POWER TRANSISTORS,
THYRISTORS (SCRs),
TRIACS AND
RECTIFIERS

The Power Semiconductor Data Book

for

Design Engineers

TEXAS INSTRUMENTS

1979

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for

Design Engineers

TEXAS INSTRUMENTS

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Product Selection Guide

PRODUCT SELECTION GUIDE
TRANSISTORS

selection by current and voltage

Device Type		I_C cont	V_{CEO} *V_{CBO}	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	min	A	V	A	W	°C	
BF715	BF716	0.03	250	50	0.05	–	–	6.25	25	TO-202
BF717	BF718	0.03	300	50	0.05	–	–	6.25	25	TO-202
BF457		0.2	160	25	0.03	1.0	0.03	12.5	25	SOT-32
BF415	BF416	0.2	250	30	0.025	1.0	0.025	6.0	25	SOT-32
BF615	BF616	0.2	250	30	0.025	1.0	0.025	10.0	25	TO-202
BF458		0.2	250	25	0.03	1.0	0.03	12.5	25	SOT-32
BF417	BF418	0.2	300	30	0.025	1.0	0.025	6.0	25	SOT-32
BF617	BF618	0.2	300	30	0.025	1.0	0.025	10.0	25	TO-202
BF459		0.2	300	25	0.03	1.0	0.03	12.5	25	SOT-32
†BD477A	†BD466A	1.0	30	10000	0.15	1.5	0.5	8.5	25	SOT-32
TIP29	TIP30	1.0	40	40	0.2	0.7	1.0	30.0	25	Use BD239/240
†BD477B	†BD466B	1.0	45	10000	0.15	1.5	0.5	8.5	25	SOT-32
BD135	BD136	1.0	45	40	0.15	0.5	0.5	6.5	25	SOT-32
TIP29A	TIP30A	1.0	60	40	0.2	0.7	1.0	30.0	25	Use BD239A/240A
BD137	BD138	1.0	60	40	0.15	0.5	0.5	6.5	25	SOT-32
TIP29B	TIP30B	1.0	80	40	0.2	0.7	1.0	30.0	25	Use BD249B/240B
BD139	BD140	1.0	80	40	0.15	0.5	0.5	6.5	25	SOT-32
TIC29C	TIC30C	1.0	100	40	0.2	0.7	1.0	30.0	25	Use BD249C/240C
2N3583		1.0	175	40	0.5	0.5	1.0	20.0	100	TO-66
TIP47		1.0	250	30	0.3	1.0	1.0	40.0	25	TO-220
TIP48		1.0	300	30	0.3	1.0	1.0	40.0	25	TO-220
BD410		1.0	325	30	0.05	0.5	0.1	20.0	25	SOT-32
TIP49		1.0	350	30	0.3	1.0	1.0	40.0	25	TO-220
TIP50		1.0	400	30	0.3	1.0	1.0	40.0	25	TO-220
BD165	BD166	1.5	45	40	0.15	0.5	0.5	20.0	25	SOT-32
BD167	BD168	1.5	60	40	0.15	0.5	0.5	20.0	25	SOT-32
BD169	BD170	1.5	80	40	0.15	0.5	0.5	20.0	25	SOT-32
BD233	BD234	2.0	45	40	0.15	0.6	1.0	25.0	25	SOT-32
BD239	BD240	2.0	45	15	1.0	0.7	1.0	30.0	25	TO-220
BD235	BD236	2.0	60	40	0.15	0.6	1.0	25.0	25	SOT-32
BD239A	BD240A	2.0	60	15	1.0	0.7	1.0	30.0	25	TO-220
BD237	BD238	2.0	80	40	0.15	0.6	1.0	25.0	25	SOT-32
2N5333		2.0	80	30	1.0	0.45	1.0	15.0	100	TO-5
2N4998	2N4999	2.0	80	30	1.0	0.85	2.0	20.0	100	TO-59
2N5000	2N5001	2.0	80	70	1.0	0.85	2.0	20.0	100	TO-59
2N5148	2N5147	2.0	80	30	1.0	0.85	2.0	4.0	100	TO-39
2N5150	2N5149	2.0	80	70	1.0	0.85	2.0	4.0	100	TO-39
2N5152		2.0	80	30	2.5	0.75	2.5	6.7	100	TO-39
2N5154		2.0	80	70	2.5	0.75	2.5	6.7	100	TO-39
BD239B	BD240B	2.0	80	15	1.0	0.7	1.0	30.0	25	TO-220
BD239C	BD240C	2.0	100	15	1.0	0.7	1.0	30.0	25	TO-220
TIP503		2.0	120	40	1.0	0.6	1.0	20.0	100	TO-66
TIP505		2.0	120	40	1.0	0.6	1.0	20.0	100	TO-59
TIP504		2.0	150	40	1.0	0.6	1.0	20.0	100	TO-66
TIP506		2.0	150	40	1.0	0.6	1.0	20.0	100	TO-59
	TIP507	2.0	150	30	1.0	1.5	2.0	20.0	100	TO-59
	TIP508	2.0	150	30	1.0	1.5	2.0	4.0	100	TO-39
	TIP521	2.0	200	20	1.0	2.5	2.0	20.0	100	TO-59
	TIP522	2.0	200	20	1.0	2.5	2.0	4.0	100	TO-39
2N3584		2.0	250	8	1.0	0.75	1.0	20.0	100	TO-66
2N3585		2.0	300	8	1.0	0.75	1.0	20.0	100	TO-66
2N4240		2.0	300	10	0.75	1.0	0.75	20.0	100	TO-66
2N3902		2.5	400	30	1.0	0.8	1.0	67.0	100	TO-3
BU105		2.5	*1500	–	–	5.0	2.5	10.0	90	TO-3
TIP31	TIP32	3.0	40	25	1.0	1.2	3.0	30.0	25	Use BD241/242
BD175	BD176	3.0	45	40	0.15	0.8	1.0	30.0	25	SOT-32
BD241	BD242	3.0	45	10	3.0	1.2	3.0	40.0	25	TO-220
BD177	BD178	3.0	60	40	0.15	0.8	1.0	30.0	25	SOT-32
TIP31A	TIP32A	3.0	60	25	1.0	1.2	3.0	30.0	25	Use BD241A/242A
BD241A	BD242A	3.0	60	10	3.0	1.2	3.0	40.0	25	TO-220
2N3418		3.0	60	10	1.0	0.25	1.0	15.0	100	TO-5
2N3420		3.0	60	15	1.0	0.25	1.0	15.0	100	TO-5
BD179	BD180	3.0	80	40	0.15	0.8	1.0	30.0	25	SOT-32

† Darlington

PRODUCT SELECTION GUIDE
TRANSISTORS

Device Type		$I_C$cont	V_{CEO} *V_{CBO}	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	MIN	A	V	A	W	°C	
TIP31B	TIP32B	3.0	80	25	1.0	1.2	3.0	30.0	25	Use BD241B/242B
BD241B	BD242B	3.0	80	10	3.0	1.2	3.0	40.0	25	TO-220
2N3419		3.0	80	10	1.0	0.25	1.0	15.0	100	TO-5
2N3421		3.0	80	15	1.0	0.25	1.0	15.0	100	TO-5
TIP31C	TIP32C	3.0	100	25	1.0	1.2	3.0	30.0	25	Use BD241C/242C
BD241C	BD242C	3.0	100	10	3.0	1.2	3.0	40.0	25	TO-220
TIP75		3.0	200	30	0.5	1.9	3.0	65.0	25	TO-220
TIP575		3.0	200	30	0.5	1.9	3.0	100.0	25	TO-3
TIP51		3.0	250	10	3.0	1.5	3.0	100.0	25	TO-3 PLASTIC
TIP75A		3.0	250	30	0.5	1.9	3.0	65.0	25	TO-220
TIP575A		3.0	250	30	0.5	1.9	3.0	100.0	25	TO-3
2N5838		3.0	250	8	3.0	1.0	3.0	57.0	100	TO-3
2N5839		3.0	275	10	2.0	1.5	2.0	57.0	100	TO-3
TIP75B		3.0	300	30	0.5	1.9	3.0	65.0	25	TO-220
TIP529		3.0	300	25	1.5	2.5	3.0	67.0	100	TO-61
TIP530		3.0	300	25	1.5	2.5	3.0	20.0	100	TO-66
TIP52		3.0	300	10	3.0	1.5	3.0	100.0	25	TO-3 PLASTIC
TIP554		3.0	300	10	3.0	1.5	3.0	100.0	100	TO-3
TIP575B		3.0	300	30	0.5	1.9	3.0	100.0	25	TO-3
TIP53		3.0	350	10	3.0	1.5	3.0	100.0	25	TO-3 PLASTIC
TIP555		3.0	350	10	3.0	1.5	3.0	100.0	100	TO-3
2N5840		3.0	350	10	2.0	1.5	2.0	57.0	100	TO-3
TIP54		3.0	400	10	3.0	1.5	3.0	100.0	25	TO-3 PLASTIC
TIP75C		3.0	400	30	0.5	1.9	3.0	65.0	25	TO-220
TIP556		3.0	400	10	3.0	1.5	3.0	100.0	100	TO-3
TIP575C		3.0	400	30	0.5	1.9	3.0	100.0	25	TO-3
2N5157		3.5	500	30	1.0	0.8	1.0	67.0	100	TO-3
†BDW53	†BDW54	4.0	45	750	1.5	4.0	4.0	40.0	25	TO-220
†BDW53A	†BDW54A	4.0	60	750	1.5	4.0	4.0	40.0	25	TO-220
†TIP110	†TIP115	4.0	60	1000	1.0	2.5	2.0	50.0	25	TO-220
†BDW53B	†BDW54B	4.0	80	750	1.5	4.0	4.0	40.0	25	TO-220
†TIP111	†TIP116	4.0	80	1000	1.0	2.5	2.0	50.0	25	TO-220
†BDW53C	†BDW54C	4.0	100	750	1.5	4.0	4.0	40.0	25	TO-220
†TIP112	†TIP117	4.0	100	1000	1.0	2.5	2.0	50.0	25	TO-220
†BDW53D	†BDW54D	4.0	120	750	1.5	4.0	4.0	40.0	25	TO-220
TIP509		4.0	120	40	2.0	0.6	2.0	30.0	100	TO-3
TIP511		4.0	120	40	2.0	0.6	2.0	30.0	100	TO-61
TIP510		4.0	150	40	2.0	0.6	2.0	30.0	100	TO-3
TIP512		4.0	150	40	2.0	0.6	2.0	30.0	100	TO-61
BD253		4.0	200	15	1.0	2.0	3.0	50.0	25	TO-3
BD253A		4.0	250	15	1.0	2.0	3.0	50.0	25	TO-3
BD253B		4.0	300	15	1.0	2.0	3.0	50.0	25	TO-3
BD253C		4.0	400	15	1.0	2.0	3.0	50.0	25	TO-3
BD539	BD540	5.0	40	30	1.0	0.8	3.0	45.0	25	TO-220
2N4913	2N4904	5.0	40	25	2.5	1.5	5.0	50.0	100	TO-3
2N5067	2N4901	5.0	40	20	1.0	1.5	5.0	87.5	25	TO-3
BD539A	BD540A	5.0	60	30	1.0	0.8	3.0	45.0	25	TO-220
2N4914	2N4905	5.0	60	25	2.5	1.5	5.0	50.0	100	TO-3
2N5068	2N4902	5.0	60	20	1.0	1.5	5.0	87.5	25	TO-3
†TIP120	†TIP125	5.0	60	1000	3.0	4.0	5.0	65.0	25	TO-220
†TIP620	†TIP625	5.0	60	1000	3.0	2.0	3.0	90.0	25	TO-3
2N5869	2N5867	5.0	60	20	1.5	2.0	3.0	87.5	25	TO-3
BD539B	BD540B	5.0	80	30	1.0	0.8	3.0	45.0	25	TO-220
	2N5385	5.0	80	20	2.0	0.6	2.0	30.0	25	TO-111
2N5069	2N4903	5.0	80	20	1.0	1.5	5.0	87.5	25	TO-3
2N4915	2N4906	5.0	80	25	2.5	1.5	5.0	87.5	25	TO-3
2N5870	2N5868	5.0	80	20	1.5	2.0	3.0	87.5	25	TO-3
2N3996		5.0	80	40	1.0	0.25	1.0	30.0	100	TO-111
2N3997		5.0	80	80	1.0	0.25	1.0	30.0	100	TO-111
2N3998		5.0	80	40	1.0	0.25	1.0	30.0	100	TO-111
2N3999		5.0	80	80	1.0	0.25	1.0	30.0	100	TO-111
	2N5384	5.0	80	20	2.0	0.6	2.0	30.0	100	TO-111
2N5002	2N5003	5.0	80	30	2.5	0.75	2.5	33.3	100	TO-59

† Darlington

TEXAS INSTRUMENTS

Device Type		$I_C$cont	V_{CEO} *V_{CBO}	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	min	A	V	A	W	°C	
2N5004	2N5005	5.0	80	70	2.5	0.75	2.5	33.3	100	TO-59
	2N5151	5.0	80	70	2.5	0.75	2.5	6.7	100	TO-39
	2N5153	5.0	80	70	2.5	0.75	2.5	6.7	100	TO-39
†TIP121	†TIP126	5.0	80	1000	3.0	4.0	5.0	65.0	25	TO-220
†TIP621	†TIP626	5.0	80	1000	3.0	2.0	3.0	90.0	25	TO-3
BD539C	BD540C	5.0	100	30	1.0	0.8	3.0	45.0	25	TO-220
†TIP122	†TIP127	5.0	100	1000	3.0	4.0	5.0	65.0	25	TO-220
†TIP622	†TIP627	5.0	100	1000	3.0	2.0	3.0	90.0	25	TO-3
BD539D	BD540D	5.0	120	30	1.0	0.8	3.0	45.0	25	TO-220
	TIP513	5.0	150	30	2.5	1.0	2.5	30.0	100	TO-59
	TIP514	5.0	150	30	2.5	1.0	2.5	20.0	100	TO-66
	TIP523	5.0	200	20	2.5	1.5	2.5	30.0	100	TO-59
	TIP524	5.0	200	20	2.5	1.5	2.5	6.0	100	TO-39
TIP525		5.0	200	30	2.5	1.2	2.5	60.0	100	TO-3
TIP526		5.0	200	30	2.5	1.2	2.5	60.0	100	TO-61
2N5241		5.0	400	10	3.5	0.7	2.5	125.0	62.5	TO-3
BUX82		5.0	400	5	2.5	3.0	4.0	60.0	25	TO-3
BU108		5.0	*1500	–	–	5.0	4.5	12.5	95	TO-3
BU208		5.0	*1500	–	–	5.0	4.5	12.5	95	TO-3
TIP41	TIP42	6.0	40	30	0.3	1.5	6.0	65.0	25	Use BD243/244
BD243	BD244	6.0	45	15	3.0	1.5	6.0	65.0	25	TO-220
†BDW63	†BDW64	6.0	45	750	2.0	4.0	6.0	60.0	25	TO-220
TIP41A	TIP42A	6.0	60	30	0.3	1.5	6.0	65.0	25	Use BD243A/244A
BD243A	BD244A	6.0	60	15	3.0	1.5	6.0	65.0	25	TO-220
†BDW63A	†BDW64A	6.0	60	750	2.0	4.0	6.0	60.0	25	TO-220
TIP41B	TIP42B	6.0	80	30	0.3	1.5	6.0	65.0	25	Use BD243B/244B
BD243B	BD244B	6.0	80	15	3.0	1.5	6.0	65.0	25	TO-220
†BDW63B	†BDW64B	6.0	80	750	2.0	4.0	6.0	60.0	25	TO-220
TIP41C	TIP42C	6.0	100	30	0.3	1.5	6.0	65.0	25	Use BD243C/244C
BD243C	BD244C	6.0	100	15	3.0	1.5	6.0	65.0	25	TO-220
†BDW63C	†BDW64C	6.0	100	750	2.0	4.0	6.0	60.0	25	TO-220
	TIP544	6.0	100	25	3.0	1.0	3.0	85.0	100	TO-3
2N5758		6.0	100	25	3.0	1.0	3.0	85.0	100	TO-3
†BDW63D	†BDW64D	6.0	120	750	2.0	4.0	6.0	60.0	25	TO-220
	TIP545	6.0	120	20	3.0	1.0	3.0	85.0	100	TO-3
2N5759		6.0	120	20	3.0	1.0	3.0	85.0	100	TO-3
	TIP546	6.0	140	15	3.0	1.0	3.0	85.0	100	TO-3
2N5760		6.0	140	15	3.0	1.0	3.0	85.0	100	TO-3
BU126		6.0	*750	15	1.0	2.0	2.0	50.0	25	TO-3
BU500		6.0	*1500	3	4.5	1.0	4.5	75.0	25	TO-3
2N5873	2N5871	7.0	60	20	2.5	2.0	5.0	115.0	25	TO-3
2N5874	2N5872	7.0	80	20	2.5	2.0	5.0	115.0	25	TO-3
†TIP150		7.0	300	150	2.5	2.0	5.0	80.0	25	TO-220
†TIP151		7.0	350	150	2.5	2.0	5.0	80.0	25	TO-220
†TIP152		7.0	400	150	2.5	2.0	5.0	80.0	25	TO-220
TI1135		7.5	50	30	2.0	1.0	2.0	50.0	100	TO-61
TI1136		7.5	50	15	2.0	1.0	2.0	50.0	100	TO-61
TI1155		7.5	50	20	5.0	2.5	5.0	50.0	100	TO-61
TI1156		7.5	50	10	5.0	2.5	5.0	50.0	100	TO-61
TI1133		7.5	75	30	2.0	1.0	2.0	50.0	100	TO-61
TI1134		7.5	75	15	2.0	1.0	2.0	50.0	100	TO-61
TI1153		7.5	75	20	5.0	2.5	5.0	50.0	100	TO-61
TI1154		7.5	75	10	5.0	2.5	5.0	50.0	100	TO-61
TI1131		7.5	100	30	2.0	1.0	2.0	50.0	100	TO-61
TI1132		7.5	100	15	2.0	1.0	2.0	50.0	100	TO-61
TI1151		7.5	100	20	5.0	2.5	5.0	50.0	100	TO-61
TI1152		7.5	100	10	5.0	2.5	5.0	50.0	100	TO-61
2N5387		7.5	200	25	2.0	2.0	5.0	100.0	100	TO-61
TIP535		7.5	200	20	5.0	1.2	5.0	100.0	100	TO-3
TIP558		7.5	200	10	1.0	2.5	10.0	100.0	100	TO-3
TIP55A		7.5	250	10	1.0	2.5	10.0	50.0	100	TO-3 PLASTIC
TIP56A		7.5	300	10	1.0	2.5	10.0	50.0	100	TO-3 PLASTIC
TIP559		7.5	250	10	1.0	2.5	10.0	100.0	100	TO-3

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PRODUCT SELECTION GUIDE
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Device Type		$I_C$cont	V_{CEO} $*V_{CBO}$	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	min	A	V	A	W	°C	
2N5388		7.5	250	25	2.0	2.0	5.0	100.0	100	TO-61
TIP536		7.5	300	20	5.0	1.2	5.0	100.0	100	TO-3
2N5389		7.5	300	25	2.0	2.0	5.0	100.0	100	TO-61
TIP560		7.5	300	10	1.0	2.5	10.0	100.0	100	TO-3
TIP57A		7.5	350	10	1.0	2.5	10.0	50.0	100	TO-3 PLASTIC
TIP537		7.5	400	20	5.0	1.2	5.0	100.0	100	TO-3
TIP58A		7.5	400	10	1.0	2.5	10.0	50.0	100	TO-3 PLASTIC
TIP561		7.5	400	10	1.0	2.5	10.0	100.0	100	TO-3
BD543	BD544	8.0	40	40	3.0	0.5	5.0	70.0	25	TO-220
†BDW73	†BDW74	8.0	45	750	3.0	4.0	8.0	80.0	25	TO-220
BD543A	BD544A	8.0	60	40	3.0	0.5	5.0	70.0	25	TO-220
†BDW73A	†BDW 74A	8.0	60	750	3.0	4.0	8.0	80.0	25	TO-220
†TIP130	†TIP135	8.0	60	1000	4.0	3.0	6.0	70.0	25	TO-220
BD543B	BD544B	8.0	80	40	3.0	0.5	5.0	70.0	25	TO-220
†BDW73B	†BDW74B	8.0	80	750	3.0	4.0	8.0	80.0	25	TO-220
†TIP131	†TIP136	8.0	80	1000	4.0	3.0	6.0	70.0	25	TO-220
†TIP132	†TIP137	8.0	100	1000	4.0	3.0	6.0	70.0	25	TO-220
BD543C	BD544C	8.0	100	40	3.0	0.5	5.0	70.0	25	TO-220
†BDW73C	†BDW74C	8.0	100	750	3.0	4.0	8.0	80.0	25	TO-220
BD543D	BD544D	8.0	120	40	3.0	0.5	5.0	70.0	25	TO-220
†BDW73D	†BDW74D	8.0	120	750	3.0	4.0	8.0	80.0	25	TO-220
	TIP519	8.0	150	30	4.0	1.0	4.0	50.0	100	TO-3
	TIP520	8.0	150	30	4.0	1.0	4.0	50.0	100	TO-61
	TIP527	8.0	200	20	4.0	1.5	4.0	60.0	100	TO-3
	TIP528	8.0	200	20	4.0	1.5	4.0	60.0	100	TO-61
2N6306		8.0	250	15	3.0	5.0	8.0	125.0	25	TO-3
2N6307		8.0	300	15	3.0	5.0	8.0	125.0	25	TO-3
TIP33	TIP34	10.0	40	20	3.0	4.0	10.0	80.0	25	Use BD245/246
BD245	BD246	10.0	45	20	3.0	5.0	10.0	80.0	25	TO-3 PLASTIC
TIP542		10.0	45	40	5.0	0.8	10.0	40.0	100	TO-59
TIP33A	TIP34A	10.0	60	20	3.0	4.0	10.0	80.0	25	Use BD245A/246A
BD245A	BD246A	10.0	60	20	3.0	4.0	10.0	80.0	25	TO-3 PLASTIC
†TIP140	†TIP145	10.0	60	1000	5.0	3.0	10.0	125.0	25	TO-3 PLASTIC
†TIP600	†TIP605	10.0	60	1000	3.0	2.5	10.0	100.0	25	TO-3
†TIP640	†TIP645	10.0	60	500	10.0	3.0	10.0	175.0	25	TO-3
2N5877	2N5875	10.0	60	20	4.0	3.0	8.0	150.0	25	TO-3
2N3713	2N3789	10.0	60	25	1.0	4.0	10.0	150.0	25	TO-3
2N3715	2N3791	10.0	60	50	1.0	4.0	10.0	150.0	25	TO-3
TIP543		10.0	65	40	5.0	0.8	10.0	40.0	100	TO-59
TIP33B	TIP34B	10.0	80	20	3.0	4.0	10.0	80.0	25	Use BD245B/246B
BD245B	BD246B	10.0	80	20	3.0	4.0	10.0	80.0	25	TO-3 PLASTIC
†TIP141	†TIP146	10.0	80	1000	5.0	3.0	10.0	125.0	25	TO-3 PLASTIC
†TIP601	†TIP606	10.0	80	1000	3,0	2.5	10.0	100.0	25	TO-3
†TIP641	†TIP646	10.0	80	500	10.0	3.0	10.0	175.0	25	TO-3
2N5878	2N5876	10.0	80	20	4.0	3.0	8.0	150.0	25	TO-3
2N3714	2N3790	10.0	80	25	1.0	4.0	10.0	150.0	25	TO-3
2N3716	2N3792	10.0	80	50	1.0	4.0	10.0	150.0	25	TO-3
2N4301		10.0	80	30	5.0	0.4	5.0	50.0	100	TO-61
TIP33C	TIP34C	10.0	100	20	3.0	4.0	10.0	80.0	25	Use BD245C/246C
BD245C	BD246C	10.0	100	20	3.0	4.0	10.0	80.0	25	TO-3 PLASTIC
†TIP142	†TIP147	10.0	100	1000	5.0	3.0	10.0	125.0	25	TO-3 PLASTIC
†TIP602	†TIP607	10.0	100	1000	3.0	2.5	10.0	100.0	25	TO-3
†TIP642	†TIP647	10.0	100	500	10.0	3.0	10.0	175.0	25	TO-3
BUY70C		10.0	200	15	1.0	5.0	4.0	75.0	25	TO-3
TIP562		10.0	300	20	1.0	1.2	10.0	100.0	100	TO-3
†TIP666		10.0	300	25	10.0	2.3	10.0	150.0	100	TO-3
†BU180		10.0	*320	200	4.0	1.5	4.0	50.0	25	TO-3 PLASTIC
†TIP160		10.0	320	200	4.0	2.9	10.0	50.0	100	TO-3 PLASTIC
†TIP660		10.0	320	200	4.0	2.9	10.0	80.0	100	TO-3
BUY70B		10.0	325	15	1.0	5.0	4.0	75.0	25	TO-3
BU124		10.0	*350	–	–	0.5	4.0	50.0	25	TO-3
†TIP161		10.0	350	200	4.0	2.9	10.0	50.0	100	TO-3 PLASTIC
†TIP661		10.0	350	200	4.0	2.9	10.0	80.0	100	TO-3

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PRODUCT SELECTION GUIDE
TRANSISTORS

Device Type		$I_C$cont	V_{CEO} $*V_{CBO}$	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	min	A	V	A	W	°C	
TIP564		10.0	350	7	7.0	3.0	10.0	150.0	100	TO-3
†TIP667		10.0	350	25	10.0	2.3	10.0	150.0	100	TO-3
†TIP162		10.0	380	200	4.0	2.9	10.0	50.0	100	TO-3 PLASTIC
†TIP662		10.0	380	200	4.0	2.9	10.0	80.0	100	TO-3
†BU180A		10.0	*400	200	4.0	1.5	4.0	50.0	25	TO-3 PLASTIC
BUY70A		10.0	400	15	1.0	5.0	4.0	75.0	25	TO-3
TIP563		10.0	400	20	1.0	1.2	10.0	100.0	100	TO-3
TIP565		10.0	400	7	7.0	3.0	10.0	150.0	100	TO-3
†TIP668		10.0	450	25	10.0	2.3	10.0	150.0	100	TO-3
BUY69C		10.0	*500	25	10.0	3.3	8.0	100.0	25	TO-3
†BU181		10.0	*600	200	3.0	1.5	4.0	65.0	25	TO-3 PLASTIC
†BUW81		10.0	*600	200	3.0	1.5	4.0	80.0	25	TO-3
†BU181A		10.0	*800	200	3.0	1.5	4.0	65.0	25	TO-3 PLASTIC
†BUW81A		10.0	*800	200	3.0	1.5	4.0	80.0	25	TO-3
BUX80		10.0	*800	5	5.0	3.0	8.0	100.0	25	TO-3
BUY69B		10.0	*800	2.5	10.0	3.3	8.0	100.0	25	TO-3
BUY69A		10.0	*1000	2.5	10.0	3.0	8.0	100.0	25	TO-3
	2N5386	12.0	80	20	6.0	0.6	6.0	50.0	100	TO-61
TIP515		12.0	120	40	6.0	0.8	6.0	80.0	100	TO-3
TIP517		12.0	120	40	6.0	0.8	6.0	80.0	100	TO-61
TIP516		12.0	150	40	6.0	0.8	6.0	80.0	100	TO-3
TIP518		12.0	150	40	6.0	0.8	6.0	80.0	100	TO-61
BU137		12.0	*1000	10	5.5	4.0	10.0	70.0	25	TO-3
BU137A		12.0	*1200	10	5.5	4.0	10.0	70.0	25	TO-3
BU157		12.0	*1500	5	6.0	5.0	6.0	70.0	25	TO-3
BD545	BD546	15.0	40	25	5.0	1.0	10.0	85.0	75	TO-3 PLASTIC
BD743	BD744	15.0	45	20	5.0	3.0	15.0	90.0	25	TO-220
†BDW83	†BDW84	15.0	45	750	6.0	4.0	15.0	150.0	25	TO-3 PLASTIC
BD545A	BD546A	15.0	60	25	5.0	1.0	10.0	85.0	75	TO-3 PLASTIC
BD743A	BD744A	15.0	60	20	5.0	3.0	15.0	90.0	25	TO-220
†BDW83A	†BDW84A	15.0	60	750	6.0	4.0	15.0	150.0	25	TO-3 PLASTIC
2N3055		15.0	60	20	4.0	8.0	10.0	115.0	25	TO-3
2N5881	2N5879	15.0	60	20	6.0	4.0	12.0	160.0	25	TO-3
TIP3055	TIP2955	15.0	70	5	10.0	3.0	10.0	90.0	25	TO-3 PLASTIC
2N5882	2N5880	15.0	80	20	6.0	4.0	12.0	160.0	25	TO-3
BD545B	BD546B	15.0	80	25	5.0	1.0	10.0	85.0	25	TO-3 PLASTIC
BD743B	BD744B	15.0	80	20	5.0	3.0	15.0	90.0	25	TO-220
†BDW83B	†BDW84B	15.0	80	750	6.0	4.0	15.0	150.0	25	TO-3 PLASTIC
BD545C	BD546C	15.0	100	25	5.0	1.0	10.0	85.0	25	TO-3 PLASTIC
BD743C	BD744C	15.0	100	20	5.0	3.0	15.0	90.0	25	TO-220
†BDW83C	†BDW84C	15.0	100	750	6.0	4.0	15.0	150.0	25	TO-3 PLASTIC
BD545D	BD546D	15.0	120	25	5.0	1.0	10.0	85.0	25	TO-3 PLASTIC
BD743D	BD744D	15.0	120	20	5.0	3.0	15.0	90.0	25	TO-220
†BDW83D	†BDW84D	15.0	120	750	6.0	4.0	15.0	150.0	25	TO-3 PLASTIC
TIP538		15.0	200	20	7.5	0.75	7.5	125.0	100	TO-3
TIP539		15.0	300	20	7.5	0.75	7.5	125.0	100	TO-3
TIP531		15.0	300	20	7.5	1.5	15.0	150.0	100	TO-3
TIP533		15.0	300	20	7.5	1.5	15.0	150.0	100	TO-63
TIP540		15.0	400	20	7.5	0.75	7.5	125.0	100	TO-3
TIP532		15.0	400	20	7.5	1.5	15.0	150.0	100	TO-3
TIP534		15.0	400	20	7.5	1.5	15.0	150.0	100	TO-63
BD745	BD746	20.0	45	20	5.0	3.0	20.0	115.0	25	TO-3 PLASTIC
BD745A	BD746A	20.0	60	20	5.0	3.0	20.0	115.0	25	TO-3 PLASTIC
2N3772		20.0	60	15	10.0	4.0	20.0	150.0	25	TO-3
2N5039		20.0	75	20	10.0	2.5	20.0	80.0	100	TO-3
BD745B	BD746B	20.0	80	20	5.0	3.0	20.0	115.0	25	TO-3 PLASTIC
2N5303		20.0	80	15	10.0	1.5	15.0	114.0	100	TO-3
2N5038		20.0	90	20	12.0	2.5	20.0	80.0	100	TO-3
BD745C	BD746C	20.0	100	20	5.0	3.0	20.0	115.0	25	TO-3 PLASTIC
BD745D	BD746D	20.0	120	40	1.0	3.0	20.0	115.0	25	TO-3 PLASTIC
2N3846		20.0	200	10	10.0	0.75	10.0	150.0	100	TO-63
†TIP663		20.0	300	250	10.0	3.0	20.0	150.0	100	TO-3
2N3847		20.0	300	10	10.0	0.75	10.0	150.0	100	TO-63
†TIP664		20.0	350	250	10.0	3.0	20.0	150.0	100	TO-3

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PRODUCT SELECTION GUIDE
TRANSISTORS

Device Type		$I_C$cont	V_{CEO} $*V_{CBO}$	h_{FE} @ I_C		$V_{CE(sat)}$ Max @ I_C		P_T @ T_C		Package/Comments
NPN	PNP	A	V	min	A	V	A	W	°C	
†TIP665		20.0	400	250	10.0	3.0	20.0	150.0	100	TO-3
TIP35	TIP36	25.0	40	10	15.0	4.0	25.0	125.0	25	Use BD249/250
BD249	BD250	25.0	45	10	15.0	4.0	25.0	125.0	25	TO-3 PLASTIC
TIP35A	TIP36A	25.0	60	10	15.0	4.0	25.0	125.0	25	Use BD249A/250A
BD249A	BD250A	25.0	60	10	15.0	4.0	25.0	125.0	25	TO-3 PLASTIC
2N5885	2N5883	25.0	60	20	10.0	4.0	20.0	200.0	25	TO-3
2N5886	2N5884	25.0	80	20	10.0	4.0	20.0	200.0	25	TO-3
TIP35B	TIP36B	25.0	80	10	15.0	4.0	25.0	125.0	25	Use BD249B/250B
BD249B	BD250B	25.0	80	10	15.0	4.0	25.0	125.0	25	TO-3 PLASTIC
TIP35C	TIP36C	25.0	100	10	15.0	4.0	25.0	125.0	25	Use BD249C/250C
BD249C	BD250C	25.0	100	10	15.0	4.0	25.0	125.0	25	TO-3 PLASTIC
	2N4398	30.0	40	15	15.0	1.0	15.0	114.0	100	TO-3
2N5301		30.0	40	15	15.0	2.0	20.0	114.0	100	TO-3
2N3771		30.0	40	15	15.0	5.0	30.0	150.0	25	TO-3
	2N4399	30.0	60	15	15.0	1.0	15.0	114.0	100	TO-3
2N5302		30.0	60	15	15.0	2.0	20.0	114.0	100	TO-3
2N6326	2N6329	30.0	60	12	15.0	3.0	30.0	200.0	25	TO-3
2N4002		30.0	80	20	15.0	1.2	30.0	100.0	100	TO-63
2N6270		30.0	80	20	15.0	1.0	15.0	150.0	100	TO-3
2N6272		30.0	80	20	15.0	1.0	15.0	150.0	100	TO-63
2N6327	2N6330	30.0	80	12	15.0	3.0	30.0	200.0	25	TO-3
2N5671		30.0	90	20	15.0	0.75	15.0	140.0	25	TO-3
2N4003		30.0	100	20	15.0	1.2	30.0	100.0	100	TO-63
2N6271		30.0	100	20	15.0	1.0	15.0	150.0	100	TO-6
2N6273		30.0	100	20	15.0	1.0	15.0	150.0	100	TO-63
2N6328	2N6331	30.0	100	12	15.0	3.0	30.0	200.0	25	TO-3
2N5672		30.0	120	20	15.0	0.75	15.0	140.0	25	TO-3
2N6322		30.0	200	40	5.0	1.5	20.0	200.0	100	TO-3
2N6323		30.0	200	40	5.0	1.5	20.0	200.0	100	TO-63
2N6324		30.0	300	30	5.0	1.5	20.0	200.0	100	TO-3
2N6325		30.0	300	30	5.0	1.5	20.0	200.0	100	TO-63
2N5685	2N5683	50.0	60	15	25.0	1.0	25.0	171.0	100	TO-3
2N5686	2N5684	50.0	80	15	25.0	1.0	25.0	171.0	100	TO-3

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PRODUCT SELECTION GUIDE
THYRISTORS (SCRs) IN PLASTIC PACKAGE

Type No.	V_{DRM}	$I_{T(RMS)}$	I_{TSM}	I_{GT} MAX	V_{GT} MAX	I_H MAX	V_T MAX @ I_T		PACKAGE
	V	A	A	mA	V	mA	V	A	
TIC44	30	0.6	6	0.2	0.8	5	1.4	0.3	TO-92 PIN CIRCLE
TIC45	60	0.6	6	0.2	0.8	5	1.4	0.3	
TIC46	100	0.6	6	0.2	0.8	5	1.4	0.3	
TIC47	200	0.6	6	0.2	0.8	5	1.4	0.3	
TIC101A	100	5.0	30	0.4	1.0	5	1.7	5.0	TO-220 (GROUNDED CATHODE)
TIC102A	100	5.0	30	5.0	1.0	5	1.7	5.0	
TIC101B	200	5.0	30	0.4	1.0	5	1.7	5.0	
TIC102B	200	5.0	30	5.0	1.0	5	1.7	5.0	
TIC101C	300	5.0	30	0.4	1.0	5	1.7	5.0	
TIC102C	300	5 0	30	5.0	1.0	5	1.7	5.0	
TIC101D	400	5.0	30	0.4	1.0	5	1.7	5.0	TO-220 (GROUNDED CATHODE)
TIC102D	400	5.0	30	5.0	1.0	5	1.7	5.0	
TIC101E	500	5.0	30	0.4	1.0	5	1.7	5.0	
TIC102E	500	5.0	30	5.0	1.0	5	1.7	5.0	
TIC101M	600	5.0	30	0.4	1.0	5	1.7	5.0	
TIC102M	600	5.0	30	5.0	1.0	5	1.7	5.0	
TIC106F	50	5.0	30	0.2	1.0	5	1.7	5.0	TO-220 (GROUNDED ANODE)
TIC106A	100	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106B	200	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106C	300	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106D	400	5.0	30	0.2	1.0	5	1.7	5.0	TO-220 (GROUNDED ANODE)
TIC106E	500	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106M	600	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106S	700	5.0	30	0.2	1.0	5	1.7	5.0	
TIC106N	800	5.0	30	0.2	1.0	5	1.7	5.0	
TIC116F	50	8.0	80	20.0	1.5	40	1.7	8.0	TO-220 (GROUNDED ANODE)
TIC116A	100	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116B	200	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116C	300	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116D	400	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116E	500	8.0	80	20.0	1.5	40	1.7	8.0	TO-220 (GROUNDED ANODE)
TIC116M	600	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116S	700	8.0	80	20.0	1.5	40	1.7	8.0	
TIC116N	800	8.0	80	20.0	1.5	40	1.7	8.0	
TIC126F	50	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126A	100	12.0	100	20.0	1.5	40	1.4	12.0	TO-220 (GROUNDED ANODE)
TIC126B	200	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126C	300	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126D	400	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126E	500	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126M	600	12.0	100	20.0	1.5	40	1.4	12.0	TO-220 (GROUNDED ANODE)
TIC126S	700	12.0	100	20.0	1.5	40	1.4	12.0	
TIC126N	800	12.0	100	20.0	1.5	40	1.4	12.0	

PRODUCT SELECTION GUIDE
TRIACS IN PLASTIC PACKAGE

Type Nr.	V_{DRM}	$I_{T(RMS)}$	I_{TSM}	I_{GT} MAX			V_{GT} MAX	V_{TM} @ I_{TM}		I_H MAX	PACKAGE
				I	II	III	I, II, III	Max			
	V	A	A	mA			V	V	A	mA	
TIC201A	100	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201B	200	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201C	300	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201D	400	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201E	500	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201M	600	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201S	700	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC201N	800	2.5	12	5	8	10	2.5	1.9	3.5	30	TO-220
TIC206A	100	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206B	200	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206C	300	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206D	400	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206E	500	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206M	600	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206S	700	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC206N	800	4.0	25	5	5	5	2.0	2.2	4.2	30	TO-220
TIC216A	100	6.0	60	5	5	5	2.2	1.7	8.4	30	TO-220
TIC216B	200	6.0	60	5	5	5	2.2	1.7	8.4	30	TO-220
TIC216D	400	6.0	60	5	5	5	2.2	1.7	8.4	30	TO-220
TIC216E	500	6.0	60	5	5	5	2.2	1.7	8.4	30	TO-220
TIC216M	600	6.0	60	5	5	5	2.2	1.7	8.4	30	TO-220
TIC225A	100	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225B	200	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225C	300	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225D	400	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225E	500	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225M	600	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225S	700	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC225N	800	8.0	70	5	10	10	2.2	2.1	12.0	30	TO-220
TIC226A	100	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226B	200	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226C	300	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226D	400	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226E	500	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226M	600	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226S	700	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC226N	800	8.0	70	50	50	50	2.5	2.1	12.0	60	TO-220
TIC236A	100	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236B	200	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236C	300	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236D	400	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236E	500	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236M	600	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236S	700	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC236N	800	12.0	100	50	50	50	2.5	2.1	17.0	50	TO-220
TIC246A	100	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246B	200	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246C	300	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246D	400	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246E	500	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246M	600	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246S	700	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC246N	800	16.0	125	50	50	50	2.5	1.7	22.5	50	TO-220
TIC253A	100	20.0	150	50	50	50	2.5	1.7	28.2	50	TO-3 PLASTIC
TIC253B	200	20.0	150	50	50	50	2.5	1.7	28.2	50	
TIC253C	300	20.0	150	50	50	50	2.5	1.7	28.2	50	TO-3 PLASTIC
TIC253D	400	20.0	150	50	50	50	2.5	1.7	28.2	50	
TIC253E	500	20.0	150	50	50	50	2.5	1.7	28.2	50	
TIC253M	600	20.0	150	50	50	50	2.5	1.7	28.2	50	
TIC253S	700	20.0	150	50	50	50	2.5	1.7	28.2	50	

PRODUCT SELECTION GUIDE
TRIACS IN PLASTIC PACKAGE

Type Nr.	V_{DRM}	$I_{T(RMS)}$	I_{TSM}	I_{GT} MAX			V_{GT} MAX	V_{TM} @ I_{TM}		I_H MAX	PACKAGE
				I	II	III	I, II, III	Max			
	V	A	A	mA			V	V	A	mA	
TIC253N	800	20.0	150	50	50	50	2.5	1.7	28.2	50	TO-3 PLASTIC
TIC263A	100	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263B	200	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263C	300	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263D	400	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263E	500	25.0	175	50	50	50	2.5	1.7	35.2	50	TO-3 PLASTIC
TIC263M	600	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263S	700	25.0	175	50	50	50	2.5	1.7	35.2	50	
TIC263N	800	25.0	175	50	50	50	2.5	1.7	35.2	50	

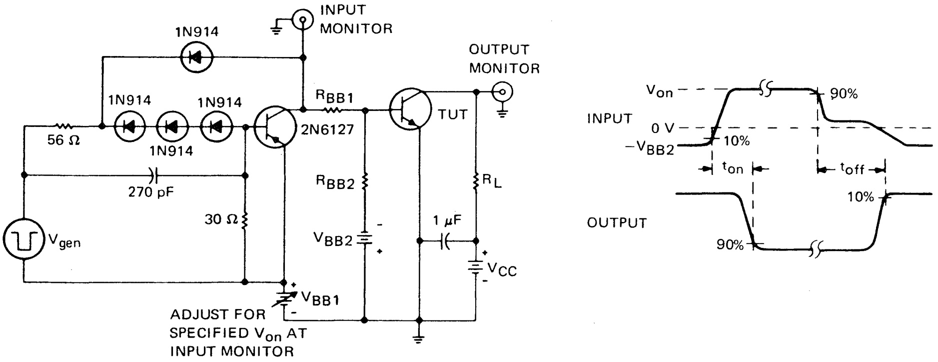
PRODUCT SELECTION GUIDE
RECTIFIERS

Type	V_R	I_O	I_{FSM}	$V_{F(max)}$ @	I_F	Anode or Cathode to Tab?	Package/Comments
	V	A	A	V	A		
BY205- 100	100	3	35	1.5	5	C	TO-220 (NO CENTRE LEAD). FAST, SOFT: $t_{rr} < 850$ ns
BY205- 200	200						
BY205- 400	400						
BY205- 600	600						
BY205- 800	800						
BY205-1000	1000						
TIR102A	100	6	40	2	9.4	C	TO-220 DUAL RECTIFIERS
TIR102B	200						
TIR102C	300						
TIR102D	400						
TIR202A	100	6	40	2	9.4	A	TO-220 DUAL RECTIFIERS
TIR202B	200						
TIR202C	300						
TIR202D	400						
TIR101A	100	12	50	2	19	C	TO-220 DUAL RECTIFIERS
TIR101B	200						
TIR101C	300						
TIR101D	400						
TIR201A	100	12	50	2	19	A	TO-220 DUAL RECTIFIERS
TIR201B	200						
TIR201C	300						
TIR201D	400						
TIR105A	100	20	120	1.84	31.4	C	TO-3 PLASTIC DUAL RECTIFIERS
TIR105B	200						
TIR105C	300						
TIR105D	400						
TIR205A	100	20	120	1.84	31.4	A	TO-3 PLASTIC DUAL RECTIFIERS
TIR205B	200						
TIR205C	300						
TIR205D	400						
TIR106A	100	30	150	1.86	47.1	C	TO-3 PLASTIC DUAL RECTIFIERS
TIR106B	200						
TIR106C	300						
TIR106D	400						
TIR206A	100	30	150	1.86	47.1	A	TO-3 PLASTIC DUAL RECTIFIERS
TIR206B	200						
TIR206C	300						
TIR206D	400						

Data Sheets

SILICON POWER TRANSISTORS
STANDARD TEST CIRCUITS

The circuits shown below are used to test many of the silicon power transistors manufactured by Texas Instruments. They are taken from the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$ $t_w = 5\ \mu s$, duty cycle $\leqslant 5\%$.

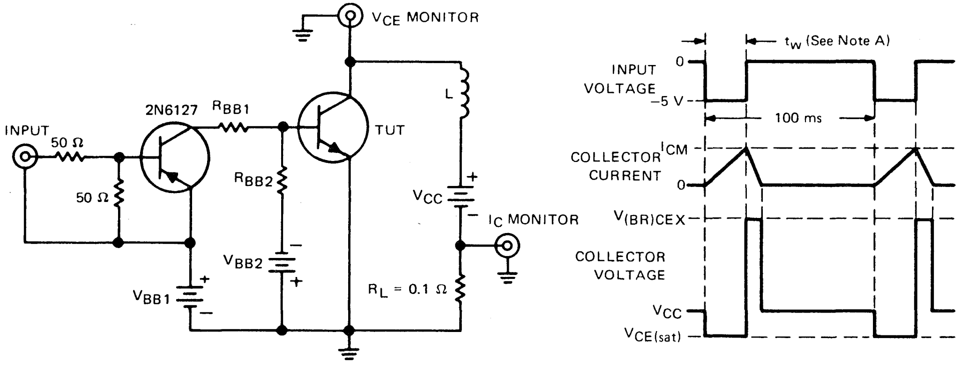
C. Waveforms are monitored on an ocsilloscope with the following characteristics: $t_r \leqslant 10$ ns, $R_{in} \geqslant 1\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

F. Circuit shown is for testing n-p-n transistors. For p-n-p transistors, all voltage supplies and waveforms are reversed and the driver transistor is type 2N6128.

FIGURE 1–SWITCHING TIMES



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. Input pulse width is increased until the peak collector current reaches the specified value of I_{CM}.

B. Circuit shown is for testing n-p-n transistors. For p-n-p transistors, all voltage supplies and waveforms are reversed and the driver transistor is type 2N6128.

FIGURE 2–INDUCTIVE LOAD SWITCHING

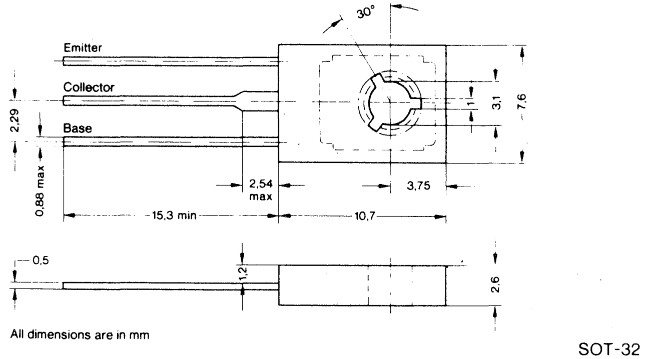
BD135, BD137, BD139
NPN EPITAXIAL PLANAR SILICON TRANSISTOR

DESIGNED FOR COMPLEMENTARY USE WITH BD136, BD138, BD140

- Driver Stages
- Active Convergence
- Control Circuits
- Switching Application
- $P_{tot} = 8$ W at $T_C = 70$ °C
- $h_{FE} > 40$ at $I_C = 150$ mA
- $V_{CE(sat)} \leqslant 0.5$ V at $I_C = 0.5$ A

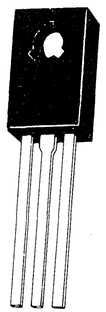
These components are tested according to the appropriate test method of MIL-STD-750. By special agreement, they can also be tested additionally to MIL- od DIN-specifications.

mechanical data



All dimensions are in mm

SOT-32



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD135	BD137	BD139
Collector-Base Voltage	45 V	60 V	80 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V
Emitter-Base Voltage	←	5 V	→
Continuous Collector Current	←	1 A	→
Peak Collector Current	←	1.5 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 70 °C Case Temperature (See Note 3)	←	8 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES:
1. This value applies when the base emitter diode is open circuited.
2. $\Theta_{JA} \leqslant 100$ °C/W
3. $\Theta_{JC} \leqslant 10$ °C/W

electrical characteristics at 25 °C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	BD135		BD137		BD139		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA, I_E = 0	45		60		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 20 mA, I_B = 0, See Note 4	45		60		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0	5		5		5		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 30 V, I_E = 0		100		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V, I_C = 5 mA	25		25		25		
		V_{CE} = 2 V, I_C = 150 mA	40	250	40	160	40	160	*
		V_{CE} = 2 V, I_C = 500 mA	25		25		25		
V_{BE}	Base-Emitter Voltage	V_{CE} = 2 V, I_C = 500 mA		1		1		1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 50 mA, I_C = 500 mA		0.5		0.5		0.5	V
f_T	Transition Frequency	V_{CE} = 5 V, I_C = 50 mA, f = 20 MHz	50		50		50		MHz

* The following h_{FE}-groups are available:

–6	h_{FE} @ V_{CE} = 2 V, I_C = 150 mA	40 - 100
–10		63 - 160
–16		100 - 250

NOTE 4: These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leqslant$2 %.

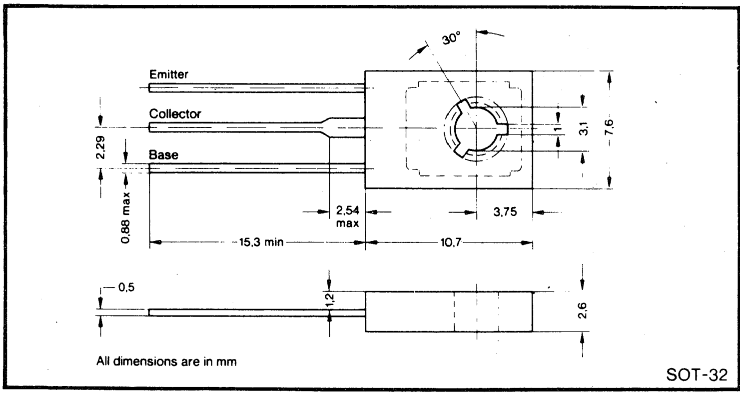
BD136, BD138, BD140
PNP EPITAXIAL PLANAR SILICON TRANSISTOR

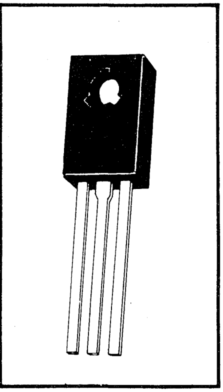
DESIGNED FOR COMPLEMENTARY USE WITH BD135, BD137, BD139

- Driver Stages
- Active Convergence
- Control Circuits
- Switching Application
- P_{tot} = 8 W at T_C = 70 °C
- $h_{FE} > 40$ at $I_C = -150$ mA
- $V_{CE(sat)} \leqslant -0.5$ V at $I_C = -0.5$ A

These components are tested according to the appropriate test method of MIL-STD-750. By special agreement, they can also be tested additionally to MIL- or DIN-specifications.

mechanical data





absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD136	BD138	BD140
Collector-Base Voltage	−45 V	−60 V	−80 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V
Emitter-Base Voltage	←	−5 V	→
Continuous Collector Current	←	−1 A	→
Peak Collector Current	←	−1.5 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 70 °C Case Temperature (See Note 3) .	←	8 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. $\Theta_{JA} \leqslant 100$ °C/W
3. $\Theta_{JC} \leqslant 10$ °C/W

electrical characteristics at 25 °C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			BD136		BD138		BD140		UNIT
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$,	$I_E = 0$		−45		−60		−80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -20\ mA$,	$I_B = 0$,	See Note 4	−45		−60		−80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30\ V$,	$I_E = 0$			−100		−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2\ V$,	$I_C = -5\ mA$		25		25		25		
		$V_{CE} = -2\ V$,	$I_C = -150\ mA$		40	250	40	160	40	160	*
		$V_{CE} = -2\ V$,	$I_C = -500\ mA$		25		25		25		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2\ V$,	$I_C = -500\ mA$			−1		−1		−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -50\ mA$,	$I_C = -500\ mA$			−0.5		−0.5		−0.5	V
f_T	Transition Frequency	$V_{CE} = -5\ V$,	$I_C = -50\ mA$,	f = 20 MHz	50		50		50		MHz

* The following h_{FE}-groups are available:

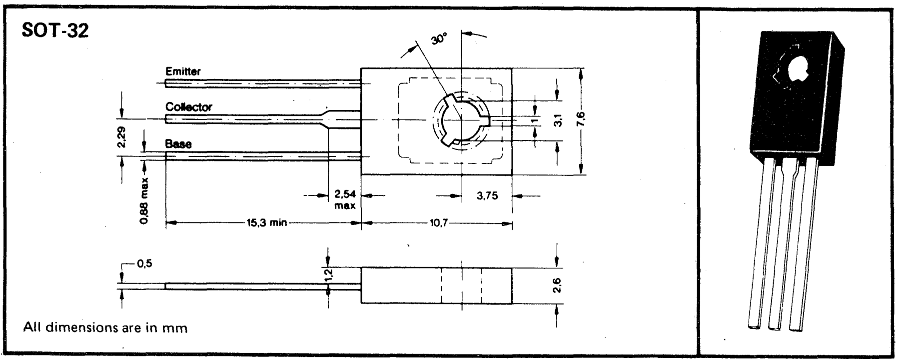
−6	h_{FE} @ $V_{CE} = -2V$, $I_C = -150mA$	40 - 100
−10		63 - 160
−16		100 - 250

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

BD165, BD167, BD169
NPN EPIBASE SILICON TRANSISTOR

- **Amplifier**
- **Driver**
- **Complementary Output Stages**
- **Power Dissipation 20 W**
- **Complementary with BD166, BD168, BD170**

mechanical data



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD165	BD167	BD169
Collector-Base Voltage	45 V	60 V	80 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V
Emitter-Base Voltage	←	5 V	→
Continuous Collector Current	←	1.5 A	→
Peak Collector Current	←	3 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	20 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES:
1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 160 mW/°C.

BD165, BD167, BD169
NPN EPIBASE SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS			BD165		BD167		BD169		UN
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		45		60		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA,	$I_B = 0$	See Note 4	45		60		80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	$I_E = 1$ mA,	$I_C = 0$		5		5		5		V
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V,	$I_C = 500$ mA	See Note 4		950		950		950	m\
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 50$ mA,	$I_C = 500$ mA	See Note 4		500		500		500	m\
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V,	$I_C = 150$ mA	See Note 4	40		40		40		
		$V_{CE} = 2$ V,	$I_C = 500$ mA	See Note 4	15		15		15		
f_T	Transition Frequency	$V_{CE} = 2$ V,	$I_C = 500$ mA,	f = 1 MHz	3		3		3		MH

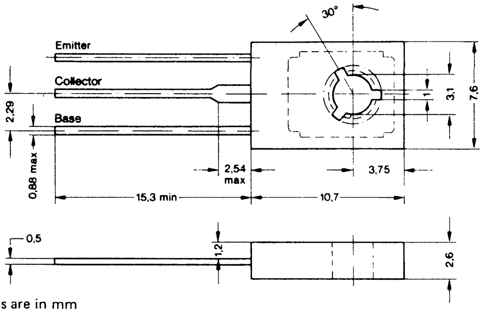
NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

BD166, BD168, BD170
PNP EPIBASE SILICON TRANSISTOR

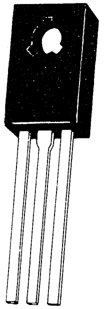
- Amplifier
- Driver
- Complementary Output Stages
- Power Dissipation 20 W
- Complementary with BD165, BD167, BD169

mechanical data

SOT-32



All dimensions are in mm



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD166	BD168	BD170
Collector-Base Voltage	–45 V	–60 V	–80 V
Collector-Emitter Voltage (See Note 1)	–45 V	–60 V	–80 V
Emitter-Base Voltage	←	–5 V	→
Continuous Collector Current	←	–1.5 A	→
Peak Collector Current	←	–3 A	→
Continuous Device Dissipation at (or below) 25 °C free-air temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	20 W	→
Storage Temperature Range	←	–55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES:
1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 160 mW/°C.

BD166, BD168, BD170
PNP EPIBASE SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature

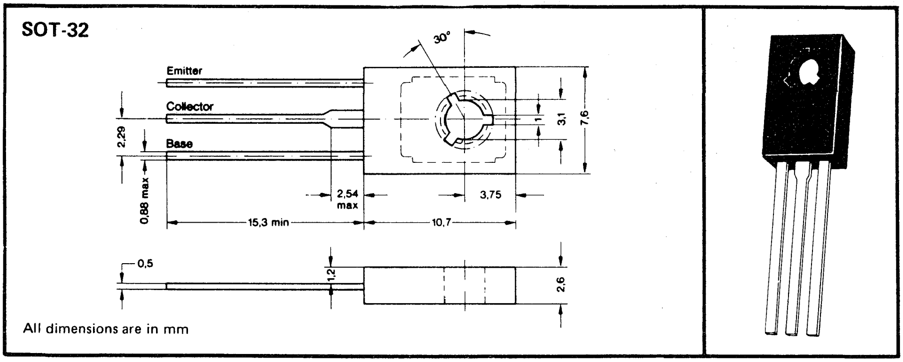
PARAMETER		TEST CONDITIONS			BD166		BD168		BD170		UNI
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$,	$I_E = 0$		–45		–60		–80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA,	$I_B = 0$	See Note 4	–45		–60		–80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	$I_E = -1$ mA,	$I_C = 0$		–5		–5		–5		V
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V,	$I_C = -500$ mA	See Note 4		–950		–950		–950	mV
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -50$ mA,	$I_C = -500$ mA	See Note 4		–500		–500		–500	mV
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $V_{CE} = -2$ V,	$I_C = -150$ mA $I_C = -500$ mA	See Note 4 See Note 4	40 15		40 15		40 15		
f_T	Transition Frequency	$V_{CE} = -2$ V,	$I_C = -500$ mA,	f = 1 MHz	3		3		3		MH

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

BD175, BD177, BD179
NPN EPIBASE SILICON TRANSISTOR

- Amplifier
- Driver
- Complementary Output Stages
- Power Dissipation 30 W
- Complementary with BD176, BD178, BD180

mechanical data


SOT-32

All dimensions are in mm

absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD175	BD177	BD179
Collector-Base Voltage	45 V	60 V	80 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V
Emitter-Base Voltage	←	5 V	→
Continuous Collector Current	←	3 A	→
Peak Collector Current	←	6 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	30 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES: 1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 240 mW/°C.

BD175, BD177, BD179
NPN EPIBASE SILICON TRANSISTOR

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS			BD175		BD177		BD179		UNIT
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		45		60		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA,	$I_B = 0$	See Note 4	45		60		80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	$I_E = 1$ mA,	$I_C = 0$		5		5		5		V
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V,	$I_C = 1$ A	See Note 4		1.3		1.3		1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 100$ mA,	$I_C = 1$ A	See Note 4		800		800		800	mV
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V,	$I_C = 150$ mA	See Note 4	40	236	40	236	40	236	
		$V_{CE} = 2$ V,	$I_C = 1$ A	See Note 4	15		15		15		
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 250$ mA,	f = 1 MHz	3		3		3		MHz

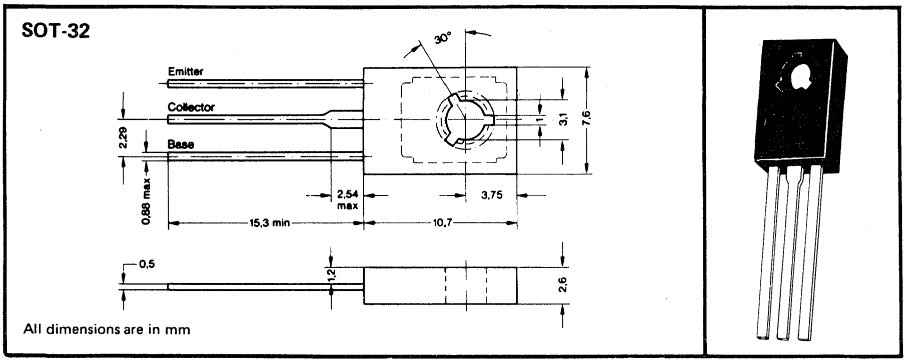
NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

BD176, BD178, BD180
PNP EPIBASE SILICON TRANSISTOR

- Amplifier
- Driver
- Complementary Output Stages
- Power Dissipation 30 W
- Complementary with BD175, BD177, BD179

mechanical data

SOT-32



All dimensions are in mm

absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD176	BD178	BD180
Collector-Base Voltage	−45 V	−60 V	−80 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V
Emitter-Base Voltage	←	−5 V	→
Continuous Collector Current	←	−3 A	→
Peak Collector Current	←	−6 A	→
Continuous Device Dissipation at (or below) 25 °C free-air temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C case temperature (See Note 3)	←	30 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES:
1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 240 mW/°C.

BD176, BD178, BD180
PNP EPIBASE SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature

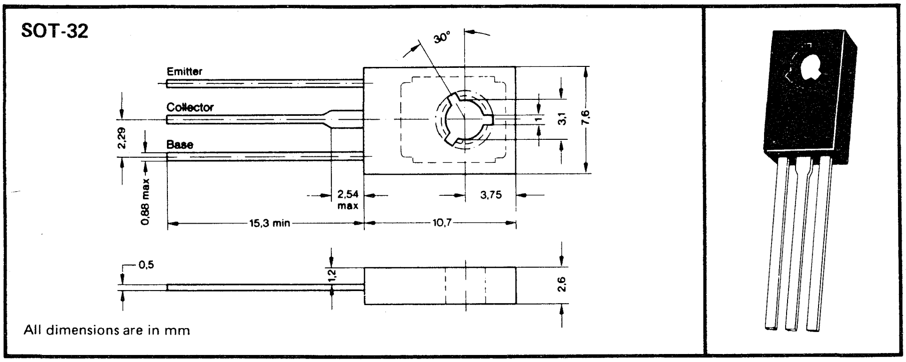
PARAMETER		TEST CONDITIONS	BD176		BD178		BD180		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−45		−60		−80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $I_B = 0$ See Note 4	−45		−60		−80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	$I_E = -1$ mA, $I_C = 0$	−5		−5		−5		V
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V, $I_C = -1$ A See Note 4		−1.3		−1.3		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -100$ mA, $I_C = -1$ A See Note 4		−800		−800		−800	mV
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -150$ mA See Note 4	40	236	40	236	40	236	
		$V_{CE} = -2$ V, $I_C = -1$ A See Note 4	15		15		15		
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -250$ mA, f = 1 MHz	3		3		3		MHz

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

BD233, BD235, BD237
NPN EPIBASE SILICON TRANSISTOR

- **Amplifier**
- **Driver**
- **Complementary Output Stages**
- **Power Dissipation 25 W**
- **Complementary with BD234, BD236, BD238**

mechanical data



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD233	BD235	BD237
Collector-Base Voltage	45 V	60 V	80 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V
Emitter-Base Voltage	←	5 V	→
Continuous Collector Current	←	2 A	→
Peak Collector Current	←	6 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	25 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES; 1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 200 mW/°C.

BD233, BD235, BD237
NPN EPIBASE SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature

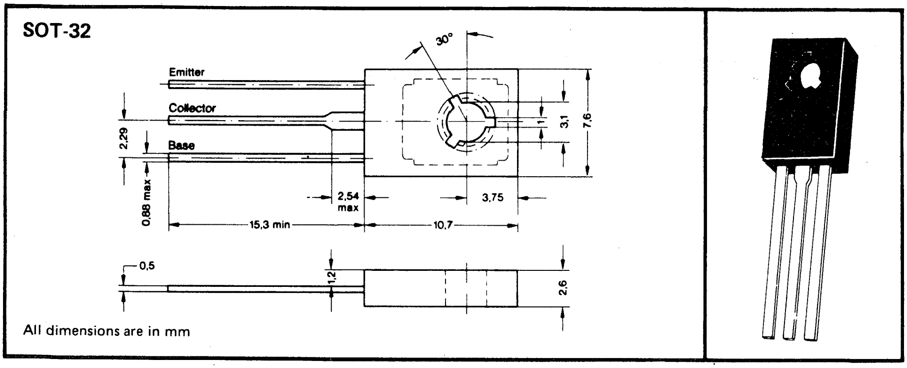
PARAMETER		TEST CONDITIONS			BD233		BD235		BD237		UNIT
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA,	I_E = 0		45		60		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 100 mA,	I_B = 0	See Note 4	45		60		80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	I_E = 1 mA,	I_C = 0		5		5		5		V
V_{BE}	Base-Emitter Voltage	V_{CE} = 2 V,	I_C = 1 A	See Note 4		1.3		1.3		1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 100 mA,	I_C = 1 A	See Note 4		600		600		600	mV
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V,	I_C = 150 mA	See Note 4	40		40		40		
		V_{CE} = 2 V,	I_C = 1 A	See Note 4	25		25		25		
f_T	Transition Frequency	V_{CE} = 10 V,	I_C = 250 mA,	f = 1 MHz	3		3		3		MHz

NOTE 4: These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leqslant$2 %.

BD234, BD236, BD238
PNP EPIBASE SILICON TRANSISTOR

- **Amplifier**
- **Driver**
- **Complementary Output Stages**
- **Power Dissipation 25 W**
- **Complementary with BD233, BD235, BD237**

mechanical data



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BD234	BD236	BD238
Collector-Base Voltage	−45 V	−60 V	−80 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V
Emitter-Base Voltage	←	−5 V	→
Continuous Collector Current	←	−2 A	→
Peak Collector Current	←	−6 A	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	25 W	→
Storage Temperature Range	←	−55 °C to 150 °C	→
Lead Temperature 1.6 mm from Case for 10 Seconds	←	260 °C	→

NOTES: 1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 200 mW/°C.

BD234, BD236, BD238
PNP EPIBASE SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BD234		BD236		BD238		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−45		−60		−80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $I_B = 0$ See Note 4	−45		−60		−80		V
$V_{(BR)EBO}$	Base-Emitter Breakdown Voltage	$I_E = -1$ mA, $I_C = 0$	−5		−5		−5		V
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V, $I_C = -1$ A See Note 4		−1.3		−1.3		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -100$ mA, $I_C = -1$ A See Note 4		−600		−600		−600	mV
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -150$ See Note 4 $V_{CE} = -2$ V, $I_C = -1$ A See Note 4	40 25		40 25		40 25		
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -250$ mA, f = 1 MHz	3		3		3		MHz

NOTE 4: These parameters must be measured using pulse techniques. t_p 300 μs, duty cycle ⩽2 %.

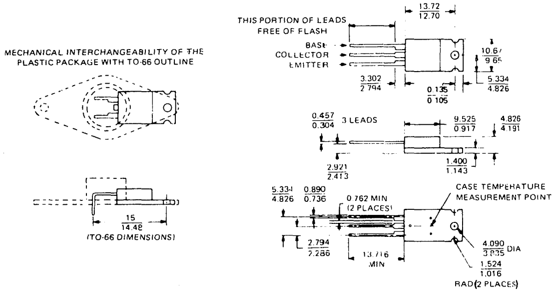
BD239, BD239A, BD239B, BD239C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

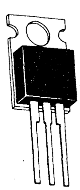
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD240A-C

- 30 W at 25 °C Case Temperature
- 2 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 200 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD239	BD239A	BD239B	BD239C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	55 V	70 V	90 V	115 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V
Emitter-Base Voltage	5 V			
Continuous Collector Current	2 A			
Peak Collector Current (See Note 2)	4 A			
Continuous Base Current	0.6 A			
Safe Operating Region at (or below) 25 °C Case Temperature	See Figure 5			
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	30 W			
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	2 W			
Unclamped Inductive Load Energy (See Note 5)	32 mJ			
Operating Collector Junction Temperature Range	−65 °C to 150 °C			
Storage Temperature Range	−65 °C to 150 °C			
Lead Temperature 3.2mm from Case for 5 Seconds	250 °C			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 0.24 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy ≈ $I_C{}^2L/2$.

BD239, BD239A, BD239B, BD239C NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS	BD239		BD239A		BD239B		BD239C		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	I_C = 30 mA, I_B = 0, See Note 6	45		60		80		100		V
I_{CEO}	V_{CE} = 30 V, I_B = 0		0.3		0.3					mA
	V_{CE} = 60 V, I_B = 0						0.3		0.3	
I_{CES}	V_{CE} = 45 V, V_{BE} = 0		0.2							mA
	V_{CE} = 60 V, V_{BE} = 0				0.2					
	V_{CE} = 80 V, V_{BE} = 0						0.2			
	V_{CE} = 100 V, V_{BE} = 0								0.2	
I_{EBO}	V_{EB} = 5 V, I_C = 0		1		1		1		1	mA
h_{FE}	V_{CE} = 4 V, I_C = 0.2 A See Notes 6 and 7	40		40		40		40		
	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7	15		15		15		15		
V_{BE}	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7		1.3		1.3		1.3		1.3	V
$V_{CE(sat)}$	I_B = 200 mA, I_C = 1 A, See Notes 6 and 7		0.7		0.7		0.7		0.7	V
h_{fe}	V_{CE} = 10 V, I_C = 0.2 A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	V_{CE} = 10 V, I_C = 0.2 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2 %.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

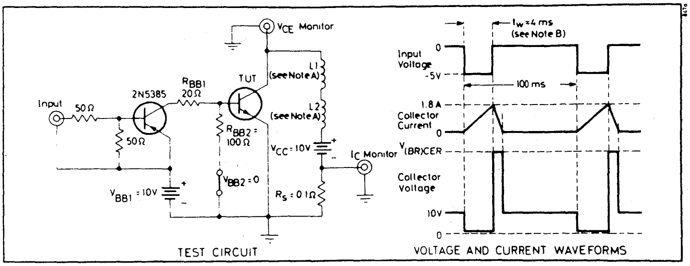
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS +	TYP	UNIT
t_{on}	I_C = 200 mA, $I_{B(1)}$ = 20 mA, $I_{B(2)}$ = 20 mA,	0.3	μs
t_{off}	$V_{BE(off)}$ = −3.4 V, R_L = 150 Ω, See Figure 1	0.8	

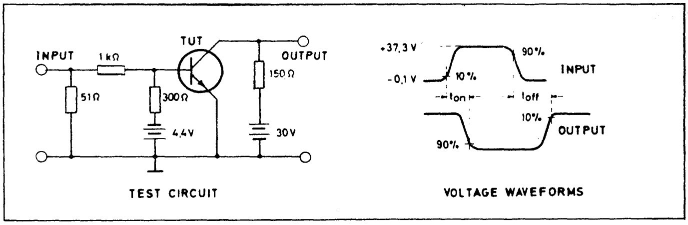
+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD239, BD239A, BD239B, BD239C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS



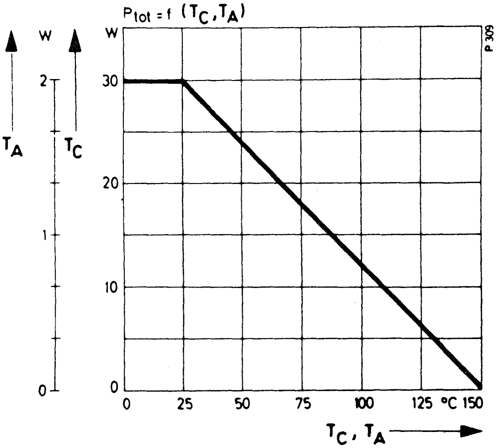
TEST CIRCUIT

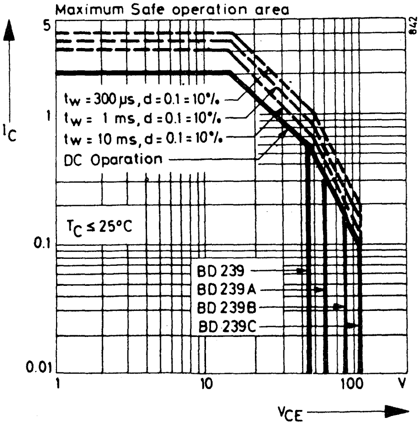
VOLTAGE AND CURRENT WAVEFORMS



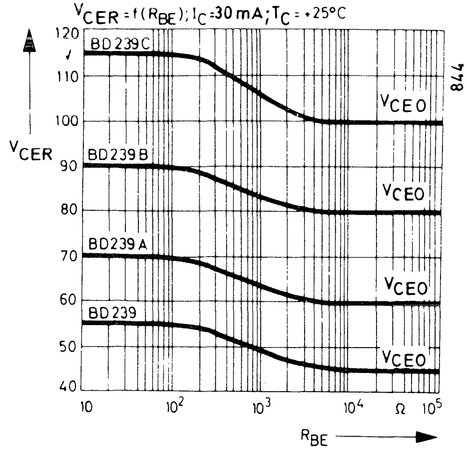
TEST CIRCUIT

VOLTAGE WAVEFORMS

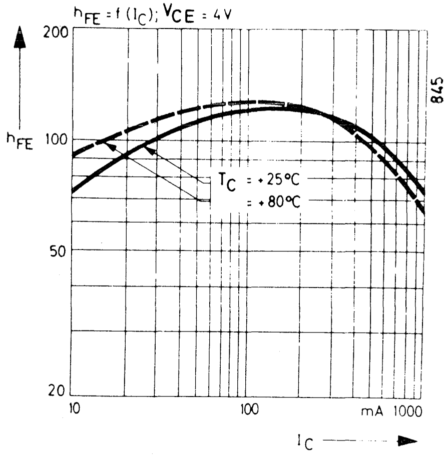




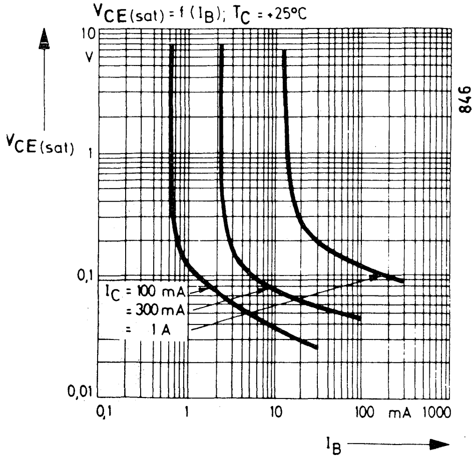
BD239, BD239A, BD239B, BD239C
NPN SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS



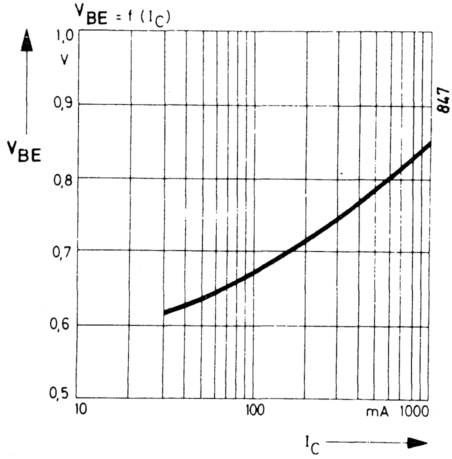
$V_{CER} = f(R_{BE})$; $I_C = 30$ mA; $T_C = +25$°C



$h_{FE} = f(I_C)$; $V_{CE} = 4$ V



$V_{CE(sat)} = f(I_B)$; $T_C = +25$°C



$V_{BE} = f(I_C)$

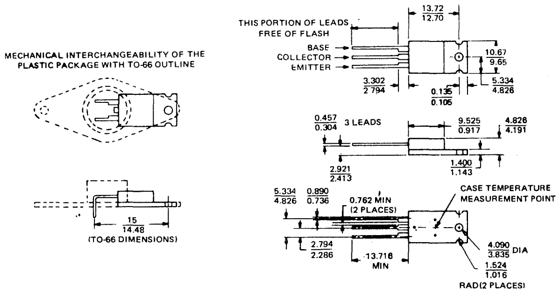
BD240, BD240A, BD240B, BD240C PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD239A-C

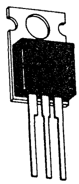
- 30 W at 25 °C Case Temperature
- 2 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 200 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD240	BD240A	BD240B	BD240C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	−55 V	−70 V	−90 V	−115 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	←		−5 V	→
Continuous Collector Current	←		−2 A	→
Peak Collector Current (See Note 2)	←		−4 A	→
Continuous Base Current	←		−0.6 A	→
Safe Operating Region at (or below) 25 °C Case Temperature	←		See Figure 5	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←		30 W	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	←		2 W	→
Unclamped Inductive Load Energy (See Note 5)	←		32 mJ	→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C	→
Storage Temperature Range	←		−65 °C to 150 °C	→
Lead Temperature 3.2mm from Case for 5 Seconds	←		250 °C	→

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10 %.
3. Derate linearly to 150 °C case temperature at the rate of 0.24 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C{}^2 L/2$.

BD240, BD240A, BD240B, BD240C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS	BD240		BD240A		BD240B		BD240C		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	I_C = −30 mA, I_B = 0, See Note 6	−45		−60		−80		−100		V
I_{CEO}	V_{CE} = −30 V, I_B = 0		−0.3		−0.3					mA
	V_{CE} = −60 V, I_B = 0						−0.3		−0.3	
I_{CES}	V_{CE} = −45 V, V_{BE} = 0		−0.2							mA
	V_{CE} = −60 V, V_{BE} = 0				−0.2					
	V_{CE} = −80 V, V_{BE} = 0						−0.2			
	V_{CE} = −100 V, V_{BE} = 0								−0.2	
I_{EBO}	V_{EB} = −5 V, I_C = 0		−1		−1		−1		−1	mA
h_{FE}	V_{CE} = −4 V, I_C = −0.2 A, See Notes 6 and 7	40		40		40		40		
	V_{CE} = −4 V, I_C = −1 A, See Notes 6 and 7	15		15		15		15		
V_{BE}	V_{CE} = −4 V, I_C = −1 A, See Notes 6 and 7		−1.3		−1.3		−1.3		−1.3	V
$V_{CE(sat)}$	I_B = −200 mA, I_C = −1 A, See Notes 6 and 7		−0.7		−0.7		−0.7		−0.7	V
h_{fe}	V_{CE} = −10 V, I_C = −0.2 A, f = 1 kHz	20		20		20		20		
$\lvert h_{fe} \rvert$	V_{CE} = −10 V, I_C = −0.2 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$ 2 %.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

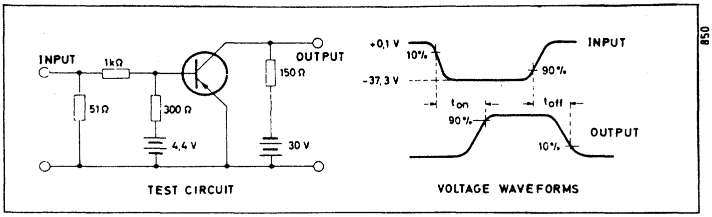
switching characteristics at 25 °C case temperature

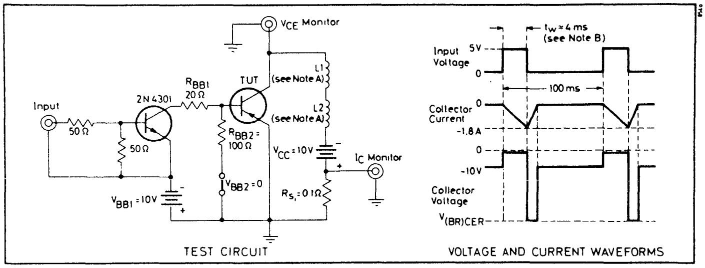
PARAMETER	TEST CONDITIONS +	TYP	UNIT
t_{on}	I_C = −200 mA, $I_{B(1)}$ = −20 mA, $I_{B(2)}$ = 20 mA,	0.2	μs
t_{off}	$V_{BE(off)}$ = 3.4 V, R_L = 150 Ω, See Figure 1	0.4	

+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

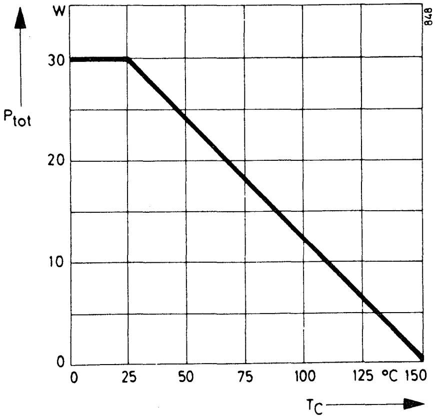
BD240, BD240A, BD240B, BD240C
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

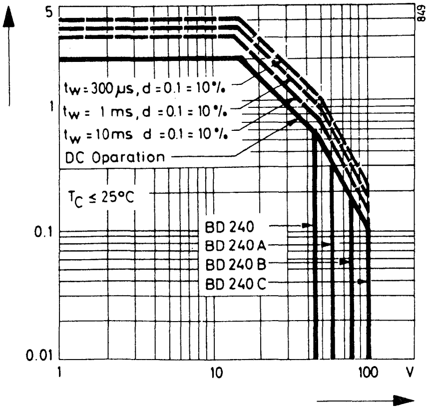
absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)



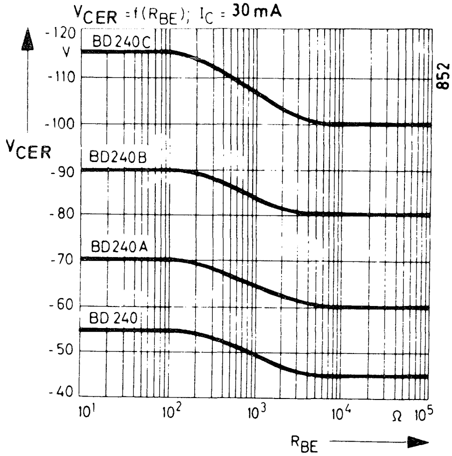


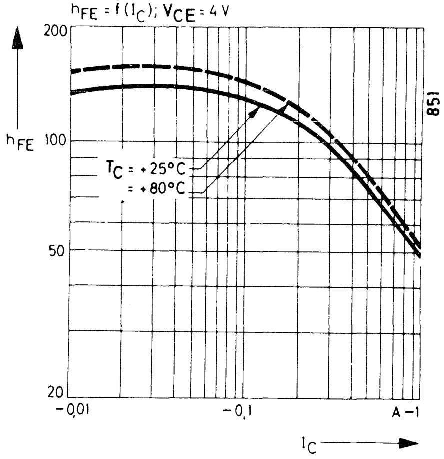
Dissipation derating curve
$P_{tot} = f\ (T_C)$

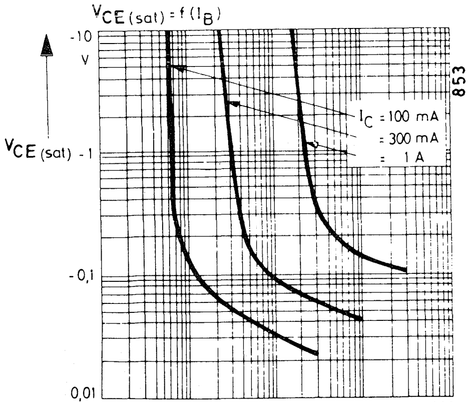


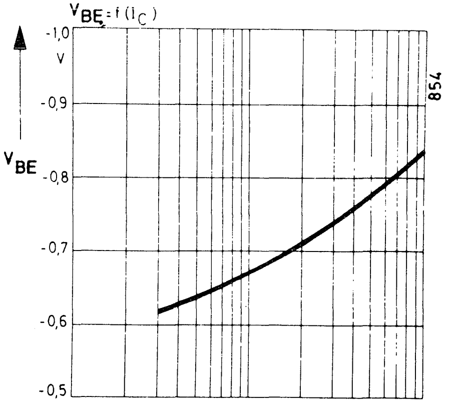


BD240, BD240A, BD240B, BD240C PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









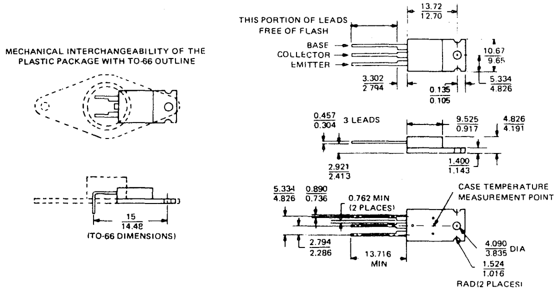
BD241, BD241A, BD241B, BD241C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD242A-C

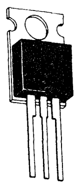
- 40 W at 25 °C Case Temperature
- 3 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD241	BD241A	BD241B	BD241C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	55 V	70 V	90 V	115 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V
Emitter-Base Voltage	← 5 V →			
Continuous Collector Current	← 3 A →			
Peak Collector Current (See Note 2)	← 5 A →			
Continuous Base Current	← 1 A →			
Safe Operating Region at (or below) 25 °C Case Temperature	← See Figure 5 →			
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	← 40 W →			
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	← 2 W →			
Unclamped Inductive Load Energy (See Note 5)	← 32 mJ →			
Operating Collector Junction Temperature Range	← −65 °C to 150 °C →			
Storage Temperature Range	← −65 °C to 150 °C →			
Lead Temperature 3.2mm from Case for 5 Seconds	← 250 °C →			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 0.32 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C{}^2L/2$.

BD241, BD241A, BD241B, BD241C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD241		BD241A		BD241B		BD241C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	$I_C = 30$ mA, See Note 6	$I_B = 0$,	45		60		80		100		V
I_{CEO}	$V_{CE} = 30$ V,	$I_B = 0$		0.3		0.3					mA
	$V_{CE} = 60$ V,	$I_B = 0$						0.3		0.3	
I_{CES}	$V_{CE} = 45$ V,	$V_{BE} = 0$		0.2							mA
	$V_{CE} = 60$ V,	$V_{BE} = 0$				0.2					
	$V_{CE} = 80$ V,	$V_{BE} = 0$						0.2			
	$V_{CE} = 100$ V,	$V_{BE} = 0$								0.2	
I_{EBO}	$V_{EB} = 5$ V,	$I_C = 0$		1		1		1		1	mA
h_{FE}	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 1$ A,	25		25		25		25		
	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 3$ A,	10		10		10		10		
V_{BE}	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 3$ A,		1.8		1.8		1.8		1.8	V
$V_{CE(sat)}$	$I_B = 600$ mA, See Notes 6 and 7	$I_C = 3$ A,		1.2		1.2		1.2		1.2	V
h_{fe}	$V_{CE} = 10$ V, f = 1 kHz	$I_C = 0.5$ A,	20		20		20		20		
$\|h_{fe}\|$	$V_{CE} = 10$ V, f = 1 MHz	$I_C = 0.5$ A	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\ \%$.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

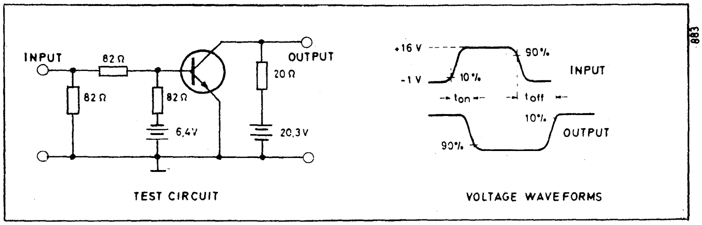
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

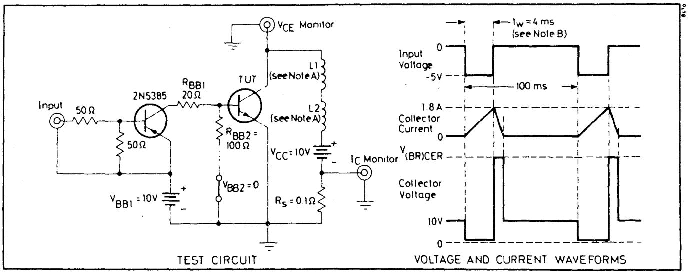
switching characteristics at 25 °C case temperature

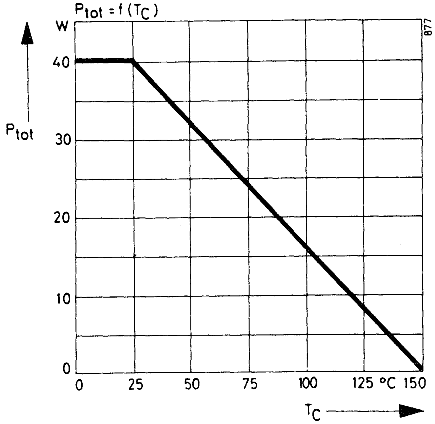
PARAMETER	TEST CONDITIONS⁺			TYP	UNIT
t_{on}	$I_C = 1$ A,	$I_{B(1)} = 100$ mA,	$I_{B(2)} = -100$ mA,	0.3	μs
t_{off}	$V_{BE(off)} = -3.7$ V,	$R_L = 20\ \Omega$,	See Figure 1	1	

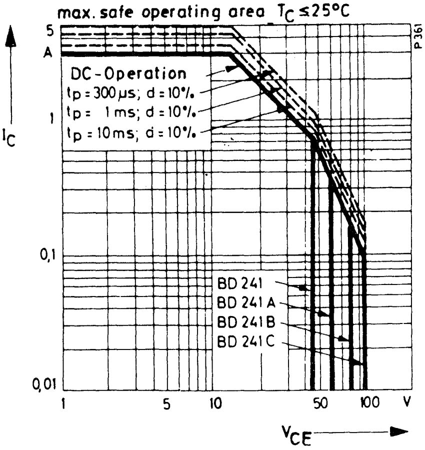
⁺ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD241, BD241A, BD241B, BD241C NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

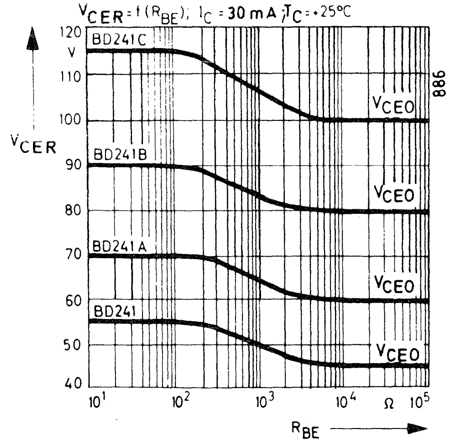


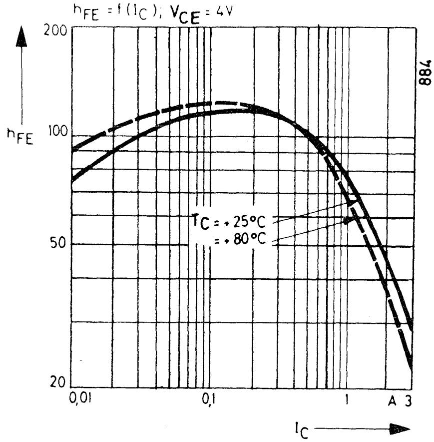


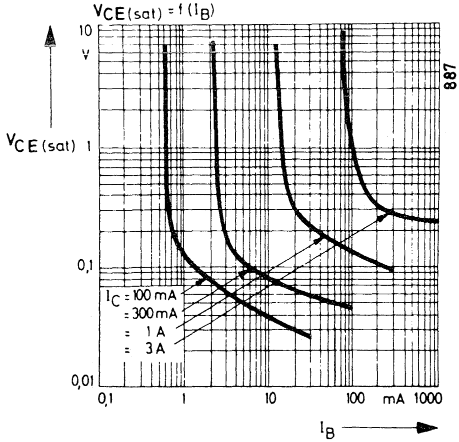


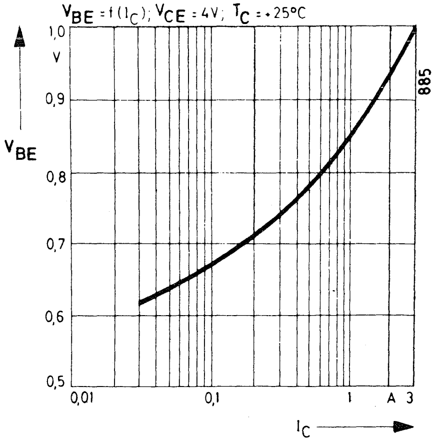


BD241, BD241A, BD241B, BD241C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









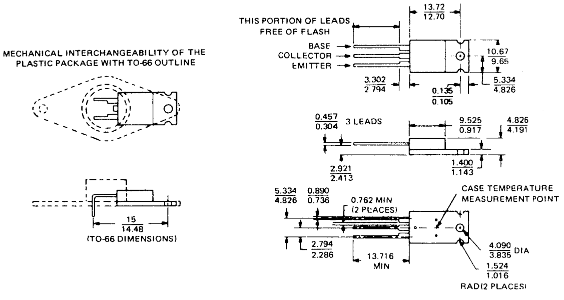
BD242, BD242A, BD242B, BD242C
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

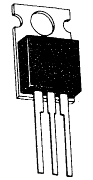
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD241A-C

- 40 W at 25 °C Case Temperature
- 3 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD242	BD242A	BD242B	BD242C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	−55 V	−70 V	−90 V	−115 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	←	−5 V		→
Continuous Collector Current	←	−3 A		→
Peak Collector Current (See Note 2)	←	−5 A		→
Continuous Base Current	←	−1 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←	See Figure 5		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	40 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	←	2 W		→
Unclamped Inductive Load Energy (See Note 5)	←	32 mJ		→
Operating Collector Junction Temperature Range	←	−65 °C to 150 °C		→
Storage Temperature Range	←	−65 °C to 150 °C		→
Lead Temperature 3.2mm from Case for 5 Seconds	←	250 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10 %.
3. Derate linearly to 150 °C case temperature at the rate of 0.32 W/°C.
4. Derate linearly to 150 °C free-air temperature at the end of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C^2 L/2$.

BD242, BD242A, BD242B, BD242C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD242		BD242A		BD242B		BD242C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	I_C = −30 mA, See Note 6	I_B = 0,	−45		−60		−80		−100		V
I_{CEO}	V_{CE} = −30 V,	I_B = 0		−0.3		−0.3					mA
	V_{CE} = −60 V,	I_B = 0						−0.3		−0.3	
I_{CES}	V_{CE} = −45 V,	V_{BE} = 0		−0.2							mA
	V_{CE} = −60 V,	V_{BE} = 0				−0.2					
	V_{CE} = −80 V,	V_{BE} = 0						−0.2			
	V_{CE} = −100 V,	V_{BE} = 0								−0.2	
I_{EBO}	V_{EB} = −5 V,	I_C = 0		−1		−1		−1		−1	mA
h_{FE}	V_{CE} = −4 V, See Notes 6 and 7	I_C = −1 A,	25		25		25		25		
	V_{CE} = −4 V, See Notes 6 and 7	I_C = −3 A,	10		10		10		10		
V_{BE}	V_{CE} = −4 V, See Notes 6 and 7	I_C = −3 A,		−1.8		−1.8		−1.8		−1.8	V
$V_{CE(sat)}$	I_B = −600 mA, See Notes 6 and 7	I_C = −3 A,		−1.2		−1.2		−1.2		−1.2	V
h_{fe}	V_{CE} = −10 V, f = 1 kHz	I_C = −0.5 A,	20		20		20		20		
$\|h_{fe}\|$	V_{CE} = −10 V, f = 1 MHz	I_C = −0.5 A,	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leq$ 2 %.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

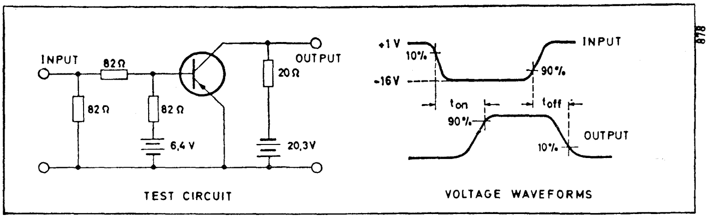
thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25 °C case temperature

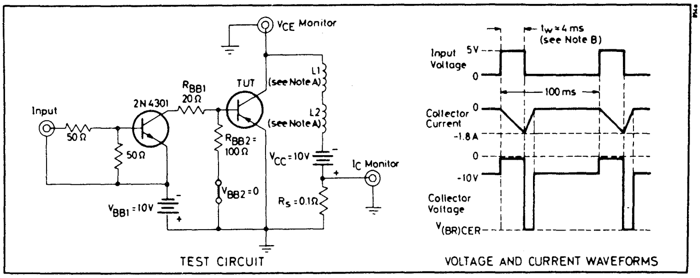
PARAMETER	TEST CONDISTIONS$^+$			TYP	UNIT
t_{on}	I_C = −1 A,	$I_{B(1)}$ = −100 mA,	$I_{B(2)}$ = 100 mA,	0.2	μs
t_{off}	$V_{BE(off)}$ = 3.7 V,	R_L = 20 Ω,	See Figure 1	0.3	

$^+$ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.



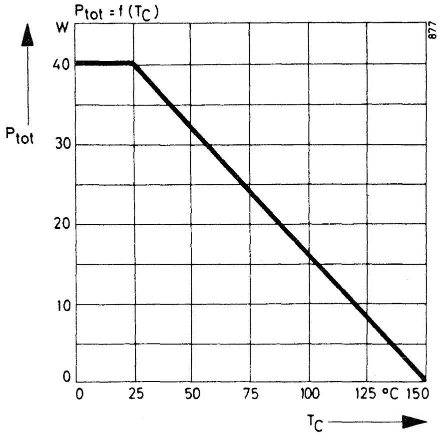
TEST CIRCUIT

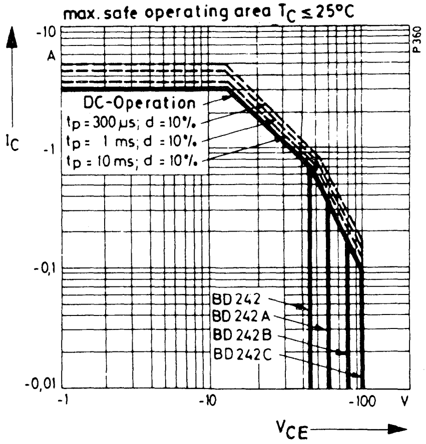
VOLTAGE WAVEFORMS



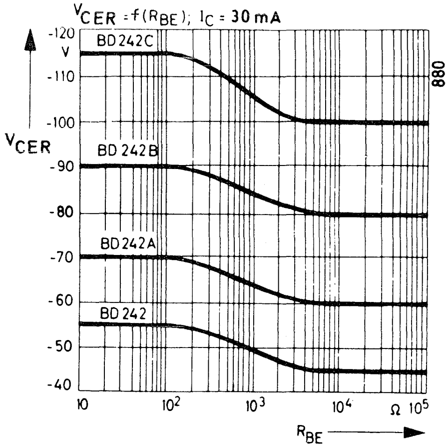
TEST CIRCUIT

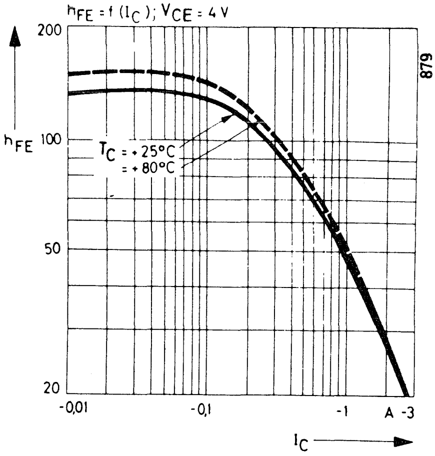
VOLTAGE AND CURRENT WAVEFORMS

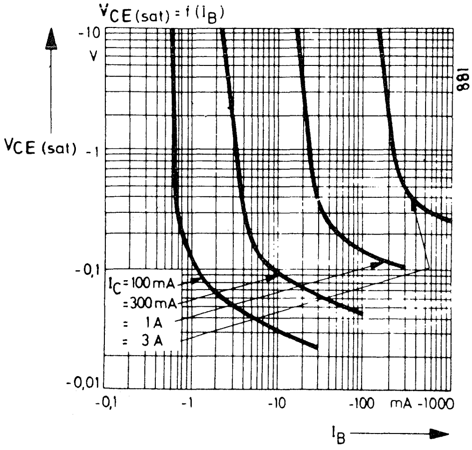


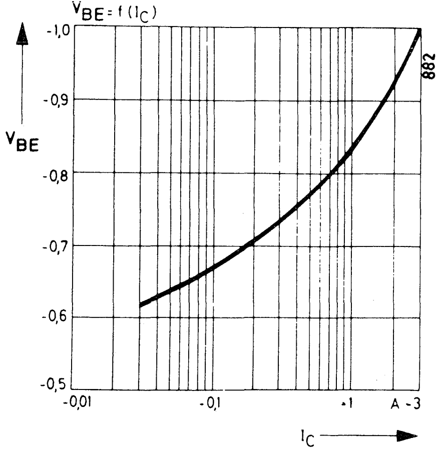


BD242, BD242A, BD242B, BD242C
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS


$V_{CER} = f(R_{BE})$; $I_C = 30$ mA


$h_{FE} = f(I_C)$; $V_{CE} = 4$ V


$V_{CE(sat)} = f(I_B)$


$V_{BE} = f(I_C)$

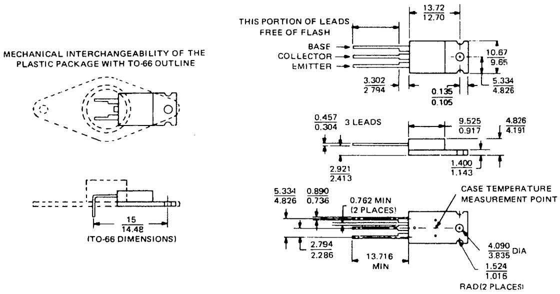
BD243, BD243A, BD243B, BD243C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD244A-C

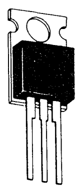
- 65 W at 25 °C Case Temperature
- 6 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD243	BD243A	BD243B	BD243C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	55 V	70 V	90 V	115 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V
Emitter-Base Voltage	←	5 V		→
Continuous Collector Current	←	6 A		→
Peak Collector Current (See Note 2)	←	10 A		→
Continuous Base Current	←	3 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←	See Figure 5		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	65 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	←	2 W		→
Unclamped Inductive Load Energy (See Note 5)	←	62.5 mJ		→
Operating Collector Junction Temperature Range	←	−65 °C to 150 °C		→
Storage Temperature Range	←	−65 °C to 150 °C		→
Lead Temperature 3.2mm from Case for 5 Seconds	←	250 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 0.52 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 0.52 W/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C{}^2 L/2$.

BD243, BD243A, BD243B, BD243C
NPN SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD243		BD243A		BD243B		BD243C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	I_C = 30 mA, See Note 6	I_B = 0,	45		60		80		100		V
I_{CEO}	V_{CE} = 30 V,	I_B = 0		0.7		0.7					mA
	V_{CE} = 60 V,	I_B = 0						0.7		0.7	
I_{CES}	V_{CE} = 45 V,	V_{BE} = 0		0.4							
	V_{CE} = 60 V,	V_{BE} = 0				0.4					
	V_{CE} = 80 V,	V_{BE} = 0						0.4			
	V_{CE} = 100 V,	V_{BE} = 0								0.4	
I_{EBO}	V_{EB} = 5 V,	I_C = 0		1		1		1		1	mA
h_{FE}	V_{CE} = 4 V, See Notes 6 and 7	I_C = 0.3 A,	30		30		30		30		
	V_{CE} = 4 V, See Notes 6 and 7	I_C = 3 A,	15		15		15		15		
V_{BE}	V_{CE} = 4 V, See Notes 6 and 7	I_C = 6 A,		2		2		2		2	V
$V_{CE(sat)}$	I_B = 1.0 A, See Notes 6 and 7	I_C = 6 A,		1.5		1.5		1.5		1.5	V
h_{fe}	V_{CE} = 10 V, f = 1 kHz	I_C = 0.5 A,	20		20		20		20		
$\|h_{fe}\|$	V_{CE} = 10 V, f = 1 MHz	I_C = 0.5 A	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 µs, duty cycle $\leqslant$ 2 %.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

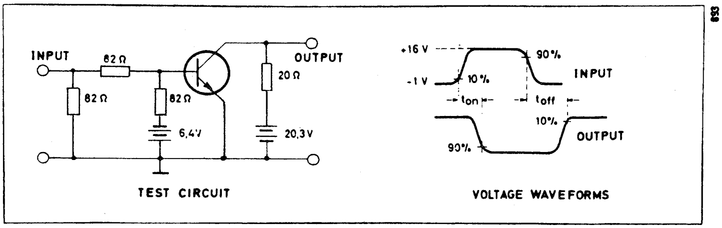
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

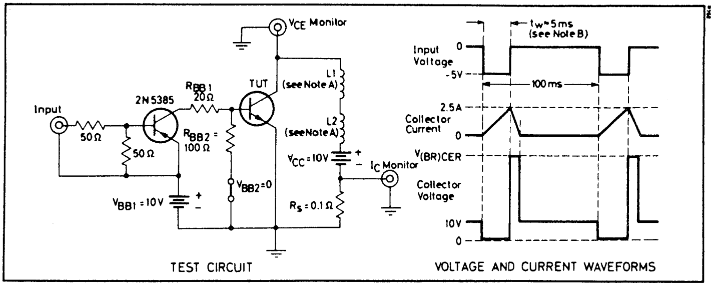
switching characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS +			TYP	UNIT
t_{on}	I_C = 1 A,	$I_{B(1)}$ = 0.1 A,	$I_{B(2)}$ = −0.1 A,	0.3	µs
t_{off}	$V_{BE(off)}$ = −3.7 V, R_L = 20 Ω,		See Figure 1	1	

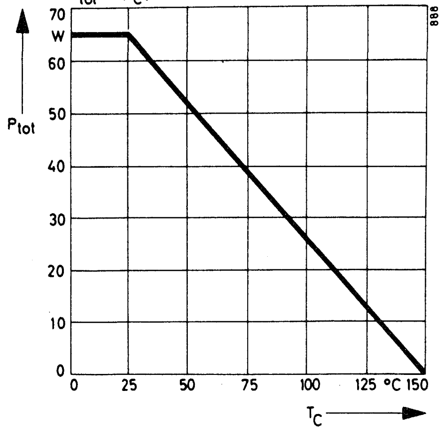
+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD243, BD243A, BD243B, BD243C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

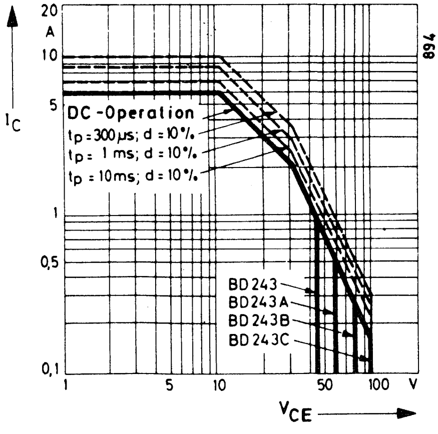




Dissipation derating curve
$P_{tot} = f(T_C)$

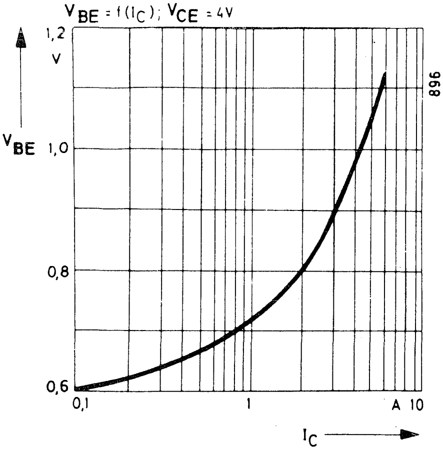


max. safe operating area $T_C \leq 25°C$

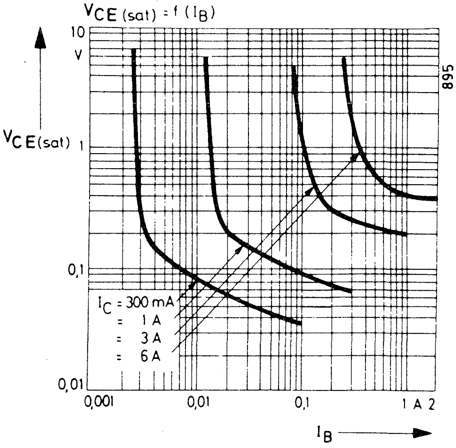


BD243, BD243A, BD243B, BD243C
NPN SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

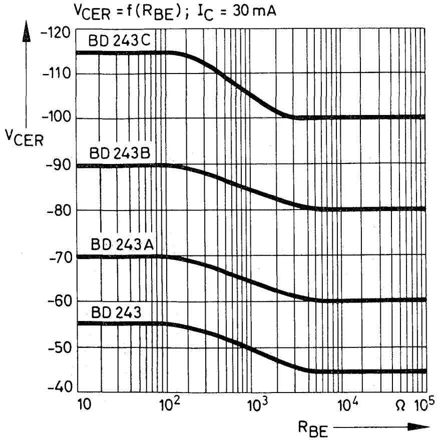
$V_{BE} = f(I_C)$; $V_{CE} = 4V$



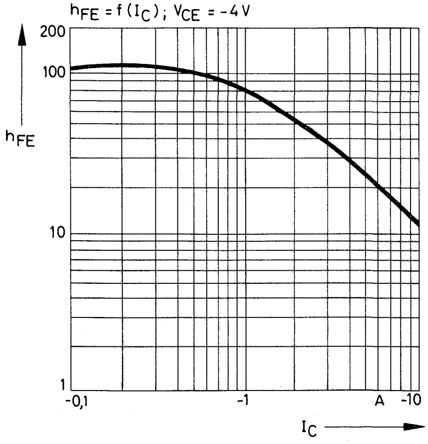
$V_{CE(sat)} = f(I_B)$



$V_{CER} = f(R_{BE})$; I_C = 30 mA



$h_{FE} = f(I_C)$; $V_{CE} = -4V$



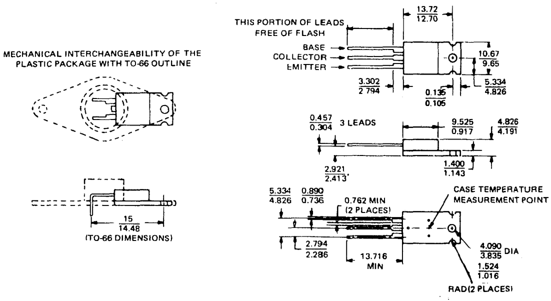
BD244, BD244A, BD244B, BD244C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH BD243A-C

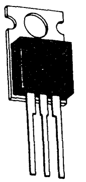
- 65 W at 25 °C Case Temperature
- 6 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD244	BD244A	BD244B	BD244C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	−55 V	−70 V	−90 V	−115 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	←	−5 V		→
Continuous Collector Current	←	−6 A		→
Peak Collector Current (See Note 2)	←	−10 A		→
Continuous Base Current	←	−3 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←	See Figure 5		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	65 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	←	2 W		→
Unclamped Inductive Load Energy (See Note 5)	←	62.5 mJ		→
Operating Collector Junction Temperature Range	←	−65 °C to 150 °C		→
Storage Temperature Range	←	−65 °C to 150 °C		→
Lead Temperature 3.2mm from Case for 5 Seconds	←	250 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 0.52 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C^2 L/2$.

BD244, BD243A, BD244B, BD244C
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD244		BD243A		BD244B		BD244C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	$I_C = -30$ mA, See Note 6	$I_B = 0$,	−45		−60		−80		−100		V
I_{CEO}	$V_{CE} = -30$ V,	$I_B = 0$		−0.7		−0.7					mA
	$V_{CE} = -60$ V,	$I_B = 0$						−0.7		−0.7	
I_{CES}	$V_{CE} = -45$ V,	$V_{BE} = 0$		−0.4							
	$V_{CE} = -60$ V,	$V_{BE} = 0$				−0.4					
	$V_{CE} = -80$ V,	$V_{BE} = 0$						−0.4			
	$V_{CE} = -100$ V,	$V_{BE} = 0$								−0.4	
I_{EBO}	$V_{EB} = -5$ V,	$I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -0.3$ A,	30		30		30		30		
	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -3$ A,	15		15		15		15		
V_{BE}	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -6$ A,		−2		−2		−2		−2	V
$V_{CE(sat)}$	$I_B = -1.0$ A, See Notes 6 and 7	$I_C = -6$ A		1.5		1.5		1.5		1.5	V
h_{fe}	$V_{CE} = -10$ V, f = 1 kHz	$I_C = -0.5$ A,	20		20		20		20		
$\lvert h_{fe} \rvert$	$V_{CE} = -10$ V, f = 1 MHz	$I_C = -0.5$ A	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\ \%$.
7. These parameters are measured with voltage sensing contacts separate from the current carrying contacts.

thermal characteristics

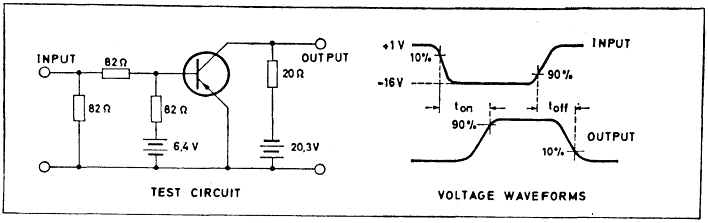
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

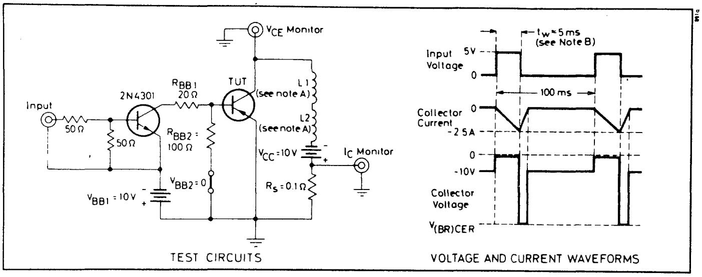
switching characteristics at 25 °C case temperature

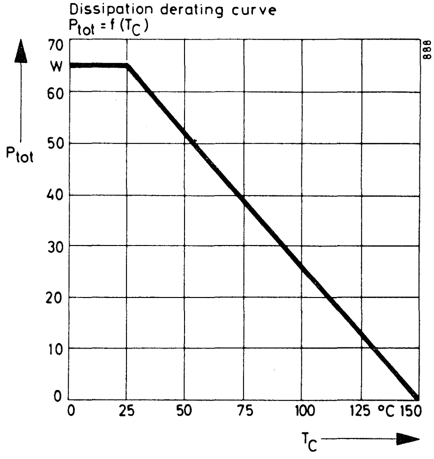
PARAMETER	TEST CONDITIONS$^+$			TYP	UNIT
t_{on}	$I_C = -1$ A,	$I_{B(1)} = -0.1$ A,	$I_{B(2)} = +0.1$ A,	0.3	µs
t_{off}	$V_{BE(off)} = +3.7$ V, $R_L = 20\ \Omega$,		See Figure 1	1	

$^+$ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

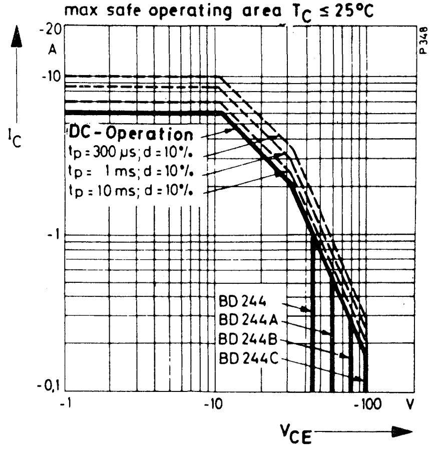
BD244, BD244A, BD244B, BD244C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS



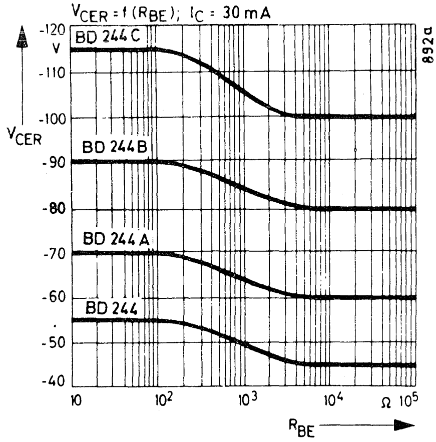


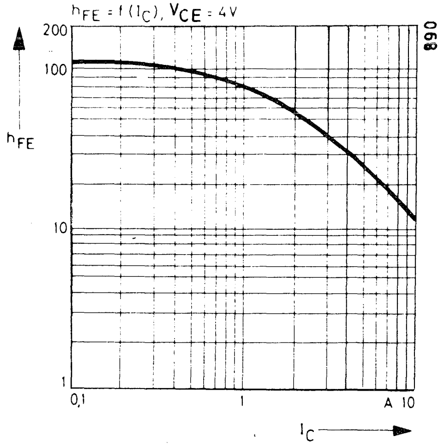

Dissipation derating curve

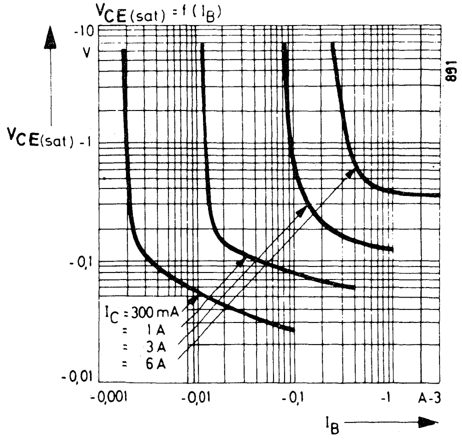
$P_{tot} = f(T_C)$

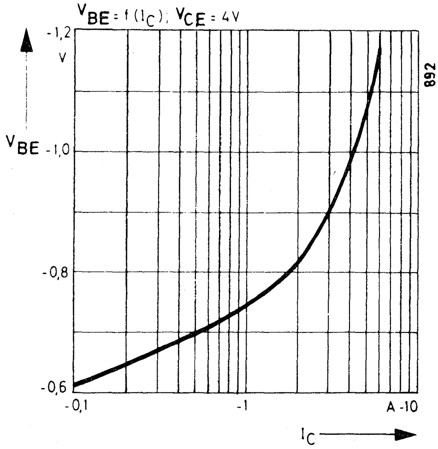

max safe operating area $T_C \leq 25°C$

BD244, BD244A, BD244B, BD244C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









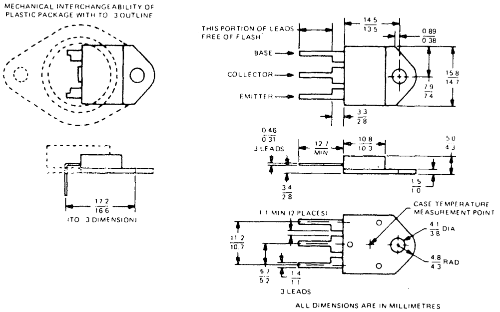
BD245, BD245A, BD245B, BD245C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

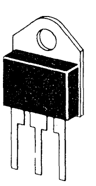
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD246A-C

- 80 W at 25 °C Case Temperature
- 10 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD245	BD245A	BD245B	BD245C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	55 V	70 V	90 V	115 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V
Emitter-Base Voltage	← 5 V →			
Continuous Collector Current	← 10 A →			
Peak Collector Current (See Note 2)	← 15 A →			
Continuous Base Current	← 3 A →			
Safe Operating Region at (or below) 25 °C Case Temperature	← See Figure 5 →			
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	← 80 W →			
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	← 3.0 W →			
Unclamped Inductive Load Energy (See Note 5)	← 62.5 mJ →			
Operating Collector Junction Temperature Range	← −65 °C to 150 °C →			
Storage Temperature Range	← −65 °C to 150 °C →			
Lead Temperature 1/8 Inch from Case for 5 Seconds	← 250 °C →			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10 %.
3. Derate linearly to 150 °C case temperature at the rate of 0.64 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C{}^2 L/2$.

BD245, BD245A, BD245B, BD245C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER			BD245		BD245A		BD245B		BD245C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	I_C = 30 mA, See Note 6	I_B = 0,	45		60		80		100		V
I_{CEO}	V_{CE} = 30 V,	I_B = 0		0.7		0.7					mA
	V_{CE} = 60 V,	I_B = 0						0.7		0.7	
I_{CES}	V_{CE} = 45 V,	V_{BE} = 0		0.4							mA
	V_{CE} = 60 V,	V_{BE} = 0				0.4					
	V_{CE} = 80 V,	V_{BE} = 0						0.4			
	V_{CE} = 100 V,	V_{BE} = 0								0.4	
I_{EBO}	V_{EB} = 5 V,	I_C = 0		1		1		1		1	mA
h_{FE}	V_{CE} = 4 V,	I_C = 1 A,	40		40		40		40		
	See Notes 6 and 7	I_C = 3 A	20		20		20		20		
	V_{CE} = 4 V, See Notes 6 and 7	I_C = 10 A	4		4		4		4		
V_{BE}	V_{CE} = 4 V, See Notes 6 and 7	I_C = 3 A,		1.6		1.6		1.6		1.6	V
	V_{CE} = 4 V, See Notes 6 and 7	I_C = 10 A		3		3		3		3	V
$V_{CE(sat)}$	I_B = 0.3 A, See Notes 6 and 7	I_C = 3 A,		1		1		1		1	V
	I_B = 2.5 A, See Notes 6 and 7	I_C = 10 A,		4		4		4		4	V
h_{fe}	V_{CE} = 10 V, f = 1 kHz	I_C = 0.5 A,	20		20		20		20		
$\|h_{fe}\|$	V_{CE} = 10 V, f = 1 MHz	I_C = 0.5 A,	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$2 %.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

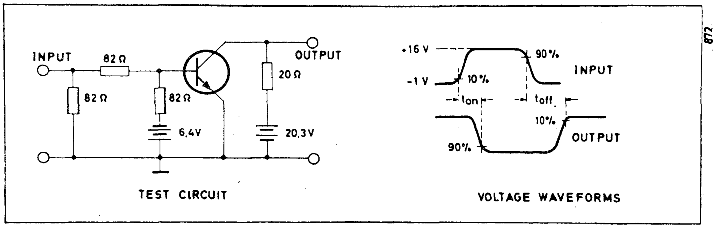
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	42.0	

switching characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS$^+$			TYP	UNIT
t_{on}	I_C = 1 A,	$I_{B(1)}$ = 0.1 A,	$I_{B(2)}$ = −0.1 A,	0.3	μs
t_{off}	$V_{BE(off)}$ = 3.7 V,	R_L = 20 Ω,	See Figure 1	1	

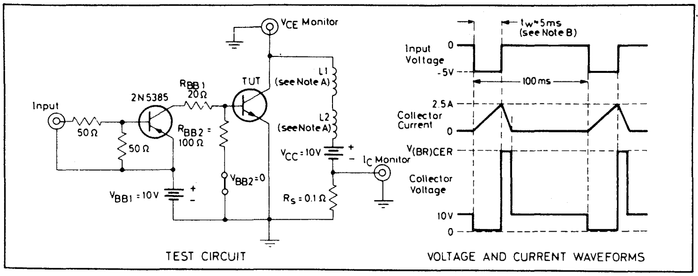
$^+$ Voltage and Current values shown are nominal; exact values vary slightly with transistor parameters.

BD245, BD245A, BD245B, BD245C
NPN SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS



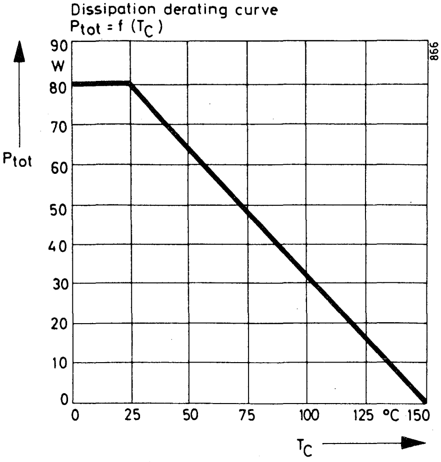
TEST CIRCUIT

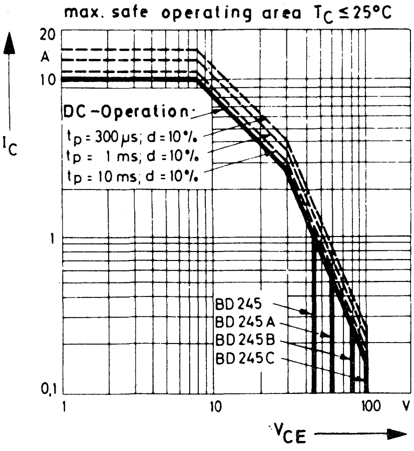
VOLTAGE WAVEFORMS



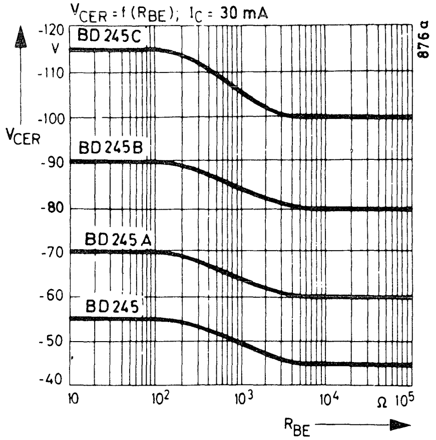
TEST CIRCUIT

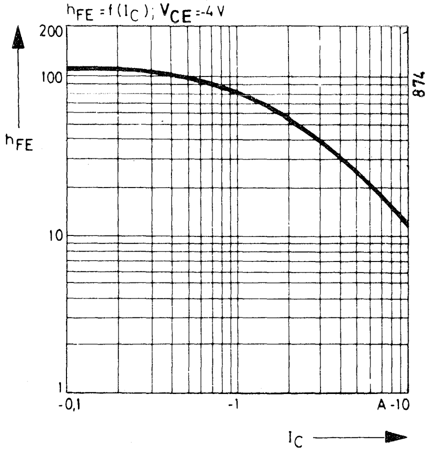
VOLTAGE AND CURRENT WAVEFORMS

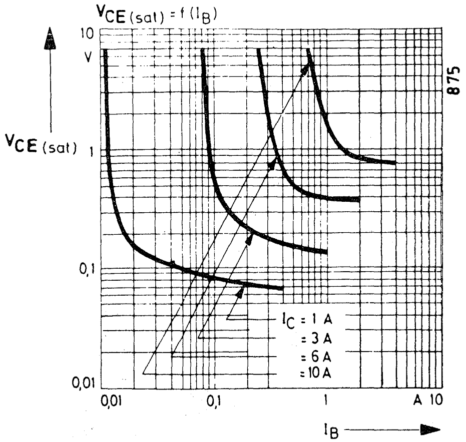


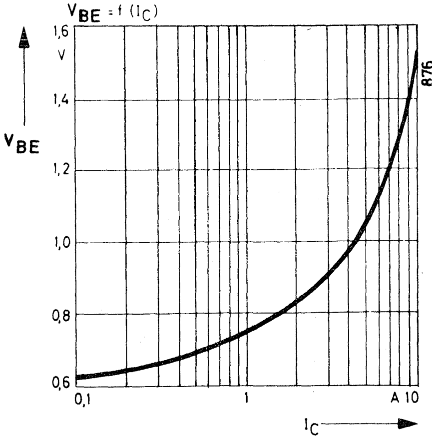


BD245, BD245A, BD245B, BD245C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









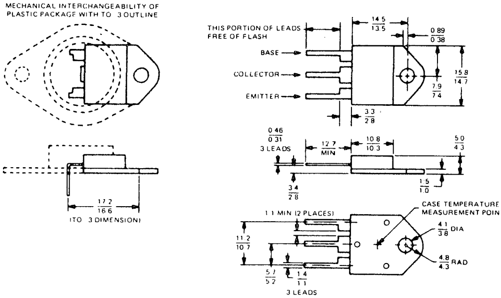
BD246, BD246A, BD246B, BD246C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD245A-C

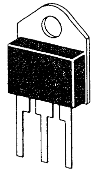
- 80 W at 25 °C Case Temperature
- 10 A Rated Collector Current
- Min f_T of 3 MHz at 10 V, 500 mA

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

<table>
<tr><th></th><th>BD246</th><th>BD246A</th><th>BD246B</th><th>BD246C</th></tr>
<tr><td>Collector-Emitter Voltage (R_{BE} = 100 Ω)</td><td>−55 V</td><td>−70 V</td><td>−90 V</td><td>−115 V</td></tr>
<tr><td>Collector-Emitter Voltage (See Note 1)</td><td>−45 V</td><td>−60 V</td><td>−80 V</td><td>−100 V</td></tr>
<tr><td>Emitter-Base Voltage</td><td colspan="4">← −5 V →</td></tr>
<tr><td>Continuous Collector Current</td><td colspan="4">← −10 A →</td></tr>
<tr><td>Peak Collector Current (See Note 2)</td><td colspan="4">← −15 A →</td></tr>
<tr><td>Continuous Base Current</td><td colspan="4">← −3 A →</td></tr>
<tr><td>Safe Operating Region at (or below) 25 °C Case Temperature</td><td colspan="4">← See Figure 5 →</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)</td><td colspan="4">← 80 W →</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)</td><td colspan="4">← 3 W →</td></tr>
<tr><td>Unclamped Inductive Load Energy (See Note 5)</td><td colspan="4">← 62.5 mJ →</td></tr>
<tr><td>Operating Collector Junction Temperature Range</td><td colspan="4">← −65 °C to 150 °C →</td></tr>
<tr><td>Storage Temperature Range</td><td colspan="4">← −65 °C to 150 °C →</td></tr>
<tr><td>Lead Temperature 1/8 Inch from Case for 5 Seconds</td><td colspan="4">← 250 °C →</td></tr>
</table>

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 0.65 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx 1/2\ I_C{}^2 L/2$.

BD246, BD246A, BD246B, BD246C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD246		BD246A		BD246B		BD246C		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	UNIT
$V_{(BR)CEO}$	$I_C = -30$ mA, See Note 6	$I_B = 0$,	−45		−60		−80		−100		V
I_{CEO}	$V_{CE} = -30$ V,	$I_B = 0$		−0.7		−0.7					mA
	$V_{CE} = -60$ V,	$I_B = 0$						−0.7		−0.7	
I_{CES}	$V_{CE} = -45$ V,	$V_{BE} = 0$		−0.4							mA
	$V_{CE} = -60$ V,	$V_{BE} = 0$				−0.4					
	$V_{CE} = -80$ V,	$V_{BE} = 0$						−0.4			
	$V_{CE} = -100$ V,	$V_{BE} = 0$								−0.4	
I_{EBO}	$V_{EB} = -5$ V,	$I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	$V_{CE} = -4$ V,	$I_C = -1$ A	40		40		40		40		
	$V_{CE} = -4$ V,	$I_C = -3$ A	20		20		20		20		
	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -10$ A	4		4		4		4		
V_{BE}	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -3$ A,		−1.6		−1.6		−1.6		−1.6	V
	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -10$ A,		−3		−3		−3		−3	
$V_{CE(sat)}$	$I_B = -0.3$ A, See Notes 6 and 7	$I_C = -3$ A,		−1		−1		−1		−1	V
	$I_B = -2.5$ A, See Notes 6 and 7	$I_C = -10$ A,		−4		−4		−4		−4	
h_{fe}	$V_{CE} = -10$ V, f = 1 kHz	$I_C = -0.5$ A,	20		20		20		20		
$\|h_{fe}\|$	$V_{CE} = -10$ V, f = 1 MHz	$I_C = -0.5$ A,	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽2 %.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

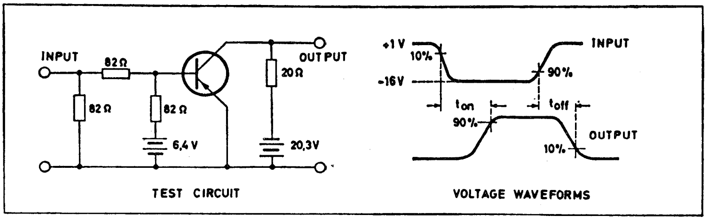
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	42.0	

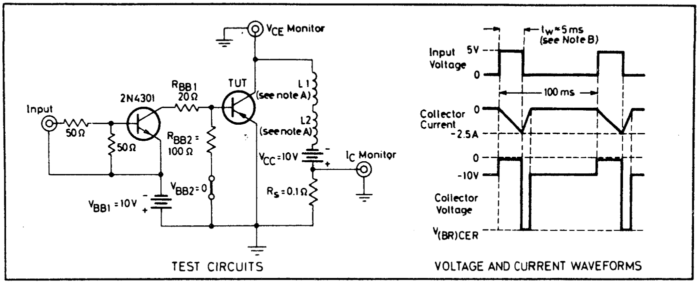
switching characteristics at 25 °C case temperature

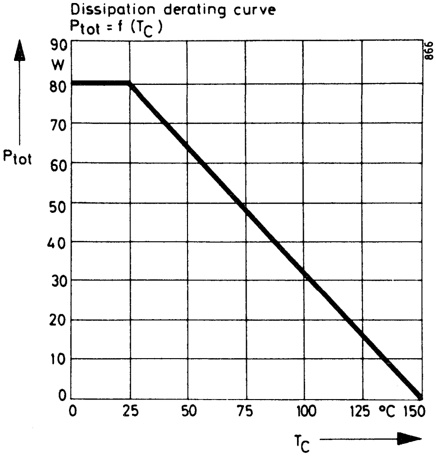
PARAMETER	TEST CONDITIONS +			TYP	UNIT
t_{on}	$I_C = 1$ A,	$I_{B(1)} = 0.1$ A,	$I_{B(2)} = 0.1$ A,	0.2	μs
t_{off}	$V_{BE(off)} = 3.7$ V,	$R_L = 20\,\Omega$,	See Figure 1	0.8	

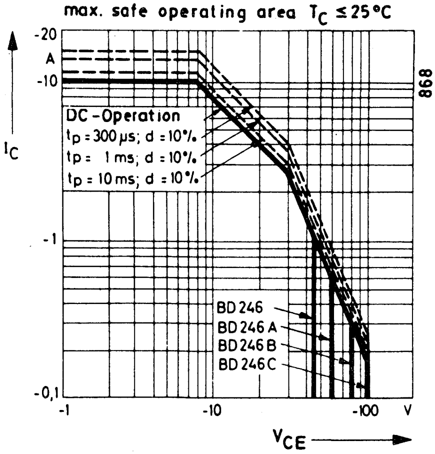
+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD246, BD246A, BD246B, BD246C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

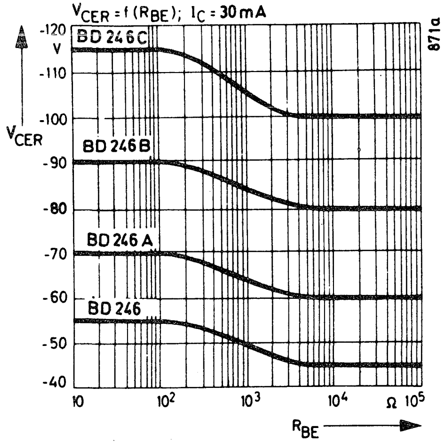


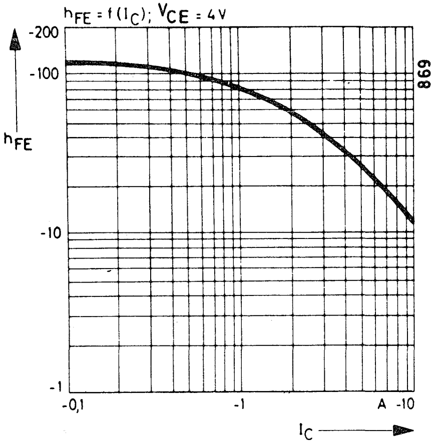


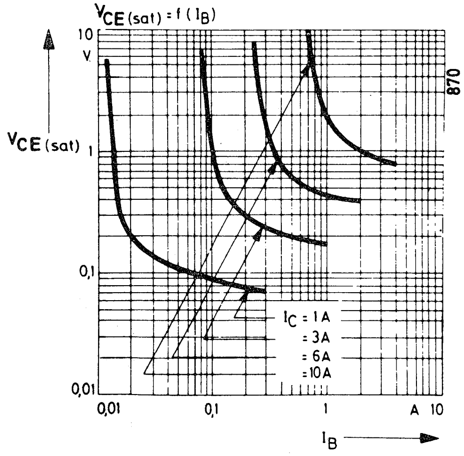


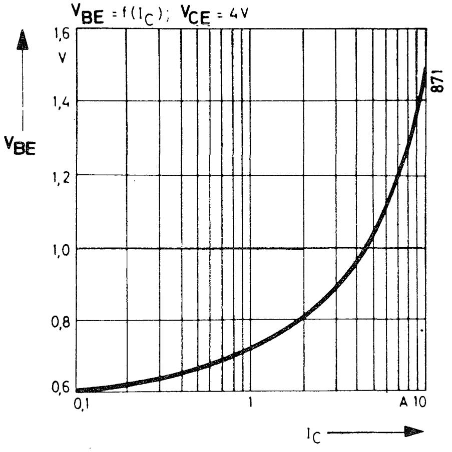


BD246, BD246A, BD246B, BD246C PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









TEXAS INSTRUMENTS

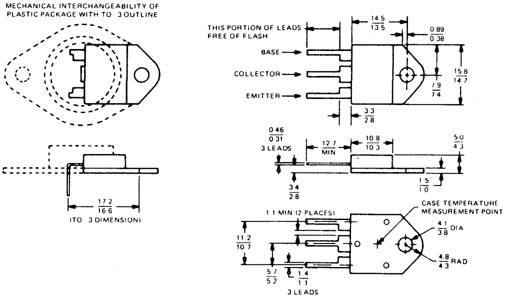
BD249, BD249A, BD249B, BD249C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD250A-C

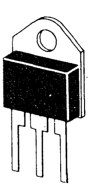
- **125 W at 25 °C Case Temperature**
- **25 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD249	BD249A	BD249B	BD249C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	55 V	70 V	90 V	115 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V
Emitter-Base Voltage	←	5 V		→
Continuous Collector Current	←	25 A		→
Peak Collector Current (See Note 2)	←	40 A		→
Continuous Base Current	←	5 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←	See Figure 5		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	←	125 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	←	3.0 W		→
Unclamped Inductive Load Energy (See Note 5)	←	90 mJ		→
Operating Collector Junction Temperature Range	←	−65 °C to 150 °C		→
Storage Temperature Range	←	−65 °C to 150 °C		→
Lead Temperature 3.2mm from Case for 5 Seconds	←	250 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10 %.
3. Derate linearly to 150 °C case temperature at the rate of 1 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy $\approx I_C^2 L/2$.

BD249, BD249A, BD249B, BD249C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD249		BD249A		BD249B		BD249C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	$I_C = 30$ mA, See Note 6	$I_B = 0$,	45		60		80		100		V
I_{CEO}	$V_{CE} = 30$ V,	$I_B = 0$		1		1					mA
	$V_{CE} = 60$ V,	$I_B = 0$						1		1	
I_{CES}	$V_{CE} = 45$ V,	$V_{BE} = 0$		0.7							mA
	$V_{CE} = 60$ V,	$V_{BE} = 0$				0.7					
	$V_{CE} = 80$ V,	$V_{BE} = 0$						0.7			
	$V_{CE} = 100$ V,	$V_{BE} = 0$								0.7	
I_{EBO}	$V_{EB} = 5$ V,	$I_C = 0$		1		1		1		1	mA
h_{FE}	$V_{CE} = 4$ V,	$I_C = 1.5$ A	25		25		25		25		
	$V_{CE} = 4$ V,	$I_C = 25$ A	5		5		5		5		
	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 15$ A	10		10		10		10		
V_{BE}	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 15$ A,		2		2		2		2	V
	$V_{CE} = 4$ V, See Notes 6 and 7	$I_C = 25$ A,		4		4		4		4	
$V_{CE(sat)}$	$I_B = 1.5$ A, See Notes 6 and 7	$I_C = 15$ A,		1.8		1.8		1.8		1.8	V
	$I_B = 5$ A, See Notes 6 and 7	$I_C = 25$ A,		4		4		4		4	
h_{fe}	$V_{CE} = 10$ V, f = 1 kHz	$I_C = 1$ A,	25		25		25		25		
$\|h_{fe}\|$	$V_{CE} = 10$ V, f = 1 MHz	$I_C = 1$ A,	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µd duty cycle $\leqslant 2$ %.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

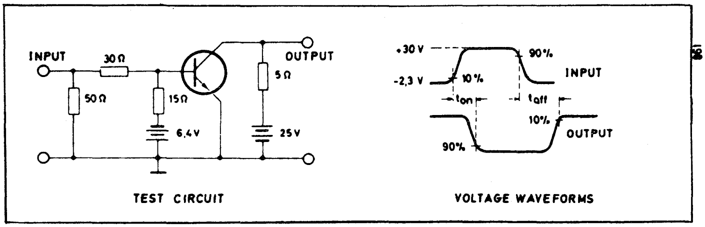
thermal characteristics

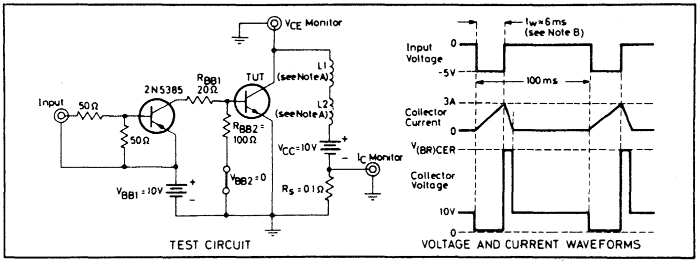
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	42	

switching characteristics at 25 °C case temperature

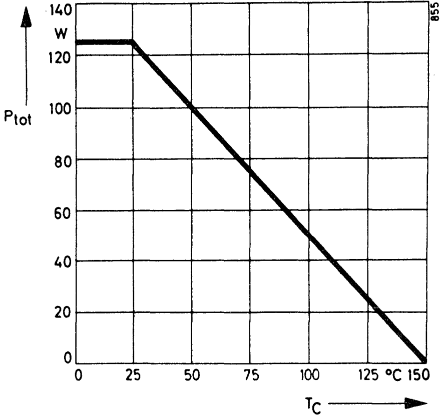
PARAMETER	TEST CONDITIONS +			TYP	UNIT
t_{on}	$I_C = 5$ A,	$I_{B(1)} = 5$ A,	$I_{B(2)} = -5$ A,	0.3	µs
t_{off}	$V_{BE(off)} = -5$ V,	$R_L = 5\ \Omega$,	See Figure 1	0.9	

+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

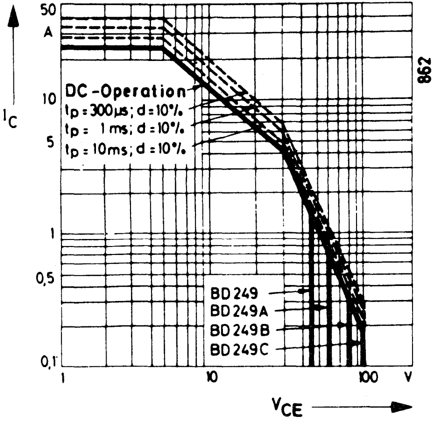




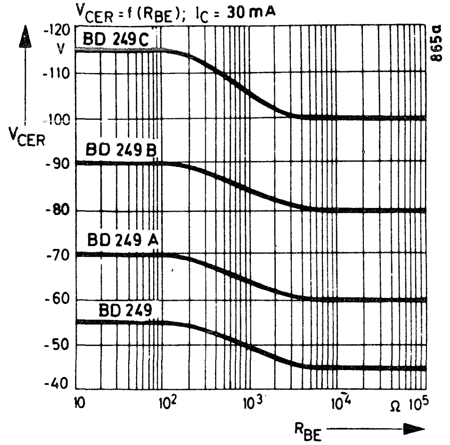
Dissipation derating curve
$P_{tot} = f(T_C)$

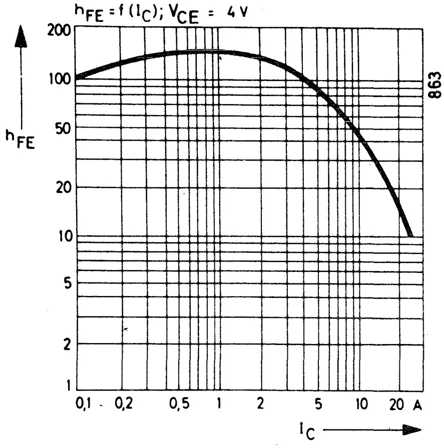


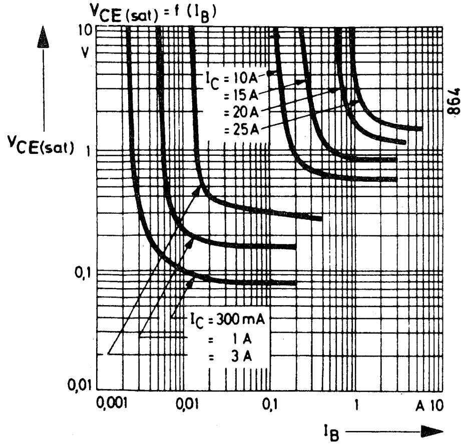
max. safe operating area $T_C \leq 25°C$

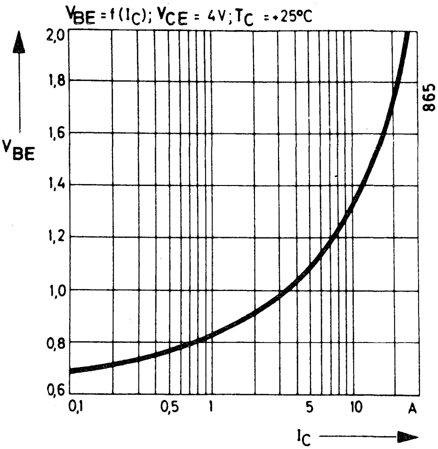


BD249, BD249A, BD249B, BD249C
NPN SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS









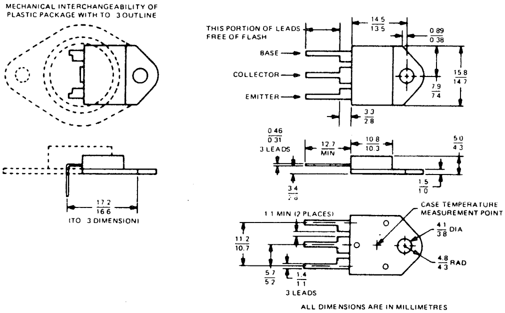
BD250, BD250A, BD250B, BD250C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

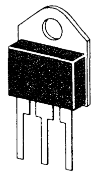
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD249A-C

- 125 W at 25 °C Case Temperature
- 15 A rated Collector Current
- Min f_T of 3 MHz at 10 V, 1 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD250	BD250A	BD250B	BD250C
Collector-Emitter Voltage (R_{BE} = 100 Ω)	−55 V	−70 V	−90 V	−115 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	← −5 V →			
Continuous Collector Current	← −25 A →			
Peak Collector Current (See Note 2)	← −40 A →			
Continuous Base Current	← −5 A →			
Safe Operating Region at (or below) 25 °C Case Temperature	← See figure 5 →			
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	← 125 W →			
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 4)	← 3.0 W →			
Unclamped Inductive Lead Energy (See Note 5)	← 90 mJ →			
Operating Collector Junction Temperature Range	← −65 °C to 150 °C →			
Storage Temperature Range	← −65 °C to 150 °C →			
Lead Temperature 3.2mm from Case for 5 Seconds	← 250 °C →			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10$ %.
3. Derate linearly to 150 °C case temperature at the rate of 1 W/°C.
4. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V, Energy $\approx I_C^2 L/2$.

BD250, BD250A, BD250B, BD250C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS		BD250		BD250A		BD250B		BD250C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	$I_C = -30$ mA, See Note 6	$I_B = 0$	−45		−60		−80		−100		V
I_{CEO}	$V_{CE} = -30$ V,	$I_B = 0$		−1		−1					mA
	$V_{CE} = -60$ V,	$I_B = 0$						−1		−1	
I_{CES}	$V_{CE} = -45$ V,	$V_{BE} = 0$		−0.7							mA
	$V_{CE} = -60$ V,	$V_{BE} = 0$				−0.7					
	$V_{CE} = -80$ V,	$V_{BE} = 0$						−0.7			
	$V_{CE} = -100$ V,	$V_{BE} = 0$								−0.7	
I_{EBO}	$V_{EB} = -5$ V,	$I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	$V_{CE} = -4$ V,	$I_C = -1.5$ A	25		25		25		25		
	$V_{CE} = -4$ V,	$I_C = -15$ A	10		10		10		10		
	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -25$ A	5		5		5		5		
V_{BE}	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -15$ A,		−2		−2		−2		−2	V
	$V_{CE} = -4$ V, See Notes 6 and 7	$I_C = -25$ A,		−4		−4		−4		−4	
$V_{CE(sat)}$	$I_B = -1.5$A, See Notes 6 and 7	$I_C = -15$ A		−1.8		−1.8		−1.8		−1.8	V
	$i_B = -5$ A, See Notes 6 and 7	$i_C = -25$ A		−4		−4		−4		−4	
h_{fe}	$V_{CE} = -10$ V, f = 1 kHz	$I_C = -1$ A	25		25		25		25		
$\|h_{fe}\|$	$V_{CE} = -10$ V, f = 1 MHz	$I_C = -1$ A	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle $\leqslant 2$ %.

