The Power Semiconductor Data Book

for

Design Engineers

TEXAS INSTRUMENTS

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Contents

Alpha-Numeric Index
to
Data Sheets

Product Selection Guide

POWER TRANSISTORS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE		fT Min (MHz)	Resistive Load Switching			Package
						Min – Max	@IC (A)		ton TYP (μs)	toff TYP (μs)	@IC (A)	
NPN	1	40	TIP29	40	12	15-75	1	3	0.5	2	1	T0220
NPN	1	60	TIP29A	60	12	15-75	1	3	0.5	2	1	T0220
NPN	1	80	TIP29B	80	12	15-75	1	3	0.5	2	1	T0220
NPN	1	100	TIP29C	100	12	15-75	1	3	0.5	2	1	T0220
NPN	1	120	TIP29D	160	12	15-	1	3	0.5	2	1	T0220
NPN	1	140	TIP29E	180	12	15-	1	3	0.5	2	1	T0220
NPN	1	160	TIP29F	200	12	15-	1	3	0.5	2	1	T0220
NPN	1	250	TIP47	350	17	30-150	0.3	10	0.2	2	1	T0220
NPN	1	300	TIP48	400	17	30-150	0.3	10	0.2	2	1	T0220
NPN	1	350	TIP49	450	17	30-150	0.3	10	0.2	2	1	T0220
NPN	1	400	TIP50	500	17	30-150	0.3	10	0.2	2	1	T0220
NPN	2	45	BD239	55	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	60	BD239A	70	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	80	BD239B	90	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	100	BD239C	115	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	120	BD239D	160	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	140	BD239E	180	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	160	BD239F	200	12	15-	1	3	0.3	0.8	0.2	T0220
NPN	2	400	BUX84	850	40	50-	.1	20				T0220
NPN	2	450	BUX85	1000	40	50-	.1	20				T0220
NPN	3	40	TIP31	40	16	10-50	3	3	0.5	2	1	T0220
NPN	3	60	TIP31A	60	16	10-50	3	3	0.5	2	1	T0220
NPN	3	80	TIP31B	80	16	10-50	3	3	0.5	2	1	T0220
NPN	3	100	TIP31C	100	16	10-50	3	3	0.5	2	1	T0220
NPN	3	120	TIP31D	160	16	5-	3	3	0.5	2	1	T0220
NPN	3	140	TIP31E	180	16	5-	3	3	0.5	2	1	T0220
NPN	3	160	TIP31F	200	16	5-	3	3	0.5	2	1	T0220
NPN	3	45	BD241	55	16	10-	3	3	0.3	1	1	T0220
NPN	3	60	BD241A	70	16	10-	3	3	0.3	1	1	T0220
NPN	3	80	BD241B	90	16	10-	3	3	0.3	1	1	T0220
NPN	3	100	BD241C	115	16	10-	3	3	0.3	1	1	T0220
NPN	3	120	BD241D	160	16	5-	3	3	0.3	1	1	T0220
NPN	3	140	BD241E	180	16	5-	3	3	0.3	1	1	T0220
NPN	3	160	BD241F	200	16	5-	3	3	0.3	1	1	T0220
NPN	3	200	TIP75	350	26	30-250	0.5	10	0.36	2.2	2	T0220
NPN	3	250	TIP51	350	40	30-150	0.3	2.5	0.25	5	1	T0218
NPN	3	250	TIP75A	400	26	30-250	0.3	10	0.36	2.2	2	T0220
NPN	3	300	TIP52	400	40	30-150	0.3	2.5	0.25	5	1	T0218
NPN	3	300	TIP75B	450	28	30-250	0.5	10	0.36	2.2	2	T0220
NPN	3	350	TIP53	450	40	30-150	0.3	2.5	0.25	5	1	T0218
NPN	3	400	TIP54	500	40	30-150	0.3	2.5	0.25	5	1	T0218
NPN	3	400	TIP75C	500	28	30-250	0.5	10	0.38	2.2	2	T0220
NPN	4	300	MJE13004	700	75	8-	2.0	4				T0220 *
NPN	4	400	MJE13005	850	75	8-	2.0	4				T0220 *
NPN	5	45	BD539	45	18	12-	3	3	0.5	2	1	T0220
NPN	5	60	BD539A	60	18	12-	3	3	0.5	2	1	T0220
NPN	5	80	BD539B	80	18	12-	3	3	0.5	2	1	T0220
NPN	5	100	BD539C	100	18	12-	3	3	0.5	2	1	T0220
NPN	5	120	BD539D	120	18	12-	3	3	0.5	2	1	T0220
NPN	6	40	TIP41	40	26	15-75	3	3	0.6	1	6	T0220
NPN	6	60	TIP41A	60	26	15-75	3	3	0.6	1	6	T0220
NPN	6	80	TIP41B	80	26	15-75	3	3	0.6	1	6	T0220
NPN	6	100	TIP41C	100	26	15-75	3	3	0.6	1	6	T0220
NPN	6	120	TIP41D	160	26	15-	3	3	0.6	1	6	T0220
NPN	6	140	TIP41E	180	26	15-	3	3	0.6	1	6	T0220
NPN	6	160	TIP41F	200	26	15-	3	3	0.6	1	6	T0220
NPN	6	45	BD243	55	26	15-	3	3	0.3	1	1	T0220
NPN	6	60	BD243A	70	26	15-	3	3	0.3	1	1	T0220
NPN	6	80	BD243B	90	26	15-	3	3	0.3	1	1	T0220
NPN	6	100	BD243C	115	26	15-	3	3	0.3	1	1	T0220

* Data Sheet on Request

PRODUCT SELECTION GUIDE

POWER TRANSISTORS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE		fT Min (MHz)	Resistive Load Switching			Package
						Min-Max	@IC (A)		ton TYP (μs)	toff TYP (μs)	@IC (A)	
NPN	6	120	BD243D	160	26	15-	3	3	0.3	1	1	T0220
NPN	6	140	BD243E	180	26	15-	3	3	0.3	1	1	T0220
NPN	6	160	BD243F	200	26	15-	3	3	0.3	1	1	T0220
NPN	6	375	BU426	800	70	30-	.6	6				T0218
NPN	6	400	BU426A	900	70	30-	.6	6				T0218
NPN	7	150	BU407	330	60	10-	5	10				T0220
NPN	7	200	BU406	400	60	10-	5	10				T0220
NPN	7.5	250	TIP55A	350	50	10-100	1		0.17	1.7	5	T0218
NPN	7.5	300	TIP56A	400	50	10-100	1		0.17	1.7	5	T0218
NPN	7.5	350	TIP57A	450	50	10-100	1		0.17	1.7	5	T0218
NPN	7.5	400	TIP58A	500	50	10-100	1		0.17	1.7	5	T0218
NPN	8	40	BD543	40	28	15-	5	3	0.6	1	6	T0218
NPN	8	60	BD543A	60	28	15-	5	3	0.6	1	6	T0218
NPN	8	80	BD543B	80	28	15-	5	3	0.6	1	6	T0218
NPN	8	100	BD543C	100	28	15-	5	3	0.6	1	6	T0218
NPN	8	120	BD543D	120	28	15-	5	3	0.6	1	6	T0218
NPN	9	400	BUV47	850	120	15-	5	3	0.6	1	6	T0218
NPN	9	400	BUV47B	850	120	15-	5	3	0.6	1	6	T0218
NPN	9	450	BUV47A	1000	120	15-	5	3	0.6	1	6	T0218
NPN	10	45	BD245	55	32	20-	3	3	0.3	1	1	T0218
NPN	10	60	BD245A	70	32	20-	3	3	0.3	1	1	T0218
NPN	10	80	BD245B	90	32	20-	3	3	0.3	1	1	T0218
NPN	10	100	BD245C	115	32	20-	3	3	0.3	1	1	T0218
NPN	10	120	BD245D	160	32	20-	3	3	0.3	1	1	T0218
NPN	10	140	BD245E	180	32	20-	3	3	0.3	1	1	T0218
NPN	10	160	BD245F	200	32	20-	3	3	0.3	1	1	T0218
NPN	10	40	TIP33	40	32	20-100	3	3	0.6	1	6	T0218
NPN	10	60	TIP33A	60	32	20-100	3	3	0.6	1	6	T0218
NPN	10	80	TIP33B	80	32	20-100	3	3	0.6	1	6	T0218
NPN	10	100	TIP33C	100	32	20-100	3	3	0.6	1	6	T0218
NPN	10	120	TIP33D	160	32	20-	3	3	0.6	1	6	T0218
NPN	10	140	TIP33E	180	32	20-	3	3	0.6	1	6	T0218
NPN	10	160	TIP33F	200	32	20-	3	3	0.6	1	6	T0218
NPN	10		BU124	350	20	-				3	4	T0218
NPN	15	40	TIP73	50	32	20-150	5	5	0.37	0.9	5	T0220 *
NPN	15	60	TIP73A	70	32	20-150	5	5	0.37	0.9	5	T0220 *
NPN	15	70	TIP3055	100	36	20-70	4		0.6	1	6	T0218
NPN	15	80	TIP73B	90	32	20-150	5	5	0.37	0.9	5	T0220
NPN	15	100	TIP73C	110	32	20-150	5	5	0.37	0.9	5	T0220
NPN	15	40	BD545	40	34	25-	5	3	0.6	1	6	T0218
NPN	15	60	BD545A	60	34	25-	5	3	0.6	1	6	T0218
NPN	15	80	BD545B	80	34	25-	5	3	0.6	1	6	T0218
NPN	15	100	BD545C	100	34	25-	5	3	0.6	1	6	T0218
NPN	15	120	BD545D	120	34	25-	5	3	0.6	1	6	T0218
NPN	15	45	BD743	50	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	60	BD743A	70	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	80	BD743B	90	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	100	BD743C	110	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	120	BD743D	130	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	140	BD743E	150	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	160	BD743F	170	36	20-150	5	5	0.37	0.9	5	T0220
NPN	15	400	BUV48	850	150							T0218
NPN	15	450	BUV48A	1000	150							T0218
NPN	20	45	BD745	50	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	60	BD745A	70	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	80	BD745B	90	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	100	BD745C	110	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	120	BD745D	130	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	140	BD745E	150	46	20-150	5	5	0.37	0.9	5	T0218
NPN	20	150	BD745F	170	46	20-150	5	5	0.37	0.9	5	T0218

* Data Sheet on Request

POWER TRANSISTORS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE Min–Max	hFE @IC (A)	fT Min (MHz)	Resistive Load Switching ton TYP (μs)	toff TYP (μs)	@IC (A)	Package
NPN	25	45	BD249	55	50	10–	15	3	0.3	0.9	5	T0218
NPN	25	60	BD249A	70	50	10–	15	3	0.3	0.9	5	T0218
NPN	25	80	BD249B	90	50	10–	15	3	0.3	0.9	5	T0218
NPN	25	100	BD249C	115	50	10–	15	3	0.3	0.9	5	T0218
NPN	25	120	BD249D	160	50	8–	15	3	0.3	0.9	5	T0218
NPN	25	140	BD249E	180	50	8–	15	3	0.3	0.9	5	T0218
NPN	25	160	BD249F	200	50	8–	15	3	0.3	0.9	5	T0218
NPN	25	40	TIP35	40	50	10–50	15	3	1.2	0.9	1.5	T0218
NPN	25	60	TIP35A	60	50	10–50	15	3	1.2	0.9	1.5	T0218
NPN	25	80	TIP35B	80	50	10–50	15	3	1.2	0.9	1.5	T0218
NPN	25	100	TIP35C	100	50	10–50	15	3	1.2	0.9	1.5	T0218
NPN	25	120	TIP35D	160	50	8–50	15	3	1.2	0.9	1.5	T0218
NPN	25	140	TIP35E	180	50	8–50	15	3	1.2	0.9	1.5	T0218
NPN	25	160	TIP35F	200	50	8–50	15	3	1.2	0.9	1.5	T0218
PNP	1	40	TIP30	40	12	15–75	1	3	0.3	1	1	T0220
PNP	1	60	TIP30A	50	12	15–75	1	3	0.3	1	1	T0220
PNP	1	80	TIP30B	80	12	15–75	1	3	0.3	1	1	T0220
PNP	1	100	TIP30C	100	12	15–75	1	3	0.3	1	1	T0220
PNP	1	120	TIP30D	160	12	15–	1	3	0.3	1	1	T0220
PNP	1	140	TIP30E	180	12	15–	1	3	0.3	1	1	T0220
PNP	1	160	TIP30F	200	12	15–	1	3	0.3	1	1	T0220
PNP	2	45	BD240	55	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	60	BD240A	70	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	80	BD240B	90	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	100	BD240C	115	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	120	BD240D	160	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	140	BD240E	180	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	2	160	BD240F	200	12	15–	1	3	0.2	0.4	0.2	T0220
PNP	3	40	TIP32	40	18	10–50	3	3	0.3	1	1	T0220
PNP	3	60	TIP32A	60	18	10–50	3	3	0.3	1	1	T0220
PNP	3	80	TIP32B	80	18	10–50	3	3	0.3	1	1	T0220
PNP	3	100	TIP32C	100	18	10–50	3	3	0.3	1	1	T0220
PNP	3	120	TIP32D	160	18	5–	3	3	0.3	1	1	T0220
PNP	3	140	TIP32E	180	18	5–	3	3	0.3	1	1	T0220
PNP	3	160	TIP32F	200	18	5–	3	3	0.3	1	1	T0220
PNP	3	45	BD242	55	16	10–	3	3	0.3	1	1	T0220
PNP	3	60	BD242A	70	16	10–	3	3	0.3	1	1	T0220
PNP	3	80	BD242B	90	16	10–	3	3	0.3	1	1	T0220
PNP	3	100	BD242C	115	16	10–	3	3	0.3	1	1	T0220
PNP	3	120	BD242D	150	16	5–	3	3	0.3	1	1	T0220
PNP	3	140	BD242E	180	16	5–	3	3	0.3	1	1	T0220
PNP	3	160	BD242F	200	16	5–	3	3	0.3	1	1	T0220
PNP	5	40	BD540	40	18	12–	3	3	0.3	1	1	T0220
PNP	5	60	BD540A	60	18	12–	3	3	0.3	1	1	T0220
PNP	5	80	BD540B	80	18	12–	3	3	0.3	1	1	T0220
PNP	5	100	BD540C	100	18	12–	3	3	0.3	1	1	T0220
PNP	5	120	BD540D	120	18	12–	3	3	0.3	1	1	T0220
PNP	6	40	TIP42	40	26	15–75	3	3	0.4	0.7	6	T0220
PNP	6	50	TIP42A	60	26	15–75	3	3	0.4	0.7	6	T0220
PNP	6	80	TIP42B	80	26	15–75	3	3	0.4	0.7	6	T0220
PNP	6	100	TIP42C	100	26	15–75	3	3	0.4	0.7	6	T0220
PNP	6	120	TIP42D	160	26	15–	3	3	0.4	0.7	6	T0220
PNP	6	140	TIP42E	180	26	15–	3	3	0.4	0.7	6	T0220
PNP	6	180	TIP42F	200	26	15–	3	3	0.4	0.7	6	T0220
PNP	6	45	BD244	55	26	15–	3	3	0.3	1	1	T0220
PNP	6	60	BD244A	70	26	15–	3	3	0.3	1	1	T0220
PNP	6	80	BD244B	90	26	15–	3	3	0.3	1	1	T0220
PNP	6	100	BD244C	115	26	15–	3	3	0.3	1	1	T0220
PNP	6	120	BD244D	160	26	15–	3	3	0.3	1	1	T0220
PNP	6	140	BD244E	180	26	15–	3	3	0.3	1	1	T0220

POWER TRANSISTORS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE		fT Min (MHz)	Resistive Load Switching			Package
						Min-Max	@IC (A)		ton TYP (μs)	toff TYP (μs)	@IC (A)	
PNP	6	160	BD244F	200	26	15-	3	3	0.3	1	1	T0220
PNP	8	40	BD544	40	28	15-	5	3	0.4	0.7	6	T0220
PNP	8	60	BD544A	60	28	15-	5	3	0.4	0.7	6	T0220
PNP	8	80	BD544B	80	28	15-	5	3	0.4	0.7	6	T0220
PNP	8	100	BD544C	100	28	15-	5	3	0.4	0.7	6	T0220
PNP	8	120	BD544D	120	28	15-	5	3	0.4	0.7	6	T0220
PNP	10	40	TIP34	40	32	20-100	3	3	0.6	1	6	T0218
PNP	10	60	TIP34A	60	32	20-100	3	3	0.6	1	6	T0218
PNP	10	80	TIP34B	80	32	20-100	3	3	0.6	1	6	T0218
PNP	10	100	TIP34C	100	32	20-100	3	3	0.6	1	6	T0218
PNP	10	120	TIP34D	160	32	20-	3	3	0.6	1	6	T0218
PNP	10	140	TIP34E	180	32	20-	3	3	0.6	1	6	T0218
PNP	10	160	TIP34F	200	32	20-	3	3	0.6	1	6	T0218
PNP	10	45	BD246	55	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	60	BD246A	70	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	80	BD246B	80	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	110	BD246C	115	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	120	BD246D	160	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	140	BD246E	180	32	20-	3	3	0.2	0.8	1	T0218
PNP	10	160	BD246F	200	32	20-	3	3	0.2	0.8	1	T0218
PNP	15	40	BD546	40	34	25-	5	3	0.4	0.7	6	T0218
PNP	15	60	BD546A	60	34	25-	5	3	0.4	0.7	6	T0218
PNP	15	80	BD546B	80	34	25-	5	3	0.4	0.7	6	T0218
PNP	15	100	BD546C	100	34	25-	5	3	0.4	0.7	6	T0218
PNP	15	120	BD546D	120	34	25-	5	3	0.4	0.7	6	T0218
PNP	15	45	BD744	50	36	20-150	5	5	0.2	0.9	5	T0220
PNP	15	60	BD744A	70	36	20-150	5	5	0.2	0.9	5	T0220
PNP	15	80	BD744B	90	36	20-150	5	5	0.2	0.9	5	T0220
PNP	15	100	BD744C	110	36	20-150	5	5	0.2	0.9	5	T0220
PNP	15	120	BD744D	130	36	20-150	5	5	0.2	0.9	5	T0220
PNP	15	40	TIP74	50	32	20-150	5	5	0.14	0.9	5	T0220 *
PNP	15	60	TIP74A	70	32	20-150	5	5	0.14	0.9	5	T0220 *
PNP	15	70	TIP2955	100	36	20-70	4		0.4	0.7	6	T0218
PNP	15	80	TIP74B	90	32	20-150	5	5	0.14	0.9	5	T0220 *
PNP	15	100	TIP74C	110	32	20-150	5	5	0.14	0.9	5	T0220 *
PNP	20	45	BD746	50	46	20-150	5	5	0.2	0.9	5	T0218
PNP	20	60	BD746A	70	46	20-150	5	5	0.2	0.9	5	T0218
PNP	20	80	BD746B	90	46	20-150	5	5	0.2	0.9	5	T0218
PNP	20	100	BD746C	110	46	20-150	5	5	0.2	0.9	5	T0218
PNP	20	120	BD746D	130	46	20-150	5	5	0.2	0.9	5	T0218
PNP	25	45	BD249	55	50	10-	15	3	0.3	0.9	5	T0218
PNP	25	60	BD249A	70	50	10-	15	3	0.3	0.9	5	T0218
PNP	25	80	BD249B	90	50	10-	15	3	0.3	0.9	5	T0218
PNP	25	100	BD249C	115	50	10-	15	3	0.3	0.9	5	T0218
PNP	25	120	BD249D	160	50	8-	15	3	0.3	0.9	5	T0218
PNP	25	140	BD249E	180	50	8-	15	3	0.3	0.9	5	T0218
PNP	25	160	BD249F	200	50	8-	15	3	0.3	0.9	5	T0218
PNP	25	40	TIP36	40	50	10-50	15	3	1.1	0.8	15	T0218
PNP	25	60	TIP36A	60	50	10-50	15	3	1.1	0.8	15	T0218
PNP	25	80	TIP36B	80	50	10-50	15	3	1.1	0.8	15	T0218
PNP	25	100	TIP36C	100	50	10-50	15	3	1.1	0.8	15	T0218
PNP	25	120	TIP36D	160	50	6-	15	3	1.1	0.8	15	T0218
PNP	25	140	TIP36E	180	50	6-	15	3	1.1	0.8	15	T0218

* Data Sheet on Request

POWER TRANSISTORS: METAL CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE		fT	Resistive Load Switching			Package
						Min-Max	@IC (A)	Min (MHz)	ton TYP (μs)	toff TYP (μs)	@IC (A)	
NPN	2	400	BUX46	850	60	30-	1.0	4.0				T03 *
NPN	5	40	2N5067	40	50	20-80	1	4	0.5	2	1	T03
NPN	5	40	2N4913	40	50	25-100	2.5	4	0.6	1.2	2.5	T03
NPN	5	60	2N5068	60	50	20-80	1	4	0.5	2	1	T03
NPN	5	60	2N5869	60	50	20-100	1.5	4	0.7	1.8	1.5	T03
NPN	5	60	2N4914	60	50	25-100	2.5	4	0.6	1.2	2.5	T03
NPN	5	80	2N5069	80	50	20-80	1	4	0.5	2	1	T03
NPN	5	80	2N5870	80	50	20-100	1.5	4	0.7	1.8	1.5	T03
NPN	5	80	2N4915	80	50	25-100	2.5	4	0.6	1.2	2.5	T03
NPN	5	200	MJ410	200	105	30-	1	2.5				T03 *
NPN	5	300	MJ411	300	100	30-	1	2.5				T03 *
NPN	5	300	2N6542	650	100	7-	3	6.0				T03
NPN	5	400	2N6543	850	100	7-	3	6.0				T03
NPN	6	100	2N5758	100	86	25-100	3	1				T03
NPN	6	120	2N5759	120	86	25-80	3	1				T03
NPN	6	140	2N5760	140	86	15-60	3	1				T03
NPN	6	350	BUX97	750	60	10-	1.0	20				T03
NPN	6	400	BUX97A	800	60	10-	1.0	20				T03
NPN	6	400	BUX82	850	60	30*	.6					T03
NPN	6	450	BUX97B	800	60	10-	1.0	20				T03
NPN	6	450	BUX83	1000	60	30*	.6					T03
NPN	7	60	2N5873	60	65	20-100	2.5	4	0.7	1.8	2.5	T03
NPN	7	80	2N5874	80	65	20-100	2.5	4	0.7	1.8	2.5	T03
NPN	7.5	250	TIP558	350	100	10-100	1		0.17	1.7	5	T03 *
NPN	7.5	300	TIP559	400	100	10-100	1		0.17	1.7	5	T03 *
NPN	7.5	350	TIP560	450	100	10-100	1		0.17	1.7	5	T03 *
NPN	7.5	400	TIP561	500	100	10-100	1		0.17	1.7	5	T03 *
NPN	8	250	2N6306	500	71	12-60	3	5	0.6	2	3	T03 *
NPN	8	300	2N6307	600	71	15-75	3	5	0.5	2	3	T03 *
NPN	8	350	2N6308	700	71	12-60	3	5	0.6	2	3	T03 *
NPN	6	300	2N6544	650	125	7-	5	6				T03
NPN	8	375	BU326	550	150	10-	5	15				T03
NPN	8	400	BU326A	550	150	10-	5	15				T03
NPN	8	400	2N6545	850	125	7-	5	6				T03
NPN	8.5	400	BUX47	850	175	-	5	-				T03
NPN	8.5	400	BUX47B	850	175							T03
NPN	8.5	450	BUX47A	1000	175							T03
NPN	10	60	2N5877	60	86	20-100	4	4	0.7	1.8	4	T03
NPN	10	60	2N3713	80	85	25-75	1	4	0.45	0.35	1	T03
NPN	10	60	2N3715	80	85	50-150	1	4	0.45	0.35	1	T03
NPN	10	80	2N5878	80	86	20-100	4	4	0.7	1.8	4	T03
NPN	10	80	2N3714	100	85	25-75	1	4	0.45	0.35	1	T03
NPN	10	80	2N3716	100	85	50-150	1	4	0.45	0.35	1	T03
NPN	10	200	BUY69C	500	57	15-	2.5	6		5	8	T03
NPN	10	200	BUY70C	500	42	15-	1	6		5	4	T03
NPN	10	300	2N6250	375	100	8-50	10	2.5				T03 *
NPN	10	300	TIP562	300	100	20-	1		0.55	1.5	10	T03 *
NPN	10	325	BUY69B	800	57	15-	2.5	6		5	8	T03
NPN	10	325	BUY70B	800	42	15-	1	6		5	4	T03
NPN	10	400	BUY69A	1000	57	15-	2.5	6		5	8	T03
NPN	10	400	BUY70A	1000	42	15-	1	6		5	4	T03
NPN	10	400	TIP563	400	100	20-	1		0.55	1.5	10	T03 *
NPN	10	350	MJ13014	550	150	12-	2.5					T03 *
NPN	10	400	MJ413	400	125	20-	.5	2.5				T03 *
NPN	10	400	MJ423	400	125	30-	1.0	2.5				T03 *
NPN	10	400	BUW34	500	125	15-	1.0					T03 *
NPN	10	400	MJ13015	600	150	12-	2.5					T03 *
NPN	10	400	BUW35	800	125	15-	1.0					T03 *
NPN	10	400	BUX80	850	100	30*	1.2					T03
NPN	10	450	BUW26	800	125	15-	1.0					T03 *

*Typical value

* Data Sheet on Request

PRODUCT SELECTION GUIDE

POWER TRANSISTORS: METAL CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE Min-Max	hFE @IC (A)	fT Min (MHz)	Resistive Load Switching ton TYP (μs)	toff TYP (μs)	@IC (A)	Package
NPN	10	450	BUW36	900	125	15-	1.0					T03 *
NPN	10	450	BUX81	1000	100	30*	1.2					T03
NPN	15	60	2N5881	60	91	20-100	6	4	0.7	1.8	6	T03
NPN	15	80	2N5882	80	91	20-100	6	4	0.7	1.8	6	T03
NPN	15	300	2N6546	650	175	6-	10	6				T03
NPN	15	400	BUW44	500	175							T03 *
NPN	15	400	BUW45	800	175							T03 *
NPN	15	400	2N6547	850	175	6-	10	6				T03
NPN	15	400	BUX48	850	175							T03
NPN	15	450	BUW46	900	175							T03 *
NPN	15	450	BUX48A	1000	175							T03
NPN	20	75	2N5039	120	140	20-	10	60				T03
NPN	20	80	2N5303	80	114	15-60		2	1	3	10	T03
NPN	20	90	2N5038	150	140	20-	12	60				T03
NPN	25	60	2N5885	60	114	20-100	10	4	0.7	1.8	10	T03
NPN	25	80	2N5886	80	114	20-100	10	4	0.7	1.8	10	T03
NPN	30	40	2N3771	50	86	15-60	15	0.2				T03
NPN	30	40	2N5301	40	114	15-60	15	2	1	3	10	T03
NPN	30	60	2N6326	80	114	6-30	30	3	0.6	0.9	15	T03
NPN	30	60	2N3772	100	86	15-60	10	0.2				T03
NPN	30	60	2N5032	60	114	15-60	15	2	1	3	10	T03 *
NPN	30	80	2N6327	80	114	6-30	30	3	0.6	0.9	15	T03
NPN	30	90	MJ802	100	200	25-	7.5	2.0				T03 *
NPN	30	100	2N6328	100	114	6-30	30	3	0.6	0.9	15	T03
NPN	30	400	BUX98	850	250							T03 *
NPN	30	450	BUX98A	1000	250							T03 *
PNP	5	40	2N4901	40	50	20-80	1	4	0.35	0.8	1	T03
PNP	5	40	2N4904	40	50	25-100	2.5	4	0.4	0.7	2.5	T03
PNP	5	60	2N4902	60	50	20-80	1	4	0.35	0.8	1	T03
PNP	5	60	2N5867	60	50	20-100	1.5	4	0.7	1.8	1.5	T03
PNP	5	60	2N4905	60	50	25-100	2.5	4	0.4	0.7	1	T03
PNP	5	80	2N4903	80	50	20-80	1	4	0.35	0.8	1	T03
PNP	5	80	2N5868	80	50	20-100	1.5	4	0.7	1.8	1.5	T03
PNP	5	80	2N4906	80	50	25-100	2.5	4	0.4	0.7	1	T03
PNP	6	100	TIP544	100	85	25-100	3					T03 *
PNP	6	120	TIP545	120	85	20-80	3	1				T03 *
PNP	6	140	TIP546	140	85	15-60	3	1				T03 *
PNP	7	60	2N5871	60	65	20-100	2.5	4	0.7	1.8	2.5	T03
PNP	7	80	2N5872	80	65	20-100	2.5	4	0.7	1.8	2.5	T03
PNP	10	80	2N5875	60	86	20-100	4	4	0.7	1.8	4	T03
PNP	10	60	2N3789	80	85	25-90	1	4	0.35	0.8	1	T03
PNP	10	60	2N3791	60	85	50-180	1	4	0.35	0.8	1	T03
PNP	10	80	2N5876	80	86	20-100	4	4	0.7	1.8	4	T03
PNP	10	80	2N3790	80	85	25-90	1	4	0.35	0.8	1	T03
PNP	10	80	2N3792	80	85	50-180	1	4	0.35	0.8	1	T03
PNP	15	80	2N5879	60	91	20-100	6	4	0.7	1.8	6	T03
PNP	15	70	2N6246	70	71	20-100	7	10				T03 *
PNP	15	80	2N5880	80	91	20-100	6	4	0.7	1.8	6	T03
PNP	15	90	2N6247	90	71	20-100	6	10				T03 *
PNP	25	80	2N5883	80	114	20-100	10	4	0.7	1.8	10	T03
PNP	25	80	2N5884	80	114	20-100	10	4	0.7	1.8	10	T03
PNP	30	40	2N4398	40	114	15-60	15	4	0.4	2.1	10	T03
PNP	30	60	2N6329	60	114	6-30	30	3	0.6	0.9	15	T03
PNP	30	60	2N4399	60	114	15-60	15	4	0.4	2.1	10	T03
PNP	30	80	2N6330	80	114	6-30	30	3	0.6	0.9	15	T03
PNP	30	100	2N6331	100	114	6-30	30	3	0.6	0.9	15	T03

*Typical value

* Data Sheet on Request

FAST-SWITCHING TRANSISTORS: 800 – 1000V

Polarity	Rated I_C (A)	Rated $V_{(BR)CEO}$ (V)	Device Number	Rated $V_{(BR)CBO}$ (V)	Power (W) 25°C	Power (W) 100°C	V_{CE} @ I_C/I_B = 5 Maximum Volts	V_{CE} @ I_C/I_B = 5 Maximum Amps	100°C Inductive Switching t_{sv}(μs) Max.	100°C Inductive Switching t_{xo}(μs) Max.	Package
NPN	4	375	TIPL760	800	80	32	2.5	4	3	0.75	TO-220
NPN	4	375	TIPL761	800	100	40	2.5	4	3	0.75	TO-218
NPN	4	375	TIPL751	800	120	68.5	2.5	4	3	0.75	TO-3
NPN	4	420	TIPL760A	1000	80	32	2.5	4	3	0.75	TO-220
NPN	4	420	TIPL761A	1000	100	40	2.5	4	3	0.75	TO-218
NPN	4	420	TIPL751A	1000	120	68.5	2.5	4	3	0.75	TO-3
NPN	6	350	TIPL762	800	120	48	2.5	6	3	0.5	TO-218
NPN	6	375	TIPL752	800	150	85.5	2.5	6	3	0.5	TO-3
NPN	6	400	TIPL762A	1000	120	48	2.5	6	3	0.5	TO-218
NPN	6	420	TIPL752A	1000	150	85.5	2.5	6	3	0.5	TO-3
NPN	8	350	TIPL763	800	120	48	2.5	8	3	0.5	TO-218
NPN	8	375	TIPL753	800	150	85.5	2.5	8	3	0.5	TO-3
NPN	8	400	TIPL763A	1000	120	48	2.5	8	3	0.5	TO-218
NPN	8	420	TIPL753A	1000	150	85.5	2.5	8	3	0.5	TO-3
NPN	10	375	TIPL765	800	125	50	2.5	10	3	0.5	TO-218
NPN	10	375	TIPL755	800	180	103	2.5	10	3	0.5	TO-3
NPN	10	420	TIPL765A	1000	125	50	2.5	10	3	0.5	TO-218
NPN	10	420	TIPL755A	1000	180	103	2.5	10	3	0.5	TO-3
NPN	15	375	TIPL757	800	200	111	2.5	15	3	0.5	TO-3 *
NPN	15	420	TIPL757A	1000	200	111	2.5	15	3	0.5	TO-3 *

* Data Sheet on Request

POWER DARLINGTONS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE Min-Max	hFE @IC (A)	fT Min (MHz)	Resistive Load Switching ton TYP (μs)	toff TYP (μs)	@IC (A)	Package
NPN	2	60	TIP110	60	20	1000-	1		2.6	4.5	2	T0220
NPN	2	80	TIP111	80	20	1000-	1		2.6	4.5	2	T0220
NPN	2	100	TIP112	100	20	1000-	1		2.6	4.5	2	T0220
NPN	4	45	BDW53	45	16	750-20,000	1.5		1	4.5	2	T0220
NPN	4	60	BDW53A	60	16	750-20,000	1.5		1	4.5	2	T0220
NPN	4	80	BDW53B	80	16	750-20,000	1.5		1	4.5	2	T0220
NPN	4	100	BDW53C	100	16	750-20,000	1.5		1	4.5	2	T0220
NPN	4	120	BDW53D	120	16	750-20,000	1.5		1	4.5	2	T0220
NPN	5	60	TIP120	60	26	1000-	3		1.5	8.5	3	T0220
NPN	5	80	TIP121	80	26	1000-	3		1.5	8.5	3	T0220
NPN	5	100	TIP122	100	26	1000-	3		1.5	8.5	3	T0220
NPN	6	45	BDW63	45	24	750-20,000	2		1	5	3	T0220
NPN	6	60	BDW63A	60	24	750-20,000	2		1	5	3	T0220
NPN	6	80	BDW63B	80	24	750-20,000	2		1	5	3	T0220
NPN	6	100	BDW63C	100	24	750-20,000	2		1	5	3	T0220
NPN	6	120	BDW63D	120	24	750-20,000	2		1	5	3	T0220
NPN	7	300	TIP150	300	32	150-	2.5		10	1.1	5	T0220
NPN	7	350	TIP151	350	32	150-	2.5		10	1.1	5	T0220
NPN	7	400	TIP152	400	32	150-	2.5		10	1.1	5	T0220
NPN	8	60	TIP100	60	32	1000-20,000	3		0.39	4.3	8	T0220
NPN	8	80	TIP101	80	32	1000-20,000	3		0.39	4.3	8	T0220
NPN	8	100	TIP102	100	32	1000-20,000	3		0.39	4.3	8	T0220
NPN	8	60	TIP130	60	28	1000-15,000	4					T0220
NPN	8	80	TIP131	80	28	1000-15,000	4					T0220
NPN	8	100	TIP132	100	28	1000-15,000	4					T0220
NPN	8	45	BDW73	45	32	750-20,000	3		1	5	3	T0220
NPN	8	60	BDW73A	60	32	750-20,000	3		1	5	3	T0220
NPN	8	80	BDW73B	80	32	750-20,000	3		1	5	3	T0220
NPN	8	100	BDW73C	100	32	750-20,000	3		1	5	3	T0220
NPN	8	120	BDW73D	120	32	750-20,000	3		1	5	3	T0220
NPN	10	60	TIP140	60	50	1000-	5		0.9	11	10	T0218
NPN	10	80	TIP141	80	50	1000-	5		0.9	11	10	T0218
NPN	10	100	TIP142	100	50	1000-	5		0.9	11	10	T0218
NPN	10	320	TIP160	320	50	200-	4		1.54	4.8	6.5	T0218
NPN	10	350	TIP161	350	50	200-	4		1.54	4.8	6.5	T0218
NPN	10	380	TIP162	380	50	200-	4		1.54	4.8	6.5	T0218
PNP	2	60	TIP115	60	20	1000-	1		2.6	4.5	2	T0220
PNP	2	80	TIP116	80	20	1000-	1		2.6	4.5	2	T0220
PNP	2	100	TIP117	100	20	1000-	1		2.6	4.5	2	T0220
PNP	4	45	BDW54	45	16	750-20,000	1.5		1	4.5	2	T0220
PNP	4	60	BDW54A	60	16	750-20,000	1.5		1	4.5	2	T0220
PNP	4	80	BDW54B	80	16	750-20,000	1.5		1	4.5	2	T0220
PNP	4	100	BDW54C	100	16	750-20,000	1.5		1	4.5	2	T0220
PNP	4	120	BDW54D	120	16	750-20,000	1.5		1	4.5	2	T0220
PNP	5	60	TIP125	60	26	1000-	3		1.5	8.5	3	T0220
PNP	5	80	TIP126	80	26	1000-	3		1.5	8.5	3	T0220
PNP	5	100	TIP127	100	26	1000-	3		1.5	8.5	3	T0220
PNP	6	45	BDW64	45	24	750-20,000	2		1.0	5	3	T0220
PNP	6	60	BDW64A	60	24	750-20,000	2		1.0	5	3	T0220
PNP	6	80	BDW64B	80	24	750-20,000	2		1.0	5	3	T0220
PNP	6	100	BDW64C	100	24	750-20,000	2		1.0	5	3	T0220
PNP	6	120	BDW64D	120	24	750-20,000	2		1.0	5	3	T0220
PNP	8	60	TIP105	60	32	1000-20,000	3		0.34	2.2	8	T0220
PNP	8	80	TIP106	80	32	1000-20,000	3		0.34	2.2	8	T0220
PNP	8	100	TIP107	100	32	1000-20,000	3		0.34	2.2	8	T0220
PNP	8	60	TIP135	60	28	1000-15,000	4					T0220
PNP	8	80	TIP136	80	28	1000-15,000	4					T0220
PNP	8	100	TIP137	100	28	1000-15,000	4					T0220
PNP	8	45	BDW74	45	32	750-20,000	3		1	5	3	T0220
PNP	8	60	BDW74A	60	32	750-20,000	3		1	5	3	T0220

POWER DARLINGTONS: PLASTIC CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE Min-Max	hFE @IC (A)	fT Min (MHz)	Resistive Load Switching ton TYP (µs)	Resistive Load Switching toff TYP (µs)	Resistive Load Switching @IC (A)	Package
PNP	8	80	BDW74B	80	32	750-20,000	3	3	1	5	3	T0220
PNP	8	100	BDW74C	100	32	750-20,000	3	3	1	5	3	T0220
PNP	8	120	BDW74D	120	32	750-20,000	3	3	1	5	3	T0220
PNP	10	60	TIP145	60	50	1000-	5	3	0.9	11	10	T0218
PNP	10	80	TIP146	80	50	1000-	5	3	0.9	11	10	T0218
PNP	10	100	TIP147	100	50	1000-	5	3	0.9	11	10	T0218

POWER DARLINGTONS: METAL CASE

Polarity	Rated IC (A)	Rated VCEO (V)	Device Number	Rated VCBO (V)	Rated PT (W)	hFE Min-Max	hFE @IC (A)	fT Min (MHz)	Resistive Load Switching ton TYP (µs)	Resistive Load Switching toff TYP (µs)	Resistive Load Switching @IC (A)	Package
NPN	5	60	TIP620	60	65	1000-	3		1.5	8.5	3	T03
NPN	5	80	TIP621	80	65	1000-	3		1.5	8.5	3	T03
NPN	5	100	TIP622	100	65	1000-	3		1.5	8.5	3	T03
NPN	10	60	TIP640	60	100	1000-	5		0.9	11	10	T03
NPN	10	60	MJ3000	60	86	1000-	5					T03 *
NPN	10	80	TIP641	80	100	1000-	5		0.9	11	10	T03
NPN	10	80	MJ3001	80	86	1000-	5					T03 *
NPN	10	100	TIP642	100	100	1000-	5		0.9	11	10	T03
NPN	10	320	TIP660	320	80	200-	4		1.5	4.8	6.5	T03
NPN	10	350	TIP661	350	80	200-	4		1.5	4.8	6.5	T03
NPN	10	380	TIP662	380	80	200-	4		1.5	4.8	6.5	T03
NPN	12	60	2N6057	60	86	750-18,000	6	4		3.1	6	T03 *
NPN	12	80	2N6058	80	86	750-18,000	6	4		3.1	6	T03 *
NPN	12	100	2N6059	100	86	750-18,000	6	4		3.1	6	T03 *
NPN	16	60	MJ4033	60	86	1000-	10					T03 *
NPN	16	80	MJ4034	80	86	1000-	10					T03 *
NPN	16	100	MJ4035	100	86	1000-	10					T03 *
PNP	5	60	TIP625	60	65	1000-	3		1.5	8.5	3	T03
PNP	5	80	TIP626	80	65	1000-	3		1.5	8.5	3	T03
PNP	5	100	TIP627	100	65	1000-	3		1.5	8.5	3	T03
PNP	10	60	TIP605	60	80	1000-	3		0.3	2.2	8	T03
PNP	10	60	TIP645	60	100	1000-	5		0.9	11	10	T03
PNP	10	60	MJ2500	60	86	1000-	5					T03 *
PNP	10	80	TIP606	80	80	1000-	3		0.3	2.2	8	T03
PNP	10	80	TIP646	80	100	1000-	5		0.9	11	10	T03
PNP	10	80	MJ2501	80	86	1000-	5					T03 *
PNP	10	100	TIP607	100	80	1000-	3		0.3	2.2	1	T03
PNP	10	100	TIP647	100	100	1000-	5		0.9	11	10	T03
PNP	12	60	2N6050	60	86	750-18,000	6	4		3.1	6	T03 *
PNP	12	80	2N6051	80	86	750-18,000	6	4		3.1	6	T03 *
PNP	12	100	2N6052	100	86	750-18,000	6	4		3.1	6	T03 *
PNP	16	60	MJ4030	60	86	1000-	10					T03 *
PNP	16	80	MJ4031	80	86	1000-	10					T03 *
PNP	16	100	MJ4032	100	86	1000-	10					T03 *

* Data Sheet on Request

FAST-SWITCHING DARLINGTONS: 150 – 400V

Polarity	Rated I_C (A)	Rated $V_{(BR)CEO}$ (V)	Device Number	Rated $V_{(BR)CBO}$ (V)	Power (W) 25°C	Power (W) 100°C	V_{CE} @ I_C/I_B = 5 Maximum Volts	V_{CE} @ I_C/I_B = 5 Maximum Amps	25°C Inductive Switching t_{sv}(μs) Max.	25°C Inductive Switching t_{xo}(μs) Max.	Package
NPN	10	120	TIPL790	150	70	28	2	10	0.45*	0.32*	TO-220
NPN	10	120	TIPL785	150	80	32	2	10	0.45*	0.32*	TO-218
NPN	10	120	TIPL775	150	100	57.2	2	10	0.45*	0.32*	TO-3
NPN	10	150	TIPL790A	200	70	28	2	10	0.45*	0.32*	TO-220
NPN	10	150	TIPL785A	200	80	32	2	10	0.45*	0.32*	TO-218
NPN	10	150	TIPL775A	200	100	57.2	2	10	0.45*	0.32*	TO-3

*Inductive switching at I_C = 10A, $I_{B(ON)}$ = 0.05A

HIGH-ENERGY POWER DARLINGTONS

Polarity	Rated I_C (A)	Rated $V_{(BR)CEO}$ (V)	Device Number	Rated $V_{(BR)CBO}$ (V)	Power (W) 25°C	Power (W) 100°C	V_{CE} @ I_C/I_B = 10 Maximum Volts	V_{CE} @ I_C/I_B = 10 Maximum Amps	V_{CE} @ I_C/I_B = 33 Maximum Volts	V_{CE} @ I_C/I_B = 33 Maximum Amps	Forward Pulse Energy (mJ)	Package
NPN	10	300	BU323	500	175	100	–	–	2.7	10	550	T03 *
NPN	10	350	BU323A	600	175	100	–	–	2.7	10	550	T03 *
NPN	20	450	TIPL774	550	175	100	3	15	–	–	300	T03

* Data Sheet on Request

3-STAGE POWER DARLINGTONS

Polarity	Rated I_C (A)	Rated $V_{(BR)CEO}$ (V)	Device Number	Rated $V_{(BR)CBO}$ (V)	Power @ 25°C (W)	$V_{CE\ SAT}$ maximum Volts	$V_{CE\ SAT}$ maximum @ I_C/I_B	$V_{CE\ SAT}$ maximum @ I_C (A)	100°C Inductive Switching t_{sv} (μs) max	100°C Inductive Switching t_{xo} (μs) max	100°C Inductive Switching @ I_C (A)	100°C Inductive Switching @ $I_{B\ OFF}$ (A)	Package
NPN	20	950	TIPL773	950	180	2.5	50	15	4.8	2.0	15	1.5	T03
NPN	20	1050	TIPL773A	1050	180	2.5	50	12.5	5.0	2.0	12.5	1.5	T03
NPN	20	1150	TIPL773B	1150	180	2.5	50	10	5.2	2.0	10	1.5	T03

*Inductive switching at 25°C

POWER THYRISTORS: SCR'S

Rated I_T (A)	Rated V_{DRM} & V_{RRM} (V)	Device Number	Rated I_{TSM} (A)	I_{GT} Max (mA)	V_{GT} Max (V)	I_H Max (mA)	V_{TM} Max (V)	V_{TM} @ I_{TM} (A)	Package	Notes
5	100	TIC106A	30	0.2	1	5	1.7	5	T0220	
5	200	TIC106B	30	0.2	1	5	1.7	5	T0220	
5	300	TIC106C	30	0.2	1	5	1.7	5	T0220	
5	400	TIC106D	30	0.2	1	5	1.7	5	T0220	
5	500	TIC106E	30	0.2	1	5	1.7	5	T0220	
5	600	TIC106M	30	0.2	1	5	1.7	5	T0220	
5	700	TIC106S	30	0.2	1	5	1.7	5	T0220	
5	800	TIC106N	30	0.2	1	5	1.7	5	T0220	
5	100	TIC108A	20	1.0	1	10	1.7	5	T0220	
5	200	TIC108B	20	1.0	1	10	1.7	5	T0220	
5	300	TIC108C	20	1.0	1	10	1.7	5	T0220	
5	400	TIC108D	20	1.0	1	10	1.7	5	T0220	
5	500	TIC108E	20	1.0	1	10	1.7	5	T0220	
5	600	TIC108M	20	1.0	1	10	1.7	5	T0220	
5	700	TIC108S	20	1.0	1	10	1.7	5	T0220	
5	800	TIC108N	20	1.0	1	10	1.7	5	T0220	
8	100	TIC116A	80	20	1.5	40	1.7	8	T0220	
8	200	TIC116M	80	20	1.5	40	1.7	8	T0220	
8	300	TIC116C	80	20	1.5	40	1.7	8	T0220	
8	400	TIC116D	80	20	1.5	40	1.7	8	T0220	
8	500	TIC116E	80	20	1.5	40	1.7	8	T0220	
8	600	TIC116M	80	20	1.5	40	1.7	8	T0220	
8	700	TIC116S	80	20	1.5	40	1.7	8	T0220	
8	800	TIC116N	80	20	1.5	40	1.7	8	T0220	
12	100	TIC126A	100	20	1.5	40	1.4	12	T0220	
12	200	TIC126B	100	20	1.5	40	1.4	12	T0220	
12	300	TIC126C	100	20	1.5	40	1.4	12	T0220	
12	400	TIC126D	100	20	1.5	40	1.4	12	T0220	
12	500	TIC126E	100	20	1.5	40	1.4	12	T0220	
12	600	TIC126M	100	20	1.5	40	1.4	12	T0220	
12	700	TIC126S	100	20	1.5	40	1.4	12	T0220	
12	800	TIC126N	100	20	1.5	40	1.4	12	T0220	

POWER THYRISTORS: TRIACS

Rated I_T (RMS) (A)	Rated V_{DRM} (V)	Device Number	Rated I_{TSM} (A)	I_{GTM} Max (mA)				V_{GTM} Max (V)				I_H Max (mA)		V_{TM}		Package
				MT2+ G+	+ −	− −	− +	MT2+ G+	+ −	− −	− +	MT2+	MT2−	Max (V)	@ I_{TM} (A)	
2.5	100	TIC201A	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	200	TIC201B	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	400	TIC201D	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	500	TIC201E	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	600	TIC201M	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	700	TIC201S	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
2.5	800	TIC201N	14	5	8	10	25	2.5	2.5	2.5		30	30	1.9	3.5	T0220
4	100	TIC206A	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	200	TIC206B	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	400	TIC206D	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	500	TIC206E	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	600	TIC206M	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	700	TIC206S	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
4	800	TIC206N	30	5	5	5	10	2	2	2	2	30	30	2.2	4.2	T0220
6	100	TIC216A	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	200	TIC216B	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	400	TIC216D	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	500	TIC216E	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	600	TIC216M	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	700	TIC216S	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
6	800	TIC216N	80	5	5	5	10	2.2	2.2	2.2	3	30	30	1.7	8.4	T0220
8	100	TIC225A	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	200	TIC225B	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	400	TIC225D	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	500	TIC225E	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	600	TIC225M	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	700	TIC225S	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	800	TIC225N	80	5	10	10	15	2.2	2.2	2.2	3	30	30	2.1	12	T0220
8	100	TIC226A	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
8	200	TIC226B	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
8	400	TIC226D	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
8	500	TIC226E	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
8	600	TIC226M	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
8	700	TIC226S	80	50	50	50		2.5	2.5	2.5		60	60	2.1	12	T0220
12	100	TIC236A	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	200	TIC236B	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	400	TIC236D	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	500	TIC236E	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	600	TIC236M	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	700	TIC236S	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
12	800	TIC236N	100	50	50	50		2.5	2.5	2.5		50	50	2.1	17	T0220
16	100	TIC246A	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	200	TIC246B	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	400	TIC246D	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	500	TIC246E	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	600	TIC246M	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	700	TIC246S	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
16	800	TIC246N	125	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0220
20	100	TIC253A	150	50	50	50		2.5	2.5	2.5		50	50	1.7	22	T0218
20	200	TIC253B	150	50	50	50		2.5	2.5	2.5		50	50	1.7	28	T0218
20	400	TIC253D	150	50	50	50		2.5	2.5	2.5		50	50	1.7	28	T0218
20	500	TIC253E	150	50	50	50		2.5	2.5	2.5		50	50	1.7	28	T0218
20	600	TIC253M	150	50	50	50		2.5	2.5	2.5		50	50	1.7	28	T0218
25	100	TIC263A	175	50	50	50		2.5	2.5	2.5		50	50	1.7	35	T0218
25	200	TIC263B	175	50	50	5U		2.5	2.5	2.5		50	50	1.7	35	T0218
25	400	TIC263D	175	50	50	50		2.5	2.5	2.5		50	50	1.7	35	T0218
25	500	TIC263E	175	50	50	50		2.5	2.5	2.5		50	50	1.7	35	T0218
25	600	TIC263M	175	50	50	50		2.5	2.5	2.5		50	50	1.7	35	T0218

Data Sheets

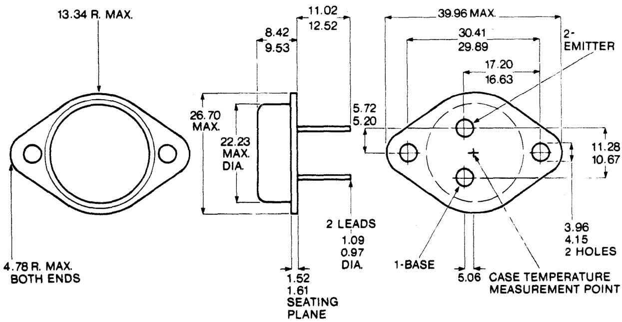
A : Advanced Planar Power

TIPL751, TIPL751A
NPN SILICON POWER TRANSISTOR

- Rugged Triple-Diffused Planar Construction.
- Specifically designed for High Voltage, Inductive Load Switching Applications.
- Operating characteristics fully guaranteed at 100°C.
- Transient Power Dissipation guaranteed at 100°C.
- ICES better than 100μA at maximum rated VCE at 100°C.
- 1000 volt blocking capability.
- VCEO(sust) 420V min TIPL751A–375V min TIPL751.

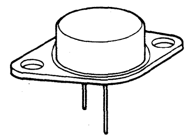
MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL751	TIPL751A
Collector-Base Voltage (IE=0)	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	375V	420V
Base-Emitter Voltage	10V	
Continuous Collector Current	4A	
Peak Collector Current (Note 1)	8A	
Continuous Dissipation (Fig. 13)	120W	
Operating Junction & Storage Temperature	-65°C – +200°C	

NOTE 1: Pulse Test, Pulse Duration ≤ 10ms, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		Standard A Type	375 420			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=375V VCE=420V		Standard A Type			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	Standard A Type Standard A Type			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 1 & 3	IC=1A IC=2.5A IC=4A IC=4A	IB=200mA IB=500mA IB=800mA IB=800mA	 100°C			0.5 1 2.5 5	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 1 & 3	IC=1A IC=2.5A IC=4A IC=4A	IB=200mA IB=500mA IB=800mA IB=800mA	 100°C			1 1.2 1.4 1.3	V V V V
hFE	Forward Current Transfer Ratio Notes 1 & 3	VCE=5V	IC=500mA		20		60	
ft	Current Gain Band-Width Product	IC=500mA F=1MHz	VCE=10V	DC		12		MHz
Cob	Output Capacitance	VCB=20V IE=0A	 F=0.1MHz			110		pF
R0jc	Thermal Resistance Junction-Case						1.46	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

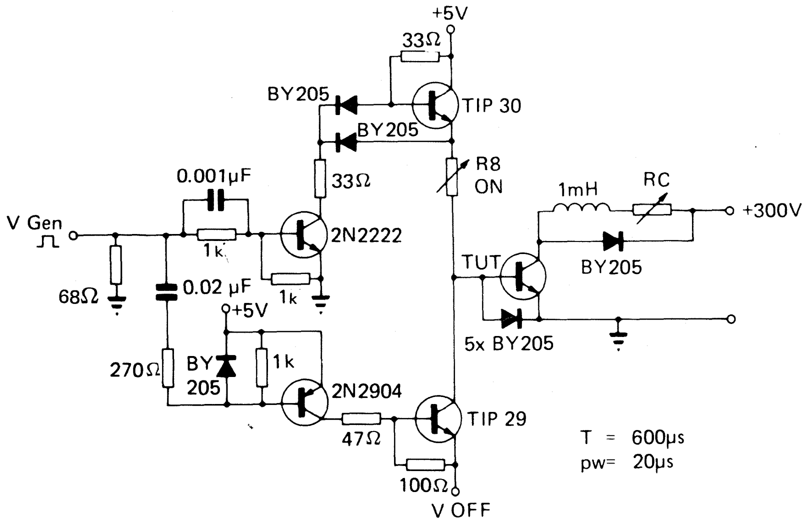
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=4A VCC=200V IBon=IBoff=800mA T Case=25°C			0.55 2.50 0.50	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=4A VCC=200V IBon=IBoff=800mA T Case=100°C			0.65 3.00 1.00	μs μs μs
INDUCTIVE LOAD						
tsv	Voltage Storage Time				2.50	μs
trv	Voltage Rise Time	IC=4A			0.30	μs
tf'	Current Fall Time	IBon=0.8A			0.25	μs
tti	Current Tail Time	VBEoff= -5V			0.15	μs
txo	Crossover Time Figures 1 & 2	T Case=25°C			0.40	μs
tsv	Voltage Storage Time				3.00	μs
trv	Voltage Rise Time	IC=4A			0.50	μs
tfi	Current Fall Time	IBon=0.8A			0.25	μs
tti	Current Tail Time	VBEoff=-5V			0.15	μs
txo	Crossover Time Figures 1 & 2	T Case=100°C			0.75	μs

NOTE 1. These parameters are measured using pulse techniques
Pulse Width=300 μs, Duty Cycle=2%

NOTE 2. Inductive Loop Switching Measurement

NOTE 3. These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

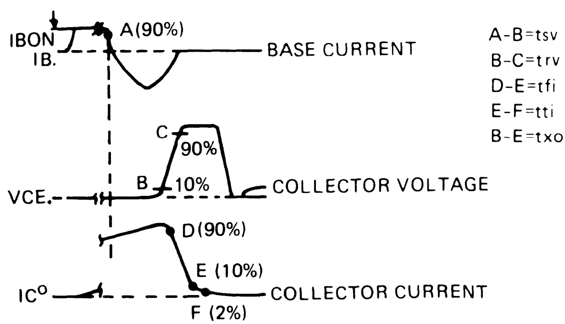
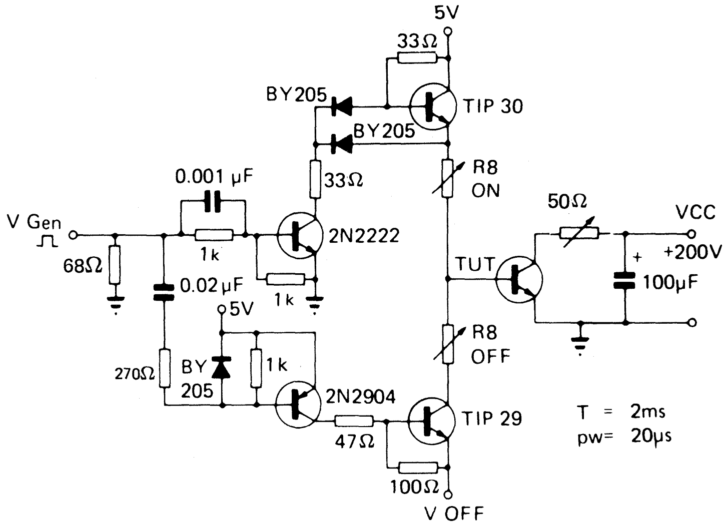


FIGURE 3 RESISTIVE SWITCHING CIRCUIT

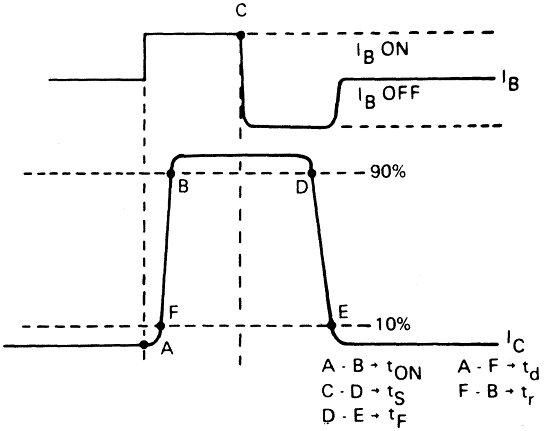


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

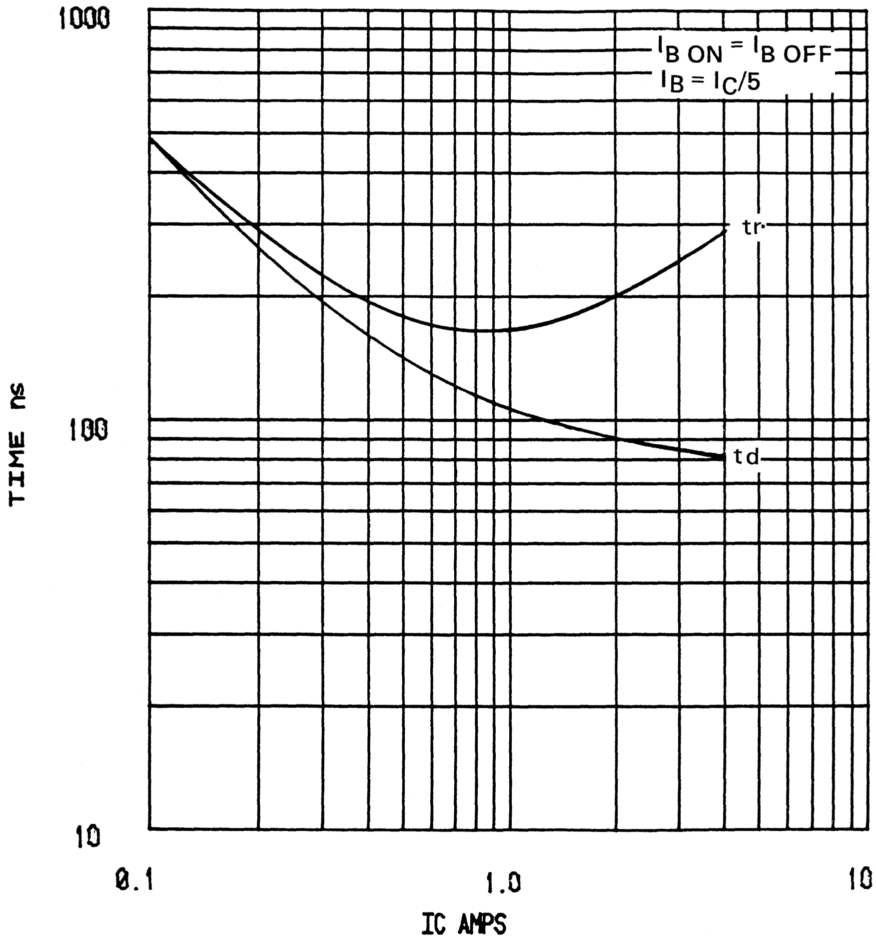
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

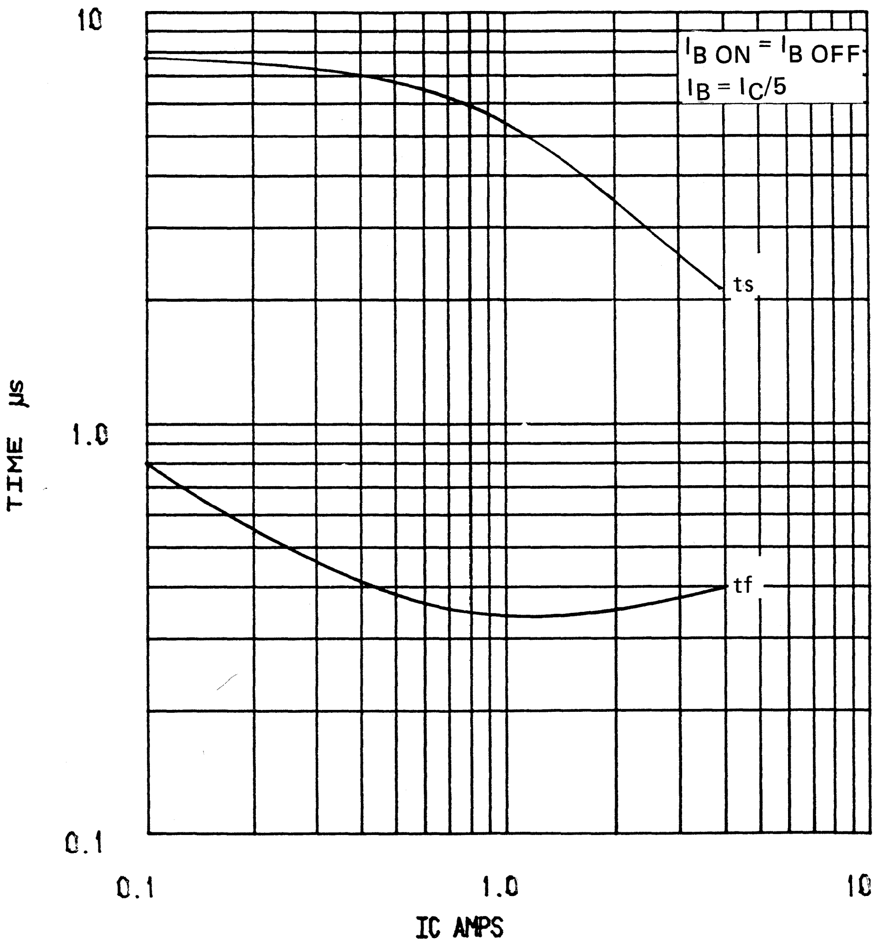


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

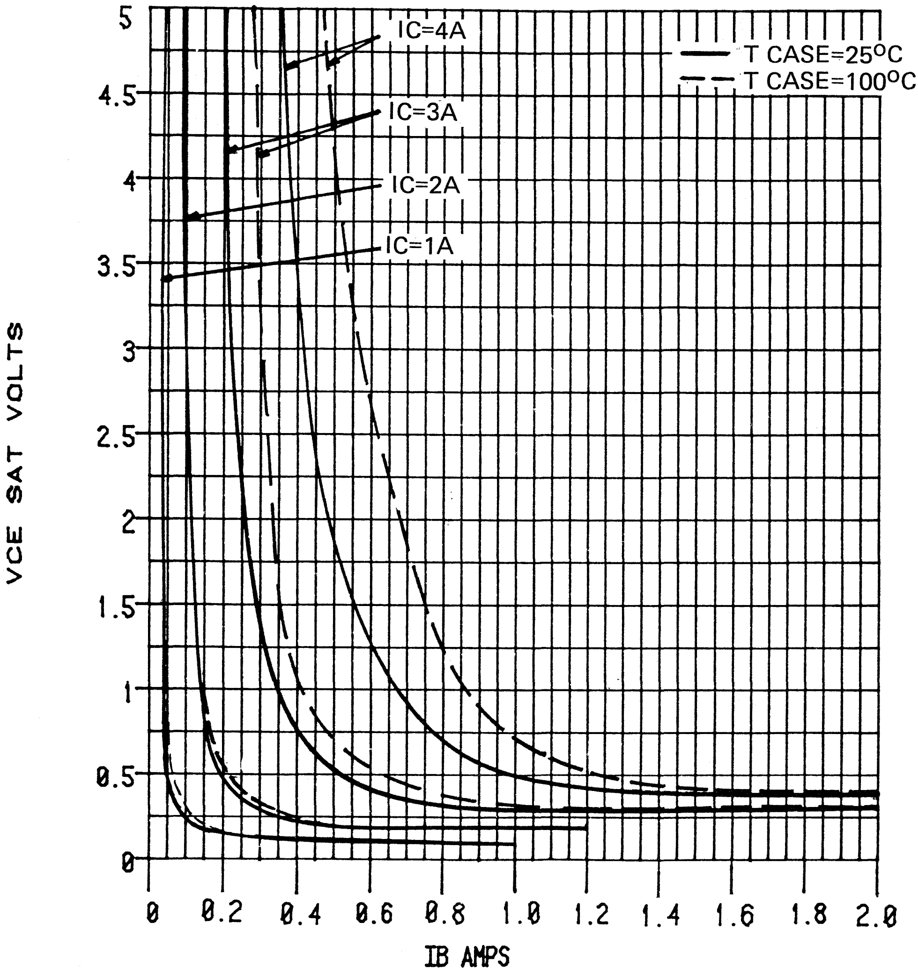


FIGURE. 8 TYPICAL BASE SATURATION REGION

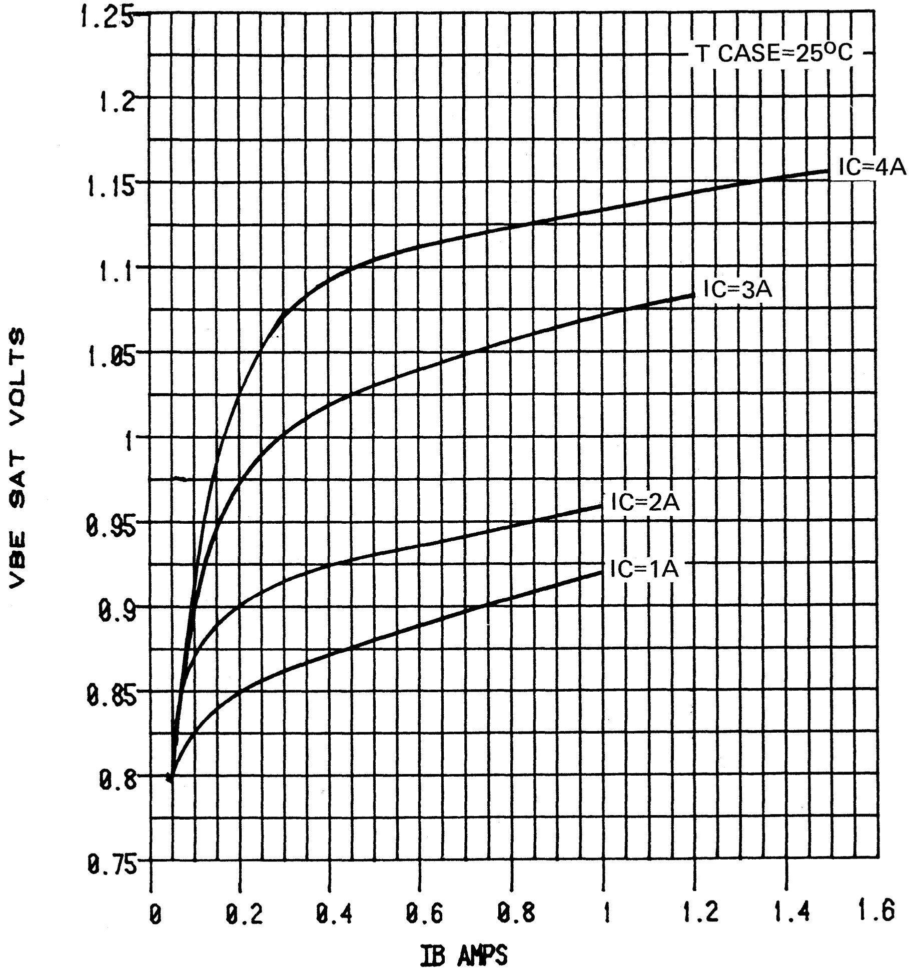


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

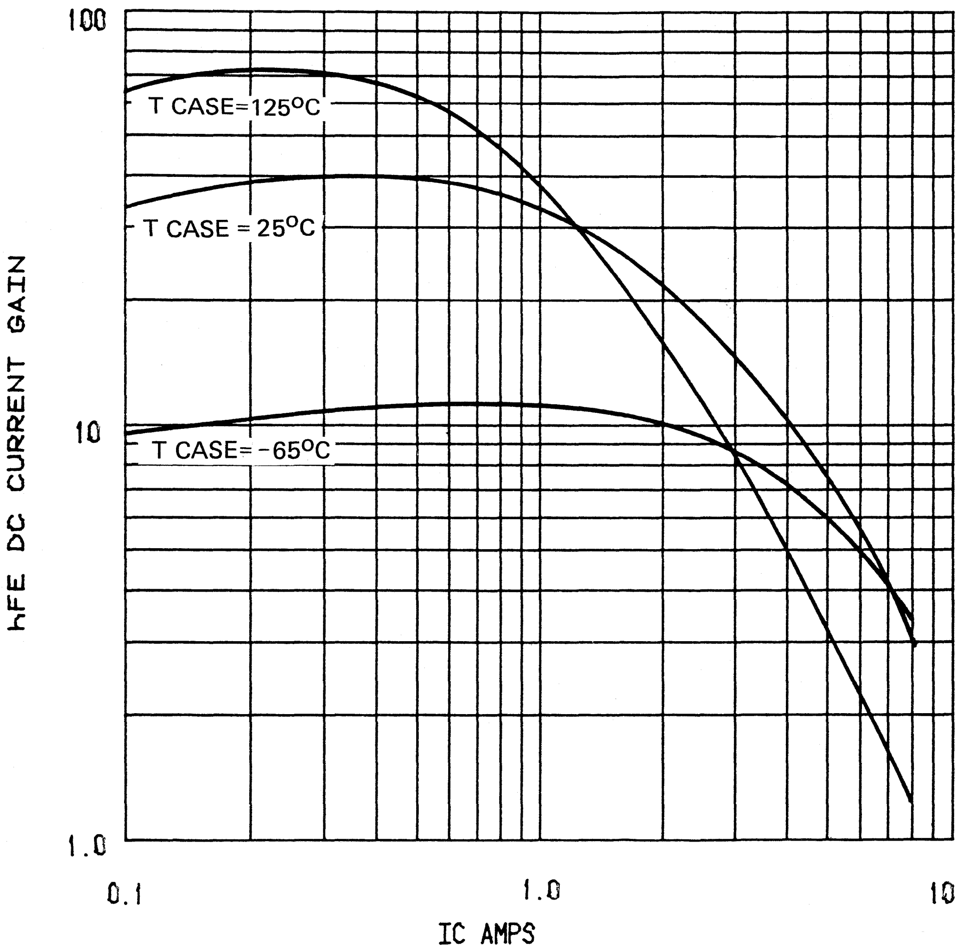


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

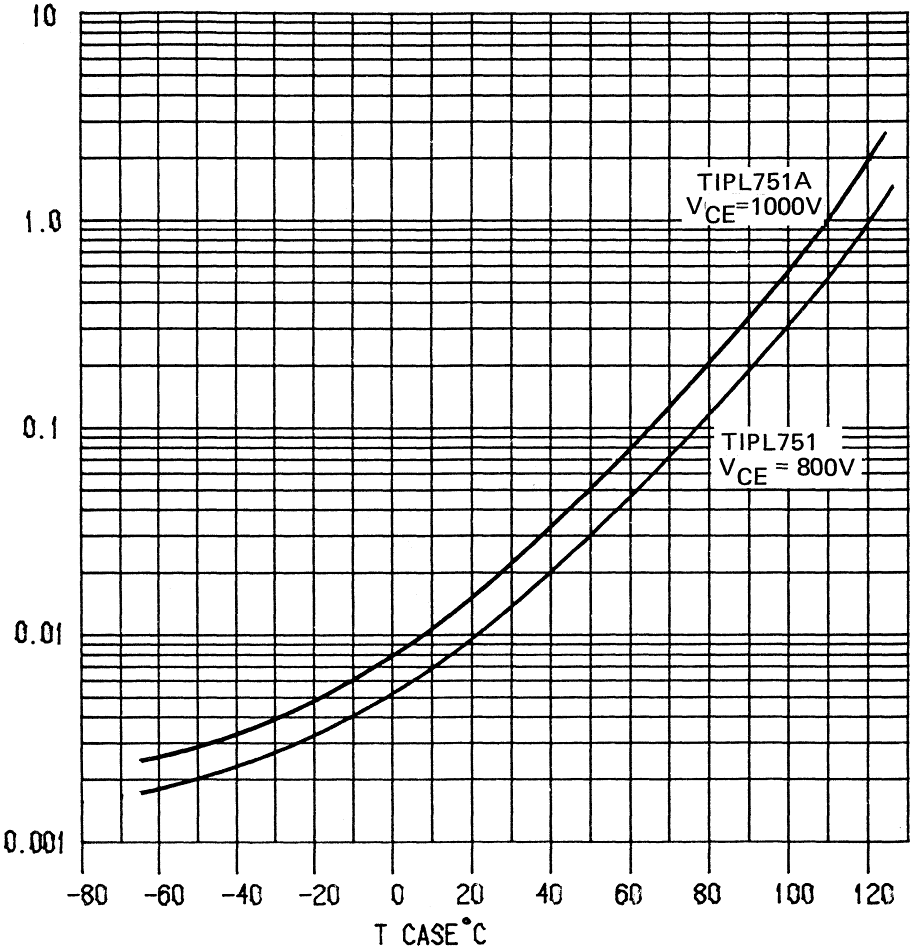


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

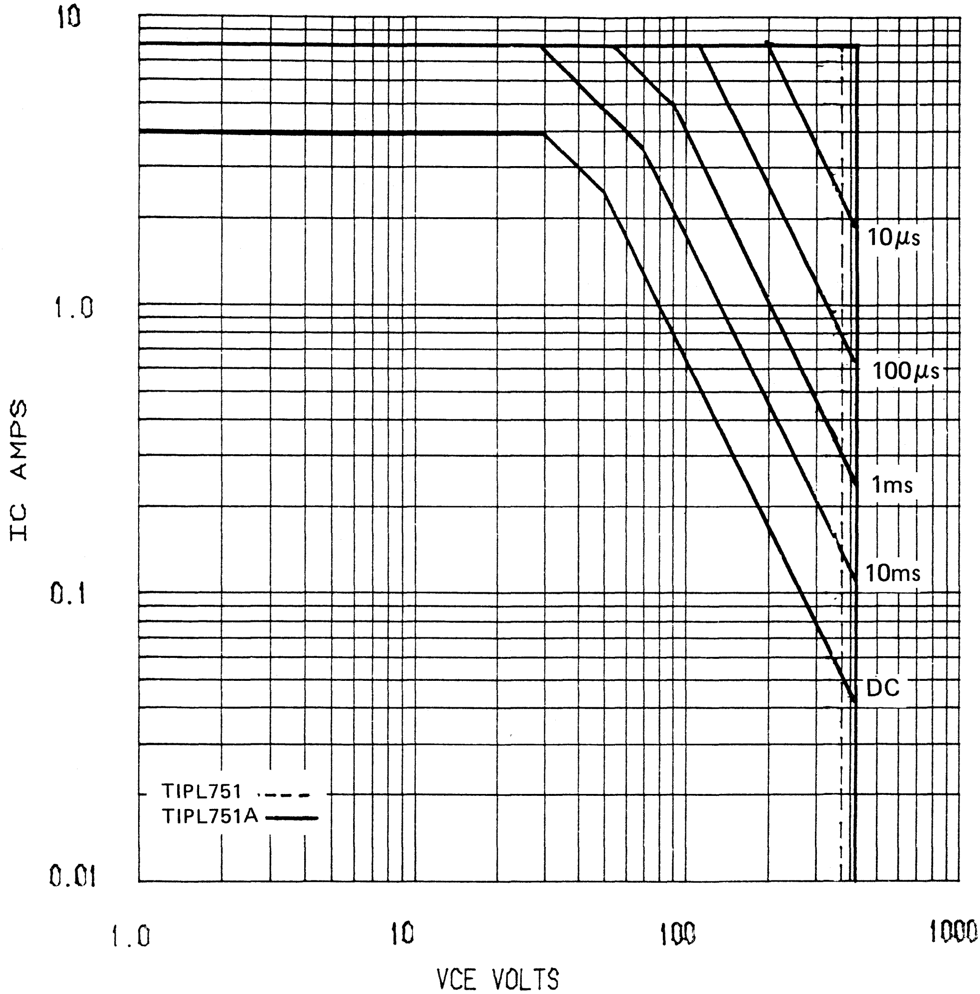


FIGURE. 12 THERMAL RESPONSE

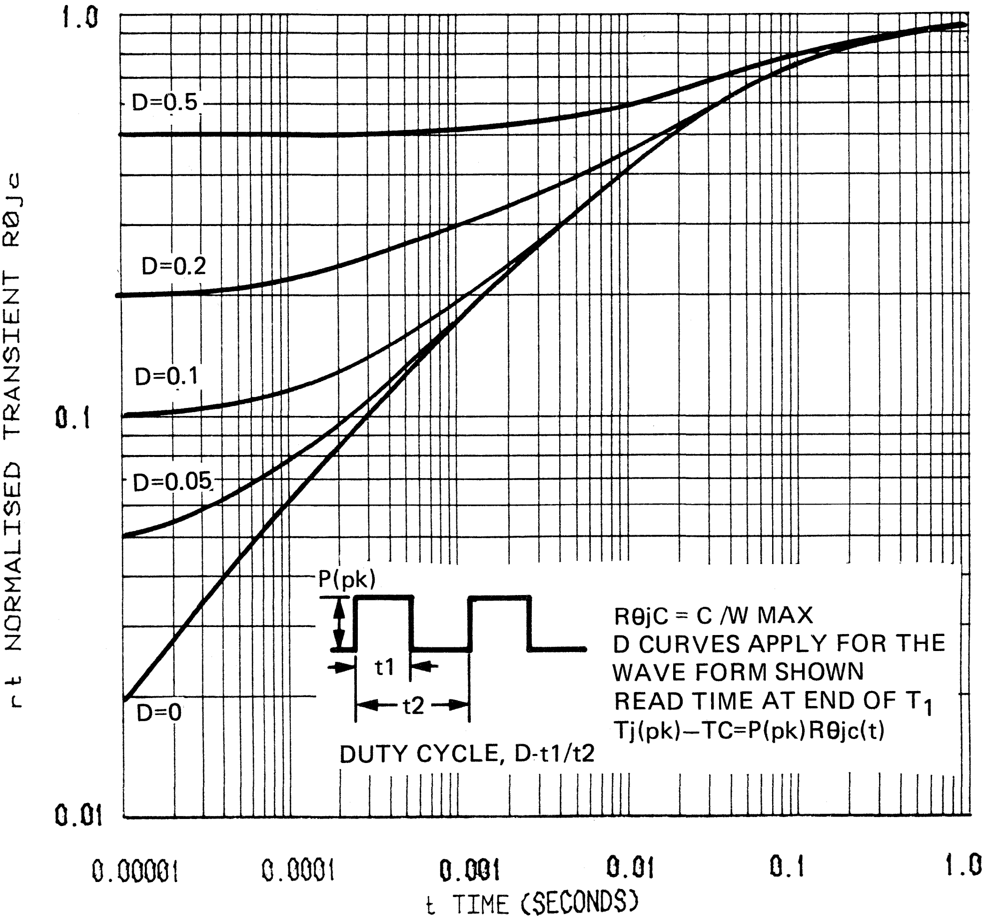


FIGURE. 13 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

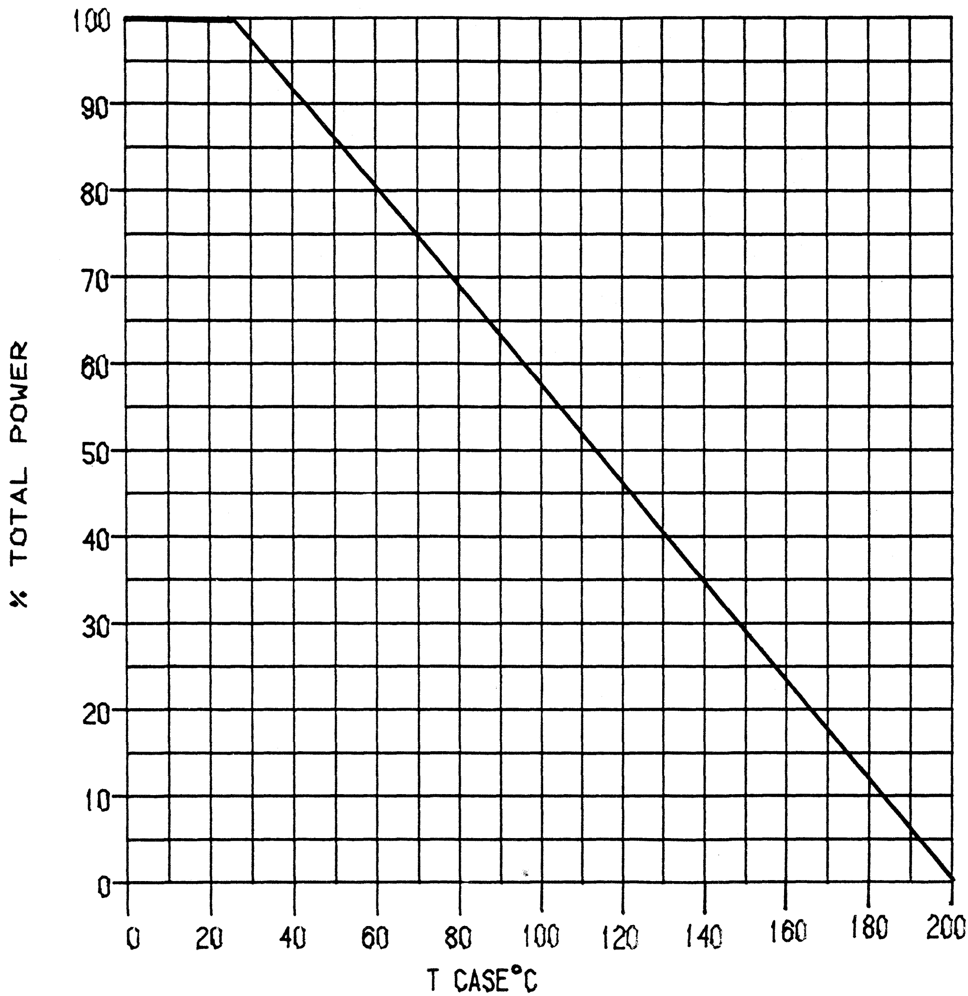


FIGURE. 14 TRANSIENT "TURN-OFF" LIMIT IC VsVCE TC≤100°C

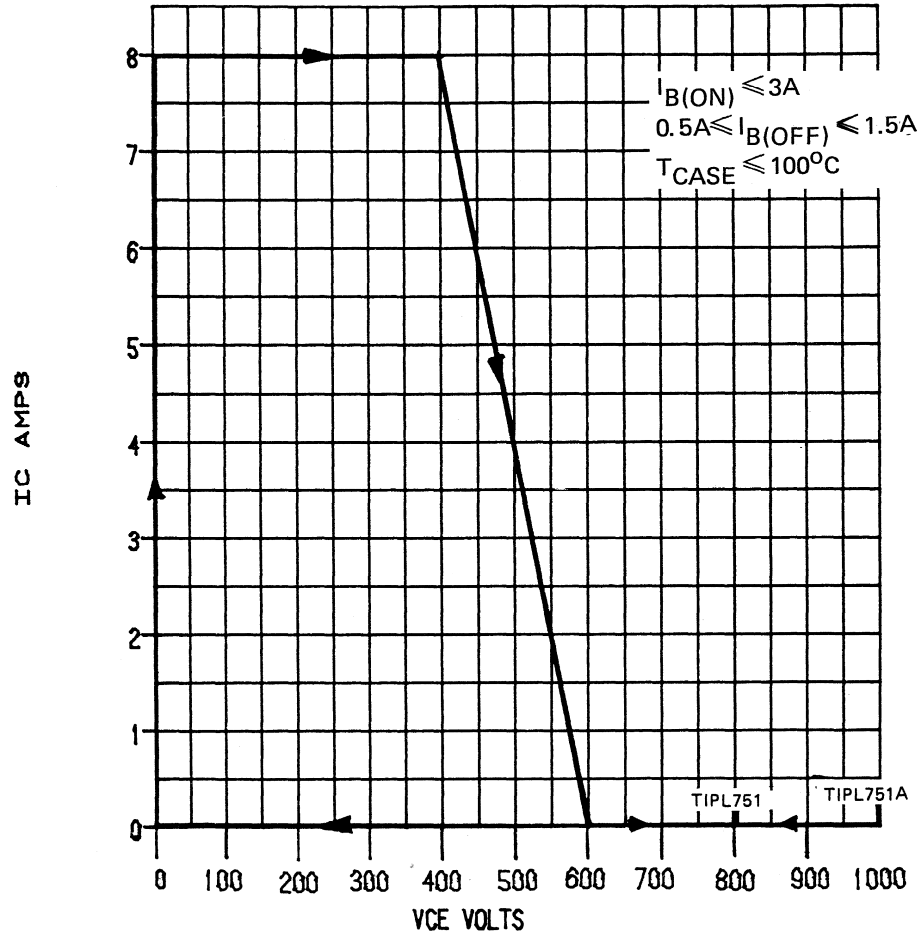
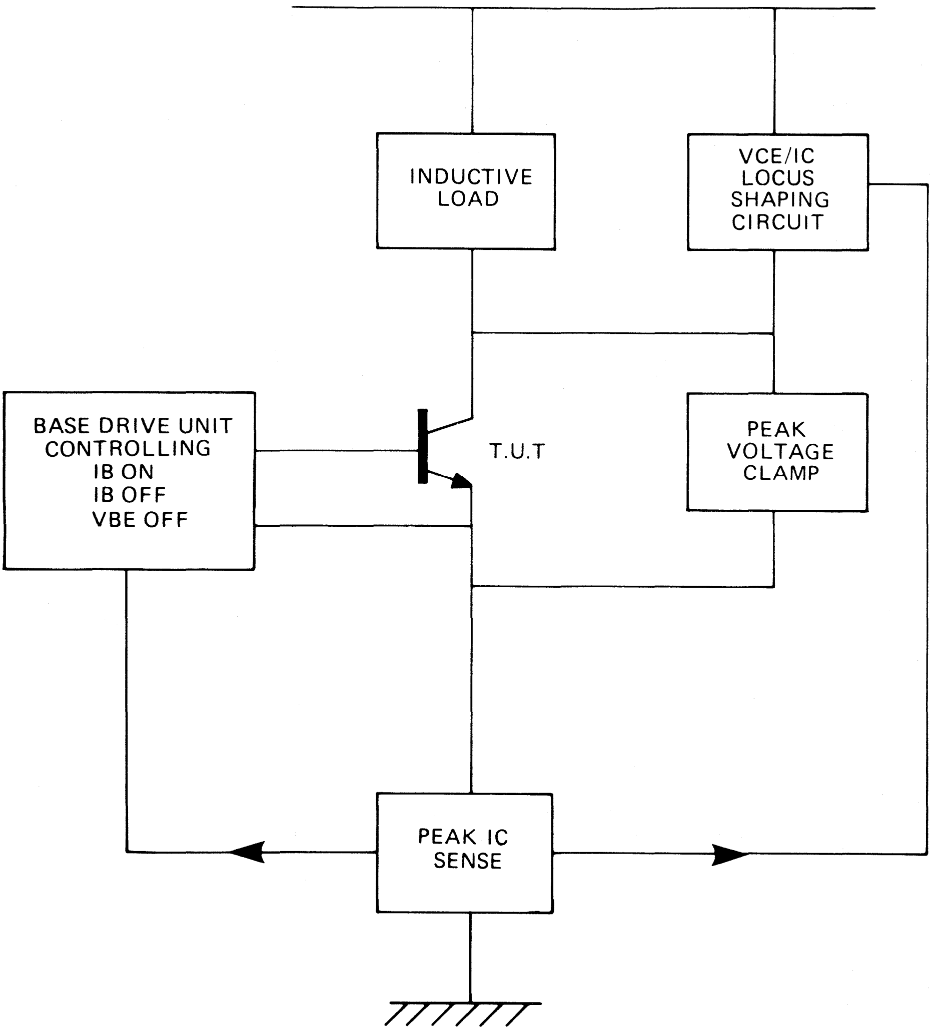


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



INDUCTIVE SWITCHING OF HIGH VOLTAGE TRANSISTORS

In inductive switching applications, such as switch mode power supplies and C.R.T. magnetic deflection, there are numerous operating and fault conditions which can cause failure of the transistor switch. In many cases, failure occurs during turn off of the transistor when high currents are still flowing and when the voltage across the device is rising rapidly.

The conventional method of defining device capability such as forward safe area and reverse energy/VCEX (sust) ratings do not relate directly to device operation during turn off in the majority of applications. Reverse energy is frequently thought to be the best guide since it can be related to the inductive energy in the circuit. This presupposes that energy is the primary cause of failure which is not always the case.

Detailed investigations have identified the key mechanisms responsible for device failure in inductive switching circuits and a new form of device specification and evaluation evolved which can be directly related to the application.

At the point of failure the device voltage collapses rapidly and latches on permanently. In the majority of cases the rapid voltage collapse results in an energy dump from the circuit which totally destroys the transistor. The voltage collapse is probably a regenerative switching action triggered by an instantaneous current density and electric field strength condition within the transistor.

However, reaching the trigger point is not simply determined by the instantaneous external terminal conditions but is also dependent on the history of device operation. In particular, the conduction period prior to turn off, collector current and bias conditions, and also the way in which the transistor is turned off can affect the current density across the chip during turn off.

The new form of reverse bias safe area definition takes into account all aspects of the operation. During characterisation the devices are subjected to many switching loci and the effects of prior conduction base bias and other influences evaluated for most practical cases. The result is a curve defining transistor capability which comprehends the total instantaneous power dissipation going from normal conduction through to turn off (See Figure 13) . If the worse case VCE/IC Locus in a given circuit configuration lies within the curve then the transistor will not normally be destroyed by any single turn off transient.

Where severe switching transients are repetitive, care should be taken not to exceed the thermal rating of the transistor.

A block diagram of the test circuit for establishing the switching locus curve is in Figure 15..

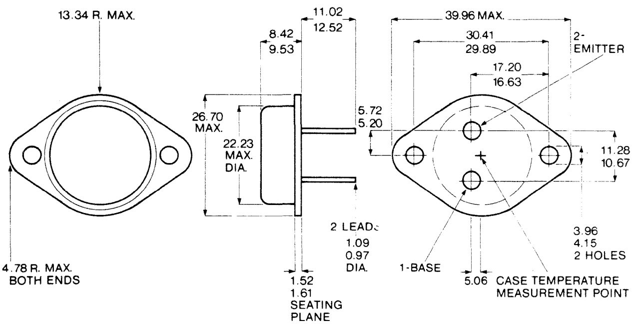
The transient VCE/IC Locus in an application can be found using a fast writing oscilloscope in an X—Y mode, ensuring that the delay matching of the X and Y channels is better than 20 ns. Beam blanking techniques can be used to enhance the turn off period.

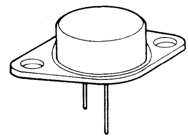
TIPL752, TIPL752A
NPN SILICON POWER TRANSISTOR

- Rugged Triple-Diffused Planar Construction.
- Specifically designed for High Voltage, Inductive Load Switching Applications.
- Operating characteristics fully guaranteed at 100°C.
- Transient Power Dissipation guaranteed at 100°C.
- ICES better than 100μA at maximum rated VCE at 100°C.
- 1000 volt blocking capability.
- VCEO(sust) 400V min TIPL752A–350V Min TIPL752.

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL752	TIPL752A
Collector-Base Voltage (IE=0)	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	350V	400V
Base-Emitter Voltage	10V	
Continuous Collector Current	6A	
Peak Collector Current (Note 1)	12A	
Continuous Dissipation (Fig. 13)	150W	
Operating Junction & Storage Temperature	-65°C – +200°C	

NOTE 1: Pulse Test, Pulse Duration ≤ 10ms, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO SUST	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		TIPL752 TIPL752A	350 400			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=350V VCE=400V		TIPL752 TIPL752A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL752 TIPL752A TIPL752 TIPL752A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 1 & 3	IC=2A IC=4A IC=6A IC=6A	IB=0.4A IB=0.8A IB=1.2A IB=1.2A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 1 & 3	IC=2A IC=4A IC=6A IC=6A	IB=0.4A IB=0.8A IB=1.2A IB=1.2A	 100°C			1.1 1.3 1.5 1.4	V V V V
hFE	Forward Current Transfer Ratio Notes 1 & 3	VCE=5V	IC=500mA		15		60	
ft	Forward Current Band-Width Product	IC=500mA F=1MHz	VCE=10V	DC		7.0		MHz
Cob	Output Capitance	VCB=20V IE=0A	 F=0. 1MHz			105		pF
R0jc	Thermal Resistance Junction-Case						1.17	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

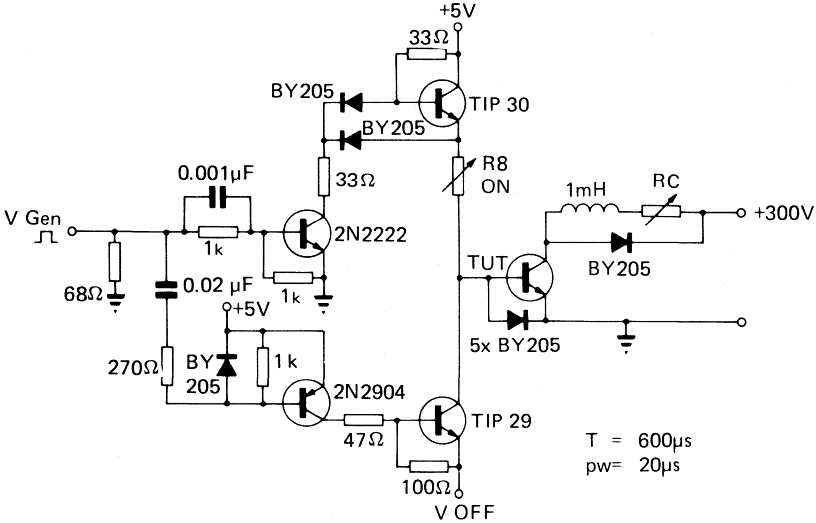
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
ton ts tf	Turn On Time Storage Time Fall Time	IC=6A VCC=100V IBon=1.2A IBoff=1.2A T Case=25°C			1.00 2.50 0.45	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time	IC=6A VCC=100V IBon=1.2A IBoff=1.2A T Case=100°C			2.50 3.00 1.00	μs μs μs
INDUCTIVE LOAD						
tsv	Voltage Storage Time				2.50	μs
trv	Voltage Rise Time	IC=6A			200	ns
tfi	Current Fall Time	IBon=1.2A			150	ns
tti	Current Tail Time	VBEoff=-10V			50	ns
txo	Crossover Time Figures 1 & 2	T Case=25°C			300	ns
tsv	Voltage Storage Time				3.00	μs
trv	Voltage Rise Time	IC=6A			300	ns
tfi	Current Fall Time	IBon=1.2A			150	ns
tti	Current Tail Time	VBEoff= -10V			50	ns
txo	Crossover Time Figures 1 & 2	T Case=100°C			500	ns

NOTE 1. These parameters are measured using pulse techniques
Pulse Width=300 μs, Duty Cycle=2%

NOTE 2. Inductive Loop Switching Measurement

NOTE 3. These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



ADJUST RC FOR REQUIRED IC

Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, $R_{in} > 10\Omega$ and $C_{in} < 11.5$ pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

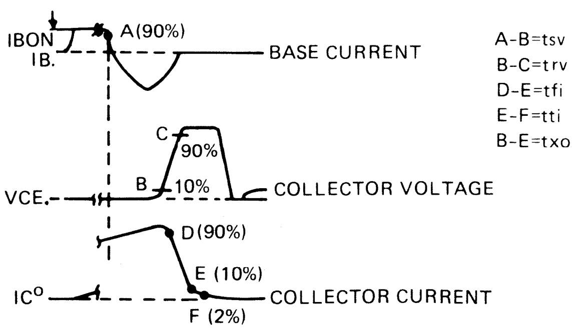
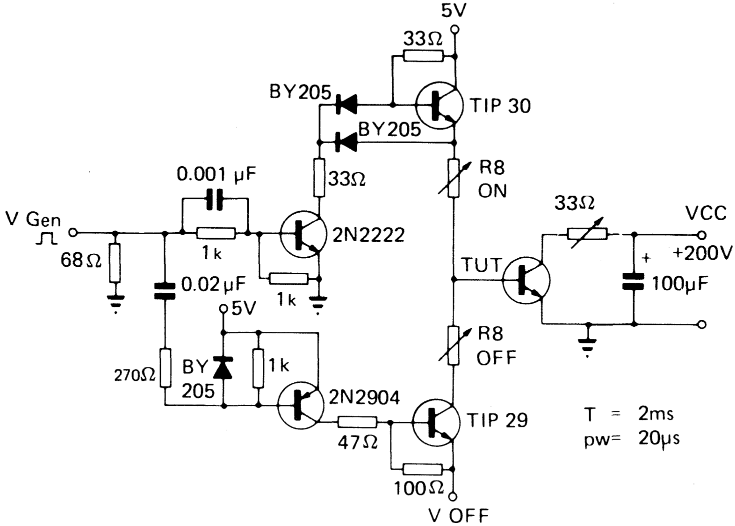


FIGURE 3 RESISTIVE SWITCHING CIRCUIT



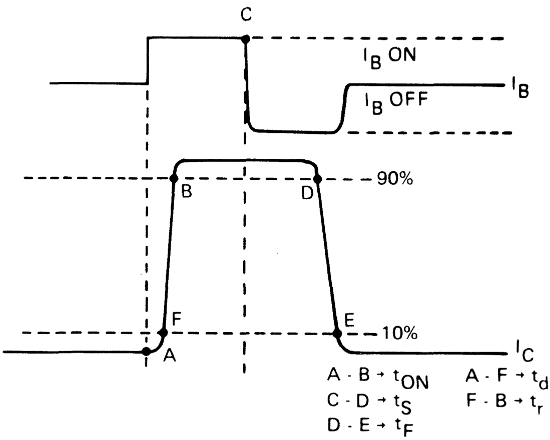
Notes

A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

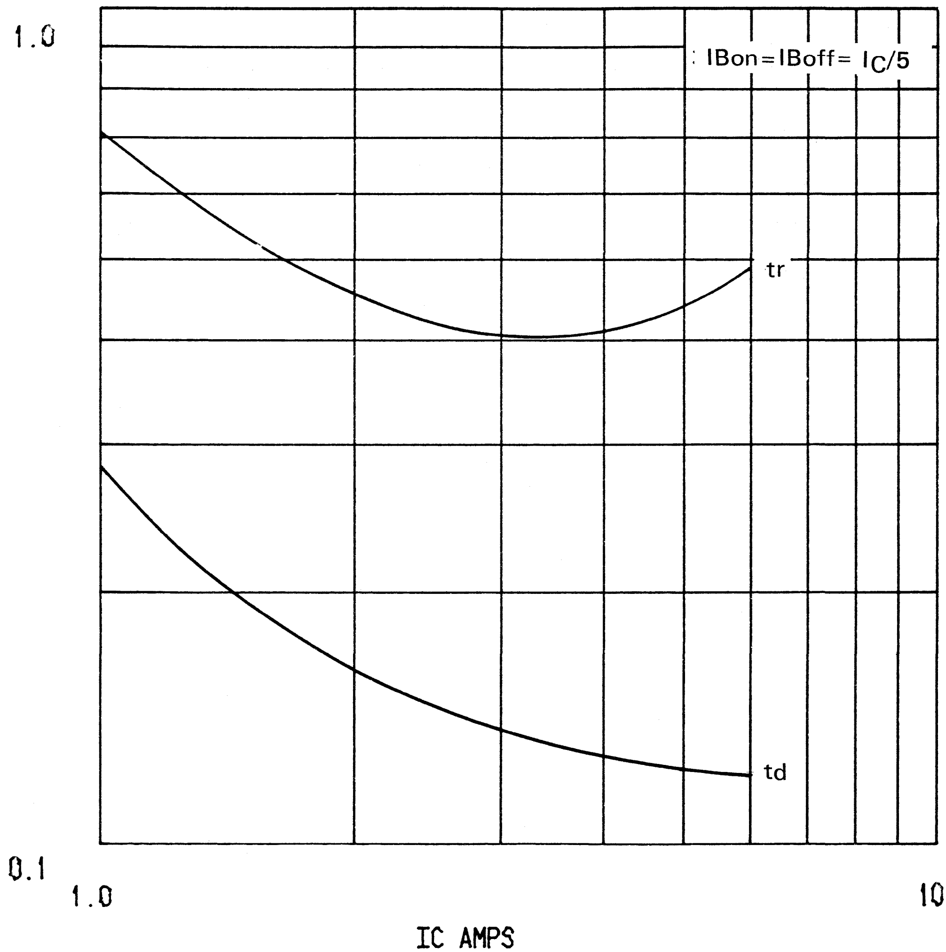
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} < 11.5pF.

C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

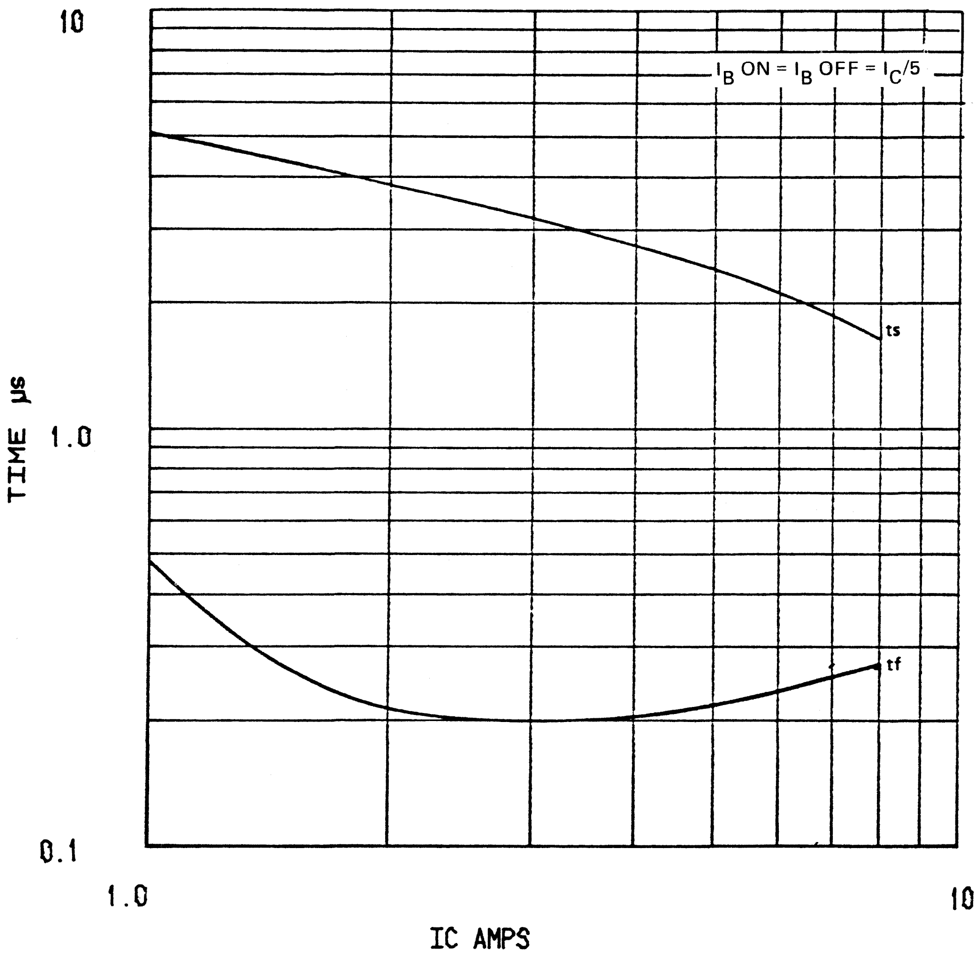


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

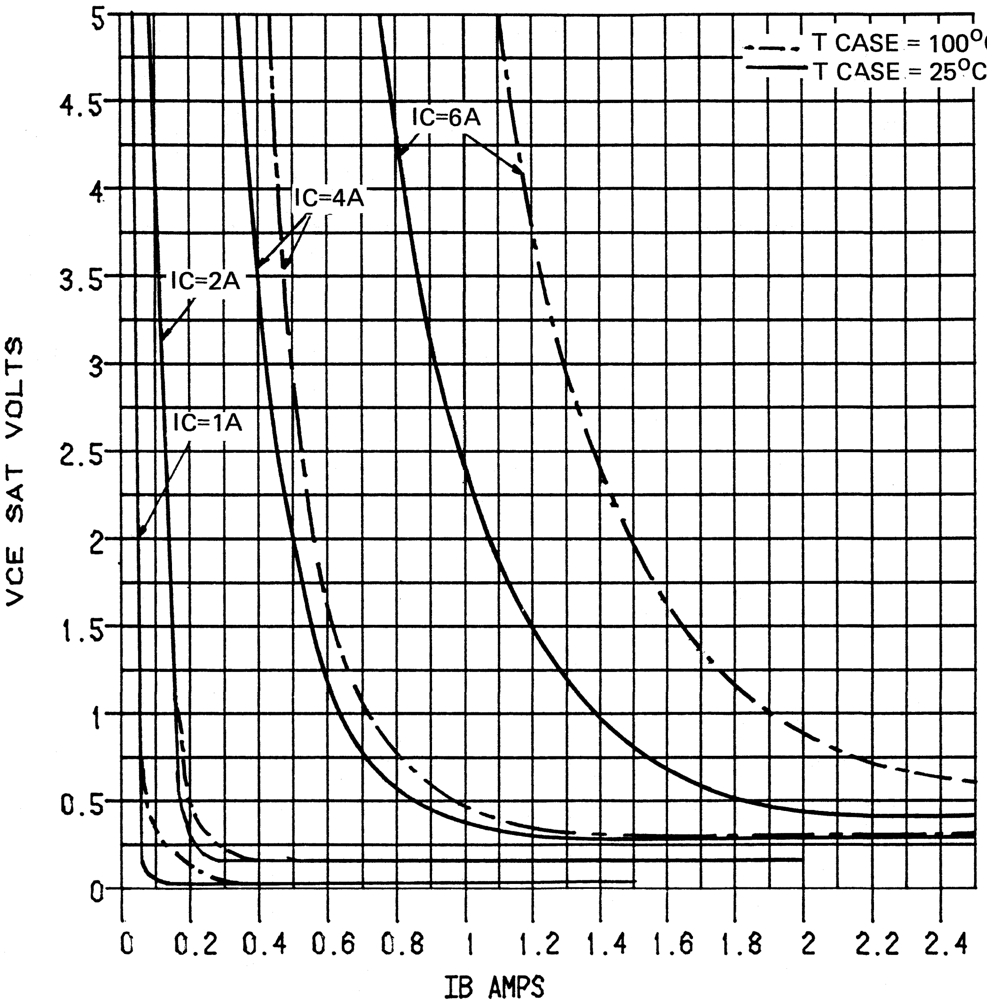


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

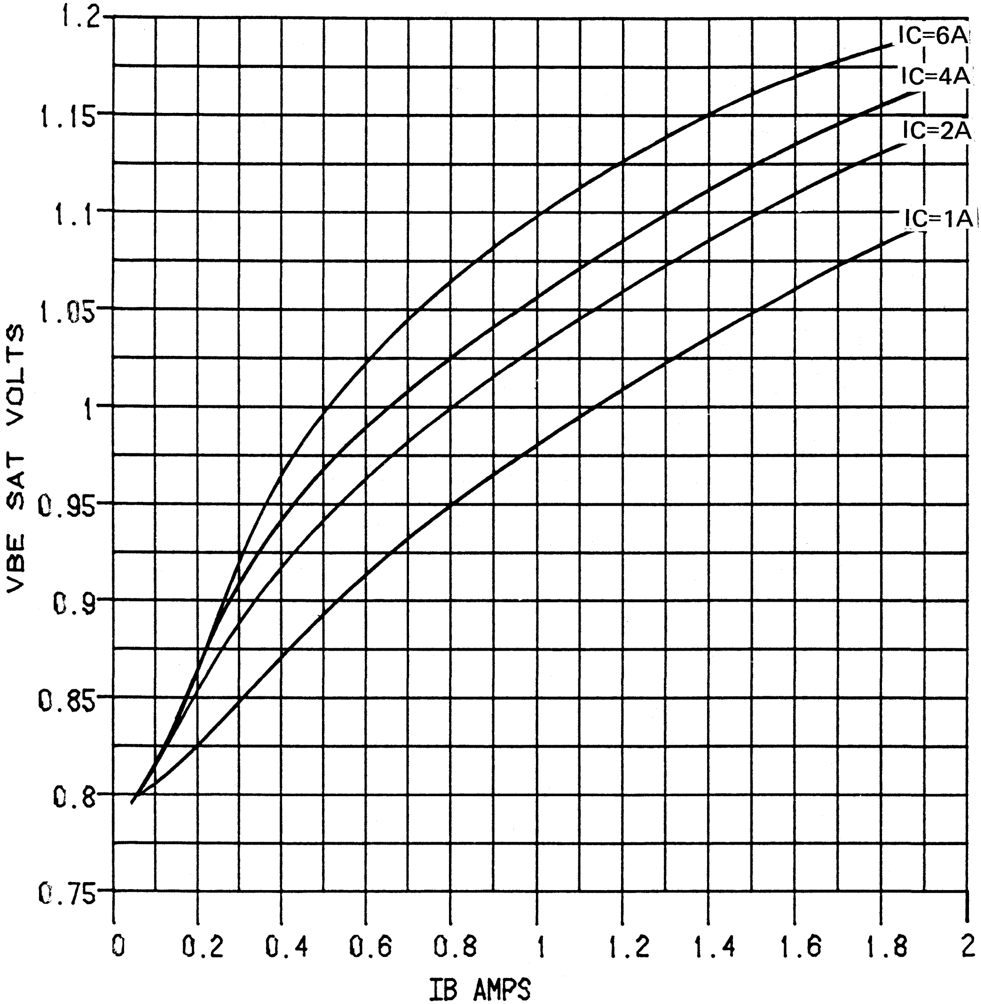


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

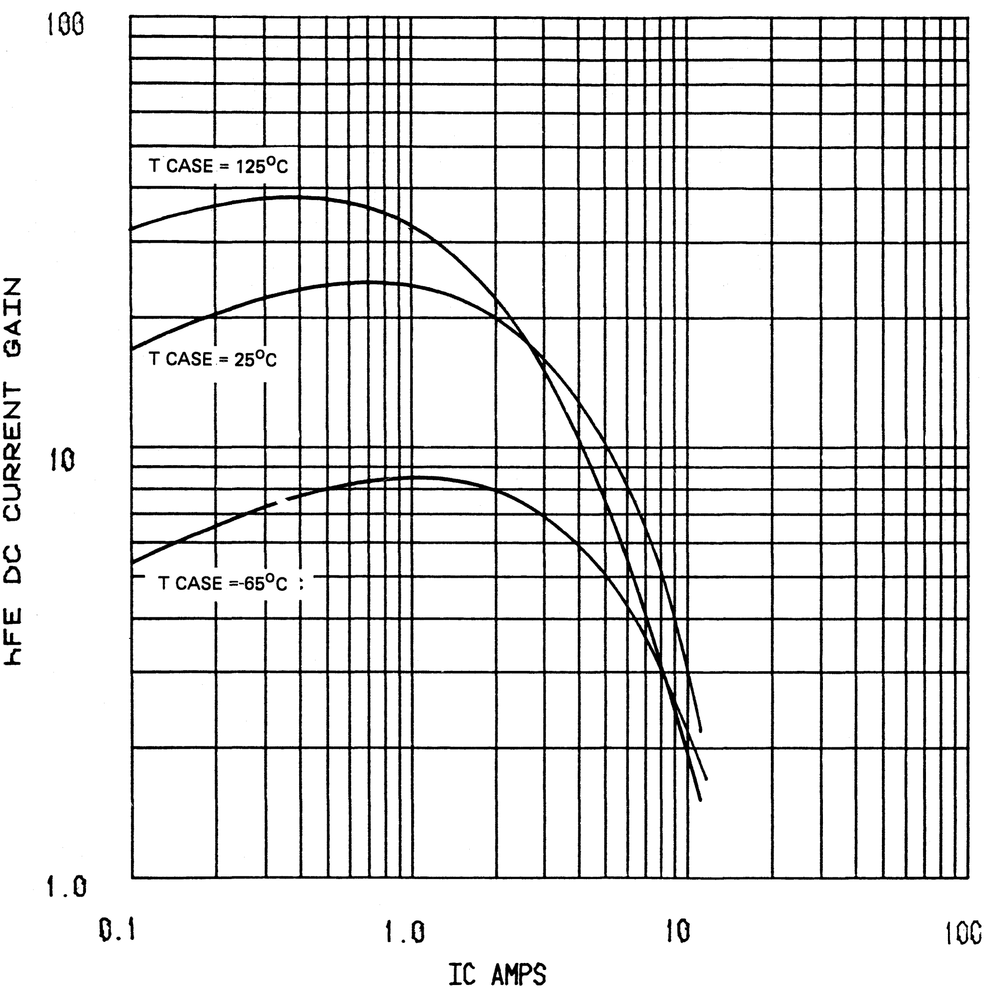


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

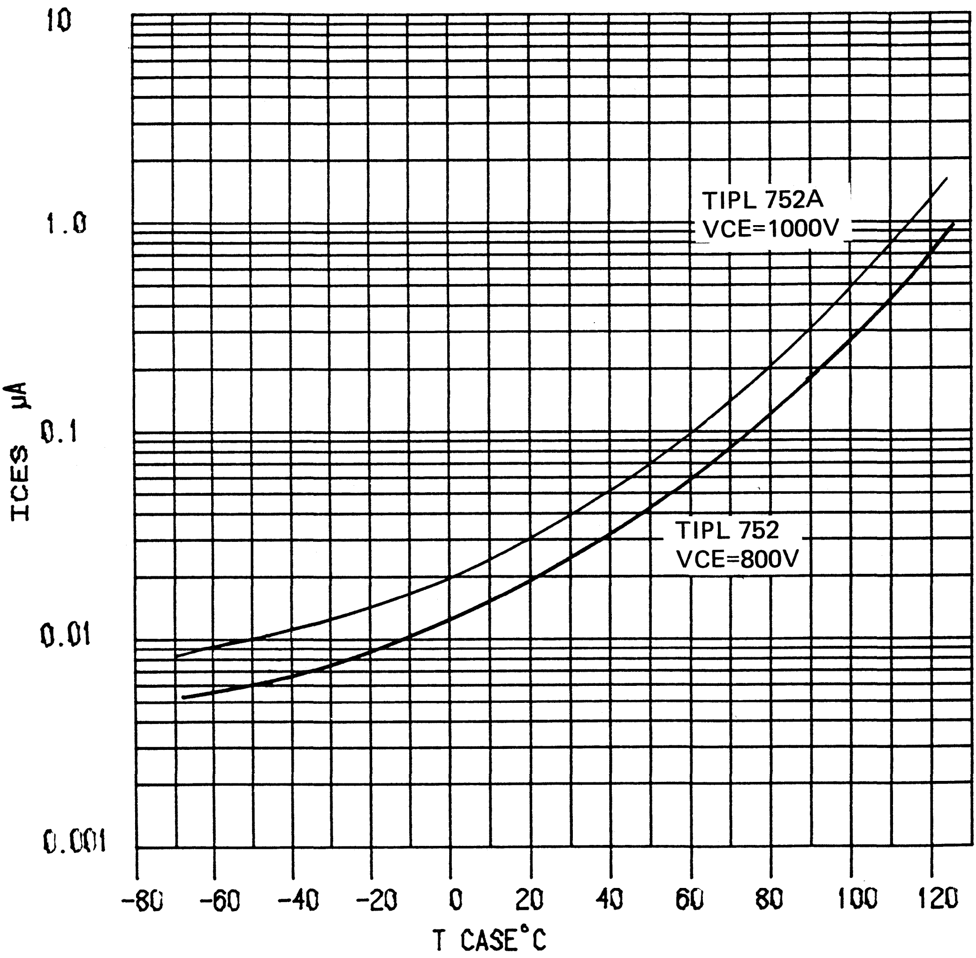


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

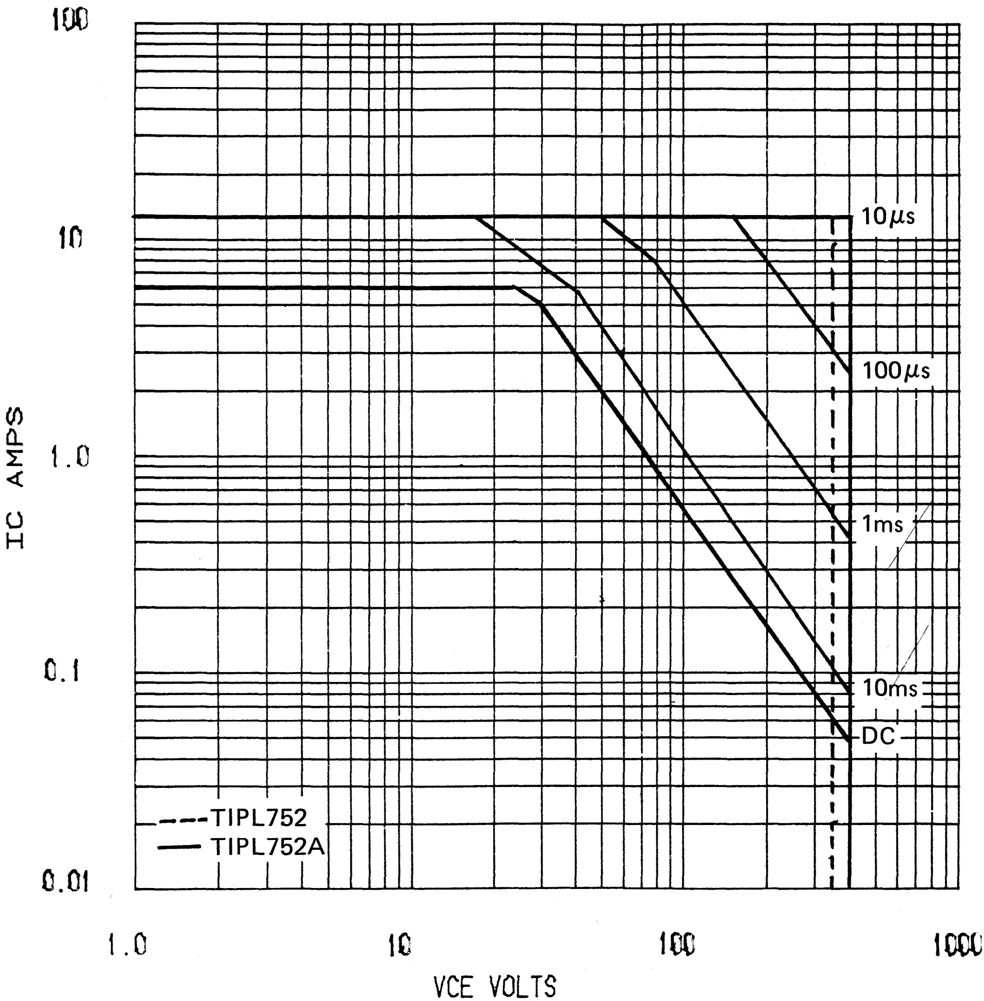


FIGURE. 12 THERMAL RESPONSE

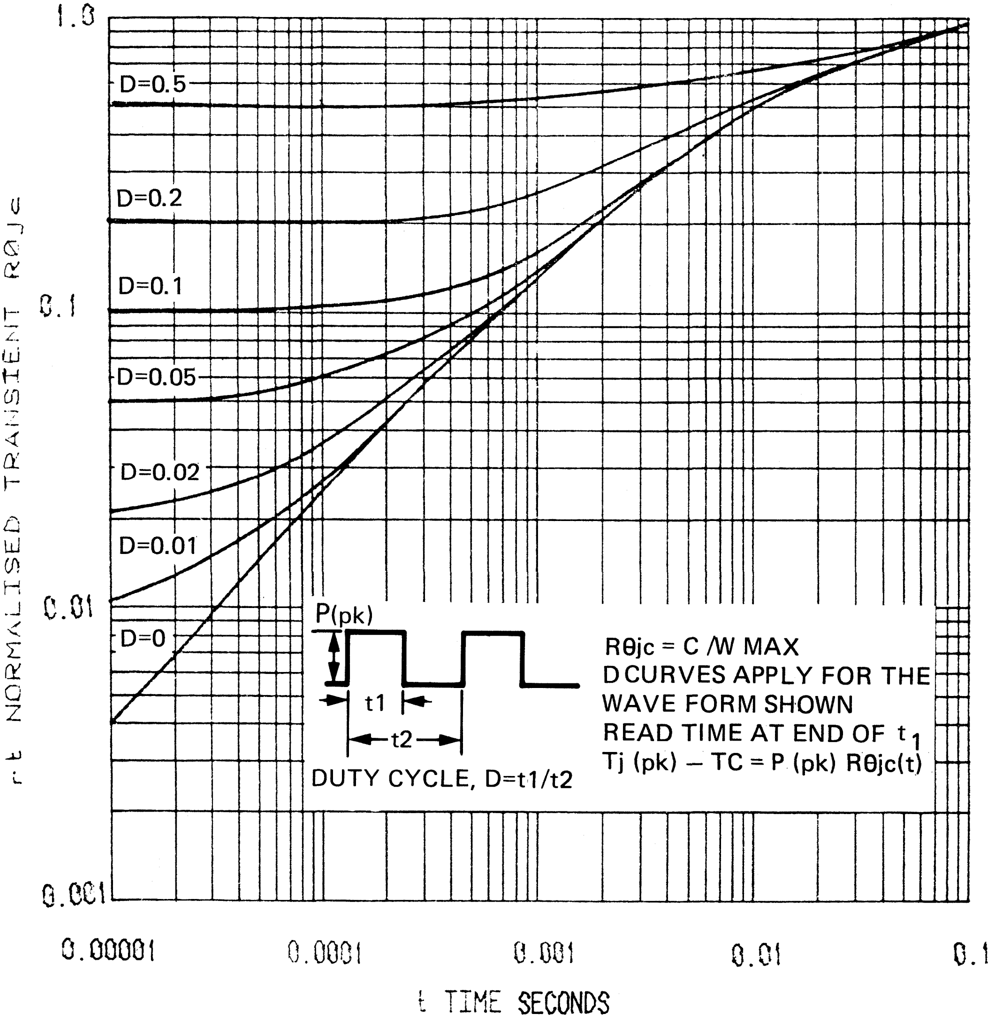


FIGURE. 13 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

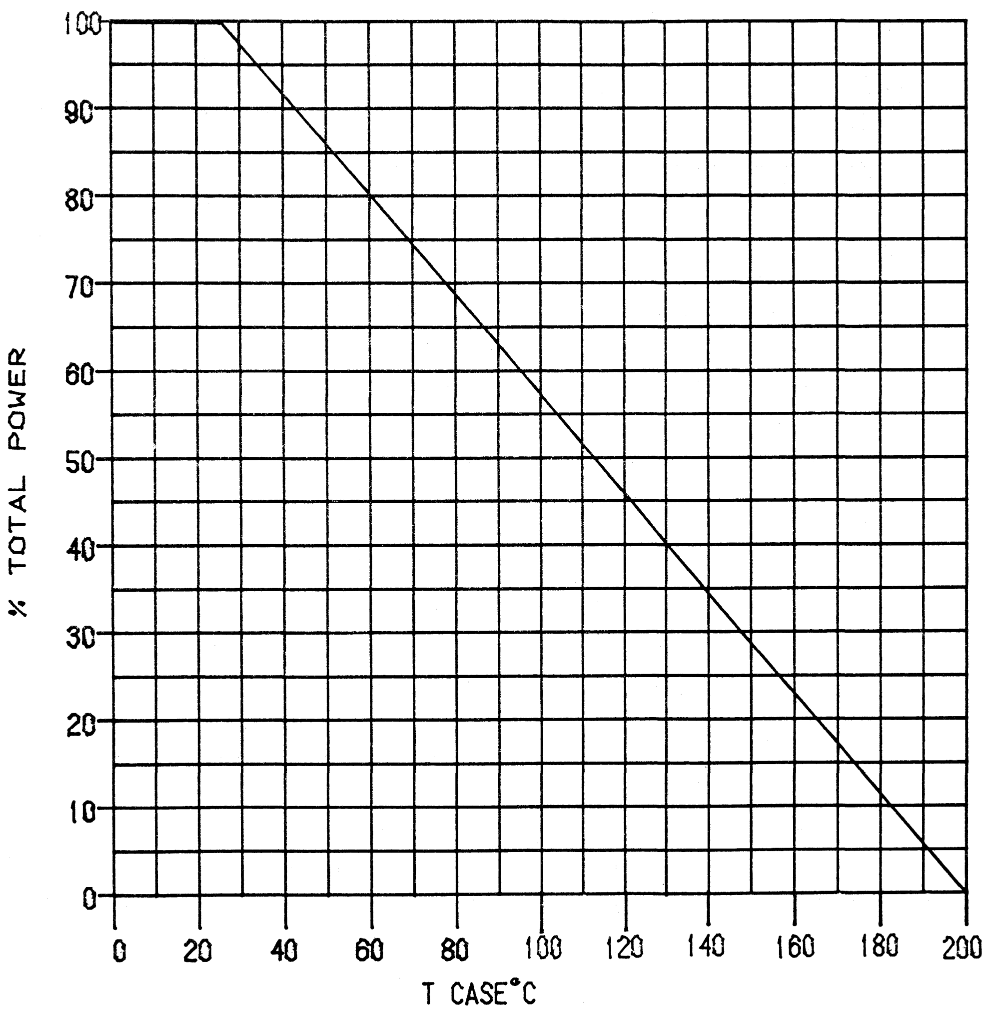


FIGURE. 14 TRANSIENT "TURN OFF" LIMIT IC VS VCE

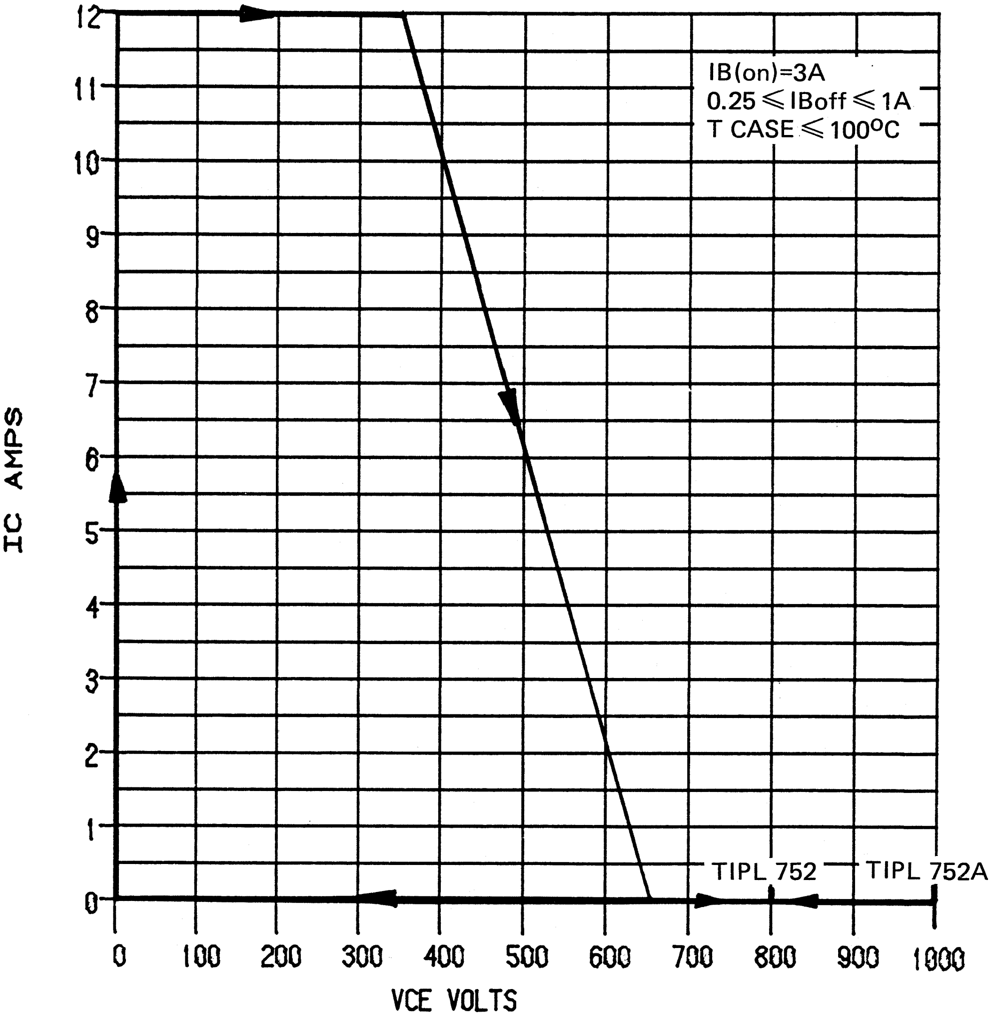
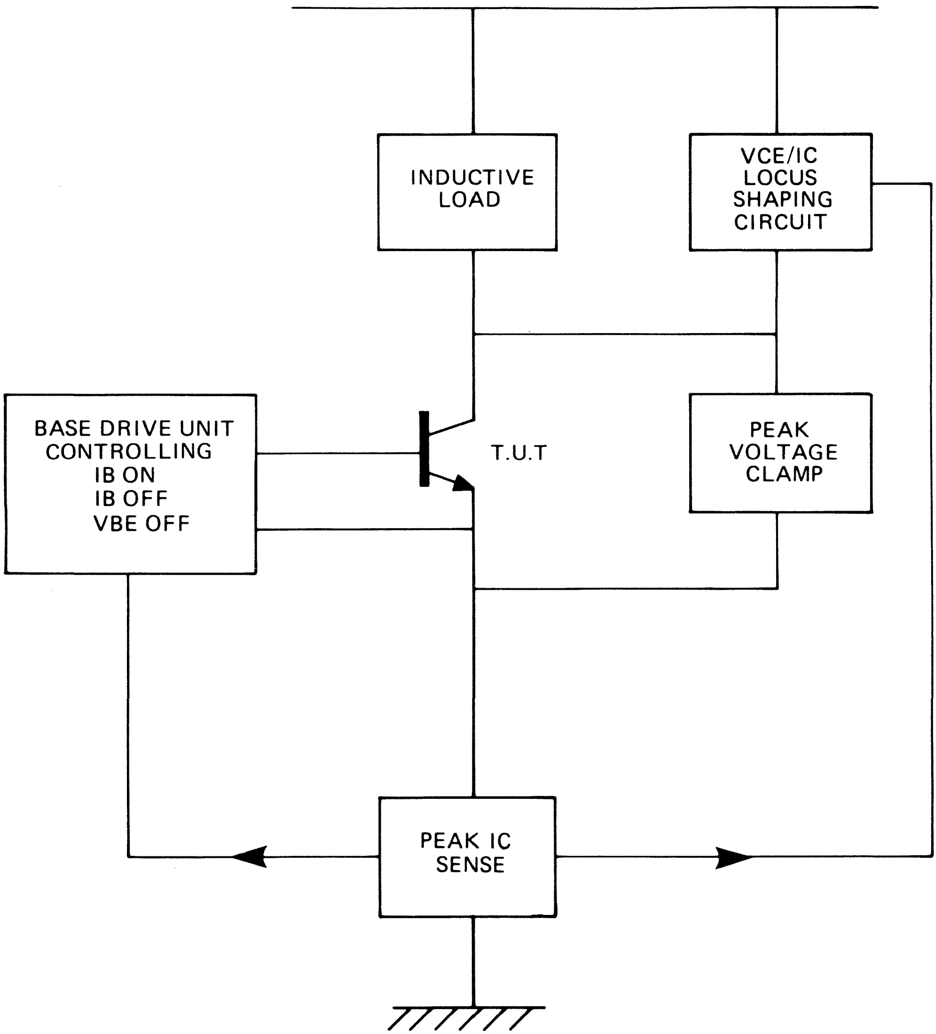


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



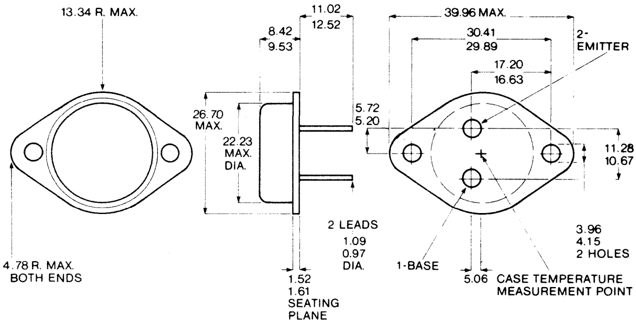
TIPL753, TIPL753A
NPN SILICON POWER TRANSISTOR

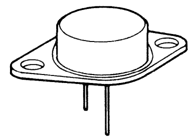
OCT 82

- Rugged Triple-Diffused Planar Construction.
- Specifically designed for High Voltage, Inductive Load Switching Applications.
- Operating characteristics fully guaranteed at 100°C.
- Transient Power Dissipation guaranteed at 100°C.
- ICES better than 100μA at maximum rated VCE at 100°C.
- 1000 volt blocking capability.
- VCEO(sust) 400V min TIPL753A – 350V min TIPL753

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL753	TIPL753A
Collector-Base Voltage (IE=0)	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	350V	400V
Base-Emitter Voltage	10V	
Continuous Collector Current	8A	
Peak Collector Current (Note 1)	14A	
Continuous Dissipation (Fig. 13)	150W	
Operating Junction & Storage Temperature	-65°C – +200°C	

NOTE 1: Pulse Test, Pulse Duration ≤ 10ms, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO SUST	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		TIPL753 TIPL753A	350 400			V
ICEO	Collector Cut-Off Current (Open Base)	VCE=350V VCE=400V		TIPL753 TIPL753A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL753 TIPL753A TIPL753 TIPL753A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Note 1 & 3	IC=2A IC=5A IC=8A IC=8A	IB=0.4A IB1.0A IB=1.6A IB=1.6A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Note 1 & 3	IC=2A IC=5A IC=8A IC=8A	IB=0.4A IB=1.0A IB=1.6A IB=1.6A	 100°C			1.1 1.3 1.6 1.5	V V V V
hFE	Forward Current Transfer Ratio Note 1 & 3	VCE=5V	IC=500mA		15		60	
ft	Forward Current Band-Width Product	IC=500mA F=1MHz	VCE=10V	DC		8.0		MHz
Cob	Output Capitance	VCB=20V IE=0A	F=0.1MHz			105		pF
R0jc	Thermal Resistance Junction-Case						1.17	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

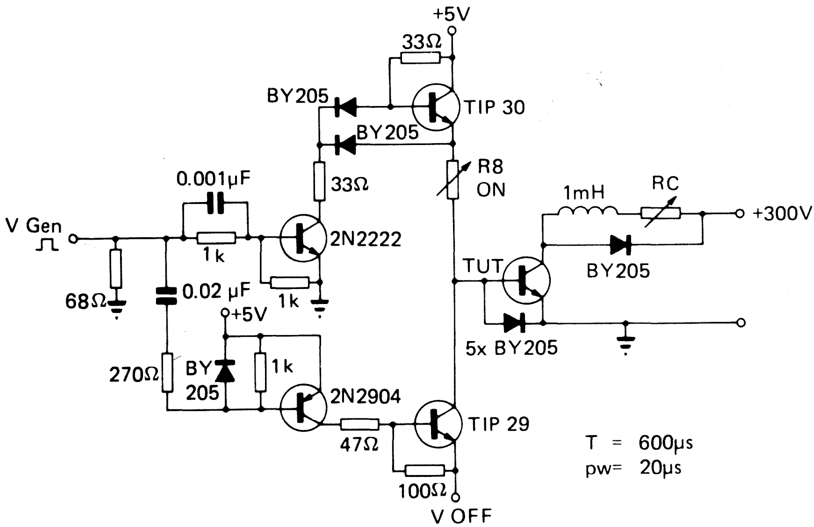
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
RESISTIVE LOAD							
ton ts tf	Turn On Time Storage Time Fall Time Figures 3–6	IC=8A IBon=1.6A T Case=25°C	VCC=200V IBoff=1.6A			0.80 2.50 0.45	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time Figures 3–6	IC=8A IBon=1.6A T Case=100°C	VCC=200V IBoff=1.6A			1.40 3.00 1.00	μs μs μs
INDUCTIVE LOAD							
tsv	Voltage Storage Time					2.50	μs
trv	Voltage Rise Time	IC=8A				200	ns
tfi	Current Fall Time	IBon=1.6A				150	ns
tti	Current Tail Time	VBEoff=10V				50	ns
txo	Cross Over Time Figures 1 & 2	T Case=25°C				300	ns
tsv	Voltage Storage Time					3.00	μs
trv	Voltage Rise Time	IC=8A				300	ns
tfi	Current Fall Time	IBon=1,6A				150	ns
tti	Current Tail Time	VBEoff=10V				50	ns
txo	Crossover Time Figures 1 & 2	T Case=100°C				500	ns

NOTE 1. These parameters are measured using pulse techniques
Pulse Width=300 μs, Duty Cycle=2%

NOTE 2. Inductive Loop Switching Measurement

NOTE 3. These parameters are measured with voltage sensing contacts separated form the current carrying contacts located within 0.125 inches (3.2mm) from the device body.

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



ADJUST RC FOR REQUIRED IC

Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

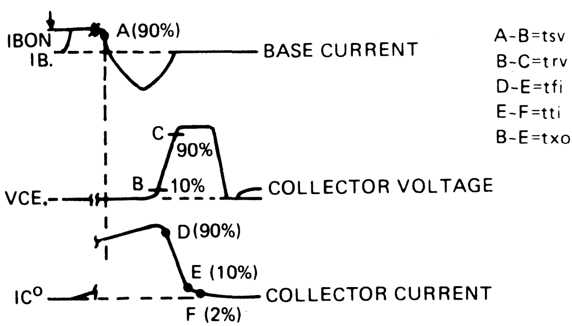
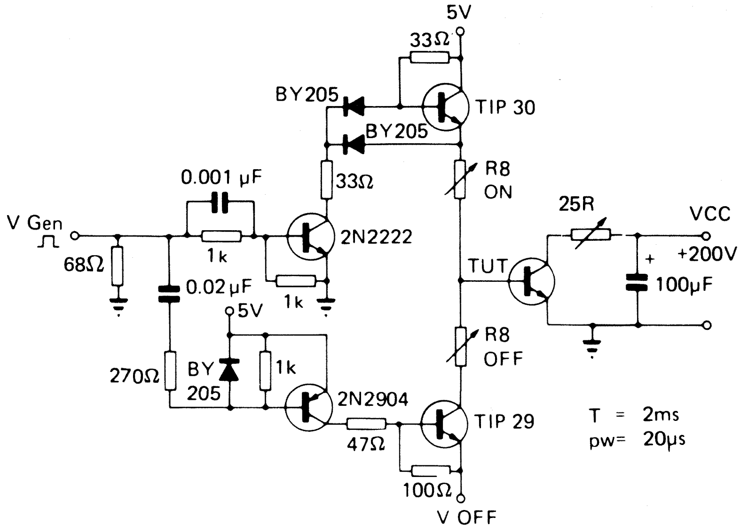


FIGURE 3 RESISTIVE SWITCHING CIRCUIT

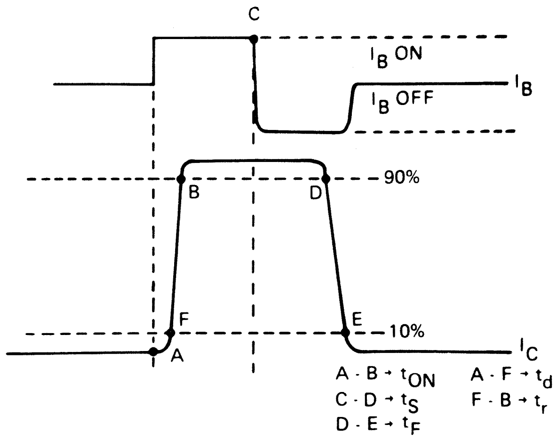


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

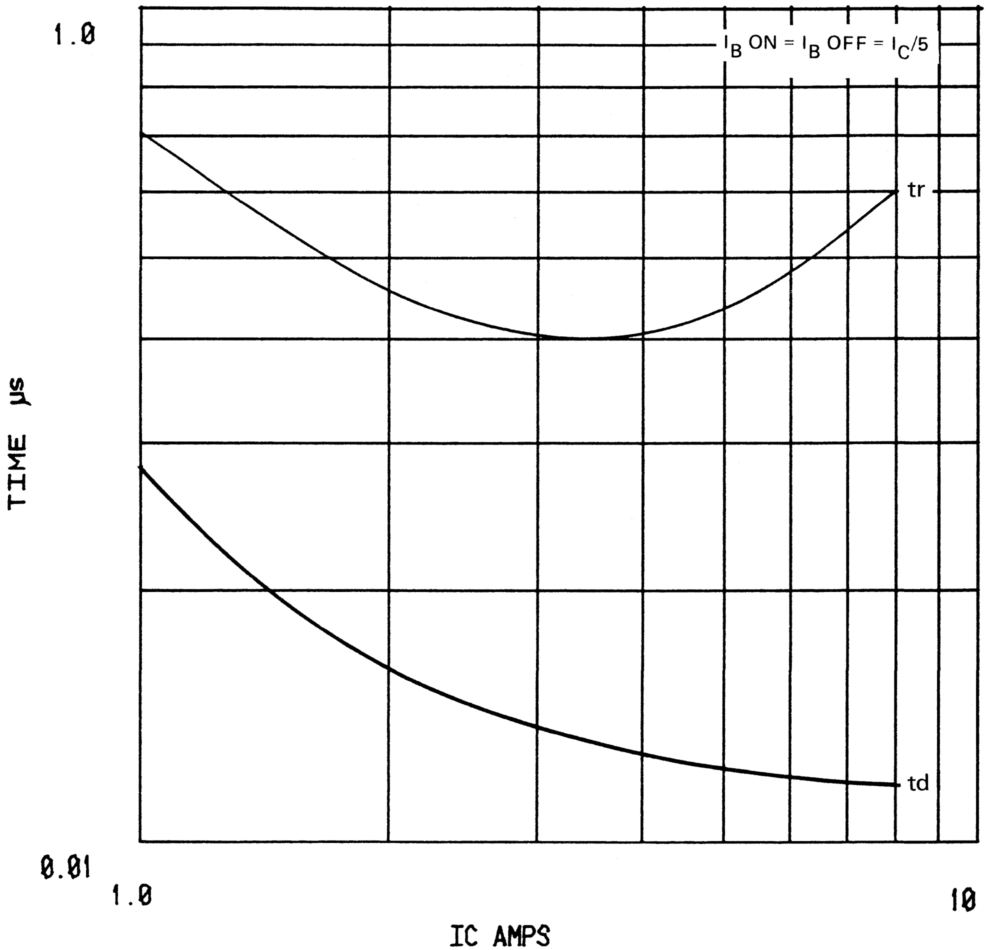
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

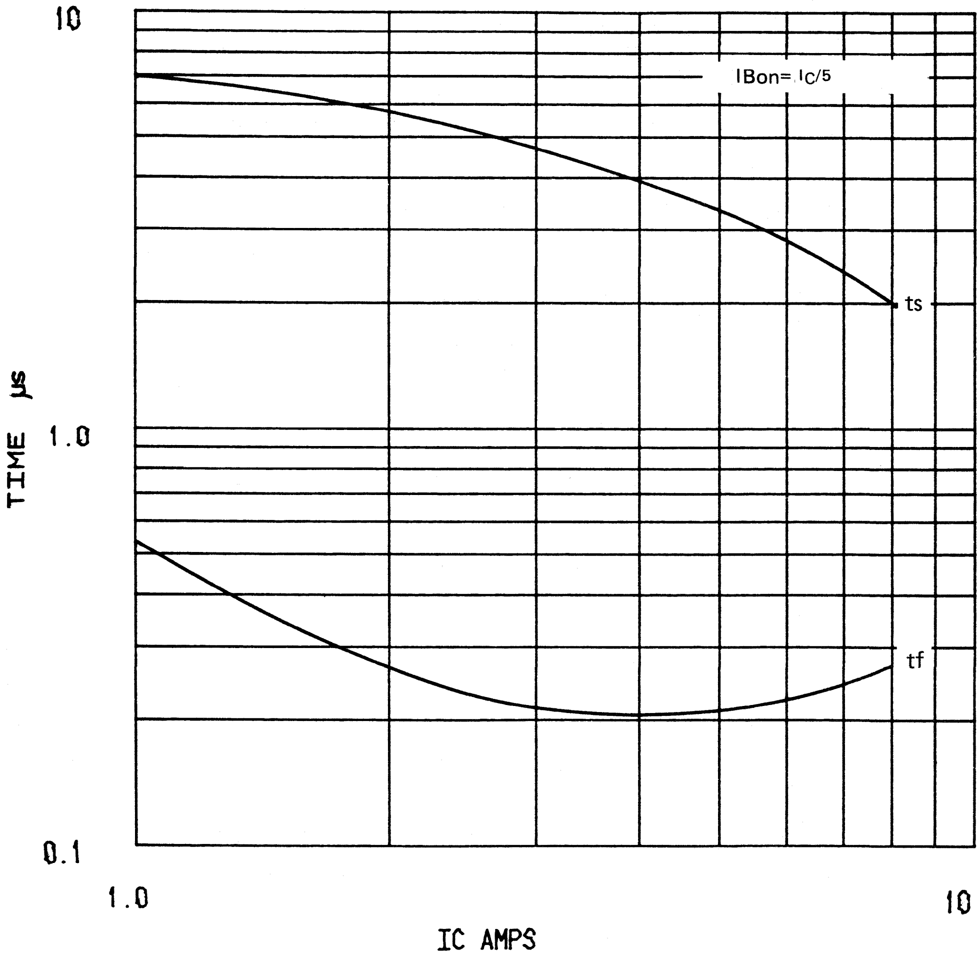


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

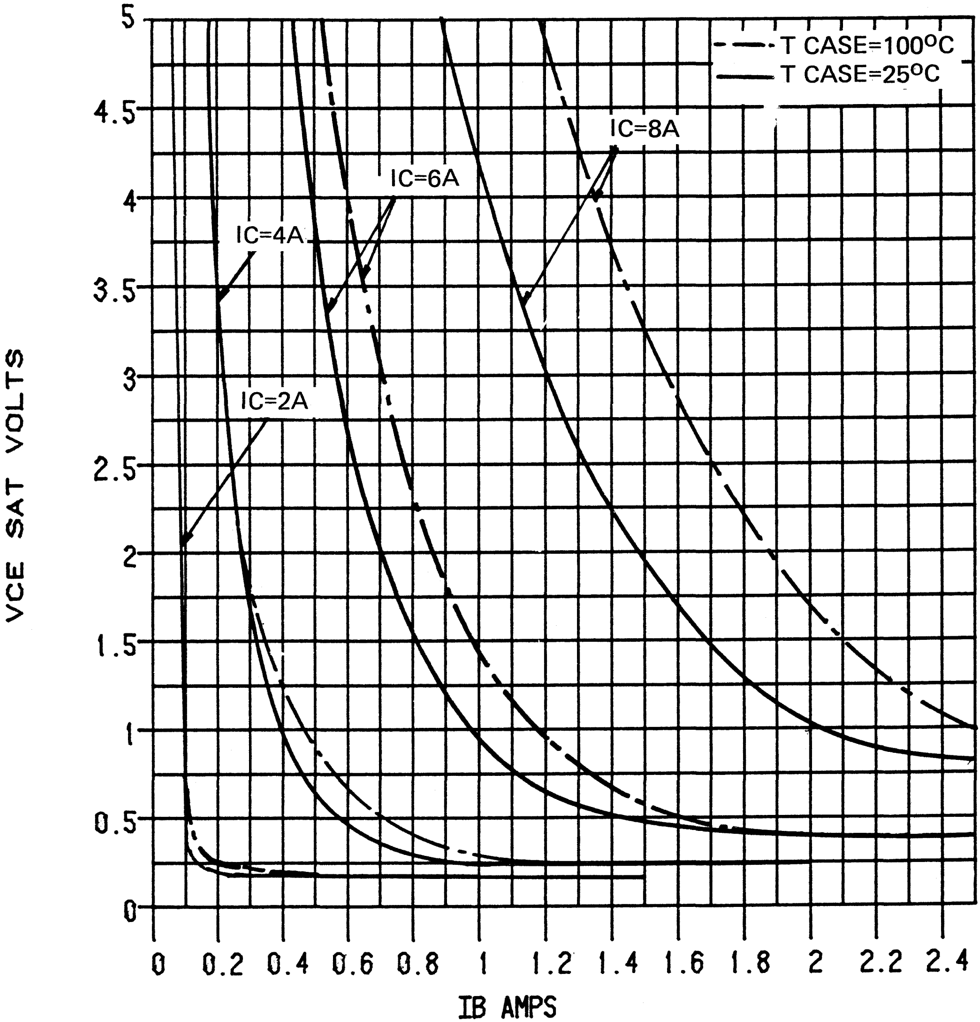


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

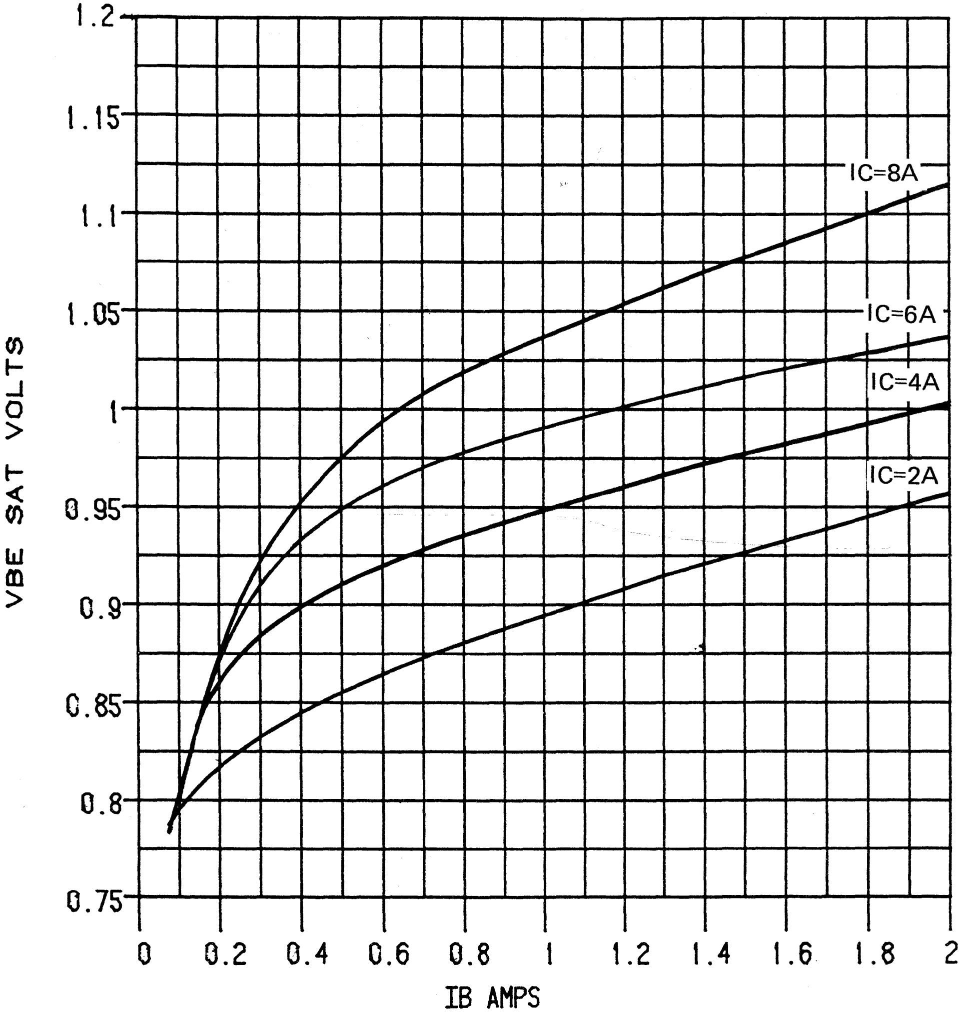


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

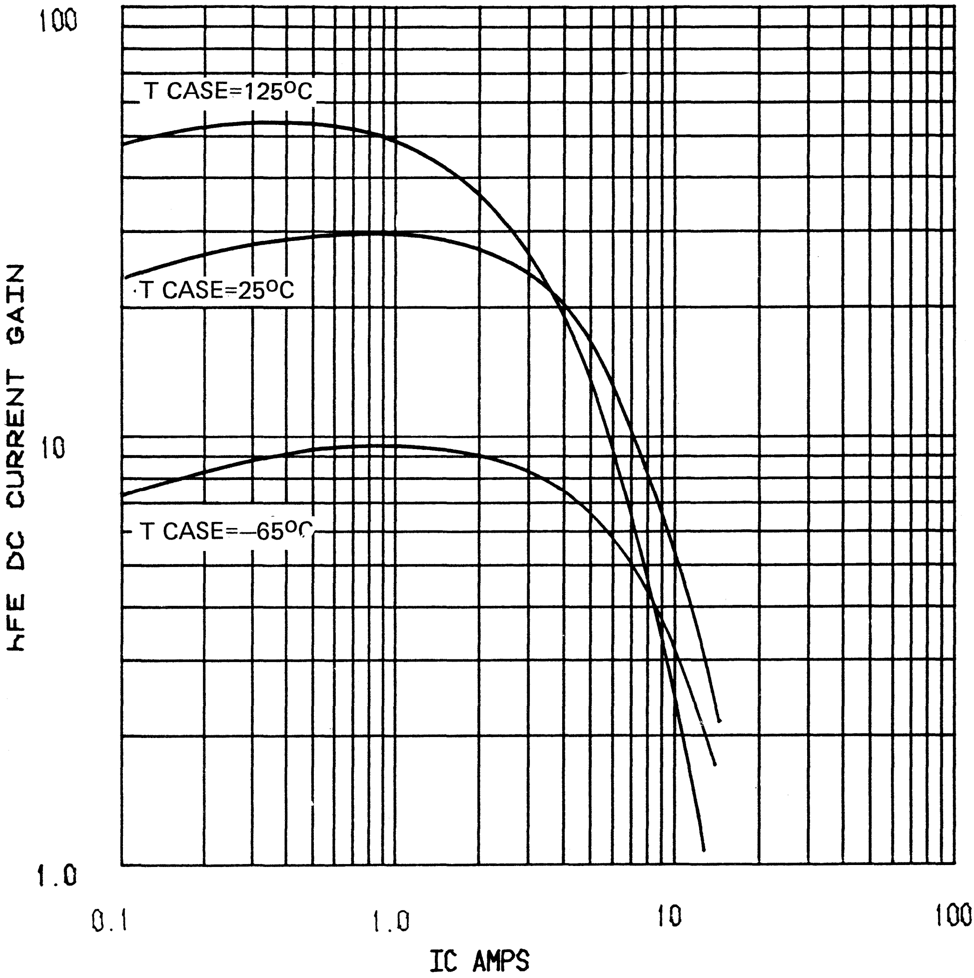


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

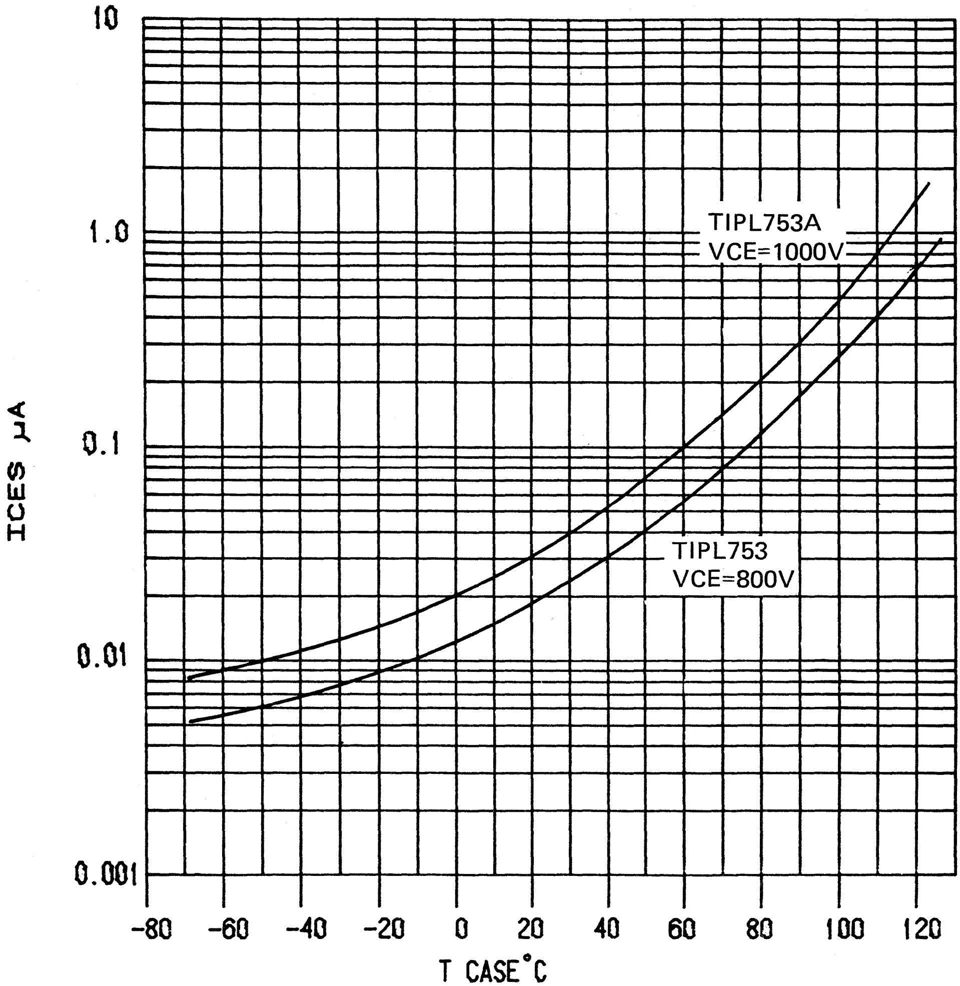


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

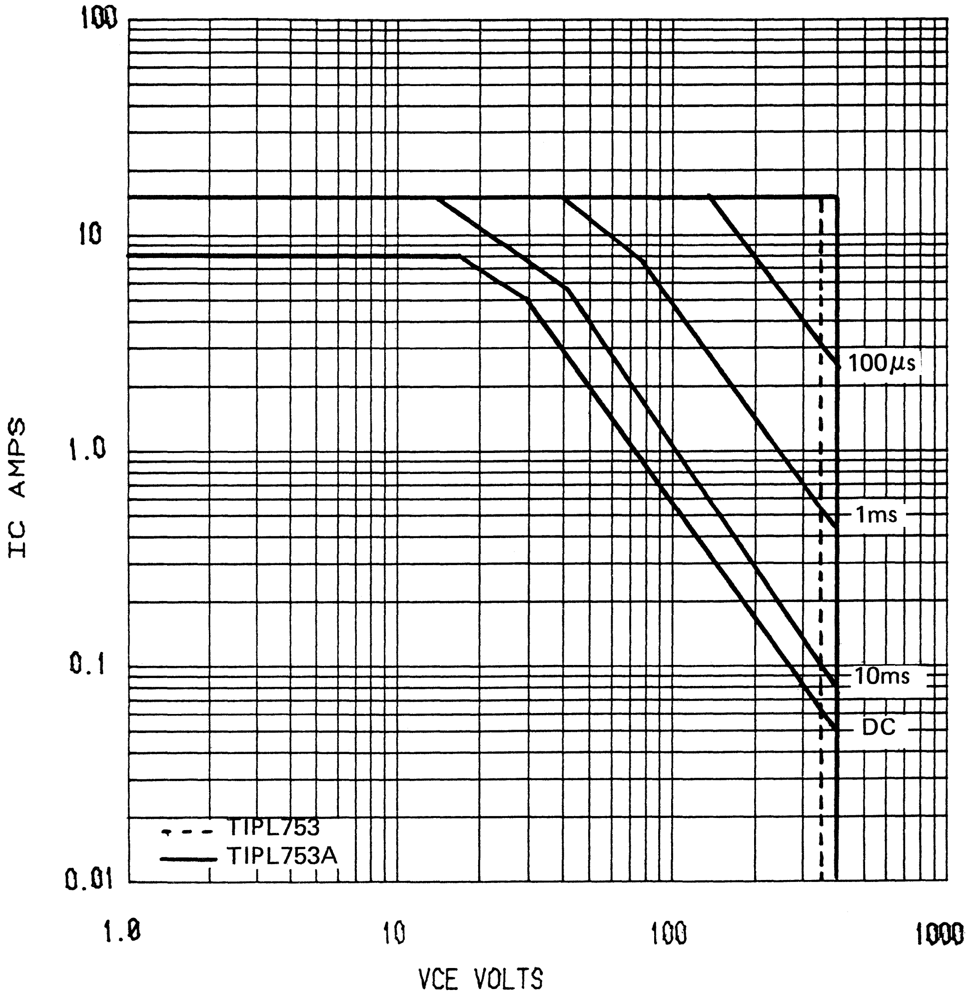


FIGURE. 12 THERMAL RESPONSE

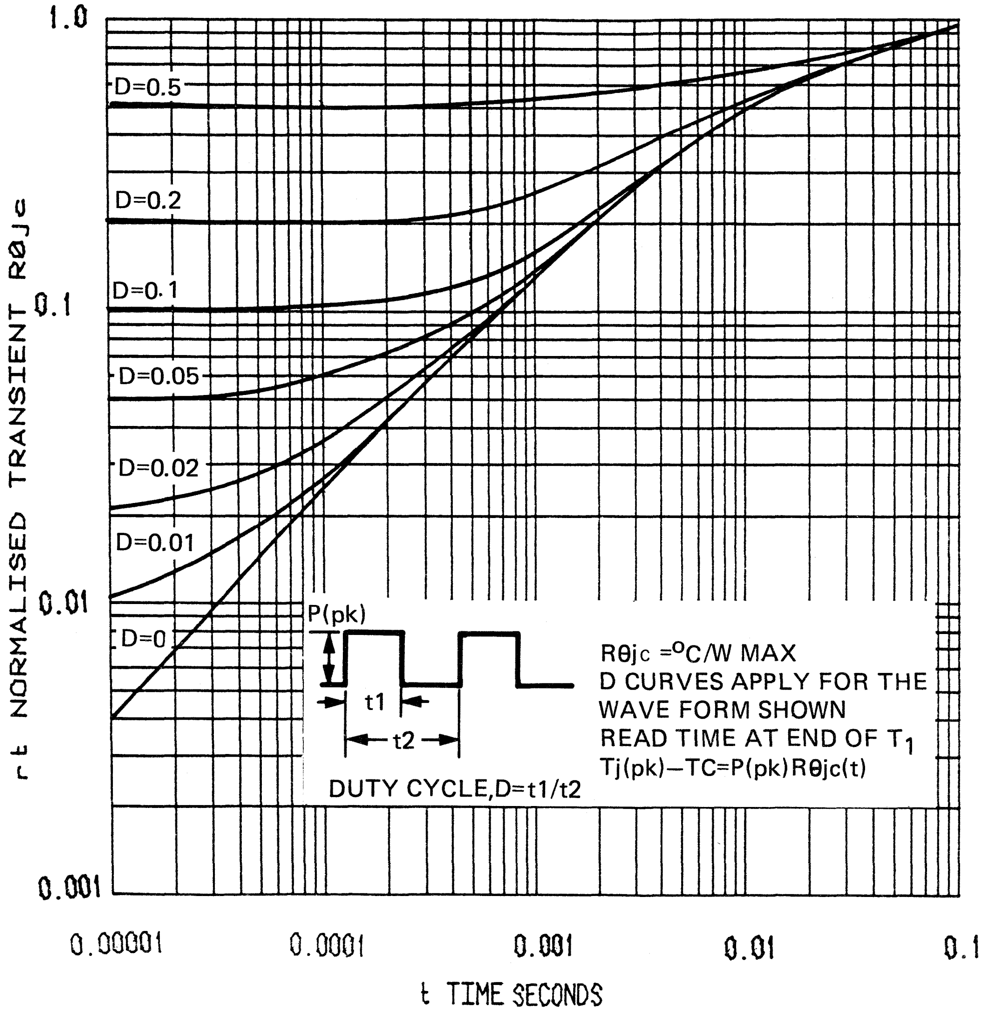


FIGURE. 13 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

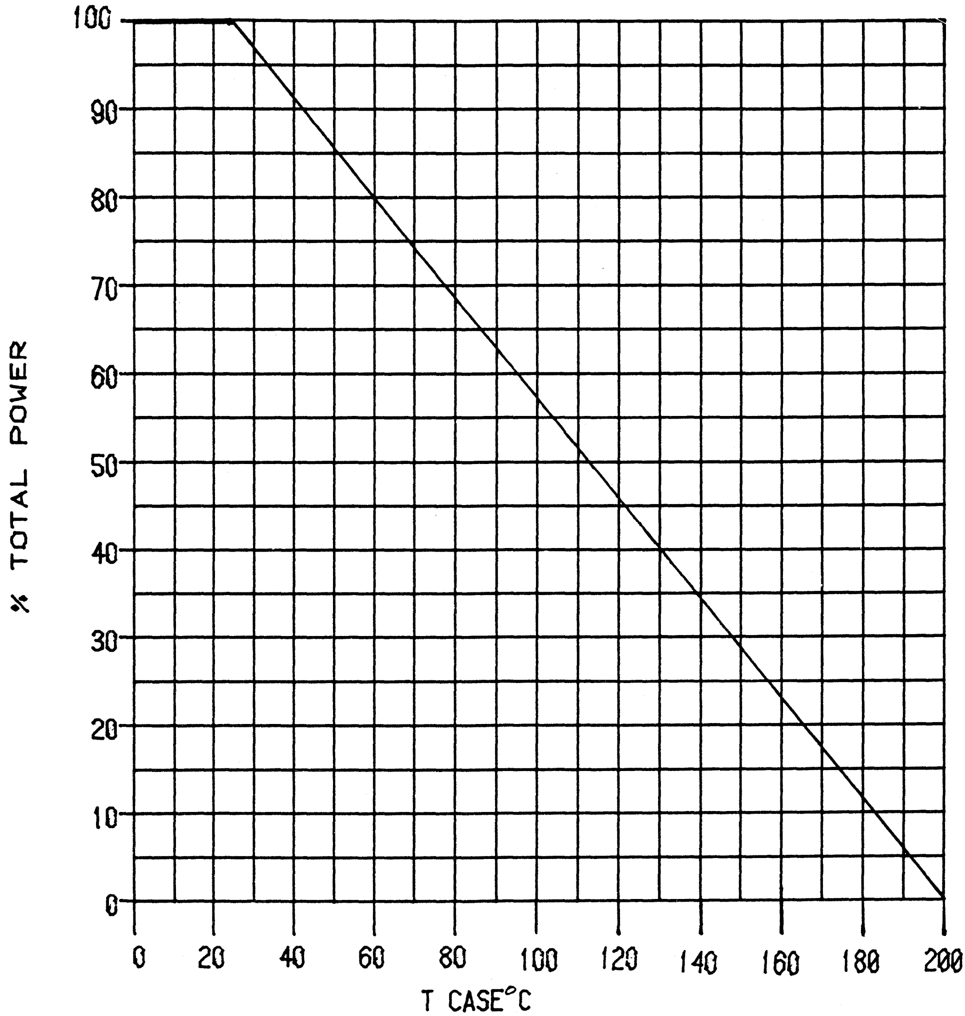


FIGURE. 14 TRANSIENT "TURN-OFF.. LIMIT IC VS VCE

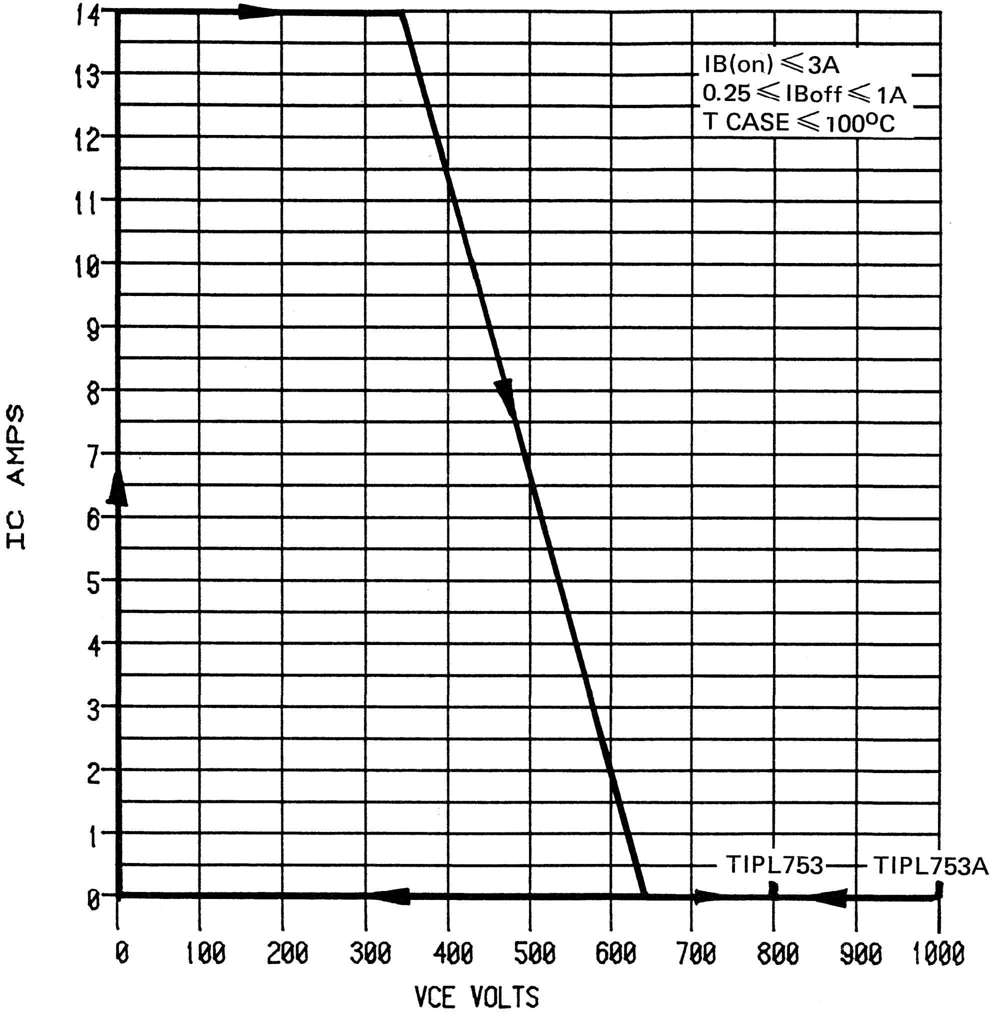
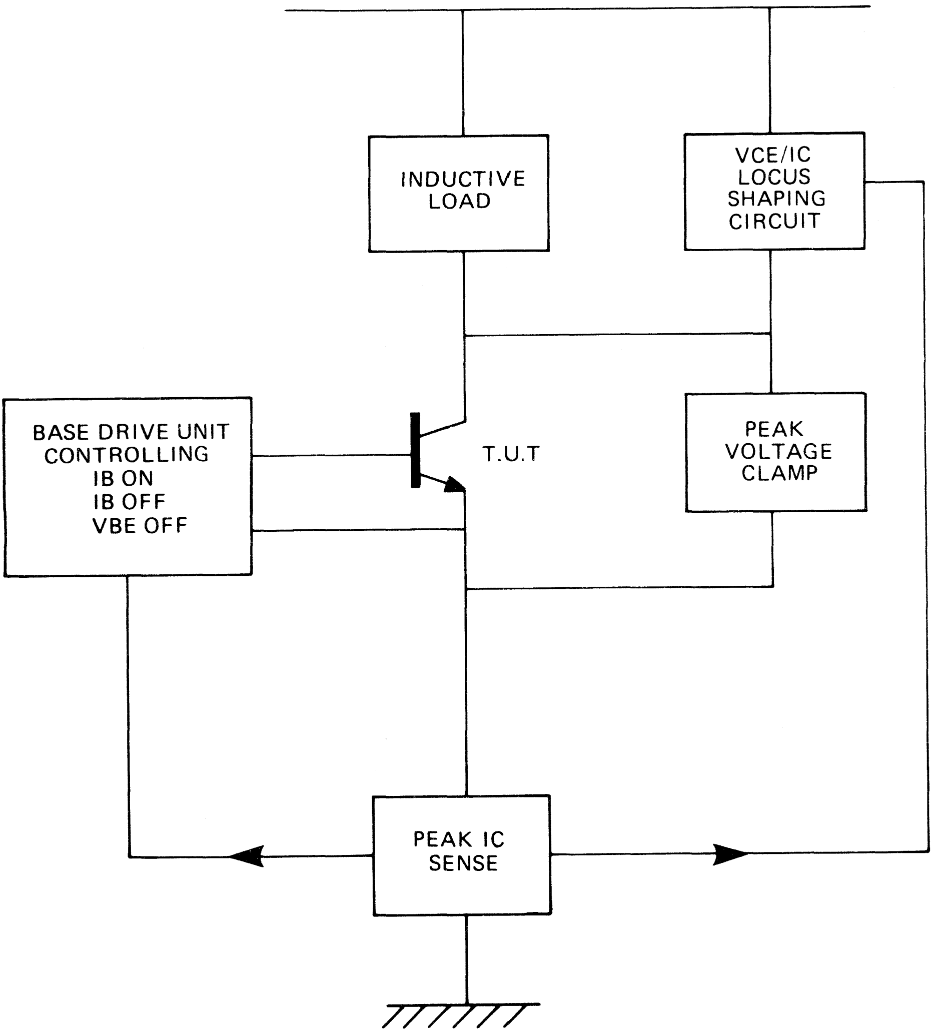


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT

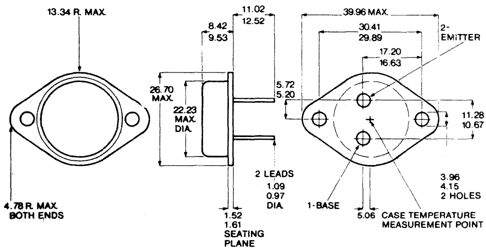


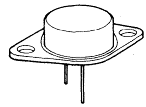
TIPL755, TIPL755A
NPN SILICON POWER TRANSISTOR

- RUGGED TRIPLE-DIFFUSED PLANAR CONSTRUCTION.
- SPECIFICALLY DESIGNED FOR HIGH VOLTAGE, INDUCTIVE LOAD SWITCHING APPLICATIONS.
- OPERATING CHARACTERISTICS FULLY GUARANTEED AT 100°C.
- TRANSIENT POWER DISSIPATION GUARANTEED AT 100°C.
- ICES BETTER THAN 100µA AT MAXIMUM RATED VCE AT 100°C
- 1000 VOLT BLOCKING CAPABILITY.
- VCEO (sust) 420V MIN TIPL755A – 375V MIN TIPL755.

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL755	TIPL755A
Collector-Base Voltage	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	375V	420V
Base-Emitter Voltage	10V	
Continuous Collector Current	10A	
Peak Collector Current (Note 1)	15A	
Continuous Dissipation (Fig. 12)	180W	
Operating Junction & Storage Temperature	-65°C to +200°C	

NOTE 1 : Pulse Test, Pulse Duration = 2ms, Duty Cycle = < 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 3	IC=100mA L=25mH		TIPL755 TIPL755A	375 420			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=375V VCE=420V		TIPL755 TIPL755A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL755 TIPL755A TIPL755 TIPL755A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 2 & 4	IC=2A IC=5A IC=10A IC=10A	IB=400mA IB=1A IB=2A IB=2A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 2 & 4	IC=2A IC=5A IC=10A IC=10A	IB=400mA IB=1A IB=2A IB=2A	 100°C			1.1 1.3 1.8 1.7	V V V V
hFE	Forward Current Transfer Ratio Notes 2 & 4	VCE=5V	IC=500mA		15		60	
ft	Current Gain Band-width Product	IC=500mA VCE=10V(dc)	F=1MHz Gain=Unity			10		MHz
Cob	Output Capacitance	VCB=20V IE=0A	 F=0. 1MHz			150		pF
Rθjc	Thermal Resistance Junction-Case						0.97	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

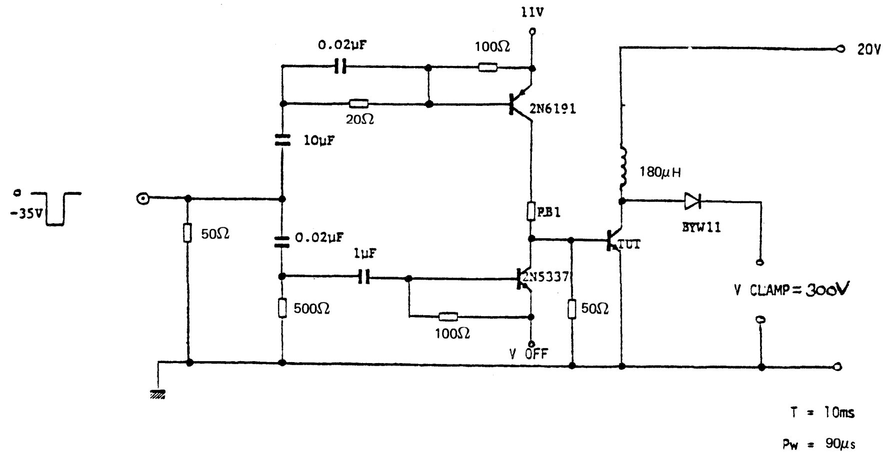
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
RESISTIVE LOAD							
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=10A IBon=2A T Case=25°C	VCC=250V IBoff=2.5A			0.75 2.00 0.50	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=10A IBon=2A T Case=100°C	VCC=250V IBoff=2.5A			1.00 2.50 1.00	μs μs μs
INDUCTIVE LOAD							
tsv trv tfi tti txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Crossover Time Figures 1 & 2	 IC=10A IBon=2A VBEoff=5V T Case=25°C				3.00 0.30 0.20 0.05 0.40	μs μs μs μs μs
tsv trv tfi tti txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Crossover Time Figures 1 & 2	 IC=10A IBon=2A VBEoff=5V T Case=100°C				3.50 0.40 0.30 0.08 0.50	μs μs μs μs μs

NOTE 2. These Parameters are measured using pulse techniques
Pulse Width ≤ 300 μs, Duty Cycle = 2%

NOTE 3. Inductive Loop Switching Measurement

NOTE 4. These Parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE. 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr $<$ 15 ns, $R_{in} > 10\Omega$ and $C_{in} < 11.5$ pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

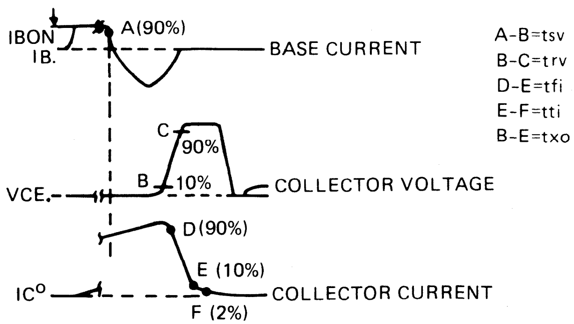
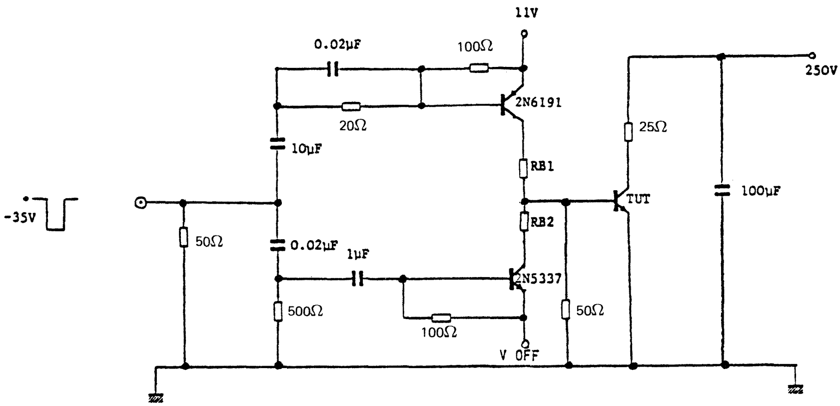


FIGURE. 3 RESISTIVE SWITCHING CIRCUIT



T = 2ms

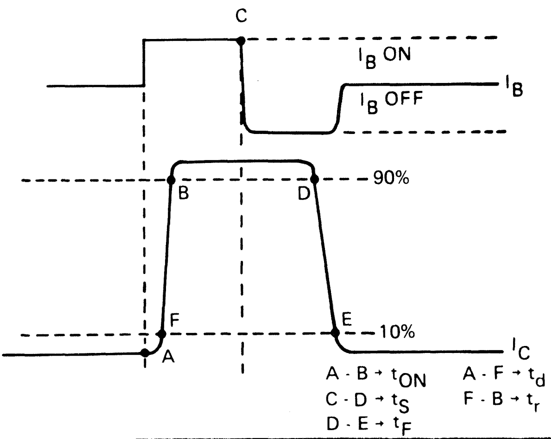
Pw = 20us

Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20µs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} < 11.5pF.

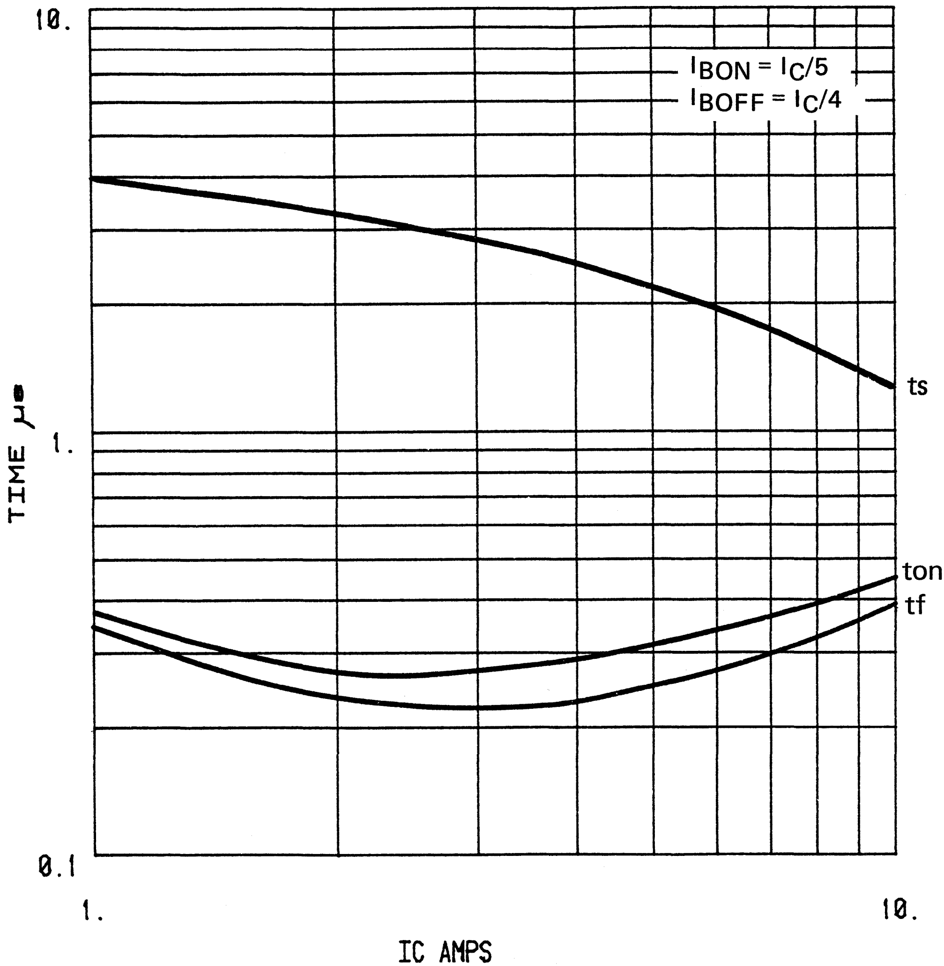
C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS

FIGURE. 5 TYPICAL TURN-ON & TURN-OFF TIMES VS IC TCASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE. 6 TYPICAL TURN-OFF TIME VS.IBoff T CASE=25°C

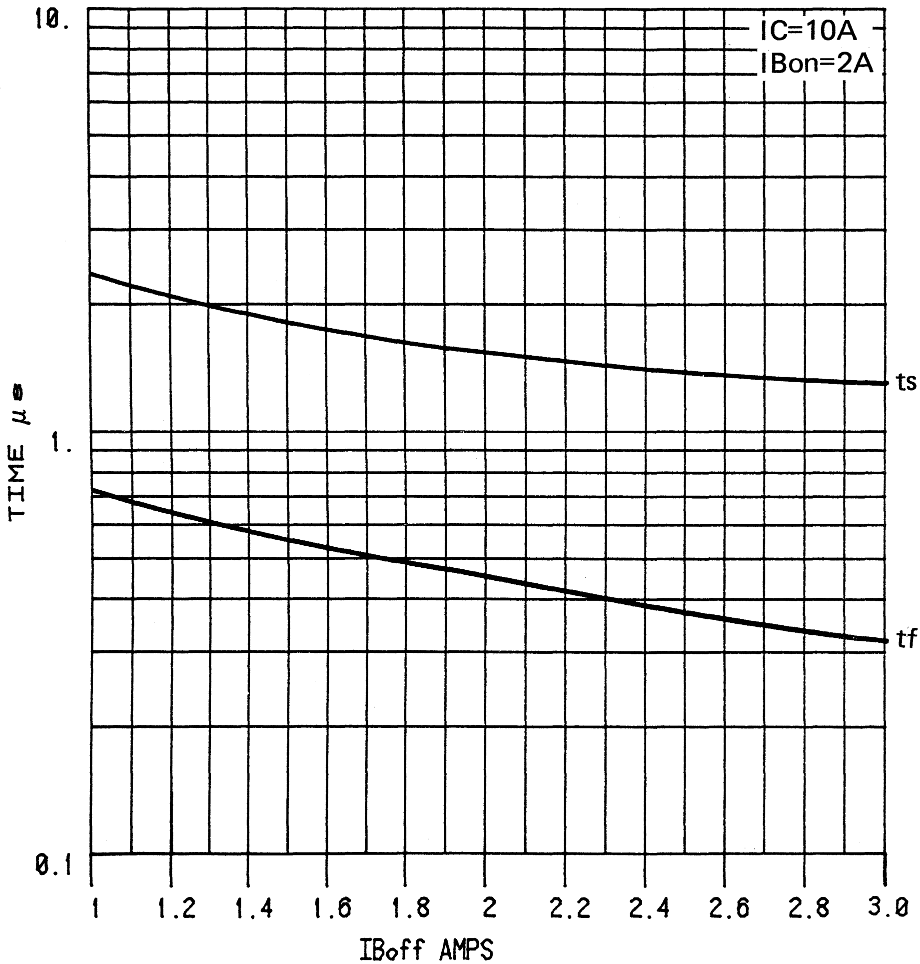


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

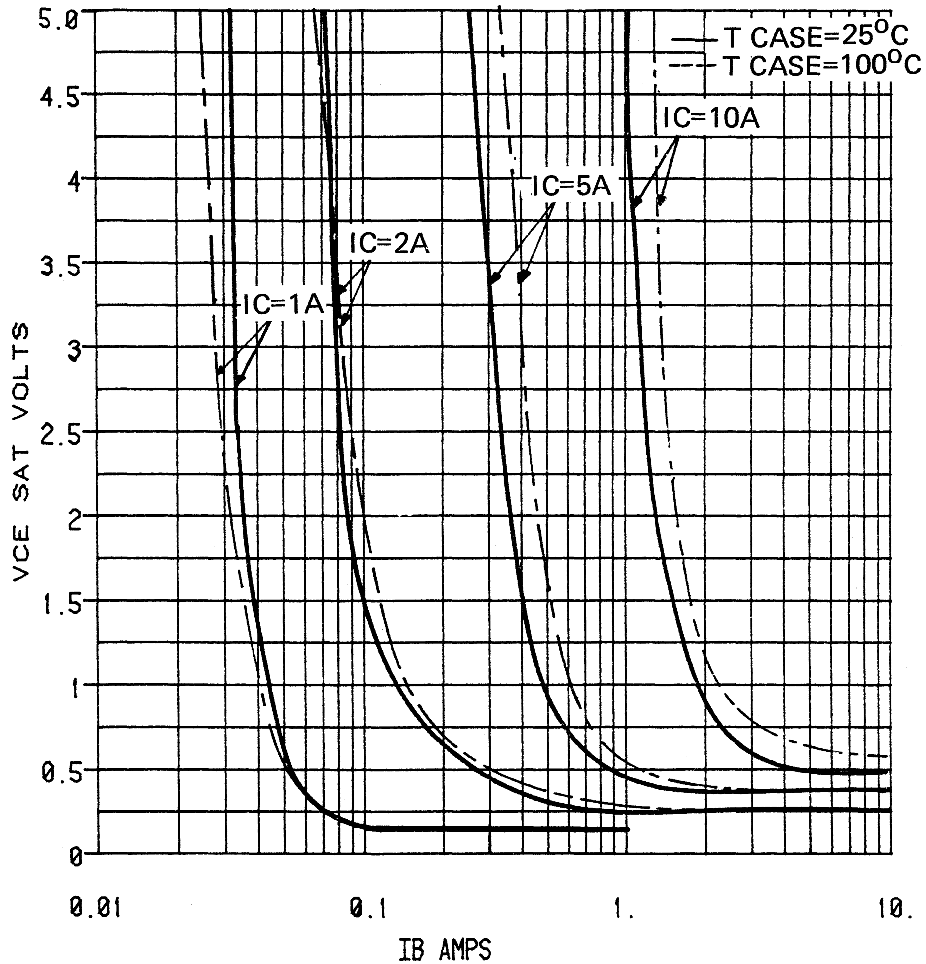


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

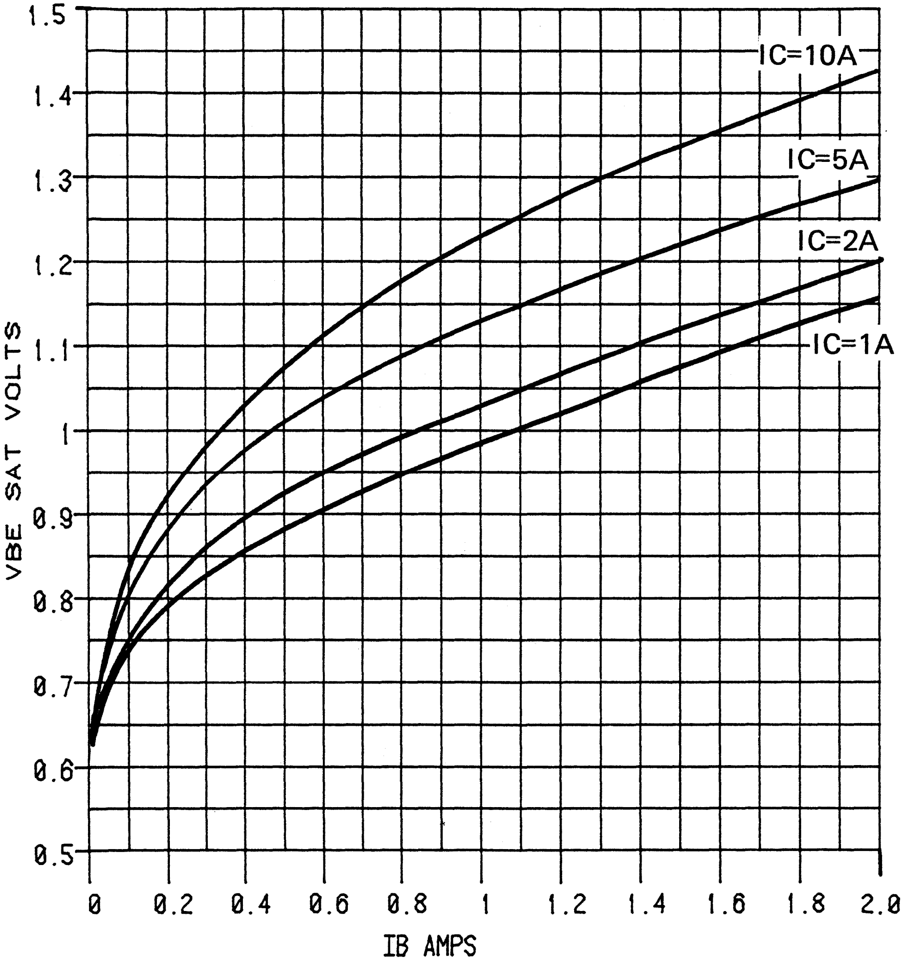


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

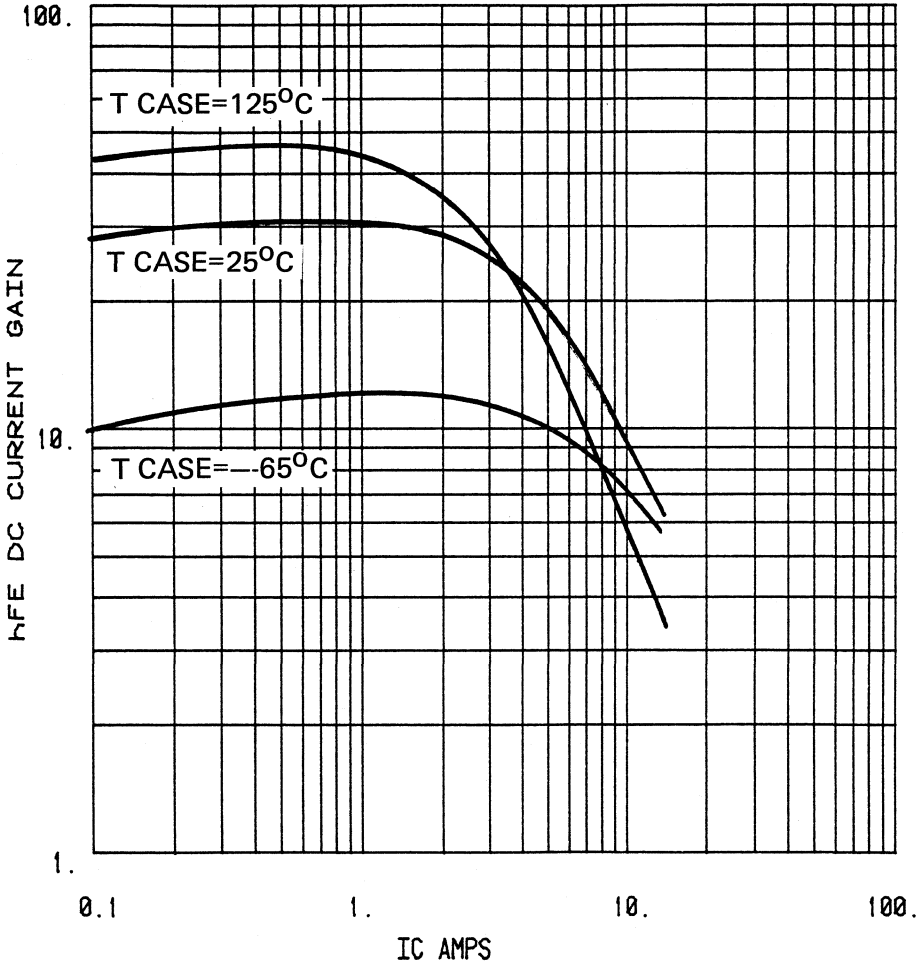


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

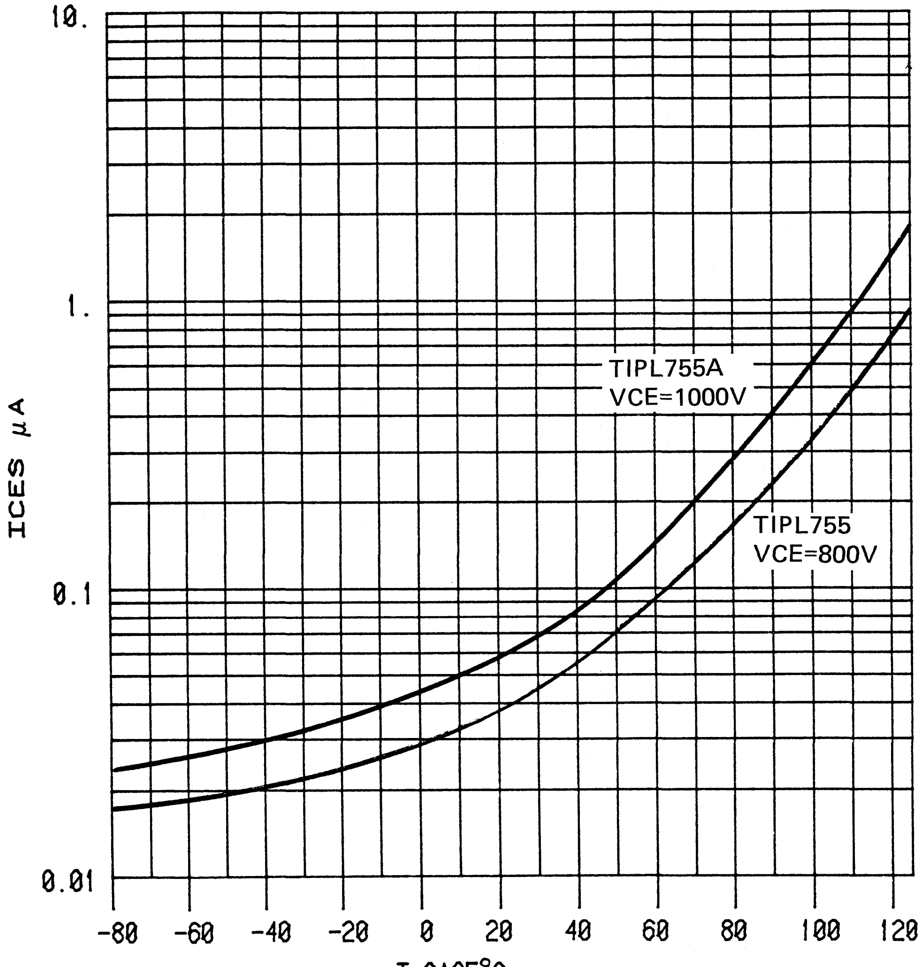


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED
T CASE=25°C

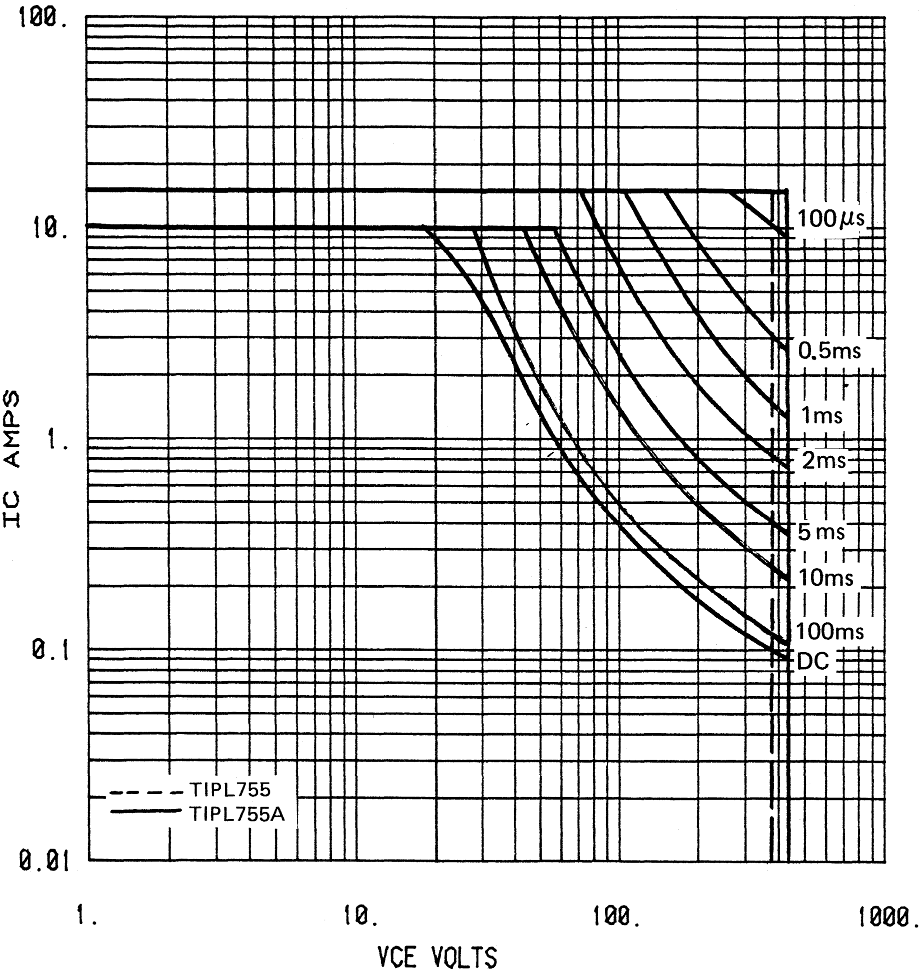


FIGURE. 12 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

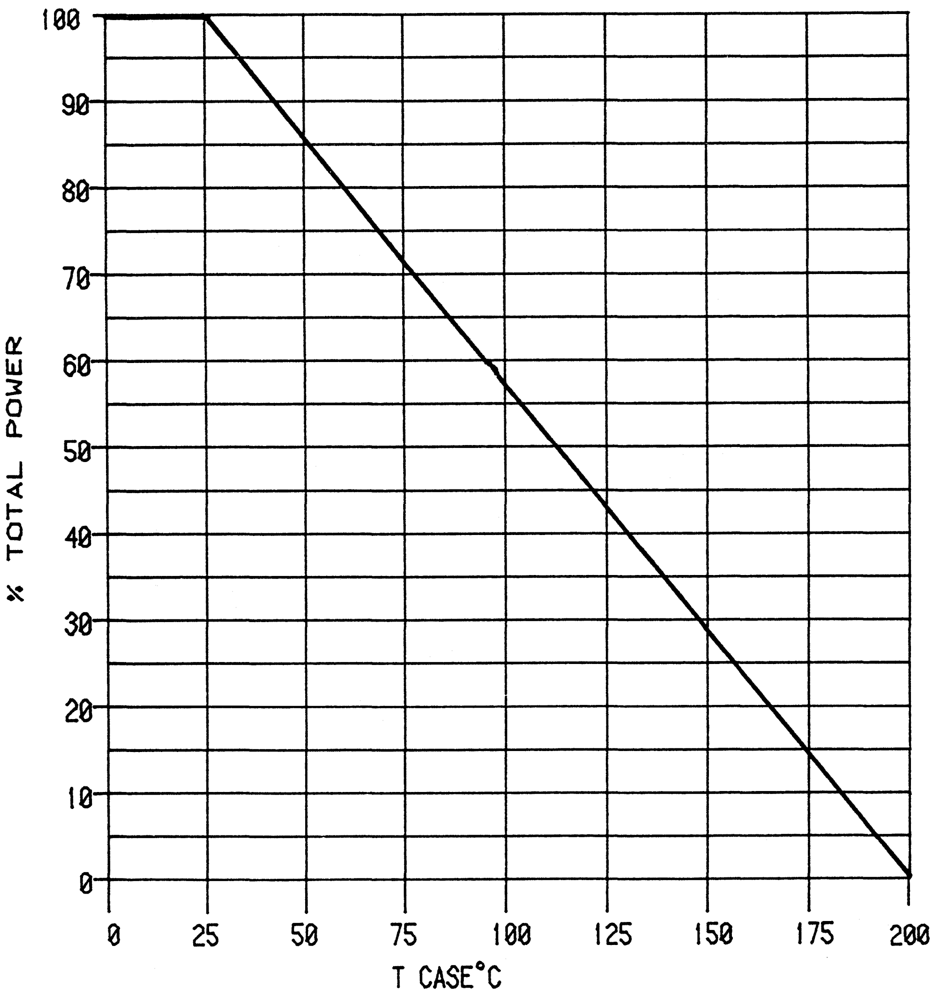


FIGURE. 13 MAXIMUM REVERSE BIAS SAFE OPERATING AREA

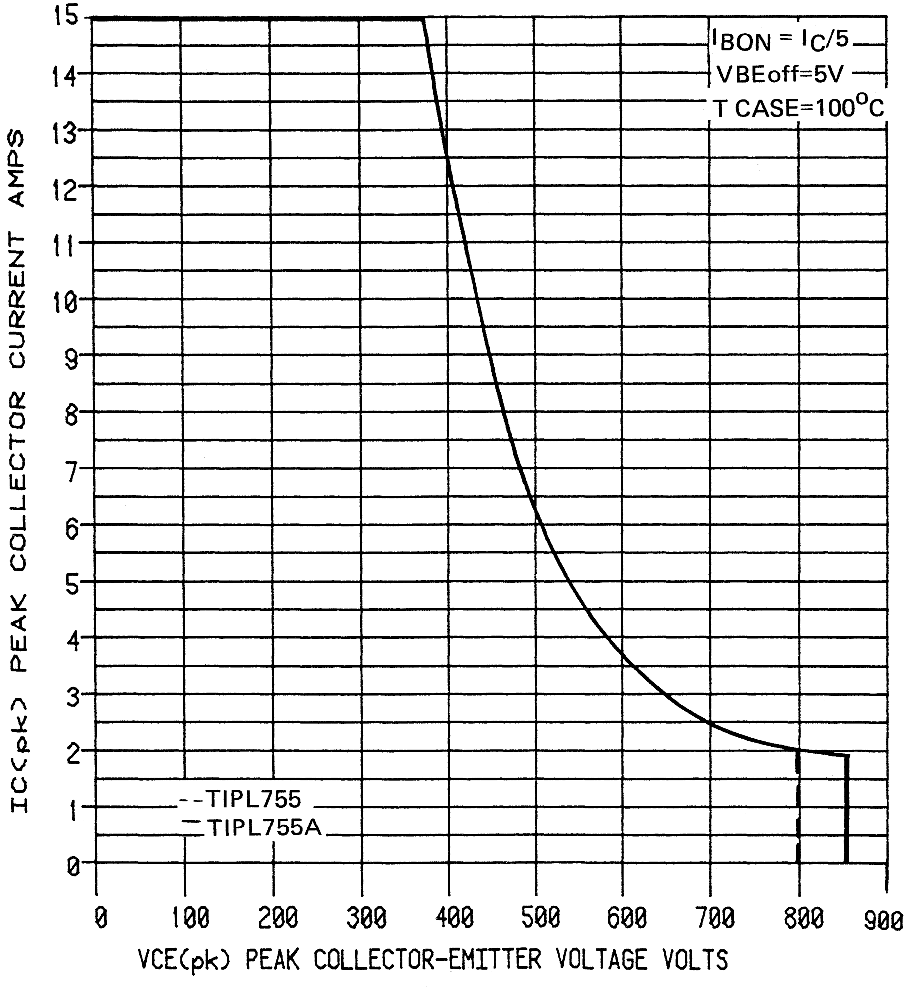


FIGURE. 14 TRANSIENT "TURN OFF" LIMIT vs. VCE T CASE<100°C

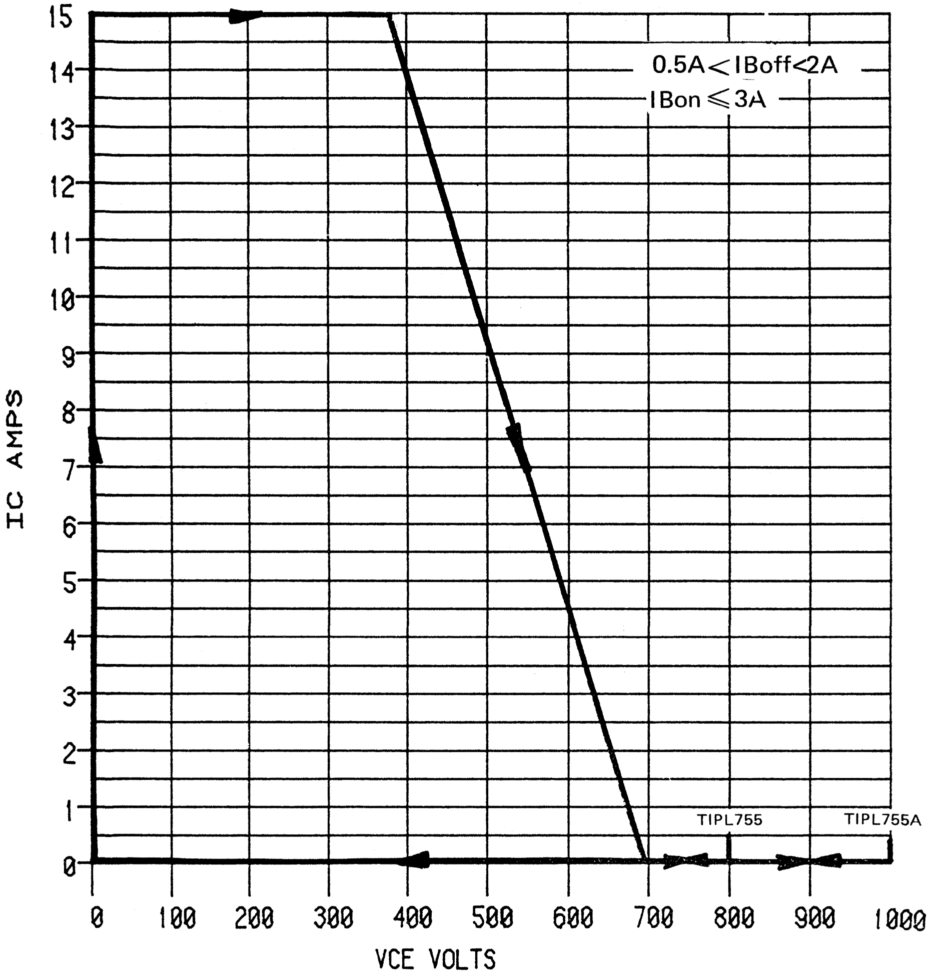
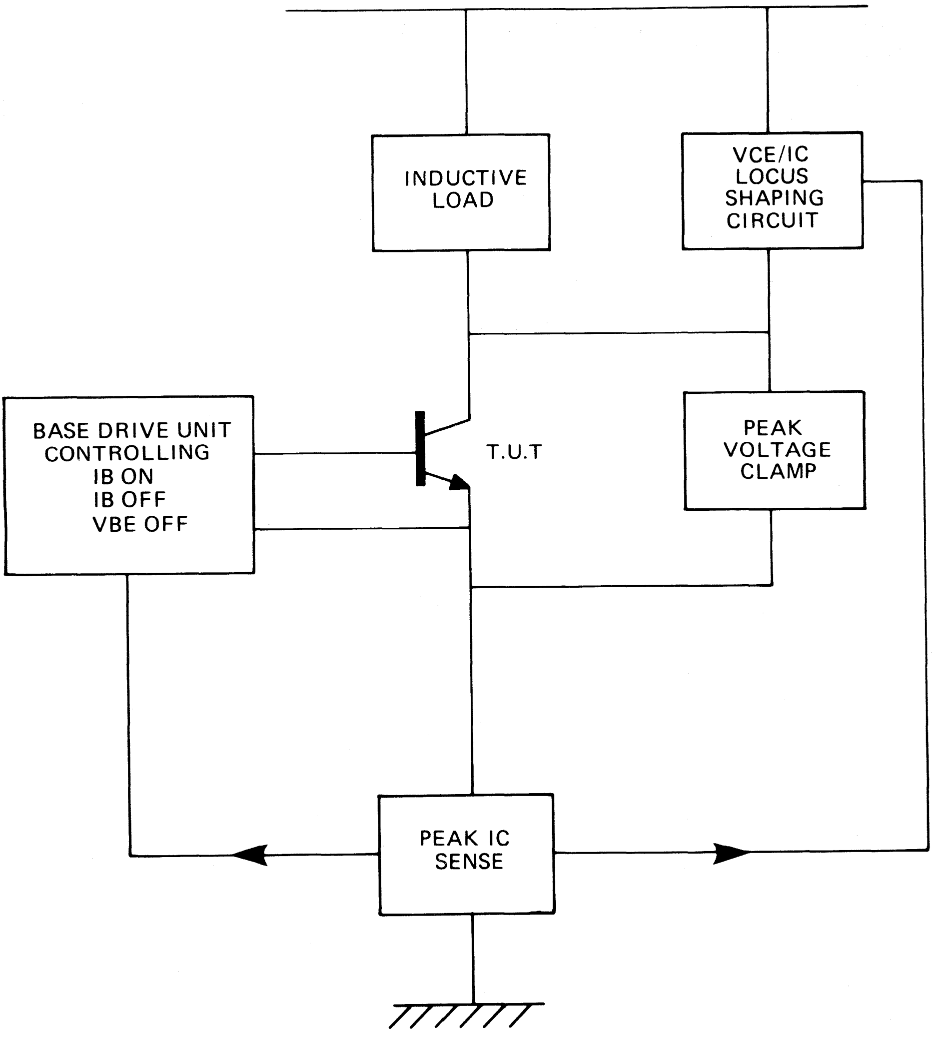


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



TIPL760A, TIPL761A
NPN SILICON POWER TRANSISTOR

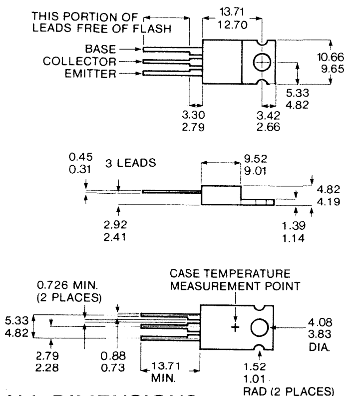
OCT 82

- RUGGED TRIPLE-DIFFUSED PLANAR CONSTRUCTION
- SPECIFICALLY DESIGNED FOR HIGH VOLTAGE, INDUCTIVE LOAD SWITCHING APPLICATIONS.
- OPERATING CHARACTERISTICS FULLY GUARANTEED AT 100°C.
- TRANSIENT POWER DISSIPATION GUARANTEED AT 100°C.
- ICES BETTER THAN 100µA AT MAXIMUM RATED VCE AT 100°C.
- 1000 VOLT BLOCKING CAPABILITY

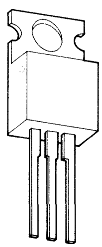
MECHANICAL SPECIFICATIONS

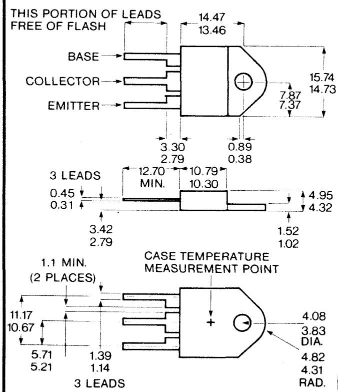
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB

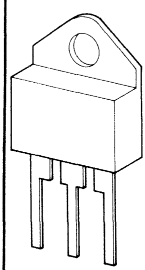
ALL JEDEC TO-220AB DIMENSIONS AND NOTES ARE APPLICABLE.



ALL DIMENSIONS ARE IN MILLIMETRES







ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TO220		TO218	
	TIPL760	TIPL760A	TIPL761	TIPL761A
Collector-Base Voltage	800V	1000V	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V	800V	1000V
Collector-Emitter Voltage (Open Base)	375V	420V	375V	420V
Base-Emitter Voltage	10V	10V	10V	10V
Continuous Collector Current	4A	4A	4A	4A
Peak Collector Current (Note 1)	8A	8A	8A	8A
Continuous Dissipation (Figs. 11 & 13)	80W	80W	100W	100W
Operating Junction & Storage Temperature	-65°C – +150°C			

NOTE 1 : Pulse Test. Pulse Duration ≤ 10ms Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH Standard A Type	375 420			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=375V Standard VCE=420V A Type			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V Standard VCE=1000V A Type VCE=800V 100°C Standard VCE=1000V 100°C A Type			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V IC=0			1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 1 & 3	IC=1A IB=200mA IC=2.5A IB=500mA IC=4A IB=800mA IC=4A IB=800mA 100°C			0.5 1 2.5 5	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 1 & 3	IC=1A IB=200mA IC=2.5A IB=500mA IC=4A IB=800mA IC=4A IB=800mA 100°C			1 1.2 1.4 1.3	V V V V
hFE	Forward Current Transfer Ratio Notes 1 & 3	VCE=5V IC=500mA	20		60	
ft	Current Gain Band-Width Product	IC=500mA VCE=10V DC F=1MHz		12		MHz
Cob	Output Capacitance	VCB=20V IE=0A F=0. 1MHz		110		pF
Rθjc	Thermal Resistance Junction-Case	TIPL760/760A TIPL761/761A			1.56 1.25	°C/W °C/W

FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

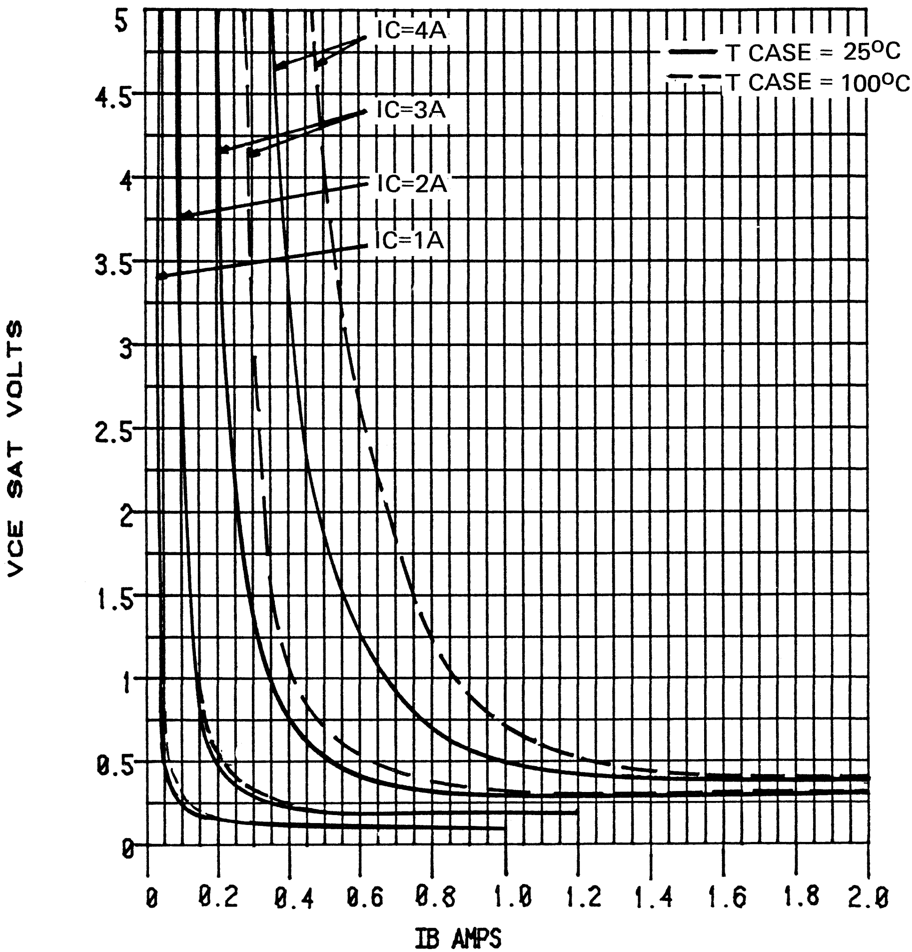
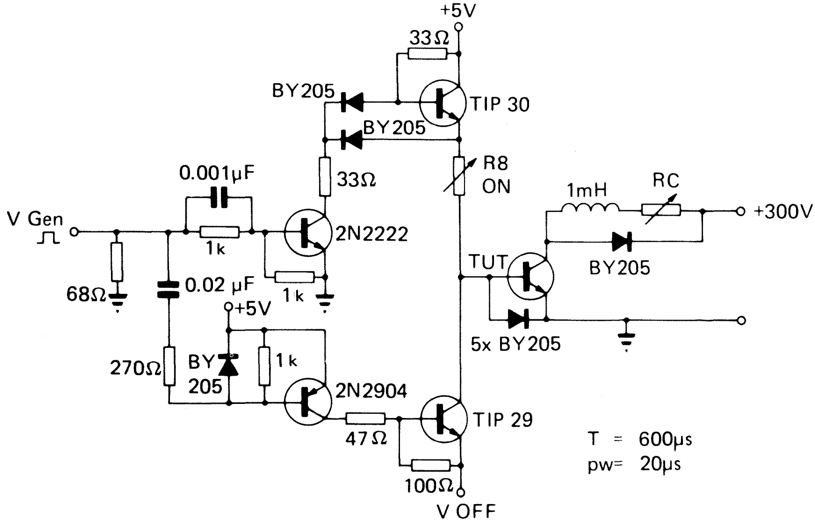


FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



ADJUST RC FOR REQUIRED IC

Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

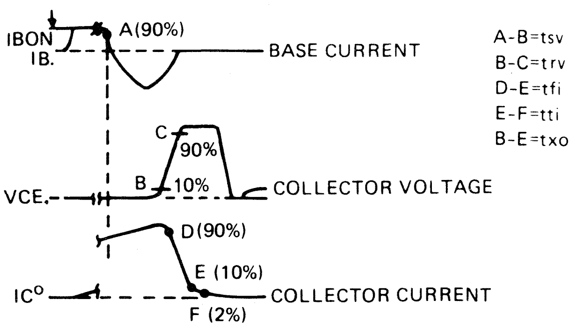
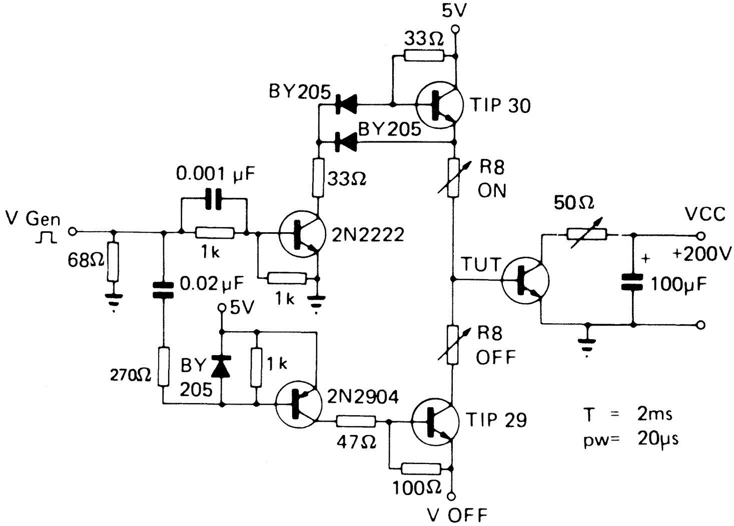


FIGURE 3 RESISTIVE SWITCHING CIRCUIT



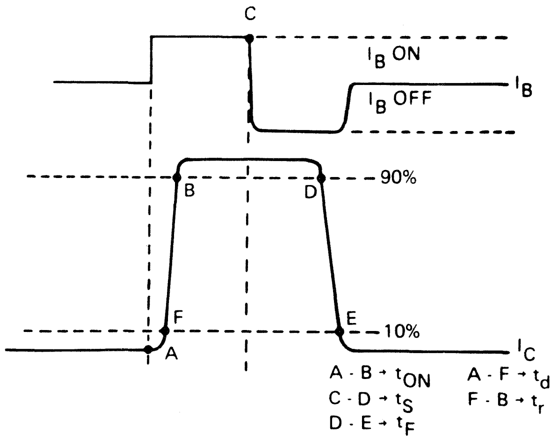
Notes

A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

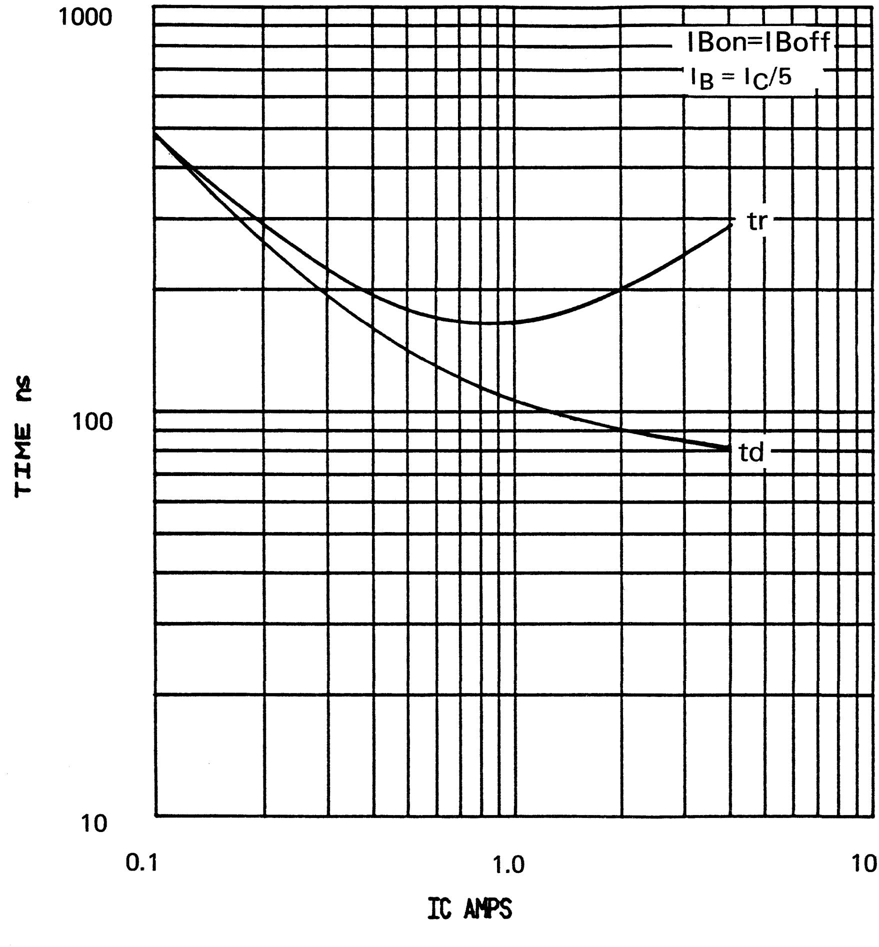
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

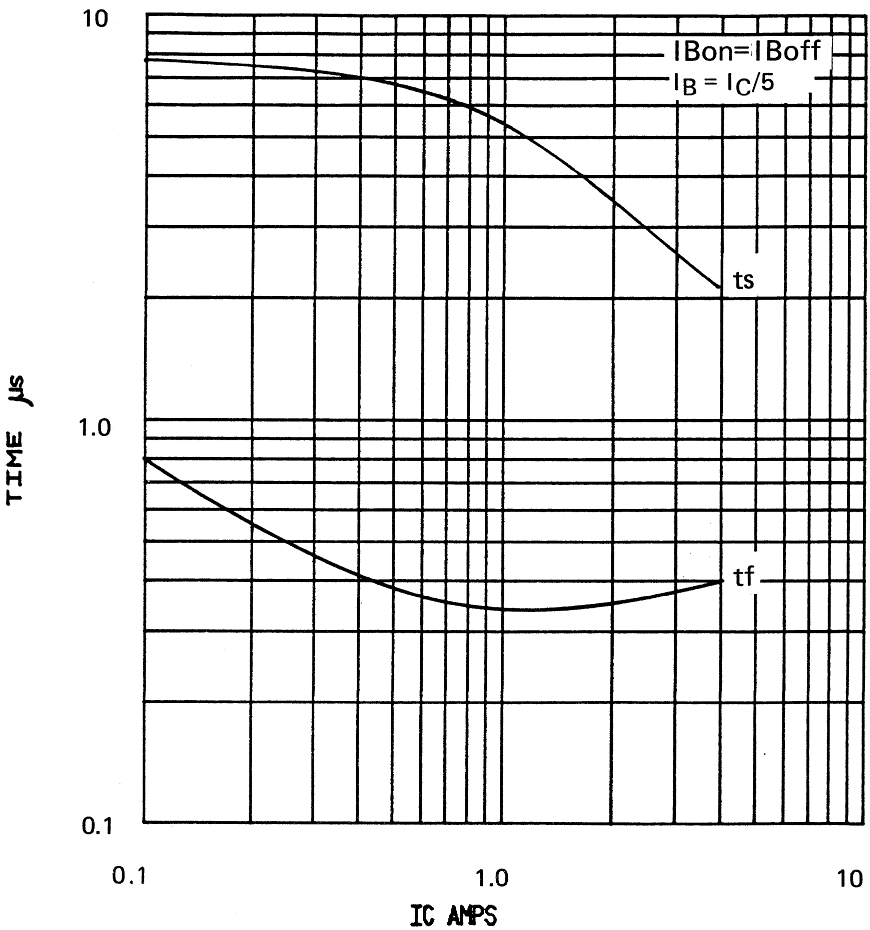
FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C



SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
ton	Turn On Time	IC=4A VCC=200V			0.55	µs
ts	Storage Time	IBon=IBoff=800mA			2.50	µs
tf	Fall Time	T Case=25°C			0.50	µs
	Figures 3–6					
ton	Turn On Time	IC=4A VCC=200V			0.65	µs
ts	Storage Time	IBon=IBoff=800mA			3.00	µs
tf	Fall Time	T Case=100°C			1.00	µs
	Figures 3–6					
INDUCTIVE LOAD						
tsv	Voltage Storage Time				2.50	µs
trv	Voltage Rise Time	IC=4A			0.30	µs
tfi	Current Fall Time	IBon=0.8A			0.25	µs
tti	Current Tail Time	VBE off=-5V			0.15	µs
txo	Crossover Time	T Case=25°C			0.40	µs
	Figures 1 & 2					
tsv	Voltage Storage Time				3.00	µs
trv	Voltage Rise Time	IC=4A			0.50	µs
tfi	Current Fall Time	IBon=0.8A			0.25	µs
tti	Current Tail Time	VBE off=-5V			0.15	µs
txo	Crossover Time	T Case=100°C			0.75	µs
	Figures 1 & 2					

NOTE 1. These Parameters are measured using Pulse techniques
Pulse width ≤ 300µs, Duty cycle ≤ 2%

NOTE 2. Inductive Loop Switching Measurement

NOTE 3. These Parameters are measured with Voltage Sensing Contacts separated from the Current Carrying Contacts located within 0.125 inches (3.2mm) from the Device Body.

