ALPHANUMERIC INDEX — CROSS-REFERENCE (Continued)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
KSB744A		MJE171	3-862
KSB772		MJE170	3-862
KSB794		MJE701	3-888
KSB795		MJE703	3-888
KSB834		2N6125	3-154
KSC1507		MJE2360T	3-900
KSC1520		MJE3440	3-908
KSC1520A		MJE2360T	3-900
KSC2073		MJE15030	3-972
KSC2233		TIP41C	3-1083
KSC2233		TIP41C	3-1083
KSC2334		MJE15028	3-972
KSC2335		MJE13007	3-950
KSC2517		TIP41C	3-1083
KSC2688		MJE3439	3-908
KSC2690		MJE340	3-876
KSC2690A		MJE340	3-876
KSC2749		MJH16008	3-742
KSC2752		2N5657	3-109
KSD288		TIP41A	3-1083
KSD362		D44H11	3-518
KSD363		MJE15028	3-972
KSD401		MJE15030	3-972
KSD526		2N6122	3-154
KSD560		SE9302	—
KSD568		D44H11	3-518
KSD569		D44H11	3-518
KSD708		D45H11	3-518
KSD73		D44H8	3-518
KSD794		MJE180	3-862
KSD794A		MJE181	3-862
KSD818		MJH16032	3-984
KSD819		MJH16032	3-984
KSD820		MJH16032	3-984
KSD821		MJH16032	3-984
KSD868		MJH16032	3-984
KSD869		MJH16032	3-984
KSD870		MJH16032	3-984
KSD871		MJH16032	3-984
KSD880		2N6122	3-154
KSD882		MJE180	3-862
KSD985		MJE801	3-888
KSD986		MJE803	3-888
MDS1678		MJE181	3-862
MDS20		2N5655	3-109
MDS21		2N5656	3-109
MDS26		MJE180	3-862
MDS27		MJE181	3-862
MDS60		MJE350	3-880
MDS73		MJE171	3-862
MDS74		MJE172	3-862
MDS75		MJE253	3-870
MDS76		MJE181	3-862
MDS77		MJE171	3-862
MJ1000	MJ1000		3-528
MJ10000	MJ10000		3-564
MJ10001	MJ10001		3-564
MJ10002	MJ10002		3-570
MJ10003		MJ10002	3-570
MJ10004	MJ10004		3-576