7. These parameters are measured with voltagesensing contacts separate from the current-carrying contacts.

thermal characteristics

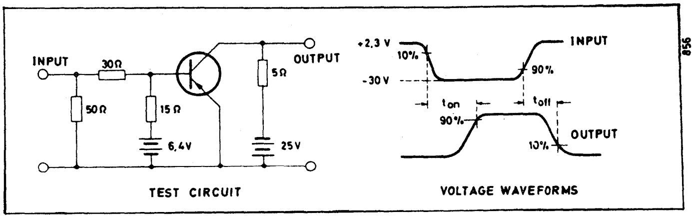
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	42.0	

switching characteristics at 25 °C case temperature

PARAMETER	TEST CONDITIONS +			TYP	UNIT
t_{on}	$I_C = -5$ A,	$I_{B(1)} = -0.5$ A,	$I_{B(2)} = 0.5$ A,	0.2	µs
t_{off}	$V_{BE(off)} = 5$ V,	$R_L = 5\,\Omega$	See Figure 1	0.4	

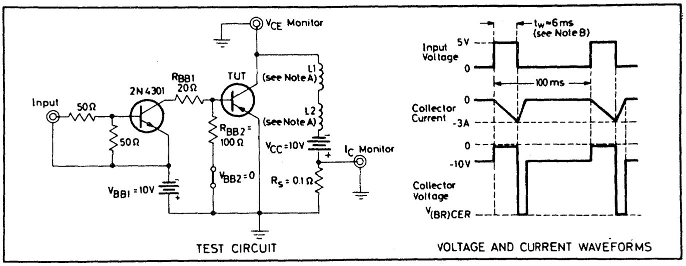
+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD250, BD250A, BD250B, BD250C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS



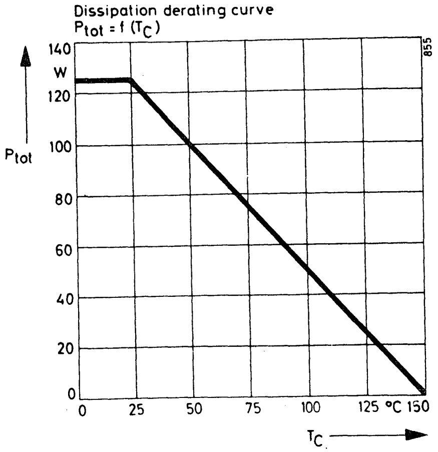
TEST CIRCUIT

VOLTAGE WAVEFORMS



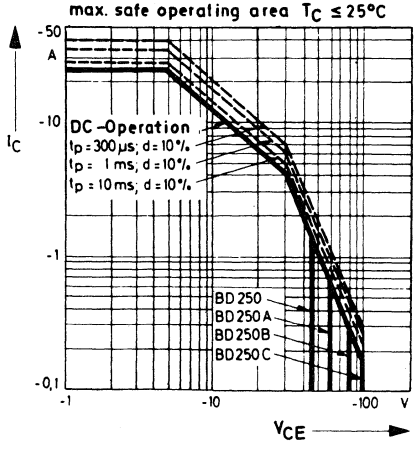
TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS



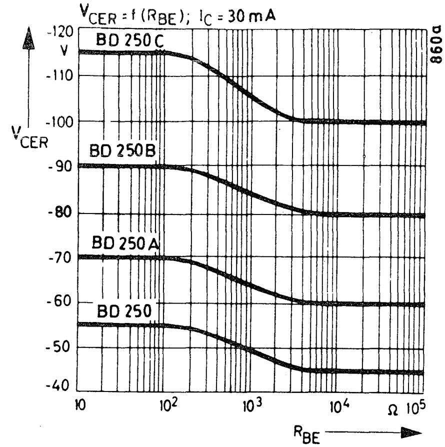
Dissipation derating curve

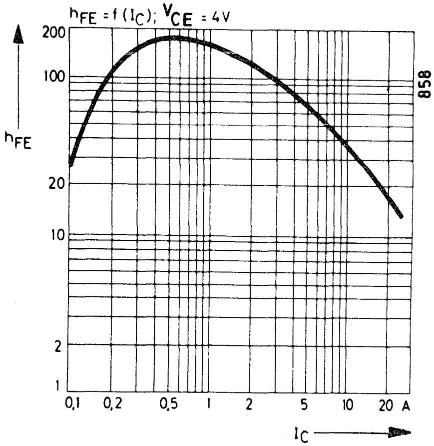
$P_{tot} = f(T_C)$

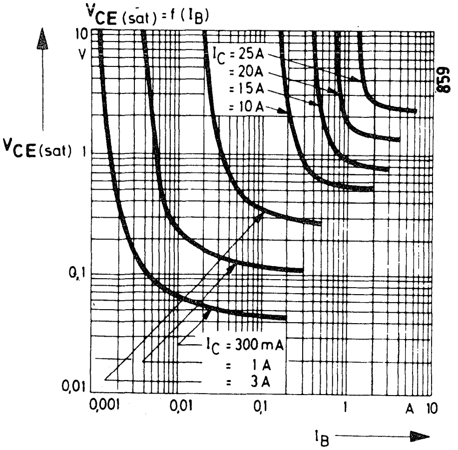


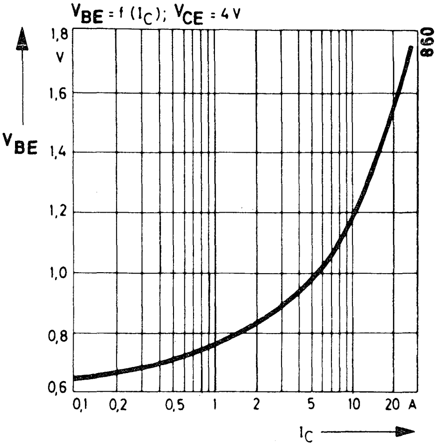
max. safe operating area $T_C \le 25°C$

BD250, BD250A, BD250B, BD250C
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS







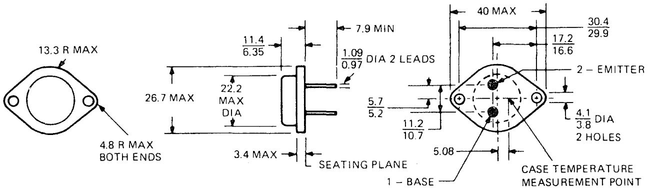


BD 253, BD 253A, BD 253B, BD 253C
NPN SILICON POWER TRANSISTORS

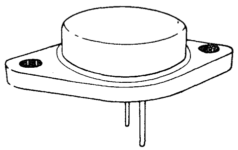
- High Voltage Rating – V_{CEX} up to 900 Volts
- High Current Rating – 6 Amps Peak
- Low Saturation Voltage at 3 Amps – 0.6 Volts typ.
- Fast Switching t_f at 3 Amps – 300 nano Secs typ.
- f_T – 25 MHz typ.

mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



All dimensions are in mm



absolute maximum ratings (T_{case} = 25 °C)

	BD253	BD253A	BD253B	BD253C
Collector-Base Voltage ($I_E = 0$)	350 V	500 V	700 V	900 V
Collector-Emitter Voltage ($-2 \geqslant V_{BE} \geqslant -8$ V)	350 V	500 V	700 V	900 V
Collector-Emitter Voltage ($I_B = 0$)	200 V	250 V	300 V	400 V
Emitter-Base Voltage	← 8 V →			
Collector Current (Peak see Note 1)	← 6 A →			
Collector Current Continuous	← 4 A →			
Base-Current Continuous	← 3 A →			
Total Dissipation ($V_{CE} \leqslant 25$ V) See Note 2	← 50 W →			
Operating Junction Temperature	← −65 °C to +175 °C →			
Storage Temperature	← −65 °C to +175 °C →			

NOTES: 1. Pulse Width ⩽ 1 ms. Duty Cycle ⩽ 25 %.
2. Refer to Figures 1 and 3

BD253, BD253A, BD253B, BD253C
NPN SILICON POWER TRANSISTORS

electrical characteristics (T_{case} = 25 °C)

PARAMETER		TEST CONDITIONS		TYPE	MIN	TYP	MAX	UNIT
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 350 V,	$I_E = 0$	BD253			2	mA
		V_{CB} = 500 V,	$I_E = 0$	BD253A			2	
		V_{CB} = 700 V,	$I_E = 0$	BD253B			2	
		V_{CB} = 900 V,	$I_E = 0$	BD253C			2	
I_{CEX}	Collector-Emitter Leakage Current	V_{CE} = 350 V,	V_{BE} = −2 V	BD253			2	mA
		V_{CE} = 500 V,	V_{BE} = −2 V	BD253A			2	
		V_{CE} = 700 V,	V_{BE} = −2 V	BD253B			2	
		V_{CE} = 900 V,	V_{BE} = −2 V	BD253C			2	
LV_{CEO}	Collector-Emitter Latching Voltage	I_C = 100 mA, See Note 3	$I_B = 0$	BD253	200			V
				BD253A	250			
				BD253B	300			
				BD253C	400			
LV_{CER}	Collector-Emitter Latching Voltage	I_E = 100 mA, See Note 3	R_{BE} = 100 Ω	BD253	300			V
				BD253A	350			
				BD253B	400			
				BD253C	500			
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 mA,	$I_C = 0$	All	8			V
h_{FE}	DC Gain	I_C = 1 A, See Note 3	V_{CE} = 4 V	All	15	50		
h_{FE}	DC Gain	I_C = 3 A, See Note 3	V_{CE} = 4 V	All	5	10		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 1 A,	I_B = .1 A	All		.5	1,2	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	See Note 3		All		.85	1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 3 A, See Note 3	I_B = 1 A	All		.6	2.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage			All		1.1	1.6	V
f_T	Transition Frequency	I_C = 0.25 A, f = 10 MHz	V_{CE} = 10 V	All	15	25		MHz
$\theta_{j\text{-}c}$	Junction to Case Thermal Resistance			All		2	3	°C/W
t_r	Collector-Current Fall Time	I_C = 3 A, $I_{B(off)}$ = 1 A,	$I_{B(on)}$ = 1 A V_{CE} = 60 V	All		0.3	1	µs
t_s	Storage Time			All		1.0	2	µs
t_{on}	Total Turn-on Time			All		0.6	1.5	µs

NOTE 3: Pulsed Test. Pulse Duration ⩽ 300 µs. Duty Cycle ⩽ 2 %.

BD253,BD253A,BD253B,BD253C
NPN SILICON POWER TRANSISTORS

FORWARD BIASED SAFE AREA OF OPERATION, D.C.
AND SINGLE NON-REPETITIVE PULSE.
CASE TEMPERATURE 25 °C

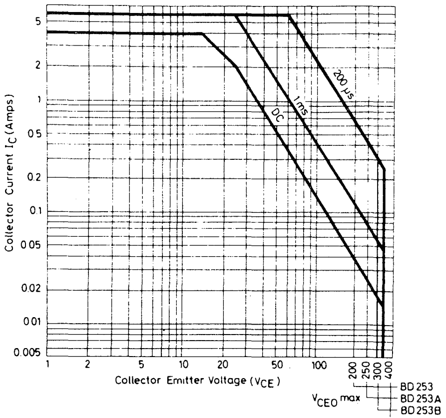


FIGURE 1

TYPICAL VARIATION OF D.C. GAIN WITH COLLECTOR
CURRENT. CASE TEMPERATURE +25 °C

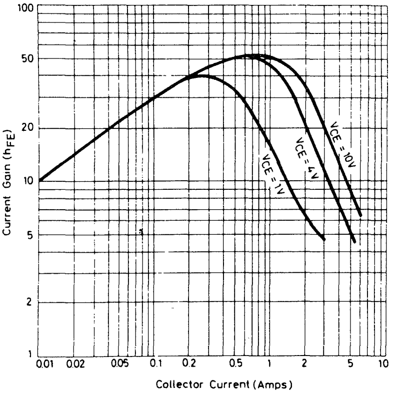


FIGURE 2

DISSIPATION DERATING CURVE

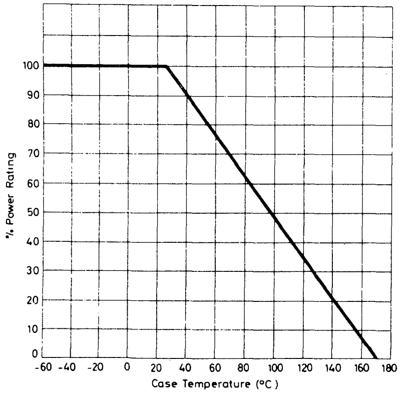


FIGURE 3

The graph on Figure 1 is for single non-repetitive rectangular power pulses, with a case temperature held at 25 C. For operation at case temperatures above 25 C derate the value of current indicated in Figure 1 by the power derating factor, determined from Figure 3.

For repetitive pulse operation the following procedure should be followed. Work out the energy of the power pulse by graphical integration and determine the equivalent rectangular power pulse, using the pulse duration and the peak voltage applied. Ensure that the equivalent power pulse, as determined, is within the safe operating area, applying a derating factor for the case temperature as indicated above. Also calculate the average power dissipation and ensure that it falls within the steady state (DC) condition, having first derated the steady state condition for the effect of case temperature.

BD410

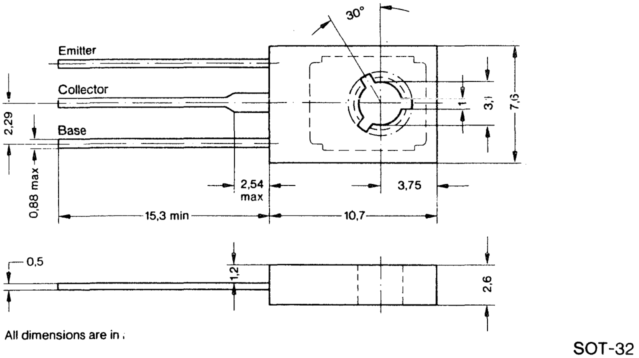
NPN TRIPLE DIFFUSED SILICON TRANSISTOR

AF-AMPLIFIER FOR HIGH SUPPLY VOLTAGE

- Control Circuits
- Vertical-Output Stages in TV-Sets
- General Purpose Application
- V_{CER} typ. 450 V at R_{BE} = 1 kΩ
- h_{FE} typ. 60 at I_C = 100 mA
- P_{tot} = 20 W

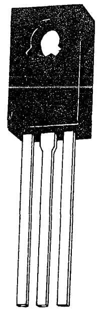
These components are tested according to the appropriate test method of MIL-STD-750. By special agreement, they can also be tested additionally to MIL- or DIN-specifications.

mechanical data



All dimensions are in ;

SOT-32



absolute maximum ratings at 25 °C free-air temeperature (unless otherwise noted)

Collector-Base Voltage	500 V
Collector-Emitter Voltage (See Note 1)	325 V
Emitter-Base Voltage	5 V
Continuous Collector Current	1 A
Peak Collector Current	1.5 A
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	1.25 W
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	20 W
Storage Temperature Range	–55 °C to 125 °C
Lead Temperature 1.6 mm from Case for 10 Seconds	260 °C

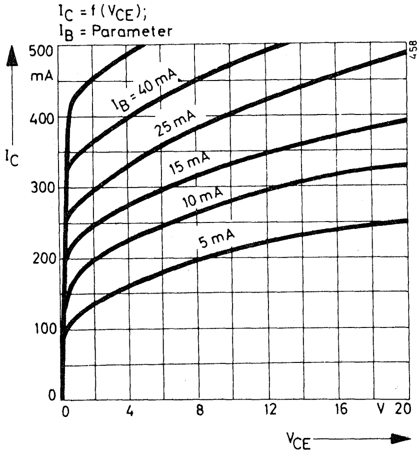
NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. See power dissipation diagram.
3. See power dissipation diagram.

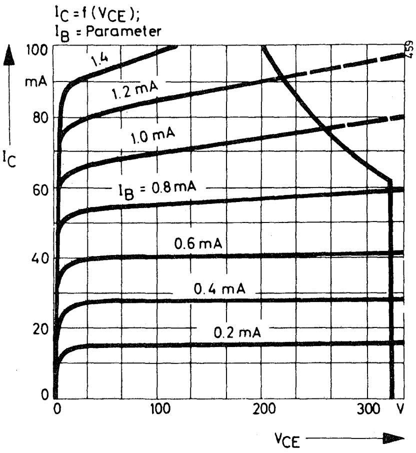
BD410
NPN TRIPLE DIFFUSED SILICON TRANSISTOR

electrical characteristics at 25 °C free-air temperature (unless otherwise noted)

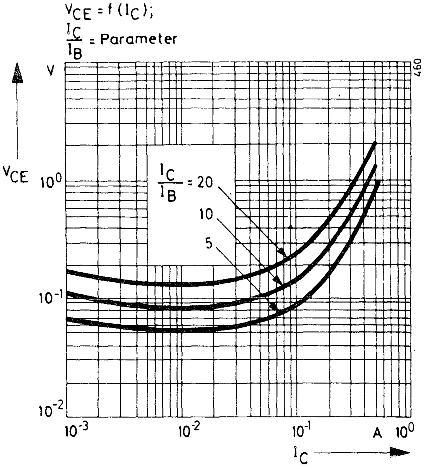
PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 500\ \mu A$	$I_E = 0$		500			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$	See Note 4	325			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 50\ \mu A$,	$I_C = 0$		5			V
I_{CES}	Collector Cutoff Current	$V_{CE} = 300$ V,	$I_B = 0$				100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $V_{CE} = 10$ V, $V_{CE} = 10$ V,	$I_C = 5$ mA $I_C = 50$ mA $I_C = 100$ mA		25 30 20	55 60 60	 240 	
V_{BE}	Base-Emitter Voltage	$I_B = 10$ mA,	$I_C = 100$ mA				1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 10$ mA,	$I_C = 100$ mA				0.5	V
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz		5.5		pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V,	$I_E = 0$,	f = 1 MHz		90		pF

NOTE: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2$ %.

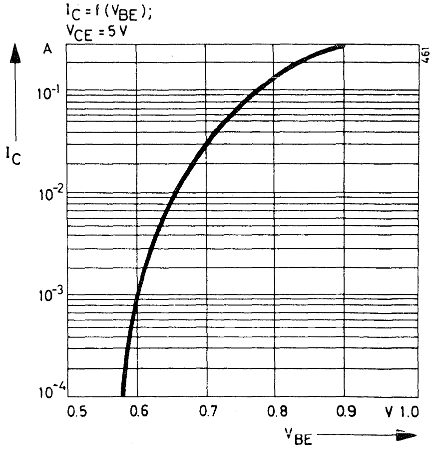




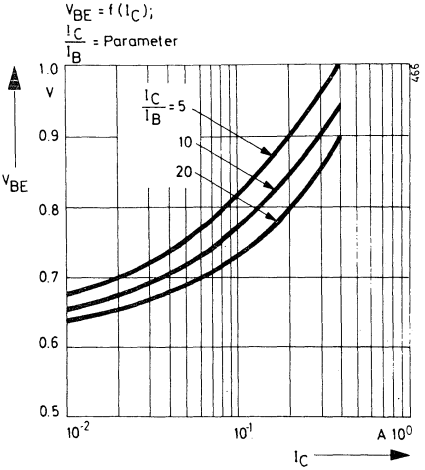
BD410
NPN TRIPLE DIFFUSED SILICON TRANSISTOR



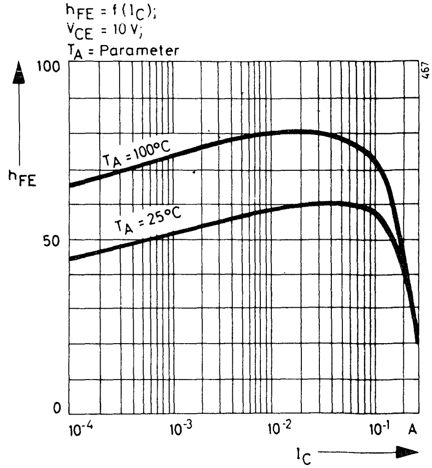
$V_{CE} = f(I_C)$; $\frac{I_C}{I_B}$ = Parameter



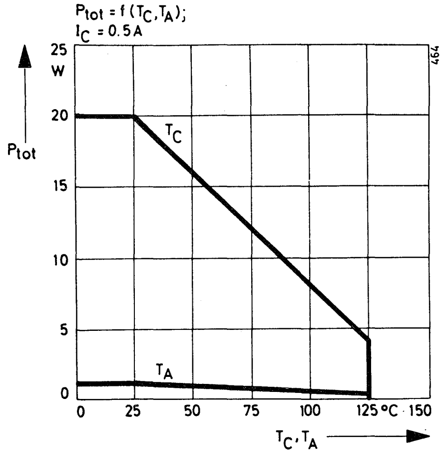
$I_C = f(V_{BE})$; $V_{CE} = 5$ V

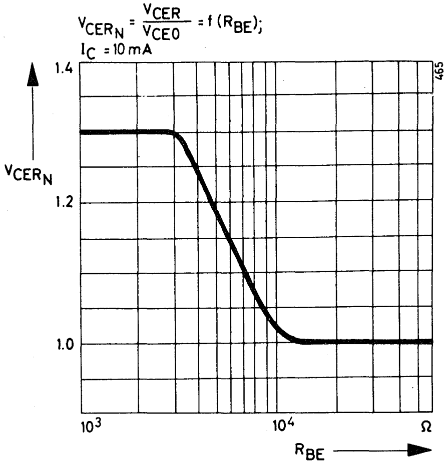


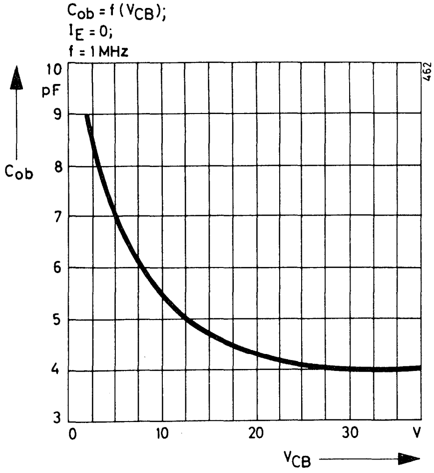
$V_{BE} = f(I_C)$; $\frac{I_C}{I_B}$ = Parameter

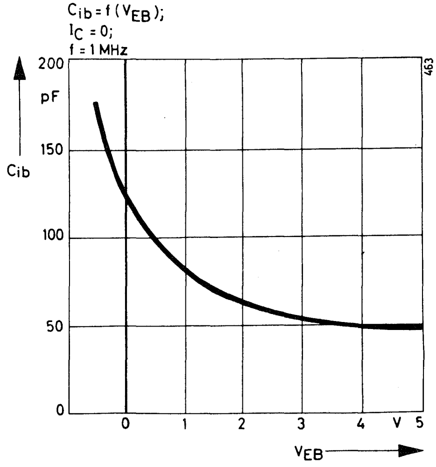


$h_{FE} = f(I_C)$; $V_{CE} = 10$ V; T_A = Parameter


$P_{tot} = f(T_C, T_A)$;
$I_C = 0.5A$
464
P_{tot}
25
W
20
15
10
5
0
T_C
T_A
0
25
50
75
100
125 °C
150
T_C, T_A


$V_{CER_N} = \frac{V_{CER}}{V_{CEO}} = f(R_{BE})$;
$I_C = 10\,mA$
465
V_{CER_N}
1.4
1.2
1.0
10^3
10^4
Ω
R_{BE}


$C_{ob} = f(V_{CB})$;
$I_E = 0$;
f = 1 MHz
462
C_{ob}
10
pF
9
8
7
6
5
4
3
0
10
20
30
V
V_{CB}

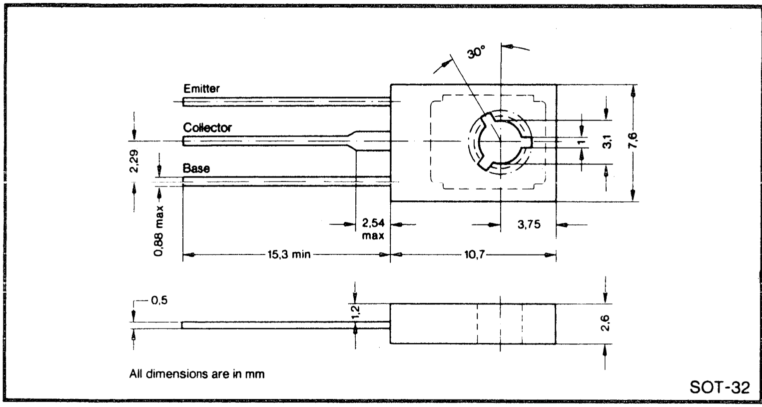

$C_{ib} = f(V_{EB})$;
$I_C = 0$;
f = 1 MHz
463
C_{ib}
200
pF
150
100
50
0
0
1
2
3
4
V
5
V_{EB}

BD466A, BD466B
PNP EPITAXIAL PLANAR SILICON TRANSISTOR

DARLINGTON CONFIGURATION

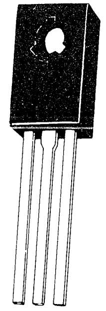
- Complementary output stages
- Stabilised Power Supplies
- High Gain Hammer Driver
- Complementary to BD 477A, BD 477B
- Minimum h_{FE} 8000

mechanical data



All dimensions are in mm

SOT-32



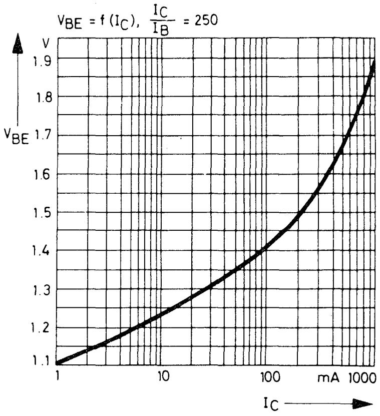
absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

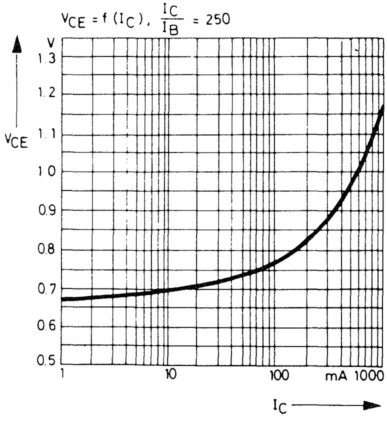
	BD 466A	BD 466B
Collector-Base Voltage	−30 V	−45 V
Collector-Emitter Voltage (see Note 1)	−30 V	−45 V
Emitter-Base Voltage	← −10 V →	
Continuous Collector Current	← −1 A →	
Peak Collector Current	← −1.5 A →	
Continuous Device Dissipation at (or below) 25 °C free Air Temperature (see Note 2)	← 1.25 W →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 3)	← 8.5 W →	
Storage Temperature Range	← −55 to 125 °C →	
Lead Temperature 1.6 mm from case for 10 sec.	← 260 °C →	

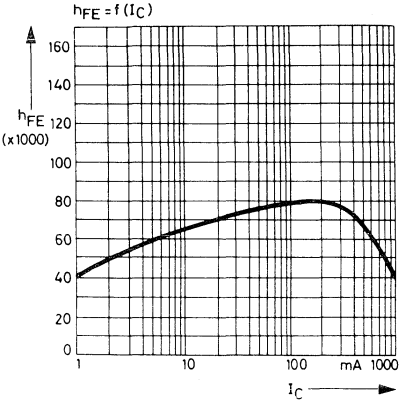
electrical characteristics at 25 °C free air temperature (unless otherwise noted)

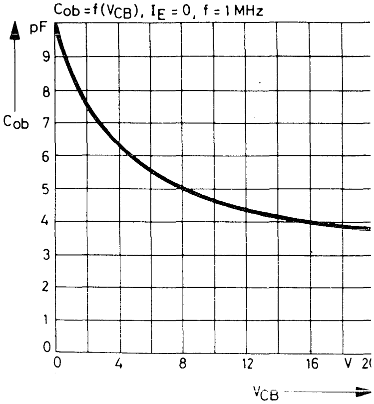
	PARAMETER	TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	A	- 30			V
			B	- 45			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -2$ mA, $I_B = 0$	A	- 30			V
		(Note 4)	B	- 45			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	A/B	– 10			V
I_{CBO}	Collector-Cutoff Current	$V_{CB} = -20$ V, $I_E = 0$	A			– 100	nA
		$V_{CB} = 30$ V, $I_E = 0$	B			– 100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -150$ mA	A/B	10 k			
		$V_{CE} = -10$ V, $I_C = -500$ mA	A/B	8 k			
V_{BE}	Base Emitter Voltage	$I_B = -2$ mA, $I_C = -500$ mA	A/B			– 1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2$ mA, $I_C = -500$ mA	A/B			–1.5	V
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -50$ mA	A/B		170		MHz
C_{ob}	Common Base Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$	A/B		4.5		pF

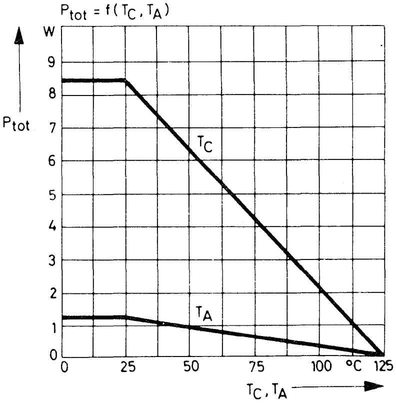
NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 125 °C free air temperature at the rate of 12.5 mW/°C.
3. Derate linearly to 125 °C case temperature at the rate of 85 mW/°C.
4. This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leqslant 2\%$






$h_{FE} = f(I_C)$
h_{FE}
(x1000)
160
140
120
100
80
60
40
20
0
1
10
100
mA 1000
I_C


$C_{ob} = f(V_{CB})$, $I_E = 0$, f = 1 MHz
pF
C_{ob}
9
8
7
6
5
4
3
2
1
0
0
4
8
12
16
V 2
V_{CB}

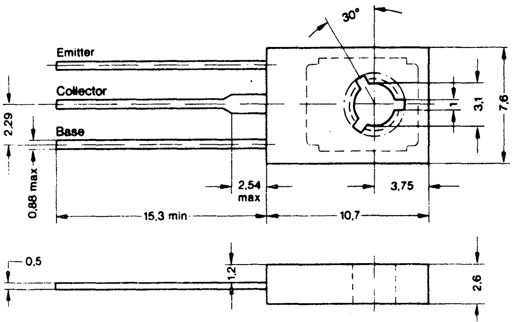

$P_{tot} = f(T_C, T_A)$
W
P_{tot}
9
8
7
6
5
4
3
2
1
0
T_C
T_A
0
25
50
75
100
°C
125
T_C, T_A

BD477A, BD477B
NPN EPITAXIAL PLANAR SILICON TRANSISTOR

DARLINGTON CONFIGURATION

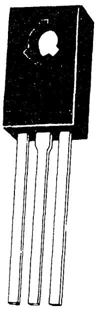
- Complementary output stages
- Stabilised Power Supplies
- High Gain Hammer Driver
- Complementary to BD 466A, BD 466B
- Minimum h_{FE} 8000

mechanical data



All dimensions are in mm

SOT-32



absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

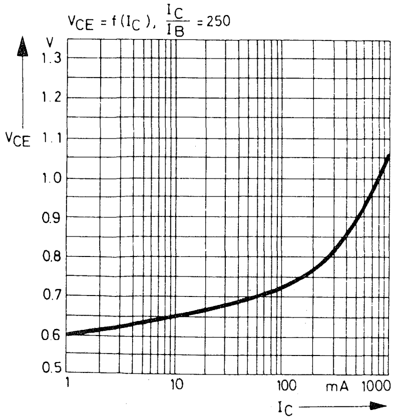
	BD 477A	BD 477B
Collector-Base Voltage	30 V	45 V
Collector-Emitter Voltage (see Note 1)	30 V	45 V
Emitter-Base Voltage	← 10 V →	
Continuous Collector Current	← 1 A →	
Peak Collector Current	← 1.5 A →	
Continuous Device Dissipation at (or below) 25 °C Free Air Temperature (see Note 2)	← 1.25 W →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 3)	← 8.5 W →	
Storage Temperature Range	← −55 to 125 °C →	
Lead Temperature 1.6 mm from case for 10 sec.	← 260 °C →	

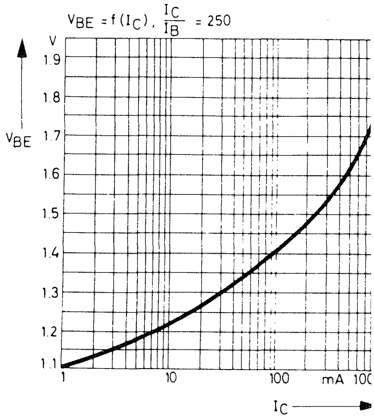
BD477A, BD477B
NPN EPITAXIAL PLANAR SILICON TRANSISTOR

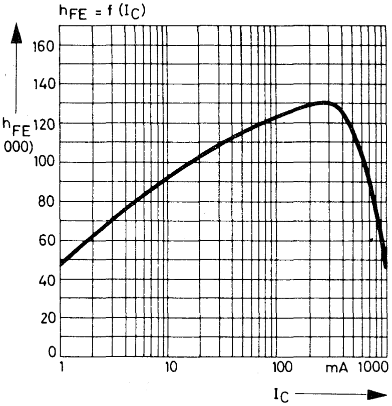
electrical characteristics at 25 °C free air temperature (unless otherwise noted)

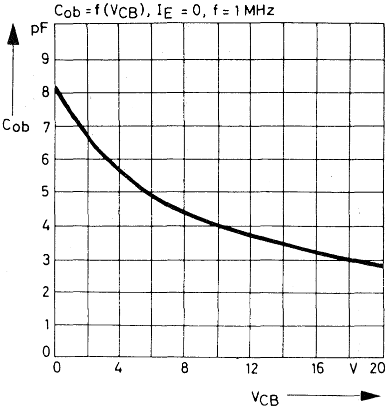
PARAMETER		TEST CONDITIONS		TYPE	MIN	TYP	MAX	UNI
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\,\mu A$,	$I_E = 0$	A	30			V
				B	45			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA,	$I_B = 0$	A	30			V
		(See Note 4)		B	45			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\,\mu A$,	$I_C = 0$	A/B	10			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V,	$I_E = 0$	A			100	nA
		$V_{CB} = 30$ V,	$I_E = 0$	B			100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 150$ mA	A/B	10 k			
		$V_{CE} = 10$ V,	$I_C = 500$ mA	A/B	8 k			
V_{BE}	Base-Emitter Voltage	$I_B = 2$ mA,	$I_C = 500$ mA	A/B			1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 2$ mA,	$I_C = 500$ mA	A/B			1.5	V
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 50$ mA	A/B		170		MHz
C_{ob}	Common Base Output Capacitance	$V_{CB} = 10$ V, f = 1 MHz	$I_E = 0$,	A/B		4.5		pF

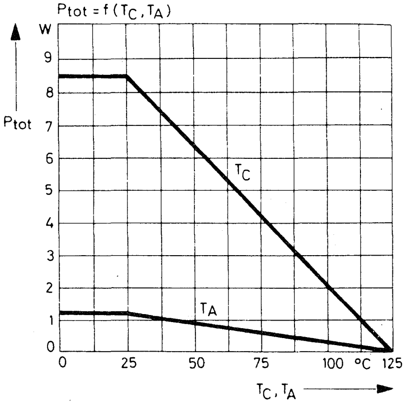
NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 125 °C free air temperature at the rate of 12.5 mW/°C.
3. Derate linearly to 125 °C case temperature at the rate of 85 mW/°C.
4. This parameter must be measured using pulse techniques. $t_p = 300\,\mu s$, duty cycle $\leqslant 2\%$






hFE = f (IC)
hFE
000)
160
140
120
100
80
60
40
20
0
1
10
100
mA 1000
IC


Cob = f (VCB), IE = 0, f = 1 MHz
pF
Cob
9
8
7
6
5
4
3
2
1
0
0
4
8
12
16
V 20
VCB


Ptot = f (TC, TA)
W
Ptot
9
8
7
6
5
4
3
2
1
0
TC
TA
0
25
50
75
100 °C 125
TC, TA

BD539 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

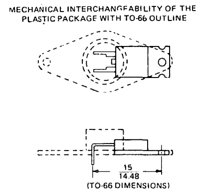
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

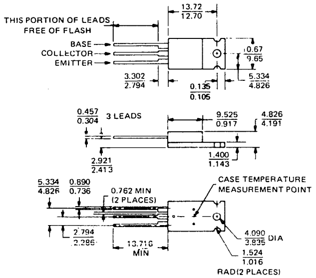
features

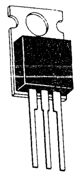
- Low Saturation Voltages $V_{CE(sat)} = 0.8V$ max @ $I_C = 3A$
- Complimentary to PNP Types BD540 Series
- 5A Rated Collector Current
- 45W at 25°C Case Temperature
- Up to 120V V_{CEO} rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB







ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD539	BD539A	BD539B	BD539C	BD539D
Collector-Base Voltage	40V	60V	80V	100V	120V
Collector-Emitter Voltage (See Note 1)	40V	60V	80V	100V	120V
Emitter-Base Voltage	← 5V →				
Continuous Collector Current	← 5A →				
Safe Operating Region at (or below) 25°C Case Temperature	← See Figure 2 →				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	← 45W →				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 3)	← 2W →				
Operating Collector Junction Temperature Range	← −65°C to 150°C →				
Storage Temperature Range	← −65°C to 150°C →				
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. Derate linearly to 150°C Case Temperature at the rate of 0.36W/°C
3. Derate linearly to 150°C Free-Air Temperature at the rate of 16mW/°C

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS		BD539		BD539A		BD539B		BD539C		BD539D		UNITS
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=30mA See Note 4	I_B=0	40		60		80		100		120		V
I_{CEO}	V_{CE}=30V	I_B=0		0.3		0.3							
	V_{CE}=60V	I_B=0						0.3		0.3			mA
	V_{CE}=90V	I_B=0										0.3	
I_{CES}	V_{CE}=40V	V_{BE}=0		0.2									
	V_{CE}=60V	V_{BE}=0				0.2							
	V_{CE}=80V	V_{BE}=0						0.2					mA
	V_{CE}=100V	V_{BE}=0								0.2			
	V_{CE}=120V	V_{BE}=0										0.2	
I_{EBO}	V_{EB}=5V	I_C=0		1		1		1		1		1	mA
h_{FE}*	I_C=0.5A	V_{CE}=4V	40		40		40		40		40		
	I_C=1.0A	V_{CE}=4V	30		30		30		30		30		
	I_C=3.0A	V_{CE}=4V	12		12		12		12		12		
$V_{BE(act)}$*	I_C=3.0A	V_{CE}=4V		1.25		1.25		1.25		1.25		1.25	V
$V_{CE(sat)}$*	I_C=1.0A	I_B=125mA		0.25		0.25		0.25		0.25		0.25	
	I_C=3.0A	I_B=375mA		0.8		0.8		0.8		0.8		0.8	V
	I_C=5.0A	I_B=1.0A		1.5		1.5		1.5		1.5		1.5	
h_{fc}	V_{CE}=10V f=1kHz	I_C=0.5A	20		20		20		20		20		
$\|h_{fe}\|$	V_{CE}=10V f=1MHz	I_C=0.5A	3		3		3		3		3		

*See Notes 4 & 5

NOTES: 4. These parameters must be measured using pulse techniques, t_w = 300μs, duty cycle ⩽2%

5. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts

thermal characteristics

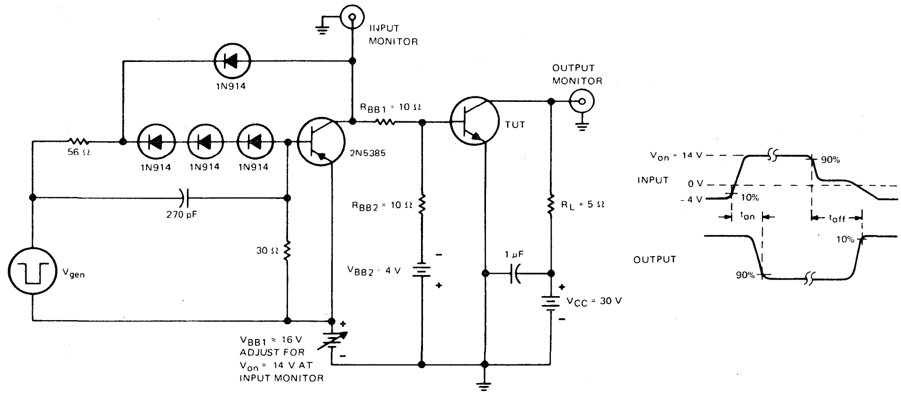
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2.78	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

	PARAMETER	TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = 1A	$I_{B(1)}$ = 100mA	$I_{B(2)}$ = −100mA	0.5	μsec.
t_{OFF}	Turn-Off Time	$V_{BE(off)}$=−4.3V	R_L = 30Ω	See Figure 1	2.0	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

MAXIMUM SAFE OPERATING REGION

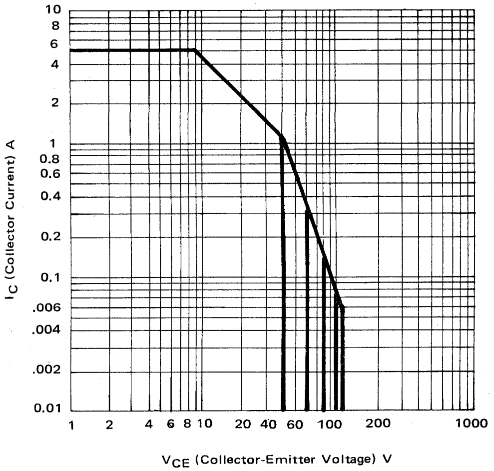


FIGURE 2. PRELIMINARY DATA.

SUPPLEMENTARY DATA MAY BE ISSUED AT A LATER DATE

BD540 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

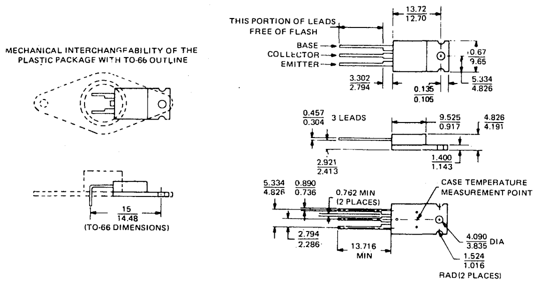
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

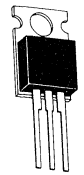
features

- Low Saturation Voltages $V_{CE(sat)} = 0.8V$ max @ $I_C = 3A$
- Complimentary to NPN Types BD539 Series
- 5A Rated Collector Current
- 45W at 25°C Case Temperature
- Up to 120V V_{CEO} rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD540	BD540A	BD540B	BD540C	BD540D
Collector-Base Voltage	−40V	−60V	−80V	−100V	−120V
Collector-Emitter Voltage (See Note 1)	−40V	−60V	−80V	−100V	−120V
Emitter-Base Voltage	← −5V →				
Continuous Collector Current	← −5A →				
Safe Operating Region at (or below) 25°C Case Temperature	← See Figure 2 →				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	← 45W →				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 3)	← 2W →				
Operating Collector Junction Temperature Range	← −65°C to 150°C →				
Storage Temperature Range	← −65°C to 150°C →				
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. Derate linearly to 150°C Case Temperature at the rate of 0.36W/°C
3. Derate linearly to 150°C Free-Air Temperature at the rate of 16mW/°C

BD540 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	BD540		BD540A		BD540B		BD540C		BD540D		UNITS
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=−30mA I_B=0 See Note 4	−40		−60		−80		−100		−120		V
I_{CEO}	V_{CE}=−30V I_B=0 V_{CE}=−60V I_B=0 V_{CE}=−90V I_B=0		−0.3		−0.3		−0.3		−0.3		−0.3	mA
I_{CES}	V_{CE}=−40V V_{BE}=0 V_{CE}=−60V V_{BE}=0 V_{CE}=−80V V_{BE}=0 V_{CE}=−100V V_{BE}=0 V_{CE}=−120V V_{BE}=0		−0.2		−0.2		−0.2		−0.2		−0.2	mA
I_{EBO}	V_{EB}=−5V I_C=0		−1		−1		−1		−1		−1	mA
h_{FE}*	I_C=−0.5A V_{CE}=−4V I_C=−1.0A V_{CE}=−4V I_C=−3.0A V_{CE}=−4V	40 30 12		40 30 12		40 30 12		40 30 12		40 30 12		
$V_{BE(act)}$*	I_C=−3.0A V_{CE}=−4V		−1.25		−1.25		−1.25		−1.25		−1.25	V
$V_{CE(sat)}$*	I_C=−1.0A I_B=−125mA I_C=−3.0A I_B=−375mA I_C=−5.0A I_B=10A		−0.25 −0.8 −1,5		−0.25 −0.8 −1.5		−0.25 −0.8 −1.5		−0.25 −0.8 −1.5		−0.25 −0.8 −1.5	V
h_{fe}	V_{CE}=−10V I_C=−0.5A f=1kHz	20		20		20		20		20		
$\|h_{fe}\|$	V_{CE}=−10V I_C=−0.5A f=1MHz	3		3		3		3		3		

*See Notes 4 & 5

NOTES: 4. These parameters must be measured using pulse techniques, t_w = 300μs, duty cycle ≤2%
5. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts

thermal characteristics

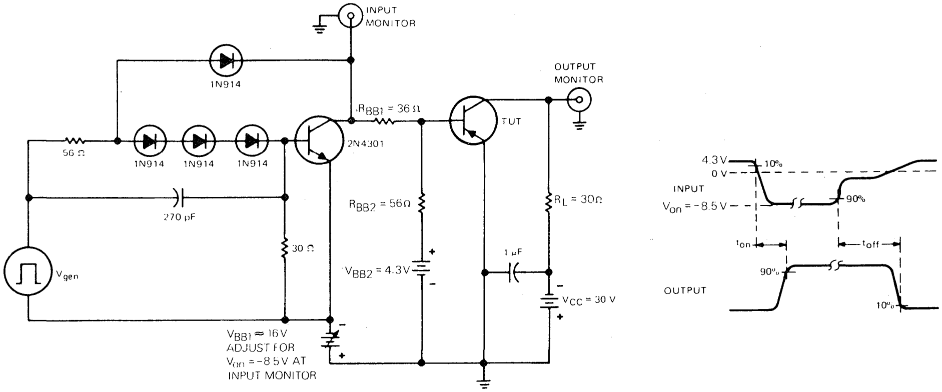
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2.78	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = −1A	$I_{B(1)}$ = −100mA	$I_{B(2)}$ = −100mA	0.3	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = 4.3V	R_L = 30Ω	See Figure 1	1.0	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

MAXIMUM SAFE OPERATING REGION

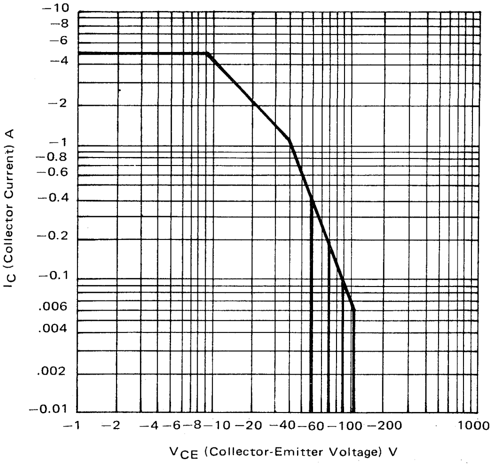


FIGURE 2. PRELIMINARY DATA

BD 543 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

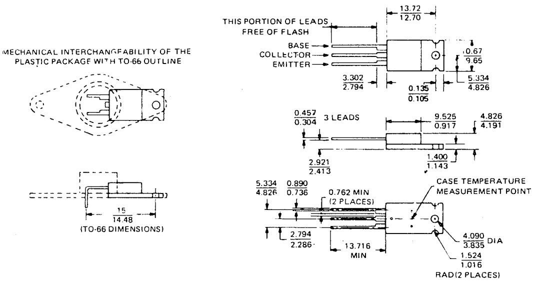
Designed for Medium Power Linear Amplifiers and Switching in Consumer Automotive and Industrial Applications

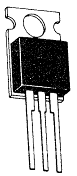
features

- Low Saturation Voltages $V_{CE(sat)} = 0.5V$ max @ $I_C = 5A$
- Complimentary to PNP Types BD544 Series
- 8A Rated Collector Current
- 70W at 25°C Case Temperature
- Up to 120V V_{CEO} Rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO 220AB DIMENSIONS

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD543	BD543A	BD543B	BD543C	BD543D
Collector-Base Voltage	40V	60V	80V	100V	120V
Collector-Emitter Voltage (See Note 1)	40V	60V	80V	100V	120V
Emitter-Base Voltage	5V				
Continuous Collector Current	8A				
Peak Collector Current (See Note 2)	10A				
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 2				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	70W				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 4)	2W				
Operating Collector Junction Temperature Range	−65°C to 150°C				
Storage Temperature Range	−65°C to 150°C				
Lead Temperature 3.2mm from Case for 10 Seconds	260°C				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. This value applies for $t_w \leqslant 0.3ms$, duty cycle $\leqslant 10\%$
3. Derate linearly to 150°C Case Temperature at the rate of 0.56W/°C
4. Derate linearly to 150°C Free-Air Temperature at the rate of 16mW/°C

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	BD543		BD543A		BD543B		BD543C		BD543D		UNITS
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=30mA I_B=0 See Note 5	40		60		80		100		120		V
I_{CEO}	V_{CE}=30V I_B=0		0.7		0.7							
	V_{CE}=60V I_B=0						0.7		0.7			mA
	V_{CE}=90V I_B=0										0.7	
I_{CES}	V_{CE}=40V V_{BE}=0		0.4									
	V_{CE}=60V V_{BE}=0				0.4							
	V_{CE}=80V V_{BE}=0						0.4					mA
	V_{CE}=100V V_{BE}=0								0.4			
	V_{CE}=120V V_{BE}=0										0.4	
I_{EBO}	V_{EB}=5V I_C=0		1		1		1		1		1	mA
h_{FE}*	I_C=1A V_{CE}=4V	60		60		60		60		60		
	I_C=3A V_{CE}=4V	40		40		40		40		40		
	I_C=5A V_{CE}=4V	15		15		15		15		15		
$V_{BE(act)}$*	I_C=5A V_{CE}=4V		1.4		1.4		1.4		1.4		1.4	V
$V_{CE(sat)}$*	I_C=3A I_B=300mA		0.5		0.5		0.5		0.5		0.5	
	I_C=5A I_B=1A		0.5		0.5		0.5		0.5		0.5	V
	I_C=8A I_B=1.6A		1.0		1.0		1.0		1.0		1.0	
h_{fe}	V_{CE}=10V I_C=0.5A f=1kHz	20		20		20		20		20		
$\|h_{fe}\|$	V_{CE}=10V I_C=0.5A f-1MHz	3		3		3		3		3		

*See Notes 5 & 6.

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300μs, duty cycle ⩽2%
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.79	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	62.5	

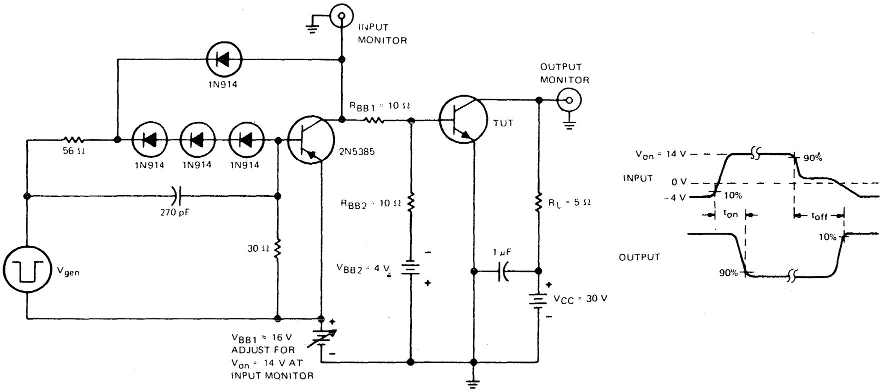
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = 6A	$I_{B(1)}$ = 0.6A	$I_{B(2)}$ = −0.6A	0.6	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −4V	R_L = 5Ω	See Figure 1	1	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

BD 543 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

MAXIMUM SAFE OPERATING REGION

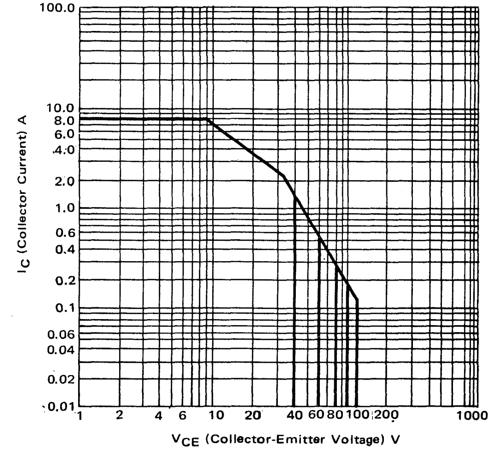


FIGURE 2. PRELIMINARY DATA

BD544 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

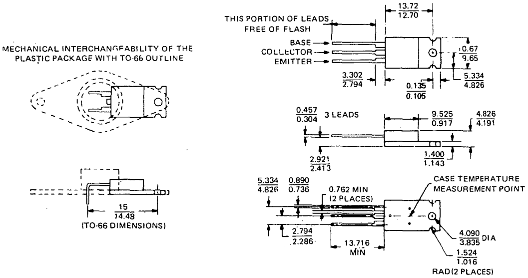
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

features

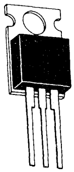
- Low Saturation Voltages $V_{CE(sat)}$ = 0.5V max @ I_C = 5A
- Complimentary to NPN Types BD543 Series
- 8A Rated Collector Current
- 70W at 25°C Case Temperature
- Up to 120V V_{CEO} Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD544	BD544A	BD544B	BD544C	BD544D
Collector-Base Voltage	–40V	–60V	–80V	–100V	–120V
Collector-Emitter Voltage (See Note 1)	–40V	–60V	–80V	–100V	–120V
Emitter-Base Voltage	← –5V →				
Continuous Collector Current	← –8A →				
Peak Collector Current (See Note 2)	← –10A →				
Safe Operating Region at (or below) 25°C Case Temperature	← See Figure 2 →				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 70W →				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 4)	← 2W →				
Operating Collector Junction Temperature Range	← –65°C to 150°C →				
Storage Temperature Range	← –65°C to 150°C →				
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. This value applies for $t_w \leqslant 0.3$ms, duty cycle $\leqslant 10\%$
3. Derate linearly to 150°C Case Temperature at the rate of 0.56W/°C
4. Derate linearly to 150°C Free-Air Temperature at the rate of 16mW/°C

BD544 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	BD544		BD544A		BD544B		BD544C		BD544D		UNITS
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=−30mA I_B=0 See Note 5	−40		−60		−80		−100		−120		V
I_{CEO}	V_{CE}=−30V I_B=0		−0.7		−0.7							
	V_{CE}=−60V I_B=0						−0.7		−0.7			mA
	V_{CE}=−90V I_B=0										−0.7	
I_{CES}	V_{CE}=−40V V_{BE}=0		−0.4									
	V_{CE}=−60V V_{BE}=0				−0.4							
	V_{CE}=−80V V_{BE}=0						−0.4					mA
	V_{CE}=−100V V_{BE}=0								−0.4			
	V_{CE}=−120 V_{BE}=0										−0.4	
I_{EBO}	V_{EB}=−5V I_C=0		−1		−1		−1		−1		−1	mA
h_{FE}*	I_C=−1A V_{CE}=−4V	60		60		60		60		60		
	I_C=−3A V_{CE}=−4V	40		40		40		40		40		
	I_C=−5A V_{CE}=−4V	15		15		15		15		15		
$V_{BE(act)}$*	I_C=−5A V_{CE}=−4V		−1.4		−1.4		−1.4		−1.4		−1.4	V
$V_{CE(sat)}$*	I_C=−3A I_B=−300mA		−0.5		−0.5		−0.5		−0.5		−0.5	
	I_C=−5A I_B=−1A		−0.5		−0.5		−0.5		−0.5		−0.5	V
	I_C=−8A I_B=−1.6A		−1.0		−1.0		−1.0		−1.0		−1.0	
h_{fe}	V_{CE}=−10V I_C=−0.5A f=1kHz	20		20		20		20		20		
$\lvert h_{fe} \rvert$	V_{CE}=−10V I_C=−0.5A f=1MHz	3		3		3		3		3		

*See Notes 5 & 6

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300μs, duty cycle ≤2%

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts

thermal characteristics

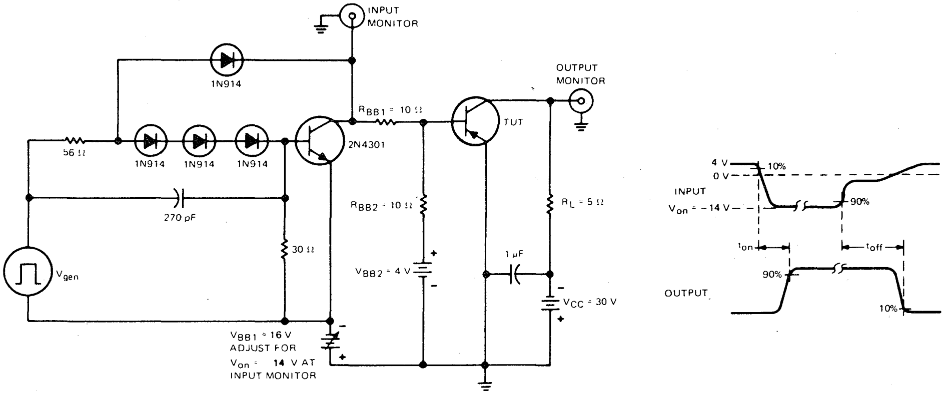
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.79	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = −6A	$I_{B(1)}$ = −0.6A	$I_{B(2)}$ = +0.6A	0.4	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = 4V	R_L = 5Ω	See Figure 1	0.7	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
- A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

MAXIMUM SAFE OPERATING REGION

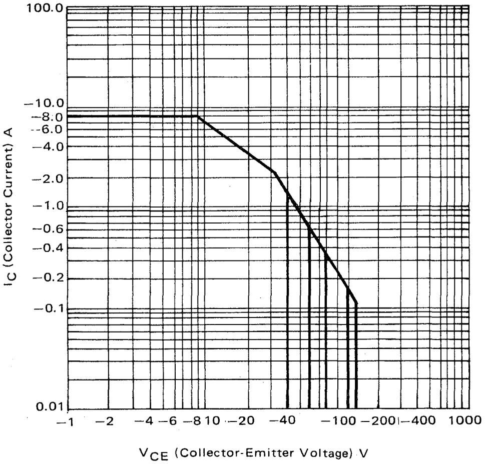


FIGURE 2

BD545 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

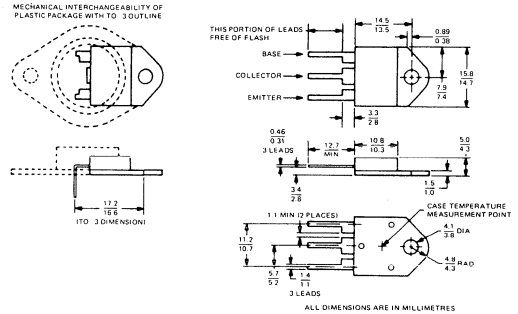
Designed for Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

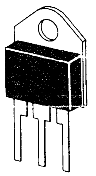
features

- Low Saturation Voltages $V_{CE(sat)} = 1V$ max @ $I_C = 10A$
- Complimentary to BD546 Series
- 15A Rated Collector Current
- 85W at 25°C Case Temperature
- Up to 120V V_{CEO}

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD545	BD545A	BD545B	BD545C	BD545D
Collector-Base Voltage	40V	60V	80V	100V	120V
Collector-Emitter Voltage (See Note 1)	40V	60V	80V	100V	120V
Emitter-Base Voltage	5V				
Continuous Collector Current	15A				
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 2				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	85W				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 3)	3.5W				
Operating Collector Junction Temperature Range	−65°C to 150°C				
Storage Temperature Range	−65°C to 150°C				
Lead Temperature 3.2mm from Case for 10 Seconds	260°C				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. Derate linearly to 150°C Case Temperature at the rate of 0.68W/°C
3. Derate linearly to 150°C Free-Air Temperature at the rate of 28mW/°C

BD545 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS		BD545		BD545A		BD545B		BD545C		BD545D		UNITS
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=30mA See Note 4	I_B=0	40		60		80		100		120		V
I_{CEO}	V_{CE}=30V	I_B=0		0.7		0.7							mA
	V_{CE}=60V							0.7		0.7			
	V_{CE}=90V											0.7	
I_{CES}	V_{CE}=40V	V_{BE}=0		0.4									mA
	V_{CE}=60V	V_{BE}=0				0.4							
	V_{CE}=80V	V_{BE}=0						0.4					
	V_{CE}=100V	V_{BE}=0								0.4			
	V_{CE}=120V	V_{BE}=0										0.4	
I_{EBO}	V_{EB}=5V	I_C=0		1		1		1		1		1	mA
h_{FE}*	I_C=1A	V_{CE}=4V	60		60		60		60		60		
	I_C=5A	V_{CE}=4V	25		25		25		25		25		
	I_C=10A	V_{CE}=4V	10		10		10		10		10		
$V_{BE(act)}$*	I_C=10A	V_{CE}=4V		1.8		1.8		1.8		1.8		1.8	V
$V_{CE(sat)}$*	I_C=5A	I_B=625mA		0.8		0.8		0.8		0.8		0.8	V
	I_C=10A	I_B=2A		1		1		1		1		1	
h_{fe}	V_{CE}=10V f=1kHz	I_C=0.5A	20		20		20		20		20		
$\lvert h_{fe} \rvert$	V_{CE}=10V f-1MHz	I_C=0.5A	3		3		3		3		3		

*See Notes 4 & 5

NOTES: 4. These parameters must be measured using pulse techniques, t_w = 300μs, duty cycle ≤2%

5. These parameters are measured with voltage sensing contacts separate from the current carrying contacts.

thermal characteristics

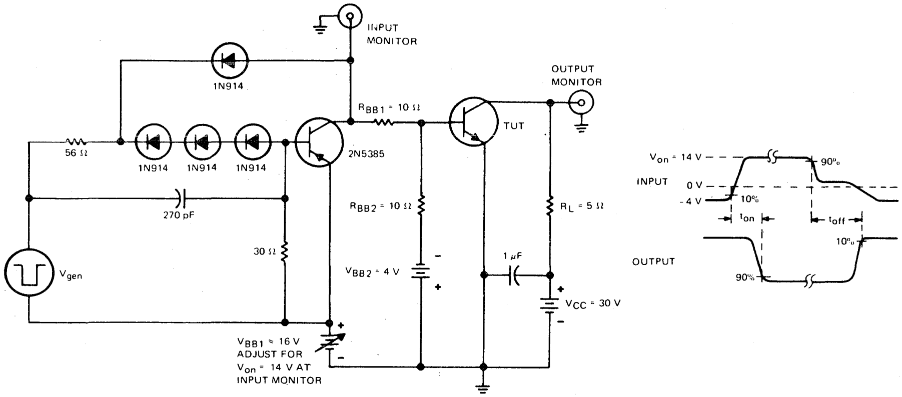
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.47	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

	PARAMETER	TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = 6A	$I_{B(1)}$ = 0.6A	$I_{B(2)}$ = –0.6A	0.6	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = –4V	R_L - 5Ω	See Figure 1	1	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

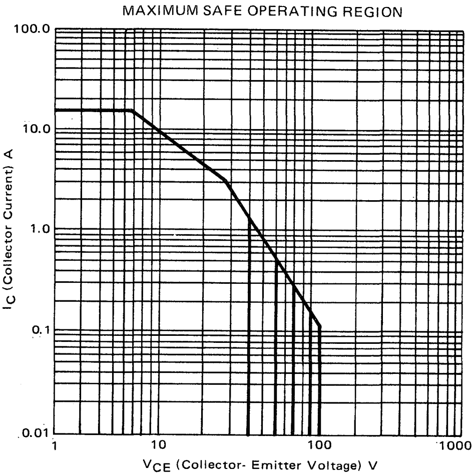


FIGURE 2. PRELIMINARY DATA

BD 546 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

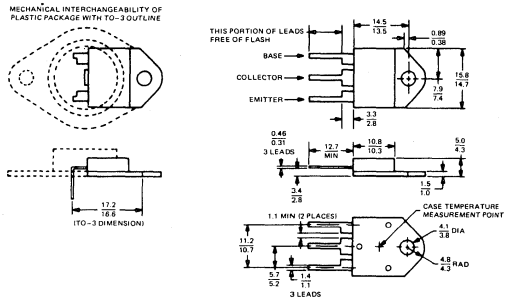
Designed for Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

Features

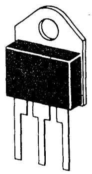
- Low Saturation Voltages $V_{CE(sat)}$ = 1V max @ 10A
- Complimentary to BD545 Series
- 15A Rated Collector Current
- 85W at 25°C Case Temperature
- Up to 120V V_{CEO}

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	BD546	BD546A	BD546B	BD546C	BD546D
Collector-Base Voltage	−40V	−60V	−80V	−100V	−120V
Collector-Emitter Voltage (See Note 1)	−40V	−60V	−80V	−100V	−120V
Emitter-Base Voltage	−5V				
Continuous Collector Current	15A				
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 2				
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	85W				
Continuous Device Dissipation at (or below) 25°C Free Air Temperature (See Note 3)	3.5W				
Operating Collector Junction Temperature Range	−65°C to 150°C				
Storage Temperature Range	−65°C to 150°C				
Lead Temperature 3.2mm from Case for 10 Seconds	260°C				

NOTES:
1. This value applies when the base-emitter diode is open-circuited
2. Derate linearly to 150°C Case Temperature at the rate of 0.68W/°C
3. Derate linearly to 150°C Free-Air Temperature at the rate of 28mW/°C

BD 546 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	BD546		BD546A		BD546B		BD546C		BD546D		UNITS
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	I_C=−30mA I_B=0 (See Note 4)	−40		−60		−80		−100		−120		V
I_{CEO}	V_{CE}=−30V I_B=0		−0.7		−0.7							mA
	V_{CE}=−60V I_B=0						−0.7		−0.7			
	V_{CE}=−90V I_B=0										−0.7	
I_{CES}	V_{CE}=−40V V_{BE}=0		−0.4									mA
	V_{CE}=−60V V_{BE}=0				−0.4							
	V_{CE}=−80V V_{BE}=0						−0.4					
	V_{CE}=−100V V_{BE}=0								−0.4			
	V_{CE}=−120V V_{BE}=0										−0.4	
I_{EBO}	V_{EB}=−5V I_C=0		−1		−1		−1		−1		−1	mA
h_{FE}*	I_C=−1A V_{CE}=−4V	60		60		60		60		60		
	I_C=−5A V_{CE}=−4V	25		25		25		25		15		
	I_C=−10A V_{CE}=−4V	10		10		10		10		8		
$V_{BE(act)}$*	I_C=−10A V_{CE}=−4V		−1.8		−1.8		−1.8		−1.8		−1.8	V
$V_{CE(sat)}$*	I_C=−5A I_B=−625mA		−0.8		−0.8		−0.8		−0.8		−0.8	V
	I_C=−10A I_B=−2A		−1		−1		−1		−1			
h_{fe}	V_{CE}=−10V I_C=−0.5A L=1kHz	20		20		20		20		20		
$\|h_{fe}\|$	V_{CE}=−10V I_C=−0.5A f=1MHz	3		3		3		3		3		

*See Notes 4 & 5

NOTES: 4. These parameters must be measured using pulse techniques, t_w=300μs, duty cycle ≤2%

5. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts

thermal characteristics

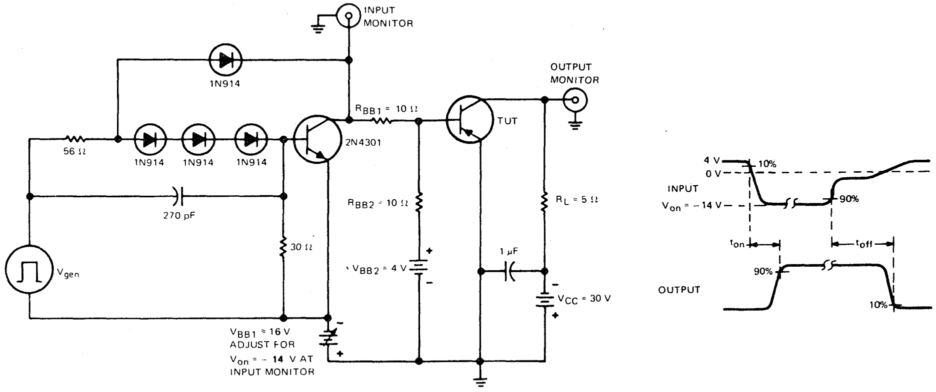
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.47	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = −6A	$I_{B(1)}$ = −0.6A	$I_{B(2)}$ = 0.6A	0.4	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = 4V	R_L = 5Ω	See Figure 1	0.7	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

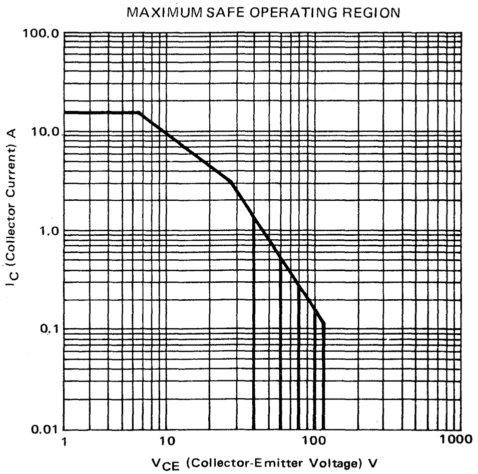

MAXIMUM SAFE OPERATING REGION

FIGURE 2. PRELIMINARY DATA

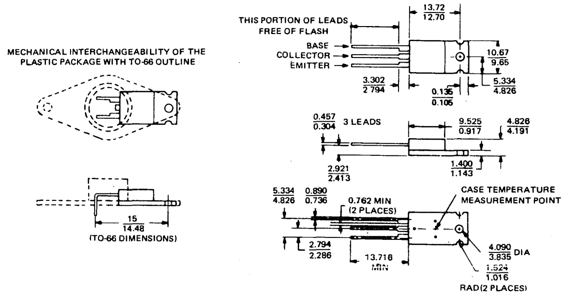
TYPES BD743, BD743A, BD743B, BD743C, BD743D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD744 SERIES

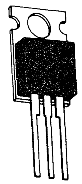
- 90 W at 25 °C Case Temperature
- 15 A Rated Collector Current
- Min f_T of 5 MHz at 4 V, 1 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD743	BD743A	BD743B	BD743C	BD743D
Collector-Base Voltage	50 V	70 V	90 V	110 V	130 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage	5 V	5 V	5 V	5 V	5 V
Continuous Collector Current	←		15 A		→
Peak Collector Current ($T_p \leqslant 300\ \mu s$, $d \leqslant 10\%$	←		20 A		→
Continuous Base Current	←		5 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←		See Figure 11		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 2)	←		90 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 3)	←		2 W		→
Unclamped Inductive Load Energy (See Note 4)	←		90 mJ		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→
Lead Temperature 3 mm from Case for 10 Seconds	←		260 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 0.72 W/°C or refer to Dissipation Derating Curve, Figure 9.
3. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy $\approx I_C^2L/2$.

TYPES BD743, BD743A, BD743B, BD743C, BD743D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BD743		BD743A		BD743B		BD743C		BD743D		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 5	45		60		80		100		120		V
$V_{(BR)CEV}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, V_{BE} = −1.5 V, See Note 5	50		70		90		110		130		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		100		100							μA
		V_{CE} = 60 V, I_B = 0						100		100		100	
I_{CBO}	Collector Cutoff Current	V_{CB} = 50 V		100									μA
		V_{CB} = 70 V				100							
		V_{CB} = 90 V						100					
		V_{CB} = 110 V								100			
		V_{CB} = 130 V										100	
I_{CBO}	Collector Cutoff Current	V_{CB} = V_{CB} rated, T_C = 125 °C		5		5		5		5		5	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		500		500		500		500		500	μA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V I_C = 1 A See Notes 5 and 6	40		40		40		40		40		
		V_{CE} = 4 V, I_C = 5 A, See Notes 5 and 6	20	150	20	150	20	150	20	150	20	150	
		V_{CE} = 4 V, I_C = 15 A, See Notes 5 and 6	5		5		5		5		5		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 5 A, See Notes 5 and 6		1		1		1		1		1	V
		V_{CE} = 4 V, I_C = 15 A, See Notes 5 and 6		3		3		3		3		3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.5 A, I_C = 5 A, See Notes 5 and 6		1		1		1		1		1	V
		I_B = 5 A, I_C = 15 A, See Notes 5 and 6		3		3		3		3		3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, f = 1 kHz	25		25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, f = 1 MHz	5		5		5		5		5		

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.4	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		62.5	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.7		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	0.9		J/°C

NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

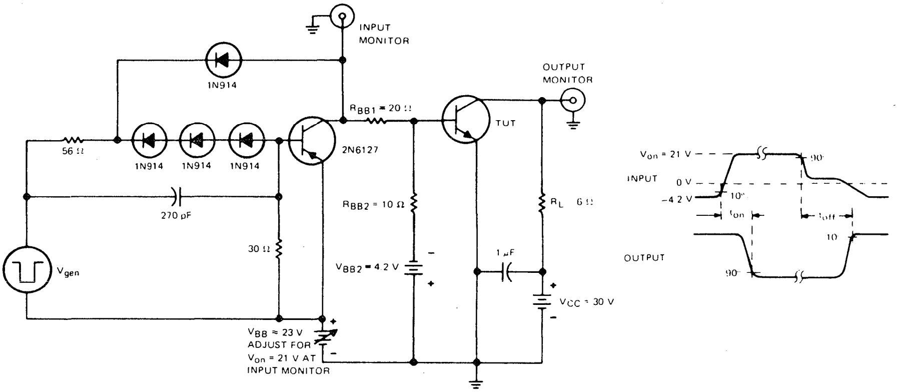
switching characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS⁺	TYP	UNIT
t_d	Delay Time	I_C = 5 A, $I_{B(1)}$ = 500 mA, $I_{B(2)}$ = −500 mA, $V_{BE(off)}$ = −4.2 V, R_L = 6 Ω, See Figure 1	20	ns
t_r	Rise Time		350	
t_s	Storage Time		500	
t_f	Fall Time		400	

⁺ *Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.*

TYPES BD743, BD743A, BD743B, BD743C, BD743D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



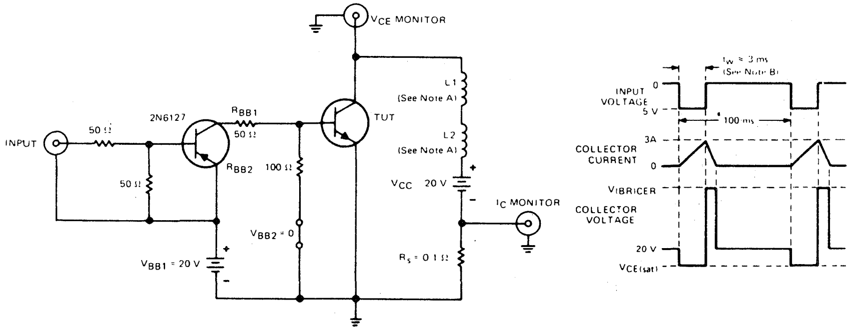
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES:
- A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C 2688, or equivalent.
- B. Input pulse width is increased until $I_{CM} = 3A$.

FIGURE 2

TYPICAL CHARACTERISTICS

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

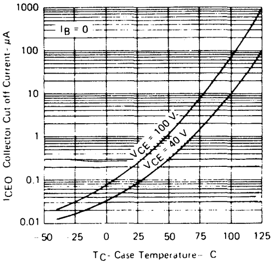


FIGURE 3

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

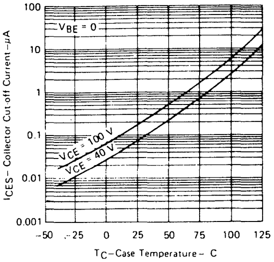


FIGURE 4

STATIC FORWARD-CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

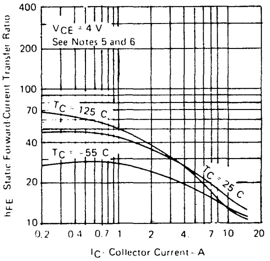


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

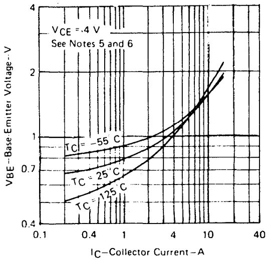


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

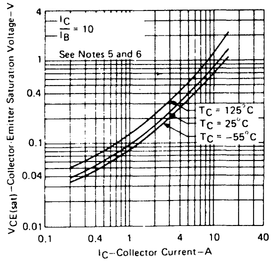


FIGURE 7

SWITCHING TIMES
vs
COLLECTOR CURRENT

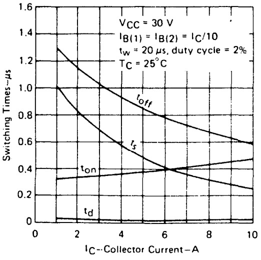


FIGURE 8

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts seperate from the current-carrying contacts and located within 3 mm inch from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

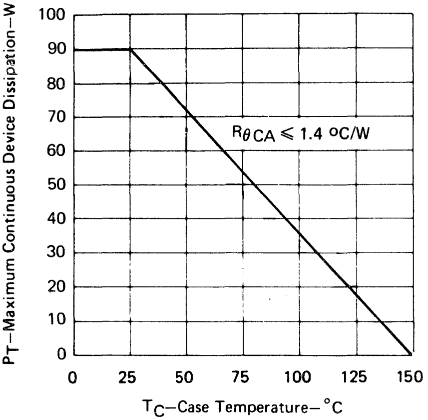


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

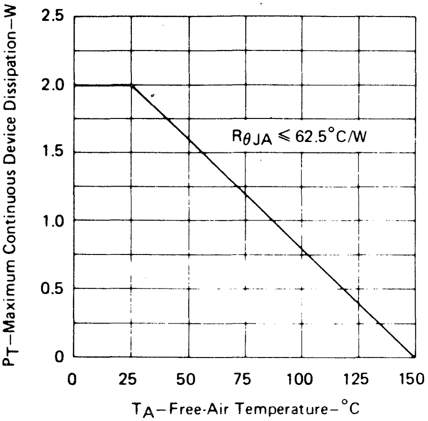


FIGURE 10

MAXIMUM SAFE OPERATING REGION

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

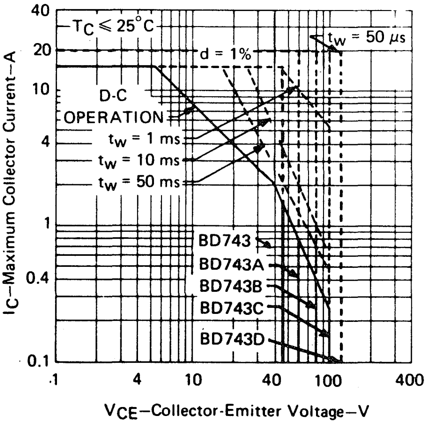


FIGURE 11

TYPES BD743, BD743A, BD743B, BD743C, BD743D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

Single Diffused Silicon Power Transistors in Plastic Package – Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
I_{C} CONT	P_{TOT}							
2 A	30 W	BD239 BD240	BD239A BD240A	BD239B BD240B	BD239C BD240C		NPN PNP	TO220
3 A	40 W	BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C		NPN PNP	TO220
5 A	45 W	BD539 BD540	BD539A BD540A	BD539B BD540B	BD539C BD540C	BD539D BD540D	NPN PNP	TO220
6 A	65 W	BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C		NPN PNP	TO220
8 A	70 W	BD543 BD544	BD543A BD544A	BD543B BD544B	BD543C BD544C	BD543D BD544D	NPN PNP	TO220
15 A	90 W	BD743 BD744	BD743A BD744A	BD743B BD744B	BD743C BD744C	BD743D BD744D	NPN PNP	TO220
10 A	80 W	BD245 BD246	BD245A BD246A	BD245B BD246B	BD245C BD246C		NPN PNP	TO3P
15 A	85 W	BD545 BD546	BD545A BD546A	BD545B BD546B	BD545C BD546C	BD545D BD546D	NPN PNP	TO3P
15 A	100 W		TIP3055 TIP2955				NPN PNP	TO3P
20 A	115 W	BD745 BD746	BD745A BD746A	BD745B BD746B	BD745C BD746C	BD745D BD746D	NPN PNP	TO3P
25 A	125 W	BD249 BD250	BD249A BD250A	BD249B BD250B	BD249C BD250C		NPN PNP	TO3P
30 A	150 W	TIP3771	TIP3772				NPN	TO3P

Single Diffused Silicon Power Darlingtons in Plastic Package – Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
I_{C} CONT	P_{TOT}							
4 A	40 W	BDW53 BDW54	BDW53A BDW54A	BDW53B BDW54B	BDW53C BDW54C	BDW53D BDW54D	NPN PNP	TO220
4 A	50 W		TIP110 TIP115	TIP111 TIP116	TIP112 TIP117		NPN PNP	TO220
5 A	65 W		TIP120 TIP125	TIP121 TIP126	TIP122 TIP127		NPN PNP	TO220
6 A	60 W	BDW63 BDW64	BDW63A BDW64A	BDW63B BDW64B	BDW63C BDW64C	BDW63D BDW64D	NPN PNP	TO220
8 A	75 W		TIP130 TIP135	TIP131 TIP136	TIP132 TIP137		NPN PNP	TO220
8 A	80 W	BDW73 BDW74	BDW73A BDW74A	BDW73B BDW74B	BDW73C BDW74C	BDW73D BDW74D	NPN PNP	TO220
10 A	125 W		TIP140 TIP145	TIP141 TIP146	TIP142 TIP147		NPN PNP	TO3P
15 A	150 W	BDW83 BDW84	BDW83A BDW84A	BDW83B BDW84B	BDW83C BDW84C	BDW83D BDW84D	NPN PNP	TO3P

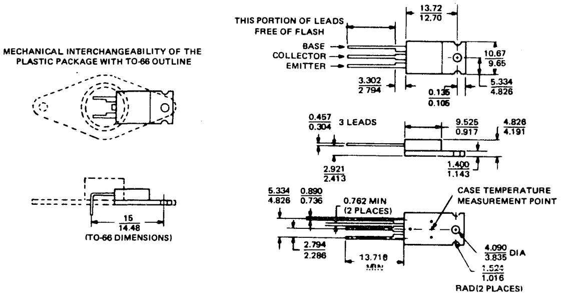
TYPES BD744, BD744A, BD744B, BD744C, BD744D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD743 SERIES

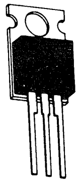
- **90 W at 25 °C Case Temperature**
- **15 A Rated Collector Current**
- **Min f_T of 5 MHz at 4 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD744	BD744A	BD744B	BD744C	BD744D
Collector-Base Voltage	−50 V	−70 V	−90 V	−110 V	−130 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V	−120 V
Emitter-Base Voltage	−5 V	−5 V	−5 V	−5 V	−5 V
Continuous Collector Current	←		−15 A		→
Peak Collector Current ($T_p \leqslant 300\ \mu s$, $d \leqslant 10\%$	←		−20 A		→
Continuous Base Current	←		−5 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←		See Figure 11		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 2)	←		90 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 3)	←		2 W		→
Unclamped Inductive Load Energy (See Note 4)	←		90 mJ		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→
Lead Temperature 3 mm from Case for 10 Seconds	←		260 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 0.72 W/°C or refer to Dissipation Derating Curve, Figure 9.
3. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = −20 V. Energy $\approx I_C{}^2 L/2$.

TYPES BD744, BD744A, BD744B, BD744C, BD744D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BD744		BD744A		BD744B		BD744C		BD744D		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 5	−45		−60		−80		−100		−130		V
$V_{(BR)CEV}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $V_{BE} = 1.5$ V, See Note 5	−50		−70		−90		−110		−130		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−100		−100							μA
		$V_{CE} = -60$ V, $I_B = 0$						−100		−100		−100	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V		−100									μA
		$V_{CB} = -70$ V				−100							
		$V_{CB} = -90$ V						−100					
		$V_{CB} = -110$ V								−100			
		$V_{CB} = -130$ V										−100	
I_{CBO}	Collector Cutoff Current	$V_{CB} = V_{CB}$ rated, $T_C = 125$°C		−5		−5		−5		−5		−5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−500		−500		−500		−500		−500	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 5 and 6	40		40		40		40		40		
		$V_{CE} = -4$ V, $I_C = -5$ A, See Notes 5 and 6	20	150	20	150	20	150	20	150	20	150	
		$V_{CE} = -4$ V, $I_C = -15$ A, See Notes 5 and 6	5		5		5		5		5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -5$ A, See Notes 5 and 6		−1		−1		−1		−1		−1	V
		$V_{CE} = -4$ V, $I_C = -15$ A, See Notes 5 and 6		−3		−3		−3		−3		−3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ A, $I_C = -5$ A, See Notes 5 and 6		−1		−1		−1		−1		−1	V
		$I_B = -5$ A, $I_C = -15$ A, See Notes 5 and 6		−3		−3		−3		−3		−3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, f = 1 kHz	25		25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, f = 1 MHz	5		5		5		5		5		

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leqslant 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.4	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		62.5	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.7		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	0.9		J/°C

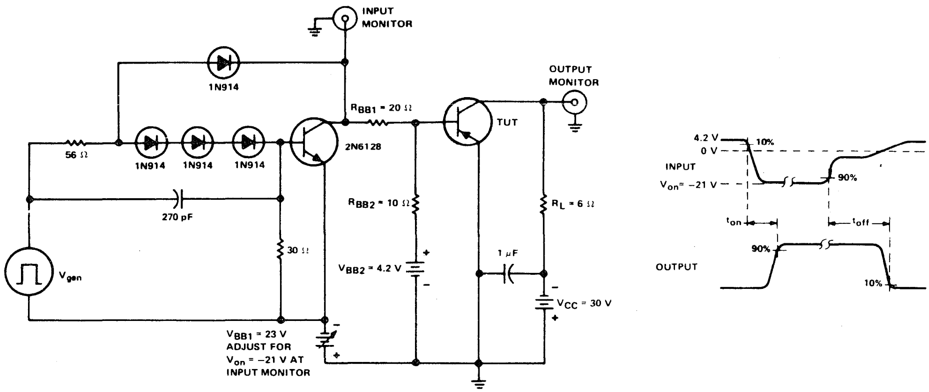
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

switching characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS⁺	TYP	UNIT
t_d	Delay Time	$I_C = -5$ A, $I_{B(1)} = -500$ mA, $I_{B(2)} = 500$ mA, $V_{BE(off)} = 4.2$ V, $R_L = 6\ \Omega$, See Figure 1	20	ns
t_r	Rise Time		120	
t_s	Storage Time		600	
t_f	Fall Time		300	

⁺ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



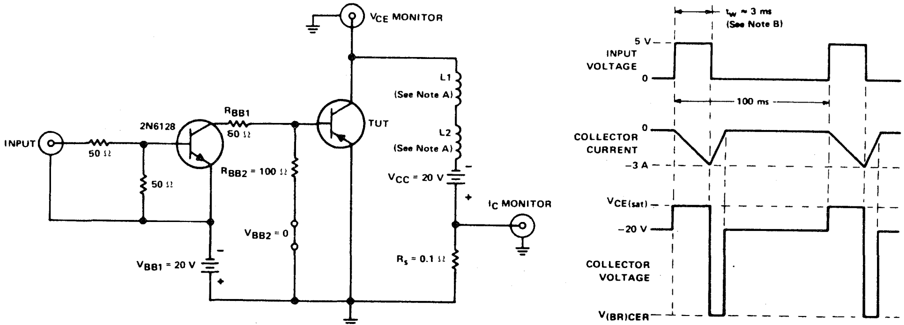
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle $\leqslant$2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES:
- A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
- B. Input pulse width is increased until I_{CM} = −3 A

FIGURE 2

TYPICAL CHARACTERISTICS

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

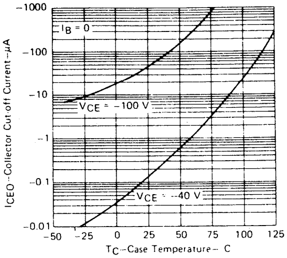


FIGURE 3

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

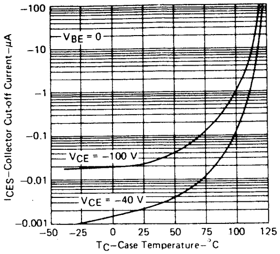


FIGURE 4

STATIC FORWARD-CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

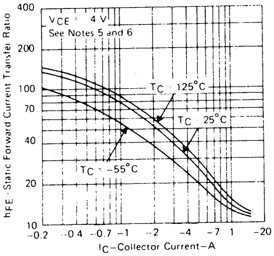


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

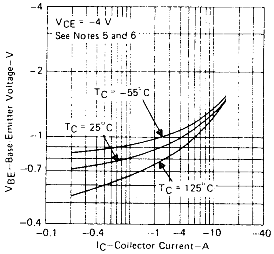


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

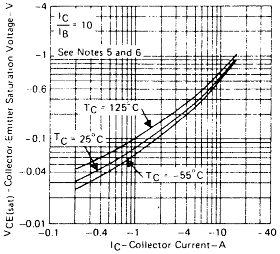


FIGURE 7

SWITCHING TIMES
vs
COLLECTOR CURRENT

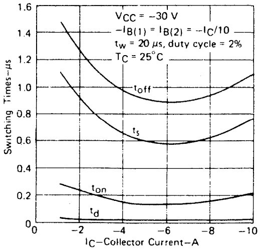


FIGURE 8

NOTES. 5. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle $\leqslant 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

THERMAL INFORMATION

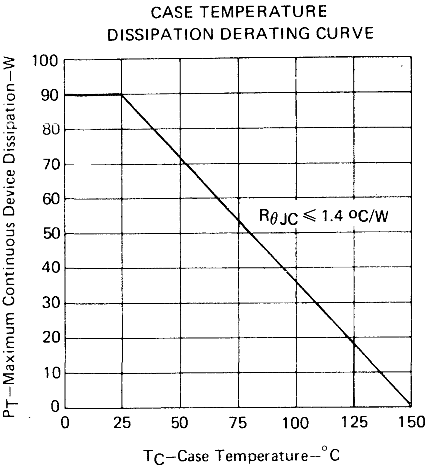


FIGURE 9

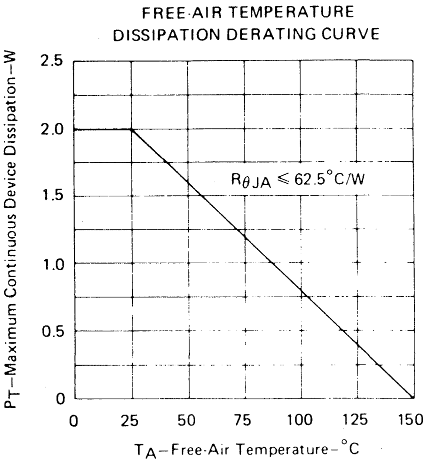


FIGURE 10

MAXIMUM SAFE OPERATION REGION

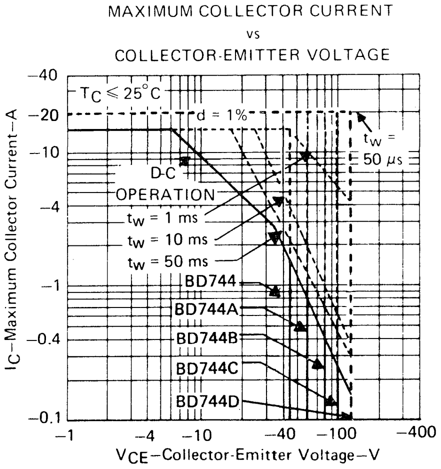


FIGURE 11

TYPES BD744, BD744A, BD744B, BD744C, BD744D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

Single Diffused Silicon Power Transistors in Plastic Package – Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
$I_{C\ CONT}$	P_{TOT}							
2 A	30 W	BD239 BD240	BD239A BD240A	BD239B BD240B	BD239C BD240C		PNP PNP	TO220
3 A	40 W	BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C		PNP PNP	TO220
5 A	45 W	BD539 BD540	BD539A BD540A	BD539B BD540B	BD539C BD540C	BD539D BD540D	NPN PNP	TO220
6 A	65 W	BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C		NPN PNP	TO220
8 A	70 W	BD543 BD544	BD543A BD544A	BD543B BD544B	BD543C BD544C	BD543D BD544D	NPN PNP	TO220
15 A	90 W	BD743 BD744	BD743A BD744A	BD743B BD744B	BD743C BD744C	BD743D BD744D	NPN PNP	TO220
10 A	80 W	BD245 BD246	BD245A BD246A	BD245B BD246B	BD245C BD246C		NPN PNP	TO3P
15 A	85 W	BD545 BD546	BD545A BD546A	BD545B BD546B	BD545C BD546C	BD545D BD546D	NPN PNP	TO3P
15 A	100 W		TIP3055 TIP2955				NPN PNP	TO3P
20 A	115 W	BD745 BD746	BD745A BD746A	BD745B BD746B	BD745C BD746C	BD745D BD746D	NPN PNP	TO3P
25 A	125 W	BD249 BD250	BD249A BD250A	BD249B BD250B	BD249C BD250C		NPN PNP	TO3P
30 A	150 W	TIP3771	TIP3772					

Single Diffused Silicon Power Darlingtons in Plastic Package – Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
$I_{C\ CONT}$	P_{TOT}							
4 A	40 W	BDW53 BDW54	BDW53A BDW54A	BDW53B BDW54B	BDW53C BDW54C	BDW53D BDW54D	NPN PNP	TO220
4 A	50 W		TIP110 TIP115	TIP111 TIP116	TIP112 TIP117		NPN PNP	TO220
5 A	65 W		TIP120 TIP125	TIP121 TIP126	TIP122 TIP127		NPN PNP	TO220
6 A	60 W	BDW63 BDW64	BDW63A BDW64A	BDW63B BDW64B	BDW63C BDW64C	BDW63D BDW64D	NPN PNP	TO220
8 A	75 W		TIP130 TIP135	TIP131 TIP136	TIP132 TIP137		NPN PNP	TO220
8 A	80 W	BDW73 BDW74	BDW73A BDW74A	BDW73B BDW74B	BDW73C BDW74C	BDW73D BDW74D	NPN PNP	TO220
10 A	125 W		TIP140 TIP145	TIP141 TIP146	TIP142 TIP147		NPN PNP	TO3P
15 A	150 W	BDW83 BDW 84	BDW83A BDW84A	BDW83B BDW84B	BDW83C BDW84C	BDW83D BDW84D	NPN PNP	TO3P

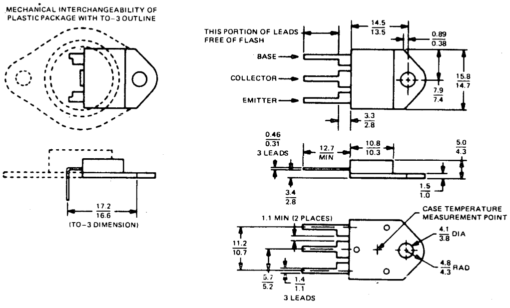
TYPES BD745, BD745A, BD745B, BD745C, BD745D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD746 SERIES

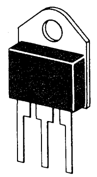
- **115 W at 25 °C Case Temperature**
- **20 A Rated Collector Current**
- **Min f_T of 5 MHz at 4 V, 1 A**

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



TO-3 P



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD745	BD745A	BD745B	BD745C	BD745D
Collector-Base Voltage	50 V	70 V	90 V	110 V	130 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage	5 V	5 V	5 V	5 V	5 V
Continuous Collector Current	←		20 A		→
Peak Collector Current ($T_p \leqslant 300\ \mu s$, $d \leqslant 10\%$	←		25 A		→
Continuous Base Current	←		5 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←		See Figure 11		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 2)	←		115 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 3)	←		3.5 W		→
Unclamped inductive Load Energy (See Note 4)	←		90 mJ		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→
Lead Temperature 3 mm from Case for 10 Seconds	←		260 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 0.92 W/°C or refer to Dissipation Derating Curve, Figure 9.
3. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C or refer to Dissipation Derating Curve, Figure 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TYPES BD745, BD745A, BD745B, BD745C, BD745D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BD745		BD745A		BD745B		BD745C		BD745D		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 5	45		60		80		100		120		V
$V_{(BR)CEV}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $V_{BE} = -1.5$ V, See Note 5	50		70		90		110		130		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		100		100							μA
		$V_{CE} = 60$ V, $I_B = 0$						100		100		100	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V		100									μA
		$V_{CB} = 70$ V				100							
		$V_{CB} = 90$ V						100					
		$V_{CB} = 110$ V								100			
		$V_{CB} = 130$ V										100	
I_{CBO}	Collector Cutoff Current	$V_{CB} = V_{CB}$ rated $T_C = 125°C$		5		5		5		5		5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		500		500		500		500		500	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A See Notes 5 and 6	40		40		40		40		40		
		$V_{CE} = 4$ V, $I_C = 5$ A, See Notes 5 and 6	20	150	20	150	20	150	20	150	20	150	
		$V_{CE} = 4$ V, $I_C = 20$ A, See Notes 5 and 6	5		5		5		5		5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 5$ A, See Notes 5 and 6		1		1		1		1		1	V
		$V_{CE} = 4$ V, $I_C = 20$ A, See Notes 5 and 6		3		3		3		3		3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ A, $I_C = 5$ A, See Notes 5 and 6		1		1		1		1		1	V
		$I_B = 5$ A, $I_C = 20$ A, See Notes 5 and 6		3		3		3		3		3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A f = 1 kHz	25		25		25		25		25		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, f = 1 MHz	5		5		5		5		5		

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		35.7	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.6		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	1.4		J/°C

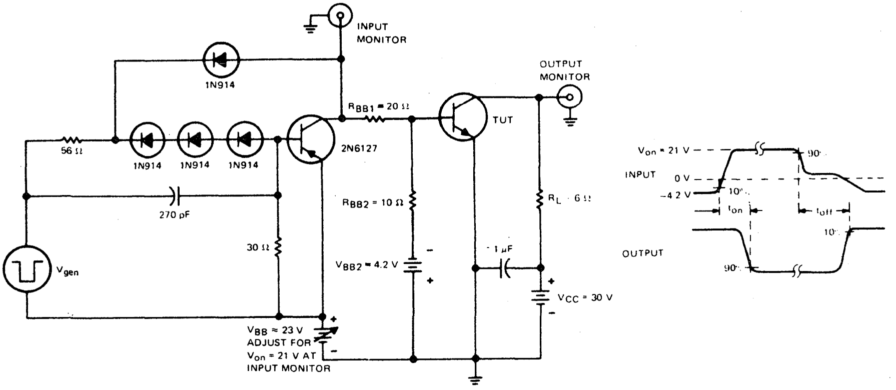
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

switching characteristics at 25 °C case temperature

	PARAMETER	TEST CONDITIONS +	TYP	UNIT
t_d	Delay Time	$I_C = 5$ A, $I_{B(1)} = 500$ mA, $I_{B(2)} = -500$ mA $V_{BE(off)} = -4.2$ V, $R_L = 6\ \Omega$, See Figure 1	20	ns
t_r	Rise Time		350	
t_s	Storage Time		500	
t_f	Fall Time		400	

+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ μs, duty cycle ≤ 2%.

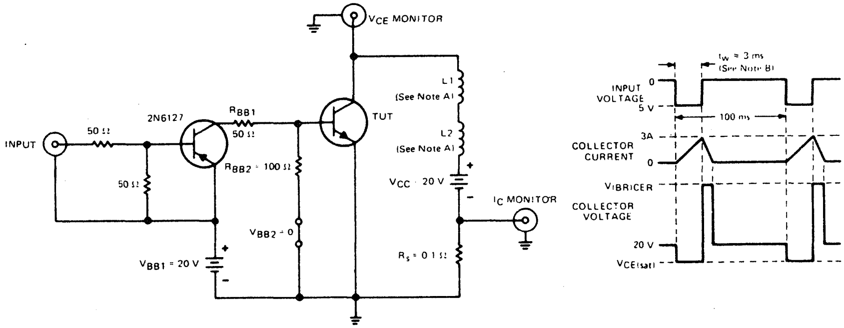
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C 2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = 3A$.

FIGURE 2

TYPICAL CHARACTERISTICS

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

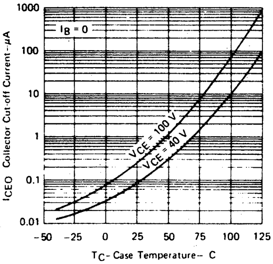


FIGURE 3

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

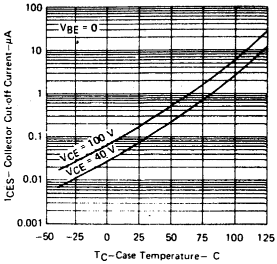


FIGURE 4

STATIC FORWARD-CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

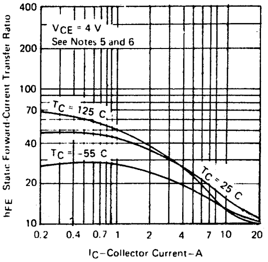


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

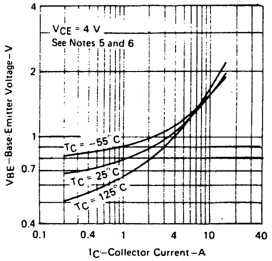


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

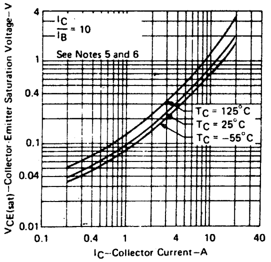


FIGURE 7

SWITCHING TIMES
vs
COLLECTOR CURRENT

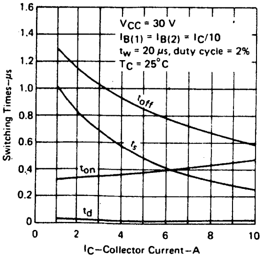


FIGURE 8

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

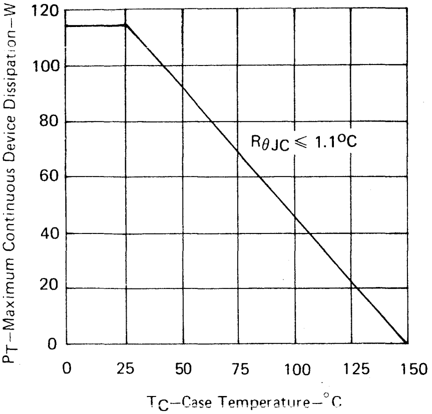


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

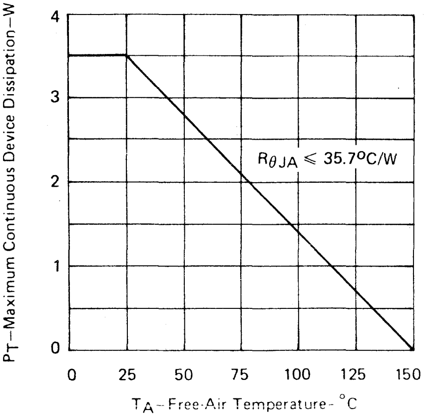


FIGURE 10

MAXIMUM SAFE OPERATION REGION

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

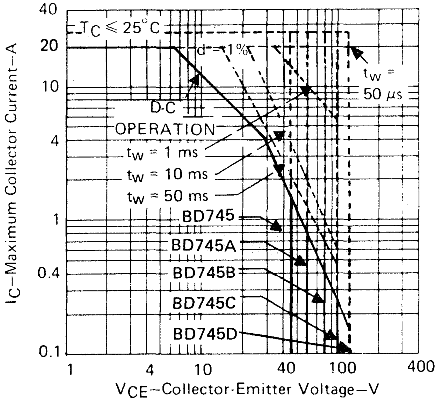


FIGURE 11

TYPES BD745, BD745A, BD745B, BD745C, BD745D
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

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$I_{C\,CONT}$	P_{TOT}							
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3 A	40 W	BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C		NPN PNP	TO220
5 A	45 W	BD539 BD540	BD539A BD540A	BD539B BD540B	BD539C BD540C	BD539D BD540D	NPN PNP	TO220
6 A	65 W	BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C		NPN PNP	TO220
8 A	70 W	BD543 BD544	BD543A BD544A	BD543B BD544B	BD543C BD544C	BD543D BD544D	NPN PNP	TO220
15 A	90 W	BD743 BD744	BD743A BD744A	BD743B BD744B	BD743C BD744C	BD743D BD744D	NPN PNP	TO220
10 A	80 W	BD245 BD246	BD245A BD246A	BD245B BD246B	BD245C BD246C		NPN PNP	TO3P
15 A	85 W	BD545 BD546	BD545A BD546A	BD545B BD546B	BD545C BD546C	BD545D BD546D	NPN PNP	TO3P
15 A	100 W		TIP3055 TIP2955				NPN PNP	TO3P
20 A	115 W	BD745 BD746	BD745A BD746A	BD745B BD746B	BD745C BD746C	BD745D BD746D	NPN PNP	TO3P
25 A	125 W	BD249 BD250	BD249A BD250A	BD249B BD250B	BD249C BD250C		NPN PNP	TO3P
30 A	150 W	TIP3771	TIP3772				NPN	TO3P

Single Diffused Silicon Power Darlingtons in Plastic Package — Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
$I_{C\,CONT}$	P_{TOT}							
4 A	40 W	BDW53 BDW54	BDW53A BDW54A	BDW53B BDW54B	BDW53C BDW54C	BDW53D BDW54D	NPN PNP	TO220
4 A	50 W		TIP110 TIP115	TIP111 TIP116	TIP112 TIP117		NPN PNP	TO220
5 A	65 W		TIP120 TIP125	TIP121 TIP126	TIP122 TIP127		NPN PNP	TO220
6 A	60 W	BDW63 BDW64	BDW63A BDW64A	BDW63B BDW64B	BDW63C BDW64C	BDW63D BDW64D	NPN PNP	TO220
8 A	75 W		TIP130 TIP135	TIP131 TIP136	TIP132 TIP137		NPN PNP	TO220
8 A	80 W	BDW73 BDW74	BDW73A BDW74A	BDW73B BDW74B	BDW73C BDW74C	BDW73D BDW74D	NPN PNP	TO220
10 A	125 W		TIP140 TIP145	TIP141 TIP146	TIP142 TIP147		NPN PNP	TO3P
15 A	150 W	BDW83 BDW84	BDW83A BDW84A	BDW83B BDW84B	BDW83C BDW84C	BDW83D BDW84D	NPN PNP	TO3P

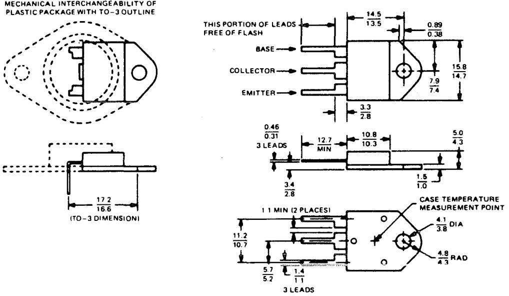
TYPES BD746, BD746A, BD746B, BD746C, BD746D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD745 SERIES

- 115 W at 25 °C Case Temperature
- 20 A Rated Collector Current
- Min f_T of 5 MHz at 4 V, 1 A

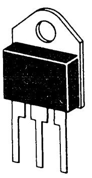
mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES

TO-3 P



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	BD746	BD746A	BD746B	BD746C	BD746D
Collector-Base Voltage	−50 V	−70 V	−90 V	−110 V	−130 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V	−80 V	−100 V	−120 V
Emitter-Base Voltage	−5 V	−5 V	−5 V	−5 V	−5 V
Continuous Collector Current	←		−20 A		→
Peak Collector Current ($T_p \leqslant 300\ \mu s$, $d \leqslant 10\%$	←		−25 A		→
Continuous Base Current	←		−5 A		→
Safe Operating Region at (or below) 25 °C Case Temperature	←		See Figure 11		→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 2)	←		115 W		→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 3)	←		3.5 W		→
Unclamped Inductive Load Energy (See Note 4)	←		90 mJ		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→
Lead Temperature 3 mm from Case for 10 Seconds	←		260 °C		→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 0.92 W/°C or refer to Dissipation Derating Curve, Figure 9.
3. Derate linearly to 150 °C free-air temperature at the rate of 28 mW/°C or refer to Dissipation Derating Curve, Figure 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = −20 V, Energy $\approx I_C^2L/2$.

TYPES BD746, BD746A, BD746B, BD746C, BD746D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BD746		BD746A		BD746B		BD746C		BD746D		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = −30 mA, I_B = 0, See Note 5	−45		−60		−80		−100		−120		V
$V_{(BR)CEV}$	Collector-Emitter Breakdown Voltage	I_C = −30 mA, V_{BE} = 1.5 V See Note 5	−50		−70		−90		−110		−130		V
I_{CEO}	Collector Cutoff Current	V_{CE} = −30 V, I_B = 0		−100		−100							µA
		V_{CE} = −60 V, I_B = 0						−100		−100		−100	
I_{CBO}	Collector Cutoff Current	V_{CB} = −50 V		−100									µA
		V_{CB} = −70 V				−100							
		V_{CB} = −90 V						−100					
		V_{CB} = −110 V								−100			
		V_{CB} = −130 V										−100	
I_{CBO}	Collector Cutoff Current	V_{CB} = V_{CO} rated, T_C = 125°C		−5		−5		−5		−5		−5	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −5 V, I_C = 0		−500		−500		−500		−500		−500	µA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = −4 V, I_C = −1 A, See Notes 5 and 6	40		40		40		40		40		
		V_{CE} = −4 V, I_C = −5 A, See Notes 5 and 6	20	150	20	150	20	150	20	150	20	150	
		V_{CE} = −4 V, I_C = −20 A, See Notes 5 and 6	5		5		5		5		5		
V_{BE}	Base-Emitter Voltage	V_{CE} = −4 V, I_C = −5 A, See Notes 5 and 6		−1		−1		−1		−1		−1	V
		V_{CE} = −4 V, I_C = −20 A, See Notes 5 and 6		−3		−3		−3		−3		−3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = −0.5 A, I_C = −5 A, See Notes 5 and 6		−1		−1		−1		−1		−1	V
		I_B = −5 A, I_C = −20 A, See Notes 5 and 6		−3		−3		−3		−3		−3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = −4 V, I_C = −1 A, f = 1 kHz	25		25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = −4 V, I_C = −1 A, f = 1 MHz	5		5		5		5		5		

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 µs, duty cycle ≤2%.

6. These parameters are measured with voltage-sensing contacts separate from the current carrying contacts and located within 3 mm from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		35.7	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.6		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	1.4		J/°C

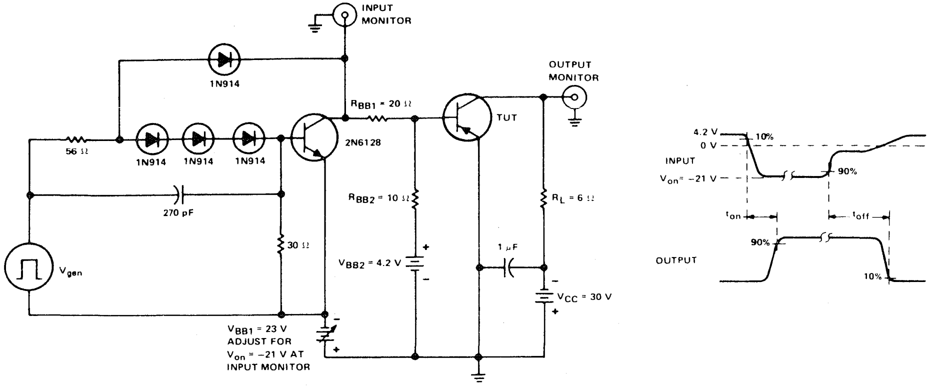
NOTE 7: This parameter is measured using a 78 µm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

switching characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS+	TYP	UNIT
t_d	Delay Time	I_C = −5 A, $I_{B(1)}$ = −500 mA, $I_{B(2)}$ = 500 mA, $V_{BE(off)}$ = 4.2 V, R_L = 6 Ω, See Figure 1	20	ns
t_r	Rise Time		120	
t_s	Storage Time		600	
t_f	Fall Time		300	

+ Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$ duty cycle $\leqslant 2\%$.

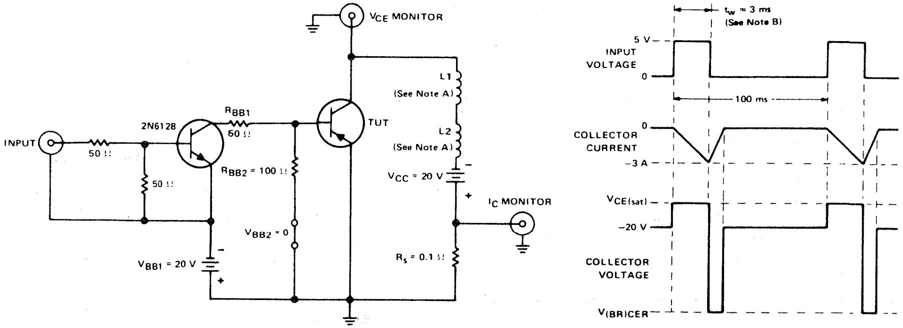
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C 2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = -3$ A

FIGURE 2

TYPICAL CHARACTERISTICS

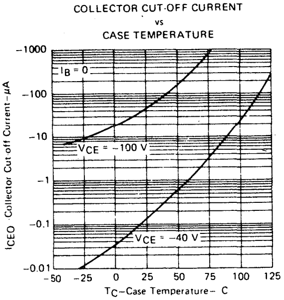

COLLECTOR CUT-OFF CURRENT vs CASE TEMPERATURE

FIGURE 3

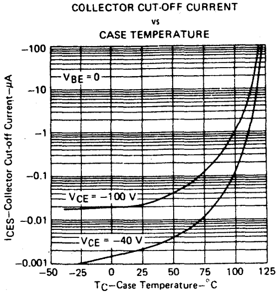

COLLECTOR CUT-OFF CURRENT vs CASE TEMPERATURE

FIGURE 4

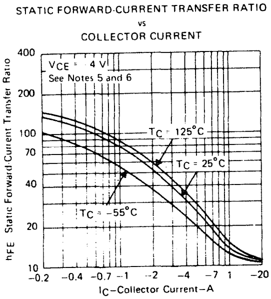

STATIC FORWARD-CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

FIGURE 5

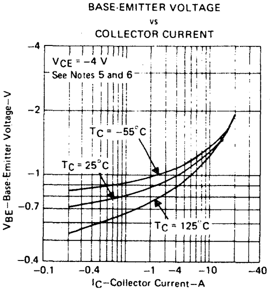

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

FIGURE 6

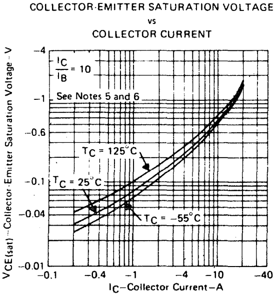

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

FIGURE 7

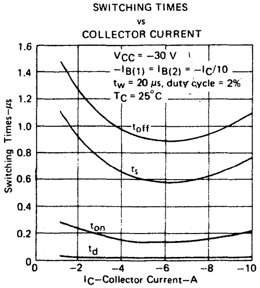

SWITCHING TIMES vs COLLECTOR CURRENT

FIGURE 8

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

THERMAL INFORMATION

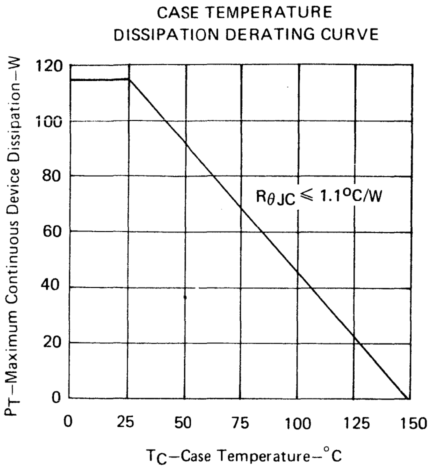


FIGURE 9

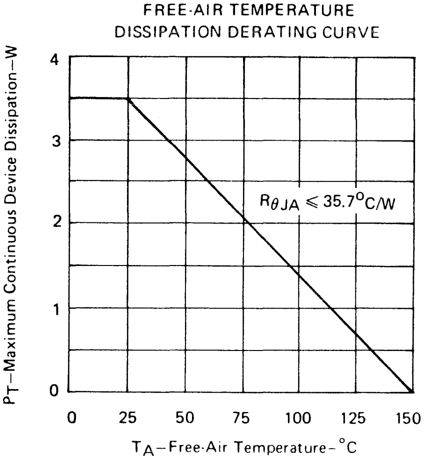


FIGURE 10

MAXIMUM SAFE OPERATION REGION

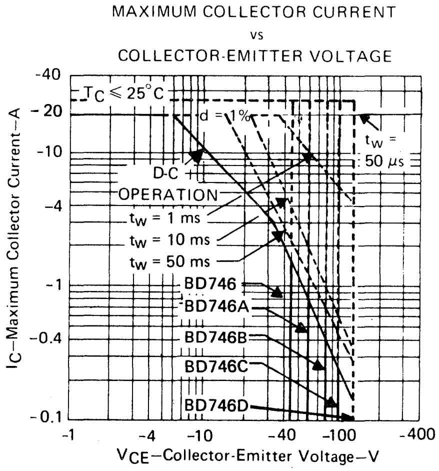


FIGURE 11

TYPES BD746, BD746A, BD746B, BD746C, BD746D
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

Single Diffused Silicon Power Transistors in Plastic Package – Product Selection Guide

U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
$I_{C\ CONT}$	P_{TOT}							
2 A	30 W	BD239 BD240	BD239A BD240A	BD239B BD240B	BD239C BD240C		PNP PNP	TO220
3 A	40 W	BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C		PNP PNP	TO220
5 A	45 W	BD539 BD540	BD539A BD540A	BD539B BD540B	BD539C BD540C	BD539D BD540D	NPN PNP	TO220
6 A	65 W	BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C		NPN PNP	TO220
8 A	70 W	BD543 BD544	BD543A BD544A	BD543B BD544B	BD543C BD544C	BD543D BD544D	NPN PNP	TO220
15 A	90 W	BD743 BD744	BD743A BD744A	BD743B BD744B	BD743C BD744C	BD743D BD744D	NPN PNP	TO220
10 A	80 W	BD245 BD246	BD245A BD246A	BD245B BD246B	BD245C BD246C		NPN PNP	TO3P
15 A	85 W	BD545 BD546	BD545A BD546A	BD545B BD546B	BD545C BD546C	BD545D BD546D	NPN PNP	TO3P
15 A	100 W		TIP3055 TIP2955				NPN PNP	TO3P
20 A	115 W	BD745 BD746	BD745A BD746A	BD745B BD746B	BD745C BD746C	BD745D BD746D	NPN PNP	TO3P
25 A	125 W	BD249 BD250	BD249A BD250A	BD249B BD250B	BD249C BD250C		NPN PNP	TO3P
30 A	150 W	TIP3771	TIP3772					

Single Diffused Silicon Power Darlingtons in Plastic Package – Product Selection Guide

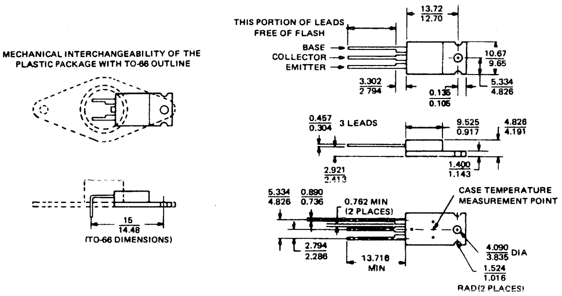
U_{CEO}		45 V	60 V	80 V	100 V	120 V	POLARITY	CASE
$I_{C\ CONT}$	P_{TOT}							
4 A	40 W	BDW53 BDW54	BDW53A BDW54A	BDW53B BDW54B	BDW53C BDW54C	BDW53D BDW54D	NPN PNP	TO220
4 A	50 W		TIP110 TIP115	TIP111 TIP116	TIP112 TIP117		NPN PNP	TO220
5 A	65 W		TIP120 TIP125	TIP121 TIP126	TIP122 TIP127		NPN PNP	TO220
6 A	60 W	BDW63 BDW64	BDW63A BDW64A	BDW63B BDW64B	BDW63C BDW64C	BDW63D BDW64D	NPN PNP	TO220
8 A	75 W		TIP130 TIP135	TIP131 TIP136	TIP132 TIP137		NPN PNP	TO220
8 A	80 W	BDW73 BDW74	BDW73A BDW74A	BDW73B BDW74B	BDW73C BDW74C	BDW73D BDW74D	NPN PNP	TO220
10 A	125 W		TIP140 TIP145	TIP141 TIP146	TIP142 TIP147		NPN PNP	TO3P
15 A	150 W	BDW83 BDW 84	BDW83A BDW84A	BDW83B BDW84B	BDW83C BDW84C	BDW83D BDW84D	NPN PNP	TO3P

NPN SILICON POWER DARLINGTON BDW53, A, B, C,
PNP SILICON POWER DARLINGTON BDW54, A, B, C,

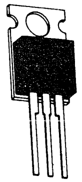
- High SOA Capability, 40 V and 1 A
- 40 W at 25 °C Case Temperature
- 4 A Rated Collector Current
- Min h_{FE} of 750 @ 1.5 A/3 V
- 25 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	NPN	BDW53	BDW53A	BDW53B	BDW53C	BDW53D
	PNP	BDW54	BDW54A	BDW54B	BDW54C	BDW54D
Collector-Base Voltage		45 V	60 V	80 V	100 V	120 V
Collector-Emitter Voltage (See Note 1)		45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage		←		5 V		→
Continuous Collector Current		←		4 A		→
Continuous Base Current		←		50 mA		→
Continuous Device Dissipation at 25 °C Case Temperature (See Note 2)		←		40 W		→
Continuous Device Dissipation at 25 °C Free Air Temperature (See Note 3)		←		2 W		→
Unclamped Inductive Load Energy (See Note 4)		←		25 mJ		→
Operating Ambient Temperature Range		←		−65 °C to 150 °C		→
Operating Collector Junction Temperature Range		←		−65 °C to 150 °C		→
Storage Temperature Range		←		−65 °C to 150 °C		→

NOTES:
1. These values apply when the base-emitter diode is open circuited
2. Derate linearly to 150 °C Case Temperature at the rate of 0.32 W/°C
3. Derate linearly to 150 °C Free-Air Temperature at the rate of 16 mW/°C
4. This rating is based on the capability of the transistor to operate safely in a circuit of: L = 100 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V, Energy $\approx I_C^2 \cdot L/2$.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BDW53 BDW54		BDW53A BDW54A		BDW53B BDW54B		BDW53C BDW54C		BDW53D BDW54D		UNITS
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$ (See Note 5)	45		60		80		100		120		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		500		500							µA
		$V_{CE} = 40$ V, $I_B = 0$						500					
		$V_{CE} = 50$ V, $I_B = 0$								500			
		$V_{CE} = 60$ V, $I_B = 0$										500	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		200									µA
		$V_{CB} = 60$ V, $I_E = 0$				200							
		$V_{CB} = 80$ V, $I_E = 0$						200					
		$V_{CB} = 100$ V, $I_E = 0$								200			
		$V_{CB} = 120$ V, $I_E = 0$										200	
I_{CBO}	$T_C = 150$ °C	45/60/80/100/120 V		5		5		5		5		5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		2		2		2		2		2	mA
h_{FE}	Static Foreward Current Transfer Ratio	$V_{CE} = 3$ V, $I_C = 1.5$ A	750	20000	750	20000	750	20000	750	20000	750	20000	
		$V_{CE} = 3$ V, $I_C = 4$ A (See Notes 5 & 6)	100		100		100		100		100		
$V_{BE(ON)}$	Base-Emitter Voltage	$V_{CE} = 3$ V, $I_C = 1.5$ A (See Notes 5 & 6)		2.5		2.5		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 1.5$ A, $I_B = 30$ mA		2.5		2.5		2.5		2.5		2.5	V
		$I_C = 4$ A, $I_B = 40$ mA (See Notes 5 & 6)		4		4		4		4		4	V
V_{FR}	Foreward Voltage of Reverse Diode	$-I_C = 2.8$ A		4		4		4		4		4	V

thermal characteristics

	PARAMETER	Max	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance (See Note 7)	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.0	°C/W

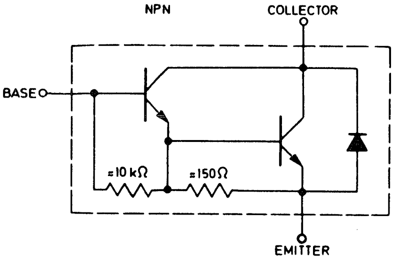
switching characteristics at 25 °C case temperature

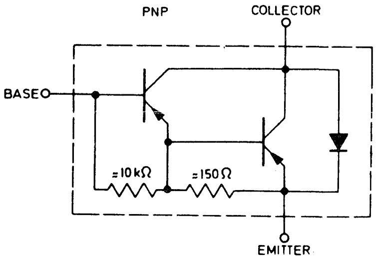
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	$I_C = 2$ A, $I_{B(1)} = 8$ mA, $I_{B(2)} = -8)$	1.0	µs
t_{OFF}	Turn-Off Time	$V_{BE(off)} = -5$ V, $R_L = 15\,\Omega$	4.5	µs

NOTES: 5. These parameters must be measured using pulse techniques, $t_w = 300$ µs, duty cycle $\leqslant 2\%$

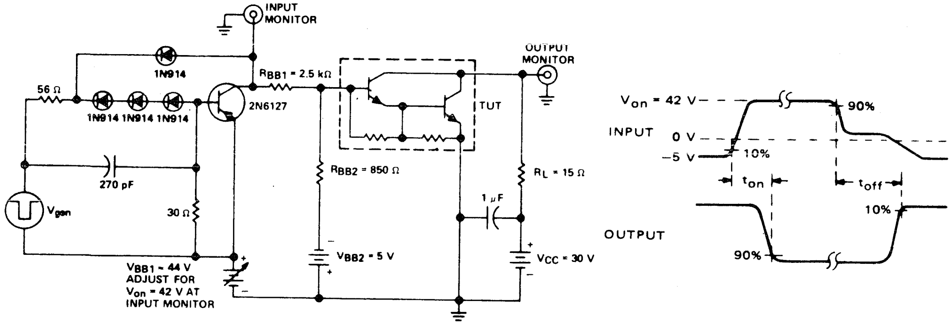
6. These parameters are measured with voltage-sensing contacts separate from the current carrying contacts and located within 3 mm from the device body

7. A 40 W Power Pulse is applied (50 ms with $I_C = 2$ A, $V_{CE} = 20$ V).
After 30 µs stabilization time ΔV_{BE} is measured $\leqslant 450$ mV. (Base test current = 3 mA).





PARAMETER MEASUREMENT INFORMATION



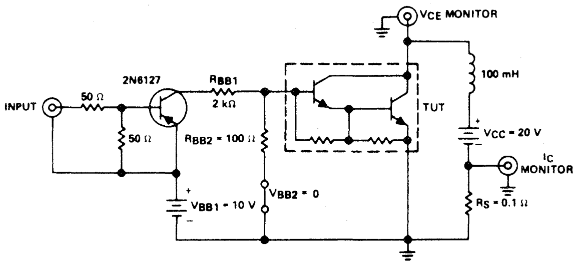
TEST CIRCUIT

VOLTAGE WAVEFORMS

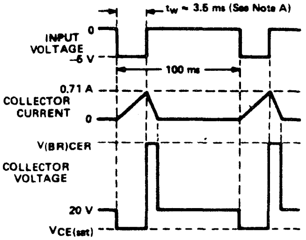
NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r < 15$ ns, $t_f < 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 0.71 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

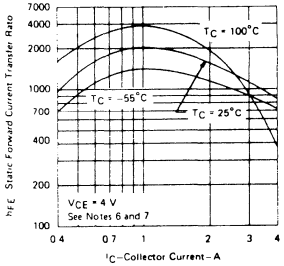


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

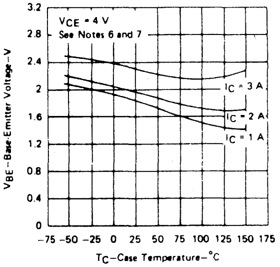


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

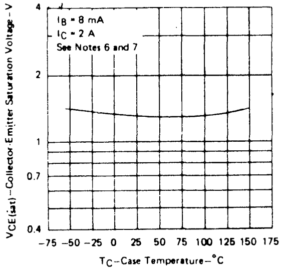


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

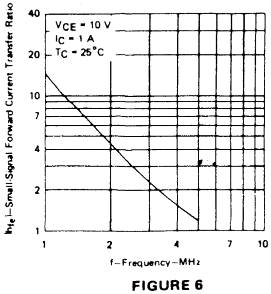


FIGURE 6

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

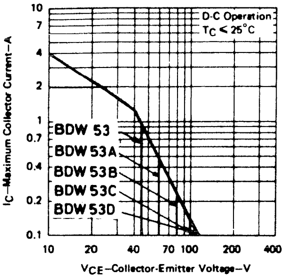


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

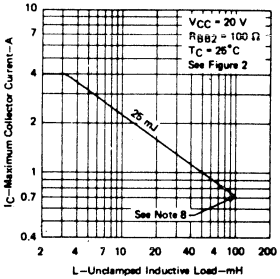


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

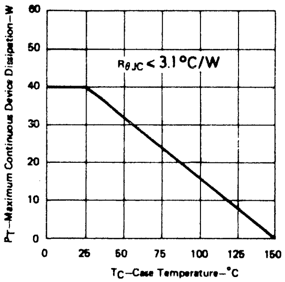


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

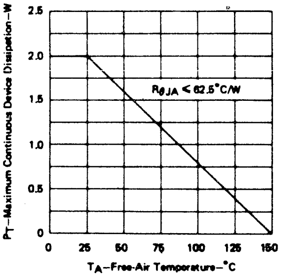


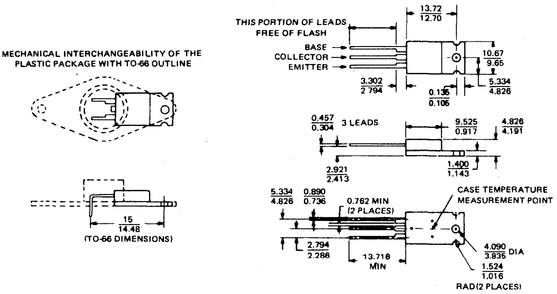
FIGURE 10

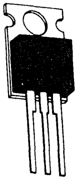
NPN SILICON POWER DARLINGTON BDW63, A, B, C, D
PNP SILICON POWER DARLINGTON BDW64, A, B, C, D

- High SOA Capability, 20 V and 3 A
- 60 W at 25 °C Case Temperature
- 6 A Rated Collector Current
- Min h_{FE} of 750 @ 2 A/3 V
- 50 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	NPN BDW63 PNP BDW64	BDW63A BDW64A	BDW63B BDW64B	BDW63C BDW64C	BDW63D BDW64D
Collector-Base Voltage	45 V	60 V	80 V	100 V	120 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage	←		5 V		→
Continuous Collector Current	←		6 A		→
Continuous Base Current	←		100 mA		→
Continuous Device Dissipation at 25 °C Case Temperature (See Note 2)	←		60 W		→
Continuous Device Dissipation at 25 °C Free-Air Temperature (See Note 3)	←		2 W		→
Unclamped Inductive Load Energy (See Note 4)	←		50 mJ		→
Operating Ambient Temperature Range	←		−65 °C to 150 °C		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→

NOTES:
1. These values apply when the base-emitter diode is open-circuited
2. Derate linearly to 150 °C Case Temperature at the rate of 0.48 W/°C
3. Derate linearly to 150 °C Free-Air Temperature at the rate of 16 mW/°C
4. This rating is based on the capability of the transistor to operate safely in a circuit of: L = 100 mH, R_{BB} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, Energy $\approx I_C^2$.L/2.

NPN SILICON POWER DARLINGTON BDW63, A, B, C, D
PNP SILICON POWER DARLINGTON BDW64, A, B, C, D

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW63 BDW64		BDW63A BDW64A		BDW63B BDW64B		BDW63C BDW64C		BDW63D BDW64D		UNIT
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, (See Note 5)	I_B = 0	45		60		80		100		120		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V,	I_B = 0		500		500							μA
		V_{CE} = 40 V,	I_B = 0						500					
		V_{CE} = 50 V,	I_B = 0								500			
		V_{CE} = 60 V,	I_B = 0										500	
I_{CBO}	Collector Cutoff Current	V_{CB} = 45 V,	I_E = 0		200									μA
		V_{CB} = 60 V,	I_E = 0				200							
		V_{CB} = 80 V,	I_E = 0						200					
		V_{CB} = 100 V,	I_E = 0								200			
		V_{CB} = 120 V,	I_E = 0										200	
I_{CBO}	T_C = 150 °C	45/60/80/100/120 V			5		5		5		5		5	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V,	I_C = 0		2		2		2		2		2	mA
h_{FE}	Static Foreward Current Transfer Ratio	V_{CE} = 3 V,	I_C = 2 A	750	20000	750	20000	750	20000	750	20000	750	20000	
		V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 6 A	100		100		100		100		100		
$V_{BE(ON)}$	Base Emitter Voltage	V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 2 A		2.5		2.5		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 2 A,	I_B = 12 mA		2.5		2.5		2.5		2.5		2.5	V
		I_C = 6 A, (See Notes 5 & 6)	I_B = 60 mA		4		4		4		4		4	
V_{FR}	Foreward Voltage of Reverse Diode	$-I_C$ = 4.2 A			4		4		4		4		4	V

thermal characteristics

	PARAMETER	Max	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance (See Note 7)	2.08	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.0	°C/W

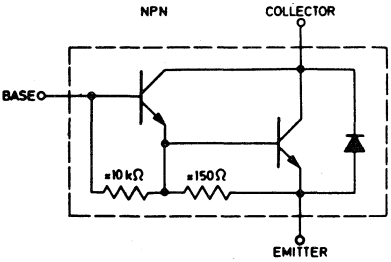
switching characteristics at 25 °C case temperature

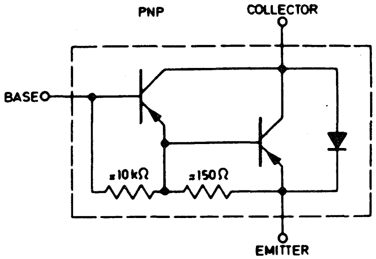
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA	1.0	μs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −4.5 V, R_L = 10 Ω	5	μs

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 μs, duty cycle ⩽2%

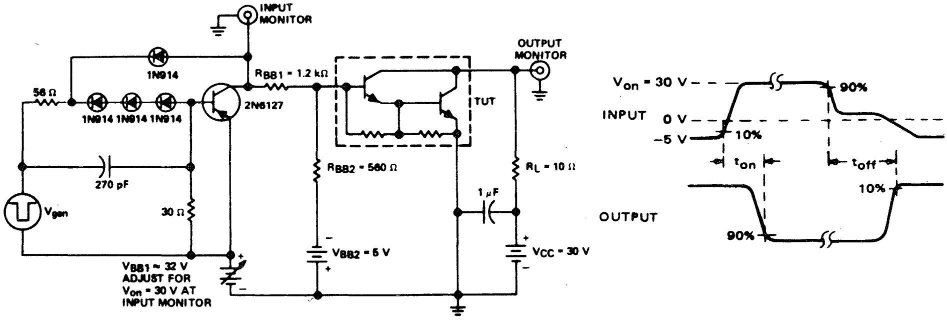
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body

7. A 40 Watt Power Pulse is applied (50 ms with I_C = 2 A, V_{CE} = 20 V).
After 30 μs stabilization time ΔV_{BE} is measured ⩽300 mV (Base test current = 3 mA)





PARAMETER MEASUREMENT INFORMATION



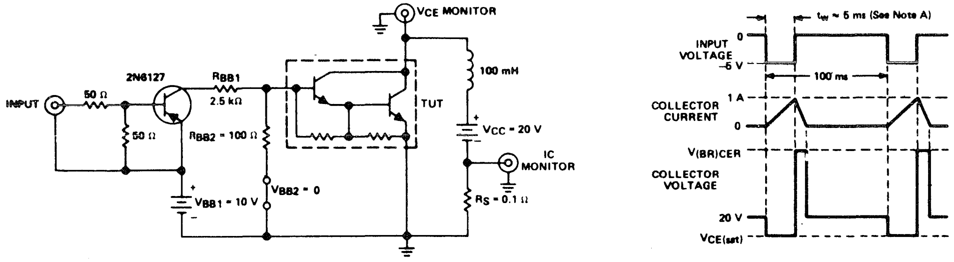
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = 1$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

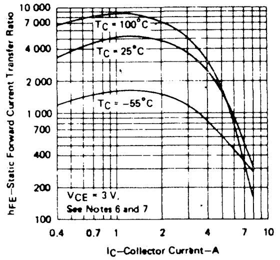


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

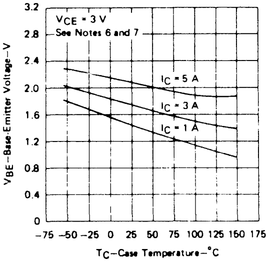


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

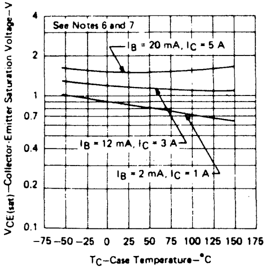


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
FREQUENCY

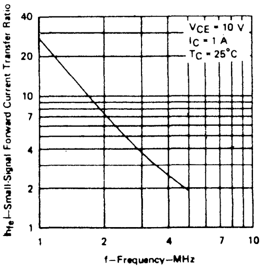


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

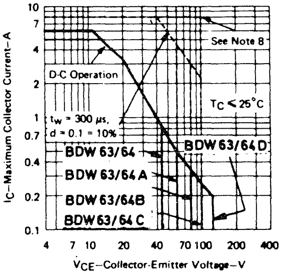


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

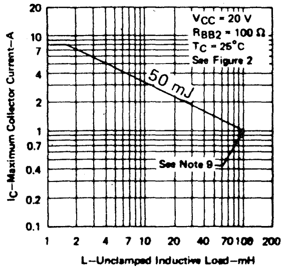


FIGURE 8

NOTES: 8. This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

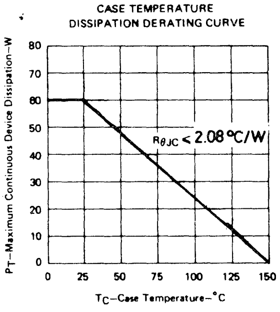


FIGURE 9

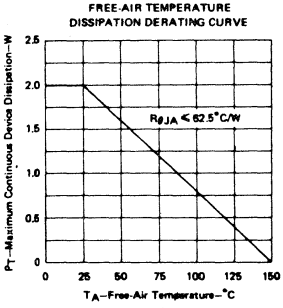


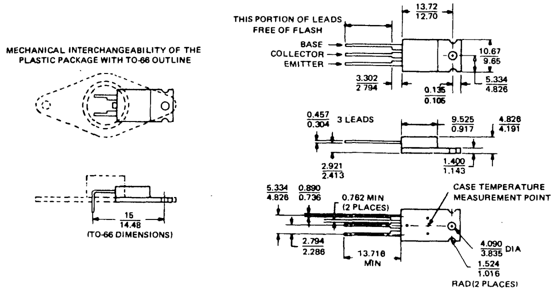
FIGURE 10

NPN SILICON POWER DARLINGTON BDW73, A, B, C, D
PNP SILICON POWER DARLINGTON BDW74, A, B, C, D

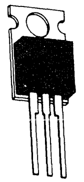
- High SOA Capability, 20 V and 4 A
- 80 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min h_{FE} of 750 @ 3 A/3 V
- 75 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	NPN PNP	BDW73 BDW74	BDW73A BDW74A	BDW73B BDW74B	BDW73C BDW74C	BDW73D BDW74D
Collector-Base Voltage		45 V	60 V	80 V	100 V	120 V
Collector-Emitter Voltage (See Note 1)		45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage		←		5 V		→
Continuous Collector Current		←		8 A		→
Continuous Base Current		←		300 mA		→
Continuous Device Dissipation at 25 °C Case Temperature (See Note 2)		←		80 W		→
Continuous Device Dissipation at 25 °C Free-Air Temperature (See Note 3)		←		2 W		→
Unclamped Inductive Load Energy (See Note 4)		←		75 mJ		→
Operating Ambient Temperature Range		←		−65 °C to 150 °C		→
Operating Collector Junction Temperature Range		←		−65 °C to 150 °C		→
Storage Temperature Range		←		−65 °C to 150 °C		→

NOTES:
1. These values apply when the base-emitter diode is open-circuited
2. Derate linearly to 150 °C Case Temperature at the rate of 0.64 W/°C
3. Derate linearly to 150 °C Free-Air Temperature at the rate of 16 mW/°C
4. This rating is based on the capability of the transistor to operate safely in a circuit of: $L = 100$ mH, $R_{BB} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V, Energy $\approx I_C{}^2.L/2$.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW73 BDW74		BDW73A BDW74A		BDW73B BDW74B		BDW73C BDW74C		BDW73D BDW74D		UNITS
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	Collector-Emitter	I_C = 30 mA,	I_B = 0	45		60		80		100		120		V
	Breakdown Voltage	(See Note 5)												
I_{CEO}	Collector Cutoff	V_{CE} = 30 V,	I_B = 0		500		500							µA
	Current	V_{CE} = 40 V,	I_B = 0						500					
		V_{CE} = 50 V,	I_B = 0								500			
		V_{CE} = 60 V,	I_B = 0										500	
I_{CBO}	Collector Cutoff	V_{CB} = 45 V,	I_E = 0		200									µA
	Current	V_{CB} = 60 V,	I_E = 0				200							
		V_{CB} = 80 V,	I_E = 0						200					
		V_{CB} = 100 V,	I_E = 0								200			
		V_{CB} = 120 V,	I_E = 0										200	
I_{CBO}	T_C = 150 °C	45/60/80/100/120 V			5		5		5		5		5	mA
I_{EBO}	Emitter Cutoff	V_{EB} = 5 V,	I_C = 0		2		2		2		2		2	mA
	Current													
h_{FE}	Static Foreward	V_{CE} = 3 V,	I_C = 3 A	750	20000	750	20000	750	20000	750	20000	750	20000	
	Current Transfer	V_{CE} = 3 V,	I_C = 8 A	100		100		100		100		100		
	Ratio	(See Notes 5 & 6)												
$V_{BE(ON)}$	Base Emitter	V_{CE} = 3 V,	I_C = 3 A		2.5		2.5		2.5		2.5		2.5	V
	Voltage	(See Notes 5 & 6)												
$V_{CE(sat)}$	Collector Emitter	I_C = 3 A,	I_B = 12 mA		2.5		2.5		2.5		2.5		2.5	V
	Saturation	I_C = 8 A,	I_B = 80 mA		4		4		4		4		4	
	Voltage	(See Notes 5 & 6)												
V_{FR}	Forward Voltage of Reverse Diode	$-I_C$ = 5.6 A			4		4		4		4		4	V

thermal characteristics

	PARAMETER	Max	UNITS
$R_{\theta JC}$	Junction -to-Case Thermal Resistance (See Note 7)	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.0	°C/W

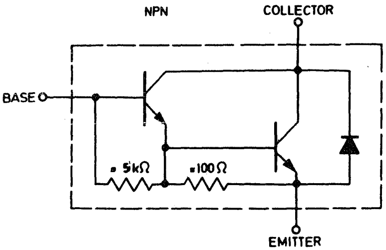
switching characteristics at 25 °C case temperature

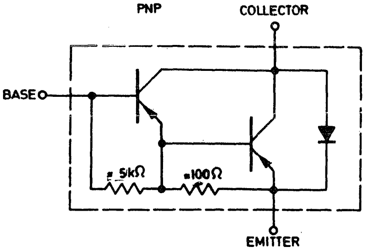
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA	1.0	µs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −3.5 V, R_L = 10 Ω	5.0	µs

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 µs, duty cycle $\leqslant$2%

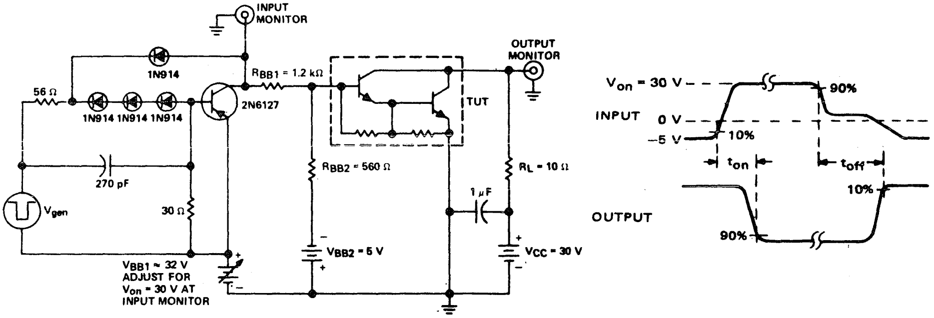
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body

7. A 40 Watt Power Pulse is applied (50 ms with I_C = 2 A, V_{CE} = 20 V).
After 30 µs stabilization time ΔV_{BE} is measured $\leqslant$225 mV. (Base test current = 3 mA).





PARAMETER MEASUREMENT INFORMATION



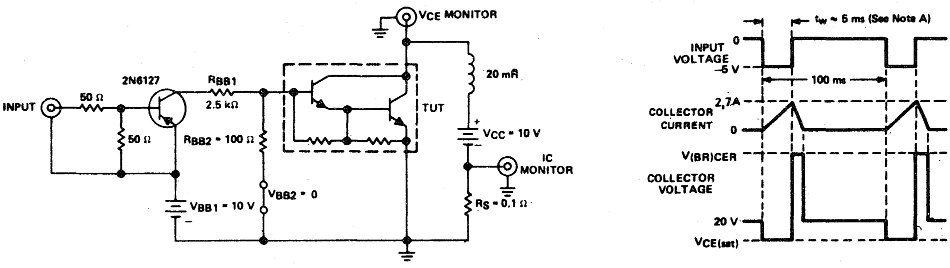
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} > 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 1 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

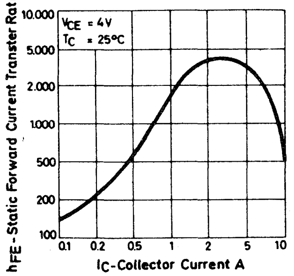


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

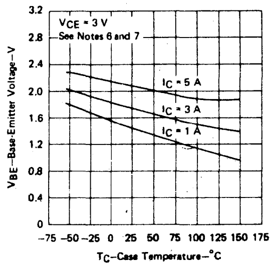


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

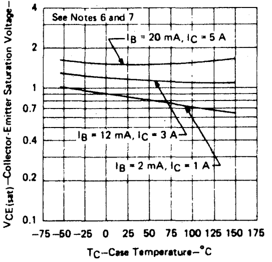


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
FREQUENCY

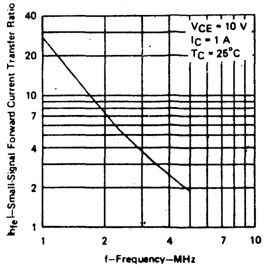


FIGURE 6

NOTES:
6. These parameters must be measured using pulse techniques. t_W = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT vs COLLECTOR-EMITTER VOLTAGE

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

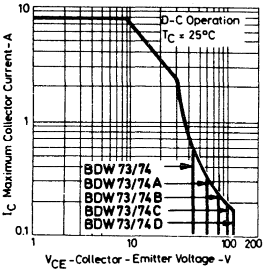


FIGURE 7

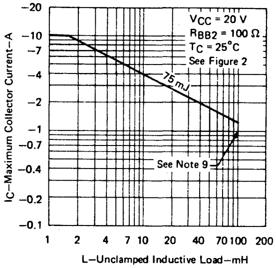


FIGURE 8

NOTES: 8. This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

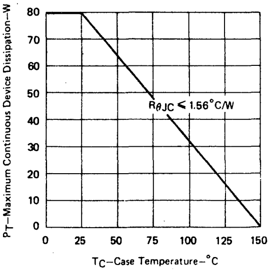


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

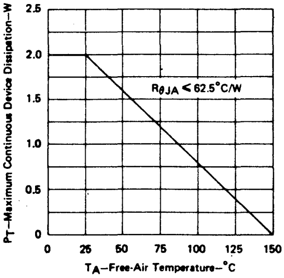


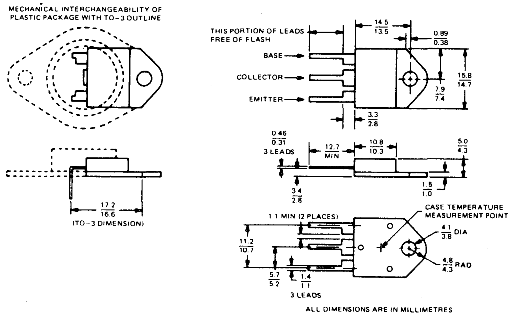
FIGURE 10

NPN SILICON POWER DARLINGTON BDW83, A, B, C, D
PNP SILICON POWER DARLINGTON BDW84, A, B, C, D

- High SOA Capability, 30 V and 5 A
- 150 W at 25 °C Case Temperature
- 15 A Rated Collector Current
- Min h_{FE} of 750 @ 6 A/3 V
- 100 mJ Reverse Energy Rating

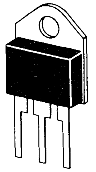
mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



TO-3 P

ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	NPN BDW83 PNP BDW84	BDW83A BDW84A	BDW83B BDW84B	BDW83C BDW84C	BDW83D BDW84D
Collector-Base Voltage	45 V	60 V	80 V	100 V	120 V
Collector-Emitter Voltage (See Note 1)	45 V	60 V	80 V	100 V	120 V
Emitter-Base Voltage	←		5 V		→
Continuous Collector Current	←		15 A		→
Continuous Base Current	←		500 mA		→
Continuous Device Dissipation at 25 °C Case Temperature (See Note 2)	←		150 W		→
Continuous Device Dissipation at 25 °C Free-Air Temperature (See Note 3)	←		3.5 W		→
Unclamped Inductive Load Energy (See Note 4)	←		100 mJ		→
Operating Ambient Temperature Range	←		−65 °C to 150 °C		→
Operating Collector Junction Temperature Range	←		−65 °C to 150 °C		→
Storage Temperature Range	←		−65 °C to 150 °C		→

NOTES:
1. These values apply when the base-emitter diode is open-circuited
2. Derate linearly to 150 °C Case Temperature at the rate of 1.2 W/°C
3. Derate linearly to 150 °C Free-Air Temperature at the rate of 28 mW/°C
4. This rating is based on the capability of the transistor to operate safely in a circuit of: $L = 100$ mH, $R_{BB} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V, Energy $\approx I_C^2 . L/2$.