FIGURE. 8 TYPICAL BASE SATURATION REGION

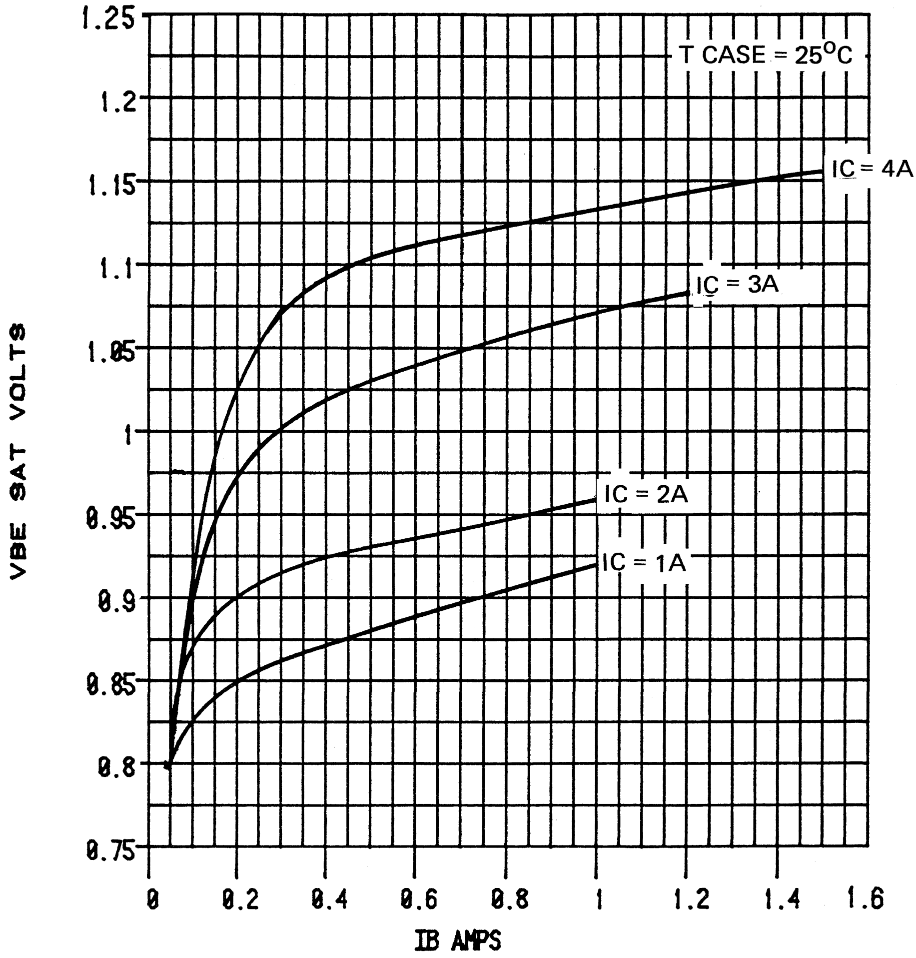


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN, VCE=5V

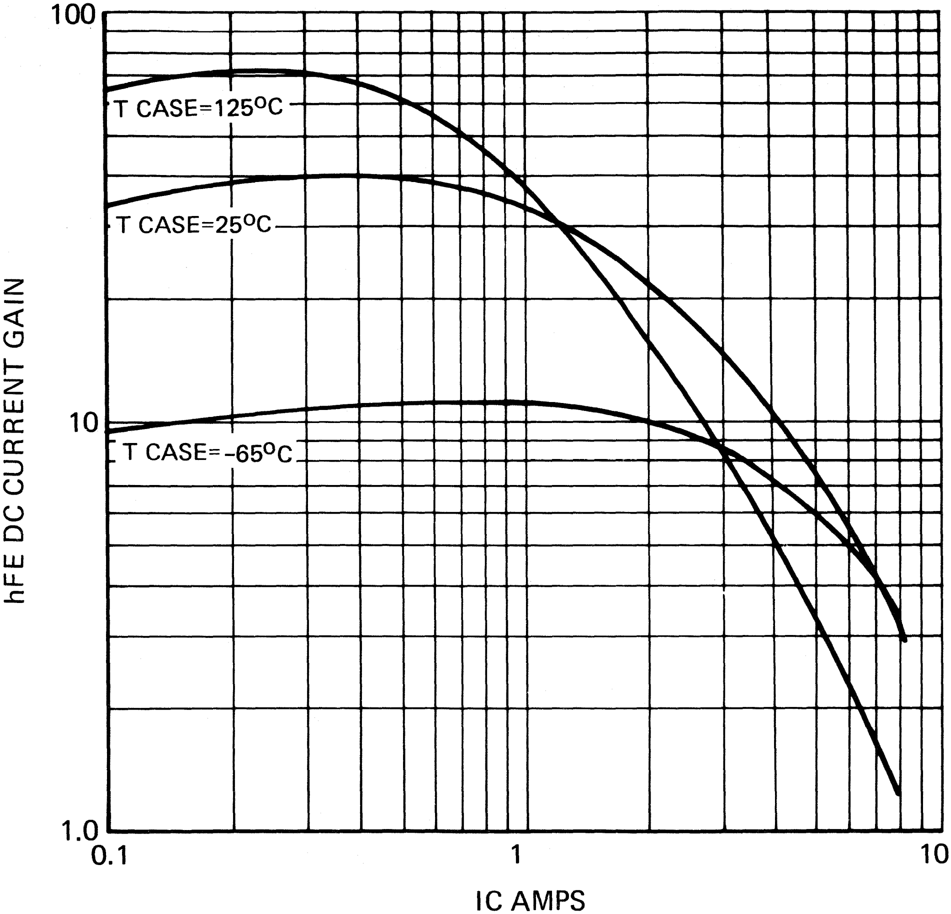


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

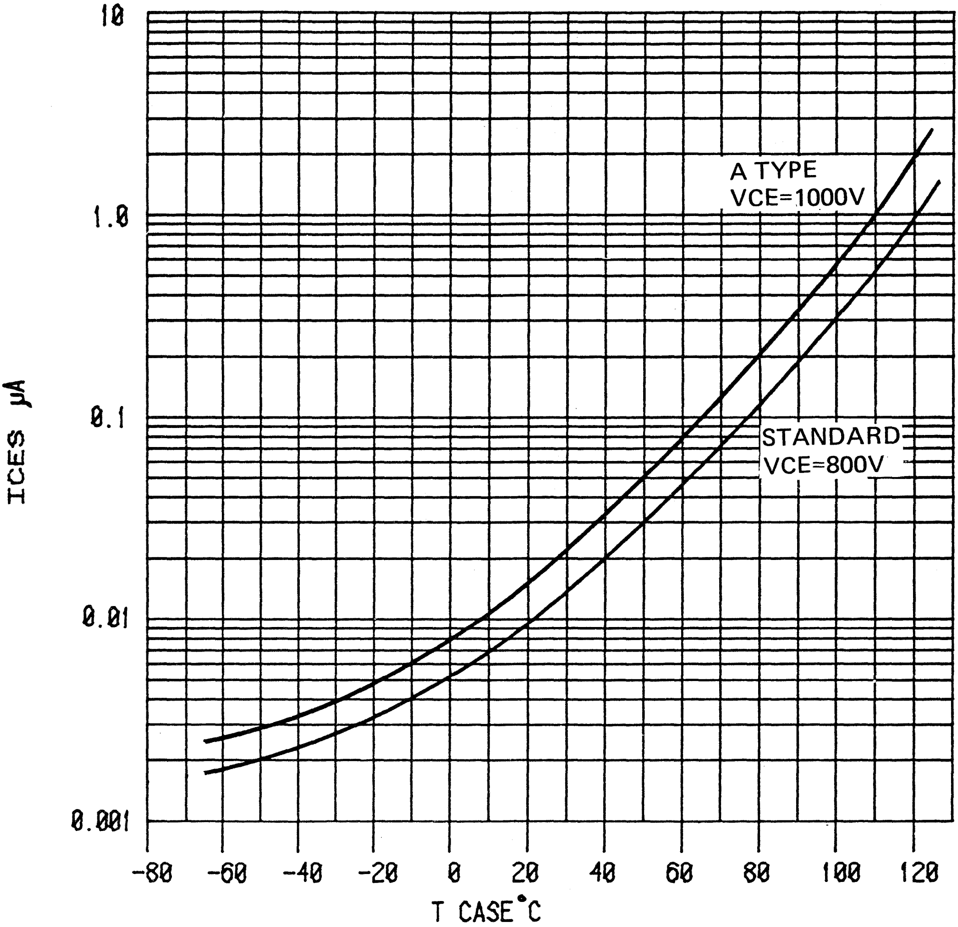


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

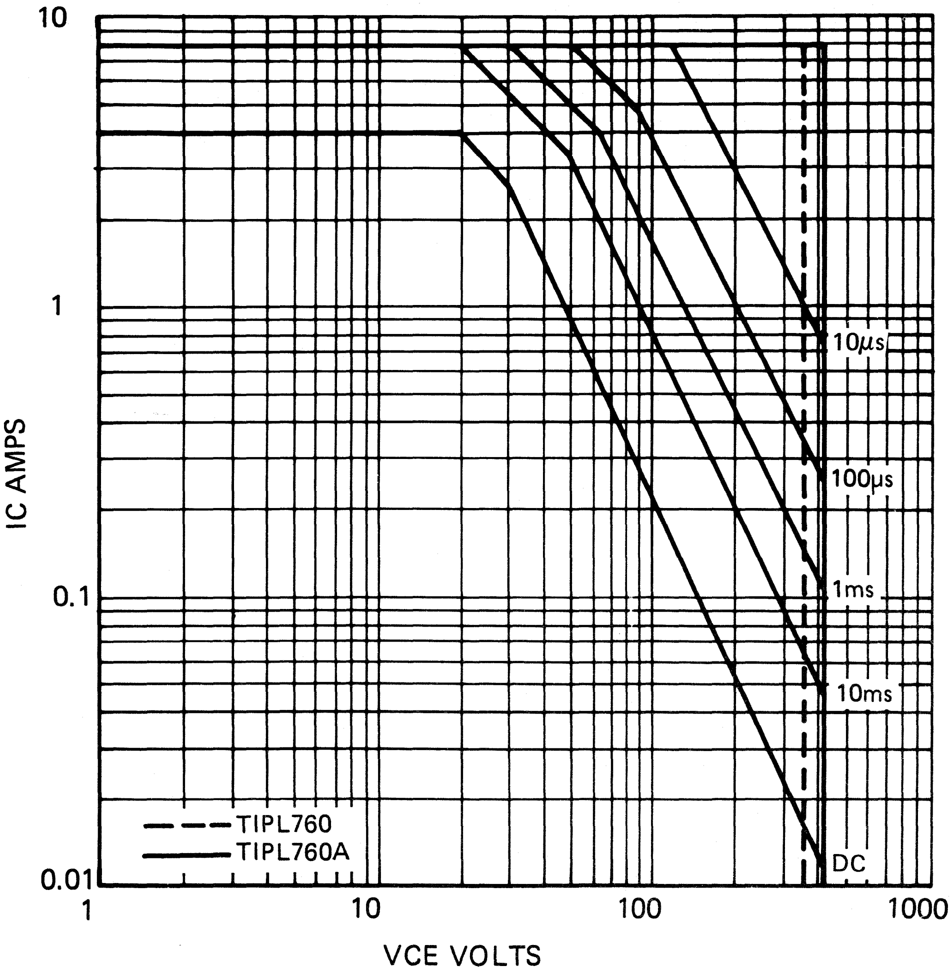


FIGURE. 12 THERMAL RESPONSE FOR TIPL760/A

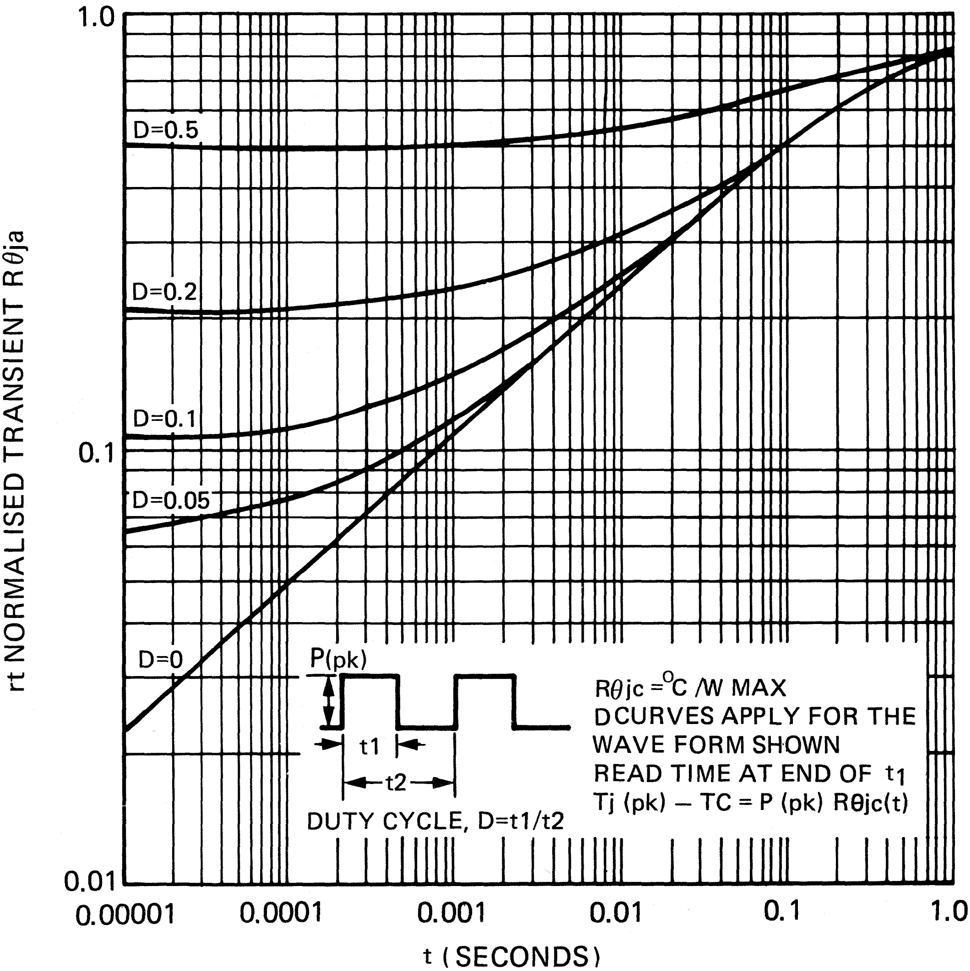


FIGURE. 13 FORWARD BIASED SAFE AREA OF OEPRATION DC & PULSED T CASE=25°C

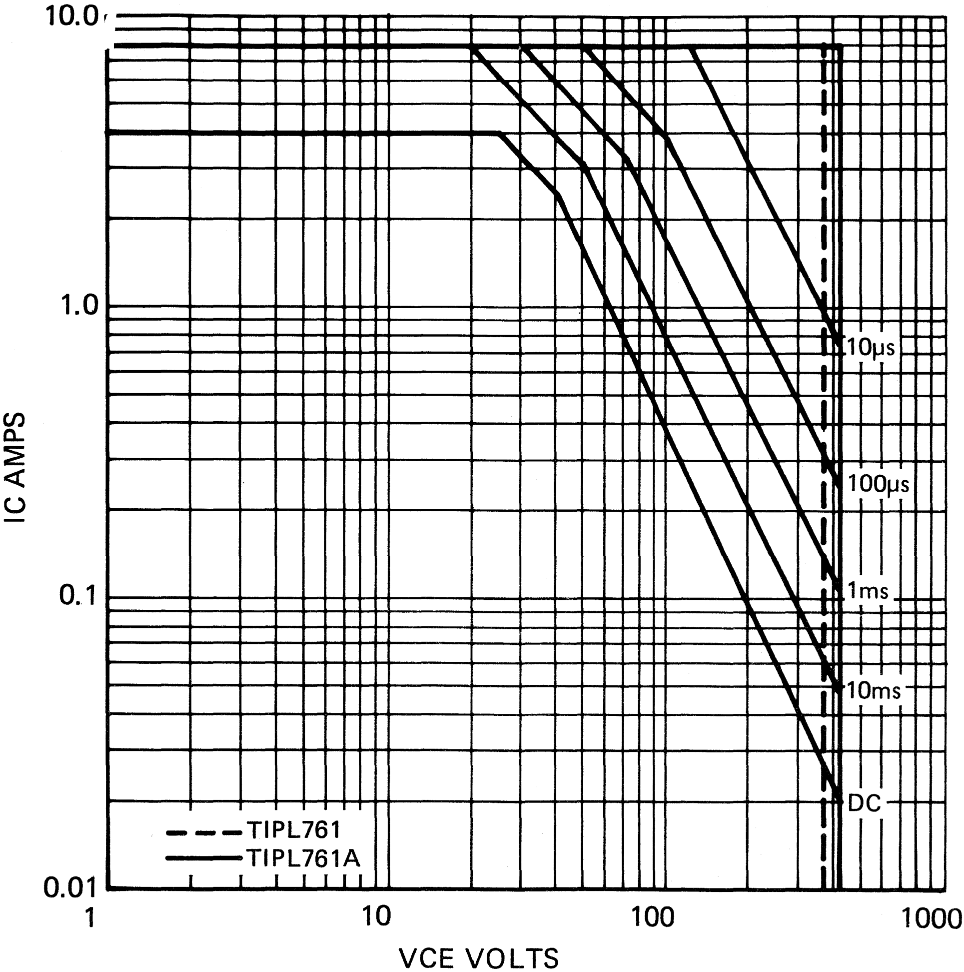


FIGURE. 14 THERMAL RESPONSE FOR TIPL761/A

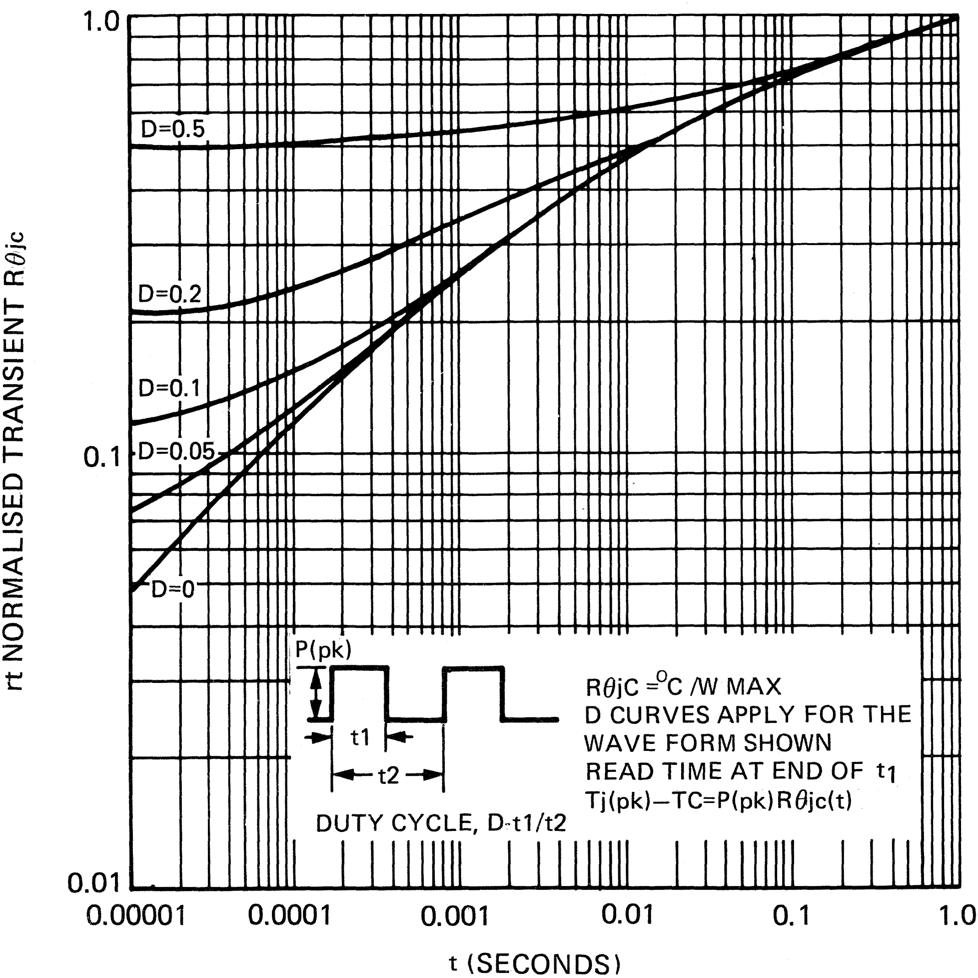


FIGURE. 15 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

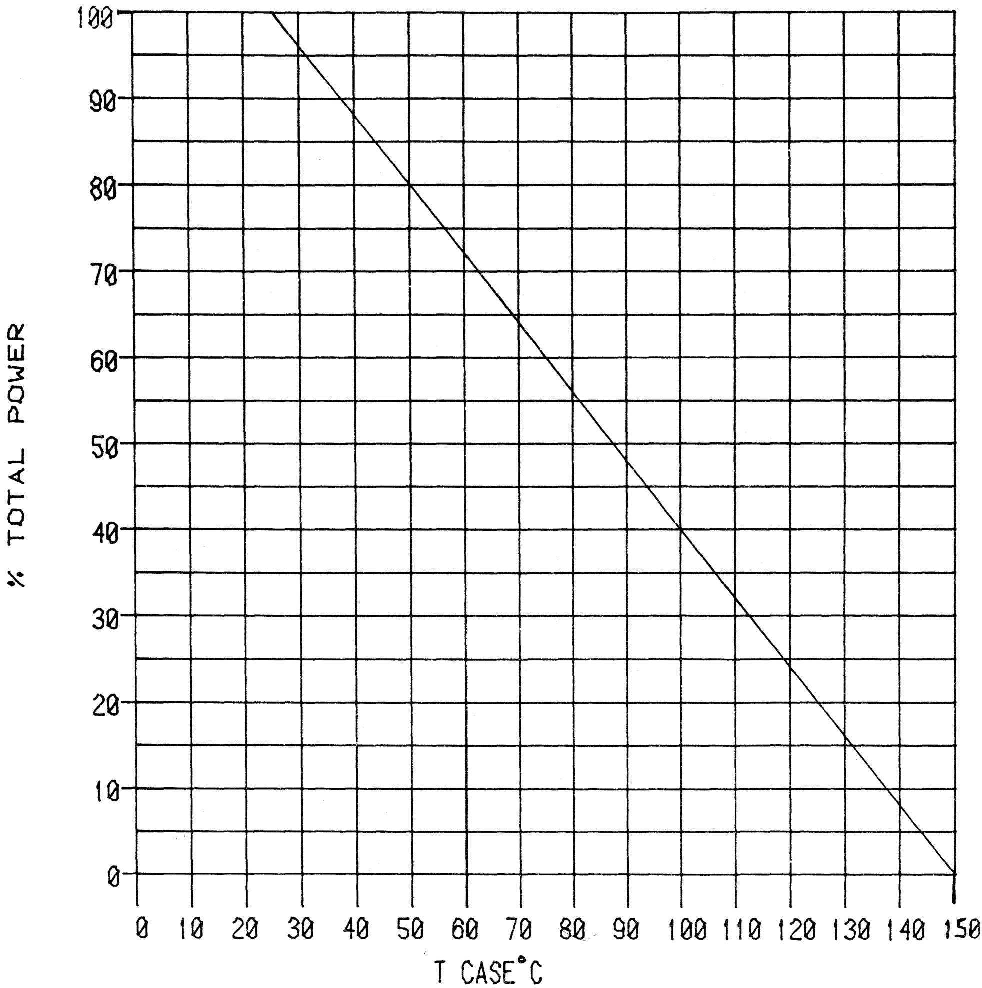


FIGURE. 16 TRANSIENT "TURN-OFF" LIMIT IC VsVCE TC≤100°C

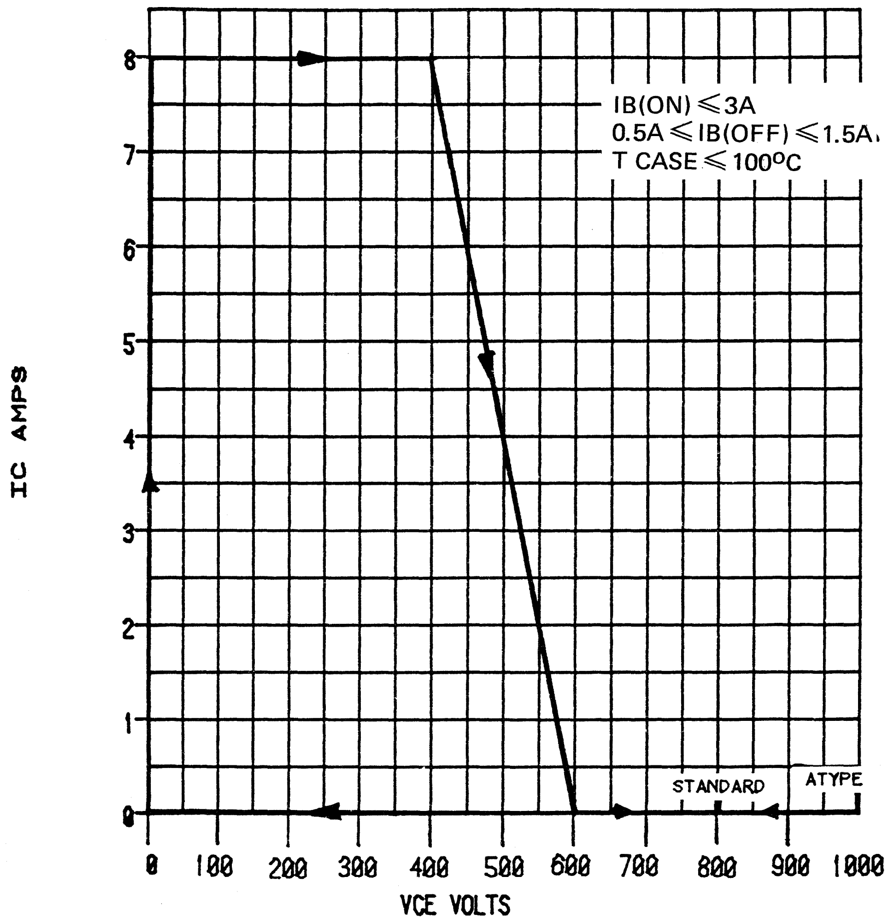
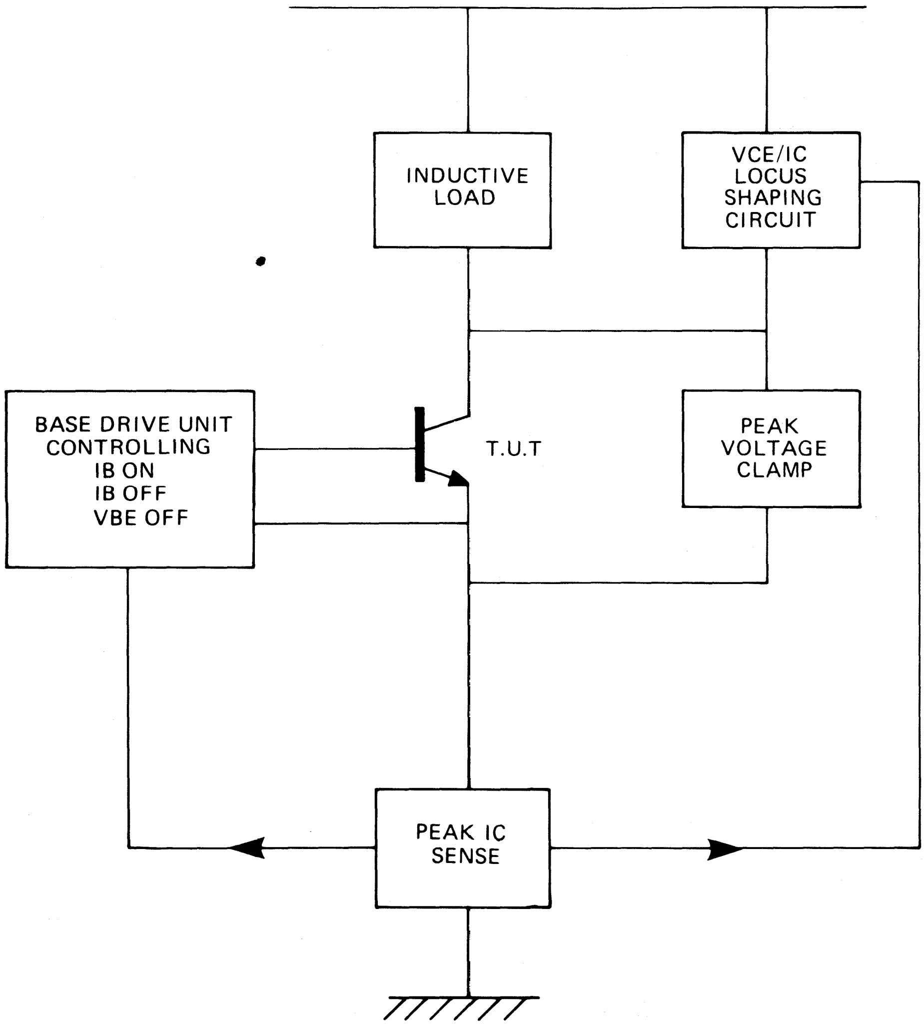


FIGURE. 17 SWITCHING LOCUS TEST CIRCUIT



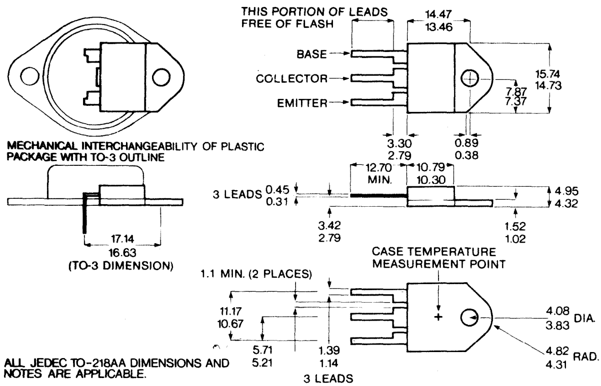
TIPL762, TIPL762A
NPN SILICON POWER TRANSISTOR

OCT 82

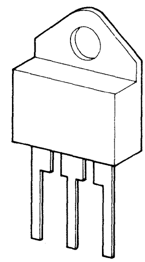
- Rugged Triple-Diffused Planar Construction.
- Specifically designed for High Voltage, Inductive Load Switching Applications.
- Operating characteristics fully guaranteed at 100°C.
- Transient Power Dissipation guaranteed at 100°C.
- ICES better than 100μA at maximum rated VCE at 100°C.
- 1000 volt blocking capability.
- VCEO(sust) 400V min TIPL762A – 350V Min TIPL762.

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL762	TIPL762A
Collector-Base Voltage (IE=0)	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	350V	400V
Base-Emitter Voltage	10V	
Continuous Collector Current	6A	
Peak Collector Current (Note 1)	12A	
Continuous Dissipation (Fig. 13)	120W	
Operating Junction & Storage Temperature	-65°C – +150°C	

NOTE 1: Pulse Test, Pulse Duration ≤ 10ms, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		TIPL762 TIPL762A	350 400			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=350V VCE=400V		TIPL762 TIPL762A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL762 TIPL762A TIPL762 TIPL762A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 1 & 3	IC=2A IC=4A IC=6A IC=6A	IB=0.4A IB=0.8A IB=1.2A IB=1.2A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 1 & 3	IC=2A IC=4A IC=6A IC=6A	IB=0.4A IB=0.8A IB=1.2A IB=1.2A	 100°C			1.1 1.3 1.5 1.4	V V V V
hFE	Forward Current Transfer Ratio Notes 1 & 3	VCE=5V	IC=500mA		15		60	
ft	Forward Current Band-Width Product	IC=500mA F=1MHz	VCE=10V	DC		7.0		MHz
Cob	Output Capitance	VCB=20V IE=0A	F=0. 1MHz			105		pF
R0jc	Thermal Resistance Junction-Case						1.25	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

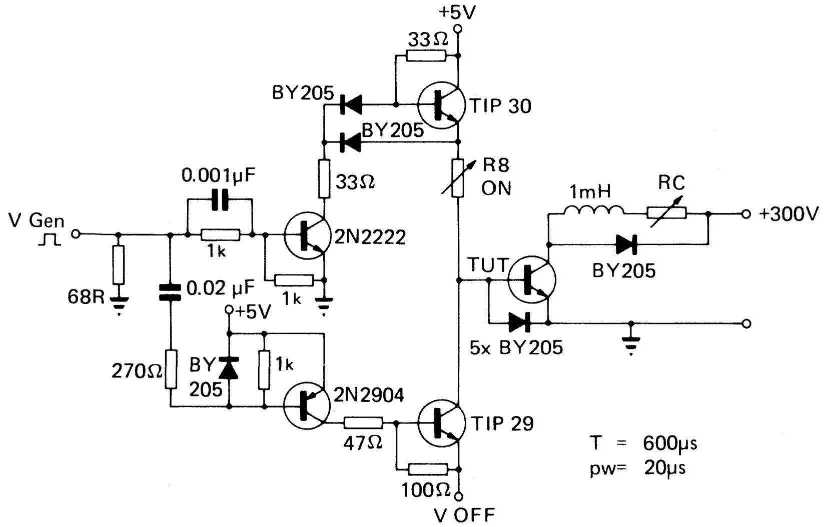
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
ton ts tf	Turn On Time Storage Time Fall Time	IC=6A VCC=100V IBon=1.2A IBoff=1.2A T Case=25°C			1.00 2.50 0.45	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time	IC=6A VCC=100V IBon=1.2A IBoff=1.2A T Case=100°C			2.50 3.00 1.00	μs μs μs
INDUCTIVE LOAD						
tsv trv tfi ttl txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Crossover Time Figures 1 & 2	IC=6A IBon=1.2A VBEoff= -10V T Case=25°C			2.50 200 150 50 300	μs ns ns ns ns
tsv trv tfi tti txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Crossover Time Figures 1 & 2	IC=6A IBon=1.2A VBEoff=-10V T Case=100°C			3.00 300 150 50 500	μs ns ns ns ns

NOTE 1. These parameters are measured using pulse techniques Pulse Width ≤ 300μs, Duty Cycle ≤ 2%

NOTE 2. Inductive Loop Switching Measurement

NOTE 3. These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



ADJUST RC FOR REQUIRED IC

Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

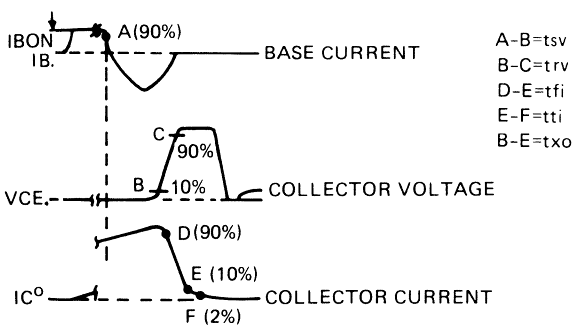
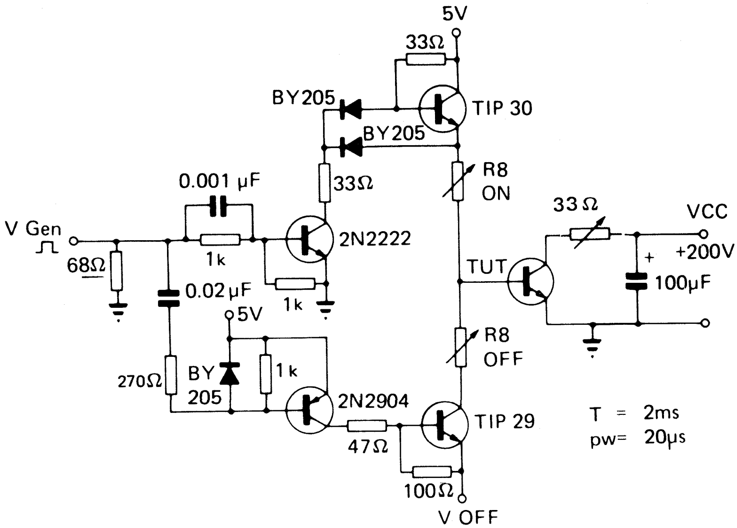


FIGURE 3 RESISTIVE SWITCHING CIRCUIT

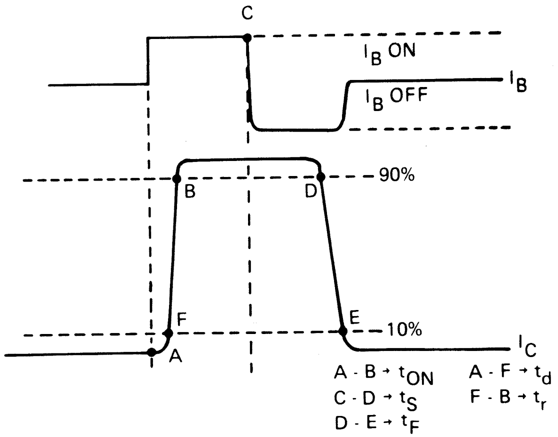


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

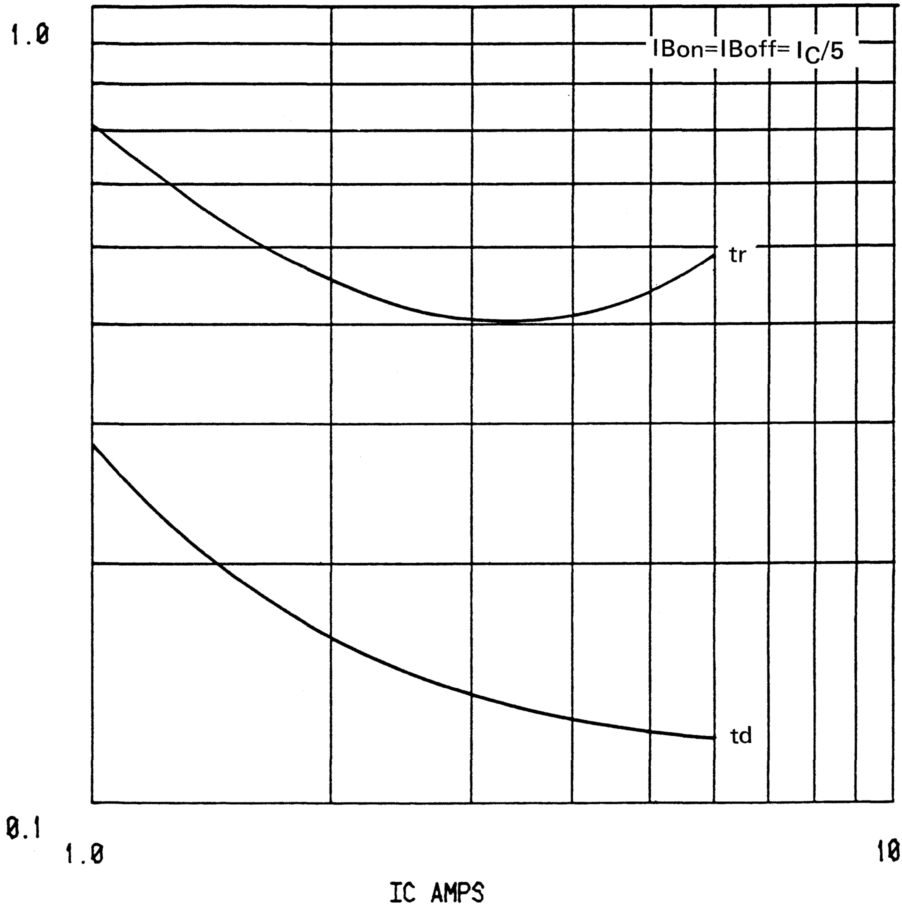
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



SISTIVE SWITCHING PARAMETERS
;URE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

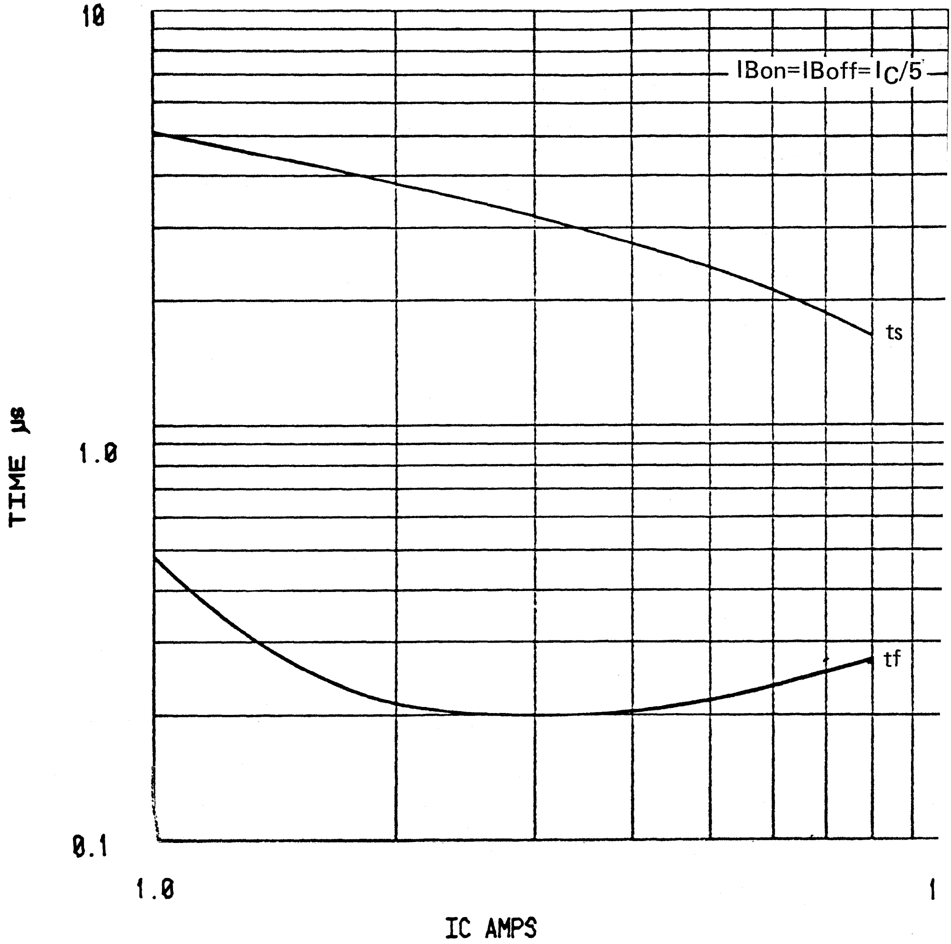


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

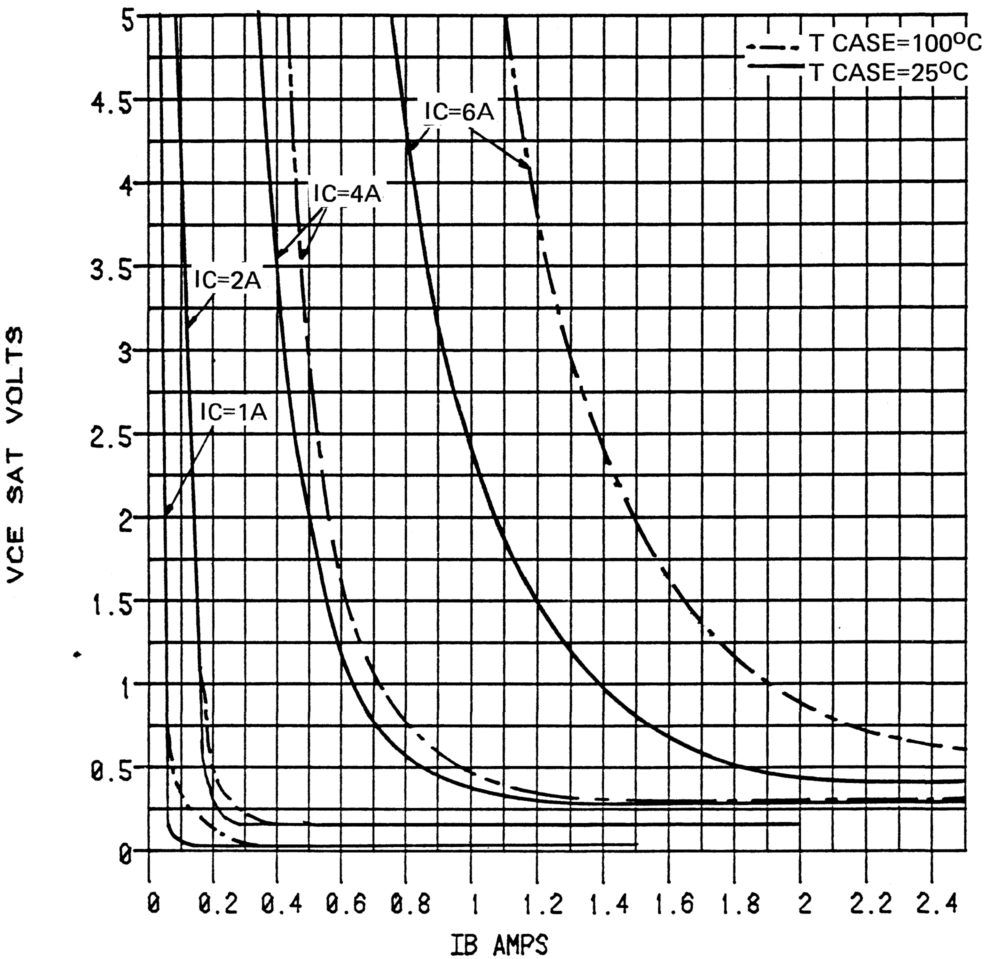


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

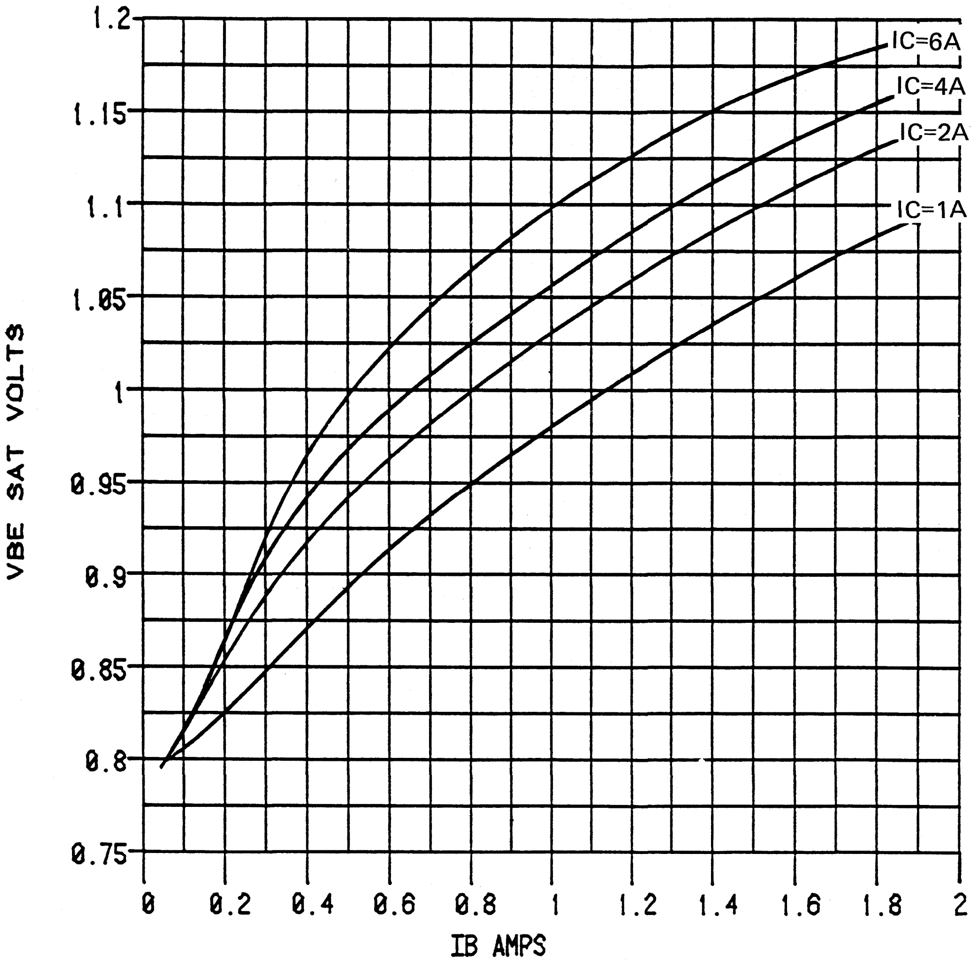


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

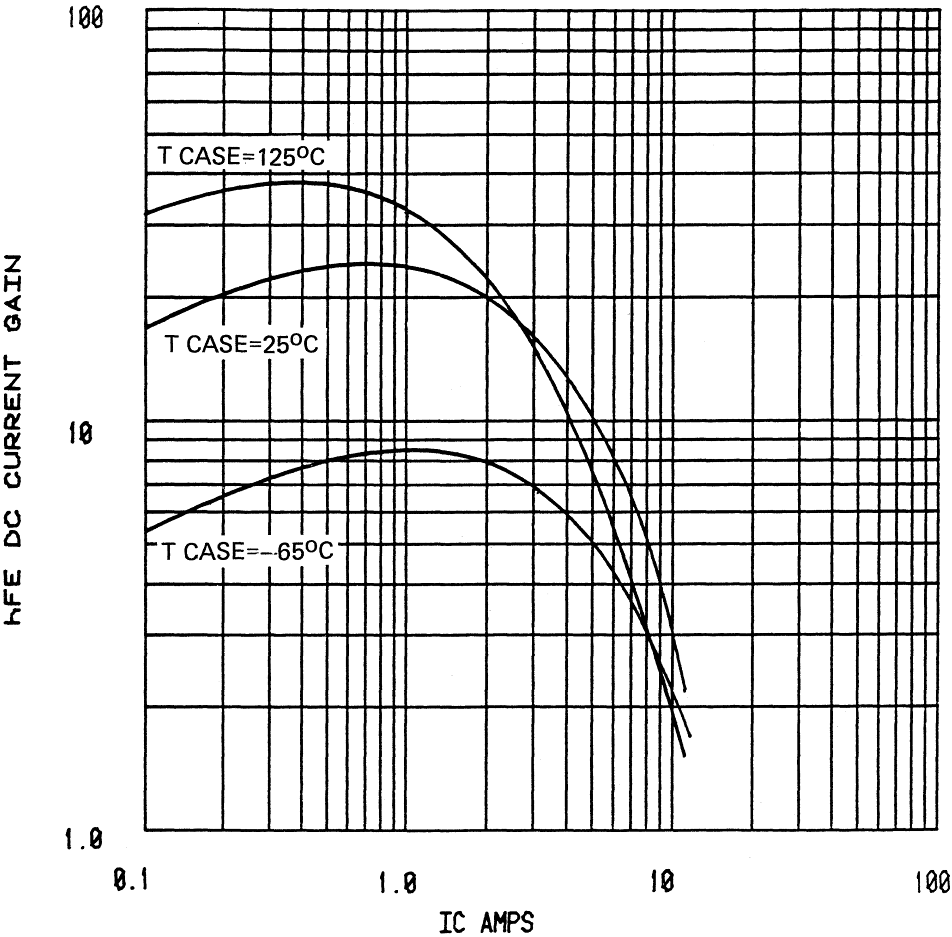


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

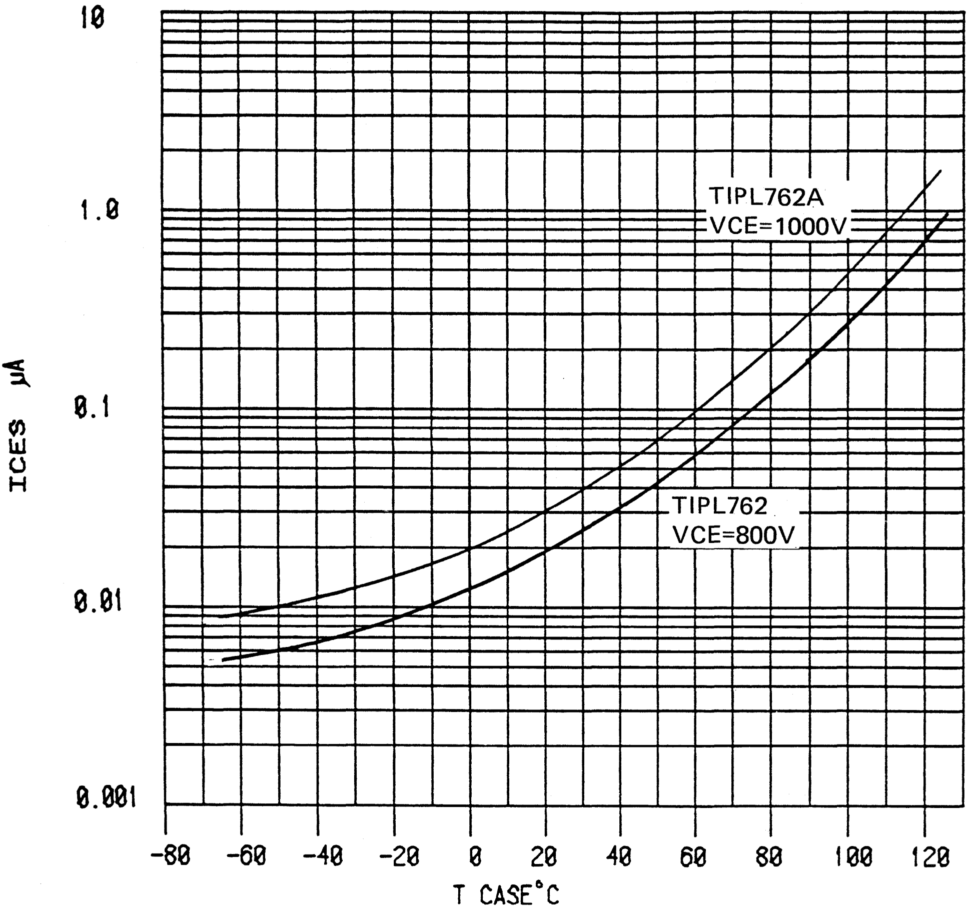


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

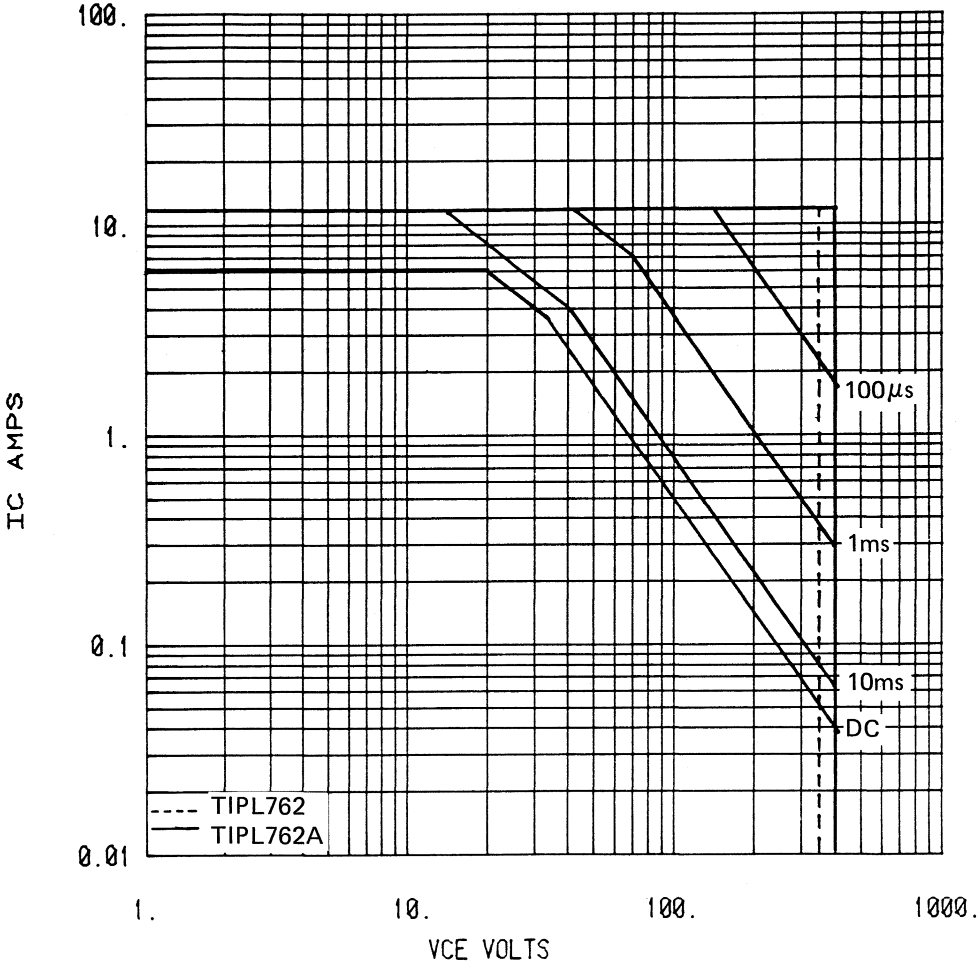


FIGURE. 12 THERMAL RESPONSE

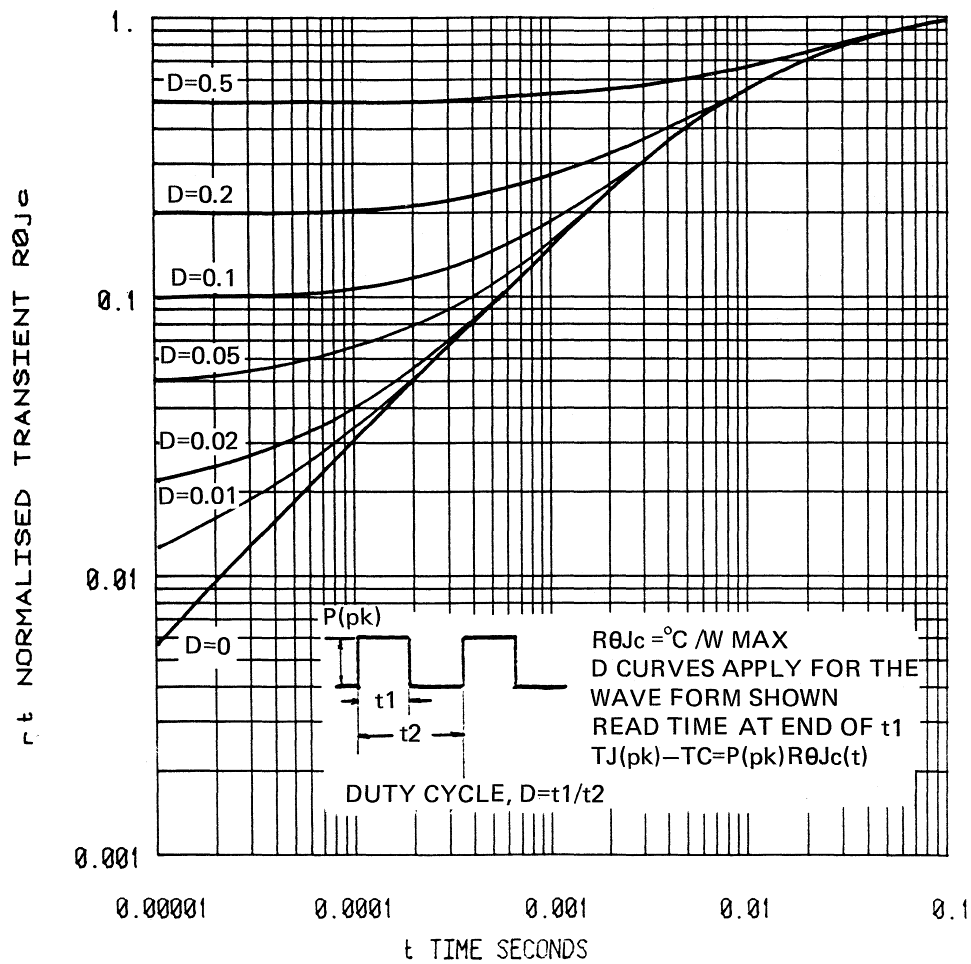


FIGURE. 13 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

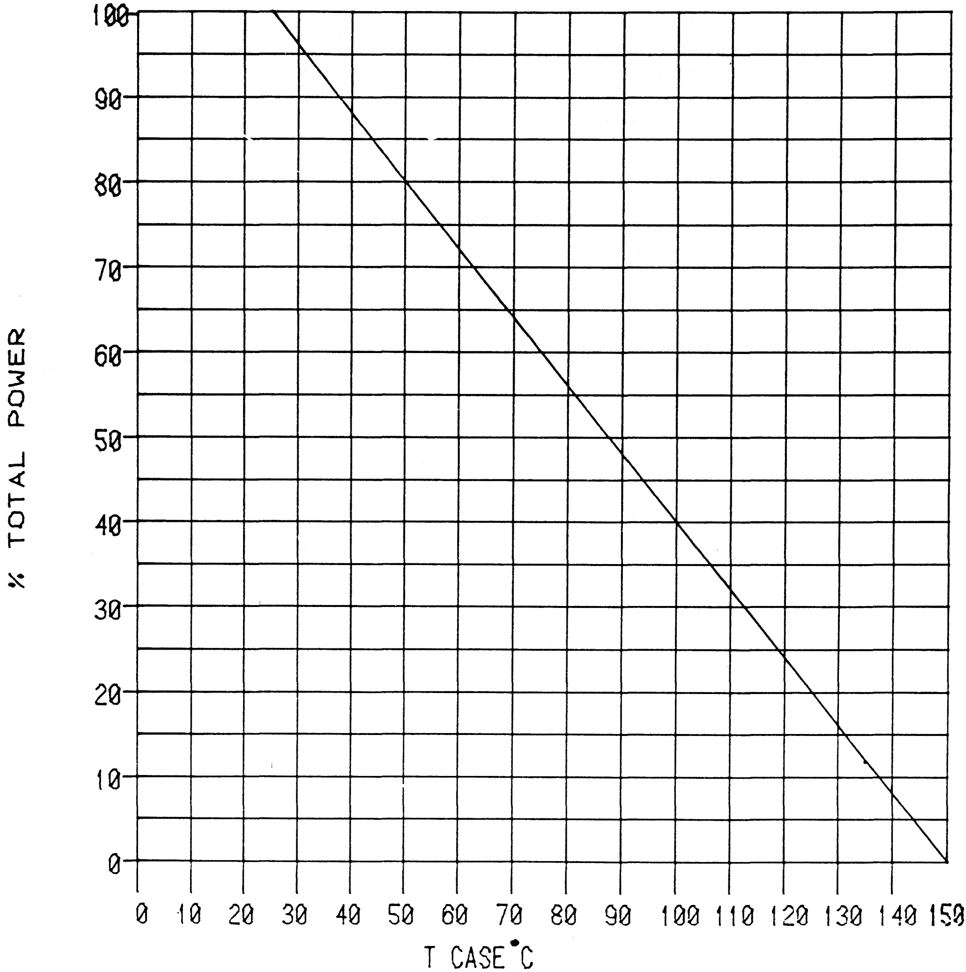


FIGURE. 14 TRANSIENT "TURN OFF" LIMIT IC VS VCE

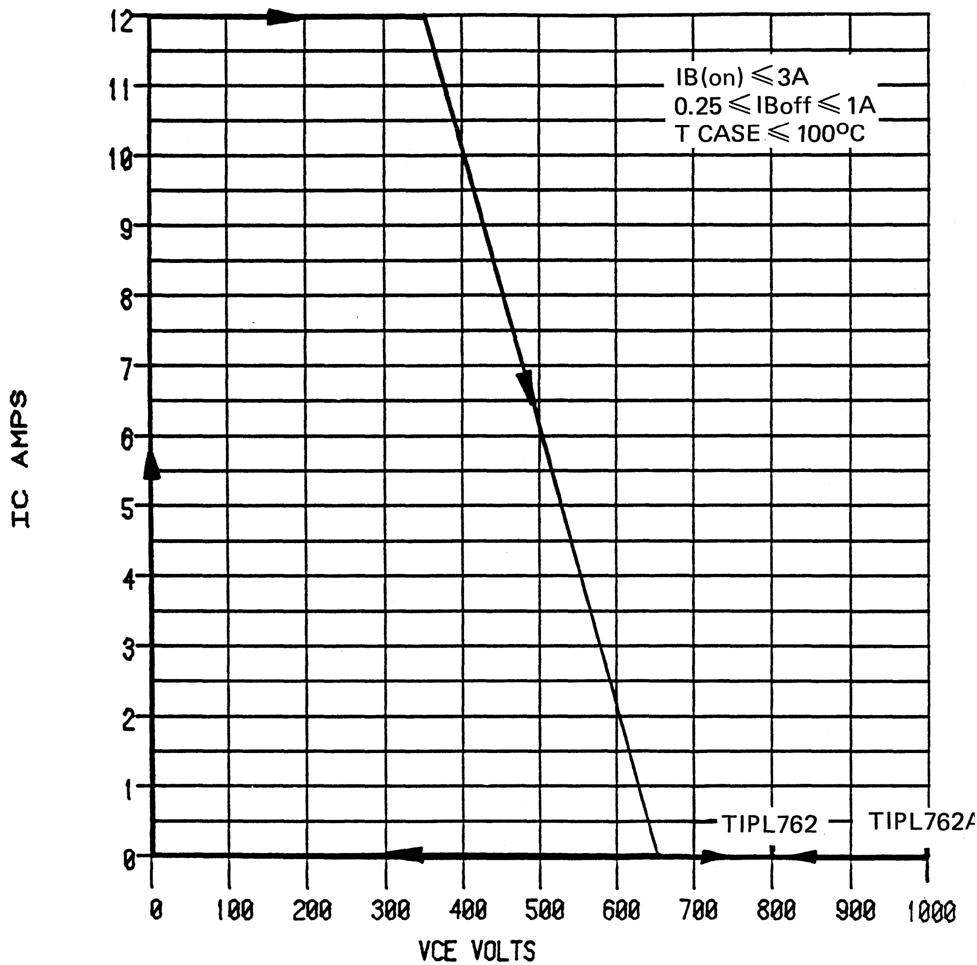
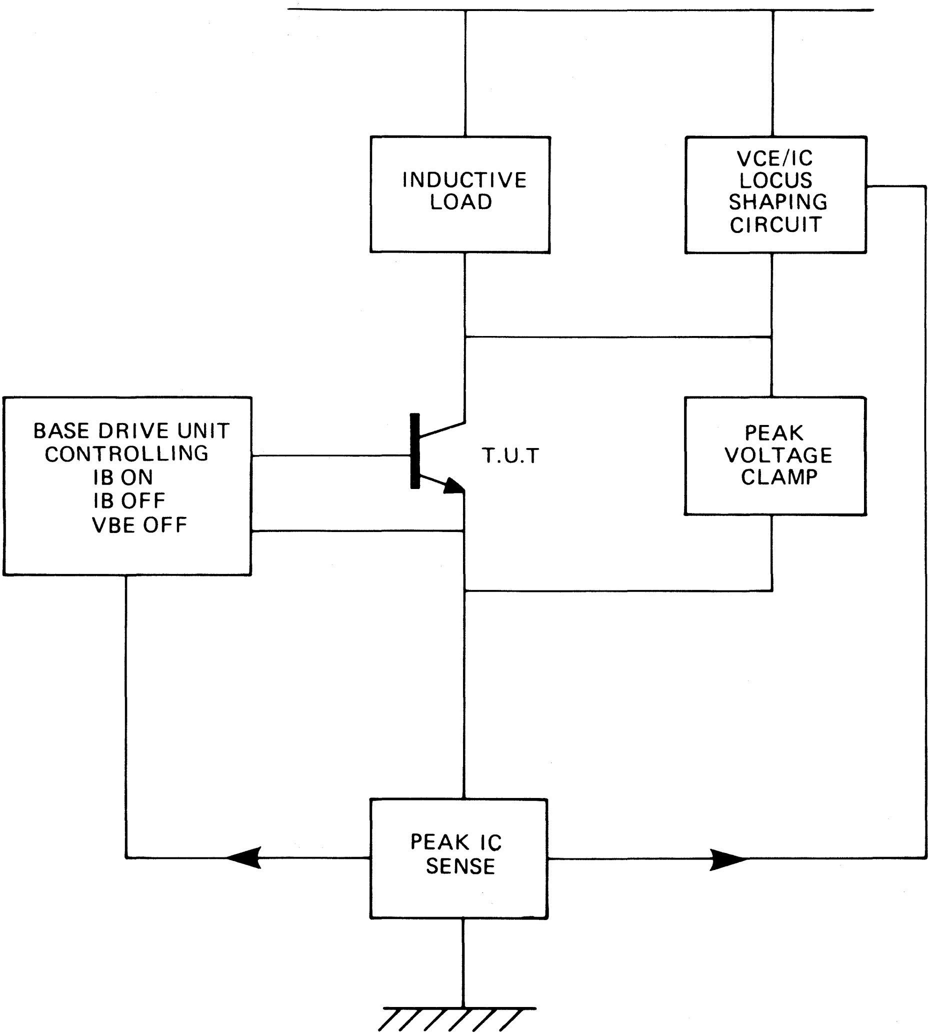


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



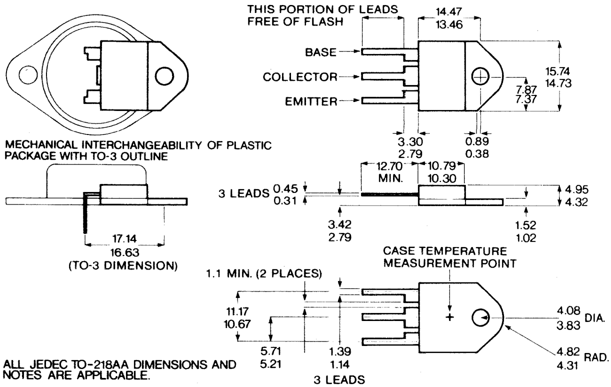
PRELIMINARY
DATA
OCT 82

TIPL763, TIPL763A
NPN SILICON POWER TRANSISTOR

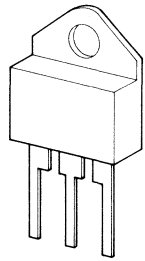
- Rugged Triple-Diffused Planar Construction.
- Specifically designed for High Voltage, Inductive Load Switching Applications.
- Operating characteristics fully guaranteed at 100°C.
- Transient Power Dissipation guaranteed at 100°C.
- ICES better than 100μA at maximum rated VCE at 100°C.
- 1000 volt blocking capability.
- VCEO(sust) 400V min TIPL763A – 350V min TIPL763.

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL763	TIPL763A
Collector-Base Voltage (IE=0)	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	350V	400V
Base-Emitter Voltage	10V	
Continuous Collector Current	8A	
Peak Collector Current (Note 1)	14A	
Continuous Dissipation (Fig. 13)	120W	
Operating Junction & Storage Temperature	-65°C – +150°C	

NOTE 1: Pulse Test, Pulse Duration ≤ 10ms, Duty Cycle ≤ 2%

TEXAS INSTRUMENTS

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO SUST	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		TIPL763 TIPL763A	350 400			V
ICEO	Collector Cut-Off Current (Open Base)	VCE=350V VCE=400V		TIPL763 TIPL763A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL763 TIPL763A TIPL763 TIPL763A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Note 1 & 3	IC=2A IC=5A IC=8A IC=8A	IB=0.4A IB=1.0A IB=1.6A IB=1.6A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Note 1 & 3	IC=2A IC=5A IC=8A IC=8A	IB=0.4A IB=1.0A IB=1.6A IB=1.6A	 100°C			1.1 1.3 1.6 1.5	V V V V
hFE	Forward Current Transfer Ratio Note 1 & 3	VCE=5V	IC=500mA		15		60	
ft	Forward Current Band-Width Product	IC=500mA F=1MHz	VCE=10V	DC		8.0		MHz
Cob	Output Capitance	VCB=20V IE=0A	 F=0.1MHz			150		pF
R0jc	Thermal Resistance Junction-Case						1.0	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

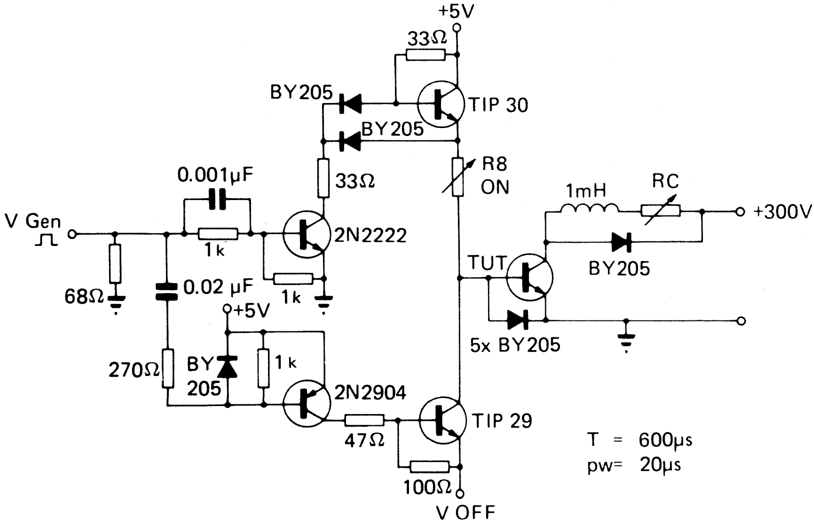
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
RESISTIVE LOAD							
ton ts tf	Turn On Time Storage Time Fall Time Figures 3–6	IC=8A IBon=1.6A T Case=25°C	VCC=200V IBoff=1.6A			0.80 2.50 0.45	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time Figures 3–6	IC=8A IBon=1.6A T Case=100°C	VCC=200V IBoff=1.6A			1.40 3.00 1.00	μs μs μs
INDUCTIVE LOAD							
tsv trv tfi tti txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Cross Over Time Figures 1 & 2	IC=8A IBon=1.6A VBEoff=10V T Case=25°C				2.50 200 150 50 300	μs ns ns ns ns
tsv trv tfi tti txo	Voltage Storage Time Voltage Rise Time Current Fall Time Current Tail Time Crossover Time Figures 1 & 2	IC=8A IBon=1.6A VBEoff=10V T Case=100°C				3.00 300 150 50 500	μs ns ns ns ns

NOTE 1. These parameters are measured using pulse techniques Pulse Width=300 μs, Duty Cycle≤2%.

NOTE 2. Inductive Loop Switching Measurement.

NOTE 3. These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body.

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



ADJUST RC FOR REQUIRED IC

Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

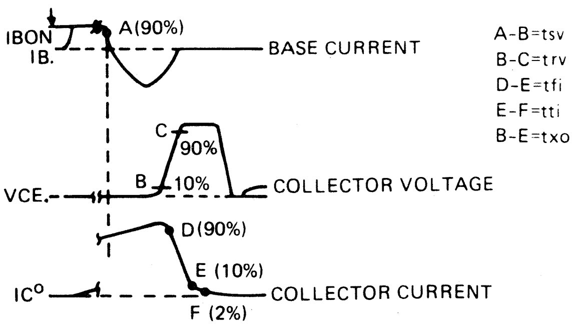
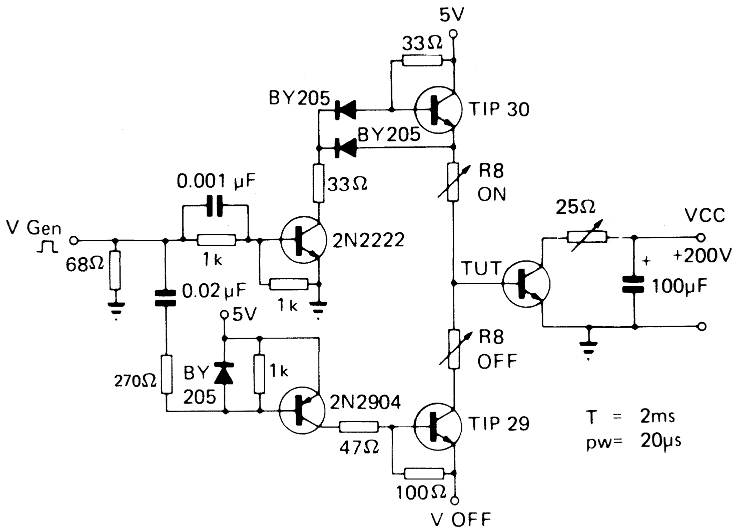


FIGURE 3 RESISTIVE SWITCHING CIRCUIT

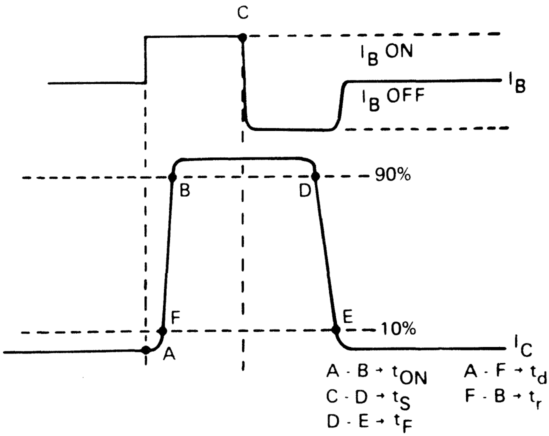


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

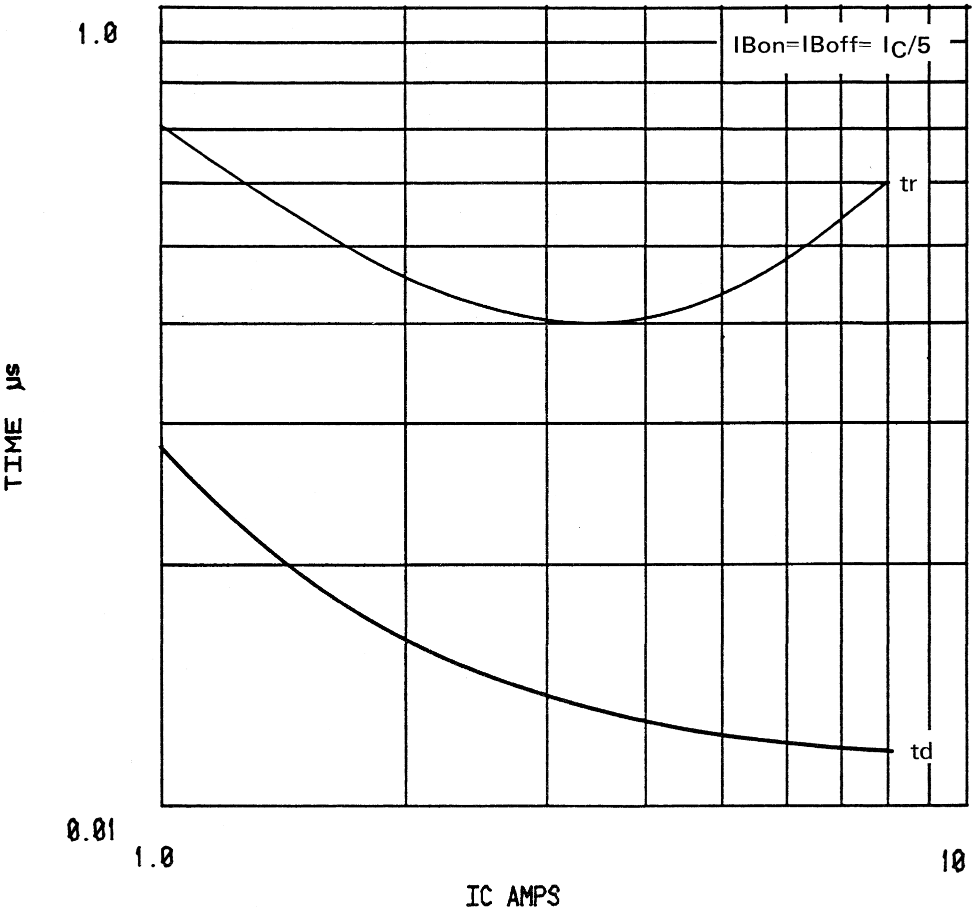
C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS

FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

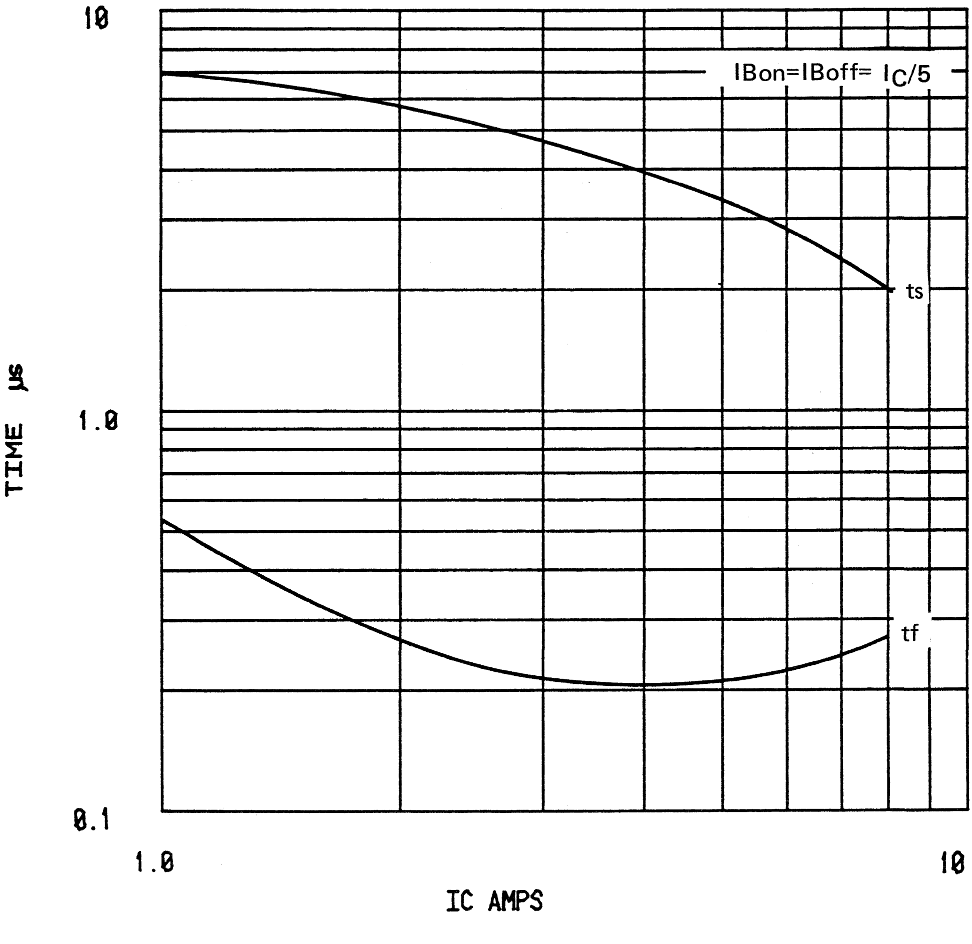


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

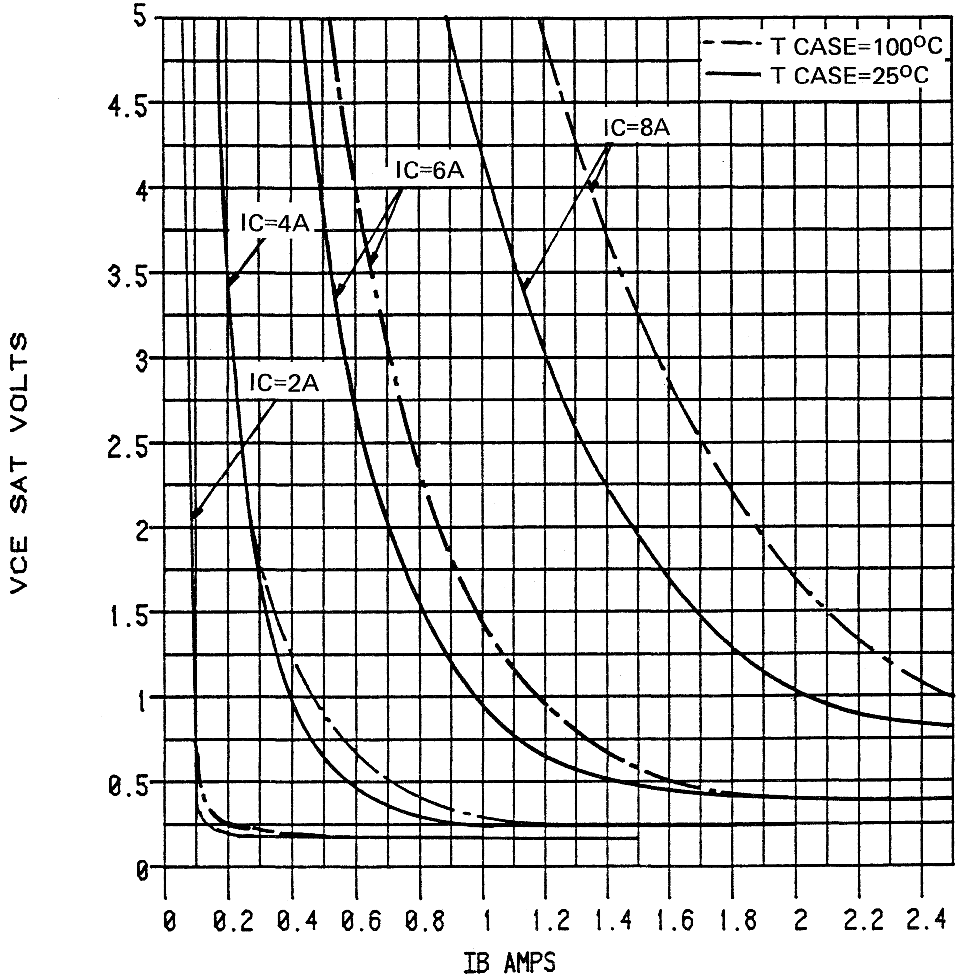


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

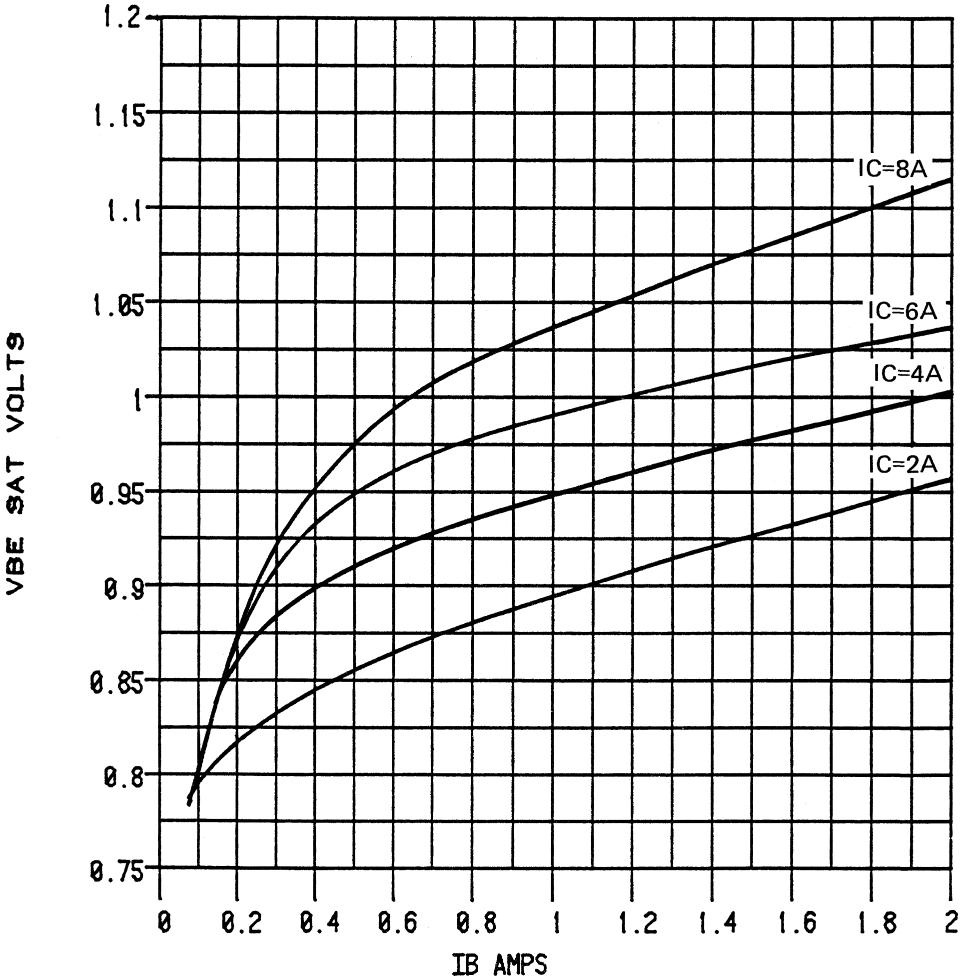


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

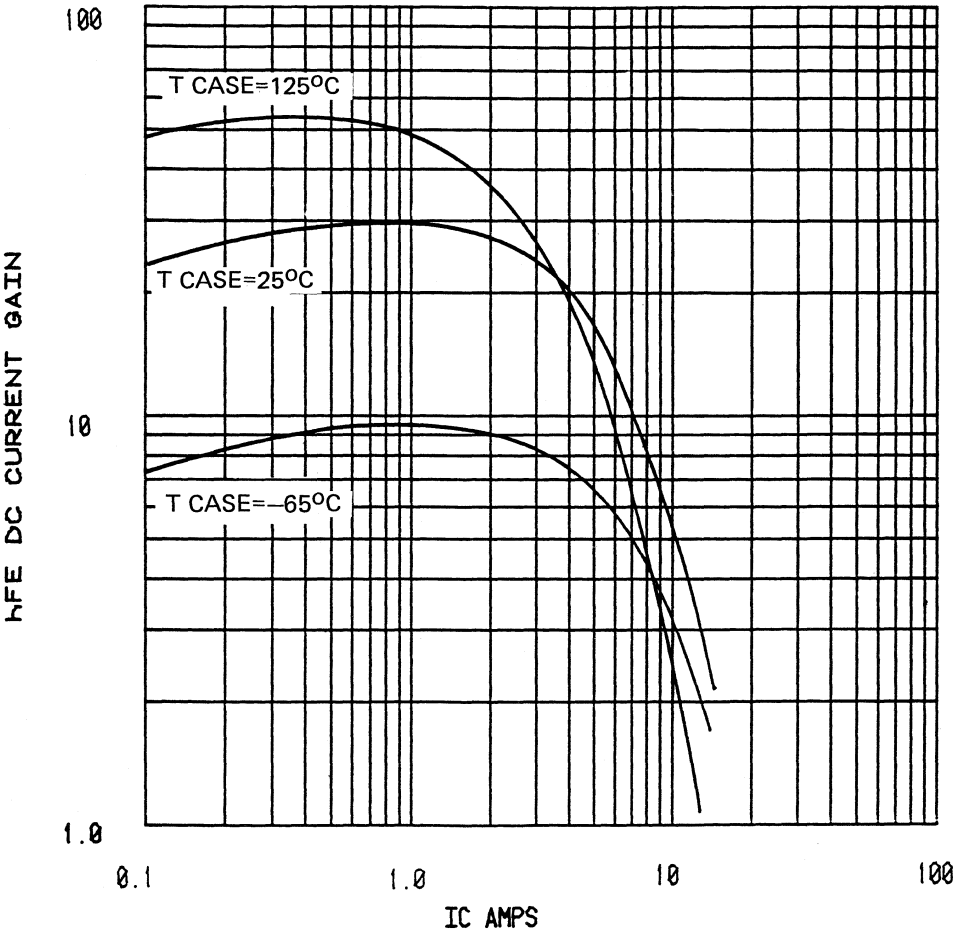


FIGURE. 10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

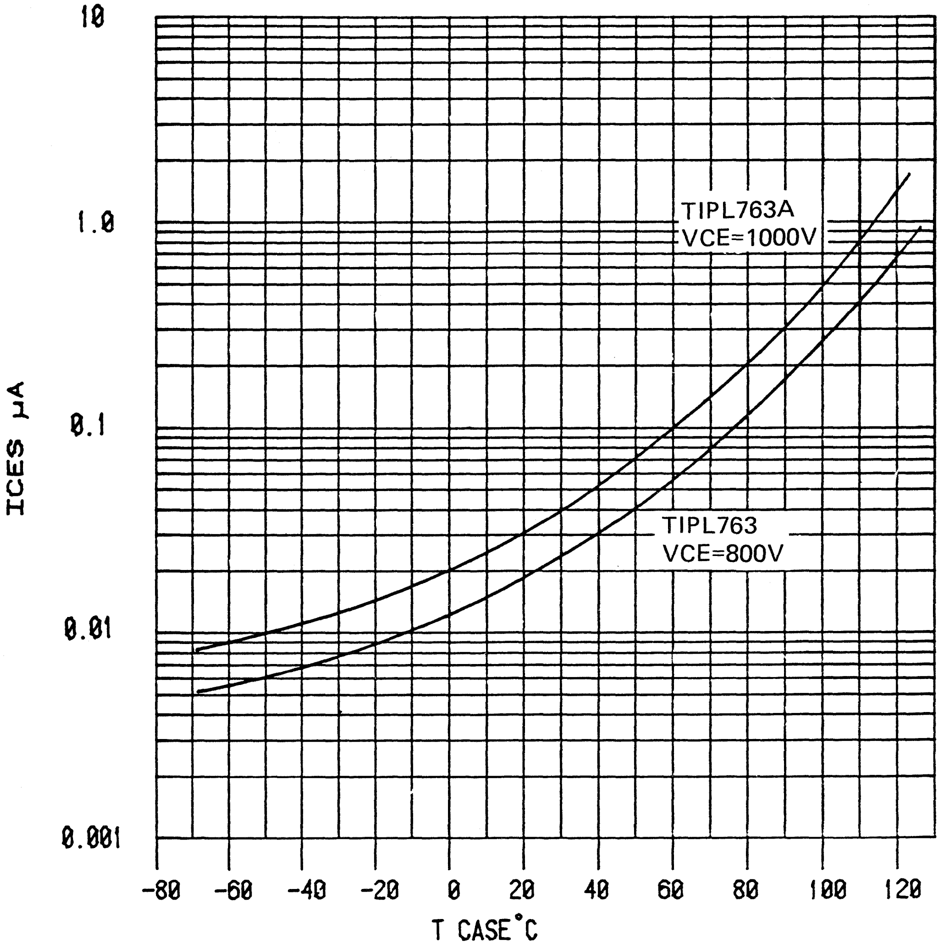


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

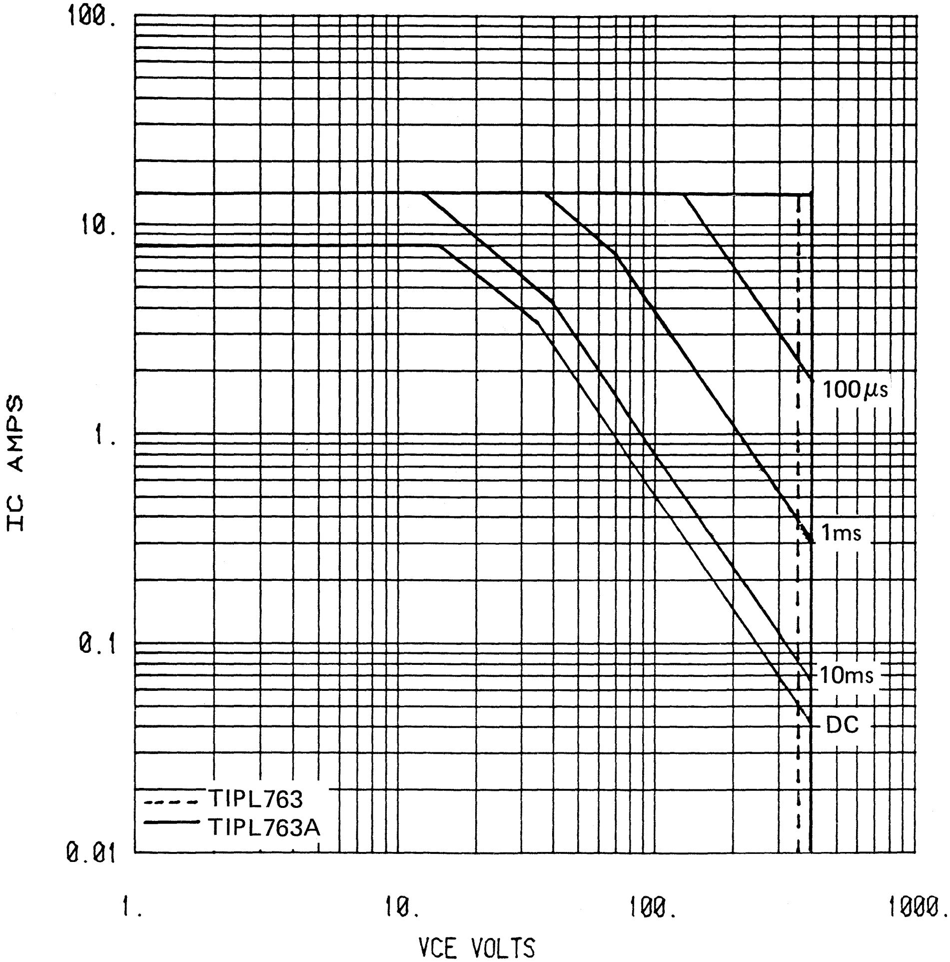


FIGURE. 12 THERMAL RESPONSE

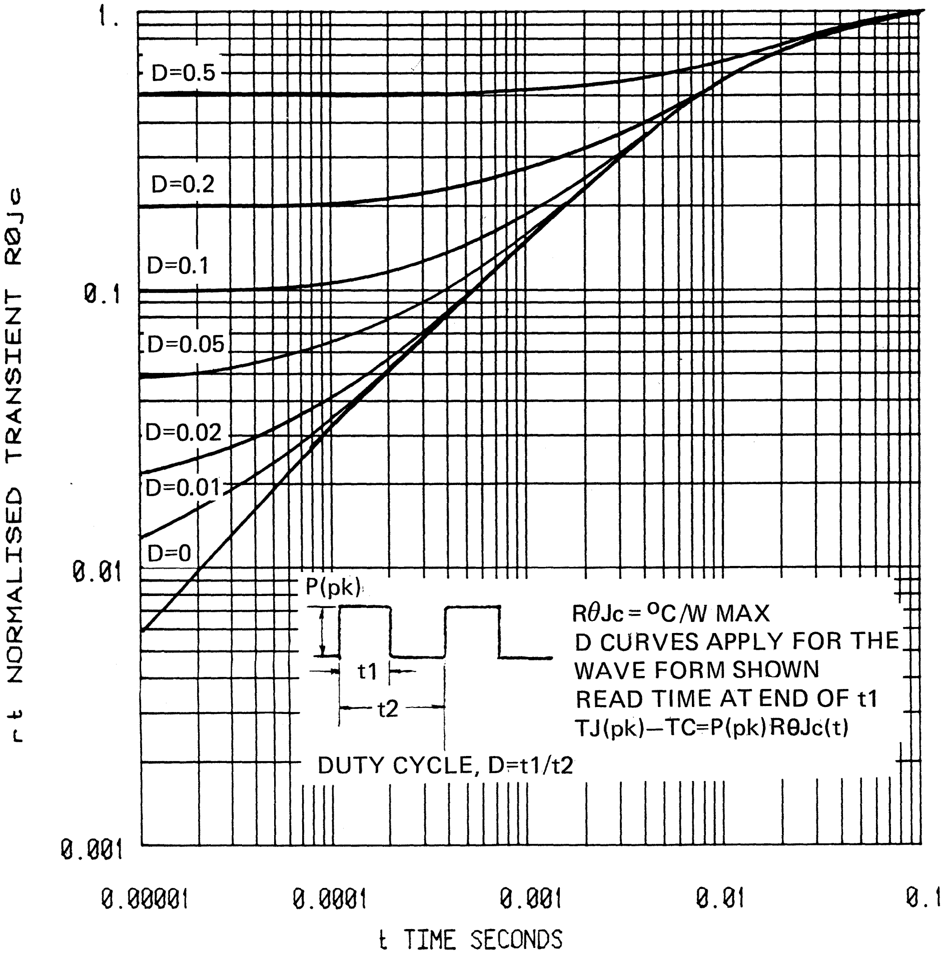


FIGURE. 13 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

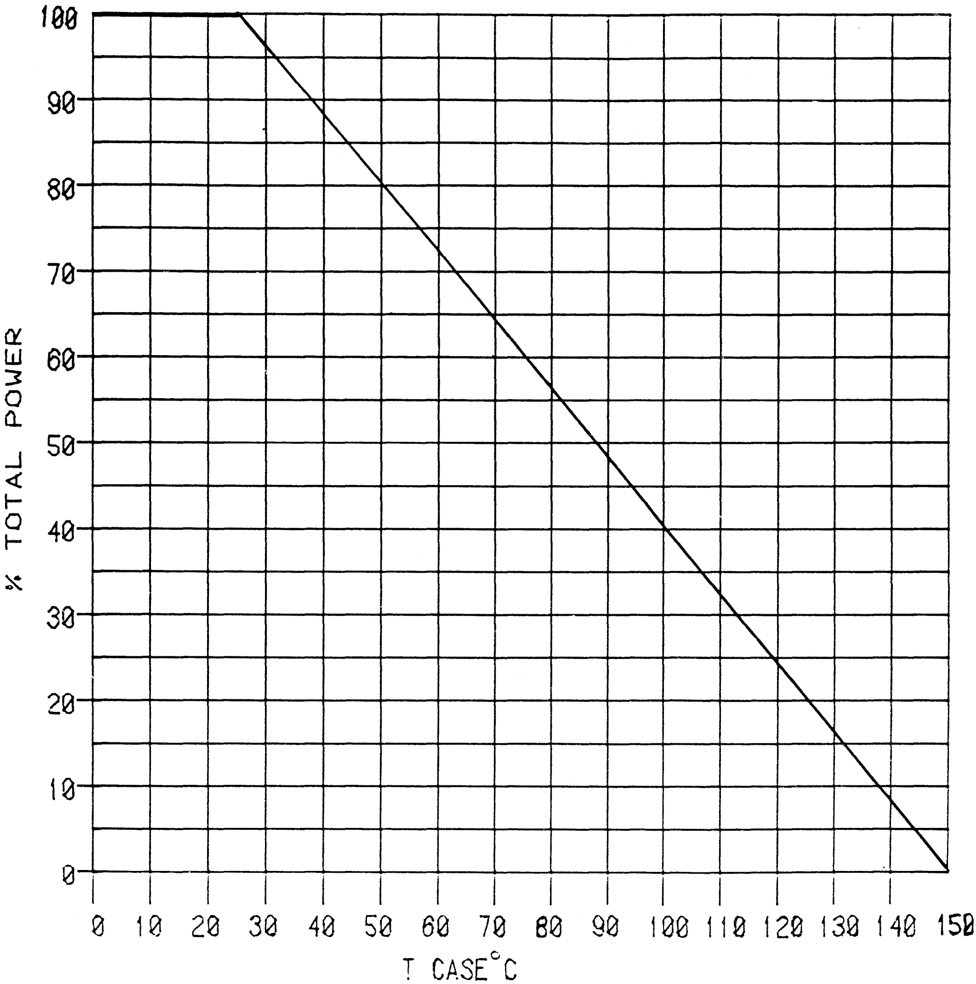


FIGURE. 14 TRANSIENT "TURN-OFF" LIMIT IC VS VCE

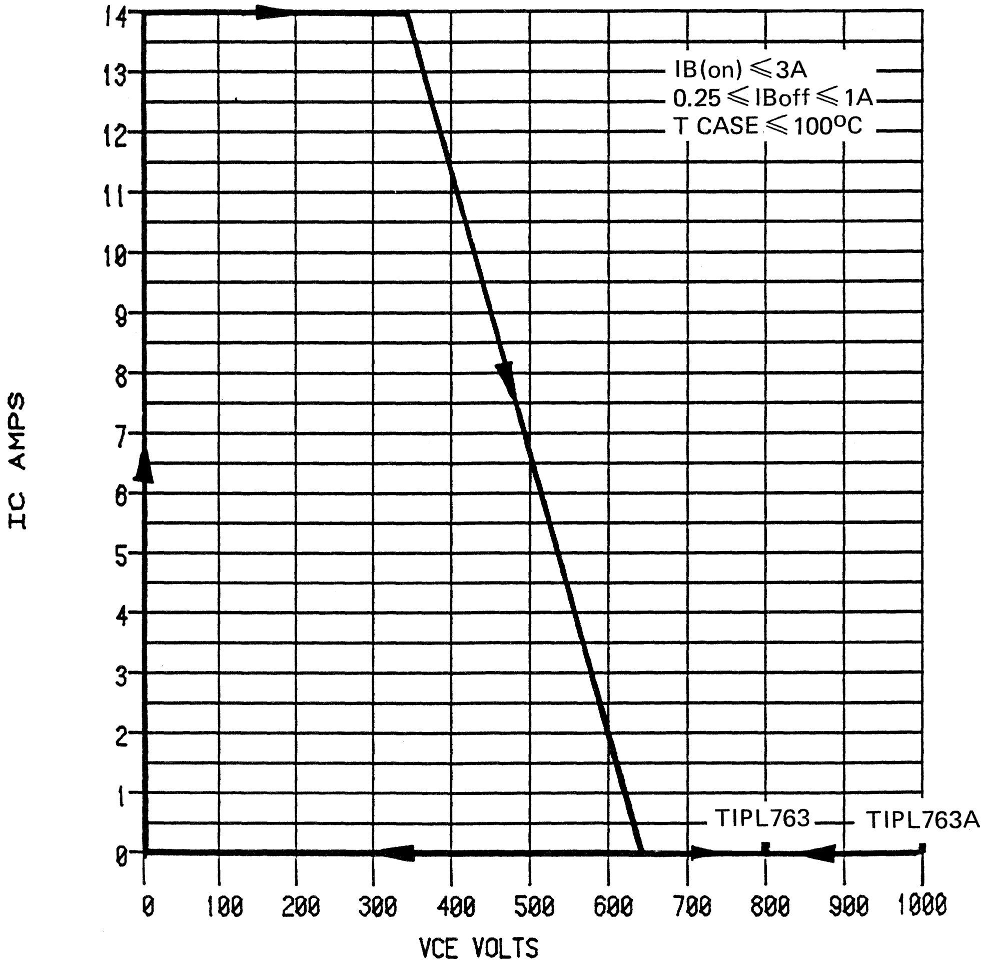
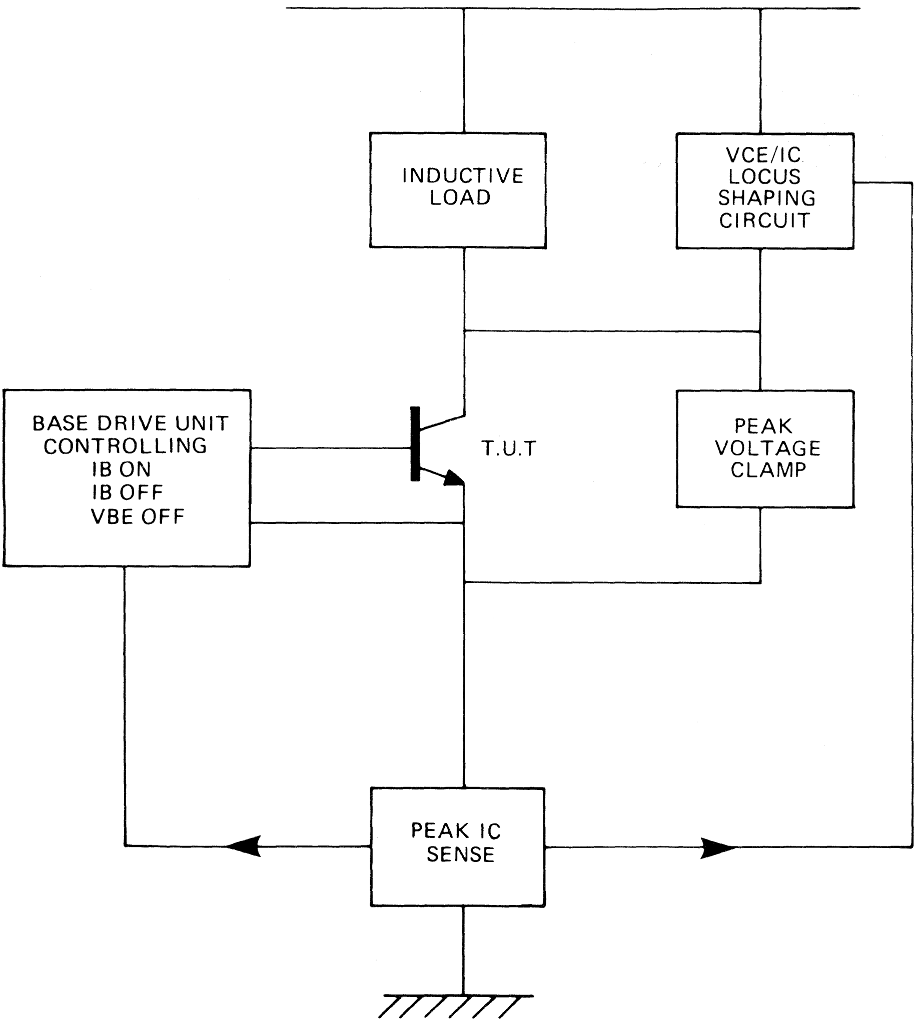


FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



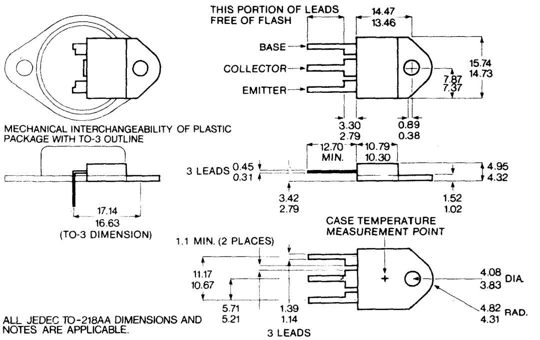
TIPL765, TIPL765A
NPN SILICON POWER TRANSISTOR

PRELIMINARY
DATA
OCT 82

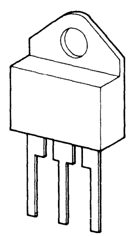
- RUGGED TRIPLE-DIFFUSED PLANAR CONSTRUCTION.
- SPECIFICALLY DESIGNED FOR HIGH VOLTAGE, INDUCTIVE LOAD SWITCHING APPLICATIONS.
- OPERATING CHARACTERISTICS FULLY GUARANTEED AT 100°C
- TRANSIENT POWER DISSIPATION GUARANTEED AT 100°C.
- ICES BETTER THAN 100μA AT MAXIMUM RATED VCE AT 100°C
- 1000 VOLT BLOCKING CAPABILITY.
- VCEO(sust) 420V MIN TIPL765A – 375V MIN TIPL765.

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL765	TIPL765A
Collector-Base Voltage	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	375V	420V
Base-Emitter Voltage	10V	
Continuous Collector Current	10A	
Peak Collector Current (Note 1)	15A	
Continuous Dissipation (Fig. 12)	125W	
Operating Junction & Storage Temperature	-65°C to + 150°C	

NOTE 1 : Pulse Test, Pulse Duration = 2ms, Duty Cycle = < 2%

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 3	IC=100mA L=25mH		TIPL765 TIPL765A	375 420			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=375V VCE=420V		TIPL765 TIPL765A			1 1	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 100°C 100°C	TIPL765 TIPL765A TIPL765 TIPL765A			1 1 100 100	μA μA μA μA
IEBO	Emitter Cut-Off Current	VEB=10V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 2 & 4	IC=2A IC=5A IC=10A IC=10A	IB=400mA IB=1A IB=2A IB=2A	 100°C			0.5 1.0 2.5 5.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 2 & 4	IC=2A IC=5A IC=10A IC=10A	IB=400mA IB=1A IB=2A IB=2A	 100°C			1.1 1.3 1.8 1.7	V V V V
hFE	Forward Current Transfer Ratio Notes 2 & 4	VCE=5V	IC=500mA		15		60	
ft	Current Gain Band-width Product	IC=500mA VCE=10V(dc)	F=1MHz Gain=Unity			10		MHz
Cob	Output Capacitance	VCB=20V IE=0A	 F=0. 1MHz			150		pF
Rθjc	Thermal Resistance Junction-Case						1.00	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

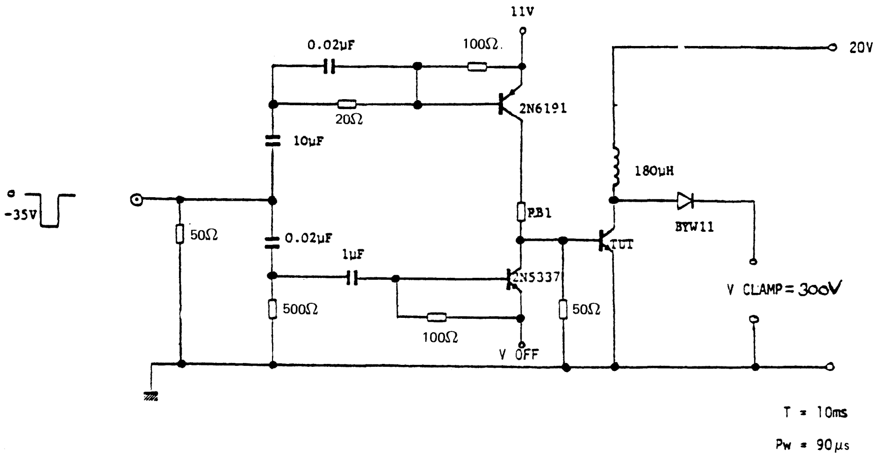
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
RESISTIVE LOAD							
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=10A IBon=2A T Case=25°C	VCC=250V IBoff=2.5A			0.75 2.00 0.50	μs μs μs
ton ts tf	Turn On Time Storage Time Fall Time Figure 3–6	IC=10A IBon=2A T Case=100°C	VCC=250V IBoff=2.5A			1.00 2.50 1.00	μs μs μs
INDUCTIVE LOAD							
tsv	Voltage Storage Time					3.00	μs
trv	Voltage Rise Time	IC=10A				0.30	μs
tfi	Current Fall Time	IBon=2A				0.20	μs
tti	Current Tail Time	VBEoff=5V				0.05	μs
txo	Crossover Time Figures 1 & 2	T Case=25°C				0.40	μs
tsv	Voltage Storage Time					3.50	μs
trv	Voltage Rise Time	IC=10A				0.40	μs
tfi	Current Fall Time	IBon=2A				0.30	μs
tti	Current Tail Time	VBEoff=5V				0.08	μs
txo	Crossover Time Figures 1 & 2	T Case=100°C				0.50	μs

NOTE 2. These Parameters are measured using pulse techniques Pulse Width ≤ 300 μs, Duty Cycle = 2%

NOTE 3. Inductive Loop Switching Measurement

NOTE 4. These Parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE. 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

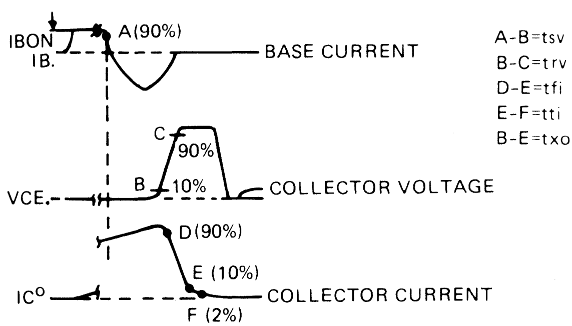
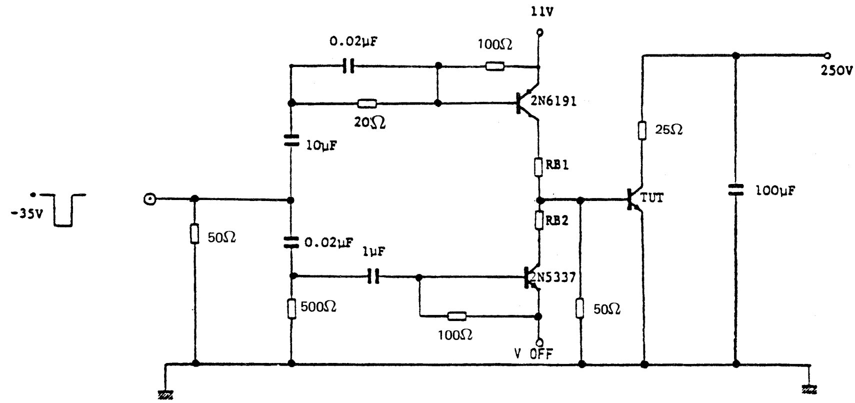


FIGURE. 3 RESISTIVE SWITCHING CIRCUIT

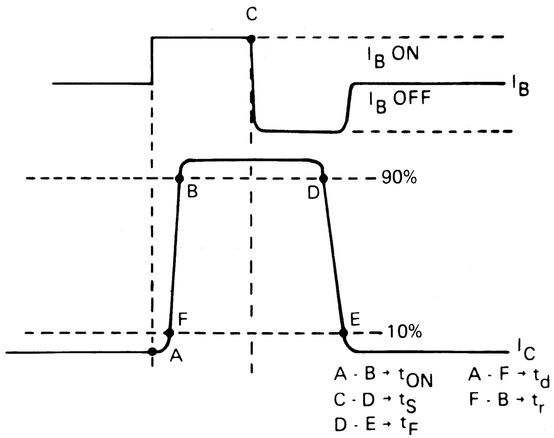


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20µs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} < 11.5pF.

C Resistors must be noninductive types.

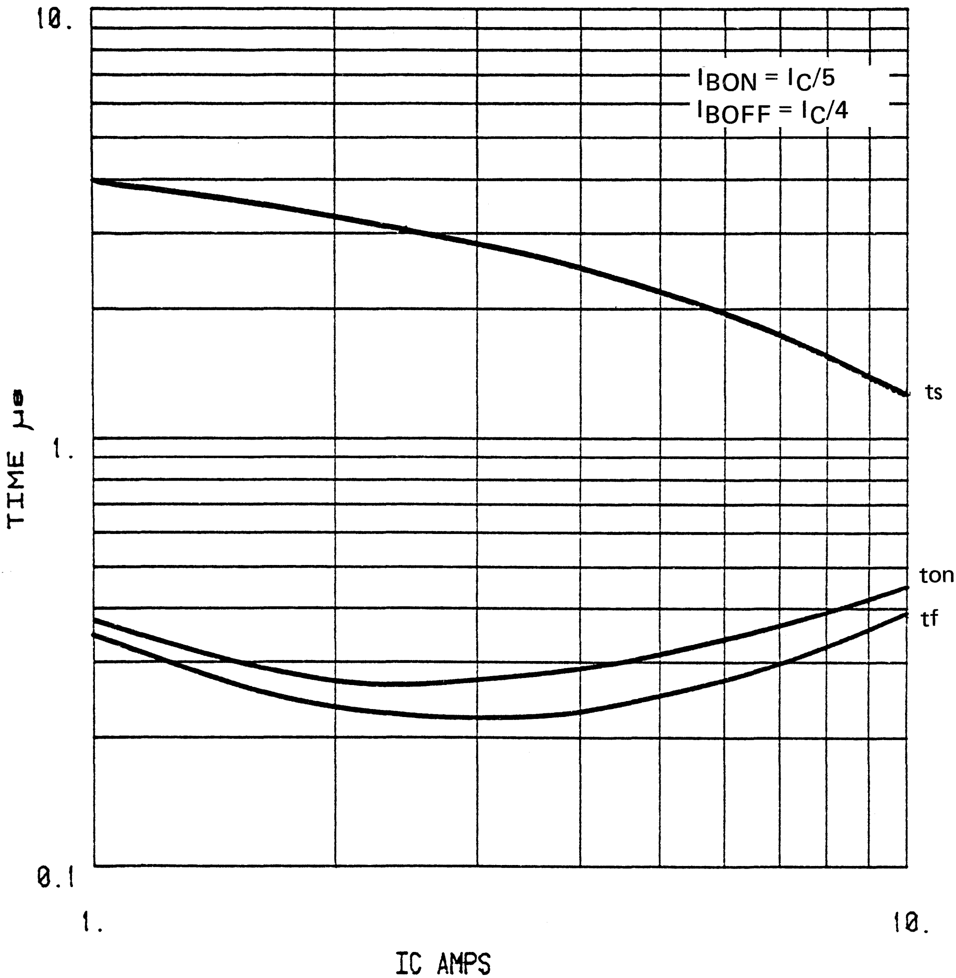
FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



TEXAS INSTRUMENTS

RESISTIVE SWITCHING PARAMETERS

FIGURE. 5 TYPICAL TURN-ON & TURN-OFF TIMES VS IC TCASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE. 6 TYPICAL TURN-OFF TIME VS. IBoff T CASE=25°C

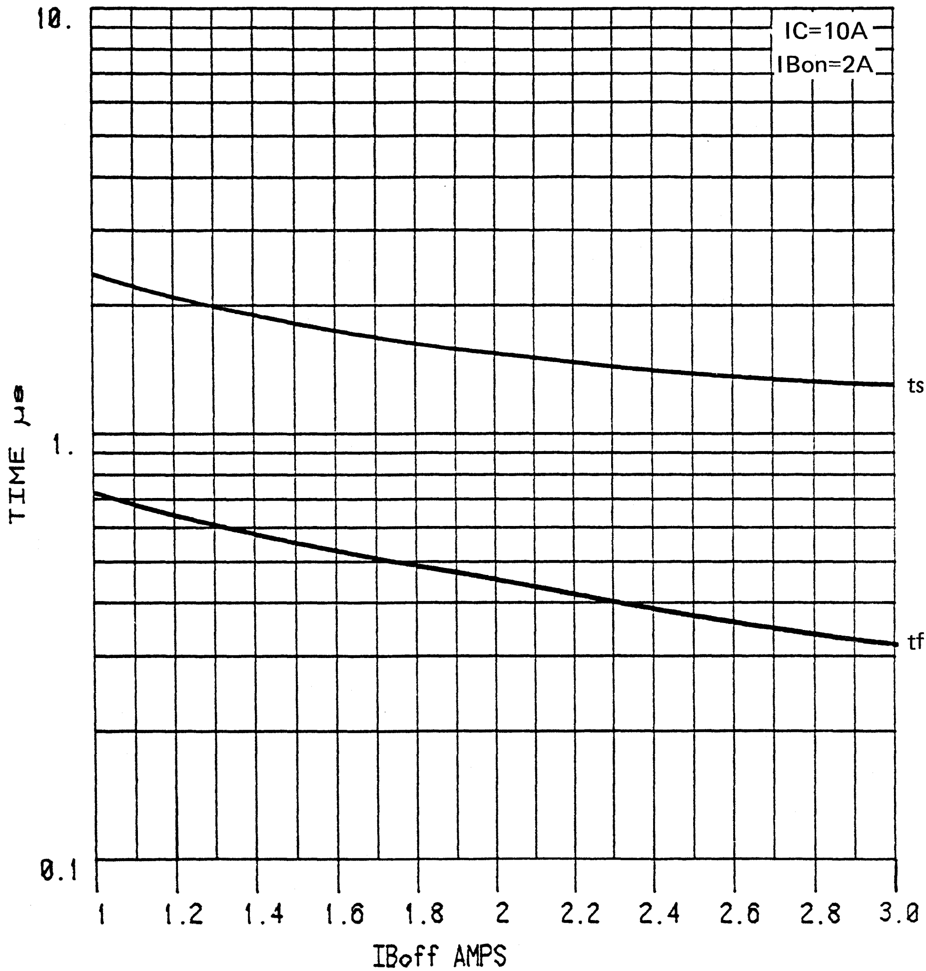


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

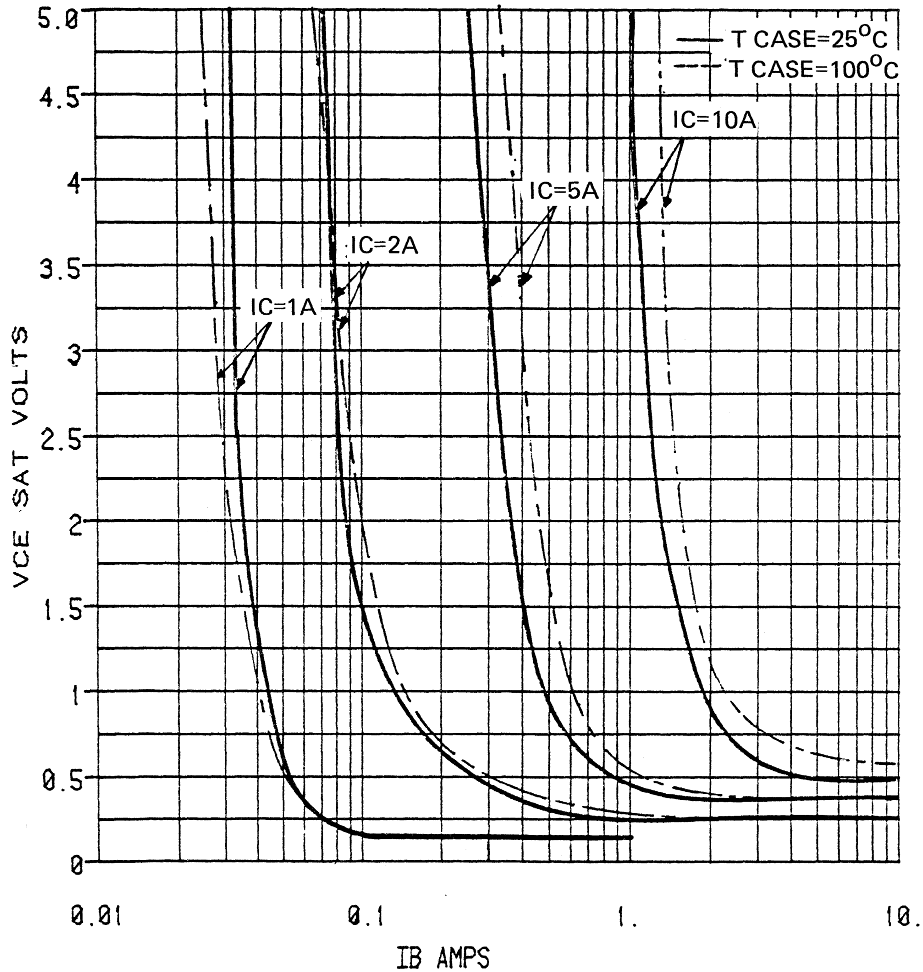


FIGURE. 8 TYPICAL BASE SATURATION REGION T CASE=25°C

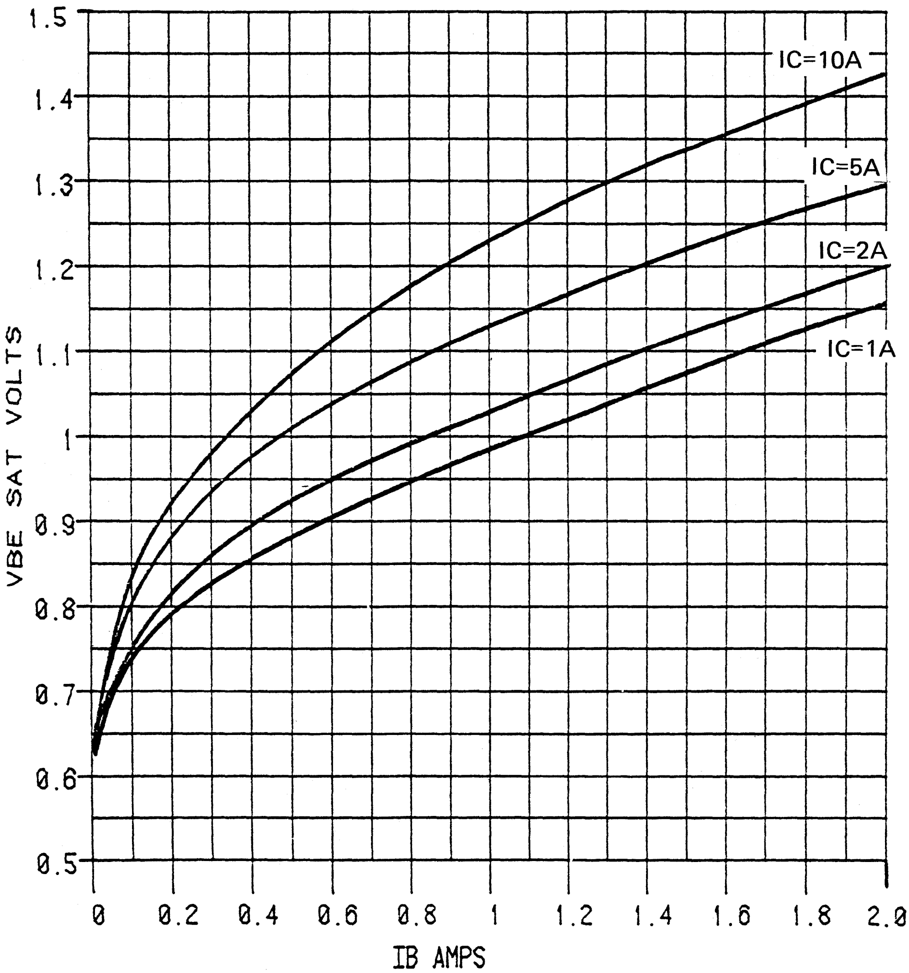


FIGURE. 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

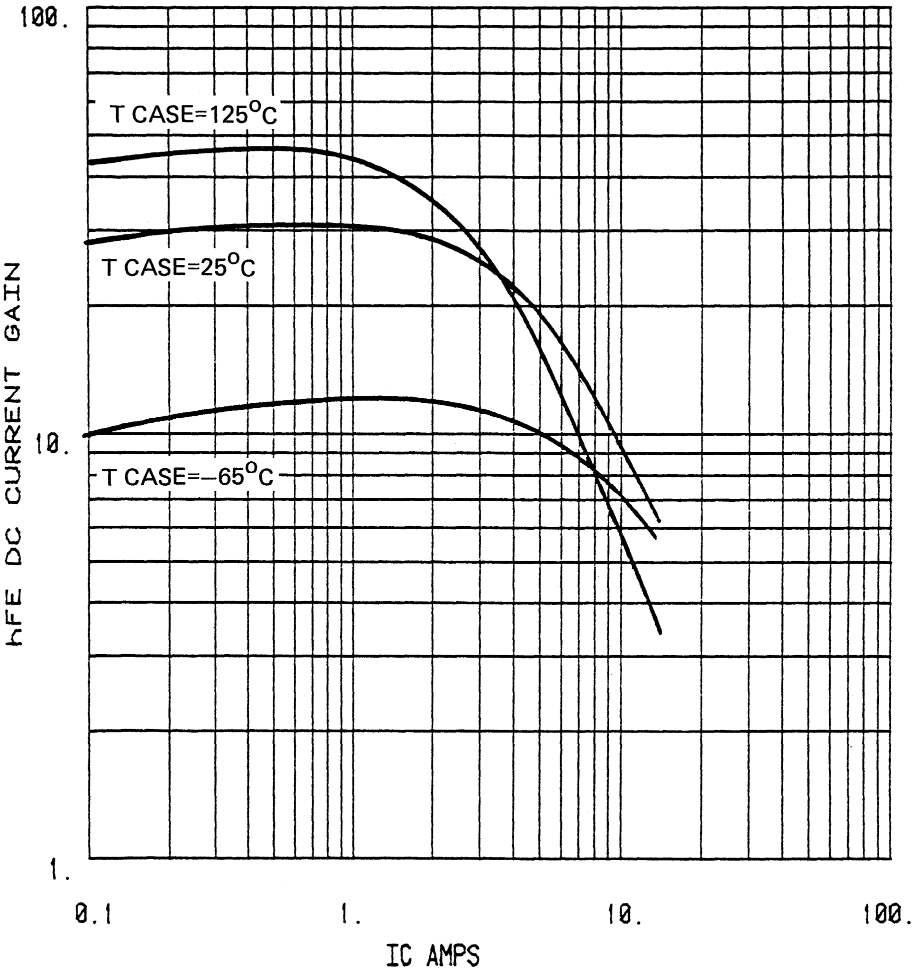


FIGURE.10 TYPICAL VARIATION OF ICES WITH TEMPERATURE

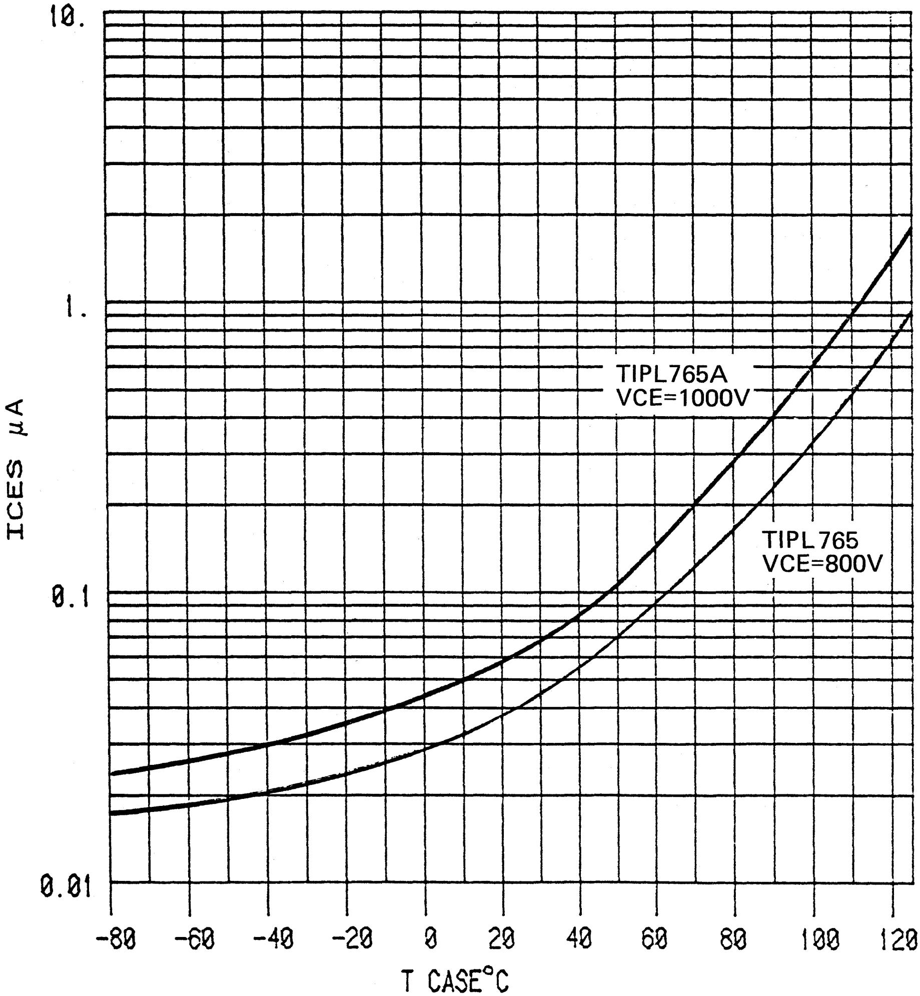


FIGURE. 11 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED
T CASE=25°C

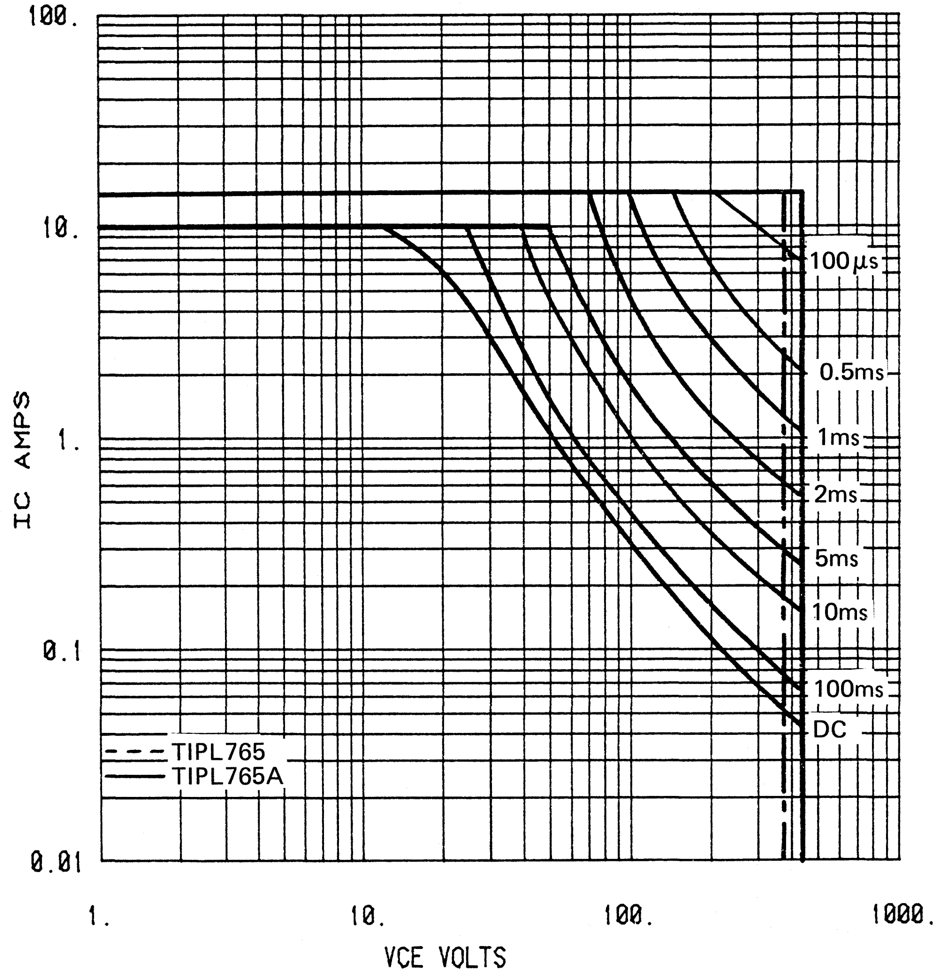


FIGURE. 12 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

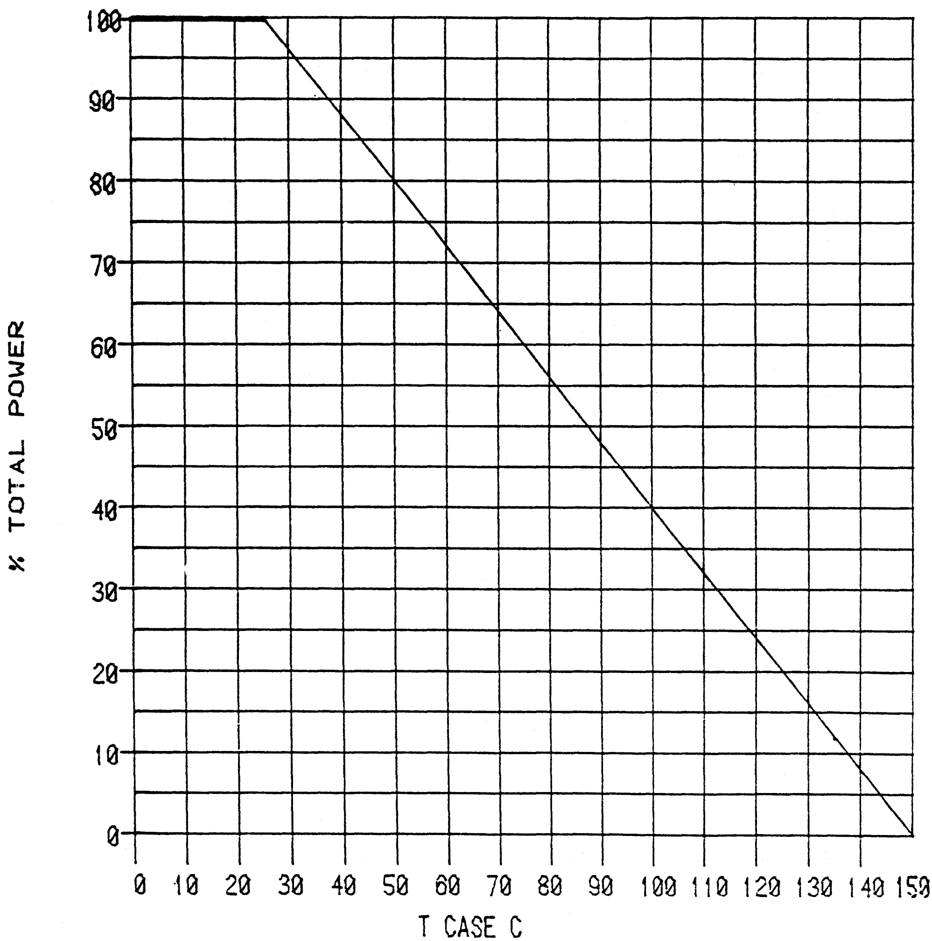


FIGURE. 13 MAXIMUM REVERSE BIAS SAFE OPERATING AREA

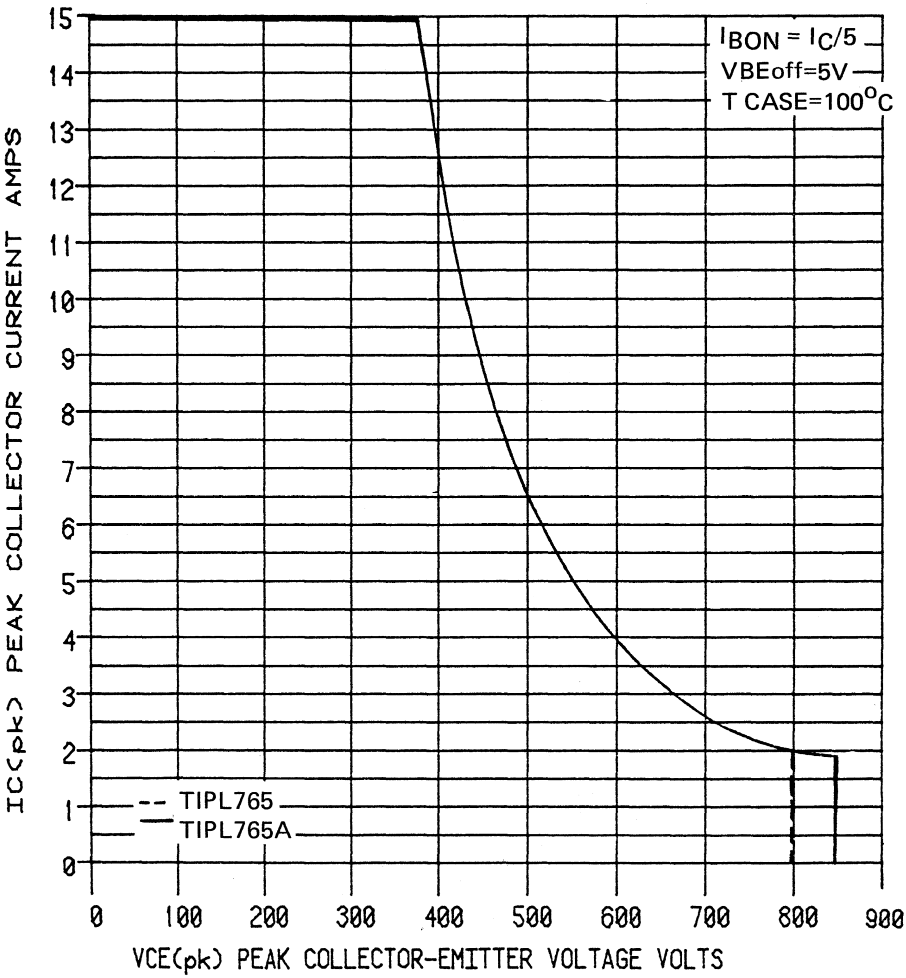


FIGURE. 14 TRANSIENT "TURN OFF" LIMIT vs. VCE T CASE<100°C

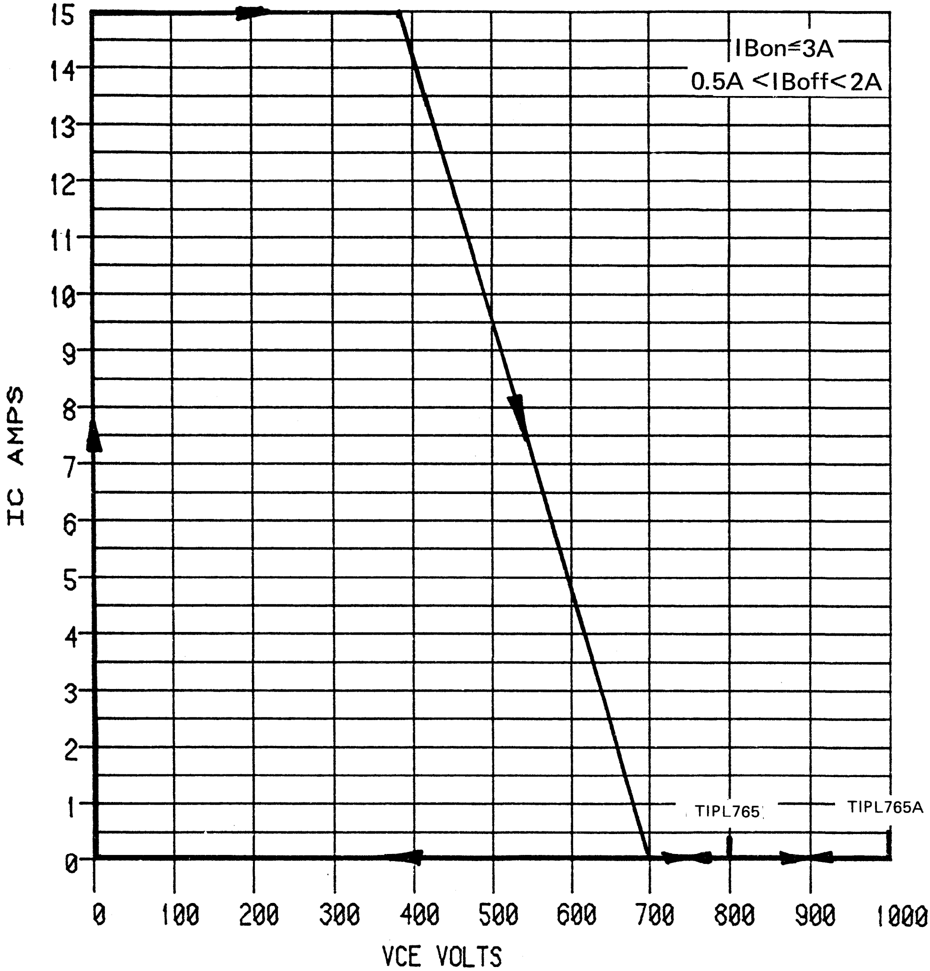
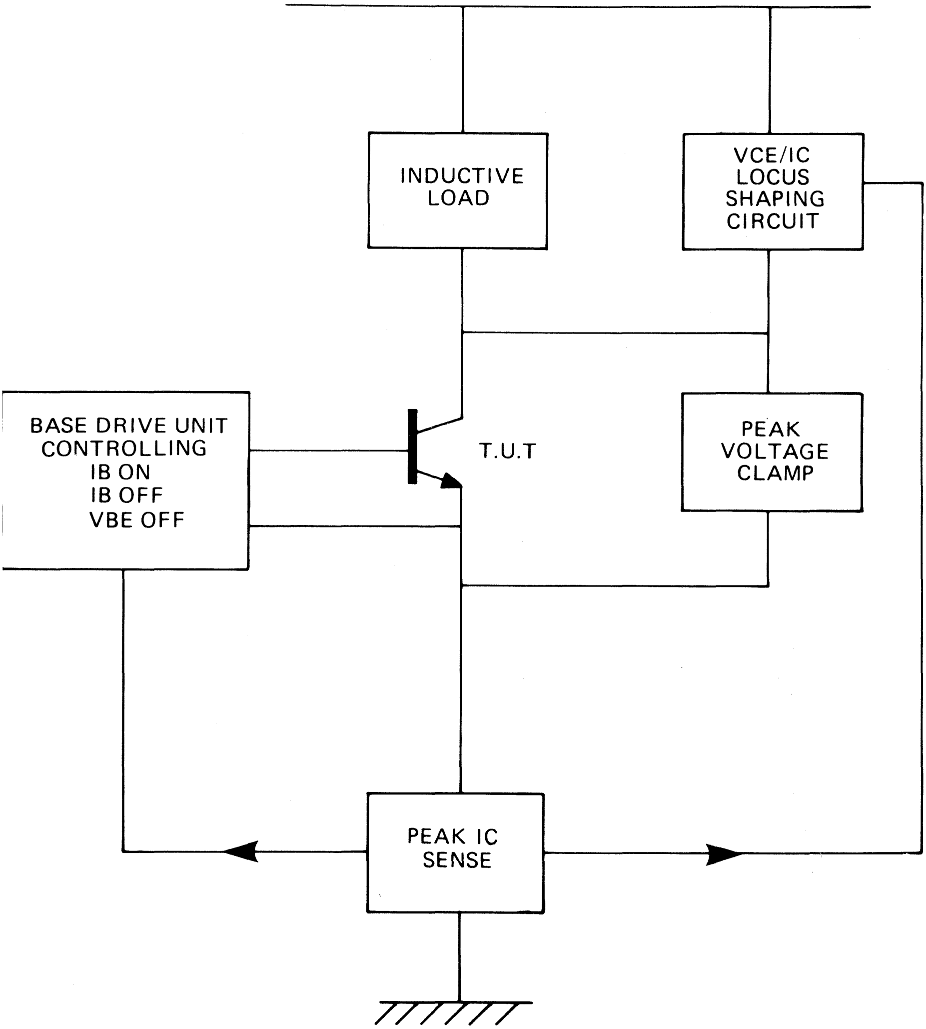


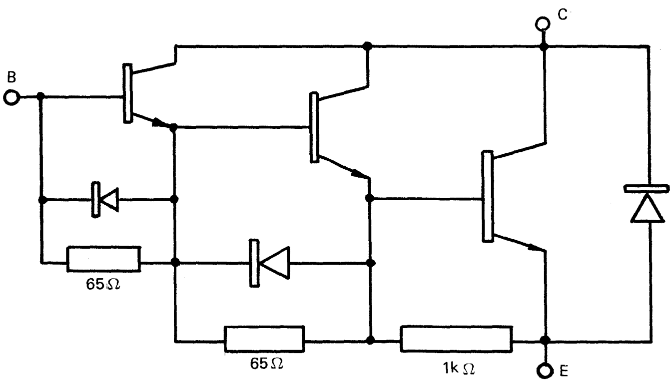
FIGURE. 15 SWITCHING LOCUS TEST CIRCUIT



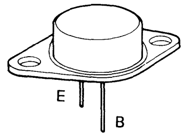
TIPL773, TIPL773A, TIPL773B
NPN SILICON TRIPLE TRANSISTOR
ADVANCED POWER DARLINGTON

OCT 82

- HIGH VOLTAGE, HIGH CURRENT, HIGH SPEED DARLINGTON INTENDED FOR SINGLE AND THREE PHASE SUPPLY INDUCTIVE SWITCHING APPLICATIONS
- ALL MAJOR PARAMETERS SPECIFIED AT 100°C
  - –ICES < 1mA @ VCES 950 - 1150V
  - –ICSAT 10-15A @ VCE = 2.5V, IC/IB = 50
  - –tfi < 500ns @ ICSAT
- LARGE RBSOA UP TO 20A @ 800V PERMITS SNUBBERLESS OPERATION



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS

	TIPL773	TIPL773A	TIPL773B
Collector-Base Voltage ($I_E = 0$)	950V	1050V	1150V
Collector-Emitter Voltage ($V_{BE} = 0$)	950V	1050V	1150V
Collector-Emitter Voltage (Open Base)	600V	700V	800V
Base-Emitter Voltage	6V	6V	6.5V
Continuous Collector Current	20A	20A	20A
Peak Collector Current (Note 1)	55A	55A	55A
Continuous Base Current	3A	3A	3 A
Peak Parallel Diode Forward Current (Note 1)	55A	55A	55A
Continuous Dissipation TCASE = 25°C	180W	180W	180W
Operating Junction and Storage Temperature	-65°C – +200°C		

Note 1: Pulse Test, Pulse Duration = 300μs, Duty Cycle = 2%

TIPL773, TIPL773A, TIPL773B
NPN SILICON TRIPLE TRANSISTOR
ADVANCED POWER DARLINGTON

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS				MIN	TYP	MAX	UNIT
V_{CEX}	Collector Emitter RBSOA Voltage Figs. 1a & 22	IBoff=1A	IC=6A		TIPL773	710			V
					TIPL773A	860			V
					TIPL773B	970			V
$V_{CEO(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C=100mA			TIPL773	600			V
		L = 25mH			TIPL773A	700			V
					TIPL773B	800			V
I_{CEV}	Collector Cut-Off Current	V_{CE} = 950V			TIPL773			100	μA
		V_{CE} = 1050V			TIPL773A			100	μA
		V_{CE} = 1150V			TIPL773B			100	μA
		$1.5V < V_{EB} < 6V$							
I_{CES}	Collector-Emitter Cut-off Current (V_{BE} = 0)	V_{CE} = 950V			TIPL773			100	μA
		V_{CE} = 1050V			TIPL773A			100	μA
		V_{CE} = 1150V			TIPL773B			100	μA
		V_{CE} = 950V	100°C		TIPL773			1	mA
		V_{CE} = 1050V	100°C		TIPL773A			1	mA
		V_{CE} = 1150V	100°C		TIPL773B			1	mA
I_{CEO}	Collector Cut-Off Current	V_{CE} = 600V			TIPL773			100	μA
		V_{CE} = 700V			TIPL773A			100	μA
		V_{CE} = 800V			TIPL773B			100	μA
I_{EBO}	Emitter Cut-Off Current	V_{EB} = 6V	I_C = 0					10	mA
$V_{CE(sat)}$	Collector Emitter Saturation Voltage Notes 1 & 3	IC=3A	IB=60mA		TIPL773			2.0	V
		IC=10A	IB=200mA					2.2	V
		IC=15A	IB=300mA					2.5	V
		IC=15A	IB=300mA	100°C				2.5	V
		IC=2.5A	IB=50mA		TIPL773A			2.0	V
		IC=7.5A	IB=150mA					2.2	V
		IC=12.5A	IB=250mA					2.5	V
		IC=12.5A	IB=250mA	100°C				2.5	V
		IC=1A	IB=20mA		TIPL773B			2.0	V
		IC=5A	IB=100mA					2.2	V
		IC=10A	IB=200mA					2.5	V
		IC=10A	IB=200mA	100°C				2.5	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage Notes 1 & 3	IC=3A	IB=60mA		TIPL773			3.0	V
		IC=10A	IB=200mA					3.5	V
		IC=15A	IB=300mA					4.0	V
		IC=15A	IB=300mA	100°C				4.0	V
		IC=2.5	IB=50mA		TIPL773A			3.0	V
		IC=7.5A	IB=150mA					3.5	V
		IC=12.5A	IB=250mA					4.0	V
		IC=12.5A	IB=250mA	100°C				4.0	V
		IC=1A	IB=20mA		TIPL773B			3.0	V
		IC=5A	IB=100mA					3.5	V
		IC=10A	IB=200mA					4.0	V
		IC=10A	IB=200mA	100°C				4.0	V

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_F	Parallel Diode Forward Voltage Notes 1 & 3	IC=15A	TIPL773			2.0	V
		IC=12.5A	TIPL773A			2.0	V
		IC=10A	TIPL773B			2.0	V
h_{FE}	Forward Current Transfer Ratio	VCE=5V IC=500mA		50			
C_{ob}	Output Capacitance	VCB=20V IE=0A F=0.1MHz			185		pF
$R_{\theta Jc}$	Thermal Resistance Junction-Case					0.97	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Resistive Load						
TIPL773	(See Fig. 1c)					
ton	Turn On Time	IC=15A VCE=250V			1.25	μs
ts	Storage Time	IBoff=1.5A			3.00	μs
tf	Fall Time	T CASE=25°C			1.00	μs
ton	Turn On Time	IC=15A VCE=250V			2.00	μs
ts	Storage Time	IBoff=1.5A			4.00	μs
tf	Fall Time	T Case=100°C			2.00	μs
TIPL773A	(See Fig. 1c)					
ton	Turn On Time	IC=12.5A VCE=250V			1.25	μs
ts	Storage Time	IBoff=1.5A			3.50	μs
tf	Fall Time	T Case=25°C			1.00	μs
ton	Turn On Time	IC=12.5A VCE=250V			2.00	μs
ts	Storage Time	IBoff=1.5A			5.00	μs
tf	Fall Time	T Case=100°C			2.00	μs
TIPL773B	(See Fig. 1c)					
ton	Turn On Time	IC=10A VCE=250V			1.25	μs
ts	Storage Time	IBoff=1.5A			4.00	μs
tf	Fall Time	T Case=25°C			1.00	μs
ton	Turn On Time	IC=10A VCE=250V			2.00	μs
ts	Storage Time	IBoff=1.5A			6.00	μs
tf	Fall Time	T Case=100°C			2.00	μs

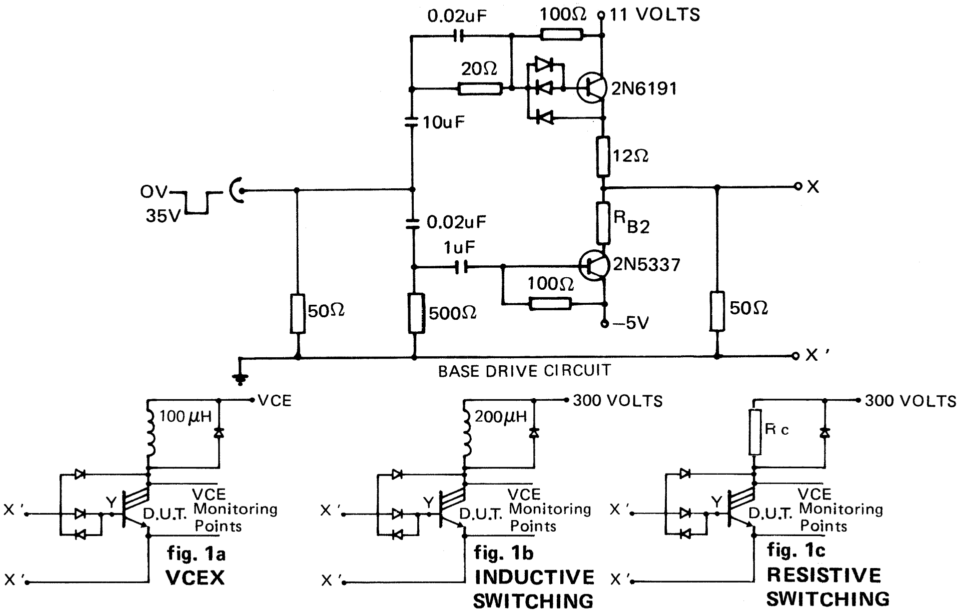
TIPL773, TIPL773A, TIPL773B
NPN SILICON TRIPLE TRANSISTOR
ADVANCED POWER DARLINGTON

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Inductive Load						
TIPL773	(See Figs. 1b, 2, 3 & 6)					
tsv	Current Storage Time				2.80	µs
trv	Voltage Rise Time	IC=15A VCE=300V			0.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.30	µs
txo	Crossover Time	T Case=25°C			0.80	µs
ttl	Current Tail Time				0.10	µs
tsv	Current Storage Time				4.80	µs
trv	Voltage Rise Time	IC=15A VCE=300V			1.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.50	µs
txo	Crossover Time	T Case=100°C			2.00	µs
ttl	Current Tail Time				0.15	µs
TIPL773A	(See Figs. 1b, 2, 4&7)					
tsv	Current Storage Time				3.00	µs
trv	Voltage Rise Time	IC=12.5A VCE=300V			0.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.30	µs
txo	Crossover Time	T Case=25°C			0.80	µs
ttl	Current Tail Time				0.10	µs
tsv	Current Storage Time				5.00	µs
trv	Voltage Rise Time	IC=12.5A VCE=300V			1.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.50	µs
txo	Crossover Time	T Case=100°C			2.00	µs
ttl	Current Tail Time				0.15	µs
TIPL773B	(See Figs. 1b, 2, 5&8)					
tsv	Current Storage Time				3.20	µs
trv	Voltage Rise Time	IC=10A VCE=300V			0.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.30	µs
txo	Crossover Time	T Case=25°C			0.80	µs
ttl	Current Tail Time				0.10	µs
tsv	Current Storage Time				5.20	µs
trv	Voltage Rise Time	IC=10A VCE=300V			1.50	µs
tfl	Current Fall Time	IBoff=1.5A			0.50	µs
txo	Crossover Time	T Case=100°C			2.00	µs
ttl	Current Tiail Time				0.15	µs

Notes
1. These parameters are measured using pulse techniques, Pulse width $\leq$300µs, duty cycle $\leq$2%.
2. Inductive loop switching measurement.
3. These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



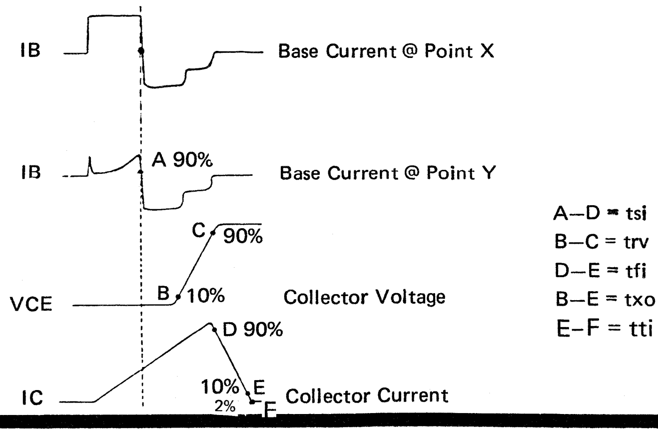
Notes.

A Waveforms are monitored on an oscilloscope with the following characteristics tr < 15ns, Rin < 10M Ω, Cin < 11.5 pf.

B Resistors must be non inductive types

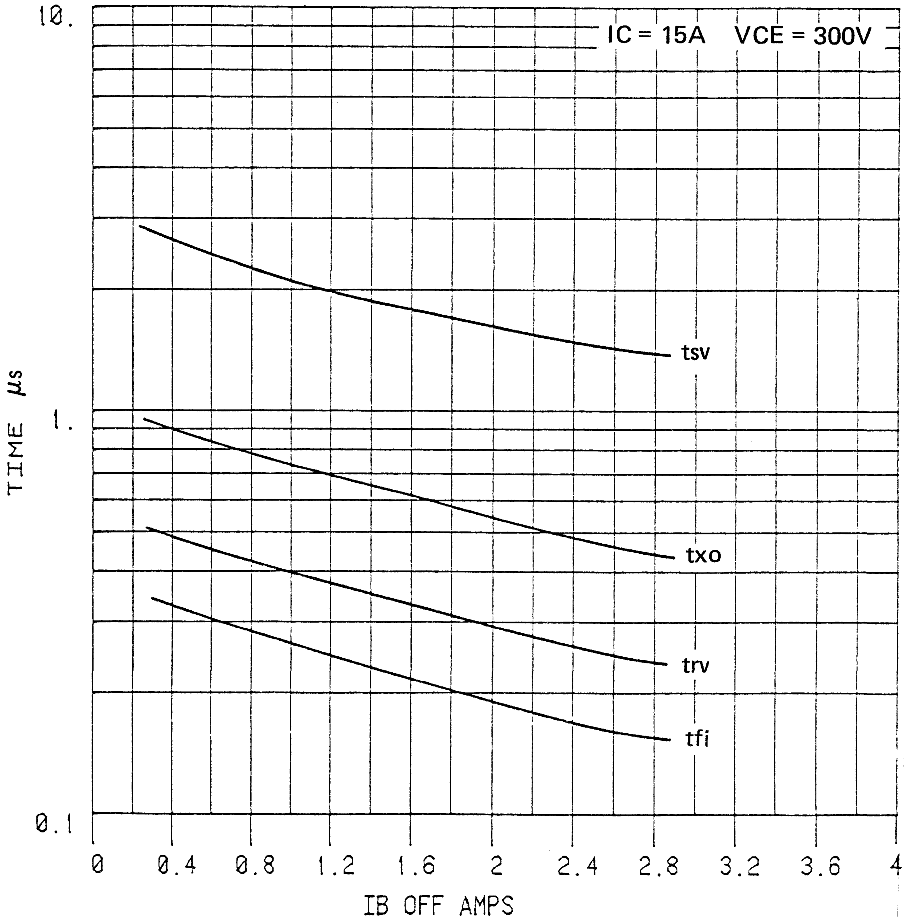
C VCE waveforms to be monitored within 3.2mm of the device body

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS



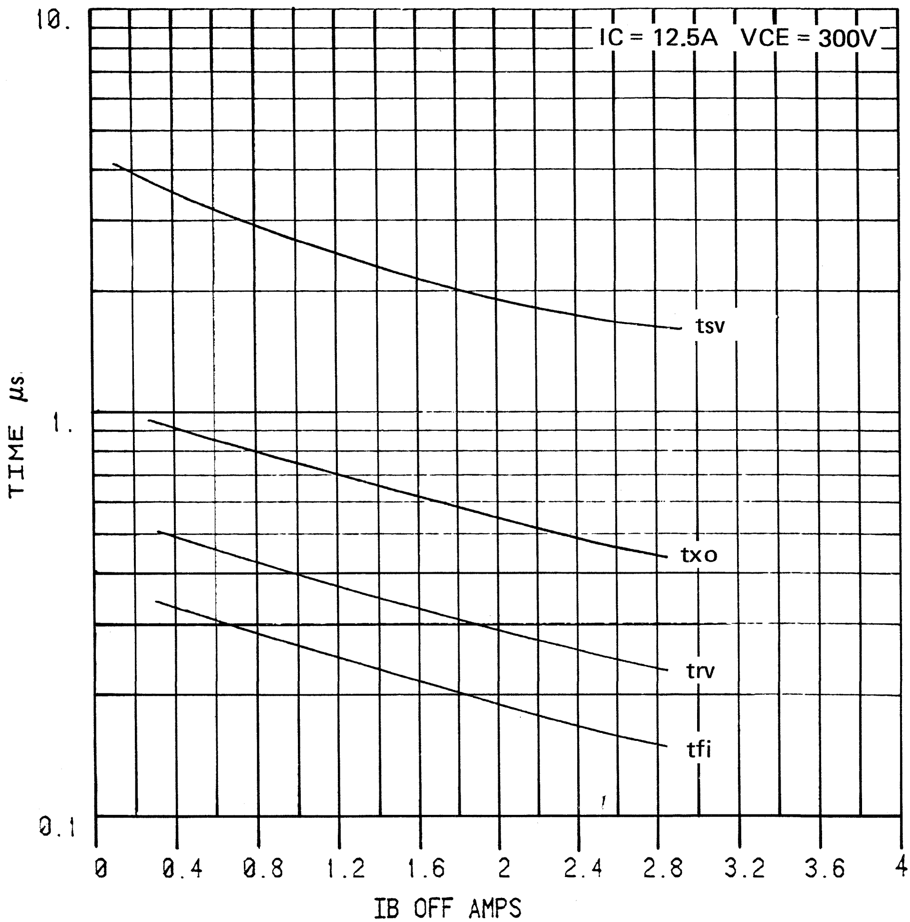
INDUCTIVE SWITCHING PARAMETERS

FIGURE 3 TYPICAL TURN–OFF TIME VS IB off T CASE = 25°C TIPL 773



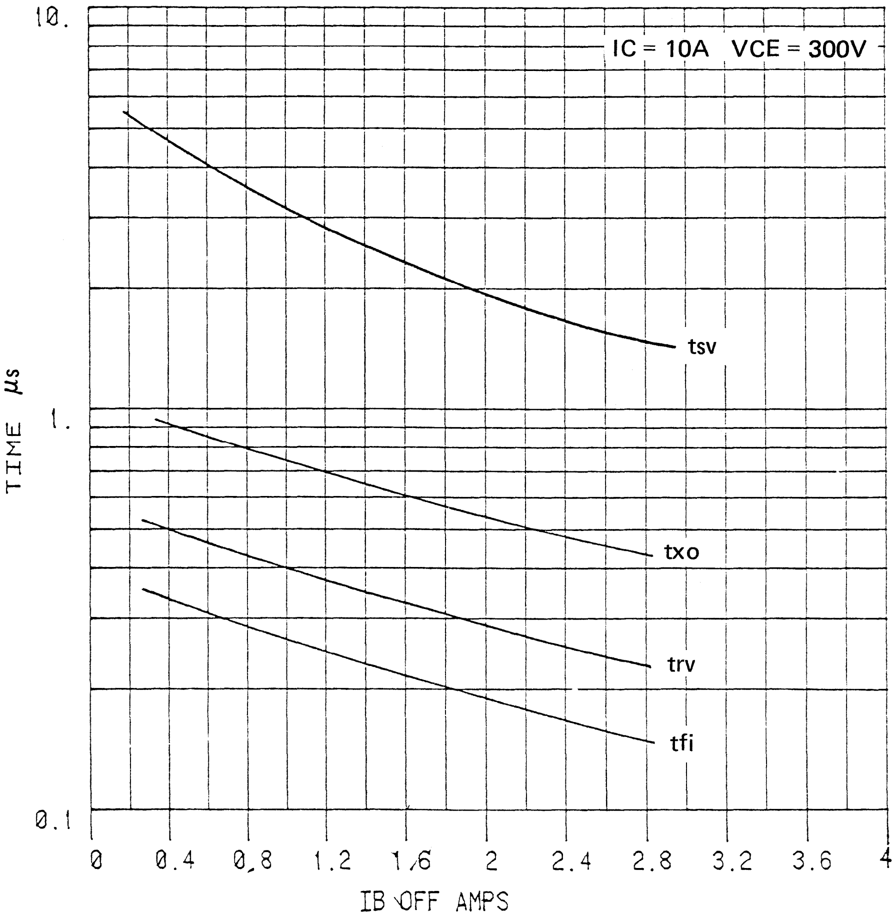
INDUCTIVE SWITCHING PARAMETERS

FIGURE 4 TYPICAL TURN–OFF TIME VS IB off T CASE = 25° C TIPL 773A



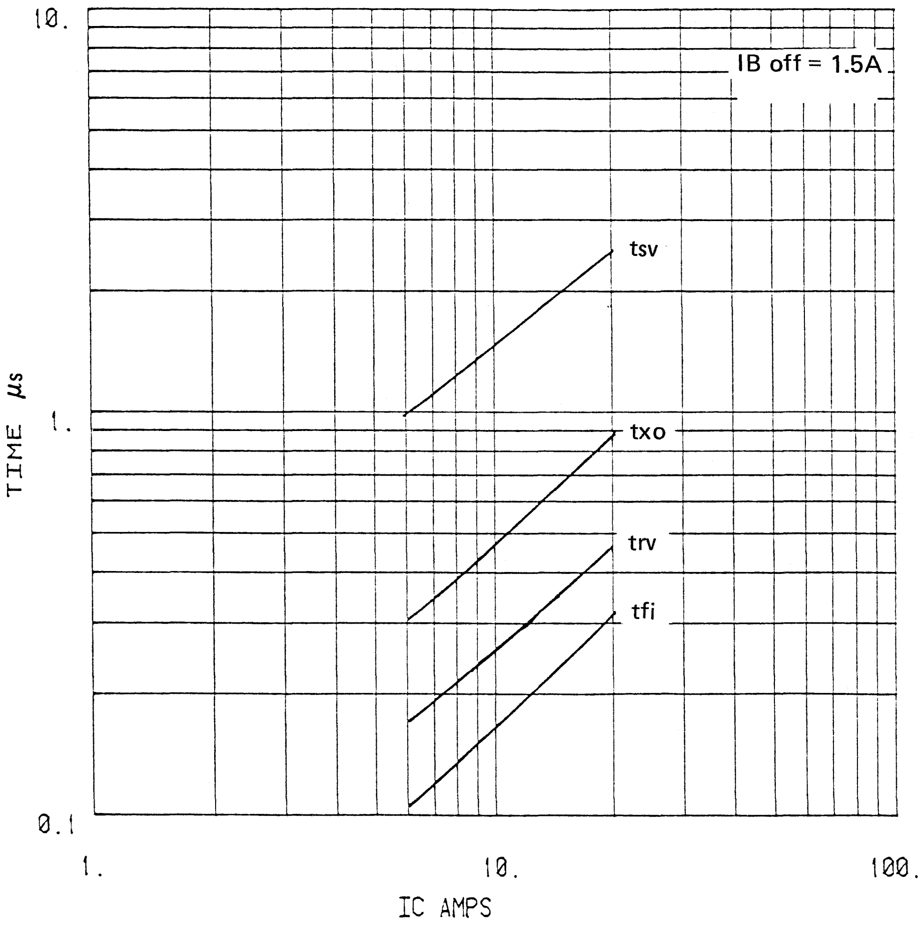
INDUCTIVE SWITCHING PARAMETERS

FIGURE 5 TYPICAL TURN–OFF TIME VS IB off T CASE = 25°C TIPL 773B



INDUCTIVE SWITCHING PARAMETERS

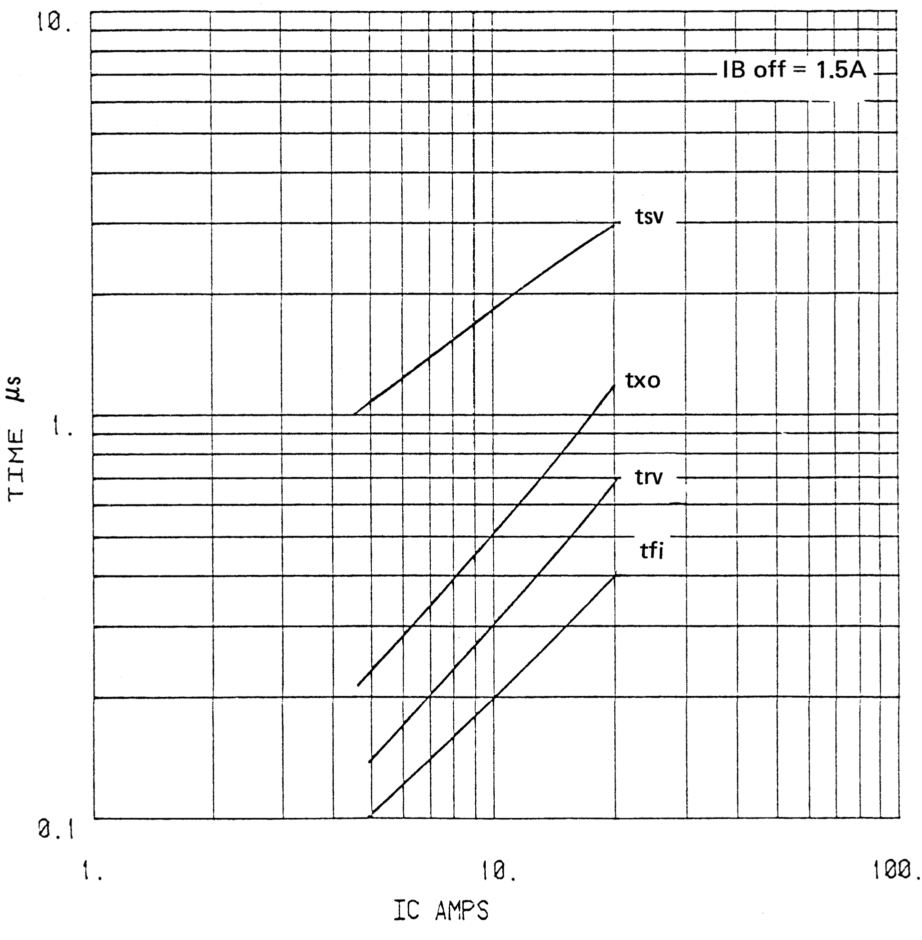
FIGURE. 6 TYPICAL TURN–OFF TIME VS IC T CASE = 25°C TIPL 773



NPN SILICON TRIPLE TRANSISTOR ADVANCED POWER DARLINGTON

INDUCTIVE SWITCHING PARAMETERS

FIGURE 7 TYPICAL TURN–OFF TIME VS IC T CASE = 25°C TIPL 773A



INDUCTIVE SWITCHING PARAMETERS

FIGURE 8 TYPICAL TURN–OFF TIME VS IC T CASE = 25°C TIPL 773B

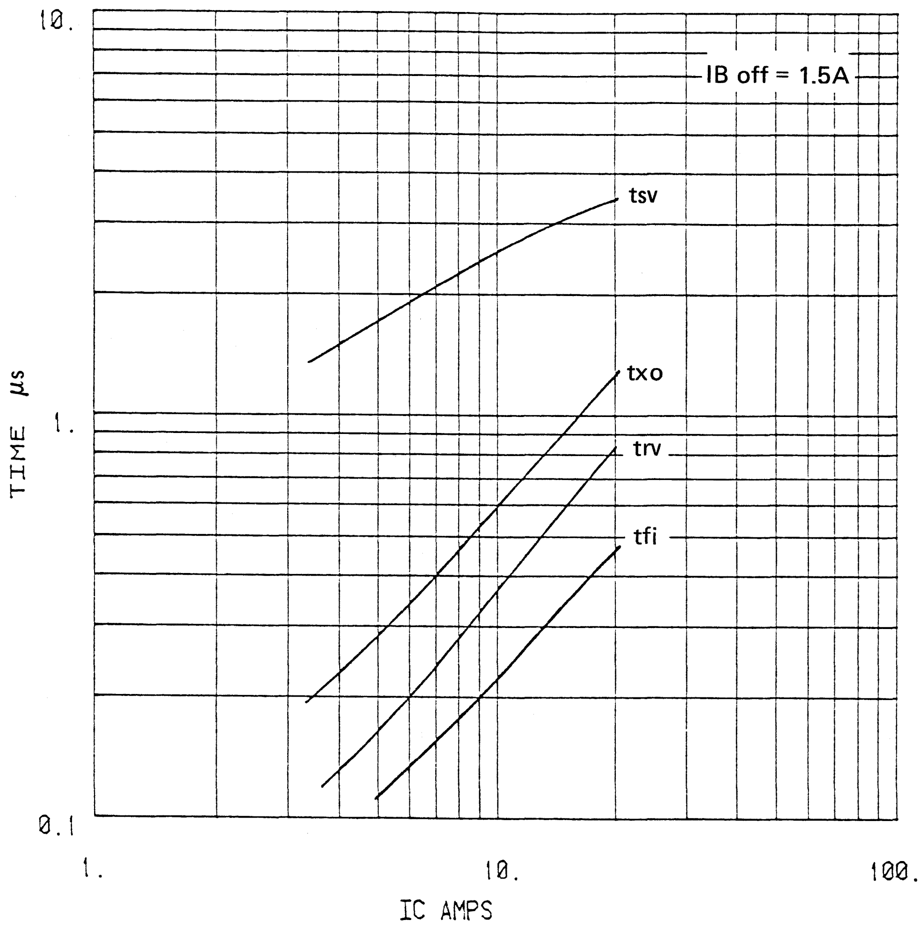


FIGURE 9 MAXIMUM COLLECTOR SATURATION REGION FOR TIPL 773
T CASE = 25°C, 90% CONFIDENCE

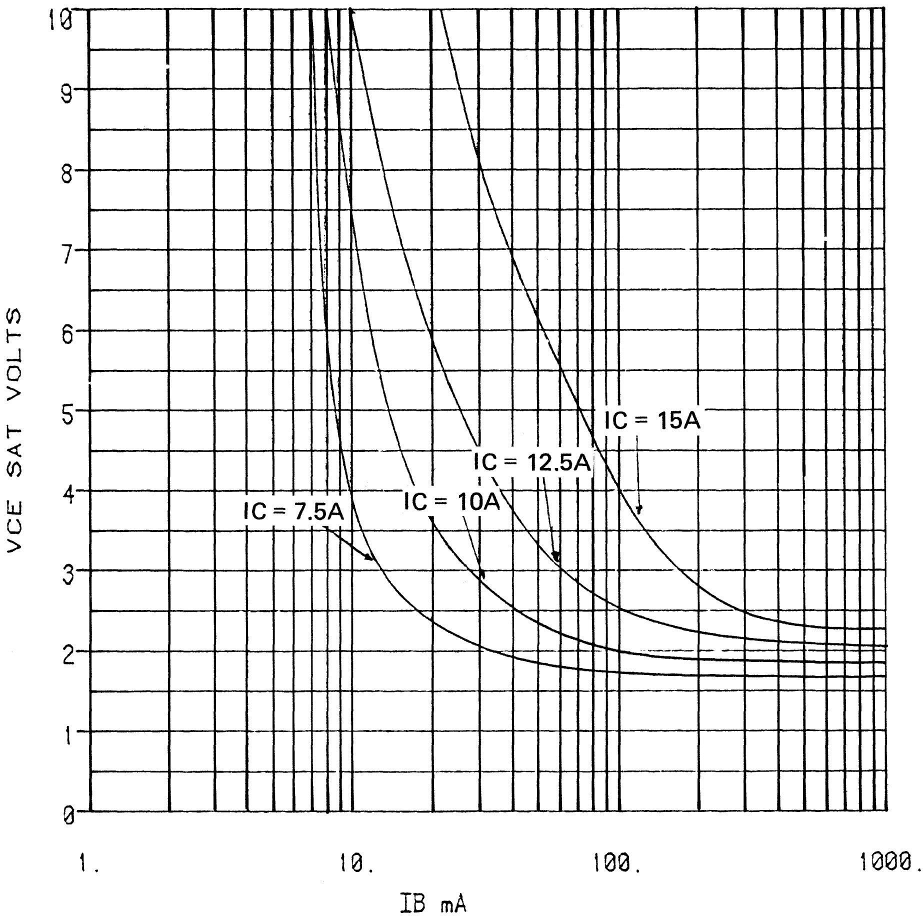


FIGURE 10 MAXIMUM COLLECTOR SATURATION REGION FOR TIPL 773A
T CASE = 25°C, 90% CONFIDENCE

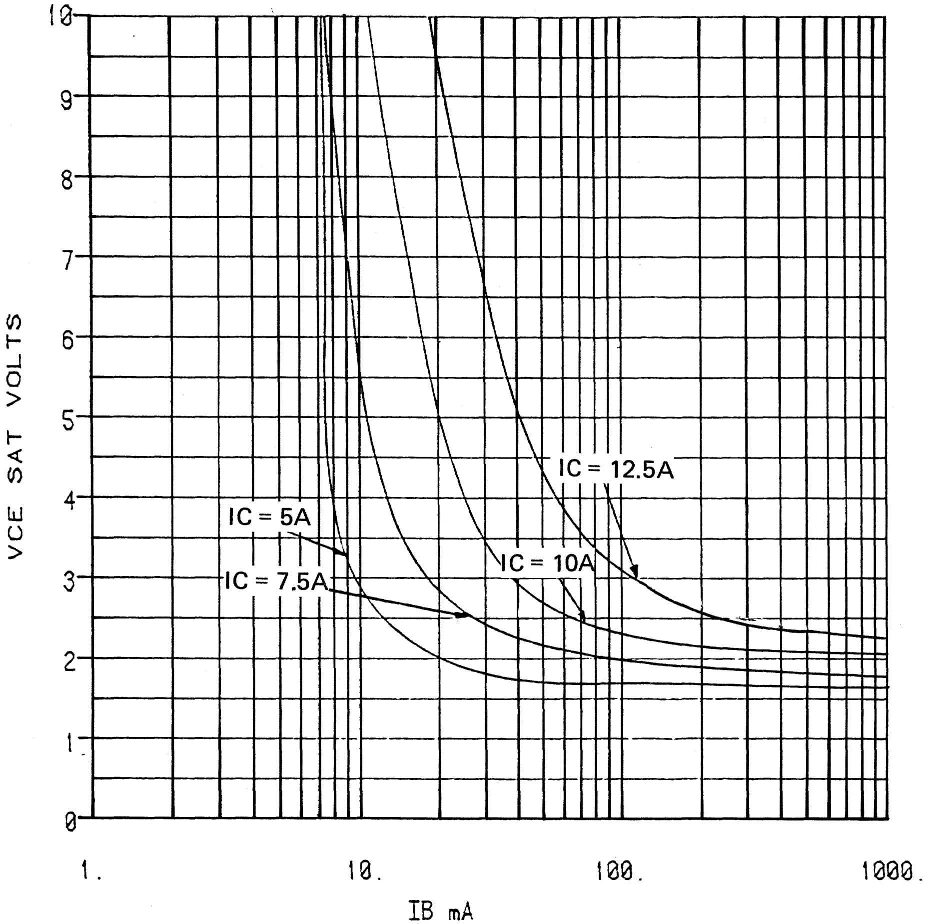


FIGURE 11 MAXIMUM COLLECTOR SATURATION REGION FOR TIPL 773B
T CASE = 25°C , 90% CONFIDENCE

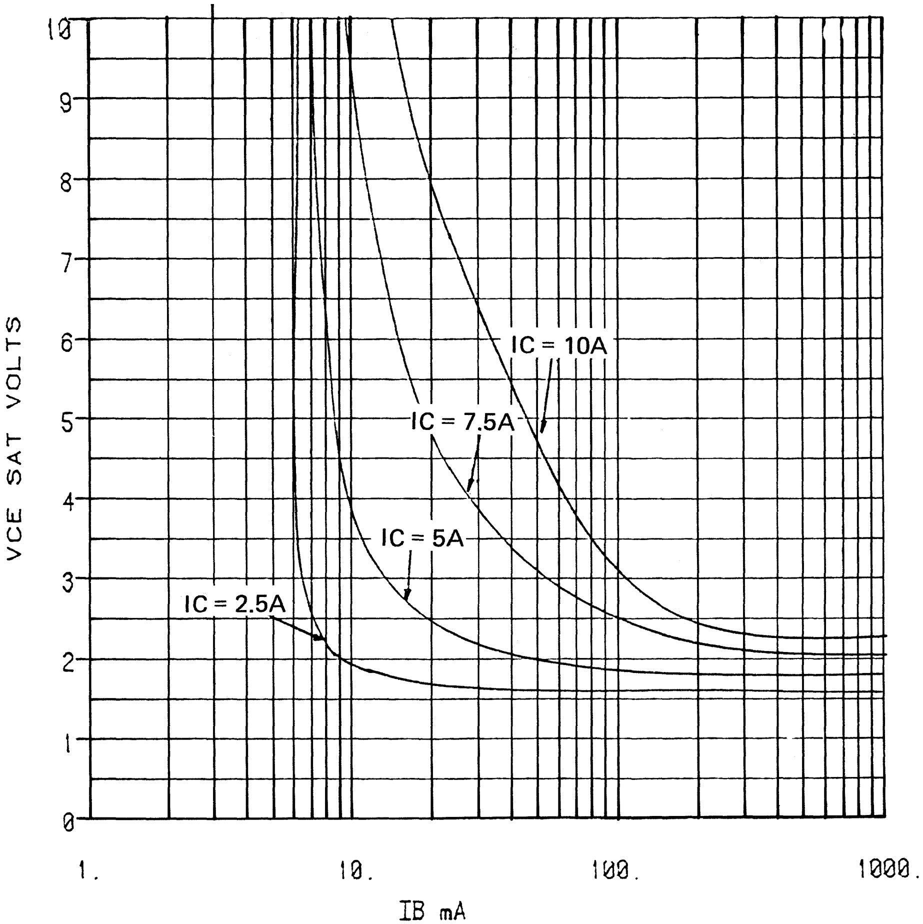


FIGURE 12 TYPICAL BASE SATURATION REGION FOR TIPL 773

T CASE = 25°C

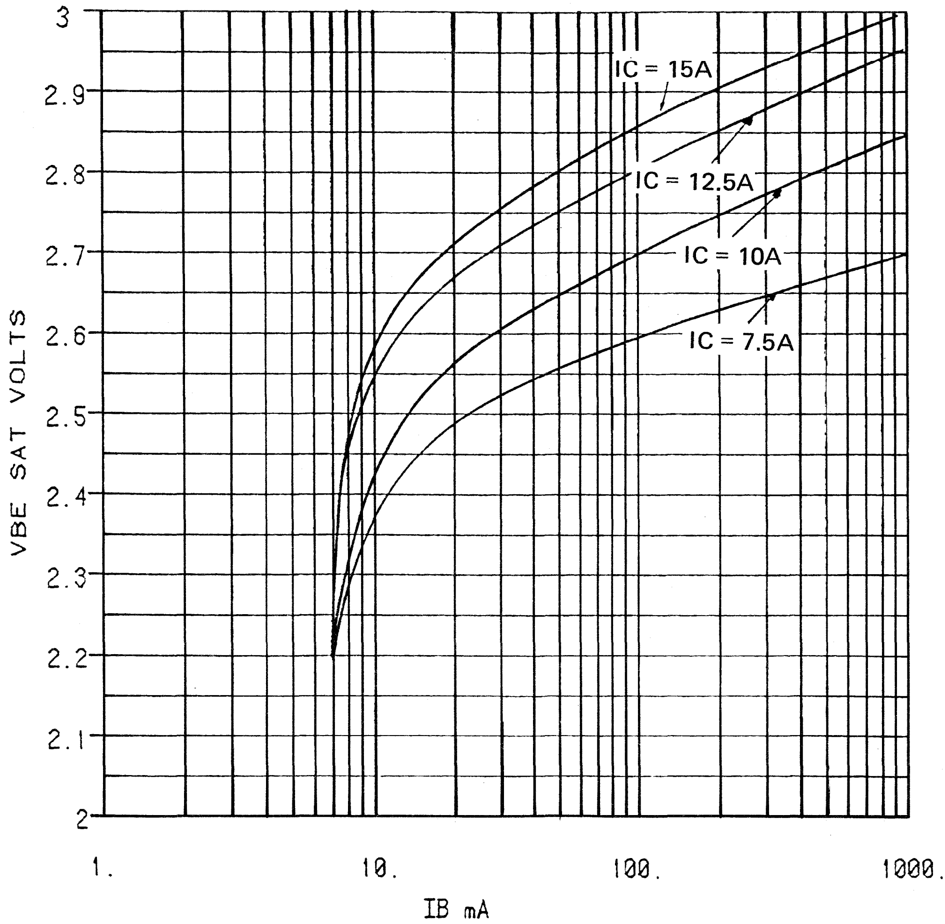


FIGURE 13 TYPICAL BASE SATURATION REGION FOR TIPL 773A

T CASE = 25°C

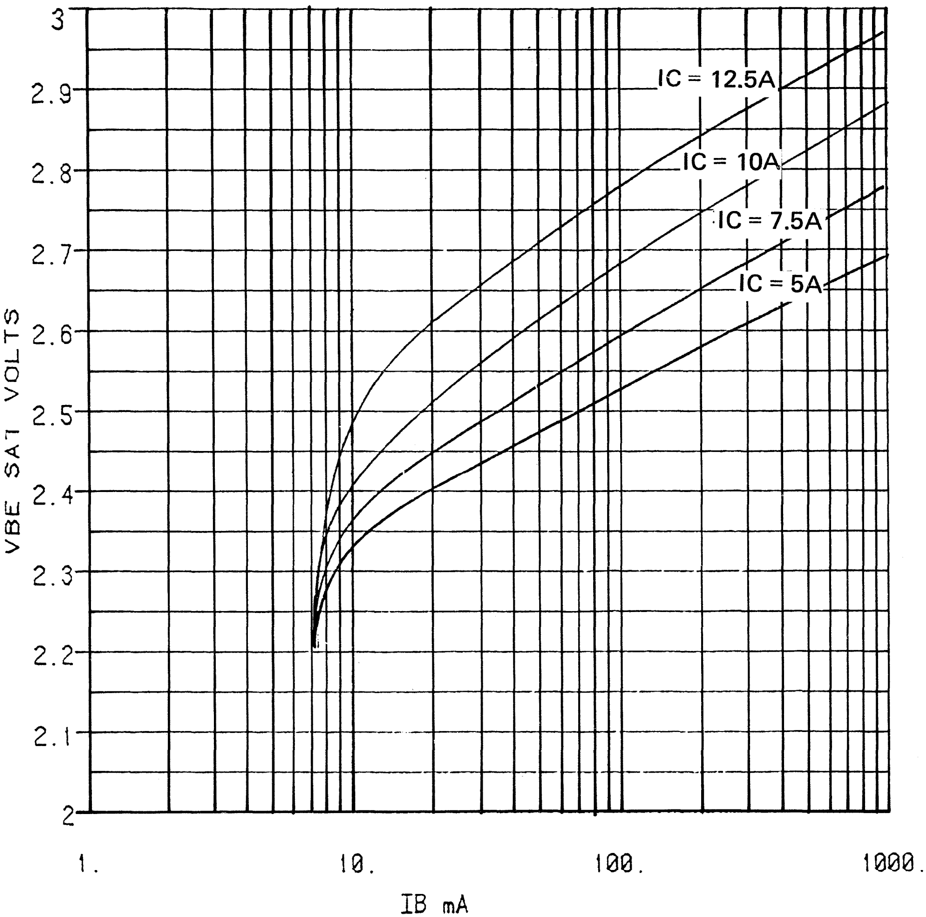


FIGURE 14 TYPICAL BASE SATURATION REGION FOR TIPL 773B
T CASE = 25°C

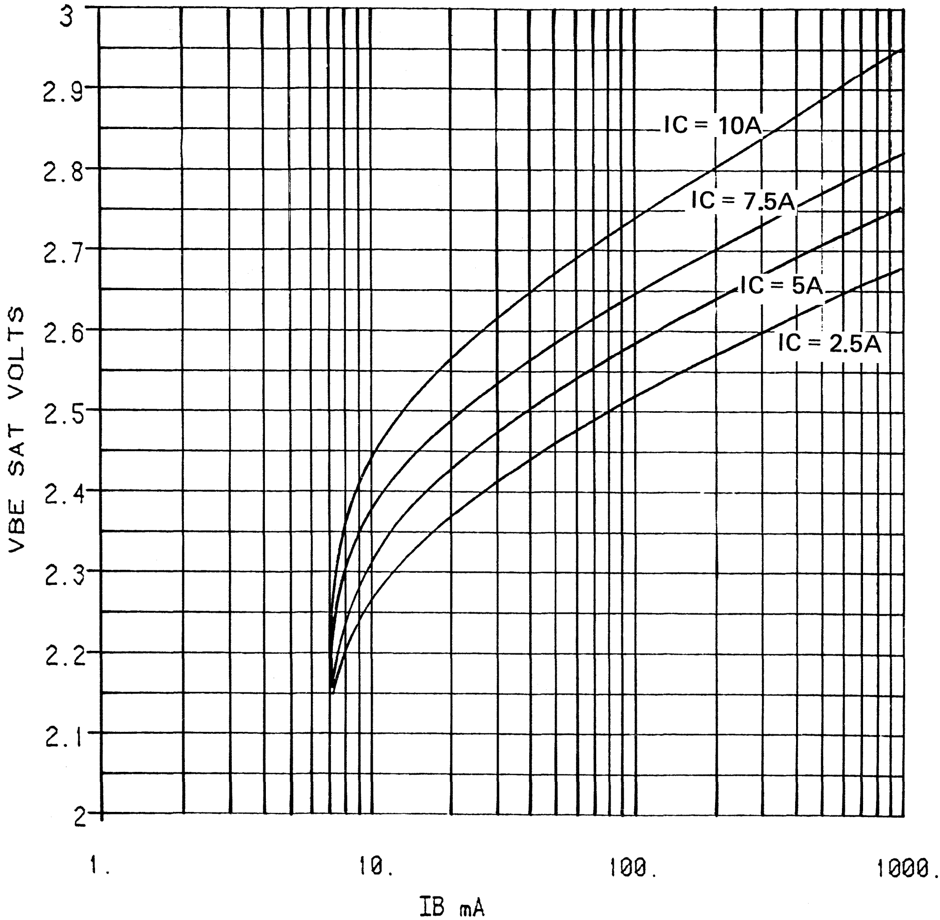


FIGURE 15 TYPICAL VARIATION OF DC CURRENT GAIN TIPL 773
VCE = 5V

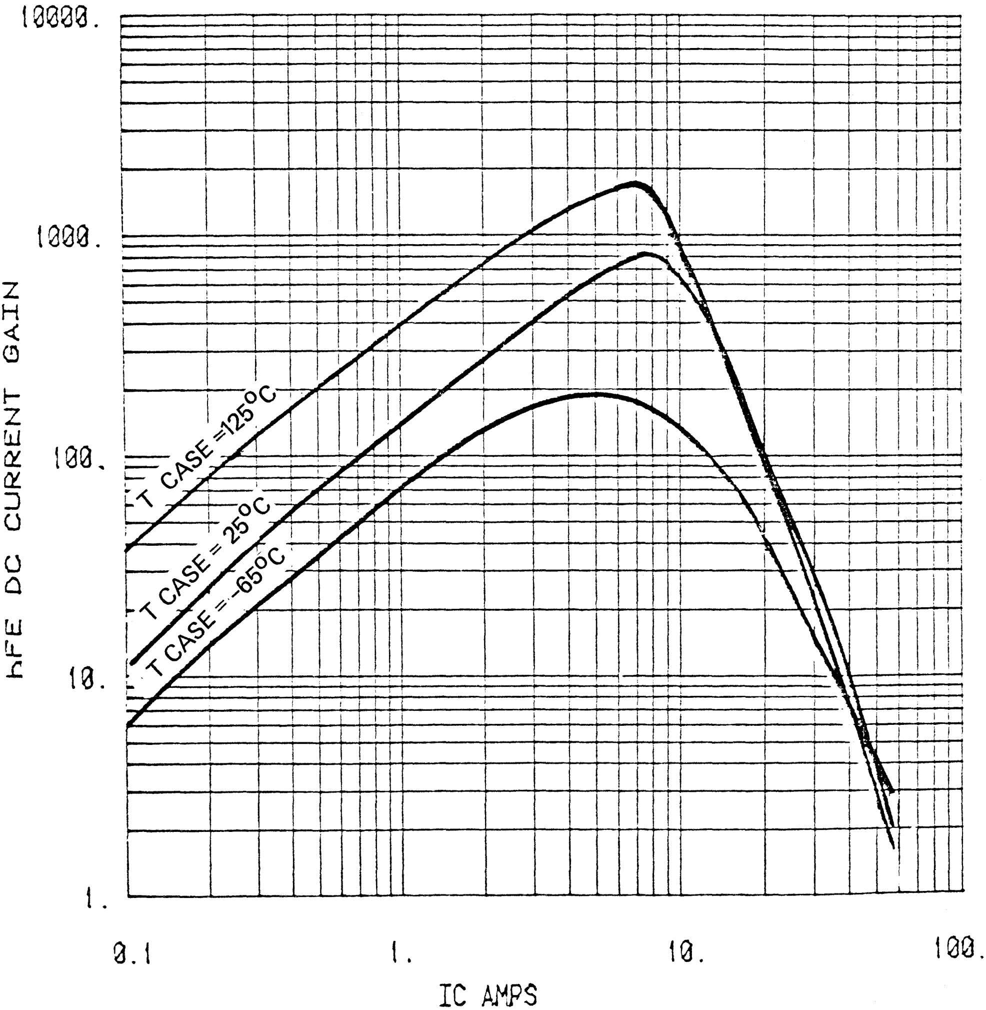


FIGURE 16 TYPICAL VARIATION OF DC CURRENT GAIN TIPL 773A
VCE = 5V

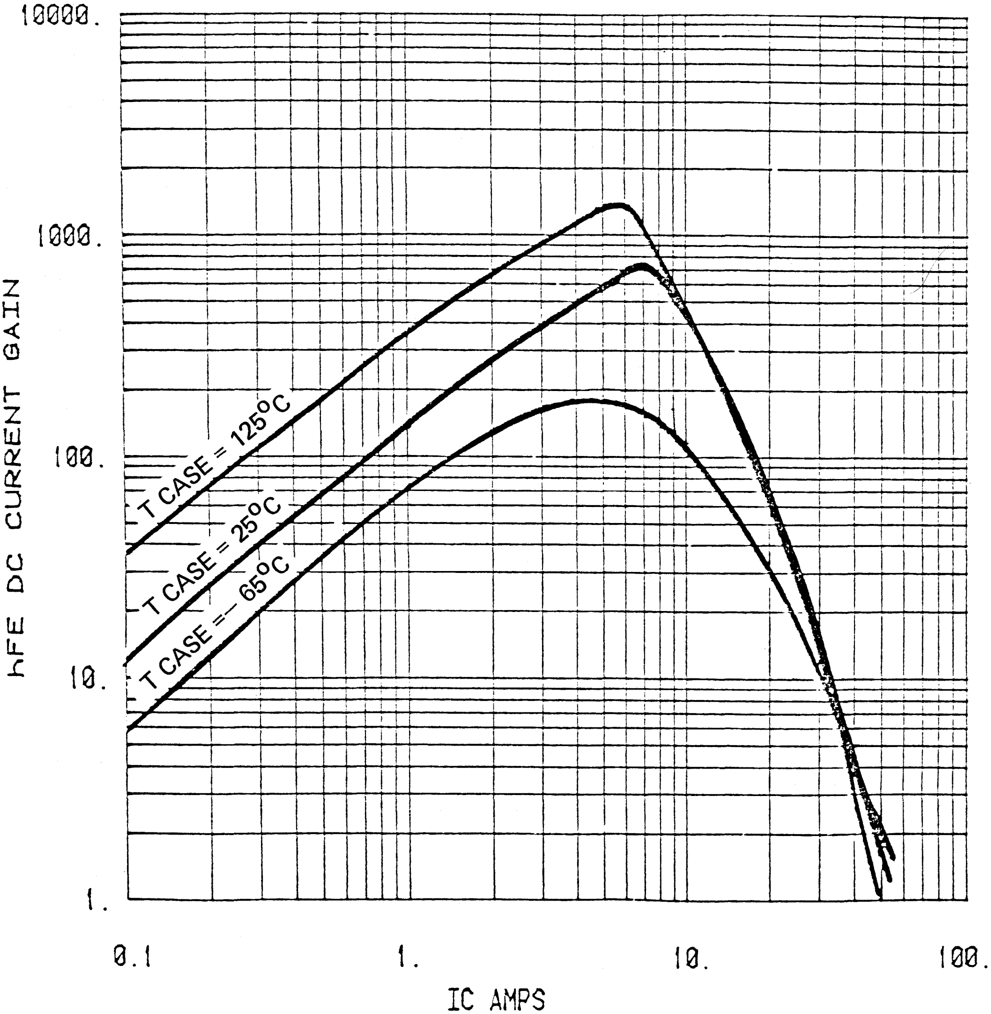


FIGURE 17 TYPICAL VARIATION OF DC CURRENT GAIN TIPL 773B

VCE = 5V

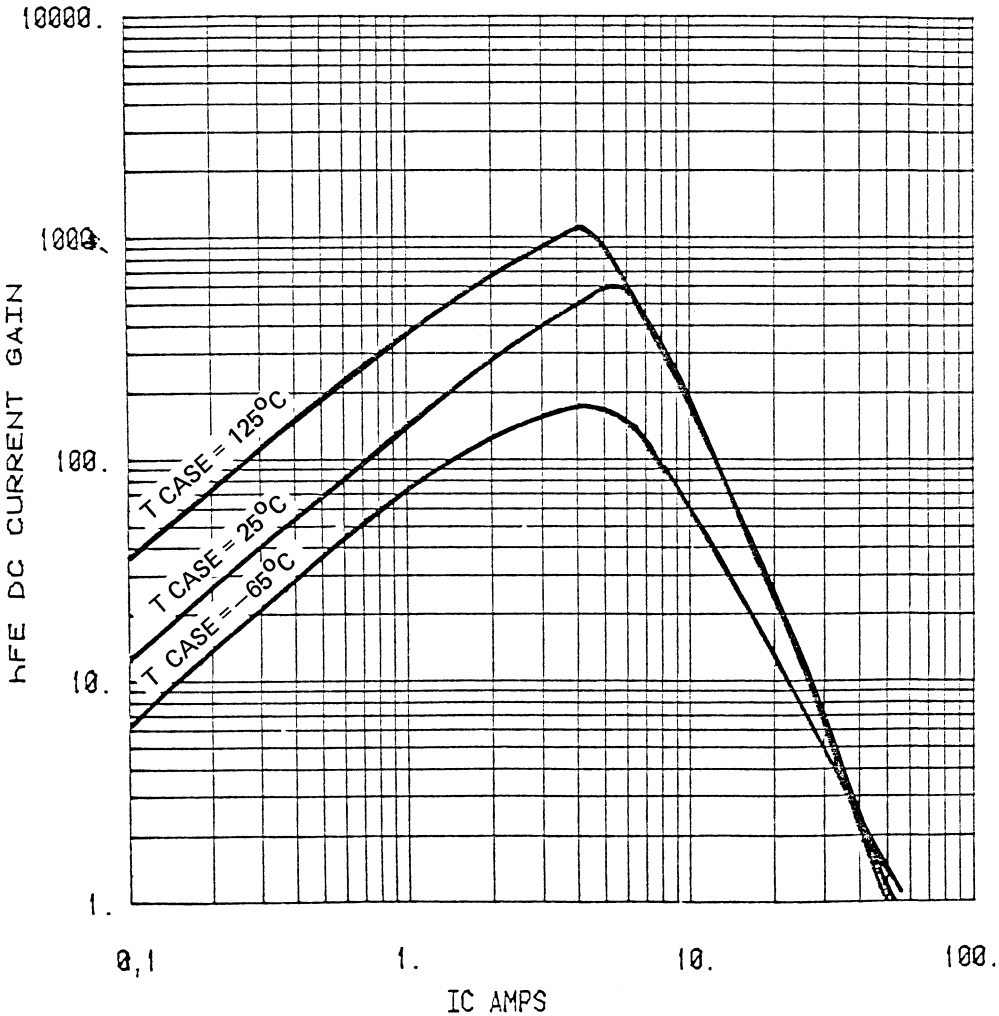


FIGURE 18 TYPICAL FORWARD VOLTAGE OF PARALLEL DIODE

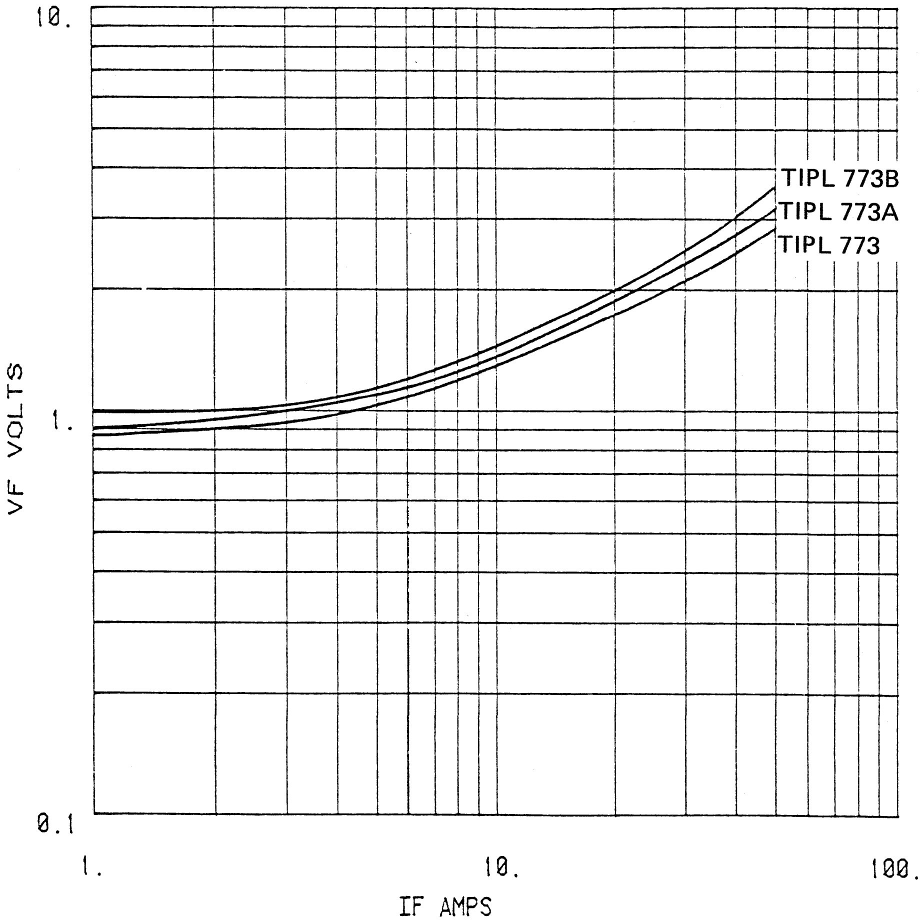


FIGURE 19 TYPICAL VARIATION OF ICES WITH TEMPERATURE FOR ALL DEVICE TYPE @ MAXIMUM RATED V_{CES}

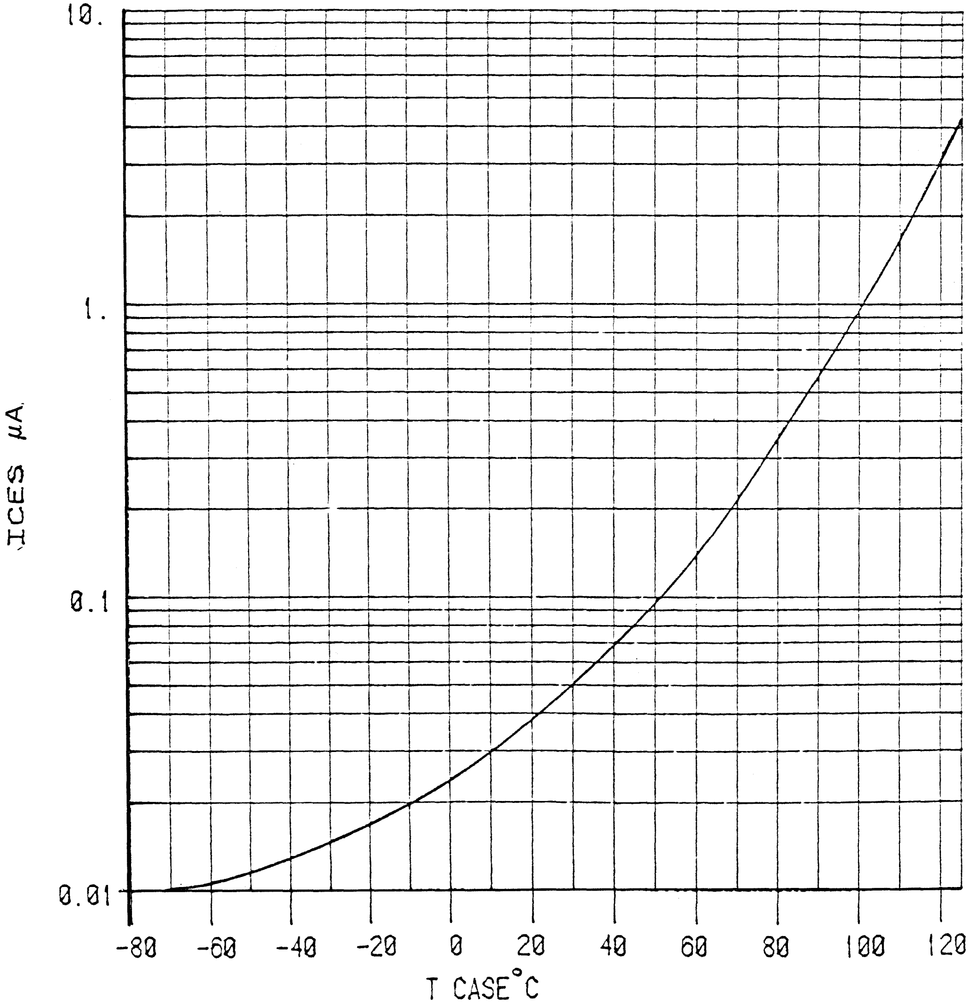


FIGURE 20 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED
T CASE = 25°C

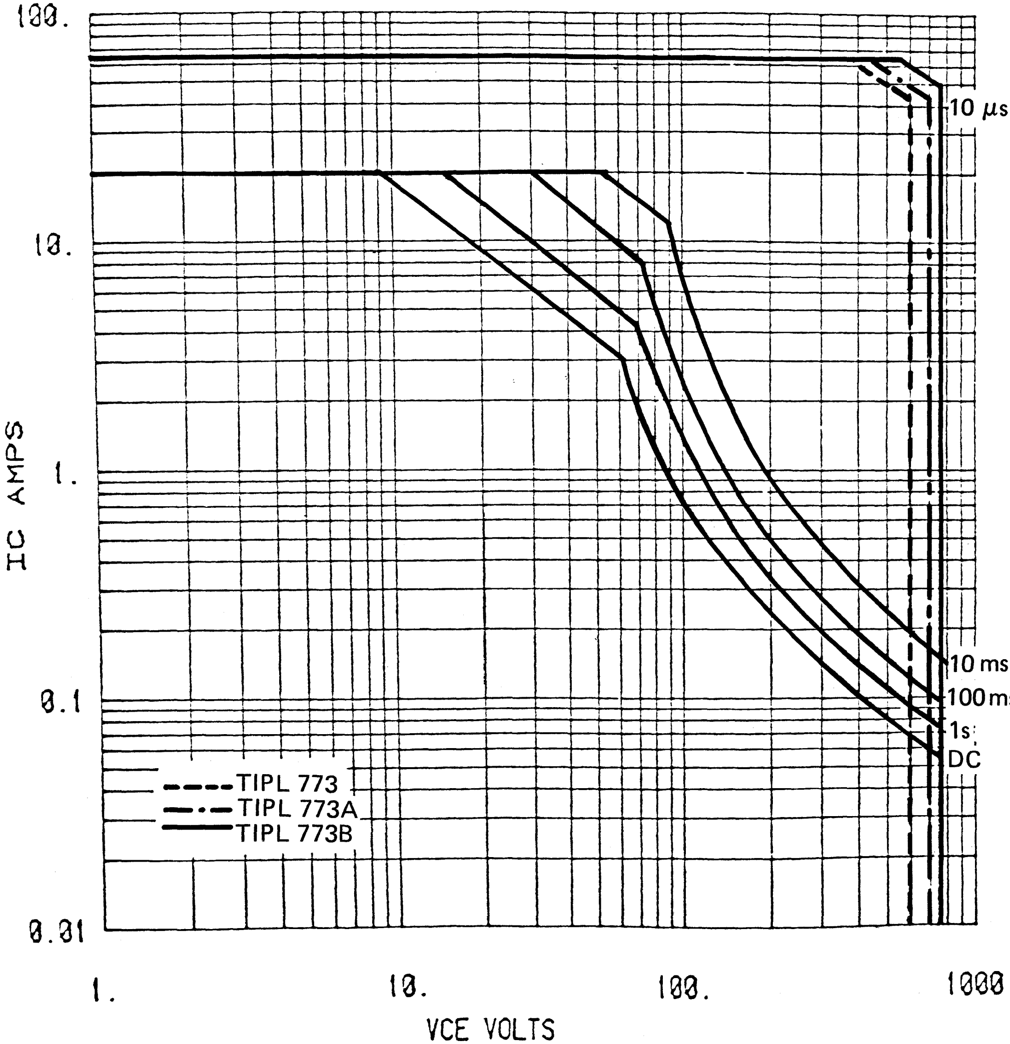


FIGURE 21 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

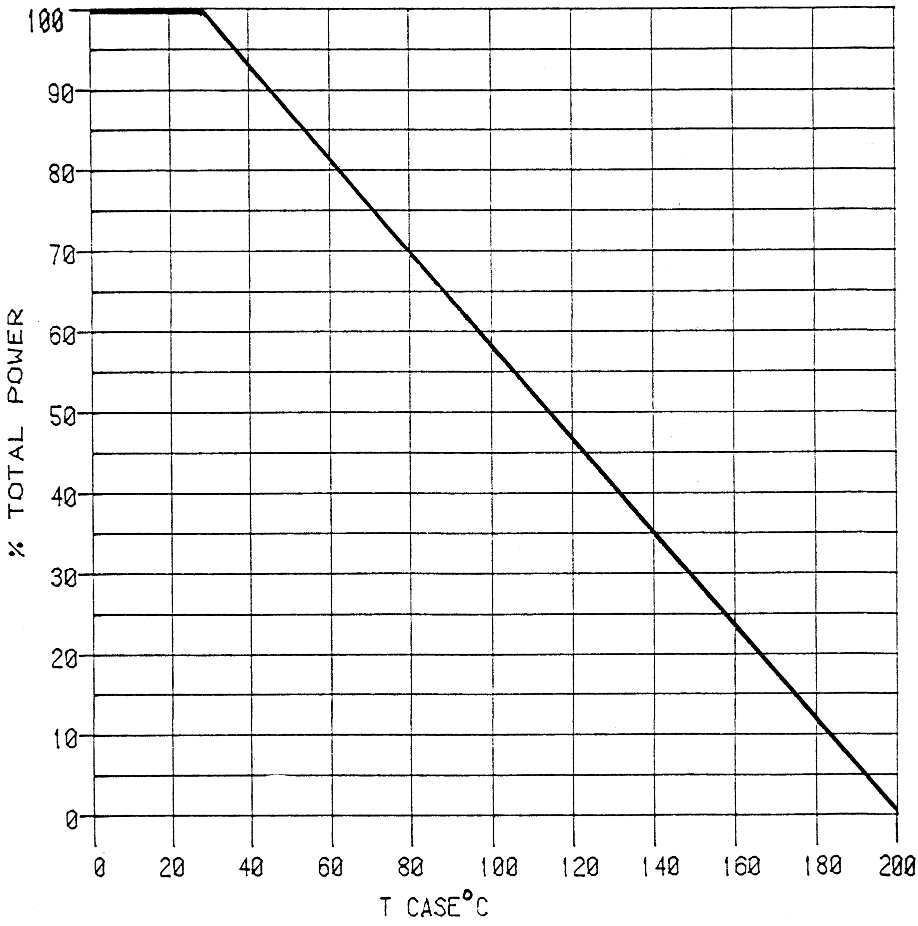


FIGURE 22 MAXIMUM REVERSE BIAS SAFE OPERATING AREA

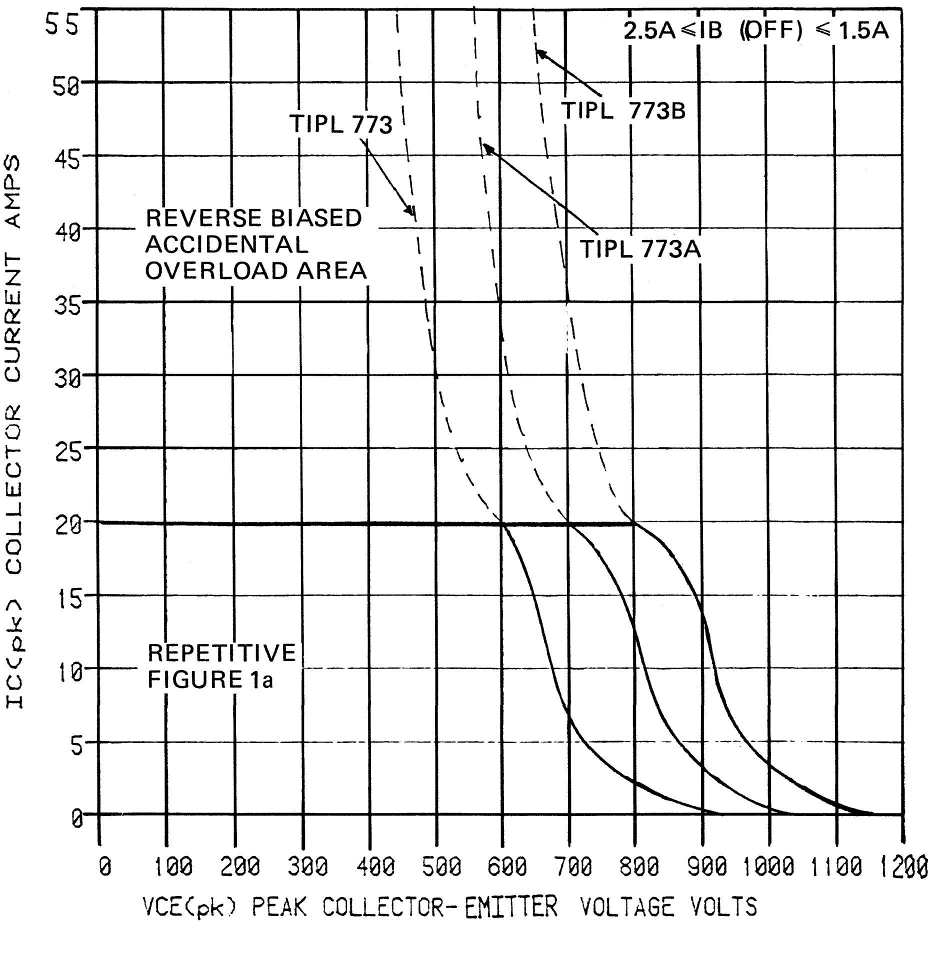


FIGURE 23 TRANSIENT 'TURN–OFF' LIMIT IC Vs VCE TIPL 773

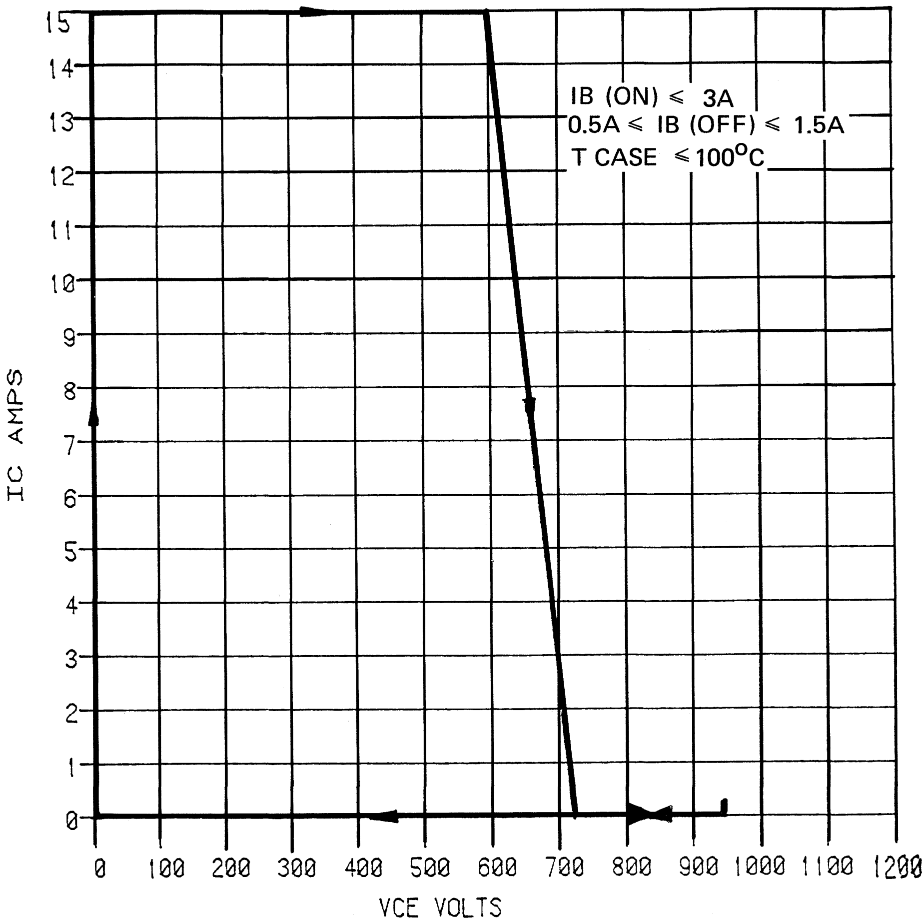


FIGURE 24 TRANSIENT 'TURN–OFF' LIMIT IC Vs VCE TIPL 773A

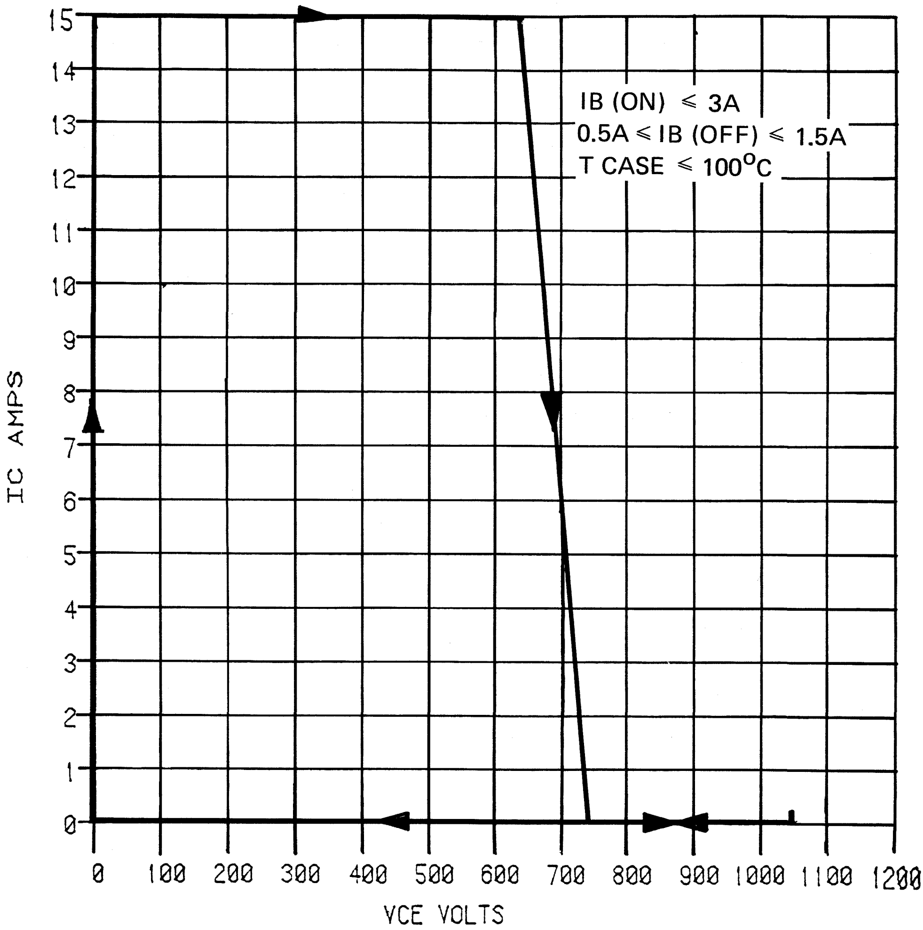


FIGURE 25 TRANSIENT 'TURN–OFF' LIMIT IC Vs VCE TIPL 773B

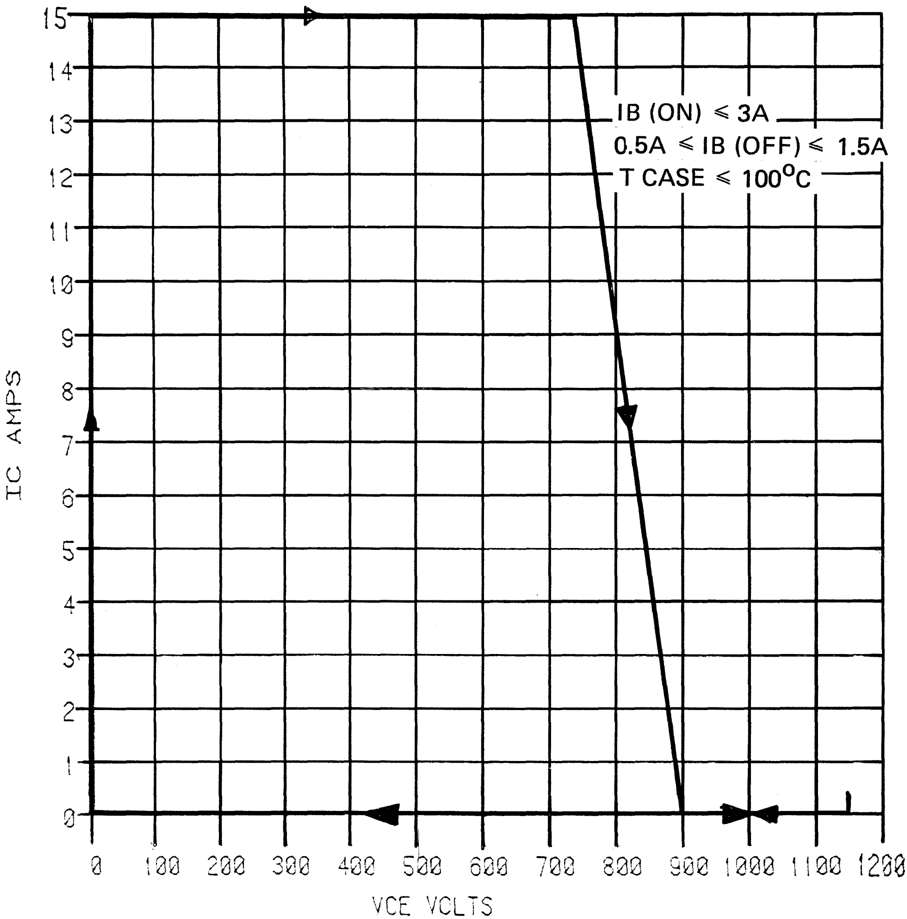
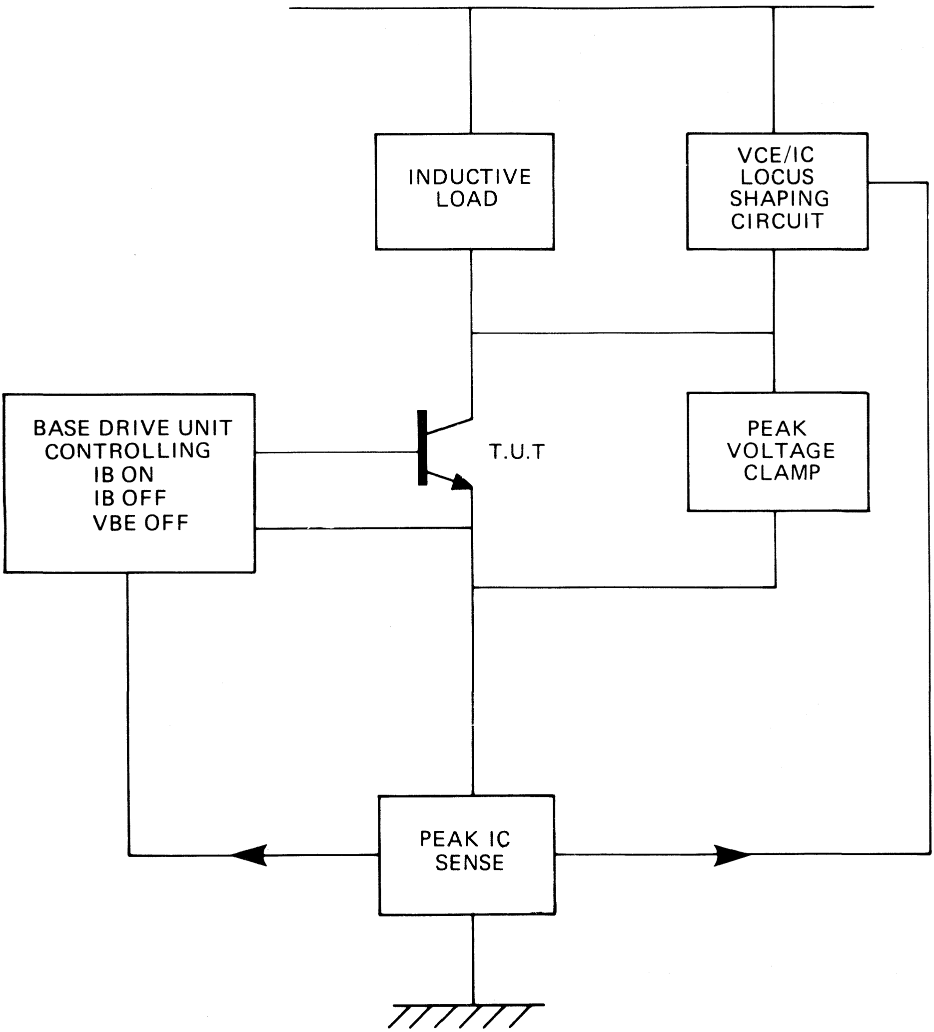


FIGURE 26 SWITCHING LOCUS TEST CIRCUIT

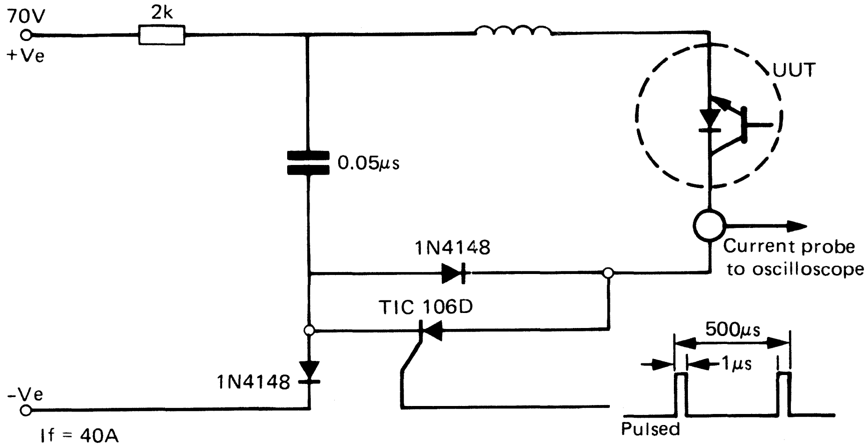


NPN SILICON TRIPLE TRANSISTOR
ADVANCED POWER DARLINGTON

FREEWHEEL DIODE CHARACTERISTICS

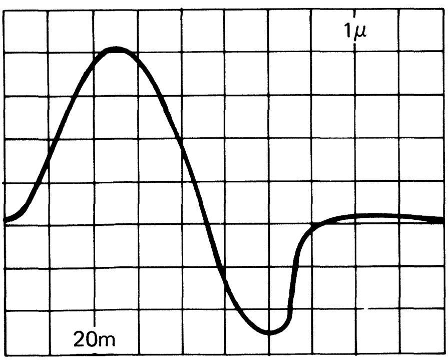
t_{rr} Typical Reverse Recovery Time
(for Circuit and Conditions See Fig 27) — All Types 2.5µs

FIG 27. TEST CONDITION OF t_{rr} MEASUREMENT



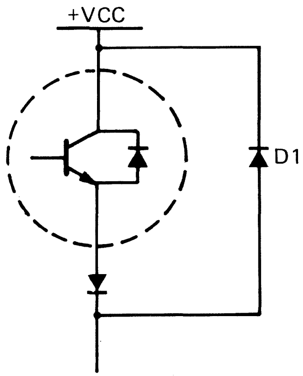
If = 40A
dI/dt = 25A/µs

FIG 28. TYPICAL t_{rr} TRACE



I = 10A/DIV
T = 1µs/DIV

FIG 29. ANTI-PARALLEL DIODE CCT.

