

ALPHANUMERIC INDEX — CROSS-REFERENCE (Continued)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
KS8744A		MJE171	3-862	MJ10005	MJ10005		3-576
KS8772		MJE170	3-862	MJ10006	MJ10006		3-582
KS8794		MJE701	3-888	MJ10007	MJ10007		3-582
KS8795		MJE703	3-888	MJ10008	MJ10008		3-588
KS8834		2N6125	3-154	MJ10009	MJ10009		3-588
KSC1507		MJE2360T	3-900	MJ1001	MJ1001		3-528
KSC1520		MJE3440	3-908	MJ10011	MJ10011		3-594
KSC1520A		MJE2360T	3-900	MJ10012	MJ10012		3-596
KSC2073		MJE15030	3-972	MJ10013	MJ10014		3-600
KSC2233		TIP41C	3-1083	MJ10014	MJ10014		3-600
KSC2233		TIP41C	3-1083	MJ10015	MJ10015		3-606
KSC2334		MJE15028	3-972	MJ10016	MJ10016		3-606
KSC2335		MJE13007	3-950	MJ10020	MJ10020		3-611
KSC2517		TIP41C	3-1083	MJ10021	MJ10021		3-611
KSC2888		MJE3439	3-908	MJ10022	MJ10022		3-617
KSC2890		MJE340	3-876	MJ10023	MJ10023		3-617
KSC2890A		MJE340	3-876	MJ10024	MJ10024		3-623
KSC2749		MJH16008	3-742	MJ10025	MJ10025		3-623
KSC2752		2N5657	3-109	MJ10044		MJ10016	3-606
KSD288		TIP41A	3-1083	MJ10047		MJ10021	3-611
KSD362		D44H11	3-518	MJ10048		MJ10021	3-611
KSD363		MJE15028	3-972	MJ105		MJ12003	3-642
KSD401		MJE15030	3-972	MJ11011	MJ11011		3-629
KSD526		2N6122	3-154	MJ11012	MJ11012		3-629
KSD560		SE9302	—	MJ11013	MJ11013		3-629
KSD568		D44H11	3-518	MJ11014	MJ11014		3-629
KSD569		D44H11	3-518	MJ11015	MJ11015		3-629
KSD708		D45H11	3-518	MJ11016	MJ11016		3-629
KSD73		D44H8	3-518	MJ11017	MJ11017		3-631
KSD794		MJE180	3-862	MJ11018	MJ11018		3-631
KSD794A		MJE181	3-862	MJ11019	MJ11019		3-631
KSD818		MJH16032	3-984	MJ11020	MJ11020		3-631
KSD819		MJH16032	3-984	MJ11021	MJ11021		3-631
KSD820		MJH16032	3-984	MJ11022	MJ11022		3-631
KSD821		MJH16032	3-984	MJ11028	MJ11028		3-635
KSD868		MJH16032	3-984	MJ11029	MJ11029		3-635
KSD869		MJH16032	3-984	MJ11030	MJ11030		3-635
KSD870		MJH16032	3-984	MJ11031	MJ11031		3-635
KSD871		MJH16032	3-984	MJ11032	MJ11032		3-635
KSD880		2N6122	3-154	MJ11033	MJ11033		3-635
KSD882		MJE180	3-862	MJ1200		2N6300	3-147
KSD985		MJE801	3-888	MJ12002	MJ12002		3-637
KSD986		MJE803	3-888	MJ12003	MJ12003		3-642
MDS1678		MJE181	3-862	MJ12004	MJ12004		3-644
MDS20		2N5655	3-109	MJ12005	MJ12005		3-650
MDS21		2N5656	3-109	MJ12005D	MJ12005D		3-652
MDS26		MJE180	3-862	MJ1201		2N6301	3-147
MDS27		MJE181	3-862	MJ12010	MJ12010		3-658
MDS60		MJE350	3-880	MJ12020	MJ12020		3-660
MDS73		MJE171	3-862	MJ12021	MJ12021		3-660
MDS74		MJE172	3-862	MJ12022	MJ12022		3-660
MDS75		MJE253	3-870	MJ13010		2N6547	3-225
MDS76		MJE181	3-862	MJ13014	MJ13014		3-670
MDS77		MJE171	3-862	MJ13015	MJ13015		3-670
MJ1000	MJ1000		3-528	MJ13018		MJ13330	3-694
MJ10000	MJ10000		3-564	MJ13019		MJ13331	3-694
MJ10001	MJ10001		3-564	MJ13070	MJ13070		3-676
MJ10002	MJ10002		3-570	MJ13071		MJ16002	3-726
MJ10003		MJ10002	3-570	MJ13080	MJ13080		3-682
MJ10004	MJ10004		3-576	MJ13081		MJ16006	3-742

*Consult Motorola if a direct replacement is necessary.