NPN SILICON POWER DARLINGTON BDW83, A, B, C, D
PNP SILICON POWER DARLINGTON BDW84, A, B, C, D

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	BDW83 BDW84		BDW83A BDW84A		BDW83B BDW84B		BDW83C BDW84C		BDW83D BDW84D		UNI
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$ (See Note 5)	45		60		80		100		120		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		1		1							mA
		$V_{CE} = 40$ V, $I_B = 0$						1					
		$V_{CE} = 50$ V, $I_B = 0$								1			
		$V_{CE} = 60$ V, $I_B = 0$										1	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		500									μA
		$V_{CB} = 60$ V, $I_E = 0$				500							
		$V_{CB} = 80$ V, $I_E = 0$						500					
		$V_{CB} = 100$ V, $I_E = 0$								500			
		$V_{CB} = 120$ V, $I_E = 0$										500	
I_{CBO}	$T_C = 150$ °C	45/60/80/100/120 V		5		5		5		5		5	mA
I_{EBO}	Emitter-Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		2		2		2		2		2	mA
h_{FE}	Static Foreward Current Transfer Ratio	$V_{CE} = 3$ V, $I_C = 6$ A	750	20000	750	20000	750	20000	750	20000	750	20000	
		$V_{CE} = 3$ V, $I_C = 15$ A (See Notes 5 & 6)	100		100		100		100		100		
$V_{BE(ON)}$	Base Emitter Voltage	$V_{CE} = 3$ V, $I_C = 6$ A (See Notes 5 & 6)		2.5		2.5		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	$I_C = 6$ A, $I_B = 12$ mA		2.5		2.5		2.5		2.5		2.5	V
		$I_C = 15$ A, $I_B = 150$ mA (See Notes 5 & 6)		4		4		4		4		4	
V_{FR}	Foreward Voltage of Reverse Diode	$-I_C = 10$ A		4		4		4		4		4	V

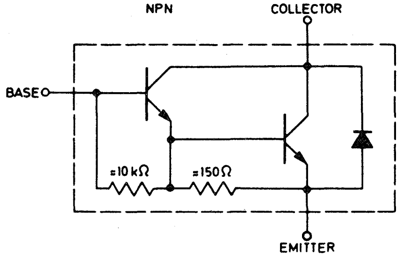
thermal characteristics

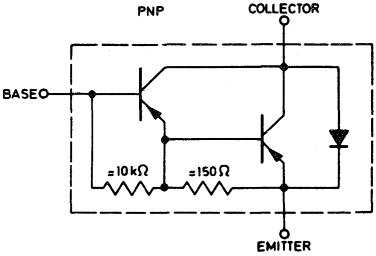
	PARAMETER	Max	UN
$R_{\theta JC}$	Junction-to-Case Thermal Resistance (See Note 7)	0.83	°C
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	°C

switching characteristics at 25 °C case temperature

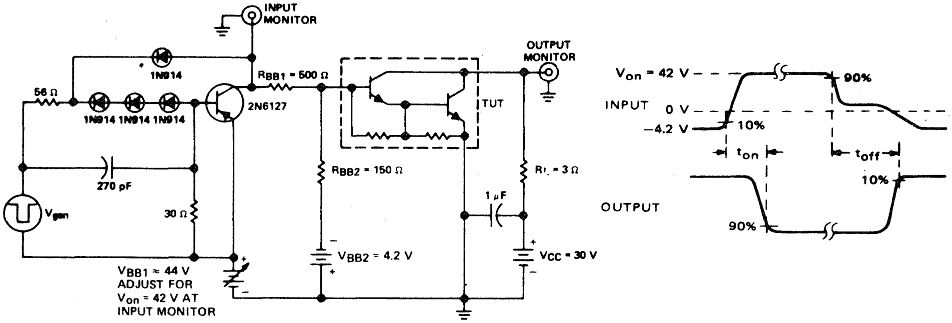
	PARAMETER	TEST CONDITIONS	Typ	UN
t_{ON}	Turn-On Time	$I_C = 10$ A, $I_{B(1)} = 40$ mA, $I_{B(2)} = -40$ mA	0.9	μs
t_{OFF}	Turn-Off Time	$V_{BE(off)} = -4.2$ V, $R_L = 3\ \Omega$	7	μs

NOTES:
5. *These parameters must be measured using pulse techniques, $t_w = 300$ μs, duty cycle $\leqslant 2\%$*
6. These parameters are measured with voltage-sensing contacts separate from the current-contacts and located within 3 mm from t device body.
7. A 62 Watt Power Pulse is applied (50 ms with $I_C = 2.5$ A, $V_{CE} = 25$ V) After 30 μs stabilization time ΔV_{BE} is measured $\leqslant 187$ mV (Base test current = 3 mA)





PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

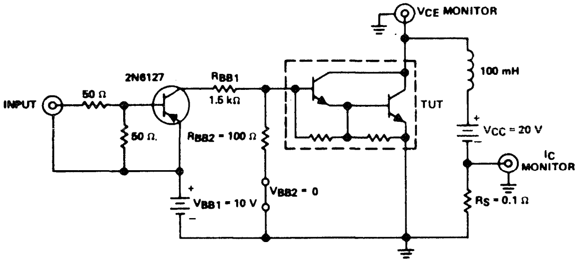
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

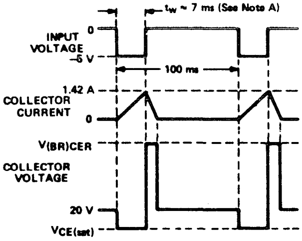
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = 1.42$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

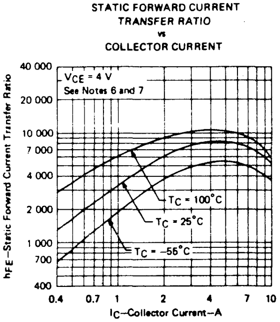


FIGURE 3

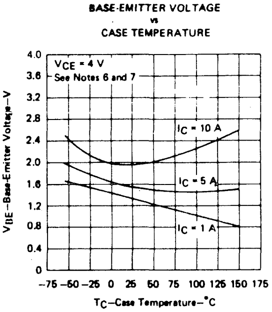


FIGURE 4

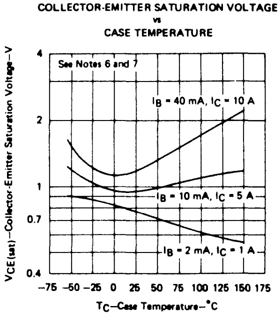


FIGURE 5

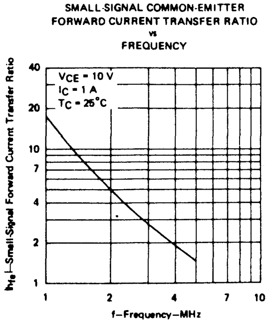


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques, $t_w = 300$ µs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREAS

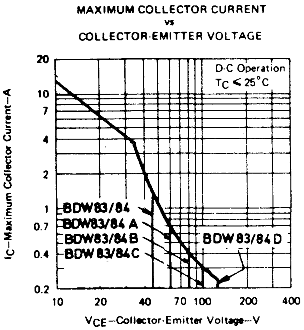

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

FIGURE 7

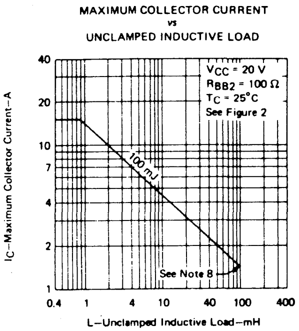

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

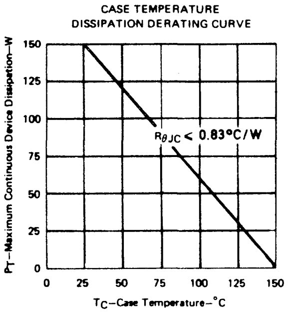

CASE TEMPERATURE
DISSIPATION DERATING CURVE

FIGURE 9

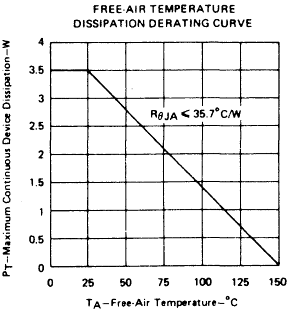
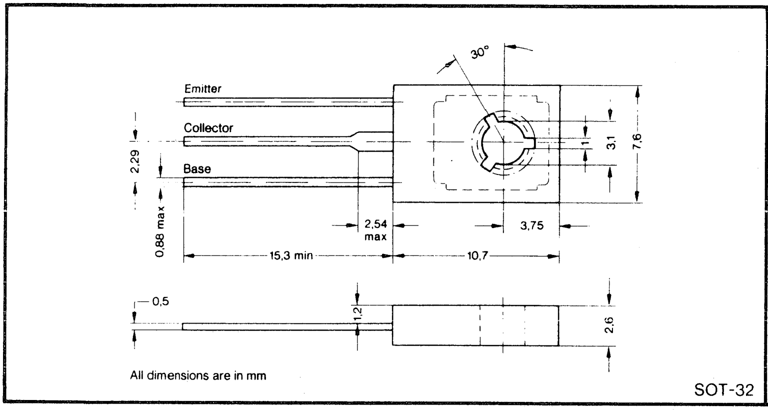

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

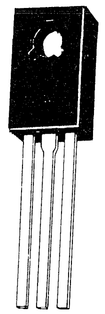
FIGURE 10

BF415, BF417
NPN EPITAXIAL PLANAR SILICON TRANSISTORS

COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF 416, 418

mechanical data





absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

	BF415	BF417
Collector-Base Voltage	250 V	300 V
Collector-Emitter Voltage (see Note 1)	250 V	300 V
Emitter-Base Voltage	5 V	5 V
Continuous Collector Current	← 200 mA →	
Peak Collector Current	← 300 mA →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 2)	← 6 W →	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 3)	← 1.25 W →	
Storage Temperature Range	−55 to 150 °C	
Lead Temperature 1.6 mm from case for 60 Sec.	← 260 °C →	

electrical characteristics at 25 °C case temperature (unless otherwise noted)

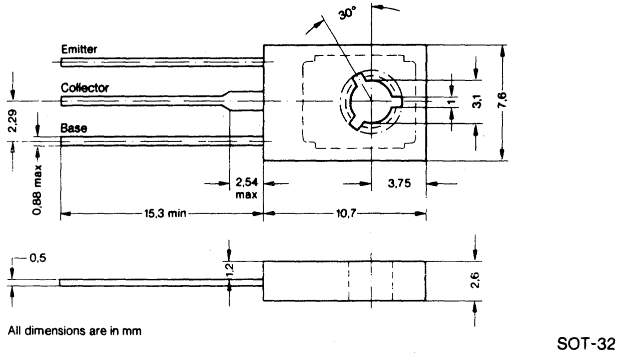
	PARAMETER	TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
$U_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 μA, I_E = 0	415	250			V
			417	300			V
$U_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0 (see Note 4)	415	250			V
			417	300			V
$U_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0	415, 7	5			V
I_{CBO}	Collector Cutoff Current	V_{CB} = 200 V, I_E = 0	415			50	nA
		V_{CB} = 250 V, I_E = 0	417			50	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 3 V, I_C = 0	415, 7			50	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 15 V, I_C = 5 mA	415, 7	25			
		V_{CE} = 15 V, I_C = 25 mA	415, 7	30			
V_{BE}	Base-Emitter Voltage	V_{CE} = 15 V, I_C = 5 mA	415, 7		0.65	0.9	V
		V_{CE} = 15 V, I_C = 25 mA	415, 7		0.72	1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 5 mA, I_B = 1 mA	415, 7		0.2	0.5	V
		I_C = 25 mA, I_B = 5 mA	415, 7		0.4	1.0	V
$V_{CE(sat)HF}$	High Frequency Saturation Voltage	I_C = 25 mA, f = 1 MHz (see Note 5)	415, 7			20	V
f_T	Transition Frequency	V_{CE} = 15 V, I_C = 25 mA f = 20 MHz	415, 7		70		MHz
C_{cb}	Collector-Base Capacitance	V_{CB} = 30 V, I_E = 0 f = 1 MHz	415, 7			4.5	pF

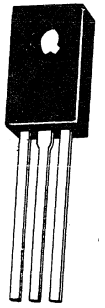
NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 48 mW/°C.
3. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
4. This parameter must be measured using pulse technique. Pulse width = 300 μs. Duty cycle $\leqslant$2%.
5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small-signal amplification in a practical circuit is decreased to 80% of the value at V_{CE} = 50 V.

BF416, BF418
PNP EPITAXIAL PLANAR SILICON TRANSISTORS

COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF 415, 417

mechanical data





absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

	BF416	BF418
Collector-Base Voltage	−250 V	−300 V
Collector-Emitter Voltage (see Note 1)	−250 V	−300 V
Emitter-Base Voltage	← −5 V →	
Continuous Collector Current	← −200 mA →	
Peak Collector Current	← −300 mA →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 2)	← 6 W →	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 3)	← 1.25 W →	
Storage Temperature Range	−55 to 150 °C	
Lead Temperature 1.6 mm from case for 60 Sec.	← 260 °C →	

electrical characteristics at 25 °C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TYPE	MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$-I_C = 10\ \mu A$,	$I_E = 0$	416	−250			V
				418	−300			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$-I_C = 10$ mA, (see Note 4)	$I_B = 0$	416	−250			V
				418	−300			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$-I_E = 10\ \mu A$,	$I_C = 0$	416, 8	−5			V
I_{CBO}	Collector Cutoff Current	$-V_{CB} = 200$ V,	$I_E = 0$	416			−50	nA
		$-V_{CB} = 250$ V,	$I_E = 0$	418			−50	nA
I_{EBO}	Emitter Cutoff Current	$-V_{EB} = 3$ V,	$I_C = 0$	416, 8			−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$-V_{CE} = 15$ V,	$-I_C = 5$ mA	416, 8	25			
		$-V_{CE} = 15$ V,	$-I_C = 25$ mA	416, 8	30			
V_{BE}	Base-Emitter Voltage	$-V_{CE} = 15$ V,	$-I_C = 5$ mA	416, 8		−0.65	−0.9	V
		$-V_{CE} = 15$ V,	$-I_C = 25$ mA	416, 8		−0.72	−1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$-I_C = 5$ mA,	$-I_B = 1$ mA	416, 8		−0.2	−0.5	V
		$-I_C = 25$ mA,	$-I_B = 5$ mA	416, 8		−0.4	−1.0	V
$V_{CE(sat)HF}$	High Frequency Saturation Voltage	$-I_C = 25$ mA, (see Note 5)	$f = 1$ MHz	416, 8			−20	V
f_T	Transition Frequency	$-V_{CE} = 15$ V, $f = 20$ MHz	$-I_C = 25$ mA	416, 8		70		MHz
C_{cb}	Collector-Base Capacitance	$-V_{CB} = 30$ V, $f = 1$ MHz	$I_E = 0$	416, 8			4.5	pF

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 48 mW/°C.
3. Derate linearly to 150 °C free-air temperature at the rate of 10 mW/°C.
4. This parameter must be measured using pulse techniques. Pulse width = 300 μs. Duty Cycle ⩽2%.
5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small-signal amplification in a practical circuit is decreased to 80% of the value at $V_{CE} = 50$ V.

BF457, BF458, BF459
NPN EPITAXIAL PLANAR SILICON TRANSISTORS

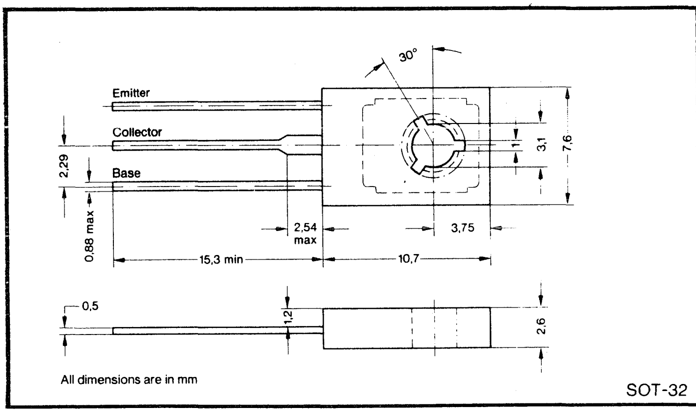
- For Video and RGB outputs

mechanical data

These transistors are plastic encapsulated. The encapsulation process , especially developed for this application, has been completely mechanised by TI.

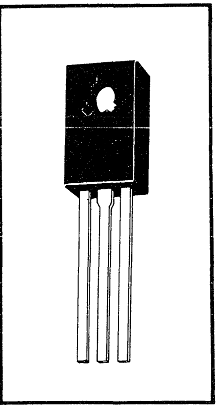
Encapsulation withstands full load temperature without distortion. Even under high humidity conditions the device shows stable behaviour and it satisfies the requirements of MIL-STD-202C method 106B.

The transistor is not light sensitive.



All dimensions are in mm

SOT-32



BF457, BF458, BF459
NPN EPITAXIAL PLANAR SILICON TRANSISTORS

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

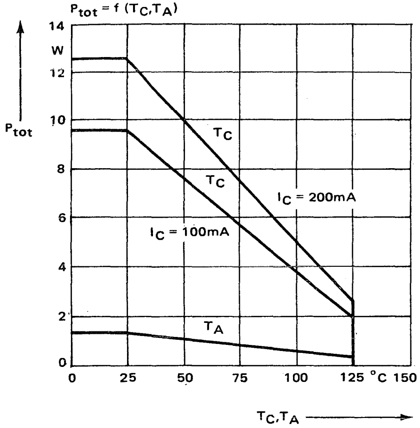
	BF457	BF458	BF459
Collector-Base Voltage	160V	250V	300V
Collector-Emitter Voltage (Note 1)	160V	250V	300V
Emitter-Base Voltage	←	5V	→
Continuous Collector Current	←	200mA	→
Peak Collector Current	←	300mA	→
Continuous Device Dissipation at (or below) T_A = 25°C (Note 2)	←	1.25W	→
Continuous Device Dissipation at (or below) T_C = 25°C (Note 2)	←	12.5W	→
Storage Temperature Range	←	−55°C to 125°C	→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←	260°C	→

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. See Dissipation Diagram.

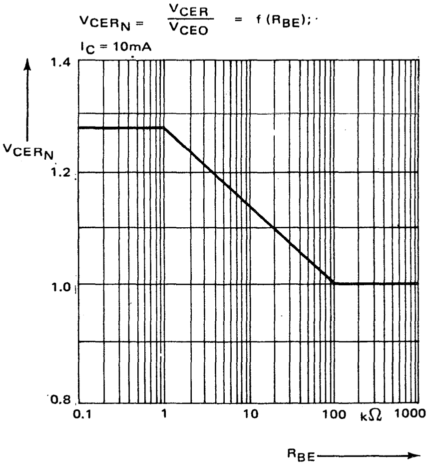
electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	BF457 MIN	BF457 TYP	BF457 MAX	BF458 MIN	BF458 TYP	BF458 MAX	BF459 MIN	BF459 TYP	BF459 MAX	UNIT
$V_{(BR)CBO}$	I_C = 100μA, I_E = 0	160			250			300			V
$V_{(BR)CEO}$	I_C = 10mA, I_B = 0 (Note 3)	160			250			300			V
$V_{(BR)EBO}$	I_E = 100μA, I_C = 0	5			5			5			V
I_{CBO}	V_{CB} = 100V, I_E = 0			50							nA
	V_{CB} = 200V, I_E = 0						50				nA
	V_{CB} = 250V, I_E = 0									50	nA
I_{EBO}	V_{EB} = 3V, I_C = 0			50			50			50	nA
h_{FE}	V_{CE} = 10V, I_C = 30mA	25			25			25			
$V_{CE(sat)}$	I_B = 6mA, I_C = 30mA			1.0			1.0			1.0	V
C_{12e}	V_{CB} = 30V, I_E = 0 f = 1MHz		4.2			4.2			4.2		pF
C_{22e}	V_{CB} = 30V, I_E = 0 f = 1MHz		5.5			5.5			5.5		pF
f_t	V_{CE} = 10V, I_C = 15mA f = 20MHz		90			90			90		MHz

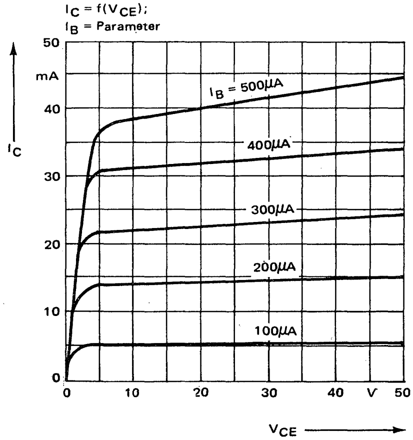
NOTE 3. These parameters must be measured using pulse techniques t_p = 300 μs, duty cycle ⩽2%



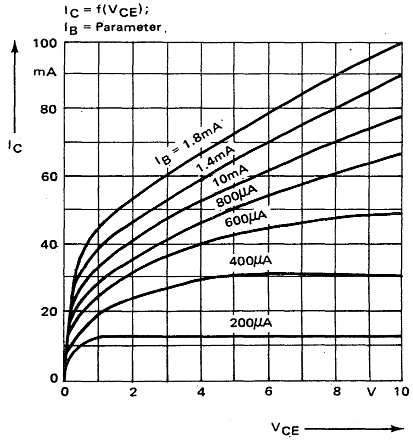
$P_{tot} = f(T_C, T_A)$
P_{tot}
14
W
12
10
8
6
4
2
0
T_C
T_C
I_C = 200mA
I_C = 100mA
T_A
0
25
50
75
100
125 °C 150
T_C, T_A



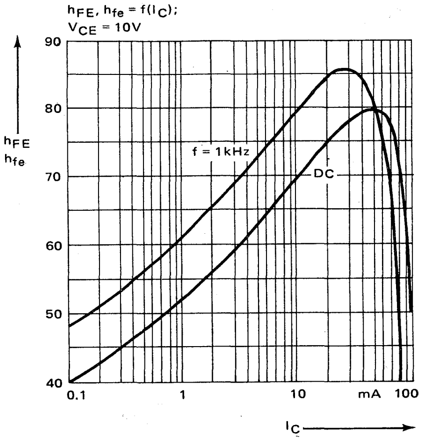
$V_{CER_N} = \frac{V_{CER}}{V_{CEO}} = f(R_{BE})$;
I_C = 10mA
1.4
V_{CER_N}
1.2
1.0
0.8
0.1
1
10
100
kΩ
1000
R_{BE}

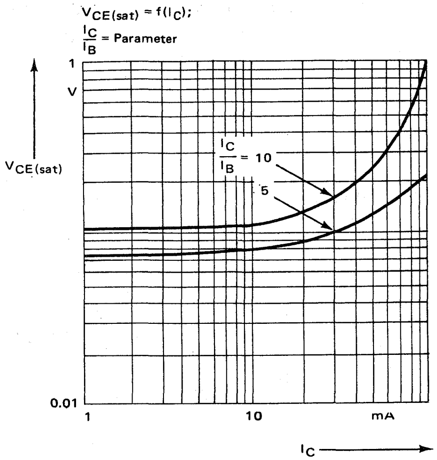


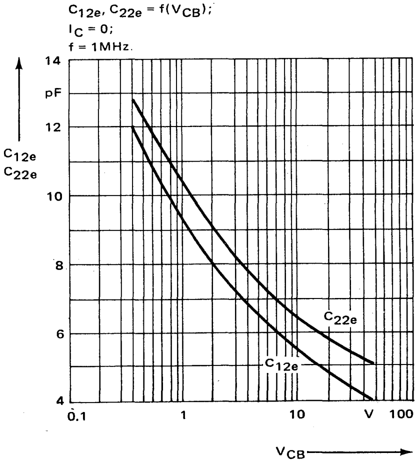
$I_C = f(V_{CE})$;
I_B = Parameter
50
mA
40
30
20
10
0
I_C
I_B = 500μA
400μA
300μA
200μA
100μA
0
10
20
30
40
V
50
V_{CE}

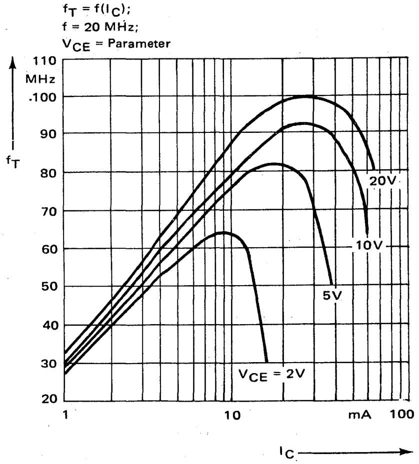


$I_C = f(V_{CE})$;
I_B = Parameter
100
mA
80
60
40
20
0
I_C
I_B = 1.8mA
1.4mA
10mA
800μA
600μA
400μA
200μA
0
2
4
6
8
V
10
V_{CE}


h_{FE}, h_{fe} = f(I_C);
V_{CE} = 10V
90
80
70
60
50
40
h_{FE}
h_{fe}
f = 1kHz
DC
0.1
1
10
mA 100
I_C


$V_{CE(sat)}$ = f(I_C);
$\frac{I_C}{I_B}$ = Parameter
1
V
$V_{CE(sat)}$
$\frac{I_C}{I_B}$ = 10
5
0.01
1
10
mA
I_C

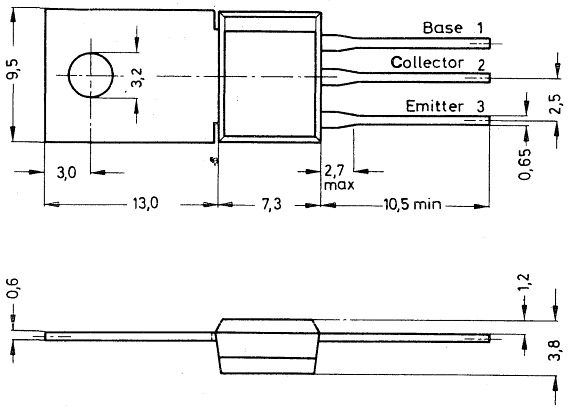

C_{12e}, C_{22e} = f(V_{CB});
I_C = 0;
f = 1MHz.
14
pF
12
10
8
6
4
C_{12e}
C_{22e}
C_{22e}
C_{12e}
0.1
1
10
V 100
V_{CB}


f_T = f(I_C);
f = 20 MHz;
V_{CE} = Parameter
110
MHz
100
90
80
70
60
50
40
30
20
f_T
20V
10V
5V
V_{CE} = 2V
1
10
mA 100
I_C

NPN EPITAXIAL PLANAR SILICON TRANSISTORS

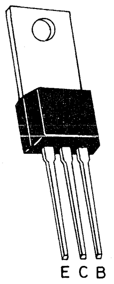
COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF616, 618

mechanical data



All dimensions are in mm

TO 202



absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

	BF615	BF617
Collector-Base Voltage	250 V	300 V
Collector-Emitter Voltage (see Note 1)	250 V	300 V
Emitter-Base Voltage	5 V	5 V
Continuous Collector Current	← 200 mA →	
Peak Collector Current	← 300 mA →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 2)	← 10 W →	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 3)	← 2 W →	
Storage Temperature Range	–55 to 150 °C	
Lead Temperature 1.6 mm from case for 10 Sec.	← 260 °C →	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 80 mW/°C.
3. Derate linearly to 150 °C free air temperature at the rate of 16 mW/°C.

electrical characteristics at 25 °C case temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
$U_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 µA, I_E = 0	615 617	250 300			V
$U_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0 (see Note 4)	615 617	250 300			V
$U_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 µA, I_C = 0	615, 7	5			V
I_{CBO}	Collector Cutoff Current	V_{CB} = 200 V, I_E = 0 V_{CB} = 250 V, I_E = 0	615 617			50 50	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 3 V, I_C = 0	615, 7			50	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 15 V, I_C = 5 mA V_{CE} = 15 V, I_C = 25 mA	615, 7 615, 7	25 30			
V_{BE}	Base-Emitter Voltage	V_{CE} = 15 V, I_C = 5 mA V_{CE} = 15 V, I_C = 25 mA	615, 7 615, 7		0.65 0.72	0.9 1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 5 mA, I_B = 1 mA I_C = 25 mA, I_B = 5 mA	615, 7 615, 7		0.2 0.4	0.5 1.0	V
$V_{CE(sat)HF}$	Hifh Frequency Saturation Voltage	I_C = 25 mA, f = 1 MHz (see Note 5)	615, 7			20	V
f_T	Transition Frequency	V_{CE} = 15 V, I_C = 25 mA f = 20 MHz	615, 7		70		MHz
C_{cb}	Collector-Base Capacitance	V_{CB} = 30 V, I_E = 0 f = 1 MHz	615, 7			3.0	pF

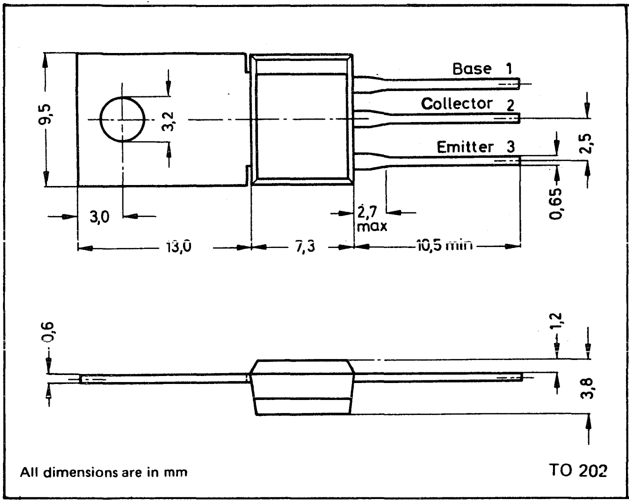
NOTES: 4. This parameter must be measured using pulse technique. Pulse width = 300 µs. Duty cycle ≤ 2%.

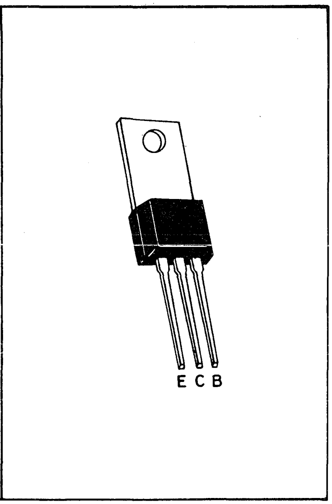
5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small-signal amplification in a practical circuit is decreased to 80% of the value at V_{CE} = 50 V.

BF616, 618
PNP EPITAXIAL PLANAR SILICON TRANSISTOR

COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF615, 617

mechanical data





absolute maximum ratings at 25 °C free air temperature (unless otherwise noted)

	BF616	BF618
Collector-Base Voltage	−250 V	−300 V
Collector-Emitter Voltage (see Note 1)	−250 V	−300 V
Emitter-Base Voltage	← −5 V →	
Continuous Collector Current	← −200 mA →	
Peak Collector Current	← −300 mA →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 2)	← 10 W →	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 3)	← 2 W →	
Storage Temperature Range	−55 to 150 °C	
Lead Temperature 1.6 mm from case for 10 Sec.	← 260 °C →	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150 °C case temperature at the rate of 80 mW/°C.
3. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.

BF616, 618
PNP EPITAXIAL PLANAR SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	TYPE	MIN	TYP	MAX	UNIT
$U_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\,\mu A$, $I_E = 0$	616	-250			V
			618	-300			
$U_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$ (see Note 4)	616	-250			V
			618	-300			
$U_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\,\mu A$, $I_C = 0$	616, 8	-5			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -200$ V, $I_E = 0$	616			-50	nA
		$V_{CB} = -250$ V, $I_E = 0$	618			-50	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$	616, 8			-50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -15$ V, $I_C = -5$ mA	616, 8	25			
		$V_{CE} = -15$ V, $I_C = -25$ mA	616, 8	30			
V_{BE}	Base-Emitter Voltage	$V_{CE} = -15$ V, $I_C = -5$ mA	616, 8		-0.65	-0.9	V
		$V_{CE} = -15$ V, $I_C = -25$ mA	616, 8		-0.72	-1.0	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = -5$ mA, $I_B = -1$ mA	616, 8		-0.2	-0.5	V
		$I_C = -25$ mA, $I_B = -5$ mA	616, 8		-0.4	-1.0	
$V_{CE(sat)HF}$	High Frequency Saturation Voltage	$I_C = -25$ mA, f = 1 MHz (see Note 5)	616, 8			-20	V
f_T	Transition Frequency	$V_{CE} = -15$ V, $I_C = -25$ mA, f = 20 MHz	616, 8		70		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -50$ V, $I_E = 0$, f = 1 MHz	616, 8			3.0	pF

NOTES: 4. This parameter must be measured using pulse technique. Pulse width = 300 μs. Duty cycle ≤ 2%.

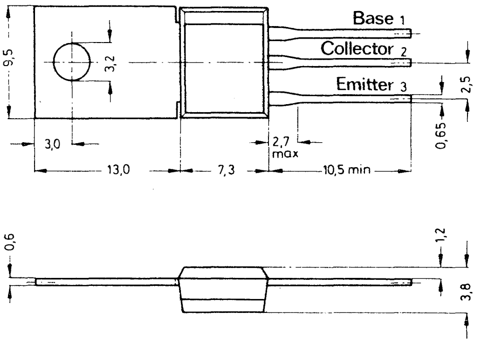
5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small signal amplification in a practical circuit is decreased to 80% of the value at $V_{CE} = 50$ V.

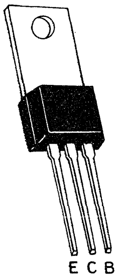
BF715, BF7
NPN EPITAXIAL PLANAR SILICON TRANSIST

COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF716, BF718

mechanical data

TO 202





All dimensions are in mm

absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BF715	BF71
Collector-Base Voltage	250 V	300 V
Collector-Emitter Voltage (See Note 1)	250 V	300 V
Emitter-Base Voltage	← 5 V →	
Continuous Collector Current	← 30 mA →	
Peak Collector Current	← 100 mA →	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	← 2 W →	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	← 6.25 W →	
Storage Temperature Range	55 °C to 150 °C	
Lead Temperature 1.6 mm from Case for 10 Seconds	← 260 °C →	

NOTES:
1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 50 mW/°C.

BF715, BF717
NPN EPITAXIAL PLANAR SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		BF715			BF717			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$	250			300			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, (See Note 4)	$I_B = 0$	250			300			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$	5			5			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 200$ V, $V_{CB} = 250$ V,	$I_E = 0$ $I_E = 0$			50			 50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			50			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 15$ V, $V_{CE} = 15$ V,	$I_C = 5$ mA $I_C = 25$ mA	50 30			50 30			
V_{BE}	Base-Emitter Voltage	$V_{CE} = 15$ V,	$I_C = 5$ mA		0.70	0.9		0.70	0.9	V
$V_{CE(sat)HF}$	High Frequency Saturation Voltage	$I_C = 10$ mA, (See Note 5)	f = 1 MHz			15			15	V
f_T	Transition Frequency	$V_{CE} = 15$ V,	$I_C = 5$ mA	60	100		60	100		MHz
C_{12e}	Collector-Base Capacitance	$V_{CB} = 30$ V,	$I_E = 0$			1.8			1.8	pF

NOTES: 4. This parameter must be measured using pulse technique. Pulse width = 300 μs. Duty cycle $\leqslant 2$ %.

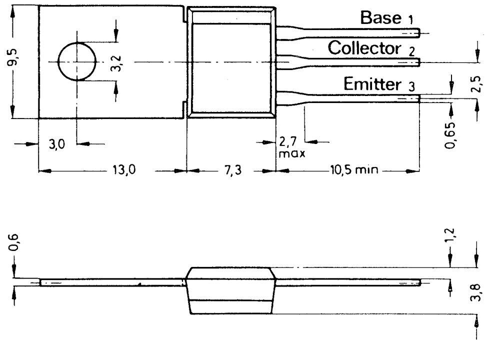
5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small-signal amplification in a practical circuit is decreased to 80 % of the value at $V_{CE} = 50$ V.

BF716, BF71
PNP EPITAXIAL PLANAR SILICON TRANSISTO

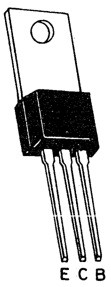
COMPLEMENTARY VIDEO OUTPUT STAGES IN COLOUR TV
COMPLEMENTARY TYPES: BF715, BF717

mechanical data

TO 202



All dimensions are in mm



absolute maximum ratings at 25 °C free-air temperature (unless otherwise noted)

	BF716	BF718
Collector-Base Voltage	−250 V	−300
Collector-Emitter Voltage (See Note 1)	−250 V	−300
Emitter-Base Voltage	← 5 V	–
Continuous Collector Current	← −30 mA	–
Peak Collector Current	← −100 mA	–
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (See Note 2)	← 2 W	–
Continuous Device Dissipation at (or below) 25 °C Case Temperature (See Note 3)	← 6.25 W	–
Storage Temperature Range	−55 °C to 150 °	
Lead Temperature 1.6 mm from Case for 10 Seconds	← 260 °C	–

NOTES:
1. This value applies when the base-emitter diode is open circuited.
2. Derate linearly to 150 °C free-air temperature at the rate of 16 mW/°C.
3. Derate linearly to 150 °C case temperature at the rate of 50 mW/°C.

BF716, BF718
PNP EPITAXIAL PLANAR SILICON TRANSISTOR

electrical characteristics at 25 °C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		BF716			BF718			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$	−250			−300			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, (See Note 4)	$I_B = 0$	−250			−300			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$	−5			−5			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -200$ V,	$I_E = 0$			−50			−50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V,	$I_C = 0$			−50			−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -15$ V $V_{CE} = -15$ V,	$I_C = -5$ mA $I_C = -25$ mA	50 30			50 30			
V_{BE}	Base Emitter Voltage	$V_{CE} = -15$ V,	$I_C = -5$ mA		−0.70	−0.9		−0.70	−0.9	V
$V_{CE(sat)HF}$	High Frequency Saturation Voltage	$I_C = -10$ mA, (See Note 5)	f = 1 MHz			−15			−15	V
f_T	Transition Frequency	$V_{CE} = -15$ V, f = 20 MHz	$I_C = -5$ mA	60	100		60	100		MHz
C_{12e}	Collector-Base Capacitance	$V_{CB} = -30$ V, f = 1 MHz	$I_E = 0$			1.8			1.8	pF

NOTES: 4. This parameter must be measured using pulse technique. Pulse width = 300 μs. Duty cycle ⩽2 %.

5. At the High Frequency Saturation Voltage $V_{CE(sat)HF}$ the small-signal amplification in a practical circuit is decreased to 80 % of the value at V_{CE} = 50 V.

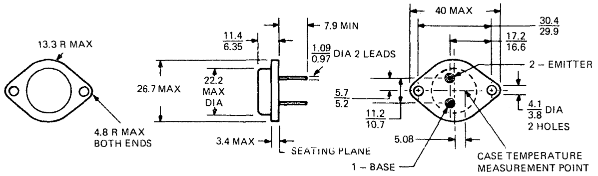
BU 105
NPN SILICON POWER TRANSISTOR

- ✱ Designed for High Voltage C.R.T. Scanning
- ✱ V_{CES} Rating 1500V
- ✱ Current Rating – 2.5 Amps
- ✱ Fast Switching – t_F at 2 Amps 0.6 Microsecond Typical

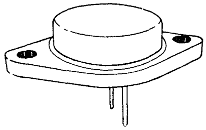
Mechanical

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN MILLIMETRES



Absolute Maximum Ratings (T_{case} = 25°C)

Collector Emitter Voltage (Peak See Note 1, $R_{BE} \leqslant 100\ \Omega$)	1500V
Collector Base Voltage (Peak See Note 1.)	1500V
Collector Current Continuous	2.5A
Base Current Continuous	1.5A
Total Dissipation ($V_{CE} \leqslant$ 100V, $T_{case} \leqslant$ 90°C) See Note 2.	10W
Operating Junction Temperature	−65°C to +115°C
Storage Temperature	−65°C to 15°C

NOTES: 1. Pulse Width $\leqslant$ 20 μs Duty cycle $\leqslant$ 25%

2. Refer to Figs 3, 4.

BU 105
NPN SILICON POWER TRANSISTOR

Electrical Characteristics ($T_{case} = 25^{o}C$)

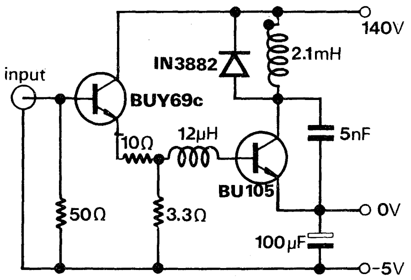
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CES}	Collector Emitter Leakage Current	V_{CE}=1500V, V_{BE}=0 (See Note 1)			1.0	mA
$V_{(BR)EBO}$	Emitter Base Breakdown Voltage	I_E=100mA, I_C=0	5	7.0		V
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	I_C=2.5A, I_B=1.5A (See Note 3)			5	V
$V_{BE(SAT)}$	Base Emitter Saturation Voltage	I_C=2.5A, I_B=1.5A (See Note 3)			1.5	V
f_T	Transition Frequency	V_{CE}=5V, I_C=0.1A, f=5MHz		7.0		MHz
C_{OBO}	Common Base Open Circuit Output Capacitance	V_{CB}=10V, I_E=I_C=0, f=1MHz		55		pF
t_f	Collector Current Fall Time	I_C=2A, $I_{B(on)}$=1.5A $I_{B(off)}$=1.0A, (See Figs 1, 2)		0.6	1.1	μs
θ_{JC}	Junction to Case Thermal Resistance				2.5	^{o}C/W

NOTES: 1. Pulse width ≤ 20 μs. Duty Cycle ≤ 25%.

3. Pulsed Test. Pulse duration ≤ 300 μs. Duty Cycle ≤ 2%.

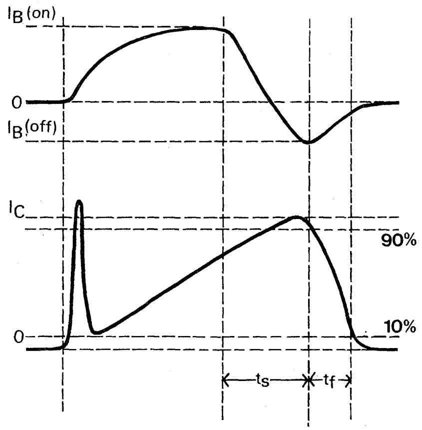
This test must be measured with voltage sensing contacts seperate from carrying contacts.

Details for measurement of switching parameters



Pulse Width = 30us
Pulse Repetition Rate = 200 p.p.s.
Resistors are Non-inductive types
Recommended Pulse Generator Mewlett Packard 214A
Current measured using Current Probe such as
TEKTRONIX type P6019, P6020, P6042
Oscilloscope to have rise better than 20ns

Fig.1



Current Waveforms of I_C and I_B

Fig.2

BU105
NPN SILICON POWER TRANSISTOR

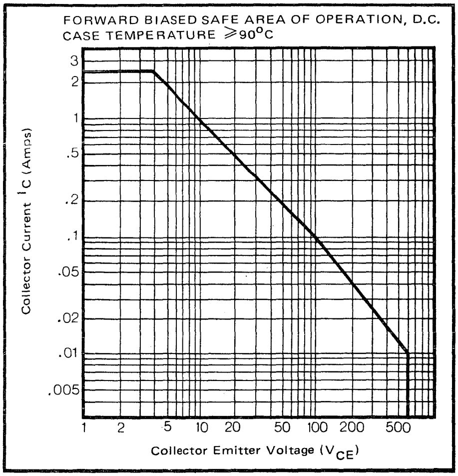

FORWARD BIASED SAFE AREA OF OPERATION, D.C. CASE TEMPERATURE ⩾90°C

Fig.3

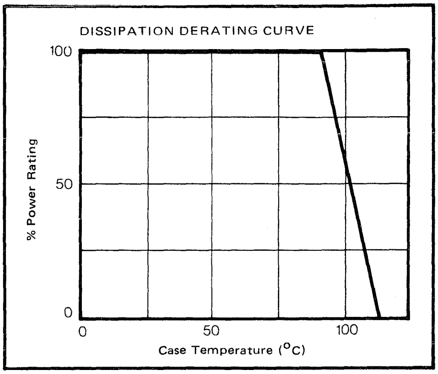

DISSIPATION DERATING CURVE

Fig.4

The graph on figure 3 is with a case temperature held at 90°C. For operation at case temperatures above 90°C derate the value of current indicated in figure 3 by the power derating factor, determined from figure 4.

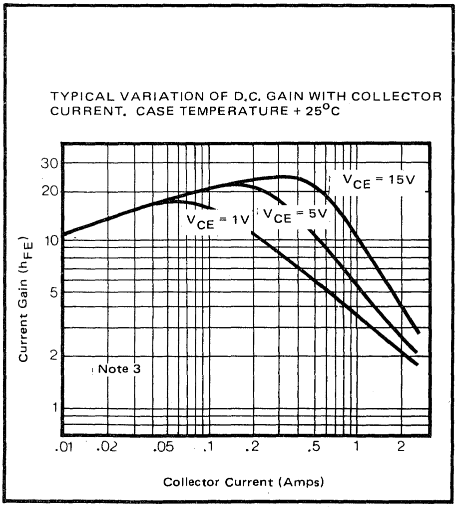

TYPICAL VARIATION OF D.C. GAIN WITH COLLECTOR CURRENT. CASE TEMPERATURE + 25°C

Fig.5

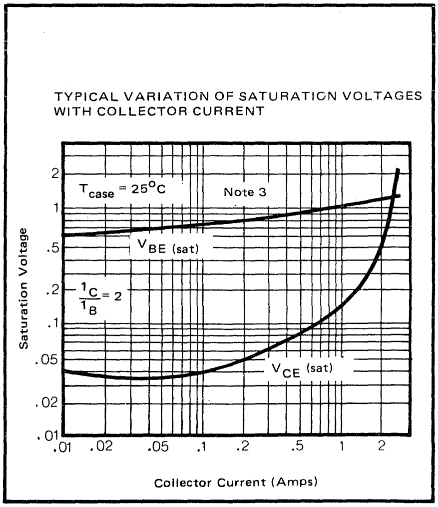

TYPICAL VARIATION OF SATURATION VOLTAGES WITH COLLECTOR CURRENT

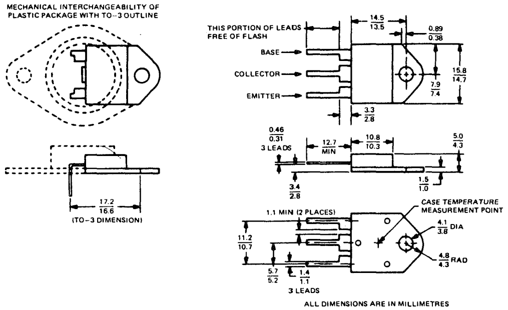
Fig.6

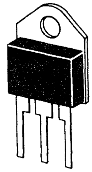
BU124
NPN SILICON POWER TRANSISTOR

- Transistor Type BU124 has been designed specifically for portable TV linescan applications.
- The plastic package makes it suitable for direct substitution for metal can (TO-3) devices.

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings (at 25°C ambient temperature)

Collector Base Voltage (IE = 0)	350V
Emitter Base Voltage	8V
Continuous Collector Current (See Note)	10A (Peak: 15A)
Continuous Dissipation ($T_{case} \leqslant 25^oC$)	50W
Operating Temperature Range	−65°C to +150°C

NOTE 1: Pulse width ⩽1mS Duty cycle 25%.

BU124
NPN SILICON POWER TRANSISTOR

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CBO}	$V_{CB} = 350V$			1	mA
BV_{EBO}	$I_B = 10mA$	8			V
$V_{CE(sat)}$	$I_C = 4A$, $I_B = 0.5A$			0.5	V
$V_{BE(sat)}$	$I_C = 4A$, $I_B = 0.5A$			1.5	V
t_f	$I_C = 4A$, $I_B = 0.5A$		0.5		μS
$\theta_{J\text{-}C}$	Junction to Case Thermal Resistance			2.5	°C/W

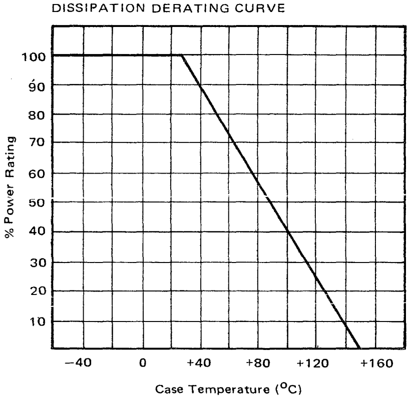


FIGURE 1.

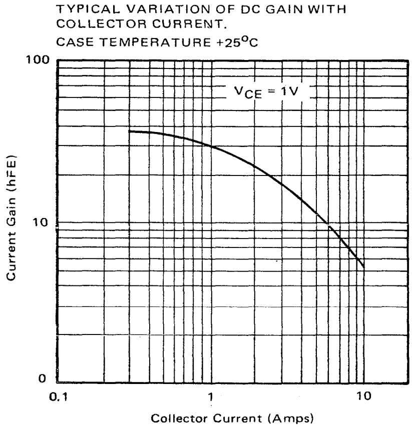
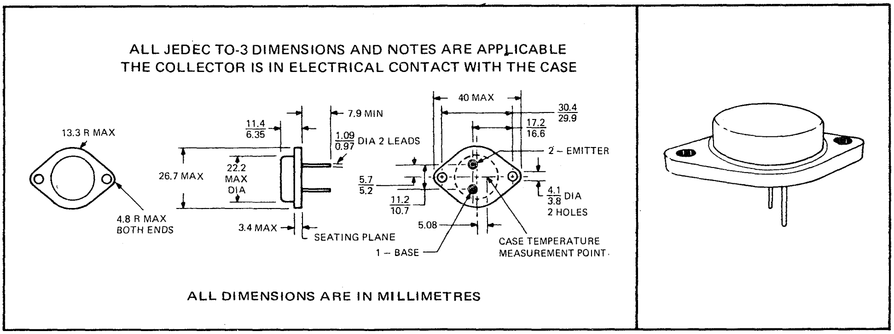


FIGURE 2.

BU126
NPN SILICON POWER TRANSISTOR

- BU126 is a high voltage NPN silicon power transistor designed for general industrial and consumer applications primarily intended for use in switching mode power supplies.

mechanical specification



ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings (at 25°C ambient temperature)

Collector-Base Voltage	750V
Collector-Emitter Voltage ($V_{BE} = -1.5V$)	750V
Continuous-Collector Current	4A
Continuous-Dissipation ($T_{amb} \leqslant 25^oC$) $V_{CE} \leqslant 25V$	50W
Operating Temperature Range	-65^oC to $+175^oC$

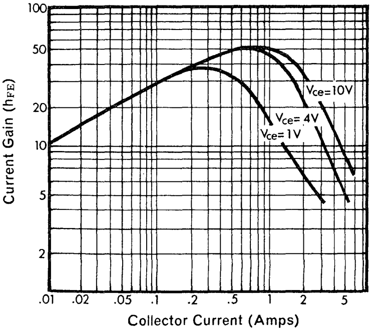
BU126
NPN SILICON POWER TRANSISTOR

electrical characteristics at T_{case} = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CEX}	Collector Emitter Cut off Current	V_{CE} = 750V, V_{EB} = 1.5V			0.5	mA
I_{EBO}	Emitter Base Cut off Current	V_{EB} = 6V			5	mA
h_{FE}	Static Forward Current Transfer Ratio (Note 1)	I_C = 1A, V_{CE} = 5V I_C = 4A, V_{CE} = 15V	15 5		60	– –
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage (Note 1)	I_C = 2.5A, I_B = 0.25A I_C = 4A, I_B = 1A			10 5	V V
$V_{BE(SAT)}$	Base Emitter Saturation Voltage	I_C = 2.5A, I_B = 0.25A			1.5	V
$V_{CEO(SUST)}$	Collector Emitter Sustaining Voltage (Note 2)	I_B = 0, I_C = 100mA L = 25mH	300			V
t_s	Collector Current Storage Time	I_{CM} = 2.5A, I_B END = 0.25A dI_B/dt = 1.5A/µS. (Fig. 1)		1.0		µS
t_f	Collector Current Fall Time			0.1		µS

NOTES: 1. Pulsed Test, Pulse duration ⩽300µs. Duty cycle ⩽2%.
2. Inductive loop switching.

TYPICAL VARIATION OF D.C. GAIN WITH COLLECTOR CURRENT. CASE TEMPERATURE + 25°C



FORWARD BIASED SAFE AREA OF OPERATION, D.C. AND SINGLE NON-REPETITIVE PULSE. CASE TEMPERATURE 25°C

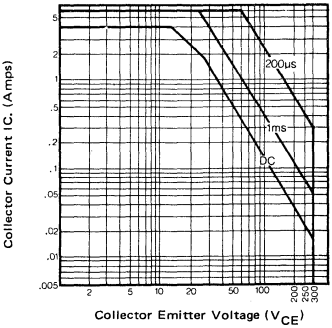
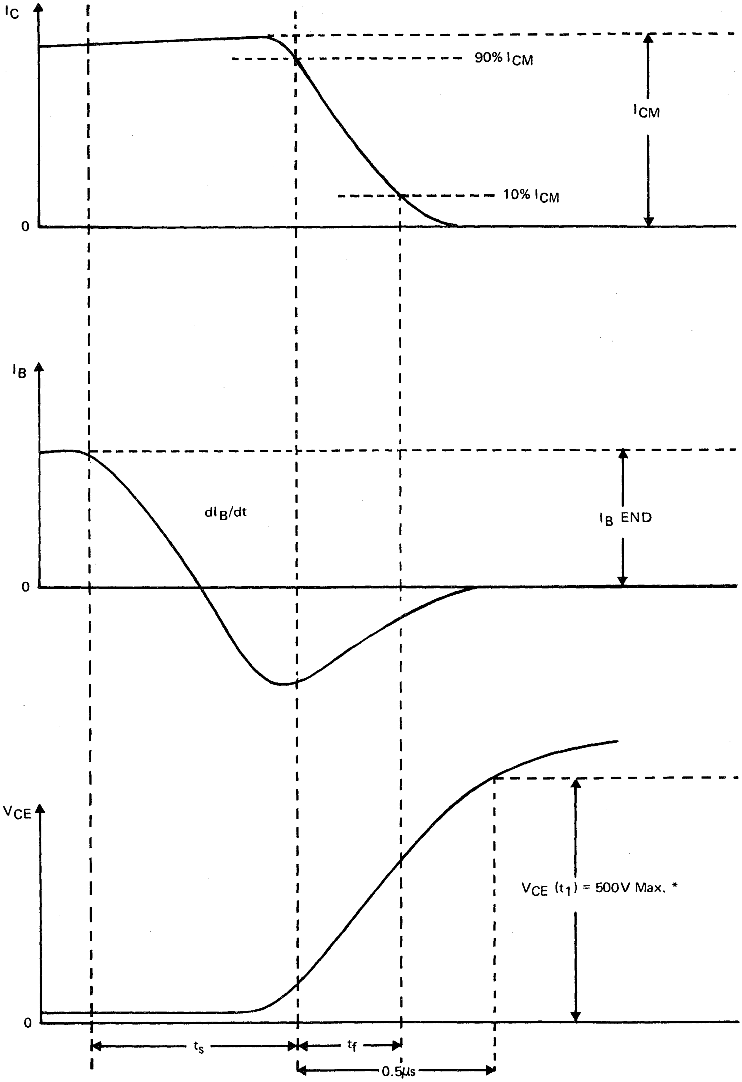


FIG. 1. TURN-OFF WAVEFORMS



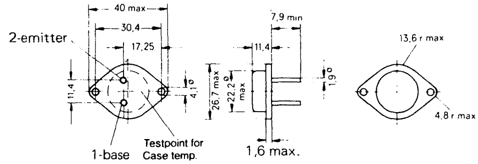
N.B. After turn off V_{CE} may rise to 750V provided that a reverse bias (greater than 1.5 Volts) is maintained between the base emitter terminals. However the rate of rise of voltage should be limited so that 0.5µs after the commencement of fall time $V_{CE(t1)}$ should be $\leqslant$500V.

BU137, BU137A
NPN SILICON POWER TRANSISTORS

DESIGNED FOR SWITCHING MODE POWER SUPPLIES, HORIZONTAL DEFLECTION AND INDUCTIVE SWITCHING IN INDUSTRIAL AND CONSUMER APPLICATIONS.

GAIN IS SPECIFIED AT UP TO 12 AMPS, AND BU137A FEATURES A COLLECTOR-EMITTER VOLTAGE RATING OF 500 VOLTS.

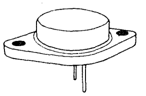
mechanical specifications



All dimensions are in mm

The Collector is in electrical contact with the case

TO-3



absolute maximum ratings (at 25 °C case temperature, unless otherwise noted)

	BU137	BU137A
Collector-base voltage	1000 V	1200 V
Collector-emitter voltage (base open-circuit)	400 V	500 V
Emitter-base voltage	7 V	
Continuous collector current	12 A	
Peak collector current	15 A	
Continuous base current	5 A	
Continuous dissipation (see figure 2)	70 W	
Peak dissipation (see note 1)	1125 W	
Case operating temperature	−55 °C to +200 °C	

NOTE 1: Pulse width 500 μs, V_{CE} = 75 V

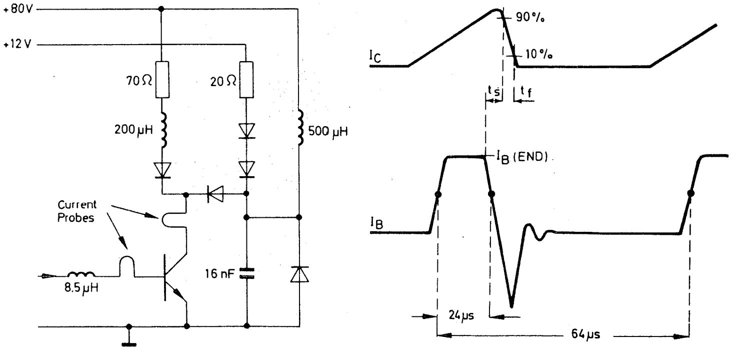
BU137, BU137A
NPN SILICON POWER TRANSISTORS

electrical characteristics (at T_C = 25 °C unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CBO}	Collector-Base Leakage current	BU137: V_{CB} = 1000 V BU137A: V_{CB} = 1200 V			200	µA
I_{CEX}	Collector-emitter Leakage current	BU137: V_{CE} = 1000 V BU137A: V_{CE} = 1200 V			200	µA
		V_{BE} = −2 V T_C = 100°C			2	mA
$V_{CEO(sus)}$	Collector-emitter Sustaining voltage	I_C = 100 mA BU137: L = 10 mH BU137A:	400 500			V
BV_{EBO}	Emitter-base breakdown voltage	I_E = 10 mA	7			V
h_{FE}	Forward current transfer ratio	I_C = 500 mA, V_{CE} = 5 V I_C = 5.5 A, V_{CE} = 10 V I_C = 12 A, V_{CE} = 10 V (Note 2)	15 10 4			
$V_{CE(sat)}$	Collector-emitter Saturation voltage	I_C = 5.5 A, I_B = 1.7 A I_C = 10 A, I_B = 2.5 A (Note 2)			1.2 4	V
$V_{BE(sat)}$	Base-emitter Saturation voltage	I_C = 5.5 A, I_B = 1.7 A I_C = 10 A, I_B = 2.5 A (Note 2)			1.25 1.4	V
t_f	Fall time	I_C = 5.5 A, I_B = 1.7 A (Figure 1)			800	ns
C_{OBO}	Capacitance	V_{CB} = 5 V, f = 1 MHz		250		pF
f_T	Transit frequency	V_{CE} = 5 V, I_C = 1 A		5		MHz
$\Theta_{J\text{-}C}$	Thermal resistance junction to case				1.785	°C/W

NOTE 2: Pulse Test. Pulse duration 300 µs

SWITCHING TIME MEASUREMENT



Simplified Circuit

Collector/Base - Current Waveforms

FIGURE 1

TYPICAL CHARACTERISTICS

CASE TEMPERATURE DISSIPATION DERATING CURVE

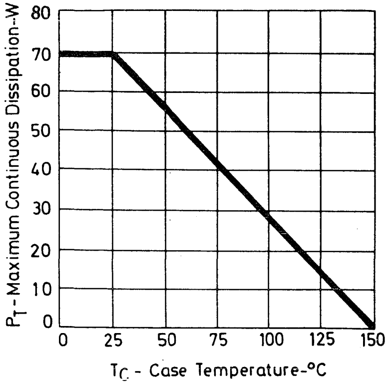


FIGURE 2

TYPICAL COLLECTOR-BASE LEAKAGE CURRENT vs CASE TEMPERATURE (AT MAXIMUM RATED V_{CB})

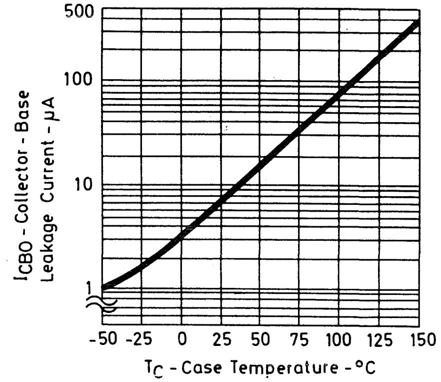


FIGURE 3

FORWARD BIASED SAFE AREA OF OPERATION (T_C = 25°C, DC AND NON-REPETITIVE PULSES)

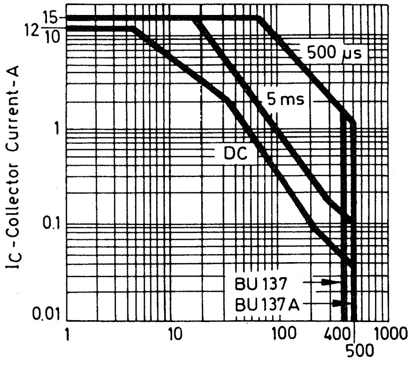


FIGURE 4

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs
COLLECTOR CURRENT/COLLECTOR-EMITTER VOLTAGE

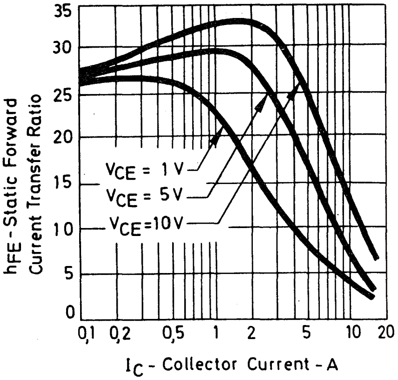


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE vs
CASE TEMPERATURE/COLLECTOR CURRENT

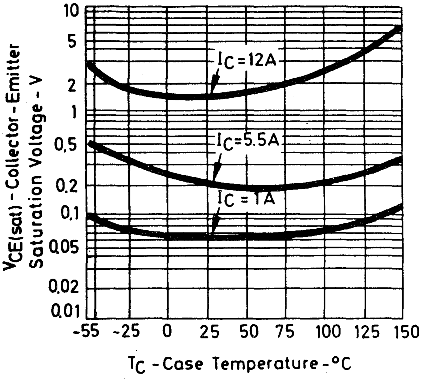


FIGURE 6

BASE-EMITTER SATURATION VOLTAGE vs
COLLECTOR CURRENT/hFE

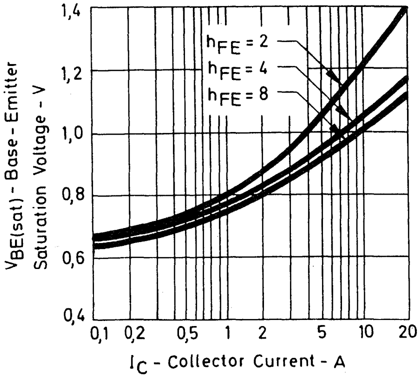


FIGURE 7

TYPICAL CHARACTERISTICS

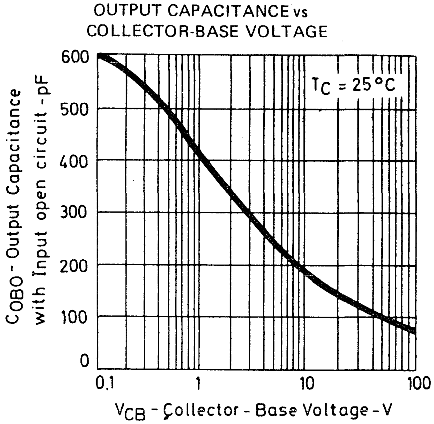


FIGURE 8

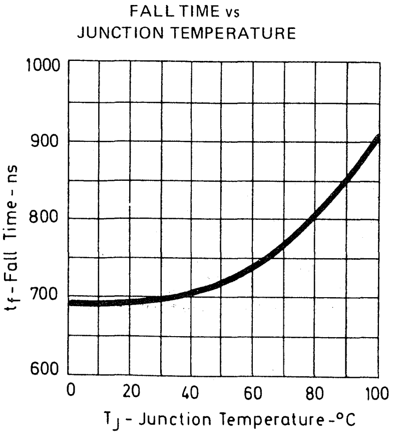


FIGURE 9

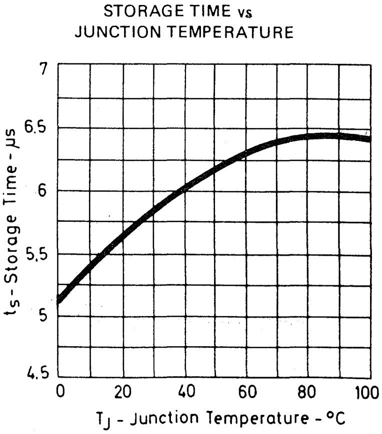
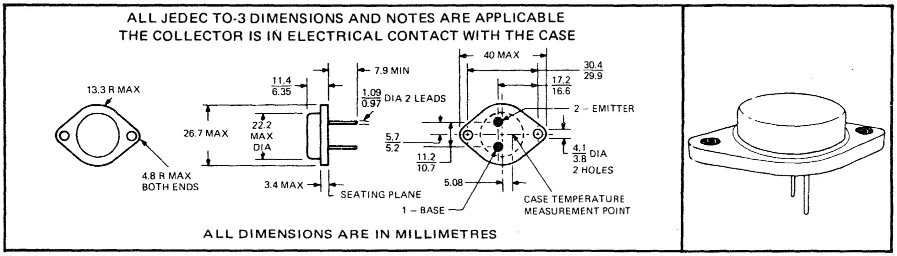


FIGURE 10

BU157
NPN SILICON POWER TRANSISTOR

- Designed for High Voltage C.R.T. Scanning

mechanical



ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings (T_{Case} = 25°C)

Collector Emitter Voltage (Peak see Note 1.) $-2V \geqslant VBE \geqslant -5V$	1500V
Collector Base Voltage (Peak see Note 1)	1500V
Emitter Base Voltage	7V
Continuous Collector Current	12A
Total Dissipation ($T_{Case} \leqslant 25^{o}C$)	70W
Operating Junction Temperature	−65°C to 150°C
Storage Temperature	−65°C to 150°C

Note 1. Pulse Width $\leqslant 20\mu S$ Duty Cycle $\leqslant 25\%$

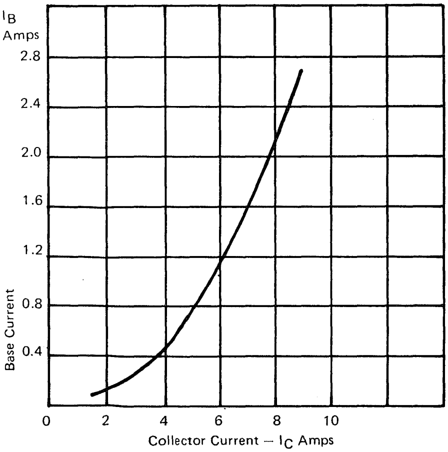
BU157
NPN SILICON POWER TRANSISTOR

electrical characteristics ($T_{Case} = 25^{o}C$)

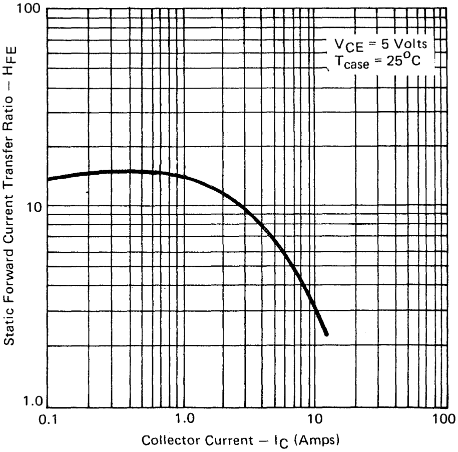
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CEX}	Collector Emitter Leakage Current	$V_{CE} = 1500V$, $V_{BE} = -2V$ (Note 1)			1	mA
I_{CBO}	Collector Base Leakage Current	$V_{CB} = 1500V$, $I_E = 0$ (Note 1)			1	mA
$V_{(BR)EBO}$	Emitter Base Breakdown Voltage	$I_E = 10mA$, $I_C = 0$	7			V
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	$I_C = 6A$, $I_B = 1.2A$ (Note 2)			5	V
$V_{BE(SAT)}$	Base Emitter Saturation Voltage				1.6	V
LV_{CEO}	Collector Emitter Voltage	$I_C = 0.5A$; $L = 10mH$ $I_B = 0$	650			V
tf	Collector Current Fall Time	$I_C = 6A$, $I_B = 1.2A$			1.0	μS

NOTES: 1. Pulsed Test Pulse duration $\leqslant 20\mu S$. Duty Cycle $\leqslant 25\%$
2. Pulsed Test Pulse duration $\leqslant 300\mu S$. Duty Cycle $\leqslant 2\%$

RECOMMENDED BASE CURRENT V COLLECTOR CURRENT

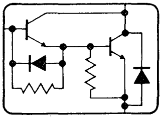


TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT



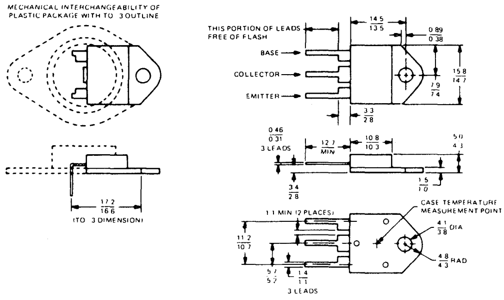
BU180,BU180A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

- High Voltage, High Speed Darlington Connected Transistor designed for C.R.T. Scanning and Switching Mode Power Supplies
- Integral Efficiency Diode
- Integral Speed-Up Diode

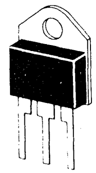


mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature

	BU180	BU180A
Collector Base Voltage	320V	400V
Continuous Collector Current	◄── 10A ──►	
Continuous Dissipation ($T_C < 25^{\circ}C$)	◄── 50W ──►	
Operating Temperature Range	◄── −55 to +150°C ──►	

BU180,BU180A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
BV_{CBO}	Collector-Base Breakdown Voltage	See Note 1 and Figure 1	BU180 BU180A	320 400			V V
$I_{CEX\,1}$	Collector-Emitter Leakage Current	V_{EB} = 1.5V Min. BU180: V_{CE} = 320V BU180A: V_{CE} = 400V				0.2 0.2	mA mA
$I_{CEX\,2}$	Collector-Emitter Leakage Current	V_{EB} = 8V Max. BU180: V_{CE} = 320V BU180A: V_{CE} = 400V				0.2 0.2	mA mA
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10mA I_C = 0		8.0			V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.02A, I_C = 4.0A				1.5	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_B = 0.02A, I_C = 4.0A				2.0	V
V_F	Parallel Diode Forward Voltage Drop	I_C = −2.0A				1.7	V
t_f	Collector Current Fall Time	See Figure 2 $I_{C(peak)}$ = 4.0A I_B = 0.02A			0.5		μs

NOTE 1: Pulse width $<$ 300μs, duty cycle $<$ 2%.

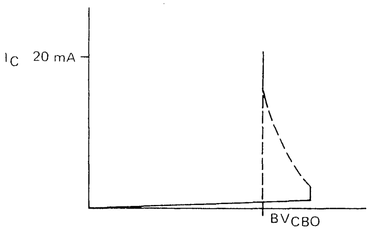


FIGURE 1 TYPICAL BV_{CBO} CHARACTERISTIC

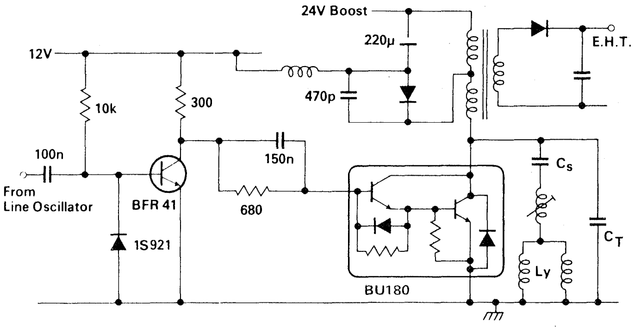
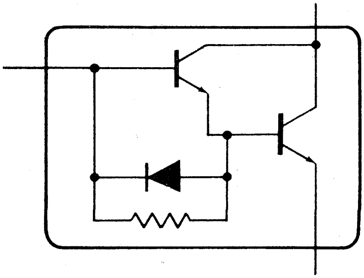


FIGURE 2 TYPICAL C.R.T. LINE SCAN CIRCUIT

BU 181, BU 181A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

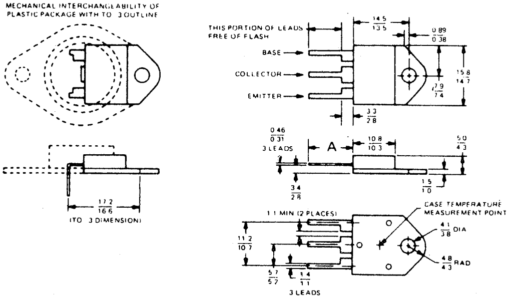
Preliminary data

- **High voltage, high speed darlington transistor designed for C.R.T. scanning and switching mode power supplies.**
- **Integral speed-up diode**



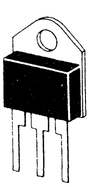
mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



Dim. A: 17.5 ±1

ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25° C case temperature

	BU 181	BU 181A
Collector-Emitter Voltage (see note 1)	600V	800V
Collector-Base Voltage ($I_E = 0$)	600V	800V
Continuous Collector Current	10A	
Peak Collector Current (see note 2)	16A	
Continuous Dissipation	65W	
Operating Temperature Range	−55 to +150 °C	

NOTE 1. $1.5 \leqslant V_{EB} \leqslant 8$ V

NOTE 2. Pulse width $\leqslant 100\ \mu s$. Duty Cycle $\leqslant 30$ %

BU 181, BU 181A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

electrical characteristics at 25 C case temperature

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)\ CBO}$	Collector-base breakdown voltage	See note 3 and Fig 1 $I_E = 0$ BU 181 BU 181A	600 800			V V
I_{CEX}	Collector-emitter leakage current	$1.5V \leqslant V_{EB} \leqslant 3V$ $V_{CE}=600V$ BU 181 $V_{CE}=800V$ BU 181A			0.1 0.1	mA mA
I_{CBO}	Collector-base leakage current	$V_{CB}=600V$ BU 181 $V_{CB}=800V$ BU 181A $I_E = 0$			0.1 0.1	mA mA
$V_{(BR)\ EBO}$	Emmiter-base breakdown voltage	$I_E=10mA$ $I_C=0$	8.0			V
$V_{CE\ (SAT)}$	Collector-emitter saturation voltage	$I_C=4.0A$ $I_B=0.04A$ $I_C=3.0A$ $I_B=0.015A$			1.5 1.5	V V
$V_{BE\ (SAT)}$	Base-emitter saturation voltage	$I_C=4.0A$ $I_B=0.04A$			2.0	V
h_{FE}	D.C. Current gain	$V_{CE}=2V$ $I_C=8.0A$ $V_{CE}=1.5V$ $I_C=3.0A$ $V_{CE}=1.5V$ $I_C=1.0A$	8.0 200 100			
t_s	Collector-current storage time	$I_C=4.0A$ $I_{B\ (ON)}=0.04A$ $L_B=3.0\mu H$ $V_{BE\ (OFF)} = -7V$		1.5		µs
t_f	Collector-current fall time			0.2	0.5	µs
t_s	Collector-current storage time	$I_C=4.0A$ $I_{B\ (ON)}=0.04A$ $L_B=3.0\mu H$ $V_{BE\ (OFF)}=-7V$ $T_{case} = 90°C$		2.0		µs
t_f	Collector-current fall time			0.25	0.75	µs

Note 1. $1.5 \leqslant V_{EB} \leqslant 8V$

Note 2. Pulse Width≤100µs, Duty Cycle≤30%

Note 3. Pulse Width≤300µs, Duty Cycle≤2%

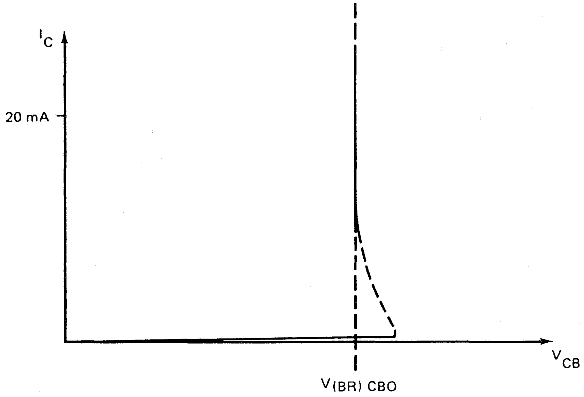


FIG 1 TYPICAL $V_{(BR)\,CBO}$ CHARACTERISTIC

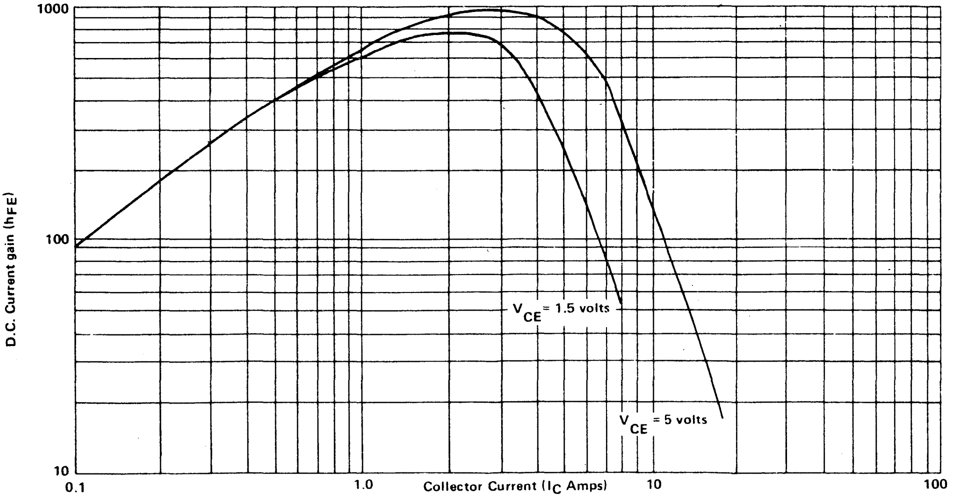


FIG 2 TYPICAL VARIATION OF h_{FE} WITH I_C AT T_{case} = 25 °C

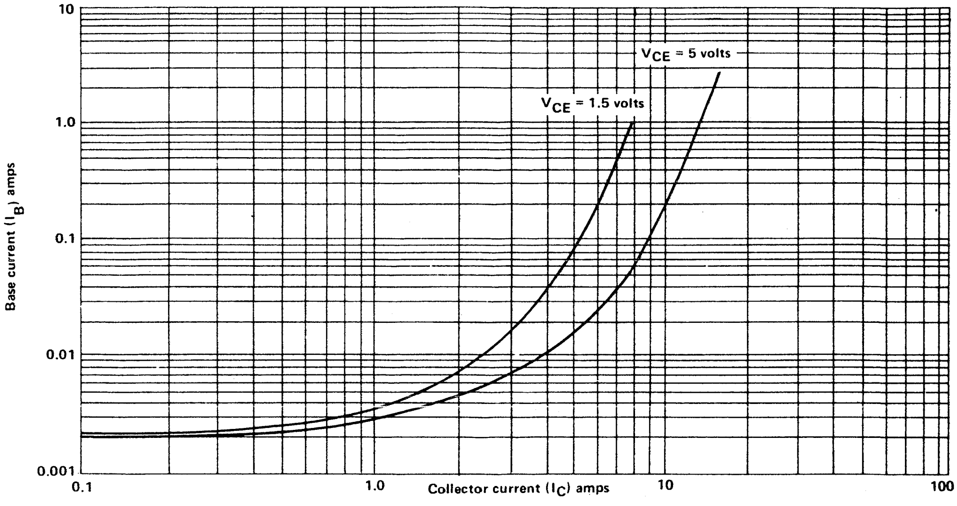
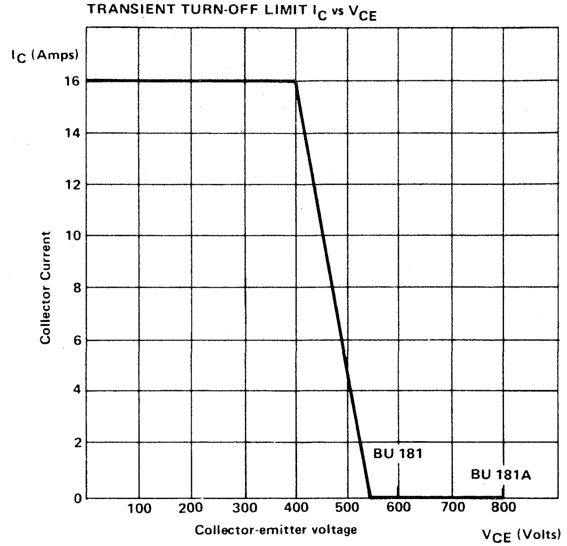
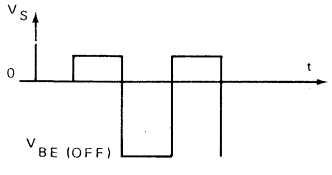
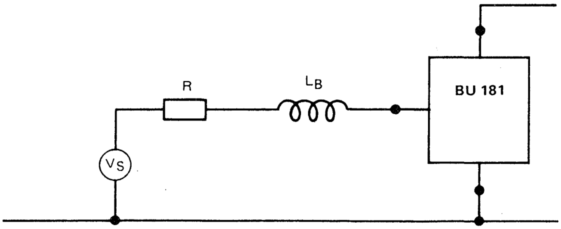


FIG 3 I_B vs I_C FOR CONSTANT V_{CE}.
LOWEST GAIN DEVICE (95% CONFIDENCE LEVEL)



Limit Base Drive Condition:
$I_{B(ON)} \leqslant 200mA$, $1.5 \leqslant V_{EB(OFF)} \leqslant 8V$,
Base Inductance $L_B = 3\mu H$, Source Resistance $R = 5\Omega$





NB. It is imperative that the repetition rate does not allow the thermal rating to be exceeded. As a guide, the worst case energy absorbed during turn-off, following the locus shown, will be approximately 10mJ.

The V_{CE}/I_C locus found in an application may be plotted using an oscilloscope provided that the bandwidth exceeds 10MHz and the delay matching of X and Y plots is better than 20ns.

FIG 4

BU181, BU181A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

Typical application circuit

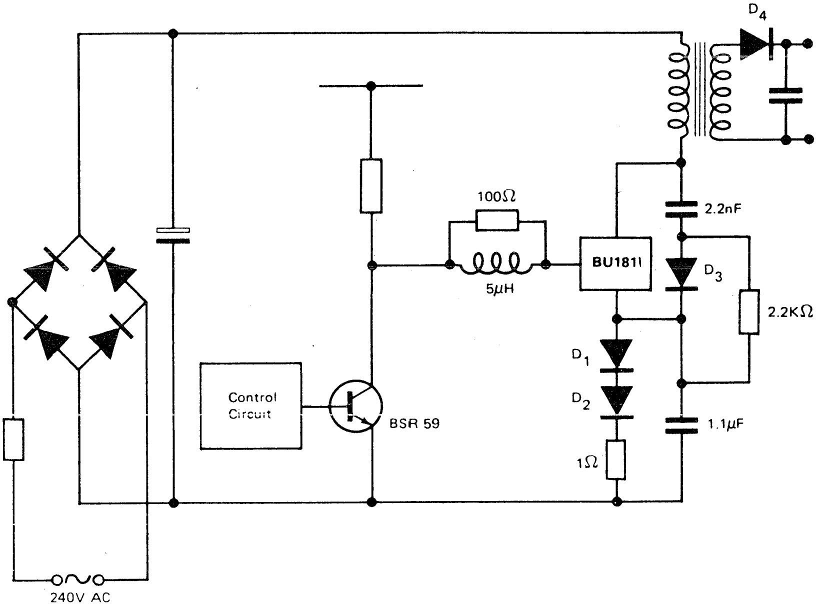


FIG 5

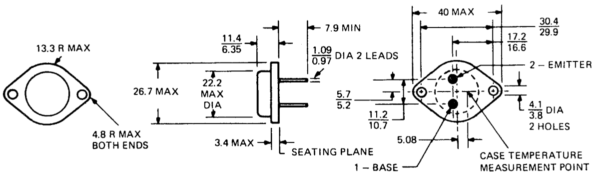
Note D3 and D4 are fast, soft recovery rectifiers.
D1 and D2 may be slow speed rectifiers.

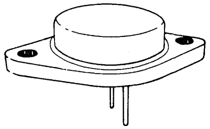
BU208
NPN SILICON POWER TRANSISTOR

- **Designed for High Voltage C.R.T. Scanning**
- **V_{CEX} Rating – 1500V Peak**
- **Collector Current Rating – 7.5 Amps Peak**
- **Fast Switching – t_f at 4.5 Amps 0.7 Microsecond Typical**

Mechanical

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

Absolute Maximum Ratings (T_{case} = 25°C)

Collector-Emitter Voltage (Peak see Note 1), $-2V \geqslant V_{BE} \geqslant -5V$	1500V
Collector-Base Voltage (Peak see Note 1)	1500V
Emitter-Base Voltage	5V
Continuous-Collector Current	5A
Continuous-Base Current	3.5A
Continuous-Emitter Current	8.5A
Total Dissipation ($V_{CE} \leqslant 100V$, $T_{case} \leqslant 95°C$) (See Note 2)	12.5W
Operating Junction Temperature	–65°C to +115°C
Storage Temperature	–65°C to +115°C

NOTES: 1. Pulse width $\leqslant 20\mu s$ Duty cycle $\leqslant 25\%$

2. Refer to Figs. 3, 4.

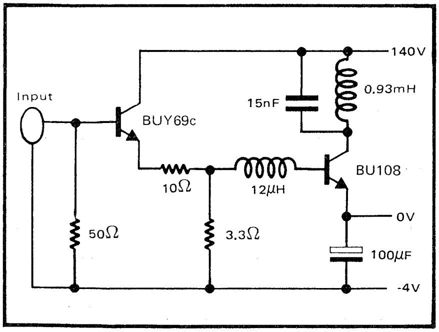
BU208
NPN SILICON POWER TRANSISTOR

Electrical Characteristics (T_{case} = 25°C)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CEX}	Collector-Emitter Leakage Current	V_{CE} = 1500V V_{BE} = −2V (Note 3)			1	mA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 1500V I_E = 0 (Note 3)			1	mA
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_C = 100mA I_C = 0	5	7		V
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	I_C = 4.5A I_B = 2A (Note 4)		.4	5	V
$V_{BE(SAT)}$	Base-Emitter Saturation Voltage			1.1	1.3	V
t_f	Collector-Current Fall Time	I_C = 4.5A $I_{B(ON)}$ = 1.8A (Note 5)		.7	1.2	µs
θ_{jc}	Junction to Case				1.6	°C/W
LV_{CEO}	Collector-Emitter Latching Voltage	I_C = 100mA I_B = 0 (Note 4) L = 25mH	700			V

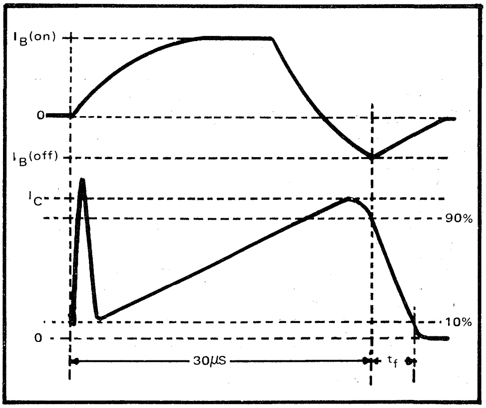
NOTES: 3. Pulsed Test. Pulse duration ⩽20 µS. Duty cycle ⩽25%.
4. Pulsed Test Pulse duration ⩽300 µS. Duty cycle ⩽2%.
5. Refer to Fig. 1, 2.

Details for the measurement of switching parameters



Pulse Width = 30µS
Pulse Repetition Rate = 200 p.p.s.
Resistors are Non-inductive types.
Recommended Pulse Generator Hewlett Packard 214A.
Current measured using Current Probe such as TEKTRONIX type P6019, P6020, P6042.
Oscilloscope to have rise better than 20nS.

FIG. 1.



Current Waveforms of I_C and I_B

FIG. 2.

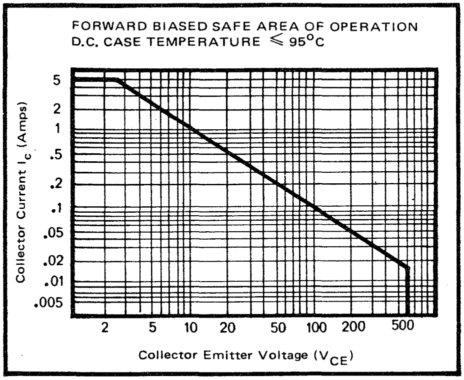


FIG. 3.

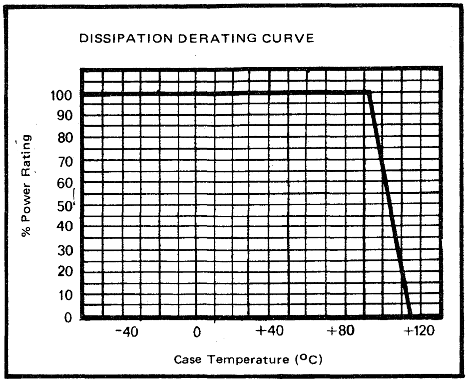


FIG. 4.

The graph on figure 3 is for a case temperature held at 95°C.
For operation at case temperatures above 95°C derate the value of current indicated in figure 3 by the power derating factor, determined from figure 4.

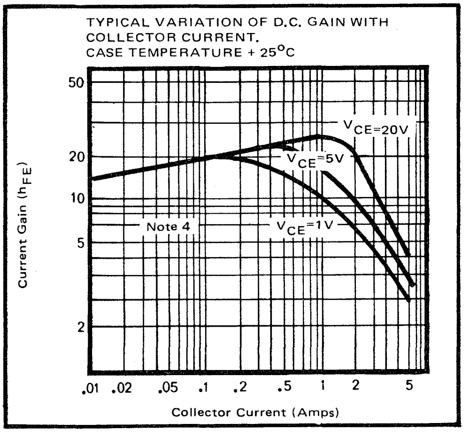


FIG. 5.

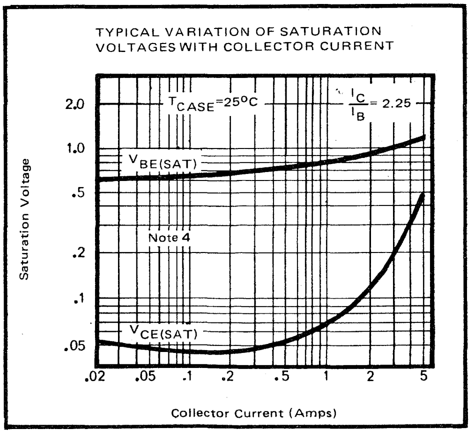
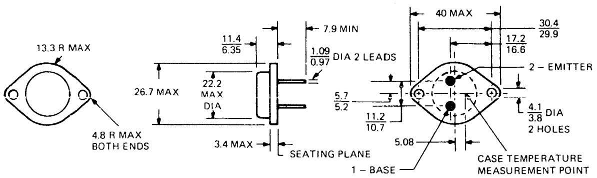


FIG. 6.

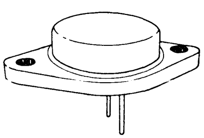
BU500
NPN SILICON POWER TRANSISTOR

- Designed for high voltage scanning of 110° in-line-gun colour television tubes
- High transient stress tolerance guaranteed
- High current rating
- Low $V_{CE(sat)}$
- Fast switching

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings

Collector emitter voltage $-2V \geqslant V_{BE} \geqslant -5V$ (see note 1)	1500V
Collector base voltage (see note 1)	1500V
Emitter base voltage (DC)	5V
Continuous collector current	6A
Peak collector current (see note 1)	16A
Continuous dissipation (figure 3)	75W
Operating junction temperature	−55°C to + 150°C
Storage temperature	−55°C to + 150°C

Note: 1. Pulse Test. Pulse duration $\leqslant 300\,\mu s$

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CEX}	Collector Emitter Leakage Current	V_{CE} = 1500V V_{BE} = −2V			1	mA
I_{CBO}	Collector Base Leakage Current	V_{CB} = 1500V I_E = 0			1	mA
I_{CBO}	Collector Base Leakage Current	V_{CB} = 1000V I_E = 0			20	µA
I_{EBO}	Emitter Base Leakage Current	V_{EB} = 4V I_C = 0			10	mA
$V_{(BR)EBO}$	Emitter Base Breakdown Voltage	I_E = 100mA I_B = 0	5	10		V
$V_{CEO(sus)}$	Collector Emitter Sustaining Voltage	I_C = 500mA I_B = 0 L = 10mH (Fig. 1)	700			V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 4.5A I_B = 2A (Note 1)			1	V
$V_{BE(sat)}$	Base Emitter Saturation Voltage	I_C = 4.5A I_B = 2A (Note 1)			1.3	V
hFE	Forward Current Transfer Ratio	I_C = 4.5A V_{CE} = 5V (Note 1)	3			
t_f	Collector Current Fall Time	I_C = 4.5A (Note 2)			1	µs
t_s	Collector Current Storage Time	I_C = 4.5A (Note 2)		8		µs
$\theta_{j\text{-}c}$	Thermal Resistance Junction to Case				1.6	°C/W

Note: 1. Pulse Test. Pulse duration $\leqslant$300 µs
2. Under recommended drive conditions. See Figures 4 and 5.

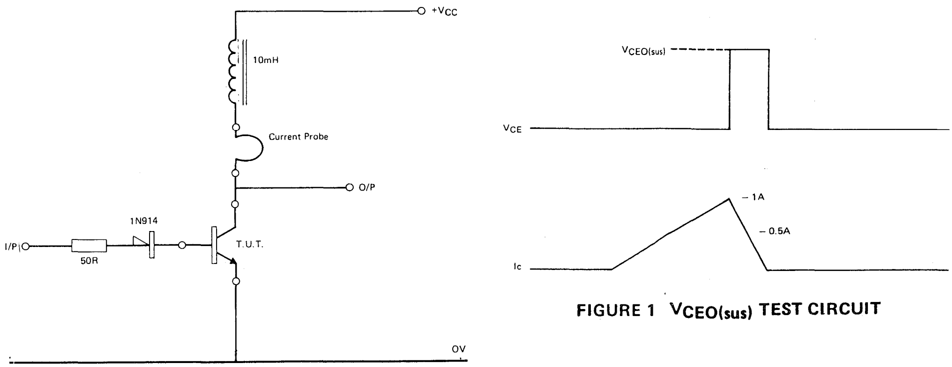


FIGURE 1 $V_{CEO(sus)}$ TEST CIRCUIT

TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT

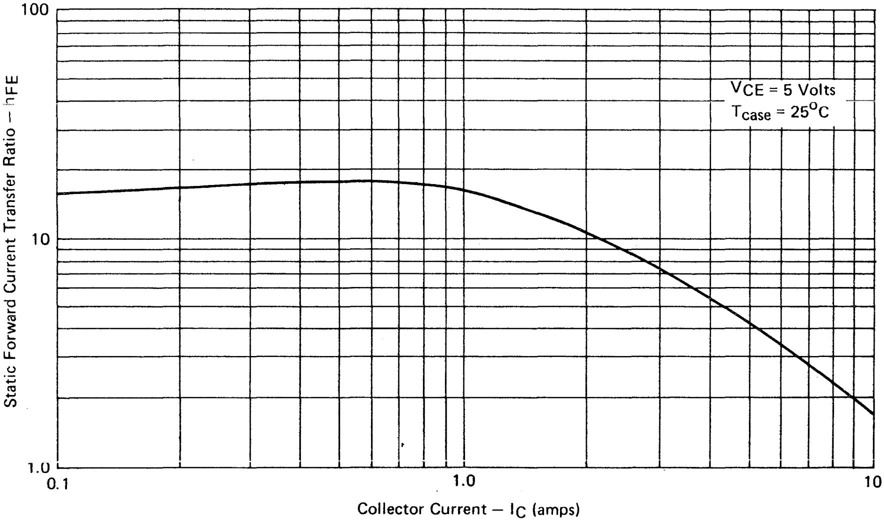


FIGURE 2

CONTINUOUS DISSIPATION DERATING CURVE

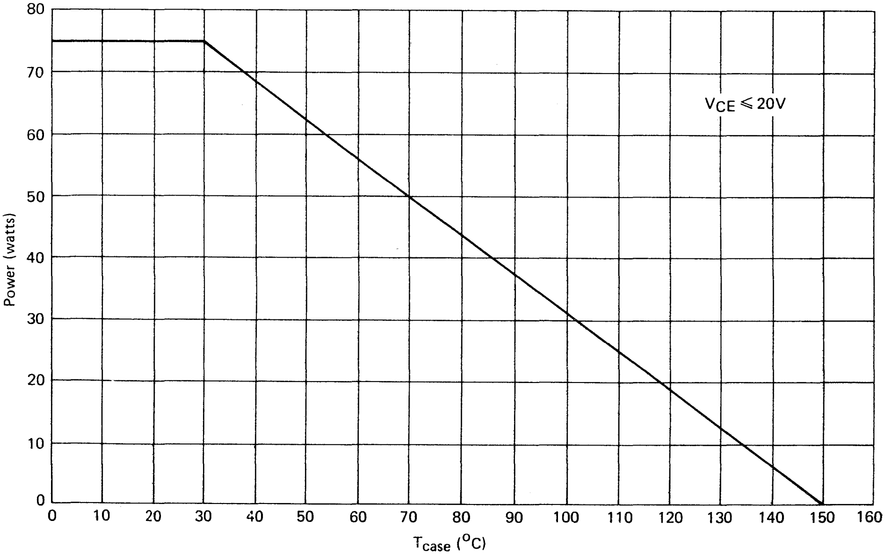


FIGURE 3

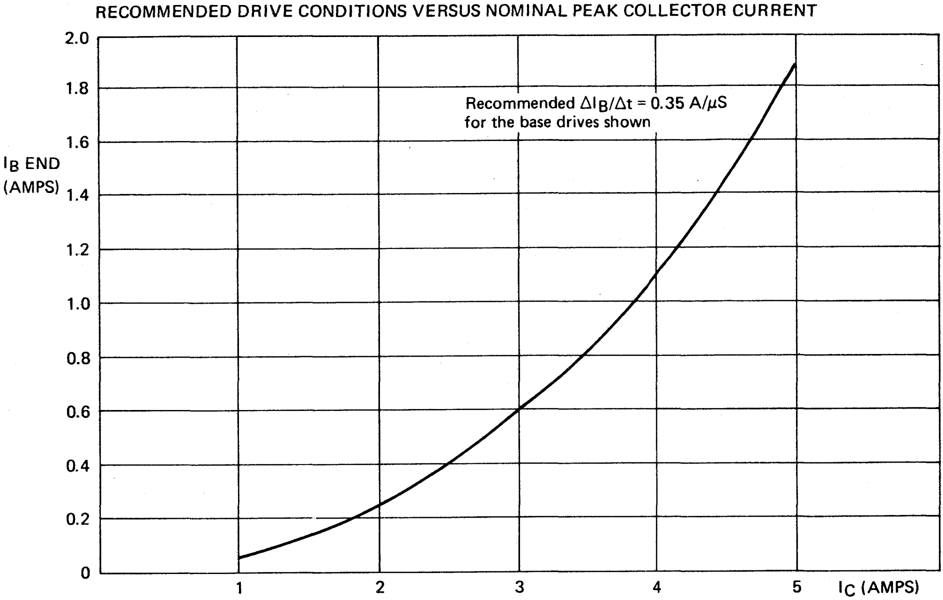
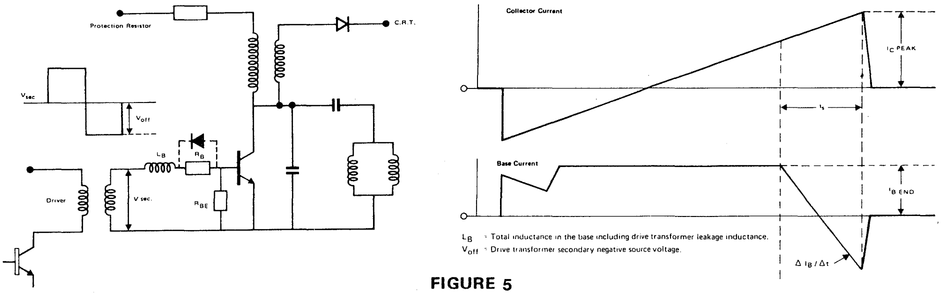


FIGURE 4



L_B = Total inductance in the base including drive transformer leakage inductance.
V_{off} = Drive transformer secondary negative source voltage.

FIGURE 5

The operating efficiency and overall reliability of deflection transistors are strong functions of the transient dissipation during device 'turn-off', which is controlled largely by the applied base drive.

The critical factors in the drive waveform have been determined[+] and the recommended values comprehend device distributions, all conditions of normal operation and the circuit tolerances experienced during equipment manufacture.

The values given in Figure 4 are for the drive parameters as defined in Figure 5 for a BU500 operating in a deflection stage and comprehend operation at case temperatures up to 90°C and variations of + 20% on nominal values due to supply and frequency variations and circuit component tolerances.

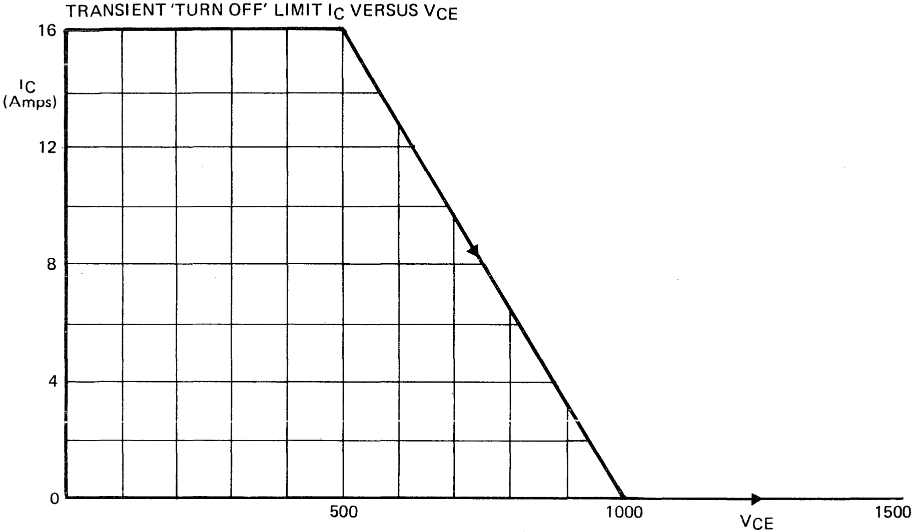


FIGURE 6

Transient conditions in deflection stages, such as picture tube flash-over, result in the deflection transistor operating at levels of collector current and collector-emitter voltage substantially in excess of those experienced during normal operation. The period during device 'turn-off', when the collector emitter voltage is rising rapidly, can be particularly severe. The ability of the deflection transistor to withstand transients is a complex function of device and circuit; however, detailed characterisation and rigorous final test procedures guarantee safe operation of the BU500 in normal circuit configurations, at $T_{case} \leqslant 90^{o}C$, provided that the worse case VCE/IC locus at device 'turn-off', during a transient, does not exceed that shown in Figure 6.

The VCE/IC locus found in an application may be plotted using an oscilloscope, provided that the bandwidth exceeds 10 MHz and the delay matching of X and Y plots is better than 20 ns.

Reference: Driver Circuit Considerations for High Voltage Line Scan Transistors M. J. Maytum and A. Lear, IEE Trans BTR May, 1972.

reliability

Life test data generated by TI's continuous reliability monitoring programme and process evaluations during 1974 and 1975 is detailed below. The data has been generated by performing high temperature blocking and power cycling tests for the range of TV line scan power devices. All these devices incorporate the same assembly techniques and for the purpose of these tests are structurally similar to BU500.

Failure rates associated with each test have been generated for a typical TV line scan application assuming a $\Delta\ T_{case}$ of 40°C and Tj max of 80°C. In addition, the power cycle failure rate assumes 3 switch on/off cycles per day and 1800 hours set operation per year.

Pulsed and DC blocking failure rates have been extrapolated from the test temperature to 80°C using established temperature acceleration factors based on the Arrhenius equation with activation energy of 0.9 eV, which gives a conservative result.

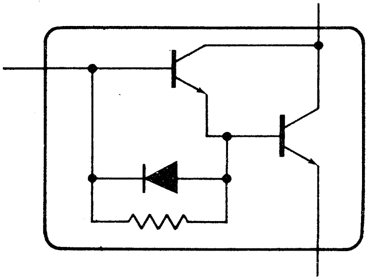
Life Test	Sample Size	Device Test Hours – normalised to 100°C	Failure Rate at 100°C %/1000 Hours P + C/C	Typical Line Scan Application Failure Rate %/1000 Hours 60% UCL
Pulsed Blocking 100% max V_{CBO} rating 12μs ON/52μs OFF pulse	118	8,240,000	.2% / .2%	.05%
DC Blocking 80% max V_{CBO} rating	3156	4,116,000	2% / 1%	not applicable
	Devices	**Cycles**	**Failure Rate at $\Delta Tc = 80^oC$**	
Power Cycling $\Delta T_{case} = 80^oC$ 12-14 watts dissipation during ON period	1229	5,800,000	6% / 4%	.014%

P: Parametric failures; unlikely to cause field failure.
C: Catastrophic failures; loss of function in typical field applications.

BUW 81, BUW 81A
NPN MONOLITHIC DARLINGTON CONNECTED
SILICON POWER TRANSISTOR

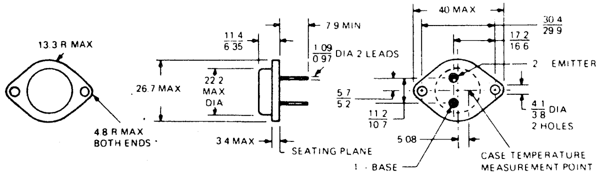
Preliminary data

- **High voltage, high speed darlington transistor designed for C.R.T. scanning and switching mode power supplies.**
- **Integral speed-up diode**

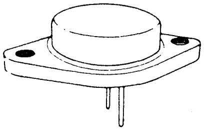


mechanical specification

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25° C case temperature

	BUW 81	BUW 81A
Collector-Emitter Voltage (see note 1)	600V	800V
Collector-Base Voltage ($I_E = 0$)	600V	800V
Continuous Collector Current	10A	
Peak Collector Current (see note 2)	16A	
Continuous Dissipation	80W	
Operating Temperature Range	–55 to +150 °C	

NOTE 1. $1.5 \leqslant V_{EB} \leqslant 8$ V

NOTE 2. Pulse width $\leqslant 100\ \mu s$. Duty Cycle $\leqslant 30$ %

BUW 81, BUW 81A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

electrical characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)\ CBO}$	Collector-base breakdown voltage	See note 3 BUW 81 and Fig 1 $I_E = 0$ BUW 81A	600 800			V V
I_{CEX}	Collector-emitter leakage current	$1.5V \leq V_{EB} \leq 8V$ V_{CE}=600V BUW 81 V_{CE}=800V BUW 81A			0.1 0.1	mA mA
I_{CBO}	Collector-base leakage current	V_{CB}=600V $I_E = 0$ BUW 81 V_{CB}=800V BUW 81A			0.1 0.1	mA mA
$V_{(BR)\ EBO}$	Emmiter-base breakdown voltage	I_E=10mA I_C=O	8.0			V
$V_{CE\ (SAT)}$	Collector-emitter saturation voltage	I_C=4.0A I_B=0.04A I_C=3.0A I_B=0.015A			1.5 1.5	V V
$V_{BE\ (SAT)}$	Base-emitter saturation voltage	I_C=4.0A I_B=0.04A			2.0	V
h_{FE}	D.C. Current gain	V_{CE}=2V I_C=8.0A V_{CE}=1.5V I_C=3.0A V_{CE}=1.5V I_C=1.0A	8.0 200 100			
t_s	Collector-current storage time	I_C=4.0A $I_{B\ (ON)}$=0.04A L_B=3.0μH $V_{BE\ (OFF)}$ = −7V		1.5		μs
t_f	Collector-current fall time			0.2	0.5	μs
t_s	Collector-current storage time	I_C=4.0A $I_{B\ (ON)}$=0.04A L_B=3.0μH $V_{3E\ (OFF)}$= -7V T_{case} = 90°C		2.0		μs
t_f	Collector-current fall time			0.25	0.75	μs

Note 1. $1.5 \leq V_{EB} \leq 8V$

Note 2. Pulse Width≤100μs, Duty Cycle≤30%

Note 3. Pulse Width≤300μs, Duty Cycle≤2%

BUW 81, BUW 81A
NPN MONOLITHIC DARLINGTON CONNECTED SILICON POWER TRANSISTOR

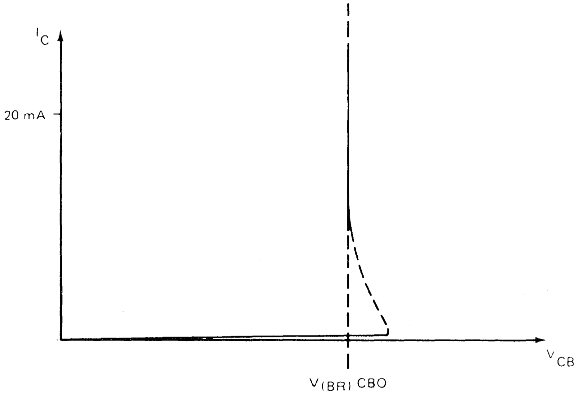


FIG 1 TYPICAL $V_{(BR)\,CBO}$ CHARACTERISTIC

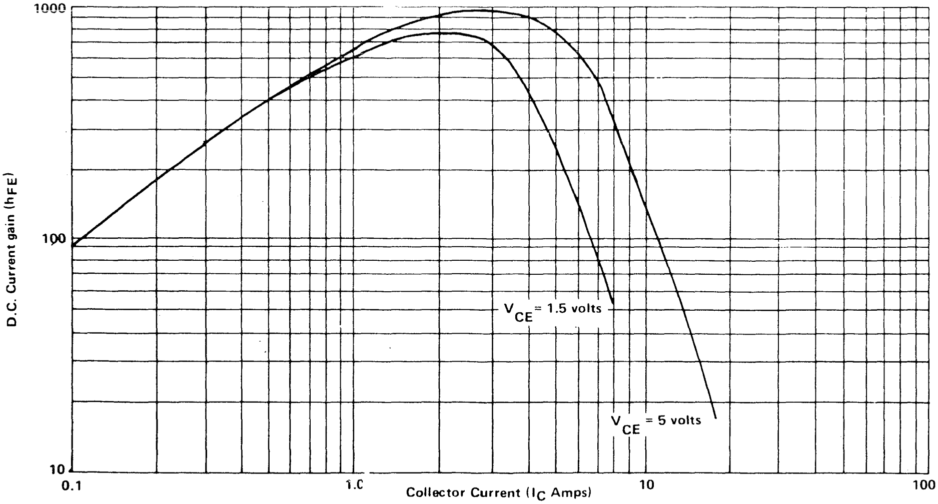


FIG 2 TYPICAL VARIATION OF h_{FE} WITH I_C AT T_{case} = 25 °C

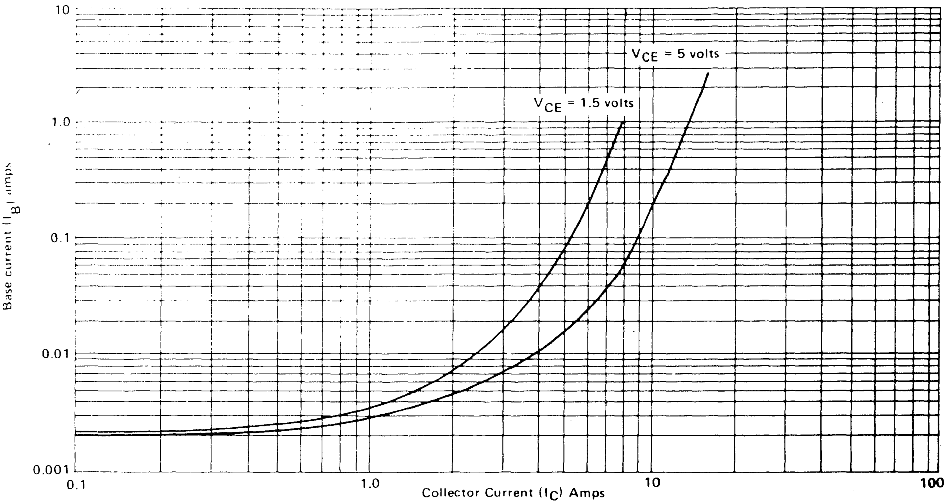
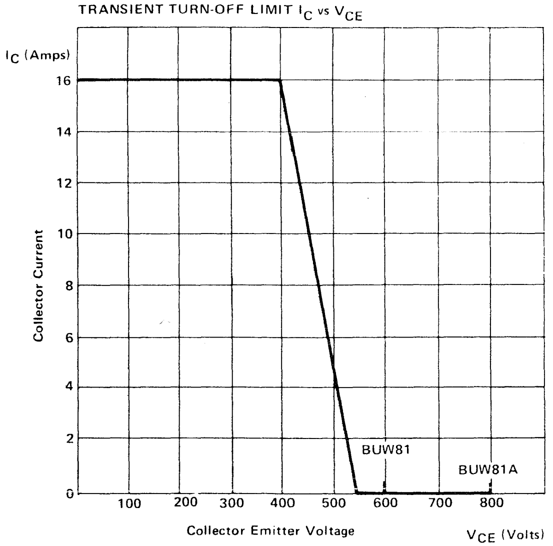
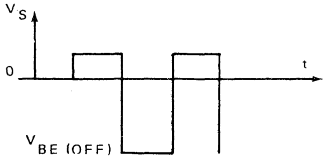
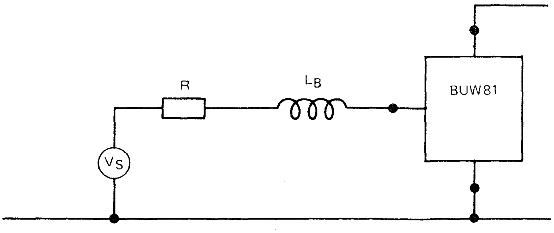


FIG 3 I_B vs I_C FOR CONSTANT V_{CE}.
LOWEST GAIN DEVICE (95% CONFIDENCE LEVEL)



Limit Base Drive Condition:
$I_{B(ON)} \leqslant 200mA$, $1.5 \leqslant V_{EB(OFF)} \leqslant 8V$,
Base Inductance $L_B = 3\mu H$, Source Resistance $R = 5\Omega$





NB. It is imperative that the repetition rate does not allow the thermal rating to be exceeded. As a guide, the worst case energy absorbed during turn-off, following the locus shown, will be approximately 10mJ.

The V_{CE}/I_C locus found in an application may be plotted using an oscilloscope provided that the bandwidth exceeds 10MHz and the delay matching of X and Y plots is better than 20ns.

FIG 4

Typical application circuit

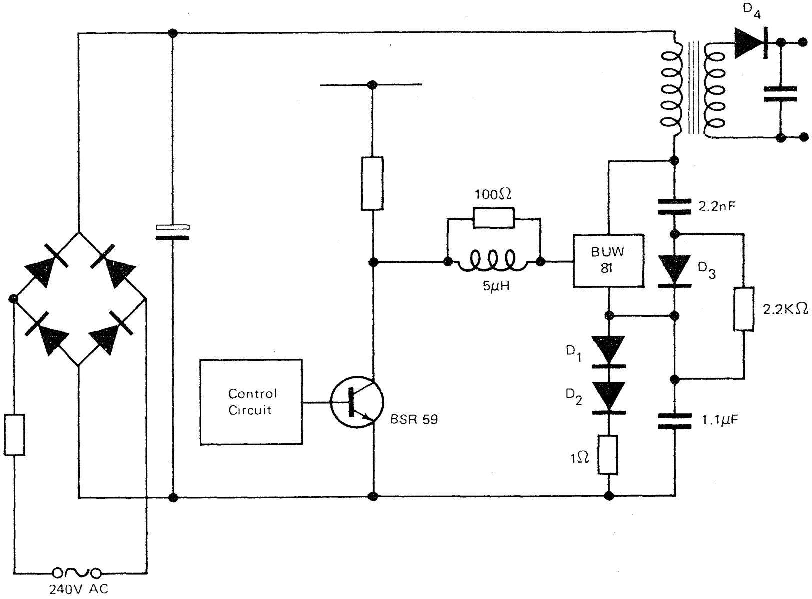


FIG 5

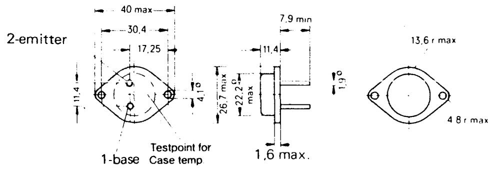
Note: D3 and D4 are fast, soft recovery rectifiers.
D1 and D2 may be slow speed rectifiers.

BUX80, BUX82
NPN SILICON POWER TRANSISTORS

DESIGNED FOR SWITCHING-MODE POWER SUPPLIES, CRT SCANNING, INVERTERS AND OTHER INDUSTRIAL APPLICATIONS, WHERE RAPID SWITCHING OF INDUCTIVE LOADS IS NECESSARY.

THIS SERIES FEATURES HIGH VOLTAGE AND PEAK CURRENT RATINGS, LOW SATURATION VOLTAGES, AND A HIGH DEGREE OF ELECTRICAL ROBUSTNESS.

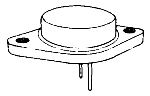
mechanical specification



All dimensions are in mm

The Collector is in electrical contact with the case

TO-3



absolute maximum ratings (at 25 °C case temperature, unless otherwise noted)

	BUX80	BUX82
Collector-Emitter Voltage ($U_{BE} = 0$)	800 V	800 V
Collector-Emitter Voltage ($I_B = 0$)	400 V	400 V
Collector-Emitter Voltage ($R_{BE} = 50\ \Omega$)	500 V	500 V
Emitter-Base Voltage ($I_C = 0$)	10 V	10 V
Collector Current Continuous	10 A	5 A
Collector Current Peak (see note)	15 A	8 A
Base Current Continuous	4 A	2 A
Total Power Dissipation (see figures 1 and 2)	100 W	60 W
Operating Temperature Range	−65 °C to +200 °C	

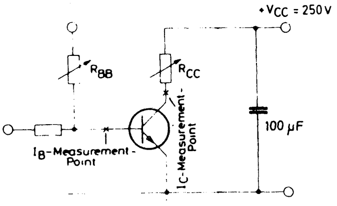
NOTE: Pulse width ⩽1 ms. Duty cycle ⩽25%

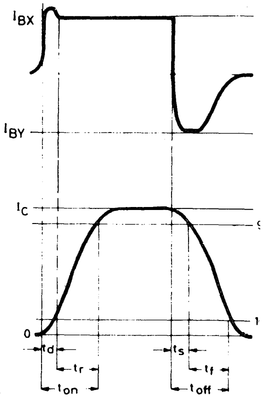
electrical characteristics (at T_J = 25 °C unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 100 mA I_B = 0 L = 25 mH		400			V
BV_{CER}	Collector-Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 50 Ω L = 15 mH		500			V
I_{CES}	Collector-Emitter Leakage Current	V_{CE} = 800 V V_{BE} = 0				1	mA
		T_J = 125 °C				3	mA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 10 V I_C = 0				10	mA
f_T	Transition Frequency	V_{CE} = 10 V, f = 1 MHz I_C = 0.2 A			8		MHz
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	**BUX80** I_C = 5 A I_B = 1 A	**BUX82** I_C = 2.5 A I_B = 0.5 A			1.5	V
		I_C = 8 A I_B = 2.5 A	I_C = 4 A I_B = 1.25 A			3.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 5 A I_B = 1 A	I_C = 2.5 A I_B = 0.5 A			1.4	V
		I_C = 8 A I_B = 2.5 A				2.0	V
			I_C = 4 A I_B = 1.25 A			1.8	V
t_{on}	Turn-On Time	V_{CC} = 250 V I_C = 5 A I_{BX} = 1 A I_{BY} = −2 A	V_{CC} = 250 V I_C = 2.5 A I_{BX} = 0.5 A I_{BY} = −1 A			0.5	μs
t_s	Storage Time					3.5	μs
t_f	Fall Time				0.3		μs

SWITCHING TIME MEASUREMENT

1. R_{CC} and R_{BB} adjusted to give I_C and I_B
2. Oscilloscope rise-time less than 20 ns
3. Recommended current probe Tektronix P6019, P6020 or P6042
4. For typical variation of switching times with collector current, see figures 7 and 8





BUX80

DISSIPATION DERATING CURVE

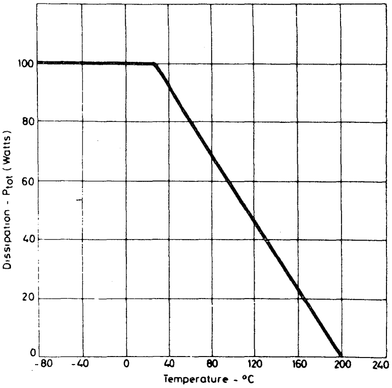


FIGURE 1

BUX82

DISSIPATION DERATING CURVE

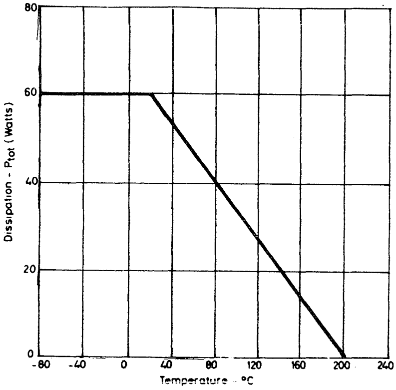


FIGURE 2

FORWARD BIASED SAFE AREA OF OPERATION
(NON REPETITIVE OPERATION) T_{jmax} = 200 °C

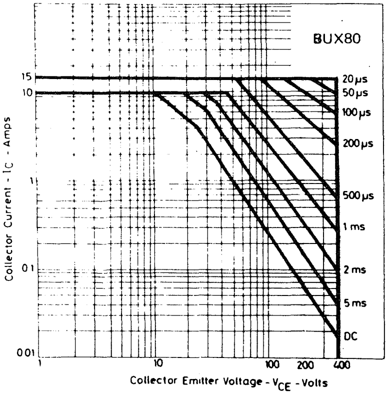


FIGURE 3

FORWARD BIASED SAFE AREA OF OPERATION
(NON REPETITIVE OPERATION) T_{jmax} = 200 °C

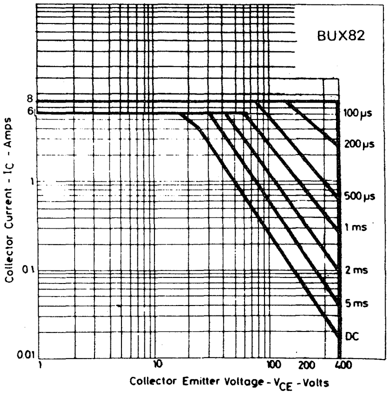


FIGURE 4

TYPICAL CHARACTERISTICS (both types)

TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

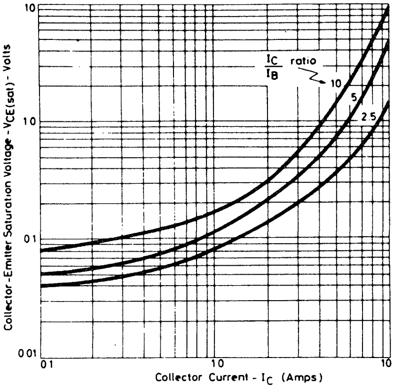


FIGURE 5

TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

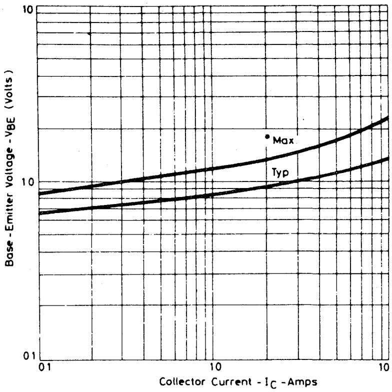


FIGURE 6

TYPICAL VARIATION OF DELAY AND RISE TIMES WITH COLLECTOR CURRENT

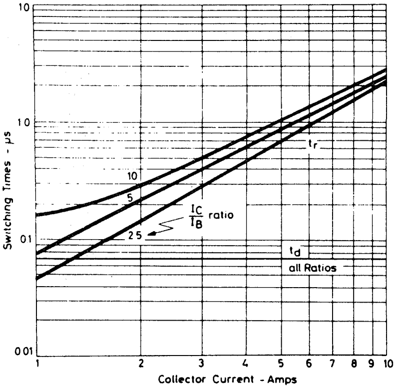


FIGURE 7

TYPICAL VARIATION OF STORAGE AND FALL TIMES WITH COLLECTOR CURRENT

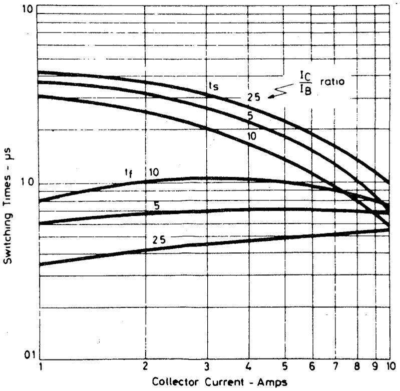


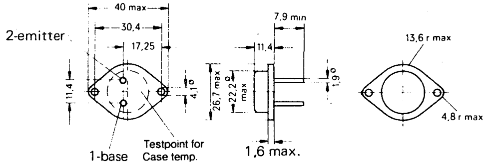
FIGURE 8

BUY69 SERIES
NPN SILICON POWER TRANSISTORS

DESIGNED FOR SWITCHING-MODE POWER SUPPLIES, CRT SCANNING, INVERTERS AND OTHER INDUSTRIAL APPLICATIONS, WHERE RAPID SWITCHING OF INDUCTIVE LOADS IS NECESSARY.

THIS SERIES FEATURES HIGH VOLTAGE AND PEAK CURRENT RATINGS, FAST SWITCHING TIMES, AND A HIGH DEGREE OF ELECTRICAL ROBUSTNESS.

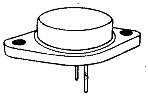
mechanical specification



All dimensions are in mm

The Collector is in electrical contact with the case

TO-3



absolute maximum ratings (at 25 °C case temperature, unless otherwise noted)

	BUY69A	BUY69B	BUY69C
Collector-base voltage ($I_E = 0$) (see note 1)	1000 V	800 V	500 V
Collector-emitter voltage ($I_B = 0$) (see note 1)	400 V	325 V	200 V
Collector-emitter voltage ($V_{BE} = -2$ V) (see note 1)	1000 V	800 V	500 V
Emitter-base voltage ($I_C = 0$) (see note 1)	8 V	8 V	8 V
Collector current continuous	10 A	10 A	10 A
Collector current peak (see note 2)	15 A	15 A	15 A
Base current continuous	3 A	3 A	3 A
Total power dissipation (see note 3)	100 W	100 W	100 W
Operating temperature range	−65 °C to +200 °C		

NOTES: 1. $T_C = -55$ °C to +100 °C. See Fig. 1 for 100 °C - 200 °C.
2. Pulse width $\leqslant$ 500 μs. Duty cycle $\leqslant$25 %.
3. V_{CE} = 17 V. See Fig. 2 for derating.

electrical characteristics (at T_C = 25 °C unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
BV_{CBO}	Collector-base breakdown voltage	I_C = 1 mA	BUY69A	1000			V
		I_E = 0	BUY69B	800			
		(See note 2)	BUY69C	500			
LV_{CEO}	Collector-emitter latching voltage	I_C = 50 mA	BUY69A	400			V
		I_B = 0	BUY69B	325			
			BUY69C	200			
BV_{EBO}	Emitter-base breakdown voltage	I_B = 10 mA	ALL	8			V
I_{CEX}	Collector-emitter leakage current	V_{CE} = 1000 V	BUY69A			1	mA
		V_{CE} = 800 V	BUY69B			1	
		V_{CE} = 500 V	BUY69C			1	
		V_{BE} = −2 V					
h_{FE}	DC current gain (see note 4)	I_C = 2.5 A V_{CE} = 10 V	ALL	15			
		I_C = 8 A V_{CE} = 3.3 V	ALL	2.5		20	
		I_C = 10 A V_{CE} = 10 V	ALL	2.5			
V_{BE}	Base-emitter voltage	I_C = 10mA V_{CE} = 10 V	ALL	0.5			V
$V_{BE(sat)}$	Base-emitter saturation voltage	I_C = 8 A	ALL			2.2	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	I_B = 2.5 A	ALL			3.3	V
f_T	Transition frequency	V_{CE} = 10 V I_C = 0.5 A	ALL	2	6		MHz
C_{OBO}	Output capacitance	V_{CB} = 20 V I_E = 0	ALL			150	pF

NOTES: 2. Pulse width $\leqslant$500 μs. Duty Cycle $\leqslant$25 %.
4. Pulse width $\leqslant$300 μs. Duty Cycle $\leqslant$2 %.

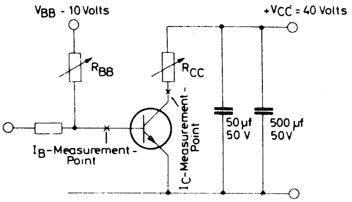
BUY69 SERIES
NPN SILICON POWER TRANSISTORS

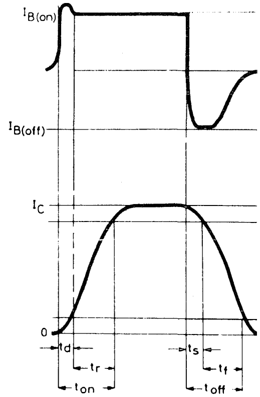
switching times (all types, at T_C = 25 °C)

SYMBOL	PARAMETER	TEST CONDITIONS	MAX	UNIT
t_{ON}	Turn-on time	I_C = 8 A, V_{CE} = 40 V $I_{B(ON)}$ = 2.5 A	3.5	μs
t_S	Storage time	I_C = 8 A, V_{CE} = 40 V $I_{B(ON)} = -I_{B(OFF)}$ = 2.5 A	3.0	μs
t_F	Fall time		1.0	μs
t_{OFF}	Turn-off time		4.0	μs

switching time measurement

1. R_{CC} and R_{BB} adjusted to give I_C and I_B.
2. Input resistor should correctly terminate pulse generator (normally 50 Ω). Input pulse 250 V, pulse width 10 μs, duty cycle 2%.
3. Oscilloscope rise-time less than 20 ns.
4. Recommended current probe Tektronix P6019, P6020 or P6042.
5. For typical variation of switching time with collector current, see Figures 9 and 10.





VOLTAGE PECENTAGE DERATING CURVE

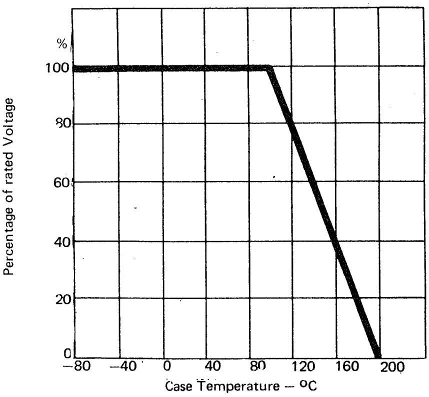


FIGURE 1

DISSIPATION DERATING CURVE

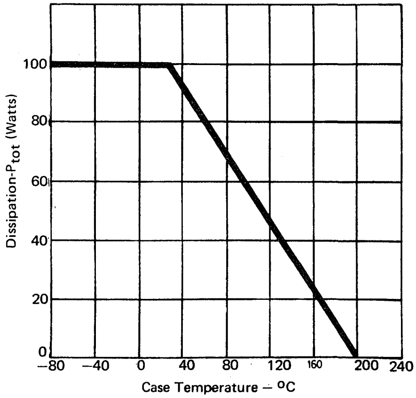


FIGURE 2

TYPICAL CHARACTERISTICS

TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT

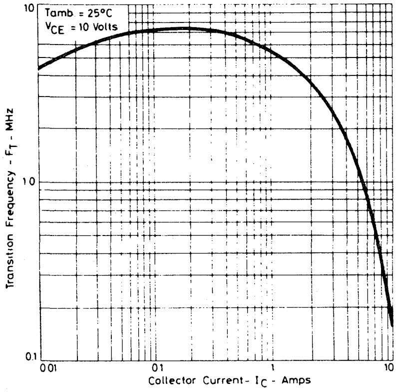


FIGURE 3

FORWARD BIASED SAFE AREA OF OPERATION (NON REPETITIVE OPERATION) $T_{j\,max}$ = 200 °C

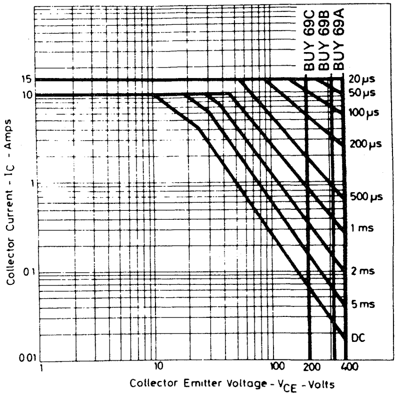


FIGURE 4

TYPICAL AND MAXIMUM VARIATION OF I_{CBO} WITH TEMPERATURE

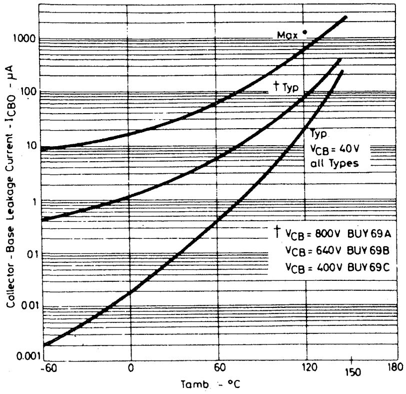


FIGURE 5

TYPICAL VARIATIONS OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

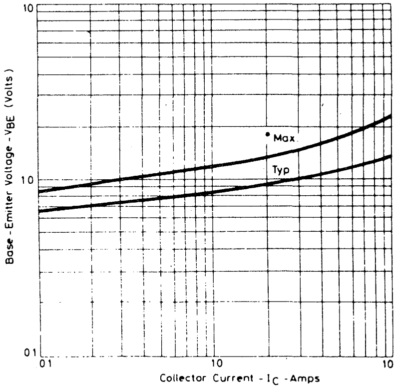


FIGURE 6

TYPICAL CHARACTERISTICS

TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIOS WITH COLLECTOR CURRENT

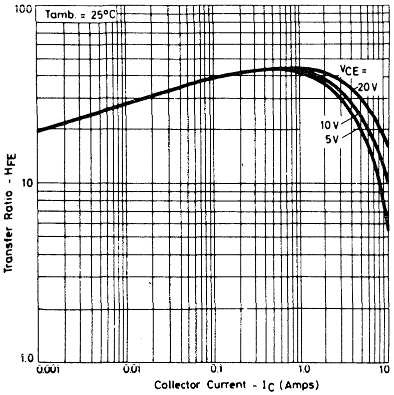


FIGURE 7

TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

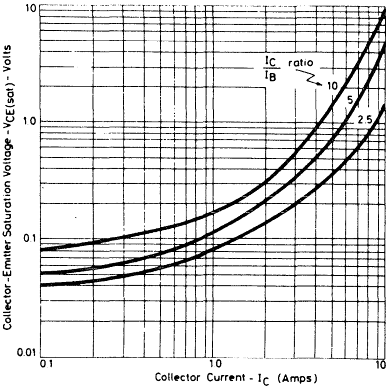


FIGURE 8

TYPICAL VARIATION OF STORAGE AND FALL TIMES WITH COLLECTOR CURRENT

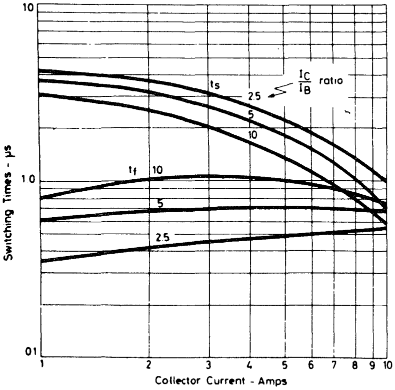


FIGURE 9

TYPICAL VARIATION OF DELAY AND RISE TIMES WITH COLLECTOR CURRENT

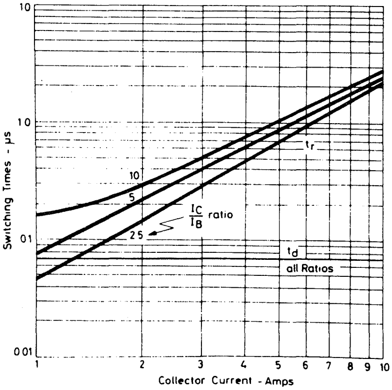


FIGURE 10

TYPICAL CHARACTERISTICS

TYPICAL VARIATION OF COLLECTOR-EMITTER LATCHING VOLTAGE WITH EXTERNAL BASE-EMITTER RESISTANCE

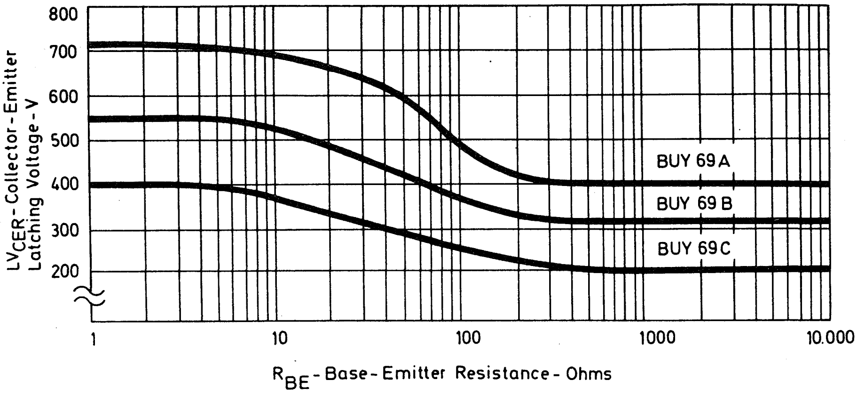


FIGURE 11

TYPICAL VARIATION OF FALL TIME WITH JUNCTION TEMPERATURE

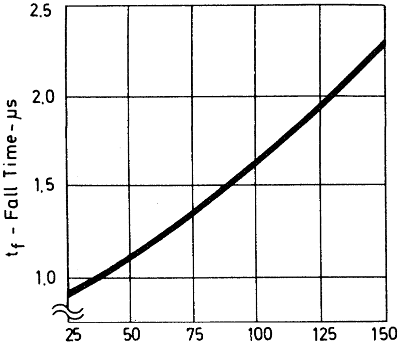


FIGURE 12

TYPICAL VARIATION OF STORAGE TIME WITH JUNCTION TEMPERATURE

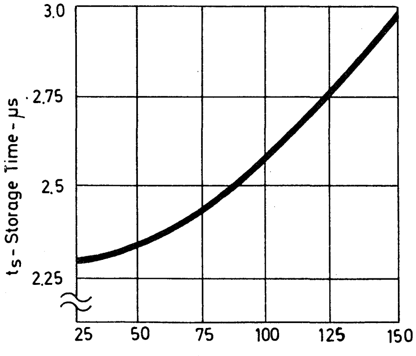


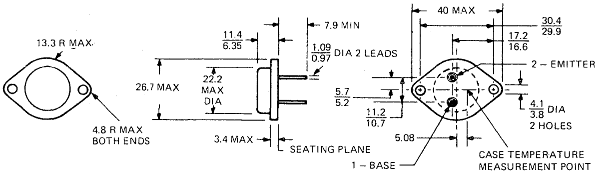
FIGURE 13

BUY70 SERIES
NPN SILICON POWER TRANSISTORS

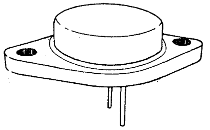
BUY70 Series Transistors are designed for use in;
Switching Mode Power Supplies, Inverters and C.R.T. Scanning Systems.
They feature High Voltage and Peak Current Capability together with Fast Switching and a High Degree of Robustness.

Mechanical Specification

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



Absolute Maximum Ratings (at 25°C case temperature)

	BUY70A	BUY70B	BUY70C	
Collector-Base Voltage (I_E = 0)	1000	800	500	V
Collector-Emitter Voltage (I_B = 0)	400	325	200	V
Emitter-Base Voltage	8	8	8	V
Collector Current Peak (See Note 1)	15	15	15	A
Collector Current Continuous	10	10	10	A
Continuous-Dissipation ($V_{CE} \leqslant 17V$) (See Note 2)	75	75	75	W
Continuous Base Current	3	3	3	
Operating Temperature Range				−65°C to +200°C

NOTES: 1. Pulse Width ⩽ 500 µSec. Duty Cycle ⩽ 25%
2. Refer to Safe Operating and Dissipation Derating Curves
3. Pulsed Test. Pulse Width ⩽ 300 µSec. Duty Cycle ⩽ 2%

Electrical Characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1mA I_E = 0 Note 2	BUY70A BUY70B BUY70C	1000 800 500			V
LV_{CEO}	Collector-Emitter Latching Voltage	I_C = 50mA I_B = 0	BUY70A BUY70B BUY70C	400 325 200			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_B = 10mA	ALL	8			V
I_{CEX}	Collector-Emitter Leakage Current	V_{CE} = 1000V V_{CE} = 800 V V_{CE} = 500V V_{BE} = −2V	BUY70A BUY70B BUY70C			1.0 1.0 1.0	mA
H_{FE}	DC Current Gain	I_C = 1.0A V_{CE} = 10V Note 2	ALL	15			
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 4.0A I_B = 0.8A Note 2	ALL			1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 4.0A I_B = 0.8A Note 2	ALL			5.0	V
t_f	Collector-Current Fall Time	I_C = 4.0A V_{CE} = 40V $I_{B(on)}$ = 0.8A $I_{B(off)}$ = 0.8A	ALL			1.0	µs
f_T	Transition Frequency	V_{CE} = 10V I_C = 0.5A	ALL		6		MHz
C_{obo}	Output Capacitance	V_{CB} = 20V I_C = 0	ALL			150	pF

TYPICAL VARIATION OF COLLECTOR EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

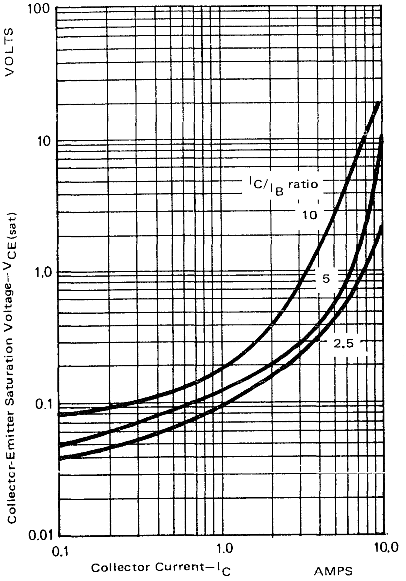


FIG 5

TYPICAL VARIATION OF STORAGE AND FALL TIMES WITH COLLECTOR CURRENT

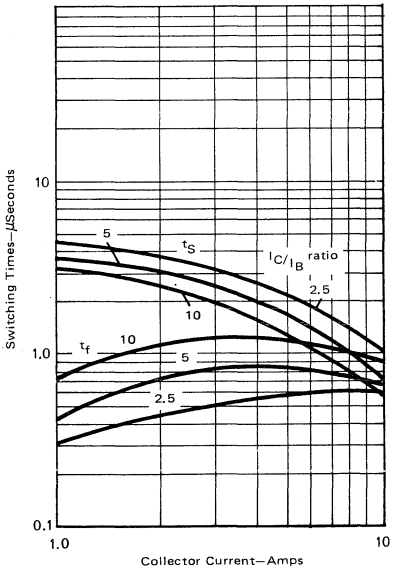


FIG 6

TYPICAL AND MAXIMUM*VARIATION OF I_{CBO} WITH TEMPERATURE

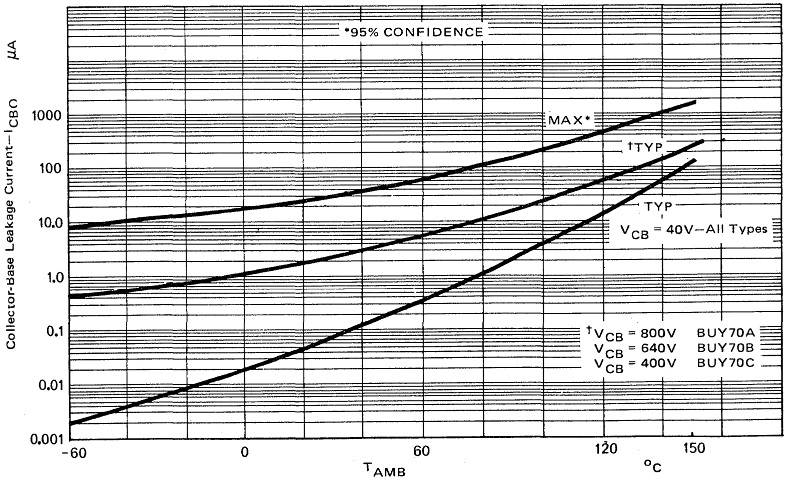


FIG 7

TYPICAL VARIATION OF BASE EMITTER
SATURATION VOLTAGE WITH COLLECTOR CURRENT

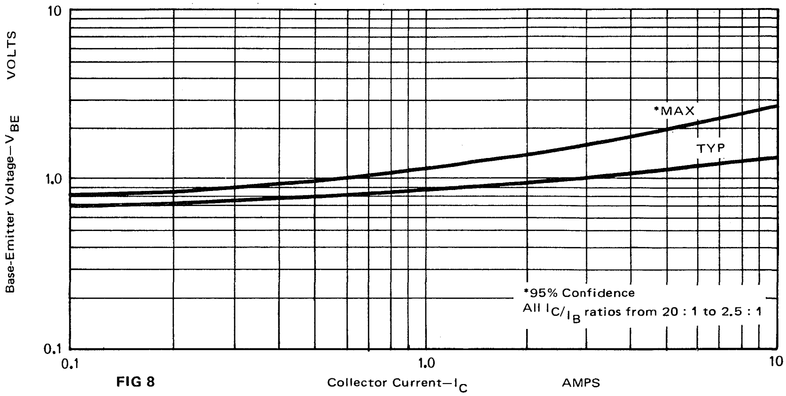


FIG 8

TYPICAL VARIATION OF TRANSITION
FREQUENCY WITH COLLECTOR CURRENT

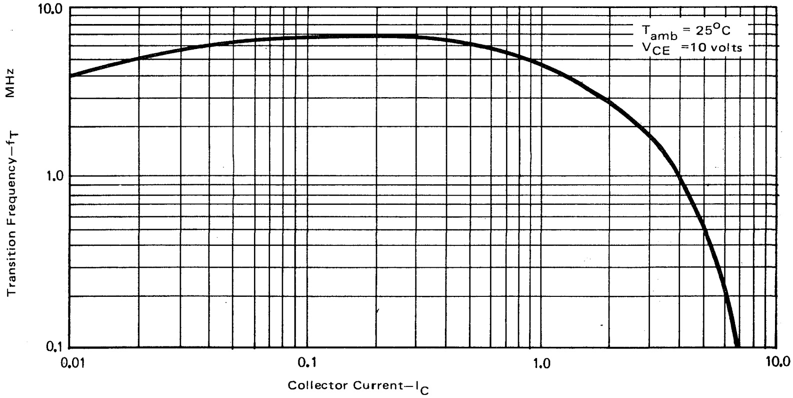


FIG 9

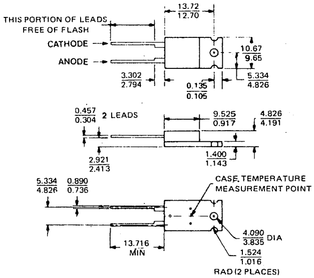
BY205-100 TO BY205-1000
DIFFUSED SILICON, FAST, SOFT RECOVERY RECTIFIERS

Designed for high frequency switching applications. Avoids transients generated by conventional fast rectifiers.

Especially suitable for T.V. Line-scan, switching mode power supplies inverters, converters. Utilises glass passivated wafers.

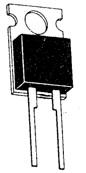
mechanical data

THE CATHODE IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES

(Mounting Hardware as for TO-66 Plastic)



absolute maximum ratings

	BY205–	100	200	400	600	800	1000	
V_{RRM}	Repetitive peak reverse voltage	100	200	400	600	800	1000	Volts
$I_{F(AV)}$	Average rectified forward current up to 125°C Case Temp.	← 3 →						Amps
I_{FRM}	Repetitive peak forward current up to 125°C Case Temp.	← 15 →						Amps
I_{FSM}	Non-repetitive forward surge current 1 cycle at 50Hz and up to 125°C Case Temp.	← 35 →						Amps
P_D	Continuous device dissipation up to 90°C Case Temp. (Note 1 and Note 4)	← 20 →						Watts
P_D	Continuous device dissipation up to 25°C ambient temp. in free air (Note 2 and Note 4)	← 2 →						Watts
T_c	Operating case temperature	← –55 to +150 →						°C
T_{stg}	Storage temperature	← –55 to +150 →						°C

electrical characteristics

BY205–	100	200	400	600	800	1000	UNITS
I_R Reverse leakage current at $V_R = V_{RRM}$ and 25°C Case Temp.	← 100 →						µA
V_F Forward Voltage drop at I_F = 5A and 25°C Case Temp. (Note 3)	← 1.5 →						Volts

BY205-100 TO BY205-1000
DIFFUSED SILICON, FAST, SOFT RECOVERY RECTIFIERS

switching characteristics

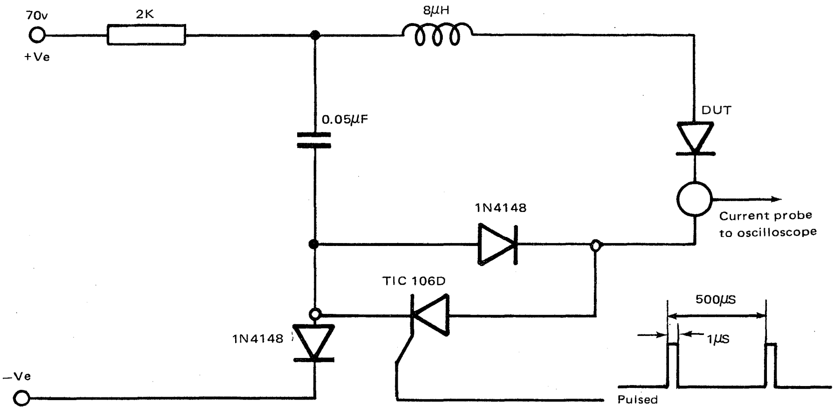
t_{rr}	Maximum reverse recovery time (For circuit and conditions see Fig. 1.	ALL TYPES – 850n. Secs.

thermal characteristics

		MAX	UNIT
θ_{j-c}	Junction-to-case thermal resistance	3	°C/W
θ_{j-a}	Junction-to-free air thermal resistance	62.5	°C/W

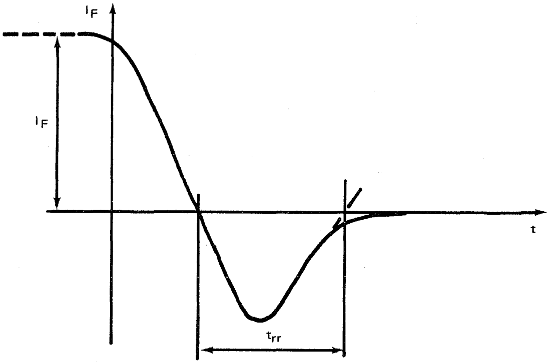
NOTES:
1. Derate linearly to 150°C case temperature at the rate of 0.33W/°C.
2. Derate linearly to 150°C free-air temperature at the rate of 16mW/°C.
3. This parameter is a pulse measurement such that there is only negligible heating of the junction.
4. Device dissipation includes forward, reverse and switching losses.

TEST CONDITIONS OF t_{rr} MEASUREMENT



$I_F = 4A$ $\quad dI/dt = 6A/\mu Sec.$

TYPICAL RECOVERY WAVE-FORM



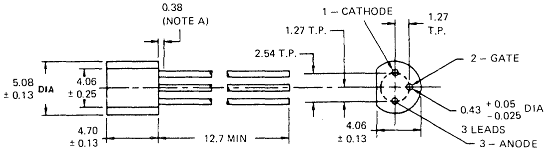
TIC44, TIC45, TIC46, TIC47
PNPN PLANAR SILICON REVERSE-BLOCKING TRIODE THYRISTORS

SILECT† THYRISTORS‡
600 mA DC • 30 thru 200 VOLTS

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin-Circle Configuration

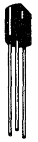
mechanical data

These thyristors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C method 106B. The thyristors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.48) shall be within 0.18 of their true positions measured in the gaging plane 1.37 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in millimetres.

THE GATE IS CONNECTED TO A P REGION



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TIC44	TIC45	TIC46	TIC47	UNIT
Static Off-State Voltage, V_D (See Note 1)	30	60	100	200	V
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	30	60	100	200	V
Static Reverse Voltage, V_R (See Note 1)	30	60	100	200	V
Repetitive Peak Reverse Voltage, V_{RRM} (See Note 1)	30	60	100	200	V
Continuous or RMS On-State Current at (or below) 55°C Case Temperature (See Note 2)	600				mA
Continuous or RMS On-State Current at (or below) 25°C Free-Air Temperature (See Note 3)	300				mA
Average On-State Current (180° Conduction Angle) at (or below) 55°C Case Temperature (See Note 4)	430				mA
Surge On-State Current (See Note 5)	6				A
Peak Negative Gate Voltage	8				V
Peak Positive Gate Current (Pulse Width ≤ 300 μs)	1				A
Peak Gate Power Dissipation (Pulse Width ≤ 300 μs)	4				W
Operating Free-Air Temperature Range	−55 to 125				°C
Storage Temperature Range	−55 to 150				°C
Lead Temperature 1.588mm from Case for 10 Seconds	260				°C

NOTES: 1. These values apply when the gate-cathode resistance $R_{GK} \leqslant 1\ k\Omega$.
2. These values apply for continuous d-c operation with resistive load. Above 55°C derate according to Figure 5.
3. These values apply for continuous d-c operation with resistive load. Above 25°C derate according to Figure 6.
4. This value may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 55°C derate according to Figure 5.
5. This value applies for one 60-Hz half sine wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

electrical characteristics at 25° C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_D	Static Off-State Current	V_D = Rated V_D, R_{GK} = 1 kΩ, T_A = 125°C		50	μA
I_R	Static Reverse Current	V_R = Rated V_R, R_{GK} = 1 kΩ, T_A = 125°C		50	μA
I_{GT}	Gate Trigger Current (See Note 6)	V_{AA} = 6 V, R_L = 100 Ω, $t_{p(g)} \geqslant$ 20 μs		200	μA
V_{GT}	Gate Trigger Voltage (See Note 6)	V_{AA} = 6 V, R_L = 100 Ω, $t_{p(g)} \geqslant$ 20 μs		0.8	V
		V_{AA} = 6 V, R_L = 100 Ω, $t_{p(g)} \geqslant$ 20 μs, T_A = 125°C	0.2		
I_H	Holding Current	R_L = 100 Ω, R_{GK} = 1 kΩ		5	mA
V_T	On-State Voltage	I_T = 300 mA, $R_{GK} \geqslant$ 1 kΩ, See Note 7		1.4	V

NOTES: 6. When measuring these parameters, a 1-kΩ resistor should be used between gate and cathode to prevent triggering by random noise.

7. This parameter is measured using pulse techniques. t_w = 1 ms, duty cycle ≤ 1%.

switching characteristics at 25° C free-air temperature

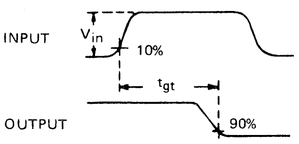
PARAMETER		TEST CONDITIONS	TYP	UNIT
t_{gt}	Gate-Controlled Turn-On Time	V_{AA} = 30 V, R_L = 50 Ω, R_G = 20 kΩ, V_{in} = 20 V, See Figure 1	3.5	μs
t_q	Circuit-Commutated Turn-Off Time	V_{AA} = 30 V, R_L = 50 Ω, I_{RM} = 1 A, See Figure 2	6.8	μs

thermal characteristics

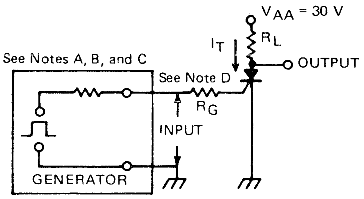
PARAMETER			MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		75	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		275	

TIC44, TIC45, TIC46, TIC47
PNPN PLANAR SILICON REVERSE-BLOCKING TRIODE THYRISTORS

PARAMETER MEASUREMENT INFORMATION



VOLTAGE WAVEFORMS



TEST CIRCUIT

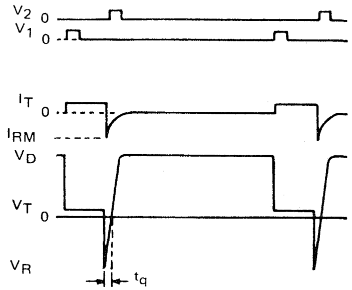
FIGURE 1—TURN-ON TIME

NOTES: A. V_{in} is measured with gate and cathode terminals connected as shown and anode terminal open.