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
MJ10005	MJ10005		3-576
MJ10006	MJ10006		3-582
MJ10007	MJ10007		3-582
MJ10008	MJ10008		3-588
MJ10009	MJ10009		3-588
MJ1001	MJ1001		3-528
MJ10011	MJ10011		3-594
MJ10012	MJ10012		3-596
MJ10013	MJ10014		3-600
MJ10014	MJ10014		3-600
MJ10015	MJ10015		3-606
MJ10016	MJ10016		3-606
MJ10020	MJ10020		3-611
MJ10021	MJ10021		3-611
MJ10022	MJ10022		3-617
MJ10023	MJ10023		3-617
MJ10024	MJ10024		3-623
MJ10025	MJ10025		3-623
MJ10044		MJ10016	3-606
MJ10047		MJ10021	3-611
MJ10048		MJ10021	3-611
MJ105		MJ12003	3-642
MJ11011	MJ11011		3-629
MJ11012	MJ11012		3-629
MJ11013	MJ11013		3-629
MJ11014	MJ11014		3-629
MJ11015	MJ11015		3-629
MJ11016	MJ11016		3-629
MJ11017	MJ11017		3-631
MJ11018	MJ11018		3-631
MJ11019	MJ11019		3-631
MJ11020	MJ11020		3-631
MJ11021	MJ11021		3-631
MJ11022	MJ11022		3-631
MJ11028	MJ11028		3-635
MJ11029	MJ11029		3-635
MJ11030	MJ11030		3-635
MJ11031	MJ11031		3-635
MJ11032	MJ11032		3-635
MJ11033	MJ11033		3-635
MJ1200		2N6300	3-147
MJ12002	MJ12002		3-637
MJ12003	MJ12003		3-642
MJ12004	MJ12004		3-644
MJ12005	MJ12005		3-650
MJ12005D	MJ12005D		3-652
MJ1201		2N6301	3-147
MJ12010	MJ12010		3-658
MJ12020	MJ12020		3-660
MJ12021	MJ12021		3-660
MJ12022	MJ12022		3-660
MJ13010		2N6547	3-225
MJ13014	MJ13014		3-670
MJ13015	MJ13015		3-670
MJ13018		MJ13330	3-694
MJ13019		MJ13331	3-694
MJ13070	MJ13070		3-676
MJ13071		MJ16002	3-726
MJ13080	MJ13080		3-682
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 NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C
6	375	BU326		30 typ	0.6	3.5	1**	2.5	6	90
	400	BU326A		30 typ	0.6	3.5	1**	2.5	6	90
7.5	80	2N3448		40/120	5	2	0.35	5	10	115
8	60	MJ1000##	MJ900##	1k min	3					90
		2N6055##	2N6053##	750/18k	4	1.5 typ	1.5 typ	4	4#	100
	80	MJ1001##	MJ901##	1k min	3					90
		2N6056##	2N6054##	750/18k	4	1.5 typ	1.5 typ	4	4#	100
	250	2N6306		15/75	3	1.6	0.4	3	5	125
	300	2N6307		15/75	3	1.6	0.4	3	5	125
	350	2N6308		12/60	3	1.6	0.4	5	5	125
	400	2N6545		7/35	5	4	1	5	6	125
			MJ6503	15 min	2	2	0.5	4		125
		MJ13080		8 min	5	1.5	0.5	5		150
	450	MJ16006		5 min	8	2.5	0.25	5		150
		MJ16008		7 min	8	2.2	0.25	5		150
		2N6835		10/30	5	2.5	0.25	5	10	150
	500	MJ16006A		5 min	8	3	0.4	5		150
	850*	MJ12021		5 min	8		0.1 typ	5		150
	1400*	MJ10011##		20 min	4		1	4		80
	1500*	MJ12005		5 min	5		1	5		100
9	400	BUX47		7 min	6	2	0.4	6		150
	450	BUX47A		7 min	5	2	0.4	5		150
10	40	2N6383##	2N6648##	1k/20k	5				20#	100
	60		2N3789	15 min	3	0.3 typ	0.4 typ	5	4	150
		2N3715	2N3791	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5877	2N5875	20/100	4	1	0.8	4	4	150
		2N6384##		1k/20k	5				20#	100
		MJ3000##	MJ2500##	1k min	5					150
	80	2N3714	2N3790	15 min	3	0.3 typ	0.4 typ	5	4	150
		2N3716	2N3792	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5878	2N5876	20/100	4	1	0.8	4	4	150
		2N6385##		1k/20k	5				20#	100
		MJ3001##	MJ2501##	1k min	5					150
	140	2N5634		15/60	5	0.9 typ	0.9 typ	5	1	150
		2N3442		20/70	4					117

* $V_{(BR)CEX}$, # $|h_{fe}|$ @ 1 MHz, ## Darlington

(continued)

JAN, JTX, JTXV Available

TABLE 14 — SWITCHMODE POWER TRANSISTORS (continued)