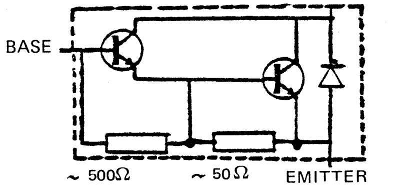


Note: For circuit configurations requiring fast diode recovery; the anti-parallel diode D1 determines the system recovery time.

TIPL774
NPN DARLINGTON CONNECTED PLANAR SILICON POWER TRANSISTOR

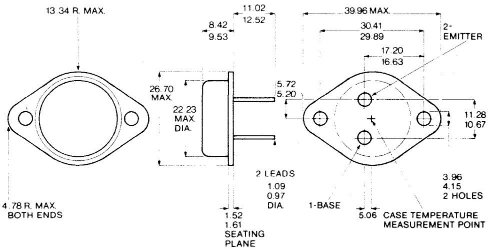
OCT 82

- HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY, DESIGNED FOR IGNITION SYSTEMS, MOTOR CONTROLS, AND SOLENOID DRIVER APPLICATIONS.
- VCEO 450V MIN
- 20A CONTINUOUS COLLECTOR CURRENT
- 150W AT 50°C CASE TEMPERATURE
- FORWARD BIAS SOA 30V, 5A
- REVERSE BIAS SOA 450V, 15A
- FORWARD PULSE ENERGY 300mJ



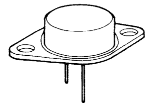
MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ABSOLUTE MAXIMUM RATINGS (AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE)

	TIPL774
Collector-Base Voltage (IE=0)	550V
Collector-Emitter Voltage (See Note 1)	450V
Emitter-Base Voltage	8V
Continuous Collector Current	20A
Peak Collector Current (See Note 2)	30A
Continuous Base Current	3A
Continuous Device Dissipation at 50°C Case Temperature (See Note 3)	150W
Continuous Device Dissipation at 25°C Free Air Temperature (See Note 4)	5.5W
Operating Collector Junction & Storage Temperature Range	-65°C to +200°C
Lead Temperature 1/8 inch (3.2mm) from Case for 10 Seconds	300°C

TIPL774
NPN DARLINGTON CONNECTED PLANAR SILICON POWER TRANSISTOR

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VCBO	Collector-Base Breakdown Voltage	IC=1mA IE=0 See Note 5	550			V
VCEO	Collector-Emitter Breakdown Voltage	IC=10mA IB=0 See Note 5	450			V
VCER (SUST)	Collector-Emitter Sustaining Voltage	IC=7A See Figure 1	450			V
ICEO	Collector Cut-Off Current	VCE=400V IB=0 VCE=400V IB=0 150°C			250 1.0	μA mA
ICES	Collector Cut-Off Current	VCE=450V VBE=0 VCE=450V VBE=0 150°C			250 1.0	μA mA
IEBO	Emitter Cut-Off Current	VEB=1V IC=0			5	mA
hFE	Static Forward Current Transfer Ratio	IC=5A VCE=10V -30°C IC=5A VCE=10V IC=5A VCE=10V 125°C See Notes 5 & 6	200 300 500			
VCE SAT	Collector Emitter Saturation Voltage	IC=5A IB=35mA IC=15A IB=1.5A See Notes 5 & 6			2.0 3.0	V V
VBE SAT	Base-Emitter Saturation Voltage	IC=5A IB=35mA See Notes 5 & 6			2.0	V
VF	Forward Voltage of Commutation Diode	IF=-IC=10A See Notes 5 & 6			3.0	V
Cob	Common-Base Open Circuit Output Capacitance	VCE=20V IE=0A F=0.1MHz		120		pF

THERMAL CHARACTERISTICS

PARAMETER		TYP	MAX	UNIT
RθJC	Junction-To-Case Thermal-Resistance		1.00	°C/W
RθJA	Junction-To-Free-Air Thermal Resistance		32	°C/W
RθCHS	Case-To-Heat-Sink Thermal Resistance (See Note 7)	0.4		°C/W
CθC	Thermal Capacitance of Case	5.3		J/°C

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE

PARAMETER		TEST CONDITIONS	TYP	MAX	UNIT
ton	Delay Time & Rise Time	IC=5A IB(1)=70mA		5	μs
ts	Storage Time	VBE(off)=0V R=100Ω(See Figure 2)		20	μs
tf	Fall Time			10	μs

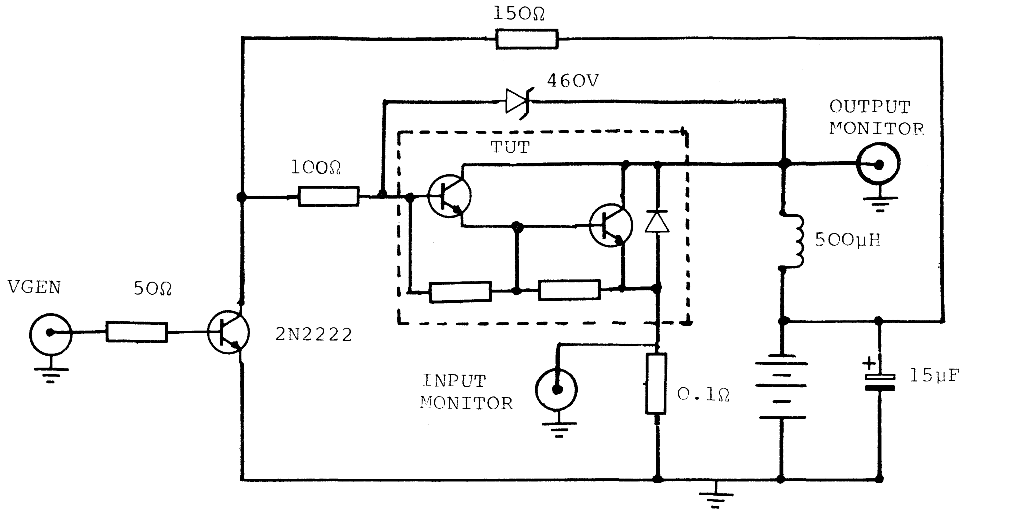
FUNCTION TESTS AT 25°C FREE-AIR TEMPERATURE

TEST	CONDITIONS	MAX	UNIT
Forward Pulse Energy $\frac{I_C^2 L}{2}$	ICM=7A L=12mH VCLAMP=400V f= 75Hz T TEST=1s (See Figure 3)	300	mJ

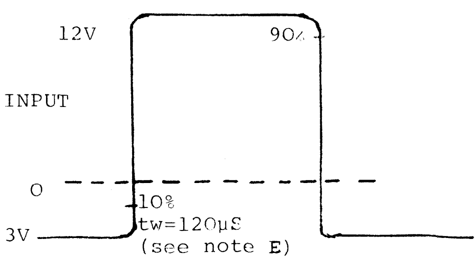
NOTES
1. These values apply when the Base-Emitter Diode is reverse-biased or open-circuited.
2. This value applies for, tw≤5ms, Duty Cycle≤10%.
3. Derate linearly to 200°C case temperature at the rate of 1W/°C or refer to dissipation derating curve, Figure 8.
4. Derate linearly to 200°C free-air temperature at the rate of 31.4 mW/°C or refer to dissipation derating curve, Figure 9.
5. These Parameters must be measured using pulse techniques, tw=300μS, Duty Cycle≤2%.
6. These Parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located with 0.125 inch (3.20 mm) from the device body.
7. This Parameter is measured using a 0.003 inch (0.08mm) mica insulator with Dow Corning 11 compound on both sides of the insulator with 0.138-32 mounting screws with bushings, and a mounting torque of 8 inch-pounds (0.9 newton meters).
8. This combination of maximum voltage and current may be achieved only when switching from saturation to cut-off with a clamped inductive load as in Figure 1, VBB=0, RBB=100Ω.

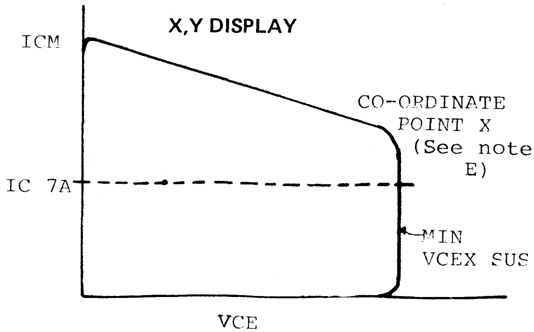
TIPL774
NPN DARLINGTON CONNECTED PLANAR SILICON POWER TRANSISTOR

FIGURE. 1 COLLECTOR EMITTER SUSTAINING VOLTAGE TEST CIRCUIT



INPUT WAVE FORM





NOTES.

A. THE V GEN WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS:
tr = 15ns, tf = 15ns, Z out = 50Ω, tw = 120μs, DUTY CYCLE = 2%

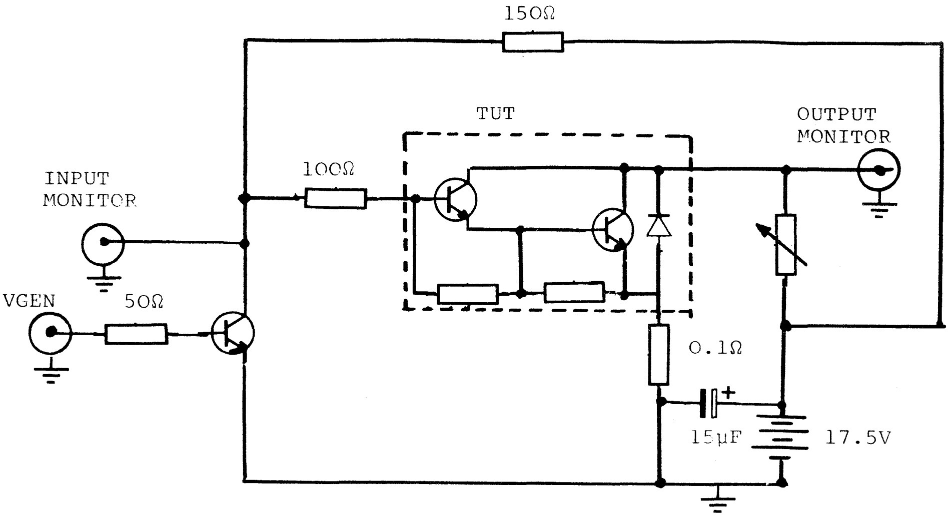
B. WAVEFORMS ARE MONITORED ON AN X–Y OSCILLOSCOPE WITH THE FOLLOWING CHARACTERISTICS:
tr = 15ns, Rin = 10M, Cin = 11.5pF.

C. RESISTORS MUST BE NON–INDUCTIVE TYPES.

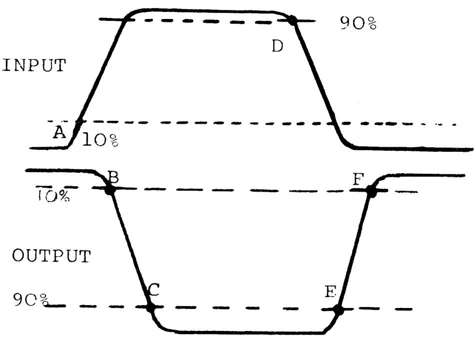
D. THE D–C POWER SUPPLIES MAY REQUIRE ADDITIONAL BY–PASSING IN ORDER TO MINIMISE RINGING.

E. ADJUST INPUT PULSE WIDTH UNTIL COLLECTOR CURRENT IS 12A AT POINT 'X', ICM MUST NOT EXCEED 30A

FIGURE. 2 SWITCHING TIME TEST CIRCUIT



VOLTAGE WAVE FORMS



A - B = td
B - C = tr
D - E = ts
E - F = tf

NOTES.

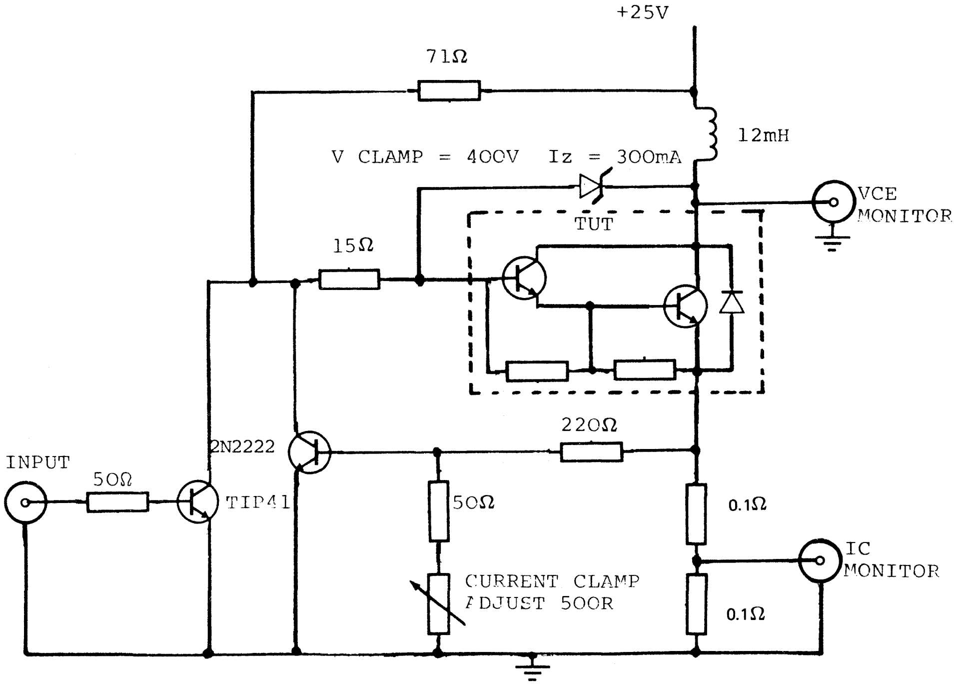
A. THE V GEN WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS:
tr = 15ns, tf = 15ns, Z out = 50Ω, tw = 120μs, DUTY CYCLE = 2%

B. WAVEFORMS ARE MONITORED ON AN X–Y OSCILLOSCOPE WITH THE FOLLOWING CHARACTERISTICS:
tr = 15ns, Rin = 10M, Cin = 11.5pF.

C. RESISTORS MUST BE NON–INDUCTIVE TYPES;

D. THE D–C POWER SUPPLIES MAY REQUIRE ADDITIONAL BY–PASSING IN ORDER TO MINIMISE RINGING.

FIGURE. 3 FORWARD PULSE ENERGY CIRCUIT

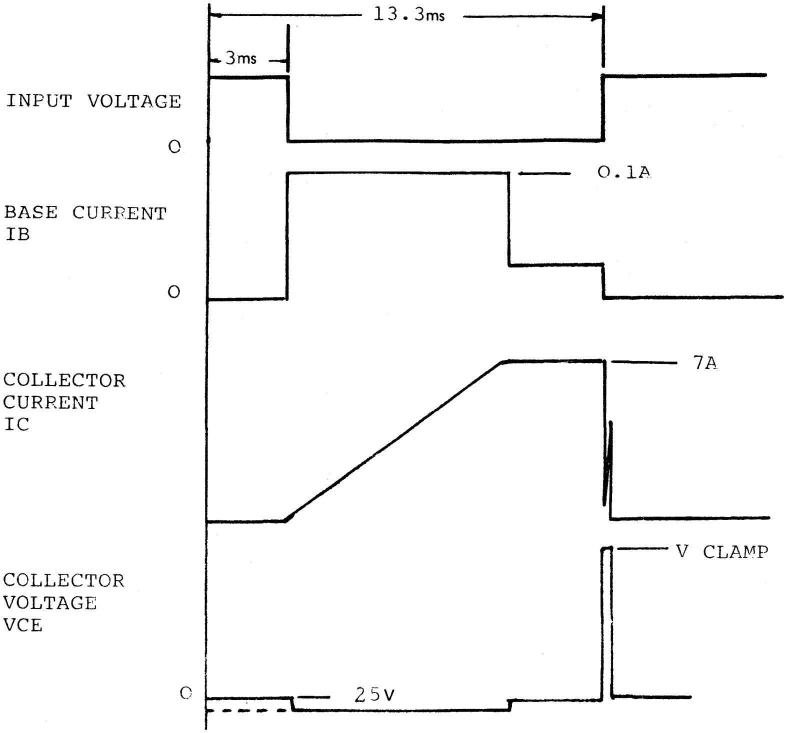


NOTES.

A. BASE AND COLLECTOR CURRENTS ARE MEASURED USING PROBES SUCH AS TEKTRONIX TYPES P6019, P6020, P6042, OR THE EQUIVALENT.

B. WAVEFORMS ARE MONITORED ON AN OSCILLOSCOPE WITH THE FOLLOWING CHARACTERISTICS $tr \leq 20ns$, $Rin \geq 10M\Omega$, $Cin \leq 11.5pF$.

FIGURE. 3 (CONT.) FORWARD PULSE ENERGY WAVE FORMS



COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVE FORM DETAIL

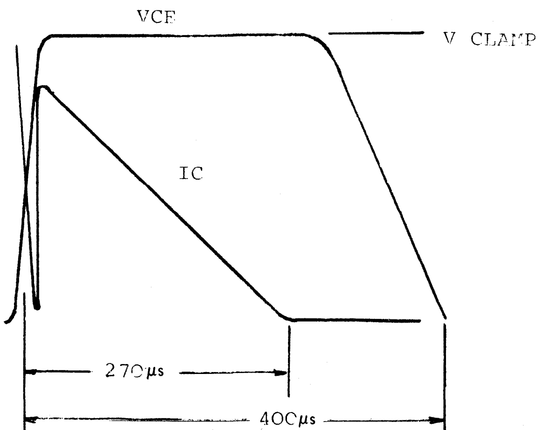


FIGURE. 4 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

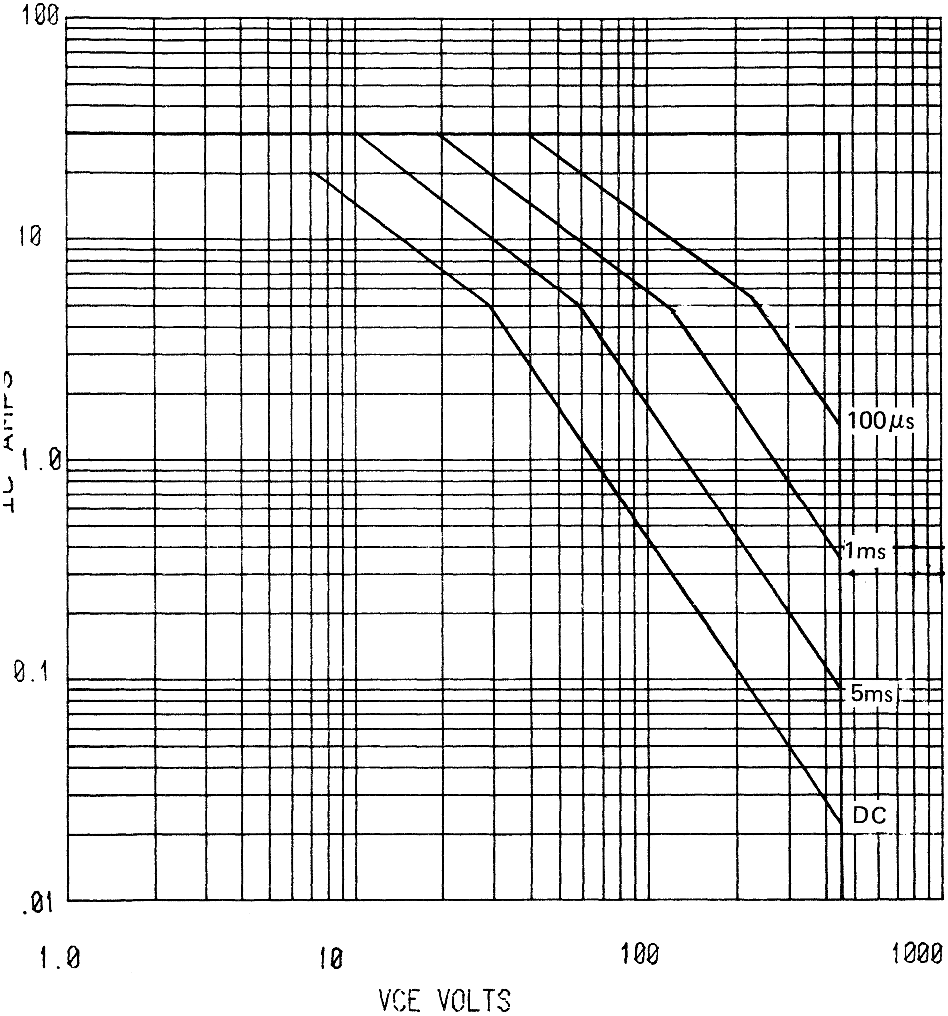


FIGURE. 5 MAXIMUM IC VS CLAMPED VCE (REVERSE BASE BIAS)

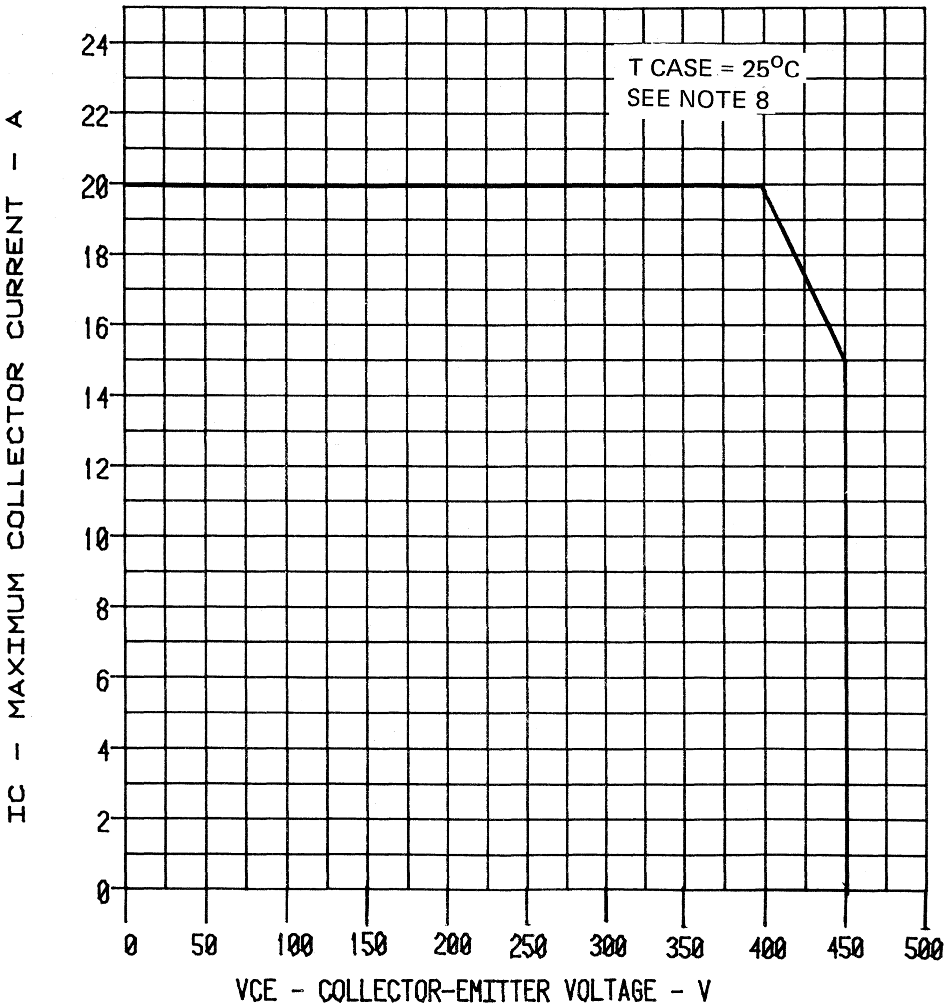


FIGURE. 6 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

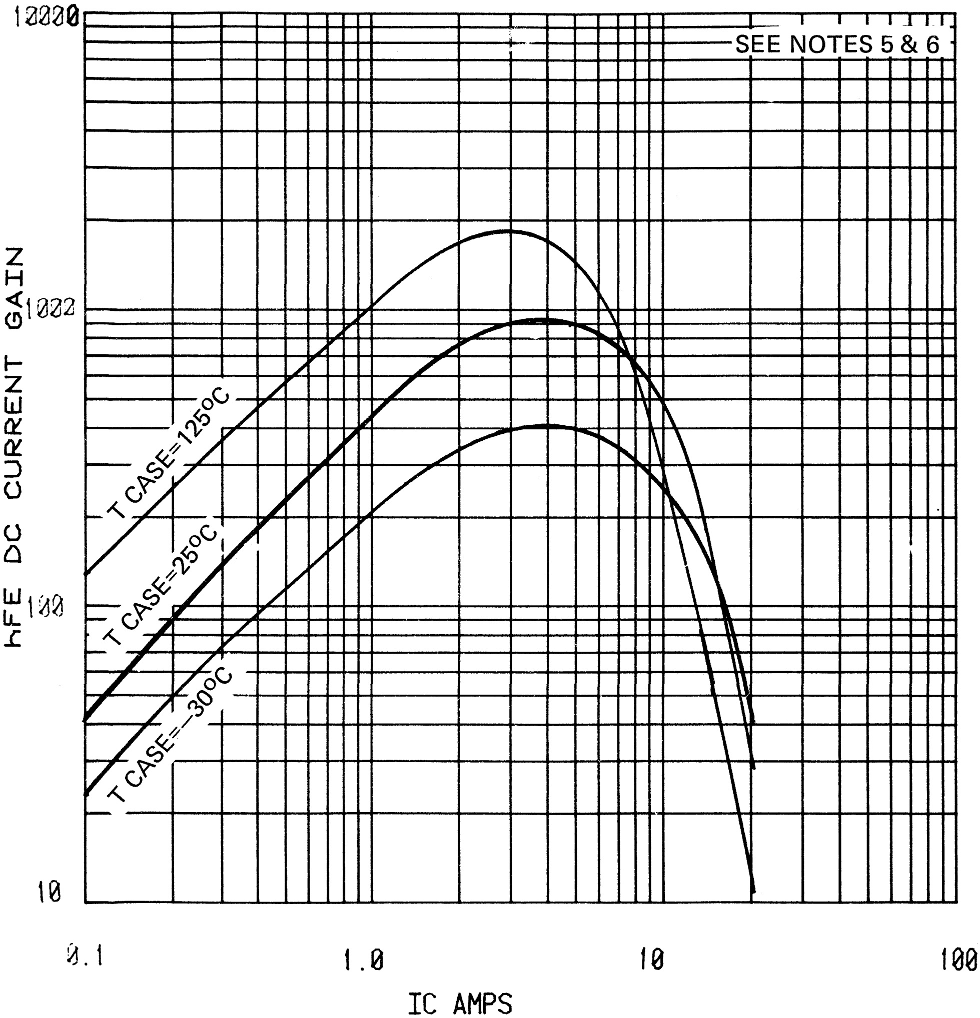


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

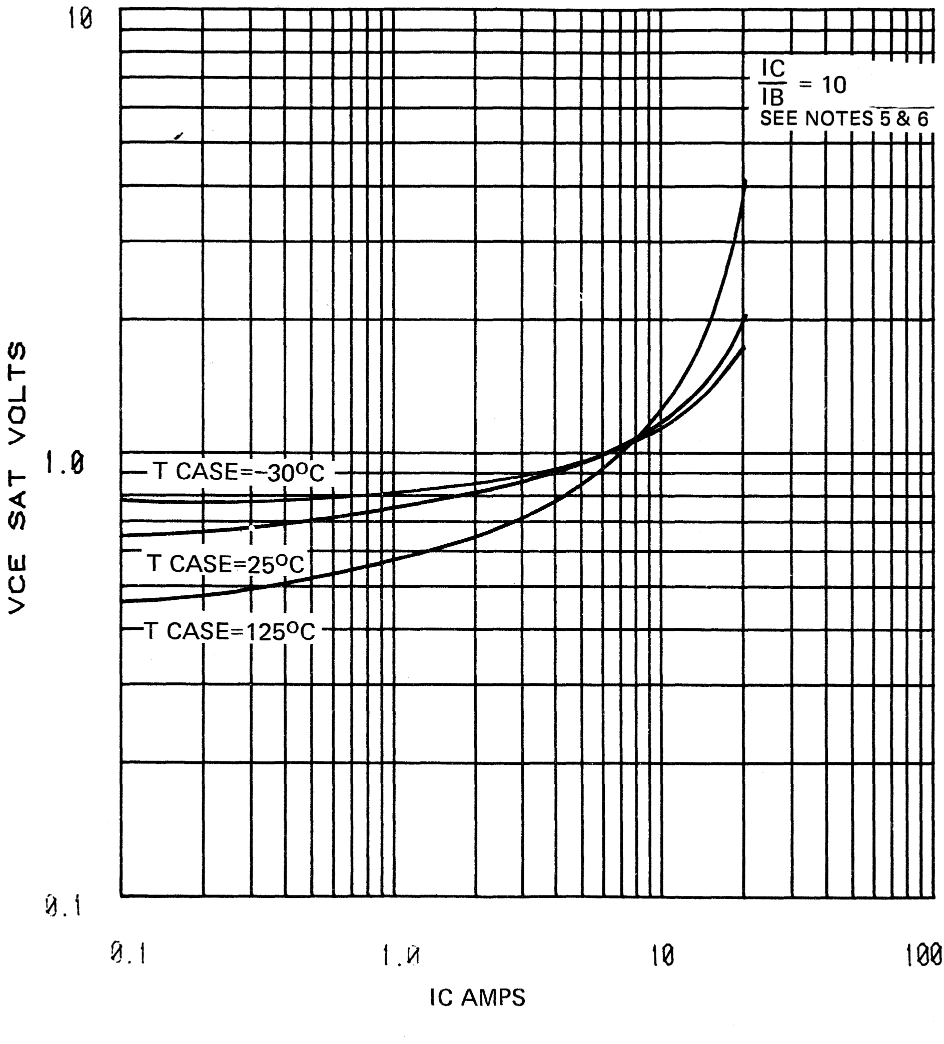


FIGURE. 8 CASE TEMPERATURE DISSIPATION DERATING CURVE

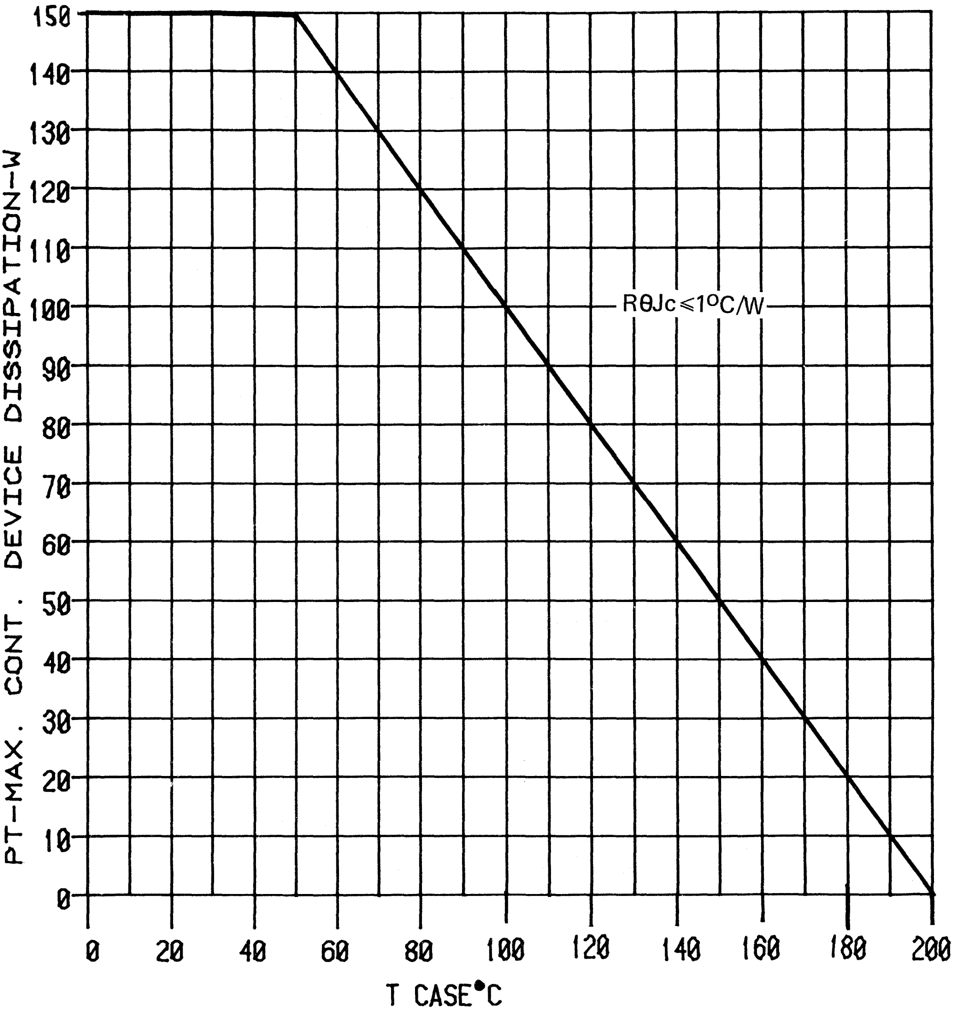
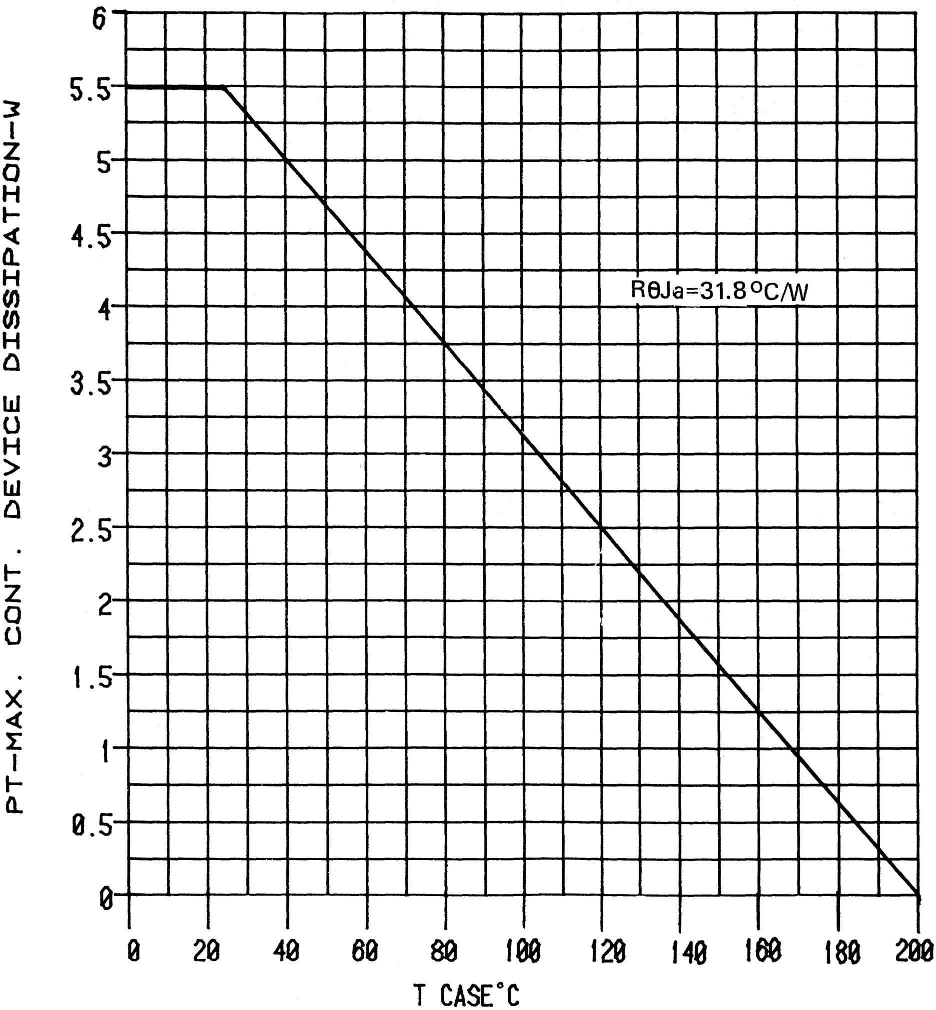


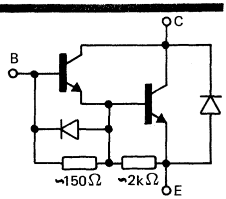
FIGURE. 9 FREE AIR TEMPERATURE DISSIPATION DERATING CURVE



TIPL775, TIPL775A
MONOLITHIC DARLINGTON CONNECTED NPN SILICON POWER TRANSISTOR

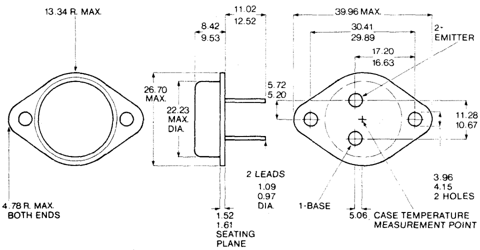
OCT 82

- RUGGED EPITAXIAL PLANAR CONSTRUCTION.
- SPECIFICALLY DESIGNED FOR LOW LOSS, HIGH CURRENT, HIGH SPEED SWITCHING APPLICATIONS.
- txo TYPICALLY 320ns, IC=10A.
- OPERATING CHARACTERISTICS FULLY GUARANTEED AT 100°C.
- ICES BETTER THAN 1mA AT MAXIMUM RATED VCE AT 100°C.
- VCEO(sust) 150V MIN TIPL775A – 120V MIN TIPL775.



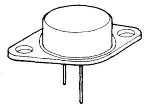
MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TIPL775	TIPL775A
Collector-Base Voltage (IE=0)	150V	200V
Collector-Emitter Voltage (VBE=0)	150V	200V
Collector-Emitter Voltage (Open Base)	120V	150V
Base-Emitter Voltage	8V	
Continuous Collector Current	10A	
Peak Collector Current (Note 1)	15A	
Peak Parallel Diode Forward Current (Note 1)	10A	
Continuous Dissipation at 25°C CASE	100W	
Operating Junction & Storage Temperature	-65°C to +200°C	

NOTE 1 : Pulse Test, Pulse Duration ≤ 2ms.

TEXAS INSTRUMENTS

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VCBO	Collector Base Breakdown Voltage Note 2	TIPL775 TIPL775A	150 200			V V
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 3	IC=100mA TIPL775 L=25mH TIPL775A	120 150			V V
ICEV	Collector Cut-Off Current	VCE=150V TIPL775 VCE=200V TIPL775A 1.5V<VEB<8V			50 50	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=150V TIPL775 VCE=200V TIPL775A VCE=150V 100°C TIPL775 VCE=200V 100°C TIPL775A			50 50 1 1	μA μA mA mA
ICEO	Collector Cut-Off Current	VCE=120V TIPL775 VCE=150V TIPL775A			50 50	μA μA
IEBO	Emitter Cut-Off Current	VEB=5V IC=0			4	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 2 & 4	IC=4A IB=0.02A IC=7A IB=0.03A IC=10A IB=0.05A IC=10A IB=0.05A 100°C			1.2 1.5 2.0 2.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 2 & 4	IC=4A IB=0.02A IC=7A IB=0.03A IC=10A IB=0.05A IC=10A IB=0.05A 100°C			1.8 1.9 2.2 2.1	V V V V
VF	Parallel Diode Forward Voltage Notes 2 & 4	IC=10A			3.0	V
hFE	Forward Current Transfer Ratio Notes 2 & 4	VCE=5V IC=500mA	60		500	
ft	Forward Current Band-Width Product	IC=500mA } F=1MHz VCE=10V(dc) } GAIN=UNITY		10		MHz
Cob	Output Capacitance	VCB=20V IE=0A F=0.1MHz		90		pF
Rθjc	Thermal Resistance Junction-Case	TIPL775/A			1.75	°C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INDUCTIVE LOAD (SEE FIGURES 1 to 4)						
tsi	Current Storage Time	IC=10A IBon=0.05A VEBoff=5V, IBoff≥2.5A		450	700	ns
trv	Voltage Rise Time			160	250	ns
tfi	Current Fall Time			250	400	ns
tti	Current Tail Time			280	450	ns
txo	Crossover Time			320	500	ns

NOTE 2. These Parameters are measured using pulse techniques
Pulse Width=300μs, Duty Cycle=2%

NOTE 3. Inductive Loop Switching Measurement

NOTE 4. These Parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE. 1 INDUCTIVE SWITCHING PARAMETERS
TYPICAL DELAY TIME USING RECOMMENDED BASE DRIVE, Tcase=25°C

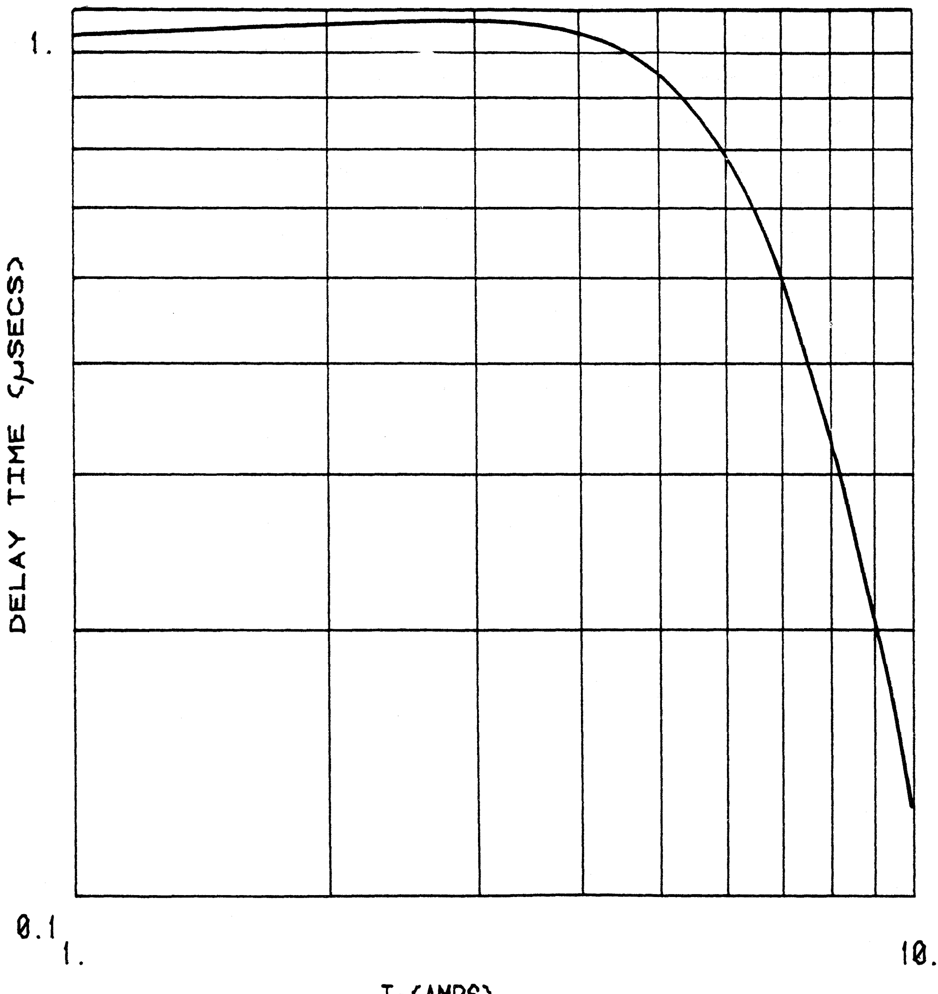


FIGURE. 2 INDUCTIVE SWITCHING PARAMETERS
TYPICAL RISE TIME(I) USING RECOMMENDED BASE DRIVE, Tcase=25°C

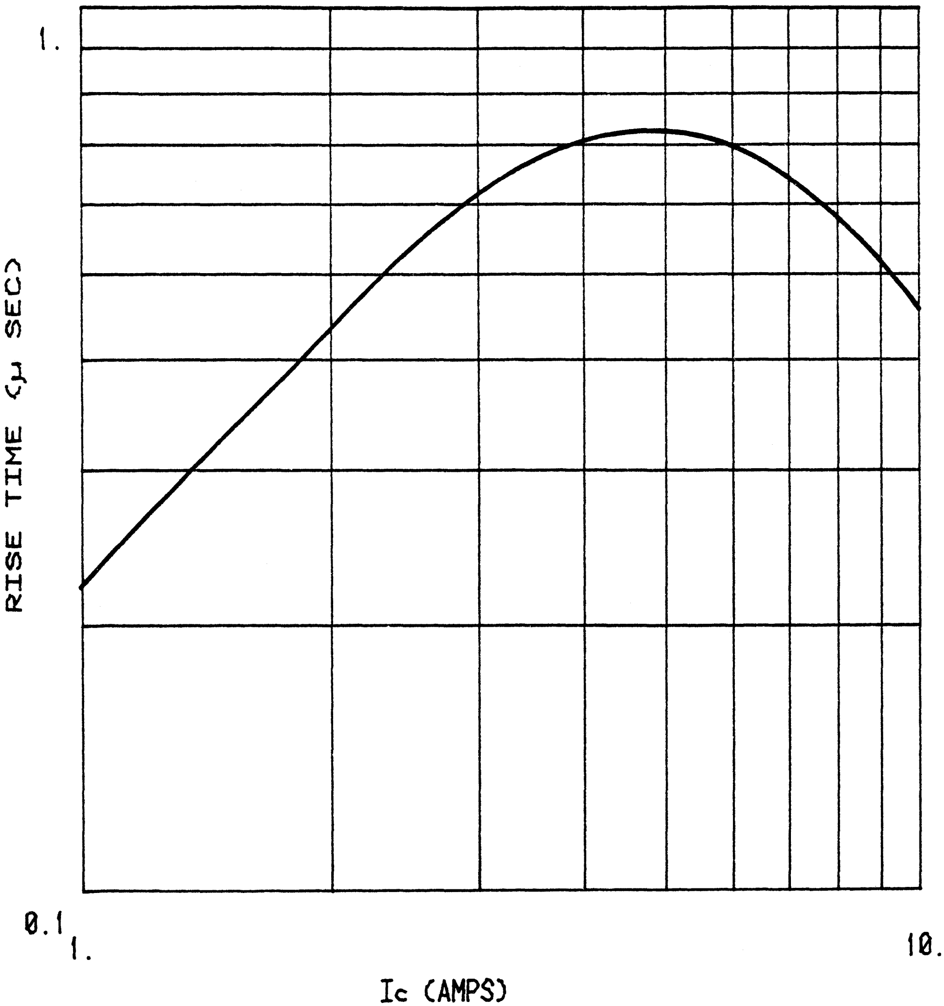


FIGURE. 3 INDUCTIVE SWITCHING PARAMETERS
RECOMMENDED BASE DRIVE T case= 25°C TO 100°C

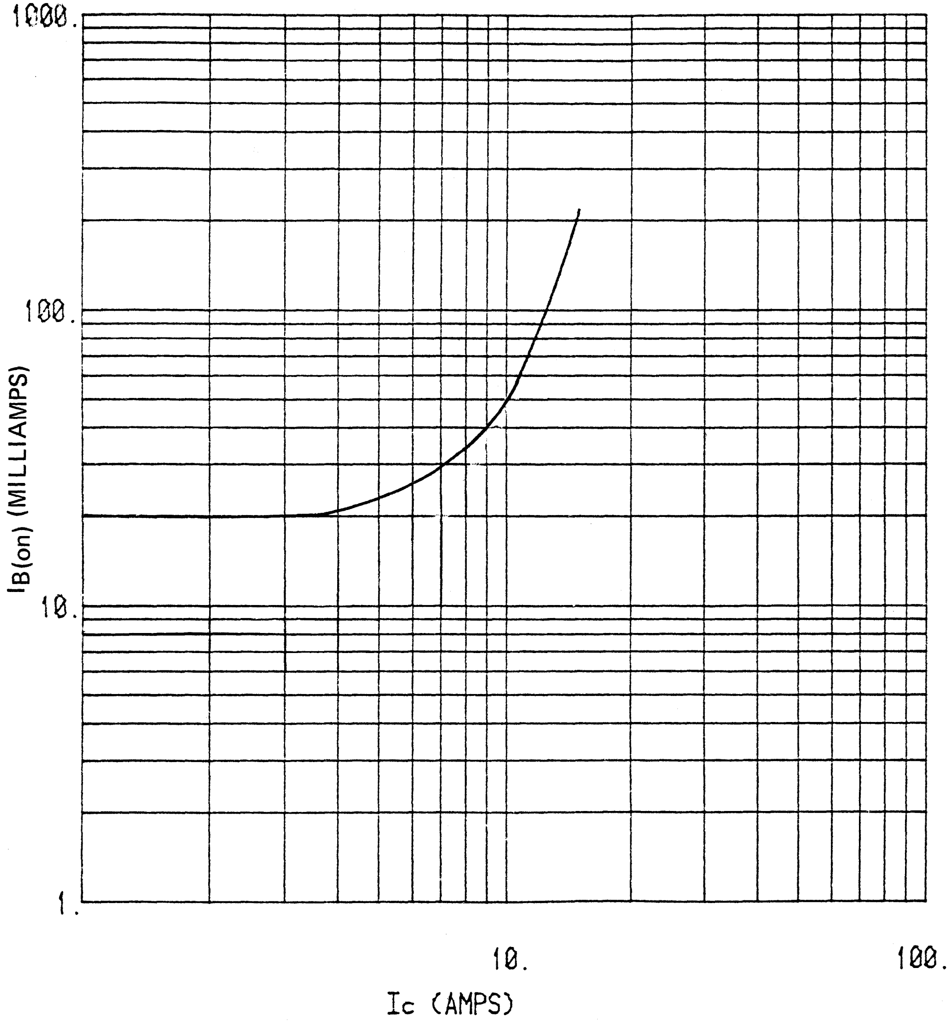


FIGURE. 4 COLLECTOR CIRCUIT USED TO MEASURE INDUCTIVE SWITCHING PARAMETERS

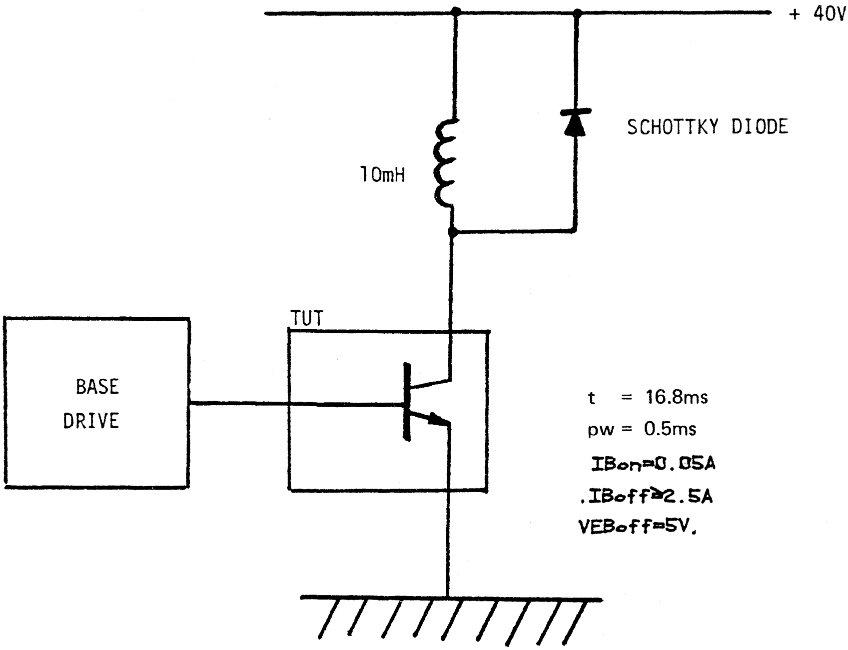


FIGURE. 5 TYPICAL COLLECTOR SATURATION REGION Tcase = 100°C

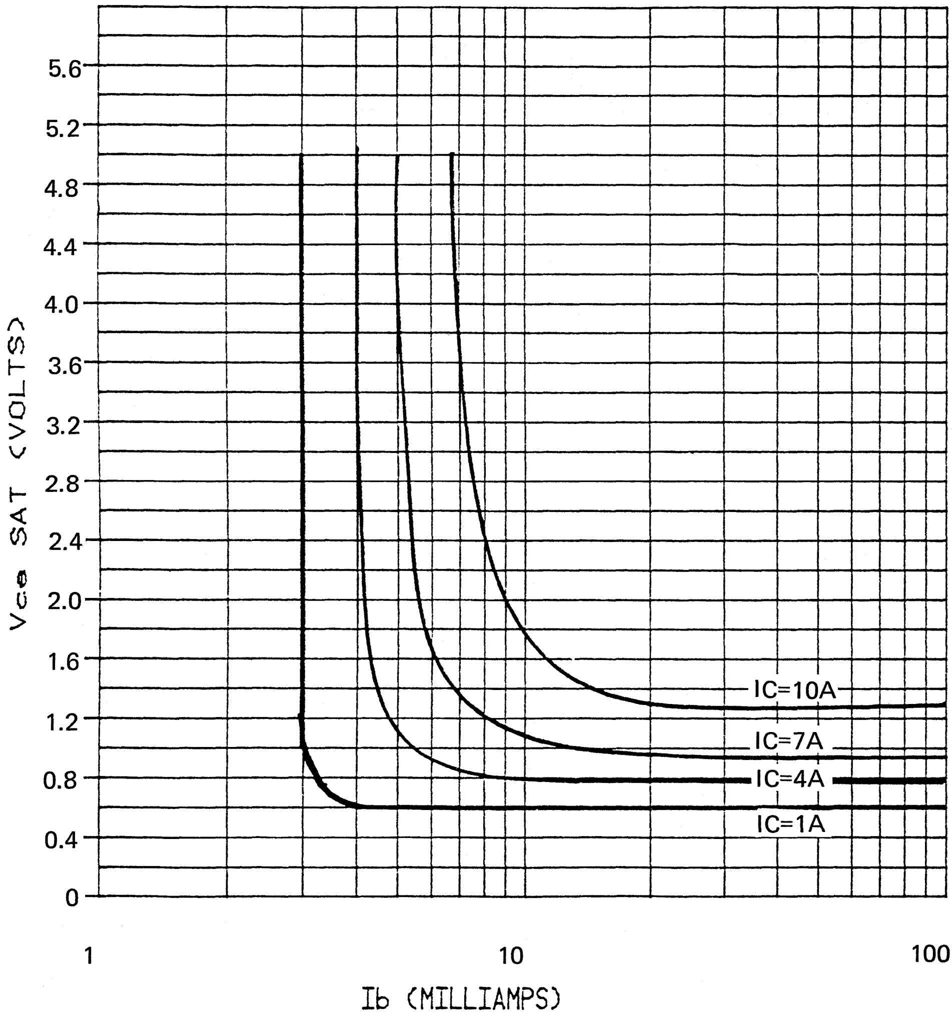


FIGURE. 6 TYPICAL BASE SATURATION REGION, Tcase=25°C

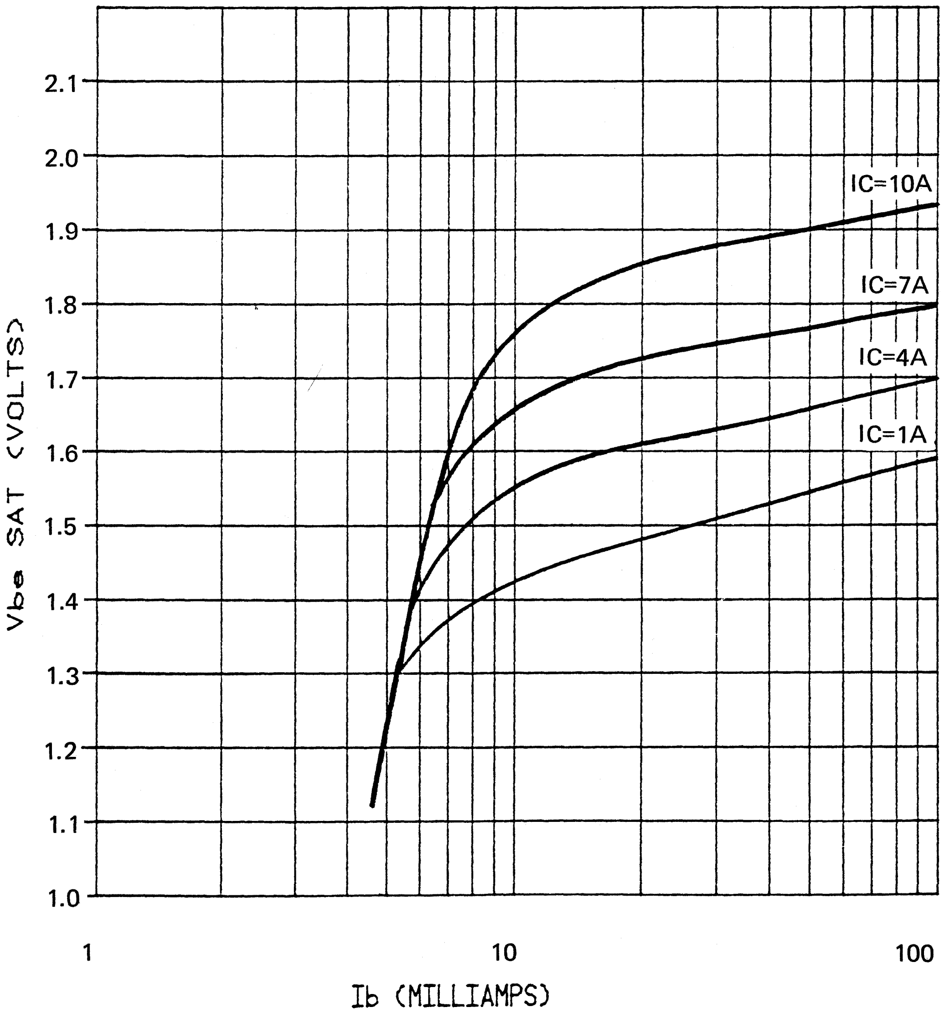


FIGURE. 7 TYPICAL VARIATION OF DC CURRENT GAIN Vce=5V

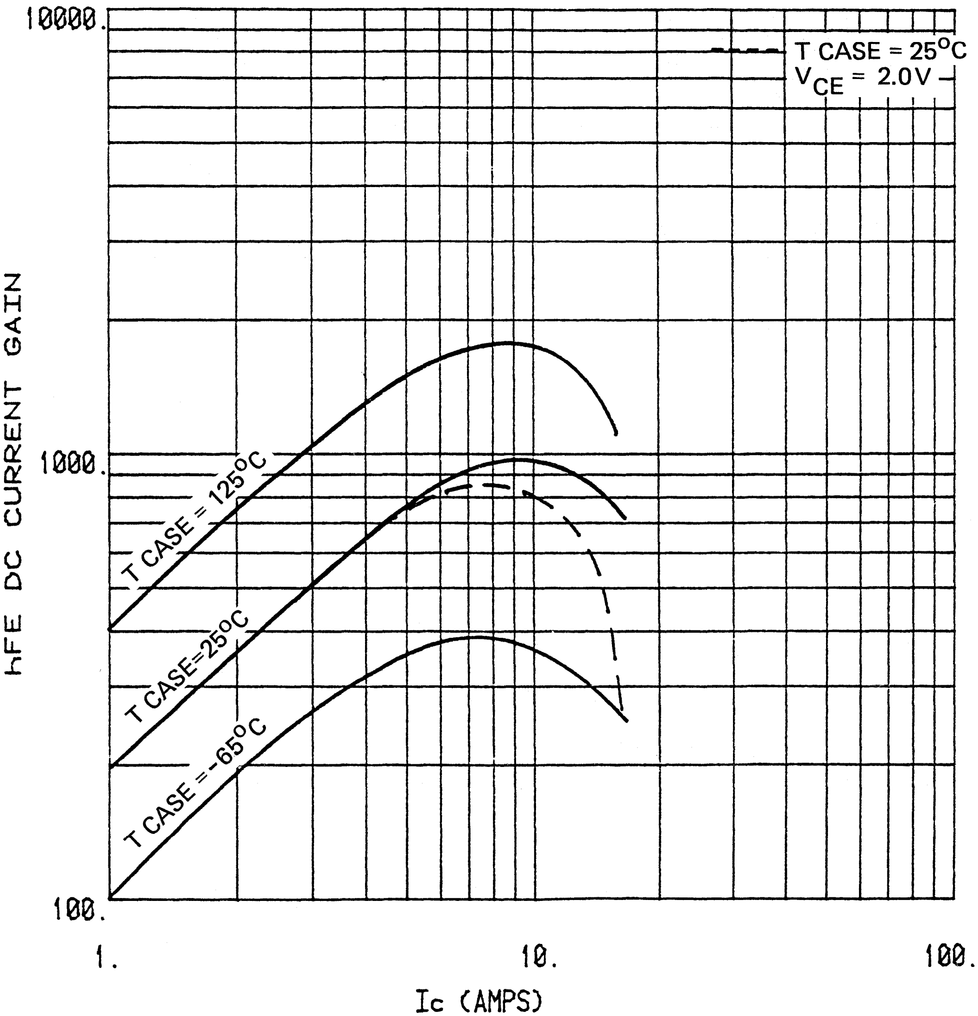


FIGURE. 8 TYPICAL VARIATION OF ICES WITH TEMPERATURE

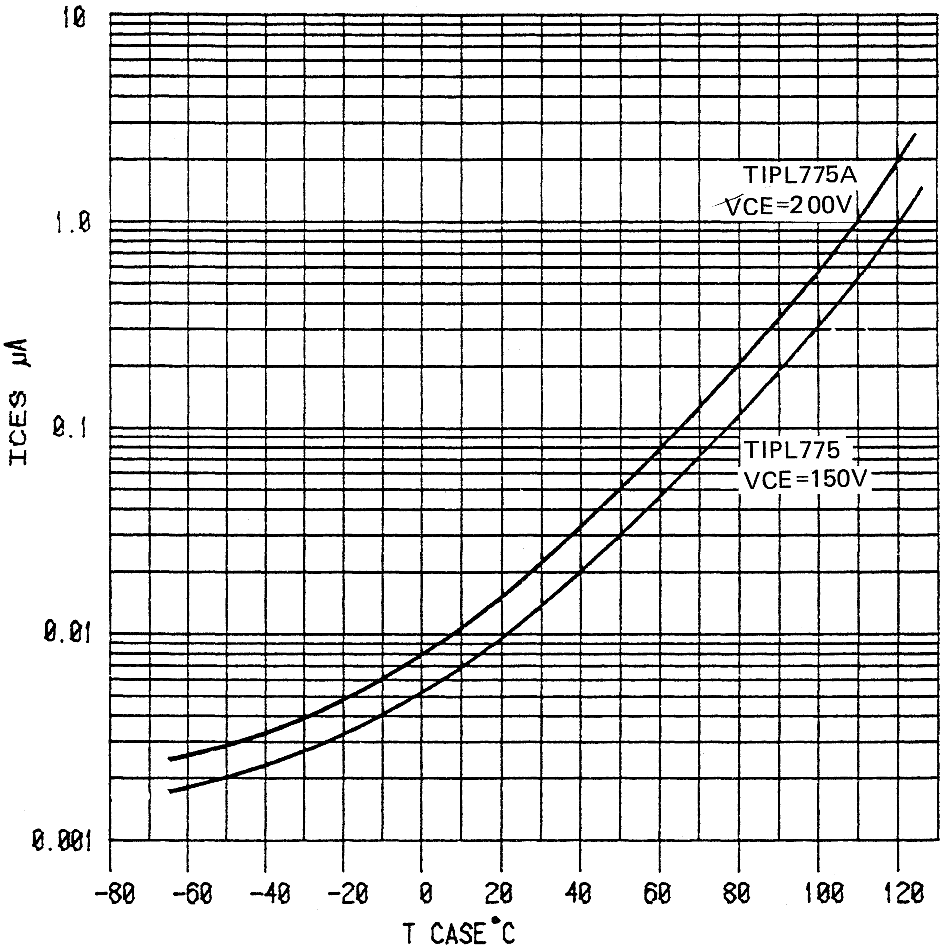


FIGURE. 9 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED Tcase=25°C

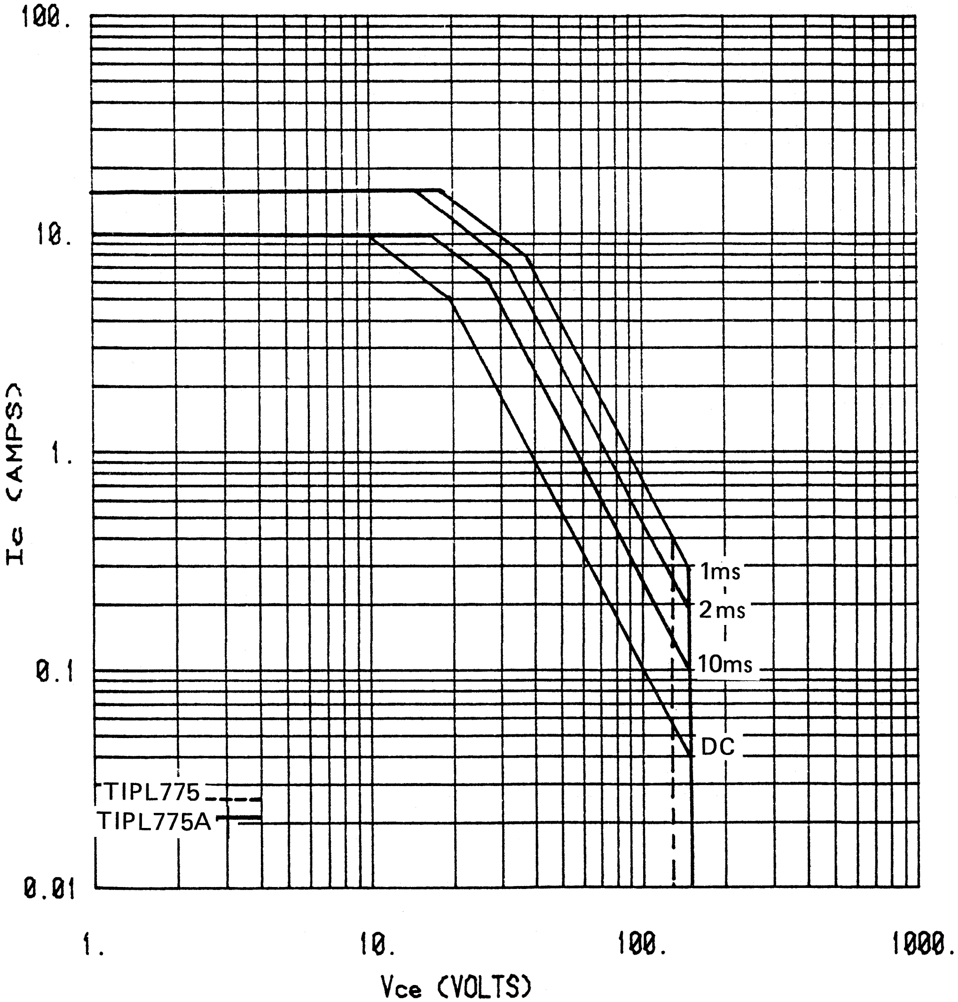
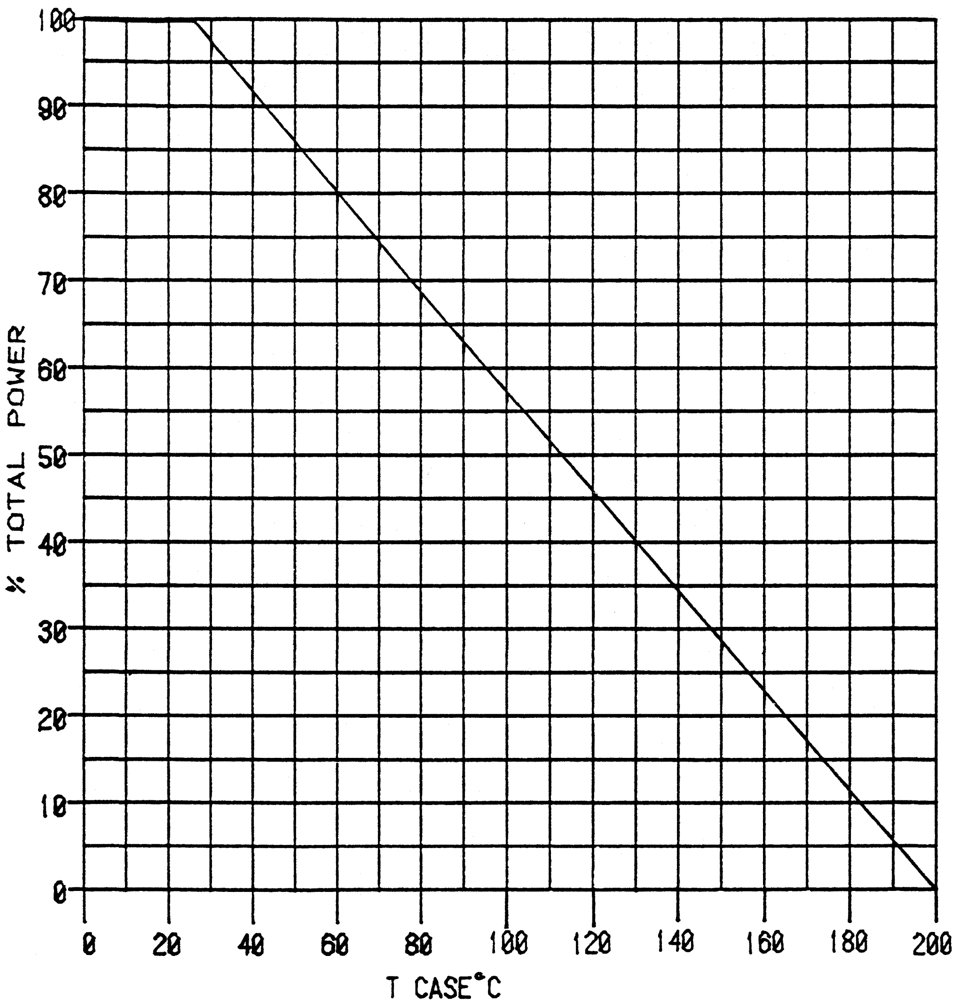
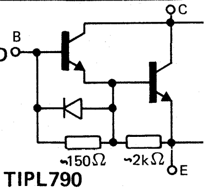


FIGURE. 10 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE



TIPL785A, TIPL790A
MONOLITHIC DARLINGTON CONNECTED NPN SILICON POWER TRANSISTOR

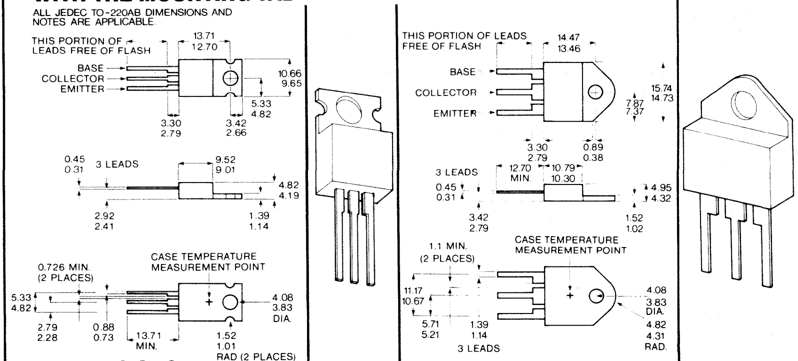
OCT 82



- RUGGED EPITAXIAL PLANAR CONSTRUCTION.
- SPECIFICALLY DESIGNED FOR LOW LOSS, HIGH CURRENT, HIGH SPEED SWITCHING APPLICATIONS.
- txo TYPICALLY 320ns, IC=10A.
- OPERATING CHARACTERISTICS FULLY GUARANTEED AT 100°C.
- ICES BETTER THAN 1mA AT MAXIMUM RATED VCE AT 100°C.
- VCEO(sust) 150V MIN TIPL785A AND TIPL790A – 120V MIN TIPL785 AND TIPL790

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES

ABSOLUTE MAXIMUM RATINGS AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE

	TO220		TO218	
	TIPL790	TIPL790A	TIPL785	TIPL785A
Collector-Base Voltage (IE=0)	150V	200V	150V	200V
Collector-Emitter Voltage (VBE=0)	150V	200V	150V	200V
Collector-Emitter Voltage (Open Base)	120V	150V	120V	150V
Base-Emitter Voltage	8V	8V	8V	8V
Continuous Collector Current	10A	10A	10A	10A
Peak Collector Current (Note 1)	15A	15A	15A	15A
Peak Parallel Diode Forward Current (Note 1)	10A	10A	10A	10A
Continuous Dissipation at 25° C Case	70W	70W	80W	80W
Operating Junction & Storage Temperature	-65°C to +150°C			

NOTE 1: Pulse Test, Pulse Duration ≤ 2ms

TIPL785A, TIPL790A
MONOLITHIC DARLINGTON CONNECTED NPN SILICON POWER TRANSISTOR

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VCBO	Collector Base Breakdown Voltage Note 2	785, 790 785A, 790A	150 200			V V
VCEO (SUST)	Collector-Emitter Sustaining Voltage See Note 3	IC=100mA 785, 790 L=25mH 785A, 790A	120 150			V V
ICEV	Collector Cut-Off Current	VCE=150V 785, 790 VCE=200V 785A, 790A 1.5V<VEB<8V			50 50	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=150V 785, 790 VCE=200V 785A, 790A VCE=150V 100°C 785, 790 VCE=200V 100°C 785A, 790A			50 50 1 1	μA μA mA mA
ICEO	Collector Cut-Off Current	VCE=120V 785, 790 VCE=150V 785A, 790A			50 50	μA μA
IEBO	Emitter Cut-Off Current	VEB=5V IC=0			4	mA
VCE SAT	Collector Emitter Saturation Voltage Notes 2 & 4	IC=4A IB=0.02A IC=7A IB=0.03A IC=10A IB=0.05A IC=10A IB=0.05A 100°C			1.2 1.5 2.0 2.0	V V V V
VBE SAT	Base-Emitter Saturation Voltage Notes 2 & 4	IC=4A IB=0.02A IC=7A IB=0.03A IC=10A IB=0.05A IC=10A IB=0.05A 100°C			1.8 1.9 2.2 2.1	V V V V
VF	Parallel Diode Forward Voltage Notes 2 & 4	IC=10A			3.0	V
hFE	Forward Current Transfer Ratio Notes 2 & 4	VCE=5V IC=500mA	60		500	
ft	Forward Current Band-Width Product	IC=500mA } F=1MHz VCE=10V(dc) } GAIN=UNITY		10		MHz
Cob	Output Capacitance	VCB=20V IE=0A F=0.1MHz		90		pF
Rθjc	Thermal Resistance Junction-Case	TIPL790/A TIPL785/A			1.79 1.56	°C/W °C/W

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INDUCTIVE LOAD (SEE FIGURES 1 to 4)					
t_{si} Current Storage Time	IC=10A IBon=0.05A VEBoff=5V, IBoff≏2.5A		450	700	ns
t_{rv} Voltage Rise Time			160	750	ns
t_{fi} Current Fall Time			250	400	ns
t_{ti} Current Tail Time			280	450	ns
t_{xo} Crossover Time			320	500	ns

NOTE 2. These Parameters are measured using pulse techniques
Pulse Width=300μs, Duty Cycle=2%

NOTE 3. Inductive Loop Switching Measurement

NOTE 4. These Parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body

FIGURE. 1 INDUCTIVE SWITCHING PARAMETERS
TYPICAL DELAY TIME USING RECOMMENDED BASE DRIVE, Tcase=25°C

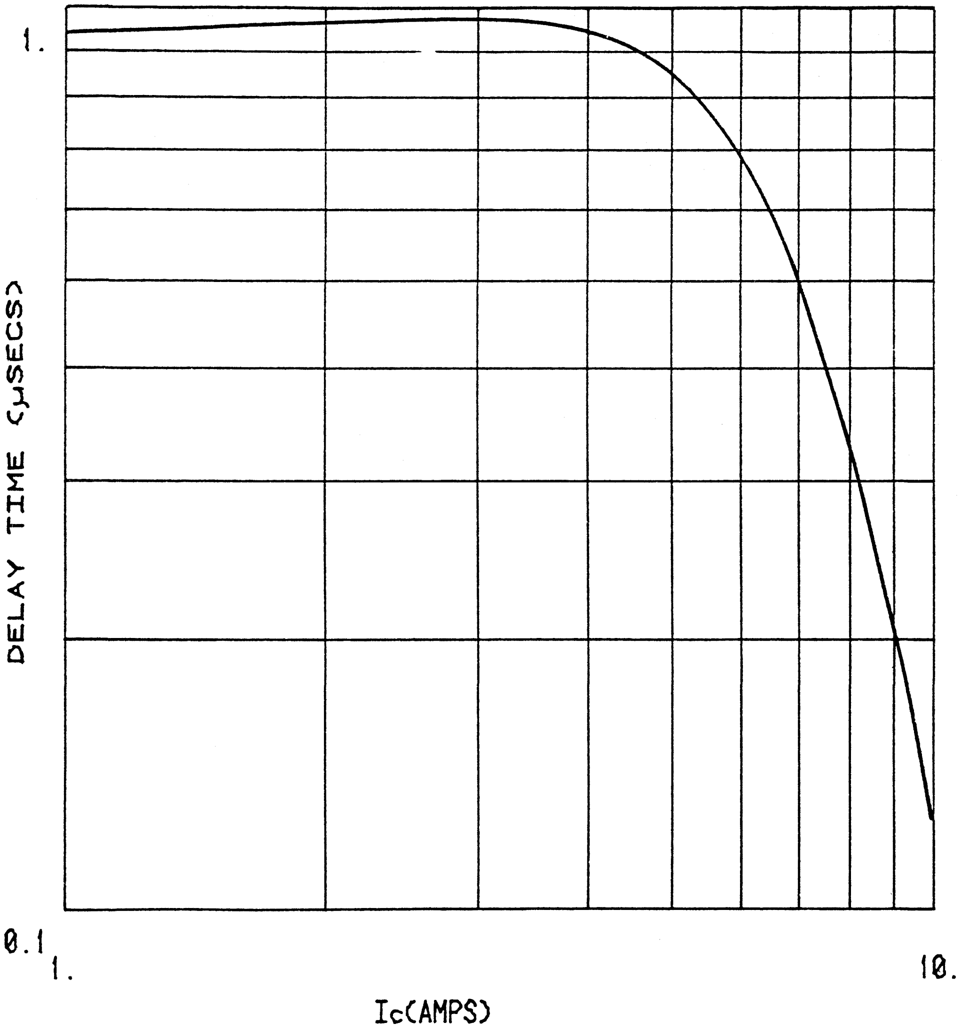


FIGURE. 2 INDUCTIVE SWITCHING PARAMETERS
TYPICAL RISE TIME USING RECOMMENDED BASE DRIVE, Tcase=25°C

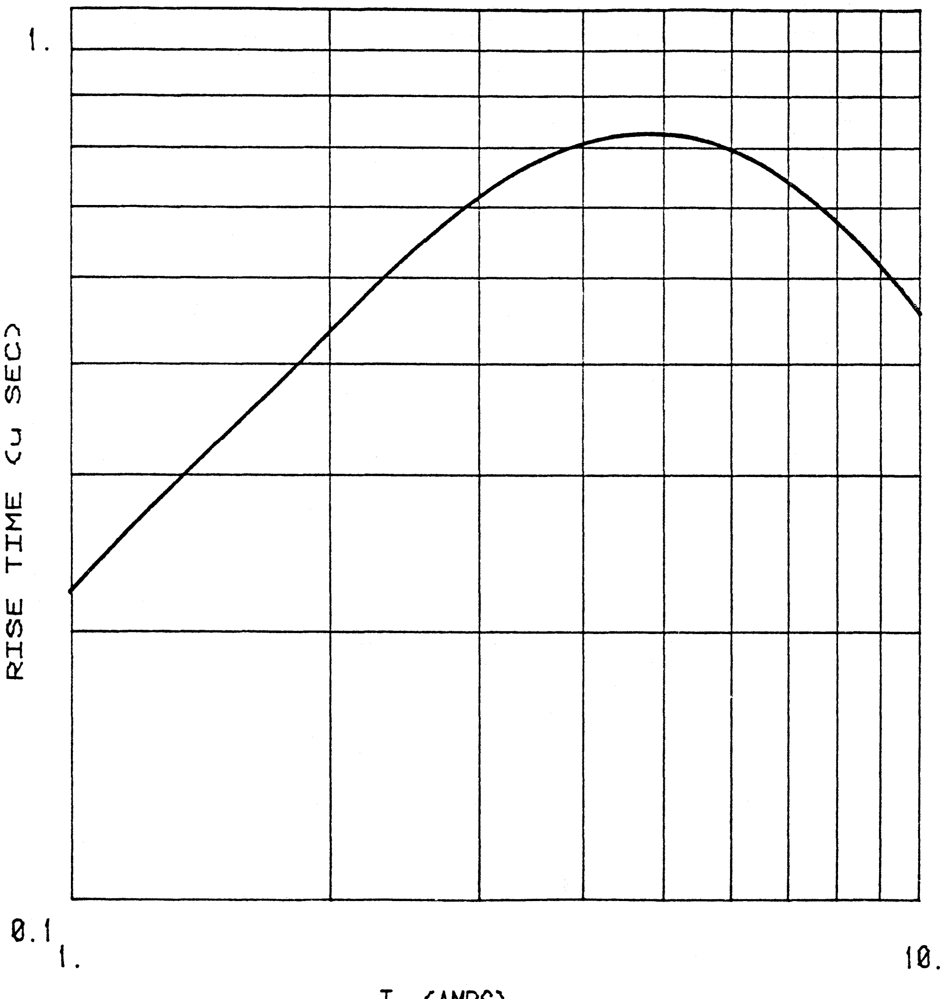


FIGURE. 3 INDUCTIVE SWITCHING PARAMETERS
RECOMMENDED BASE DRIVE T case= 25°C TO 100°C

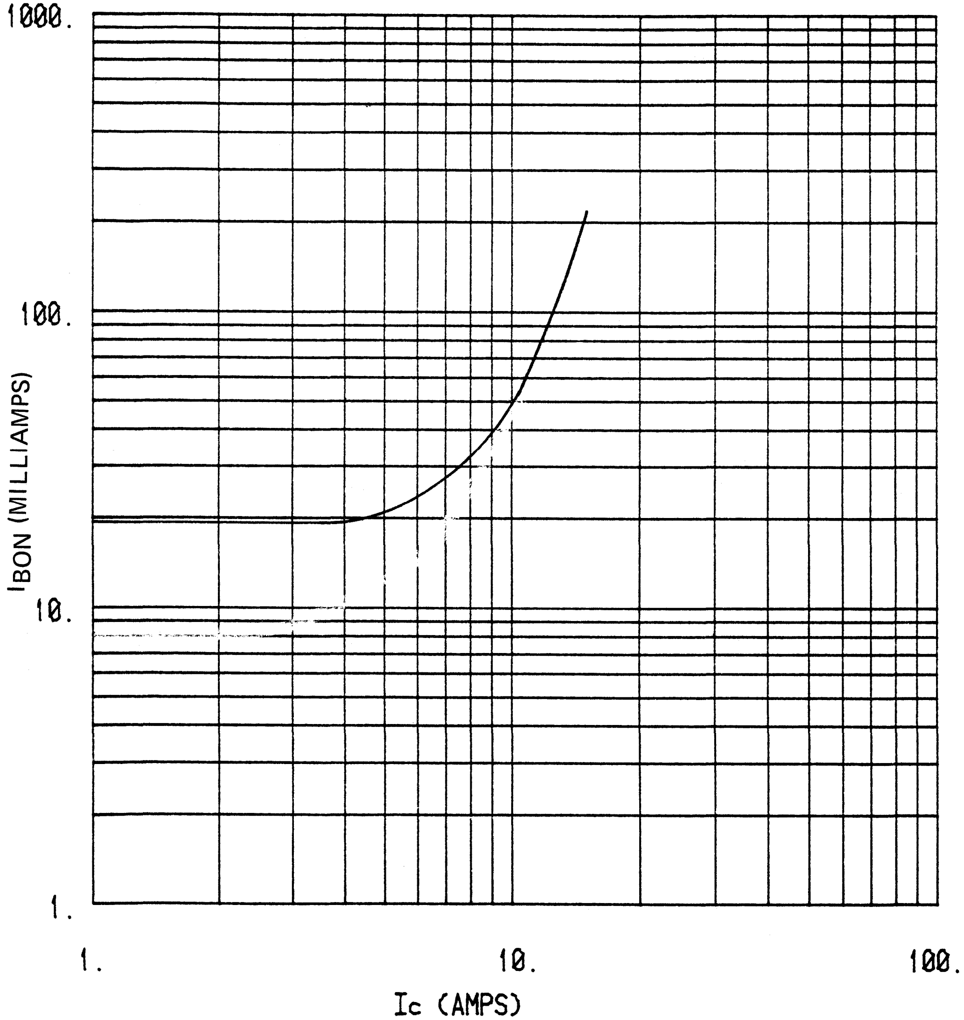


FIGURE. 4 COLLECTOR CIRCUIT USED TO MEASURE INDUCTIVE SWITCHING PARAMETERS

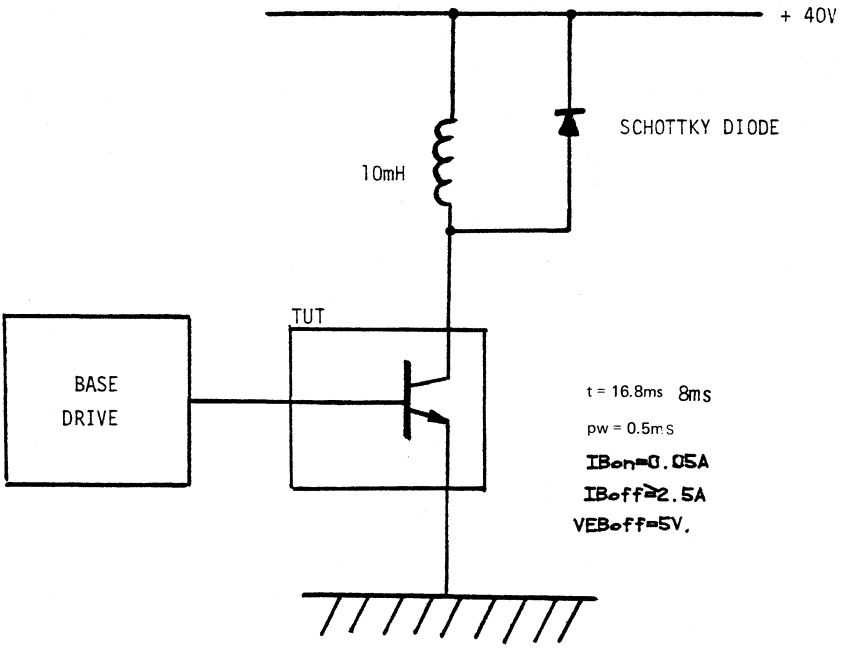


FIGURE. 5 TYPICAL COLLECTOR SATURATION REGION Tcase = 100°C

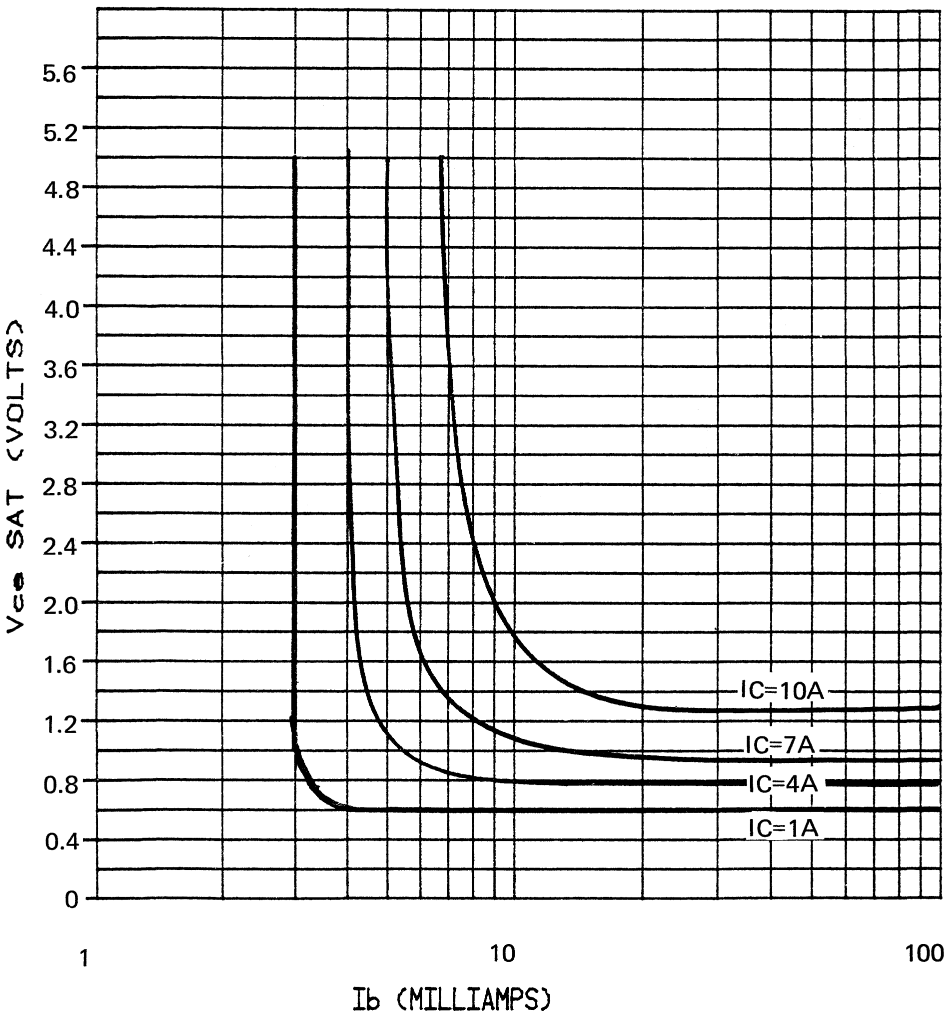


FIGURE. 6 TYPICAL BASE SATURATION REGION, Tcase=25°C

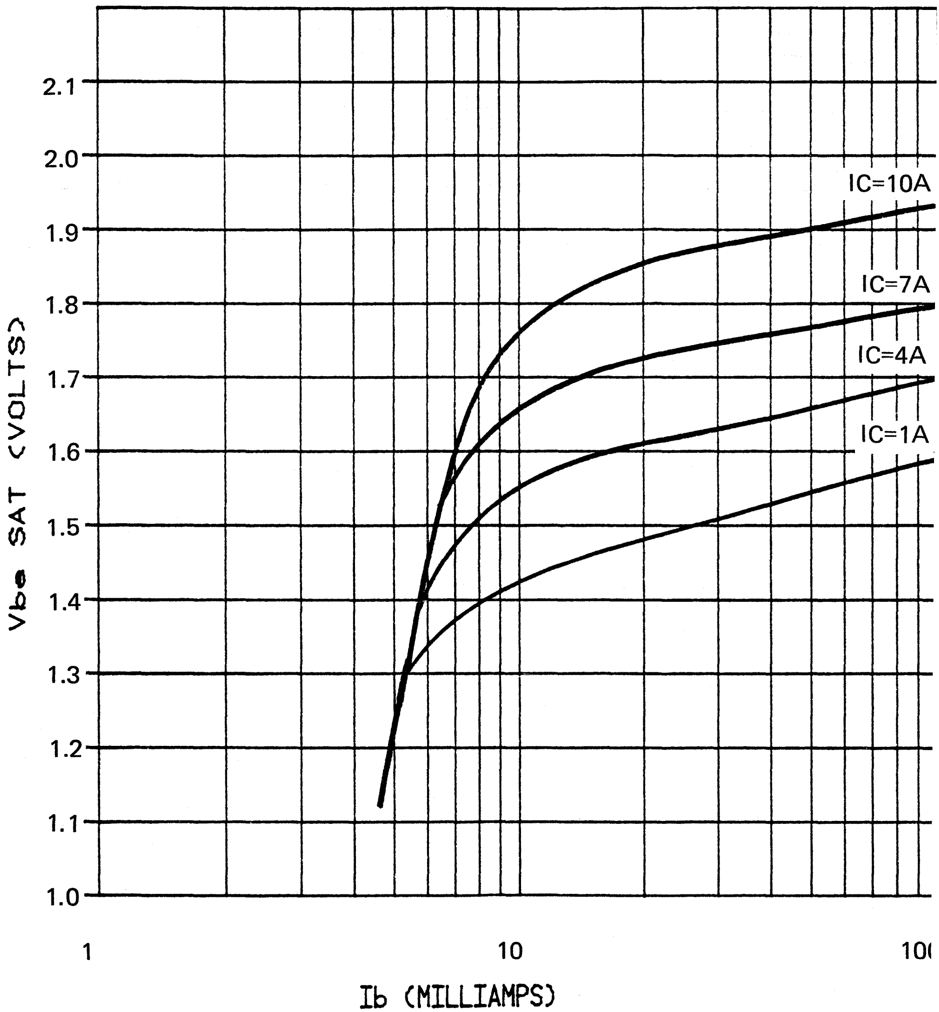


FIGURE. 7 TYPICAL VARIATION OF DC CURRENT GAIN Vce=5V

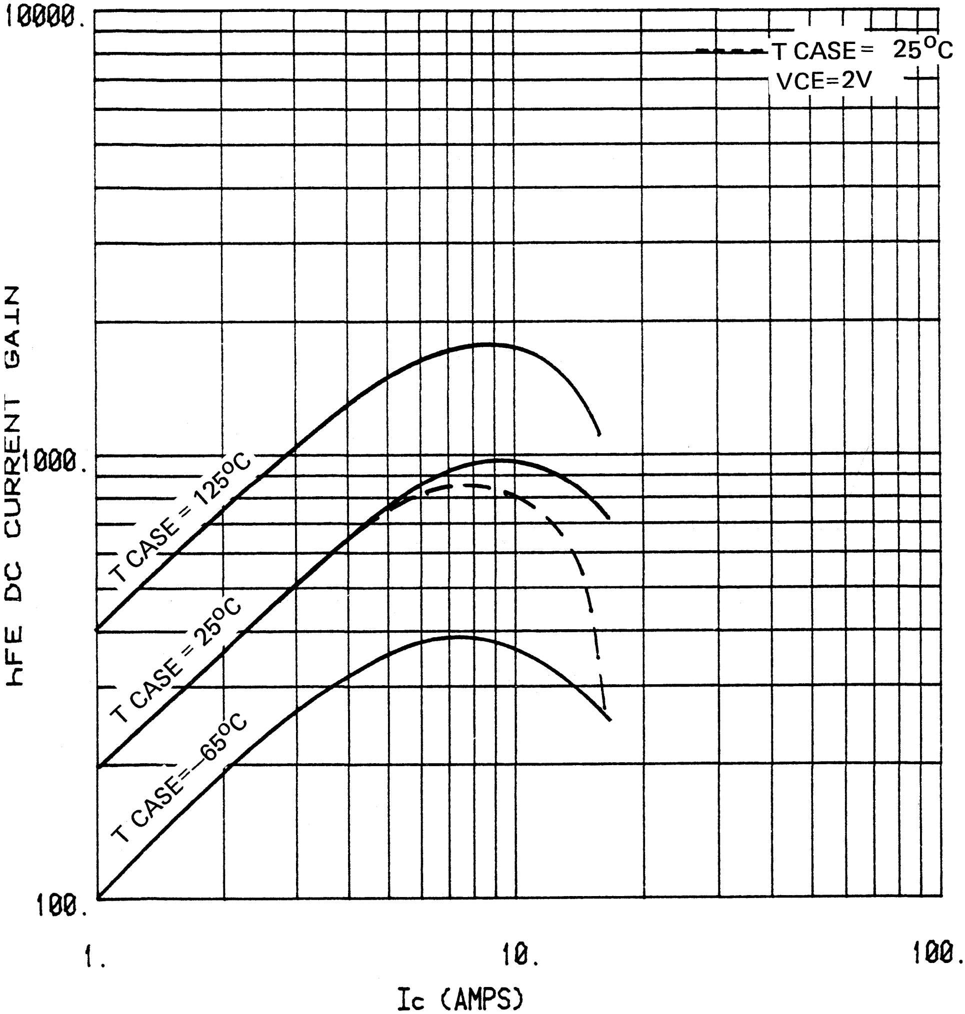


FIGURE. 8 TYPICAL VARIATION OF ICES WITH TEMPERATURE

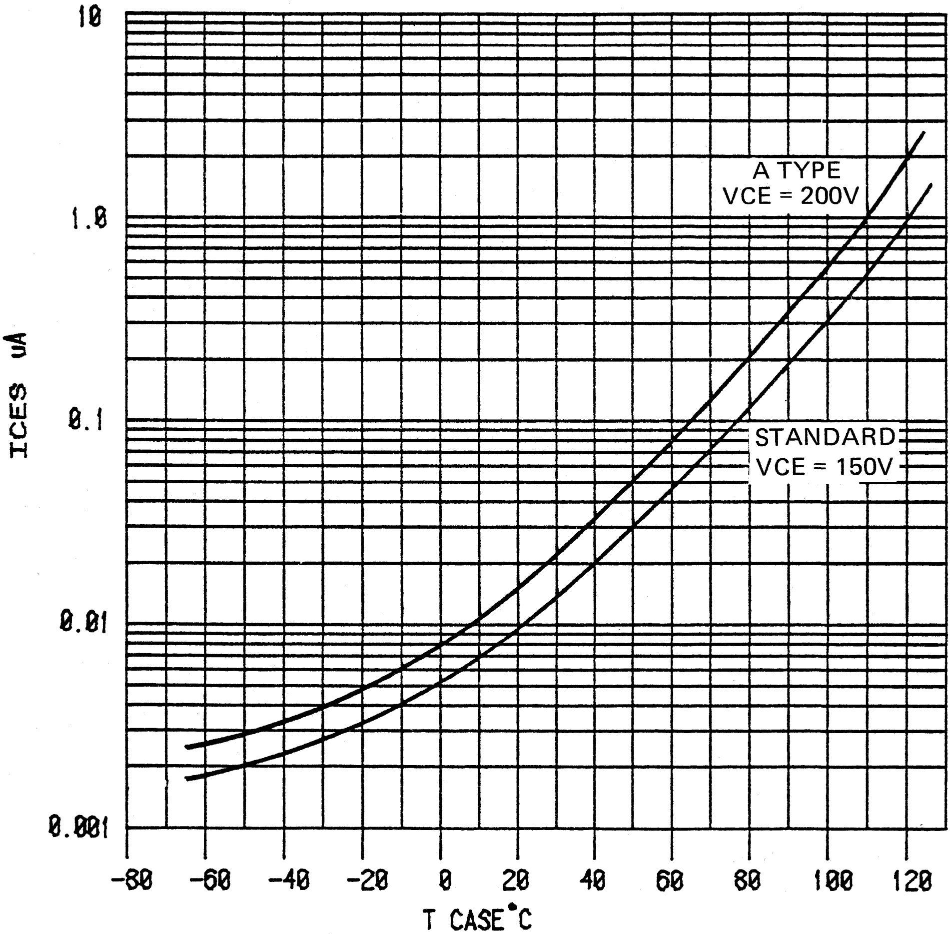


FIGURE. 9
FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED Tcase=25°C

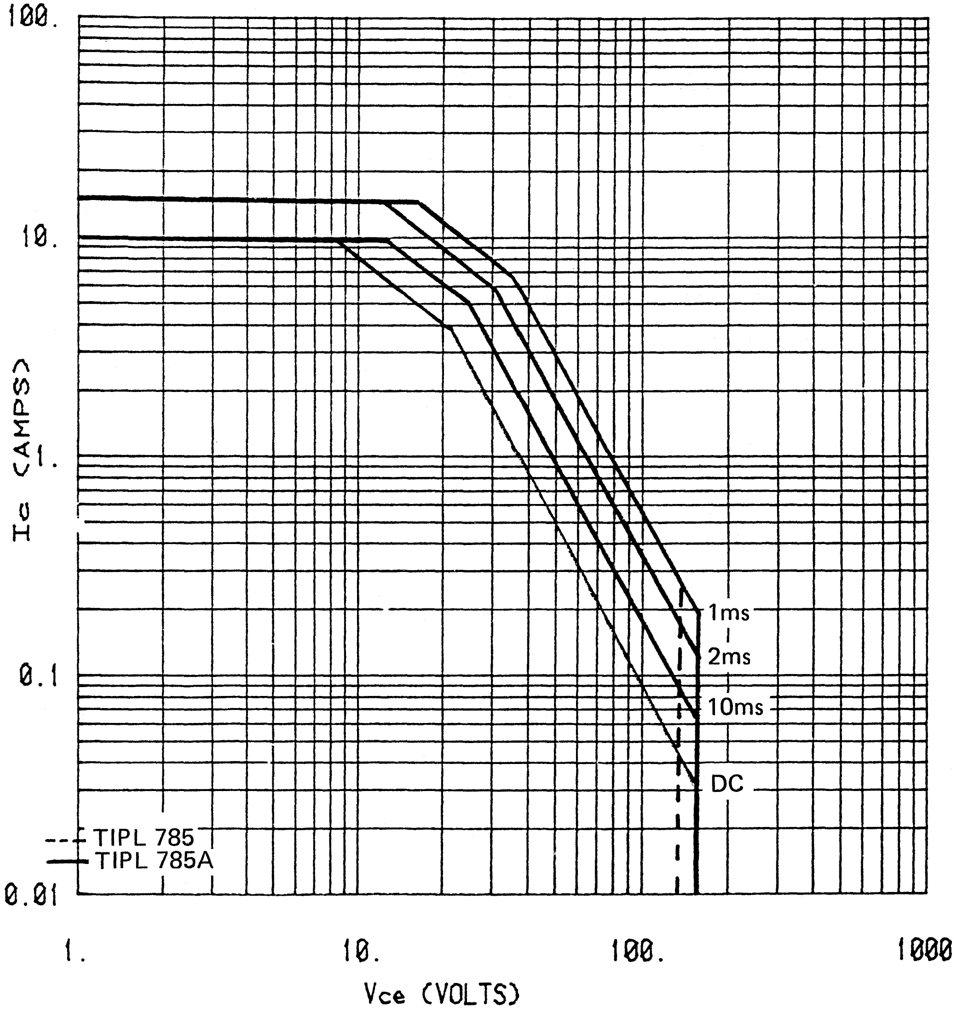


FIGURE. 10
FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED Tcase=25°C

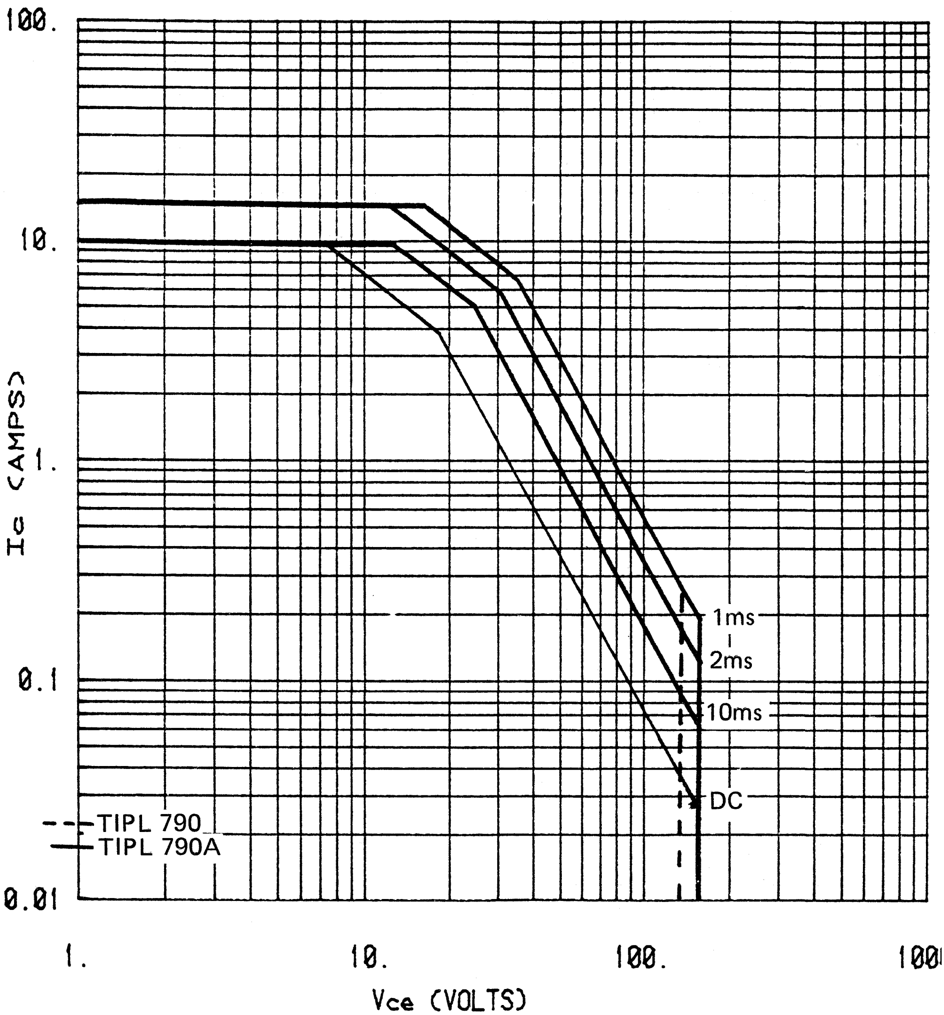
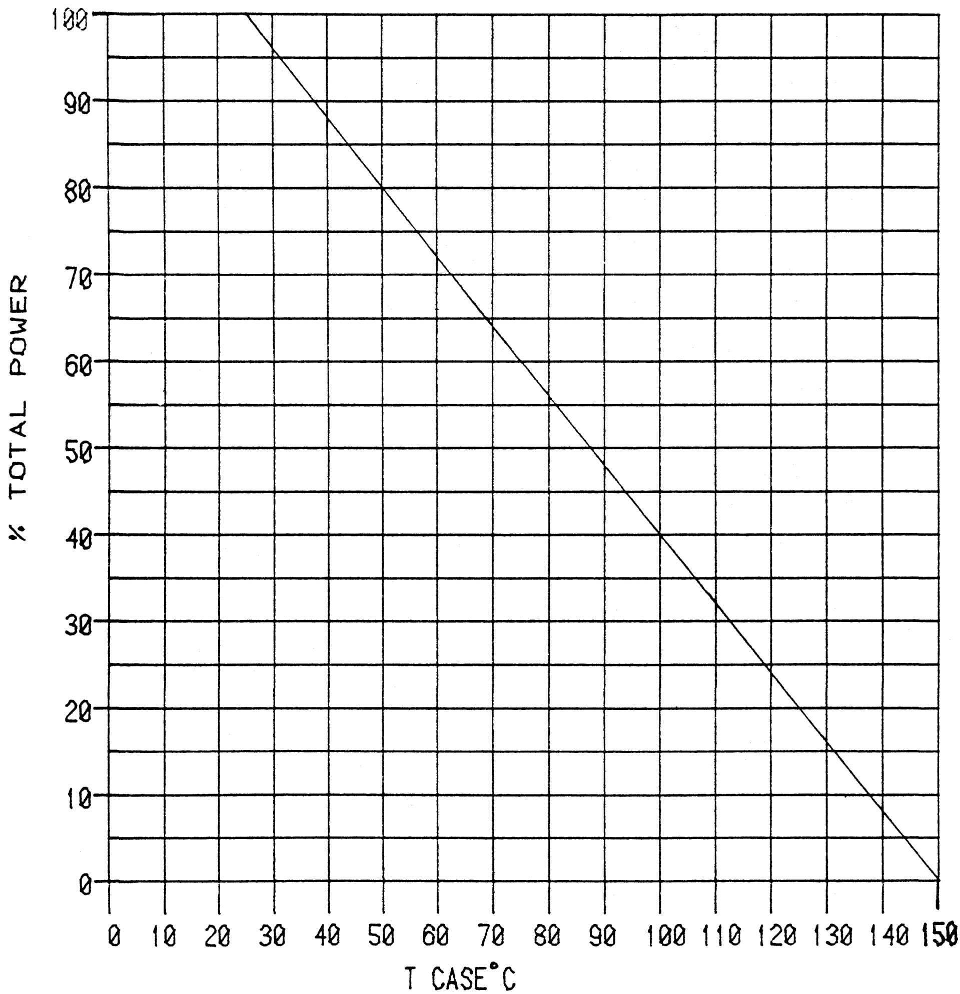


FIGURE. 11 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

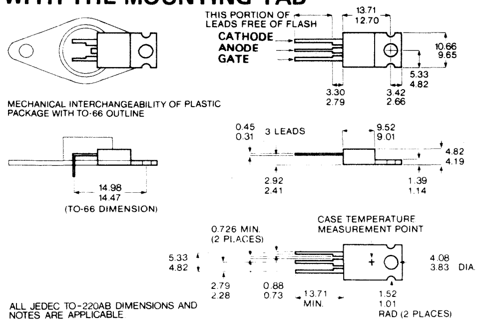


B: Thyristors

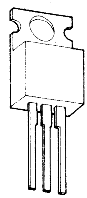
- GLASS-PASSIVATED WAFER
- 30 V to 800 V
- 30 A Surge-Current
- 5 A DC
- MAX I_{GT} of 200 μA

mechanical data

THE ANODE IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 kΩ. 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 50-Hz half-sine-wave operation with resistive load. Above 80°C derate according to Figure 3.
4. This value applies for one 50Hz 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 20 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, $t_{p(g)} \geq$ 20 μs,	R_L = 100 Ω, R_{GK} = 1 kΩ, T_C = −40°C			1.2	V
		V_{AA} = 6 V, $t_{p(g)} \geq$ 20 μs	R_L = 100 Ω, R_{GK} = 1 kΩ,	0.4	0.6	1	
		V_{AA} = 6 V, $t_{p(g)} \geq$ 20 μs,	R_L = 100 Ω, R_{GK} = 1 kΩ, T_C = 110°C	0.2			
I_H	Holding Current	V_{AA} = 6 V, T_C = −40°C	R_{GK} = 1 kΩ, Initiating I_T = 10 mA,			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

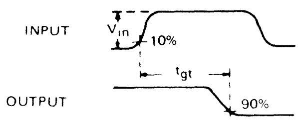
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.5	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

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.

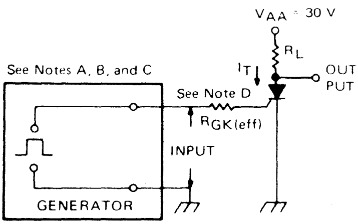
switching characteristics at 25°C case temperature

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

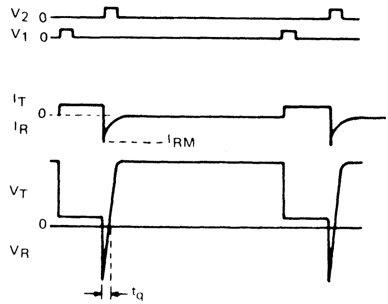


VOLTAGE WAVEFORMS

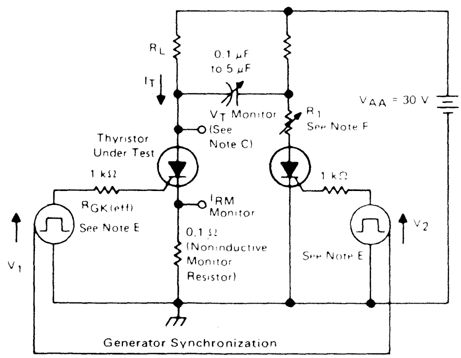


TEST CIRCUIT

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} ≈ 8A.

THERMAL INFORMATION

AVERAGE ANODE
FORWARD CURRENT DERATING CURVE

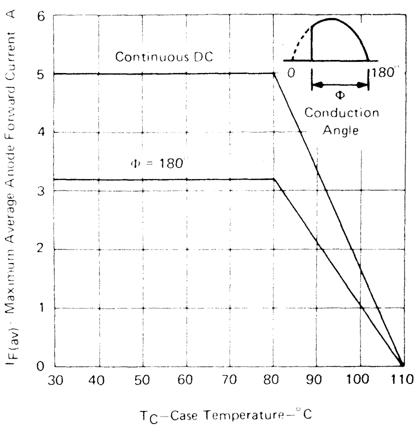


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ANODE FORWARD CURRENT

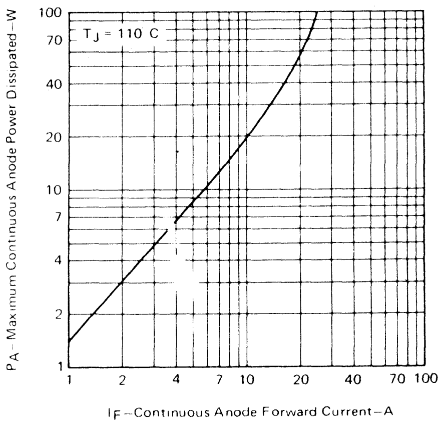


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

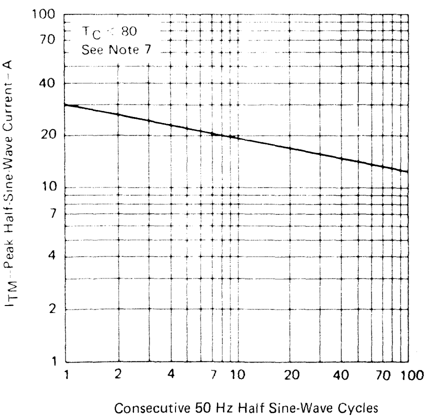


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

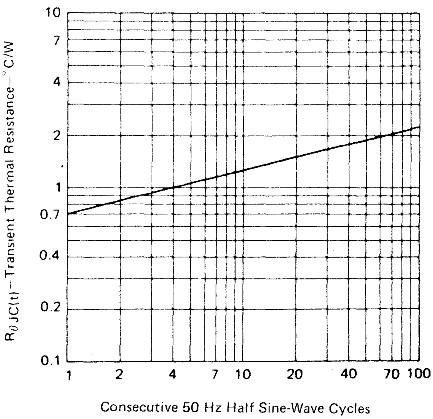


FIGURE 6

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

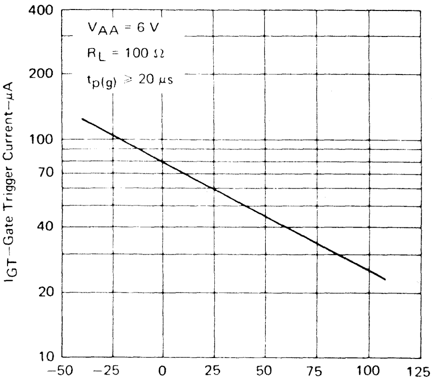


FIGURE 7

GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

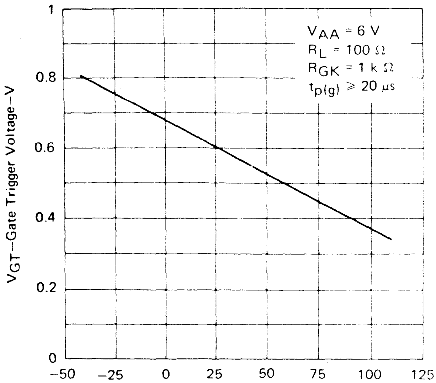


FIGURE 8

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

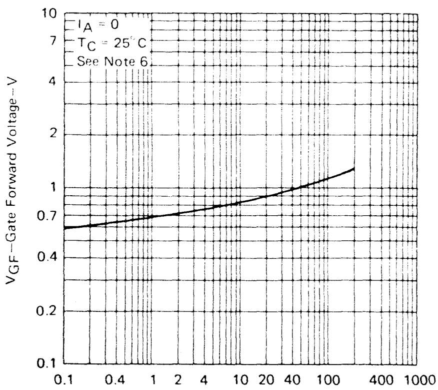


FIGURE 9

HOLDING CURRENT
vs
CASE TEMPERATURE

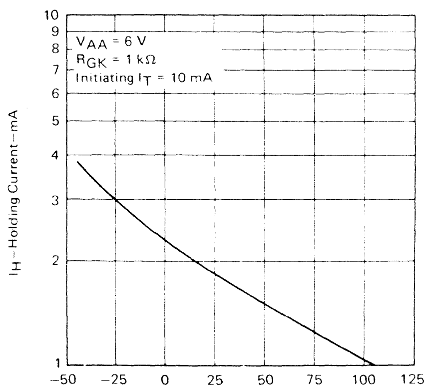


FIGURE 10

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

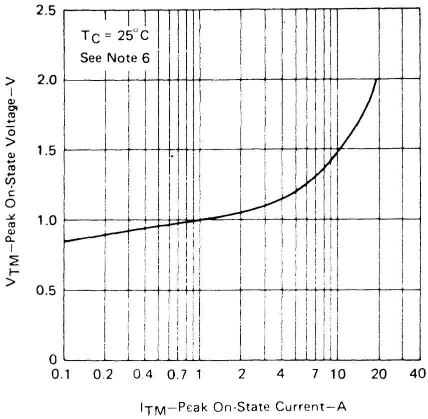


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

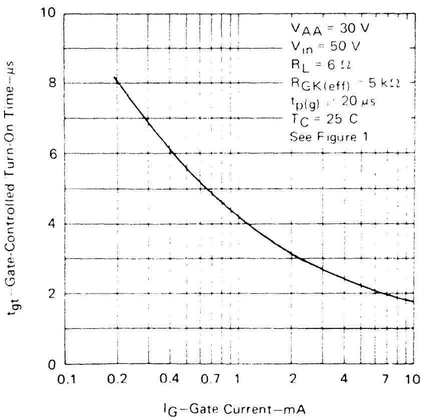


FIGURE 12

CIRCUIT-COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

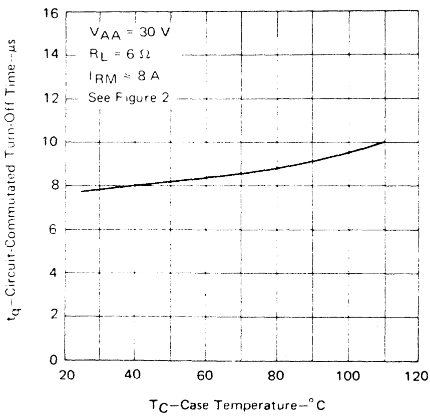
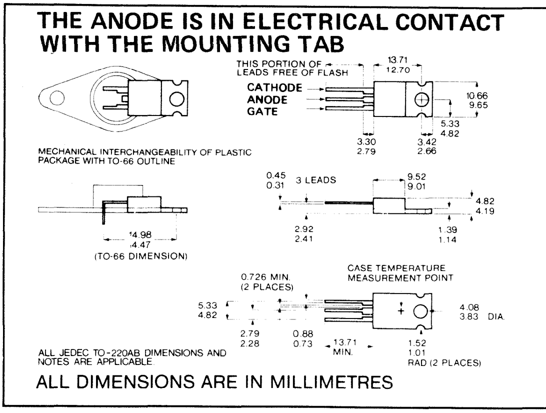


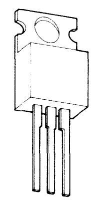
FIGURE 13

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.

- Minimum and Maximum Gate Current Guaranteed
- 100 V to 800 V
- 5 A DC, 20 A Surge Current
- Glass-Passivated Wafer

mechanical data





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

Parameter	Device	Value
Repetitive Peak Off-State Voltage V_{DRM} (See Note 1) / Repetitive Peak Reverse Voltage V_{RRM}	TIC108A	100 V
	TIC108B	200 V
	TIC108C	300 V
	TIC108D	400 V
	TIC108E	500 V
	TIC108M	600 V
	TIC108S	700 V
	TIC108N	800 V
Continuous On-State Current at (or below) 80 °C Case Temperature (See Note 2)		5 A
Average On-State Current (180 °C Conduction Angle) at (or below) 80 °C Case Temperature (See Note 3)		3.2 A
Peak On-State Surge Current I_{TSM} (See Note 4)		20 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 kΩ. When available, Thyristors of higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC108B (200 V), TIC108D (400 V) 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 50 Hz half-sine-wave operation with resistive load. Above 80 °C derate according to Figure 3.
4. This value applies for one 50 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 20 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	0.2		1	mA
V_{GT}	Gate Trigger Voltage	V_{AA} = 6 V, $t_{p(g)} \geq$ 20 μs,	R_L = 100 Ω, R_{GK} = 1 kΩ, T_C = −40°C			1.2	V
		V_{AA} = 6 V, $t_{p(g)} \geq$ 20 μs	R_L = 100 Ω, R_{GK} = 1 kΩ,	0.4	0.6	1	
		V_{AA} = 6 V, $t_{p(g)} \geq$ 20 μs,	R_L = 100 Ω, R_{GK} = 1 kΩ, T_C = 110°C	0.2			
I_H	Holding Current	V_{AA} = 6 V, T_C = −40°C	R_{GK} = 1 kΩ, Initiating I_T = 10 mA,			15	mA
		V_{AA} = 6 V,	R_{GK} = 1 kΩ, Initiating I_T = 10 mA			10	
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		80		V/μs

thermal characteristics

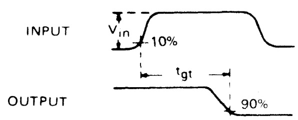
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.5	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

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.

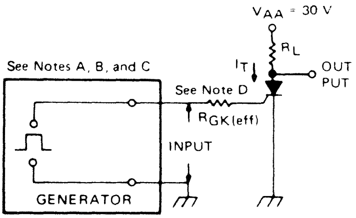
switching characteristics at 25°C case temperature

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	2.9	μs
t_q	Circuit-Commutated Turn-Off Time	V_{AA} = 30 V, R_L = 6 Ω, I_{RM} ≈ 8 A, See Figure 2	13.3	μs

PARAMETER MEASUREMENT INFORMATION

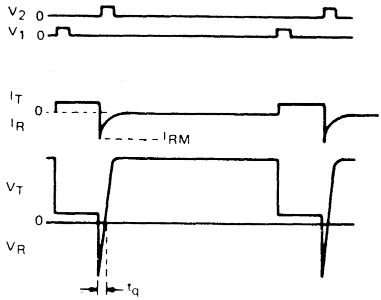


VOLTAGE WAVEFORMS

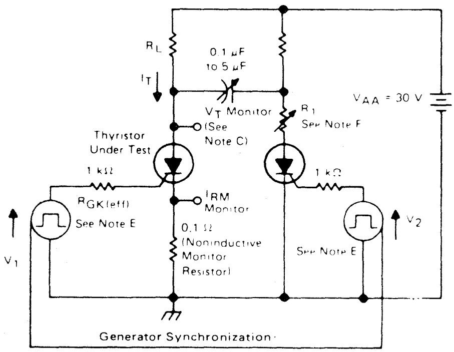


TEST CIRCUIT

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: $t_r \leq 40$ ns, $t_w \geq 20$ μs.
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 14$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 12$ 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} ≈ 8A.

THERMAL INFORMATION

AVERAGE ANODE
FORWARD CURRENT DERATING CURVE

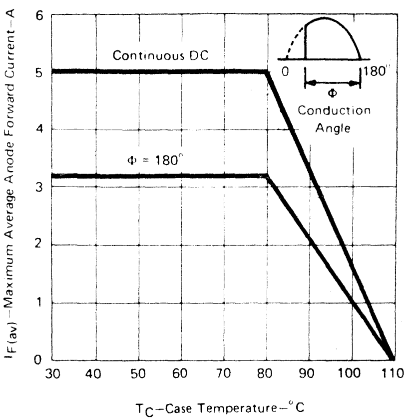


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ANODE FORWARD CURRENT

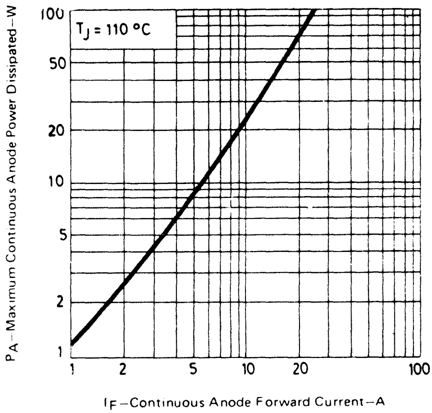


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

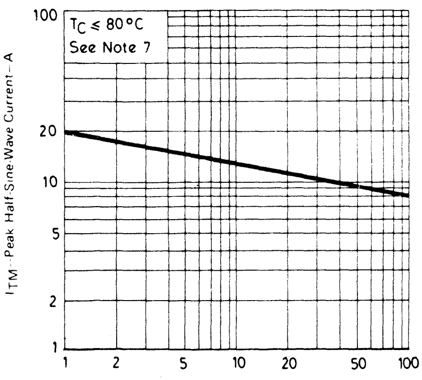


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

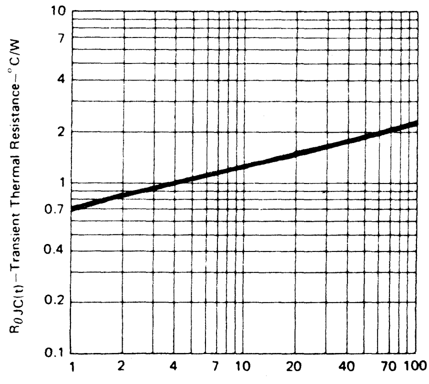


FIGURE 6

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

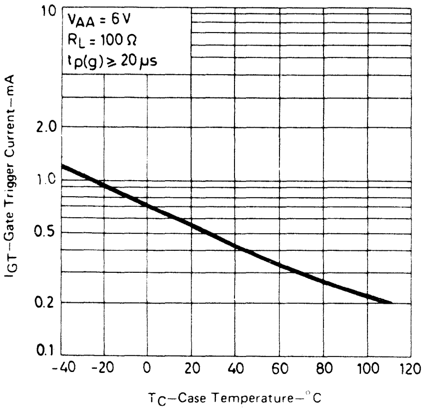


FIGURE 7

GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

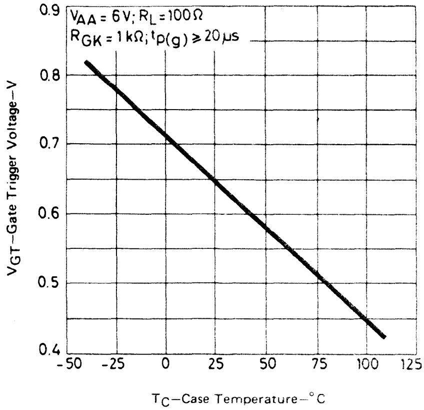


FIGURE 8

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

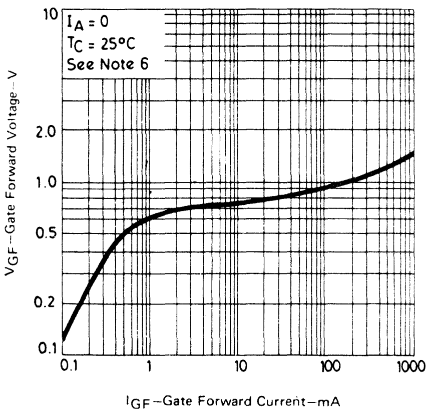


FIGURE 9

HOLDING CURRENT
vs
CASE TEMPERATURE

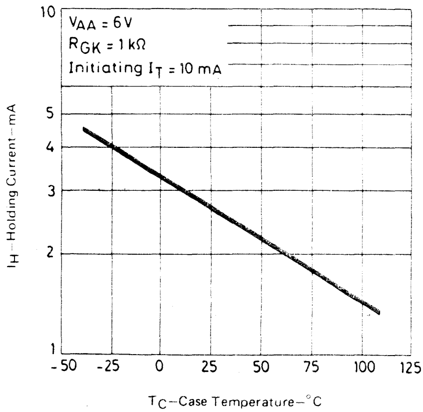


FIGURE 10

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

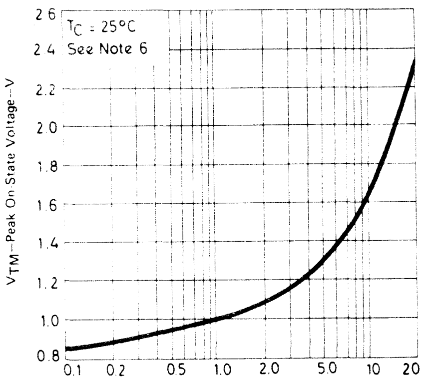


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

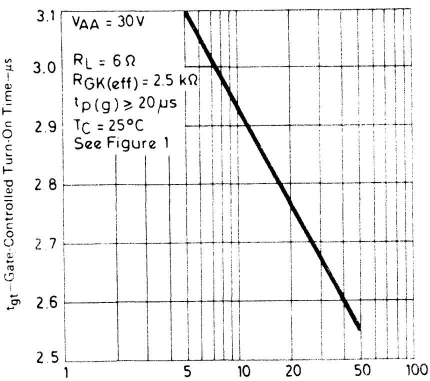


FIGURE 12

CIRCUIT-COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

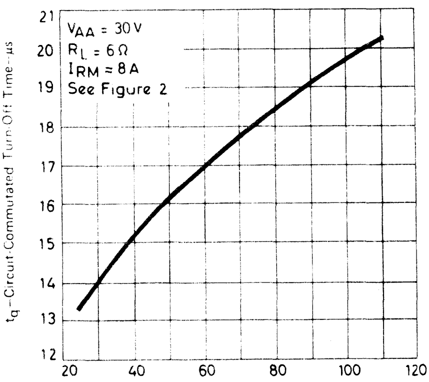


FIGURE 13

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.

TI cannot assume any responsibility for any circuits shown or represent that they are free from patent infringement. Texas Instruments reserves the right to make changes at any time in order to improve design and to supply the best product possible.

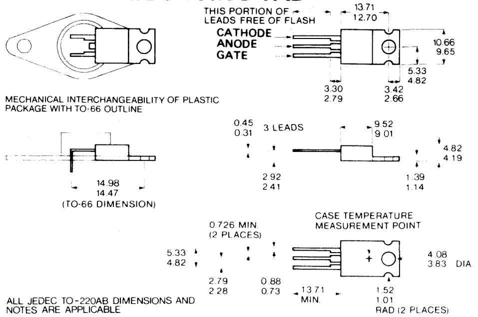
GB 789 259 SC

SILICON CONTROLLED RECTIFIERS

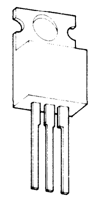
- 8 A and 12 A DC
- 50 V to 600 V
- 80 A and 100 A Surge Current
- MAX I_{GT} of 20 mA

mechanical data

THE ANODE 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 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 1.588mm from Case for 10 Seconds		230		°C

NOTES:
1. These values apply when the gate-cathode resistance $R_{GK} = 1\ k\Omega$.
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, 50-Hz, half-sine-wave operation with resistive load. Above 70°C derate according to Figure 3.
4. This value applies for one 50-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 20 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, $t_{p(g)} \geq 20\ \mu s$	All		5	20	mA
V_{GT}	Gate Trigger Voltage	V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20\ \mu s$, T_C = −40°C	All			2.5	V
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20\ \mu s$	All		0.8	1.5	
		V_{AA} = 6 V, R_L = 100 Ω, R_{GK} = 1 kΩ, $t_{p(g)} \geq 20\ \mu s$, 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 MAX	SERIES TIC126 MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3	2.4	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	62.5	°C/W

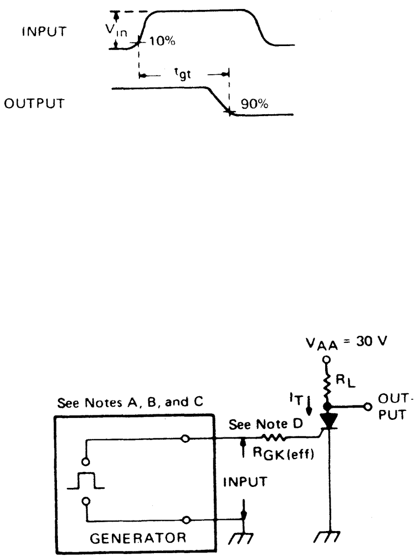
NOTE 6: This parameter must be measured using pulse techniques, t_w = 300 μs, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2mm from the device body.

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

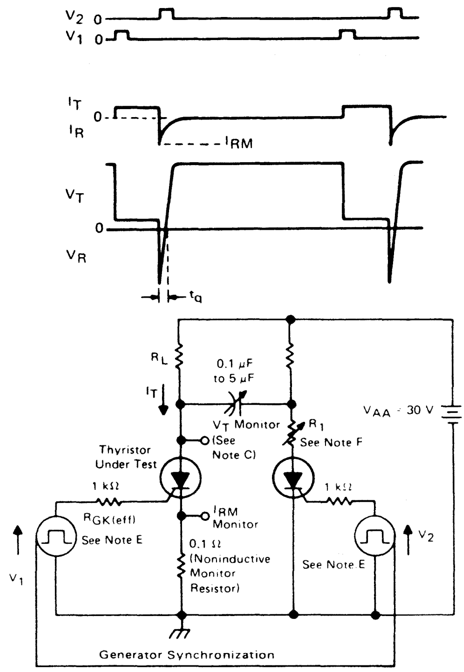
VOLTAGE WAVEFORMS



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: $t_r \leq 40$ ns, $t_w \geq 20$ μs.
- C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 14$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 12$ 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 ON-STATE CURRENT DERATING CURVE

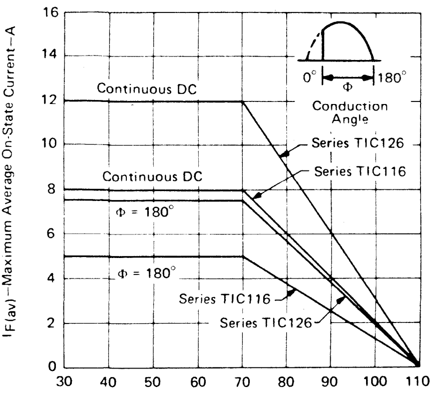


FIGURE 3

MAXIMUM CONTINUOUS ANODE POWER DISSIPATED
vs
CONTINUOUS ON-STATE CURRENT

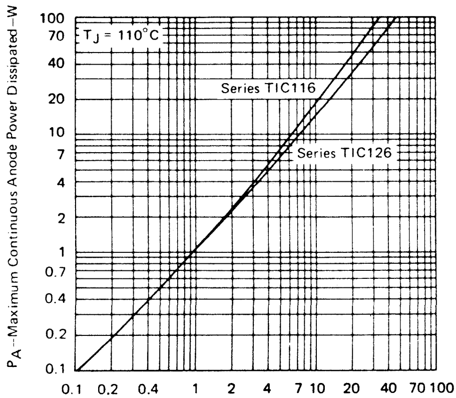


FIGURE 4

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

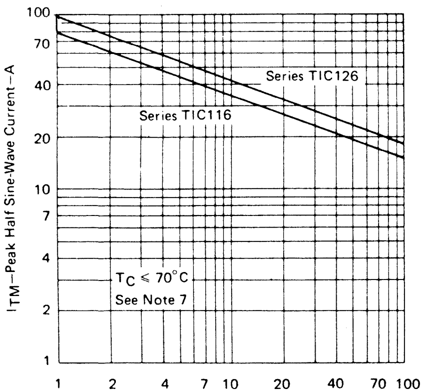


FIGURE 5

TRANSIENT THERMAL RESISTANCE
vs
CYCLES OF CURRENT DURATION

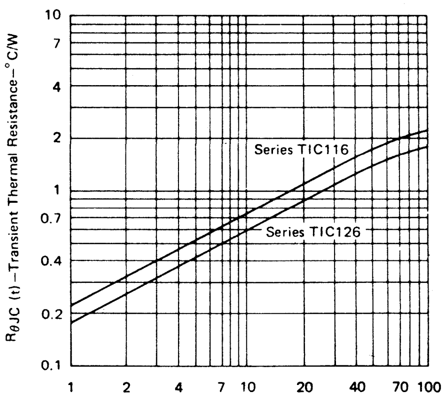


FIGURE 6

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

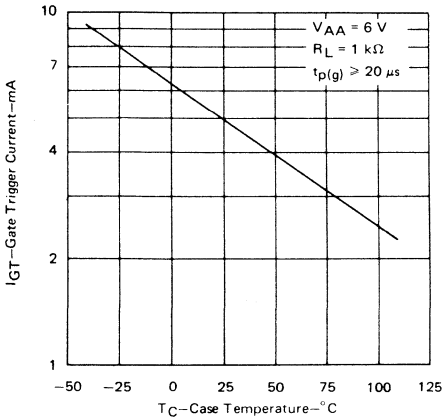


FIGURE 7

GATE TRIGGER VOLTAGE
vs
CASE TEMPERATURE

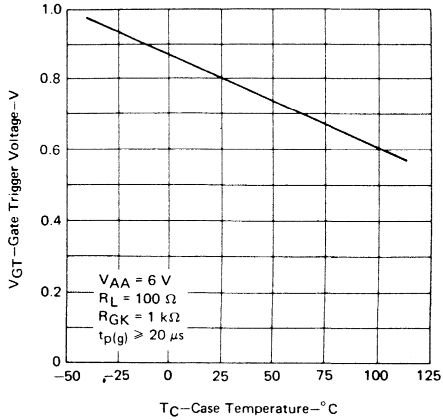


FIGURE 8

GATE FORWARD VOLTAGE
vs
GATE FORWARD CURRENT

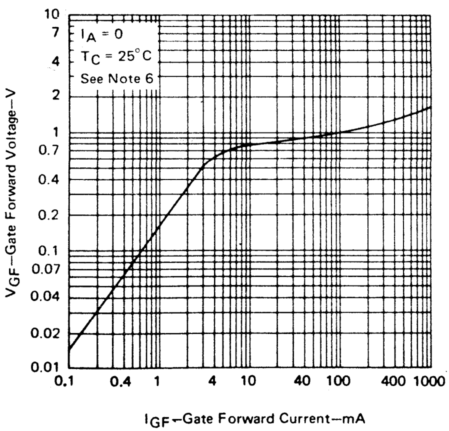


FIGURE 9

HOLDING CURRENT
vs
CASE TEMPERATURE

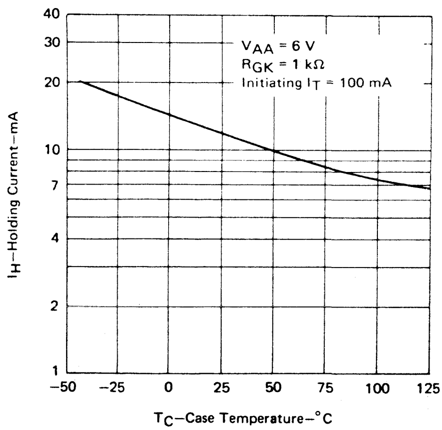


FIGURE 10

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

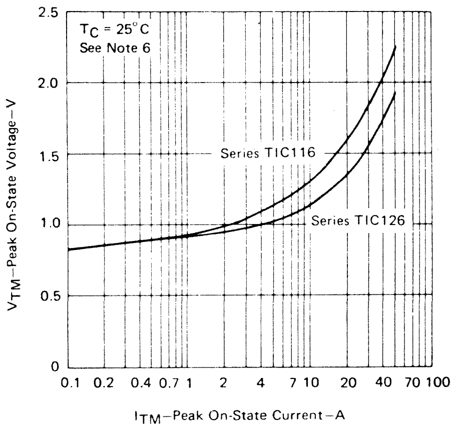


FIGURE 11

GATE-CONTROLLED TURN-ON TIME
vs
GATE CURRENT

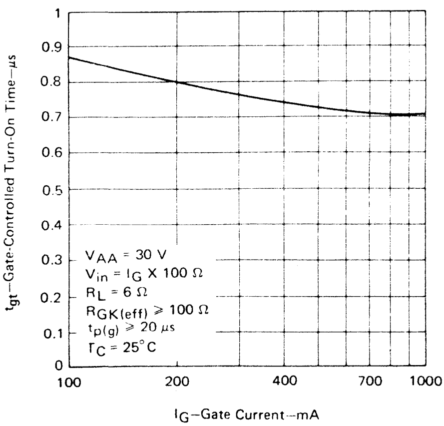


FIGURE 12

CIRCUIT-COMMUTATED TURN-OFF TIME
vs
CASE TEMPERATURE

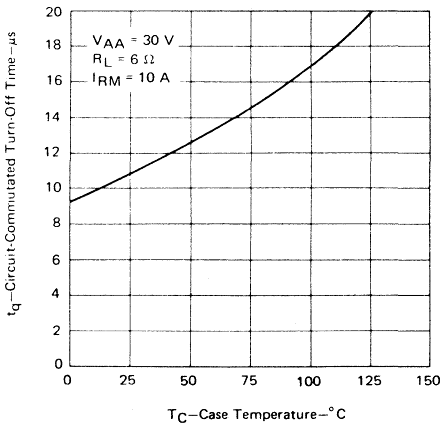


FIGURE 13

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.

SENSITIVE-GATE TRIACS WITH GLASS-PASSIVATED WAFER

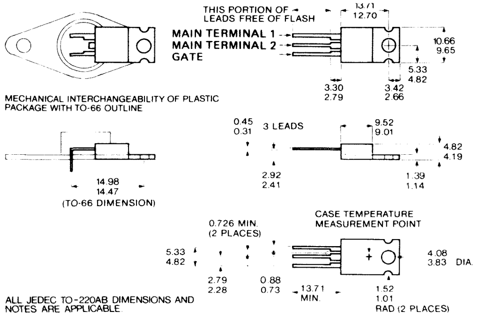
- 100 V to 800 V
- 2.5 A RMS
- MAX I_{GT} of 5 mA (Quadrant 1)

description

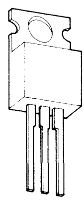
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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)

			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 50 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 50 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 20 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} = ±3.5A, I_G = 50mA, See Note 6			±1.9	V
I_H	Holding Current	V_{supply} = +12V†, $I_G = 0$, Initiating I_{TM} = 100mA			30	mA
		V_{supply} = -12V†, $I_G = 0$, Initiating I_{TM} = 100mA			-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} = ±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. $t_w \leq 1$ ms, duty cycle $\leq 2\%$. 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

SENSITIVE-GATE TRIAC WITH GLASS-PASSIVATED WAFER

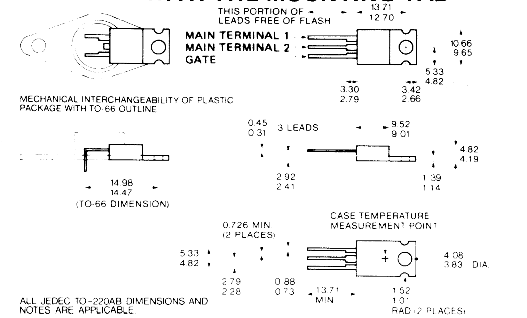
- 100 V to 800 V
- 4 A RMS
- MAX I_{GT} of 5 mA (Quadrants 1-3)

description

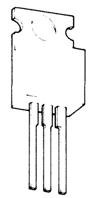
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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)

			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 $<200 \mu s$)		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 50 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 50 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 20 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 = 10Ω, $t_{p(g)} > 20\mu s$		0.5	5	mA
		V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		-1.5	-5	mA
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		-2	-5	mA
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		3.6	10	mA
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		0.7	2	V
		V_{supply} = +12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		-0.7	-2	V
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		-0.8	-2	V
		V_{supply} = -12V†, R_L = 10Ω, $t_{p(g)} > 20\mu s$		0.8	2	V
V_{TM}	Peak On-State Voltage	I_{TM} = ±4.2A, I_G = 50mA, See Note 6		±1.3	±2.2	V
I_H	Holding Current	V_{supply} = +12V†, I_G = 0, Initiating I_{TM} = 100 mA		2	15	mA
		V_{supply} = -12V†, I_G = 0, Initiating I_{TM} = −100 mA		-4	-15	mA
I_L	Latching Current	V_{supply} = +12V†, See Note 7			30	mA
		V_{supply} = -12V†, See Note 7			-30	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} = ±4.2 A T_C = 85°C	1	1.3	2.5	V/μs

† Supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

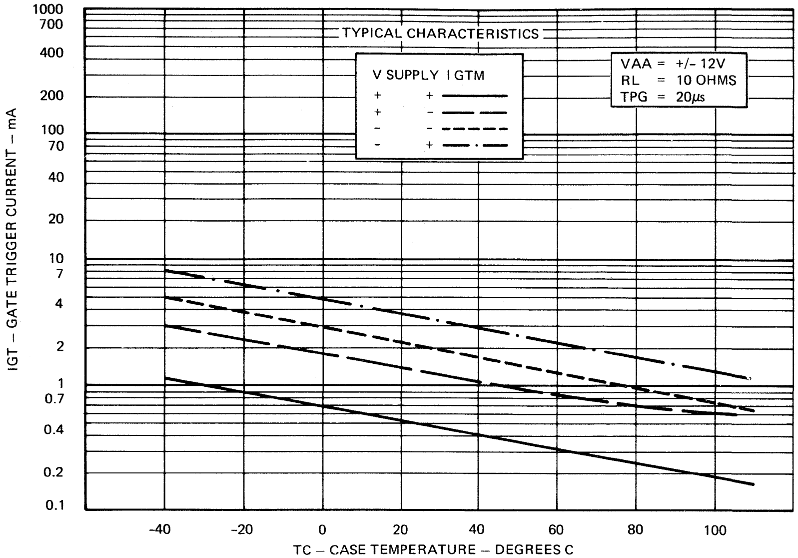
NOTES: 6. This parameter must be measured using pulse techniques. $t_w \leq 1$ ms, duty cycle $\leq 2\%$. Voltage-sensing contacts, separate from the the current-carrying contacts, are located within 3.2 mm from the device body.
7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: R_G = 100 Ω, t_w = 20 μs, 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

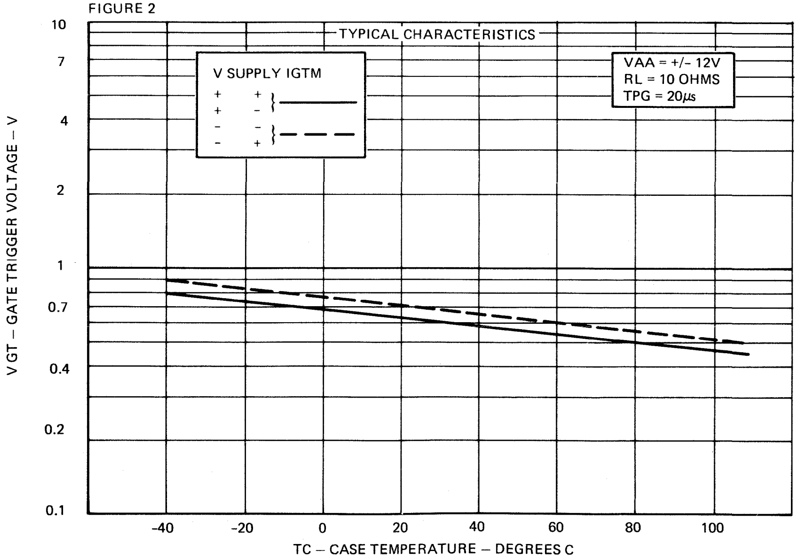
GATE TRIGGER VOLTAGE VS TEMPERATURE

FIGURE 1



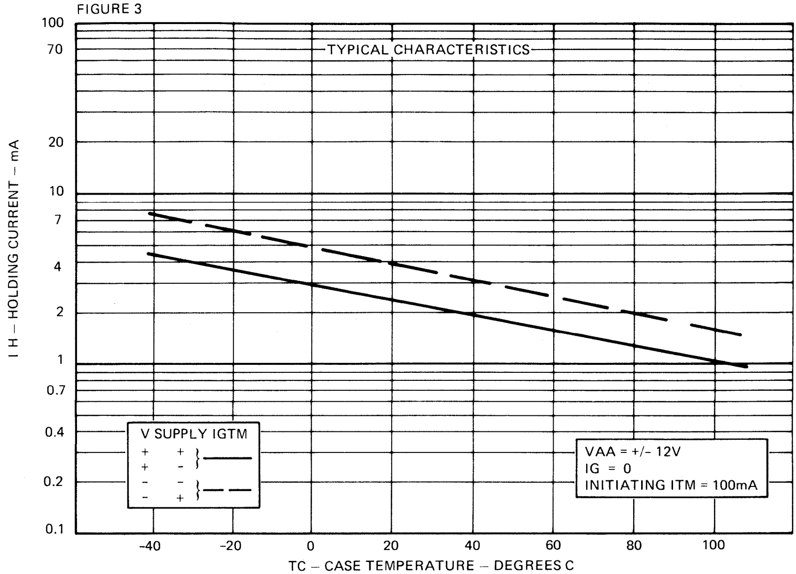
GATE TRIGGER CURRENT VS TEMPERATURE

FIGURE 2



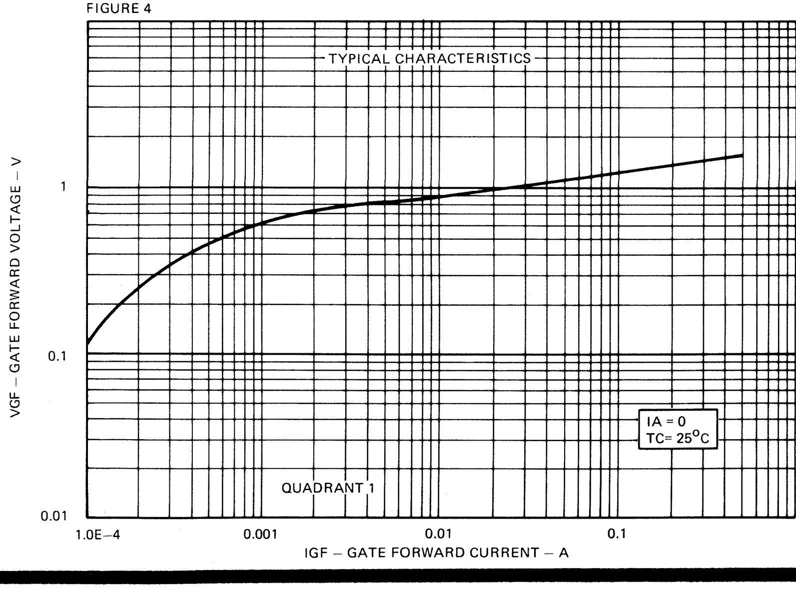
HOLDING CURRENT VS TEMPERATURE

FIGURE 3



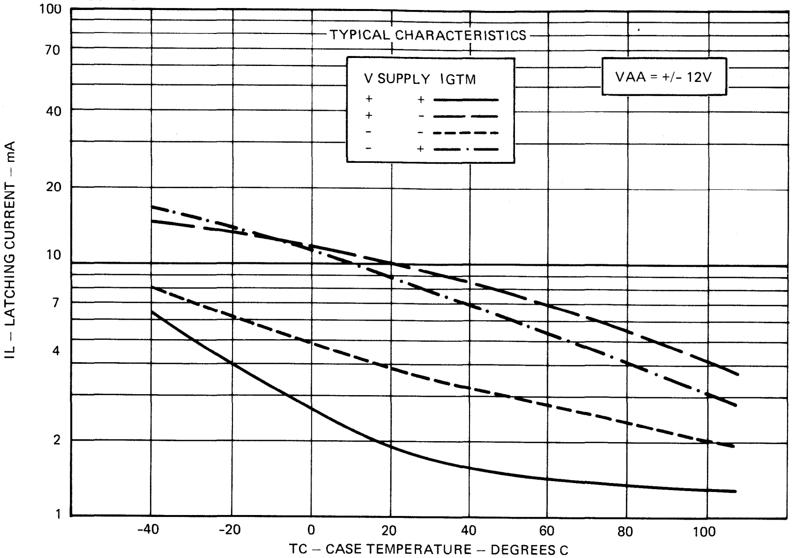
GATE FORWARD VOLTAGE VS GATE FORWARD CURRENT

FIGURE 4



LATCHING CURRENT VS TEMPERATURE

FIGURE 5



TIC216 SERIES
SILICON TRIACS

6 Amp sensitive-gate triac with glass-passivated wafer for power control with resistive and inductive loads

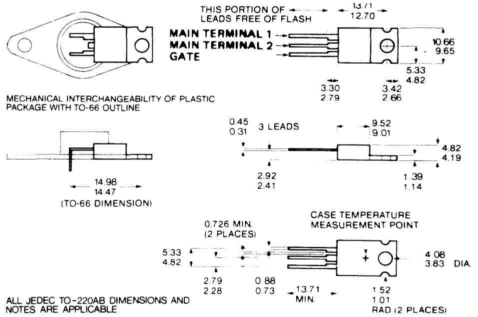
- 100 V to 800 V
- 6A RMS, 70A Peak
- MAX I_{GT} of 5 mA (Quadrants 1 - 3)
- Typ. dv/dt of 50 V/μs

description

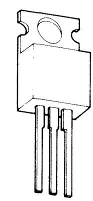
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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)

			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 higher 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 the rate of 150 mW/°C.
3. This value applies for one 50 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 50 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 20 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	$V_{supply} = +12V^†$, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$			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}, $I_G = 0$, $T_C = 110°C$		50		V/μs
dv/dt	Critical Rate of Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, $I_{TRM} = \pm 84A$, $T_C = 70°C$	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

	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

TIC225 SERIES
SILICON TRIACS

8 Amp sensitive-gate triac with glass-passivated wafer for power control with resistive and inductive loads

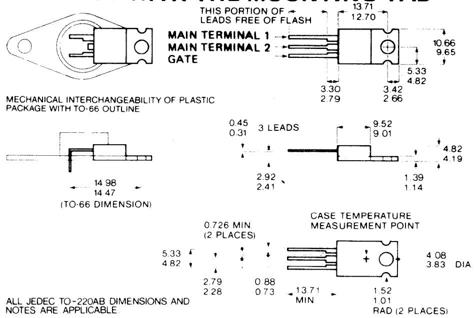
- 100 V to 800 V
- 8A RMS, 70A Peak
- MAX I_{GT} of 5 mA (Quadrant 1)
- Typ dv/dt of 50 V/μs

description

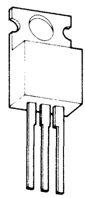
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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)

			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 higher voltage than ordered may be supplied without extra charge. For example, against an order for TIC225B (200V), TIC225D (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 200 mA/°C. Figure 7.
3. This value applies for one 50 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 50 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 20 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†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		0.8	5	mA
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-4.5	-20	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-3.5	-10	mA
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		11.7	30	mA
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		0.7	2	V
		V_{supply} = +12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-0.7	-2	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		-0.8	-2	V
		V_{supply} = -12V†, $R_L = 10\Omega$, $t_{p(g)} > 20\mu s$		0.9	2	V
V_{TM}	Peak On-State Voltage	I_{TM} = ±12A, I_G = 50mA, See Note 6		±1.6	±2.1	V
I_H	Holding Current	V_{supply} = +12V†, $I_G = 0$, Initiating I_{TM} = 100mA		3	20	mA
		V_{supply} = -12V†, $I_G = 0$, Initiating I_{TM} = -100mA		-4.7	-20	mA
I_L	Latching Current	V_{supply} = +12V†, See Note 7			30	mA
		V_{supply} = -12V†, See Note 7			-30	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} = ±12A, $T_C = 70^oC$	1	1.5	4.5	V/μs

†The supply voltage is called positive when it causes Main Terminal 2 to be positive with respect to Main Terminal 1.

NOTES:

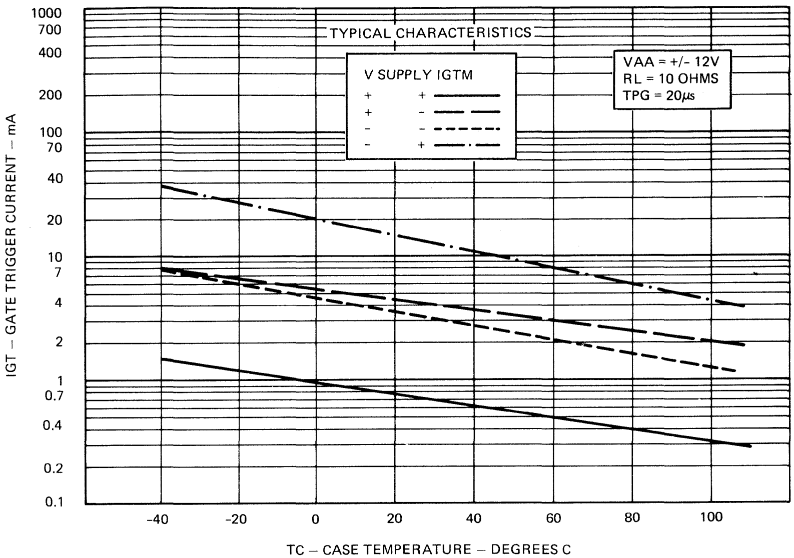
6. This parameter must be measured using pulse techniques $t_w \leqslant 1$ ms, duty cycle $\leqslant 2$ %. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.
7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied 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

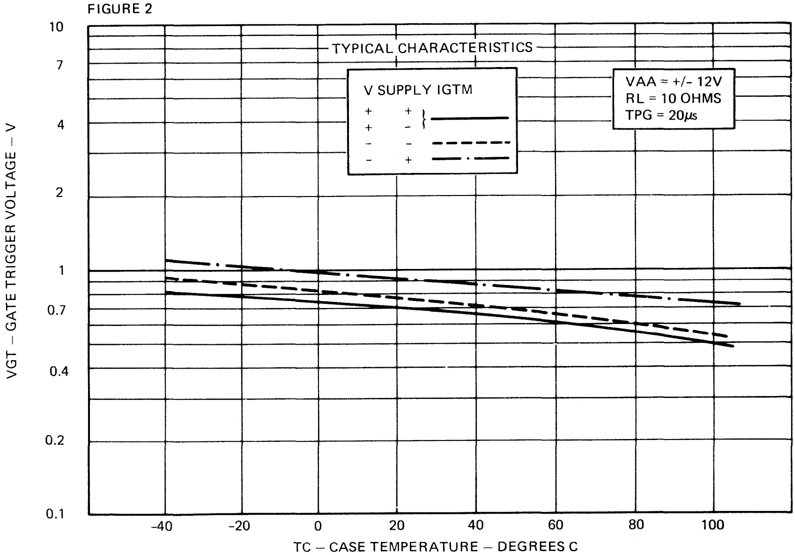
GATE TRIGGER CURRENT VS TEMPERATURE

FIGURE 1



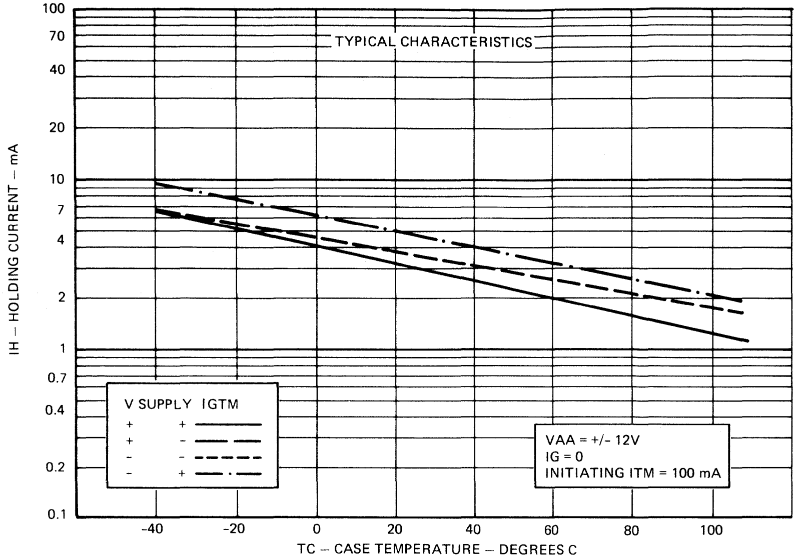
GATE TRIGGER VOLTAGE VS TEMPERATURE

FIGURE 2



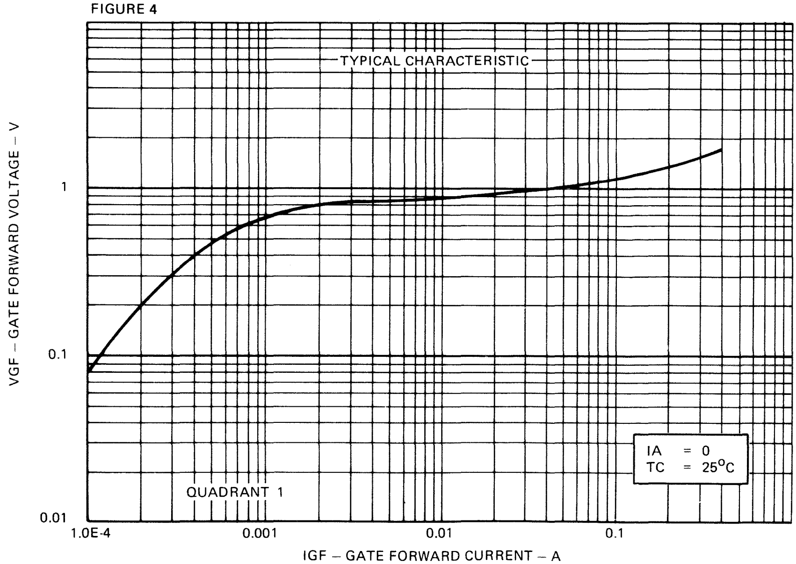
HOLDING CURRENT VS TEMPERATURE

FIGURE 3



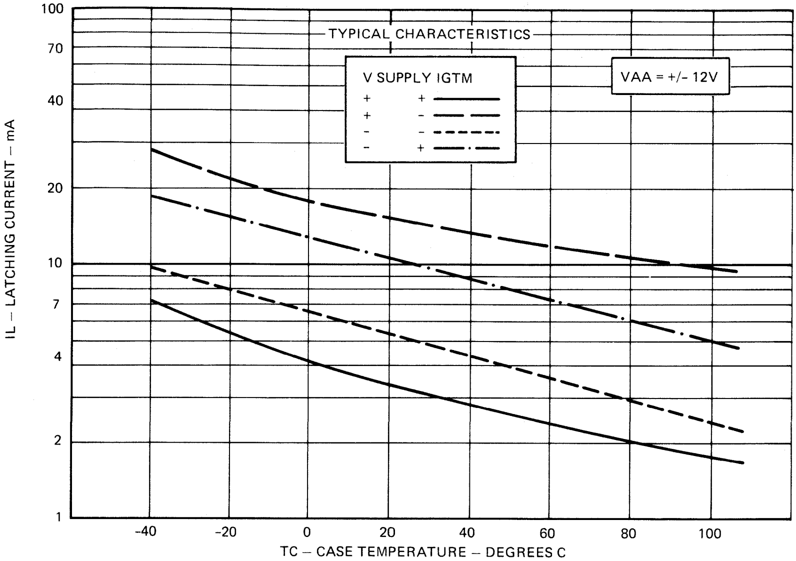
GATE FORWARD VOLTAGE VS GATE FORWARD CURRENT

FIGURE 4



LATCHING CURRENT VS TEMPERATURE

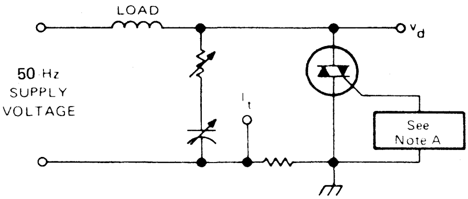
FIGURE 5



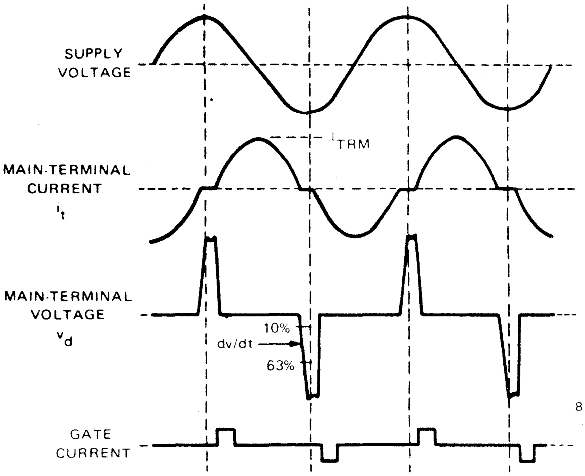
PARAMETER MEASUREMENT INFORMATION

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 6 - COMMUTATING dv/dt

THERMAL INFORMATION

MAXIMUM RMS ON-STATE CURRENT
vs
CASE TEMPERATURE

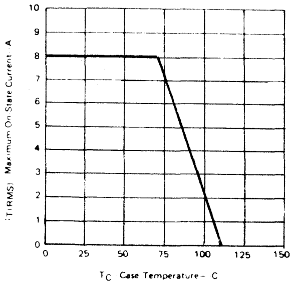


Figure 7.

SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

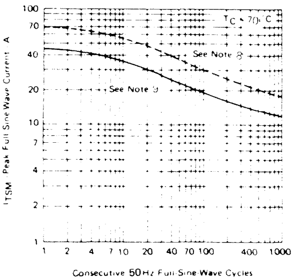


FIGURE 8

NOTES:

8 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.

9 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.

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.

TIC226 SERIES
SILICON TRIACS

8 AMP TRIAC WITH GLASS-PASSIVATED WAFER FOR POWER CONTROL WITH RESISTIVE AND INDUCTIVE LOADS

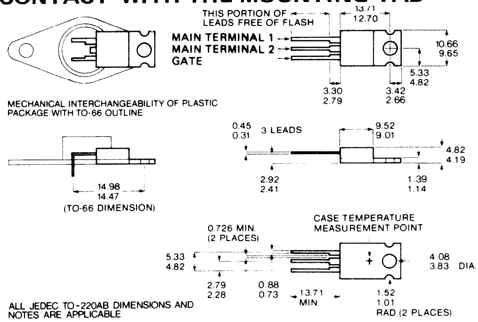
- 100 V to 800 V
- 8 A RMS, 70 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)
- Typ dv/dt of 500 V/µs

description

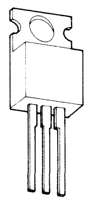
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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) *

			UNIT
Repetitive Peak Off-State Voltage, V_{DRM} (See Note 1)	TIC226A	100	V
	TIC226B	200	V
	TIC226C	300	V
	TIC226D	400	V
	TIC226E	500	V
	TIC226M	600	V
	TIC226S	700	V
	TIC226N	800	V
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 full-sine-wave operation with resistive load. Above 85°C derate according to Figure 7.
3. This value applies for one 50-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 50-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 20 ms.

* All voltage values are with respect to Main Terminal 1.

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†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		2	50	mA
		V_{supply} = +12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-12	-50	
		V_{supply} = −12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-9	-50	
		V_{supply} = −12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		20		
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = +12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		0.7	2	V
		V_{supply} = +12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-0.8	-2	
		V_{supply} = −12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-0.8	-2	
		V_{supply} = −12 V†, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		0.9	2	
V_{TM}	Peak On-State Voltage	I_{TM} = ±12 A, I_G = 50 mA, See Note 6		±1.6	±2.1	V
I_H	Holding Current	V_{supply} = +12 V†, $I_G = 0$, Initiating I_{TM} = 100 mA		5	30	mA
		V_{supply} = −12 V†, $I_G = 0$, Initiating I_{TM} = -100mA		-9	-30	
I_L	Latching Current	V_{supply} = +12 V†, See Note 7			50	mA
		V_{supply} = −12 V†, See Note 7			-50	
dv/dt	Critical Rate of Rise of Off-State Voltage	V_{DRM} = Rated V_{DRM}, $I_G = 0$, $T_C = 110°C$		100		V/μs
dv/dt	Critical Rate of Rise of Commutation Voltage	V_{DRM} = Rated V_{DRM}, I_{TRMS} = ±12 A, $T_C = 85°C$, See Figure 9.	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 the current-carrying contacts, are located within 3.2mm from the device body.

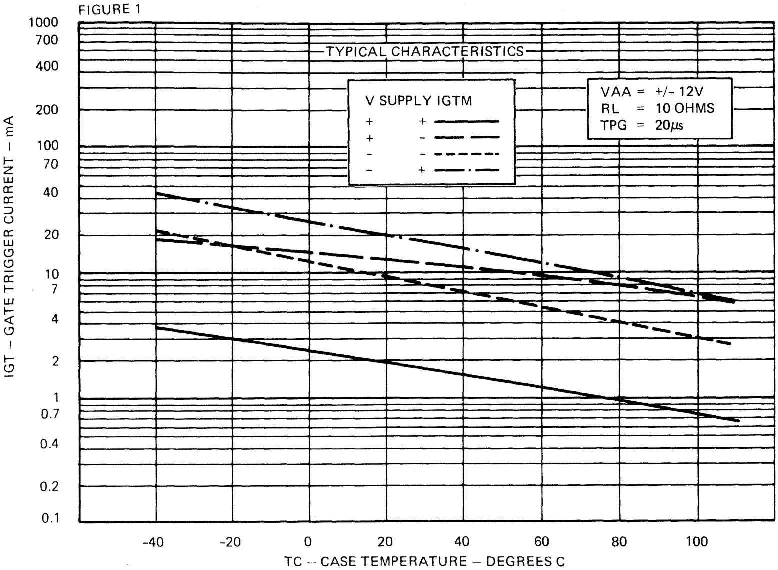
7. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r \leq 15$ ns, $t_f \leq 15$ ns, f = 1 kHz.

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	

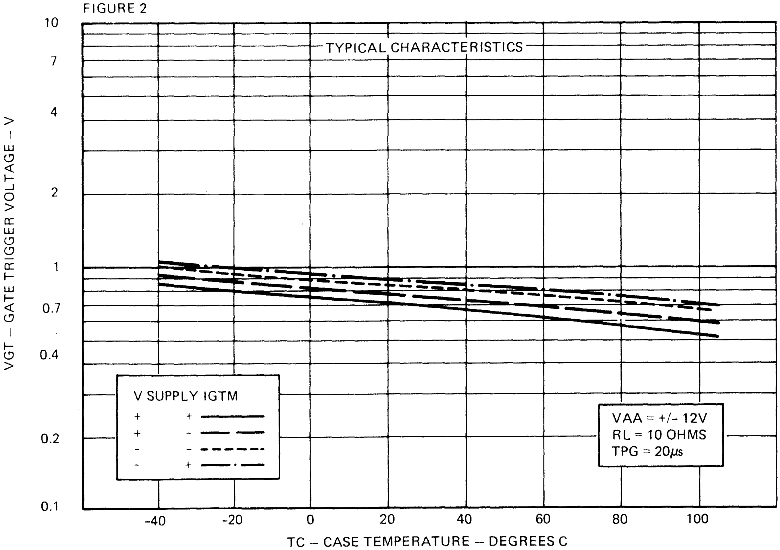
GATE TRIGGER CURRENT VS TEMPERATURE

FIGURE 1



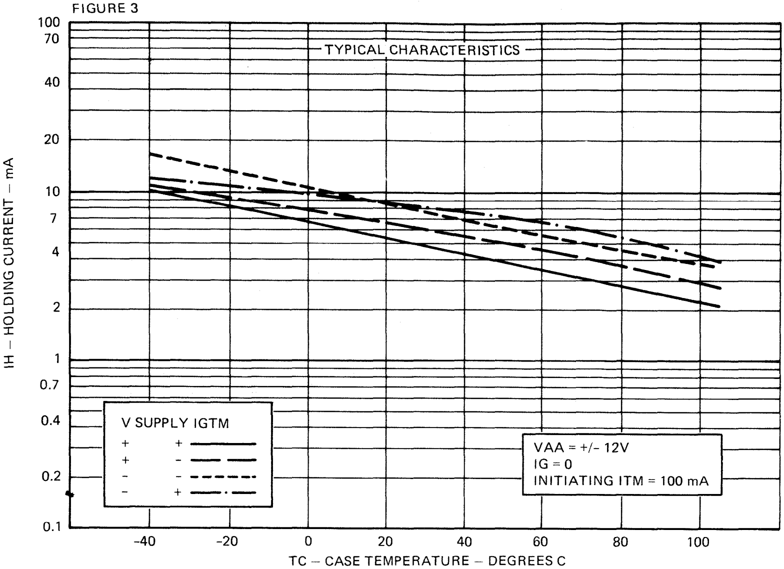
GATE TRIGGER VOLTAGE VS TEMPERATURE

FIGURE 2



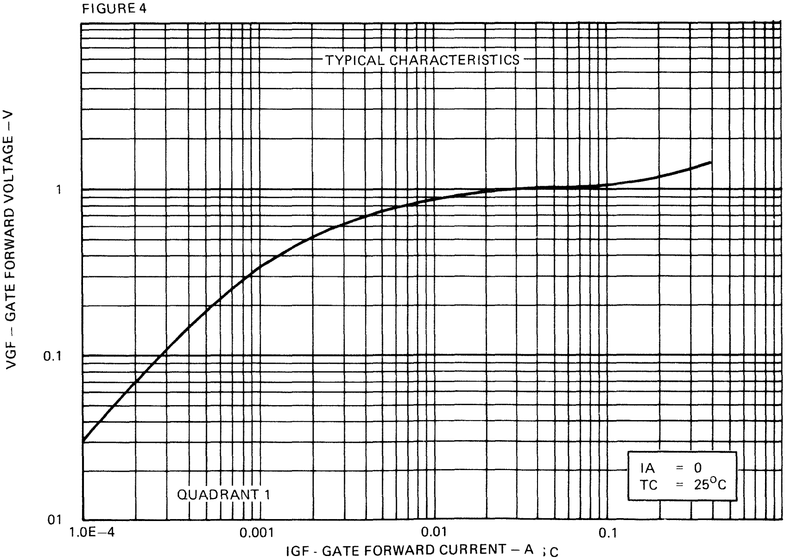
HOLDING CURRENT VS TEMPERATURE

FIGURE 3



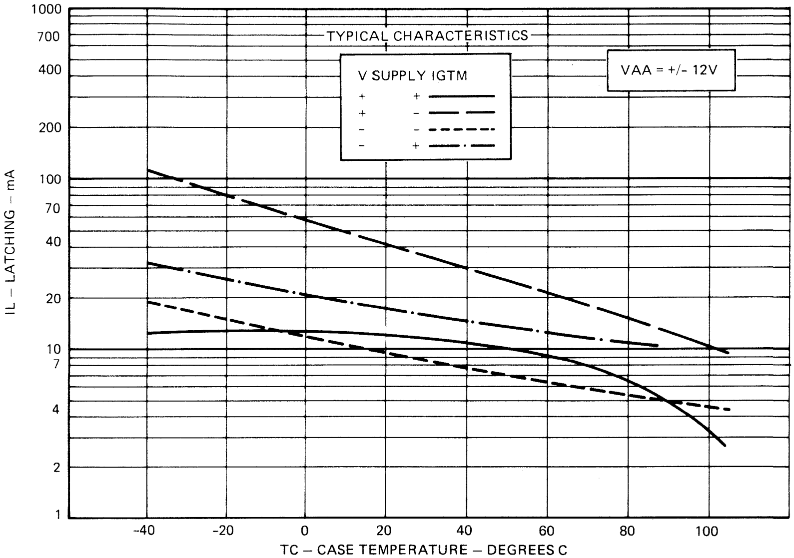
GATE FORWARD VOLTAGE VS GATE FORWARD CURRENT

FIGURE 4



LATCHING CURRENT VS TEMPERATURE

FIGURE 5



SURGE ON-STATE CURRENT
vs
CYCLES OF CURRENT DURATION

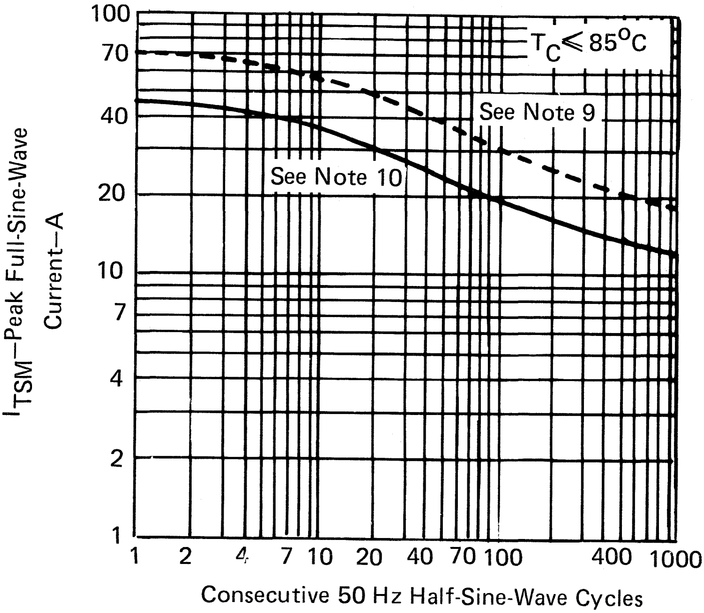


FIGURE 6

NOTES: 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.

THERMAL INFORMATION

MAXIMUM RMS ON-STATE CURRENT vs CASE TEMPERATURE

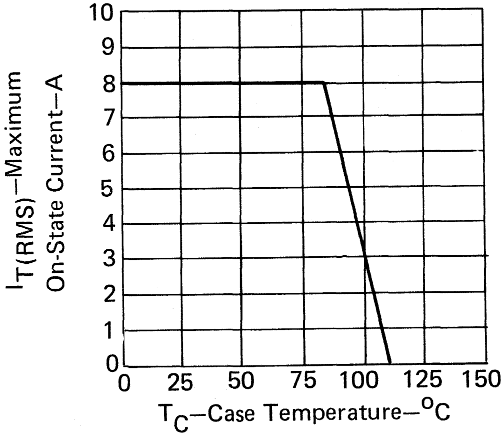


FIGURE 7

NOTE: 8. For operation at current greater than 8 amps rms, see Figure 6.

MAXIMUM AVERAGE POWER DISSIPATED vs RMS ON-STATE CURRENT

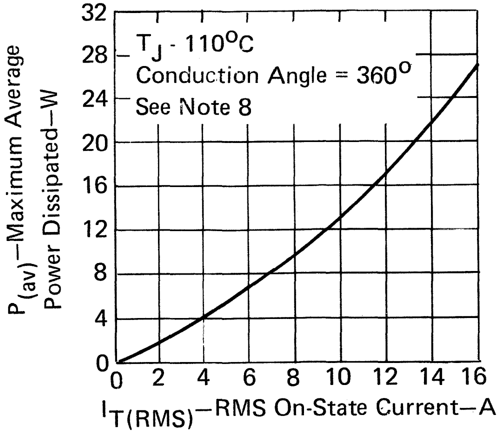
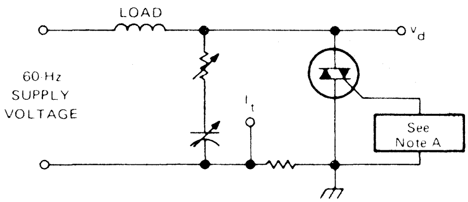


FIGURE 8

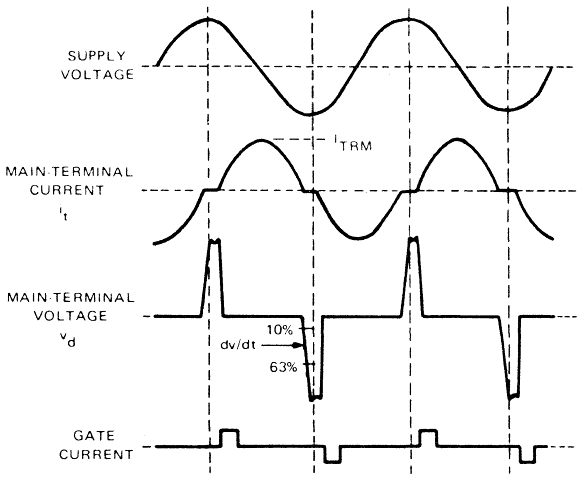
PARAMETER MEASUREMENT INFORMATION

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 9 – 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.

TIC236, TIC246
SILICON TRIACS

HIGH-CURRENT TRIACS WITH GLASS-PASSIVATED WAFER

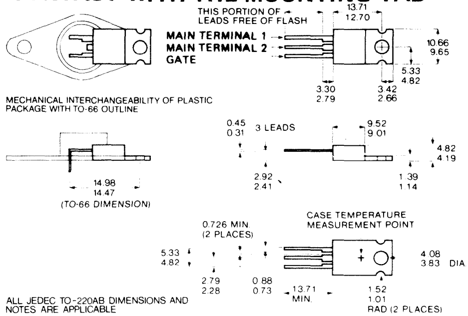
- 100 V to 800 V
- 12 A and 16 A RMS, 100 A and 125 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)

description

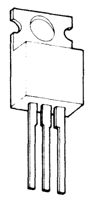
This device is a bidirectional triode thyristor (triac) which may be triggered from the off-state to the on-state by either polarity of gate signal with Main Terminal 2 at either polarity.

mechanical data

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 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 50-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	$V_{supply} = +12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		5	50		5	50	mA
		$V_{supply} = +12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-11	−50		-11	−50	
		$V_{supply} = -12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-20	−50		-20	−50	
		$V_{supply} = -12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		28			28		
V_{GTM}	Peak Gate Trigger Voltage	$V_{supply} = +12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		0.7	2		0.7	2	V
		$V_{supply} = +12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-0.8	2		-0.8	2	
		$V_{supply} = -12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		-0.8	2		0.8	2	
		$V_{supply} = -12\ V^†$, $R_L = 10\ \Omega$, $t_{p(g)} \geq 20\ \mu s$		0.9	2		0.9	2	
V_{TM}	Peak On-State Voltage	$I_{TM} = \pm 17\ A$, $I_G = 100\ mA$, See Note 4		±1.5	±2.1				V
		$I_{TM} = \pm 22.5\ A$, $I_G = 100\ mA$, See Note 4					±1.4	±1.7	
I_H	Holding Current	$V_{supply} = +12\ V^†$, $I_G = 0$, Initiating I_{TM} = 100mA		12	40		12	40	mA
		$V_{supply} = -12\ V^†$, $I_G = 0$, Initiating I_{TM} = -100mA		-12	-40		-12	-40	
I_L	Latching Current	$V_{supply} = +12\ V^†$, See Note 5			80			80	mA
		$V_{supply} = -12\ V^†$, See Note 5			-80			-80	
DV/DT	Critical Rate of Rise of Off State Voltage	V_D = Rated V_D I_G=0, T_C = 110°C		400			400		V/μs
DV/DT	Critical Rate of Rise of Commutating Voltage	V_R = Rated V_D T_C=80°C, DI/DT = 0.5 I_{TRMS}/MS, I_T = 1.4 I_{TRMS}	1.2	2		1.2	2		V/μs
DI/DT	Critical Rate of Rise of On-State Current	V_D = Rated V_D T_C=110°C, I_{GT}= 50mA D_{IG}/D_T=50mA/μs, I_{TMAX}= 300 A		200			200		A/μs

†All voltage values are with respect to Main Terminal 1.

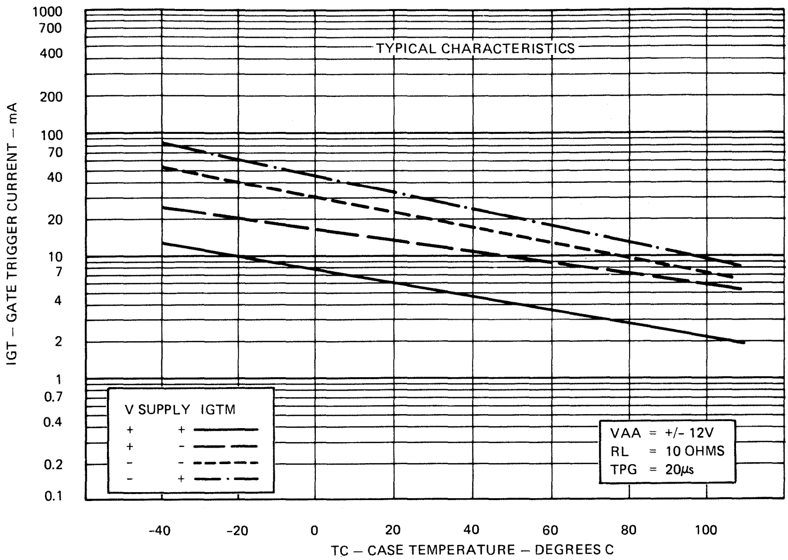
NOTES: 4. This parameter must be measured using pulse techniques. $t_w \leq 1$ ms, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.2 mm from the device body.

5. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics: $R_G = 100\ \Omega$, $t_w = 20\ \mu s$, $t_r \leq 15$ ns, $t_f \leq 15$ ns, f = 1 kHz.

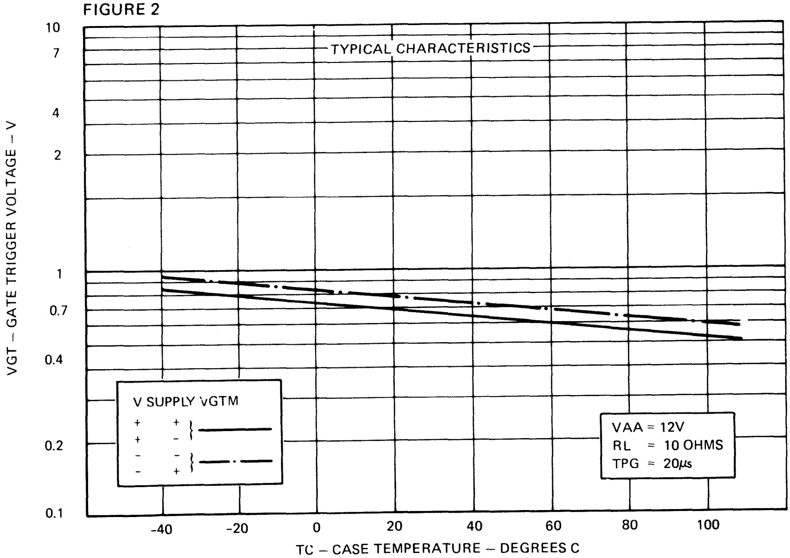
thermal characteristics

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	°C/W

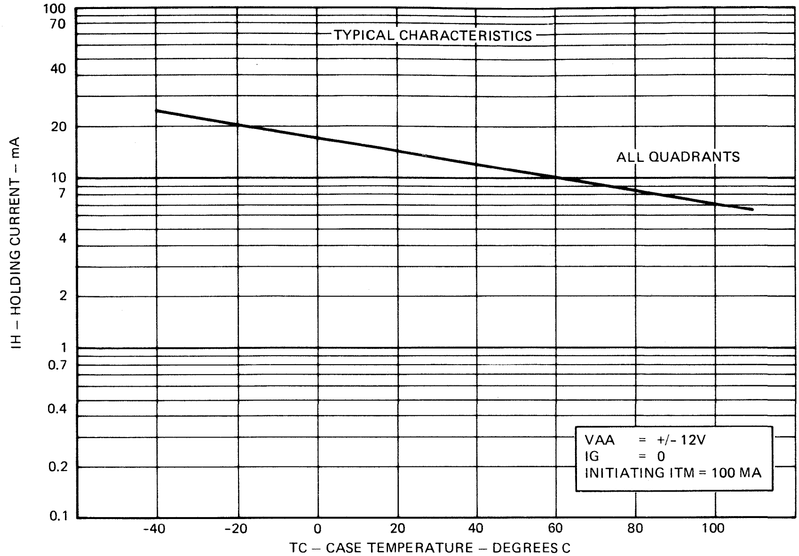
GATE TRIGGER CURRENT VS TEMPERATURE
FIGURE 1



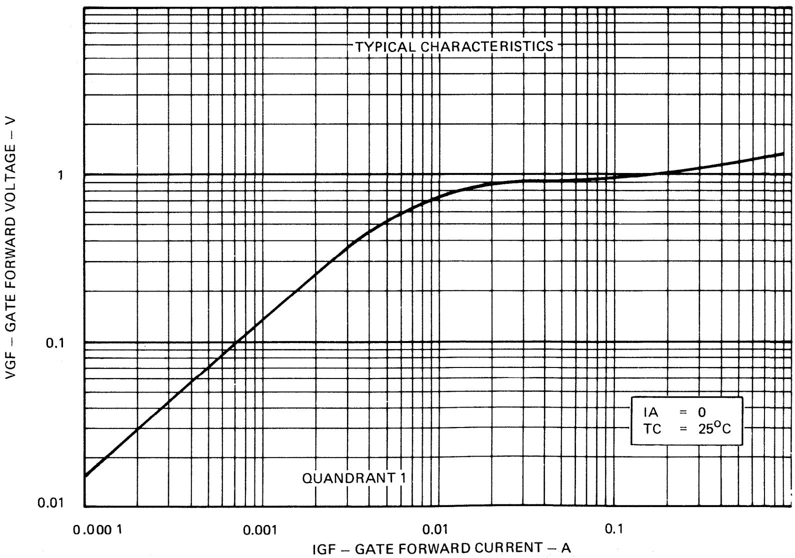
GATE TRIGGER VOLTAGE VS TEMPERATURE
FIGURE 2



HOLDING CURRENT VS TEMPERATURE
FIGURE 3

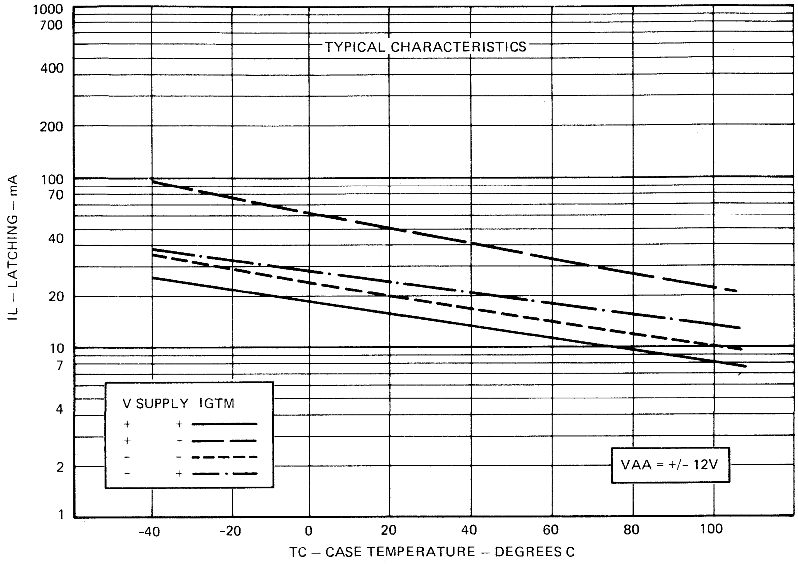


GATE FORWARD VOLTAGE VS GATE FORWARD CURRENT
FIGURE 4



LATCHING CURRENT VS TEMPERATURE

FIGURE 5



HIGH-CURRENT TRIACS WITH GLASS-PASSIVATED WAFER

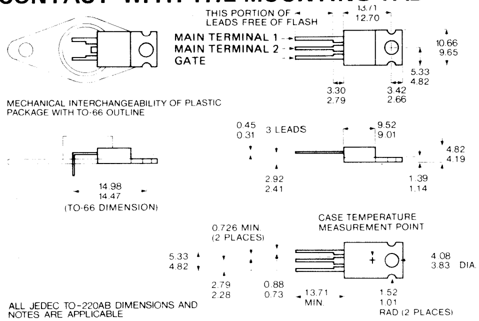
- 100 V to 800 V
- 20 A and 25 A RMS, 100 and 175 A Peak
- MAX I_{GT} of 50 mA (Quadrants 1-3)

description

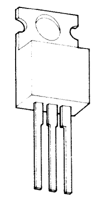
These devices are bidirectional triode thyristors (triacs) which may be triggered from the off-state by either polarity of gate signal with Main Terminal 2 at either polarity.

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 50-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†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		7	50		7	50	mA
		V_{supply} = +12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		-15	−50		-15	−50	
		V_{supply} = −12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		-16	−50		-16	−50	
		V_{supply} = −12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		28			28		
V_{GTM}	Peak Gate Trigger Voltage	V_{supply} = +12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		0.7	2		0.7	2	V
		V_{supply} = +12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		-0.7	-2		-0.7	-2	
		V_{supply} = −12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		-0.8	-2		-0.8	-2	
		V_{supply} = −12 V†,	R_L = 10 Ω,	$t_{p(g)} \geq 20\ \mu s$		0.8	2		0.8	2	
V_{TM}	Peak On-State Voltage	I_{TM} = ±28.2 A,	I_G = 50 mA, See Note 4			±1.4	±1.7				V
		I_{TM} = 35.2 A,	I_G = 50 mA, See Note 4						±1.5	±1.7	
I_H	Holding Current	V_{supply} = +12 V†,	I_G = 0,	Initiating I_{TM} = 100 mA		6	40		6	40	mA
		V_{supply} = −12 V†,	I_G = 0,	Initiating I_{TM} = −100 mA		-13	-40		-13	-40	
I_L	Latching Current	V_{supply} = +12 V†,	See Note 5			20			20		mA
		V_{supply} = −12 V†,	See Note 5			−20			−20		
DV/DT Critical Rate of Rise of of Off State Voltage		V_D = Rated V_D I_G=0 T_C = 110°C				450			450		V/µs
DV/DT Critical Rate of Rise of Commutating Voltage		V_R = Rated V_D, T_C = 80°C D_I/D_T = 0				1			1		
DI/DT Critical Rate of Rise of On State Current		V_D = Rated V_D, T_C = 110°C I_{GT} = 50mA DI_G/D_T = 50mA/µs I_T MAX = 300A				200			200		A/µs

† All voltage values are with respect to Main Terminal 1.

NOTES: 4. This parameter must be measured using pulse techniques. $t_w \leq 1$ ms, duty cycle ≤ 2%. Voltage-sensing contacts, separate from the current-carrying contacts, are located within 3.175 mm from the device body.

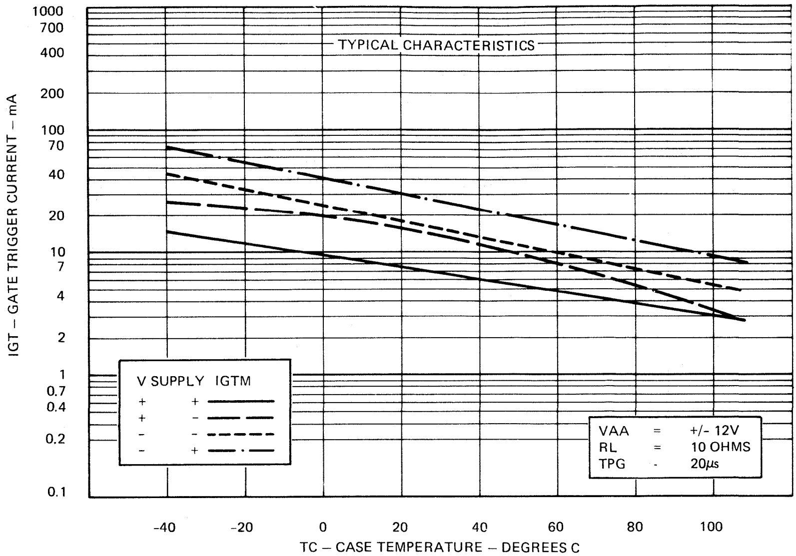
5. The triacs are triggered by a 15-V (open-circuit amplitude) pulse supplied by a generator with the following characteristics R_G = 100 Ω, t_w = 20 µs, $t_r \leq 15$ ns, $t_f \leq 15$ ns, f = 1 kHz.

thermal characteristics

PARAMETER		SERIES TIC253 MAX	SERIES TIC263 MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.52	1.22	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	36	36	°C/W

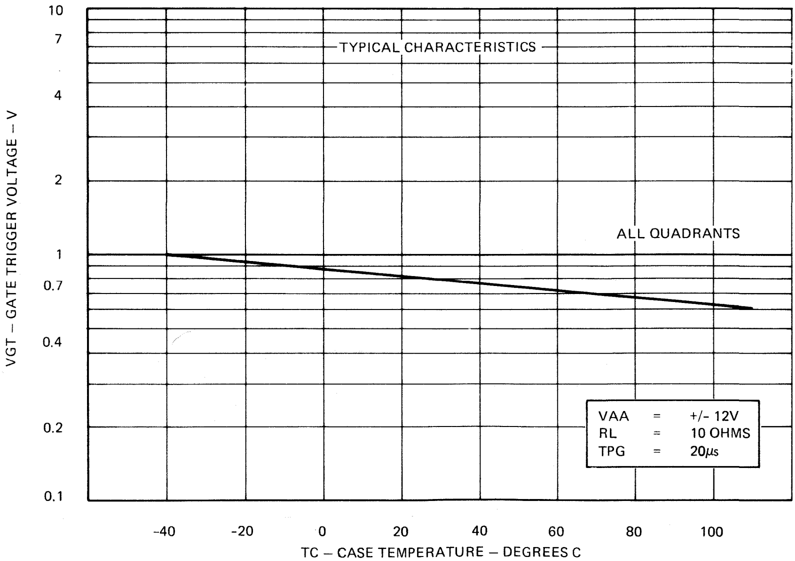
GATE TRIGGER CURRENT VS TEMPERATURE

FIGURE 1



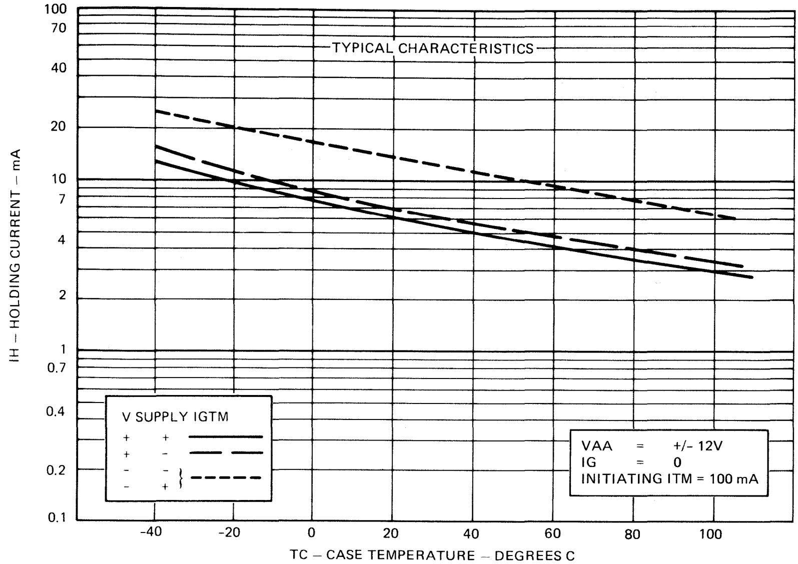
GATE TRIGGER VOLTAGE VS TEMPERATURE

FIGURE 2



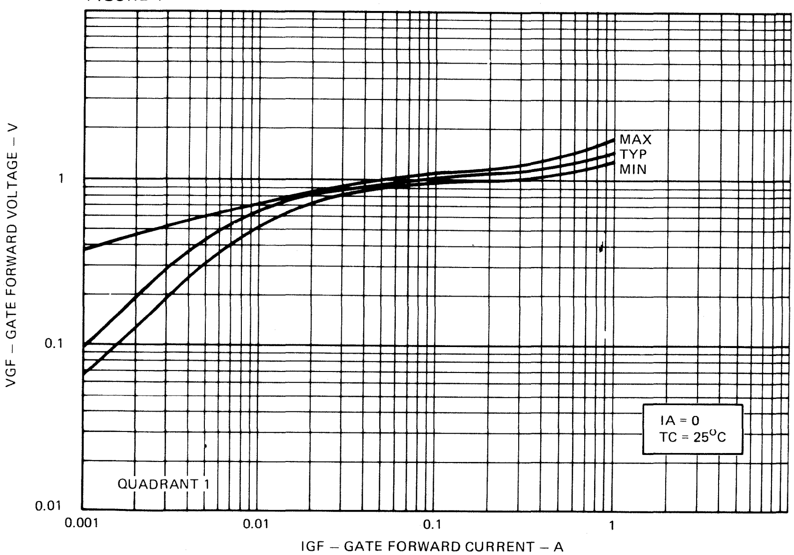
HOLDING CURRENT VS TEMPERATURE

FIGURE 3



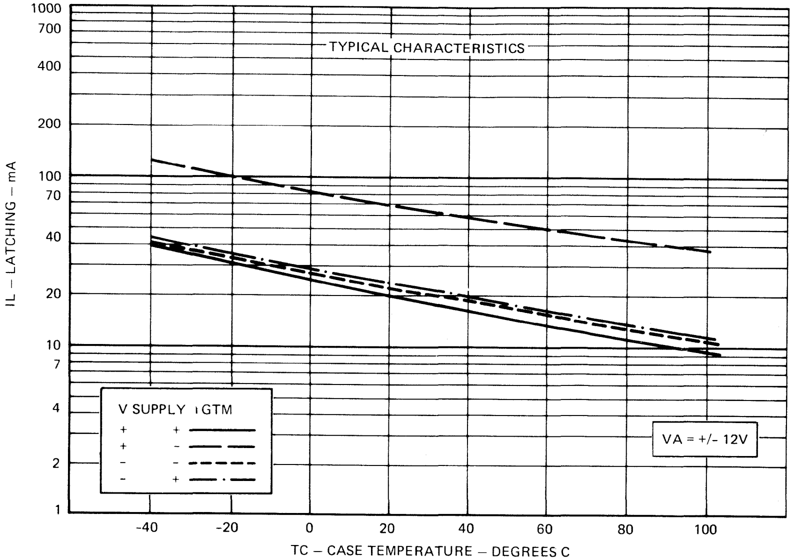
GATE FORWARD VOLTAGE VS GATE FORWARD CURRENT

FIGURE 4



LATCHING CURRENT VS TEMPERATURE

FIGURE 5



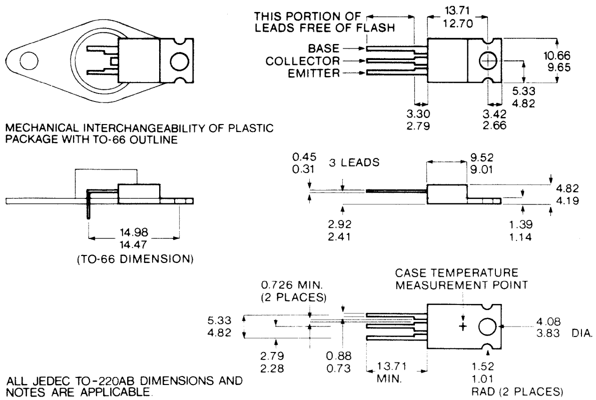
C: Transistors and Darlingtons

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD240 SERIES

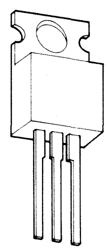
- **30W at 25°C Case Temperature**
- **2A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 200 mA**
- **Customer-Specified Selections Available**
- **European Version of TIP29**

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)

PARAMETER	BD239	BD239A	BD239B	BD239C	BD239D	BD239E	BD239F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	55	70	90	115	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	2A
Peak Collector Current[2]	4A
Continuous Base Current	0.6A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	30W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 0.24W/°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 in Figure 2.

NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD239/239A		BD239B/239C		BD239D/239E/239F		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V	I_B = 0		0.3					mA
		V_{CE} = 60V	I_B = 0				0.3			
		V_{CE} = 90V	I_B = 0						0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER}, V_{BE} = 0			0.2		0.2		0.2	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V	I_C = 0		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V	I_C = 0.2A	40		40		40		
		V_{CE} = 4V	I_C = 1.0A	15		15		15		
		See Notes 6 & 7								
V_{BE}	Base-Emitter Voltage	V_{CE} = 4V, See Notes 6 & 7	I_C=1A		1.3		1.3		1.3	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = 200mA, See Notes 6 & 7	I_C = 1.0A		0.7		0.7		0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V, f = 1 KHz	I_C = 0.2A	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V, f = 1 MHz	I_C = 0.2A	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.

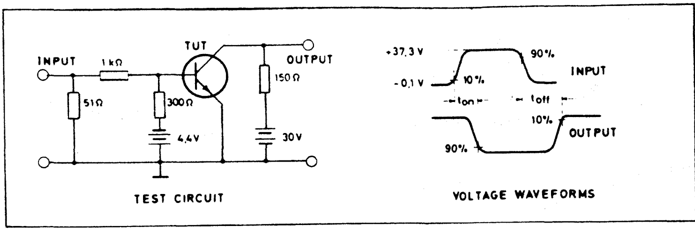


FIGURE 1

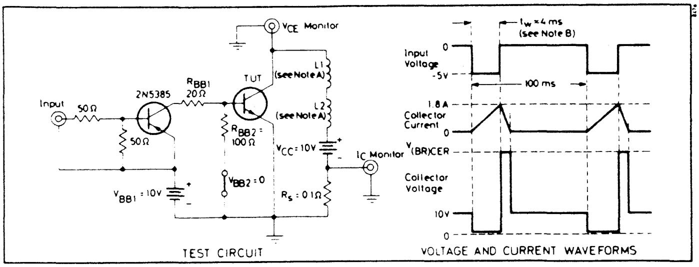


FIGURE 2

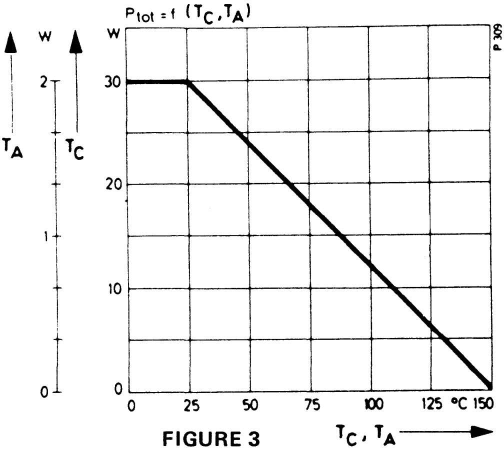


FIGURE 3

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

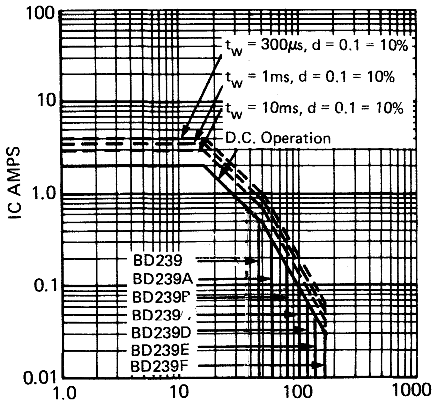
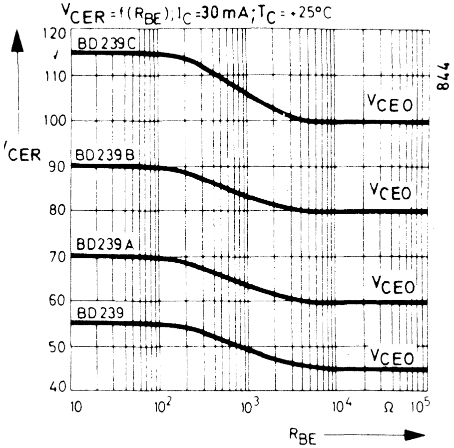
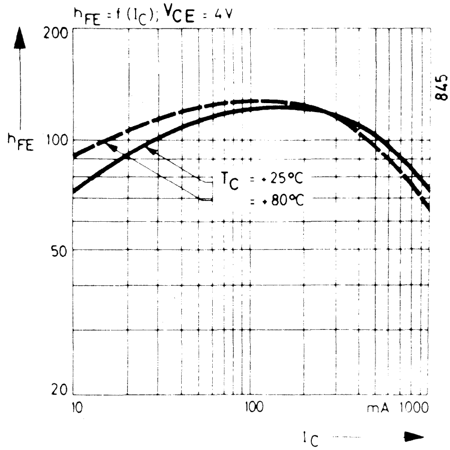
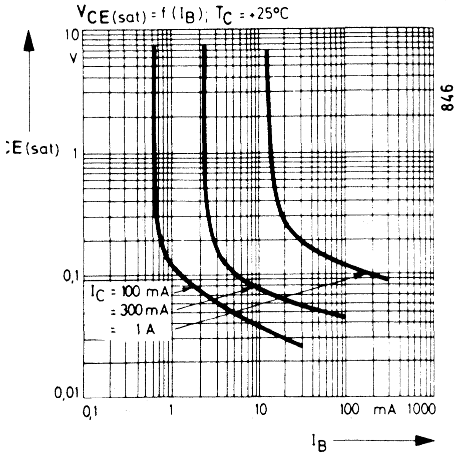


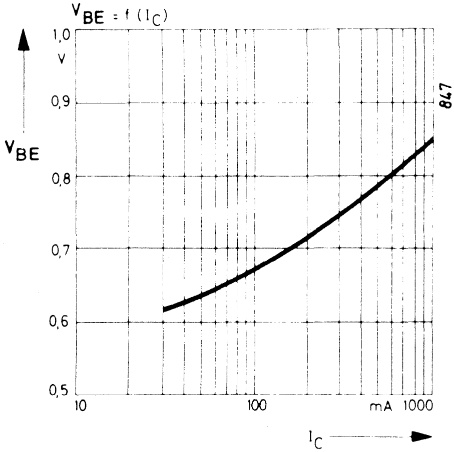
FIGURE 4

NOTES. A. L1 and L2 are 10mH, 0.11Ω, Chicago Standard Transformer Co C-2688
B. Input pulse width is increased until I_{cm} = 1.8A.


$V_{CER} = f(R_{BE})$; I_C = 30 mA; T_C = +25°C
BD239C
BD239B
BD239A
BD239
V_{CEO}
V_{CER}
R_{BE}
844


$h_{FE} = f(I_C)$; V_{CE} = 4 V
h_{FE}
T_C = +25°C
= +80°C
I_C
mA
845


$V_{CE(sat)} = f(I_B)$; T_C = +25°C
I_C = 100 mA
= 300 mA
= 1 A
I_B
mA
846


$V_{BE} = f(I_C)$
V_{BE}
I_C
mA
847

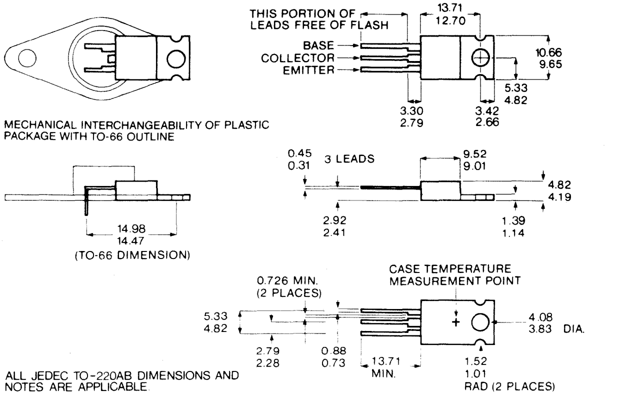
BD240 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD239 SERIES

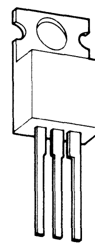
- 30W at 25°C Case Temperature
- -2A Rated Collector Current
- Minimum f_T of 3MHz at-10V, -200mA
- Customer-Specified Selections Available
- European Version of TIP30

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

PARAMETER	BD240	BD240A	BD240B	BD240C	BD240D	BD240E	BD240F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	-55	-70	-90	-115	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-2A
Peak Collector Current[2]	-4A
Continuous Base Current	-0.6A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	30W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	32mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 ⩽ 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 in Figure 2.

BD240, SERIES
PNP SINGLE-DIFFUSED MESA
SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	BD240/240A		BD240B/240C		BD240D/240E 240F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.3					mA
		V_{CE} = -60V I_B = 0				-0.3			
		V_{CE} = -90V I_B = 0						-0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER} V_{BE} = 0		-0.2		-0.2		-0.2	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -0.2A	40		40		40		
		V_{CE} = -4V I_C = -1.0A See Notes 6 & 7	15		15		15		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -1A See Notes 6 & 7		-1.3		-1.3		-1.3	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -200mA I_C = -1A See Notes 6 & 7		-0.7		-0.7		-0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.2A f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.2A f = 1MHz	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,	0.2	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.