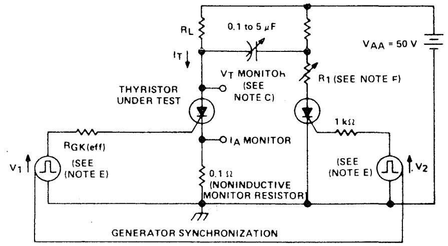
B. The input waveform of Figure 1 has the following characteristics: $t_r \leqslant 40$ ns, $t_w \geqslant 20$ μs.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 14$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 12$ pF.

D. R_G includes the total resistance of the generator and the external resistor.



WAVEFORMS



TEST CIRCUIT

FIGURE 2—COMMUTATING TURN-OFF TIME

NOTES: E. Pulse generators for V_1 and V_2 are synchronized to provide an anode current waveform with the following characteristics: $t_w = 50$ to 300 μs, duty cycle = 1%. The pulse widths of V_1 and V_2 are $\geqslant 10$ μs.

F. Resistor R_1 is adjusted for $I_{RM} = 1$ A.

THERMAL INFORMATION

The minimum heat-sink requirements may be calculated for any on-state current, heat-sink combination by the following procedure:

1. Determine worst-case power dissipation from Figure 3.
2. Calculate maximum allowable case-to-free-air thermal resistance by use of the equation.

$$R_{\theta CA} = \frac{T_J - T_A}{P_{A(av)}} - R_{\theta JC}$$

where: T_J = Junction temperature

T_A = Free-air temperature

$P_{A(av)}$ = Average anode power dissipation (see Figure 3 for worst-case values)

$R_{\theta JC}$ = Junction-to-case thermal resistance = 75°C/W maximum.

3. Determine area of heat sink from Figure 4.

EXAMPLE

Determine: Minimum size of 1/16"-thick aluminum heat sink for safe operation of thyristor at an average current of 0.4 A with a conduction angle of 180°

Given: Maximum T_J = 125°C

T_A = 35°C

$R_{\theta JC}$ = 75°C

Solution: From Figure 3, $P_{A(av)}$ = 0.84 W for 0.4 A with 180° conduction angle. Using the equation of step 2 above:

$$R_{\theta CA} = \frac{125°C - 35°C}{0.84\ W} - 75°C/W = 32°C/W$$

Figure 4 shows that for $R_{\theta CA}$ of 32°C/W, the area is 18 sq. in. The minimum dimensions of the sides should be:

$$\sqrt{\frac{area}{2}} \times \sqrt{\frac{area}{2}} = \sqrt{\frac{18}{2}} \times \sqrt{\frac{18}{2}} = 3'' \times 3''$$

MAXIMUM AVERAGE ANODE POWER DISSIPATED
vs
AVERAGE ON-STATE CURRENT

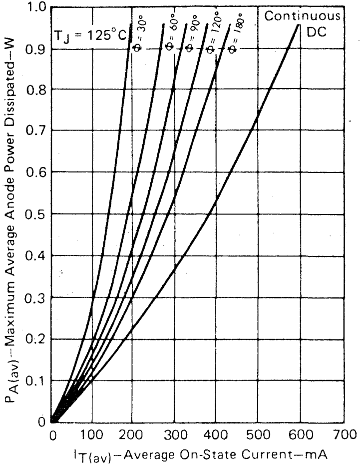


FIGURE 3

TYPICAL HEAT-SINK AREA
vs
CASE-TO-FREE-AIR THERMAL RESISTANCE
1/16"-THICK ALUMINUM HEAT SINK

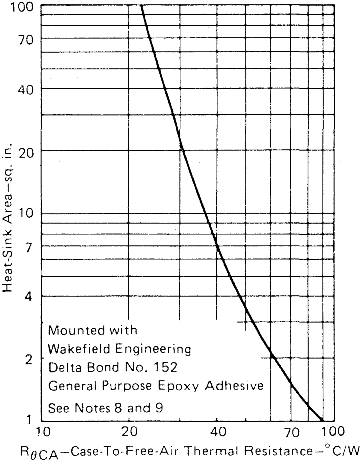


FIGURE 4

NOTES: 8. The thyristor is mounted in the center of a square heat sink vertically positioned in still free air with both sides exposed. The heat-sink area is twice the area of one side.

9. $R_{\theta CA}$ includes the case-to-heat sink thermal resistance, $R_{\theta CHS}$, in addition to the heat-sink-to-free-air thermal resistance, $R_{\theta HSA}$ and is defined by the equation, $R_{\theta CA} = R_{\theta CHS} + R_{\theta HSA}$.

THERMAL INFORMATION

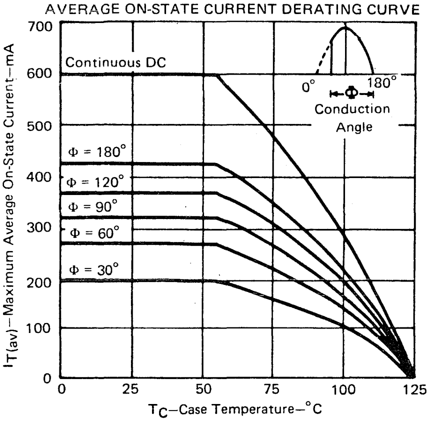

AVERAGE ON-STATE CURRENT DERATING CURVE

FIGURE 5

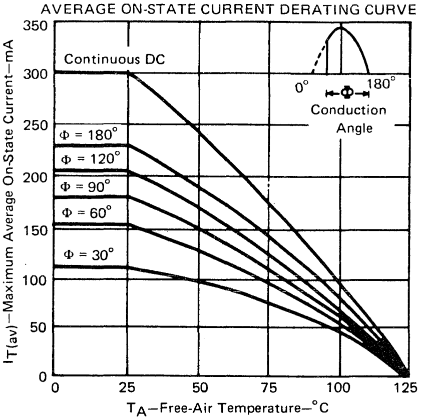

AVERAGE ON-STATE CURRENT DERATING CURVE

FIGURE 6

TYPICAL CHARACTERISTICS

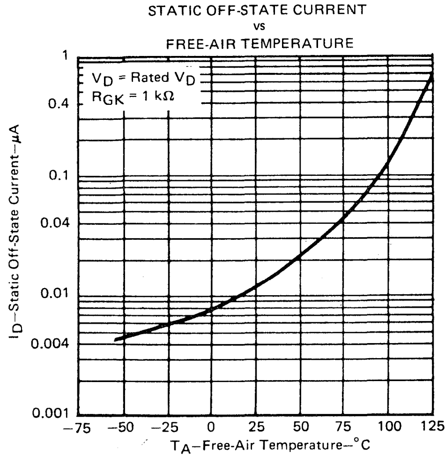

STATIC OFF-STATE CURRENT
vs
FREE-AIR TEMPERATURE

FIGURE 7

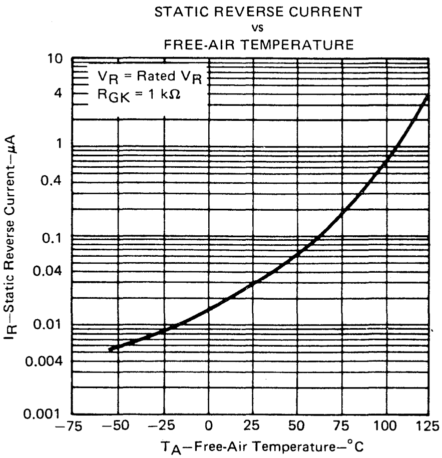

STATIC REVERSE CURRENT
vs
FREE-AIR TEMPERATURE

FIGURE 8

TYPICAL CHARACTERISTICS

GATE TRIGGER CURRENT
vs
FREE-AIR TEMPERATURE

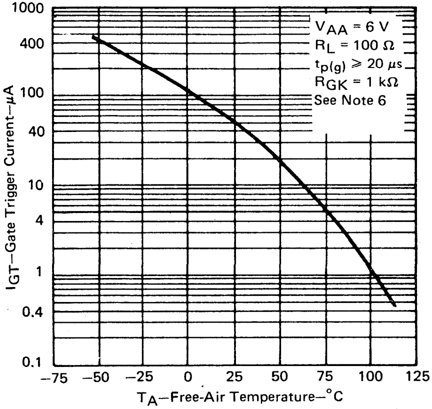


FIGURE 9

GATE TRIGGER VOLTAGE
vs
FREE-AIR TEMPERATURE

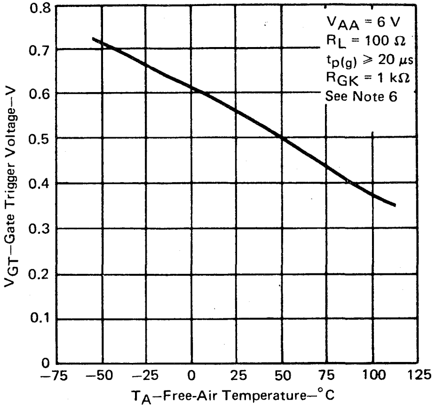


FIGURE 10

NOTE 6: When measuring these parameters, a 1-kΩ resistor should be used between gate and cathode to prevent triggering by random noise.

HOLDING CURRENT
vs
FREE-AIR TEMPERATURE

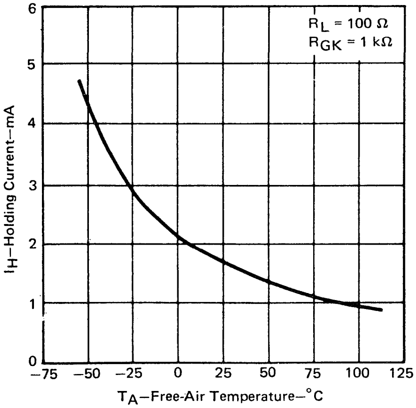


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

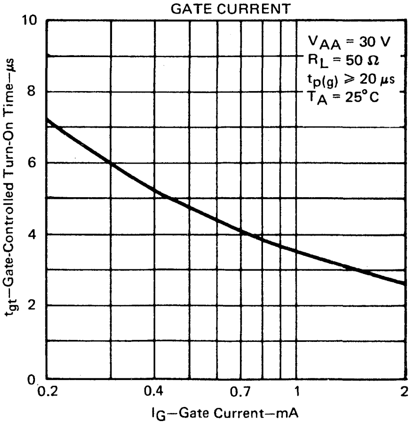


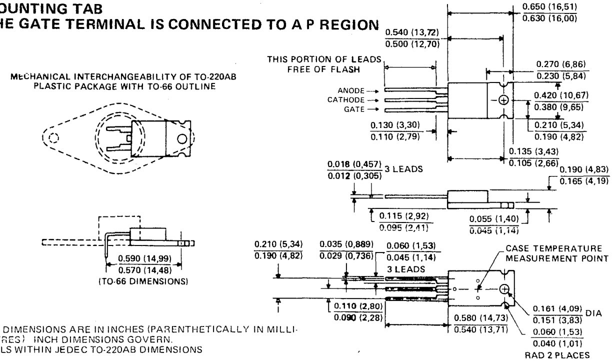
FIGURE 12

GROUNDED-CATHODE CONSTRUCTION ELIMINATES NEED FOR ELECTRICAL INSULATION IN MOST APPLICATIONS

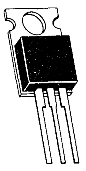
- 5 A DC
- 30 V to 600 V
- 30 A Surge-Current
- Max I_{GT} of 400 μA (TIC101 Series) or 5000 μA (TIC102 Series)

mechanical data

THE CATHODE IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB
THE GATE TERMINAL IS CONNECTED TO A P REGION



ALL DIMENSIONS ARE IN INCHES (PARENTHETICALLY IN MILLIMETRES) INCH DIMENSIONS GOVERN.
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted)

	TIC101Y TIC102Y	TIC101F TIC102F	TIC101A TIC102A	TIC101B TIC102B	TIC101D TIC102D	TIC101M TIC102M	UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	30	50	100	200	400	600	V
Repetitive Peak Reverse Voltage, V_{RRM}	30	50	100	200	400	600	V
Continuous On-State Current at (or below) 80°C Case Temperature (See Note 2)	5						A
Average On-State Current (180° Conduction Angle) at (or below) 80°C Case Temperature (See Note 3)	3.2						A
Surge On-State Current (See Note 4)	30						A
Peak Positive Gate Current (Pulse Width $\leqslant$ 300 μs)	0.2						A
Peak Gate Power Dissipation (Pulse Width $\leqslant$ 300 μs)	1.3						W
Average Gate Power Dissipation (See Note 5)	0.3						W
Operating Case Temperature Range	–40 to 110						°C
Storage Temperature Range	–40 to 125						°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230						°C

NOTES:
1. These values apply when the gate-cathode resistance R_{GK} = 1 kΩ.
2. These values apply for continuous d-c operation with resistive load. Above 80°C derate according to Figure 3.
3. This value may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Above 80°C derate according to Figure 3.
4. This value applies for one 60-Hz half-sine-wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SERIES TIC101			SERIES TIC102			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
I_{DRM}	Repetitive Peak Off-State Current	V_D = Rated V_{DRM}, R_{GK} = 1 kΩ, T_C = 110°C			400			400	µA
I_{RRM}	Repetitive Peak Reverse Current	V_R = Rated V_{RRM}, I_G = 0, T_C = 110°C			1			1	mA
I_{GT}	Gate Trigger Current	V_{AA} = 6 V, R_L = 100 Ω, $t_{w(g)} \geq 20$ µs		110	400			5000	µA
V_{GT}	Gate Trigger Voltage	V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{w(g)} \geq 20$ µs, T_C = −40°C			1.2			1.2	V
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{w(g)} \geq 20$ µs	0.3	0.5	1	0.3		1	
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{w(g)} \geq 20$ µs, T_C = 110°C	0.2			0.2			
I_H	Holding Current	V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 10 mA, T_C = 40°C			8			8	mA
		V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 10 mA			5			5	
V_{TM}	Peak On-State Voltage	I_{TM} = 5 A, See Note 6			1.7			1.7	V
dv/dt	Critical Rate of Rise of Off-State Voltage	V_D = Rated V_D, R_{GK} = 1 kΩ, T_C = 110°C		7			7		V/µs

thermal characteristics

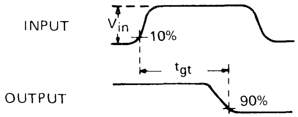
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.5	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 0.125 inch from the device body.

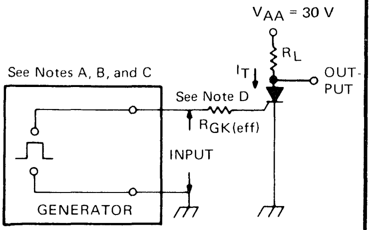
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TYP	UNIT
t_{gt}	Gate-Controlled Turn-On-Time	$V_{AA} = 30$ V, $R_L = 6\ \Omega$, $R_{GK(eff)} = 5$ kΩ, $V_{in} = 50$ V, See Figure 1	2	μs
t_q	Circuit-Commutated Turn-Off Time	$V_{AA} = 30$ V, $R_L = 6\ \Omega$, $I_{RM} \approx 8$ A, See Figure 2	20	μs

PARAMETER MEASUREMENT INFORMATION

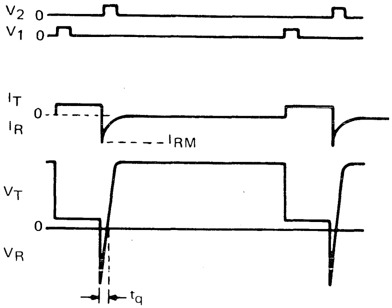


VOLTAGE WAVEFORMS

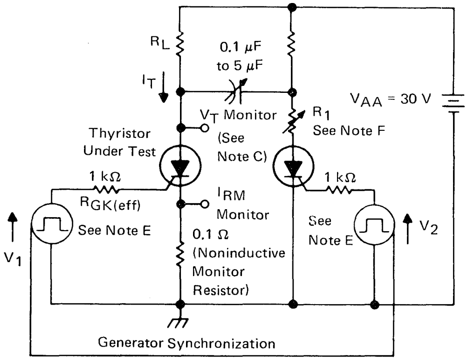


TEST CIRCUIT

FIGURE 1 – GATE-CONTROLLED TURN-ON TIME



WAVEFORMS



TEST CIRCUIT

FIGURE 2—CIRCUIT-COMMUTATED TURN-OFF TIME

NOTES:
- A. V_{in} is measured with gate and cathode terminals open.
- B. The input waveform of Figure 1 has the following characteristics: $t_r \leqslant 40$ ns, $t_w \geqslant 20$ μs.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 14$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 12$ pF.
- D. $R_{GK(eff)}$ includes the total resistance of the generator and the external resistor.
- E. Pulse generators for V_1 and V_2 are synchronized to provide an anode current waveform with the following characteristics: $t_w = 50$ to 300 μs, duty cycle = 1%. The pulse widths of V_1 and V_2 are $\geqslant 10$ μs.
- F. Resistor R_1 is adjusted for $I_{RM} \approx 8$ A.

THERMAL INFORMATION

AVERAGE ON-STATE
CURRENT DERATING CURVE

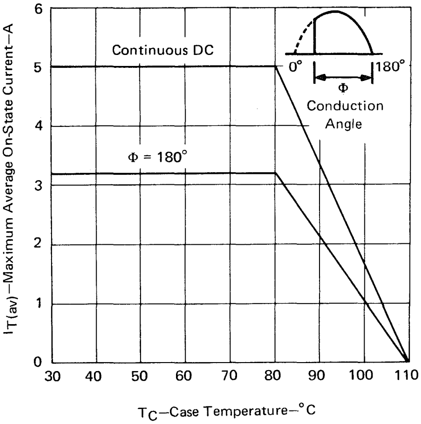


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ON-STATE CURRENT

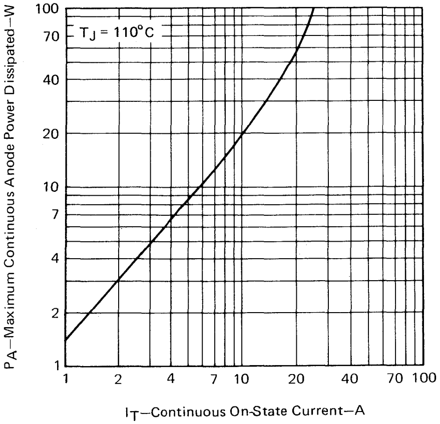


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

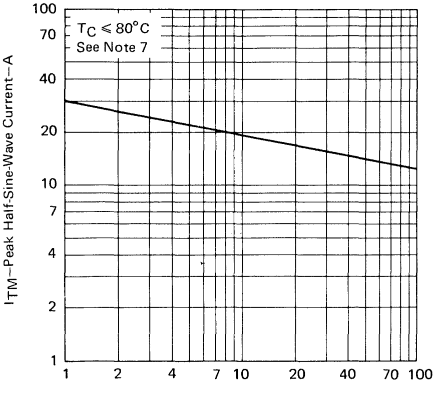


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

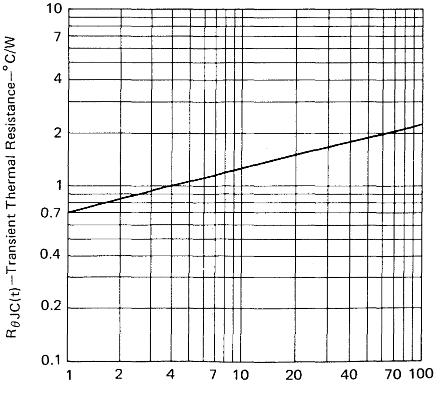


FIGURE 6

NOTE 7: This curve shows the maximum number of cycles of surge current for which gate control is guaranteed provided the device is initially at nonoperating thermal equilibrium.

TYPICAL CHARACTERISTICS

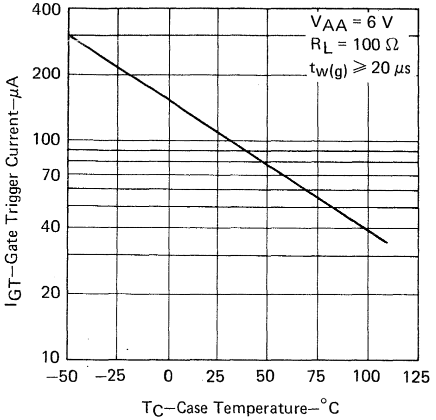

SERIES TIC101
GATE TRIGGER CURRENT
vs
CASE TEMPERATURE

FIGURE 7

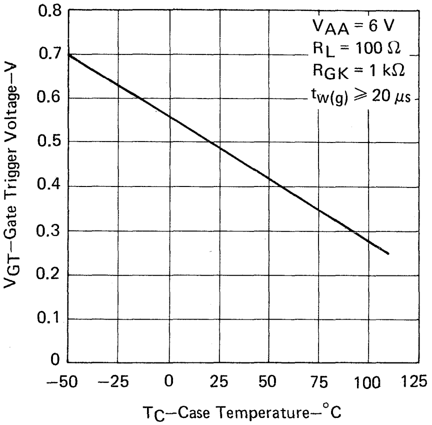

SERIES TIC101
GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

FIGURE 8

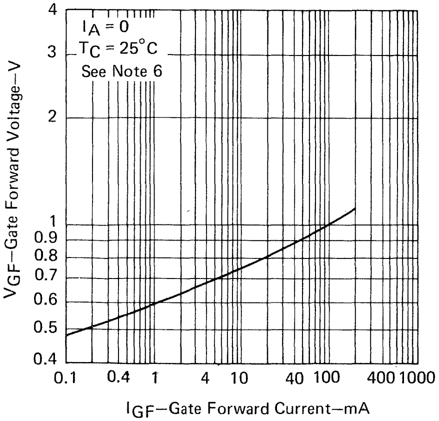

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

FIGURE 9

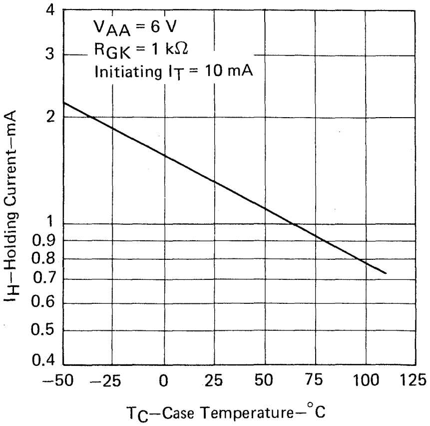

HOLDING CURRENT
vs
CASE TEMPERATURE

FIGURE 10

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 0.125 inch from the device body.

TYPICAL CHARACTERISTICS

PEAK ON-STATE VOLTAGE
vs
PEAK ON-STATE CURRENT

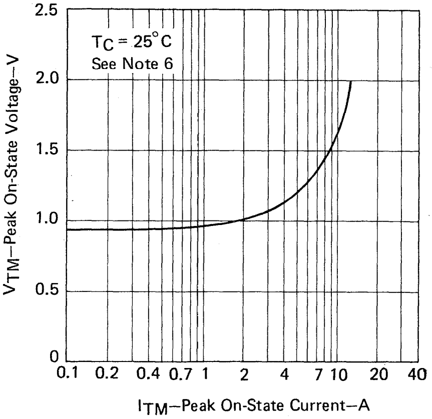


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

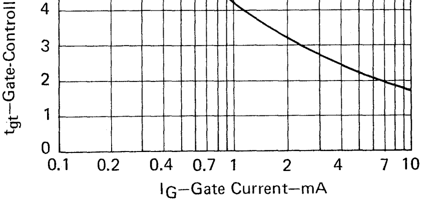


FIGURE 12

CIRCUIT COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

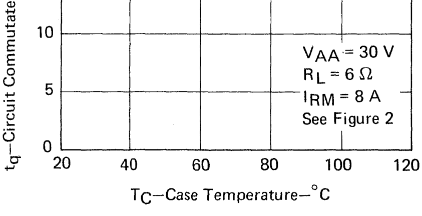


FIGURE 13

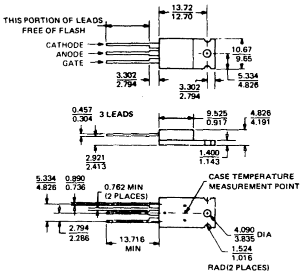
NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 0.125 inch from the device body.

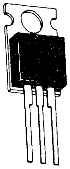
TIC106
SILICON THYRISTORS

- GLASS-PASSIVATED WAFER
- 30 V to 800 V
- 30 A Surge-Current
- 5 A DC
- MAX I_{GT} of 200 μA

mechanical data

THE ANODE IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings over operating case temperature range (unless otherwise noted)

			UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1) Repetitive Peak Reverse Voltage, V_{RRM}	TIC106F	50	V
	TIC106A	100	
	TIC106B	200	
	TIC106C	300	
	TIC106D	400	
	TIC106E	500	
	TIC106M	600	
	TIC106S	700	
	TIC106N	800	
Continuous On-State Current at (or below) 80°C Case Temperature (See Note 2)	5		A
Average On-State Current (180° Conduction Angle) at (or below) 80°C Case Temperature (See Note 3)	3.2		A
Surge On-State Current (See Note 4)	30		A
Peak Positive Gate Current (Pulse Width ≤ 300 μs)	0.2		A
Peak Gate Power Dissipation (Pulse Width ≤ 300 μs)	1.3		W
Average Gate Power Dissipation (See Note 5)	0.3		W
Operating Case Temperature Range	−40 to 110		°C
Storage Temperature Range	−40 to 125		°C
Lead Temperature 1.6 mm from Case for 10 Seconds	230		°C

NOTES:
1. These values apply when the gate-cathode resistance $R_{GK} = 1\ k\Omega$. When available, THYRISTORS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC106B (200V), TIC106D (400V) may be supplied.
2. These values apply for continuous d-c operation with resistive load. Above 80°C derate according to Figure 3.
3. This value may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Above 80°C derate according to Figure 3.
4. This value applies for one 60-Hz half-sine-wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_D = Rated V_{DRM}, R_{GK} = 1 kΩ, T_C = 110°C			400	µA
I_{RRM}	Repetitive Peak Reverse Current	V_R = Rated V_{RRM}, I_G = 0, T_C = 110°C			1	mA
I_{GT}	Gate Trigger Current	V_{AA} = 6 V, R_L = 100 Ω, $t_{p(g)} \geq 20$ µs		60	200	µA
V_{GT}	Gate Trigger Voltage	V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20$ µs, T_C = −40°C			1.2	V
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20$ µs	0.4	0.6	1	
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20$ µs, T_C = 110°C	0.2			
I_H	Holding Current	V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 10 mA, T_C = −40°C			8	mA
		V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 10 mA			5	
V_{TM}	Peak On-State Voltage	I_{TM} = 5 A, See Note 6			1.7	V
dv/dt	Critical Rate of Rise of Off-State Voltage	V_D = Rated V_D, R_{GK} = 1 kΩ, T_C = 110°C		10		V/µs

thermal characteristics

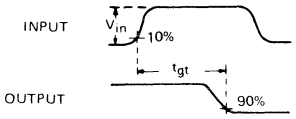
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.5	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

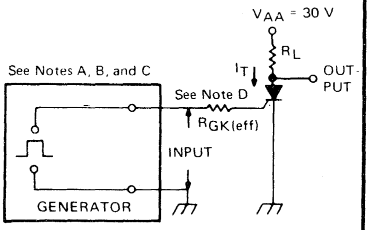
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TYP	UNIT
t_{gt}	Gate-Controlled Turn-On-Time	V_{AA} = 30 V, R_L = 6 Ω, $R_{GK(eff)}$ = 5 kΩ, V_{in} = 50 V, See Figure 1	1.75	μs
t_q	Circuit-Commutated Turn-Off Time	V_{AA} = 30 V, R_L = 6 Ω, I_{RM} ≈ 8 A, See Figure 2	7.7	μs

PARAMETER MEASUREMENT INFORMATION

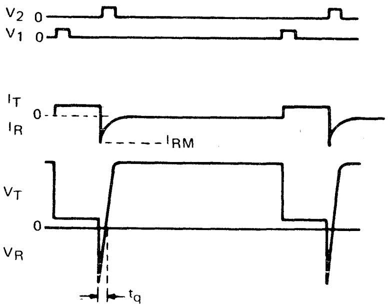


VOLTAGE WAVEFORMS

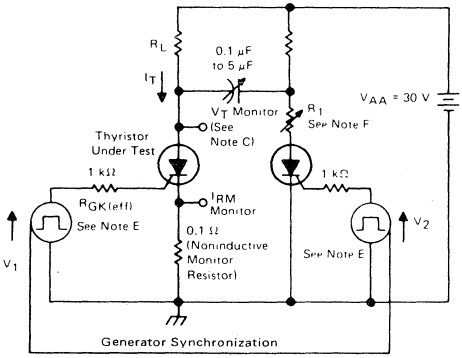


TEST CIRCUIT

FIGURE 1 – GATE-CONTROLLED TURN-ON TIME



WAVEFORMS



TEST CIRCUIT

FIGURE 2—CIRCUIT-COMMUTATED TURN-OFF TIME

NOTES:
- A. V_{in} is measured with gate and cathode terminals open.
- B. The input waveform of Figure 1 has the following characteristics: $t_r \leqslant 40$ ns, $t_w \geqslant 20$ μs.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 14$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 12$ pF.
- D. $R_{GK(eff)}$ includes the total resistance of the generator and the external resistor.
- E. Pulse generators for V_1 and V_2 are synchronized to provide an anode current waveform with the following characteristics: t_w = 50 to 300 μs, duty cycle = 1%. The pulse widths of V_1 and V_2 are ⩾ 10 μs.
- F. Resistor R_1 is adjusted for $I_{RM} \approx 10$ A.

THERMAL INFORMATION

AVERAGE ANODE
FORWARD CURRENT DERATING CURVE

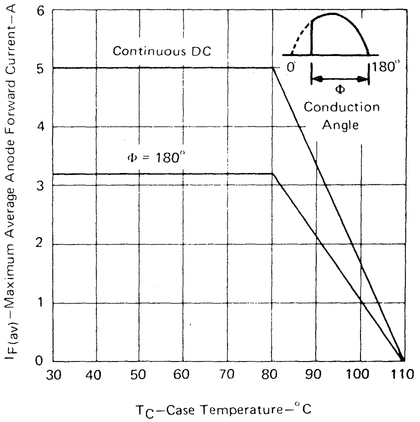


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ANODE FORWARD CURRENT

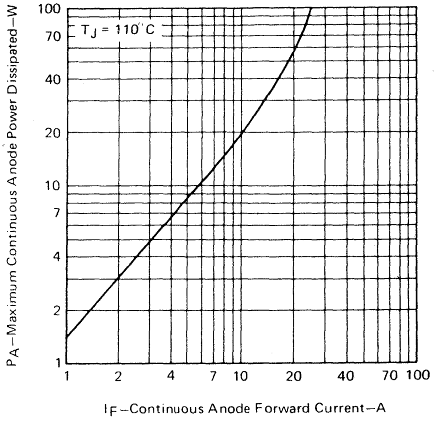


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

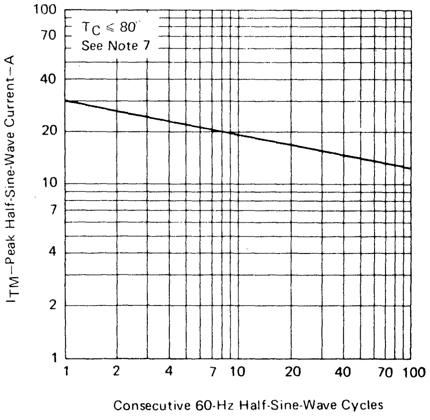


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

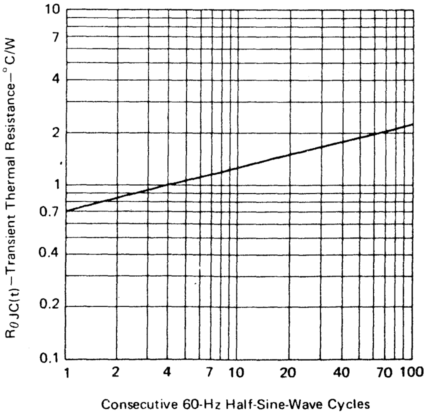


FIGURE 6

NOTE 7: This curve shows the maximum number of cycles of surge current for which gate control is guaranteed provided the device is initially at nonoperating thermal equilibrium.

TYPICAL CHARACTERISTICS

GATE TRIGGER CURRENT
vs
CASE TEMPERATURE

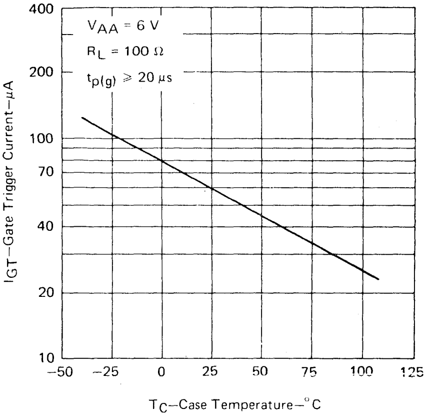


FIGURE 7

GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

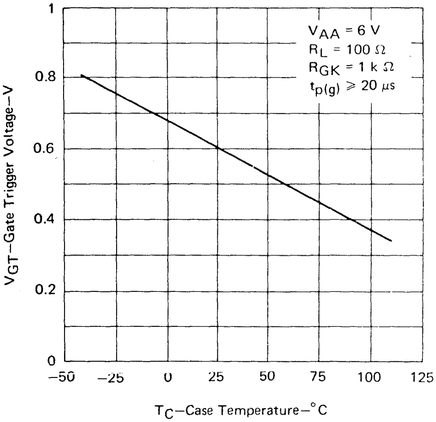


FIGURE 8

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

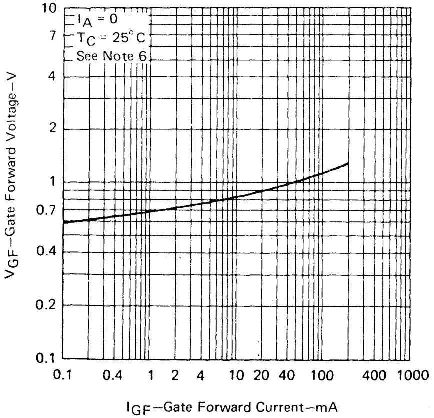


FIGURE 9

HOLDING CURRENT
vs
CASE TEMPERATURE

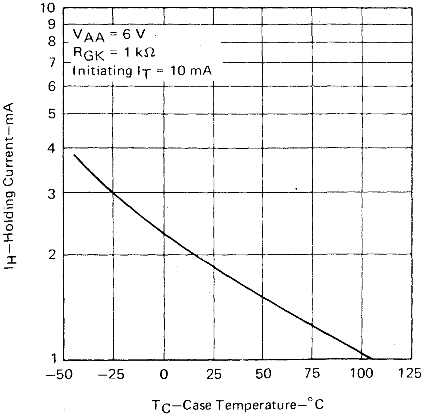


FIGURE 10

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

TYPICAL CHARACTERISTICS

PEAK ON-STATE VOLTAGE
vs
PEAK-ON-STATE CURRENT

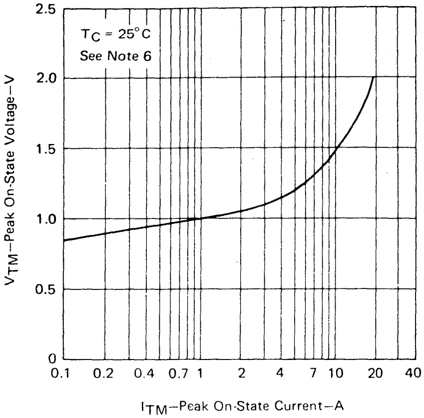


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

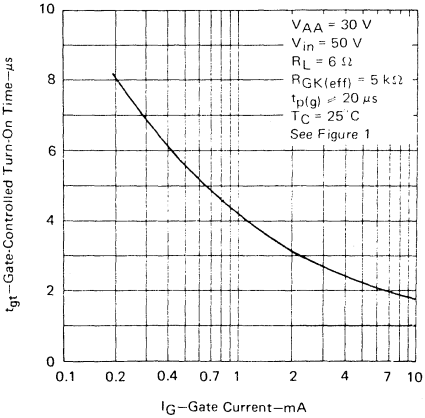


FIGURE 12

CIRCUIT-COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

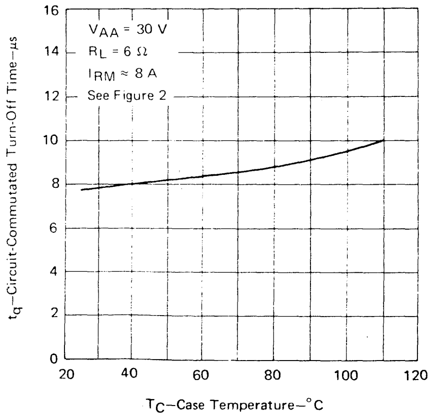


FIGURE 13

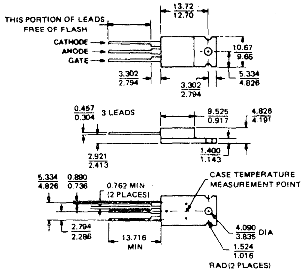
NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 0.125 inch from the device body.

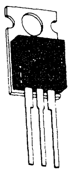
TIC116, TIC126
SILICON THYRISTORS

- GLASS-PASSIVATED WAFER
- 8 A and 12 A DC
- 80 A and 100 A Surge Current
- 50 V to 800 V
- MAX I_{GT} of 20 mA

mechanical data

THE ANODE IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB
THE GATE TERMINAL IS CONNECTED TO A P REGION





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings over operating case temperature range (unless otherwise noted)

		SERIES TIC116	SERIES TIC126	UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1) Repetitive Peak Reverse Voltage, V_{RRM}	F Suffix	50	50	V
	A Suffix	100	100	
	B Suffix	200	200	
	C Suffix	300	300	
	D Suffix	400	400	
	E Suffix	500	500	
	M Suffix	600	600	
	S Suffix	700	700	
	N Suffix	800	800	
Continuous On-State Current at (or below) 70°C Case Temperature (See Note 2)		8	12	A
Average On-State Current (180° Conduction Angle) at (or below) 70°C Case Temperature (See Note 3)		5	7.5	A
Surge On-State Current (See Note 4)		80	100	A
Peak Positive Gate Current (Pulse Width ≤ 300 μs)		3		A
Peak Gate Power Dissipation (Pulse Width ≤ 300 μs)		5		W
Average Gate Power Dissipation (See Note 5)		1		W
Operating Case Temperature Range		−40 to 110		°C
Storage Temperature Range		−40 to 125		°C
Lead Temperature 1.6 mm from Case for 10 Seconds		230		°C

NOTES:
1. These values apply when the gate-cathode resistance R_{GK} = 1 kΩ. When available, THYRISTORS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC116B (200V), TIC116D (400V) may be supplied.
2. These values apply for continuous d-c operation with resistive load. Above 70°C derate according to Figure 3.
3. This value may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 70°C derate according to Figure 3.
4. This value applies for one 60-Hz half sine wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SERIES	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_D = Rated V_{DRM}, R_{GK} = 1 kΩ, T_C = 110°C	All			2	mA
I_{RRM}	Repetitive Peak Reverse Current	V_R = Rated V_{RRM}, I_G = 0, T_C = 110°C	All			2	mA
I_{GT}	Gate Trigger Current	V_{AA} = 6 V, R_L = 100 Ω, $t_{p(g)} \geqslant 20\ \mu s$	All		5	20	mA
V_{GT}	Gate Trigger Voltage	V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geqslant 20\ \mu s$, T_C = −40°C	All			2.5	V
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geqslant 20\ \mu s$	All		0.8	1.5	
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geqslant 20\ \mu s$, T_C = 110°C	All	0.2			
I_H	Holding Current	V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 100 mA, T_C = −40°C	All			70	mA
		V_{AA} = 6 V, R_{GK} = 1 kΩ, Initiating I_T = 100 mA	All			40	
V_{TM}	Peak On-State Voltage	I_{TM} = 8 A, See Note 6	TIC116			1.7	V
		I_{TM} = 12 A, See Note 6	TIC126			1.4	
dv/dt	Critical Rate of Rise of Off-State Voltage	V_D = Rated V_D, I_G = 0, T_C = 110°C	All		100		V/µs

thermal characteristics

PARAMETER		SERIES TIC116	SERIES TIC126	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3	2.4	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	62.5	

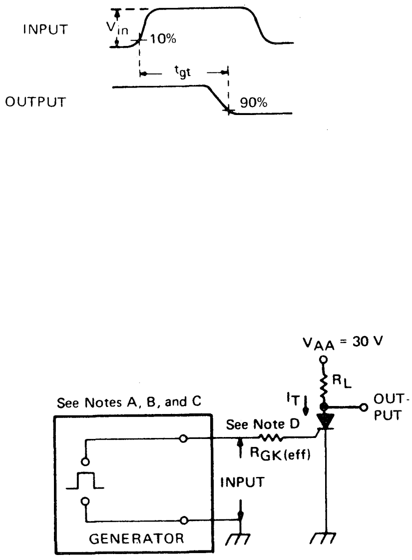
NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TYP	UNIT
t_{gt}	Gate-Controlled Turn-On Time	V_{AA} = 30 V, R_L = 6 Ω, $R_{GK(eff)}$ = 100 Ω, V_{in} = 20 V, See Figure 1	0.8	μs
t_q	Circuit-Commutated Turn-Off Time	V_{AA} = 30 V, R_L = 6 Ω, I_{RM} = 10 A, See Figure 2	11	μs

PARAMETER MEASUREMENT INFORMATION

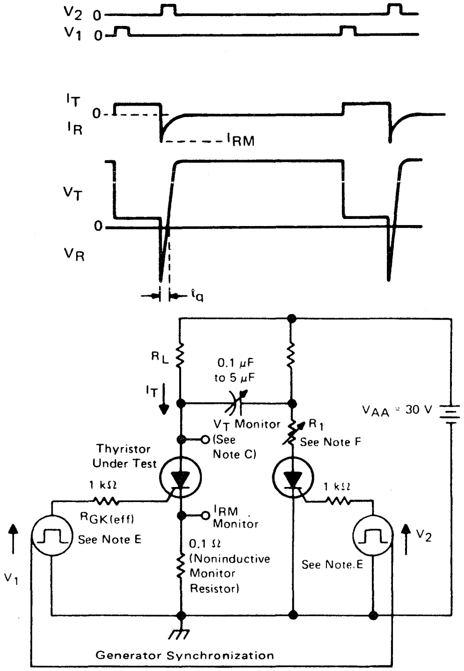
VOLTAGE WAVEFORMS



TEST CIRCUIT

FIGURE 1 – GATE-CONTROLLED TURN-ON TIME

WAVEFORMS



TEST CIRCUIT

FIGURE 2–CIRCUIT-COMMUTATED TURN-OFF TIME

NOTES:
A. V_{in} is measured with gate and cathode terminals open.
B. The input waveform of Figure 1 has the following characteristics: $t_r \leqslant 40$ ns, $t_w \geqslant 20$ μs.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 14$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 12$ pF.
D. $R_{GK(eff)}$ includes the total resistance of the generator and the external resistor.
E. Pulse generators for V_1 and V_2 are synchronized to provide an anode current waveform with the following characteristics: t_w = 50 to 300 μs, duty cycle = 1%. The pulse widths of V_1 and V_2 are $\geqslant 10$ μs.
F. Resistor R_1 is adjusted for $I_{RM} \approx 10$ A.

THERMAL INFORMATION

AVERAGE ON-STATE CURRENT DERATING CURVE

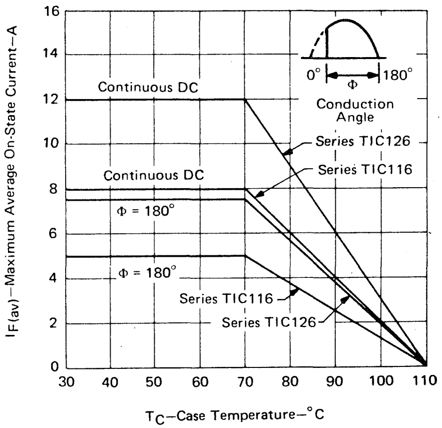


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ON-STATE CURRENT

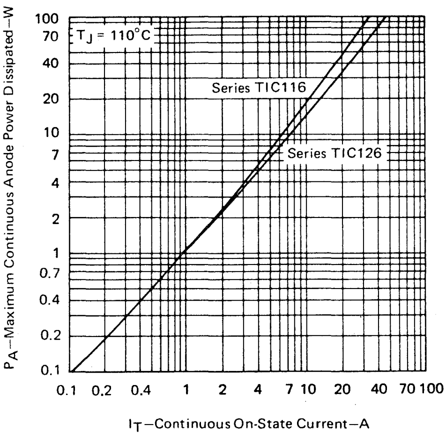


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

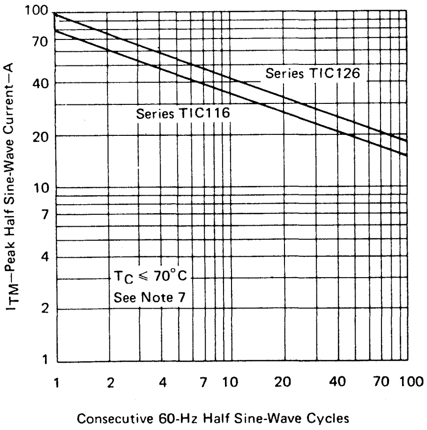


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

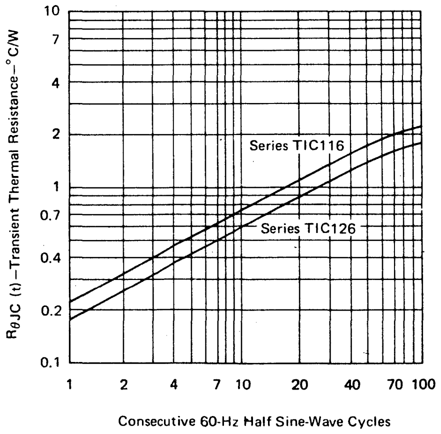


FIGURE 6

NOTE 7: This curve shows the maximum number of cycles of surge current for which gate control is guaranteed provided the device is initailly at nonoperating thermal equilibrium.

TYPICAL CHARACTERISTICS

GATE TRIGGER CURRENT
vs
CASE TEMPERATURE

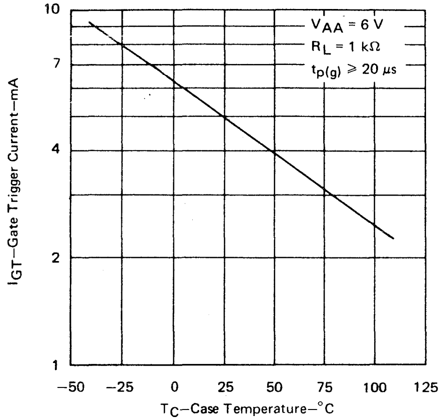


FIGURE 7

GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

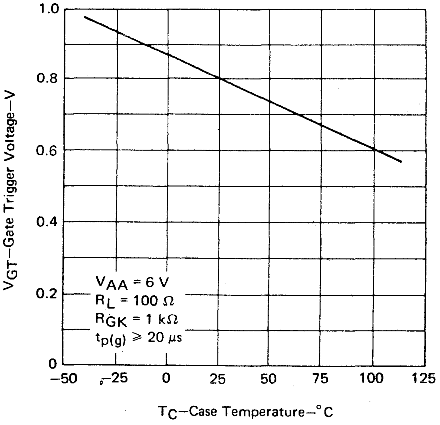


FIGURE 8

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

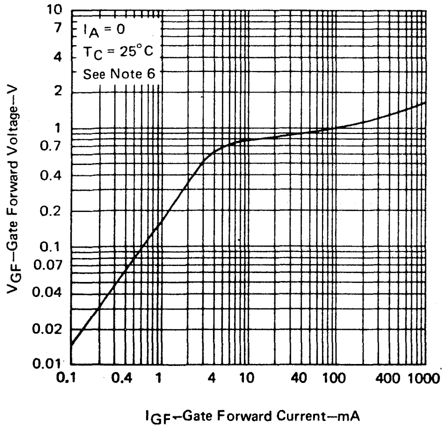


FIGURE 9

HOLDING CURRENT
vs
CASE TEMPERATURE

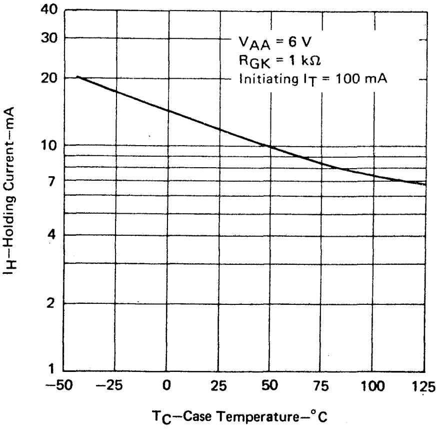


FIGURE 10

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

TYPICAL CHARACTERISTICS

PEAK ON-STATE VOLTAGE
vs
PEAK ON-STATE CURRENT

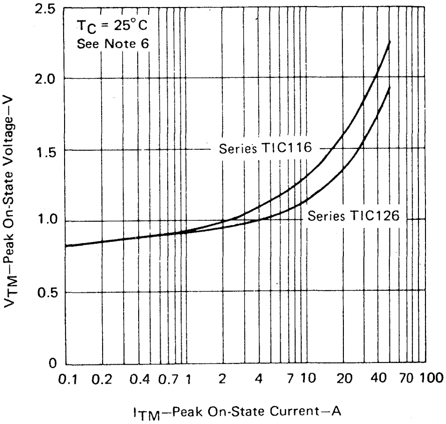


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

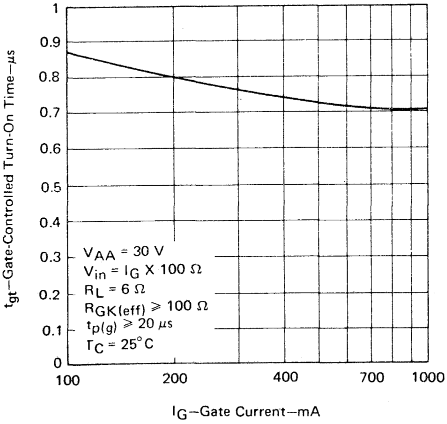


FIGURE 12

CIRCUIT-COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

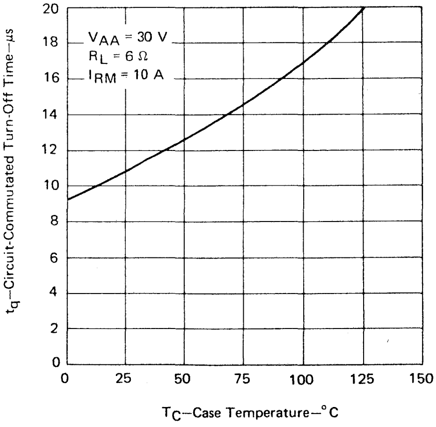


FIGURE 13

NOTE 6: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

TIC201
SILICON TRIACS

SENSITIVE-GATE TRIACS WITH GLASS-PASSIVATED WAFER

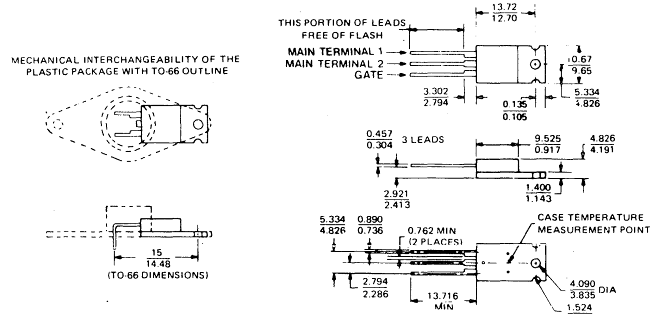
- 100 V to 800 V
- 2.5 A RMS
- MAX I_{GT} of 5 mA (Quadrant 1)

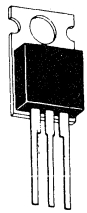
description

These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings over operating case temperature range (unless otherwise noted)

			UNIT
Repetitive Peak Off-State Voltage V_{DRM} (See Note 1)	TIC201A	100	V
	TIC201B	200	
	TIC201C	300	
	TIC201D	400	
	TIC201E	500	
	TIC201M	600	
	TIC201S	700	
	TIC201N	800	
Full-Cycle RMS On-State Current at (or below) 85°C Case Temp. $I_{T(RMS)}$ (See Note 2)		2.5	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		12	A
Peak On-State Surge Current, Half-Sine-Wave, I_{TSM} (See Note 4)		14	A
Peak Gate Current, I_{GM}		±0.2	A
Peak Gate Power Dissipation, P_{GM}, at (or below) 85°C Case Temp. (Pulse Width <200μs)		1.3	W
Average Gate Power Dissipation, $P_{G(av)}$, at (or below) 85°C Case Temp. (See Note 5)		0.3	W
Operating Case Temperature Range		–40 to 110	°C
Storage Temperature Range		–40 to 125	°C
Lead Temperature 3.2 mm from Case for 10 Seconds		230	°C

NOTES:
1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, TRIACS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC201D (400V), TIC201M (600V) may be supplied.
2. This value applies for 50-Hz full-sine-wave operation with resistive load. Above 85 °C derate linearly to 110 °C case temperature at the rate of 100 mA/°C.
3. This value applies for one 60-Hz full-sine-wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
4. This value applies for one 60-Hz half-sine-wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, $I_G = 0$, T_C =110 °C			± 1	mA
I_{GTM}	Peak Gate Trigger Current	V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			5	mA
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-8	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-10	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			25	mA
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		0.9	2.5	V
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-1.2	-2.5	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-1.2	-2.5	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		1.2		V
V_{TM}	Peak On-State Voltage	$I_{TM} = \pm 3.5A$, I_G = 50mA, See Note 6			±1.9	V
I_H	Holding Current	V_{supply} = +12V†, $I_G = 0$, Initiating I_{TM} 20mA			30	mA
		V_{supply} = -12V†, $I_G = 0$, Initiating I_{TM} = -20mA			-30	mA
I_L	Latching Current	V_{supply} = +12V†, See Note 7			40	mA
		V_{supply} = -12V†, See Note 7			-40	mA
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM}, $I_G = 0$, T_C = 110°C		50		V/μs
dv/dt	Critical Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, $I_{TRM} = \pm 3.5A$ T_C = 85°C	2			V/μs

† Supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES: 6. This parameter must be measured using pulse techniques. $t_w \leqslant 1$ ms, duty cycle $\leqslant 2\%$. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.

7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r < 15$ ns, f = 1 kHz.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	10	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

TIC2
SILICON TRIA

SENSITIVE-GATE TRIAC WITH GLASS-PASSIVATED WAFER

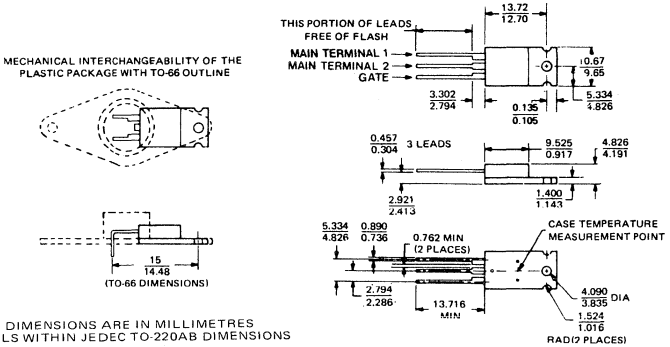
- 100 V to 800 V
- 4 A RMS
- MAX I_{GT} of 5 mA (Quadrants 1-3)

description

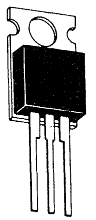
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted)

			UNIT
Repetitive Peak Off-State Voltage V_{DRM} (See Note 1)	TIC206A	100	V
	TIC206B	200	
	TIC206C	300	
	TIC206D	400	
	TIC206E	500	
	TIC206M	600	
	TIC206S	700	
	TIC206N	800	
Full-Cycle RMS On-State Current at (or below) 85°C Case Temp. $I_{T(RMS)}$ (See Note 2)		4	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		25	A
Peak On-State Surge Current, Half-Sine-Wave, I_{TSM} (See Note 4)		30	A
Peak Gate Current, I_{GM}		±0.2	A
Peak Gate Power Dissipation, P_{GM}, at (or below) 85°C Case Temp. (Pulse Width <200μs)		1.3	W
Average Gate Power Dissipation, $P_{G(av)}$, at (or below) 85°C Case Temp. (See Note 5)		0.3	W
Operating Case Temperature Range		–40 to 110	°C
Storage Temperature Range		–40 to 125	°C
Lead Temperature 3.2 mm from Case for 10 Seconds		230	°C

NOTES:
1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, TRIACS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC206B (200V), TIC206D (400V) may be supplied.
2. This value applies for 50-Hz full-sine-wave operation with resistive load. Above 85 °C derate linearly to 110 °C case temperature at the rate of 120 mA/°C.
3. This value applies for one 60-Hz full-sine-wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
4. This value applies for one 60-Hz half-sine-wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, $I_G = 0$, $T_C = 110^{o}C$			±1	mA
I_{GTM}	Peak Gate Trigger Current	$V_{supply} = +12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			5	mA
		$V_{supply} = +12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-5	mA
		$V_{supply} = -12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-5	mA
		$V_{supply} = -12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			10	mA
V_{GTM}	Peak Gate Trigger Voltage	$V_{supply} = +12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		0.9	2	V
		$V_{supply} = +12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-1.2	-2	V
		$V_{supply} = -12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-1.2	-2	V
		$V_{supply} = -12V^{\dagger}$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		1.2	2	V
V_{TM}	Peak On-State Voltage	$I_{TM} = \pm 4.2A$, $I_G = 50mA$, See Note 6			±2.2	V
I_H	Holding Current	$V_{supply} = +12V^{\dagger}$, $I_G = 0$, Initiating $I_{TM} = 100$ mA			30	mA
		$V_{supply} = -12V^{\dagger}$, $I_G = 0$, Initiating $I_{TM} = -100$ mA			-30	mA
I_L	Latching Current	$V_{supply} = +12V^{\dagger}$, See Note 7			40	mA
		$V_{supply} = -12V^{\dagger}$, See Note 7			-40	mA
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM}, $I_G = 0$, $T_C = 110^{o}C$		50		V/μs
dv/dt	Critical Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, $I_{TRM} = \pm 4.2A$ $T_C = 85^{o}C$	2			V/μs

† Supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES: 6. This parameter must be measured using pulse techniques. $t_w \leqslant 1$ ms, duty cycle $\leqslant 2\%$. Voltage-sensing contacts, separate from the the current-carrying contacts, are located within 3.2 mm from the device body.

7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r < 15$ ns, f = 1 kHz.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	7.8	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

TIC216
SILICON TRIACS

6 Amp sensitive-gate triac with glass-passivated wafer for power control with resistive and inductive loads

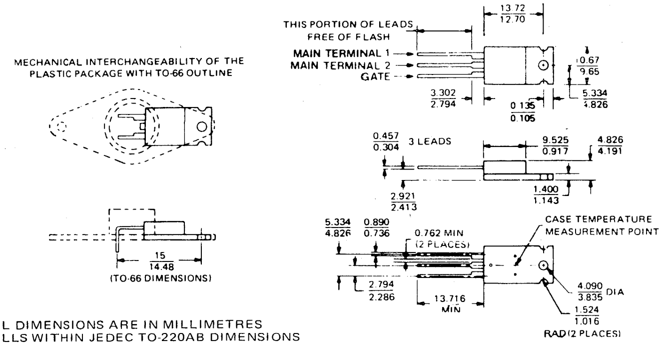
- 100 V to 800 V
- 6A RMS, 70A Peak
- MAX I_{GT} of 5 mA (Quadrants 1 - 3)
- Typ. dv/dt of 50 V/μs

description

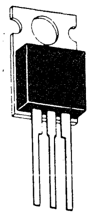
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted)

			UNIT
Repetitive Peak Off-State Voltage V_{DRM} (See Note 1)	TIC216A	±100	V
	TIC216B	±200	
	TIC216C	±300	
	TIC216D	±400	
	TIC216E	±500	
	TIC216M	±600	
	TIC216S	±700	
	TIC216N	±800	
Full-Cycle RMS On-State Current at (or below) 70°C Case Temp. $I_{T\ (RMS)}$ (See Note 2)		6	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		60	A
Peak On-State Surge Current, Half-Sine-Wave, I_{TSM} (See Note 4)		70	A
Peak Gate Current, I_{GM}		1	A
Peak Gate Power Dissipation, P_{GM}, at (or below) 70°C Case Temp. (Pulse Width <200μs)		2.2	W
Average Gate Power Dissipation, $P_{G\ (av)}$, at (or below) 70°C Case Temp. (See Note 5)		0.9	W
Operating Case Temperature Range		−40 to 110	°C
Storage Temperature Range		−40 to 125	°C
Lead Temperature 1.6 mm from Case for 10 Seconds		230	°C

NOTES:
1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, triacs of highe voltage than ordered may be supplied without extra charge. For example, against an order for TIC216B (200V), TIC216D(400V may be supplied.
2. This value applies for 50 Hz full-sine-wave operation with resistive load. Above 70°C derate linearly to 110°C case temperature at th rate of 150mW/°C.
3. This value applies for one 60 Hz full-sine-wave when the device is operating at (or below) the rated value of on-state current. Surg may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
4. This value applies for one 60 Hz half-sine-wave when the device is operating at (or below) the rated value of on-state current. Surg may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, $I_G = 0$ $T_C = 110^oC$			±2	mA
I_{GTM}	Peak Gate Trigger Current	V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			5	mA
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			−5	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			−5	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			10	mA
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			2.2	V
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-2.2	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			-2.2	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			3	V
V_{TM}	Peak On-State Voltage	I_{TM} = 8.4A, I_G = 50mA, See Note 6			± 1.7	mA
I_H	Holding Current	V_{supply} = +12V†, $I_G = 0$, Initiating I_{TM} = 100 mA			30	mA
		V_{supply} = -12V†, $I_G = 0$, Initiating I_{TM} = −100 mA			-30	mA
I_L	Latching Current	V_{supply} = +12V†, See Note 7		50		mA
		V_{supply} = -12V†, See Note 7		-20		mA
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM}, $I_G = 0$, $T_C = 110^oC$		50		V/μs
dv/dt	Critical Rate of Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, I_{TRM} = ±8.4A, $T_C = 70^oC$	5			V/μs

†The supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES:

6. This parameter must be measured using pulse techniques $t_w \leqslant 1$ ms, duty cycle $\leqslant 2$ %. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.
7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\Omega$, $t_w = 20\mu s$, $t_r < 15$ns, f = 1 kHz, $t_f \leqslant 15$ns.

Thermal characteristics

	PARAMETERS	MAX	UNIT
$R_{\theta\ JC}$	Junction-to-Case Thermal Resistance	2.5	°C/W
$R_{\theta\ JC}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

TIC22
SILICON TRIAC

8 Amp sensitive-gate triac with glass-passivated wafer for power control with resistive and inductive loads

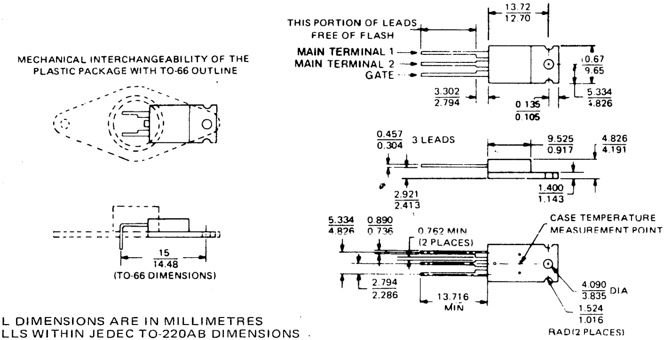
- 100 V to 800 V
- 8A RMS, 70A Peak
- MAX I_{GT} of 5 mA (Quadrant 1)
- Typ dv/dt of 50 V/μs

description

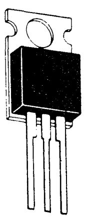
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted)

			UNIT
Repetitive Peak Off-State Voltage V_{DRM} (See Note 1)	TIC225A	±100	V
	TIC225B	±200	
	TIC225C	±300	
	TIC225D	±400	
	TIC225E	±500	
	TIC225M	±600	
	TIC225S	±700	
	TIC225N	±800	
Full-Cycle RMS On-State Current at (or below) 70°C Case Temp. $I_{T(RMS)}$ (See Note 2)		8	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		70	A
Peak On-State Surge Current, Half-Sine-Wave, I_{TSM} (See Note 4)		80	A
Peak Gate Current, I_{GM}		1	A
Peak Gate Power Dissipation, P_{GM}, at (or below) 70°C Case Temp. (Pulse Width <200μs)		2.2	W
Average Gate Power Dissipation, $P_{G(av)}$, at (or below) 70°C Case Temp. (See Note 5)		0.9	W
Operating Case Temperature Range		–40 to 110	°C
Storage Temperature Range		–40 to 125	°C
Lead Temperature 1.6 mm from Case for 10 Seconds		230	°C

NOTES:
1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, triacs of high voltage than ordered may be supplied without extra charge. For example, against an order for TIC225B (200V), TIC225D (400 may be supplied.
2. This value applies for 50 Hz full-sine-wave operation with resistive load. Above 70°C derate linearly to 110°C case temperature at t rate of 200 mA/°C. Figure 2.
3. This value applies for one 60 Hz full-sine-wave when the device is operating at (or below) the rated value of on-state current. Sur may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
4. This value applies for one 60 Hz half-sine-wave when the device is operating at (or below) the rated value of on-state current. Sur may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
5. This value applies for a maximum averaging time of 16.6 ms.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, $I_G = 0$ T_C = 110°C			±2	mA
I_{GTM}	Peak Gate Trigger Current	V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			5	mA
		V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			-10	mA
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			-10	mA
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			15	mA
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			2.2	V
		V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			-2.2	V
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			-2.2	V
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$			3	V
V_{TM}	Peak On-State Voltage	I_{TM} = ±12A, I_G = 50mA, See Note 6			±2.1	V
I_H	Holding Current	V_{supply} = +12V†, $I_G = 0$, Initiating I_{TM} = 20mA			30	mA
		V_{supply} = -12V†, $I_G = 0$, Initiating I_{TM} = -20mA			-30	mA
I_L	Latching Current	V_{supply} = +12V†, See Note 7		50		mA
		V_{supply} = -12V†, See Note 7		-20		mA
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM}, $I_G = 0$, T_C = 110°C		50		V/µs
dv/dt	Critical Rate of Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, I_{TRM} = ±12A, T_C = 70°C	5			V/µs

†The supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES:

6. This parameter must be measured using pulse techniques $t_w \leqslant 1$ ms, duty cycle $\leqslant 2$ %. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.
7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\Omega$, $t_w = 20\mu s$, $t_r < 15ns$, f = 1 kHz, $t_f \leqslant 15ns$.

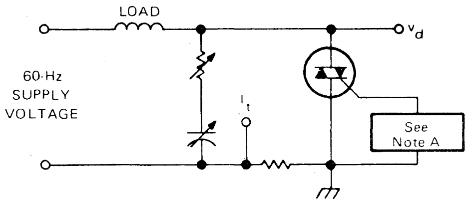
thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2.5	°C/W
$R_{\theta JC}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

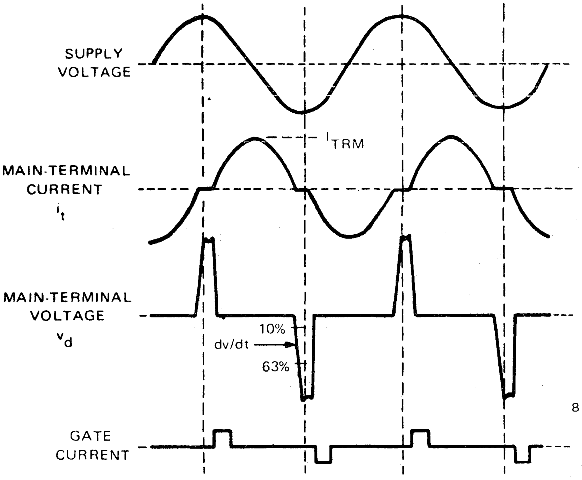
PARAMETER MEASUREMENT INFORMATION

The rate of rise of commutation voltage is defined as the slope of the line connecting the 10 % and 63 % test voltage points.

The critical rate of rise of commutation voltage is the rate above which the device will not sustain the off-state following conduction but will conduct current in the opposite direction in the absence of a gate-trigger signal. While this failure to switch to the off-state is not detrimental to the thyristor, it does result in loss of control of power to the load.



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1—COMMUTATING dv/dt

THERMAL INFORMATION

MAXIMUM RMS ON-STATE CURRENT
vs
CASE TEMPERATURE

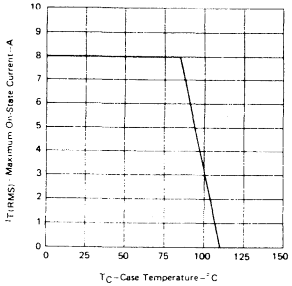


FIGURE 2

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

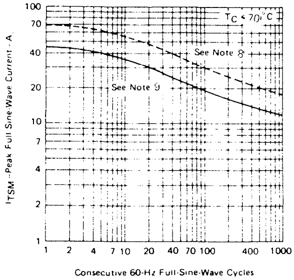


FIGURE 3

NOTES:

8 The dashed curve shows the maximum number o cycles of surge current recommended for safe opera tion provided the device is initially operating at, o below, the rated value of on-state current; however during the surge period gate control of the device ma be lost.

9 The solid curve shows the maximum number of cycle of surge current for which gate control is guarantee provided the device is initially at nonoperating therma equilibrium.

NOTE A: The gate-current pulse is furnished by a trigger circuit which presents essentially an open circuit between pulses. The pulse is time so that the off-state-voltage duration is approximately 800 μs.

TIC226
SILICON TRIACS

8 AMP TRIAC WITH GLASS-PASSIVATED WAFER FOR POWER CONTROL WITH RESISTIVE AND INDUCTIVE LOADS

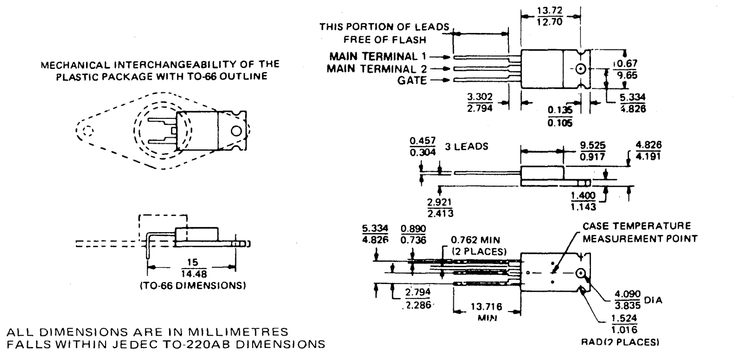
- 100 V to 800 V
- 8 A RMS, 70 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)
- Typ dv/dt of 500 V/μs

description

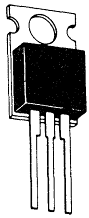
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted) *

			UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	TIC226A	100	V
	TIC226B	200	
	TIC226C	300	
	TIC226D	400	
	TIC226E	500	
	TIC226M	600	
	TIC226S	700	
	TIC226N	800	
Full-Cycle RMS On-State Current at (or below) 85°C Case Temperature, $I_{T(RMS)}$ (See Note 2)		8	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		70	A
Peak On-State Surge Current, Half-Sine-Wave, I_{TSM} (See Note 4)		80	A
Peak Gate Current, I_{GM}		1	A
Peak Gate Power Dissipation, P_{GM}, at (or below) 85°C Case Temperature (Pulse Width ≤ 200 μs)		2.2	W
Average Gate Power Dissipation, $P_{G(av)}$, at (or below) 85°C Case Temperature (See Note 5)		0.9	W
Operating Case Temperature Range		−40 to 110	°C
Storage Temperature Range		−40 to 125	°C
Lead Temperature 1.6 mm from Case for 10 Seconds		230	°C

NOTES: 1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, TRIACS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC226B (200V), TIC226D (400V) may be supplied.

2. This value applies for 50-Hz to 60-Hz full-sine-wave operation with resistive load. Above 85°C derate according to Figure 2.
3. This value applies for one 60-Hz full sine wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
4. This value applies for one 60-Hz half sine wave when the device is operating at (or below) the rated value of on-state current. Surge may be repeated after the device has returned to original thermal equilibrium. During the surge, gate control may be lost.
5. This value applies for a maximum averaging time of 16.6 ms.

* All voltage values are with respect to Main Terminal 1.

TIC226
SILICON TRIACS

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM},	$I_G = 0$	$T_C = 110°C$			±2	mA
I_{GTM}	Peak Gate Trigger Current	$V_{supply} = +12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		15	50	mA
		$V_{supply} = +12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		−25	−50	
		$V_{supply} = -12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		−30	−50	
		$V_{supply} = -12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		75		
V_{GTM}	Peak Gate Trigger Voltage	$V_{supply} = +12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		0.9	2.5	V
		$V_{supply} = +12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		−1.2	−2.5	
		$V_{supply} = -12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		−1.2	−2.5	
		$V_{supply} = -12\ V†$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geq 20\ \mu s$		1.2		
V_{TM}	Peak On-State Voltage	$I_{TM} = \pm 12\ A$,	$I_G = 100\ mA$,	See Note 6			±2.1	V
I_H	Holding Current	$V_{supply} = +12\ V†$,	$I_G = 0$,	Initiating $I_{TM} = 500\ mA$		20	60	mA
		$V_{supply} = -12\ V†$,	$I_G = 0$,	Initiating $I_{TM} = -500\ mA$		−30	−60	
I_L	Latching Current	$V_{supply} = +12\ V†$,	See Note 7			30	70	mA
		$V_{supply} = -12\ V†$,	See Note 7			−40	−70	
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM},	$I_G = 0$,	$T_C = 110°C$		500		V/µs
dv/dt	Critical Rate of Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, $I_{TRM} = \pm 12\ A$, $T_C = 85°C$, See Figure 3			5			V/µs

†The supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES: 6. This parameter must be measured using pulse techniques. $t_w \leq 1$ ms, duty cycle $\leq 2\%$. Voltage-sensing contacts, separate from th current-carrying contacts, are located within 3.2mm from the device body.

7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r \leq 15$ ns, $t_f \leq 15$ ns, f = 1 kHz.

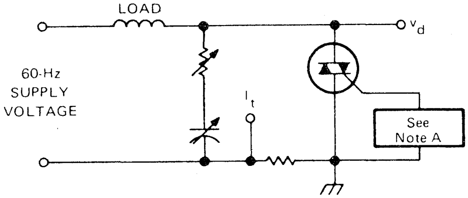
thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1,8	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

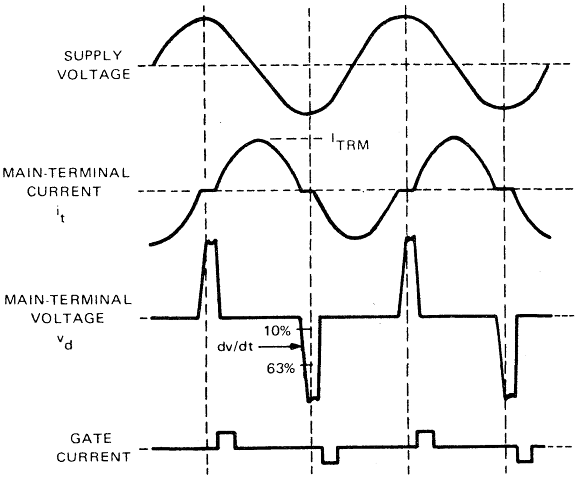
PARAMETER MEASUREMENT INFORMATION

The rate of rise of commutation voltage is defined as the slope of the line connecting the 10% and 63% test voltage points.

The critical rate of rise of commutation voltage is the rate above which the device will not sustain the off-state following conduction but will conduct current in the opposite direction in the absence of a gate-trigger signal. While this failure to switch to the off-state is not detrimental to the thyristor, it does result in loss of control of power to the load.



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1—COMMUTATING dv/dt

NOTE A: The gate-current pulse is furnished by a trigger circuit which presents essentially an open circuit between pulses. The pulse is timed so that the off-state-voltage duration is approximately 800 μs.

THERMAL INFORMATION

MAXIMUM RMS ON-STATE CURRENT
vs
CASE TEMPERATURE

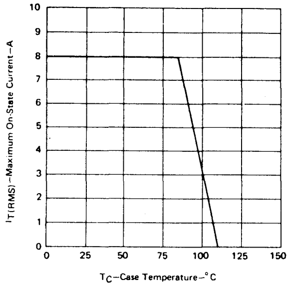


FIGURE 2

MAXIMUM AVERAGE POWER DISSIPATED
vs
RMS ON-STATE CURRENT

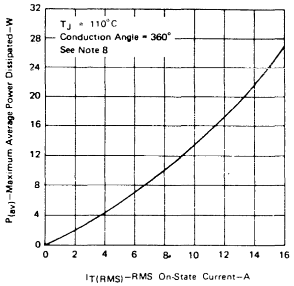


FIGURE 3

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

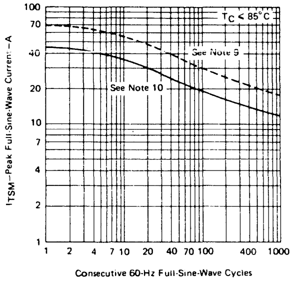


FIGURE 4

NOTES: 8. For operation at current greater than 8 amps rms, see Figure 4.

9. The dashed curve shows the maximum number of cycles of surge current recommended for safe operation provided the device is initially operating at, or below, the rated value of on-state current; however, during the surge period gate control of the device may be lost.

10. The solid curve shows the maximum number of cycles of surge current for which gate control is guaranteed provided the device is initially at nonoperating thermal equilibrium.

TYPICAL CHARACTERISTICS

PEAK GATE TRIGGER CURRENT
vs
CASE TEMPERATURE

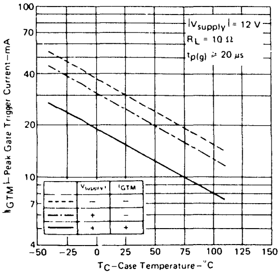


FIGURE 5

PEAK GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

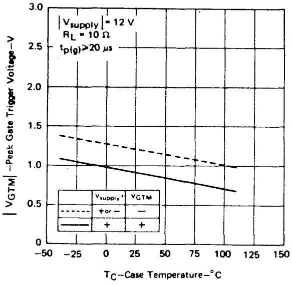


FIGURE 6

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† The supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

TIC236, TIC246
SILICON TRIACS

HIGH-CURRENT TRIACS WITH GLASS-PASSIVATED WAFER

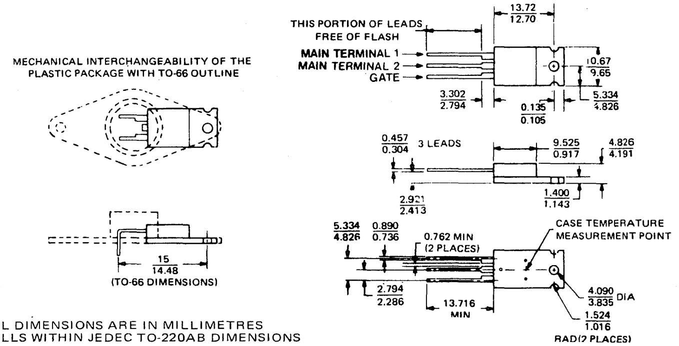
- 100 V to 800 V
- 12 A and 16 A RMS, 100 A and 125 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)

description

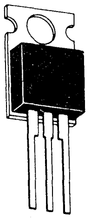
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

THE MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings over operating case temperature range (unless otherwise noted)

		SERIES TIC236	SERIES TIC246	UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	A Suffix	100	100	V
	B Suffix	200	200	
	C Suffix	300	300	
	D Suffix	400	400	
	E Suffix	500	500	
	M Suffix	600	600	
	S Suffix	700	700	
	N Suffix	800	800	
Full-Cycle RMS On-State Current at (or below) 70°C Case Temperature, $I_{T(RMS)}$ (See Note 2)		12	16	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 2)		100	125	A
Peak Gate Current, I_{GM}		±1	±1	A
Operating Case Temperature Range		−40 to 110		°C
Storage Temperature Range		−40 to 125		°C
Terminal Temperature 1,6 mm from Case for 10 Seconds		230		°C

NOTES:
1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, TRIACS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC236B (200V), TIC236 (400V) may be supplied.
2. This value applies for 50-Hz full-sine-wave operation with resistive load. Above 70°C derate linearly to 110°C case temperature at the rate of 300 mA/°C for Series TIC236 and 400 mA/°C for Series TIC 246.
3. This value applies for one 60-Hz full-sine-wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.

electrical characteristics at 25°C case temperature (unless otherwise noted)[†]

PARAMETER		TEST CONDITIONS	SERIES TIC236			SERIES TIC246			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, I_G = 0, T_C = 110°C			±2			±2	mA
I_{GTM}	Peak Gate Trigger Current	V_{supply} = +12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		15	50		15	50	mA
		V_{supply} = +12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		−25	−50		−25	−50	
		V_{supply} = −12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		−30	−50		−30	−50	
		V_{supply} = −12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		75			75		
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = +12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		1.2	2.5		1.2	2.5	V
		V_{supply} = +12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		−1.2	−2.5		−1.2	−2.5	
		V_{supply} = −12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		−1.2	−2.5		−1.2	−2.5	
		V_{supply} = −12 V[†], R_L = 10 Ω, $t_{p(g)} \geqslant 20\ \mu s$		1.2			1.2		
V_{TM}	Peak On-State Voltage	I_{TM} = ±17 A, I_G = 100 mA, See Note 4			±2.1				V
		I_{TM} = ±22.5 A, I_G = 100 mA, See Note 4						±1.7	
I_H	Holding Current	V_{supply} = +12 V[†], I_G = 0, Initiating I_{TM} = 150 mA			50			50	mA
		V_{supply} = −12 V[†], I_G = 0, Initiating I_{TM} = −150 mA			−50			−50	
I_L	Latching Current	V_{supply} = +12 V[†], See Note 5		20			20		mA
		V_{supply} = −12 V[†], See Note 5		−20			−20		

[†] All voltage values are with respect to Main Terminal 1.

NOTES: 4. This parameter must be measured using pulse techniques. $t_w \leqslant 1$ ms, duty cycle $\leqslant 2\%$. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.

5. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: R_G = 100 Ω, t_w = 20 μs, $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, f = 1 kHz.

thermal characteristics

PARAMETER		SERIES TIC236	SERIES TIC246	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2	1.9	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	62.5	

TIC253, TIC263
SILICON TRIACS

HIGH-CURRENT TRIACS WITH GLASS-PASSIVATED WAFER

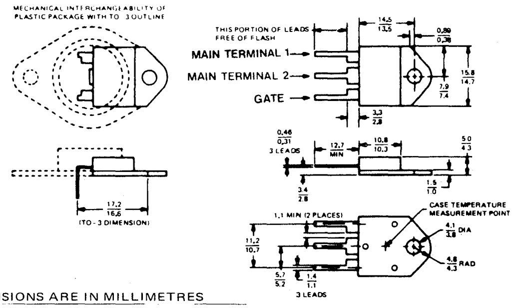
- 100 V to 800 V
- 20 A and 25 A RMS, 100 and 175 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)

description

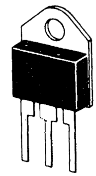
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

MAIN TERMINAL 2 IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings over operating case temperature range (unless otherwise noted)

		SERIES TIC253	SERIES TIC263	UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	A Suffix	100	100	V
	B Suffix	200	200	
	C Suffix	300	300	
	D Suffix	400	400	
	E Suffix	500	500	
	M Suffix	600	600	
	S Suffix	700	700	
	N Suffix	800	800	
Full-Cycle RMS On-State Current at (or below) 70°C Case Temperature, $I_{T(RMS)}$ (See Note 2)		20	25	A
Peak On-State Surge Current, Full-Sine-Wave, I_{TSM} (See Note 3)		150	175	A
Peak Gate Current, I_{GM}		±1	±1	A
Operating Case Temperature Range		−40 to 110		°C
Storage Temperature Range		−40 to 125		°C
Terminal Temperature 1,6 mm from Case for 10 Seconds		230		°C

NOTES: 1. These values apply bidirectionally for any value of resistance between the gate and Main Terminal 1. When available, TRIACS of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC253B (200V), TIC253D (400V) may be supplied.

2. This value applies for 50-Hz full-sine-wave operation with resistive load. Above 70°C derate linearly to 110°C case temperature at the rate of 500 mA/°C for Series TIC253 and 625 mA/°C for Series TIC263.

3. This value applies for one 60-Hz full sine wave when the device is operating at (or below) rated values of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.

electrical characteristics at 25°C case temperature (unless otherwise noted)†

PARAMETER		TEST CONDITIONS			SERIES TIC253			SERIES TIC263			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
I_{DRM}	Repetitive Peak Off-State Current	V_{DRM} = Rated V_{DRM}, $I_G = 0$		T_C = 110°C			±2			±2	mA
I_{GTM}	Peak Gate Trigger Current	$V_{supply} = +12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			50			50	mA
		$V_{supply} = +12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			−50			−50	
		$V_{supply} = -12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			−50			−50	
		$V_{supply} = -12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$		50			50		
V_{GTM}	Peak Gate Trigger Voltage	$V_{supply} = +12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			2.5			2.5	V
		$V_{supply} = +12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			−2.5			−2.5	
		$V_{supply} = -12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$			−2.5			−2.5	
		$V_{supply} = -12\ V^{\dagger}$,	$R_L = 10\ \Omega$,	$t_{p(g)} \geqslant 20\ \mu s$		1.2			1.2		
V_{TM}	Peak On-State Voltage	$I_{TM} = \pm 28.2$ A,	I_G = 100 mA,	See Note 4			±1.7				V
		I_{TM} = 35.2 A,	I_G = 100 mA,	See Note 4						±1.7	
I_H	Holding Current	$V_{supply} = +12\ V^{\dagger}$,	$I_G = 0$,	Initiating I_{TM} = 100 mA			50			50	mA
		$V_{supply} = -12\ V^{\dagger}$,	$I_G = 0$,	Initiating I_{RM} = −100 mA			−50			−50	
I_L	Latching Current	$V_{supply} = +12\ V^{\dagger}$,	See Note 5			20			20		mA
		$V_{supply} = -12\ V^{\dagger}$,	See Note 5			−20			−20		

†All voltage values are with respect to Main Terminal 1.

NOTES: 4. This parameter must be measured using pulse techniques. $t_w \leqslant 1$ ms, duty cycle $\leqslant 2\%$. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.175 mm from the device body.

5. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, f = 1 kHz.

thermal characteristics

PARAMETER		SERIES TIC253	SERIES TIC263	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.52	1.22	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	36	36	

TIP29,TIP29A,TIP29B,TIP29C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

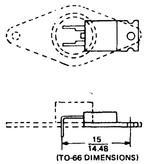
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP30, TIP30A, TIP30B, TIP30C

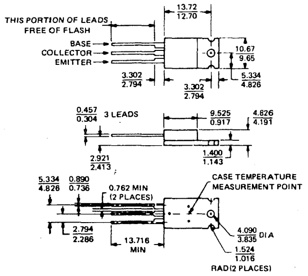
- **30 W at 25° C Case Temperature**
- **1 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 200 mA**

mechanical data

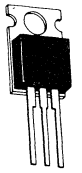
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB

MECHANICAL INTERCHANGEABILITY OF THE PLASTIC PACKAGE WITH TO-66 OUTLINE





ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP29	TIP29A	TIP29B	TIP29C
Collector-Base Voltage	40 V	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V	100 V
Emitter-Base Voltage	◄——— 5 V ———►			
Continuous Collector Current	◄——— 1 A ———►			
Peak Collector Current (See Note 2)	◄——— 3 A ———►			
Continuous Base Current	◄——— 0.4 A ———►			
Safe Operating Region at (or below) 25°C Case Temperature	◄——— See Figure 5 ———►			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄——— 30 W ———►			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄——— 2 W ———►			
Unclamped Inductive Load Energy (See Note 5)	◄——— 32 mJ ———►			
Operating Collector Junction Temperature Range	◄——— −65°C to 150°C ———►			
Storage Temperature Range	◄——— −65°C to 150°C ———►			
Lead Temperature 3.2mm from Case for 10 Seconds	◄——— 260°C ———►			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.24 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP29, TIP29A, TIP29B, TIP29C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP29		TIP29A		TIP29B		TIP29C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	40		60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		0.3		0.3					mA
		V_{CE} = 60 V, I_B = 0						0.3		0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = 40 V, V_{BE} = 0		0.2							mA
		V_{CE} = 60 V, V_{BE} = 0				0.2					
		V_{CE} = 80 V, V_{BE} = 0						0.2			
		V_{CE} = 100 V, V_{BE} = 0								0.2	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 0.2 A, See Notes 6 and 7	40		40		40		40		
		V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7	15	75	15	75	15	75	15	75	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7		1.3		1.3		1.3		1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 125 mA, I_C = 1 A, See Notes 6 and 7		0.7		0.7		0.7		0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.2 A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.2 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

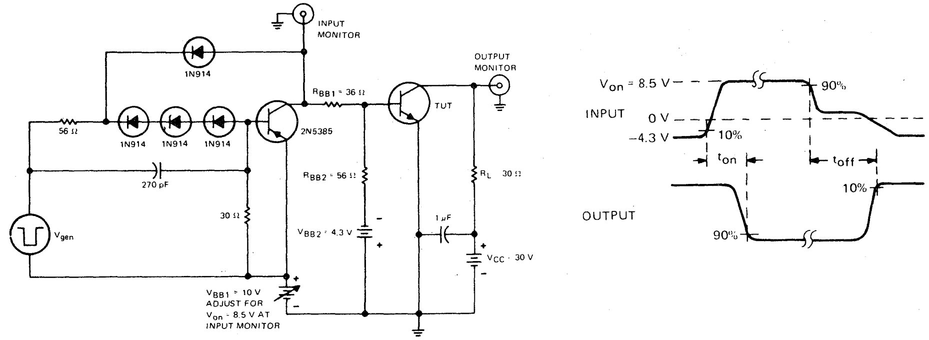
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 1 A, $I_{B(1)}$ = 100 mA, $I_{B(2)}$ = −100 mA,	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.3 V, R_L = 30 Ω, See Figure 1	2	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

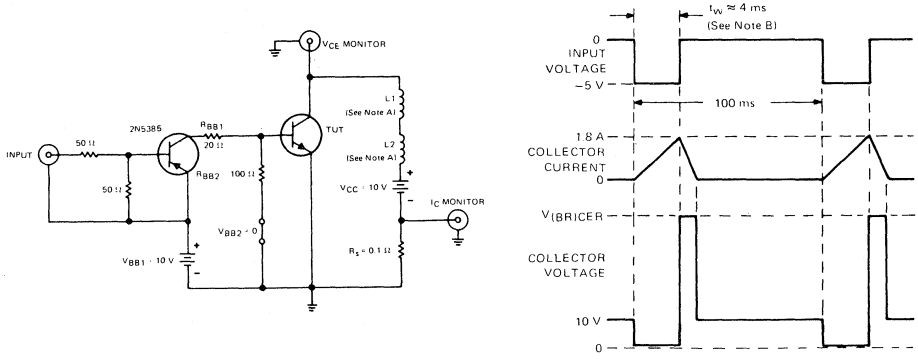
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = 1.8$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

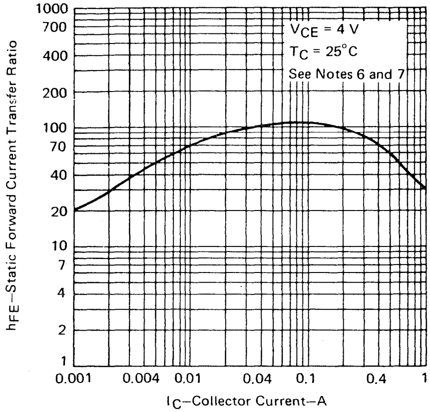


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

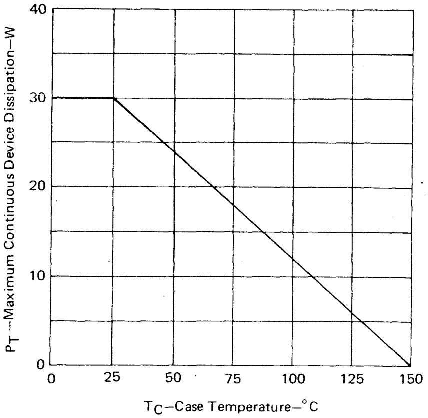


FIGURE 4

MAXIMUM SAFE OPERATING REGION

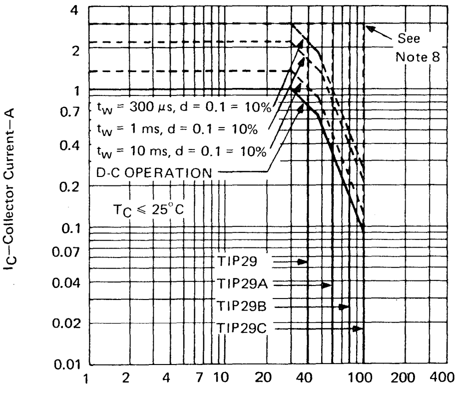


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

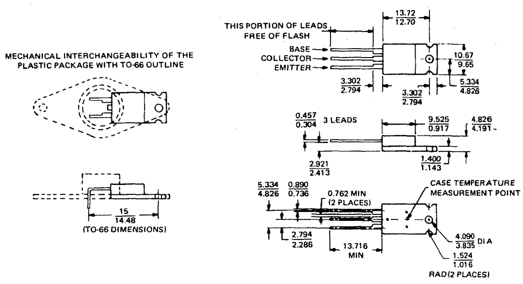
TIP30,TIP30A,TIP30B,TIP30C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

For Power-Amplifier and High-Speed-Switching Applications
Designed for Complementary use with TIP29, TIP29A, TIP29B, TIP29C

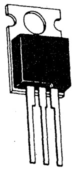
- **30W at 25°C Case Temperature**
- **1A Rated Collector Current**
- **Min f_T of 3MHz at 10V, 200mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP30	TIP30A	TIP30B	TIP30C
Collector-Base Voltage	−40 V	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	◄ −5 V ►			
Continuous Collector Current	◄ −1 A ►			
Peak Collector Current (See Note 2)	◄ −3 A ►			
Continuous Base Current	◄ −0.4 A ►			
Safe Operating Region at (or below) 25°C Case Temperature	◄ See Figure 5 ►			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄ 30 W ►			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄ 2 W ►			
Unclamped Inductive Load Energy (See Note 5)	◄ 32 mJ ►			
Operating Collector Junction Temperature Range	◄ −65°C to 150°C ►			
Storage Temperature Range	◄ −65°C to 150°C ►			
Lead Temperature 3.2mm from Case for 10 Seconds	◄ 260°C ►			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 150°C case temperature at the rate of 0.24 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP30,TIP30A,TIP30B,TIP30C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP30		TIP30A		TIP30B		TIP30C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−40		−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.3		−0.3					mA
		$V_{CE} = -60$ V, $I_B = 0$						−0.3		−0.3	
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 0$		−0.2							mA
		$V_{CE} = -60$ V, $V_{BE} = 0$				−0.2					
		$V_{CE} = -80$ V, $V_{BE} = 0$						−0.2			
		$V_{CE} = -100$ V, $V_{BE} = 0$								−0.2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -0.2$ A, See Notes 6 and 7	40		40		40		40		
		$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 6 and 7	15	75	15	75	15	75	15	75	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 6 and 7		−1.3		−1.3		−1.3		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -125$ mA, $I_C = -1$ A, See Notes 6 and 7		−0.7		−0.7		−0.7		−0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.2$ A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.2$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

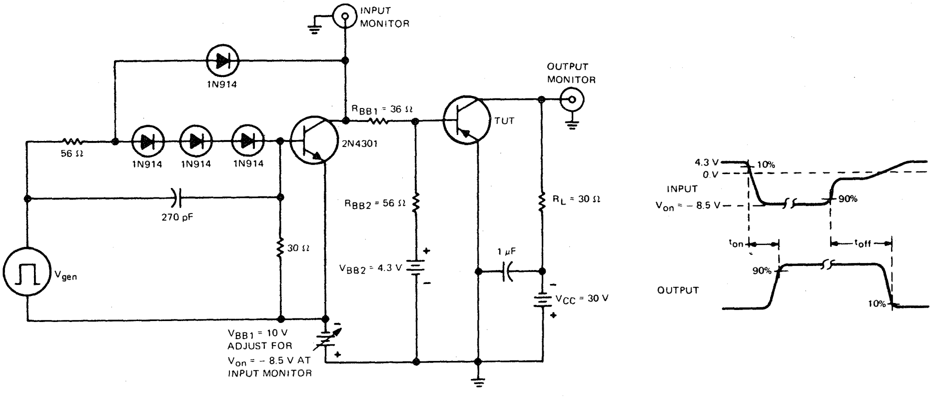
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -1$ A, $I_{B(1)} = -100$ mA, $I_{B(2)} = 100$ mA,	0.3	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.3$ V, $R_L = 30\ \Omega$, See Figure 1	1.0	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



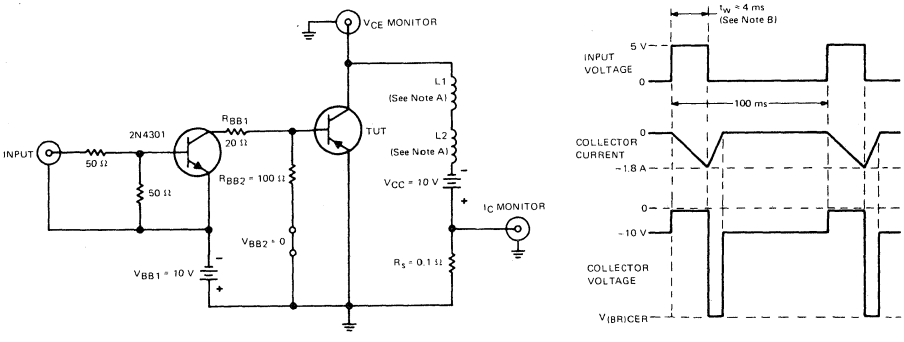
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES:
A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
B. Input pulse width is increased until $I_{CM} = -1.8$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

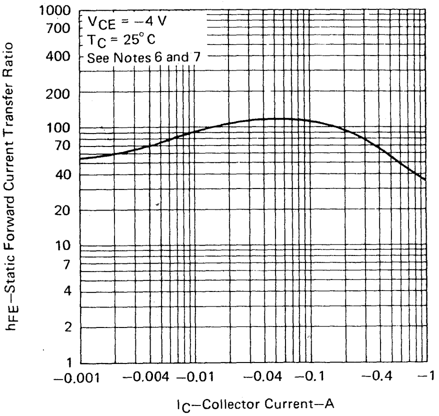


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

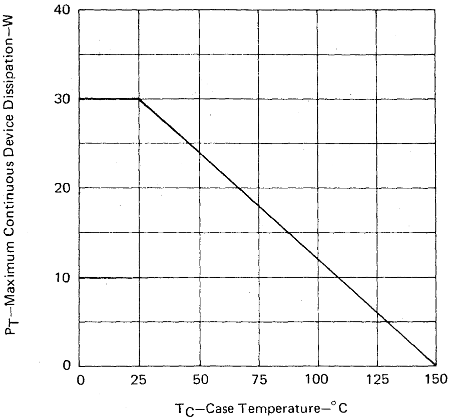


FIGURE 4

MAXIMUM SAFE OPERATING REGION

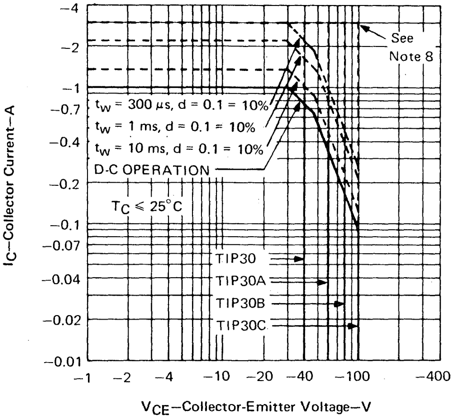


FIGURE 5

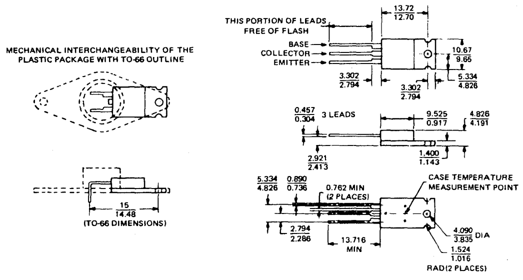
NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

TIP31,TIP31A,TIP31B,TIP31C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

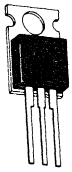
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP32, TIP32A, TIP32B, TIP32C

- **40 W at 25°C Case Temperature**
- **3 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 500 mA**

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP31	TIP31A	TIP31B	TIP31C
Collector-Base Voltage	40 V	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V	100 V
Emitter-Base Voltage	◄ 5 V ►			
Continuous Collector Current	◄ 3 A ►			
Peak Collector Current (See Note 2)	◄ 5 A ►			
Continuous Base Current	◄ 1 A ►			
Safe Operating Region at (or below) 25°C Case Temperature	◄ See Figure 5 ►			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄ 40 W ►			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄ 2 W ►			
Unclamped Inductive Load Energy (See Note 5)	◄ 32 mJ ►			
Operating Collector Junction Temperature Range	◄ −65°C to 150°C ►			
Storage Temperature Range	◄ −65°C to 150°C ►			
Lead Temperature 3.2mm from Case for 10 Seconds	◄ 260°C ►			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 150°C case temperature at the rate of 0.32W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 20 mH, R_{BB1} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 10 V. Energy ≈ $I_C{}^2L/2$.

TIP31,TIP31A,TIP31B,TIP31C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP31		TIP31A		TIP31B		TIP31C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	40		60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		0.3		0.3					mA
		V_{CE} = 60 V, I_B = 0						0.3		0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = 40 V, V_{BE} = 0		0.2							mA
		V_{CE} = 60 V, V_{BE} = 0				0.2					
		V_{CE} = 80 V, V_{BE} = 0						0.2			
		V_{CE} = 100 V, V_{BE} = 0								0.2	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7	25		25		25		25		
		V_{CE} = 4 V, I_C = 3 A, See Notes 6 and 7	10	50	10	50	10	50	10	50	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 3 A, See Notes 6 and 7		1.8		1.8		1.8		1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 375 mA, I_C = 3 A, See Notes 6 and 7		1.2		1.2		1.2		1.2	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.5 A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.5 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

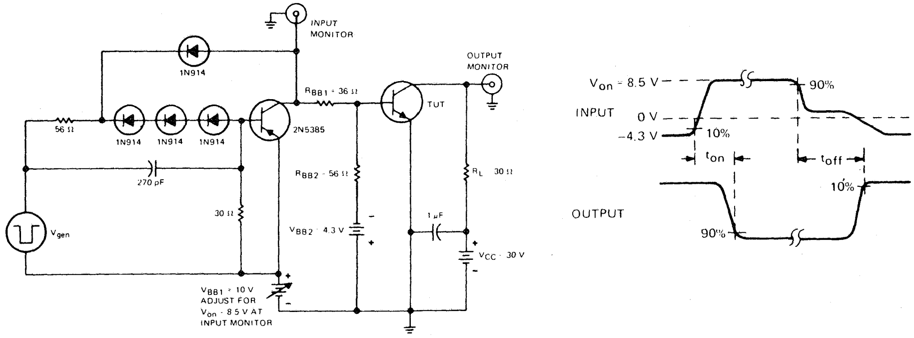
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 1 A, $I_{B(1)}$ = 100 mA, $I_{B(2)}$ = −100 mA,	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.3 V, R_L = 30 Ω, See Figure 1	2	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

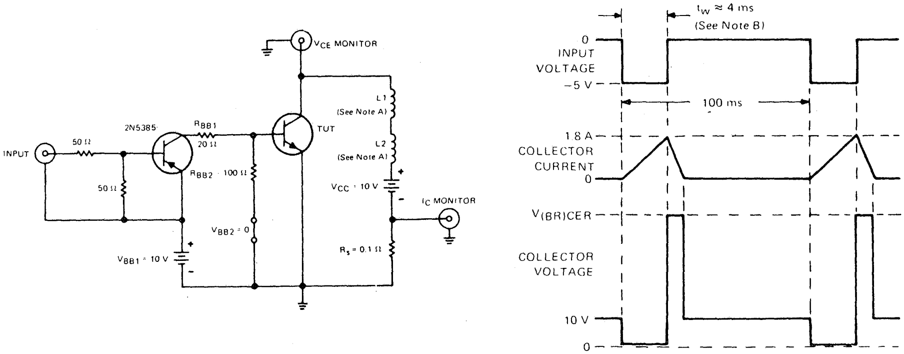
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = 1.8$ A.

FIGURE 2

TIP31,TIP31A,TIP31B,TIP31C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

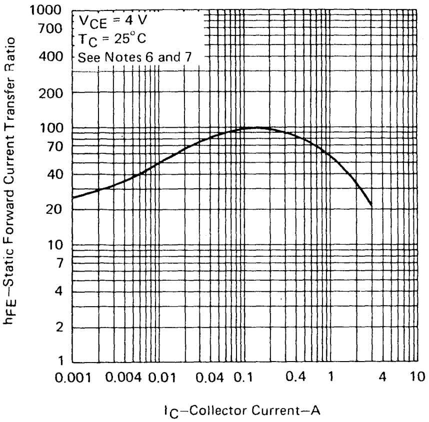


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

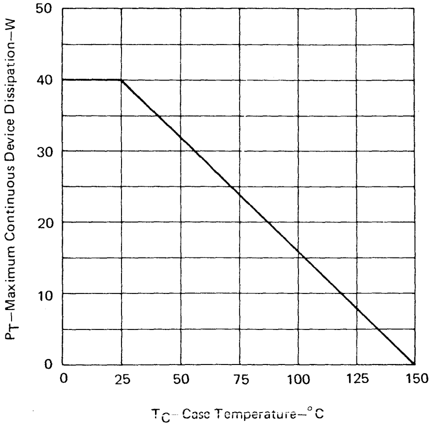


FIGURE 4

MAXIMUM SAFE OPERATING REGION

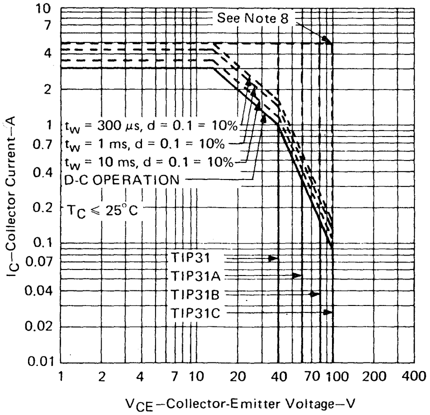


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

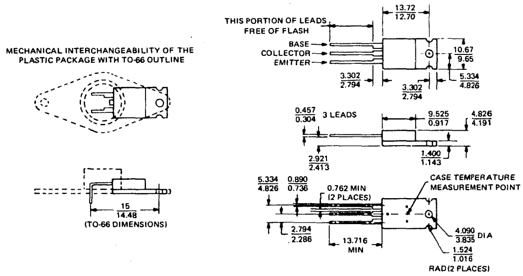
TIP32,TIP32A,TIP32B,TIP32C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

For Power-Amplifier and High-Speed-Switching Applications
Designed for Complementary use with TIP31, TIP31A, TIP31B, TIP31C

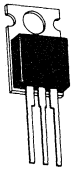
- **40W at 25°C Case Temperature**
- **3A Rated Collector Current**
- **Min f_T of 3 MHz at 10V, 500mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP32	TIP32A	TIP32B	TIP32C
Collector-Base Voltage	−40 V	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V			
Continuous Collector Current	−3 A			
Peak Collector Current (See Note 2)	−5 A			
Continuous Base Current	−1 A			
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	40 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W			
Unclamped Inductive Load Energy (See Note 5)	32 mJ			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 3.2mm from Case for 10 Seconds	260°C			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.32 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP32,TIP32A,TIP32B,TIP32C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP32		TIP32A		TIP32B		TIP32C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−40		−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.3		−0.3					mA
		$V_{CE} = -60$ V, $I_B = 0$						−0.3		−0.3	
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 0$		−0.2							mA
		$V_{CE} = -60$ V, $V_{BE} = 0$				−0.2					
		$V_{CE} = -80$ V, $V_{BE} = 0$						−0.2			
		$V_{CE} = -100$ V, $V_{BE} = 0$								−0.2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 6 and 7	25		25		25		25		
		$V_{CE} = -4$ V, $I_C = -3$ A, See Notes 6 and 7	10		10		10		10		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -3$ A, See Notes 6 and 7		−1.8		−1.8		−1.8		−1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -375$ mA, $I_C = -3$ A, See Notes 6 and 7		−1.2		−1.2		−1.2		−1.2	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

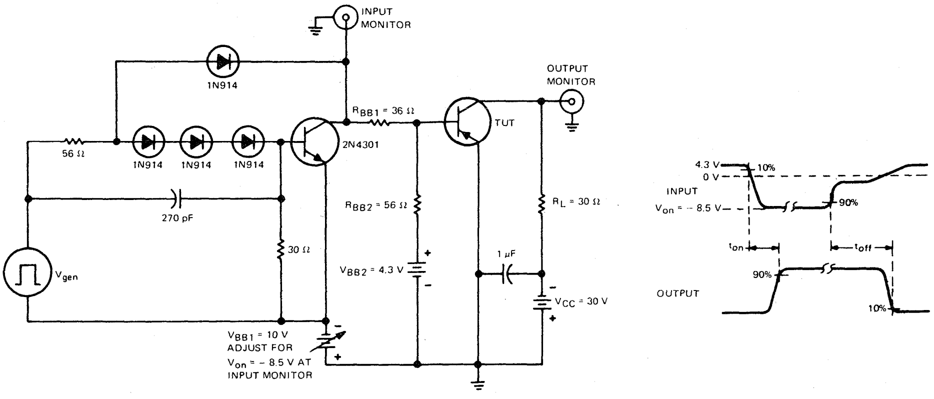
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -1$ A, $I_{B(1)} = -100$ mA, $I_{B(2)} = 100$ mA, $V_{BE(off)} = 4.3$ V, $R_L = 30\ \Omega$, See Figure 1	0.3	µs
t_{off}	Turn-Off Time		1.0	

†Voltages and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

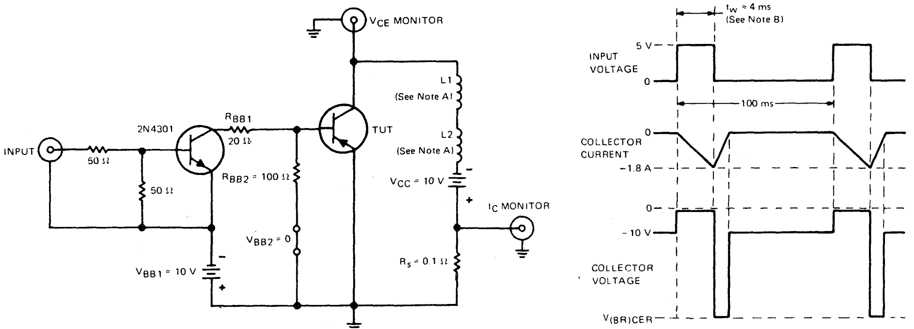
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = -1.8$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

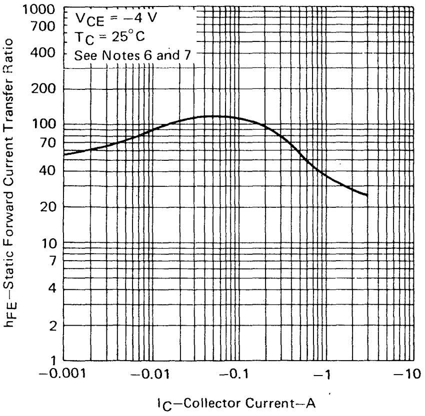


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

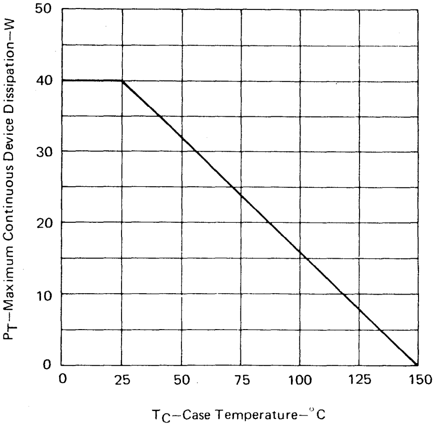


FIGURE 4

MAXIMUM SAFE OPERATING REGION

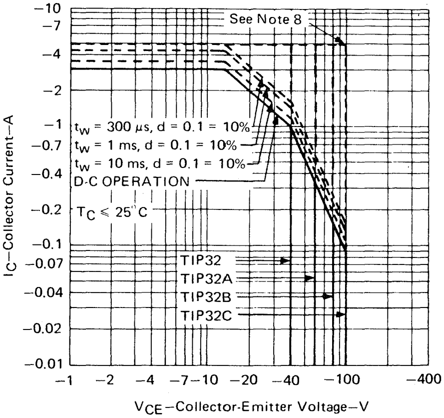


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

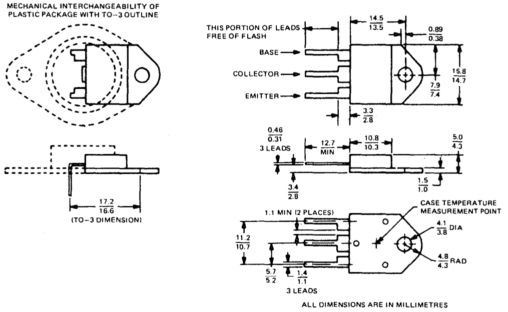
TIP33,TIP33A,TIP33B,TIP33C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP34, TIP34A, TIP34B, TIP34C

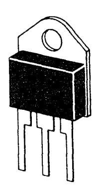
- **80 W at 25°C Case Temperature**
- **10 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 500 mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP33	TIP33A	TIP33B	TIP33C
Collector-Base Voltage	40 V	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V	100 V
Emitter-Base Voltage	◄— 5 V —►			
Continuous Collector Current	◄— 10 A —►			
Peak Collector Current (See Note 2)	◄— 15 A —►			
Continuous Base Current	◄— 3 A —►			
Safe Operating Region at (or below) 25°C Case Temperature	◄— See Figure 5 —►			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄— 80 W —►			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄— 3.5 W —►			
Unclamped Inductive Load Energy (See Note 5)	◄— 62.5 mJ —►			
Operating Collector Junction Temperature Range	◄— −65°C to 150°C —►			
Storage Temperature Range	◄— −65°C to 150°C —►			
Lead Temperature 3.2mm from Case for 10 Seconds	◄— 260°C —►			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 150°C case temperature at the rate of 0.64 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP33,TIP33A,TIP33B,TIP33C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP33		TIP33A		TIP33B		TIP33C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 6	40		60		80		100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.7		0.7					mA
		$V_{CE} = 60$ V, $I_B = 0$						0.7		0.7	
I_{CES}	Collector Cutoff Current	$V_{CE} = 40$ V, $V_{BE} = 0$		0.4							mA
		$V_{CE} = 60$ V, $V_{BE} = 0$				0.4					
		$V_{CE} = 80$ V, $V_{BE} = 0$						0.4			
		$V_{CE} = 100$ V, $V_{BE} = 0$								0.4	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, See Notes 6 and 7	40		40		40		40		
		$V_{CE} = 4$ V, $I_C = 3$ A, See Notes 6 and 7	20	100	20	100	20	100	20	100	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 3$ A, See Notes 6 and 7		1.6		1.6		1.6		1.6	V
		$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 6 and 7		3		3		3		3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.3$ A, $I_C = 3$ A, See Notes 6 and 7		1		1		1		1	V
		$I_B = 2.5$ A, $I_C = 10$ A, See Notes 6 and 7		4		4		4		4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 6$ A, $I_{B(1)} = 0.6$ A, $I_{B(2)} = -0.6$ A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -4$ V, $R_L = 5\ \Omega$, See Figure 1	1	

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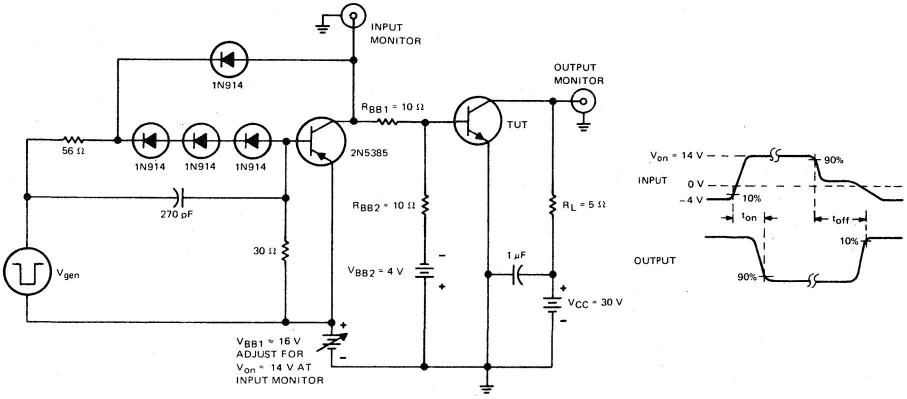
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

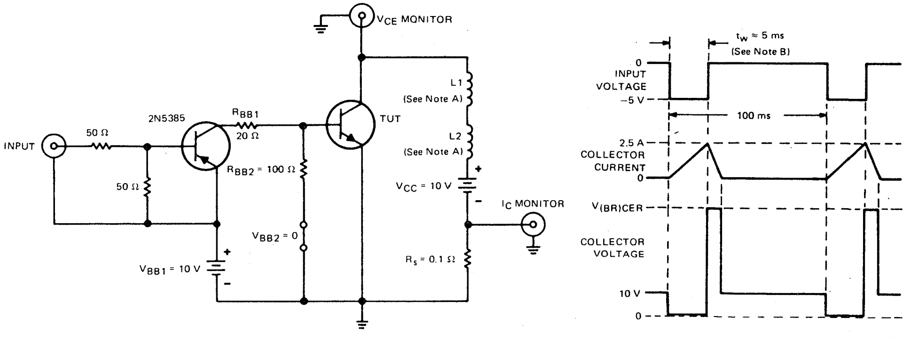
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = 2.5$ A.

FIGURE 2

TIP33,TIP33A,TIP33B,TIP33C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

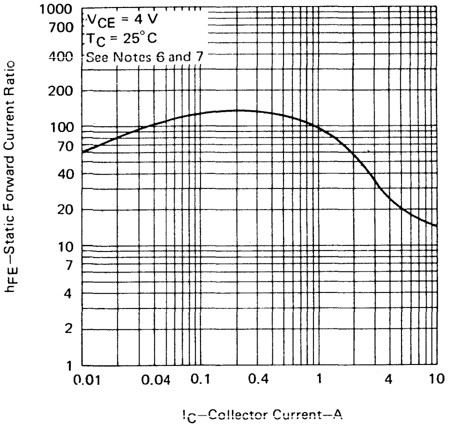


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

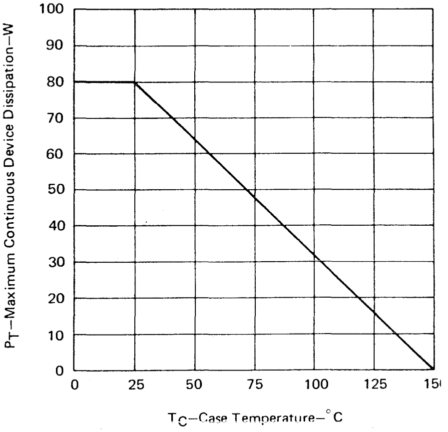


FIGURE 4

MAXIMUM SAFE OPERATING REGION

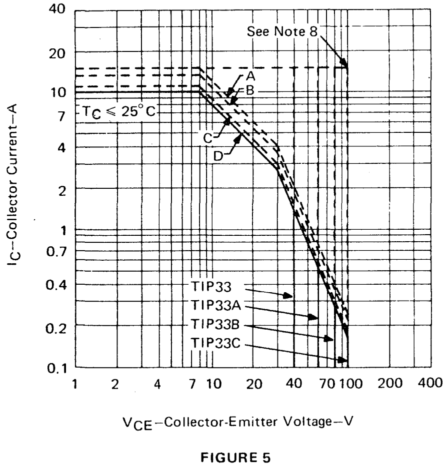


FIGURE 5

KEY FOR FIGURE 5

CURVE	CONDITIONS
A	t_w = 300 μs, d = 0.1 = 10%
B	t_w = 1 ms, d = 0.1 = 10%
C	t_w = 10 ms, d = 0.1 = 10%
D	D-C OPERATION

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clampe inductive load.

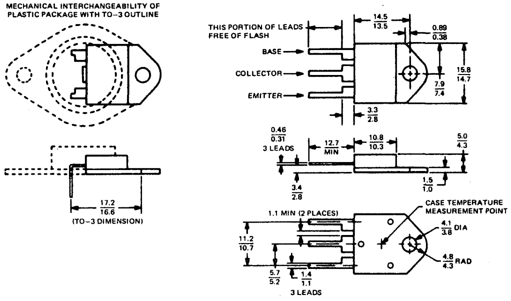
TIP34,TIP34A,TIP34B,TIP34C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP33, TIP33A, TIP33B, TIP33C

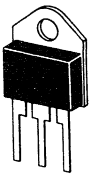
- **80 W at 25°C Case Temperature**
- **10 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 500 mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

<table>
<tr><th></th><th>TIP34</th><th>TIP34A</th><th>TIP34B</th><th>TIP34C</th></tr>
<tr><td>Collector-Base Voltage</td><td>−40 V</td><td>−60 V</td><td>−80 V</td><td>−100 V</td></tr>
<tr><td>Collector-Emitter Voltage (See Note 1)</td><td>−40 V</td><td>−60 V</td><td>−80 V</td><td>−100 V</td></tr>
<tr><td>Emitter-Base Voltage</td><td colspan="4">◄—— −5 V ——►</td></tr>
<tr><td>Continuous Collector Current</td><td colspan="4">◄—— −10 A ——►</td></tr>
<tr><td>Peak Collector Current (See Note 2)</td><td colspan="4">◄—— −15 A ——►</td></tr>
<tr><td>Continuous Base Current</td><td colspan="4">◄—— −3 A ——►</td></tr>
<tr><td>Safe Operating Region at (or below) 25°C Case Temperature</td><td colspan="4">◄—— See Figure 5 ——►</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)</td><td colspan="4">◄—— 80 W ——►</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)</td><td colspan="4">◄—— 3.5 W ——►</td></tr>
<tr><td>Unclamped Inductive Load Energy (See Note 5)</td><td colspan="4">◄—— 62.5 mJ ——►</td></tr>
<tr><td>Operating Collector Junction Temperature Range</td><td colspan="4">◄—— −65°C to 150°C ——►</td></tr>
<tr><td>Storage Temperature Range</td><td colspan="4">◄—— −65°C to 150°C ——►</td></tr>
<tr><td>Lead Temperature 3.2mm from Case for 10 Seconds</td><td colspan="4">◄—— 260°C ——►</td></tr>
</table>

NOTES:

1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.64 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\Omega$ $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx 1/2\ I_C^2 L/2$.

TIP34,TIP34A,TIP34B,TIP34C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP34		TIP34A		TIP34B		TIP34C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−40		−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.7		−0.7					mA
		$V_{CE} = -60$ V, $I_B = 0$						−0.7		−0.7	
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 0$		−0.4							mA
		$V_{CE} = -60$ V, $V_{BE} = 0$				−0.4					
		$V_{CE} = -80$ V, $V_{BE} = 0$						−0.4			
		$V_{CE} = -100$ V, $V_{BE} = 0$								−0.4	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 6 and 7	40		40		40		40		
		$V_{CE} = -4$ V, $I_C = -3$ A, See Notes 6 and 7	20	100	20	100	20	100	20	100	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -3$ A, See Notes 6 and 7		−1.6		−1.6		−1.6		−1.6	V
		$V_{CE} = -4$ V, $I_C -10$ A, See Notes 6 and 7		−3		−3		−3		−3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.3$ A, $I_C = -3$ A, See Notes 6 and 7		−1		−1		−1		−1	V
		$I_B = -2.5$ A, $I_C = -10$ A, See Notes 6 and 7		−4		−4		−4		−4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 kHz	20		20		20		20		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

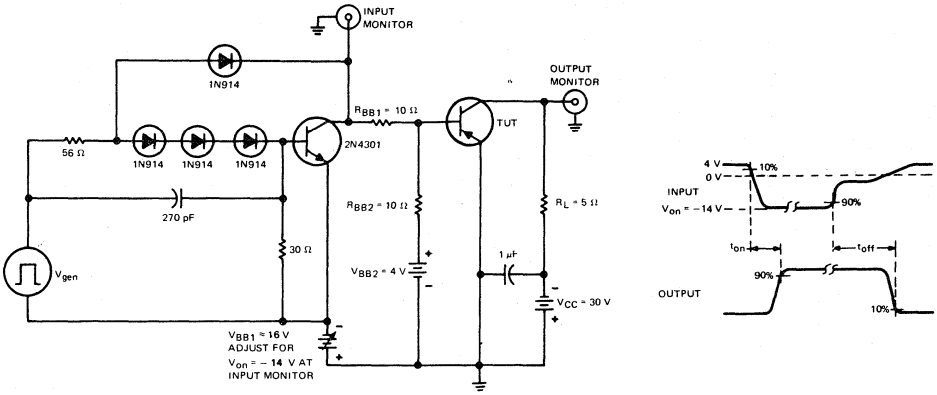
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	$I_C = -6$ A,	$I_{B(1)} = -0.6$ A,	$I_{B(2)} = 0.6$ A,	0.4	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4$ V,	$R_L = 5\ \Omega$,	See Figure 1	0.7	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

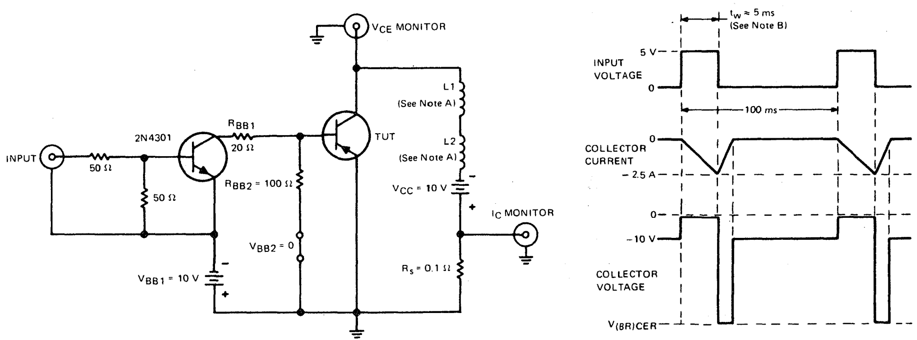
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = -2.5$ A.

FIGURE 2

TIP34,TIP34A,TIP34B,TIP34C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

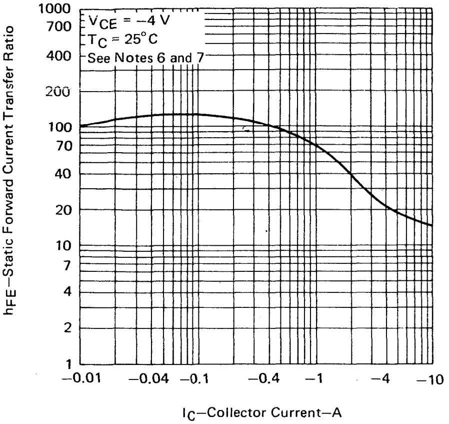


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

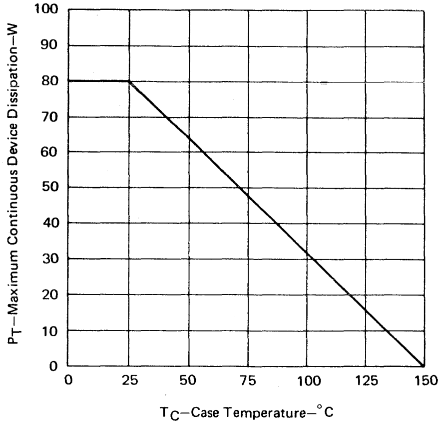
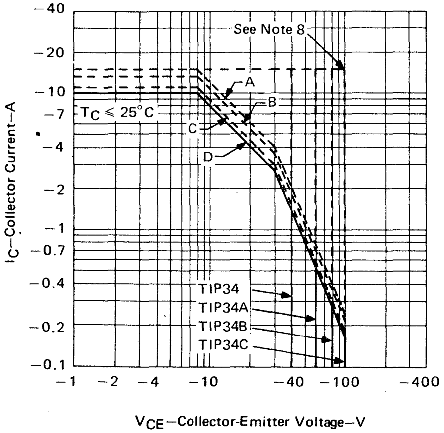


FIGURE 4

MAXIMUM SAFE OPERATING REGION



KEY FOR FIGURE 5

CURVE	CONDITIONS
A	$t_w = 300$ μs, d = 0.1 = 10%
B	$t_w = 1$ ms, d = 0.1 = 10%
C	$t_w = 10$ ms, d = 0.1 = 10%
D	D-C OPERATION

FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

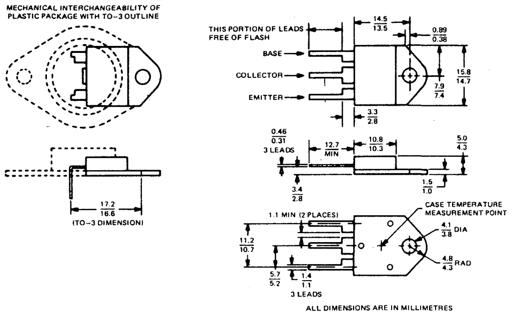
TIP35,TIP35A,TIP35B,TIP35C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP36, TIP36A, TIP36B, TIP36C

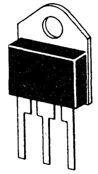
- **125 W at 25°C Case Temperature**
- **25 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP35	TIP35A	TIP35B	TIP35C
Collector-Base Voltage	40 V	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V	100 V
Emitter-Base Voltage	5 V			
Continuous Collector Current	25 A			
Peak Collector Current (See Note 2)	40 A			
Continuous Base Current	5 A			
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	125 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	3.5 W			
Unclamped Inductive Load Energy (See Note 5)	90 mJ			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 3.2mm from Case for 10 Seconds	260°C			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 1 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP35, TIP35A, TIP35B, TIP35C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP35		TIP35A		TIP35B		TIP35C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	40		60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		1		1					mA
		V_{CE} = 60 V, I_B = 0						1		1	
I_{CES}	Collector Cutoff Current	V_{CE} = 40 V, V_{BE} = 0		0.7							mA
		V_{CE} = 60 V, V_{BE} = 0				0.7					
		V_{CE} = 80 V, V_{BE} = 0						0.7			
		V_{CE} = 100 V, V_{BE} = 0								0.7	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1.5 A, See Notes 6 and 7	25		25		25		25		
		V_{CE} = 4 V, I_C = 15 A, See Notes 6 and 7	10	50	10	50	10	50	10	50	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 15 A, See Notes 6 and 7		2		2		2		2	V
		V_{CE} = 4 V, I_C = 25 A, See Notes 6 and 7		4		4		4		4	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1.5 A, I_C = 15 A, See Notes 6 and 7		1.8		1.8		1.8		1.8	V
		I_B = 5 A, I_C = 25 A, See Notes 6 and 7		4		4		4		4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 1 kHz	25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 µs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

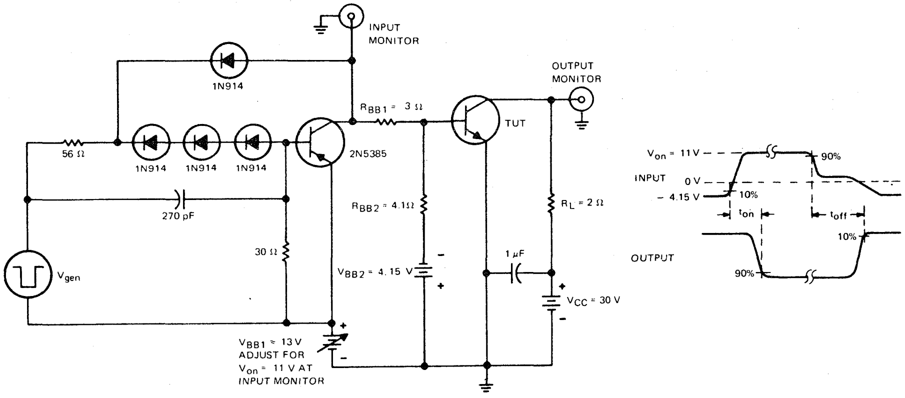
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 15 A, $I_{B(1)}$ = 1.5 A, $I_{B(2)}$ = −1.5 A,	1.2	µs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.15 V, R_L = 2 Ω, See Figure 1	0.9	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.

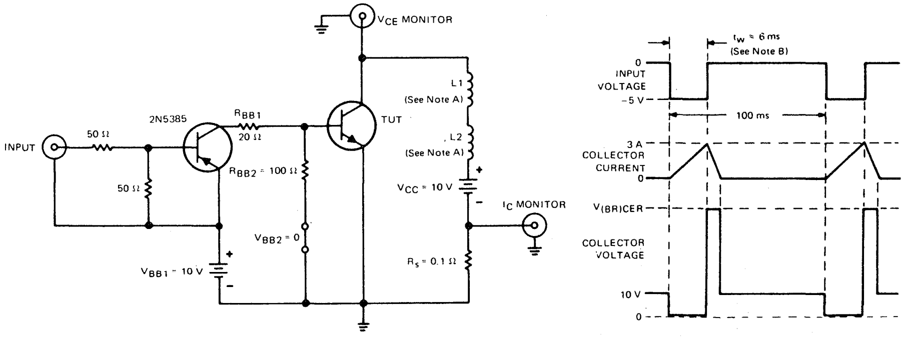
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = 3$ A.

FIGURE 2

TIP35,TIP35A,TIP35B,TIP35C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

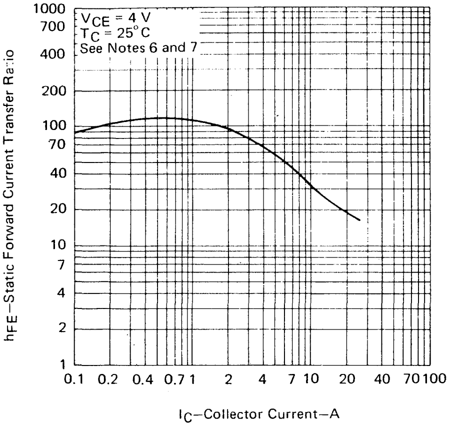


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

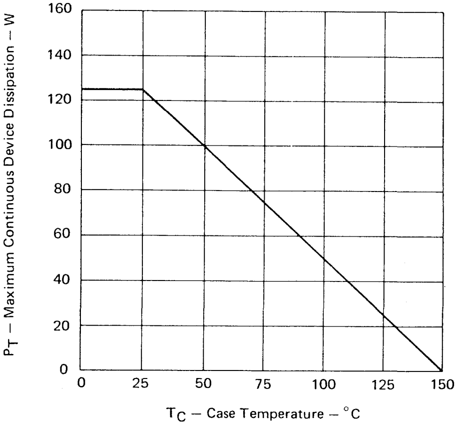
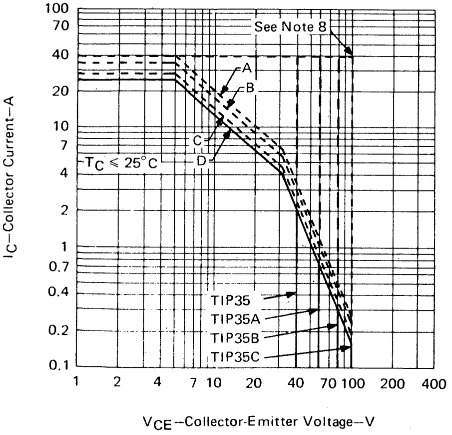


FIGURE 4

MAXIMUM SAFE OPERATING REGION



KEY FOR FIGURE 5

CURVE	CONDITIONS
A	t_w = 300 μs, d = 0.1 = 10%
B	t_w = 1 ms, d = 0.1 = 10%
C	t_w = 10 ms, d = 0.1 = 10%
D	D-C OPERATION

FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

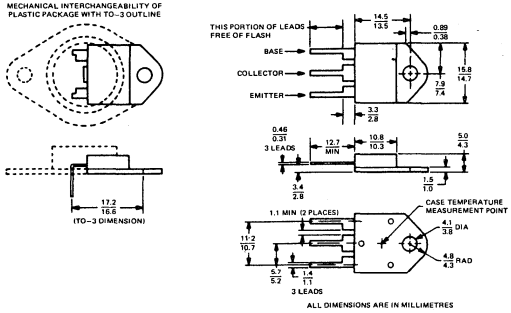
TIP36,TIP36A,TIP36B,TIP36C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

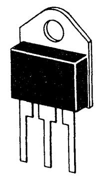
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP35, TIP35A, TIP35B, TIP35C

- **125 W at 25°C Case Temperature**
- **25 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP36	TIP36A	TIP36B	TIP36C
Collector-Base Voltage	−40 V	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V			
Continuous Collector Current	−25 A			
Peak Collector Current (See Note 2)	−40 A			
Continuous Base Current	−5 A			
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	125 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	3.5 W			
Unclamped Inductive Load Energy (See Note 5)	90 mJ			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 3.2mm from Case for 10 Seconds	260°C			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 1 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP36,TIP36A,TIP36B,TIP36C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP36		TIP36A		TIP36B		TIP36C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−40		−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−1		−1					mA
		$V_{CE} = -60$ V, $I_B = 0$						−1		−1	
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 0$		−0.7							mA
		$V_{CE} = -60$ V, $V_{BE} = 0$				−0.7					
		$V_{CE} = -80$ V, $V_{BE} = 0$						−0.7			
		$V_{CE} = -100$ V, $V_{BE} = 0$								−0.7	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1.5$ A, See Notes 6 and 7	25		25		25		25		
		$V_{CE} = -4$ V, $I_C = -15$ A, See Notes 6 and 7	10	50	10	50	10	50	10	50	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -15$ A, See Notes 6 and 7		−2		−2		−2		−2	V
		$V_{CE} = -4$ V, $I_C = -25$ A, See Notes 6 and 7		−4		−4		−4		−4	
$V_{CE(sat)}$	Collector-Emitter Voltage	$I_B = -1.5$ A, $I_C = -15$ A, See Notes 6 and 7		−1.8		−1.8		−1.8		−1.8	V
		$I_B = -5$ A, $I_C = -25$ A, See Notes 6 and 7		−4		−4		−4		−4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ A, f = 1 kHz	25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant$ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -15$ A, $I_{B(1)} = -1.5$ A, $I_{B(2)} = 1.5$ A,	1.1	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.15$ V, $R_L = 2\ \Omega$, See Figure 1	0.8	

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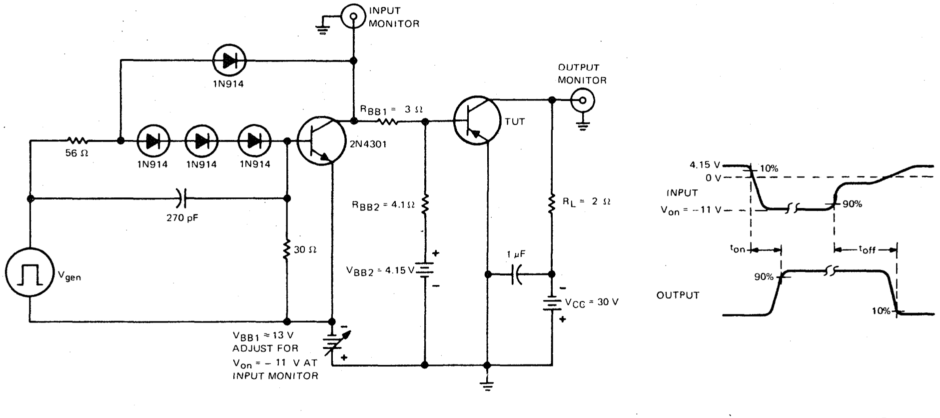
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

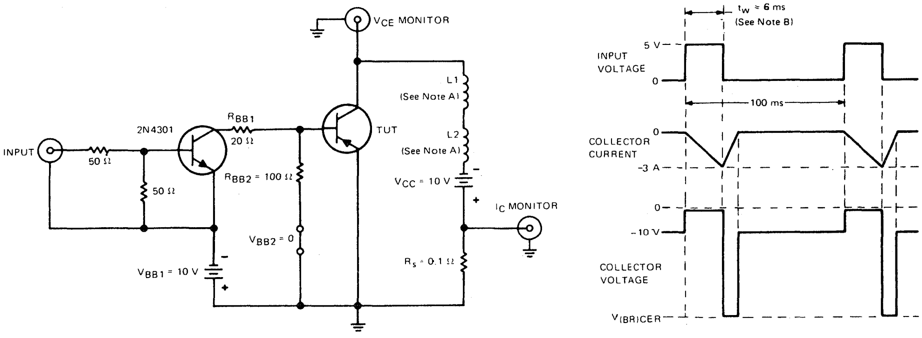
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTES: A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.

B. Input pulse width is increased until $I_{CM} = -3$ A.

FIGURE 2

TIP36,TIP36A,TIP36B,TIP36C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

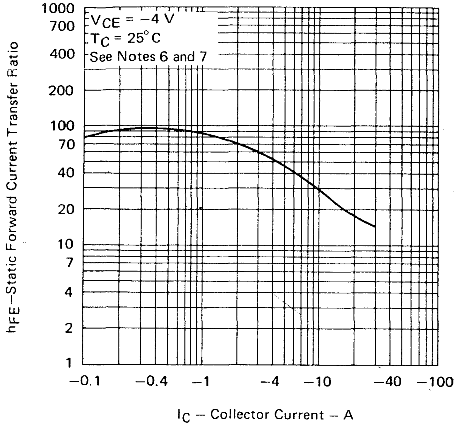


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leqslant 2\%$.

7. These parameters are measured with voltage sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

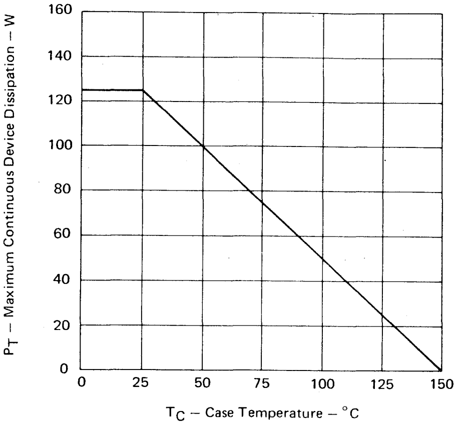
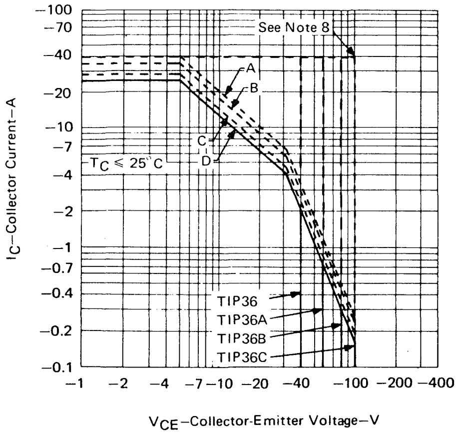


FIGURE 4

MAXIMUM SAFE OPERATING REGION



KEY FOR FIGURE 5

CURVE	CONDITIONS
A	$t_w = 300$ μs, d = 0.1 = 10%
B	$t_w = 1$ ms, d = 0.1 = 10%
C	$t_w = 10$ ms, d = 0.1 = 10%
D	D-C OPERATION

FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

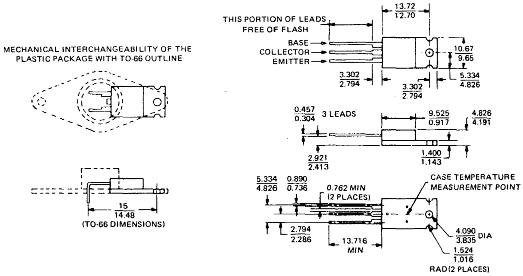
TIP41,TIP41A,TIP41B,TIP41C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP42, TIP42A, TIP42B, TIP42C FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS

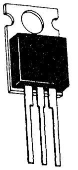
- **65 W at 25°C Case Temperature**
- **6 A Rated Collector Current**
- **Min f_T of 3 MHz at 10 V, 500 mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP41	TIP41A	TIP41B	TIP41C
Collector-Base Voltage	40 V	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V	100 V
Emitter-Base Voltage	◄— 5 V —►			
Continuous Collector Current	◄— 6 A —►			
Peak Collector Current (See Note 2)	◄— 10 A —►			
Continuous Base Current	◄— 3 A —►			
Safe Operating Region at (or below) 25°C Case Temperature	◄— See Figure 5 —►			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄— 65 W —►			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄— 2 W —►			
Unclamped Inductive Load Energy (See Note 5)	◄— 62.5 mJ —►			
Operating Collector Junction Temperature Range	◄— −65°C to 150°C —►			
Storage Temperature Range	◄— −65°C to 150°C —►			
Lead Temperature 3.2mm from Case for 10 Seconds	◄— 260°C —►			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.52 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP41,TIP41A,TIP41B,TIP41C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP41		TIP41A		TIP41B		TIP41C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	40		60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		0.7		0.7					mA
		V_{CE} = 60 V, I_B = 0						0.7		0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = 40 V, V_{BE} = 0		0.4							mA
		V_{CE} = 60 V, V_{BE} = 0				0.4					
		V_{CE} = 80 V, V_{BE} = 0						0.4			
		V_{CE} = 100 V, V_{BE} = 0								0.4	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 0.3 A, See Notes 6 and 7	30		30		30		30		
		V_{CE} = 4 V, I_C = 3 A, See Notes 6 and 7	15	75	15	75	15	75	15	75	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 6 A, See Notes 6 and 7		2		2		2		2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.6 A, I_C = 6 A, See Notes 6 and 7		1.5		1.5		1.5		1.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.5 A, f = 1 kHz	20		20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.5 A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

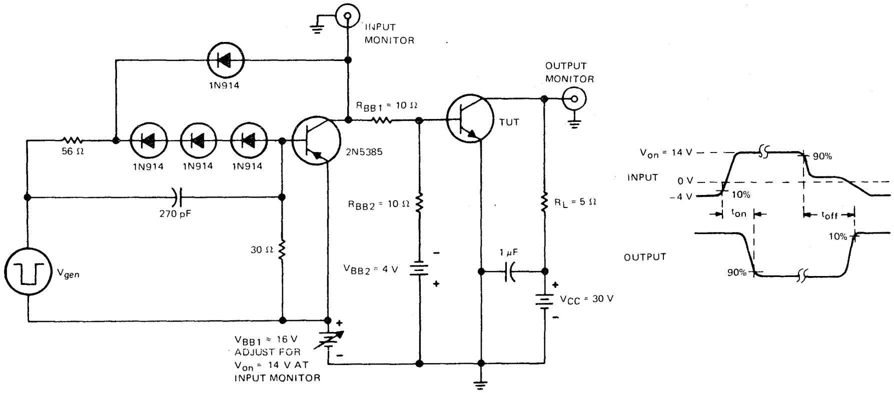
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = 6 A,	$I_{B(1)}$ = 0.6 A,	$I_{B(2)}$ = −0.6 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V,	R_L = 5 Ω,	See Figure 1	1	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

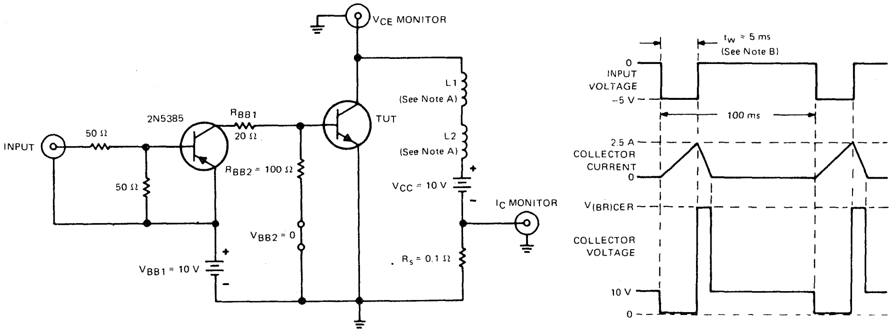


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTES:
A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
B. Input pulse width is increased until $I_{CM} = 2.5$ A.

