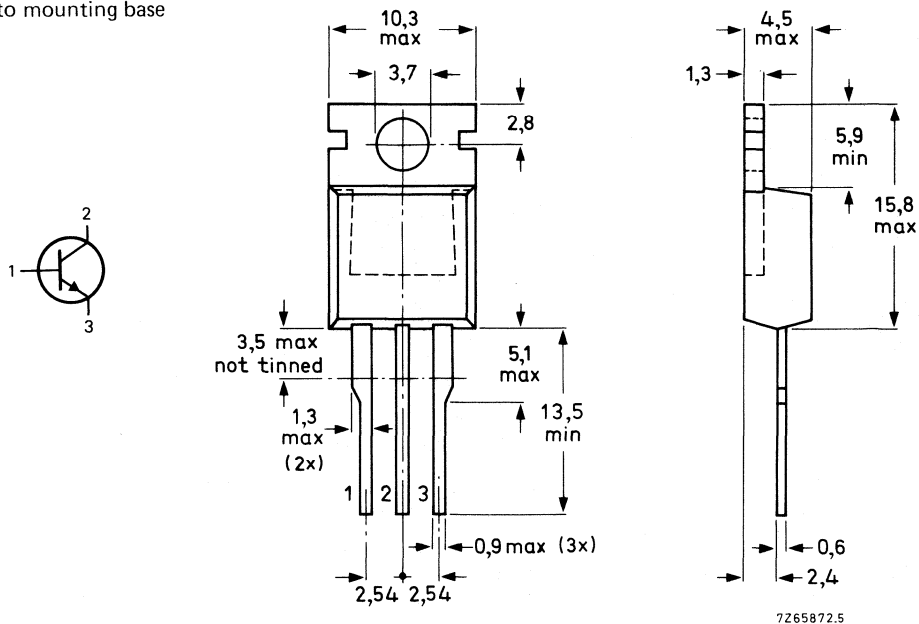
Collector-emitter voltage (open base)	V_{CEO}	max.	80 V
Collector-base voltage (open emitter)	V_{CBO}	max.	100 V
Collector current (DC)	I_C	max.	8 A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.	60 W
D.C. current gain $I_C = 2\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	>	30
Cut-off frequency $I_C = 0,3\text{ A}; V_{CE} = 3\text{ V}$	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

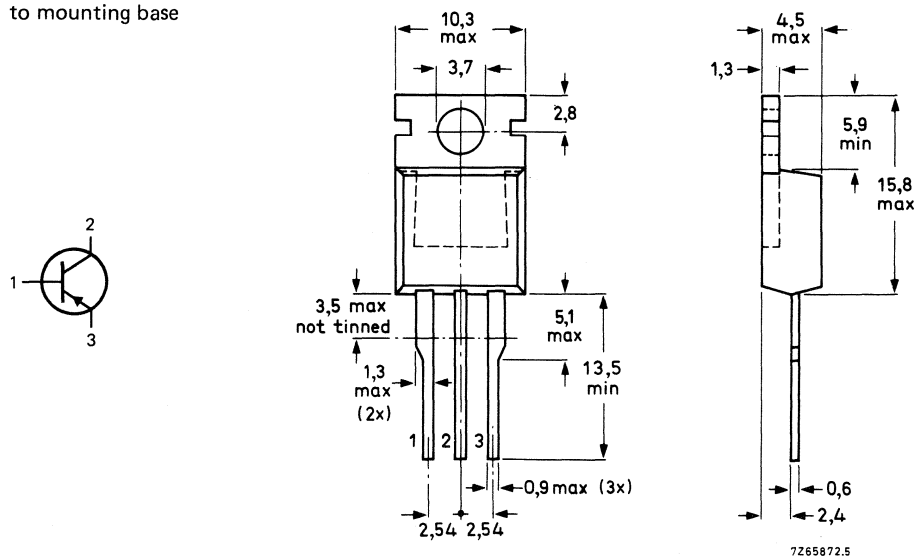
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80 V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100 V
Collector current (DC)	$-I_C$	max.	8 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	60 W
D.C. current gain	h_{FE}	>	30
$-I_C = 2\text{ A}; -V_{CE} = 2\text{ V}$			
Cut-off frequency	f_{hfe}	>	25 kHz
$-I_C = 0,3\text{ A}; -V_{CE} = 3\text{ V}$			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220

Collector connected
to mounting base



SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. P-N-P complements are BDX92, BDX94 and BDX96.

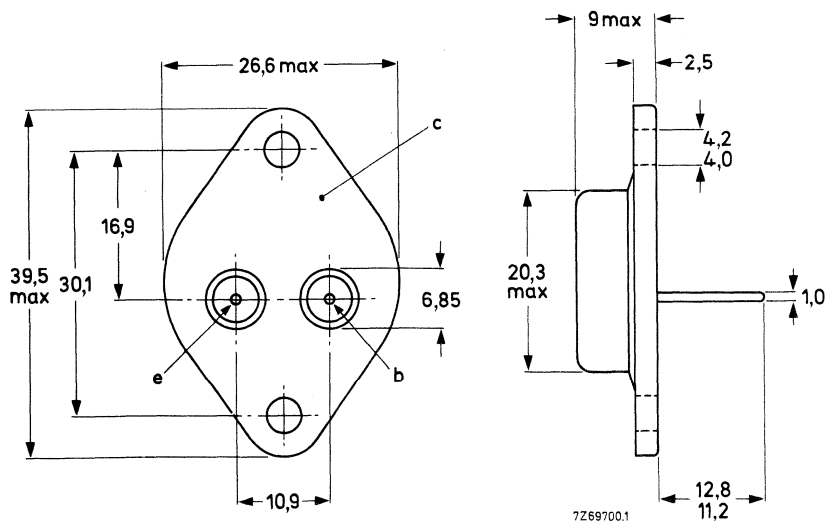
QUICK REFERENCE DATA

		BDX91	BDX93	BDX95	
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 $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	90		W
Junction temperature	T_j	max.	200		$^\circ\text{C}$
D.C. current gain $I_C = 3\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	>	20		
Transition frequency $I_C = 1\text{ A}; V_{CE} = 10\text{ V}$	f_T	>	4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDX91	BDX93	BDX95
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.		10	A
→ Collector current (peak value)	I_{CM}	max.		15	A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.		90	W
Storage temperature	T_{stg}			-65 to +200	$^\circ\text{C}$
Junction temperature	T_j	max.		200	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=		1,94	K/W
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CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = V_{CBOmax}$	I_{CBO}	<		0,1	mA
$I_E = 0; V_{CB} = \frac{1}{2}V_{CBOmax}; T_j = 200\text{ }^\circ\text{C}$	I_{CBO}	<		2	mA
→ $I_B = 0; V_{CE} = V_{CEOmax}$	I_{CEO}	<		0,2	mA

Emitter cut-off current

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

D.C. current gain*

$I_C = 3\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	>		20	
$I_C = 5\text{ A}; V_{CE} = 2\text{ V}$	h_{FE}	>		10	

Base-emitter voltage*

$I_C = 3\text{ A}; V_{CE} = 2\text{ V}$	V_{BE}	<		1,4	V
---	----------	---	--	-----	---

Collector-emitter saturation voltage*

$I_C = 3\text{ A}; I_B = 0,3\text{ A}$	V_{CEsat}	<		0,8	V
$I_C = 5\text{ A}; I_B = 1\text{ A}$	V_{CEsat}	<		1	V

Base-emitter saturation voltage*

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

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

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

$I_C = 0,5 \text{ A}; V_{CE} = 10 \text{ V}$

$h_{fe} > 40$

Transition frequency

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

$f_T > 4 \text{ MHz}$

Collector-emitter breakdown voltage*

$I_C = 100 \text{ mA}$

	BDX91	BDX93	BDX95
$V_{(BR)CEO} >$	60	80	100 V

Switching times

(between 10% and 90% levels)

$I_{Con} = 3 \text{ A}; I_{B on} = -I_{B off} = 0,3 \text{ A}$

Turn-on time

$t_{on} \begin{matrix} \text{typ.} & 0,2 & \mu\text{s} \\ < & 1 & \mu\text{s} \end{matrix}$

Turn-off time

$t_{off} \begin{matrix} \text{typ.} & 1,2 & \mu\text{s} \\ < & 2 & \mu\text{s} \end{matrix}$

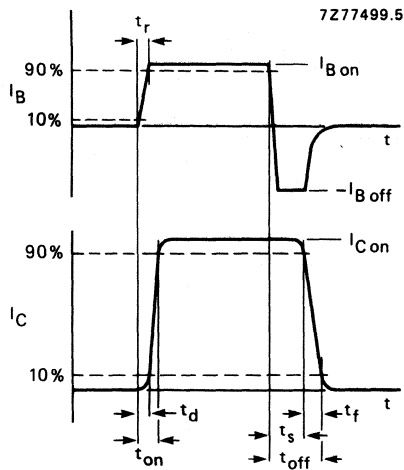
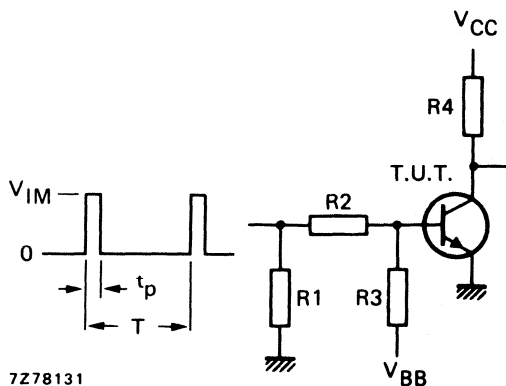


Fig. 2 Switching times waveforms.



- $V_{IM} = 55 \text{ V}$
- $V_{CC} = 30 \text{ V}$
- $-V_{BB} = 5 \text{ V}$
- $R1 = 150 \Omega$
- $R2 = 82 \Omega$
- $R3 = 20 \Omega$
- $R4 = 10 \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

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

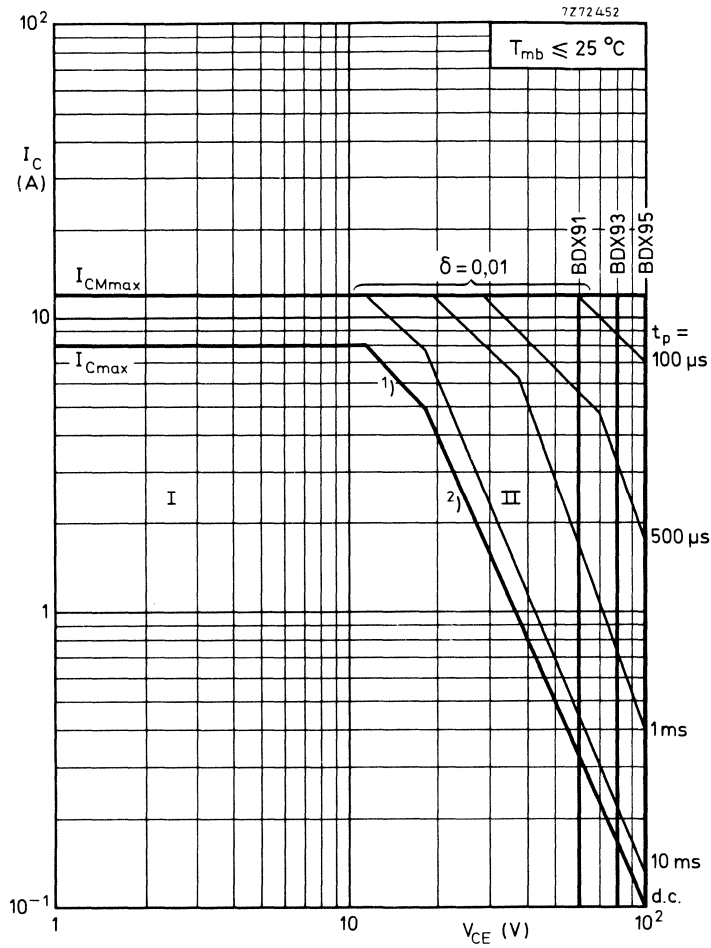


Fig. 4 Safe Operating Area at $T_{mb} \leq 25^{\circ}\text{C}$.

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

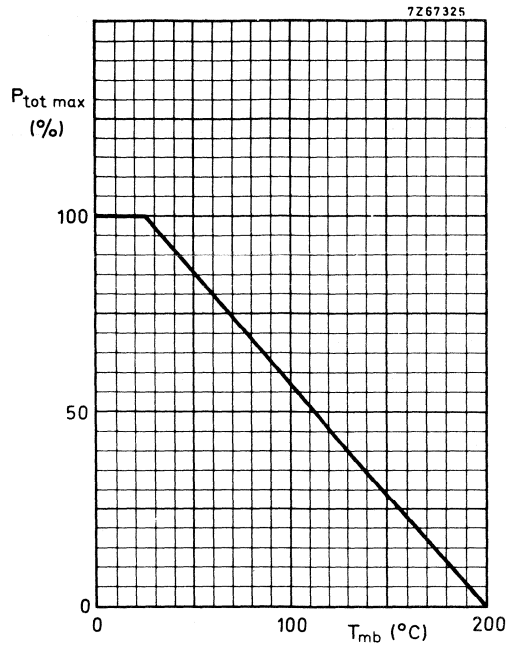


Fig. 5 Power derating curve

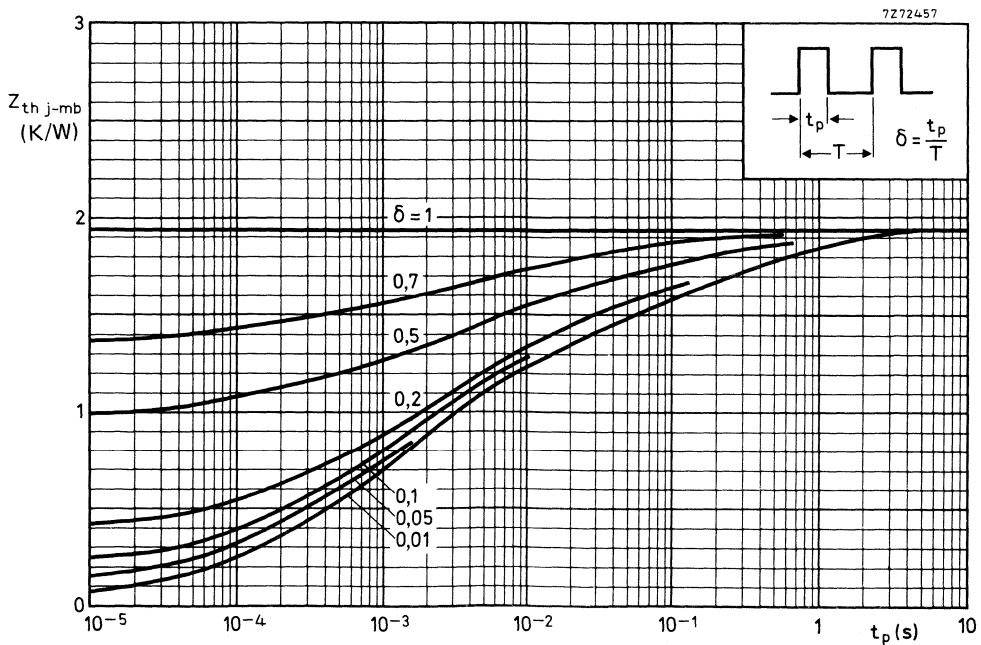


Fig. 6 Pulse power rating chart.

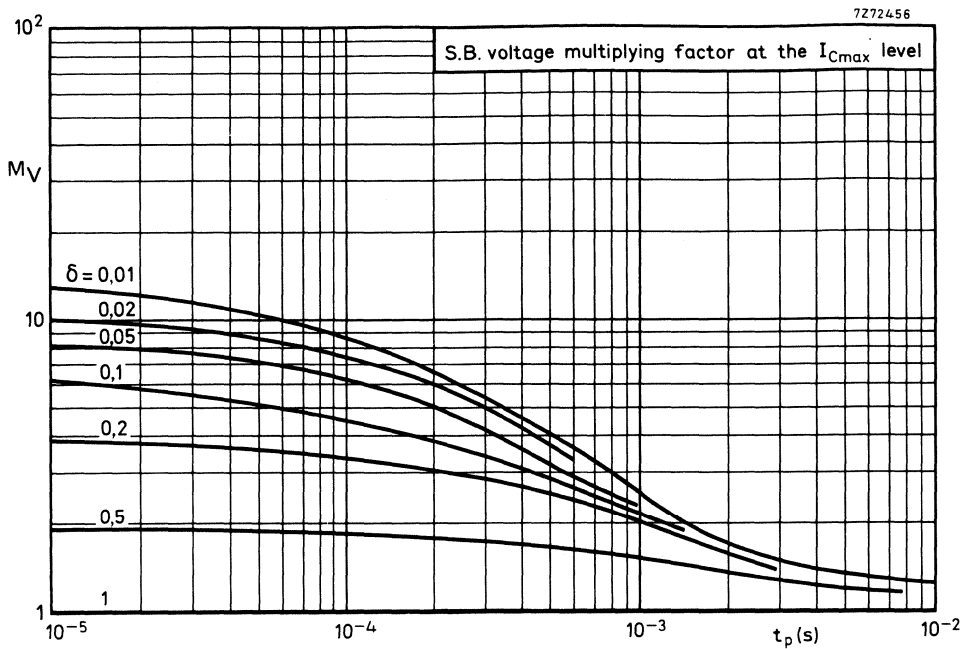


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

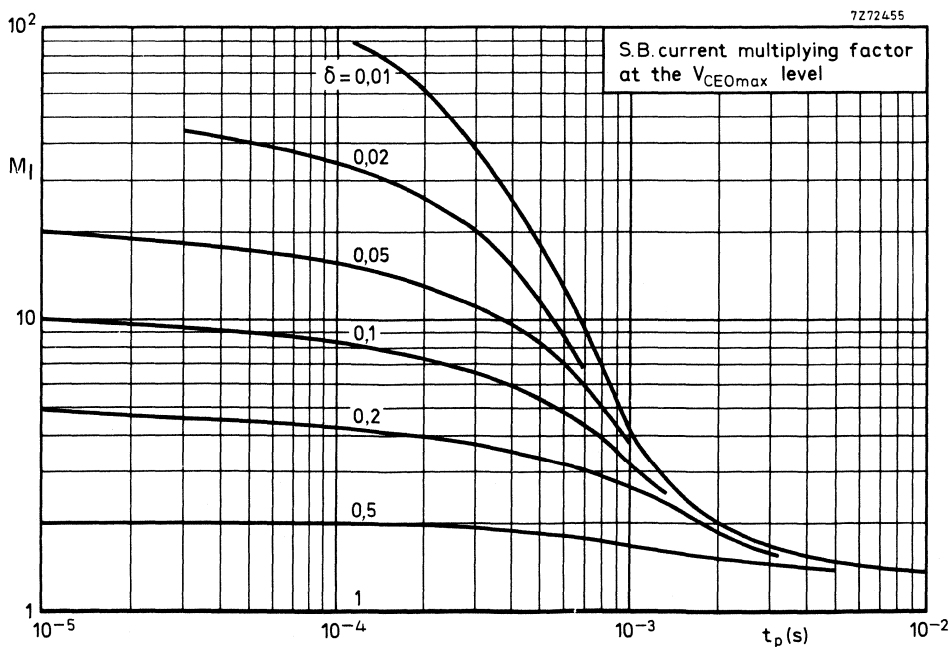


Fig. 8 S.B. current multiplying factor at the V_{CE0max} level.

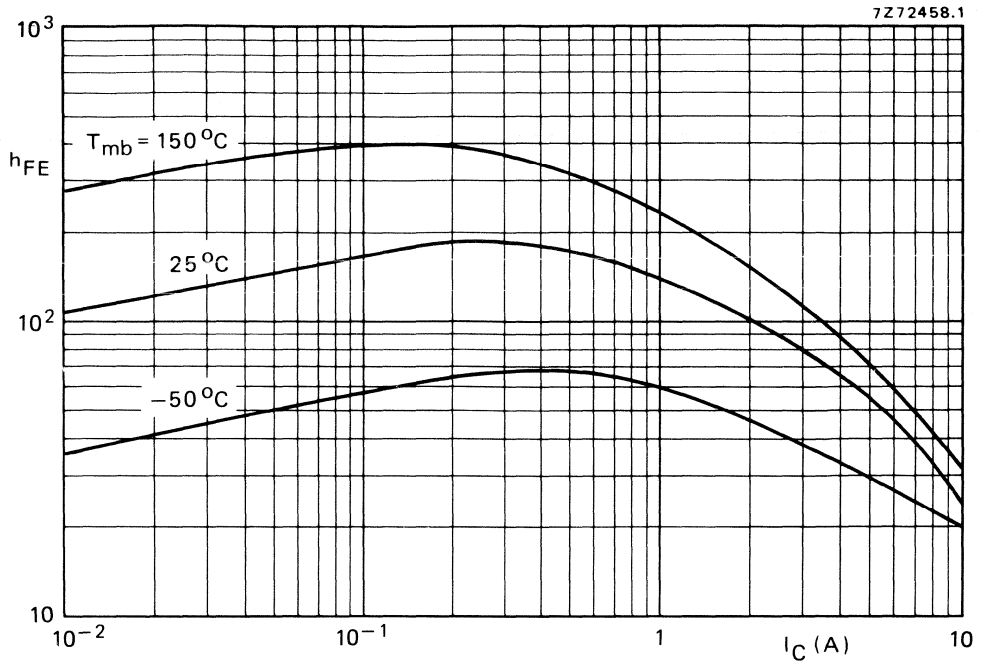


Fig. 9 D.C. current gain at $V_{CE} = 2\text{ V}$; $T_j = 25^\circ\text{C}$.

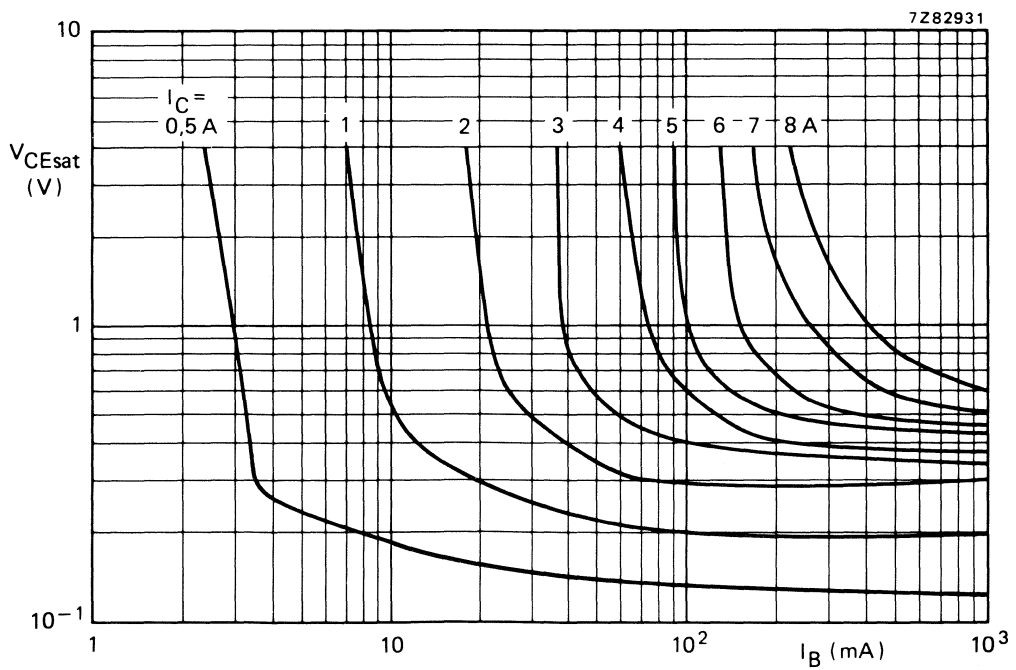


Fig. 10 Typical values collector-emitter saturation voltage.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. N-P-N complements are BDX91, BDX93 and BDX95.

QUICK REFERENCE DATA

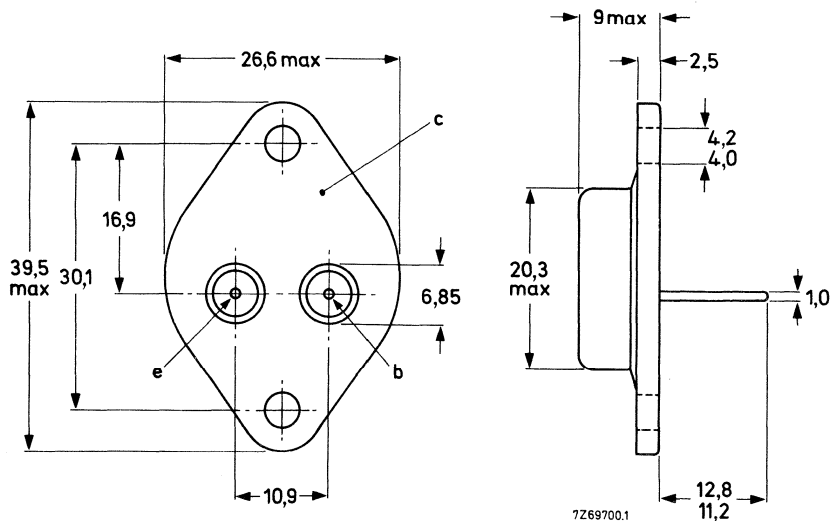
			BDX92	BDX94	BDX96
Collector-base voltage (open emitter)	$-V_{CB0}$	max.	60	80	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100 V
Collector current (d.c.)	$-I_C$	max.	10		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	90		W
Junction temperature	T_j	max.	200		$^\circ\text{C}$
D.C. current gain $-I_C = 3\text{ A}; -V_{CE} = 2\text{ V}$	h_{FE}	>	20		
Transition frequency $-I_C = 1\text{ A}; -V_{CE} = 10\text{ V}$	f_T	>	4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to envelope



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BDX92	BDX94	BDX96
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.	10	A
Collector current (peak value)	$-I_{CM}$	max.	15	A
Total power dissipation up to $T_{mb} = 25\text{ }^{\circ}\text{C}$	P_{tot}	max.	90	W
Storage temperature	T_{stg}		-65 to +200	$^{\circ}\text{C}$
Junction temperature	T_j	max.	200	$^{\circ}\text{C}$
THERMAL RESISTANCE				
From junction to mounting base	$R_{th\ j-mb}$		1,94	K/W

CHARACTERISTICS

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

Collector cut-off current

$$I_E = 0; -V_{CB} = -V_{CB0\max} \quad -I_{CBO} < 0,1 \text{ mA}$$

$$I_E = 0; -V_{CB} = 30 \text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX92} \quad -I_{CBO} < 2 \text{ mA}$$

$$I_E = 0; -V_{CB} = 40 \text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX94} \quad -I_{CBO} < 2 \text{ mA}$$

$$I_E = 0; -V_{CB} = 50 \text{ V}; T_j = 200\text{ }^\circ\text{C}; \text{BDX96} \quad -I_{CBO} < 2 \text{ mA}$$

$$I_B = 0; -V_{CE} = -V_{CE0\max} \quad -I_{CEO} < 0,2 \text{ mA} \quad \leftarrow$$

Emitter cut-off current

$$I_C = 0; -V_{EB} = 5 \text{ V} \quad -I_{EBO} < 0,1 \text{ mA} \quad \leftarrow$$

D.C. current gain ¹⁾

$$-I_C = 3 \text{ A}; -V_{CE} = 2 \text{ V} \quad h_{FE} > 20$$

$$-I_C = 5 \text{ A}; -V_{CE} = 2 \text{ V} \quad h_{FE} > 10$$

Base-emitter voltage¹⁾

$$-I_C = 3 \text{ A}; -V_{CE} = 2 \text{ V} \quad -V_{BE} < 1,4 \text{ V}$$

Collector-emitter saturation voltage¹⁾

$$-I_C = 3 \text{ A}; -I_B = 0,3 \text{ A} \quad -V_{CEsat} < 0,8 \text{ V}$$

$$-I_C = 5 \text{ A}; -I_B = 1 \text{ A} \quad -V_{CEsat} < 1 \text{ V}$$

Base-emitter saturation voltage¹⁾

$$-I_C = 3 \text{ A}; -I_B = 0,3 \text{ A} \quad -V_{BEsat} < 1,5 \text{ V}$$

$$-I_C = 5 \text{ A}; -I_B = 1 \text{ A} \quad -V_{BEsat} < 2 \text{ V}$$

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

$$-I_C = 0,5 \text{ A}; -V_{CE} = 10 \text{ V} \quad h_{fe} > 40$$

Transition frequency

$$-I_C = 1 \text{ A}; -V_{CE} = 10 \text{ V} \quad f_T > 4 \text{ MHz}$$

¹⁾ Measured under pulse conditions: $t_p < 300 \mu\text{s}$, $\delta < 2\%$.

CHARACTERISTICS (continued)

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

Switching times (between 10% and 90% levels)

$-I_{Con} = 3\text{ A}$; $-I_{Bon} = I_{Boff} = 0,3\text{ A}$; $V_{CC} = -30\text{ V}$

Turn-on time	t_{on}	typ.	0,2 μs
		<	1 μs
Turn-off time	t_{off}	typ.	1 μs
		<	2 μs

Test circuit

$V_{IM} = 55\text{ V}$
 $t_r = t_f = 15\text{ ns}$
 $t_p = 10\text{ }\mu\text{s}$
 $T = 500\text{ }\mu\text{s}$

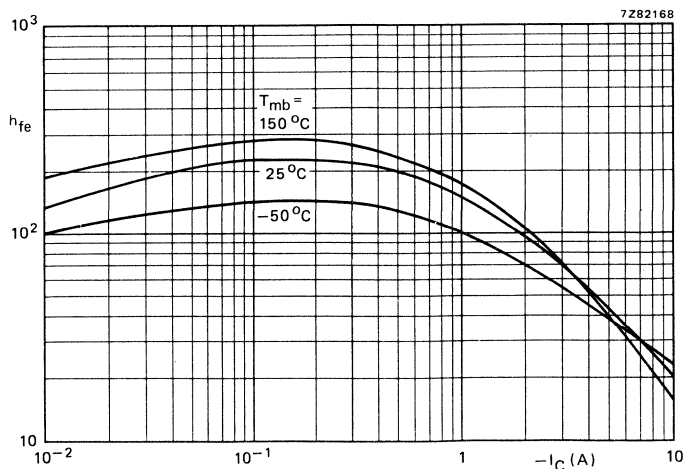
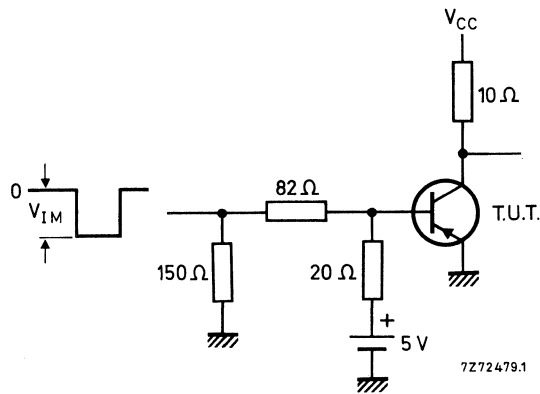


Fig. 3 Typical small-signal current gain as a function of collector current; $-V_{CE} = 2\text{ V}$.

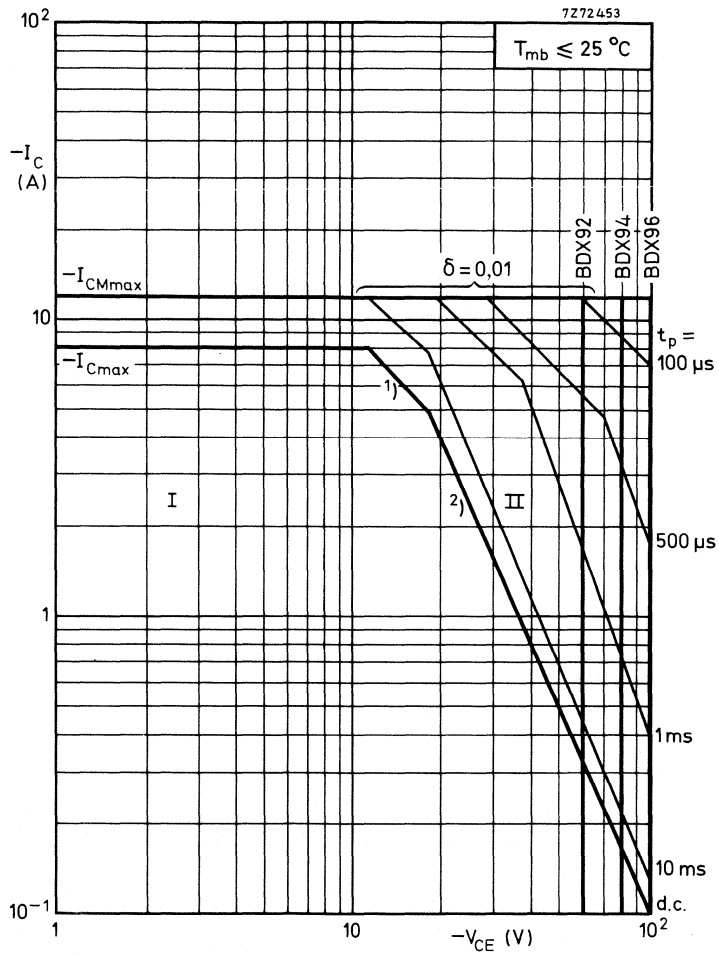


Fig. 4 Safe Operating Area with the transistor forward biased

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.

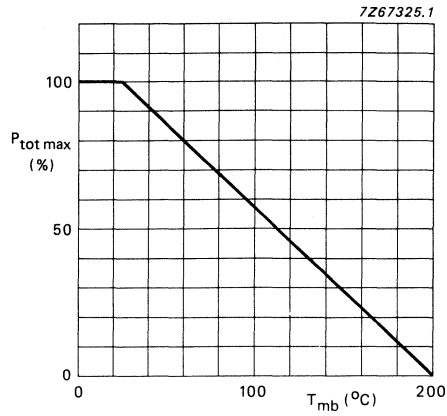


Fig. 5.

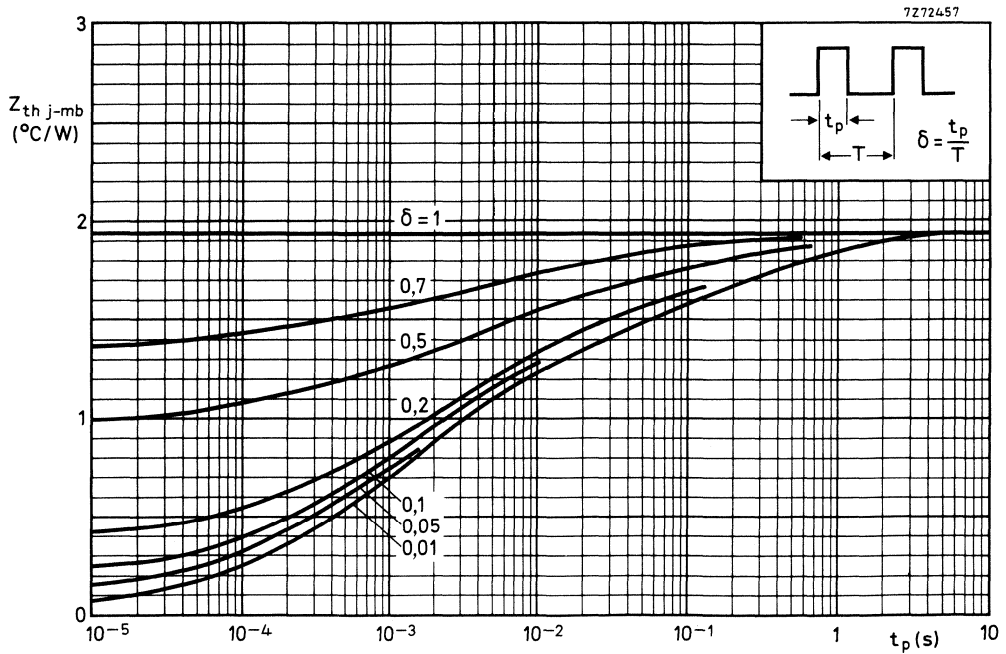


Fig. 6.

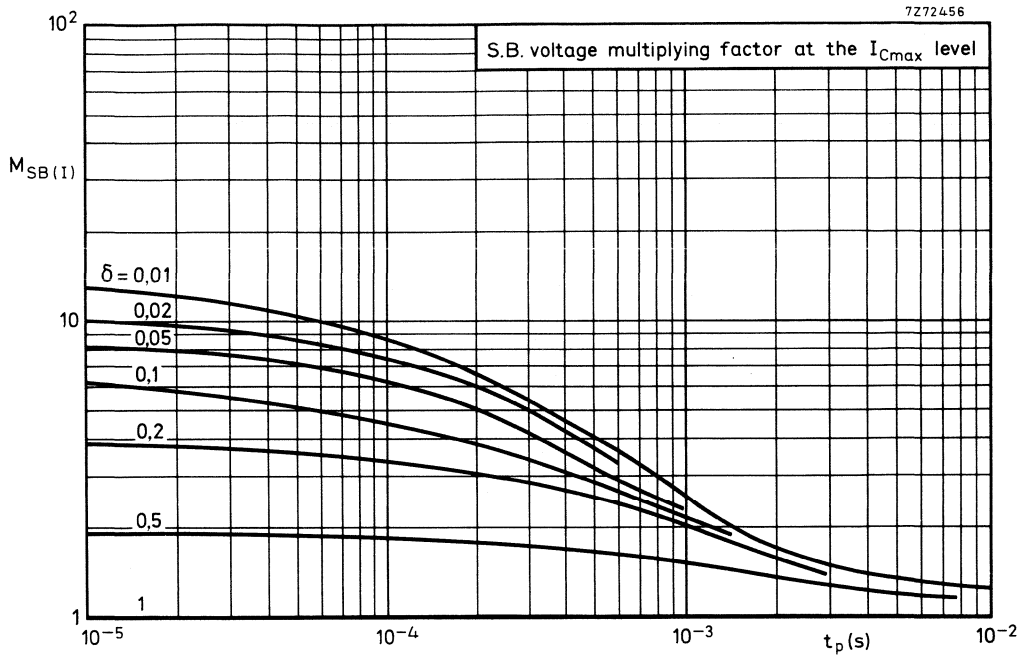


Fig. 7.

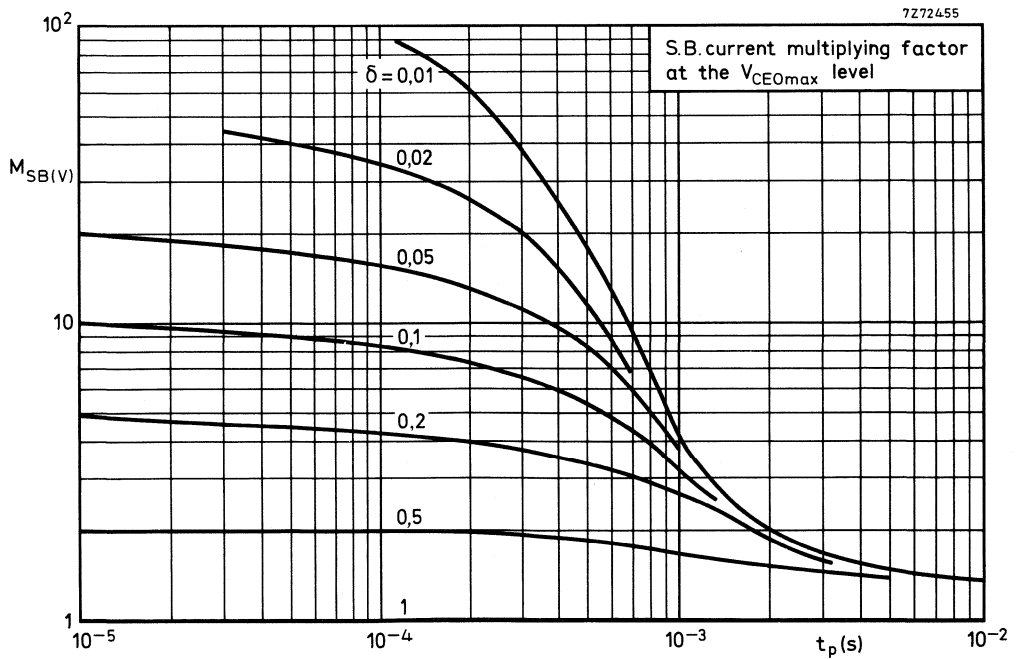


Fig. 8.

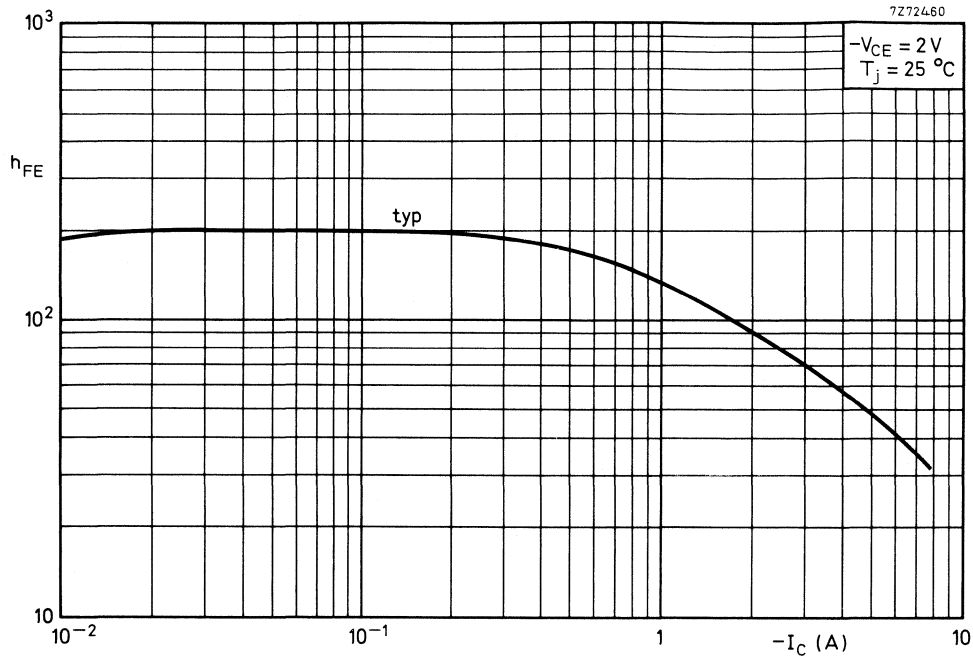


Fig. 9.

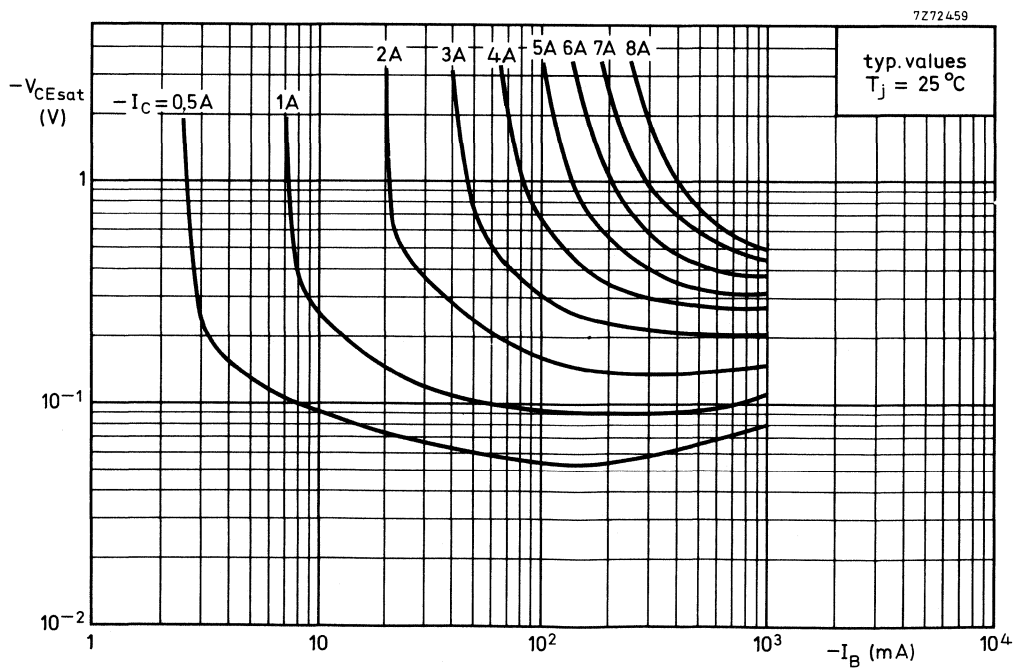


Fig. 10.

SILICON DIFFUSED POWER TRANSISTORS

High-speed switching n-p-n transistors in a metal envelope intended for use in converters, inverters, switching regulators and switching control amplifiers.