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

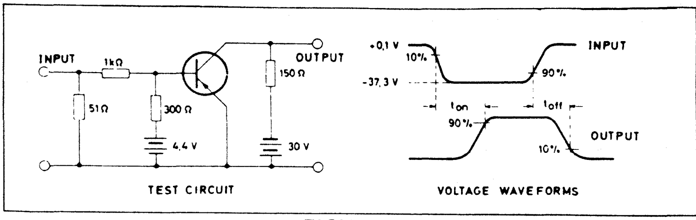


FIGURE 1

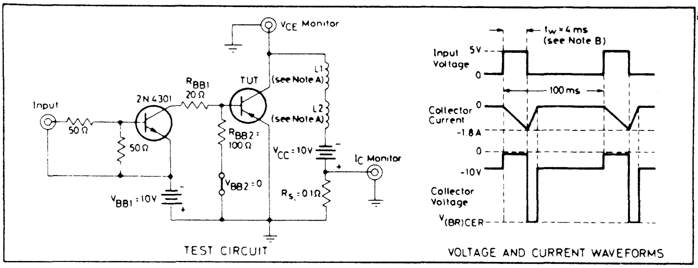


FIGURE 2

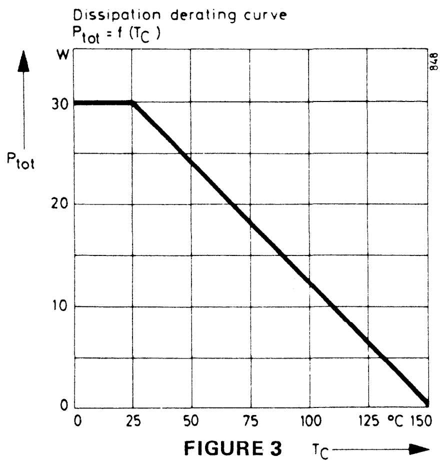


FIGURE 3

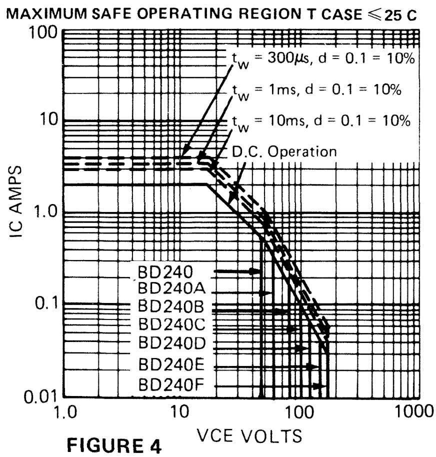
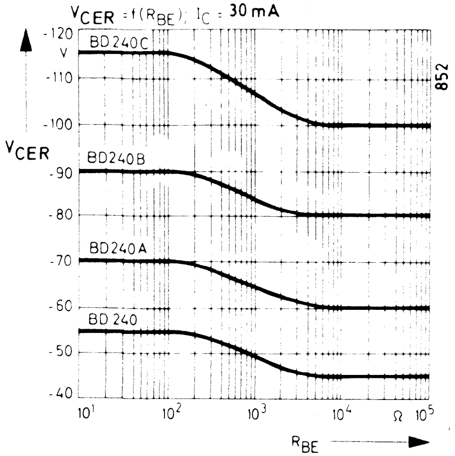
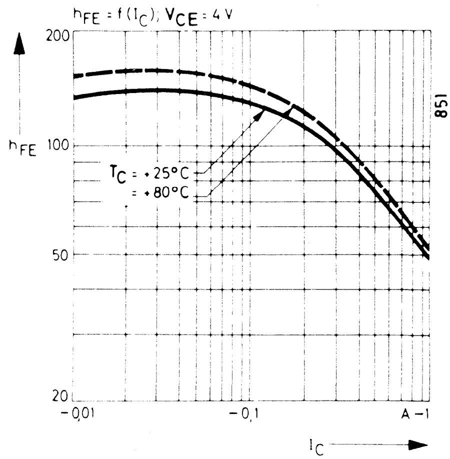


FIGURE 4

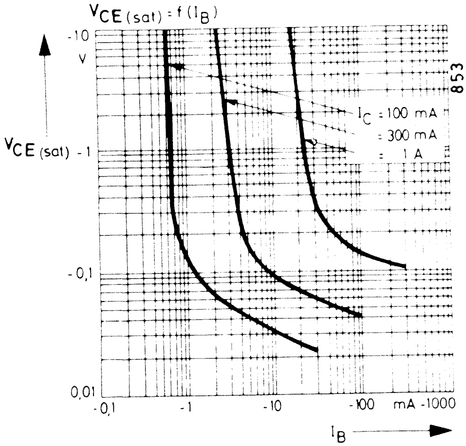
Notes A L1 and L2 are 10mH, 0.11Ω
B Input pulse width is increased until I_{cm} = 1.8A



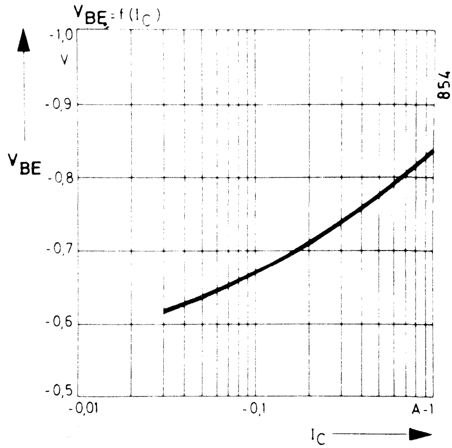
VCER = f(RBE); IC = 30 mA
VCER
-120 V
-110
-100
-90
-80
-70
-60
-50
-40
BD240C
BD240B
BD240A
BD 240
10^1
10^2
10^3
10^4
Ω 10^5
RBE
852



hFE = f(IC); VCE = 4 V
hFE
200
100
50
20
TC = +25°C
= +80°C
-0,01
-0,1
A -1
IC
851



VCE(sat) = f(IB)
VCE(sat)
-10 V
-1
-0,1
0,01
IC = 100 mA
= 300 mA
= 1 A
-0,1
-1
-10
-100
mA -1000
IB
853



VBE = f(IC)
VBE
-1,0 V
-0,9
-0,8
-0,7
-0,6
-0,5
-0,01
-0,1
A -1
IC
854

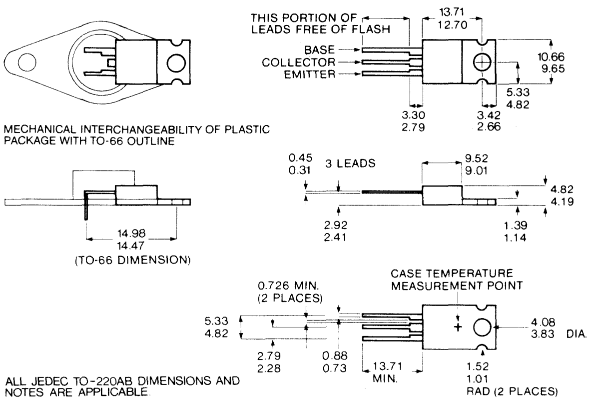
BD241 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD242 SERIES

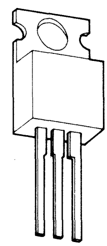
- 40W at 25°C Case Temperature
- 3A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 500 mA
- Customer-Specified Selections Available
- European Version of TIP31

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)

PARAMETER	BD241	BD241A	BD241B	BD241C	BD241D	BD241E	BD241F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	55	70	90	115	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	3A
Peak Collector Current[2]	5A
Continuous Base Current	1A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	40 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies 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 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 in Figure 2.

BD241 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD241/241A		BD241B/241C		BD241D/241E 241F		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30V$	$I_B = 0$		0.3					mA
		$V_{CE} = 60V$	$I_B = 0$				0.3			
		$V_{CE} = 90V$	$I_B = 0$						0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated $V_{BE} = 0$	BV_{CER}		0.2		0.2		0.2	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5V$	$I_C = 0$		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4V$ See Notes 6 & 7	$I_C = 1A$	25		25		25		
		$V_{CE} = 4V$	$I_C = 3A$	10		10		5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4V$ See Notes 6 & 7	$I_C = 3A$		1.8		1.8		1.8	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.6A$ See Notes 6 & 7	$I_C = 3A$		1.2		1.2			V
		$I_B = 0.75A$	$I_C = 3A$						2.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ f = 1KHz	$I_C = 0.5A$	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ f = 1MHz	$I_C = 0.5A$	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.

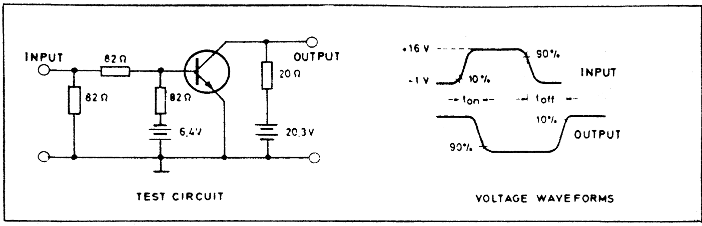


FIGURE 1

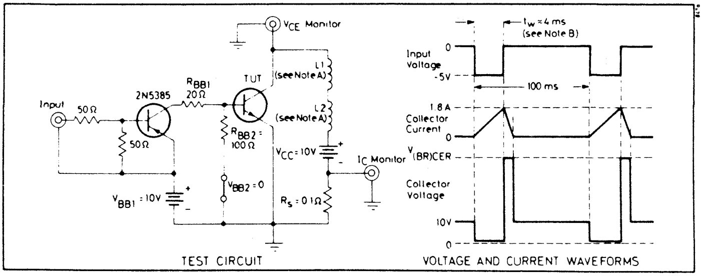


FIGURE 2

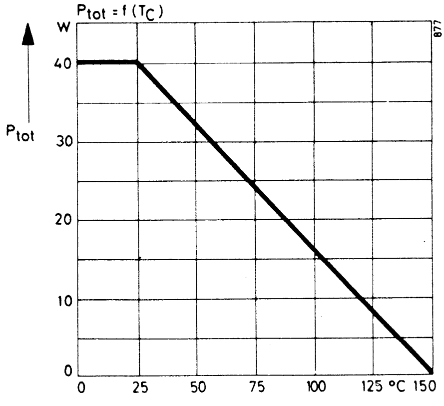


FIGURE 3

MAXIMUM SAFE OPERATION REGION T CASE ⩽25 C

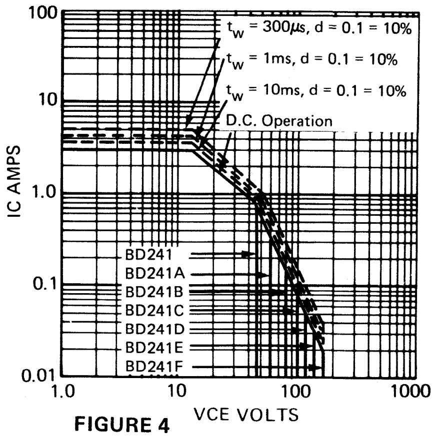
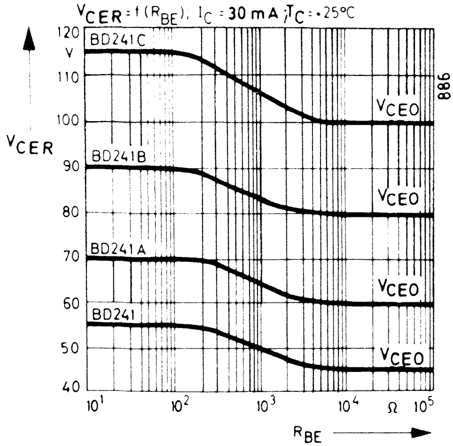
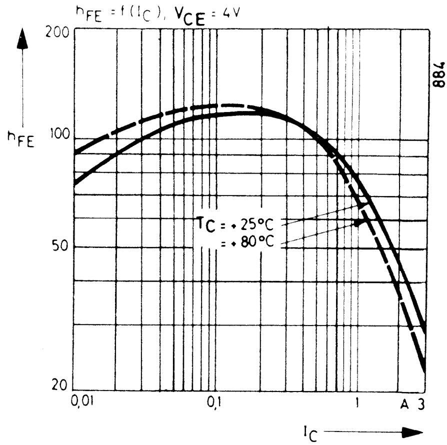


FIGURE 4

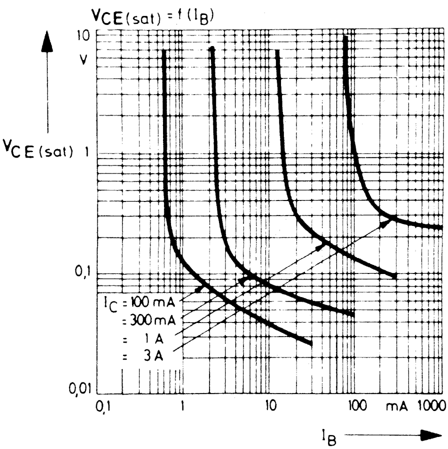
Notes A L1 and L2 are 10mH, 0.11Ω
B Input pulse width is increased until I_{cm} = 1.8A



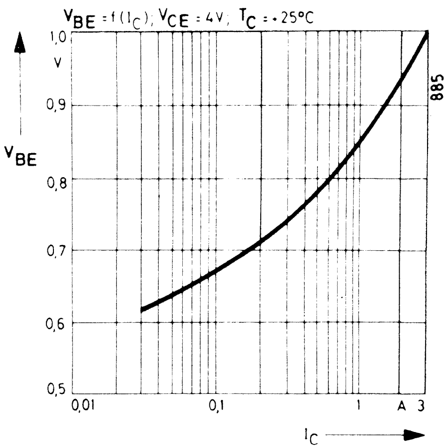
VCER = f (RBE); IC = 30 mA ; TC = +25°C
VCER
RBE
BD241C
BD241B
BD241A
BD241
VCEO
886



hFE = f (IC), VCE = 4V
hFE
IC
TC = +25°C
= +80°C
884



VCE(sat) = f (IB)
VCE(sat)
IB
IC = 100 mA
= 300 mA
= 1 A
= 3 A
887



VBE = f (IC); VCE = 4V; TC = +25°C
VBE
IC
885

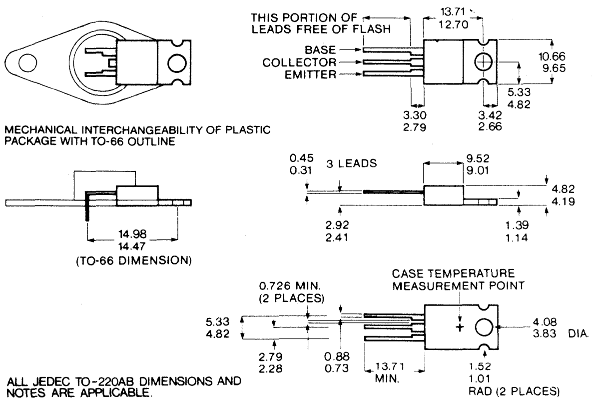
BD242 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD241 SERIES

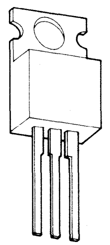
- 40W at 25°C Case Temperature
- 3A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 500 mA
- Customer-Specified Selections Available
- European Version of TIP32

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)

PARAMETER	BD242	BD242A	BD242B	BD242C	BD242D	BD242E	BD242F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	-55	-70	-90	-115	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-3A
Peak Collector Current[2]	-5A
Continuous Base Current	-1A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	40 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	BD241/241A		BD241B/241C		BD241D/241E 241E		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.3					mA
		V_{CE} = -60V I_B = 0				-0.3			
		V_{CE} = -90V I_B = 0						-0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER} V_{BE} = 0		-0.2		-0.2		-0.2	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -1A See Notes 6 & 7	25		25		25		
		V_{CE} = -4V I_C = -3A	10		10		5		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -3A See Notes 6 & 7		-1.8		-1.8		-1.8	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -0.6A I_C = -3A		-1.2		-1.2			
		I_B = -0.75A I_C = -3A See Notes 6 & 7						-2.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.5A f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.5A f = 1MHz	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 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.

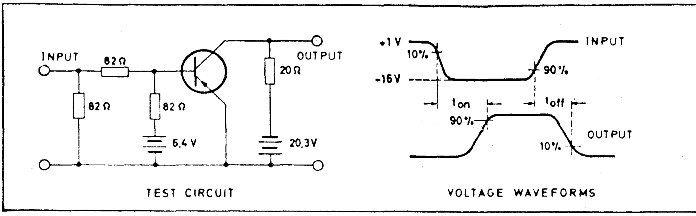


FIGURE 1

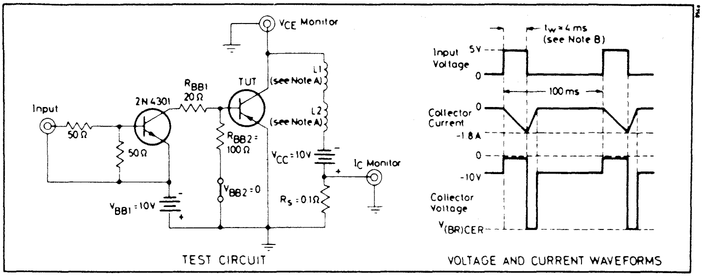


FIGURE 2

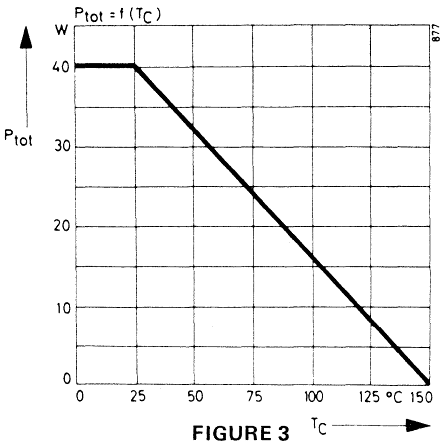


FIGURE 3

MAXIMUM SAFE OPERATION REGION T CASE ≤25 C

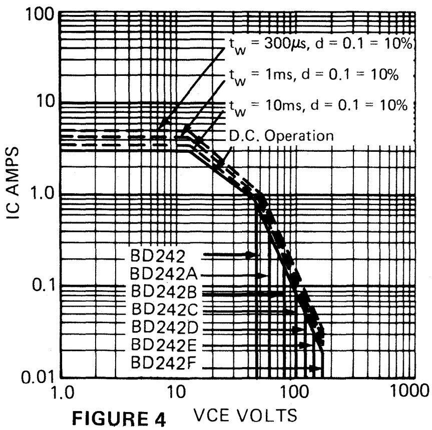
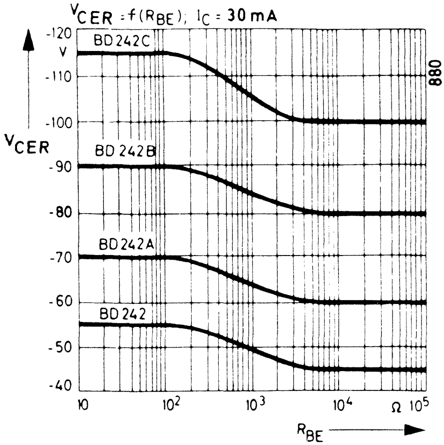


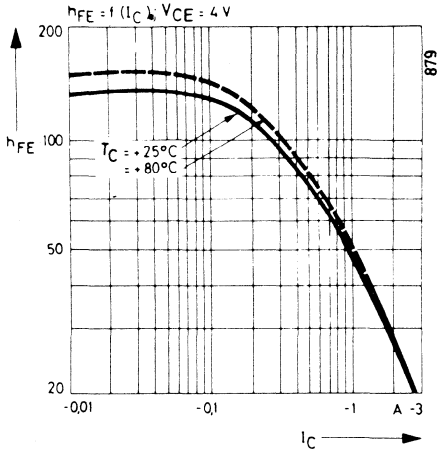
FIGURE 4

Notes A L1 and L2 are 10mH, 0.11Ω

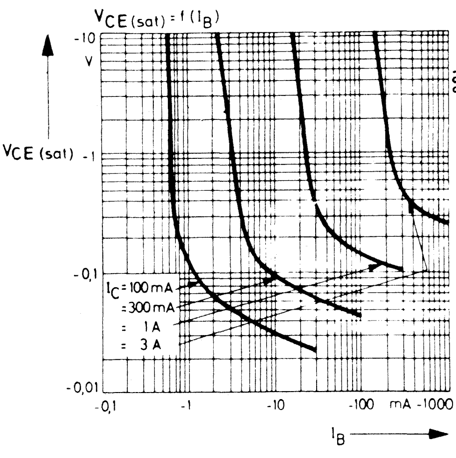
B Input pulse width is increased until I_{cm} = 1.8A



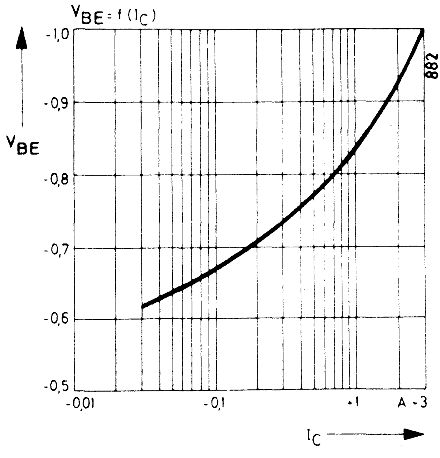
VCER = f(RBE); IC = 30 mA
BD242C
BD 242B
BD242A
BD242
VCER
V
-120
-110
-100
-90
-80
-70
-60
-50
-40
10
10^2
10^3
10^4
Ω 10^5
RBE
880



hFE = f (IC); VCE = 4 V
hFE
200
100
50
20
TC = +25°C
= +80°C
-0,01
-0,1
-1
A -3
IC
879



VCE(sat) = f (IB)
VCE (sat)
-10
V
-1
-0,1
-0,01
IC = 100 mA
= 300 mA
= 1 A
= 3 A
-0,1
-1
-10
-100
mA -1000
IB
881



VBE = f (IC)
VBE
-1,0
-0,9
-0,8
-0,7
-0,6
-0,5
-0,01
-0,1
-1
A -3
IC
882

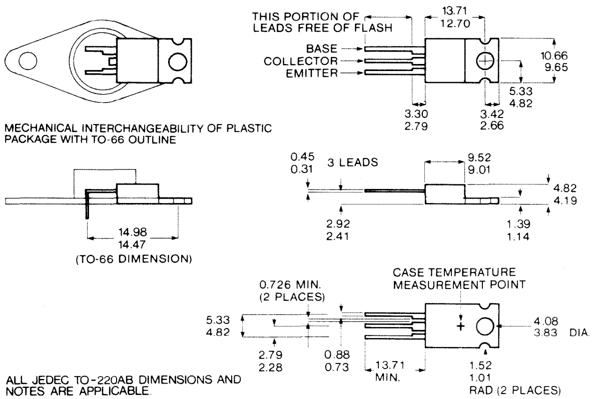
BD243 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD244 SERIES

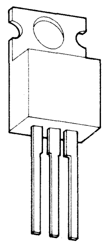
- **65W at 25°C Case Temperature**
- **6A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 500 mA**
- **Customer-Specified Selections Available**
- **European Version of TIP41**

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)

PARAMETER	BD243	BD243A	BD243B	BD243C	BD243D	BD243E	BD243F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	55	70	90	115	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	6A
Peak Collector Current[2]	10A
Continuous Base Current	3A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	65 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 in Figure 2.

BD243 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD243/243A		BD243B/243C		BD243D/243E 243F		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V	I_B = 0		0.7					mA
		V_{CE} = 60V	I_B = 0				0.7			
		V_{CE} = 90V	I_B = 0						0.7	
I_{CES}	Collector Cutoff Current	V_{CC} = Rated V_{BE} = 0	BV_{CER}		0.4		0.4		0.4	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V	I_C = 0		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V See Notes 6 & 7	I_C = 0.3A	30		30		30		
		V_{CE} = 4V	I_C = 3A	15		15		15		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4V See Notes 6 & 7	I_C = 6A		2		2		2	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = 1.0A	I_C = 6A		1.5		1.5			V
		I_B = 1.5A See Notes 6 & 7	I_C = 6A						1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V f = 1KHz	I_C = 0.5A	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V f = 1MHz	I_C = 0.5A	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	°C/W

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	μs

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

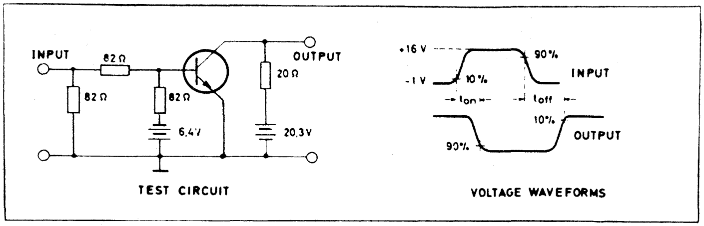


FIGURE 1

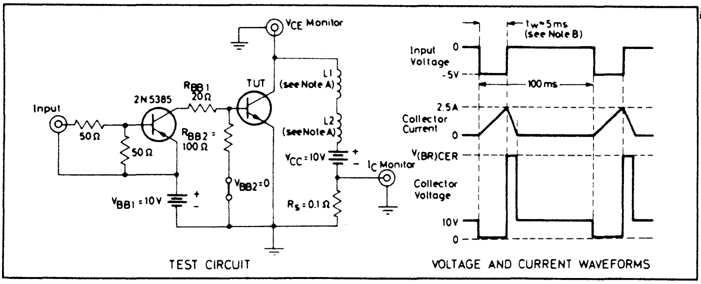


FIGURE 2

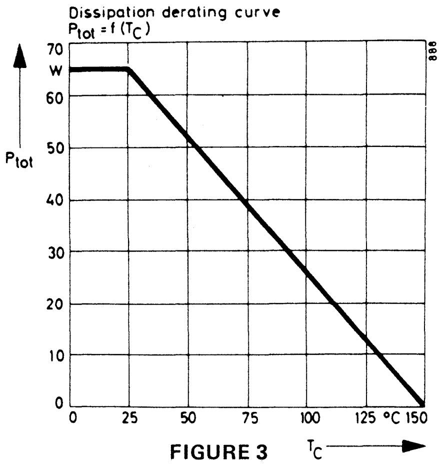


FIGURE 3

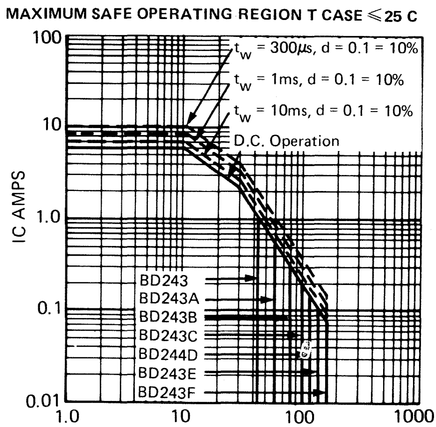
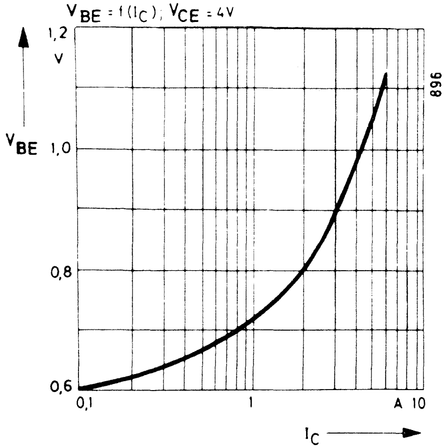


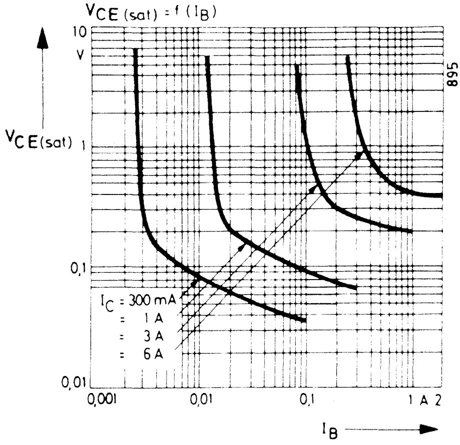
FIGURE 4

Notes A L1 and L2 are 10mH, 0.11Ω

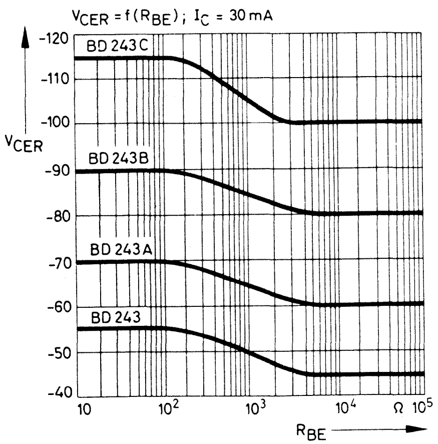
B Input pulse width is increased until I_{cm} = 2.5A



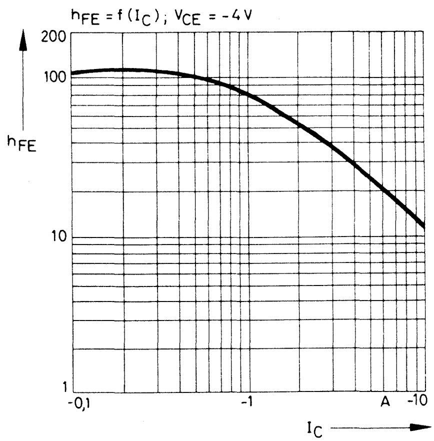
$V_{BE} = f(I_C)$; $V_{CE} = 4V$
1,2
V
V_{BE}
1,0
0,8
0,6
0,1
1
A 10
I_C
896



$V_{CE(sat)} = f(I_B)$
10
V
$V_{CE(sat)}$
1
0,1
0,01
I_C = 300 mA
= 1 A
= 3 A
= 6 A
0,001
0,01
0,1
1 A 2
I_B
895



$V_{CER} = f(R_{BE})$; I_C = 30 mA
-120
-110
-100
V_{CER}
-90
-80
-70
-60
-50
-40
BD 243C
BD 243B
BD 243A
BD 243
10
10^2
10^3
10^4
Ω 10^5
R_{BE}



$h_{FE} = f(I_C)$; V_{CE} = -4 V
200
100
h_{FE}
10
1
-0,1
-1
A -10
I_C

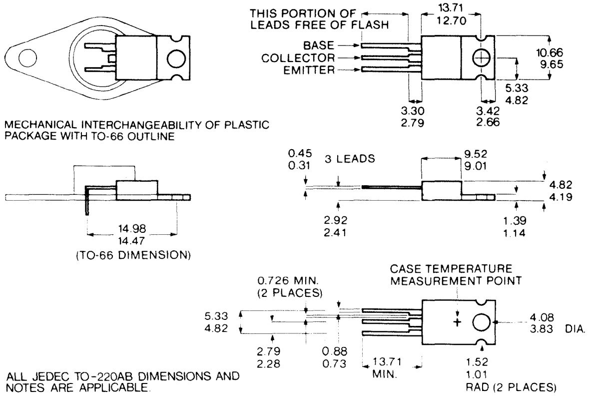
BD244 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD243 SERIES

- 65W at 25°C Case Temperature
- -6A Rated Collector Current
- Minimum f_T of 3MHz at -10V, -500 mA
- Customer-Specified Selections Available
- European Version of TIP42

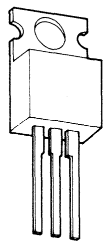
MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL JEDEC TO-220AB DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	BD244	BD244A	BD244B	BD244C	BD244D	BD244E	BD244F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	-55	-70	-90	-115	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-6A
Peak Collector Current[2]	-10A
Continuous Base Current	-3A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	65 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2 W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 ≤ 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 in Figure 2.

PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	BD244/244A MIN	BD244/244A MAX	BD244B/244C MIN	BD244B/244C MAX	BD244D/244E 244F MIN	BD244D/244E 244F MAX	UNIT
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.7					mA
		V_{CE} = -60V I_B = 0				-0.7			
		V_{CE} = -90V I_B = 0						-0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER} V_{BE} = 0		-0.4		-0.4		-0.4	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -0.3A See Notes 6 & 7	30		30		30		
		V_{CE} = -4V I_C = -3A	15		15		15		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -6A See Notes 6 & 7		-2		-2		-2	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -1.0A I_C = -6A		-1.5		-1.5			V
		I_B = 1.5A I_C = -6A See Notes 6 & 7						-1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = - 0.5A f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.5A f = 1MHz	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}	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.

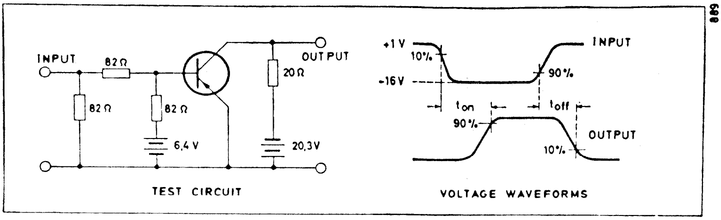


FIGURE 1

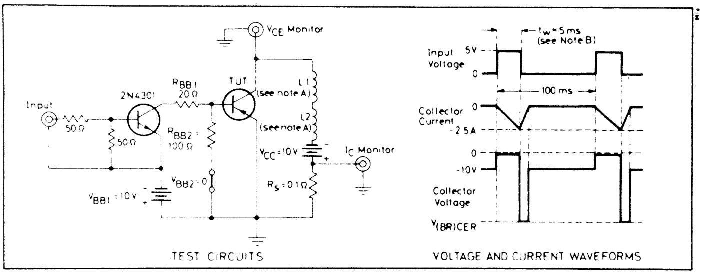


FIGURE 2

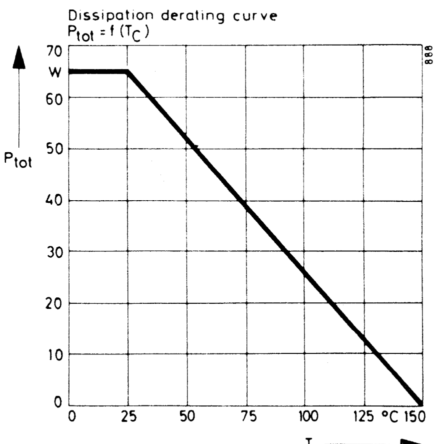


FIGURE 3

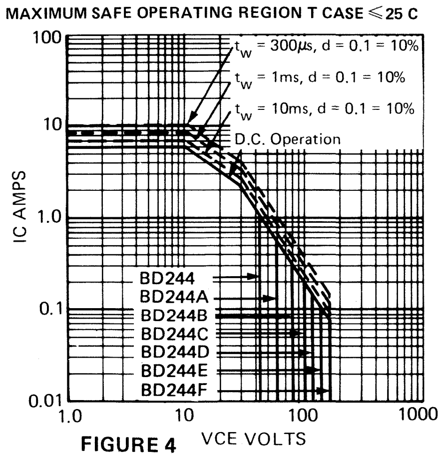
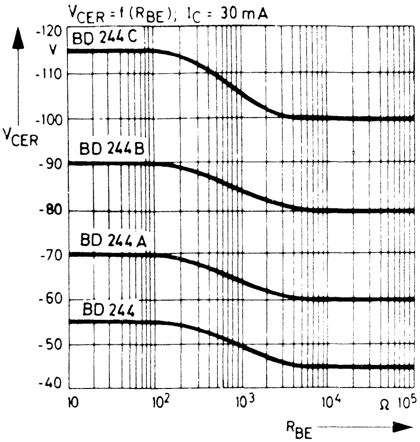
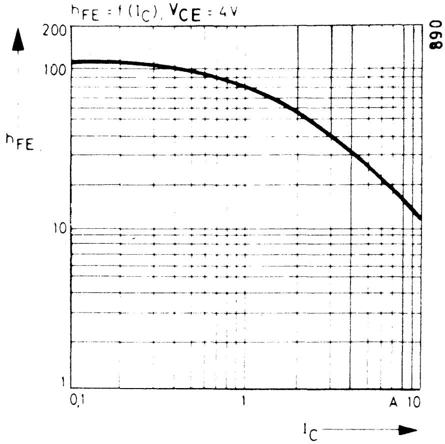


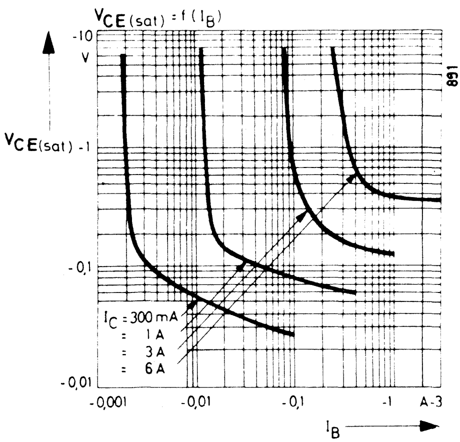
FIGURE 4

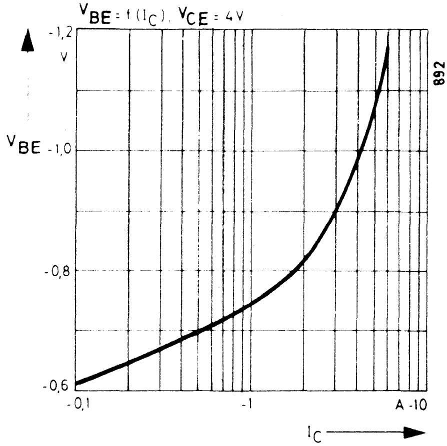
Notes A L1 and L2 are 10mH, 0.11Ω
B Input pulse width is increased until I_{cm} = -2.5A

PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









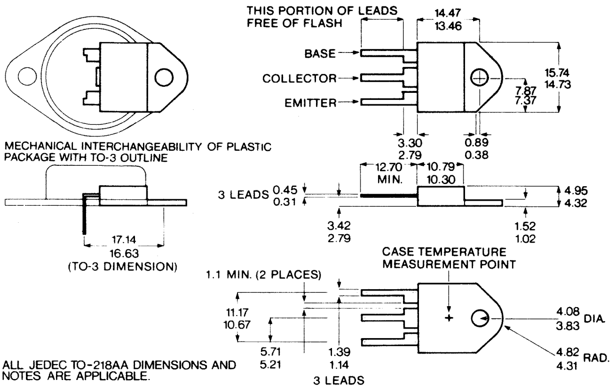
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH BD246 SERIES

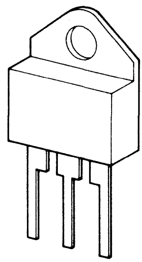
- 80W at 25°C Case Temperature
- 10A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 500 mA
- Customer-Specified Selections Available
- European Version of TIP33

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)

PARAMETER	BD245	BD245A	BD245B	BD245C	BD245D	BD245E	BD245F	UNIT
Collector-Emitter Voltage (R_{BE}=100Ω)	55	70	90	115	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	10A
Peak Collector Current[2]	15A
Continuous Base Current	3A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	80 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.0 W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 ⩽ 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 in Figure 2.

NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD245/245A		BD245B/245E		BD245D/245E 245F		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V	I_B = 0		0.7					mA
		V_{CE} = 60V	I_B = 0				0.7			
		V_{CE} = 90V	I_B = 0						0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER}			0.4		0.4		0.4	mA
		V_{CE} = 0								
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V	I_C = 0		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V	I_C = 1A	40		40		40		
		V_{CE} = 4V	I_C = 3A	20		20		20		
		V_{CE} = 4V	I_C = 10A	4		4		3		
		See Notes 6 & 7								
V_{BE}	Base-Emitter Voltage	V_{CE} = 4V	I_C = 3A		1.6		1.6		1.6	V
		See Notes 6 & 7								
		V_{CE} = 4V	I_C = 10A		3		3		3	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.3A	I_C = 3A		1		1		1	V
		See Notes 6 & 7								
		I_B = 2.5A	I_C = 10A		4		4			
		I_B = 3.3A	I_C = 10A						4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V	I_C = 0.5A	20		20		20		
		f = 1KHz								
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V	I_C = 0.5A	3		3		3		
		f = 1MHz								

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	1.56	°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.

NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

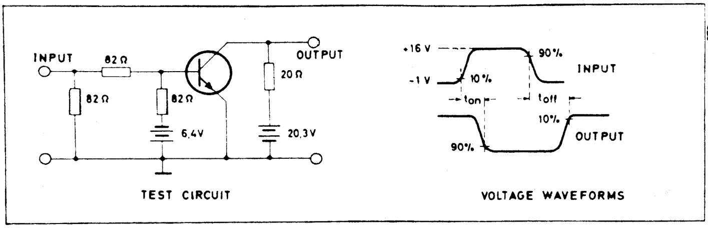


FIGURE 1

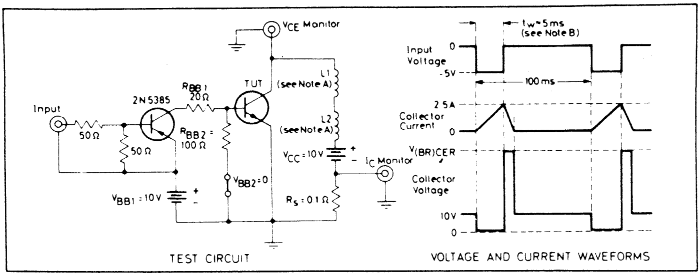


FIGURE 2

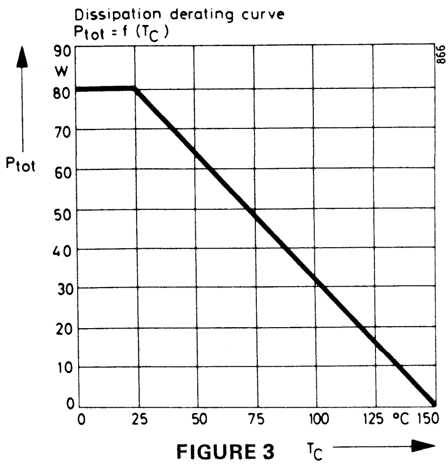


FIGURE 3

MAXIMUM SAFE OPERATION REGION T CASE ≤ 25 C

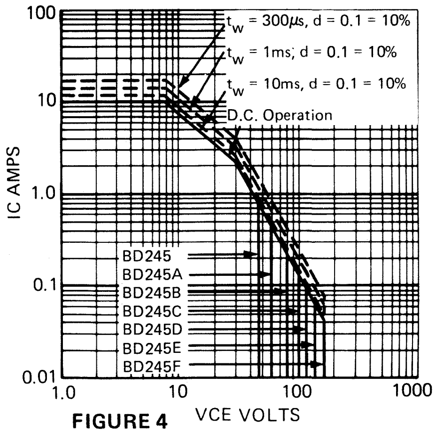
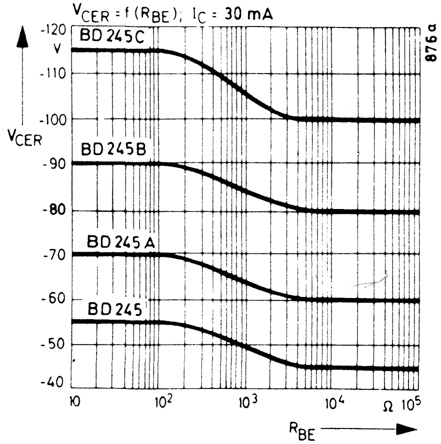
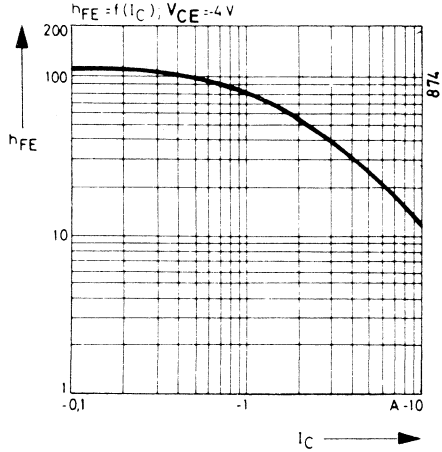


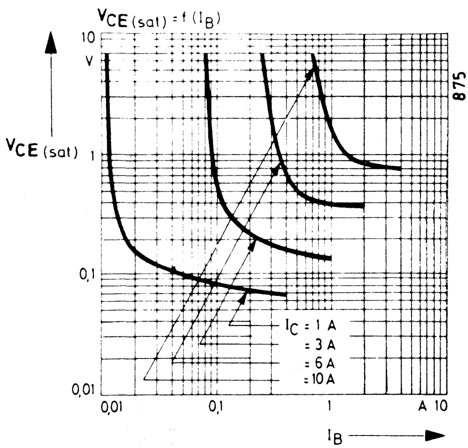
FIGURE 4

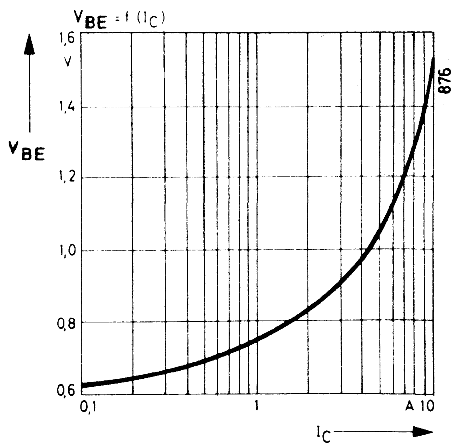
Notes A L1 and L2 are 10mH, 0.11Ω

B Input pulse width is increased until I_{cm} = 2.5A


VCER = f (RBE); IC = 30 mA
BD 245 C
BD 245 B
BD 245 A
BD 245
-120 V
-110
-100
-90
-80
-70
-60
-50
-40
VCER
10
10²
10³
10⁴
Ω 10⁵
RBE
876a


hFE = f (IC); VCE = -4 V
200
100
10
1
hFE
-0,1
-1
A -10
IC
874


VCE(sat) = f (IB)
10 V
1
0,1
0,01
VCE (sat)
IC = 1 A
= 3 A
= 6 A
= 10 A
0,01
0,1
1
A 10
IB
875


VBE = f (IC)
1,6 V
1,4
1,2
1,0
0,8
0,6
VBE
0,1
1
A 10
IC
876

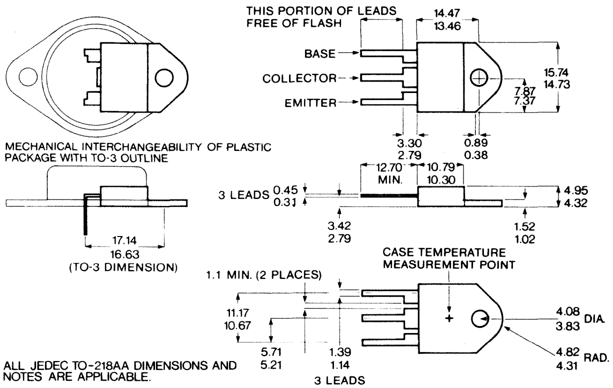
BD246 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD245 SERIES

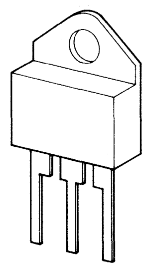
- **80W at 25°C Case Temperature**
- **10A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 500 mA**
- **Customer-Specified Selections Available**
- **European Version of TIP34**

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)

PARAMETER	BD246	BD246A	BD246B	BD246C	BD246D	BD246E	BD246F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	-55	-70	-90	-115	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-10A
Peak Collector Current[2]	-15A
Continuous Base Current	-3A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	80 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.0 W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies 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 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 in Figure 2.

PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	BD246/246A		BD246B/246C		BD246D/246E 246F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.7					mA
		V_{CE} = -60V I_B = 0				-0.7			
		V_{CE} = -90V I_B = 0						-0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER}, V_{BE} = 0		-0.4		-0.4		-0.4	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -1A	40		40		40		
		V_{CE} = -4V I_C = -3A	20		20		20		
		V_{CE} = -4V I_C = -10A	4		4		3		
		See Notes 6 & 7							
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -3A		-1.6		-1.6		-1.6	V
		See Notes 6 & 7							
		V_{CE} = -4V I_C = -10A		-3		-3		-3	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -0.3A I_C = -3A		-1		-1		-1	V
		See Notes 6 & 7							
		I_B = -2.5A I_C = -10A		-4		-4			
		I_B = -3.3A I_C = -10A						-4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 0.5A, f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 0.5A, f = 1MHz	3		3		3		

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.

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 Ω, See Figure 1	0.8	

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

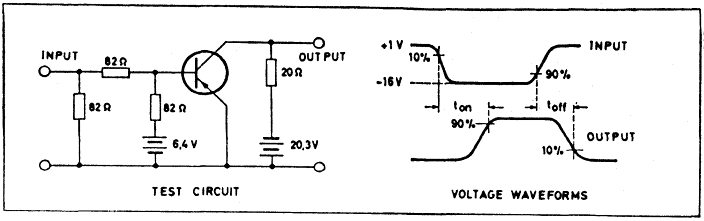


FIGURE 1

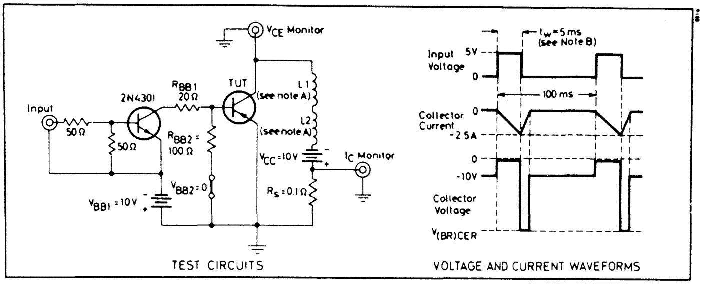


FIGURE 2

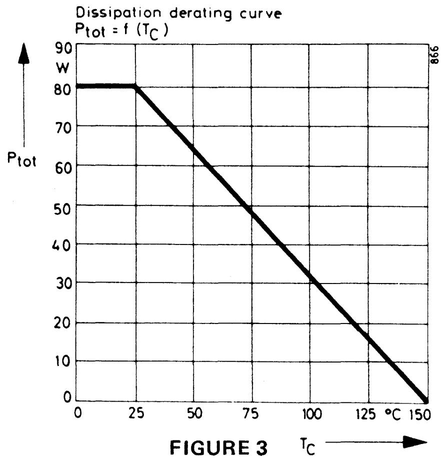


FIGURE 3

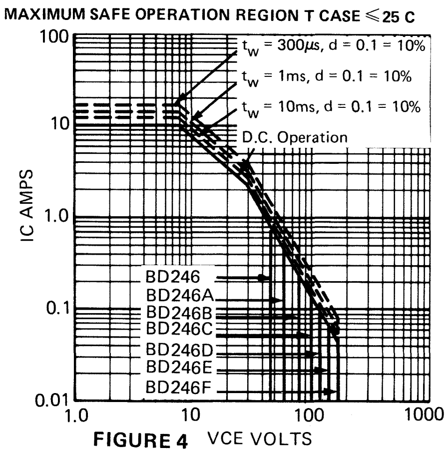
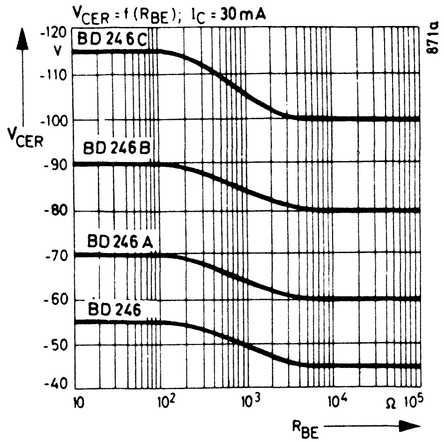
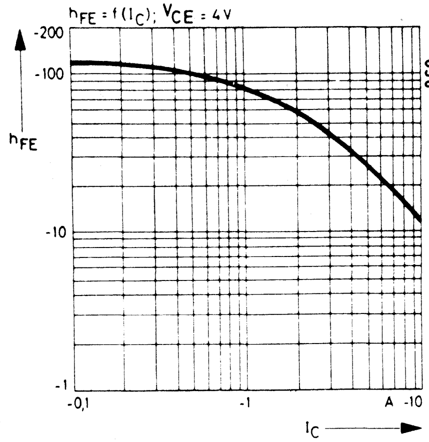


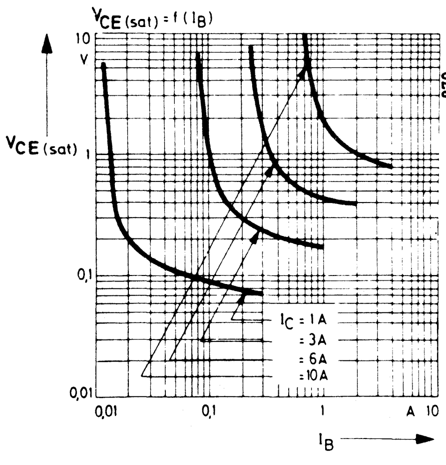
FIGURE 4

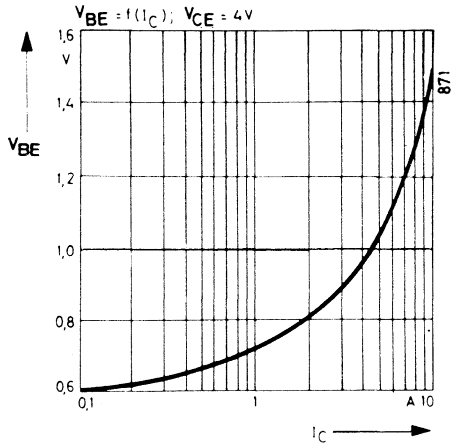
Notes A L1 and L2 are 10mH, 0.11Ω
B Input pulse width is increased until I_{cm} =-2.5A

PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS









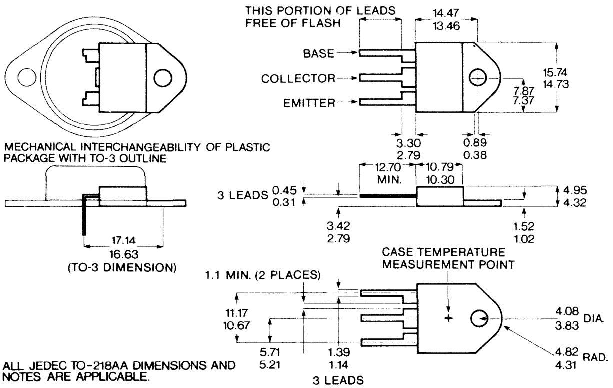
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH BD250 SERIES

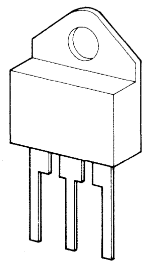
- 125W at 25°C Case Temperature
- 25A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 1A
- Customer-Specified Selections Available
- European Version of TIP35

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)

PARAMETER	BD249	BD249A	BD249B	BD249C	BD249D	BD249E	BD249F	UNIT
Collector-Emitter Voltage (RBE=100Ω)	55	70	90	115	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	25A
Peak Collector Current[2]	40A
Continuous Base Current	5A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	125 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.0 W
Unclamped Inductive Load Energy[5]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

BD249 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD249/249A MIN	BD249/249A MAX	BD249B/249C MIN	BD249B/249C MAX	BD249D/249E 249F MIN	BD249D/249E 249F MAX	UNIT
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V	I_B = 0		1					mA
		V_{CE} = 60V	I_B = 0				1			
		V_{CE} = 90V	I_B = 0						1	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CER}, V_{BE} = 0			0.7		0.7		0.7	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V	I_C = 0		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V	I_C = 1.5A	25		25		25		
		V_{CE} = 4V	I_C =15A	10		10		8		
		V_{CE} = 4V	I_C = 25A	10		5		5		
		See Notes 6 & 7								
V_{BE}	Base-Emitter Voltage	V_{CE} = 4V	I_C = 15A		2		2		2	V
		See Notes 6 & 7								
		V_{CE} = 4V	I_C = 25A		4		4		4	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = 1.5A	I_C = 15A		1.8		1.8			V
		I_B = 5.0A	I_C = 25A		4.0		4.0			
		I_B = 3.0A	I_C = 15A						2.5	
		I_B = 6.25A	I_C = 25A						5.0	
		See Notes 6 & 7								
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V, f = 1 KHz	I_C = 1A	25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V, f = 1MHz	I_C = 1A	3		3		3		

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 µd 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	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 Ω,	See Figure 1	0.9	

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

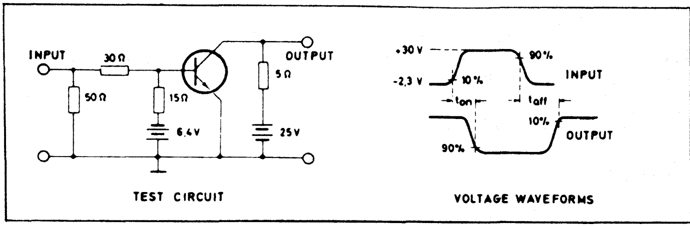


FIGURE 1

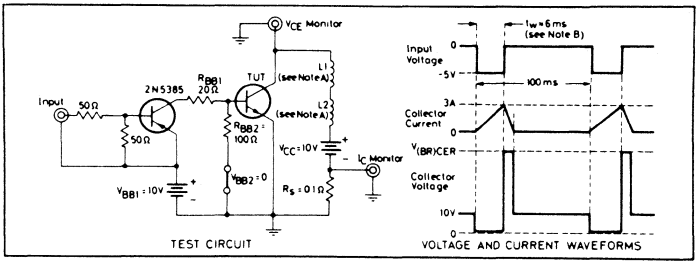


FIGURE 2

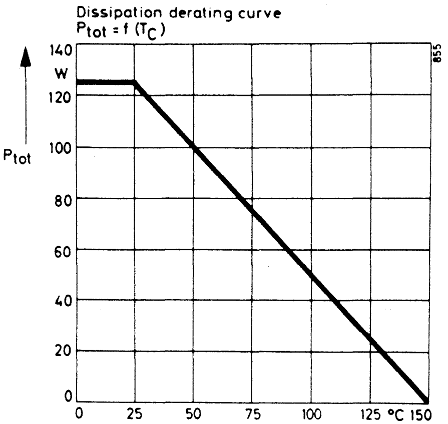


FIGURE 3

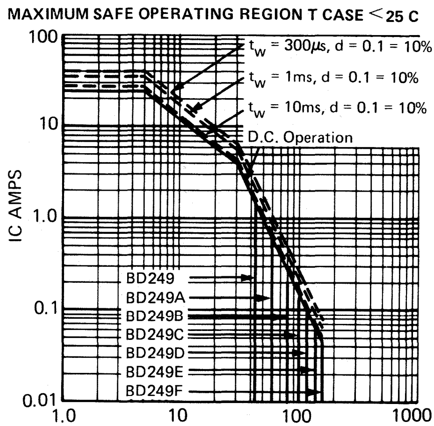
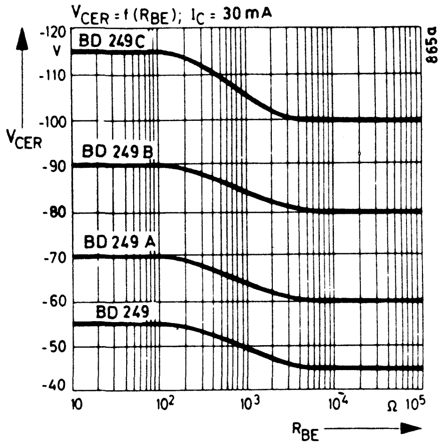


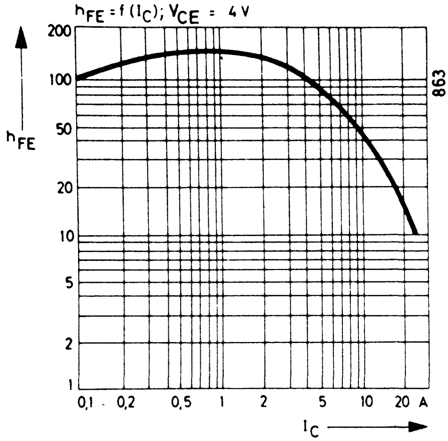
FIGURE 4

Notes A L1 and L2 are 10mH, 0.11Ω

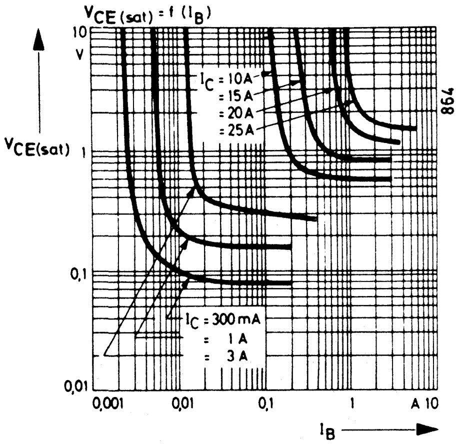
B Input pulse width is increased until I_{cm} = 3A



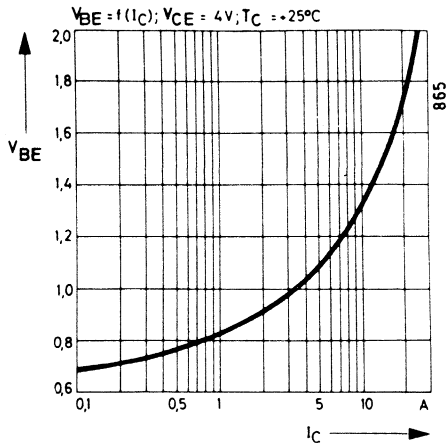
VCER = f (RBE); IC = 30 mA
865a
VCER
V
BD 249 C
BD 249 B
BD 249 A
BD 249
-120
-110
-100
-90
-80
-70
-60
-50
-40
10
10²
10³
10⁴
Ω 10⁵
RBE



hFE = f (IC); VCE = 4 V
863
hFE
200
100
50
20
10
5
2
1
0,1
0,2
0,5
1
2
5
10
20 A
IC



VCE (sat) = f (IB)
864
VCE(sat)
10
V
1
0,1
0,01
IC = 10A
= 15 A
= 20 A
= 25 A
IC = 300 mA
= 1 A
= 3 A
0,001
0,01
0,1
1
A 10
IB



VBE = f (IC); VCE = 4 V; TC = +25°C
865
VBE
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,1
0,5
1
5
10
A
IC

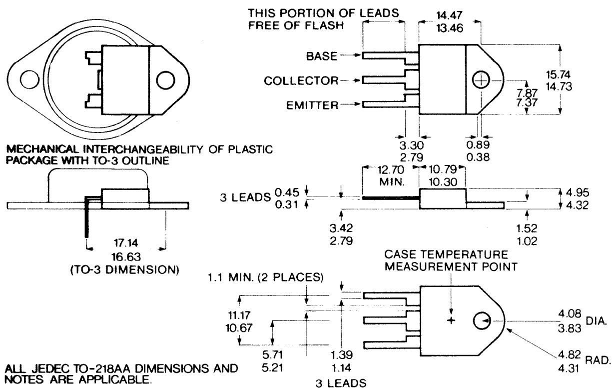
BD250 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH BD249 SERIES

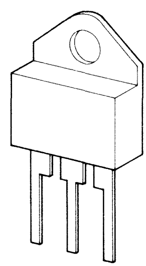
- 125W at 25°C Case Temperature
- 25A Rated Collector Current
- Minimum f_T of 3MHz at-10V,-1A
- Customer-Specified Selections Available
- European Version of TIP36

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)

PARAMETER	BD250	BD250A	BD250B	BD250C	BD250D	BD250E	BD250F	UNIT
Collector – Emitter Voltage (RBE = 100Ω)	-55	-70	-90	-115	-160	-180	- 200	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-25A
Peak Collector Current[2]	-40A
Continuous Base Current	-5A
Safe Operating Area	See Figure 4
Continuous Device Dissipation[3]	125W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.0W
Unclamped Inductive Load Energy[5]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 ⩽ 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 in Figure 2.

BD250 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		BD2/2A		BD2B/2C		BD2D/2 E/2		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V	I_B = 0		-1					mA
		V_{CE} = -60V	I_B = 0				-1			
		V_{CE} = -90V	I_B = 0						-1	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated V_{CE} = 0	BV_{CBO}		-0.7		-0.7		-0.7	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V	I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V	I_C = -1.5A	25		25		25		
		V_{CE} =-4V	I_C = -15A	10		10		8		
		V_{CE} = -4V	I_C = -25A	5		5		5		
		See Notes 6 & 7								
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V	I_C = -15A		-2		-2		-2	V
		See Notes 6 & 7								
		V_{CE} = -4V	I_C = -25A		-4		-4		-4	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -1.5A	I_C = -15A		-1.8		-1.8			V
		I_B = -5.0A	I_C = -25A		-4.0		-4.0			
		I_B = -3.0A	I_C = -15A						-2.5	
		I_B = -6.25A	I_C = -25A						-5.0	
		See Notes 6 & 7								
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V f = 1KHz	I_C = -1A	25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V f = 1MHz	I_C = -1A	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 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	°C/W

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 Ω	See Figure 1	0.4	µs

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

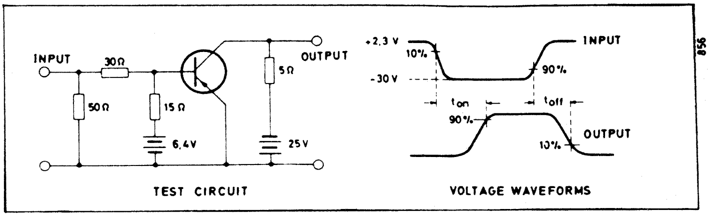


FIGURE 1

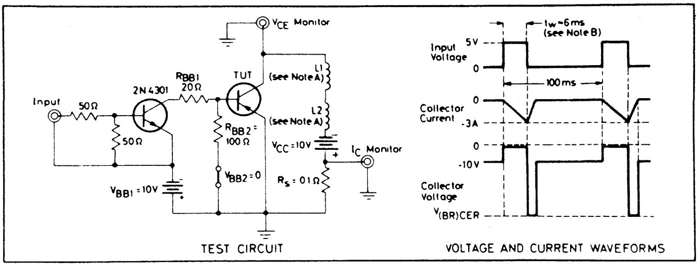


FIGURE 2

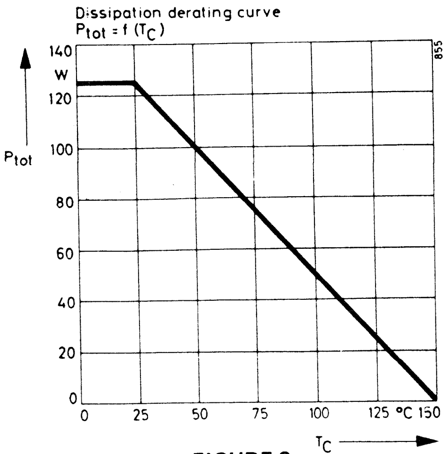


FIGURE 3

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

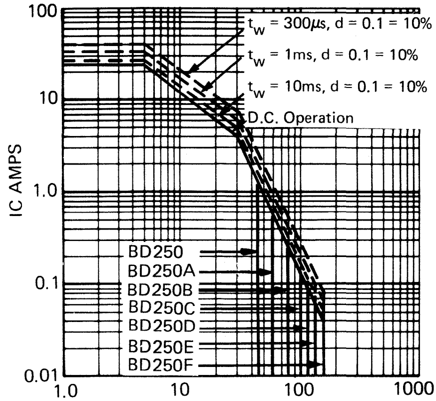
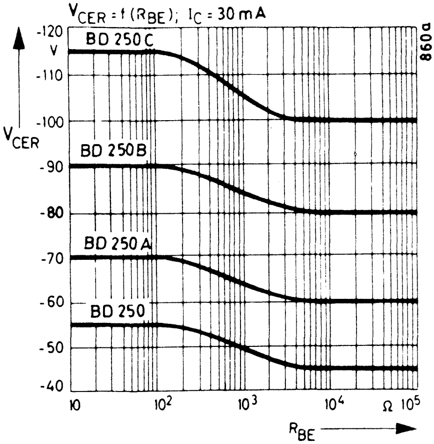


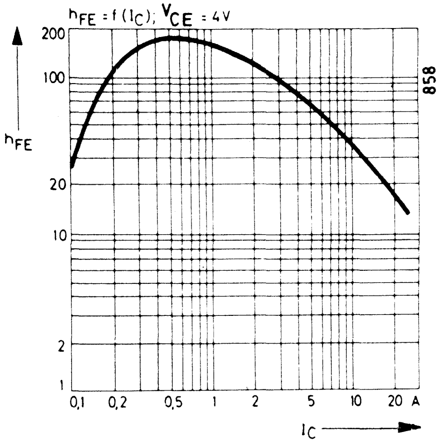
FIGURE 4

Notes A L1 and L2 are 10mH, 0.11Ω

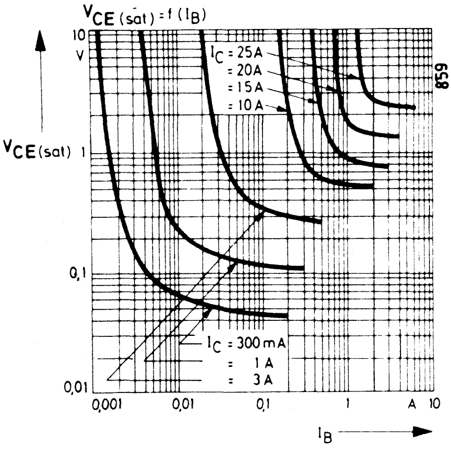
B Input pulse width is increased until I_{cm} = -3A



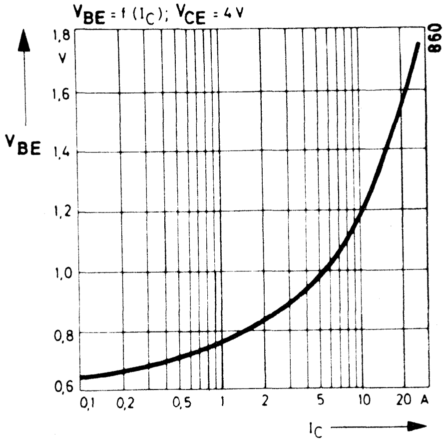
VCER = f (RBE); IC = 30 mA
860a
BD 250 C
BD 250 B
BD 250 A
BD 250
VCER
-120 V
-110
-100
-90
-80
-70
-60
-50
-40
10
10²
10³
10⁴
Ω 10⁵
RBE



hFE = f (IC); VCE = 4 V
858
hFE
200
100
20
10
2
1
0,1
0,2
0,5
1
2
5
10
20 A
IC



VCE (sat) = f (IB)
859
IC = 25 A
= 20 A
= 15 A
= 10 A
IC = 300 mA
= 1 A
= 3 A
VCE(sat)
10 V
1
0,1
0,01
0,001
0,01
0,1
1
A 10
IB



VBE = f (IC); VCE = 4 V
860
VBE
1,8 V
1,6
1,4
1,2
1,0
0,8
0,6
0,1
0,2
0,5
1
2
5
10
20 A
IC

NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

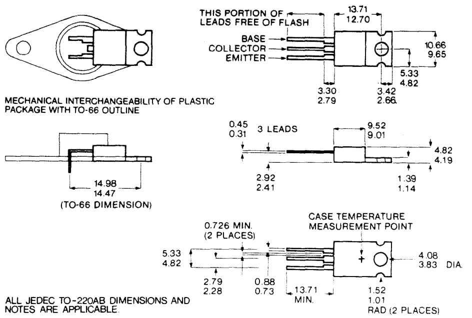
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

features

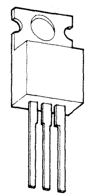
- Low Saturation Voltages $V_{CE(sat)}$ = 0.8V max @ I_C = 3A
- Complimentary to PNP Types BD540 Series
- 5A Rated Collector Current
- 45W at 25°C Case Temperature
- Up to 120V V_{CEO} rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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							mA
	V_{CE}=60V	I_B=0						0.3		0.3			
	V_{CE}=90V	I_B=0										0.3	
I_{CES}	V_{CE}=40V	V_{BE}=0		0.2									mA
	V_{CE}=60V	V_{BE}=0				0.2							
	V_{CE}=80V	V_{BE}=0						0.2					
	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	V
	I_C=3.0A	I_B=375mA		0.8		0.8		0.8		0.8		0.8	
	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

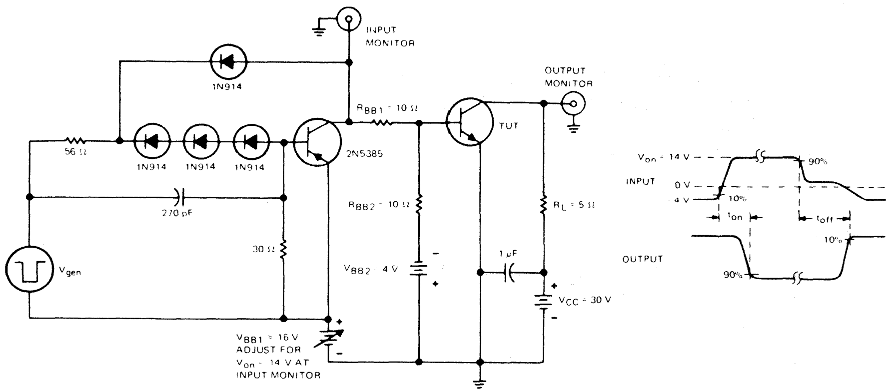
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2.78	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

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: $t_r \leq 15$ 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

MAXIMUM SAFE OPERATING REGION

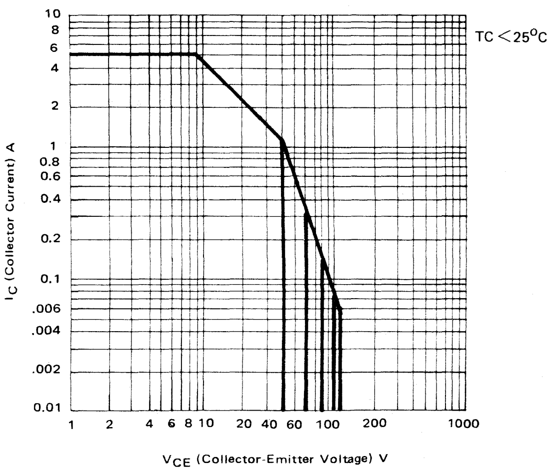


FIGURE 2.

PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

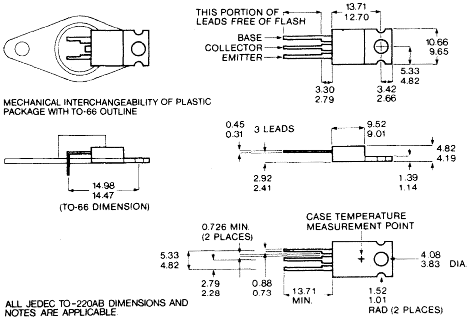
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

features

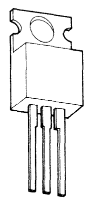
- Low Saturation Voltages $V_{CE(sat)}$ = 0.8V max @ I_C = 3A
- Complimentary to NPN Types BD539 Series
- 5A Rated Collector Current
- 45W at 25°C Case Temperature
- Up to 120V V_{CEO} rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	BD540 Min	BD540 Max	BD540A Min	BD540A Max	BD540B Min	BD540B Max	BD540C Min	BD540C Max	BD540D Min	BD540D Max	UNITS
$V_{(BR)CEO}$	I_C=–30mA I_B=0 See Note 4	–40		–60		–80		–100		–120		V
I_{CEO}	V_{CE}=–30V I_B=0		–0.3		–0.3							mA
	V_{CE}=–60V I_B=0						–0.3		–0.3			
	V_{CE}=–90V I_B=0										–0.3	
I_{CES}	V_{CE}=–40V V_{BE}=0		–0.2									mA
	V_{CE}=–60V V_{BE}=0				–0.2							
	V_{CE}=–80V V_{BE}=0						–0.2					
	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	V
	I_C=–3.0A I_B=–375mA		–0.8		–0.8		–0.8		–0.8		–0.8	
	I_C= –5.0A I_B = –1.0A		–1,5		–1.5		–1.5		–1.5		–1.5	
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

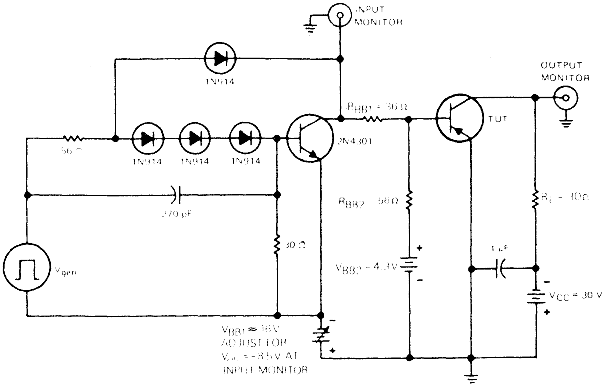
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	2.78	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

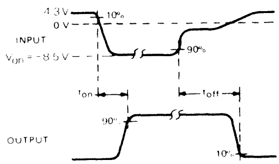
	PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_{ON}	Turn-On Time	I_C = –1A $I_{B(1)}$ = –100mA $I_{B(2)}$ = –100mA	0.3	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = 4.3V R_L = 30Ω See Figure 1	1.0	

†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: $t_r \leq 15$ 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

MAXIMUM SAFE OPERATING REGION

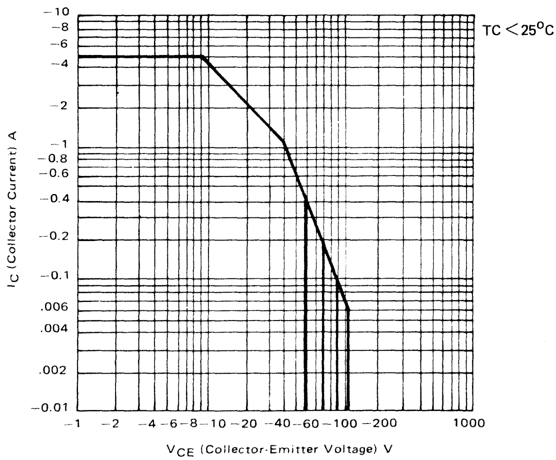


FIGURE 2.

TEXAS INSTRUMENTS

NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

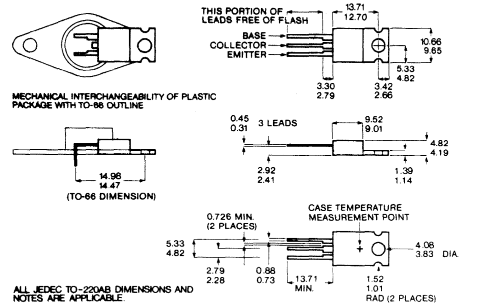
Designed for Medium Power Linear Amplifiers and Switching in Consumer Automotive and Industrial Applications

features

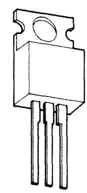
- Low Saturation Voltages $V_{CE(sat)}$ = 0.5V max @ I_C = 5A
- Complimentary to PNP Types BD544 Series
- 8A Rated Collector Current
- 70W at 25°C Case Temperature
- Up to 120V V_{CEO} Rating

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 $t_w \leq 0.3$ms, duty cycle $\leq 10\%$
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

NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

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 See Note 5	I_B=0	40		60		80		100		120		V
I_{CEO}	V_{CE}=30V V_{CE}=60V V_{CE}=90V	I_B=0 I_B=0 I_B=0		0.7		0.7		0.7		0.7		0.7	mA
I_{CES}	V_{CE}=40V V_{CE}=60V V_{CE}=80V V_{CE}=100V V_{CE}=120V	V_{BE}=0 V_{BE}=0 V_{BE}=0 V_{BE}=0 V_{BE}=0		0.4		0.4		0.4		0.4		0.4	mA
I_{EBO}	V_{EB}=5V	I_C=0		1		1		1		1		1	mA
h_{FE}*	I_C=1A I_C=3A I_C=5A	V_{CE}=4V V_{CE}=4V V_{CE}=4V	60 40 15		60 40 15		60 40 15		60 40 15		60 40 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_C=5A I_C=8A	I_B=300mA I_B=1A I_B=1.6A		0.5 0.5 1.0		0.5 0.5 1.0		0.5 0.5 1.0		0.5 0.5 1.0		0.5 0.5 1.0	V
h_{fe}	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 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

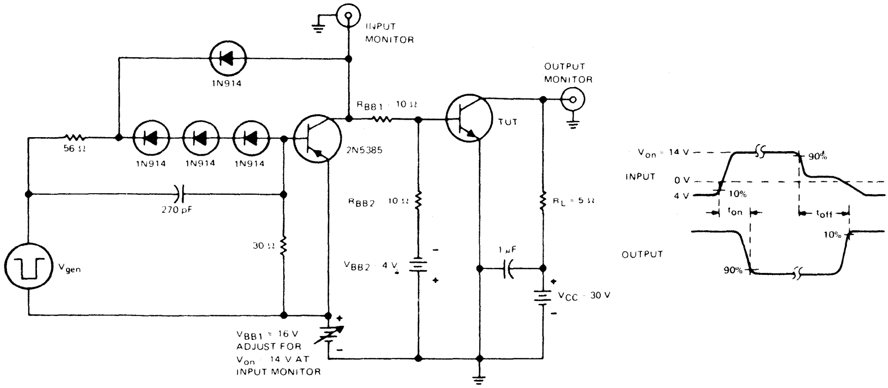
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.79	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	62.5	

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.

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

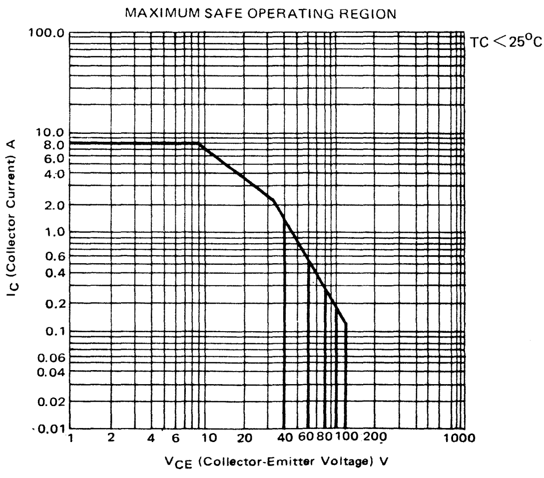


FIGURE 2.

BD544 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

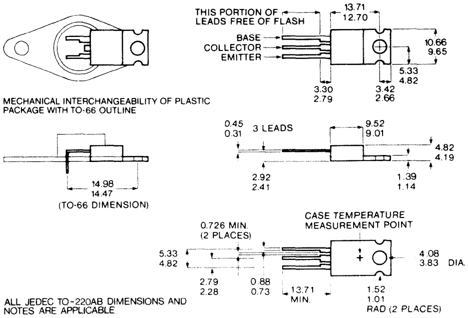
Designed for Medium Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

features

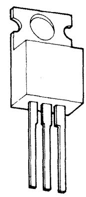
- Low Saturation Voltages $V_{CE(sat)} = 0.5V$ max @ $I_C = 5A$
- Complimentary to NPN Types BD543 Series
- 8A Rated Collector Current
- 70W at 25°C Case Temperature
- Up to 120V V_{CEO} Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 $t_w \leq 0.3$ms, duty cycle $\leq 10\%$
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

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, See Note 5	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	I_B=0						−0.7		−0.7			mA
	V_{CE}=−90V	I_B=0										−0.7	mA
I_{CES}	V_{CE}=−40V	V_{BE}=0		−0.4									mA
	V_{CE}=−60V	V_{BE}=0				−0.4							mA
	V_{CE}=−80V	V_{BE}=0						−0.4					mA
	V_{CE}=−100V	V_{BE}=0								−0.4			mA
	V_{CE}=−120	V_{BE}=0										−0.4	mA
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	V
	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	V
h_{fe}	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 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

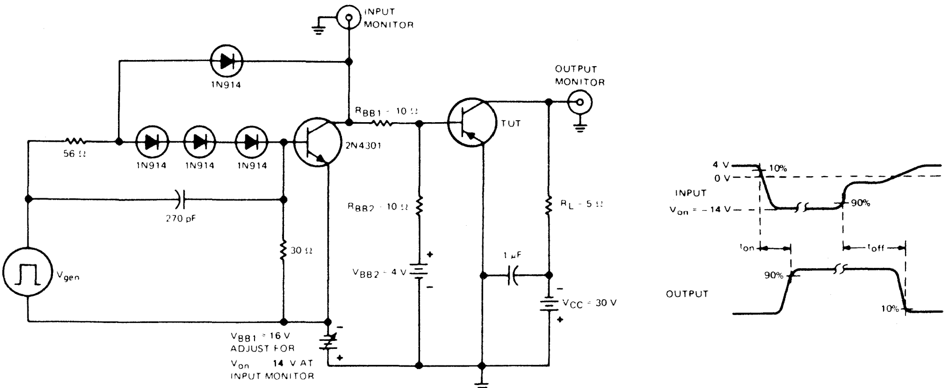
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.79	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

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	μsec

†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

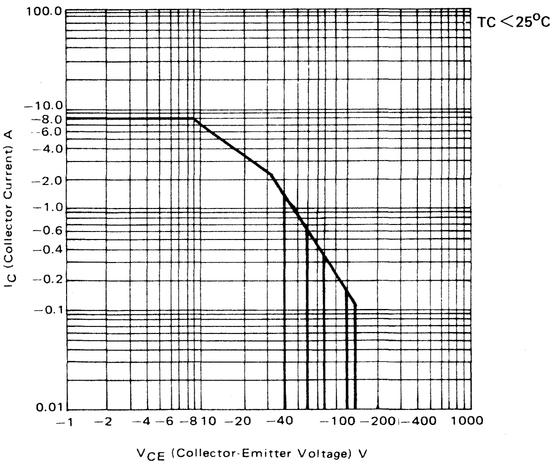


FIGURE 2

BD545 SERIES
NPN SINGLE DIFFUSED SILICON POWER TRANSISTORS

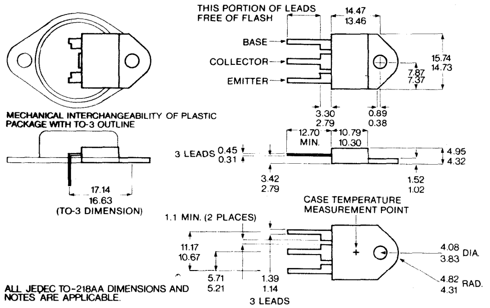
Designed for Power Linear Amplifiers and Switching in Consumer, Automotive and Industrial Applications

features

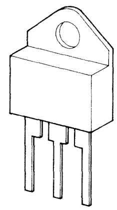
- Low Saturation Voltages $V_{CE(sat)}$ = 1V max @ I_C = 10A
- Complimentary to BD546 Series
- 15A Rated Collector Current
- 85W at 25°C Case Temperature
- Up to 120V V_{CEO}

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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

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 V_{CE}=60V V_{CE}=90V	I_B=0		0.7		0.7		0.7		0.7		0.7	mA
I_{CES}	V_{CE}=40V V_{CE}=60V V_{CE}=80V V_{CE}=100V V_{CE}=120V	V_{BE}=0 V_{BE}=0 V_{BE}=0 V_{BE}=0 V_{BE}=0		0.4		0.4		0.4		0.4		0.4	mA
I_{EBO}	V_{EB}=5V	I_C=0		1		1		1		1		1	mA
h_{FE}*	I_C=1A I_C=5A I_C=10A	V_{CE}=4V V_{CE}=4V V_{CE}=4V	60 25 10		60 25 10		60 25 10		60 25 10		60 25 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_C=10A	I_B=625mA I_B=2A		0.8 1		0.8 1		0.8 1		0.8 1		0.8 1	V
h_{fe}	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

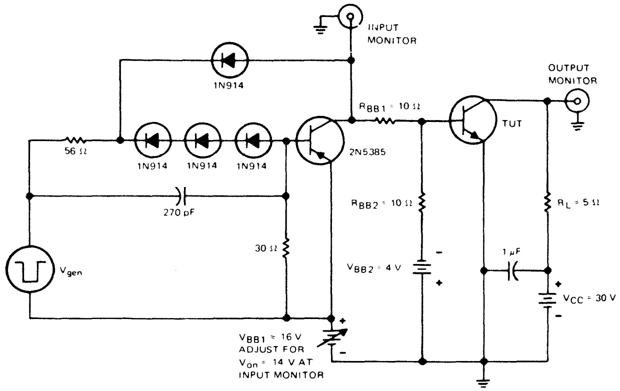
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.47	°C/W
$R_{\theta JR}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

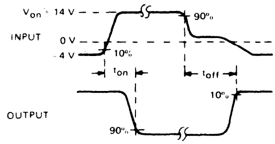
	PARAMETER	TEST CONDITIONS†			TYP	UNIT
t_{ON}	Turn-On Time	I_C = 6A	$I_{B(1)}$ = 0.6A	$I_{B(2)}$ = −0.6A	0.6	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −4V	R_L - 5Ω	See Figure 1	1	

†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: $t_r \leq 15$ 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

MAXIMUM SAFE OPERATING REGION

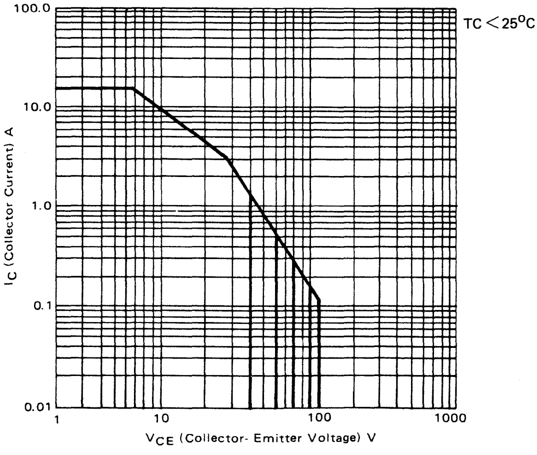


FIGURE 2.

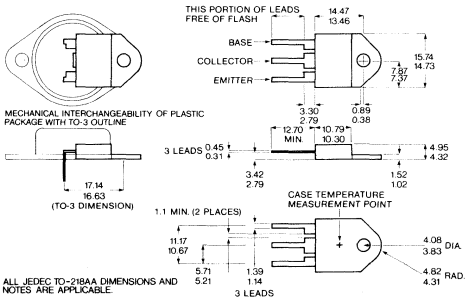
BD 546 SERIES
PNP SINGLE DIFFUSED SILICON POWER TRANSISTORS

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

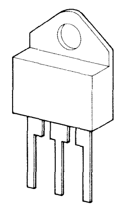
Features
- Low Saturation Voltages $V_{CE(sat)}$ = 1V max @ 10A
- Complimentary to BD545 Series
- 15A Rated Collector Current
- 85W at 25^{o}C Case Temperature
- Up to 120V V_{CEO}

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings at 25^{o}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^{o}C Case Temperature	← See Figure 2 →				
Continuous Device Dissipation at (or below) 25^{o}C Case Temperature (See Note 2)	← 85W →				
Continuous Device Dissipation at (or below) 25^{o}C Free Air Temperature (See Note 3)	← 3.5W →				
Operating Collector Junction Temperature Range	← −65^{o}C to 150^{o}C →				
Storage Temperature Range	← −65^{o}C to 150^{o}C →				
Lead Temperature 3.2mm from Case for 10 Seconds	← 260^{o}C →				

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

electrical characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS	BD546 Min	BD546 Max	BD546A Min	BD546A Max	BD546B Min	BD546B Max	BD546C Min	BD546C Max	BD546D Min	BD546D Max	UNITS
$V_{(BR)CEO}$	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

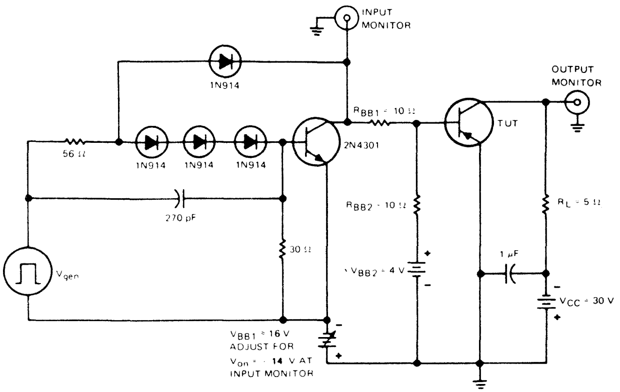
	PARAMETER	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.47	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

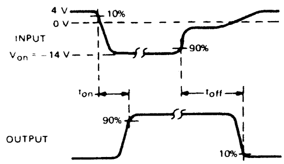
	PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_{ON}	Turn-On Time	I_C = −6A $I_{B(1)}$ = −0.6A $I_{B(2)}$ = 0.6A	0.4	μsec
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = 4V R_L = 5Ω See Figure 1	0.7	μsec

† 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

MAXIMUM SAFE OPERATING REGION

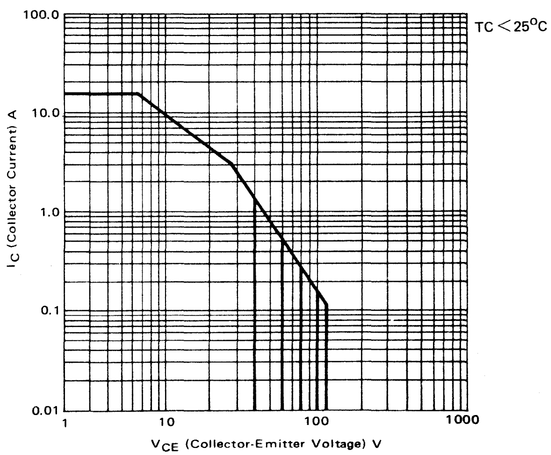


FIGURE 2.

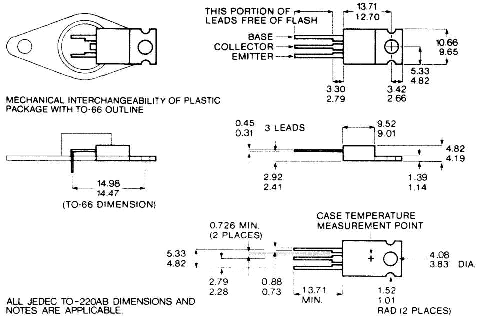
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

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

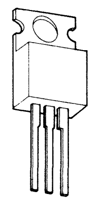
- **90 W at 25 °C Case Temperature**
- **15 A Rated Collector Current**
- **Min f_T of 5 MHz at 4 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	BD743	BD743A	BD743B	BD743C	BD743D	BD743E	BD743F	UNIT
Collector-Base Voltage	50	70	90	110	130	150	170	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	15 A
Peak Collector Current[1] ($T_p \leqslant 300 \mu s$, $d \leqslant 10\%$)	20 A
Continuous Base Current	5A
Safe Operating Area	See Figure 11
Continuous Device Dissipation[2]	90 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[3]	2 W
Unclamped Inductive Load Energy[4]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°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. Fig 9.
3. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C Fig 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit in Figure 2.

BD743 SERIES
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

PARAMETER		TEST CONDITIONS AT 25°C	BD743/BD743A		BD743B/BD743C		BD743D/BD743E BD743F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30V$ $I_B = 0$		0.1					
		$V_{CE} = 60V$ $I_B = 0$				0.1			mA
		$V_{CE} = 90V$ $I_B = 0$						0.1	
I_{CBO}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, $V_{BE} = 0$, TC = 25°C		0.1		0.1		0.1	mA
		TC = 125°C		5.0		5.0		5.0	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5V$ $I_C = 0$		0.5		0.5		0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4V$ $I_C = 1A$	40		40		40		
		$V_{CE} = 4V$ $I_C = 5A$	20	150	20	150	20		
		$V_{CE} = 4V$ $I_C = 15A$ See Notes 5 & 6	5		5		5		
V_{BE}	Base Emitter Voltage	$V_{CE} = 4V$ $I_C = 5A$ See Notes 5 &6		1		1		1	V
		$V_{CE} = 4V$ $I_C = 15A$		3		3		3	V
$V_{CE(Sat)}$	Collector Emitter Saturation Voltage	$I_B = 0.5A$ $I_C = 5A$		1		1		1	V
		$I_B = 5A$ $I_C = 15A$ See Notes 5 &6		3		3		3	V
h_{fe}	Small Signal Common Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ $I_C = 1A$ f = 1 KHz	25		25		25		
$\|h_{fe}\|$	Small Signal Common Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ $I_C = 1A$ f = 1MHz	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		1.4	°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

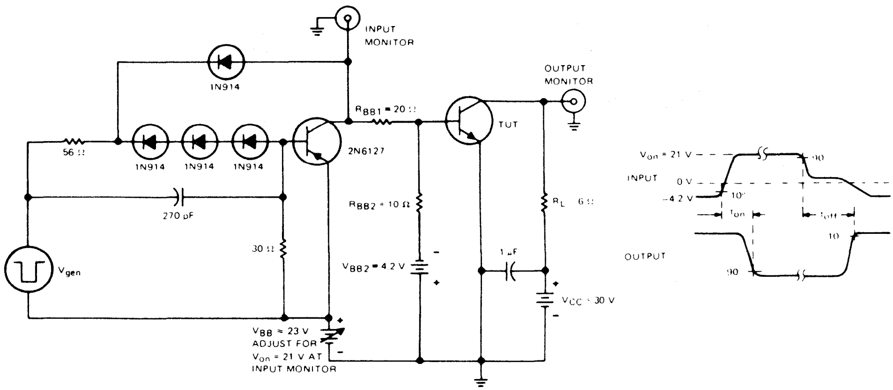
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

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		350	ns
t_s	Storage Time		500	ns
t_f	Fall Time		400	ns

+ 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%.

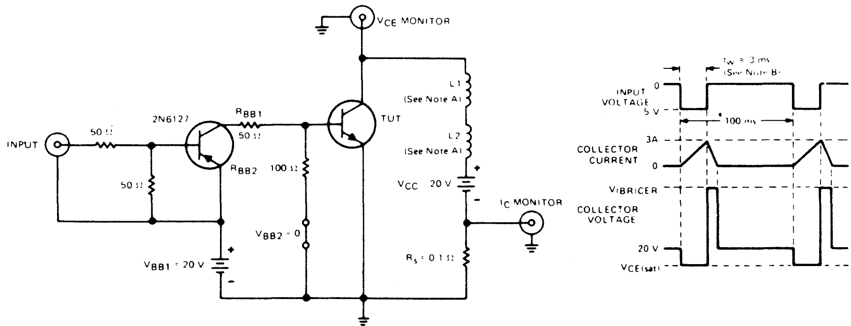
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

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} = 3A.

FIGURE 2

TYPICAL CHARACTERISTICS

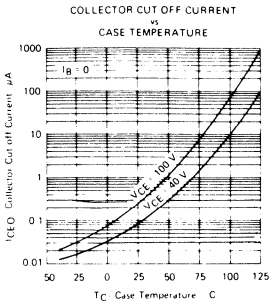


FIGURE 3

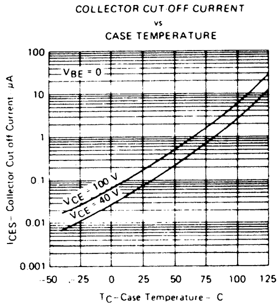


FIGURE 4

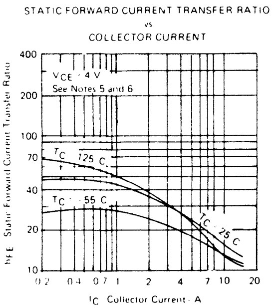


FIGURE 5

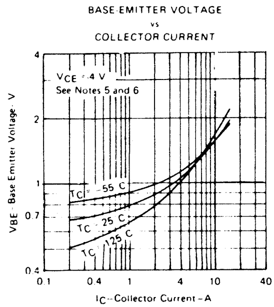


FIGURE 6

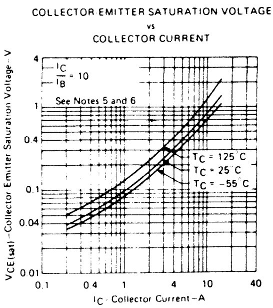


FIGURE 7

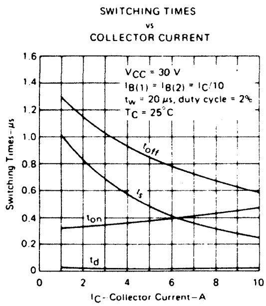


FIGURE 8

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

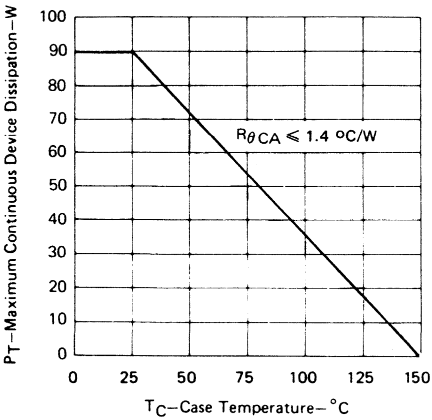


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

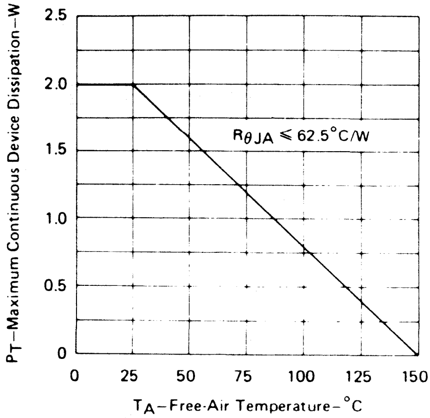


FIGURE 10

MAXIMUM SAFE OPERATING REGION T CASE ≤25 C

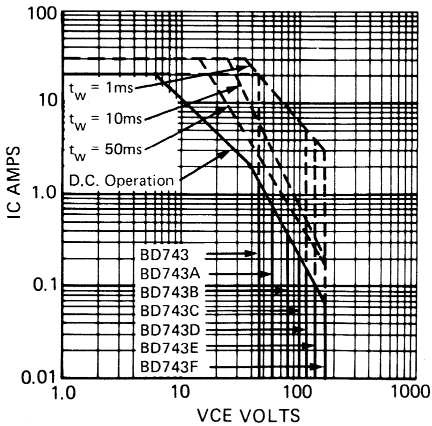


FIGURE 11

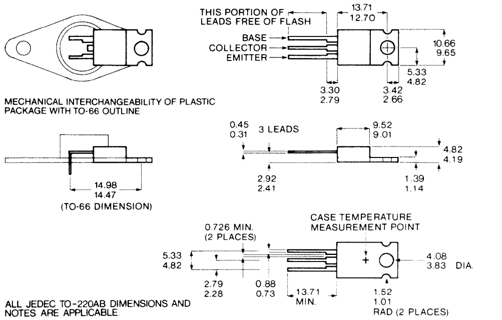
BD744 SERIES
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

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

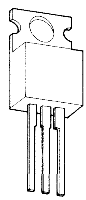
- 90 W at 25 °C Case Temperature
- 15 A Rated Collector Current
- Min f_T of 5 MHz at 4 V, 1 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	BD744	BD744A	BD744B	BD744C	BD744D	BD744E	BD744F	UNIT
Collector-Base Voltage	50	70	90	110	130	150	170	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-15 A
Peak Collector Current[1] (Tp ⩽ 300 μs, d ⩽ 10%)	-20 A
Continuous Base Current	-5A
Safe Operating Area	See Figure 11
Continuous Device Dissipation[2]	90 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[3]	2 W
Unclamped Inductive Load Energy[4]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°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. Fig 9.
3. Derate linearly to 150°C free-air temperature at the rate of 16 mW/°C Fig 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit in Figure 2.

PARAMETER		TEST CONDITIONS AT 25°C	BD744/BD744A		BD744B/BD744C		BD744D/BD744E BD744F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.1					
		V_{CE} = -60V I_B = 0				-0.1			mA
		V_{CE} = -90V I_B = 0						-0.1	
I_{CBO}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, V_{BE} = 0, TC = 25°C		-0.1		-0.1		-0.1	mA
		TC = 125°C		-5.0		-5.0		-5.0	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V I_C = 0		-0.5		-0.5		-0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} =-4V I_C =-1A	40		40		40		
		V_{CE} =-4V I_C =-5A	20	150	20	150	20		
		V_{CE} =-4V I_C =-15A See Notes 5 & 6	5		5		5		
V_{BE}	Base Emitter Voltage	V_{CE} =-4V I_C =-5A See Notes 5 &6		1		1		1	V
		V_{CE} =-4V I_C =-15A		3		3		3	V
$V_{CE(Sat)}$	Collector Emitter Saturation Voltage	I_B =-0.5A I_C =-5A		1		1		1	V
		I_B =-5A I_C =-15A See Notes 5 & 6		3		3		3	V
h_{fe}	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 1A f = 1 KHz	25		25		25		
$\|h_{fe}\|$	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 1A f = 1MHz	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

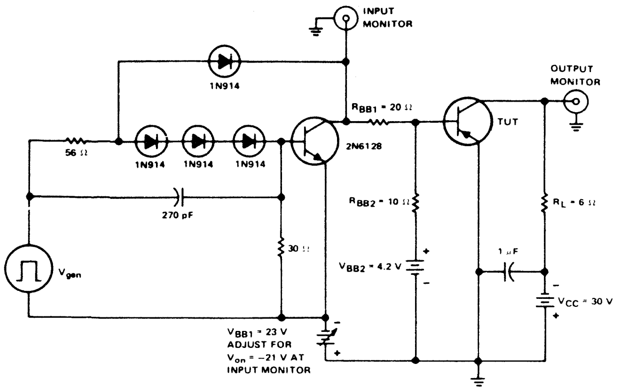
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

switching characteristics at 25 °C case temperature

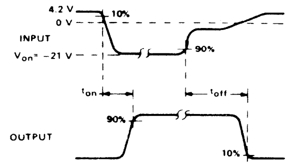
PARAMETER		TEST CONDITIONS +	TYP	UNIT
t_d	Delay Time	I_C = −5 A, $I_{B(1)}$ = −500 mA, $I_{B(2)}$ = 500 mA, $V_{BE(off)}$ = 4.2 V, R_L = 6 Ω, See Figure 1	20	ns
t_r	Rise Time		120	
t_s	Storage Time		600	
t_f	Fall Time		300	

+ 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 ⩽2%.

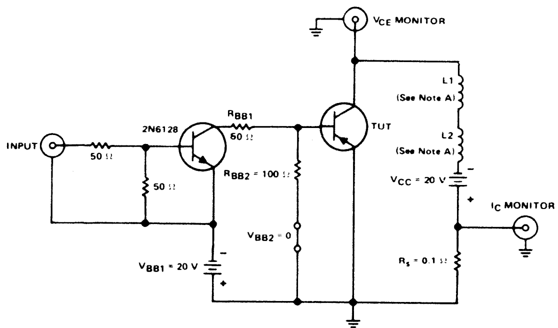
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

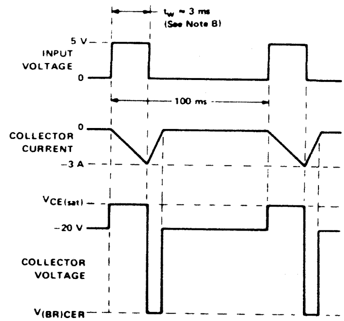
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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

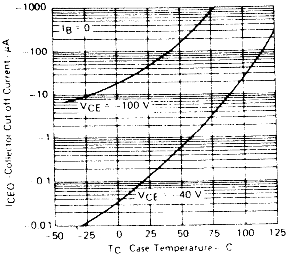


FIGURE 3

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

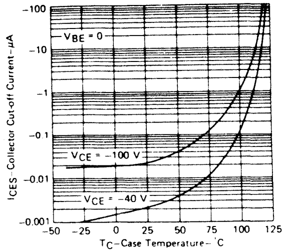


FIGURE 4

STATIC FORWARD-CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

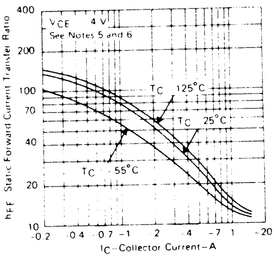


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

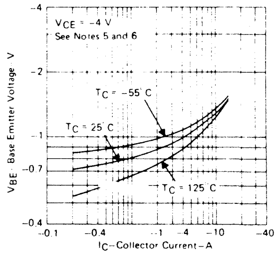


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

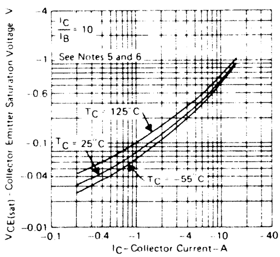


FIGURE 7

SWITCHING TIMES
vs
COLLECTOR CURRENT

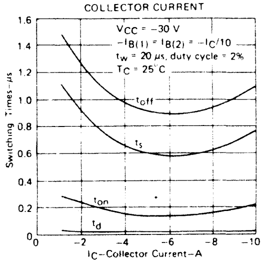


FIGURE 8

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

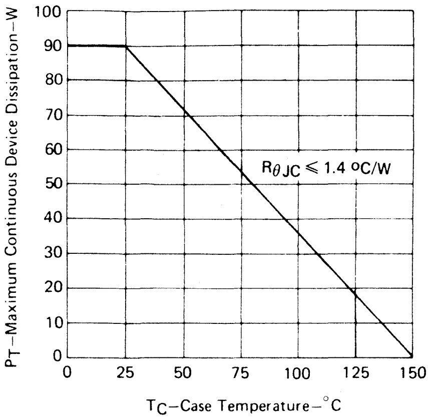


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

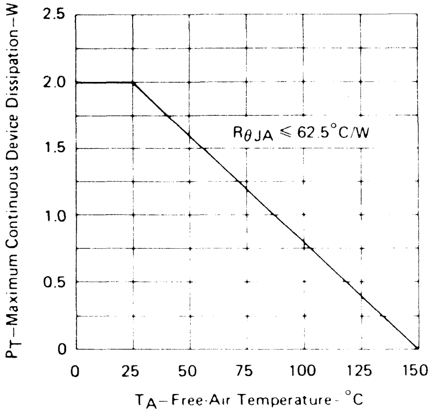


FIGURE 10

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

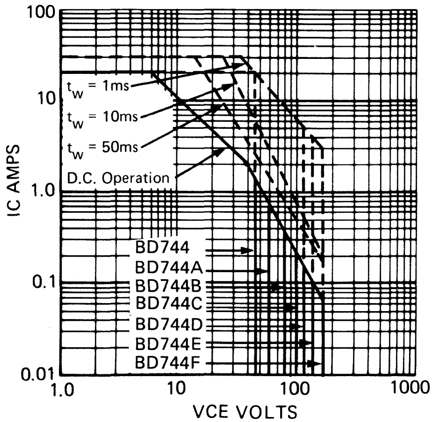


FIGURE 11

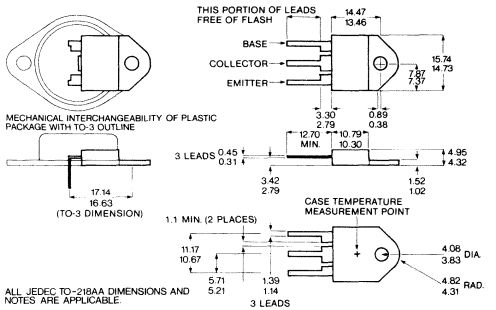
NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

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

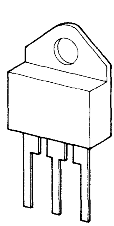
- **115 W at 25 °C Case Temperature**
- **20 A Rated Collector Current**
- **Min f_T of 5 MHz at 4 V, 1 A**

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	BD745	BD745A	BD745B	BD745C	BD745D	BD745E	BD745F	UNIT
Collector-Base Voltage	50	70	90	110	130	150	170	V
Collector-Emitter Voltage[1] @ 30mA	45	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	20 A
Peak Collector Current[1] ($T_p \leqslant 300 \mu s$, $d \leqslant 10\%$)	25 A
Continuous Base Current	7 A
Safe Operating Area	See Figure 11
Continuous Device Dissipation[2]	115 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[3]	3.5 W
Unclamped Inductive Load Energy[4]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°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. Fig 9.
3. Derate linearly to 150°C free-air temperature at the rate of 28 mW/°C Fig 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit in Figure 2.

NPN SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

PARAMETER		TEST CONDITIONS AT 25°C	BD745/BD745A MIN	BD745/BD745A MAX	BD745B/BD745C MIN	BD745B/BD745C MAX	BD745D/BD745E BD745F MIN	BD745D/BD745E BD745F MAX	UNIT
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V I_B = 0		0.1					
		V_{CE} = 60V I_B = 0				0.1			mA
		V_{CE} = 90V I_B = 0						0.1	
I_{CBO}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, V_{BE} = 0, TC = 25°C		0.1		0.1		0.1	mA
		TC = 125°C		5.0		5.0		5.0	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V I_C = 0		0.5		0.5		0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V I_C = 1A	40		40		40		
		V_{CE} = 4V I_C = 5A	20	150	20	150	20		
		V_{CE} = 4V I_C = 20A	5		5		2.8		
		See Notes 5 & 6							
V_{BE}	Base Emitter Voltage	V_{CE} = 4V I_C = 5A		1		1		1	V
		See Notes 5 &6							
		V_{CE} = 4V I_C = 20A		3		3		3	V
$V_{CE(Sat)}$	Collector Emitter Saturation Voltage	I_B = 0.5A I_C = 5A		1		1		1	V
		I_B = 5A I_C = 20A		3		3			V
		See Notes 5 & 6 I_B = 7A I_C = 20A						4	V
h_{fe}	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 1A, f = 1 KHz	25		25		25		
$\|h_{fe}\|$	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 1A, f = 1MHz	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

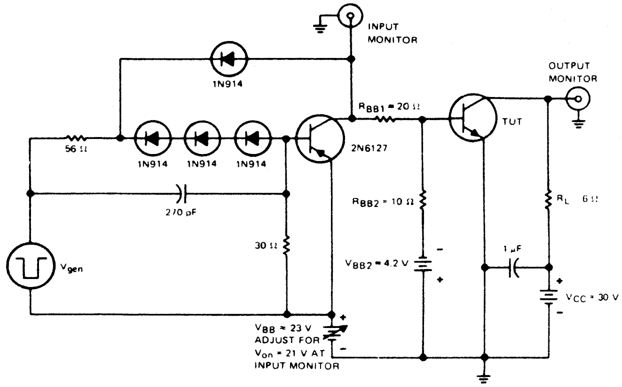
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

switching characteristics at 25 °C case temperature

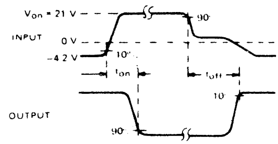
	PARAMETER	TEST CONDITIONS +	TYP	UNIT
t_d	Delay Time	I_C = 5 A, $I_{B(1)}$ = 500 mA, $I_{B(2)}$ = −500 mA, $V_{BE(off)}$ = −4 2 V, R_L = 6 Ω, See Figure 1	20	ns
t_r	Rise Time		350	ns
t_s	Storage Time		500	ns
t_f	Fall Time		400	ns

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

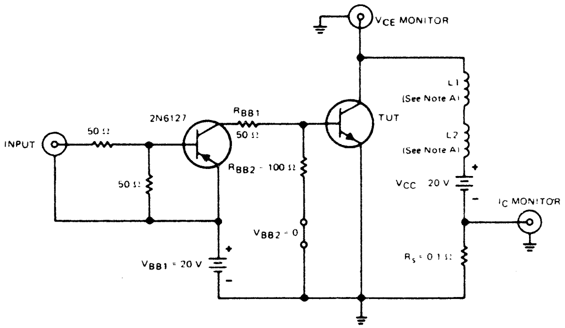


VOLTAGE WAVEFORMS

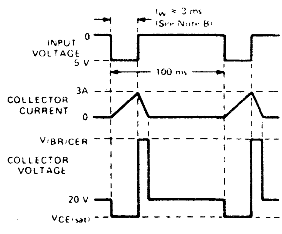
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
C. Waveforms are monitored on an oscilloscope 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

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

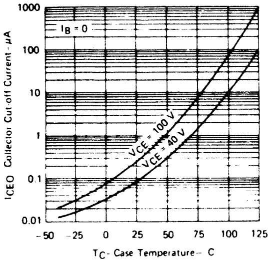


FIGURE 3

COLLECTOR CUT-OFF CURRENT
vs
CASE TEMPERATURE

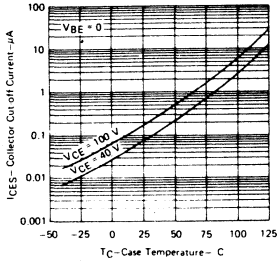


FIGURE 4

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

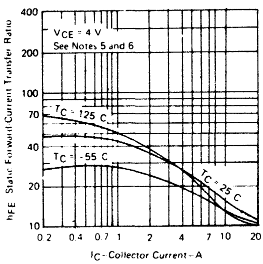


FIGURE 5

BASE EMITTER VOLTAGE
vs
COLLECTOR CURRENT

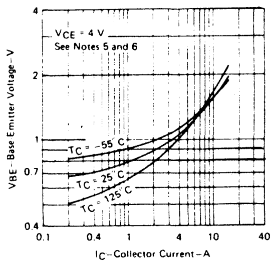


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

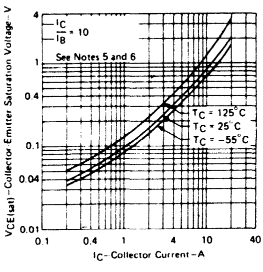


FIGURE 7

SWITCHING TIMES
vs
COLLECTOR CURRENT

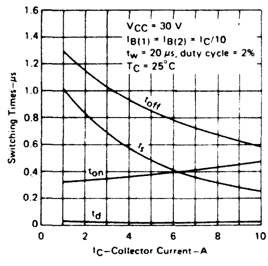


FIGURE 8

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

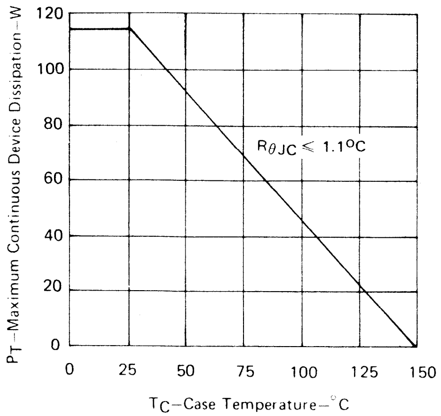


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

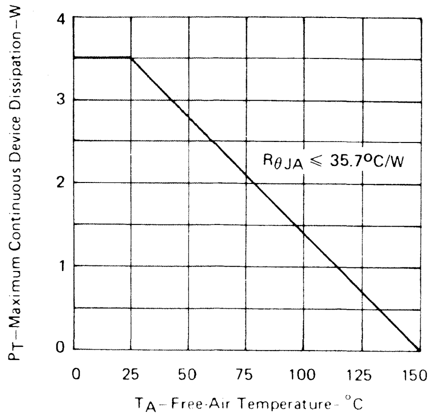


FIGURE 10

MAXIMUM SAFE OPERATING REGION T CASE ≤25 C

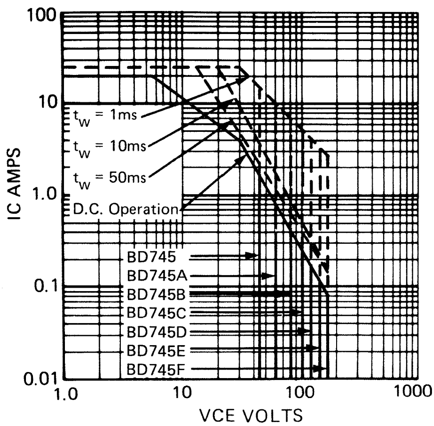


FIGURE 11

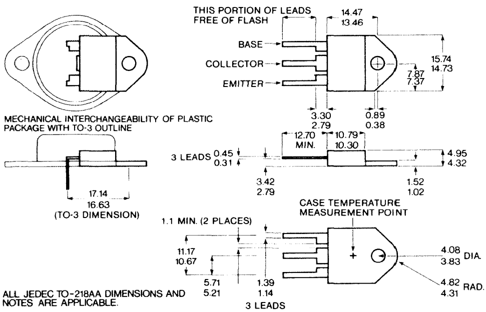
BD746 SERIES
PNP SINGLE-DIFFUSED EPITAXIAL BASE POWER TRANSISTORS

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

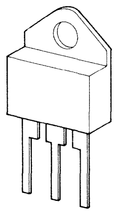
- **115 W at 25 °C Case Temperature**
- **20 A Rated Collector Current**
- **Min f_T of 5 MHz at 4 V, 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	BD746	BD746A	BD746B	BD746C	BD746D	BD746E	BD746F	UNIT
Collector-Base Voltage	-50	-70	-90	-110	-130	-150	-170	V
Collector-Emitter Voltage[1] @ 30mA	-45	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	−20 A
Peak Collector Current[1] (Tp ≤ 300 μs, d ≤ 10%)	−25 A
Continuous Base Current	−7 A
Safe Operating Area	See Figure 11
Continuous Device Dissipation[2]	115 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[3]	3.5 W
Unclamped Inductive Load Energy[4]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°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 0.92W/°C Fig 9.
3. Derate linearly to 150°C free-air temperature at the rate 28 mW/°C Fig 10.
4. This rating is based on the capability of the transistor to operate safely in the circuit in Figure 2.

PARAMETER		TEST CONDITIONS AT 25°C	BD746/BD746A		BD746B/BD746C		BD746D/BD746E BD746F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = −30V I_B = 0		−0.1					
		V_{CE} = −60V I_B = 0				−0.1			mA
		V_{CE} = −90V I_B = 0						−0.1	
I_{CBO}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, V_{BE} = 0, TC = 25°C		−0.1		−0.1		−0.1	mA
		TC = 125°C		−5.0		−5.0		−5.0	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-0.5		-0.5		-0.5	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = −4V I_C = −1A	40		40		40		
		V_{CE} = −4V I_C = −5A	20	150	20	150	20		
		V_{CE} = −4V I_C = −20A	5		5		2.8		
		See Notes 5 & 6							
V_{BE}	Base Emitter Voltage	V_{CE} = −4V I_C = −5V See Notes 5 &6		−1		−1		−1	V
		V_{CE} = −5V I_C = −20 A		-3		-3		-3	V
$V_{CE(Sat)}$	Collector Emitter Saturation Voltage	I_B = −0.5A I_C = −5A		−1		−1		−1	V
		I_B = −5A I_C = −20A		−3		−3			V
		See Notes 5 & 6 I_B = −7 A I_C = −20 A						−4	
h_{fe}	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = −10V I_C = -1A f = 1 KHz	25		25		25		
$\|h_{fe}\|$	Small Signal Common Emitter Forward Current Transfer Ratio	V_{CE} = −10V I_C = -1A f = 1MHz	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

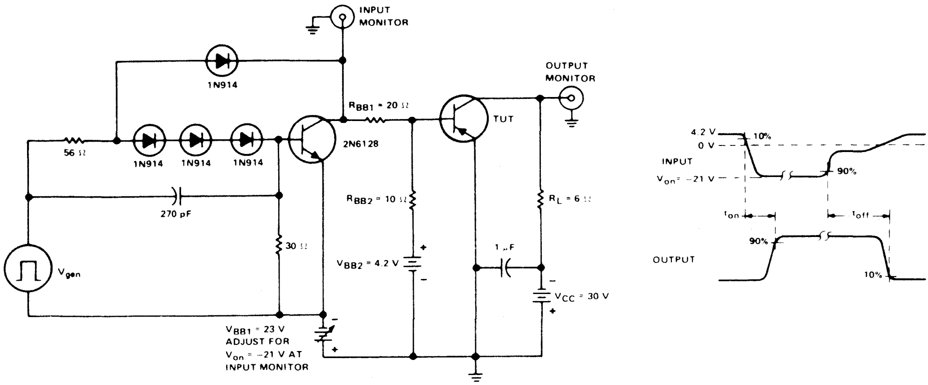
NOTE 7: This parameter is measured using a 78 μm mica insulator with Dow Corning II compound on both sides of the insulator, a M3 mounting screw with bushing, and a mounting torque of 10 kpcm.

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	ns
t_s	Storage Time		600	ns
t_f	Fall Time		300	ns

+ 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%.

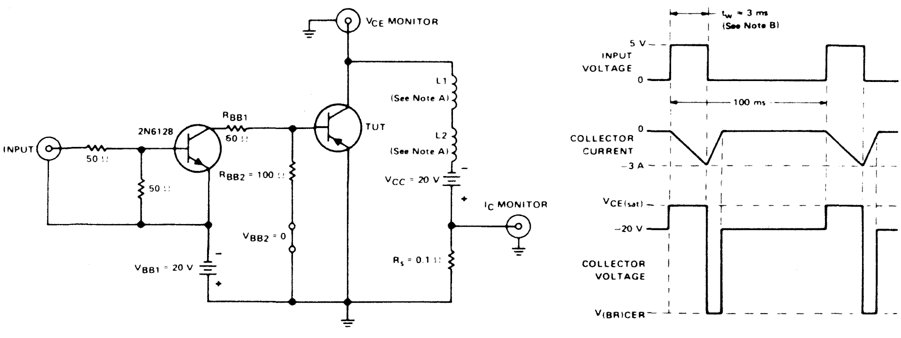
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

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

FIGURE 1

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

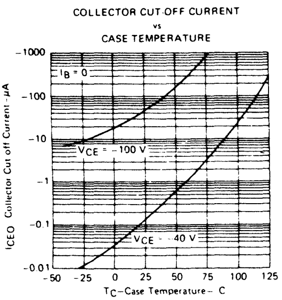


FIGURE 3

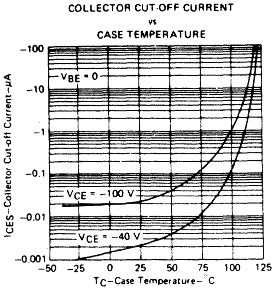


FIGURE 4

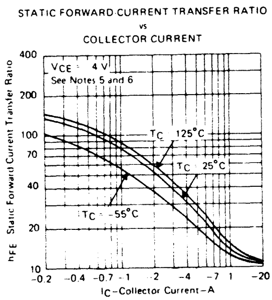


FIGURE 5

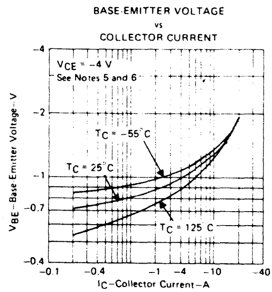


FIGURE 6

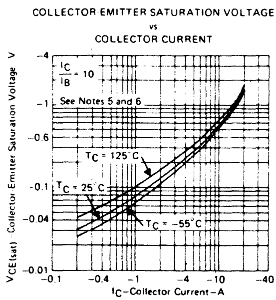


FIGURE 7

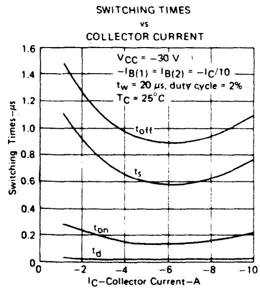


FIGURE 8

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

CASE TEMPERATURE
DISSIPATION DERATING CURVE

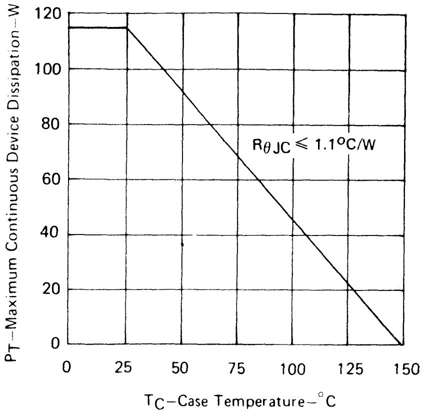


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

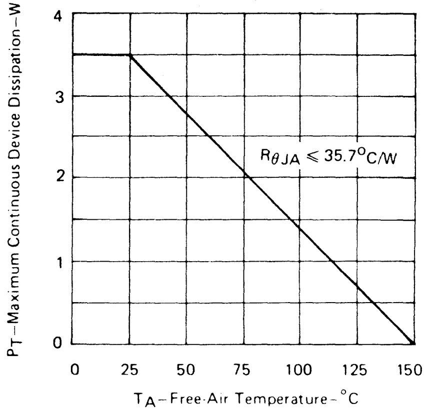


FIGURE 10

MAXIMUM SAFE OPERATING REGION T CASE ≤25 C

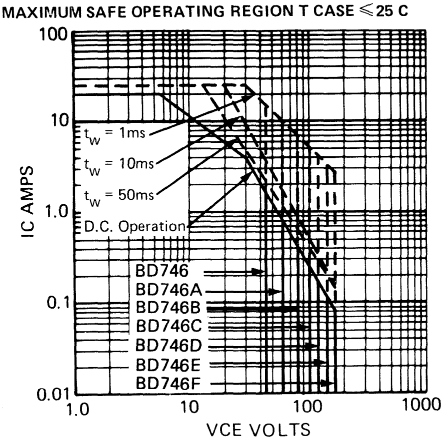


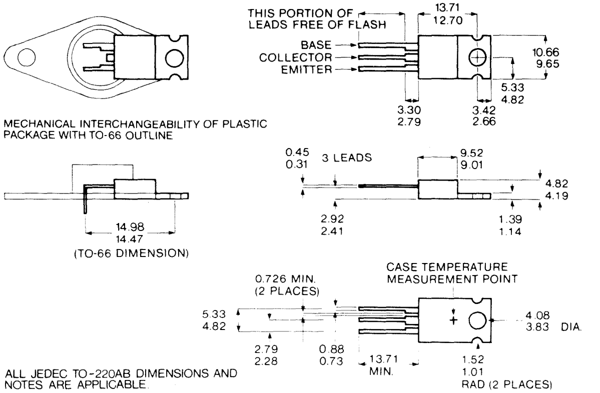
FIGURE 11

NPN SILICON POWER DARLINGTON BDW53 SERIES
PNP SILICON POWER DARLINGTON BDW54 SERIES

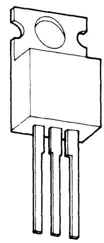
- High SOA Capability, 40 V and 1 A
- 40 W at 25 °C Case Temperature
- 4 A Rated Collector Current
- Min h_{FE} of 750 @ 1.5 A/3 V
- 25 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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

	NPN PNP	BDW53 BDW54	BDW53A BDW54A	BDW53B BDW54B	BDW53C BDW54C	BDW53D 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 = 20 mH , R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V, Energy ≈ $I_C^2 \cdot L/2$.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW53 BDW54 Min	BDW53 BDW54 Max	BDW53A BDW54A Min	BDW53A BDW54A Max	BDW53B BDW54B Min	BDW53B BDW54B Max	BDW53C BDW54C Min	BDW53C BDW54C Max	BDW53D BDW54D Min	BDW53D BDW54D Max	UNITS
$V_{(BR)CEO}$	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 Forward 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, (See Notes 5 & 6)	I_C = 4 A	100		100		100		100		100		
$V_{BE(ON)}$	Base-Emitter Voltage	V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 1.5 A		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, (See Notes 5 & 6)	I_B = 40 mA		4		4		4		4		4	V
V_{FR}	Forward Voltage of Reverse Diode	$-I_C$ = 4A			3.5		3.5		3.5		3.5		3.5	V

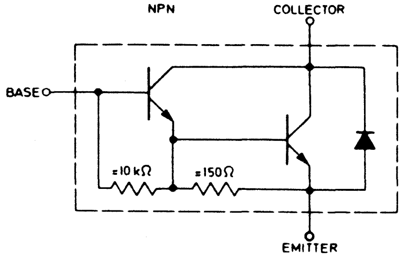
thermal characteristics

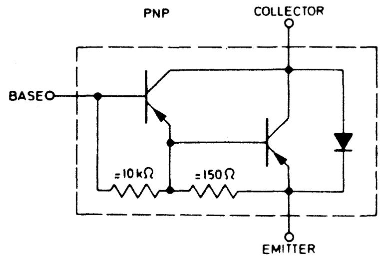
	PARAMETER	Max	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance (See Note 7)	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.0	°C/W

switching characteristics at 25 °C case temperature

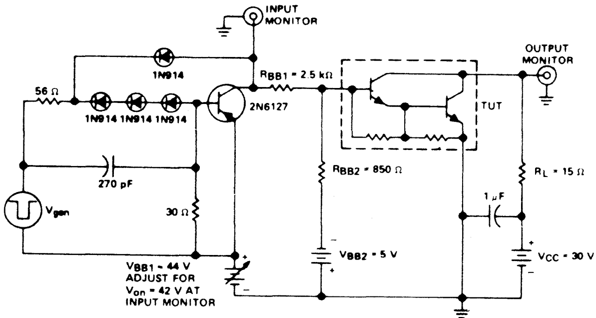
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 2 A, $I_{B(1)}$ = 8 mA, $I_{B(2)}$ = −8)	1.0	μs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −5 V, R_L = 15 Ω	4.5	μs

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 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 ≤ 450 mV. (Base test current = 3 mA).

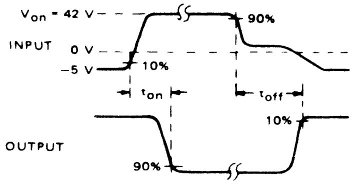




PARAMETER MEASUREMENT INFORMATION



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 Ω, t_w = 20 μs, duty cycle ≤ 2%.

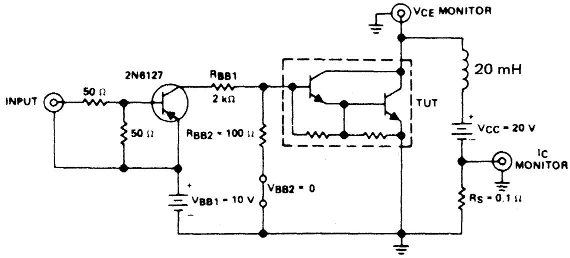
C. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 15 ns, R_{in} ≥ 10 MΩ, C_{in} ≤ 11.5 pF.

D. Resistors must be noninductive types.

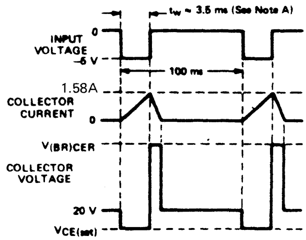
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 1.58A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

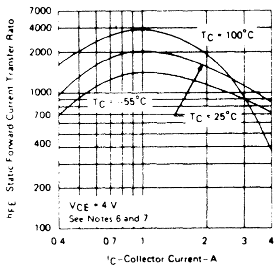


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

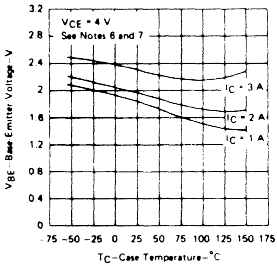


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

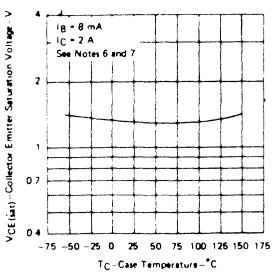


FIGURE 5

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

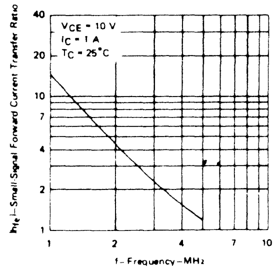


FIGURE 6

MAXIMUM SAFE OPERATING AREAS

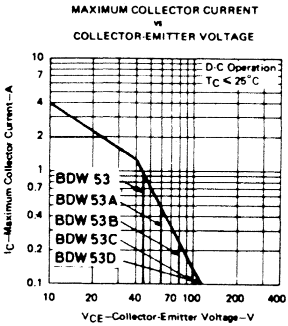


FIGURE 7

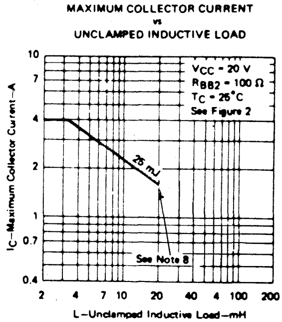


FIGURE 8

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

THERMAL INFORMATION

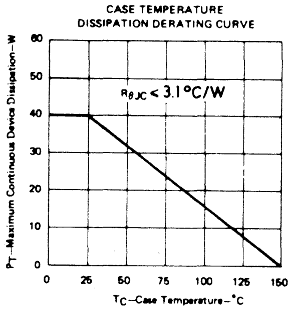


FIGURE 9

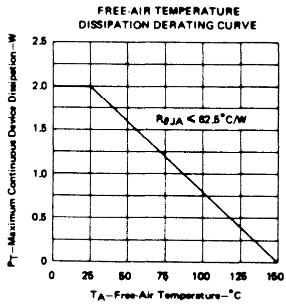


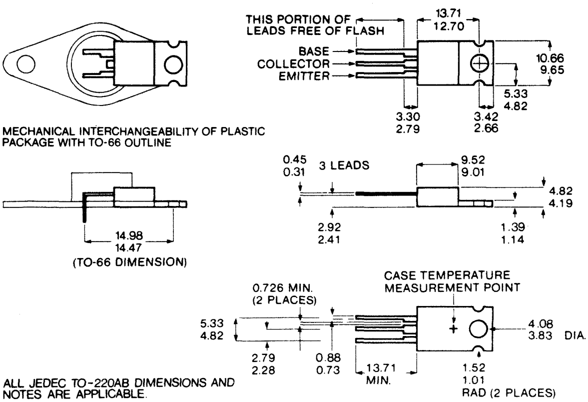
FIGURE 10

NPN SILICON POWER DARLINGTON BDW63 SERIES
PNP SILICON POWER DARLINGTON BDW64 SERIES

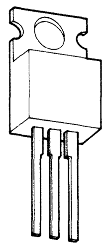
- High SOA Capability, 20 V and 3 A
- 60 W at 25 °C Case Temperature
- 6 A Rated Collector Current
- Min h_{FE} of 750 @ 2 A/3 V
- 50 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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

	NPN / PNP	BDW63 / 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 = 20 mH, R_{BB} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, Energy ≈ I_C^2.L/2.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW63 BDW64 Min	BDW63 BDW64 Max	BDW63A BDW64A Min	BDW63A BDW64A Max	BDW63B BDW64B Min	BDW63B BDW64B Max	BDW63C BDW64C Min	BDW63C BDW64C Max	BDW63D BDW64D Min	BDW63D BDW64D Max	UNITS
$V_{(BR)CEO}$	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 Forward 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}	Forward Voltage of Reverse Diode	$-I_C$ = 6A			3.5		3.5		3.5		3.5		3.5	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

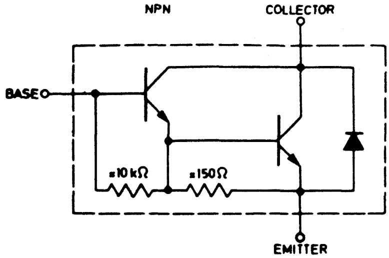
switching characteristics at 25 °C case temperature

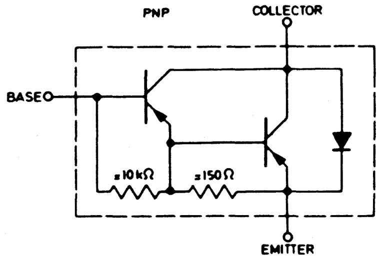
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA	1.0	μs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −4.5 V, R_L = 10 Ω	5	μs

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

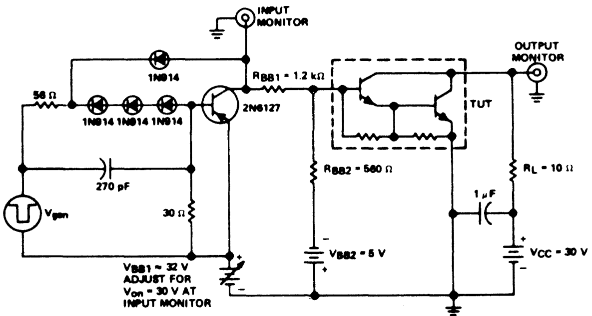
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3 mm from the device body

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)

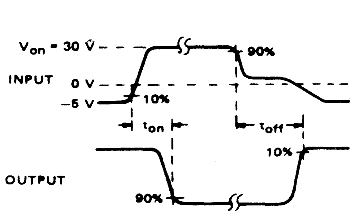




PARAMETER MEASUREMENT INFORMATION



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 $\leq 2\%$.

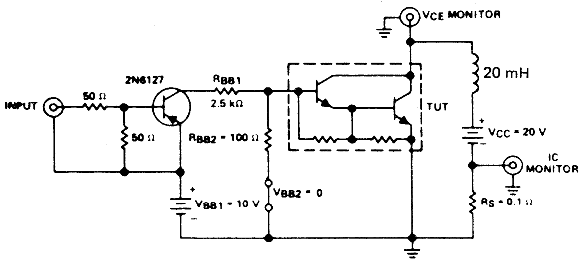
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

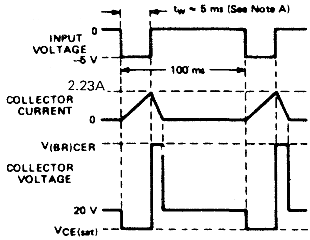
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 2.23A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

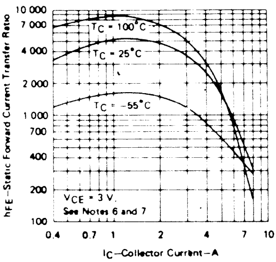


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

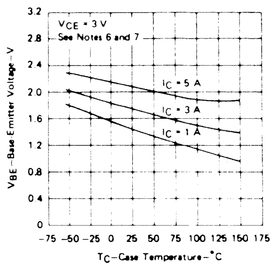


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

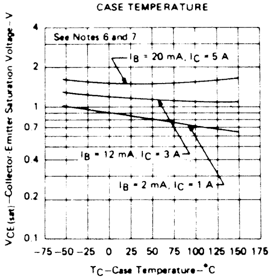


FIGURE 5

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

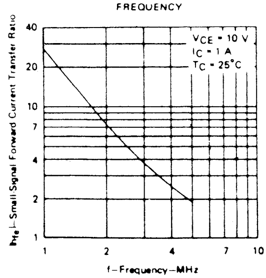


FIGURE 6

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

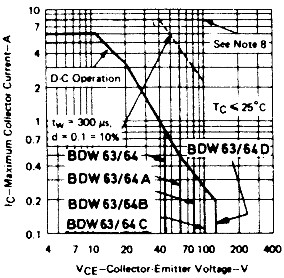


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

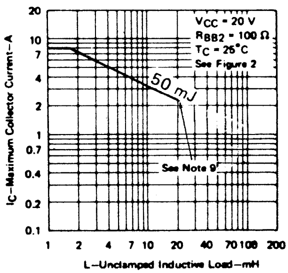


FIGURE 8

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

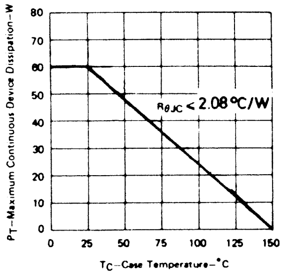


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

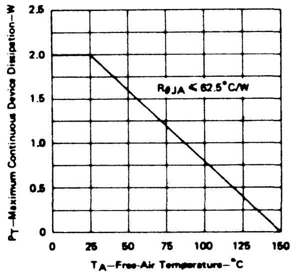
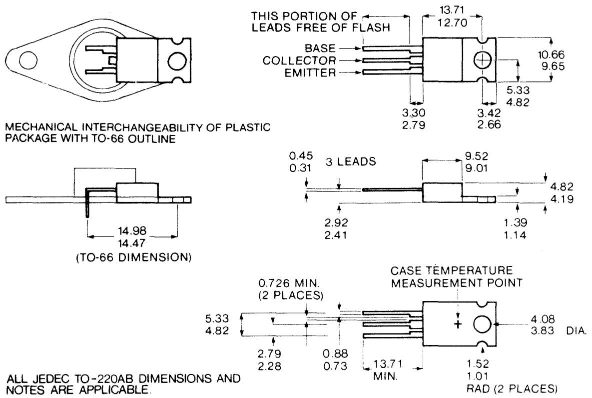


FIGURE 10

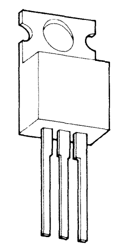
- High SOA Capability, 20 V and 4 A
- 80 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min h_{FE} of 750 @ 3 A/3 V
- 75 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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: $L = 20$ mH, $R_{BB} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V, Energy $\approx I_C^2 \cdot L/2$.

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW73 BDW74 Min	BDW73 BDW74 Max	BDW73A BDW74A Min	BDW73A BDW74A Max	BDW73B BDW74B Min	BDW73B BDW74B Max	BDW73C BDW74C Min	BDW73C BDW74C Max	BDW73D BDW74D Min	BDW73D BDW74D Max	UNITS
$V_{(BR)CEO}$	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					µA
		V_{CE} = 50 V,	I_B = 0								500			µA
		V_{CE} = 60 V,	I_B = 0										500	µA
I_{CBO}	Collector Cutoff Current	V_{CB} = 45 V,	I_E = 0		200									µA
		V_{CB} = 60 V,	I_E = 0				200							µA
		V_{CB} = 80 V,	I_E = 0						200					µA
		V_{CB} = 100 V,	I_E = 0								200			µA
		V_{CB} = 120 V,	I_E = 0										200	µA
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 Forward Current Transfer Ratio	V_{CE} = 3 V,	I_C = 3 A	750	20000	750	20000	750	20000	750	20000	750	20000	
		V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 8 A	100		100		100		100		100		
$V_{BE(ON)}$	Base Emitter Voltage	V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 3 A		2.5		2.5		2.5		2.5		2.5	V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 3 A,	I_B = 12 mA		2.5		2.5		2.5		2.5		2.5	V
		I_C = 8 A, (See Notes 5 & 6)	I_B = 80 mA		4		4		4		4		4	V
V_{FR}	Forward Voltage of Reverse Diode	$-I_C$ = 8 A			3.5		3.5		3.5		3.5		3.5	V

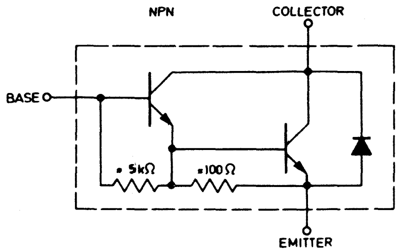
thermal characteristics

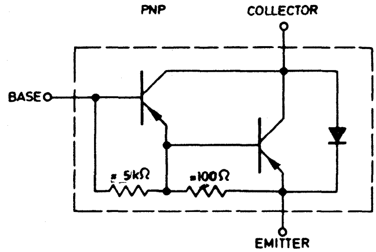
	PARAMETER	Max	UNITS
$R_{\theta JC}$	Junction -to-Case Thermal Resistance (See Note 7)	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.0	°C/W

switching characteristics at 25 °C case temperature

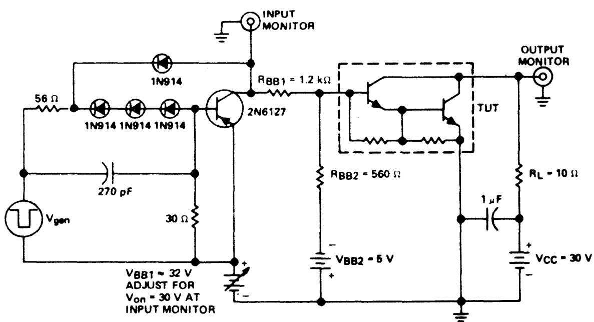
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA	1.0	µs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −3.5 V, R_L = 10 Ω	5.0	µs

NOTES: 5. These parameters must be measured using pulse techniques, t_w = 300 µs, duty cycle ≤ 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 ≤ 225 mV. (Base test current = 3 mA).

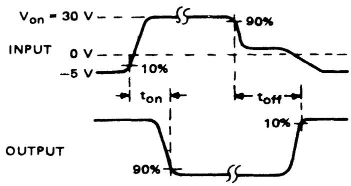




PARAMETER MEASUREMENT INFORMATION



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: $t_r < 15$ ns, $t_f < 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $< 2\%$.

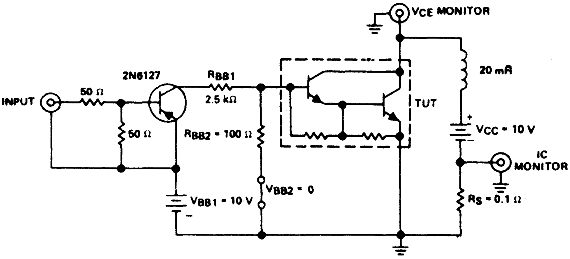
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 15$ ns, $R_{in} > 10\ M\Omega$, $C_{in} < 11.5$ pF.

D. Resistors must be noninductive types.

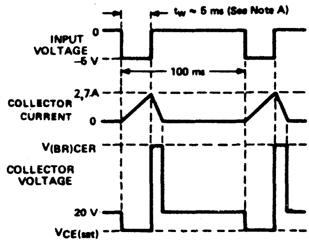
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 2.74 A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

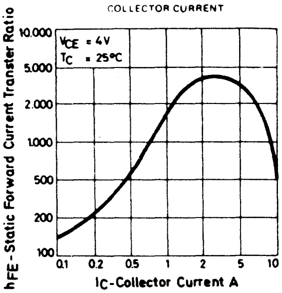


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

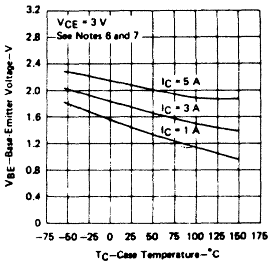


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

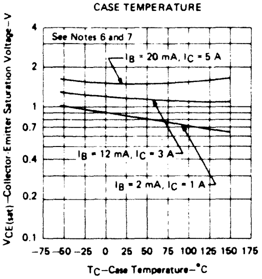


FIGURE 5

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

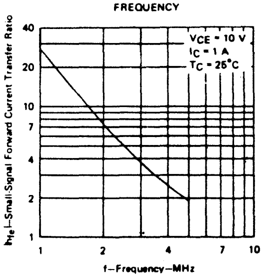


FIGURE 6

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

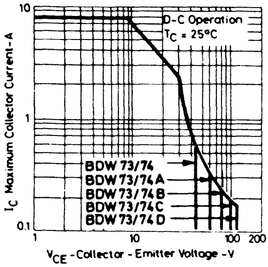


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

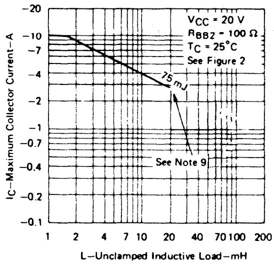


FIGURE 8

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

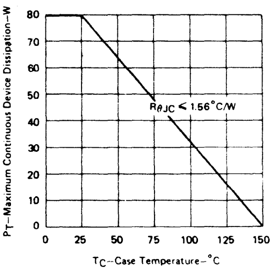


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

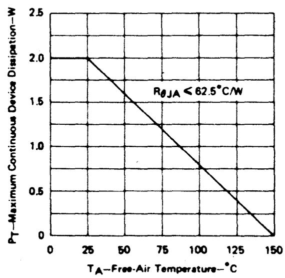


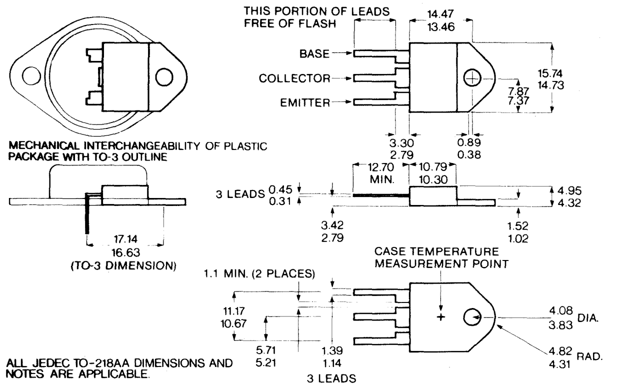
FIGURE 10

NPN SILICON POWER DARLINGTON BDW83 SERIES
PNP SILICON POWER DARLINGTON BDW84 SERIES

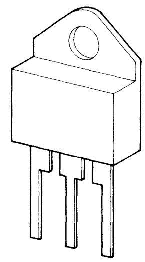
- High SOA Capability, 30 V and 5 A
- 150 W at 25 °C Case Temperature
- 15 A Rated Collector Current
- Min h_{FE} of 750 @ 6 A/3 V
- 100 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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

	NPN / PNP	BDW83 / 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 = 20 mH, R_{BB} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V, Energy ≈ $I_C{}^2 L/2$.

TEXAS INSTRUMENTS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS		BDW83 BDW84 Min	Max	BDW83A BDW84A Min	Max	BDW83B BDW84B Min	Max	BDW83C BDW84C Min	Max	BDW83D BDW84D Min	Max	UNITS
$V_{(BR)CEO}$	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		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 Forward 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, (See Notes 5 & 6)	I_C = 15 A	100		100		100		100		100		
$V_{BE(ON)}$	Base Emitter Voltage	V_{CE} = 3 V, (See Notes 5 & 6)	I_C = 6 A		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, (See Notes 5 & 6)	I_B = 150 mA		4		4		4		4		4	
V_{FR}	Forward Voltage of Reverse Diode	$-I_C$ = 15 A			3.5		3.5		3.5		3.5		3.5	V

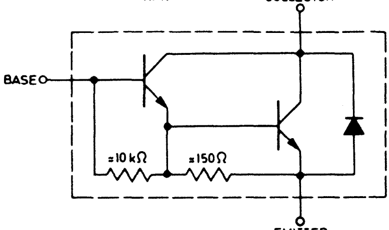
thermal characteristics

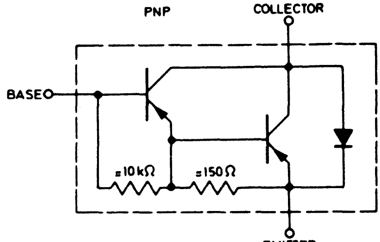
	PARAMETER	Max	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance (See Note 7)	0.83	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	°C/W

switching characteristics at 25 °C case temperature

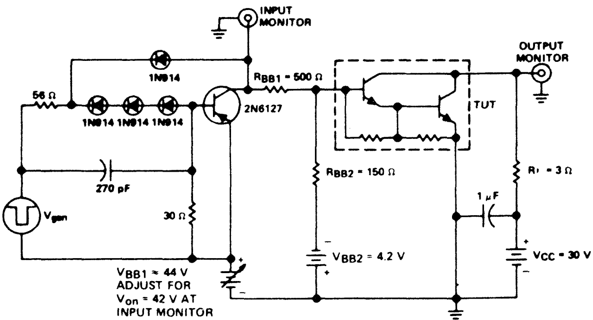
	PARAMETER	TEST CONDITIONS	Typ	UNIT
t_{ON}	Turn-On Time	I_C = 10 A, $I_{B(1)}$ = 40 mA, $I_{B(2)}$ = −40 mA	0.9	μs
t_{OFF}	Turn-Off Time	$V_{BE(off)}$ = −4.2 V, R_L = 3 Ω	7	μs

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 contacts and located within 3 mm from the 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 ≤ 187 mV (Base test current = 3 mA)

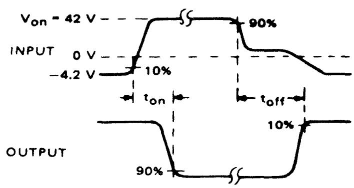




PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

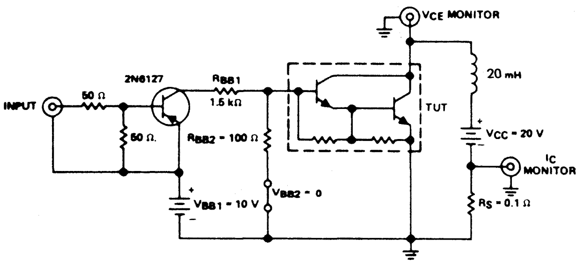


VOLTAGE WAVEFORMS

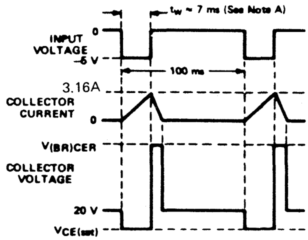
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
C. Waveforms are monitored on an oscilloscope 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} = 3.16 A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

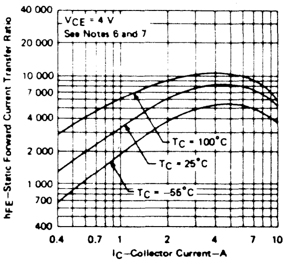


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

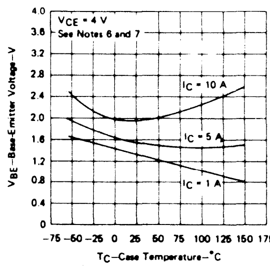


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

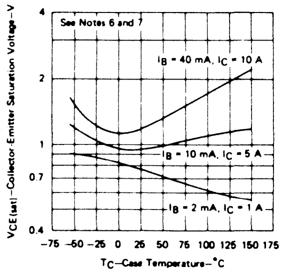


FIGURE 5

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

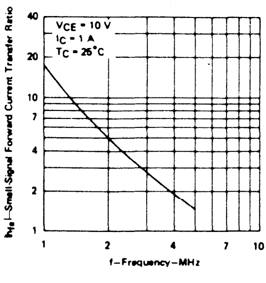


FIGURE 6

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

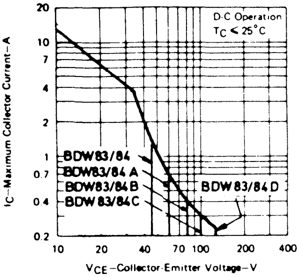


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

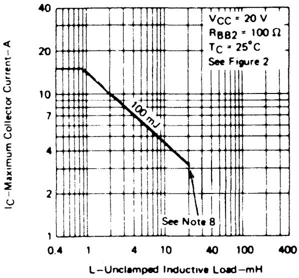


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

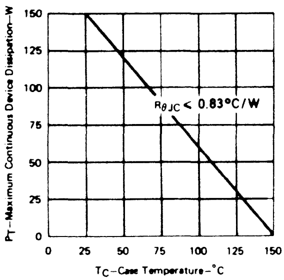


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

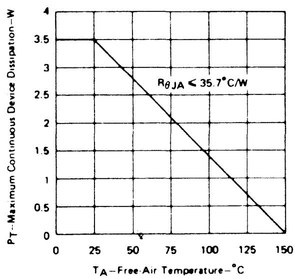


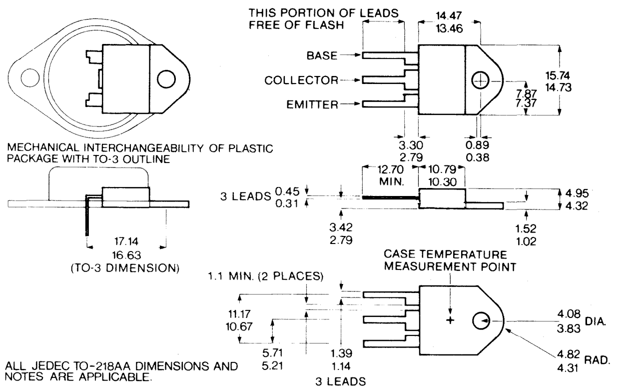
FIGURE 10

BU124, BU124A
NPN SILICON POWER TRANSISTOR

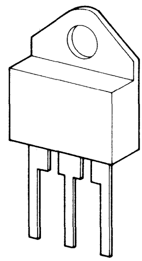
- Specifically designed for Portable TV Linescan Applications and other Switching Functions
- Plastic Package Compatible with Metal Can T0-3 layout
- 10A Continuous Collector Current, 400V VCBO
- 350V V_{CBO} BU124, 400V V_{CBO} BU124A.

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)

	BU124	BU124A
V_{CBO} Collector Base Voltage (IE = O)	350V	400V
V_{CEO} Collector Emitter Voltage (I_B = O)	150V	150V
V_{CEX} Collector Emitter Voltage VBE = −2V	350V	400V
V_{EB} Emitter Base Voltage	8V	8V
I_B Continuous Base Current	3A	3A
I_C Continuous Collector Current	10A	10A
I_C (peak) Pulsed Collector Current (see note 1)	15A	15A
P tot Continuous Dissipation (T case = 25°C)	50W	50W
T_J Operating Junction Temperature Range	−55°C to 150°C	

Note 1. Pulse Width = 1mS Duty Cycle 25%.

electrical characteristics at T case = 25°C (unless otherwise stated)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I_{CBO}	Collector-base leakage current	V_{CB} = 300V (BU124) V_{CB} = 350V (BU124A)				500	μA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage	I_C = 50 mA, I_B = 0.		150			V
$V_{(BR)EBO}$	Emitter-base breakdown voltage	I_E = 10mA, I_C = 0		8			V
$V_{(BR)CBO}$	Collector-base breakdown voltage	I_C = 1mA	BU124	350			V
			BU124A	400			V
$V_{CE(sat)}$	Collecter-emitter saturation voltage	I_C = 4A I_B = 0.5A (see note 2)				0.5	V
		I_C = 8A I_B = 2A (see note 2)				1.0	V
$V_{BE(sat)}$	Base-emitter saturation voltage	I_C = 4A I_B = 0.5A (see note 2)				1.2	V
		I_C = 8A I_B = 2A (see note 2)				1.4	V
h_{FE}	Static forward current transfer ratio	I_C = 4A V_{CE} = 10V (see note 2)		12			
		I_C = 0.5A V_{CE} = 10V (see note 2)		20			
t_s	Storage time (see Fig. 1)	I_C = 4A I_{Bend} = 0.5A			2.7		μs
t_f	Fall time (see Fig. 1)	I_C = 4A I_{Bend} = 0.5A				1.0	μs
f_t	Transition frequency	I_C = 0.5A V_{CE} = 5V f = 1MHz			6.0		MHz
C_{obo}	Common-base output capacitance	V_{CB} = 20V I_E = 0 f = 1MHz			60		pF
$R\theta_{jc}$	Junction-to-case thermal resistance					2.5	°C/W

NOTE 2. Measured using pulse techniques
pulse width, tp = 300μs
duty cycle, d = 2%

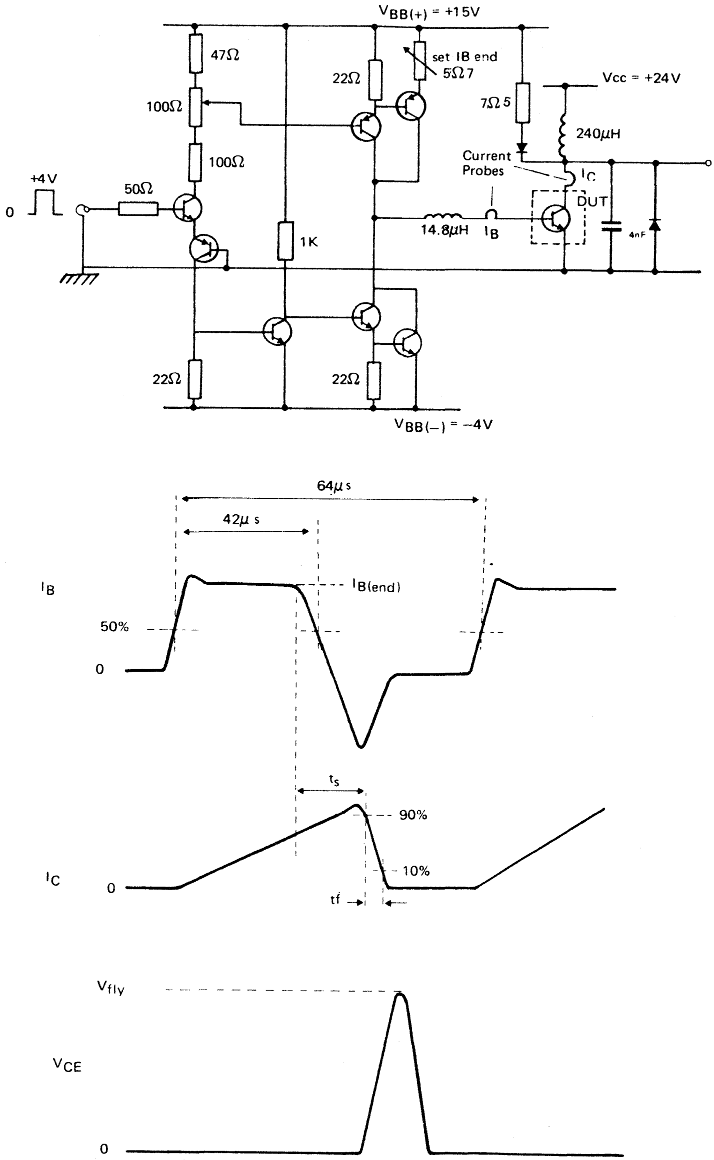


FIGURE 1. DETAILS FOR THE MEASUREMENT OF SWITCHING PARAMETERS.

FIGURE 2. D.C. F.S.A. – FORWARD BIASED SAFE AREA OF OPERATION AT Tcase = 25°C

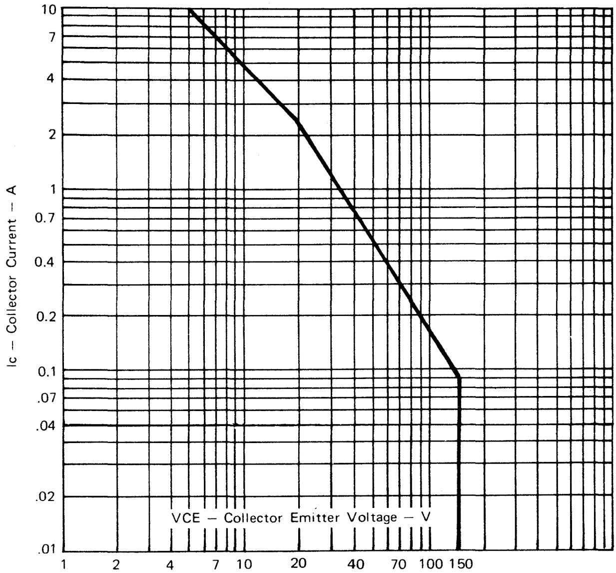


FIGURE 3. MINIMUM* AND TYPICAL h_{FE} AS A FUNCTION OF Ic AND V_{CE}. T_J = 25°C

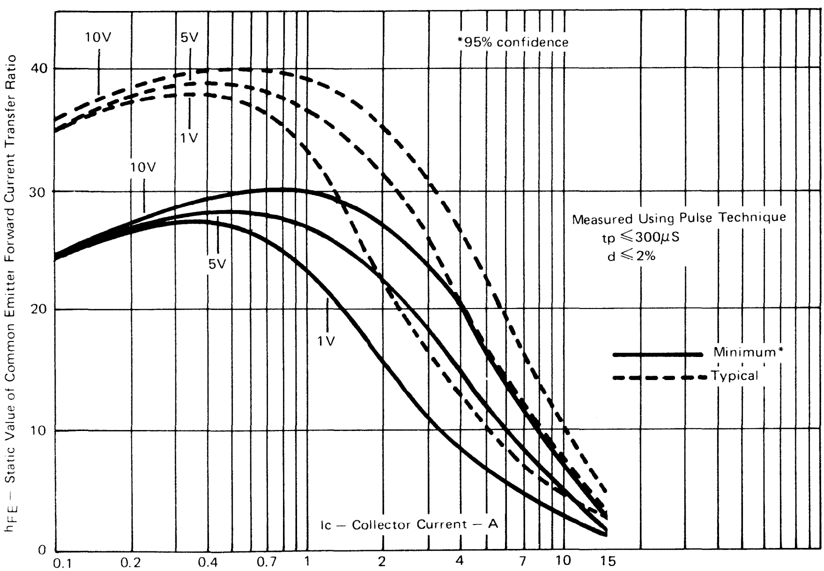


FIGURE 4. TYPICAL h_{FE} AS A FUNCTION OF IC AND JUNCTION TEMPERATURE AT VCE = 5V

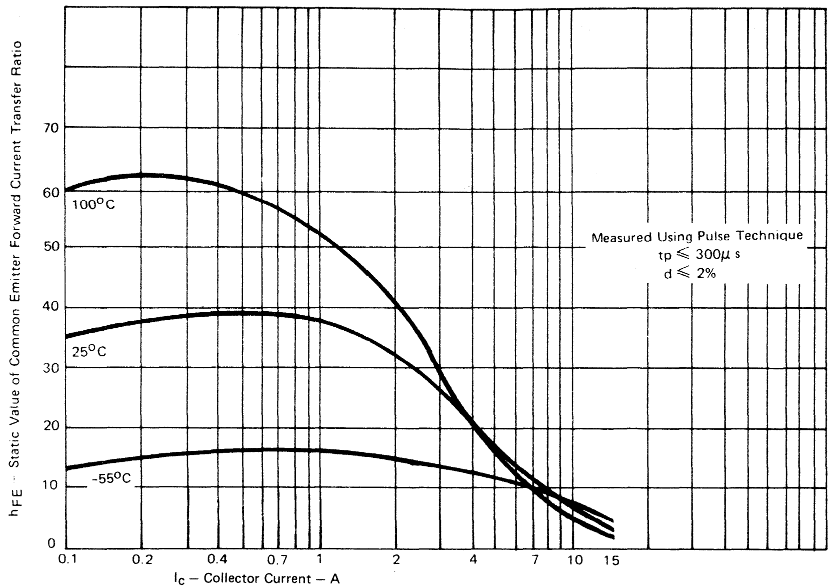
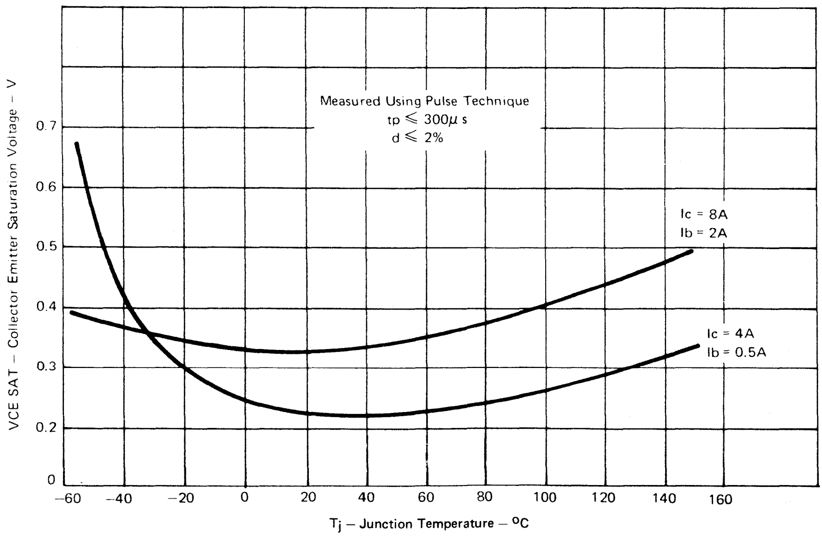


FIGURE 5. TYPICAL VCE(SAT) AS A FUNCTION OF JUNCTION TEMPERATURE



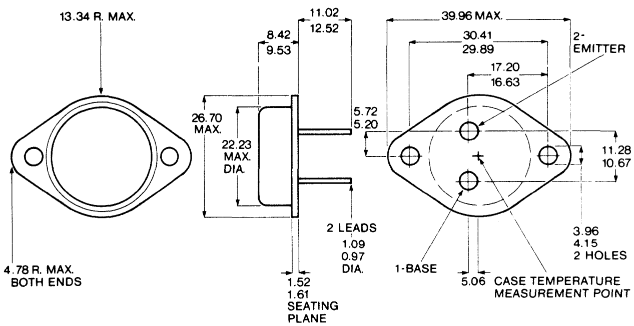
BU326/BU326A
NPN SILICON POWER TRANSISTOR

OCT 82

- High-voltage, high speed switching NPN triple diffused planar power transistor in metal T0-3 package, designed for general industrial and consumer high voltage switching applications, primarily intended for use in switching mode power supplies.
- Guaranteed transient 'turn-off' locus.

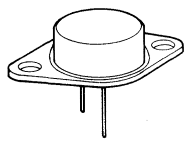
mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



absolute maximum ratings

	BU326	BU326A
Collector - Base Voltage	800V	900V
Collector - Emitter Voltage (V_{BE} = 0)	800V	900V
Collector - Emitter Voltage (Open Base)	375V	400V
Emitter - Base Voltage	10V	
Continuous Collector Current	6A	
Peak Collector Current (See Note 1)	8A	
Continuous Base Current	+2A, -0.1A	
Peak Base Current (See Note 1).	± 3	
Continuous Dissipation (See Figures 1 and 2)	60W	
Operating Junction Temperature	-65°C to +150°C	

Note 1: Pulse Test, Pulse Duration ≤ 2ms

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CES}	Collector-Emitter Cut-off Current	BU326: V_{CE} = 800V; V_{BE} = 0 BU326A: V_{CE} = 900V; V_{BE} = 0			1.0	mA
I_{CES}	Collector-Emitter Cut-off Current	BU326 V_{CE} = 800V V_{BE} = 0 T_j = 125°C BU326A V_{CE} = 900V V_{BE} = 0 T_j = 125°C			2.0	mA
I_{EBO}	Emitter-Base Cut-off Current	V_{EB} = 10V; I_C = 0			10	mA
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 2.5A; I_B = 0.5A I_C = 4A; I_B = 1.25A			1.5 3.0	V V
$V_{BE\ (SAT)}$	Base-Emitter Saturation Voltage	I_C = 2.5A; I_B = 0.5A I_C = 4A; I_B = 1.25A			1.4 1.6	V V
$V_{CEO(SUST)}$	Collector-Emitter Sustaining Voltage (See Note 2)	I_C = 100mA; BU326: L = 25mH; BU326A:	375 400			V
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V; I_C = 0.6A		40		
t_{on}	Collector Current Turn-On Time	I_C = 2.5A; $I_{B(ON)}$ = 0.5A; $-I_{B(OFF)}$ = 1.0A; V_{CC} = 250V Resistive Switching (See Figures 3 & 4)		0.3	0.5	μs
t_s	Collector Current Storage Time			2.0	3.5	μs
t_f	Collector Current Fall Time			0.15		μs
t_f	Collector Current Fall Time	Conditions as above T_C = 95°C		0.20	1.0	μs
$R_{\theta jc}$	Thermal Resistance Junction to Case				1.67	°C/W

Note 2: Inductive Loop Switching Measurement.

MAX. POWER DISSIPATION VERSUS CASE TEMPERATURE

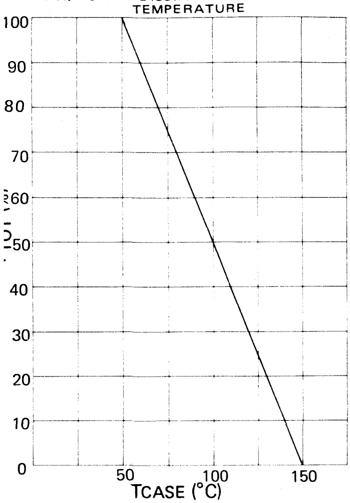


FIGURE 1

FORWARD BIASED SAFE AREA OF OPERATION, D.C. AND SINGLE NON-REPETITIVE PULSE. CASE TEMPERATURE ≤50°C

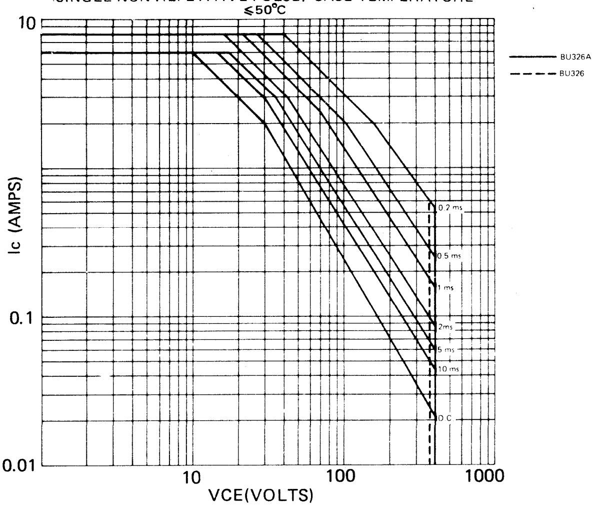
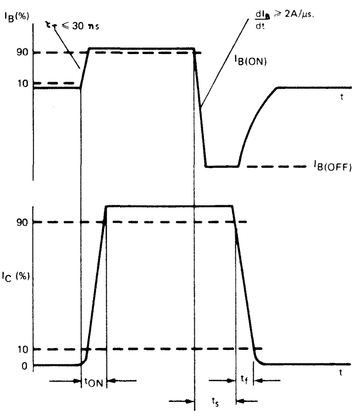


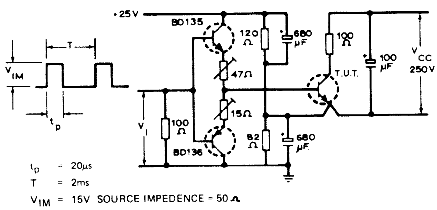
FIGURE 2

SWITCHING TIME MEASURMENT DATA



WAVEFORMS

FIGURE 3



TEST CIRCUIT

FIGURE 4

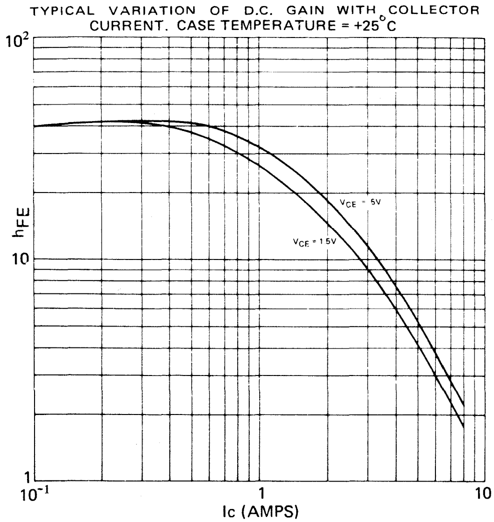


FIGURE 5

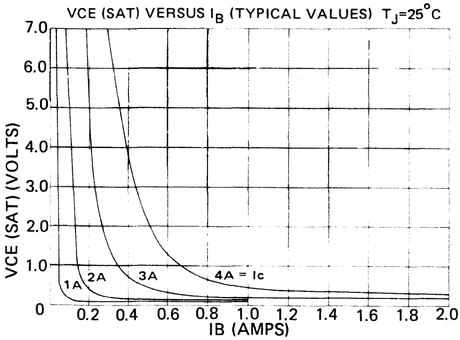


FIGURE 6

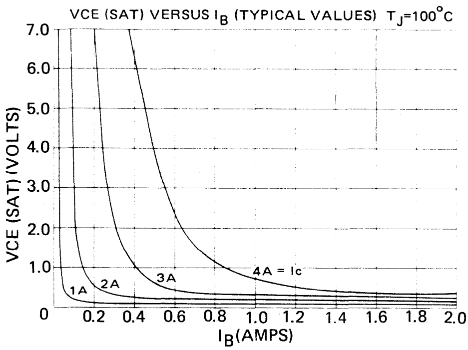


FIGURE 7

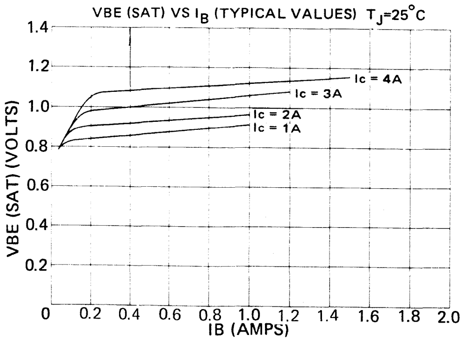


FIGURE 8

RELEVANT WAVEFORMS OF SWITCHING TRANSISTOR

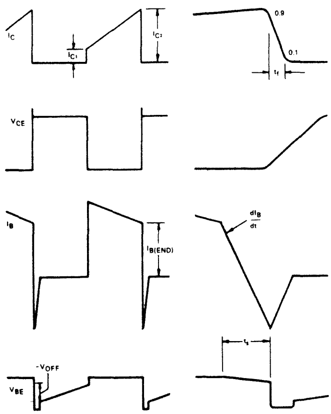


FIGURE 9

RECOMMENDED BASE DRIVE VERSUS NOMINAL PEAK COLLECTOR CURRENT

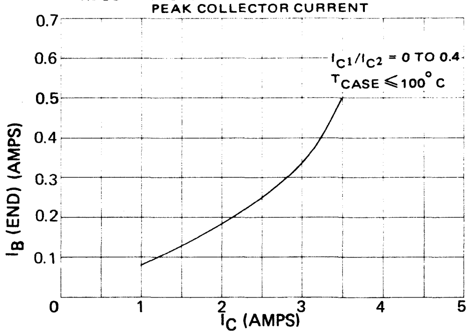


FIGURE 10

RECOMMENDED dI_B/dt VERSUS NOMINAL PEAK COLLECTOR CURRENT

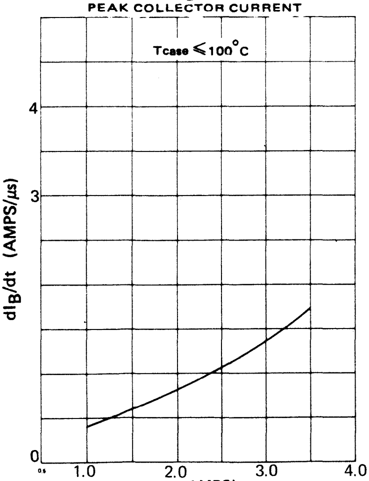


FIGURE 11

RECOMMENDED MINIMUM INDUCTANCE AND NEGATIVE DRIVE VOLTAGE VERSUS NOMINAL PEAK COLLECTOR CURRENT

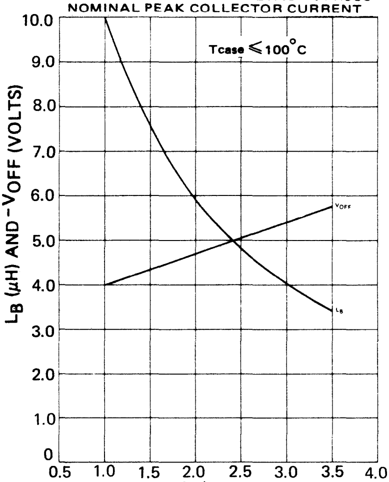


FIGURE 12

application notes

The operating efficiency and overall reliability of high voltage switching transistors are strong functions of the transient dissipation during device "turn-off", which is controlled largely by the applied base drive. (Ref. 1).

The maximum slope of the base current during turn-off considerably influences the transistor dissipation. The parameter is given by:

$$\frac{dI_B}{dt} \approx - \frac{(|V_{OFF}| + V_{BE})}{L_B}$$

where V_{OFF} is the negative drive voltage, V_{BE} the base-emitter voltage during switching and L_B is the total base inductance.

Recommended dI_B/dt is plotted as a function of nominal peak collector current in Fig. 11. The recommended base drive, I_{BEND}, also as a function of peak collector current is shown in Fig. 10 for I_{C1}/I_{C2} from 0 to 0.4. (See Fig. 9 for the definition of the waveforms). The recommended minimum value for the total base inductance and negative drive voltage to achieve the dI_B/dt is given as a function of peak collector current in Fig. 12.

The total power dissipation of a typical transistor as a function of peak collector current in a typical application using the recommended drive conditions (± 20%) is shown in Fig. 13.

The ability of the switching 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 BU326 in normal circuit configurations, at $T_{case} \leqslant 100°C$, provided that the worse case V_{CE}/I_C locus at device "turn-off", during a transient, does not exceed that shown in Fig. 14, for limit base drive conditions: $\hat{I}_{B(ON)} \leqslant 3$ Amp, and 0.05 Amp $\leqslant \hat{I}_{B(OFF)} \leqslant 1.5$ Amp. The V_{CE} locus found in an application may be plotted using an oscilloscope, provided that the bandwith exceeds 10 MHz and the delay matching of X and Y plots is better than 20 ns.

N.B. It is imperative that the repetition rate does not allow the thermal rating to be exceeded.

Reference 1 Driver Circuit Considerations for High Voltage Line Scan Transistors, M.J. Maytum and A. Lear, I.E.E.E. Trans BTR May, 1972

MAX. TOTAL POWER DISSIPATION OF A TYPICAL TRANSISTOR IF THE BASE CURRENT IS CHOSEN IN ACCORDANCE WITH RECOMMENDED DRIVE CONDITIONS

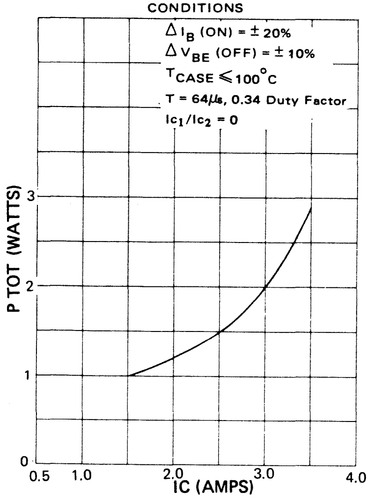


FIGURE 13

TRANSIENT 'TURNOFF' LIMIT IC VERSUS VCE

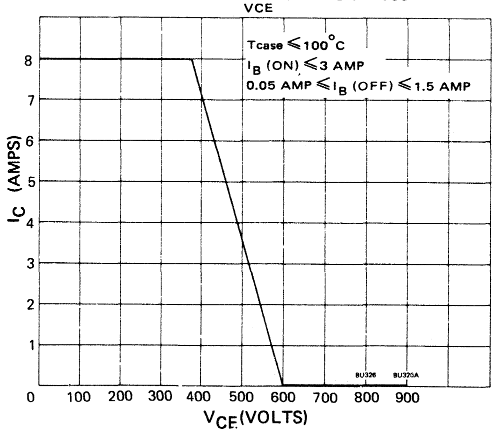


FIGURE 14

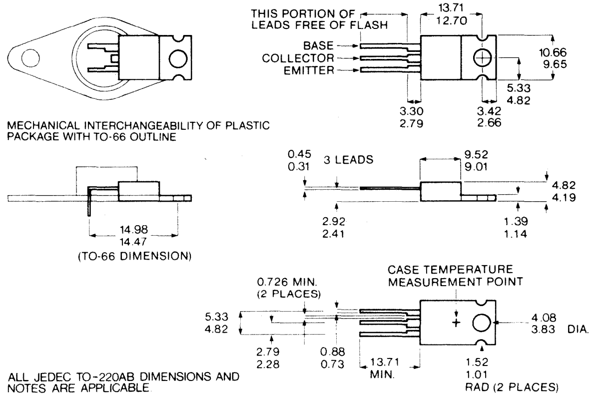
BU406, BU407
NPN SILICON POWER TRANSISTOR

OCT 82

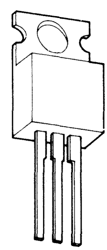
- Specifically designed for Portable TV Linescan Applications for MTV Receiver with 110° Tubes
- Plastic Package T0-220
- 7A Continuous Collector Current
- 330V V_{CBO} BU407, 400V V_{CBO} BU406

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)

	BU407	BU406
V_{CBO} Collector Base Voltage (IE = O)	330V	400V
V_{CEO} Collector Emitter Voltage (I_B = O)	150V	200V
V_{CEX} Collector Emitter Voltage VBE = −2V	330V	400V
V_{EB} Emitter Base Voltage	6V	6V
I_B Continuous Base Current	4A	4A
I_C Continuous Collector Current	7A	7A
I_C (peak) Pulsed Collector Current (see note 1)	15A	15A
P tot Continuous Dissipation (T case = 25°C)	60W	60W
T_J Operating Junction Temperature Range	−55°C to 150°C	

Note 1. Pulse Width = 10 mS, Duty Cycle 25%.

electrical characteristics at T case = 25°C (unless otherwise stated)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CES}	Collector Emitter leakage current	V_{CE} = 330V BU407 V_{CE} = 400V BU406			5.0	mA
		V_{CE} = 200V BU407 V_{CE} = 250V BU406			0.1	mA
		V_{CE} = 200V BU407 T_{case} 150°C V_{CE} = 250V BU406 T_{case} 150°C			1	mA
I_{EBO}	Emitter-base leakage current	V_{EB} = 6V			1.0	mA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage	I_C = 30 mA, I_B = 0.	140			V
$V_{CE(sat)}$	Collecter-emitter saturation voltage	I_C = 5A I_B = 0.5A (see note 2)			1.0	V
$V_{BE(sat)}$	Base-emitter saturation voltage	I_C = 5A I_B = 0.5A (see note 2)			1.2	V
h_{FE}	Static forward current transfer ratio	I_C = 4A V_{CE} = 10V (see note 2)	12			
		I_C = 0.5A V_{CE} = 10V (see note 2)	20			
t_s	Storage time (see Fig. 1)	I_C = 5A I_{Bend} = 0.5A		2.7		µs
toff	Fall time (see Fig. 1)	I_C = 5A I_{Bend} = 0.5A			0.75	µs
f_t	Transition frequency	I_C = 0.5A V_{CE} = 5V f = 1MHz		6.0		MHz
C_{obo}	Common-base output capacitance	V_{CB} = 20V I_E = 0 f = 1MHz		60		pF
$R\theta_{jc}$	Junction-to-case thermal resistance				2.08	°C/W
$R\theta_{ja}$	Junction-to-ambient Thermal resistance				70	°C/W

NOTE 2. Measured using pulse techniques
pulse width, tp = 300µs
duty cycle, d = 2%

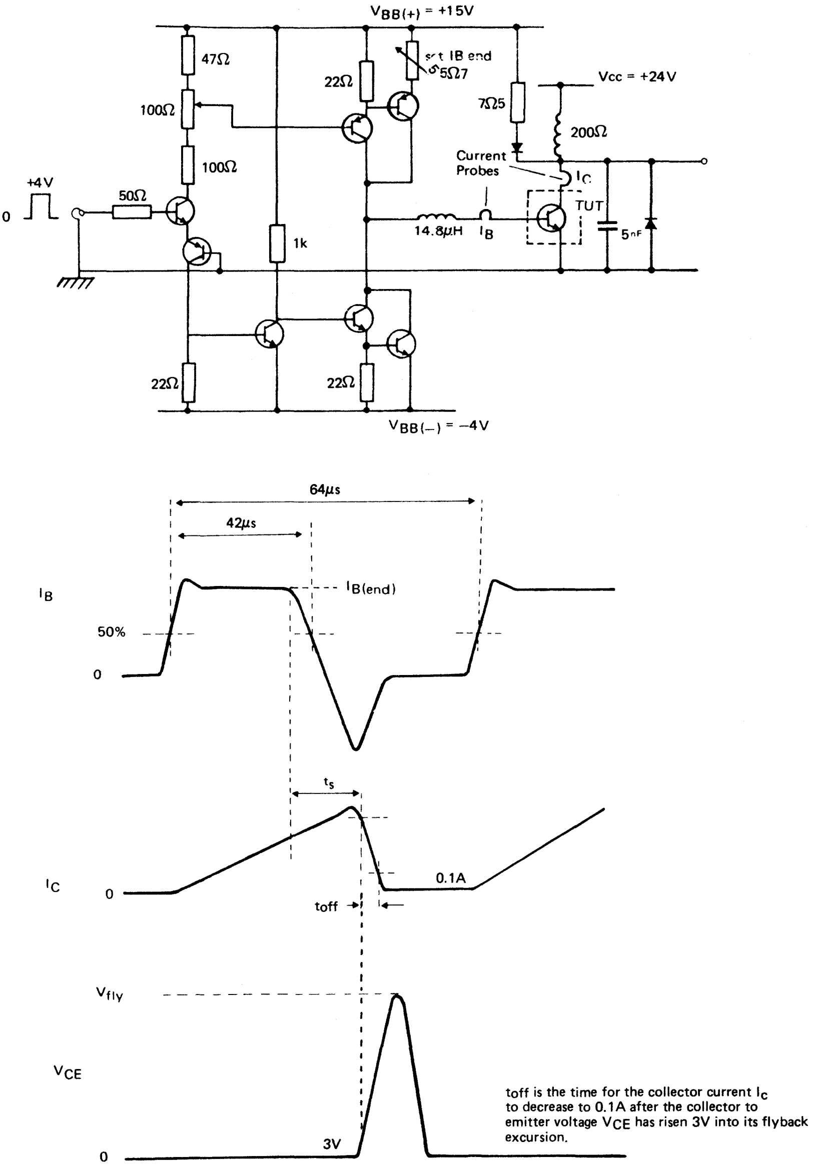


FIGURE 1. DETAILS FOR THE MEASUREMENT OF SWITCHING PARAMETERS.

FIGURE 2. D.C. – FORWARD BIASED SAFE AREA OF OPERATION AT Tcase = 25°C

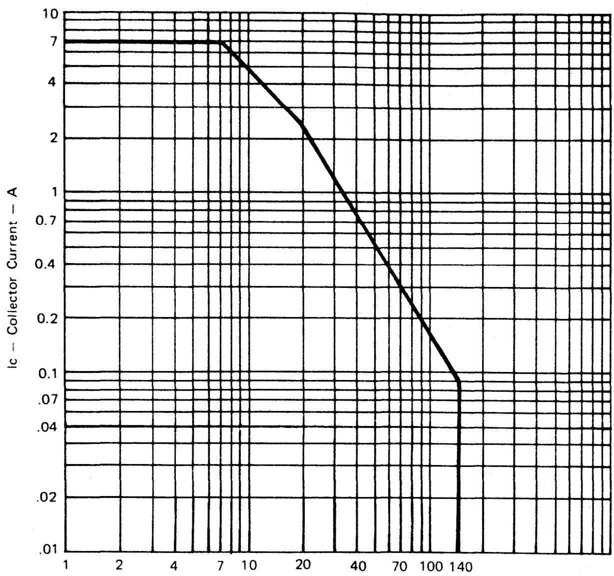


FIGURE 3. MINIMUM* AND TYPICAL h_{FE} AS A FUNCTION OF Ic AND V_{CE}. T_J = 25°C

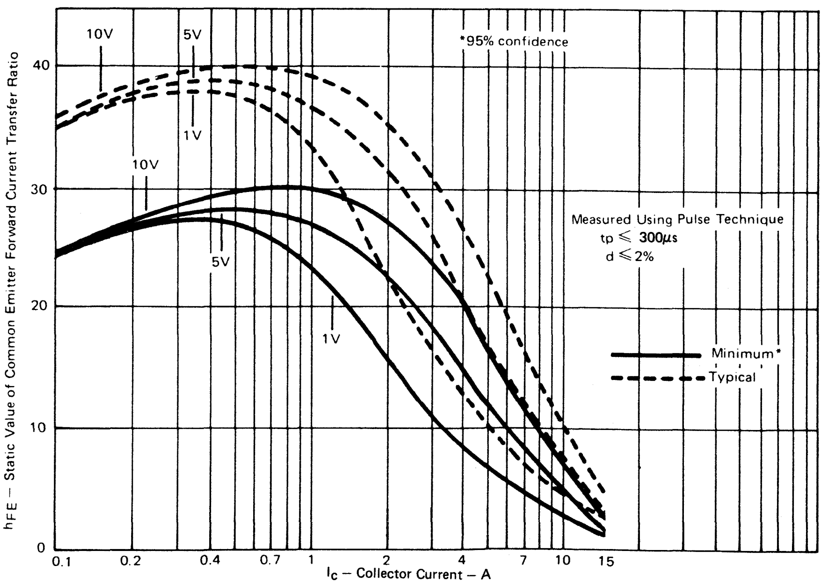


FIGURE 4. TYPICAL h_{FE} AS A FUNCTION OF IC AND JUNCTION TEMPERATURE AT VCE = 5V

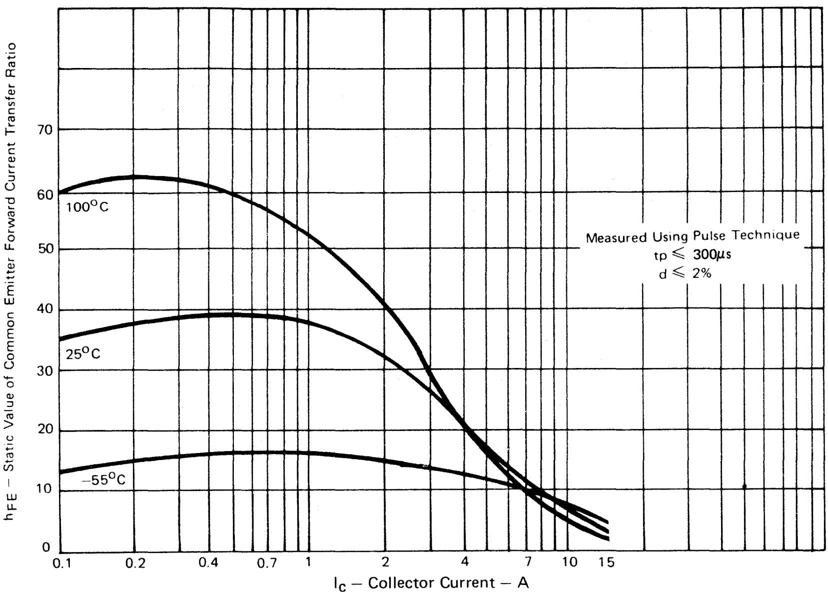
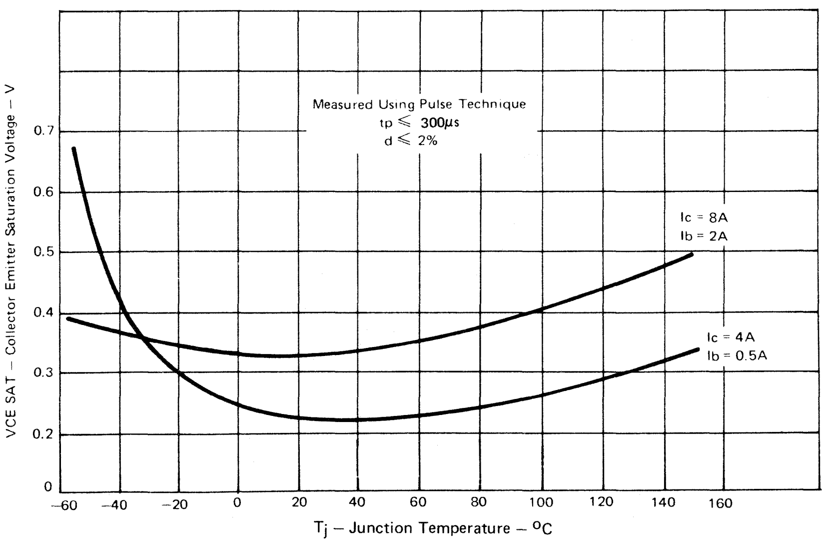


FIGURE 5. TYPICAL VCE(SAT) AS A FUNCTION OF JUNCTION TEMPERATURE



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TEXAS INSTRUMENTS RESERVES THE RIGHT TO MAKE CHANGES AT ANY TIME IN ORDER TO IMPROVE DESIGN AND TO SUPPLY THE BEST PRODUCT POSSIBLE

BU426/BU426A

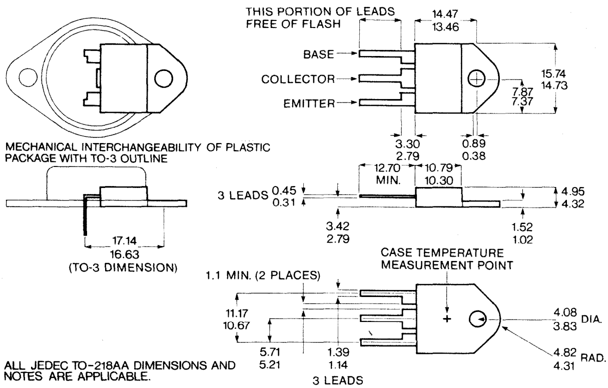
NPN SILICON POWER TRANSISTOR

OCT 82

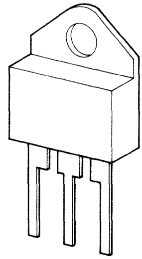
- **High-voltage, high speed switching NPN triple diffused planar power transistor in plastic T0-218 package, designed for general industrial and consumer high voltage switching applications, primarily intended for use in switching mode power supplies.**
- **Guaranteed transient 'turn-off' locus;**

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



absolute maximum ratings (at 25°C ambient temperature)

	BU426	BU426A
Collector - Base Voltage	800V	900V
Collector - Emitter Voltage (V_{BE} = 0)	800V	900V
Collector - Emitter Voltage (Open Base)	375V	400V
Continuous Collector Current	6A	
Peak Collector Current (See Note 1)	10A	
Continuous Base Current	+2A, -0.1A	
Peak Base Current	±3A	
Continuous Dissipation (See Figures 1 and 2)	70W	
Operating Junction Temperature	-65°C to +150°C	

Note 1: Pulse Test, Pulse Duration ≤2ms

TEXAS INSTRUMENTS

electrical characteristics at 25° case temperature (unless otherwise specified)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CES}	Collector-Emitter Cut-off Current	BU426: V_{CE} = 800V; V_{BE} = 0 BU426A: V_{CE} = 900V; V_{BE} = 0			1.0	mA
		BU426 V_{CE} = 800V T_{case} = 125°C BU426A V_{CE} = 900V T_{case} = 125°C			2.0	mA
I_{EBO}	Emitter-Base Cut-off Current	V_{EB} = 10V; I_C = 0			10	mA
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 2.5A; I_B = 0.5A I_C = 4A; I_B = 1.25A			1.5 3	V V
$V_{BE\ (SAT)}$	Base-Emitter Saturation Voltage	I_C = 2.5A; I_B = 0.5A I_C = 4A; I_B = 1.25A			1.4 1.6	V V
$V_{CEO\ (SUST)}$	Collector-Emitter Sustaining Voltage (See Note 2)	I_C = 100mA; BU426 L = 25mH; BU426A	375 400			V V
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V; I_C = 0.6A		30	60	
t_{on}	Collector Current Turn-on Time	I_C = 2.5A; $I_{B(ON)}$ = 0.5A; $-I_{B(OFF)}$ = 1.0A; V_{CC} = 250V Resistive Switching (See Figures 3 & 4)		0.3	0.6	μs
t_s	Collector Current Storage Time			2.0	3.5	μs
t_f	Collector Current Fall Time			0.15		μs
t_f	Collector Current Fall Time	Conditions as above T_C = 95°C		0.20	0.75	μs
$R\theta_{jc}$	Thermal Resistance Junction to Case				1.1	°C/W

NOTE 2: Inductive Loop Switching Measurement.

MAX. POWER DISSIPATION VERSUS CASE TEMPERATURE

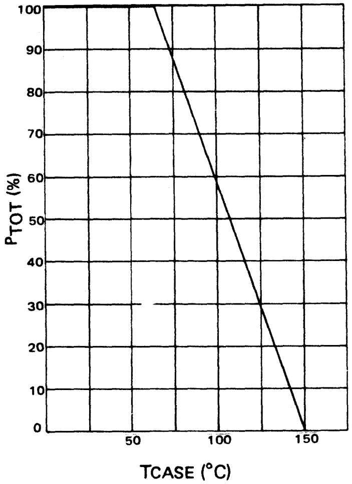


FIGURE 1

FORWARD BIASED SAFE AREA OF OPERATION, D.C. AND SINGLE NON-REPRETITIVE PULSE CASE TEMPERATURE ≤73°C

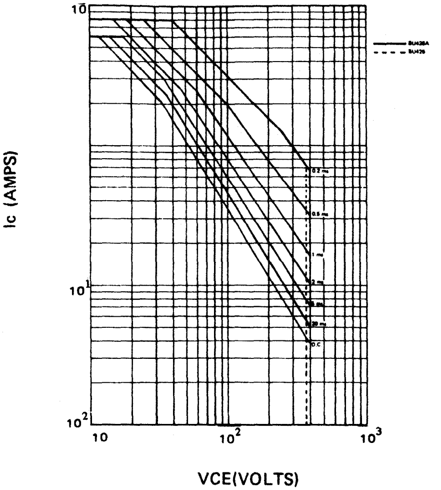
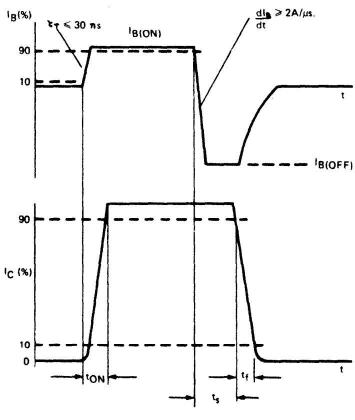


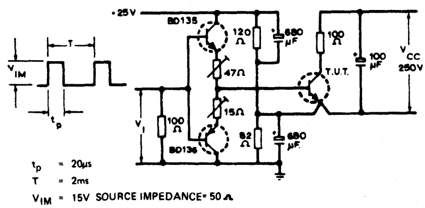
FIGURE 2

SWITCHING TIME MEASURMENT DATA



WAVEFORMS

FIGURE 3



TEST CIRCUIT

FIGURE 4

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

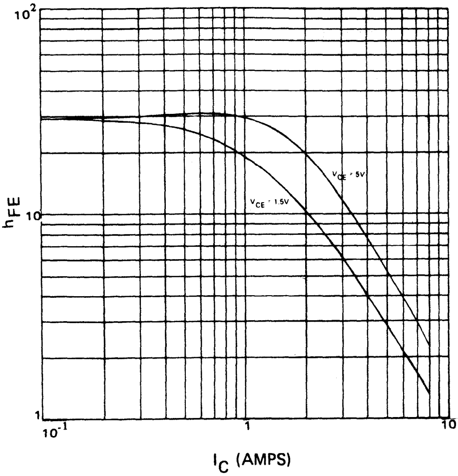


FIGURE 5

VCE (SAT) VERSUS I_B (TYPICAL VALUES) T_J=25°C

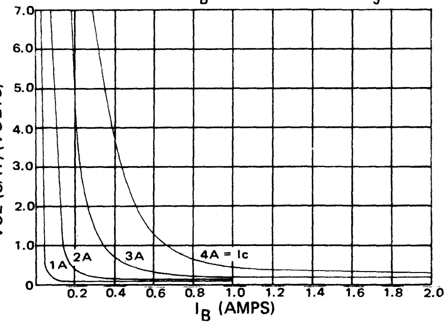


FIGURE 6

VCE (SAT) VERSUS I_B (TYPICAL VALUES) T_J=100°C

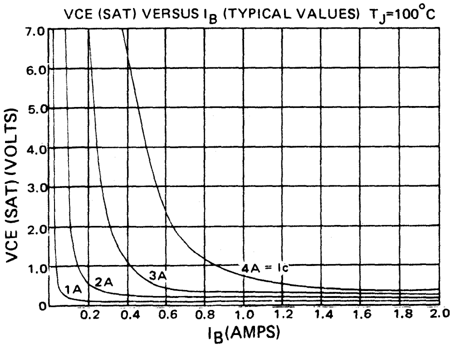


FIGURE 7

VBE (SAT) VS I_B (TYPICAL VALUES) T_J=25°C

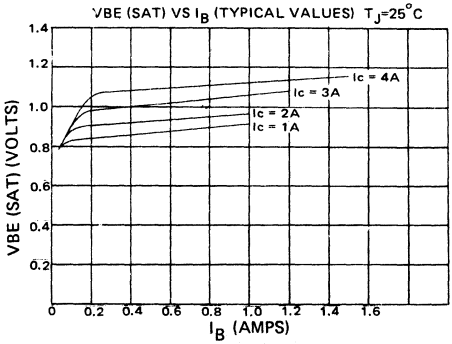


FIGURE 8

RELEVANT WAVEFORMS OF SWITCHING TRANSISTOR

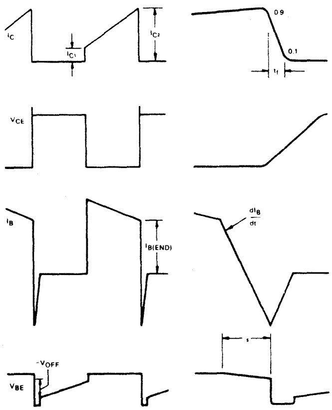


FIGURE 9

RECOMMENDED BASE DRIVE VERSUS NOMINAL PEAK COLLECTOR CURRENT

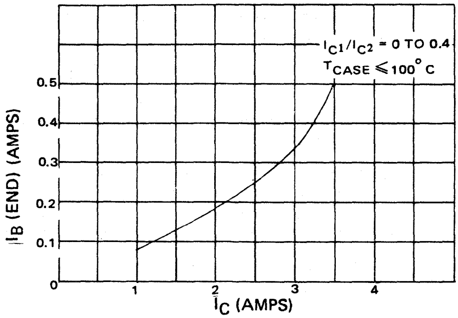


FIGURE 10

RECOMMENDED dI_B/dt VERSUS NOMINAL PEAK COLLECTOR CURRENT

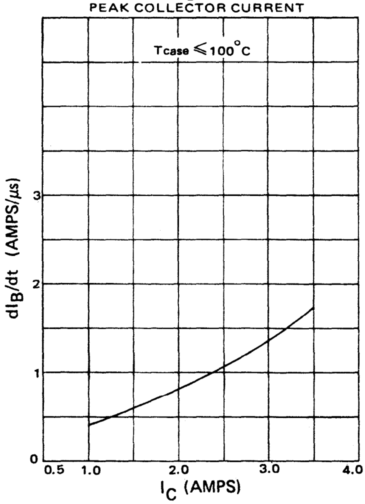


FIGURE 11

RECOMMENDED MINIMUM INDUCTANCE AND NEGATIVE DRIVE VOLTAGE VERSUS NOMINAL PEAK COLLECTOR CURRENT

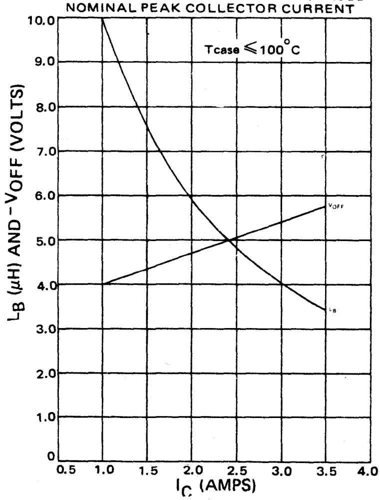


FIGURE 12

application notes

The operating efficiency and overall reliability of high voltage switching transistors are strong functions of the transient dissipation during device "turn-off", which is controlled largely by the applied base drive. (Ref. 1).

The maximum slope of the base current during turn-off considerably influences the transistor dissipation. The parameter is given by:

$$\frac{dI_B}{dt} \approx - \frac{(|V_{OFF}| + V_{BE})}{L_B}$$

where V_{OFF} is the negative drive voltage, V_{BE} the base-emitter voltage during switching and L_B is the total base inductance.

Recommended dI_B/dt is plotted as a function of nominal peak collector current in Fig. 11. The recommended base drive, I_BEND, also as a function of peak collector current is shown in Fig. 10 for I_{C1}/I_{C2} from 0 to 0.4 (See Fig. 9 for the definition of the waveforms) The recommended minimum value for the total base inductance and negative drive voltage to achieve the dI_B/dt is given as a function of peak collector current in Fig. 12.

The total power dissipation of a typical transistor as a function of peak collector current in a typical application using the recommended drive conditions (± 20%) is shown in Fig. 13.

The ability of the switching 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 BU426 in normal circuit configurations, at T_{case} $\leqslant$100°C, provided that the worse case V_{CE}/I_C locus at device "turn-off", during a transient, does not exceed that shown in Fig. 14, for limit base drive conditions: $\hat{I}_{B(ON)} \leqslant 3$ Amp, and 0.05 Amp $\leqslant \hat{I}_{B(OFF)} \leqslant 1.5$ Amp. The V_{CE} locus found in an application may be plotted using an oscilloscope, provided that the bandwith exceeds 10 MHz and the delay matching of X and Y plots is better than 20 ns.

N.B. It is imperative that the repetition rate does not allow the thermal rating to be exceeded.

Reference 1: Driver Circuit Considerations for High Voltage Line Scan Transistors M.J. Maytum and A. Lear, I.E.E.E. Trans BTR May, 1972.