$V_{CEO(sus)}$ Volts Min	I_CCont Amps Max	V_{CEV} Volts Min	Device Type NPN unless otherwise noted	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s µs Max	t_f µs Max	@ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C	Case JEDEC/MOT
400	**8**	**850**	**2N6545★**	7/35	5	4	1	5	6		TO-204/1
		800	**MJE5742#**	200/400	4	8 typ	2 typ	6			TO-220/221A
		800	**MJE16080**	5 min	8	2	0.5	5		80	TO-220/221A
		850	**BUW12**	6 min	6	4	0.8	5		125	TO-218/340
		850	**BUX84**	30 min	0.1	3.5	1.4	1	4	50	TO-220/221A
		700	**MJE13007★**	6/30	5	3	0.7	5	4		TO-220/221A
		650	**MJ13080★**	8 min	5	1.5	0.5	5			TO-204/1
		650	**MJE16106**	6/25	8	2 typ	0.1 typ	5		100	TO-220/221A
		650	**MJH16106**	6/25	8	2 typ	0.1 typ	5		125	TO-218/340
		450	**MJ6503-PNP★**	15 min	2	2	0.5	4			TO-204/1
		450	**MJE5852-PNP★**	15 min	2	2	0.5	4			TO-220/221A
	6	**900**	**BU326A**	30 typ	0.6	3.5	1**	2.5	6	90	TO-204/1
		900	**BU426A**	30 typ	0.6	2 typ	0.5 typ	2.5	6 typ	113	TO-218/340D
	5	**850**	**2N6543★**	7/35	3	4	0.8	3	6		TO-204/1
		850	**BUW11**	6 min	3	4	0.8	3		125	TO-218/340
		650	**MJ13070★**	8 min	3	1.5	0.5	3			TO-204/1
		650	**MJE13070★**	8 min	3	1.5	0.5	3			TO-220/221A
	4	**700**	**MJE13005★**	6/30	3	3	0.7	3	4		TO-220/221A
	1.5	**700**	**MJE13003★**	5/25	1	4	0.7	1	5		TO-225AA/77R
	0.5	**400**	**MJ4647-PNP**	20 min	0.5	0.72*		0.05	40		TO-205AD/79
375	**6**	**800**	**BU326**	30 typ	0.6	3.5	1**	2.5	6	90	TO-204/1
		800	**BU426**	30 typ	0.6	2 typ	0.5 typ	2.5	6 typ	113	TO-218/340D
350	**40**	**450**	**MJ10022##★**	50/600	10	2.5	0.9	20			TO-204/197
	20	**450**	**MJ10000#★**	40/400	10	3	1.8	10	10**		TO-204/1
		450	**MJ10004##★**	40/400	10	1.5	0.5	10	10**		TO-204/1
	15	**375**	**2N6251**	6/50	10	3.5	1	10	2.5		TO-204/1
	10	**450**	**MJ10002#★**	30/300	5	2.5	1	5	10**		TO-204/1
		450	**MJ10006##★**	30/300	5	1.5	0.5	5	10**		TO-204/1
		400	**MJ13014★**	8/20	5	2	0.5	5			TO-204/1
	8	**700**	**2N6308**	12/60	3	1.6	0.4	5	5		TO-204/1
		700	**MJE5741#**	200/400	4	8 typ	2 typ	6			TO-220/221A
		400	**MJE5851-PNP**	15 min	2	2	0.5	4			TO-220/221A
	2	**400**	**2N6213-PNP**	10/100	1	2.5	0.6	1	4		TO-213AA/80
325	**30**	**400**	**BUV23**	8 min	16	1.8	0.4	16	8	250	TO-204/197
	15	**400**	**BUX13**	8 min	8	2.5	0.8	8	8	150	TO-204/1
	5	**350**	**2N6235**	25/125	1	3.5	0.5	1	20		TO-213AA/80
300	**15**	**650**	**2N6546★**	6/30	10	4	0.7	10	6 to 24		TO-204/1
	12	**600**	**MJE13008★**	6/30	8	3	0.7	8	4**		TO-220/221A
	8	**600**	**2N6307**	15/75	3	1.6	0.4	3	5		TO-204/1
		600	**MJE13006★**	6/30	5	3	0.7	5	4		TO-220/221A
		600	**MJE5740**	200/400	4	8 typ	2 typ	6			TO-220/221A
		350	**MJE5850-PNP★**	15 min	2	2	0.5	4			TO-220/221A
	5	**400**	**2N6498**	10/75	2.5	1.8	0.8	2.5	5		TO-220/221A
	4	**600**	**MJE13004★**	6/30	3	3	0.7	3	4		TO-220/221A
	2	**500**	**2N3585**	25/100	1	4	3	1	10		TO-213AA/80
		500	**2N6422-PNP**	25/100	1	4	3	1	10		TO-213AA/80
		350	**2N6212-PNP**	10/100	1	2.5	0.6	1	4		TO-213AA/80
	1.5	**600**	**MJE13002★**	5/25	1	4	0.7	1	5		TO-225AA/77R