QUICK REFERENCE DATA

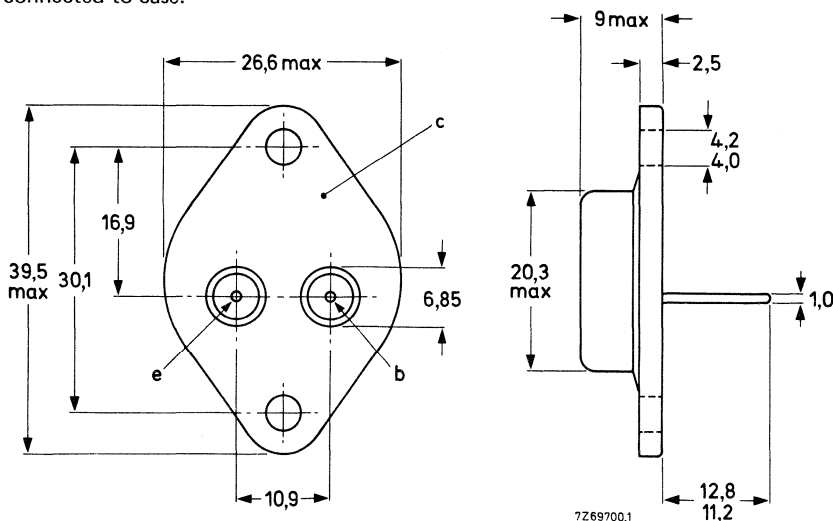
		BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max. 120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max. 100	80	60	V
Collector current (peak value)	I_{CM}	max.	15		A
Total power dissipation up to $T_{mb} = 70\text{ }^{\circ}\text{C}$	P_{tot}	max.	40		W
Collector-emitter saturation voltage $I_C = 10\text{ A}; I_B = 1\text{ A}$	V_{CEsat}	<	1		V
Fall time $I_C = 5\text{ A}; I_B = -I_{BM} = 0,5\text{ A}$ $V_{CC} = 30\text{ V}$	t_f	<	0,2		μs
Transition frequency at $f = 5\text{ MHz}$ $I_C = 0,5\text{ A}; V_{CE} = 5\text{ V}$	f_T	typ.	70		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max. 120	100	80	V
Collector-emitter voltage ($V_{EB} = 1,5$ V)	V_{CEX}	max. 120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max. 100	80	60	V
Emitter-base voltage (open collector)	V_{EBO}	max. 6	6	6	V
Collector current (d.c.)	I_C	max.	10		A
Collector current (peak value)	I_{CM}	max.	15		A
Base current (d.c.)	I_B	max.	2		A
Base current (peak value)	I_{BM}	max.	3		A
Emitter current (d.c.)	$-I_E$	max.	11		A
Emitter current (peak value)	$-I_{EM}$	max.	15		A
Total power dissipation up to $T_{mb} = 70$ °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	$R_{th\ j-mb} =$	2,0	K/W
--------------------------------	------------------	-----	-----

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current

$$V_{EB} = 1,5 \text{ V}; V_{CE} = V_{CEXmax}; I_{CEX} < 1 \text{ mA}$$

$$V_{EB} = 1,5 \text{ V}; V_{CE} = V_{CEXmax}; T_{mb} = 150 \text{ °C}; I_{CEX} < 3 \text{ mA}$$

Saturation voltages

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

$$V_{BEsat} < 1,2 \text{ V}$$

$$I_C = 10 \text{ A}; I_B = 1 \text{ A}; V_{CEsat} < 1,0 \text{ V}$$

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

CHARACTERISTICS

D.C. current gain

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

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

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

$h_{FE} > 35$

$h_{FE} 30 \text{ to } 120$

$h_{FE} > 20$

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

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

$f_T \text{ typ. } 70 \text{ MHz}$

Switching times

Turn on time

$I_C = 5 \text{ A}; I_B = -I_{BM} = 0,5 \text{ A}$

$V_{CC} = 30 \text{ V}$

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

Turn off time

$I_C = 5 \text{ A}; I_B = -I_{BM} = 0,5 \text{ A}$

$V_{CC} = 30 \text{ V}$ storage time

fall time

$t_s < 1,3 \mu\text{s}$

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

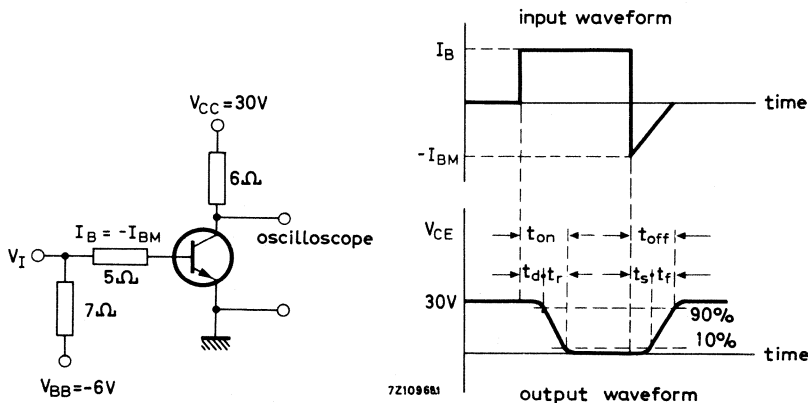


Fig. 2 Test circuit and waveforms.

Pulse generator:

Rise time $t_r < 50 \text{ ns}$

Fall time $t_f < 50 \text{ ns}$

Pulse duration $t_p = 20 \mu\text{s}$

Duty cycle $\delta = 0,02$

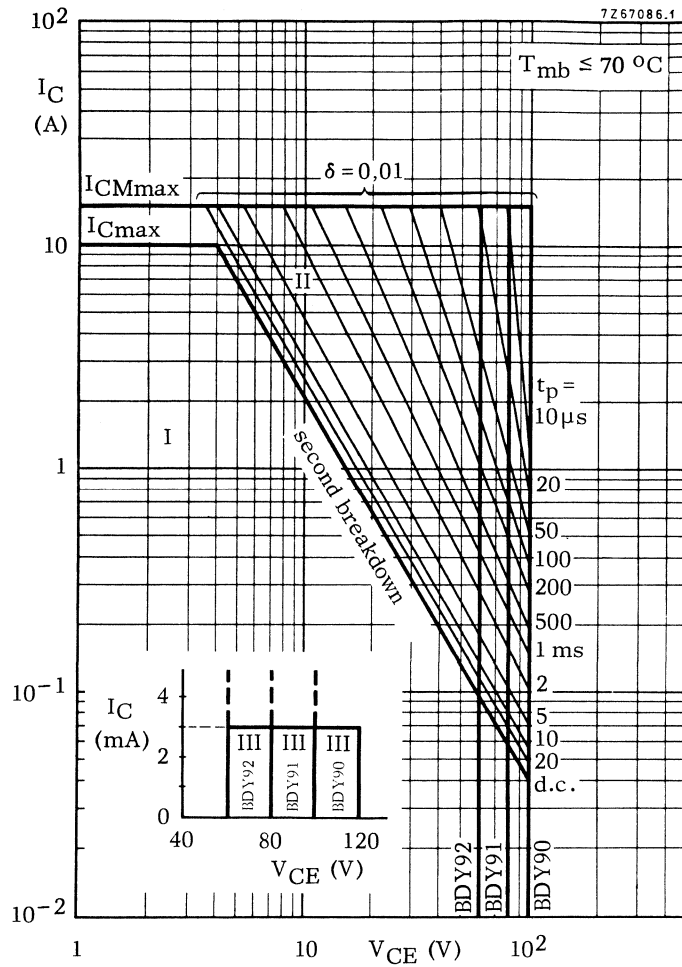


Fig. 3 Safe Operating ARea (Regions I and II forward biased).

- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Repetitive pulse operation in this region is allowable, provided $-V_{BE} \geq 1,5 \text{ V}$

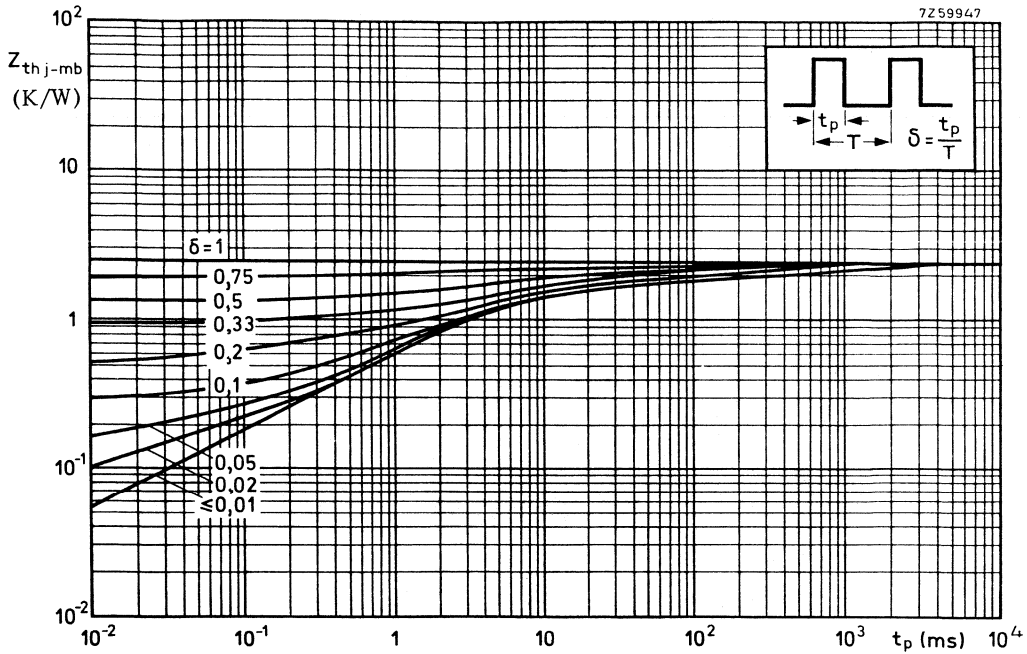


Fig. 4 Pulse power rating chart.

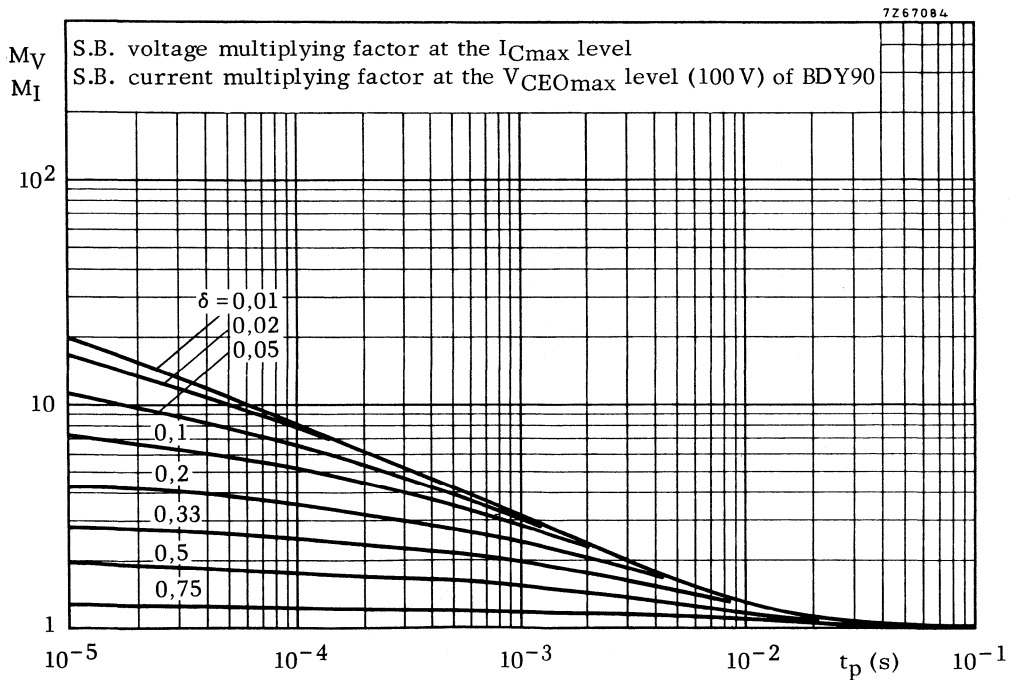


Fig. 5 S.B. voltage multiplying factor at the I_C max level.
S.B. current multiplying factor at the BDY90 V_{CE0max} level (100 V).

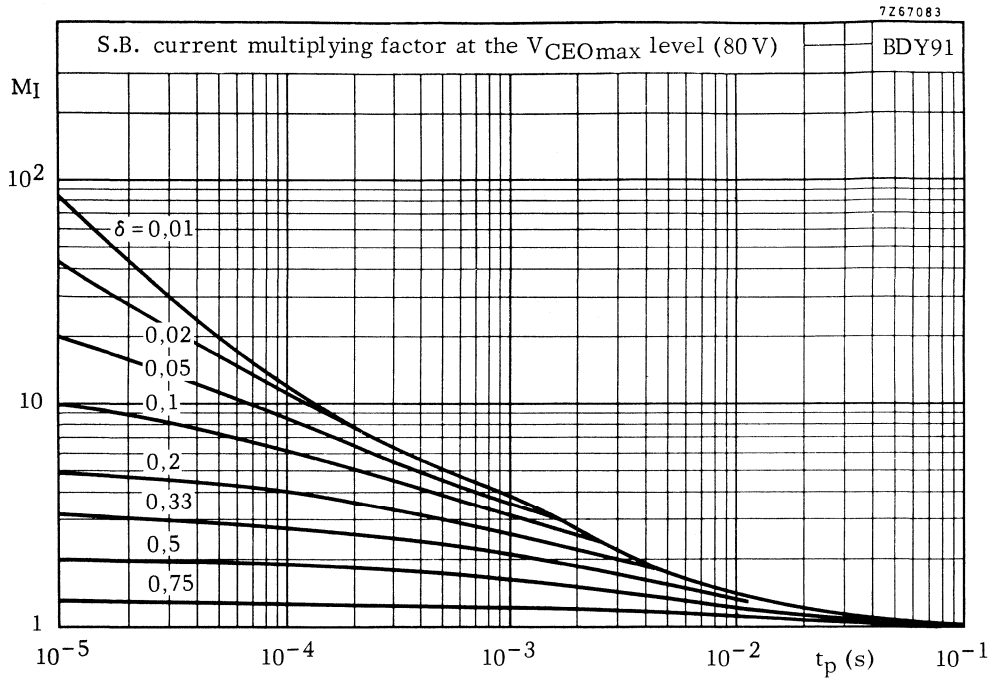


Fig. 6 S.B. current multiplying factor.

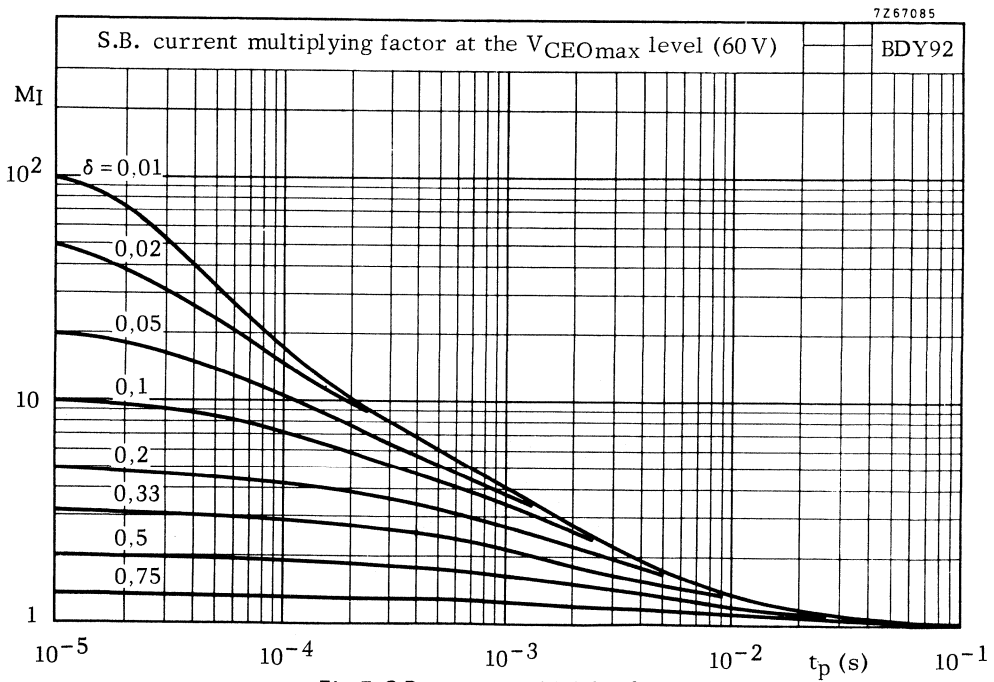


Fig. 7 S.B. current multiplying factor.

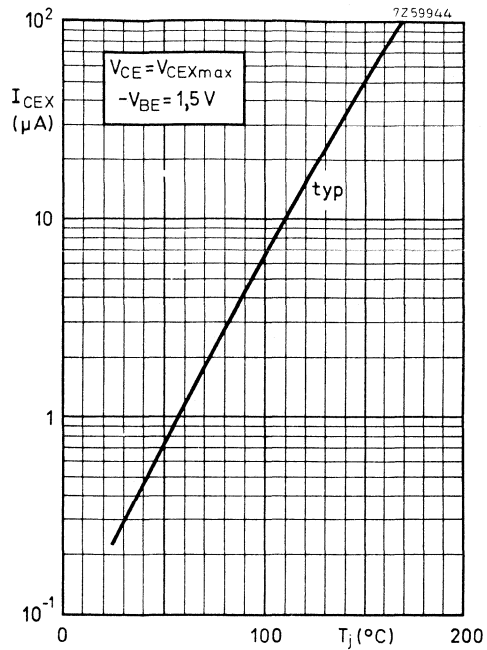


Fig. 8 Collector-emitter current.

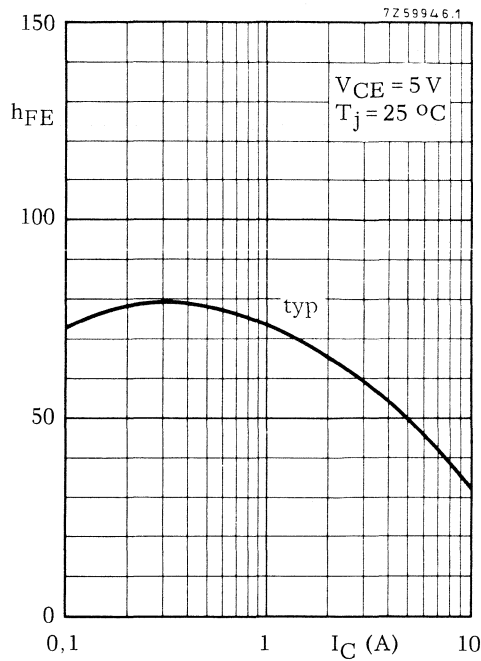


Fig. 9 D.C. current gain.

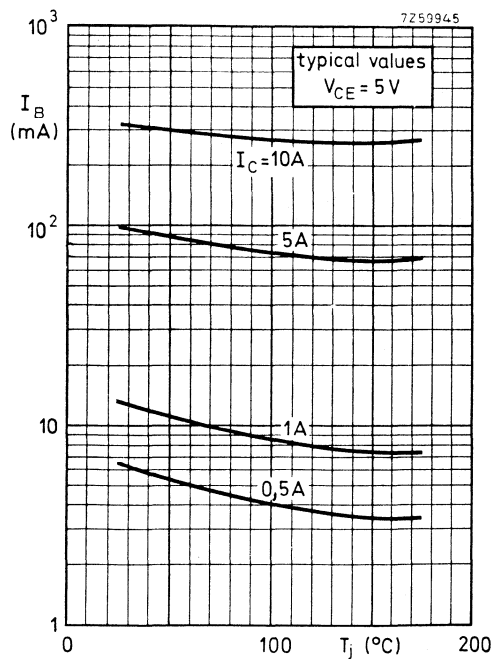


Fig. 10 Typical base current.

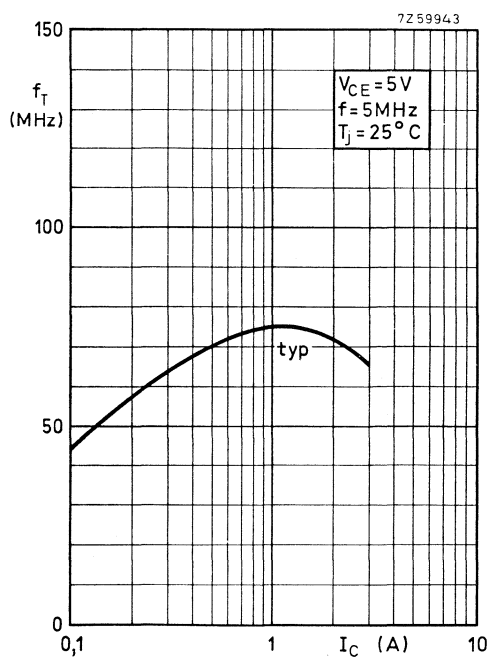


Fig. 11 Transition frequency.

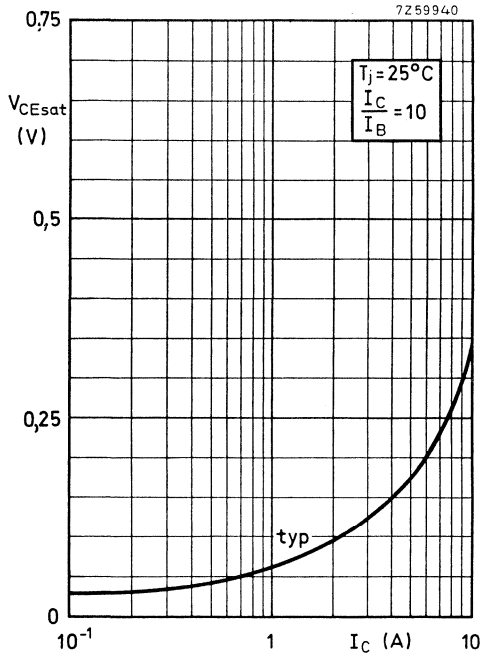


Fig. 12 Collector-emitter saturation voltage as a function of collector current.

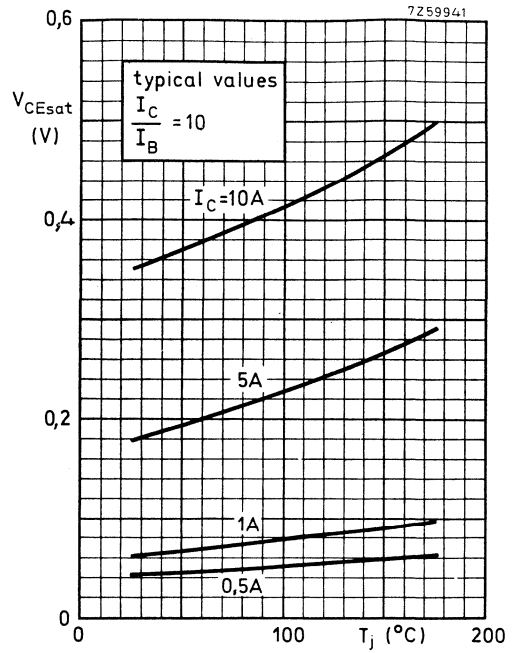


Fig. 13 Collector-emitter saturation voltage as a function of junction temperature.

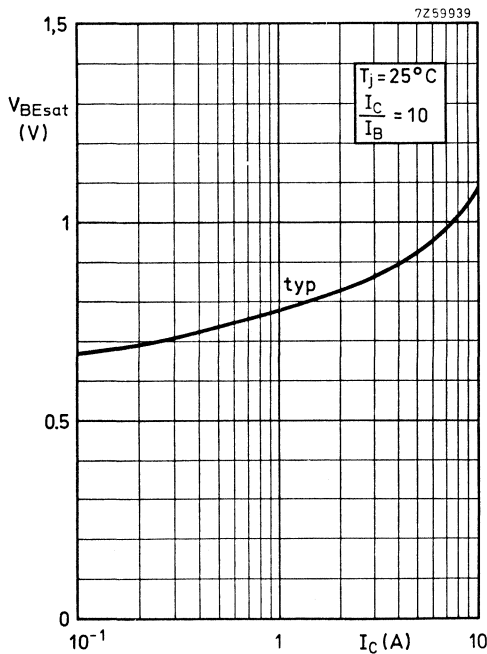


Fig. 14 Typical base-emitter saturation voltage.

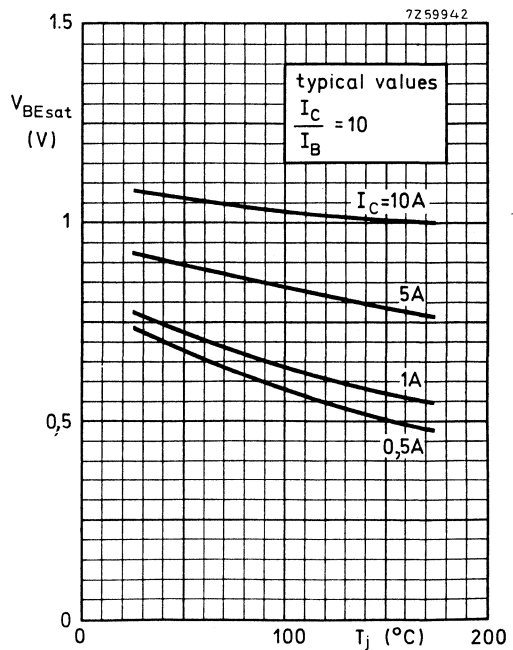


Fig. 15 Typical base-emitter saturation voltage.

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.

QUICK REFERENCE DATA

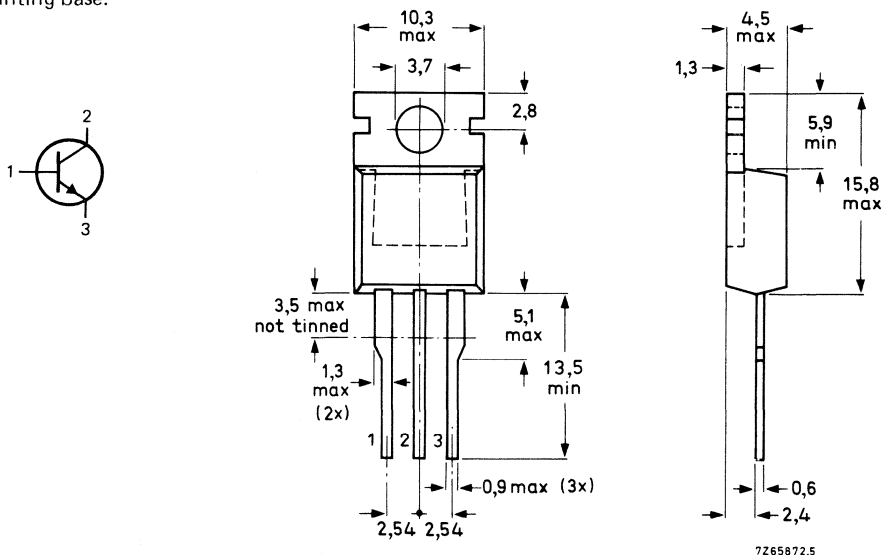
		TIP29	A	B	C	
Collector-base voltage	V_{CBO}	max.	80	100	120	140 V
Collector-emitter voltage	V_{CEO}	max.	40	60	80	100 V
Collector current (d.c.)	I_C	max.	1			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	30			W
Junction temperature	T_j	max.	150			$^\circ\text{C}$
D.C. current gain						
$I_C = 200\text{ mA}; V_{CE} = 4\text{ V}$	h_{FE}	>	40			
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}		15 to 75			
Transition frequency at $f = 1\text{ MHz}$						
$I_C = 200\text{ mA}; V_{CE} = 10\text{ V}$	f_T	>	3			MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



For more information see BDT29 series data.
See also chapters Mounting Instructions and Accessories.

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.

QUICK REFERENCE DATA

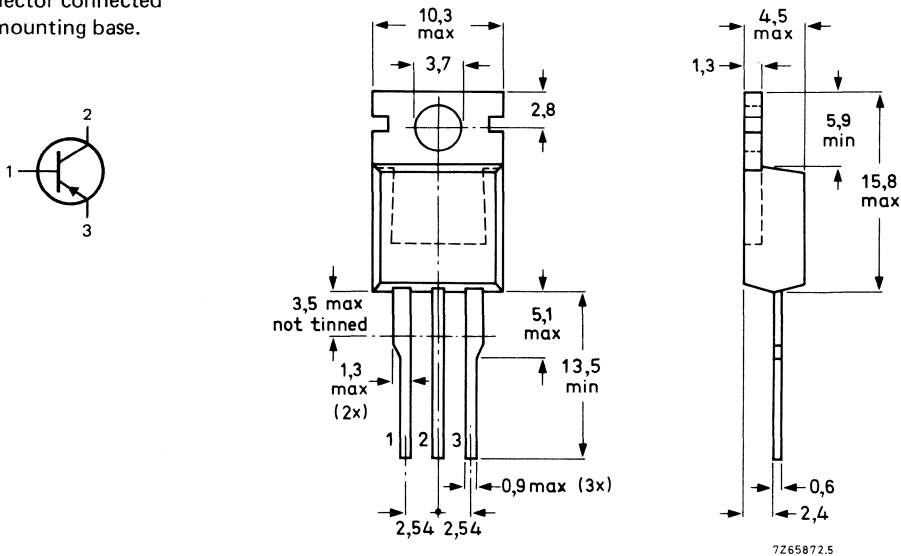
			TIP30	A	B	C
Collector-base voltage	$-V_{CBO}$	max.	80	100	120	140 V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100 V
Collector current (d.c.)	$-I_C$	max.	1			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	30			W
Junction temperature	T_j	max.	150			$^\circ\text{C}$
D.C. current gain			15 to 75			
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}					
Transition frequency			3			MHz
$-I_C = 200\text{ mA}; -V_{CE} = 10\text{ V}$	f_T	>				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



For more information see BDT30 series data.
See also chapters Mounting Instructions and Accessories.

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.

QUICK REFERENCE DATA

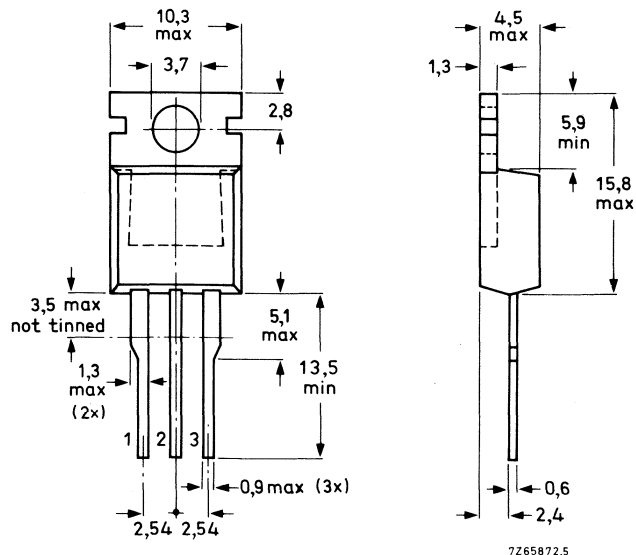
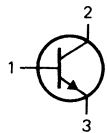
		TIP31				
		A	B	C		
Collector-base voltage (open emitter)	V_{CBO}	max. 80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max. 40	60	80	100	V
Collector current (d.c.)	I_C	max. 3		A		
Collector current (peak value)	I_{CM}	max. 5		A		
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max. 40		W		
Junction temperature	T_j	max. 150		$^\circ\text{C}$		
D.C. current gain				25		
$I_C = 1\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}	>		10 to 50		
$I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}			10 to 50		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



For more information see BDT31 series data.
See also chapters Mounting Instructions and Accessories.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-220 envelope. They are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

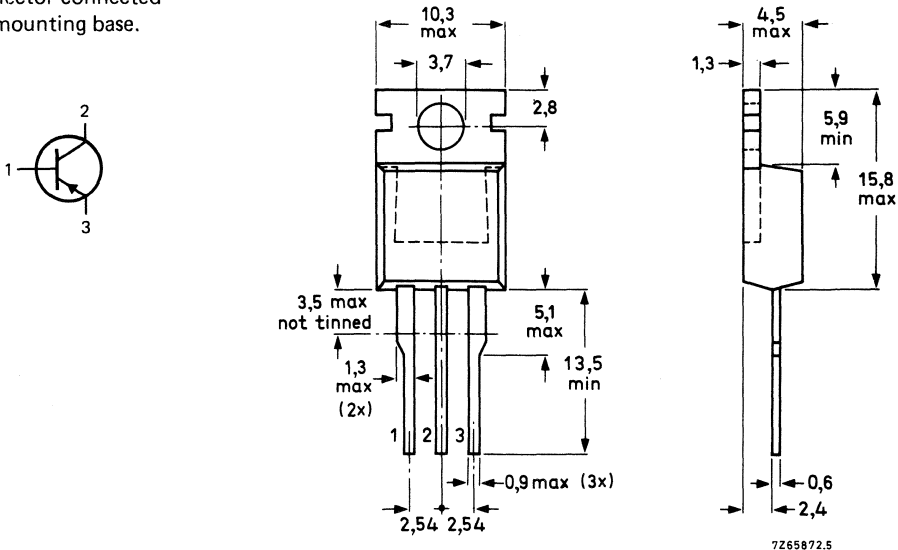
		TIP32	A	B	C
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	80	100	120	140 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	40	60	80	100 V
Collector current (d.c.)	$-I_C$ max.			3	A
Collector current (peak value)	$-I_{CM}$ max.			5	A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot} max.			40	W
Junction temperature	T_j max.			150	$^\circ\text{C}$
D.C. current gain				25	
$-I_C = 1\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}	>		10 to 50	
$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$	h_{FE}				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



For more information see BDT32 series data.
See also chapters Mounting Instructions and Accessories.

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

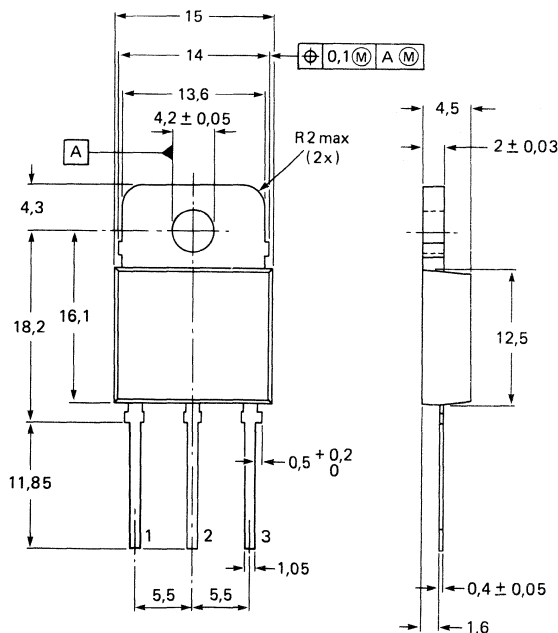
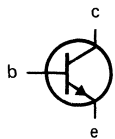
		TIP33	33A	33B	33C	
Collector-base voltage (open emitter)	V_{CBO} max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO} max.	40	60	80	100	V
Collector current (d.c.)	I_C max.		10			A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM} max.		15			A
Power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.		80			W
D.C. current gain	h_{FE}		20 to 100			
$V_{CE} = 4$ V; $I_C = 3$ A						
Collector-emitter saturation voltage	$V_{CEsat} <$		1			V
$I_C = 3$ A; $I_B = 0,3$ A						

MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:
1 = base
2 = collector
3 = emitter



Dimensions in mm

7Z96696

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	$R_{th\ j-mb}$	=		1,56	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		35,7	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

→ Collector cut-off currents

$V_{CE} = V_{CBOmax}; I_B = 0$		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
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Collector-emitter sustaining voltage

$I_C = 30$ mA; $I_B = 0$	TIP33	$V_{CEO_{sust}}$	>	40	V
	TIP33A	$V_{CEO_{sust}}$	>	60	V
	TIP33B	$V_{CEO_{sust}}$	>	80	V
	TIP33C	$V_{CEO_{sust}}$	>	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

$I_C = 3 \text{ A}; I_B = 0,3 \text{ A}$

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

$I_C = 10 \text{ A}; I_B = 2,5 \text{ A}$

$V_{CEsat} < 4 \text{ V}$

Small-signal current gain

$V_{CE} = 10 \text{ V}; I_C = 0,5 \text{ A}; f = 1 \text{ kHz}$

$h_{fe} > 20$

Transition frequency

$V_{CE} = 10 \text{ V}; I_C = 0,5 \text{ A}; f = 1 \text{ MHz}$

$f_T > 3 \text{ MHz}$

Turn-off breakdown energy (see Fig. 2)

$L = 20 \text{ mH}; I_C = 2,5 \text{ A}$

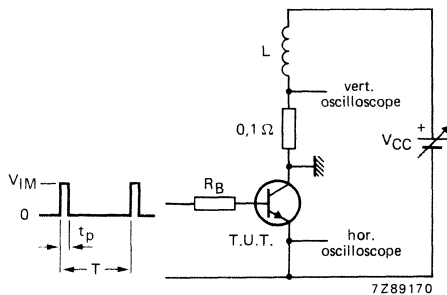
$E(BR) > 62,5 \text{ mJ}$

Switching times (see Figs 3 and 4)

$I_C = 6 \text{ A}; I_{Bon} = -I_{Boff} = 0,6 \text{ A}; V_{CC} = 30 \text{ V}$

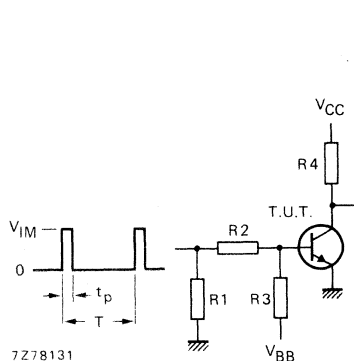
turn-on time t_{on} typ. 0,6 μs

turn-off time t_{off} typ. 1,7 μs



$V_{IM} = 12 \text{ V}$
 $R_B = 270 \Omega$
 $L = 20 \text{ mH}$
 $I_{CC} = 2,5 \text{ A}$
 $\delta \leq 1 \%$
 $t_p = 1 \text{ ms}$

Fig. 2 Test circuit for turn-off breakdown energy.



$V_{IM} = 47 \text{ V}$
 $V_{CC} = 30 \text{ V}$
 $-V_{BB} = 4 \text{ V}$
 $R_1 = 56 \Omega$
 $R_2 = 39 \Omega$
 $R_3 = 10 \Omega$
 $R_4 = 5 \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \mu\text{s}$
 $T = 500 \mu\text{s}$

Fig. 3 Switching times test circuit.

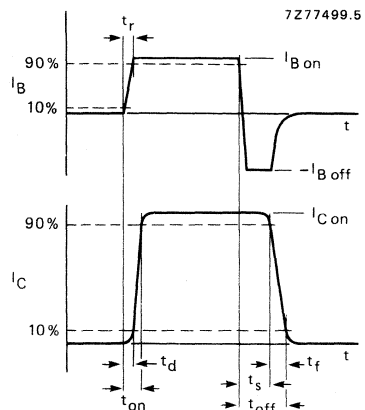


Fig. 4 Switching times waveforms.

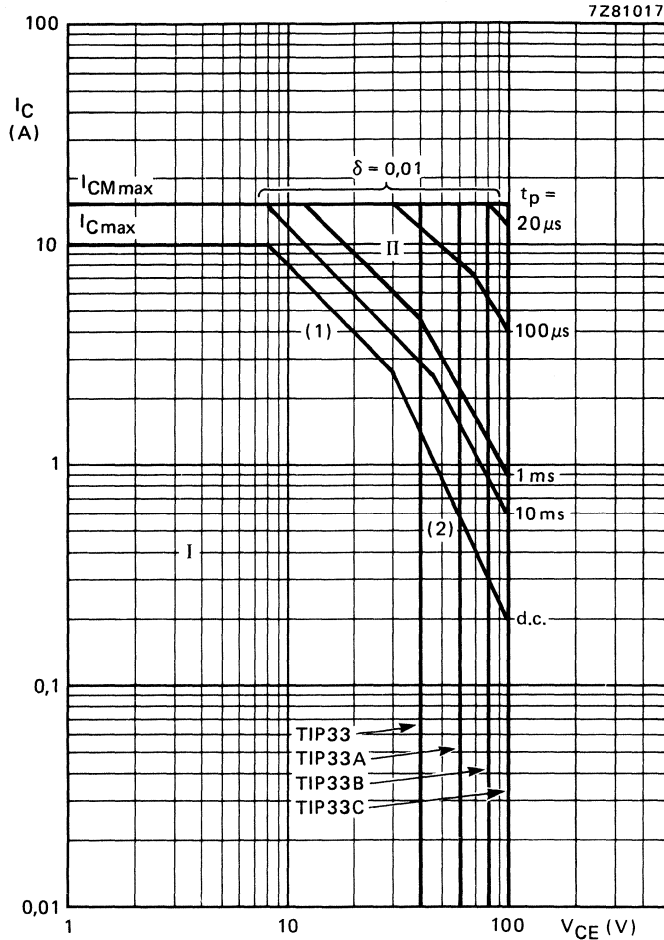


Fig. 5 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

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

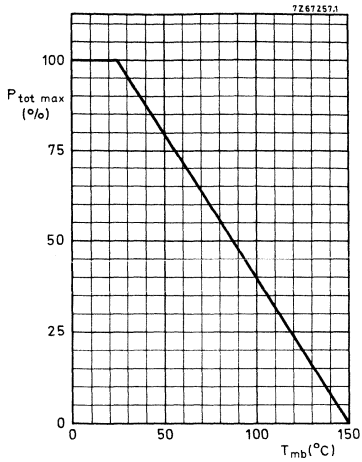


Fig. 6 Power derating curve.

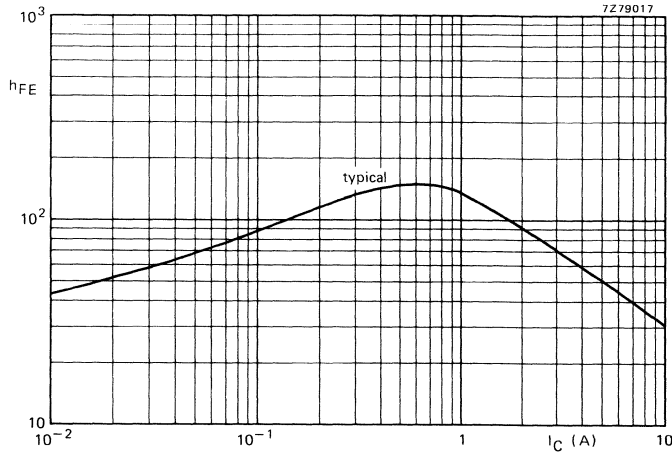


Fig. 7 $V_{CE} = 4\ V$; $T_j = 25\ ^\circ C$.

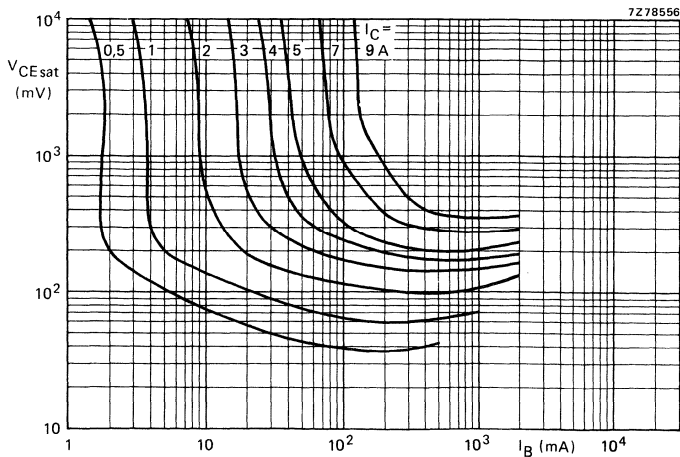


Fig. 8 Typical collector-emitter saturation voltage; $T_j = 25\ ^\circ C$.