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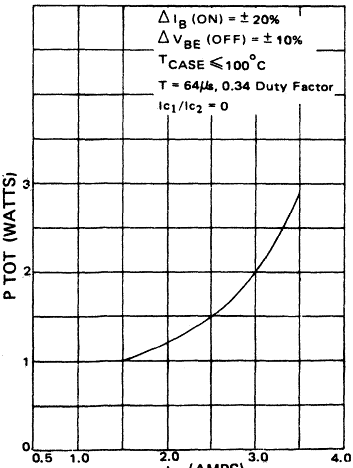


FIGURE 13

TRANSIENT 'TURNOFF' LIMIT IC VERSUS VCE

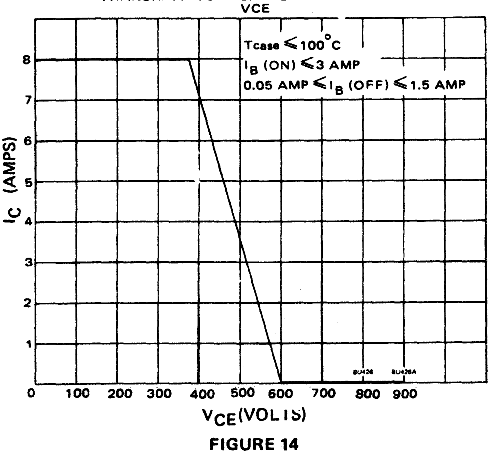


FIGURE 14

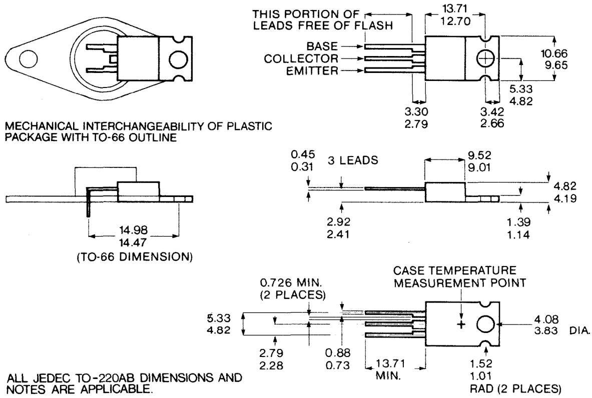
OCT 82

NPN SILICON POWER TRANSISTOR

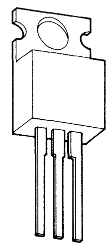
- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'Turn-off' locus

MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUV46
Collector-Emitter Voltage (VBE = -2.5V)	850V
Collector-Emitter Voltage (Open Base)	400V
Emitter-Base Voltage	7V
Continuous Collector Current	6A
Peak Collector Current (Note 1)	8A
Base Current	2A
Peak Base Current	4 A
Continuous Dissipation T Case = 25°C	70W
Operating Junction Temperature	–65°C – +150°C

Note 1: Pulse Test, Pulse Duration = 10ms

BUV46
NPN SILICON POWER TRANSISTOR

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CEO(SUS)}$	Collector-Emitter Sustaining Voltage See Note 1	I_C = 200 mA L = 25 mH	400			V
I_{CEX}	Collector-Emitter Cut-off Current (V_{BE} = -2.5V)	V_{CE} = 850V V_{CE} = 850V 125°C			0.1 1	mA mA
I_{CER}	Collector-Emitter Cut-off Current ($R_{BE} \leqslant 10\Omega$)	V_{CE} = 850V V_{CE} = 850V 125°C			0.3 2	mA mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 5V I_C = 0			1	mA
B_{VEBO}	Emitter Base Breakdown Voltage	I_E = 50mA I_C = 0	7		30	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 2.5A I_B = 0.5A I_C = 3.5A I_B = 0.7A See Notes 3 and 4			1.5 5	V V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 2.5A I_B = 0.5A See Notes 5 and 4			1.3	V
f_t	Current Gain Band-Width Product	I_C = 500mA V_{CE} = 10V (dc) F = 1MHz		12		MHz
C_{ob}	Output Capacitance	V_{CB} = 20V I_C = 0A F = 0.1 MHz		110		pf
$R_{\theta jc}$	Thermal Resistance Junction-Case				1.79	°C/W

Note 2: Inductive Loop Switching Measurement.
Note 3: These parameters must be measured using pulse techniques, tw = 300µs, duty cycle ≤2%
Note 4: 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 UNLESS OTHERWISE SPECIFIED

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
t_{on}	Turn on Time	I_C = 2.5A V_{CC} = 150V			1.0	µs
t_s	Storage Time	I_{BON} = 0.5A I_{BOFF} = 0.5A			3.0	µs
t_f	Fall Time	T Case-25°C See Fig. 2			0.8	µs
INDUCTIVE LOAD						
t_f	Fall Time	I_C = 2.5A V_{CC} = 300V I_{BON} = 0.5A V_B = -5V L_b = 3µH T Case = See Fig. 1		0.15		µs

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT

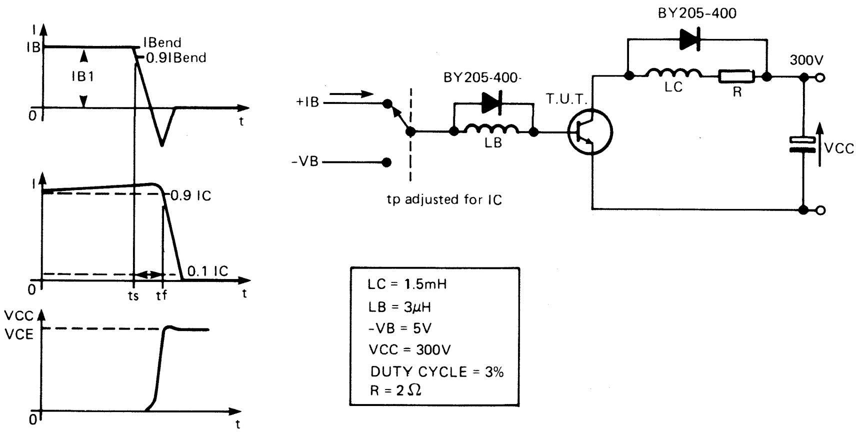
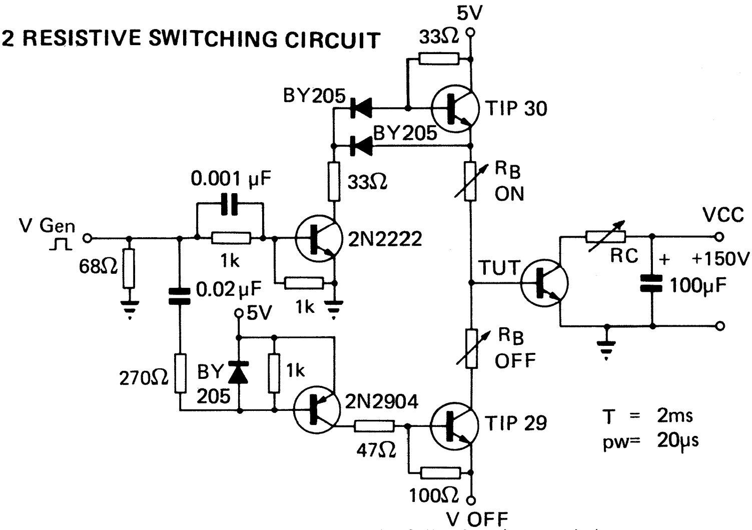


FIGURE 2 RESISTIVE SWITCHING CIRCUIT

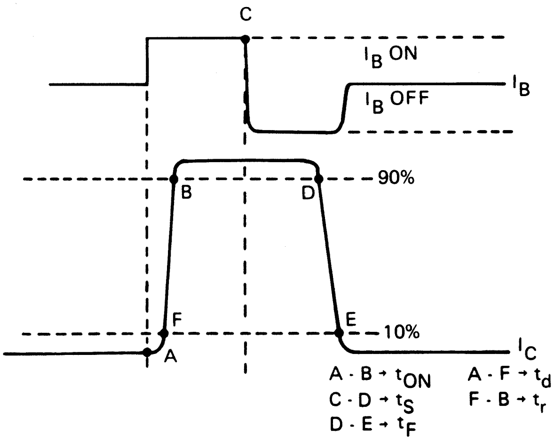


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

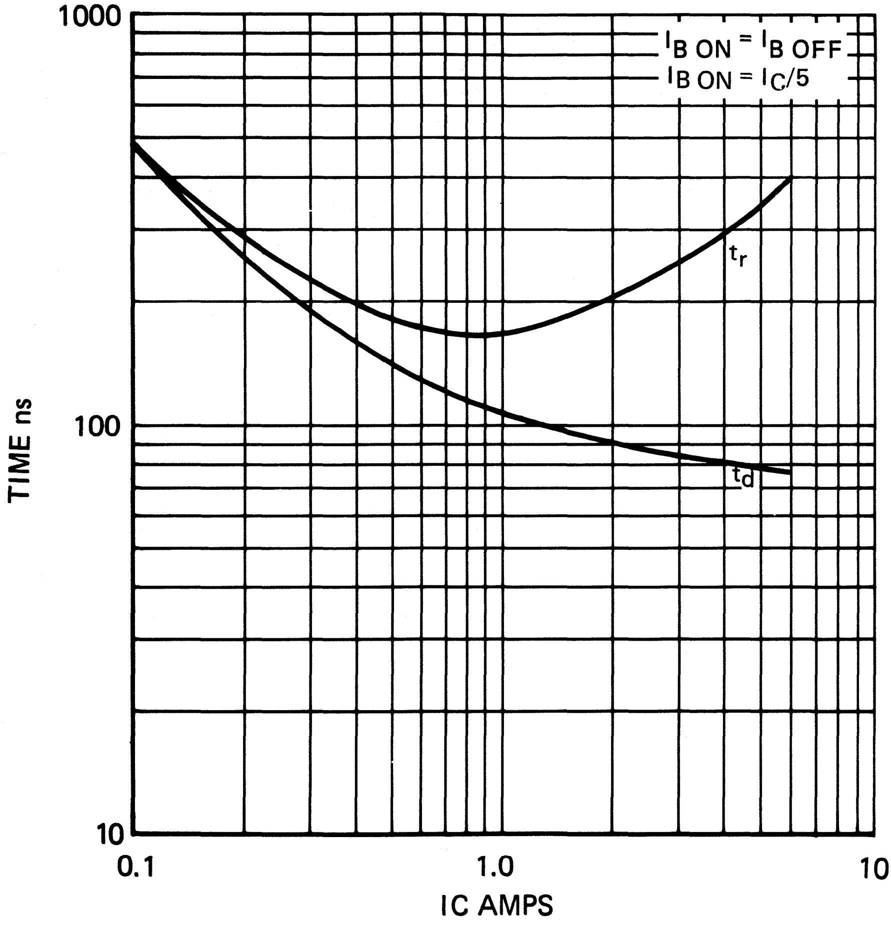
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 3 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 4 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-OFF TIME T CASE=25°C

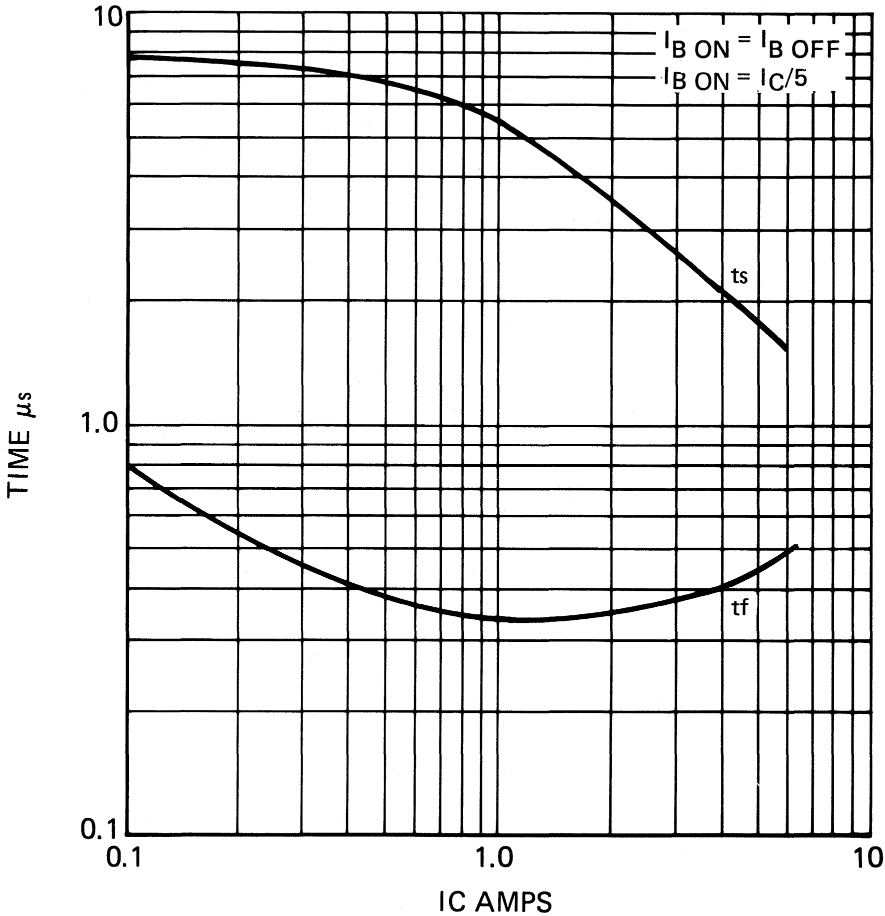


FIGURE. 6 TYPICAL COLLECTOR SATURATION REGION

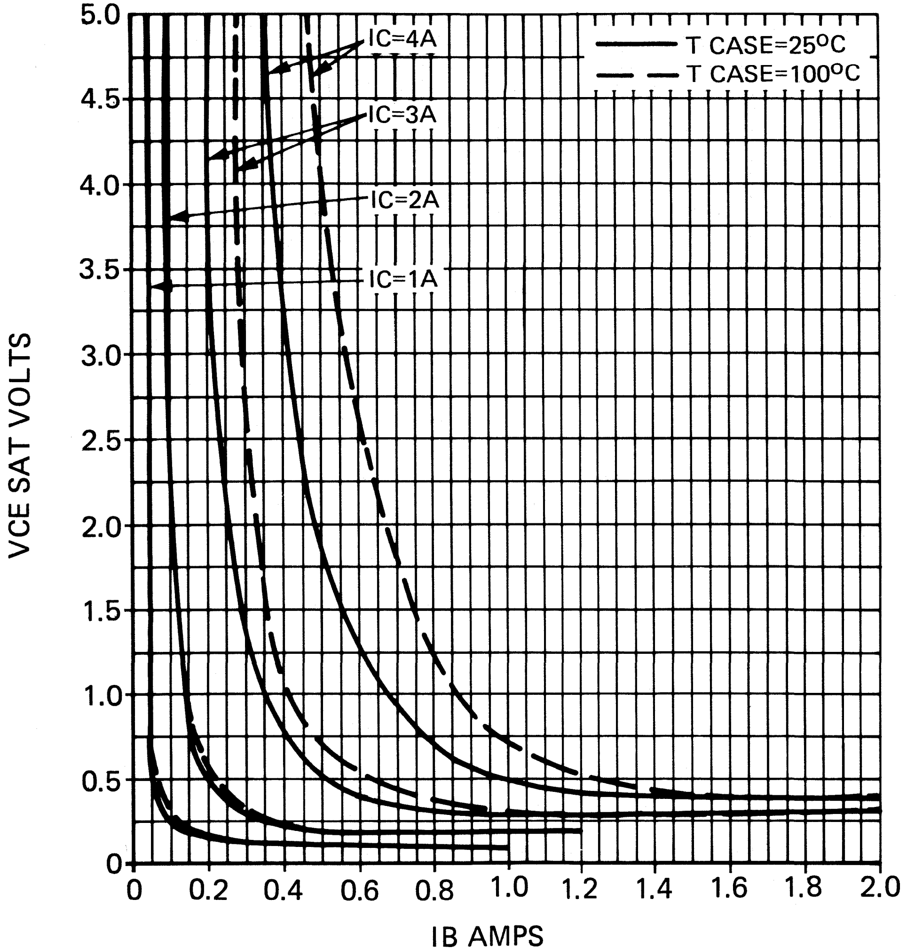


FIGURE. 7 TYPICAL VARIATION OF DC CURRENT GAIN, VCE=5V

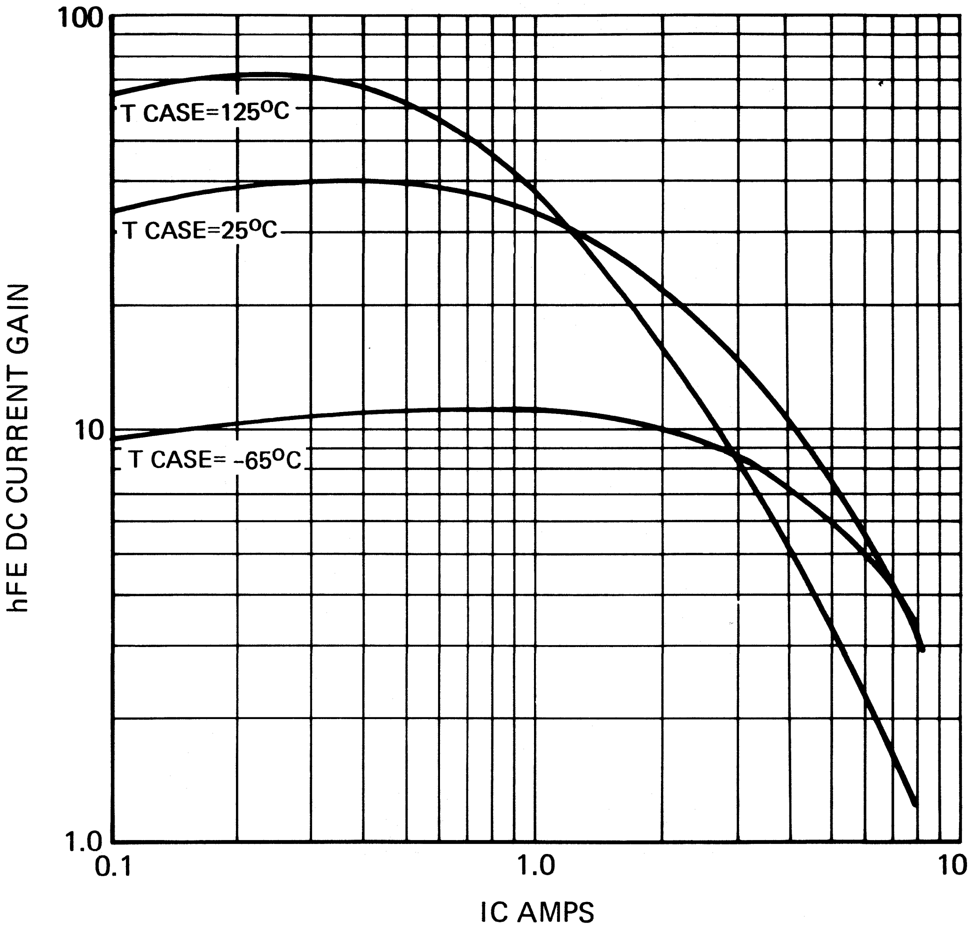


FIGURE. 8 TYPICAL VARIATION OF ICES WITH TEMPERATURE

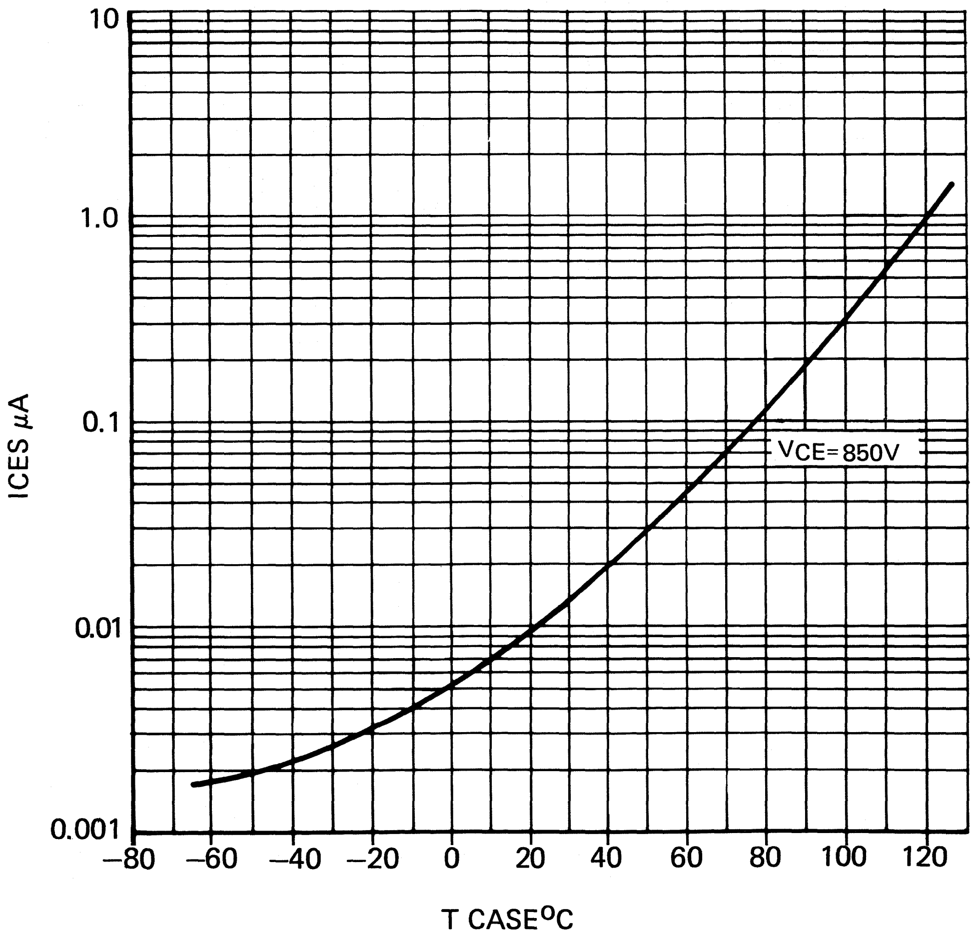


FIGURE. 9 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

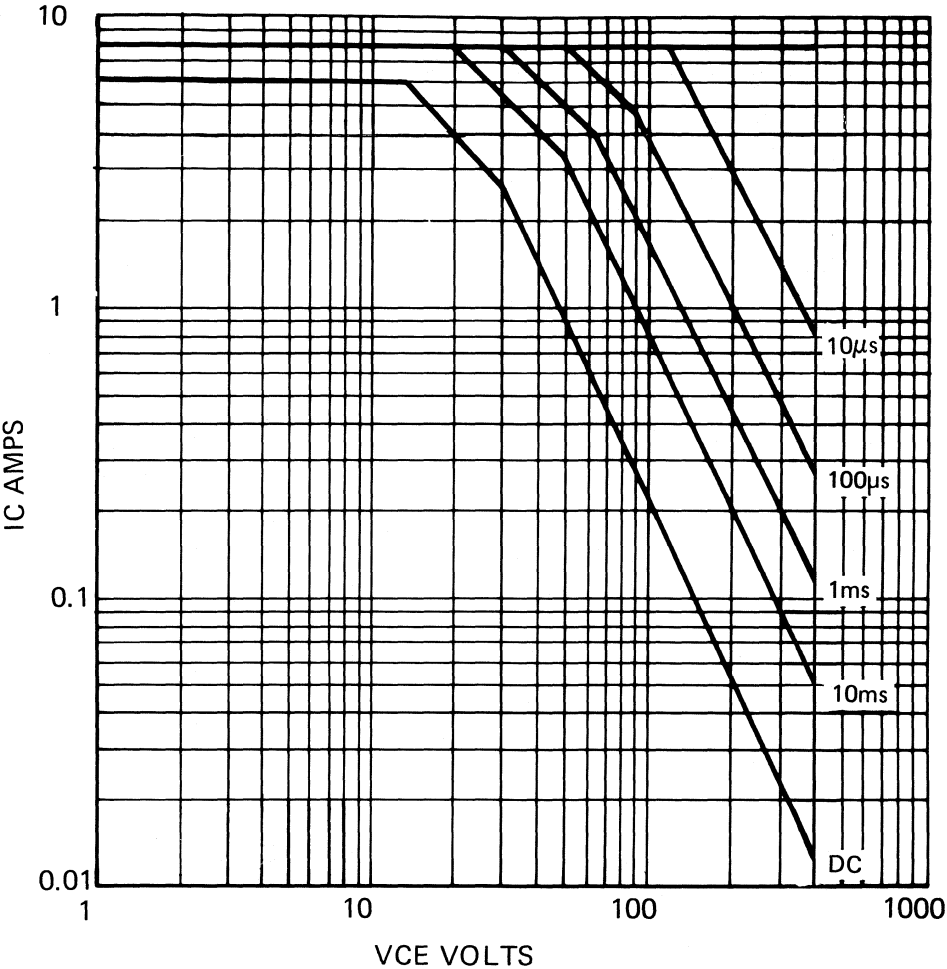


FIGURE. 10 THERMAL RESPONSE FOR BUV46

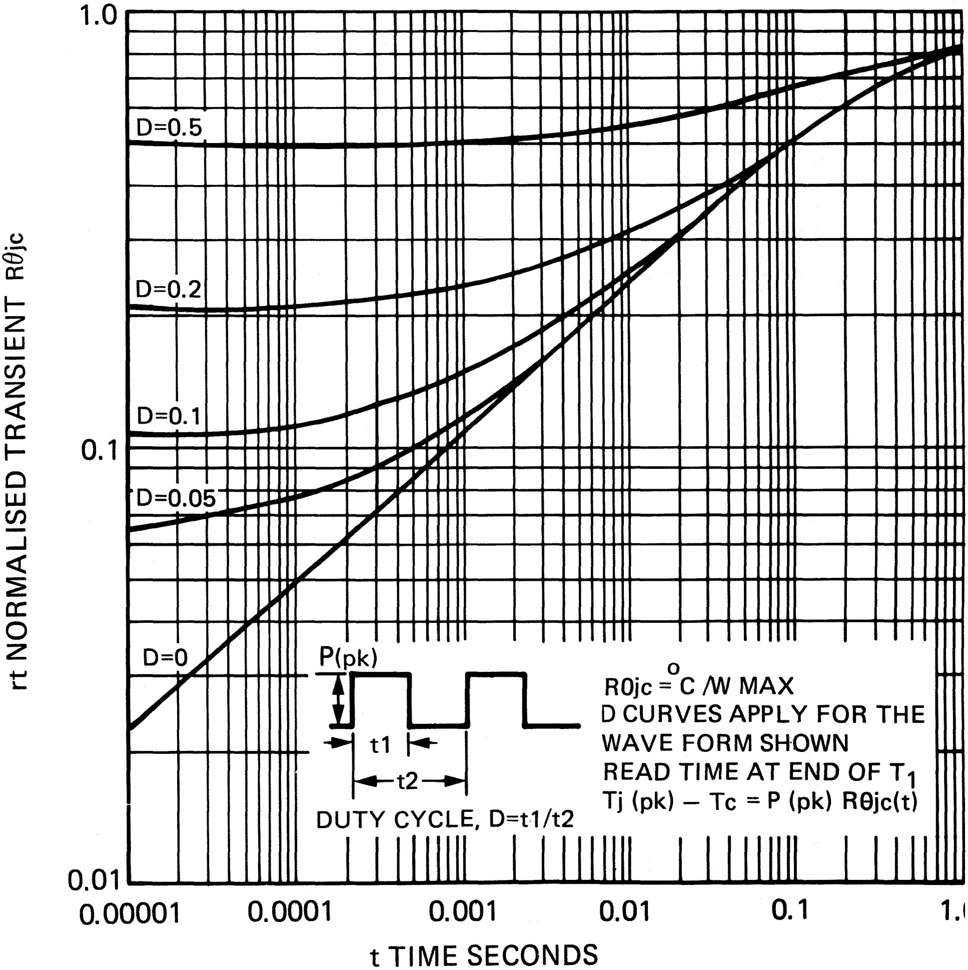


FIGURE. 11 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

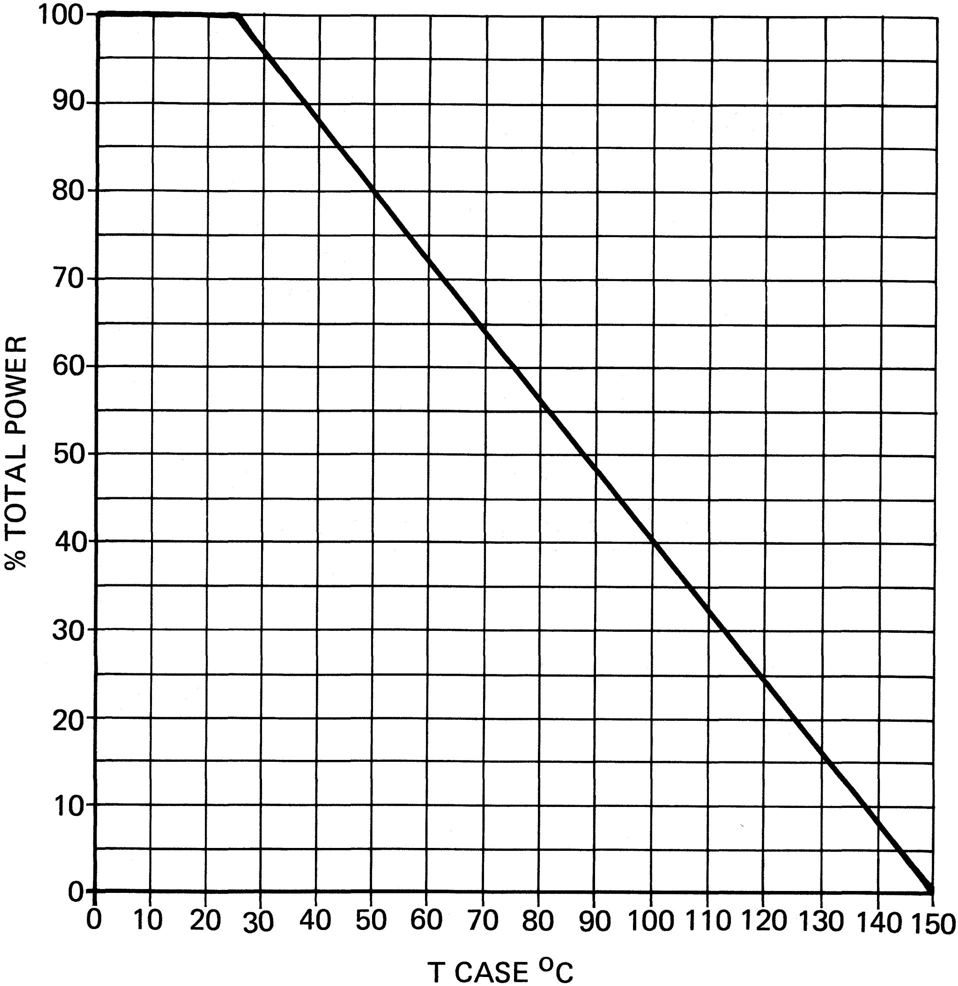


FIGURE. 12 TRANSIENT "TURN-OFF" LIMIT IC VsVCE TC=100°C

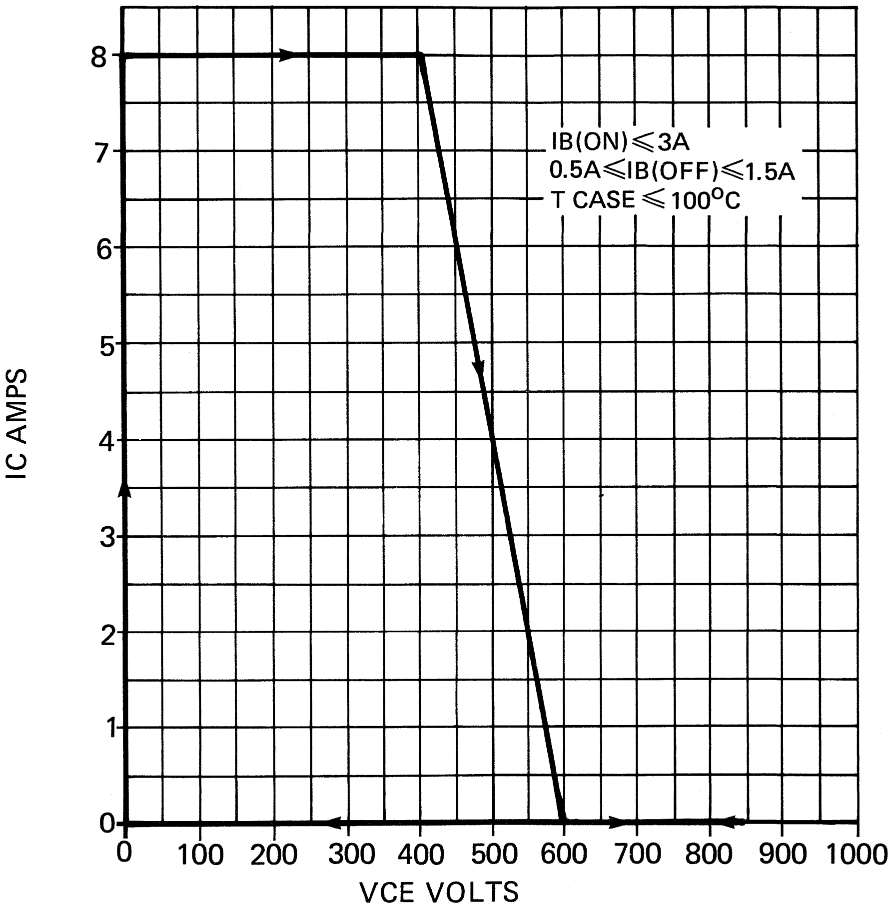
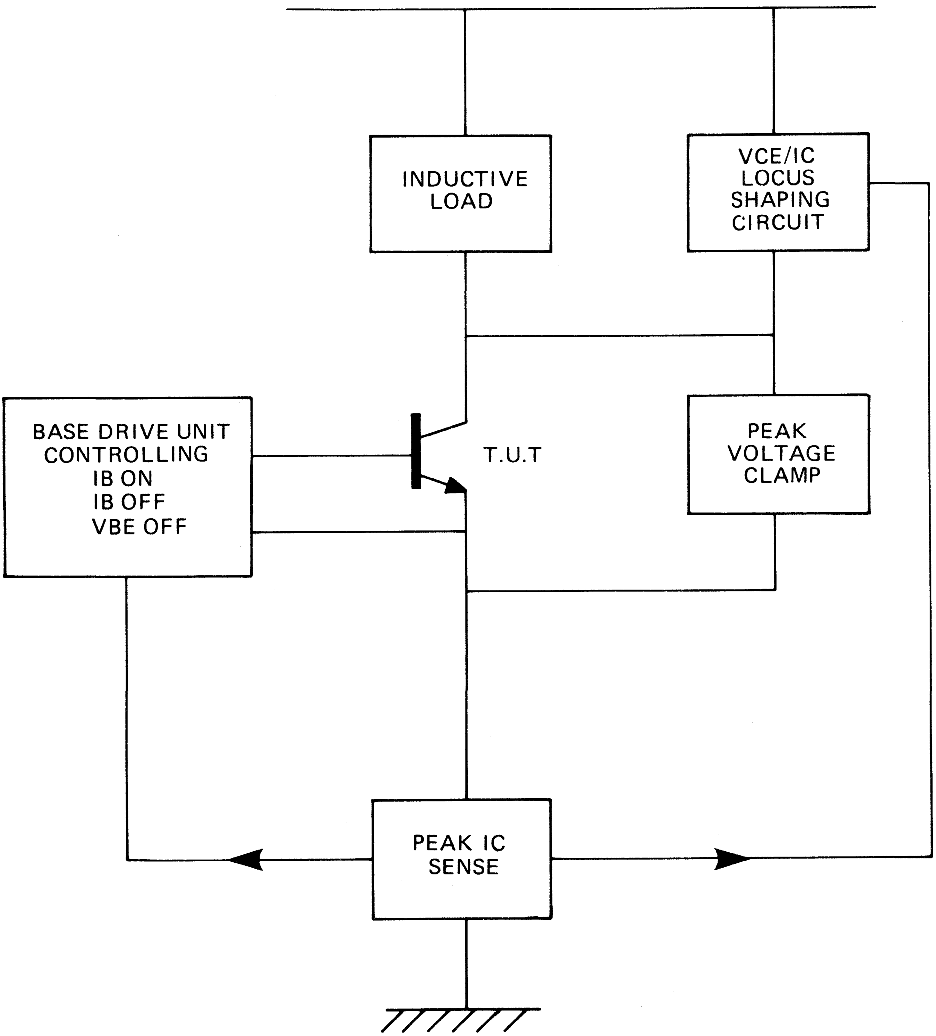


FIGURE 13 SWITCHING LOCUS TEST CIRCUIT



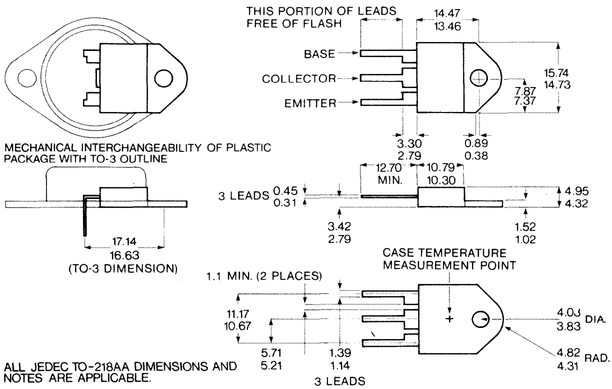
PRELIMINARY
DATA
OCT 82

BUV 47, BUV 47A, BUV 47B
NPN SILICON POWER TRANSISTOR

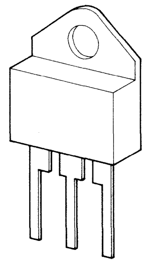
- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'Turn-off' locus

MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUV47	BUV47A	BUV47B
Collector-Emitter Voltage (VBE = -2.5V)	850V	1000V	850V
Collector-Emitter Voltage (RBE = 10Ω)	850V	1000V	850V
Collector-Emitter Voltage (Open Base)	400V	450V	400V
Continuous Collector Current	9A	9A	9A
Peak Collector Current (Note 1)	15A	15A	15A
Peak Base Current (Note 1)	6A	6A	6A
Base Current	3A	3A	3A
Continuous Dissipation T Case = 25°C	120W	120W	120W
Operating Junction Temperature	-65°C – 150°C		

Note 1: Pulse Test, Pulse Duration = 5ms

BUV 47, BUV 47A, BUV 47B
NPN SILICON POWER TRANSISTOR

PRELIMINARY DATA

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

	PARAMETER	TEST CONDITIONS				MIN	TYP	MAX	UNIT
V_{CEO} (SUST)	Collector-Emitter Sustaining Voltage See Note 2	I_C = 200 mA		BUV47 BUV47B		400			V
		L = 25 mH		BUV47A		450			V
I_{CEX}	Collector-Emitter Cut-off Current (V_{BE} = -2.5V)	V_{CE} = 850V		BUV47 BUV47B				0.15	mA
		V_{CE} = 1000V		BUV 47A				0.15	mA
		V_{CE} = 850V	125°C	BUV47 BUV47B				1.5	mA
		V_{CE} = 1000V	125°C	BUV47A				1.5	mA
I_{CER}	Collector-Emitter Cut-off Current (R_{BE} = 10Ω)	V_{CE} = 850V		BUV47 BUV47B				0.4	mA
		V_{CE} = 1000V		BUV47A				0.4	mA
		V_{CE} = 850V	125°C	BUV47 BUV47B				3.0	mA
		V_{CE} = 1000V	125°C	BUV47A				3.0	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 5V	I_C = 0					1	mA
B_{VEBO}	Emitter Base Breakdown Voltage	I_E = 50mA	I_C = 0			7		30	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 6A	I_B = 1.2A	BUV47B	See Notes 3 & 4			1.5	V
		I_C = 9A	I_B = 3A	BUV47B				3.0	V
		I_C = 5A	I_B = 1A	BUV47A BUV47				1.5	V
		I_C = 8A	I_B = 2.5A	BUV47A, BUV47				3.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 5A	I_B = 1A	BUV47 BUV47A	See Notes 3 & 4			1.6	V
		I_C = 6A	I_B = 1.2A	BUV47B				1.6	V
f_t	Current Gain Band-Width Product	I_C = 500mA, F = 1MHz	V_{CE} = 10V (dc)				8.0		MHz
C_{ob}	Output Capacitance	V_{CB} = 20V, F = 0.1 MHz	I_C = 0A				105		pf
$R_{\theta jc}$	Thermal Resistance Junction-Case							1.25	°C/W

Note 2: Inductive Loop Switching Measurement.
Note 3: These parameters must be measured using pulse techniques, tw = 300μs, duty cycle ≤2%
Note 4: 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 UNLESS OTHERWISE SPECIFIED

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
t_{on}	Turn on Time	I_C = 5A V_{CC} = 150V BUV47			1.0	µs
t_s	Storage Time	I_{BON} = 1.0A I_{BOFF} = 1.0A BUV47A			3.0	µs
t_f	Fall Time	T Case-25°C See Fig 2			0.80	µs
t_{on}	Turn on Time	I_C = 6A V_{CC} = 150V BUV47B			1.0	µs
t_s	Storage Time	I_{BON} = 1.2A I_{BOFF} = 1.2A			3.0	µs
t_f	Fall Time	T Case = 25 C See Fig 2			0.80	µs
INDUCTIVE LOAD						
t_s	Storage Time	I_C = 5A V_{CC} = 300V BUV47			4.0	µs
t_f	Fall Time	I_{BON} = 1.0A V_B = 5V BUV47A L_B = 3µH T Case = 100°C See Fig 1			0.4	µs
t_s	Storage Time	I_C = 6A V_{CC} = 300V BUV 47B			4.0	µs
t_f	Fall Time	I_{BON} = 1.2A V_B = 5V LB = 3µH T Case = 100°C See Fig. 1			0.4	µs

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT

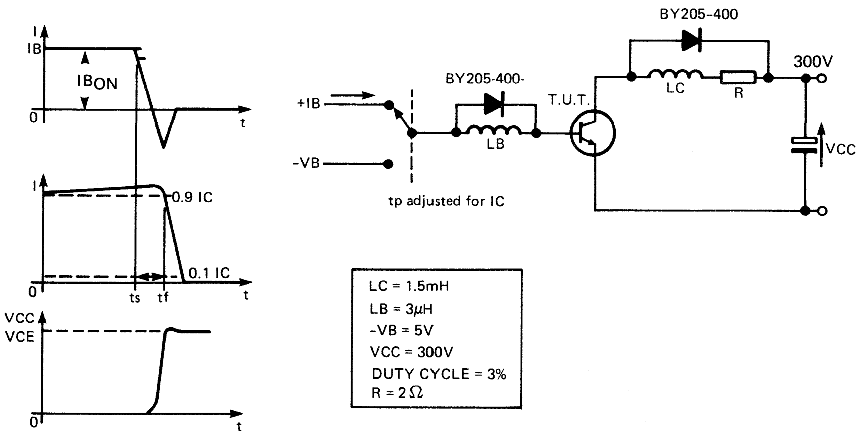
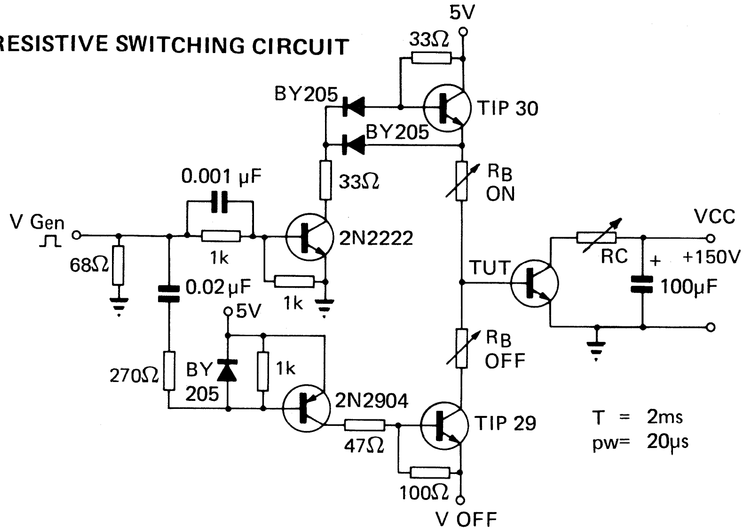


FIGURE 2 RESISTIVE SWITCHING CIRCUIT

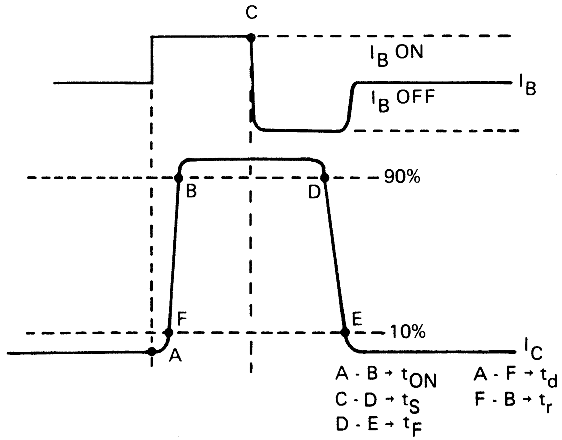


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20µs duty cycle <2%

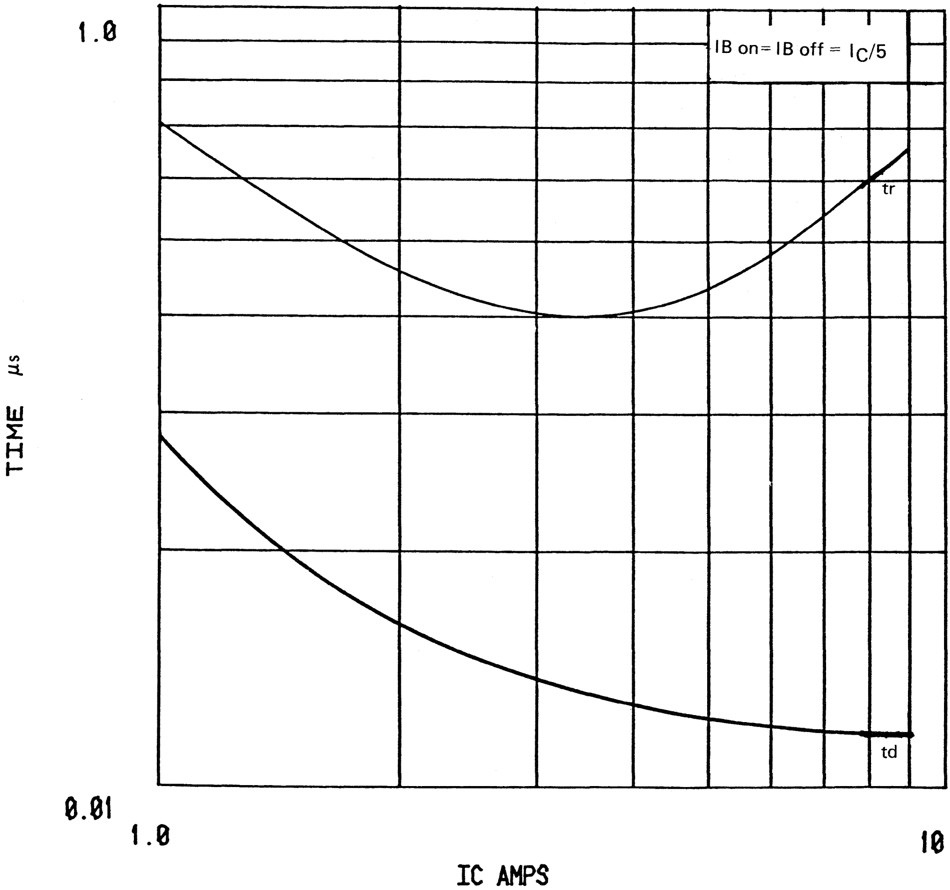
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 3 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE 4 TYPICAL TURN-ON TIME T CASE = 25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE 5 TYPICAL TURN-OFF TIME T CASE = 25°C

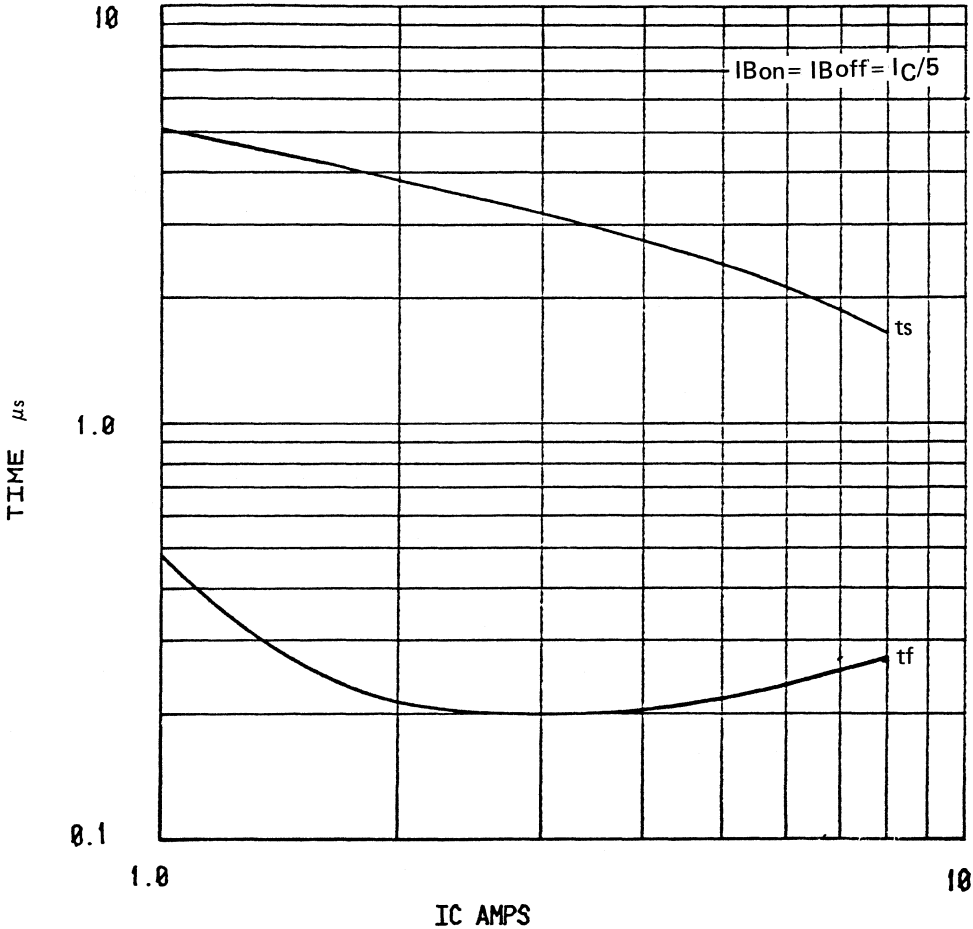


FIGURE 6 TYPICAL VARIATION OF ICES WITH TEMPERATURE

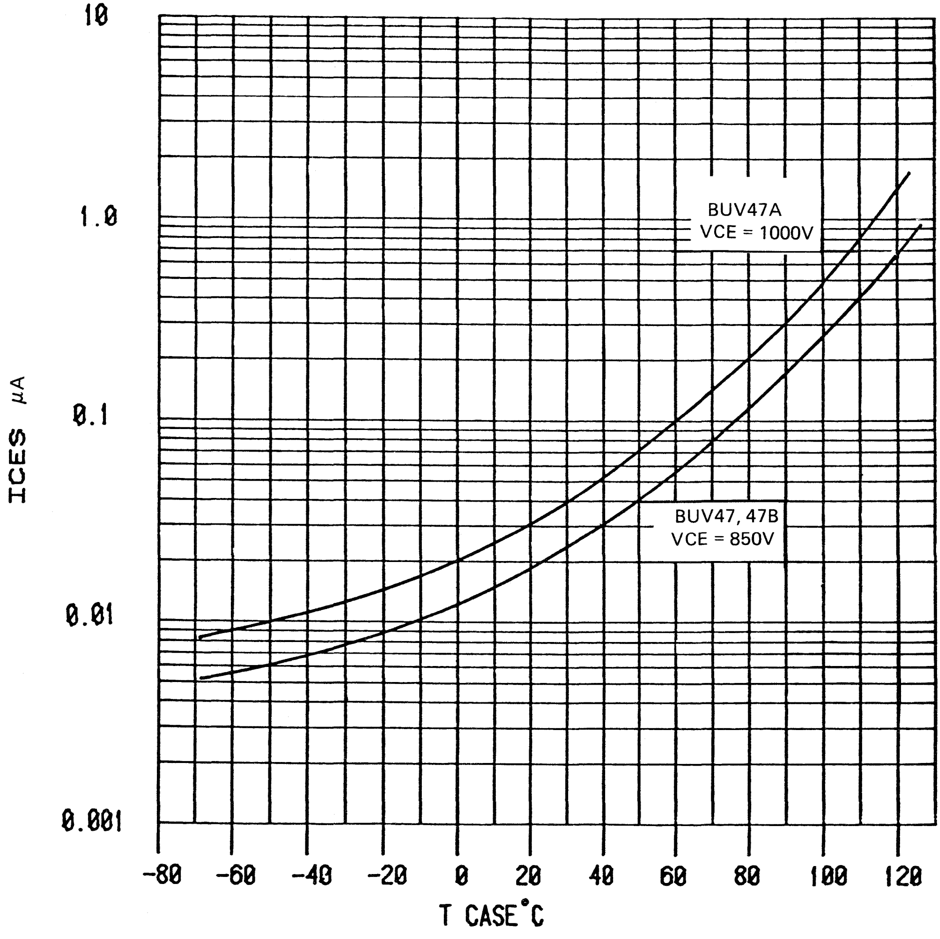


FIGURE 7 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

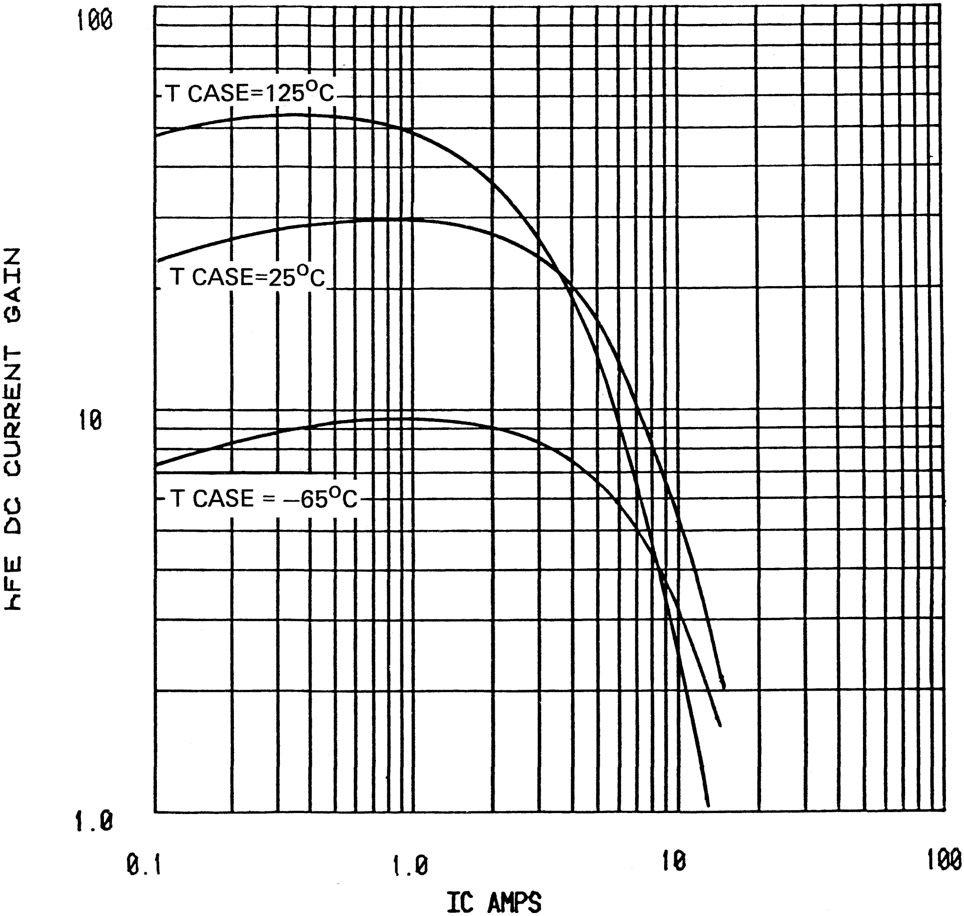


FIGURE 8 TYPICAL COLLECTOR SATURATION REGION

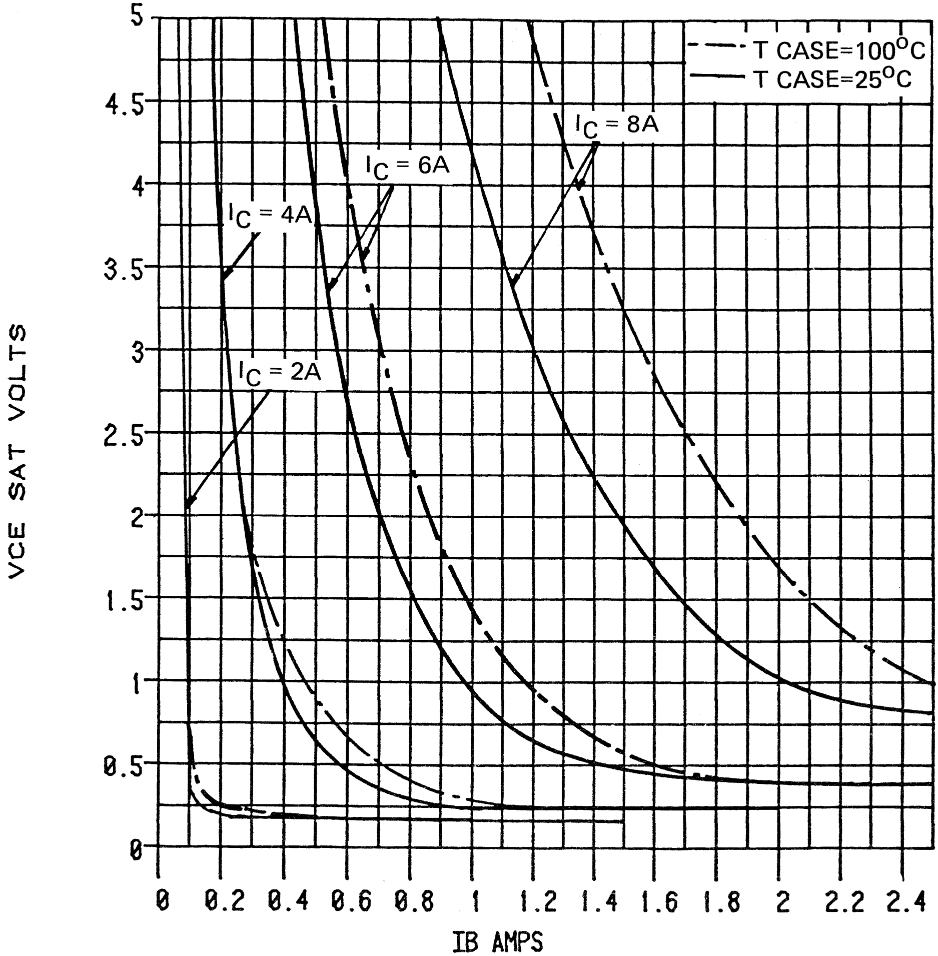


FIGURE 9 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE = 25°C

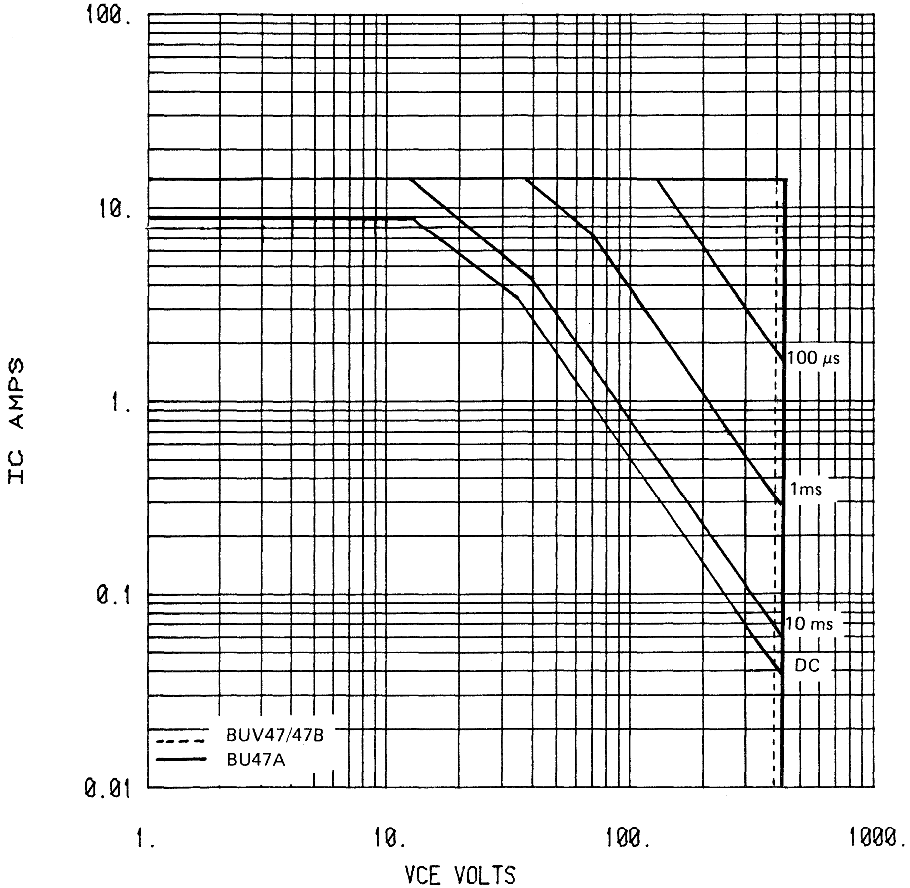


FIGURE. 10 MAXIMUM POWER DISSIPATION Vs CASE TEMPERATURE

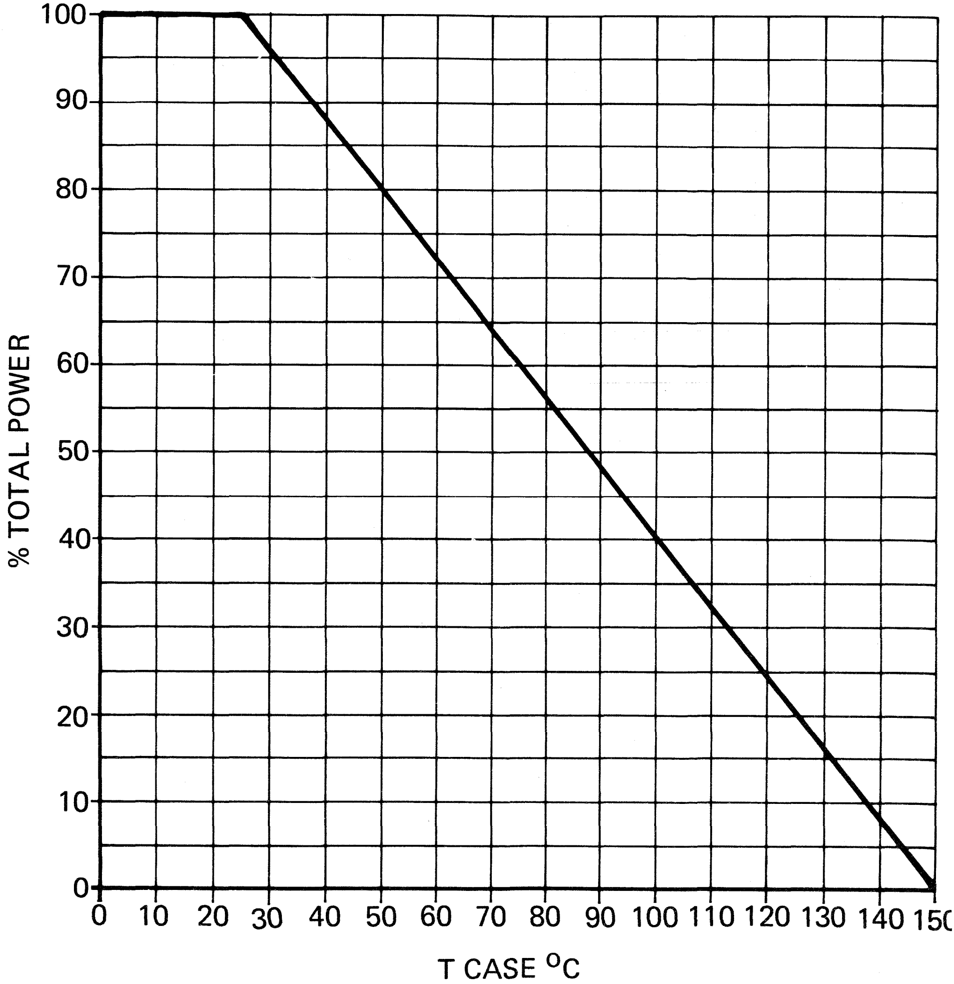


FIGURE 11 THERMAL RESPONSE

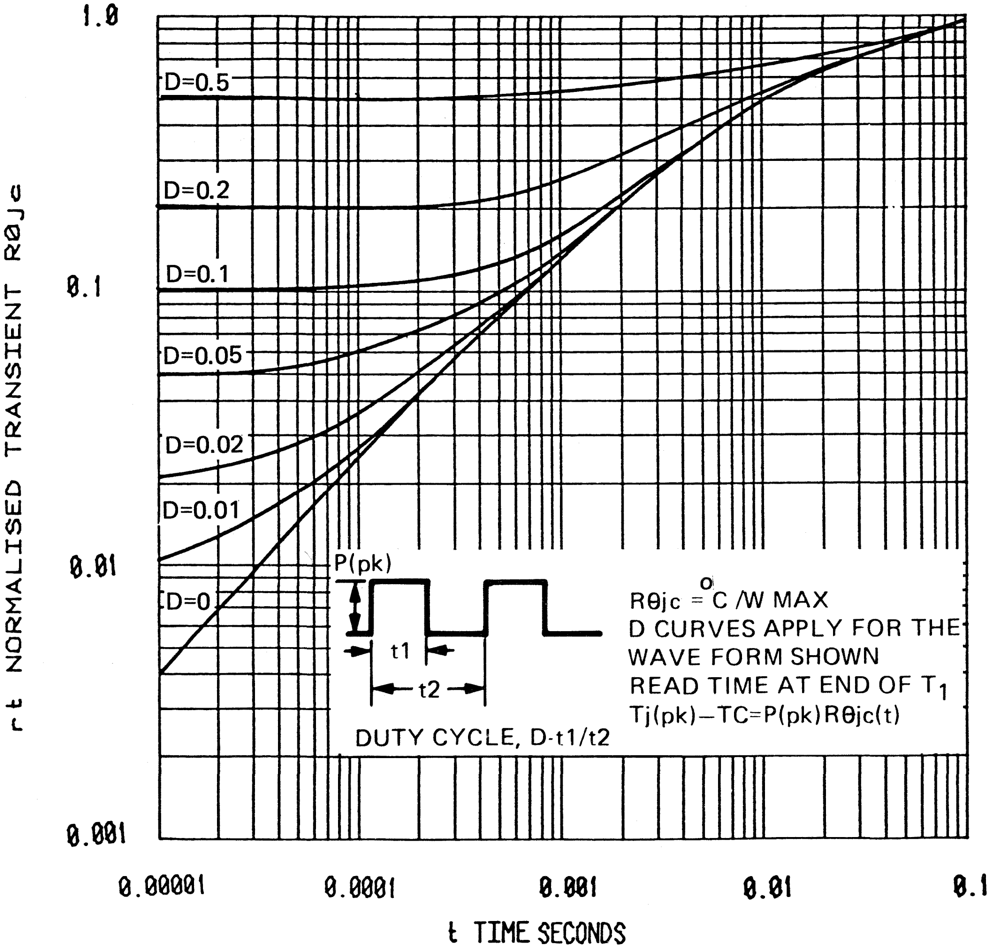


FIGURE 12 SWITCHING LOCUS TEST CIRCUIT

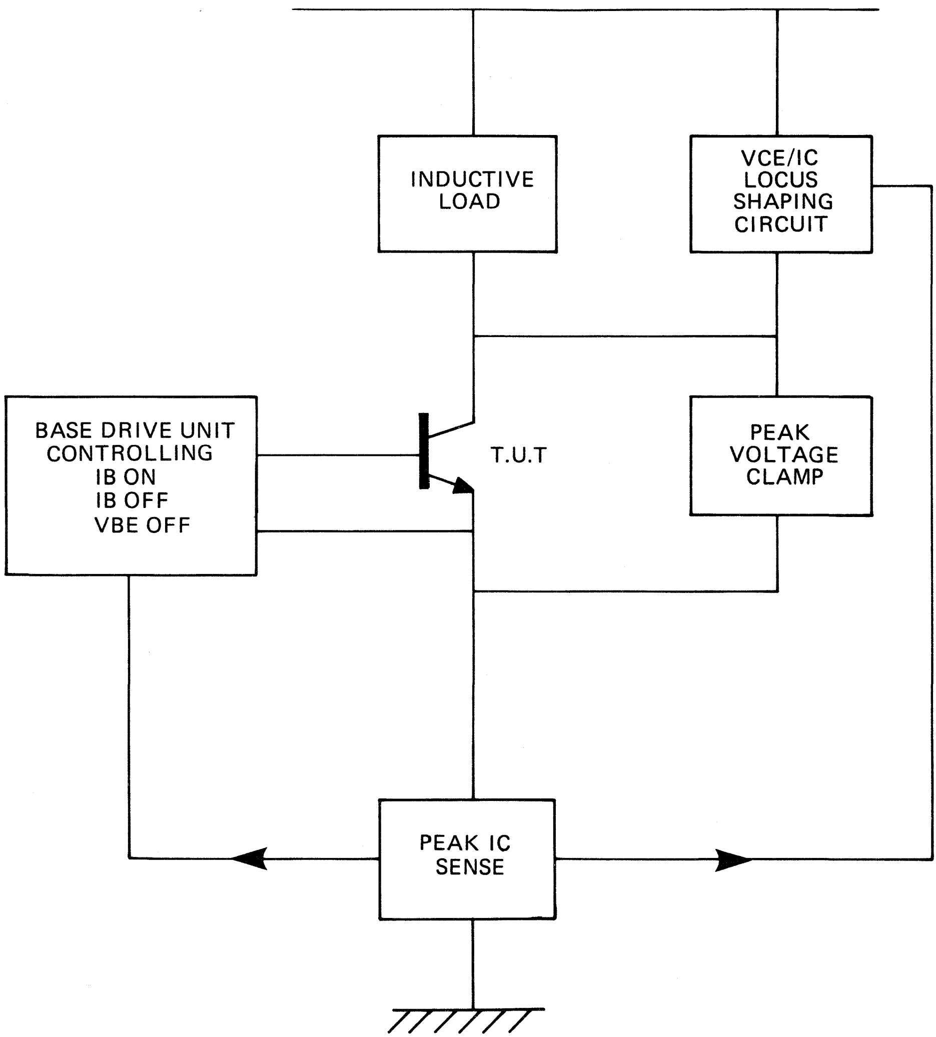
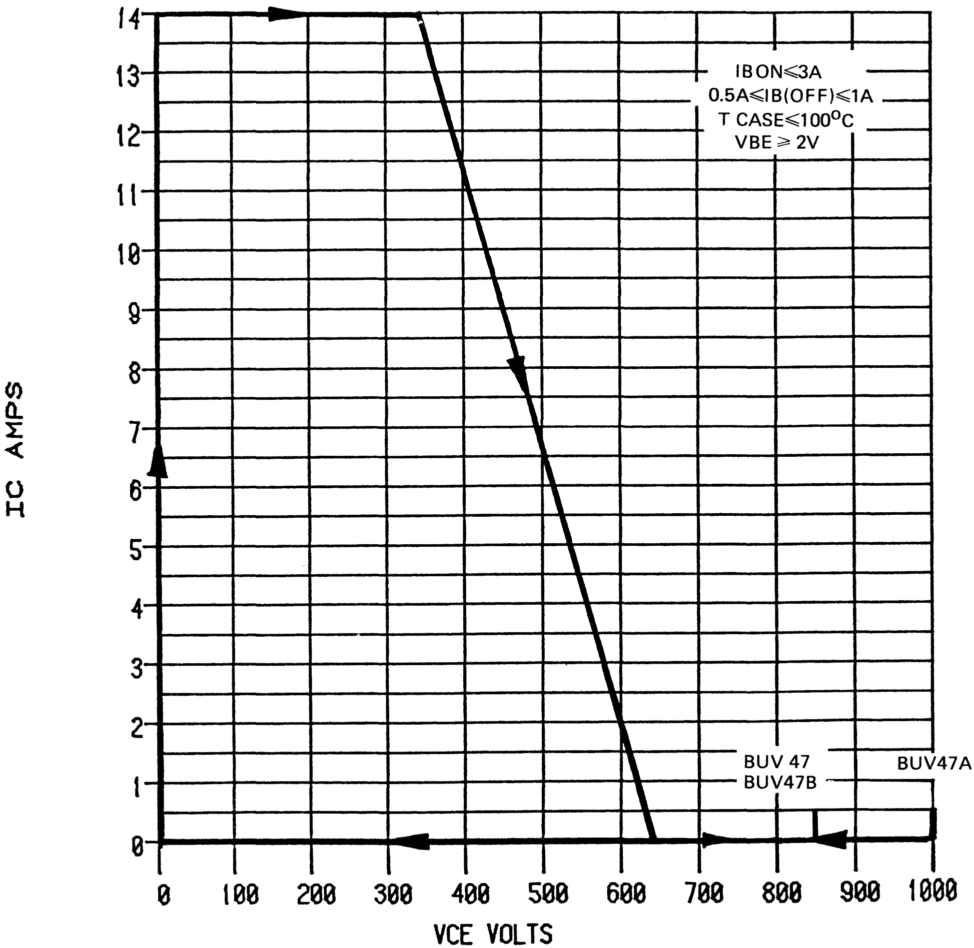


FIGURE 13 TRANSIENT 'TURN-OFF' LIMIT IC VS VCE



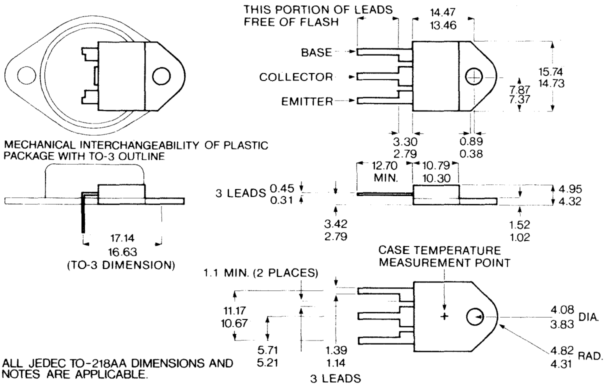
PRELIMINARY DATA
OCT 82

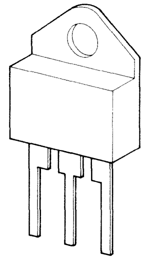
BUV 48, BUV 48A
NPN SILICON POWER TRANSISTOR

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'Turn-off' locus

MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES

ABSOLUTE MAXIMUM RATINGS (AT 25^{o}C AMBIENT TEMPERATURE)

	BUV48	BUV48A
Collector-Emitter Voltage (VBE = -2.5V)	850V	1000V
Collector-Emitter Voltage (RBE =10Ω)	850V	1000V
Collector-Emitter Voltage (Open Base)	400V	450V
Continuous Collector Current	15A	15 A
Peak Collector Current (Note 1)	30A	30 A
Non Repetitive Accidental Peak Surge Current	55A	55 A
Continous Base Current	4A	4A
Peak Base Current Note 1	20A	20A
Continuous Dissipation T Case = 60^{o}C	125W	125W
Operating Junction Temperature	-65^{o}C – +150^{o}C	

Note 1: Pulse Test, Pulse Duration = 2ms.

TEXAS INSTRUMENTS

BUV 48, BUV 48A
NPN SILICON POWER TRANSISTOR

PRELIMINARY DATA

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

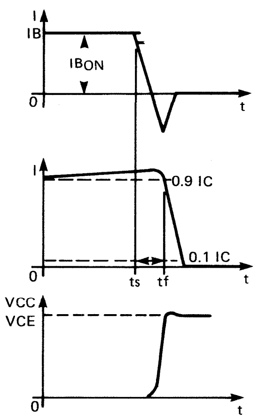
PARAMETER		TEST CONDITIONS				MIN	TYP	MAX	UNIT
$V_{CEO(SUS)}$	Collector-Emitter	I_C = 200 mA		BUV48		400			V
	Sustaining Voltage	L = 25 mH		BUV48A		450			V
	See Note 2								
I_{CEX}	Collector-Emitter	V_{CE} = 850V		BUV48				0.2	mA
	Cut-off Current	V_{CE} = 1000V		BUV48A				0.2	mA
	(V_{BE} = -2.5V)	V_{CE} = 850V	125°C	BUV48				2	mA
		V_{CE} = 1000V	125°C	BUV48A				2	mA
I_{CER}	Collector-Emitter	V_{CE} = 850V		BUV48				0.5	mA
	Cut-off Current	V_{CE} = 1000V		BUV48A				0.5	mA
	($R_{BE} < 10\Omega$)	V_{CE} = 850V	125°C	BUV48				4	mA
		V_{CE} = 1000V	125°C	BUV48A				4	mA
I_{EBO}	Emitter	V_{EB} = 5V	I_C = 0					1	mA
	Cut-off Current								
BV_{EBO}	Emitter Base	I_E = 0.05A	I_C = 0			7		30	V
	Breakdown Voltage								
$V_{CE(sat)}$	Collector-Emitter	I_C = 10A	I_B = 2A	BUV48	See Notes 3 & 4			1.5	V
	Saturation	I_C = 15A	I_B = 3A	BUV48				5.0	V
	Voltage	I_C = 8A	I_B = 1.6A	BUV48A				1.5	V
		I_C = 12A	I_B = 2.4A	BUV48A				5.0	V
$V_{BE(sat)}$	Base-Emitter	I_C = 10A	I_B = 2A	BUV48	See Notes 3 & 4			1.6	V
	Saturation Voltage	I_C = 8A	I_B = 1.6A	BUV48A				1.6	V
f_t	Current Gain	I_C = 500mA	V_{CE} = 10V (dc)				10		MHz
	Band-Width Product	F = 1MHz							
C_{ob}	Output Capacitance	V_{CB} = 20V	I_C = 0A				150		pf
		F = 0.1 MHz							
$R_{\theta jc}$	Thermal Resistance Junction-Case							1.00	°C/W

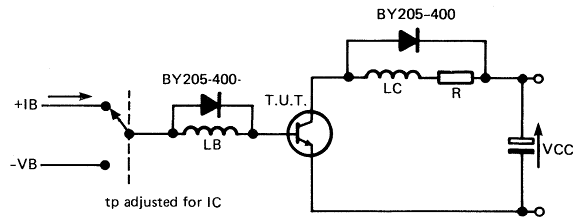
Note 2: Inductive Loop Switching Measurement.
Note 3: These parameters must be measured using pulse techniques, tw = 300μs, duty cycle $\leqslant$ 2%
Note 4: These parameters are measured with voltage-sensing contacts separate from the current carrying contacts and located within 32mm from the device body.

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
t_{on}	Turn on Time	I_C = 10A V_{CC} = 150V BUV48			1.0	μs
t_s	Storage Time	I_{BON} = 2.0A I_{BOFF} = 2.0A			3.0	μs
t_f	Fall Time	T Case-25°C			0.80	μs
t_{on}	Turn on Time	I_C = 8.0A V_{CC} = 150V BUV48A			1.0	μs
t_s	Storage Time	I_{BON} = 1.6A I_{BOFF} = 1.6A			3.0	μs
t_f	Fall Time	T Case = 25 C			0.80	μs
INDUCTIVE LOAD Figure 1						
t_s	Storage Time	I_C = 10 A V_{CC} = 300V BUV48			4.0	μs
t_f	Fall Time	I_{BON} = 2A V_B = 5V L_h = 3μH T Case = 100°C			0.4	μs
t_s	Storage Time	I_C = 8A V_{CC} = 300V BUV48A			4.0	μs
t_f	Fall Time	I_{BON} = 1.6A V_B = 5V LB = 3μH T Case = 100°C			0.4	μs

FIGURE 1 INDUCTIVE SWITCHING CIRCUIT





LC = 1.5mH
LB = 3μH
-VB = 5V
VCC = 300V
DUTY CYCLE = 3%
R = 2Ω

FIGURE 2 COLLECTOR CURRENT vs COLLECTOR EMITTER VOLTAGE T CASE=25°C

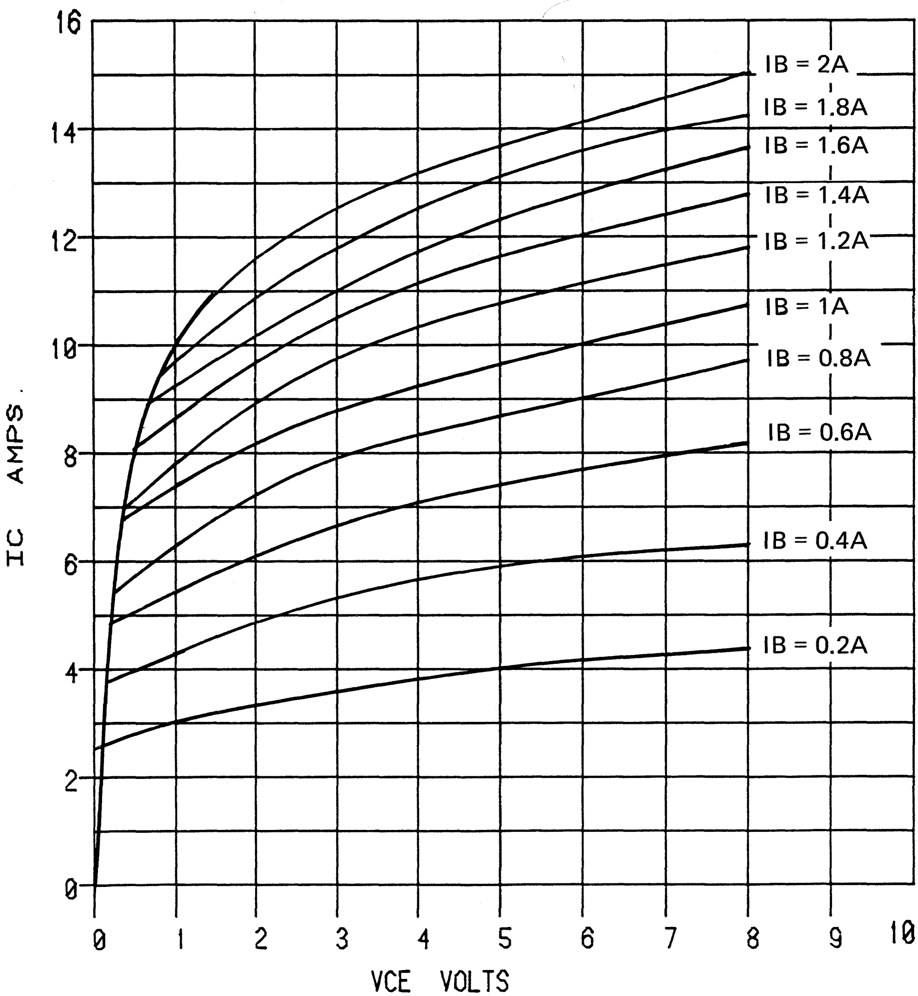


FIGURE 3 TYPICAL COLLECTOR SATURATION REGION

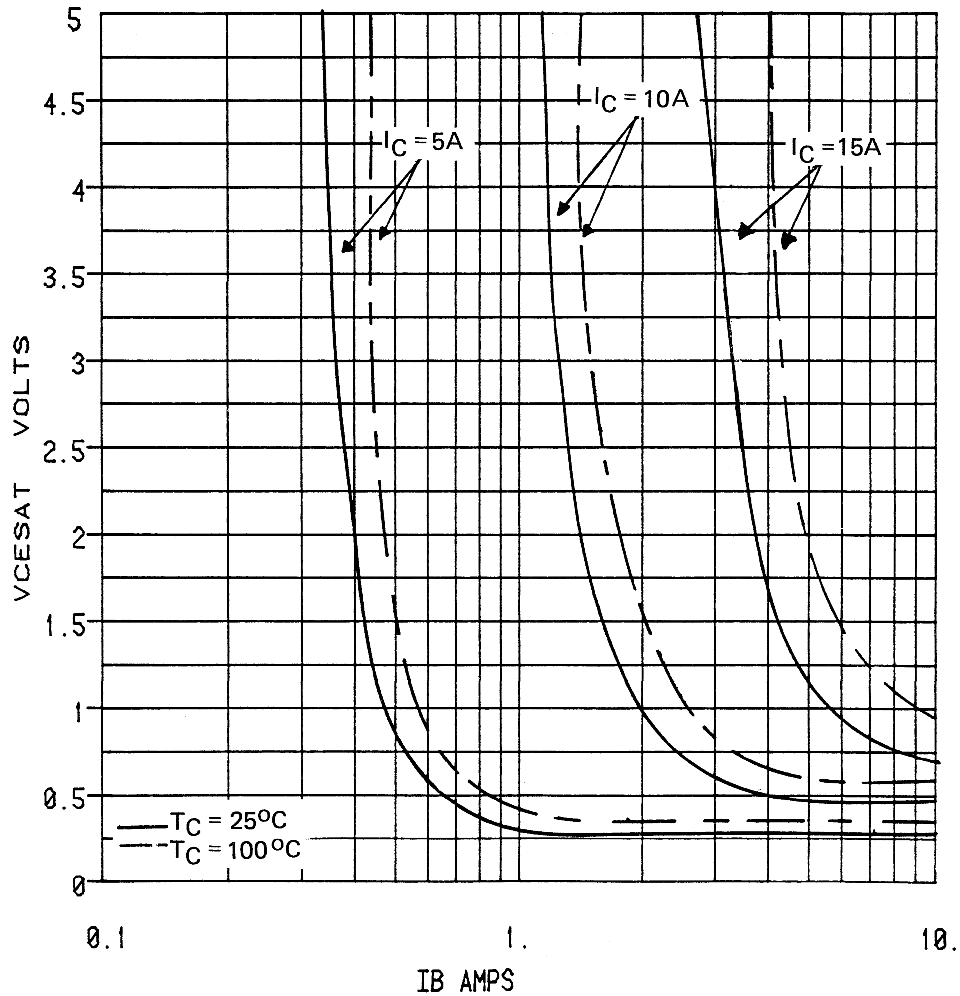


FIGURE 4 TYPICAL BASE SATURATION VOLTAGE T CASE=25°C

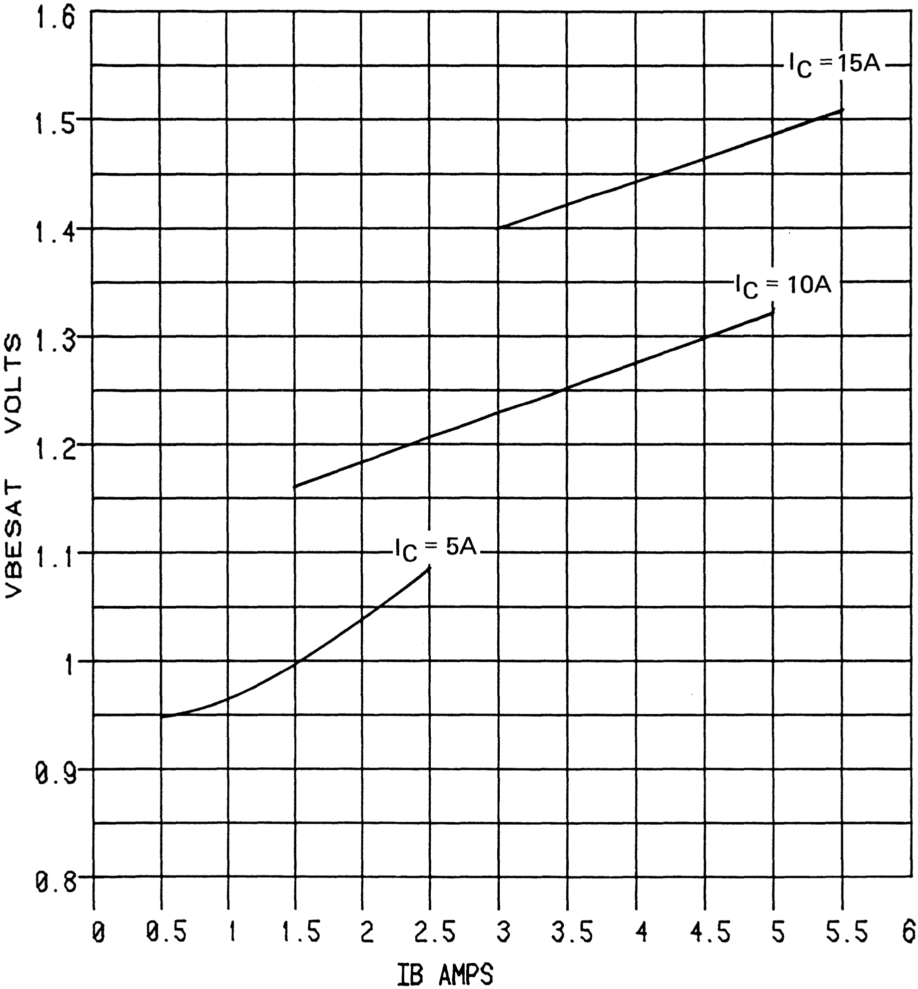


FIGURE 5 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

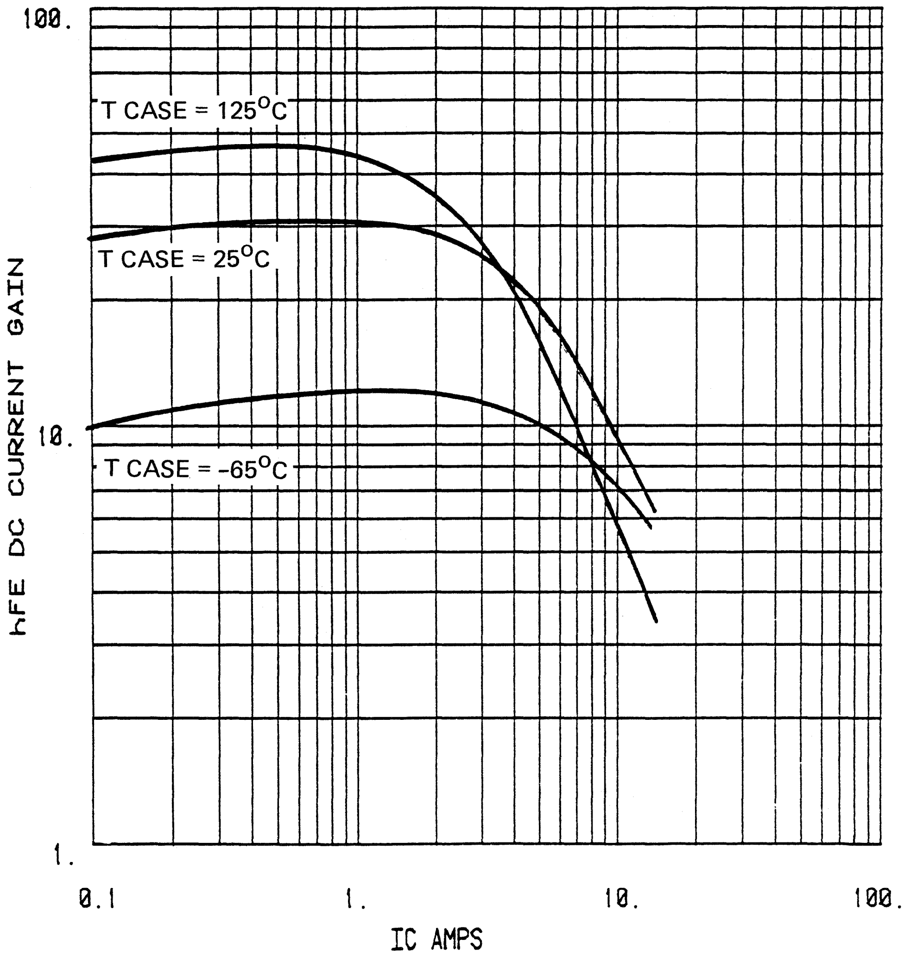


FIGURE 6 COLLECTOR EMITTER VOLTAGE VS BASE-EMITTER RESISTANCE T CASE=25°C

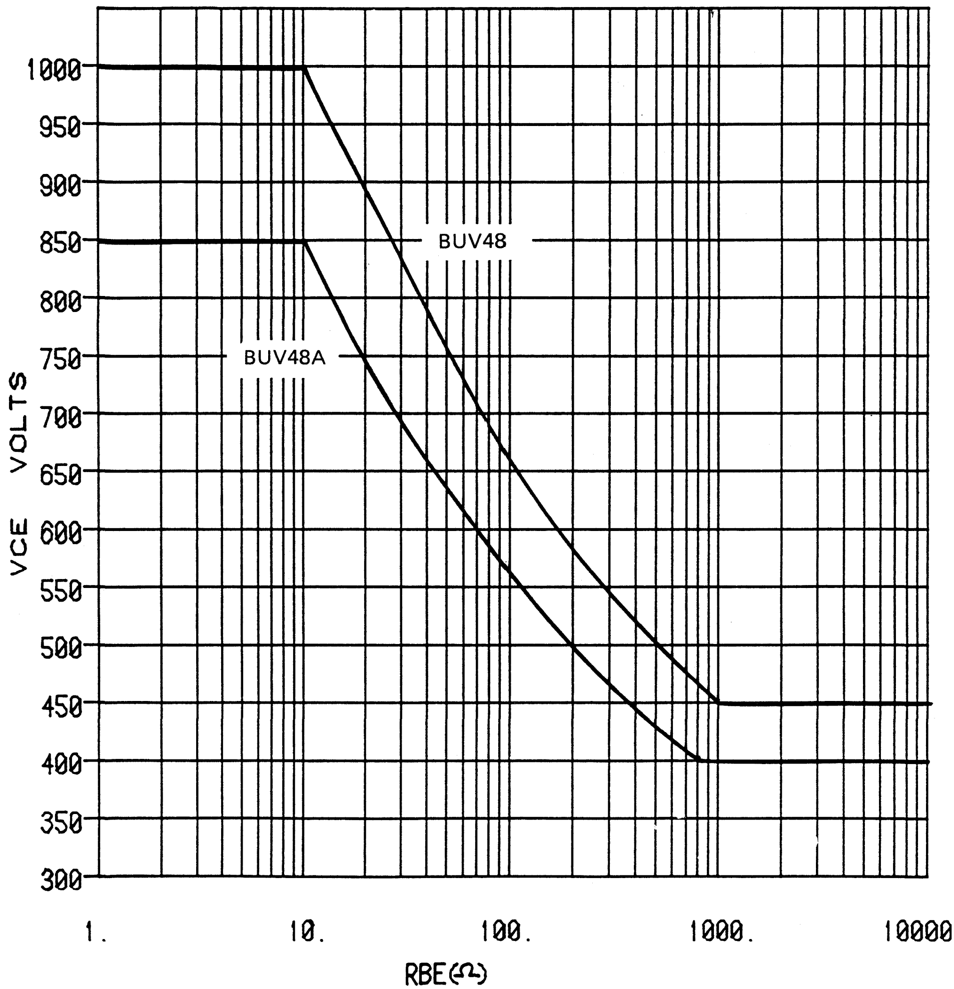


FIGURE 7 TYPICAL VARIATION OF ICES WITH TEMPERATURE

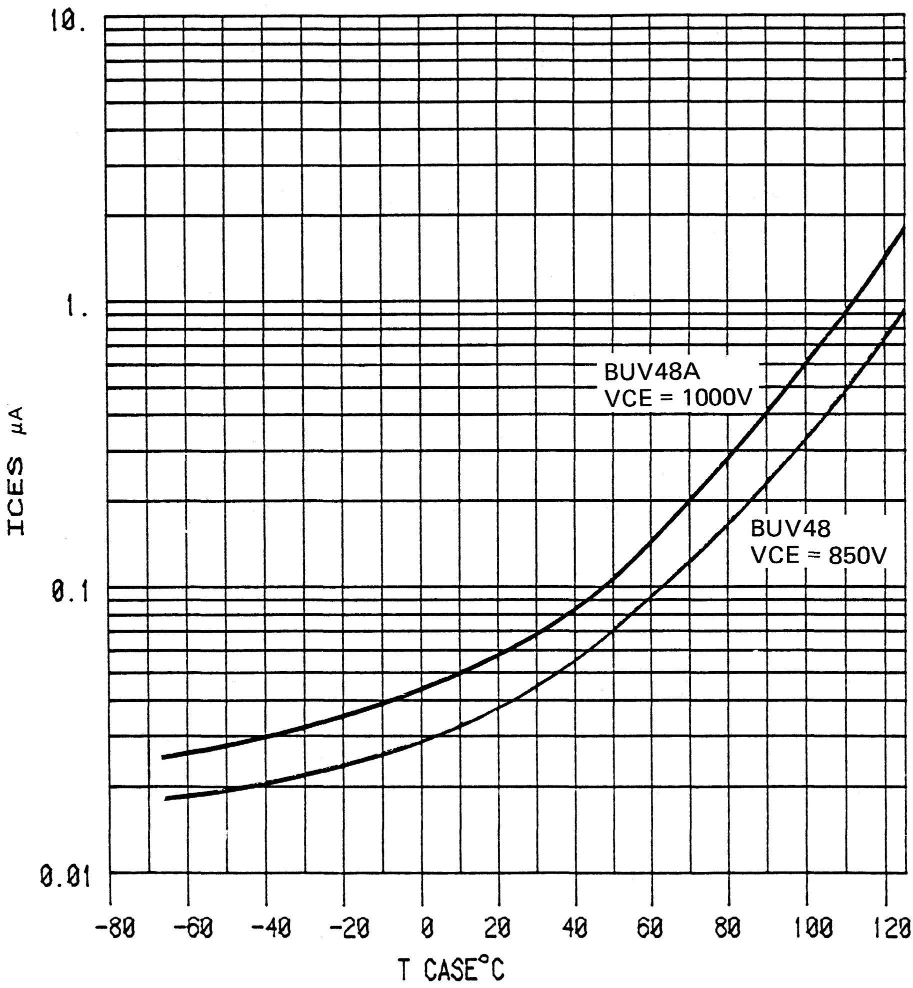


FIGURE. 8 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

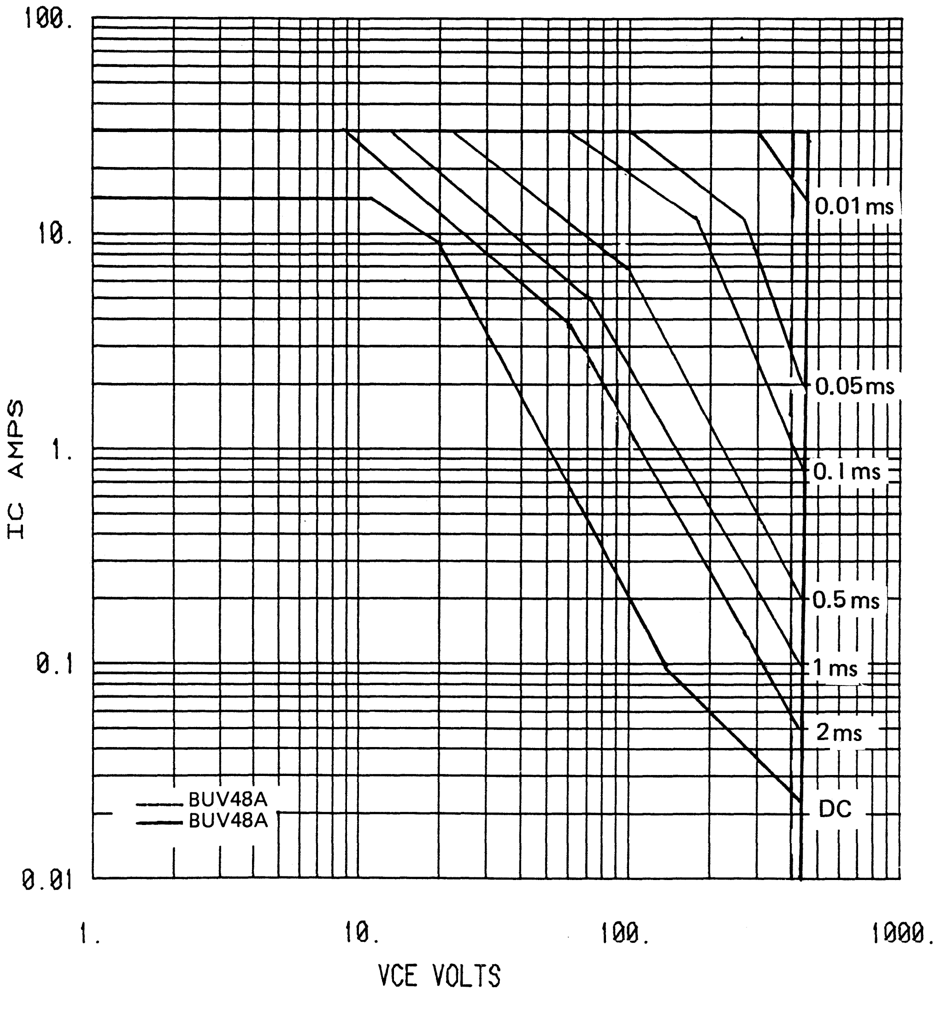


FIGURE 9 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

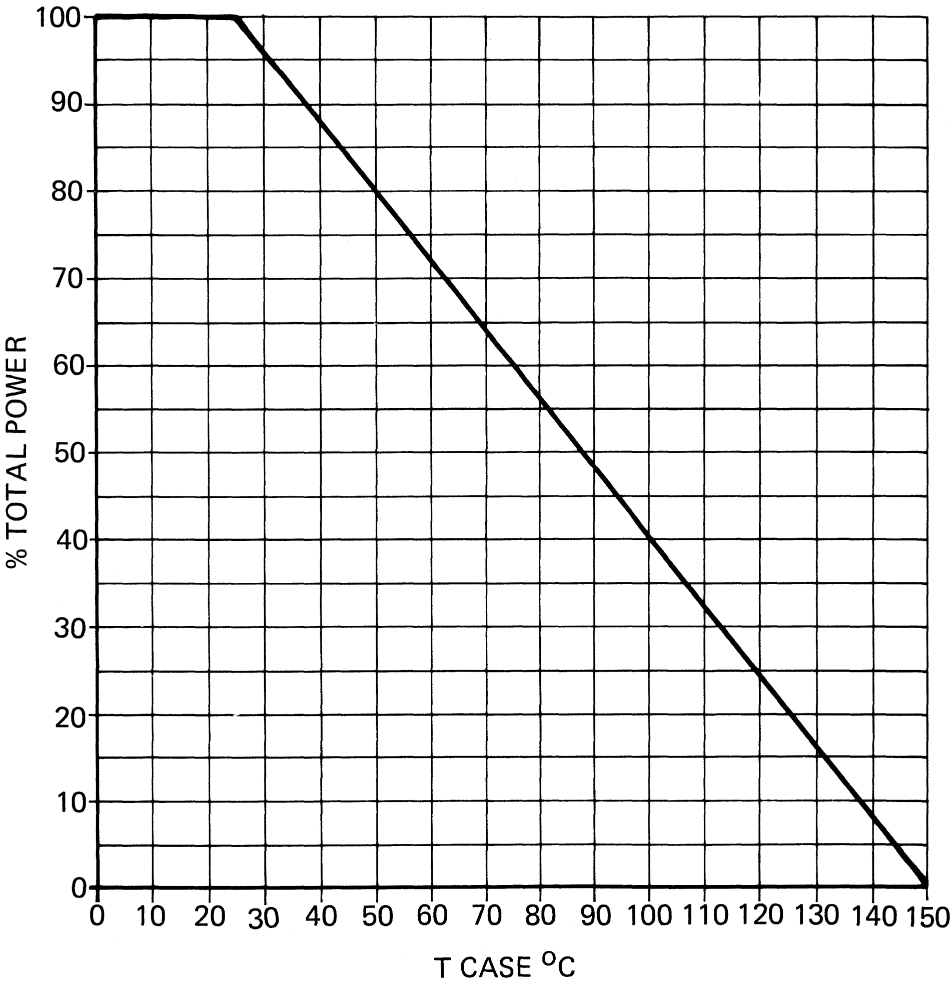


FIGURE 10 MAXIMUM REVERSE BIAS SAFE OPERATING AREA

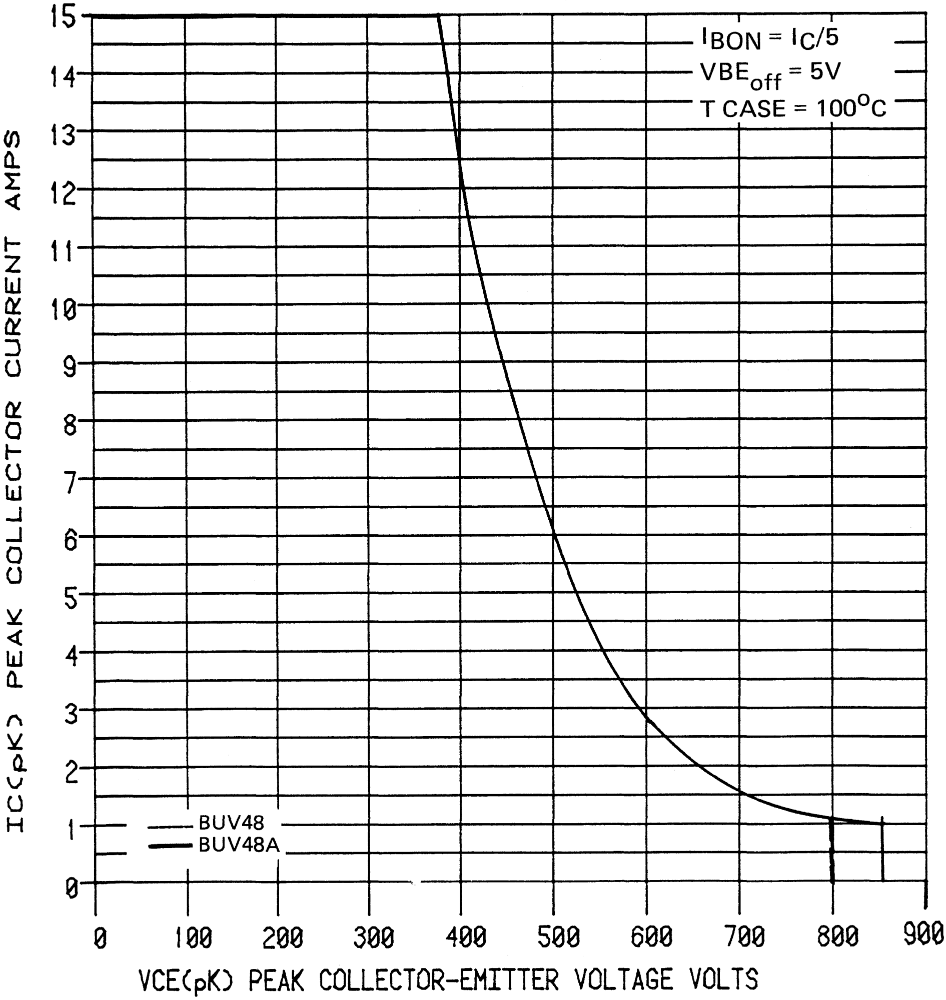


FIGURE 11 TRANSIENT "TURN OFF" LIMIT VS VCE T CASE<100°C

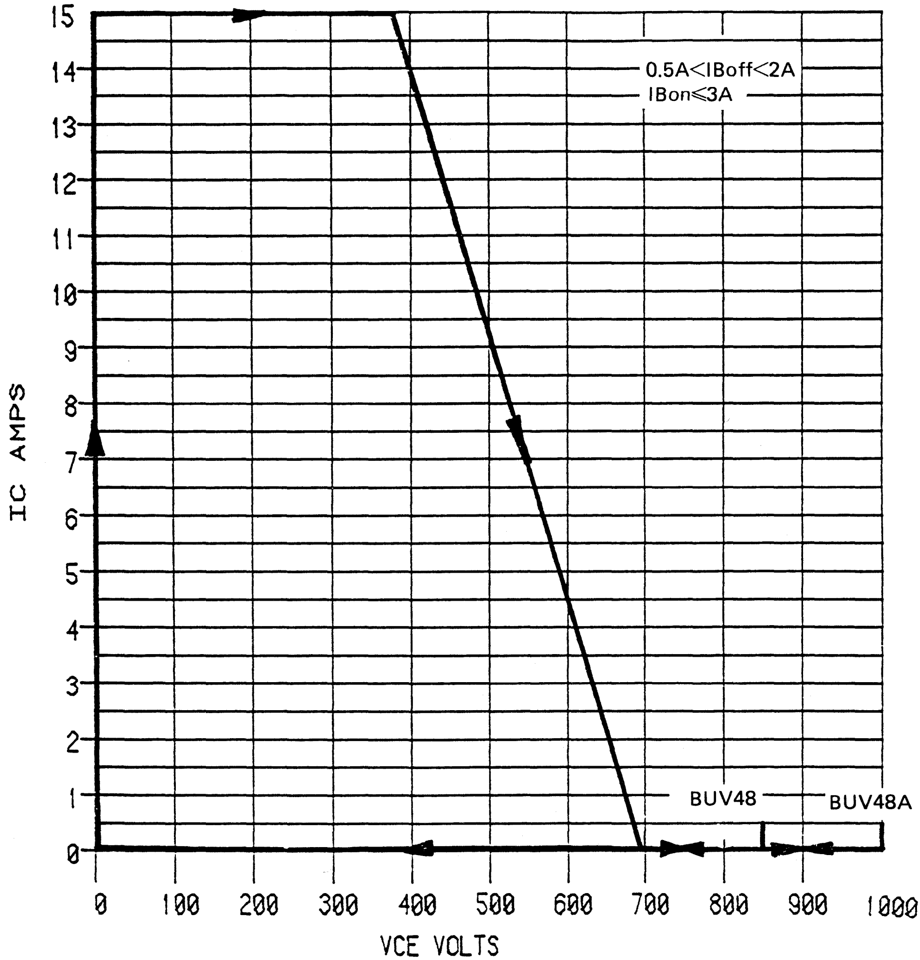
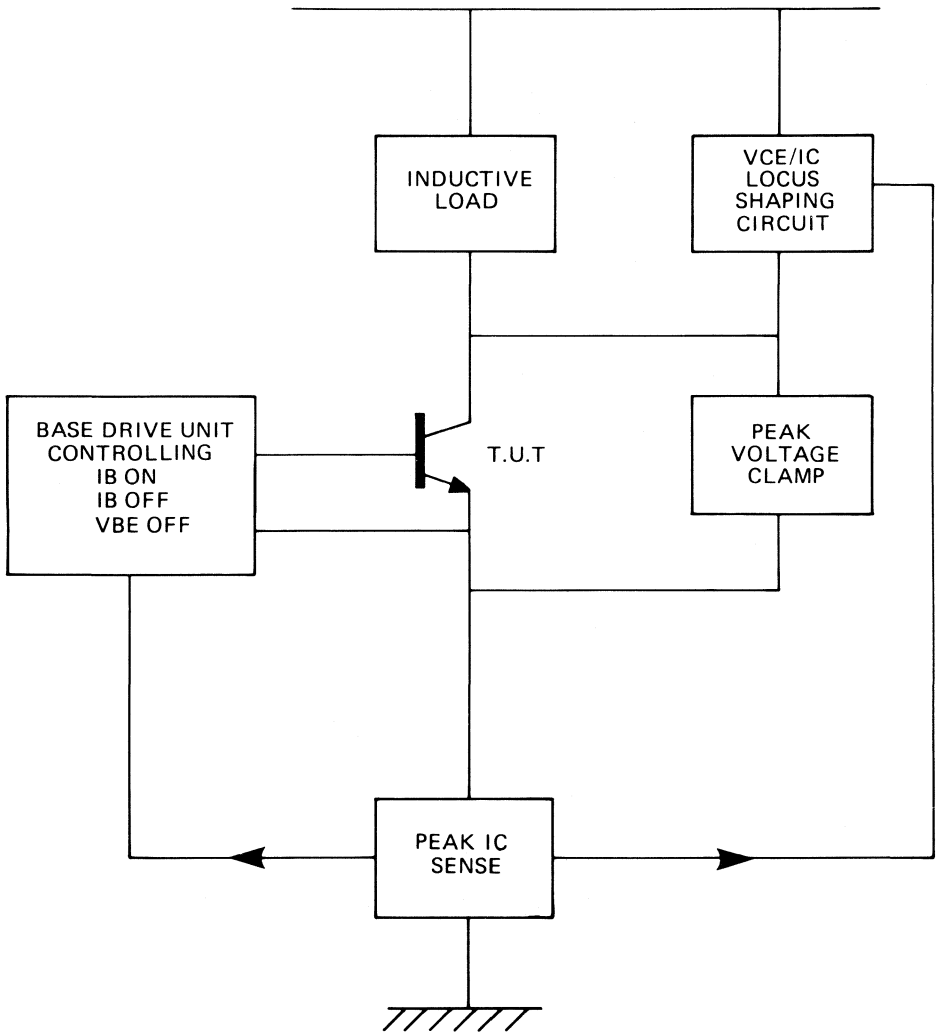


FIGURE 12 SWITCHING LOCUS TEST CIRCUIT



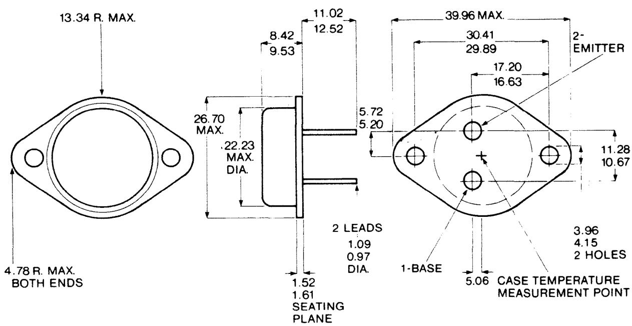
BUX 47, BUX 47A, BUX 47B
NPN SILICON POWER TRANSISTOR

OCT 82

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'Turn-off' locus

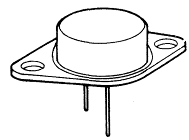
MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUX47	BUX47A	BUX47B
Collector-Emitter Voltage (VBE = -2.5V)	850V	1000V	850V
Collector-Emitter Voltage (RBE = 10Ω)	850V	1000V	850V
Collector-Emitter Voltage (Open Base)	400V	450V	400V
Continuous Collector Current	9A	9A	9A
Peak Collector Current (Note 1)	15A	15A	15A
Base Current	3A	3A	3A
Peak Base Current (Note 1)	6A	6A	6A
Continuous Dissipation T Case = 25°C	125W	125W	125W
Operating Junction Temperature	-65°C - +200°C		

Note 1: Pulse Test, Pulse Duration = 5ms

BUX 47, BUX 47A, BUX 47B
NPN SILICON POWER TRANSISTOR

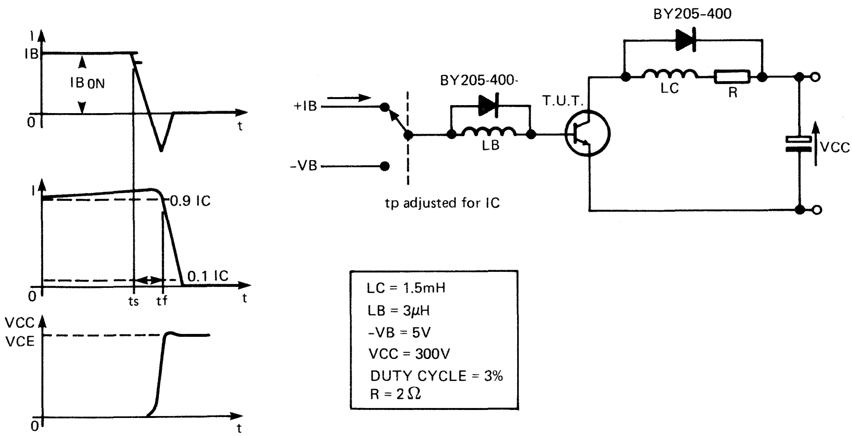
ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{CEO} (SUST)	Collector-Emitter	I_C = 200 mA		BUX47, BUX478	400			V
	Sustaining Voltage	L = 25 mH		BUX47A	450			V
	See Note 1							
I_{CEX}	Collector-Emitter	V_{CE} = 850V		BUX47, BUX47B			0.15	mA
	Cut-off Current	V_{CE} = 1000V		BUX 47A			0.15	mA
	(V_{BE} = -2.5V)	V_{CE} = 850V	125°C	BUX47 BUX47B			1.5	mA
		V_{CE} = 1000V	125°C	BUX47A			1.5	mA
I_{CER}	Collector-Emitter	V_{CE} = 850V		BUX47, BUX47B			0.4	mA
	Cut-off Current	V_{CE} = 1000V		BUX47A			0.4	mA
	($R_{BE} \leqslant 10\Omega$)	V_{CE} = 850V	125°C	BUX47, BUX47B			3.0	mA
		V_{CE} = 1000V	125°C	BUX47A			3.0	mA
I_{EBO}	Emitter	V_{EB} = 5V	I_C = 0				1	mA
	Cut-off Current							
BV_{EBO}	Emitter Base	I_E = 50mA	I_C = 0		7		30	V
	Breakdown Voltage							
$V_{CE(sat)}$	Collector-Emitter	I_C = 6A	I_B = 1.2A	BUX47B			1.5	V
	Saturation	I_C = 9A	I_B = 3A				3.0	V
	Voltage	I_C = 5A	I_B = 1A	BUX47, BUX47A			1.5	V
		I_C = 8A	I_B = 2.5A	BUX47			3.0	V
$V_{BE(sat)}$	Base-Emitter	I_C = 5A	I_B = 1A	BUX47, BUX47A			1.6	V
	Saturation Voltage	I_C = 6A	I_B = 1.2A	BUX47B			1.6	V
f_t	Current Gain	I_C = 500mA	V_{CE} = 10V (dc)			8.0		MHz
	Band-Width Product	F = 1MHz						
C_{ob}	Output Capacitance	V_{CB} = 20V	I_C = 0A			105		pf
		F = 0.1 MHz						
$R_{\theta jc}$	Thermal						1.4	°C/W
	Resistance							
	Junction-Case							

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

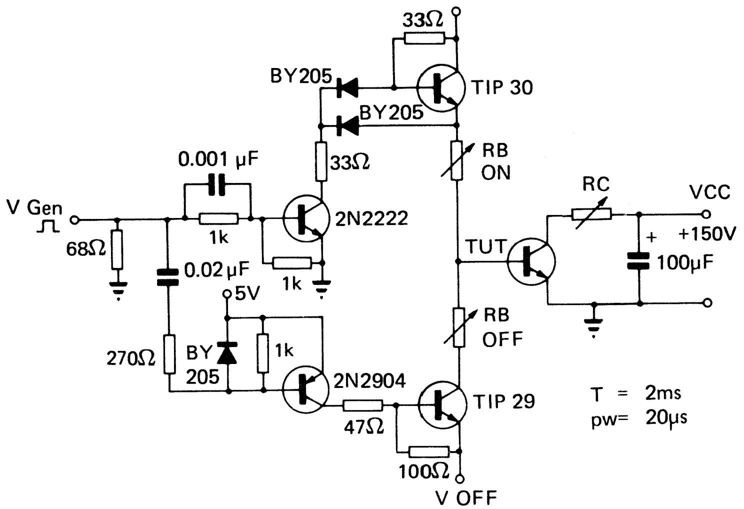
PARAMETERS		TEST CONDITIONS			MIN	TYP	MAX	UNIT
RESISTIVE LOAD								
t_{on}	Turn on Time	I_C = 5A	V_{CC} = 150V	BUX47			1.0	μs
t_s	Storage Time	I_{BON} = 1.0A	I_{BOFF} = 1.0A	BUX47A			3.0	μs
t_f	Fall Time	T Case-25°C					0.80	μs
t_{on}	Turn on Time	I_C = 6A	V_{CC} = 150V	BUX47B			1.0	μs
t_s	Storage Time	I_{BON} = 1.2A	I_{BOFF} = 1.2A				3.0	μs
t_f	Fall Time	T Case = 25°C					0.80	μs
INDUCTIVE LOAD								
t_s	Storage Time	I_C = 5A	V_{CC} = 300V	BUX47			4.0	μs
t_f	Fall Time	I_{BON} = 1.0A	$-V_B$ = 5V	BUX47A			0.4	μs
		L_b = 3μH	T Case = 100°C					
t_s	Storage Time	I_C = 6A	V_{CC} = 300V	BUX 47B			4.0	μs
t_f	Fall Time	I_{BON} = 1.2A	V_B = 5V				0.4	μs
		LB = 3μH T Case = 100°C						

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



LC = 1.5mH
LB = 3μH
-VB = 5V
VCC = 300V
DUTY CYCLE = 3%
R = 2Ω

FIGURE 2 RESISTIVE SWITCHING CIRCUIT

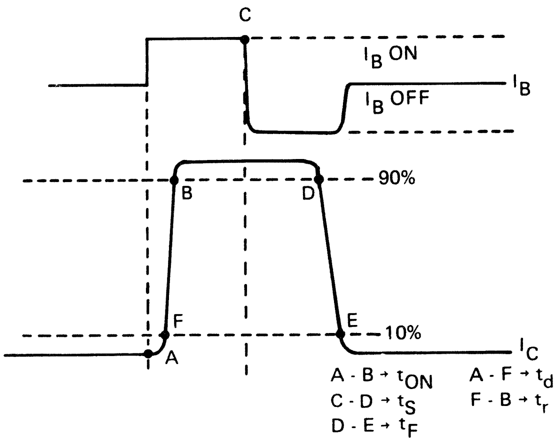


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

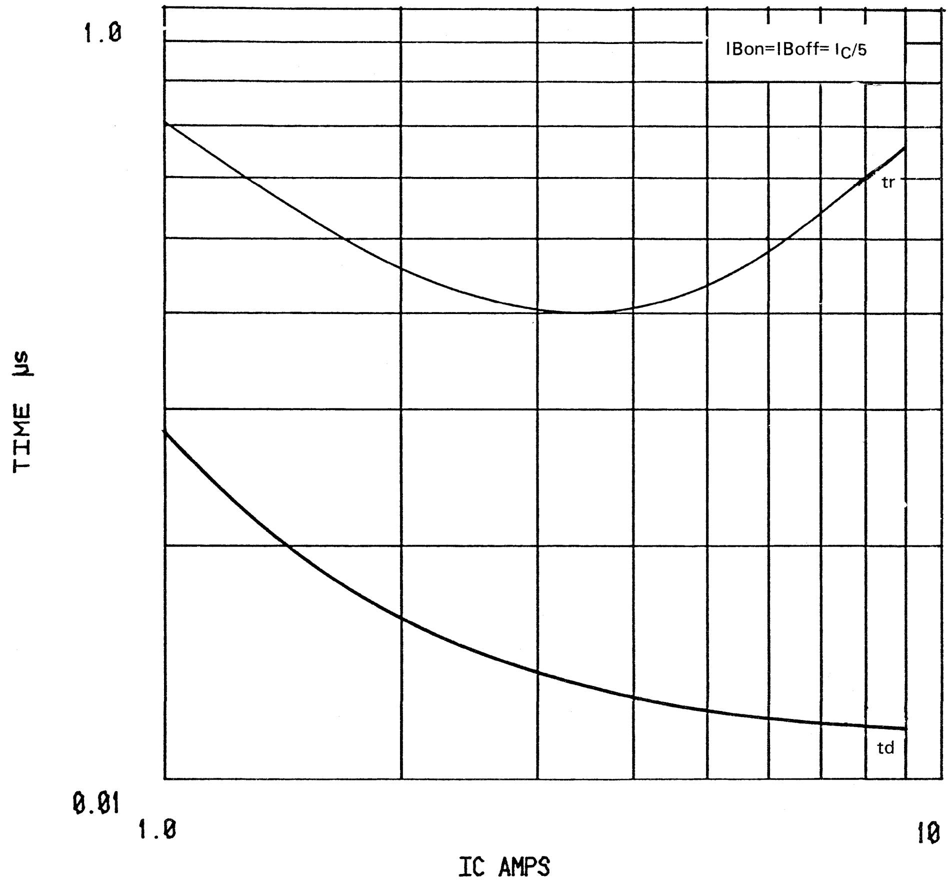
C Resistors must be noninductive types.

FIGURE 3 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS

FIGURE 4 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE 5 TYPICAL TURN-OFF TIME T CASE=25°C

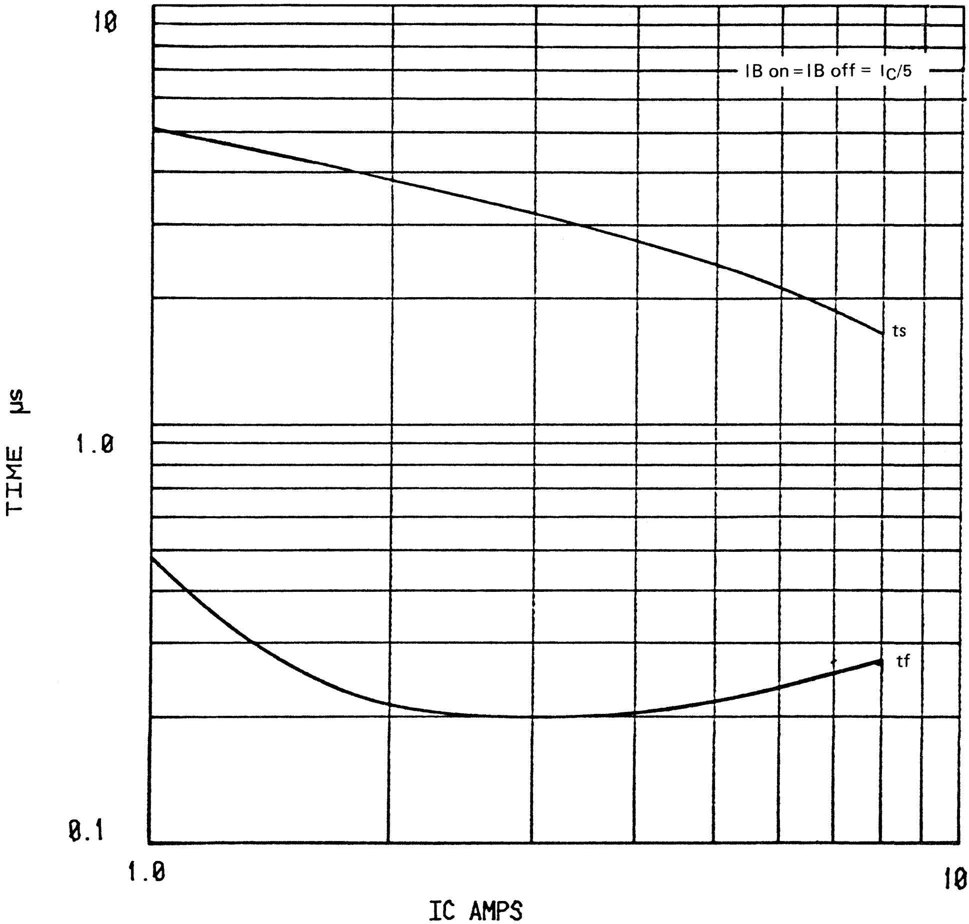


FIGURE 6 TYPICAL VARIATION OF ICES WITH TEMPERATURE

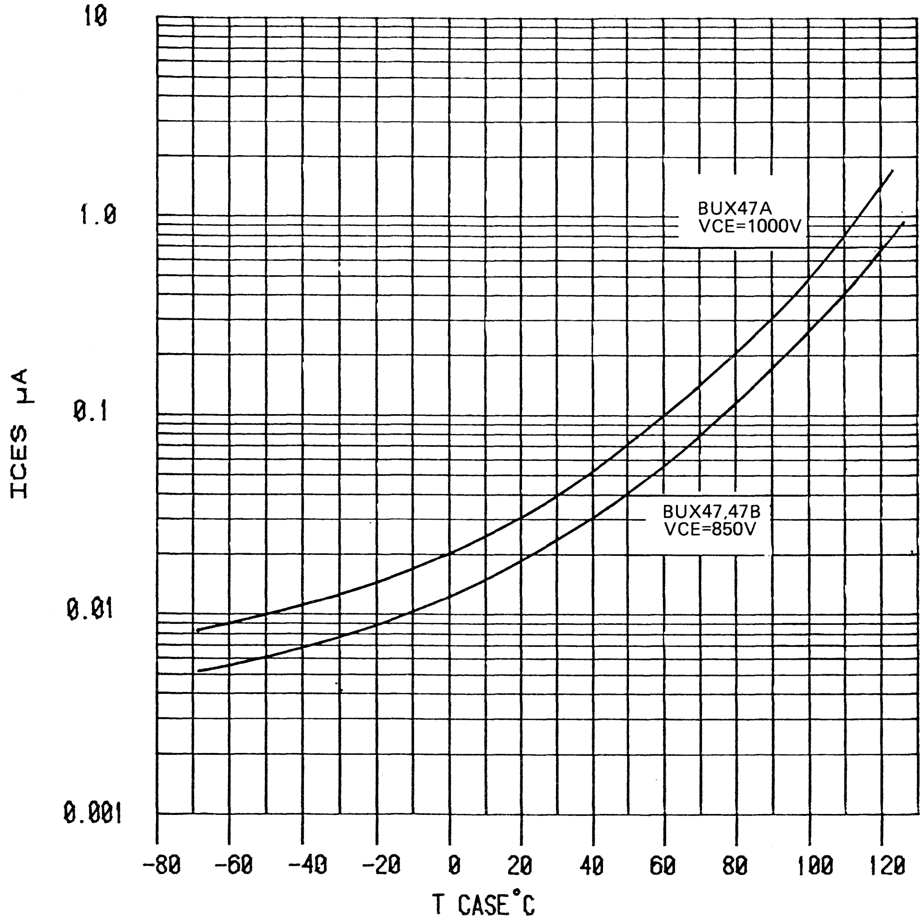


FIGURE 7 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

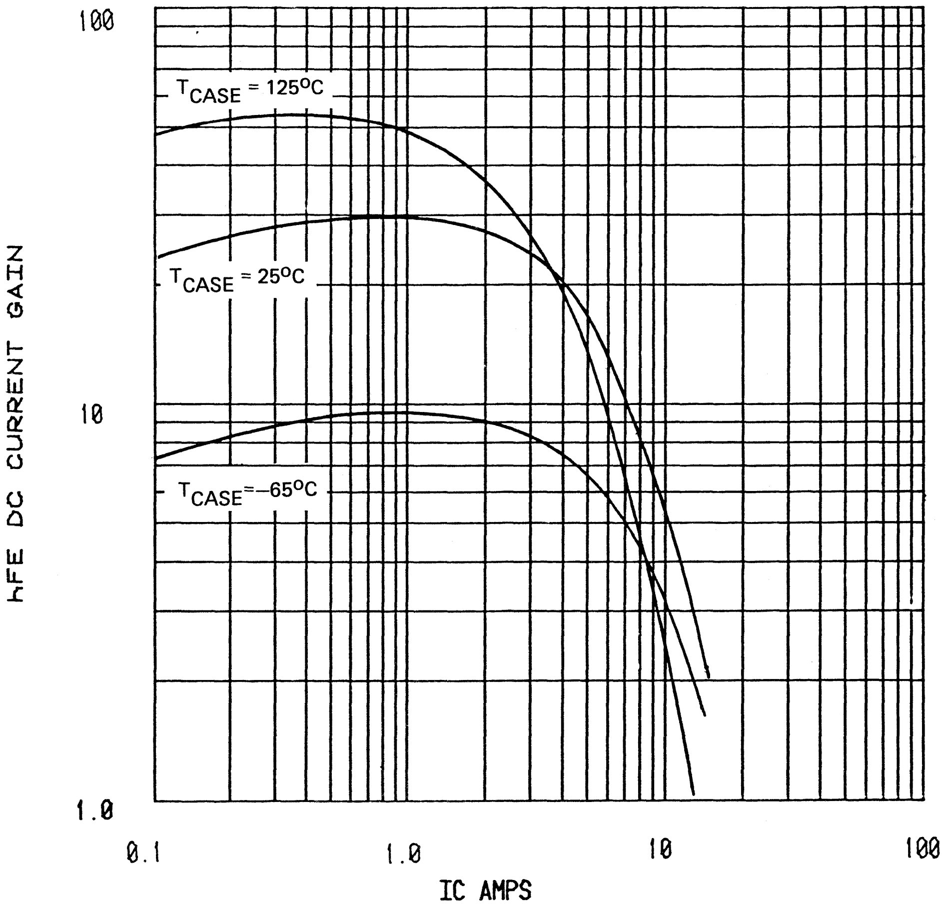


FIGURE 8 TYPICAL COLLECTOR SATURATION REGION

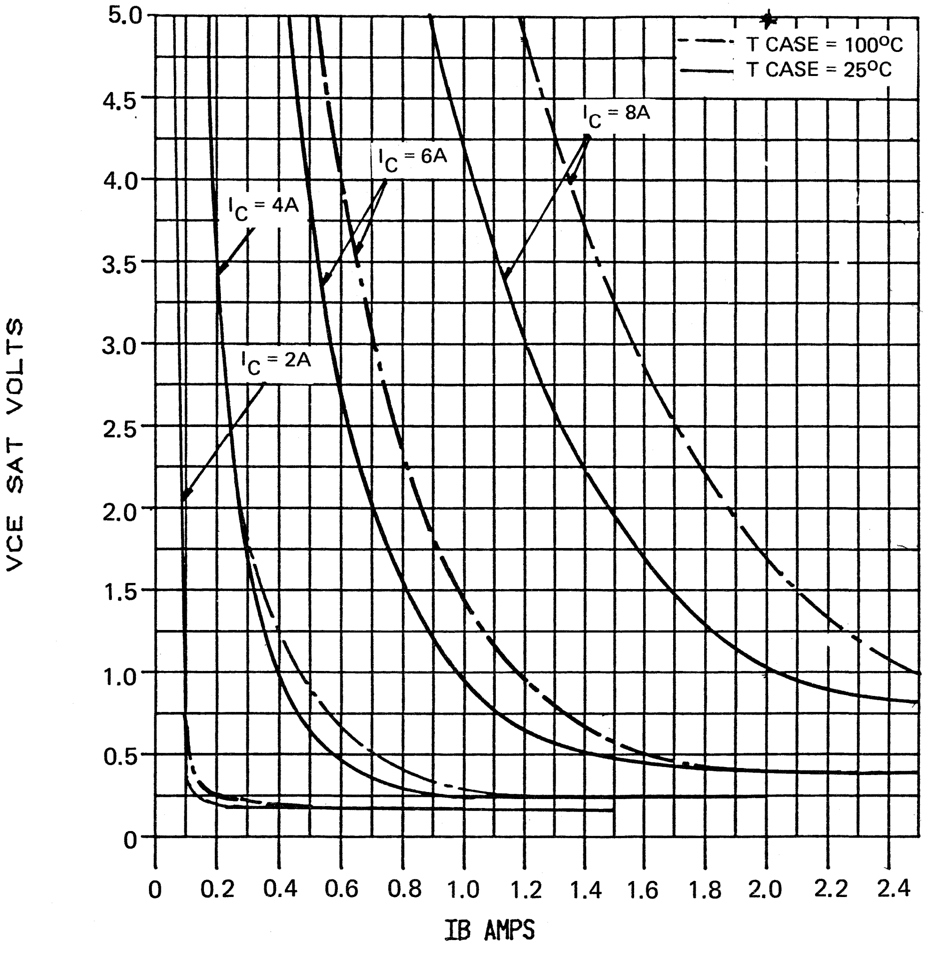


FIGURE 9 FORWARD BIASED SAFE AREA OF OPERATION DC AND PULSED T CASE=25°C

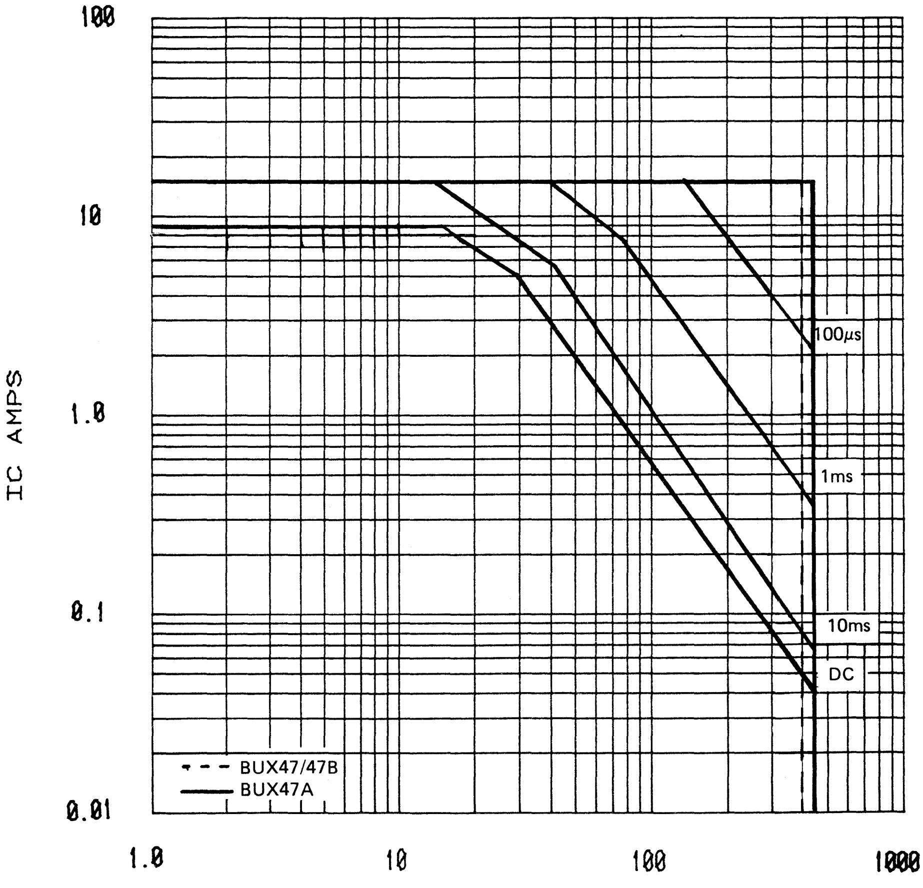


FIGURE 10 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

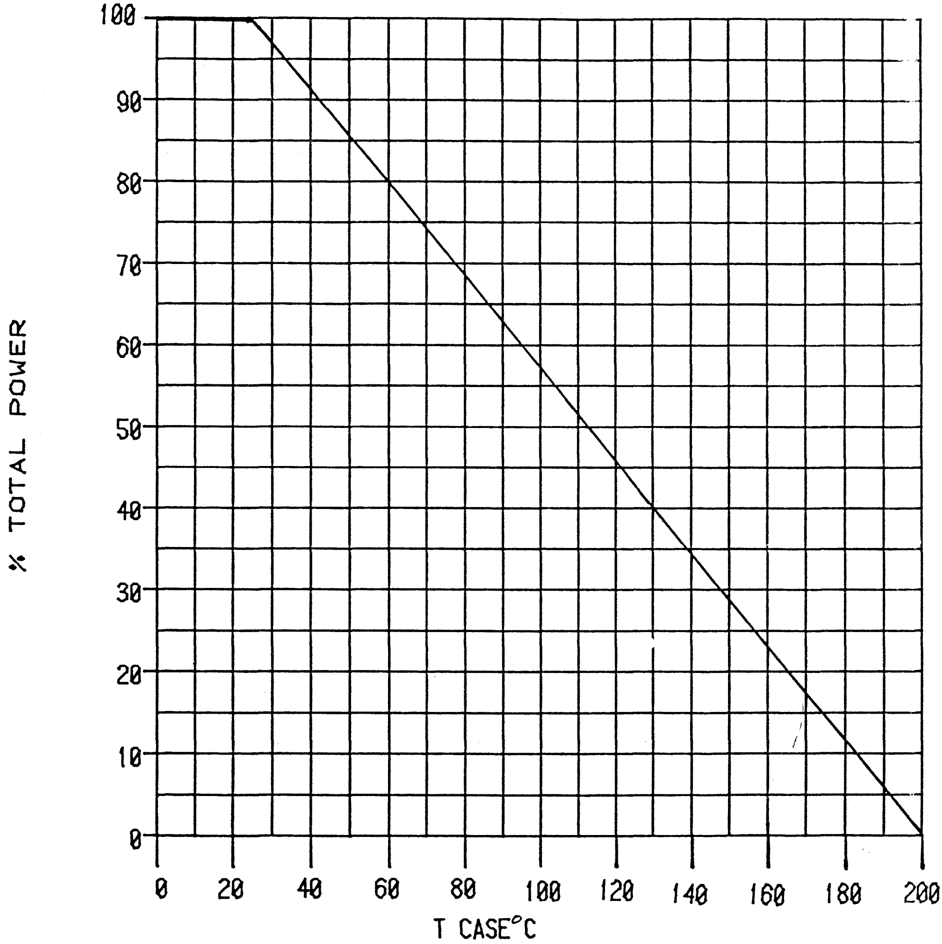


FIGURE 11 THERMAL RESPONSE

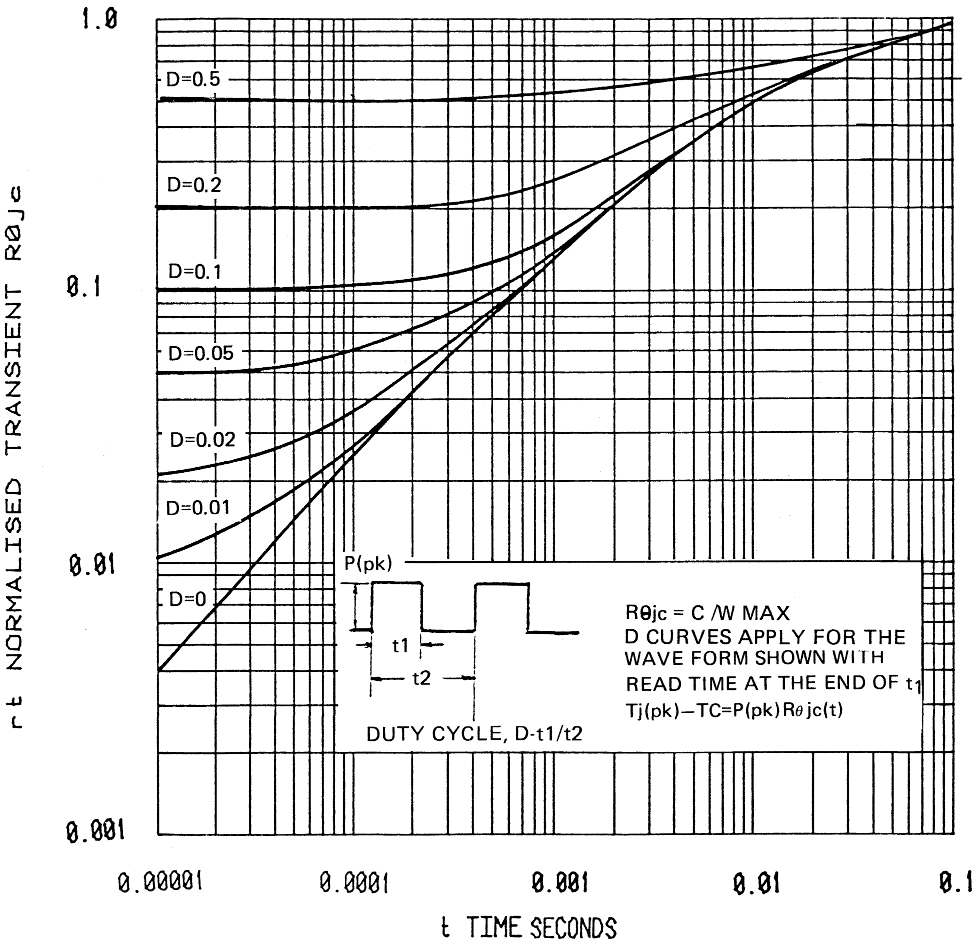


FIGURE 12 SWITCHING LOCUS TEST CIRCUIT

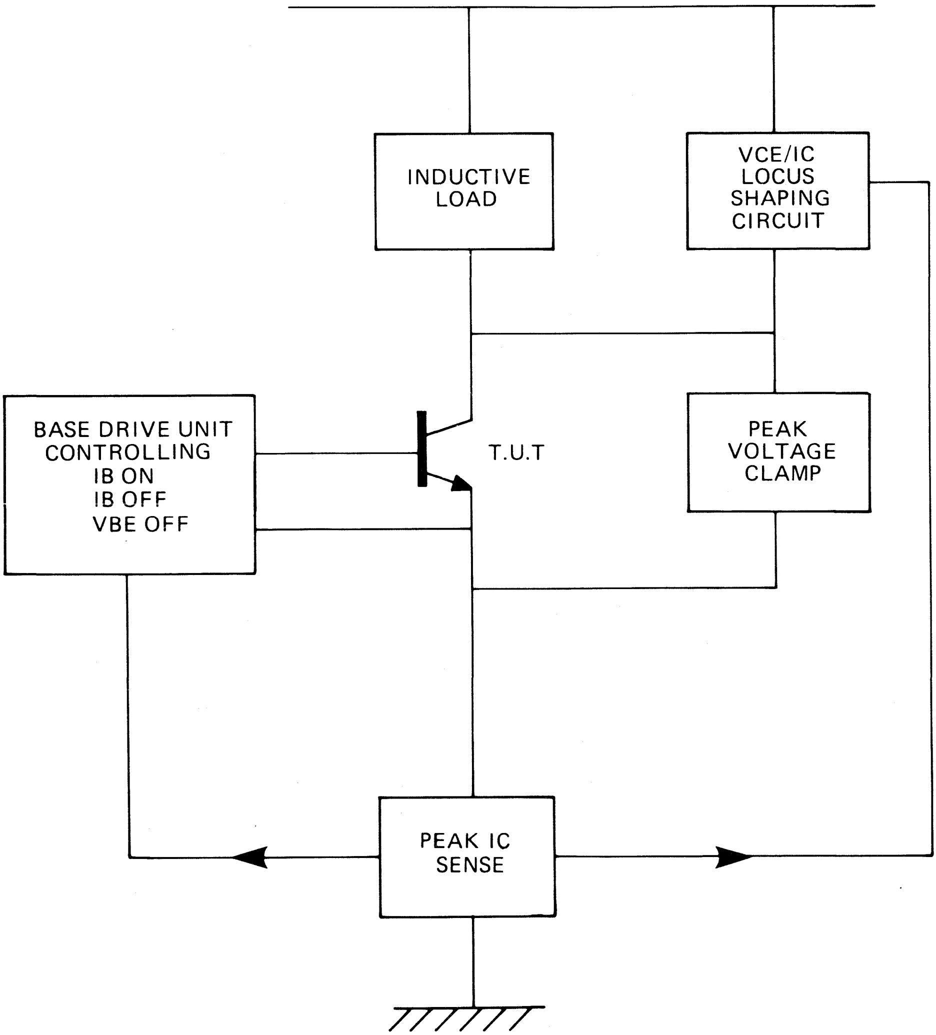
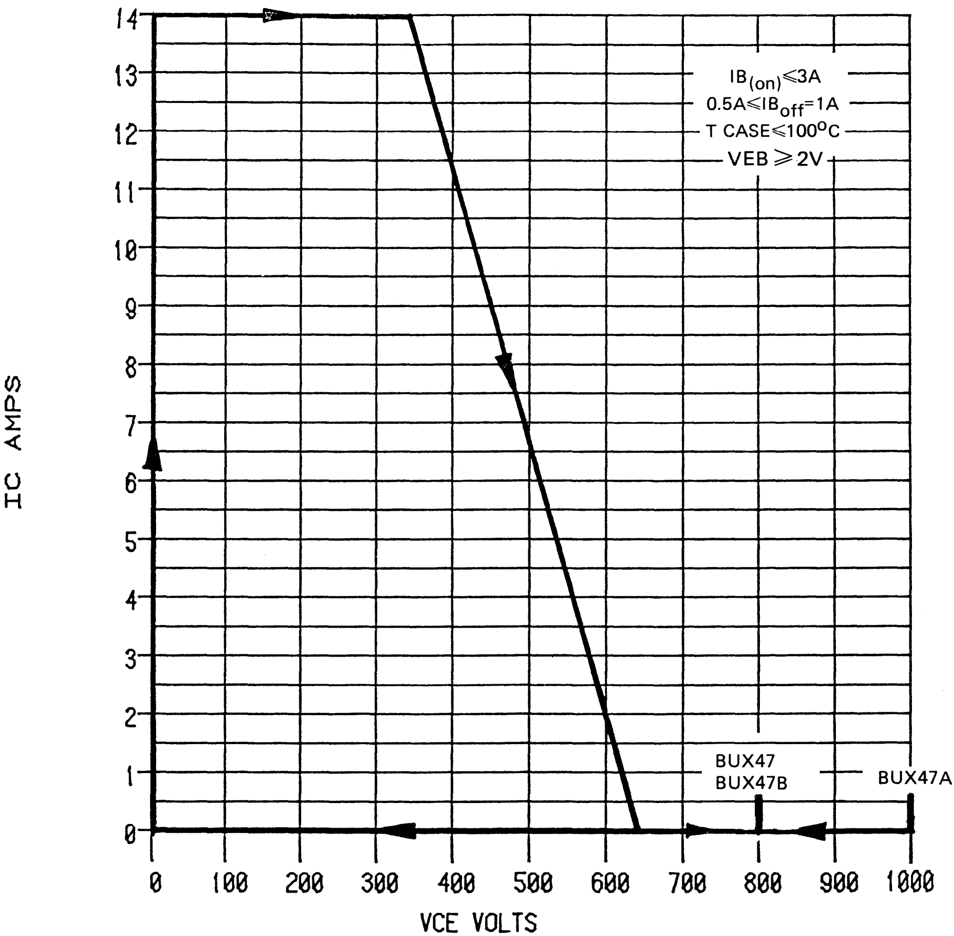


FIGURE 13 TRANSIENT "TURN-OFF" LIMIT IC VS VCE



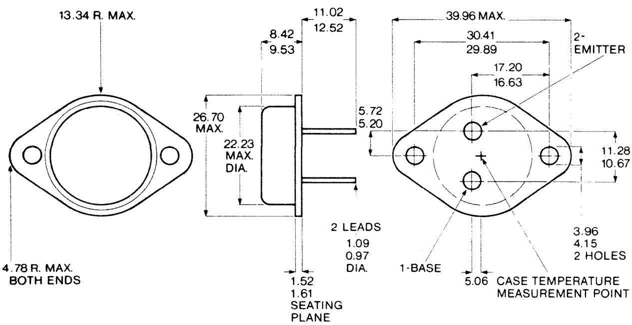
BUX 48, BUX 48A
NPN SILICON POWER TRANSISTOR

OCT 82

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'Turn-off' locus

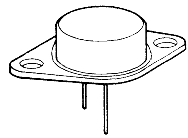
MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUX48	BUX48A
Collector-Emitter Voltage (VBE = -2.5V)	850V	1000V
Collector-Emitter Voltage (RBE =10Ω)	850V	1000V
Collector-Emitter Voltage (Open Base)	400V	450V
Continuous Collector Current	15A	15A
Peak Collector Current (Note 1)	30A	30A
Non Repetitive Accidental Peak Surge Current	55A	55A
Continuous Base Current	4A	4A
Peak Base Current (Note 1)	20A	20A
Continuous Dissipation T Case = 25°C	175W	175W
Operating Junction Temperature	-65°C - +200°C	

Note 1: Pulse Test, Pulse Duration = 5ms

NPN SILICON POWER TRANSISTOR

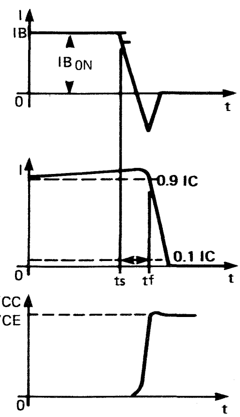
ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

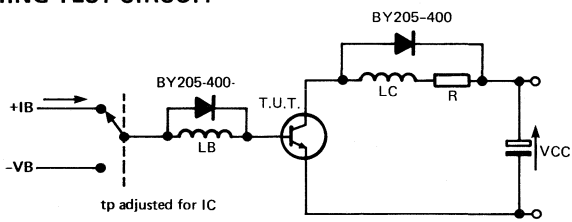
PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{CEO} (SUST)	Collector-Emitter	I_C = 200 mA		BUX48	400			V
	Sustaining Voltage	L = 25 mH		BUX48A	450			V
	See Note 1							
I_{CEX}	Collector-Emitter	V_{CE} = 850V		BUX48			0.2	mA
	Cut-off Current	V_{CE} = 1000V		BUX48A			0.2	mA
	(V_{BE} = -2.5V)	V_{CE} = 850V	125°C	BUX48			2	mA
		V_{CE} = 1000V	125°C	BUX48A			2	mA
I_{CER}	Collector-Emitter	V_{CE} = 850V		BUX48			0.5	mA
	Cut-off Current	V_{CE} = 1000V		BUX48A			0.5	mA
	($R_{BE} \leqslant 10\Omega$)	V_{CE} = 850V	125°C	BUX48			4	mA
		V_{CE} = 1000V	125°C	BUX48A			4	mA
I_{EBO}	Emitter	V_{EB} = 5V	I_E = 0				1	mA
	Cut-off Current							
B_{VEBO}	Emitter Base	I_E = 0.05A	I_C = 0		7		30	V
	Breakdown Voltage							
$V_{CE(sat)}$	Collector-Emitter	I_C = 10A	I_B = 2A	BUX48			1.5	V
	Saturation	I_C = 15A	I_B = 3A				5.0	V
	Voltage	I_C = 8A	I_B = 1.6A	BUX48A			1.5	V
		I_C = 12A	I_B = 2.4A				5.0	V
$V_{BE(sat)}$	Base-Emitter	I_C = 10A	I_B = 2A	BUX48			1.6	V
	Saturation Voltage	I_C = 6A	I_B = 1.6A	BUX48A			1.6	V
f_t	Current Gain	I_C = 500mA	V_{CE} = 10V (dc)			10		MHz
	Band-Width Product	F = 1MHz						
C_{ob}	Output Capacitance	V_{CB} = 20V	I_C = 0A			150		pf
		F = 0.1 MHz						
$R_{\theta jc}$	Thermal						1.0	°C/W
	Resistance							
	Junction-Case							

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
t_{on}	Turn on Time	I_C = 10A V_{CC} = 150V BUX48			1.0	μs
t_s	Storage Time	I_{BON} = 2.0A I_{BOFF} = 2.0A			3.0	μs
t_f	Fall Time	T Case-25°C			0.80	μs
t_{on}	Turn on Time	I_C = 8.0A V_{CC} = 150V BUX48A			1.0	μs
t_s	Storage Time	I_{BON} = 1.6A I_{BOFF} = 1.6A			3.0	μs
t_f	Fall Time	T Case = 25 C			0.80	μs
INDUCTIVE LOAD						
t_s	Storage Time	I_C = 10 A V_{CC} = 300V BUX48			5.0	μs
t_f	Fall Time	I_{BON} = 2A $-V_B$ = 5V L_b = 3μH T Case = 100°C			0.4	μs
t_s	Storage Time	I_C = 8A V_{CC} = 300V BUX 48A			5.0	μs
t_f	Fall Time	I_{BON} = 1.6A $-V_B$ = 5V LB = 3μH T Case = 100°C			0.4	μs

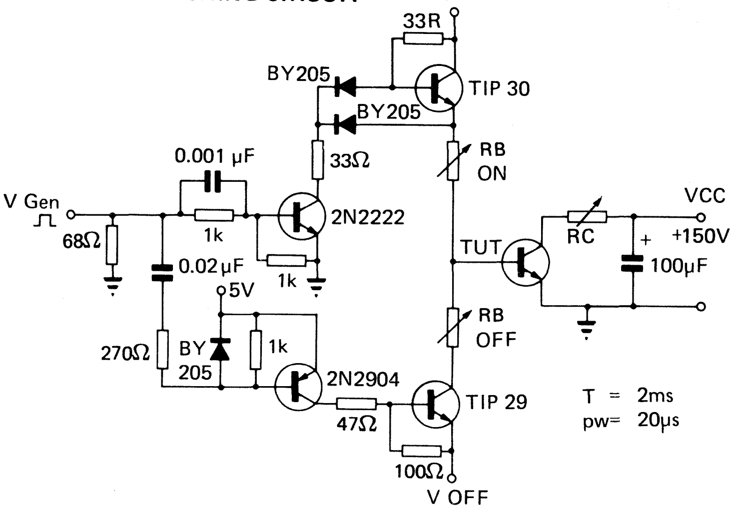
FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT





LC = 1.5mH
LB = 3μH
-VB = 5V
VCC = 300V
DUTY CYCLE = 3%
R = 2Ω

FIGURE 2 RESISTIVE SWITCHING CIRCUIT



Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} < 11.5pF.

C Resistors must be noninductive types.

FIGURE 3 RESISTIVE SWITCHING WAVEFORMS

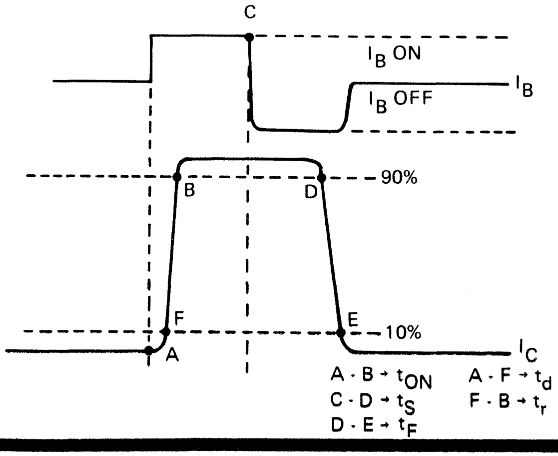


FIGURE. 4 COLLECTOR CURRENT VS COLLECTOR EMITTER VOLTAGE T CASE=25°C

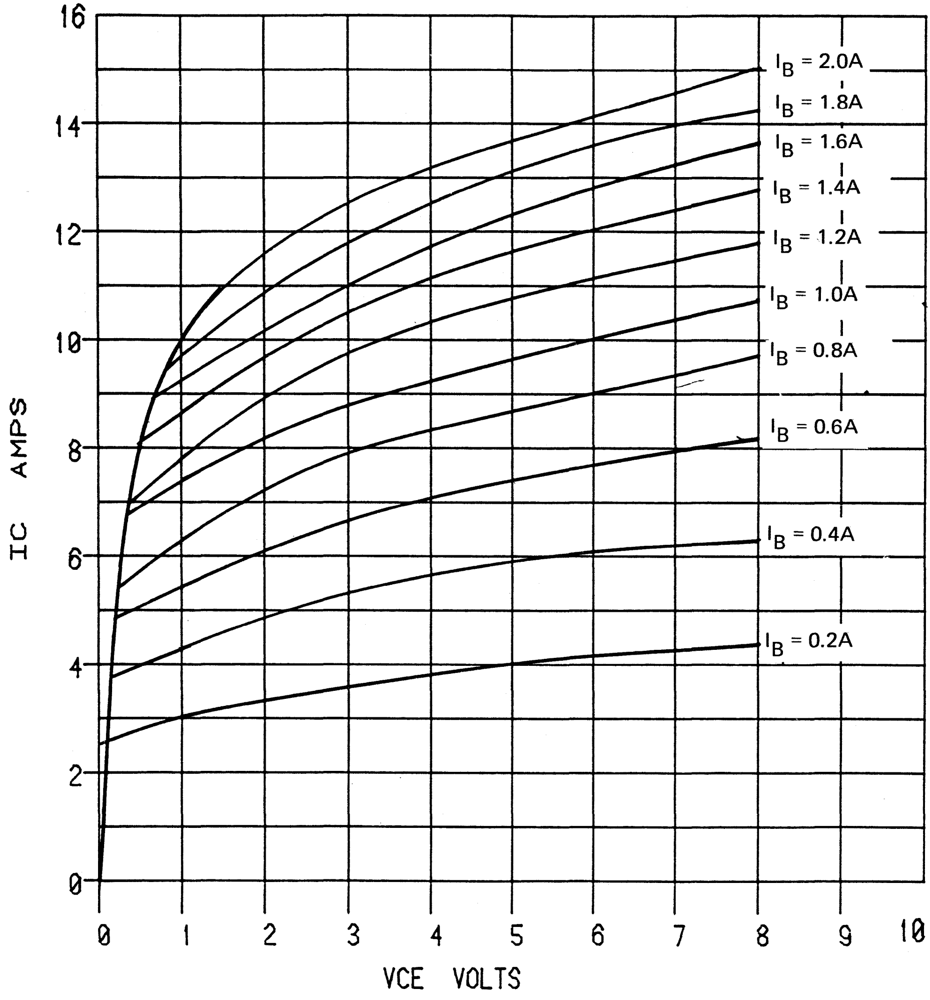


FIGURE. 5 TYPICAL COLLECTOR SATURATION REGION

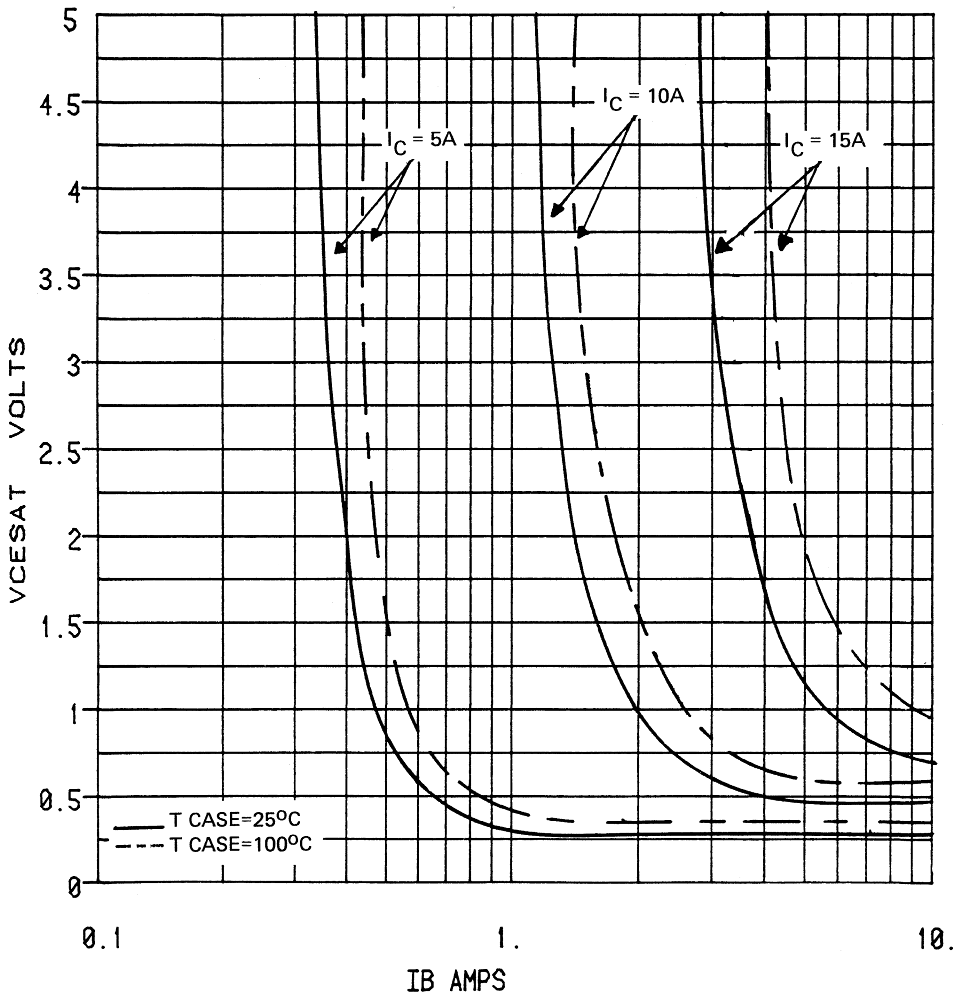


FIGURE. 6 TYPICAL BASE SATURATION VOLTAGE T CASE=25°C

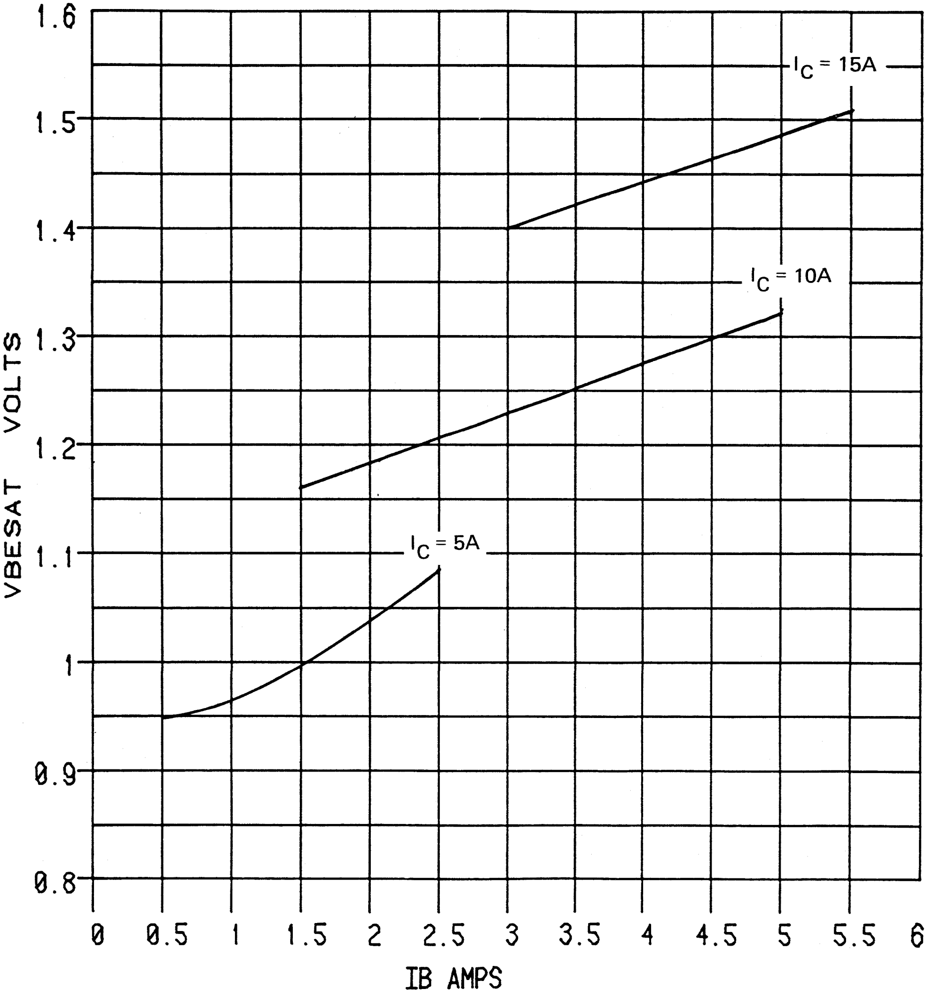


FIGURE. 7 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

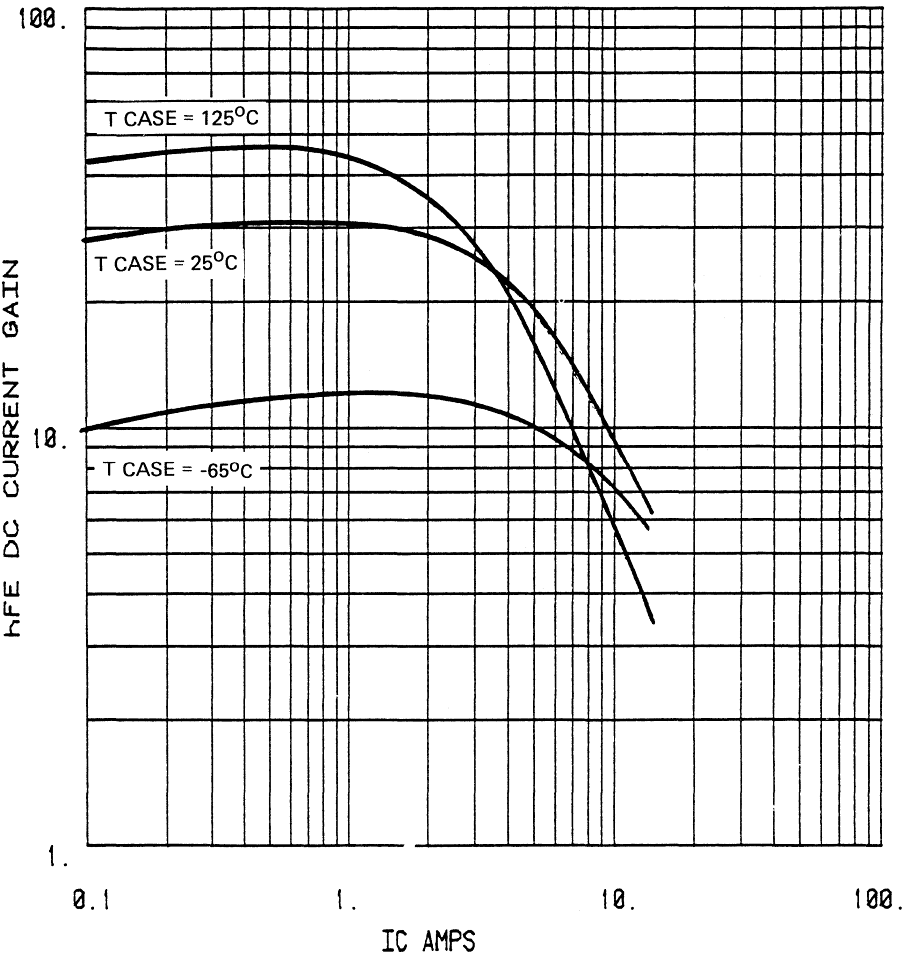


FIGURE. 8 COLLECTOR EMITTER VOLTAGE VS BASE-EMITTER RESISTANCE T CASE=25°C

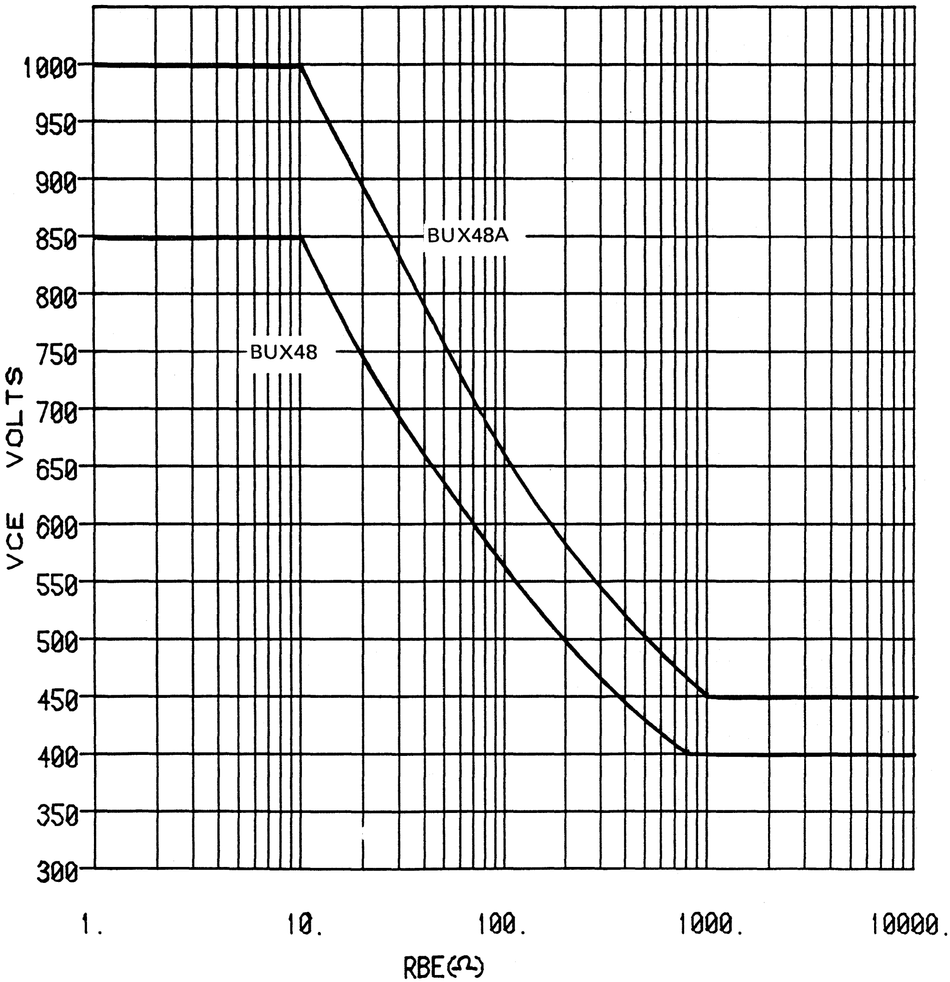


FIGURE. 9 TYPICAL VARIATION OF ICES WITH TEMPERATURE

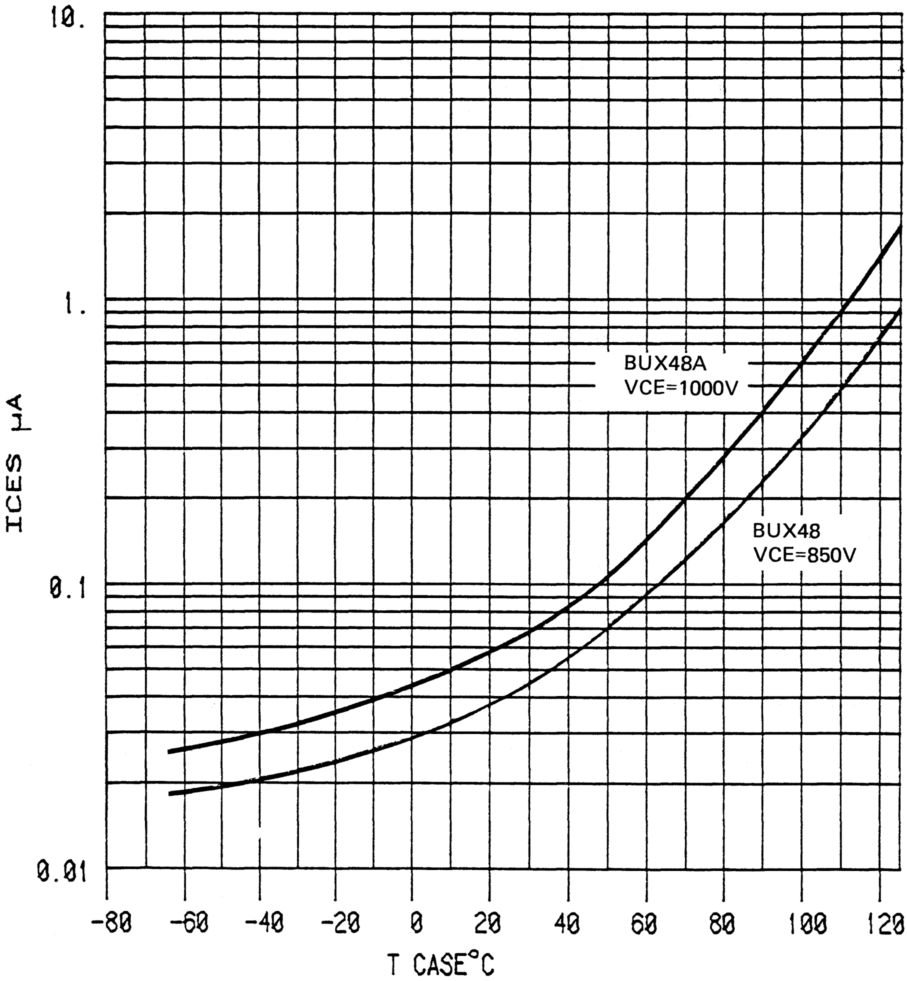


FIGURE. 10 FORWARD BIASED SAFE AREA OF OPERATION DC AND PULSED T CASE=25°C

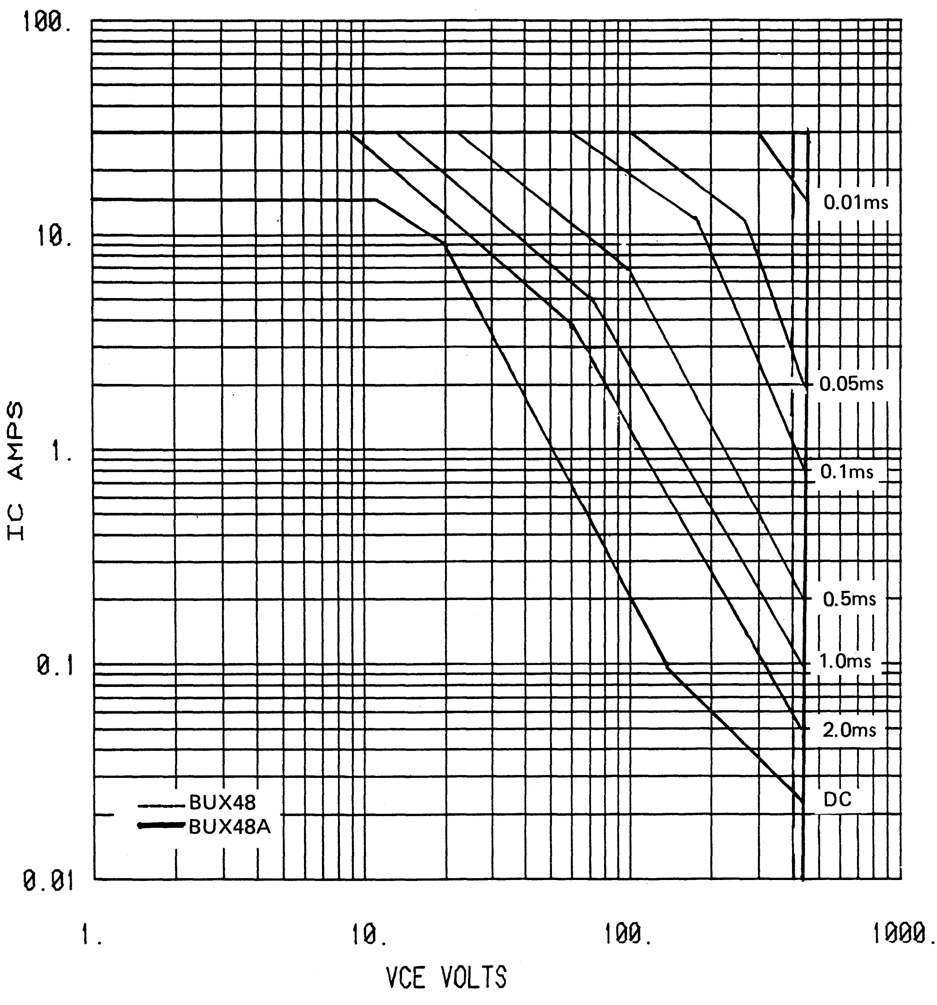


FIGURE. 11 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

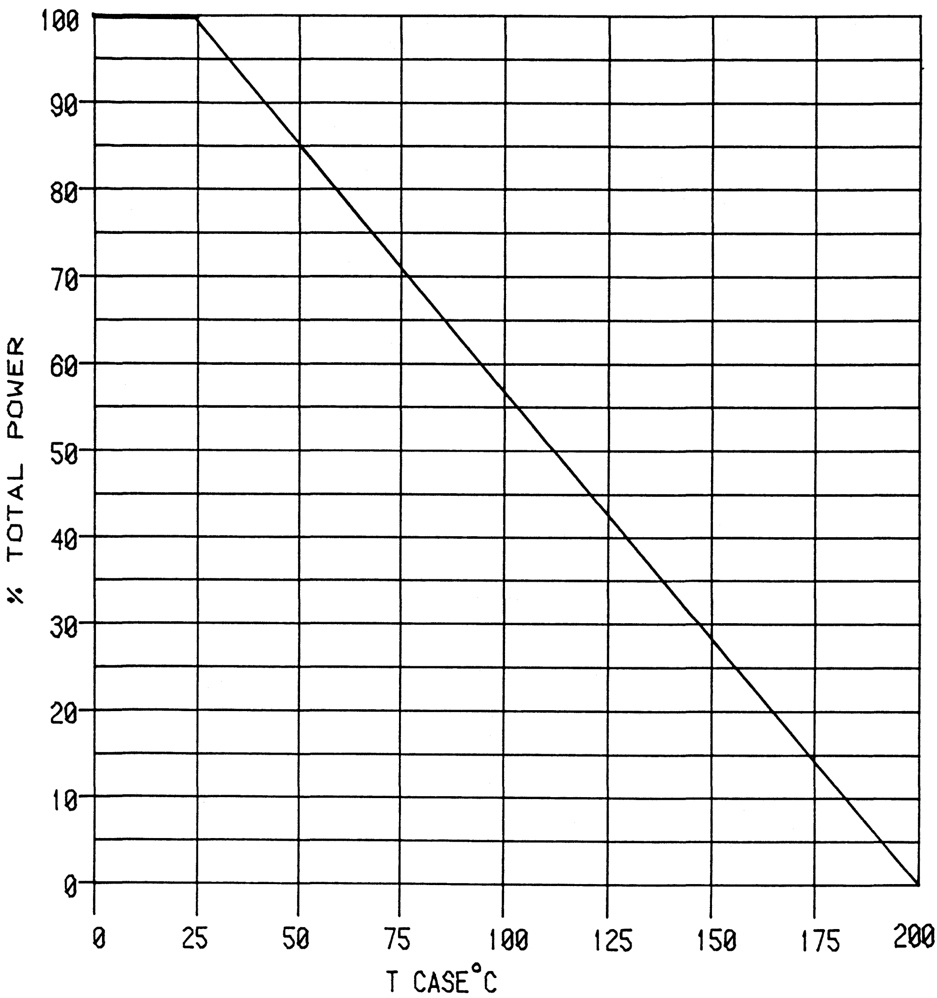


FIGURE. 12 MAXIMUM REVERSE BIAS SAFE OPERATING AREA

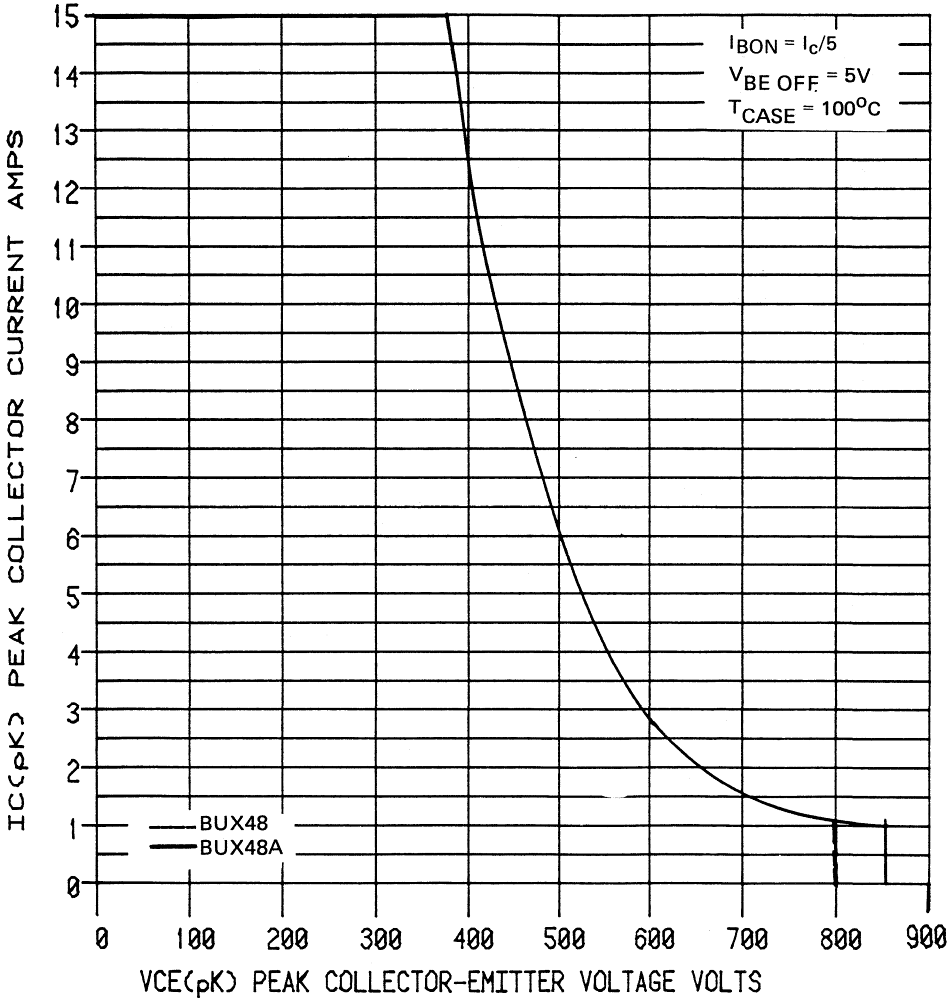


FIGURE. 13 TRANSIENT "TURN-OFF" LIMIT VS BCE T CASE <100°C

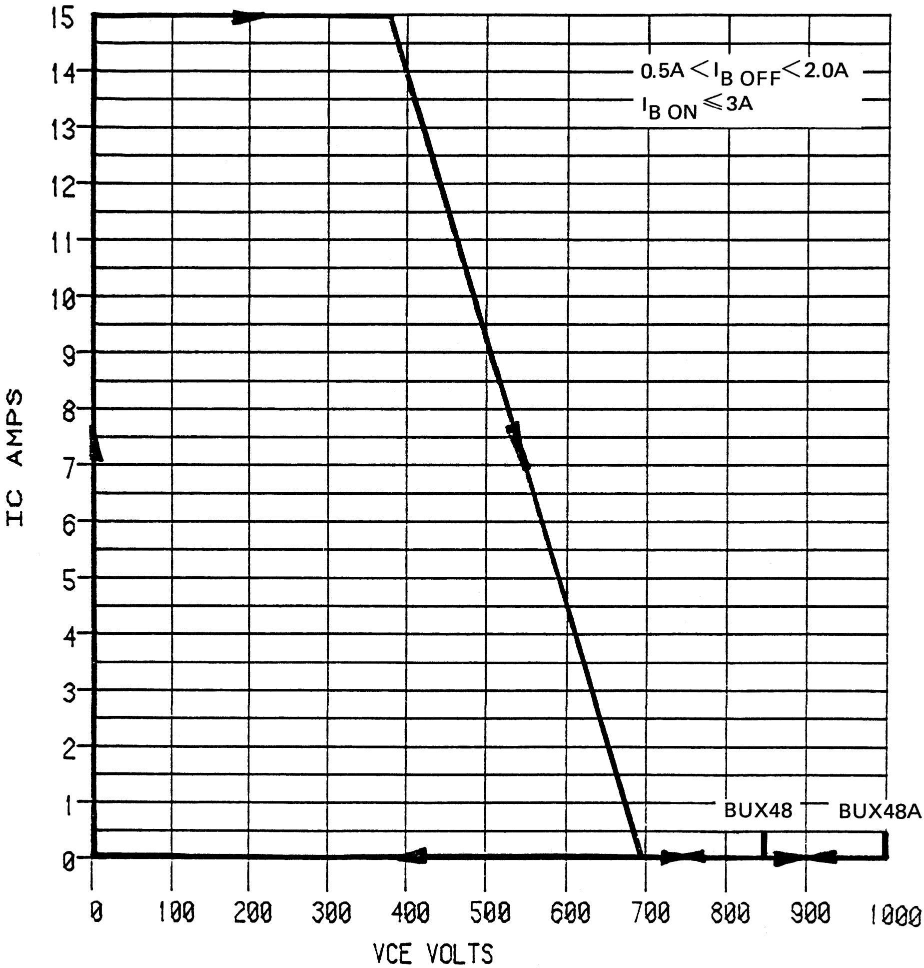
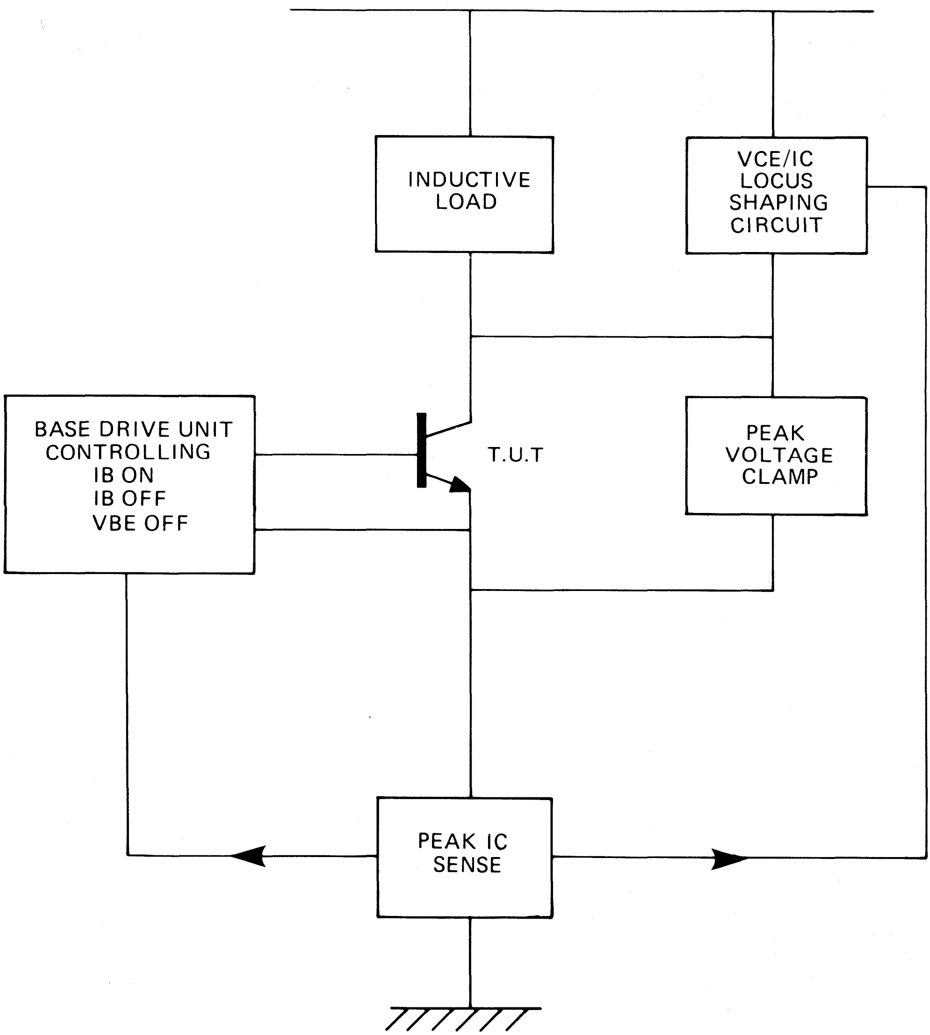


FIGURE. 14 SWITCHING LOCUS TEST CIRCUIT



BUX 80, BUX 81
NPN SILICON POWER TRANSISTOR

OCT 82

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
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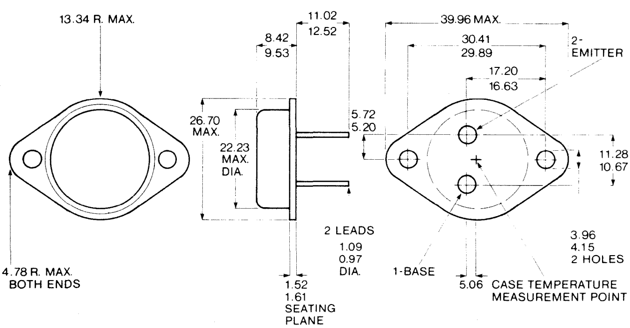
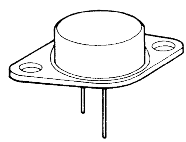
- Guaranteed Transient 'Turn-off' locus

MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUX80	BUX81
Collector-Emitter Voltage (VBE = 0)	800V	1000V
Collector-Emitter Voltage (RBE = 10Ω)	500V	500V
Collector-Emitter Voltage (Open Base)	400V	450V
Continuous Collector Current	10A	10A
Peak Collector Current (Note 1)	15A	15A
Base Current	+4A/-0.1A	+4A/-0.1A
Peak Base Current (Note 1)	±6A	±6A
Continuous Dissipation T Case = 25°C	150W	150W
Operating Junction Temperature	-65°C - +200°C	

Note 1: Pulse Test, Pulse Duration = 2ms.

TEXAS INSTRUMENTS

BUX 80, BUX 81
NPN SILICON POWER TRANSISTOR

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{CEO} (SUST)	Collector-Emitter Sustaining Voltage See Note 2	I_C = 100 mA		BUX80	400			V
		L = 25 mH		BUX81	450			V
V_{CER} (SUST)	Collector-Emitter Sustaining Voltage See Note 2	I_C = 100mA		BUX80	500			V
		R_{BE} = 50Ω, L = 15mH		BUX81	500			V
I_{CES}	Collector-Emitter Cut-off Current (V_{BE} = 0)	V_{CE} = 800V		BUX80			1	mA
		V_{CE} = 1000V		BUX81			1	mA
		V_{CE} = 800V	125°C	BUX80			3	mA
		V_{CE} = 1000V	125°C	BUX81			3	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 10V	I_C = 0				10	mA
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage Notes 1 & 3	I_C = 5A	I_B = 1.0A				1.5	V
		I_C = 8A	I_B = 2.5A				3.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage Notes 1 & 3	I_C = 5A	I_B = 1.0A				1.4	V
		I_C = 8A	I_B = 2.5A				1.8	V
f_t	Current Gain Band-Width Product	I_C = 500mA, F = 1MHz	V_{CE} = 10V (dc)			8.0		MHz
C_{ob}	Output Capacitance	V_{CB} = 20V, F = 0.1 MHz	I_E = 0A			105		pf
$R_{\theta jc}$	Thermal Resistance Junction-Case	F=1MHz		BUX80/81			1.17	°C/W

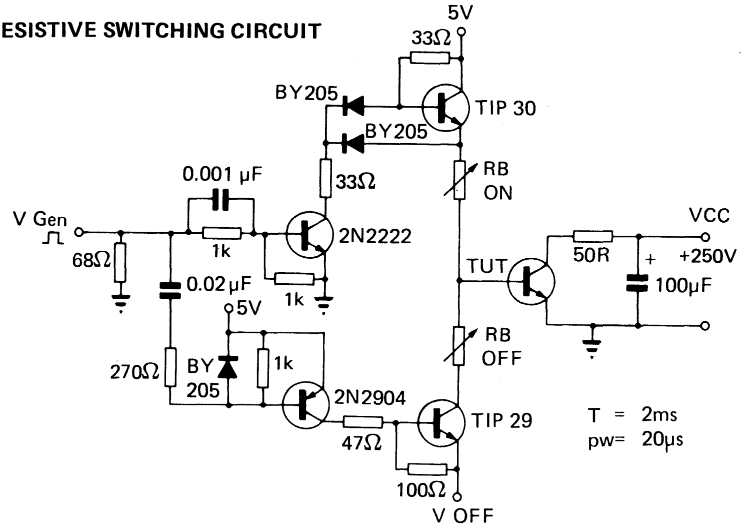
Notes 1 These parameters are measured using pulse techniques pulse width = 300 μs, duty cycle = 2%.
2 Inductive Loop switching measurement
3 These parameters are measured with voltage sensing contacts separated from the current carrying contacts located within 0.125 inches (3.2mm) from the device body.

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RESISTIVE LOAD						
t_{on}	Turn on Time	I_C = 5A V_{CC} = 250V T_{case} = 25°C			0.50	μs
t_s	Storage Time	I_{BON} = 1.0A I_{BOFF} = 2.0A			3.50	μs
t_f	Fall Time Figures 1 - 4	T_{case} = 95°C			0.8	μs

TEXAS INSTRUMENTS

FIGURE 1 RESISTIVE SWITCHING CIRCUIT

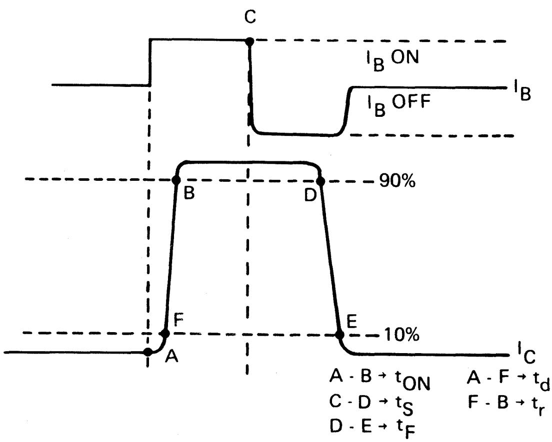


Notes A The V_{gen} Waveform is supplied by the following characteristics:
tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20μs duty cycle <2%

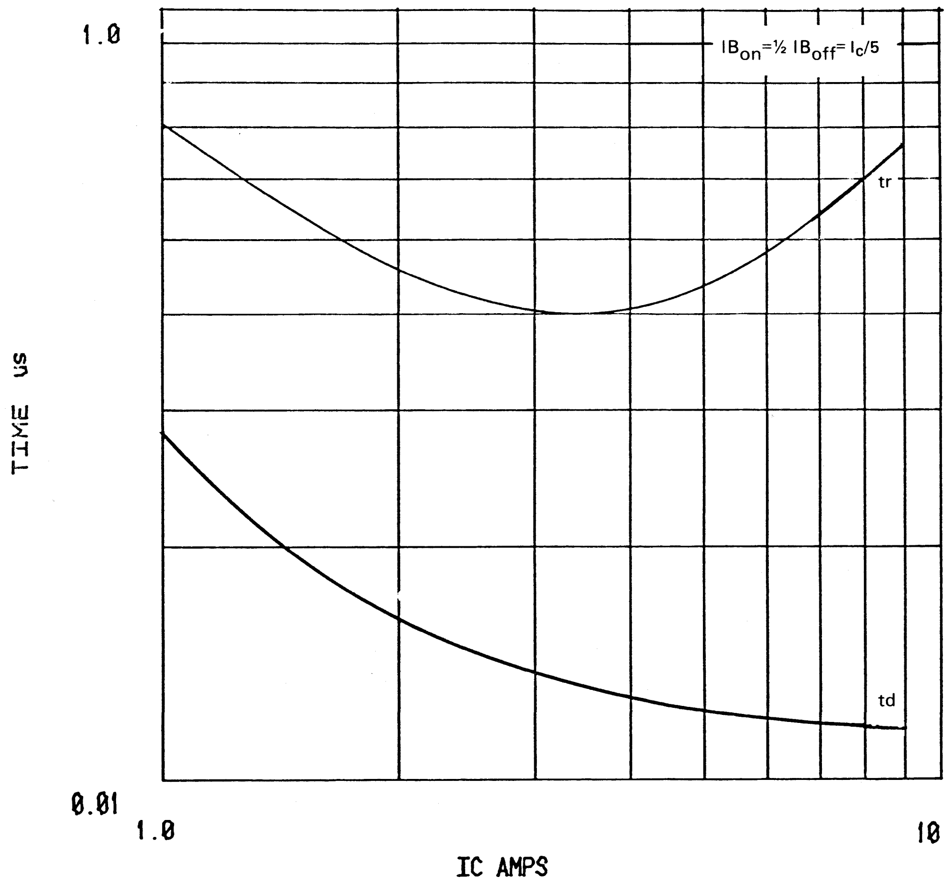
B Waveforms are monitored on an oscilloscope with the following characteristics:
tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 2 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE 3 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE 4 TYPICAL TURN-OFF TIME T CASE=25°C

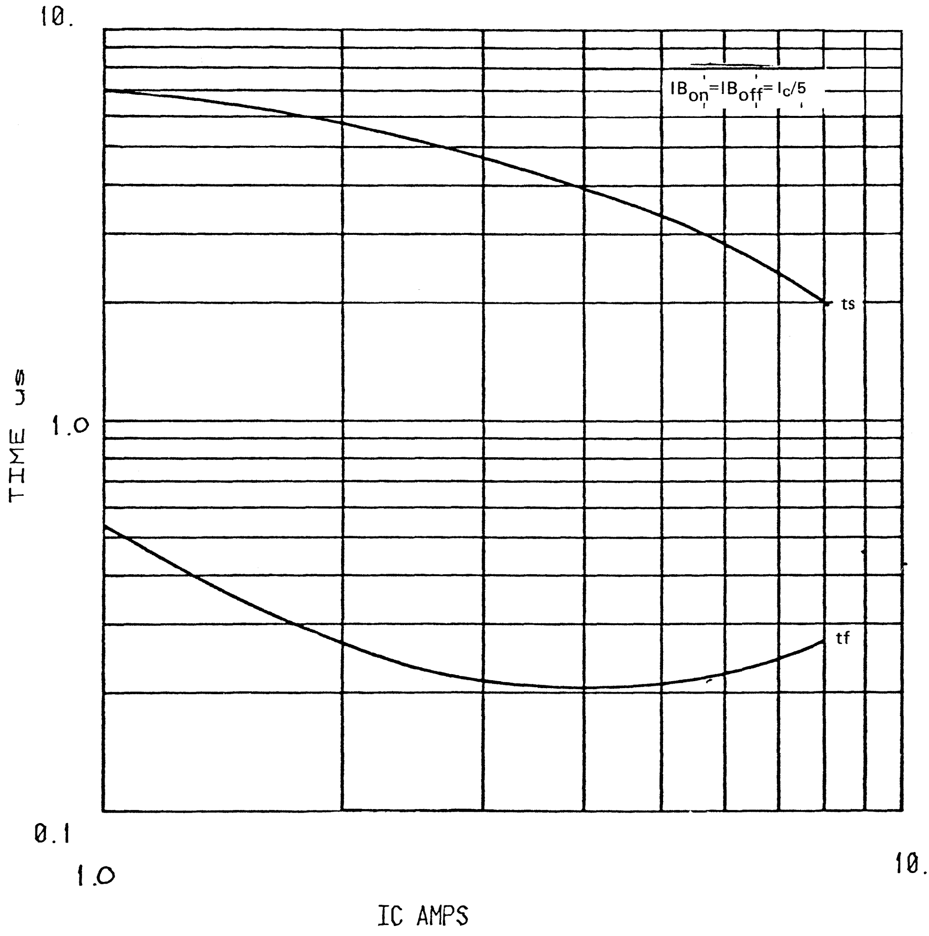


FIGURE 5 TYPICAL VARIATION OF ICES WITH TEMPERATURE

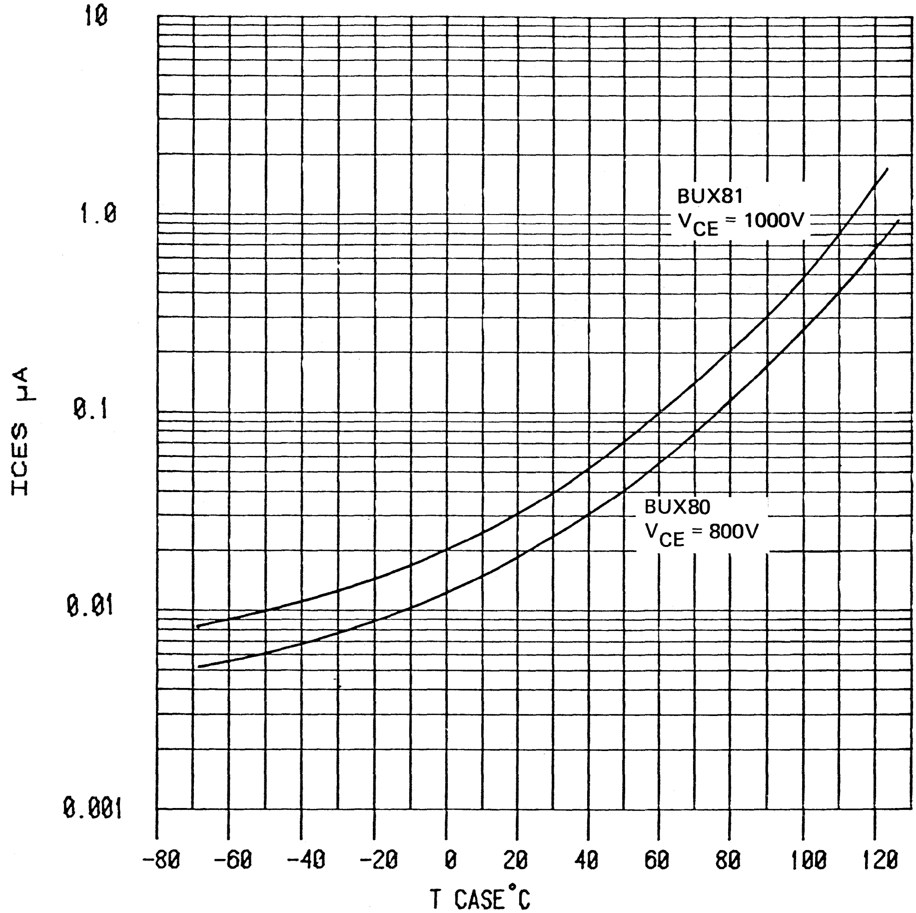


FIGURE 6 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

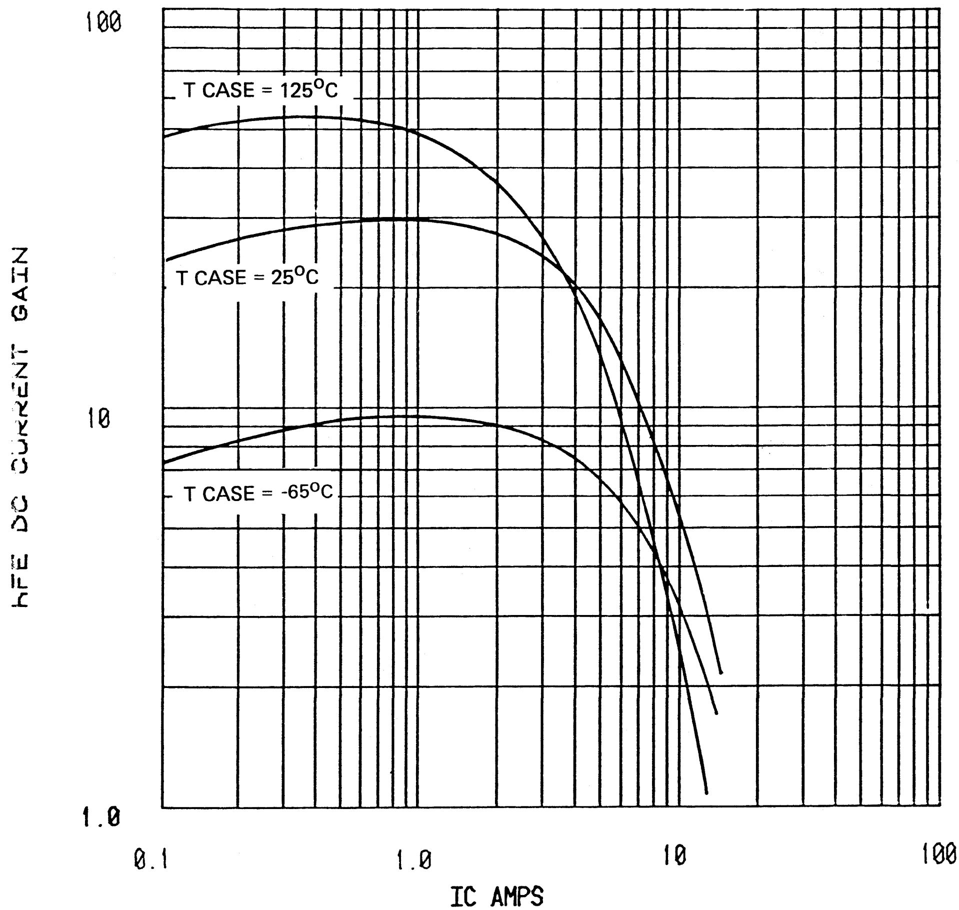


FIGURE 7 TYPICAL COLLECTOR SATURATION REGION

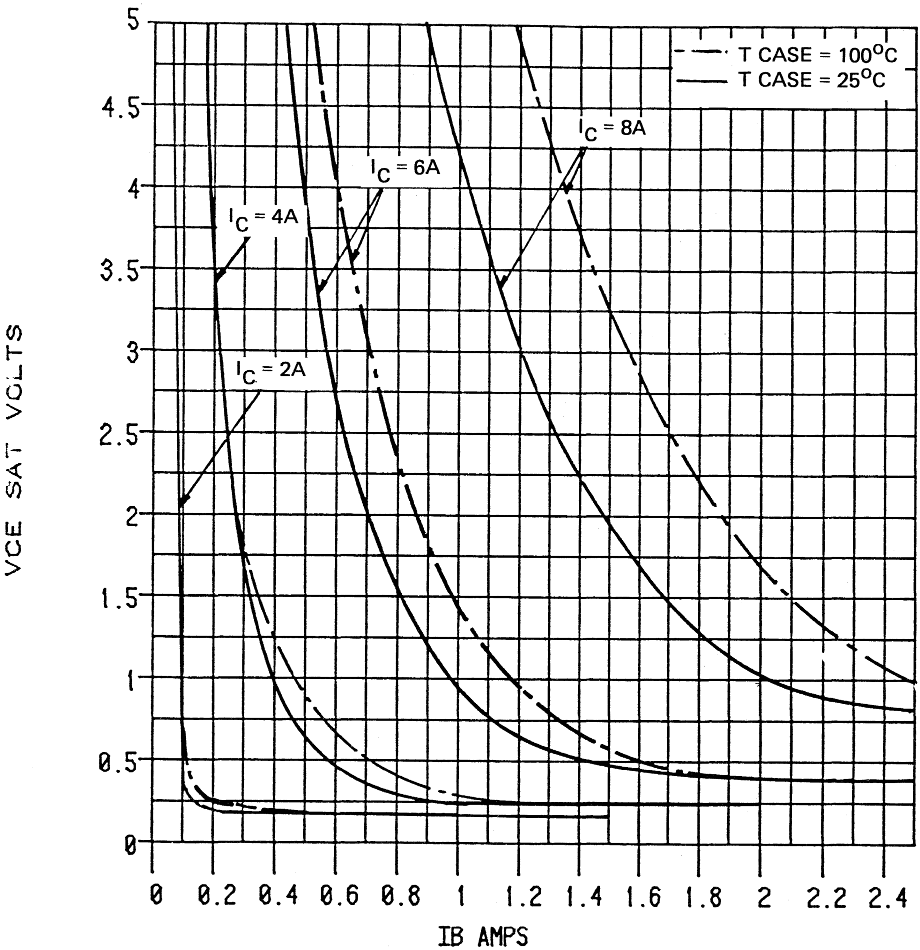


FIGURE 8 TYPICAL BASE SATURATION REGION T CASE=25°C

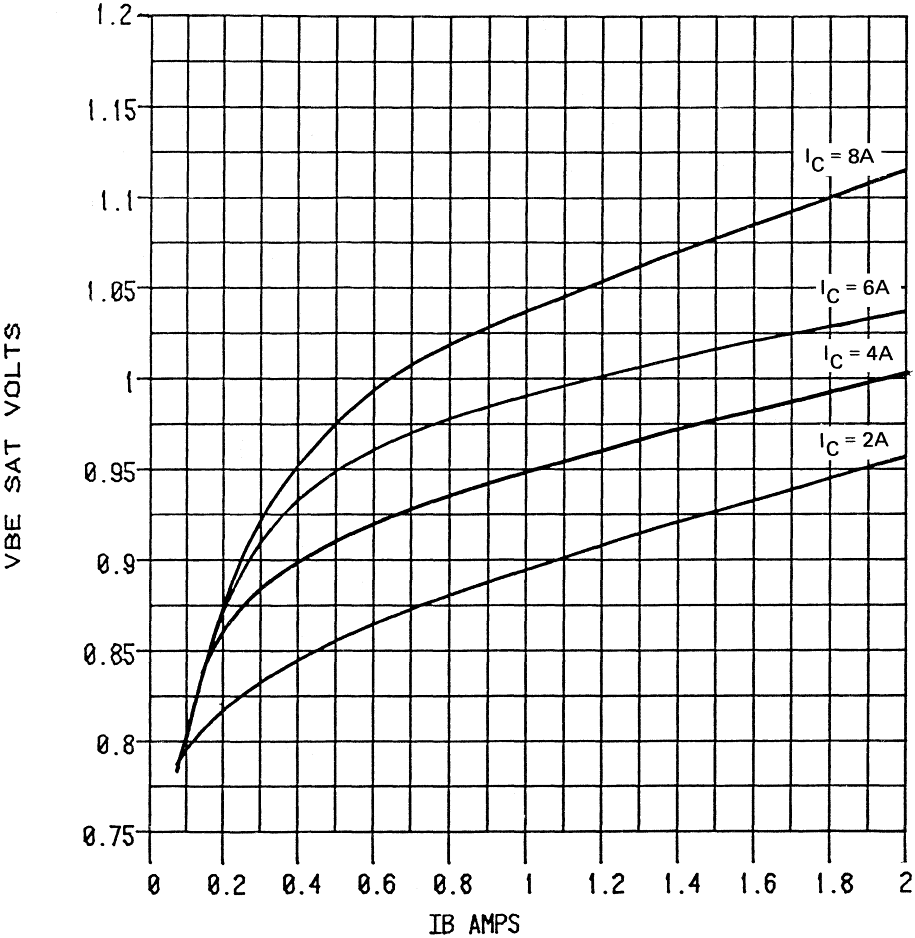


FIGURE 9 FORWARD BIASED SAFE AREA OF OPERATION DC AND PULSED T CASE=25°C

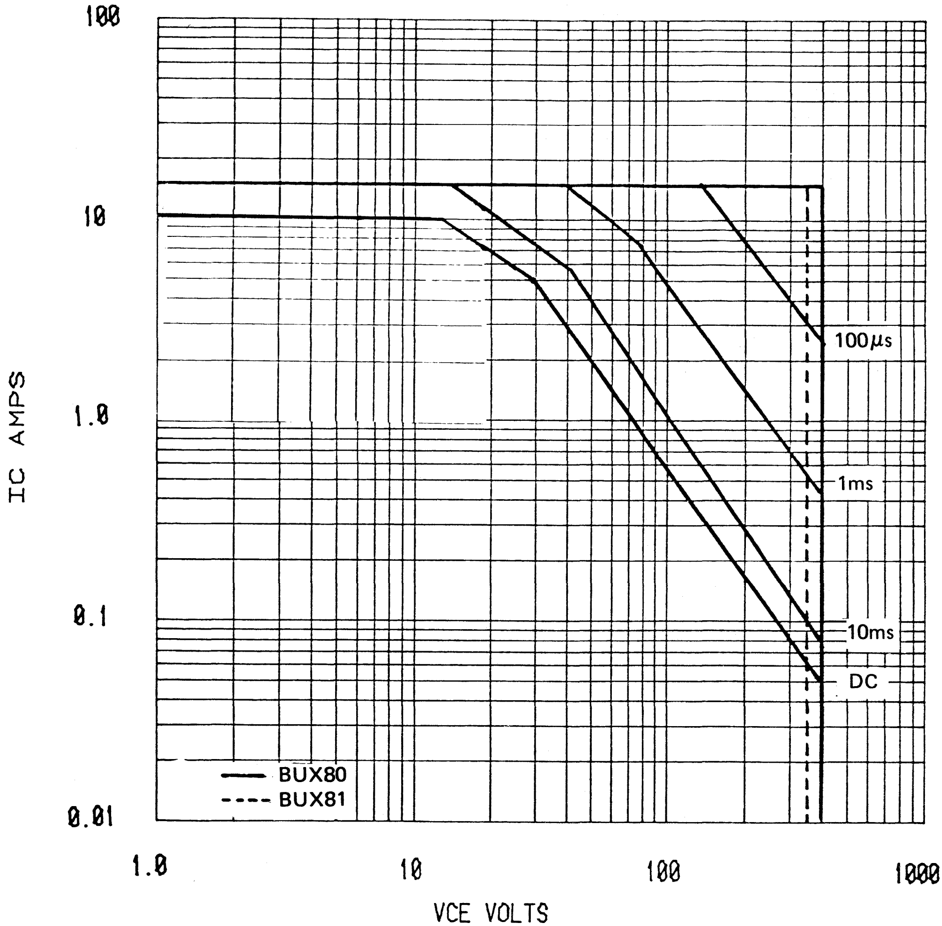


FIGURE 10 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

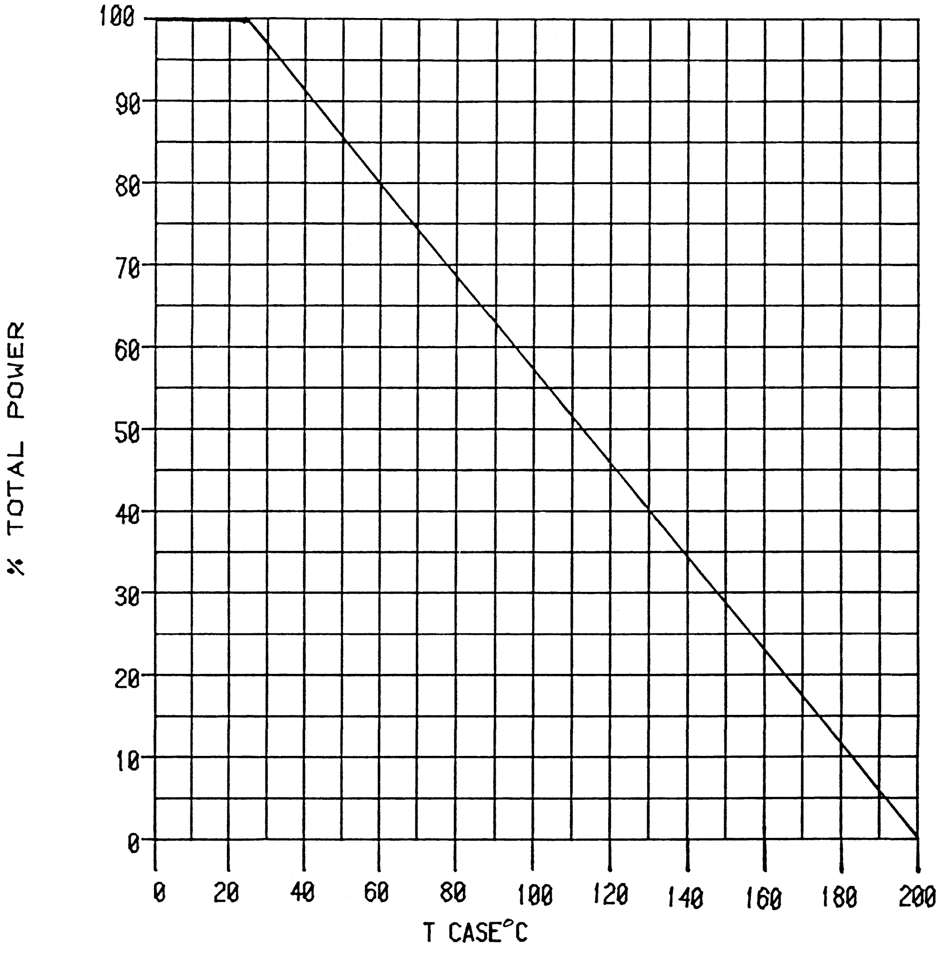


FIGURE 11 THERMAL RESPONSE

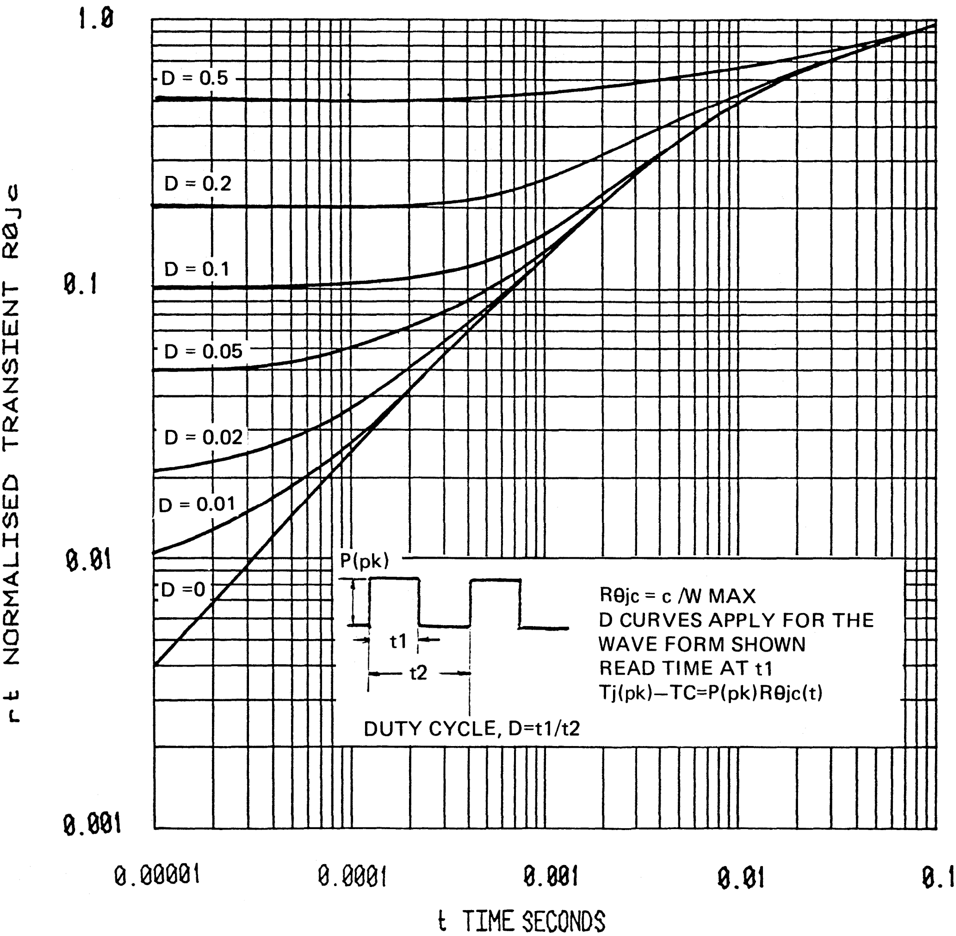


FIGURE 12 TRANSIENT "TURN-OFF" LIMIT IC VS VCE

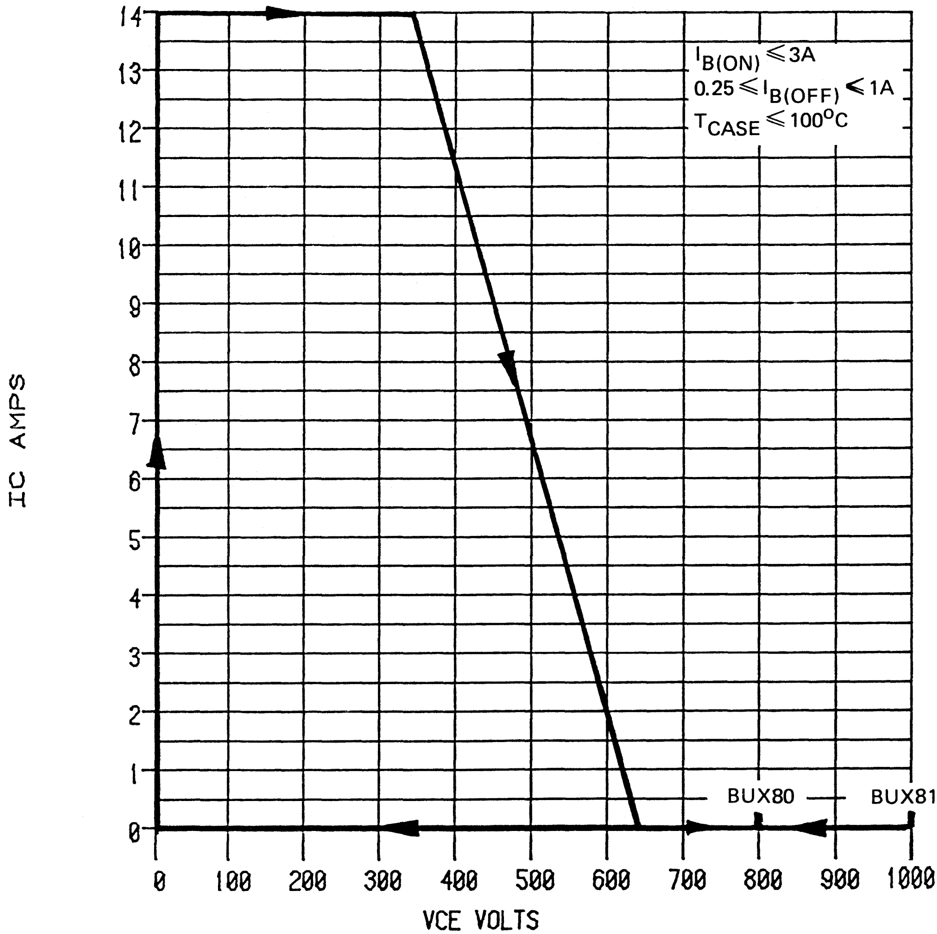
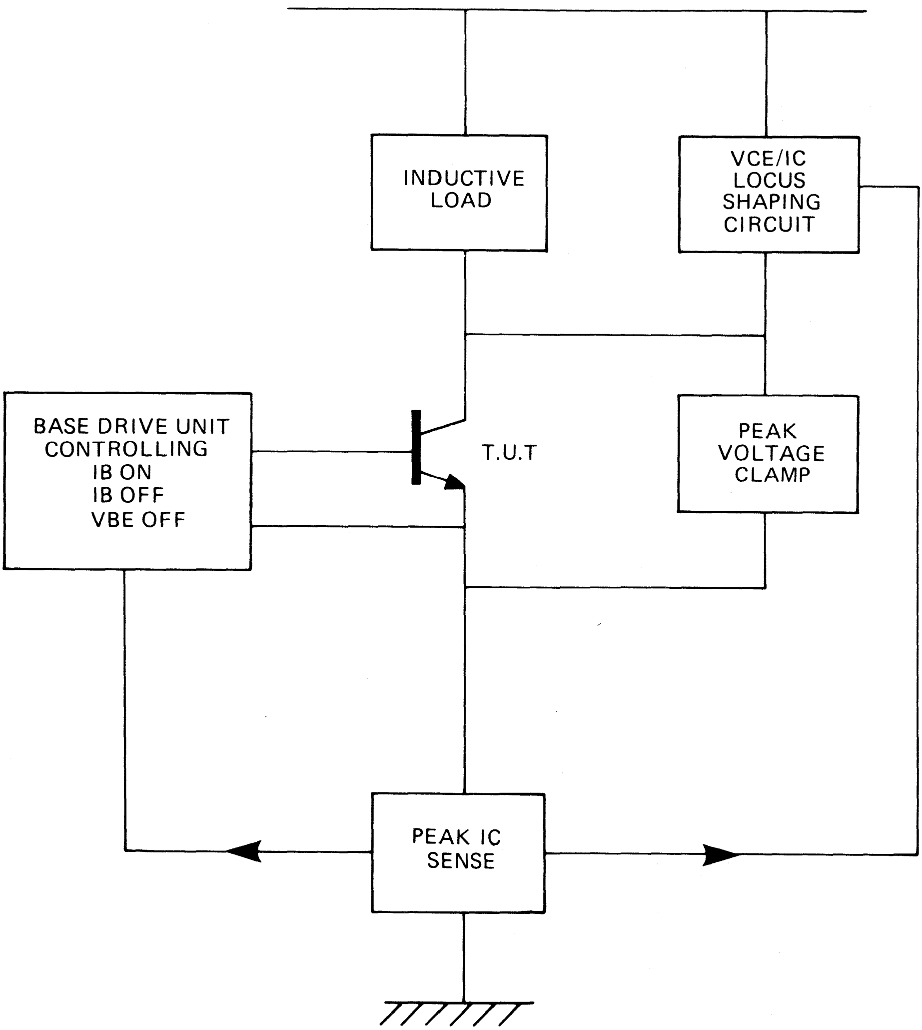


FIGURE 13 SWITCHING LOCUS TEST CIRCUIT



BUX82, BUX83
NPN SILICON POWER TRANSISTOR

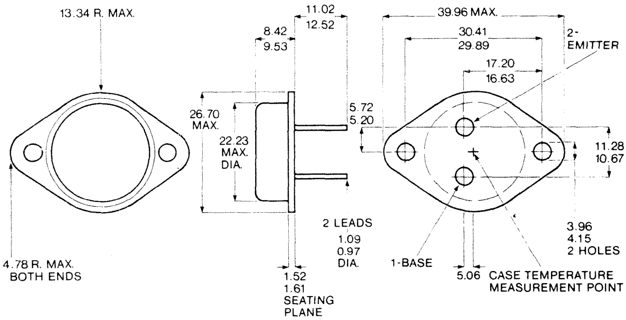
OCT 82

- **Designed for Switching-mode Power Supplies, CRT Scanning, Inverters and other Industrial Applications, where rapid switching of Inductive Load is necessary**

  This Series features High Voltage and Peak Current Ratings, Low Saturation Voltages, and a high degree of Electrical Robustness
- **Guaranteed Transient 'Turn-Off' Locus**

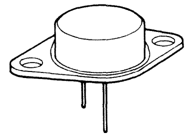
mechanical specifications

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



absolute maximum ratings (at 25 degrees centigrade ambient temperature)

	BUX82	BUX83
Collector-Base Voltage	800V	1000V
Collector-Emitter Voltage (VBE-0)	800V	1000V
Collector-Emitter Voltage (Open Base)	400V	450V
Continuous Collector Current	6A	6A
Peak Collector Current (Note 1)	8A	8A
Continuous Base Current	+2A/-0.1A	+2A/-0.1A
Peak Base Current (Note 1)	±3A	±3A
Continuous Dissipation Tcase = 50°C	60W	60W
Operating Junction Temperature	-65°C – 150°C	

Note 1 : Pulse Test, Pulse Duration = 2ms

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
VCEO SUST	Collector-emitter Sustaining voltage See Note 1	IC=100mA L=25mH	BUX82	400			V
			BUX83	450			V
V_{CER} SUST	Collector-emitter Sustaining voltage See Note 1	I_C = 100mA L = 15mH R_{BE} = 100Ω	BUX82 BUX83	500			V
ICEO	Collector cut-off Current (open base)	VCE=400V	BUX82			1	μA
		VCE=450V	BUX83			1	μA
ICES	Collector-emitter Cut-off current (VBE=0)	VCE=800V	BUX82			1	μA
		VCE=1000V	BUX83			1	μA
		VCE=800V 125°C	BUX82			150	μA
		VCE=1000V 125°C	BUX83			150	μA
IEBO	Emitter cut-off Current	VEB=10V IC=0				1	mA
VCE SAT	Collector emitter Saturation Voltage	IC=2.5A	IB=500mA			1.0	V
		IC=4A	IB=1.25A			2.0	V
VBE SAT	Base-emitter Saturation Voltage	IC=2.5A	IB=500mA			1.2	V
		IC-4A	IB=1.25A			1.4	V
hFE	Forward current Transistor ratio See Note 2	VCE-5V	IC=600mA		40		
ft	Current gain Band-width product	IC=200mA VCE=10V DC F=1MHz			12		MHz
Cob	Out put Capacitance	VCB=20V IC=OA F=0.1MHz			110		pF
Rθjc	Thermal Resistance Junction-case		BUX82/83			1.65	°C/W

switching characteristics at 25°C case temperature (unless otherwise specified)

Resistive Load		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ton	Turn on time	IC=2.5A VCC-250V			0.40	μs
ts	Storage time	IBON=0.5A IBOFF=1A			2.50	μs
tf	Fall time	T case=25°C			0.25	μs
ton	Turn on time	IC=2.5A VCC=250V			0.80	μs
ts	Storage time	IBON=0.5A IBOFF=1A			3.00	μs
tf	Fall time	T case=100°C			0.50	μs

Note 1. Inductive loop switching measurement
Note 2. Pulse width=300μs, duty cycle≤2%

FIGURE. 1 RESISTIVE SWITCHING CIRCUIT

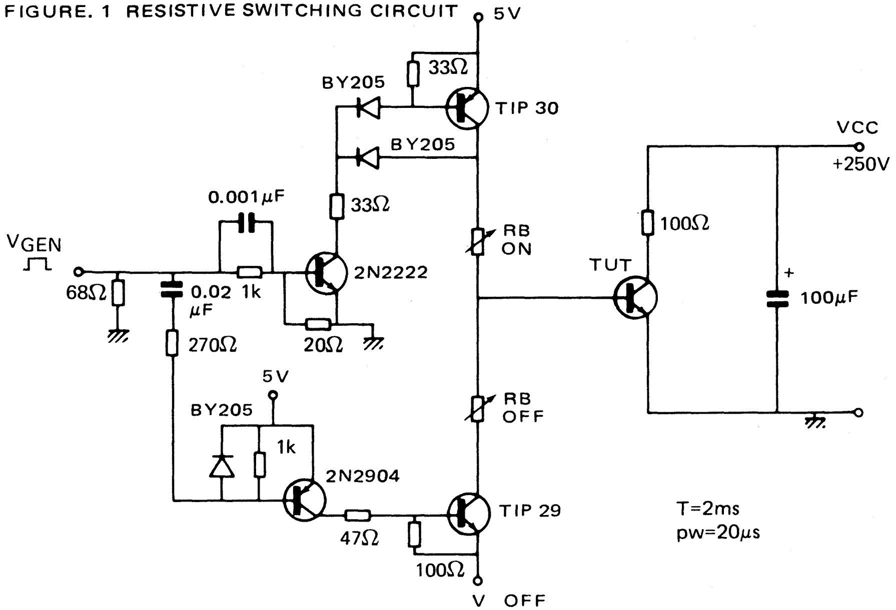


FIGURE 2. RESISTIVE SWITCHING WAVEFORMS

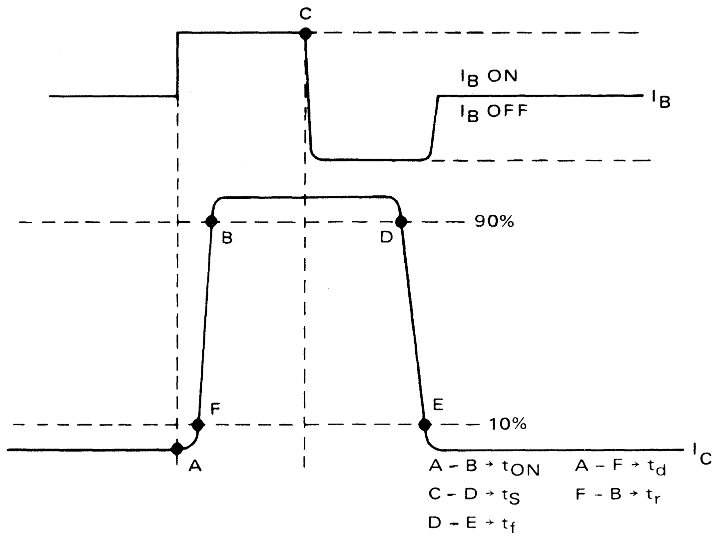


FIGURE 3. TYPICAL TURN-ON TIME T CASE=25°C (SEE FIGURE 1)

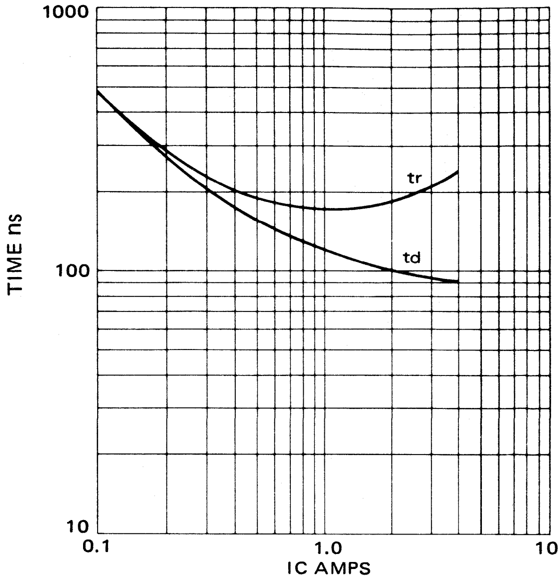


FIGURE 4. TYPICAL TURN-OFF TIME T CASE=25 C (SEE FIGURE 1)

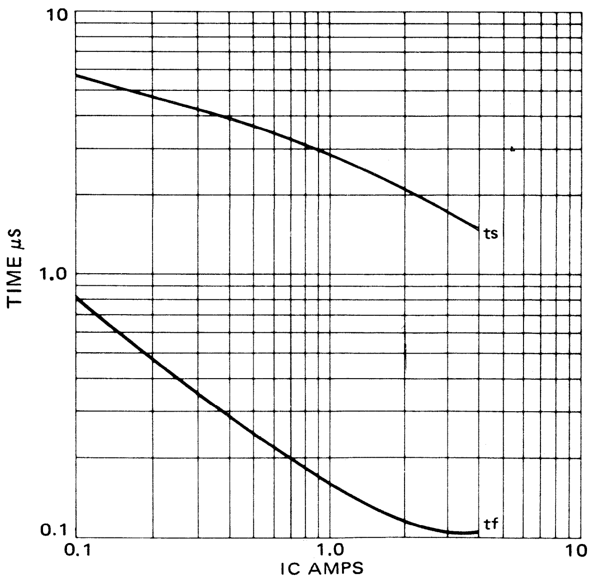


FIGURE 5. TYPICAL VARIATION OF VCESAT WITH IB

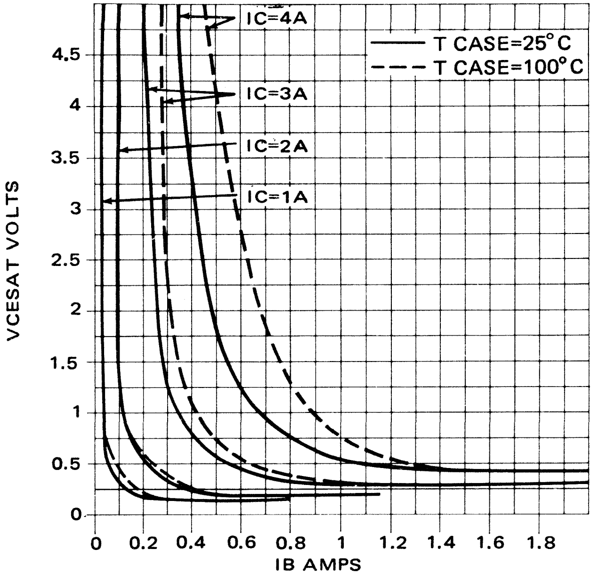


FIGURE 6. TYPICAL VARIATION OF VBESAT WITH IB

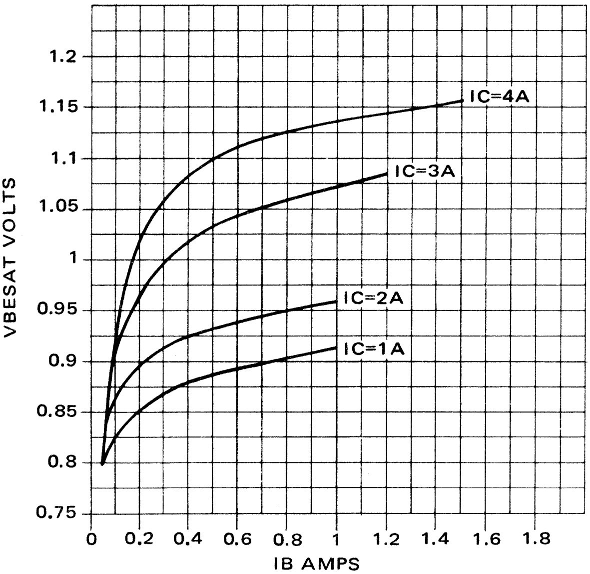


FIGURE 7. TYPICAL VARIATION OF FORWARD CURRENT TRANSFER RATIO VCE=5V

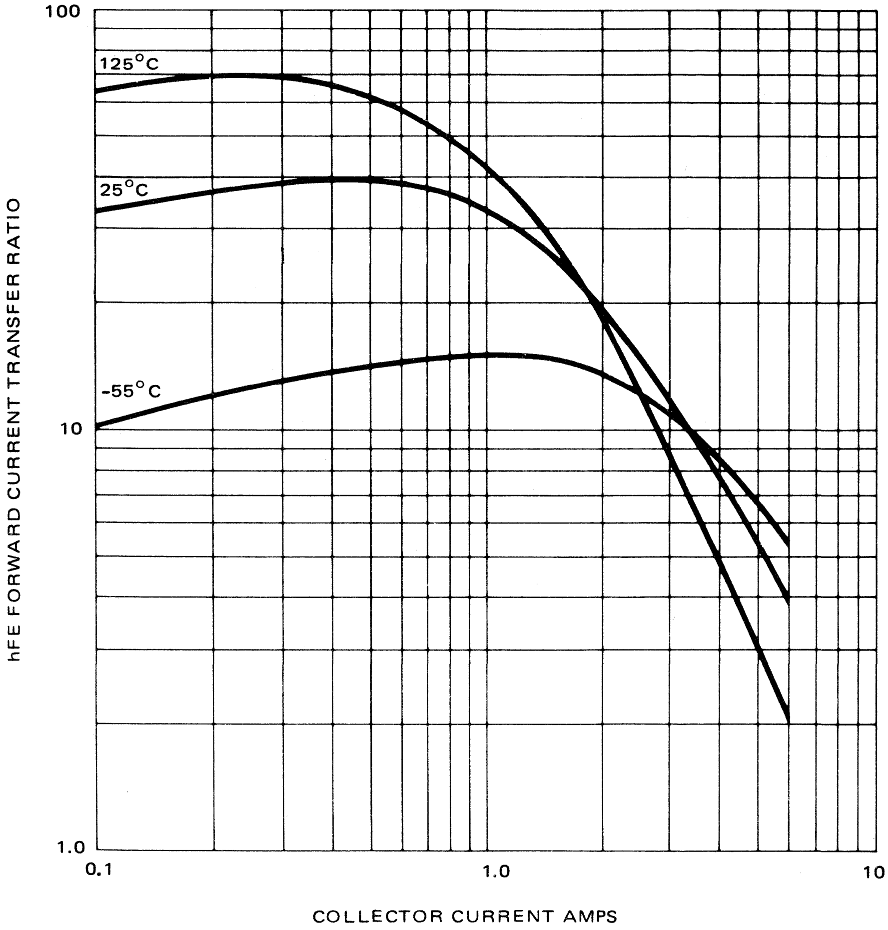


FIGURE 8. TYPICAL VARIATION OF ICES WITH TEMPERATURE

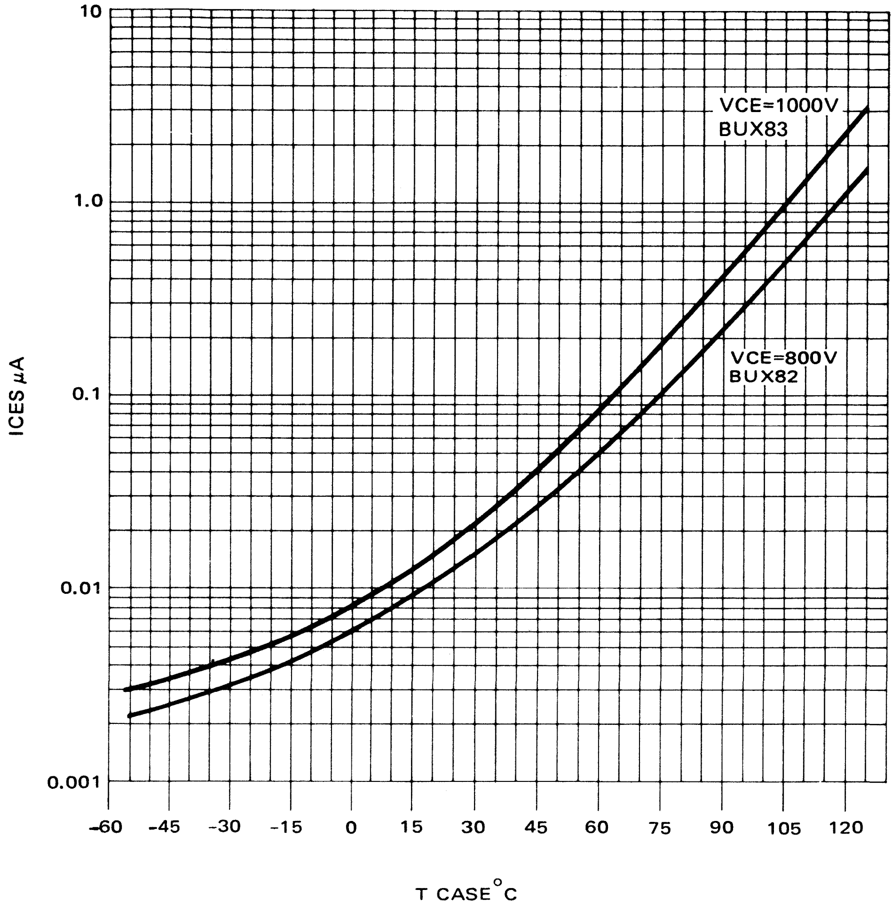


FIGURE 9. FORWARD BIASED SAFE AREA OF OPERATION DC & REP PULSE TC=25°C

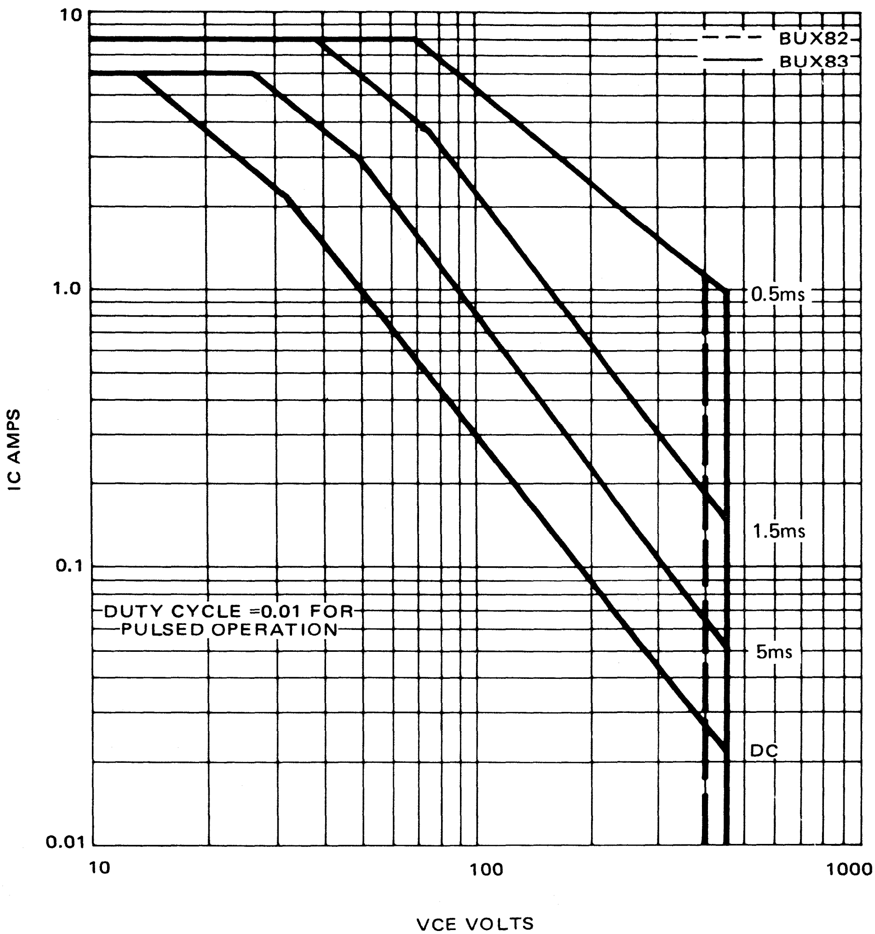


FIGURE 10. THERMAL RESPONSE

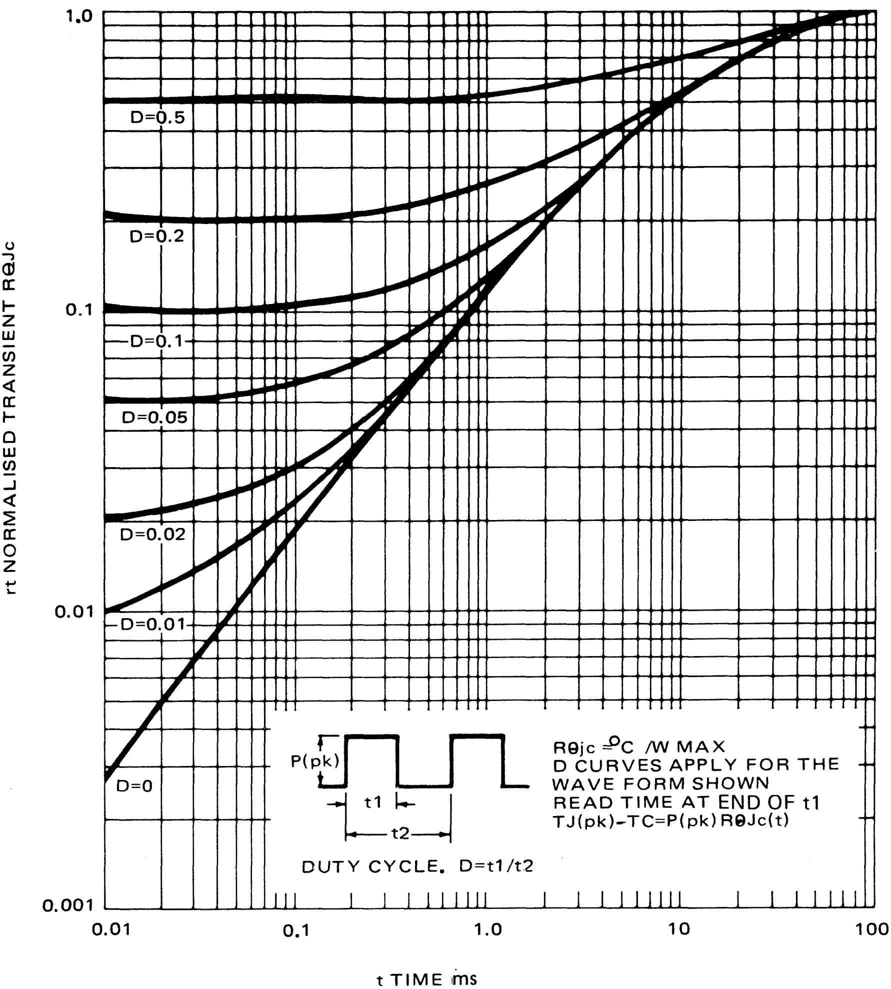


FIGURE 11. MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

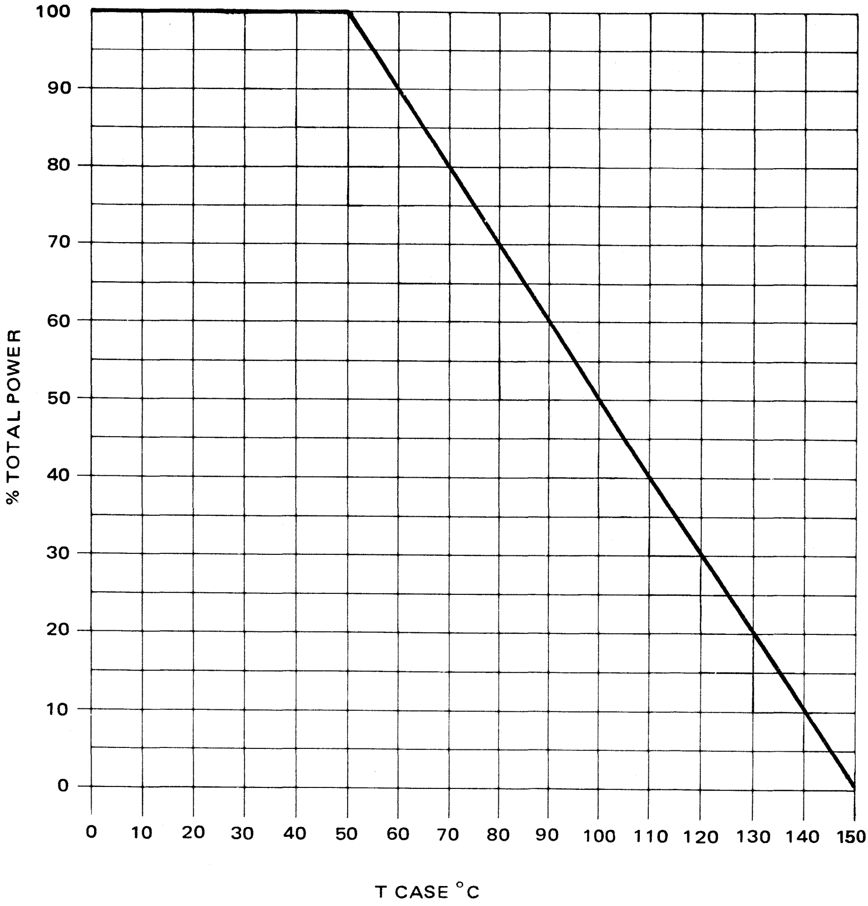


FIGURE 12. TRANSIENT 'TURN-OFF' LIMIT IC VS VCE TC=100°C

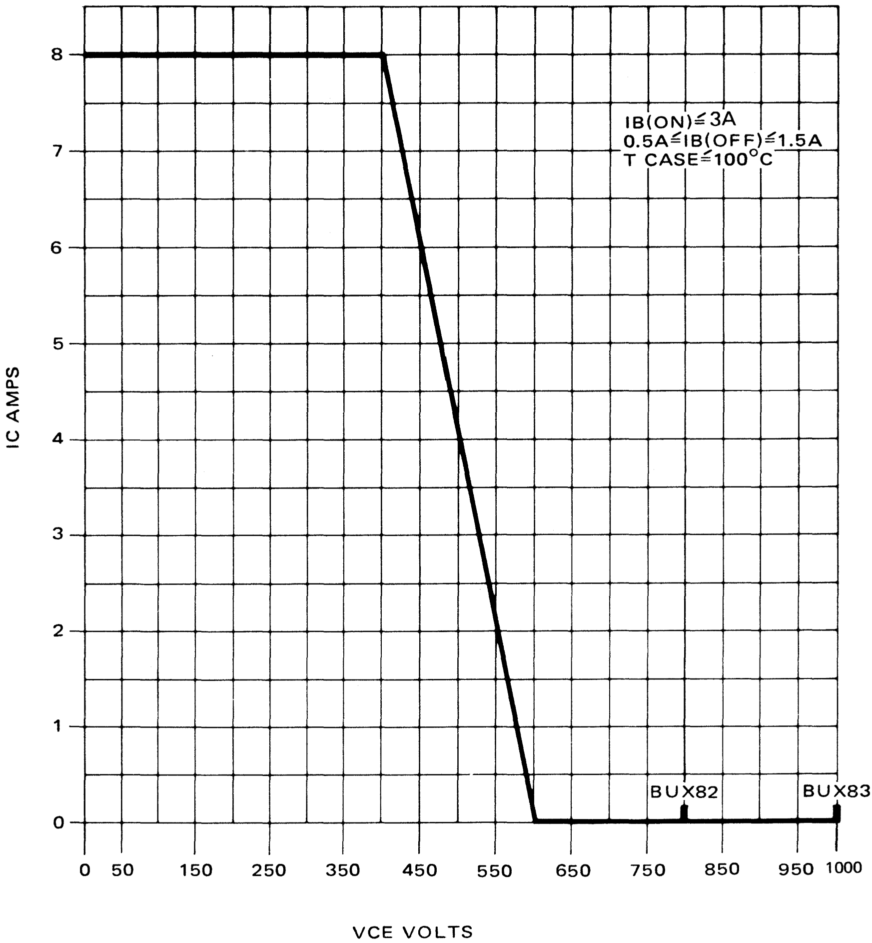
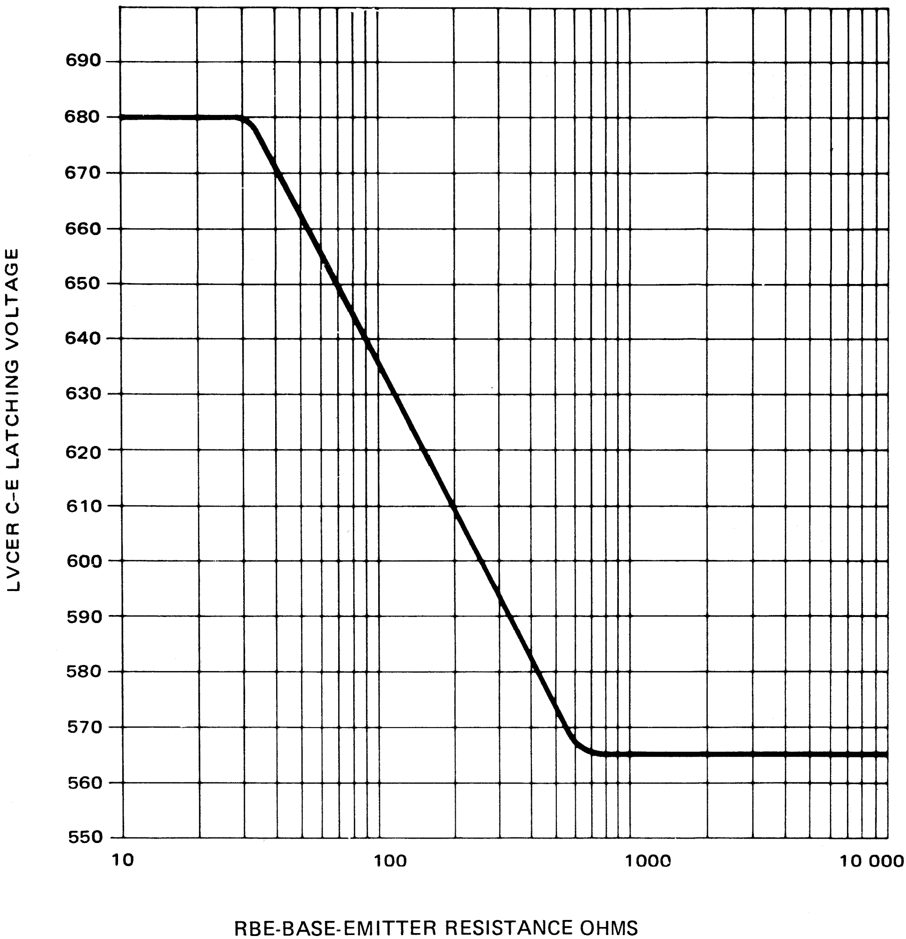


FIGURE 13. TYPICAL VARIATION OF LVCER WITH RBE



BUX84, BUX85
NPN SILICON POWER TRANSISTOR

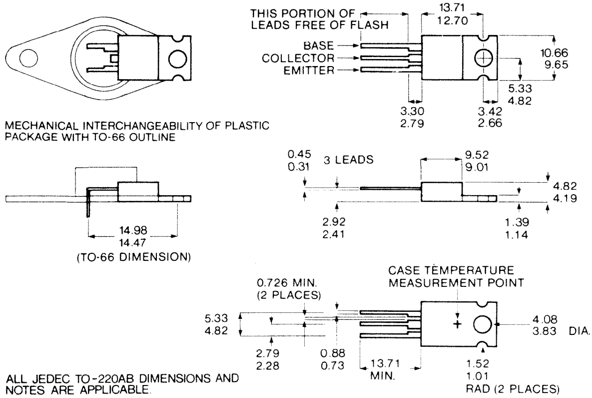
OCT 82

PRELIMINARY DATA

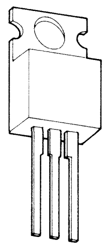
- DESIGNED FOR SWITCHING-MODE POWER SUPPLIES, CRT SCANNING, INVERTERS AND OTHER INDUSTRIAL APPLICATIONS, WHERE RAPID SWITCHING OF INDUCTIVE LOAD IS NECESSARY

MECHANICAL SPECIFICATION

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS (AT 25 DEGREES CENTIGRADE AMBIENT TEMPERATURE)

	BUX84	BUX85
Collector-Base Voltage	800V	1000V
Collector-Emitter Voltage (VBE=0)	800V	1000V
Collector-Emitter Voltage (Open Base)	400V	450V
Continuous Collector Current	2A	2A
Peak Collector Current (Note 1)	3A	3A
Continuous Base Current	0.75A	0.75A
Peak Base Current	±1A	±1A
Continuous Dissipation	40W	40W
Operating Junction Temperature	-65°C to +150°C	

NOTE 1 : Pulse Test, Pulse Duration = 2ms

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE SPECIFIED)

	PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
VCEO SUST	Collector-Emitter Sustaining Voltage See Note 2	IC=100mA L=25mH		BUX84 BUX85	400 450			V V
ICEO	Collector Cut-Off Current (Open Base)	VCE=400V VCE=450V		BUX84 BUX85			200 200	μA μA
ICES	Collector-Emitter Cut-Off Current (VBE=0)	VCE=800V VCE=1000V VCE=800V VCE=1000V	 125°C 125°C	BUX84 BUX85 BUX84 BUX85			200 200 1.5 1.5	μA μA mA mA
IEBO	Emitter Cut-Off	VEB=5V	IC=0				1	mA
VCE SAT	Collector Emitter Saturation Voltage	IC=0.3A I_C = 1.0A	IB=30mA I_B = 0.2A				0.8 1.0	V V
VBE SAT	Base-Emitter Saturation Voltage	IC=1.0A	IB=200mA				1.1	V
hFE	Forward Current Transfer Ratio See Note 3	VCE=5V	IC=1A			35		
ft	Current Gain Band-Width Product	IC=200mA F=1MHz	VCE=10V DC			12		MHz
Cob	Output Capacitance	VCB=20V F=0.1MHZ	IC=0A			110		pf
Rθjc	Thermal Resistance Junction-Case			BUX84/85			2.5	°C/W
$R\theta_{ja}$	Thermal Resistance Junction-Ambient			BUX84/85			70	°C/W

SWITCHING CHARACTERISTICS AT 25°C (UNLESS OTHERWISE STATED)

	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
RESISTIVE LOAD							
ton	Turn On Time	IC=1.0A	VCC=250V		0.25	0.50	μs
ts	Storage Time	IBON=0.2A	IBOFF=0.4A		2.50	3.5	μs
tf	Fall Time	T CASE=25°C			0.4		μs
tf	Fall Time	T CASE=95°C				1.40	μs

NOTE 2: Inductive Loop Switching Measurement
NOTE 3: Pulse Width=300μs, Duty Cycle=2%

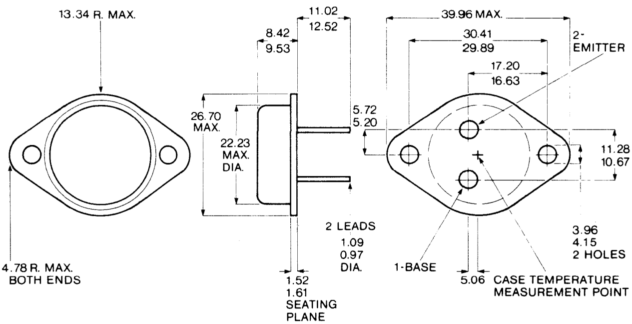
BUX 97, BUX 97A, BUX 97B
NPN SILICON POWER TRANSISTOR

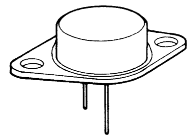
OCT 82

- Designed for switching-mode power supplies, CRT scanning inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness

MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

	BUX97	BUX97A	BUX97B
Collector-Emitter Voltage (VBE = -2.5V)	750V	800V	800V
Collector-Emitter Voltage (RBE = 10Ω)	500V	500V	500V
Collector-Emitter Voltage (Open Base)	350V	400V	450V
Continuous Collector Current	6A	6A	6A
Peak Collector Current (Note 1)	8A	8A	8A
Base Current	3A	3A	3A
Continuous Dissipation T Case = 75 °C	60W	60W	60W
Operating Junction Temperature	-65°C - +175°C		

Note 1: Pulse Test, Pulse Duration = 2ms.