★ Designers Data Sheet characterization
\# Darlington ## Darlington with speed-up diode * t_{off} ** $|h_{fe}|$ @ 1 MHz

(continued)

2

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

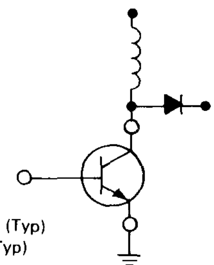
MJ13080

Designer's Data Sheet

SWITCHMODE II SERIES
NPN SILICON POWER TRANSISTOR

The MJ13080 transistor is designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. It is particularly suited for line-operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits



Fast Turn-Off Times
- 100 ns Inductive Fall Time @ 25°C (Typ)
- 150 ns Inductive Crossover Time @ 25°C (Typ)
- 400 ns Inductive Storage Time @ 25°C (Typ)

Operating Temperature Range -65 to +200°C

100°C Performance Specified for:
- Reverse-Biased SOA with Inductive Loads
- Switching Times with Inductive Loads
- Saturation Voltages
- Leakage Currents

8 AMPERE
NPN SILICON POWER TRANSISTOR

400 VOLTS
150 WATTS

Designer's Data for "Worst Case" Conditions

The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics *boundaries — are given to facilitate* "worst case" design.

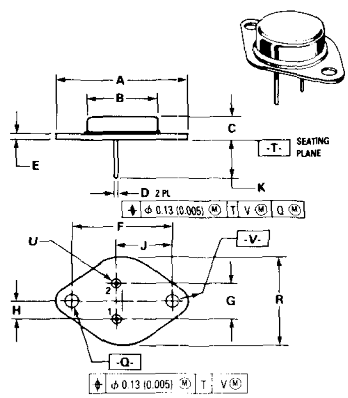
MAXIMUM RATINGS

Rating	Symbol	MJ13080	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Emitter Voltage	V_{CEV}	650	Vdc
Emitter Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous — Peak (1)	I_C I_{CM}	8.0 12	Adc
Base Current — Continuous — Peak (1)	I_B I_{BM}	3.0 6.0	Adc
Total Power Dissipation @ $T_C = 25°C$ @ $T_C = 100°C$ Derate above 25°C	P_D	150 85.5 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.17	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T_L	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



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 MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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	0.038	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)

3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)							
Collector-Emitter Sustaining Voltage (Table 1) (I_C = 100 mA, I_B = 0)			$V_{CEO(sus)}$	400	—	—	Vdc
Collector Cutoff Current (V_{CEV} = Rated Value, $V_{BE(off)}$ = 1.5 Vdc) (V_{CEV} = Rated Value, $V_{BE(off)}$ = 1.5 Vdc, T_C = 100°C)			I_{CEV}	— —	— —	0.5 2.5	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEV}, R_{BE} = 50 Ω, T_C = 100°C)			I_{CER}	—	—	3.0	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)			I_{EBO}	—	—	1.0	mAdc
SECOND BREAKDOWN							
Second Breakdown Collector Current with Base Forward Biased			$I_{S/b}$	See Figure 12			
Clamped Inductive SOA with Base Reverse Biased			RBSOA	See Figure 13			
ON CHARACTERISTICS (1)							
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc			h_{FE}	8.0	—	—	—
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 1.0 Adc) (I_C = 8.0 Adc, I_B = 1.6 Adc) (I_C = 5.0 Adc, I_B = 1.0 Adc, T_C = 100°C)			$V_{CE(sat)}$	— — —	— — —	1.0 3.0 2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 1.0 Adc) (I_C = 5.0 Adc, I_B = 1.0 Adc, T_C = 100°C)			$V_{BE(sat)}$	— —	— —	1.5 1.5	Vdc
DYNAMIC CHARACTERISTICS							
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f_{test} = 1.0 kHz)			C_{ob}	—	—	300	pF
SWITCHING CHARACTERISTICS							
Resistive Load (Table 1)							
Delay Time	(V_{CC} = 250 Vdc, I_C = 5.0 Adc, I_{B1} = 0.7 Adc, t_p = 30 μs, Duty Cycle ≤2%, $V_{BE(off)}$ = 5.0 Vdc)		t_d	—	0.025	0.05	μs
Rise Time			t_r	—	0.10	0.50	
Storage Time			t_s	—	0.50	1.50	
Fall Time			t_f	—	0.15	0.50	
Inductive Load, Clamped (Table 1)							
Storage Time	($I_{C(pk)}$ = 5.0 A, I_{B1} = 0.7 Adc, $V_{BE(off)}$ = 5.0 Vdc, $V_{CE(pk)}$ = 250 V)	(T_J = 100°C)	t_{sv}	—	0.75	2.20	μs
Crossover Time			t_c	—	0.22	0.40	
Fall Time			t_{fi}	—	0.175	0.35	
Storage Time		(T_J = 25°C)	t_{sv}	—	0.40	—	
Crossover Time			t_c	—	0.15	—	
Fall Time			t_{fi}	—	0.10	—	