FIGURE 2

TIP41,TIP41A,TIP41B,TIP41C
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

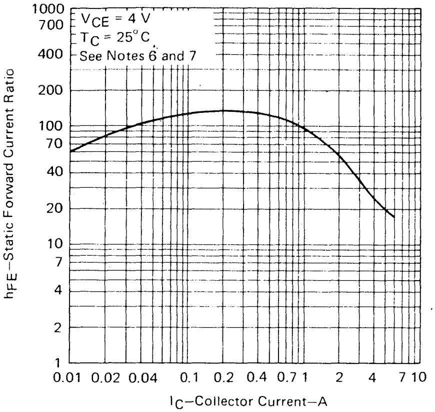


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

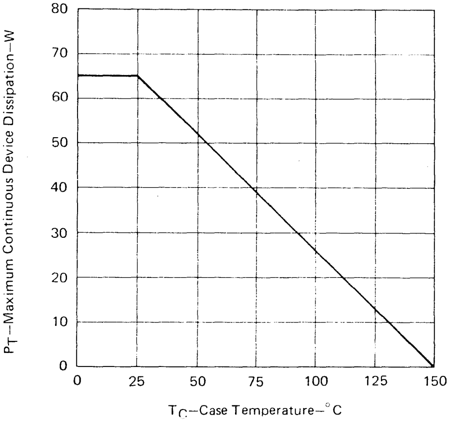


FIGURE 4

MAXIMUM SAFE OPERATING REGION

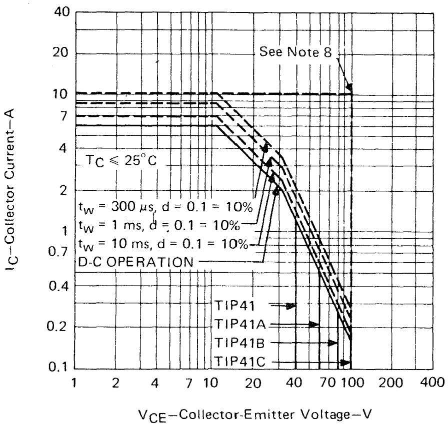


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

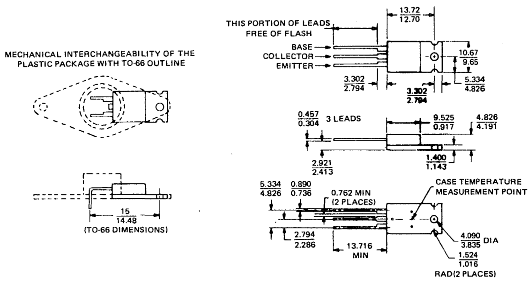
TIP42,TIP42A,TIP42B,TIP42C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP41, TIP41A, TIP41B, TIP41C

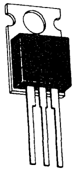
- **65 W at 25°C Case Temperature**
- **6 A Rated Collector Current**
- **Min f_T of 3 MHz at 10V, 500mA**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP42	TIP42A	TIP42B	TIP42C
Collector-Base Voltage	−40 V	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V			
Continuous Collector Current	−6 A			
Peak Collector Current (See Note 2)	−10 A			
Continuous Base Current	−3 A			
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	65 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W			
Unclamped Inductive Load Energy (See Note 5)	62.5 mJ			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 3.2mm from Case for 10 Seconds	260°C			

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.52 W/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

TIP42,TIP42A,TIP42B,TIP42C
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP42		TIP42A		TIP42B		TIP42C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−40		−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.7		−0.7					mA
		$V_{CE} = -60$ V, $I_B = 0$						−0.7		−0.7	
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 0$		−0.4							mA
		$V_{CE} = -60$ V, $V_{BE} = 0$				−0.4					
		$V_{CE} = -80$ V, $V_{BE} = 0$						−0.4			
		$V_{CE} = -100$ V, $V_{BE} = 0$								−0.4	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−1		−1		−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -0.3$ A, See Notes 6 and 7	30		30		30		30		
		$V_{CE} = -4$ V, $I_C = -3$ A, See Notes 6 and 7	15	75	15	75	15	75	15	75	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -6$ A, See Notes 6 and 7		−2		−2		−2		−2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.6$ A, $I_C = -6$ A, See Notes 6 and 7		−1.5		−1.5		−1.5		−1.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 kHz	20		20		20		20		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 MHz	3		3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	$I_C = -6$ A,	$I_{B(1)} = -0.6$ A,	$I_{B(2)} = 0.6$ A,	0.4	µs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4$ V,	$R_L = 5\ \Omega$,	See Figure 1	0.7	

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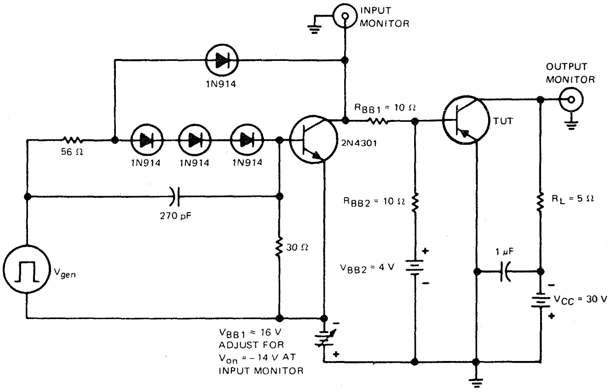
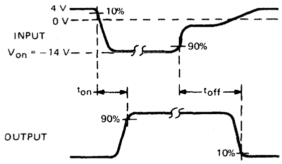
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



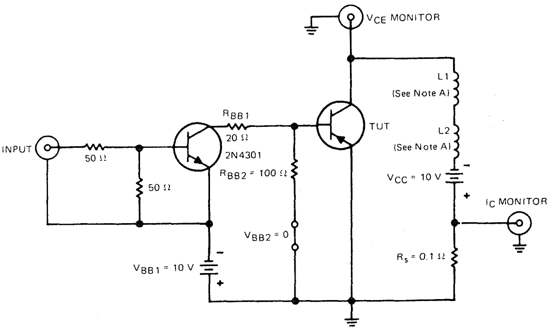
TEST CIRCUIT



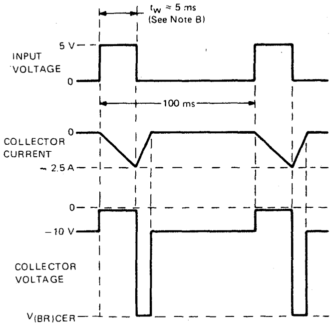
VOLTAGE WAVEFORMS

NOTES:
A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTES:
A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
B. Input pulse width is increased until $I_{CM} = -2.5$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

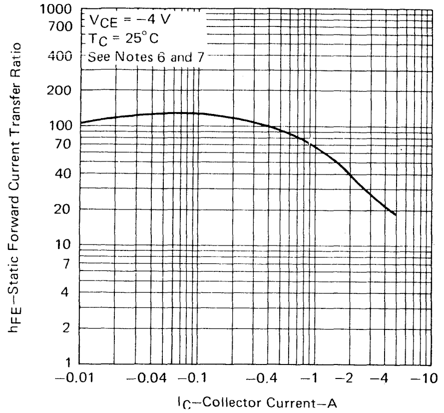


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

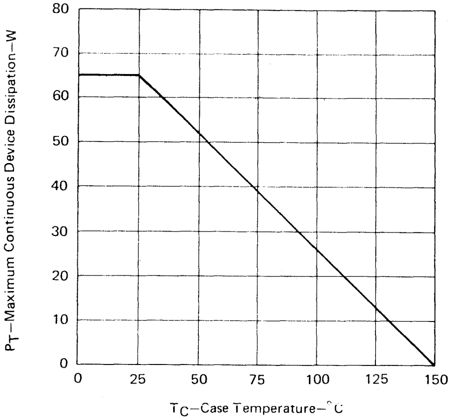


FIGURE 4

MAXIMUM SAFE OPERATING REGION

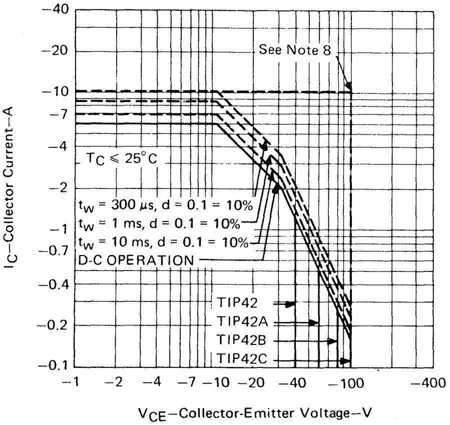


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

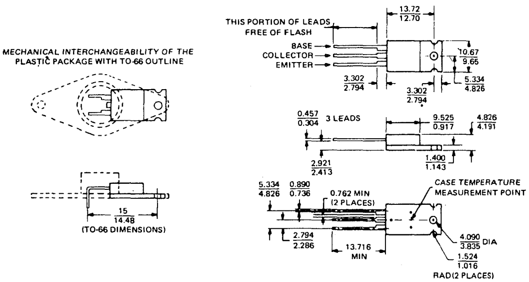
TIP47, TIP48, TIP49, TIP50
NPN SILICON POWER TRANSISTORS

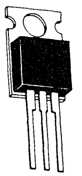
HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR INDUSTRIAL AND CONSUMER APPLICATION

- 20 mJ Reverse-Energy Rating
- 250 V to 400 V Min $V_{(BR)CEO}$
- 40 W at 25°C Case Temperature
- 1-A Rated Collector Current
- 10 MHz Min f_T at 10 V, 0.2 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP47	TIP48	TIP49	TIP50
Collector-Base Voltage	350 V	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	250 V	300 V	350 V	400 V
Emitter-Base Voltage	5 V	5 V	5 V	5 V
Continuous Collector Current	1 A			
Peak Collector Current (See Note 2)	2 A			
Continuous Base Current	0.6 A			
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 6 and 7			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	40 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W			
Unclamped Inductive Load Energy (See Note 5)	20 mJ			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Terminal Temperature 3.2mm from Case for 10 Seconds	260°C			

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. For operation above 25°C case temperature, refer to Dissipation Derating Curve, Figure 8.
4. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 9.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 5. $L = 100$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP47, TIP48, TIP49, TIP50
NPN SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP47		TIP48		TIP49		TIP50		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0,	See Note 6	250		300		350		400		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 150 V, I_B = 0			1							mA
		V_{CE} = 200 V, I_B = 0					1					
		V_{CE} = 250 V, I_B = 0							1			
		V_{CE} = 300 V, I_B = 0									1	
I_{CES}	Collector Cutoff Current	V_{CE} = 350 V, V_{BE} = 0			1							mA
		V_{CE} = 400 V, V_{BE} = 0					1					
		V_{CE} = 450 V, V_{BE} = 0							1			
		V_{CE} = 500 V, V_{BE} = 0									1	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0			1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.3 A	See Notes 6 and 7	30	150	30	150	30	150	30	150	
		V_{CE} = 10 V, I_C = 1 A		10		10		10		10		
V_{BE}	Base-Emitter Voltage	V_{CE} = 10 V, I_C = 1 A	See Notes 6 and 7		1.5		1.5		1.5		1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.2 A, I_C = 1 A	See Notes 6 and 7		1		1		1		1	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.2 A, f = 1 kHz		25		25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.2 A, f = 2 MHz		5		5		5		5		

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = 1 A,	$I_{B(1)}$ = 100 mA,	$I_{B(2)}$ = −100 mA,	0.2	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −5 V,	R_L = 200 Ω,	See Figure 4	2	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

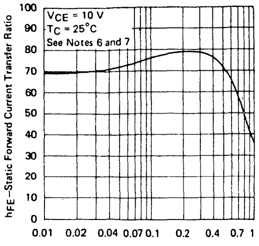


FIGURE 1

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

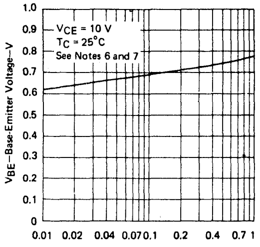


FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

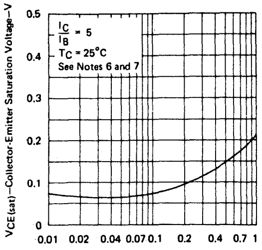
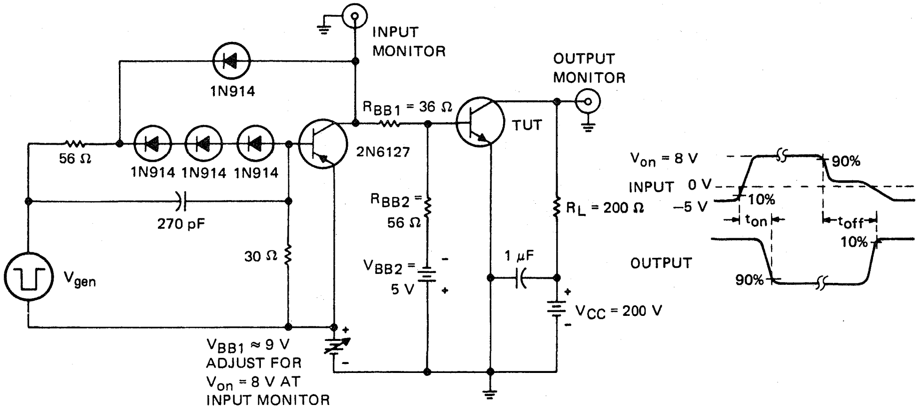


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

PARAMETER MEASUREMENT INFORMATION

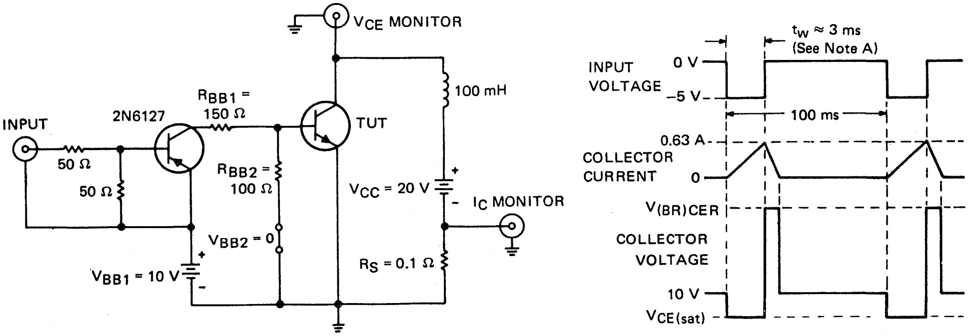


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
- A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ µs, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 4

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until I_{CM} = 0.63 A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

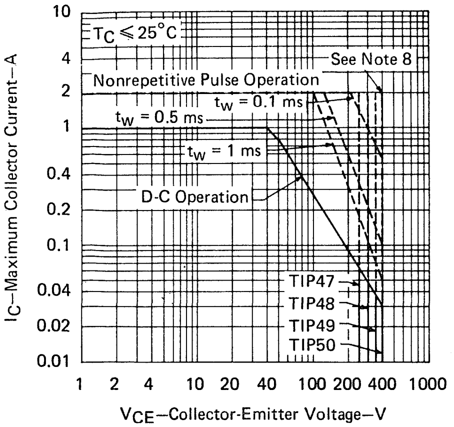


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

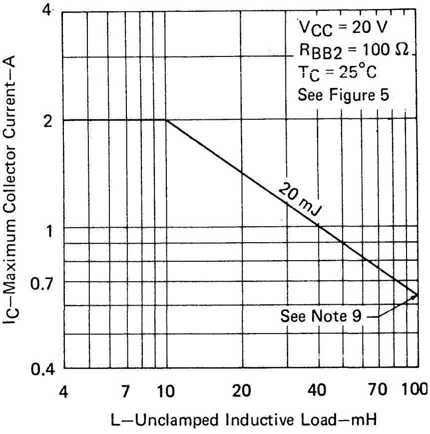


FIGURE 7

NOTES: 8. This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

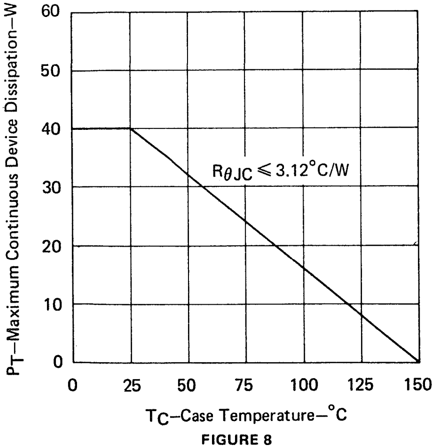


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

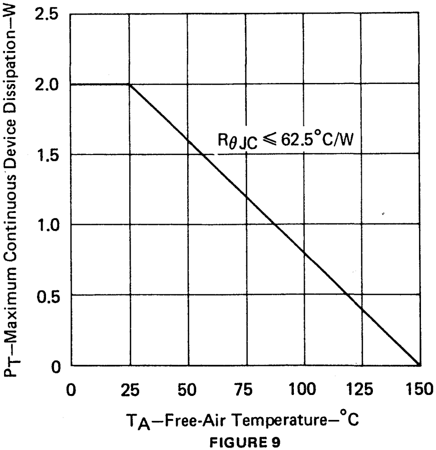


FIGURE 9

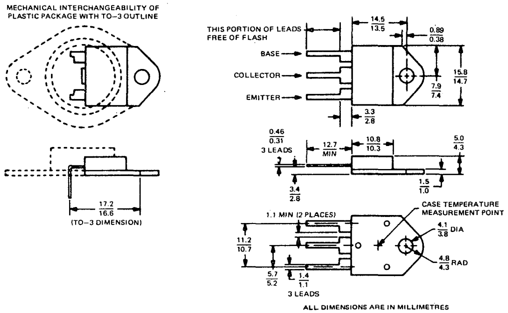
TIP 51, TIP 52, TIP 53, TIP 54
NPN SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR INDUSTRIAL AND CONSUMER APPLICATIONS

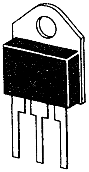
- 100 mJ Reverse-Energy Rating
- 250 V to 400 V Min $V_{(BR)CEO}$
- 100 W at 25°C Case Temperature
- 5 A Peak Collector Current
- 2.5 MHz Min f_T at 10 V, 0.2 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

<table>
<tr><th></th><th>TIP51</th><th>TIP52</th><th>TIP53</th><th>TIP54</th></tr>
<tr><td>Collector-Base Voltage</td><td>350 V</td><td>400 V</td><td>450 V</td><td>500 V</td></tr>
<tr><td>Collector-Emitter Voltage (See Note 1)</td><td>250 V</td><td>300 V</td><td>350 V</td><td>400 V</td></tr>
<tr><td>Emitter-Base Voltage</td><td>5 V</td><td>5 V</td><td>5 V</td><td>5 V</td></tr>
<tr><td>Continuous Collector Current</td><td colspan="4">3 A</td></tr>
<tr><td>Peak Collector Current (See Note 2)</td><td colspan="4">5 A</td></tr>
<tr><td>Continuous Base Current</td><td colspan="4">0.6 A</td></tr>
<tr><td>Safe Operating Areas at (or below) 25°C Case Temperature</td><td colspan="4">See Figures 6 and 7</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)</td><td colspan="4">100 W</td></tr>
<tr><td>Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)</td><td colspan="4">3.5 W</td></tr>
<tr><td>Unclamped Inductive Load Energy (See Note 5)</td><td colspan="4">100 mJ</td></tr>
<tr><td>Operating Collector Junction Temperature Range</td><td colspan="4">−65°C to 150°C</td></tr>
<tr><td>Storage Temperature Range</td><td colspan="4">−65°C to 150°C</td></tr>
<tr><td>Terminal Temperature 3.2mm from Case for 10 Seconds</td><td colspan="4">260°C</td></tr>
</table>

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. For operation above 25°C case temperature, refer to Dissipation Derating Curve, Figure 8.
4. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 9.
5. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 5. $L = 30$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP51		TIP52		TIP53		TIP54		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 6	250		300		350		400		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 150$ V, $I_B = 0$		1							mA
		$V_{CE} = 200$ V, $I_B = 0$				1					
		$V_{CE} = 250$ V, $I_B = 0$						1			
		$V_{CE} = 300$ V, $I_B = 0$								1	
I_{CES}	Collector Cutoff Current	$V_{CE} = 350$ V, $V_{BE} = 0$		1							mA
		$V_{CE} = 400$ V, $V_{BE} = 0$				1					
		$V_{CE} = 450$ V, $V_{BE} = 0$						1			
		$V_{CE} = 500$ V, $V_{BE} = 0$								1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.3$ A, See Notes 6 and 7	30	150	30	150	30	150	30	150	
		$V_{CE} = 10$ V, $I_C = 3$ A, See Notes 6 and 7	10		10		10		10		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 3$ A, See Notes 6 and 7		1.5		1.5		1.5		1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.6$ A, $I_C = 3$ A, See Notes 6 and 7		1.5		1.5		1.5		1.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.2$ A, f = 1 kHz	30		30		30		30		
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.2$ A, f = 1 MHz	2.5		2.5		2.5		2.5		

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 1$ A, $I_{B(1)} = 100$ mA, $I_{B(2)} = -100$ mA, $V_{BE(off)} = -5$ V, $R_L = 200\ \Omega$, See Figure 4	0.25	μs
t_{off}	Turn-Off Time		5	

†Voltage and current values snown are nominal; exact values vary slightly with transistor parameters.

TYPICAL CHARACTERISTICS

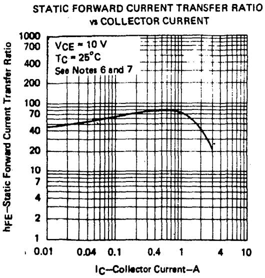


FIGURE 1

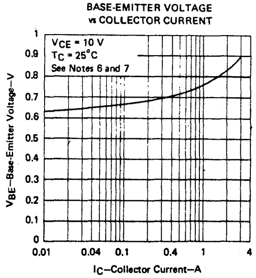


FIGURE 2

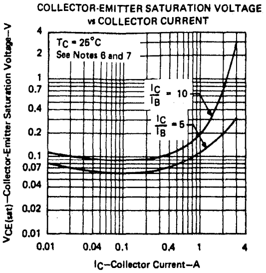
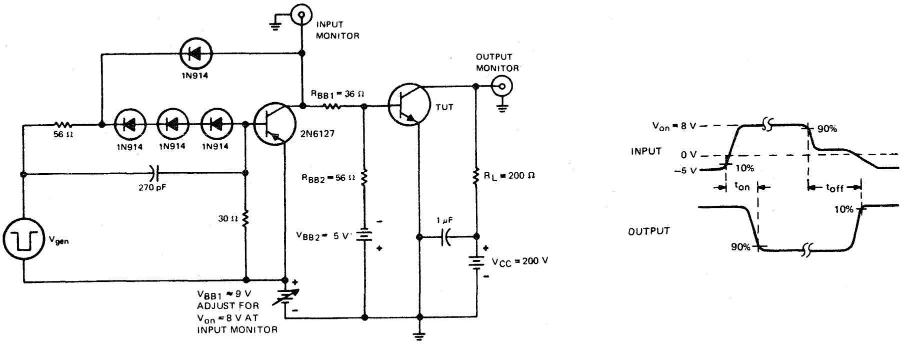


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

PARAMETER MEASUREMENT INFORMATION

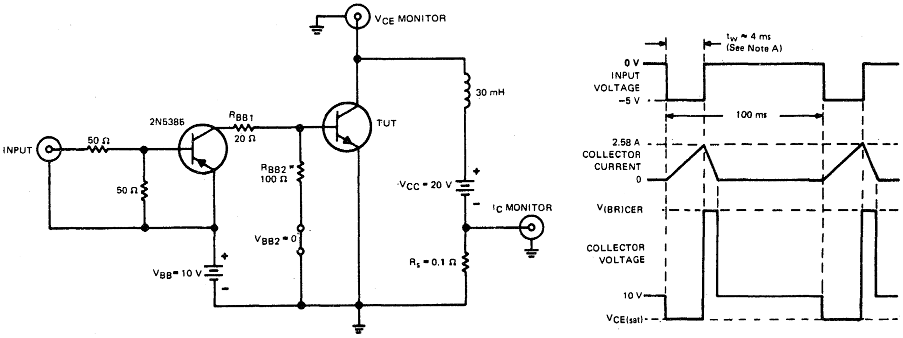


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
- A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplies by a generator with the following characteristics: $t_r \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 4

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until I_{CM} = 2.58 A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs COLLECTOR-EMITTER VOLTAGE

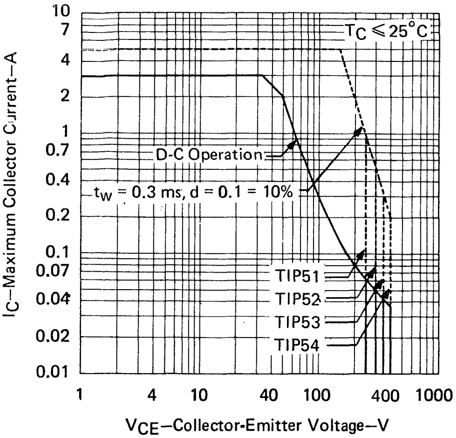


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs UNCLAMPED INDUCTIVE LOAD

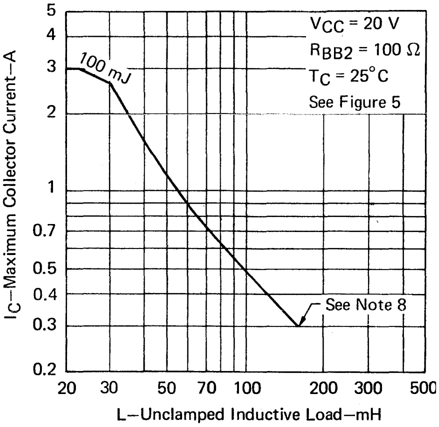


FIGURE 7

NOTE 8: Above this point, the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

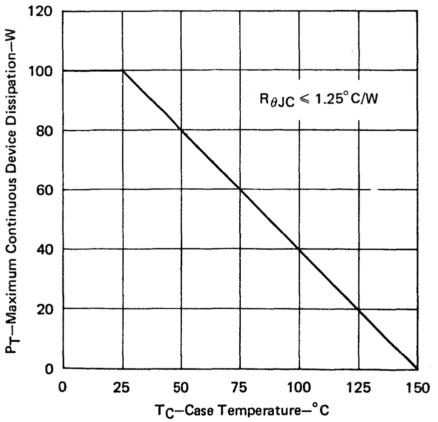


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

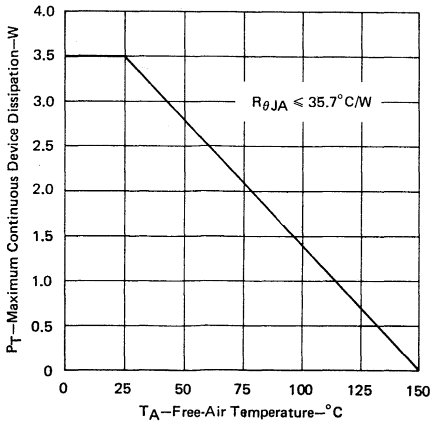


FIGURE 9

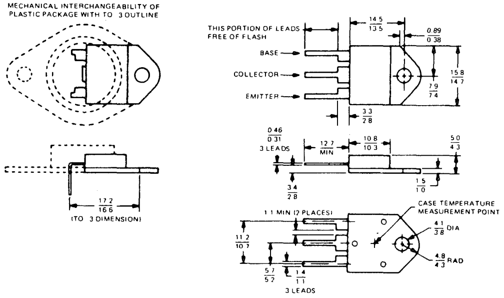
TYPES TIP55A, TIP56A, TIP57A, TIP58A
N-P-N SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR AUTOMOTIVE IGNITION AND SWITCHING REGULATOR APPLICATIONS

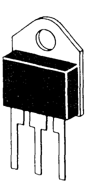
- Min $V_{(BR)CEO}$ of 250 V to 400 V
- 50 W at 100°C Case Temperature
- 10 A Peak Collector Current
- Functional Verification Tests for Ignition and Switching Regulator Applications

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP55A	TIP56A	TIP57A	TIP58A
Collector-Base Voltage	350 V	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	250 V	300 V	350 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V	8 V
Continuous Collector Current	7.5 A			
Peak Collector Current (See Note 2)	10 A			
Continuous Base Current	4 A			
Safe Operating Area	See Figure 8			
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	50 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	3 W			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 1/8 Inch from Case for 10 Seconds	300°C			

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 10$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 24 mW/°C or refer to Dissipation Derating Curve, Figure 10.

TYPES TIP55A, TIP56A, TIP57A, TIP58A
N-P-N SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP55A		TIP56A		TIP57A		TIP58A		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 20$ mA, $I_B = 0$, See Note 5	250		300		350		400		V
I_{CER}	Collector Cutoff Current	$V_{CE} = 350$ V, $R_{BE} = 27\ \Omega$		100							μA
		$V_{CE} = 400$ V, $R_{BE} = 27\ \Omega$				100					
		$V_{CE} = 450$ V, $R_{BE} = 27\ \Omega$						100			
		$V_{CE} = 500$ V, $R_{BE} = 27\ \Omega$								100	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 8$ V, $I_C = 0$		100		100		100		100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V, $I_C = 1$ A, See Notes 5 and 6	10	100	10	100	10	100	10	100	
		$V_{CE} = 2$ V, $I_C = 5$ A	6		6		6		6		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ A, $I_C = 5$ A, See Notes 5 and 6		1.5		1.5		1.5		1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ A, $I_C = 5$ A, See Notes 5 and 6		1.2		1.2		1.2		1.2	V
		$I_B = 4$ A, $I_C = 10$ A		2.5		2.5		2.5		2.5	

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		41.7	
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.6		
$C_{\theta C}$	Thermal Capacitance of Case	1.4		J/°C

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = 5$ A, $I_{B(1)} = 1$ A, $I_{B(2)} = -1$ A, $V_{BE(off)} = -4$ V, $R_L = 40\ \Omega$, See Figure 1	0.04	μs
t_r	Rise Time		0.13	
t_s	Storage Time		1.5	
t_f	Fall Time		0.2	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

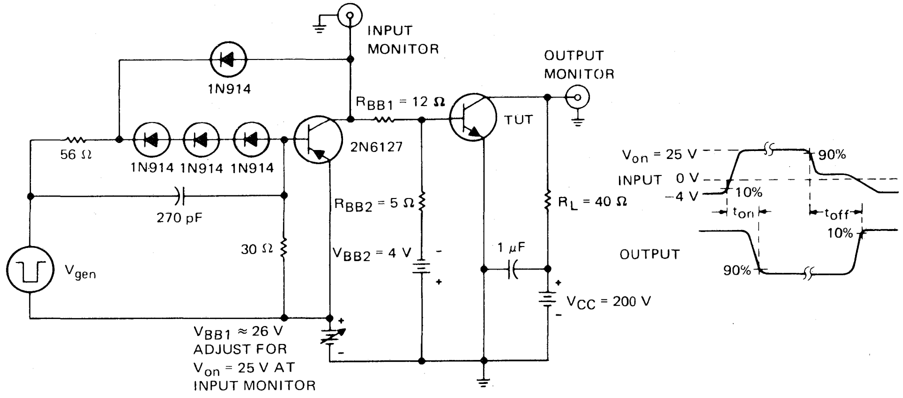
TEST	CONDITIONS			LEVEL
Power ($V_{CE} \cdot I_C$)	$V_{CE} = 50$ V,	$I_C = 2$ A,	$t_{test} = 0.15$ s	100 W
Reverse Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	$I_{CM} = 5$ A, $t_{test} = 0.5$ s,	L = 2 mH, See Figure 2	f = 10 Hz,	25 mJ
Forward Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	$I_{CM} = 10$ A, f = 60 Hz,	L = 5 mH, $t_{test} = 0.5$ s,	$V_{clamp} = V_{CEO}$ max rating, See Figure 3	250 mJ
Operation as Commutating Switch	$I_{load} = 5$ A, $t_{test} = 0.5$ s,	$V_{CC} = 0.8\ V_{CEO}$ max rating, See Figure 4	f = 20 kHz,	

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

7. This parameter must be measured using a 0.003-inch mica insulator with Dow-Corning II compound on both sides of the insulator, 6-32 mounting screw with bushing, and a mounting torque of 8 inch-pound.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

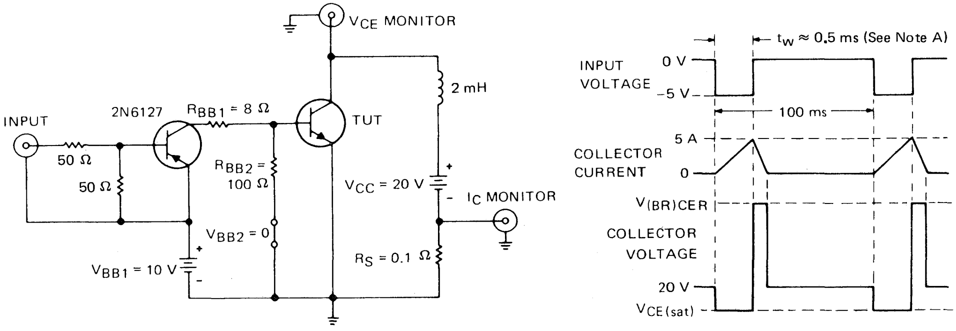
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1—SWITCHING TIMES

FUNCTIONAL TEST INFORMATION



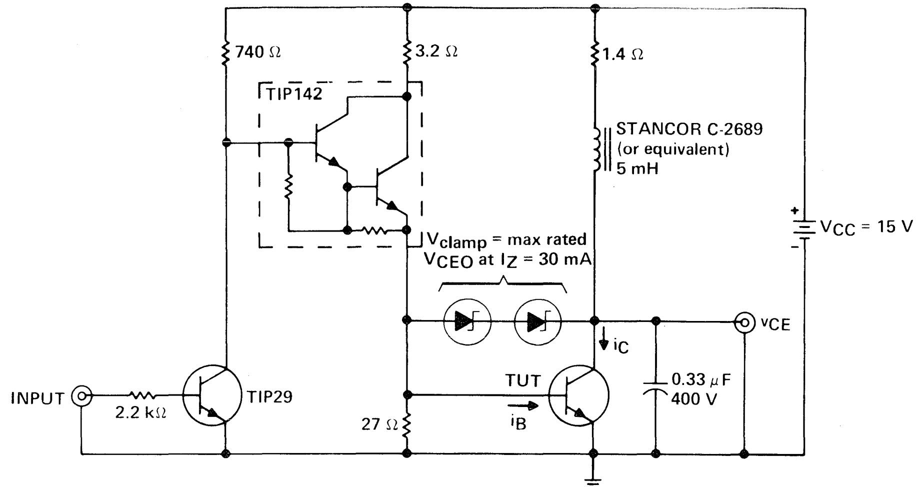
TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

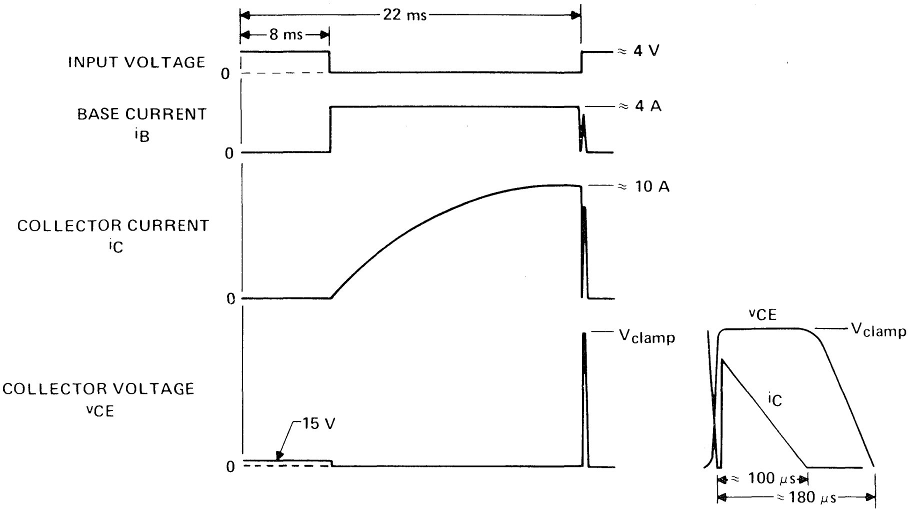
NOTE A: Input pulse width is increased until I_{CM} = 5 A.

FIGURE 2—REVERSE PULSE ENERGY

FUNCTIONAL TEST INFORMATION



TEST CIRCUIT



WAVEFORMS

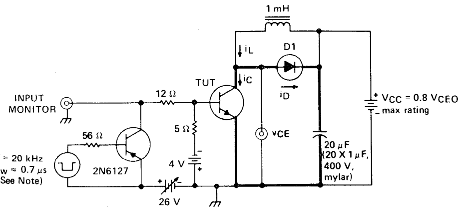
COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTES: A. Base and collector currents are measured using current probes such as Tektronix types P6019, P6020, P6021, P6042, or the equivalent.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 20$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

FIGURE 3—FORWARD PULSE ENERGY

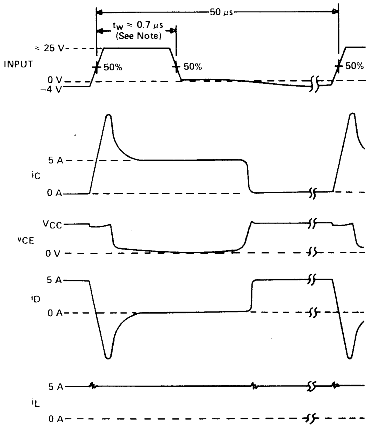
FUNCTIONAL TEST INFORMATION



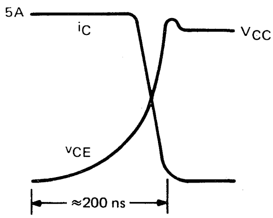
D1: RCA 40960 (or equivalent)
Rated I_{FM} > 125 A
Rated V_{RRM} > 600 V
V_F < 1.8 V at I_F = 100 A
t_{rr} < 0.35 μs at I_{FRM} = 125 A, di/dt = 25 A/μs, t_w = 15 μs

Heavy lines denote copper bus 0.5 inch X 0.125 inch

TEST CIRCUIT



WAVEFORMS



COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTE: Increase pulse width until i_C = 5 A following its peak.

FIGURE 4—OPERATION AS COMMUTATING SWITCH

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

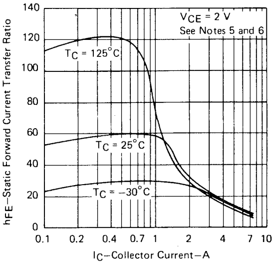


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

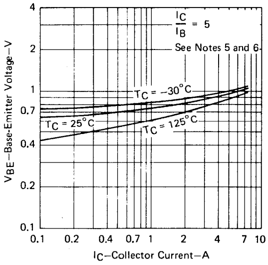


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

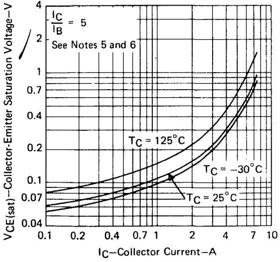
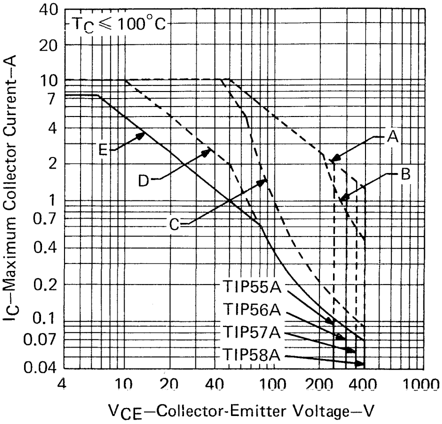


FIGURE 7

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR EMITTER VOLTAGE



CURVE	CONDITIONS
A	t_w = 100 μs, d = 0.1 = 10%
B	t_w = 1 ms, d = 0.1 = 10%
C	t_w = 10 ms, d = 0.1 = 10%
D	t_w = 150 ms, d = 0.01 = 1%
E	D-C OPERATION

FIGURE 8

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

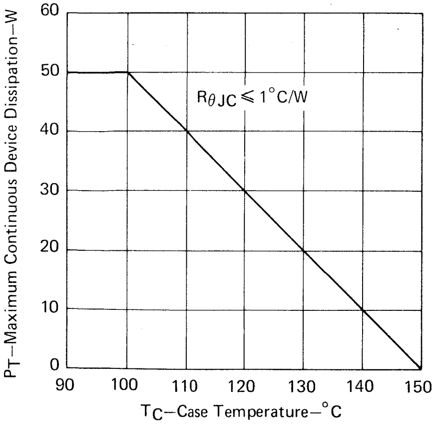


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

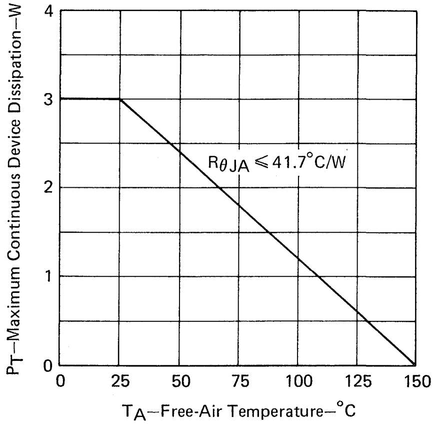


FIGURE 10

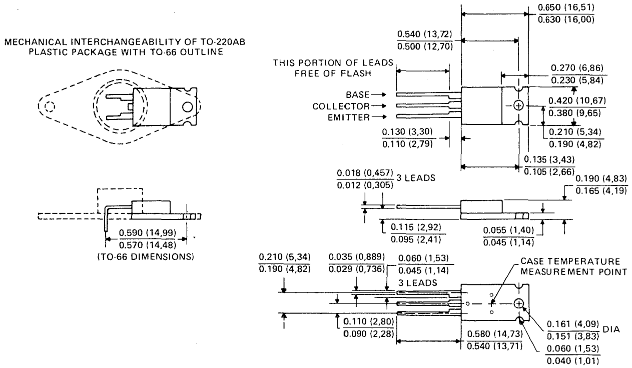
TYPES TIP75, TIP75A, TIP75B, TIP75C
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY DESIGNED FOR AUTOMOTIVE IGNITION, LINEAR AMPLIFIER, AND SWITCHING REGULATOR APPLICATIONS

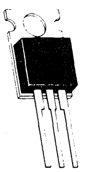
- Reverse-Bias SOA . . . 200 V to 400 V, 3A
- 65 W at 25°C Case Temperature
- 5 A Peak Collector Current
- Designed to Replace Motorola MJE2160

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN INCHES (PARENTHETICALLY IN MILLIMETRES) INCH DIMENSIONS GOVERN.
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP75	TIP75A	TIP75B	TIP75C
Collector-Base Voltage	350 V	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	200 V	250 V	300 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V	8 V
Continuous Collector Current	3 A			
Peak Collector Current (See Note 2)	5 A			
Continuous Base Current	1.5 A			
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 10 and 11			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	65 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W			
Operating Collector Junction Temperature Range	−65°C to 150°C			
Storage Temperature Range	−65°C to 150°C			
Lead Temperature 1/8 Inch (3,2 mm) from Case for 10 Seconds	260°C			

NOTES:
1. *These values apply when the base-emitter diode is reverse-biased or open-circuited.*
2. This value applies for $t_W \leqslant 5$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.52 W/°C or refer to Dissipation Derating Curve, Figure 12.
4. Derate lineraly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 13.

TYPES TIP75, TIP75A, TIP75B, TIP75C
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP75		TIP75A		TIP75B		TIP75C		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10$ mA, $I_E = 0$, See Note 5		350		400		450		500		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 5		200		250		300		400		V
$V_{CEX(sus)}$	Collector-Emitter Breakdown Voltage	$i_C = 3$ A,	See Figure 1	200		250		300		400		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 150$ V, $I_B = 0$			150		150					μA
		$V_{CE} = 250$ V, $I_B = 0$							150		150	
I_{CES}	Collector Cutoff Current	$V_{CE} = 300$ V, $V_{BE} = 0$			50							μA
		$V_{CE} = 350$ V, $V_{BE} = 0$					50					
		$V_{CE} = 400$ V, $V_{BE} = 0$							50			
		$V_{CE} = 450$ V, $V_{BE} = 0$									50	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 8$ V, $I_C = 0$			1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 500$ mA	See Notes 5 and 6	30	250	30	250	30	250	30	250	
		$V_{CE} = 2$ V, $I_C = 2$ A		12		12		12		12		
		$V_{CE} = 4$ V, $I_C = 3$ A		10		10		10		10		
V_{BE}	Base-Emitter Voltage	$I_B = 50$ mA, $I_C = 500$ mA	See Notes 5 and 6		1		1		1		1	V
		$I_B = 600$ mA, $I_C = 3$ A			1.2		1.2		1.2		1.2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 50$ mA, $I_C = 500$ mA	See Notes 5 and 6		0.5		0.5		0.5		0.5	V
		$I_B = 600$ mA, $I_C = 3$ A			1.9		1.9		1.9		1.9	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 500$ mA, f = 1 kHz		30		30		30		30		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 500$ mA, f = 1 MHz		10		10		10		10		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz			275		275		275		275	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leqslant$ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		62.5	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.7		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	0.9		J/°C

NOTE 7: This parameter is measured using a 0.003-inch (0,08 mm) mica insulator with Dow Corning II compound on both sides of the insulator, a 0.138-32 (formerly 6-32) mounting screw with bushing, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

inductive-load switching characteristics at 25° C case temperature

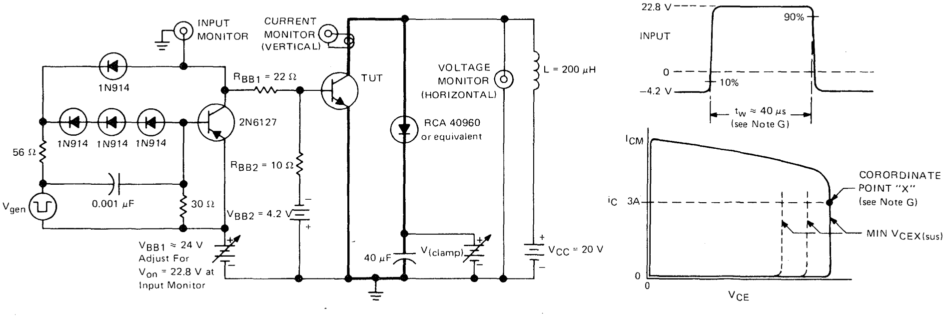
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)}$ = MIN $V_{CEX(sus)}$, I_{CM} = 3A, $I_{B(1)}$ = 500 mA, $I_{B(2)}$ = −500 mA, See Figure 2	1700	ns
t_{si}	Current Storage Time		2300	ns
t_{tv}	Voltage Transition Time		700	ns
t_{ti}	Current Transition Time		700	ns
t_{xo}	Cross-over Time		1300	ns

resistive-load switching characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 2 A, $I_{B(1)}$ = 200 mA, $I_{B(2)}$ = −200 mA, $V_{BE(off)}$ = −4 V, R_L = 100 Ω, See Figure 3	20	ns
t_r	Rise Time		340	ns
t_s	Storage Time		1400	ns
t_f	Fall Time		800	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



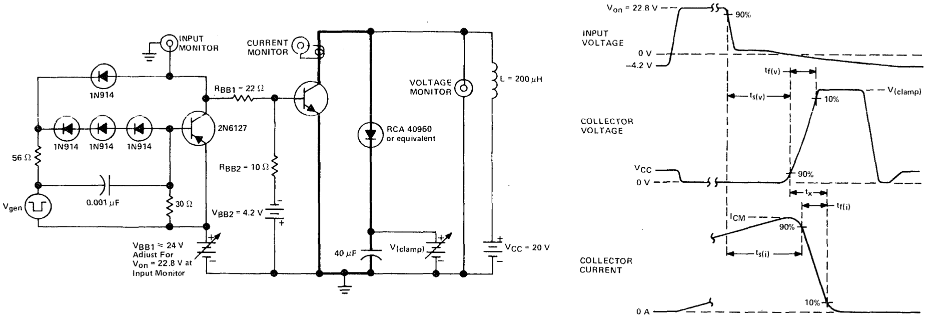
TEST CIRCUIT

INPUT WAVEFORM AND X-Y DISPLAY

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, $t_w \approx 40$ μs, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an X-Y oscilloscope with the following characteristics: $t_r \leqslant$ 15 ns, $R_{in} \geqslant$ 10 MΩ, $C_{in} \leqslant$ 11.5 pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.
- F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.
- G. Adjust input pulse width until collector current is 3 A at point "X". I_{CM} must not exceed 5 A.

FIGURE 1—COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50$ Ω, $t_w \approx 25$ µs duty cycle ⩽ 2%. Pulse width is adjusted for I_{CM} = 3A.

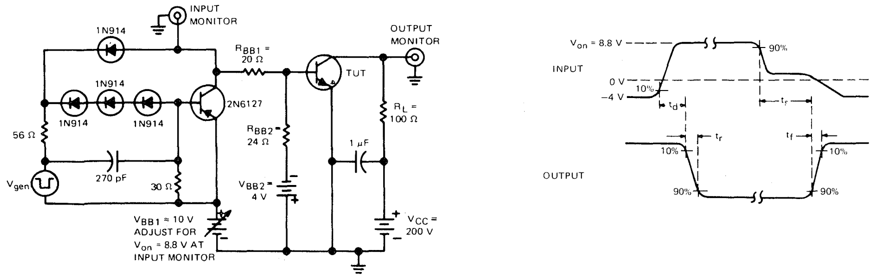
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

F. Heavy lines denote copper bus 0.5 inch by 0.125 (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

FIGURE 2—INDUCTIVE-LOAD SWITCHING TIMES



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ µs, duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 3—RESISTIVE-LOAD SWITCHING TIMES

TYPICAL CHARACTERISTICS

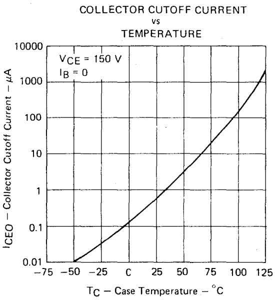

COLLECTOR CUTOFF CURRENT vs TEMPERATURE

FIGURE 4

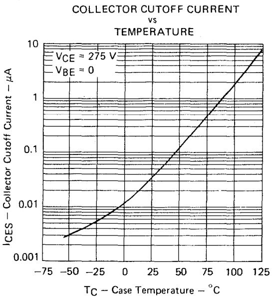

COLLECTOR CUTOFF CURRENT vs TEMPERATURE

FIGURE 5

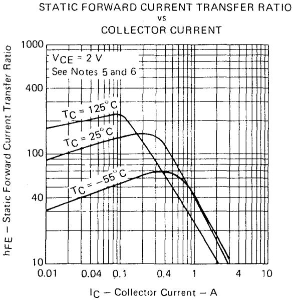

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

FIGURE 6

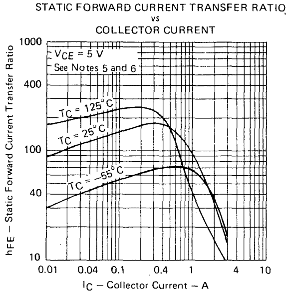

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

FIGURE 7

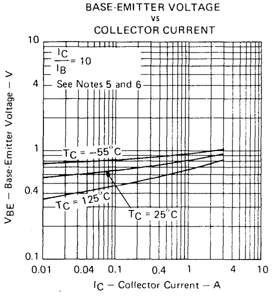

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

FIGURE 8

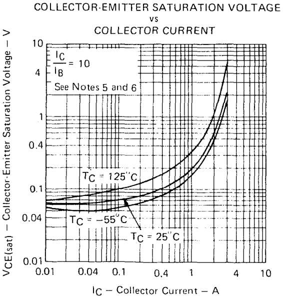

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

FIGURE 9

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

TYPES TIP75, TIP75A, TIP75B, TIP75C
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

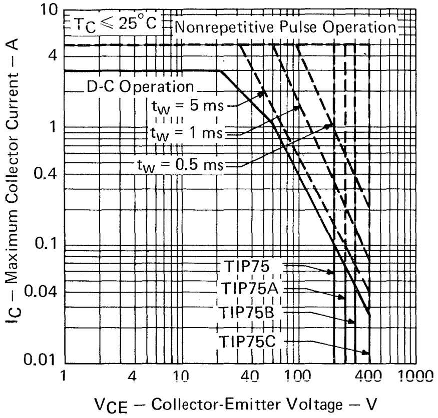


FIGURE 10

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

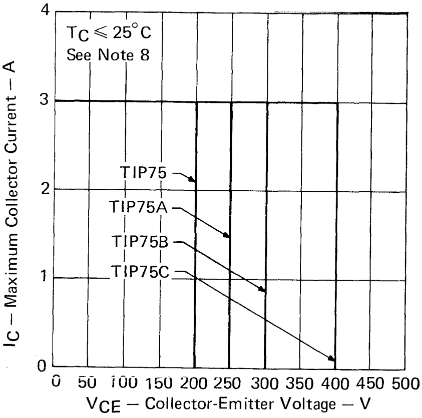


FIGURE 11

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load as in Figure 1.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

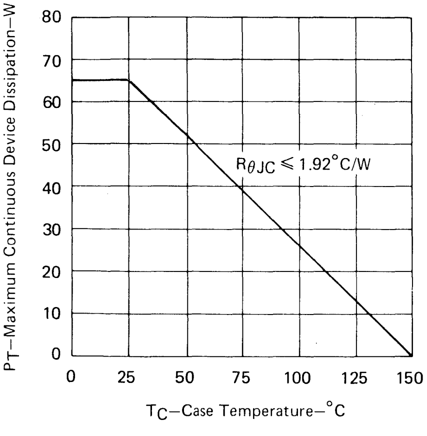


FIGURE 12

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

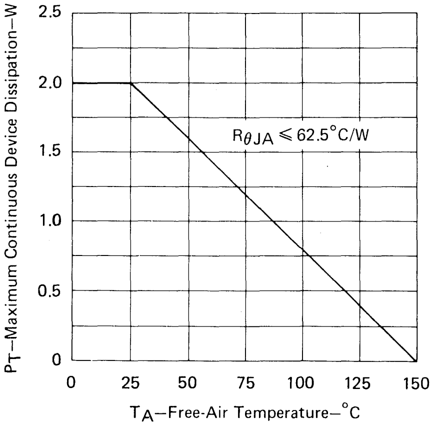


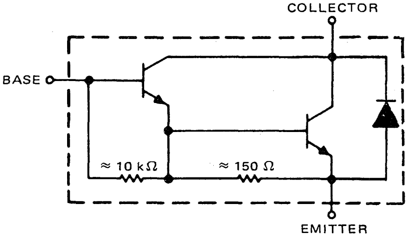
FIGURE 13

TIP110, TIP111, TIP112
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP115, TIP116, TIP117

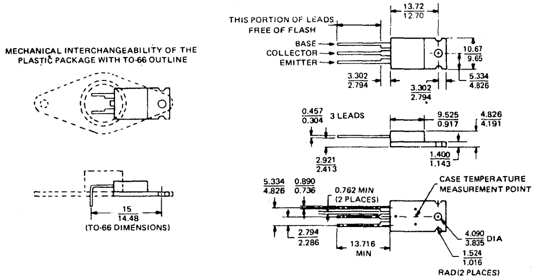
- High SOA Capability, 40 V and 1.25 A
- 50 W at 25°C Case Temperature
- 4-A Rated Collector Current
- Min h_{FE} of 500 at 4 V, 2 A
- 25-mJ Reverse Energy Rating

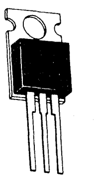
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





† FALLS WITHIN JEDEC TO-220AB DIMENSIONS

ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP110	TIP111	TIP112
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	← 4 A →		
Peak Collector Current (See Note 2)	← 4 A →		
Continuous Base Current	← 50 mA →		
Safe Operating Areas at (or below) 25°C Case Temperature	← See Figures 7 and 8 →		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 50 W →		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 2 W →		
Unclamped Inductive Load Energy (See Note 5)	← 25 mJ →		
Operating Collector Junction Temperature Range	← −65°C to 150°C →		
Storage Temperature Range	← −65°C to 150°C →		
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.4 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 100$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP 110, TIP 111, TIP 112
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP110		TIP111		TIP112		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		2					mA
		V_{CE} = 40 V, I_B = 0				2			
		V_{CE} = 50 V, I_B = 0						2	
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0		1					mA
		V_{CB} = 80 V, I_E = 0				1			
		V_{CB} = 100 V, I_E = 0						1	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		2		2		2	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7	1000		1000		1000		
		V_{CE} = 4 V, I_C = 2 A	500		500		500		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 2 A, See Notes 6 and 7		2.8		2.8		2.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 8 mA, I_C = 2 A, See Notes 6 and 7		2.5		2.5		2.5	V

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

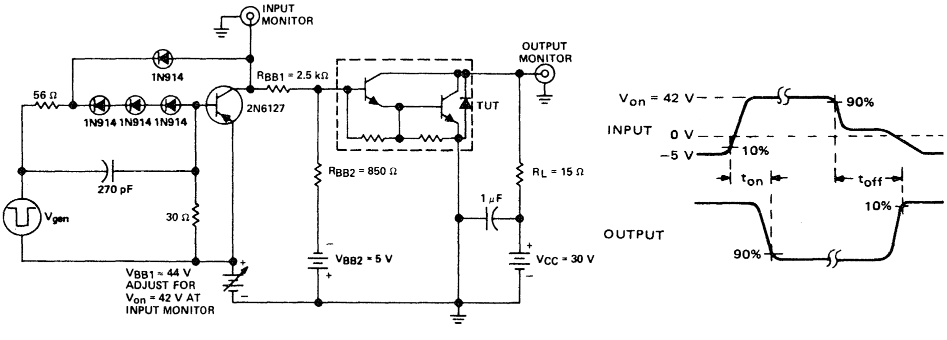
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 2 A, $I_{B(1)}$ = 8 mA, $I_{B(2)}$ = −8 mA, $V_{BE(off)}$ = −5 V, R_L = 15 Ω, See Figure 1	2.6	μs
t_{off}	Turn-Off Time		4.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ⩽ 15 ns, t_f ⩽ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

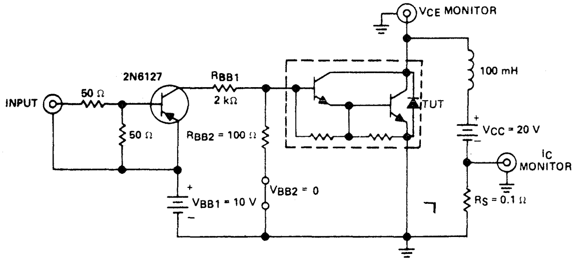
C. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ⩽ 15 ns, R_{in} ⩾ 10 MΩ, C_{in} ⩽ 11.5 pF.

D. Resistors must be noninductive types.

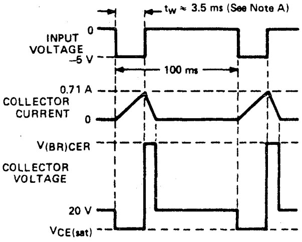
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 0.71 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

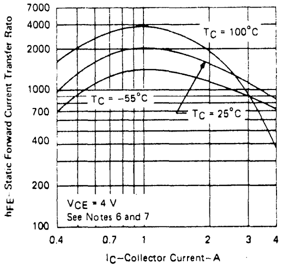


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

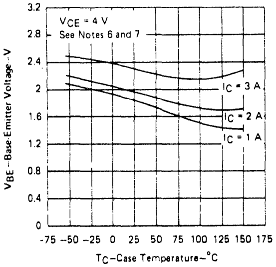


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

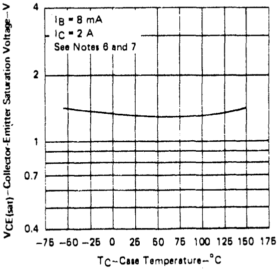


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

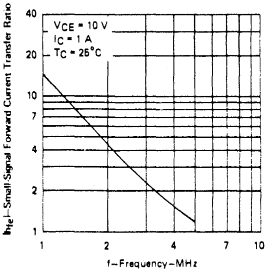


FIGURE 6

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

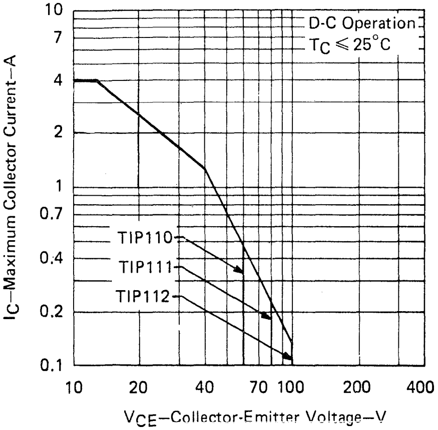


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

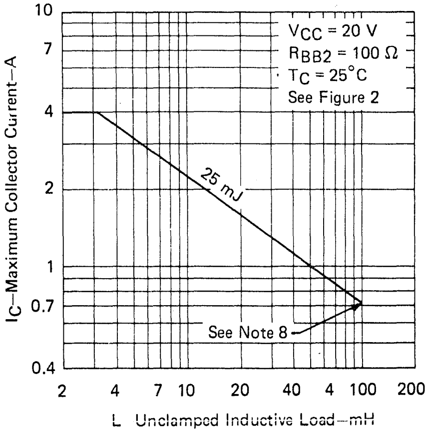


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

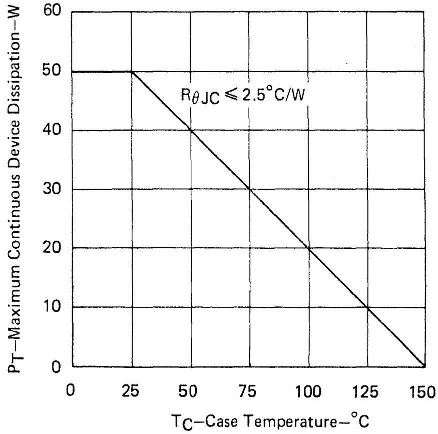


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

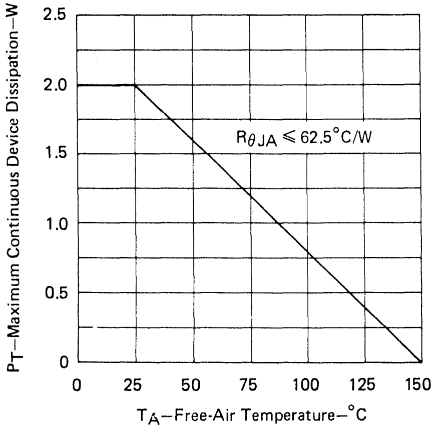


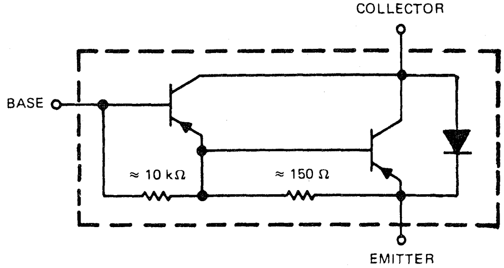
FIGURE 10

TIP115, TIP116, TIP117
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP110, TIP111, TIP112

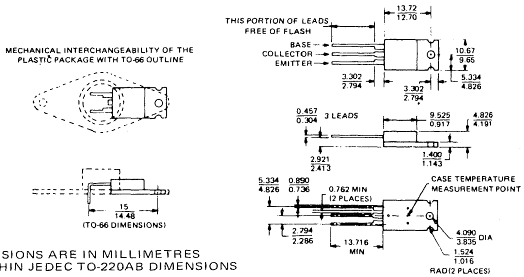
- High SOA Capability, 40 V and 1.25 A
- 50 W at 25°C Case Temperature
- Min h_{FE} of 500 at 4 V, 2 A
- 4-A Rated Collector Current
- 25-mJ Reverse Energy Rating

device schematic

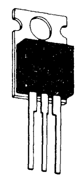


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP115	TIP116	TIP117
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	◄—— −4 A ——►		
Peak Collector Current (See Note 2)	◄—— −4 A ——►		
Continuous Base Current	◄—— −50 mA ——►		
Safe Operating Areas at (or below) 25°C Case Temperature	◄—See Figures 7 and 8—►		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄—— 50 W ——►		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄—— 2 W ——►		
Unclamped Inductive Load Energy (See Note 5)	◄—— 25 mJ ——►		
Operating Collector Junction Temperature Range	◄—— −65°C to 150°C ——►		
Storage Temperature Range	◄—— −65°C to 150°C ——►		
Lead Temperature 3.2mm from Case for 10 Seconds	◄—— 260° ——►		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.4 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 100$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP115, TIP116, TIP117
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP115		TIP116		TIP117		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−2					mA
		$V_{CE} = -40$ V, $I_B = 0$				−2			
		$V_{CE} = -50$ V, $I_B = 0$						−2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$		−1					mA
		$V_{CB} = -80$ V, $I_E = 0$				−1			
		$V_{CB} = -100$ V, $I_E = 0$						−1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−2		−2		−2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -1$ A, See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = -4$ V, $I_C = -2$ A	500		500		500		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -2$ A, See Notes 6 and 7		−2.8		−2.8		−2.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -8$ mA, $I_C = -2$ A, See Notes 6 and 7		−2.5		−2.5		−2.5	V

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ⩽ 2%.

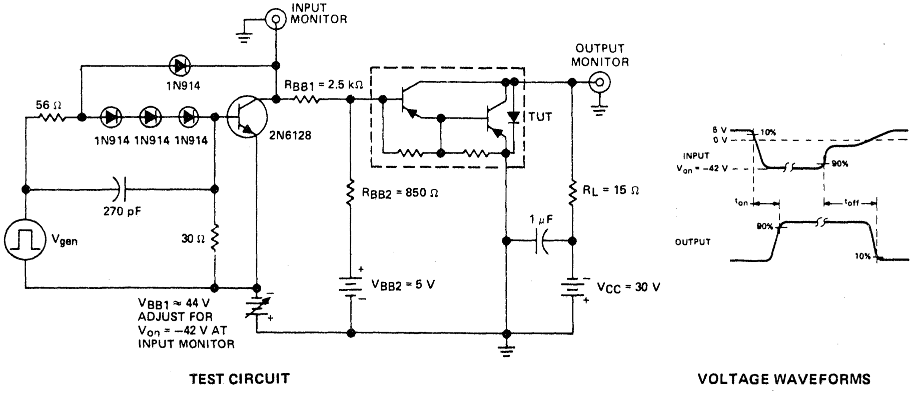
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -2$ A, $I_{B(1)} = -8$ mA, $I_{B(2)} = 8$ mA,	2.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 5$ V, $R_L = 15\ \Omega$, See Figure 1	4.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

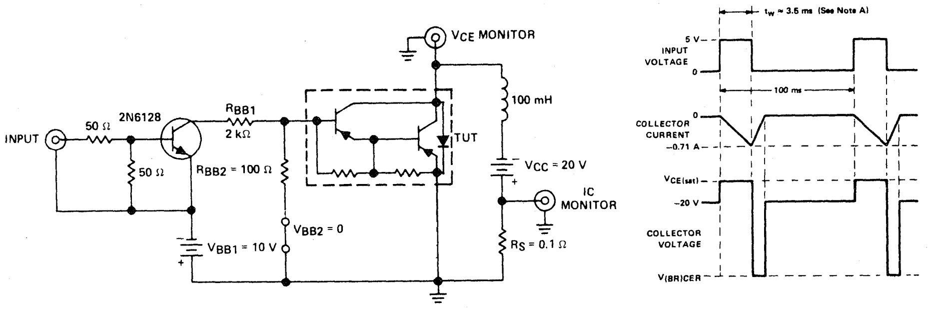
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -0.71$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

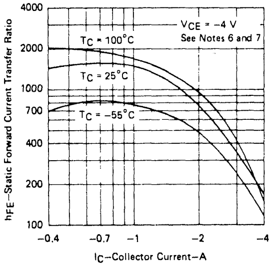


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

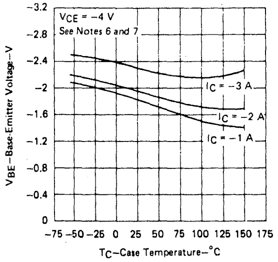


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

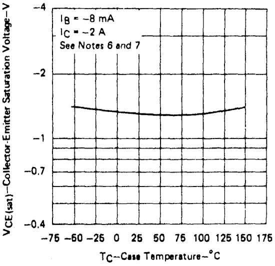


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

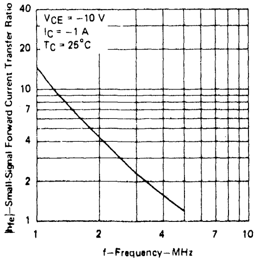


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

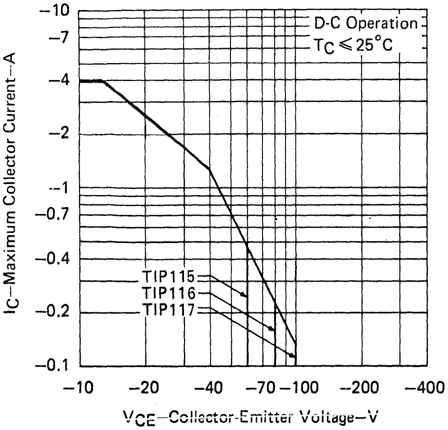


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

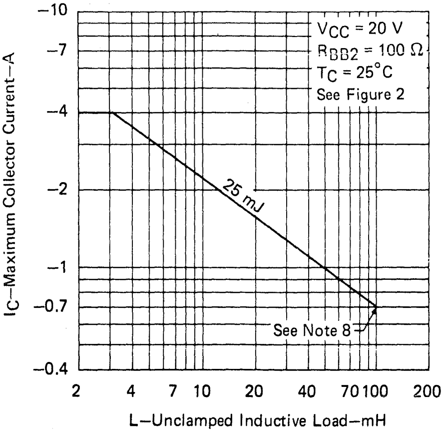


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

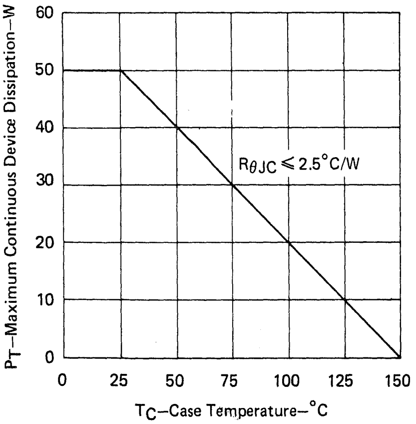


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

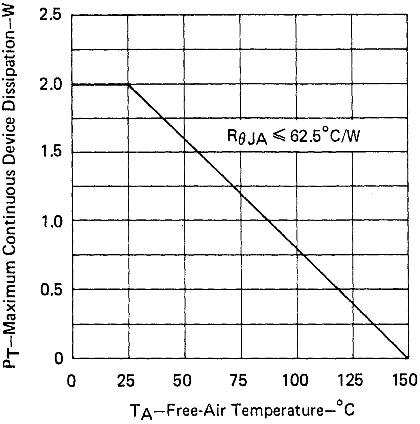


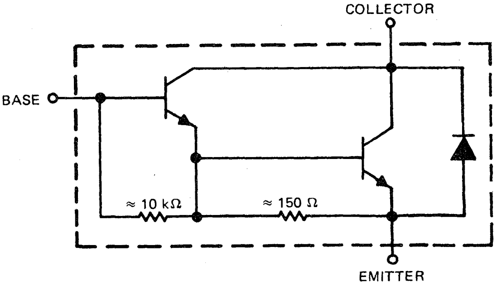
FIGURE 10

TIP120,TIP121,TIP122
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP125, TIP126, TIP127

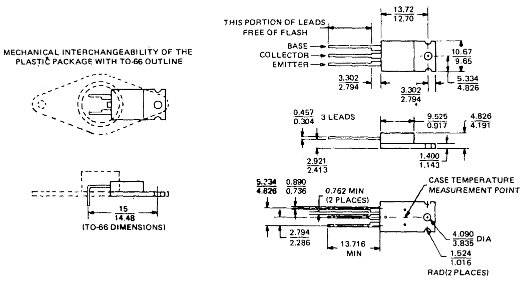
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

device schematic

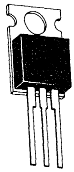


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP120	TIP121	TIP122
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	5 A		
Peak Collector Current (See Note 2)	8 A		
Continuous Base Current	0.1 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	65 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W		
Unclamped Inductive Load Energy (See Note 5)	50 mJ		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 3.2mm from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.52 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP120,TIP121,TIP122
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP120		TIP121		TIP122		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.5					mA
		$V_{CE} = 40$ V, $I_B = 0$				0.5			
		$V_{CE} = 50$ V, $I_B = 0$						0.5	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$		0.2					mA
		$V_{CB} = 80$ V, $I_E = 0$				0.2			
		$V_{CB} = 100$ V, $I_E = 0$						0.2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		2		2		2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 3$ V, $I_C = 0.5$ A, See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = 3$ V, $I_C = 3$ A, See Notes 6 and 7	1000		1000		1000		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 3$ V, $I_C = 3$ A, See Notes 6 and 7		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 12$ mA, $I_C = 3$ A, See Notes 6 and 7		2		2		2	V
		$I_B = 20$ mA, $I_C = 5$ A, See Notes 6 and 7		4		4		4	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

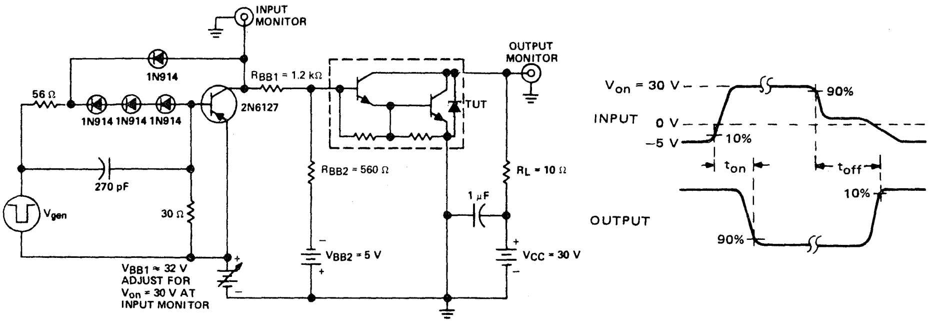
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 3$ A, $I_{B(1)} = 12$ mA, $I_{B(2)} = -12$ mA,	1.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -5$ V, $R_L = 10\ \Omega$, See Figure 1	8.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

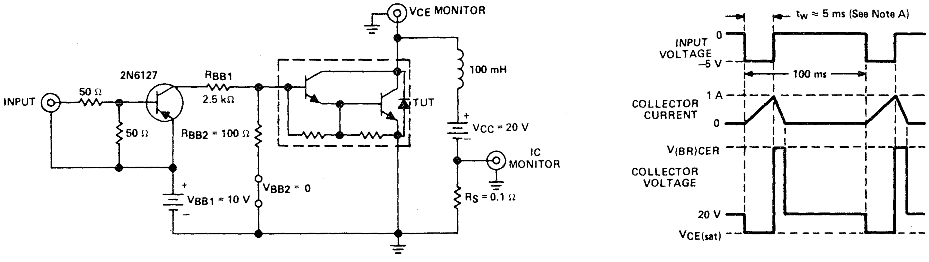
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 1 A.

FIGURE 2

TYPICAL CHARACTERISTICS

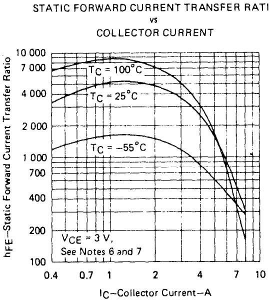


FIGURE 3

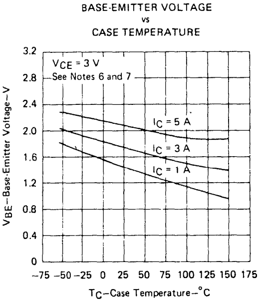


FIGURE 4

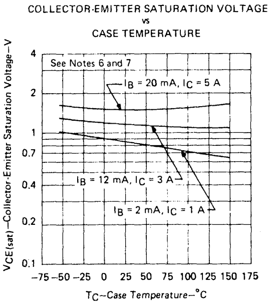


FIGURE 5

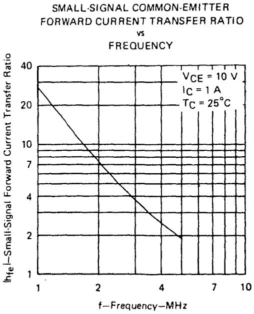


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

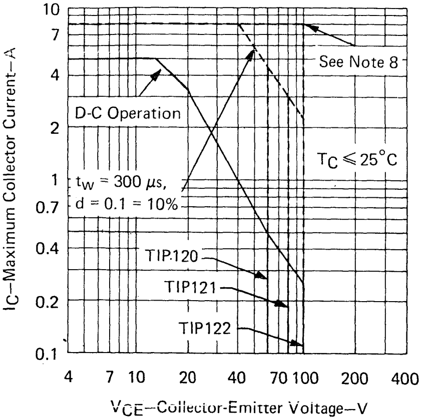


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

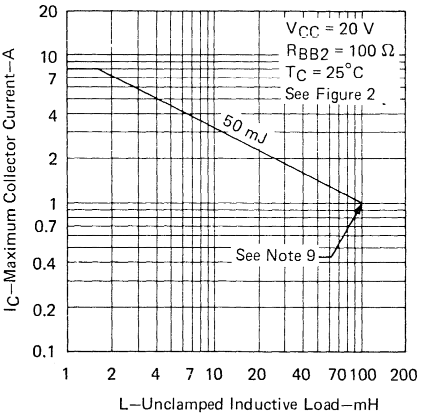


FIGURE 8

NOTES: 8. This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

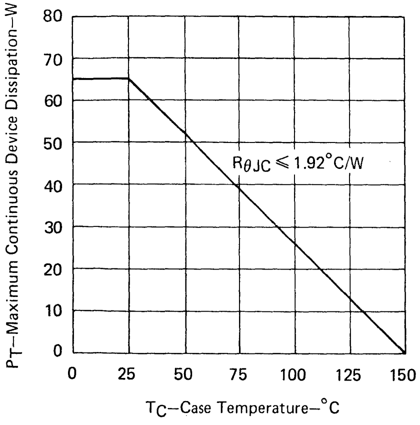


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

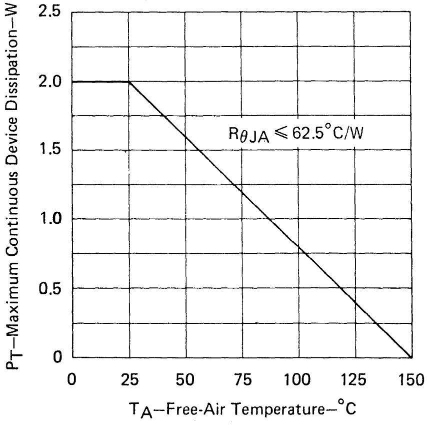


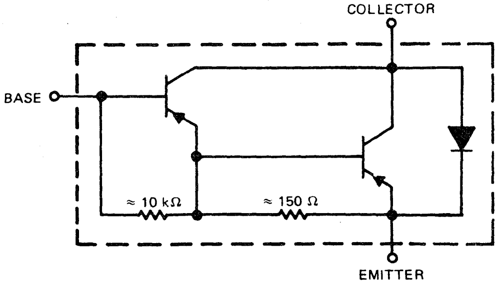
FIGURE 10

TIP125,TIP126,TIP127
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP120, TIP121, TIP122

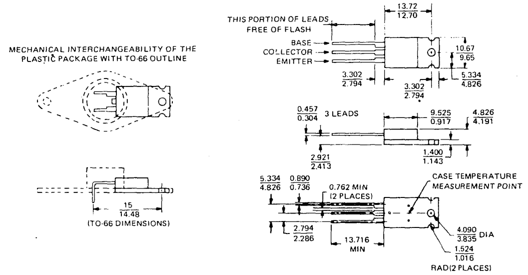
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

device schematic

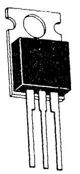


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP125	TIP126	TIP127
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	−5 A		
Peak Collector Current (See Note 2)	−8 A		
Continuous Base Current	−0.1 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	65 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W		
Unclamped Inductive Load Energy (See Note 5)	50 mJ		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 3.2mm from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 0.52 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 100$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP125,TIP126,TIP127
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP125		TIP126		TIP127		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.5					mA
		$V_{CE} = -40$ V, $I_B = 0$				−0.5			
		$V_{CE} = -50$ V, $I_B = 0$						−0.5	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$		−0.2					mA
		$V_{CB} = -80$ V, $I_E = 0$				−0.2			
		$V_{CB} = -100$ V, $I_E = 0$						−0.2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−2		−2		−2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -3$ V, $I_C = -0.5$ A, See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = -3$ V, $I_C = -3$ A	1000		1000		1000		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -3$ V, $I_C = -3$ A, See Notes 6 and 7		−2.5		−2.5		−2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -12$ mA, $I_C = -3$ A, See Notes 6 and 7		−2		−2		−2	V
		$I_B = -20$ mA, $I_C = -5$ A		−4		−4		−4	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

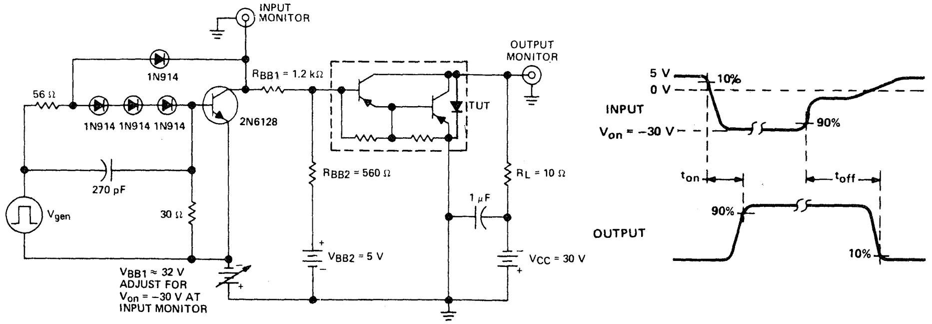
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3,2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -3$ A, $I_{B(2)} = -12$ mA, $I_{B(2)} = 12$ mA, $V_{BE(off)} = 5$ V, $R_L = 10\ \Omega$, See Figure 1	1.5	μs
t_{off}	Turn-Off Time		8.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

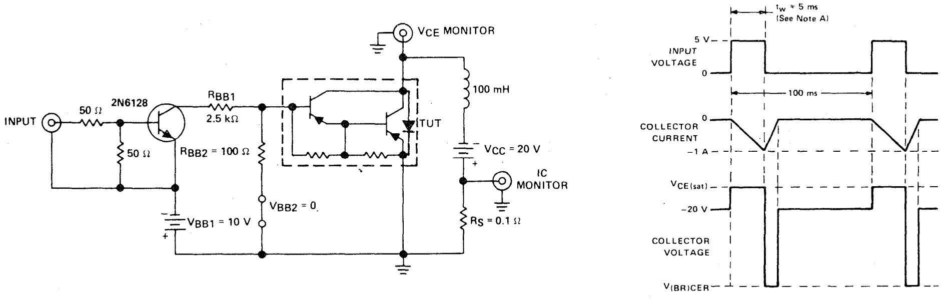
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



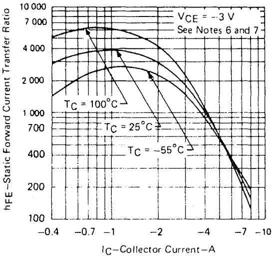
TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width in increased until $I_{CM} = -1$ A.

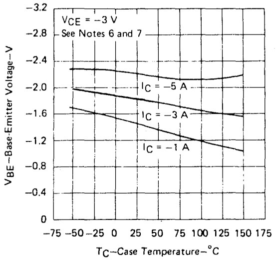
FIGURE 2

TYPICAL CHARACTERISTICS



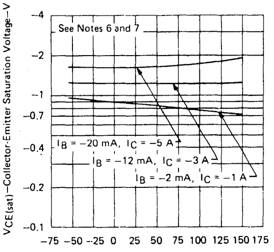
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 3



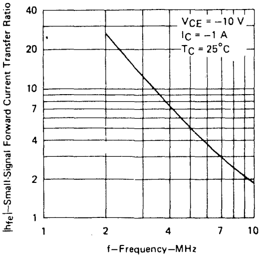
BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

FIGURE 4



COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

FIGURE 5



SMALL-SIGNAL COMMON-EMITTER
FORWARD-CURRENT TRANSFER RATIO
vs
FREQUENCY

FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

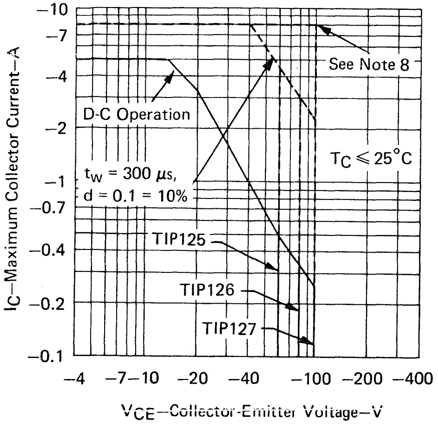


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

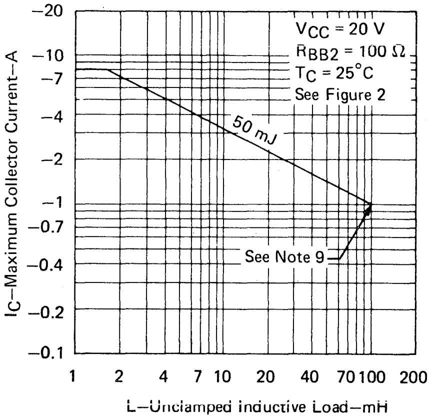


FIGURE 8

NOTES: 8. These combinations of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

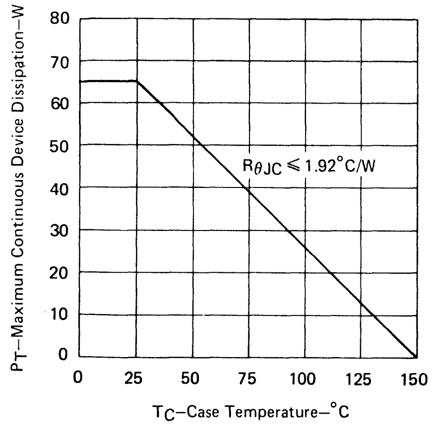


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

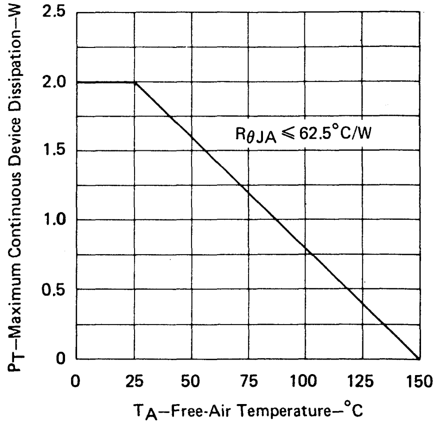


FIGURE 10

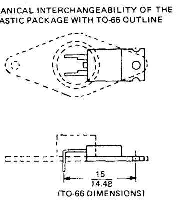
TIP130, TIP131, TIP132
NPN SILICON POWER DARLINGTON TRANSISTORS

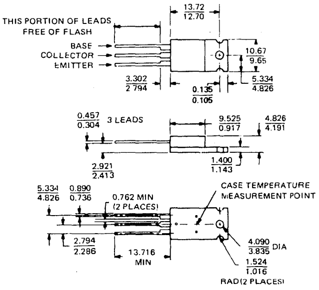
DESIGNED FOR COMPLEMENTARY USE WITH TIP135, TIP136, TIP137

- 70 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min H_{FE} of 1000 @ 4 V/4 A
- 75 mJ Reverse Energy Rating

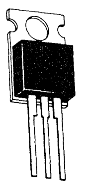
mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	TIP130	TIP131	TIP132
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (see Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	←	8 A	→
Peak Collector Current (see Note 2)	←	12 A	→
Continuous Base Current	←	0.3 A	→
Safe Operating Area at (or below) 25 °C Case Temperature	←	See Figure 1	→
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 3)	←	See Figure 2 70 W	→
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 4)	←	2 W	→
Unclamped Inductive Load Energy (see Note 5)	←	75 mJ	→
Operating Collector Junction Temperature Range	←	−65 °C to +150 °C	→
Storage Temperature Range	←	−65 °C to +150 °C	→

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150 °C case temperature at the rate of 0.56 W/°C or refer to Dissipation Derating Curve, Figure 2.
4. Derate linearly to 150 °C free-air temperature at the rate of 20 mW/°C or refer to Dissipation Derating Curve.
5. This rating is based on the capability of the transistor to operate safely in a circuit of: $L = 20$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V, Energy $\approx I_C{}^2L/2$.

TIP130, TIP131, TIP132
NPN SILICON POWER DARLINGTON TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	TIP130		TIP131		TIP132		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0 See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff	V_{CE} = 30 V, I_B = 0		0.5					
	Current	V_{CE} = 40 V, I_B = 0				0.5			mA
		V_{CE} = 50 V, I_B = 0						0.5	
I_{CBO}	Collector Cutoff	V_{CB} = 60 V, I_E = 0		0.2					
	Current	V_{CB} = 80 V, I_E = 0				0.2			mA
		V_{CB} = 100 V, I_E = 0						0.2	
I_{CBO}	@T_C = 100 °C	60/80/100 V		1		1		1	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		5		5		5	mA
H_{FE}	Static Forward Current	V_{CE} = 4 V, I_C = 1 A	500		500		500		
	Transfer Ratio	V_{CE} = 4 V, I_C = 4 A See Notes 6 an 7	1000	15000	1000	15000	1000	15000	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 4 A See Notes 6 and 7		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter	I_B = 16 mA, I_C = 4 A		2		2		2	
	Saturation Voltage	I_B = 30 mA, I_C = 6 A See Notes 6 and 7		3		3		3	V
C_{OB}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0		200		200		200	pF

NOTES: 6. These parameters must be measured using pulse techniques, t_W = 300 μs, duty cycle ⩽2%

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

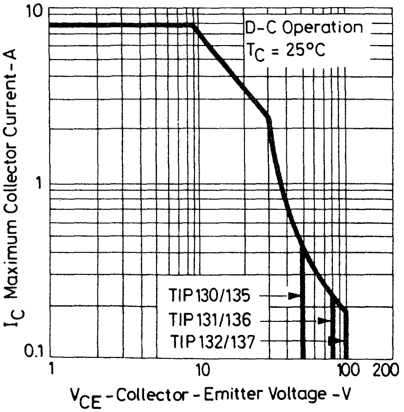


FIGURE 1

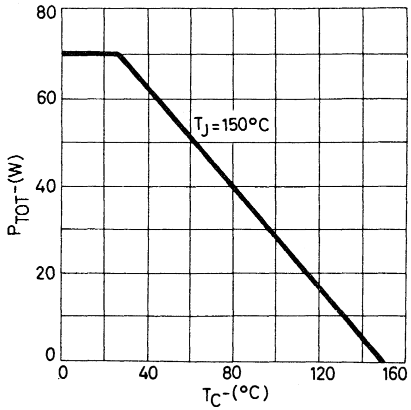
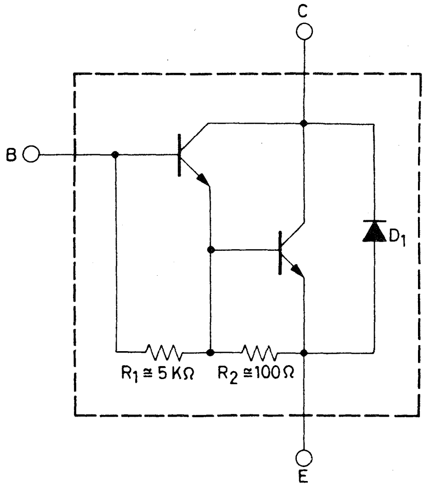


FIGURE 2

TIP130, TIP131, TIP132
NPN SILICON POWER DARLINGTON TRANSISTORS



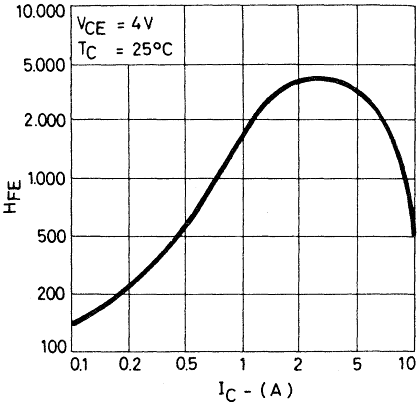


FIGURE 3

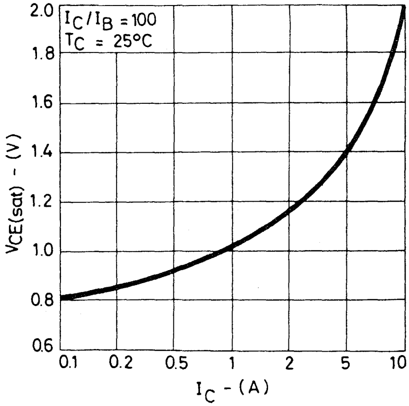


FIGURE 4

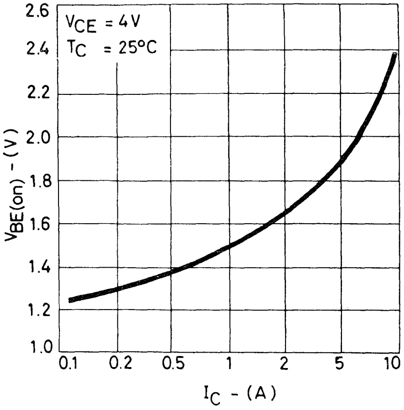


FIGURE 5

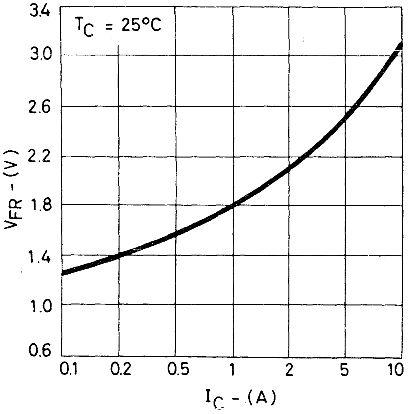


FIGURE 6

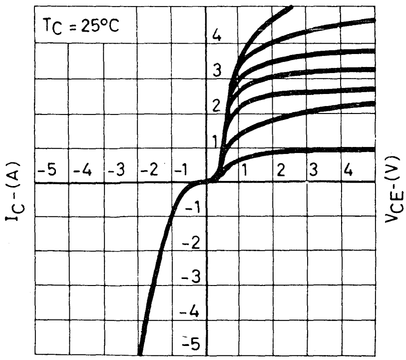


FIGURE 7

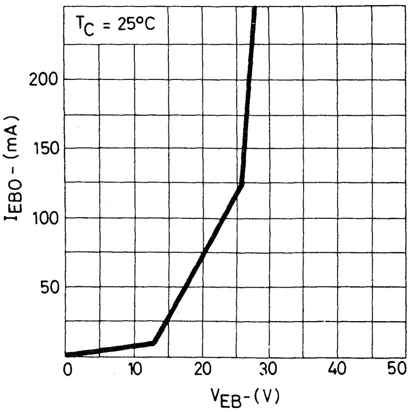


FIGURE 8

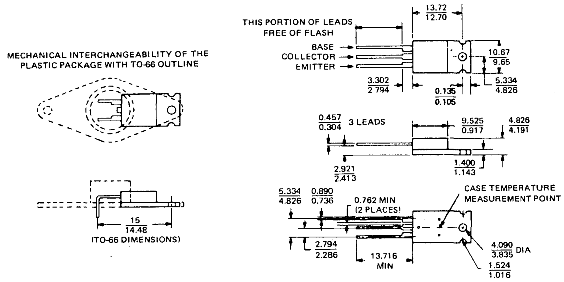
TIP135,TIP136,TIP137
PNP SILICON POWER DARLINGTON TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP130, TIP131, TIP132

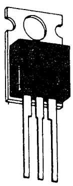
- 70 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min H_{FE} of 1000 @ 4 V/4 A
- 75 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES
FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25 °C case temperature (unless otherwise noted)

	TIP135	TIP136	TIP137
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (see Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current		−8 A	
Peak Collector Current (see Note 2)		−12 A	
Continuous Base Current		−0.3 A	
Safe Operating Area at (or below) 25 °C Case Temperature		See Figure 1	
Continuous Device Dissipation at (or below) 25 °C Case Temperature (see Note 3)		See Figure 2 70 W	
Continuous Device Dissipation at (or below) 25 °C Free-Air Temperature (see Note 4)		2 W	
Unclamped Inductive Load Energy (see Note 5)		75 mJ	
Operating Collector Junction Temperature Range		−65 °C to +150 °C	
Storage Temperature Range		−65 °C to +150 °C	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150 °C case temperature at the rate of 0.56 W/°C or refer to Dissipation Derating Curve, Figure 2.
4. Derate linearly to 150 °C free-air temperature at the rate of 20 mW/°C or refer to Dissipation Derating Curve.
5. This rating is based on the capability of the transistor to operate safely in a circuit of: $L = 20$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V, Energy $\approx I_C 2L/2$.

TIP135,TIP136,TIP137
PNP SILICON POWER DARLINGTON TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	TIP135		TIP136		TIP137		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$ See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.5					mA
		$V_{CE} = 40$ V, $I_B = 0$				0.5			
		$V_{CE} = 50$ V, $I_B = 0$						0.5	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$		0.2					mA
		$V_{CB} = 80$ V, $I_E = 0$				0.2			
		$V_{CB} = 100$ V, $I_E = 0$						0.2	
I_{CBO}	@$T_C = 100$ °C	60/80/100 V		1		1		1	mA
I_{EBO}	Emitter Cutoff	$V_{EB} = 5$ V, $I_C = 0$		5		5		5	mA
H_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A	500		500		500		
		$V_{CE} = 4$ V, $I_C = 4$ A See Notes 6 and 7	1000	15000	1000	15000	1000	15000	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 4$ A See Notes 6 and 7		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 16$ mA, $I_C = 4$ A		2		2		2	V
		$I_B = 30$ mA, $I_C = 6$ A See Notes 6 and 7		3		3		3	
C_{OB}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$		200		200		200	pF

NOTES: 6. These parameters must be measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

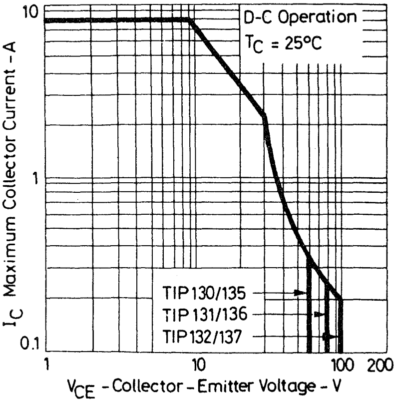


FIGURE 1

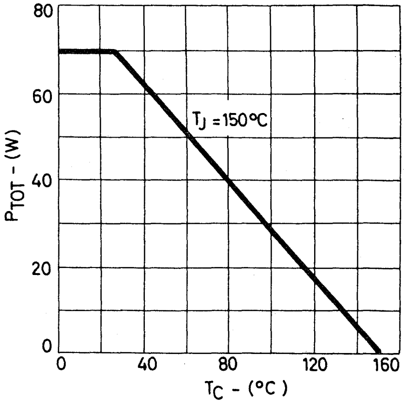
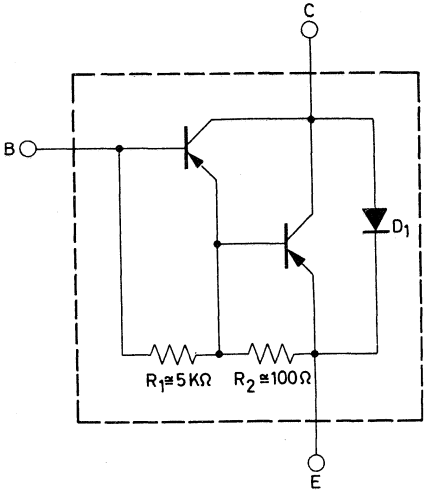


FIGURE 2

TEXAS INSTRUMENTS



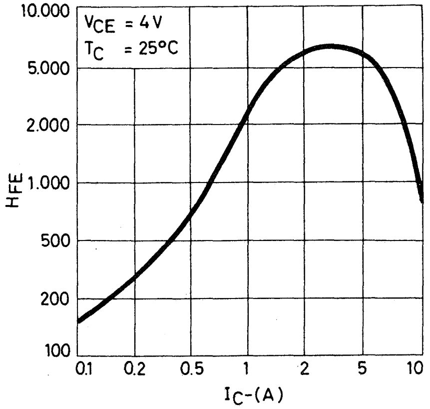


FIGURE 3

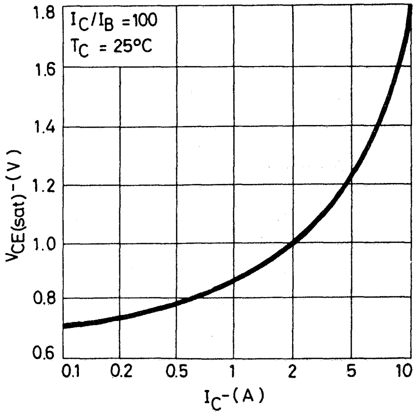


FIGURE 4

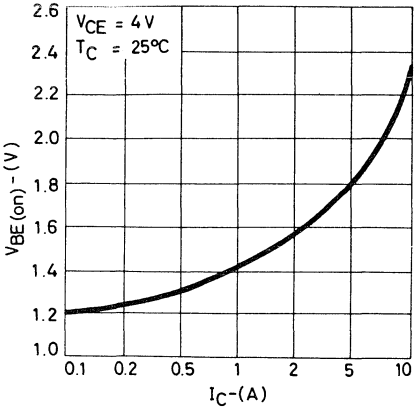


FIGURE 5

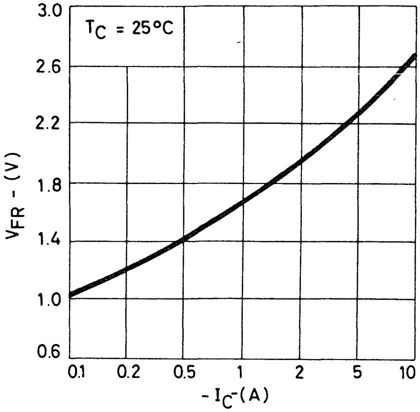


FIGURE 6

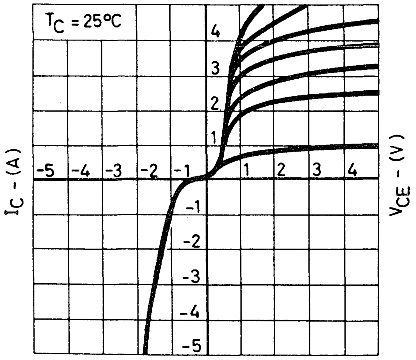


FIGURE 7

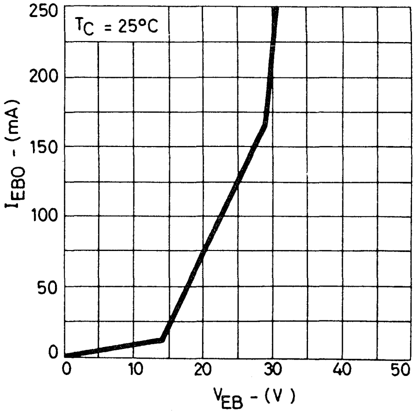


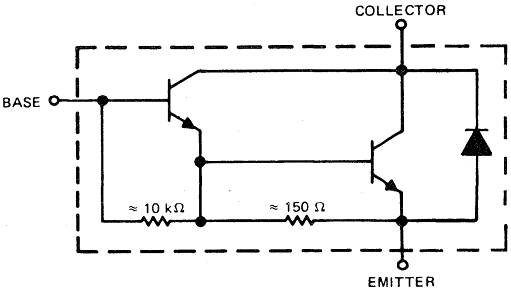
FIGURE 8

TIP140,TIP141,TIP142
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP145, TIP146, TIP147

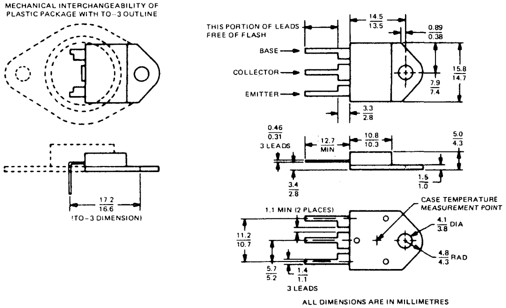
- 125 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100-mJ Reverse Energy Rating

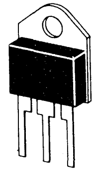
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP140	TIP141	TIP142
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	10 A		
Peak Collector Current (See Note 2)	15 A		
Continuous Base Current	0.5 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	125 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	3.5 W		
Unclamped Inductive Load Energy (See Note 5)	100 mJ		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 3.2mm from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 150°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 100$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP 140,TIP 141,TIP 142
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP140		TIP141		TIP142		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		2					mA
		V_{CE} = 40 V, I_B = 0				2			
		V_{CE} = 50 V, I_B = 0						2	
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0		1					mA
		V_{CB} = 80 V, I_E = 0				1			
		V_{CB} = 100 V, I_E = 0						1	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		2		2		2	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 5 A, See Notes 6 and 7	1000		1000		1000		
		V_{CE} = 4 V, I_C = 10 A	500		500		500		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 10 A, See Notes 6 and 7		3		3		3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 10 mA, I_C = 5 A, See Notes 6 and 7		2		2		2	V
		I_B = 40 mA, I_C = 10 A		3		3		3	

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

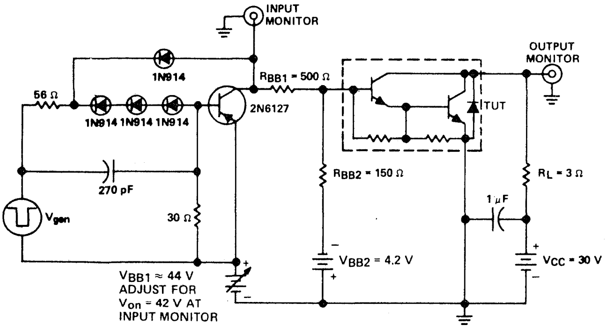
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

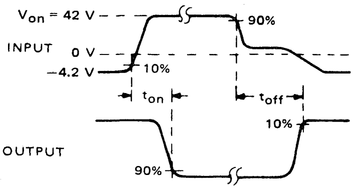
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 10 A, $I_{B(1)}$ = 40 mA, $I_{B(2)}$ = −40 mA,	0.9	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.2 V, R_L = 3 Ω, See Figure 1	11	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ⩽ 15 ns, t_f ⩽ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

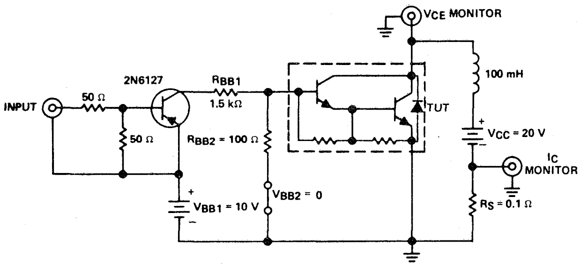
C. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ⩽ 15 ns, R_{in} ⩾ 10 MΩ, C_{in} ⩽ 11.5 pF.

D. Resistors must be noninductive types.

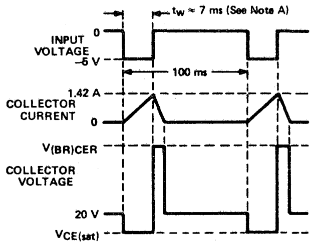
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 1.42 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

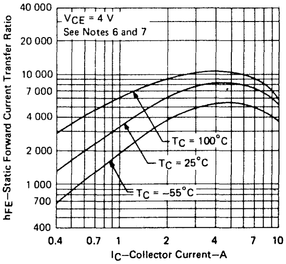


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

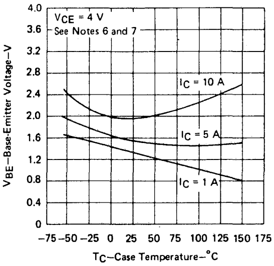


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

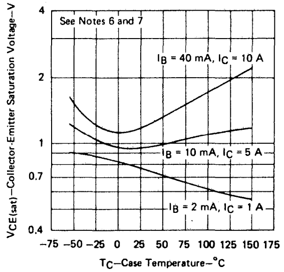


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

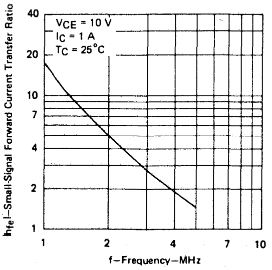


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques, t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

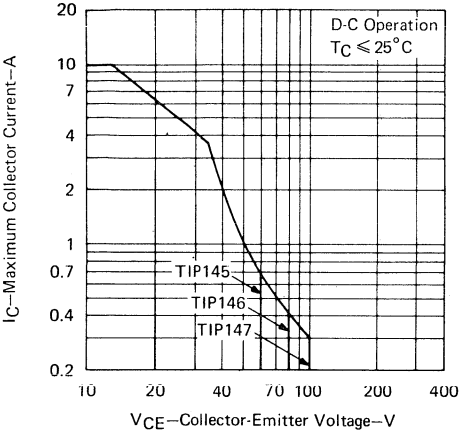


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

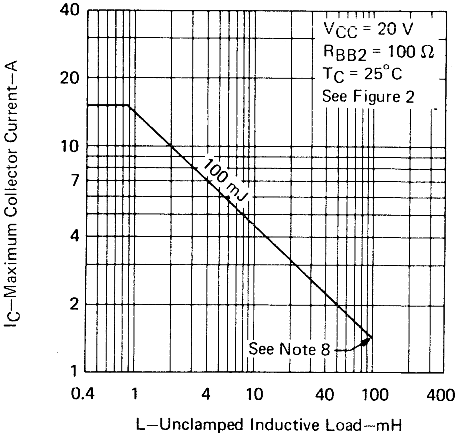


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

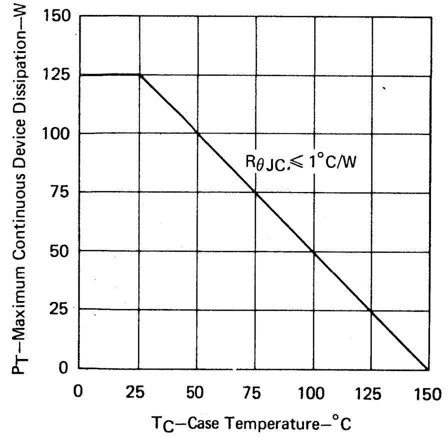


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

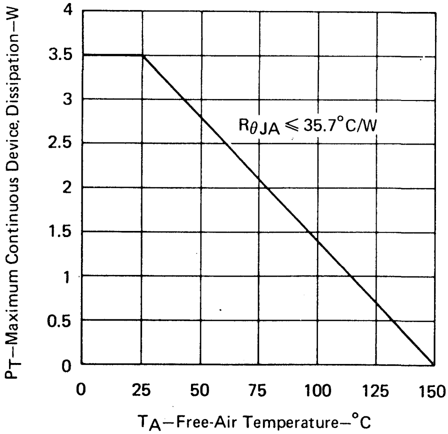


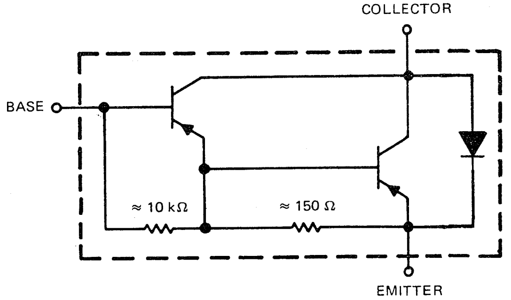
FIGURE 10

TIP145,TIP146,TIP147
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP140, TIP141, TIP142

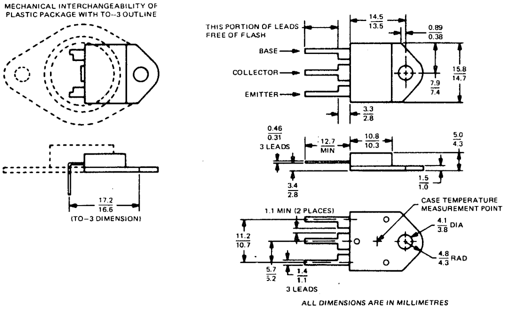
- 125 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100 mJ Reverse Energy Rating

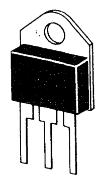
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP145	TIP146	TIP147
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	−10 A		
Peak Collector Current (See Note 2)	−15 A		
Continuous Base Current	−0.5 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	125 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	3.5 W		
Unclamped Inductive Load Energy (See Note 5)	100 mJ		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 3.2mm from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 150°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

TIP145,TIP146,TIP147
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP145		TIP146		TIP147		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−2					mA
		$V_{CE} = -40$ V, $I_B = 0$				−2			
		$V_{CE} = -50$ V, $I_B = 0$						−2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$		−1					mA
		$V_{CB} = -80$ V, $I_E = 0$				−1			
		$V_{CB} = -100$ V, $I_E = 0$						−1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−2		−2		−2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -5$ A, See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = -4$ V, $I_C = -10$ A	500		500		500		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -10$ A, See Notes 6 and 7		−3		−3		−3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -10$ mA, $I_C = -5$ A, See Notes 6 and 7		−2		−2		−2	V
		$I_B = -40$ mA, $I_C = -10$ A		−3		−3		−3	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

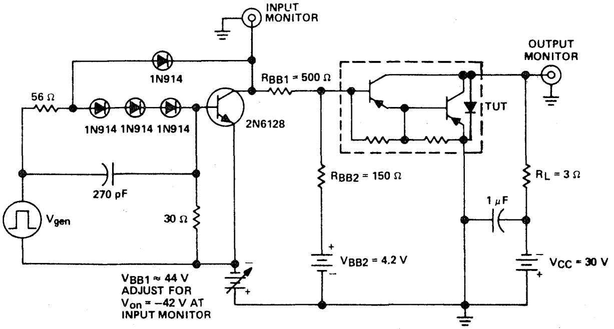
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

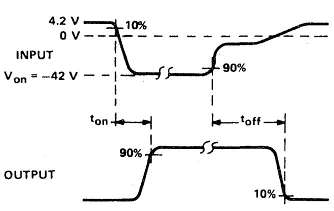
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -10$ A, $I_{B(1)} = -40$ mA, $I_{B(2)} = 40$ mA, $V_{BE(off)} = 4.2$ V, $R_L = 3\ \Omega$, See Figure 1	0.9	μs
t_{off}	Turn-Off Time		11	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.

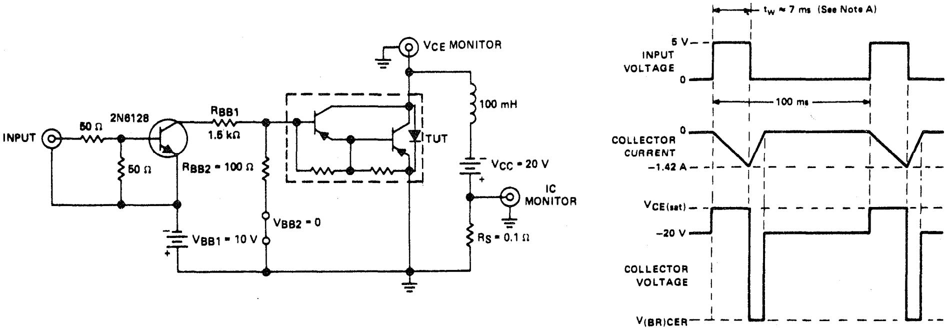
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



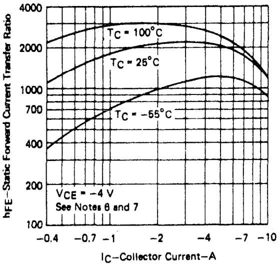
TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -1.42$ A.

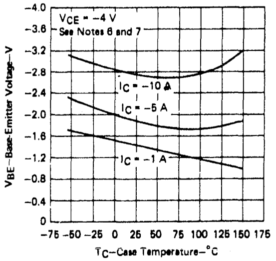
FIGURE 2

TYPICAL CHARACTERISTICS



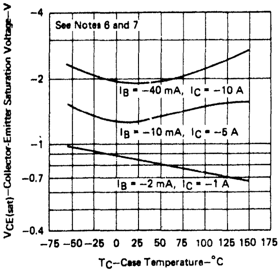
STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

FIGURE 3



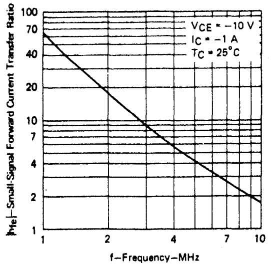
BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

FIGURE 4



COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

FIGURE 5



SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_W = 300\ \mu s$, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

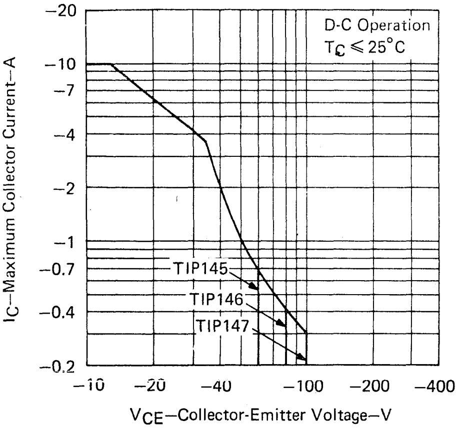


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

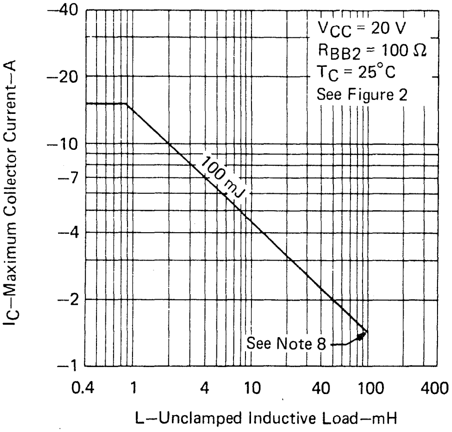


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

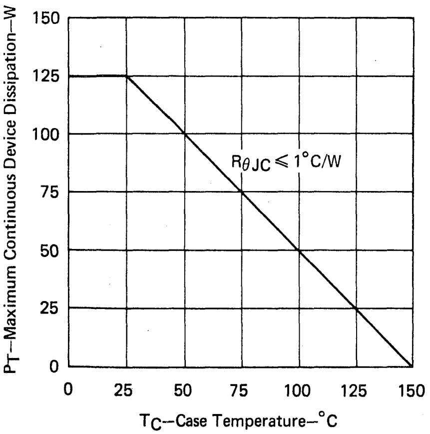


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

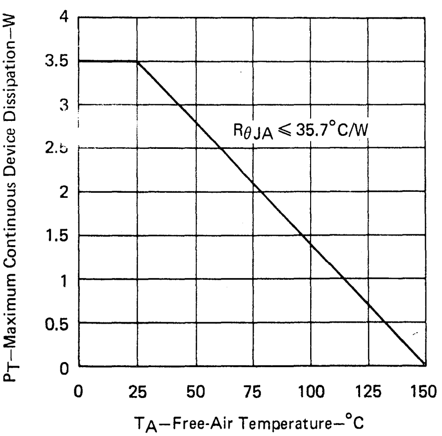


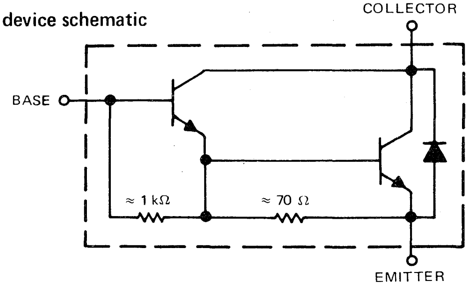
FIGURE 10

TYPES TIP150, TIP151, TIP152
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY

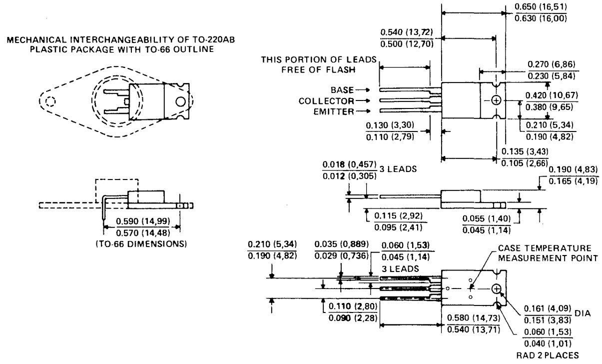
- $V_{CEX(sus)}$ . . . 300 V to 400 V at 7 A
- Reverse-Bias SOA . . . 300 V to 400 V at 7 A
- 80 W at 25°C Case Temperature
- 10 A Peak Collector Current

device schematic



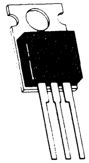
mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.

FALLS WITHIN JEDEC TO-220AB DIMENSIONS



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP150	TIP151	TIP152
Collector-Base Voltage	300 V	350 V	400 V
Collector-Emitter Voltage (See Note 1)	300 V	350 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V
Continuous Collector Current	7 A		
Peak Collector Current (See Note 2)	10 A		
Continuous Base Current	1.5 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 8 and 9		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	80 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 1/8 Inch (3,2 mm) from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is reverse biased or open-circuited.
2. This value applies for $t_w \leqslant 5$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 150°C case temperature at the rate of 0.64 W/°C or refer to Dissipation Derating Curve, Figure 10.
4. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C or refer to Dissipation Derating Curve, Figure 11.

TYPES TIP150, TIP151, TIP152
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP150		TIP151		TIP152		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 1 mA, I_E = 0, See Note 5	300		350		400		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0, See Note 5	300		350		400		V
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage	i_C = 7 A, See Figure 1	300		350		400		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 300 V, I_B = 0		250					μA
		V_{CE} = 350 V, I_B = 0				250			
		V_{CE} = 400 V, I_B = 0						250	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 8 V, I_C = 0		15		15		15	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 2.5 A, See Notes 5 and 6	150		150		150		
		V_{CE} = 5 V, I_C = 5 A, See Notes 5 and 6	50		50		50		
		V_{CE} = 5 V, I_C = 7 A, See Notes 5 and 6	15		15		15		
V_{BE}	Base-Emitter Voltage	I_B = 100 mA, I_C = 2 A, See Notes 5 and 6		2.2		2.2		2.2	V
		I_B = 250 mA, I_C = 5 A, See Notes 5 and 6		2.3		2.3		2.3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 10 mA I_C = 1 A, See Notes 5 and 6		1.5		1.5		1.5	V
		I_B = 100 mA, I_C = 2 A, See Notes 5 and 6		1.5		1.5		1.5	
		I_B = 250 mA, I_C = 5 A, See Notes 5 and 6		2		2		2	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C$ = 7 A, See Notes 5 and 6		2.8		2.8		2.8	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.5 A, f = 1 kHz	200		200		200		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.5 A, f = 1 MHz	10		10		10		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz		100		100		100	pF

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		62.5	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.7		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	0.9		J/°C

NOTE: 7. This parameter is measured using a 0.003-inch (0,08 mm) mica insulator with Dow Corning II compound on both sides of the insulator, a 0.138-32 (formerly 6-32) mounting screw with bushing, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

inductive-load switching characteristics at 25°C case temperature

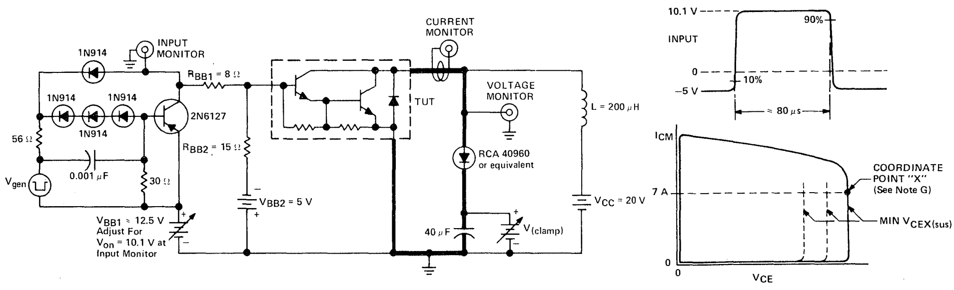
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)}$ = MIN $V_{CEX(sus)}$, I_{CM} = 5 A, $I_{B(1)}$ = 250 mA, $I_{B(2)}$ = −250 mA, See Figure 2	3900	ns
t_{si}	Current Storage Time		4700	ns
t_{tv}	Voltage Transition Time		1200	ns
t_{ti}	Current Transition Time		1200	ns
t_{xo}	Cross-over Time		2000	ns

resistive-load switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 5 A, $I_{B(1)}$ = 250 mA, $I_{B(2)}$ = −250 mA, $V_{BE(off)}$ = −7.3 V, R_L = 50 Ω, See Figure 3	20	ns
t_r	Rise Time		160	ns
t_s	Storage Time		3400	ns
t_f	Fall Time		1520	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



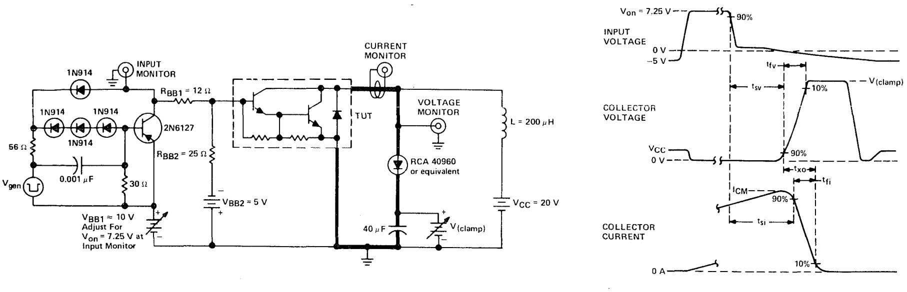
TEST CIRCUIT

INPUT WAVEFORM AND X-Y DISPLAY

NOTES:
- A. V_{gen} is a −20-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, $t_w \approx 80$ μs, duty cycle = 20%.
- C. Waveforms are monitored on an X-Y oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.
- F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.
- G. Adjust input pulse width until collector current is 7 A at point "X". I_{CM} must not exceed 10 A.

FIGURE 1—COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST

PARAMETER MEASUREMENT INFORMATION

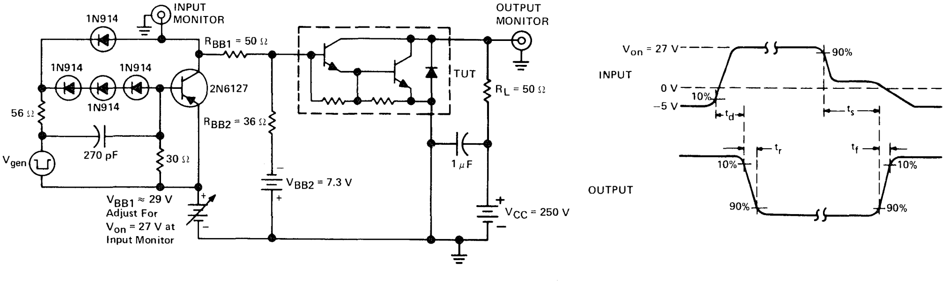


TEST CIRCUIT

WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w \approx 50\ \mu s$, duty cycle ⩽ 2%. Pulse width is adjusted for $I_{CM} = 3$ A.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.
- F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

FIGURE 2—INDUCTIVE-LOAD SWITCHING TIMES



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 3—RESISTIVE-LOAD SWITCHING TIMES

TYPICAL CHARACTERISTICS

TIP152
COLLECTOR CUTOFF CURRENT
vs
CASE TEMPERATURE

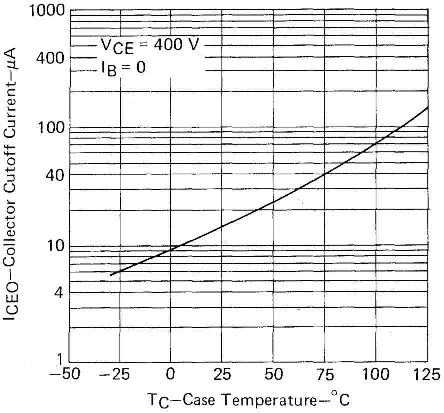


FIGURE 4

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

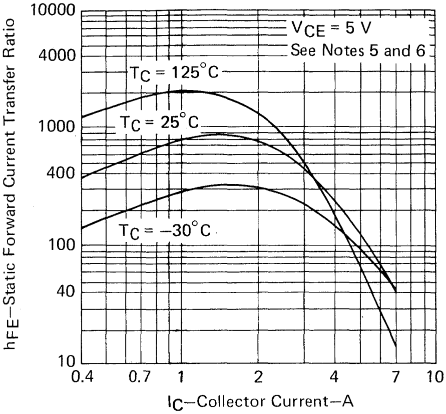


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

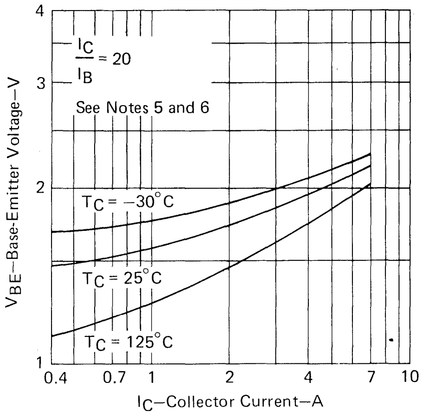


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR-CURRENT

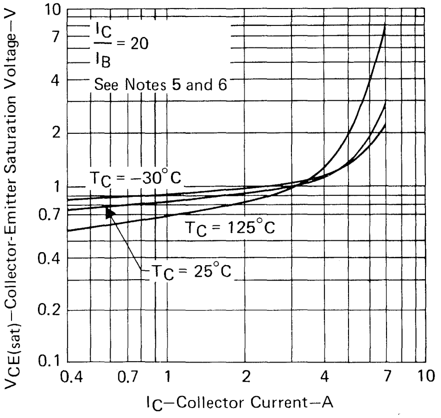


FIGURE 7

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

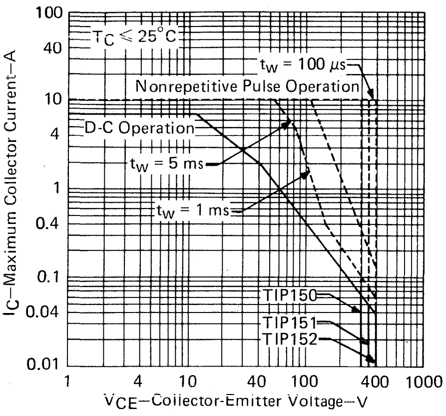


FIGURE 8

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

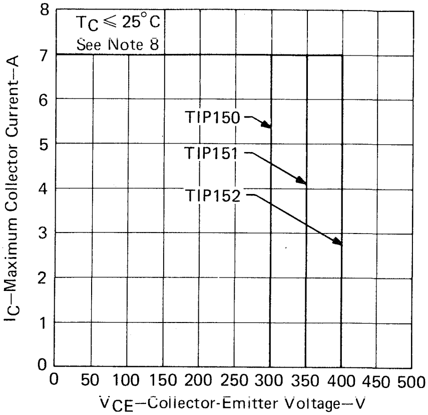


FIGURE 9

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load as in Figure 1.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

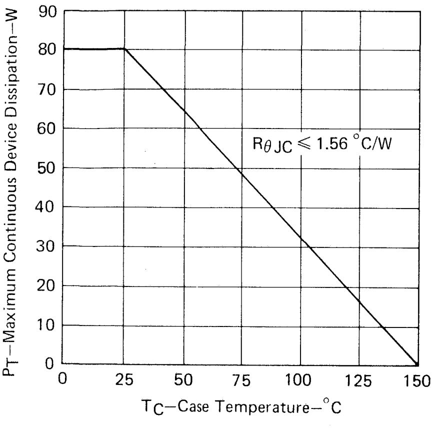


FIGURE 10

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

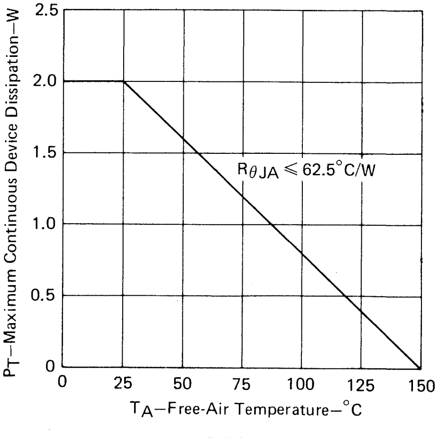


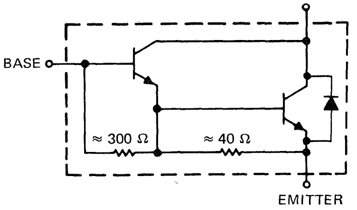
FIGURE 11

TYPES TIP160, TIP161, TIP162
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR AUTOMOTIVE IGNITION APPLICATIONS

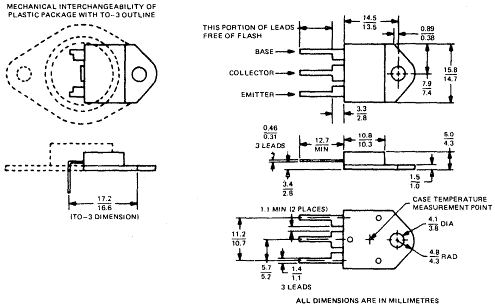
- 50 W at 100°C Case Temperature
- 10-A Rated Continuous Collector Current
- Max $V_{CE(sat)}$ of 2.8 V at 6.5 A
- Functional Verification Tests for Ignition Applications

device schematic

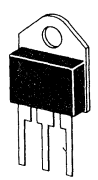


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP160	TIP161	TIP162
Collector-Base Voltage	320 V	350 V	380 V
Collector-Emitter Voltage (See Note 1)	320 V	350 V	380 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	10 A		
Peak Collector Current (See Note 2)	15 A		
Commutating Diode Current (See Note 3)	10A		
Continuous Base Current	1 A		
Safe Operating Area at (or below) 100°C Case Temperature	See Figure 8		
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 4)	50 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	3 W		
Operating Collector Junction Temperature Range	−65°C to 150°C		
Storage Temperature Range	−65°C to 150°C		
Lead Temperature 1/8 Inch from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 10$ ms, duty cycle $\leqslant 10\%$.
3. This applies to the total collector-terminal current when the collector is at negative potential with respect to the emitter.
4. Derate linearly to 150°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
5. Derate linearly to 150°C free-air temperature at the rate of 24 mW/°C or refer to Dissipation Derating Curve, Figure 10.

TYPES TIP160, TIP161, TIP162
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIP160		TIP161		TIP162		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = 320 V, I_B = 0		1					mA
		V_{CE} = 350 V, I_B = 0				1			
		V_{CE} = 380 V, I_B = 0						1	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		100		100		100	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2.2 V, I_C = 4 A, See Notes 6 and 7	200		200		200		
V_{BE}	Base-Emitter Voltage	I_B = 0.1 A, I_C = 6.5 A, See Notes 6 and 7		2.2		2.2		2.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.1 A, I_C = 6.5 A, See Notes 6 and 7		2.8		2.8		2.8	V
		I_B = 1 A, I_C = 10 A, See Notes 6 and 7		2.9		2.9		2.9	
V_F	Forward Voltage of Commutating Diode	$I_F = -I_C$ = 10 A, I_B = 0, See Notes 6 and 7		3		3		3	V

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		41.7	
$R_{\theta CHS}$	Case-to-Heat Sink Thermal Resistance (See Note 8)	0.6		
$C_{\theta C}$	Thermal Capacitance of Case	1.4		J/°C

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 6.5 A, $I_{B(1)}$ = 100 mA, $I_{B(2)}$ = −100 mA, $V_{BE(off)}$ = −5 V, R_L = 5 Ω, See Figure 1	0.04	μs
t_r	Rise Time		1.5	
t_s	Storage Time		2.2	
t_f	Fall Time		2.6	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

TEST	CONDITIONS	LEVEL
Power ($V_{CE} \cdot I_C$)	V_{CE} = 40 V, I_C = 2 A, t_{test} = 0.15 s	80 W
Reverse Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 6 A, L = 100 μH, f = 10 Hz, t_{test} = 0.5 s, See Note 9	1.8 mJ
Forward Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 7 A, L = 5 mH, $V_{clamp} = V_{CEO}$ max rating, f = 60 Hz, t_{test} = 0.5 s, See Figure 2	122.5 mJ

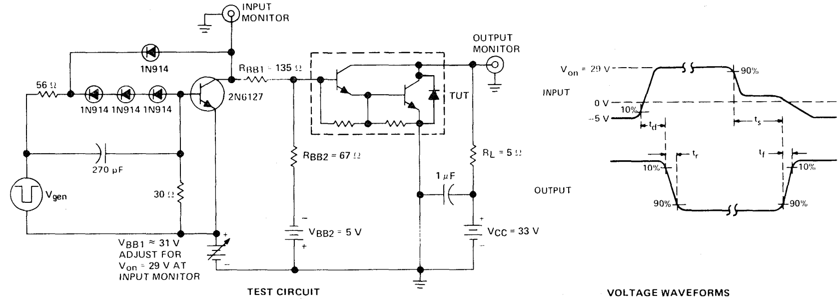
NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

8. This parameter is measured using a 0.003-inch mica insulator with Dow Corning 11 compound on both sides of the insulator, 6-32 mounting screw with bushing, and a mounting torque of 8 inch-pounds.

9. The test circuit is the unclamped inductive load circuit shown in Figure 2 on page 5-1 of the Texas Instruments "Power Semiconductor Data Book", CC-404. L = 100 μH, R_{BB1} = 20 Ω, R_{BB2} = 100 Ω, V_{BB1} = 20 V, V_{BB2} = 0 V, R_L = 0.1 Ω, V_{CC} = 20 V, I_{CM} = 6 A.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

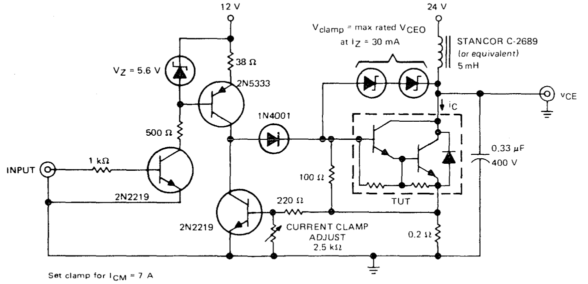
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

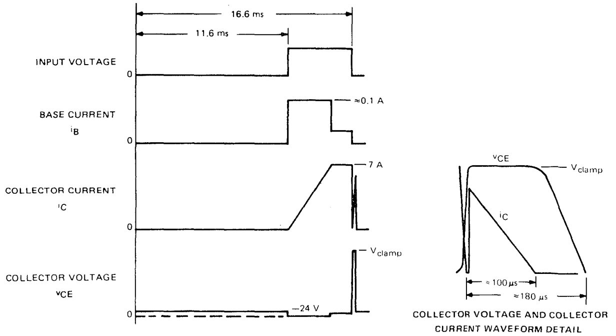
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

FUNCTIONAL TEST INFORMATION



TEST CIRCUIT



WAVEFORMS

COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTES: A. Base and collector currents are measured using current probes such as Tektronix types P6019, P6020, P6021, P6042, or the equivalent.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 20$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT
TRANSFER RATIO
vs
COLLECTOR CURRENT

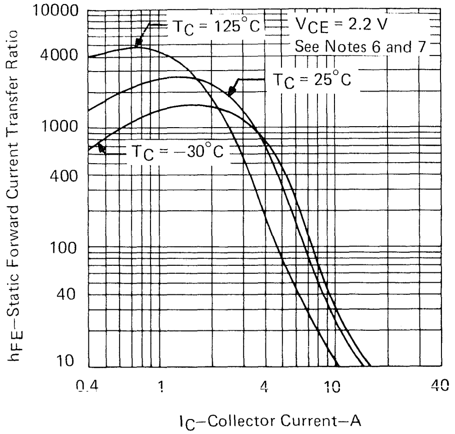


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

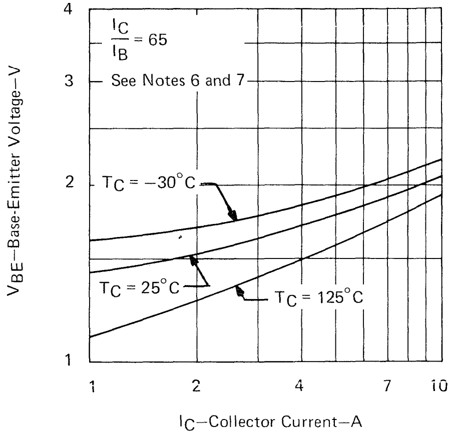


FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

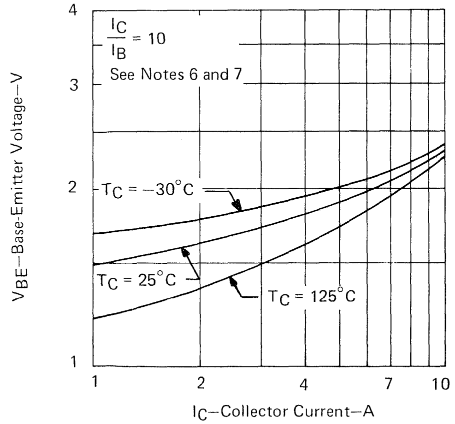


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

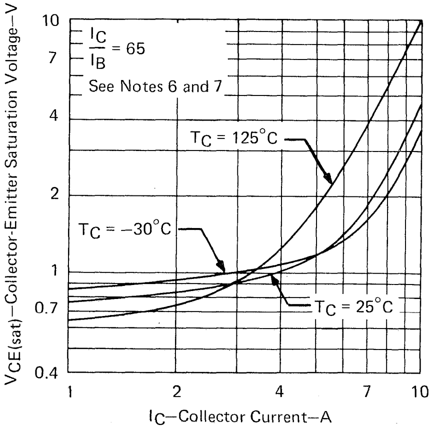


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

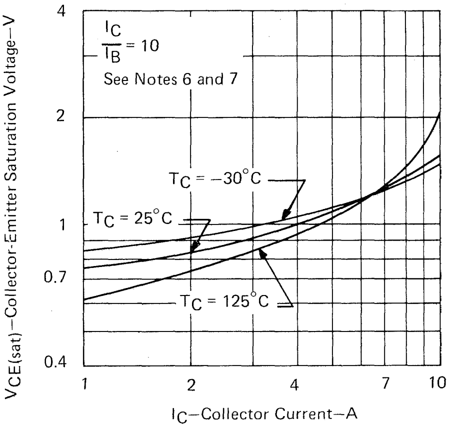


FIGURE 7

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

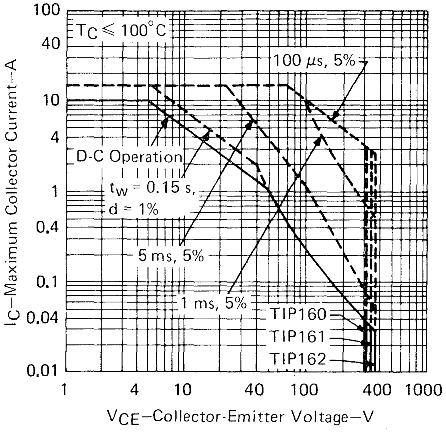


FIGURE 8

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

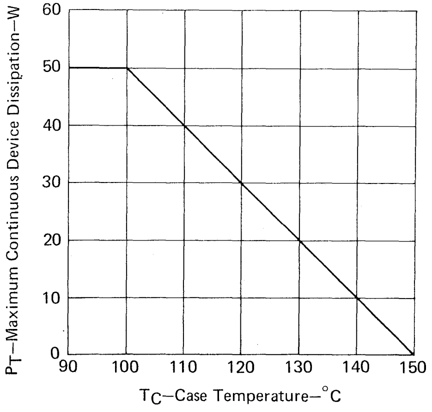


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

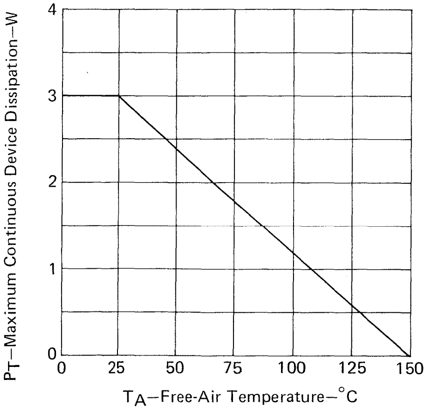


FIGURE 10

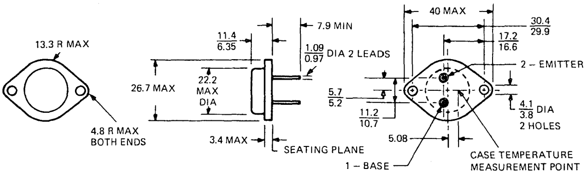
TIP538, TIP539, TIP540
NPN SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS

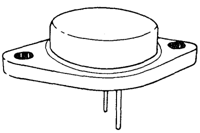
- 200 V, 300 V, 400 V Min $V_{(BR)CEO}$
- 15-A Rated Continuous Collector Current
- 125 Watts at 100°C Case Temperature
- Min f_T of 10 MHz at 10 V, 1 A

mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP538	TIP539	TIP540
Collector-Base Voltage	300 V	400 V	500 V
Collector-Emitter Voltage (See Note 1)	200 V	300 V	400 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	15 A		
Peak Collector Current (See Note 2)	25 A		
Continuous Base Current	5 A		
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	125 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Terminal Temperature 1.588mm from Case for 10 Seconds	300°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.25 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIP538		TIP539		TIP540		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 5	200		300		400		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 100 V, I_B = 0		2					mA
		V_{CE} = 150 V, I_B = 0				2			
		V_{CE} = 200 V, I_B = 0						2	
I_{CES}	Collector Cutoff Current	V_{CE} = 300 V, I_B = 0		1					mA
		V_{CE} = 400 V, I_B = 0				1			
		V_{CE} = 500 V, I_B = 0						1	
		V_{CE} = 150 V, I_B = 0, T_C = 150°C		10					
		V_{CE} = 200 V, I_B = 0, T_C = 150°C				10			
		V_{CE} = 250 V, I_B = 0, T_C = 150°C						10	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 4 V, I_C = 0		0.5		0.5		0.5	mA
		V_{EB} = 5 V, I_C = 0		1		1		1	
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 7.5 A, See Notes 5 and 6	20	100	20	100	20	100	
		V_{CE} = 4 V, I_C = 15 A	5		5		5		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 15 A, See Notes 5 and 6		2		2		2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.75 A, I_C = 7.5 A, See Notes 5 and 6		0.75		0.75		0.75	V
		I_B = 3.75 A, I_C = 15 A		2.5		2.5		2.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 1 kHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 5 MHz	2		2		2		

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current carrying contacts and located within 3.2mm from the device body.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	0.8	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35	

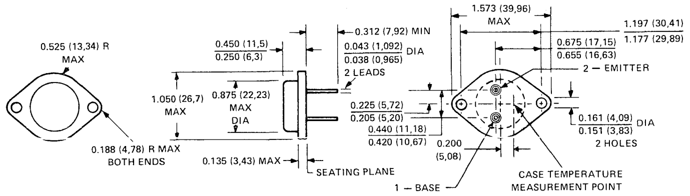
TYPES TIP558, TIP559, TIP560, TIP561
N-P-N SILICON POWER TRANSISTORS

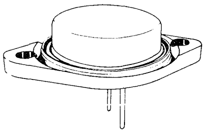
HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR AUTOMOTIVE IGNITION AND SWITCHING REGULATOR APPLICATIONS

- Min $V_{(BR)CEO}$ of 250 V to 400 V
- 100 W at 100°C Case Temperature
- 10 A Peak Collector Current
- Functional Verification Tests for Ignition and Switching Regulator Applications

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE





ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP558	TIP559	TIP560	TIP561
Collector-Base Voltage	350 V	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	250 V	300 V	350 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V	8 V
Continuous Collector Current	7.5 A			
Peak Collector Current (See Note 2)	10 A			
Continuous Base Current	4 A			
Safe Operating Area	See Figure 8			
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	100 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5.5 W			
Operating Collector Junction Temperature Range	−65°C to 200°C			
Storage Temperature Range	−65°C to 200°C			
Lead Temperature 1/8 Inch from Case for 10 Seconds	300°C			

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 10$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to Dissipation Derating Curve, Figure 10.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP558		TIP559		TIP560		TIP561		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 20 mA, I_B = 0, See Note 5		250		300		350		400		V
I_{CER}	Collector Cutoff Current	V_{CE} = 350 V, R_{BE} = 27 Ω			100							µA
		V_{CE} = 400 V, R_{BE} = 27 Ω					100					
		V_{CE} = 450 V, R_{BE} = 27 Ω							100			
		V_{CE} = 500 V, R_{BE} = 27 Ω									100	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 8 V, I_C = 0			100		100		100		100	µA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V, I_C = 1 A	See Notes 5 and 6	10	100	10	100	10	100	10	100	
		V_{CE} = 2 V, I_C = 5 A		6		6		6		6		
V_{BE}	Base-Emitter Voltage	I_B = 1 A, I_C = 5 A, See Notes 5 and 6			1.5		1.5		1.5		1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1 A, I_C = 5 A	See Notes 5 and 6		1.2		1.2		1.2		1.2	V
		I_B = 4 A, I_C = 10 A			2.5		2.5		2.5		2.5	

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1	
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 5 A, $I_{B(1)}$ = 1 A, $I_{B(2)}$ = −1 A, $V_{BE(off)}$ = −4 V, R_L = 40 Ω, See Figure 1	0.04	µs
t_r	Rise Time		0.13	
t_s	Storage Time		1.5	
t_f	Fall Time		0.2	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

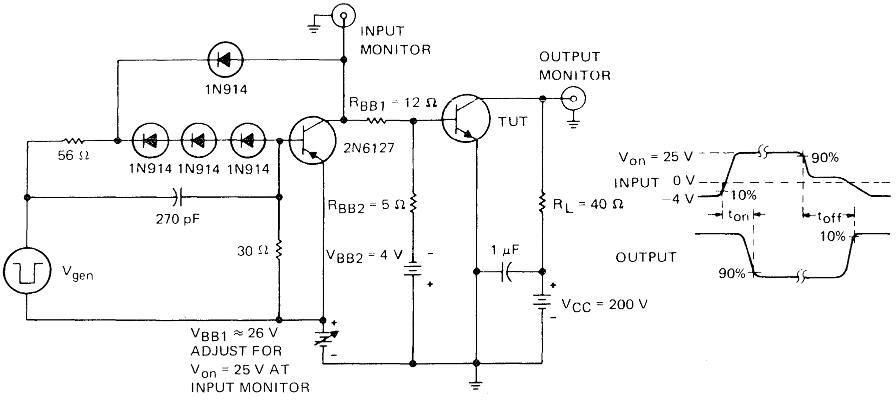
TEST	CONDITIONS			LEVEL
Power ($V_{CE} \cdot I_C$)	V_{CE} = 50 V,	I_C = 2 A,	t_{test} = 1 s	100 W
Reverse Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 5 A, t_{test} = 0.5 s,	L = 2 mH, See Figure 2	f = 10 Hz,	25 mJ
Forward Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 10 A, f = 60 Hz,	L = 5 mH, t_{test} = 0.5 s,	V_{clamp} = V_{CEO} max rating, See Figure 3	250 mJ
Operation as Commutating Switch	I_{load} = 5 A, t_{test} = 0.5 s,	V_{CC} = 0.8 V_{CEO} max rating, See Figure 4	f = 20 kHz,	

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 µs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

7. This parameter must be measured using a 0.003-inch mica insulator with Dow-Corning II compound on both sides of the insulator, 6-32 mounting screws with bushings, and a mounting torque of 8 inch-pounds.

PARAMETER MEASUREMENT INFORMATION



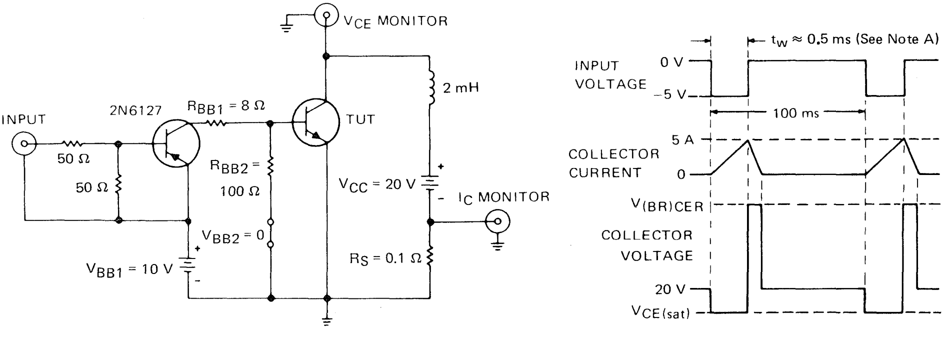
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, t_w = 20 μ duty cycle ≤ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1—SWITCHING TIMES

FUNCTIONAL TEST INFORMATION



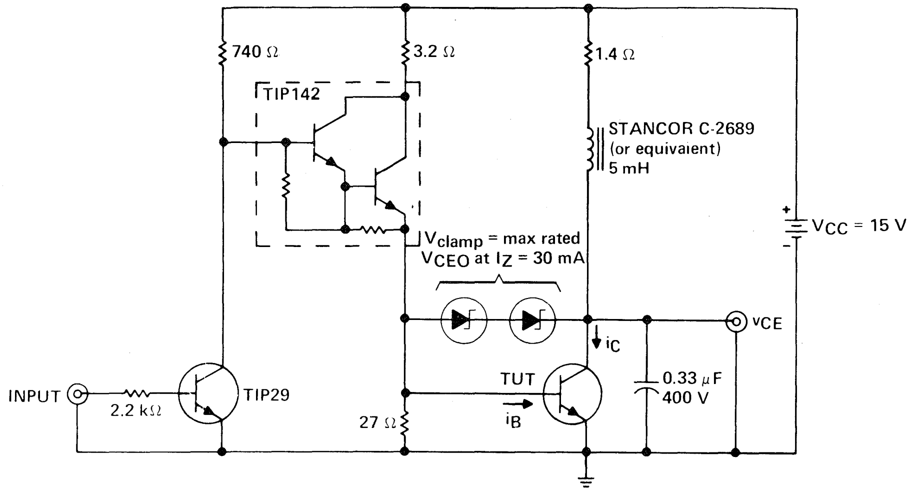
TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

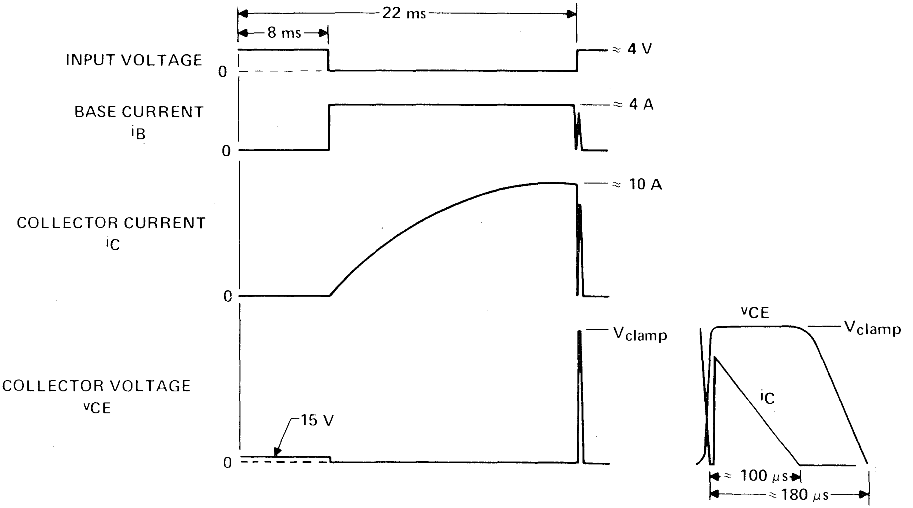
NOTE A: Input pulse width is increased until I_{CM} = 5 A.

FIGURE 2—REVERSE PULSE ENERGY

FUNCTIONAL TEST INFORMATION



TEST CIRCUIT



WAVEFORMS

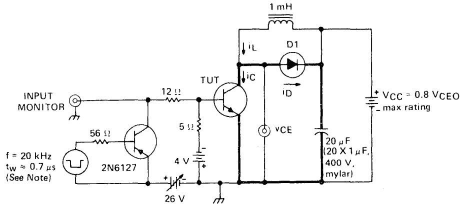
COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTES: A. Base and collector currents are measured using current probes such as Tektronix types P6019, P6020, P6021, P6042, or the equivalent.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 20$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

FIGURE 3—FORWARD PULSE ENERGY

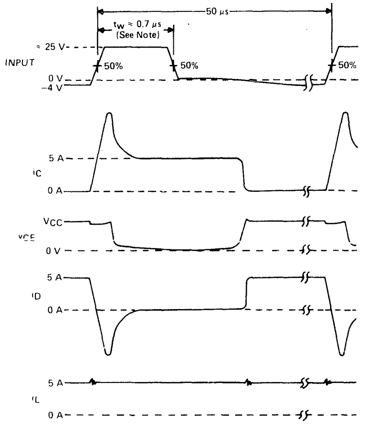
FUNCTIONAL TEST INFORMATION



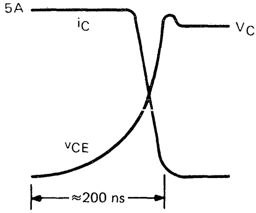
D1: RCA 40960 (or equivalent)
Rated $I_{FM} \geq 125$ A
Rated $V_{RRM} \geq 600$ V
$V_F \leq 1.8$ V at $I_F = 100$ A
$t_{rr} \leq 0.35$ μs at $I_{FRM} = 125$ A, di/dt = 25 A/μs, t_w = 15 μs

Heavy lines denote copper bus 0.5 inch X 0.125 inch

TEST CIRCUIT



WAVEFORMS



COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTE: Increase pulse width until i_C = 5 A following its peak.