TABLE 1 — METAL TO-204, TO-204AE (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min	Device Type		h _{FE} Min/Max	@ I _C Amp	Resistive Switching			f _T MHz Min	P _D (Case) Watts @ 25°C
		NPN	PNP			t _s μs Max	t _f μs Max	@ I _C Amp		
10	250	MJ15011	MJ15012	20/100	2					200
	300	MJ3041##		250 min	2.5					175
	325	MJ413 MJ423 MJ431		20/80 30/90 15/35	0.5 1 2.5				2.5 2.5 2.5	125 125 125
	350	BU323## MJ3042## MJ13014 MJ10002## MJ10006##		150 min 250 min 8/20 3/300 30/300	6 2.5 5 5 5	7.5 typ 2 2.5 1.5	5.2 typ 0.5 1 0.5	6 5 5 5	10# 10#	175 175 150 150 150
	400	BU323A## MJ10007## MJ10012## MJ13015		150 min 30/300 100/2k 8/20	6 5 6 5	7.5 typ 1.5 15 2	5.2 typ 0.5 15 0.5	6 5 6 5	10#	175 150 175 150
	600	MJ10014##		10/250	10	2.5	0.8	10		175
	700	MJ8504		7.5 min	1.5	4	2	5		175
	800	MJ8505 MJ16018		7.5 min 4 min	1.5 5	4 4.5 typ	2 0.2 typ	5 5		175 150
	950*	MJ12010		4.2 min	5		1	5		100
12	60	2N6057##	2N6050##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
	80	2N6058##	2N6051##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
	100	2N6059##	2N6052##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
15	60	2N3055 2N3055A 2N6576## 2N5881	MJ2955 MJ2955A 2N5879	20/70 20/70 2k/20k 20/100	4 4 4 6	0.7 typ 2 1	0.3 typ 7 0.8	4 10 6	2.5 0.8 10-200# 4	115 115 120 160
	80	2N5882	2N5880	20/100	6	1	0.8	6	4	160
	90	2N6577##		2k/20k	4	2	7	10	10-200#	120
	120	MJ15015 2N6578##	MJ15016	20/70 2k/20k	4 4	2	7	10	1 10-200#	180 120
	140	MJ15001	MJ15002	25/150	4				2	200
	150	MJ11018##	MJ11017##	100 min	15				3#	175
	200	BUX41 2N6249 MJ11020##	MJ11019##	8 min 10/50 100 min	8 10 15	1.5 3.5	0.4 1	8 10	8 2.5 3#	120 175 175
	250	MJ11022##	MJ11021##	100 min	15				3#	175
	275	2N6250		8/50	10	3.5	1	10	2.5	175
	300	2N6546		6/30	10	4	0.7	10	6 to 24	175
	325	BUX13		8 min	8	2.5	0.8	8	8	150
	400	BUX48 2N6547 MJ13090 MJ16110		8 min 6/30 8 min 6/20	10 10 10 15	2 4 2.5 0.8 typ	0.4 0.7 0.5 0.1 typ	10 10 10	6 to 24	175 175 175 175
	450	BUX48A MJ16010		8 min 5 min	8 15	2 1.2 typ	0.4 0.2 typ	10 10		175 175

* V(BR)CEX. # |h_{FE}| @ 1 MHz, ## Darlington

(continued)

 JAN, JTX, JTXV Available

TABLE 12 — POWER DARLINGTONS (continued)