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					20 to 100			
$-V_{CE} = 4$ V; $-I_C = 3$ A	h_{FE}							
Collector-emitter saturation voltage								
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<			1		V	

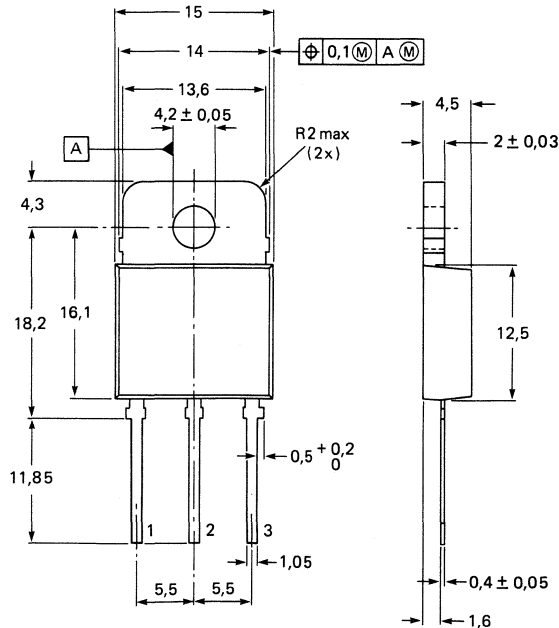
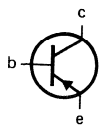
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:
 1 = base
 2 = collector
 3 = emitter



7296696

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); $t_p \leq 0,3$ 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	$R_{th j-mb}$	=		1,56		K/W
From junction to ambient in free air	$R_{th j-a}$	=		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; $I_B = 0$	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
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Collector-emitter sustaining voltage

$-I_C = 30$ mA; $I_B = 0$	TIP34 $-V_{CEO_{sust}}$	>		40		V
	TIP34A $-V_{CEO_{sust}}$	>		60		V
	TIP34B $-V_{CEO_{sust}}$	>		80		V
	TIP34C $-V_{CEO_{sust}}$	>		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

$-I_C = 3 \text{ A}; -I_B = 0,3 \text{ A}$

$-I_C = 10 \text{ A}; -I_B = 2,5 \text{ A}$

Small-signal current gain

$-V_{CE} = 10 \text{ V}; -I_C = 0,5 \text{ A}; f = 1 \text{ kHz}$

Transition frequency

$-V_{CE} = 10 \text{ V}; -I_C = 0,5 \text{ A}; f = 1 \text{ MHz}$

Turn-off breakdown energy (see Fig. 2)

$L = 20 \text{ mH}; -I_C = 2,5 \text{ A}$

Switching times (see Figs 3 and 4)

$-I_C = 6 \text{ A}; -I_{B\text{on}} = +I_{B\text{off}} = 0,6 \text{ A}; -V_{CC} = 30 \text{ V}$

turn-on time

turn-off time

$-V_{CE\text{sat}} < 1 \text{ V}$

$-V_{CE\text{sat}} < 4 \text{ V}$

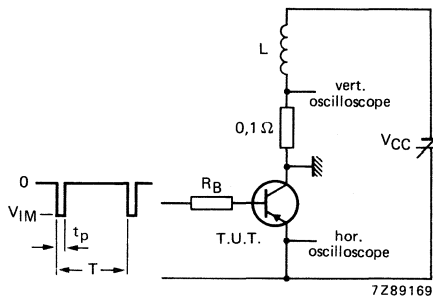
$h_{fe} > 20$

$f_T > 3 \text{ MHz}$

$E(\text{BR}) > 62,5 \text{ mJ}$

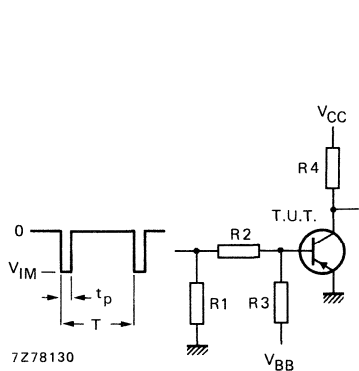
$t_{\text{on}} \text{ typ. } 0,4 \text{ } \mu\text{s}$

$t_{\text{off}} \text{ typ. } 0,7 \text{ } \mu\text{s}$



$-V_{IM} = 12 \text{ V}$
 $R_B = 270 \text{ } \Omega$
 $L = 20 \text{ mH}$
 $-I_{CC} = 2,5 \text{ A}$
 $t_p = 1 \text{ ms}$
 $\delta = 1 \%$

Fig. 2 Test circuit for turn-off breakdown energy.



$-V_{IM} = 47 \text{ V}$
 $-V_{CC} = 30 \text{ V}$
 $V_{BB} = 4 \text{ V}$
 $R_1 = 56 \text{ } \Omega$
 $R_2 = 39 \text{ } \Omega$
 $R_3 = 10 \text{ } \Omega$
 $R_4 = 5 \text{ } \Omega$
 $t_r = t_f = 15 \text{ ns}$
 $t_p = 10 \text{ } \mu\text{s}$
 $T = 500 \text{ } \mu\text{s}$

Fig. 3 Switching times test circuit.

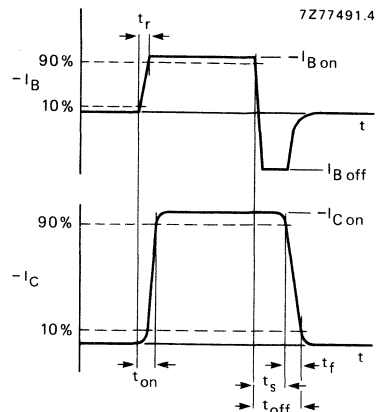


Fig. 4 Switching times waveforms.

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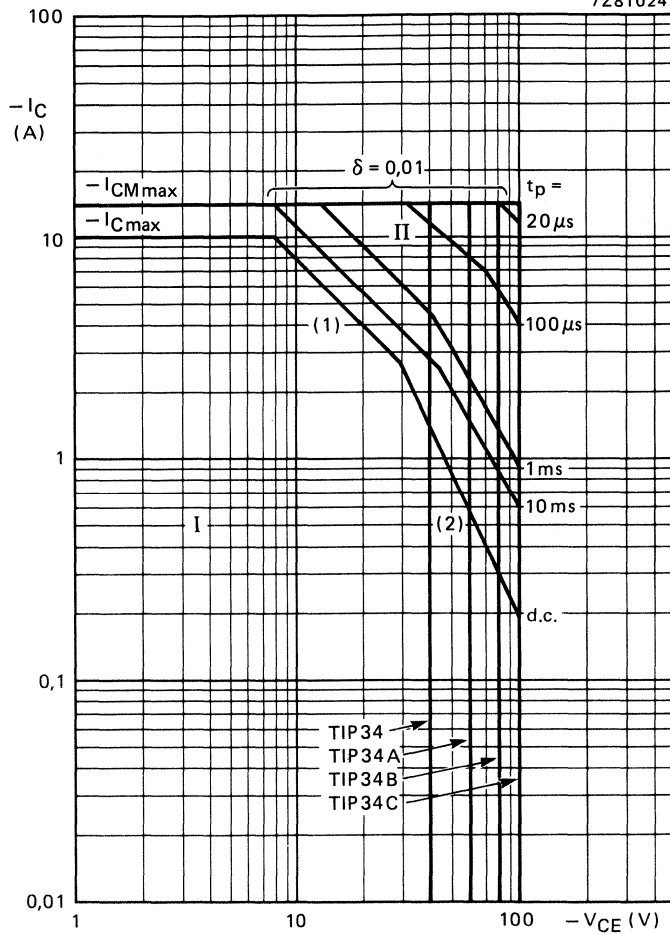


Fig. 5 Safe Operating ARea at $T_{mb} = 25^\circ\text{C}$.

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

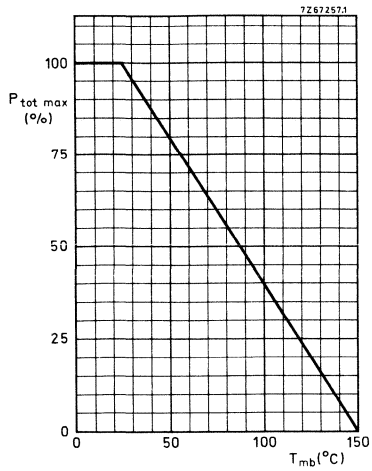


Fig. 6 Power derating curve.

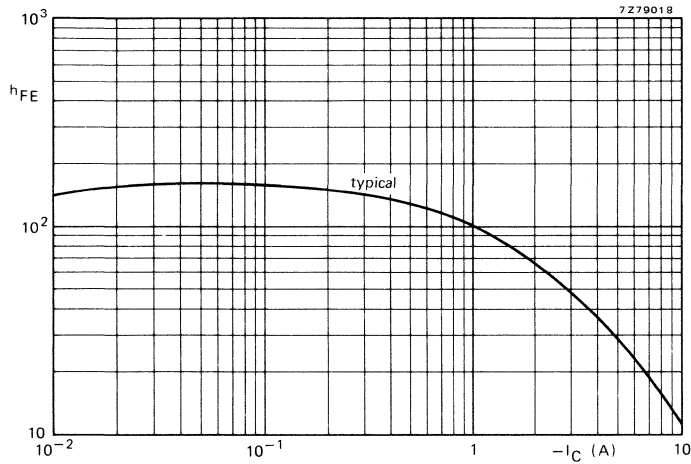


Fig. 7 $-V_{CE} = 4\ V; T_j = 25\ ^\circ C.$

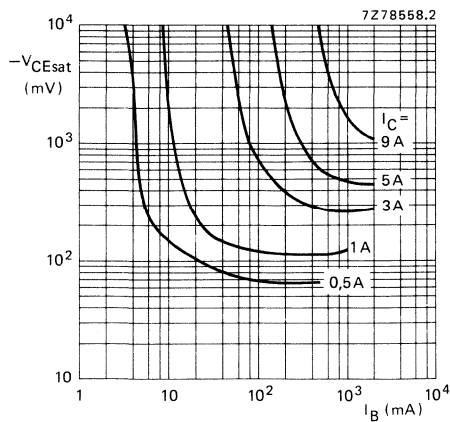


Fig. 8 Typical collector-emitter saturation voltage. $T_j = 25\ ^\circ C.$

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in general purpose amplifier and switching applications.

QUICK REFERENCE DATA

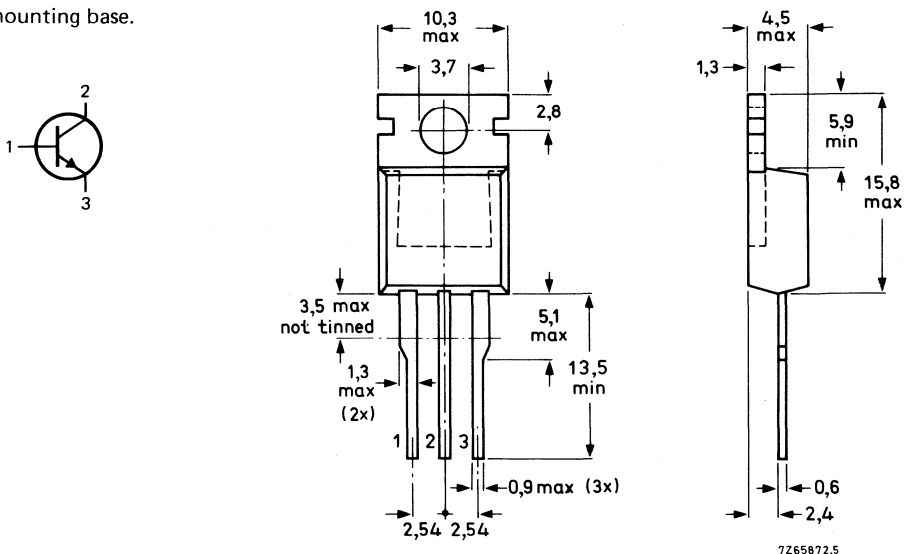
		TIP41	A	B	C
Collector-base voltage (open emitter)	V_{CBO}	max. 80	100	120	140 V
Collector-emitter voltage (open base)	V_{CEO}	max. 40	60	80	100 V
Collector current (d.c.)	I_C	max.	6		A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	65		W
Junction temperature	T_j	max.	150		$^\circ\text{C}$
D.C. current gain $I_C = 3\text{ A}; V_{CE} = 4\text{ V}$	h_{FE}		15 to 75		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



For more information see BDT41 series data.
See also chapters Mounting Instructions and Accessories.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in general output stages of amplifier circuits and switching applications.

QUICK REFERENCE DATA

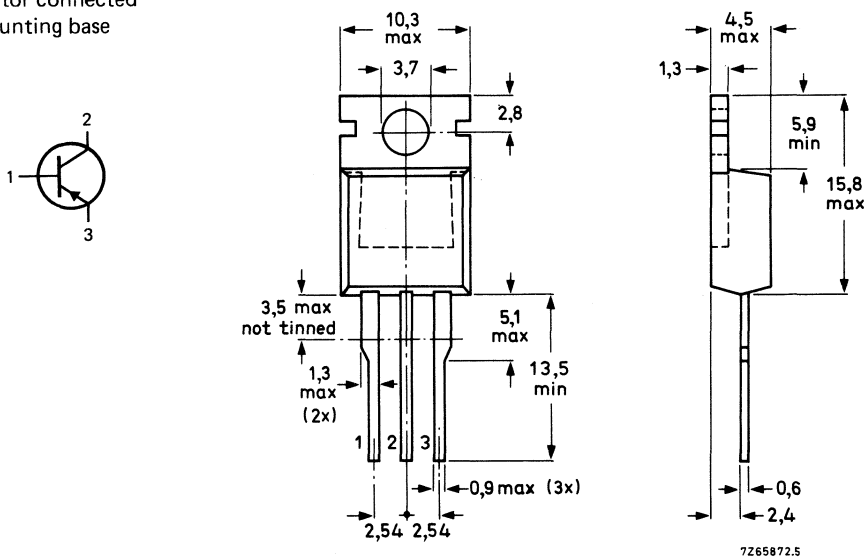
		TIP42	A	B	C	
Collector-base voltage	$-V_{CBO}$	max.	80	100	120	140 V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100 V
Collector current (d.c.)	$-I_C$	max.	6			A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	65			W
Junction temperature	T_j	max.	150			$^\circ\text{C}$
D.C. current gain	h_{FE}		15 to 75			
			$-I_C = 3\text{ A}; -V_{CE} = 4\text{ V}$			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base



For more information see BDT42 series data.
See also chapters Mounting Instructions and Accessories.

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

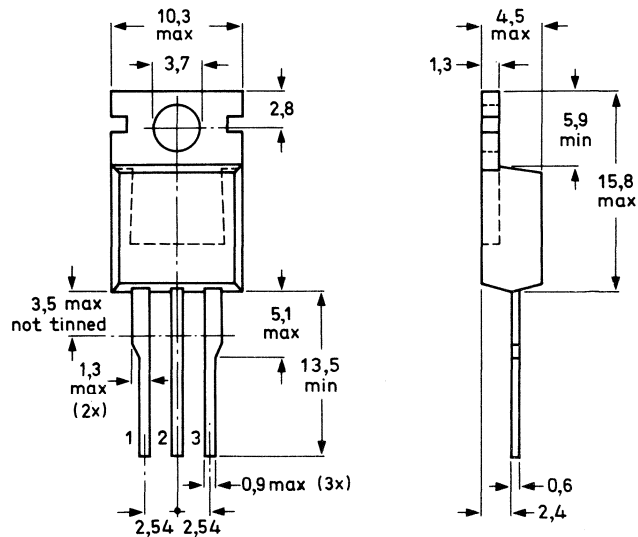
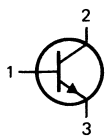
		TIP110	TIP111	TIP112	
Collector-base voltage (open emitter)	V_{CB0} max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO} max.	60	80	100	V
Collector current (d.c.)	I_C max.		4		A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM} max.		6		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.		50		W
D.C. current gain					
$V_{CE} = 4$ V; $I_C = 2$ 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-220AB.

Collector connected to mounting base.



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CIRCUIT DIAGRAM

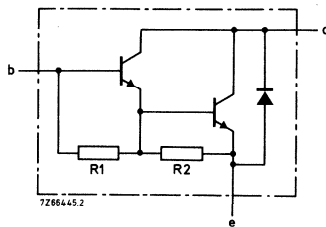


Fig. 2.
R1 typ. 6 kΩ
R2 typ. 100 Ω

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 $T_{mb} = 25$ °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	$R_{th j-mb}$	=		2,5		K/W
From junction to ambient in free air	$R_{th j-a}$	=		62,5		K/W

CHARACTERISTICS

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

$V_{EB} = 5\text{ V}; I_C = 0$	I_{EBO}	<	5	mA
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Collector-emitter sustaining voltage

$I_C = 30\text{ mA}; I_B = 0$	TIP110	$V_{CEOsust}$	>	60	V
	TIP111	$V_{CEOsust}$	>	80	V
	TIP112	$V_{CEOsust}$	>	100	V

D.C. current gain

$V_{CE} = 4\text{ V}; I_C = 1\text{ A}$	h_{FE}	>	1000
$V_{CE} = 4\text{ V}; I_C = 2\text{ A}$	h_{FE}	>	500

Base-emitter voltage

$V_{CE} = 4\text{ V}; I_C = 2\text{ A}$	V_{BE}	<	2,8	V
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Collector-emitter saturation voltage

$I_C = 2\text{ A}; I_B = 8\text{ mA}$	V_{CEsat}	<	2,5	V
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Switching times

$I_C = 2\text{ A}; I_{B on} = -I_{B off} = 8\text{ mA}; V_{CC} = 30\text{ V}$

turn-on time	t_{on}	typ.	2,6	μs
turn-off time	t_{off}	typ.	4,5	μs

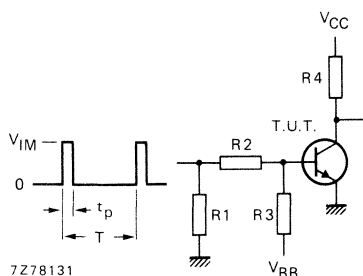


Fig. 3 Switching times test circuit with resistive load.

$V_{IM} = 12\text{ V}$	$R1 = 56\text{ }\Omega$	$t_r = t_f = 15\text{ ns}$
$V_{CC} = 30\text{ V}$	$R2 = 750\text{ }\Omega$	$t_p = 10\text{ }\mu\text{s}$
$-V_{BB} = 5\text{ V}$	$R3 = 910\text{ }\Omega$	$T = 500\text{ }\mu\text{s}$
	$R4 = 15\text{ }\Omega$	

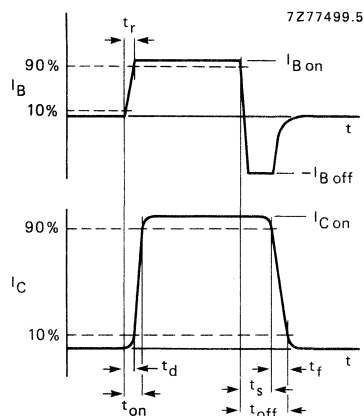


Fig. 4 Switching times waveforms.

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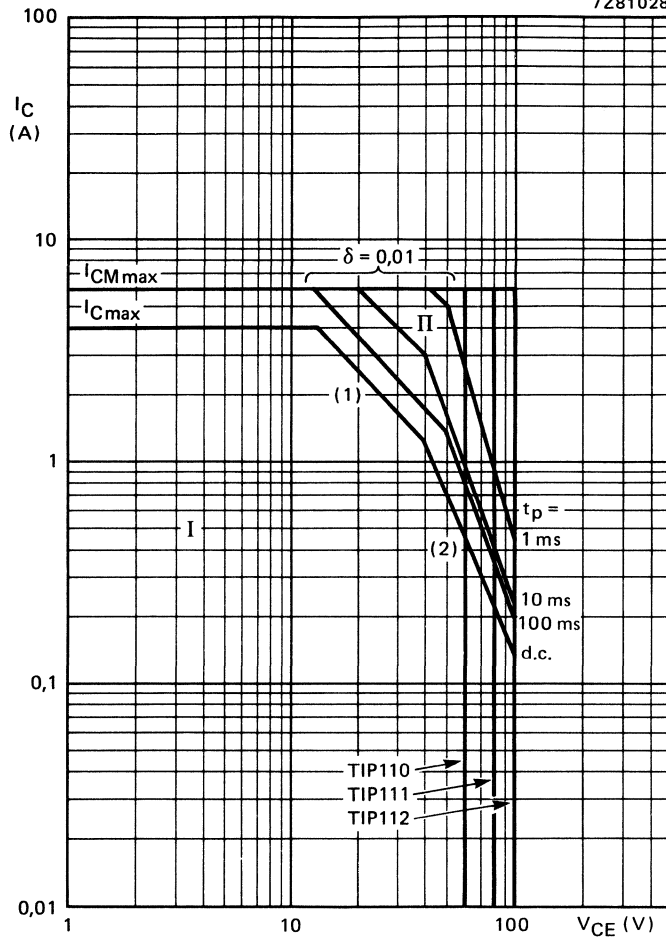


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

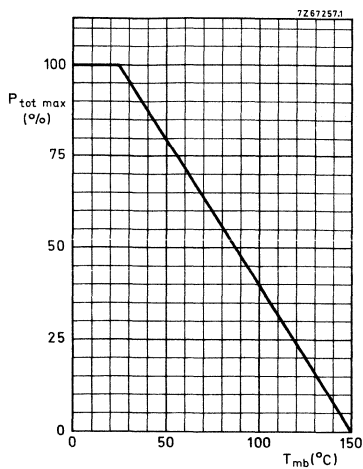


Fig. 6 Power derating curve.

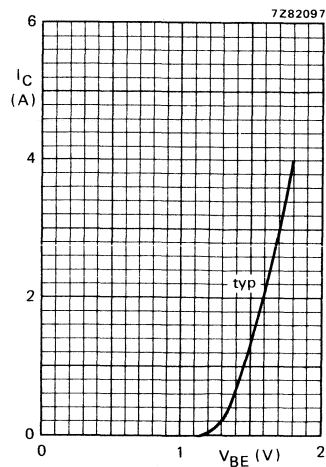


Fig. 7 $V_{CE} = 4\ V; T_j = 25\ ^\circ C$.

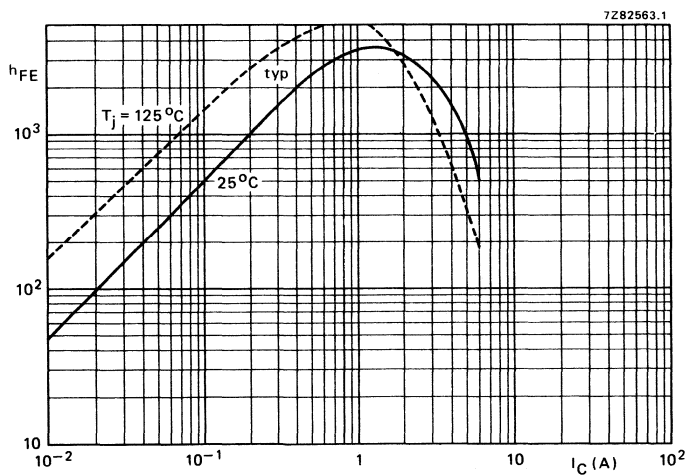


Fig. 8 Typical d.c. current gain; $V_{CE} = 4\ V$.

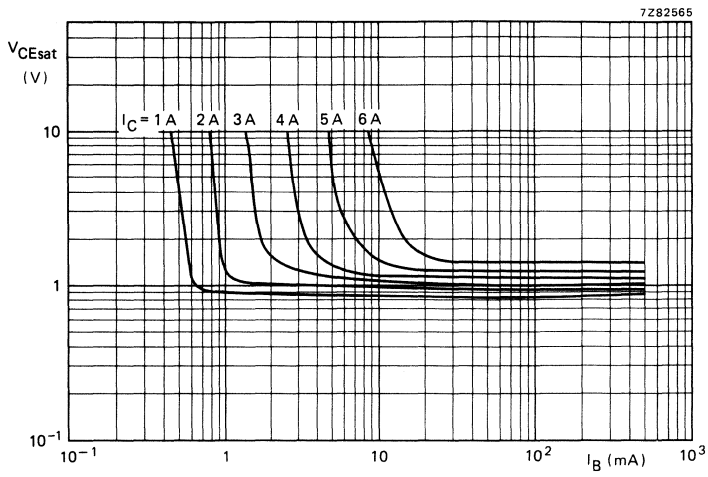


Fig. 9 Typical values; $T_j = 25^\circ C$.

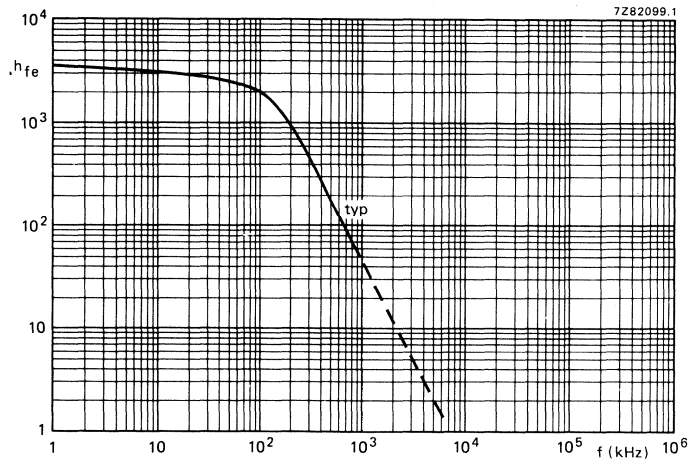


Fig. 10 Small-signal current gain; $I_C = 1,5 A$; $V_{CE} = 4 V$; $T_j = 25^\circ C$.

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

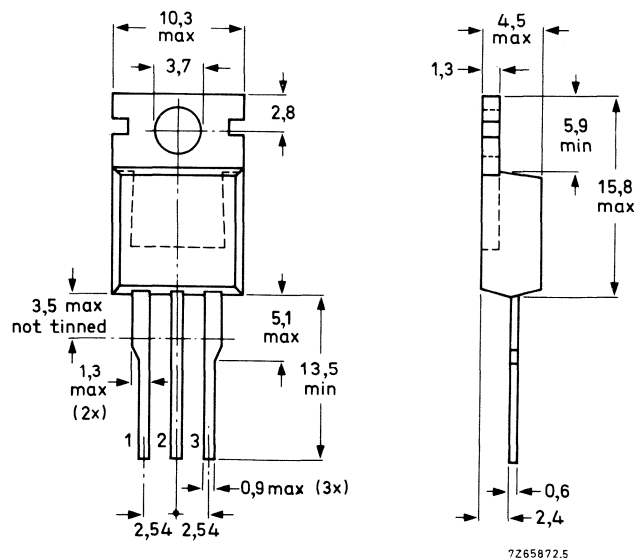
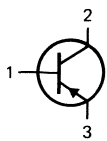
			TIP115	TIP116	TIP117	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		4		A
Collector current (peak value); $t_p \leq 0,3$ ms	$-I_{CM}$	max.		6		A
Total power dissipation up to $T_{mb} = 25$ °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-220AB.

Collector connected to mounting base.



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CIRCUIT DIAGRAM

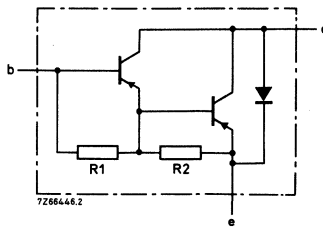


Fig. 2.
R1 typ. 6 k Ω
R2 typ. 100 Ω

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	$R_{th\ j-mb}$	=		2,5		K/W
From junction to ambient in free air	$R_{th\ j-a}$	=		62,5		K/W

CHARACTERISTICS

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

Collector cut-off currents

$-V_{CB} = -V_{CB0max}; I_E = 0$	$-I_{CBO}$	<	0,2	mA	←
$-V_{CE} = 1/2 V_{CE0max}; I_B = 0$	$-I_{CEO}$	<	0,2	mA	←

Emitter cut-off current

$-V_{EB} = 5\text{ V}; I_C = 0$	$-I_{EBO}$	<	5	mA
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Collector-emitter sustaining voltage

$-I_C = 30\text{ mA}; I_B = 0$	TIP115	$-V_{CE0sust}$	>	60	V
	TIP116	$-V_{CE0sust}$	>	80	V
	TIP117	$-V_{CE0sust}$	>	100	V

D.C. current gain

$-V_{CE} = 4\text{ V}; -I_C = 1\text{ A}$	h_{FE}	>	1000
$-V_{CE} = 4\text{ V}; -I_C = 2\text{ A}$	h_{FE}	>	500

Base-emitter voltage

$-V_{CE} = 4\text{ V}; -I_C = 2\text{ A}$	$-V_{BE}$	<	2,8	V
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Collector-emitter saturation voltage

$-I_C = 2\text{ A}; -I_B = 8\text{ mA}$	$-V_{CEsat}$	<	2,5	V
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Switching times

$-I_C = 2\text{ A}; -I_{B0n} = +I_{B0ff} = 8\text{ mA};$
 $-V_{CC} = 30\text{ V}$

turn-on time	t_{on}	typ.	2,6	μs
turn-off time	t_{off}	typ.	4,5	μs

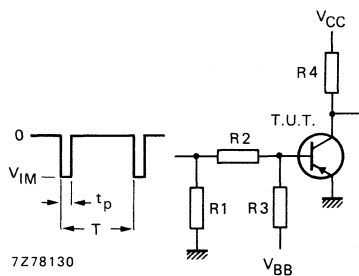


Fig. 3 Switching times test circuit.

$-V_{IM} = 12\text{ V}$	$R1 = 56\text{ }\Omega$	$t_r = t_f = 15\text{ ns}$
$-V_{CC} = 30\text{ V}$	$R2 = 750\text{ }\Omega$	$t_p = 10\text{ }\mu\text{s}$
$+V_{BB} = 5\text{ V}$	$R3 = 910\text{ }\Omega$	$T = 500\text{ }\mu\text{s}$
	$R4 = 15\text{ }\Omega$	

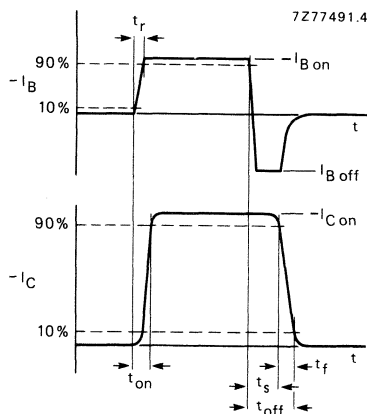


Fig. 4 Switching times waveforms.

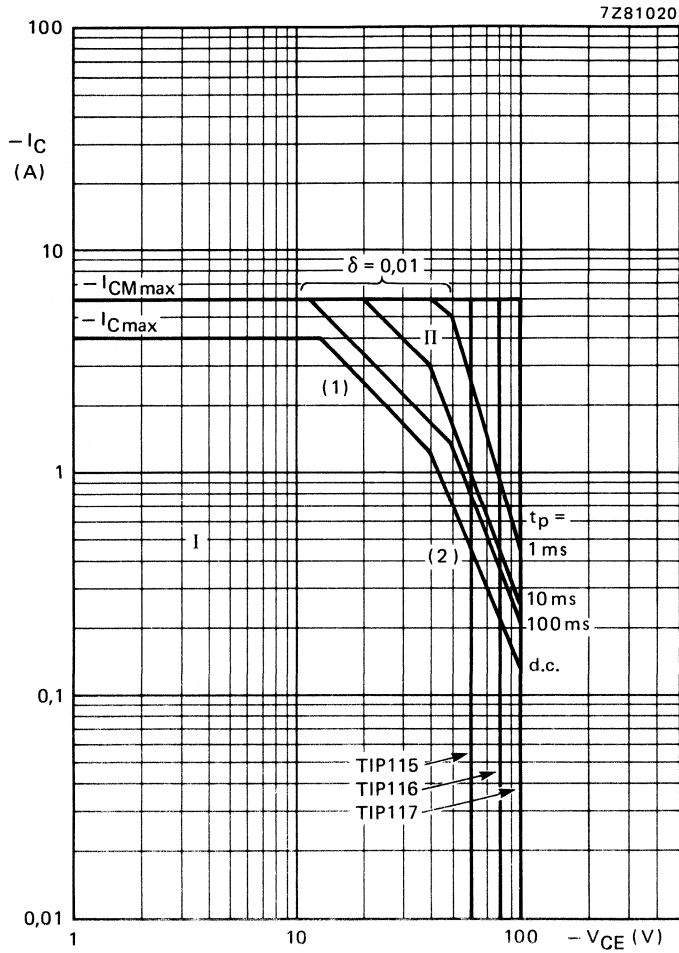


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

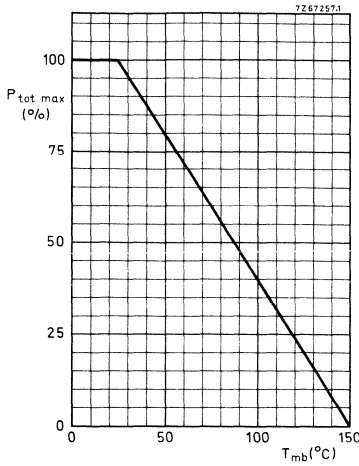


Fig. 6 Power derating curve.

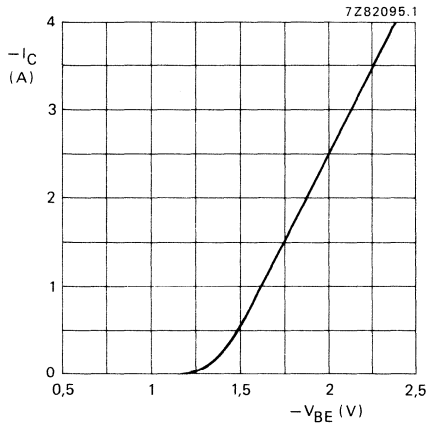


Fig. 7 $-V_{CE} = 4 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$; typical values.

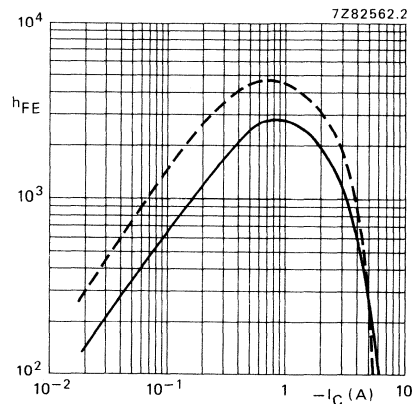


Fig. 8 Typical d.c. current gain; $-V_{CE} = 4 \text{ V}$;
— $T_j = 25 \text{ }^\circ\text{C}$; - - - $T_j = 125 \text{ }^\circ\text{C}$.

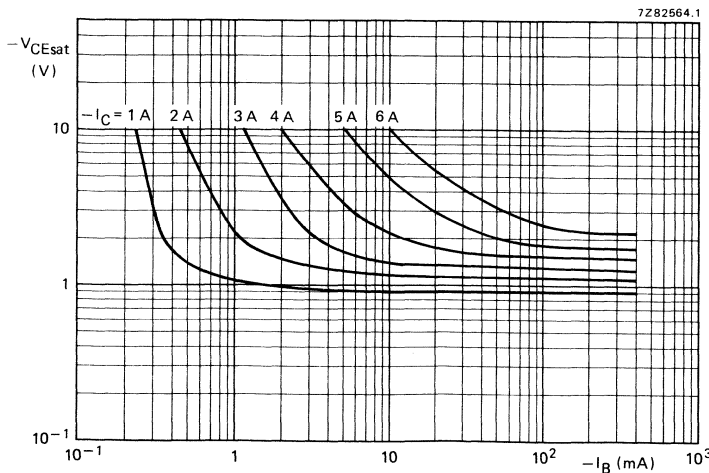


Fig. 9 Typical collector-emitter saturation voltage at $T_j = 25 \text{ }^\circ\text{C}$.

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

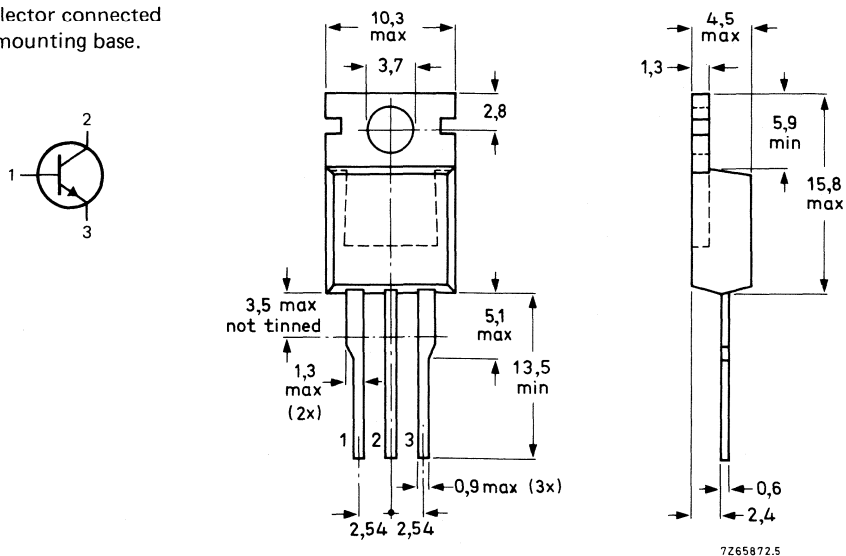
			TIP120	TIP121	TIP122	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max.		8		A
Total power dissipation up to $T_{mb} = 25$ °C	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-220AB.

Collector connected to mounting base.



TIP120 TIP121
TIP122

CIRCUIT DIAGRAM

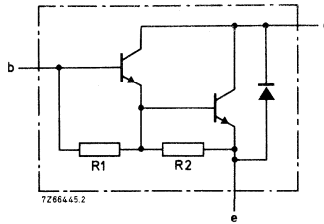


Fig. 2.

R1 typ. 4 k Ω
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); $t_p \leq 0,3$ 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	$R_{th j-mb}$	=	1,92		K/W
From junction to ambient in free air	$R_{th j-a}$	=	62,5		K/W

CHARACTERISTICS

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

Collector cut-off currents

$V_{CB} = V_{CB0\text{max}}; I_E = 0$	I_{CBO}	<	0,1	mA	←
$V_{CE} = 1/2 V_{CE0\text{max}}; I_B = 0$	I_{CEO}	<	0,2	mA	←

Emitter cut-off current

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

Collector-emitter sustaining voltage

$I_C = 30\text{ mA}; I_B = 0$	TIP120	$V_{CE0\text{sust}}$	>	60	V
	TIP121	$V_{CE0\text{sust}}$	>	80	V
	TIP122	$V_{CE0\text{sust}}$	>	100	V

D.C. current gain

$V_{CE} = 3\text{ V}; I_C = 0,5\text{ A}$	h_{FE}	>	1000
$V_{CE} = 3\text{ V}; I_C = 3\text{ A}$	h_{FE}	>	1000

Base-emitter voltage

$V_{CE} = 3\text{ V}; I_C = 3\text{ A}$	V_{BE}	<	2,5	V
---	----------	---	-----	---

Collector-emitter saturation voltage

$I_C = 3\text{ A}; I_B = 12\text{ mA}$	$V_{CE\text{sat}}$	<	2,0	V
$I_C = 5\text{ A}; I_B = 20\text{ mA}$	$V_{CE\text{sat}}$	<	4,0	V

Switching times

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

$V_{CC} = 30\text{ V}$

turn-on time t_{on} typ. 1,5 μs

turn-off time t_{off} typ. 8,5 μs

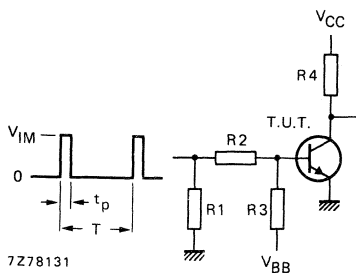


Fig. 3 Switching times test circuit.

$V_{CC} = 30\text{ V}$	$R1 = 56\ \Omega$	$t_r = t_f = 15\text{ ns}$
$V_{IM} = 10\text{ V}$	$R2 = 410\ \Omega$	$t_p = 10\ \mu\text{s}$
$-V_{BB} = 5\text{ V}$	$R3 = 560\ \Omega$	$T = 500\ \mu\text{s}$
	$R4 = 10\ \Omega$	

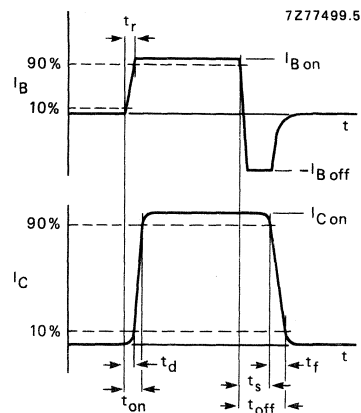


Fig. 4 Switching times waveforms.

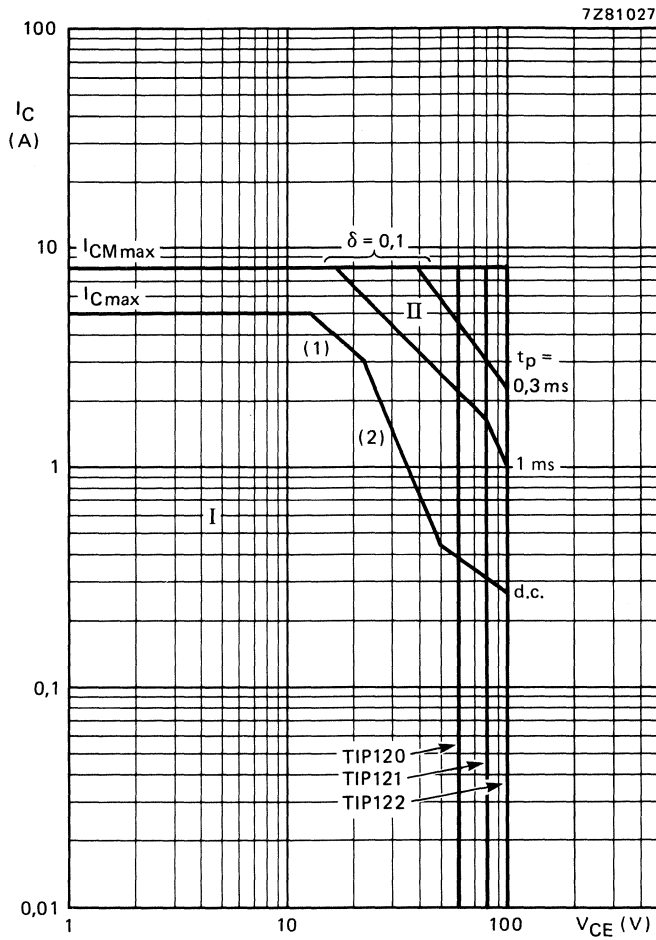


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

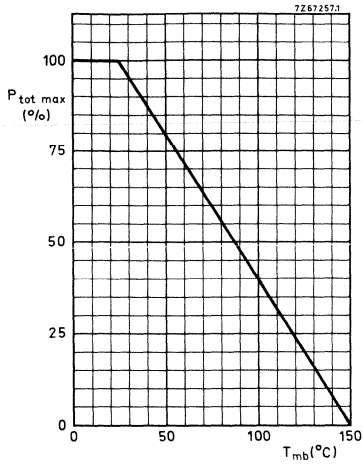


Fig. 6 Power derating curve.

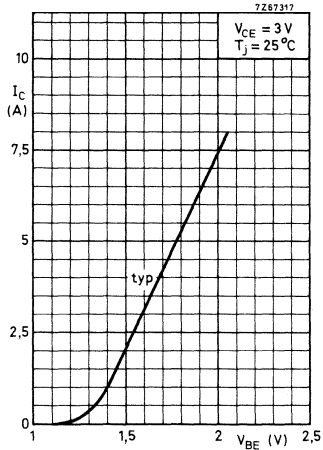


Fig. 7.

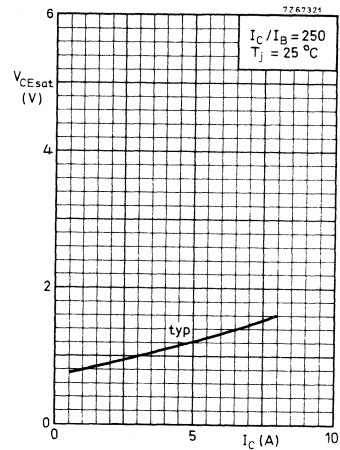


Fig. 8.

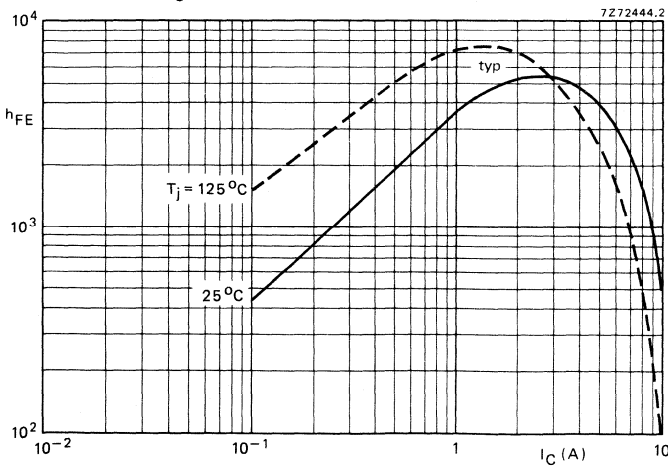


Fig. 9 Typical d.c. current gain; $V_{CE} = 3\ V$.

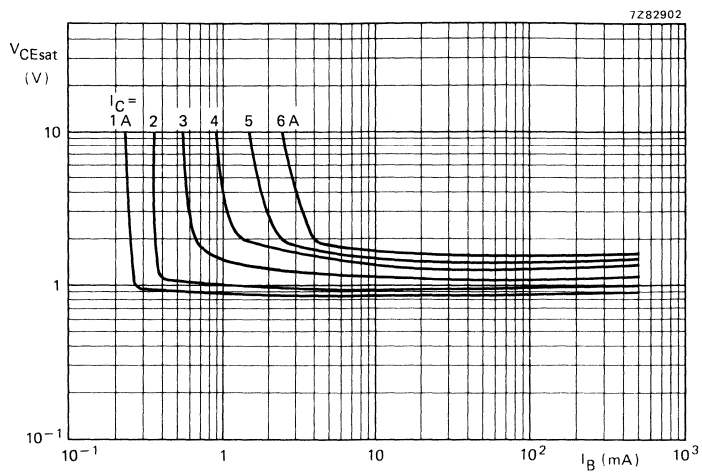


Fig. 10 Typical values; $T_j = 25^\circ\text{C}$.

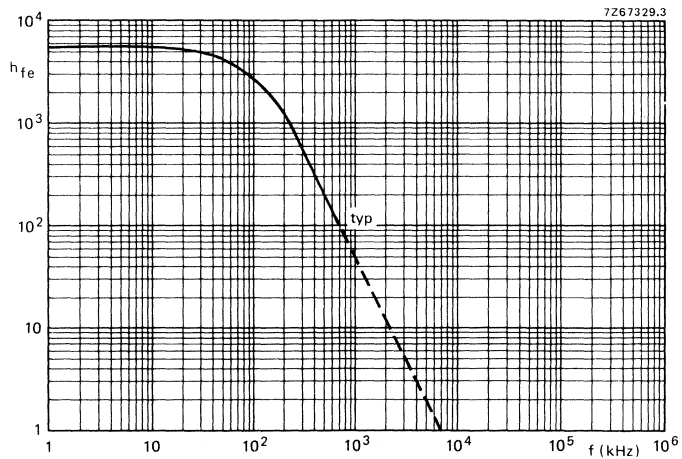


Fig. 11 Small signal current gain at $I_C = 3\text{ A}$; $V_{CE} = 3\text{ V}$; $T_j = 25^\circ\text{C}$.