FIGURE 4—OPERATION AS COMMUTATING SWITCH

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

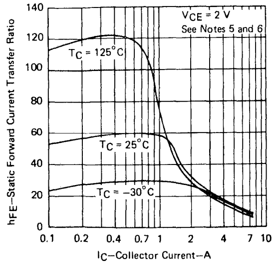


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

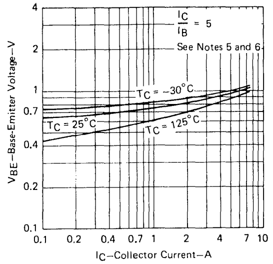


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

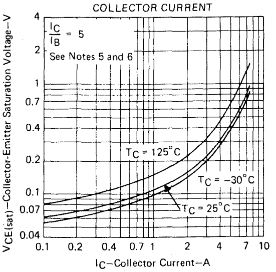
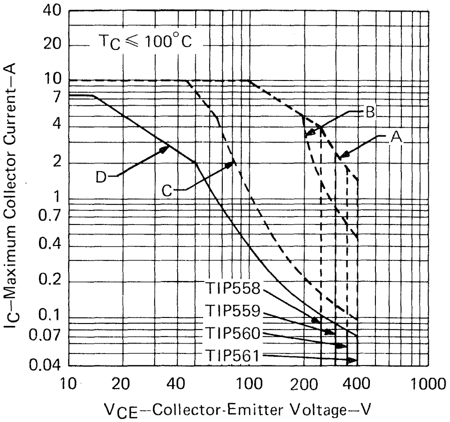


FIGURE 7

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located withi 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE



CURVE	CONDITIONS
A	t_w = 100 μs, d = 0.1 = 10%
B	t_w = 1 ms, d = 0.1 = 10%
C	t_w = 10 ms, d = 0.1 = 10%
D	D-C OPERATION

FIGURE 8

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

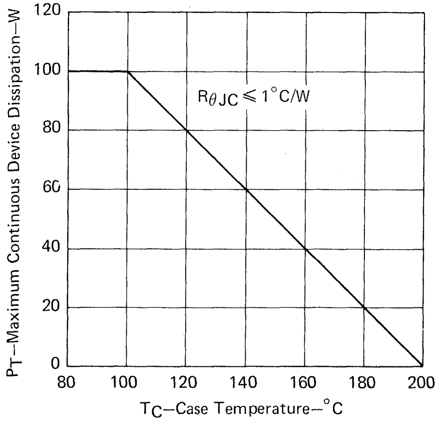


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

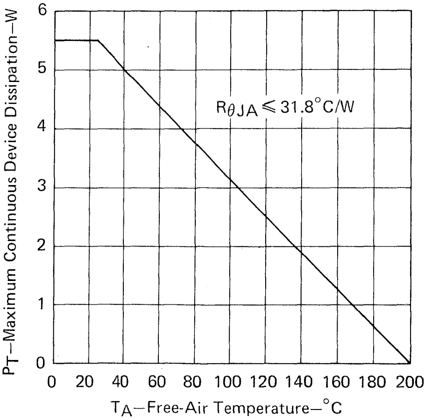


FIGURE 10

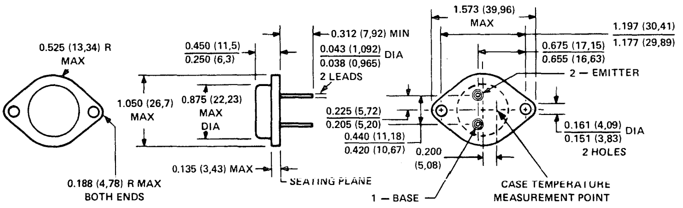
TYPES TIP562, TIP563
N-P-N SILICON POWER TRANSISTORS

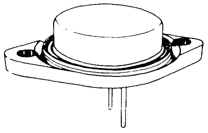
FOR HIGH-VOLTAGE SWITCHING REGULATOR APPLICATIONS

- Min $V_{(BR)CEO}$ of 300 V and 400 V
- 10 A Rated Continuous Collector Current
- 100 W at 100°C Case Temperature

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE





ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP562	TIP563
Collector-Base Voltage	300 V	400 V
Collector-Emitter Voltage (See Note 1)	300 V	400 V
Emitter-Base Voltage	8 V	8 V
Continuous Collector Current	← 10 A →	
Peak Collector Current (See Note 2)	← 15 A →	
Continuous Base Current	← 2 A →	
Peak Base Current (See Note 2)	← 5 A →	
Safe Operating Area at (or below) 100°C Case Temperature	See Figure 6	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	← 100 W →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 5.5 W →	
Operating Collector Junction Temperature Range	−65°C to 200°C	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/8 Inch from Case for 10 Seconds	← 300°C →	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_W \leqslant 10$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C.

electrical characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS		TIP562		TIP563		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,	See Note 5	300		400		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 270$ V, $I_B = 0$			1			mA
		$V_{CE} = 360$ V, $I_B = 0$					1	
I_{CBO}	Collector Cutoff Current	$V_{CE} = 300$ V, $I_E = 0$			100			μA
		$V_{CE} = 400$ V, $I_E = 0$					100	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 8$ V, $I_C = 0$			5		5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A	See Notes 5 and 6	20		20		
		$V_{CE} = 4$ V, $I_C = 10$ A		8		8		
V_{BE}	Base-Emitter Voltage	$I_B = 1.66$ A, $I_C = 10$ A,	See Notes 5 and 6		1.4		1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1.66$ A, $I_C = 10$ A	See Notes 5 and 6		1.2		1.2	V
		$I_B = 5$ A, $I_C = 15$ A			2		2	

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

switching characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = 10$ A, $I_{B(1)} = 2$ A, $I_{B(2)} = -2$ A, $V_{BE(off)} = -5.2$ V, $R_L = 18\ \Omega$, See Figure 1	0.05	μs
t_r	Rise Time		0.5	
t_s	Storage Time		1.2	
t_f	Fall Time		0.3	

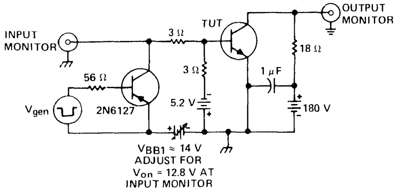
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

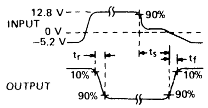
TEST	CONDITIONS	LEVEL
Power ($V_{CE} \cdot I_C$)	$V_{CE} = 40$ V, $I_C = 2.5$ A, $t_{test} = 1$ s	100 W
Reverse Pulse Energy $\left(\frac{I_C{}^2 L}{2}\right)$	$I_{CM} = 5$ A, L = 2 mH, f = 10 Hz, $t_{test} = 0.5$ s, See Note 8	25 mJ
Operation as Commutating Switch	$i_L = 10$ A, $V_{CC} = 0.8\ V_{CEO}$ max rating, f = 20 kHz, $t_{test} = 0.5$ s, See Figure 2	

NOTES:
5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.
7. This parameter is measured using a 0.003-inch mica insulator with Dow Corning 11 compound on both sides of the insulator, 6-32 mounting screws with bushings, and a mounting torque of 8-inch pounds.
8. The test circuit is the unclamped inductive load circuit shown in Figure 2 on page 5-1 of the Texas Instruments "Power Semiconductor Data Book", CC-404, L = 2 nH, $R_{BB1} = 8\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 20$ V, $I_{CM} = 5$ A.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

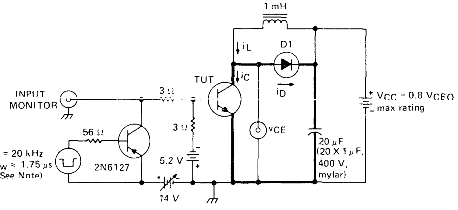


VOLTAGE WAVEFORMS

FIGURE 1—SWITCHING TIMES

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50$ Ω, $t_w = 1.5$ μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

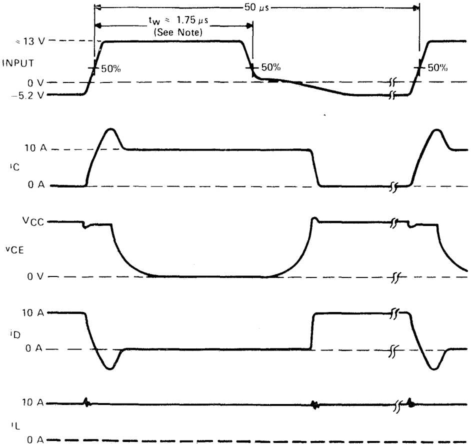
FUNCTIONAL TEST INFORMATION



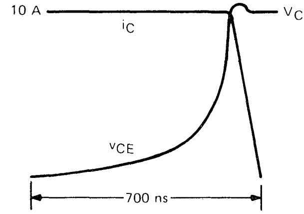
D1: RCA 40960 (or equivalent)
Rated $I_{FM} \geq 125$ A
Rated $V_{RRM} \geq 600$ V
$V_F \leq 1.6$ V at $I_F = 100$ A
$t_{rr} \leq 0.35$ μs at I_{FRM} = 125 A, di/dt = 25 A/μs, t_w = 15 μs

Heavy lines denote copper bus 0.5 inch X 0.125 inch

TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS



COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTE: Increase pulse width until i_C = 10 A following its peak.

FIGURE 2—OPERATION AS COMMUTATING SWITCH

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

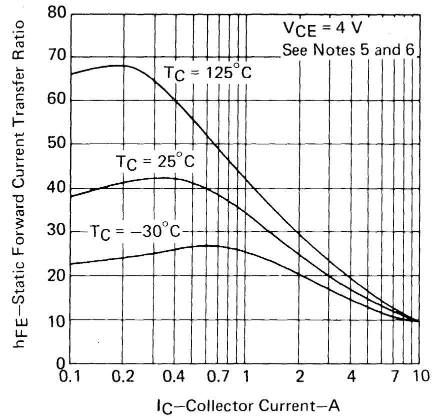


FIGURE 3

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

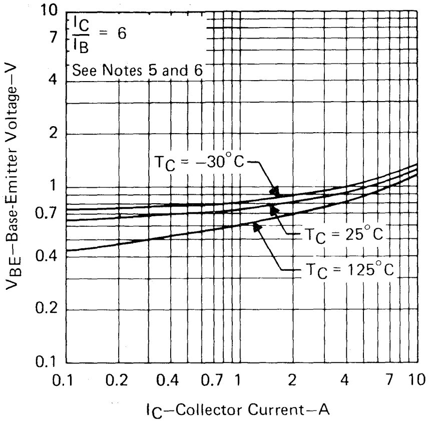


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

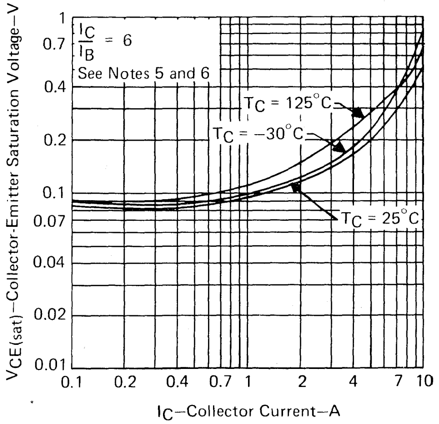


FIGURE 5

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT vs COLLECTOR-EMITTER VOLTAGE

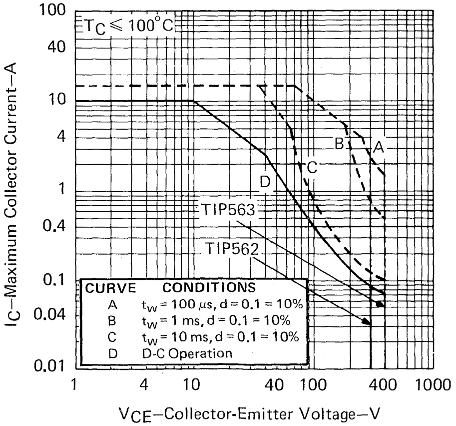


FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

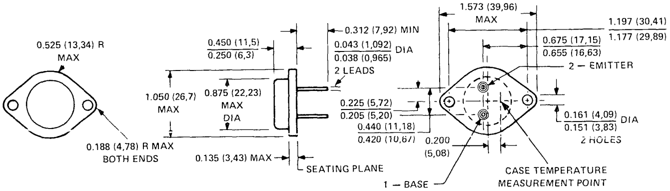
TYPES TIP564, TIP565
N-P-N SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH POWER, FAST SWITCHING, DESIGNED FOR SWITCHING REGULATOR APPLICATIONS

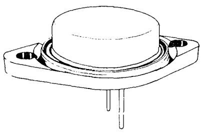
- Reverse Bias SOA . . . 400 V to 450 V, 10 A
- 150 W at 100° C Case Temperature
- 15 A Peak Collector Current
- 20 MHz Min f_T at 10 V, 1 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.



absolute maximum ratings at 25° C case temperature (unless otherwise noted)

	TIP564	TIP565
Collector-Base Voltage	400 V	450 V
Collector-Emitter Voltage (See Note 1)	350 V	400 V
Emitter-Base Voltage	8 V	8 V
Continuous Collector Current	10 A	
Peak Collector Current (See Note 2)	15 A	
Continuous Base Current	7 A	
Safe Operating Areas at (or below) 100°C Case Temperature	See Figures 7 and 8	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	150 W	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5.5 W	
Operating Collector Junction Temperature Range	−65°C to 200°C	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/8 Inch (3,2 mm) from Case for 10 Seconds	300°C	

NOTES:
1. These values apply when the base-emitter diode is reverse-biased or open-circuited.
2. This value applies for $t_w \leqslant 5$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.5 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to Dissipation Derating Curve, Figure 10.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIP564		TIP565		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 200$ mA, $I_B = 0$, See Note 5	350		400		V
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage	$i_C = 10$ A, See Figure 1	350		400		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 400$ V, $I_E = 0$		0.1			mA
		$V_{CB} = 450$ V, $I_E = 0$				0.1	
		$V_{CB} = 400$ V, $I_E = 0$, $T_C = 100°C$		2			
		$V_{CB} = 450$ V, $I_E = 0$, $T_C = 100°C$				2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 8$ V, $I_C = 0$		250		250	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 3$ V, $I_C = 1$ A, See Notes 5 and 6		50		50	
		$V_{CE} = 3$ V, $I_C = 7$ A, See Notes 5 and 6	7	35	7	35	
V_{BE}	Base-Emitter Voltage	$I_B = 1.4$ A, $I_C = 7$ A, See Notes 5 and 6		1.4		1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1.4$ A, $I_C = 7$ A, See Notes 5 and 6		1		1	V
		$I_B = 2$ A, $I_C = 10$ A, See Notes 5 and 6		3		3	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ A, f = 10 MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz	100	300	100	300	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		0.67	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

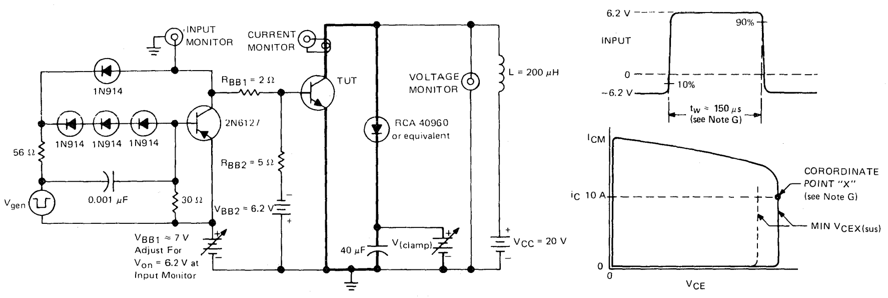
NOTE 7: This parameter is measured using a 0.003-inch (0,08-mm) mica insulator with Dow-Corning II compound on both sides of the insulator, 0.138-32 (formerly 6-32) mounting screw with bushing, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

inductive-load switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)} =$ MIN $V_{CEX(sus)}$, $I_{CM} = 7$ A, $I_{B(1)} = 1.4$ A, $I_{B(2)} = -1.4$ A, See Figure 2	2400	ns
t_{si}	Current Storage Time		2600	ns
t_{tv}	Voltage Transition Time		170	ns
t_{ti}	Current Transition Time		130	ns
t_{xo}	Cross-over Time		330	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

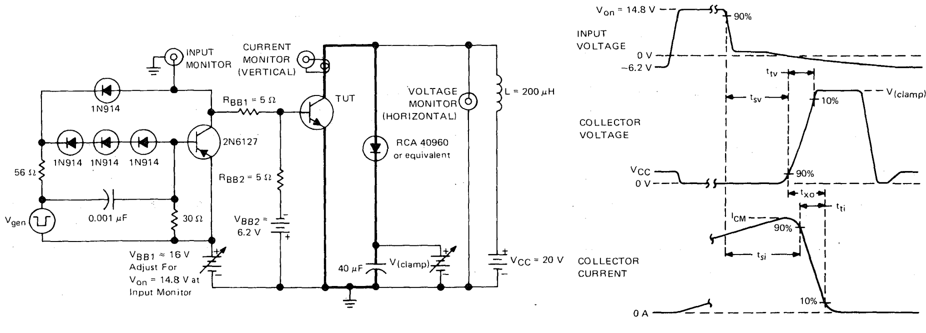


TEST CIRCUIT

INPUT WAVEFORM AND X-Y DISPLAY

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w \approx 150$ μs, duty cycle ⩽ 2%.
C. Waveforms are monitored on an X-Y oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.
F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.
G. Adjust input pulse width until collector current is 10 A at point "X." I_{CM} must not exceed 15 A.

FIGURE 1—COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST



TEST CIRCUIT

WAVEFORMS

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w \approx 70$ μs, duty cycle ⩽ 2%. Pulse width is adjusted for $I_{CM} = 7$ A.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.
F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

FIGURE 2—INDUCTIVE-LOAD SWITCHING TIMES

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

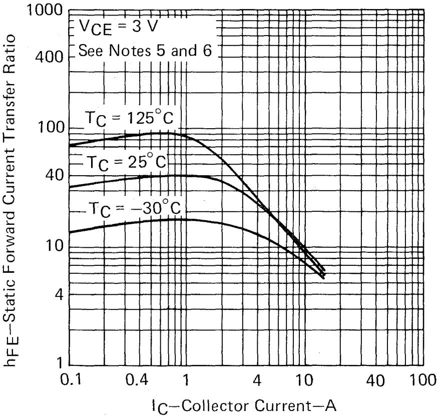


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

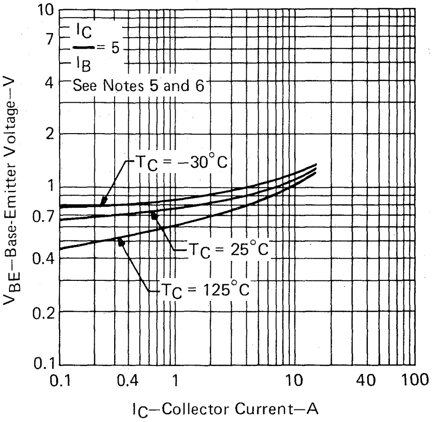


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

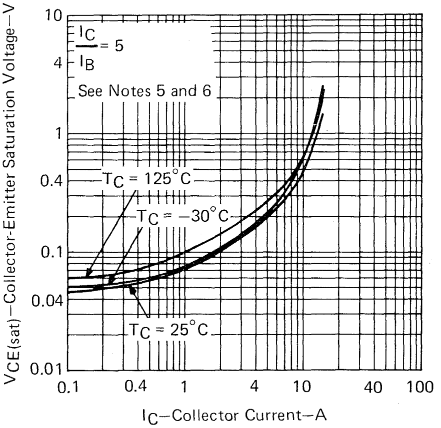


FIGURE 5

COLLECTOR CURRENT
vs
INDUCTIVE-LOAD SWITCHING TIMES

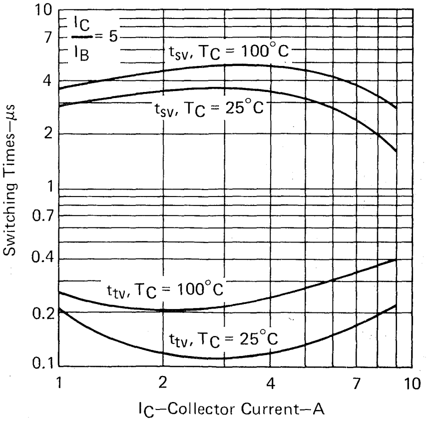


FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

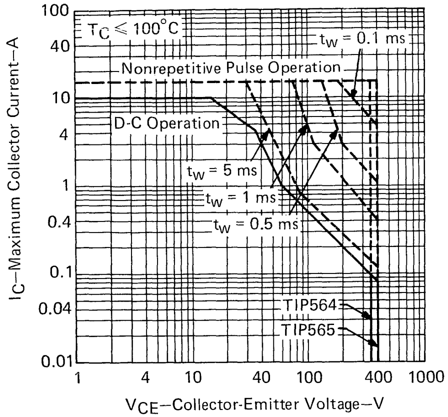


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

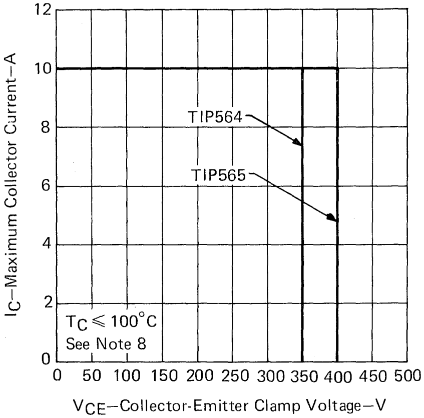


FIGURE 8

NOTE 8: This combimation of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load as in Figure 1.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

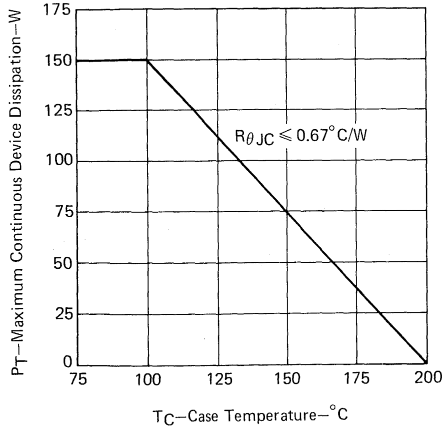


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

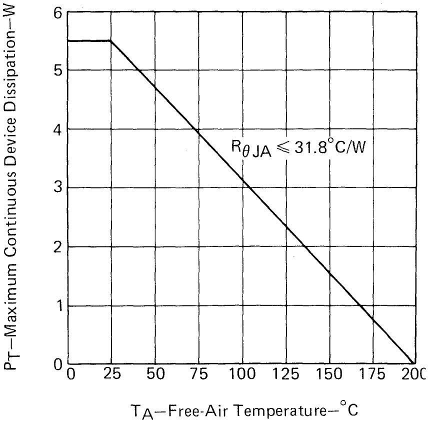


FIGURE 10

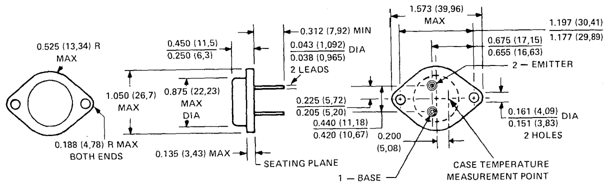
TYPES TIP575, TIP575A, TIP575B, TIP575C
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

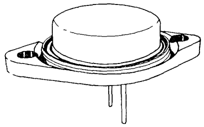
HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY DESIGNED FOR AUTOMOTIVE IGNITION, LINEAR AMPLIFIER AND SWITCHING REGULATOR APPLICATIONS

- Reverse-Bias SOA . . . 200 V to 400 V, 3 A
- 100 W at 25°C Case Temperature
- 5 A Peak Collector Current

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE





ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP575	TIP575A	TIP575B	TIP575C
Collector-Base Voltage	350 V	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	200 V	250 V	300 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V	8 V
Continuous Collector Current	← 3 A →			
Peak Collector Current (See Note 2)	← 5 A →			
Continuous Base Current	← 1.5 A →			
Safe Operating Areas at (or below) 100°C Case Temperature	← See Figures 10 and 11 →			
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 100 W →			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 5.5 W →			
Operating Collector Junction Temperature Range	← −65°C to 200°C →			
Storage Temperature Range	← −65°C to 200°C →			
Lead Temperature 1/8 Inch (3,2 mm) from Case for 10 Seconds	← 300°C →			

NOTES:
1. These values apply when the base-emitter diode is reverse-biased or open-circuited.
2. This value applies for $t_w \leqslant 5$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 12.
4. Derate lineraly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to Dissipation Derating Curve, Figure 13.

TYPES TIP575, TIP575A, TIP575B, TIP575C
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP575		TIP575A		TIP575B		TIP575C		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 mA, I_E = 0, See Note 5		350		400		450		500		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0, See Note 5		200		250		300		400		V
$V_{CEX(sus)}$	Collector-Emitter Breakdown Voltage	i_c = 3A, See Figure 1		200		250		300		400		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 150 V, I_B = 0			150		150					μA
		V_{CE} = 250 V, I_B = 0							150		150	
I_{CES}	Collector Cutoff Current	V_{CE} = 300 V, V_{BE} = 0			50							μA
		V_{CE} = 350 V, V_{BE} = 0					50					
		V_{CE} = 400 V, V_{BE} = 0							50			
		V_{CE} = 450 V, V_{BE} = 0									50	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 8 V, I_C = 0			1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 500 mA	See Notes 5 and 6	30	250	30	250	30	250	30	250	
		V_{CE} = 2 V, I_C = 2 A		12		12		12		12		
		V_{CE} = 4 V, I_C - 3 A		10		10		10		10		
V_{BE}	Base-Emitter Voltage	I_B = 50 mA, I_C = 500 mA	See Notes 5 and 6		1		1		1		1	V
		I_B = 600 mA, I_C = 3 A			1.2		1.2		1.2		1.2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 50 mA I_C = 500 mA	See Notes 5 and 6		0.5		0.5		0.5		0.5	V
		I_B = 600 mA, I_C = 3 A			1.9		1.9		1.9		1.9	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.5 A, f = 1 kHz		30		30		30		30		
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.5 A, f = 1 MHz		10		10		10		10		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz			275		275		275		275	pF

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.1 inch (3,2 mm) from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

NOTE 7: This parameter is measured using a 0.003-inch (0,08 mm) mica insulator with Dow Corning II compound on both sides of t insulator, a 0.138-32 (formerly 6-32) mounting screw with bushing, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

inductive-load switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)}$ = MIN $V_{CEX(sus)}$, I_{CM} = 3A, $I_{B(1)}$ = 500 mA, $I_{B(2)}$ = −500 mA, See Figure 2	1700	ns
t_{si}	Current Storage Time		2300	ns
t_{tv}	Voltage Transition Time		700	ns
t_{ti}	Current Transition Time		700	ns
t_{xo}	Cross-over Time		1300	ns

resistive-load switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 2 A, $I_{B(1)}$ = 200 mA, $I_{B(2)}$ = −200 mA, $V_{BE(off)}$ = −4 V, R_L = 100 Ω, See Figure 3	20	ns
t_r	Rise Time		340	ns
t_s	Storage Time		1400	ns
t_f	Fall Time		800	ns

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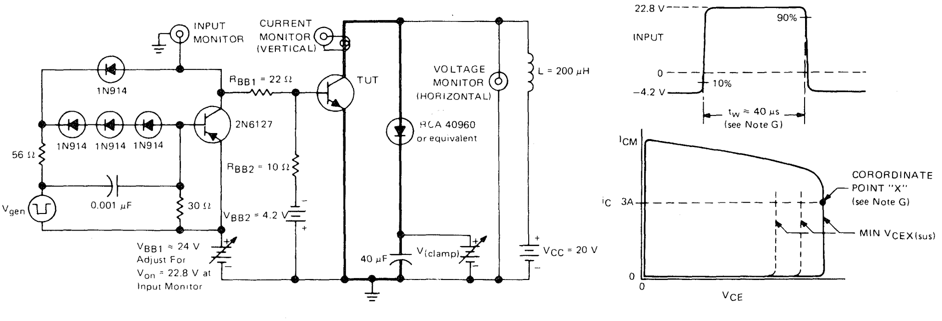
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

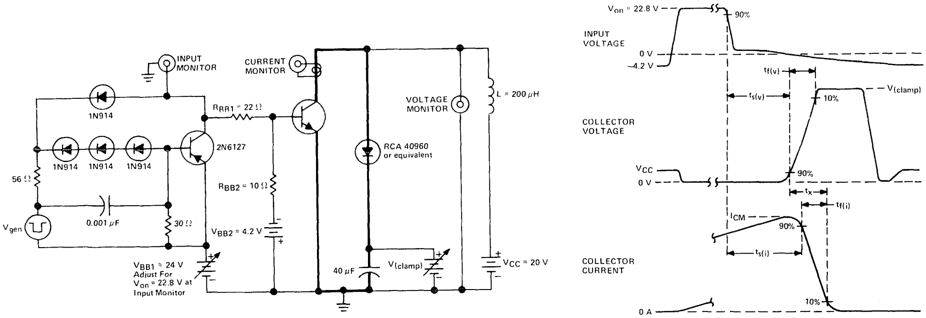


TEST CIRCUIT **INPUT WAVEFORM AND X-Y DISPLAY**

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, $t_w \approx 40$ μs, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an X-Y oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.
- F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.
- G. Adjust input pulse width until collector current is 3 A at point "X". I_{CM} must not exceed 5 A.

FIGURE 1—COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w \approx 25\ \mu$ duty cycle ⩽ 2%. Pulse width is adjusted for $I_{CM} = 3$A.

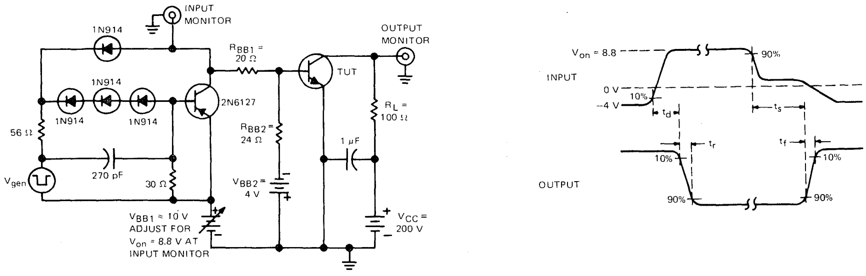
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ \mathrm{M}\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

FIGURE 2—INDUCTIVE-LOAD SWITCHING TIMES



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$ duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ \mathrm{M}\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 3—RESISTIVE-LOAD SWITCHING TIMES

TYPICAL CHARACTERISTICS

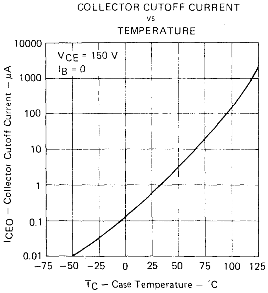


FIGURE 4

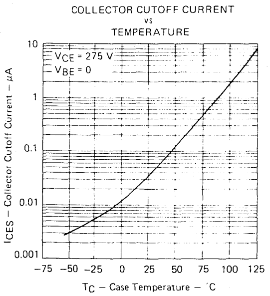


FIGURE 5

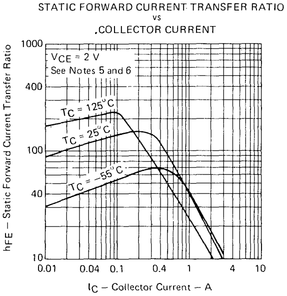


FIGURE 6

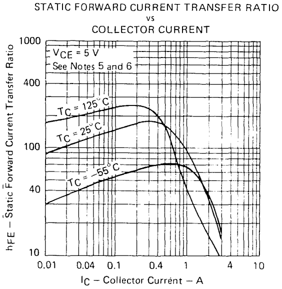


FIGURE 7

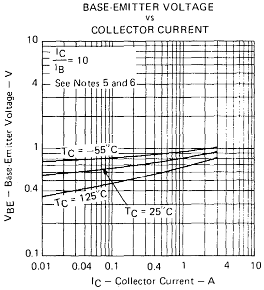


FIGURE 8

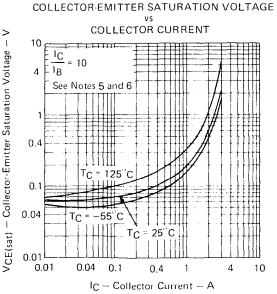


FIGURE 9

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

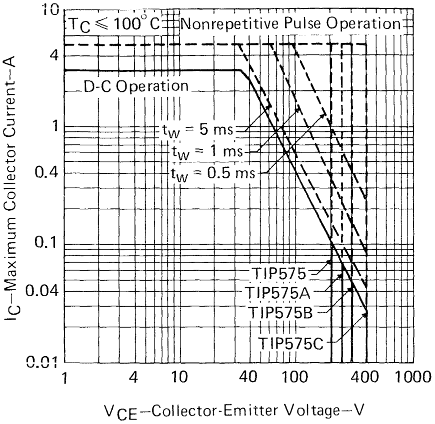


FIGURE 10

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

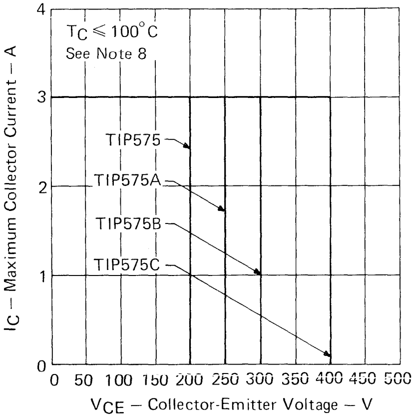


FIGURE 11

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load as in Figure 1.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

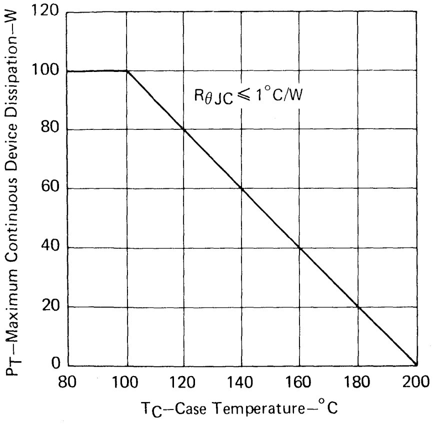


FIGURE 12

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

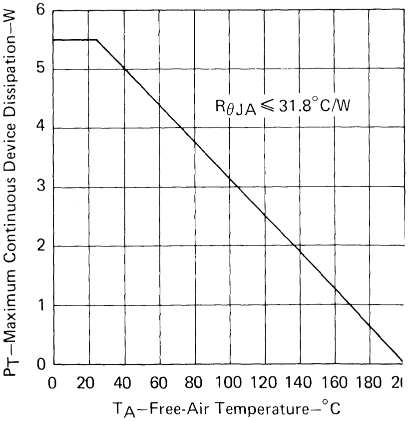


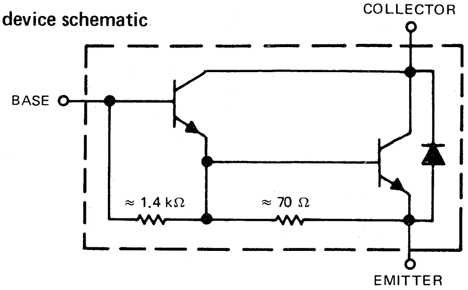
FIGURE 13

TYPES TIP600, TIP601, TIP602
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP605, TIP606, TIP607

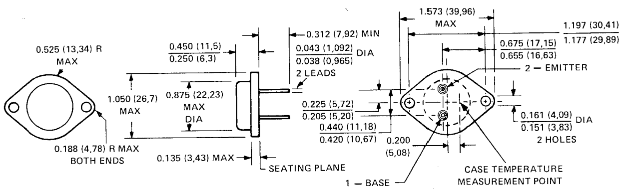
- 100 W at 25°C Case Temperature
- 10 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 10 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 10 A
- Similar to 2N6055, 2N6056, 2N6383, 2N6384, 2N6385

device schematic

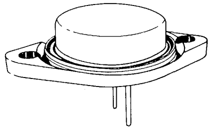


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP100	TIP601	TIP602
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	10 A		
Peak Collector Current (See Note 2)	15 A		
Continuous Base Current	1 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	100 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Lead Temperature 1/8 Inch from Case for 10 Seconds	300°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant$ 10%.
3. Derate linearly to 200°C case temperature at the rate of 0.57 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 10.

TYPES TIP600, TIP601, TIP602
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP600		TIP601		TIP602		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0,	See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V, I_B = 0			50					μA
		V_{CE} = 40 V, I_B = 0					50			
		V_{CE} = 50 V, I_B = 0							50	
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0			50					μA
		V_{CB} = 80 V, I_E = 0					50			
		V_{CB} = 100 V, I_E = 0							50	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0			8		8		8	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 3 A	See Notes 5 and 6	1000	20 000	1000	20 000	1000	20 000	
		V_{CE} 4 V, I_C = 10 A		200		200		200		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 10 A,	See Notes 5 and 6		2.8		2.8		2.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 6 mA, I_C = 3 A	See Notes 5 and 6		2		2		2	V
		I_B = −100 mA, I_C = 10 A			2.5		2.5		2.5	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C$ = 10 A, I_B = 0,	See Notes 5 and 6		2.8		2.8		2.8	V

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.75	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		35	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

NOTE 7: This parameter is measured using a 0.003-inch mica Insulator with Dow-Corning II compound on both sides of the insulator, a 6-32 mounting screw with bushing, and a mounting torque of 8 inch-pound.

switching characteristics at 25°C case temperature

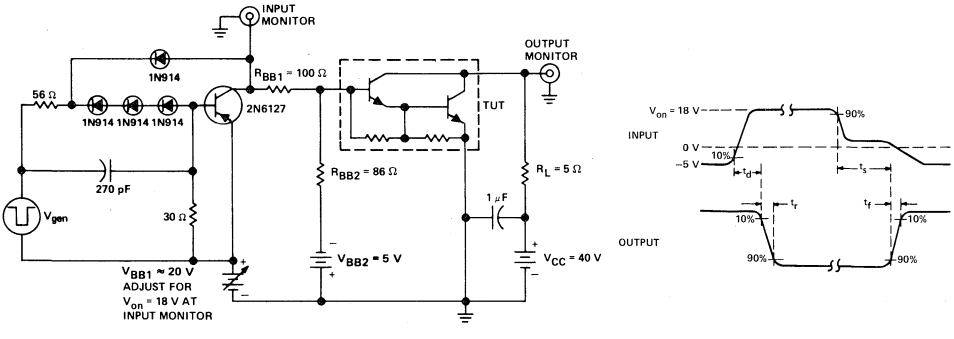
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 8 A, $I_{B(1)}$ = 80 mA $I_{B(2)}$ = −80 mA, $V_{BE(off)}$ = −5 V, R_L = 5 Ω, See Figure 1	0.035	μs
t_r	Rise Time		0.35	
t_s	Storage Time		1.8	
t_f	Fall Time		2.45	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

TEST	CONDITIONS			LEVEL
Power ($V_{CE} \cdot I_C$)	V_{CE} = 40 V,	I_C = 2 A,	t_{test} = 0.15 s	80 W
Reverse Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	I_{CM} = 1A, t_{test} = 0.5 s,	L = 20 mH, See Figure 2	f = 10 Hz,	10 mJ

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.

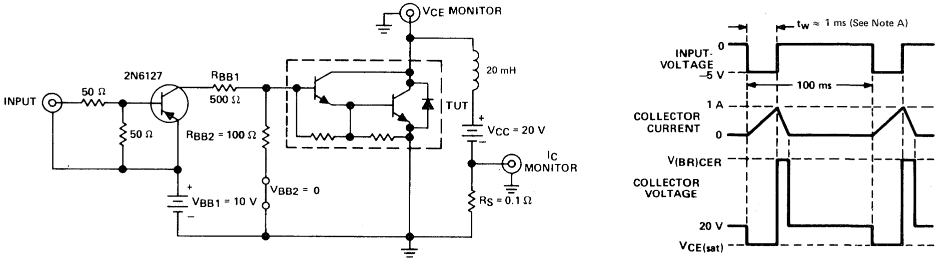
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = 1$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

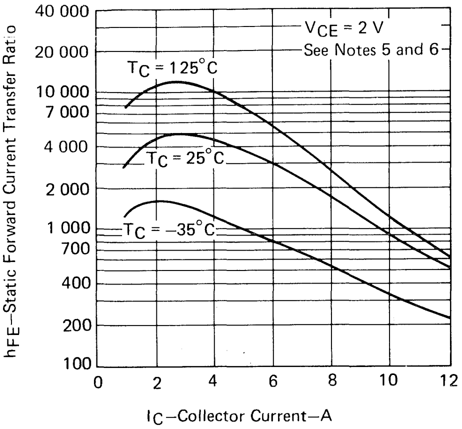


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

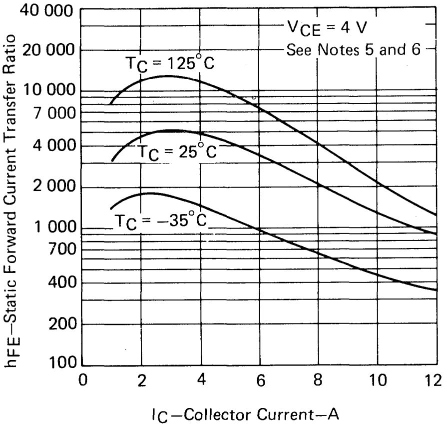


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

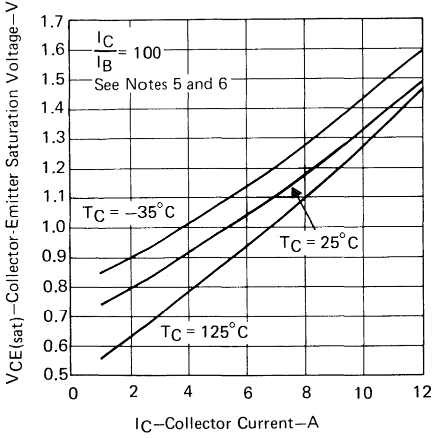


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

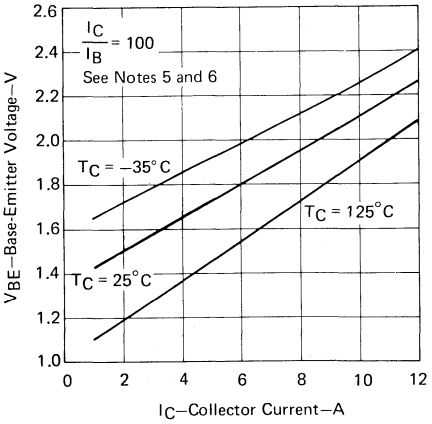


FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

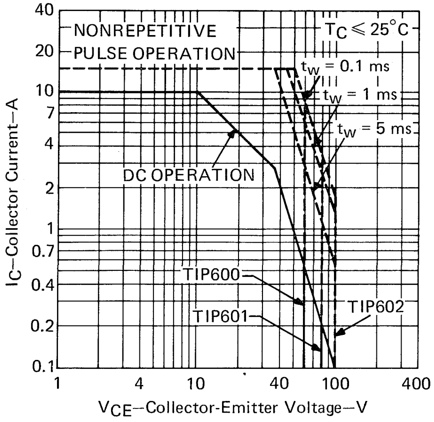


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

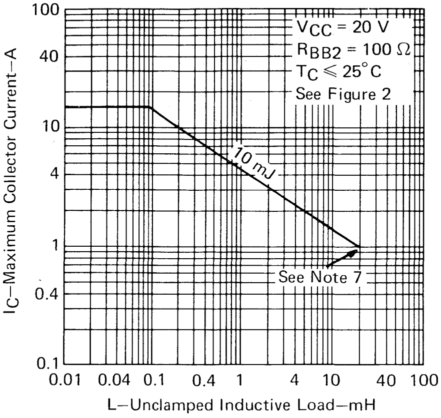


FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

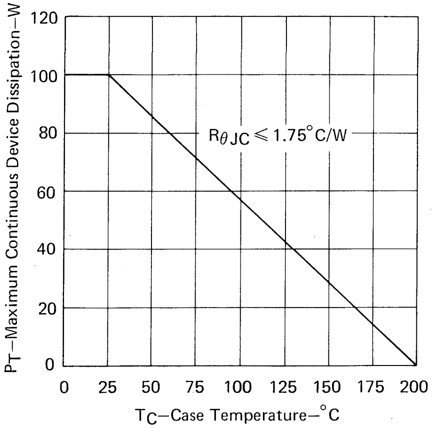


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

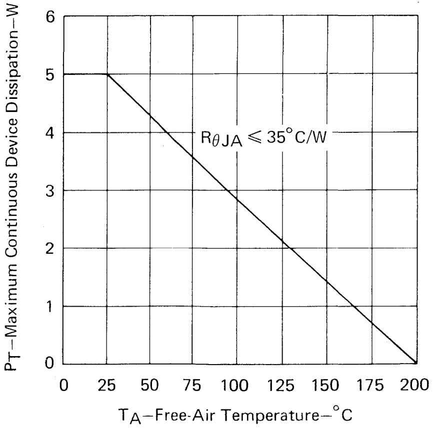


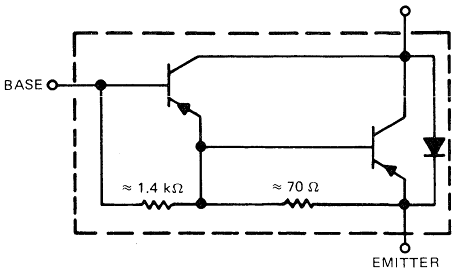
FIGURE 10

TYPES TIP605,TIP606,TIP607
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP600, TIP601, TIP602

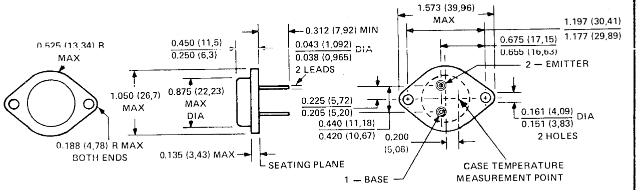
- 100 W at 25°C Case Temperature
- 10 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 10 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 10 A
- Similar to 2N6053, 2N6054, RCA8350, RCA8350A, RCA8350B

device schematic

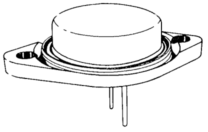


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP605	TIP606	TIP607
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	−10 A		
Peak Collector Current (See Note 2)	−15 A		
Continuous Base Current	−1 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	100 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5W		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Lead Temperature 1/8 Inch from Case for 10 Seconds	300°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.57 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 10.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP605		TIP606		TIP607		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$,	See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$			−50					μA
		$V_{CE} = -40$ V, $I_B = 0$					−50			
		$V_{CE} = -50$ V, $I_B = 0$							−50	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$			−50					μA
		$V_{CB} = -80$ V, $I_E = 0$					−50			
		$V_{CB} = -100$ V, $I_E = 0$							−50	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$			−8		−8		−8	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -3$ A	See Notes 5 and 6	1000	20 000	1000	20 000	1000	20 000	
		$V_{CE} = -4$ V, $I_C = -10$ A		200		200		200		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -10$ A	See Notes 5 and 6		−2.8		−2.8		−2.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -6$ mA, $I_C = -3$ A	See Notes 5 and 6		−2		−2		−2	V
		$I_B = -100$ mA, $I_C = -10$ A			−2.5		−2.5		−2.5	
V_F	Forward Voltage of Commutation Diode	$I_F = I_C = 10$ A, $I_B = 0$	See Notes 5 and 6		2.8		2.8		2.8	V

NOTES: 5. These parameters must be measured using pulse techniques, $t_w = 300$ μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.75	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		35	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	0.3		J/°C

NOTE 7: This parameter is measured using a 0.003-inch mica insulator with Dow-Corning II compound on both sides of the insulator, a 6-32 mounting screw with bushing, and a mounting torque of 8 inch-pound.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = -8$ A, $I_{B(1)} = -80$ mA $I_{B(2)} = 80$ mA, $V_{BE(off)} = 5$ V, $R_L = 5\ \Omega$ See Figure 1	0.035	μs
t_r	Rise Time		0.3	
t_s	Storage Time		0.9	
t_f	Fall Time		1.3	

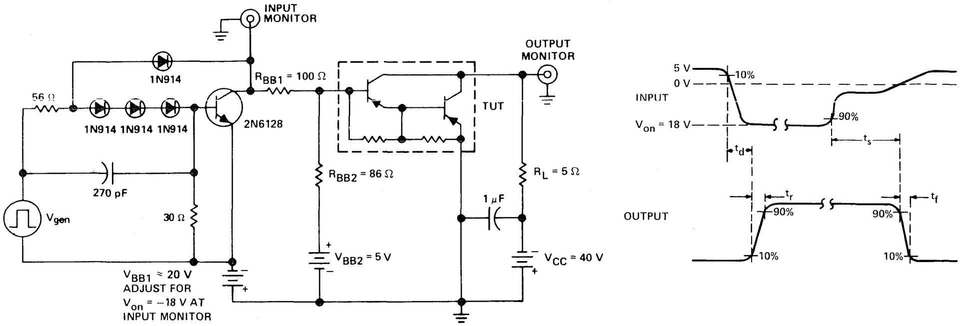
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

TEST	CONDITIONS	LEVEL
Power ($V_{CE} \cdot I_C$)	$V_{CE} = -40$ V, $I_C = -2$ A, $t_{test} = 0.15$ s	80 W
Reverse Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	$I_{CM} = -1$A, L = 20 mH, f = 10 Hz, $t_{test} = 0.5$ s, See Figure 2	10 mJ

TYPES TIP605,TIP606,TIP607
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ μs, duty cycle ≤ 2%.

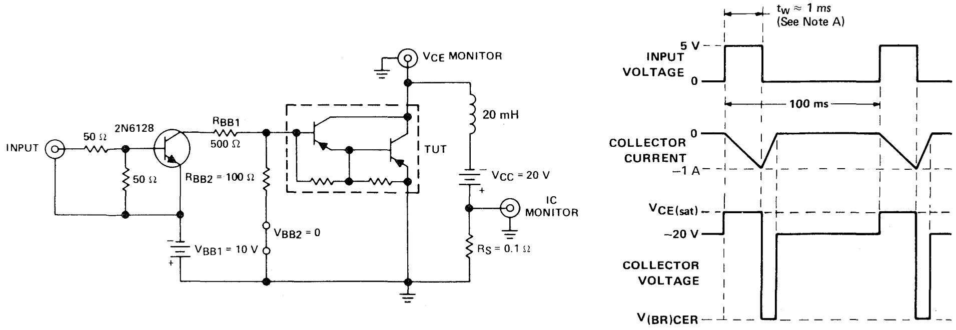
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -1$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

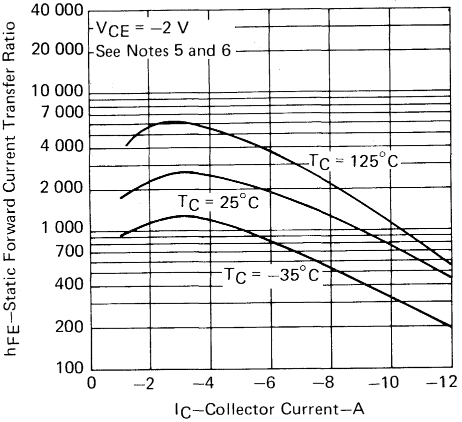


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

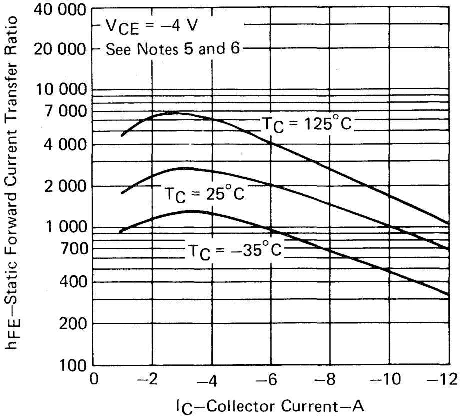


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

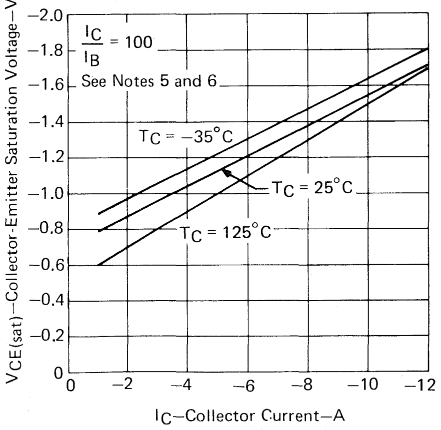


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

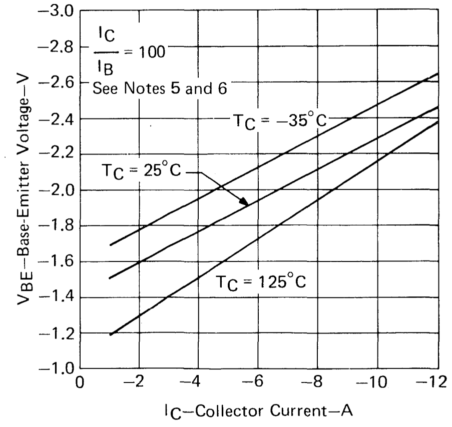


FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREAS

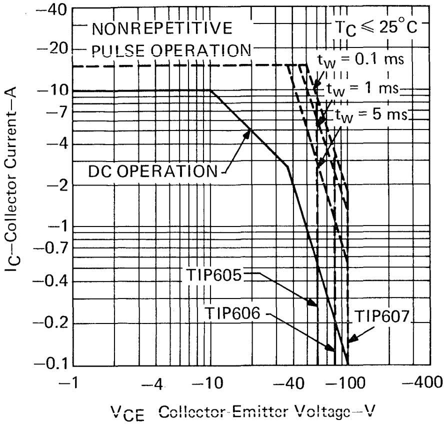

MAXIMUM COLLECTOR CURRENT vs COLLECTOR-EMITTER VOLTAGE

FIGURE 7

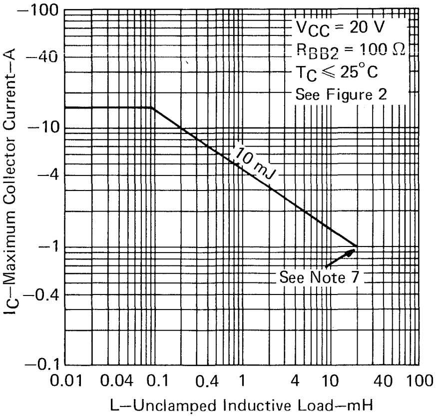

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

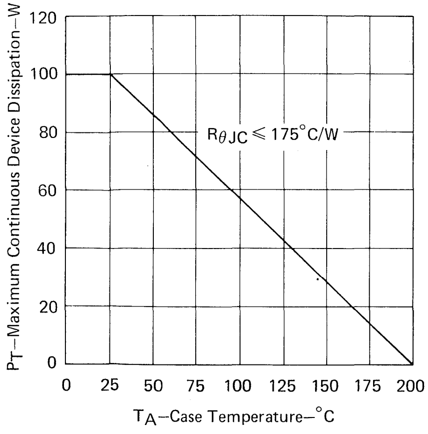

CASE TEMPERATURE DISSIPATION DERATING CURVE

FIGURE 9

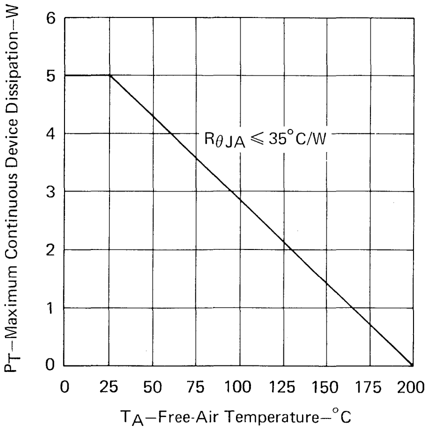

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

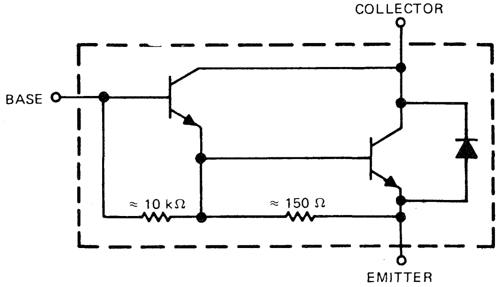
FIGURE 10

TYPES TIP620, TIP621, TIP622
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP625, TIP626, TIP627

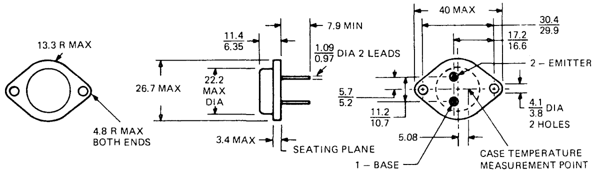
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

device schematic

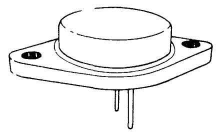


mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP620	TIP621	TIP622
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	← 5 A →		
Peak Collector Current (See Note 2)	← 8 A →		
Continuous Base Current	← 0.1 A →		
Safe Operating Area at (or below) 100°C Case Temperature	← See Figures 7 and 8 →		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 65 W →		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 4 W →		
Unclamped Inductive Load Energy (See Note 5)	← 50 mJ →		
Operating Collector Junction Temperature Range	← −65°C to 200°C →		
Storage Temperature Range	← −65°C to 200°C →		
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.37 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 23 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

TYPES TIP620, TIP621, TIP622
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS			TIP620		TIP621		TIP622		UNIT
					MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA,	I_B = 0,	See Note 6	60		80		100		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V,	I_E = 0			0.2					mA
		V_{CB} = 80 V,	I_E = 0					0.2			
		V_{CB} = 100 V,	I_E = 0							0.2	
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V,	I_B = 0			0.5					mA
		V_{CE} = 40 V,	I_B = 0					0.5			
		V_{CE} = 50 V,	I_B = 0							0.5	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V,	I_C = 0			2		2		2	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 3 V,	I_C = 0.5 A	See Notes 6 and 7	1000		1000		1000		
		V_{CE} = 3 V,	I_C = 3 A		1000		1000		1000		
V_{BE}	Base-Emitter Voltage	V_{CE} = 3 V,	I_C = 3 A,	See Notes 6 and 7		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 12 mA,	I_C = 3 A	See Notes 6 and 7		2		2		2	V
		I_B = 20 mA,	I_C = 5 A			4		4		4	

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

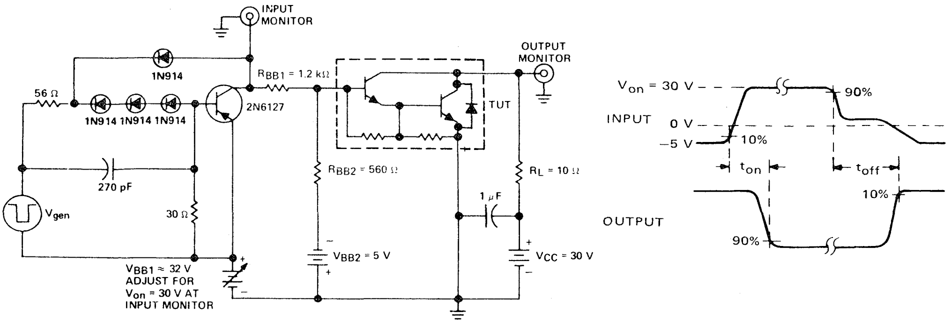
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA, $V_{BE(off)}$ = −5 V, R_L = 10 Ω, See Figure 1	1.5	μs
t_{off}	Turn-Off Time		8.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ⩽ 15 ns, t_f ⩽ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

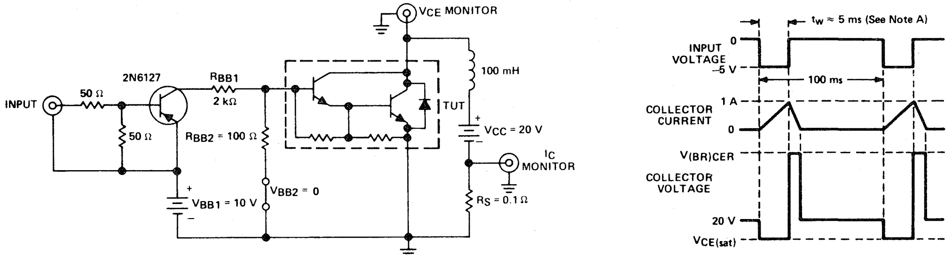
C. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ⩽ 15 ns, R_{in} ⩾ 10 MΩ, C_{in} ⩽ 11.5 pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until I_{CM} = 1 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

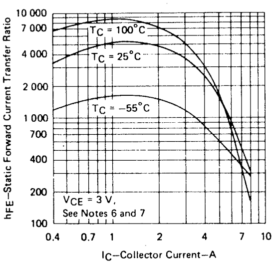


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

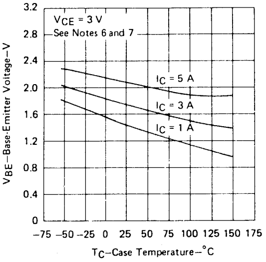


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

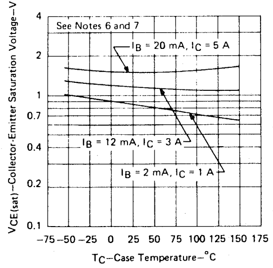


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
FREQUENCY

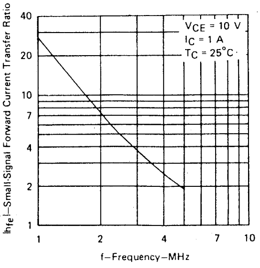


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

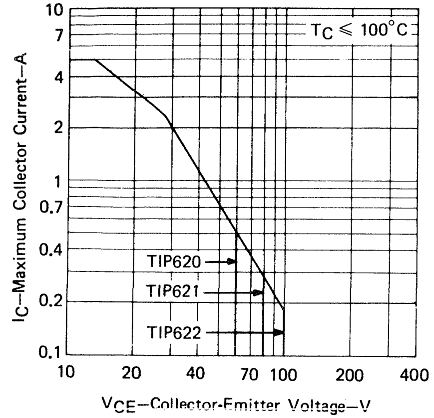


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

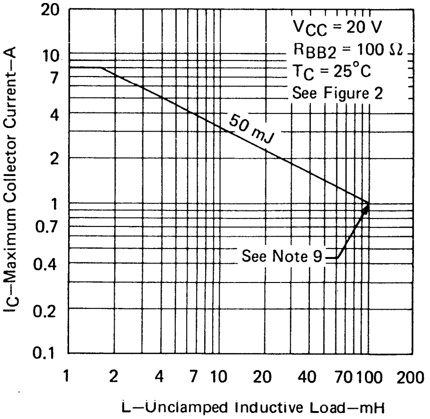


FIGURE 8

NOTES: 8. This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

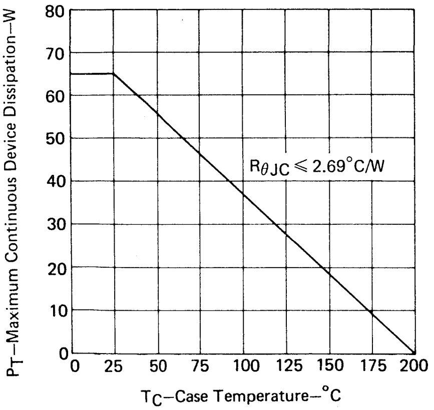


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

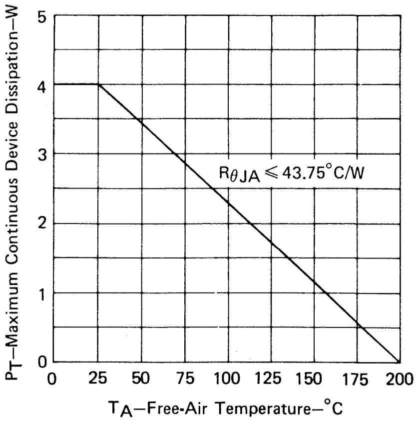


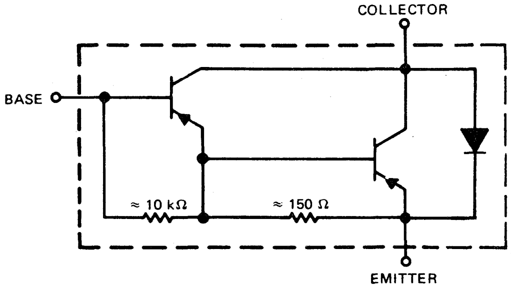
FIGURE 10

TYPES TIP625, TIP626, TIP627
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP620, TIP621, TIP622

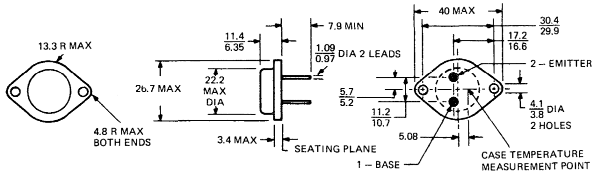
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

device schematic

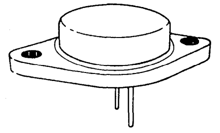


mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP625	TIP626	TIP627
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	−5 A		
Peak Collector Current (See Note 2)	−8 A		
Continuous Base Current	−0.1 A		
Safe Operating Area at (or below) 100°C Case Temperature	See Figures 7 and 8		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	65 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	4 W		
Unclamped Inductive Load Energy (See Note 5)	50 mJ		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Lead Temperature 3.2mm from Case for 10 Seconds	260°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.37 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 23 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TYPES TIP625, TIP626, TIP627
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP625		TIP626		TIP627		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 6	−60		−80		−100		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$		−0.2					mA
		$V_{CB} = -80$ V, $I_E = 0$				−0.2			
		$V_{CB} = -100$ V, $I_E = 0$						−0.2	
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		−0.5					mA
		$V_{CE} = -40$ V, $I_B = 0$				−0.5			
		$V_{CE} = -50$ V, $I_B = 0$						−0.5	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−2		−2		−2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -3$ V, $I_C = -0.5$ A, See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = -3$ V, $I_C = -3$ A	1000		1000		1000		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -3$ V, $I_C = -3$ A, See Notes 6 and 7		−2.5		−2.5		−2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -12$ mA, $I_C = -3$ A, See Notes 6 and 7		−2		−2		−2	V
		$I_B = -20$ mA, $I_C = -5$ A		−4		−4		−4	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ⩽ 2%.

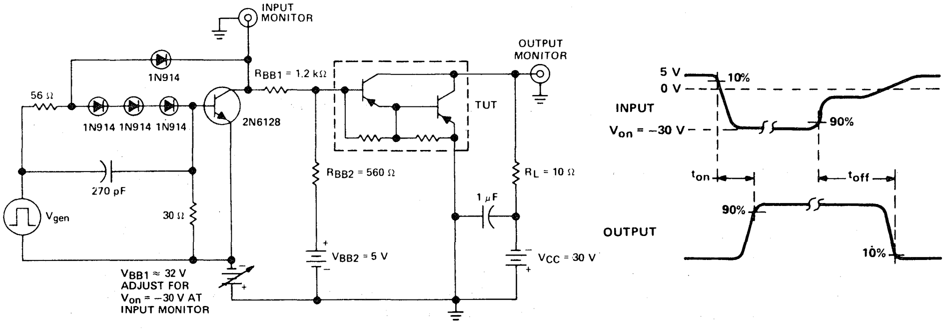
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -3$ A, $I_{B(1)} = -12$ mA, $I_{B(2)} = 12$ mA, $V_{BE(off)} = 5$ V, $R_L = 10\ \Omega$, See Figure 1	1.5	µs
t_{off}	Turn-Off Time		8.5	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ⩽ 15 ns, t_f ⩽ 15 ns, Z_{out} = 50 Ω, t_w = 20 µs, duty cycle ⩽ 2%.

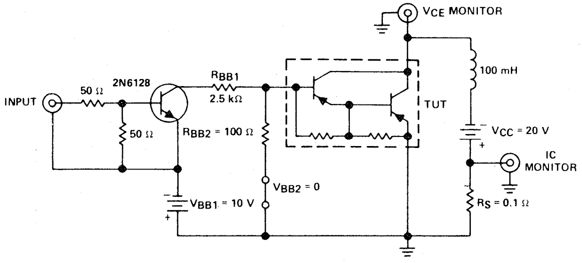
C. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ⩽ 15 ns, R_{in} ⩾ 10 MΩ, C_{in} ⩽ 11.5 pF.

D. Resistors must be noninductive types.

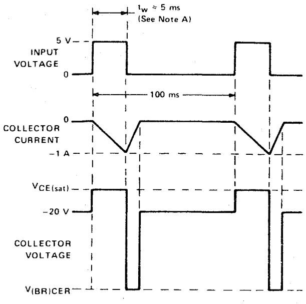
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width in increased until $I_{CM} = -1$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

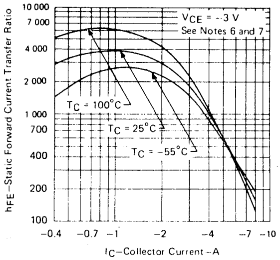


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

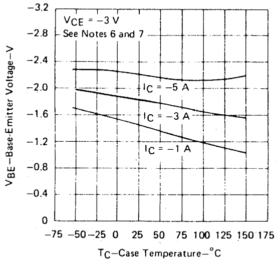


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

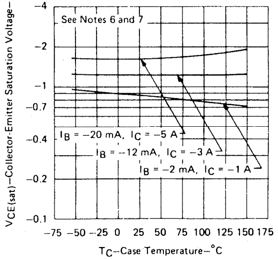


FIGURE 5

SMALL-SIGNAL COMMON-EMITTER
FORWARD-CURRENT TRANSFER RATIO
vs
FREQUENCY

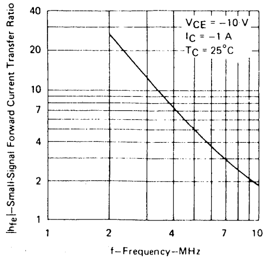


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

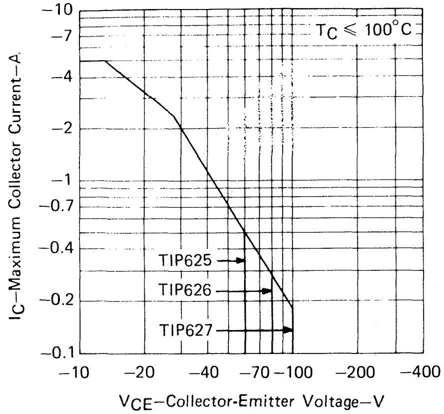


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

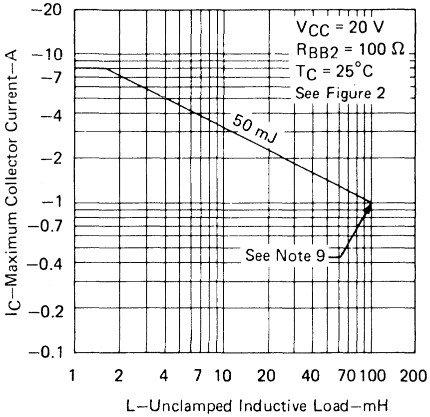


FIGURE 8

NOTES: 8. These combinations of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

9. Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

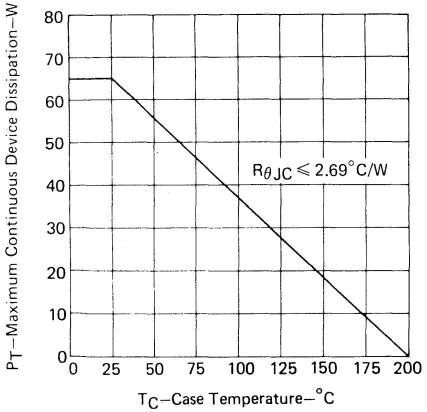


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

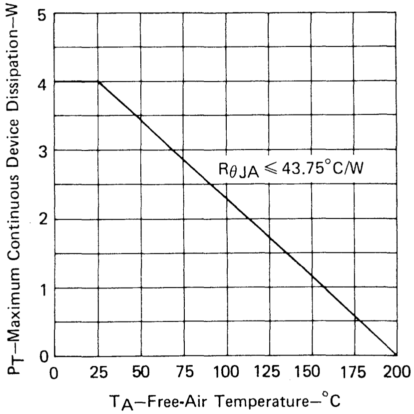


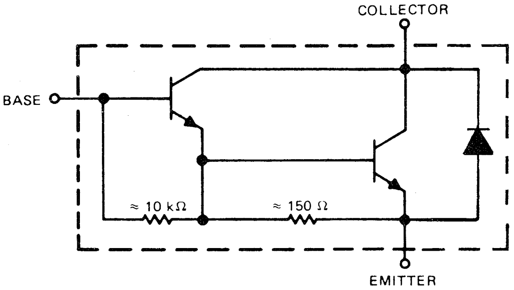
FIGURE 10

TIP640, TIP641, TIP642
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP645, TIP646, TIP647

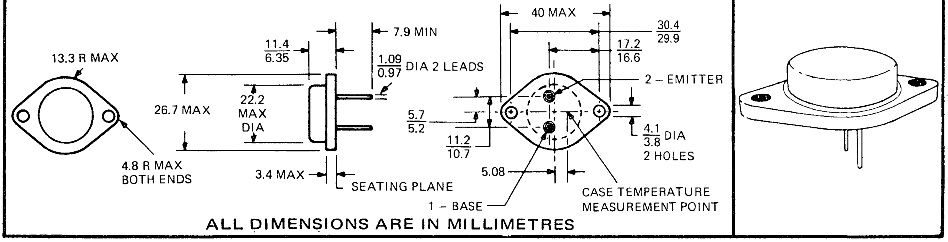
- 175 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100-mJ Reverse Energy Rating

device schematic



mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP640	TIP641	TIP642
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	← 10 A →		
Peak Collector Current (See Note 2)	← 15 A →		
Continuous Base Current	← 0.5 A →		
Safe Operating Areas at (or below) 25°C Case Temperature	← See Figures 7 and 8 →		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 175 W →		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 5 W →		
Unclamped Inductive Load Energy (See Note 5)	← 100 mJ →		
Operating Collector Junction Temperature Range	← −65°C to 200°C →		
Storage Temperature Range	← −65°C to 200°C →		
Lead Temperature 3.2mm from Case for 10 Seconds	← 260°C →		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leq 0.3$ ms, duty cycle $\leq$ 10%.
3. Derate linearly to 200°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

TIP640, TIP641, TIP642
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP640		TIP641		TIP642		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 6		60		80		100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$			2					mA
		$V_{CE} = 40$ V, $I_B = 0$					2			
		$V_{CE} = 50$ V, $I_B = 0$							2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$			1					mA
		$V_{CB} = 80$ V, $I_E = 0$					1			
		$V_{CB} = 100$ V, $I_E = 0$							1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			2		2		2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 5$ A	See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = 4$ V, $I_C = 10$ A		500		500		500		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 10$ A,	See Notes 6 and 7		3		3		3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 10$ mA, $I_C = 5$ A	See Notes 6 and 7		2		2		2	V
		$I_B = 40$ mA, $I_C = 10$ A			3		3		3	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

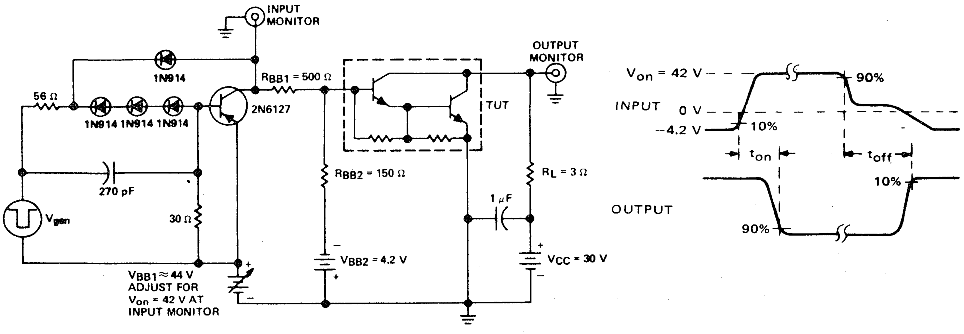
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 10$ A, $I_{B(1)} = 40$ mA, $I_{B(2)} = -40$ mA,	0.9	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -4.2$ V, $R_L = 3\ \Omega$, See Figure 1	11	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ μs, duty cycle ⩽ 2%.

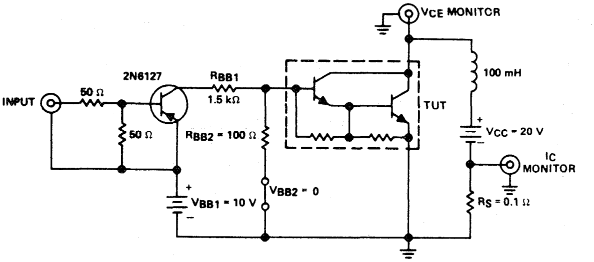
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

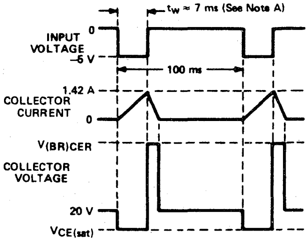
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 1.42 A.

TYPICAL CHARACTERISTICS

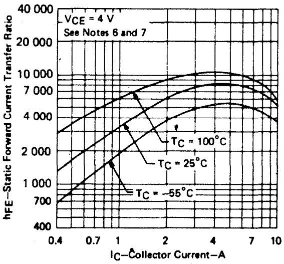

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

FIGURE 3

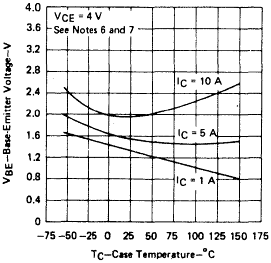

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

FIGURE 4

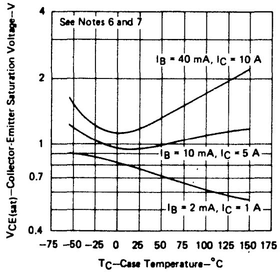

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

FIGURE 5

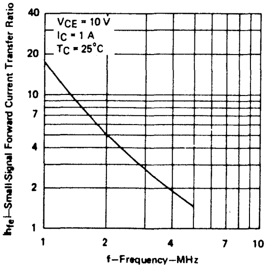

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

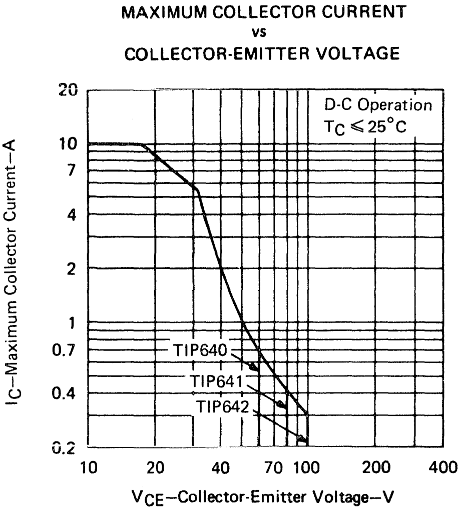


FIGURE 7

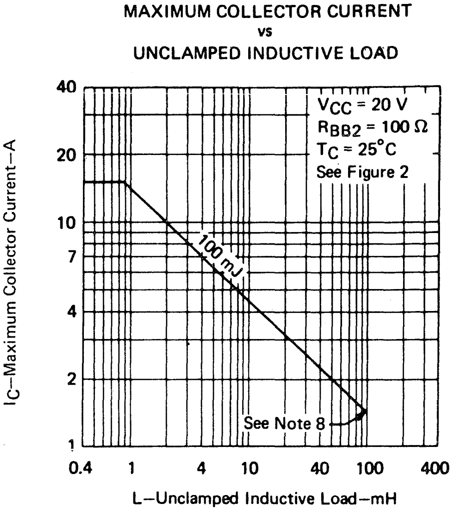


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

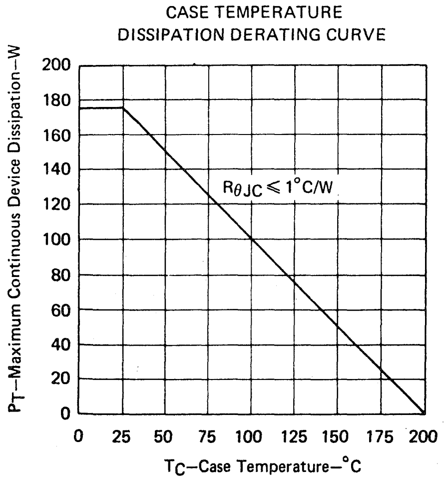


FIGURE 9

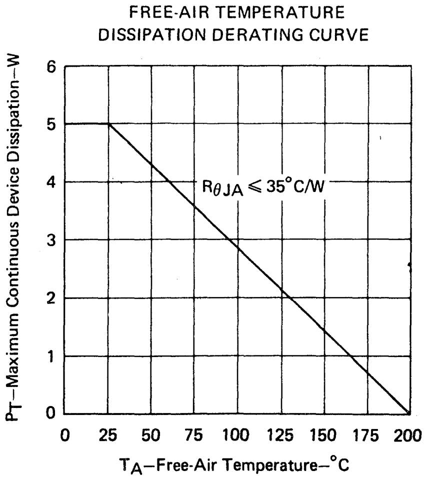


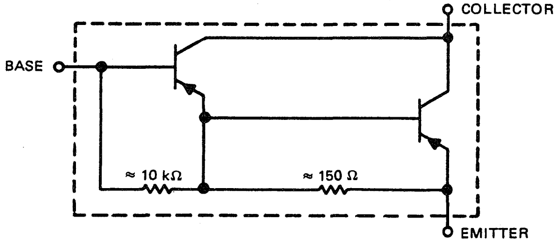
FIGURE 10

TIP645, TIP646, TIP647
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP640, TIP641, TIP642

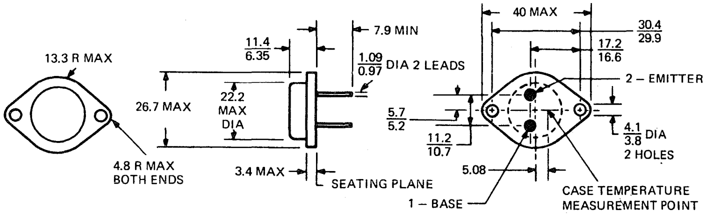
- 175 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100 mJ Reverse Energy Rating

device schematic

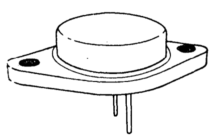


mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP645	TIP646	TIP647
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current		−10 A	
Peak Collector Current (See Note 2)		−15 A	
Continuous Base Current		−0.5 A	
Safe Operating Areas at (or below) 25°C Case Temperature		See Figures 7 and 8	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)		175 W	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)		5 W	
Unclamped Inductive Load Energy (See Note 5)		100 mJ	
Operating Collector Junction Temperature Range		−65°C to 200°C	
Storage Temperature Range		−65°C to 200°C	
Terminal Temperature 3.2mm from Case for 10 Seconds		260°C	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leq 0.3$ ms, duty cycle $\leq$ 10%.
3. Derate linearly to 200°C case temperature at the rate of 1 W/°C or refer to Dissipation Derating Curve, Figure 9.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 10.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. L = 100 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C^2L/2$.

TIP645,TIP646,TIP647
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP645		TIP646		TIP647		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$,	See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$			−2					mA
		$V_{CE} = -40$ V, $I_B = 0$					−2			
		$V_{CE} = -50$ V, $I_B = 0$							−2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$			−1					mA
		$V_{CB} = -80$ V, $I_E = 0$					−1			
		$V_{CB} = -100$ V, $I_E = 0$							−1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$			−2		−2		−2	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -5$ A	See Notes 6 and 7	1000		1000		1000		
		$V_{CE} = -4$ V, $I_C = -10$ A		500		500		500		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -10$ A,	See Notes 6 and 7		−3		−3		−3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -10$ mA, $I_C = -5$ A	See Notes 6 and 7		−2		−2		−2	V
		$I_B = -40$ mA, $I_C = -10$ A			−3		−3		−3	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.

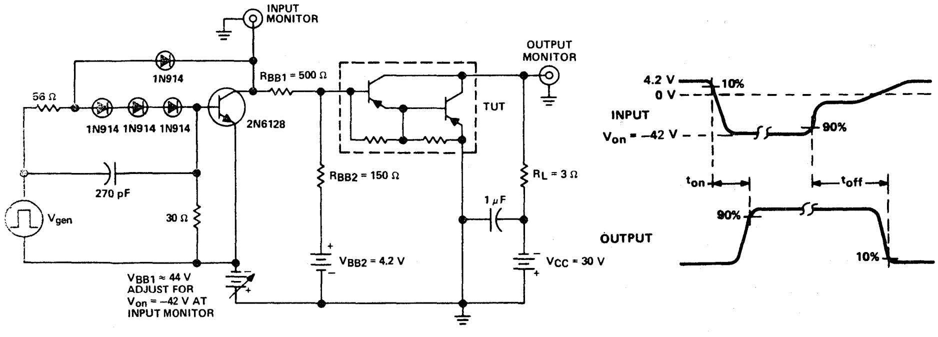
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -10$ A, $I_{B(1)} = -40$ mA, $I_{B(2)} = 40$ mA,	0.9	µs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.2$ V, $R_L = 3\ \Omega$, See Figure 1	11	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ µs, duty cycle ≤ 2%.

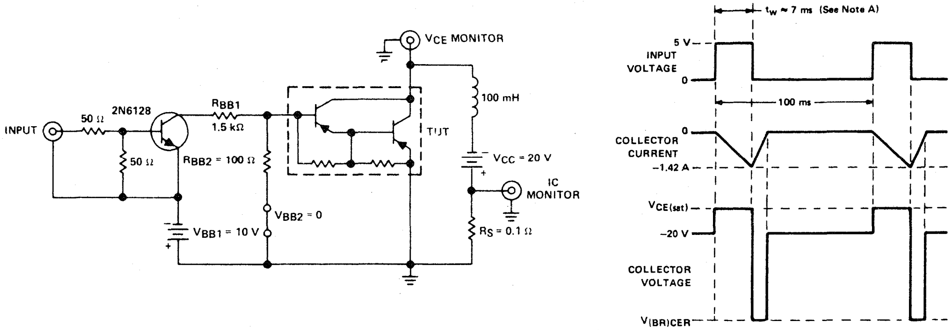
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



NOTE A: Input pulse width is increased until $I_{CM} = -1.42$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

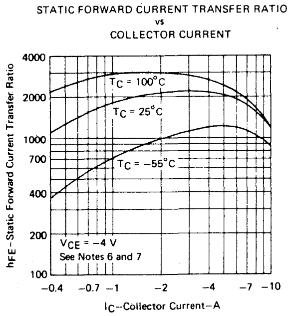


FIGURE 3

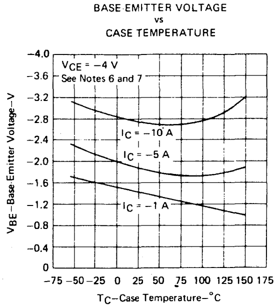


FIGURE 4

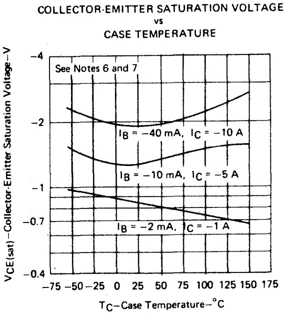


FIGURE 5

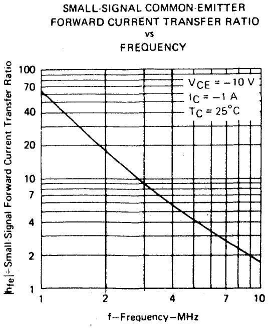


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

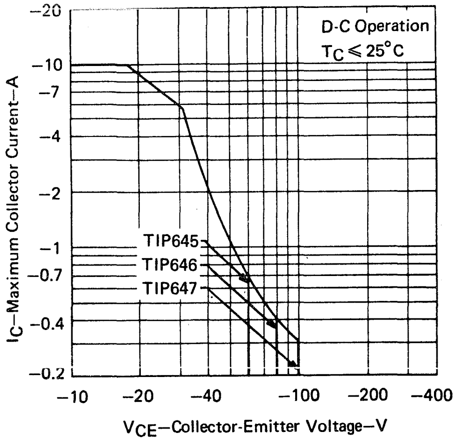


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

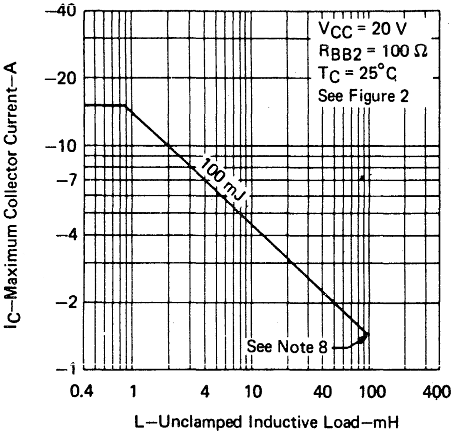


FIGURE 8

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

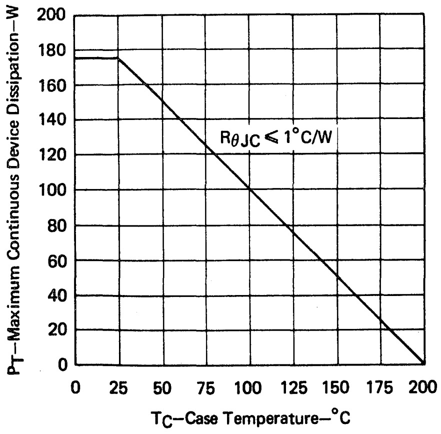


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

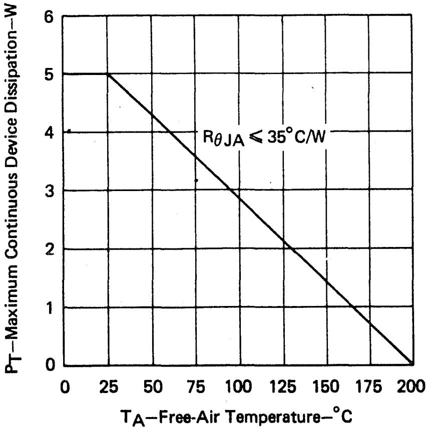


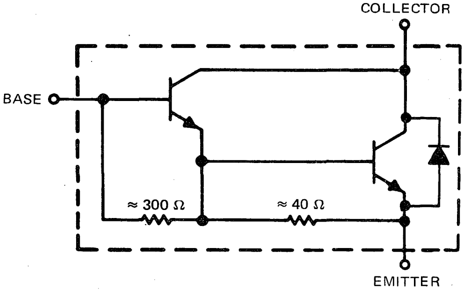
FIGURE 10

TYPES TIP660, TIP661, TIP662
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR AUTOMOTIVE IGNITION APPLICATIONS

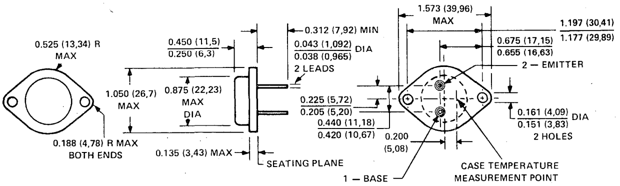
- **80 W at 100°C Case Temperature**
- **10-A Rated Continuous Collector Current**
- **Max $V_{CE(sat)}$ of 2.8 V at 6.5 A**
- **Functional Verification Tests for Ignition Applications**

device schematic

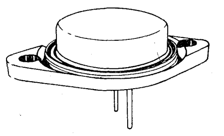


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	TIP660	TIP661	TIP662
Collector-Base Voltage	320 V	350 V	380 V
Collector-Emitter Voltage (See Note 1)	320 V	350 V	380 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	10 A		
Peak Collector Current (See Note 2)	15 A		
Commutating Diode Current (See Note 3)	10 A		
Continuous Base Current	1 A		
Safe Operating Area at (or below) 100°C Case Temperature	See Figure 8		
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 4)	80 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	5.5 W		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Lead Temperature 1/8 Inch from Case for 10 Seconds	300°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 10$ ms, duty cycle $\leqslant 10\%$.
3. This applies to the total collector-terminal current when the collector is at negative potential with respect to the emitter.
4. Derate linearly to 200°C case temperature at the rate of 0.8 W/°C or refer to Dissipation Derating Curve, Figure 9.
5. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to Dissipation Derating Curve, Figure 10.

electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIP660		TIP661		TIP662		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 320$ V, $I_B = 0$		1					mA
		$V_{CE} = 350$ V, $I_B = 0$				1			
		$V_{CE} = 380$ V, $I_B = 0$						1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		100		100		100	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2.2$ V, $I_C = 4$ A, See Notes 6 and 7	200		200		200		
V_{BE}	Base-Emitter Voltage	$I_B = 0.1$ A, $I_C = 6.5$ A, See Notes 6 and 7		2.2		2.2		2.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1$ A, $I_C = 6.5$ A, See Notes 6 and 7		2.8		2.8		2.8	V
		$I_B = 1$ A, $I_C = 10$ A		2.9		2.9		2.9	
V_F	Forward Voltage of Commutating Diode	$I_F = -I_C = 10$ A, $I_B = 0$, See Notes 6 and 7		3		3		3	V

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.25	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 8)	0.4		
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = 6.5$ A, $I_{B(1)} = 100$ mA, $I_{B(2)} = -100$ mA, $V_{BE(off)} = -5$ V, $R_L = 5\ \Omega$, See Figure 1	0.04	µs
t_r	Rise Time		1.5	
t_s	Storage Time		2.2	
t_f	Fall Time		2.6	

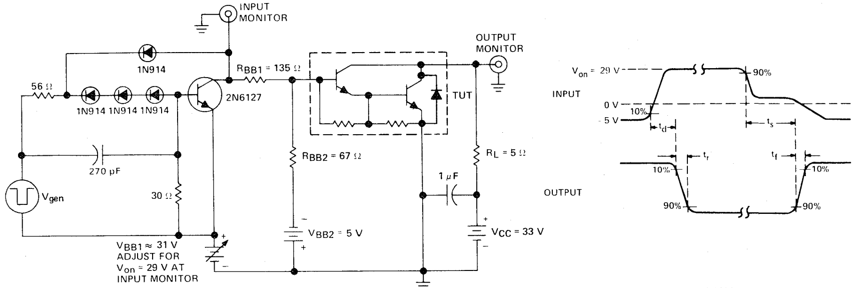
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

TEST	CONDITIONS	LEVEL
Power ($V_{CE} \cdot I_C$)	$V_{CE} = 40$ V, $I_C = 2$ A, $t_{test} = 1$ s	80 W
Reverse Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	$I_{CM} = 6$ A, $L = 100\ \mu$H, $f = 10$ Hz, $t_{test} = 0.5$ s, See Note 9	1.8 mJ
Forward Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	$I_{CM} = 7$ A, $L = 5$ mH, $V_{clamp} = V_{CEO}$ max rating, $f = 60$ Hz, $t_{test} = 0.5$ s, See Figure 2	122.5 mJ

NOTES:
6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu$s, duty cycle $\leqslant 2\%$.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.
8. This parameter is measured using a 0.003-inch mica insulator with Dow Corning 11 compound on both sides of the insulator, 6-32 mounting screws with bushings, and a mounting torque of 8 inch-pounds.
9. The test circuit is the unclamped inductive load circuit shown in Figure 2 on page 5-1 of the Texas Instruments "Power Semiconductor Data Book", CC-404. $L = 100\ \mu$H, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 20$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 20$ V, $I_{CM} = 6$ A.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

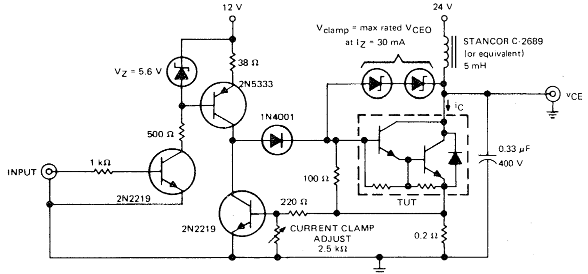
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

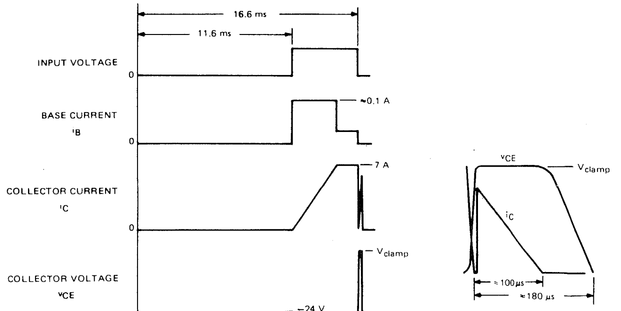
FIGURE 1

FUNCTIONAL TEST INFORMATION



Set clamp for $I_{CM} \approx 7$ A

TEST CIRCUIT



COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

WAVEFORMS

NOTES: A. Base and collector currents are measured using current probes such as Tektronix types P6019, P6020, P6021, P6042, or the equivalent.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 20$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

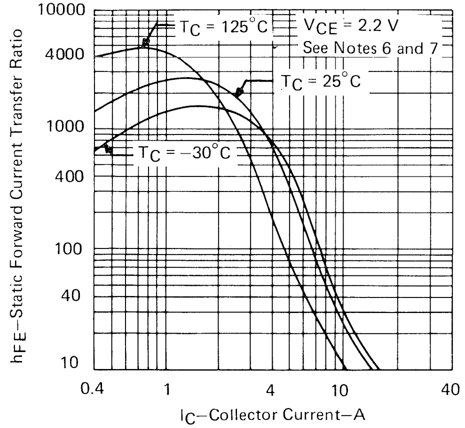


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

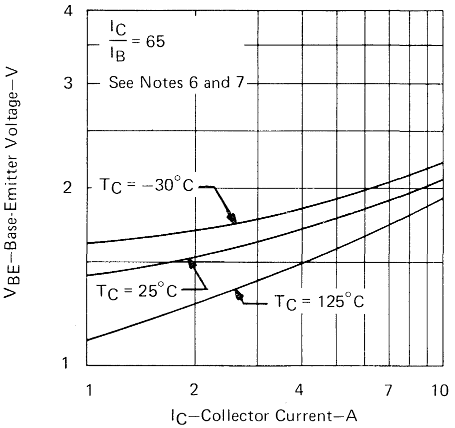


FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

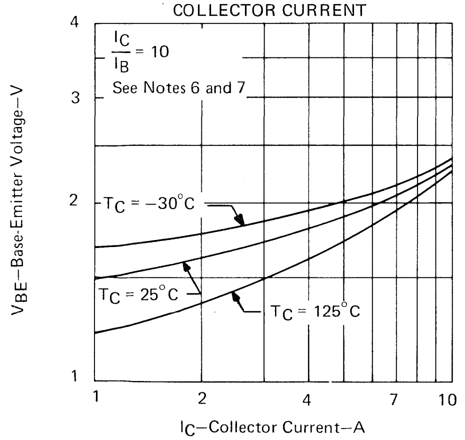


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

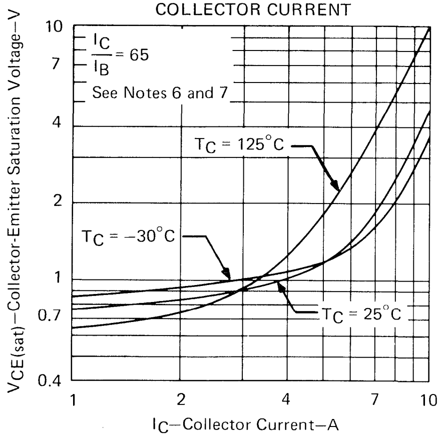


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

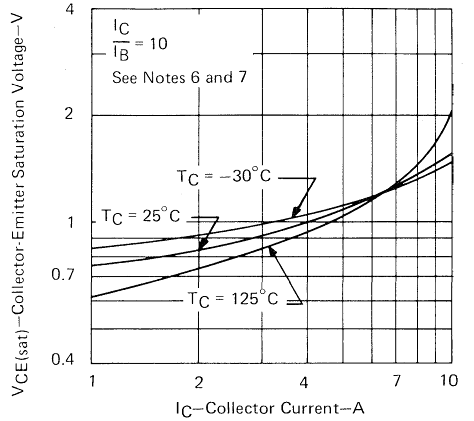


FIGURE 7

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

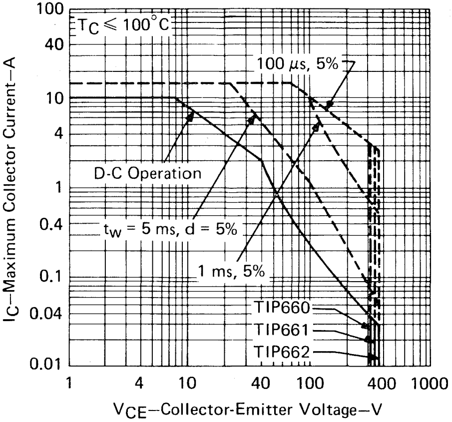


FIGURE 8

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

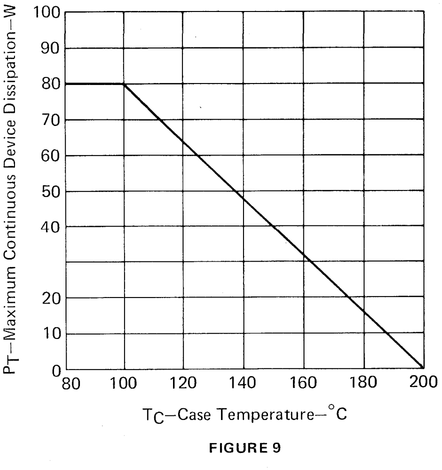


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

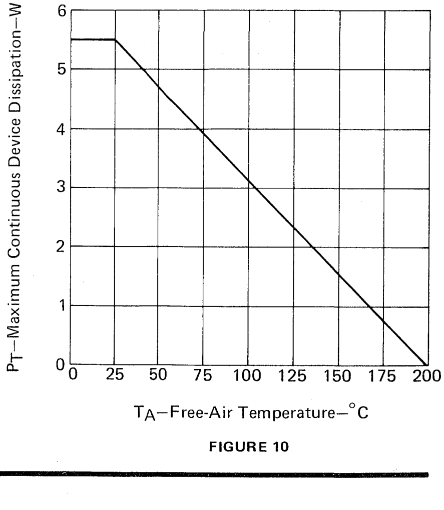


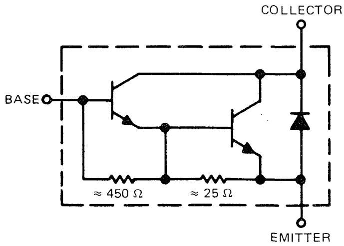
FIGURE 10

TYPES TIP663, TIP664, TIP665
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY DESIGNED FOR IGNITION SYSTEMS, MOTOR CONTROLS, AND SOLENOID DRIVER APPLICATIONS

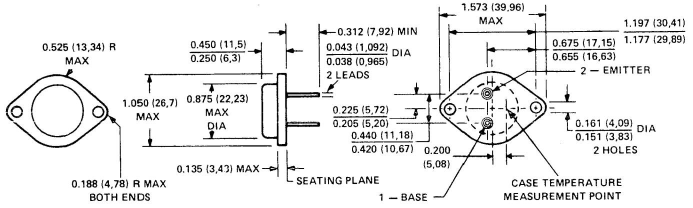
- Reverse-Bias SOA . . . 300 V to 400 V, 10 A
- Forward-Bias SOA . . . 30 V, 5 A
- 20 A Continuous Collector Current
- Min h_{FE} . . . 250 at 5 V, 10 A
- 150 W at 100° C Case Temperature

device schematic

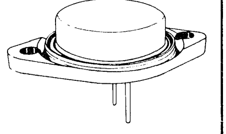


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.



absolute maximum ratings at 25° C case temperature (unless otherwise noted)

	TIP663	TIP664	TIP665
Collector-Base Voltage	400 V	450 V	500 V
Collector-Emitter Voltage (See Note 1)	300 V	350 V	400 V
Emitter-Base Voltage	8 V	8 V	8 V
Continuous Collector Current	←20 A→		
Peak Collector Current (See Note 2)	←30 A→		
Continuous Base Current	←5 A→		
Safe Operating Areas	←See Figures 8 and 9→		
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	←150 W→		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	←5.5 W→		
Operating Collector Junction Temperature Range	←−65°C to 200°C→		
Storage Temperature Range	←−65°C to 200°C→		
Lead Temperature 1/8 inch (3,2 mm) from Case for 10 Seconds	←300°C→		

NOTES:
1. These values apply when the base-emitter diode is reverse-biased or open-circuited.
2. This value applies for $t_w \leqslant 5$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.5 W/°C or refer to Dissipation Derating Curve, Figure 10.
4. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to Dissipation Derating Curve, Figure 11.

electrical characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS		TIP663		TIP664		TIP665		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 1 mA, See Note 5	I_E = 0,	400		450		500		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, See Note 5	I_B = 0,	300		350		400		V
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage	i_C = 20 A,	See Figure 1	300		350		400		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 250 V,	I_B = 0		250					μA
		V_{CE} = 300 V,	I_B = 0				250			
		V_{CE} = 350 V,	I_B = 0						250	
I_{CES}	Collector Cutoff Current	V_{CE} = 350 V,	V_{BE} = 0		250					μA
		V_{CE} = 400 V,	V_{BE} = 0				250			
		V_{CE} = 450 V,	V_{BE} = 0						250	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 8 V,	I_C = 0		50		50		50	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, See Notes 5 and 6	I_C = 5A,	500	10,000	500	10,000	500	10,000	
		V_{CE} = 5 V, See Notes 5 and 6	I_C = 10 A,	250		250		250		
		V_{CE} = 5 V, See Notes 5 and 6	I_C = 20 A,	25		25		25		
V_{BE}	Base-Emitter Voltage	I_B = 1 A, See Notes 5 and 6	I_C = 10A,		2.1		2.1		2.1	V
		I_B = 1 A, See Notes 5 and 6	I_C = 20 A,		2.5		2.5		2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 400 mA, See Notes 5 and 6	I_C = 10 A,		1.3		1.3		1.3	V
		I_B = 1 A, See Notes 5 and 6	I_C = 20 A,		3		3		3	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C$ = 20 A, See Notes 5 and 6			2.8		2.8		2.8	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, f = 1 kHz	I_C = 1 A,	1000		1000		1000		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, f = 5 MHz	I_C = 1 A,	2		2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, f = 1 MHz	I_E = 0,		250		250		250	pF

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

TYPES TIP663, TIP664, TIP665
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		0.67	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance		31.8	°C/W
$R_{\theta CHS}$	Case-to-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
$C_{\theta C}$	Thermal Capacitance of Case	8.3		J/°C

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 10 A, $I_{B(1)}$ = 400 mA, $I_{B(2)}$ = −440 mA, $V_{BE(off)}$ = −7.1 V, R_L = 25 Ω, See Figure 2	0.05	μs
t_r	Rise Time		0.22	
t_s	Storage Time		6.5	
t_f	Fall Time		1.3	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

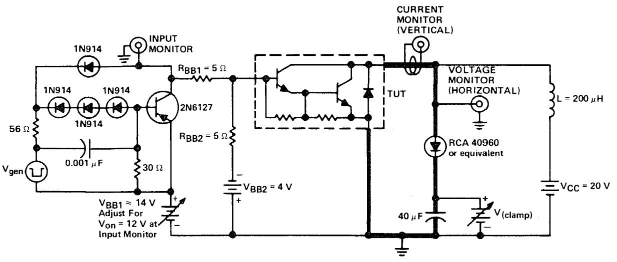
functional tests at 25°C free-air temperature

TEST	CONDITIONS			LEVEL
Power ($V_{CE} \cdot I_C$)	V_{CE} = 30 V,	I_C = 5 A,	t_{test} = 1 s	150 W
Reverse Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 25 A, t_{test} = 0.5 s,	L = 100 μH, See Note 8	f = 10 Hz,	31.2 mJ
Forward Pulse Energy $\left(\frac{I_C{}^2L}{2}\right)$	I_{CM} = 8 A, f = 75 Hz.	L = 10 mH, t_{test} = 0.5 s,	V_{clamp} = 320 V, See Figure 3	320 mJ

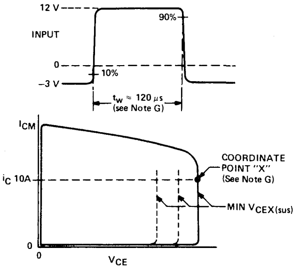
NOTES: 7. This parameter is measured using a 0.003-inch (0,08 mm) mica insulator with Dow Corning II Compound on both sides of the insulator, 0.138-32 (formerly 6-32) mounting screws with bushings, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

8. The test circuit is the unclamped inductive load circuit shown in Figure 2 on page 5-1 of the Texas Instruments *Power Semiconductor Data Book,* CC-404. L = 100 μH, R_{BB1} = 20 Ω, R_{BB2} = 100 Ω, V_{BB1} = 20 V, V_{BB2} = 0 V, R_L= 0.1 Ω, V_{CC} = 20 V, I_{CM} = 25 A.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



INPUT WAVEFORM AND X-Y DISPLAY

NOTES: A. V_{gen} is a −20 V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, $t_w \approx 120$ μs, duty cycle ⩽ 2%.

C. Waveforms are monitored on an X-Y oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

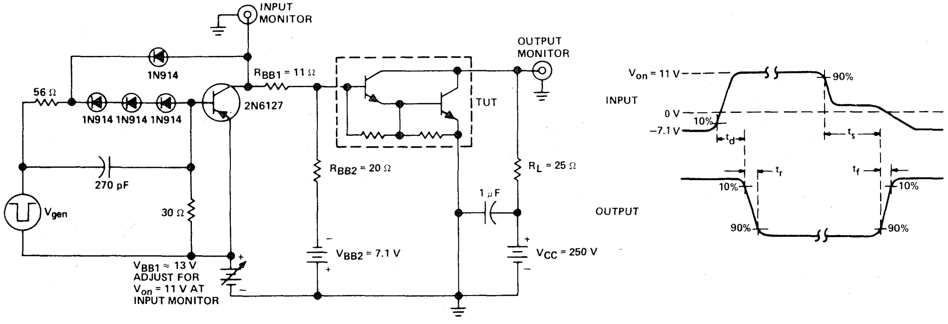
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

G. Adjust input pulse width until collector current is 20 A at point "X." I_{CM} must not exceed 30 A.

FIGURE 1—COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.

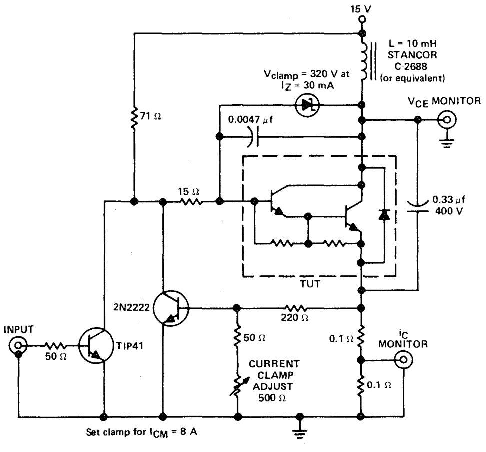
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

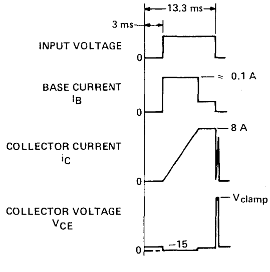
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 2—SWITCHING CHARACTERISTICS

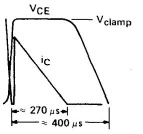
FUNCTIONAL TEST INFORMATION



TEST CIRCUIT



WAVEFORMS



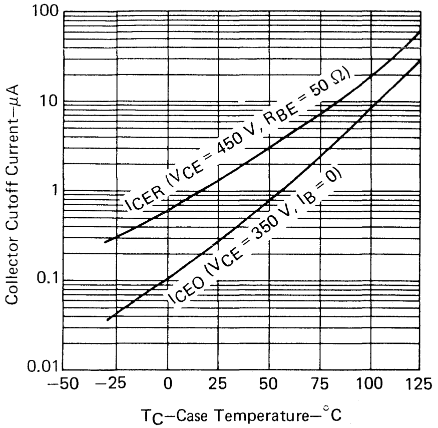
COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

NOTES: A. Base and collector currents are measured using current probes such as Tektronix types P6019, P6020, P6021, P6042, or the equivalent.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 20$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

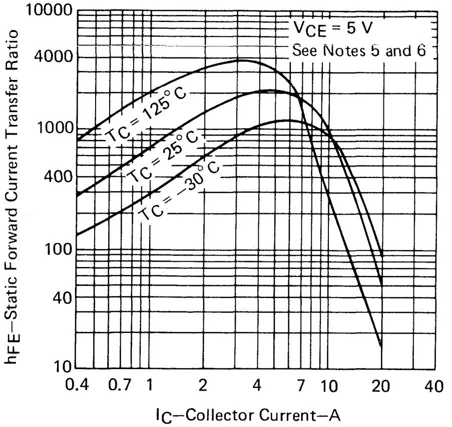
FIGURE 3—FORWARD-PULSE ENERGY TEST

TYPICAL CHARACTERISTICS



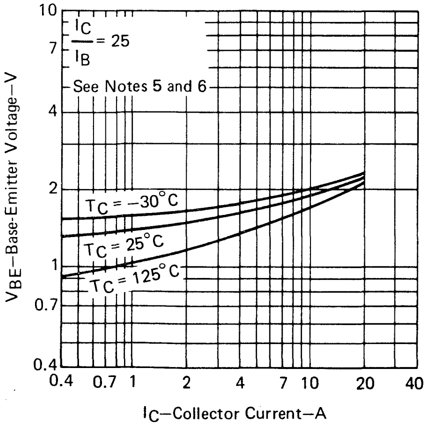
TIP665
COLLECTOR CUTOFF CURRENT
vs
CASE TEMPERATURE

FIGURE 4



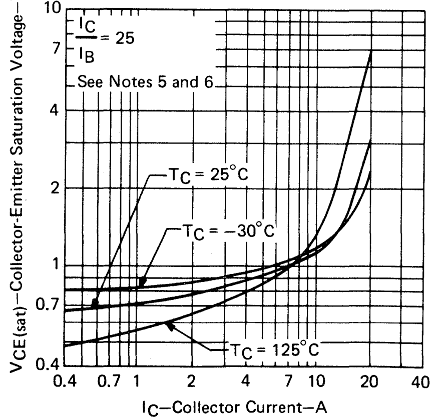
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 5



BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 6



COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 7

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 0.125 inch (3,2 mm) from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

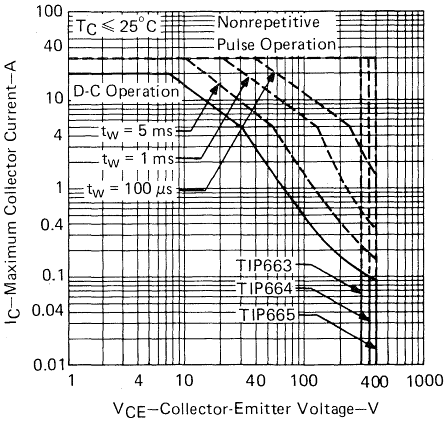


FIGURE 8

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

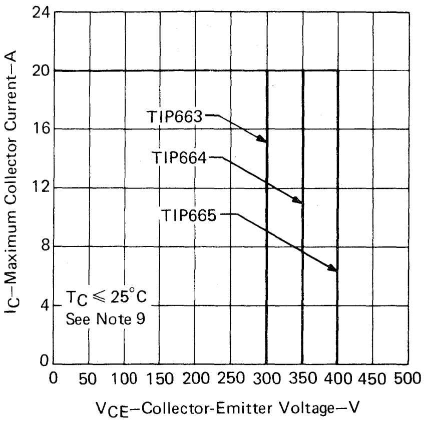


FIGURE 9

NOTE 9: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load as in Figure 1.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

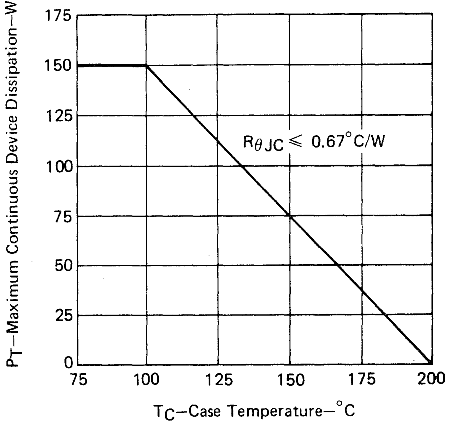


FIGURE 10

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

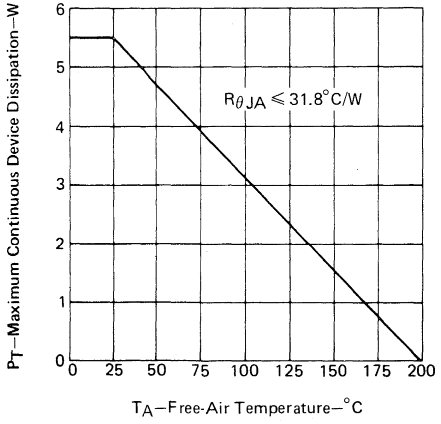


FIGURE 11

TIP2955

PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

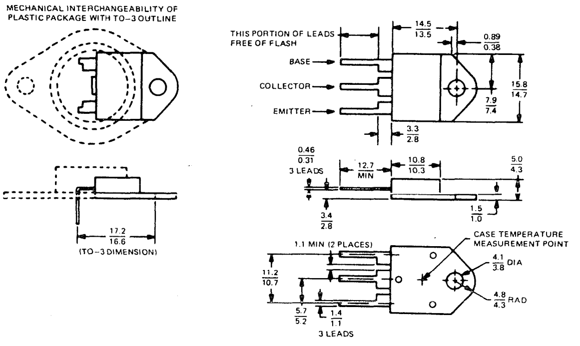
For power-amplifier and high-speed-switching applications

- 100 Watts at 25°C case temperature
- 15A rated collector current

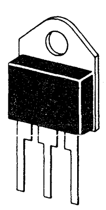
Designed for complementary use with TIP3055

Mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



Absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	−100 V
Collector-Emitter Voltage (See Note 1)	−70 V
Emitter-Base Voltage	−7 V
Continuous Collector Current	−15 A
Continuous Base Current	−7 A
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	100 W
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	3.5 W
Unclamped Inductive Load Energy (See Note 4)	62.5 mJ
Operating Collector Junction Temperature Range	−65°C to 150°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature 3.2mm from Case For 10 Seconds	260°C

NOTES:
1. This value applies when the base emitter resistance $R_{BE} = 100\Omega$
2. Derate linearly to 150°C case temperature at the rate of 0.72W/°C
3. Derate linearly to 150°C free air temperature at the rate of 28mW/°C
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L=20mH$, $R_{BB1}=100\Omega$ $V_{BB2}=0V$, $R_S=0.1\Omega$, $V_{CC}=10V$. Energy $\approx I_C{}^2L/2$.

TIP2955
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

Electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ mA, $I_B = 0$, See Note 5	−60		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		− 0.7	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -100$ V, $V_{BE} = -1.5$ V		− 5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		− 5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -4$ A, See Notes 5 and 6	20		
		$V_{CE} = -4$ V, $I_C = -10$ A, See Notes 5 and 6	5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -4$ A, See Notes 5 and 6		−1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -400$ mA, $I_C = -4$ A, See Notes 5 and 6		−1.1	V
		$I_B = -3.3$ A, $I_C = -10$ A, See Notes 5 and 6		− 3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ $I_C = -0.5$ f = 1 kHz	20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ $I_C = -0.5$	3		MHz

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

Thermal characteristics

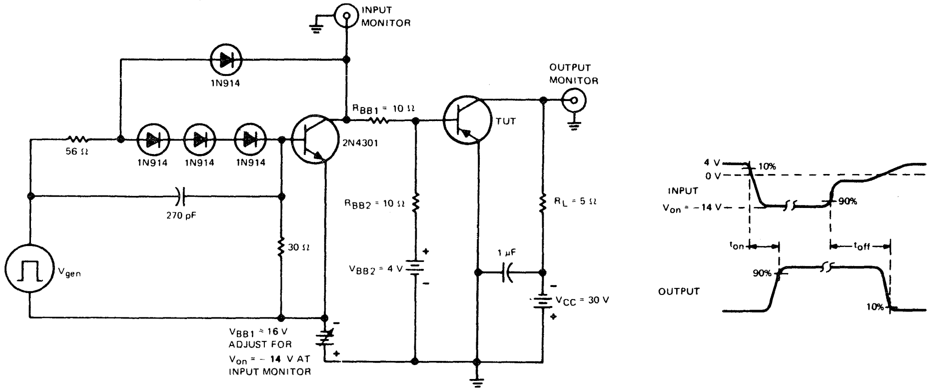
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.39	C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

Switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -6$ A, $I_{B(1)} = -0.6$ A, $I_{B(2)} = 0.6$ A,	0·4	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4$ V, $R_L = 5\ \Omega$, See Figure 1	0·7	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



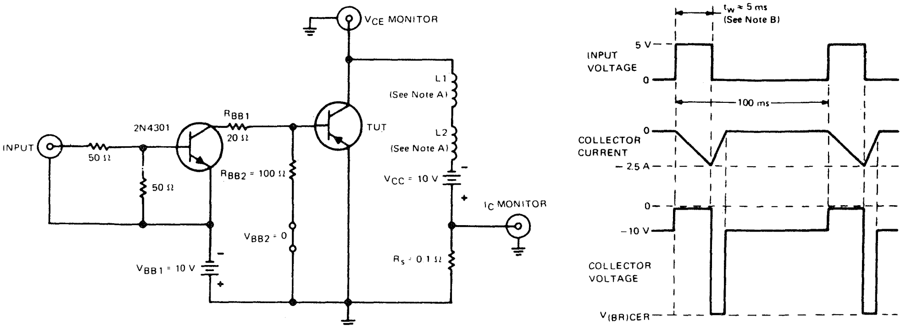
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES:
A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES:
A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
B. Input pulse width is increased until $I_{CM} = -2.5$ A.

FIGURE 2

TIP2955
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIC
vs
COLLECTOR CURRENT

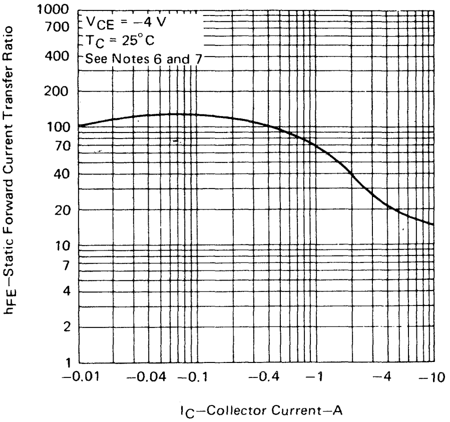


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

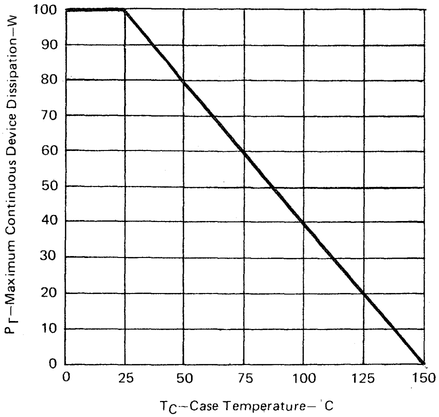


FIGURE 4

MAXIMUM SAFE OPERATING REGION

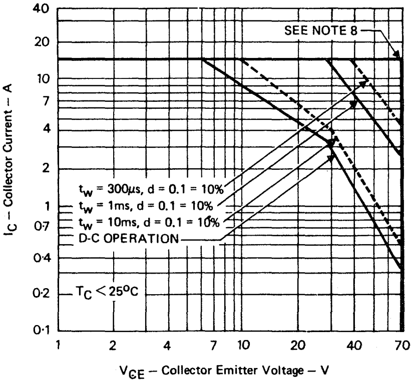


FIGURE 5

NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

TIP3055
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

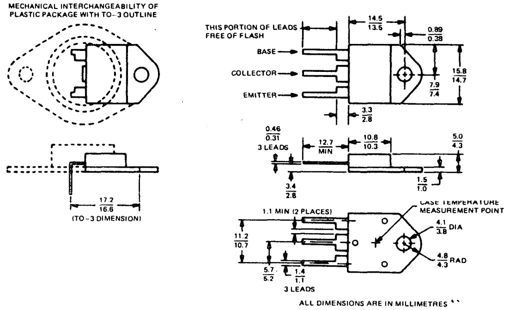
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
PLASTIC-CASE REPLACEMENT FOR 2N3055

- **100 Watts at 25°C Case Temperature**
- **15 A Rated Collector Current**

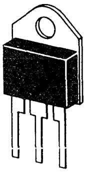
DESIGNED FOR COMPLEMENTARY USE WITH TIP2955

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	100 V
Collector-Emitter Voltage (See Note 1)	70 V
Emitter-Base Voltage	7 V
Continuous Collector Current	15 A
Continuous Base Current	7 A
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 5
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	100 W
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	3.5 W
Unclamped Inductive Load Energy (See Note 4)	62.5 mJ
Operating Collector Junction Temperature Range	−65°C to 150°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature 3.2mm from Case for 10 Seconds	260°C

NOTES:
1. This value applies when the base-emitter resistance $R_{BE} = 100\ \Omega$
2. Derate linearly to 150°C case temperature at the rate of 0.72 W/°C.
3. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB1} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C{}^2L/2$.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 5	60		V
I_{CER}	Collector Cutoff Current	$V_{CE} = 70$ V, $R_{BE} = 100\ \Omega$		1	mA
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.7	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 100$ V, $V_{BE} = -1.5$ V		5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 7$ V, $I_C = 0$		5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 4$ A, See Notes 5 and 6	20	70	
		$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 5 and 6	5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 4$ A, See Notes 5 and 6		1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 400$ mA, $I_C = 4$ A, See Notes 5 and 6		1.1	V
		$I_B = 3.3$ A, $I_C = 10$ A, See Notes 5 and 6		3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, $f = 1$ kHz	15		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, $f = 1$ MHz, See Note 7	3		MHz

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

7. f_{hfe} is the frequency at which the magnitude of the small-signal forward current transfer ratio is 0.707 of its low-frequency value. For this device, the reference measurement is made at 1 kHz.

thermal characteristics

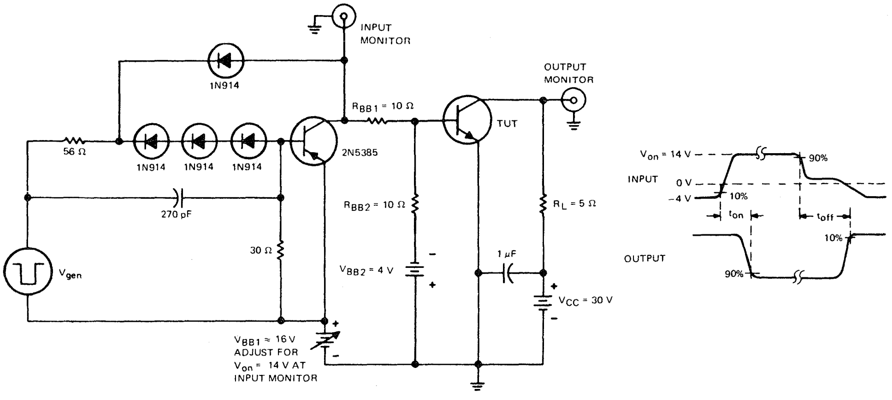
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.39	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 6$ A, $I_{B(1)} = 0.6$ A, $I_{B(2)} = -0.6$ A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -4$ V, $R_L = 5\ \Omega$, See Figure 1	1	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

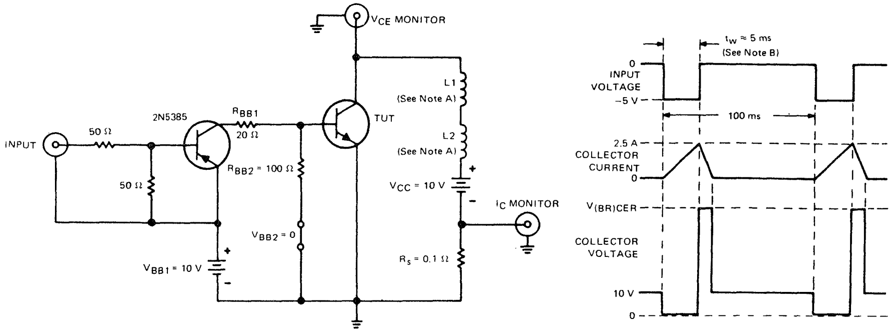


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTES:
A. L1 and L2 are 10 mH, 0.11 Ω, Chicago Standard Transformer Corporation C-2688, or equivalent.
B. Input pulse width is increased until I_{CM} = 2.5 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

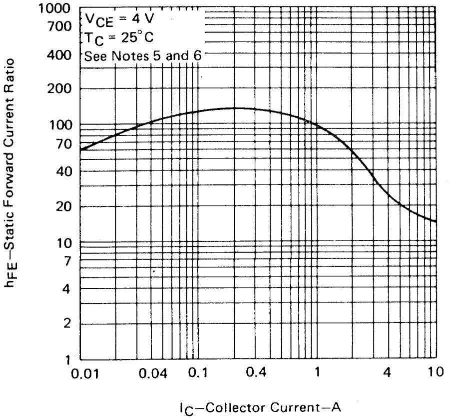


FIGURE 3

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

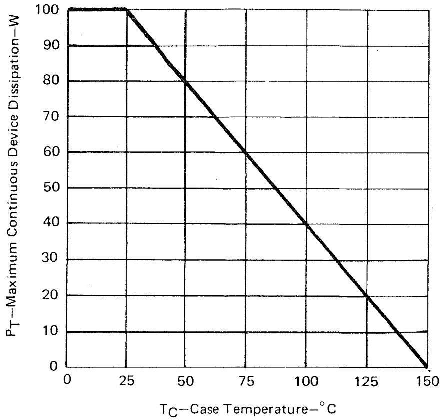


FIGURE 4

MAXIMUM SAFE OPERATING REGION

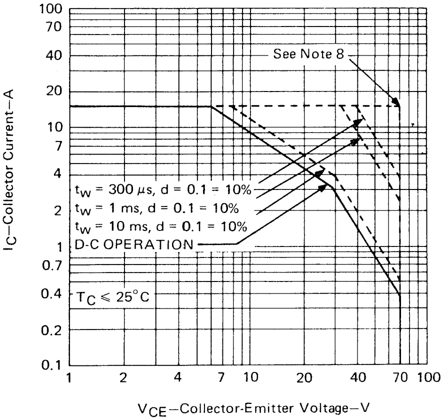


FIGURE 5

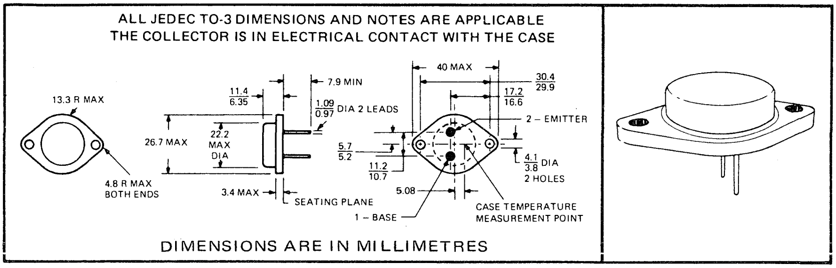
NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

TYPE 2N3055
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

FOR POWER-AMPLIFIER APPLICATIONS

- **115 W at 25°C Case Temperature**
- **Max I_C of 15 A**
- **Min f_{hfe} of 20 kHz**

*mechanical data



ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

DIMENSIONS ARE IN MILLIMETRES

*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	100 V
Collector-Emitter Voltage (See Note 1)	70 V
Emitter-Base Voltage	7 V
Continuous Collector Current	15 A
Continuous Base Current	7 A
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	115 W
Operating Case Temperature Range	–65°C to 200°C
Storage Temperature Range	–65°C to 200°C
Lead Temperature 0.8mm from Case for 10 Seconds	235°C

NOTES: 1. This value applies when the base-emitter resistance $R_{BE} = 100\ \Omega$.

2. Derate linearly to 200°C case temperature at the rate of 0.66 W/deg.

---

*Indicates JEDEC registered data

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 200$ mA, $I_B = 0$, See Note 4	60		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 200$ mA, $R_{BE} = 100\ \Omega$	70		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.7	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 100$ V, $V_{BE} = -1.5$ V		5	mA
		$V_{CE} = 100$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$		30	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 7$ V, $I_C = 0$		5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 4$ A, See Notes 3 and 4	20	70	
		$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 3 and 4	5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 4$ A, See Notes 3 and 4		1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 400$ mA, $I_C = 4$ A, See Notes 3 and 4		1.1	V
		$I_B = 3.3$ A, $I_C = 10$ A, See Notes 3 and 4		8	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, $f = 1$ kHz	15	60	
f_{hfe}	Small-Signal Common-Emitter Forward Current Transfer Ratio Cutoff Frequency	$V_{CE} = 4$ V, $I_C = 1$ A, See Note 5	10		kHz

NOTES: 3. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

4. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

5. f_{hfe} is the frequency at which the magnitude of the small-signal forward current transfer ratio is 0.707 of its low-frequency value. For this device, the reference measurement is made at 1 kHz.

*Indicates JEDEC registered data

thermal characteristics

PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	1.52	deg/W

2N3418, 2N3419, 2N3420, 2N3421
NPN EPITAXIAL PLANAR SILICON MEDIUM-POWER TRANSISTORS

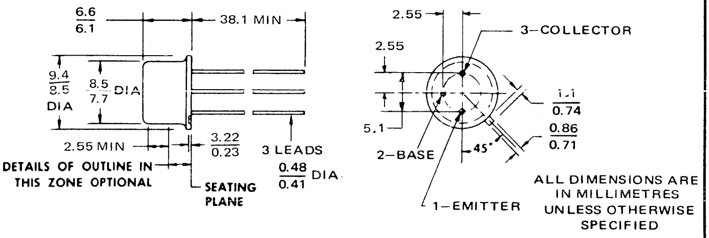
High-Frequency Medium-Power Transistors
Formerly TIX3033/34/35/36

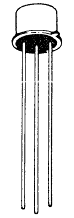
- ✻ **High-Power Dissipation in TO-5 Package: 15 watts at T_C = 100°C**
- ✻ **Low-Leakage Current: 0.5 μa at max voltage**
- ✻ **Low-Saturation Voltage: $V_{CE(sat)} = 0.25$ v max at $I_C = 1$ a**
- ✻ **High f_T: 40 Mc min at 10 v, 100 ma**

mechanical data

These transistors are in precision welded, hermetically sealed enclosures. Extreme cleanliness during the assembly process prevents sealed-in contamination. The approximate unit weight is 1.8 grams.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N3418 2N3420	2N3419 2N3421
Collector-Base Voltage	85 v	125 v
Collector-Emitter Voltage (See Note 1)	60 v	80 v
Emitter-Base Voltage	←— 8 v —→	
Collector Current, Continuous	←— 3 a —→	
Collector Current, Peak (See Note 2)	←— 5 a —→	
Base Current	←— 1 a —→	
Safe Operating Region	See Figures 8 and 9	
Total Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	←— 15 w —→	
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	←— 1 w —→	
Operating Case Temperature Range	−65°C to 200°C	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1.60mm from Case for 10 Seconds	←— 230°C —→	

NOTES:

1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for PW ≤ 1 msec, Duty Cycle ≤ 50%.
3. Derate linearly to 200°C case temperature at the rate of 0.15 w/C°.
4. Derate linearly to 200°C free-air temperature at the rate of 5.72 mw/C°.

*Indicates JEDEC registered data.

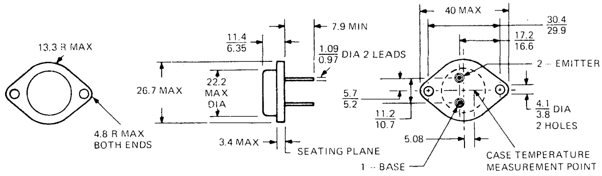
TYPES 2N3713, 2N3714, 2N3715, 2N3716
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND SWITCHING APPLICATIONS

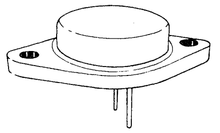
- **150 W at 25°C Case Temperature**
- **10 A Rated Collector Current**
- **Min f_{hfe} of 30 kHz**
- **Min f_T of 4 MHz**

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N3713	2N3714	2N3715	2N3716
*Collector-Base Voltage	80 V	100 V	80 V	100 V
*Collector-Emitter Voltage (See Note 1)	60 V	80 V	60 V	80 V
*Emitter-Base Voltage	7 V			
*Continuous Collector Current	10 A			
Peak Collector Current (See Note 2)	15 A			
*Continuous Base Current	4 A			
*Safe Operating Region at (or below) 25°C Case Temperature	See Figures 8 and 9			
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	150 W			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	4 W			
*Operating Collector Junction Temperature Range	−65°C to 200°C			
*Storage Temperature Range	−65°C to 200°C			
Lead Temperature 1.588mm from Case for 10 Seconds	235°C			

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for t_p = 0.3 ms, duty cycle ≤ 10%.
3. Derate linearly to 200°C case temperature at the rate of 0.855 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

TYPES 2N3713, 2N3714, 2N3715, 2N3716
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3713		2N3714		2N3715		2N3716		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 200$ mA, $I_B = 0$, See Note 5	60		80		60		80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		0.7				0.7			mA
		$V_{CE} = 40$ V, $I_B = 0$				0.7				0.7	
I_{CEV}	Collector Cutoff Current	$V_{CE} = 80$ V, $V_{BE} = -1.5$ V		1				1			mA
		$V_{CE} = 100$ V, $V_{BE} = -1.5$ V				1				1	
		$V_{CE} = 60$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$		10				10			mA
		$V_{CE} = 80$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$				10				10	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 7$ V, $I_C = 0$		1		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V, $I_C = 1$ A, See Notes 5 and 6	25	75	25	75	50	150	50	150	
		$V_{CE} = 2$ V, $I_C = 3$ A, See Notes 5 and 6	15		15		30		30		
		$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 5 and 6	5		5		5		5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V, $I_C = 5$ A, See Notes 5 and 6		2		2		1.8		1.8	V
		$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 5 and 6		4		4		4		4	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ A, $I_C = 5$ A, See Notes 5 and 6		1		1		0.8		0.8	V
		$I_B = 2$ A, $I_C = 10$ A, See Notes 5 and 6		4		4		4		4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, $f = 1$ kHz	25	250	25	250	25	250	25	250	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, $f = 1$ MHz	4		4		4		4		
f_{hfe}	Small-Signal Common-Emitter Forward Current Transfer Ratio Cutoff Frequency	$V_{CE} = 10$ V, $I_C = 0.5$ A	30		30		30		30		kHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 100$ kHz		250		250		250		250	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	1.17	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	

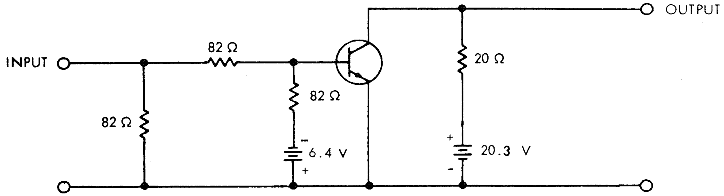
*Indicates JEDEC registered data

switching characteristics at 25°C case temperature

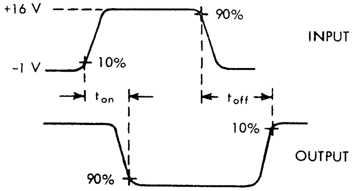
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 1$ A, $I_{B(1)} = 100$ mA, $I_{B(2)} = -100$ mA, $V_{BE(off)} = -3.7$ V, $R_L = 20\ \Omega$, See Figure 1	450	ns
t_{off}	Turn-Off Time		350	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_p = 10\ \mu s$, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

TYPES 2N3713, 2N3714, 2N3715, 2N3716
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

2N3713, 2N3714

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

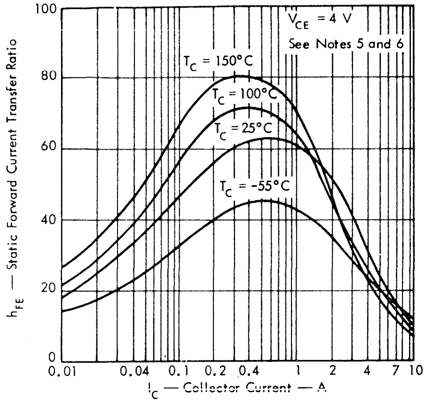


FIGURE 2

2N3715, 2N3716

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

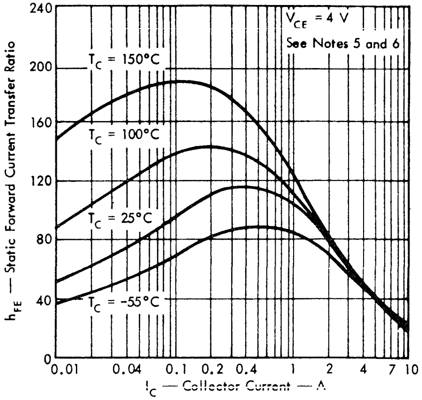


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

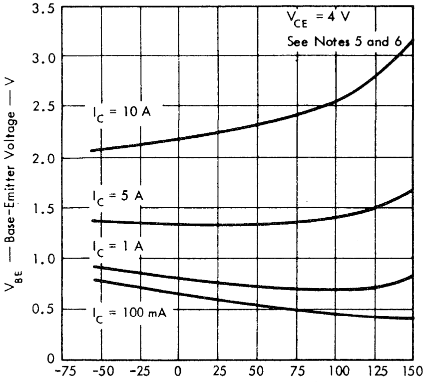


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

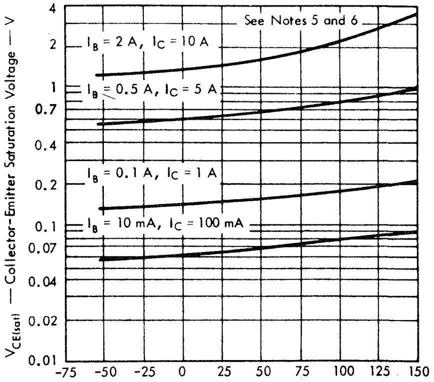


FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

TYPICAL CHARACTERISTICS

NORMALIZED COLLECTOR-EMITTER BREAKDOWN VOLTAGE
vs
BASE-EMITTER RESISTANCE

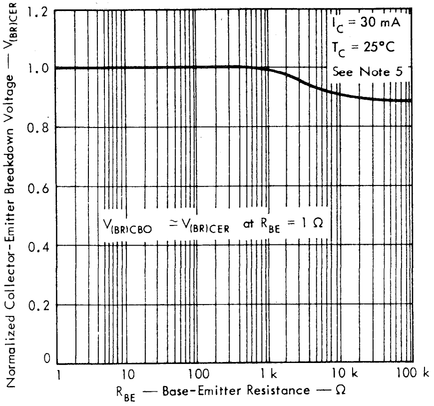


FIGURE 6

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

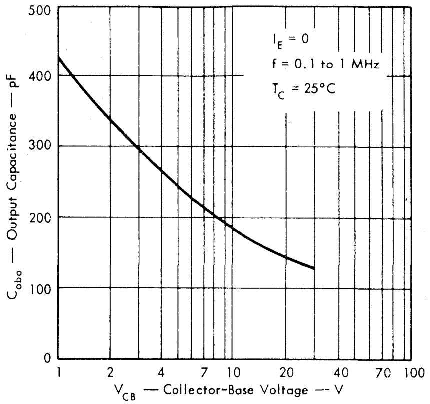


FIGURE 7

MAXIMUM SAFE OPERATING REGIONS

2N3713, 2N3715

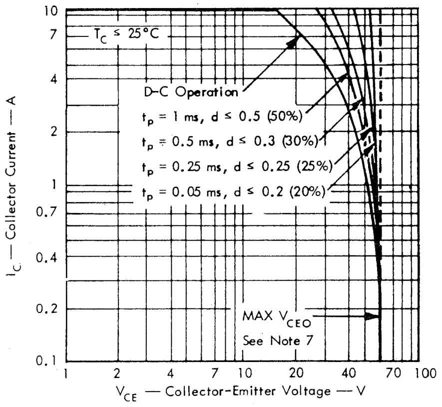


FIGURE 8

2N3714, 2N3716

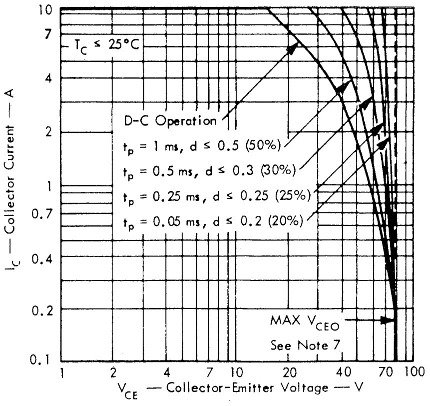


FIGURE 9

NOTES: 5. This parameter must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.
7. Operation above maximum V_{CEO} is permissible if the base is reverse-voltage biased with respect to the emitter and the collector-base-voltage rating is not exceeded.

TYPES 2N3713, 2N3714, 2N3715, 2N3716
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

THERMAL INFORMATION

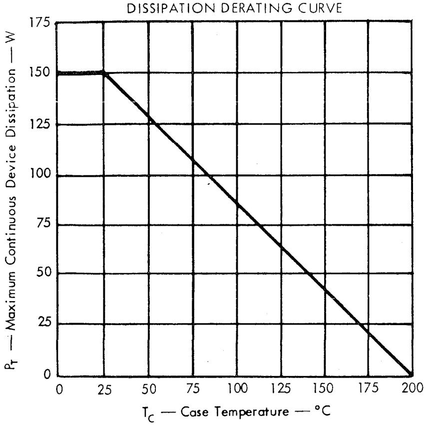


FIGURE 10

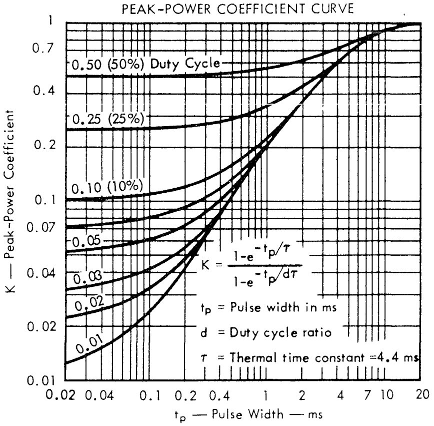


FIGURE 11

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	1.17	deg/W
$\theta_{C\text{-}A}$	Case-to-Free-Air Thermal Resistance	42.5	deg/W
$\theta_{C\text{-}HS}$	Case-to-Heat-Sink Thermal Resistance		deg/W
$\theta_{HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance		deg/W
T_A	Free-Air Temperature		°C
T_C	Case Temperature		°C
$T_{J(av)}$	Average Junction Temperature	≤ 200	°C
$T_{J(max)}$	Peak Junction Temperature	≤ 200	°C
K	Peak-Power Coefficient	See Figure 11	
t_p	Pulse Width		ms
t_x	Pulse Period		ms
d	Duty Cycle Ratio (t_p/t_x)		

Equation No. 1 — Application: d-c power dissipation, heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for . . °C} \le T_C \le 200\text{°C, as in figure 10.}$$

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \quad \text{for } 25\text{°C} \le T_A \le 200\text{°C}$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}} \quad \text{for } 25\text{°C} \le T_C \le 200\text{°C}$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C\text{-}A} + K\theta_{J\text{-}C}} \quad \text{for } 25\text{°C} \le T_A \le 200\text{°C}$$

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C\text{-}HS} + \theta_{HS\text{-}A} = 2.25$ deg/W (From information supplied with heat sink.)

$T_{J(av)}$ (design limit) $= 200$°C

$T_A = 50$°C

$d = 10\%\ (0.1)$

$t_p = 0.1$ ms

Solution:

From figure 11, Peak-Power Coefficient K = 0.11 and by use of equation No. 3

$$P_{T(max)} \doteq \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(1.17)} = 424\text{ W}$$

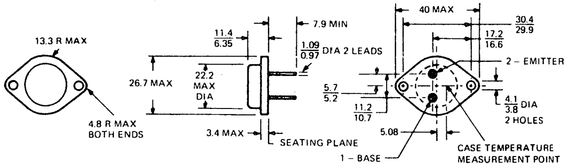
TYPES 2N3771, 2N3772
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR UNTUNED POWER-AMPLIFIER APPLICATIONS

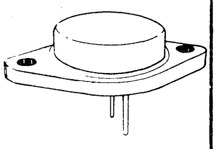
150 W at 25°C Case Temperature
30-A Rated Continuous Collector Current (2N3771)
20-A Rated Continuous Collector Current (2N3772)

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N3771	2N3772
Collector-Base Voltage	50 V*	100 V*
Collector-Emitter Voltage (See Note 1)	50 V*	100 V† 80 V*
Collector-Emitter Voltage (See Note 2)	40 V*	60 V*
Emitter-Base Voltage	5 V*	7 V*
Continuous Collector Current	30 A*	20 A*
Peak Collector Current (See Note 3)	←— 30 A* —→	
Continuous Base Current	7.5 A*	5 A*
Peak Base Current	←— 15 A* —→	
Safe Operating Region	See Figure 1*	
Continuous Dissipation at (or below) 25°C Case Temperature (See Note 4)	←— 150 W* —→	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Lead Temperature 1.588mm from Case for 10 Seconds	←— 235°C* —→	

NOTES: 1. These values apply when the base-emitter voltage $V_{BE} = -1.5$ V.
2. These values apply when the base-emitter diode is open-circuited.
3. This value applies for a nonrepetitive pulse of any duration for the 2N3771, or of 500-ms maximum duration for the 2N3772.
4. Derate linearly to 200°C case temperature at the rate of 0.855 W/deg see figure 2.