TEXAS INSTRUMENTS

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{CEO} (SUST)	Collector-Emitter	I_C = 100 mA		BUX97	350			V
	Sustaining Voltage			BUX97A	400			V
	See Note 1			BUX97B	450			
I_{CES}	Collector-Emitter	V_{CE} = 750V		BUX97			1.0	mA
	Cut-off Current	V_{CE} = 800V		BUX 97A BUX97B			1.0	mA
	(V_{BE} = 0)	V_{CE} = 750V	150°C	BUX97			3.0	mA
		V_{CE} = 800V	150°C	BUX97A BUX97B			3.0	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 7V	I_C = 0				1	mA
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage See Note 1	I_C = 1A	I_B = 0.2A				1.0	V
		I_C = 4A	I_B = 1.25A				3.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage See Note 2	I_C = 1A	I_B = 0.2A				1.3	V
		I_C = 4A	I_B = 1.25A				1.8	V
h_{FE}	Forward Current Transfer Ratio See Note 2	V_{CE} = 5V	I_C = 1A		10		70	
f_t	Current Gain Band-Width Product	I_C = 200mA F = 1MHz	V_{CE} = 10V (dc)			12		MHz
C_{ob}	Output Capacitance	V_{CB} = 20V F = 0.1 MHz	I_C = 0A			110		pf
$R_{\theta jc}$	Thermal Resistance Junction-Case						1.67	°C/W

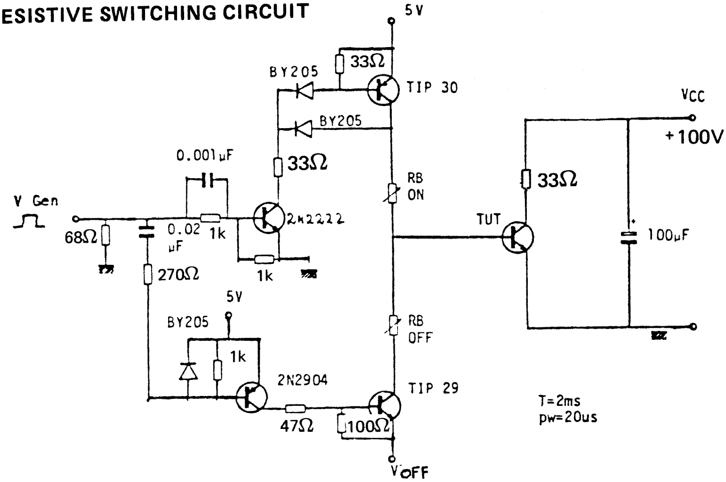
RESISTIVE LOAD

		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{on}	Turn-on Time	I_C = 4A V_{CC} = 100V		0.6		μs
t_s	Storage Time	I_{BON} = $-I_{BOFF}$ = 1.25A		2.0		μs
t_f	Fall Time	See figure 1.		0.5		μs

NOTE 1: These parameters are measured using pulse techniques
Pulse Width = 300μs, Duty cycle = 2%

NOTE 2: Inductive loop switching measurement

FIGURE 1 RESISTIVE SWITCHING CIRCUIT



Notes A The V_{gon} Waveform is supplied by the following characteristics:
$tr < 15ns$, $tf < 15ns$, Z out = 50Ω, tw=20µs duty cycle <2%

B Waveforms are monitored on an oscilloscope with the following characteristics:
$tr < 15ns$, $R_{in} > 10M\Omega$, $C_{in} < 11.5pF$.

C Resistors must be noninductive types.

FIGURE 2 RESISTIVE SWITCHING WAVEFORMS

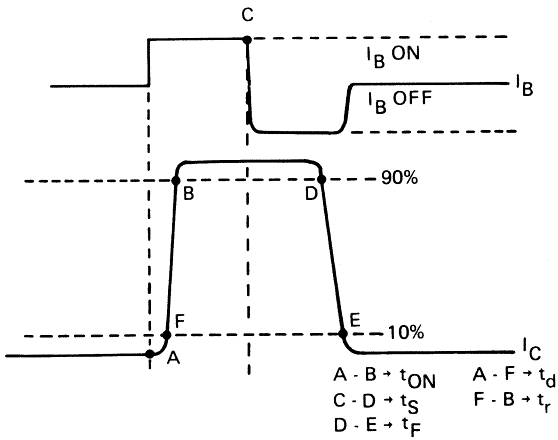


FIGURE 3 TYPICAL COLLECTOR SATURATION REGION

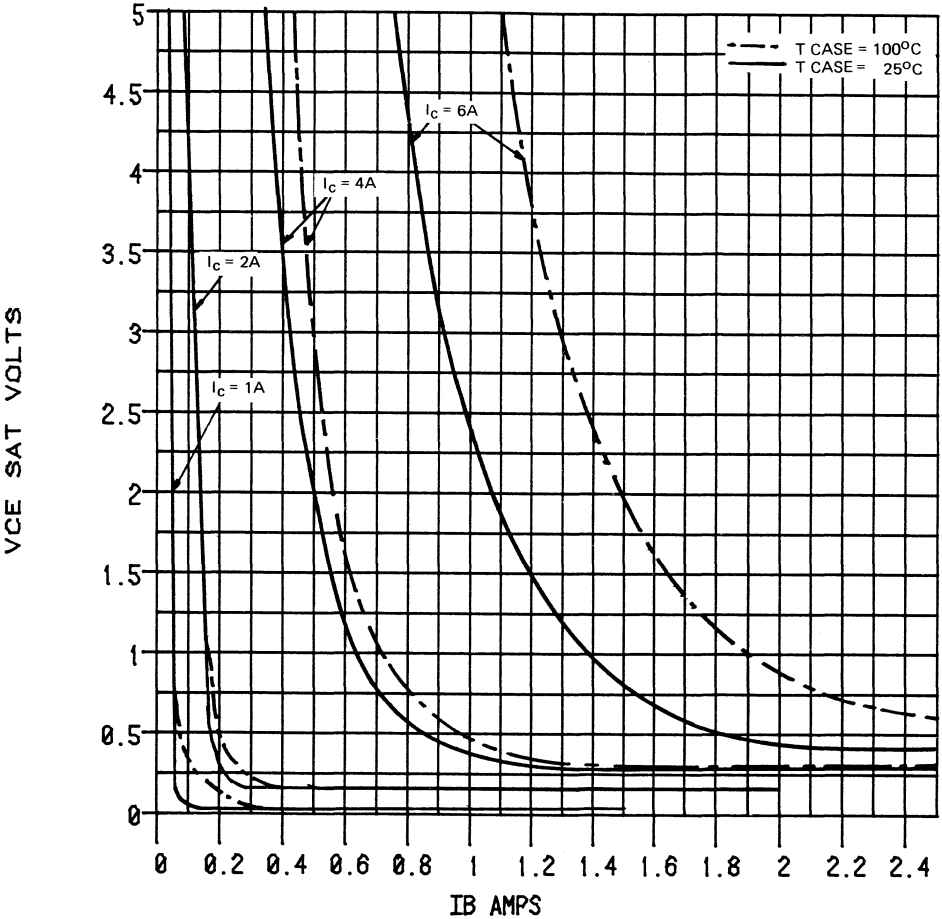


FIGURE 4 TYPICAL BASE SATURATION REGION T CASE=25°C

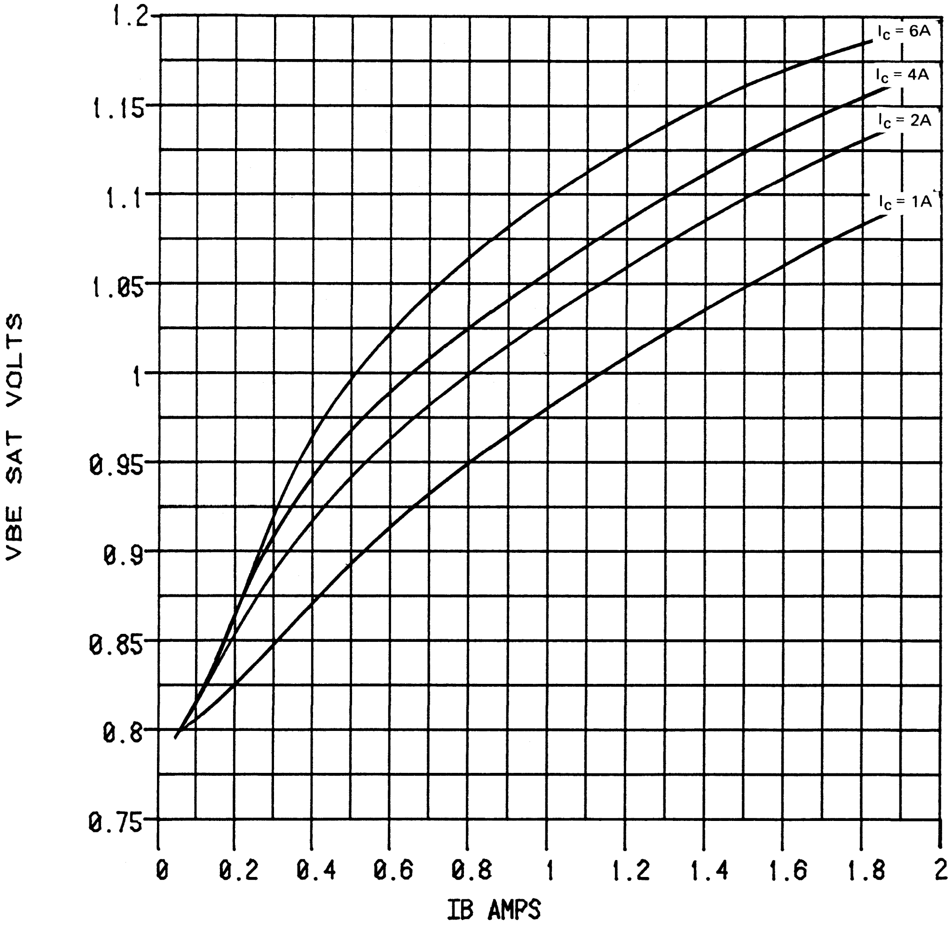


FIGURE 5 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

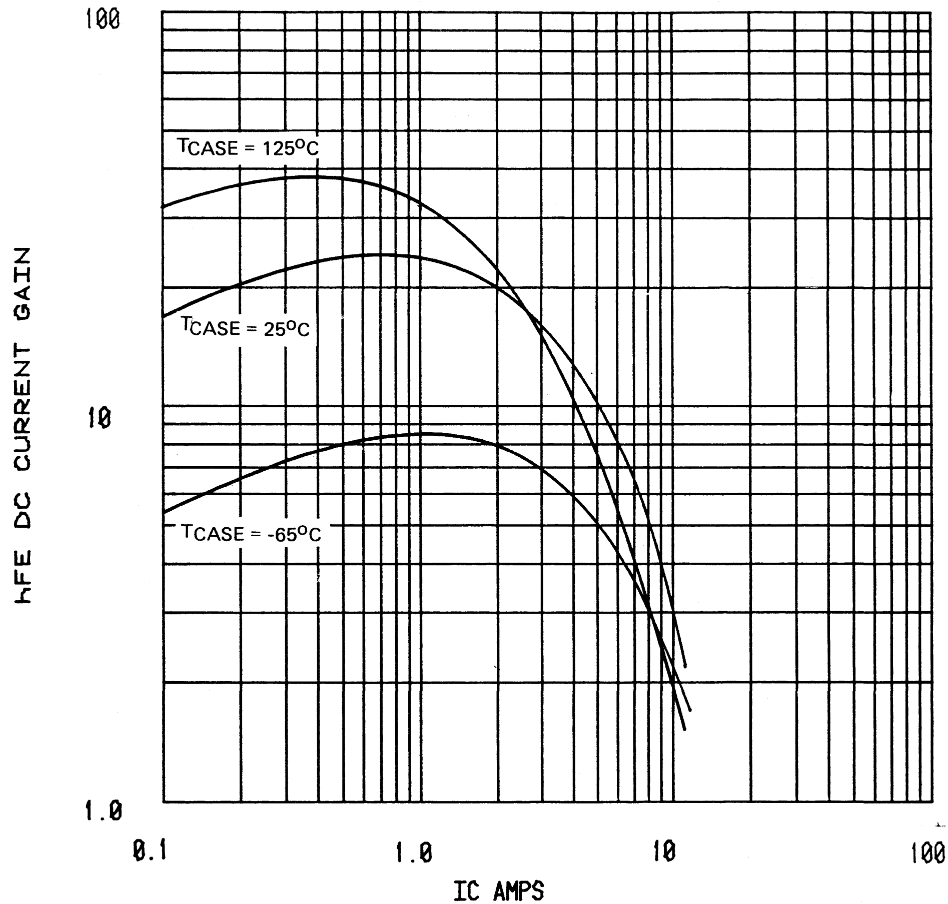


FIGURE 6 TYPICAL VARIATION OF ICES WITH TEMPERATURE

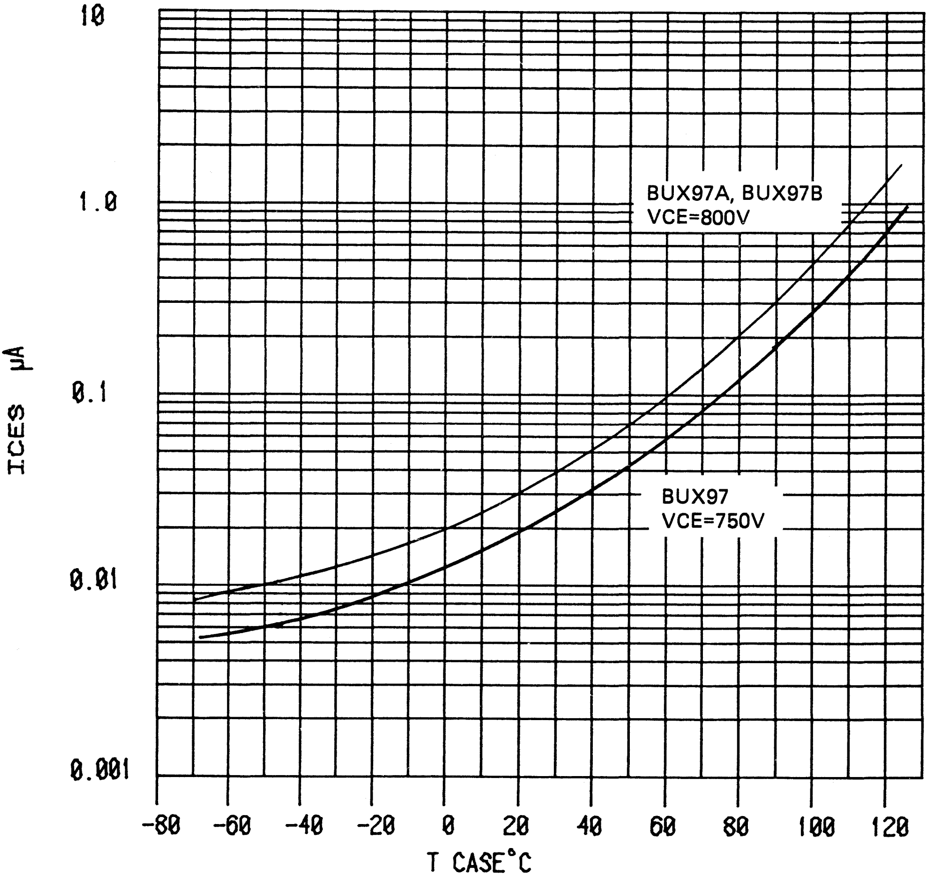


FIGURE. 7 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=75°C

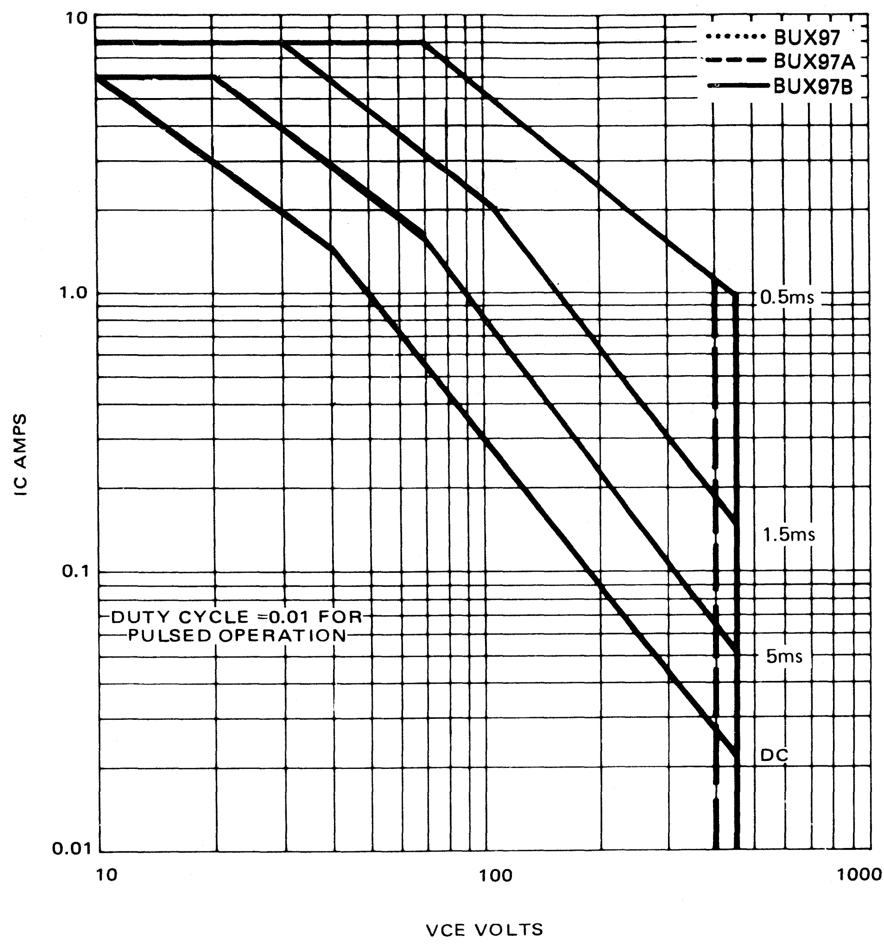


FIGURE 8 THERMAL RESPONSE

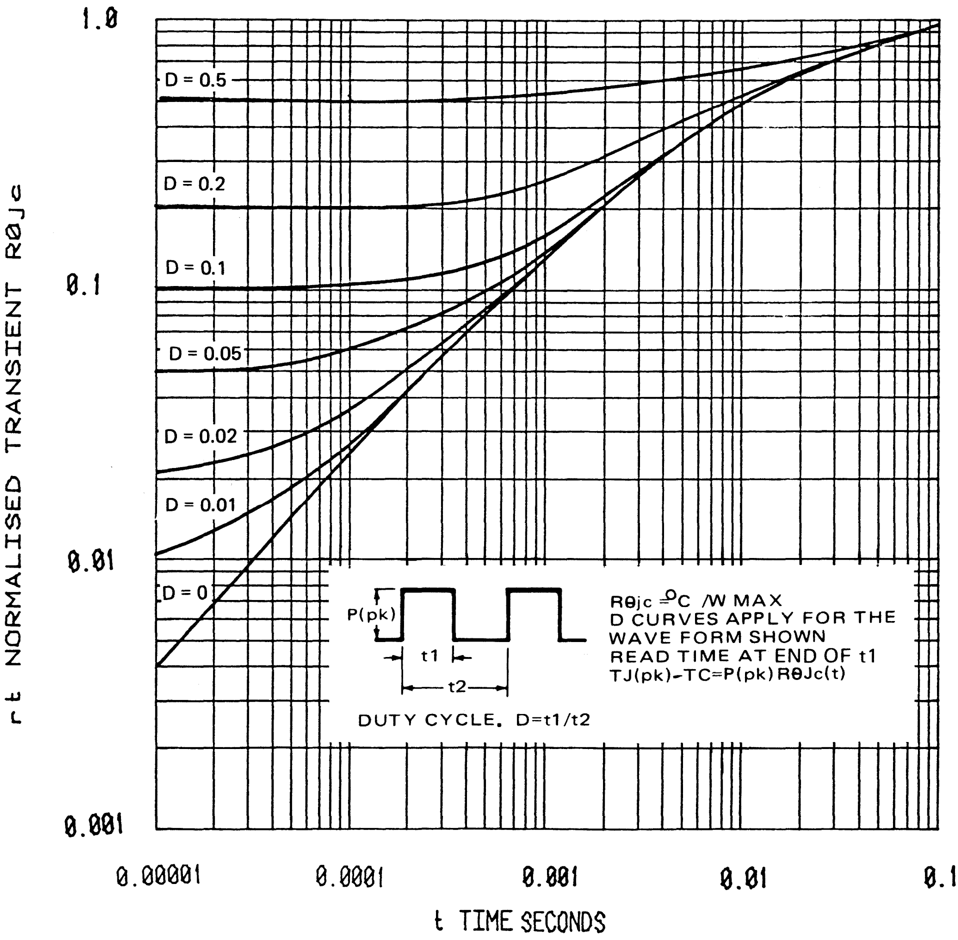
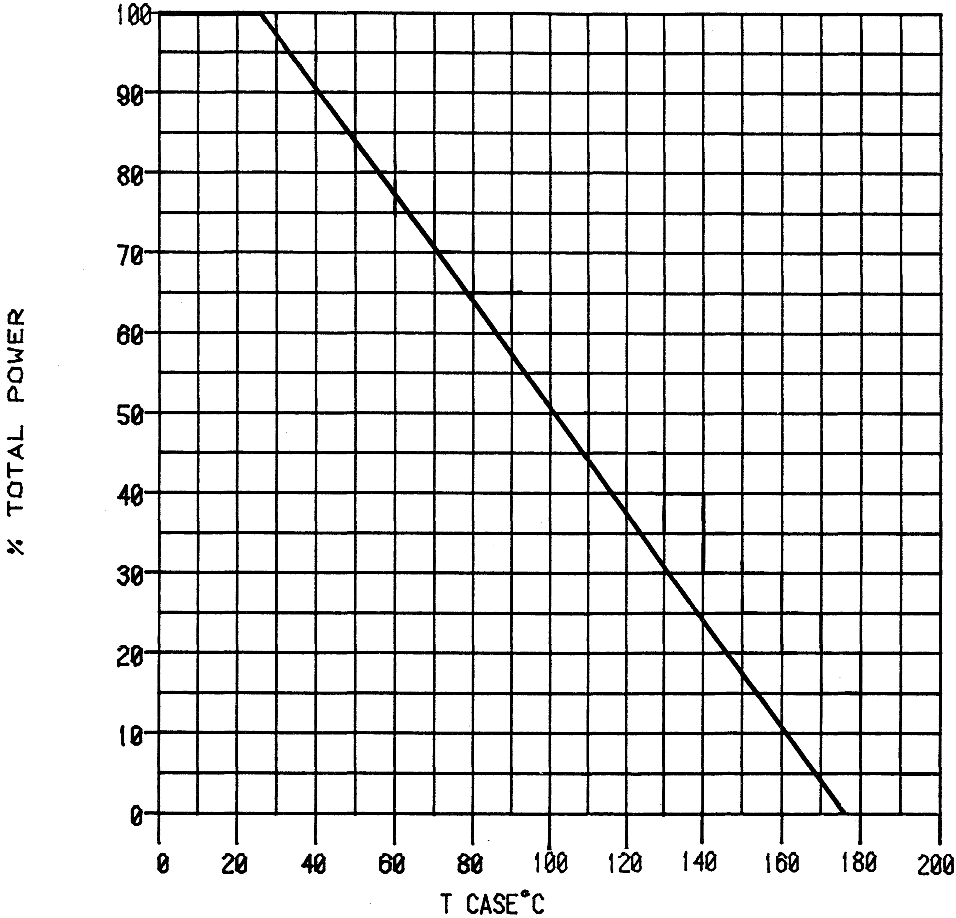


FIGURE 9 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE



BUY69 SERIES
NPN SILICON POWER TRANSISTORS

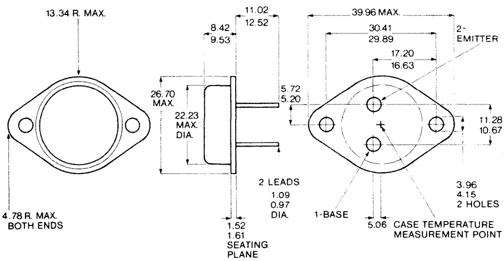
OCT 82

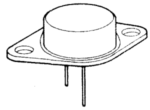
DESIGNED FOR SWITCHING-MODE POWER SUPPLIES, CRT SCANNING, INVERTERS AND OTHER INDUSTRIAL APPLICATIONS, WHERE RAPID SWITCHING OF INDUCTIVE LOADS IS NECESSARY.

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

mechanical specification

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

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

NOTES: 1. Pulse width ≤ 500 μs. Duty cycle ≤ 25 %.
2. 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 I_E = 0 (See note 2)	BUY69A BUY69B BUY69C	1000 800 500			V
LV_{CEO}	Collector-emitter latching voltage	I_C = 50 mA I_B = 0	BUY69A BUY69B BUY69C	400 325 200			V
BV_{EBO}	Emitter-base breakdown voltage	I_B = 10 mA	ALL	8			V
I_{CEX}	Collector-emitter leakage current	V_{CE} = 1000 V V_{CE} = 800 V V_{CE} = 500 V V_{BE} = −2 V	BUY69A BUY69B BUY69C			1 1 1	mA
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	3.2		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
$R\theta_{jc}$	Thermal Resistance Junction to Case					1.75	°C/W

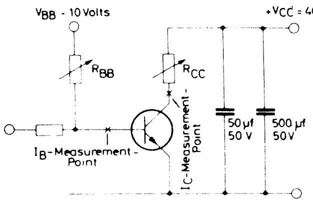
NOTES: 2. Pulse width ⩽ 500 μs. Duty Cycle ⩽ 25 %.
4. Pulse width ⩽ 300 μs. Duty Cycle ⩽ 2 %.

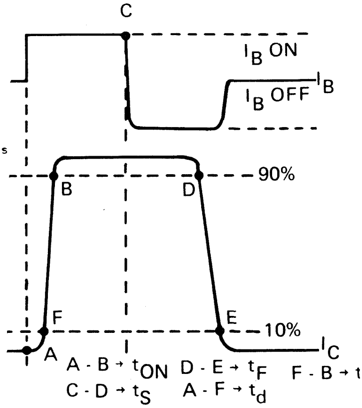
switching times (all types, at T_C = 25 °C) RESISTIVE

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

FIGURE 1 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 25 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.





DISSIPATION DERATING CURVE

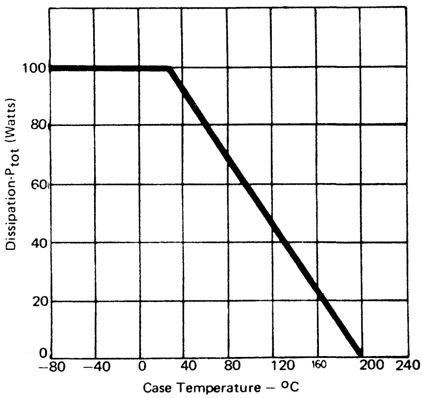


FIGURE 2

TYPICAL CHARACTERISTICS

TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT

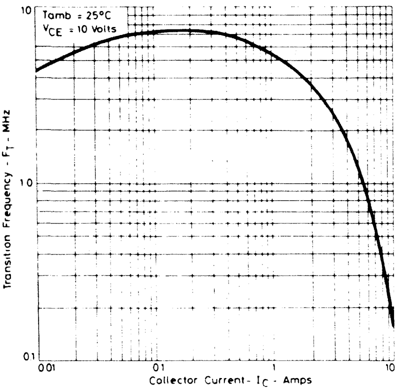


FIGURE 3

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

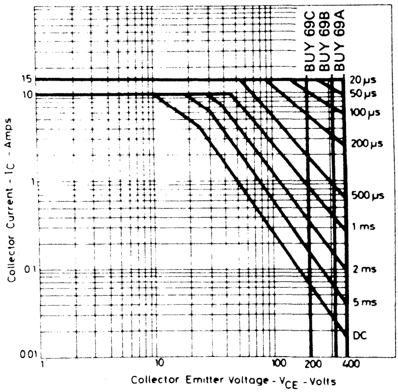


FIGURE 4

TYPICAL AND MAXIMUM VARIATION OF I_{CBO} WITH TEMPERATURE

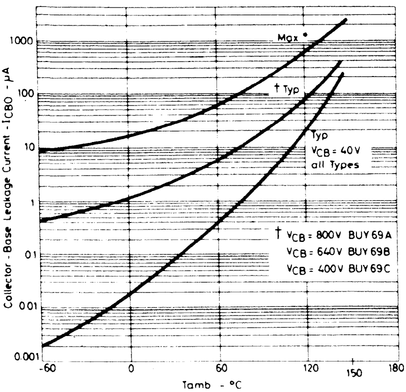


FIGURE 5

TYPICAL VARIATIONS OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

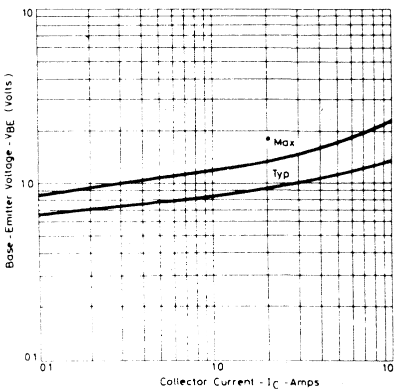


FIGURE 6

TYPICAL CHARACTERISTICS

TYPICAL VARIATION OF
STATIC FORWARD CURRENT TRANSFER RATIOS
WITH COLLECTOR CURRENT

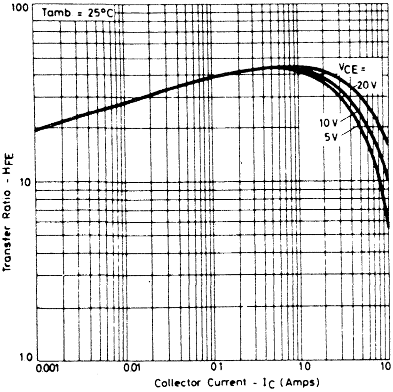


FIGURE 7

TYPICAL VARIATION OF COLLECTOR-EMITTER
SATURATION VOLTAGE WITH COLLECTOR CURRENT

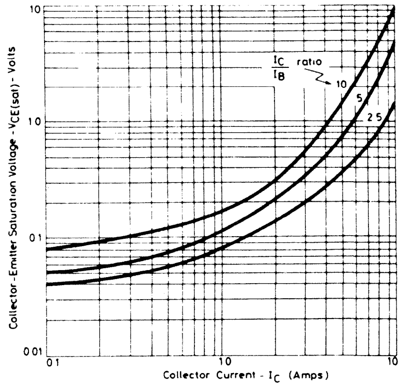


FIGURE 8

TYPICAL VARIATION OF STORAGE AND
FALL TIMES WITH COLLECTOR CURRENT

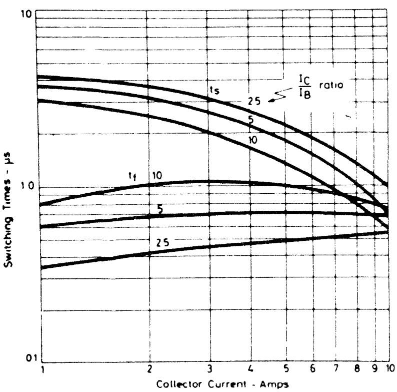


FIGURE 9

TYPICAL VARIATION OF DELAY AND RISE
TIMES WITH COLLECTOR CURRENT

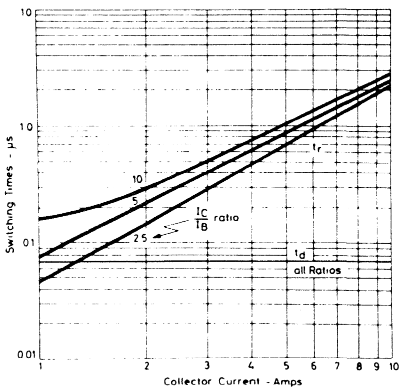


FIGURE 10

TYPICAL CHARACTERISTICS

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

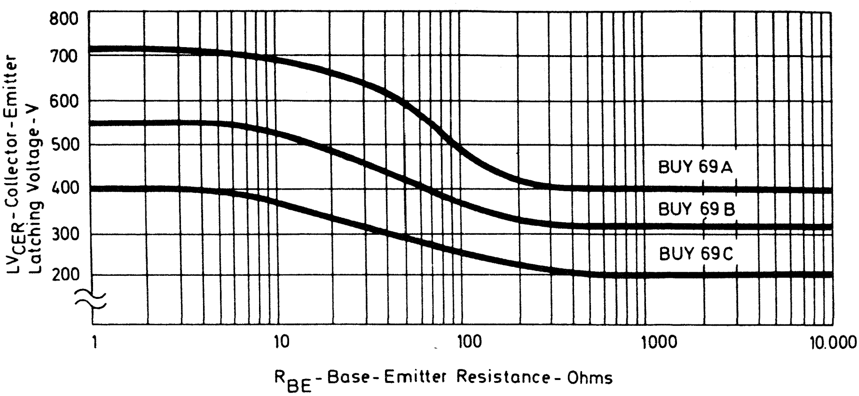


FIGURE 11

TYPICAL VARIATION OF STORAGE TIME WITH JUNCTION TEMPERATURE

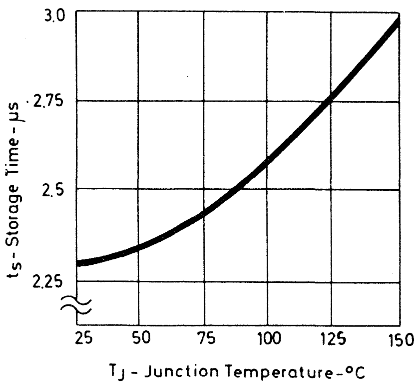
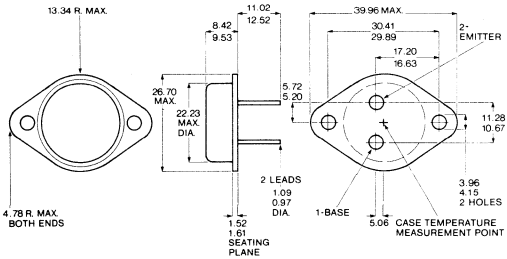


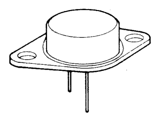
FIGURE 12

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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

Absolute Maximum Ratings (at 25°C case temperature)

	BUY70A	BUY70B	BUY70C	UNITS
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 Base Current	3	3	3	A
Continuous-Dissipation ($V_{CE} \leqslant$ 17V) (See Note 2)	75	75	75	W
Operating Temperature Range	−65°C to +200°C			

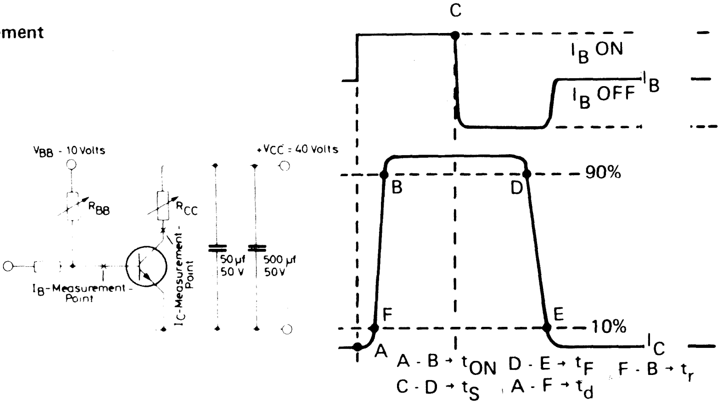
NOTES:
1. Pulse Width $\leqslant$ 500 μSec. Duty Cycle $\leqslant$ 25%
2. Refer to Safe Operating and Dissipation Derating Curves
3. Pulsed Test. Pulse Width $\leqslant$ 300 μSec. Duty Cycle $\leqslant$ 2%

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
$R\theta_{jc}$	Thermal Resistance Junction Case					2.3	°C/W

FIGURE 1 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 25 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 swithing time with collector current, see Figures 9 and 10.



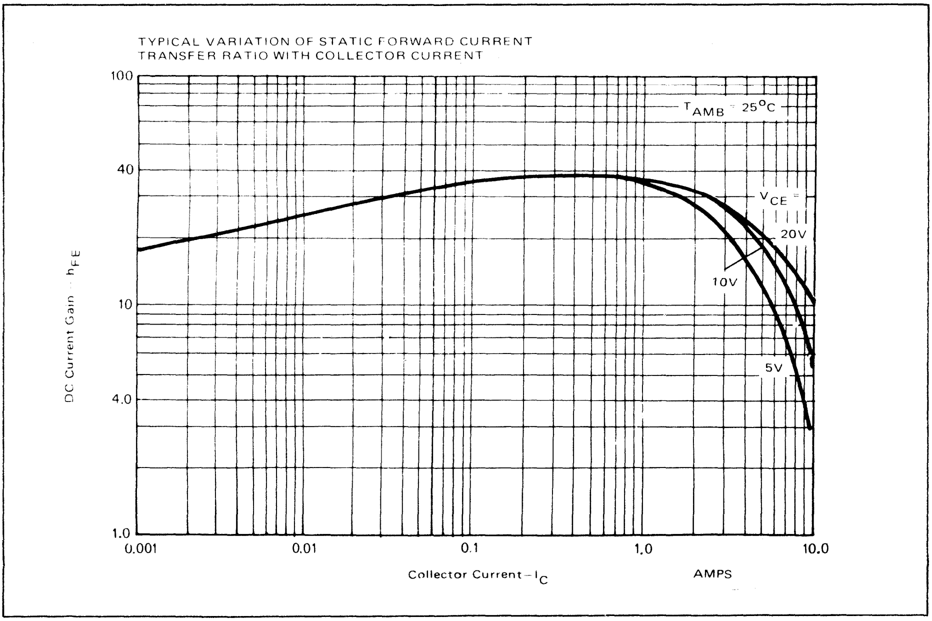


FIG 2

FORWARD BIASED SAFE AREA OF OPERATION
(NON REPETITIVE OPERATION)

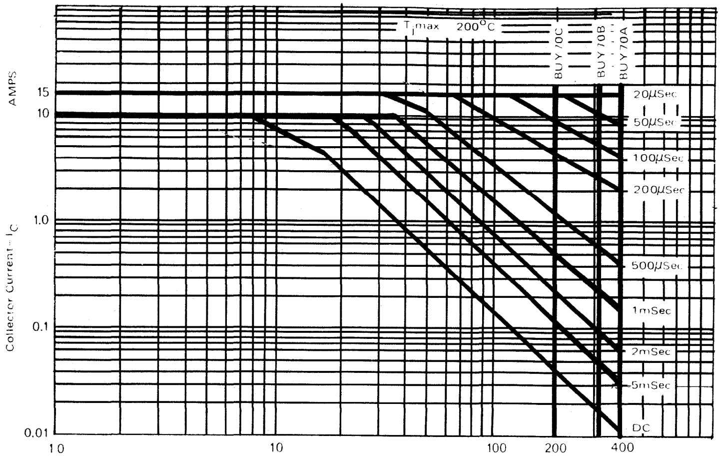


FIG 3

The graph of Forward Biased Safe Area of Operation is for single non-repetitive rectangular power pulses, with a case temperature held at 25°C.

For operation at case temperature above 25°C derate the value of current indicated in figure 3 by the power derating factor, determined from the derating curve.

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 from the derating curve.

Also calculate the average power dissipation and ensure that it falls within the steady state (DC) condition for the peak voltage applied, having first derated the steady state condition for the effect of case temperature.

DISSIPATION DERATING CURVE

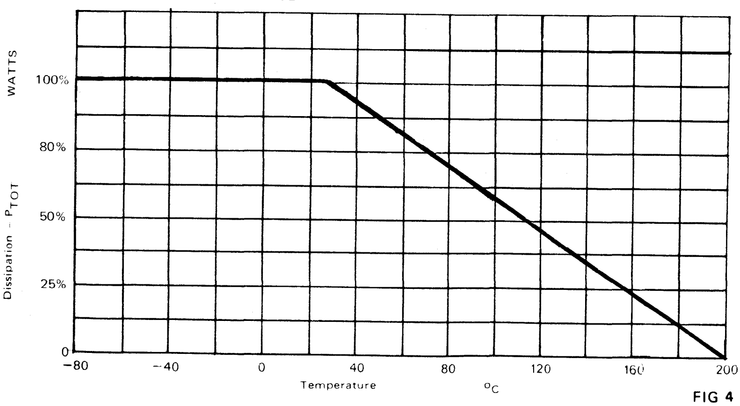


FIG 4

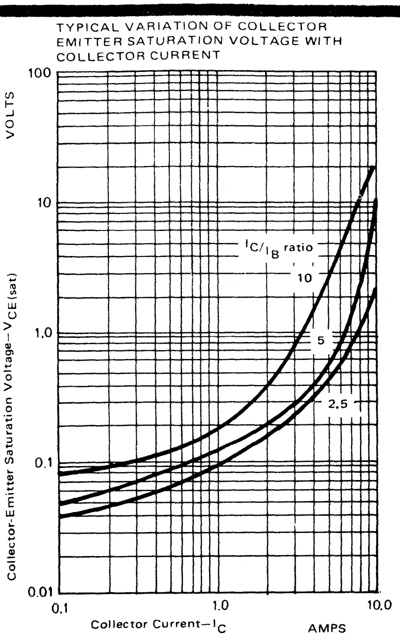


FIG 5

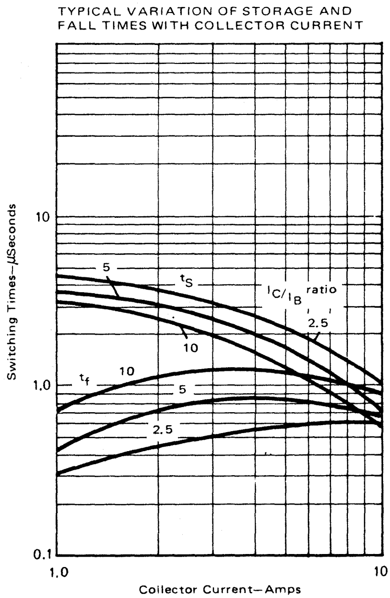


FIG 6

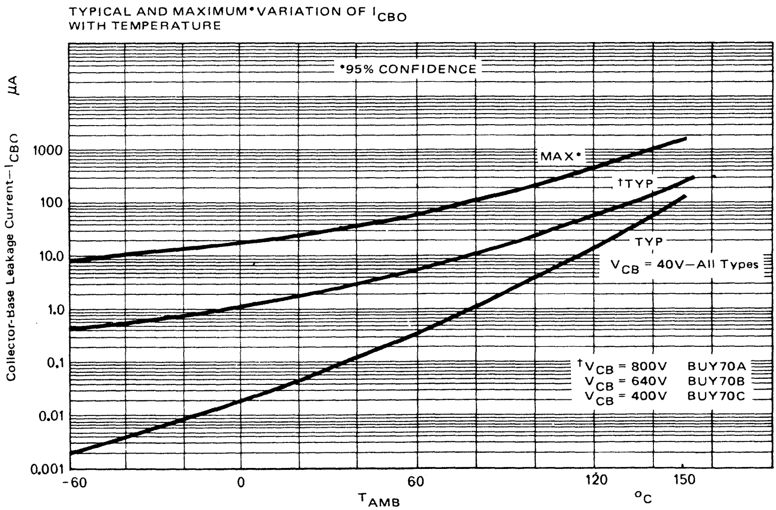


FIG 7

TYPICAL VARIATION OF BASE EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

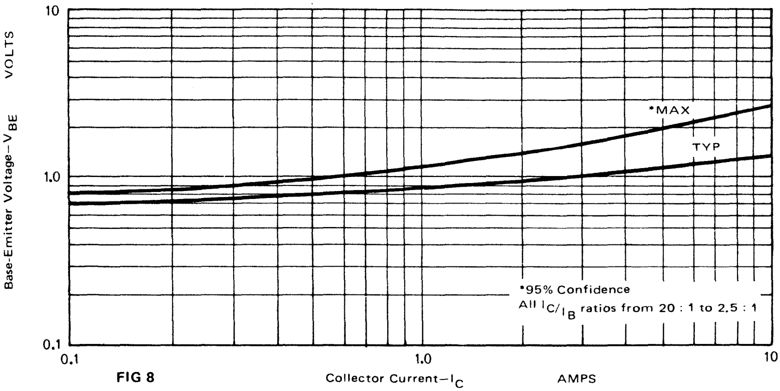


FIG 8

TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT

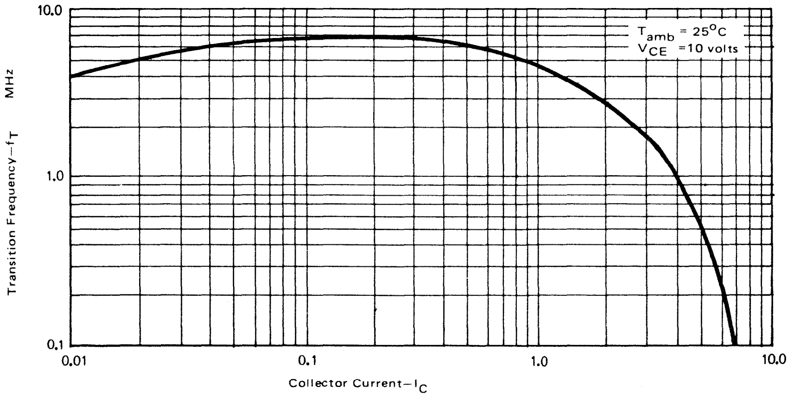


FIG 9

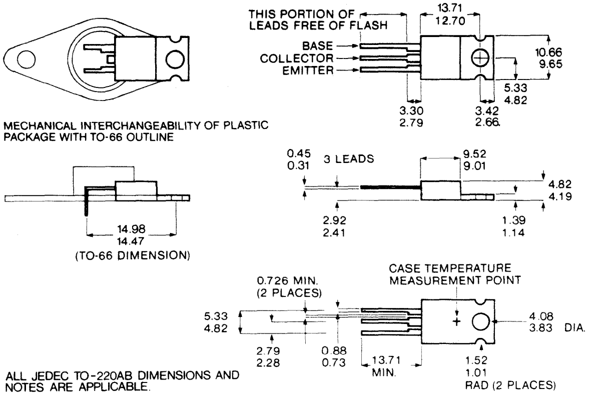
TIP29 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP30 SERIES

- **30W at 25°C Case Temperature**
- **1A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 200 mA**
- **Customer-specified selections available**
- **Also Available in Europe as BD239**

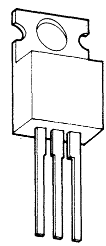
MECHANICAL DATA

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL JEDEC TO-220AB DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN MILLIMETRES



ABSOLUTE MAXIMUM RATINGS AT 25°C CASE TEMPERATURE (UNLESS OTHERWISE NOTED)

PARAMETER	TIP29	TIP29A	TIP29B	TIP29C	TIP29D	TIP29E	TIP29F	UNIT
Collector-Base Voltage	80	100	120	140	160	180	200	V
Collector-Emitter Voltage[1] @ 30 mA	40	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	1A
Peak Collector Current[2]	3A
Continuous Base Current	0.4A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	30W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP29/29A		TIP29B/29C		TIP29D/29F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = 30V I_B = 0 V_{CE} = 60V I_B = 0 V_{CE} = 90V I_B = 0		0.3		0.3		0.3	mA
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO} V_{BE} = 0		0.2		0.2		0.2	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5V I_C = 0		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 4V I_C = 0.2A V_{CE} = 4V I_C = 1A See Notes 6 and 7	40 15	 75	40 15	 75	40 15		
V_{BE}	Base-Emitter Voltage	V_{CE} = 4V I_C = 1A See Notes 6 and 7		1.3		1.3		1.3	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = 125mA I_C = 1A See Notes 6 and 7		0.7		0.7		0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 0.2A f = 1 KHz	20		20			20	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V I_C = 0.2A f = 1MHz	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

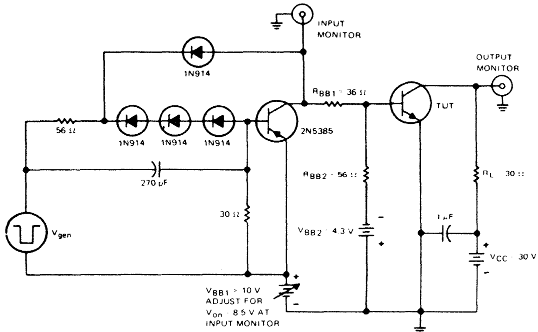
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

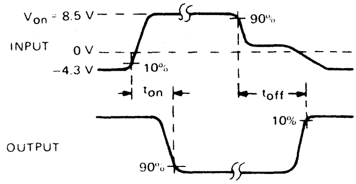
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 1 A, $I_{B(1)}$ = 100 mA, $I_{B(2)}$ = −100 mA,	0.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.3 V, R_L = 30 Ω, See Figure 1	2	

†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: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.

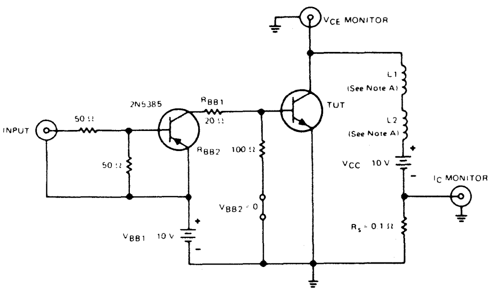
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

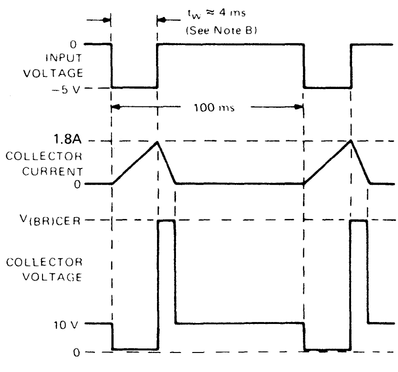
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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} = 1.8 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

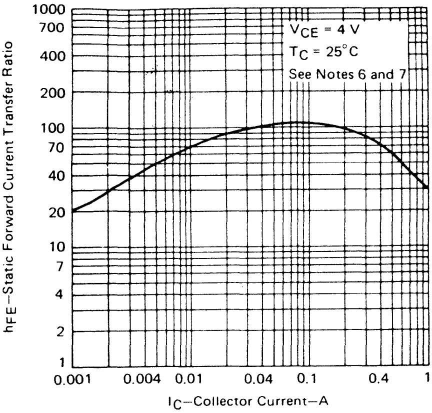


FIGURE 3

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

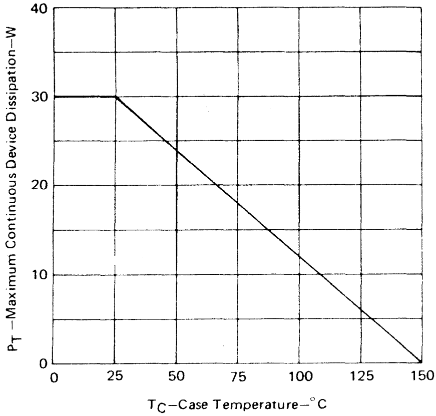


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

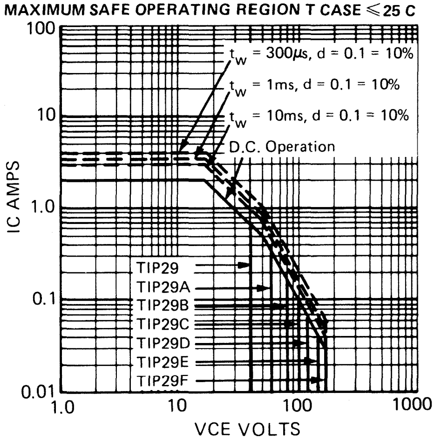


FIGURE 5

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

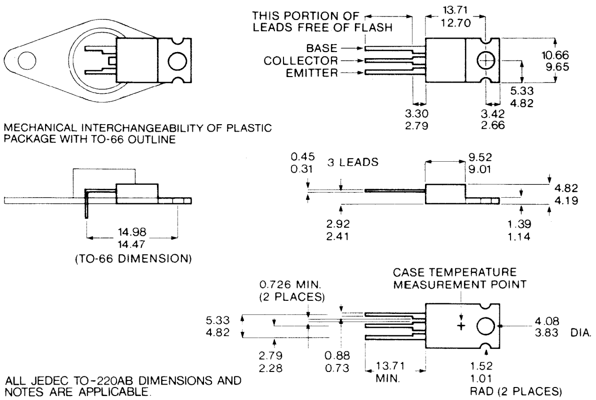
TIP30 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP29 SERIES

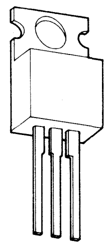
- **30W at 25°C Case Temperature**
- **1A Rated Collector Current**
- **Minimum f_T of 3MHz at -10V, -200 mA**
- **Customer-specified selections available**
- Also Available in Europe as BD240

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)

PARAMETER	TIP30	TIP30A	TIP30B	TIP30C	TIP30D	TIP30E	TIP30F	UNIT
Collector-Base Voltage	–80	–100	–120	–140	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-40	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-1A
Peak Collector Current[2]	-3A
Continuous Base Current	-0.4A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	30W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	32mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies 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 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP30/30A		TIP30B/30C		TIP30D/30F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30V$ $I_B = 0$		-0.3					mA
		$V_{CE} = -60V$ $I_B = 0$				-0.3			
		$V_{CE} = -90V$ $I_B = 0$						-0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, $V_{BE} = 0$		-0.2		-0.2		-0.2	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5V$ $I_C = 0$		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4V$ $I_C = -0.2A$	40		40		40		
		$V_{CE} = -4V$ $I_C = -1A$ See Notes 6 and 7	15	75	15	75	15		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4V$ $I_C = 1A$ See Notes 6 and 7		-1.3		-1.3		-1.3	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	$I_B = -125mA$ $I_C = -1A$ See Notes 6 and 7		-0.7		-0.7		-0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10V$ $I_C = -0.2A$ f = 1KHz	20		20			20	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10V$ $I_C = -0.2A$ f = 1MHz	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

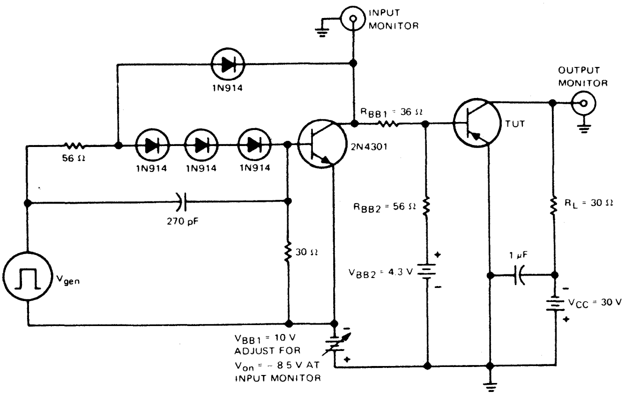
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	4.17	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

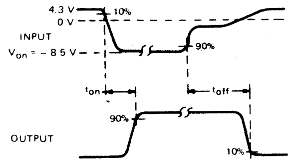
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -1$ A, $I_{B(1)} = -100$ mA, $I_{B(2)} = 100$ mA,	0.3	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.3$ V, $R_L = 30\ \Omega$, See Figure 1	1.0	

†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: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ μs, duty cycle ≤ 2%.

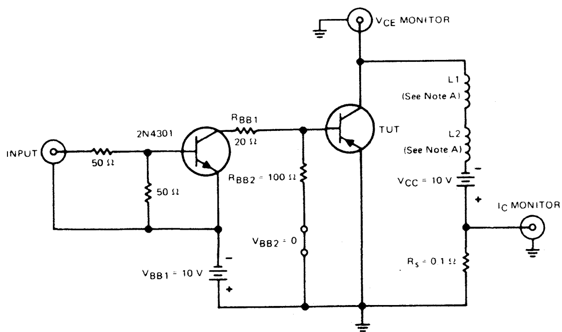
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

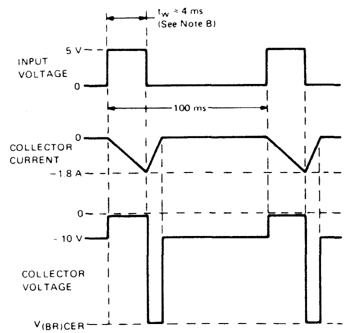
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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 $I_{CM} = -1.8$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

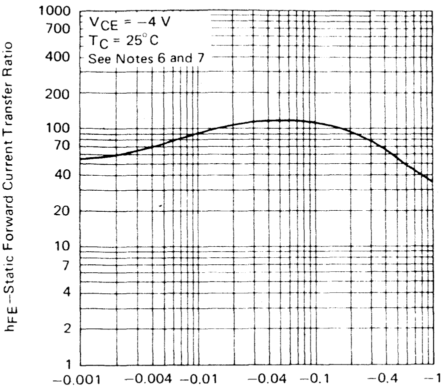


FIGURE 3

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

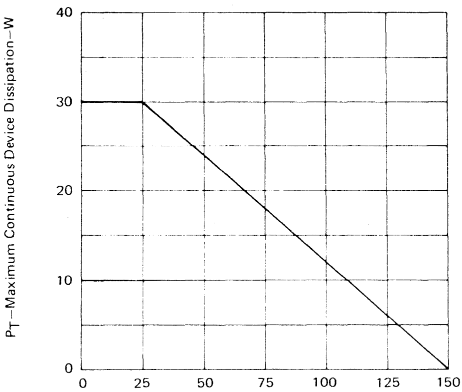


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE ≤25 C

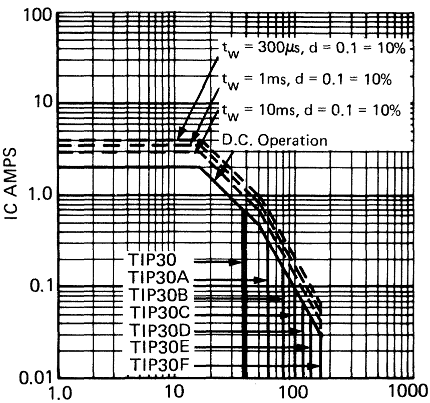


FIGURE 5

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

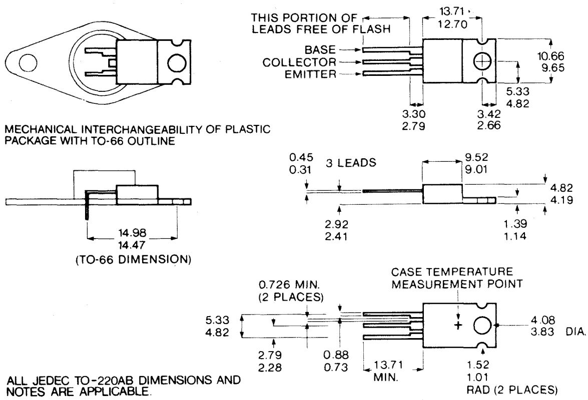
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP32 SERIES

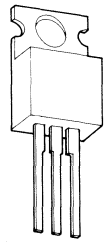
- **40W at 25°C Case Temperature**
- **3A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 500 mA**
- **Customer-specified selections available**
- **Also Available in Europe as BD241**

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)

PARAMETER	TIP31	TIP31A	TIP31B	TIP31C	TIP31D	TIP31E	TIP31F	UNIT
Collector-Base Voltage	80	100	120	140	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	40	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	3A
Peak Collector Current[2]	5A
Continuous Base Current	1A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	40W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	TIP31/31A		TIP31B/31C		TIP31D/31E 31F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30V$, $I_B = 0$		0.3					mA
		$V_{CE} = 60V$, $I_B = 0$				0.3			
		$V_{CE} = 90V$, $I_B = 0$						0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, $V_{BE} = 0$		0.2		0.2		0.2	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5V$, $I_C = 0$		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4V$, $I_C = 1A$, See Notes 6 & 7	25		25		25		
		$V_{CE} = 4V$, $I_C = 3A$	10	50	10	50	5		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4V$, $I_C = 3A$, See Notes 6 & 7		1.8		1.8		1.8	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	$I_B = 375mA$, $I_C = 3A$		1.2		1.2			V
		$I_B = 750mA$, $I_C = 3A$, See Notes 6 & 7						2.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$, $I_C = 0.5A$, f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$, $I_C = 0.5A$, f = 1MHz	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

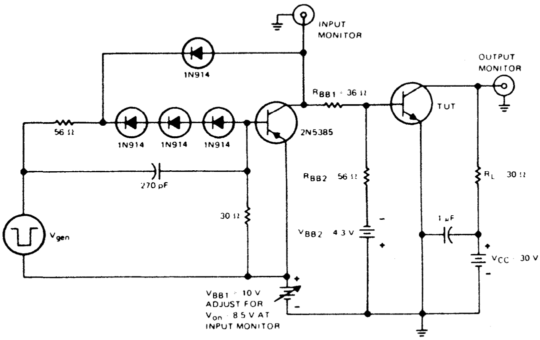
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	°C/W

switching characteristics at 25°C case temperature

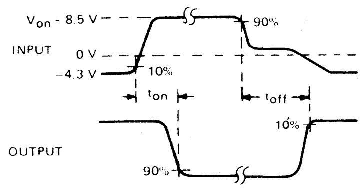
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 1\ A$, $I_{B(1)} = 100\ mA$, $I_{B(2)} = -100\ mA$,	0.5	µs
t_{off}	Turn-Off Time	$V_{BE(off)} = -4.3\ V$, $R_L = 30\ \Omega$, See Figure 1	2	µs

†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%.

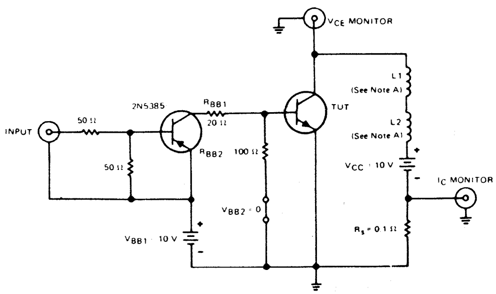
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

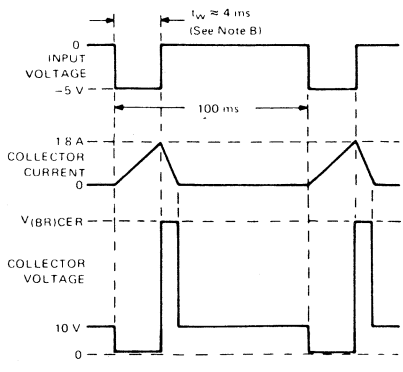
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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} = 1.8 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

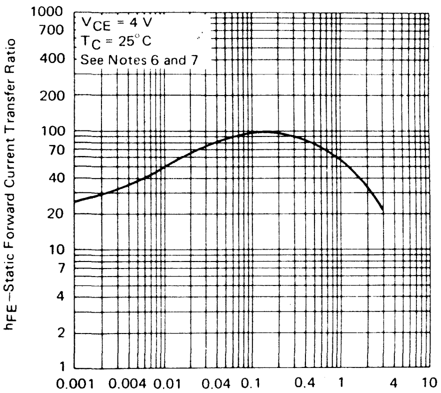


FIGURE 3

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

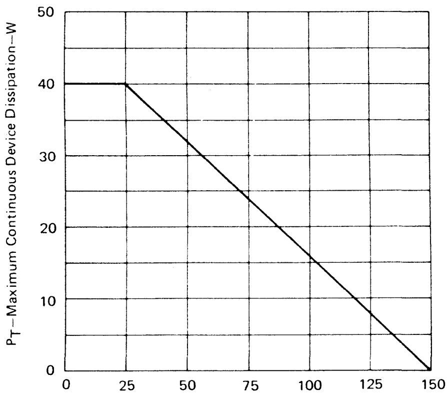


FIGURE 4

MAXIMUM SAFE OPERATION REGION T CASE ≤ 25 C

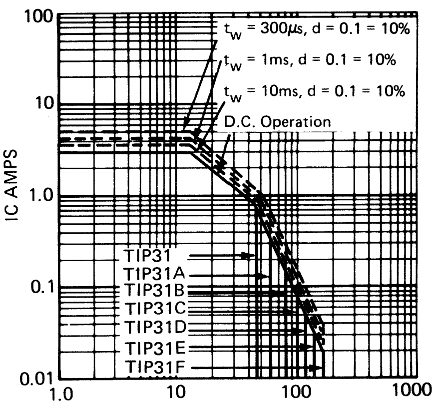


FIGURE 5

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

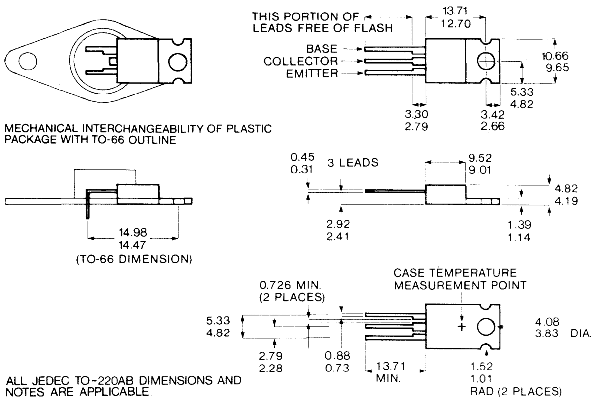
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP31 SERIES

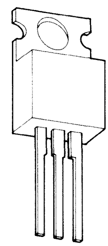
- **40W at 25°C Case Temperature**
- **3A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 500 mA**
- **Customer-specified selections available**
- **Also Available in Europe as BD242**

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)

PARAMETER	TIP 32	TIP32A	TIP32B	TIP32C	TIP32D	TIP32E	TIP32F	UNIT
Collector-Base Voltage	−80	−100	−120	−140	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-40	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-3A
Peak Collector Current[2]	-5A
Continuous Base Current	-1A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	40W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	32 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

TIP32 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	TIP32/32A		TIP32B/32C		TIP32D/32E 32F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-0.3					mA
		V_{CE} = -60V I_B = 0				-0.3			
		V_{CE} = -90V I_B = 0						-0.3	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO} V_{BE} = 0		-0.2		-0.2		-0.2	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -1A See Notes 6 & 7	25		25		25		
		V_{CE} = -4V I_C = -3A	10	50	10	50	5		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -3A See Notes 6 & 7		-1.8		-1.8		-1.8	V
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -375mA I_C = -3A		-1.2		-1.2			V
$V_{CE(Sat)}$		I_B = -750mA I_C = -3A See Notes 6 & 7						-2.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.5A f = 1KHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -0.5A f = 1MHz	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

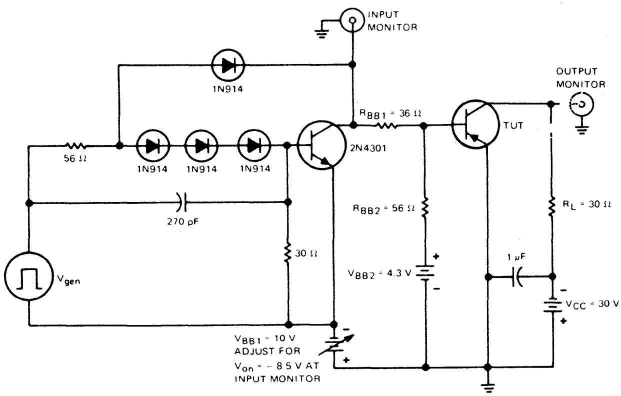
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	3.125	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

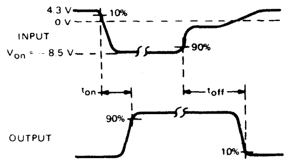
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = −1 A,	$I_{B(1)}$ = −100 mA,	$I_{B(2)}$ = 100 mA,	0.3	µs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 4.3 V,	R_L = 30 Ω,	See Figure 1	1.0	

†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: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 Ω, t_w = 20 µs, duty cycle ≤ 2%.

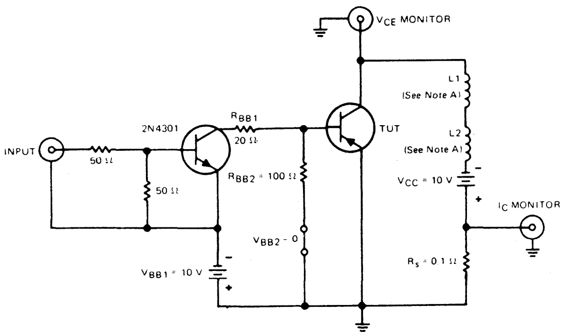
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

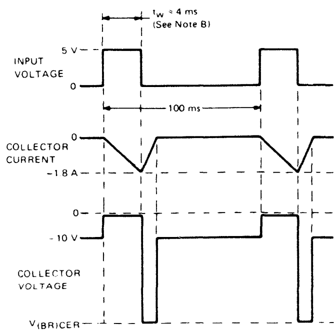
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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} = −1.8 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

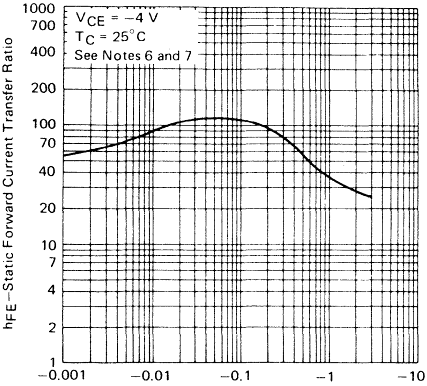


FIGURE 3

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

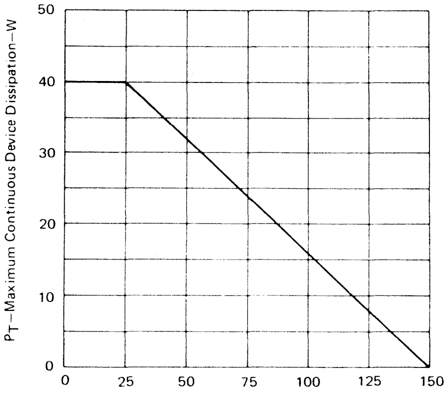


FIGURE 4

MAXIMUM SAFE OPERATION REGION T CASE ≤ 25 C

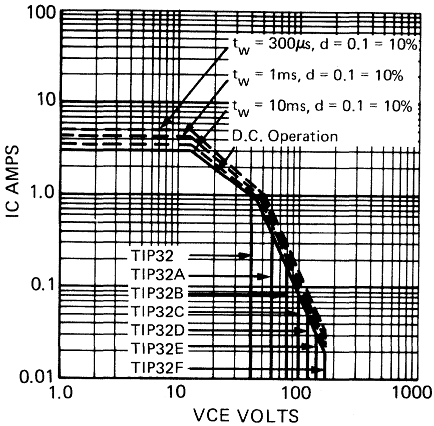


FIGURE 5

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

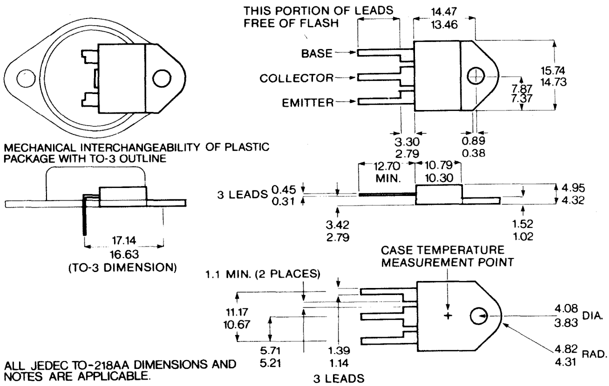
TIP33 SERIES
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP34 SERIES

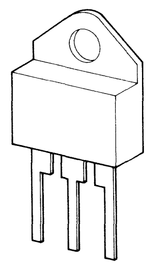
- **80W at 25°C Case Temperature**
- **10A Rated Collector Current**
- **Minimum f_T of 3MHz at 10V, 500 mA**
- **Customer-specified selections available**
- **Also Available in Europe as BD245**

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)

PARAMETER	TIP33	TIP33A	TIP33B	TIP33C	TIP33D	TIP33E	TIP33F	UNIT
Collector-Base Voltage	80	100	120	140	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	40	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	10A
Peak Collector Current[2]	15A
Continuous Base Current	3A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	80W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.5W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		TIP33/33A MIN	TIP33/33A MAX	TIP33B/33C MIN	TIP33B/33C MAX	TIP33D/33E 33F MIN	TIP33D/33E 33F MAX	UNIT
I_{CEO}	Collector	V_{CE} = 30V	I_B = 0		0.7					
	Cutoff Current	V_{CE} = 60V	I_B = 0				0.7			mA
		V_{CE} = 90V	I_B = 0						0.7	
I_{CES}	Collector	V_{CE} = Rated	BV_{CBO}		0.4		0.4		0.4	mA
	Cutoff Current	V_{BE} = 0								
I_{EBO}	Emitter	V_{EB} = 5V	I_C = 0		1		1		1	mA
	Cutoff Current									
h_{FE}	Static Forward	V_{CE} = 4V	I_C = 1A	40		40		40		
	Current Transfer	See Notes 6 & 7								
	Ratio	V_{CE} = 4V	I_C = 3A	20	100	20	100	20		
V_{BE}	Base-Emitter	V_{CE} = 4V	I_C = 3A		1.6		1.6		1.6	V
	Voltage	See Notes 6 & 7								
		V_{CE} = 4V	I_C = 10A		3.0		3.0		3.0	
$V_{CE(Sat)}$	Collector-Emitter	I_B = 0.3A	I_C = 3A		1		1		1	
	Saturation Voltage	See Notes 6 & 7								V
		I_B = 2.5A	I_C = 10A		4		4			
		I_B = 3.3A	I_C = 10A						4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V	I_C = 0.5A	20		20		20		
		f = 1KHz								
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10V	I_C = 0.5A	3		3		3		
		f = 1MHz								

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

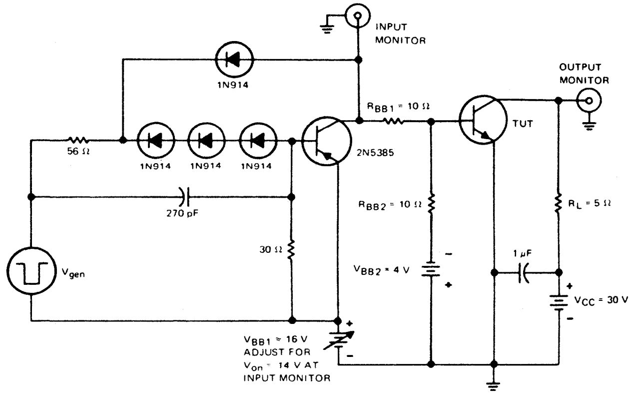
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

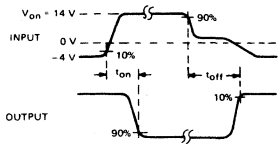
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = 6 A,	$I_{B(1)}$ = 0.6 A,	$I_{B(2)}$ = −0.6 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V,	R_L = 5 Ω,	See Figure 1	1	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

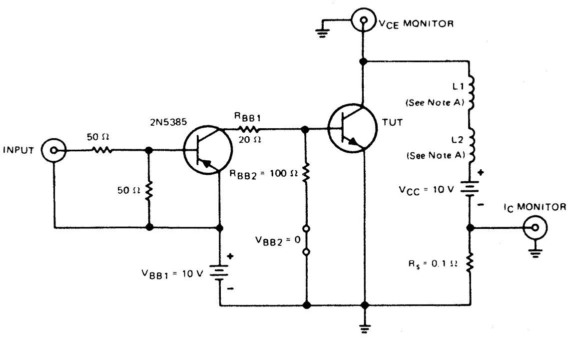


VOLTAGE WAVEFORMS

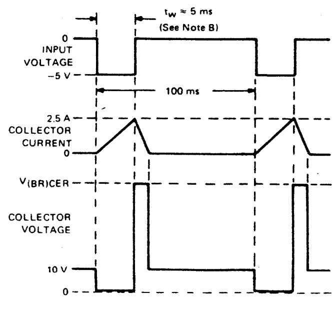
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50$ Ω, $t_w = 20$ μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following 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} = 2.5 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

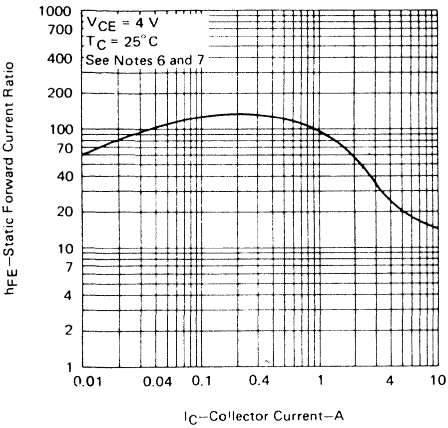


FIGURE 3

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

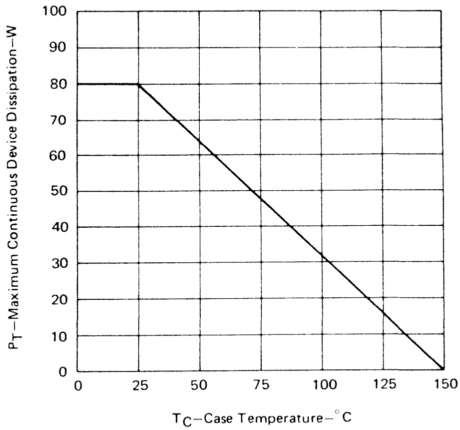


FIGURE 4

MAXIMUM SAFE OPERATION REGION T CASE ≤25 C

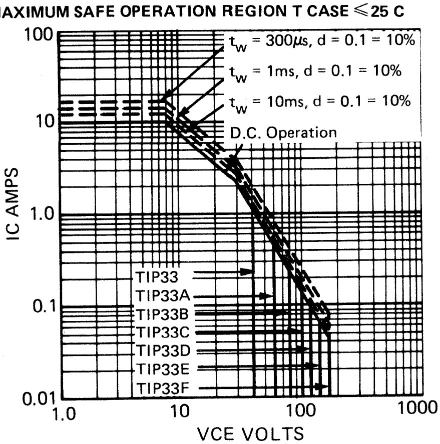


FIGURE 5

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

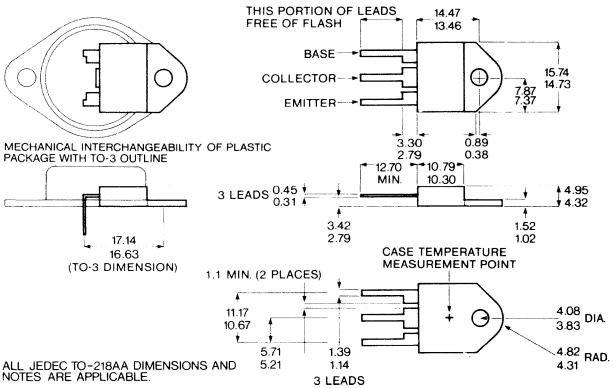
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP33 SERIES

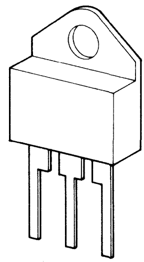
- 80W at 25° Case Temperature
- 10A Rated Collector Current
- Minimum f_T of 3MHz at -10V, -500 mA
- Customer-specified selection available
- Also Available in Europe as BD246

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)

PARAMETER	TIP34	TIP34A	TIP34B	TIP34C	TIP34D	TIP34E	TIP34F	UNIT
Collector-Base Voltage	−80	−100	−120	−140	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-40	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-10A
Peak Collector Current[2]	-15A
Continuous Base Current	-3A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	80W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.5W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	TIP34/34A MIN	TIP34/34A MAX	TIP34B/34C MIN	TIP34B/34C MAX	TIP34D/34E 34F MIN	TIP34D/34E 34F MAX	UNIT
I_{CEO}	Collector Cutoff Current	$V_{CE} = -30V$ $I_B = 0$		-0.7					mA
		$V_{CE} = -60V$ $I_B = 0$				-0.7			
		$V_{CE} = -90V$ $I_B = 0$						-0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, $V_{BE} = 0$		-0.4		-0.4		-0.4	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5V$ $I_C = 0$		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -4V$ $I_C = -1A$ See Notes 6 & 7	40		40		40		
		$V_{CE} = -4V$ $I_C = -3A$	20	100	20	100	20		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4V$ $I_C = -3A$ See Notes 6 & 7		-1.6		-1.6		-1.6	V
		$V_{CE} = -4V$ $I_C = -10A$		-3.0		-3.0		-3.0	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.3A$ $I_C = -3A$ See Notes 6 & 7		-1		-1		-1	V
		$I_B = -2.5A$ $I_C = -10A$		-4		-4			
		$I_B = -3.3A$ $I_C = -10A$						-4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10V$ $I_C = -0.5A$ f = 1kHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10V$ $I_C = -0.5A$ f = 1MHz	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

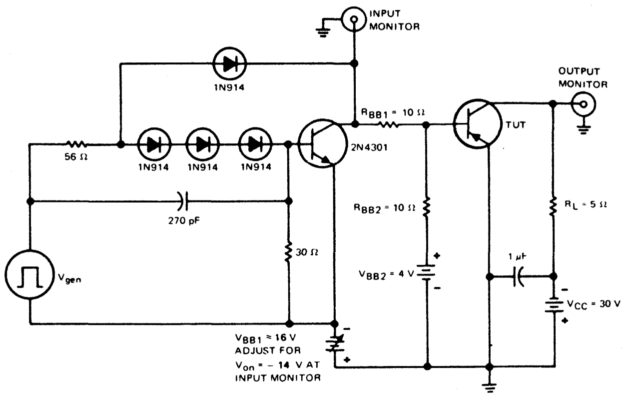
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.56	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

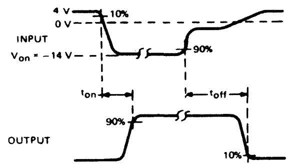
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	$I_C = -6$ A,	$I_{B(1)} = -0.6$ A,	$I_{B(2)} = 0.6$ A,	0.4	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4$ V,	$R_L = 5\ \Omega$,	See Figure 1	0.7	

†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%.

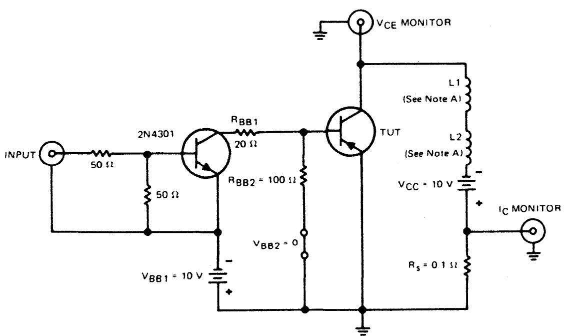
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

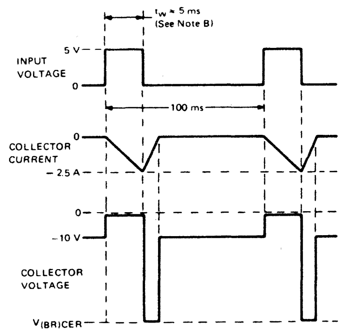
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

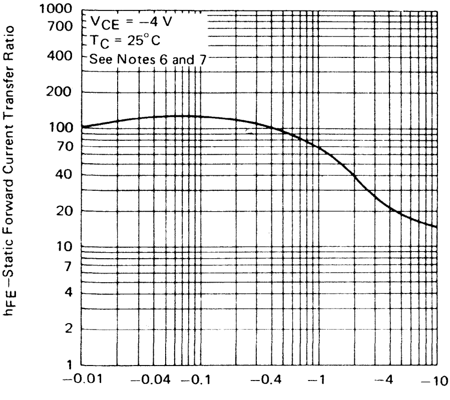


FIGURE 3

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

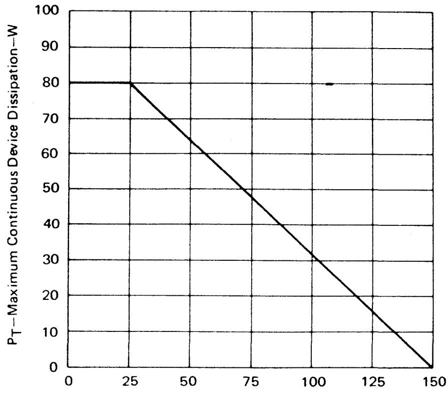


FIGURE 4

MAXIMUM SAFE OPERATION REGION T CASE ≤ 25 C

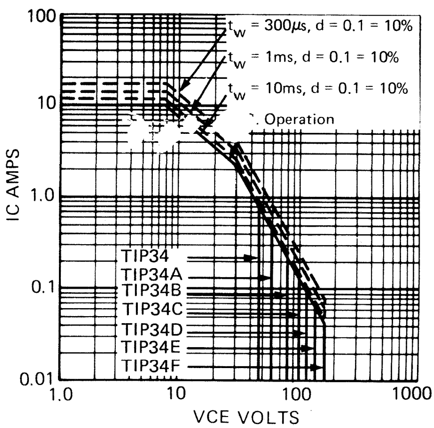


FIGURE 5

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

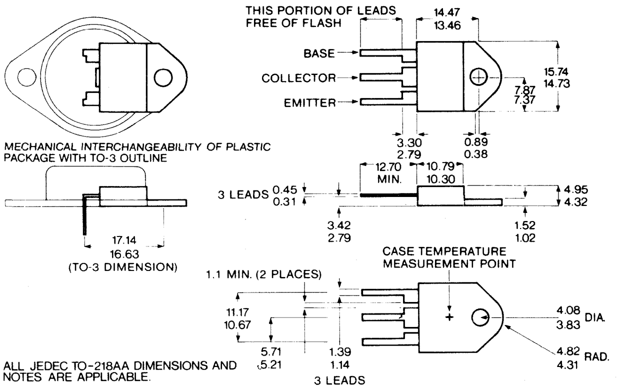
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

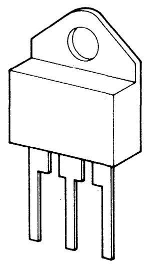
FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP36 SERIES

- 125W at 25°C Case Temperature
- 25A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 1A
- Customer-Specified Selections Available
- Also Available in Europe as BD249

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)

PARAMETER	TIP35	TIP35A	TIP35B	TIP35C	TIP35D	TIP35E	TIP35F	UNIT
Collector-Base Voltage	80	100	120	140	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	40	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	25A
Peak Collector Current[2]	40A
Continuous Base Current	5A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	125 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.5W
Unclamped Inductive Load Energy[5]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETERS		TEST CONDITIONS		TIP35/35A		TIP35B/35C		TIP35D/35E 35F		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30V$	$I_B = 0$		1					mA
		$V_{CE} = 60V$	$I_B = 0$				1			
		$V_{CE} = 90V$	$I_B = 0$						1	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, $V_{CE} = 0$			0.7		0.7		0.7	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5V$	$I_C = 0$		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4V$, See Notes 6 & 7	$I_C = 1.5A$	25		25		25		
		$V_{CE} = 4V$	$I_C = 15A$	10	50	10	50	8		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4V$, See Notes 6 & 7	$I_C = 15A$		2		2		2	V
		$V_{CE} = 4V$	$I_C = 25A$		4		4		4	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1.5A$	$I_C = 15A$		1.8		1.8			V
		$I_B = 5.0A$	$I_C = 25A$		4.0		4.0			
		$I_B = 3.0A$	$I_C = 15A$						2.5	
		$I_B = 6.25A$, See Notes 6 & 7	$I_C = 25A$						5.0	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$, f = 1kHz	$I_C = 1A$	25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$, f = 1MHz	$I_C = 1A$	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

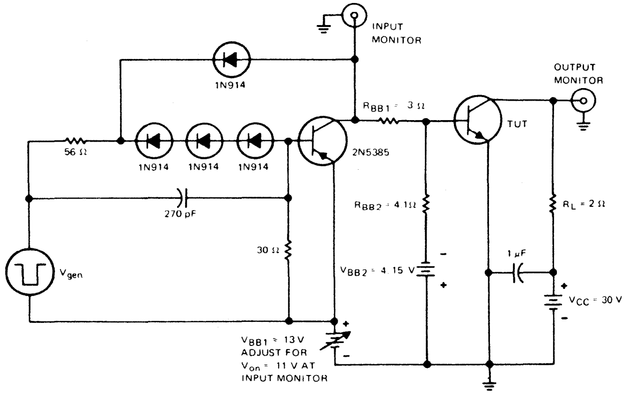
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	C/W

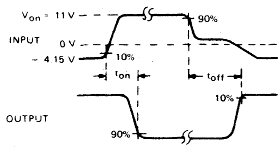
switching characteristics at 25°C case temperature

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	µs

† 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%.

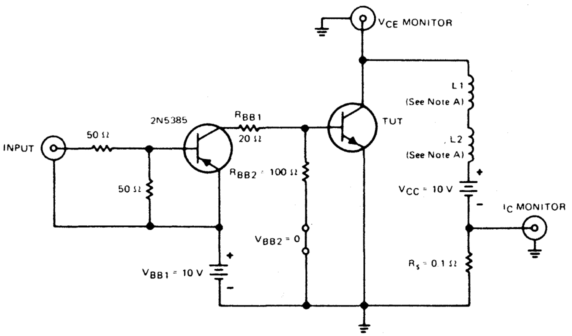
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

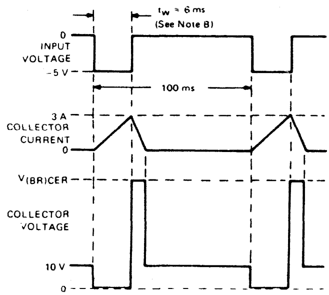
D. Resistors must be noninductive types.

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} = 3 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

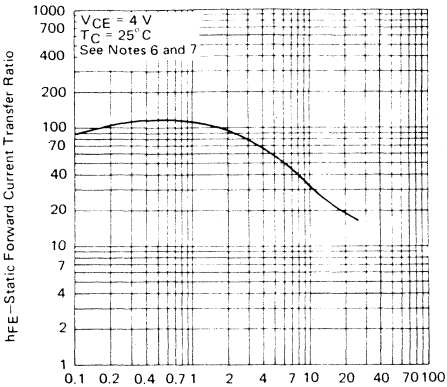


FIGURE 3

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

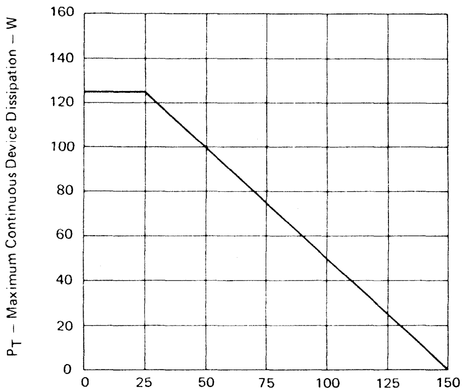


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

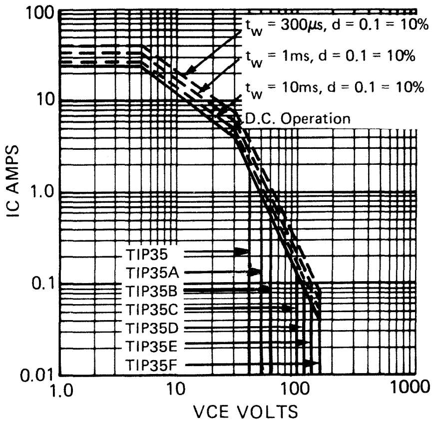


FIGURE 5

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

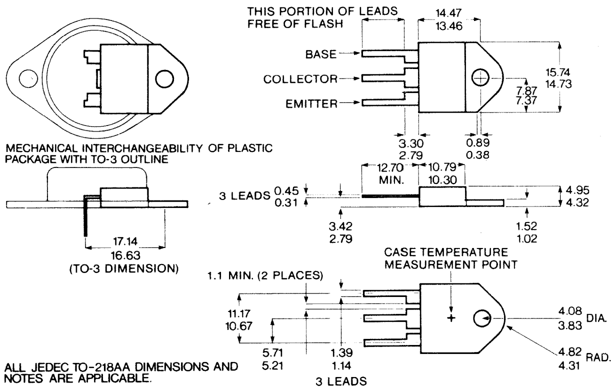
TIP36 SERIES
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP35 SERIES

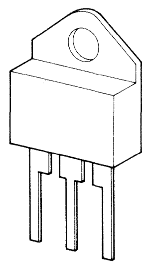
- 125W at 25°C Case Temperature
- 25A Rated Collector Current
- Minimum f_T of 3MHz at -10V, -1A
- Customer-Specified Selections Available
- Also Available in Europe as BD250

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)

PARAMETER	TIP36	TIP36A	TIP36B	TIP36C	TIP36D	TIP36E	TIP36F	UNIT
Collector-Base Voltage	−80	−100	−120	−140	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-40	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-25A
Peak Collector Current[2]	40A
Continuous Base Current	-5A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	125 W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	3.5W
Unclamped Inductive Load Energy[5]	90 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 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 ⩽ 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	TIP36/36A MIN	TIP36/36A MAX	TIP36B/36C MIN	TIP36B/36C MAX	TIP36D/36E 36F MIN	TIP36D/36E 36F MAX	UNIT
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V I_B = 0		-1					mA
		V_{CE} = -60V I_B = 0				-1			
		V_{CE} = -90V I_B = 0						-1	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BVCBO, V_{BE} = 0		-0.7		-0.7		-0.7	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V I_C = 0		- 1		- 1		- 1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V I_C = -1.5A	25		25		25		
		See Notes 6 & 7							
		V_{CE} = -4V I_C = -15A	10	50	10	50	8		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V I_C = -15A		-2		-2		-2	V
		See Notes 6 & 7							
		V_{CE} = -4V I_C = -25A		-4		-4		-4	
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -1.5A I_C = -15A		-1.8		-1.8			
		I_B = -5.0A I_C = -25A		-4.0		-4.0			
		I_B = -3.0A I_C = -15A						-2.5	V
		I_B = -6.25A I_C = -25A						-5.0	
		See Notes 6 & 7							
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = - 10V I_C = -1A, f = 1kHz	25		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V I_C = -1A, f = 1MHz	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

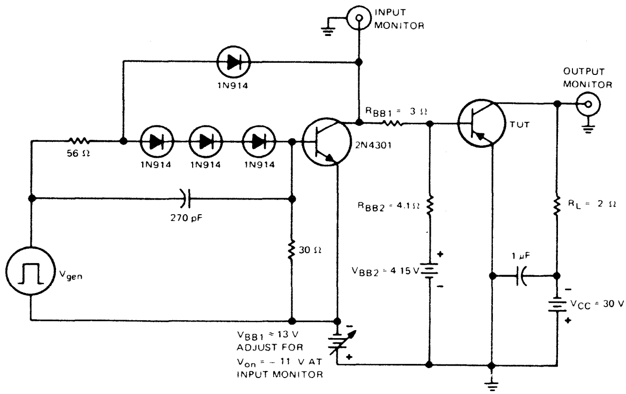
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

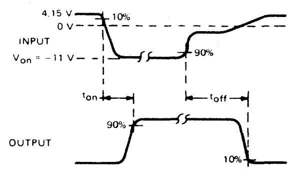
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = −15 A, $I_{B(1)}$ = −1.5 A, $I_{B(2)}$ = 1.5 A,	1.1	µs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 4.15 V, R_L = 2 Ω, See Figure 1	0.8	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

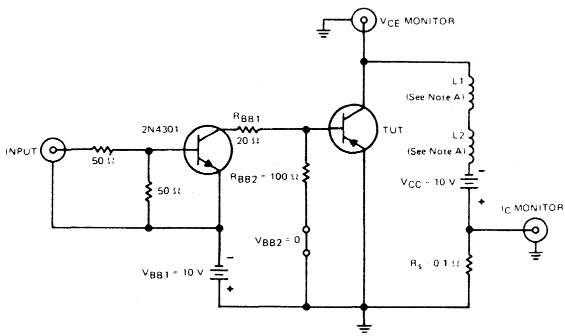


VOLTAGE WAVEFORMS

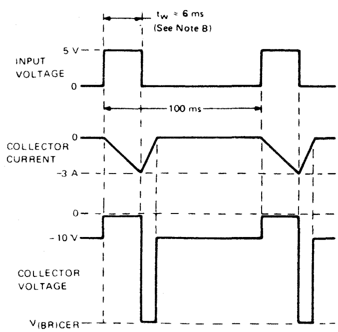
NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
C. Waveforms are monitored on an oscilloscope 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 $I_{CM} = -3$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

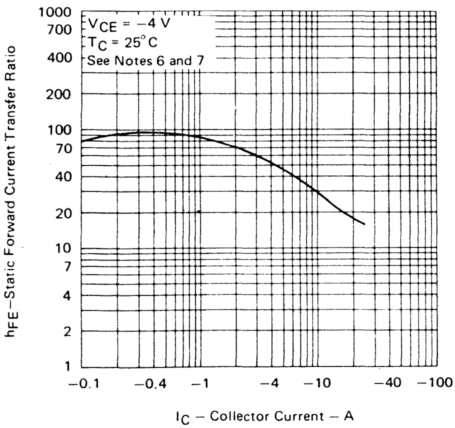


FIGURE 3

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

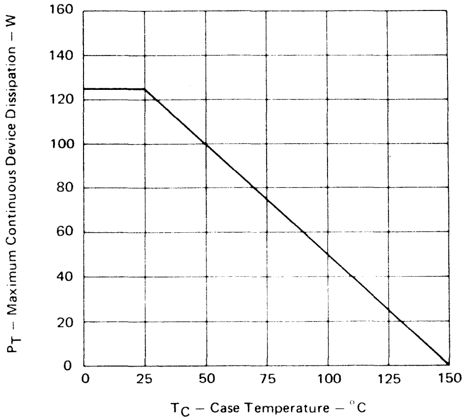


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE <25 C

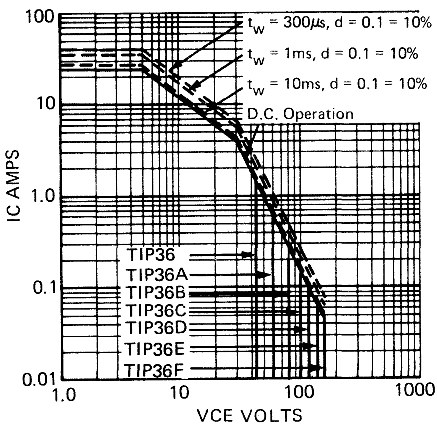


FIGURE 5

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

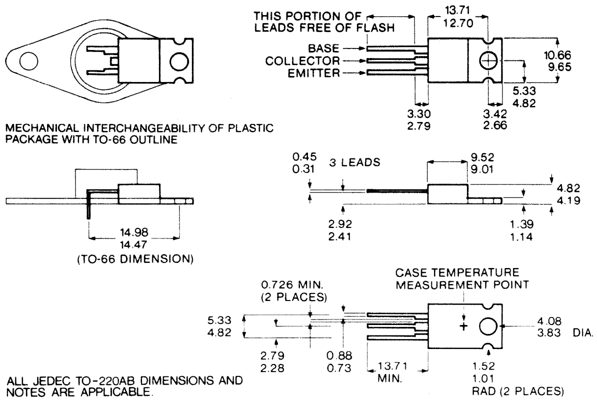
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS DESIGNED FOR COMPLEMENTARY USE WITH TIP42 SERIES

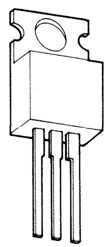
- 65W at 25°C Case Temperature
- 6A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 500 mA
- Customer-specified selections available
- Also Available in Europe as BD243

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)

PARAMETER	TIP41	TIP41A	TIP41B	TIP41C	TIP41D	TIP41E	TIP41F	UNIT
Collector-Base Voltage	80	100	80	140	160	180	200	V
Collector-Emitter Voltage[1] @ 30mA	40	60	80	100	120	140	160	V

Emitter-Base Voltage	5V
Continuous Collector Current	6A
Peak Collector Current[2]	10A
Continuous Base Current	3A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	65W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature [illegible] mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C	TIP41/41A		TIP41B/41C		TIP41D/41E 41F		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{CEO}	Collector Cutoff Current	$V_{CE} = 30V$ $I_B = 0$		0.7					mA
		$V_{CE} = 60V$ $I_B = 0$				0.7			
		$V_{CE} = 90V$ $I_B = 0$						0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO} $V_{BE} = 0$		0.4		0.4		0.4	mA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5V$ $I_C = 0$		1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4V$ $I_C = 0.3A$ See Notes 6 & 7	30		30		30		
		$V_{CE} = 4V$ $I_C = 3A$	15	75	15	75	15		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4V$ $I_C = 6A$ See Notes 6 & 7		2		2		2	V
$V_{CE\ (Sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.6A$ $I_C = 6A$ See Notes 6 & 7		1.5		1.5			V
		$I_B = 1.5A$ $I_C = 6A$						1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ $I_C = 0.5A$ f = 1kHz	20		20		20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10V$ $I_C = 0.5A$ f = 1MHz	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

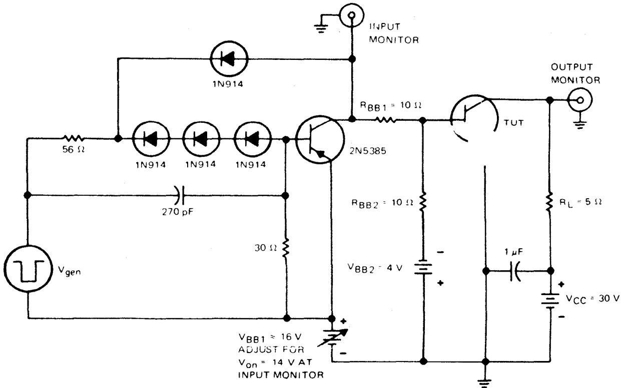
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

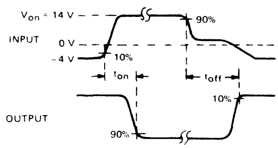
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 6 A, $I_{B(1)}$ = 0.6 A, $I_{B(2)}$ = −0.6 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V, R_L = 5 Ω, See Figure 1	1	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

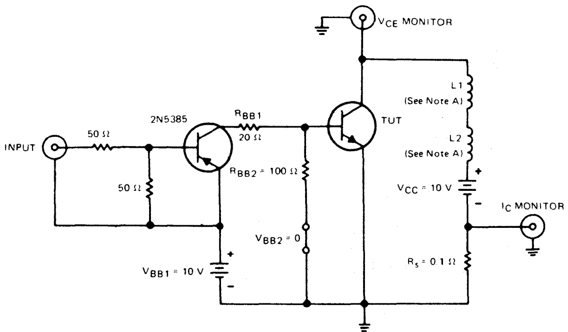


VOLTAGE WAVEFORMS

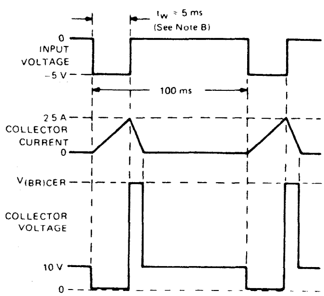
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 Ω, t_w = 20 µs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following 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} = 2.5 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

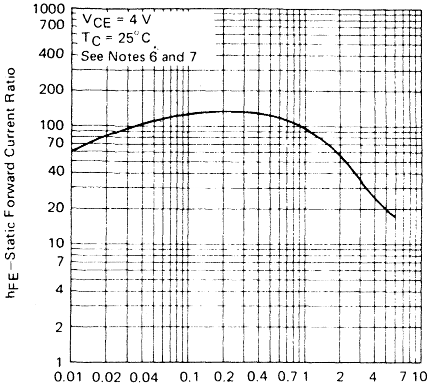


FIGURE 3

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

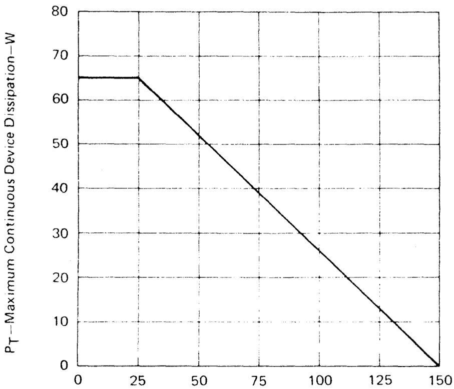


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE ≤ 25 C

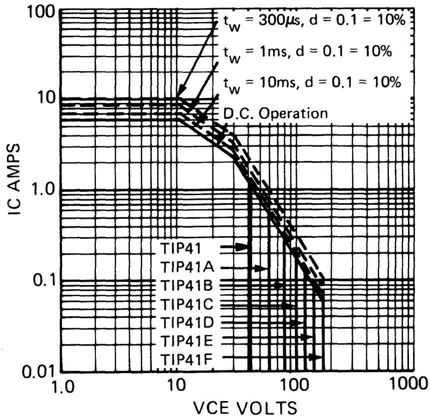


FIGURE 5

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

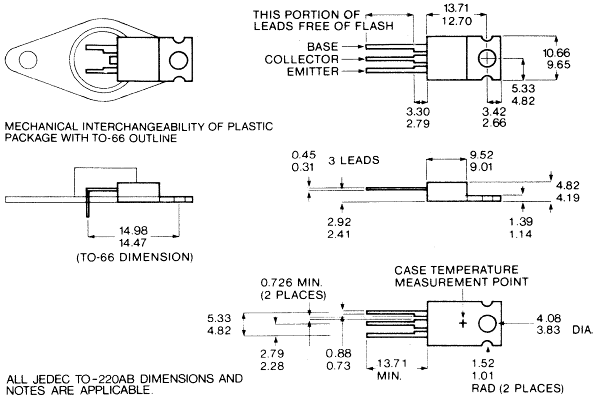
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH TIP41 SERIES

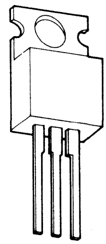
- 65W at 25°C Case Temperature
- 6A Rated Collector Current
- Minimum f_T of 3MHz at 10V, 500 mA
- Customer-specified selections available
- Also Available in Europe as BD244

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)

PARAMETER	TIP42	TIP42A	TIP42B	TIP42C	TIP42D	TIP42E	TIP42F	UNIT
Collector-Base Voltage	−80	−100	−120	−140	-160	-180	-200	V
Collector-Emitter Voltage[1] @ 30mA	-40	-60	-80	-100	-120	-140	-160	V

Emitter-Base Voltage	-5V
Continuous Collector Current	-6A
Peak Collector Current[2]	-10A
Continuous Base Current	-3A
Safe Operating Area	See Figure 5
Continuous Device Dissipation[3]	65W
Continuous Device Dissipation at (or Below) 25°C Free-Air Temperature[4]	2W
Unclamped Inductive Load Energy[5]	62.5 mJ
Operating Collector Junction Temperature Range	-65°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature 3.2 mm from Case for 10 Seconds	250°C

Notes
1. This value applies when the base-emitter diode is open circuited.
2. This value applies for $t_w \leq 0.3$ ms, Duty Cycle ≤ 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 in Figure 2.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS AT 25°C		TIP42/42A MIN	TIP42/42A MAX	TIP42B/42C MIN	TIP42B/42C MAX	TIP42D/42E 42F MIN	TIP42D/42E 42F MAX	UNIT
I_{CEO}	Collector Cutoff Current	V_{CE} = -30V	I_B = 0		-0.7					mA
		V_{CE} = -60V	I_B = 0				-0.7			
		V_{CE} = -90V	I_B = 0						-0.7	
I_{CES}	Collector Cutoff Current	V_{CE} = Rated BV_{CBO}, V_{BE} = 0			-0.4		-0.4		-0.4	mA
I_{EBO}	Emitter Cutoff Current	V_{EB} = -5V	I_C = 0		-1		-1		-1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = -4V	I_C = -0.3A	30		30		30		
		See Notes 6 & 7								
		V_{CE} = -4V	I_C = -3A	15	75	15	75	15		
V_{BE}	Base-Emitter Voltage	V_{CE} = -4V	I_C = -6A		-2		-2		-2	V
		See Notes 6 & 7								
$V_{CE(Sat)}$	Collector-Emitter Saturation Voltage	I_B = -0.6A	I_C = -6A		-1.5		-1.5			V
		See Notes 6 & 7								
		I_B = -1.5A	I_C = -6A						-1.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V	I_C = -0.5A	20		20		20		
		f = 1KHz								
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = -10V	I_C = -0.5A	3		3		3		
		f = 1MHz								

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

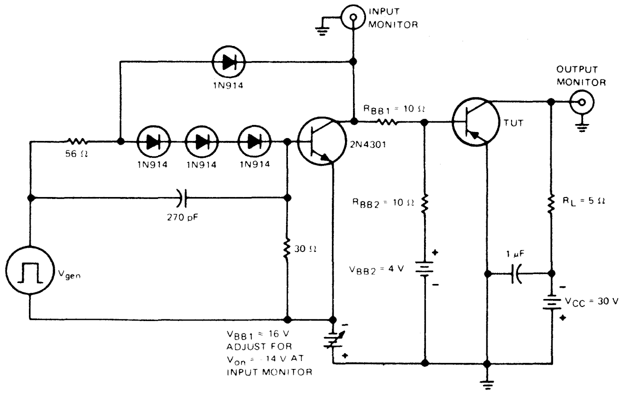
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.92	C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	62.5	

switching characteristics at 25°C case temperature

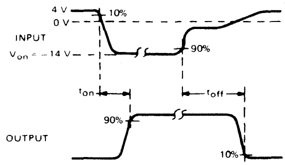
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = −6 A, $I_{B(1)}$ = −0.6 A, $I_{B(2)}$ = 0.6 A,	0.4	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 4 V, R_L = 5 Ω, See Figure 1 .	0.7	

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

PARAMETER MEASUREMENT INFORMATION



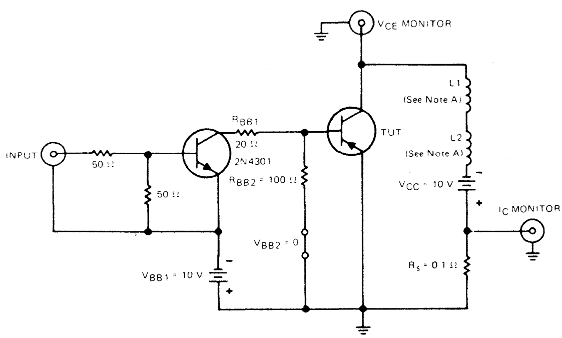
TEST CIRCUIT



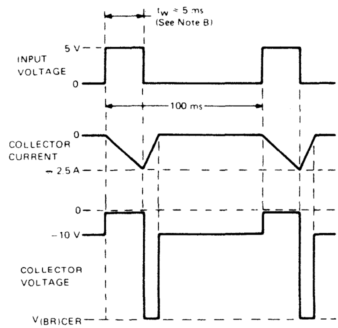
VOLTAGE WAVEFORMS

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, $R_{in} \geq 10$ 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.

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

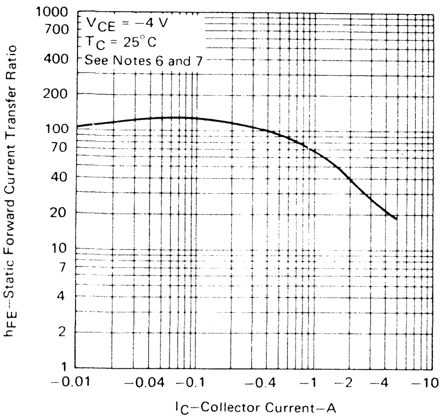


FIGURE 3

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

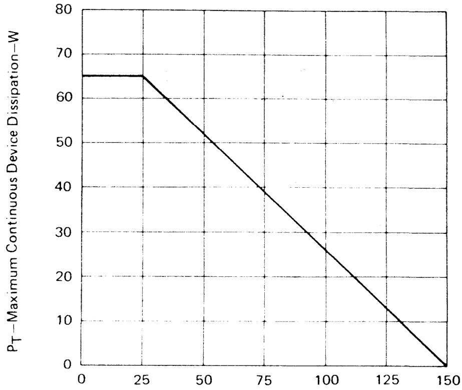


FIGURE 4

MAXIMUM SAFE OPERATING REGION T CASE ≤25 C

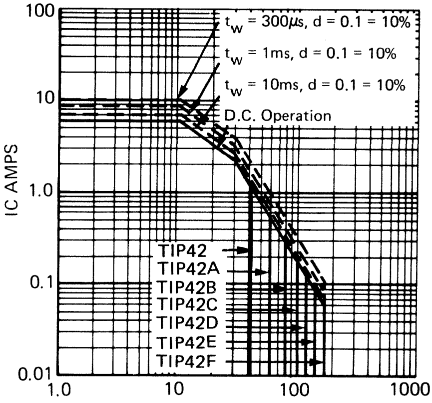


FIGURE 5

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

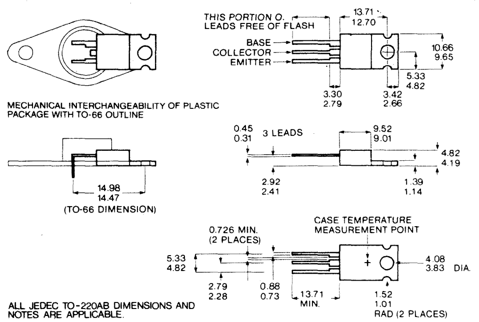
TIP47, TIP48, TIP49, TIP50
NPN SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR INDUSTRIAL AND CONSUMER APPLICATION

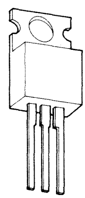
- 20 mJ Reverse-Energy Rating
- 250 V to 400 V Min $V_{(BR)CEO}$
- 40 W at 25°C Case Temperature
- 1-A Rated Collector Current
- 10 MHz Min f_T at 10 V, 0.2 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
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 = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C^2 L/2$.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP47 MIN	TIP47 MAX	TIP48 MIN	TIP48 MAX	TIP49 MIN	TIP49 MAX	TIP50 MIN	TIP50 MAX	UNIT
$V_{(BR)CEO}$	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, $R_L = 200\ \Omega$, See Figure 4	2	µs

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

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

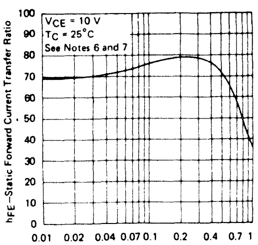


FIGURE 1

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

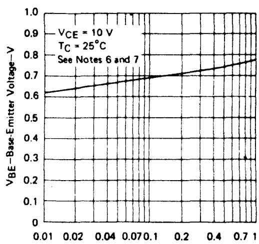


FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

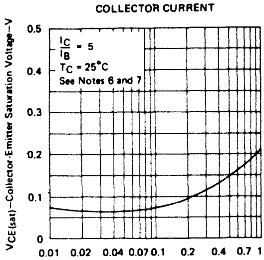
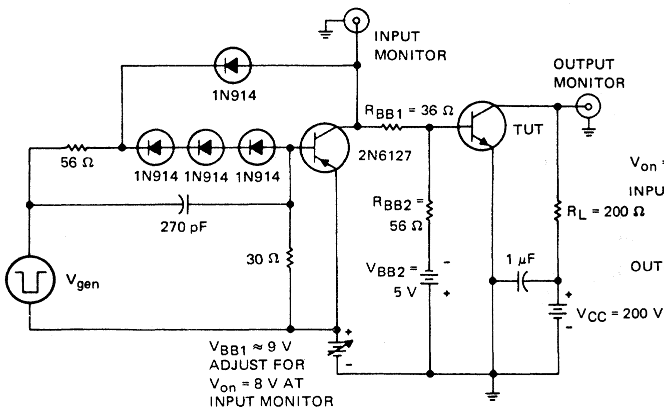


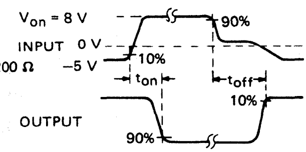
FIGURE 3

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

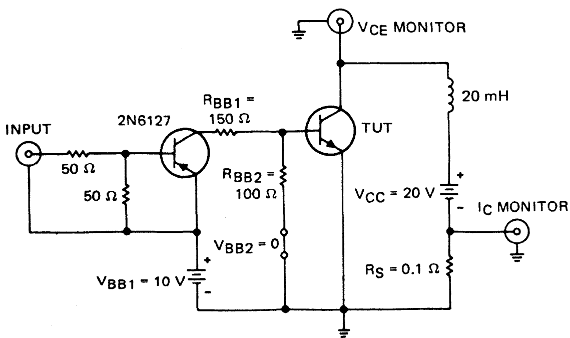


VOLTAGE WAVEFORMS

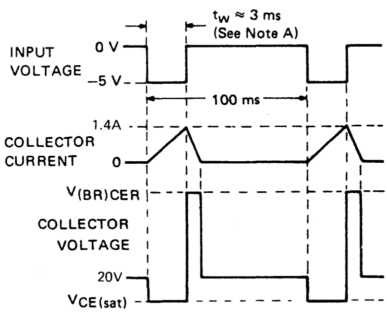
NOTES: A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.
C. Waveforms are monitored on an oscilloscope with the following 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 4

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = 1.4$ A

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

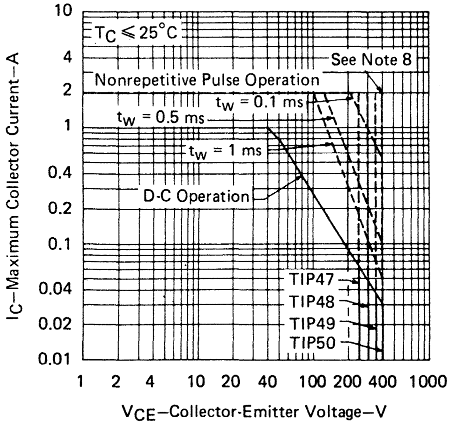


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

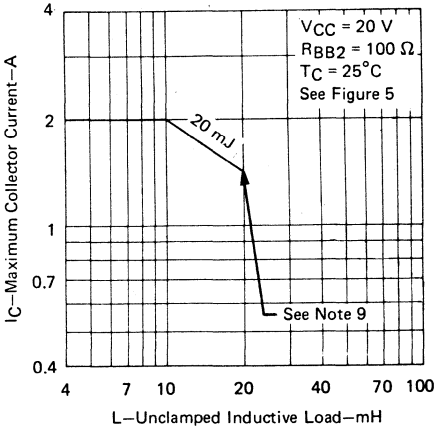


FIGURE 7

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

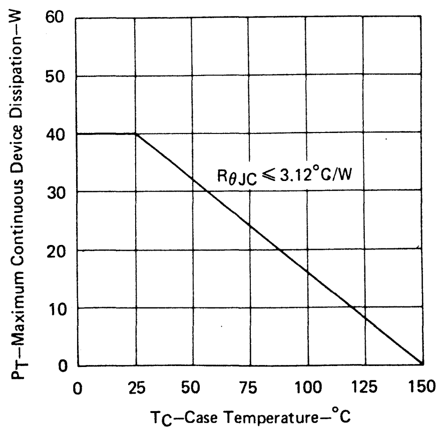


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

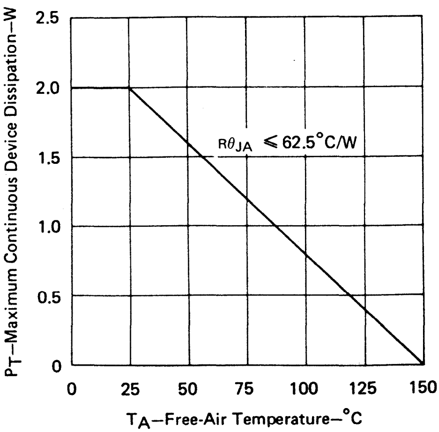


FIGURE 9

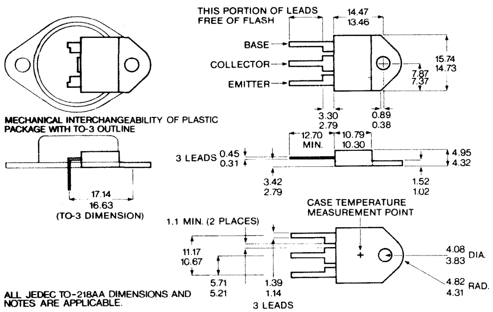
TIP 51, TIP 52, TIP 53, TIP 54
NPN SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR INDUSTRIAL AND CONSUMER APPLICATIONS

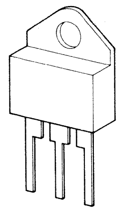
- 100 mJ Reverse-Energy Rating
- 250 V to 400 V Min $V_{(BR)CEO}$
- 100 W at 25°C Case Temperature
- 5 A Peak Collector Current
- 2.5 MHz Min f_T at 10 V, 0.2 A

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)

	TIP51	TIP52	TIP53	TIP54
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	3 A			
Peak Collector Current (See Note 2)	5 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)	100 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			
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. 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 = 20 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C^2 L/2$.

electrical characteristics at 25°C case temperature

	PARAMETER	TEST CONDITIONS	TIP51 MIN	TIP51 MAX	TIP52 MIN	TIP52 MAX	TIP53 MIN	TIP53 MAX	TIP54 MIN	TIP54 MAX	UNIT
$V_{(BR)CEO}$	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,	0.25	µs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −5 V, R_L = 200 Ω, See Figure 4	5	

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

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

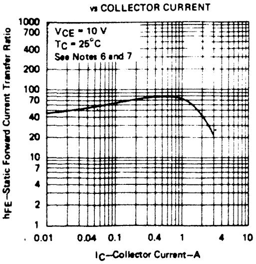


FIGURE 1

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

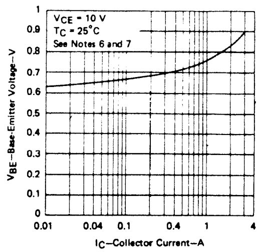


FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

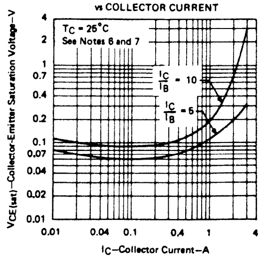
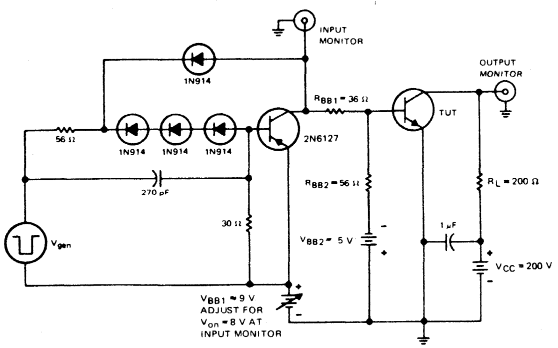


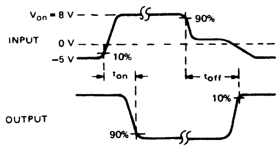
FIGURE 3

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 supplies by a generator with the following characteristics: $t_r < 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leq 2\%$.

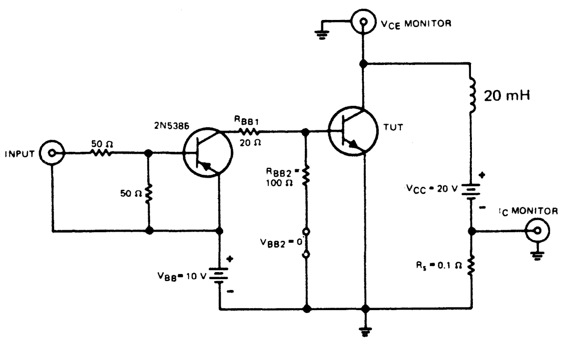
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

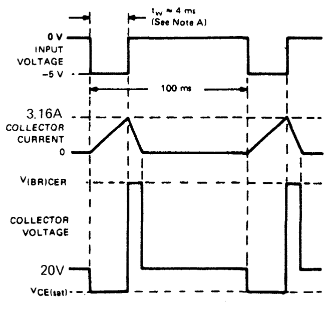
D. Resistors must be noninductive types.

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

FIGURE 4

INDUCTIVE LOAD SWITCHING





TEST CIRCUIT **VOLTAGE AND CURRENT WAVEFORMS**

NOTE A: Input pulse width is increased until I_{CM} = 3.16 A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs COLLECTOR-EMITTER VOLTAGE

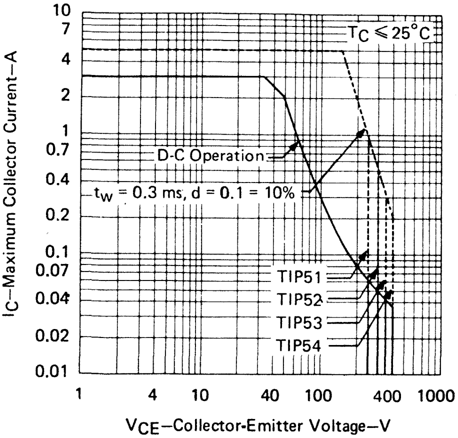


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs UNCLAMPED INDUCTIVE LOAD

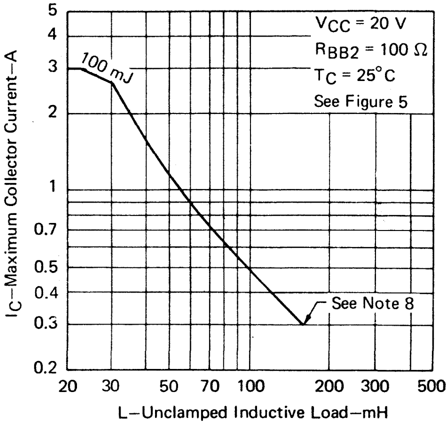


FIGURE 7

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

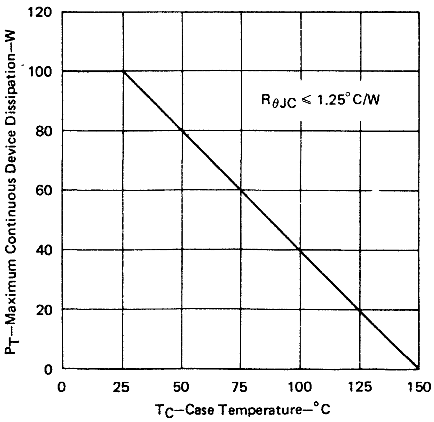


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

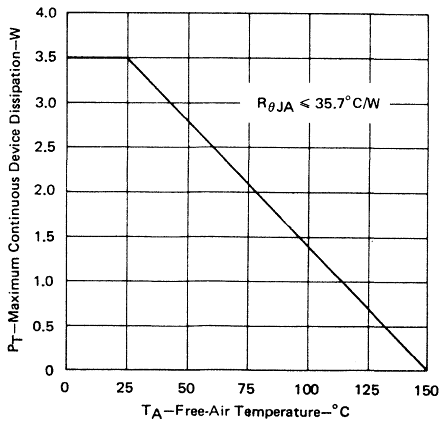


FIGURE 9

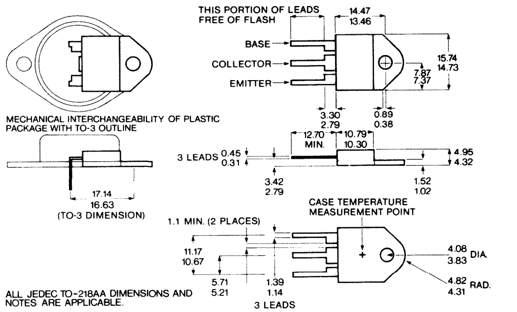
TYPES TIP55A, TIP56A, TIP57A, TIP58A N-P-N SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR AUTOMOTIVE IGNITION AND SWITCHING REGULATOR APPLICATIONS

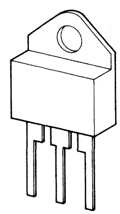
- Min $V_{(BR)CEO}$ of 250 V to 400 V
- 50 W at 100°C Case Temperature
- 10 A Peak Collector Current
- Functional Verification Tests for Ignition and Switching Regulator Applications

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 $t_w \leq 10$ ms, duty cycle $\leq 10\%$.
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.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP55A MIN	TIP55A MAX	TIP56A MIN	TIP56A MAX	TIP57A MIN	TIP57A MAX	TIP58A MIN	TIP58A MAX	UNIT
$V_{(BR)CEO}$	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	

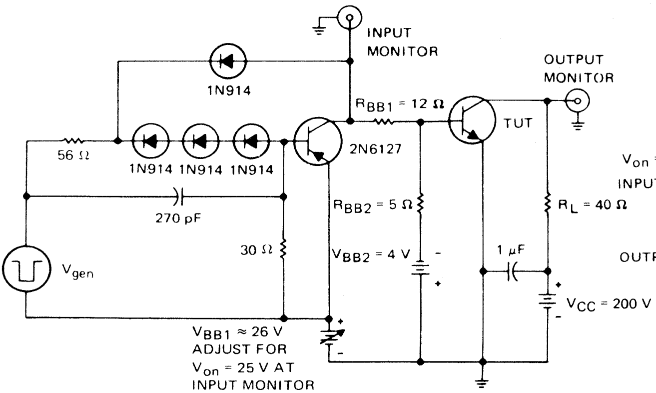
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

functional tests at 25°C free-air temperature

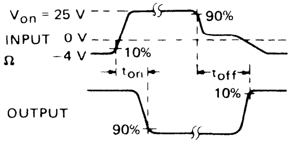
TEST	CONDITIONS			LEVEL
Power ($V_{CE} \cdot I_C$)	$V_{CE} = 50$ V,	$I_C = 2$ A,	$t_{test} = 0.15$ s	100 W
Reverse Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	$I_{CM} = 5$ A, $t_{test} = 0.5$ s,	L = 2 mH, See Figure 2	f = 10 Hz,	25 mJ
Forward Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	$I_{CM} = 10$ 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. $t_w = 300$ 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 screw with bushing, and a mounting torque of 8 inch-pound.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

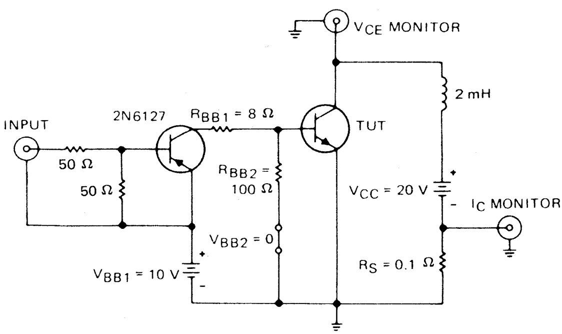


VOLTAGE WAVEFORMS

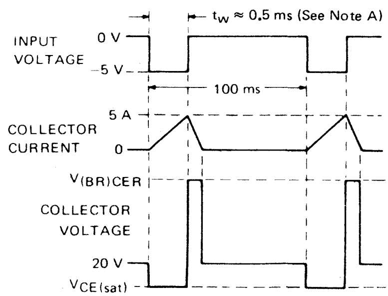
NOTES:
A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following 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—SWITCHING TIMES

FUNCTIONAL TEST INFORMATION



TEST CIRCUIT

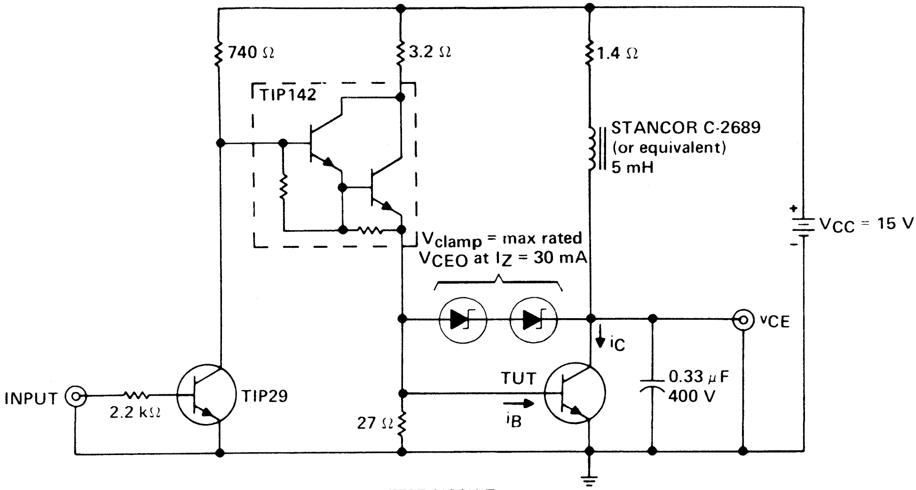


VOLTAGE AND CURRENT WAVEFORMS

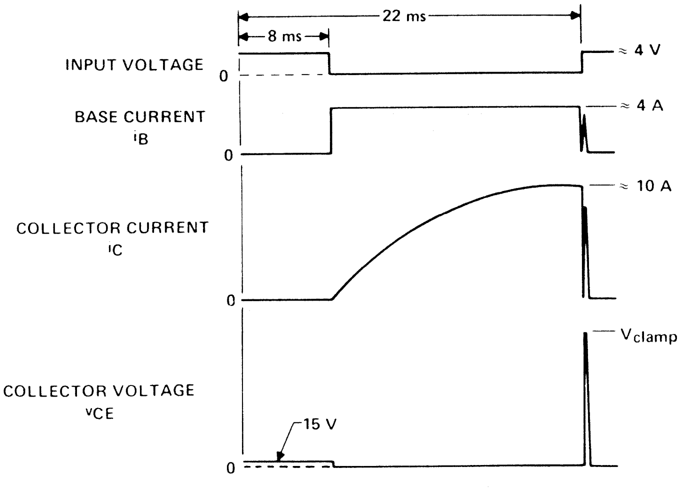
NOTE A: Input pulse width is increased until I_{CM} = 5 A.

FIGURE 2—REVERSE PULSE ENERGY

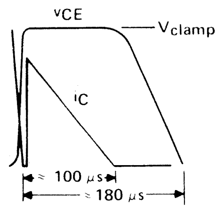
FUNCTIONAL TEST INFORMATION



TEST CIRCUIT



WAVEFORMS



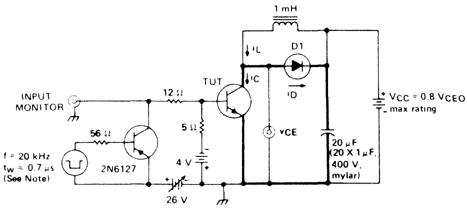
COLLECTOR VOLTAGE AND COLLECTOR CURRENT WAVEFORM DETAIL

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

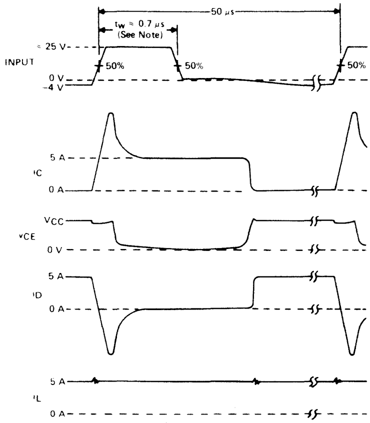
FUNCTIONAL TEST INFORMATION



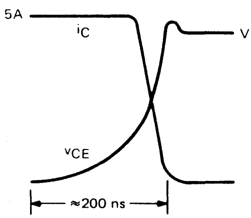
D1: RCA 40960 (or equivalent)
Rated $I_{FM} \geq 125$ A
Rated $V_{RRM} \geq 600$ V
$V_F \leq 1.8$ V at $I_F = 100$ A
$t_{rr} \leq 0.35$ μs at I_{FRM} = 125 A, di/dt = 25 A/μs, t_w = 15 μs

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

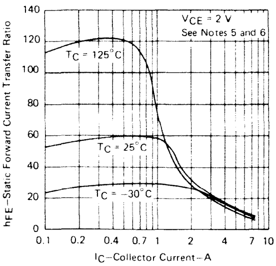


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

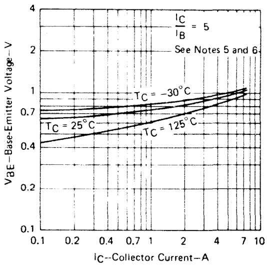


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

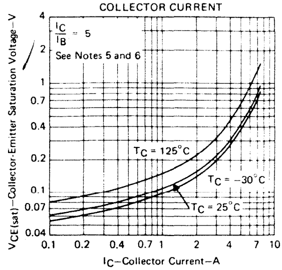
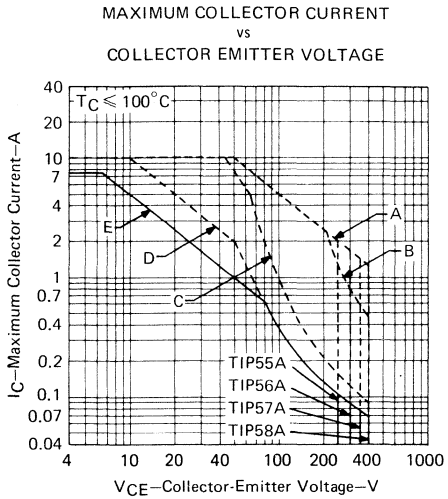


FIGURE 7

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 within 0.125 inch from the device body.

MAXIMUM SAFE OPERATING AREA



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

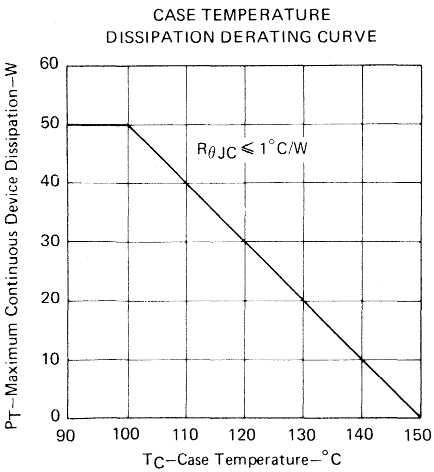


FIGURE 9

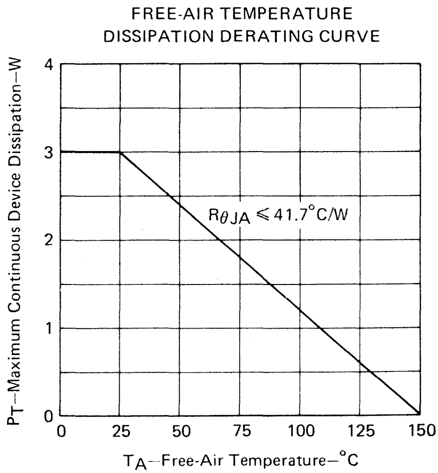


FIGURE 10

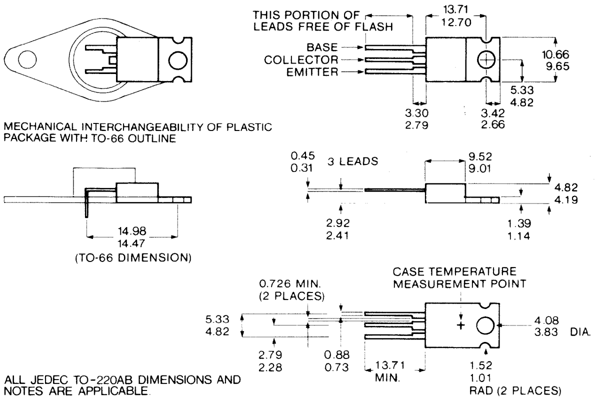
TIP 75 SERIES
N-P-N SINGLE-DIFFUSED MESA SILICON POWER TRANSISTORS

HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY
DESIGNED FOR AUTOMOTIVE IGNITION, LINEAR AMPLIFIER, AND
SWITCHING REGULATOR APPLICATIONS

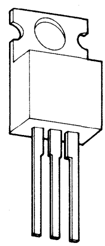
- Reverse-Bias SOA . . . 200 V to 400 V, 3A
- 65 W at 25°C Case Temperature
- 5 A Peak Collector Current
- Designed to Replace Motorola MJE2160

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP75 MIN	TIP75 MAX	TIP75A MIN	TIP75A MAX	TIP75B MIN	TIP75B MAX	TIP75C MIN	TIP75C MAX	UNIT
$V_{(BR)CBO}$	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		
$\|h_{fe}\|$	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 ⩽ 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

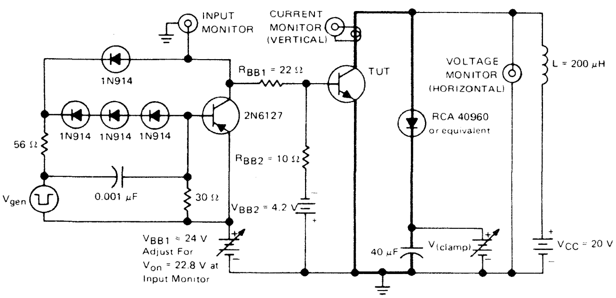
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)}$ = MIN $V_{CEX(sus)}$, I_{CM} = 3A, $I_{B(1)}$ = 500 mA, $I_{B(2)}$ = −500 mA, See Figure 2	1700	ns
t_{si}	Current Storage Time		2300	ns
t_{tv}	Voltage Transition Time		700	ns
t_{ti}	Current Transition Time		700	ns
t_{xo}	Cross-over Time		1300	ns

resistive-load switching characteristics at 25°C case temperature

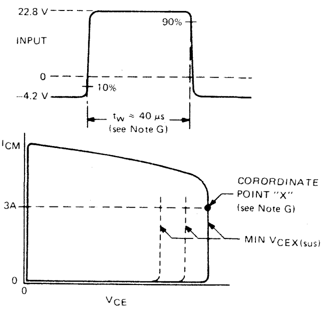
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 2 A, $I_{B(1)}$ = 200 mA, $I_{B(2)}$ = −200 mA, $V_{BE(off)}$ = −4 V, R_L = 100 Ω, See Figure 3	20	ns
t_r	Rise Time		340	ns
t_s	Storage Time		1400	ns
t_f	Fall Time		800	ns

†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: $t_r \leq 15$ ns, $t_f \leq 15$ 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: $t_r \leq$ 15 ns, $R_{in} \geq$ 10 MΩ, $C_{in} \leq$ 11.5 pF.

D. Resistors must be noninductive types.

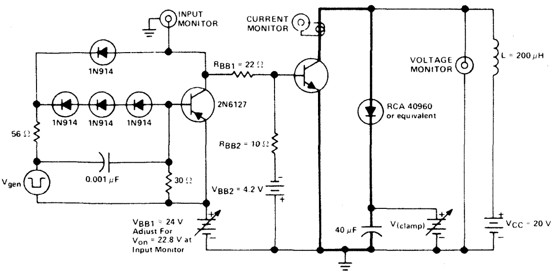
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

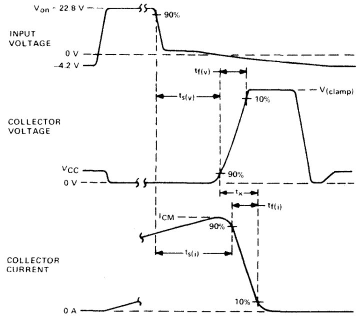
F. Heavy lines denote copper bus 0.5 inch by 0.125 inch (12,7 mm by 3,2 mm) fabricated to have minimum inductance.

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, $Z_{out} = 50\ \Omega$, $t_w \approx 25\ \mu s$, duty cycle ⩽ 2%. Pulse width is adjusted for $I_{CM} = 3A$.

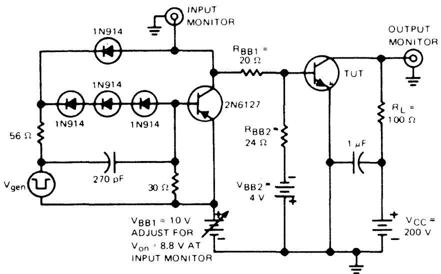
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

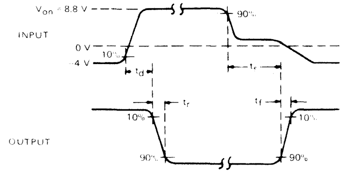
D. Resistors must be noninductive types.

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 (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

COLLECTOR CUTOFF CURRENT
vs
TEMPERATURE

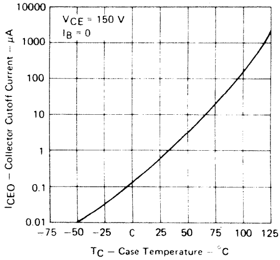


FIGURE 4

COLLECTOR CUTOFF CURRENT
vs
TEMPERATURE

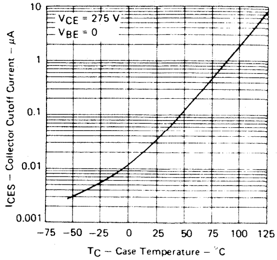


FIGURE 5

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

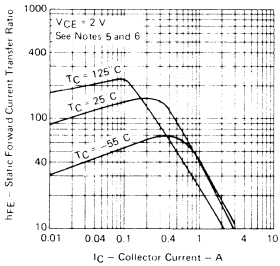


FIGURE 6

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

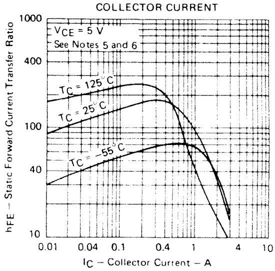


FIGURE 7

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

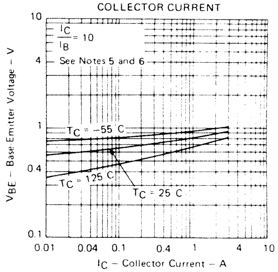


FIGURE 8

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

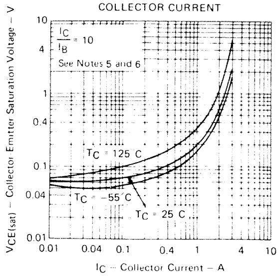


FIGURE 9

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.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE
(FORWARD BASE BIAS)

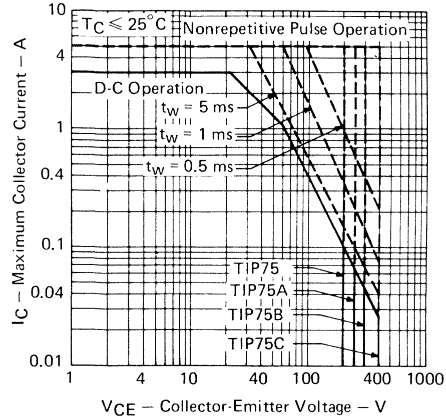


FIGURE 10

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

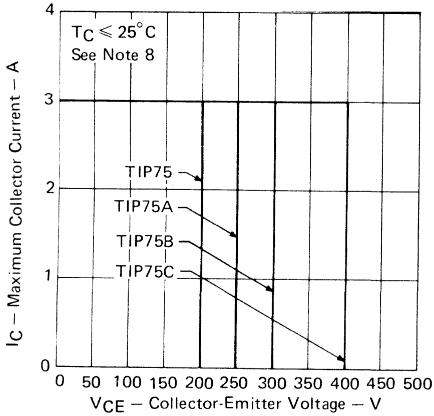


FIGURE 11

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

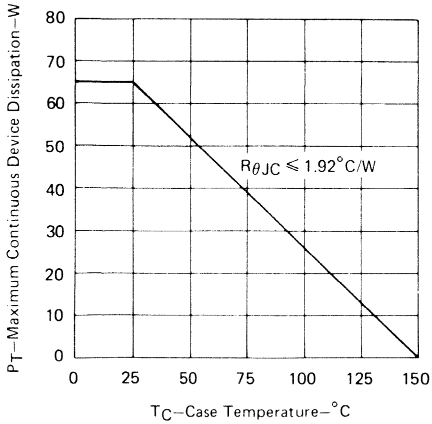


FIGURE 12

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

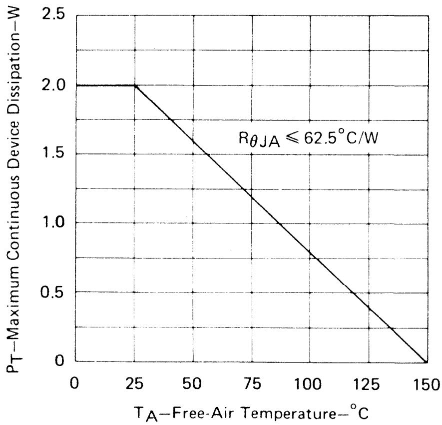
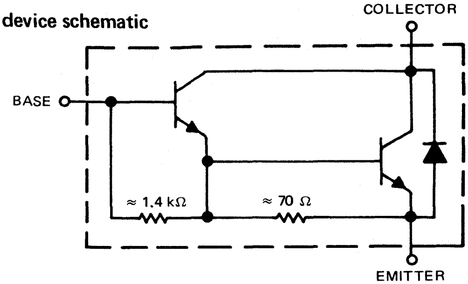


FIGURE 13

DESIGNED FOR COMPLEMENTARY USE WITH TIP105, TIP106, TIP107

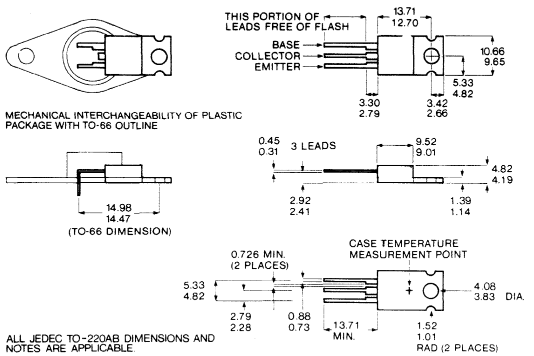
- 80 W at 25°C Case Temperature
- 8 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 8 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 8 A
- Designed to Replace:
  2N6045 Series 2N6388 Series
  MJE6045 Series SE9302 Series

device schematic

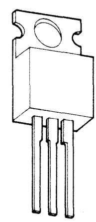


mechanical data

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)

	TIP100	TIP101	TIP102
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)	← 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)	← 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 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 0.64 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.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS			TIP100 MIN	TIP100 MAX	TIP101 MIN	TIP101 MAX	TIP102 MIN	TIP102 MAX	UNIT
$V_{(BR)CEO}$	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,	$I_C = 8$ A		200		200		200		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 4$ V,	$I_C = 8$ 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
		$I_B = 80$ mA,	$I_C = 8$ A			2.5		2.5		2.5	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C = 8$ A,	$I_B = 0$,	See Notes 5 and 6		3.5		3.5		3.5	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 contracts and located within 0.125 inch from the device body.

thermal characteristics

PARAMETER		TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance		1.56	°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 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

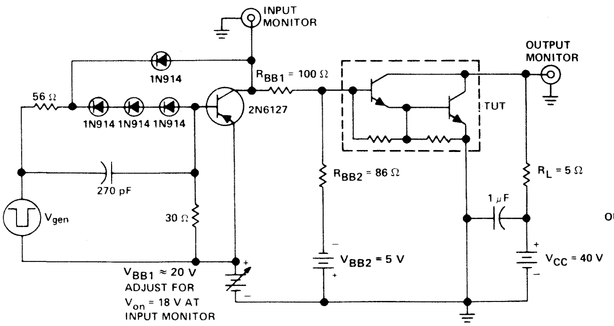
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = 8$ A, $I_{B(1)} = 80$ mA, $I_{B(2)} = -80$ mA, $V_{BE(off)} = -5$ V, $R_L = 5\ \Omega$, See Figure 1	0.035	μs
t_r	Rise Time		0.35	
t_s	Storage Time		1.8	
t_f	Fall Time		2.45	

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

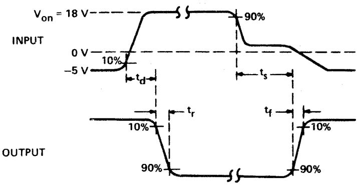
functional tests at 25°C free-air temperature

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 $\left(\frac{I_C{}^2 L}{2}\right)$	$I_{CM} = 1$ A, L = 20 mH, f = 10 Hz, $t_{test} = 0.5$ s, See Figure 2	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 Ω, t_w = 20 μs, duty cycle ≤ 2%.

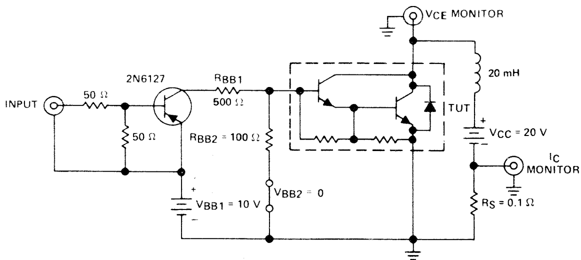
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

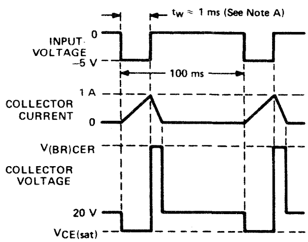
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

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

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

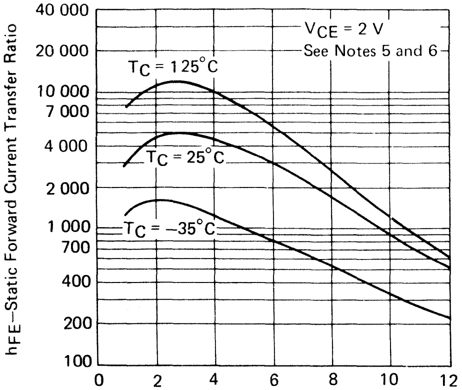


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

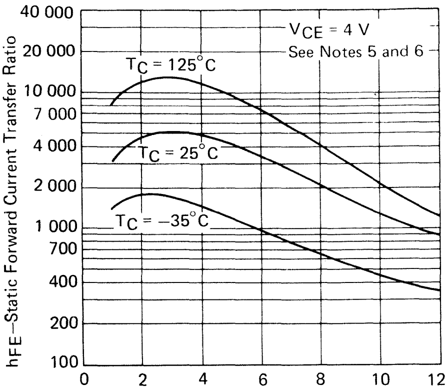


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

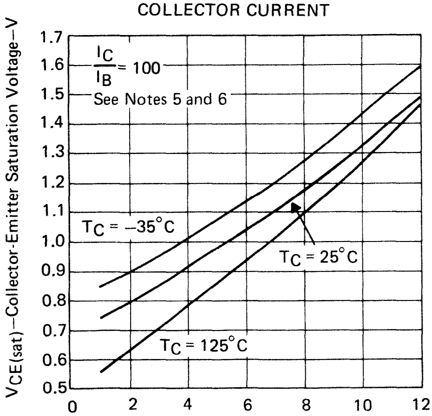


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

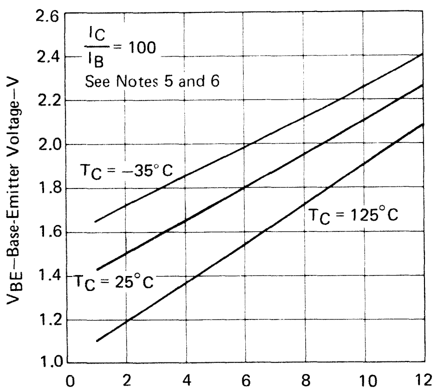


FIGURE 6

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

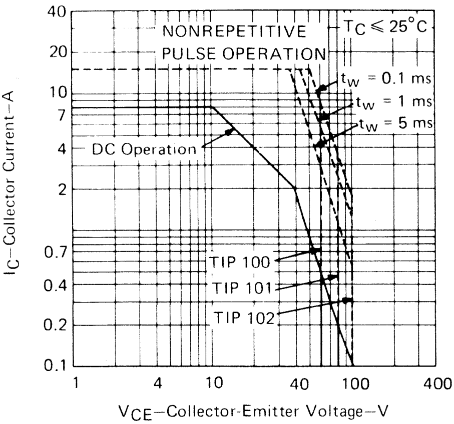


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

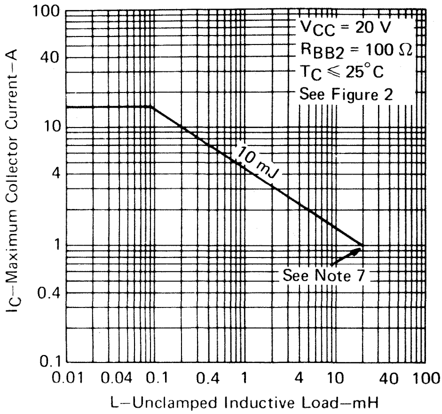


FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

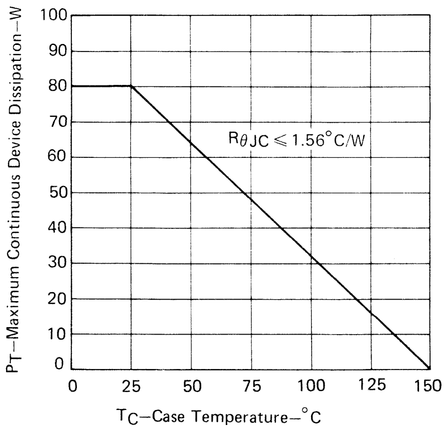


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

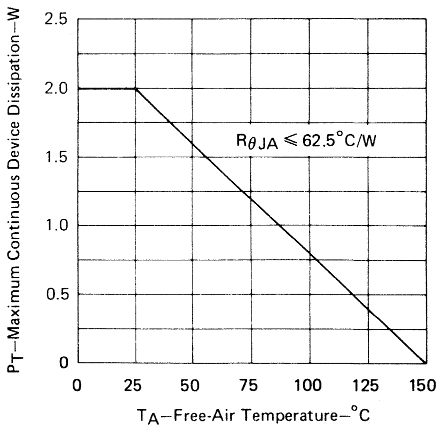


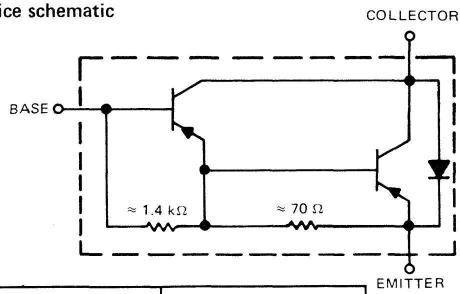
FIGURE 10

TYPES TIP105, TIP106, TIP107
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP100, TIP101, TIP102

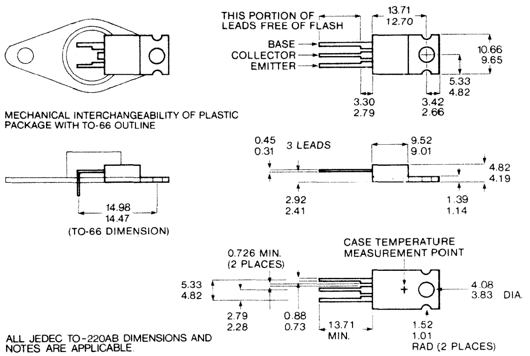
- 80 W at 25°C Case Temperature
- 8 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 8 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 8 A
- Designed to Replace:
  2N6042 Series SE 9402 Series
  MJE6042 Series RCA 8203B Series

device schematic

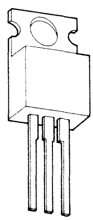


mechanical data

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)

	TIP105	TIP106	TIP107
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)	← −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)	← 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 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 ≤ 10%.
3. Derate linearly to 150°C case temperature at the rate of 0.64 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.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP105 MIN	TIP105 MAX	TIP106 MIN	TIP106 MAX	TIP107 MIN	TIP107 MAX	UNIT
$V_{(BR)CEO}$	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, $I_C = -8$ A		200		200		200		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -4$ V, $I_C = -8$ 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
		$I_B = -80$ mA, $I_C = -8$ A			−2.5		−2.5		−2.5	
V_F	Forward Voltage of Commutation Diode	$I_F = I_C = 8$ A, $I_B = 0$,	See Notes 5 and 6		3.5		3.5		3.5	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 contracts and located within 3.2mm 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 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

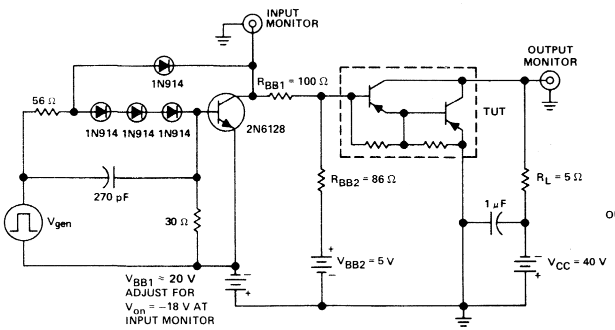
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = -8$ A, $I_{B(1)} = -80$ mA, $I_{B(2)} = 80$ mA, $V_{BE(off)} = 5$ V, $R_L = 5\ \Omega$, See Figure 1	0.035	μs
t_r	Rise Time		0.3	
t_s	Storage Time		0.9	
t_f	Fall Time		1.3	

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

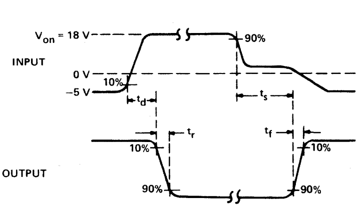
functional tests at 25°C free-air temperature

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 $\left(\frac{I_C{}^2 L}{2}\right)$	$I_{CM} = -1$ A, L = 20 mH, f = 10 Hz, $t_{test} = 0.5$ s, See Figure 2	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: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\leqslant 2\%$.

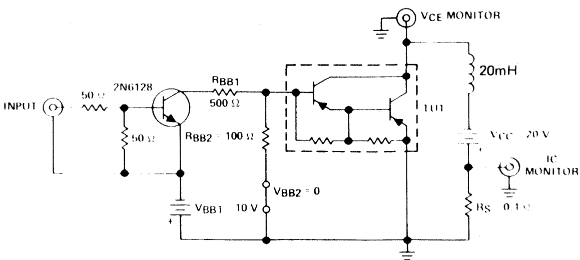
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10\ M\Omega$, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

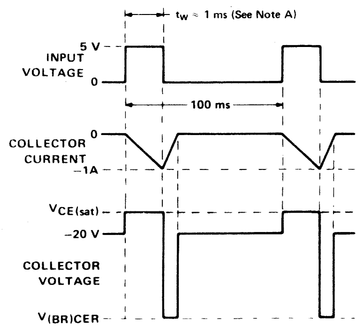
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

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

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

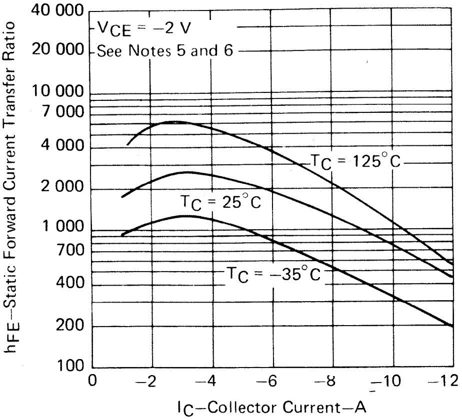


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

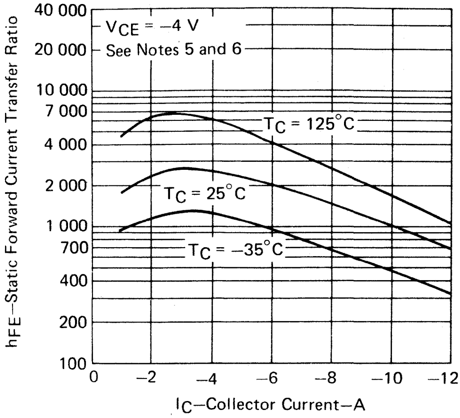


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

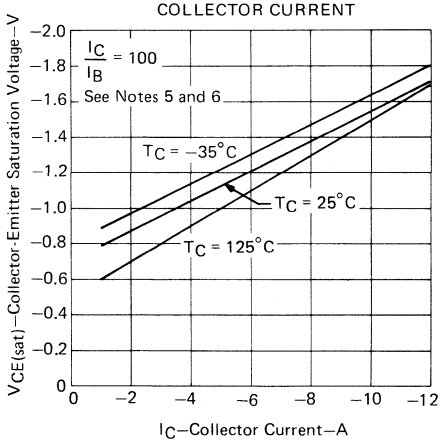


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

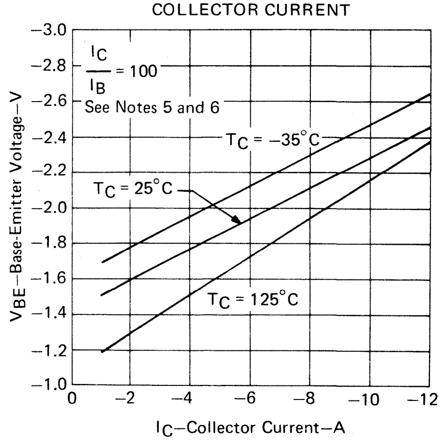


FIGURE 6

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

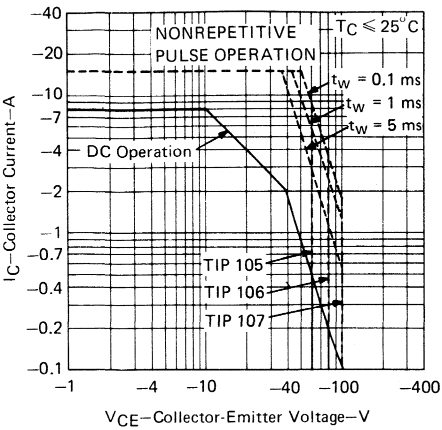


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

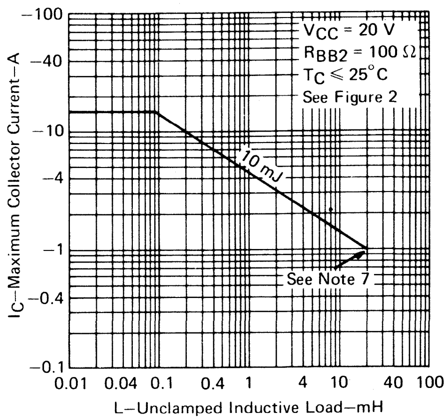


FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE DISSIPATION DERATING CURVE

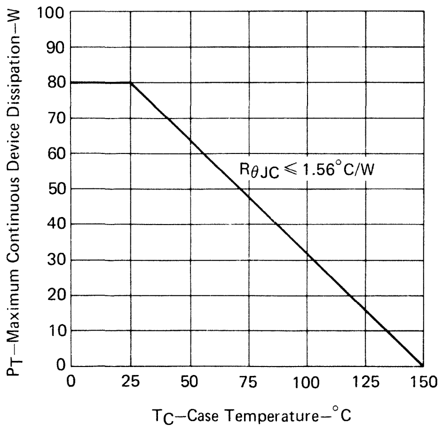


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

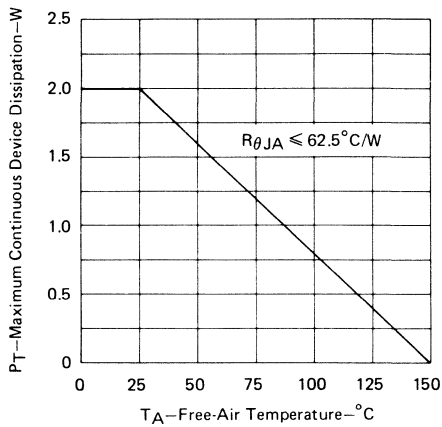


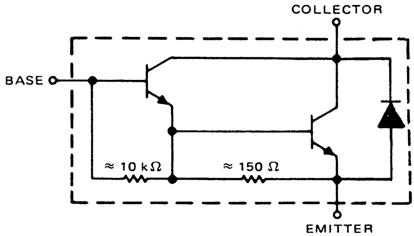
FIGURE 10

TIP110, TIP111, TIP112
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP115, TIP116, TIP117

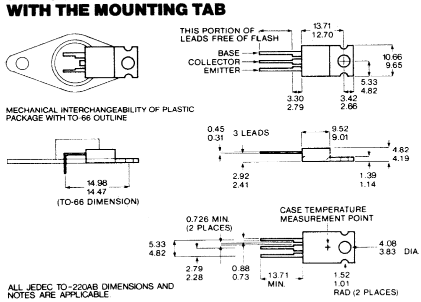
- High SOA Capability, 40 V and 1.25 A
- 50 W at 25°C Case Temperature
- 4-A Rated Collector Current
- Min h_{FE} of 500 at 4 V, 2 A
- 25-mJ Reverse Energy Rating

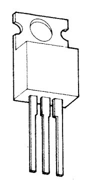
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





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)	← 6A →		
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 $t_w \leq 0.3$ ms, duty cycle $\leq 10\%$.
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 = 20mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ 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		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
V_F	Forward Voltage of commutation diode	$I_F = -I_C = 4$A See Notes 6 and 7			3.5		3.5		3.5	V

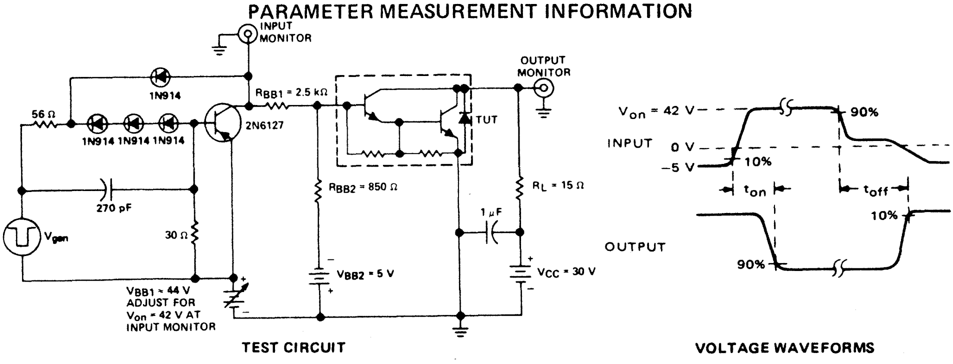
NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

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.

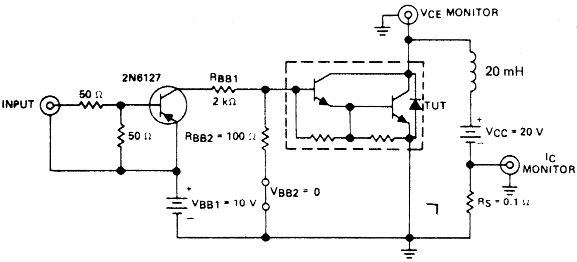
PARAMETER MEASUREMENT INFORMATION



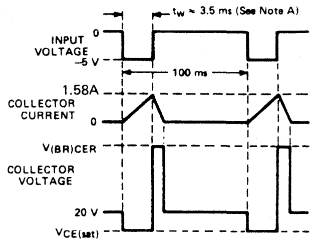
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ≤ 15 ns, t_f ≤ 15 ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ µs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following 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} = 1.58 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

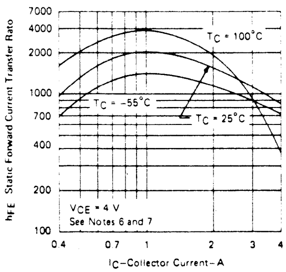


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

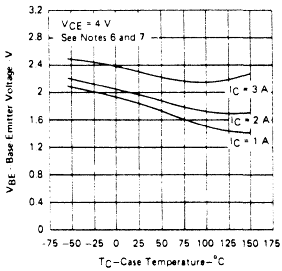


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

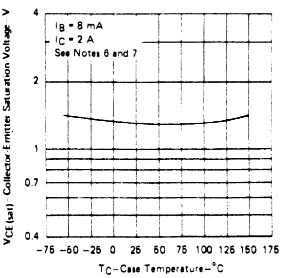


FIGURE 5

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

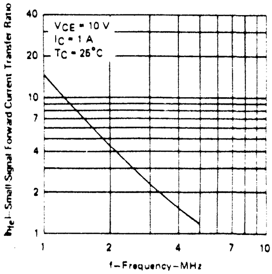


FIGURE 6

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

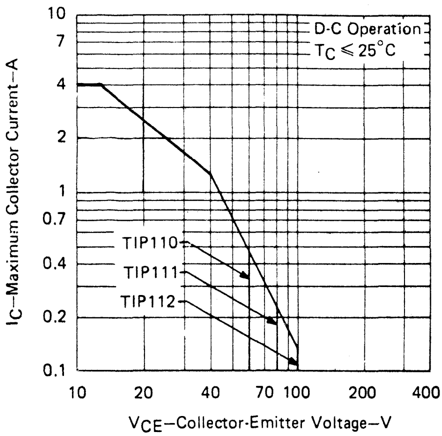


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

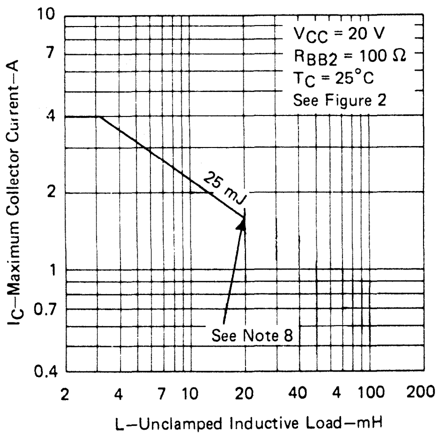


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

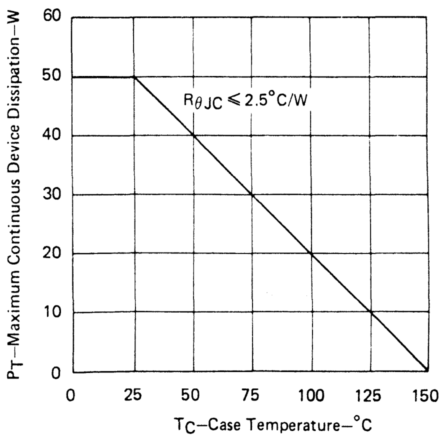


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

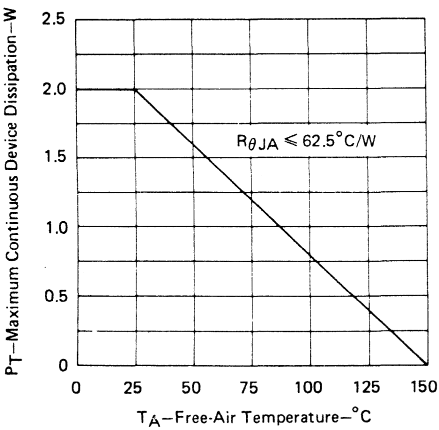


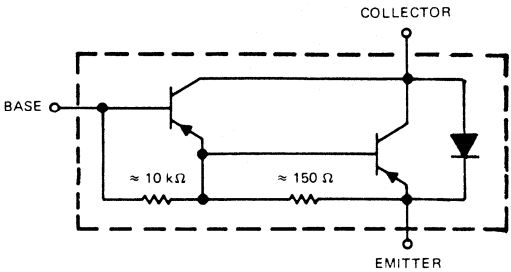
FIGURE 10

PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP110, TIP111, TIP112

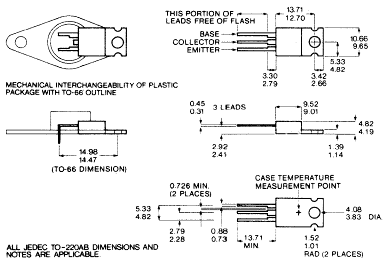
- High SOA Capability, 40 V and 1.25 A
- 50 W at 25°C Case Temperature
- Min h_{FE} of 500 at 4 V, 2 A
- 4-A Rated Collector Current
- 25-mJ Reverse Energy Rating

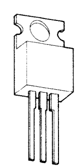
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES

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)	←—— −6A ——→		
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 $t_w \leq 0.3$ ms, duty cycle $\leq 10\%$.
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 = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

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
V_F	Forward Voltage of commutation diode	$I_F = -I_C =$ SA, $I_B = 0$	See notes 6 and 7		3.5		3.5		3.5	V

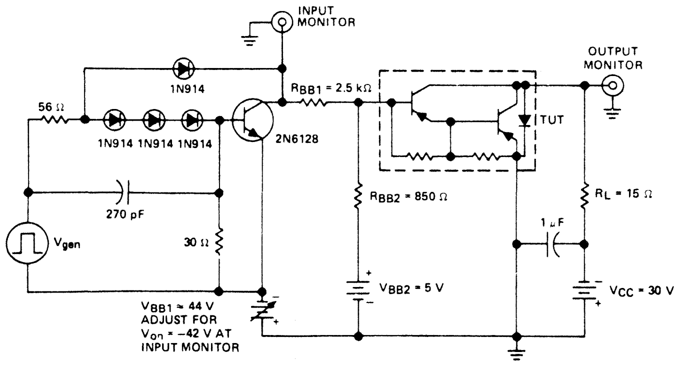
NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

switching characteristics at 25°C case temperature

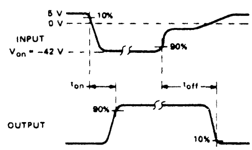
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	$I_C = -2$ A,	$I_{B(1)} = -8$ mA,	$I_{B(2)} = 8$ mA,	2.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 5$ V,	$R_L = 15\ \Omega$,	See Figure 1	4.5	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

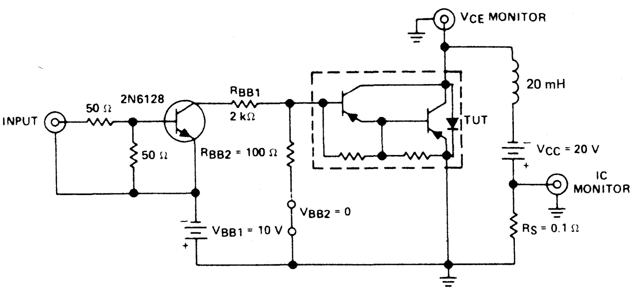


VOLTAGE WAVEFORMS

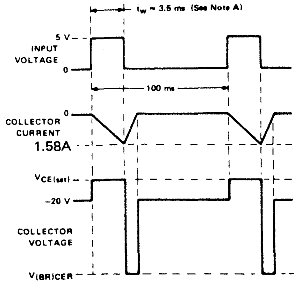
NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the 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



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -1.58$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

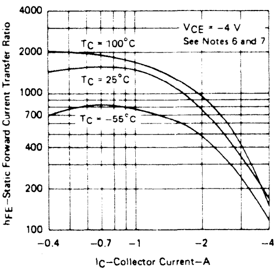


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

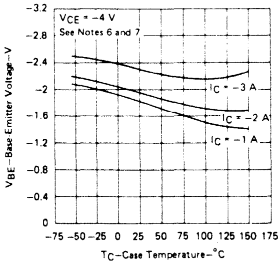


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

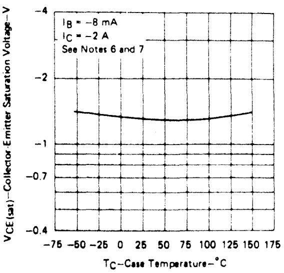


FIGURE 5

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

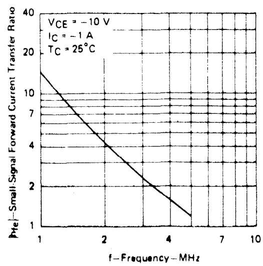


FIGURE 6

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 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT vs COLLECTOR-EMITTER VOLTAGE

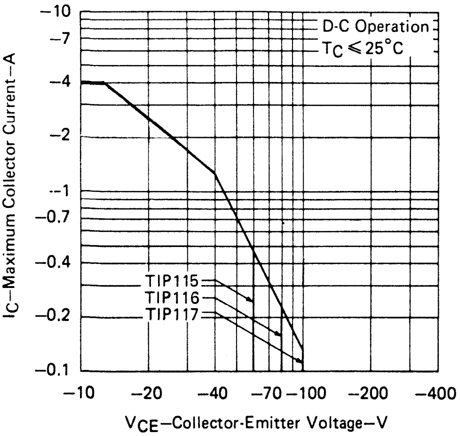


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

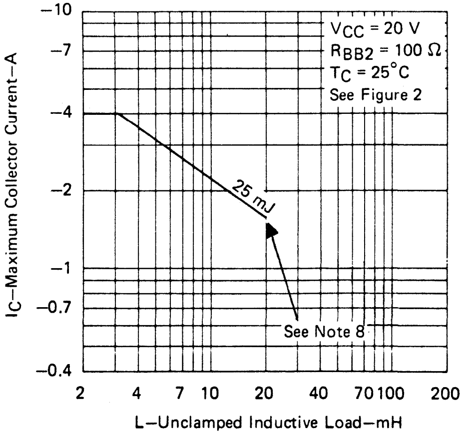


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE DISSIPATION DERATING CURVE

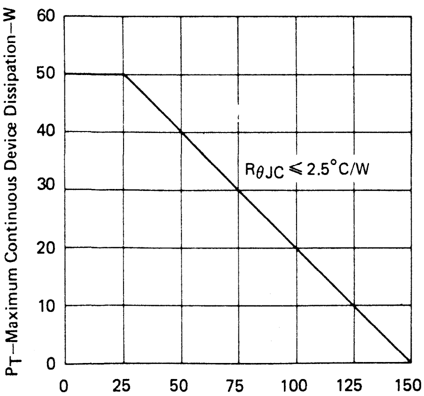


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

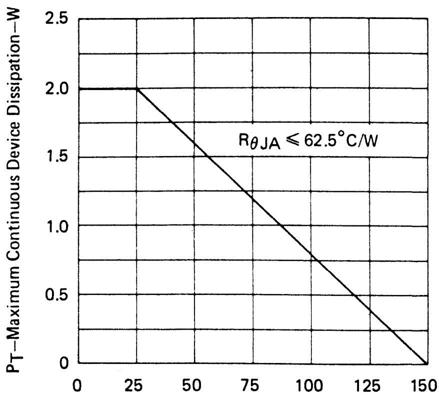


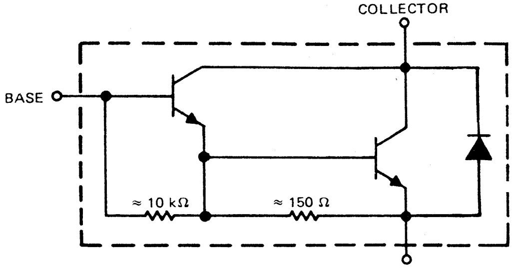
FIGURE 10

TIP120, TIP121, TIP122
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

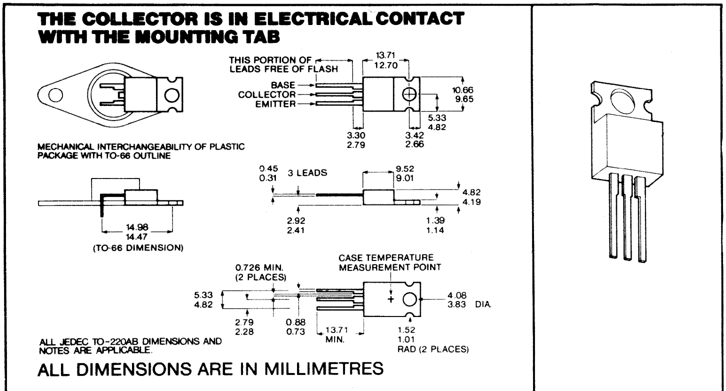
DESIGNED FOR COMPLEMENTARY USE WITH TIP125, TIP126, TIP127

- 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



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 $t_w \leq 0.3$ ms, duty cycle $\leq 10\%$.
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 = 20 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2L/2$.

TIP120, TIP121, TIP122
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP120 MIN	TIP120 MAX	TIP121 MIN	TIP121 MAX	TIP122 MIN	TIP122 MAX	UNIT
$V_{(BR)CEO}$	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	
V_F	Forward Voltage of Commutating Diode	$I_F = -I_C$ = 5 A, I_B = 0, See Notes 6 and 7		3.5		3.5		3.5	V

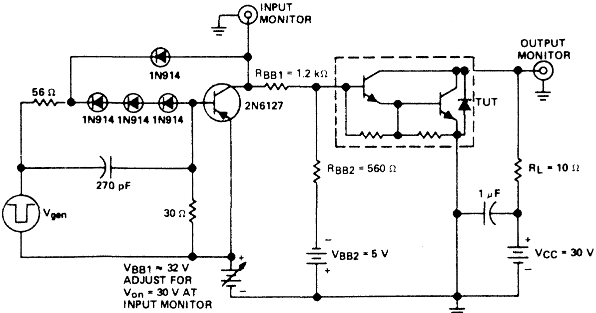
NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

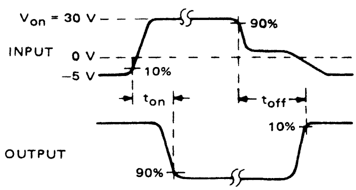
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 3 A, $I_{B(1)}$ = 12 mA, $I_{B(2)}$ = −12 mA,	1.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −5 V, R_L = 10 Ω, See Figure 1	8.5	μs

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

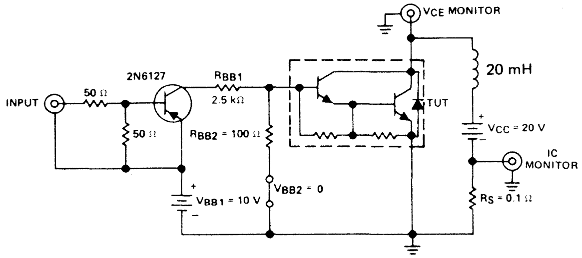


VOLTAGE WAVEFORMS

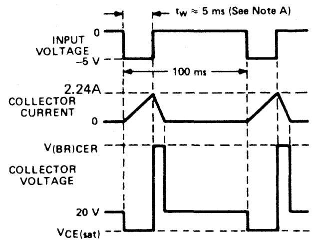
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ≤ 15 ns, t_f ≤ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: 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} = 2.24 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

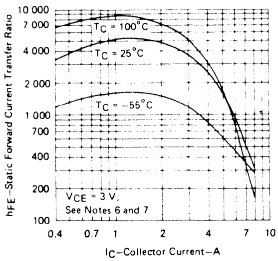


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

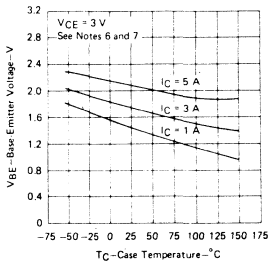


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

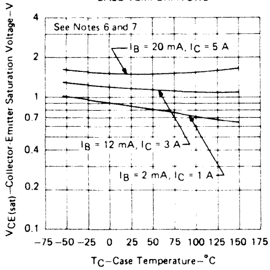


FIGURE 5

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

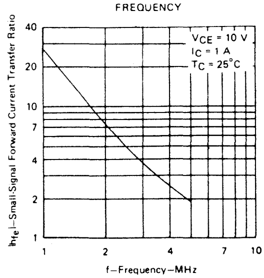


FIGURE 6

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

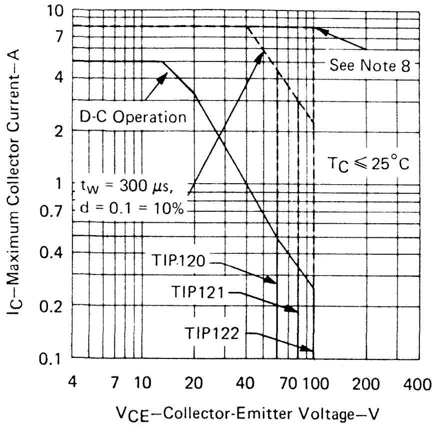


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

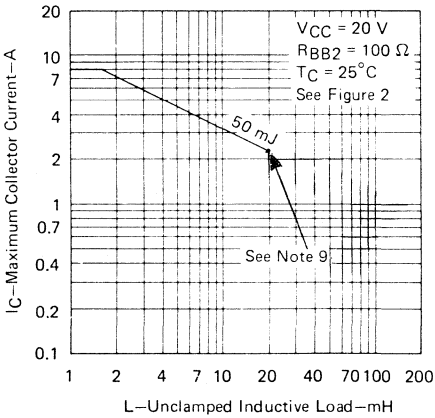


FIGURE 8

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

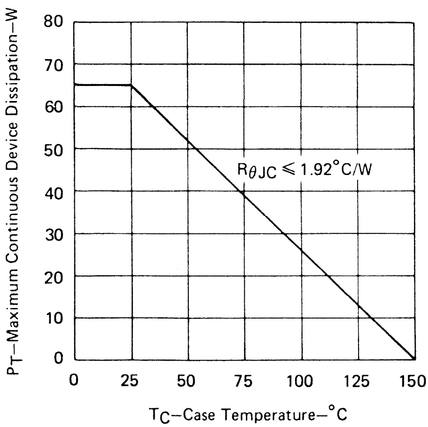


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

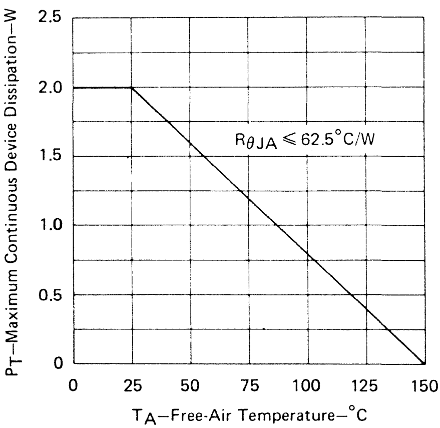


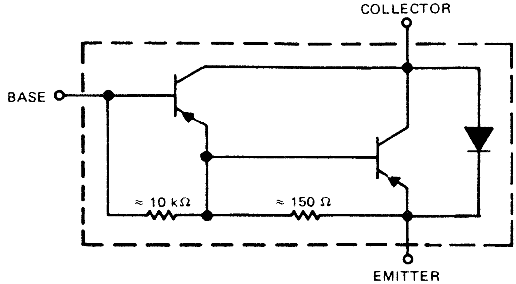
FIGURE 10

TIP125, TIP126, TIP127
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP120, TIP121, TIP122

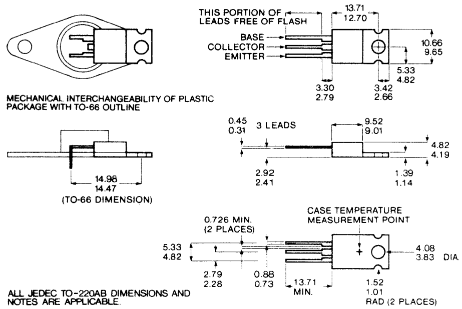
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

device schematic

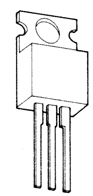


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 $t_w \leq 0.3$ ms, duty cycle $\leq$ 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 = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C^2L/2$.

TIP125, TIP126, TIP127
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	TIP125 MIN	TIP125 MAX	TIP126 MIN	TIP126 MAX	TIP127 MIN	TIP127 MAX	UNIT
$V_{(BR)CEO}$	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	
V_F	Forward Voltage of Commutating Diode	$I_F = I_C = 5$ A, $I_B = 0$, See Notes 6 and 7		3.5		3.5		3.5	V

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

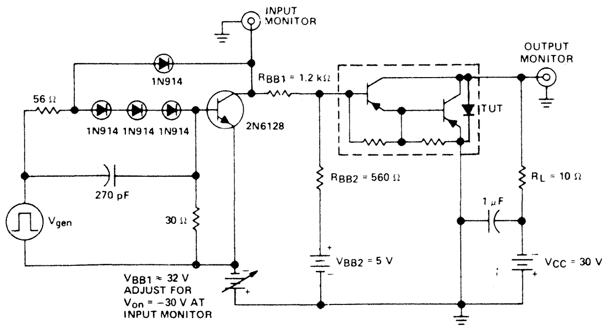
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3,2 mm from the device body.

switching characteristics at 25°C case temperature

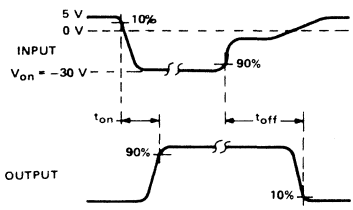
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -3$ A, $I_{B(2)} = -12$ mA, $I_{B(2)} = 12$ mA,	1.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 5$ V, $R_L = 10\ \Omega$, See Figure 1	8.5	

†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, $Z_{out} = 50\ \Omega$, $t_w = 20$ μs, duty cycle ⩽ 2%.

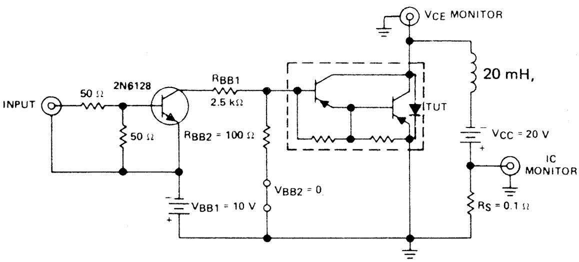
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $R_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.

D. Resistors must be noninductive types.

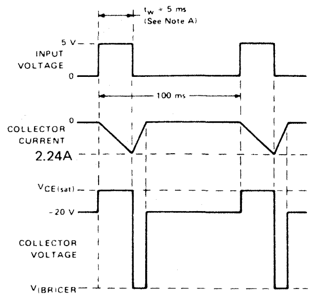
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 1

INDUCTIVE LOAD SWITCHING



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width in increased until $I_{CM} = -2.24$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

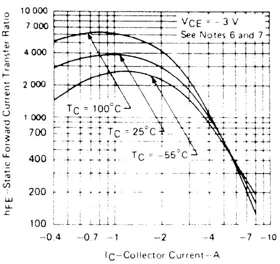


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

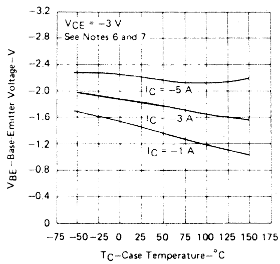


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

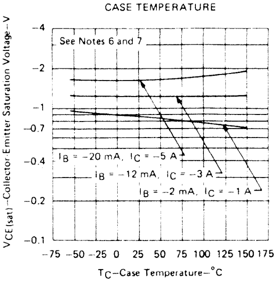


FIGURE 5

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

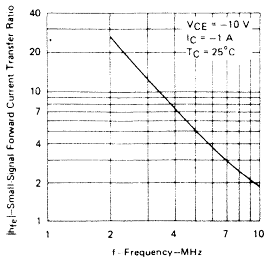


FIGURE 6

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

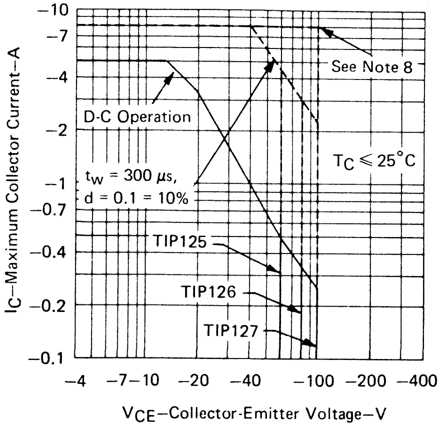


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

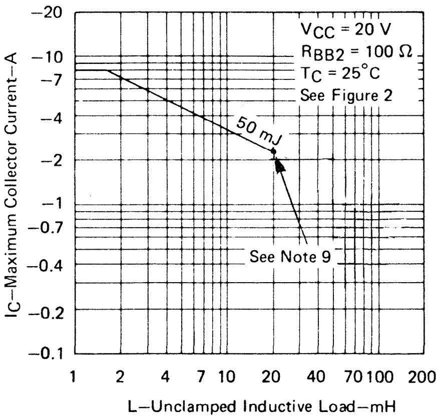


FIGURE 8

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

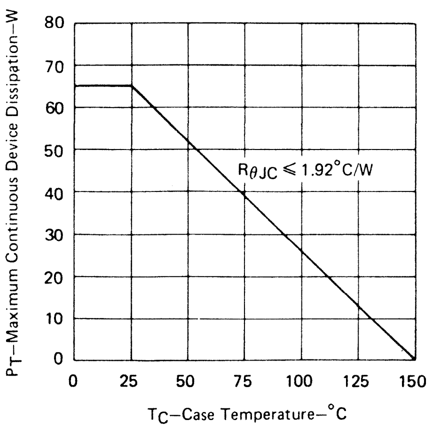


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

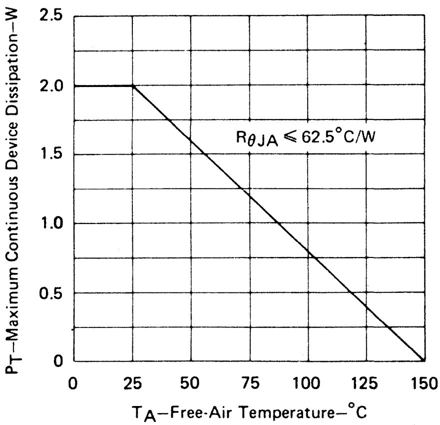


FIGURE 10

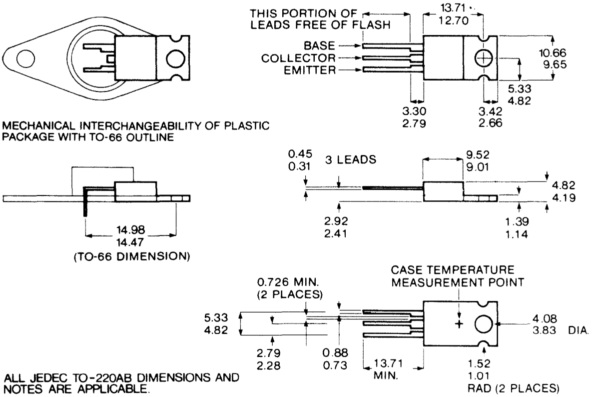
NPN SILICON POWER DARLINGTON TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP135, TIP136, TIP137

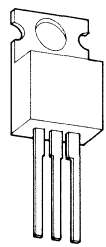
- 70 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min H_{FE} of 1000 @ 4 V/4 A
- 75 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20V, Energy $\approx I_C{}^2L/2$.

NPN SILICON POWER DARLINGTON TRANSISTORS

electrical characteristics at 25 °C case temperature

PARAMETER		TEST CONDITIONS	TIP130 MIN	TIP130 MAX	TIP131 MIN	TIP131 MAX	TIP132 MIN	TIP132 MAX	UNIT
$V_{(BR)CEO}$	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 V_{CE} = 40 V, I_B = 0 V_{CE} = 50 V, I_B = 0		0.5		0.5		0.5	mA
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0 V_{CB} = 100 V, I_E = 0		0.2		0.2		0.2	mA
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 Transfer Ratio	V_{CE} = 4 V, I_C = 1 A V_{CE} = 4 V, I_C = 4 A See Notes 6 an 7	500 1000	 15000	500 1000	 15000	500 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 I_B = 30 mA, I_C = 6 A See Notes 6 and 7		2 3		2 3		2 3	V
C_{OB}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0		200		200		200	pF
V_F	Forward Voltage of Commutating Diode	I_F = $-I_C$ = 8 A, I_B = 0, See Notes 6 and 7		3.5		3.5		3.5	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.

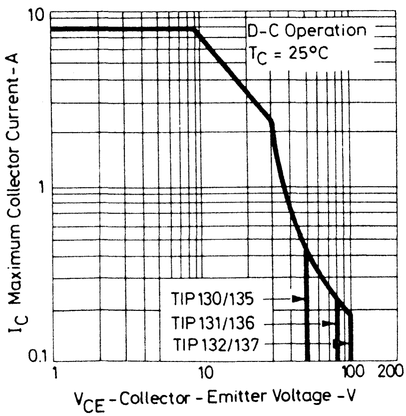


FIGURE 1

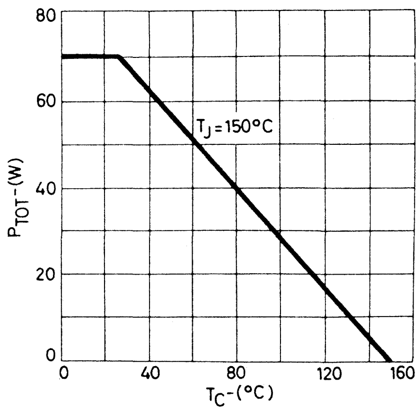
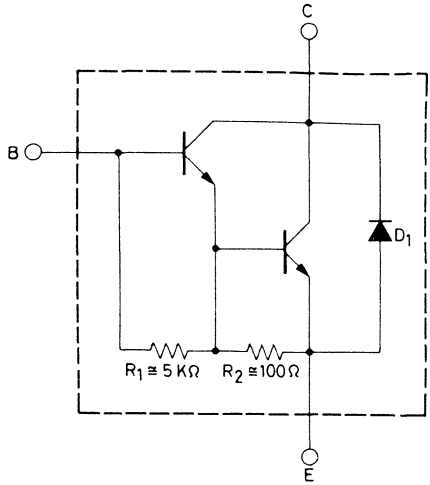


FIGURE 2



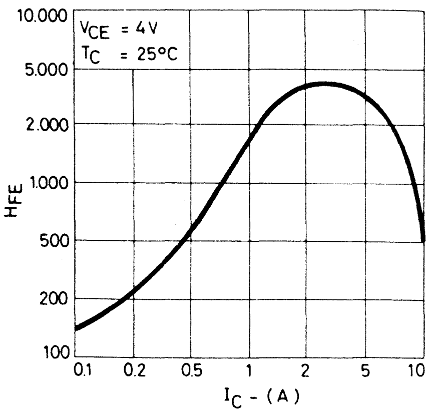


FIGURE 3

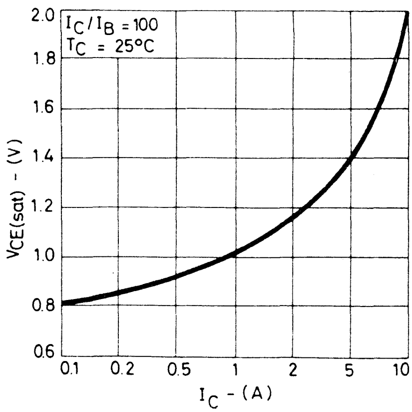


FIGURE 4

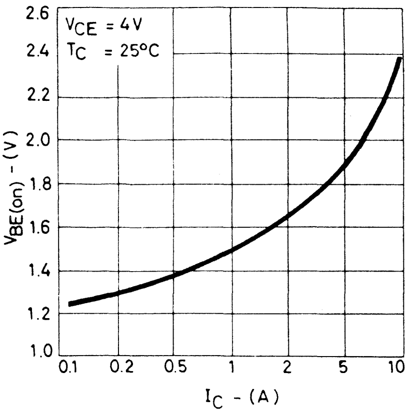


FIGURE 5

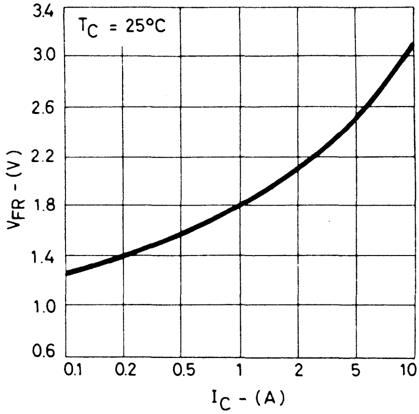


FIGURE 6

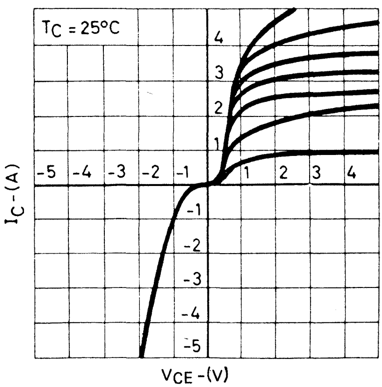


FIGURE 7

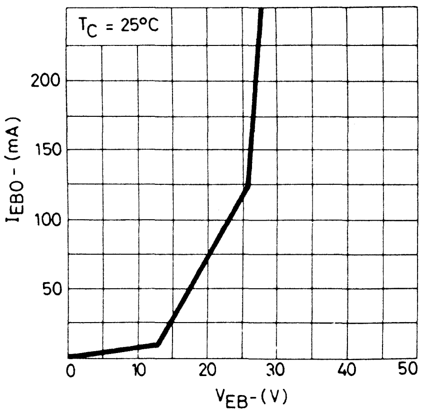


FIGURE 8

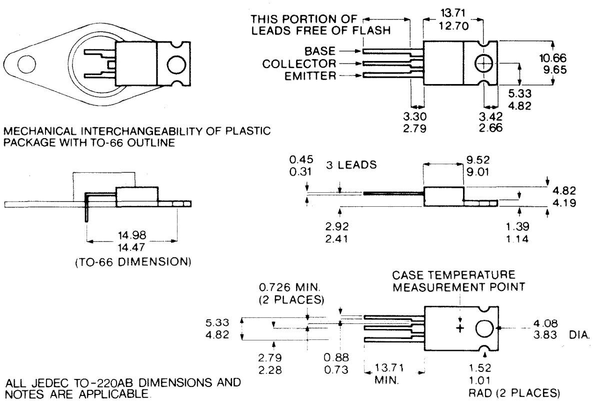
TIP135, TIP136, TIP137
PNP SILICON POWER DARLINGTON TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP130, TIP131, TIP132

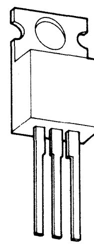
- 70 W at 25 °C Case Temperature
- 8 A Rated Collector Current
- Min H_{FE} of 1000 @ 4 V/4 A
- 75 mJ Reverse Energy Rating

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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, $R_S = 0.1\ \Omega$, $V_{CC} = 20$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 MIN	TIP135 MAX	TIP136 MIN	TIP136 MAX	TIP137 MIN	TIP137 MAX	UNIT
$V_{(BR)CEO}$	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 V_{CE} = 40 V, I_B = 0 V_{CE} = 50 V, I_B = 0		0.5		0.5		0.5	mA
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0 V_{CB} = 100 V, I_E = 0		0.2		0.2		0.2	mA
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 V_{CE} = 4 V, I_C = 4 A See Notes 6 and 7	500 1000	 15000	500 1000	 15000	500 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 I_B = 30 mA, I_C = 6 A See Notes 6 and 7		2 3		2 3		2 3	V
C_{OB}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0		200		200		200	pF
V_F	Forward Voltage of Commutating Diode	I_F = I_C = 8 A, I_B = 0, See Notes 6 and 7		3.5		3.5		3.5	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.