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

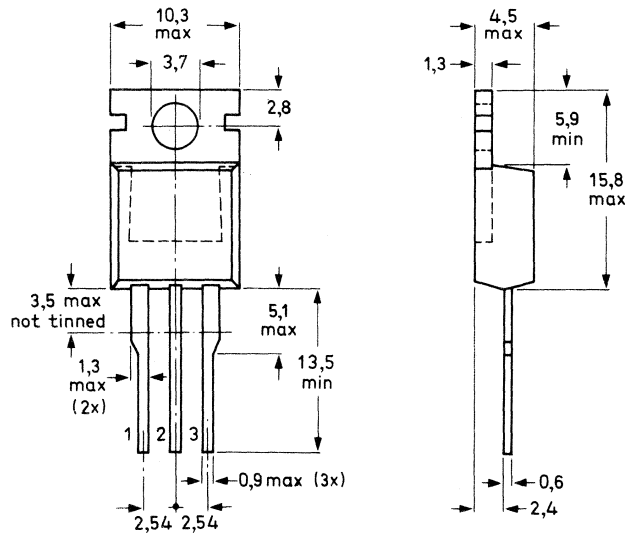
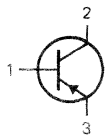
			TIP125	TIP126	TIP127	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		5		A
Collector current (peak value; $t_p \leq 0,3$ ms)	$-I_{CM}$	max.		8		A
Total power dissipation up to $T_{mb} = 25$ °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-220AB.

Collector connected to mounting base.



7265872.5

TIP125 TIP126 TIP127

CIRCUIT DIAGRAM

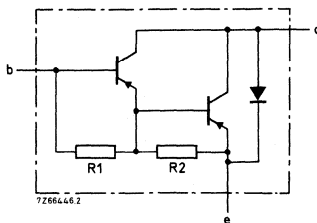


Fig. 2.
R1 typ. 4 k Ω
R2 typ. 80 Ω

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_{thj-mb}	=		1,92		K/W
From junction to ambient in free air	R_{thj-a}	=		62,5		K/W

CHARACTERISTICS

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

Collector cut-off currents

$V_{CB} = V_{CB0max}; I_E = 0$	$-I_{CBO}$	<	0,1	mA	←
$V_{CE} = 1/2 V_{CE0max}; I_B = 0$	$-I_{CEO}$	<	0,2	mA	←

Emitter cut-off current

$-V_{EB} = 5\text{ V}; I_C = 0$	$-I_{EBO}$	<	5,0	mA
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Collector-emitter sustaining voltage

$-I_C = 30\text{ mA}; I_B = 0$	TIP125	$-V_{CE0sust}$	>	60	V
	TIP126	$-V_{CE0sust}$	>	80	V
	TIP127	$-V_{CE0sust}$	>	100	V

D.C. current gain

$-V_{CE} = 3\text{ V}; -I_C = 0,5\text{ A}$	h_{FE}	>	1000
$-V_{CE} = 3\text{ V}; -I_C = 3\text{ A}$	h_{FE}	>	1000

Base-emitter voltage

$-V_{CE} = 3\text{ V}; -I_C = 3\text{ A}$	$-V_{BE}$	<	2,5	V
---	-----------	---	-----	---

Collector-emitter saturation voltage

$-I_C = 3\text{ A}; -I_B = 12\text{ mA}$	$-V_{CEsat}$	<	2,0	V
$-I_C = 5\text{ A}; -I_B = 20\text{ mA}$	$-V_{CEsat}$	<	4,0	V

Switching times

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

$-V_{CC} = 30\text{ V}$

turn-on time	t_{on}	typ.	1,5	μs
turn-off time	t_{off}	typ.	8,5	μs

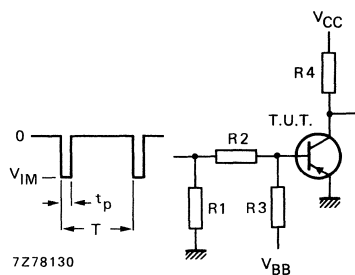


Fig. 3 Switching times test circuit.

$-V_{IM} = 10\text{ V}$	$R1 = 56\ \Omega$	$t_r = t_f = 15\text{ ns}$
$-V_{CC} = 30\text{ V}$	$R2 = 410\ \Omega$	$t_p = 10\ \mu\text{s}$
$+V_{BB} = 5\text{ V}$	$R3 = 560\ \Omega$	$T = 500\ \mu\text{s}$
	$R4 = 10\ \Omega$	

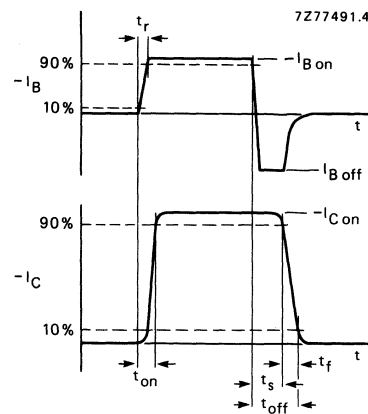


Fig. 4 Switching times waveforms.

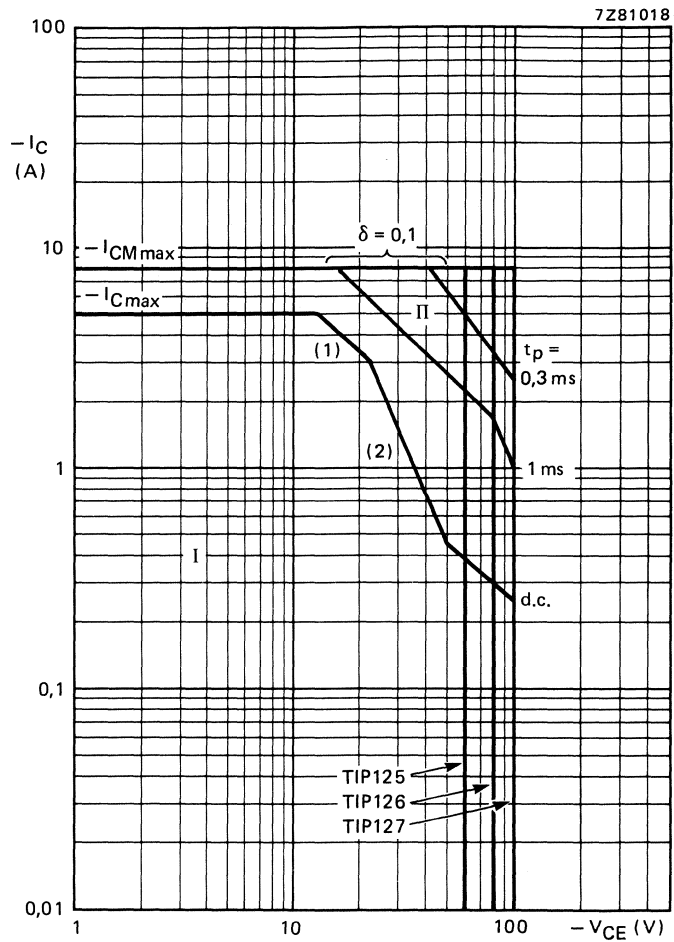


Fig. 5 Safe Operating ARea at $T_{mb} = 25^\circ\text{C}$.

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

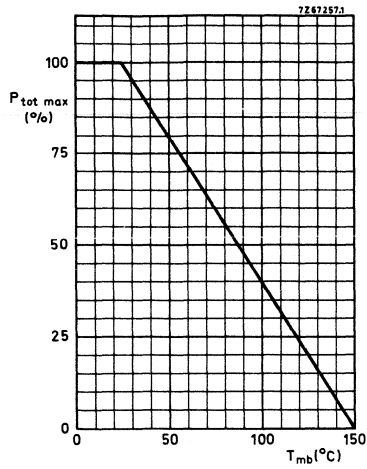


Fig. 6 Power derating curve.

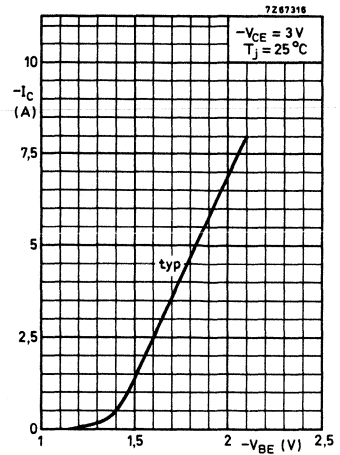


Fig. 7.

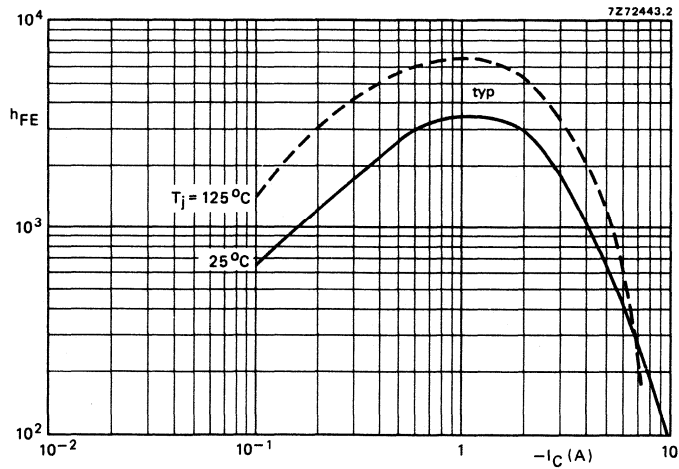


Fig. 8 D.C. current gain at $-V_{CE} = 3\text{ V}$.

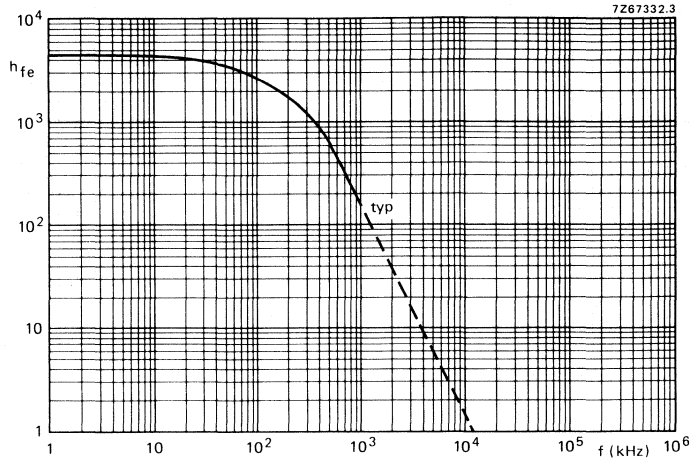


Fig. 9 Small-signal current gain at $-I_C = 3 \text{ A}$; $-V_{CE} = 3 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$.

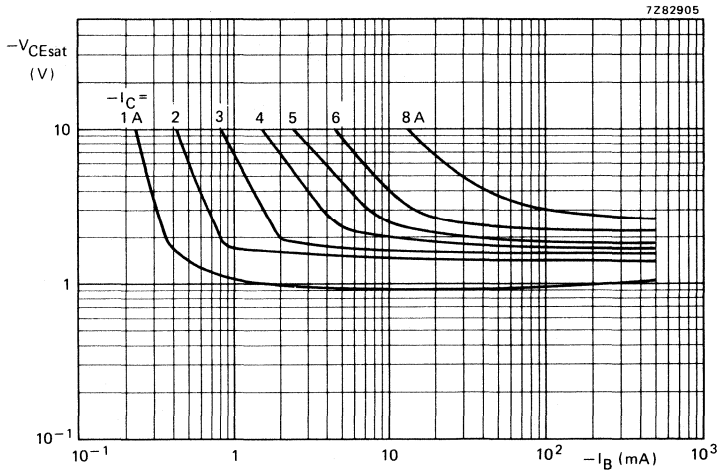


Fig. 10 Typical collector-emitter saturation voltage at $T_j = 25 \text{ }^\circ\text{C}$.

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

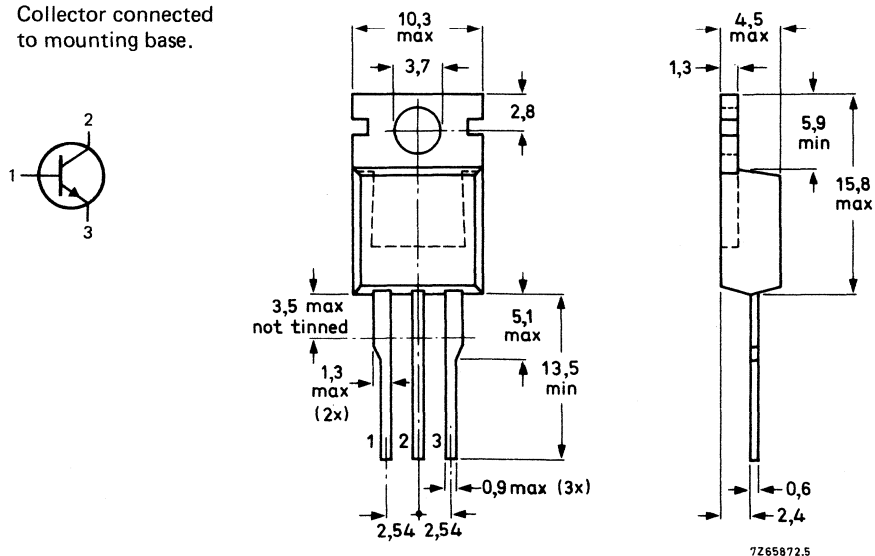
		TIP130	TIP131	TIP132	
Collector-base voltage (open emitter)	V_{CBO}	max. 60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max. 60	80	100	V
Collector current (d.c.)	I_C	max. 8			A
Collector current (peak value); $t_p \leq 0,3$ ms	I_{CM}	max. 12			A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 70			W
D.C. current gain	h_{FE}	1000 to 15 000			
$V_{CE} = 4$ V; $I_C = 4$ A					
Collector-emitter saturation voltage	V_{CEsat}	< 2			V
$I_C = 4$ A; $I_B = 16$ mA					

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



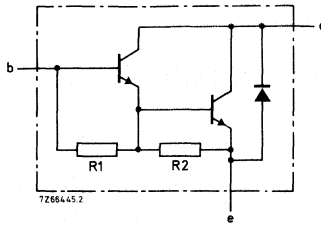


Fig. 2.
R1 typ. 8 kΩ
R2 typ. 100 kΩ

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 $T_{mb} = 25$ °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	$R_{th j-mb}$	=		1,79		K/W
From junction to ambient in free air	$R_{th j-a}$	=		62,5		K/W

CHARACTERISTICS

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

Collector cut-off currents

$V_{CB} = V_{CB0max}; I_E = 0$	I_{CB0}	<	0,2	mA
$V_{CB} = V_{CB0max}; I_E = 0; T_j = 100\text{ }^\circ\text{C}$	I_{CB0}	<	1	mA
$V_{CE} = 1/2 V_{CE0max}; I_B = 0$	I_{CEO}	<	0,5	mA

Emitter cut-off current

$V_{EB} = 5\text{ V}; I_C = 0$	I_{EBO}	<	5	mA
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Collector-emitter sustaining voltage

$I_C = 30\text{ mA}; I_B = 0$	TIP130	$V_{CE0sust}$	>	60	V
	TIP131	$V_{CE0sust}$	>	80	V
	TIP132	$V_{CE0sust}$	>	100	V

D.C. current gain

$V_{CE} = 4\text{ V}; I_C = 1\text{ A}$	h_{FE}	>	500	
$V_{CE} = 4\text{ V}; I_C = 4\text{ A}$	h_{FE}		1000 to 15000	

Base-emitter voltage

$V_{CE} = 4\text{ V}; I_C = 4\text{ A}$	V_{BE}	<	2,5	V
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Collector-emitter saturation voltage

$I_C = 4\text{ A}; I_B = 16\text{ mA}$	V_{CEsat}	<	2	V
$I_C = 6\text{ A}; I_B = 30\text{ mA}$	V_{CEsat}	<	3	V

Collector-base capacitance

$V_{CB} = 10\text{ V}; I_E = 0$	C_{ob}	<	200	pF
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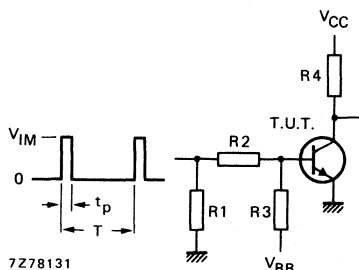
Switching times

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

$V_{CC} = 10\text{ V}$

turn-on time	t_{on}	typ.	1	μs
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turn-off time	t_{off}	typ.	5	μs
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7Z78131

Fig. 3 Switching times test circuit with resistive load.

$V_{IM} = 10\text{ V}$	$R1 = 56\ \Omega$	$t_r = t_f = 15\text{ ns}$
$V_{CC} = 10\text{ V}$	$R2 = 410\ \Omega$	$t_p = 10\ \mu\text{s}$
$-V_{BB} = 4\text{ V}$	$R3 = 560\ \Omega$	$T = 500\ \mu\text{s}$
	$R4 = 3\ \Omega$	

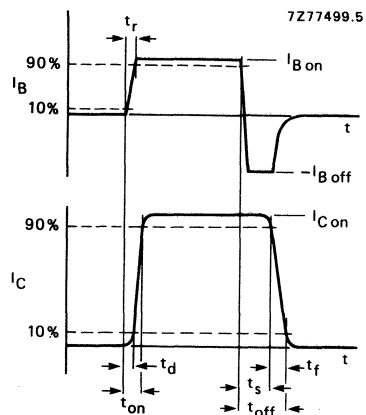


Fig. 4 Switching times waveforms.

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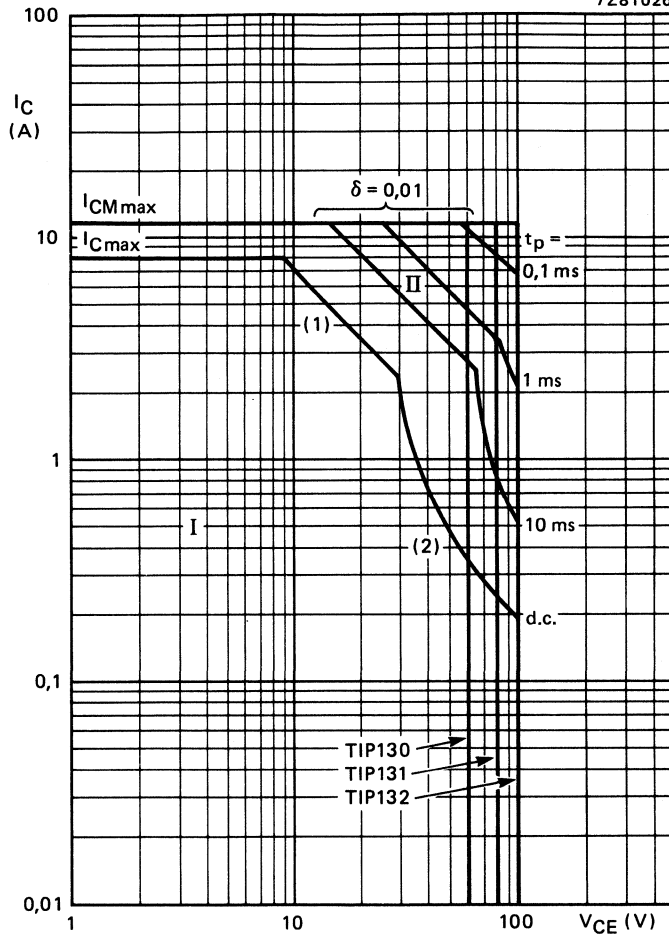


Fig. 5 Safe Operating Area; $T_{mb} = 25\ ^\circ\text{C}$.

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

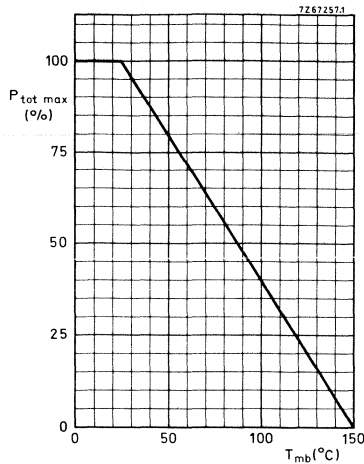


Fig. 6 Power derating curve.

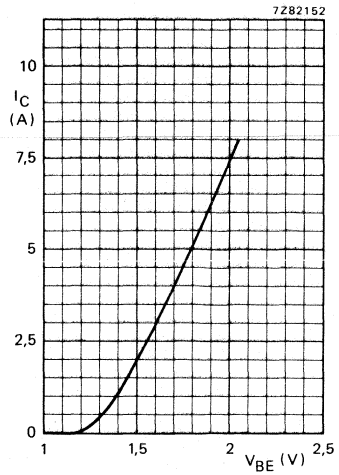


Fig. 7 Typical values;
 $V_{CE} = 4\ V$; $T_j = 25\ ^\circ C$.

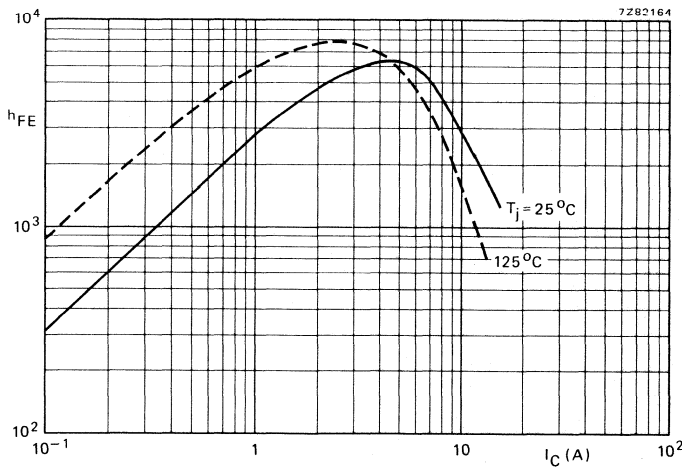


Fig. 8 Typical d.c. current gain at $V_{CE} = 4\ V$.

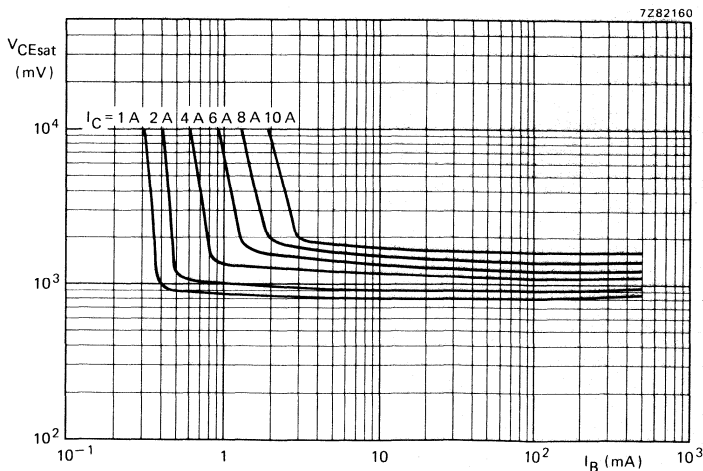


Fig. 9 Typical values;
 $T_j = 25\ ^\circ C$.

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

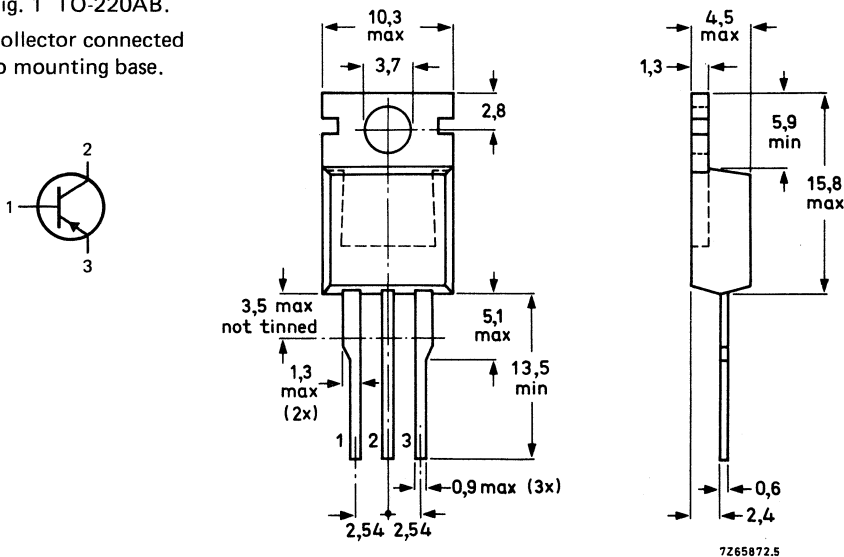
		TIP135			TIP136			TIP137		
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V				
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V				
Collector current (d.c.)	$-I_C$	max.		8		A				
Collector current (peak value); $t_p \leq 0,3$ ms	$-I_{CM}$	max.		12		A				
Total power 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-220AB.

Collector connected to mounting base.



CIRCUIT DIAGRAM

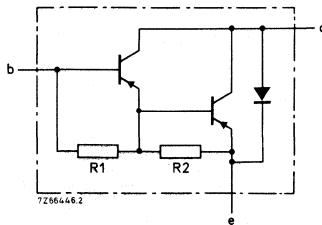


Fig. 2.
R1 typ. 4 kΩ
R2 typ. 60 Ω

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	$R_{th j-mb}$	=		1,79		K/W
From junction to ambient in free air	$R_{th j-a}$	=		62,5		K/W

CHARACTERISTICS

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

Collector cut-off currents

$-V_{CB} = -V_{CB0max}; I_E = 0$	$-I_{CBO}$	<	0,2	mA
$-V_{CB} = -V_{CB0max}; I_E = 0; T_j = 100\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1	mA
$-V_{CE} = -1/2 V_{CE0max}; I_B = 0$	$-I_{CEO}$	<	0,5	mA

Emitter cut-off current

$-V_{EB} = 5\text{ V}; I_C = 0$	$-I_{EBO}$	<	5	mA
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Collector-emitter sustaining voltage

$-I_C = 30\text{ mA}; I_B = 0$	TIP135	$-V_{CE0sust}$	>	60	V
	TIP136	$-V_{CE0sust}$	>	80	V
	TIP137	$-V_{CE0sust}$	>	100	V

D.C. current gain

$-V_{CE} = 4\text{ V}; -I_C = 1\text{ A}$	h_{FE}	>	500	
$-V_{CE} = 4\text{ V}; -I_C = 4\text{ A}$	h_{FE}		1000 to 15 000	

Base-emitter voltage

$-V_{CE} = 4\text{ V}; -I_C = 4\text{ A}$	$-V_{BE}$	<	2,5	V
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Collector-emitter saturation voltage

$-I_C = 4\text{ A}; -I_B = 16\text{ mA}$	$-V_{CEsat}$	<	2	V
$-I_C = 6\text{ A}; -I_B = 30\text{ mA}$	$-V_{CEsat}$	<	3	V

Collector-base capacitance

$-V_{CB} = 10\text{ V}; I_E = 0$	C_{ob}	<	200	pF
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Switching times

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

$-V_{CC} = 10\text{ V}$

turn-on time	t_{on}	typ.	0,5	μs
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turn-off time	t_{off}	typ.	2,5	μs
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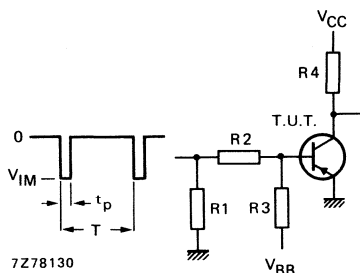


Fig. 3 Switching times test circuit.

$-V_{IM} = 10\text{ V}$	$R1 = 56\text{ }\Omega$	$t_r = t_f = 15\text{ ns}$
$-V_{CC} = 10\text{ V}$	$R2 = 410\text{ }\Omega$	$t_p = 10\text{ }\mu\text{s}$
$+V_{BB} = 4\text{ V}$	$R3 = 560\text{ }\Omega$	$T = 500\text{ }\mu\text{s}$
	$R4 = 3\text{ }\Omega$	

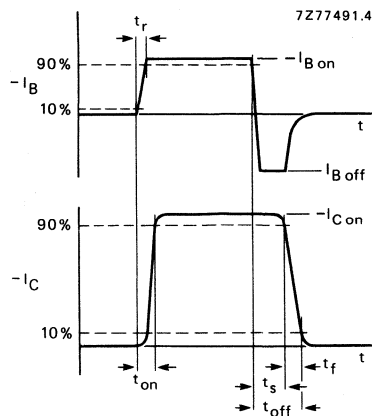


Fig. 4 Switching times waveforms.

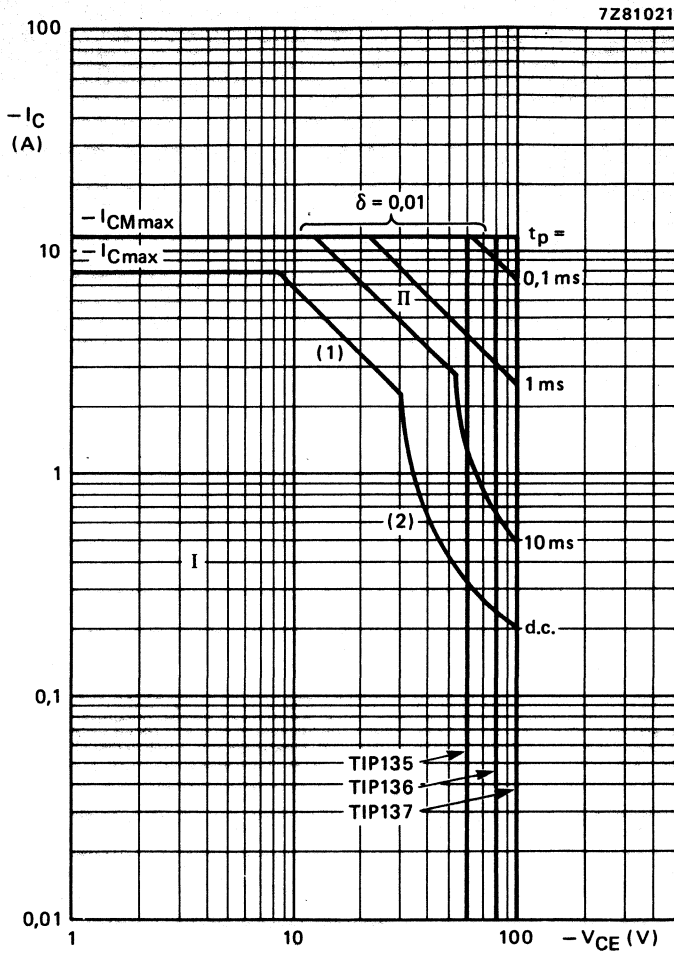


Fig. 5 Safe Operating ARea; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

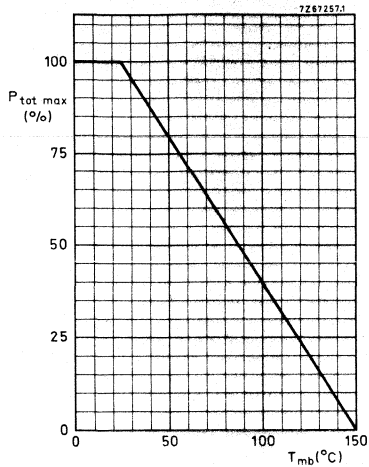


Fig. 6 Power derating curve.

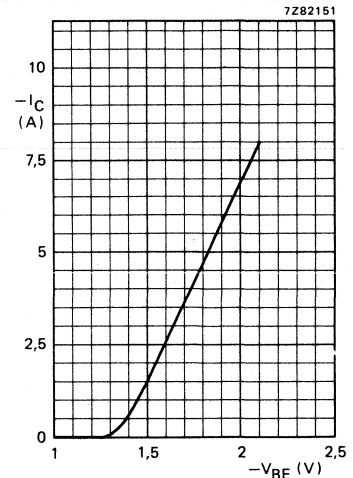


Fig. 7 Typical values;
 $-V_{CE} = 4\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$.

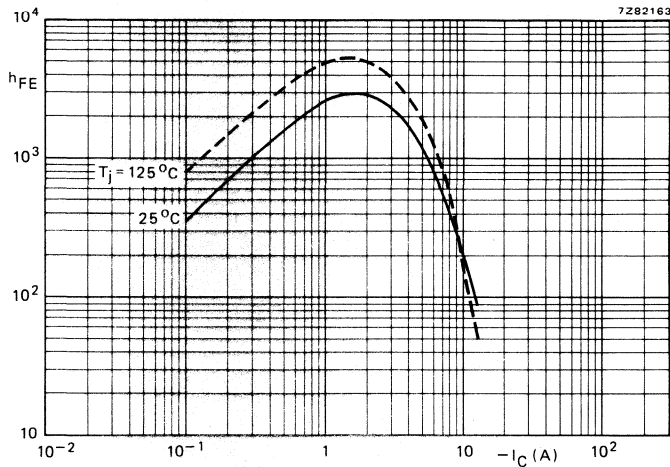


Fig. 8 Typical d.c. current gain at $-V_{CE} = 4\text{ V}$.

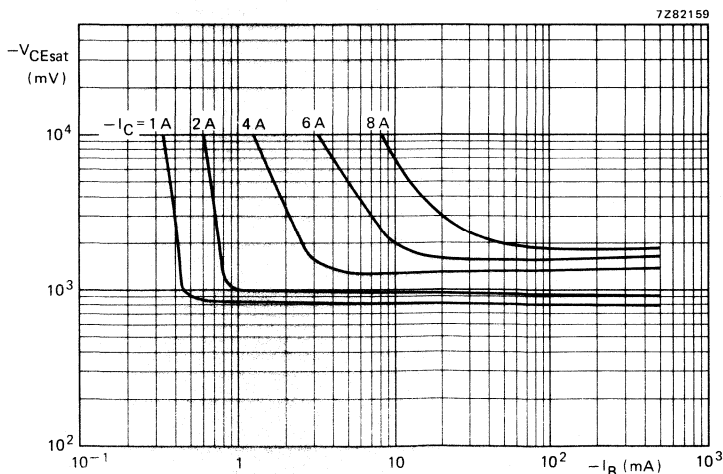


Fig. 9 Typical collector-emitter saturation voltage; $T_j = 25\text{ }^\circ\text{C}$.

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	h_{FE}	>		1000		
$V_{CE} = 4$ V; $I_C = 5$ A						
Collector-emitter saturation voltage	V_{CEsat}	<		2,0		V
$I_C = 5$ A; $I_B = 10$ mA						

MECHANICAL DATA

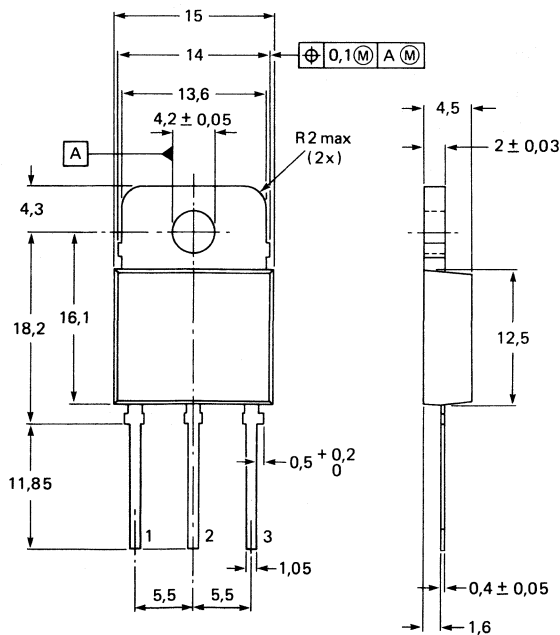
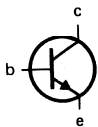
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:

- 1 = base
- 2 = collector
- 3 = emitter



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CIRCUIT DIAGRAM

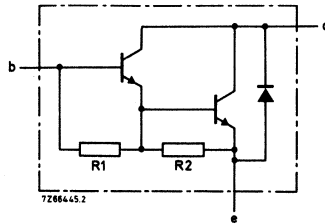


Fig. 2.
R1 typ. 5 kΩ
R2 typ. 80 Ω

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); $t_p \leq 0,3$ 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_{thj-mb}	=		1		K/W
From junction to ambient in free air	R_{thj-a}	=		35,7		K/W

CHARACTERISTICS

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

Collector cut-off currents

$V_{CB} = V_{CB0max}; I_E = 0$	I_{CBO}	<	0,4	mA	←
$V_{CE} = 1/2 V_{CE0max}; I_B = 0$	I_{CEO}	<	0,2	mA	←

Emitter cut-off current

$V_{EB} = 5\text{ V}; I_C = 0$	I_{EBO}	<	5	mA
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Collector-emitter sustaining voltage

$I_C = 30\text{ mA}; I_B = 0$	TIP140	$V_{CE0sust}$	>	60	V
	TIP141	$V_{CE0sust}$	>	80	V
	TIP142	$V_{CE0sust}$	>	100	V

D.C. current gain

$V_{CE} = 4\text{ V}; I_C = 5\text{ A}$	h_{FE}	>	1000
$V_{CE} = 4\text{ V}; I_C = 10\text{ A}$	h_{FE}	>	500

Base-emitter voltage

$V_{CE} = 4\text{ V}; I_C = 10\text{ A}$	V_{BE}	<	3	V
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Collector-emitter saturation voltage

$I_C = 5\text{ A}; I_B = 10\text{ mA}$	V_{CEsat}	<	2	V
$I_C = 10\text{ A}; I_B = 40\text{ mA}$	V_{CEsat}	<	3	V

Switching times (see Figs 3 and 4)

$I_C = 10\text{ A}; I_{B0n} = -I_{B0f} = 40\text{ mA}$

$V_{CC} = 30\text{ V}$

turn-on time	t_{on}	typ.	0,9	μs
turn-off time	t_{off}	typ.	11	μs

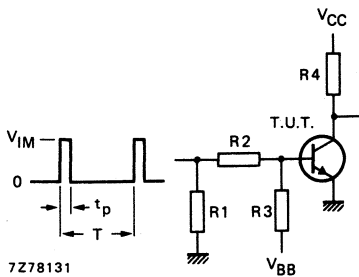


Fig. 3 Switching times test circuit.

$V_{IM} = 33\text{ V}$	$R1 = 56\text{ }\Omega$	$t_r = t_f = 15\text{ ns}$
$V_{CC} = 30\text{ V}$	$R2 = 410\text{ }\Omega$	$t_p = 10\text{ }\mu\text{s}$
$V_{BB} = -4,2\text{ V}$	$R3 = 150\text{ }\Omega$	$T = 500\text{ }\mu\text{s}$
	$R4 = 3\text{ }\Omega$	

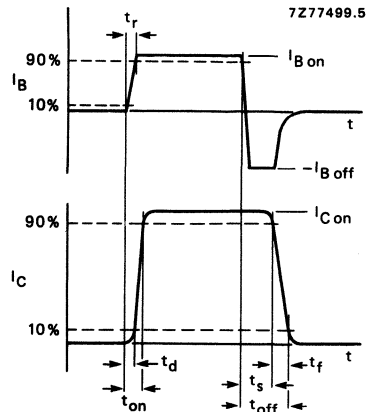


Fig. 4 Waveforms showing t_{on} ; $t_s + t_f = t_{off}$.

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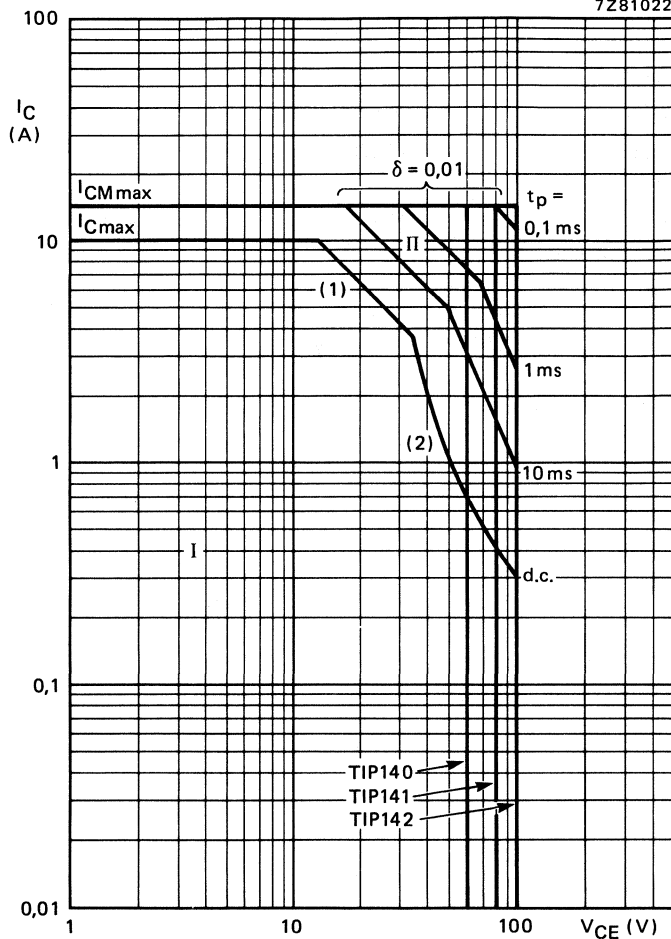


Fig. 5 Safe Operating Area; $T_{mb} \leq 25^\circ\text{C}$.

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

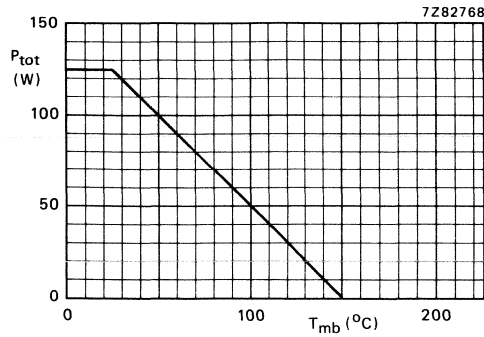


Fig. 6 Power derating curve.

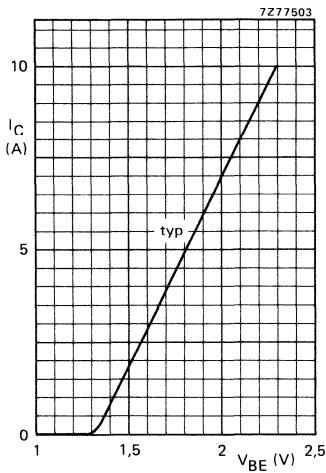


Fig. 7 $V_{CE} = 4$ V; $T_j = 25$ °C.

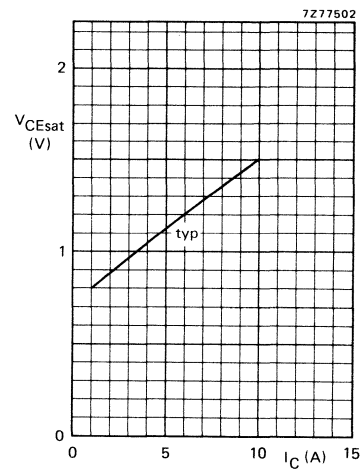


Fig. 8 $I_C/I_B = 250$; $T_j = 25$ °C.

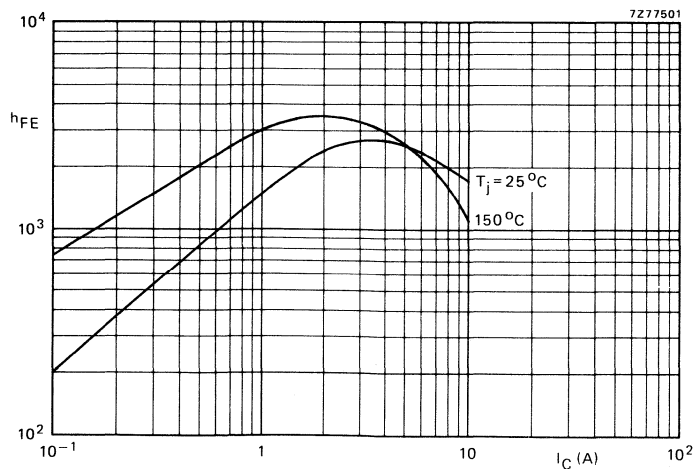


Fig. 9 Typical values; $V_{CE} = 4$ V.