I _C Cont Amps Max	V _{CE(sus)} Volts Min	Device Type		h _{FE} Min/Max	@ I _C Amp	Resistive Switching			h _{fe} @ 1 MHz Min	P _D (Case) Watts @ 25°C	Case JEDEC/MOT
		NPN	PNP			t _s μs Max	t _f μs Max	@ I _C Amp			
10	400	MJ10012		100/2k	6	15	15	6		175	TO-204/1
	600	MJ10014●		10/250	10	2.5	0.8	10		175	TO-204/1
12	60	2N6057	2N6050	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	80	2N6058	2N6051	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	100	2N6059	2N6052	750/18k	6	1.6 typ	1.5 typ	6		150	TO-204/1
	1000	BUT16●		5 min	8	3.3	1.5	8		150	TO-204/1
15	60	2N6576		2k/20k	4	2	7	10	10/200	120	TO-204/1
	90	2N6577		2k/20k	4	2	7	10	10/200	120	TO-204/1
	120	2N6578		2k/20k	4	2	7	10	10/200	120	TO-204/1
	150	MJ11018 MJH11018	MJ11017 MJH11017	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	200	MJ11020 MJH11020	MJ11019 MJH11019	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	250	MJ11022 MJH11022	MJ11021 MJH11021	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	500	BUT51P		40 min	5	1.1	0.16	10		125	TO-218/340D
20	60	2N6282 MJH6282	2N6285 MJH6285	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	80	2N6283 MJH6283	2N6286 MJH6286	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	100	2N6284 MJH6284	2N6287 MJH6287	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	350	MJ10000 MJ10004●		40/400 40/400	10 10	3 1.5	1.8 0.5	10 10	10 10	175 175	TO-204/1 TO-204/1
	400	MJ10001 MJ10005●		40/400 40/400	10 10	3 1.5	1.8 0.5	10 10	10 10	175 175	TO-204/1 TO-204/1
	450	MJ10008●		30/300	10	2	0.6	10	8	175	TO-204/1
	500	MJ10009●		30/300	10	2	0.6	10	8	175	TO-204/1
	700	BUT15●		15 min	12	2.5	0.8	12		175	TO-204/1
	750	MJ10024●		50/600	5	5	1.8	10		250	TO-204/1
	850	MJ10025●		50/600	5	5	1.8	10		250	TO-204/1
25	500	BUT14●		15 min	16	2.8	0.8	16		175	TO-204/1
28	400	BUT13●		20 min	20	2.6	0.8	18		175	TO-204/1
30	60	MJ11012	MJ11011	1k min	20				4	200	TO-204/1
	90	MJ11014	MJ11013	1k min	20				4	200	TO-204/1
	120	MJ11016	MJ11015	1k min	20				4	200	TO-204/1
40	350	MJ10022●		50/600	10	2.5	0.9	20		250	TO-204/197
	400	MJ10023●		50/600	10	2.5	0.9	20		250	TO-204/197
	700	BUT35●		15 min	24	4	1.2	24		250	TO-204/197
50	60	MJ11028	MJ11029	400 min	50					300	TO-204/197

● Darlington with speed-up diode.

(continued)

TABLE 14 — SWITCHMODE POWER TRANSISTORS (continued)

V _{CEO(sus)} Volts Min	I _C Cont Amps Max	V _{CEV} Volts Min	Device Type NPN unless otherwise noted	h _{FE} Min/Max	@ I _C Amp	Resistive Switching			f _T MHz Min	P _D (Case) Watts @ 25°C	Case JEDEC/MOT
						t _s μs Max	t _f μs Max	@ I _C Amp			
300	0.5	300	MJ4646-PNP	20 min	0.5	0.72*		0.05	40		TO-205AD/79
275	15	300	2N6250	8/50	10	3.5	1	10	2.5		TO-204/1
250	60	350	MJ10021##★	25 min	30	3.5	0.5	30			TO-204/197
	40	300	BUV22	10 min	20	1.1	0.35	20	8	250	TO-204/1
		350	BUS52	15 min	40					350	TO-204/1
	20	300	BUV12	10 min	10	1.5	0.5	10	8	150	TO-204/1
		450	MJ13331★	8/40	10	3.5	0.7	10	5/40		TO-204/1
	15	250	MJ11021#-PNP	100 min	15				3#		TO-204/1
		250	MJ11022#	100 min	15				3#		TO-204/1
	8	500	2N6306	15/75	3	1.6	0.4	3	5		TO-204/1
		400	MJ6502-PNP★	15 min	2	2	0.5	4			TO-204/1
225	5	500	MJ3029	30 min	0.4		1	3			TO-204/1
		350	2N6497	10/75	2.5	1.8	0.8	2.5	5		TO-220/221A
	2	375	2N3584	25/100	1	4	3	1	10		TO-213AA/80
		375	2N6421-PNP	25/100	1	4	3	1	10		TO-213AA/80
	1	250	2N5344-PNP	25/100	0.5	0.6	0.1	0.5	60		TO-213AA/80
225	2	275	2N6211	10/100	1	2.5	0.6	1	20		TO-213AA/80
200	60	300	MJ10020##★	25 min	30	3.5	0.5	30			TO-204/197
	50	300	BUS51	15 min	50					350	TO-204/1
	40	250	BUV21	10 min	25	1.8	0.4	25	8	150	TO-204/1
	20	250	BUV11	10 min	12	1.8	0.4	12	8	150	TO-204/1
		400	MJ13330★	8/40	10	3.5	0.7	10	5/40		TO-204/1
	15	225	2N6249	10/50	10	3.5	1	10	2.5		TO-204/1
		250	BUX41	8 min	8	1.5	0.4	8	8	120	TO-204/1
		200	MJ11019#-PNP	100 min	15				3#		TO-204/1
		200	MJ11020#	100 min	15				3#		TO-204/1
	3	250	BUY49P	30 min	0.5				25	20	TO-225AA/77