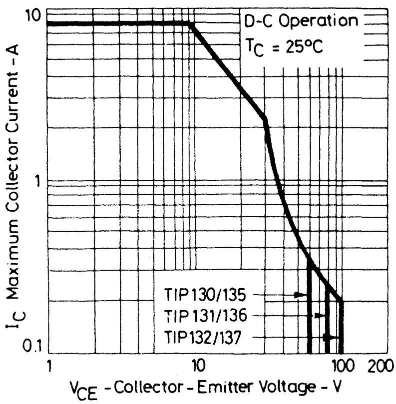


FIGURE 1

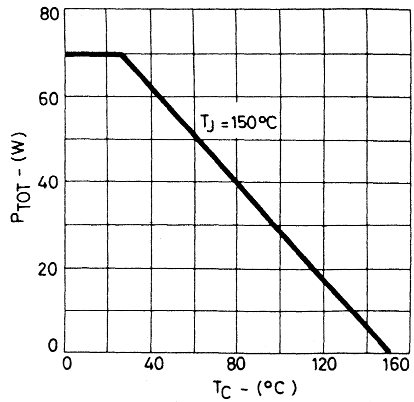
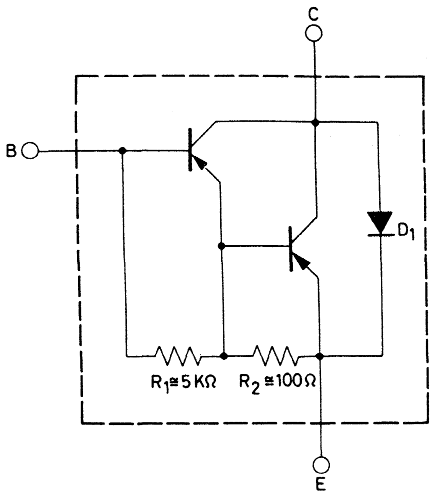


FIGURE 2

TEXAS INSTRUMENTS



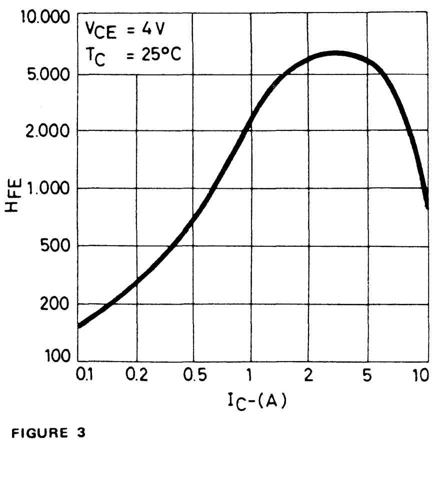


FIGURE 3

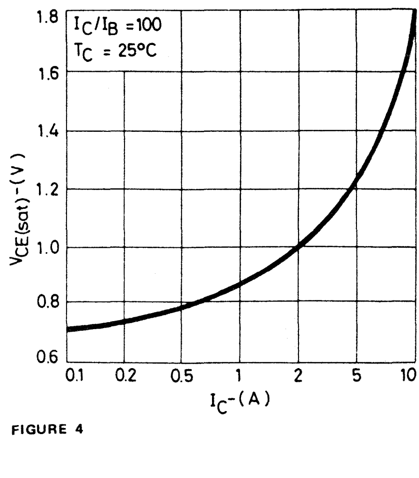


FIGURE 4

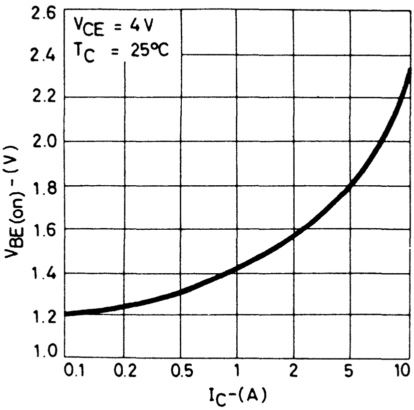


FIGURE 5

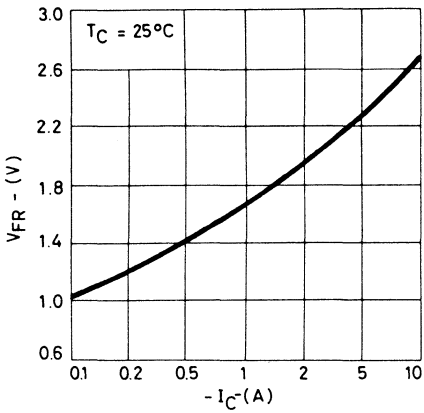


FIGURE 6

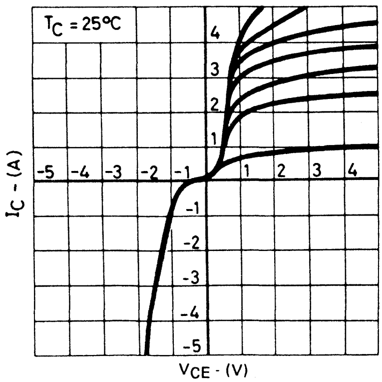


FIGURE 7

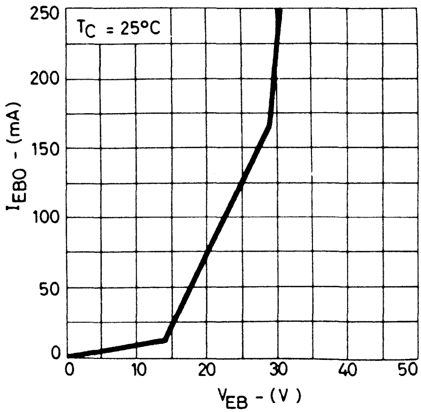


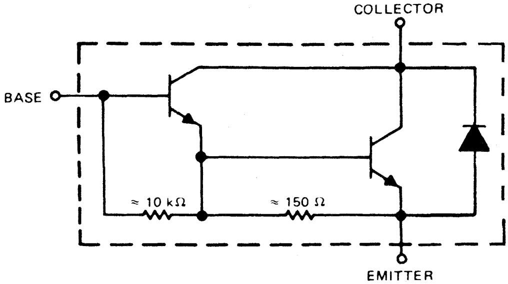
FIGURE 8

TIP140, TIP141, TIP142
NPN DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP145, TIP146, TIP147

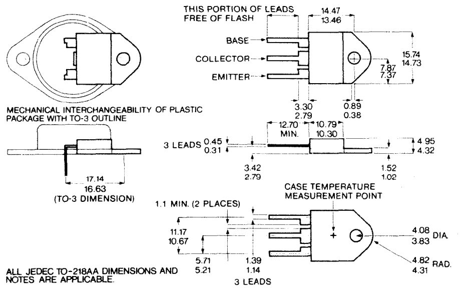
- 125 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100-mJ Reverse Energy Rating

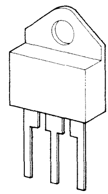
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB





ALL DIMENSIONS ARE IN MILLIMETRES

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 $t_w \leq 0.3$ ms, duty cycle $\leq 10\%$.
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 = 20 mH, R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C^2 L/2$.

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	
V_F	Forward Voltage of Commutating Diode	$I_F = -I_C$ = 10 A,	I_B = 0,	See Notes 6 and 7		3.5		3.5		3.5	V

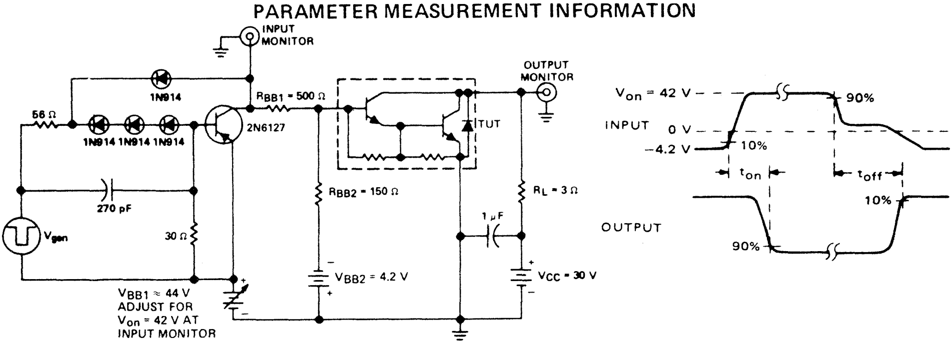
NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 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



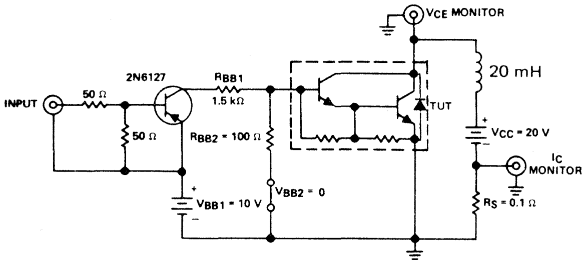
TEST CIRCUIT

VOLTAGE WAVEFORMS

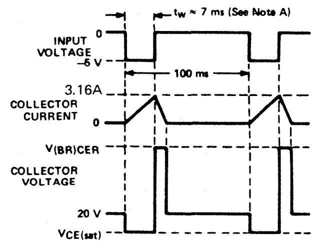
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ≤ 15 ns, t_f ≤ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: 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} = 3.16 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

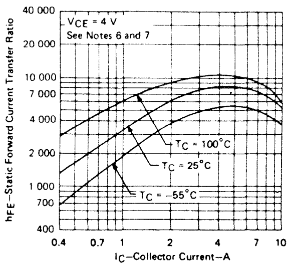


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

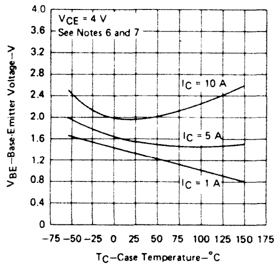


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

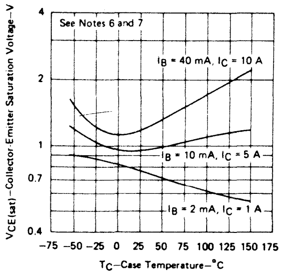


FIGURE 5

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

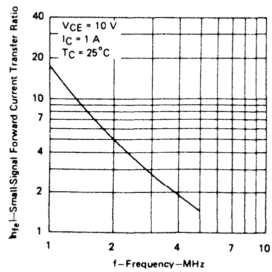


FIGURE 6

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

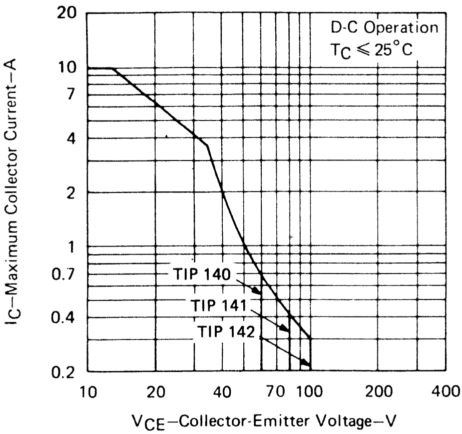


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

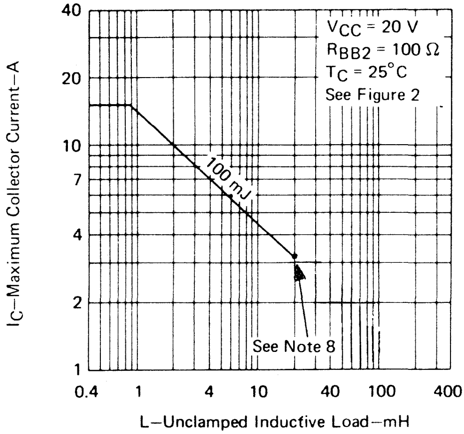


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

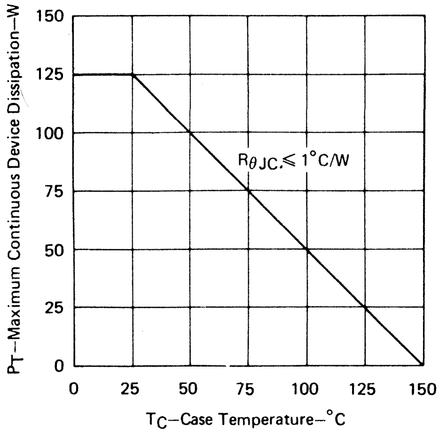


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

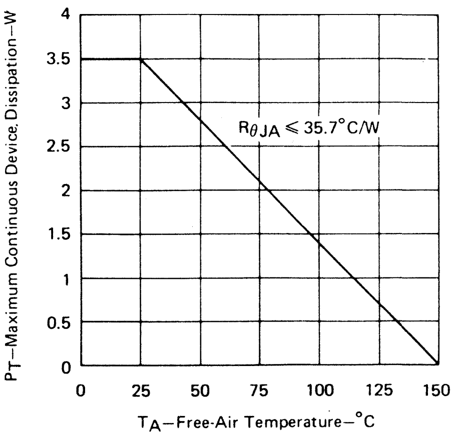


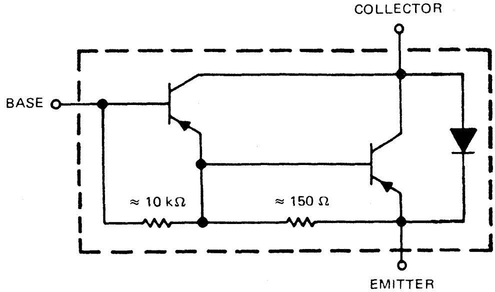
FIGURE 10

TIP145, TIP146, TIP147
PNP DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP140, TIP141, TIP142

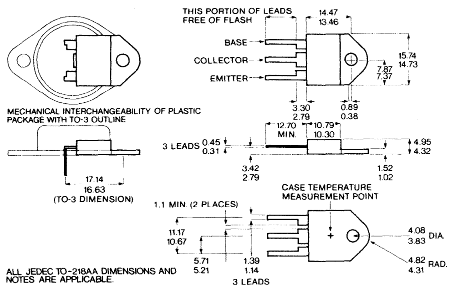
- 125 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100 mJ Reverse Energy Rating

device schematic

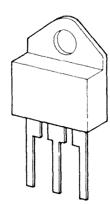


mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE MOUNTING TAB



ALL DIMENSIONS ARE IN MILLIMETRES



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 $t_w \leq 0.3$ ms, duty cycle $\leq 10\%$.
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 = 20 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 MIN	TIP145 MAX	TIP146 MIN	TIP146 MAX	TIP147 MIN	TIP147 MAX	UNIT
$V_{(BR)CEO}$	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			mA
		$V_{CE} = -50$ V, $I_B = 0$							−2	mA
I_{CBO}	Collector Cutoff Current	$V_{CB} = -60$ V, $I_E = 0$			−1					mA
		$V_{CB} = -80$ V, $I_E = 0$					−1			mA
		$V_{CB} = -100$ V, $I_E = 0$							−1	mA
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	See Notes 6 and 7	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	See Notes 6 and 7		−3		−3		−3	V
V_F	Forward Voltage of Commutating Diode	$I_F = I_C = 10$ A, $I_B = 0$,	See Notes 6 and 7		3.5		3.5		3.5	V

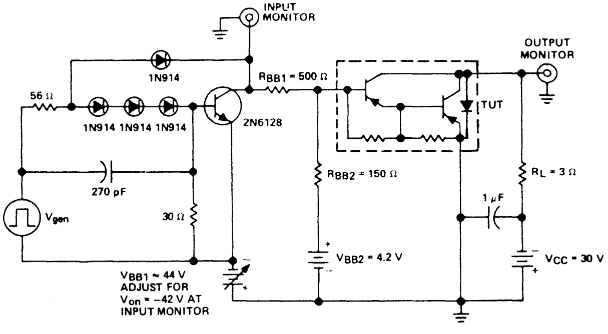
NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

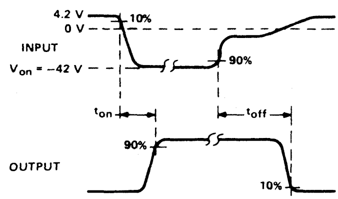
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -10$ A, $I_{B(1)} = -40$ mA, $I_{B(2)} = 40$ mA,	0.9	µs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.2$ V, $R_L = 3\ \Omega$, See Figure 1	11	µs

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

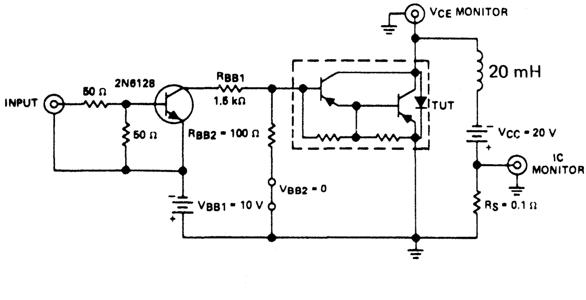


VOLTAGE WAVEFORMS

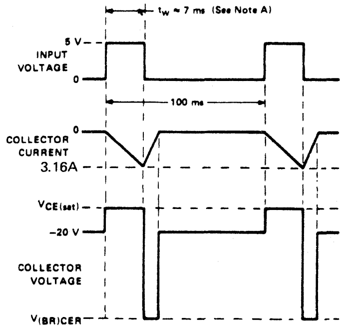
NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ µs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the 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



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until $I_{CM} = -3.16$ A.

FIGURE 2

TYPICAL CHARACTERISTICS

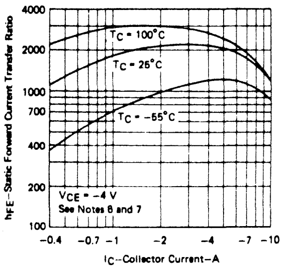


FIGURE 3

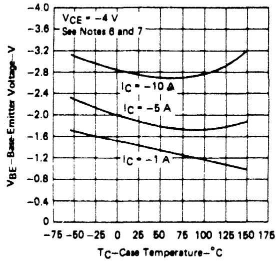


FIGURE 4

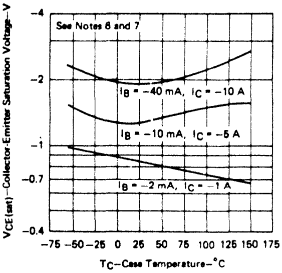


FIGURE 5

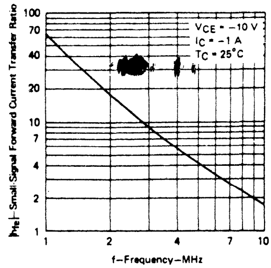


FIGURE 6

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 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

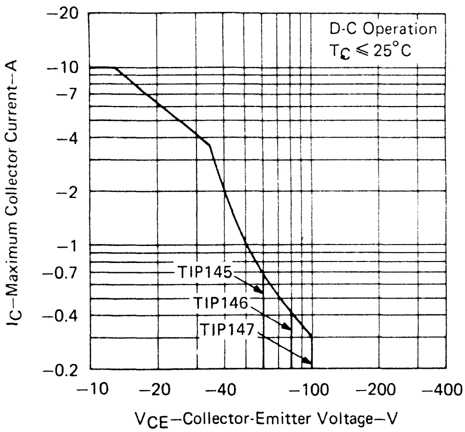


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

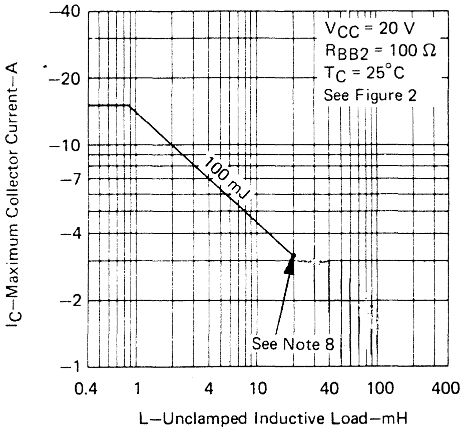


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

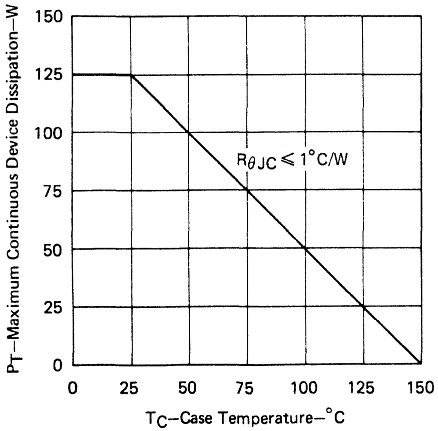


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

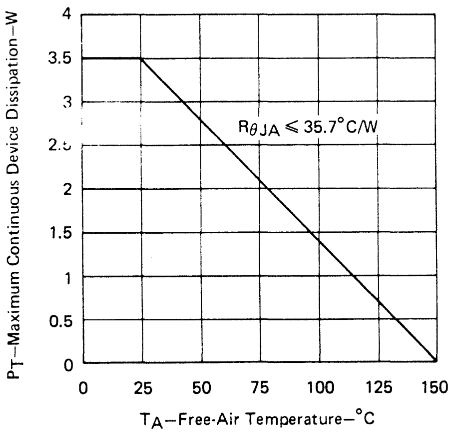
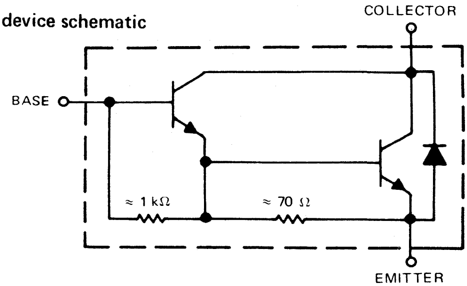


FIGURE 10

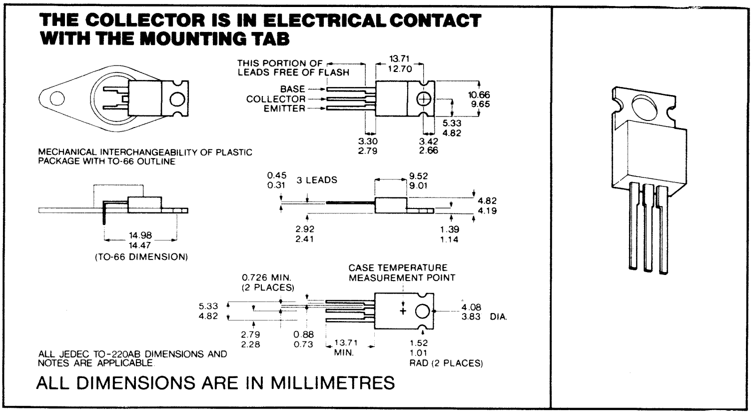
HIGH VOLTAGE, HIGH FORWARD AND CLAMPED REVERSE ENERGY

- $V_{CEX(sus)}$ . . . 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



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.

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		3.5		3.5		3.5	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

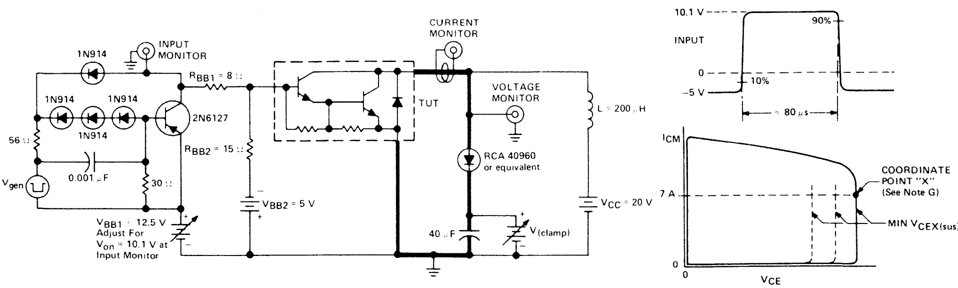
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{sv}	Voltage Storage Time	$V_{(clamp)}$ = MIN $V_{CEX(sus)}$, I_{CM} = 5 A, $I_{B(1)}$ = 250 mA, $I_{B(2)}$ = −250 mA, See Figure 2	3900	ns
t_{si}	Current Storage Time		4700	ns
t_{tv}	Voltage Transition Time		1200	ns
t_{ti}	Current Transition Time		1200	ns
t_{xo}	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: $t_r \leq 15$ ns, $t_f \leq 15$ 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: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

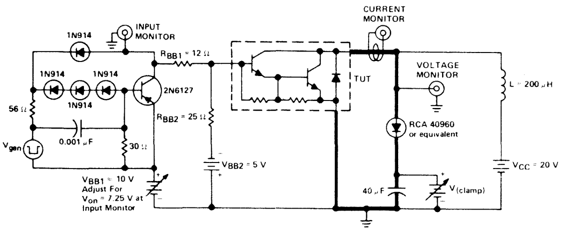
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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.

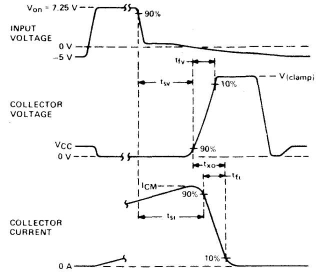
G. Adjust input pulse width until collector current is 7 A at point "X". I_{CM} must not exceed 10 A.

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: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w \approx 50\ \mu s$, duty cycle $\leq$ 2%. Pulse width is adjusted for $I_{CM} = 3$ A.

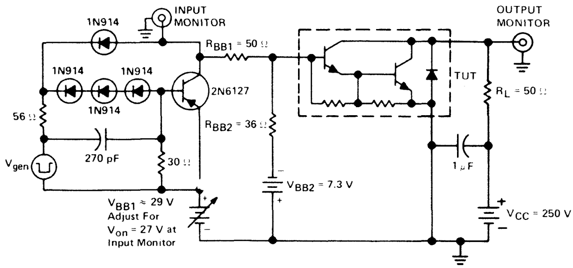
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

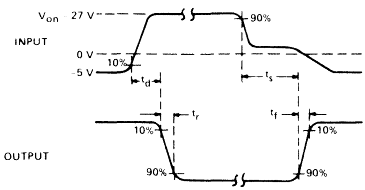
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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: $t_r \leq 15$ 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 3—RESISTIVE-LOAD SWITCHING TIMES

TYPICAL CHARACTERISTICS

TIP152
COLLECTOR CUTOFF CURRENT
vs
CASE TEMPERATURE

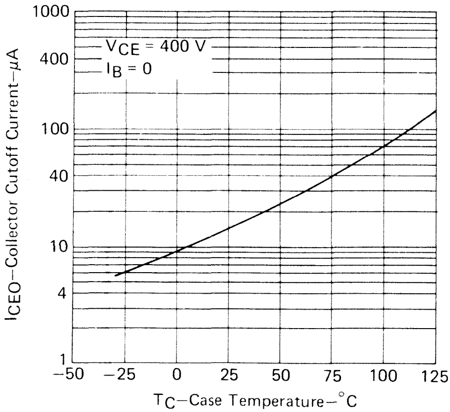


FIGURE 4

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

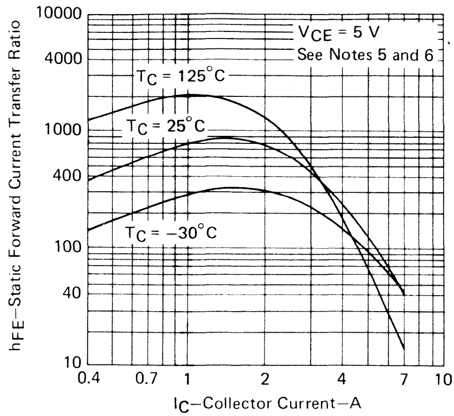


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

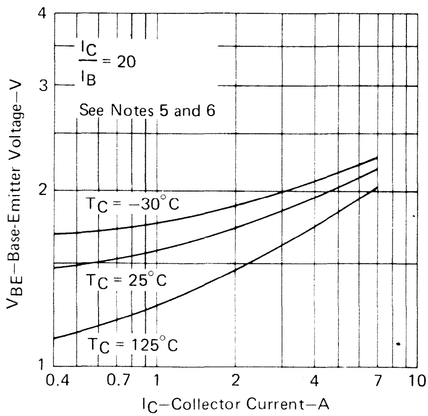


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR-CURRENT

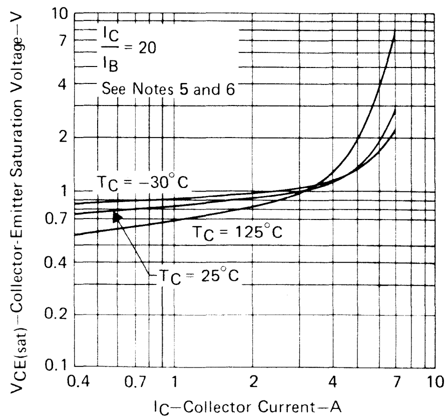


FIGURE 7

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

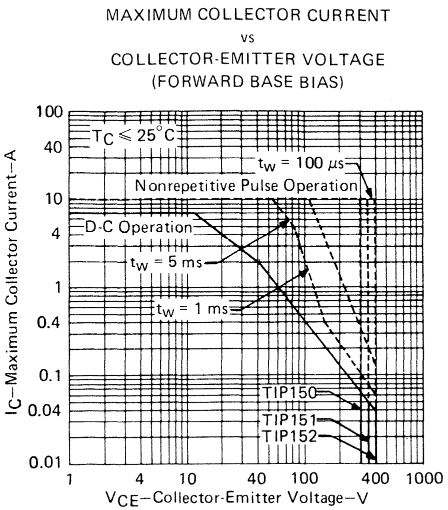


FIGURE 8

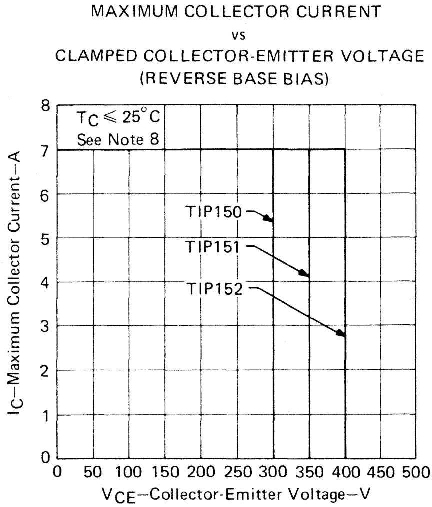


FIGURE 9

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

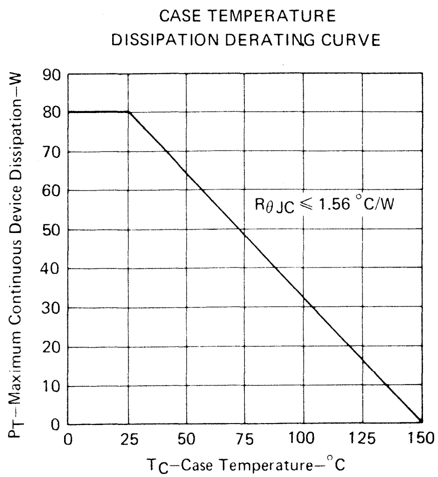


FIGURE 10

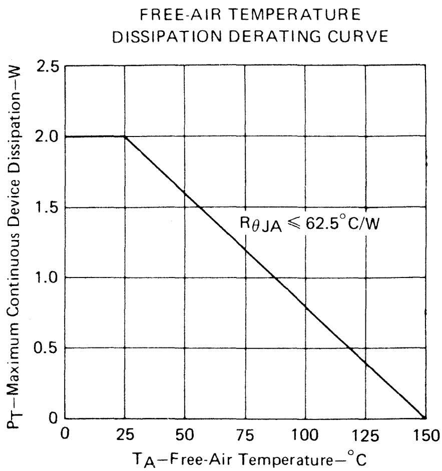
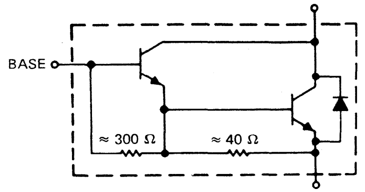


FIGURE 11

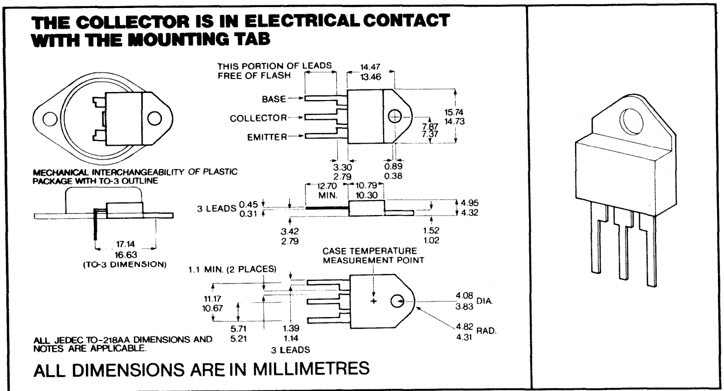
HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY
DESIGNED FOR AUTOMOTIVE IGNITION APPLICATIONS

- 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



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 $t_w \leq 10$ ms, duty cycle $\leq 10\%$.
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.

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

PARAMETER		TEST CONDITIONS	TIP160 MIN	TIP160 MAX	TIP161 MIN	TIP161 MAX	TIP162 MIN	TIP162 MAX	UNIT
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		3.5		3.5	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

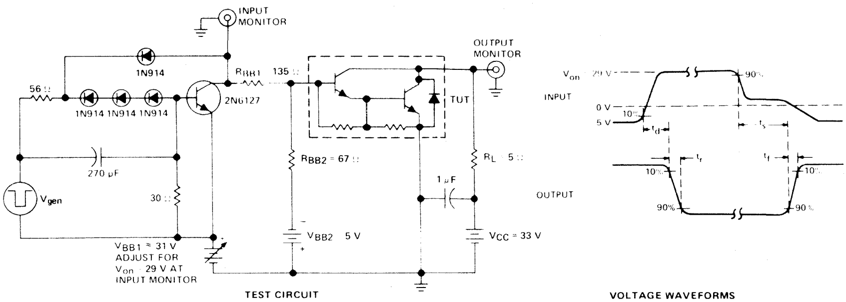
NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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.

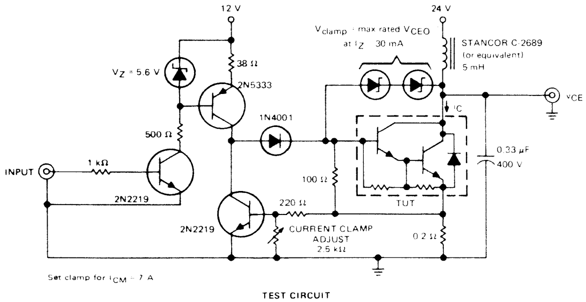
PARAMETER MEASUREMENT INFORMATION

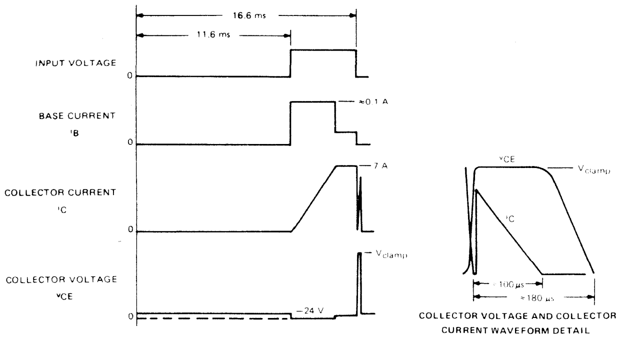


NOTES: A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with 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

FUNCTIONAL TEST INFORMATION





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, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

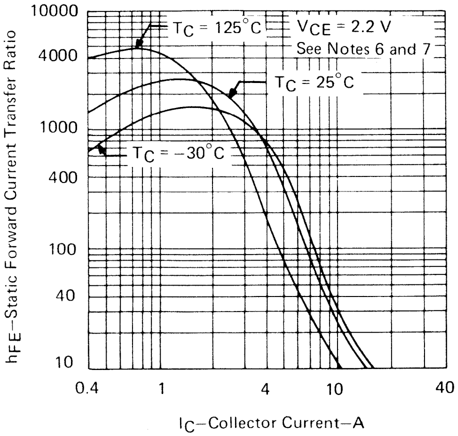


FIGURE 3

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

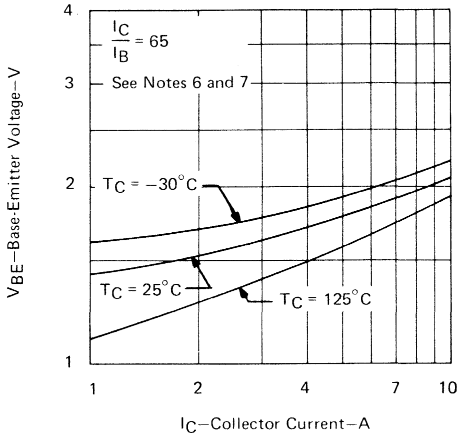


FIGURE 4

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

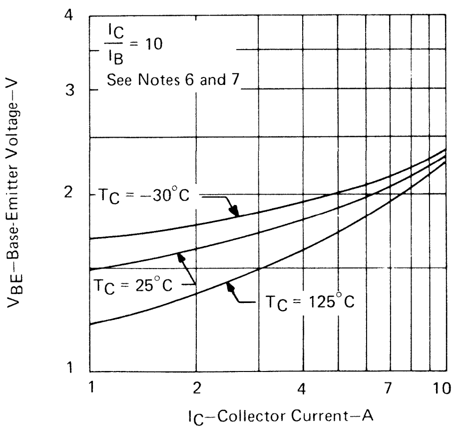


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

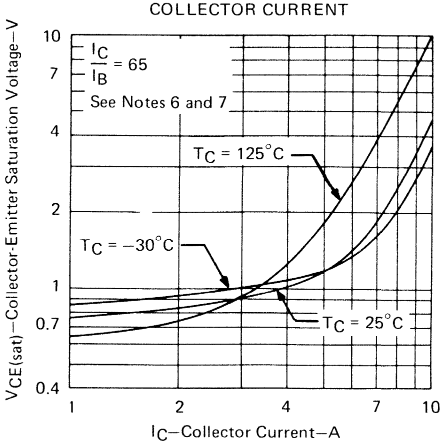


FIGURE 6

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

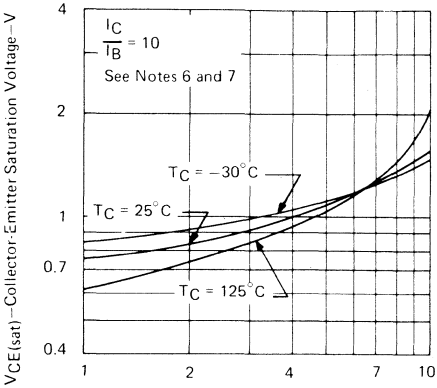


FIGURE 7

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

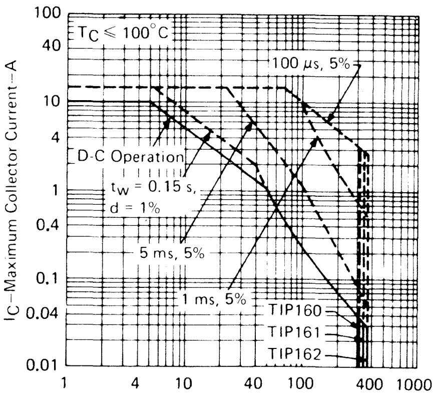


FIGURE 8

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 3.2mm from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

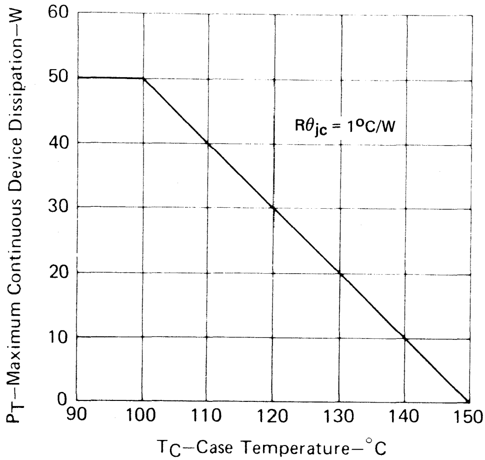


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

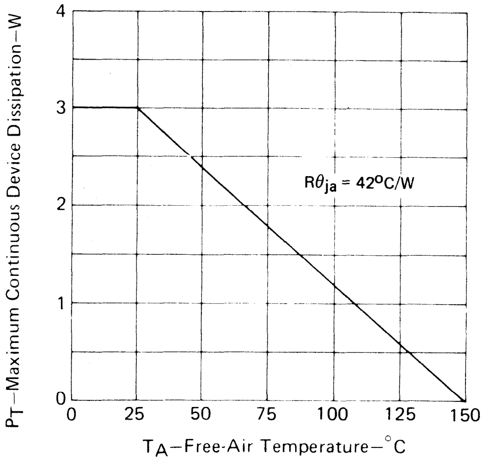
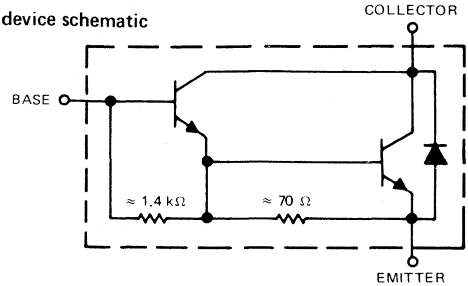


FIGURE 10

DESIGNED FOR COMPLEMENTARY USE WITH TIP605, TIP606, TIP607

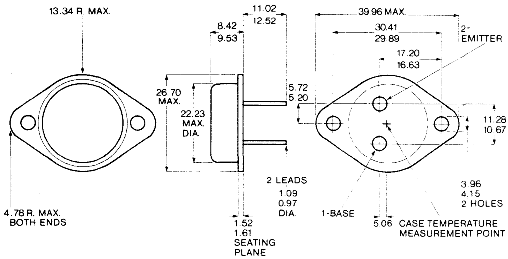
- 100 W at 25°C Case Temperature
- 10 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 10 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 10 A
- Similar to 2N6055, 2N6056, 2N6383, 2N6384, 2N6385

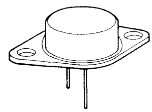
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

	TIP600	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 3.2mm 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 $t_w \leq 0.3$ ms, duty cycle ≤ 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	TIP600 MIN	TIP600 MAX	TIP601 MIN	TIP601 MAX	TIP602 MIN	TIP602 MAX	UNIT
$V_{(BR)CEO}$	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, See Notes 5 and 6	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, See Notes 5 and 6		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		3.5		3.5		3.5	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 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

NOTE 7: This parameter is measured using a 0.08mm 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 0.9 Newton meter.

switching characteristics at 25°C case temperature

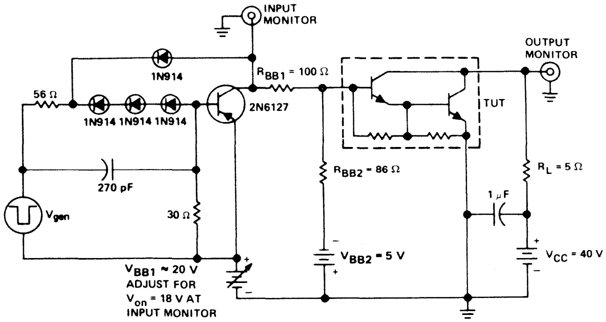
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	I_C = 8 A, $I_{B(1)}$ = 80 mA, $I_{B(2)}$ = −80 mA, $V_{BE(off)}$ = −5 V, R_L = 5 Ω, See Figure 1	0.035	μs
t_r	Rise Time		0.35	
t_s	Storage Time		1.8	
t_f	Fall Time		2.45	

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

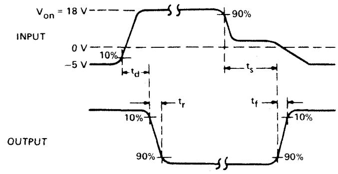
functional tests at 25°C free-air temperature

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, L = 20 mH, f = 10 Hz, t_{test} = 0.5 s, See Figure 2	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 ≤ 2%.

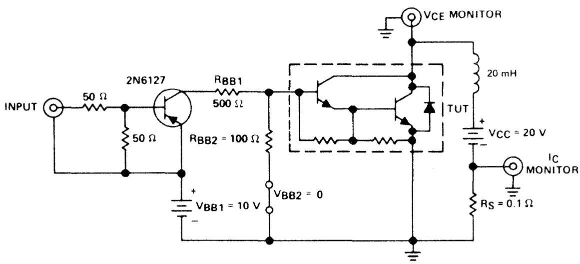
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

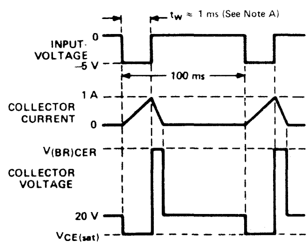
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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

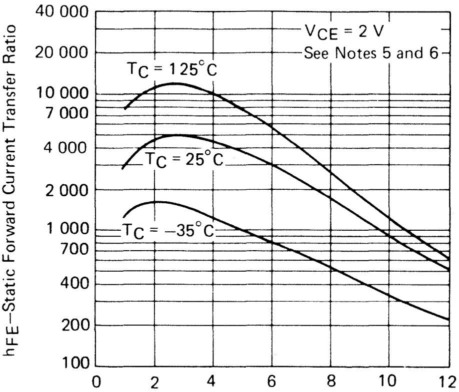


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

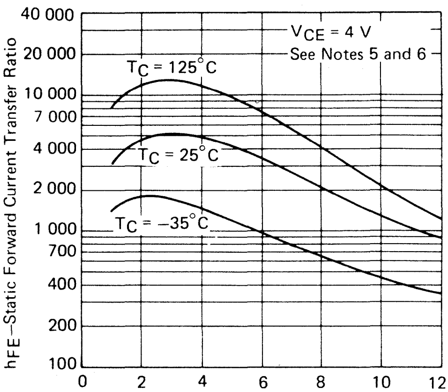


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

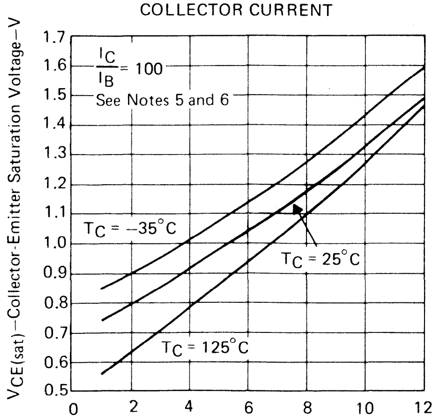


FIGURE 5

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

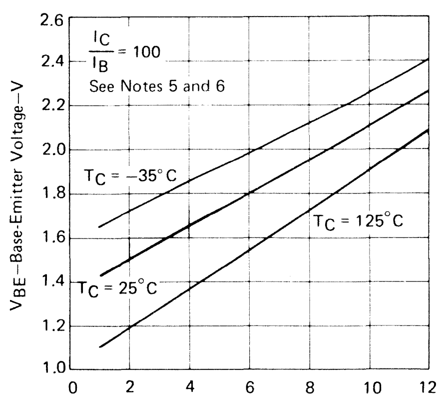


FIGURE 6

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 3.2mm from the device body.

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

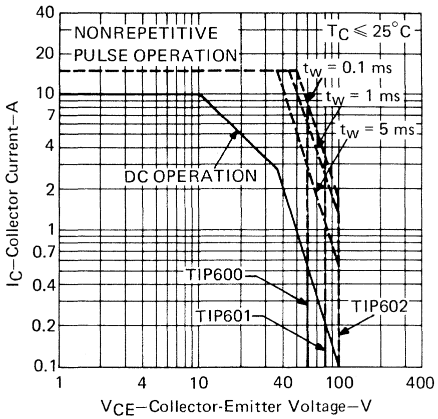


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

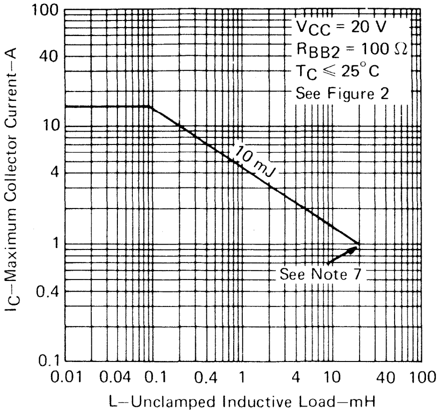


FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

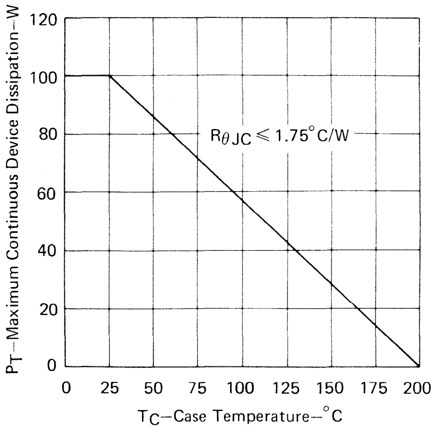


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

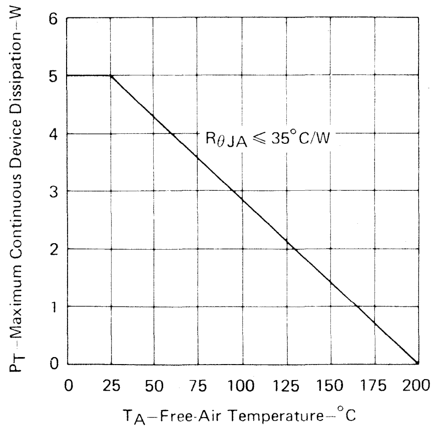


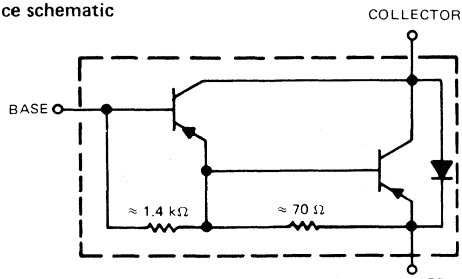
FIGURE 10

TYPES TIP605, TIP606, TIP607
P-N-P DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP600, TIP601, TIP602

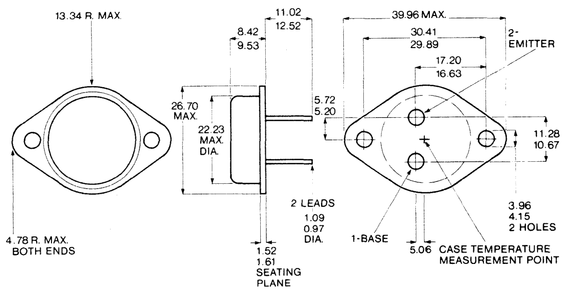
- 100 W at 25°C Case Temperature
- 10 A Rated Collector Current
- Min h_{FE} of 200 at 4 V, 10 A
- Max I_{CEO} of 50 μA
- Max $V_{CE(sat)}$ of 2.5 V at I_C = 10 A
- Similar to 2N6053, 2N6054, RCA8350, RCA8350A, RCA8350B

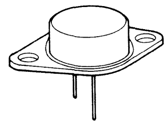
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 3.2mm 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 $t_w \leq 0.3$ ms, duty cycle ≤ 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 MIN	TIP605 MAX	TIP606 MIN	TIP606 MAX	TIP607 MIN	TIP607 MAX	UNIT
$V_{(BR)CEO}$	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		3.5		3.5		3.5	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 3.2mm 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 0.08mm 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 0.9mm Newton-meter.

switching characteristics at 25°C case temperature

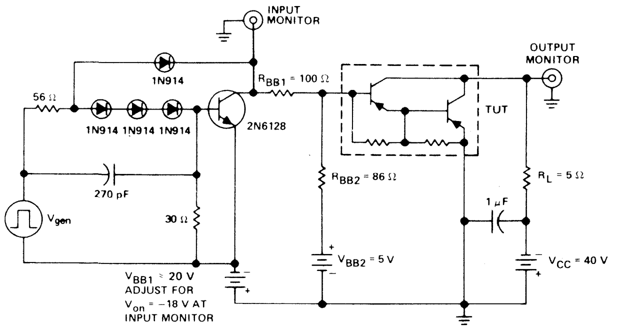
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_d	Delay Time	$I_C = -8$ A,	$I_{B(1)} = -80$ mA	$I_{B(2)} = 80$ mA,	0.035	μs
t_r	Rise Time	$V_{BE(off)} = 5$ V,	$R_L = 5\ \Omega$	See Figure 1	0.3	
t_s	Storage Time				0.9	
t_f	Fall Time				1.3	

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

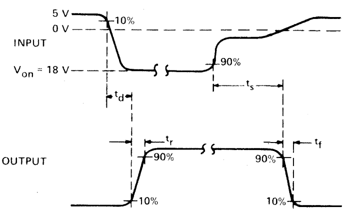
functional tests at 25°C free-air temperature

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 $\left(\frac{I_C^2 L}{2}\right)$	$I_{CM} = -1$A, $t_{test} = 0.5$ 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 ≤ 2%.

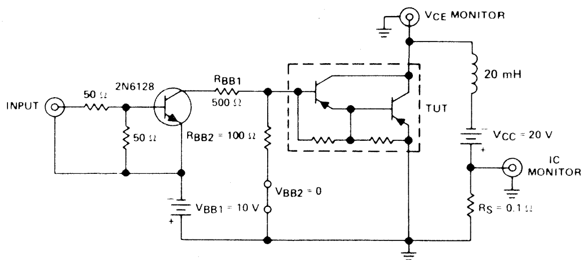
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

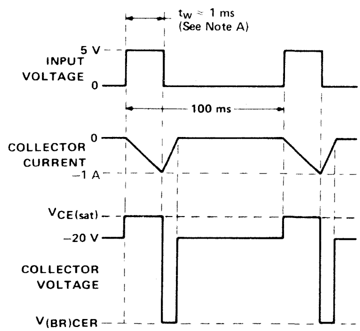
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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

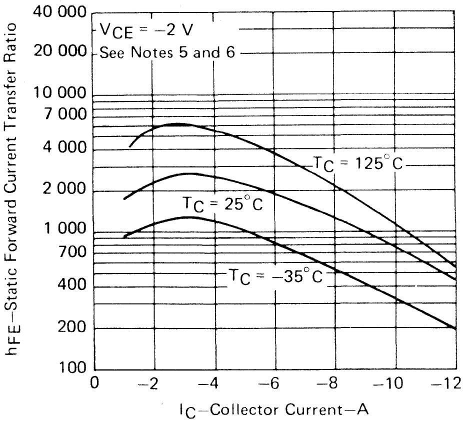


FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

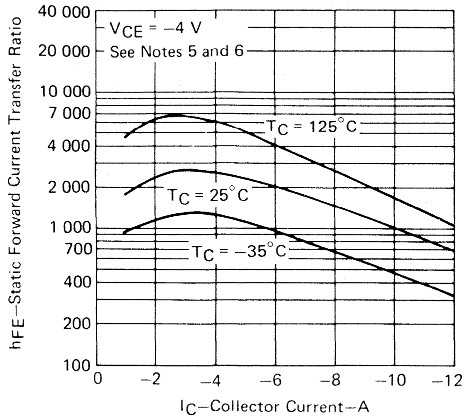


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

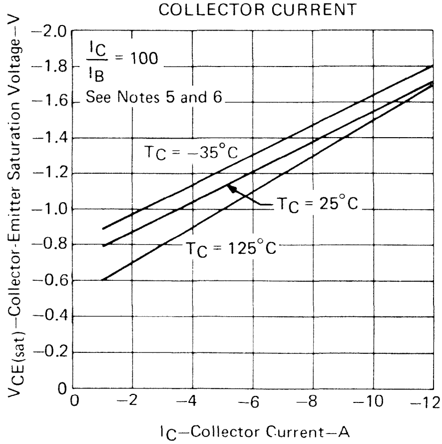


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

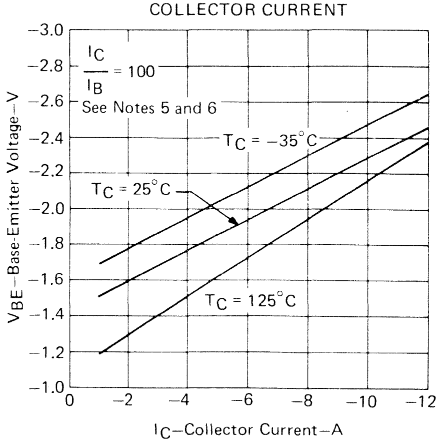


FIGURE 6

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

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 AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

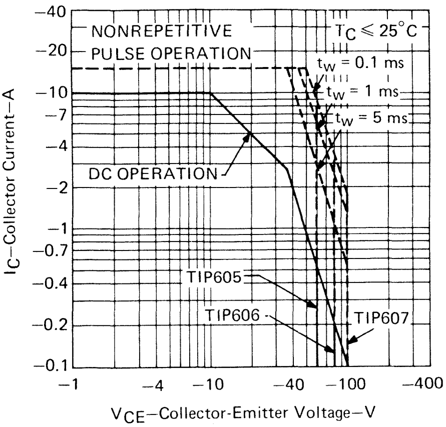


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

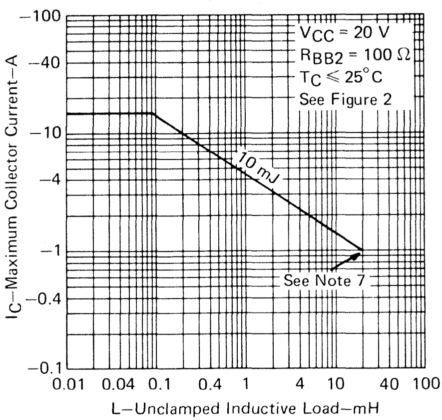


FIGURE 8

NOTE 7: Above this point the safe operating area has not been defined.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

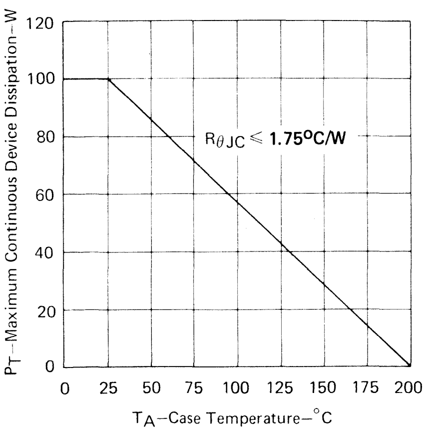


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

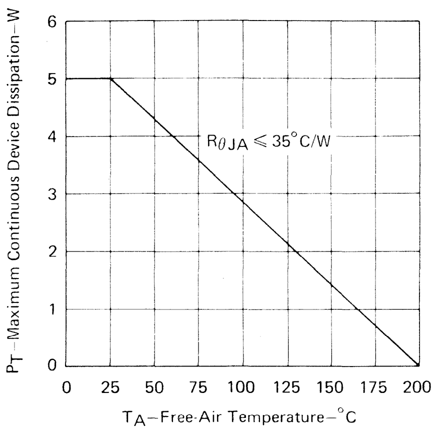
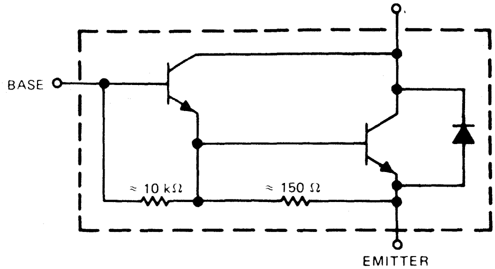


FIGURE 10

DESIGNED FOR COMPLEMENTARY USE WITH TIP625, TIP626, TIP627

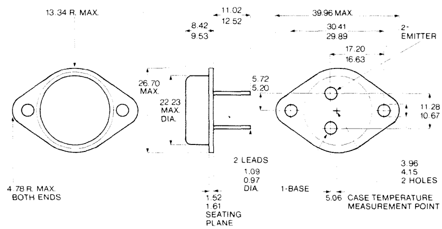
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

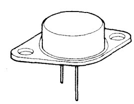
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 →		
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 $t_w \leq 0.3$ ms, duty cycle ≤ 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 = 20mH , R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C^2 L/2$.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP620 MIN	TIP620 MAX	TIP621 MIN	TIP621 MAX	TIP622 MIN	TIP622 MAX	UNIT
$V_{(BR)CEO}$	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	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C = 5$A, $I_B = 0$	See notes 6 and 7		3.5		3.5		3.5	V

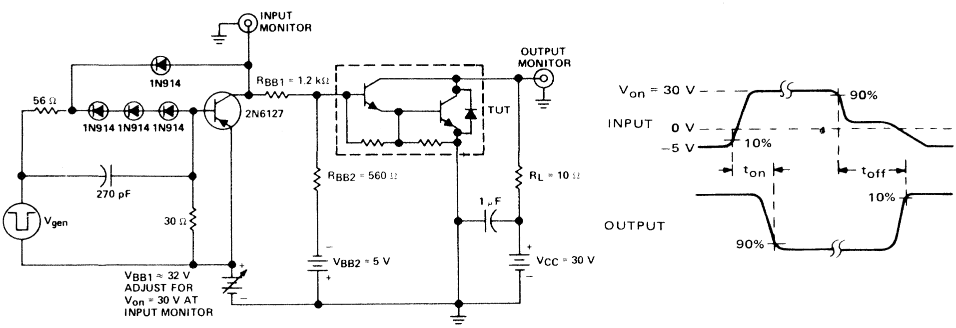
NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

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,	1.5	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -5$ V, $R_L = 10\ \Omega$, See Figure 1	8.5	μs

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

PARAMETER MEASUREMENT INFORMATION



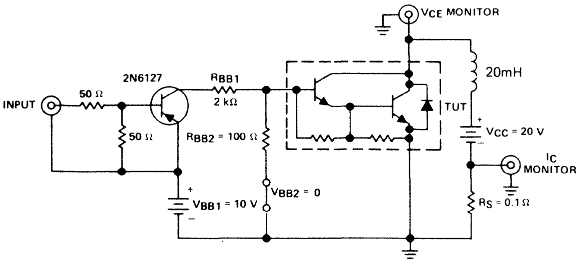
TEST CIRCUIT

VOLTAGE WAVEFORMS

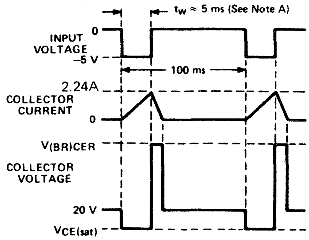
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with 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



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width is increased until I_{CM} = 2.24A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

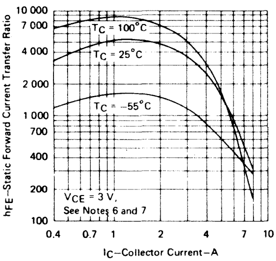


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

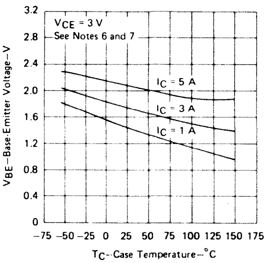


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

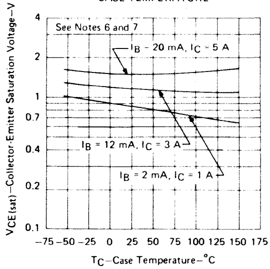


FIGURE 5

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

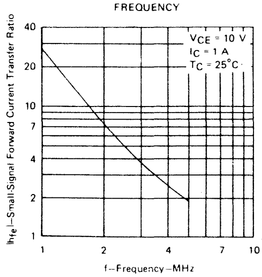


FIGURE 6

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

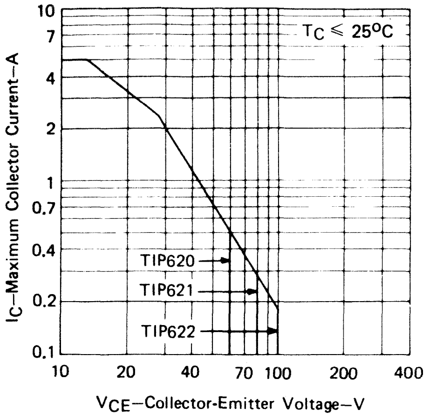


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

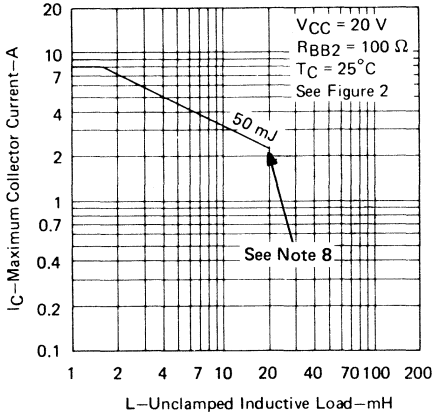


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

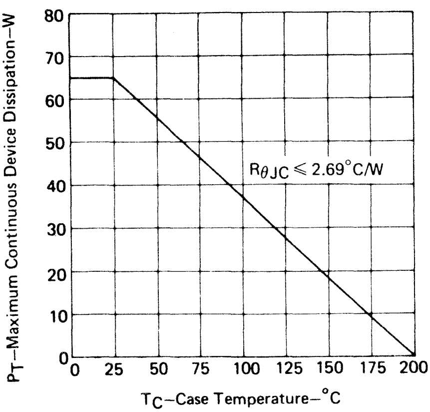


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

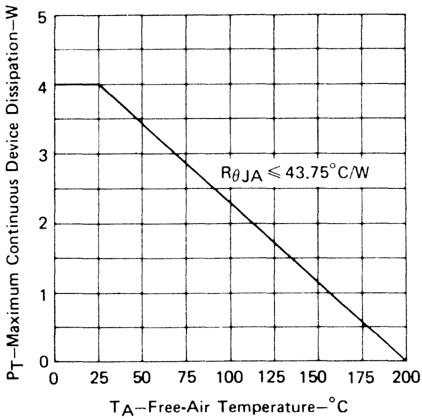
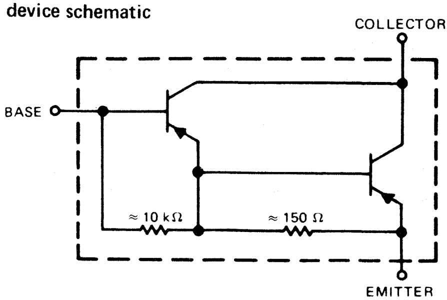


FIGURE 10

DESIGNED FOR COMPLEMENTARY USE WITH TIP620, TIP621, TIP622

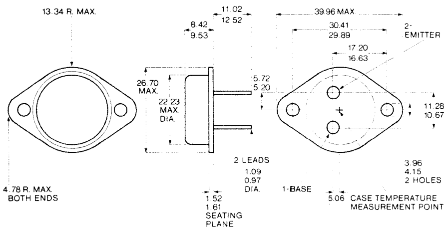
- 65 W at 25°C Case Temperature
- 5 A Rated Collector Current
- Min h_{FE} of 1000 at 3 V, 3 A
- 50 mJ Reverse Energy Rating

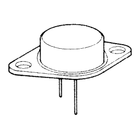
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 →		
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 $t_w \leq 0.3$ ms, duty cycle $\leq$ 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 = 20mH , R_{BB2} = 100 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS		TIP625 MIN	TIP625 MAX	TIP626 MIN	TIP626 MAX	TIP627 MIN	TIP627 MAX	UNIT
$V_{(BR)CEO}$	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	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C = 10$A, $I_B = 0$	See notes 6 and 7		3.5		3.5		3.5	V

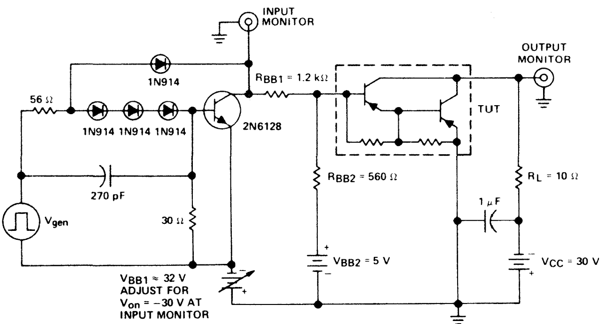
NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2mm from the device body.

switching characteristics at 25°C case temperature

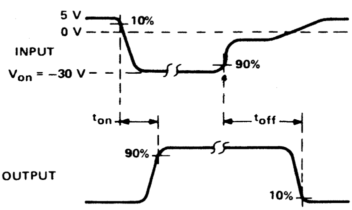
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -3$ A, $I_{B(1)} = -12$ mA, $I_{B(2)} = 12$ mA,	1.5	µs
t_{off}	Turn-Off Time	$V_{BE(off)} = 5$ V, $R_L = 10\ \Omega$, See Figure 1	8.5	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

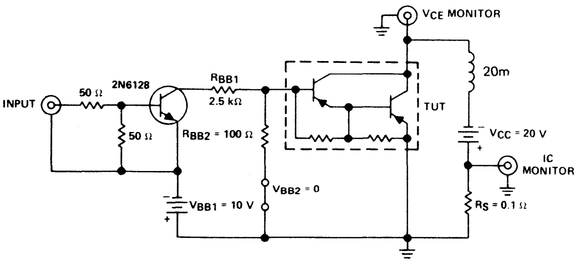


VOLTAGE WAVEFORMS

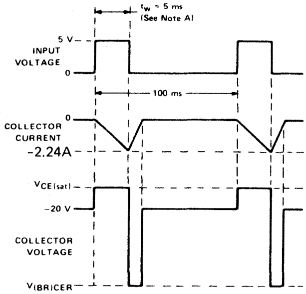
NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20$ µs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the 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



TEST CIRCUIT



VOLTAGE AND CURRENT WAVEFORMS

NOTE A: Input pulse width in increased until I_{CM} = -2.24A

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

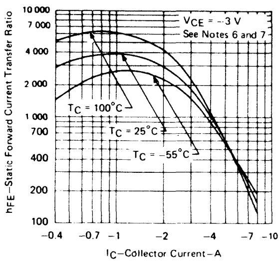


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

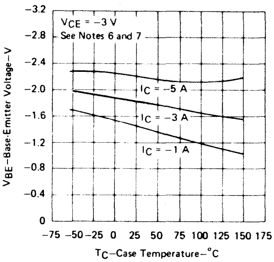


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

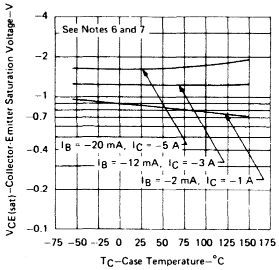


FIGURE 5

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

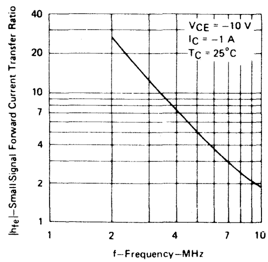


FIGURE 6

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

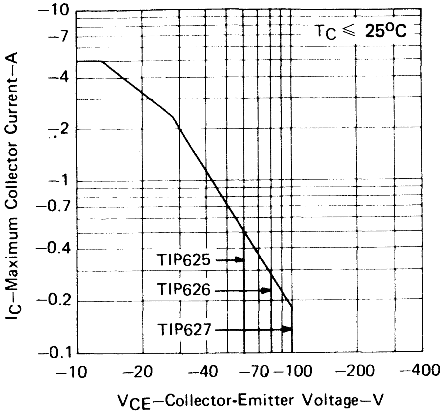


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

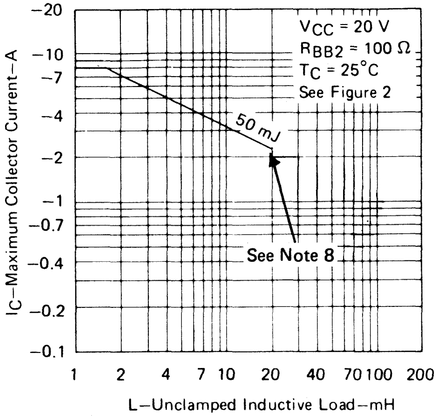


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

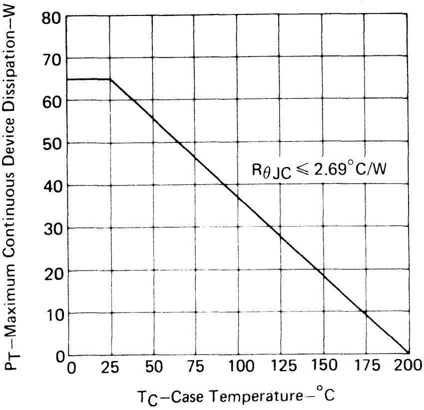


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

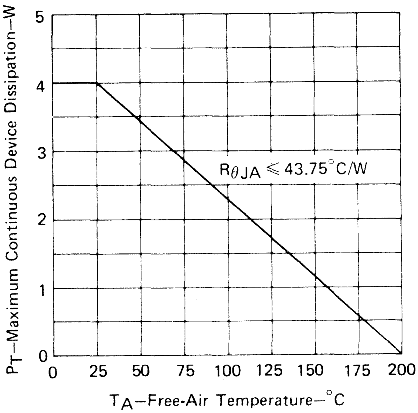


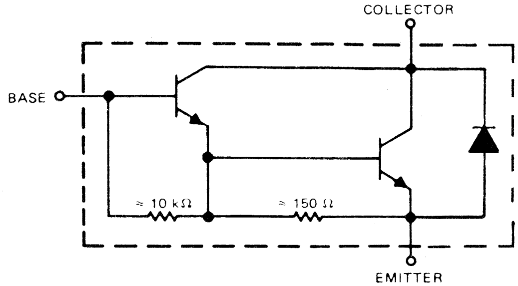
FIGURE 10

TYPES TIP640, TIP641, TIP642
N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP645, TIP646, TIP647

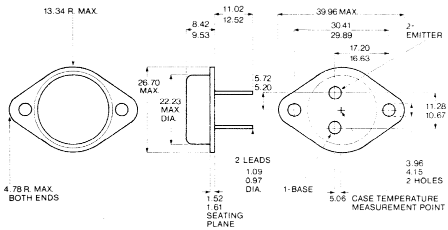
- 175 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100-mJ Reverse Energy Rating

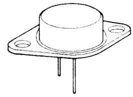
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 = 20mH $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 20$ V. Energy $\approx I_C{}^2 L/2$.

TYPES TIP640, TIP641, TIP642
N-P-N 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	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C$ = 10A, I_B = 0		See notes 6 and 7		3.5		3.5		3.5	V

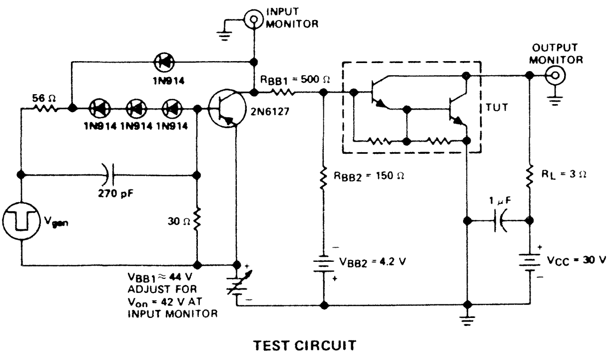
NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

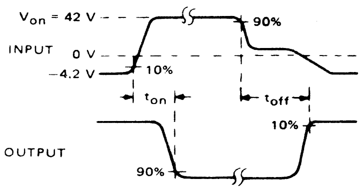
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 10 A, $I_{B(1)}$ = 40 mA, $I_{B(2)}$ = −40 mA,	0.9	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4.2 V, R_L = 3 Ω, See Figure 1	11	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

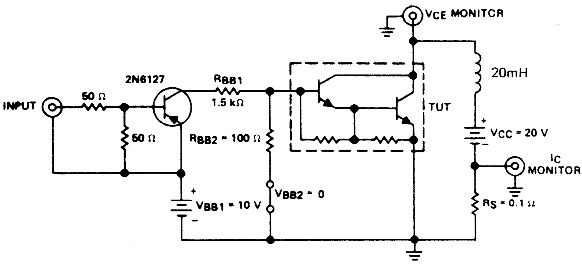


VOLTAGE WAVEFORMS

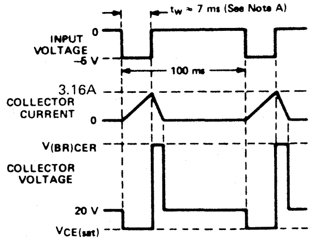
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: t_r ≤ 15 ns, t_f ≤ 15 ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following characteristics: 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} = 3.16A

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

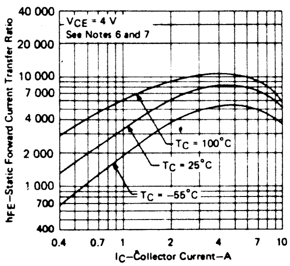


FIGURE 3

BASE-EMITTER VOLTAGE vs CASE TEMPERATURE

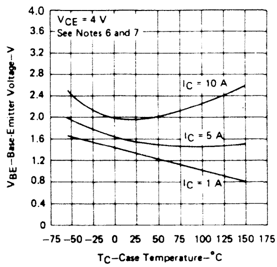


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE vs CASE TEMPERATURE

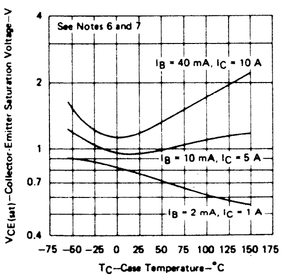


FIGURE 5

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

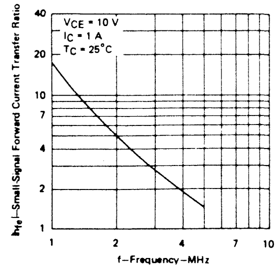


FIGURE 6

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

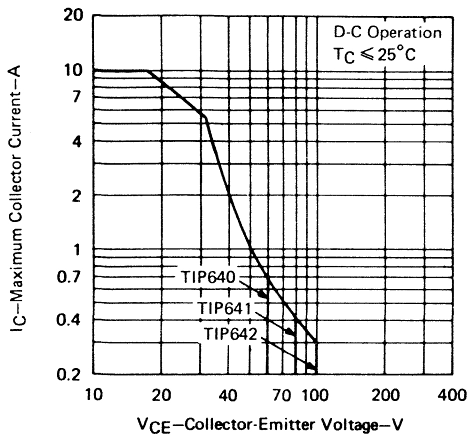


FIGURE 7

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

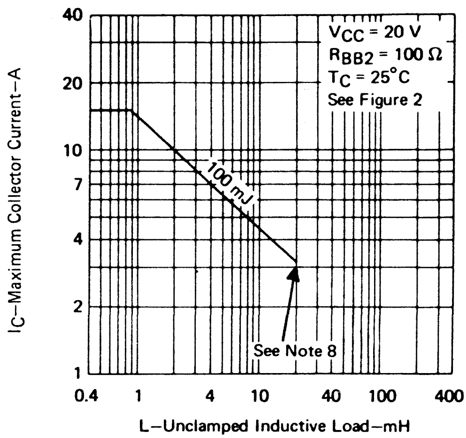


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

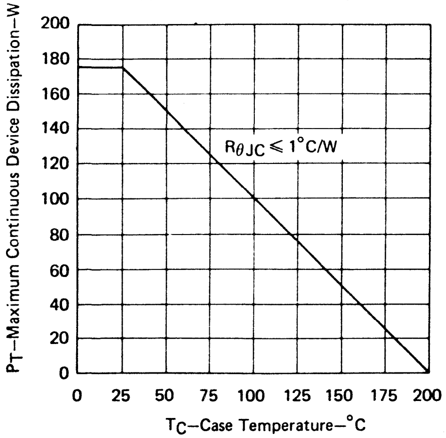


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

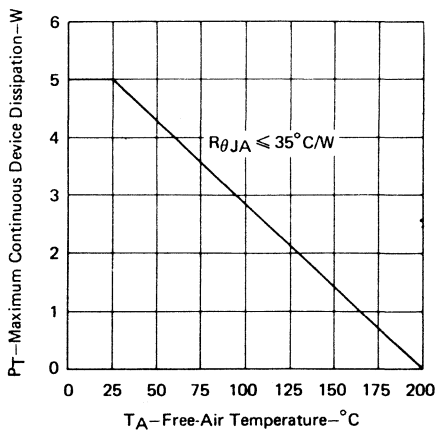


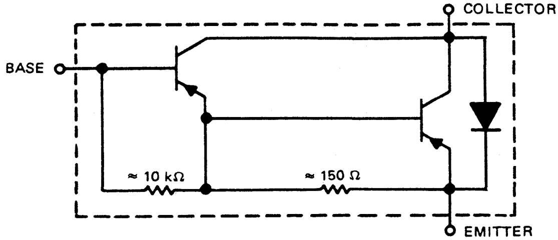
FIGURE 10

N-P-N DARLINGTON-CONNECTED SILICON POWER TRANSISTORS

DESIGNED FOR COMPLEMENTARY USE WITH TIP640, TIP641, TIP642

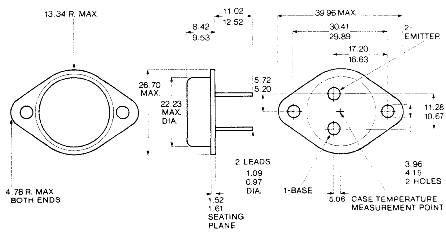
- 175 W at 25°C Case Temperature
- 10-A Rated Collector Current
- Min h_{FE} of 1000 at 4 V, 5 A
- 100 mJ Reverse Energy Rating

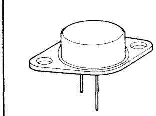
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 = 20mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ 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		TIP645 MIN	TIP645 MAX	TIP646 MIN	TIP646 MAX	TIP647 MIN	TIP647 MAX	UNIT
$V_{(BR)CEO}$	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	
V_F	Forward Voltage of Commutation Diode	$I_F = -I_C = 10$A	See notes 6 and 7		3.5		3.5		3.5	V

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

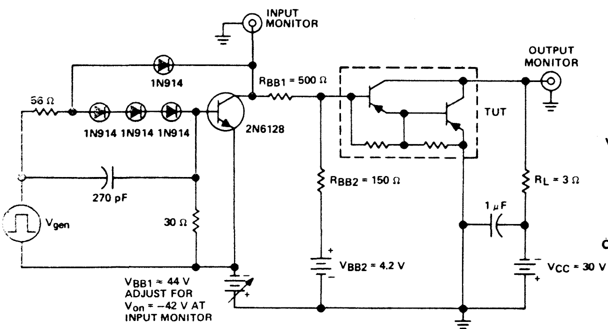
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located within 3.2 mm from the device body.

switching characteristics at 25°C case temperature

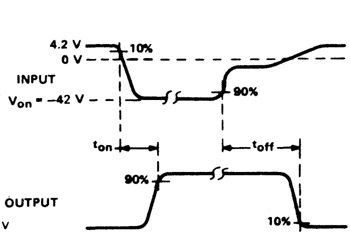
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -10$ A, $I_{B(1)} = -40$ mA, $I_{B(2)} = 40$ mA,	0.9	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4.2$ V, $R_L = 3\ \Omega$, See Figure 1	11	

†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%.

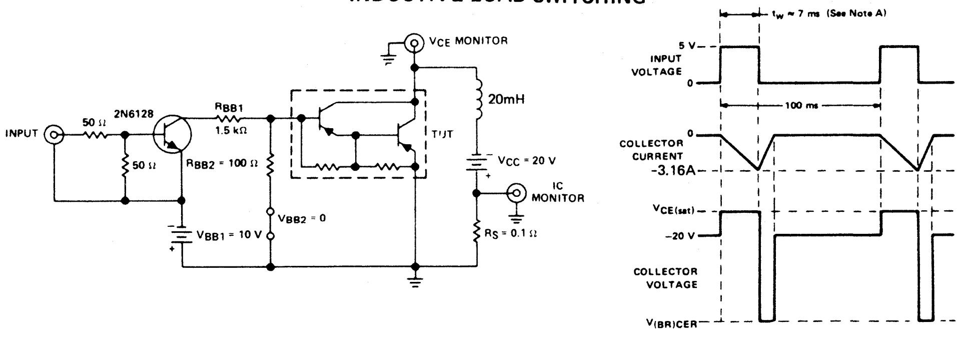
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

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} = -3.16A

FIGURE 2

TYPICAL CHARACTERISTICS

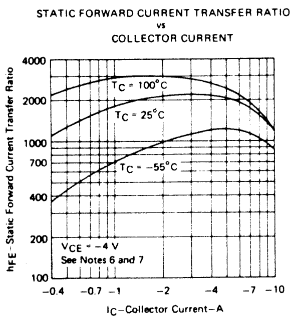


FIGURE 3

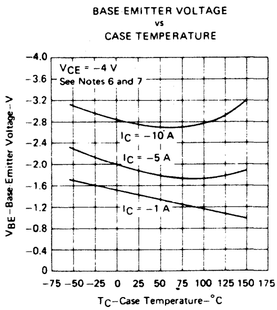


FIGURE 4

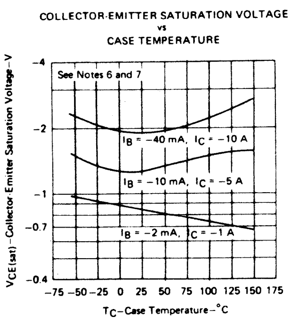


FIGURE 5

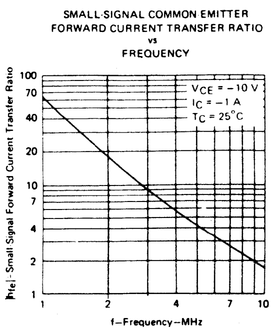


FIGURE 6

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

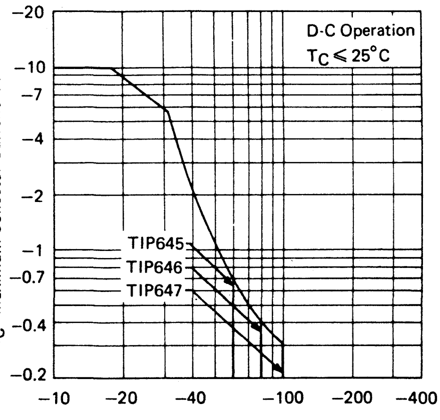


FIGURE 7

MAXIMUM COLLECTOR CURRENT vs UNCLAMPED INDUCTIVE LOAD

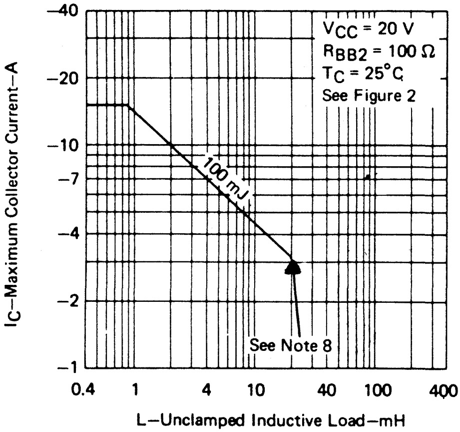


FIGURE 8

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

THERMAL INFORMATION

CASE TEMPERATURE DISSIPATION DERATING CURVE

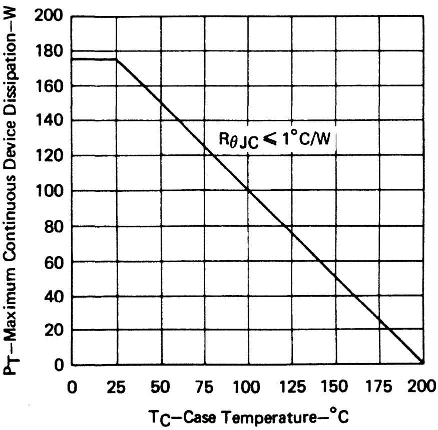


FIGURE 9

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

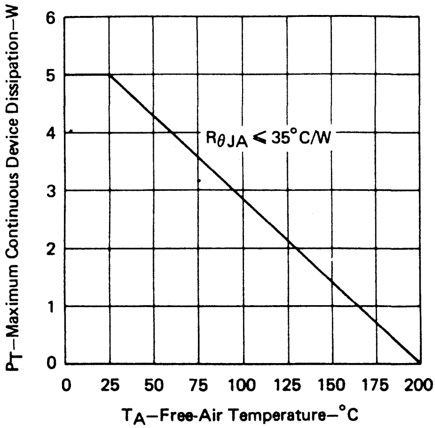
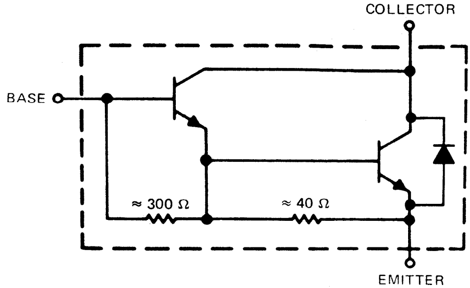


FIGURE 10

HIGH VOLTAGE, HIGH FORWARD AND REVERSE ENERGY DESIGNED FOR AUTOMOTIVE IGNITION APPLICATIONS

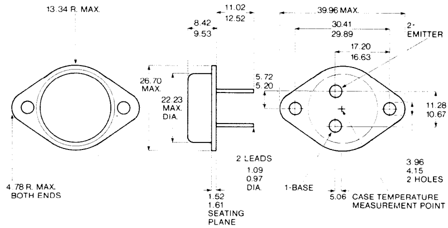
- 80 W at 100°C Case Temperature
- 10-A Rated Continuous Collector Current
- Max $V_{CE(sat)}$ of 2.8 V at 6.5 A
- Functional Verification Tests for Ignition Applications

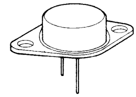
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 3.2mm 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 $t_w \leq 10$ ms, duty cycle $\leq 10\%$.
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			3.5		3.5		3.5	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		

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	

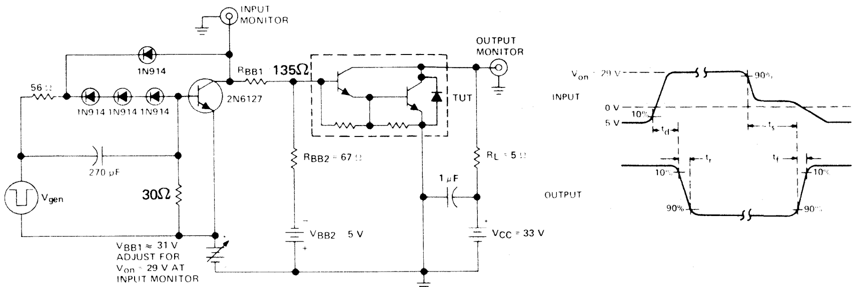
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

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} = 1 s	80 W
Reverse Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	I_{CM} = 6 A, L = 100 μH, f = 10 Hz, t_{test} = 0.5 s, See Note 9	1.8 mJ
Forward Pulse Energy $\left(\frac{I_C^2 L}{2}\right)$	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 **3.2mm from the device body.**
8. This parameter is measured using a **0.08mm** mica insulator with Dow Corning 11 compound on both sides of the insulator. 6-32 mounting screws with bushings, and a mounting torque of **0.9 Newton meter.**
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



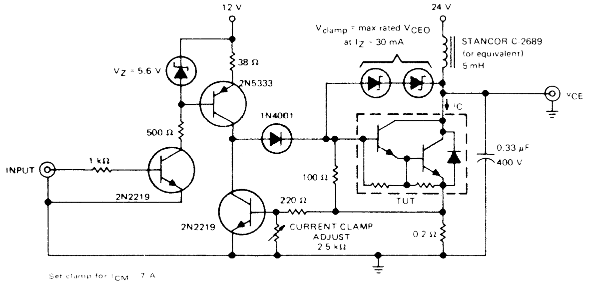
TEST CIRCUIT

VOLTAGE WAVEFORMS

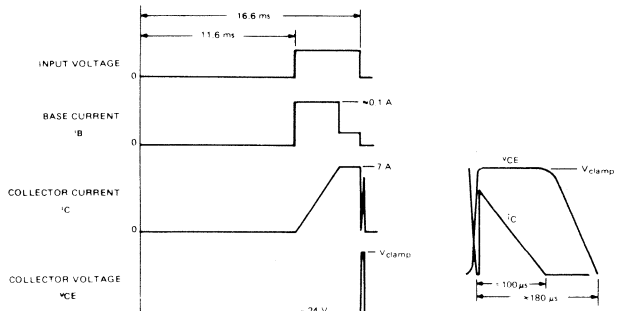
NOTES:
A. V_{gen} is a −30 V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ⩽ 2%.
C. Waveforms are monitored on an oscilloscope 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



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

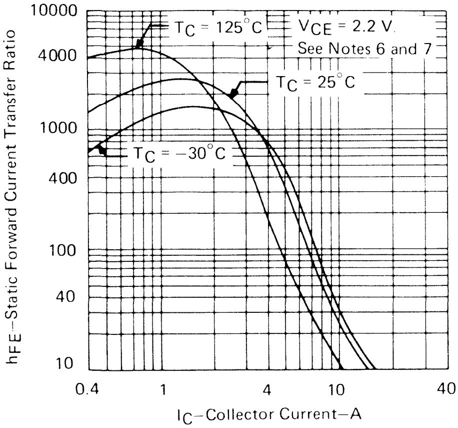


FIGURE 3

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

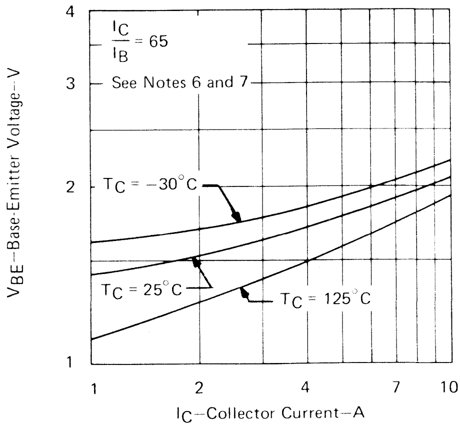


FIGURE 4

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

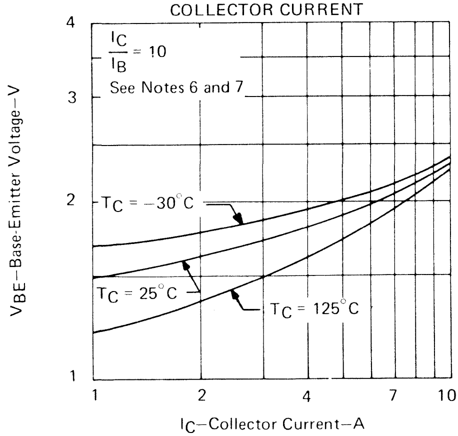


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

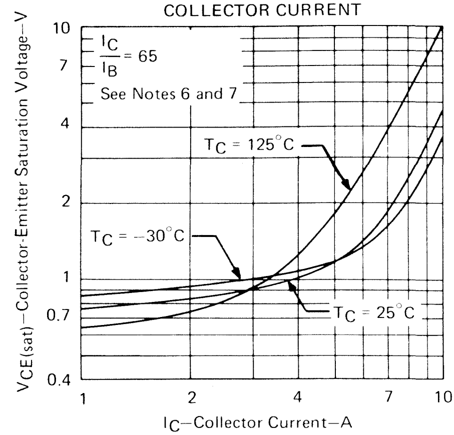


FIGURE 6

NOTES: 6. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts and located wit 3.2mm from the device body.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

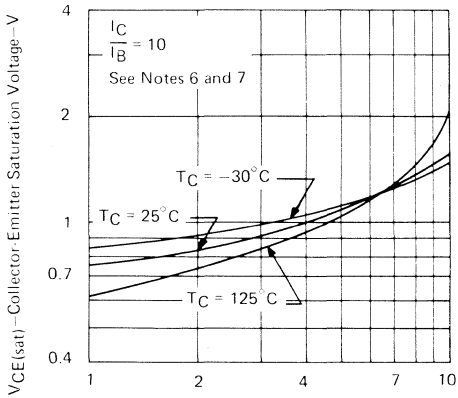


FIGURE 7

MAXIMUM SAFE OPERATING AREA

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

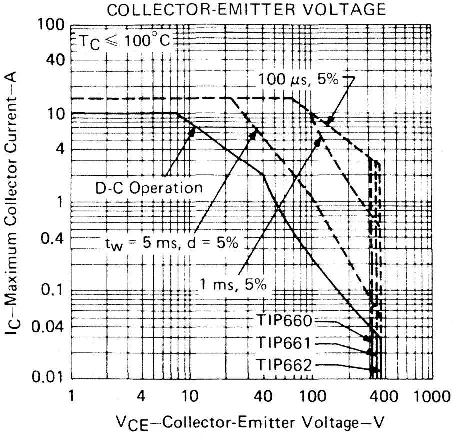


FIGURE 8

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 3.2mm from the device body.

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

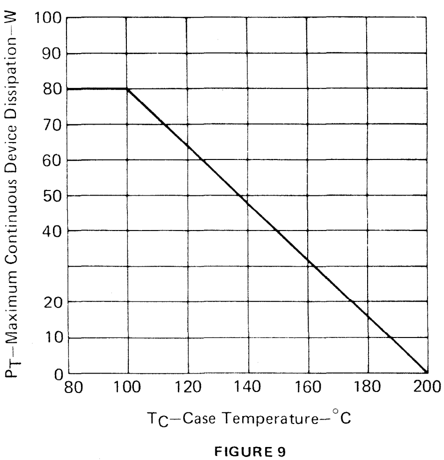


FIGURE 9

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

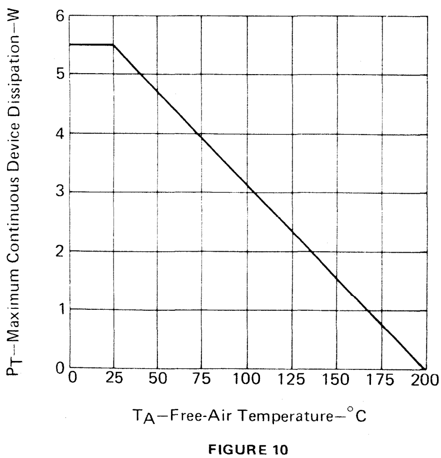


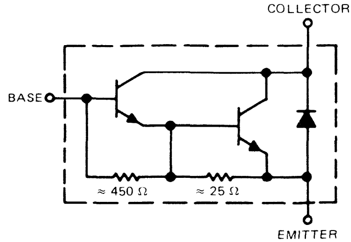
FIGURE 10

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

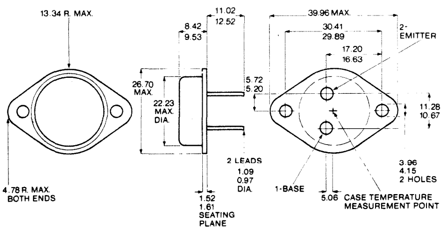
- Reverse-Bias SOA . . . 300 V to 400 V, 10 A
- Forward-Bias SOA . . . 30 V, 5 A
- 20 A Continuous Collector Current
- Min h_{FE} . . . 250 at 5 V, 10 A
- 150 W at 100°C Case Temperature

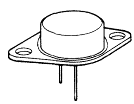
device schematic



mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $t_w \leq 5$ ms, duty cycle $\leq 10\%$.
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 MIN	TIP663 MAX	TIP664 MIN	TIP664 MAX	TIP665 MIN	TIP665 MAX	UNIT
$V_{(BR)CBO}$	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			3.5		3.5		3.5	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		
$\|h_{fe}\|$	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.

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

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.

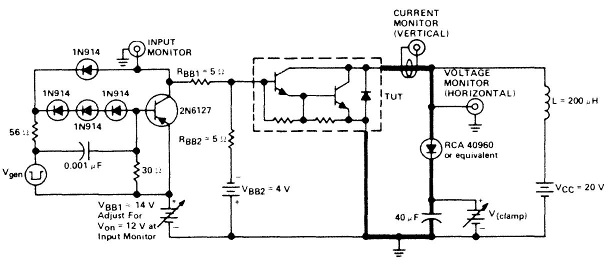
functional tests at 25°C free-air temperature

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

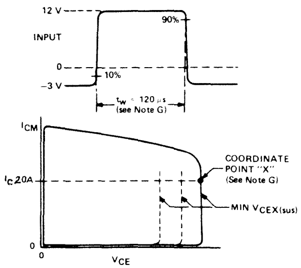
NOTES: 7. This parameter is measured using a 0.003-inch (0,08 mm) mica insulator with Dow Corning II Compound on both sides of the insulator, 0.138-32 (formerly 6-32) mounting screws with bushings, and a mounting torque of 8 inch-pounds (0,9 newton-meter).

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 $\leqslant$ 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.

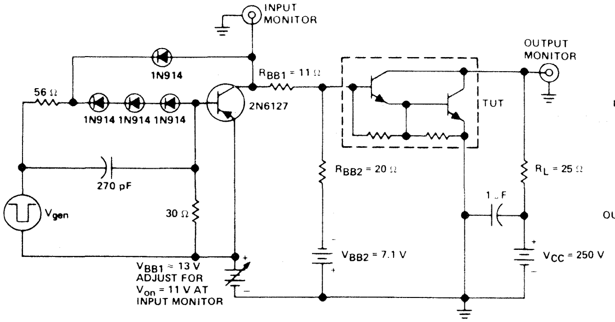
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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.

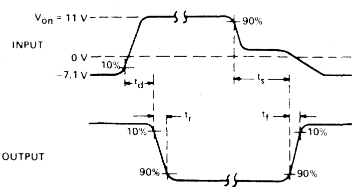
G. Adjust input pulse width until collector current is 20 A at point "X." I_{CM} must not exceed 30 A.

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: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.

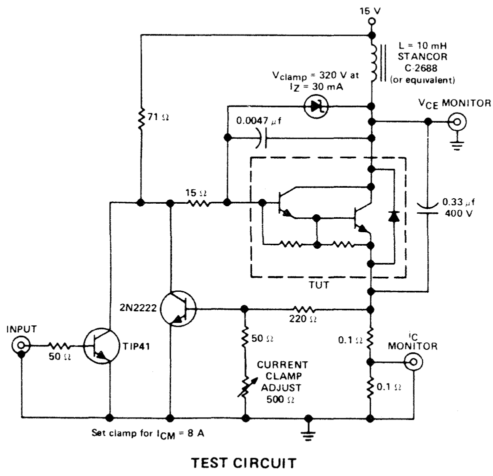
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

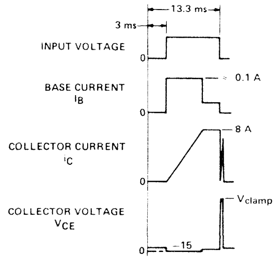
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 2—SWITCHING CHARACTERISTICS

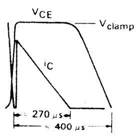
FUNCTIONAL TEST INFORMATION



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: $t_r \leq 20$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.

FIGURE 3—FORWARD-PULSE ENERGY TEST

TYPICAL CHARACTERISTICS

TIP665
COLLECTOR CUTOFF CURRENT vs CASE TEMPERATURE

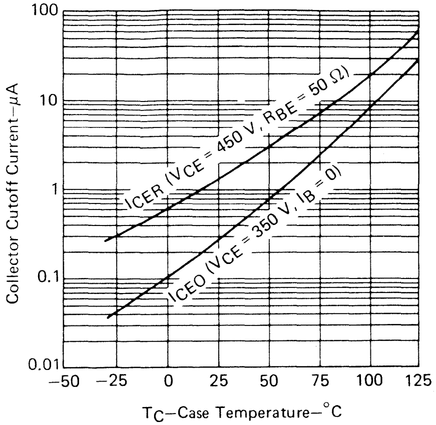


FIGURE 4

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

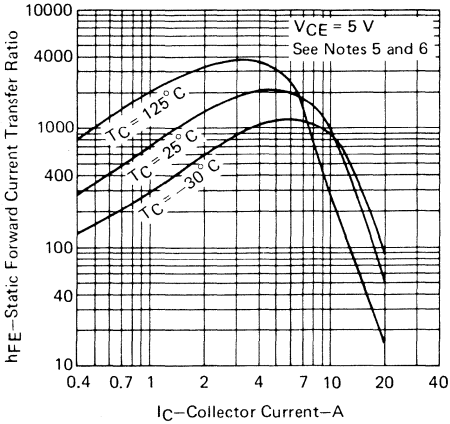


FIGURE 5

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

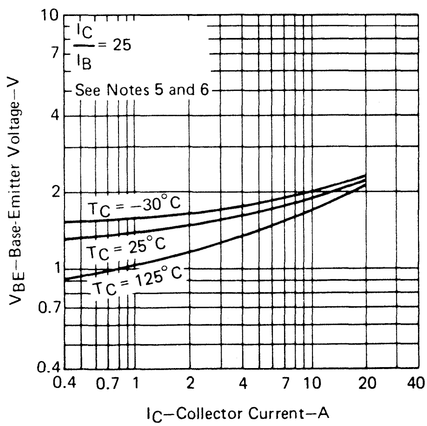


FIGURE 6

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

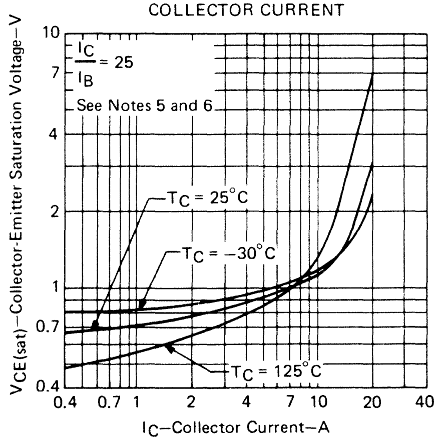


FIGURE 7

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)

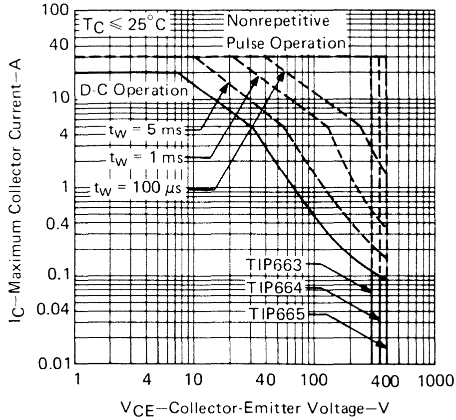


FIGURE 8

MAXIMUM COLLECTOR CURRENT
vs
CLAMPED COLLECTOR-EMITTER VOLTAGE
(REVERSE BASE BIAS)

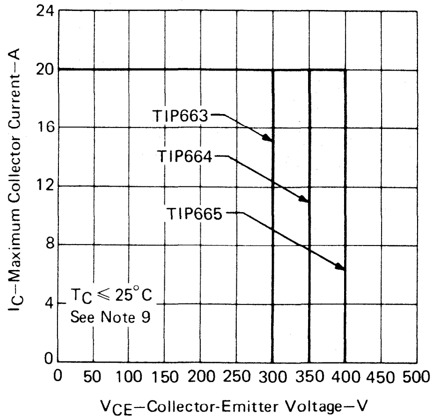


FIGURE 9

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

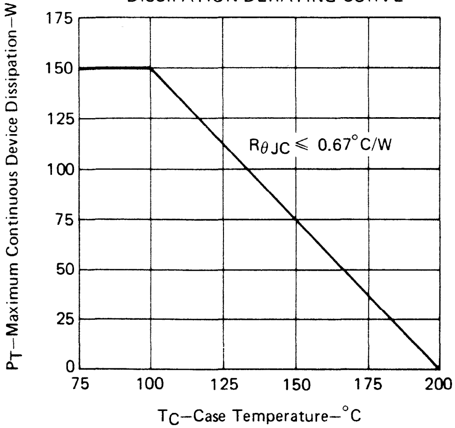


FIGURE 10

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

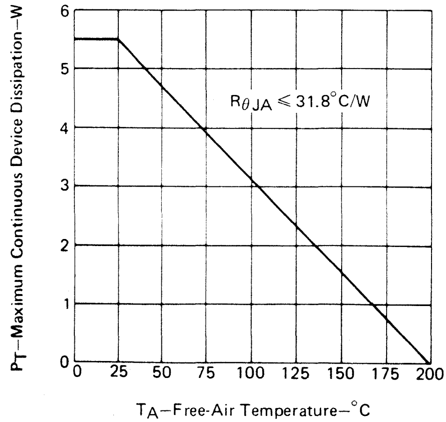


FIGURE 11

TIP2955
PNP SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

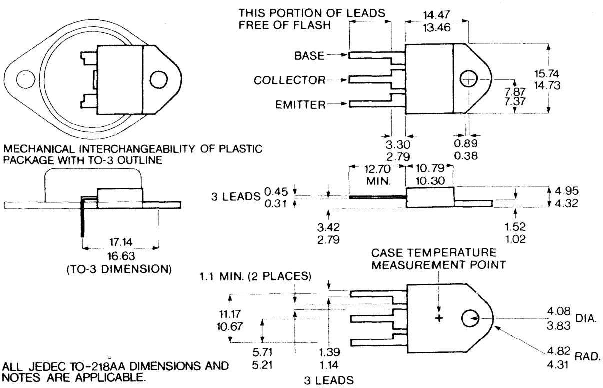
For power-amplifier and high-speed-switching applications

- **90 Watts at 25°C case temperature**
- **15A rated collector current**

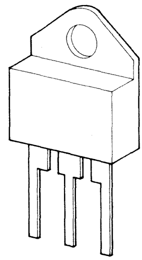
Designed for complementary use with TIP3055

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)	90W
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} = 100Ω
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}=100Ω V_{BB2}=0V, R_S=0.1Ω, V_{CC}=10V. Energy $\approx I_C^2L/2$.

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	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	$V_{CE} = -10$V	$I_C = -0.5$A	f = 1 kHz	20		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$V	$I_C = -0.5$A		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

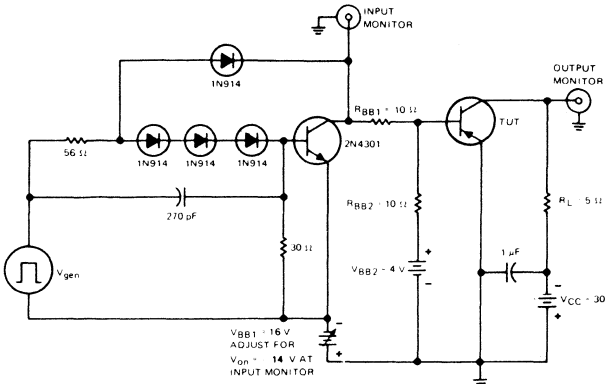
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.39	C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

Switching characteristics at 25°C case temperature

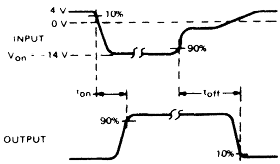
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -6$ A, $I_{B(1)} = -0.6$ A, $I_{B(2)} = 0.6$ A,	0.4	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 4$ V, $R_L = 5\ \Omega$, See Figure 1	0.7	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

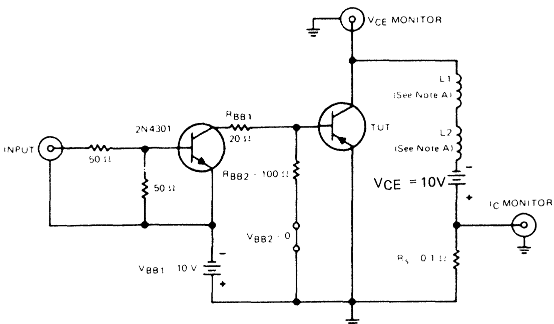


VOLTAGE WAVEFORMS

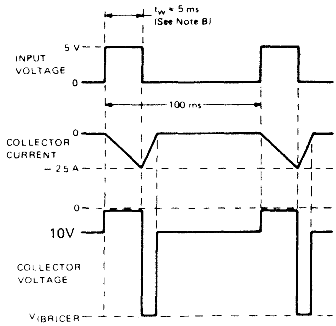
NOTES: A. V_{gen} is a 30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with 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

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

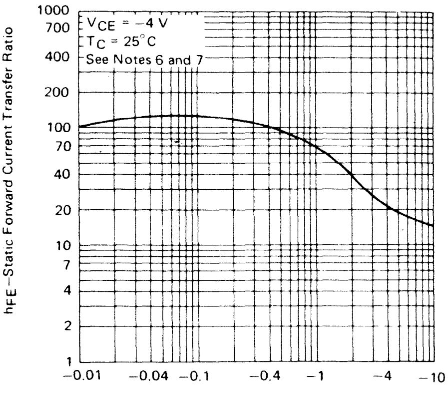


FIGURE 3

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

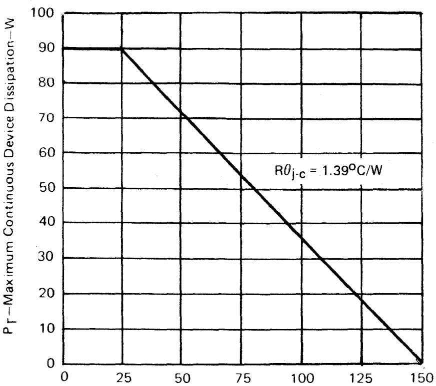


FIGURE 4

MAXIMUM SAFE OPERATING REGION

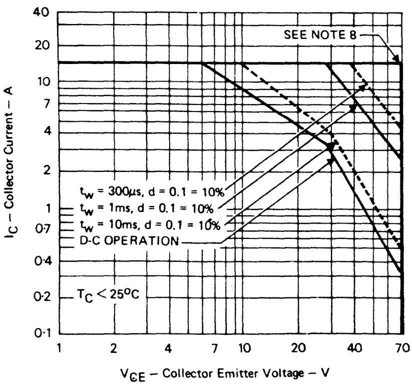


FIGURE 5

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

TIP3055
NPN SINGLE-DIFFUSED MESA SILICON POWER TRANSISTOR

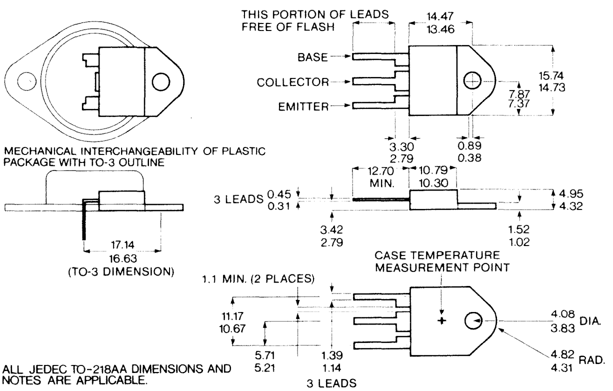
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
PLASTIC-CASE REPLACEMENT FOR 2N3055

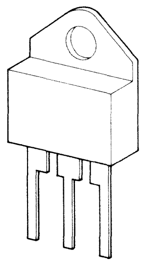
- 90 Watts at 25°C Case Temperature
- 15 A Rated Collector Current

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)	90W
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 $\approx I_C^2L/2$.

TEXAS INSTRUMENTS

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 Ω			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		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, f = 1 MHz	I_C = 0.5 A,	See Note 7	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.
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

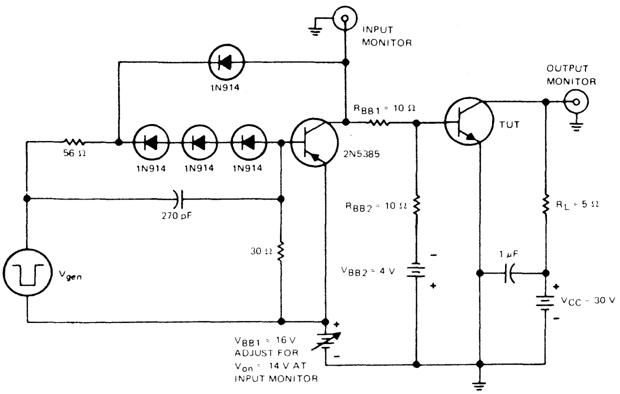
PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	1.39	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	35.7	

switching characteristics at 25°C case temperature

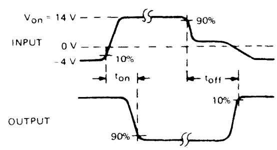
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = 6 A, $I_{B(1)}$ = 0.6 A, $I_{B(2)}$ = −0.6 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V, R_L = 5 Ω, See Figure 1	1	

† 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 Ω, t_w = 20 µs, duty cycle ≤ 2%.

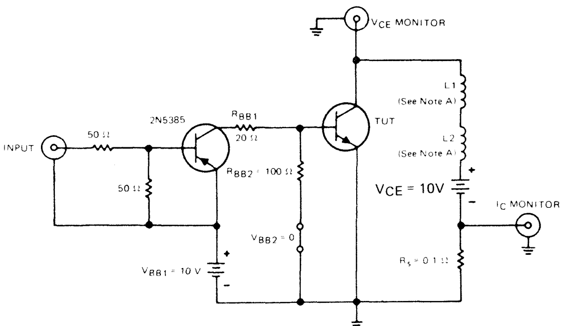
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

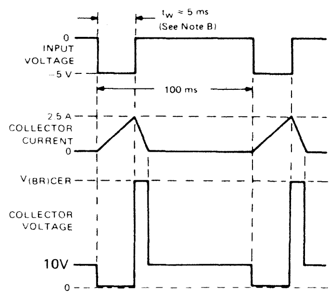
E. The d-c power supplies may require additional bypassing in order to minimize ringing.

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} = 2.5 A.

FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

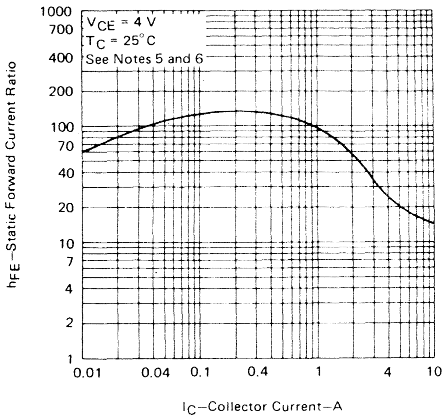


FIGURE 3

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

THERMAL INFORMATION

DISSIPATION DERATING CURVE

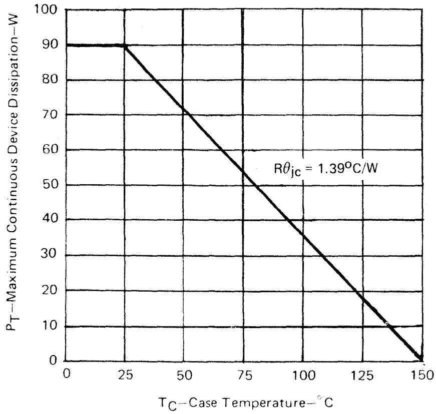


FIGURE 4

MAXIMUM SAFE OPERATING REGION

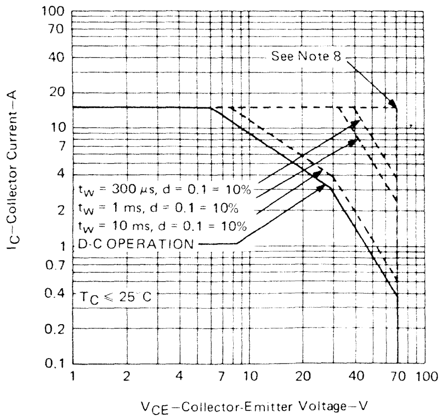


FIGURE 5

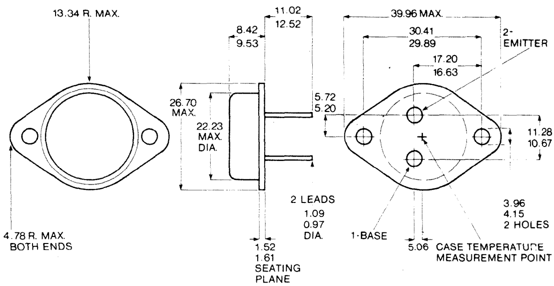
NOTE 8: This combination of maximum voltage and current may be achieved only when switching from saturation to cutoff with a clamped inductive load.

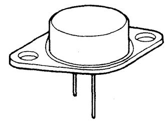
FOR POWER-AMPLIFIER AND SWITCHING APPLICATIONS

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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.

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

	PARAMETER	TEST CONDITIONS	2N3713 MIN	2N3713 MAX	2N3714 MIN	2N3714 MAX	2N3715 MIN	2N3715 MAX	2N3716 MIN	2N3716 MAX	UNIT
$V_{(BR)CEO}$	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 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

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	

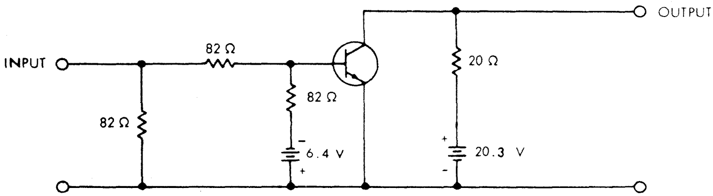
*Indicates JEDEC registered data

switching characteristics at 25°C case temperature

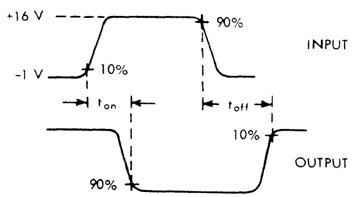
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = 1$ A, $I_{B(1)} = 100$ mA, $I_{B(2)} = -100$ mA,	450	ns
t_{off}	Turn-Off Time	$V_{BE(off)} = -3.7$ V, $R_L = 20\ \Omega$, See Figure 1	350	

†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, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

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

TYPICAL CHARACTERISTICS

2N3713, 2N3714
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

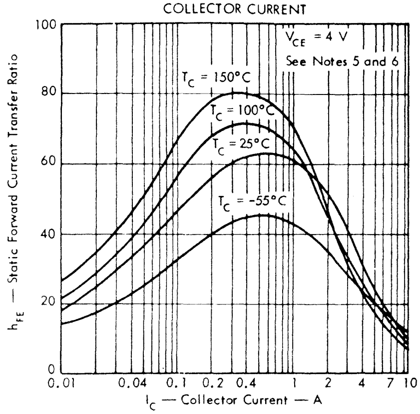


FIGURE 2

2N3715, 2N3716
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

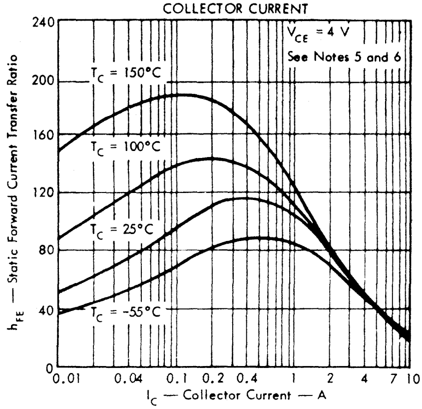


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

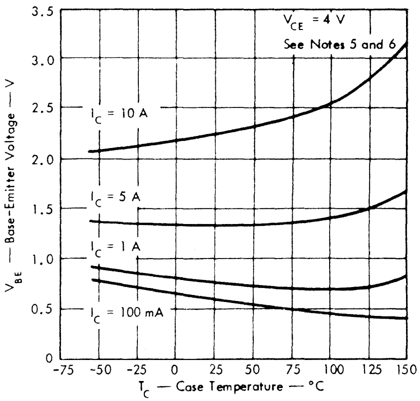


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

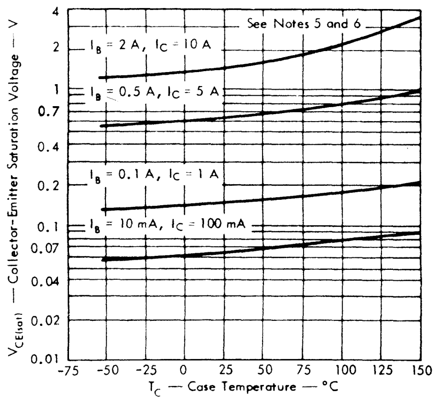


FIGURE 5

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

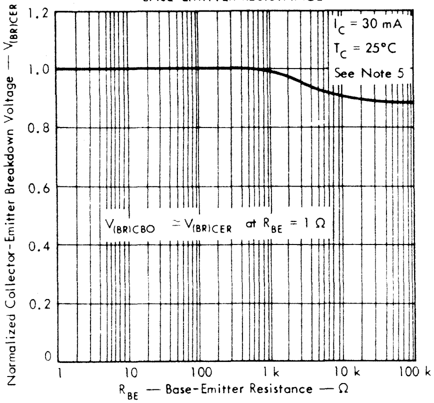


FIGURE 6

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE vs COLLECTOR-BASE VOLTAGE

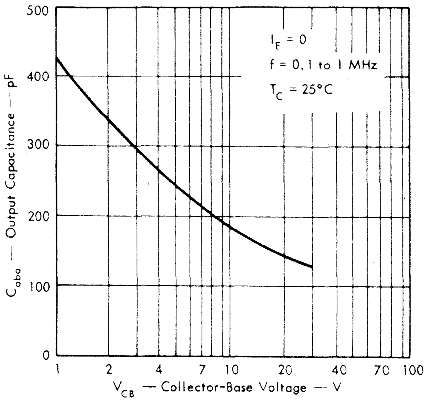


FIGURE 7

MAXIMUM SAFE OPERATING REGIONS

2N3713, 2N3715

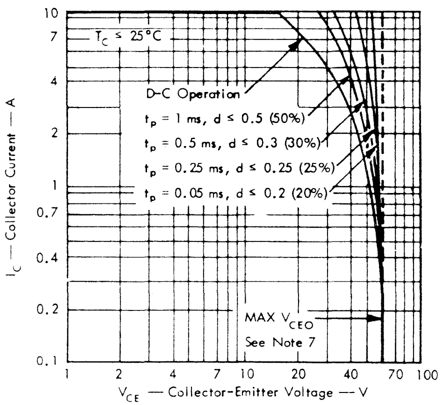


FIGURE 8

2N3714, 2N3716

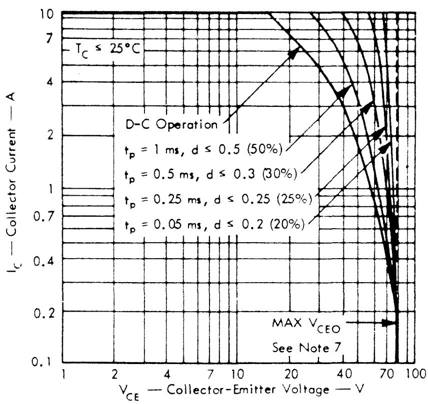


FIGURE 9

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.

THERMAL INFORMATION

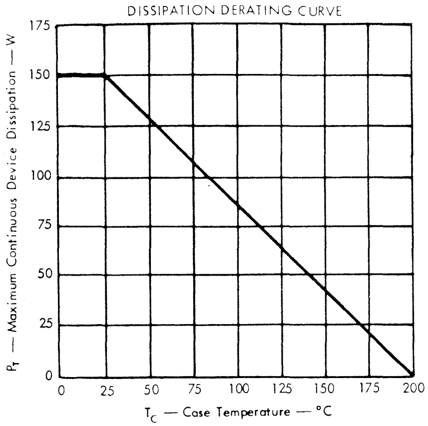


FIGURE 10

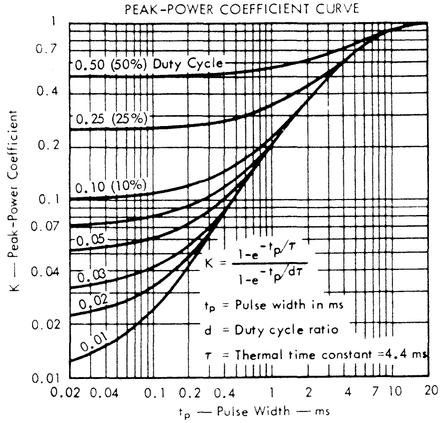


FIGURE 11

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
θ_{J-C}	Junction-to-Case Thermal Resistance	1.17	deg/W
θ_{C-A}	Case-to-Free-Air Thermal Resistance	42.5	deg/W
θ_{C-HS}	Case-to-Heat-Sink Thermal Resistance		deg/W
θ_{HS-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.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J-C} + \theta_{C-HS} + \theta_{HS-A}} \quad \text{for . °C} \le T_C \le 200°C\text{, as in figure 10.}$$

Equation No. 2 — Application: d-c power dissipation, *no heat sink used.*

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J-A}} \quad \text{for } 25°C \le T_A \le 200°C$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C-HS} + \theta_{HS-A}) + K\,\theta_{J-C}} \quad \text{for } 25°C \le T_C \le 200°C$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C-A} + K\theta_{J-C}} \quad \text{for } 25°C \le T_A \le 200°C$$

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C-HS} + \theta_{HS-A} = 2.25$ 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

$$P_{T(max)} \doteq \frac{T_{J(max)} - T_A}{d\,(\theta_{C-HS} + \theta_{HS-A}) + K\,\theta_{J-C}}$$

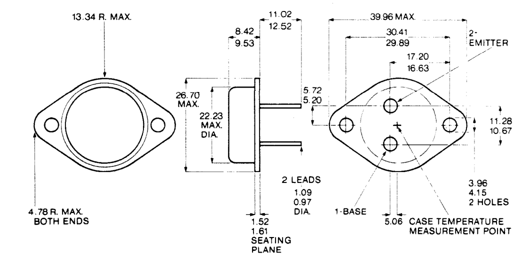
$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(1.17)} = 424 \text{ W}$$

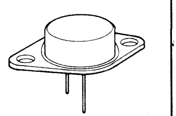
FOR UNTUNED POWER-AMPLIFIER APPLICATIONS

150 W at 25°C Case Temperature
30-A Rated Continuous Collector Current (2N3771)
20-A Rated Continuous Collector Current (2N3772)

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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.

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

PARAMETER		TEST CONDITIONS	2N3771 MIN	2N3771 MAX	2N3772 MIN	2N3772 MAX	UNIT
$V_{(BR)CEO}$	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 µs, duty cycle ≤ 2%.

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

*Indicates JEDEC registered data

MAXIMUM SAFE OPERATING REGION

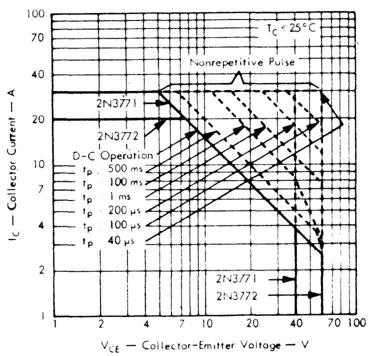


FIGURE 1

THERMAL INFORMATION

DISSIPATION DERATING CURVE

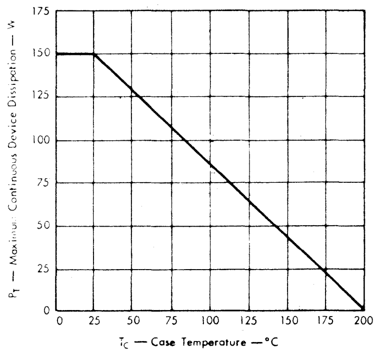


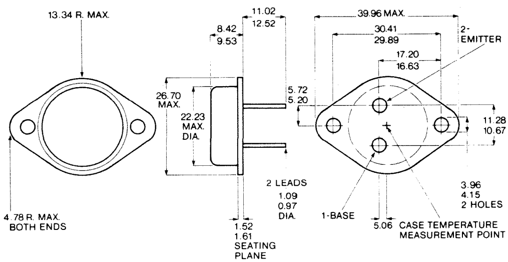
FIGURE 2

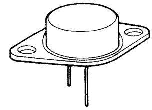
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N3713 THRU 2N3716

- **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**

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $\leq 10\%$.
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	
$\|h_{fe}\|$	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, 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 ≤ 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

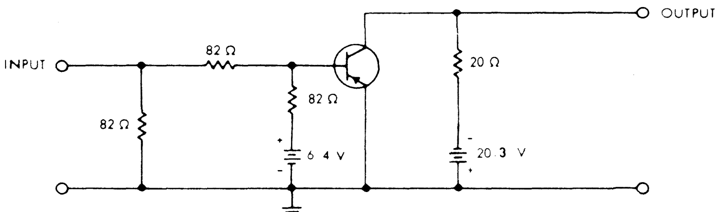
PARAMETER		MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	1.17	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	deg/W

switching characteristics at 25°C case temperature

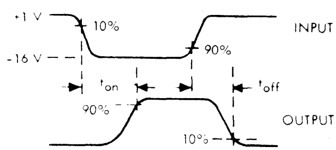
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	I_C = -1 A, $I_{B(1)}$ = -100 mA, $I_{B(2)}$ = 100 mA,	0.35	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 3.7 V, R_L = 20 Ω, See Figure 1	0.8	

† 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 Ω, t_p = 10 μs, duty cycle ≤ 2%.

b. 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.

c. Resistors must be noninductive types.

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

TYPICAL CHARACTERISTICS

2N3789, 2N3790
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

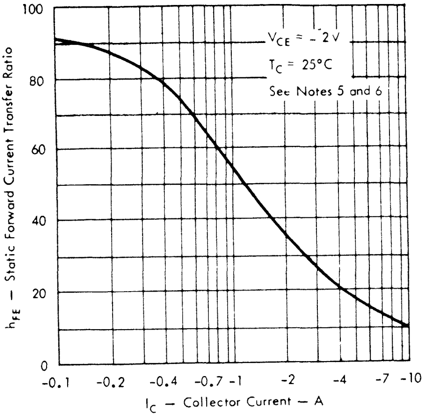


FIGURE 2

2N3791, 2N3792
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

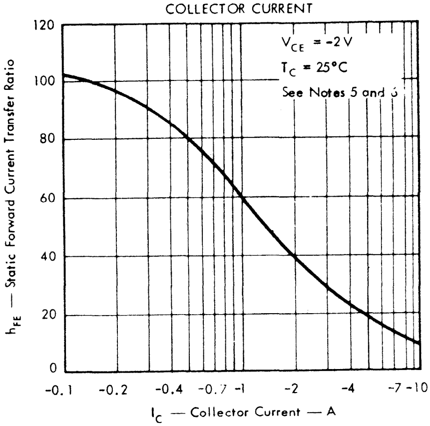


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

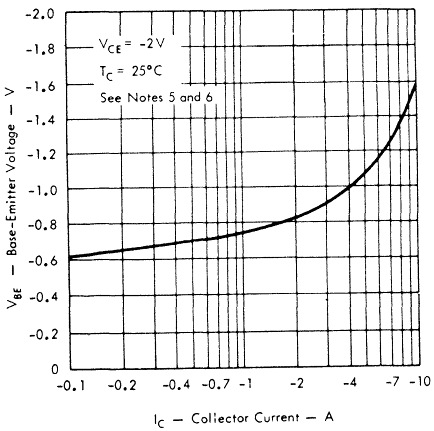


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

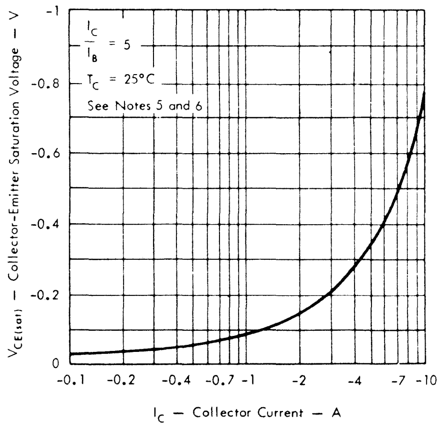


FIGURE 5

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

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

MAXIMUM SAFE OPERATING REGIONS

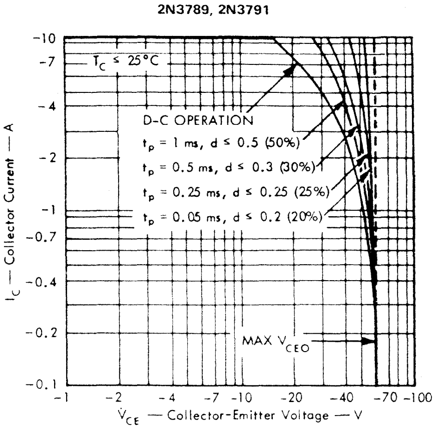


FIGURE 6

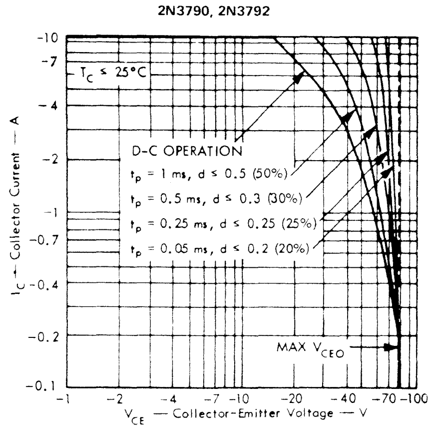


FIGURE 7

THERMAL INFORMATION

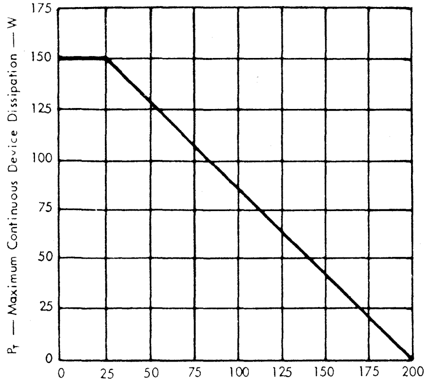


FIGURE 8

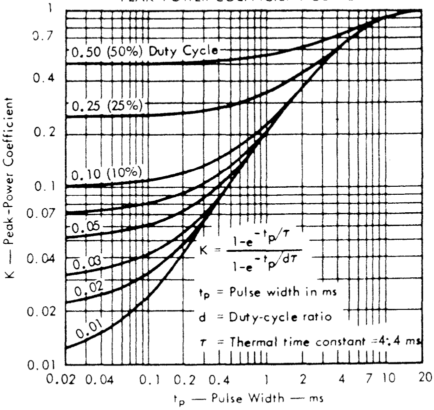


FIGURE 9

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	$\leq$ 200	°C
$T_{J(max)}$	Peak Junction Temperature	$\leq$ 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.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 25\,°C \leq T_C \leq 200\,°C, \text{ as in Figure 8.}$$

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \quad \text{for } 25°C \leq T_A \leq 200°C$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}} \quad \text{for } 25\,°C \leq T_C \leq 200°C$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C\text{-}A} + K\,\theta_{J\text{-}C}} \quad \text{for } 25°C \leq T_A \leq 200°C$$

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 9, Peak-Power Coefficient $K = 0.11$ and by use of equation No. 3

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\,\theta_{J\text{-}C}}$$

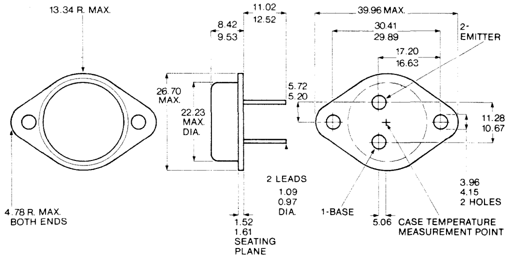
$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(1.17)} = 424\text{ W}$$

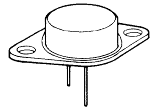
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5301, 2N5302

- 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 COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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.

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

PARAMETER		TEST CONDITIONS		2N4398 MIN	2N4398 MAX	2N4399 MIN	2N4399 MAX	UNIT
$V_{(BR)CEO}$	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 ≤2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

PARAMETER		MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	0.875	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	35	

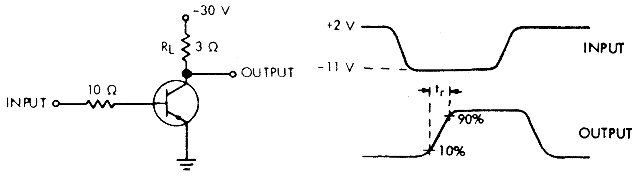
*switching characteristics at 25°C case temperature

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 Ω, 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 Ω, See Figure 2	0.6	

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

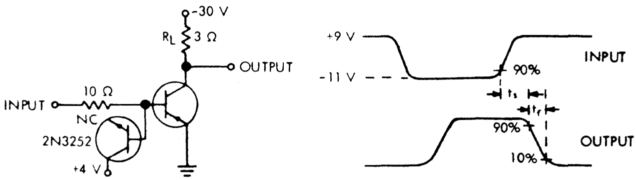
*Indicates JEDEC registered data

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT — VOLTAGE WAVEFORMS

FIGURE 1 – RISE TIME



TEST CIRCUIT — VOLTAGE WAVEFORMS

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 ≤ 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

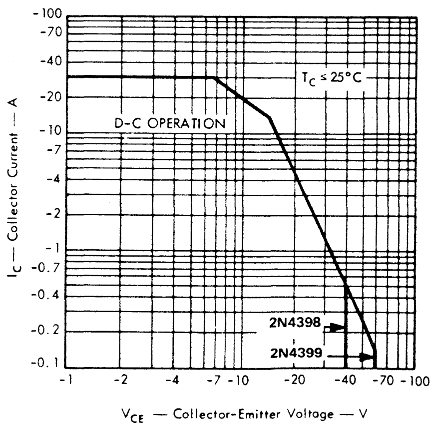


FIGURE 3

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

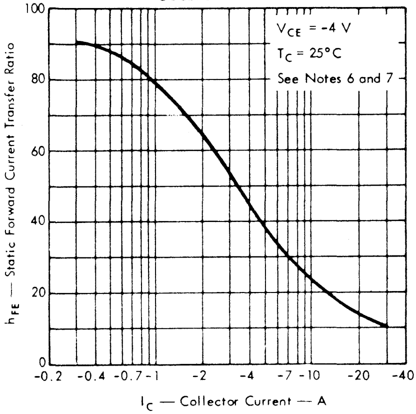


FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

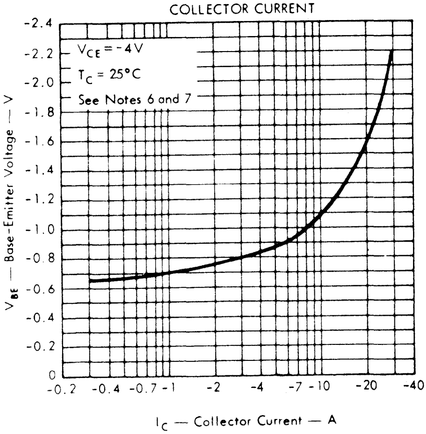


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

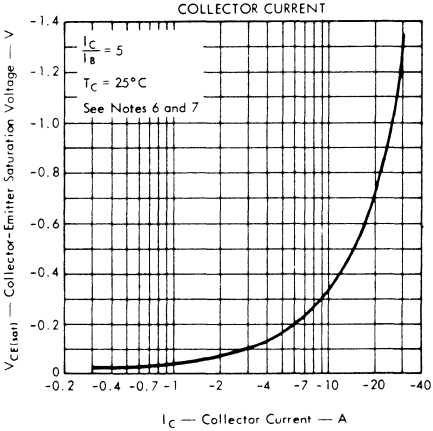


FIGURE 6

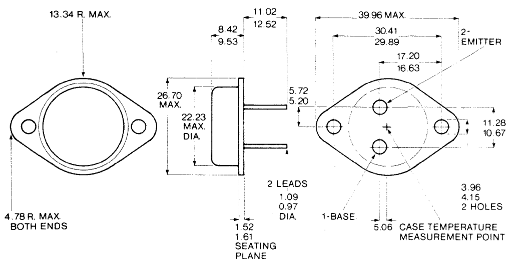
NOTES 6. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.
7. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

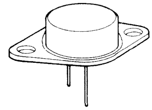
FOR POWER-AMPLIFIER AND SWITCHING APPLICATIONS

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

	2N4901	2N4902	2N4903
*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	← -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 →		
*Terminal Temperature 1.6 mm from Case for 10 Seconds	← 235°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 0.5 W/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

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

PARAMETER		TEST CONDITIONS	2N4901 MIN	2N4901 MAX	2N4902 MIN	2N4902 MAX	2N4903 MIN	2N4903 MAX	UNIT
$V_{(BR)CEO}$	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, $I_C = -1$ A, See Notes 5 and 6	20	80	20	80	20	80	
		$V_{CE} = -2$ V, $I_C = -5$ A, See Notes 5 and 6	7		7		7		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -2$ V, $I_C = -1$ A, See Notes 5 and 6		-1.2		-1.2		-1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.1$ A, $I_C = -1$ A, See Notes 5 and 6		-0.4		-0.4		-0.4	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 ≤ 2%.

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

*Indicates JEDEC registered data

thermal characteristics

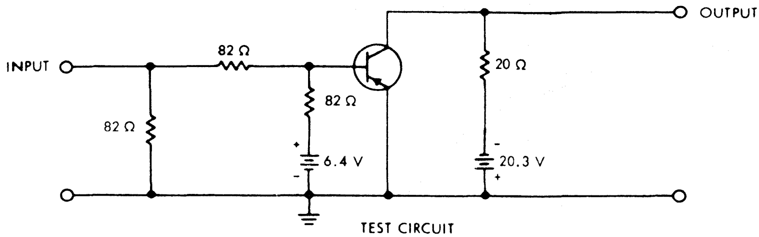
PARAMETER		MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	2	°C/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	43.7	

switching characteristics at 25°C case temperature

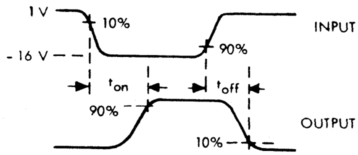
PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_{on}	Turn-On Time	$I_C = -1$ A, $I_{B(1)} = -0.1$ A, $I_{B(2)} = 0.1$ A,	0.35	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = 3.7$ V, $R_L = 20\ \Omega$, See Figure 1	0.8	

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

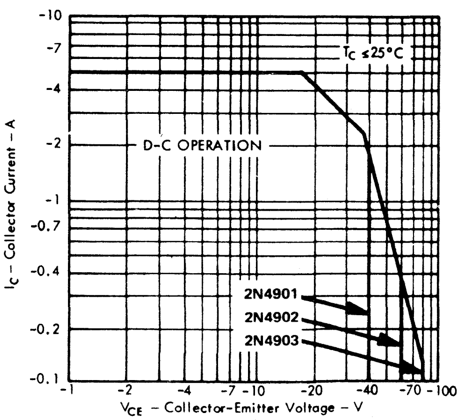


FIGURE 2

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

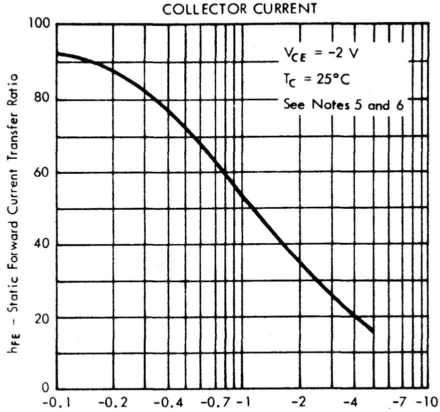


FIGURE 3

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

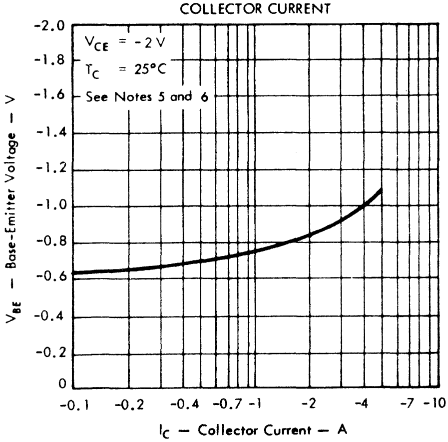


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

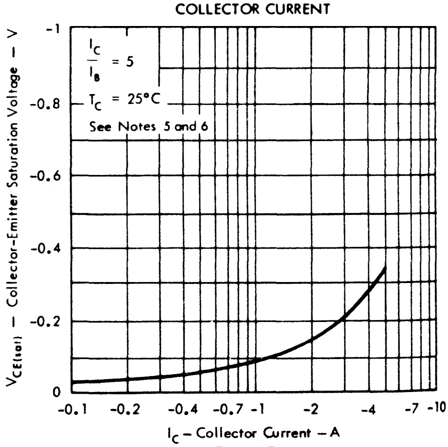


FIGURE 5

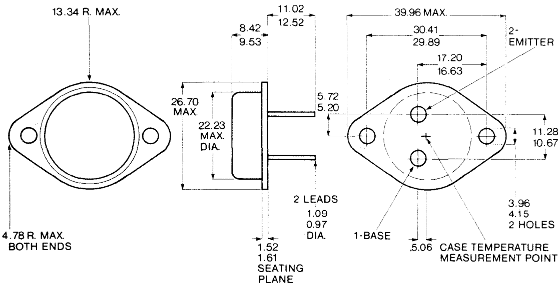
NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

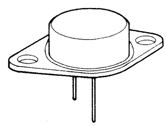
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N4913, 2N4914, 2N4915

- **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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 MIN	2N4904 MAX	2N4905 MIN	2N4905 MAX	2N4906 MIN	2N4906 MAX	UNIT
$V_{(BR)CEO}$	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 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

*Indicates JEDEC registered data

thermal characteristics

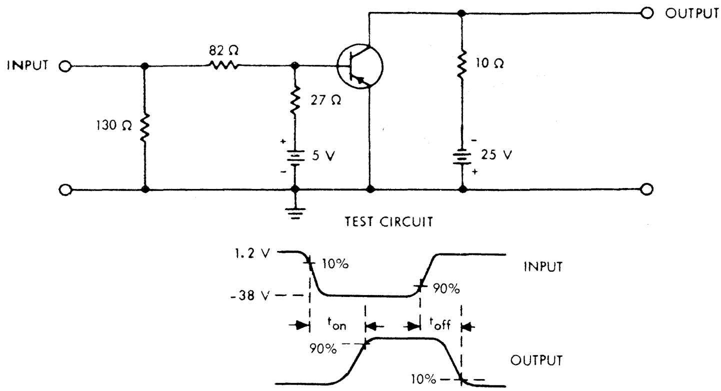
PARAMETER		MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	2	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	deg/W

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,	0.4	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = 4.1 V, R_L = 10 Ω, See Figure 1	0.7	μs

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

PARAMETER MEASUREMENT INFORMATION



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

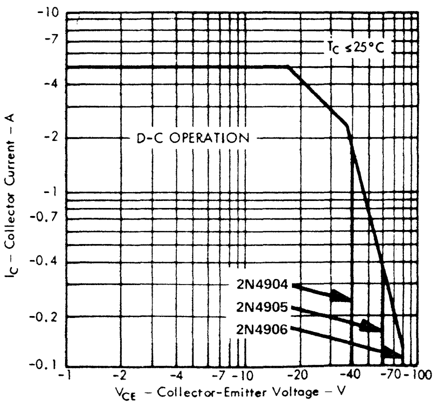


FIGURE 2

TYPICAL CHARACTERISTICS

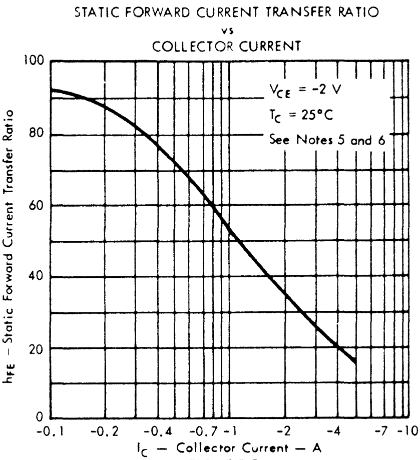


FIGURE 3

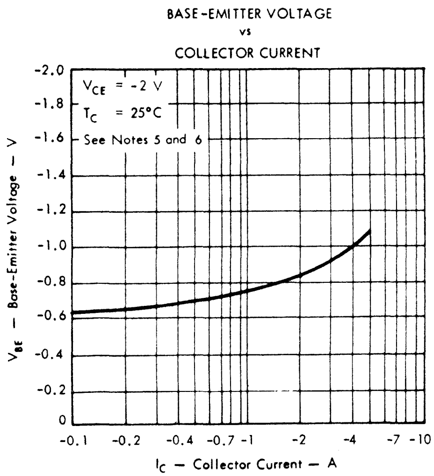


FIGURE 4

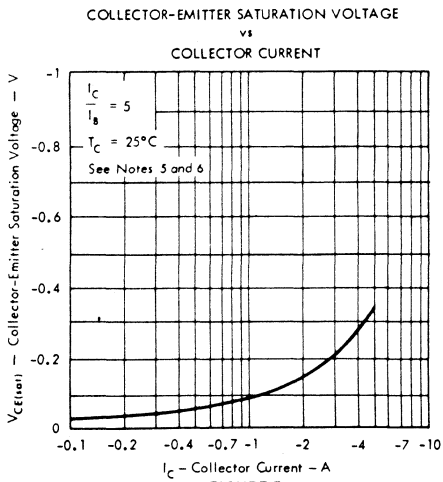


FIGURE 5

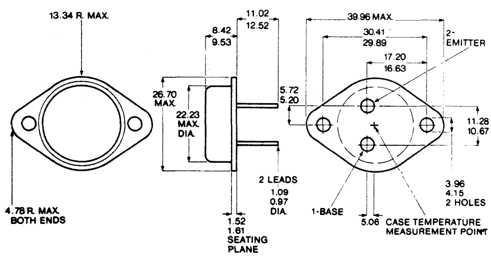
NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

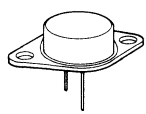
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N4904 THRU 2N4906

- **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**

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 ≤ 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 MIN	2N4913 MAX	2N4914 MIN	2N4914 MAX	2N4915 MIN	2N4915 MAX	UNIT
$V_{(BR)CEO}$	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. $t_p = 300\ \mu s$, 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	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,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)} = -4.1$ V,	$R_L = 10\ \Omega$,	See Figure 1	1.2	

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

PARAMETER MEASUREMENT INFORMATION

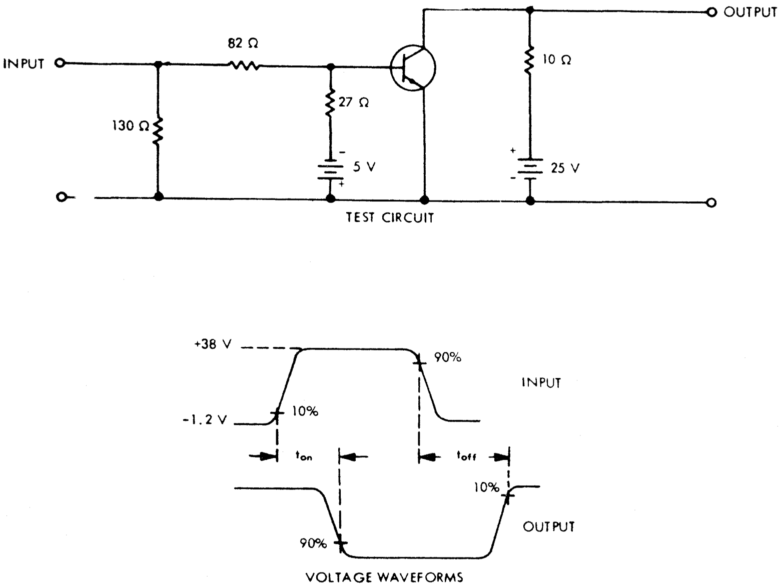


FIGURE 1

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

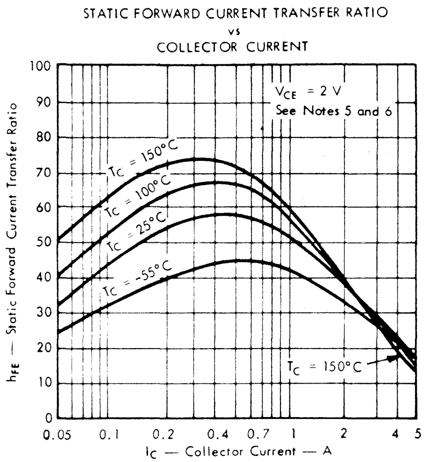


FIGURE 2

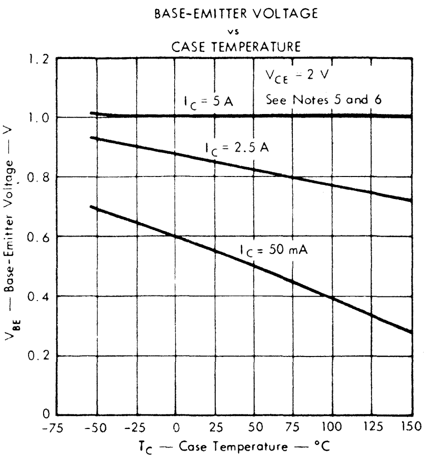


FIGURE 3

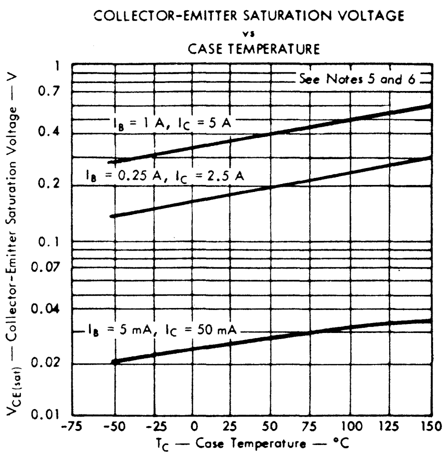


FIGURE 4

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

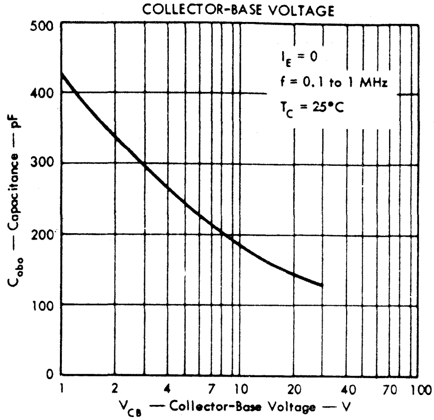


FIGURE 5

MAXIMUM SAFE OPERATING REGION

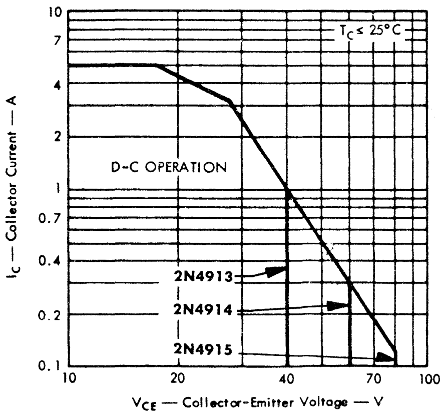


FIGURE 6

THERMAL INFORMATION

DISSIPATION DERATING CURVE

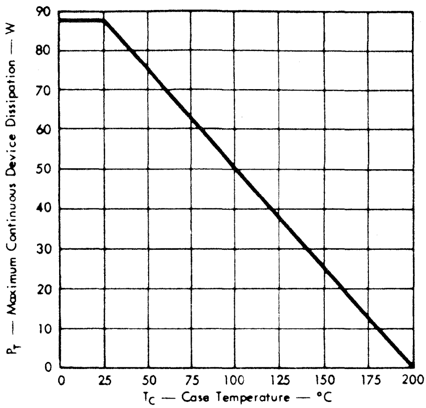


FIGURE 7

PEAK-POWER COEFFICIENT CURVE

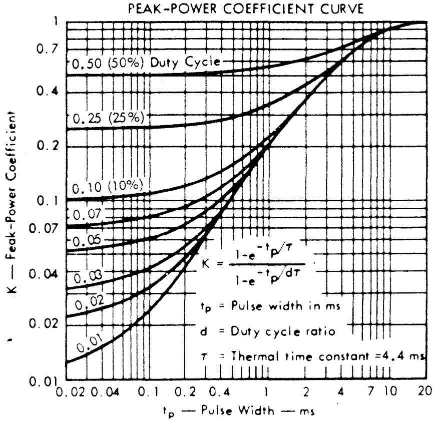


FIGURE 8

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(av)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
θ_{J-C}	Junction-to-Case Thermal Resistance	2	deg/W
θ_{C-A}	Case-to-Free-Air Thermal Resistance	41.7	deg/W
θ_{C-HS}	Case-to-Heat-Sink Thermal Resistance		deg/W
θ_{HS-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.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J-C} + \theta_{C-HS} + \theta_{HS-A}}$$ for $25\,°C \leq T_C \leq 200°C$, as in figure 7.

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J-A}}$$ for $25°C \leq T_A \leq 200°C$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C-HS} + \theta_{HS-A}) + K\,\theta_{J-C}}$$ for $25°C \leq T_C \leq 200°C$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,\theta_{C-A} + K\theta_{J-C}}$$ for $25°C \leq T_A \leq 200°C$

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$\theta_{C-HS} + \theta_{HS-A} = 2.25$ deg/W (From info :iation 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

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C-HS} + \theta_{HS-A}) + K\,\theta_{J-C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1(2.25) + 0.11(2)} = 337\ \text{W}$$

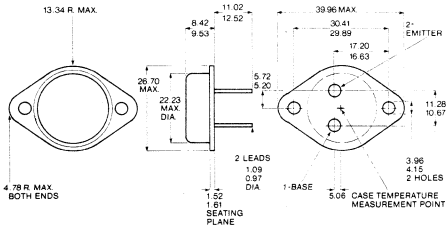
TYPES 2N5038, 2N5039
N-P-N SILICON POWER TRANSISTORS

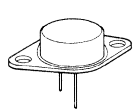
FOR POWER-AMPLIFIER AND HIGH-SPEED SWITCHING APPLICATIONS

- **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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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	← 7V →	
*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 offstate 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.

TYPES 2N5038, 2N5039
N-P-N SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS	2N5038 MIN	2N5038 MAX	2N5039 MIN	2N5039	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA, I_B = 0, See Note 5	90		75		V
I_{CEV}	Collector Cut-off 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} = −1.5V, 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		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	
$\lvert h_{fe} \rvert$	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 = 300μs, 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.

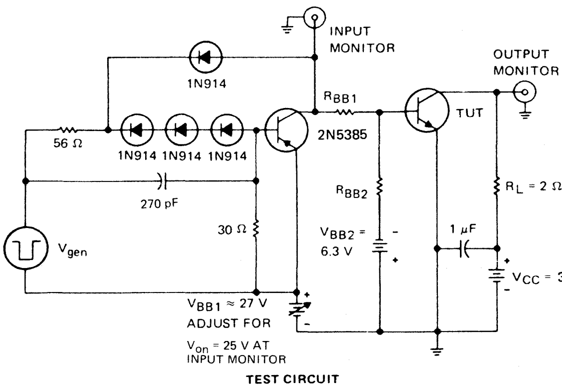
***switching characteristics at 25°C case temperature**

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,	1.5	
t_f	Fall Time	$V_{BE(off)}$ = −6.3 V,	R_L = 2.5 Ω,	See Figure 1	0.5	
t_{on}	Turn-On Time	2N5039 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	

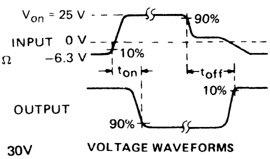
† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

• JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

CIRCUIT CONDITIONS

I_C	R_L	R_{BB1}	R_{BB2}
10A	3Ω	12Ω	7.32Ω
12A	2.5Ω	10Ω	6Ω

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

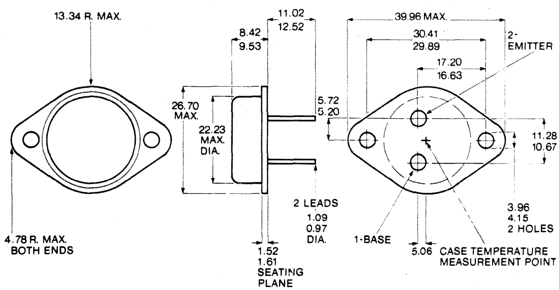
TYPES 2N5067, 2N5068, 2N5069
N-P-N SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N4901 THRU 2N4903

- **87.5 W at 25°C Case Temperature**
- **5-A Rated Collector Current**
- **Min f_T of 4 MHz at 10 V, 1 A**
- **62.5 mJ Reverse Energy Rating**

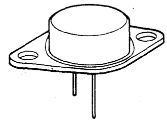
***mechanical data**

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



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

	2N5067	2N5068	2N5069
*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	← 5 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 6 and 7 →		
*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 →		
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 1.6mm from Case for 10 Seconds	← 235°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 0.5 W/°C or refer to Dissipation Derating Curve, Figure 8.
4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/°C or refer to Dissipation Derating Curve, Figure 9.
5. This rating is based on the capability of the transistors to operate safely in the circuit of Figure 5. L = 20 mH, $R_{BB2} = 100\ \Omega$, $V_{BB2} = 0$ V, $R_S = 0.1\ \Omega$, $V_{CC} = 10$ V. Energy $\approx I_C^2 L/2$.

TYPES 2N5067, 2N5068, 2N5069
N-P-N SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS	2N5067 MIN	2N5067 MAX	2N5068 MIN	2N5068 MAX	2N5069 MIN	2N5069 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA, I_B = 0, See Note 6	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		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		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 = 1 A, See Notes 6 and 7	20	80	20	80	20	80	
		V_{CE} = 2 V, I_C = 5 A, See Notes 6 and 7	7		7		7		
V_{BE}	Base-Emitter Voltage	V_{CE} = 2 V, I_C = 1 A, See Notes 6 and 7		1.2		1.2		1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.1 A, I_C = 1 A, See Notes 6 and 7		0.4		0.4		0.4	V
		I_B = 1 A, I_C = 5 A, See Notes 6 and 7		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		

*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, $V_{BE(off)}$ = −4.3 V, R_L = 30 Ω, See Figure 4	0.5	μs
t_{off}	Turn-Off Time		2	

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

TYPICAL CHARACTERISTICS

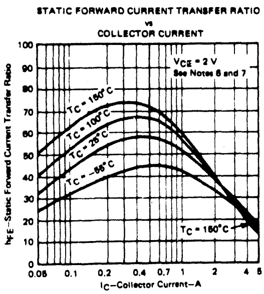


FIGURE 1

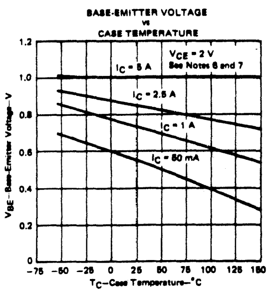


FIGURE 2

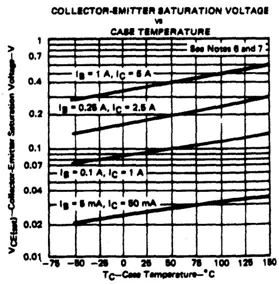
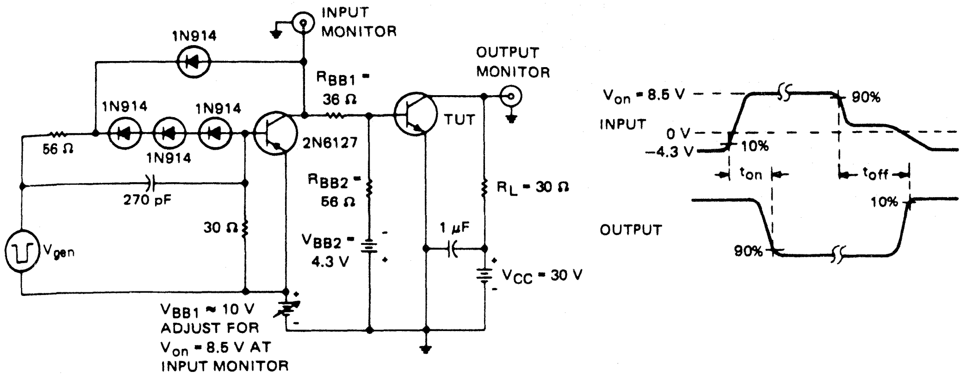


FIGURE 3

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 3.2 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: $t_r \le 15$ ns, $t_f \le 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 20\ \mu s$, duty cycle $\le 2\%$.

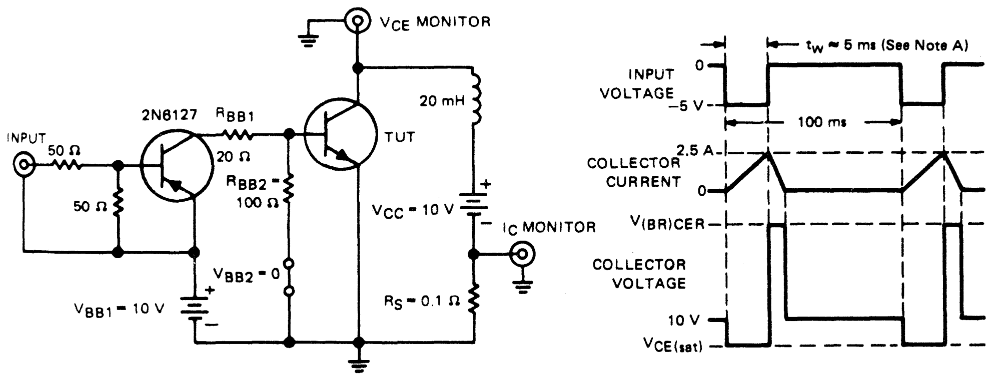
C. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 15$ ns, $R_{in} \ge 10\ M\Omega$, $C_{in} \le 11.5$ pF.

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} = 2.5 A.

FIGURE 5

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

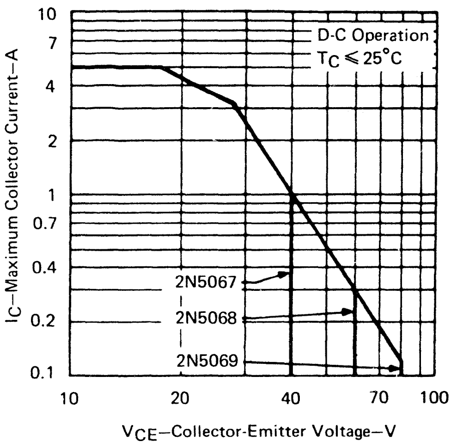


FIGURE 6

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

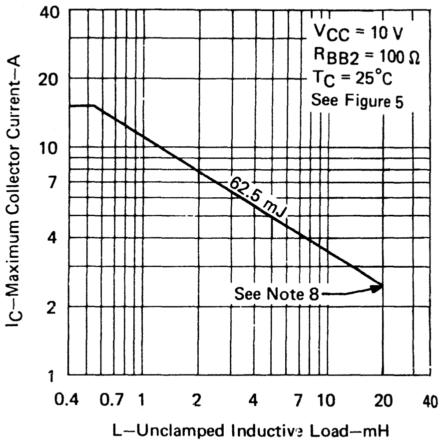


FIGURE 7

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

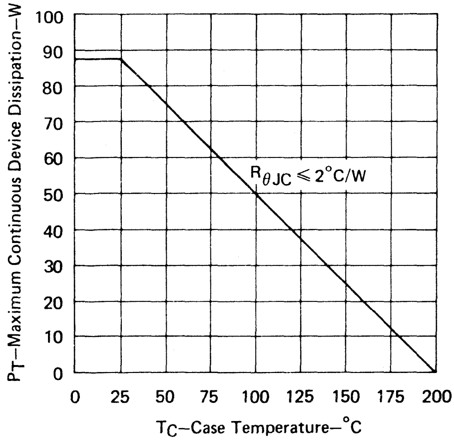


FIGURE 8

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

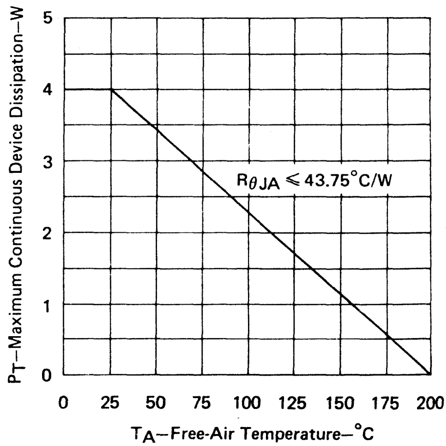


FIGURE 9

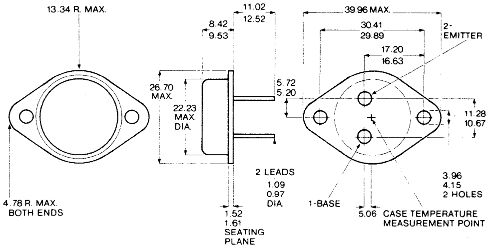
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS

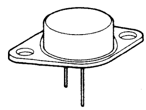
2N5301, 2N5302 DESIGNED FOR COMPLEMENTARY USE WITH 2N4398, 2N4399

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 MIN	2N5301 MAX	2N5302 MIN	2N5302 MAX	2N5303 MIN	2N5303 MAX	UNIT
$V_{(BR)CEO}$	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		
$\|h_{fe}\|$	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 ≤2%.

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

*Indicates JEDEC registered data

thermal characteristics

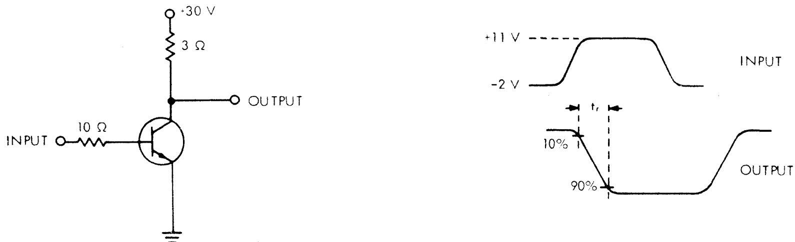
	PARAMETER	MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	0.875	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	35	

*switching characteristics at 25°C case temperature

	PARAMETER	TEST CONDITIONS†			MAX	UNIT
t_r	Rise Time	I_C = 10 A, R_L = 3 Ω,	$I_{B(1)}$ = 1 A, See Figure 1	$V_{BE(off)}$ = -2 V,	1	μs
t_s	Storage Time	I_C = 10 A,	$I_{B(1)}$ = 1 A,	$I_{B(2)}$ = -1 A,	2	
t_f	Fall Time	R_L = 3 Ω,	See Figure 2		1	

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

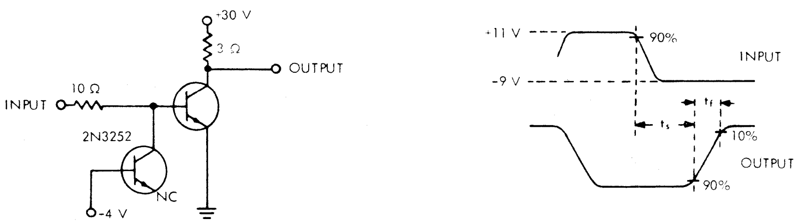
*PARAMETER MEASUREMENT INFORMATION



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 Ω, t_p = 10 μs to 100 μs, duty cycle ≤ 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

TYPICAL CHARACTERISTICS

2N5301, 2N5302
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

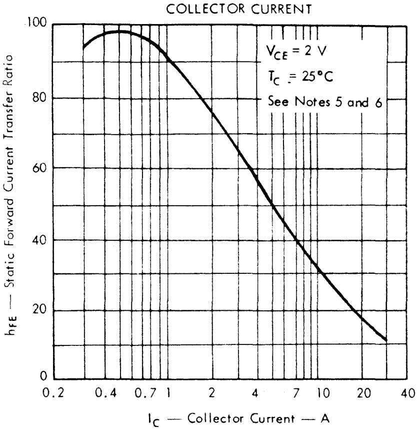


FIGURE 3

2N5303
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

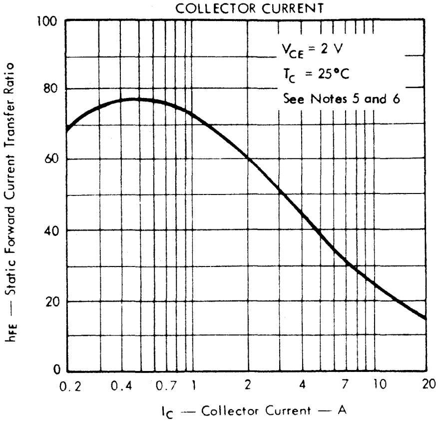


FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

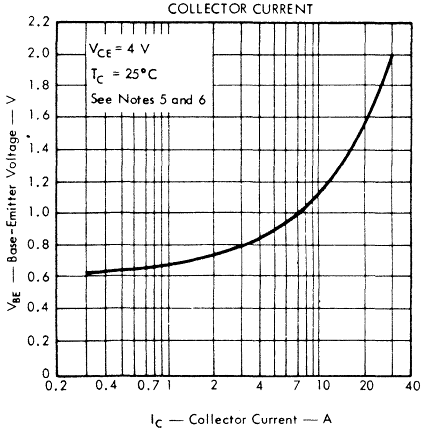


FIGURE 5

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
COLLECTOR CURRENT

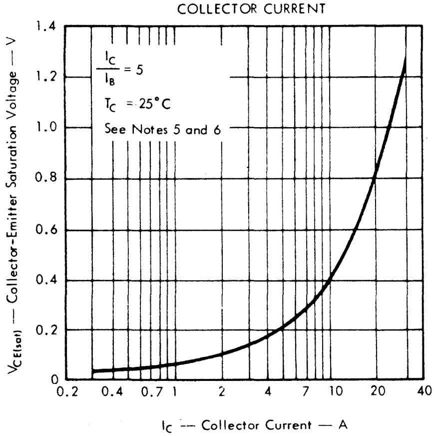


FIGURE 6

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

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

MAXIMUM SAFE OPERATING REGIONS

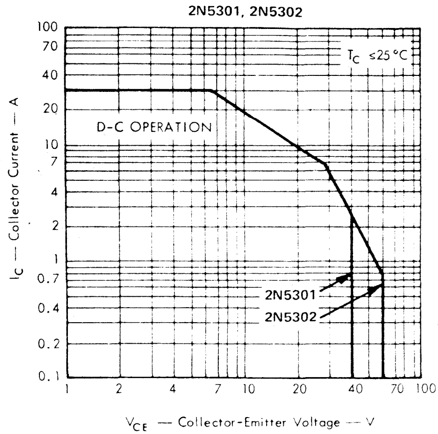


FIGURE 7

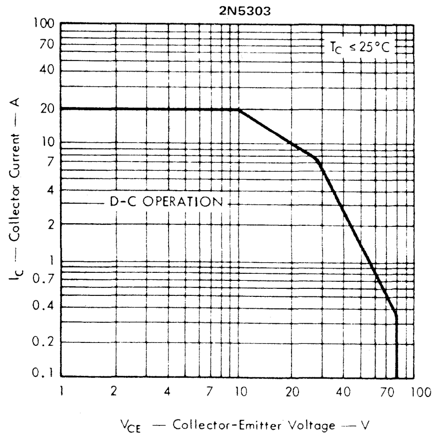


FIGURE 8

THERMAL INFORMATION

DISSIPATION DERATING CURVE

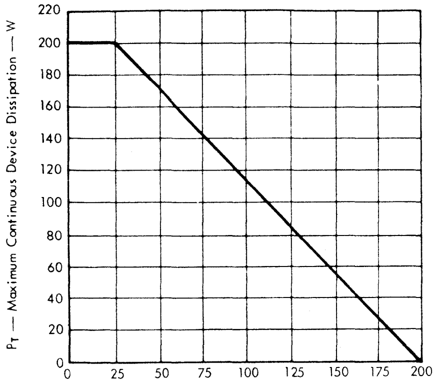


FIGURE 9

PEAK-POWER COEFFICIENT CURVE

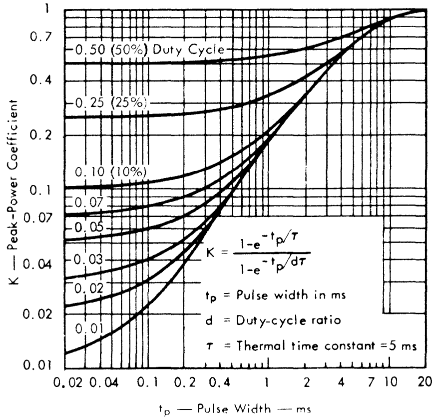


FIGURE 10

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.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 100°C \le T_C \le 200°C \text{ as in Figure 9}$$

Equation No. 2 – Application: d-c power dissipation, no heat sink used.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \quad \text{for } 25°C \le T_A \le 200°C$$

Equation No. 3 – Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\theta_{J\text{-}C}} \quad \text{for } 100°C \le T_C \le 200°C$$

Equation No. 4 – Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\theta_{C\text{-}A} + K\theta_{J\text{-}C}} \quad \text{for } 25°C \le T_A \le 200°C.$$

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 10, Peak-Power Coefficient K = 0.109 and by use of equation No. 3

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\,(\theta_{C\text{-}HS} + \theta_{HS\text{-}A}) + K\theta_{J\text{-}C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1\,(2.25) + 0.109\,(0.875)} = 469\text{ W}$$

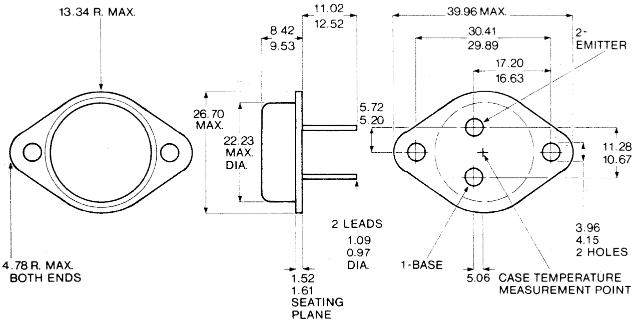
TYPES 2N5758, 2N5759, 2N5760
N-P-N SILICON POWER TRANSISTORS

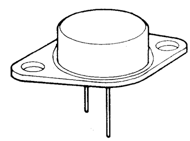
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS

- 150 W at 25°C Case Temperature
- 6-A Rated Continuous Collector Current
- Min f_T of 1 MHz at 20 V, 0.5 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

	2N5758	2N5759	2N5760
*Collector-Base Voltage	100 V	120 V	140 V
*Collector-Emitter Voltage (See Note 1)	100 V	120 V	140 V
*Emitter-Base Voltage	7 V	7 V	7 V
*Continuous Collector Current	← 6 A →		
*Peak Collector Current (See Note 2)	← 10 A →		
*Continuous Base Current	← 4 A →		
*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 →		
*Operating Collector Junction Temperature Range	−65°C to 200°C		
*Storage Temperature Range	−65°C to 200°C		
*Terminal Temperature 1,6 mm from Case for 10 Seconds.	← 235°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 ≤ 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.

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

PARAMETER		TEST CONDITIONS			2N5758 MIN	2N5758 MAX	2N5759 MIN	2N5759 MAX	2N5760 MIN	2N5760 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 200 mA,	I_B = 0,	See Note 5	100		120		140		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 100 V,	I_E = 0			1					mA
		V_{CB} = 120 V,	I_E = 0					1			
		V_{CB} = 140 V,	I_E = 0							1	
I_{CEO}	Collector Cutoff Current	V_{CE} = 50 V,	I_B = 0			1					mA
		V_{CE} = 60 V,	I_B = 0					1			
		V_{CE} = 70 V,	I_B = 0							1	
I_{CEV}	Collector Cutoff Current	V_{CE} = 100 V,	V_{BE} = −1.5 V			1					mA
		V_{CE} = 120 V,	V_{BE} = −1.5 V					1			
		V_{CE} = 140 V,	V_{BE} = −1.5 V							1	
		V_{CE} = 100 V,	V_{BE} = −1.5 V, T_C = 150°C			5					
		V_{CE} = 120 V,	V_{BE} = −1.5 V, T_C = 150°C					5			
		V_{CE} = 140 V,	V_{BE} = −1.5 V, T_C = 150°C							5	
I_{EBO}	Emitter Cutoff Current	V_{EB} = 7 V,	I_C = 0			1		1		1	mA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 2 V,	I_C = 3 A	See Notes 5 and 6	25	100	20	80	15	60	
		V_{CE} = 2 V,	I_C = 6 A		5		5		5		
V_{BE}	Base-Emitter Voltage	V_{CE} = 2 V,	I_C = 3 A,	See Notes 5 and 6		1.5		1.5		1.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.3 A,	I_C = 3 A	See Notes 5 and 6		1		1		1	V
		I_B = 1.2 A,	I_C = 6 A			2		2		2	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 2 A,	f = 1 kHz	15		15		15		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 20 V,	I_C = 0.5 A,	f = 0.5 MHz	2		2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V,	I_E = 0,	f = 0.1 MHz		300		300		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 from device body.

*JEDEC registered data

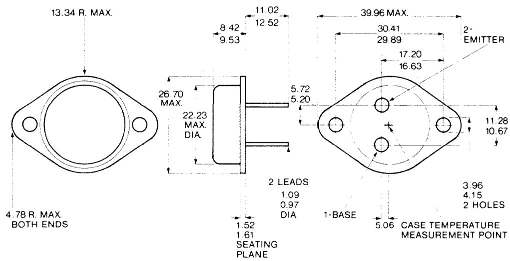
TYPES 2N5867, 2N5868
P-N-P SILICON POWER TRANSISTORS

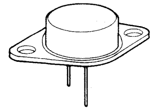
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5869, 2N5870

- **87.5 Watts at 25°C Case Temperature**
- **5-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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

	2N5867	2N5868
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	−5 A† / −3 A*	
Peak Collector Current (See Note 2)	−7 A	
Continuous Base Current	−1 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)	87.5 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 1,6 mm	250°C*	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.5 mW/°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 $\approx I_C^2L/2$.

TYPES 2N5867, 2N5868
P-N-P SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS			2N5867 MIN	2N5867 MAX	2N5868 MIN	2N5868 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA,	$I_B = 0$,	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			−0.1			mA
		$V_{CE} = -80$ V,	$V_{BE} = 1.5$ V					−0.1	
		$V_{CE} = -60$ 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,	$I_E = 0$			−0.1			mA
		$V_{CB} = -80$ V,	$I_E = 0$					−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,	$I_C = -300$ mA	See Notes 6 and 7	35		35		
		$V_{CE} = -4$ V,	$I_C = -1.5$ A		20	100	20	100	
		$V_{CE} = -4$ V,	$I_C = -3$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -200$ mA,	$I_C = -2$ A	See Notes 6 and 7		−1.6		−1.6	V
		$V_{CE} = -4$ V,	$I_C = -3$ A,			−2		−2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -200$ mA,	$I_C = -2$ A	See Notes 6 and 7		−1		−1	V
		$I_B = -0.6$ A,	$I_C = -3$ A			−2		−2	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -0.25$ 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	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

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	$I_C = -1.5$ A, $I_{B(1)} = -0.15$ A, $I_{B(2)} = 0.15$ A, $V_{BE(off)} = 5$ V, $R_L = 20\ \Omega$, 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 JEDEC publication *Suggested Standards on Power Transistors.* $V_{BB1} = 25$ V, $V_{BB2} = 5$ V, $V_{CC} = 30$ V, $V_{on} = -23$ V, $R_{BB1} = 73\ \Omega$, $R_{BB2} = 39\ \Omega$.

MAXIMUM SAFE OPERATING AREA

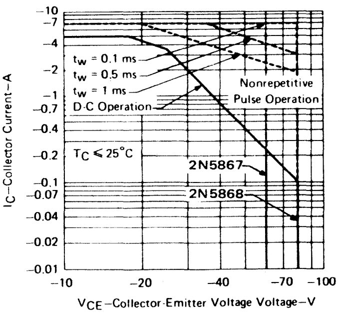


FIGURE 1

THERMAL CHARACTERISTICS

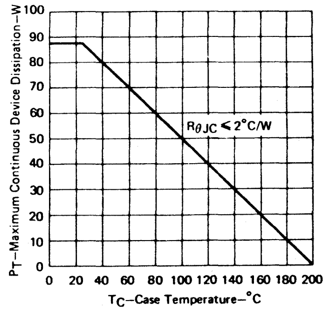


FIGURE 2

TEXAS INSTRUMENTS

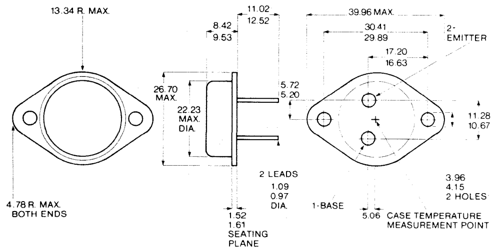
TYPES 2N5869, 2N5870
N-P-N SILICON POWER TRANSISTORS

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5867, 2N5868

- 87.5 Watts at 25°C Case Temperature
- 5-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 0.25 A
- 62.5-mJ Reverse Energy Rating

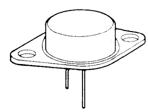
*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



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

	2N5869	2N5870
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	← {5 A† / 3 A*} →	
Peak Collector Current (See Note 2)	← 17 A →	
Continuous Base Current	← 1 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)	← 87.5 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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.50 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 ~ $I_C{}^2L/2$.

*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.

TYPES 2N5869, 2N5870
N-P-N SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS	2N5869 MIN	2N5869 MAX	2N5870 MIN	2N5870 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 100 mA, 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	mA
I_{CEV}	Collector Cutoff Current	V_{CE} = 60 V, V_{BE} = −1.5 V		0.1			mA
		V_{CE} = 80 V, V_{BE} = −1.5 V				0.1	mA
		V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C		2			mA
		V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C				2	mA
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0		0.1			mA
		V_{CB} = 80 V, I_E = 0				0.1	mA
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 = 300mA, See Notes 6 and 7	35		35		
		V_{CE} = 4 V, I_C = 1.5 A, See Notes 6 and 7	20	100	20	100	
		V_{CE} = 4 V, I_C = 3 A, See Notes 6 and 7	5		5		
V_{BE}	Base-Emitter Voltage	I_B = 200 mA, I_C = 2 A, See Notes 6 and 7		1.6		1.6	V
		V_{CE} = 4 V, I_C = 3 A, See Notes 6 and 7		2		2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 200mA, I_C = 2 A, See Notes 6 and 7		1		1	V
		I_B = 0.6 A, I_C = 3 A, See Notes 6 and 7		2		2	V
h_{fe}	Small Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 0.25A, 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		150		150	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 = 1.5 A, $I_{B(1)}$ = 0.15 A, $I_{B(2)}$ = −0.15 A, $V_{BE(off)}$ = −5 V, R_L = 20 Ω, See Note 8		0.7	μs
t_s	Storage Time			[illegible]	μs
t_f	Fall Time			0.8	μs

†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 JEDEC publication *Standards on Power Transistors.* V_{BB1} = 25 V, V_{BB2} = 5 V, V_{CC} = 30 V, V_{on} = 23 V, R_{BB1} = 73 Ω, R_{BB2} = 39 Ω.

MAXIMUM SAFE OPERATING AREA

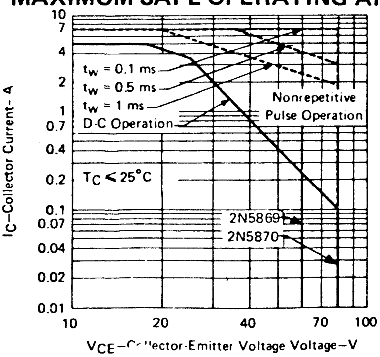


FIGURE 1

THERMAL CHARACTERISTICS

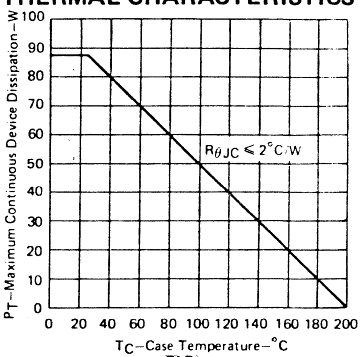


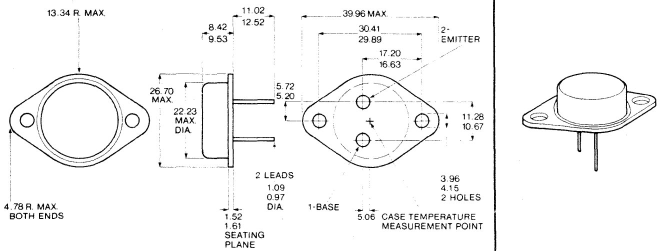
FIGURE 2

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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
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 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			2N5871 MIN	2N5871 MAX	2N5872 MIN	2N5872 MAX	UNIT
$V_{(BR)CEO}$	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. $t_w = 300\ \mu s$, 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	$I_C = -2.5$ 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 JEDEC publication *Suggested Standards on Power Transistors.* $V_{BB1} = 24$ V, $V_{BB2} = 4.6$ V, $V_{CC} = 30$ V, $V_{on} = 22.5$ V, $R_{BB1} = 43\ \Omega$, $R_{BB2} = 22\ \Omega$.

MAXIMUM SAFE OPERATING AREA

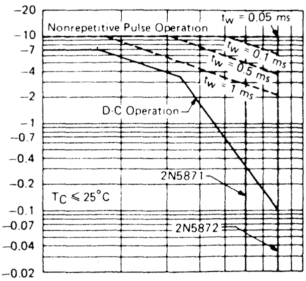


FIGURE 1

THERMAL CHARACTERISTICS

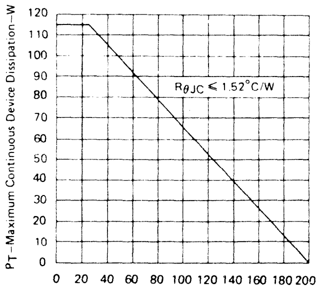


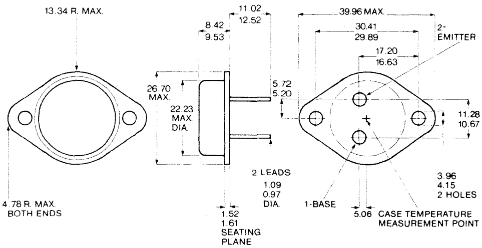
FIGURE 2

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

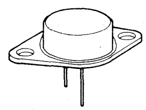
*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
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 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			2N5873 MIN	2N5873 MAX	2N5874 MIN	2N5874 MAX	UNIT
$V_{(BR)CEO}$	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		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.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
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 Ω, 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 JEDEC publication *Suggested Standards on Power Transistors* V_{BB1} = 24 V, V_{BB2} = 4.6 V, V_{CC} = 30 V, V_{on} = 22.5 V, R_{BB1} = 43 Ω, R_{BB2} = 22 Ω.

MAXIMUM SAFE OPERATING AREA

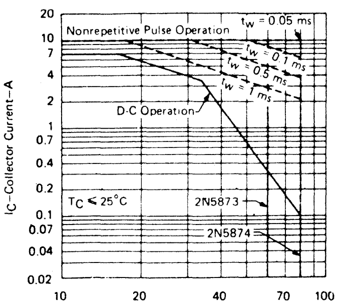


FIGURE 1

THERMAL CHARACTERISTICS

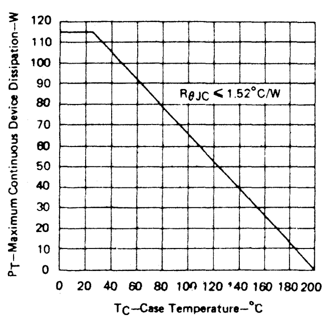


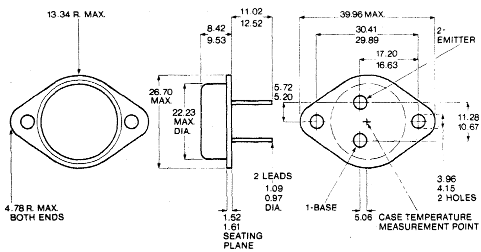
FIGURE 2

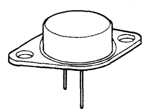
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5877, 2N5878

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES
ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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.

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

PARAMETER		TEST CONDITIONS			2N5875 MIN	2N5875 MAX	2N5876 MIN	2N5876 MAX	UNIT
$V_{(BR)CEO}$	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		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, $I_{B(1)} = -0.4$ A, $I_{B(2)} = 0.4$ A, $V_{BE(off)} = 5$ V, $R_L = 7.5\ \Omega$,		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 OPERATION AREAS

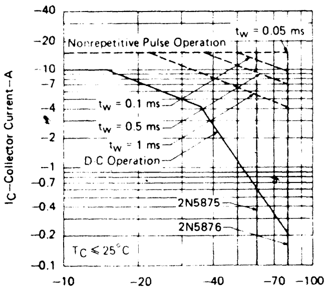


FIGURE 1

THERMAL CHARACTERISTICS

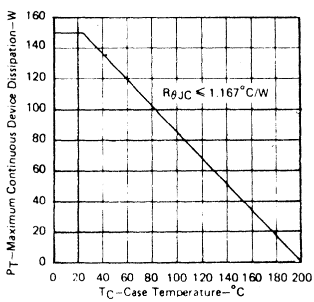


FIGURE 2

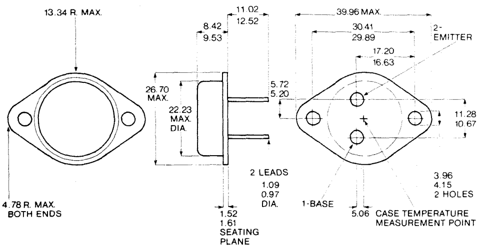
TYPES 2N5877, 2N5878 N-P-N SILICON POWER TRANSISTORS

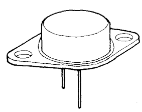
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5875, 2N5876

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
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.

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

PARAMETER		TEST CONDITIONS			2N5877 MIN	2N5877 MAX	2N5878 MIN	2N5878 MAX	UNIT
$V_{(BR)CEO}$	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

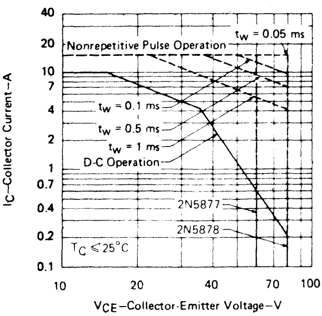


FIGURE 1

THERMAL CHARACTERISTICS

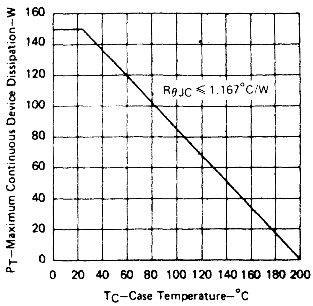


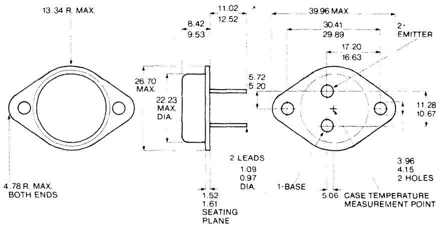
FIGURE 2

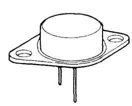
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5881, 2N5882

- 160 Watts at 25°C Case Temperature
- 15-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 1 A
- 90 mJ-Reverse Energy Rating

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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

	2N5879	2N5880
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	←{−15 A†, −12 A*}→	
Peak Collector Current (See Note 2)	← −20 A →	
Continuous Base Current	← −4 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)	← 160 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 1.6 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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.915 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, $I_{CM} = -3$ A. 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.
†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			2N5879 MIN	2N5879 MAX	2N5880 MIN	2N5880 MAX	UNIT
$V_{(BR)CEO}$	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,	$I_C = -2$ A	See Notes 6 and 7	35		35		
		$V_{CE} = -4$ V,	$I_C = -6$ A		20	100	20	100	
		$V_{CE} = -4$ V,	$I_C = -12$ A		5		5		
V_{BE}	Base-Emitter Voltage	$I_B = -0.7$ A,	$I_C = -7$ A	See Notes 6 and 7		−1.6		−1.6	V
		$V_{CE} = -4$ V,	$I_C = -12$ A			−2.5		−2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.7$ A,	$I_C = -7$ A	See Notes 6 and 7		−1		−1	V
		$I_B = -2.4$ A,	$I_C = -12$ A			−4		−4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V,	$I_C = -2$ 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		600		600	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

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	$I_C = -6$ A, $I_{B(1)} = -0.6$ A, $I_{B(2)} = 0.6$ A, $V_{BE(off)} = 5$ V, $R_L = 5\ \Omega$,		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

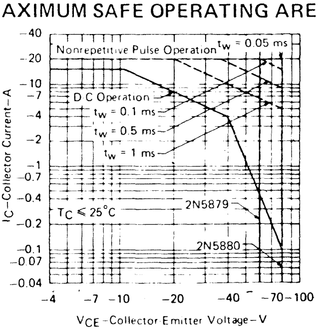


FIGURE 1

THERMAL CHARACTERISTICS

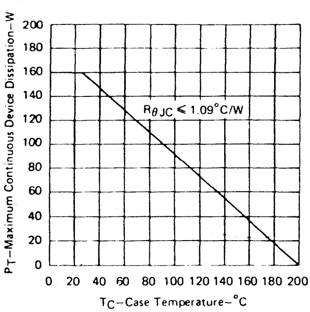


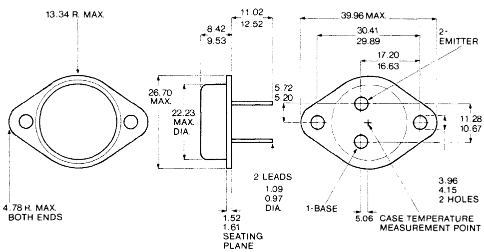
FIGURE 2

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5879, 2N5880

- 160 Watts at 25°C Case Temperature
- 15-A Rated Continuous Collector Current
- Min f_T of 4 MHz at 10 V, 1 A
- 90-mJ Reverse Energy Rating

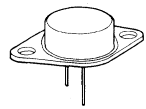
*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE



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

	2N5881	2N5882
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	← 15 A† / 12 A* →	
Peak Collector Current (See Note 2)	← 20 A →	
Continuous Base Current	← 4 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)	← 160 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 1.6 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 $t_w \leq 1$ ms, duty cycle $\leq 10\%$.
3. Derate linearly to 200°C case temperature at the rate of 0.915 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, $I_{CM} = 3$ A. 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.
†Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

TYPES 2N5881, 2N5882
N-P-N SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS	2N5881 MIN	2N5881 MAX	2N5882 MIN	2N5882 MAX	UNIT
$V_{(BR)CEO}$	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 = 2 A, See Notes 6 and 7	35		35		
		V_{CE} = 4 V, I_C = 6 A	20	100	20	100	
		V_{CE} = 4 V, I_C = 12 A	5		5		
V_{BE}	Base-Emitter Voltage	I_B = 0.7 A, I_C = 7 A, See Notes 6 and 7		1.6		1.6	V
		V_{CE} = 4 V, I_C = 12 A		2.5		2.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.7 A, I_C = 7 A, See Notes 6 and 7		1		1	V
		I_B = 2.4 A, I_C = 12 A		4		4	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 4 V, I_C = 2 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		400		400	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.

*switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_r	Rise Time	I_C = 6 A, $I_{B(1)}$ = 0.6 A, $I_{B(2)}$ = −0.6 A, $V_{BE(off)}$ = −5 V, R_L = 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

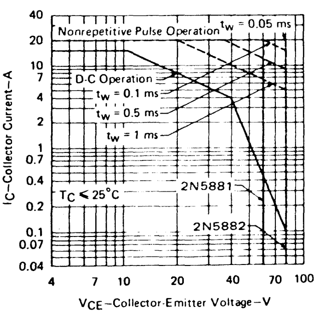


FIGURE 1

THERMAL CHARACTERISTICS

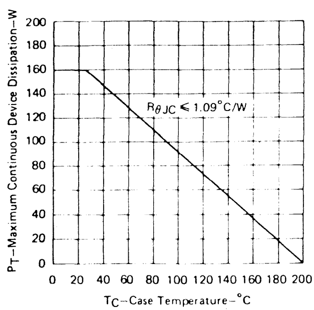


FIGURE 2

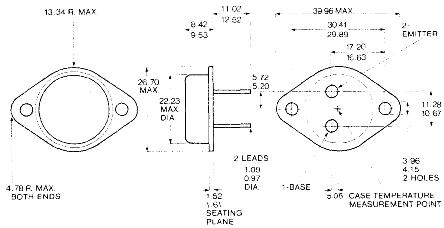
TYPES 2N5883, 2N5884 P-N-P SILICON POWER TRANSISTORS

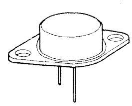
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N5885, 2N5886

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $t_w \leq 1$ ms, duty cycle $\leq$ 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 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 $\approx I_C^2L/2$.

*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	2N5883 MIN	2N5883 MAX	2N5884 MIN	2N5884 MAX	UNIT
$V_{(BR)CEO}$	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, See Notes 6 and 7	20	100	20	100	
		$V_{CE} = -4$ V, $I_C = -20$ A, See Notes 6 and 7	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, See Notes 6 and 7		−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, See Notes 6 and 7		−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. $t_w = 300\ \mu s$, 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 JEDEC publication *Suggested Standards on Power Transistors*.‡ $V_{BB1} = 25$ V, $V_{BB2} = 4$ V, $V_{CC} = 30$ V, $V_{on} = -23$ V, $R_{BB1} = 11\ \Omega$, $R_{BB2} = 5\ \Omega$.

MAXIMUM SAFE OPERATING AREA

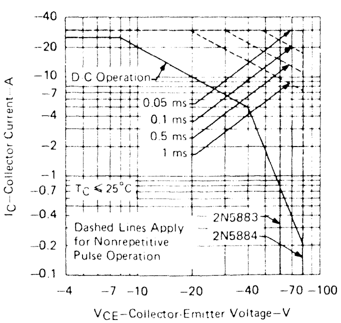


FIGURE 1

THERMAL CHARACTERISTICS

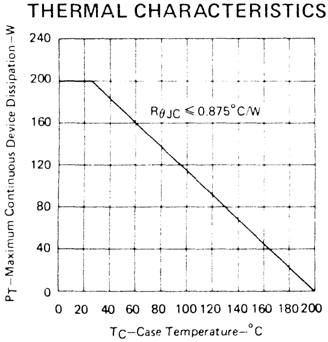


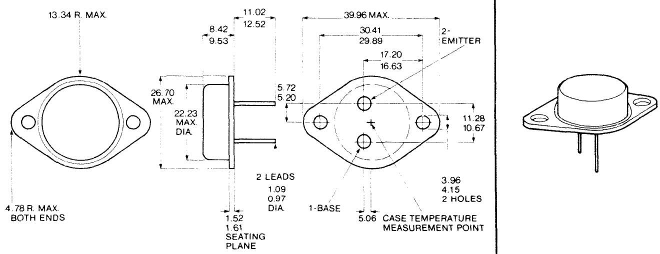
FIGURE 2

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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

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 $t_w \leq 1$ ms, duty cycle $\leq$ 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 JEDEC publication *Suggested Standards on Power Transistors.* L = 20 mH, R_{BB1} = 20 Ω, R_{BB2} = 100 Ω, V_{BB1} = 10 V, V_{BB2} = 0 V, R_L = 0.1 Ω, V_{CC} = 10 V, I_{CM} = 3 A. Energy ≈ $I_C^2L/2$.

*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.

TYPES 2N5885, 2N5886
N-P-N SILICON POWER TRANSISTORS

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

PARAMETER		TEST CONDITIONS	2N5885 MIN	2N5885 MAX	2N5886 MIN	2N5886 MAX	UNIT
$V_{(BR)CEO}$	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 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 Ω, 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 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 Ω, R_{BB2} = 5 Ω.

MAXIMUM SAFE OPERATING AREA

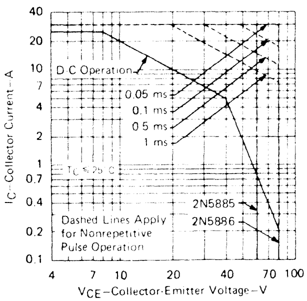


FIGURE 1

THERMAL CHARACTERISTICS

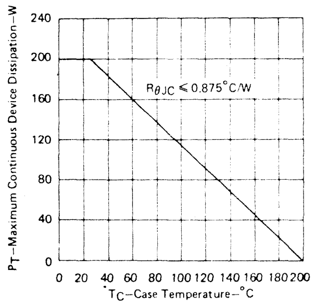


FIGURE 2

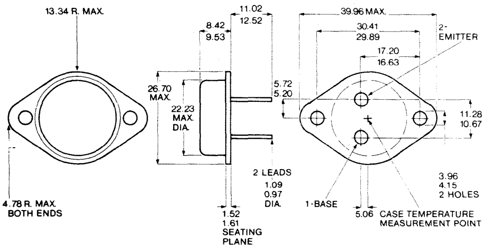
TEXAS INSTRUMENTS

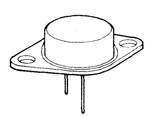
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N6329, 2N6330, 2N6331

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

*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 1.6 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 $\approx I_C{}^2L/2$.

*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	2N6326 MIN	2N6326 MAX	2N6327 MIN	2N6327 MAX	2N6328 MIN	2N6328 MAX	UNIT
$V_{(BR)CEO}$	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, See Notes 6 and 7	12		12		12		
		V_{CE} = 4 V, I_C = 30 A, See Notes 6 and 7	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, See Notes 6 and 7		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, See Notes 6 and 7		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.

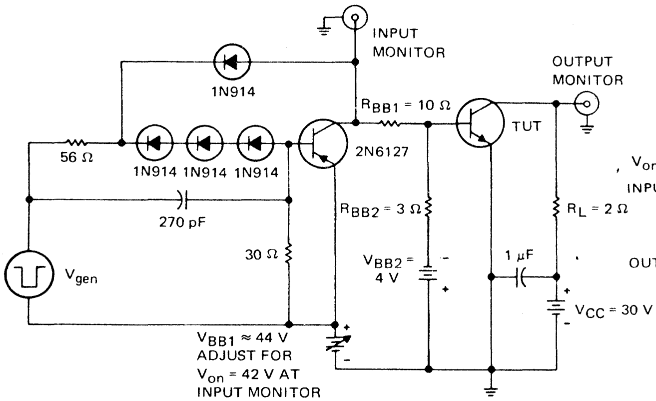
*JEDEC registered data

switching characteristics at 25°C case temperature

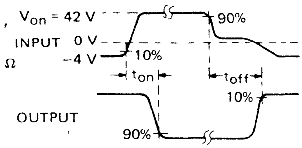
PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_{on}	Turn-On Time	I_C = 15 A,	$I_{B(1)}$ = 2 A,	$I_{B(2)}$ = −2 A,	0.6	μs
t_{off}	Turn-Off Time	$V_{BE(off)}$ = −4 V,	R_L = 2 Ω,	See Figure 1	0.9	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

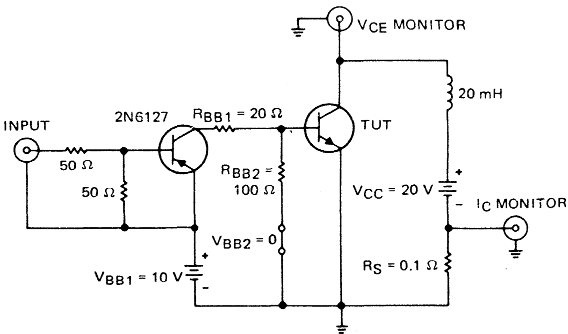


VOLTAGE WAVEFORMS

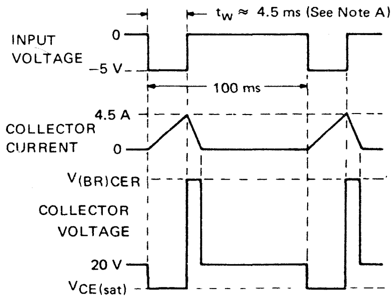
NOTES: A. V_{gen} is a −30-V pulse (from 0 V) into a 50-Ω termination.
B. The V_{gen} waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 Ω, t_w = 20 μs, duty cycle ≤ 2%.
C. Waveforms are monitored on an oscilloscope with the following 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} = 4.5 A.

FIGURE 2

MAXIMUM SAFE OPERATING AREAS

MAXIMUM COLLECTOR CURRENT
vs
COLLECTOR-EMITTER VOLTAGE

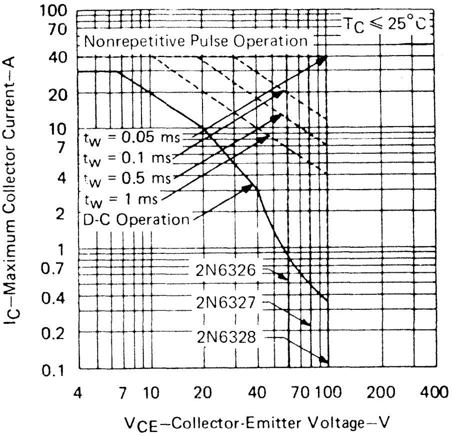


FIGURE 3

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

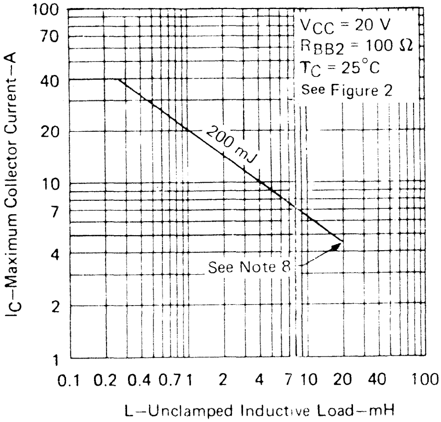


FIGURE 4

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

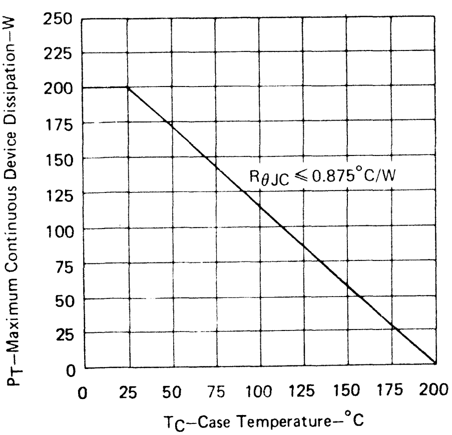


FIGURE 5

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

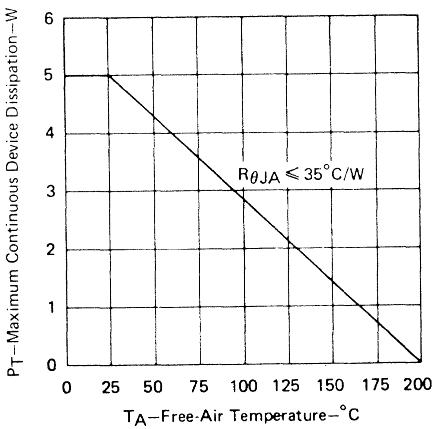


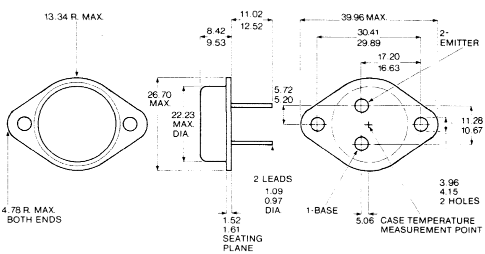
FIGURE 6

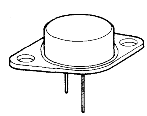
FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS
DESIGNED FOR COMPLEMENTARY USE WITH 2N6326, 2N6327, 2N6328

- 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

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

*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 1.6mm 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 $t_w \leq 1$ ms, duty cycle $\leq$ 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 Ω, V_{BB2} = 0 V, R_S = 0.1 Ω, V_{CC} = 20 V. Energy ≈ $I_C{}^2L/2$.

*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			2N6329 MIN	2N6329 MAX	2N6330 MIN	2N6330 MAX	2N6331 MIN	2N6331 MAX	UNIT
$V_{(BR)CEO}$	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				mA
		$V_{CE} = -50$ V,	$I_B = 0$						−1		mA
I_{CES}	Collector Cutoff Current	$V_{CE} = -60$ V,	$V_{BE} = 0$			−0.5					mA
		$V_{CE} = -80$ V,	$V_{BE} = 0$					−0.5			mA
		$V_{CE} = -100$ V,	$V_{BE} = 0$							−0.5	mA
		$V_{CE} = -30$ V,	$V_{BE} = 0$,	$T_C = 150°C$		−5					mA
		$V_{CE} = -40$ V,	$V_{BE} = 0$,	$T_C = 150°C$				−5			mA
		$V_{CE} = -50$ V,	$V_{BE} = 0$,	$T_C = 150°C$						−5	mA
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	See Notes 6 and 7	12		12		12		
		$V_{CE} = -4$ V,	$I_C = -30$ A	See Notes 6 and 7	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	See Notes 6 and 7		−4		−4		−4	V
$V_{CE(sat)}$	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	See Notes 6 and 7		−3		−3		−3	V
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. $t_w = 300\ \mu s$; 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.

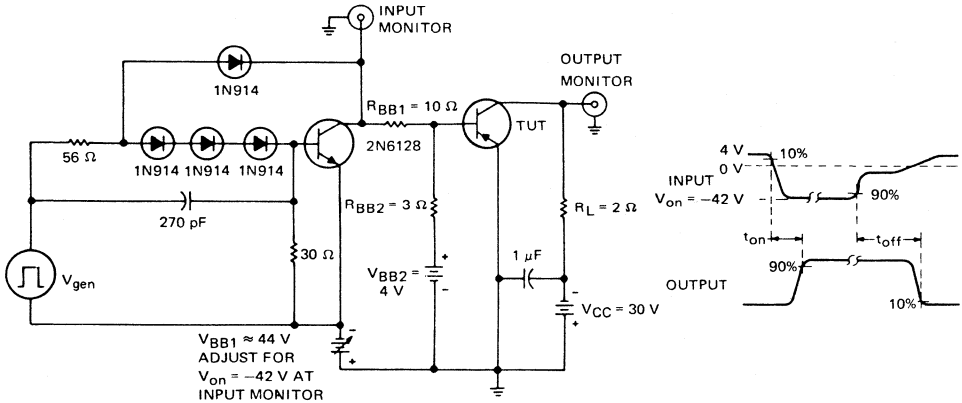
*JEDEC registered data

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,	$R_L = 2\ \Omega$,	See Figure 1	0.9	μs

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

PARAMETER MEASUREMENT INFORMATION



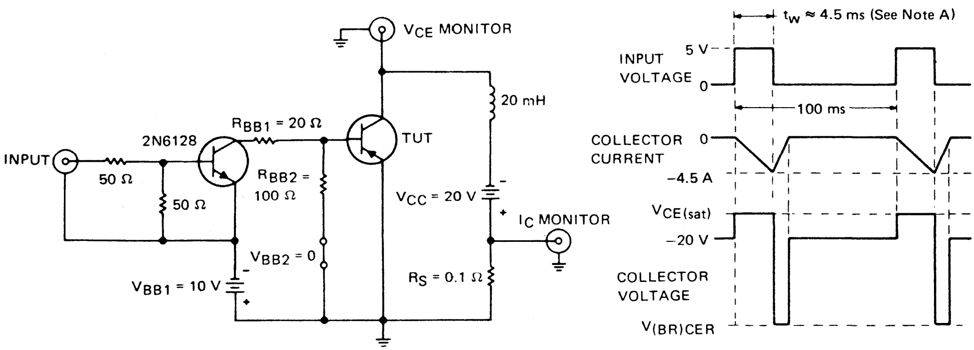
TEST CIRCUIT

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

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

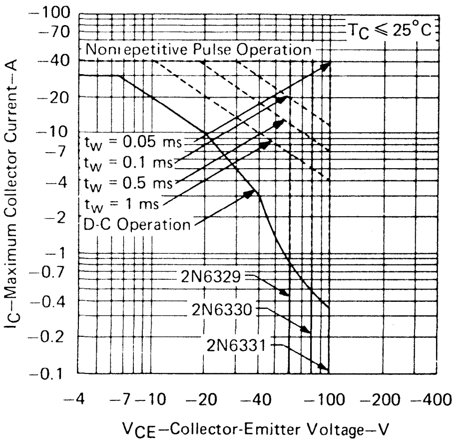


FIGURE 3

MAXIMUM COLLECTOR CURRENT
vs
UNCLAMPED INDUCTIVE LOAD

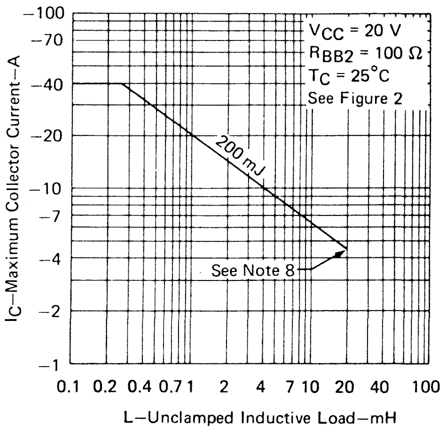


FIGURE 4

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

THERMAL INFORMATION

CASE TEMPERATURE
DISSIPATION DERATING CURVE

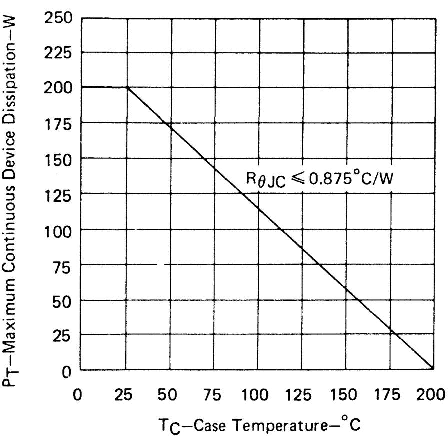


FIGURE 5

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

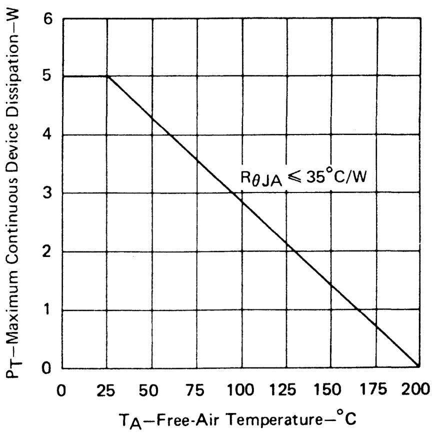


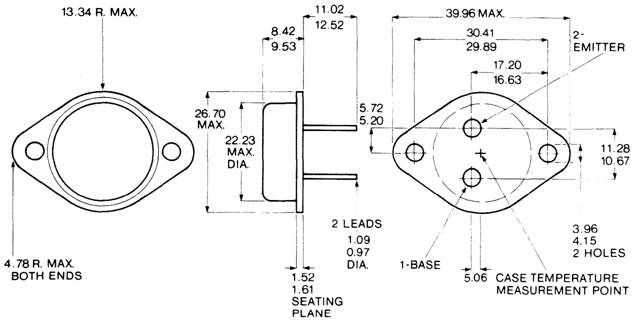
FIGURE 6

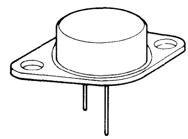
TYPES 2N6542, 2N6543
N-P-N SILICON POWER TRANSISTORS

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'turn-off' locus

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

		2N6542	2N6543
Collector-Emitter Voltage	$V_{CEO(SUS)}$	300V	400V
Collector-Emitter Voltage	$V_{CEX(SUS)}$	350V	450V
Collector-Emitter Voltage	V_{CEV}	650V	850V
Base-Emitter Voltage		8V	
Continuous Collector Current		5A	
Peak Collector Current (Note 1)		10A	
Continuous Base Current		5A	
Peak Base Current		10A	
Continuous Dissipation		100W	
Operating Junction Temperature		-65°C to +200°C	

Note 1: Pulse Test, Pulse Duration = 2ms

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{CEO(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C = 100 mA	2N6542	300		V
		I_B=0	2N6543	400		V
$V_{CEX(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C = 2.6A, 100°C	2N6542	350		V
		V_{CLAMP} = Rated V_{CEX}	2N6543	450		V
		I_C = 5.0A, 100°C	2N6542	200		V
		V_{CLAMP} = Rated V_{CEO} -100V	2N6543	300		V
I_{CEX}	Collector Cut-off Current	V_{CEX} = Rated Value, V_X = -1.5V			0.5	mA
		V_{CEX} = Rated Value, V_X = -1.5V 100°C			3.0	mA
I_{CER}	Collector Cut-off	V_{CE} = Rated V_{CEX}, R_{BE} = 50Ω 100°C			3.0	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 8V I_C = 0			1.0	mA
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 3.0A, I_B = 0.6A	See Notes 3 & 4		1.0	V
		I_C = 5.0A, I_B = 1.0A			5.0	V
		I_C = 3.0A, I_B = 0.6A, 100°C			2.0	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 3.0A, I_B = 0.6A	See Notes 3 & 4		1.4	V
		I_C = 3.0A, I_B = 0.6A, 100°C			1.4	V
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 2V, I_C = 1.5A	See Notes 3 & 4	12	60	–
		V_{CE} = 3V, I_C = 3.0A		7	35	–
f_T	Current Gain Bandwidth Product	I_C = 200mA, V_{CE} = 10V (dc) } F = 1 MHz, GAIN = UNITY		6	28	MHz
C_{OB}	Output Capacitance	V_{CB} = 10V F = 1 MHz, I_E = 0A		50	200	pF
$R_{\theta jc}$	Thermal Resistance Junction Case				1.75	°C/W

Note 2: Inductive Load Switching Test

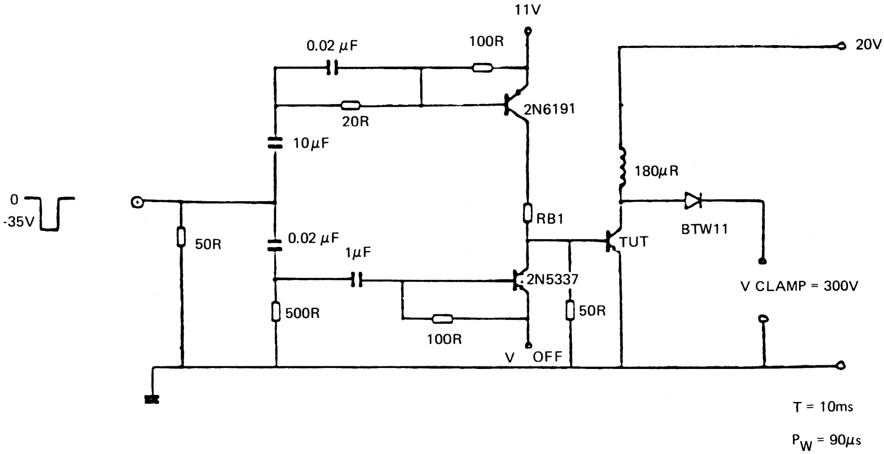
Note 3: These parameters must be measured using pulse techniques t_W = 300 μs duty cycle ≤ 2%

Note 4: 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 UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	TYP	MAX	UNIT
RESISTIVE LOAD (See Figs. 3 & 4)					
t_{on}	Turn on Time	I_C = 3A V_{CC} = 250V		0.75	μs
t_s	Storage Time	I_{BON} = 0.6A I_{BOFF} = 0.6A		4.0	μs
t_f	Fall Time			0.8	μs
INDUCTIVE LOAD [See Figs. 1,2]					
t_{sv}	Storage Time	I_C = 3A, V_{CLAMP} = Rated V_{CEX}		4.0	μs
t_c	Crossover Time	I_{BON} = 0.6A, $V_{BE(OFF)}$ = 5V	0.6		μs
t_{fI}	Fall Time	T Case = 100°C		0.8	μs
t_{sv}	Storage Time	I_C = 3A, V_{CLAMP} = Rated V_{CEX}	0.8		μs
t_c	Crossover Time	I_{BON} = 0.6A, $V_{BE(OFF)}$ = 5V	0.3		μs
t_{fi}	Fall Time	T Case = 25°C	0.2		μs

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 15$ ns, $R_{in} > 10 M\Omega$ and $C_{in} < 11.5$ pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

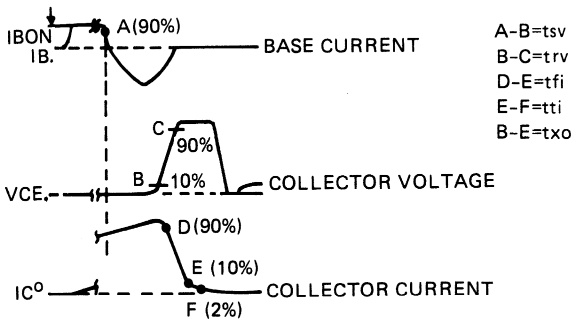
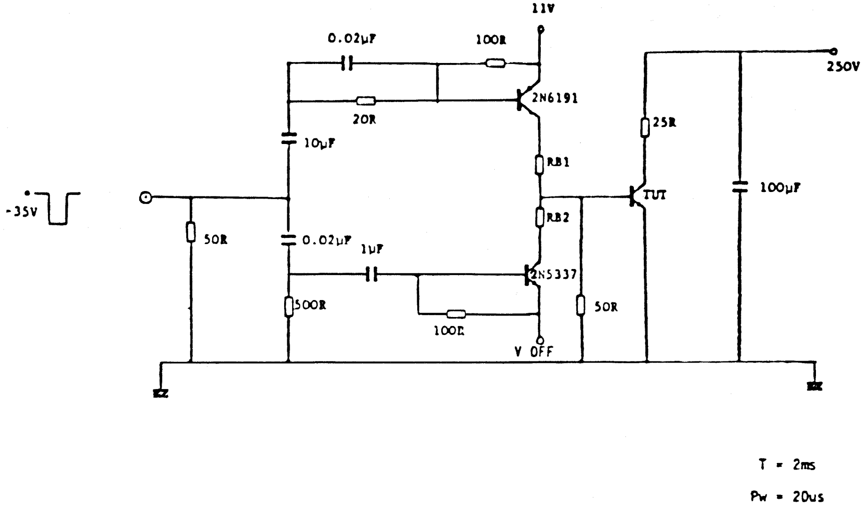


FIGURE 3 RESISTIVE SWITCHING CIRCUIT

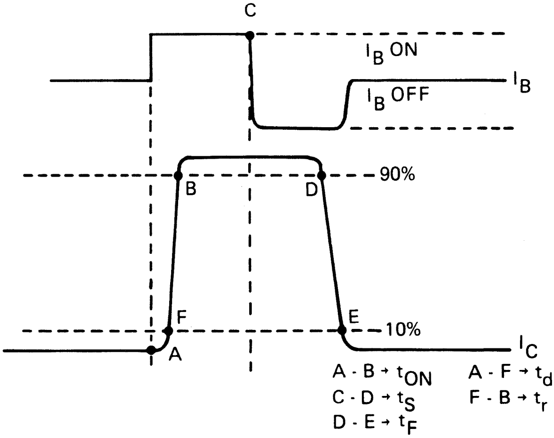


Notes A The V_{gen} Waveform is supplied by the following characteristics: tr < 15ns, tf < 15ns, Z out = 50Ω, tw=20µs duty cycle <2%

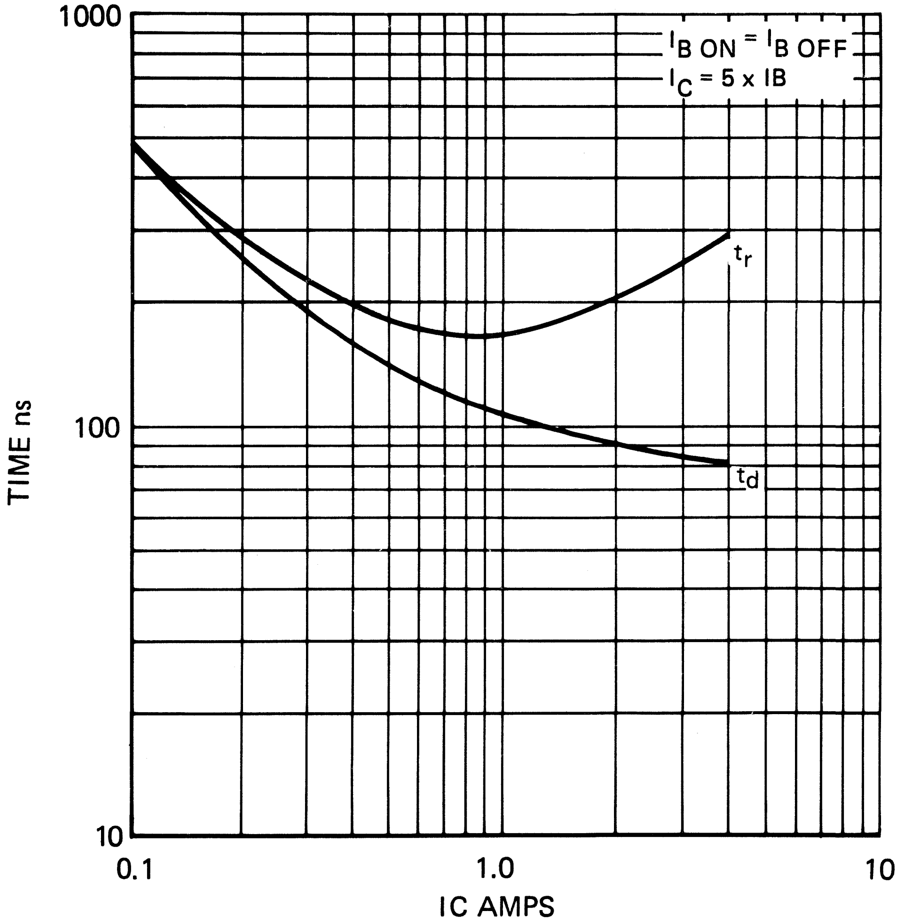
B Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15ns, R_{in} > 10MΩ, C_{in} <11.5pF.