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 $T_{mb} = 25$ °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

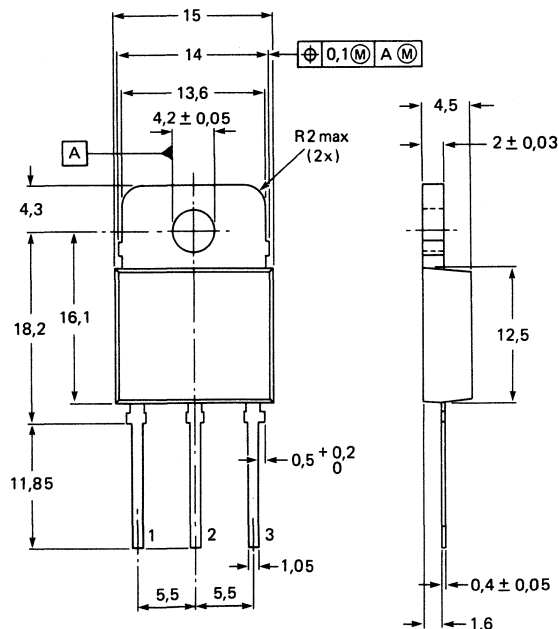
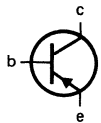
MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning:

- 1 = base
- 2 = collector
- 3 = emitter



Dimensions in mm

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CIRCUIT DIAGRAM

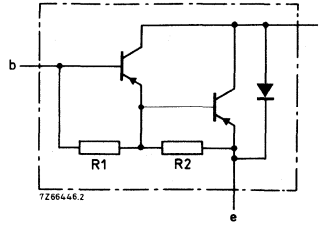


Fig. 2.
R1 typ. 5 kΩ
R2 typ. 80 Ω

RATINGS

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

			TIP145	TIP146	TIP147	
Collector-base voltage ($I_E = 0$)	$-V_{CB0}$	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); $t_p \leq 0,3$ 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_{thj-mb}	=		1		K/W
From junction to ambient in free air	R_{thj-a}	=		35,7		K/W

CHARACTERISTICS

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

Collector cut-off currents

$-V_{CB} = -V_{CB0max}; I_E = 0$	$-I_{CBO}$	<	0,4	mA	←
$-V_{CE} = 1/2 V_{CE0max}; I_B = 0$	$-I_{CEO}$	<	0,2	mA	←

Emitter cut-off current

$-V_{EB} = 5\text{ V}; I_C = 0$	$-I_{EBO}$	<	5	mA
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Collector-emitter sustaining voltage

$-I_C = 30\text{ mA}; I_B = 0$	TIP145	$-V_{CE0sust}$	>	60	V
	TIP146	$-V_{CE0sust}$	>	80	V
	TIP147	$-V_{CE0sust}$	>	100	V

D.C. current gain

$-V_{CE} = 4\text{ V}; -I_C = 5\text{ A}$	h_{FE}	>	1000
$-V_{CE} = 4\text{ V}; -I_C = 10\text{ A}$	h_{FE}	>	500

Base-emitter voltage

$-V_{CE} = 4\text{ V}; -I_C = 10\text{ A}$	$-V_{BE}$	<	3	V
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Collector-emitter saturation voltage

$-I_C = 5\text{ A}; -I_B = 10\text{ mA}$	$-V_{CEsat}$	<	2	V
$-I_C = 10\text{ A}; -I_B = 40\text{ mA}$	$-V_{CEsat}$	<	3	V

Switching times (see Figs 3 and 4)

$-I_C = 10\text{ A}; -I_{Bon} = I_{Boff} = 40\text{ mA}$				
$-V_{CC} = 30\text{ V}$				
turn-on time	t_{on}	typ.	0,9	μs
turn-off time	t_{off}	typ.	11	μs

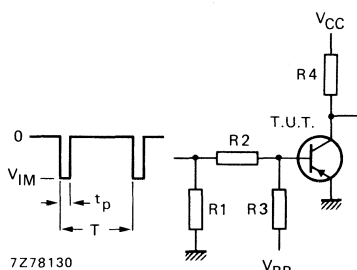


Fig. 3 Switching times test circuit.

$-V_{IM} = 33\text{ V}$	$R1 = 56\text{ }\Omega$	$t_r = t_f = 15\text{ ns}$
$-V_{CC} = 30\text{ V}$	$R2 = 410\text{ }\Omega$	$t_p = 10\text{ }\mu\text{s}$
$V_{BB} = 4,2\text{ V}$	$R3 = 150\text{ }\Omega$	$T = 500\text{ }\mu\text{s}$
	$R4 = 3\text{ }\Omega$	

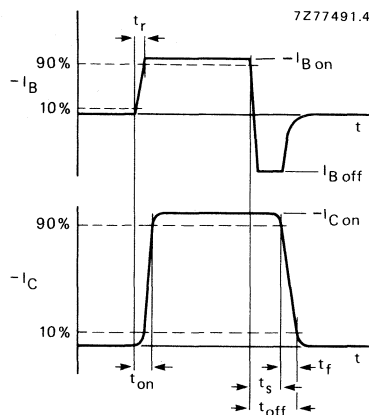


Fig. 4 Switching times waveforms.

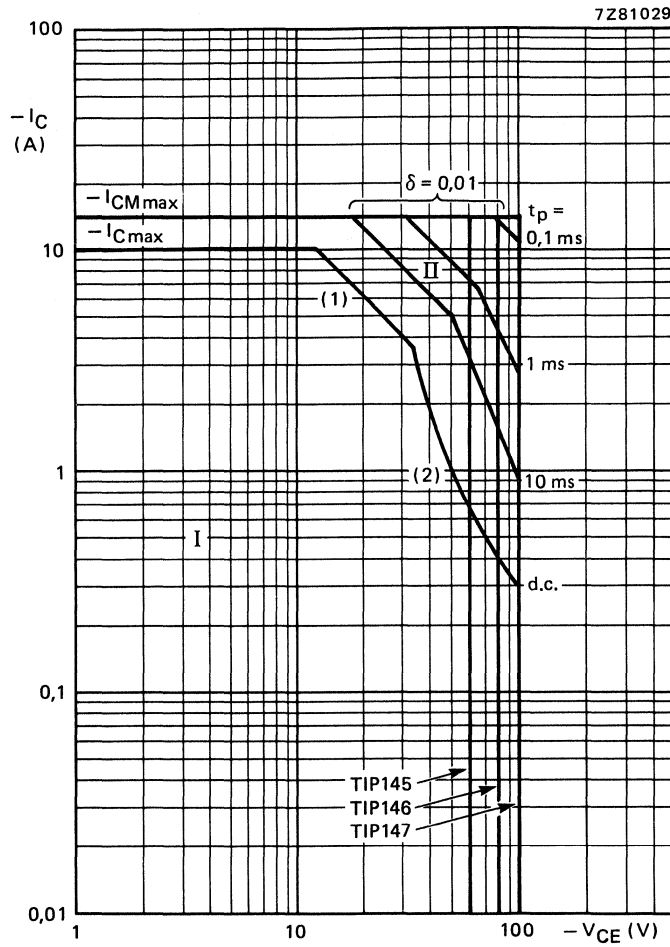


Fig. 5 Safe Operating Area; $T_{mb} \leq 25^\circ\text{C}$.

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

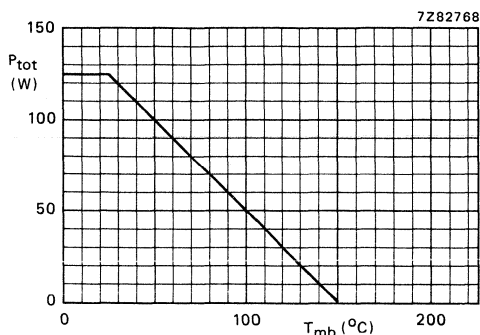


Fig. 6 Power derating curve.

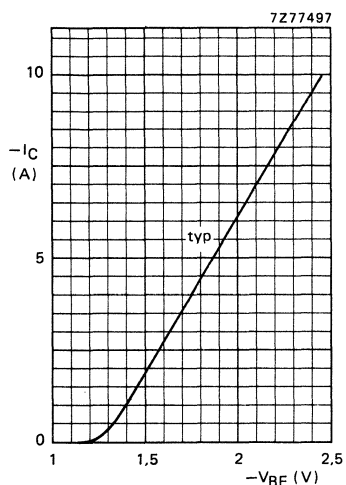


Fig. 7 $-V_{CE} = 4$ V; $T_j = 25$ °C.

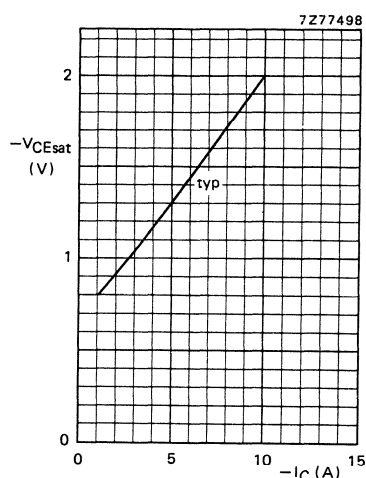


Fig. 8 $-I_C/I_B = 250$; $T_j = 25$ °C.

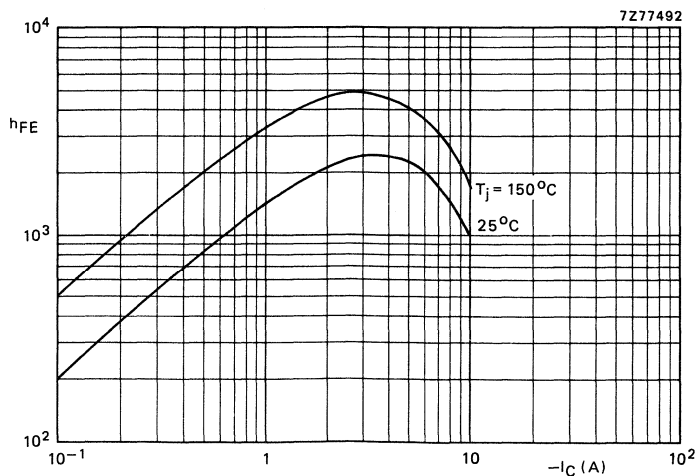


Fig. 9 Typical values; $-V_{CE} = 4$ V.

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 ($R_{BE} \leq 100 \Omega$)	$-V_{CER}$	max.	70 V
Collector current (d.c.)	$-I_C$	max.	15 A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	100 W
D.C. current gain	h_{FE}		20 – 70
$-V_{CE} = 4 \text{ V}; -I_C = 4 \text{ A}$			
Collector-emitter saturation voltage	$-V_{CEsat}$	<	1,1 V
$-I_C = 4 \text{ A}; -I_B = 0,4 \text{ A}$			
Transition frequency	f_T	>	3 MHz
$-V_{CE} = 10 \text{ V}; -I_C = 0,5 \text{ A}; f = 1 \text{ MHz}$			

MECHANICAL DATA

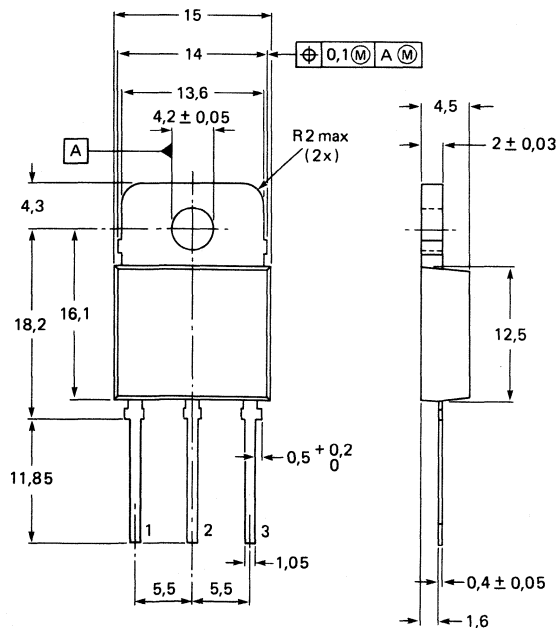
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



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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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	100 W
Total power dissipation in free air	P_{tot}	max.	3,5 W
Storage temperature	T_{stg}		-65 to + 150 $^\circ\text{C}$
Junction temperature	T_j	max.	150 $^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,25 K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	35,7 K/W

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

Collector cut-off currents

$-V_{CE} = 100 \text{ V}; +V_{BE} = 1,5 \text{ V}$	$-I_{CEX}$	<	5 mA
$-V_{CE} = 30 \text{ V}; I_B = 0$	$-I_{CEO}$	<	0,7 mA

Emitter cut-off current

$-V_{EB} = 7 \text{ V}; I_C = 0$	$-I_{EBO}$	<	5 mA
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Collector-emitter sustaining voltage

$-I_C = 30 \text{ mA}; I_B = 0$	$-V_{CEO_{sust}}$	>	60 V
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D.C. current gain

$-V_{CE} = 4 \text{ V}; -I_C = 4 \text{ A}$	h_{FE}		20 – 70
$-V_{CE} = 4 \text{ V}; -I_C = 10 \text{ A}$	h_{FE}	>	5

Base-emitter voltage

$-V_{CE} = 4 \text{ V}; -I_C = 4 \text{ A}$	$-V_{BE}$	<	1,8 V
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Collector-emitter saturation voltage

$-I_C = 4 \text{ A}; -I_B = 0,4 \text{ A}$	$-V_{CE_{sat}}$	<	1,1 V
$-I_C = 10 \text{ A}; -I_B = 3,3 \text{ A}$	$-V_{CE_{sat}}$	<	3,0 V

Small-signal current gain

$-V_{CE} = 10 \text{ V}; -I_C = 0,5 \text{ A}; f = 1 \text{ kHz}$	h_{fe}	>	20
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Transition frequency

$-V_{CE} = 10 \text{ V}; -I_C = 0,5 \text{ A}; f = 1 \text{ MHz}$	f_T	>	3 MHz
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Unclamped inductive load energy

$L = 20 \text{ mH}; -I_C = 2,5 \text{ A}$

$E(\text{BR}) < 62,5 \text{ mJ}$

Switching times

$-I_C = 6 \text{ A}; -I_{B\text{on}} = I_{B\text{off}} = 0,6 \text{ A}; -V_{CC} = 30 \text{ V}$

turn-on time

$t_{\text{on}} \text{ typ. } 0,4 \mu\text{s}$

turn-off time

$t_{\text{off}} \text{ typ. } 0,7 \mu\text{s}$

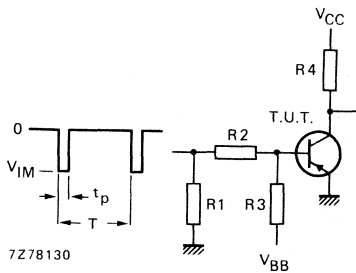


Fig. 2 Switching times test circuit.

$-V_{CC} = 30 \text{ V}$

$-V_{IM} = 24 \text{ V}$

$V_{BB} = 4 \text{ V}$

$R1 = 56 \Omega$

$R2 = 24 \Omega$

$R3 = 10 \Omega$

$R4 = 5 \Omega$

$t_r = t_f = 15 \text{ ns}$

$t_p = 10 \mu\text{s}$

$T = 500 \mu\text{s}$

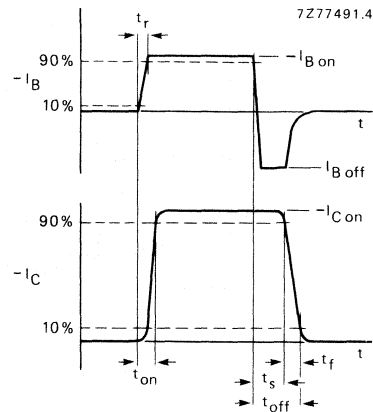


Fig. 3 Switching times waveforms.

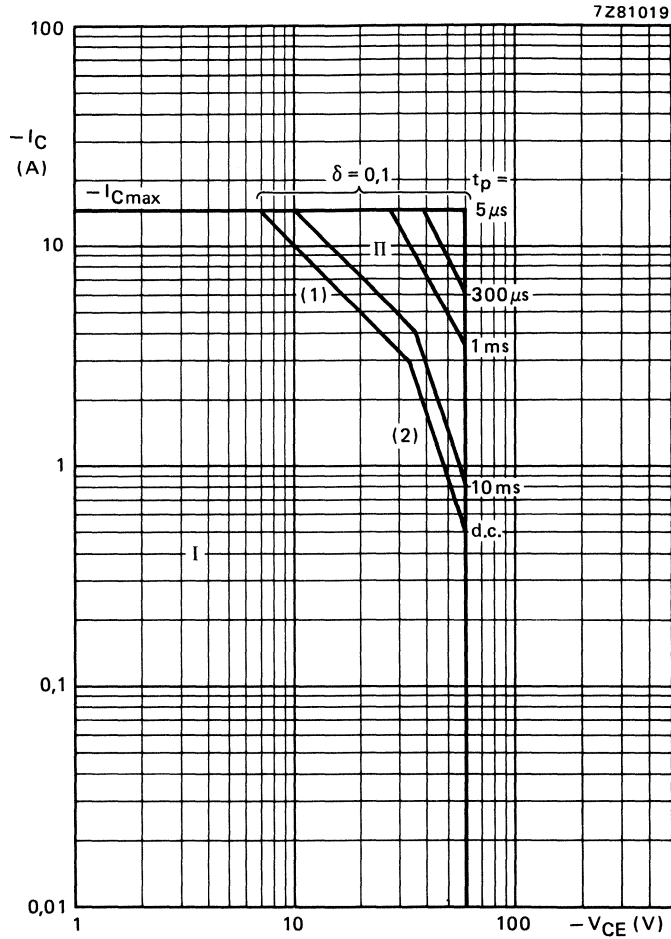


Fig. 4 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

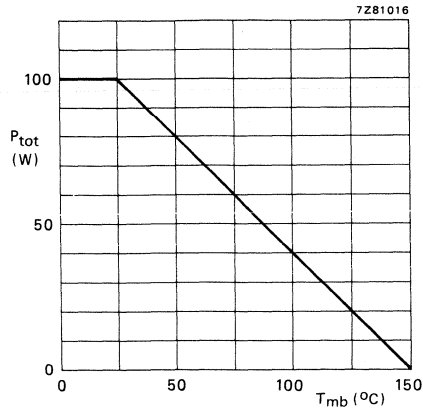


Fig. 5 Power derating curve.

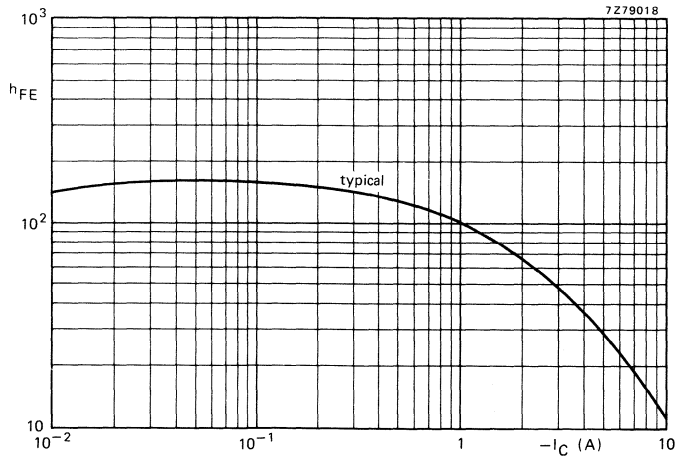


Fig. 6 $-V_{CE} = 4\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

TIP2955T

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

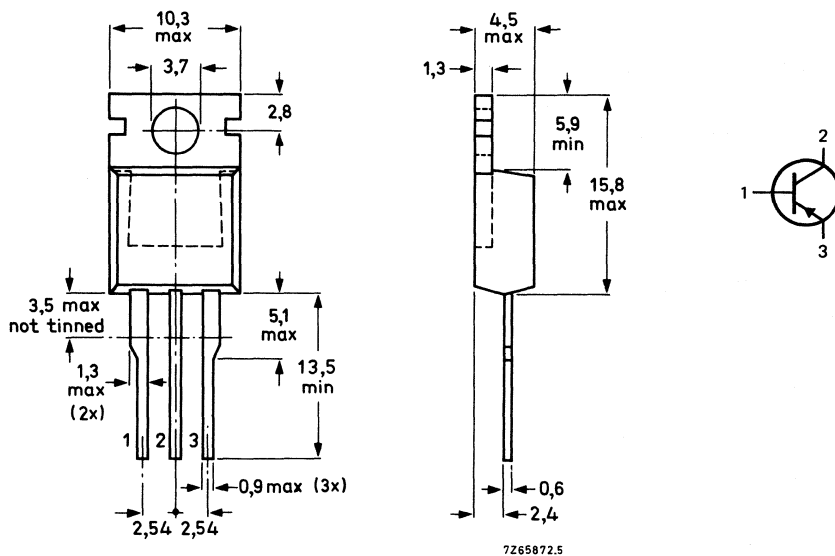
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60 V
Collector current (d.c.)	$-I_C$ max.	10 A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot} max.	75 W
Transition frequency at $f = 1$ MHz $-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	> 2 MHz

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	$R_{th\ j-mb}$	=	1,67 K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70 K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

→ Collector cut-off current			
$I_B = 0; -V_{CE} = 30$ 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: $t_p < 300$ μ s, $\delta < 2\%$.

Switching times

$-I_{Con} = 2 \text{ A}; I_{Bon} = I_{Boff} = 0,2 \text{ A}$

turn-on time

turn-off time

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

$t_{off} < 2 \mu\text{s}$

DEVELOPMENT DATA

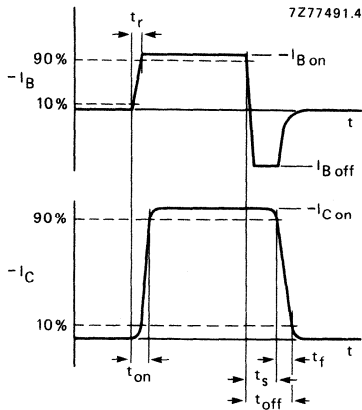


Fig. 2 Switching times waveforms.

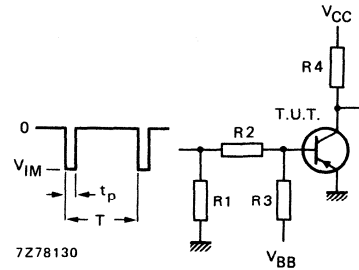


Fig. 3 Switching times test circuit.

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

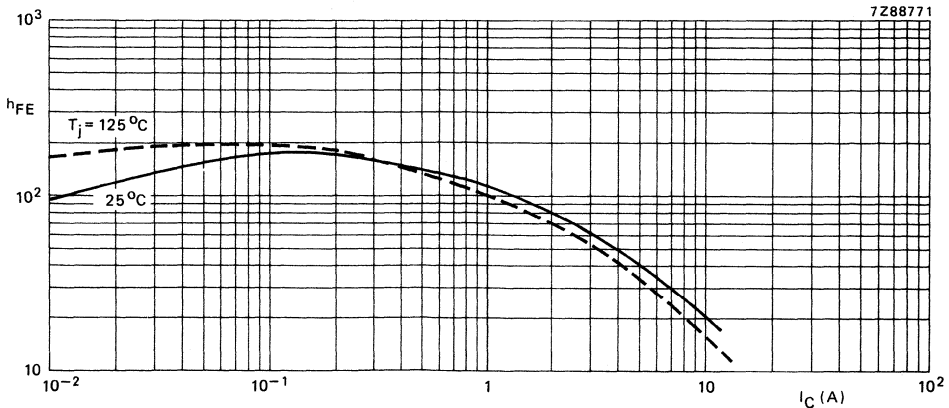


Fig. 4 Typical values d.c. current gain at $-V_{CE} = 2 \text{ V}$.

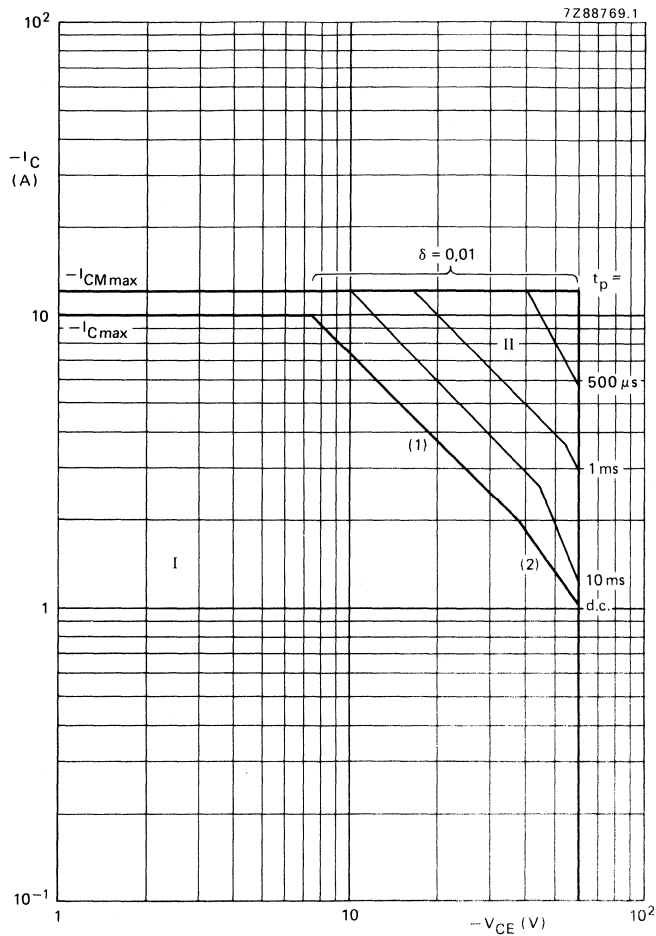


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) $P_{tot\ max}$ 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_{CB0}	max.	100 V
Collector-emitter voltage ($R_{BE} \leq 100 \Omega$)	V_{CER}	max.	70 V
Collector current (d.c.)	I_C	max.	15 A
Total power dissipation up to $T_{mb} = 25^\circ C$	P_{tot}	max.	100 W
D.C. current gain	h_{FE}		20 to 70
$V_{CE} = 4 V; I_C = 4 A$			
Collector-emitter saturation voltage	V_{CEsat}	<	1,1 V
$I_C = 4 A; I_B = 0,4 A$			
Transition frequency	f_T	>	3 MHz
$V_{CE} = 10 V; I_C = 0,5 A; f = 1 MHz$			

MECHANICAL DATA

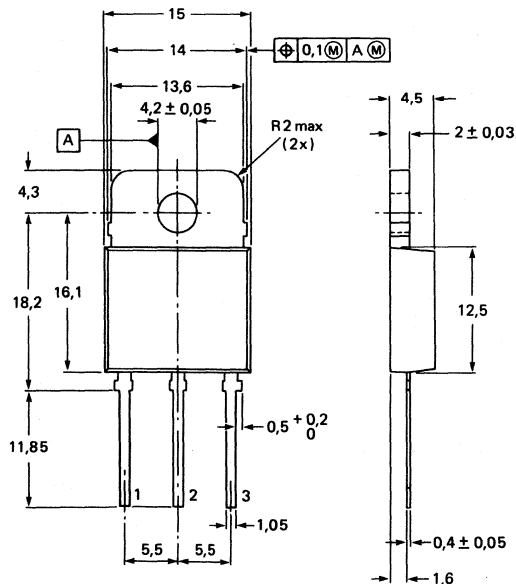
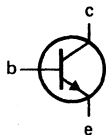
Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.

Pinning

- 1 = base
- 2 = collector
- 3 = emitter



7296696

RATINGS

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

Collector-base voltage ($I_E = 0$)	V_{CB0}	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 $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	100 W
Total power dissipation in free air	P_{tot}	max.	3,5 W
Storage temperature	T_{stg}		-65 to + 150 $^\circ\text{C}$
Junction temperature	T_j	max.	150 $^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	1,25 K/W
From junction to ambient in free air	R_{thj-a}	=	35,7 K/W

CHARACTERISTICS

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

Collector cut-off currents

$V_{CE} = 100 \text{ V}; -V_{BE} = 1,5 \text{ V}$	I_{CEX}	<	5 mA
$V_{CE} = 30 \text{ V}; I_B = 0$	I_{CEO}	<	0,7 mA

Emitter cut-off current

$V_{EB} = 7 \text{ V}; I_C = 0$	I_{EBO}	<	5 mA
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Collector-emitter sustaining voltage

$I_C = 30 \text{ mA}; I_B = 0$	$V_{CEO_{sust}}$	>	60 V
--------------------------------	------------------	---	------

D.C. current gain

$V_{CE} = 4 \text{ V}; I_C = 4 \text{ A}$	h_{FE}		20 to 70
$V_{CE} = 4 \text{ V}; I_C = 10 \text{ A}$	h_{FE}	>	5

Base-emitter voltage

$V_{CE} = 4 \text{ V}; I_C = 4 \text{ A}$	V_{BE}	<	1,8 V
---	----------	---	-------

Collector-emitter saturation voltage

$I_C = 4 \text{ A}; I_B = 0,4 \text{ A}$	$V_{CE_{sat}}$	<	1,1 V
$I_C = 10 \text{ A}; I_B = 3,3 \text{ A}$	$V_{CE_{sat}}$	<	3,0 V

Small-signal current gain

$V_{CE} = 10 \text{ V}; I_C = 0,5 \text{ A}; f = 1 \text{ kHz}$	h_{fe}	>	20
---	----------	---	----

Transition frequency

$V_{CE} = 10 \text{ V}; I_C = 0,5 \text{ A}; f = 1 \text{ MHz}$	f_T	>	3 MHz
---	-------	---	-------

Unclamped inductive load energy

$L = 20 \text{ mH}; I_C = 2,5 \text{ A}$

Switching times (see Figs 2 and 3)

$I_C = 6 \text{ A}; I_{B\text{on}} = -I_{B\text{off}} = 0,6 \text{ A}; V_{CC} = 30 \text{ V}$

turn-on time

turn-off time

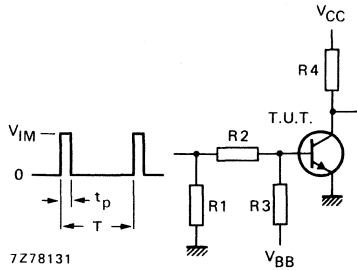


Fig. 2 Switching times test circuit.

- $V_{CC} = 30 \text{ V}$
- $V_{IM} = 24 \text{ V}$
- $V_{BB} = -4 \text{ V}$
- $R1 = 56 \Omega$
- $R2 = 24 \Omega$
- $R3 = 10 \Omega$
- $R4 = 5 \Omega$
- $t_r = t_f = 15 \text{ ns}$
- $t_p = 10 \mu\text{s}$
- $T = 500 \mu\text{s}$

$E_{(BR)} > 62,5 \text{ mJ}$

t_{on}	typ.	0,6 μs
t_{off}	typ.	1,0 μs

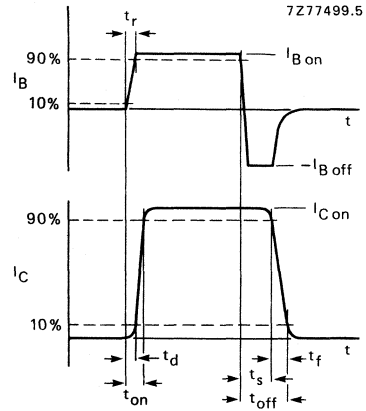


Fig. 3 Switching times waveforms.

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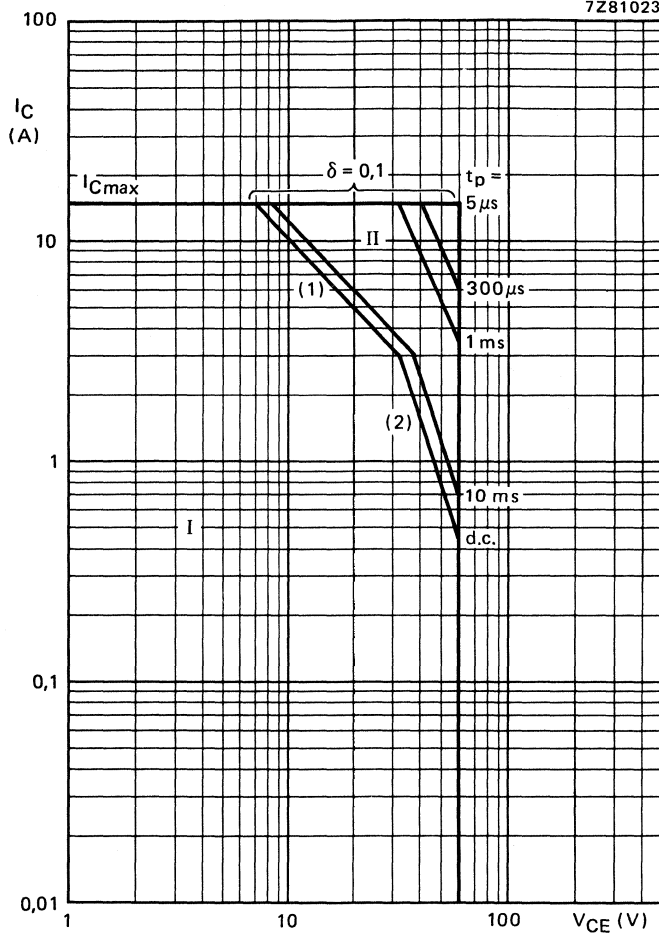


Fig. 4 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

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

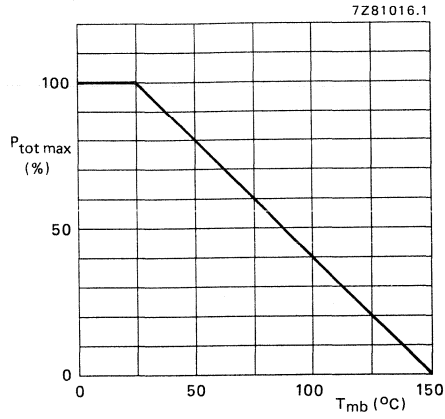


Fig. 5 Power derating curve.

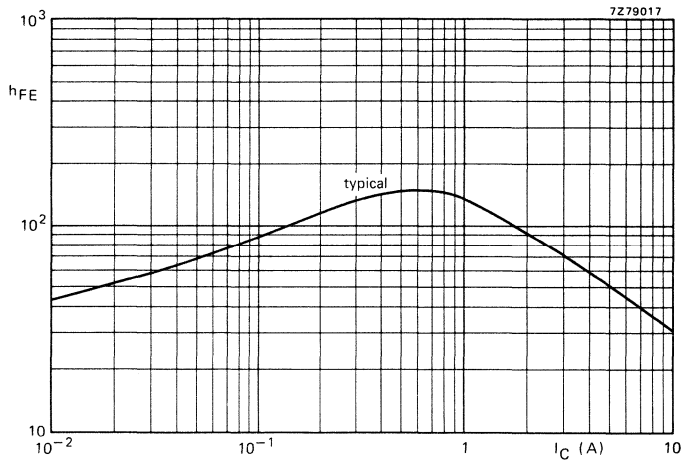


Fig. 6 $V_{CE} = 4\ V$; $T_j = 25\ ^\circ C$.

DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

TIP3055T

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

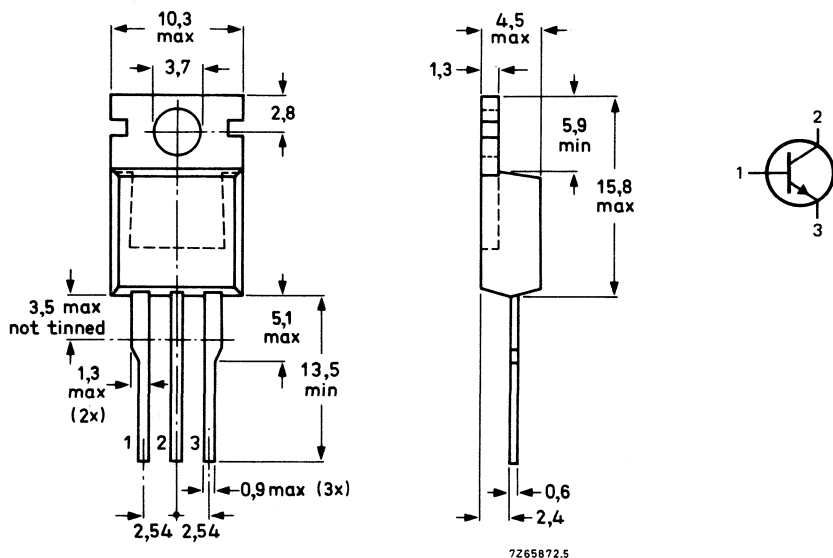
Collector-emitter voltage (open base)	V_{CEO}	max.	60 V
Collector current (d.c.)	I_C	max.	10 A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot}	max.	75 W
Transition frequency at $f = 1\text{ MHz}$ $I_C = 0,5\text{ A}; V_{CE} = 10\text{ V}$	f_T	>	2 MHz

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	$R_{th\ j-mb}$	=	1,67 K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70 K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

→ Collector cut-off current

$I_B = 0; V_{CE} = 30$ 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
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Base-emitter voltage*

$I_C = 4$ A; $V_{CE} = 4$ V	V_{BE}	<	1,8 V
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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
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* Measured under pulse conditions: $t_p < 300$ μ s, $\delta < 2\%$.

Switching times

$I_{Con} = 2 \text{ A}; I_{Bon} = -I_{Boff} = 0,2 \text{ A}$

Turn-on time

Turn-off time

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

$t_{off} < 4 \mu\text{s}$

DEVELOPMENT DATA

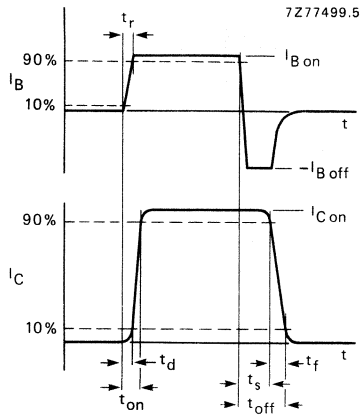


Fig. 2 Switching time waveforms.

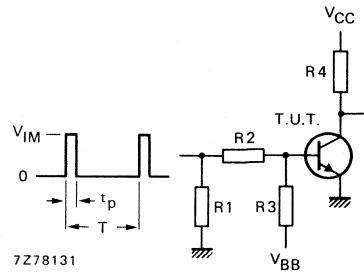


Fig. 3 Switching times test circuit.

- $V_{IM} = 15 \text{ V}$
- $V_{CC} = 20 \text{ V}$
- $V_{BB} = -4 \text{ V}$
- $R1 = \text{none}$
- $R2 = 33 \Omega$
- $R3 = 22 \Omega$
- $R4 = 10 \Omega$
- $t_r = t_f \leq 15 \text{ ns}$
- $t_p = 20 \mu\text{s}$
- $T = 500 \mu\text{s}$

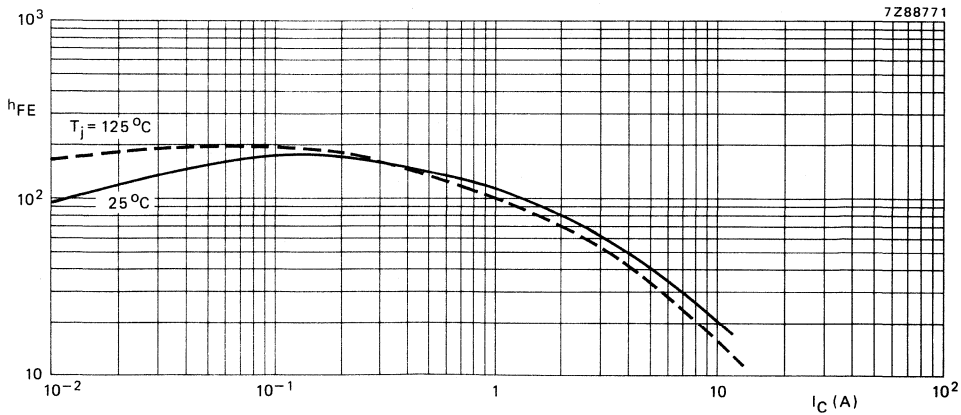


Fig. 4 Typical values d.c. current gain at $V_{CE} = 2 \text{ V}$.

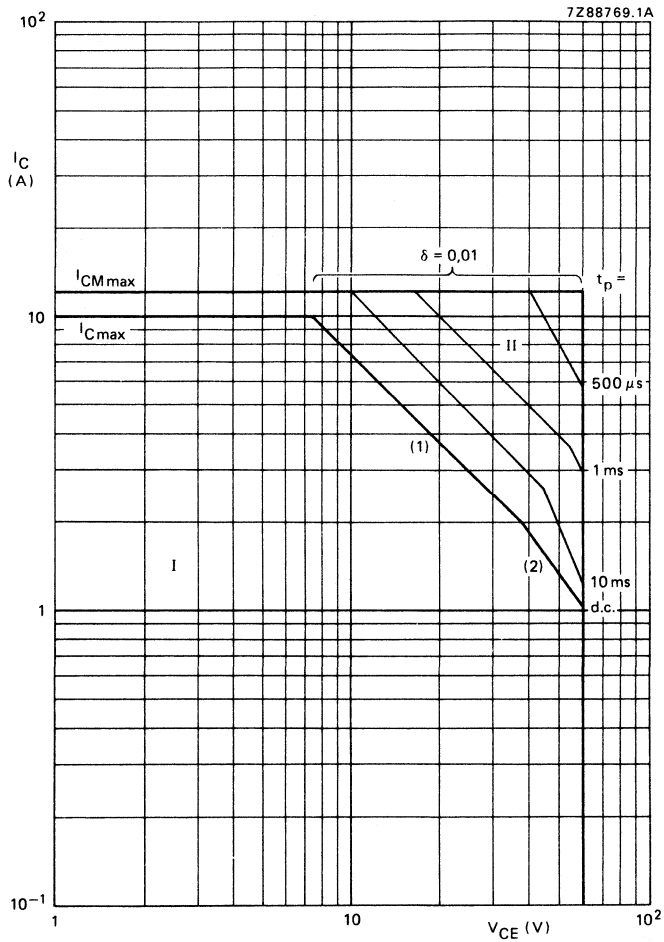


Fig. 5 Safe Operating ARea, $T_{mb} \leq 25^\circ\text{C}$.

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

HYBRID MODULES

HYBRID INTEGRATED CIRCUIT HI-FI AUDIO POWER AMPLIFIERS

The OM931 and OM961 are thin-film hybrid integrated circuit hi-fi audio amplifiers for sinusoidal output power up to 60 W. 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 especially designed for low transient and harmonic distortion. All built-in resistors are dynamically adjusted for optimum performance over a wide temperature range.

QUICK REFERENCE DATA

	OM931	OM961
Sinusoidal output power for $d_{tot} < 0,2\%$ $f = 20 \text{ Hz to } 20 \text{ kHz}$ $R_L = 4 \Omega$ $R_L = 8 \Omega$	$P_o > 30 \text{ W at } \pm 23 \text{ V}$ $P_o > 30 \text{ W at } \pm 26 \text{ V}$	$> 60 \text{ W at } \pm 31 \text{ V}$ $> 60 \text{ W at } \pm 35 \text{ V}$
Total harmonic distortion $P_o = 1 \text{ W}; f = 1 \text{ kHz}$	d_{tot} typ. 0,02	0,02 %

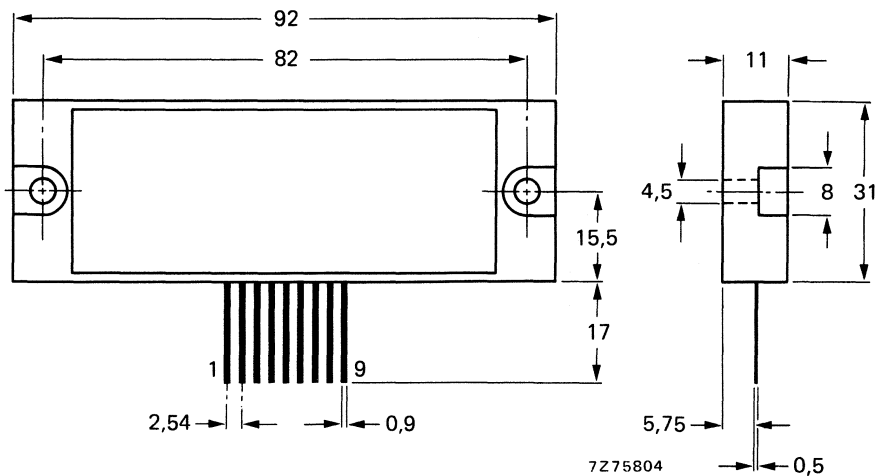
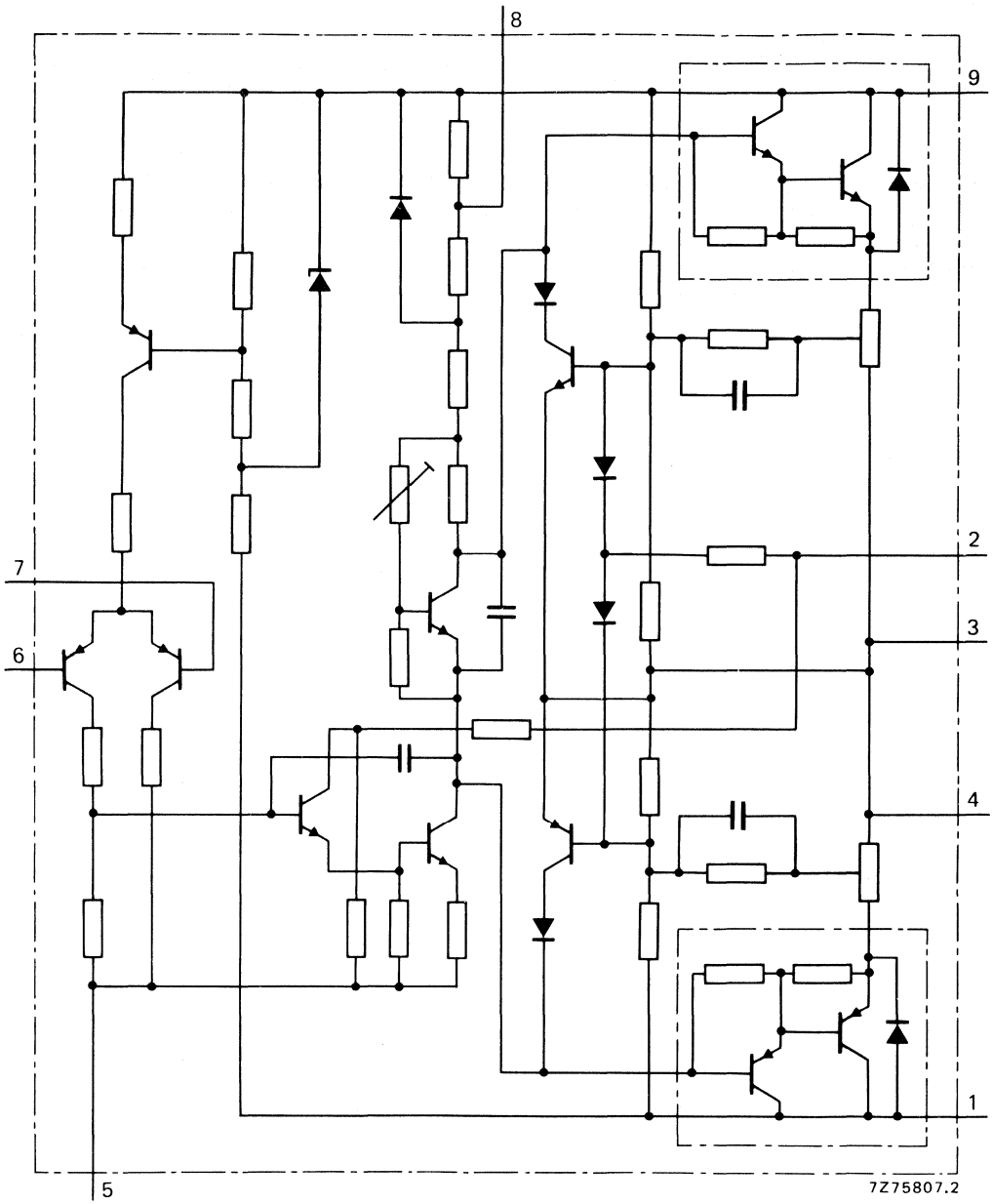


Fig. 1 Outline; dimensions in mm.