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤2%.

$\beta_f = \frac{I_C}{I_B}$

3

FIGURE 1 — DC CURRENT GAIN

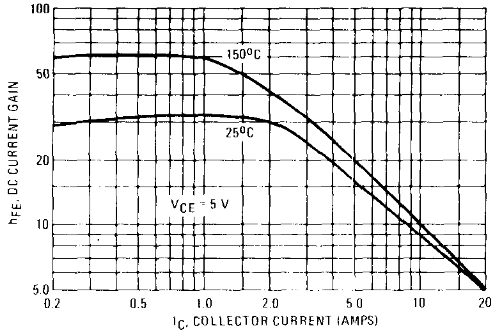


FIGURE 2 — COLLECTOR SATURATION REGION

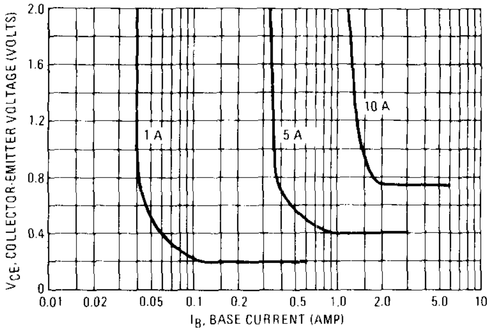


FIGURE 3 — COLLECTOR-EMITTER SATURATION REGION

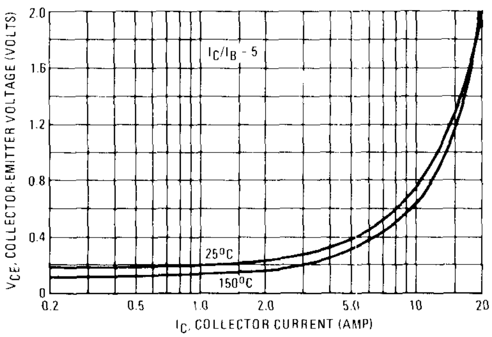


FIGURE 4 — BASE-EMITTER VOLTAGE

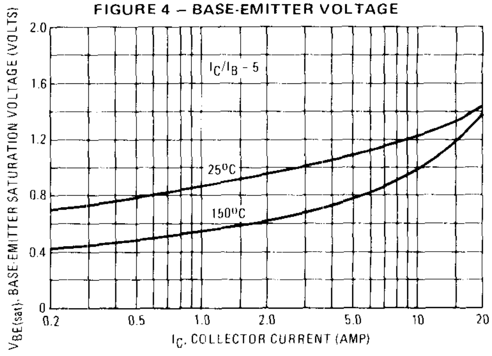


FIGURE 5 — COLLECTOR CUTOFF REGION

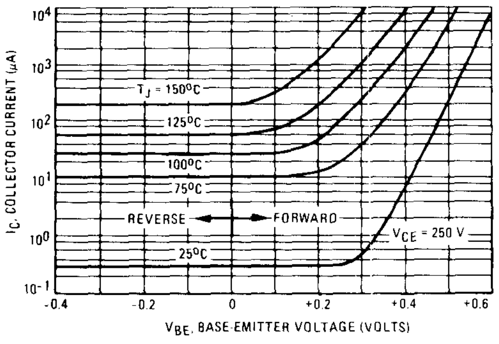
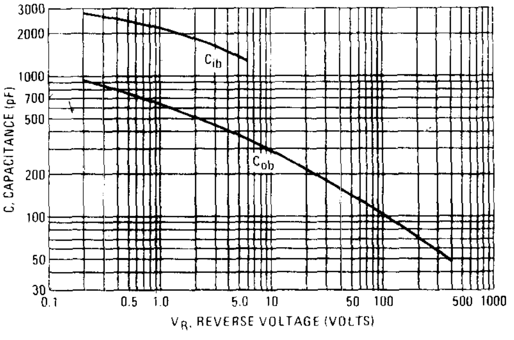