C Resistors must be noninductive types.

FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS
FIGURE. 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS
FIGURE. 6 TYPICAL TURN-OFF TIME T CASE=25°C

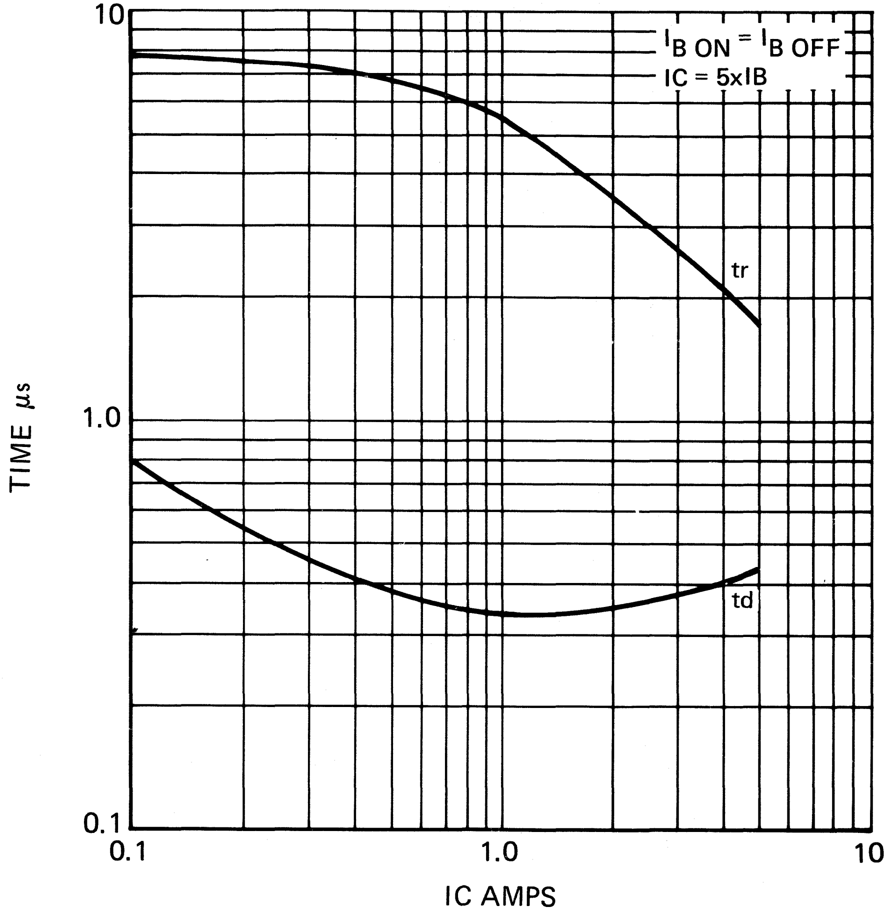


FIGURE. 7 TYPICAL COLLECTOR SATURATION REGION

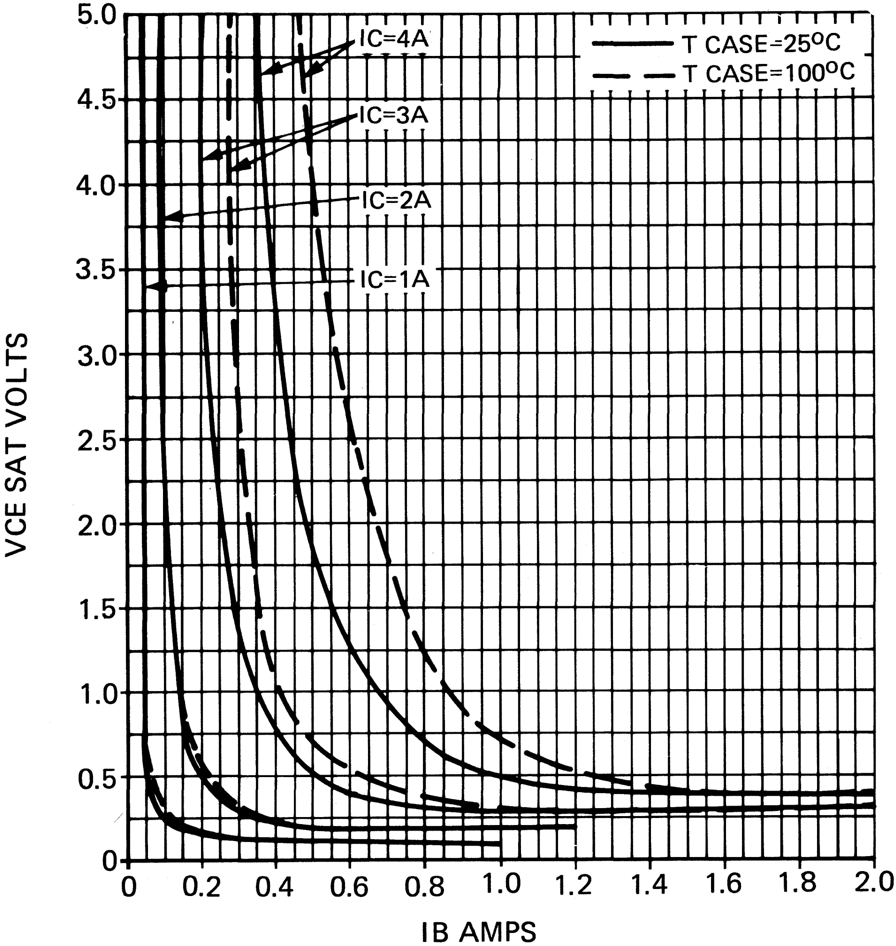


FIGURE.8 TYPICAL BASE SATURATION REGION

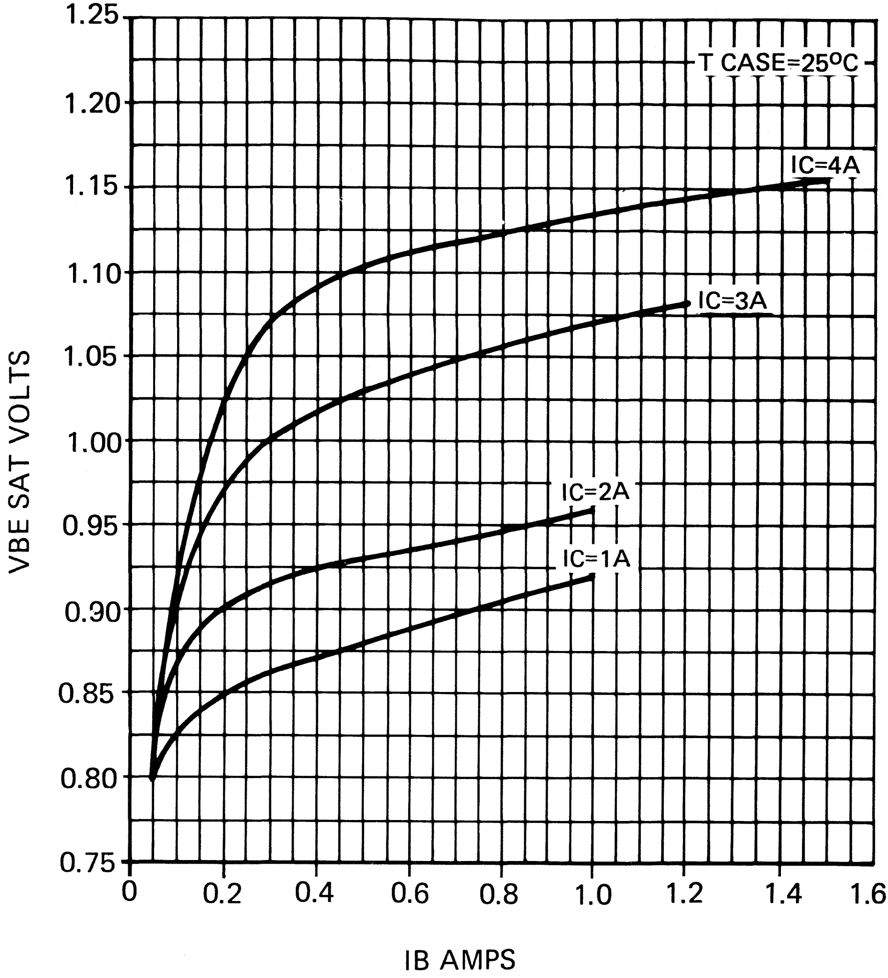


FIGURE. 9 THERMAL RESPONSE

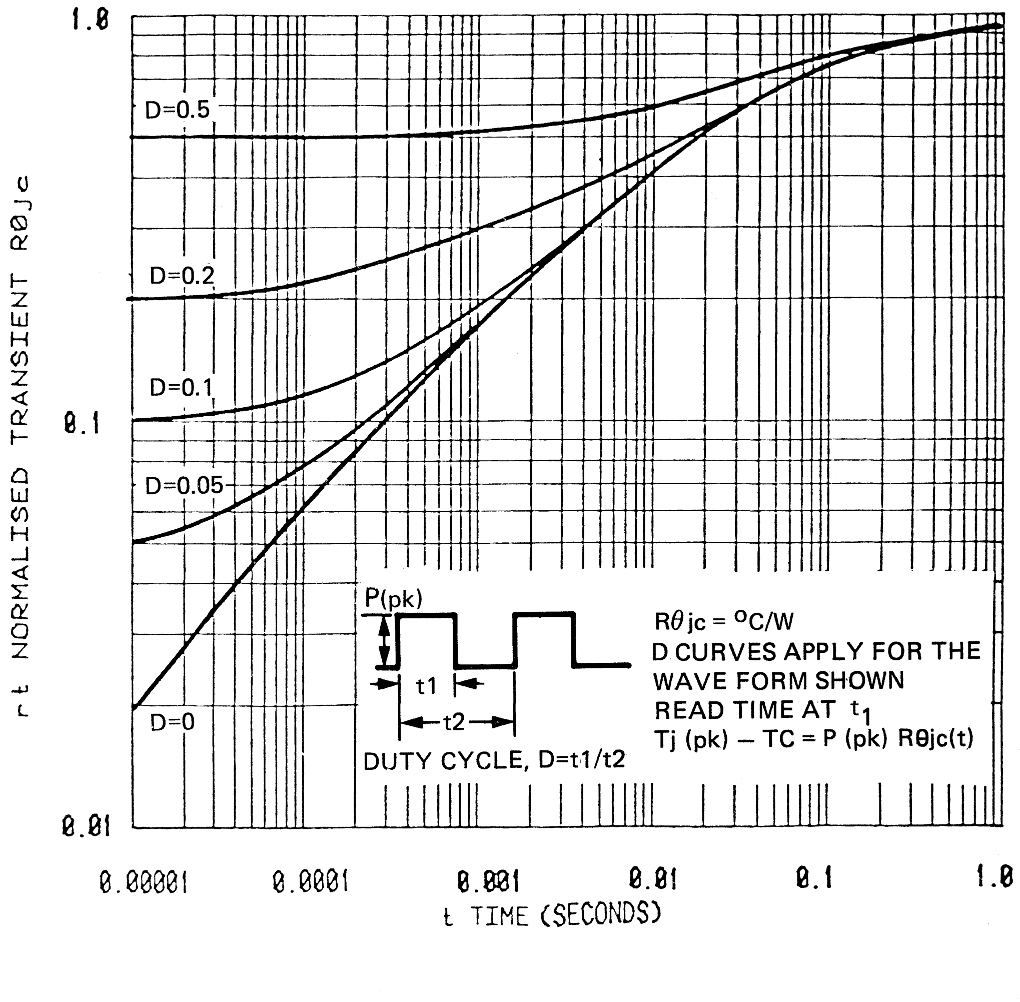


FIGURE.10 TYPICAL VARIATION OF DC CURRENT GAIN, VCE=5V

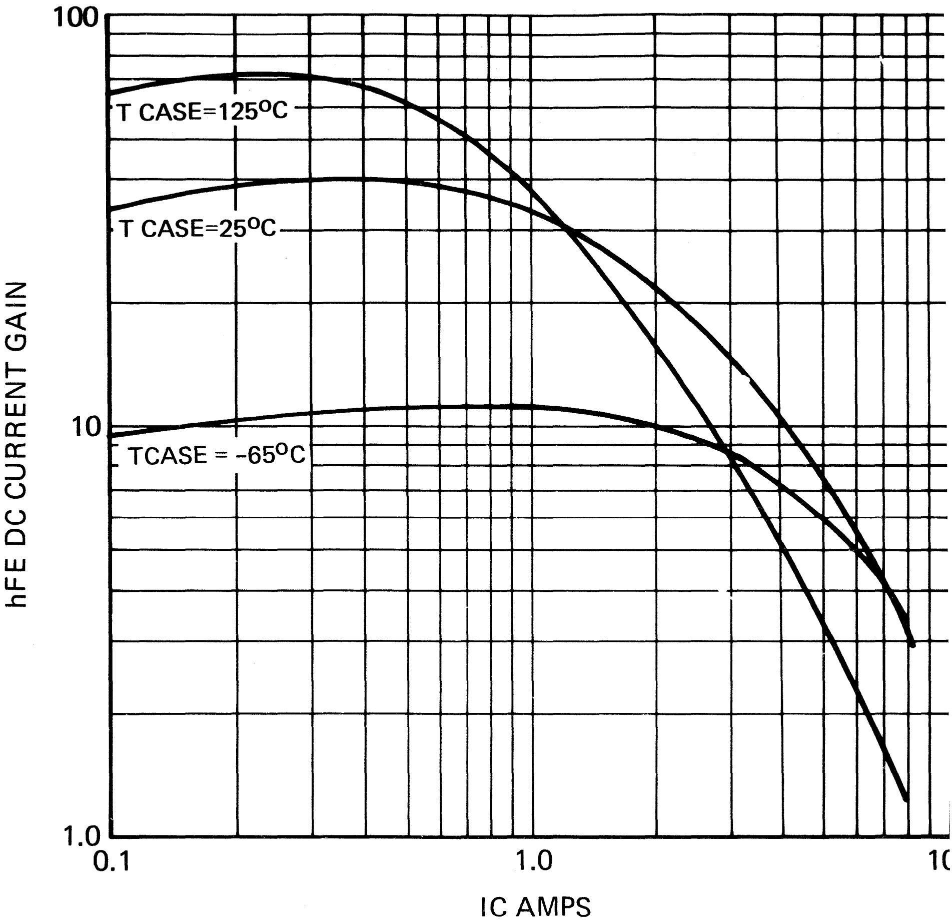


FIGURE 11 FORWARD BIASED SAFE AREA OF OPERATION DC AND PULSED T CASE=25°C

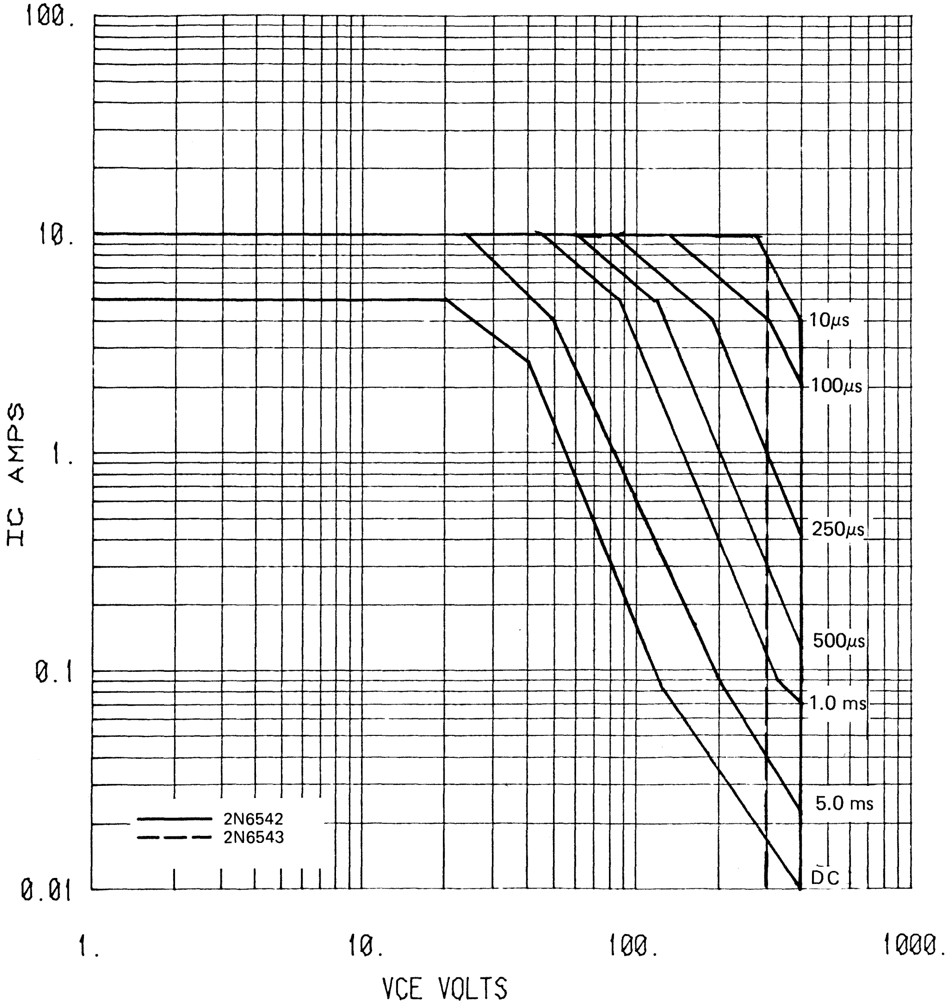


FIGURE 12 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

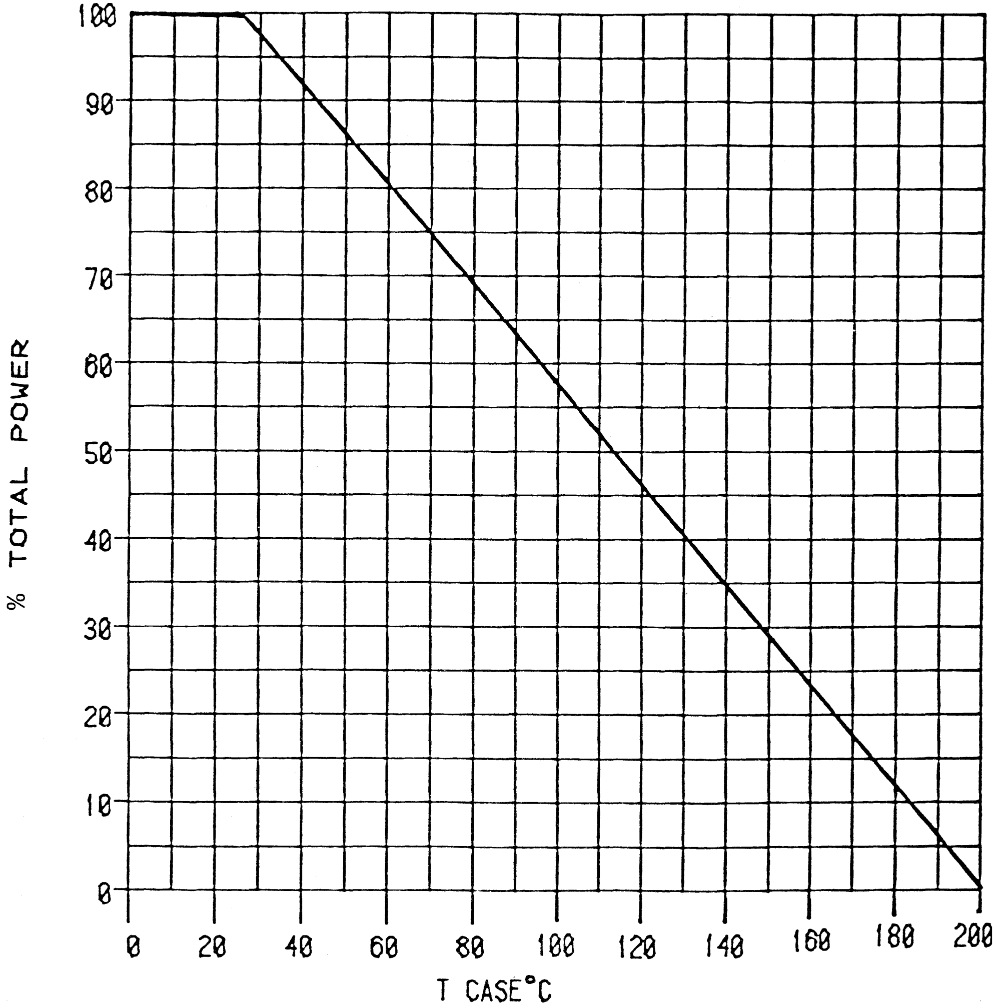


FIGURE 13 TRANSIENT "TURN-OFF" LIMIT IC Vs VCE

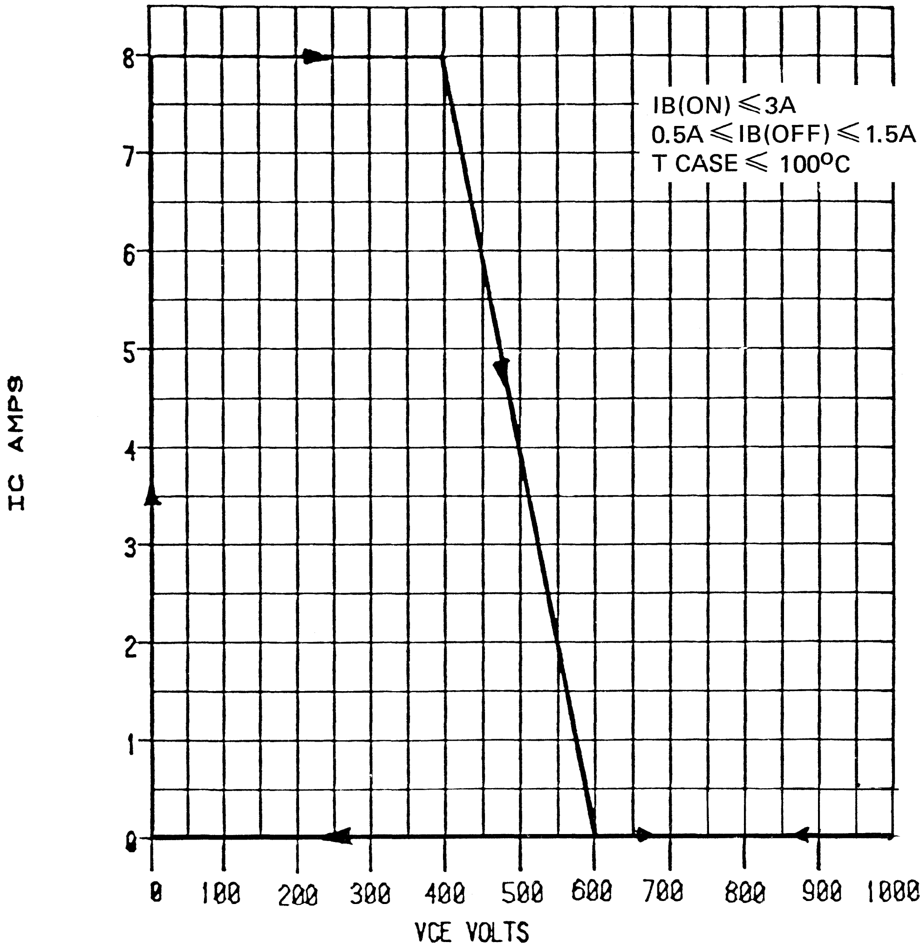
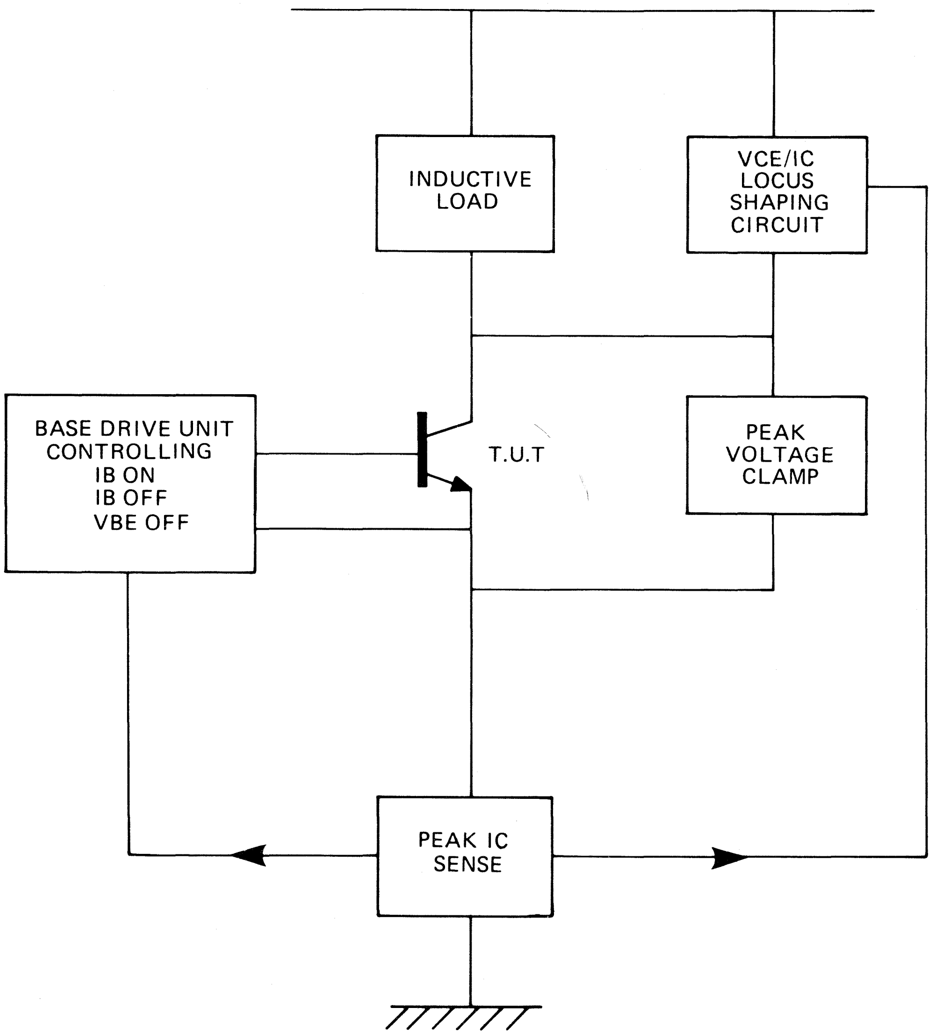


FIGURE 14 SWITCHING LOCUS TEST CIRCUIT



INDUCTIVE SWITCHING OF HIGH VOLTAGE TRANSISTORS

In inductive switching applications, such as switch mode power supplies and C.R.T. magnetic deflection, there are numerous operating and fault conditions which can cause failure of the transistor switch. In many cases, failure occurs during turn off of the transistor when high currents are still flowing and when the voltage across the device is rising rapidly.

The conventional method of defining device capability such as forward safe area and reverse energy/VCEX (sust) ratings do not relate directly to device operation during turn off in the majority of applications. Reverse energy is frequently thought to be the best guide since it can be related to the inductive energy in the circuit. This presupposes that energy is the primary cause of failure which is not always the case.

Detailed investigations have identified the key mechanisms responsible for device failure in inductive switching circuits and a new form of device specification and evaluation evolved which can be directly related to the application.

At the point of failure the device voltage collapses rapidly and latches on permanently. In the majority of cases the rapid voltage collapse results in an energy dump from the circuit which totally destroys the transistor. The voltage collapse is probably a regenerative switching action triggered by an instantaneous current density and electric field strength condition within the transistor.

However, reaching the trigger point is not simply determined by the instantaneous external terminal conditions but is also dependent on the history of device operation. In particular, the conduction period prior to turn off, collector current and bias conditions, and also the way in which the transistor is turned off can affect the current density across the chip during turn off.

The new form of reverse bias safe area definition takes into account all aspects of the operation. During characterisation the devices are subjected to many switching loci and the effects of prior conduction base bias and other influences evaluated for most practical cases. The result is a curve defining transistor capability which comprehends the total instantaneous power dissipation going from normal conduction through to turn off (See Figure 13). If the worse case VCE/IC Locus in a given circuit configuration lies within the curve then the transistor will not normally be destroyed by any single turn off transient.

Where severe switching transients are repetitive, care should be taken not to exceed the thermal rating of the transistor.

A block diagram of the test circuit for establishing the switching locus curve is in Figure 12.

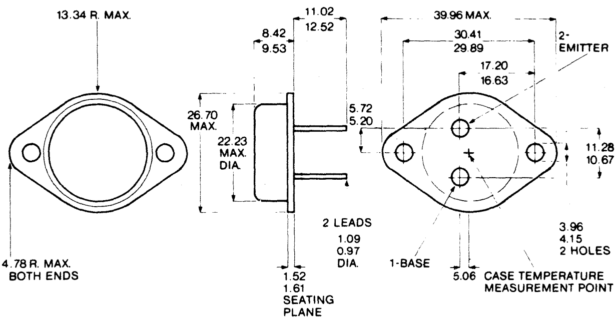
The transient VCE/IC Locus in an application can be found using a fast writing oscilloscope in an X–Y mode, ensuring that the delay matching of the X and Y channels is better than 20 ns. Beam blanking techniques can be used to enhance the turn off period.

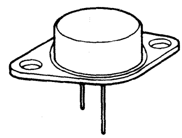
TYPES 2N6544, 2N6545
N-P-N SILICON POWER TRANSISTORS

- **Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching of inductive load is necessary**
- **This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness**
- **Guaranteed Transient 'turn-off' locus**

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

		2N6544	2N6545
Collector-Emitter Voltage	$V_{CEO(SUS)}$	300V	400V
Collector-Emitter Voltage	$V_{CEX(SUS)}$	350V	450V
Collector-Emitter Voltage	V_{CEV}	650V	850V
Base-Emitter Voltage		9V	
Continuous Collector Current		8A	
Peak Collector Current (Note 1)		16A	
Continuous Base Current		8A	
Peak Base Current		16A	
Continuous Dissipation		125W	
Operating Junction Temperature		−65°C to +200°C	

Note 1: Pulse Test, Pulse Duration = 2ms

TEXAS INSTRUMENTS

SWITCHING CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{CEO(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C = 100 mA 2N6544	300		V
		2N6545	400		V
$V_{CEX(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C = 4.5A, 100°C 2N6544	350		V
		V_{CLAMP} = Rated V_{CEX} 2N6545	450		V
		I_C = 8.0A, 100°C 2N6544	200		V
		V_{CLAMP} = Rated V_{CEO} -100 V 2N6545	300		V
I_{CEX}	Collector Cut-off Current	V_{CEX} = Rated Value, V_X = -1.5V		0.5	mA
		V_{CEX} = Rated Value, V_X = -1.5V 100°C		2.5	mA
I_{CER}	Collector Cut-off	V_{CE} = Rated V_{CEX}, R_{BE} = 50Ω 100°C		3.0	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 9V I_C = 0		1.0	mA
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 5.0A, I_B = 1.0A See Notes 3 & 4		1.5	V
		I_C = 8.0A, I_B = 2.0A		5.0	V
		I_C = 5.0A, I_B = 1.0A, 100°C		2.5	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 5.0A, I_B = 1.0A, See Notes 3 & 4		1.6	V
		I_C = 5.0A, I_B = 1.0A, 100°C		1.6	V
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 3V, I_C = 2.5A See Notes 3 & 4	12	60	–
		V_{CE} = 3V, I_C = 5.0A	7.0	35	–
f_T	Current Gain Bandwidth Product	I_C = 300 mA, V_{CE} = 10V (dc) } F = 1 MHz, GAIN = UNITY	6.0	28	MHz
C_{OB}	Output Capacitance	V_{CB} = 10V F = 1 MHz I_E = 0A	75	300	pF
$R_{\theta jc}$	Thermal Resistance Junction Case			1.4	°C/W

Note 2: Inductive loop switching measurement

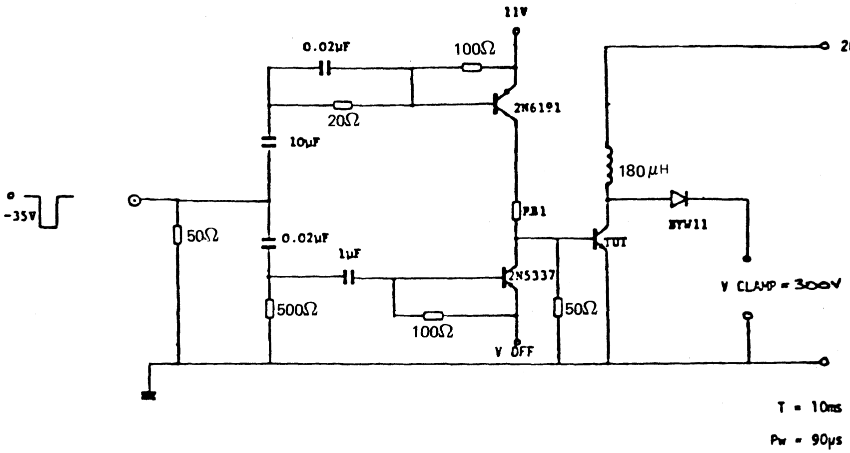
Note 3: These parameters must be measured using pulse techniques t_w = 300 μs duty cycle ⩽ 2%

Note 4: These parameters are measured with voltage sensing contacts. Separate from the current carrying contacts and located within 3.2 mm from the device body.

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	TYP	MAX	UNIT
RESISTIVE LOAD (See Fig. 3 & 4)					
t_d	Delay Time	$I_C = 5.0A$, $V_{CC} = 250V$ $I_{BON} = \|I_{BOFF}\| = 1.0A$		0.05	μs
t_r	Rise Time			1.0	μs
t_s	Storage Time			4.0	μs
t_f	Fall Time			1.0	μs
INDUCTIVE LOAD (See Fig. 1 & 2)					
t_s	Storage Time	$I_C = 5.0A$, V_{CLAMP} = Rated V_{CEX} $I_B = 1.0A$, $V_{BE(OFF)} = 5.0V$ $T_C = 100°C$		4.0	μs
t_f	Fall Time			0.9	μs
t_s	Storage Time	$I_C = 5.0A$, V_{CLAMP} = Rated V_{CEX} $I_B = 1.0A$, $V_{BE(OFF)} = 5.0V$ $T_C = 25°C$	1.2		μs
t_f	Fall Time		0.18		μs

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: tr < 15 ns, R_{in} > 10M Ω and C_{in} < 11.5 pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

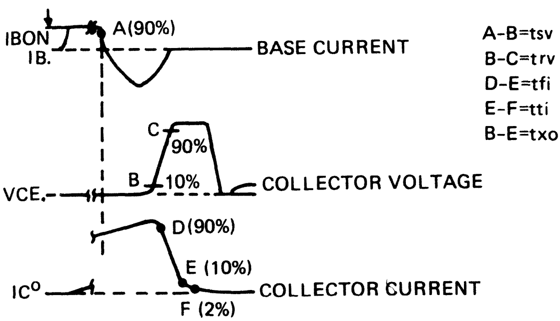
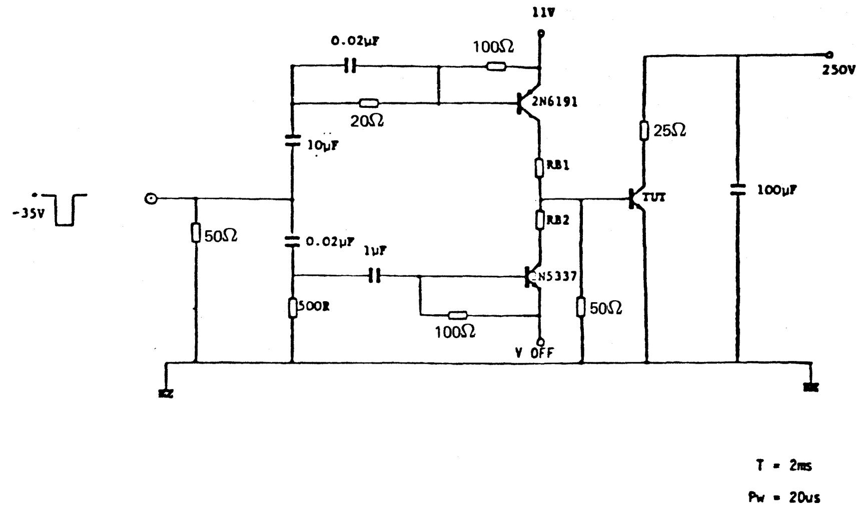


FIGURE 3 RESISTIVE SWITCHING CIRCUIT



Notes A The V_{gen} Waveform is supplied by the following characteristics:
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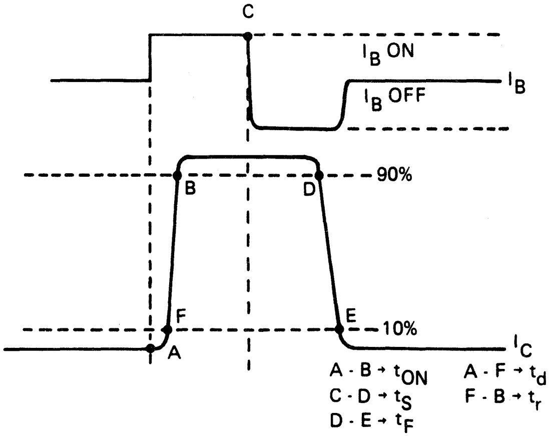
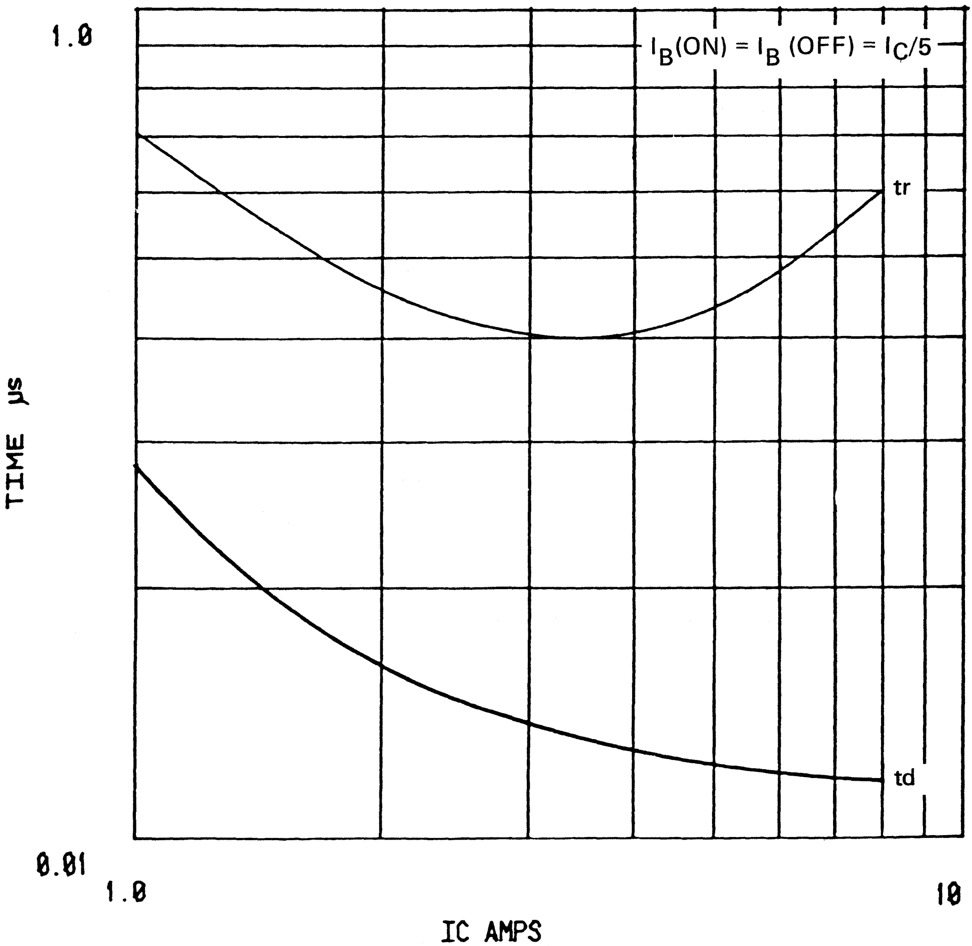


RESISTIVE SWITCHING PARAMETERS

FIGURE 5 TYPICAL TURN-ON TIME T CASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE 6 TYPICAL TURN-OFF TIME T CASE=25°C

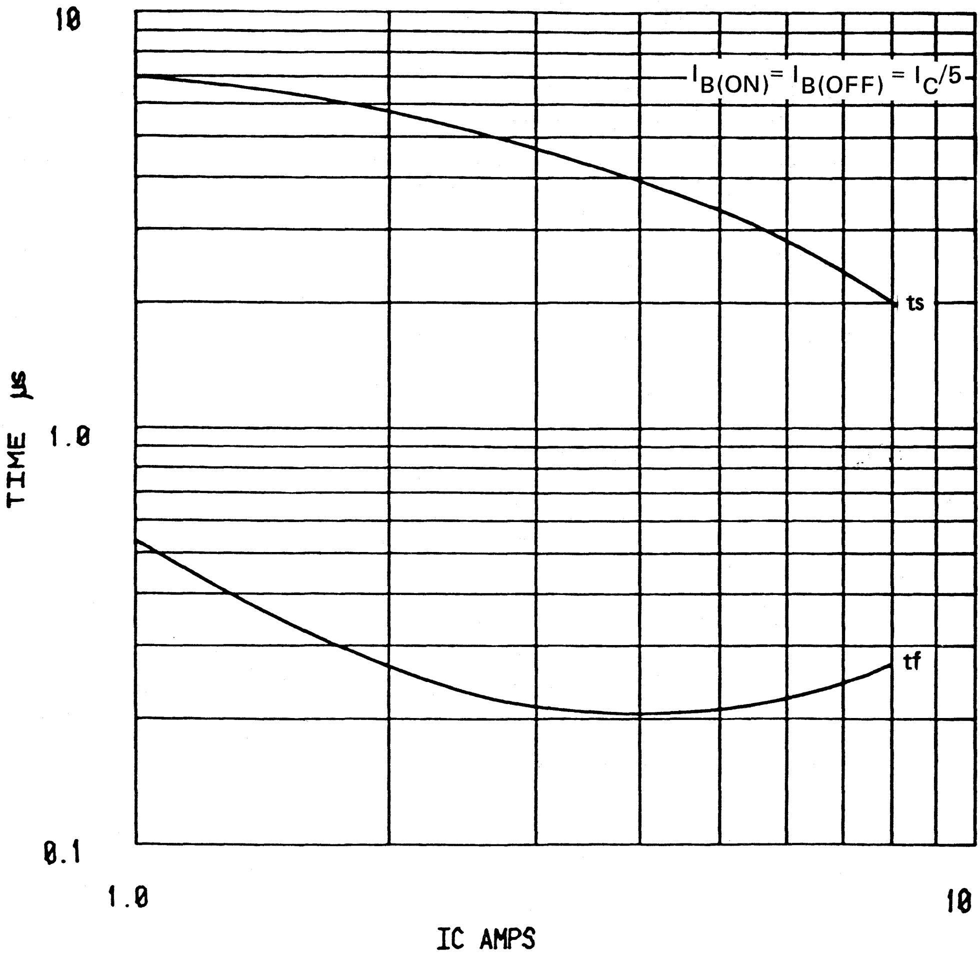


FIGURE 7 TYPICAL COLLECTOR SATURATION REGION

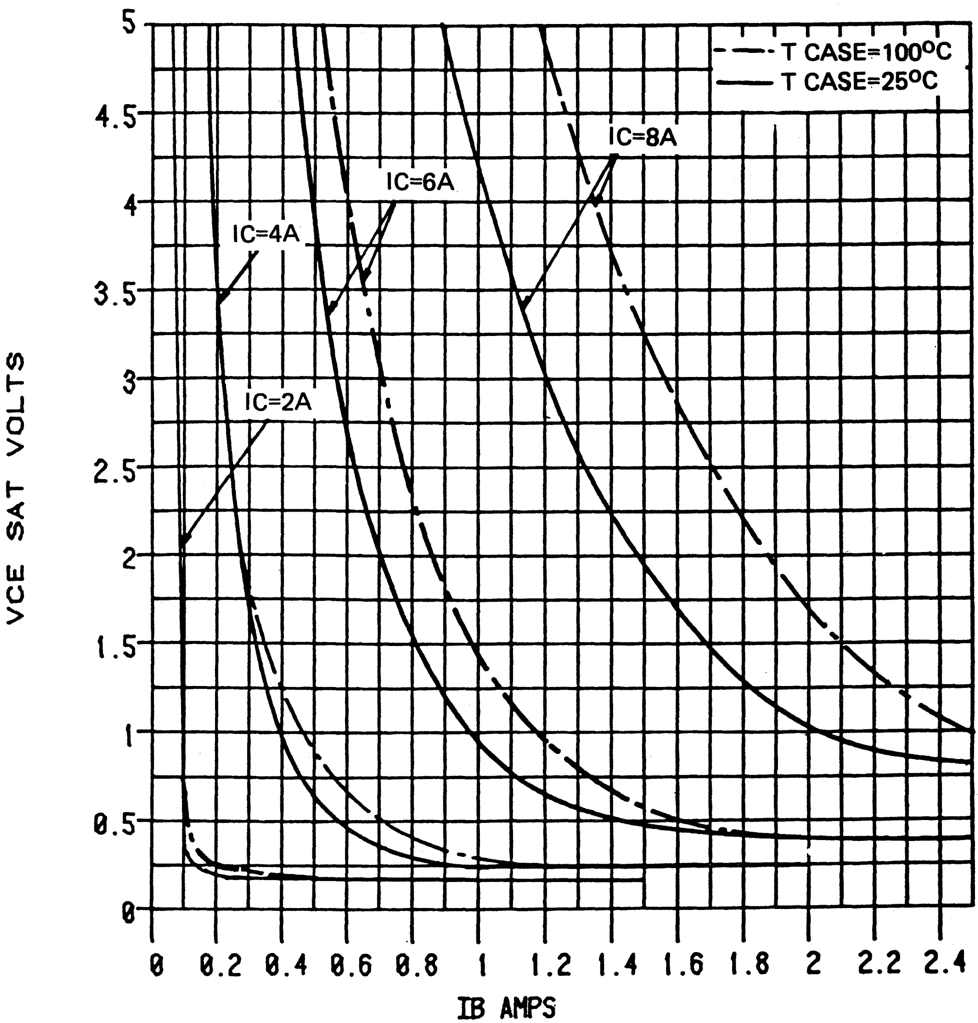


FIGURE 8 TYPICAL BASE SATURATION REGION T CASE=25°C

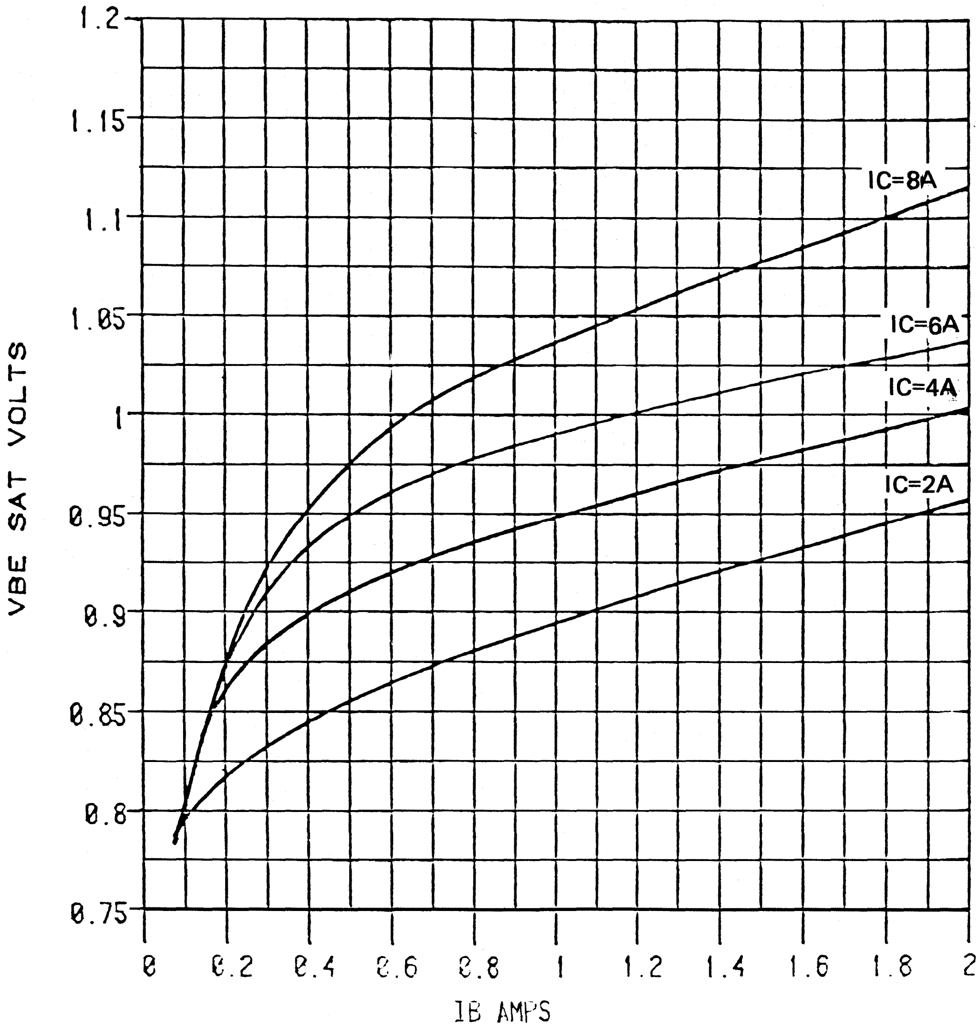


FIGURE 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

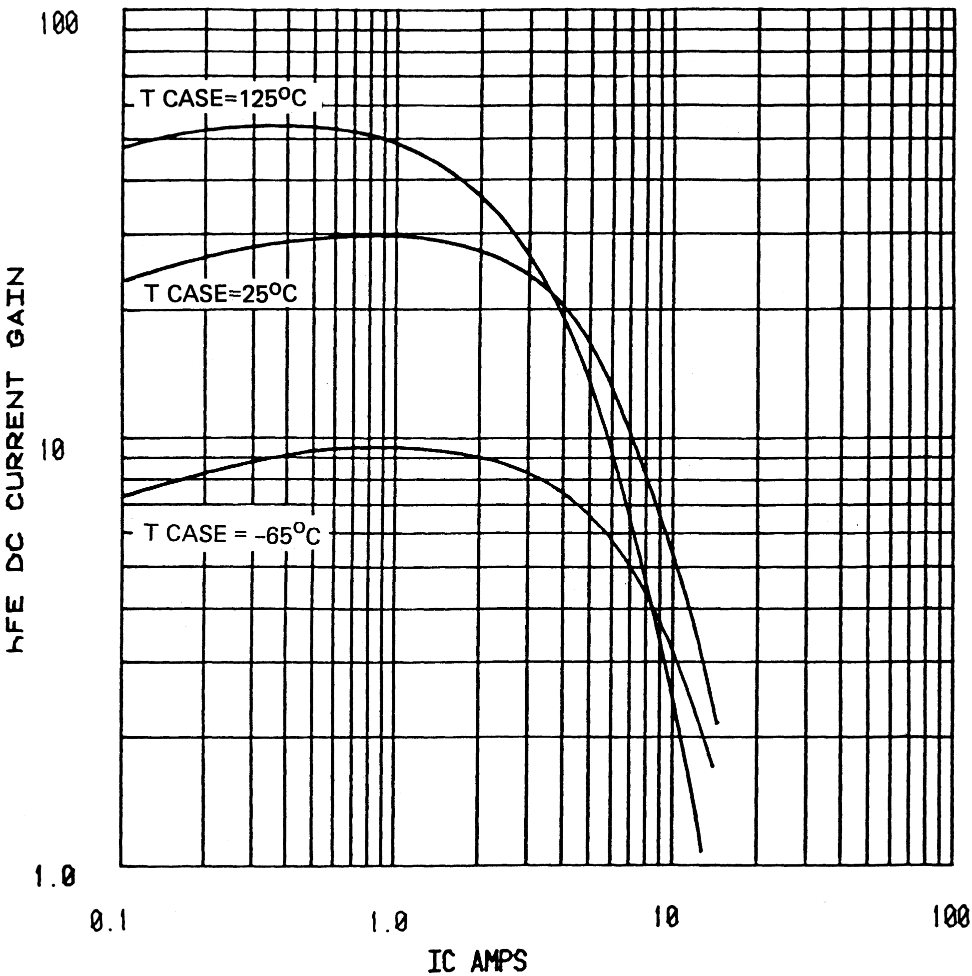


FIGURE 10 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

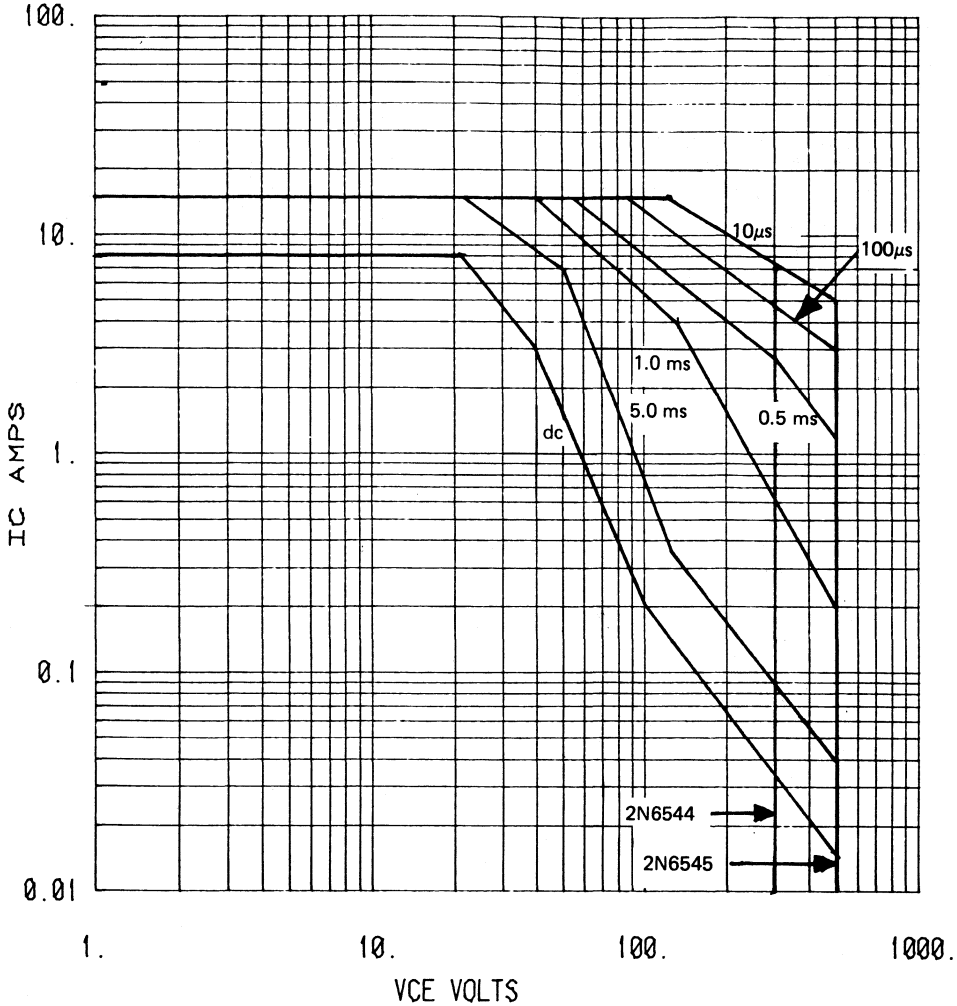


FIGURE 11 THERMAL RESPONSE

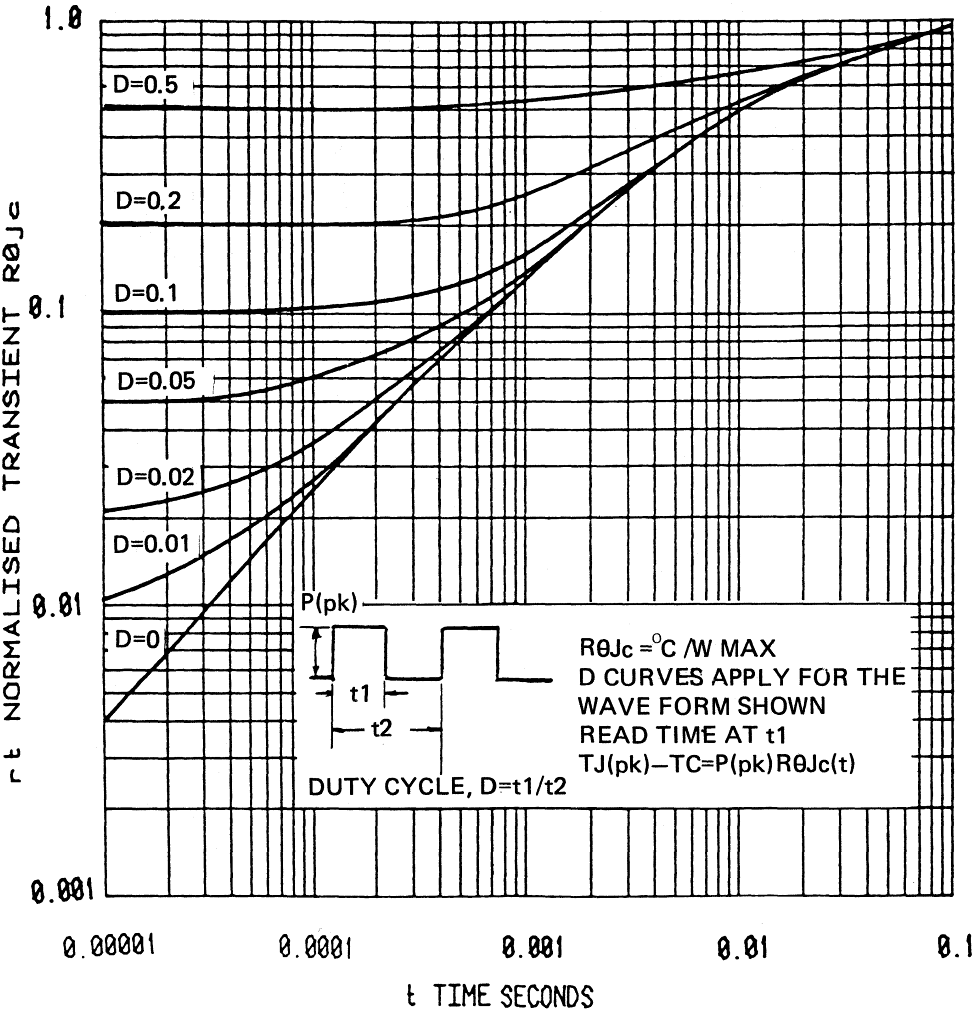


FIGURE 12 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

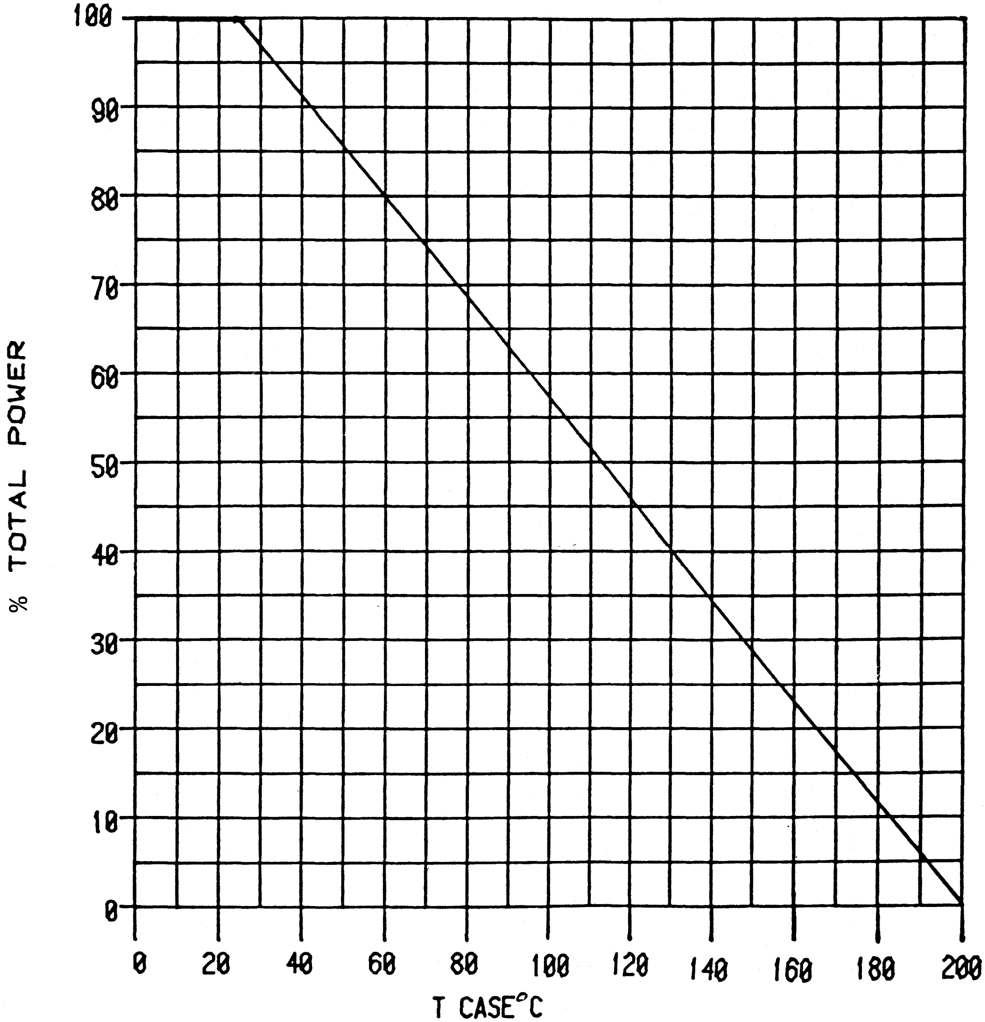


FIGURE 13 TRANSIENT "TURN OFF" LIMIT IC VS VCE

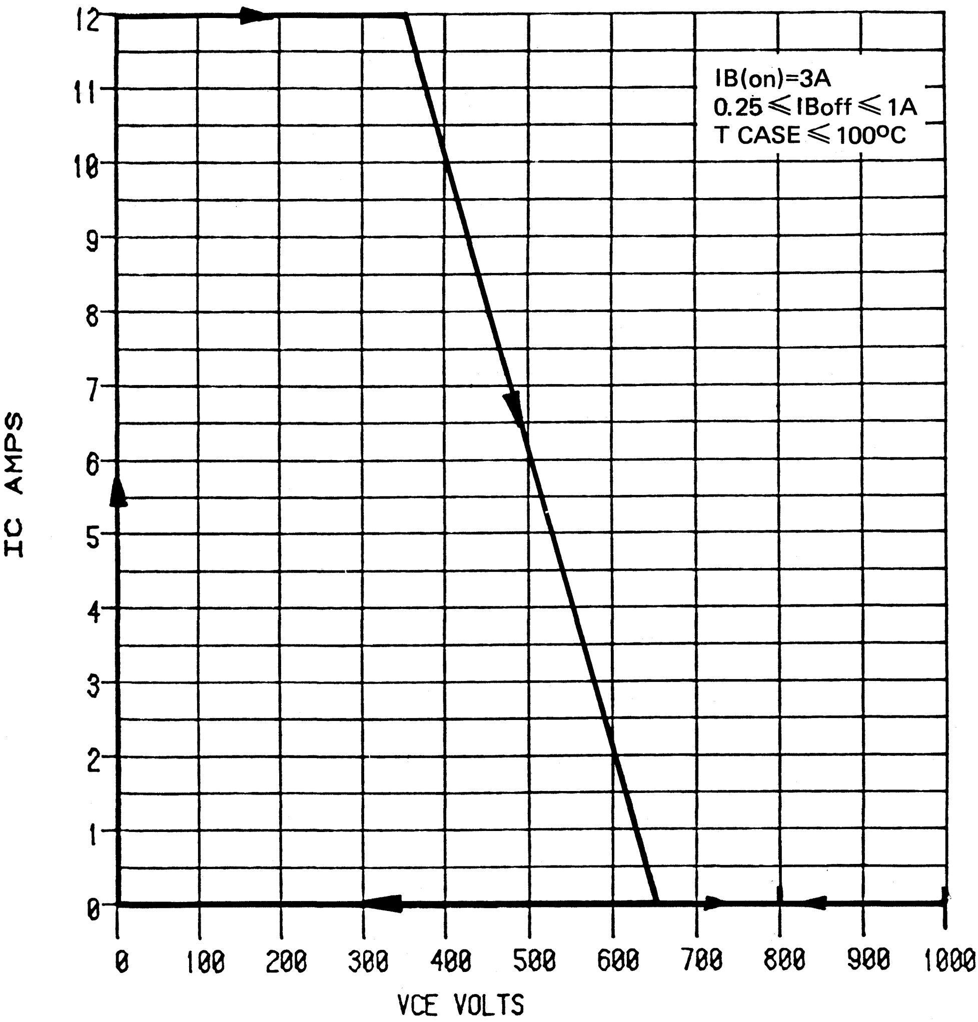
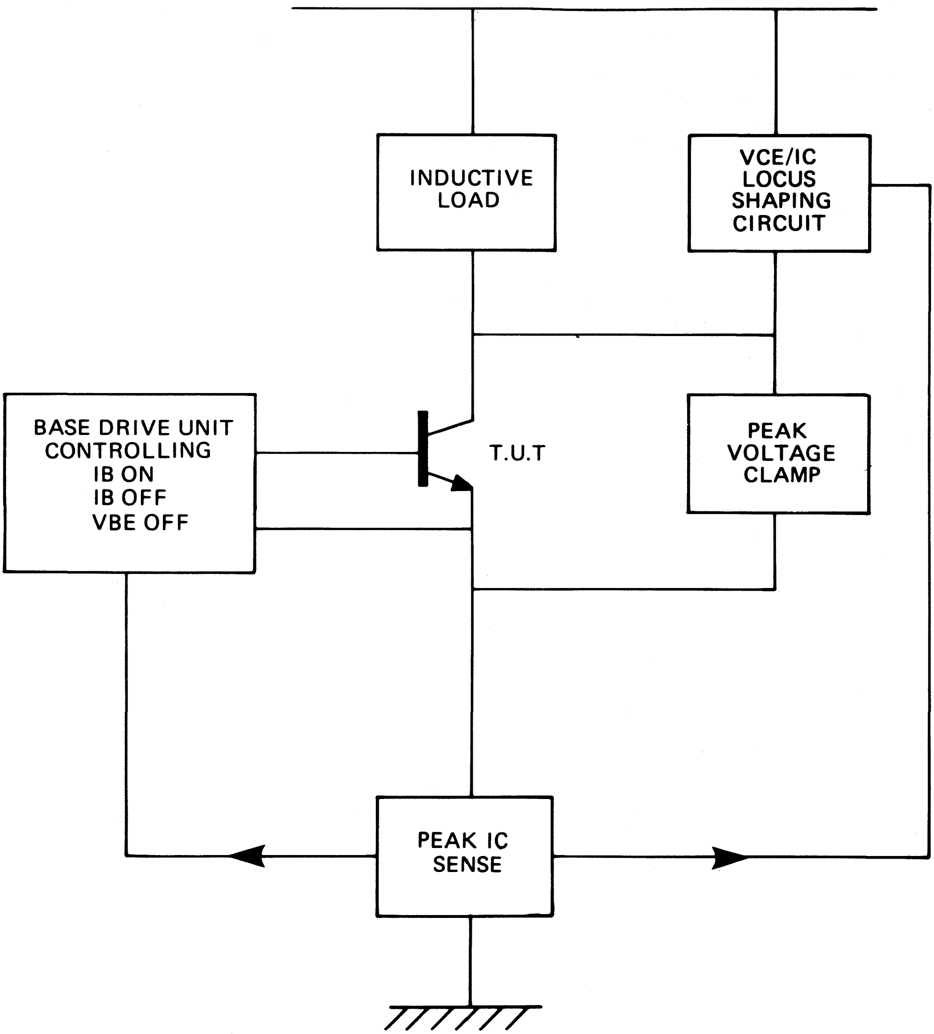


FIGURE 14 SWITCHING LOCUS TEST CIRCUIT



INDUCTIVE SWITCHING OF HIGH VOLTAGE TRANSISTORS

In inductive switching applications, such as switch mode power supplies and C.R.T. magnetic deflection, there are numerous operating and fault conditions which can cause failure of the transistor switch. In many cases, failure occurs during turn off of the transistor when high currents are still flowing and when the voltage across the device is rising rapidly.

The conventional method of defining device capability such as forward safe area and reverse energy/VCEX (sust) ratings do not relate directly to device operation during turn off in the majority of applications. Reverse energy is frequently thought to be the best guide since it can be related to the inductive energy in the circuit. This presupposes that energy is the primary cause of failure which is not always the case.

Detailed investigations have identified the key mechanisms responsible for device failure in inductive switching circuits and a new form of device specification and evaluation evolved which can be directly related to the application.

At the point of failure the device voltage collapses rapidly and latches on permanently. In the majority of cases the rapid voltage collapse results in an energy dump from the circuit which totally destroys the transistor. The voltage collapse is probably a regenerative switching action triggered by an instantaneous current density and electric field strength condition within the transistor.

However, reaching the trigger point is not simply determined by the instantaneous external terminal conditions but is also dependent on the history of device operation. In particular, the conduction period prior to turn off, collector current and bias conditions, and also the way in which the transistor is turned off can affect the current density across the chip during turn off.

The new form of reverse bias safe area definition takes into account all aspects of the operation. During characterisation the devices are subjected to many switching loci and the effects of prior conduction base bias and other influences evaluated for most practical cases. The result is a curve defining transistor capability which comprehends the total instantaneous power dissipation going from normal conduction through to turn off (See Figure 13) . If the worse case VCE/IC Locus in a given circuit configuration lies within the curve then the transistor will not normally be destroyed by any single turn off transient.

Where severe switching transients are repetitive, care should be taken not to exceed the thermal rating of the transistor.

A block diagram of the test circuit for establishing the switching locus curve is in Figure 12.

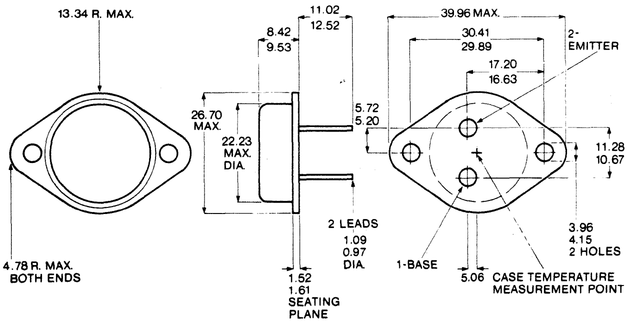
The transient VCE/IC Locus in an application can be found using a fast writing oscilloscope in an X–Y mode, ensuring that the delay matching of the X and Y channels is better than 20 ns. Beam blanking techniques can be used to enhance the turn off period.

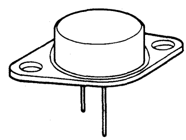
TYPES 2N6546, 2N6547
N-P-N SILICON POWER TRANSISTORS

- Designed for switching-mode power supplies, CRT scanning, inverters and other industrial applications, where rapid switching or inductive load is necessary
- This series features high voltage and peak current ratings, low saturation voltages, and a high degree of electrical robustness
- Guaranteed Transient 'turn-off' locus

MECHANICAL SPECIFICATIONS

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN MILLIMETRES

ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE

ABSOLUTE MAXIMUM RATINGS (AT 25°C AMBIENT TEMPERATURE)

		2N6546	2N6547
Collector-Emitter Voltage	$V_{CEO(SUS)}$	300V	400V
Collector-Emitter Voltage	$V_{CEX(SUS)}$	350V	450V
Collector-Emitter Voltage	V_{CEV}	650V	850V
Base-Emitter Voltage		9V	
Continuous Collector Current		15A	
Peak Collector Current (Note 1)		30A	
Continuous Base Current		10A	
Peak Base Current		20A	
Continuous Dissipation		175W	
Operating Junction Temperature		-65°C to +200°C	

Note 1: Pulse Test, Pulse Duration = 2ms

ELECTRICAL CHARACTERISTICS AT 25°C CASE TEMPERATURE UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{CEO(SUST)}$	Collector-Emitter Sustaining Voltage See Note 2	I_C = 100 mA 2N6546	300		V
		2N6547	400		V
$V_{CEX(SUST)}$	Collector-Emitter Sustaining Voltage	I_C = 8A, 100°C 2N6546	350		V
		V_{CLAMP} = Rated V_{CEX} 2N6547	450		V
		I_C = 15A, 100°C 2N6546	200		V
	See Note 2	V_{CLAMP} = Rated V_{CEO} -100V 2N6547	300		V
I_{CEX}	Collector Cut-off Current	V_{CEX} = Rated Value, V_X = -1.5V		1.0	mA
		V_{CEX} = Rated Value, V_X = -1.5V 100°C		4.0	mA
I_{CER}	Collector Cut-off	V_{CE} = Rated V_{CEX}, R_{BE} = 50Ω 100°C		5.0	mA
I_{EBO}	Emitter Cut-off Current	V_{EB} = 9V I_C = 0		1.0	mA
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	I_C = 10A, I_B = 2.0A See Notes 3 & 4		1.5	V
		I_C = 15A, I_B = 3.0A		5.0	V
		I_C = 10A, I_B = 2.0A, 100°C		2.5	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 10A, I_B = 2.0A, See Notes 3 & 4		1.6	V
		I_C = 10A, I_B = 2.0A, 100°C		1.6	V
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 2V, I_C = 5.0A See Notes 3 & 4	12	60	–
		V_{CE} = 2V, I_C = 10.0A	6	30	–
f_T	Current Gain Bandwidth Product	I_C = 500mA, V_{CE} = 10V (dc) F = 1MHz, GAIN = UNITY	6	28	MHz
C_{OB}	Output Capacitance	V_{CB} = 10V F = 1 MHz I_E = 0A	125	500	pF
$R_{\theta jc}$	Thermal Resistance Junction Case			1.0	°C/W

Note 2: Inductive Loop Switching Measurement

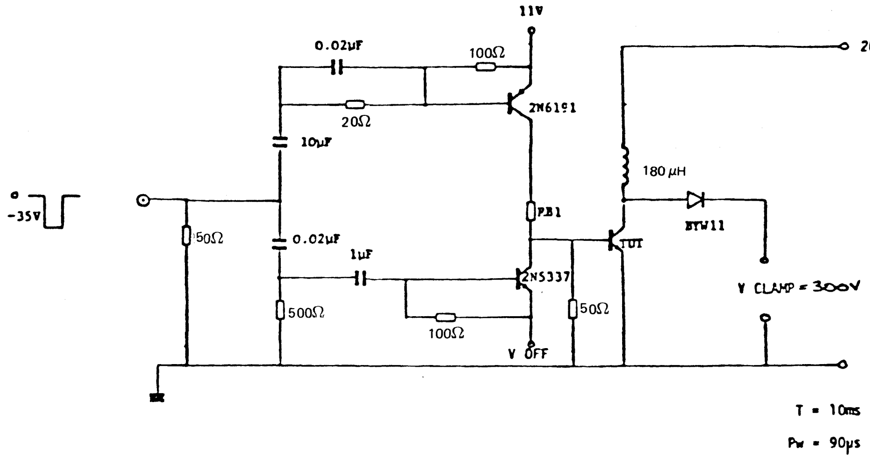
Note 3: These Parameters must be measured using pulse technique t_w = 300 μs duty cycle ⩽ 2%.

Note 4: 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 UNLESS OTHERWISE SPECIFIED

PARAMETER		TEST CONDITIONS	TYP	MAX	UNIT
RESISTIVE LOAD (See Fig. 3 & 4)					
t_d	Delay Time	I_C = 10A, V_{CC} = 250V I_{BON} = I_{BOFF} = 2A		0.05	μs
t_r	Rise Time			1.0	μs
t_s	Storage Time			4.0	μs
t_f	Fall Time			0.7	μs
INDUCTIVE LOAD (See Fig. 1 & 2)					
t_s	Storage Time	I_C = 10A, V_{CLAMP} = Rated V_{CEX} I_B = 2A, $V_{BE(OFF)}$ = 5V T_C = 100°C		5.0	μs
t_f	Fall Time			1.5	μs
t_s	Storage Time	I_C = 10A, V_{CLAMP} = Rated V_{CEX} I_B = 2A , $V_{BE(OFF)}$ = V T_C = 25°C	2.0		μs
t_f	Fall Time		0.09		μs

FIGURE 1 INDUCTIVE SWITCHING TEST CIRCUIT



Notes: A Waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 15$ ns, $R_{in} > 10M\Omega$ and $C_{in} < 11.5$ pF.

B Resistors must be noninductive types.

FIGURE 2 INDUCTIVE SWITCHING WAVEFORMS

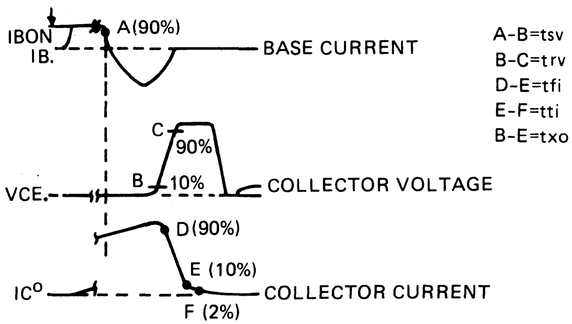
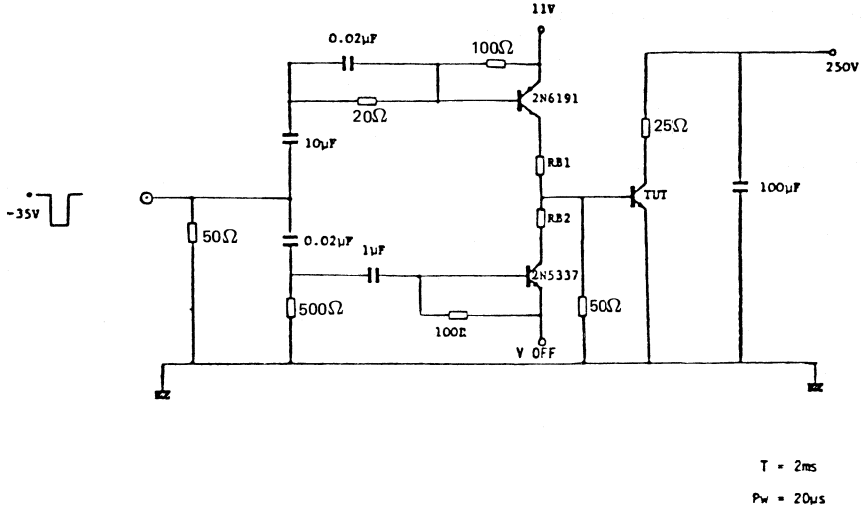


FIGURE 3 RESISTIVE SWITCHING CIRCUIT



Notes A The V_{gen} Waveform is supplied by the following characteristics:
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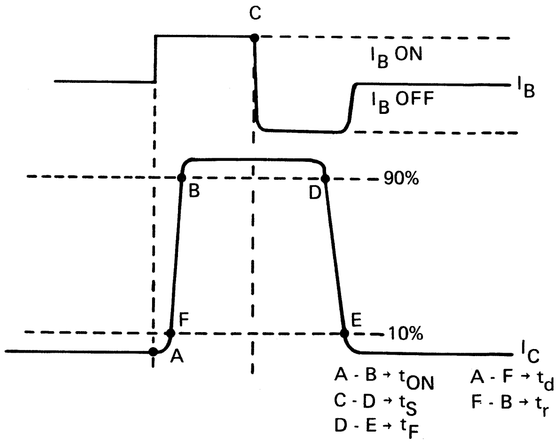
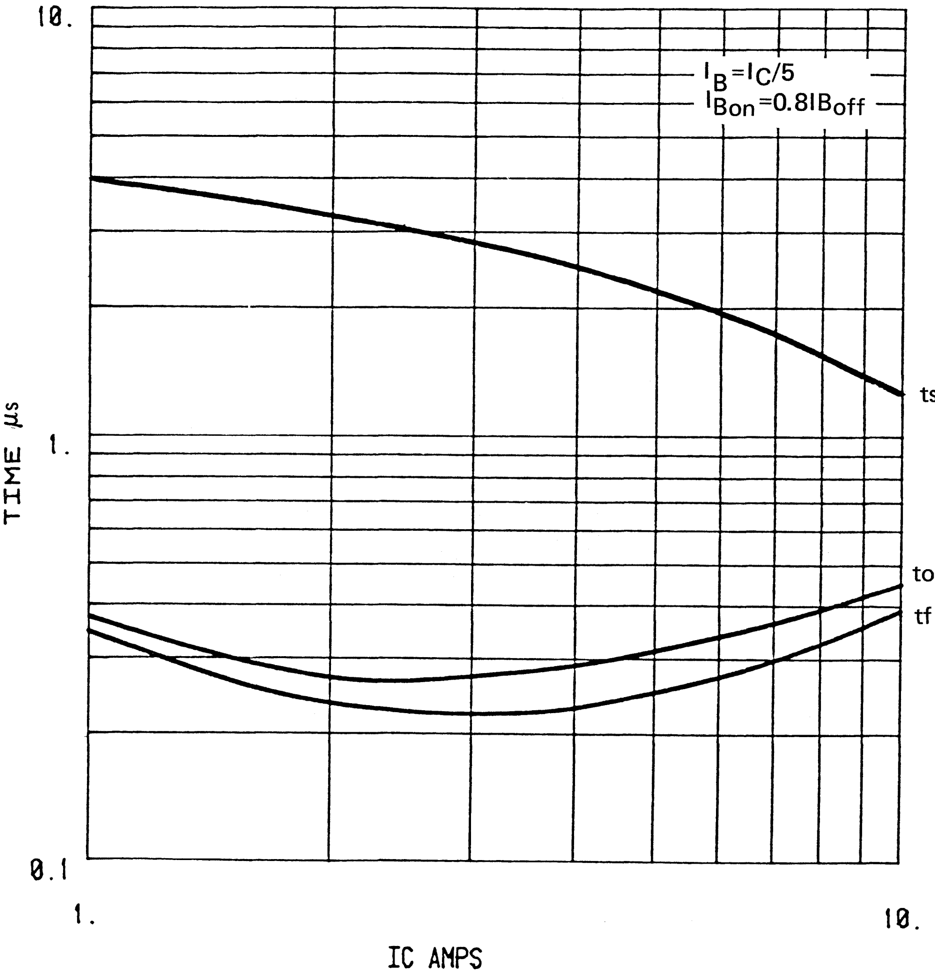
FIGURE 4 RESISTIVE SWITCHING WAVEFORMS



RESISTIVE SWITCHING PARAMETERS

FIGURE 5 TYPICAL TURN-ON & TURN-OFF TIMES VS IC TCASE=25°C



RESISTIVE SWITCHING PARAMETERS

FIGURE 6 TYPICAL TURN-OFF TIME VS IBoff T CASE=25°C

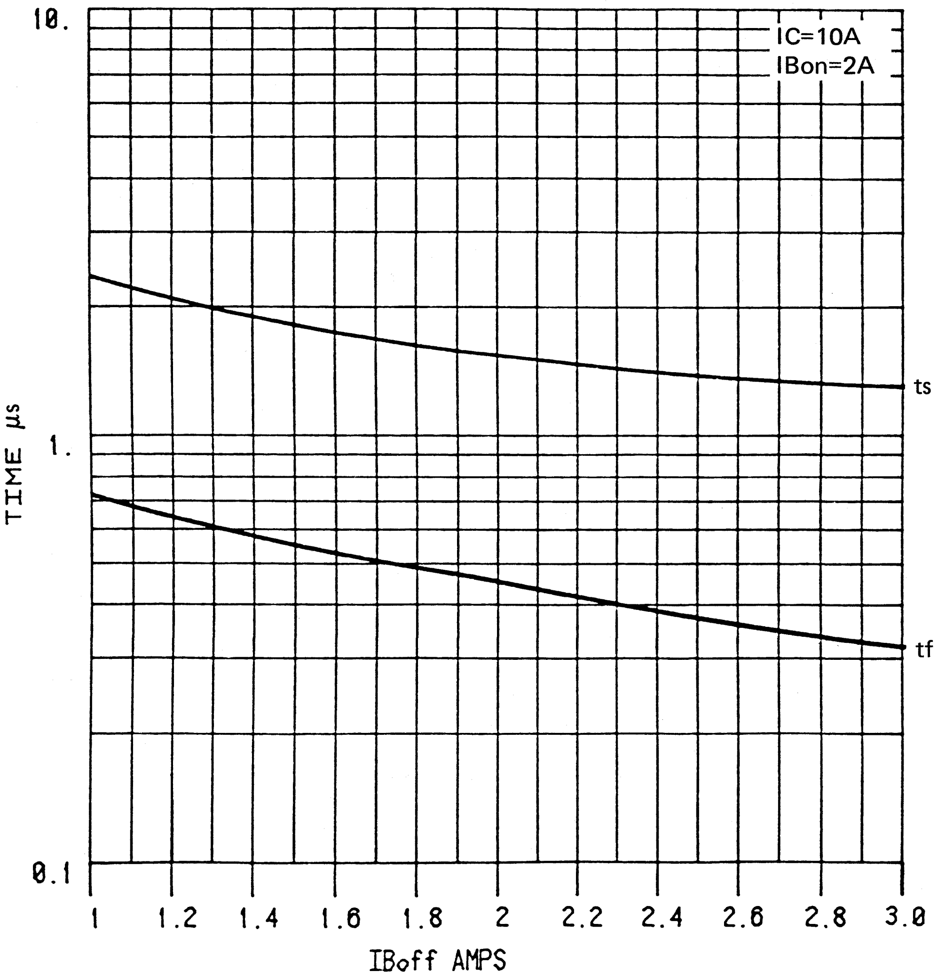


FIGURE 7 TYPICAL COLLECTOR SATURATION REGION

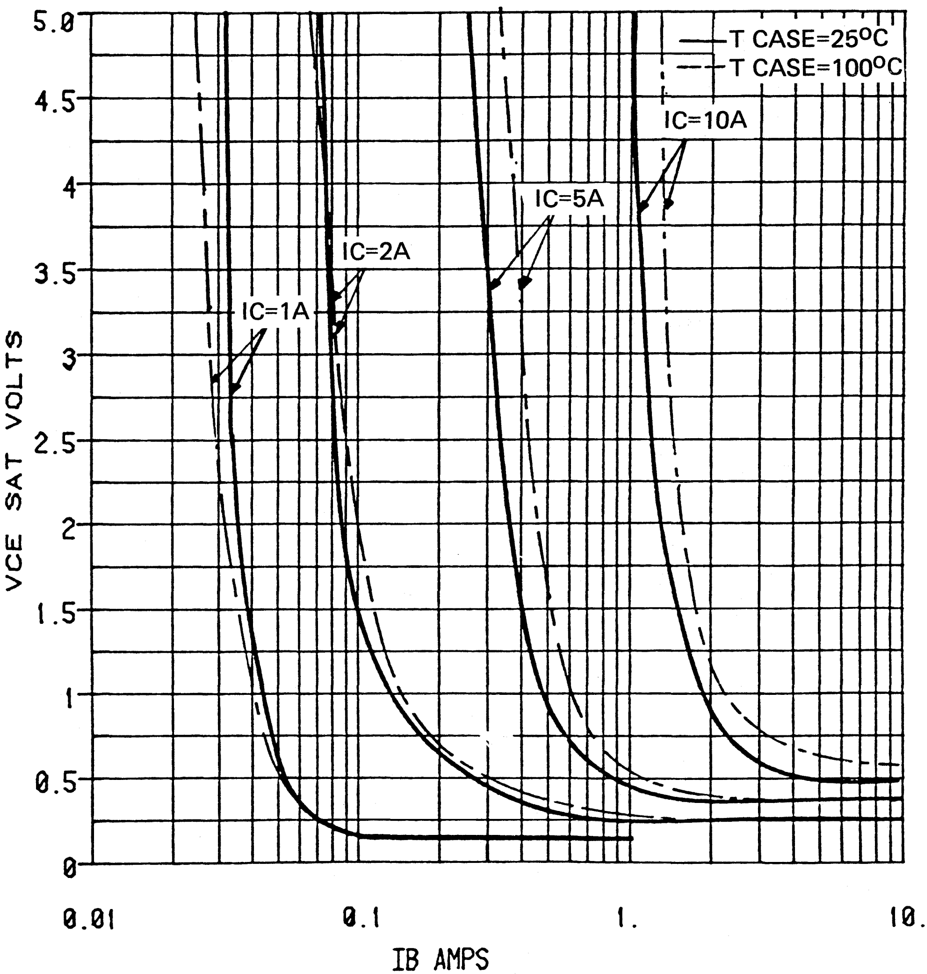


FIGURE 8 TYPICAL BASE SATURATION REGION T CASE=25°C

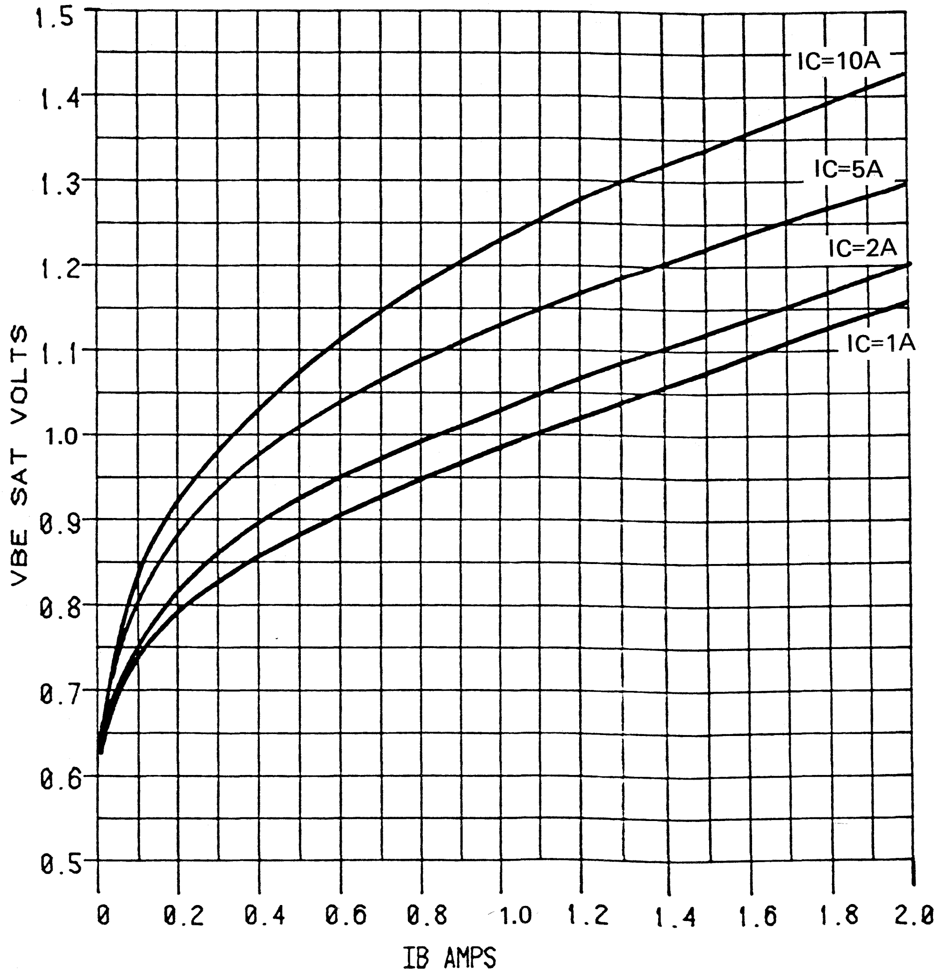


FIGURE 9 TYPICAL VARIATION OF DC CURRENT GAIN VCE=5V

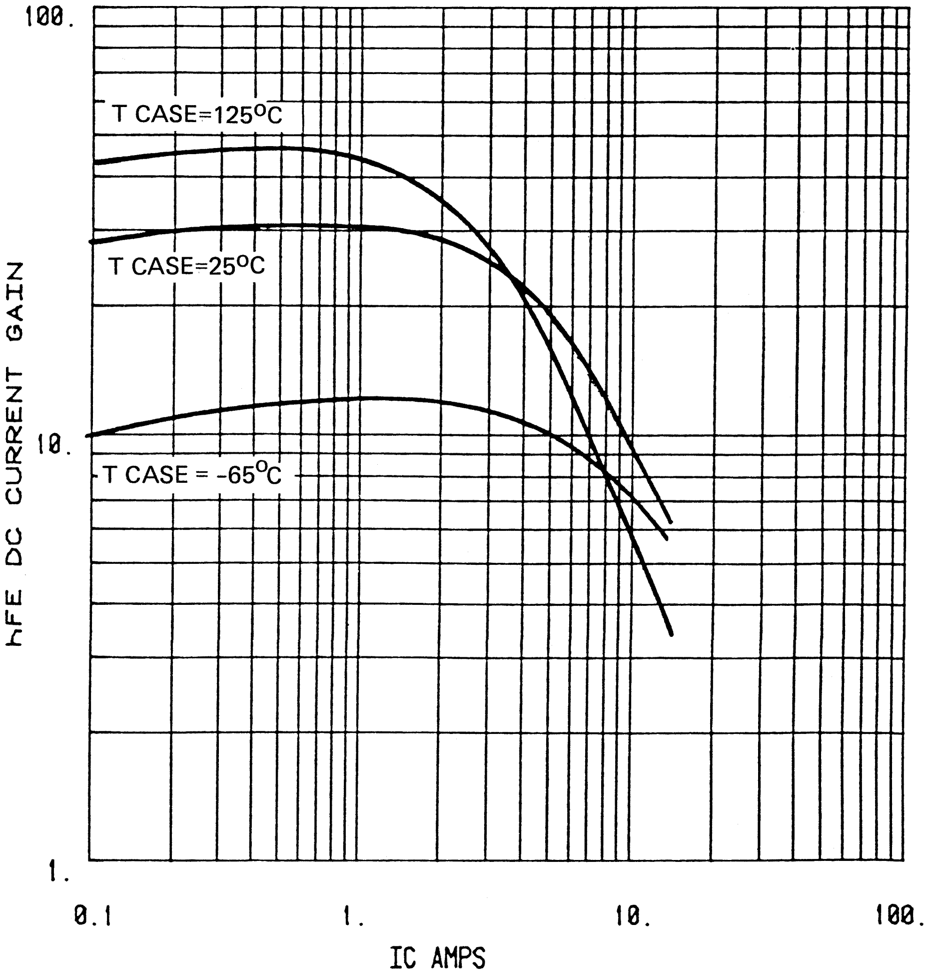


FIGURE 10 FORWARD BIASED SAFE AREA OF OPERATION DC & PULSED T CASE=25°C

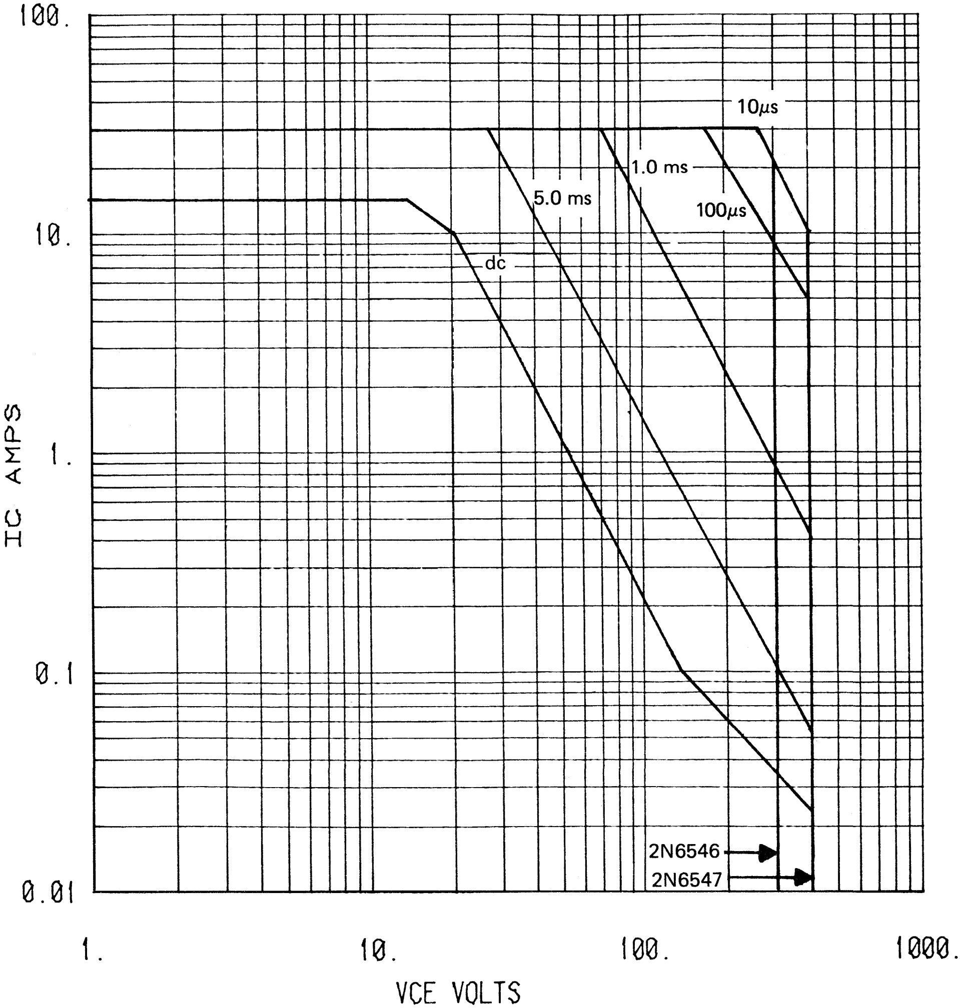


FIGURE 11 MAXIMUM POWER DISSIPATION VS CASE TEMPERATURE

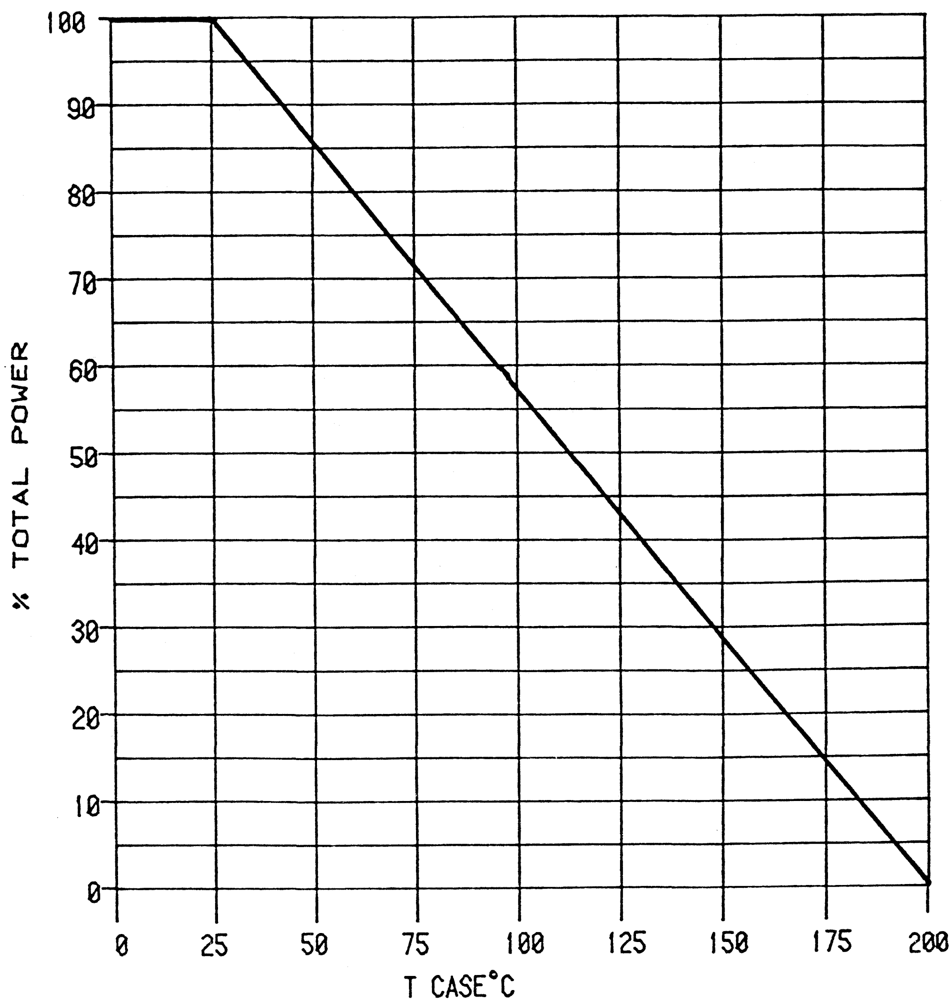


FIGURE 12 TRANSIENT "TURN OFF" LIMIT vs VCE T CASE$<100^{o}$C

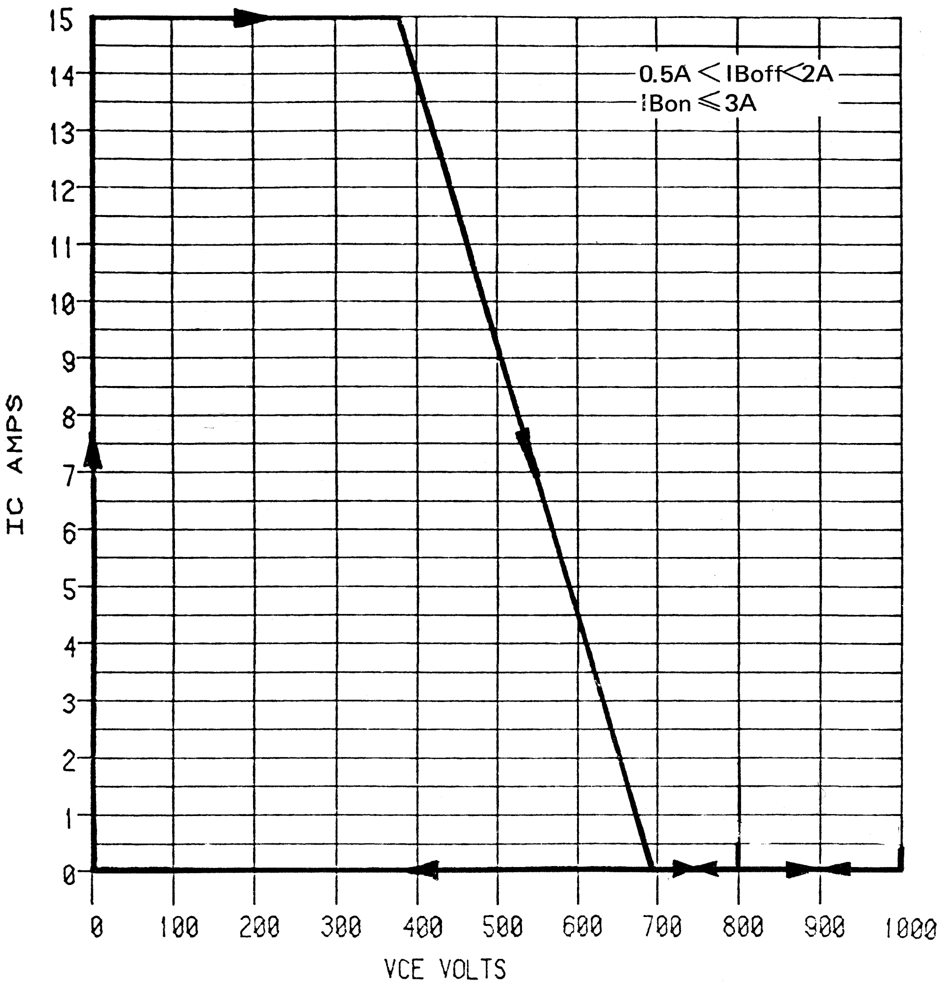
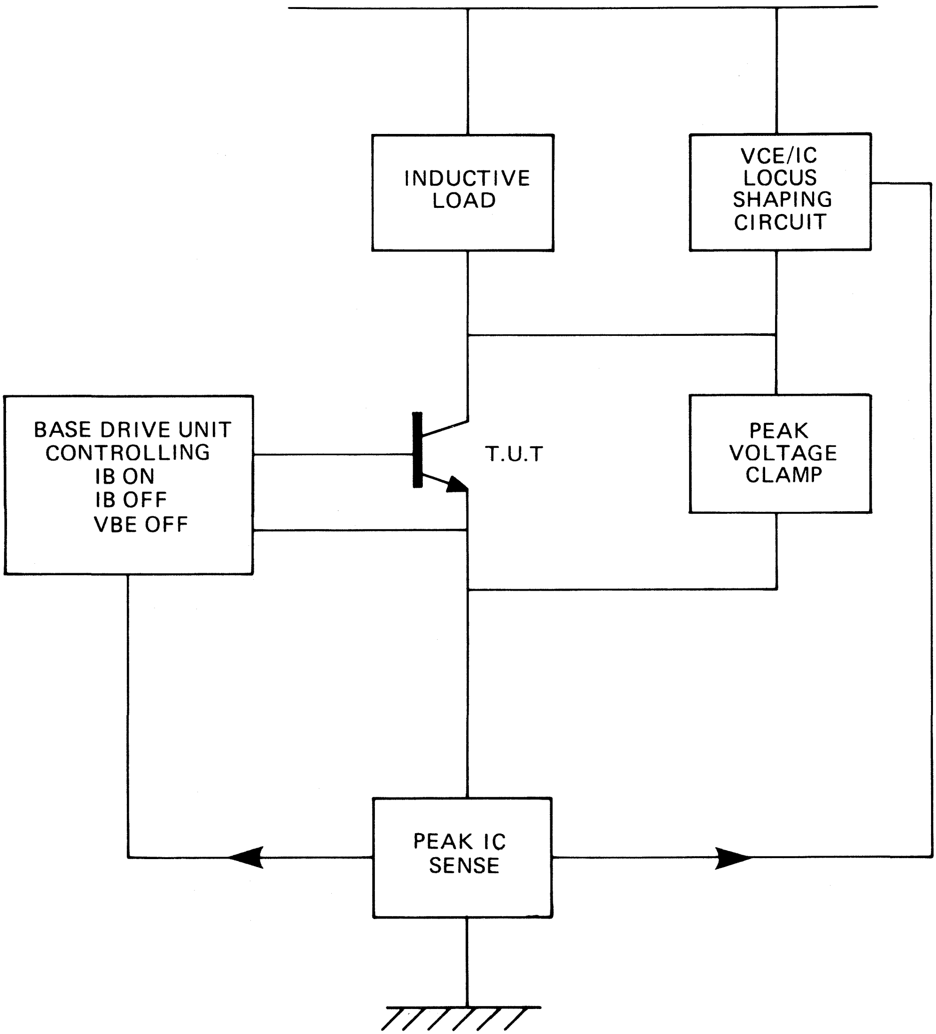


FIGURE 13 SWITCHING LOCUS TEST CIRCUIT



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Applications Information

IMPROVED TECHNOLOGY FOR POWER TRANSISTORS

Derek Colman, Ph.D.

A recently developed high voltage planar technology, I^2P, is described which provides improved ruggedness and reliability whilst being extremely cost effective.

IMPROVED TECHNOLOGY FOR POWER TRANSISTORS

Power transistors are typically used to control the application of power to a load. When power is not required by the load then the whole supply voltage must be sustained by the transistor. If the load is inductive then the transistor may have to sustain a voltage greater than the supply.

A transistor is normally rated for operation up to a certain maximum voltage. Depending on the application, the important parameter may be BV_{CEO}, the maximum voltage which may be applied with the base open circuit, or it may be the breakdown voltage where there is some connection between base and emitter. The optimum breakdown voltage is obtained when the base is either shorted to emitter (BV_{CES}) or returned to a negative voltage (BV_{CEX}).

The maximum voltage rating is determined by the resistivity and thickness of the n- collector region (Figure 1). The maximum field strength in the device is of the order of 20 volts per micrometer and in a well designed device the depletion will extend across the whole n- region at maximum rated voltage. Although the device may be correctly designed to sustain the required voltage in the bulk of the transistor, the junction must terminate at a silicon surface and this region represents the major problem in device design. If the device design is such that the field is higher at the surface than the bulk the premature breakdown will occur round the periphery. The result of this is not just that the full potential of the device is not obtained, in addition, breakdown is confined to the surface giving localised heating instead of a uniform heating over the whole device area. This means that the device will be much less robust and is more likely to be destroyed under fault conditions which impose high voltages.

Various techniques have been developed with more or less success to reduce the surface field such that bulk breakdown occurs (Figure 1). Typical examples are bevelled junction, glass filled moat, and planar with ion implanted p- region. All these processes are capable of producing the required breakdown and the choice of process depends upon the relative cost of processing, yield of good devices and reliability of the structure under environmental stress.

RELATIVE MERITS OF SURFACE PASSIVATION TECHNIQUES

Junction bevelling is relatively straightforward to understand theoretically. The optimum angle is a shallow positive bevel which causes the depletion at the surface to spread to a considerably greater width than in the bulk. The angle is produced by grinding then chemical etching to remove the damage. This is a relatively expensive operation and the technique suffers from the problem that it is not possible to reject the bad units until after assembly.

The exposed junction is protected from the atmosphere with a proprietary conformal coating and the quality of this passivation is key to the reliability of the product. A popular way to evaluate the reliability of the product is to subject it to a reverse collector junction bias of 80% its rated maximum for a period of time at elevated temperature. Key parameters such as junction leakage current are monitored. Typical drift of leakage resulting from life test is shown in Figure 2(a).

The original technique for surface passivation was the top mesa (Figure 1(b)). The base diffusion was localised by etching away the silicon round the periphery of the device to a depth greater than the base penetration. The exposed junction was protected by applying a proprietary coating over the surface.

A later development was the moat etch (Figure 1(c)). Again the junction is exposed and passivation is achieved by filling the moat with a proprietary glass compound. The stability of the junction is profoundly affected by the existence and mobility of charge in the glass. The performance of glass moat devices is strongly dependent on good process control. With good control results as in Figure 2(b) can be obtained. A problem with this structure is the weakening of the silicon slices which results from the moat etching, leading to increased slice breakage in production.

There are several techniques for applying the glass passivation. In one example a glass powder is suspended in water and the mesa etched slice is coated with the liquid. After wiping, centrifuging and drying the slice is heated to fuse the glass. In the electrophoretic process the slice is dipped into the glass suspension and a voltage is applied to cause the glass to be deposited in the areas of bare silicon. The glass may also be deposited by means of a suspension in photoresist. The slice is coated with the glass filled photoresist and then the photoresist is selectively removed by exposing and developing. The remaining photoresist is burned off leaving the glass deposited in the regions of interest and this glass is then fused.

All these techniques are designed to place glass in the desired regions but the stability of the junction is a function of the glass itself.

It is well known that the lowest junction leakages combined with optimum stability results from the use of a planar junction where the periphery is passivated by a thermally grown silicon dioxide layer. Use of the planar technology for power devices has, however, been inhibited by the field enhancement problem at the periphery which prevents full voltage potential of the device to be realised and results in poor device robustness.

There are several techniques which have been used to relieve the surface field. By diffusing rings around the base simultaneously with the base diffusion the depletion at the surface can be caused to spread out. To obtain good field relief, several rings are needed and their spacing must be carefully controlled. This multiplicity of rings consumes a considerable chip area thereby increasing the device cost.

The field plate approach can be used to reduce surface fields. Metal which is clamped at base potential is taken over the base periphery and extends a certain way over silicon at collector potential. The thickness of the oxide upon which the metal sits is an important parameter. Unfortunately, the optimum oxide thickness is continuously varying with distance from the junction edge. This is impractical for a production device. Practical devices use a compromise oxide thickness and breakdown initiates at the periphery with a resulting poor robustness. Devices have been manufactured with a two step oxide which is a closer approximation to the ideal but still having peripheral breakdown.

At Texas Instruments the problem has been overcome by the use of an auxiliary p- diffusion in the base region referred to as Ion-Implanted Planar or I^2P. Computer aided simulation of the two dimensional field profile resulting from the use of this additional diffusion allows the designer to choose values of diffusion parameters such that the field is reduced at the junction periphery and curvature compared to the bulk. On such a device breakdown occurs in the bulk of the device rather than the periphery, giving an extremely robust structure which can be taken into breakdown with considerable energy dissipation and no damage to the device.

Furthermore, the auxiliary p- diffusion does not compromise any other device parameter such as base depth as would be the case for certain approaches. Hence, the main base diffusion can be chosen to best fit the requirements of the product application such as switching speed, safe area etc. rather than be compromised by the requirements of the voltage rating.

In addition the area which is required to implement this extra diffusion is relatively small and therefore the solution is cost effective. The low values of surface field which can be achieved reduce the probability of surface breakdown thereby giving high probe yields.

The stability of the planar structure under temperature and voltage stress is presented in Figure 2(c). It will be noted that the collector leakage currents are an order of magnitude better than any other technology and that the drift of leakage with stress is also considerably better.

CONCLUSION

The design of a transistor switch which is optimised for a particular application involves a careful trade off between several contradictory requirements.

However, the introduction by Texas Instruments of the planar structure with p- field relief ring has resulted in a step function improvement in collector junction stability without having to compromise any other parameter. The result is an extremely stable, robust device from a cost effective process.

I^2P is such a significant improvement that devices utilising this technology will have a special numbering system with a TIPL prefix designating Texas Instruments Planar.

AUTHOR

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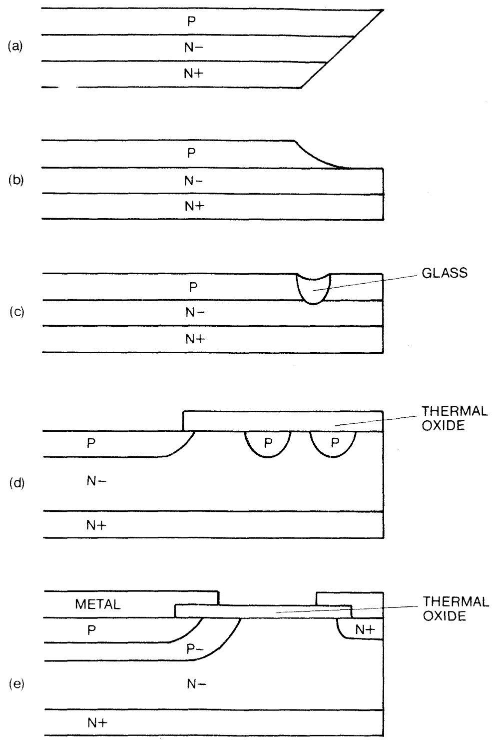


FIGURE 1. Various approaches to reducing surface fields in high voltage structures
(a) bevelled junction; (b) mesa; (c) glass moat;
(d) guard ring; (e) planar with P- field relief (I^2P)

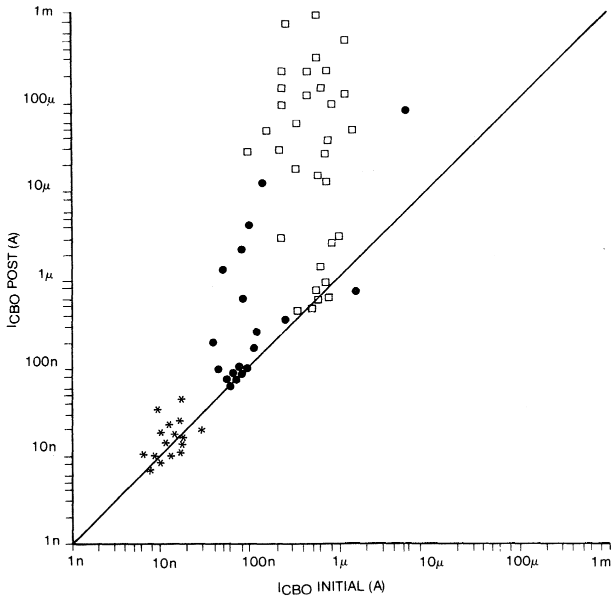


FIGURE 2. Cluster diagram showing drift of collector leakage current resulting from 720V reverse blocking at 150°C for 1000 hrs for

(a) □ bevelled junction
(b) ● glass moat
(c) * Planar P- (I^2P)

TIPL773 SERIES : 1150V, 55A, 200ns 3-TRANSISTOR ADVANCED POWER DARLINGTONS

Richard Schwarz

The TIPL773 monolithic Advanced Darlington represents a major breakthrough in power switching performance. Its features and their impact on systems design are discussed. Suggestions are made on driver circuit implementation, a 220V/7A isolated A.C. switch design and A.C. power supplies stabilised by switching techniques.

INTRODUCTION

The recent dramatic increase in the capabilities and reduction in cost of complex integrated circuits has clearly highlighted the need for improvements in power handling techniques to take full advantage of the sophisticated control functions now widely available.

In the past the high drive requirement and related cost associated with transistorised power switches has precluded their widespread use and to date mainly SCR's and TRIAC's have been used for this function.

However, the trend towards higher switching frequencies in search of greater efficiency and the increasing need for improved short-circuit protection is now severely limiting the scope of such thyristor switches and consequently designers are turning increasingly towards transistors.

The development of the Advanced Darlington has now completely changed the whole power control situation by making possible dramatic improvements in both circuit efficiency and cost-effectiveness by utilising the latest "state-of-the-art" developments.

APPLICATIONS AND HISTORY

The first semiconductor power switches were used for converters, where they replaced mechanical choppers, which had extremely low lifetimes. As a second step, control of the energy flow was achieved through varying the on and off times of the switches. Today this technique, known as pulse width modulation, is the principal one used for switch mode power supplies and motor controls.

The first power switches could only switch low currents and voltages and had limited switching speeds. About 10 years ago switching transistors were available that could switch 400V. Not much later 1200 and 1500V switches were used for TV applications. Further developments improved reliability by generation of special structures, widening the power capability of these high voltage switches.

A serious problem always was the very low current gain for high voltage switches. Darlington arrays could solve the gain problem but were rather unpopular because of their poor switching and voltage blocking ability, on account of leakage current being amplified by the main device.

Texas Instruments, invested much effort into solving the various Darlington shortcomings in several developmental steps, and developed the new and innovative product family of improved Darlingtons.

The first step was the integration of a "speed-up" diode to enable hard turn-off base drive to the main device T3 (Figure 1). A further step forward was the introduction of high voltage planar technology. This technology enables mass production of high voltage devices with leakage currents of a few nano amps (even at high chip temperatures). It also offers good stability of parameters, that can be determined by computer modelling techniques and implemented by accurate control of the diffusion. This introduced new ways for fast switching power Darlington design which in the next step made use of higher integration on the power chip.

The Advanced Darlington TIPL773 family is a semiconductor switch with a wide range of applications due to its outstanding performance to cost ratio. It can switch voltages up to 1150 volts and currents up to 15A. The gain of the typical device is 400 at I_C=7A and V_{CE}=2.5V. This enables direct drive from a standard IC-output. The turn-off-charge is typically 1.5μC resulting in a 3μs storage time and a 300ns **maximum** falltime, turning off 7A with 500mA negative base drive.

Switching speeds of this magnitude make 50-100kHz SMPSU designs practical.

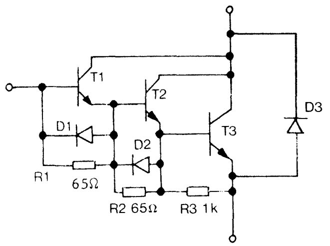
Due to these features the Advanced Darlington is not only perfectly suitable for high power switch mode power supplies but also for motor control and direct off-line switching applications. In the design special attention was given to the safe-operating-area. Tests have shown, that the device can take short circuit current spikes of 55A for 10μs (with 5ms repetition) connected directly to a voltage source of 400 to 600V. This is a transient energy capability of 0.33J and a peak power of 33kW!

In future applications fast switching will be important because of the regulations regarding mains pollution. Filtering is much easier and cheaper at higher switching frequencies than it is at 50 or 100Hz. New transistorized converters are able to generate sinusoidal waveforms with very little harmonic content.

DEVICE DESCRIPTION

The Advanced Darlington is a three transistor Darlington with integrated speed-up diodes, base-emitter resistors and a recovery diode across emitter-collector of the main device.

FIGURE 1—TIPL773 Advanced Darlington Configuration



Each single transistor stage is carefully optimised in order to enhance the overall performance of the Darlington. The main device T3 is designed to achieve very wide safe operating area and to turn off at maximum voltage even when the base of the Darlington is disconnected from the base-drive circuitry. Current regulating mechanisms keep the stored charge of the device to the very minimum necessary for proper saturation.

The low ohmic base resistors R1, R2 of T1 and T2 determine base current thresholds of about 10mA for these transistors. This guarantees high noise immunity and collector emitter dV/dt capability. If the base and emitter of the Advanced Darlington are shorted externally, the internal base of the main device T3 is shunted by about 130ohms. This gives a good collector-emitter blocking range in the off state. For negative biased base the 1k base resistor R3 of T3 limits the static negative base currents to very low values. For fast turn-off the speed up diodes allow access to the base of the main device.

Under fault conditions it is possible that the base drive may become disabled while the device is conducting high collector currents. Measurements have shown that the Advanced Darlington can turn off a current of 7A at 800V under these conditions, a total energy capability of approximately 700mJ.

APPLICATIONS

Initially the Advanced Darlington was developed for DC motor control applications, where high current and pulse power capability are essential. Due to the high switching speed the operating frequency range for motor controls can be extended from 5kHz to 20kHz. The high current gain permits inexpensive driver and auxiliary supply circuits.

Obviously such a device is also perfectly suitable for high power switch mode power supplies, convert , and inductive load switching applications.

For the circuit development engineer it is important to recognise that the Advanced Darlington device is a design tool that offers a totally new approach to transistorized switching. Although the conducting voltage drop is high (2V typ.) compared to a mechanical contact, this disadvantage is negligible at high voltage operation. The power dissipation for the conduction period e.g. at rectified mains operation can be as low as 1% of the output power.

1. AUXILIARY POWER SUPPLY

For switching loads that are connected to the mains input it is normally necessary to use an isolated auxiliary power supply for the control/drive circuit. Due to the high gain of the Advanced Darlington the drive power can be as low as 0.6W. For fast switching, a negative rail of about −6V is very helpful. In general the best results can be obtained using a ±6V auxiliary supply. The most common way of providing this is shown in figure 2.

FIGURE 2—Auxiliary Power Supply — 1

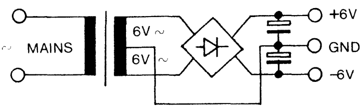
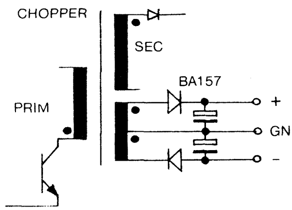


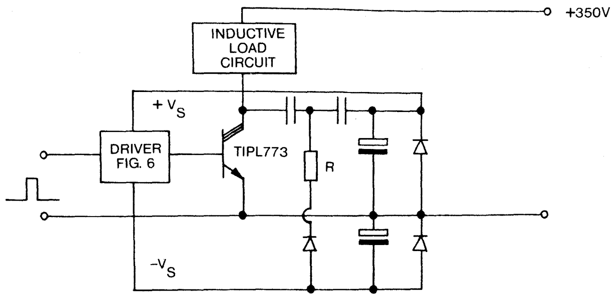
Figure 3 shows an auxiliary power supply that uses the flyback voltage of a converter or switch mode power supply. In this case it is necessary to use fast recovery diodes for rectifying the transformer pulses. Since the power consumption for the base drive of the Advanced Darlington is very low, it normally is possible to add an additional secondary winding to an existing transformer without influencing its previous function.

FIGURE 3—Auxiliary Power Supply — 2



Although the Advanced Darlington does not in itself require snubbing, in some cases, especially when switching high power inductive loads, network for limiting the turn-off dV/dt of the power switch may be used. Figure 4 shows such a network and how it can be applied to not only limit dV/dt but also provide the auxiliary voltage rails for the base drive.

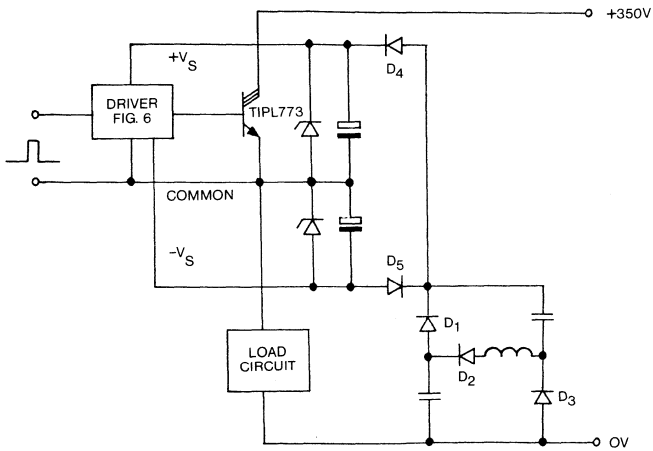
FIGURE 4. Auxiliary Power Supply—3



The resistor in the "Snubber" circuit figure 4 dissipates part of the turn off losses of the switch array. For elimination of all the turn off losses, non-dissipative snubbers can be used. Figure 5 shows such a circuit and how it can be used to generate auxiliary voltage supply rails for the driver circuit.

All diodes of the snubber have to be fast switching types. Diodes D4 and D5 can be low voltage type but diodes D1, D2 and D3 have to be able to block the input voltage.

FIGURE 5, Auxiliary Power Supply — 4

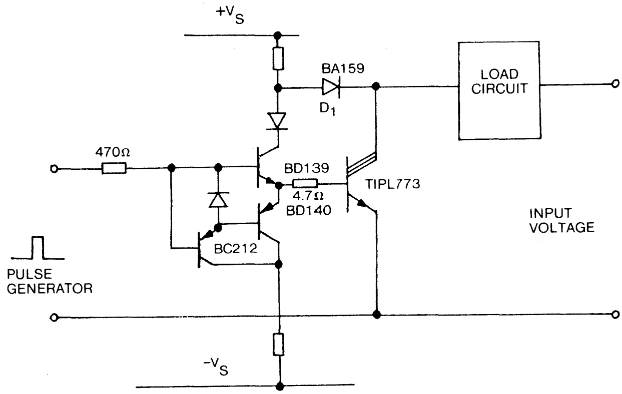


2. DRIVER CIRCUIT

Figure 6 shows a driver circuit for optimum drive conditions.

Diode D1 senses the saturation voltage of the Advanced Darlington and controls the base current to an optimum value. It has to be a fast diode with input voltage blocking capability. Such a driver circuit can easily be controlled by an opto coupler. For several applications this gives a new possibility for solid state isolated power switching.

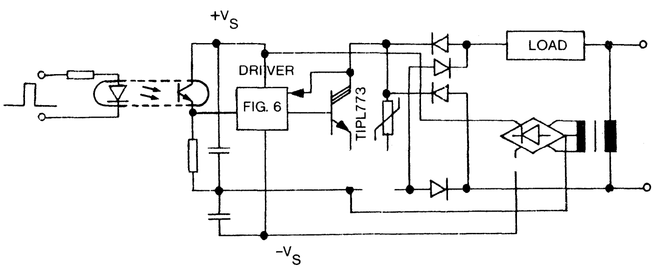
FIGURE 6. Driver Circuit



APPLICATIONS

In the following, basic circuit diagrams show how the Advanced Darlington can be used in new applications.

FIGURE 7. Isolated AC 220V/7A Switch



With two of figure 7 switches a controlled or stablized AC-power supply can be built.

With about 5kHz operating frequency and pulse width modulation this AC-step down converter can provide a 50Hz sine wave stabilized output voltage. This is the A.C. equivalent of the D.C. linear regulator.

By exchanging input and output a step up function is provided.

(V_o max = 0.9 x V_{input})

FIGURE 8. A.C. Supply Generator

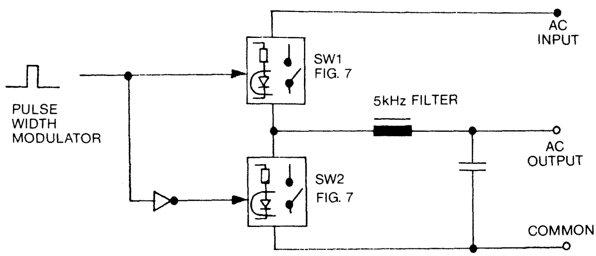
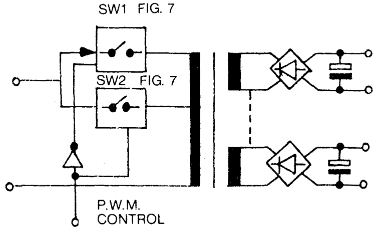


Figure 9 shows a transformer with stabilized output.

By controlling the switches the turns ratio of the primary of the transformer can be controlled. Using a 400 Hz operation frequency and pulse width modulation, stable and isolated DC outputs can be obtained for variable input voltages.

Texas Instruments have designed an I.C., the TL377, which when used in conjunction with the Advanced Darlington provides a sophisticated switch mode motor speed control complete with protection circuitry. The system operates directly off 240V A.C. with a minimum of external components.

FIGURE 9. Transformer With Stabilised Output



CONCLUSION

The Advanced Darlington is a device that due to its technical performance, can not only open ways to new applications but also save expense by simplifying circuit design. The outstanding robustness of the TIPL773 family makes the design of reliable high power switching circuits very easy.

REFERENCES

TIPL773/773A/773B Data Sheet

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INDUSTRIAL FAST POWER DARLINGTON AS 120V/10A INDUCTIVE LOAD SWITCH

Richard Schwarz

The TIPL775 series of fast power Darlingtons achieves the normal single diffused product costs with an order of magnitude improvement in switching time permitting circuit designs operating up to 50kHz. Recommended drive circuits are given and interfacing techniques described.

INTRODUCTION

Semiconductor switches have a much higher reliability and longer life than mechanical contacts, if sufficient care is taken in circuit design to protect the switch under all operating conditions. In addition, semi-conductor switches can be used at very high switching speeds without reducing their life expectancy.

When electro-mechanical transducers of limited mechanical speed are to be controlled, the fast response of a semiconductor switch gives good control of the current through the electrical part of the system, enabling the dynamic behaviour of the mechanical part to be optimised.

COMPARISON OF AVAILABLE SEMICONDUCTOR TECHNOLOGIES

In most switching applications today the system cost can be reduced by using higher operating frequencies. This requires low cost solid state semiconductor switches.

In the past, single diffused Darlingtons have been used for many applications because of their relatively low cost and high current gain. For many applications the switching performance is not good enough and the switching losses are high, especially at high frequencies.

Power MOS switching devices are able to fulfil the switching speed requirements, but are costly. Simply replacing a single diffused Darlington with a MOS device does not improve the switching very much. It takes some additional negative base-drive circuitry to achieve the very good results expected of this technology.

Texas Instruments have introduced a new family of epitaxial planar devices with type numbers TIPL775 (TO3), TIPL785 (TO218 plastic) and TIPL790 (TO220 plastic). These are fast Darlingtons with an integrated speed-up diode. Another diode is also integrated for reverse collector-emitter current protection. This technology combines the high gain and low cost of single diffused Darlingtons, and the speed of power MOSFET. This combination can provide low system cost. In Figure 1 the TIPL775/785/790 (electrically identical in this context) is compared with a MOS device. It is interesting to note that the wafer area of the TIPL775/785/790 is 25% that of the MOSFET which has equivalent saturation and breakdown voltage ratings.

FIGURE 1. SWITCHING TIME VS OFF-DRIVE

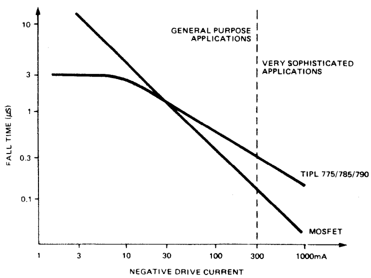
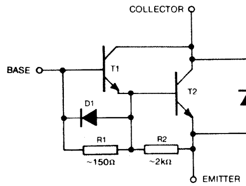


Figure 1 shows that for low drive currents the TIPL775/785/790 can be turned off much faster than the MOS device. Increasing the negative drive current improves the switching times of both technologies. However, within the range of drive currents provided by I.C. output stages the fall time of the TIPL775/785/790 is typically 300 nanoseconds. Faster fall times are needed only in very sophisticated switch mode power supplies and converters using more than 50 kHz chopping frequencies.

TIPL775/785/790
INDUSTRIAL FAST POWER DARLINGTON AS 120V/10A INDUCTIVE LOAD SWITCH

DESCRIPTION OF THE TIPL775/785/790 DEVICES

FIGURE 2. INTERNAL CIRCUIT DIAGRAM

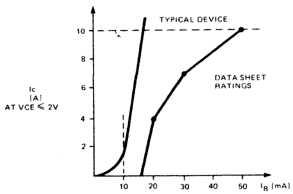


The TIPL775/785/790 differs from the usual Darlington design having an integrated speed-up diode D1 and a low ohmic resistor R1 across the base of the driver device. The speed-up diode allows access to the base of the main transistor T2, which is discharged using negative base drive, and is needed to achieve fall times below 1 microsecond with the 150 ohm resistor alone switching times of less than 5 microseconds may be obtained simply by shorting the base to emitter. This is very useful in the many applications where it would be difficult to provide the auxiliary supply to generate negative base drive.

The epitaxial planar technology is known for its high stability of electrical parameters under operation, even at high case temperatures, and also the long term stability of leakage currents, which are also very low.

For high stability, and improved turn off, the low level current gain is low. To turn the devices on, the base current has typically to exceed a 10mA threshold before significant collector current can be drawn. Figure 3. shows that by increasing the base drive only a few milliamps above the threshold base current the device can be driven into full conduction owing to the high Darlington gain.

FIGURE 3. DARLINGTON CURRENT GAIN



APPLICATIONS

Without additional circuitry for generating negative base drive the TIPL775/785/790 is fast enough for operating frequencies up to 10kHz. Thus, it can be recommended in DC and stepping motor control applications. By the addition of only one small external capacitor to the base drive circuit, the frequency range can be extended up to 50kHz. This makes the TIPL775/785/790 family perfectly suitable for switchmode power supplies, converters and sophisticated motor controls.

The high current gain of the device enables the base drive to be provided by 25 mA IC output stages.

In the following circuit (figure 4) a NE555 timer IC operates as a pulse generator and drives the TIPL775/785/790 power Darlington.

FIGURE 4. SWITCHING TEST CIRCUIT

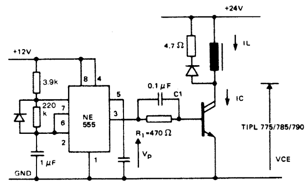


Figure 5 shows the collector current fall time and the effect of adding an external speed-up capacitor C1 connected in parallel with the base drive resistor R_1 in Figure 4. The fast power Darlington switches a load current of 7 A with a fall time of 3 microseconds. The dissipation energy is less than 0.58 milliwatt-seconds in the one turn off cycle, with a 55 volt de-magnetising voltage peak.

Using a maximum switching frequency of 300 Hz in this application, the switching losses would be 0.17 watts for a 24 volt 7A inductor. Adding a speed up capacitor C1 of 0.47 microfarads the switching losses can be as low as 1.75 watts in a 24 volt switch-mode power supply, switching 7A load current at 36kHz operating frequency.

FIGURE 5. FALL TIME VS CAPACITOR C1

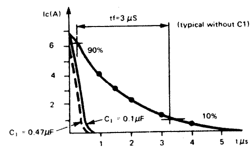
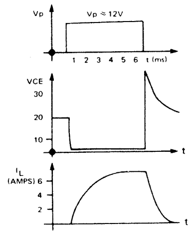


Figure 6 shows the voltage and current waveforms obtained in the test circuit of figure 4.

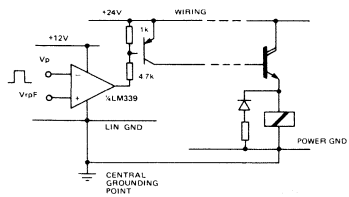
FIGURE 6. TEST CIRCUIT WAVEFORMS



On a 24 volt supply rail the circuit can switch loads up to 250 watts and 600 watts on a 60 volt supply. The specified minimum breakdown voltage is 120 volts for the TIPL775/785/790 and 150 volts for the TIPL775A/785A/790A. There is thus enough remaining voltage difference for the fast de-magnetisation of inductive loads.

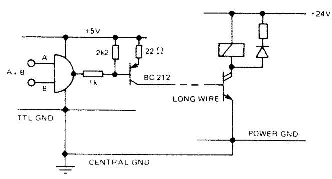
The following applications show the TIPL775/785/790 fast power Darlington as a logic power output interface. In Figure 7 the Darlington is driven by a high voltage small signal PNP transistor ($I_C = 25$ mA) allowing the load to be earth connected. The differential input of the comparator rejects difference in earth potential. Thus, the power earth can be separated from the signal earth to give maximum noise immunity. The switching speed of this circuit is the same as that in Figure 5 but cannot be increased further by a capacitor.

FIGURE 7. COMPARATOR WITH POWER BOOSTER



This circuit is specially suitable for linear input applications. The load is actuated when the input voltage Vp exceeds a preset reference voltage level. Obviously the circuit can also be triggered by pulsed input voltages, generated by MOS or TTL logic gates. If ground connection of the load is not required, the drive transistor can be a low voltage PNP type, like BC212. In Figure 8 the drive transistor is used as a current source giving good decoupling of the logic ground and +5V supply, and the +24V power supply.

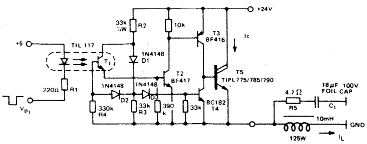
FIGURE 8. TTL—POWER OUTPUT INTERFACE



In TTL—power interfaces this needs special attention, otherwise switching spikes generated by the power output can cause problems to the logic operation.

For total isolation of the power switch an optically coupled interface is shown in Figure 9. The special feature of this circuit is that no auxiliary supply voltage for the base drive of the TIPL775/785/790 fast Darlington is required. This is very useful if the switch potential is

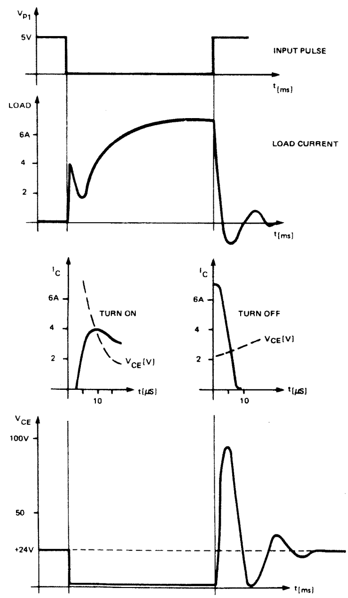
FIGURE 9. FAST ISOLATED SWITCH



floating while the switch is actuated. The switch capacitance to the surroundings can be minimised. Figure 9 shows the TIPL775/785/790 fast power Darlington as driver for a 125W electro magnet.

The input of the opto coupler can be driven by a TTL output buffer which is able to sink about 1 mA. Adapting to other drivers can easily be achieved by varying R1. The voltage ratings of transistors T2 and T3 have to be higher than the maximum operating collector-emitter voltage of T5. T4 is a standard small signal transistor. It improves the turn off of the power Darlington. R_2 is the start up resistor. The collector voltage of T1 is clamped by diodes D1, D3 and the base of D4, to about 1.8V. Transistor T4 is in the on-state, blocking the power Darlington.

FIGURE 10 — VOLTAGE AND CURRENT WAVEFORMS



INDUSTRIAL FAST POWER DARLINGTON AS 120V/10A INDUCTIVE LOAD SWITCH

If the LED of the opto-coupler is biased, transistor T1 is turned on, switching on T2, T3 and T5. The collector voltage of T1 decreases to about 1.2V, which is the saturation voltage of T1 plus the base threshold of T2. In fact, the phototransistor T1 cannot be totally saturated because D2 and R3 remove excessive base drive as soon as the collector voltage of T1 sinks below 1.2V. This provides good switching and low storage times.

In the on state of the switch, transistor T4 is turned off, because the anode voltage of D3 sinks to 0.6V, removing the base voltage of T4.

A second drive charge regulating mechanism is used in the circuit, providing optimum drive conditions for T2, T3 and T5. With resistors R2 and R3 the saturation voltage of the switch circuit can be set. Giving R3 the same value as R2 the on-state voltage drop of the switch array is kept at about 1.8V and is fairly independent of the load current. If the switch saturates below that value, the voltage drop across D1 stays constant (0.6V) and the cathode voltage of D1 sinks below 0.6V. Since the saturation voltage of T1 is regulated to 0.6V, the base voltage of T2 will be equal to the cathode voltage of D1 and will also sink below 0.6V. Lowering the base voltage of T2 results in desaturation of T2, T3 and T5 until a new current balance is achieved.

All of these circuit details are required for constant switching behaviour, which is independent of the LED drive current and switch array load current.

Since negative basedrive is not available for increasing switching speed the collector current falltime is about 5 microseconds. The switching losses can be neglected for pulse frequencies up to 5kHz in applications equivalent or similar to Figure 9. Figure 10 shows voltage and current waveforms of the circuit.

The capacitor C_1 and damping resistor R5 in parallel to the load, perform perfect demagnetisation of the core by a damped oscillation of the entire resonant circuit after the switch turn off.

References

TIPL775 Data Sheets
TIPL785/790 Data Sheet

AUTHOR

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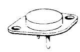
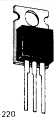
	 TO 3		 TO 218		 TO 220	
	TIPL775	TIPL775A	TIPL785	TIPL785A	TIPL790	TIPL790A
MAXIMUM CONTINUOUS DISSIPATION 250 DEG C	100W		80W		70W	
BVCBO – VOLTS	150	200	150	200	150	200
BVCEO (SUS) – VOLTS	120	150	120	150	120	150

For all Devices

Max V_{EBO} = 5V

I_C Peak = 15A (pulse, duration ≤ 2ms)

I_{CSAT}

10A V_{CE} = 2V IB = 50mA

7A V_{CE} = 1.5V IB = 30mA

4A V_{CE} = 1.2V IB = 20mA

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TIPL POWER TRANSISTORS IN A 100W TDA4600 - CONTROLLED FLYBACK SMPS

V. Bose

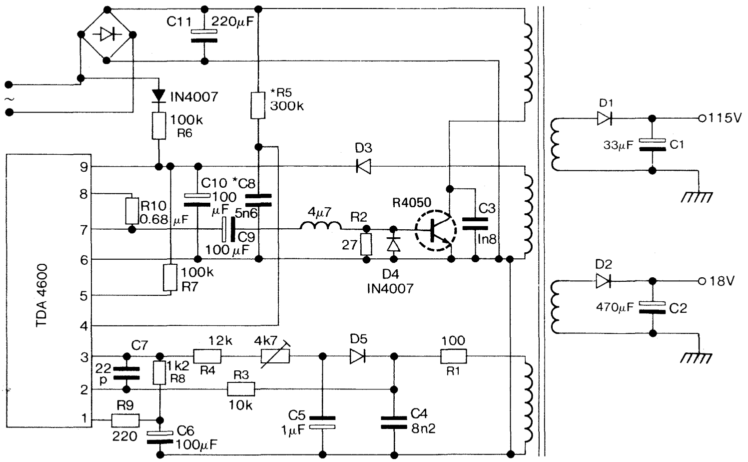
This report outlines the application of ion-implanted planar "TIPL" power transistors in S.M.P.S. using the TDA4600[1] integrated circuit as controller. Salient points in device/component selection and circuit operation are highlighted without undertaking a detailed S.M.P.S. design[2]. Particular attention is paid to the supply start-up.

INTRODUCTION
This P.S.U. is a 100W direct off-line, isolated, complete energy transfer system. It is controlled by a Siemens TDA4600 I.C. which directly drives an ion-implanted planar power transistor (TIPL760A/761A/R4050) and outputs 115V and 18V rails.

1.0 Design Details

1.1 TDA4600
A few of the salient features of the TDA4600 are listed below:
* Variable frequency and duty cycle operation
* Operating frequency range (f_o) 16kHz to 76kHz
* Duty cycle variation 1:2 to 1:20 i.e. the maximum and minimum transistor conduction periods (t_{on}) are

$\hat{t}_{on} = \frac{0.33}{fo}$ and $\check{t}_{on} = \frac{0.048}{fo}$



*SEE TEXT (2.3) ON MAX. PULSE WIDTH

FIGURE 1—S.M.P.S. CIRCUIT DIAGRAM

1.2 Power Transistor Rating

The ratings are evaluated for the maximum output power $\hat{P}_o$ of 95W. The design input voltage range is 185Va.c. to 265Va.c. giving rectified d.c. voltages (V_{in}) of $\check{V}_{in} = 260V$ and $\hat{V}_{in} = 375V$. A 15% margin is allowed for on the maximum conduction period $\hat{t}_{on} = \frac{0.28}{f_o}$, and minimum frequency $f_o = 18kHz$.

The maximum peak collector current $\hat{I}_c$ occurs at $\check{V}_{in}$ and $\hat{P}_o$, assuming a 100% efficiency this is given by:

$$\hat{I}_c = \frac{2 \times \hat{P}_o}{\check{V}_{in} \times \hat{t}_{on} \times \check{f}_o}$$

$$= 2.6A$$

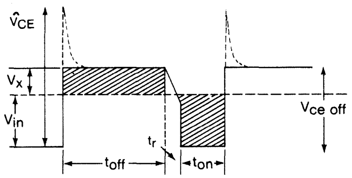


FIGURE 2—V_{CE} WAVEFORM

Figure 2 shows the typical V_{ce} waveform. The relaxation time [2], t_r is approximated to $\frac{0.1}{f_o}$ for calculation of the energy transfer time t_{off}. As the t_r contribution is small, the two shaded volt-second areas can be equated.

$$V_X \times t_{off} = V_{in} \times t_{on}$$

This gives the reflected secondary voltage (V_X) as

$$V_X = \frac{V_{in} \times t_{on}}{t_{off}}$$

For $\check{V}_{in} = 260V$; $\hat{t}_{on} = \frac{0.28}{f_o}$; and with $t_o = t_{off} + t_r + \hat{t}_{on}$

giving $t_{off} = \frac{1}{f_o} - \frac{0.1}{f_o} - \frac{0.28}{f_o} = \frac{0.62}{f_o}$

then $V_X = \frac{260 \times 0.28}{0.62} = \underline{117V}$

This voltage does not change with supply voltage but the transistors voltage is maximised at $\hat{V}_{in}$ giving

$$V_{ce\ (off)} = \hat{V}_{in} + V_X$$
$$= 492V \text{ say } \underline{500V}$$

This is the ideal $V_{ce\ (off)}$ but in practice there will be a voltage overshoot at turn-off. The extent of the overshoot is determined by the primary voltage clamp network, if any, in circuit, and the secondary load clamping action.

Case (a): No primary clamp network and allowing a worst case 100% overshoot on $V_{ce\ (off)}$
$V_{ce} = \underline{1000V}$

Case (b): with a primary clamp and allowing 50% overshoot,
$V_{ce} = \underline{750V}$

1.3 Device Selection

Allowing a 25% safety margin on the $\hat{I}_c$ and $\hat{V}_{ce}$ values above, the transistor requirements are:

	case (a)	case (b)
Peak Collector Current	3.25A	3.25A
Collector-Emitter Voltage	1250V	938V

Suitable devices for:
Case (a): 1300V/8A R4050 , TO218 plastic package
Case (b): 1000V/8A TIPL761A, TO218 plastic package
or
1000V/8A TIPL760A, TO220 plastic package

2.0 CIRCUIT OPERATION

The circuit of figure 1 was evaluated with a 1300V R4050 as the power transistor (as no primary clamp was incorporated), a 160Ω secondary load on the 115V rail, realising 82W output which represented a P.S.U. efficiency of 86%. The resultant waveforms are shown in figures 6 to 11. The performance of the TIPL760A and TIPL761A would be similar except for V_{ce} which would be clamped.

2.1 I_b, I_c, V_{ce}

Figures 3, 4 and 5 show the I_c, V_{ce}, I_b and V_{be} waveforms under stated conditions. Just prior to the base drive current reversing, its value ($I_{b(end)}$) is 0.6A giving a forced gain of: $I_c = \frac{2.6}{0.6} = 4.3$

This is within the recommended value of 5.

The V_{ce} peaks at 900V (figure 5) during turn-off. V_{ces} is the design limitation in this mode of operation.

POINTS OF NOTE:

* Forced again, sufficient for saturation
* V_{ces} rating selected to match circuit configuration.

2.2 Switching performance

Figures 6, 7 and 8 show the turn-on and turn-off waveforms displayed on a reduced scan scale.

$I_{b(off)} = I_{b(end)}$ is acceptable for the TIPL range and results in giving turn-off waveforms (figures 7 and 8). For even faster turn-off times $I_{b(off)} = 1.5\ I_{b(end)}$ is recommended and this can be achieved by removing the base-emitter reverse clamp diode D4 in figure 1. This can lead to base-emitter breakdown zenering but that is not detrimental to the operation of the TIPL range of devices.

Figure 6 shows during turn-on the dv/dt capacitor C3 is discharged giving the initial collector current spike. This spike will vary in amplitude and duration for differing values of H_{FE}, all else being constant, because the transistor operates in the linear region initially, as the I_b gradually ramps up. The operation limits are provided by the FBSOA curve and the operation in this case is within those limits.

The discharging of the capacitor into the transistor represents an "energy dump". An experimental "energy dump" test was performed on the TIPL devices, whereby a 1n8F (dv/dt capacitor) was charged to 900V (i.e. 0.7 mJ of energy) and "dumped" into the transistors successfully. In normal operation the "energy dump" would be of the order of 0.05 mJ each cycle.

The turn-off waveforms of figure 7 show a smooth current transition with no "tail", a fall time, t_f, of 500ns, and the voltage rising at 1000V/μs. The t_f will be dependent on $I_{b(off)}$ and dI_b/dt.

TIPL data sheets have a transient turn-off limit [4] curve which guarantees safe operation if the worst case turn-off Vce/Ic locus is within its enclave.

Figure 8 shows the STORAGE TIME (t_{sv}) to be in the region of 4μs. The t_{sv} is dependent on the drive conditions.

Switching times t_{sv} and t_f are the main parameters in determining the maximum operating frequency. They also vary with temperature.

TIPL parameters are guaranteed to 100°C operation making for accurate definition of high temperature operation.

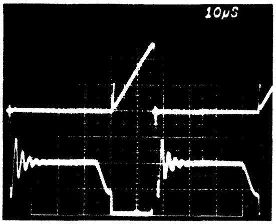


FIG. 3
MAXIMUM LOAD & MINIMUM INPUT SUPPLY

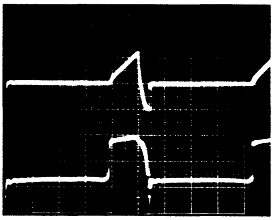


FIG. 4
MAXIMUM LOAD & MINIMUM INPUT SUPPLY

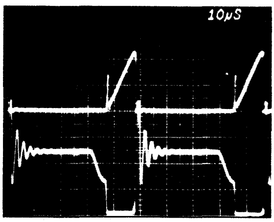


FIG. 5
MAXIMUM LOAD AND MAXIMUM INPUT SUPPLY

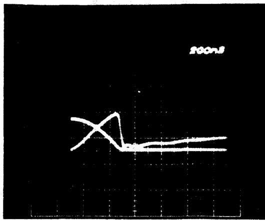


FIG. 6
TURN ON CHARACTERISTIC: MAX. LOAD & INPUT SUPPLY

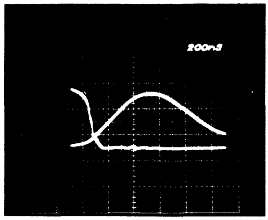


FIG. 7
TURN OFF CHARACTERISTIC: MAX LOAD & NOMINAL INPUT SUPPLY

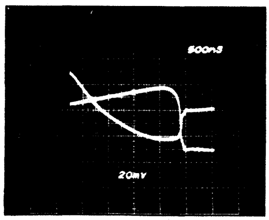
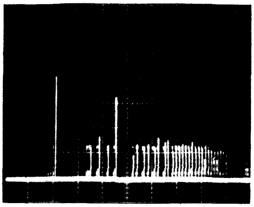


FIG. 8
STORAGE TIME: MAX. LOAD & NOM. INPUT SUPPLY

TIPL POWER TRANSISTORS IN A 100W TDA4600 - CONTROLLED FLYBACK SMPS

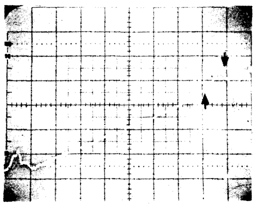
→ lmS/DIV



I_C: 1A/DIV

FIG. 9
START-UP: R5 = 560kΩ, C_8 = 5n6F
(SEE TEXT)

→ 2μs/DIV



I_C: 1.3A/DIV

FIG. 10
START-UP TRANSFORMER CORE SATURATION (SEE TEXT)
R_5 = 560 kΩ, C8 = 5n6F

POINTS TO NOTE:

* Turn-on transients should conform to FBSOA limits.
* Recommended $I_{b(off)} = 1.5\ I_{b(end)}$
* Collector current turn-off smooth with no 'tail'
* Collector voltage rising at 1000V/μs at turn-off
* Worst case turn-off locus should be within transient turn-off limits curve
* Storage and fall times determine maximum operating frequency
* TIPL parameters guaranteed to 100°C

2.3 Start-up

The first output pulse from the TDA4600 I.C. is of narrow pulse-width (∠ 5μs) but the subsequent pulses are circuit design/status dependent. The pulse width is dependent on the regulating feedback voltage at pin 3 and the values of resistor R5 and capacitor C8. Capacitor C8 charges up from a lower threshold voltage of 2V towards an upper threshold, which is the sum of the 4V reference and a negative regulating voltage feed-back to pin 3, via resistor R5. The charge time represents the pulse-width duration. If the feed-back has not been established on account of, say, poor transformer coupling, capacitor C8 will charge to the full 4V and this charge time is the absolute maximum pulse width capability of the circuit. In normal operation the maximum pulse width is shorter in duration.

During start-up, after the first pulse, any of the subsequent pulses could vary widely in pulse-width duration as it is circuit status dependent. Figure 9 shows a typical start-up I_C sequence, with R5/C8 component values as stated, for the system evaluated. The occasional large I_C spike represents a long pulse-width output from the I.C.

If the transformer core is selected for an $\hat{I}_C$ calculated from the design maximum pulse width, in this case,

$$t_{on} = \frac{0.28}{f_o} = \frac{0.28}{18 \times 10^3} = 15.5\mu s$$

and not the absolute maximum pulse width then, the transformer core could saturate. Figure 10 shows the occurrence of a pulse width (approximately 17.5μs), larger than the design value and the increase in I_C slope after 16μs indicates the transformer core saturating. Figures 9 and 10 were taken with a R5/C8 component time constant twice that shown in Figure 1 to illustrate the possibility of core saturation with longer time constants.

Transformer core saturation causes the collector current to increase much more rapidly. The base current continues to increase at its previous rate so demanding increasing dynamic h_{FE} from the transistor to remain saturated. Within a very short time the transistor runs out of gain and the collector voltage approaches the supply volts and the transistor operation could go beyond the FBSOA limits. This may result in transistor failure.

The solution is to determine the absolute maximum pulse width by calculating the charge time of C8 via R5 between 2V and 4V for the lowest rectified mains supply voltage, at which the TDA4600 becomes operational, and comprehend the resultant $\hat{I}_C$ in the transformer design. *Also, the transformer coupling should be tight to immediately establish the feedback circuit.*

POINTS TO NOTE:

* Possibility of pulse longer than design max. during start-up sequence
* Extra wide pulse widths give danger of core saturation, hence malfunction.

SOLUTIONS:

* Careful selection of R5/C8 components to limit the absolute maximum pulse width
* Comprehend resultant $\hat{I}_C$ in transformer design
* Tight primary/secondary coupling

2.4 Power Dissipation

The overall power dissipation is approximately 2.5W. The main areas of dissipation are during the turn-on (65% of total) and turn-off (23%) periods. This dissipation is low enabling a small heat-sink.

3.0 APPLICATIONS

This type of system is well matched to loads which vary *over a 3:1 range and transformer ratios of up to 4:1.*

With an $\hat{I}_C$ capability of 8A for the TIPL range discussed here, secondary power outputs of 160W are possible working on 70% conversion efficiency and a 25% operating safety margin for the transistor. This opens up a wide market. The following,

— V.C.R.'s, Video Monitors, CRT Deflection
— Audio: amplifiers, active speakers etc
— Electronic musical instruments: organs, pianos etc
— Computer systems: 24V floppy/Winchester drives, ± 12V memory boards, 5V logic circuits.
— Instrumentation: oscilloscopes, P.S.U.'s, analysers, etc
— Flash tubes in copying machines

are a few possibilities.

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GUARDING AGAINST REVERSE BIAS SECOND BREAKDOWN BY DESIGNING WITH TRANSIENT TURN-OFF LIMIT DATA

V. Bose & M. Maytum

Typically power transistors suffer the greatest stress when switching off with a predominantly inductive load. If a critical value of stress is exceeded reverse bias second breakdown occurs. The transient turnoff limit technique provides a powerful design method of evaluating safety margins for both repetitive and fault turnoff conditions.

1. Introduction

When a transistor, which has established current flow in an inductive load, tries to turn-off the collector-emitter voltage rises very rapidly due to the inductive back e.m.f. generated. This voltage opposes the supply voltage and is at any instant given by — $L di_L/dt$ where L is the inductance and di_L/dt is the rate of change of inductor current. The situation is further compounded by the transistor's switching speed being enhanced at higher voltage levels which further increases the back-e.m.f.

Failure of the transistor to support voltage levels below BV_{CEO} and possibly up to V_{CEV} during turn-off when negative (reverse) base drive is being applied is termed Reverse bias Second Breakdown. Once the mechanism is triggered the voltage across the transistor collapses rapidly and the transistor latches on. In the majority of cases the resulting energy dump from the circuit will be sufficient to destroy the transistor[1].

2. Methods of defining Reverse-bias Breakdown capability

The complex interaction between the transistor, the circuit configuration and the systems operating history dictates a graphical representation of Reverse-bias Breakdown capability to present it in the most general form. Ideally the circuit and the drive conditions used to define the capability should be as generalised as possible, or at least represent the worst case application. If the test circuit is too specific the designer is forced to emulate the test circuit in his system or make a judgement on how much safety margin he should allow for in his particular case.

2.1 Reverse-bias Energy Rating $E_{s/b}$

Strictly, this rating is not relevant to the present discussion but it is included on the ground that it was one of the first attempts to quantify breakdown and it is sometimes mistakenly used as an operating safe area indication.

Figure 1 shows the test circuit and figure 2 shows the resultant data.

In the test circuit the transistor is turned on by application of forward base current and the collector current builds up in a sawtooth manner, until a predetermined peak collector current I_C is reached. The forward drive is then removed and reverse drive applied. As the transistor switches off the inductive energy $E_{S/b} = \frac{1}{2} L I_C^2$ forces the transistor into BV_{CEX} breakdown and

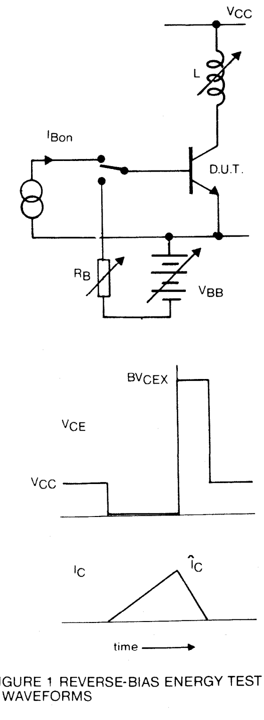


FIGURE 1 REVERSE-BIAS ENERGY TEST CIRCUIT & WAVEFORMS

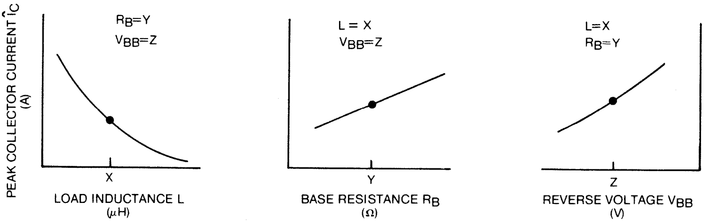


FIGURE 2. REVERSE BIAS ENERGY CURVES

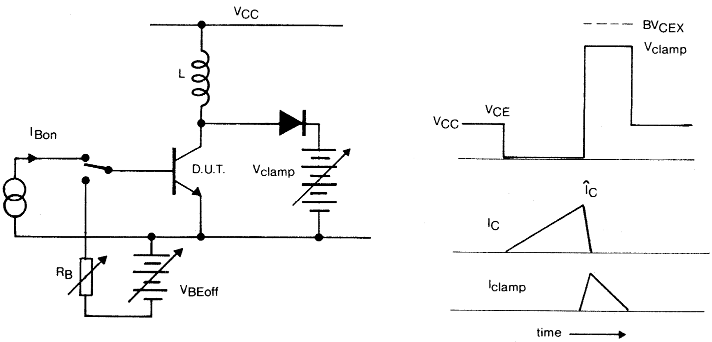


FIGURE 3. R.B.S.O.A. TEST CIRCUIT AND WAVEFORMS

maintains this condition until all the inductive energy has been dumped into the transistor. It will be noted that higher values of peak current $\hat{I}_C$, load inductance L, (both increasing energy) and reverse voltage V_{BB} and lower values of base resistance R_B (both increasing I_{Boff}) all decrease the energy capability. It should be noted that the collector current falltime is determined by the circuit and BV_{CEX}, *and not the normal switching speed of the* transistor.

This type of information is relevant for applications such as hammer drivers where minimum return time is required and the unclamped inductive energy is dumped into the transistor in a BV_{CEX} mode. However, in the majority of switching applications it is highly undesirable to break the transistors down in this manner and consequently this type of information is of limited value.

2.2 Clamped Reverse-bias Safe Operating Area (R.B.S.O.A.)

A voltage clamp added to the previous test circuit allows the bulk of the inductor's energy to be dumped into the clamp (Figures 3, 4). Hence the transistor only suffers the transient energy until the clamp voltage is reached.

The operation of Figure 3 circuit is exactly the same as the previous Figure 1 circuit until the voltage reaches V_{clamp} and then the clamp circuit progressively takes over the inductor's current during the collector current fall time.

Using a given set of circuit conditions and a set value of $\hat{I}_C$, V_{clamp} is progressively increased until failure occurs defining one of figure 4 loci. This test needs to be repeated for a larger number of transistors with different

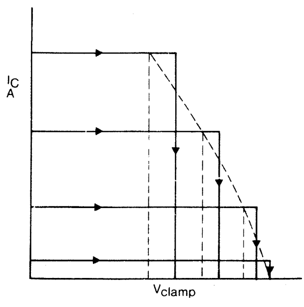


FIGURE 4. R.B.S.O.A. GENERATED FROM MULTIPLE SQUARE LOOPS

values of $\hat{I}_C$ to completely define the capabilities of that transistor family under the test configuration. After a safety inset the R.B.S.O.A. can be presented as a locus of the $\hat{I}_C$, V_{clamp} end points or as a series of steps where a coarser series of tests have been made.

Having described the usual method of R.B.S.O.A. generation it will be clear that it does not guarantee a transistor will survive a switching transient which takes the transistor around the periphery of the curve. Rather for a given value of $\hat{I}_C$ it defines the maximum allowable voltage which the transistor should be subjected to. This needs further qualification in that the R.B.S.O.A. drive conditions are implemented and other parts of the transistors operation do not materially effect the single shot R.B.S.O.A.

2.1 Drive Conditions

Typically systems will be designed so that under normal operation the transistor power loss is minimised; conditions such as start-up or overload would be evaluated later in the design. Optimised drive conditions leading to a fast "clean" collector current turn usually require I_{Boff} to be in the range of $\hat{I}_C/5$ to $\hat{I}_C/2.5$.

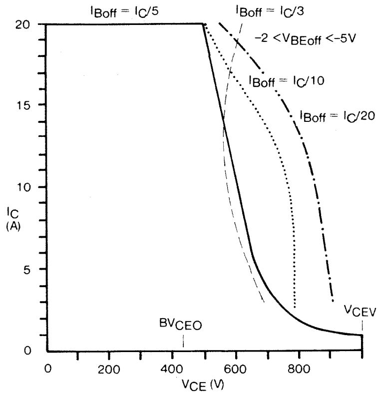


FIGURE 5—EFFECT OF I_{Boff} ON R.B.S.O.A.

Figure 5 shows the effect of I_C/I_{Boff} ratio on R.B.S.O.A. This illustrates the sensitivity of R.B.S.O.A. to I_{Boff}. Provided V_{BEoff} is greater than a few volts I_{Boff} is the key parameter. Changing from a ratio of 5 to 10 at I_C = 10A increases the $\hat{V}_{CE}$ by 150V, this however would be quite detrimental to the switching speed.

R.B.S.O.A. curves generated with a constant ratio of I_C/I_{Boff} tend to be the most pessimistic. In practice, if a transistor is switching optimised at I_C = 10A with I_C/I_{Boff} = 5, an overload to I_C = 20A will not increase I_{Boff} but reduce it due to the shorter storage time so that at 20A the I_C/I_{Boff} ratio would increase to, say, 20 giving an extra 50V on the rating at 20A. If the I_{Boff} current is reduced too far there is a danger the transistor could latch up in an BV_{CEO} mode if the fall time degrades too far.

It should be noticed that the dynamics of the switch-off period permit the transistor to switch off to above V_{CEO}. A similar situation is more widely known about turn-on where transistors can be switched on above V_{CEO} with no detrimental effects provided the over voltage period is relatively short.

Ideally the R.B.S.O.A. should be independent of base drive circuitry. In some "off" drive circuit configurations (such as open collector) with R_B = O, I_{Boff} can be of the same order as I_C. Under these conditions early emitter current cut off occurs and the fall-time degenerates into the collector-base diode t_{rr}. The level of I_{Boff} is highly dependent on "off" driver h_{FE} and usually V_{BEoff} as well. R.B.S.O.A. curves generated with this sort of drive circuit tend to be enhanced (compared with more normal methods) and have V_{BEoff} as the varying parameter.

R.B.S.O.A. curves with an I_{Boff} range of currents specified are probably more realistic for most applications provided the I_{Boff} range gives optimised drive conditions for the the transistors normal operating collector currents. Prudent designers will be looking for R.B.S.O.A. curves which characterise a transistor to its peak current rating (as the F.B.S.O.A. is) rather than its I_{CSat} measurement level.

The increasing use of antisaturation, (or more correctly reduced saturation), circuits mean in these applications less stored charge is present in the transistor and for a given value of I_{Boff} the R.B.S.O.A. is likely to be enhanced.

2.3 Transient Turn-Off Limit (T.T.O.L.)

To overcome the designer's dilemma that conventional R.B.S.O.A. is not really a safe area for all loci, Texas Instruments, after considerable research, have defined a Transient Turn-off Limit. A device operating within the area bounded by the T.T.O.L. locus will be safe from breakdown provided the recommended drive conditions are met. From the previous explanations it will be obvious that T.T.O.L. will be contained within the R.B.S.O.A as illustrated in figure 6. T.T.O.L. is also made more realistic by preconditioning the transistor prior to turn-off with operational stresses consistent with inductive switching applications.

For T.T.O.L. testing the R.B.S.O.A. test circuit has two modifications; one is that the supply voltage V_{CC} is much higher, and two, that a locus shaping circuit is added across the inductor L. As before, an iterative approach is used to define transistor limits which are then inset with a safety margin.

From a manufacturing viewpoint T.T.O.L. is a very powerful test since in a single operation it exercises the total transistor capability. R.B.S.O.A. can at best only be tested at a few selected points.

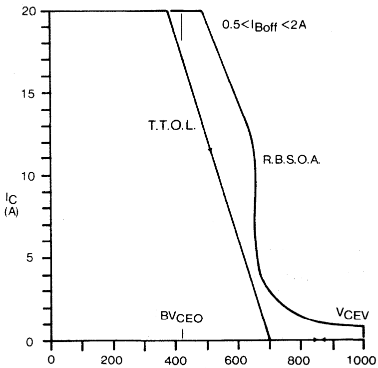
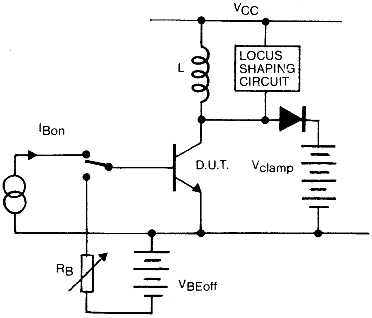


FIGURE 6—T.T.O.L. AND R.B.S.O.A. CURVES

GUARDING AGAINST REVERSE BIAS SECOND BREAKDOWN BY DESIGNING WITH TRANSIENT TURN-OFF LIMIT DATA



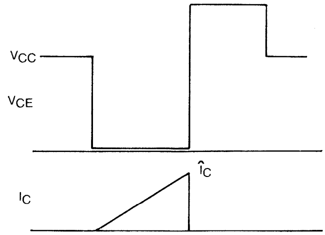


FIGURE 7—T.T.O.L. TEST CIRCUIT AND WAVEFORMS

3.1 Applications of T.T.O.L.
Designers wishing to take advantage of the TIPL power transistor range's reliability and consistency[2] in their established designs, can evaluate the system's transient V_{CE}/I_C locus by using a fast-writing storage oscilloscope in the X-Y mode, ensuring that the delay matching of the X and Y channels is better than tf/20.

Beam-Blanking techniques can be used to enhance the turn-off period. Alternatively V_{CE} and I_C turn-off waveforms can be displayed against time and a series of points plotted on the transistors T.T.O.L. System and T.T.O.L. drive compatability should be checked. Overall operation power dissipation is covered in Power Note 6.

Two types of loci usually result from these measurements—square loop and triangular.

3.2 Square loop (clamped) switching
Series and bridge type switching power systems typify square loop switching, i.e. during turn-off the V_{CE} rises to a maximum value before the current starts to decrease to zero, (figure 8).
The peak V_{CE} on the transistor will also be the same as the supply voltage V_S and, although not strictly necessary in switching applications, many designers will set the minimum V_{CEO} to this value. As the T.T.O.L. normally has its "knee" in this region fault conditions can be allowed up to the peak I_C for the transistor. Even though the normal R.B.S.O.A. is formed with this type of switching locus the T.T.O.L. is a more relevant curve as it comprehends device pre-conditioning due to previous operations.

3.3 Triangular loop switching
In this situation a "snubber" circuit provides an alternative path for the inductive current during the voltage rise at switch off allowing the transistor to be completely "off" by the time peak voltage is reached (figure 8). The "snubber" network could, at its simplest, be a capacitor across the transistor, or, in its more sophisticated forms, a resistor/diode/capacitor combination and ultimately elaborate diode/capacitor/inductor "non-dissipative" varieties.

3.4 Special Cases
When transistors are paralleled or used in Darlington configurations differences in storage times force the slowest transistor to take over the full load current during the latter part of its storage time and for the fall time.

In the Darlington case the increase might only be 20% but paralleled devices could suffer 100% for two, 200% for three etc. Another case when the collector current could increase during turn off is when series connected transistors in bridge configuration have no "dead time" between the on and offs.

4.0 Conclusion
The T.T.O.L. is an improved version of the normal R.B.S.O.A. and is generated under realistic operating conditions. Designers may use this curve confident in the knowledge that it represents a "real" safe area specified up to the peak transistor ratings.

References
(1) "Inductive Switching of High Voltage Transistors." A. Lear, New Electronics, 10 July 1979.
(2) "TIPN1 — Improved Technology for Power Transistors." D. Colman
(3) "TIPN6 — Switching Losses, Which are the most significant?" V. Bose

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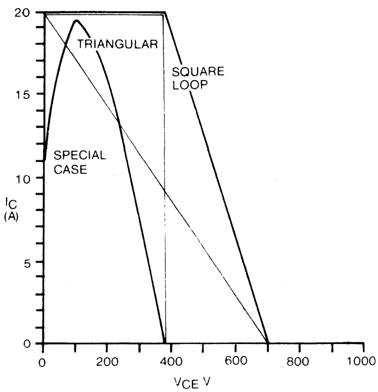

FIGURE 8—VARIOUS LOCI ON THE T.T.O.L.

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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: $I_C = I_{C2}$

$V_{CE} = V_{CE2}$

$T_C = 55^\circ C$ for $T_{J\,max} \leqslant 125^\circ C$

$T_C = 100^\circ C$ for $T_{J\,max} > 125^\circ C$

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:

$$T_C \leqslant T_{J\,max} - \frac{P_T}{P_{Tn}} (T_{J\,max} - 55°C) \quad \text{for } T_{J\,max} \leqslant 125°C$$

$$T_C \leqslant T_{J\,max} - \frac{P_T}{P_{Tn}} (T_{J\,max} - 100°C) \quad \text{for } T_{J\,max} > 125°C$$

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 $T_C = 55°C$ for $T_{J\,max} \leqslant 125°C$ or $T_C = 100°C$ for $T_{J\,max} > 125°C$.

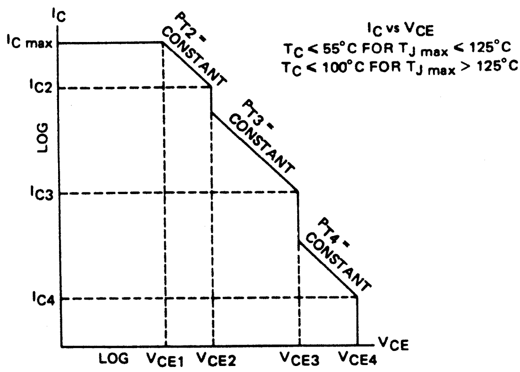


FIGURE 1

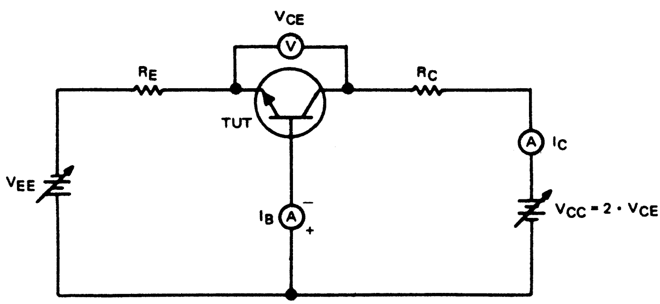


FIGURE 2

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:

$$I_{CQ1} = 2 \left(\frac{V_{BB2} + 1.5\ V}{R_{BB2}} + \frac{I_{C\,max}}{h_{FE\,min\,(TUT)}} \right)$$

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.

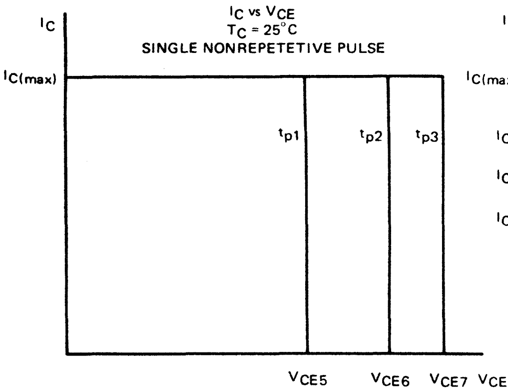


FIGURE 3

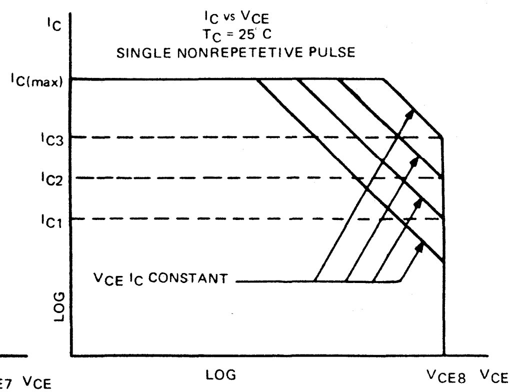


FIGURE 4

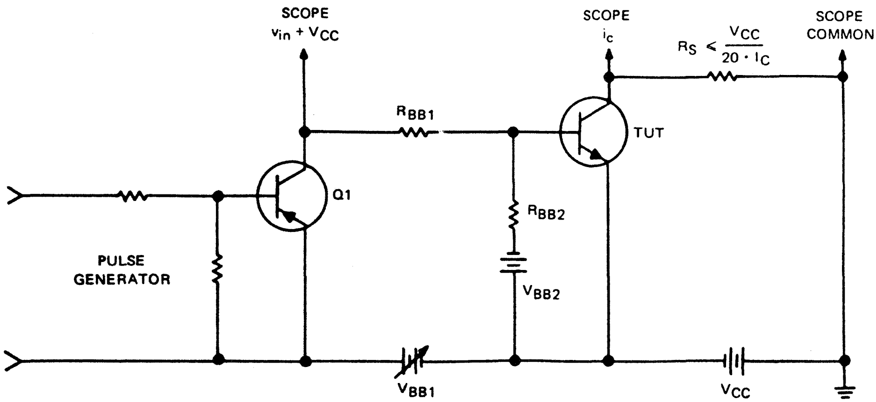


FIGURE 5

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:

$$T_C = 25°C$$
$$I_C = I_{C\ max}$$
$$V_{CE} = V_{CE\ max}$$
$$R_{BB1} = R_{BB1(1)}$$
$$R_{BB2} = R_{BB2(1)}$$
$$V_{BB1} = V_{BB1(1)}$$
$$V_{BB2} = V_{BB2(1)}$$

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.

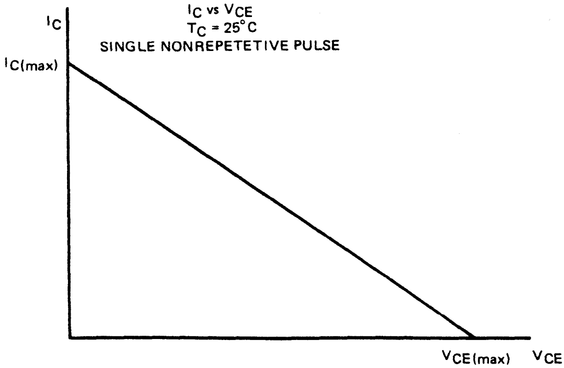


FIGURE 6

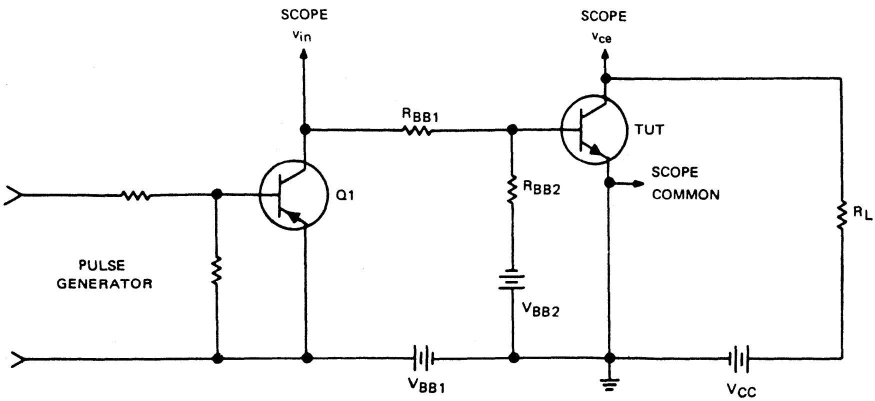


FIGURE 7

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 Operati~g Area of Figure 8 can be verified.

Test Precedure:

Test Point Example: $T_C = 25°C$

$I_C = I_{C\,max}$

$V_{CE} = V_{CE9}$

$R_L = R_{L1}$

$L = L_1$

$R_{BB1} = R_{BB1(1)}$

$R_{BB2} = R_{BB2(1)}$

$V_{BB1} = V_{BB1(1)}$

$V_{BB2} = V_{BB2(1)}$

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.

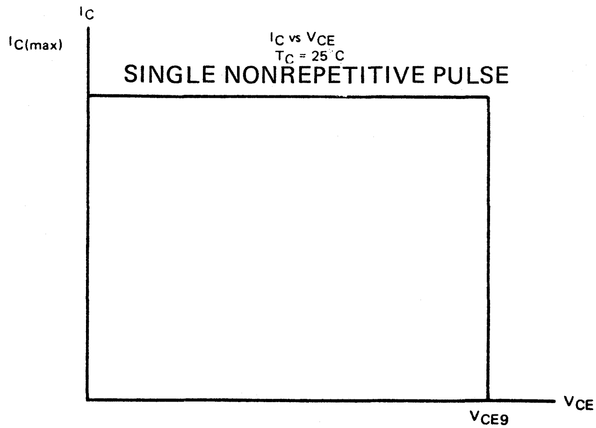


FIGURE 8

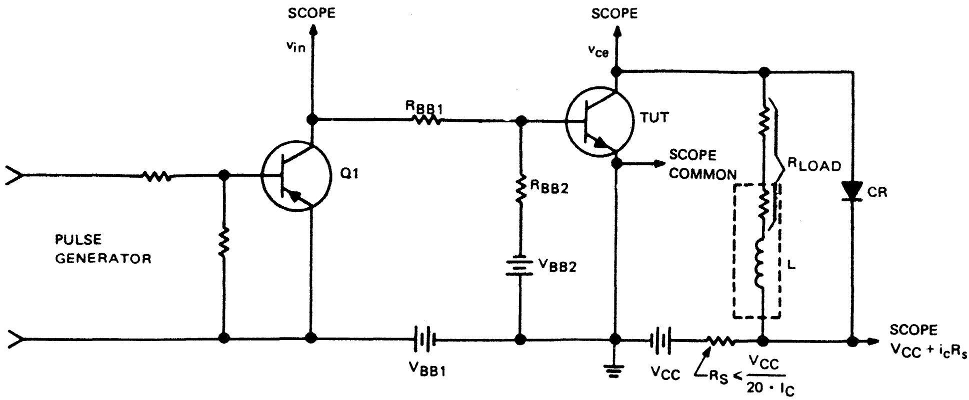


FIGURE 9

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 $V_{(BR)CEX} \gg V_{CC}$ 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: $T_C = 25°C$

$I_C = I_{C4}$

$V_{CC} = V_{CC2} \leq 15$ V

$R_L = R_{L2} \leq V_{CC2}/2I_{C4}$

$L = L_2$

$R_{BB1} = R_{BB1(2)}$

$R_{BB2} = R_{BB2(2)}$

$V_{BB1} = V_{BB1(2)}$

$V_{BB2} = V_{BB2(2)}$

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.

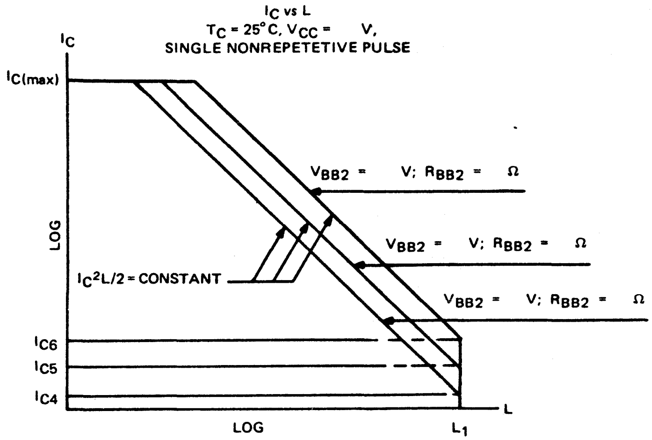


FIGURE 10

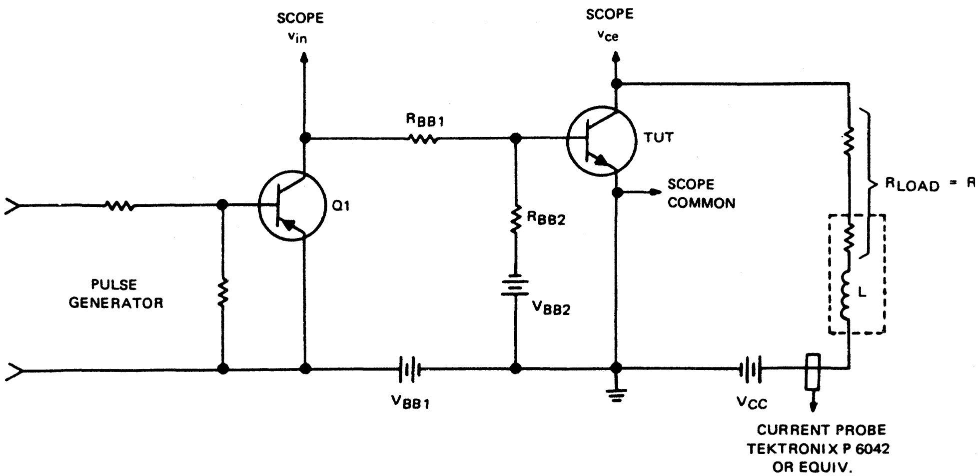


FIGURE 11

Temperature Derating for Pulsed Forward-Biased Operation and Switching

A safe maximum case temperature ($T_C \geq 25°C$) for a given I_C and average total power dissipation $P_{T(AVG)}$ due to repetitive pulses can be calculated as follows:

$$T_C \leq T_{J\,max} - \frac{I_C}{I_{Cn}}(T_{J\,max} - 25°C) - R_{\theta JC}\,P_{T(AVG)}$$

T_C = Case temperature

$T_{J\,max}$ = Maximum operating junction temperature.

I_C = Collector current during saturation

I_{Cn} = Maximum allowed collector current at $T_C = 25°C$

$R_{\theta JC}$ = Thermal resistance junction to case

$P_{T(AVG)}$ = Average total power dissipation

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.

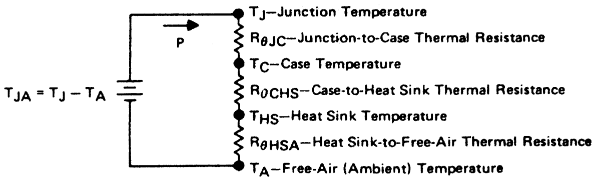


FIGURE 1

The corresponding thermal circuit for a device dissipating continuous power in free air is shown in Figure 2.

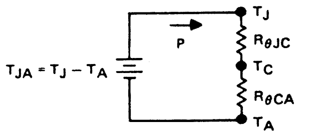


FIGURE 2

The most frequent thermal requirement which must be met is $T_J \leq T_{J(max)}$. For a given power dissipation this means the sum of all thermal resistances from junction-to-ambient must be:

$$R_{\theta JA} \leq \frac{T_{J(max)} - T_A}{P}$$

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.

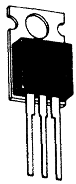
Case-to-Heat-Sink Thermal Resistance—$R\theta_{CHS}$.

$R\theta_{CHS}$ 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



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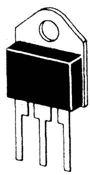
PLASTIC REPLACEMENT FOR TO-3



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CASE-TO-HEAT-SINK THERMAL RESISTANCE vs MOUNTING TORQUE

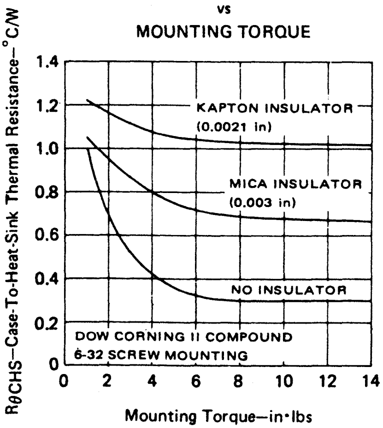


FIGURE 3

CASE-TO-HEAT-SINK THERMAL RESISTANCE vs MOUNTING TORQUE

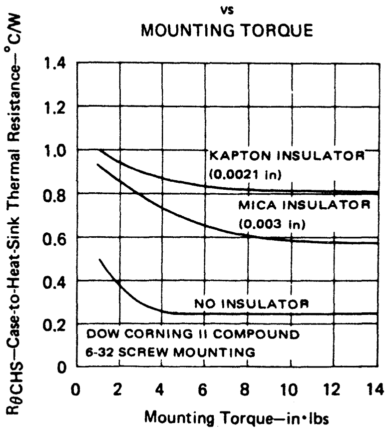


FIGURE 4

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 $R_{\theta JC} + R_{\theta CA}$.

Appendices

- TERMS, DEFINITIONS & TESTING PROCEDURES
- STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

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.

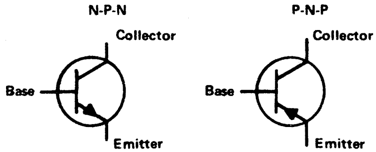
Power Transistor Terms and Definitions

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.

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 the 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 point on the appropriate characteristic curve. (Ref. IEEE #255 par. 2.2.1)
terminal	An externally available point of connection to one or more electrodes. (Ref. RS-282 par. 1.14)
thermal resistance (steady-state)	The temperature difference between two specified points or regions divided by the power dissipation under conditions of thermal 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.

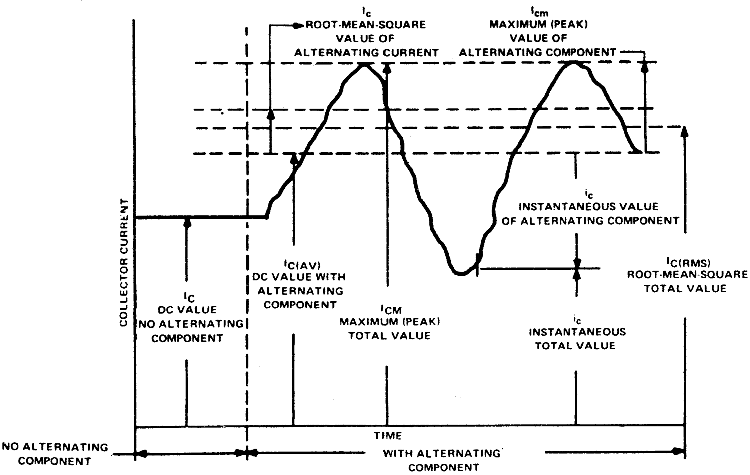


Power Transistor Letter Symbols, Terms, and Definitions

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 signal 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 base 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) component of the small-signal ac base-emitter voltage to the ac base current with the collector terminal 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 the small-signal ac base-emitter voltage to the ac base current with the collector terminal short-circuited to the emitter terminal for ac.
h_{oe}	small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to the small-signal ac collector-emitter voltage with the base 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)

TERMS AND DEFINITIONS
POWER TRANSISTORS

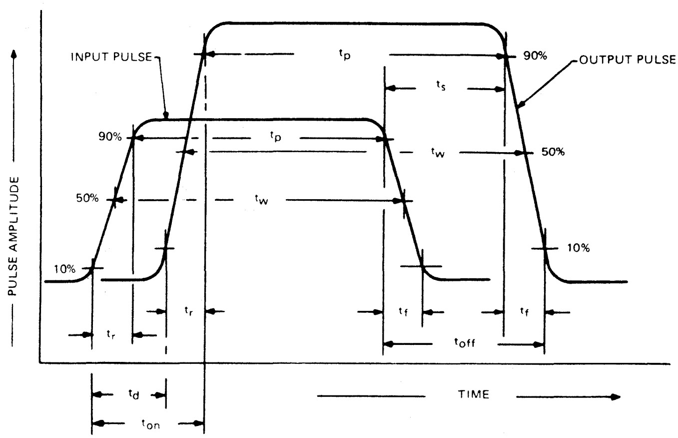
Symbol	Term	Definition
I_{CEO} I_{CER} I_{CES} I_{CEV} I_{CEX}	collector cutoff current, dc (base open resistance between base and emitter, base short-circuited to emitter, voltage between base and emitter, circuit between base and emitter)	The dc current into the collector terminal when it is biased 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_{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 and 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 input currents and voltages.
$r_b'C_c$	collector-base time constant	The product of the intrinsic base resistance and collector capacitance under specified small-signal conditions.

*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.

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)

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



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}) $V_{(BR)CER}$, (formerly BV_{CER}) $V_{(BR)CES}$, (formerly BV_{CES}) $V_{(BR)CEV}$, (formerly BV_{CEV}) $V_{(BR)CEX}$ (formerly BV_{CEX})	breakdown voltage, collector-to-emitter with (base open, resistance between base and emitter, base short-circuited to emitter, voltage between base and emitter, circuit between base and emitter)	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)
$V_{(BR)EBO}$, (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}, V_{BE}, V_{CB}, V_{CE} V_{EB}, V_{EC}	voltage, dc or average (base-to-collector, base-to-emitter, collector-to-base, collector-to-emitter, emitter-to-base, emitter-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).
$V_{BE(sat)}$	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.

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):
V_{CER}	resistance between base and emitter,	O = open-circuited.
V_{CES}	base short-circuited to emitter,	R = returned to the emitter terminal through a specified resistance.
V_{CEV}	voltage between base and emitter,	S = short-circuited to the emitter terminal.
		V = returned to the emitter terminal through a specified voltage.
V_{CEX}	circuit between base and emitter)	X = returned to the emitter terminal through a specified circuit.
$V_{CEO(sus)}$	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):
$V_{CER(sus)}$	resistance between base and emitter,	O = open-circuited
$V_{CES(sus)}$	base short-circuited to emitter,	R = returned to the emitter terminal through a specified resistance
$V_{CEV(sus)}$	voltage between base and emitter,	S = short-circuited to the emitter terminal
$V_{CEX(sus)}$	circuit between base and emitter)	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.
$V_{EB(fl)}$	dc open-circuit voltage (floating potential) (emitter-to-base)	The dc open-circuit voltage (floating potential) between the emitter terminal and the base terminal 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.

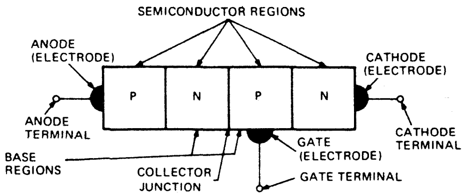
NOTE: Although not an official definition, the term unidirectional is sometimes used to describe the single switching class of thyristors consisting of reverse-blocking and reverse-conducting thyristors. This term is useful for comparing or contrasting this class of thyristor with bidirectional thyristors.

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

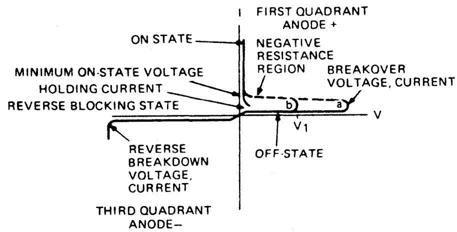
A thyristor which can be switched from the on-state to the off-state and vice versa by applying control signals of appropriate polarities to the gate terminal, with the ratio of triggering power to triggered power appreciably less than one.



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.

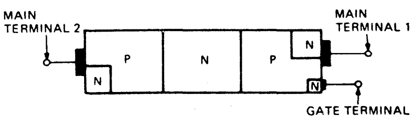
FIGURE 1



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.

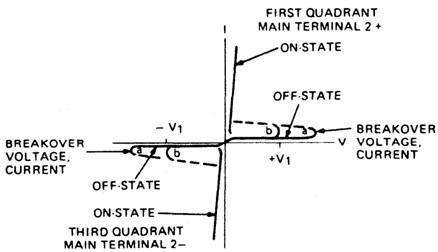
FIGURE 2



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 $\pm V_1$.

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., $n\text{-}n^+$, p-n, $p\text{-}p^+$ 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.

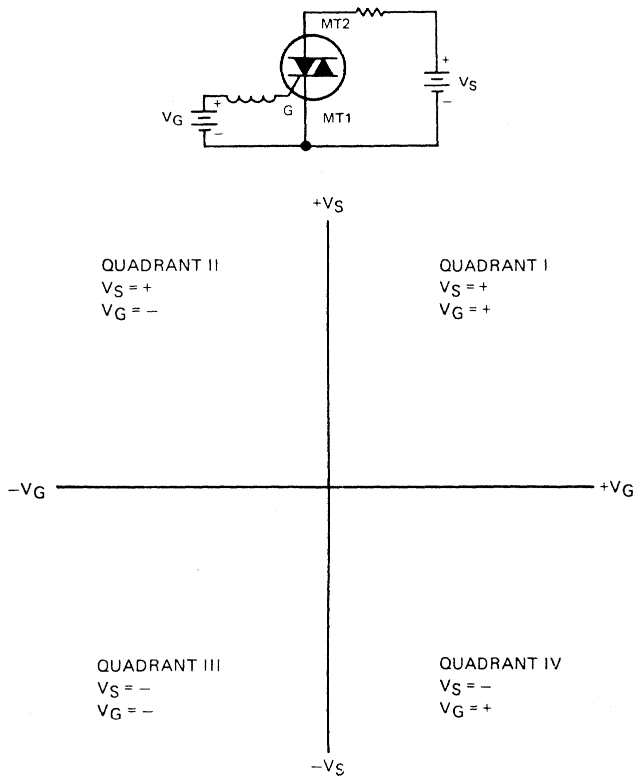
Reverse-Blocking Impedance (of a Reverse-Blocking Thyristor)

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

Symbols, Terms and Definitions

Symbol	Term	Definition
$I_{(BO)}$ $i_{(BO)}$	Static Breakover Current Instantaneous Breakover Current	The principal current at the breakover point.
$I_{(BR)R}$ $i_{(BR)R}$	Static Reverse Breakdown Current Instantaneous Reverse Breakdown Current	The principal current at the reverse breakdown voltage.
$I_{D(RMS)}$ I_D $I_{D(AV)}$ i_D I_{DM}	RMS Off-State Current Static Off-State Current Average Off-State Current Instantaneous Off-State Current Peak Off-State Current	The principal current when the thyristor is in the off-state.
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 $I_{G(AV)}$ i_G I_{GM}	Static Gate Current Average Gate Current Instantaneous Gate Current Peak 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_{GD} i_{GD} I_{GDM}	Static Gate Nontrigger Current Instantaneous Gate Nontrigger Current Peak Gate Nontrigger Current	The maximum gate current which will not cause the thyristor to switch from the off-state to the on-state.
I_{GQ} i_{GQ} I_{GQM}	Static Gate Turn-Off Current Instantaneous Gate Turn-Off Current Peak Gate Turn-Off Current	The minimum gate current required to switch a thyristor from the on-state to the off-state.
I_{GT} i_{GT} I_{GTM}	Static Gate Trigger Current Instantaneous Gate Trigger Current Peak Gate Trigger Current	The minimum gate current required to switch a thyristor from the off-state to the on-state.

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	

Symbol	Term	Definition
T_A	Free-Air Temperature (Ambient 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 (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 defice, without any power applied, is stored. (Ref. MIL-S-19500D par. 20.20.3)
t_{gt}	Gate-Controlled Turn-On Time	The time interval between a specified point at the beginning of the gate pulse and the instant when the principal voltage (current) has dropped (risen) to a specified low (high) value during switching of a thyristor from the off-state to the on-state by a gate pulse.
t_{gq}	Gate-Controlled Turn-Off Time	The time interval between a specified point at the beginning of the gate pulse and the instant when the principal current has decreased to a specified value during switching from the on-state to the off-state by a gate pulse.
t_q	Circuit-Commutated Turn-Off Time	The time interval between the instant when the principal current has decreased to zero after external switching of the principal voltage circuit, and the instant when the thyristor is capable of supporting a 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 the 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-off 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 trigger 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 reverse voltage which occurs across the thyristor, including all repetitive transient voltages, but excluding all nonrepetitive transient voltages.
V_{RSM}	Nonrepetitive Peak Reverse Voltage	The maximum instantaneous value of any nonrepetitive transient reverse voltage which occurs across a thyristor.
V_{RWM}	Working Peak Reverse Voltage	The maximum instantaneous value of the reverse voltage which occurs across the thyristor, excluding all repetitive and nonrepetitive transient voltages.
$V_{T(RMS)}$	RMS On-State Voltage	The principal voltage when the thyristor is in the 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)

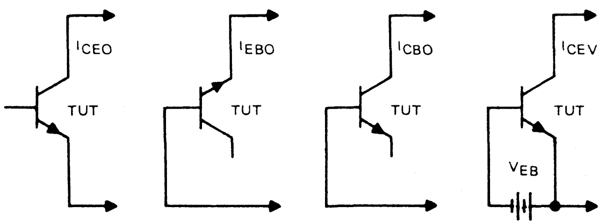
"P" – Pulsed by a 300 μs, 2% duty cycle pulse

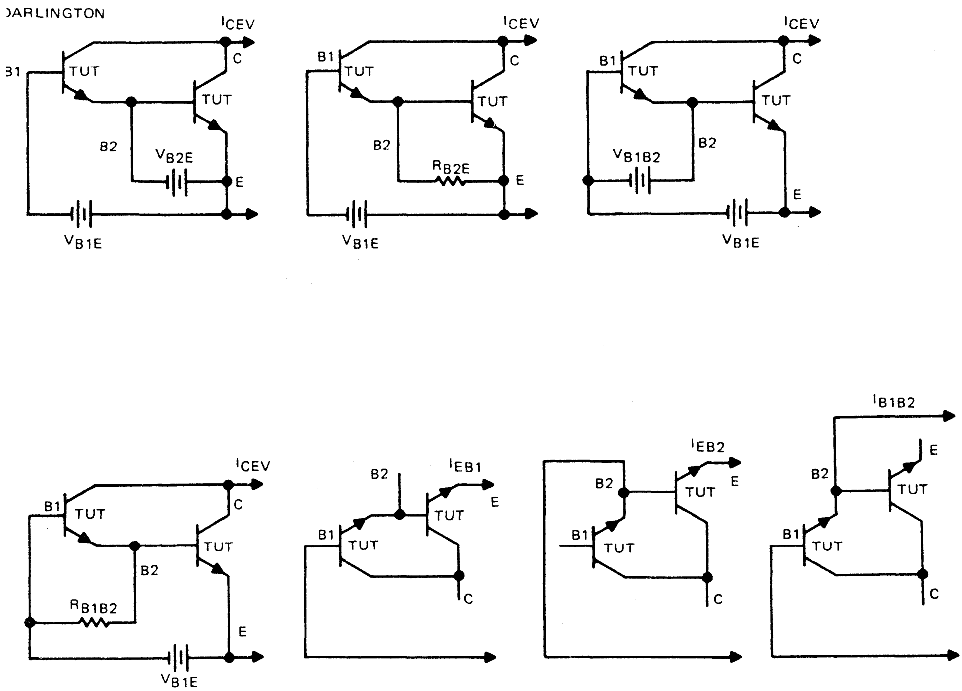
CUT-OFF CURRENT [I_{CEO}, I_{EBO}, I_{CBO}, I_{CEV}, I_{EB1}, I_{EB2}, I_{B1B2}]

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.

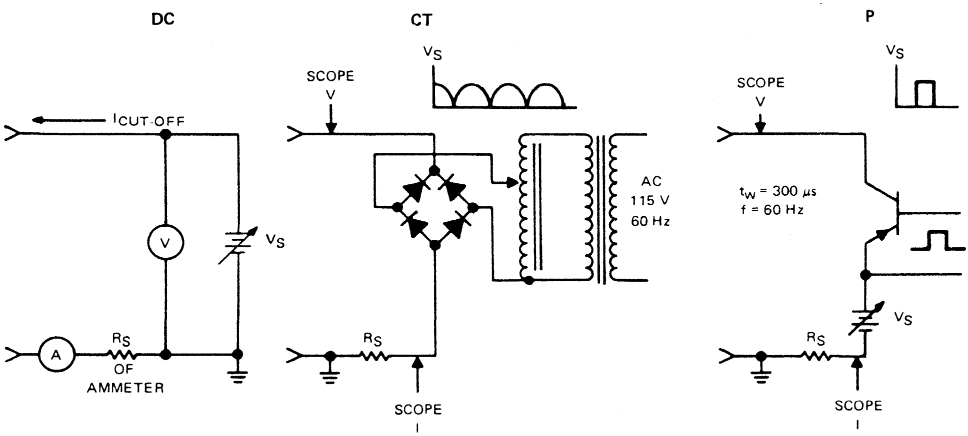
Transistor Connections





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 in the pulse test circuit has to be small compared to the measured cut-off current. The cut-off current is measured with an ammeter or with an oscilloscope.



Test Conditions to be Specified

Case temperature if not T_C = 25°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}

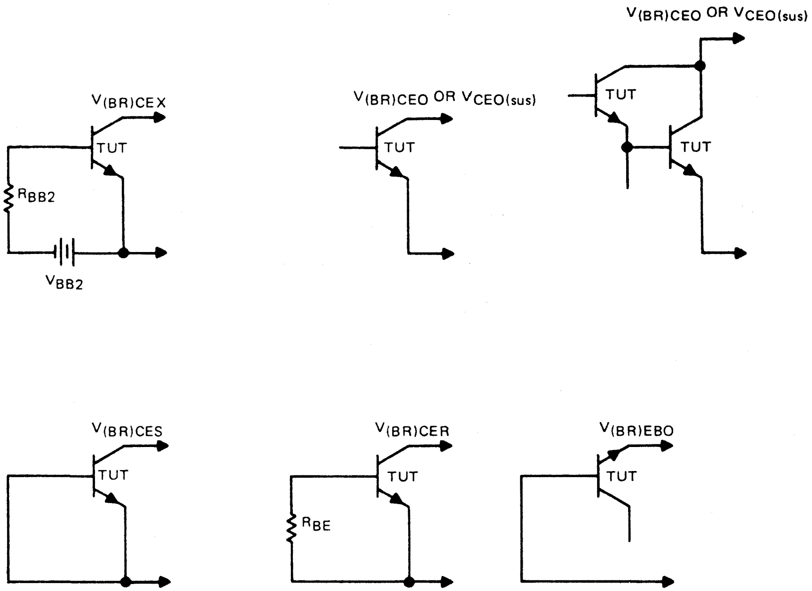
Technique: DC, CT, P

BREAKDOWN VOLTAGE [$V_{(BR)CEX}$, $V_{(BR)CEO}$ OR $V_{CEO(sus)}$, $V_{(BR)CES}$, $V_{(BR)EBO}$, $V_{(BR)CER}$]

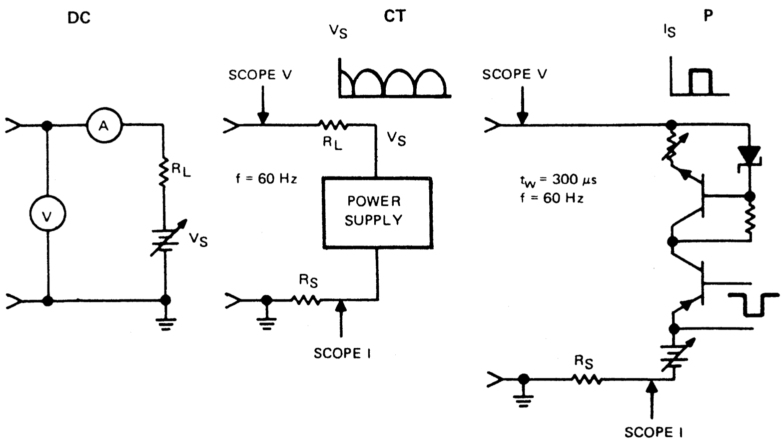
Description

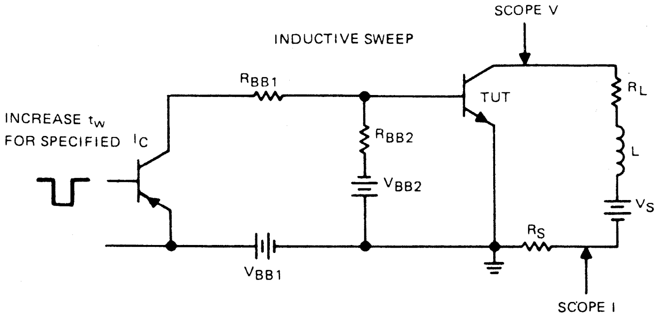
For breakdown measured in the sustaining region, the current should be high enough to ensure that the breakdown voltage is relatively insensitive to current changes.

Transistor Connections



Test Circuits





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

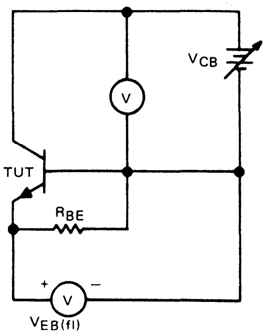
FLOATING POTENTIAL [$V_{EB(fl)}$]

Description

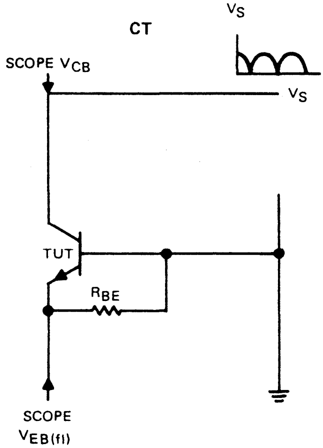
This measurement is related to the thickness of the base region.

Test Circuit

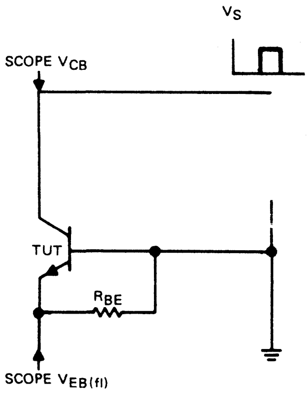
DC



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}

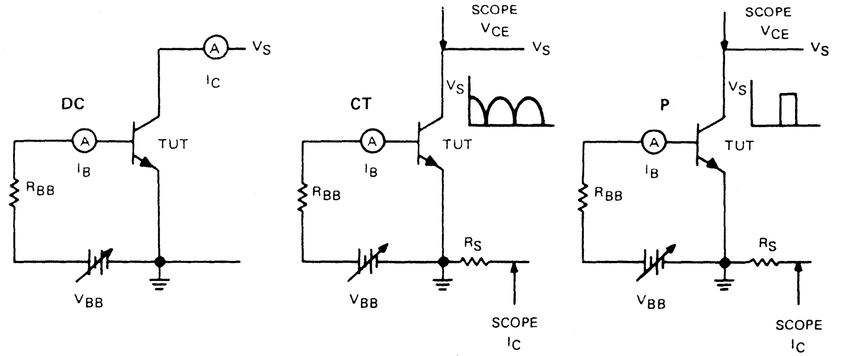
Technique: DC, CT, P

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}.

*ΔV_{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

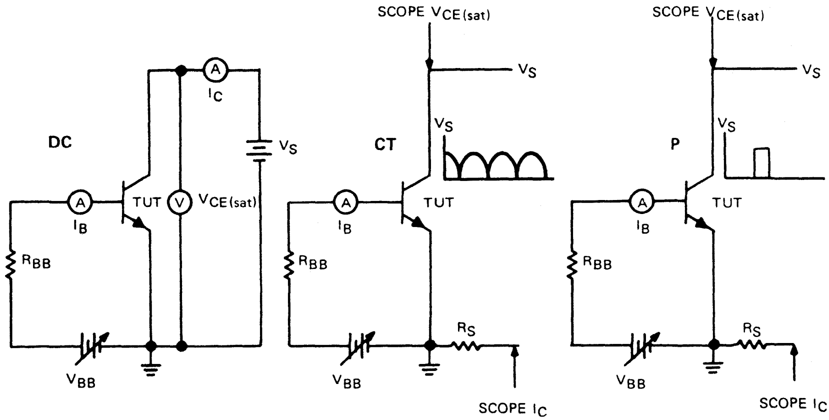
SATURATION VOLTAGE [$V_{CE(sat)}$]

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.

ELECTRICAL CHARACTERISTIC TESTS

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

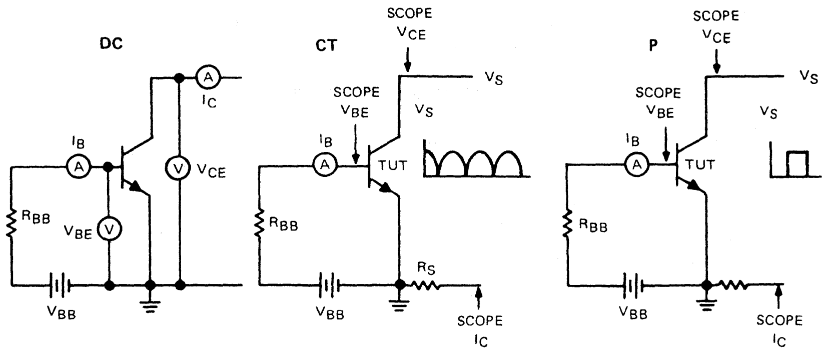
BASE-TO-EMITTER VOLTAGE [V_{BE}]

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}

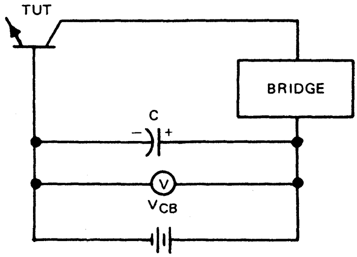
Technique: DC, CT, P

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 $T_C = 25°C$

Collector-to-base voltage: V_{CB}

Frequency: f

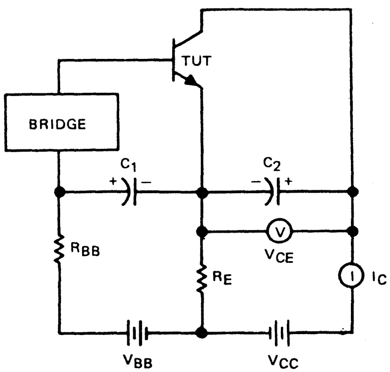
SMALL-SIGNAL SHORT-CIRCUIT INPUT IMPEDANCE [h_{ie}, $h_{ie(real)}$, $h_{ie(imag)}$]

Description

The input impedance is $h_{ie} = V_{be}/I_b$ with $V_{ce} = 0$. The real and imaginary components are important for input matching networks.

Circuits

Capacitors C1 and C2 must represent a short-circuit at the measuring frequency. The bridge must be nulled with a short across the base and emitter terminals and $V_{BB} = 0$. When h_{ie} is measured at 1 kHz, I_b can be measured with 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

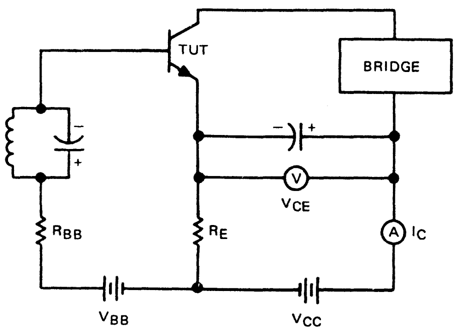
Frequency: f for $h_{ie(real)}$ and $h_{ie(imag)}$

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.

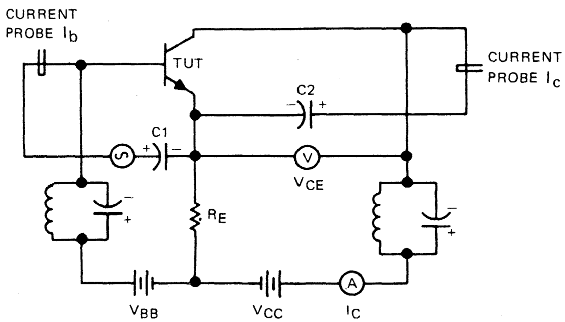
$h_{fe} = I_c/I_b$ (with $V_{ce} = 0$) at low frequency.

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_b 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 to 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

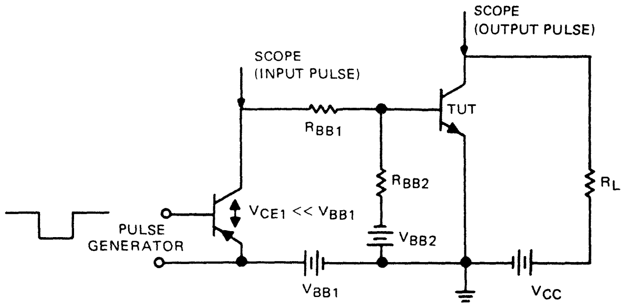
For h_{fe} and f_T only: f

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°C

V_{BB1}, V_{BB2}, V_{CC}, R_{BB1}, R_{BB2}, R_L, t_w and f of pulse generator.

Standard Mounting Hardware for Power Semiconductors

STANDARD MOUNTING HARDWARE FOR POWER SEMICONDUCTORS

This section identifies those standard hardware kits which may be 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.

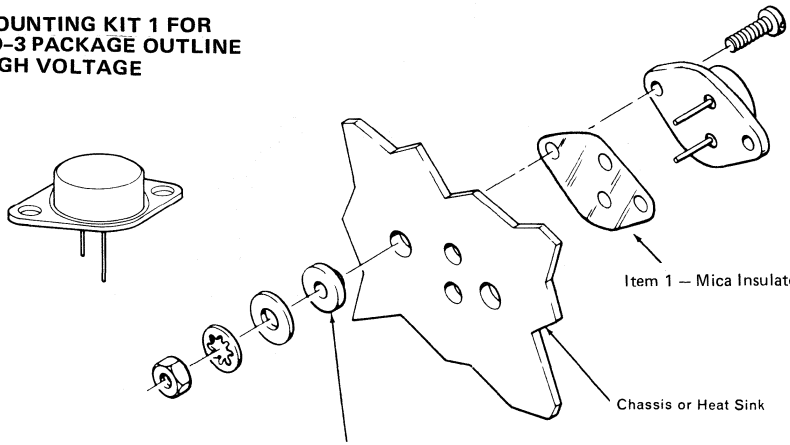
DIRECTORY

OUTLINE	KIT No.
TO - 3 (HIGH VOLTAGE)	1
TO - 218	2
TO - 220	3

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.

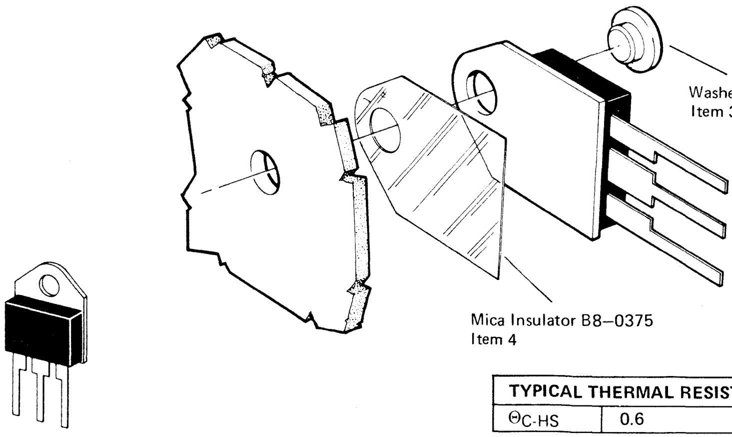
MOUNTING KIT 1 FOR TO-3 PACKAGE OUTLINE HIGH VOLTAGE



TYPICAL THERMAL RESISTANCE			
TO-3	θ_{C-HS}	1·5	deg/W

FIGURE 1

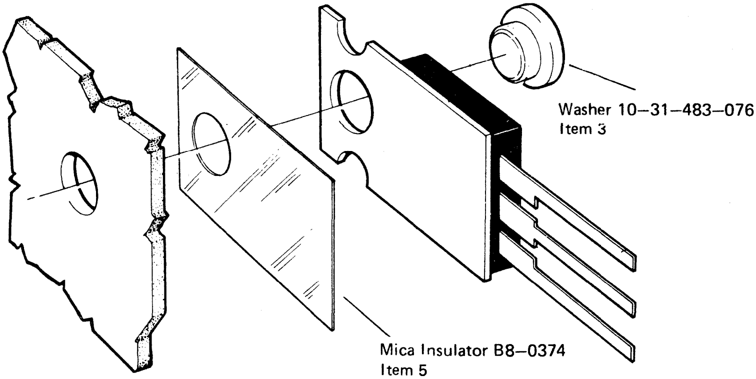
MOUNTING KIT 2 FOR TO-218 PACKAGE OUTLINE

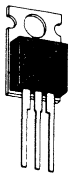


TYPICAL THERMAL RESISTANCE		
Θ_{C-HS}	0.6	deg C/W

FIGURE 2

MOUNTING KIT 3 FOR TO-220 PACKAGE OUTLINE

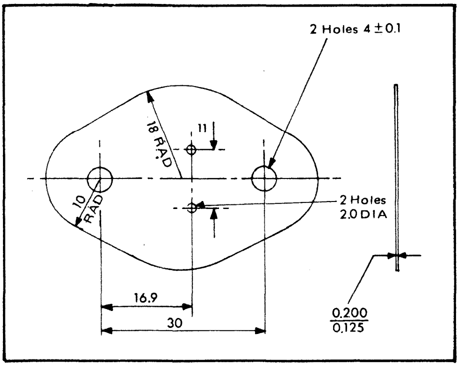




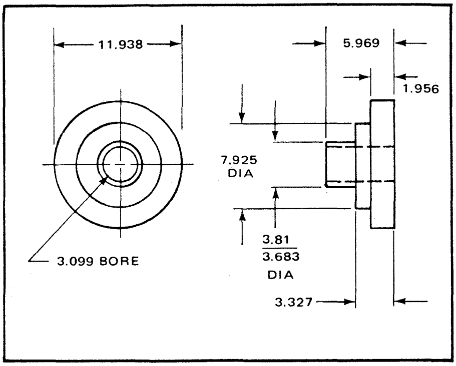
TYPICAL THERMAL RESISTANCE		
$\Theta_{C\text{-}HS}$	0.7	deg C/W

FIGURE 3

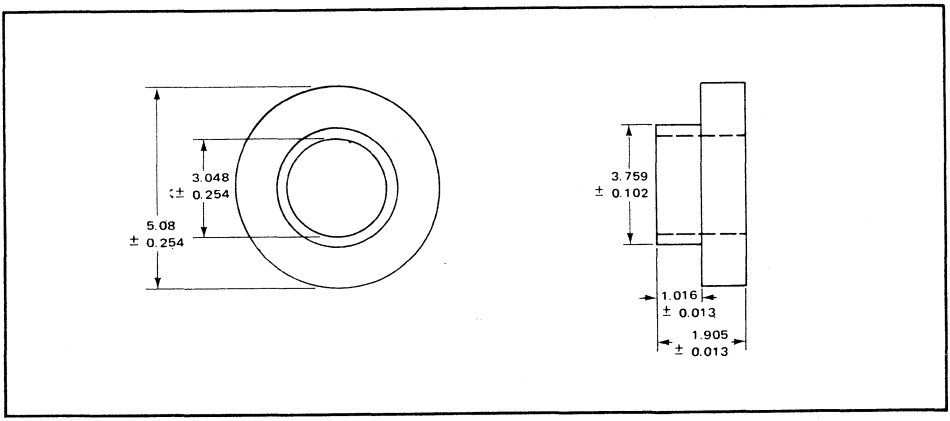
Section B — Mechanical Drawings of Hardware Items†



Item 1 INSULATOR

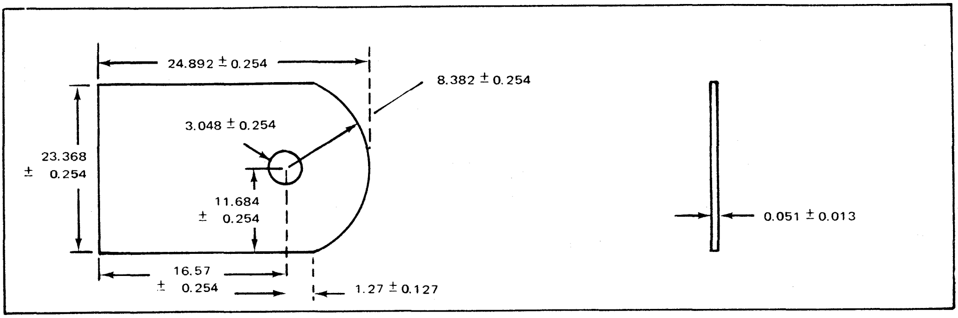


Item 2 INSULATOR SHOULDER WASHER

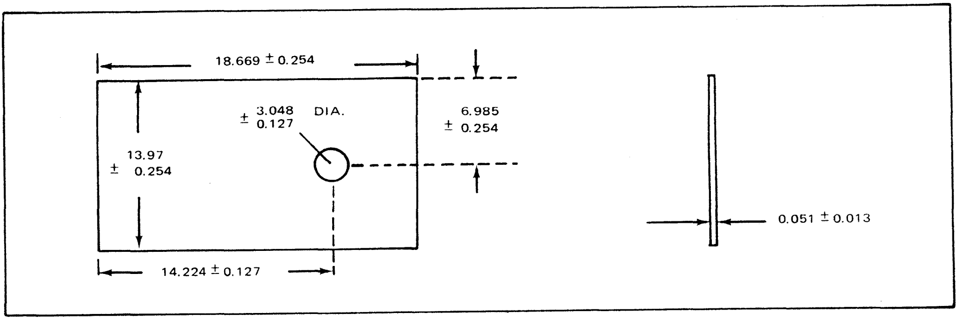


Item 3 WASHER

† All dimensions are in mm unless otherwise stated



Item 4 INSULATOR



Item 5 INSULATOR