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Fig. 2 Circuit diagram.

RATINGS

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

Symmetrical supply voltage	OM931	V_S	max.	± 40 V
	OM961	V_S	max.	± 45 V
Operating mounting base temperature		T_{mb}	max.	95 °C
Storage temperature		T_{stg}		-30 to +100 °C

CHARACTERISTICS

Mounted on a heatsink with $R_{th\ h-a} = 1,4$ K/W (OM931) and $R_{th\ h-a} = 0,8$ K/W (OM961); measured in the circuit of Fig. 3.

	OM931				OM961	
Symmetrical supply voltage	V_S	typ.	± 23	± 26	± 31	± 35 V
Total supply current (zero signal)	I_{tot}	typ.	80		100 mA	
Sinusoidal output power for $d_{tot} < 0,2\%$ $f = 20$ Hz to 20 kHz (Federal Trade Commission, U.S.A.) $R_L = 4\ \Omega$ $R_L = 8\ \Omega$	P_O	$>$	30	—	60	— W*
	P_O	$>$	—	30	—	60 W*
Clipping level at $f = 1$ kHz; $R_L = 4\ \Omega$; $d_{tot} = 0,7\%$	P_O	typ.	40		75 W	
Total harmonic distortion $P_O = 1$ W; $f = 1$ kHz	d_{tot}	typ.	0,02		0,02 %	
Intermodulation distortion at $f_1 = 250$ Hz and $f_2 = 8$ kHz; amplitude ratio $V_{f1}/V_{f2} = 4/1$ $P_O = 1$ W $P_O = \text{rated value}$	d_{im}	typ.	0,05		0,05 %	
	d_{im}	typ.	0,1		0,1 %	
Input sensitivity for $P_O = \text{rated value}$	V_i	typ.	0,7	1	1	1,4 V
Input impedance determined by input circuitry					R_i	typ. 10 k Ω
Open loop gain					G_O	typ. 80 dB
Closed loop gain					G_C	typ. 24 dB
Frequency response $P_O = \text{rated value} - 10$ dB (-1 dB)					f	30 Hz to 40 kHz
Power bandwidth (-3 dB)					f_p	20 Hz to 40 kHz
Signal-to-noise ratio (unweighted) $P_O = 50$ mW; wide band					S/N	typ. 75 dB
Signal-to-noise ratio (weighted) $P_O = 50$ mW; A-curve					S/N	typ. 87 dB
D.C. output offset voltage					V_{off}	typ. ± 20 mV
Ripple rejection					RR	\geq 65 dB
Output impedance					R_O	typ. 0,05 Ω

* P_O is stated as rated value.

APPLICATION INFORMATION

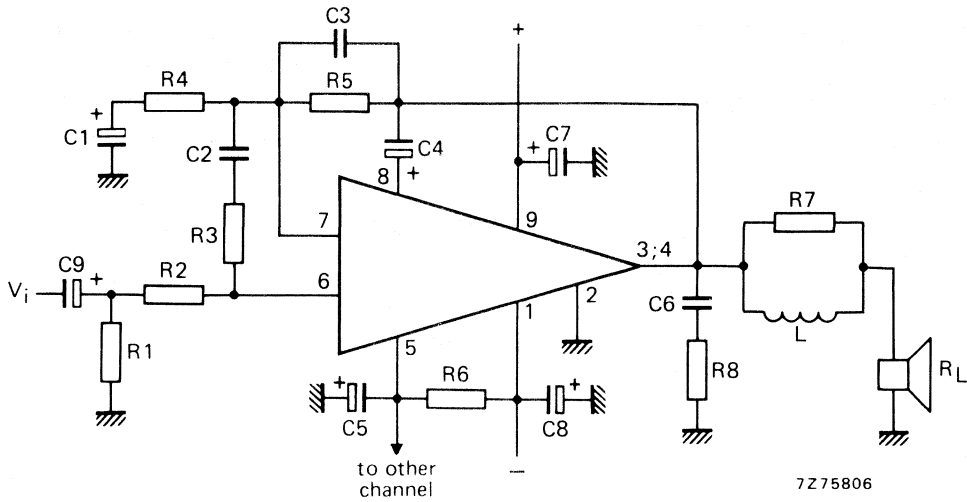


Fig. 3 Example of an amplifier with external components.

List of components:

R1 = 10 k Ω (0,25 W)
 R2 = 4,7 k Ω (0,25 W)
 R3 = 300 Ω (0,25 W)
 R4 = 680 Ω (0,25 W)
 R5 = 10 k Ω (0,25 W)
 R6 = 22 Ω (0,5 W)
 R7 = 2,2 Ω (0,25 W)
 R8 = 10 Ω (0,5 W)

C1 = 47 μ F (10 V)
 C2 = 270 pF (10%)
 C3 = 120 pF (10%)
 C4 = 100 μ F
 C5 = 470 μ F
 C6 = 100 nF
 C7 = 10 μ F (63 V)
 C8 = 10 μ F (63 V)
 C9 = 1 μ F (63 V)

L = 4 μ H

R_L = 4 or 8 Ω

MOUNTING RECOMMENDATIONS

The modules are delivered with leads in SIL (single in-line) but leads may also be bent to DIL (dual in-line).

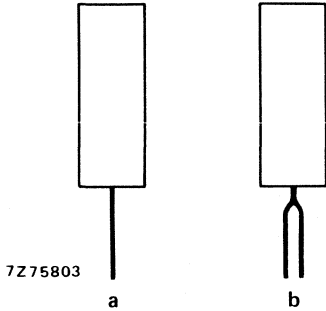
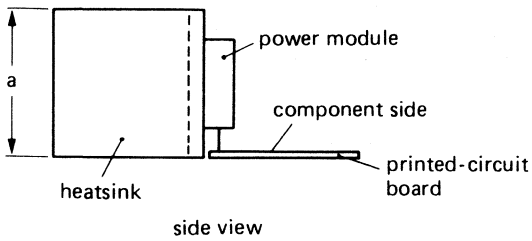


Fig. 4:
a. Single in-line (SIL) leads.
b. Dual in-line (DIL) leads.



Thermal resistance values from heatsink to ambient for various heatsink lengths (a):

- $R_{th\ h-a} = 1,4\ K/W$ a = 50 mm
- $R_{th\ h-a} = 1,0\ K/W$ a = 75 mm
- $R_{th\ h-a} = 0,8\ K/W$ a = 90 mm

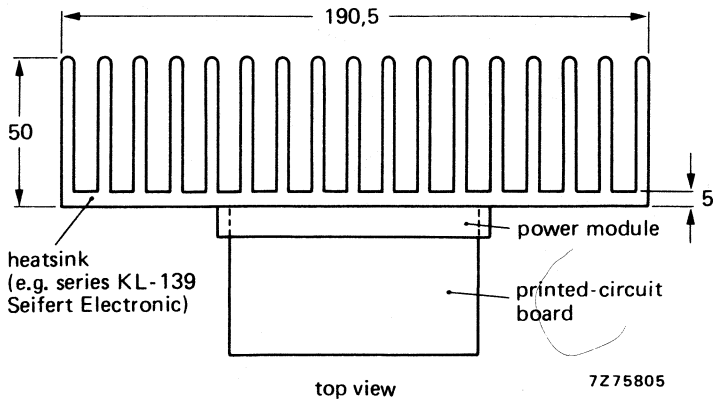


Fig. 5 Example of a heatsink to be used for the module; dimensions in mm.

PRINTED-CIRCUIT BOARDS for OM931 and OM961

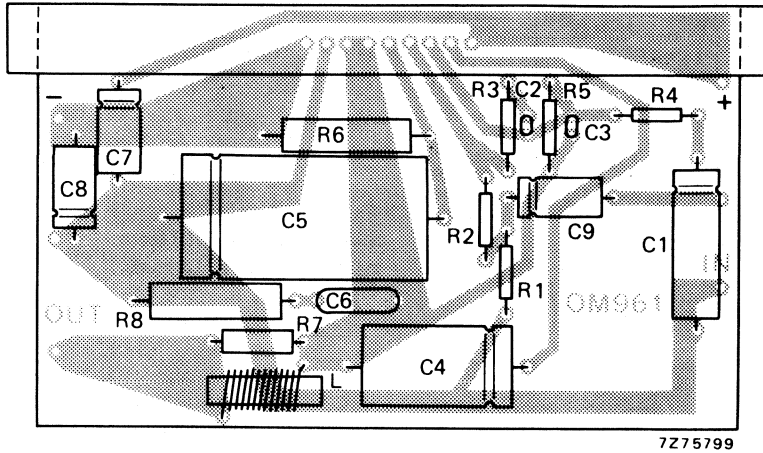


Fig. 6 Component side of SIL-version showing component layout.

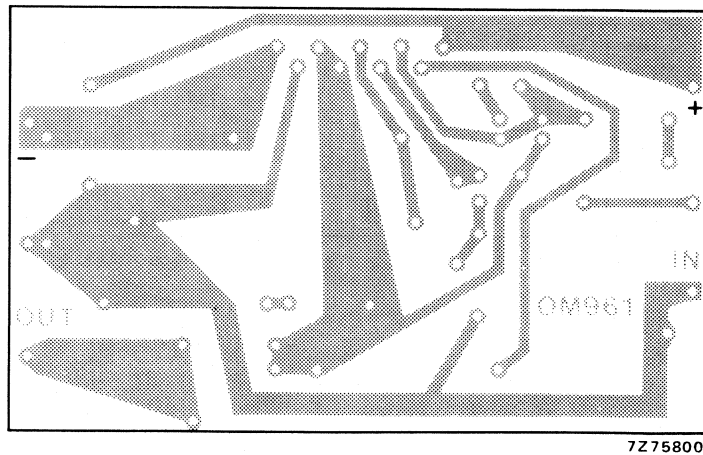


Fig. 7 Component side of DIL-version; for component layout see Fig. 6.

Dimensions in mm

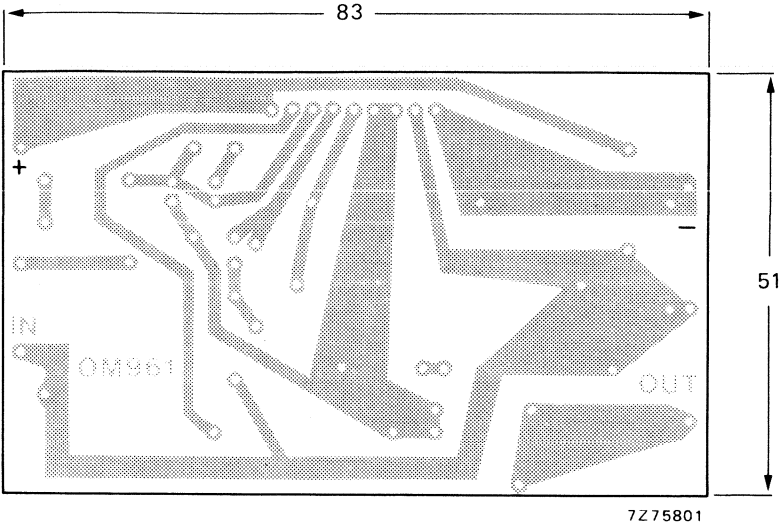


Fig. 8 Track side of SIL-version.

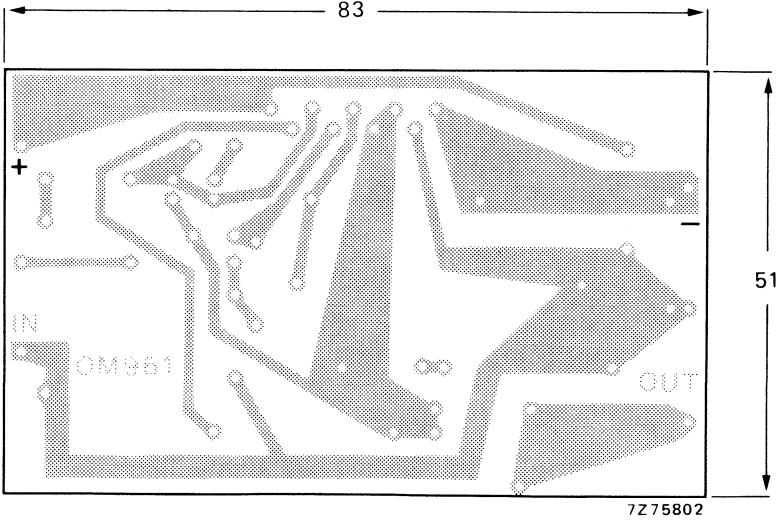


Fig. 9 Track side of DIL-version.

ACCESSORIES

TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	TO-3
56353	spring clip	TO-126/SOT82
56354	mica insulator	TO-126/SOT82
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer (brass)	TO-220
56363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT93
56368b	insulating bush (up to 800 V)	SOT93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT93
56379	spring clip	SOT93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

SELECTION GUIDE

CLIP MOUNTING

envelope	direct mounting		insulated mounting		
	clip		mica	alumina	clip
TO-126 (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) up to 300 V	56326	M3	56387a	56387b	56326	M2,5
TO-220 (SOT78) up to 800 V up to 1000 V	56360a	M3	56359b 56359b	56359c 56359d	56360a 56360a	M3 M3
SOT186	56360a	M3				
SOT93	—	M4	56368a	56368b		M3
SOT199	—	M				
TO-3 (SOT3) up to 500 V	—	M4	56201d	56201j or 56261a		M3
up to 2000 V			56339	56352		M3

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

Mounting TO-126 and SOT82 envelopes.

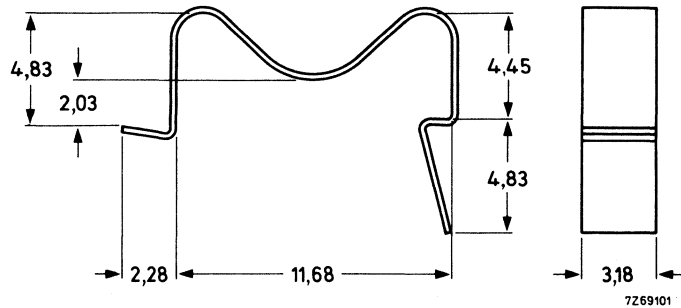
56353

CLIP for TO-126 and SOT82 envelopes

MECHANICAL DATA

Material: high carbon spring steel

Dimensions in mm



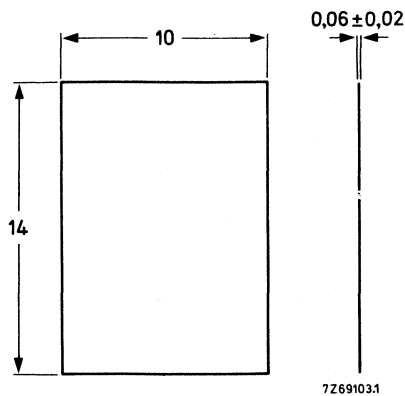
Spring clip suitable for heatsink of 1,5 to 2 mm.

56354

MICA INSULATOR for TO-126 and SOT82 envelopes

MECHANICAL DATA

Dimensions in mm



Mounting of TO-126 envelopes

56326

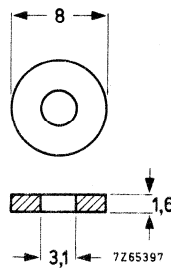
WASHER

for direct mounting of TO-126 envelopes

MECHANICAL DATA

Material: brass, nickel plated

Dimensions in mm



g390 238 6012

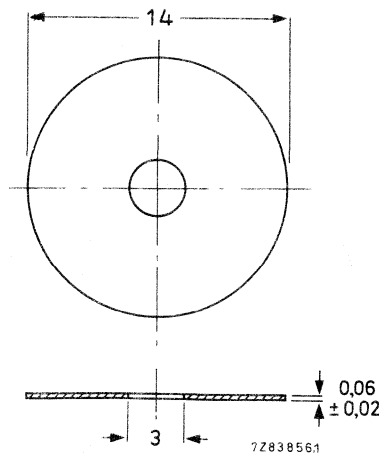
56387a

MICA WASHER

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Dimensions in mm



Mounting of TO-126 envelopes

56387b

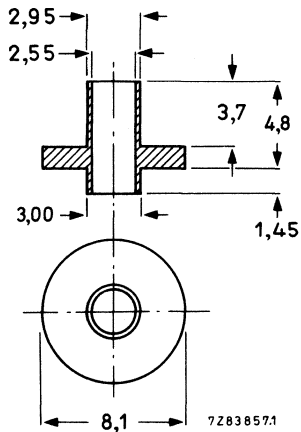
INSULATING BUSH

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

T_{max} 150 °C

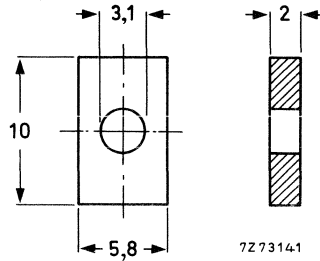
56360a

RECTANGULAR WASHER

For direct and insulated mounting.

MECHANICAL DATA

Material: brass; nickel plated.



Dimensions in mm

56363

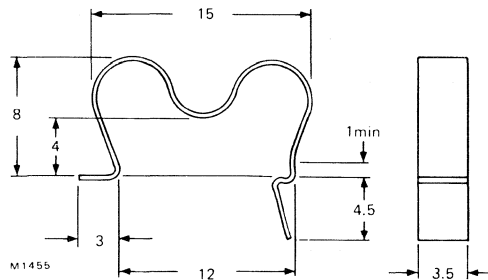
SPRING CLIP

For direct mounting.

MECHANICAL DATA

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).



Dimensions in mm

56364

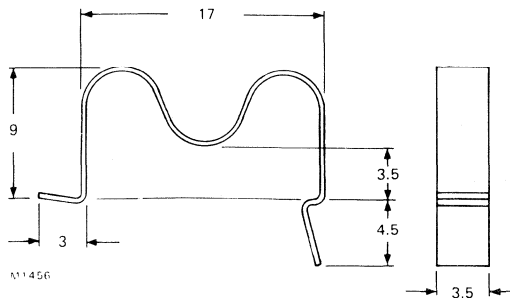
SPRING CLIP

For insulated mounting.

MECHANICAL DATA

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).



Dimensions in mm

To be used in
conjunction with
insulators 56367
or 56369

56367

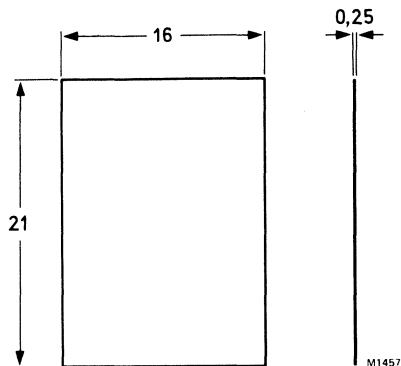
ALUMINA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA

Material: 96-alumina.

Dimensions in mm



*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

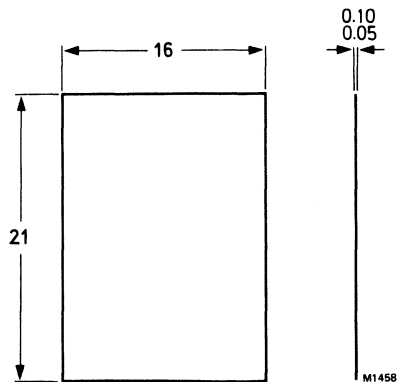
56369

MICA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA

Dimensions in mm



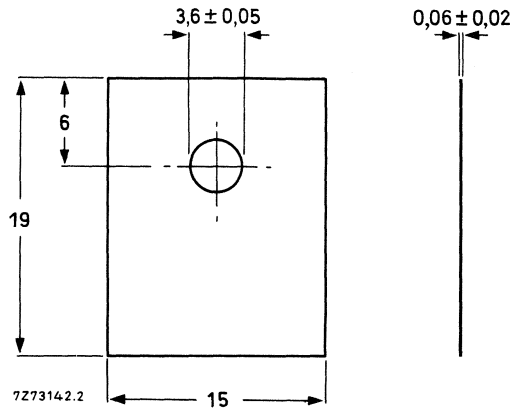
Mounting TO-220 envelopes

56359b

MICAWASHER

for TO-220 envelopes (up to 1000 V)

Dimensions in mm



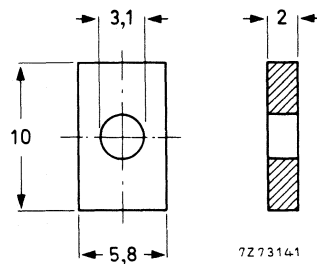
56360a

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

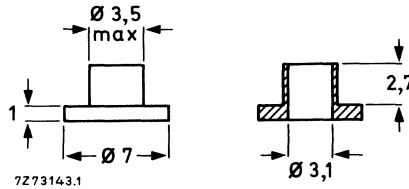
Material: polyester

TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Dimensions in mm



56359d

RECTANGULAR INSULATING BUSH

for TO-220 envelopes (up to 1000 V)

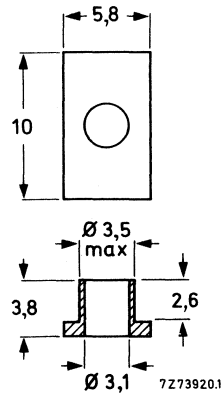
MECHANICAL DATA

TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Dimensions in mm



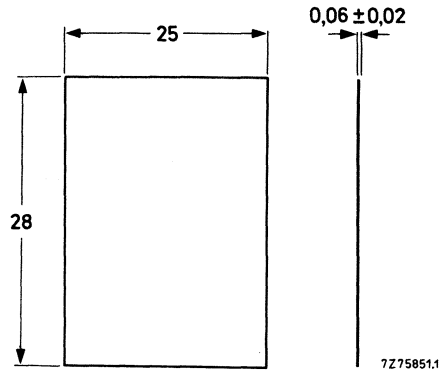
Clip mounting of SOT93 envelopes.

56378

MICA INSULATOR
for SOT93 clip mounting (up to 1500 V)

MECHANICAL DATA

Dimensions in mm



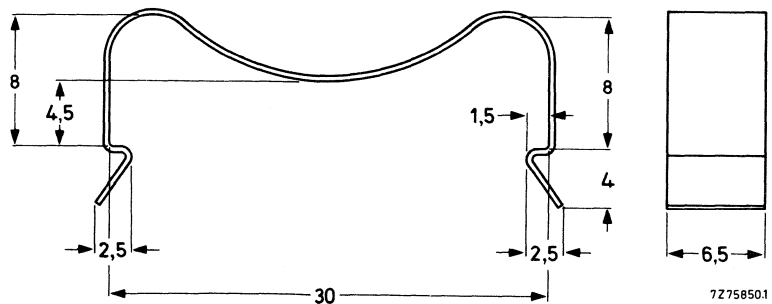
56379

SPRING CLIP
for direct and insulated mounting of SOT93 envelopes

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness $0,4 \pm 0,04$.



Screw mounting of SOT93 envelopes.

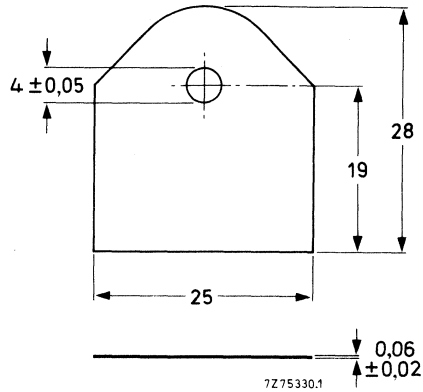
56368a

MICA INSULATOR

for insulated screw mounting of SOT93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



56368b

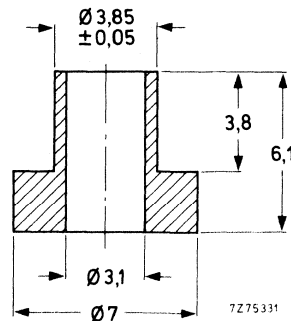
INSULATING BUSH

for insulated screw mounting of SOT93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

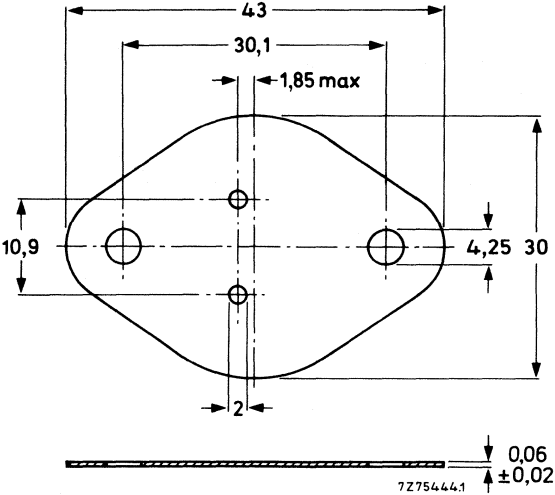
Mounting TO-3 envelopes

56201d MICA WASHER

Mica washer for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA

Dimensions in mm



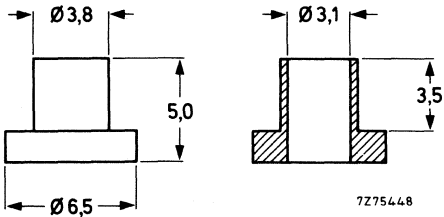
56201j 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA

material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Mounting TO-3 envelopes

56261a

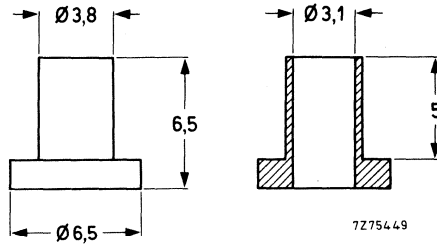
2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

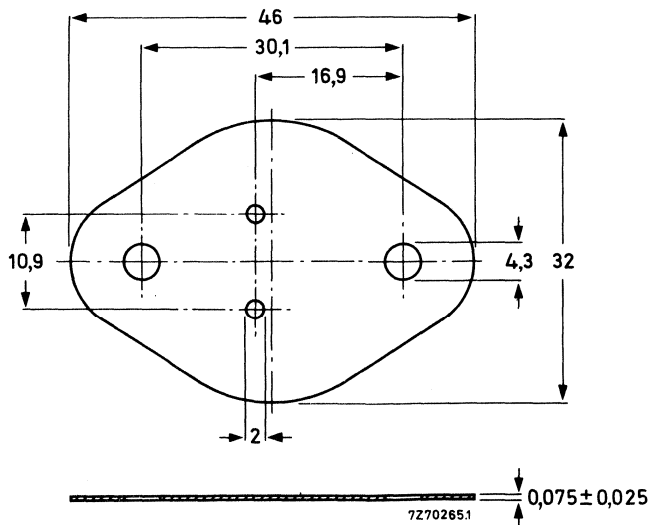
56339

MICA WASHER

Mica washer for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mounting support 56352.

MECHANICAL DATA

Dimensions in mm



Mounting TO-3 envelopes

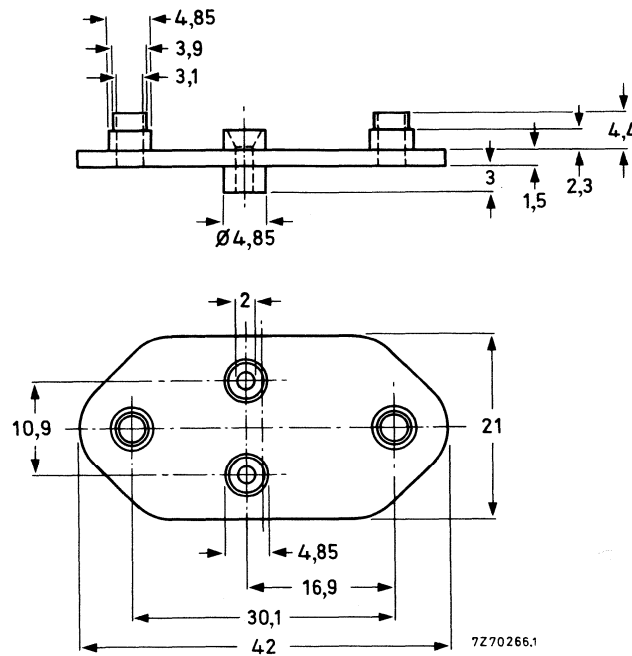
56352**MOUNTING SUPPORT**

Mounting support for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mica washer 56339.

MECHANICAL DATA

Dimensions in mm

Material: polyester

**TEMPERATURE**

Maximum permissible temperature

 $T_{\max} = 125\text{ }^{\circ}\text{C}$

MOUNTING INSTRUCTIONS

General note on flat heatsinks

All information on thermal resistances of the accessories combined with flat heatsinks is valid for *square* heatsinks of *1,5 mm blackened aluminium*.

For a few variations the thermal resistance may be derived as follows:

- Rectangular heatsinks (sides a and 2a)
 - When mounted with long side horizontal, multiply by 0,95.
 - When mounted with short side horizontal, multiply by 1,10.
- Unblackened or thinner heatsinks
 - Multiply by the factor given in Fig. 1 as a function of the heatsink size A.

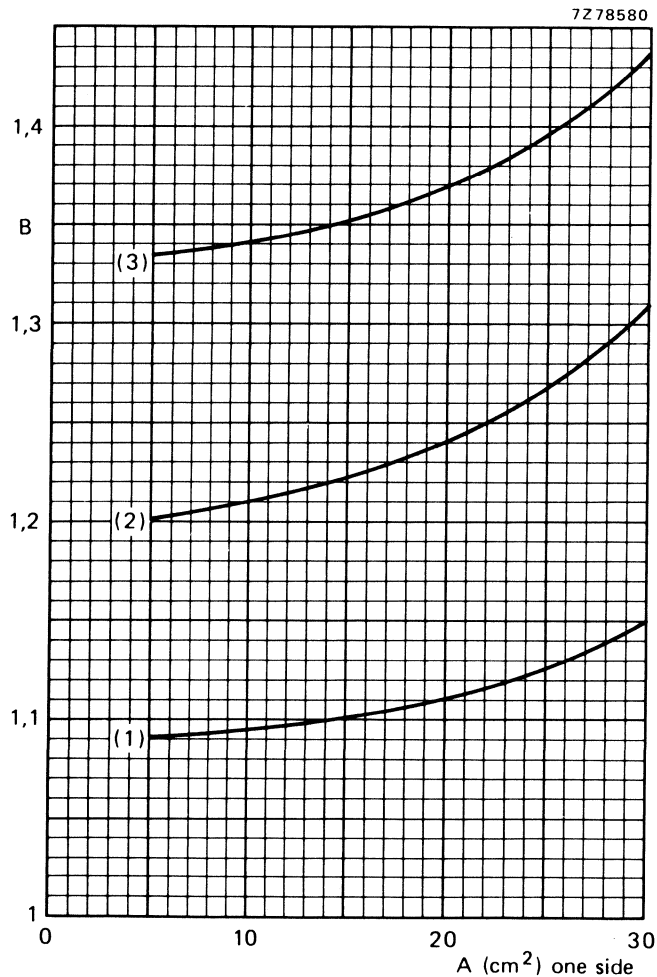


Fig. 1 Multiplication factor (B) as a function of heatsink area (A).
 (1) 1 mm blackened aluminium.
 (2) 1,5 mm unblackened aluminium.
 (3) 1 mm unblackened aluminium.

MOUNTING INSTRUCTIONS FOR TO-3 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Instructions for direct mounting.

Mounting instructions for up to 500 V insulation.

Using insulating bushes 56201j or 56261a and mica washer 56201d.

Mounting instructions for 500 to 2000 V insulation.

Using mounting support 56352 and mica washer 56339.

Heatsink requirements

Flatness in the mounting area: 0,05 mm per 40 mm

Mounting holes must be deburred.

Mounting torques

Minimum torque (for good heat transfer) 0,4 Nm (4 kgcm)

Maximum torque (to avoid damaging the transistor) 0,6 Nm (6 kgcm)

N.B.: When the driven nut or screw is in direct contact with a toothed lock washer (e.g. Fig. 10), the torques are as follows:

Minimum torque 0,55 Nm (5,5 kgcm)

Maximum torque 0,8 Nm (8 kgcm)

Thermal data

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a heat conducting compound between transistor and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

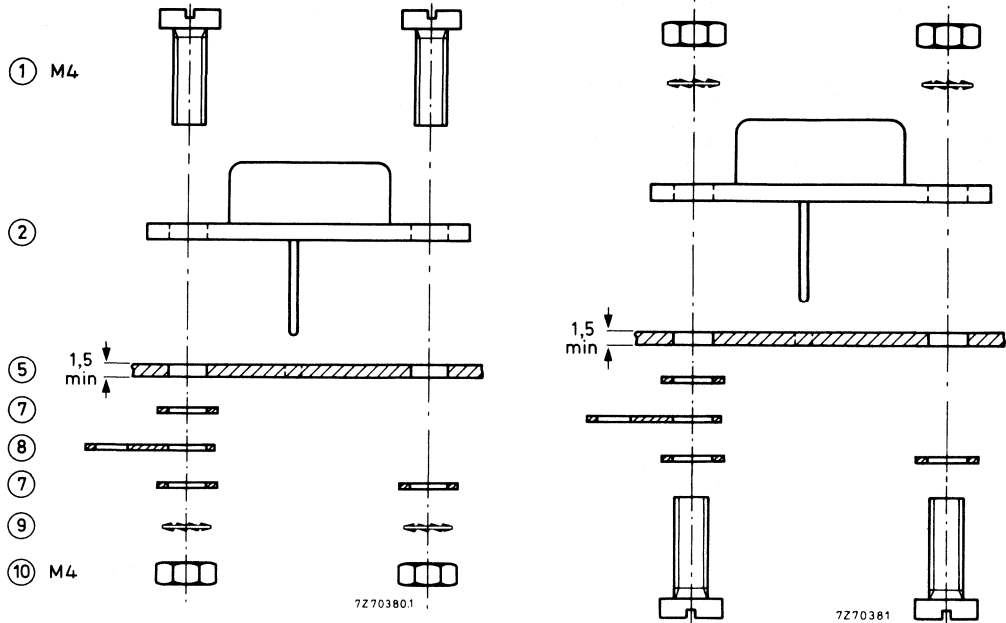
		Direct mounting	Insulated mounting		
			500 V mica	2000 V mica	
From mounting base to heatsink	without heatsink compound	$R_{th\ mb-h}$ 0,6	1,0	1,25	K/W
	with heatsink compound	$R_{th\ mb-h}$ 0,1	0,3	0,5	K/W

MOUNTING INSTRUCTIONS TO-3

INSTRUCTIONS FOR DIRECT MOUNTING

The transistors should be mounted with M4 screws, see Figs 1 and 2. Minimum heatsink thickness (for good heat transfer) 1,5 mm. Hole pattern: Fig. 3.

A heatsink with tapped holes or insert nuts can also be used, but a torque washer is necessary between metal washer and transistor. See Fig. 4.



Figs 1 and 2. Direct mounting with nuts.

Legend for TO-3 mounting figures

- (1) = screw
 - (2) = TO-3
 - (4) = mica
 - (5) = heatsink
 - (6) = insulating bush
 - (7) = metal washer
 - (8) = soldering tag
 - (9) = lock washer
 - (10) = nut
 - (11) = tapped hole
 - (12) = insert nut
- Dimensions in mm

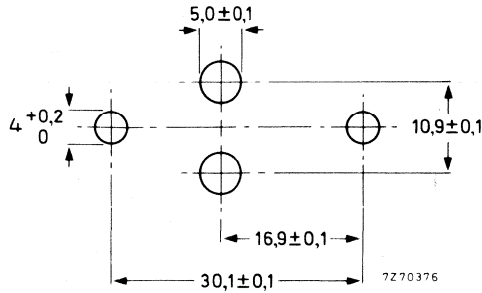


Fig. 3 Hole pattern for direct mounting with nuts.

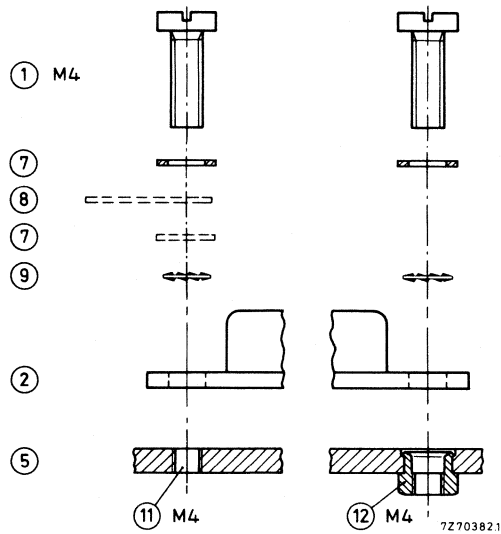


Fig. 4 Direct mounting with tapped holes or insert nuts.

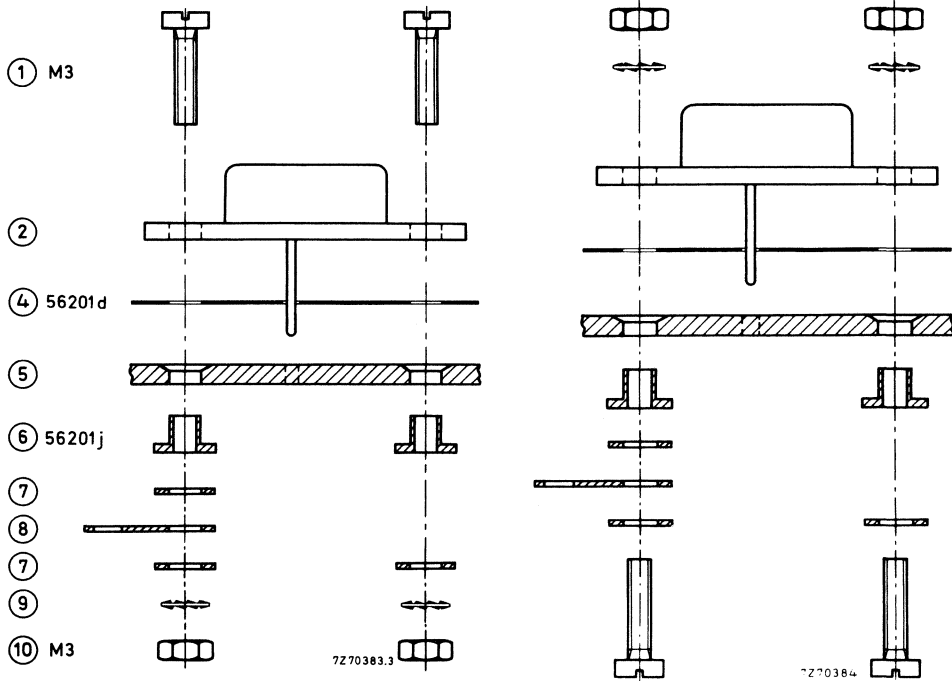
MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

Using insulating bushes 56201j and mica washer 56201d

For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.

Using insulating bush 56261a and mica washer 56201d

For an arrangement with M3 screws and nuts see Fig. 9, mounting holes are given in Figs 7 and 8. The accessories can also be used in combination with M3 screws and heatsinks provided with tapped holes or insert nuts. Lock washers are necessary between screw-head and metal washer, see Fig. 10. For an assembly drawing with tapped holes see Fig. 11, with insert nuts see Fig. 12.



Figs 5 and 6. Insulated mounting (500 V) with 56201j and 56201d. Heatsink thickness: 1,5 to 2,5 mm.

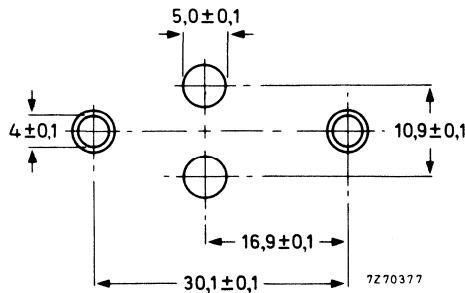


Fig. 7 Hole pattern for 500 V insulation, nut fastening.

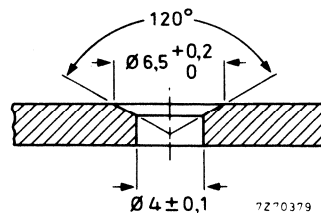


Fig. 8 Shape of hole for 500 V insulation, nut fastening.

For legend see Figs 1 and 2.

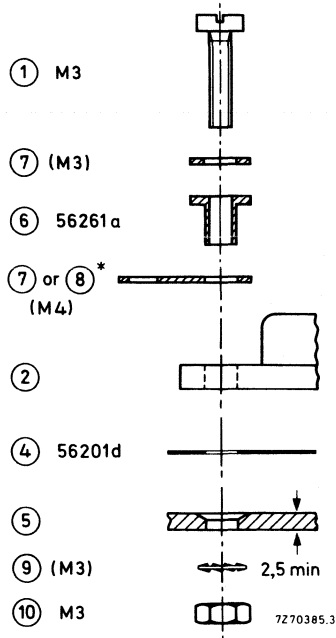


Fig. 9 Insulated mounting (500 V) with nuts.

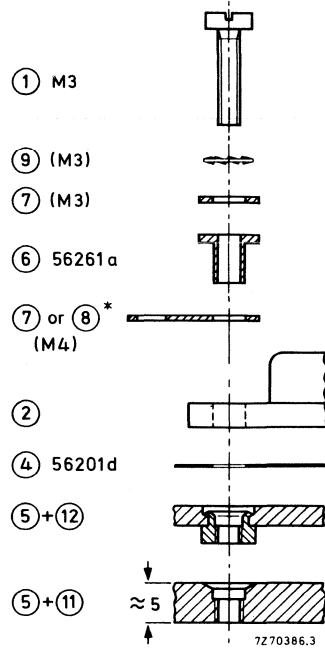


Fig. 10 Insulated mounting (500 V) with tapped holes or insert nuts.

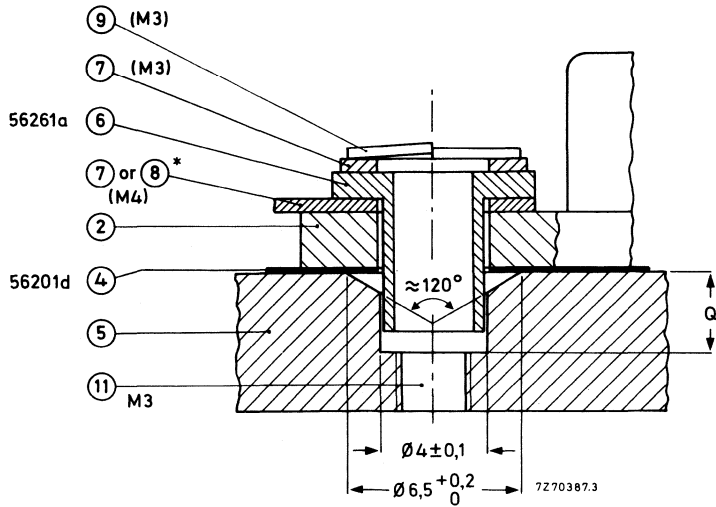


Fig. 11 Assembly (partial) for Fig. 10 - tapped holes.
Q minimum 2,5 mm.

For legend see Figs 1 and 2.

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING
INSTRUCTIONS
TO-3

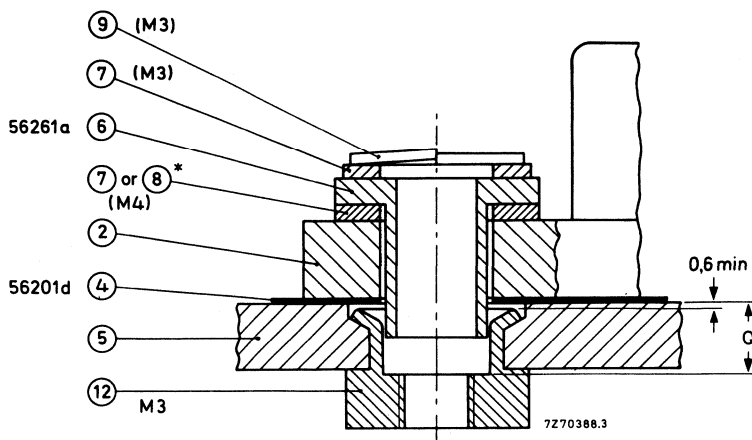


Fig. 12 Assembly (partial) for Fig. 10 - insert nuts Q minimum 2,5 mm.