*Indicates JEDEC registered data
†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

TYPES 2N3771, 2N3772
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3771		2N3772		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector Emitter Breakdown Voltage	$I_C = 200$ mA, $I_B = 0$, See Note 5	40		60		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V, $I_B = 0$		10			mA
		$V_{CE} = 50$ V, $I_B = 0$				10	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V, $I_E = 0$		2			mA
		$V_{CB} = 100$ V, $I_E = 0$				5	
I_{CEV}	Collector Cutoff Current	$V_{CE} = 50$ V, $V_{BE} = -1.5$ V		2			mA
		$V_{CE} = 100$ V, $V_{BE} = -1.5$ V				5	
		$V_{CE} = 30$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$		10		10	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		5			mA
		$V_{EB} = 7$ V, $I_C = 0$				5	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 5 and 6			15	60	
		$V_{CE} = 4$ V, $I_C = 15$ A, See Notes 5 and 6	15	60			
		$V_{CE} = 4$ V, $I_C = 20$ A, See Notes 5 and 6			5		
		$V_{CE} = 4$ V, $I_C = 30$ A, See Notes 5 and 6	5				
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V, $I_C = 10$ A, See Notes 5 and 6				2.2	V
		$V_{CE} = 4$ V, $I_C = 15$ A, See Notes 5 and 6		2.7			
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ A, $I_C = 10$ A, See Notes 5 and 6				1.4	V
		$I_B = 1.5$ A, $I_C = 15$ A, See Notes 5 and 6		2			
		$I_B = 4$ A, $I_C = 20$ A, See Notes 5 and 6				4	
		$I_B = 6$ A, $I_C = 30$ A, See Notes 5 and 6		4			
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, f = 1 kHz	40		40		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V, $I_C = 1$ A, f = 50 kHz	4		4		

NOTES: 5. These parameters must be measured using pulse techniques: $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

*Indicates JEDEC registered data

MAXIMUM SAFE OPERATING REGION

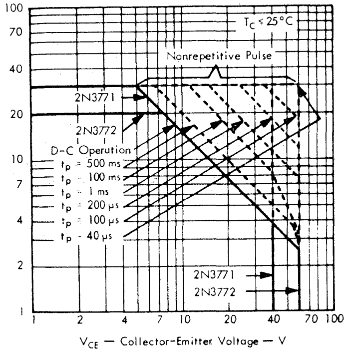


FIGURE 1

THERMAL INFORMATION

DISSIPATION DERATING CURVE

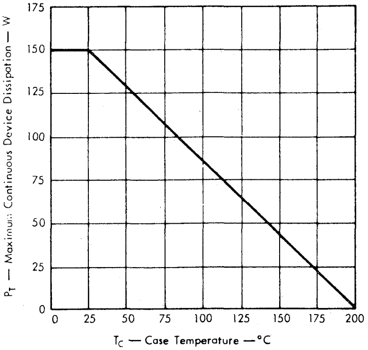


FIGURE 2

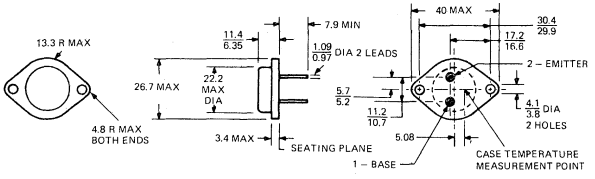
TYPES 2N3789, 2N3790, 2N3791, 2N3792
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N3713 THRU 2N3716

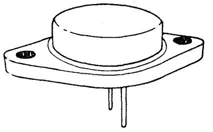
- **150 Watts at 25°C Case Temperature**
- **10 A Rated Collector Current**
- **Min f_T of 4 MHz at 10 V, 500 mA**
- **Min f_{hfe} of 30 kHz at 10 V, 500 mA**

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N3789 2N3791	2N3790 2N3792
*Collector-Base Voltage	-60 V	-80 V
*Collector-Emitter Voltage (See Note 1)	-60 V	-80 V
*Emitter-Base Voltage	← -7 V →	
*Continuous Collector Current	← -10 A →	
Peak Collector Current (See Note 2)	← -15 A →	
*Continuous Base Current	← -4 A →	
*Safe Operating Region at (or below) 25°C Case Temperature	See Figures 6 and 7	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 150 W →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 4 W →	
*Operating Collector Junction Temperature Range	-65°C to 200°C	
*Storage Temperature Range	-65°C to 200°C	
Lead Temperature 1.588mm from Case for 10 Seconds	← 235°C →	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for t_p = 0.3 ms, duty cycle ≤10%.
3. Derate linearly to 200°C case temperature at the rate of 0.855 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

*Indicates JEDEC registered data

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3789		2N3790		2N3791		2N3792		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -200$ mA, $I_B = 0$, See Note 5	-60		-80		-60		-80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V, $I_B = 0$		-10				-10			mA
		$V_{CE} = -40$ V, $I_B = 0$				-10				-10	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V, $V_{BE} = 1.5$ V		-1				-1			mA
		$V_{CE} = -80$ V, $V_{BE} = 1.5$ V				-1				-1	
		$V_{CE} = -60$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$		-5				-5			
		$V_{CE} = -80$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$				-5				-5	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -7$ V, $I_C = 0$		-5		-5		-5		-5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -1$ A, See Notes 5 and 6	25	90	25	90	50	180	50	180	
		$V_{CE} = -2$ V, $I_C = -3$ A, See Notes 5 and 6	15		15		30		30		
		$V_{CE} = -4$ V, $I_C = -10$ A, See Notes 5 and 6	4		4		4		4		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V, $I_C = -5$ A, See Notes 5 and 6		-2		-2		-1.8		-1.8	V
		$V_{CE} = -4$ V, $I_C = -10$ A, See Notes 5 and 6		-4		-4		-4		-4	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.4$ A, $I_C = -4$ A, See Notes 5 and 6		-1		-1					V
		$I_B = -0.5$ A, $I_C = -5$ A, See Notes 5 and 6						-1		-1	
		$I_B = -2$ A, $I_C = -10$ A, See Notes 5 and 6		-4		-4		-4		-4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 kHz	25	250	25	250	25	250	25	250	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 MHz	4		4		4		4		
f_{hfe}	Small-Signal Common-Emitter Forward Current Transfer Ratio Cutoff Frequency	$V_{CE} = -10$ V, $I_C = -0.5$ A, See Note 7	30		30		30		30		kHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 100 kHz		500		500		500		500	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300$ μs, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

7. f_{hfe} is the frequency at which the magnitude of the small-signal forward current transfer ratio is 0.707 of its low-frequency value. For this device, the reference measurement is made at 1 kHz.

*Indicates JEDEC registered data

thermal characteristics

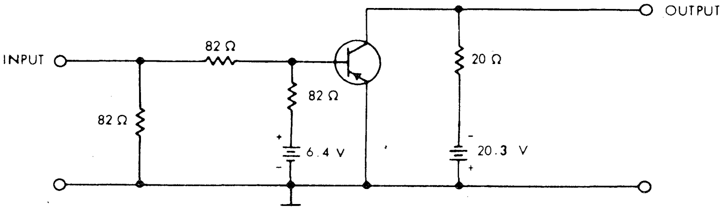
PARAMETER		MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	1.17	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	

switching characteristics at 25°C case temperature

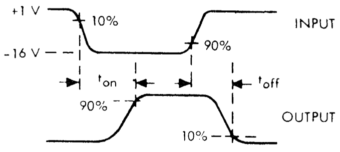
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -1$ A, $I_{B(1)} = -100$ mA, $I_{B(2)} = 100$ mA,	0.35	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 3.7$ V, $R_L = 20\ \Omega$, See Figure 1	0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_p = 10\ \mu s$, duty cycle $\leq 2\%$.

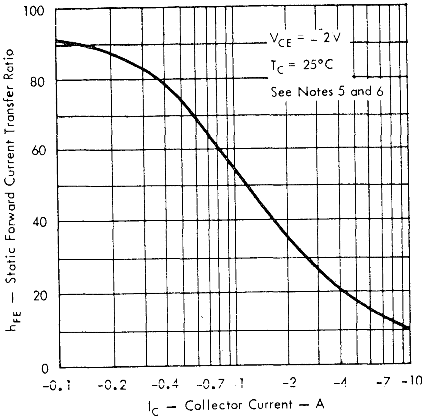
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

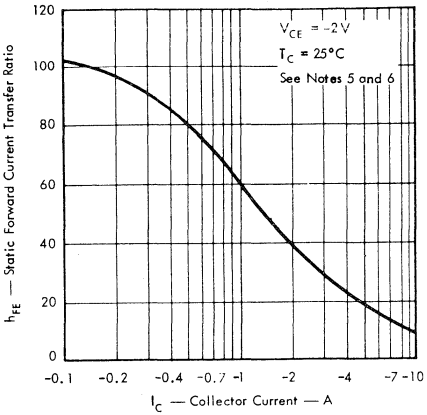
TYPES 2N3789, 2N3790, 2N3791, 2N3792
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS


2N3789, 2N3790

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 2


2N3791, 2N3792

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 3

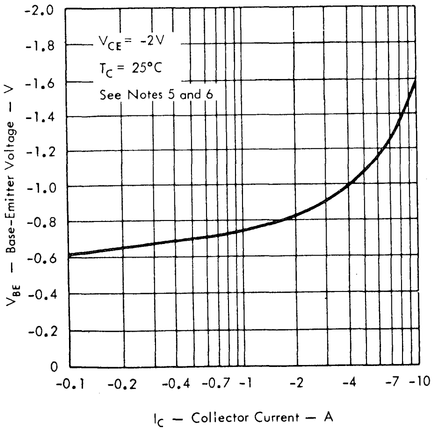

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 4

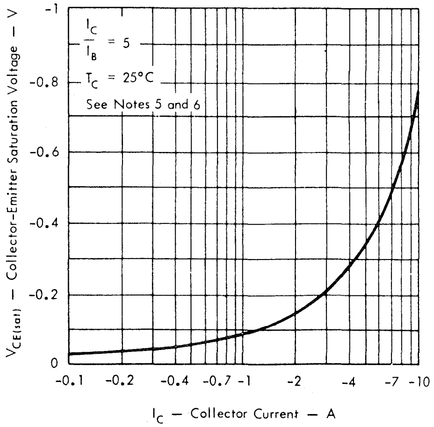

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

MAXIMUM SAFE OPERATING REGIONS

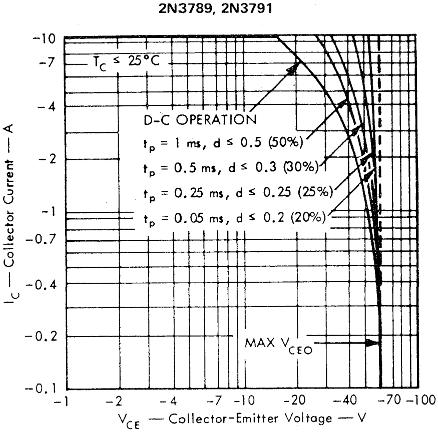


FIGURE 6

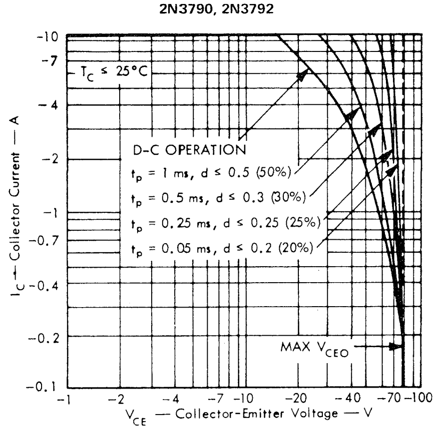


FIGURE 7

THERMAL INFORMATION

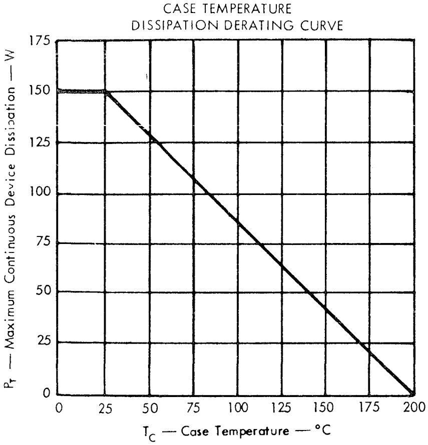


FIGURE 8

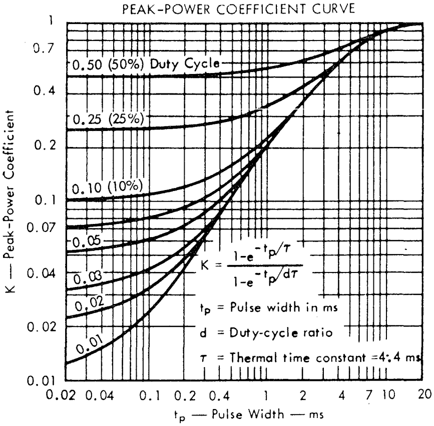


FIGURE 9

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	1.17	deg/W
$\theta_{C\text{-}A}$	Case-to-Free-Air Thermal Resistance	42.5	deg/W
$\theta_{C\text{-}HS}$	Case-to-Heat-Sink Thermal Resistance		deg/W
$\theta_{HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance		deg/W
T_A	Free-Air Temperature		°C
T_C	Case Temperature		°C
$T_{J(av)}$	Average Junction Temperature	≤ 200	°C
$T_{J(max)}$	Peak Junction Temperature	≤ 200	°C
K	Peak-Power Coefficient	See Figure 9	
t_p	Pulse Width		ms
t_x	Pulse Period		ms
d	Duty Cycle Ratio (t_p/t_x)		

Equation No. 1 — Application: d-c power dissipation, heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}}$$ for 25 °C ≤ T_C ≤ 200°C, as in Figure 8.

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}}$$ for 25°C ≤ T_A ≤ 200°C

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$ for 25 °C ≤ T_C ≤ 200°C

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C\text{-}A} + K\theta_{J\text{-}C}}$$ for 25°C ≤ T_A ≤ 200°C

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C\text{-}HS} + \theta_{HS\text{-}A} = 2.25$ deg/W (From information supplied with heat sink.)

$T_{J(av)}$ (design limit) = 200°C

$T_A = 50$°C

d = 10% (0.1)

$t_p = 0.1$ ms

Solution:

From Figure 9, Peak-Power Coefficient K = 0.11 and by use of equation No. 3

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(1.17)} = 424 \text{ W}$$

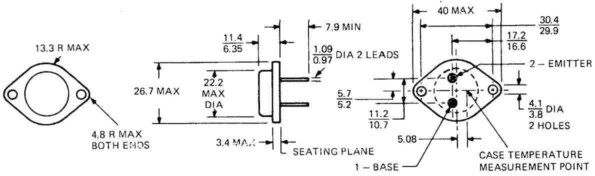
2N3902
NPN SILICON POWER TRANSISTOR

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR INDUSTRIAL AND MILITARY APPLICATIONS

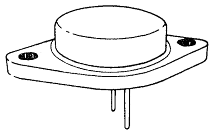
- 100 W at 75°C Case Temperature
- 400 V Collector-Emitter Off-State Voltage
- Min $V_{(BR)CEO}$ of 325 V
- Max t_{off} of 1.7 μs at $I_C = 1$ A
- Typ $V_{CE(sat)}$ of 0.25 V at $I_C = 2.5$ A
- Typ f_T of 5 MHz at 10 V, 0.2 A

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

*Collector-Emitter Voltage (See Note 1)	400 V
*Emitter-Base Voltage	5 V
*Continuous Collector Current	2.5 A
*Continuous Base Current	1 A
Safe Operating Area at (or below) 75°C Case Temperature	See Figure 6
*Continuous Device Dissipation at (or below) 75°C Case Temperature (See Note 2)	100 W
Continuous Device Dissipation at (or below 25°C Free-Air Temperature (See Note 3)	4 W
Unclamped Inductive Load Energy (See Note 4)	180 mJ
*Operating Collector Junction Temperature Range	−65°C to 150°C
*Storage Temperature Range	−65°C to 200°C
*Terminal Temperature 1.588mm from Case for 10 Seconds	300°C

NOTES:
1. This value applies only when the collector-emitter voltage is applied with the transistor in the off-state and the base-emitter diode is open-circuited or reverse-biased. In operation, the limitations of Figure 7 must be observed.
2. Derate linearly to 150°C case temperature at the rate of 1.33 W/°C.
3. Derate linearly to 150°C free-air temperature at the rate of 32 mW/°C.
4. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 2. L = 40 mH, $R_{BB2} = 3\ k\Omega$, $V_{BB2} = 1.5$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 50$ V. Energy $\approx I_C{}^2 L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

2N3902
NPN SILICON POWER TRANSISTOR

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA, $I_B = 0$, See Note 5	325			V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 400$ V, $I_B = 0$			0.25	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 400$ V, $V_{BE} = -1.5$ V			0.25	mA
		$V_{CE} = 400$ V, $V_{BE} = -1.5$ V, $T_C = 125°$C			0.5	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ A, See Notes 5 and 6	30		90	
		$V_{CE} = 5$ V, $I_C = 2.5$ A, See Notes 5 and 6	10			
V_{BE}	Base-Emitter Voltage	$I_B = 0.5$ A, $I_C = 2.5$ A, See Notes 5 and 6		1	2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1$ A, $I_C = 1$ A, See Notes 5 and 6		0.2	0.8	V
		$I_B = 0.5$ A, $I_C = 2.5$ A, See Notes 5 and 6		0.25	2.5	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.2$ A, f = 1 MHz		5		
f_{hfe}	Small-Signal Common-Emitter Forward Current Transfer Ratio Cutoff Frequency	$V_{CE} = 12$ V, $I_C = 0.2$ A, See Note 7	40			kHz

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

7. f_{hfe} is the frequency at which the magnitude of the small-signal forward current transfer ratio is 0.707 of its low-frequency value. For this device, the reference measurement is made at 1 kHz.

thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	0.75	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	31.25	

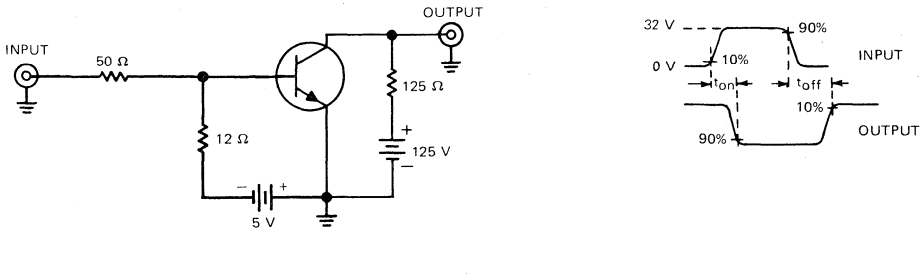
*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_r	Rise Time	$I_C = 1$ A, $I_{B(1)} = 0.1$ A, $I_{B(2)} = -0.1$ A, $V_{BE(off)} = -5$ V, $R_L = 125\ \Omega$, See Figure 1	0.8	µs
t_s	Storage Time		0.9	
t_f	Fall Time		0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



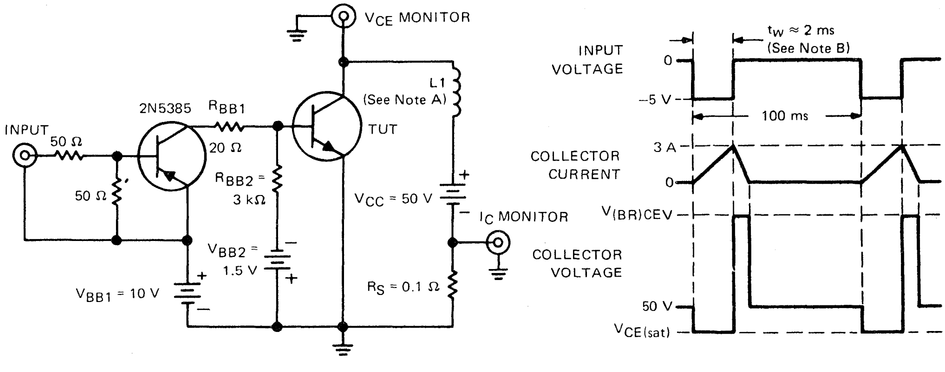
TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. The input waveform is supplied by a generator with the following characteristics: $t_r \leqslant 20$ ns, $t_f \leqslant 20$ ns, $Z_{out} = 50\ \Omega$, $t_w = 5\ \mu s$, duty cycle $\leqslant 5\%$.
B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 20$ ns, $R_{in} \geqslant 100\ k\Omega$, $C_{in} \leqslant 50$ pF.
C. Resistors must be noninductive types.
D. The d-c power supply may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTES: A. L1 is a 40-mH inductor.
B. Input pulse width is increased until $I_{CM} = 3$ A.

FIGURE 2

2N3902
NPN SILICON POWER TRANSISTOR

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT
TRANSFER RATIO
VS
COLLECTOR CURRENT

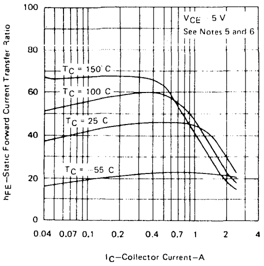


FIGURE 3

BASE-EMITTER VOLTAGE
VS
CASE TEMPERATURE

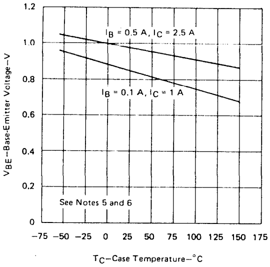


FIGURE 4

COLLECTOR-EMITTER
SATURATION VOLTAGE
VS
CASE TEMPERATURE

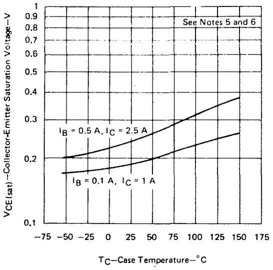


FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREA

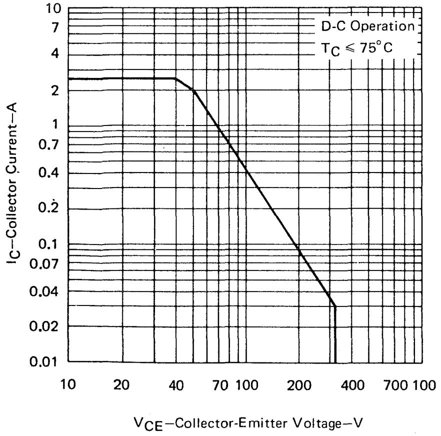


FIGURE 6

THERMAL INFORMATION

DISSIPATION DERATING CURVE

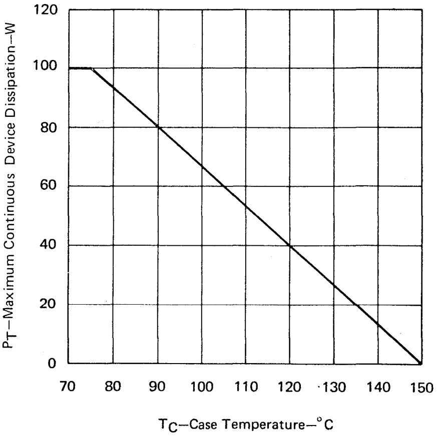


FIGURE 7

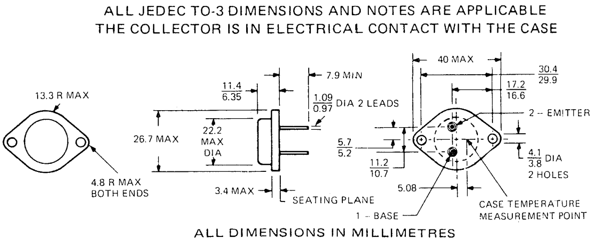
TYPES 2N4398, 2N4399
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

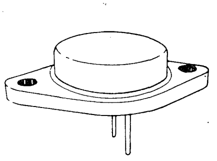
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5301, 2N5302

- 200 Watts at 25°C Case Temperature
- 30 A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 1 A

*mechanical data

The case outline falls within JEDEC TO-3 except for lead diameter.





absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N4398	2N4399
*Collector-Base Voltage	-40 V	-60 V
*Collector-Emitter Voltage (See Note 1)	-40 V	-60 V
*Collector-Emitter Voltage (See Note 2)	-40 V	-60 V
*Emitter-Base Voltage	←— -5 V —→	
*Continuous Collector Current	←— -30 A —→	
*Peak Collector Current (See Note 3)	←— -50 A —→	
*Continuous Base Current	←— -7.5 A —→	
*Peak Base Current (See Note 3)	←— -15 A —→	
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 2	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	←— 200 W —→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	←— 5 W —→	
*Operating Collector Junction Temperature Range	-65°C to 200°C	
*Storage Temperature Range	-65°C to 200°C	
*Lead Temperature 1.588mm from Case for 10 Seconds	←— 235°C —→	

NOTES:
1. These values apply when the base-emitter voltage V_{BE} = 1.5 V.
2. These values apply when the base-emitter diode is open-circuited.
3. This value applies for $t_p \leq 0.3$ ms, duty cycle $\leq 10\%$.
4. Derate linearly to 200°C case temperature at the rate of 1.15 W/deg.
5. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/deg.

TYPES 2N4398, 2N4399
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N4398		2N4399		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -200$ mA, $I_B = 0$	See Note 6	-40		-60		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V, $I_E = 0$			-1			mA
		$V_{CB} = -60$ V, $I_E = 0$					-1	
I_{CEO}	Collector Cutoff Current	$V_{CE} = -40$ V, $I_B = 0$			-5			mA
		$V_{CE} = -60$ V, $I_B = 0$					-5	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 1.5$ V			-5			mA
		$V_{CE} = -60$ V, $V_{BE} = 1.5$ V					-5	
		$V_{CE} = -30$ V, $V_{BE} = 1.5$ V, $T_C = 150°$C			-10		-10	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$			-5		-5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -1$ A	See Notes 6 and 7	40		40		
		$V_{CE} = -4$ V, $I_C = -15$ A		15	60	15	60	
		$V_{CE} = -4$ V, $I_C = -30$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -1.5$ A, $I_C = -15$ A	See Notes 6 and 7		-1.85		-1.85	V
		$V_{CE} = -2$ V, $I_C = -15$ A			-1.7		-1.7	
		$V_{CE} = -4$ V, $I_C = -30$ A			-3		-3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ A, $I_C = -10$ A	See Notes 6 and 7		-0.75		-0.75	V
		$I_B = -1.5$ A, $I_C = -15$ A			-1		-1	
		$I_B = -6$ A, $I_C = -30$ A			-4		-4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ A, f = 1 kHz		40		40		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ A, f = 1 MHz		4		4		

NOTES: 6. These parameters must be measured using pulse techniques. $t_p = 300$ μs, duty cycle $\leq 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	0.875	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	35	

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_r	Rise Time	$I_C = -10$ A, $I_{B(1)} = -1$ A, $V_{BE(off)} = 2$ V, $R_L = 3\ \Omega$, See Figure 1	0.4	μs
t_s	Storage Time	$I_C = -10$ A, $I_{B(1)} = -1$ A, $I_{B(2)} = 1$ A,	1.5	
t_f	Fall Time	$R_L = 3\ \Omega$, See Figure 2	0.6	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*Indicates JEDEC registered data

*PARAMETER MEASUREMENT INFORMATION

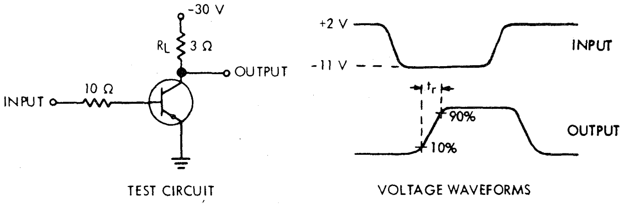


FIGURE 1 – RISE TIME

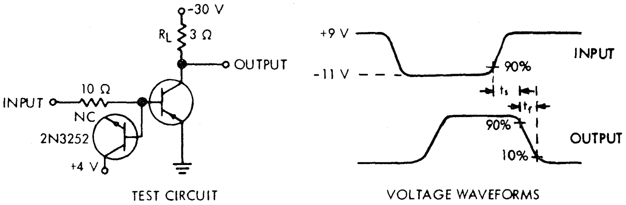


FIGURE 2 – STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: $t_r \leq 20$ ns, $t_f \leq 20$ ns, t_p = 10 μs to 100 μs, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 20$ ns, $R_{in} \geq 10$ kΩ, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

*Indicates JEDEC registered data

MAXIMUM SAFE OPERATING REGION

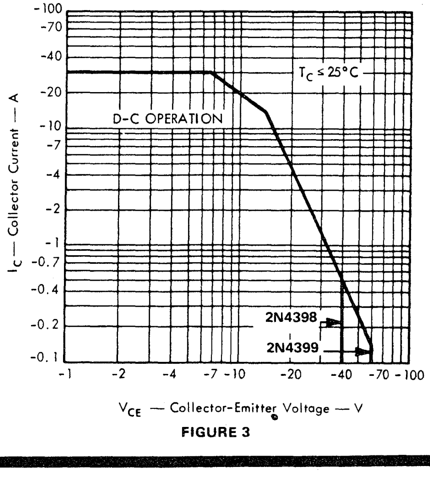


FIGURE 3

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

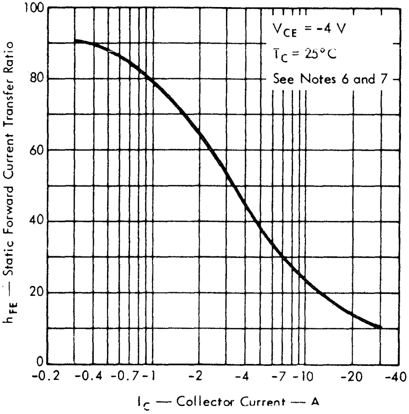


FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

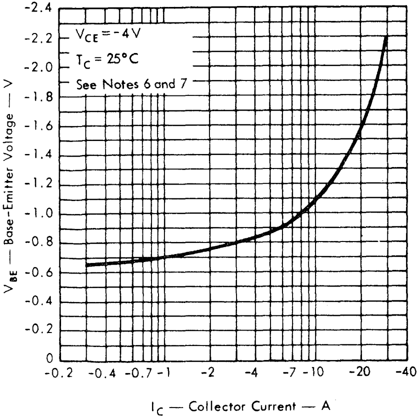


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

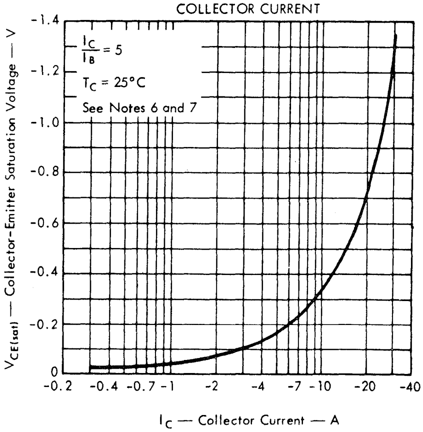


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

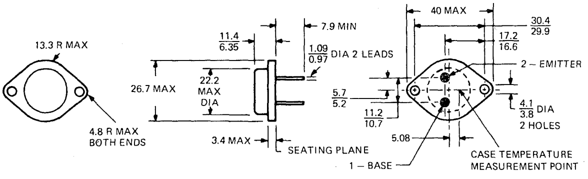
TYPES 2N4904, 2N4905, 2N4906
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N4913, 2N4914, 2N4915

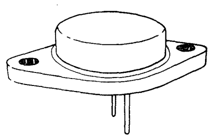
- **87.5 W at 25°C Case Temperature**
- **5 A Rated Collector Current**
- **Min f_T of 4 MHz at 10 V, 500 mA**

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N4904	2N4905	2N4906
*Collector-Base Voltage	-40 V	-60 V	-80 V
*Collector-Emitter Voltage (See Note 1)	-40 V	-80 V	-80 V
*Emitter-Base Voltage	←	-5 V	→
*Continuous Collector Current	←	-5 A	→
Peak Collector Current (See Note 2)	←	-15 A	→
*Continuous Base Current	←	-1 A	→
Safe Operating Region at (or below) 25°C Case Temperature	←	See Figure 2	→
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←	87.5 W	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	←	4 W	→
*Operating Collector Junction Temperature Range	←	-65°C to 200°C	→
*Storage Temperature Range	←	-65°C to 200°C	→
*Lead Temperature 1.588mm from Case for 10 Seconds	←	235°C	→

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_p \leq 0.3$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.5 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

*Indicates JEDEC registered data

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4904		2N4905		2N4906		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -200$ mA, $I_B = 0$, See Note 5	-40		-60		-80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -40$ V, $I_B = 0$		-1					mA
		$V_{CE} = -60$ V, $I_B = 0$				-1			
		$V_{CE} = -80$ V, $I_B = 0$						-1	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 1.5$ V		-0.1					mA
		$V_{CE} = -60$ V, $V_{BE} = 1.5$ V				-0.1			
		$V_{CE} = -80$ V, $V_{BE} = 1.5$ V						-0.1	
		$V_{CE} = -40$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$		-2					
		$V_{CE} = -60$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$				-2			
		$V_{CE} = -80$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$						-2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -2.5$ A, See Notes 5 and 6	25	100	25	100	25	100	
		$V_{CE} = -2$ V, $I_C = -5$ A, See Notes 5 and 6	7		7		7		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V, $I_C = -2.5$ A, See Notes 5 and 6		-1.4		-1.4		-1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.25$ A, $I_C = -2.5$ A, See Notes 5 and 6		-1		-1		-1	V
		$I_B = -1$ A, $I_C = -5$ A, See Notes 5 and 6		-1.5		-1.5		-1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 kHz	40		40		40		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.5$ A, f = 1 MHz	4		4		4		

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

*Indicates JEDEC registered data

thermal characteristics

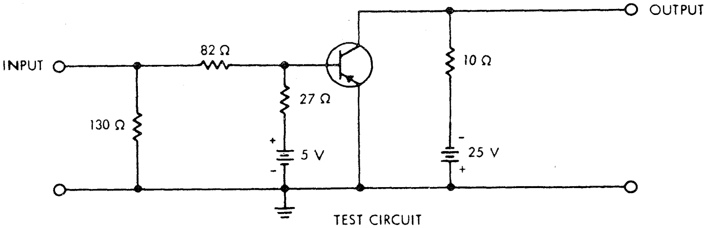
PARAMETER		MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	2	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	

switching characteristics at 25°C case temperature

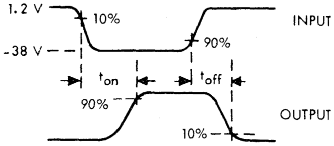
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -2.5$ A, $I_{B(1)} = -250$ mA, $I_{B(2)} = 250$ mA, $V_{BE(off)} = 4.1$ V, $R_L = 10\ \Omega$, See Figure 1	0.4	μs
t_{off}	Turn-Off Time		0.7	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES:
a. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_p = 10\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
c. Resistors must be noninductive types.
d. The d-c power supplies may require additional bypassing in order to minimize ringing.

MAXIMUM SAFE OPERATING REGION

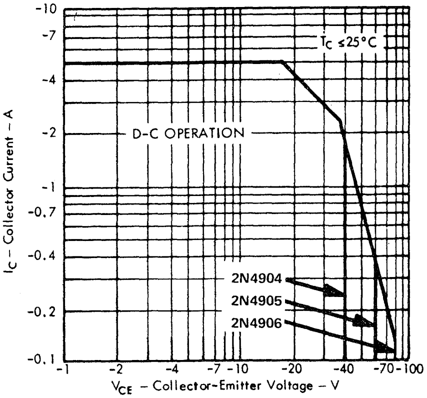


FIGURE 2

TYPICAL CHARACTERISTICS

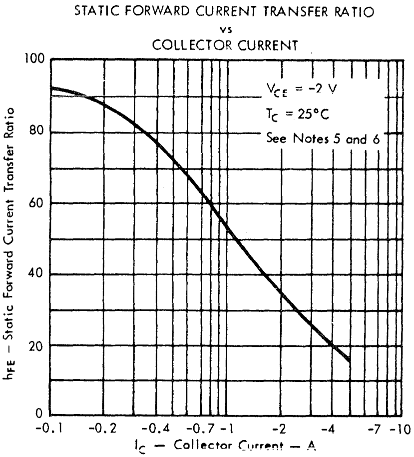


FIGURE 3

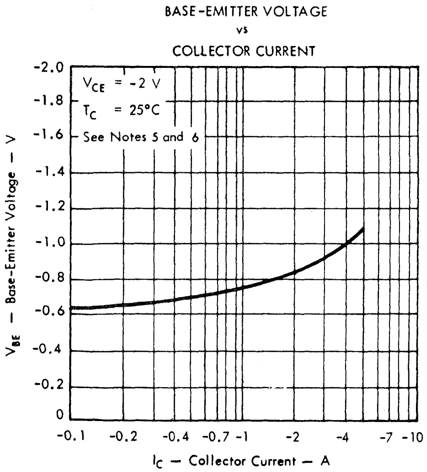


FIGURE 4

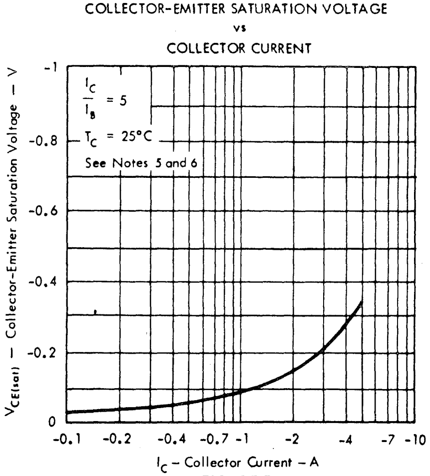


FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

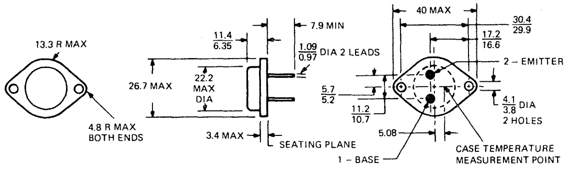
TYPES 2N4913, 2N4914, 2N4915
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

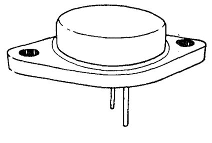
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH 2N4904 THRU 2N4906

- **87.5 W at 25°C Case Temperature**
- **5 A Rated Collector Current**
- **Min f_T of 4 MHz at 10 V, 1 A**

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N4913	2N4914	2N4915
*Collector-Base Voltage	40 V	60 V	80 V
*Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V
*Emitter-Base Voltage	5 V		
*Continuous Collector Current	5 A		
Peak Collector Current (See Note 2)	15 A		
*Continuous Base Current	1 A		
Safe Operating Region at (or below) 25°C Case Temperature	See Figure 6		
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	87.5 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	4 W		
*Operating Collector Junction Temperature Range	−65°C to 200°C		
*Storage Temperature Range	−65°C to 200°C		
*Lead Temperature 1.588mm from Case for 10 Seconds	235°C		

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_p = 0.3$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.5 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

*Indicates JEDEC registered data

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4913		2N4914		2N4915		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 200$ mA, $I_B = 0$, See Note 5	40		60		80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 40$ V, $I_B = 0$		1					mA
		$V_{CE} = 60$ V, $I_B = 0$				1			
		$V_{CE} = 80$ V, $I_B = 0$						1	
I_{CEV}	Collector Cutoff Current	$V_{CE} = 40$ V, $V_{BE} = -1.5$ V		0.1					mA
		$V_{CE} = 60$ V, $V_{BE} = -1.5$ V				0.1			
		$V_{CE} = 80$ V, $V_{BE} = -1.5$ V						0.1	
		$V_{CE} = 40$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$		2					
		$V_{CE} = 60$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$				2			
		$V_{CE} = 80$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$						2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V, $I_C = 2.5$ A, See Notes 5 and 6	25	100	25	100	25	100	
		$V_{CE} = 2$ V, $I_C = 5$ A, See Notes 5 and 6	7		7		7		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V, $I_C = 2.5$ A, See Notes 5 and 6		1.4		1.4		1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.25$ A, $I_C = 2.5$ A, See Notes 5 and 6		0.75		0.75		0.75	V
		$I_B = 1$ A, $I_C = 5$ A, See Notes 5 and 6		1.5		1.5		1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 0.5$ A, $f = 1$ kHz	20		20		20		
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ A, $f = 1$ MHz	4		4		4		

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300$ μs, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	2	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	

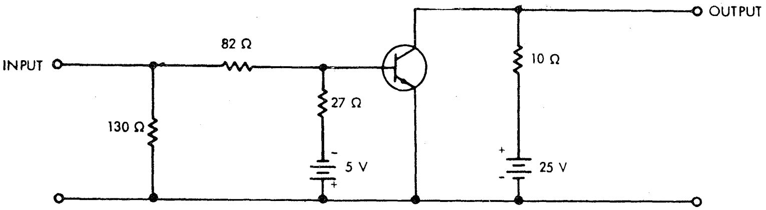
*Indicates JEDEC registered data

switching characteristics at 25°C case temperature

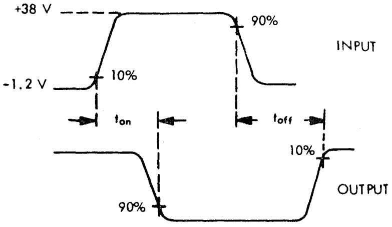
PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_{on} Turn-On Time	I_C = 2.5 A, $I_{B(1)}$ = 250 mA, $I_{B(2)}$ = −250 mA, $V_{BE(off)}$ = −4.1 V, R_L = 10 Ω, See Figure 1	0.6	μs
t_{off} Turn-Off Time		1.2	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_p = 10\ \mu s$, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

TYPICAL CHARACTERISTICS

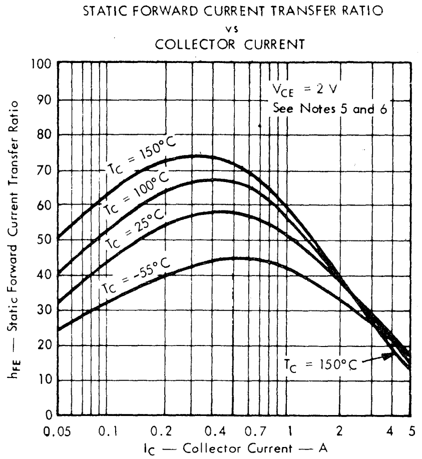


FIGURE 2

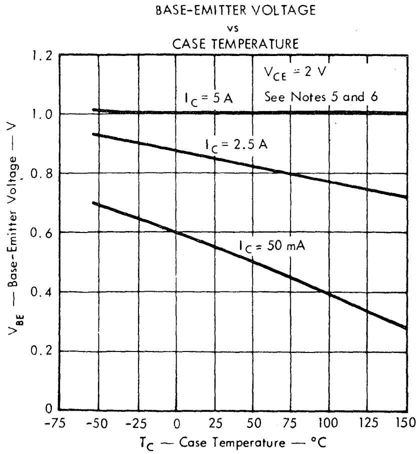


FIGURE 3

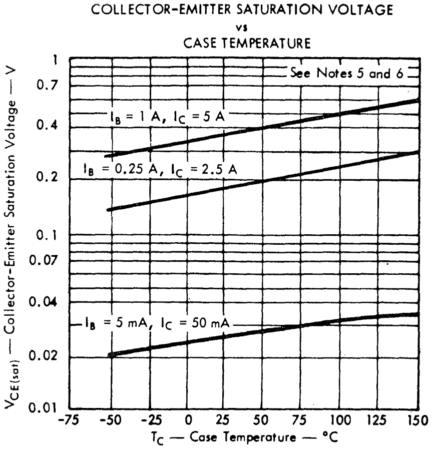


FIGURE 4

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

TYPICAL CHARACTERISTICS

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

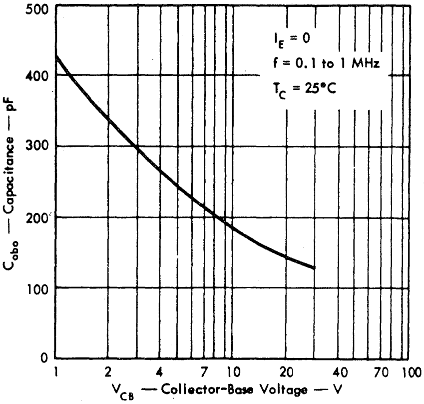


FIGURE 5

MAXIMUM SAFE OPERATING REGION

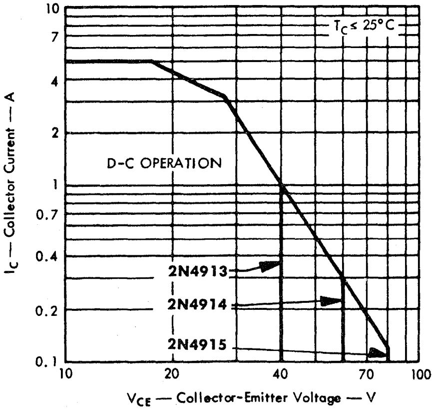


FIGURE 6

THERMAL INFORMATION

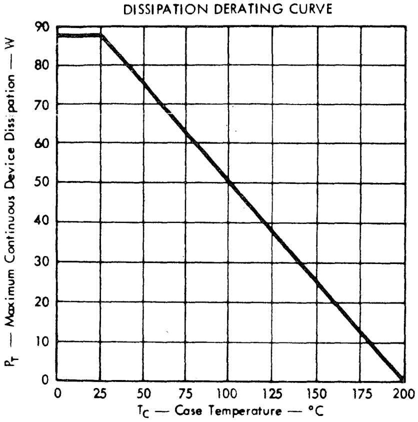

DISSIPATION DERATING CURVE

FIGURE 7

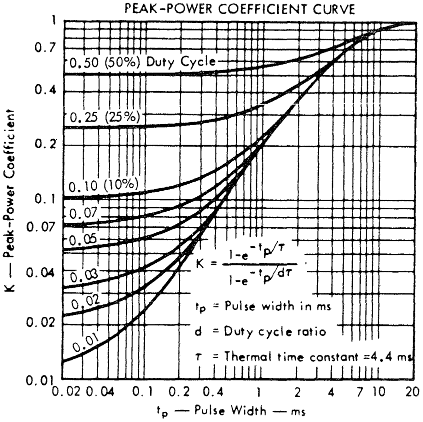

PEAK-POWER COEFFICIENT CURVE

FIGURE 8

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	2	deg/W
$\theta_{C\text{-}A}$	Case-to-Free-Air Thermal Resistance	41.7	deg/W
$\theta_{C\text{-}HS}$	Case-to-Heat-Sink Thermal Resistance		deg/W
$\theta_{HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance		deg/W
T_A	Free-Air Temperature		°C
T_C	Case Temperature		°C
$T_{J(av)}$	Average Junction Temperature	≤ 200	°C
$T_{J(max)}$	Peak Junction Temperature	≤ 200	°C
K	Peak-Power Coefficient	See Figure 8	
t_p	Pulse Width		ms
t_x	Pulse Period		ms
d	Duty Cycle Ratio (t_p/t_x)		

Equation No. 1 — Application: d-c power dissipation, heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 25\,°C \leq T_C \leq 200°C, \text{ as in figure 7.}$$

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \text{ for } 25°C \leq T_A \leq 200°C$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}} \text{ for } 25\,°C \leq T_C \leq 200°C$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C\text{-}A} + K\,\theta_{J\text{-}C}} \text{ for } 25°C \leq T_A \leq 200°C$$

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C\text{-}HS} + \theta_{HS\text{-}A} = 2.25$ deg/W (From information supplied with heat sink.)

$T_{J(av)}$ (design limit) $= 200°C$

$T_A = 50°C$

$d = 10\%\ (0.1)$

$t_p = 0.1$ ms

Solution:

From figure 8, Peak-Power Coefficient $K = 0.11$ and by use of equation No. 3

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(2)} = 337 \text{ W}$$

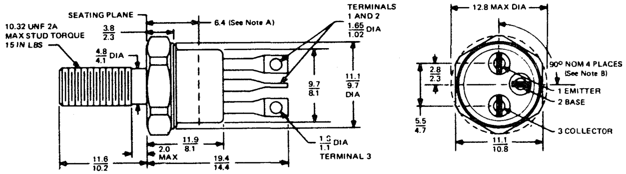
2N4998, 2N5000, 2N5148, 2N5150
NPN SILICON POWER TRANSISTORS

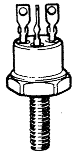
HIGH-FREQUENCY POWER TRANSISTORS WITH COMPUTER-DESIGNED ISOTHERMAL GEOMETRY

- **For Complementary Use With 2N4999, 2N5001, 2N5147 and 2N5149**
- **Isolated Stud Package; 30 W at 40 V, $T_C = 50°C$ (2N4998, 2N5000)**
- **Min f_T of 50 and 60 MHz at 5 V, 200 mA**

*mechanical data

ALL TERMINALS ARE INSULATED FROM THE CASE

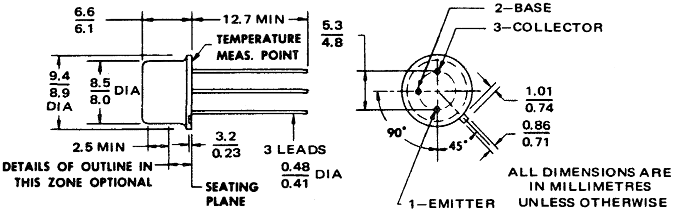


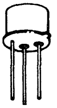


ALL JEDEC TO-59 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES:
A. Within this dimension, case diameter may vary
B. Position of terminals with respect to hexagon is not controlled.
C. The case temperature may be measured anywhere on the seating plane within 3.2mm of the stud.
D. All dimensions are in mm unless otherwise specified.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N4998 2N5000	2N5148 2N5150
Collector-Base Voltage	←100 V*→	
Collector-Emitter Voltage (See Note 1)	←80 V*→	
Emitter-Base Voltage	←6 V*→	
Continuous Collector Current	2 A*	2 A*
Peak Collector Current (See Note 2)	5 A*	5 A
Continuous Base Current	1 A*	1 A*
Safe Operating Area at (or below) 25°C Case Temperature	See Figures 7 and 8*	
Continuous Device Dissipation at 50°C Case Temperature (See Note 3)	30 W*	6 W*
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	20 W*	4 W*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W	1 W*
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Lead or Terminal Temperature 3.2mm from Case for 10 Seconds	←300°C*→	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 8.3$ ms, duty cycle $\leqslant 1\%$.
3. For operation above (or below) 50°C case temperature, refer to Dissipation Derating Curves, Figures 9 and 10.
4. Derate linearly to 200°C free-air temperature at the rate of 11.4 mW/°C for 2N4998 and 2N5000, 5.7 mW/°C for 2N5148 and 2N5150.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

2N4998, 2N5000, 2N5148, 2N5150
NPN SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N4998 2N5148		2N5000 2N5150		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 100 mA, I_B = 0,	See Note 5	80		80		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 40 V, I_B = 0			50		50	µA
I_{CES}	Collector Cutoff Current	V_{CE} = 60 V, V_{BE} = 0			1		1	µA
		V_{CE} = 100 V, V_{BE} = 0			1		1	mA
I_{CEV}	Collector Cutoff Current	V_{CE} = 60 V, V_{BE} = −2 V, T_C = 150°C			500		500	µA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0			1		1	µA
		V_{EB} = 6 V, I_C = 0			1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 50 mA	See Notes 5 and 6	20		50		
		V_{CE} = 5 V, I_C = 1 A		30	90	70	200	
		V_{CE} = 5 V, I_C = 2 A		15		30		
		V_{CE} = 5 V, I_C = 3 A		5		15		
		V_{CE} = 5 V, I_C = 1 A, T_C = −55°C		15		35		
V_{BE}	Base-Emitter Voltage	I_B = 100 mA, I_C = 1 A	See Notes 5 and 6		1.2		1.2	V
		I_B = 200 mA, I_C = 2 A			1.5		1.5	
		V_{CE} = 5 V, I_C = 2 A			1.5		1.5	
		V_{CE} = 5 V, I_C = 3 A			3		3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 100 mA, I_C = 1 A	See Notes 5 and 6		0.46		0.46	V
		I_B = 200 mA, I_C = 2 A			0.85		0.85	
		I_B = 600 mA, I_C = 3 A			5		5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.1 A, f = 1 kHz		20		50		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 0.2 A, f = 20 MHz		2.5		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz			70		70	pF

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 µs, duty cycle ⩽ 1%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

thermal characteristics

PARAMETER		2N4998 2N5000	2N5148 2N5150	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	5	25	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	87.5	175	

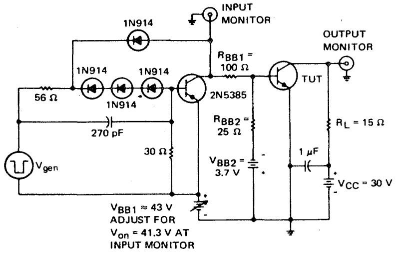
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			ALL TYPES	UNIT
					TYP	
t_{on}	Turn-On Time	I_C = 2 A,	$I_{B(1)}$ = 200 mA,	$I_{B(2)}$ = −200 mA,	0.1	µs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −3.7 V,	R_L = 15 Ω,	See Figure 1	1.1	

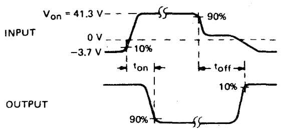
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

TYPICAL CHARACTERISTICS

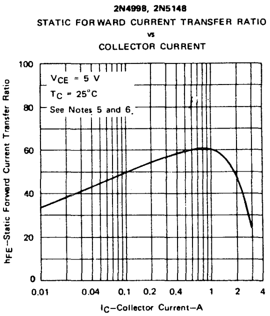

2N4998, 2N5148
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 2

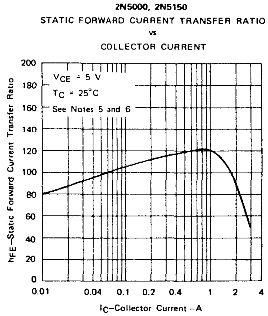

2N5000, 2N5150
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 3

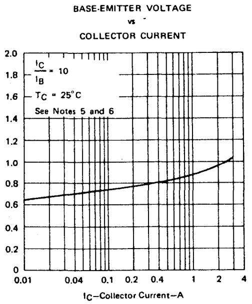

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 4

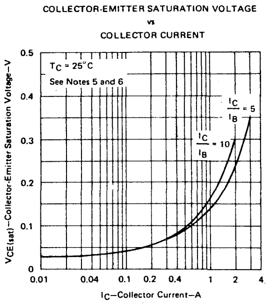

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 5

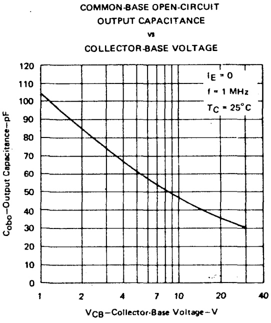

COMMON-BASE OPEN-CIRCUIT
OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

FIGURE 6

NOTES:
- 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 1%.
- 6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREA

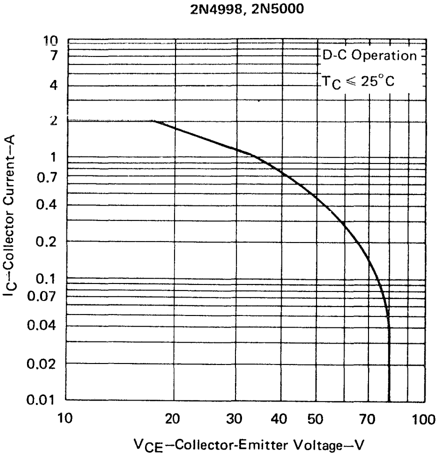


FIGURE 7

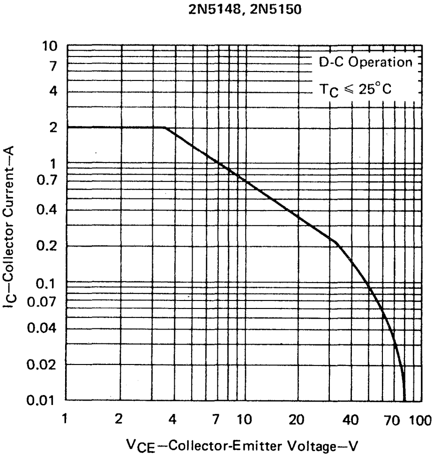


FIGURE 8

THERMAL CHARACTERISTICS

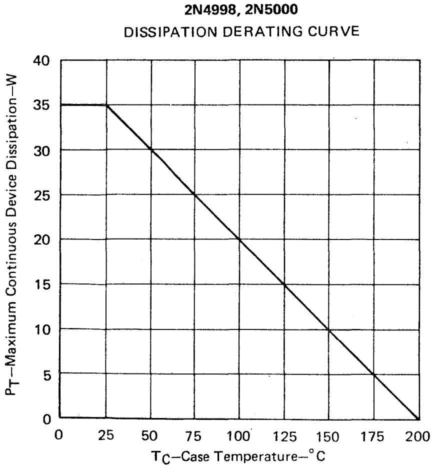


FIGURE 9

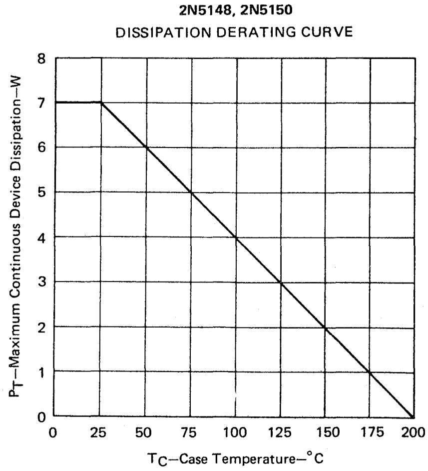


FIGURE 10

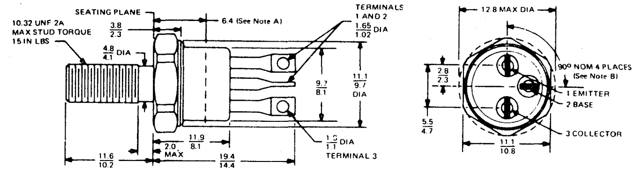
TYPES 2N4999, 2N5001, 2N5147, 2N5149
P-N-P SILICON POWER TRANSISTORS

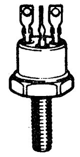
HIGH-FREQUENCY POWER TRANSISTORS WITH COMPUTER-DESIGNED ISOTHERMAL GEOMETRY

- For Complementary Use With 2N4998, 2N5000, 2N5148 and 2N5150
- Isolated Stud Package; 30 W at 40 V, T_C = 50°C (2N4999, 2N5001)
- Min f_T of 50 and 60 MHz at 5 V, 200 mA

*mechanical data

ALL TERMINALS ARE INSULATED FROM THE CASE

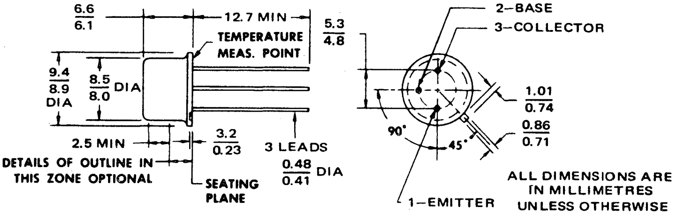


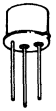


ALL JEDEC TO-59 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES:
- A. Within this dimension, case diameter may vary
- B. Position of terminals with respect to hexagon is not controlled.
- C. The case temperature may be measured anywhere on the seating plane within 3.2mm of the stud.
- D. All dimensions are in mm unless otherwise specified.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N4999 2N5001	2N5147 2N5149
Collector-Base Voltage	−100 V*	
Collector-Emitter Voltage (See Note 1)	−80 V*	
Emitter-Base Voltage	−5.5 V*	
Continuous Collector Current	−2 A*	−2 A*
Peak Collector Current (See Note 2)	−5 A*	−5 A
Continuous Base Current	−1 A*	−1 A*
Safe Operating Area at (or below) 25°C Case Temperature	See Figures 7 and 8*	
Continuous Device Dissipation at 50°C Case Temperature (See Note 3)	30 W*	6 W*
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	20 W	4 W
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	2 W	1 W*
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Lead or Terminal Temperature 3.2mm from Case for 10 Seconds	300°C*	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 8.3$ ms, duty cycle ⩽ 1%.
3. For operation above (or below) 50°C case temperature, refer to Dissipation Derating Curves Figures 9 and 10.
4. Derate linearly to 200°C free-air temperature at the rate of 11.4 mW/°C for 2N4999 and 2N5001, 5.7 mW/°C for 2N5147 and 2N5149.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPES 2N4999, 2N5001, 2N5147, 2N5149
P-N-P SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N4999 2N5147		2N5001 2N5149		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $I_B = 0$,	See Note 5	−80		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -40$ V, $I_B = 0$			−50		−50	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = -60$ V, $V_{BE} = 0$			−1		−1	μA
		$V_{CE} = -100$ V, $V_{BE} = 0$			−1		−1	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V, $V_{BE} = 2$ V, $T_C = 150°C$			−500		−500	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−1		−1	μA
		$V_{EB} = -5.5$ V, $I_C = 0$			−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -50$ mA	See Notes 5 and 6	20		50		
		$V_{CE} = -5$ V, $I_C = -1$ A		30	90	70	200	
		$V_{CE} = -5$ V, $I_C = -2$ A		15		30		
		$V_{CE} = -5$ V, $I_C = -3$ A		5		15		
		$V_{CE} = -5$ V, $I_C = -1$ A, $T_C = -55°C$		15		35		
V_{BE}	Base-Emitter Voltage	$I_B = -100$ mA, $I_C = -1$ A	See Notes 5 and 6		−1.2		−1.2	V
		$I_B = -200$ mA, $I_C = -2$ A			−1.5		−1.5	
		$V_{CE} = -5$ V, $I_C = -2$ A			−1.5		−1.5	
		$V_{CE} = -5$ V, $I_C = -3$ A			−3		−3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -100$ mA, $I_C = -1$ A	See Notes 5 and 6		−0.46		−0.46	V
		$I_B = -200$ mA, $I_C = -2$ A			−0.85		−0.85	
		$I_B = -600$ mA, $I_C = -3$ A			−5		−5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.1$ A, $f = 1$ kHz		20		50		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.2$ A, $f = 20$ MHz		2.5		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 1$ MHz			120		120	pF

NOTES: 5. This parameter must be measured using pulse techniques: $t_w = 300$ μs, duty cycle ⩽ 1%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

thermal characteristics

PARAMETER		2N4999 2N5001	2N5147 2N5149	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	5	25	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	87.5	175	

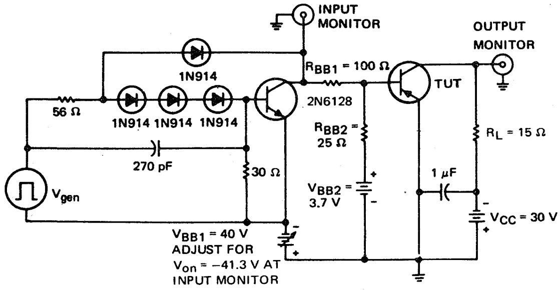
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			ALL TYPES	UNIT
					TYP	
t_{on}	Turn-On Time	$I_C = -2$ A,	$I_{B(1)} = -200$ mA,	$I_{B(2)} = 200$ mA,	0.2	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 3.7$ V,	$R_L = 15\ \Omega$,	See Figure 1	0.4	

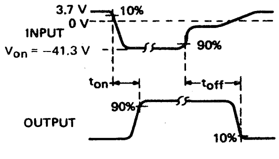
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

TYPICAL CHARACTERISTICS

2N4999, 2N5147
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

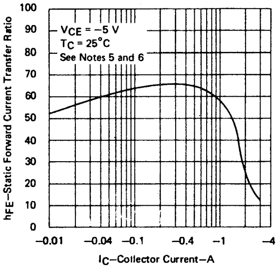


FIGURE 2

2N5001, 2N5149
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

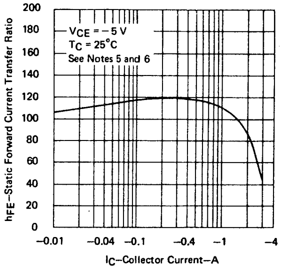


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

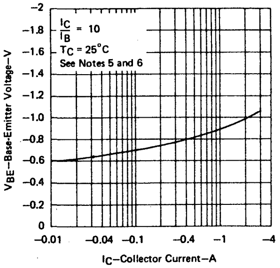


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

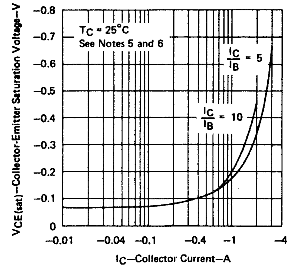


FIGURE 5

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

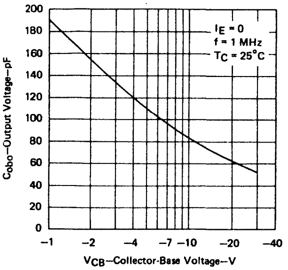


FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 1%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREA

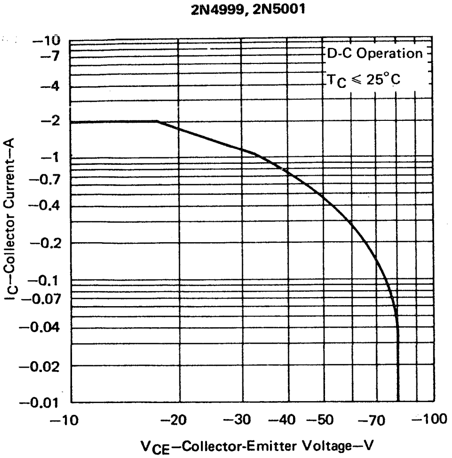


FIGURE 7

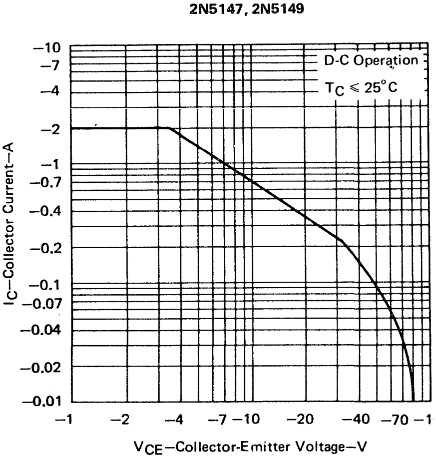


FIGURE 8

THERMAL CHARACTERISTICS

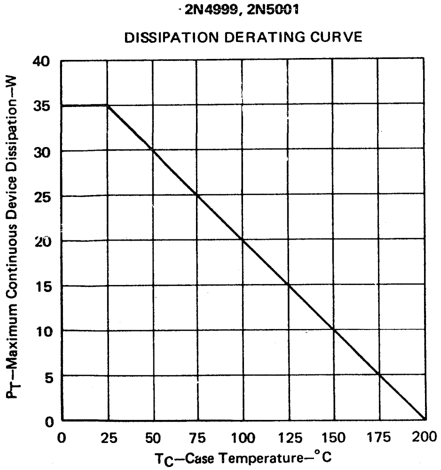


FIGURE 9

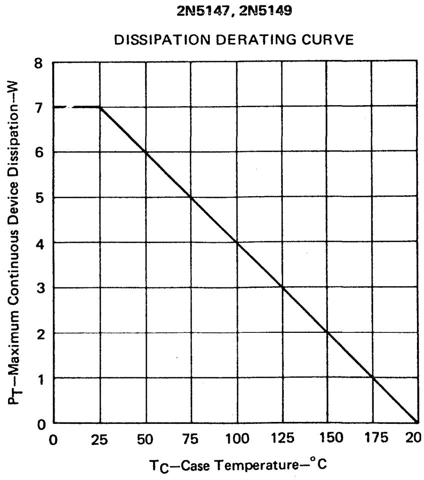


FIGURE 10

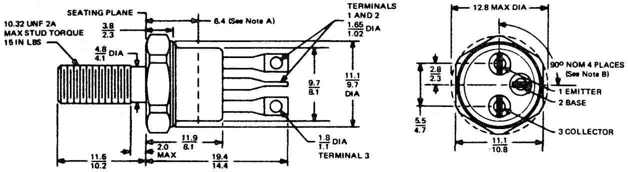
2N5002, 2N5004, 2N5152, 2N5154
NPN SILICON POWER TRANSISTORS

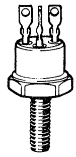
HIGH-FREQUENCY POWER TRANSISTORS WITH COMPUTER-DESIGNED ISOTHERMAL GEOMETRY

- For Complementary Use with 2N5003, 2N5005, 2N5151, and 2N5153
- Isolated Stud Package; 50 W at 40 V, T_C = 50°C (2N5002, 2N5004)
- Min f_T of 60 and 70 MHz at 5 V, 500 mA

*mechanical data

ALL TERMINALS ARE INSULATED FROM THE CASE

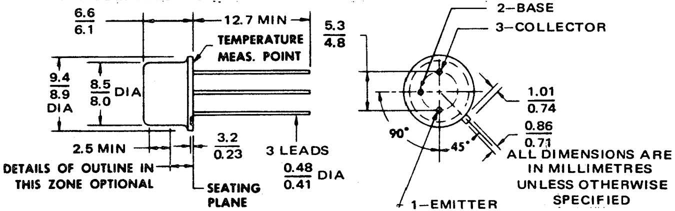


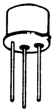


ALL JEDEC TO-59 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES:
A. Within this dimension, case diameter may vary.
B. Position of terminals with respect to hexagon is not controlled.
C. The case temperature may be measured anywhere on the seating plane within 3.2mm of the stud.
D. All dimensions are in mm unless otherwise specified.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5002 2N5004	2N5152 2N5154
Collector-Base Voltage	◄— 100 V* —►	
Collector-Emitter Voltage (See Note 1)	◄— 80 V* —►	
Emitter-Base Voltage	◄— 6 V* —►	
Continuous Collector Current	5 A*	2 A*
Peak Collector Current (See Note 2)	10 A*	10 A
Continuous Base Current	2 A*	1 A*
Safe Operating Area at (or below) 25°C Case Temperature	See Figures 7 and 8*	
Continuous Device Dissipation at 50°C Case Temperature (See Note 3)	50 W*	10 W*
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	33.3 W	6.7 W
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)		1 W*
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Lead or Terminal Temperature 3.2mm from Case for 10 Seconds	◄— 300°C* —►	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 8.3$ ms, duty cycle ⩽ 1%.
3. For operation above (or below) 50°C case temperature, refer to Dissipation Derating Curves, Figures 9 and 10.
4. Derate linearly to 200°C free-air temperature at the rate of 5.7 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TEXAS INSTRUMENTS

2N5002, 2N5004, 2N5152, 2N5154
NPN SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N5002 2N5152		2N5004 2N5154		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA, $I_B = 0$,	See Note 5	80		80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 40$ V, $I_B = 0$			50		50	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = 0$			1		1	μA
		$V_{CE} = 100$ V, $V_{BE} = 0$			1		1	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = -2$ V, $T_C = 150°C$			500		500	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			1		1	μA
		$V_{EB} = 6$ V, $I_C = 0$			1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 50$ mA	See Notes 5 and 6	20		50		
		$V_{CE} = 5$ V, $I_C = 2.5$ A		30	90	70	200	
		$V_{CE} = 5$ V, $I_C = 5$ A		20		40		
		$V_{CE} = 5$ V, $I_C = 2.5$ A, $T_C = -55°C$		15		35		
V_{BE}	Base-Emitter Voltage	$I_B = 250$ mA, $I_C = 2.5$ A	See Notes 5 and 6		1.45		1.45	V
		$I_B = 500$ mA, $I_C = 5$ A			2.2		2.2	
		$V_{CE} = 5$ V, $I_C = 2.5$ A			1.45		1.45	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 250$ mA, $I_C = 2.5$ A	See Notes 5 and 6		0.75		0.75	V
		$I_B = 500$ mA, $I_C = 5$ A			1.5		1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.1$ A, $f = 1$ kHz		20		50		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.5$ A, $f = 20$ MHz		3		3.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_B = 0$, $f = 1$ MHz			250		250	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 1%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

thermal characteristics

PARAMETER		2N5002 2N5004	2N5152 2N5154	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3	15	°C/W

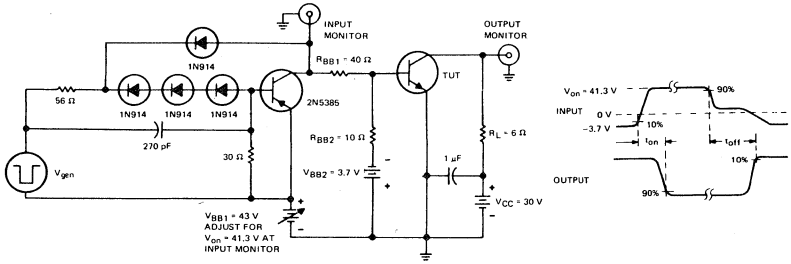
switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	All TYPES	UNIT
			TYP	
t_{on}	Turn-On Time	$I_C = 5$ A, $I_{B(1)} = 500$ mA, $I_{B(2)} = -500$ mA,	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -3.7$ V, $R_L = 6\ \Omega$, See Figure 1	1.3	

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION

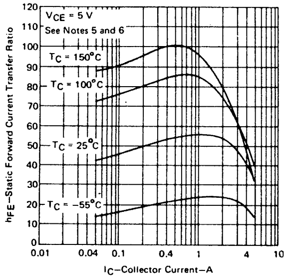


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: A. V_{gen} is a −30 V pulse (from 0 V) into a 50 Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

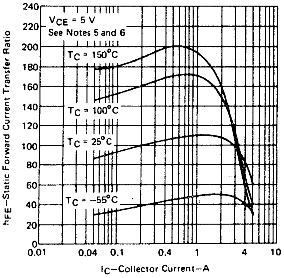
FIGURE 1

TYPICAL CHARACTERISTICS



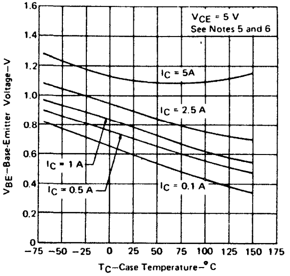
2N5002, 2N5152
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 2



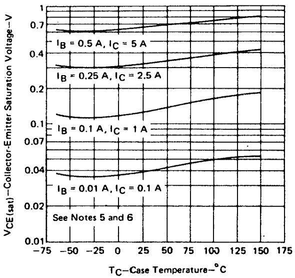
2N5004, 2N5154
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 3



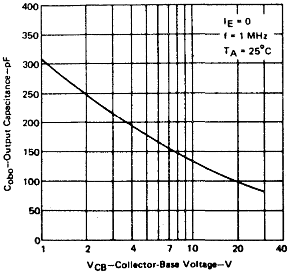
BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

FIGURE 4



COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

FIGURE 5



COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 1\%$.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREA

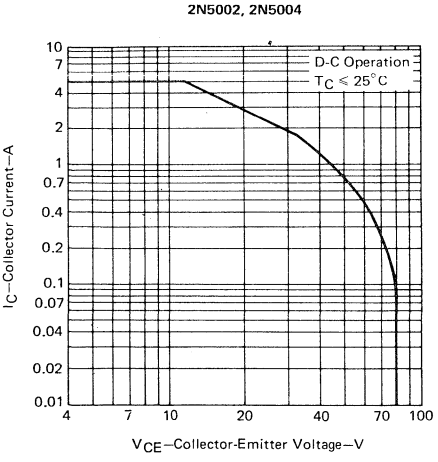


FIGURE 7

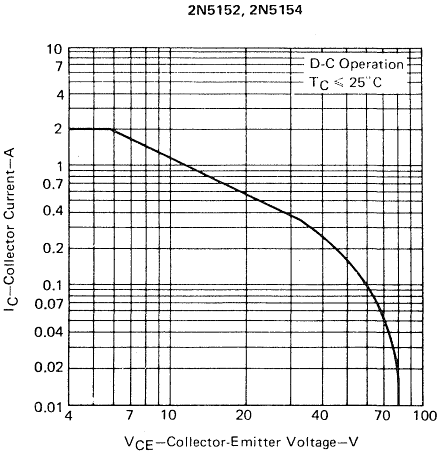


FIGURE 8

THERMAL CHARACTERISTICS

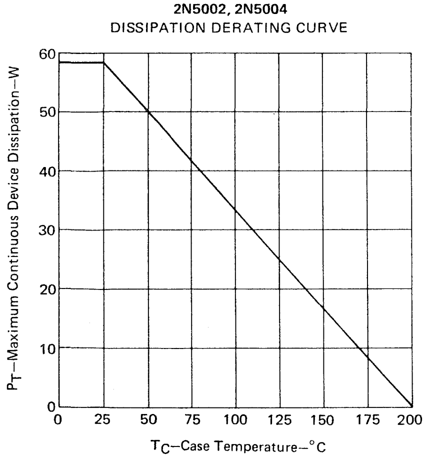


FIGURE 9

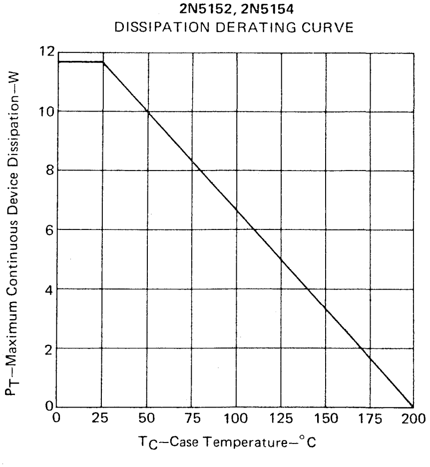


FIGURE 10

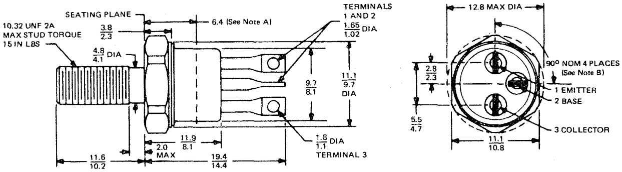
TYPES 2N5003, 2N5005, 2N5151, 2N5153
P-N-P SILICON POWER TRANSISTORS

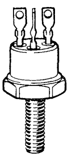
HIGH-FREQUENCY POWER TRANSISTORS WITH COMPUTER-DESIGNED ISOTHERMAL GEOMETRY

- For Complementary Use With 2N5002, 2N5004, 2N5152, 2N5154
- 15 mJ Reverse Energy Rating with I_C = 10 A and 4 V Reverse Bias

*mechanical data

ALL TERMINALS ARE INSULATED FROM THE CASE

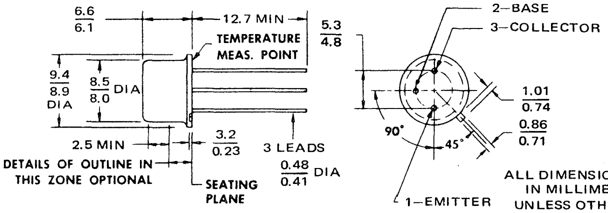




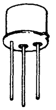
ALL JEDEC TO-59 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES:
A. Within this dimension, case diameter may vary.
B. Position of terminals with respect to the hexagon is not controlled.
C. The case temperature may be measured anywhere on the seating plane within 3.2mm of the stud.
D. All dimensions are in millimetres unless otherwise specified.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5003 2N5005	2N5151 2N5153
Collector-Base Voltage	←—100 V*—→	
Collector-Emitter Voltage (See Note 1)	←—80 V*—→	
Emitter-Base Voltage	←—5.5 V*—→	
Continuous Collector Current	−5 A*	−5 A*
Peak Collector Current (See Note 2)	−10 A*	−10 A
Continuous Base Current	−2 A*	−2.5 A*
Safe Operating Areas	See Figures 7* and 8	
Continuous Device Dissipation at 50°C Case Temperature (See Note 3)	50 W*	10 W*
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	33.3 W	6.7 W
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)		1 W*
Unclamped Inductive Load Energy (See Note 5)	←—15 mJ—→	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Lead or Terminal Temperature 3.2mm from Case for 60 Seconds	←—300°C*—→	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 8.3$ ms, duty cycle $\leqslant 1\%$.
3. For operation above (or below) 50°C case temperature, refer to Dissipation Derating Curves, Figures 9 and 10.
4. Derate linearly to 200°C free-air temperature at the rate of 5.7 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors*†. $L = 0.3$ mH, $R_{BB1} = 10\ \Omega$, $R_{BB2} = 100\Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 4$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = 10$ A. Energy $\approx I_C{}^2L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPES 2N5003, 2N5005, 2N5151, 2N5153
P-N-P SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N5003 2N5151		2N5005 2N5153		UNIT
				MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $I_B = 0$,	See Note 6	−80		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -40$ V, $I_B = 0$			−50		−50	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = -60$ V, $V_{BE} = 0$			−1		−1	μA
		$V_{CE} = -100$ V, $V_{BE} = 0$			−1		−1	mA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V, $V_{BE} = 2$ V, $T_C = 150°C$			−500		−500	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−1		−1	μA
		$V_{EB} = -5.5$ V, $I_C = 0$			−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -50$ mA	See Notes 6 and 7	20		50		
		$V_{CE} = -5$ V, $I_C = -2.5$ A		30	90	70	200	
		$V_{CE} = -5$ V, $I_C = -5$ A		20		40		
		$V_{CE} = -5$ V, $I_C = -2.5$ A, $T_C = -55°C$		15		35		
V_{BE}	Base-Emitter Voltage	$I_B = -250$ mA, $I_C = -2.5$ A	See Notes 6 and 7		−1.45		−1.45	V
		$I_B = -500$ mA, $I_C = -5$ A			−2.2		−2.2	
		$V_{CE} = -5$ V, $I_C = -2.5$ A			−1.45		−1.45	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -250$ mA, $I_C = -2.5$ A	See Notes 6 and 7		−0.75		−0.75	V
		$I_B = -500$ mA, $I_C = -5$ A			−1.5		−1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.1$ A, $f = 1$ kHz		20		50		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.5$ A, $f = 20$ MHz		3		3.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 1$ MHz			250		250	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 1%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

*JEDEC registered data

thermal characteristics

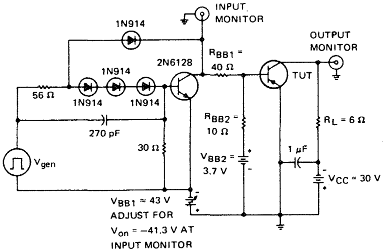
PARAMETER		2N5003 2N5005	2N5151 2N5153	UNIT
		MAX	MAX	
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3	15	°C/W

switching characteristics at 25°C case temperature

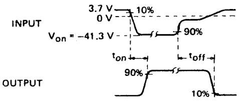
PARAMETER		TEST CONDITIONS†			ALL TYPES	UNIT
					TYP	
t_{on}	Turn-On Time	$I_C = -5$ A,	$I_{B(1)} = -500$ mA,	$I_{B(2)} = 500$ mA,	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 3.7$ V,	$R_L = 6\ \Omega$,	See Figure 1	1.3	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

TYPICAL CHARACTERISTICS

2N5003, 2N5151
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

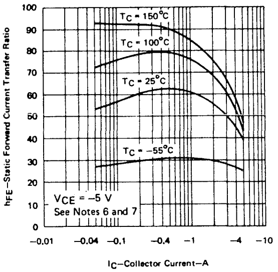


FIGURE 2

2N5005 and 2N5153
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

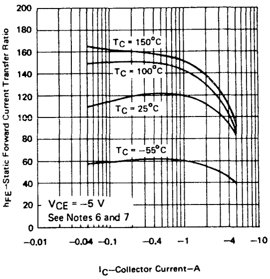


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

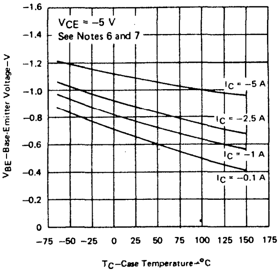


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

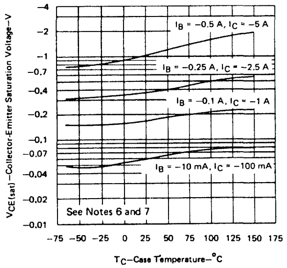


FIGURE 5

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE
vs
COLLECTOR-BASE VOLTAGE

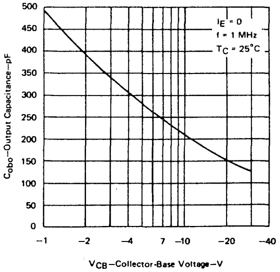


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 1%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

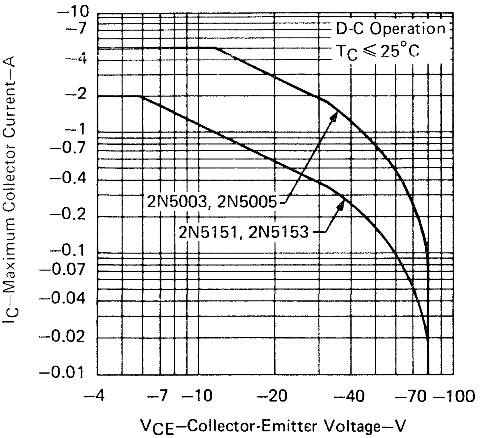


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

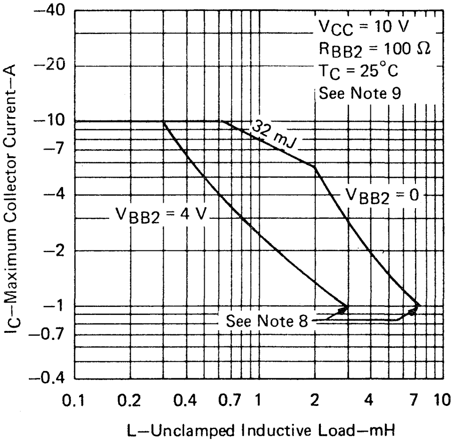


FIGURE 8

NOTES: 8. Above these points the safe operating areas have not been defined.

9. These curves are based on the capability of the transistors to operate safely in the unclamped inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*† $R_{BB1} = 10 \cdot V_{BB1}/I_C$, $V_{BB1} = 10$ V, $R_L = 0.1\ \Omega$. Energy $\approx I_C{}^2L/2$.

†This circuit appears on page 5-1 of this data book.

THERMAL INFORMATION

2N5003, 2N5005
DISSIPATION DERATING CURVE

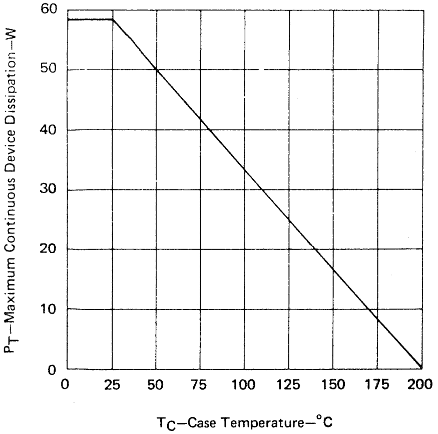


FIGURE 9

2N5151, 2N5153
DISSIPATION DERATING CURVE

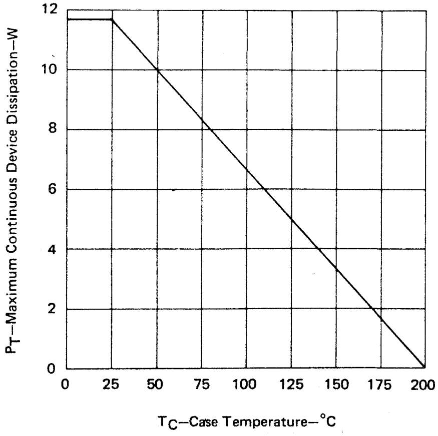


FIGURE 10

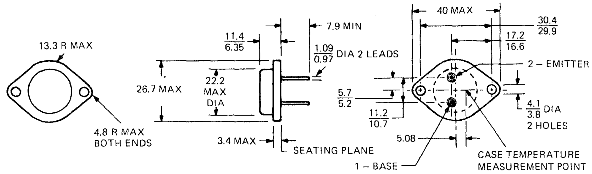
2N5038, 2N5039
N-P-N SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED SWITCHING APPLICATIONS

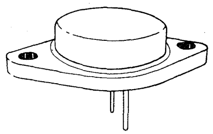
- Min $V_{(BR)CEO}$ of 90 V (2N5038)
- Min f_T of 60 MHz at 10 V, 2 A
- 20-A Rated Continuous Collector Current

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5038	2N5039
*Collector-Emitter Voltage ($V_{BE} = -1.5$ V, See Note 1)	150 V	120 V
Collector-Emitter Voltage (Base Open, See Note 1)	90 V	75 V
*Emitter-Base Voltage	←7 V→	
*Continuous Collector Current	←20 A→	
*Peak Collector Current (See Note 2)	←30 A→	
*Continuous Base Current	←5 A→	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←140 W→	
*Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	←80 W→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	←5 W→	
*Operating Collector Junction Temperature Range	−65°C to 200°C	
*Storage Temperature Range	−65°C to 200°C	
Terminal Temperature 0.8mm from Case for 10 Seconds	←230°C→	

NOTES:
1. These values apply only when the collector-emitter voltage is applied with the transistor in the off-state with the base-emitter diode reverse-biased or open-circuited, as specified.
2. This value applies for $t_w \leqslant 10$ ms, duty cycle $\leqslant 50\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.8 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

2N5038, 2N5039
N-P-N SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5038		2N5039		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA, I_B = 0, See Note 5	90		75		V
I_{CEV}	Collector Cutoff Current	V_{CE} = 140 V, V_{BE} = −1.5 V		50			mA
		V_{CE} = 110 V, V_{BE} = −1.5 V				50	
		V_{CE} = 85 V, V_{BE} = −1.5 V, T_C = 150°C				10	
		V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C		10			
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		5		15	mA
		V_{EB} = 7 V, I_C = 0		50		50	
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 10 A, See Notes 5 and 6			20	100	
		V_{CE} = 5 V, I_C = 12 A, See Notes 5 and 6	20	100			
V_{BE}	Base-Emitter Voltage	I_B = 5 A, I_C = 20 A, See Notes 5 and 6		3.3		3.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 5 A, I_C = 20 A, See Notes 5 and 6		2.5		2.5	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 2 A, f = 5 MHz	12		12		

NOTES: 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

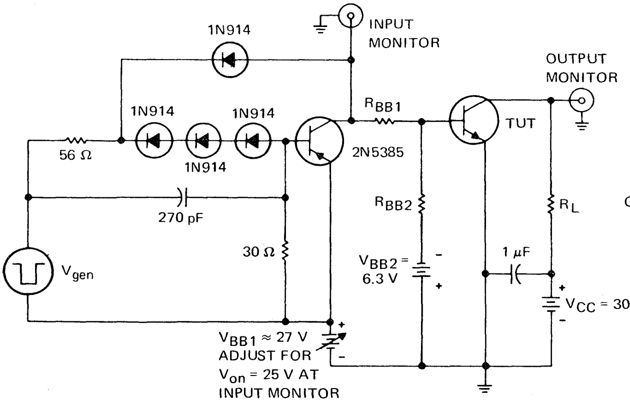
*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_r	Rise Time	**2N5038**	0.5	μs
t_s	Storage Time	I_C = 12 A, $I_{B(1)}$ = 1.2 A, $I_{B(2)}$ = −1.2 A, $V_{BE(off)}$ = −6.3 V, R_L = 2.5 Ω, See Figure 1	1.5	
t_f	Fall Time	**2N5039**	0.5	
t_{on}	Turn-On Time	I_C = 10 A, $I_{B(1)}$ = 1 A, $I_{B(2)}$ = −1 A,	0.5	
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −6.3 V, R_L = 3 Ω, See Figure 1	2	

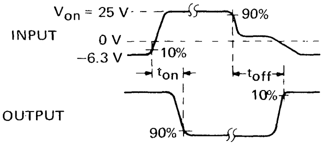
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

CIRCUIT CONDITIONS

I_C	R_L	R_{BB1}	R_{BB2}
10 A	3 Ω	12 Ω	7.32 Ω
12 A	2.5 Ω	10 Ω	6 Ω

NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ⩽ 2%.

C. Waveforms are monitored on an oscillioscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

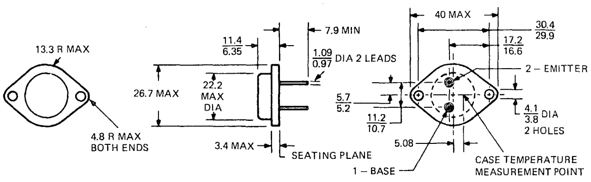
TYPES 2N5301, 2N5302, 2N5303
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
2N5301, 2N5302 DESIGNED FOR COMPLEMENTARY USE WITH 2N4398, 2N4399

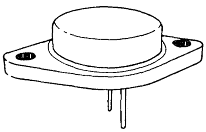
200 W at 25°C Case Temperature
30-A Rated Continuous Collector Current (2N5301, 2N5302)
20-A Rated Continuous Collector Current (2N5303)
Min f_T of 2 MHz at 10 V, 1 A

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5301	2N5302	2N5303
*Collector-Base Voltage	40 V	60 V	80 V
*Collector-Emitter Voltage (See Note 1)	40 V	60 V	80 V
*Emitter-Base Voltage	5 V	5 V	5 V
*Continuous Collector Current	30 A	30 A	20 A
*Peak Collector Current (See Note 2)	← 50 A →		
*Continuous Base Current	← 7.5 A →		
Safe Operating Region at (or below) 25°C Case Temperature	See Figures 7 and 8		
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 200 W →		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 5 W →		
*Operating Collector Junction Temperature Range	-65°C to 200°C		
*Storage Temperature Range	-65°C to 200°C		

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_p \leq 0.3$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.14 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/deg.

*Indicates JEDEC registered data

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N5301		2N5302		2N5303		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA, I_B = 0,	See Note 5	40		60		80		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 40 V, I_E = 0			1					mA
		V_{CB} = 60 V, I_E = 0					1			
		V_{CB} = 80 V, I_E = 0							1	
I_{CEO}	Collector Cutoff Current	V_{CE} = 40 V, I_B = 0			5					mA
		V_{CE} = 60 V, I_B = 0					5			
		V_{CE} = 80 V, I_B = 0							5	
I_{CEV}	Collector Cutoff Current	V_{CE} = 40 V, V_{BE} = -1.5 V			1					mA
		V_{CE} = 60 V, V_{BE} = -1.5 V					1			
		V_{CE} = 80 V, V_{BE} = -1.5 V							1	
		V_{CE} = 40 V, V_{BE} = -1.5 V, T_C = 150°C			10					
		V_{CE} = 60 V, V_{BE} = -1.5 V, T_C = 150°C					10			
		V_{CE} = 80 V, V_{BE} = -1.5 V, T_C = 150°C							10	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0			5		5		5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V, I_C = 1 A	See Notes 5 and 6	40		40		40		
		V_{CE} = 2 V, I_C = 10 A						15	60	
		V_{CE} = 2 V, I_C = 15 A		15	60	15	60			
		V_{CE} = 2 V, I_C = 20 A						5		
		V_{CE} = 2 V, I_C = 30 A		5		5				
V_{BE}	Base-Emitter Voltage	I_B = 1 A, I_C = 10 A	See Notes 5 and 6		1.7		1.7		1.7	V
		I_B = 1.5 A, I_C = 15 A			1.8		1.8		2	
		I_B = 2 A, I_C = 20 A			2.5		2.5			
		I_B = 4 A, I_C = 20 A							2.5	
		V_{CE} = 2 V, I_C = 10 A							1.5	
		V_{CE} = 2 V, I_C = 15 A			1.7		1.7			
		V_{CE} = 4 V, I_C = 20 A							2.5	
		V_{CE} = 4 V, I_C = 30 A			3		3			
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1 A, I_C = 10 A	See Notes 5 and 6		0.75		0.75		1	V
		I_B = 1.5 A, I_C = 15 A							1.5	
		I_B = 2 A, I_C = 20 A			2		2			
		I_B = 4 A, I_C = 20 A							2	
		I_B = 6 A, I_C = 30 A			3		3			
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A,	f = 1 kHz	40		40		40		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A,	f = 1 MHz	2		2		2		

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

*Indicates JEDEC registered data

thermal characteristics

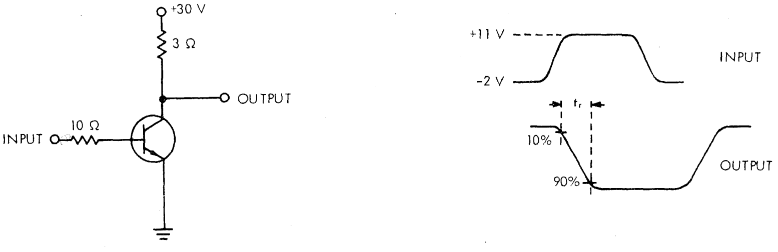
PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	0.875	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	35	

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_r	Rise Time	$I_C = 10$ A, $I_{B(1)} = 1$ A, $V_{BE(off)} = -2$ V, $R_L = 3\ \Omega$, See Figure 1	1	μs
t_s	Storage Time	$I_C = 10$ A, $I_{B(1)} = 1$ A, $I_{B(2)} = -1$ A, $R_L = 3\ \Omega$, See Figure 2	2	
t_f	Fall Time		1	

†Voltage and current values shown are nominal, exact values vary slightly with transistor parameters.

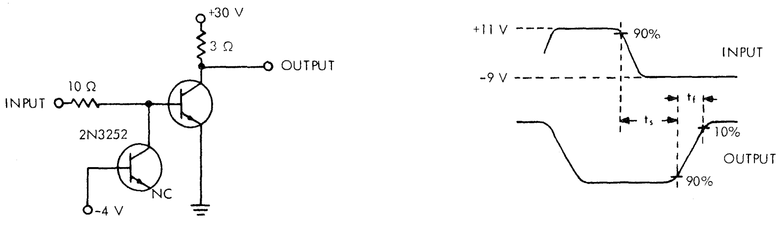
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1 – RISE TIME



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 2 – STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $t_r \leq 20$ ns, $t_f \leq 20$ ns, $Z_{out} = 50\ \Omega$, $t_p = 10\ \mu s$ to $100\ \mu s$, duty cycle $\leq 2\%$.

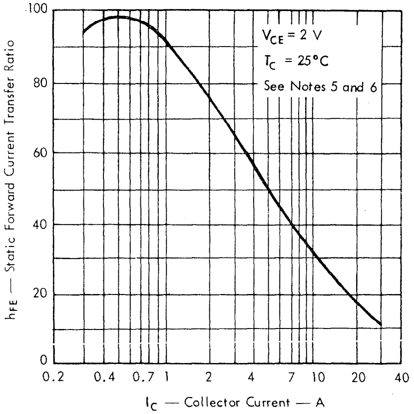
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 20$ ns, $R_{in} \geq 10\ k\Omega$, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

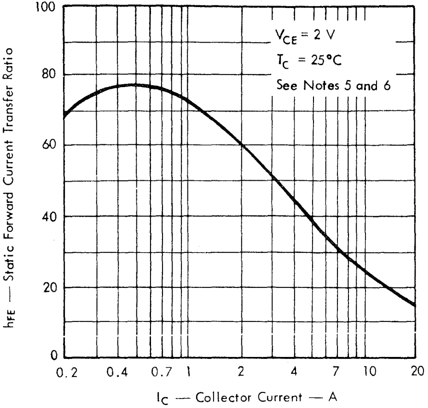
*Indicates JEDEC registered data

TYPICAL CHARACTERISTICS



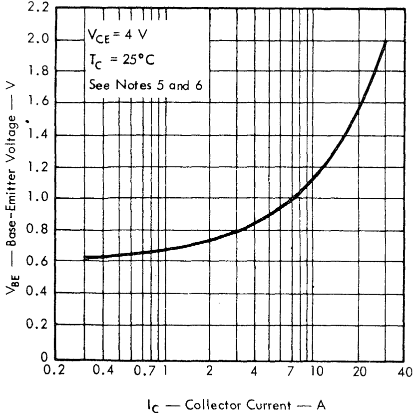
2N5301, 2N5302
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 3



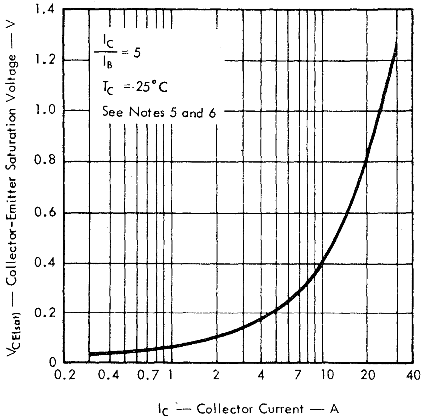
2N5303
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

FIGURE 4



BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 5



COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

FIGURE 6

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$2%.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

MAXIMUM SAFE OPERATING REGIONS

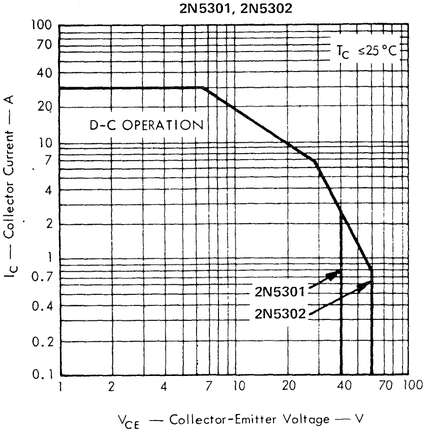


FIGURE 7

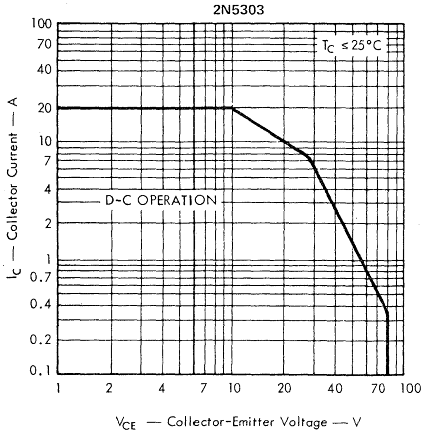


FIGURE 8

TYPES 2N5301, 2N5302, 2N5303
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

THERMAL INFORMATION

DISSIPATION DERATING CURVE

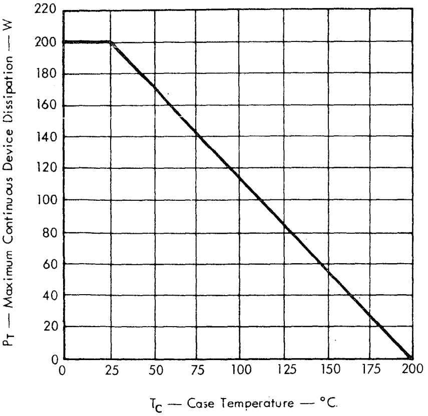


FIGURE 9

PEAK-POWER COEFFICIENT CURVE

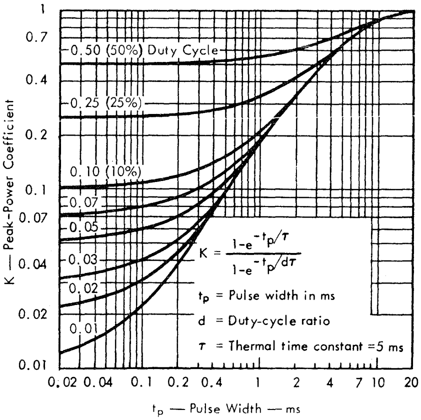


FIGURE 10

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	35	deg/W
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	0.875	deg/W
$\theta_{C\text{-}A}$	Case-to-Free-Air Thermal Resistance	34.125	deg/W
$\theta_{C\text{-}HS}$	Case-to-Heat-Sink Thermal Resistance		deg/W
$\theta_{HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance		deg/W
T_A	Free-Air Temperature		°C
T_C	Case Temperature		°C
$T_{J(av)}$	Average Junction Temperature	≤200	°C
$T_{J(max)}$	Peak Junction Temperature	≤200	°C
K	Peak-Power Coefficient	See Figure 10	
t_p	Pulse Width		ms
t_x	Pulse Period		ms
d	Duty-Cycle Ratio (t_p/t_x)		

Equation No. 1 – Application: d-c power dissipation, heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 100^\circ C \leq T_C \leq 200^\circ C \text{ as in Figure 9}$$

Equation No. 2 – Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \quad \text{for } 25^\circ C \leq T_A \leq 200^\circ C$$

Equation No. 3 – Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\theta_{J\text{-}C}} \quad \text{for } 100^\circ C \leq T_C \leq 200^\circ C$$

Equation No. 4 – Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\theta_{C\text{-}A} + K\theta_{J\text{-}C}} \quad \text{for } 25^\circ C \leq T_A \leq 200^\circ C.$$

Example – Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C\text{-}HS} + \theta_{HS\text{-}A}$ = 2.25 deg/W (From information supplied with heat sink.)

$T_{J(av)}$ (design limit) = 200°C

T_A = 50°C

d = 10% (0.1)

t_p = 0.1 ms

Solution:

From Figure 10, Peak-Power Coefficient K = 0.109 and by use of equation No. 3

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\theta_{J\text{-}C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1\,(2.25) + 0.109\,(0.875)} = 469 \text{ W}$$

TYPES 2N5683, 2N5684
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

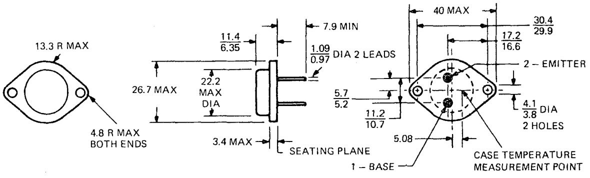
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5685, 2N5686

- 300 Watts at 25°C Case Temperature
- 50-A Rated Continuous Collector Current
- Min f_T of 2 MHz at 10 V, 5 A

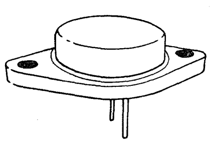
*mechanical data

The case outline falls within JEDEC-TO-3 except for lead diameter.

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5683	2N5684
*Collector-Base Voltage	−60 V	−80 V
*Collector-Emitter Voltage (See Note 1)	−60 V	−80 V
*Emitter-Base Voltage	−5 V	−5 V
*Continuous Collector Current	−50 A	
*Continuous Base Current	−15 A	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	300 W	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	5 W	
*Operating Collector Junction Temperature Range	−65°C to 200°C	
*Storage Temperature Range	−65°C to 200°C	
*Terminal Temperature 1.588mm from Case for 10 Seconds	235°C	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C case temperature at the rate of 1.715 W/°C or refer to Dissipation Derating Curve, Figure 1.
3. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 2.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5683		2N5684		UNIT
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -200$ mA,	$I_B = 0$,	See Note 6	−60		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V,	$I_B = 0$			−1			mA
		$V_{CE} = -40$ V,	$I_B = 0$					−1	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V			−2			mA
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V					−2	
		$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°$C		−10			
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°$C				−10	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V,	$I_E = 0$			−2			mA
		$V_{CB} = -80$ V,	$I_E = 0$					−2	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V,	$I_C = 0$			−5		−5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V,	$I_C = -25$ A	See Notes 6 and 7	15	60	15	60	
		$V_{CE} = -5$ V,	$I_C = -50$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -2.5$ A,	$I_C = -25$ A	See Notes 6 and 7		−2		−2	V
		$V_{CE} = -2$ V,	$I_C = -25$ A			−2		−2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2.5$ A,	$I_C = -25$ A	See Notes 6 and 7		−1		−1	V
		$I_B = -10$ A,	$I_C = -50$ A			−5		−5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V,	$I_C = -10$ A,	f = 1 kHz	15		15		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -5$ A,	f = 1 MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 0.1 MHz		2000		2000	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

THERMAL INFORMATION

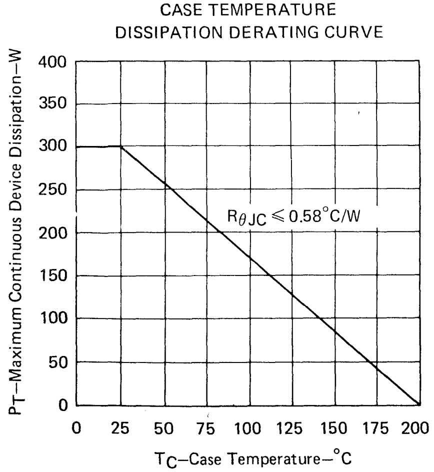


FIGURE 1

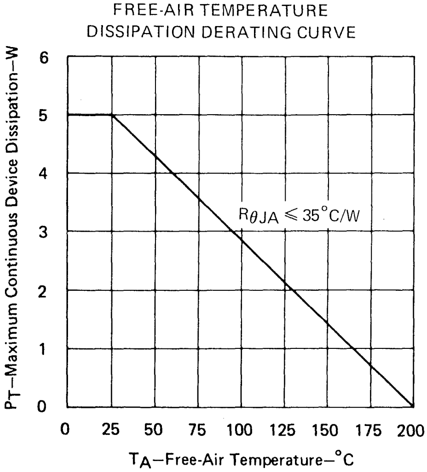


FIGURE 2

TYPES 2N5685, 2N5686
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

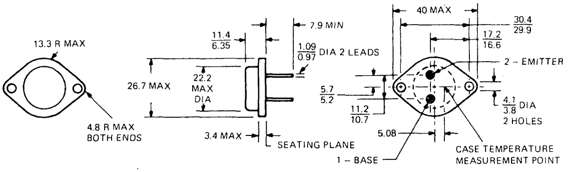
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5683, 2N5684

- 300 Watts at 25°C Case Temperature
- 50-A Rated Continuous Collector Current
- Min f_T of 2 MHz at 10 V, 5 A

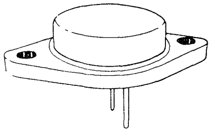
*mechanical data

The case outline falls within JEDEC-TO-3 except for lead diameter.

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5685	2N5686
*Collector-Base Voltage	60 V	80 V
*Collector-Emitter Voltage (See Note 1)	60 V	80 V
*Emitter-Base Voltage	5 V	5 V
*Continuous Collector Current	◄—50 A—►	
*Continuous Base Current	◄—15 A—►	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	◄—300 W—►	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	◄—5 W—►	
*Operating Collector Junction Temperature Range	−65°C to 200°C	
*Storage Temperature Range	−65°C to 200°C	
*Terminal Temperature 1.588mm from Case for 10 Seconds	◄— 235°C —►	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C case temperature at the rate of 1.715 W/°C or refer to Dissipation Derating Curve, Figure 1.
3. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 2.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPES 2N5685, 2N5686
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5685		2N5686		UNIT
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA,	I_B = 0,	See Note 6	60		80		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V,	I_B = 0			1			mA
		V_{CE} = 40 V,	I_B = 0					1	
I_{CEV}	Collector Cutoff Current	V_{CE} = 60 V,	V_{BE} = −1.5 V			2			mA
		V_{CE} = 80 V,	V_{BE} = −1.5 V					2	
		V_{CE} = 60 V,	V_{BE} = −1.5 V,	T_C = 150°C		10			
		V_{CE} = 80 V,	V_{BE} = −1.5 V,	T_C = 150°C				10	
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V,	I_E = 0			2			mA
		V_{CB} = 80 V,	I_E = 0					2	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V,	I_C = 0			5		5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V,	I_C = 25 A	See Notes 6 and 7	15	60	15	60	
		V_{CE} = 5 V,	I_C = 50 A		5		5		
V_{BE}	Base-Emitter Voltage	I_B = 2.5 A,	I_C = 25 A	See Notes 6 and 7		2		2	V
		V_{CE} = 2 V,	I_C = 25 A			2		2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 2.5 A,	I_C = 25 A	See Notes 6 and 7		1		1	V
		I_B = 10 A,	I_C = 50 A			5		5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V,	I_C = 10 A,	f = 1 kHz	15		15		
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 5 A,	f = 1 MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V,	I_E = 0,	f = 0.1 MHz		1200		1200	pF

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

THERMAL INFORMATION

CASE TEMPERATURE DISSIPATION DERATING CURVE

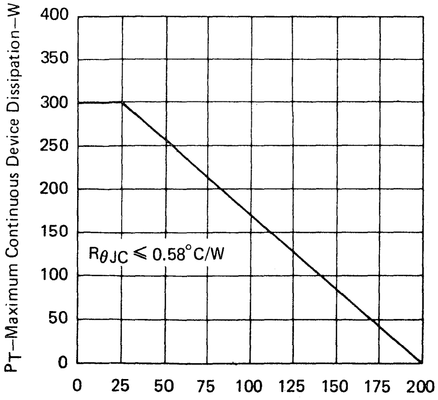


FIGURE 1

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

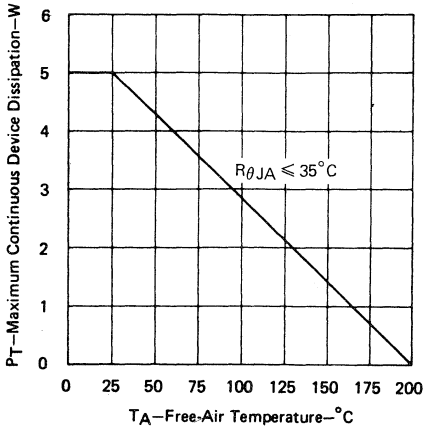


FIGURE 2

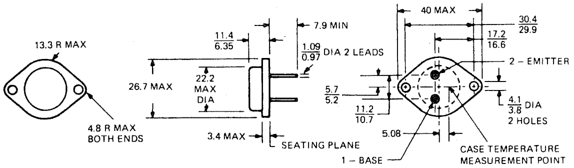
TYPES 2N5871, 2N5872
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5873, 2N5874

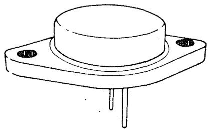
- 115 Watts at 25°C Case Temperature
- 7-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 0.25 A
- 62.5-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5871	2N5872
Collector-Base Voltage	−60 V*	−80 V*
Collector-Emitter Voltage (See Note 1)	−60 V*	−80 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	←— {−7 A† −5 A*} —→	
Peak Collector Current (See Note 2)	←——10 A——→	
Continuous Base Current	←——1.5 A*——→	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←—— 115 W*——→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	←——5 W——→	
Unclamped Inductive Load Energy (See Note 5)	←—— 62.5 mJ——→	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	←——250°C*——→	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.66 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*‡ $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = -2.5$ A. Energy $\approx I_C^2L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.
‡This circuit appears on the first page of the data section of this book.

TYPES 2N5871, 2N5872
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5871		2N5872		UNI
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -0.1$ A,	$I_B = 0$,	See Note 6	−60		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V,	$I_B = 0$			−0.5			mA
		$V_{CE} = -40$ V,	$I_B = 0$					−0.5	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V			−0.25			mA
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V					−0.25	
		$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$		−2			
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$				−2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V,	$I_E = 0$			−0.25			mA
		$V_{CB} = -80$ V,	$I_E = 0$					−0.25	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V,	$I_C = 0$			−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -0.5$ A	See Notes 6 and 7	35		35		
		$V_{CE} = -4$ V,	$I_C = -2.5$ A		20	100	20	100	
		$V_{CE} = -4$ V,	$I_C = -5$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -0.4$ A,	$I_C = -4$ A	See Notes 6 and 7		−1.6		−1.6	V
		$V_{CE} = -4$ V,	$I_C = -5$ A			−2		−2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.4$ A,	$I_C = -4$ A	See Notes 6 and 7		−1		−1	V
		$I_B = -1$ A,	$I_C = -5$ A			−2		−2	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -0.5$ A,	f = 1 kHz	20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V	$I_C = -0.25$ A,	f = 1 MHz	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		300		300	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 2 mm from the device body.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNI
t_r	Rise Time	$I_C = -2.5$ A, $I_{B(1)} = -0.25$ A, $I_{B(2)} = 0.25$ A, $V_{BE(off)} = 4.6$ V, $R_L = 12\ \Omega$, See Note 8		0.7	μs
t_s	Storage Time			1	
t_f	Fall Time			0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data.

NOTE 8: These characteristics are measured in the circuit of clause 3.3.13.2 of the forthcoming JEDEC publication *Suggested Standards o Power Transistors.*‡ $V_{BB1} = 24$ V, $V_{BB2} = 4.6$ V, $V_{CC} = 30$ V, $V_{on} = 22.5$ V, $R_{BB1} = 43\ \Omega$, $R_{BB2} = 22\ \Omega$.

‡This circuit appears on the first page of the data section of this book.

MAXIMUM SAFE OPERATING AREA

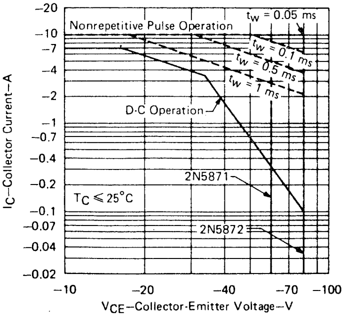


FIGURE 1

THERMAL CHARACTERISTICS

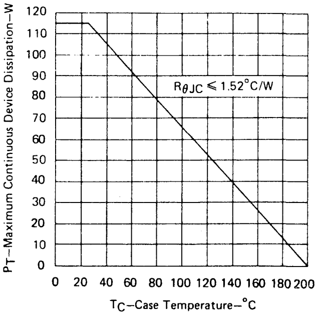


FIGURE 2

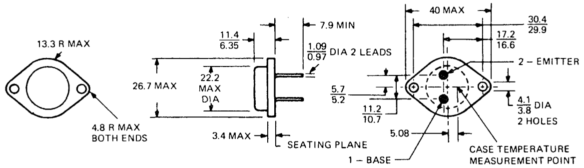
TYPES 2N5873, 2N5874
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH 2N5871, 2N5872

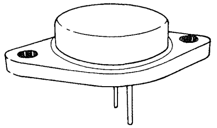
- 115 Watts at 25°C Case Temperature
- 7-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 0.25 A
- 62.5-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5873	2N5874
Collector-Base Voltage	60 V*	80 V*
Collector-Emitter Voltage (See Note 1)	60 V*	80 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	7 A† 5 A*	
Peak Collector Current (See Note 2)	10 A	
Continuous Base Current	1.5 A*	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	115 W*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W	
Unclamped Inductive Load Energy (See Note 5)	62.5 mJ	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	250°C*	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.66 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.* ‡ $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = 2.5$ A. Energy $\approx I_C{}^2L/2$.

JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

This circuit appears on the first page of the data section of this book

TYPES 2N5873, 2N5874
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5873		2N5874		U
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 0.1$ A,	$I_B = 0$,	See Note 6	60		80		
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V,	$I_B = 0$			0.5			
		$V_{CE} = 40$ V,	$I_B = 0$					0.5	
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60$ V,	$V_{BE} = -1.5$ V			0.25			
		$V_{CE} = 80$ V,	$V_{BE} = -1.5$ V					0.25	
		$V_{CE} = 60$ V,	$V_{BE} = -1.5$ V,	$T_C = 150°C$		2			
		$V_{CE} = 80$ V,	$V_{BE} = -1.5$ V,	$T_C = 150°C$				2	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V,	$I_E = 0$			0.25			
		$V_{CB} = 80$ V,	$I_E = 0$					0.25	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V,	$I_C = 0$			1		1	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V,	$I_C = 0.5$ A	See Notes 6 and 7	35		35		
		$V_{CE} = 4$ V,	$I_C = 2.5$ A		20	100	20	100	
		$V_{CE} = 4$ V,	$I_C = 5$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = 0.4$ A	$I_C = 4$ A	See Notes 6 and 7		1.6		1.6	
		$V_{CE} = 4$ V,	$I_C = 5$ A			2		2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.4$ A,	$I_C = 4$ A	See Notes 6 and 7		1		1	
		$I_B = 1$ A,	$I_C = 5$ A			2		2	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V,	$I_C = 0.5$ A,	f = 1 kHz	20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 0.25$ A,	f = 1 MHz	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz		200		200	

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leqslant 2\%$.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX
t_r	Rise Time	$I_C = 2.5$ A, $I_{B(1)} = 0.25$ A, $I_{B(2)} = -0.25$ A, $V_{BE(off)} = -4.6$ V, $R_L = 12\ \Omega$, See Note 8		0.7
t_s	Storage Time			1
t_f	Fall Time			0.8

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data.

NOTE 8: These characteristics are measured in the circuit of clause 3.3.13.2 of the forthcoming JEDEC publication *Suggested Standard Power Transistors*‡. $V_{BB1} = 24$ V, $V_{BB2} = 4.6$ V, $V_{CC} = 30$ V, $V_{on} = 22.5$ V, $R_{BB1} = 43\ \Omega$, $R_{BB2} = 22\ \Omega$.

‡This circuit appears on the first page of the data section of this book

MAXIMUM SAFE OPERATING AREA

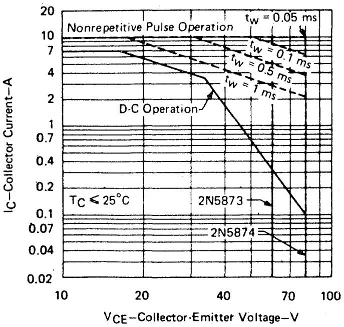


FIGURE 1

THERMAL CHARACTERISTICS

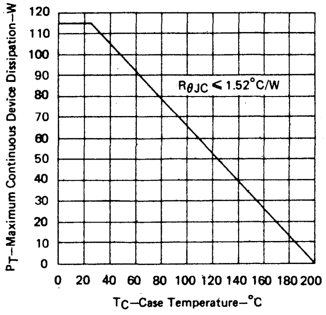


FIGURE 2

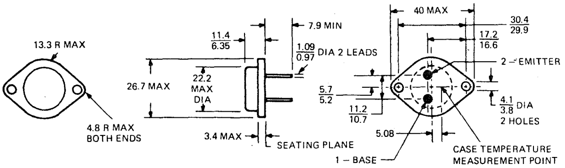
TYPES 2N5875, 2N5876
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

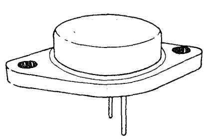
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5877, 2N5878

- 150 Watts at 25°C Case Temperature
- 10-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 0.5 A
- 62.5-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5875	2N5876
Collector-Base Voltage	−60 V*	−80 V*
Collector-Emitter Voltage (See Note 1)	−60 V*	−80 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	−10 A† −8 A*	
Peak Collector Current (See Note 2)	−15 A	
Continuous Base Current	−2 A*	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	150 W*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W	
Unclamped Inductive Load Energy (See Note 5)	62.5 mJ	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	250°C*	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.857 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the JEDEC publication *Suggested Standards on Power Transistors.*‡ $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = -2.5$ A. Energy $\approx I_C{}^2L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.
‡This circuit appears on the first page of the data section

TYPES 2N5875, 2N5876
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS				2N5875		2N5876		UNIT
						MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -0.2$ A,	$I_B = 0$,	See Note 6		−60		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V,	$I_B = 0$				−1			mA
		$V_{CE} = -40$ V,	$I_B = 0$						−1	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V				−0.5			mA
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V						−0.5	
		$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$			−5			
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$					−5	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V,	$I_E = 0$				−0.5			mA
		$V_{CB} = -80$ V,	$I_E = 0$						−0.5	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V,	$I_C = 0$				−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -1$ A		See Notes 6 and 7	35		35		
		$V_{CE} = -4$ V,	$I_C = -4$ A			20	100	20	100	
		$V_{CE} = -4$ V,	$I_C = -8$ A			5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -0.5$ A,	$I_C = -5$ A		See Notes 6 and 7		−1.6		−1.6	V
		$V_{CE} = -4$ V,	$I_C = -8$ A				−2.5		−2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ A,	$I_C = -5$ A		See Notes 6 and 7		−1		−1	V
		$I_B = -1.6$ A,	$I_C = -8$ A				−3		−3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -1$ A,	f = 1 kHz		20		20		
$\lvert h_{fe} \rvert$	Small Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -0.5$ A,	f = 1 MHz		4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz			500		500	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

*switching characteristics at 25° C case temperature

PARAMETER		TEST CONDITIONS†			MIN	MAX	UNIT
t_r	Rise Time	$I_C = -4$ A, $V_{BE(off)} = 5$ V,	$I_{B(1)} = -0.4$ A, $R_L‡ = 7.5\ \Omega$,	$I_{B(2)} = 0.4$ A, See Note 8		0.7	μs
t_s	Storage Time					1	
t_f	Fall Time					0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data.

NOTE 8: These characteristics are measured in the circuit of clause 3.3.13.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.* ‡$V_{BB1} = 24$ V, $V_{BB2} = 5$ V, $V_{CC} = 30$ V, $V_{on} = -22$ V, $R_{BB1} = 26\ \Omega$, $R_{BB2} = 15\ \Omega$.

‡This circuit appears on the first page of the data section

MAXIMUM SAFE OPERATION AREAS

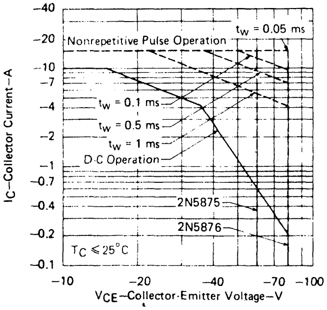


FIGURE 1

THERMAL CHARACTERISTICS

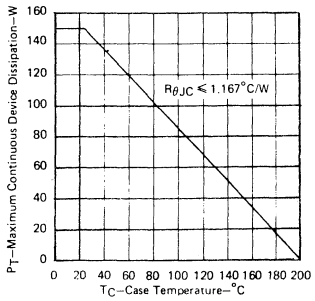


FIGURE 2

TEXAS INSTRUMENTS

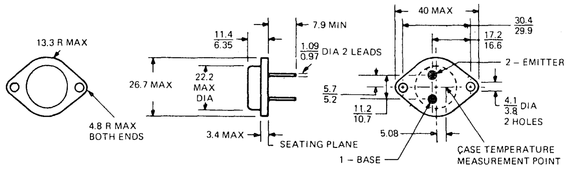
TYPES 2N5877, 2N5878
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5875, 2N5876

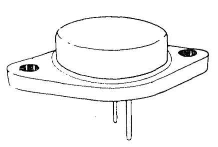
- 150 Watts at 25°C Case Temperature
- 10-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 0.5 A
- 62.5-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5877	2N5878
Collector-Base Voltage	60 V*	80 V*
Collector-Emitter Voltage (See Note 1)	60 V*	80 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	10 A† 8 A*	
Peak Collector Current (See Note 2)	15 A	
Continuous Base Current	2 A*	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	150 W*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W	
Unclamped Inductive Load Energy (See Note 5)	62.5 mJ	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	250°C*	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.857 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.* $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = 2.5$ A. Energy $\approx I_C{}^2L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Texas Instruments guarantees this value in addition to the JEDEC registered value which-is also shown.

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5877		2N5878		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 0.2 A, I_B = 0, See Note 6	60		80		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0		1			mA
		V_{CE} = 40 V, I_B = 0				1	
I_{CEV}	Collector Cutoff Current	V_{CE} = 60 V, V_{BE} = −1.5 V		0.5			mA
		V_{CE} = 80 V, V_{BE} = −1.5 V				0.5	
		V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C		5			
		V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C				5	
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0		0.5			mA
		V_{CB} = 80 V, I_E = 0				0.5	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, See Notes 6 and 7	35		35		
		V_{CE} = 4 V, I_C = 4 A	20	100	20	100	
		V_{CE} = 4 V, I_C = 8 A	5		5		
V_{BE}	Base-Emitter Voltage	I_B = 0.5 A, I_C = 5 A, See Notes 6 and 7		1.6		1.6	V
		V_{CE} = 4 V, I_C = 8 A		2.5		2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.5 A, I_C = 5 A, See Notes 6 and 7		1		1	V
		I_B = 1.6 A, I_C = 8 A		3		3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 1 A, f = 1 kHz	20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 0.5 A, f = 1 MHz	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz		300		300	pF

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	I_C = 4 A, $I_{B(1)}$ = 0.4 A, $I_{B(2)}$ = −0.4 A, $V_{BE(off)}$ = −5 V, R_L = 7.5 Ω,		0.7	μs
t_s	Storage Time			1	
t_f	Fall Time			0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data.

MAXIMUM SAFE OPERATING AREA

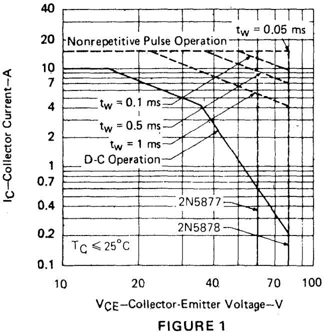


FIGURE 1

THERMAL CHARACTERISTICS

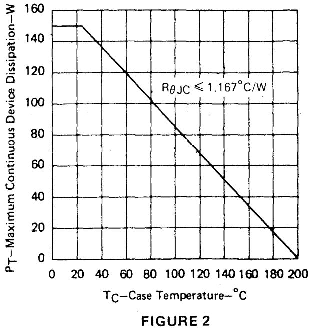


FIGURE 2

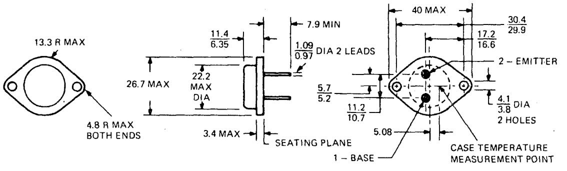
TYPES 2N5883, 2N5884
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

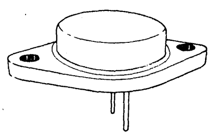
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH 2N5885, 2N5886

- 200 Watts at 25°C Case Temperature
- 25-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 1 A
- 90-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





DIMENSIONS ARE IN MILLIMETRES

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5883	2N5884
Collector-Base Voltage	−60 V*	−80 V*
Collector-Emitter Voltage (See Note 1)	−60 V*	−80 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	◄— −25 A† −20 A* —►	
Peak Collector Current (See Note 2)	◄— −30 A —►	
Continuous Base Current	◄— −6 A* —►	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	◄— 200 W* —►	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	◄— 5 W —►	
Unclamped Inductive Load Energy (See Note 5)	◄— 90 mJ —►	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	◄— 250°C* —►	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.14 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*‡ $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = -3$ A, Energy $\approx I_C{}^2L/2$.

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*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.
‡This circuit appears on the first page of the data section of this book.

TYPES 2N5883, 2N5884
P-N-P SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5883		2N5884		UNIT
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -0.2$ A,	$I_B = 0$,	See Note 6	−60		−80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30$ V,	$I_B = 0$			−2			mA
		$V_{CE} = -40$ V,	$I_B = 0$					−2	
I_{CEV}	Collector Cutoff Current	$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V			−1			mA
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V					−1	
		$V_{CE} = -60$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$		−10			
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V,	$T_C = 150°C$				−10	
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V,	$I_E = 0$			−1			mA
		$V_{CB} = -80$ V,	$I_E = 0$					−1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V,	$I_C = 0$			−1		−1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -3$ A	See Notes 6 and 7	35		35		
		$V_{CE} = -4$ V,	$I_C = -10$ A		20	100	20	100	
		$V_{CE} = -4$ V,	$I_C = -20$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -1.5$ A,	$I_C = -15$ A	See Notes 6 and 7		−1.8		−1.8	V
		$V_{CE} = -4$ V,	$I_C = -20$ A			−2.5		−2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1.5$ A,	$I_C = -15$ A	See Notes 6 and 7		−1		−1	V
		$I_B = -4$ A,	$I_C = -20$ A			−4		−4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -3$ A,	f = 1 kHz	20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -1$ A,	f = 1 MHz	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		800		800	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ⩽ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	$I_C = -10$ A, $I_{B(1)} = -1$ A, $I_{B(2)} = 1$ A $V_{BE(off)} = 4$ V, $R_L = 3\ \Omega$, See Note 8		0.7	μs
t_s	Storage Time			1	
t_f	Fall Time			0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

NOTE 8: These characteristics are measured in the circuit of clause 3.3.13.2 of the forthcoming JEDEC publication *Suggested Standards o Power Transistors.*‡ $V_{BB1} = 25$ V, $V_{BB2} = 4$ V, $V_{CC} = 30$ V, $V_{on} = -23$ V, $R_{BB1} = 11\ \Omega$, $R_{BB2} = 5\ \Omega$.

‡This circuit appears on the first page of the data section of this book.

MAXIMUM SAFE OPERATING AREA

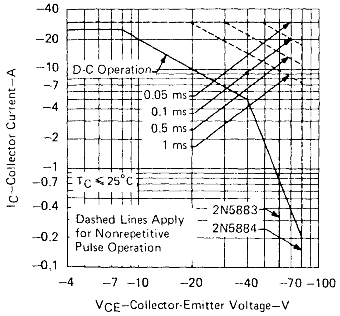


FIGURE 1

THERMAL CHARACTERISTICS

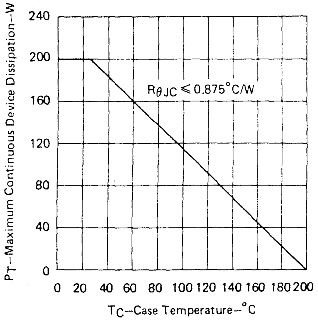


FIGURE 2

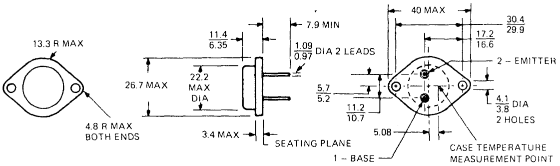
TYPES 2N5885, 2N5886
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5883, 2N5884

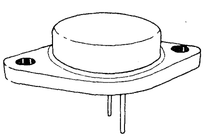
- 200 Watts at 25°C Case Temperature
- 25-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 1 A
- 90-mJ Reverse Energy Rating

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N5885	2N5886
Collector-Base Voltage	60 V*	80 V*
Collector-Emitter Voltage (See Note 1)	60 V*	80 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	← 25 A† 20 A* →	
Peak Collector Current (See Note 2)	← 30 A →	
Continuous Base Current	← 6 A* →	
Safe Operating Area at (or below) 25°C Case Temperature	See Figure 1	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 200 W* →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 5 W →	
Unclamped Inductive Load Energy (See Note 5)	← 90 mJ →	
Operating Collector Junction Temperature Range	−65°C to 200°C*	
Storage Temperature Range	−65°C to 200°C*	
Terminal Temperature 1.588mm from Case for 10 Seconds	← 250°C* →	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.14 W/°C.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C.
5. This rating is based on the capability of the transistors to operate safely in the unclamped-inductive load circuit of Section 3.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*‡ $L = 20$ mH, $R_{BB1} = 20\ \Omega$, $R_{BB2} = 100\ \Omega$, $V_{BB1} = 10$ V, $V_{BB2} = 0$ V, $R_L = 0.1\ \Omega$, $V_{CC} = 10$ V, $I_{CM} = 3$ A. Energy $\approx I_C{}^2L/2$.

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*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

‡This circuit appears on the first page of the data section of this book.

TYPES 2N5885, 2N5886
N-P-N SINGLE-DIFFUSED SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5885		2N5886		UNIT
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 0.2$ A,	$I_B = 0$,	See Note 6	60		80		V
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30$ V,	$I_B = 0$			2			mA
		$V_{CE} = 40$ V,	$I_B = 0$					2	
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60$ V,	$V_{BE} = -1.5$ V			1			mA
		$V_{CE} = 80$ V,	$V_{BE} = -1.5$ V					1	
		$V_{CE} = 60$ V,	$V_{BE} = -1.5$ V,	$T_C = 150°C$		10			
		$V_{CE} = 80$ V,	$V_{BE} = -1.5$ V,	$T_C = 150°C$				10	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V,	$I_E = 0$			1			mA
		$V_{CB} = 80$ V,	$I_E = 0$					1	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V,	$I_C = 0$			1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4$ V,	$I_C = 3$ A	See Notes 6 and 7	35		35		
		$V_{CE} = 4$ V,	$I_C = 10$ A		20	100	20	100	
		$V_{CE} = 4$ V,	$I_C = 20$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = 1.5$ A,	$I_C = 15$ A	See Notes 6 and 7		1.8		1.8	V
		$V_{CE} = 4$ V,	$I_C = 20$ A			2.5		2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1.5$ A,	$I_C = 15$ A	See Notes 6 and 7		1		1	V
		$I_B = 4$ A,	$I_C = 20$ A			4		4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4$ V,	$I_C = 3$ A,	f = 1 kHz	20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 1$ A,	f = 1 MHz	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz		500		500	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	$I_C = 10$ A, $I_{B(1)} = 1$ A, $I_{B(2)} = -1$ A, $V_{BE(off)} = -4$ V, $R_L = 3\ \Omega$, See Note 8		0.7	µs
t_s	Storage Time			1	
t_f	Fall Time			0.8	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data.

NOTE 8: These characteristics are measured in the circuit of clause 3.3.13.2 of the forthcoming JEDEC publication *Suggested Standards on Power Transistors.*‡ $V_{BB1} = 25$ V, $V_{BB2} = 4$ V, $V_{CC} = 30$ V, $V_{on} = 23$ V, $R_{BB1} = 11\ \Omega$, $R_{BB2} = 5\ \Omega$.

‡This circuit appears on the first page of the data section of this book.

MAXIMUM SAFE OPERATING AREA

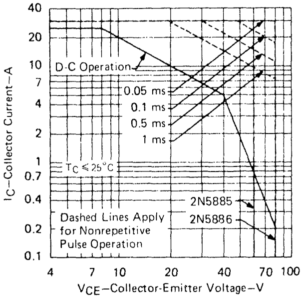


FIGURE 1

THERMAL CHARACTERISTICS

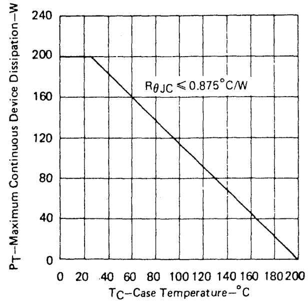


FIGURE 2

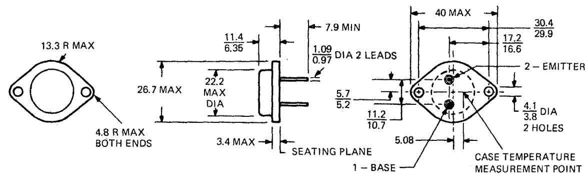
2N6270, 2N6271, 2N6272, 2N6273
NPN SILICON POWER TRANSISTORS

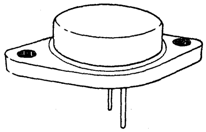
FOR POWER-AMPLIFIER AND HIGH-SPEED SWITCHING APPLICATIONS

- 100-mJ Reverse-Energy Rating
- 30-A Rated Continuous Collector Current
- 150 Watts at 100°C Case Temperature
- Min f_T of 75 MHz at 10 V, 1 A

*mechanical data

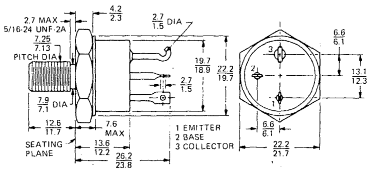
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





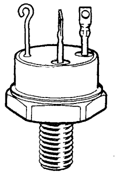
ALL DIMENSIONS ARE IN MILLIMETRES

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-63 DIMENSIONS AND NOTES ARE APPLICABLE

CASE TEMPERATURE MEASUREMENT POINT IS UNDERSIDE OF FLAT SURFACE WITHIN 3.2mm FROM STUD



ALL DIMENSIONS ARE IN MILLIMETRES

*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N6270 2N6272	2N6271 2N6273
Collector-Base Voltage	100 V	120 V
Collector-Emitter Voltage (See Note 1)	80 V	100 V
Emitter-Base Voltage	8 V	8 V
Continuous Collector Current	← 30 A →	
Peak Collector Current (See Note 2)	← 40 A →	
Continuous Base Current	← 10 A →	
Safe Operating Areas	See Figures 6 and 7	
Unclamped Inductive Load Energy (See Note 3 and Figure 7)	← 100 mJ →	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 4)	← 150 W →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	← 5 W →	
Operating Collector Junction Temperature Range	−65°C to 200°C	
Storage Temperature Range	−65°C to 200°C	
Terminal Temperature 1.588mm from Case for 10 Seconds	← 300°C →	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 5. $L = 1$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V, Energy $\approx I_C{}^2L/2$.
4. For operation above 100°C case temperature, refer to Dissipation Derating Curve, Figure 8.
5. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 9.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication..

2N6270, 2N6271, 2N6272, 2N6273
NPN SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N6270 2N6272		2N6271 2N6273		UNIT
					MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA,	I_B = 0,	See Note 6	80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 40 V,	I_B = 0			1			mA
		V_{CE} = 50 V,	I_B = 0					1	
I_{CES}	Collector Cutoff Current	V_{CE} = 100 V,	V_{BE} = 0			1			mA
		V_{CE} = 120 V,	V_{BE} = 0					1	
		V_{CE} = 60 V,	V_{BE} = 0,	T_C = 150°C		2		2	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V,	I_C = 0			0.1		0.1	mA
		V_{EB} = 8 V,	I_C = 0			1		1	
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V,	I_C = 15 A,	See Notes 6 and 7	20	100	20	100	
		V_{CE} = 4 V,	I_C = 30 A,	See Notes 6 and 7	10		10		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V,	I_C = 30 A,	See Notes 6 and 7		2.2		2.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1.5 A,	I_C = 15 A,	See Notes 6 and 7		1		1	V
		I_B = 6 A,	I_C = 30 A,	See Notes 6 and 7		2		2	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 1 A,	f = 1 kHz	30		30		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 1 A,	f = 5 MHz	15		15		

*JEDEC registered data

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			2N6270 2N6272	2N6271 2N6273	UNIT
					TYP	TYP	
t_{on}	Turn-On Time	I_C = 15 A,	$I_{B(1)}$ = 1.2 A,	$I_{B(2)}$ = −1.2 A,	0.5	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −6.3 V,	R_L = 2 Ω,	See Figure 1	1.3	1.3	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

TYPICAL CHARACTERISTICS

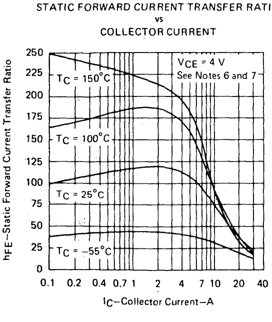


FIGURE 1

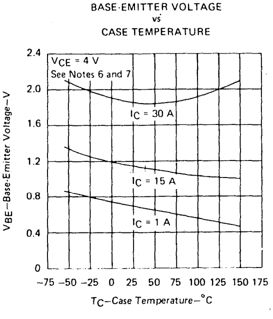


FIGURE 2

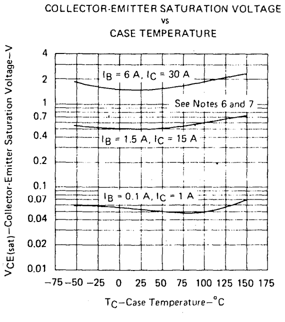
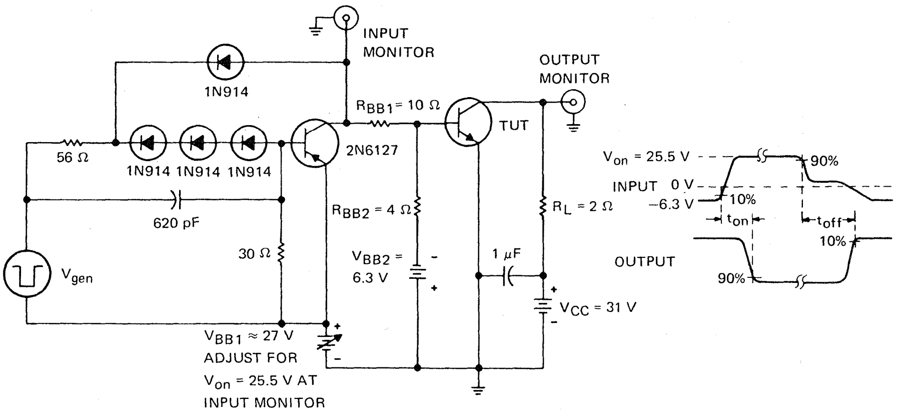


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2n from the device body.

PARAMETER MEASUREMENT INFORMATION

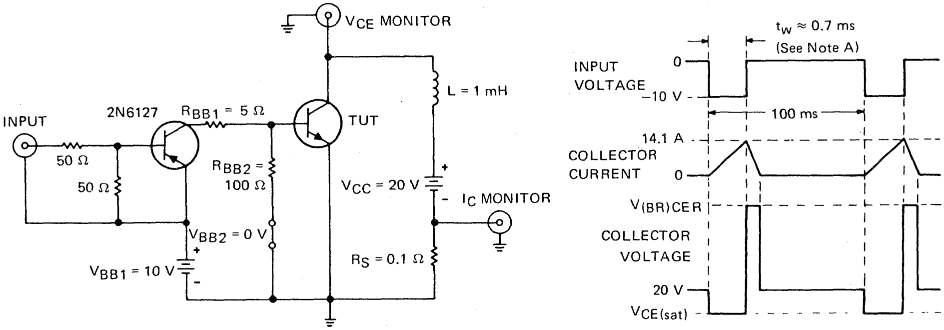


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
- A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
- B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
- D. Resistors must be noninductive types.
- E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 4

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until $I_{CM} = 14.1$ A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

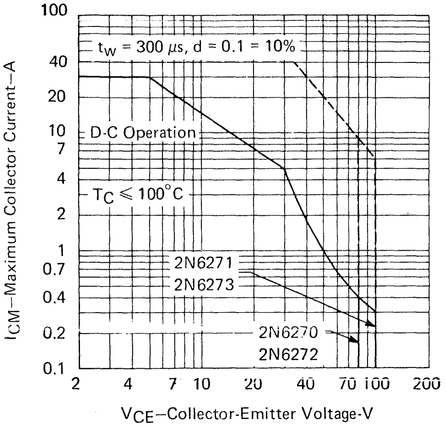


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

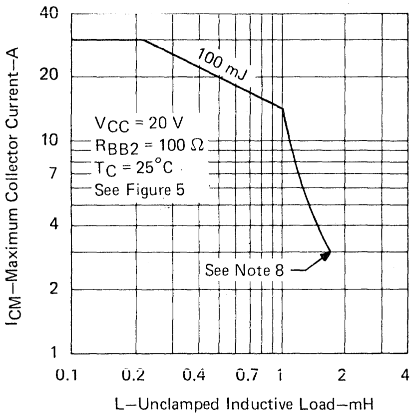


FIGURE 7

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

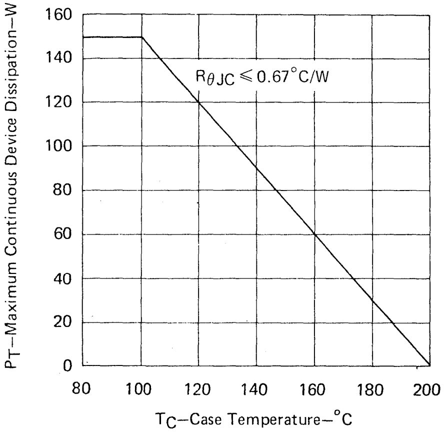


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

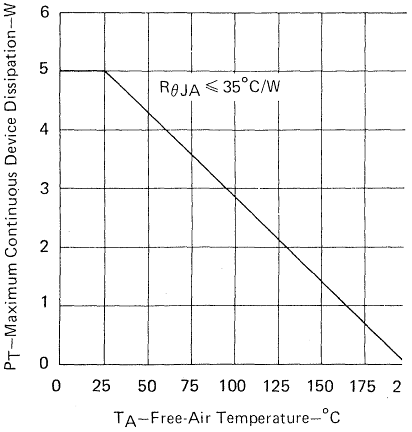


FIGURE 9

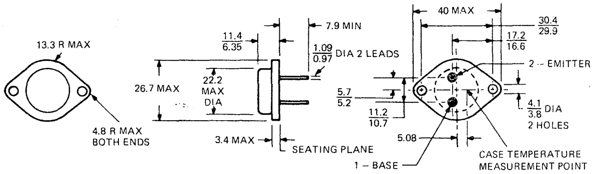
2N6322, 2N6323, 2N6324, 2N6325
NPN SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR INDUSTRIAL AND MILITARY APPLICATIONS

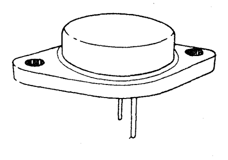
- 100-mJ Reverse-Energy Rating
- 30-A Rated Continuous Collector Current
- 200 Watts at 100°C Case Temperature
- Min $V_{(BR)CEO}$ of 300 V (2N6323, 2N6325)

*mechanical data

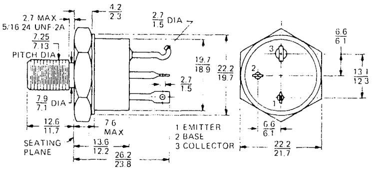
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



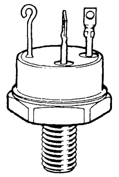
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-63 DIMENSIONS AND NOTES ARE APPLICABLE

CASE TEMPERATURE MEASUREMENT POINT IS UNDERSIDE OF FLAT SURFACE WITHIN 3.2mm FROM STUD

ALL DIMENSIONS ARE IN MILLIMETRES



*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N6322 2N6324	2N6323 2N6325
Collector-Base Voltage	300 V	400 V
Collector-Emitter Voltage (See Note 1)	200 V	300 V
Emitter-Base Voltage	5 V	5 V
Continuous Collector Current	←— 30 A —→	
Peak Collector Current (See Note 2)	←— 40 A —→	
Continuous Base Current	←— 10 A —→	
Safe Operating Areas	See Figures 6 and 7	
Unclamped Inductive Load Energy (See Note 3 and Figure 7)	←— 100 mJ —→	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 4)	←— 200 W —→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	←— 5 W —→	
Operating Collector Junction Temperature Range	−65°C to 200°C	
Storage Temperature Range	−65°C to 200°C	
Terminal Temperature 1.588mm from Case for 10 Seconds	←— 230°C —→	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 0.3$ ms, duty cycle $\leqslant 10\%$.
3. This rating is based on the capability of the transistor to operate safely in the circuit of Figure 5. $L = 30$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V, Energy $\approx I_C{}^2L/2$.
4. For operation above 100°C case temperature, refer to Dissipation Derating Curve, Figure 8.
5. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 9.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication..

2N6322, 2N6323, 2N6324, 2N6325
NPN SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N6322 2N6324		2N6323 2N6325		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 6	200		300		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 100 V, I_B = 0		5			mA
		V_{CE} = 150 V, I_B = 0				5	
I_{CES}	Collector Cutoff Current	V_{CE} = 300 V, V_{BE} = 0		2			mA
		V_{CE} = 400 V, V_{BE} = 0				2	
		V_{CE} = 200 V, V_{BE} = 0, T_C = 150°C		10		10	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		5		5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 5 A, See Notes 6 and 7	40	150	30	150	
		V_{CE} = 5 V, I_C = 20 A	12		12		
		V_{CE} = 5 V, I_C = 30 A	6		6		
V_{BE}	Base-Emitter Voltage	V_{CE} = 5 V, I_C = 30 A, See Notes 6 and 7		2.5		2.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.5 A, I_C = 5 A, See Notes 6 and 7		0.5		0.5	V
		I_B = 2 A, I_C = 20 A		1.5		1.5	
		I_B = 6 A, I_C = 30 A		3		3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 1 kHz	35		30		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A, f = 5 MHz	2		2		

*JEDEC registered data

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 20 A, $I_{B(1)}$ = 2 A, $I_{B(2)}$ = −2 A,	0.8	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −3 V, R_L = 2 Ω, See Figure 4	3	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

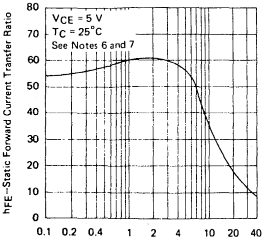


FIGURE 1

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

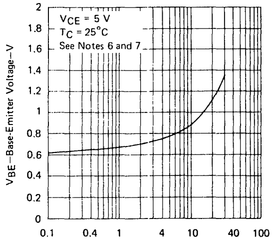


FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

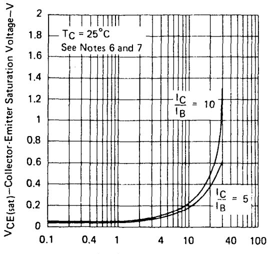
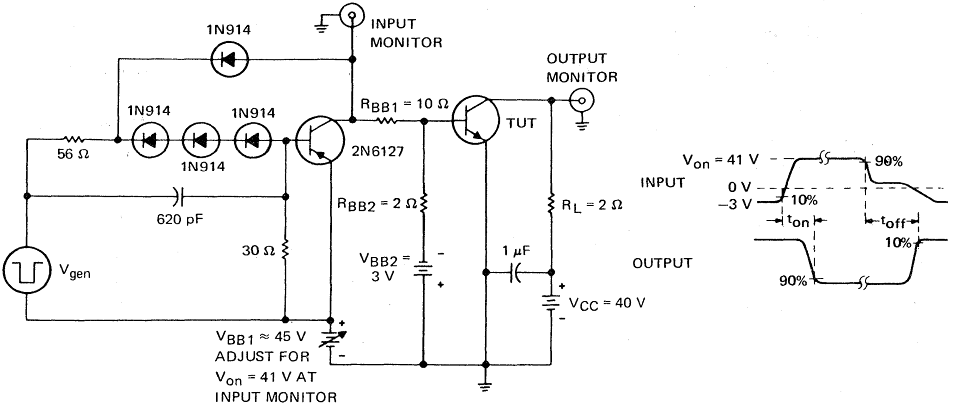


FIGURE 3

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mr from the device body.