★ Designers Data Sheet characterization

Darlington

Darlington with speed-up diode

* t_{off}

** |h_{fe}| @ 1 MHz

MOTOROLA SEMICONDUCTOR TECHNICAL DATA

PNP
MJ11017
MJ11019
MJ11021

NPN
MJ11018
MJ11020
MJ11022

COMPLEMENTARY DARLINGTON SILICON POWER TRANSISTORS

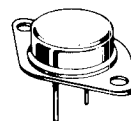
... designed for use as general purpose amplifiers, low frequency switching and motor control applications.

- High dc Current Gain @ 10 Adc — $h_{FE} = 400$ Min (All Types)
- Collector-Emitter Sustaining Voltage
 $V_{CE(sus)} = 150$ Vdc (Min) — MJ11018, 17
 $= 200$ Vdc (Min) — MJ11020, 19
 $= 250$ Vdc (Min) — MJ11022, 21
- Low Collector-Emitter Saturation
 $V_{CE(sat)} = 1.0$ V (Typ) @ $I_C = 5.0$ A
 $= 1.8$ V (Typ) @ $I_C = 10$ A
- Monolithic Construction
- 100% SOA Tested @ $V_{CE} = 44$ V, $I_C = 4.0$ A, $t = 250$ ms.

15 AMPERE

DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

150, 200, 250 VOLTS
175 WATTS



MAXIMUM RATINGS

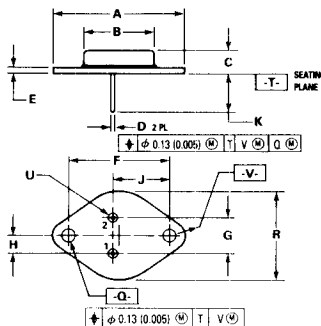
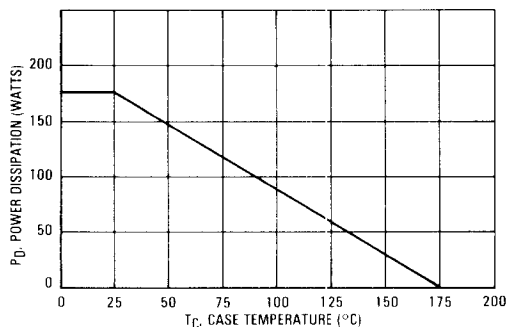
Rating	Symbol	MJ11018 MJ11017	MJ11020 MJ11019	MJ11022 MJ11021	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous Peak	I_C	15 30			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate Above 25°C	P_D	175 1.16			Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J T_{stg}	-65 to +175 -65 to +200			$^\circ\text{C}$ $^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.86	$^\circ\text{C}/\text{W}$

(1) Pulse Test: Pulse Width 5.0 ms, Duty Cycle $\leq 10\%$

FIGURE 1 — POWER DERATING



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. ALL RULES AND NOTES ASSOCIATED WITH REFERENCED TO-204AA OUTLINE SHALL APPLY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	8.25	0.250	0.325
D	0.97	1.09	0.039	0.043
E	1.40	1.77	0.055	0.070
F	30.15 BSC	—	1.187 BSC	—
G	10.92 BSC	—	0.430 BSC	—
H	5.46 BSC	—	0.215 BSC	—
J	16.89 BSC	—	0.665 BSC	—
K	11.18	12.19	0.440	0.480
Q	3.84	4.19	0.151	0.165
R	—	26.67	—	1.050
U	4.83	5.33	0.190	0.210
V	3.84	4.19	0.151	0.165