For legend see Figs 1 and 2.

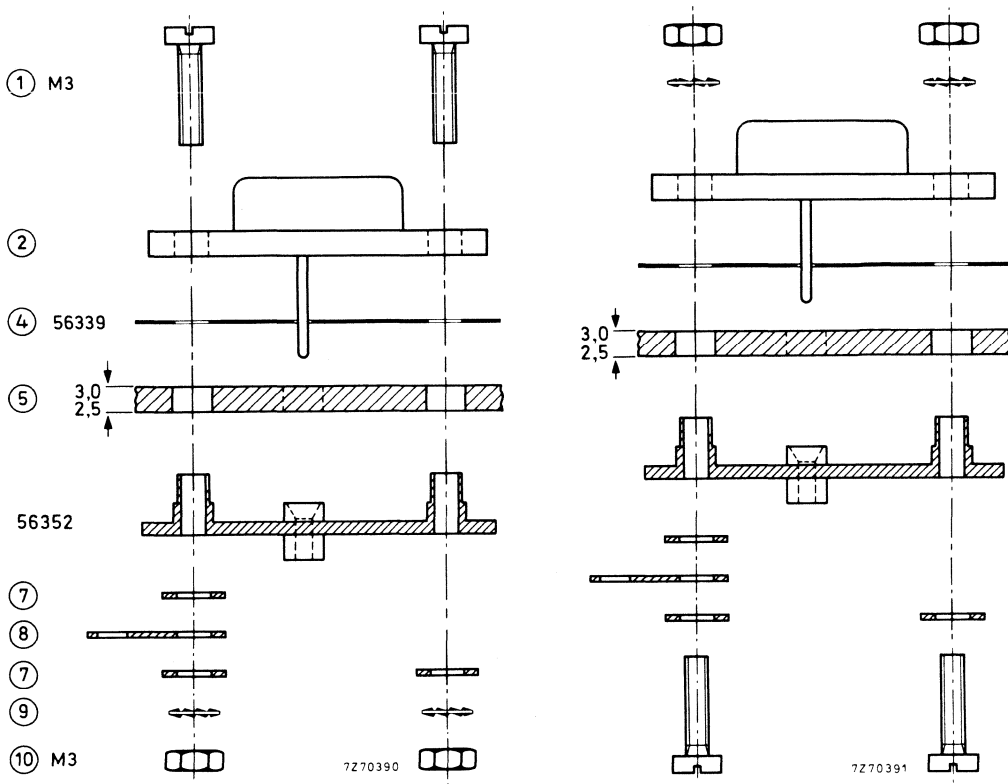
Dimensions in mm

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION

Using mounting support 56352 and mica washer 56339

The transistor should be mounted with M3 screws. For component arrangement see Figs 13 and 14. For hole pattern see Fig. 15. Thickness of heatsink 2,5 mm to 3 mm.



Figs 13 and 14. Insulated mounting (500 V–2000 V).

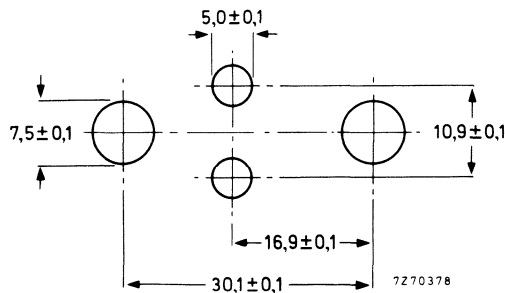


Fig. 15 Hole pattern for Figs 13 and 14.

For legend see Figs 1 and 2.

MOUNTING INSTRUCTIONS FOR TO-126 AND SOT-82 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the devices to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Heatsink requirements

Minimum thickness: 2 mm.

Flatness in the mounting area: 0,02 mm maximum per 10 mm.

Mounting holes must be deburred and should also be perpendicular to the plane of the heatsink, within 10° tolerance for M2,5 thread and within 2° tolerance for M3 thread. If the hole in the heatsink is threaded, it should be counter-sunk and free of burrs.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting (TO-126 and SOT-82)

Mounting by means of spring clip offers:

- a. A good thermal contact under the crystal area.
- b. Safe insulation for mains and high voltage operation

2. M2,5 and M3 screw mounting. (TO-126 only).

The spacing washer should be inserted between screw head and body.

Mounting torque for screw mounting:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B. when the driven nut or screw is in direct contact with a toothed lock washer the torques are as follows:

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

3. Body mounting (SOT-82).

A SOT-82 envelope can be adhesive mounted or soldered into a hybrid circuit.

For soldering a copper plate or an anodized aluminium plate with copper layer is recommended.

When adhesive mounting is applied also a ceramic substrate may be used.

MOUNTING INSTRUCTIONS TO-126/SOT-82

Thermal data

From mounting base to heatsink

	$R_{th\ mb-h}$ (K/W)			
	clip mounting		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 Sn/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56353

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (see Fig. 3).

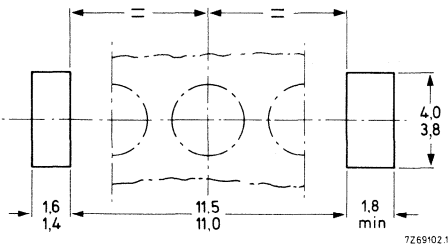


Fig. 1 Heatsink requirements.

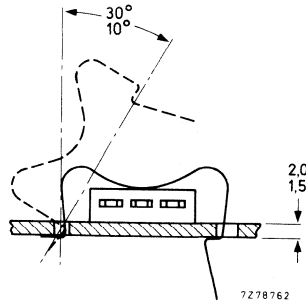


Fig. 2 Mounting spring clip.

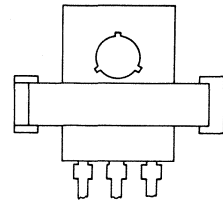


Fig. 3 Position of transistor (top view).

Insulated mounting with clip 56353 and mica 56354 (up to 1000 V insulation)

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 4 and 5).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (Fig. 6). Ensure that the device is centred on the mica insulator to prevent creepage.

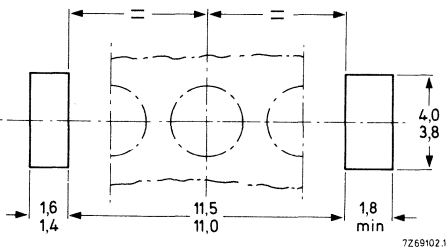


Fig. 4 Heatsink requirements.

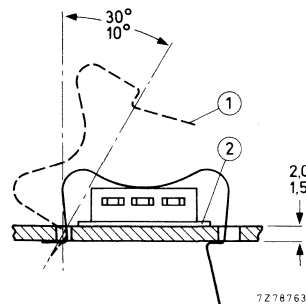


Fig. 5 Mounting.
(1) spring clip 56353.
(2) insulator 56354.

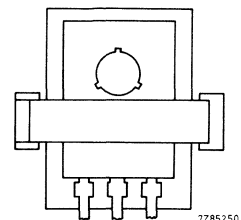


Fig. 6 Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING
Direct mounting with screw and spacing washer

Dimensions in mm

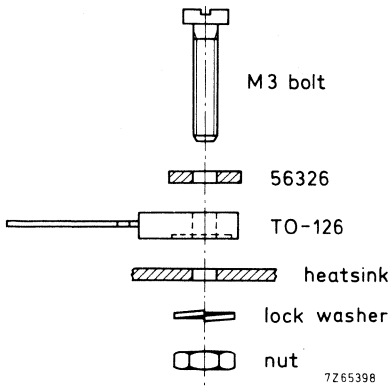


Fig. 7 Assembly through heatsink with nut.

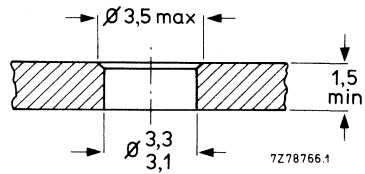


Fig. 8 Heatsink requirements.

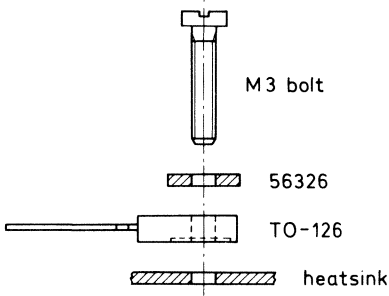


Fig. 9 Assembly into tapped heatsink.

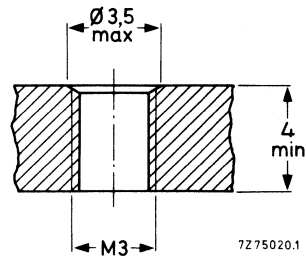


Fig. 10 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56326, 56387a and 56387b (up to 300 V)

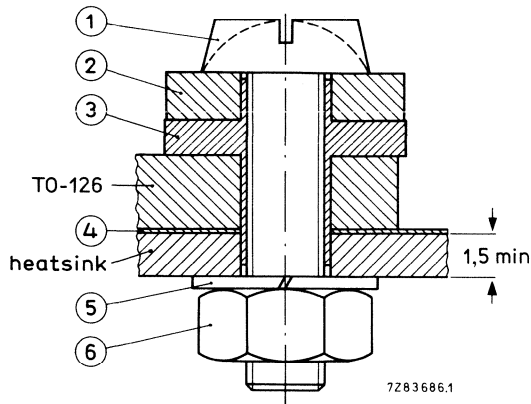


Fig. 15 Assembly through heatsink with nut.

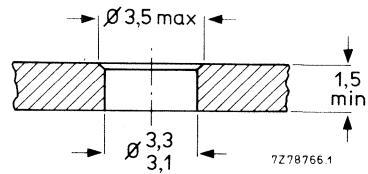


Fig. 16 Heatsink requirements.

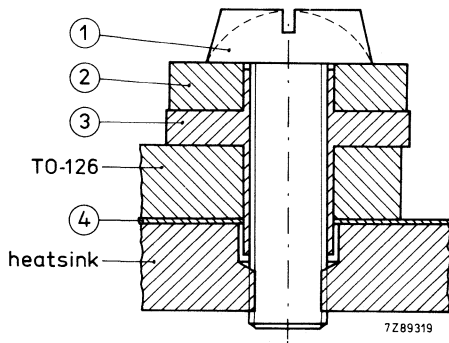


Fig. 17 Assembly with tapped heatsink.

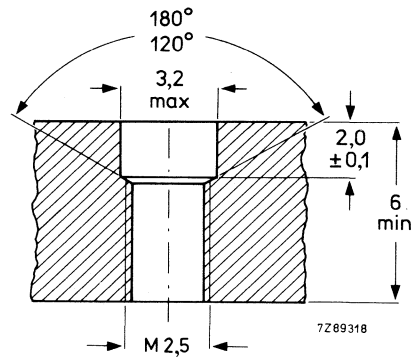


Fig. 18 Heatsink requirements.

Legend

- | | |
|--------------------------|-----------------------|
| 1 M2,5 screw | 4 mica washer 56387 a |
| 2 metal washer 56326 | 5 lock washer |
| 3 insulating bush 56387b | 6 M2,5 nut |

MOUNTING INSTRUCTIONS FOR TO-220 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 ($R_{th\ mb-h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting

Mounting with a spring clip gives:

- a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb-h}$ values than screw mounting.
- b. Safe insulation for mains operation.

2. M3 screw mounting

It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

Mounting torque for screw mounting:

(For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-riveted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

		clip mounting	screw mounting	
From mounting base to heatsink				
with heatsink compound, direct mounting	$R_{th\ mb-h}$	= 0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb-h}$	= 1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb-h}$	= 2,2	—	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb-h}$	= 0,8	—	K/W
with heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	1,6	K/W
without heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_j\ max \leq 175$ °C, soldering temperature $T_{sld\ max} = 275$ °C.

Devices with $T_j\ max \leq 110$ °C, soldering temperature $T_{sld\ max} = 240$ °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)

62 Sn/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the transistor on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

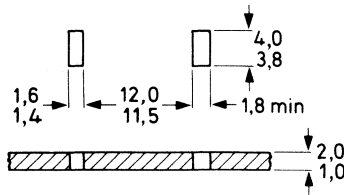


Fig. 1 Heatsink requirements.

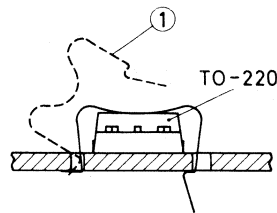


Fig. 2 Mounting.
(1) spring clip 56363.

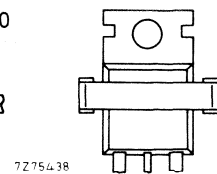


Fig. 2a Position of transistor (top view).

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.

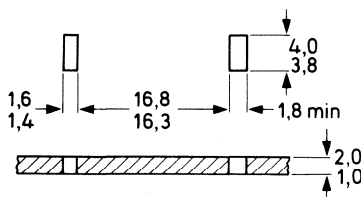


Fig. 3 Heatsink requirements.

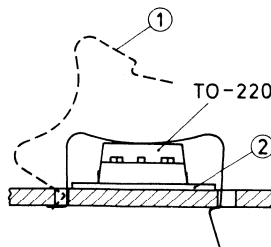


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

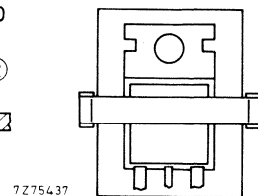


Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting with screw and spacing washer

- *through heatsink with nut*

Dimensions in mm

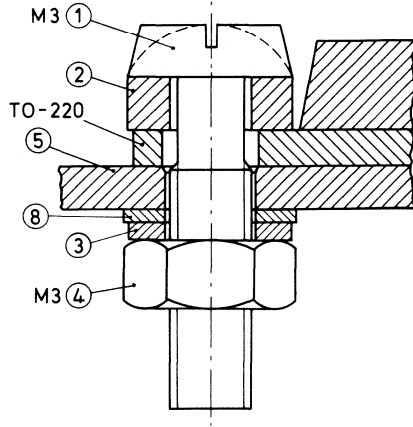
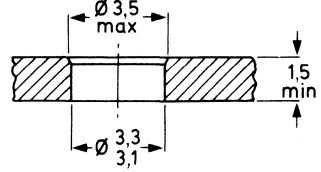


Fig. 5 Assembly.

- (1) M3 screw.
- (2) rectangular washer (56360a).
- (3) lock washer.
- (4) M3 nut.
- (5) heatsink.
- (8) plain washer.



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Fig. 6 Heatsink requirements.

- *into tapped heatsink*

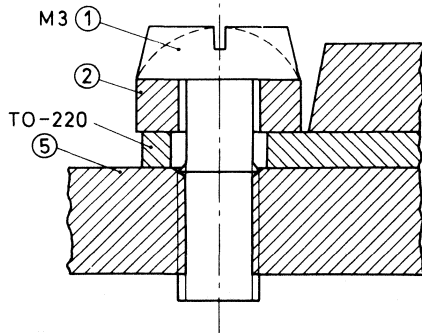
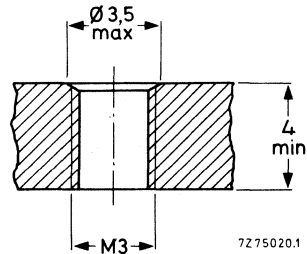


Fig. 7 Assembly.

- (1) M3 screw.
- (2) rectangular washer 56360a.
- (5) heatsink.



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Fig. 8 Heatsink requirements.

Insulated mounting with screw and spacing washer
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

• *through heatsink with nut*

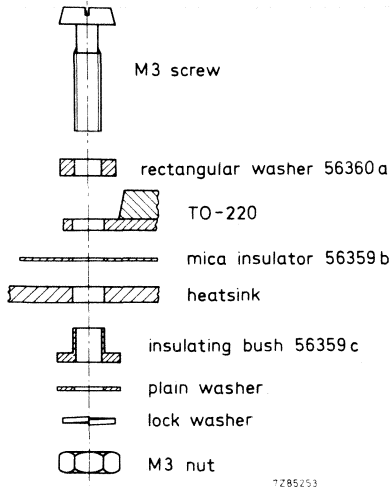


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

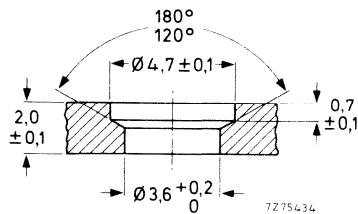


Fig. 10 Heatsink requirements for 500 V insulation.

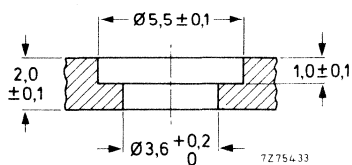


Fig. 11 Heatsink requirements for 800 V insulation.

• *into tapped heatsink*

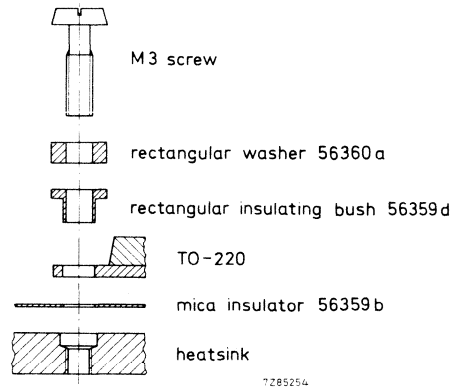


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

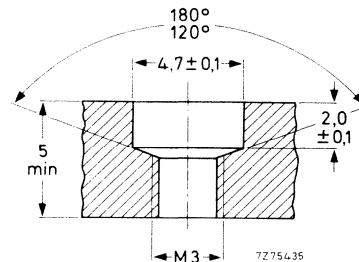


Fig. 13 Heatsink requirements for 500 V insulation.

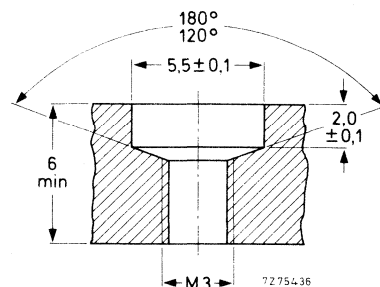


Fig. 14 Heatsink requirements for 1000 V insulation.

MOUNTING INSTRUCTIONS FOR SOT-93 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rule

Avoid any sudden forces on leads and body; these forces, such as from falling on a hard surface, are easily underestimated. In the direct screw mounting an M4 screw must be used; an M3 screw in the insulating mounting.

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
The mounting hole must be deburred.

Heatsink compound

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a metallic-oxide heatsink compound between the contact surfaces. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Maximum play

The bush or the washer may only just touch the plastic part of the body, but should not exert any force on that part. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Mounting torques

For M3 screw (insulated mounting):

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

For M4 screw (direct mounting only):

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	1,0 Nm (10 kgcm)

Note: The M4 screw head should not touch the plastic part of the envelope.

Lead bending

Maximum permissible tensile force on the body for 5 s	20 N (2 kgf)
---	--------------

No torsion is permitted at the emergence of the leads.

Bending or twisting is not permitted within a lead length of 0,3 mm.

The leads can be bent through 90° maximum, twisted or straightened; to keep forces within the above-mentioned limits, the leads are generally clamped near the body.

Soldering

Recommendations for devices with a maximum junction temperature rating ≤ 175 °C:

a. 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.

b. 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.

Thermal data

Thermal resistance from mounting base to heatsink

direct mounting

with heatsink compound

	clip mounting	screw mounting
$R_{th\ mb-h}$ =	0,3	0,3 K/W
$R_{th\ mb-h}$ =	1,5	0,8 K/W
$R_{th\ mb-h}$ =	0,8	0,8 K/W
$R_{th\ mb-h}$ =	3,0	2,2 K/W

without heatsink compound

with 0,05 mm mica washer

with heatsink compound

without heatsink compound

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

- Place the device on the heatsink, applying heatsink compound to the mounting base.
- Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Fig. 1b).
- Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 1(c)).

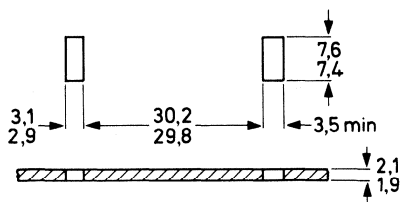


Fig. 1a Heatsink requirements.

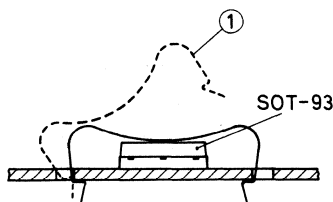


Fig. 1b Mounting.
(1) = spring clip 56379.

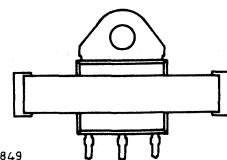


Fig. 1c Position
of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Figs 2a and 2b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2c). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

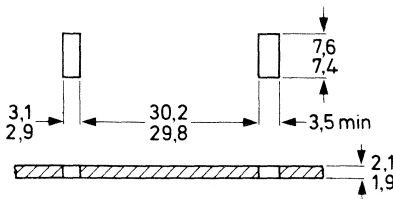


Fig. 2a Heatsink requirements.

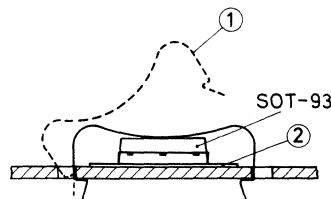


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

7Z75848

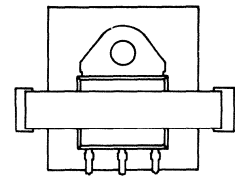


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

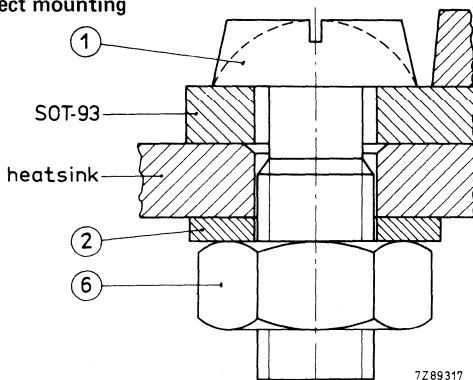


Fig. 3a Assembly through heatsink with nut.

7Z89317

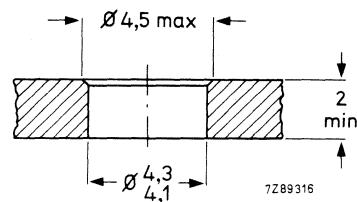


Fig. 3b Heatsink requirements.

7Z89316

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.

Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

Insulated screw mounting with nut; up to 800 V.

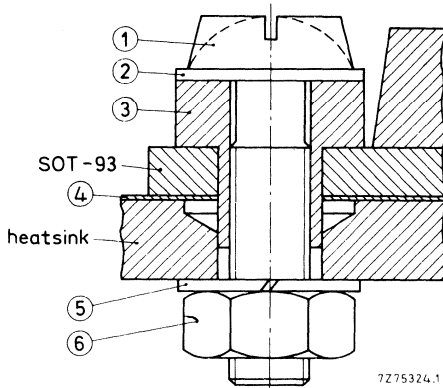


Fig. 4 Assembly.
See also Fig. 9.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer
- (6) M3 nut

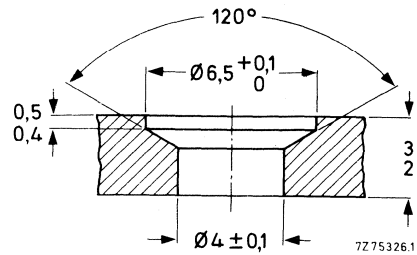


Fig. 5 Heatsink requirements
up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.

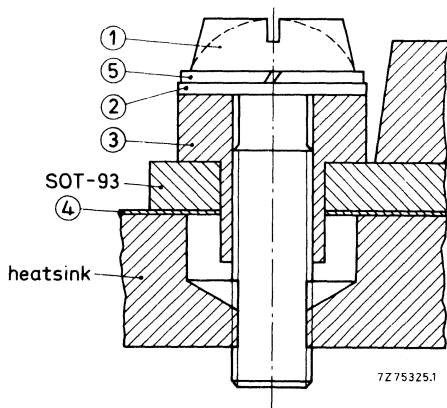


Fig. 6 Assembly.
See also Fig. 9.

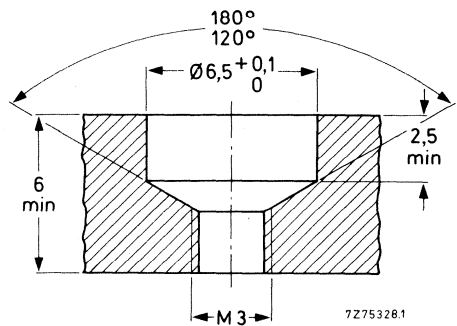


Fig. 7 Heatsink requirements
up to 800 V insulation.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer

Insulated screw mounting with insert nut; up to 500 V

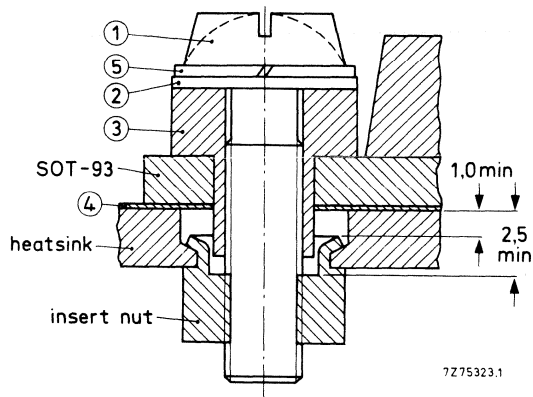


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer

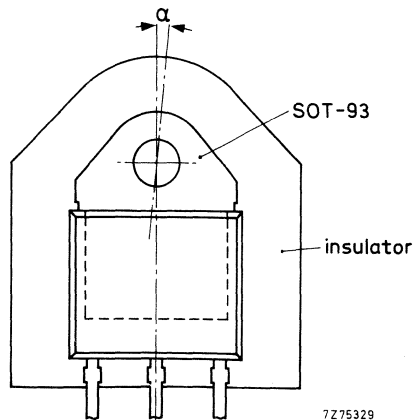


Fig. 9 Mica insulator.

The axial deviation (α) between SOT-93 and mica should not exceed 5° .

INDEX OF TYPE NUMBERS

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

type no.	book	section	type no.	book	section	type no.	book	section
BA220	SC01	SD	BAS28	SC01/10	SD/Mm	BAV45	SC01	Sp
BA221	SC01	SD	BAS29	SC01/10	SD/Mm	BAV70	SC01/10	SD/Mm
BA223	SC01	T	BAS31	SC01/10	SD/Mm	BAV74	SC01	SD
BA281	SC01	SD	BAS32	SC01/10	SD/Mm	BAV99	SC01/10	SD/Mm
BA314	SC01	Vrg	BAS32L	SC01/10	SD/Mm	BAV100	SC01/10	SD/Mm
BA315	SC01	Vrg	BAS35	SC01/10	SD/Mm	BAV101	SC01/10	SD/Mm
BA316	SC01	SD	BAS45	SC01	SD	BAV102	SC01/10	SD/Mm
BA317	SC01	SD	BAS45L	SC01/10	SD/Mm	BAV103	SC01/10	SD/Mm
BA318	SC01	SD	BAS56	SC01/10	SD/Mm	BAV105	SC01/10	SD/Mm
BA423	SC01	T	BAS85	SC01	SD	BAW56	SC01/10	SD/Mm
BA423L	SC01	T	BAT17	SC01/10	T/Mm	BAW62	SC01	SD
BA480	SC01	T	BAT18	SC01/10	T/Mm	BAX12	SC01	SD
BA481	SC01	T	BAT54	SC01/10	SD/Mm	BAX14	SC01	SD
BA482	SC01	T	BAT74	SC01/10	SD/Mm	BAX18	SC01	SD
BA483	SC01	T	BAT81	SC01	T	BAY80	SC01	SD
BA484	SC01	T	BAT82	SC01	T	BB112	SC01	T
BA682	SC01/10	T/Mm	BAT83	SC01	T	BB119	SC01	T
BA683	SC01/10	T/Mm	BAT85	SC01	T	BB130	SC01	T
BAS11	SC01	SD	BAT86	SC01	T	BB204B	SC01	T
BAS15	SC01	SD	BAV10	SC01	SD	BB204G	SC01	T
BAS16	SC01/10	SD/Mm	BAV18	SC01	SD	BB212	SC01	T
BAS17	SC01/10	Vrg/Mm	BAV19	SC01	SD	BB215	SC01/10	SD/Mm
BAS19	SC01/10	SD/Mm	BAV20	SC01	SD	BB219	SC01/10	SD/Mm
BAS20	SC01/10	SD/Mm	BAV21	SC01	SD	BB240	SC01/10	T/Mm
BAS21	SC01/10	SD/Mm	BAV23	SC01/10	SD/Mm	BB241	SC01/10	T/Mm

Key to handbook sections

A = Accessories	SEN = Semiconductor sensors
FET = Field-effect transistors	SD = Small-signal diodes
I = Infrared devices	Sm = Small-signal transistors
LED = Light-emitting diodes	Sp = Special diodes
LCD = Liquid crystal displays	SP = Low-frequency switching power diodes
Mm = Surface-mounted devices	St = Rectifier stacks
M = Microwave transistors	T = Tuner diodes
P = Low-frequency power transistors and modules	Th = Thyristors
PDT = Photodiodes or transistors	Tri = Triacs
Ph = Photoconductive devices	TS = Transient suppressor diodes
PhC = Photocouplers	Vrf = Voltage reference diodes
PM = PowerMOS transistors	Vrg = Voltage regulator diodes
R = Rectifier diodes	WBT = Wideband hybrid IC transistors
RFP = RF power transistors and modules	WBM = Wideband hybrid IC modules
RT = Triplers	

* series.

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BB417	SC01	T	BC560	SC04	Sm	BCV61	SC10	Mm
BB804	SC01/10	T/Mm	BC635	SC04	Sm	BCV62	SC10	Mm
BB809	SC01	T	BC636	SC04	Sm	BCV63	SC10	Mm
BB909A	SC01	T	BC637	SC04	Sm	BCV64	SC10	Mm
BB909B	SC01	T	BC638	SC04	Sm	BCV65	SC10	Mm
BB910	SC01	T	BC639	SC04	Sm	BCV71;R	SC10	Mm
BB911	SC01	T	BC640	SC04	Sm	BCV72;R	SC10	Mm
BBY31	SC01/10	T/Mm	BC807	SC10	Mm	BCW29;R	SC10	Mm
BBY39	SC01	T	BC808	SC10	Mm	BCW30;R	SC10	Mm
BBY40	SC01/10	T/Mm	BC817	SC10	Mm	BCW31;R	SC10	Mm
BBY42	SC01	T	BC818	SC10	Mm	BCW32;R	SC10	Mm
BBY62	SC01	T	BC846	SC10	Mm	BCW33;R	SC10	Mm
BC107	SC04	Sm	BC847	SC10	Mm	BCW60*	SC10	Mm
BC108	SC04	Sm	BC848	SC10	Mm	BCW61*	SC10	Mm
BC109	SC04	Sm	BC849	SC10	Mm	BCW69;R	SC10	Mm
BC140	SC04	Sm	BC850	SC10	Mm	BCW70;R	SC10	Mm
BC141	SC04	Sm	BC856	SC10	Mm	BCW71;R	SC10	Mm
BC160	SC04	Sm	BC857	SC10	Mm	BCW72;R	SC10	Mm
BC161	SC04	Sm	BC858	SC10	Mm	BCW81;R	SC10	Mm
BC177	SC04	Sm	BC859	SC10	Mm	BCW89;R	SC10	Mm
BC178	SC04	Sm	BC860	SC10	Mm	BCX17;R	SC10	Mm
BC179	SC04	Sm	BC868	SC10	Mm	BCX18;R	SC10	Mm
BC264A	SC07	FET	BC869	SC10	Mm	BCX19;R	SC10	Mm
BC264B	SC07	FET	BCF29;R	SC10	Mm	BCX20;R	SC10	Mm
BC264C	SC07	FET	BCF30;R	SC10	Mm	BCX51	SC10	Mm
BC264D	SC07	FET	BCF32;R	SC10	Mm	BCX52	SC10	Mm
BC327;A	SC04	Sm	BCF33;R	SC10	Mm	BCX53	SC10	Mm
BC328	SC04	Sm	BCF70;R	SC10	Mm	BCX54	SC10	Mm
BC337;A	SC04	Sm	BCF81;R	SC10	Mm	BCX55	SC10	Mm
BC338	SC04	Sm	BGP51	SC10	Mm	BCX56	SC10	Mm
BC368	SC04	Sm	BGP52	SC10	Mm	BCX58	SC04	Sm
BC369	SC04	Sm	BGP53	SC10	Mm	BCX59	SC04	Sm
BC375	SC04	Sm	BGP54	SC10	Mm	BCX70*	SC10	Mm
BC376	SC04	Sm	BGP55	SC10	Mm	BCX71*	SC10	Mm
BC516	SC04	Sm	BGP56	SC10	Mm	BCX78	SC04	Sm
BC517	SC04	Sm	BGP68	SC10	Mm	BCX79	SC04	Sm
BC546	SC04	Sm	BGP69	SC10	Mm	BCY56	SC04	Sm
BC547	SC04	Sm	BCV26	SC10	Mm	BCY57	SC04	Sm
BC548	SC04	Sm	BCV27	SC10	Mm	BCY58	SC04	Sm
BC549	SC04	Sm	BCV28	SC10	Mm	BCY59	SC04	Sm
BC550	SC04	Sm	BCV29	SC10	Mm	BCY65	SC04	Sm
BC556	SC04	Sm	BCV46	SC10	Mm	BCY70	SC04	Sm
BC557	SC04	Sm	BCV47	SC10	Mm	BCY71	SC04	Sm
BC558	SC04	Sm	BCV48	SC10	Mm	BCY72	SC04	Sm

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BCY78	SC04	Sm	BD243	SC05	P	BD720	SC05	P
BCY79	SC04	Sm	BD243A	SC05	P	BD721	SC05	P
BCY87	SC04	Sm	BD243B	SC05	P	BD722	SC05	P
BCY88	SC04	Sm	BD243C	SC05	P	BD723	SC05	P
BCY89	SC04	Sm	BD244	SC05	P	BD724	SC05	P
BD131	SC05	P	BD244A	SC05	P	BD725	SC05	P
BD132	SC05	P	BD244B	SC05	P	BD726	SC05	P
BD135	SC05	P	BD244C	SC05	P	BD825	SC05	P
BD136	SC05	P	BD329	SC05	P	BD826	SC05	P
BD137	SC05	P	BD330	SC05	P	BD827	SC05	P
BD138	SC05	P	BD331	SC05	P	BD828	SC05	P
BD139	SC05	P	BD332	SC05	P	BD829	SC05	P
BD140	SC05	P	BD333	SC05	P	BD830	SC05	P
BD201;F	SC05	P	BD334	SC05	P	BD839	SC05	P
BD202;F	SC05	P	BD335	SC05	P	BD840	SC05	P
BD203;F	SC05	P	BD336	SC05	P	BD841	SC05	P
BD204;F	SC05	P	BD337	SC05	P	BD842	SC05	P
BD226	SC05	P	BD338	SC05	P	BD843	SC05	P
BD227	SC05	P	BD433	SC05	P	BD844	SC05	P
BD228	SC05	P	BD434	SC05	P	BD933;F	SC05	P
BD229	SC05	P	BD435	SC05	P	BD934;F	SC05	P
BD230	SC05	P	BD436	SC05	P	BD935;F	SC05	P
BD231	SC05	P	BD437	SC05	P	BD936;F	SC05	P
BD233	SC05	P	BD438	SC05	P	BD937;F	SC05	P
BD234	SC05	P	BD643;F	SC05	P	BD938;F	SC05	P
BD235	SC05	P	BD644;F	SC05	P	BD939;F	SC05	P
BD236	SC05	P	BD645;F	SC05	P	BD940;F	SC05	P
BD237	SC05	P	BD646;F	SC05	P	BD941;F	SC05	P
BD238	SC05	P	BD647;F	SC05	P	BD942;F	SC05	P
BD239	SC05	P	BD648;F	SC05	P	BD943;F	SC05	P
BD239A	SC05	P	BD649;F	SC05	P	BD944;F	SC05	P
BD239B	SC05	P	BD650;F	SC05	P	BD945;F	SC05	P
BD239C	SC05	P	BD651;F	SC05	P	BD946;F	SC05	P
BD240	SC05	P	BD652;F	SC05	P	BD947;F	SC05	P
BD240A	SC05	P	BD675	SC05	P	BD948;F	SC05	P
BD240B	SC05	P	BD676	SC05	P	BD949;F	SC05	P
BD240C	SC05	P	BD677	SC05	P	BD950;F	SC05	P
BD241	SC05	P	BD678	SC05	P	BD951;F	SC05	P
BD241A	SC05	P	BD679	SC05	P	BD952;F	SC05	P
BD241B	SC05	P	BD680	SC05	P	BD953;F	SC05	P
BD241C	SC05	P	BD681	SC05	P	BD954;F	SC05	P
BD242	SC05	P	BD682	SC05	P	BD955;F	SC05	P
BD242A	SC05	P	BD683	SC05	P	BD956;F	SC05	P
BD242B	SC05	P	BD684	SC05	P	BDT29;F	SC05	P
BD242C	SC05	P	BD719	SC05	P	BDT29A;F	SC05	P

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BDT29B;F	SC05	P	BDT65B;F	SC05	P	BDX46	SC05	P
BDT29C;F	SC05	P	BDT65C;F	SC05	P	BDX47	SC05	P
BDT30;F	SC05	P	BDT81;F	SC05	P	BDX62	SC05	P
BDT30A;F	SC05	P	BDT82;F	SC05	P	BDX62A	SC05	P
BDT30B;F	SC05	P	BDT83;F	SC05	P	BDX62B	SC05	P
BDT30C;F	SC05	P	BDT84;F	SC05	P	BDX62C	SC05	P
BDT31;F	SC05	P	BDT85;F	SC05	P	BDX63	SC05	P
BDT31A;F	SC05	P	BDT86;F	SC05	P	BDX63A	SC05	P
BDT31B;F	SC05	P	BDT87;F	SC05	P	BDX63B	SC05	P
BDT31C;F	SC05	P	BDT88;F	SC05	P	BDX63C	SC05	P
BDT31DF	SC05	P	BDT91;F	SC05	P	BDX64	SC05	P
BDT32;F	SC05	P	BDT92;F	SC05	P	BDX64A	SC05	P
BDT32A;F	SC05	P	BDT93;F	SC05	P	BDX64B	SC05	P
BDT32B;F	SC05	P	BDT94;F	SC05	P	BDX64C	SC05	P
BDT32C;F	SC05	P	BDT95;F	SC05	P	BDX65	SC05	P
BDT32DF	SC05	P	BDT96;F	SC05	P	BDX65A	SC05	P
BDT41A;F	SC05	P	BDV64	SC05	P	BDX65B	SC05	P
BDT41B;F	SC05	P	BDV64A	SC05	P	BDX65C	SC05	P
BDT41C;F	SC05	P	BDV64B	SC05	P	BDX66	SC05	P
BDT42;F	SC05	P	BDV64C	SC05	P	BDX66A	SC05	P
BDT42A;F	SC05	P	BDV65	SC05	P	BDX66B	SC05	P
BDT42B;F	SC05	P	BDV65A	SC05	P	BDX66C	SC05	P
BDT42C;F	SC05	P	BDV65B	SC05	P	BDX67	SC05	P
BDT60;F	SC05	P	BDV65C	SC05	P	BDX67A	SC05	P
BDT60A;F	SC05	P	BDV66A	SC05	P	BDX67B	SC05	P
BDT60B;F	SC05	P	BDV66B	SC05	P	BDX67C	SC05	P
BDT60C;F	SC05	P	BDV66C	SC05	P	BDX68	SC05	P
BDT61;F	SC05	P	BDV66D	SC05	P	BDX68A	SC05	P
BDT61A;F	SC05	P	BDV67A	SC05	P	BDX68B	SC05	P
BDT61B;F	SC05	P	BDV67B	SC05	P	BDX68C	SC05	P
BDT61C;F	SC05	P	BDV67C	SC05	P	BDX69	SC05	P
BDT62;F	SC05	P	BDV67D	SC05	P	BDX69A	SC05	P
BDT62A;F	SC05	P	BDV91	SC05	P	BDX69B	SC05	P
BDT62B;F	SC05	P	BDV92	SC05	P	BDX69C	SC05	P
BDT62C;F	SC05	P	BDV93	SC05	P	BDX77;F	SC05	P
BDT63;F	SC05	P	BDV94	SC05	P	BDX78;F	SC05	P
BDT63A;F	SC05	P	BDV95	SC05	P	BDX91	SC05	P
BDT63B;F	SC05	P	BDV96	SC05	P	BDX92	SC05	P
BDT63C;F	SC05	P	BDX35	SC05	P	BDX93	SC05	P
BDT64;F	SC05	P	BDX36	SC05	P	BDX94	SC05	P
BDT64A;F	SC05	P	BDX37	SC05	P	BDX95	SC05	P
BDT64B;F	SC05	P	BDX42	SC05	P	BDX96	SC05	P
BDT64C;F	SC05	P	BDX43	SC05	P	BDY90	SC05	P
BDT65;F	SC05	P	BDX44	SC05	P	BDY91	SC05	P
BDT65A;F	SC05	P	BDX45	SC05	P	BDY92	SC05	P

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BF198	SC04	Sm	BF720	SC10	Mm	BFG90A	SC14	WBT
BF199	SC04	Sm	BF721	SC10	Mm	BFG91A	SC14	WBT
BF240	SC04	Sm	BF722	SC10	Mm	BFG92A	SC14	WBT
BF241	SC04	Sm	BF723	SC10	Mm	BFG93A	SC14	WBT
BF245A	SC07	FET	BF763	SC14	WBT	BFG96	SC14	WBT
BF245B	SC07	FET	BF820	SC10	Mm	BFG97	SC14/10	WBT/Mm
BF245C	SC07	FET	BF821	SC10	Mm	BFG135	SC14/10	WBT/Mm
BF247A	SC07	FET	BF822	SC10	Mm	BFG195	SC14	WBT
BF247B	SC07	FET	BF823	SC10	Mm	BFG198	SC14/10	WBT/Mm
BF247C	SC07	FET	BF824	SC10	Mm	BFP90A	SC14	WBT
BF256A	SC07	FET	BF840	SC10	Mm	BFP91A	SC14	WBT
BF256B	SC07	FET	BF841	SC10	Mm	BFP96	SC14	WBT
BF256C	SC07	FET	BF926	SC04	Sm	BFQ10	SC07	FET
BF324	SC04	Sm	BF936	SC04	Sm	BFQ11	SC07	FET
BF370	SC04	Sm	BF939	SC04	Sm	BFQ12	SC07	FET
BF410A	SC07	FET	BF960	SC07	FET	BFQ13	SC07	FET
BF410B	SC07	FET	BF964S	SC07	FET	BFQ14	SC07	FET
BF410C	SC07	FET	BF965	SC07	FET	BFQ15	SC07	FET
BF410D	SC07	FET	BF966S	SC07	FET	BFQ16	SC07	FET
BF420	SC04	Sm	BF967	SC04	Sm	BFQ17	SC14/10	WBT/Mm
BF421	SC04	Sm	BF970	SC04	Sm	BFQ18A	SC14/10	WBT/Mm
BF422	SC04	Sm	BF970A	SC04	Sm	BFQ19	SC14/10	WBT/Mm
BF423	SC04	Sm	BF979	SC04	Sm	BFQ22S	SC14	WBT
BF450	SC04	Sm	BF980	SC07	FET	BFQ23	SC14	WBT
BF451	SC04	Sm	BF980A	SC07	FET	BFQ23C	SC14	WBT
BF483	SC04	Sm	BF981	SC07	FET	BFQ24	SC14	WBT
BF485	SC04	Sm	BF982	SC07	FET	BFQ32	SC14	WBT
BF487	SC04	Sm	BF989	SC07/10	FET/Mm	BFQ32C	SC14	WBT
BF494	SC04	Sm	BF990A	SC07/10	FET/Mm	BFQ32M	SC14	WBT
BF495	SC04	Sm	BF990AR	SC07/10	FET/Mm	BFQ32S	SC14	WBT
BF496	SC04	Sm	BF991	SC07/10	FET/Mm	BFQ33	SC14	WBT
BF510	SC07/10	FET/Mm	BF992	SC07/10	FET/Mm	BFQ33C	SC14	WBT
BF511	SC07/10	FET/Mm	BF992R	SC07/10	FET/Mm	BFQ34	SC14	WBT
BF512	SC07/10	FET/Mm	BF994S	SC07/10	FET/Mm	BFQ34T	SC14	WBT
BF513	SC07/10	FET/Mm	BF994SR	SC07/10	FET/Mm	BFQ42	SC08	RFP
BF550;R	SC10	Mm	BF996S	SC07/10	FET/Mm	BFQ43	SC08	RFP
BF569	SC10	Mm	BF996SR	SC07/10	FET/Mm	BFQ43S	SC08	RFP
BF570	SC10	Mm	BF997	SC07/10	FET/Mm	BFQ51	SC14	WBT
BF579	SC10	Mm	BFG23	SC14	WBT	BFQ51C	SC14	WBT
BF620	SC10	Mm	BFG32	SC14	WBT	BFQ52	SC14	WBT
BF621	SC10	Mm	BFG34	SC14	WBT	BFQ53	SC14	WBT
BF622	SC10	Mm	BFG35	SC14/10	WBT/Mm	BFQ63	SC14	WBT
BF623	SC10	Mm	BFG51	SC14	WBT	BFQ65	SC14	WBT
BF660;R	SC10	Mm	BFG65	SC14	WBT	BFQ66	SC14	WBT
BF689K	SC14	WBT	BFG67	SC14/10	WBT/Mm	BFQ67	SC14/10	WBT/Mm