PARAMETER MEASUREMENT INFORMATION

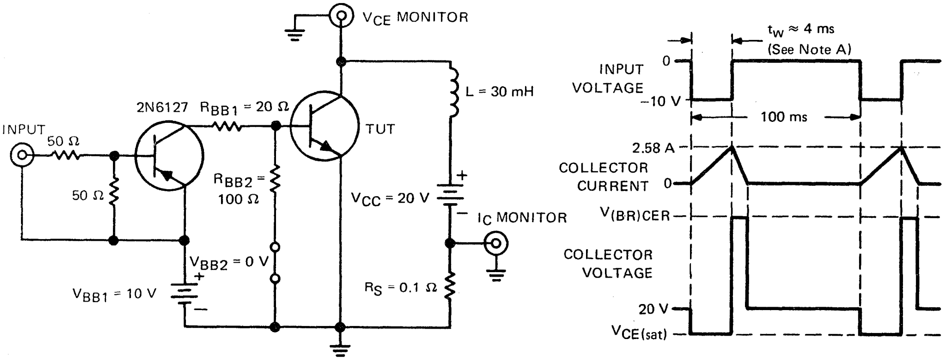


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 4

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until $I_{CM} = 2.58$ A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

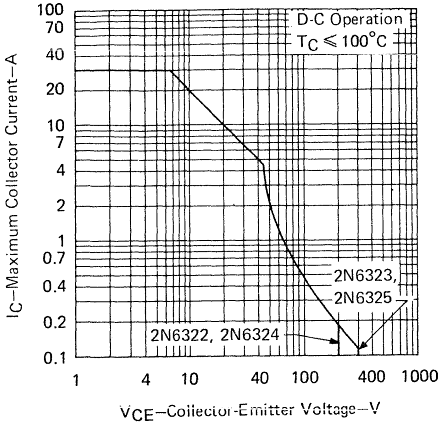


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

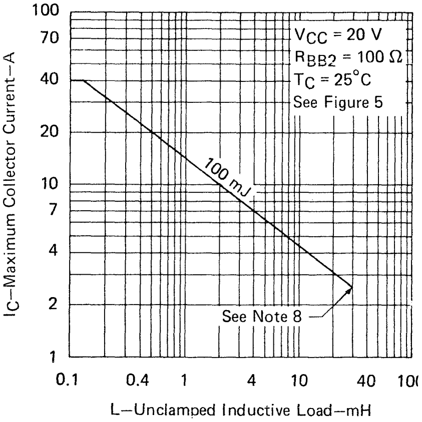


FIGURE 7

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

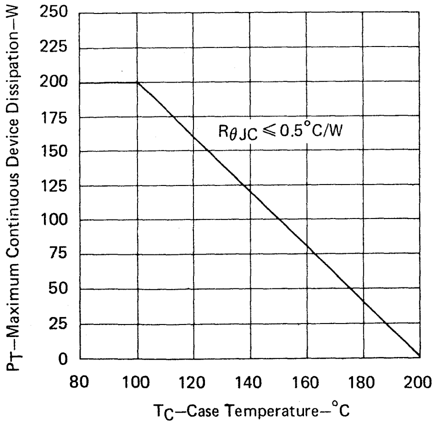


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

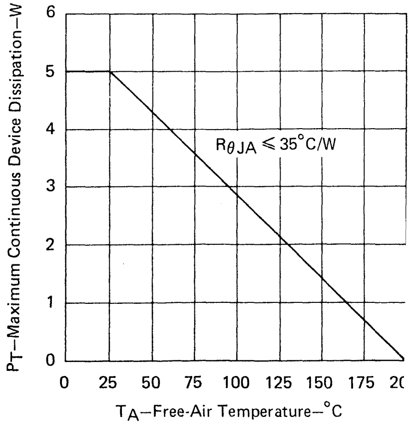


FIGURE 9

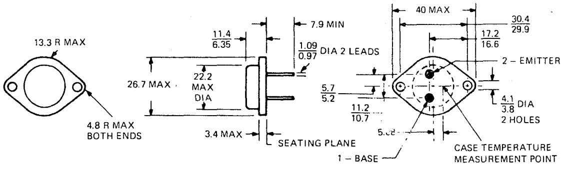
TYPES 2N6326, 2N6327, 2N6328
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH 2N6329, 2N6330, 2N6331

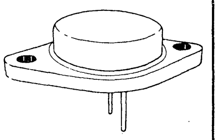
- 200 W at 25°C Case Temperature
- 30-A Rated Collector Current
- 200-mJ Reverse Energy Rating
- High SOA Capability, 20 V and 10 A

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



DIMENSIONS ARE IN MILLIMETRES



*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N6326	2N6327	2N6328
Collector-Base Voltage	60 V	80 V	100 V
Collector-Emitter Voltage (See Note 1)	60 V	80 V	100 V
Emitter-Base Voltage	5 V	5 V	5 V
Continuous Collector Current	30 A		
Peak Collector Current (See Note 2)	40 A		
Continuous Base Current	10 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 3 and 4		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	200 W		
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	114 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W		
Unclamped Inductive Load Energy (See Note 5)	200 mJ		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Terminal Temperature 3.2 mm from Case for 10 Seconds	250°C		

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.14 W/°C or refer to Dissipation Derating Curve, Figure 5.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 6.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2 L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPES 2N6326, 2N6327, 2N6328
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N6326		2N6327		2N6328		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0,	See Note 6	60		80		100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = 30 V, I_B = 0			1					mA
		V_{CE} = 40 V, I_B = 0					1			
		V_{CE} = 50 V, I_B = 0							1	
I_{CES}	Collector Cutoff Current	V_{CE} = 60 V, V_{BE} = 0			0.5					mA
		V_{CE} = 80 V, V_{BE} = 0					0.5			
		V_{CE} = 100 V, V_{BE} = 0							0.5	
		V_{CE} = 30 V, V_{BE} = 0,	T_C = 150°C		5					
		V_{CE} = 40 V, V_{BE} = 0,	T_C = 150°C				5			
		V_{CE} = 50 V, V_{BE} = 0,	T_C = 150°C						5	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0,			0.5		0.5		0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 5 A	See Notes 6 and 7	25		25		25		
		V_{CE} = 4 V, I_C = 15 A		12		12		12		
		V_{CE} = 4 V, I_C = 30 A		6	30	6	30	6	30	
V_{BE}	Base-Emitter Voltage	V_{CE} = 4 V, I_C = 15 A	See Notes 6 and 7		2		2		2	V
		V_{CE} = 4 V, I_C = 30 A			4		4		4	
$V_{CE(sat)}$	Collector-Emitter Voltage	I_B = 2 A, I_C = 15 A	See Notes 6 and 7		1.5		1.5		1.5	V
		I_B = 7.5 A, I_C = 30 A			3		3		3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A,	f = 1 kHz	30		30		30		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 A,	f = 1 MHz	3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

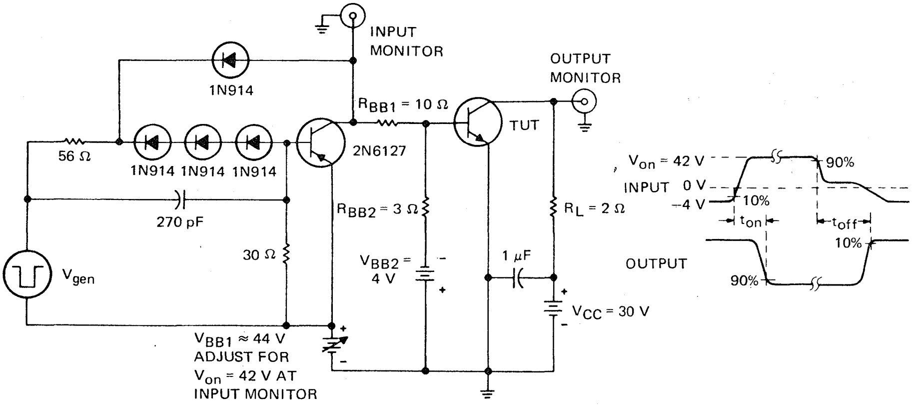
*JEDEC registered data

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = 15 A,	$I_{B(1)}$ = 2 A,	$I_{B(2)}$ = −2 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V,	R_L = 2 Ω,	See Figure 1	0.9	

†Voltage and current values shown are nominal, exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

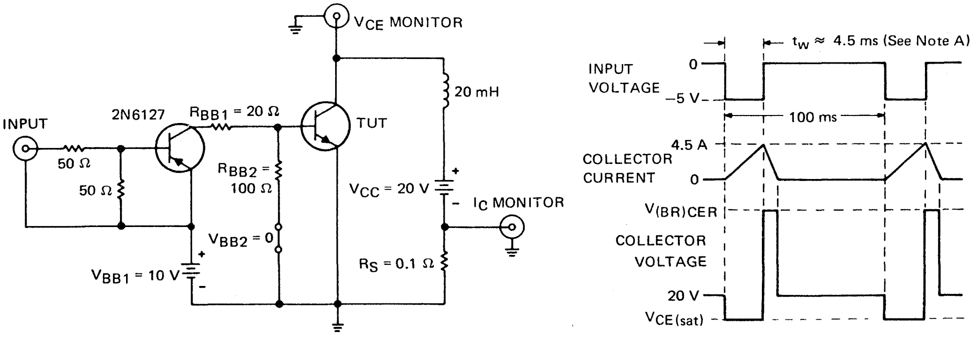


TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.
D. Resistors must be noninductive types.
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until $I_{CM} = 4.5$ A.

FIGURE 2

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

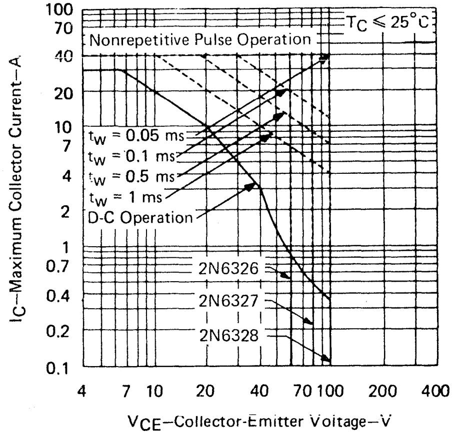


FIGURE 3

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

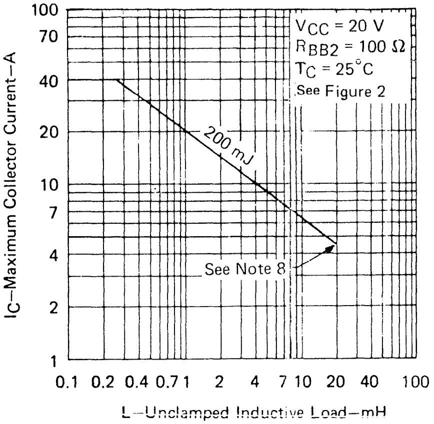


FIGURE 4

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

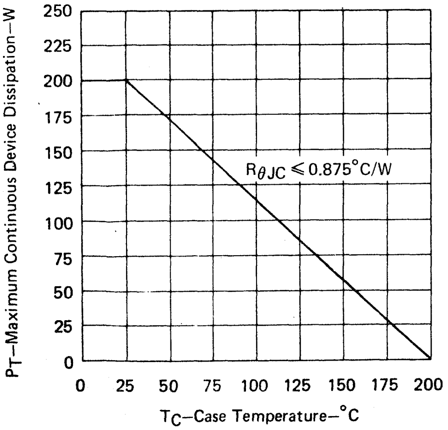


FIGURE 5

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

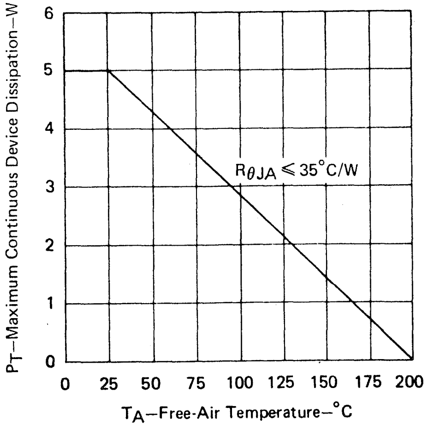


FIGURE 6

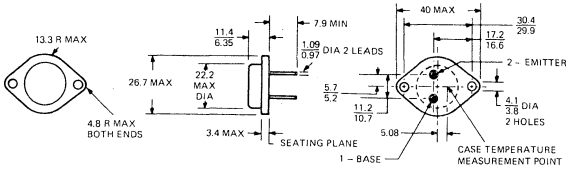
TYPES 2N6329, 2N6330, 2N6331
P-N-P SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N6326, 2N6327, 2N6328

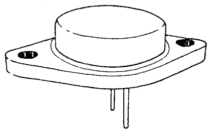
- 200 W at 25°C Case Temperature
- 30-A Rated Collector Current
- 200-mJ Reverse Energy Rating
- High SOA Capability, 20 V and 10 A

*mechanical data

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES



*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N6329	2N6330	2N6331
Collector-Base Voltage	−60 V	−80 V	−100 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−100 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	−30 A		
Peak Collector Current (See Note 2)	−40 A		
Continuous Base Current	−10 A		
Safe Operating Areas at (or below) 25°C Case Temperature	See Figures 3 and 4		
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	200 W		
Continuous Device Dissipation at 100°C Case Temperature (See Note 3)	114 W		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	5 W		
Unclamped Inductive Load Energy (See Note 5)	200 mJ		
Operating Collector Junction Temperature Range	−65°C to 200°C		
Storage Temperature Range	−65°C to 200°C		
Terminal Temperature 3.2mm from Case for 10 Seconds	250°C		

NOTES:
1. These value apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leqslant 1$ ms, duty cycle $\leqslant 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 1.14 W/°C or refer to Dissipation Derating Curve, Figure 5.
4. Derate linearly to 200°C free-air temperature at the rate of 28.6 mW/°C or refer to Dissipation Derating Curve, Figure 6.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 2. $L = 20$ mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPES 2N6329, 2N6330, 2N6331
P-N-P SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N6329		2N6330		2N6331		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = −30 mA, I_B = 0,	See Note 6	−60		−80		−100		V
I_{CEO}	Collector Cutoff Current	V_{CE} = −30 V, I_B = 0		−1						mA
		V_{CE} = −40 V, I_B = 0				−1				
		V_{CE} = −50 V, I_B = 0						−1		
I_{CES}	Collector Cutoff Current	V_{CE} = −60 V, V_{BE} = 0			−0.5					mA
		V_{CE} = −80 V, V_{BE} = 0					−0.5			
		V_{CE} = −100 V, V_{BE} = 0							−0.5	
		V_{CE} = −30 V, V_{BE} = 0,	T_C = 150°C		−5					
		V_{CE} = −40 V, V_{BE} = 0,	T_C = 150°C				−5			
		V_{CE} = −50 V, V_{BE} = 0,	T_C = 150°C						−5	
I_{EBO}	Emitter Cutoff Current	V_{EB} = −5 V, I_C = 0,			−0.5		−0.5		−0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = −4 V, I_C = −5 A	See Notes 6 and 7	25		25		25		
		V_{CE} = −4 V, I_C = −15 A		12		12		12		
		V_{CE} = −4 V, I_C = −30 A		6	30	6	30	6	30	
V_{BE}	Base-Emitter Voltage	V_{CE} = −4 V, I_C = −15 A	See Notes 6 and 7		−2		−2	4	−2	V
		V_{CE} = −4 V, I_C = −30 A			−4		−4		−4	
$V_{CE(sat)}$	Collector-Emitter Voltage	I_B = −2 A, I_C = −15 A	See Notes 6 and 7		−1.5		−1.5		−1.5	V
		I_B = −7.5 A, I_C = −30 A			−3		−3		−3	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = −10 V, I_C = −1 A,	f = 1 kHz	30		30		30		
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = −10 V, I_C = −1 A,	f = 1 MHz	3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.

7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

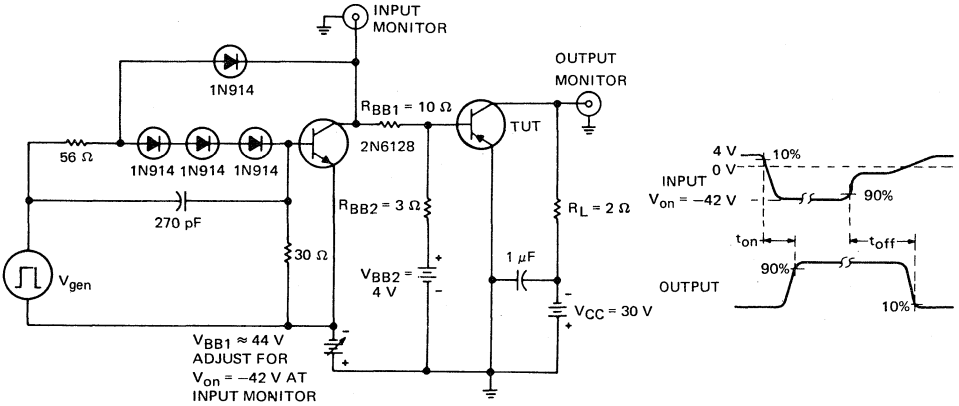
*JEDEC registered data

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = −15 A,	$I_{B(1)}$ = −2 A,	$I_{B(2)}$ = 2 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 4 V,	R_L = 2 Ω,	See Figure 1	0.9	

†Voltage and current values shown are nominal, exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.

B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.

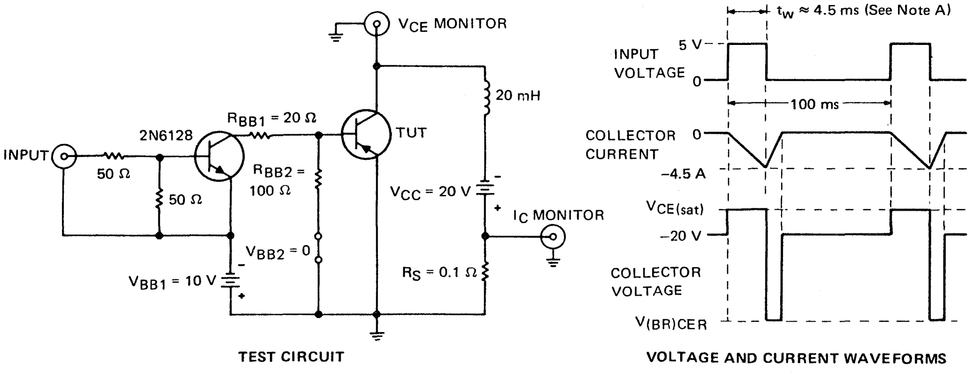
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT

VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -4.5$ A.

FIGURE 2

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

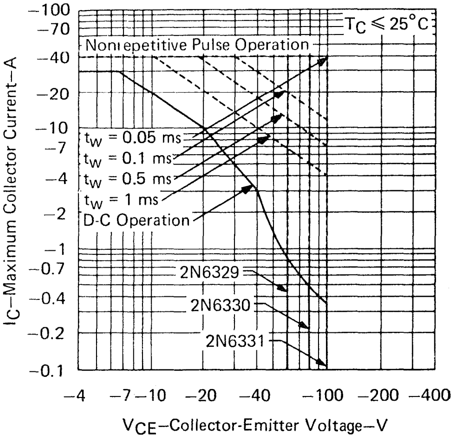


FIGURE 3

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

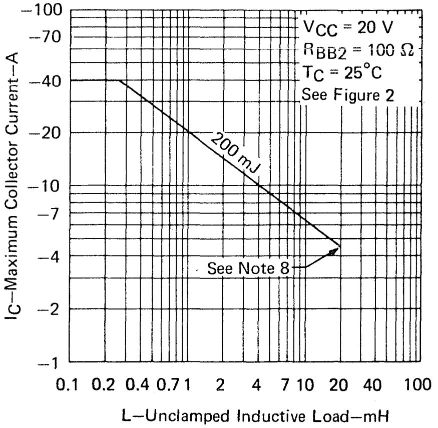


FIGURE 4

NOTE 8: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

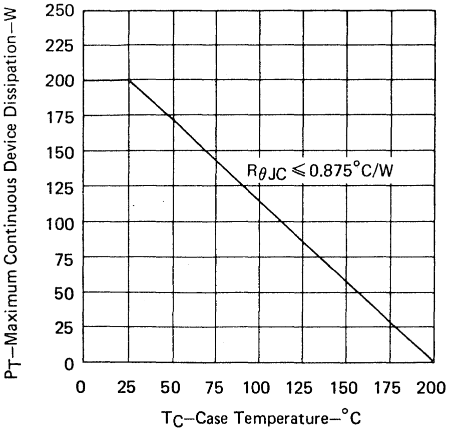


FIGURE 5

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

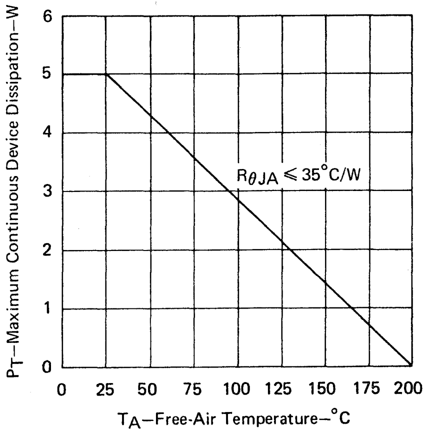


FIGURE 6

Standard Mounting Hardware for Power Semiconductors

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

This section identifies those standard hardware kits which are supplied with each device. At additional cost, nonstandard hardware items will be supplied.

The mounting hardware assembly drawings of Section A (Figures 1 through 11) specify the individual hardware items that are included in each mounting hardware kit. Section A also references the package outlines for which each kit is designed and shows the typical thermal resistance associated with the mounting hardware ($\Theta_{C\text{-}HS}$)[†].

Section B contains mechanical drawings of the individual hardware items that are referenced in Figures 1 through 11.

DIRECTORY

OUTLINE	KIT No.
SO-10	11
TO-3	5
TO-3 (High Voltage)	6
TO-3 (Plastic)	9
TO-53	7
TO-59	1 and 2
TO-61	3
TO-63	4
TO-66 (Plastic)	10
TO-66	8
TO-111	1 and 2

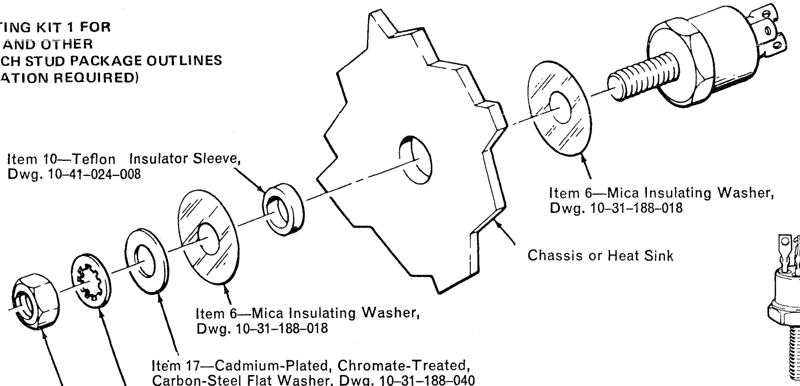
Texas Instruments reserves the right to substitute similar parts at any time in order to expedite delivery or improve design.

[†] $\Theta_{C\text{-}HS}$ is the thermal resistance from the mounting base of the semiconductor-device case to the mounting surface of the heat sink. The heat sink used to determine this value was a smooth, flat, copper plate, with the thermocouple mounted 1.3mm below the mounting surface in an area beneath the device. The device was mounted directly to a clean, dry heat-sink surface, without the use of a thermal compound and a torque of 0.113 Newton Meters (ten inch-pounds) was applied to the stud or each of the mounting screws.

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

Section A – Mounting Hardware Assembly Drawings

MOUNTING KIT 1 FOR
TO-111 AND OTHER
7/16-INCH STUD PACKAGE OUTLINES
(INSULATION REQUIRED)



Item 10—Teflon Insulator Sleeve, Dwg. 10-41-024-008

Item 6—Mica Insulating Washer, Dwg. 10-31-188-018

Chassis or Heat Sink

Item 6—Mica Insulating Washer, Dwg. 10-31-188-018

Item 17—Cadmium-Plated, Chromate-Treated, Carbon-Steel Flat Washer, Dwg. 10-31-188-040

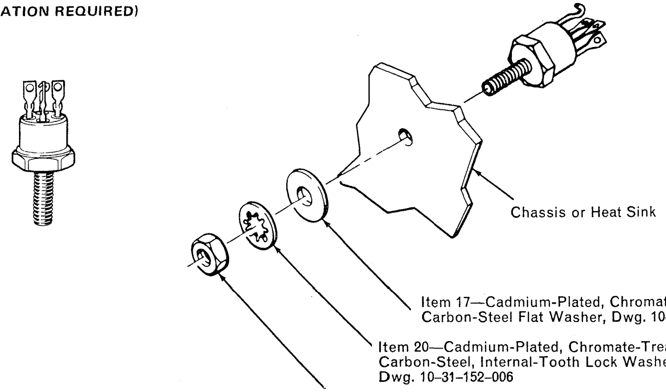
Item 20—Cadmium-Plated, Chromate-Treated, Carbon-Steel Internal-Tooth Lock Washer, Dwg. 10-31-152-006

Item 25—Cadmium-Plated, Chromate-Treated, Carbon-Steel Hex Nut, Dwg. 10-31-036-009

TYPICAL THERMAL RESISTANCE		
θ_{C-HS}	3·8	deg/W

FIGURE 1.

MOUNTING KIT 2 FOR
TO-59, TO-111, AND OTHER
7/16-INCH STUD PACKAGE OUTLINES
(NO INSULATION REQUIRED)



Chassis or Heat Sink

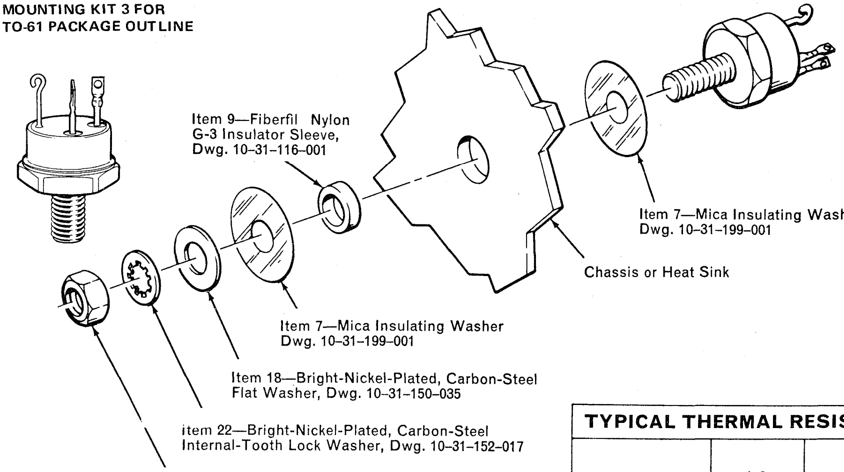
Item 17—Cadmium-Plated, Chromate-Treated, Carbon-Steel Flat Washer, Dwg. 10-31-188-040

Item 20—Cadmium-Plated, Chromate-Treated, Carbon-Steel, Internal-Tooth Lock Washer Dwg. 10-31-152-006

Item 25—Cadmium-Plated, Chromate-Treated, Carbon-Steel Hex Nut, Dwg. 10-31-036-009

FIGURE 2.

MOUNTING KIT 3 FOR TO-61 PACKAGE OUTLINE



Item 9—Fiberfil Nylon G-3 Insulator Sleeve, Dwg. 10-31-116-001

Item 7—Mica Insulating Washer Dwg. 10-31-199-001

Chassis or Heat Sink

Item 7—Mica Insulating Washer Dwg. 10-31-199-001

Item 18—Bright-Nickel-Plated, Carbon-Steel Flat Washer, Dwg. 10-31-150-035

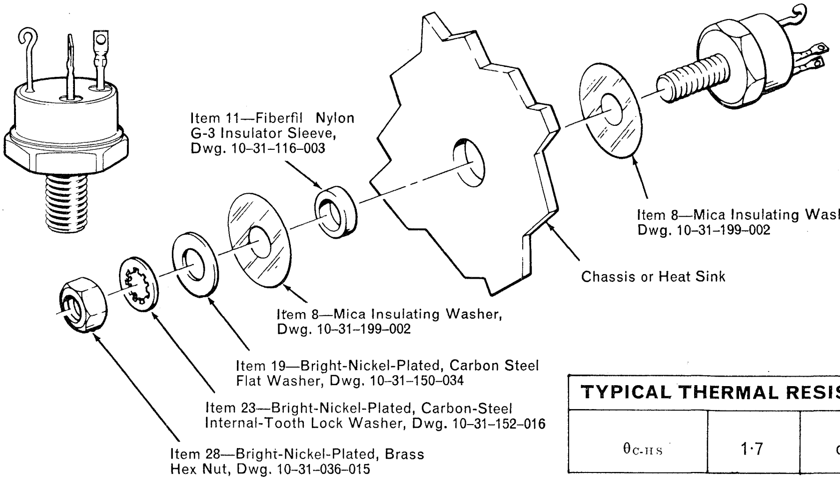
Item 22—Bright-Nickel-Plated, Carbon-Steel Internal-Tooth Lock Washer, Dwg. 10-31-152-017

Item 27—Bright-Nickel-Plated, Brass Hex Nut, Dwg. 10-31-036-016

TYPICAL THERMAL RESISTANCE		
θ_{C-HS}	1·3	deg/W

FIGURE 3.

MOUNTING KIT 4 FOR TO-63 PACKAGE OUTLINE



Item 11—Fiberfil Nylon G-3 Insulator Sleeve, Dwg. 10-31-116-003

Item 8—Mica Insulating Washer, Dwg. 10-31-199-002

Chassis or Heat Sink

Item 8—Mica Insulating Washer, Dwg. 10-31-199-002

Item 19—Bright-Nickel-Plated, Carbon Steel Flat Washer, Dwg. 10-31-150-034

Item 23—Bright-Nickel-Plated, Carbon-Steel Internal-Tooth Lock Washer, Dwg. 10-31-152-016

Item 28—Bright-Nickel-Plated, Brass Hex Nut, Dwg. 10-31-036-015

TYPICAL THERMAL RESISTANCE		
θ_{C-HS}	1·7	deg/W

FIGURE 4.

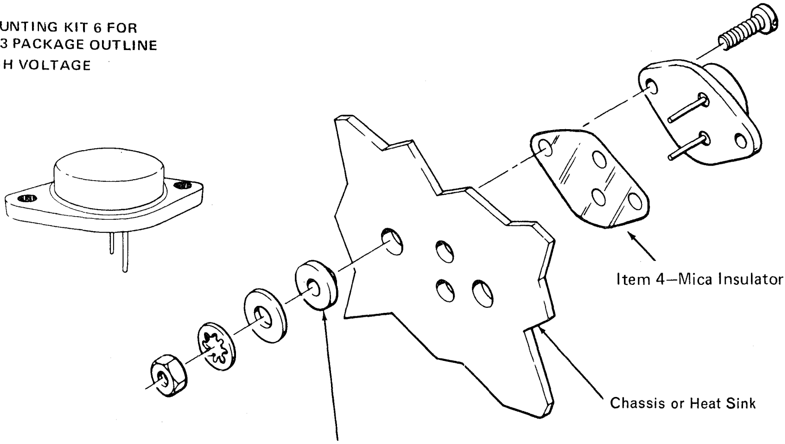
STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

MOUNTING KIT 5 FOR
TO-3 PACKAGE OUTLINE

TYPICAL THERMAL RESISTANCE			
TO-3	$\theta_{C\text{-}HS}$	1·5	deg/W

FIGURE 5.

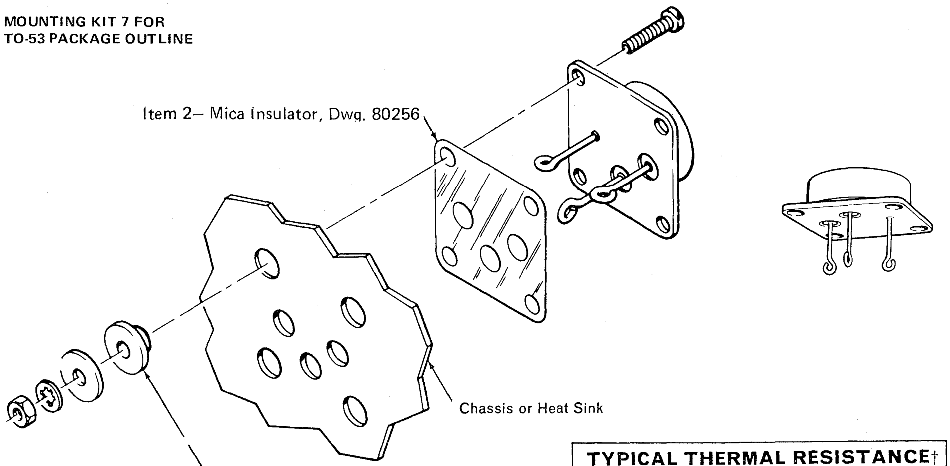
MOUNTING KIT 6 FOR
TO-3 PACKAGE OUTLINE
HIGH VOLTAGE



TYPICAL THERMAL RESISTANCE			
TO-3	$\theta_{C\text{-}HS}$	1·5	deg/W

FIGURE 6.

MOUNTING KIT 7 FOR
TO-53 PACKAGE OUTLINE



Item 2– Mica Insulator, Dwg. 80256

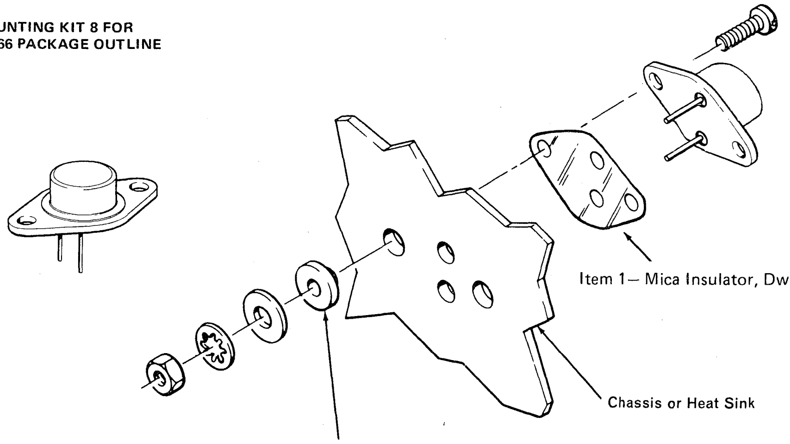
Chassis or Heat Sink

Item 13—Fiberfil Nylon G-3 Insulating Shoulder Washer, Dwg. 10–31–188–019

TYPICAL THERMAL RESISTANCE†		
$\theta_{C\text{-}HS}$	1·6	deg/W

FIGURE 7.

MOUNTING KIT 8 FOR
TO-66 PACKAGE OUTLINE



Item 1– Mica Insulator, Dwg. 311–502–904

Chassis or Heat Sink

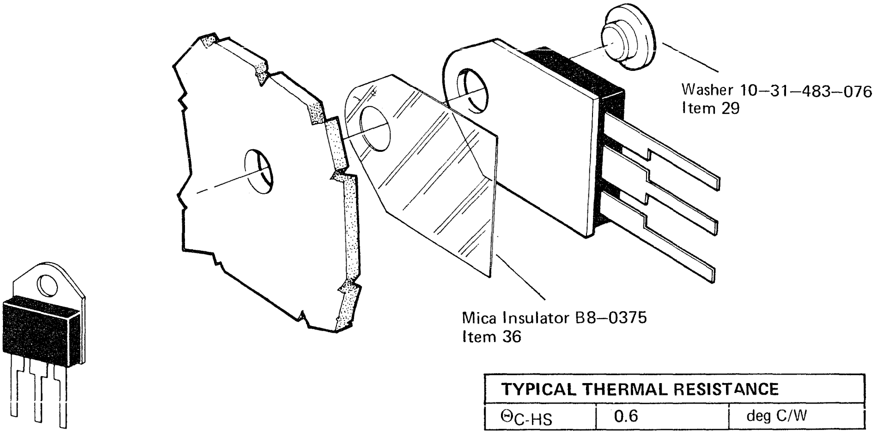
Item 15—Vulcanized-Fiber, Insulating Shoulder Washer, Dwg. 10–31–188–122

TYPICAL THERMAL RESISTANCE†			
TO-66	$\theta_{C\text{-}HS}$	3·75	deg/W

FIGURE 8.

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

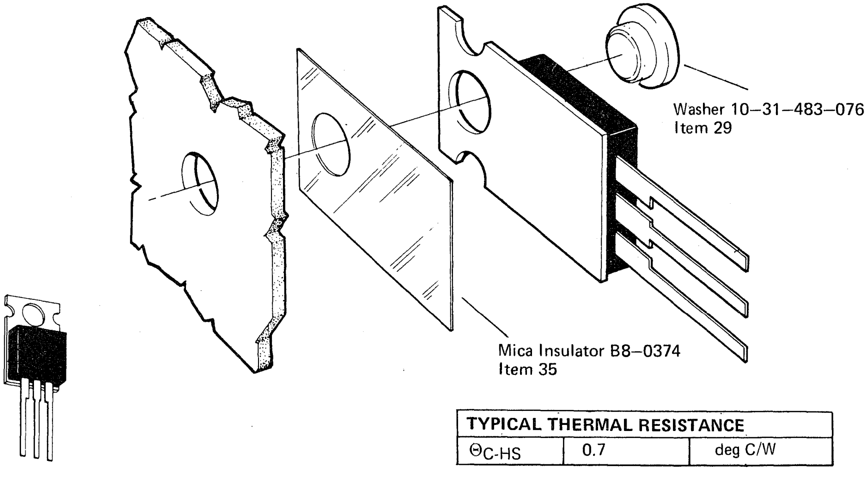
MOUNTING KIT 9 FOR
TO-3 PLASTIC PACKAGE OUTLINE



TYPICAL THERMAL RESISTANCE		
$\Theta_{C\text{-}HS}$	0.6	deg C/W

FIGURE 9.

MOUNTING KIT 10 FOR
TO-66 PLASTIC PACKAGE OUTLINE



TYPICAL THERMAL RESISTANCE		
$\Theta_{C\text{-}HS}$	0.7	deg C/W

FIGURE 10.

**MOUNTING KIT 11 FOR
SO-10 PACKAGE OUTLINE**

TYPICAL THERMAL RESISTANCE		
θC-HS	3.8	deg C/W.

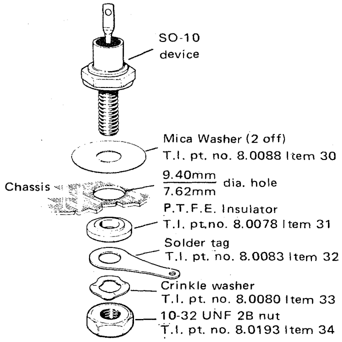
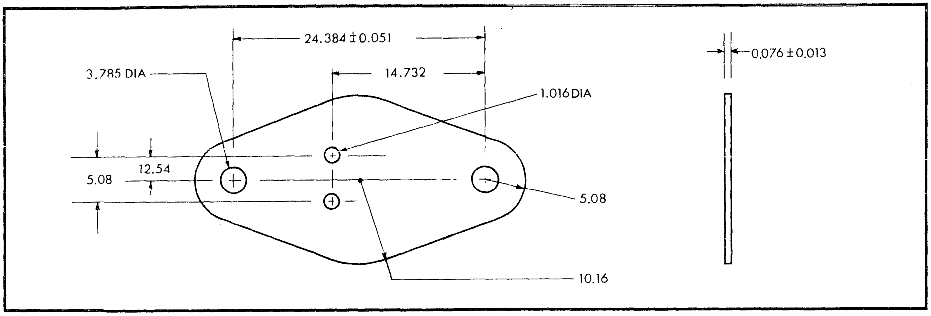


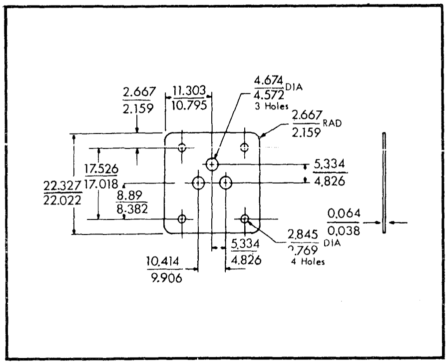
FIGURE 11.

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

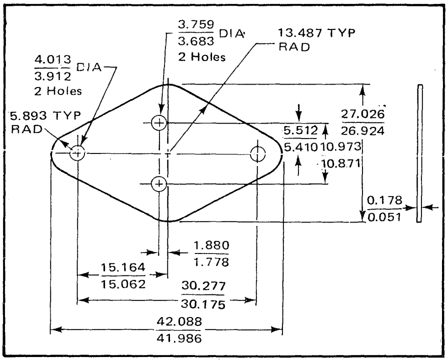
Section B – Mechanical Drawings of Hardware Items†



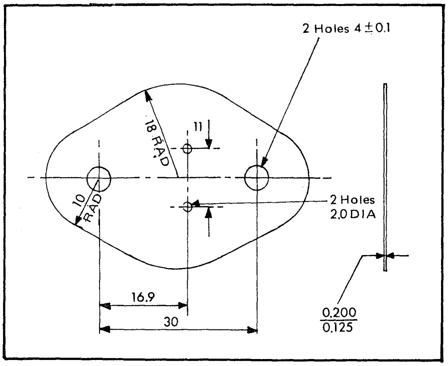
Item 1 INSULATOR



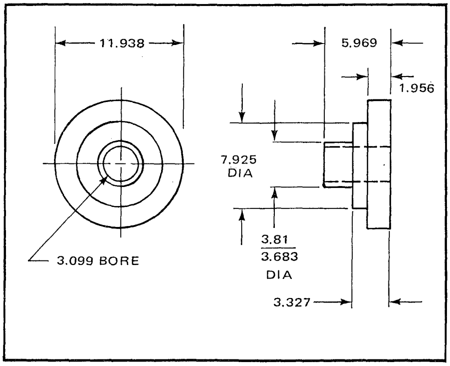
Item 2 INSULATOR



Item 3 INSULATOR



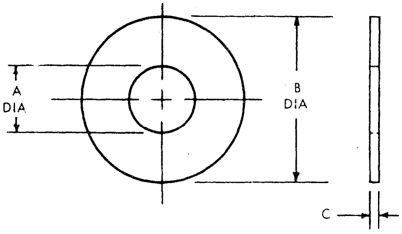
Item 4 INSULATOR



Item 5 INSULATOR SHOULDER WASHER

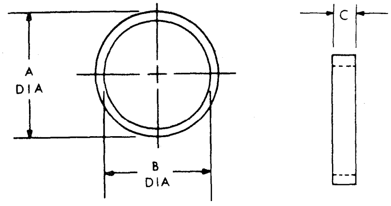
---

†All dimensions are in mm unless otherwise specified.



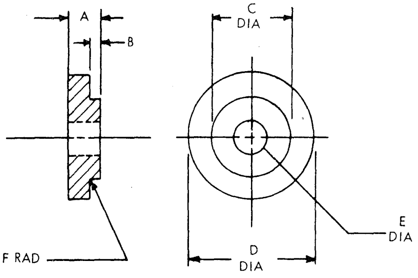
Item	A	B	C
6	5.207 4.953	13.614 13.360	0.127 0.025
7	6.858 6.604	22.479 21.971	0.064 0.038
8	8.458 8.204	26.797 26.289	0.089 0.038

INSULATING WASHER
Item 6 thru 8



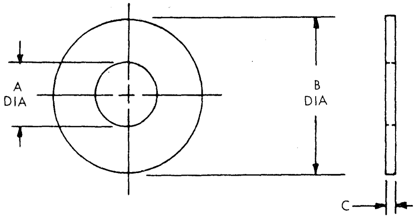
Item	A	B	C
9	8.636 8.382	6.858 6.604	1.829 1.321
10	6.883 6.375	5.156 4.851	1.27 0.889
11	10.287 10.033	8.458 8.204	1.829 1.321
12	5.309 5.055	3.683 3.429	0.914 0.660

INSULATING SLEEVE
Item 9 thru 12



Item	A	B	C	D	E	F
13	2.54 2.032	1.016 0.508	5.08 4.826	8.738 7.112	2.921 2.819	0.406 MAX
15	2.667 1.905	1.143 0.381	6.35 5.842	9.931 9.119	4.369 3.556	NA

INSULATING SHOULDER WASHER
Items 13 and 15

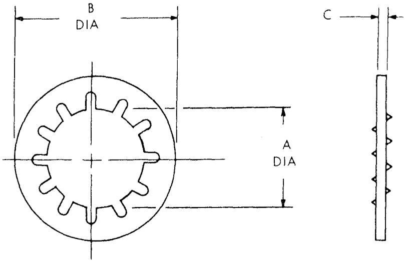


Item	A	B	C
16	3.81 3.607	7.239 6.985	0.356 0.229
17	5.283 5.029	12.827 12.573	1.295 1.041
18	7.010 6.477	16.129 15.621	1.753 0.864
19	8.204 7.671	19.304 18.796	2.032 1.295

Item 16 thru 19

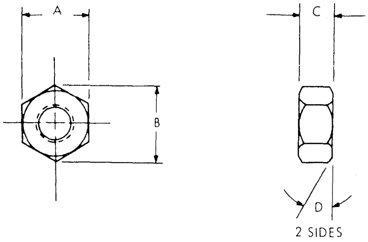
†All dimensions are in mm unless otherwise specified.

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS



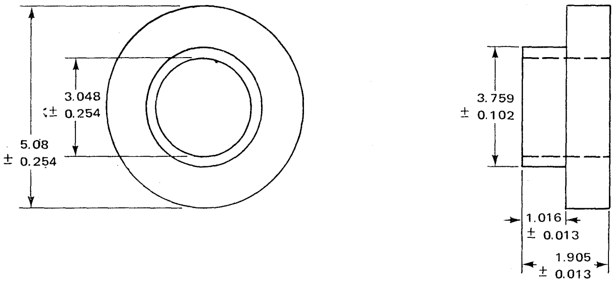
Item	A	B	C
20	5.182 4.953	9.677 9.271	0.635 0.508
21	3.81 3.607	7.493 6.985	0·031 0·015
22	6.781 6.502	12.141 11.836	0.685 0.584
23	8.433 8.128	15.418 15.088	0.813 0.711

INTERNAL TOOTH LOCK WASHER
Item 20 thru 23



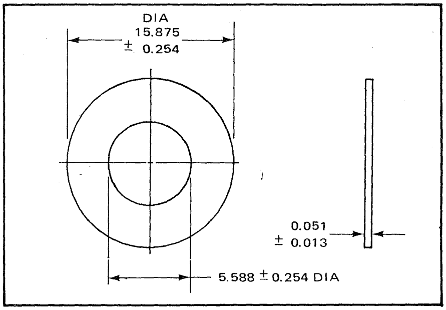
Item	Thread	A	B	C	D
25	10–32 UNF-2B	9.525 9.195	10.998 10.490	3.302 2.972	30°
26	6–32 UNC-2B	6.35 6.121	7.341 6.985	2.489 2.210	30°
27	1/4–28 UNF-2B	11.125 10.744	12.852 12.395	4.902 4.521	30°
28	5/16–24 UNF-2B	14.300 13.843	16.51 15.937	5.715 5.283	30°

HEXAGONAL NUT
Item 25 thru 28

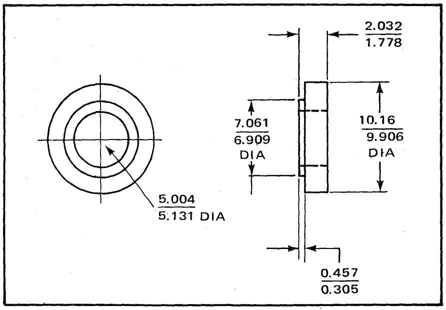


Item 29 WASHER

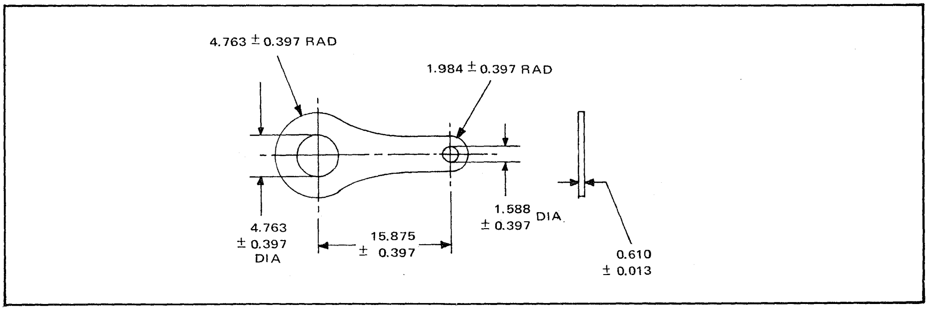
All dimensions are in mm unless otherwise stated



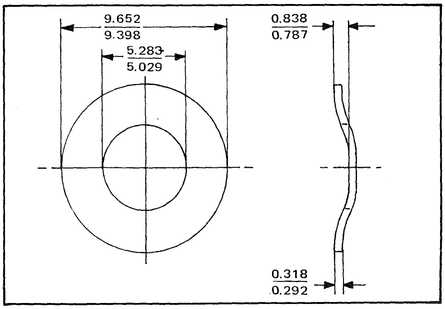
Item 30 WASHER



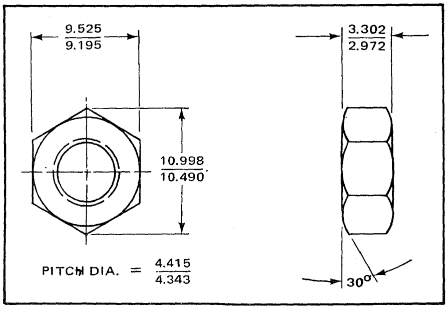
Item 31 INSULATOR



Item 32 SOLDER TAG

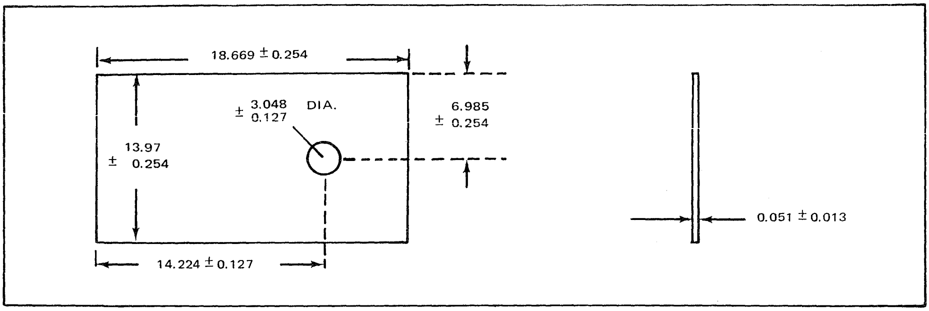


Item 33 CRINKLE WASHER

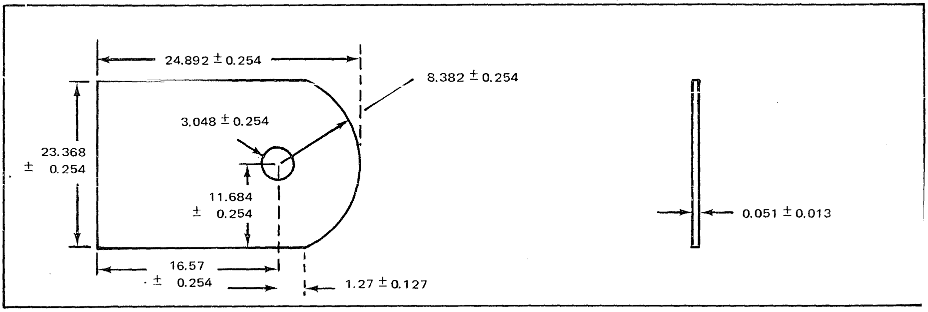


Item 34 NUT

All dimensions are in mm unless otherwise stated



Item 35 INSULATOR



Item 36 INSULATOR

Terms, Definitions, and Testing Procedures

POWER TRANSISTORS

POWER TRANSISTOR SAFETY CONSIDERATIONS

The designer, maker, and user of electrical equipment containing power transistors should give attention to the following points relative to the safety of personnel that may operate the equipment.

The electrical potentials of the collector, emitter, and base terminals on the transistor present an electrical shock hazard when the equipment is energized.

The normal operating case temperature of energized transistors is often high enough to present burn hazards to both operating personnel and flammable material touching the transistor.

If the transistor is falsely turned "on" or fails, power will be applied to the equipment load. Operator safety may be affected by an unexpected energizing of the load.

In the event that an equipment output short or internal fault condition develops, very high surge current can be passed through the transistor. If this condition exceeds transistor ratings for magnitude and duration, the transistor may be damaged; and if the surge is severe enough, internal heating can cause the transistor to rupture and perhaps sustain an arc.

POWER TRANSISTOR STANDARDS

Following are sources of standard material relating to Power Transistors:

EIA and JEDEC Standards:
Electronic Industries Association
2001 Eye St. N.W., Washington, D.C. 20006
Telephone: 202-659-2200

JC-25 Power Transistor Registration Formats RDF-1 to RDF-6

Test Procedures for Verification of Maximum Ratings of Power Transistors–JEDEC Publication No.65

Thermal Resistance Measurements of Conduction Cooled Power Transistors–EIA Standard RS-313-A

JEDEC Recommendations for Letter Symbols, Abbreviations, Terms, and Definitions for Semiconductor Device Data Sheets and Specifications–JEDEC Publication No. 77

Standard List of Values to be used in Power Transistor Device Registration and Minimum Differences for Discretness of Registration–JEDEC Publication NO. 74

IEC Standards

American National Standards Institute, Inc.
1430 Broadway
New York, N. Y. 10018
Telephone: 212-868-1220

IEC Publication 147: Essential Ratings and Characteristics of Semiconductor Devices and General Principles of Measuring Methods.

IEC Publication 148: Letter Symbols for Semiconductor Devices and Integrated Microcircuits

IEC Publication 191: Mechanical Standardization of Semiconductor Devices.

Military Standards
Commanding Officer, U.S. Naval Publications and Forms Center,
5801 Tabor Avenue, Philadelphia, Pa., 19120.

MIL-S-19500: Semiconductor Devices, General Specification for

MIL-STD-105: Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-202: Test Methods for Electronic and Electrical Component Parts

MIL-STD-750: Test Methods for Semiconductor Devices

MIL-STD-883: Test Methods and Procedures for Microelectronics

BSI Standards
British Standards Institute
101 Pentonville Rd
London N1

BS 204. Glossary of terms used in telecommunication (including radio) and electronics. (See also IEC publication 147–0.)
BS 2011. Methods for the environmental testing of electronic components and electronic equipment. (See also IEC publication 68.)
BS 3363. Schedule for letter symbols for semiconductor devices, (See also IEC publication 148.)
BS 3494. Recommendations on semiconductor devices.
BS 3934. Dimensions of semiconductor devices. (See also IEC publication 191–2.)
BS 3939. Graphical symbols for electrical power, telecommunications and electonics diagrams. (See also IEC publication 117.)

POWER TRANSISTOR TERMS, DEFINITIONS, AND LETTER SYMBOLS

Introduction

This part contains letter symbols, abbreviations, terms, and definitions commonly used with Power Transistors. Most of the information was obtained from JEDEC Publication No. 77. This document and the JC-25 JEDEC registration formats have over-riding authority where any conflict may occur.

Power Transistor Terms and Definitions

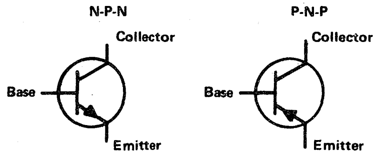
Term	Definition
base (B, b)*	A region which lies between an emitter and collector of a transistor and into which minority carriers are injected. (Ref. 60 IRE 28.S1)
breakdown	A phenomenon occurring in a reverse-biased semiconductor junction, the initiation of which is observed as a transition from a region of high small-signal resistance to a region of substantially lower small-signal resistance for an increasing magnitude of reverse current. (Ref RS-282 par. 1.38)
breakdown region	A region of the volt-ampere characteristic beyond the initiation of breakdown for an increasing magnitude of reverse current. (Ref RS-282 par. 1.37)
breakdown voltage	The voltage measured at a specified current in a breakdown region. (Ref MIL-S-19500D par. 20.3)
collector (C, c)*	A region through which a primary flow of charge carriers leaves the base. (Ref. 60 IRE 28.S1)
emitter (E, e)*	A region from which charge carriers that are minority carriers in the base are injected into the base. (Ref. 60 IRE 28.S1)
junction, collector	A semiconductor junction normally biased in the high-resistance direction, the current through which can be controlled by the introduction of minority carriers into the base. (Ref. 60 IRE 28.S1)
junction, emitter	A semiconductor junction normally biased in the low-resistance direction to inject minority carriers into the base. (Ref. 60 IRE 28.S1)
open-circuit	A circuit shall be considered as open-circuited if halving the magnitude of the terminating impedance does not produce a change in the parameter being measured greater than the required accuracy of the measurement. (Ref MIL-S-19500D par. 20.8)
reverse current	The current that flows through a semiconductor junction in the reverse direction.

*NOTE: References to base, collector, and emitter symbolism (B, b, C, c, E, and e) refer to the device terminals connected to those regions.

TERMS AND DEFINITIONS
POWER TRANSISTORS

Term	Definition
reverse direction	The direction of current flow which results when the n-type semiconductor region is at a positive potential relative to the p-type region
saturation	A base-current and a collector-current condition resulting in a forward-biased collector junction.
second breakdown	A condition of the transistor, resulting from a lateral current instability, in which the electrical characteristics are determined principally by the spreading resistance of a thermally maintained current constriction. The initiation of second breakdown is observed as a decrease in the voltage sustained by the collector. NOTE: Second breakdown differs from thermal failure in that its initiation can not be predicted from low-voltage thermal resistance measurements. Unless the current and duration in second breakdown are limited, the high junction temperature at the current constriction will result in failure, usually as a collector-to-emitter short-circuit. Second breakdown can occur at postitive, negative, or zero base current. (To protect a transistor against second breakdown, see section: "Safe Operating Areas for Power Transistors.")
semiconductor device	A device whose essential characteristics are due to the flow of charge carriers within a semiconductor. (Ref. RS-282 par. 1.09)
semiconductor junction	A region of transition between semiconductor regions of different electrical properties (e.g., n-n+, p-n, p-p+ semiconductors), or between a metal and a semiconductor. (Ref. RS-282 par. 1.0)
short-circuit	A circuit in which doubling the magnitude of the terminating impedance does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement. (Ref. MIL-S-19500D par. 20.16)
small-signal	A signal which when doubled in magnitude does not produce a change in the parameter being measured that is greater than th required accuracy of the measurement. (Ref. MIL-S-19500D par. 20.17)
static value	A non-varying value or quantity of measurement at a specified fixed point, or the slope of the line from the origin to the operating poin on the appropriate characteristic curve. (Ref. IEEE #255 par. 2.2.1
terminal	An externally available point of connection to one or mor electrodes. (Ref. RS-282 par. 1.14)
thermal resistance (steady-state)	The temperature difference between two specified points or region divided by the power dissipation under conditions of therma equilibrium. (Ref. IEEE #223)

Term	Definition
transient thermal impedance	The change of temperature difference between two specified points or regions at the end of a time interval divided by the step function change in power dissipation at the beginning of the same time interval causing the change of temperature difference. (Ref. IEEE #223)
transistor	An active semiconductor device capable of providing power amplification and having three or more terminals. (Ref. IEC #147-0 par. 0-2.8)
transistor, junction, multijunction type	A transistor having a base and two or more junctions. Graphic symbols for emitter, base, collector transistors: (Ref. ANS Y32.2) NOTE: In the graphic symbols, the envelope is optional if no element is connected to the envelope.



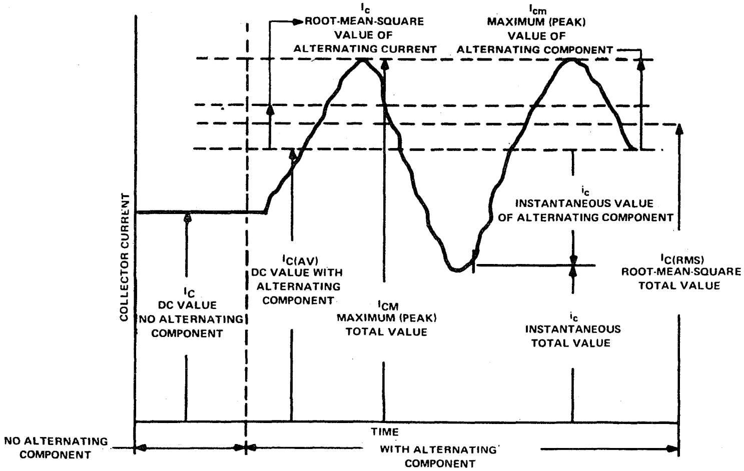
TERMS AND DEFINITIONS
POWER TRANSISTORS

Power Transistor Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
C_{ibo}	open-circuit input capacitance	The capacitance measured across the input terminals (emitter and base) with the collector open-circuited for ac. (Ref. IEEE #255)
C_{obo}	open-circuit output capacitance	The capacitance measured across the output terminals (collector and base) with the input open-circuited to ac. (Ref. IEEE #255)
f_{hfe}	small-signal short-circuit forward current transfer ratio cutoff frequency (common-emitter)	The lowest frequency at which the magnitude of the small-signal short-circuit forward current transfer ratio is 0.707 of its value at a specified low frequency (usually 1 kHz or less). (Ref. IEEE #255)
f_T	transition frequency or frequency at which small-signal forward current transfer ratio (common-emitter) extrapolates to unity	The product of the modulus (magnitude) of the common-emitter small-signal short-circuit forward current transfer ratio, h_{fe}, and the frequency of measurement when this frequency is sufficiently high so that the modulus (magnitude) of h_{fe} is decreasing with a slope of approximately 6 dB per octave. (Ref. IEEE #255)
G_{PE}	large-signal insertion power gain (common-emitter)	The ratio, usually expressed in dB, of the signa power delivered to the load to the large-signal power delivered to the input.
h_{FE}	static forward current transfer ratio (common-emitter)	The ratio of the dc collector current to the dc base current. (Ref. MIL-S-19500D par. 30.28)
h_{fe}	small-signal short-circuit forward current transfer ratio (common-emitter)	The ratio of the ac collector current to the small-signal ac base current with the collector short-circuited to the emitter for ac. (Ref MIL-S-19500D par. 30.20)
h_{IE}	static input resistance (common-emitter)	The ratio of the dc base-emitter voltage to the dc basi current. (Ref. MIL-S-19500D par. 30.29)
h_{ie}	small-signal short-circuit input impedance (common-emitter)	The ratio of the small-signal ac base-emitter voltage to the ac base current with the collector short-circuited to the emitter for ac. (Ref. MIL-S-19500D par. 30.24)
$h_{ie(imag)}$	imaginary part of the small-signal short-circuit input impedance, (common-emitter)	The ratio of the out-of-phase (imaginary) componen of the small-signal ac base-emitter voltage to the a base current with the collector termina short-circuited to the emitter terminal for ac.
$h_{ie(real)}$	real part of the small-signal short-circuit input impedance, (common-emitter)	The ratio of the in-phase (real) component of th small-signal ac base-emitter voltage to the ac bas current with the collector terminal short-circuited t the emitter terminal for ac.
h_{oe}	small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to th small-signal ac collector-emitter voltage with the bas terminal open-circuited to ac. (Ref. MIL-S-19500D par. 30.15)

Symbol	Term	Definition
$h_{oe(imag)}$	imaginary part of the small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to the out-of-phase (imaginary) component of the small-signal collector-emitter voltage with the base terminal open-circuited to ac.
$h_{oe(real)}$	real part of the small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to the in-phase (real) component of the small-signal collector-emitter voltage with the base terminal open-circuited to ac.
I_B, I_C, I_E	current, dc (base-terminal, collector-terminal, emitter-terminal)	The value of the dc current into the terminal indicated by the subscript.
I_b, I_c, I_e	current, rms value of alternating component (base-terminal, collector-terminal, emitter-terminal)	The root-mean-square value of alternating current into the terminal indicated by the subscript.
i_B, i_C, i_E	current, instantaneous total value (base-terminal, collector-terminal, emitter-terminal)	The instantaneous total value of alternating current into the terminal indicated by the subscript.

DIAGRAM ILLUSTRATING FOREGOING CURRENTS (Ref IEEE # 255)



Symbol	Term	Definition
I_{CBO}	collector cutoff current, dc, emitter open	The dc current into the collector terminal when it is biased in the reverse direction with respect to the base terminal and the emitter terminal is open-circuited. (Ref. IEEE #255)

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Symbol	Term	Definition
I_{CEO}	collector cutoff current, dc (base open	The dc current into the collector terminal when it is biased in the reverse direction* with respect to the emitter terminal and the base terminal is (as indicated by the first subscript letter as follows): O = open-circuited R = returned to the emitter terminal through a specified resistance. S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a speified voltage. X = returned to the emitter terminal through a speified circuit. (Ref. IEEE #255)
I_{CER}	resistance between base and emitter,	
I_{CES}	base short-circuited to emitter,	
I_{CEV}	voltage between base and emitter,	
I_{CEX}	circuit between base and emitter)	
I_{EBO}	emitter cutoff current, dc, collector open	The dc current into the emitter terminal when it is baised in the reverse direction with respect to the base terminal and the collector terminal is open-circuited. (Ref. IEEE #255)
P_{BE}	power input, dc (to the base, common-emitter)	The product of the dc input current and voltage with the common-emitter circuit configuration.
p_{BE}	power input; instantaneous total (to the base, common-emitter)	The product of the instantaneous input current and voltage with the common-emitter circuit configuration.
P_{OE}	large-signal output power (common-emitter)	The product of the large-signal ac output current and voltage with the common-emitter circuit configuration.
P_T	total nonreactive power input to all terminals	The sum of the products of the dc input currents anc voltages, i.e.. $V_{BE} \cdot I_B + V_{CE} \cdot I_C$ or $V_{BE} \cdot I_E + V_{CB} \cdot I_C$
p_T	nonreactive power input, instantaneous total, to all terminals	The sum of the products of the instantaneous inpu currents and voltages.
$r_b'C_c$	collector-base time constant	The product of the intrinsic base resistance anc collector capacitance under specified small-signal con ditions.

*For these parameters, the collector terminal is co sidered to be biased in the reverse direction when i is made positive for N-P-N transistors or negative fo P-N-P transistors with respect to the emitter terminal

Symbol	Term	Definition
R_θ (formerly θ)	thermal resistance	Refer to thermal resistance (steady state), page 1-4.
$R_{\theta CA}$	thermal resistance case-to-ambient	The thermal resistance (steady-state) from the device case to the ambient.
$R_{\theta JA}$ (formerly $\theta_{J\text{-}A}$)	thermal resistance junction-to-ambient	The thermal resistance (steady-state) from the semiconductor junction (s) to the ambient.
$R_{\theta JC}$ (formerly $\theta_{J\text{-}C}$)	thermal resistance junction-to-case	The thermal resistance (steady-state) from the semiconductor junction (s) to a stated location on the case.
$R_{\theta JM}$	thermal resistance junction-to-mounting surface	The thermal resistance (steady-state) from the semiconductor junction (s) to a stated location on the mounting surface.
T_A	ambient temperature or free-air temperature	The air temperature measured below a device, in an environment of substantially uniform temperature, cooled only by natural air convection and not materially affected by reflective and radiant surfaces. (Ref. MIL-S-19500D par. 20.20.1)
T_C	case temperature	The temperature measured at a specified location on the case of a device. (Ref. MIL-S-19500D par. 20.20.2)
T_J	virtual junction temperature	A theoretical temperature based on a simplified representation of the thermal and electrical behavior of the semiconductor device. NOTE: This term (and its definition) is taken from IEC standards. It is particularly applicable to multi-junction semiconductors and is used in this publication to denote the temperature of the active semiconductor element when required in specifications and test methods. The term "junction temperature" is used interchangeably with the term "virtual junction temperature" in this publication.
T_{stg}	storage temperature	The temperature at which the device, without any power applied, is stored. (Ref. MIL-S-19500D par. 20.20.3)
t_d	delay time	The time interval from the point at which the leading edge of the input pulse has reached 10 percent of its maximum amplitude to the point at which the leading edge of the output pulse has reached 10 percent of its maximum amplitude. (Ref. MIL-S-19500D par. 20.13)
t_f	fall time	The time duration during which the trailing edge of a pulse is decreasing from 90 to 10 percent of its maximum amplitude. (Ref. MIL-S-19500D par. 20.12)

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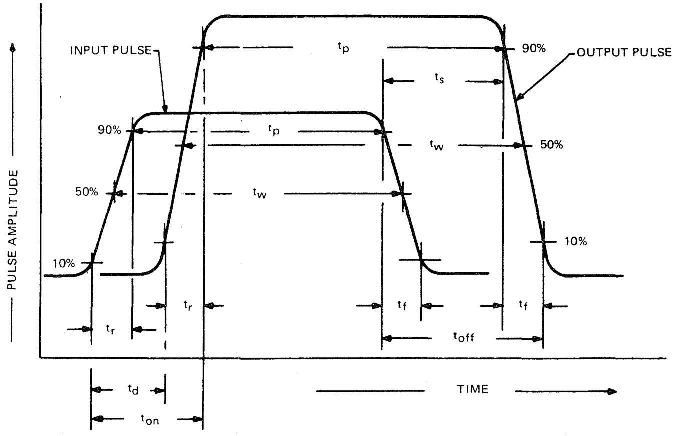
POWER TRANSISTORS

Symbol	Term	Definition
t_{off}	turn-off time	The sum of $t_s + t_f$.
t_{on}	turn-on time	The sum of $t_d + t_r$.
t_p	pulse time	The time duration from the point on the leading edge which is 90 percent of the maximum amplitude to the point on the trailing edge which is 90 percent of the maximum amplitude. (Ref. MIL-S-19500D par. 20.15)
t_r	rise time	The time duration during which the amplitude of the leading edge of a pulse is increasing from 10 to 90 percent of its maximum amplitude. (Ref. MIL-S-19500D par. 20.13)
t_s	storage time	The time interval from a point 90 percent of the maximum amplitude on the trailing edge of the input pulse to a point 90 percent of the maximum amplitude on the trailing edge of the output pulse. (Ref. MIL-S-19500D par. 20.14)
t_w	pulse average time	The time duration from the point on the leading edge which is 50 percent of the maximum amplitude to a point on the trailing edge which is 50 percent of the maximum amplitude. (Ref. MIL-S-19500D par. 20.10)

DIAGRAM ILLUSTRATING PULSE TIME SYMBOLOGY



TERMS AND DEFINITIONS
POWER TRANSISTORS

Symbol	Term	Definition
$V_{(BR)CBO}$ (formerly BV_{CBO})	breakdown voltage collector-to-base, emitter open	The breakdown voltage between the collector terminal and the base terminal when the collector terminal is biased in the reverse direction with respect to the base terminal and the emitter terminal is open-circuited. (Ref. IEEE #255)
$V_{(BR)CEO}$, (formerly BV_{CEO})	breakdown voltage, collector-to-emitter with (base open,	The breakdown voltage between the collector terminal and the emitter terminal when the collector terminal is biased in the reverse direction* with respect to the emitter terminal and the base terminal is (as indicated by the last subscript letter as follows): O = open-circuited. R = returned to the emitter terminal through a specified resistance. S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a specified voltage. X = returned to the emitter terminal through a specified circuit. (Ref. IEEE #255)
$V_{(BR)CER}$, (formerly BV_{CER})	resistance between base and emitter,	
$V_{(BR)CES}$, (formerly BV_{CES})	base short-circuited to emitter,	
$V_{(BR)CEV}$, (formerly BV_{CEV})	voltage between base and emitter,	
$V_{(BR)CEX}$ (formerly BV_{CEX})	circuit between base and emitter)	
$V_{(BR)EBO}$, (formerly BV_{EBO})	breakdown voltage, emitter-to-base, collector open	The breakdown voltage between the emitter and base terminals when the emitter terminal is biased in the reverse direction with respect to the base terminal and the collector terminal is open-circuited. (Ref. IEEE #255)
V_{BB}, V_{CC}, V_{EE}	supply voltage, dc (base, collector, emitter)	The dc supply voltage applied to a circuit connected to the reference terminal.
V_{BC},	voltage, dc or average (base-to-collector,	The dc voltage between the terminal indicated by the first subscript and the reference terminal (stated in terms of the polarity at the terminal indicated by the first subscript).
V_{BE},	base-to-emitter,	
V_{CB},	collector-to-base,	
V_{CE}	collector-to-emitter,	
V_{EB},	emitter-to-base,	
V_{EC}	emitter-to-collector)	
$V_{BE(sat)}$	saturation voltage, dc, base-to-emitter	The dc voltage between the base and emitter terminals for specified base-current and collector-current conditions which are intended to ensure that the collector junction is forward-biased.

*For these parameters, the collector terminal is considered to be biased in the reverse direction when it is made positive for N-P-N transistors or negative for P-N-P transistors with respect to the emitter terminal.

TERMS AND DEFINITIONS
POWER TRANSISTORS

Symbol	Term	Definition
V_{CBO}	collector-to-base voltage, dc, emitter open	The dc voltage between the collector terminal and the base terminal when the emitter terminal is open-circuited.
$V_{CE(sat)}$	saturation voltage, dc, collector-to-emitter	The dc voltage between the collector and the emitter terminals for specified saturation conditions. (Ref. IEEE #255)
V_{CEO}	collector-to-emitter voltage, dc, with (base open,	The dc voltage between the collector terminal and the emitter terminal when the base terminal is (as indicated by the last subscript letter): O = open-circuited. R = returned to the emitter terminal through a specified resistance. S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a specified voltage. X = returned to the emitter terminal through a specified circuit.
V_{CER}	resistance between base and emitter,	
V_{CES}	base short-circuited to emitter,	
V_{CEV}	voltage between base and emitter,	
V_{CEX}	circuit between base and emitter)	
$V_{CEO(sus)}$	sustaining voltage, collector-to-emitter with (base open,	The collector-to-emitter breakdown voltage at relatively high values of collector current where the breakdown voltage is relatively insensitive to changes in collector current. The base terminal is (as indicated by the third subscript letter as follows): O = open-circuited R = returned to the emitter terminal through a specified resistance S = short-circuited to the emitter terminal V = returned to the emitter terminal through a specified voltage X = returned to the emitter terminal through a specified circuit. NOTE: This would be the transient voltage between the collector and emitter terminals during switching with an inductive load from a forward-biased base-emitter to an external condition described by the third subscript letter.
$V_{CER(sus)}$	resistance between base and emitter,	
$V_{CES(sus)}$	base short-circuited to emitter,	
$V_{CEV(sus)}$	voltage between base and emitter,	
$V_{CEX(sus)}$	circuit between base and emitter)	
$V_{EB(fl)}$	dc open-circuit voltage (floating potential) (emitter-to-base)	The dc open-circuit voltage (floating potential) between the emitter terminal and the base termina when the collector terminal is biased in the reverse direction with respect to the base terminal (Ref. IEEE #255)

Symbol	Term	Definition
V_{EBO}	emitter-to-base voltage, dc, collector open	The dc voltage between the emitter terminal and the base terminal with the collector terminal open-circuited.
$Z_{\theta(t)}$ (formerly $\theta_{(t)}$)	transient thermal impedance	Refer to transient thermal impedance, page 1-5.
$Z_{\theta JA(t)}$ (formerly $\theta_{J\text{-}A(t)}$)	transient thermal impedance, junction-to-ambient	The transient thermal impedance from the semiconductor junction (s) to the ambient.
$Z_{\theta JC(t)}$ (formerly $\theta_{JC(t)}$)	transient thermal impedance, junction-to-case	The transient thermal impedance from the semiconductor junction (s) to a stated location on the case.

THYRISTORS

Thyristor Standards

The documents listed below have overriding authority where any conflict may occur with this data book.

EIA and JEDEC Standards

The thyristor terms and definitions presented in this data book were obtained from EIA Standards Proposal No. 1101. This standard is in the process of publication and will be available from:

Electronic Industries Association
2001 Eye St. N.W.,
Washington, D.C. 20006
Telephone: 202-659-2200

IEEE Standards

Institute of Electrical and Electronic Engineers, Inc.
345 East 47th. Street
New York, N.Y. 10017

IEEE No. 233: Standard Definitions of Terms for Thyristors

International Electrotechnical Commission Standards

American National Standards Institute, Inc.
1430 Broadway
New York, N.Y. 10018

IEC Publication 147-IC: Essential Ratings and Characteristics of Semiconductor Devices and General Principles of Measuring Methods

IEC Publication 148: Letter Symbols for Semiconductor Devices and Integrated Circuits

IEC Publication 191: Mechanical Standardization of Semiconductor Devices.

Military Standards

Commanding Officer, U.S. Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, Pa., 19120

MIL-S-19500: Semiconductor Devices, General Specification for

MIL-STD-105: Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-202: Test Methods for Electronic and Electrical Component Parts

MIL-STD-750: Test Methods for Semiconductor Devices

Classes of Thyristors

Bidirectional Diode Thyristor

A two-terminal thyristor having substantially the same switching behavior in the first and third quadrants of the principal voltage-current characteristic. (See Figure 4).

Bidirectional Triode Thyristor

A three-terminal thyristor having substantially the same switching behavior in the first and third quadrants of the principal voltage-current characteristic. (See Figure 4).

N-Gate Thyristor

A thyristor in which the gate terminal is connected to the N-region adjacent to the region to which the anode terminal is connected and which is normally switched to the on-state by applying a negative signal between gate and anode terminals.

P-Gate Thyristor

A thyristor in which the gate terminal is connected to the P-region adjacent to the region to which the cathode terminal is connected and which is normally switched to the on-state by applying a positive signal between gate and cathode terminals.

Reverse-Blocking Diode Thyristor

A two-terminal thyristor which switches only for positive anode-to-cathode voltages and exhibits a reverse-blocking state for negative anode-to-cathode voltages.

Reverse-Blocking Triode Thyristor

A three-terminal thyristor which switches only for positive anode-to-cathode voltages and exhibits a reverse-blocking state for negative anode-to-cathode voltages.

Reverse-Conducting Diode Thyristor

A two-terminal thyristor which switches only for positive anode-to-cathode voltages and conducts large currents at negative anode-to-cathode voltages comparable in magnitude to the on-state voltage.

Reverse-Conducting Triode Thyristor

A three-terminal thyristor which switches only for positive anode-to-cathode voltages and conducts large currents at negative anode-to-cathode voltages comparable in magnitude to the on-state voltage.

Semiconductor Controlled Rectifier (SCR)

An alternative name used for the reverse-blocking triode thyristor.

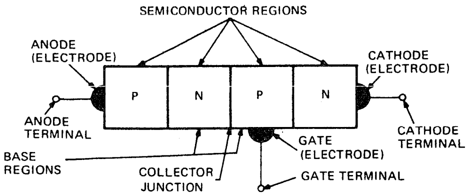
NOTE: Although not an official definition, the term unidirectional is sometimes used to describe the single switching class of thyristors consisting of reverse-blocking and reverse-conducting thyristors. This term is useful for comparing or contrasting this class of thyristor with bidirectional thyristors.

Thyristor

A bistable semiconductor device comprising three or more junctions, which can be switched from the off-state to the on-state or vice versa, such switching occuring within at least one quadrant of the principle voltage-current characteristic. (See Figures 1 through 5).

Turn-Off Thyristor

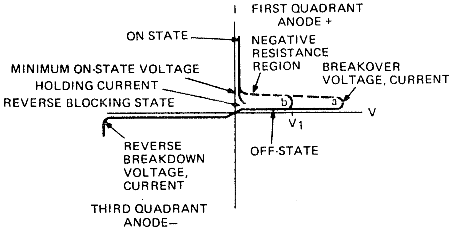
A thyristor which can be switched from the on-state to the off-state and vice versa by applying control signals of appropriate polarities to the gate terminal, with the ratio of triggering power to triggered power appreciably less than one.



Schematic representation of a reverse-blocking triode thyristor.

Note: The gate electrode is connected to the N-type base region in some structures or omitted in the case of a diode thyristor.

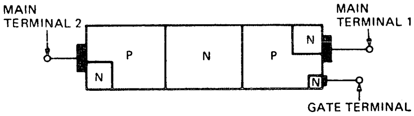
FIGURE 1



Principal voltage-current characteristics (anode-to-cathode voltage-current characteristic) of a typical reverse-blocking thyristor.

Note: Curve "a" applies for zero gate current or a diode thyristor. Curve "b" is with gate trigger current present when off-state voltage is V_1.

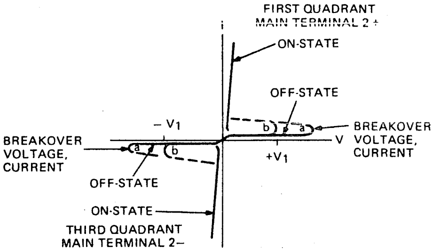
FIGURE 2



Schematic representation of typical bidirectional triode thyristor.

Note: Gate is omitted in a diode bidirectional thyristor.

FIGURE 3



Principal voltage-current characteristic of a typical bidirectional thyristor.

Note: Curve "a" applies for zero gate current or a diode bidirectional thyristor. Curve "b" applies for the case of gate trigger current applied when the off-state voltage is ± V_1.

FIGURE 4

Physical Structure Nomenclature

Anode

The electrode by which current enters the thyristor when the thyristor is in the on-state with the gate open-circuited.

NOTE: This term does not apply to bidirectional thyristors.

Anode Terminal

The terminal which is connected to the anode.

NOTE: This term does not apply to bidirectional thyristors.

Cathode

The electrode by which current leaves the thyristor when the thyristor is in the on-state with the gate open-circuited.

NOTE: This term does not apply to bidirectional thyristors.

Cathode Terminal

The terminal which is connected to the cathode.

NOTE: This term does not apply to bidirectional thyristors.

Collector Junction

The junction across which the polarity of the voltage reverses when switching occurs. (See Figure 1).

Electrode (of a Semiconductor Device)

An electrical and mechanical contact to a region of a semiconductor device.

Gate

An electrode connected to one of the semiconductor regions for introducing control current.

Gate Terminal

A terminal which is connected to a gate.

Junction (of a Semiconductor Device)

A region of transition between semiconductor regions of different electrical properties (e.g., n-n^+, p-n, p-p^+ semiconductors), or between a metal and a semiconductor.

Main Terminals

The terminals through which the principal current flows.

Main Terminal 1 (of a Bidirectional Thyristor)

The main terminal which is named "1" by the device manufacturer. This is normally the referance terminal for all voltages.

Main Terminal 2 (of a Bidirectional Thyristor)

The main terminal which is named "2" by the device manufacturer.

Terminal (of a Semiconductor Device)

The externally available point of connection to one or more electrodes.

Electrical Characteristic and Rating Terms (See Note at end of section)

Anode-to-Cathode Voltage (Anode Voltage)

The voltage between the anode terminal and the cathode terminal.

NOTE: It is called positive when the anode potential is more positive than the cathode potential, and called negative when the anode potential is less positive than the cathode potential.

Anode-to-Cathode Voltage-Current Characteristic (Anode Characteristic)

A function, usually represented graphically, relating the anode-to-cathode voltage to the principal current with gate current, where applicable, as a parameter.

NOTE: This term does not apply to bidirectional thyristors.

Breakover Point

Any point on the principal voltage-current characteristic for which the differential resistance is zero and where the principal voltage reaches a maximum value. (See Figures 2 and 4).

Negative-Differential-Resistance Region

Any portion of the principal voltage-current characteristic in the switching quadrant(s) within which the differential resistance is negative. (See Figures 2 and 4).

Off-Impedance

The differential impedance between the terminals through which the principal current flows when the thyristor is in the off-state at a stated operating point.

Off-State

The condition of the thyristor corresponding to the high-resistance, low-current portion of the principal voltage-current characteristic between the origin and the breakover point(s) in the switching quadrant(s).

On-Impedance

The differential impedance between the terminals through which the principal current flows when the thyristor is in the on-state at a stated operating point.

On-State

The condition of the thyristor corresponding to the low-resistance, low-voltage portion of the principal voltage-current characteristic in the switching quadrant(s).

NOTE: In the case of reverse-conducting thyristors, this definition is applicable only for a positive anode-to-cathode voltage.

Principal Voltage

The voltage between the main terminals.

NOTES: 1. In the case of reverse-blocking and reverse-conducting thyristors, the principal voltage is called positive when the anode potential is more positive then the cathode potential, and called negative when the anode potential is less positive than the cathode potential.

2. For bidirectional thyristors, the principal voltage is called positive when the potential of main terminal 2 is more positive than the potential of main terminal 1.

Principal Voltage-Current Characteristic (Principal.Characteristic)

The function, usually represented graphically, relating the principal voltage to the principal current with gate current, where applicable, as a parameter.

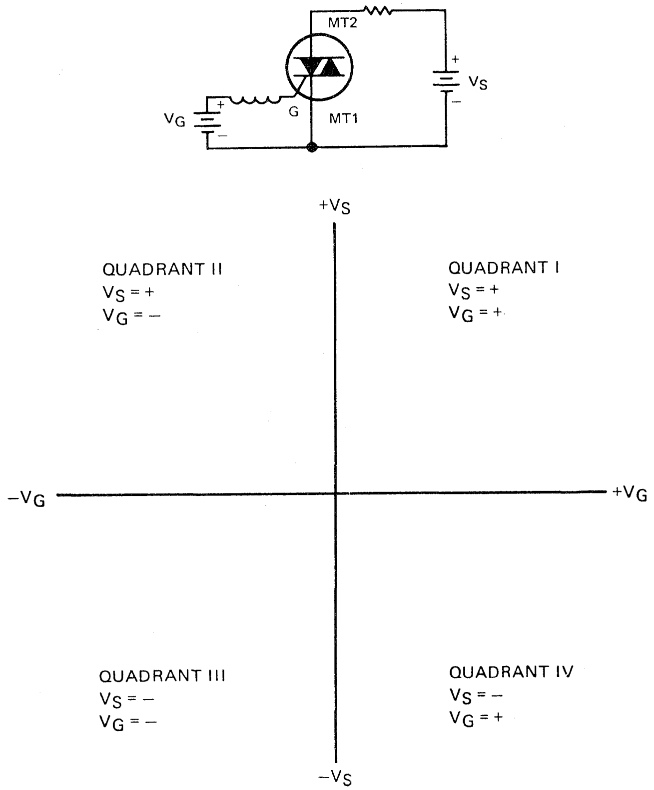
Reverse-Blocking Impedance (of a Reverse-Blocking Thyristor)

The differential impedance between the two terminals through which the principal current flows when the thyristor is in the reverse-blocking state at a stated operating point.

Reverse-Blocking State (of a Reverse-Blocking Thyristor)

The condition of a reverse-blocking thyristor corresponding to the portion of the anode-to-cathode voltage-current characteristic for which reverse currents are of lower magnitude than the reverse breakdown current. (See Figure 2).

QUADRANT DEFINITIONS



The polarities of V_S and V_G are with respect to Main Terminal 1.

FIGURE 5

TERMS AND DEFINITIONS
THYRISTORS

Symbols, Terms and Definitions

Symbol	Term	Definition
$I_{(BO)}$	Static Breakover Current	The principal current at the breakover point.
$i_{(BO)}$	Instantaneous Breakover Current	
$I_{(BR)R}$	Static Reverse Breakdown Current	The principal current at the reverse breakdown voltage.
$i_{(BR)R}$	Instantaneous Reverse Breakdown Current	
$I_{D(RMS)}$	RMS Off-State Current	The principal current when the thyristor is in the off-state.
I_D	Static Off-State Current	
$I_{D(AV)}$	Average Off-State Current	
i_D	Instantaneous Off-State Current	
I_{DM}	Peak Off-State Current	
I_{DRM}	Repetitive Peak Off-State Current	The maximum instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage.
I_G	Static Gate Current	The current that results from the gate voltage. NOTES: 1. Positive gate current refers to conventional current entering the gate terminal. 2. Negative gate current refers to conventional current leaving the gate terminal
$I_{G(AV)}$	Average Gate Current	
i_G	Instantaneous Gate Current	
I_{GM}	Peak Gate Current	
I_{GD}	Static Gate Nontrigger Current	The maximum gate current which will not cause the thyristor to switch from the off-state to the on-state.
i_{GD}	Instantaneous Gate Nontrigger Current	
I_{GDM}	Peak Gate Nontrigger Current	
I_{GQ}	Static Gate Turn-Off Current	The minimum gate current required to switch a thyristor from the on-state to the off-state.
i_{GQ}	Instantaneous Gate Turn-Off Current	
I_{GQM}	Peak Gate Turn-Off Current	
I_{GT}	Static Gate Trigger Current	The minimum gate current required to switch a thyristor from the off-state to the on-state.
i_{GT}	Instantaneous Gate Trigger Current	
I_{GTM}	Peak Gate Trigger Current	

Symbol	Term	Definition
I_H	Static Holding Current	The minimum principal current required to maintain the thyristor in the on-state.
i_H	Instantaneous Holding Current	
I_L	Static Latching Current	The minimum principal current required to maintain the thyristor in the on-state immediately after switching from the off-state to the on-state has occurred and the triggering signal has been removed.
i_L	Instantaneous Latching Current	
$I_{R(RMS)}$	RMS Reverse Current	The current for negative anode-to-cathode voltage.
I_R	Static Reverse Current	
$I_{R(AV)}$	Average Reverse Current	
i_R	Instantaneous Reverse Current	
I_{RM}	Peak Reverse Current	
I_{RRM}	Repetitive Peak Reverse Current	The maximum instantaneous value of the reverse current that results from the application of repetitive peak reverse voltage.
$I_{T(RMS)}$	RMS On-State Current	The principal current when the thyristor is in the on-state.
I_T	Static On-State Current	
$I_{T(AV)}$	Average On-State Current	
i_T	Instantaneous On-State Current	
I_{TM}	Peak On-State Current	
$I_{T(OV)}$	Overload Peak On-State Current	An on-state current of substantially the same waveshape as the normal on-state current and having a greater value than the normal on-state current.
I_{TRM}	Repetitive Peak On-State Current	The peak value of the on-state current including all repetitive transient currents.
I_{TSM}	Surge (Nonrepetitive) Peak On-State Current	An on-state current of short-time duration and specified waveshape.
P_G	Static Gate Power Dissipation	
$P_{G(AV)}$	Average Gate Power Dissipation	
p_G	Instantaneous Gate Power Dissipation	
P_{GM}	Peak Gate Power Dissipation	

TERMS AND DEFINITIONS
THYRISTORS

Symbol	Term	Definition
T_A	Free-Air Temperature (Ambient Temperature)	The air temperature measured below a device, in a environment of substantially uniform temperature cooled only by natural air convection and no materially affected by reflective and radiant surfaces (Ref. MIL-S-19500D par. 20.20.1)
T_C	Case Temperature	The temperature measured at a specified location o the case of a device. (Ref. MIL-S-19500D par 20.20.2)
T_J	Virtual Junction Temperature (Junction Temperature)	A theoretical temperature based on a simplifie representation of the thermal and electrical behavio of the semiconductor device. NOTE: This term (and its definition) is taken fro IEC standards. It is particularly applicable t multi-junction semiconductors and is used i this publication to denote the temperature c the active semiconductor element whe required in specifications and test method The term "junction temperature" is use interchangeably with the term "virtu junction temperature" in this publication.
T_{stg}	Storage Temperature	The temperature at which the defice, without an power applied, is stored. (Ref. MIL-S-19500D pa 20.20.3)
t_{gt}	Gate-Controlled Turn-On Time	The time interval between a specified point at th beginning of the gate pulse and the instant when th principal voltage (current) has dropped (risen) to specified low (high) value during switching of thyristor from the off-state to the on-state by a ga pulse.
t_{gq}	Gate-Controlled Turn-Off Time	The time interval between a specified point at th beginning of the gate pulse and the instant when th principal current has decreased to a specified val during switching from the on-state to the off-state b a gate pulse.
t_q	Circuit-Commutated Turn-Off Time	The time interval between the instant when th principal current has decreased to zero after extern switching of the principal voltage circuit, and th instant when the thyristor is capable of supporting specified principal voltage without turning on.

Symbol	Term	Definition
R_θ	Thermal Resistance	The temperature difference between two specified points or regions divided by the power dissipation under conditions of thermal equilibrium.
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	
$R_{\theta CA}$	Thermal Resistance, Case-to-Ambient	
$V_{(BO)}$	Static Breakover Voltage	The principal voltage at the breakover point.
$v_{(BO)}$	Instantaneous Breakover Voltage	
$V_{(BR)R}$	Static Reverse Breakdown Voltage	The value of negative anode-to-cathode voltage at which the differential resistance between the anode and cathode terminals changes from a high value to a substantially lower value.
$v_{(BR)R}$	Instantaneous Reverse Breakdown Voltage	
$V_{D(RMS)}$	RMS Off-State Voltage	The principal voltage when the thyristor is in the off-state.
V_D	Static Off-State Voltage	
$V_{D(AV)}$	Average Off-State Voltage	
v_D	Instantaneous Off-State Voltage	
V_{DM}	Peak Off-State Voltage	
V_{DRM}	Repetitive Peak Off-State Voltage	The maximum instantaneous value of the off-state voltage which occurs across a thyristor, including all repetitive transient voltages, but excluding all non-repetitive transient voltages.
V_{DSM}	Nonrepetitive Peak Off-State Voltage	The maximum instantaneous value of any non-repetitive transient off-state voltage which occurs across the thyristor.
V_{DWM}	Working Peak Off-State Voltage	The maximum instantaneous value of the off-state voltage which occurs across a thyristor, excluding all repetitive and nonrepetitive transient voltages.
V_G	Static Gate Voltage	The voltage between a gate terminal and a specified main terminal. NOTE: Gate voltage polarity is referenced to the specified main terminal.
$V_{G(AV)}$	Average Gate Voltage	
v_G	Instantaneous Gate Voltage	
V_{GM}	Peak Gate Voltage	

TERMS AND DEFINITIONS
THYRISTORS

Symbol	Term	Definition
V_{GD}	Static Gate Nontrigger Voltage	The maximum gate voltage which will not cause th thyristor to switch from the off-state to the on-state
v_{GD}	Instantaneous Gate Nontrigger Voltage	
V_{GDM}	Peak Gate Nontrigger Voltage	
V_{GQ}	Static Gate Turn-Off Voltage	The gate voltage required to produce the gate turn-of current.
v_{GQ}	Instantaneous Gate Turn-Off Voltage	
V_{GQM}	Peak Gate Turn-Off Voltage	
V_{GT}	Static Gate Trigger Voltage	The gate voltage required to produce the gate trigge current.
v_{GT}	Instantaneous Gate Trigger Voltage	
V_{GTM}	Peak Gate Trigger Voltage	
$V_{R(RMS)}$	RMS Reverse Voltage	A negative anode-to-cathode voltage.
V_R	Static Reverse Voltage	
$V_{R(AV)}$	Average Reverse Voltage	
v_R	Instantaneous Reverse Voltage	
V_{RM}	Peak Reverse Voltage	
V_{RRM}	Repetitive Peak Reverse Voltage	The maximum instantaneous value of the revers voltage which occurs across the thyristor, includin all repetitive transient voltages, but excluding al nonrepetitive transient voltages.
V_{RSM}	Nonrepetitive Peak Reverse Voltage	The maximum instantaneous value of any non repetitive transient reverse voltage which occur across a thyristor.
V_{RWM}	Working Peak Reverse Voltage	The maximum instantaneous value of the revers voltage which occurs across the thyristor, excludin all repetitive and nonrepetitive transient voltages.
$V_{T(RMS)}$	RMS On-State Voltage	The principal voltage when the thyristor is in th on-state.
V_T	Static On-State Voltage	
$V_{T(AV)}$	Average On-State Voltage	
v_T	Instantaneous On-State Voltage	
V_{TM}	Peak On-State Voltage	

Symbol	Term	Definition
$V_{T(MIN)}$	Static Minimum On-State Voltage	The minimum positive principal voltage for which the differential resistance is zero with the gate open-circuited.
$Z_{\theta}(t)$ $Z_{\theta JA}(t)$ $Z_{\theta JC}(t)$	Transient Thermal Impedance Transient Thermal Impedance, Junction-to-Ambient Transient Thermal Impedance, Junction-to-Case	The change of temperature difference between two specified points or regions at the end of a time interval divided by the step function change in power dissipation at the beginning of the same time interval causing the change of temperature difference.

POWER TRANSISTOR ELECTRICAL CHARACTERISTIC TESTS

INDEX

GENERAL

In this section, accepted test practices are described as a guide to making power transistor characteristic tests. The material has been adapted from the forthcoming JEDEC Publication *Suggested Standards on Power Transistors.* Only those electrical characteristics included in EIA JC-25 registration formats are listed.

MEASUREMENTS

All measurements should be made at thermal equilibrium. A condition of thermal equilibrium is achieved if halving the time between application of power and measurement causes no change in the result within the required accuracy.

The connecting lines shown in the circuit diagrams have no resistance compared to their lowest terminating impedance. Shown are resistors, inductors, and capacitors having an ideal characteristic at the used frequency range. Voltage sources have zero impedance, and current sources have an infinite resistance. All voltmeters and scopes have infinite input resistance and all ammeters have zero resistance, unless otherwise noted.

The listing of the following tests does not imply that all must be performed by either the manufacturer or the user. It is the responsibility of the user and manufacturer to agree to any series of specific tests or test conditions, and the further responsibility of the user to establish meaningful relationship between these tests and the performance of the power transistor in a particular application.

An npn transistor is used in the test methods below. These test methods will also apply to pnp devices by changing polarities. For small-signal measurements, a signal is used which, when doubled in magnitude, does not produce a change in the measured parameter that is greater than the required accuracy.

The transistor connections are shown separate from the test circuits for "DC", "CT", and "P" techniques.

"DC" – D-C continuous condition

"CT" – Curve tracer (60 cycle full rectified sinewave)

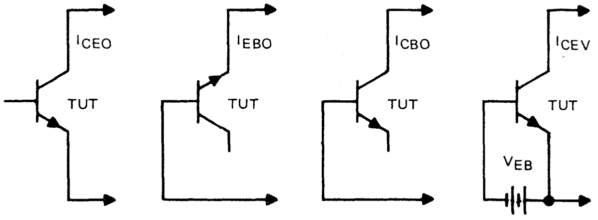
"P" – Pulsed by a 300 μs, 2% duty cycle pulse

CUT-OFF CURRENT [I_{CEO}, I_{EBO}, I_{CBO}, I_{CEV}, I_{EB1}, I_{EB2}, I_{B1B2}]

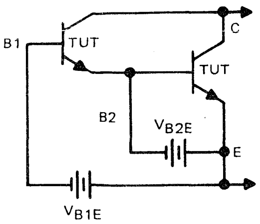
Description

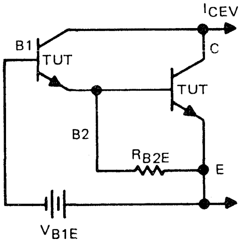
The reverse voltage is applied and the cut-off current is measured. The cut-off current is temperature sensitive. If testing is done at elevated temperature, a heat sink may be necessary to prevent thermal runaway.

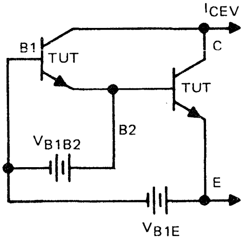
Transistor Connections

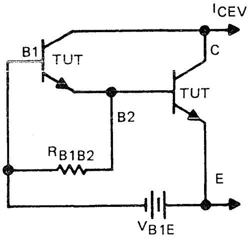


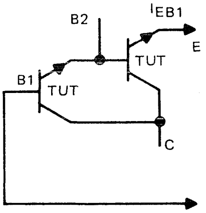
DARLINGTON

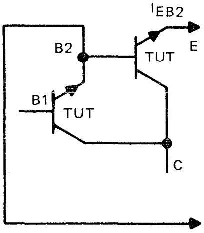


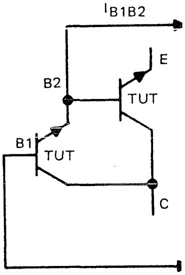








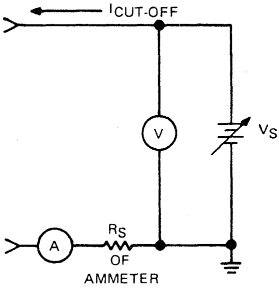




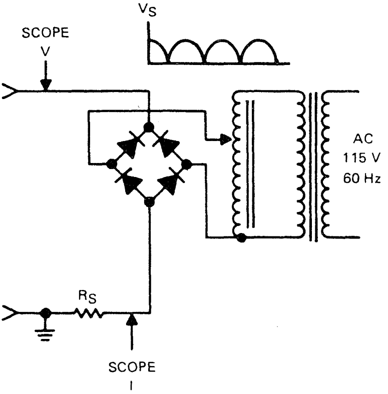
Test Circuits

The supply voltage V_S should equal R_S $I_{CUT\text{-}OFF}$ plus the specified test voltage. The current of the transistor i the pulse test circuit has to be small compared to the measured cut-off current. The cut-off current is measure with an ammeter or with an oscilloscope.

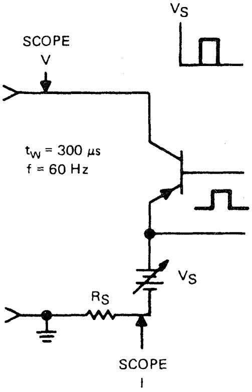
DC



CT



P



Test Conditions to be Specified

Case temperature if not $T_C = 25^\circ C$

Voltage applied to the device: V_{CEO}, V_{EBO}, V_{CBO}, V_{CEV}, V_{EB1}, V_{B1B2}, V_{EB2}

Base termination: V_{EB}, V_{B2E}, R_{B2E}, V_{B1B2}, R_{B1B2}

Technique: DC, CT, P

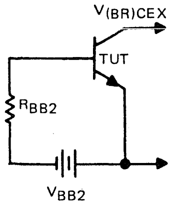
BREAKDOWN VOLTAGE [$V_{(BR)CEX}$, $V_{(BR)CEO}$ OR $V_{CEO(sus)}$, $V_{(BR)CES}$, $V_{(BR)EBO}$, $V_{(BR)CER}$]

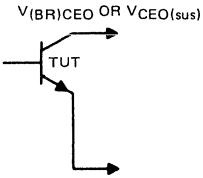
Description

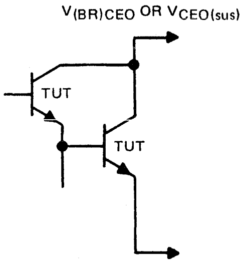
For breakdown measured in the sustaining region, the current should be high enough to ensure that the breakdown voltage is relatively insensitive to current changes.

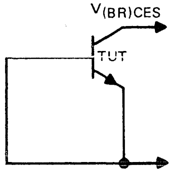
ELECTRICAL CHARACTERISTIC TESTS

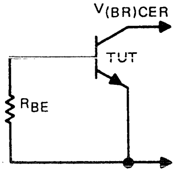
Transistor Connections

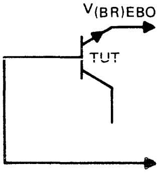






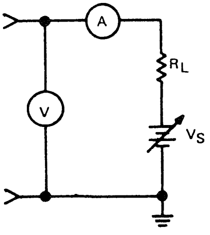




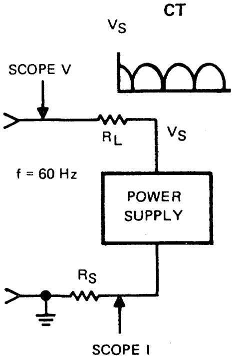


Test Circuits

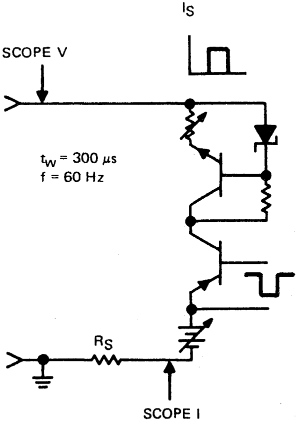
DC

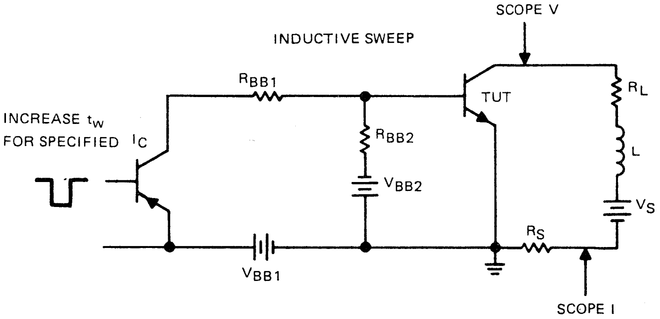


CT



P





In addition to the test circuits for "DC", "CT", and "P", an inductive sweep circuit is shown. This test circuit is particularly useful to measure transistors in their sustaining region.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Current applied to the device: I_{CEX}, I_{CEO}, I_{CES}, I_{EBO}, I_{CER}

Base termination: V_{BB2}, V_{BB1}, R_{BB2}, R_{BB1}, R_{BE}, pulse width, duty cycle

Technique: DC, CT, P, Inductive Sweep

Load resistance, inductance, and supply voltage where applicable: R_L, L, V_S

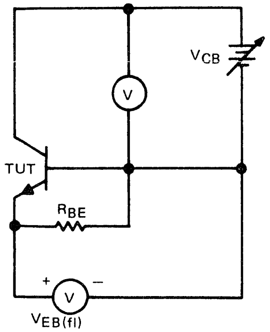
FLOATING POTENTIAL [$V_{EB(fl)}$]

Description

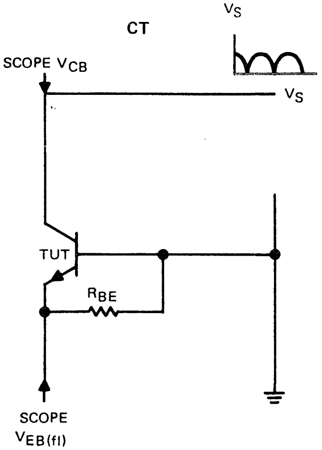
This measurement is related to the thickness of the base region.

Test Circuit

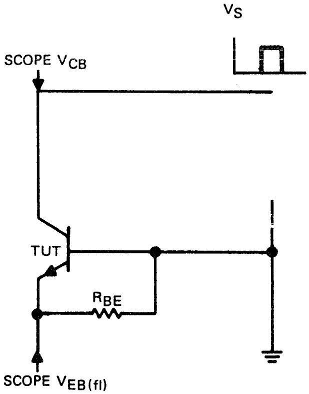
DC



CT



P



Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector-base voltage: V_{CB}

Base-emitter resistance: R_{BE}

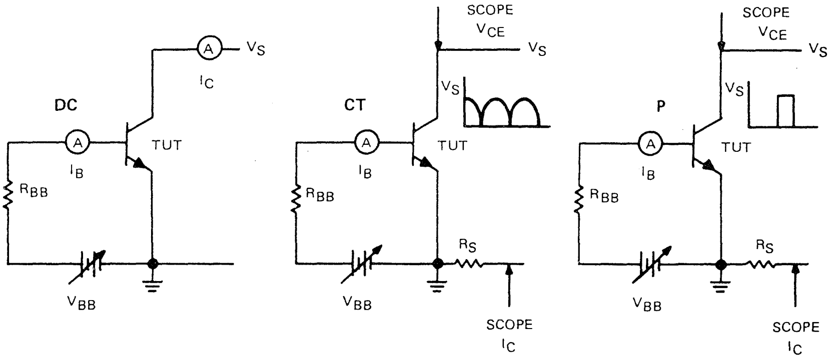
Technique: DC, CT, P

CURRENT GAIN [h_{FE}]

Description

The static forward current transfer ratio in the common-emitter configuration is one of the most important gain characteristic for power transistors. It measures the ratio of collector current to base current.

Test Circuit



The current gain is given by $h_{FE} = I_C/I_B$. For the CT and P tests, $V_{BB} >> \Delta V_{BE}{}^*$ so that I_B is constant and relatively independent of V_{BE}.

$^*\Delta V_{BE}$ is the range of V_{BE} for various devices to be tested.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector-emitter voltage: V_{CE}

Collector current: I_C

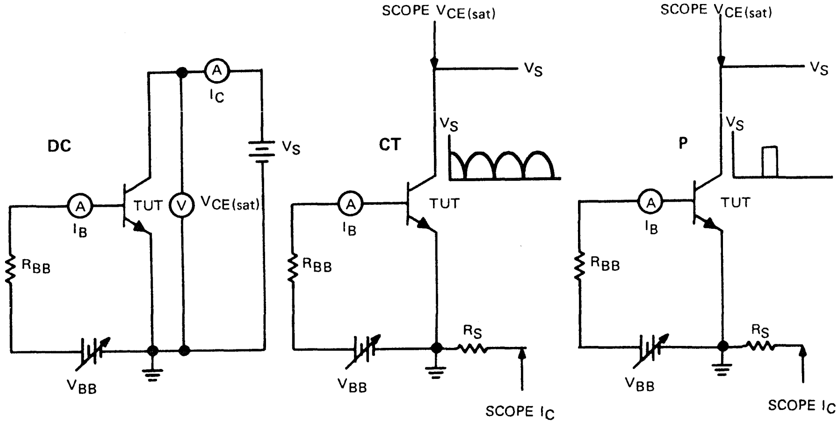
Technique: DC, CT, P

SATURATION VOLTAGE [$V_{CE(sat)}$]

Description

The collector-to-emitter saturation voltage is especially important for switching applications. Together with the collector current, it is the basis to calculate the power dissipation in the "on" state.

Test Circuit



For the CT and P tests, $V_{BB} >> V_{BE}$ in order to make I_B independent of V_{BE} changes during the "on' condition.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector current: I_C

Base current: I_B

Technique: DC, CT, P

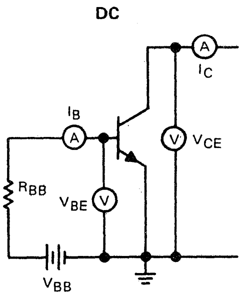
BASE-TO-EMITTER VOLTAGE [V_{BE}]

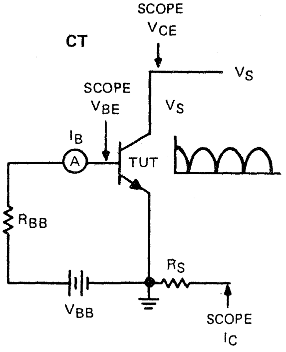
Description

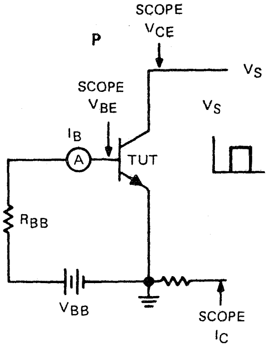
There are two conditions of interest for the static base-to-emitter voltage:

1. The transistor in saturation (commonly referred to as $V_{BE(sat)}$)
2. The transistor out of saturation (V_{BE})

Test Circuit







For the CT and P tests, $V_{BB} >> V_{BE}$ in order to make I_B independent of V_{BE} changes during the "on" condition. The base terminal for Darlington transistors is B1.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

1. The transistor in saturation: ($V_{BE(sat)}$)

   Collector Current: I_C

   Base Current: I_B

2. The transistor out of saturation: (V_{BE})

   Collector current: I_C

   Collector-to-emitter voltage: V_{CE}

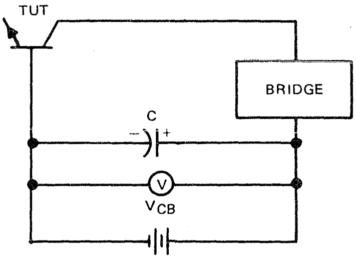
Technique: DC, CT, P

OPEN-CIRCUIT OUTPUT CAPACITANCE [C_{obo}]

Description

The open-circuit output capacitance indicates the frequency limitations of a transistor.

Test Circuit



Capacitor C has to be sufficiently large to provide a short-circuit at the test frequency. The bridge has to be nulled with the base-to-collector open. The base terminal for Darlington transistors is B1.

Test Conditions To Be Specified

Case temperature if not $T_C = 25^\circ C$

Collector-to-base voltage: V_{CB}

Frequency: f

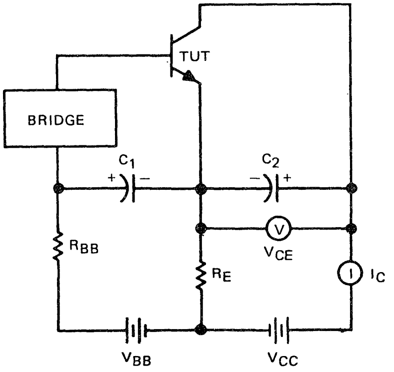
SMALL-SIGNAL SHORT-CIRCUIT INPUT IMPEDANCE [h_{ie}, $h_{ie(real)}$, $h_{ie(imag)}$]

Description

The input impedance is $h_{ie} = V_{be}/I_b$ with $V_{ce} = 0$. The real and imaginary components are important for inpu matching networks.

Circuits

Capacitors C1 and C2 must represent a short-circuit at the measuring frequency. The bridge must be nulled with short across the base and emitter terminals and $V_{BB} = 0$. When h_{ie} is measured at 1 kHz, I_b can be measured wit a current probe and V_{be} with a scope.



Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector-to-emitter voltage: V_{CE}

Collector current: I_C

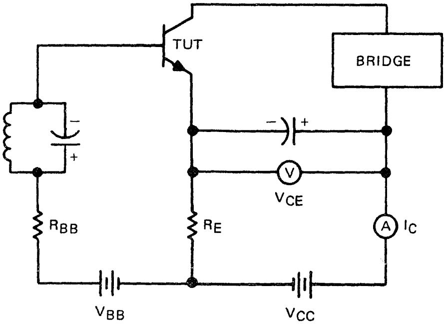
Frequency: f for $h_{ie(real)}$ and $h_{ie(imag)}$

SMALL-SIGNAL OPEN-CIRCUIT OUTPUT ADMITTANCE [$h_{oe(real)}$]

Description

The purpose of this test is to determine the real part of the output admittance.

Test Circuit



The L-C network in the base circuit must have a large impedance compared with h_{ie} at the test frequency. Capacitor C1 shall present a short-circuit at the test frequency.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector-to-emitter voltage: V_{CE}

Collector current: I_C

Frequency: f

SMALL-SIGNAL FORWARD CURRENT TRANSFER RATIO [h_{fe}], CUT-OFF FREQUENCY [f_{hfe}], AND FREQUENCY AT WHICH $|h_{fe}|$ EXTRAPOLATES TO UNITY [f_T]

Description

These measurements indicate the gain h_{fe} and the frequency response capability of transistors. Both measurements are dependent on the operating point.

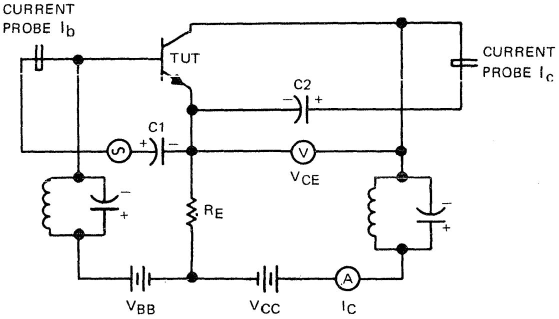
$h_{fe} = I_c/I_b$ (with $V_{ce} = 0$) at low frequency.

f_{hfe} = frequency at which h_{fe} is 3 dB down from its 1-kHz measurement

$f_T = |h_{fe}| \times f$. The absolute small-signal $|h_{fe}|$ has to be measured at a frequency f where $|h_{fe}|$ is decreasing approximately 6 dB per octave.

The measurement as specified does not assure the 6-dB-per-octave region. The 6-dB-per-octave region can be determined by plotting $|h_{fe}|$ versus f.

Test Circuit



The L-C networks must have a very large impedance compared to the capacitors C1 and C2. The amplitude of I_I and I_C is measured with a current probe.

The ac impedance represented by C2, the current probe for I_C, and associated wiring shall be small compared t the output impedance of the Transistor Under Test.

Test Conditions To Be Specified

Case temperature if not $T_C = 25°C$

Collector-to-emitter voltage: V_{CE}

Collector current: I_C

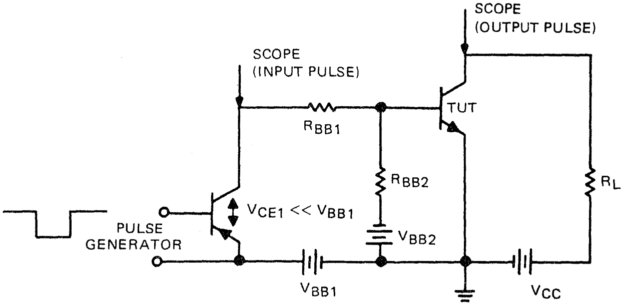
For h_{fe} and f_T only: f

SWITCHING TIME [t_d, t_r, t_s, t_f]

Description

It is desirable to minimize the large possible variations in switching circuits. A circuit similar to the following is recommended for switching times registered on the JC-25 RDF-2 format. For definition of t_d, t_r, t_s, and t_f, see section on "Letter Symbols, Abbreviations, Terms, and Definitions." The transistor parameter "rise time" refers to the time interval during which the magnitude of the collector current is increasing and the magnitude of the collector voltage is descreasing.

Test Circuit



The rise and fall time of the input pulse shall be smaller than 10% of the maximum specified rise and fall time of the output pulse. Changing the pulse width t_w by a factor of two should not change the storage time t_s by more than the desired accurancy of the measurement.

Test Conditions To Be Specified

Case temperature if not $T_C = 25^\circ C$

V_{BB1}, V_{BB2}, V_{CC}, R_{BB1}, R_{BB2}, R_L, t_w and f of pulse generator.

Application Information

Application Information

A. APPLICATION REPORTS

Texas Instruments Applications Laboratories produce a series of Application Reports as an aid to the Design Engineer. Listed in this section are several reports which deal with applications of Power Semiconductors.

B61–Triacs–Theory and General Application 20p

The construction and electrical characteristics of the Triac are compared with the thyristor (SCR). Practical applications of the Triacs are given with advantages over thyristor circuits noted. Some guidance on protection and cooling is also included.

The appendix discusses Triacs with inductive loads.

B75–Solid State Switching Using Triacs and Thyristors 20p

Although most of the solid state switching circuits in this report are single phase, some three phase and D.C. circuits are included. The actuation of solid state contactors by logic, a light beam and pilot switches are described.

B76–Switching Mode Power Supplies 20p

This report deals with the practical possibilities of Switching mode power supplies to deliver stabilised voltages of 60 Volts at 2A and 30 Volts at 3A, directly from a half-wave rectified mains supply. The complexity of all stages and their associated problems are discussed. Some of the safeguards against failure modes are explained.

B83–Inverters 30p

General inverter principles are discussed emphasising their influence on device selection in the design stage. Transient losses, high frequency operation and device operating area are considered in detail. Thirteen practical converter circuits are included with maximum power outputs in the 10W to 300W range running at various frequencies between 400Hz and 50kHz.

B86–Burst Firing Techniques Using Triacs 20p

Two Triac Burst Firing circuits are discussed in this report. The first uses the transistor pump technique and the second mark-space control. The modes of operation of the circuit are described.

B100–Thyristor Reversible D.C. Supply 20p

The report describes a circuit which reverses the D.C. polarity across a load each time the supply is switched. With a simple modification to the switching a new circuit emerges giving a cycloconverter type of frequency changer.

B114–Monochrome TV Switching Regulator and Line Driver 20p

The concept described is a novel one which uses the low pass filter coil as the voltage step down transformer, and, employing the low cost BD410 transistor as the series switch offers considerable cost and power dissipation advantages over the conventional 135–150V regulated power sources for BU105 line output stages. Auxiliary low tension supplies may be obtained by additional windings on the filter choke and the circuit is protected against the rail being shorted to earth or a collector-emitter series switch short circuit.

APPLICATIONS INFORMATION
APPLICATION REPORT SUMMARY

B116—Chopper Power Supplies Using BUY69/70 High Voltage Power Transistors 20p

The BUY69/70 range of high power high voltage switching transistors has produced an upsurge of interest in switching mode regulators operating directly from mains. Isolation of the supply input and output and any step-up or down of the primary voltage required, is achieved by small size high frequency transformers. The basic design criteria are discussed. It is shown that power outputs of 800W are obtainable from a single device and 1500W from a push pull arrangement.

B118—H.V. Stacks, Parallel Operation and System Design 20p

The effect while running H.V. stacks in parallel of load sharing at nominal load and during fault conditions is considered and recommendations made for satisfactory current sharing and protection. One of the most common connections for H.V. power conversion being a three phase bridge, a complete circuit design approach for such a circuit is given. Practical figures are then used to illustrate the calculations necessary for such an approach.

B126—Monochrome TV Circuit Design Using the BUY71 2.2kV Transistor 20p

Advances in technology have made available 2200V silicon transistors (BUY71) suitable for monochrome television linescan applications. The impact of the BUY71 transistor's ratings on the associated television circuitry are examined from both cost and performance viewpoints. Detailed design procedures are given for the BUY71 transistor's operating conditions and its driver stage. The report concludes with a circuit diagram detailing all the power functions of a monochrome television.

B130—Power Control with Triacs 20p

Various ways in which Triacs controlling a load can be switched are described, starting with simple circuits using for instance; contacts, integrated circuits with and without isolation, and optoelectronic devices. More sophisticated methods then given include using the zero voltage switching integrated circuit. SN72440, as an automatic temperature controller, and employing it with burst firing techniques to switch transformer and inductive loads. Finally circuits are given and explained where the phase control is achieved by the variation of the voltage input.

B131—High Voltage Switching Transistor 20p

The ratings and characteristics of high voltage switching transistors are described including methods of measurement. Although the transistor is intended for any high voltage switching circuits it is commonly used in television line output stages and this application has been used as a basis for characterization. The effectiveness in operation is determined by the control of the switching waveforms and the circuit designer is given sufficient information to simplify design in any high voltage application.

B139—Inverter/Converter Systems

The general principles of various inverter/converters are described. No in-depth calculations or explanations are supplied but a number of examples are given to illustrate practical circuits.

These include e.g., inverters which operate from a 12V battery and provide a 300W 50Hz output or drive a 13W fluorescent lamp; a 120W power supply unit; and a stage by stage construction of a switching mode power supply.

APPLICATION REPORT SUMMARY

B157–Television Horizontal Deflection using the BU124 Plastic Encapsulated Transistor 20p

The BU124 is a high voltage silicon transistor designed primarily for horizontal deflection applications in small and medium size monochrome T.V. sets. The device replaces germanium pnp transistors with a few simple circuit modifications and offers a more cost effective solution than silicon devices in the metal can T03 package. The plastic T03 package is immediately interchangeable with the metal can version. In designing the device, particular attention has been paid to its ability to withstand picture tube flashover.

B159–Industrial Switching Mode Power Supplies 20p

Employing power transistors, and switching techniques, three power supplies are described. The first uses a shunt chopper circuit, operates from simply rectified a.c. mains or 24 ± 8V d.c., provides a multiple number of isolated outputs, and, using a range of output stages, delivers total output currents of 1A (15W) to 30A (300W). The second system is a multi-purpose high current (40A) supply suitable for, e.g. certain welding, spark erosion or battery charging equipment. The third shows how the disadvantage encountered when using a single saturating transformer converter with a high turns ratio, can be turned into advantage by adapting it into a sinewave converter to give a high voltage 14kV (@ 1mA) supply suitable for, e.g. use with photo-multipliers, high vacuum systems using thermionic emission, etc.

B167–Second Breakdown and Power Transistors Area of Operation 20p

A description and explanation of forward biased second breakdown is given. It is then shown how these characteristics may be measured and explains the need for the area of operation specification of power transistors.

D4–DC Power Supply Circuits Using Silicon Rectifiers 20p

The aim of this report is to draw attention to the particular design features of circuits using silicon rectifiers. The more common single-phase and three-phase rectifier circuits are described. Design procedures are discussed for circuits using capacitor input and choke input filters and for additional filter sections. Worked examples are given and attention is drawn to the precautions necessary to avoid misuse of silicon rectifiers. For convenience graphs used in the design procedure are collated at the end of the report.

Copies of these reports and a summary of the complete range of Application Reports can be obtained in the UK from: Texas Instruments Ltd., Data Service Department, Manton Lane, Bedford MK41 7PA. Overseas Customers should contact their local Sales Office.

B. SAFE OPERATING AREAS FOR POWER TRANSISTORS

The Safe Operating Area encloses all points representing simultaneous values of two variables which a transistor can safely handle under specified conditions. The majority of transistor applications can be reduced to one or more of the following operations:

Forward-Biased Continuous Operation

Pulsed Forward-Biased Operation

Switching Between Saturation and Cutoff

Each operation is discussed in reference to:

Presentation

Test Circuit

Test Points

Test Procedure

Temperature Derating

The maximum operating capability of each individual transistor is a complex function of I_C, V_{CE}, I_B, T_C and t_p. To characterize the full capability of a device would require an unreasonable number of test points. Therefore, it is necessary to simplify a rating and derating theory. No reference to the type of failure mode is made.

FORWARD-BIASED CONTINUOUS OPERATION

Presentation

Figure 1 shows a Forward-Biased Continuous Safe Operating Area. For $V_{CE} \leqslant V_{CE1}$ the total power dissipation P_T is limited by $I_{C\ max}$. At increasing V_{CE} the power dissipation capability of most transistors is decreasing gradually. Because the rate of decrease depends on the individual transistor, it is suggested to use P_{T3} for $V_{CE2} < V_{CE} \leqslant V_{CE3}$ and P_{T4} for $V_{CE3} < V_{CE} \leqslant V_{CE4}$.

For the area given in Figure 1, safe operation is assured with forward bias only (I_B is positive for npn transistors, negative for pnp transistors). High-current germanium transistors may have I_{CEO} leakage currents of 1 A or more at high junction temperatures. It is not recommended to operate transistors continuously at currents smaller than I_{CEO} except in a temperature-stable cutoff condition.

Test Circuit

The Forward-Biased Continuous Safe Operating Area can be verified by using the temperature-stable common-base circuit illustrated in Figure 2. The Transistor Under Test (TUT) dissipates $P_T \approx I_C V_{CE}$ for $V_{CE} >> 1$ V.

Test Points

The number of test points is arbitrary. The Safe Operating Area in Figure 1 requires three (3) test points: I_{C2} at V_{CE2}, I_{C3} at V_{CE3} and I_{C4} at V_{CE4}. Test points should be selected using the principle that only the verified P_{Tn} is assured for V_{CE}'s smaller than the test point voltage V_{CEn}.

Test Procedure

Test Point Example: $I_C = I_{C2}$

$V_{CE} = V_{CE2}$

$T_C = 55°C$ for $T_{J\ max} \leqslant 125°C$

$T_C = 100°C$ for $T_{J\ max} > 125°C$

Test Duration: 1 minute

Determine: $R_C = \frac{V_{CE2}}{I_{C2}}$

$$R_E \geqslant \frac{5\ V}{I_{C2}}$$

Test Sequence:

1. Start with V_{CC} and V_{EE} at low voltage.
2. Increase V_{CC} to approximately V_{CE2}.
3. Increase V_{EE} to obtain I_{C2}.
4. Increase V_{CC} to two times V_{CE2}.
5. Adjust V_{EE} to obtain V_{CE2} and I_{C2}.
6. Operate transistor at specified case temperature for one (1) minute. The transistor is not acceptable if I_C varies more than $0.1 \cdot I_{C2}$ during the one (1) minute test.
7. Decrease V_{CC} to V_{CE2}.
8. Turn off V_{EE}.
9. Turn off V_{CC}.

Evaluation:

The device shall be capable of meeting the specification

Temperature Derating for Continuous Operation

The maximum allowable case temperature for a given P_T can be calculated as follows:

$$T_C \leqslant T_{J\,max} - \frac{P_T}{P_{Tn}} (T_{J\,max} - 55^\circ C) \text{ for } T_{J\,max} \leqslant 125^\circ C$$

$$T_C \leqslant T_{J\,max} - \frac{P_T}{P_{Tn}} (T_{J\,max} - 100^\circ C) \text{ for } T_{J\,max} > 125^\circ C$$

T_C = Case Temperature

$T_{J\,max}$ = Maximum Operating Junction Temperature

P_T = Total power dissipation at $V_{CE} \leqslant V_{CEn}$

P_{Tn} = Total power Dissipation at Test Point V_{CEn} and $T_C = 55^\circ C$ for $T_{J\,max} \leqslant 125^\circ C$ or $T_C = 100^\circ C$ for $T_{J\,max} > 125^\circ C$.

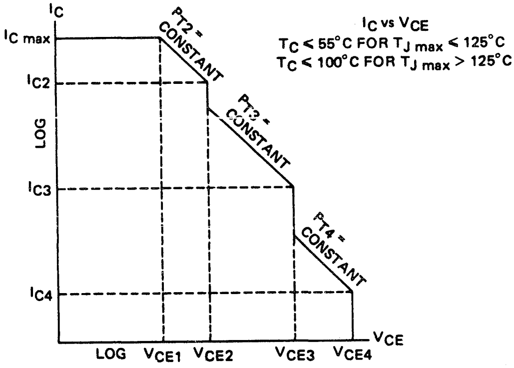


FIGURE 1

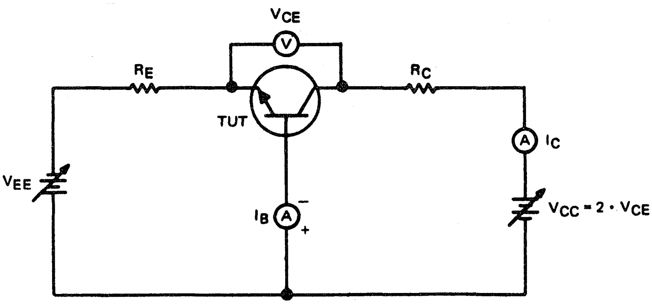


FIGURE 2

PULSED FORWARD-BIASED OPERATION

Presentation

Figure 3 shows three pulse width areas for $t_{p1} \geqslant t_{p2} \geqslant t_{p3}$; however additional pulse width areas may be added. The presentation in Figure 3 has the advantage of specifying the maximum capability of a transistor type at $I_{C\ max}$ whereas the area in Figure 4 is based on maximum capability at highest allowable V_{CE}. The area in Figure 4 is limited by $I_{C\ max}$ and curves representing constant $I_C \cdot V_{CE}$ product. Therefore, the test point at highest V_{CE} assures all other operating points within a given t_p area, but on the other hand, this method derates the capability of a transistor at $I_{C\ max}$.

Test Circuits

In test circuit Figure 5 the Pulsed Forward-Biased capability of a transistor can be verified. The transistor Q_1 can be replaced by a switch such as a mercury relay. Some test circuits require an emitter resistor for the Transistor Under Test (TUT). Such a resistor is not desirable because it complicates specification writing as well as testing procedures.

Test Points

The number of test points equals the number of pulse width areas. The following table shows the required specification for verification at $T_C = 25°C$:

FIGURE	TEST POINT	I_C	V_{CE}	t_p
3	#1	$I_{C\ max}$	V_{CE5}	t_{p1}
	#2	$I_{C\ max}$	V_{CE6}	t_{p2}
	#3	$I_{C\ max}$	V_{CE7}	t_{p3}
4	#1	I_{C1}	V_{CE8}	t_{p1}
	#2	I_{C2}	V_{CE8}	t_{p2}
	#3	I_{C3}	V_{CE8}	t_{p3}

In addition the duty cycle has to be specified.

Test Procedure

Test Point Example: $T_C = 25°C$

$I_C = I_{C\,max}$

$V_{CE} = V_{CE5}$

$t_p = t_{p1}$

Duty Cycle = d1

Determine: $V_{CC1} = V_{CE5} + I_{C\,max} R_S$

The collector current capability of Q_1 should be approximately:

$$I_{CQ1} = 2 \left(\frac{V_{BB2} + 1.5\text{ V}}{R_{BB2}} + \frac{I_{C\,max}}{h_{FE\,min\,(TUT)}} \right)$$

The current supplied to the base of Q_1 should be sufficient to drive Q_1 into saturation for I_{CQ1}. Transistor Q_1 may be replaced by a rela,. The rise and fall time of the collector current should be small compared to the pulse width t_p.

Test Sequence:

1. With all voltage supplies turned off adjust the pulse generator for $t_p = t_{p1}$ and d = d1.
2. Turn on V_{CC} to V_{CC1}.
3. Increase V_{BB1} until i_c reaches $I_{C\,max}$ by applying single pulses.
4. Check that the following conditions are met:

   $t_r << t_p$

   $t_f << t_p$

   $T_C = 25°C$
5. The transistor is not acceptable if i_c varies more than $0.1 \cdot I_{C\,max}$ during t_{p1}. The duration of test is only that time adequate to make the reading.
6. Adjust V_{BB1} to zero and turn off V_{CC}.

For subsequent transistors to be tested, only steps 2, 3, 5 and 6 have to be repeated.

Evaluation:

The device shall still be capable of meeting the specification.

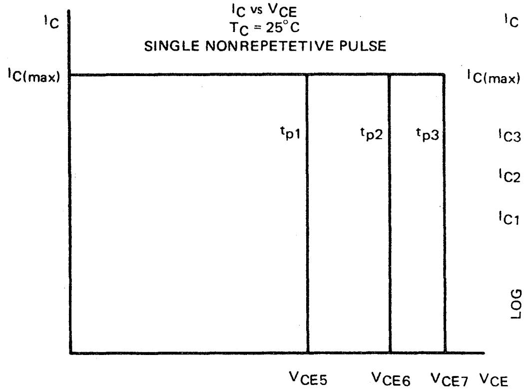


FIGURE 3

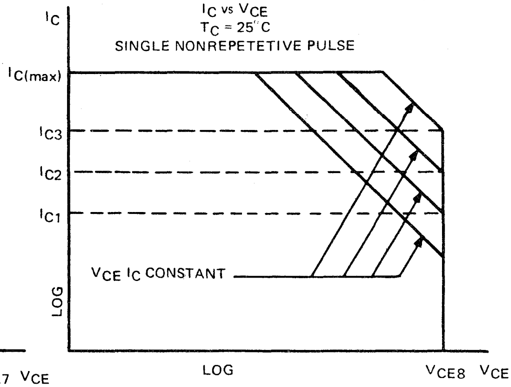


FIGURE 4

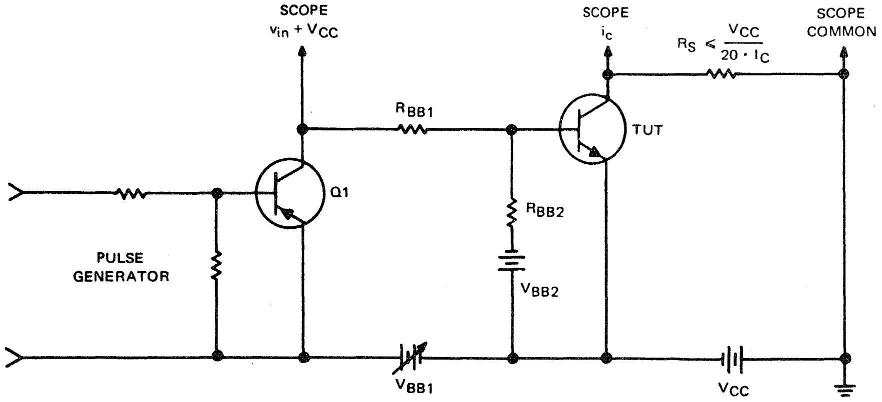


FIGURE 5

SWITCHING BETWEEN SATURATION AND CUTOFF

Resistive Load

Presentation

Figure 6 shows the area within which the load line has to be located for safe operation with a resistive load.

Test Circuit

Verification of the Safe Operating Area is performed by switching the transistor on and off with a single non-repetitive pulse in circuit Figure 7.

Test Points

Only one test point has to be verified. This is accomplished by switching from $V_{CE\ max}$ to saturation at $I_{C\ max}$ and back again to $V_{CE\ max}$.

Test Procedure

Test Point Example: $T_C = 25^\circ C$

$I_C = I_{C\ max}$

$V_{CE} = V_{CE\ max}$

$R_{BB1} = R_{BB1(1)}$

$R_{BB2} = R_{BB2(1)}$

$V_{BB1} = V_{BB1(1)}$

$V_{BB2} = V_{BB2(1)}$

Determine:

$$R_L = \frac{V_{CE\ max}}{I_{C\ max}}$$

$$V_{CC} = V_{CE\ max}$$

The collector current capability of Q_1 should be approximately:

$$I_{CQ1} = 2\left(\frac{V_{BB2} + 1.5\ V}{R_{BB2}} + \frac{V_{BB1} - 1.5\ V}{R_{BB1}}\right)$$

The current supplied to be base of Q_1 should be sufficient to drive Q_1 into saturation for I_{CQ1}.

Test Sequence

1. Adjust V_{BB1}, V_{BB2}, and V_{CC}.
2. Apply single pulses with increasing pulse width until $I_C = I_{C\ max}$ using the specified duty cycle.
3. The transistor is not acceptable if the cutoff state after the pulse cannot be maintained. The duration of the test is only that time adequate to make the reading.
4. Turn off all supplies.

Evaluation:

The device shall still be capable of meeting the specification.

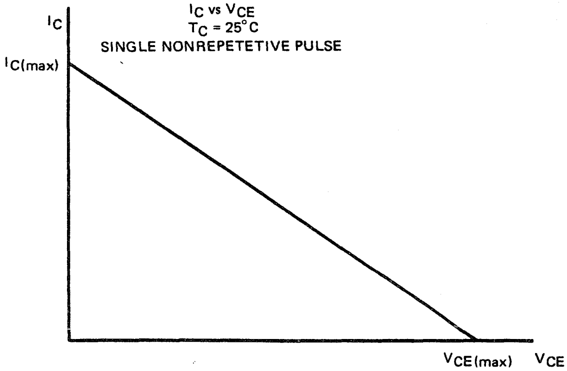


FIGURE 6

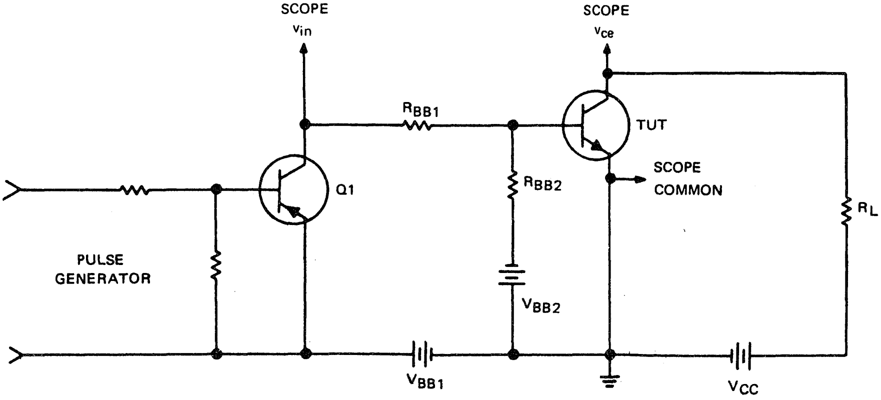


FIGURE 7

Clamped Inductive Load

Presentation

Figure 8 shows the area within which the load line has to be located for safe operation with a clamped inductive load.

Test Circuit

The test circuit in Figure 9 is similar to the one shown in Figure 7 except for the load in the collector circuit. R_{LOAD} represents the total resistive part of the load.

Test Points

By switching through the worst allowable load line during turn off, the Safe Operating Area of Figure 8 can be verified.

Test Precedure:

Test Point Example: $T_C = 25^\circ C$

$I_C = I_{C\,max}$

$V_{CE} = V_{CE9}$

$R_L = R_{L1}$

$L = L_1$

$R_{BB1} = R_{BB1(1)}$

$R_{BB2} = R_{BB2(1)}$

$V_{BB1} = V_{BB1(1)}$

$V_{BB2} = V_{BB2(1)}$

CR = 1NXXXX

$V_{CC} = V_{CE9}$

The collector current capability of Q_1 should be approximately:

$$I_{CQ1} = 2\left(\frac{V_{BB2(1)} + 1.5\text{ V}}{R_{BB2(1)}} + \frac{V_{BB1(1)} - 1.5\text{ V}}{R_{BB1(1)}}\right)$$

The current supplied to the base of Q_1 should be sufficient to drive Q_1 into saturation for I_{CQ1}.

Test Sequence

1. Adjust V_{BB1} to make $v_{in} = V_{BB1(1)}$, V_{BB2} to $V_{BB2(1)}$, and V_{CC} to V_{CE9}.
2. Apply single pulses with increasing pulse width until $i_c = I_{C\ max}$ with duty cycle as specified.
3. The transistor is not acceptable if the cutoff state after the pulse cannot be maintained. The duration of the test is only that time adequate to make the reading.
4. Turn off all supplies.

Evaluation:

The device shall still be capable of meeting the specification.

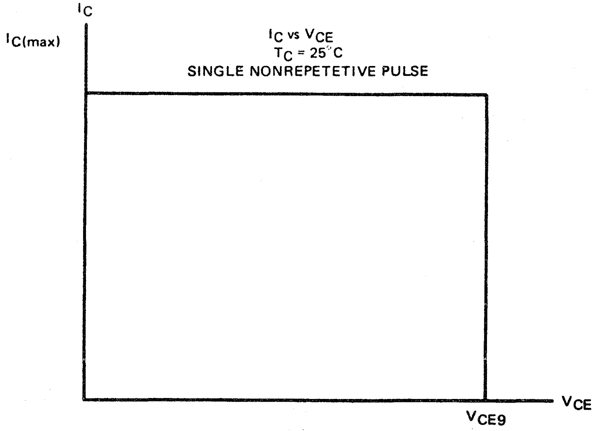


FIGURE 8

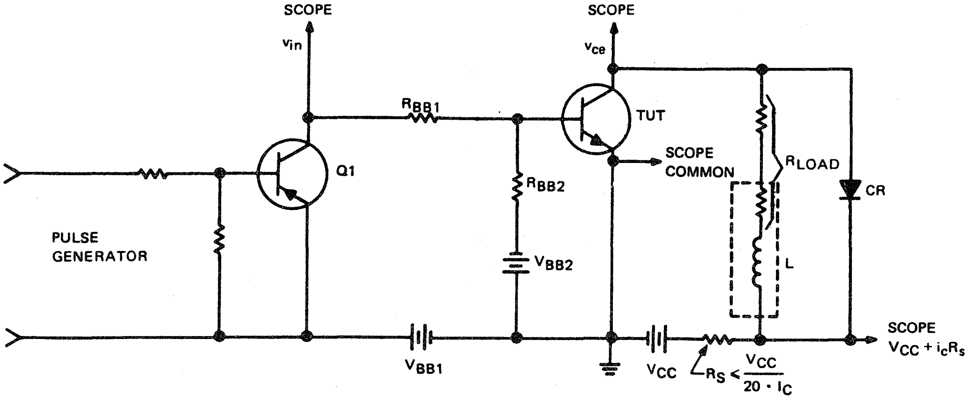


FIGURE 9

Unclamped Inductive Load

Presentation

Figure 10 shows three different areas depending on V_{BB2} and R_{BB2}. The number of areas is arbitrary. The areas are limited by $I_{C\,max}$, curves representing constant energy, $I_C{}^2L/2$, and a reasonable amount of maximum inductance L_1 associated with circuits for which the transistor type is intended for.

Test Circuit

Verification of the Safe Operating Area is performed by switching the transistor from cutoff to saturation to cutoff with a single non-repetitive pulse in the circuit of Figure 11.

Test Points

Testing transistors with I_{C4}, I_{C5}, and I_{C6} and L_1 assures the respective safe operating areas because the capability of absorbing inductive energy increases with increasing collector current. This method derates the capability of a transistor at $I_{C\,max}$ but decreases the amount of testing at higher currents otherwise necessary to verify a curve which attempts to follow the actual capability of the device.

The energy absorbed by the transistor is given by:

$$E_T = E_L + E_S - E_R = \frac{3 \cdot L \cdot I_C{}^2 \cdot V_{(BR)CEX}}{6\ V_{(BR)CEX} - 6\ V_{CC} + 4\ R_L\ I_C}$$

where:

E_L = Inductive Energy Stored in L. $E_L = I_C{}^2L/2$

E_S = Energy from Power Supply During "Turnoff" Transient

E_R = Energy Absorbed by Resistive Component of the Load During "Turnoff" Transient

E_T = Energy Absorbed by Transistor During "Turnoff" Transient.

$V_{(BR)CEX}$ = Breakdown Voltage of Transistor Under Test ($V_{(BR)CEO}$, $V_{(BR)CER}$ or $V_{(BR)CEX}$ – Depending on V_{BB2} and R_{BB2}).

Transistors with $V_{(BR)CEX} >> V_{CC}$ absorb a lower energy E_T during the test than transistors with $V_{(BR)CEX} \approx V_{CC}$. If the E_T capability of a transistor has to be predicted without knowing $V_{(BR)CEX}$, the following E_T can be absorbed at $T_C = 25°C$ for a single non-repetitive pulse:

$$E_T = \frac{1}{2} L \cdot I_C{}^2$$

It is desirable to choose $V_{CC} \leqslant 15$ V. This tends to decrease damage to transistors which are unable to pass the specified test point.

Test Procedure

Test Point Example: $T_C = 25°C$

$I_C = I_{C4}$

$V_{CC} = V_{CC2} \leqslant 15$ V

$R_L = R_{L2} \leqslant V_{CC2}/2I_{C4}$

$L = L_2$

$R_{BB1} = R_{BB1(2)}$

$R_{BB2} = R_{BB2(2)}$

$V_{BB1} = V_{BB1(2)}$

$V_{BB2} = V_{BB2(2)}$

Determine:

The approximate required pulse-width to reach I_{C4} is given by:

$$t_{p4} = \frac{L_2}{V_{CC}} I_C$$

The collector current capability of Q_1 should be approximately:

$$I_{CQ1} = 2 \left(\frac{V_{BB2(2)} + 1.5 \text{ V}}{R_{BB2(2)}} + \frac{V_{BB1(2)} - 1.5 \text{ V}}{R_{BB1(2)}} \right)$$

The current supplied to the base of Q_1 should be sufficient to drive Q_1 into saturation for I_{CQ1}.

Test Sequence

1. Adjust V_{BB1} to make $v_{in} = V_{BB1(2)}$, V_{BB2} to $V_{BB2(2)}$, and V_{CC} to V_{CC2}.
2. Apply single pulses with $t_p << t_{p4}$. Increase pulse width until $i_c = I_{C4}$. (Duty cycle should be such that $T_{J(AVG)} \approx 25°C$.)
3. The transistor is not acceptable if the collector-emitter voltage collapses or oscillates during the collector current fall time t_f. The transistor must be capable to maintain $V_{(BR)CEX}$ during t_f within ±10% of $V_{(BR)CEX}$. The duration of the test is only that time adequate to make the reading.
4. Turn off all supplies.

Evaluation:

The device shall still be capable of meeting the specification.

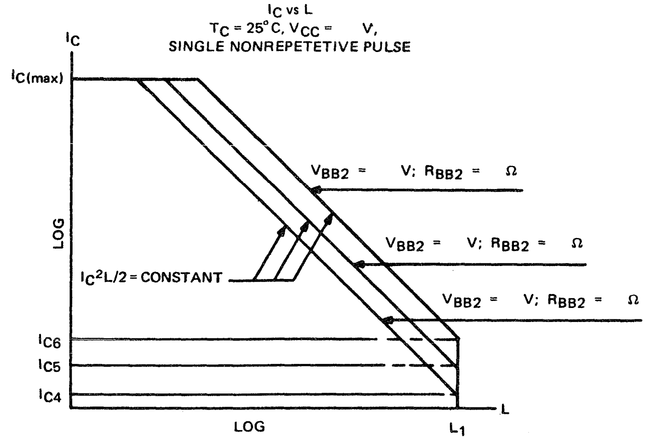


FIGURE 10

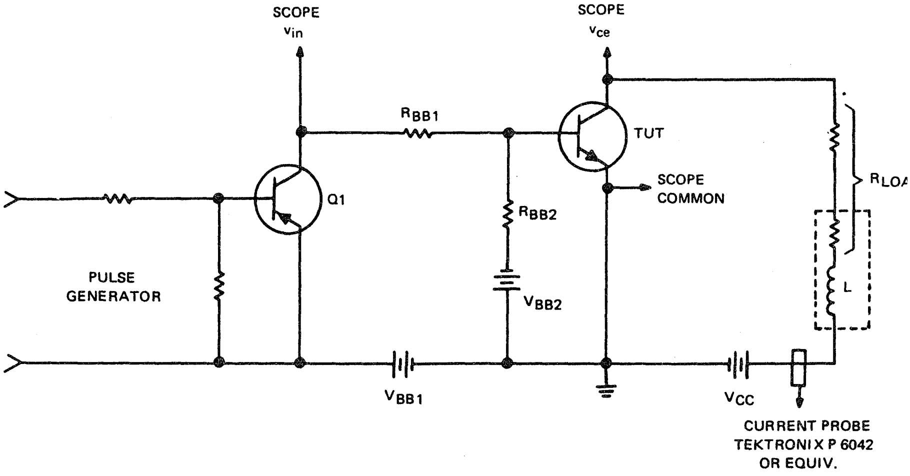


FIGURE 11

Temperature Derating for Pulsed Forward-Biased Operation and Switching

A safe maximum case temperature ($T_C \geqslant 25^\circ C$) for a given I_C and average total power dissipation $P_{T(AVG)}$ due to repetitive pulses can be calculated as follows:

$$T_C \leqslant T_{J\,max} - \frac{I_C}{I_{Cn}}(T_{J\,max} - 25^\circ C) - R_{\theta JC}\,P_{T(AVG)}$$

T_C = Case temperature

$T_{J\,max}$ = Maximum operating junction temperature.

I_C = Collector current during saturation

I_{Cn} = Maximum allowed collector current at $T_C = 25^\circ C$

$R_{\theta JC}$ = Thermal resistance junction to case

$P_{T(AVG)}$ = Average total power dissipation

C. THERMAL CONSIDERATIONS

Heat Flow

To understand the flow of heat through a solid, it is helpful to use an electrical analogy.

ELECTRICAL TERM	THERMAL TERM
V—Voltage differential [V]	T—Temperature differential [°C]
I—Current [A]	P—Power [W]
R—Resistance [Ω]	R_θ—Thermal resistance [°C/W]

Figure 1 illustrates the thermal circuit as it applies to a semiconductor device dissipating a continuous power into an air-cooled heat sink.

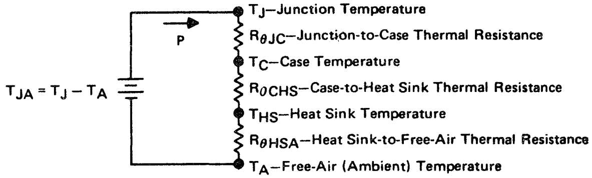


FIGURE 1

The corresponding thermal circuit for a device dissipating continuous power in free air is shown in Figure 2.

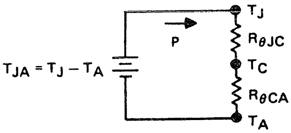


FIGURE 2

The most frequent thermal requirement which must be met is $T_J \leqslant T_{J(max)}$. For a given power dissipation this means the sum of all thermal resistances from junction-to-ambient must be:

$$R_{\theta JA} \leqslant \frac{T_{J(max)} - T_A}{P}$$

Junction-to-Case Thermal Resistance—$R_{\theta JC}$

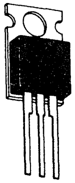
$R_{\theta JC}$ is the temperature difference between the power dissipating junction and a point specified on the case divided by the power dissipation. Most TI power device data sheets specify $R_{\theta JC}$. The case temperature measurement point is shown under "Mechanical Data". Derating should be performed as outlined in SECTION B, Safe Operating Areas for Power Transistors, under "Temperature Derating for Continuous Operation". This is necessary because $R_{\theta JC}$ increases with increasing collector-emitter voltage. Depending on the transistor construction, there is an additional increase or decrease of $R_{\theta JC}$ with increasing collector current. In applying the Safe Operating Area concept, $R_{\theta JC}$ variations with operating point do not have to be considered.

Case-to-Heat-Sink Thermal Resistance—$R_{\theta CHS}$.

$R_{\theta CHS}$ is a function of the following conditions:

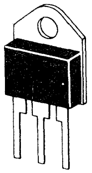
- Torque applied to the machine screw or stud
- Use of thermal compound and type of compound
- Use of insulator and material of insulator
- Flatness of device and heat sink
- Surface finish
- Heat-sink material

The effect of mounting torque as well as insulator material is shown in Figure 3 and Figure 4 for plastic transistors.



PLASTIC
REPLACEMENT
FOR TO-66

GG



PLASTIC
REPLACEMENT
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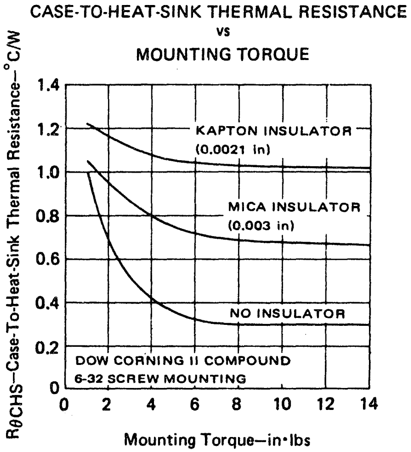
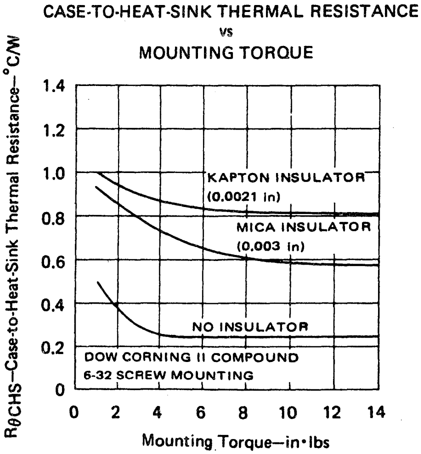


CASE-TO-HEAT-SINK THERMAL RESISTANCE vs MOUNTING TORQUE

FIGURE 3



CASE-TO-HEAT-SINK THERMAL RESISTANCE vs MOUNTING TORQUE

FIGURE 4

Following is a table of $R\theta_{CHS}$ using a mica insulating washer. The heat sink used to determine this value was a smooth, flat, copper plate, with the thermocouple mounted 0.05 inch below the mounting surface in an area beneath the device. The device was mounted using a 2-mil mica washer to a clean, dry, heat-sink surface, without the use of a thermal compound. A torque of ten inch-pounds was applied to the stud or to each of the mounting screws.

PACKAGE	$R\theta$CHS [°C/W]
TO-3	1.5
TO-53	1.6
TO-59, TO-60, TO-111	3.8
TO-61	1.3
TO-63	1.1

By using a thermal compound, the above thermal resistances can be decreased more than 0.6 °C/W, depending upon the type of compound used.

Case-to-Free-Air Thermal Resistance—$R\theta_{CA}$

$R\theta_{CA}$ is more of a constant than $R\theta_{CHS}$ because $R\theta_{CA}$ is not dependent on so many variables. Most TI power device data sheets specify $R\theta_{JA}$ which is $R\theta_{JC} + R\theta_{CA}$.

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