STYLE 1.
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

CASE 1-06
TO-204AA
(TO-3)

PNP MJ11017, MJ11019, MJ11021 NPN MJ11018, MJ11020, MJ11022

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ Unless Otherwise Noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 0.1 \text{ A dc}$, $I_B = 0$)	$V_{CE(sus)}$	150 200 250	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 75$, $I_B = 0$) ($V_{CE} = 100$, $I_B = 0$) ($V_{CE} = 125$, $I_B = 0$)	I_{CEO}	— — —	1.0 1.0 1.0	mAdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CB}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = \text{Rated } V_{CB}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_J = 150^\circ\text{C}$)	I_{CEV}	— —	0.5 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	2.0	mAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 10 \text{ A dc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 15 \text{ A dc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	400 100	15,000 —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ A dc}$, $I_B = 100 \text{ mA}$) ($I_C = 15 \text{ A dc}$, $I_B = 150 \text{ mA}$)	$V_{CE(sat)}$	— —	2.0 3.4	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ A}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	2.8	Vdc
Base-Emitter Saturation Voltage ($I_C = 15 \text{ A dc}$, $I_B = 150 \text{ mA}$)	$V_{BE(sat)}$	—	3.8	Vdc

DYNAMIC CHARACTERISTICS

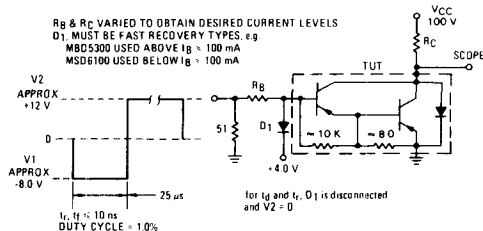
Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio ($I_C = 10 \text{ A dc}$, $V_{CE} = 3.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	$ h_{fe} $	3.0	—	—
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1 \text{ MHz}$) MJ11018, MJ11020, MJ11022 MJ11017, MJ11019, MJ11021	C_{ob}	— —	400 600	pF
Small-Signal Current Gain ($I_C = 10 \text{ A dc}$, $V_{CE} = 3.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	100	—	—

SWITCHING CHARACTERISTICS

Characteristics	Symbol	Typical		Unit
		NPN	PNP	
Delay Time	t_d	150	75	ns
Rise Time	t_r	1.2	0.5	μs
Storage Time	t_s	4.0	2.7	μs
Fall Time	t_f	10.0	2.5	μs

(1) Pulsed Test: Pulse Width = 300 μs , Duty Cycle $\leq 2\%$.

FIGURE 2 — SWITCHING TIMES TEST CIRCUIT



For NPN test circuit reverse diode and voltage polarities.

**PNP MJ11017, MJ11019, MJ11021
NPN MJ11018, MJ11020, MJ11022**

FIGURE 3 — THERMAL RESPONSE

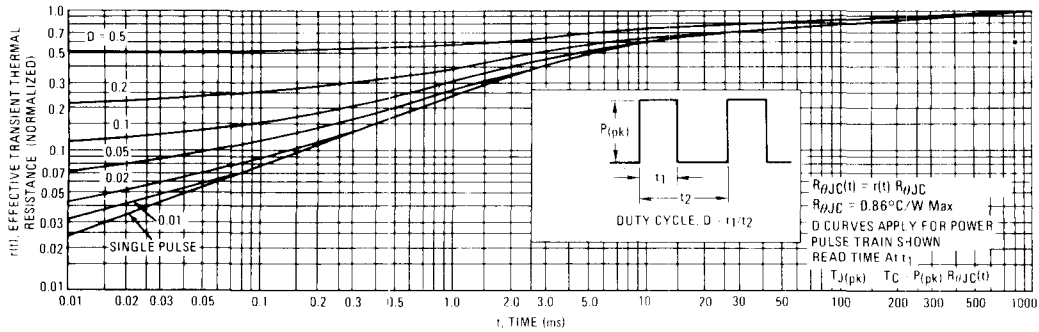
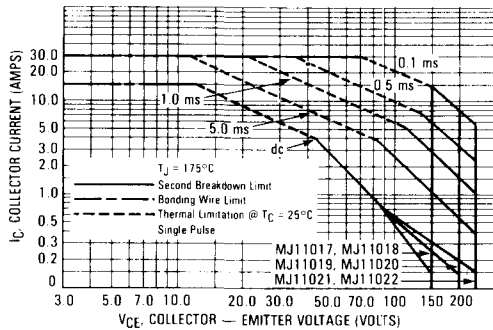