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BFQ68	SC14	WBT	BFW17A	SC14	WBT	BGY49A	SC09	RFP
BFQ136	SC14	WBT	BFW30	SC14	WBT	BGY49B	SC09	RFP
BFR29	SC07	FET	BFW61	SC07	FET	BGY50	SC14	WBM
BFR30	SC07/10	FET/Mm	BFW92	SC14	WBT	BGY51	SC14	WBM
BFR31	SC07/10	FET/Mm	BFW92A	SC14	WBT	BGY52	SC14	WBM
BFR49	SC14	WBT	BFW93	SC14	WBT	BGY53	SC14	WBM
BFR53	SC14/10	WBT/Mm	BFX34	SC04	Sm	BGY54	SC14	WBM
BFR54	SC04	Sm	BFX89	SC14	WBT	BGY55	SC14	WBM
BFR64	SC14	WBT	BFY50	SC04	Sm	BGY56	SC14	WBM
BFR65	SC14	WBT	BFY51	SC04	Sm	BGY57	SC14	WBM
BFR84	SC07	FET	BFY52	SC04	Sm	BGY58	SC14	WBM
BFR90	SC14	WBT	BFY55	SC04	Sm	BGY58A	SC14	WBM
BFR90A	SC14	WBT	BFY90	SC14	WBT	BGY59	SC14	WBM
BFR91	SC14	WBT	BG2000	SC01	RT	BGY60	SC14	WBM
BFR91A	SC14	WBT	BG2097	SC01	RT	BGY61	SC14	WBM
BFR92	SC14/10	WBT/Mm	BGD102	SC14	WBM	BGY65	SC14	WBM
BFR92A	SC14/10	WBT/Mm	BGD102E	SC14	WBM	BGY67	SC14	WBM
BFR93	SC14/10	WBT/Mm	BGD104	SC14	WBM	BGY67A	SC14	WBM
BFR93A	SC14/10	WBT/Mm	BGD104E	SC14	WBM	BGY70	SC14	WBM
BFR94	SC14	WBT	BGD502	SC14	WBM	BGY71	SC14	WBM
BFR95	SC14	WBT	BGD504	SC14	WBM	BGY74	SC14	WBM
BFR96	SC14	WBT	BGX885	SC14	WBM	BGY75	SC14	WBM
BFR96S	SC14	WBT	BGY22	SC09	RFP	BGY78	SC14	WBM
BFR101A;B	SC07/10	FET/Mm	BGY22A	SC09	RFP	BGY84	SC14	WBM
BFS17	SC14/10	WBT/Mm	BGY23	SC09	RFP	BGY84A	SC14	WBM
BFS17A	SC14	WBT	BGY23A	SC09	RFP	BGY85	SC14	WBM
BFS18;R	SC10	Mm	BGY32	SC09	RFP	BGY85A	SC14	WBM
BFS19;R	SC10	Mm	BGY33	SC09	RFP	BGY86	SC14	WBM
BFS20;R	SC10	Mm	BGY35	SC09	RFP	BGY87	SC14	WBM
BFS21	SC07	FET	BGY36	SC09	RFP	BGY88	SC14	WBM
BFS21A	SC07	FET	BGY40A	SC09	RFP	BGY90A	SC09	RFP
BFS22A	SC08	RFP	BGY40B	SC09	RFP	BGY90B	SC09	RFP
BFS23A	SC08	RFP	BGY41A	SC09	RFP	BGY91A	SC09	RFP
BFT24	SC14	WBT	BGY41B	SC09	RFP	BGY91B	SC09	RFP
BFT25	SC14/10	WBT/Mm	BGY43	SC09	RFP	BGY93A	SC09	RFP
BFT44	SC04	Sm	BGY45A	SC09	RFP	BGY93B	SC09	RFP
BFT45	SC04	Sm	BGY45B	SC09	RFP	BGY93C	SC09	RFP
BFT46	SC07/10	FET/Mm	BGY45C	SC09	RFP	BGY94A	SC09	RFP
BFT92	SC14/10	WBT/Mm	BGY46A	SC09	RFP	BGY94B	SC09	RFP
BFT93	SC14/10	WBT/Mm	BGY46B	SC09	RFP	BGY94C	SC09	RFP
BFW10	SC07	FET	BGY47A	SC09	RFP	BGY95A	SC09	RFP
BFW11	SC07	FET	BGY47F	SC09	RFP	BGY95B	SC09	RFP
BFW12	SC07	FET	BGY48A	SC09	RFP	BGY96A	SC09	RFP
BFW13	SC07	FET	BGY48B	SC09	RFP	BGY96B	SC09	RFP
BFW16A	SC14	WBT	BGY48C	SC09	RFP	BGY110A	SC09	RFP

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BGY110B	SC09	RFP	BLV94	SC08	RFP	BLX92A	SC08	RFP
BGY584A	SC14	WBM	BLV95	SC08	RFP	BLX93A	SC08	RFP
BGY585A	SC14	WBM	BLV97	SC08	RFP	BLX94A	SC08	RFP
BGY586	SC14	WBM	BLV98	SC08	RFP	BLX94C	SC08	RFP
BGY587	SC14	WBM	BLV99	SC08	RFP	BLX95	SC08	RFP
BLF242	SC08	RFP/FET	BLW29	SC08	RFP	BLX96	SC08	RFP
BLF244	SC08	RFP/FET	BLW31	SC08	RFP	BLX97	SC08	RFP
BLF245	SC08	RFP/FET	BLW32	SC08	RFP	BLX98	SC08	RFP
BLT90/SL	SC08	RFP	BLW33	SC08	RFP	BLY87A	SC08	RFP
BLT91/SL	SC08	RFP	BLW34	SC08	RFP	BLY87C	SC08	RFP
BLT92/SL	SC08	RFP	BLW50F	SC08	RFP	BLY88A	SC08	RFP
BLU20/12	SC08	RFP	BLW60	SC08	RFP	BLY88C	SC08	RFP
BLU30/12	SC08	RFP	BLW60C	SC08	RFP	BLY89A	SC08	RFP
BLU45/12	SC08	RFP	BLW76	SC08	RFP	BLY89C	SC08	RFP
BLU50	SC08	RFP	BLW77	SC08	RFP	BLY90	SC08	RFP
BLU51	SC08	RFP	BLW78	SC08	RFP	BLY91A	SC08	RFP
BLU52	SC08	RFP	BLW79	SC08	RFP	BLY91C	SC08	RFP
BLU53	SC08	RFP	BLW80	SC08	RFP	BLY92A	SC08	RFP
BLU60/12	SC08	RFP	BLW81	SC08	RFP	BLY92C	SC08	RFP
BLU97	SC08	RFP	BLW83	SC08	RFP	BLY93A	SC08	RFP
BLU98	SC08	RFP	BLW84	SC08	RFP	BLY93C	SC08	RFP
BLU99	SC08	RFP	BLW85	SC08	RFP	BLY94	SC08	RFP
BLV10	SC08	RFP	BLW86	SC08	RFP	BPF24	SC12	PDT
BLV11	SC08	RFP	BLW87	SC08	RFP	BPW22A	S8a/b	PDT
BLV20	SC08	RFP	BLW89	SC08	RFP	BPW50	S8a/b	PDT
BLV21	SC08	RFP	BLW90	SC08	RFP	BPW71	SC12	PDT
BLV25	SC08	RFP	BLW91	SC08	RFP	BPX25	SC12	PDT
BLV30	SC08	RFP	BLW95	SC08	RFP	BPX29	SC12	PDT
BLV30/12	SC08	RFP	BLW96	SC08	RFP	BPX40	SC12	PDT
BLV31	SC08	RFP	BLW97	SC08	RFP	BPX41	SC12	PDT
BLV32F	SC08	RFP	BLW98	SC08	RFP	BPX42	SC12	PDT
BLV33	SC08	RFP	BLW99	SC08	RFP	BPX61	SC12	PDT
BLV33F	SC08	RFP	BLX13	SC08	RFP	BPX61P	SC12	PDT
BLV36	SC08	RFP	BLX13C	SC08	RFP	BPX71	SC12	PDT
BLV45/12	SC08	RFP	BLX14	SC08	RFP	BPX72	SC12	PDT
BLV57	SC08	RFP	BLX15	SC08	RFP	BR100/03	S2b	Th
BLV59	SC08	RFP	BLX39	SC08	RFP	BR101	SC04	Sm
BLV75/12	SC08	RFP	BLX65	SC08	RFP	BR210*	S2a	Th
BLV80/28	SC08	RFP	BLX65E	SC08	RFP	BR216*	S2a	Th
BLV90	SC08	RFP	BLX65ES	SC08	RFP	BR220*	S2a	Th
BLV90/SL	SC08	RFP	BLX67	SC08	RFP	BRY39	SC04	Sm
BLV91	SC08	RFP	BLX68	SC08	RFP	BRY56	SC04	Sm
BLV91/SL	SC08	RFP	BLX69A	SC08	RFP	BRY61	SC10	Mm
BLV92	SC08	RFP	BLX91A	SC08	RFP	BRY62	SC10	Mm
BLV93	SC08	RFP	BLX91CB	SC08	RFP	BS107	SC07	FET

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BS107A	SC07	FET	BSR15;R	SC10	Mm	BSS87	SC07	FET
BS170	SC07	FET	BSR16;R	SC10	Mm	BSS89	SC07	FET
BS250	SC07	FET	BSR17;R	SC10	Mm	BSS91	SC07	FET
BSD10	SC07	FET	BSR17A;R	SC10	Mm	BSS92	SC07	FET
BSD12	SC07	FET	BSR18;R	SC10	Mm	BST15	SC10	Mm
BSD20	SC07/10	FET/Mm	BSR18A;R	SC10	Mm	BST16	SC10	Mm
BSD22	SC07/10	FET/Mm	BSR19	SC10	Mm	BST39	SC10	Mm
BSD212	SC07	FET	BSR19A	SC10	Mm	BST40	SC10	Mm
BSD213	SC07	FET	BSR20	SC10	Mm	BST50	SC10	Mm
BSD214	SC07	FET	BSR20A	SC10	Mm	BST51	SC10	Mm
BSD215	SC07	FET	BSR30	SC10	Mm	BST52	SC10	Mm
BSJ111	SC07	FET	BSR31	SC10	Mm	BST60	SC10	Mm
BSJ112	SC07	FET	BSR32	SC10	Mm	BST61	SC10	Mm
BSJ113	SC07	FET	BSR33	SC10	Mm	BST62	SC10	Mm
BSJ174	SC07	FET	BSR40	SC10	Mm	BST70A	SC07	FET
BSJ175	SC07	FET	BSR41	SC10	Mm	BST72A	SC07	FET
BSJ176	SC07	FET	BSR42	SC10	Mm	BST74A	SC07	FET
BSJ177	SC07	FET	BSR43	SC10	Mm	BST76A	SC07	FET
BSN205	SC07	FET	BSR50	SC04	Sm	BST78	SC07	FET
BSN205A	SC07	FET	BSR51	SC04	Sm	BST80	SC07/10	FET/Mm
BSN254	SC07	FET	BSR52	SC04	Sm	BST82	SC07/10	FET/Mm
BSN254A	SC07	FET	BSR56	SC07/10	FET/Mm	BST84	SC07/10	FET/Mm
BSP15	SC10	Mm	BSR57	SC07/10	FET/Mm	BST86	SC07/10	FET/Mm
BSP16	SC10	Mm	BSR58	SC07/10	FET/Mm	BST95	SC07	FET
BSP19	SC10	Mm	BSR60	SC04	Sm	BST97	SC07	FET
BSP20	SC10	Mm	BSR61	SC04	Sm	BST100	SC07	FET
BSP30	SC10	Mm	BSR62	SC04	Sm	BST110	SC07	FET
BSP31	SC10	Mm	BSR111	SC07/10	FET/Mm	BST120	SC07/10	FET/Mm
BSP32	SC10	Mm	BSR112	SC07/10	FET/Mm	BST122	SC07/10	FET/Mm
BSP33	SC10	Mm	BSR113	SC07/10	FET/Mm	BSV15	SC04	Sm
BSP40	SC10	Mm	BSR174	SC07/10	FET/Mm	BSV16	SC04	Sm
BSP41	SC10	Mm	BSR175	SC07/10	FET/Mm	BSV17	SC04	Sm
BSP42	SC10	Mm	BSR176	SC07/10	FET/Mm	BSV52;R	SC10	Mm
BSP43	SC10	Mm	BSR177	SC07/10	FET/Mm	BSV64	SC04	Sm
BSP50	SC10	Mm	BSS38	SC04	Sm	BSV78	SC07	FET
BSP51	SC10	Mm	BSS50	SC04	Sm	BSV79	SC07	FET
BSP52	SC10	Mm	BSS51	SC04	Sm	BSV80	SC07	FET
BSP60	SC10	Mm	BSS52	SC04	Sm	BSV81	SC07	FET
BSP61	SC10	Mm	BSS60	SC04	Sm	BSW66A	SC04	Sm
BSP62	SC10	Mm	BSS61	SC04	Sm	BSW67A	SC04	Sm
BSP204	SC07	FET	BSS62	SC04	Sm	BSW68A	SC04	Sm
BSP204A	SC07	FET	BSS63;R	SC10	Mm	BSX19	SC04	Sm
BSR12;R	SC10	Mm	BSS64;R	SC10	Mm	BSX20	SC04	Sm
BSR13;R	SC10	Mm	BSS68	SC04	Sm	BSX32	SC04	Sm
BSR14;R	SC10	Mm	BSS83	SC07/10	FET/Mm	BSX45	SC04	Sm

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BSX46	SC04	Sm	BU306F	SC06	SP	BUV48;A	SC06	SP
BSX47	SC04	Sm	BU505	SC06	SP	BUV82	SC06	SP
BSX59	SC04	Sm	BU506	SC06	SP	BUV83	SC06	SP
BSX60	SC04	Sm	BU506D	SC06	SP	BUV89	SC06	SP
BSX61	SC04	Sm	BU508A	SC06	SP	BUV90	SC06	SP
BT136*	S2b	Tri	BU508D	SC06	SP	BUV90F	SC06	SP
BT136F*	S2b	Tri	BU705	SC06	SP	BUV98(V);A	SC06	SP
BT137*	S2b	Tri	BU706	SC06	SP	BUV298(V);A	SC06	SP
BT137F*	S2b	Tri	BU706D	SC06	SP	BUW11;A	SC06	SP
BT138*	S2b	Tri	BU806	SC06	SP	BUW12;A	SC06	SP
BT138F*	S2b	Tri	BU807	SC06	SP	BUW12F;AF	SC06	SP
BT139*	S2b	Tri	BU808	SC06	SP	BUW13;A	SC06	SP
BT139F*	S2b	Tri	BU824	SC06	SP	BUW13F;AF	SC06	SP
BT145*	S2b	Tri	BU826	SC06	SP	BUW84	SC06	SP
BT149*	S2b	Th	BUP22*	SC06	SP	BUW85	SC06	SP
BT150	S2b	Th	BUP23*	SC06	SP	BUW86	SC06	SP
BT151*	S2b	Th	BUS11;A	SC06	SP	BUW87;A	SC06	SP
BT151F*	S2b	Th	BUS12;A	SC06	SP	BUW131*	SC06	SP
BT152*	S2b	Th	BUS13;A	SC06	SP	BUW132*	SC06	SP
BT153	S2b	Th	BUS14;A	SC06	SP	BUW133*	SC06	SP
BT157*	S2b	Th	BUS21*	SC06	SP	BUX46;A	SC06	SP
BT169*	S2b	Th	BUS22*	SC06	SP	BUX47;A	SC06	SP
BTA140*	S2b	Tri	BUS23*	SC06	SP	BUX48;A	SC06	SP
BTR59*	S2b	Tri	BUS24*	SC06	SP	BUX84	SC06	SP
BTS59*	S2b	Tri	BUS131*	SC06	SP	BUX84F	SC06	SP
BTV58*	S2b	Th	BUS132*	SC06	SP	BUX85	SC06	SP
BTV59*	S2b	Th	BUS133*	SC06	SP	BUX85F	SC06	SP
BTV59D*	S2b	Th	BUT11;A	SC06	SP	BUX86	SC06	SP
BTV60*	S2b	Th	BUT11F;AF	SC06	SP	BUX87	SC06	SP
BTV60D*	S2b	Th	BUT12;A	SC06	SP	BUX88	SC06	SP
BTV70*	S2b	Th	BUT12F;AF	SC06	SP	BUX98;A	SC06	SP
BTV70D*	S2b	Th	BUT18;A	SC06	SP	BUX99	SC06	SP
BTW23*	S2b	Th	BUT18F;AF	SC06	SP	BUY89	SC06	SP
BTW38*	S2b	Th	BUT21B;C	SC06	SP	BUZ10	S9	PM
BTW40*	S2b	Th	BUT21BF;CF	SC06	SP	BUZ11	S9	PM
BTW42*	S2b	Th	BUT22B;C	SC06	SP	BUZ11A	S9	PM
BTW43*	S2b	Tri	BUT22BF;CF	SC06	SP	BUZ14	S9	PM
BTW45*	S2b	Th	BUT131	SC06	SP	BUZ15	S9	PM
BTW58*	S2b	Th	BUV26;A	SC06	SP	BUZ20	S9	PM
BTW62*	S2b	Th	BUV26F;AF	SC06	SP	BUZ21	S9	PM
BTW62D*	S2b	Th	BUV27;A	SC06	SP	BUZ23	S9	PM
BTW63*	S2b	Th	BUV27F;AF	SC06	SP	BUZ24	S9	PM
BTY79*	S2b	Th	BUV28;A	SC06	SP	BUZ25	S9	PM
BTY91*	S2b	Th	BUV28F;AF	SC06	SP	BUZ31	S9	PM
BU306	SC06	SP	BUV47;A	SC06	SP	BUZ32	S9	PM

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type no.	book	section	type no.	book	section	type no.	book	section
BUZ34	S9	PM	BUZ347	S9	PM	BY714	SC01	R
BUZ35	S9	PM	BUZ348	S9	PM	BY715	SC01	R
BUZ36	S9	PM	BUZ349	S9	PM	BY716	SC01	R
BUZ41A	S9	PM	BUZ350	S9	PM	BY717	SC01	R
BUZ42	S9	PM	BUZ351	S9	PM	BY718	SC01	R
BUZ45	S9	PM	BUZ355	S9	PM	BY719	SC01	R
BUZ45A	S9	PM	BUZ356	S9	PM	BY720	SC01	R
BUZ45B	S9	PM	BUZ357	S9	PM	BY721	SC01	R
BUZ50A	S9	PM	BUZ358	S9	PM	BY722	SC01	R
BUZ50B	S9	PM	BUZ384	S9	PM	BY723	SC01	R
BUZ50C	S9	PM	BUZ385	S9	PM	BY724	SC01	R
BUZ53A	S9	PM	BY224*	S2a	R	BYD11 *	SC01	R
BUZ54	S9	PM	BY225*	S2a	R	BYD13 *	SC01	R
BUZ54A	S9	PM	BY228	SC01	R	BYD14 *	SC01	R
BUZ60	S9	PM	BY229*	S2a	R	BYD17 *	SC01/10	R/Mm
BUZ63	S9	PM	BY229F*	S2a	R	BYD31 *	SC01	R
BUZ64	S9	PM	BY249*	S2a	R	BYD33 *	SC01	R
BUZ71	S9	PM	BY260*	S2a	R	BYD34 *	SC01	R
BUZ71A	S9	PM	BY261*	S2a	R	BYD37 *	SC01/10	R/Mm
BUZ72	S9	PM	BY328	SC01	SD	BYD73 *	SC01	R
BUZ72A	S9	PM	BY329*	S2a	R	BYD74 *	SC01	R
BUZ73	S9	PM	BY359*	S2a	R	BYD77 *	SC01	R
BUZ73A	S9	PM	BY438	SC01	R	BYM26 *	SC01	R
BUZ74	S9	PM	BY448	SC01	R	BYM36 *	SC01	R
BUZ74A	S9	PM	BY458	SC01	R	BYM56 *	SC01	R
BUZ76	S9	PM	BY505	SC01	R	BYP21*	S2a	R
BUZ76A	S9	PM	BY509	SC01	R	BYP22*	S2a	R
BUZ78	S9	PM	BY527	SC01	R	BYP59*	S2a	R
BUZ80	S9	PM	BY584	SC01	R	BYQ27*	SC01	R
BUZ80A	S9	PM	BY588	SC01	R	BYQ28*	S2a	R
BUZ83	S9	PM	BY609	SC01	R	BYR29*	S2a	R
BUZ83A	S9	PM	BY610	SC01	R	BYR29F*	S2a	R
BUZ84	S9	PM	BY614	SC01	R	BYR30*	SC01	R
BUZ84A	S9	PM	BY619	SC01	R	BYR79*	SC01	R
BUZ90	S9	PM	BY620	SC01	R	BYT28*	S2a	R
BUZ90A	S9	PM	BY627	SC01	R	BYT79*	S2a	R
BUZ94	S9	PM	BY705	SC01	R	BYT23OPIV	SC01	R
BUZ211	S9	PM	BY706	SC01	R	BYV10*	SC01	R
BUZ307	S9	PM	BY707	SC01	R	BYV18*	S2a	R
BUZ308	S9	PM	BY708	SC01	R	BYV19*	S2a	R
BUZ310	S9	PM	BY709	SC01	R	BYV20*	S2a	R
BUZ311	S9	PM	BY710	SC01	R	BYV21*	S2a	R
BUZ326	S9	PM	BY711	SC01	R	BYV22*	S2a	R
BUZ330	S9	PM	BY712	SC01	R	BYV23*	S2a	R
BUZ331	S9	PM	BY713	SC01	R	BYV24*	S2a	R

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BYV26 *	SC01/S2a	R	BYX10G	SC01	R	CNX21	SC12	PhC
BYV27*	SC01/S2a	R	BYX25*	S2a	R	CNX35	SC12	PhC
BYV28*	SC01/S2a	R	BYX30*	S2a	R	CNX35U	SC12	PhC
BYV29*	S2a	R	BYX32*	S2a	R	CNX36	SC12	PhC
BYV29F*	S2a	R	BYX38*	S2a	R	CNX36U	SC12	PhC
BYV30*	S2a	R	BYX39*	S2a	R	CNX38	SC12	PhC
BYV31*	S2a	R	BYX42*	S2a	R	CNX38U	SC12	PhC
BYV32*	S2a	R	BYX46*	S2a	R	CNX39	SC12	PhC
BYV32F*	S2a	R	BYX50*	S2a	R	CNX39U	SC12	PhC
BYV33*	S2a	R	BYX52*	S2a	R	CNX44	SC12	PhC
BYV33F*	S2a	R	BYX56*	S2a	R	CNX44A	SC12	PhC
BYV34*	S2a	R	BYX90G	SC01	R	CNX46	SC12	PhC
BYV36 *	SC01	R	BYX96*	S2a	R	CNX48	SC12	PhC
BYV39*	S2a	R	BYX97*	S2a	R	CNX48U	SC12	PhC
BYV42*	S2a	R	BYX98*	S2a	R	CNX62	SC12	PhC
BYV43*	S2a	R	BYX99*	S2a	R	CNX72	SC12	PhC
BYV43F*	S2a	R	BZD23	SC01	Vrg	CNX82	SC12	PhC
BYV44*	S2a	R	BZD27	SC01/10	Vrg/Mm	CNX83	SC12	PhC
BYV54V	SC01	R	BZT03	SC01	Vrg	CNX91	SC12	PhC
BYV60*	S2a	R	BZV10	SC01	Vrf	CNX92	SC12	PhC
BYV72*	S2a	R	BZV11	SC01	Vrf	CNY17-1	SC12	PhC
BYV73*	S2a	R	BZV12	SC01	Vrf	CNY17-2	SC12	PhC
BYV74*	S2a	R	BZV13	SC01	Vrf	CNY17-3	SC12	PhC
BYV79*	S2a	R	BZV14	SC01	Vrf	CNY50	SC12	PhC
BYV92*	S2a	R	BZV37	SC01	Vrf	CNY57	SC12	PhC
BYV95A	SC01	R	BZV49*	SC01/10	Vrg/Mm	CNY57A	SC12	PhC
BYV95B	SC01	R	BZV55*	SC10	Mm	CNY57AU	SC12	PhC
BYV95C	SC01	R	BZV60	SC01	Vrg	CNY57U	SC12	PhC
BYV96D	SC01	R	BZV80	SC01	Vrf	CNY62	SC12	PhC
BYV96E	SC01	R	BZV81	SC01	Vrf	CNY63	SC12	PhC
BYW25*	S2a	R	BZV85*	SC01	Vrg	CQF24	SC12	Ph
BYW29*	S2a	R	BZV86	SC01	SD	CQL10A	SC12	Ph
BYW29F*	S2a	R	BZWO3*	SC01	Vrg	CQL13A	SC12	Ph
BYW30*	S2a	R	BZW14	SC01	Vrg	CQL16	SC12	Ph
BYW31*	S2a	R	BZW86*	S2a	TS	CQW58A	S8a	I
BYW54	SC01	R	BZX55*	SC01	Vrg	CQW89A	S8a	I
BYW55	SC01	R	BZX70*	S2a	Vrg	CQW89B	S8a	I
BYW56	SC01	R	BZX75*	SC01	Vrg	CQY58A	S8a	I
BYW92*	S2a	R	BZX79*	SC01	Vrg	CQY89A	S8a	I
BYW93*	S2a	R	BZX84*	SC01/10	Vrg/Mm	CQY89F	S8a	I
BYW95A	SC01	R	BZY91*	S2a	Vrg	ESM3045A(V)	SC06	SP
BYW95B	SC01	R	BZY93*	S2a	Vrg	ESM3045D(V)	SC06	SP
BYW95C	SC01	R	CNG35	SC12	PhC	ESM4045A(V)	SC06	SP
BYW96D	SC01	R	CNG36	SC12	PhC	ESM4045D(V)	SC06	SP
BYW96E	SC01	R	CNR36	SC12	PhC	ESM5045D(V)	SC06	SP

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ESM6045A(V)	SC06	SP	LKE2015T	SC15	M	MPS6515	SC04	Sm
ESM6045D(V)	SC06	SP	LKE21004R	SC15	M	MPS6517	SC04	Sm
Fresnel-lens	SC12	A	LKE21015T	SC15	M	MPS6518	SC04	Sm
H11A1	SC12	PhC	LKE21050T	SC15	M	MPS6519	SC04	Sm
H11A2	SC12	PhC	LKE27010R	SC15	M	MPS6520	SC04	Sm
H11A3	SC12	PhC	LKE27025R	SC15	M	MPS6521	SC04	Sm
H11A4	SC12	PhC	LKE32002T	SC15	M	MPS6522	SC04	Sm
H11A5	SC12	PhC	LKE32004T	SC15	M	MPS6523	SC04	Sm
H11B1	SC12	PhC	LTE21009R	SC15	M	MPSA05	SC04	Sm
H11B2	SC12	PhC	LTE21015R	SC15	M	MPSA06	SC04	Sm
H11B3	SC12	PhC	LTE21025R	SC15	M	MPSA13	SC04	Sm
H11B255	SC12	PhC	LTE4002S	SC15	M	MPSA14	SC04	Sm
KMZ10A	SC13	SEN	LTE42005S	SC15	M	MPSA42	SC04	Sm
KMZ10B	SC13	SEN	LTE42008R	SC15	M	MPSA43	SC04	Sm
KMZ10C	SC13	SEN	LTE42012R	SC15	M	MPSA55	SC04	Sm
KP100A	SC13	SEN	LUE2003S	SC15	M	MPSA56	SC04	Sm
KP101A	SC13	SEN	LUE2009S	SC15	M	MPSA63	SC04	Sm
KP220G	SC13	SEN	LV1721E50R	SC15	M	MPSA64	SC04	Sm
KP221G	SC13	SEN	LV2024E45R	SC15	M	MPSA92	SC04	Sm
KTY81-100*	SC13	SEN	LV2327E40R	SC15	M	MPSA93	SC04	Sm
KTY81-200*	SC13	SEN	LV2931E50S	SC15	M	MRB11080Y	SC15	M
KTY83-100*	SC13	SEN	LV3742E16R	SC15	M	MRB11175Y	SC15	M
KTY84-100*	SC13	SEN	LV3742E24R	SC15	M	MRB11350Y	SC15	M
KTY85-100*	SC10	SEN	LVE21050R	SC15	M	MRB12175YR	SC15	M
LAE2001R	SC15	M	LWE2015R	SC15	M	MRB12350YR	SC15	M
LAE4000Q	SC15	M	LWE2025R	SC15	M	MS1011B700Y	SC15	M
LAE4001R	SC15	M	LZ1418E100R	SC15	M	MS6075B800Z	SC15	M
LAE4002S	SC15	M	MCA230	SC12	PhC	MSB11900Y	SC15	M
LAE6000Q	SC15	M	MCA231	SC12	PhC	MSB12900Y	SC15	M
LBE1004R	SC15	M	MCA255	SC12	PhC	MZ0912B75Y	SC15	M
LBE1010R	SC15	M	MCT2	SC12	PhC	MZ0912B150Y	SC15	M
LBE2003S	SC15	M	MCT26	SC12	PhC	OM286; M	SC13	SEN
LBE2005Q	SC15	M	MJE13004	SC06	SP	OM287; M	SC13	SEN
LBE2008T	SC15	M	MJE13005	SC06	SP	OM320	SC14	WBM
LBE2009S	SC15	M	MJE13006	SC06	SP	OM321	SC14	WBM
LCE1004R	SC15	M	MJE13007	SC06	SP	OM322	SC14	WBM
LCE1010R	SC15	M	MJE13008	SC06	SP	OM323	SC14	WBM
LCE2003S	SC15	M	MJE13009	SC06	SP	OM323A	SC14	WBM
LCE2005Q	SC15	M	MKB12040WS	SC15	M	OM335	SC14	WBM
LCE2008T	SC15	M	MKB12100WS	SC15	M	OM336	SC14	WBM
LCE2009S	SC15	M	MKB12140W	SC15	M	OM337	SC14	WBM
LJE42002T	SC15	M	MO6075B200Z	SC15	M	OM337A	SC14	WBM
LKE1004R	SC15	M	MO6075B400Z	SC15	M	OM339	SC14	WBM
LKE2002T	SC15	M	MPS6513	SC04	Sm	OM345	SC14	WBM
LKE2004T	SC15	M	MPS6514	SC04	Sm	OM350	SC14	WBM

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OM360	SC14	WBM	PKB3003U	SC15	M	PLED-TR12E	S8a	LED
OM361	SC14	WBM	PKB3005U	SC15	M	PLED-TR12F	S8a	LED
OM370	SC14	WBM	PKB12005U	SC15	M	PLED-TR12G	S8a	LED
OM386B	SC13	SEN	PKB20010U	SC15	M	PLED-TR42DL	S8a	LED
OM386M	SC13	SEN	PKB23001U	SC15	M	PLED-Y313A	S8a	LED
OM387B	SC13	SEN	PKB23003U	SC15	M	PLED-Y313N	S8a	LED
OM387M	SC13	SEN	PKB23005U	SC15	M	PLED-Y314A	S8a	LED
OM388B	SC13	SEN	PKB25006T	SC15	M	PLED-Y314N	S8a	LED
OM389B	SC13	SEN	PKB32001U	SC15	M	PLED-Y511C	S8a	LED
OM931	SC05	P	PKB32003U	SC15	M	PLED-Y513C	S8a	LED
OM961	SC05	P	PKB32005U	SC15	M	PLED-Y513M	S8a	LED
OSB9115	S2a	St	PLED-G313A	S8a	LED	PLED-Y514B	S8a	LED
OSB9215	S2a	St	PLED-G313N	S8a	LED	PLED-Y514M	S8a	LED
OSB9415	S2a	St	PLED-G314A	S8a	LED	PLED-Y544KL	S8a	LED
OSM9115	S2a	St	PLED-G314N	S8a	LED	PLED-Y544LL	S8a	LED
OSM9215	S2a	St	PLED-G511C	S8a	LED	PLED-YR14E	S8a	LED
OSM9415	S2a	St	PLED-G513C	S8a	LED	PLED-YR14F	S8a	LED
OSM9510	S2a	St	PLED-G513M	S8a	LED	PLED-YR14G	S8a	LED
OSM9511	S2a	St	PLED-G514B	S8a	LED	PLED-YR44DL	S8a	LED
OSM9512	S2a	St	PLED-G514M	S8a	LED	PMBD914	SC01	SD
OSS9115	S2a	St	PLED-G544KL	S8a	LED	PMBD2835	SC01	SD
OSS9215	S2a	St	PLED-G544LL	S8a	LED	PMBD2836	SC01	SD
OSS9415	S2a	St	PLED-GR14E	S8a	LED	PMBD2837	SC01	SD
P2105	SC12	I	PLED-GR14F	S8a	LED	PMBD2838	SC01	SD
PDE1001U	SC15	M	PLED-GR14G	S8a	LED	PMBD6050	SC01	SD
PDE1003U	SC15	M	PLED-GR44DL	S8a	LED	PMBD6100	SC01	SD
PDE1005U	SC15	M	PLED-H313A	S8a	LED	PMBD7000	SC01	SD
PDE1010U	SC15	M	PLED-H314A	S8a	LED	PMBF170	SC07/10	FET/Mm
PEE1001U	SC15	M	PLED-H511C	S8a	LED	PMBF4391	SC07/10	FET/Mm
PEE1003U	SC15	M	PLED-H514B	S8a	LED	PMBF4392	SC07/10	FET/Mm
PEE1005U	SC15	M	PLED-H544KL	S8a	LED	PMBF4393	SC07/10	FET/Mm
PEE1010U	SC15	M	PLED-H544LL	S8a	LED	PMBFJ174	SC07/10	FET/Mm
PH2222/A	SC04	Sm	PLED-HR14E	S8a	LED	PMBFJ175	SC07/10	FET/Mm
PH2369	SC04	Sm	PLED-HR14F	S8a	LED	PMBFJ176	SC07/10	FET/Mm
PH2907	SC04	Sm	PLED-HR14G	S8a	LED	PMBFJ177	SC07/10	FET/Mm
PH2907A	SC04	Sm	PLED-HR44DL	S8a	LED	PMBT2222	SC10	Mm
PH5415	SC04	Sm	PLED-O313N	S8a	LED	PMBT2222A	SC10	Mm
PH5416	SC04	Sm	PLED-O314N	S8a	LED	PMBT2369	SC10	Mm
PH6659	SC07	FET	PLED-O513M	S8a	LED	PMBT2907	SC10	Mm
PH6660	SC07	FET	PLED-O514M	S8a	LED	PMBT2907A	SC10	Mm
PH6661	SC07	FET	PLED-P313N	S8a	LED	PMBT3903	SC10	Mm
PH13002	SC06	SP	PLED-P314N	S8a	LED	PMBT3904	SC10	Mm
PH13003	SC06	SP	PLED-P513M	S8a	LED	PMBT3906	SC10	Mm
PHSD51	S2a	R	PLED-P514M	S8a	LED	PMBT4401	SC10	Mm
PKB3001U	SC15	M	PLED-T512B	S8a	LED	PMBT4403	SC10	Mm

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PMBT5550	SC10	Mm	PTB32001X	SC15	M	RPY100	SC12	I
PMBT5551	SC10	Mm	PTB32003X	SC15	M	RPY101	SC12	I
PMBT6428	SC10	Mm	PTB32005X	SC15	M	RPY102	SC12	I
PMBT6429	SC10	Mm	PTB42001X	SC15	M	RPY103	SC12	I
PMBTA05	SC10	Mm	PTB42002X	SC15	M	RPY107	SC12	I
PMBTA06	SC10	Mm	PTB42003X	SC15	M	RPY109	SC12	I
PMBTA13	SC10	Mm	PV3742B4X	SC15	M	RV2833B5X	SC15	M
PMBTA14	SC10	Mm	PVB42004X	SC15	M	RV3135B5X	SC15	M
PMBTA42	SC10	Mm	PXT2222	SC10	Mm	RX1011B250Y	SC15	M
PMBTA43	SC10	Mm	PXT2222A	SC10	Mm	RX1011B350Y	SC15	M
PMBTA55	SC10	Mm	PXT2907	SC10	Mm	RX1214B150Y	SC15	M
PMBTA56	SC10	Mm	PXT2907A	SC10	Mm	RX1214B300Y	SC15	M
PMBTA63	SC10	Mm	PXT3904	SC10	Mm	RX2731B90W	SC15	M
PMBTA64	SC10	Mm	PXT3906	SC10	Mm	RX3034B70W	SC15	M
PMBTA92	SC10	Mm	PXT4401	SC10	Mm	RXB12350Y	SC15	M
PMBTA93	SC10	Mm	PXT4403	SC10	Mm	RZ1214B35Y	SC15	M
PMBZ5226	SC01	SD	PXTA14	SC10	Mm	RZ1214B65Y	SC15	M
PMLL4148	SC01/10	SD/Mm	PXTA27	SC10	Mm	RZ1214B125Y	SC15	M
PMLL4150	SC01/10	SD/Mm	PXTA64	SC10	Mm	RZ1214B150Y	SC15	M
PMLL4151	SC01/10	SD/Mm	PXTA77	SC10	Mm	RZ2731B45W	SC15	M
PMLL4153	SC01/10	SD/Mm	PZ1418B15U	SC15	M	RZ2731B60W	SC15	M
PMLL4446	SC01/10	SD/Mm	PZ1418B30U	SC15	M	RZ2833B15W	SC15	M
PMLL4448	SC01/10	SD/Mm	PZ1721B12U	SC15	M	RZ2833B30W	SC15	M
PMLL5225B to			PZ1721B25U	SC15	M	RZ2833B45W	SC15	M
PMLL5267B	SC01/10	SD/Mm	PZ2024B10U	SC15	M	RZ2833B60W	SC15	M
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PN2222A	SC04	Sm	PZ2327B15U	SC15	M	RZ3135B30W	SC15	M
PN2369	SC04	Sm	PZB16035U	SC15	M	RZ3135B40W	SC15	M
PN2369A	SC04	Sm	PZB16040U	SC15	M	RZ3135B50W	SC15	M
PN2907	SC04	Sm	PZB27020U	SC15	M	RZB12050Y	SC15	M
PN2907A	SC04	Sm	PZT2222	SC10	Mm	RZB12100Y	SC15	M
PN3439	SC04	Sm	PZT2222A	SC10	Mm	RZB12250Y	SC15	M
PN3440	SC04	Sm	PZT2907	SC10	Mm	SL5500	SC12	PhC
PN4391	SC07	FET	PZT2907A	SC10	Mm	SL5501	SC12	PhC
PN4392	SC07	FET	PZT3904	SC10	Mm	SL5502R	SC12	PhC
PN4393	SC07	FET	PZT3906	SC10	Mm	SL5504	SC12	PhC
PN5415	SC04	Sm	PZTA13	SC10	Mm	SL5504S	SC12	PhC
PN5416	SC04	Sm	PZTA14	SC10	Mm	SL5505S	SC12	PhC
P044	SC12	PhC	PZTA42	SC10	Mm	SL5511	SC12	PhC
P044A	SC12	PhC	PZTA43	SC10	Mm	TIP29*	SC05	P
PPC5001T	SC15	M	PZTA63	SC10	Mm	TIP30*	SC05	P
PQC5001T	SC15	M	PZTA64	SC10	Mm	TIP31*	SC05	P
PTB23001X	SC15	M	PZTA92	SC10	Mm	TIP32*	SC05	P

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TIP41*	SC05	P	1N3890	S2a	R	2N2222	SC04	Sm
TIP42*	SC05	P	1N3891	S2a	R	2N2222A	SC04	Sm
TIP47	SC06	P	1N3892	S2a	R	2N2297	SC04	Sm
TIP48	SC06	P	1N3893	S2a	R	2N2369	SC04	Sm
TIP49	SC06	P	1N3909	S2a	R	2N2369A	SC04	Sm
TIP50	SC06	P	1N3910	S2a	R	2N2483	SC04	Sm
TIP110	SC05	P	1N3911	S2a	R	2N2484	SC04	Sm
TIP111	SC05	P	1N3912	S2a	R	2N2904	SC04	Sm
TIP112	SC05	P	1N3913	S2a	R	2N2904A	SC04	Sm
TIP115	SC05	P	1N4001D	SC01	R	2N2905	SC04	Sm
TIP116	SC05	P	1N4002D	SC01	R	2N2905A	SC04	Sm
TIP117	SC05	P	1N4003D	SC01	R	2N2906	SC04	Sm
TIP120	SC05	P	1N4004D	SC01	R	2N2906A	SC04	Sm
TIP121	SC05	P	1N4005D	SC01	R	2N2907	SC04	Sm
TIP122	SC05	P	1N4006D	SC01	R	2N2907A	SC04	Sm
TIP125	SC05	P	1N4007D	SC01	R	2N3019	SC04	Sm
TIP126	SC05	P	1N4001G	SC01	R	2N3020	SC04	Sm
TIP127	SC05	P	1N4002G	SC01	R	2N3053	SC04	Sm
TIP130	SC05	P	1N4003G	SC01	R	2N3375	SC08	RFP
TIP131	SC05	P	1N4004G	SC01	R	2N3553	SC08	RFP
TIP132	SC05	P	1N4005G	SC01	R	2N3632	SC08	RFP
TIP135	SC05	P	1N4006G	SC01	R	2N3822	SC07	FET
TIP136	SC05	P	1N4007G	SC01	R	2N3823	SC07	FET
TIP137	SC05	P	1N4148	SC01	SD	2N3866	SC08	RFP
TIP140	SC05	P	1N4150	SC01	SD	2N3903	SC04	Sm
TIP141	SC05	P	1N4151	SC01	SD	2N3904	SC04	Sm
TIP142	SC05	P	1N4153	SC01	SD	2N3905	SC04	Sm
TIP145	SC05	P	1N4446	SC01	SD	2N3906	SC04	Sm
TIP146	SC05	P	1N4448	SC01	SD	2N3924	SC08	RFP
TIP147	SC05	P	1N4531	SC01	SD	2N3926	SC08	RFP
TIP2955;T	SC05	P	1N4532	SC01	SD	2N3927	SC08	RFP
TIP3055;T	SC05	P	1N4933	SC01	R	2N3966	SC07	FET
1N821;A	SC01	Vrf	1N5059	SC01	R	2N4030	SC04	Sm
1N823;A	SC01	Vrf	1N5060	SC01	R	2N4031	SC04	Sm
1N825;A	SC01	Vrf	1N5061	SC01	R	2N4032	SC04	Sm
1N827;A	SC01	Vrf	1N5062	SC01	R	2N4033	SC04	Sm
1N829;A	SC01	Vrf	1N5225B to			2N4091	SC07	FET
1N914	SC01	SD	1N5267B	SC01	R	2N4092	SC07	FET
1N916	SC01	SD	2N918	SC14	WBT	2N4093	SC07	FET
1N3879	S2a	R	2N930	SC04	Sm	2N4123	SC04	Sm
1N3880	S2a	R	2N1613	SC04	Sm	2N4124	SC04	Sm
1N3881	S2a	R	2N1711	SC04	Sm	2N4125	SC04	Sm
1N3882	S2a	R	2N1893	SC04	Sm	2N4126	SC04	Sm

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2N4400	SC04	Sm	56326	SC06	A
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2N4402	SC04	Sm	56352	SC06	A
2N4403	SC04	Sm	56353	SC06	A
2N4427	SC08	RFP	56354	SC06	A
2N4856	SC07	FET	56359b	S2/4	A
2N4857	SC07	FET	56359c	S2/4	A
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2N6661	SC07	FET			
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S4a	SC05	Low-frequency power transistors and hybrid IC power modules
S4b	SC06	High-voltage and switching power transistors
S5	SC07*	Small-signal field-effect transistors
S6	SC08*	RF power transistors
	SC09	RF power modules
S7	SC10	Surface mounted semiconductors
S8a	SC11*	Light emitting diodes
S8b	SC12	Optocouplers
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S15**	SC16	Laser diodes
S13	SC17	Semiconductor sensors
S14	SC18*	Liquid crystal displays and driver ICs for LCDs

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C2	DC03*	Television tuners, coaxial aerial input assemblies
C3	DC04*	Loudspeakers
C20	DC05*	Wire-wound components for TVs and monitors

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C11	PA02*	Varistors, thermistors and sensors
C12	PA03*	Potentiometers, encoders and switches
C7	PA04*	Variable capacitors
C22	PA05*	Film capacitors
C15	PA06*	Ceramic capacitors
C9	PA07*	Piezoelectric quartz devices
C13	PA08*	Fixed resistors

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T2a	*	Transmitting tubes for communications, glass types
T2b	*	Transmitting tubes for communications, ceramic types
T3	PC01**	High-power klystrons
T4	*	Magnetrons for microwave heating
T5	PC02**	Cathode-ray tubes
T6	PC03**	Geiger-Müller tubes
T9	PC04**	Photo and electron multipliers
T10	PC05**	Plumbicon camera tubes and accessories
T11	PC06**	Microwave diodes and sub-assemblies
T12	PC07	Vidicon and Newvicon camera tubes and deflection units
T13	PC08	Image intensifiers
T15	PC09**	Dry reed switches
C8	PC10	Variable mains transformers; annular fixed transformers
	PC11	Solid state image sensors and peripheral integrated circuits

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current code	new code	handbook title
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C16	MA02**	Permanent magnet materials
C19	MA03**	Piezoelectric ceramics

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