FIGURE 6 — CAPACITANCE



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

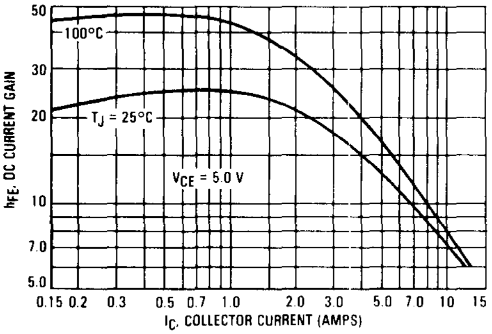


FIGURE 2 — COLLECTOR SATURATION REGION

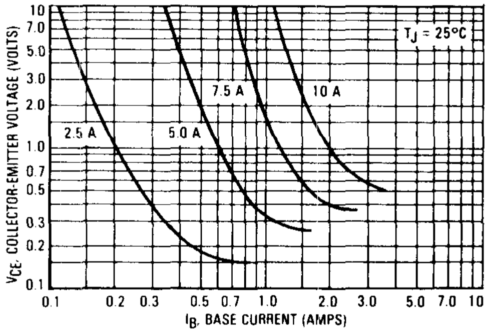


FIGURE 3 — COLLECTOR-EMITTER SATURATION VOLTAGE

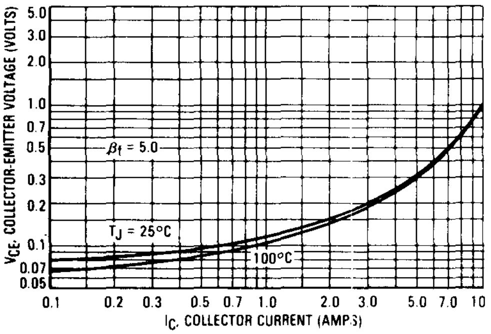


FIGURE 4 — BASE-EMITTER VOLTAGE

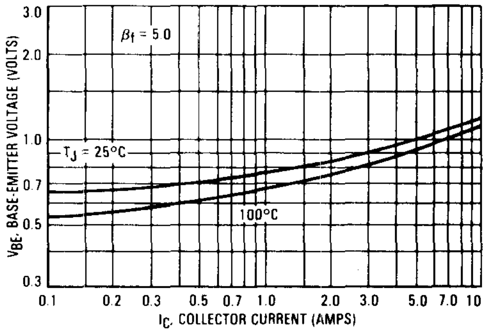


FIGURE 5 — COLLECTOR CUTOFF REGION

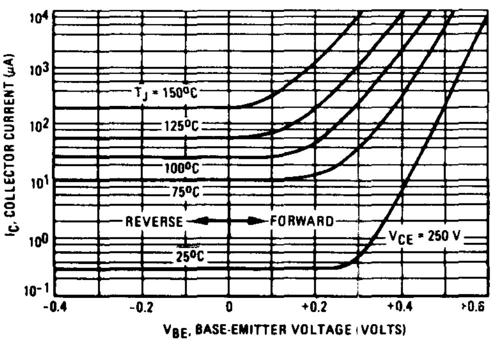


FIGURE 6 — CAPACITANCE

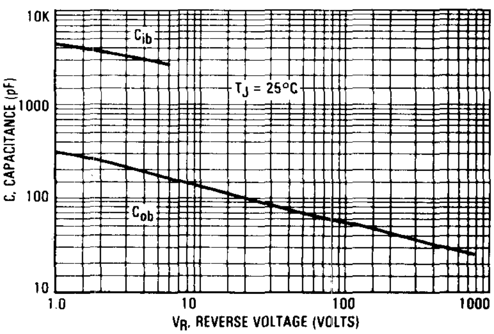


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TABLE 1 – TEST CONDITIONS FOR DYNAMIC PERFORMANCE

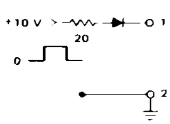
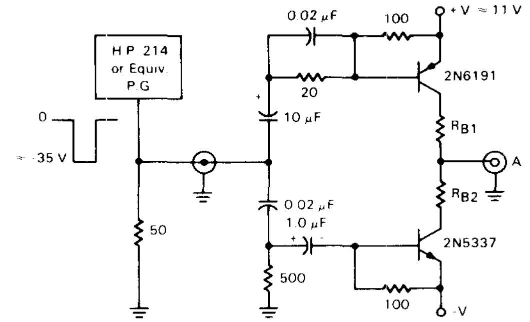
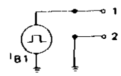
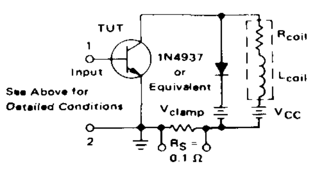
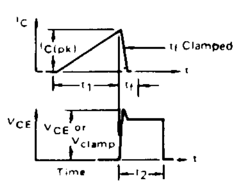
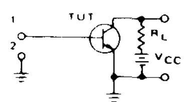