FIGURE 4 — MAXIMUM RATED FORWARD BIAS SAFE OPERATING AREA (FBSOA)

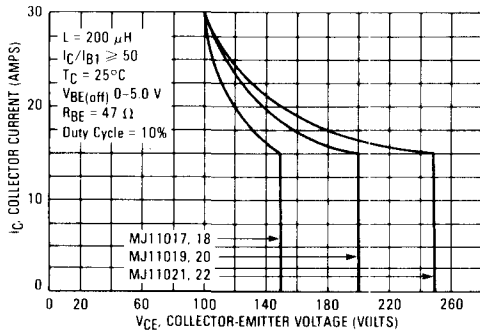


FORWARD BIAS

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C V_{CE} limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on $T_{J(pk)} = 175^\circ\text{C}$. T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 175^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 5 — MAXIMUM RBSOA, REVERSE BIAS SAFE OPERATING AREA



REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 5 gives RBSOA characteristics.

PNP MJ11017, MJ11019, MJ11021
NPN MJ11018, MJ11020, MJ11022

FIGURE 6 — DC CURRENT GAIN

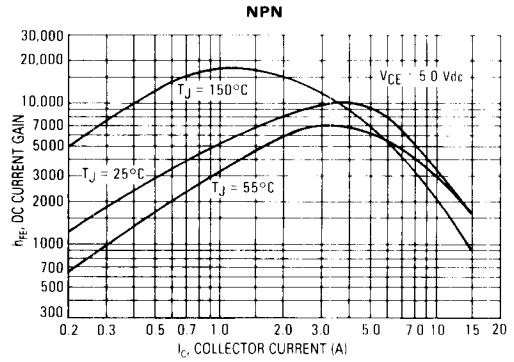
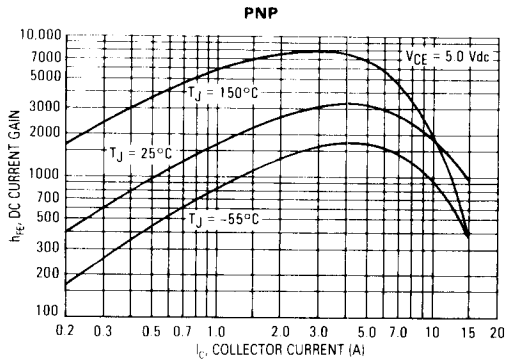


FIGURE 7 — COLLECTOR SATURATION REGION

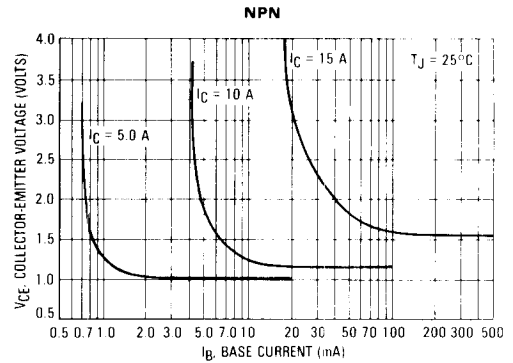
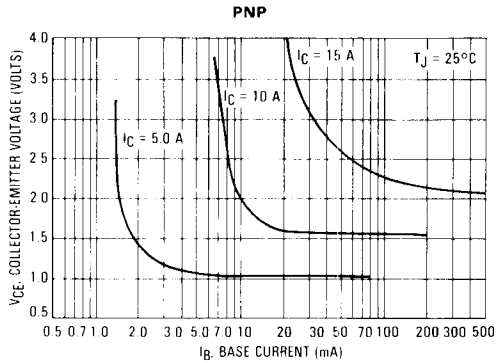


FIGURE 8 — "ON" VOLTAGES