	VCEO(sus)	RBSOA AND INDUCTIVE SWITCHING	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain I_C = 100 mA	 Adjust R1 to obtain I_{B1} For switching and RB_{SOA}, R2 = 0 For $V_{CEO(sus)}$, R2 = ∞	TURN ON TIME  I_{B1} adjusted to obtain the forced h_{FE} desired TURN OFF TIME Use inductive switching driver as the input to the resistive test circuit.
CIRCUIT VALUES	L_{coil} = 80 mH V_{CC} = 10 V R_{coil} = 0.7 Ω	L_{coil} 180 μH R_{coil} 0.05 Ω V_{CC} 20 V V_{clamp} 250 V R_B adjusted to attain desired I_{B1}	V_{CC} 250 V R_L = 50 Ω Pulse Width = 30 μs
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT 	OUTPUT WAVEFORMS  t_1 Adjusted to Obtain I_C $t_1 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{CC}}$ $t_2 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{clamp}}$ Test Equipment Scope – Tektronix 475 or Equivalent	RESISTIVE TEST CIRCUIT 

FIGURE 7 — INDUCTIVE SWITCHING MEASUREMENTS

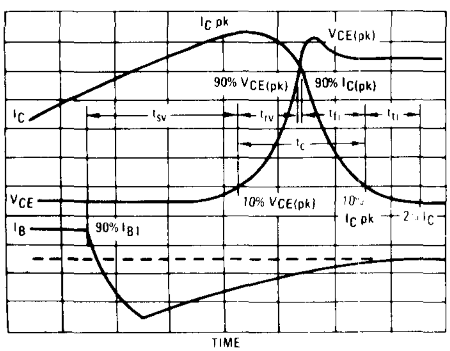
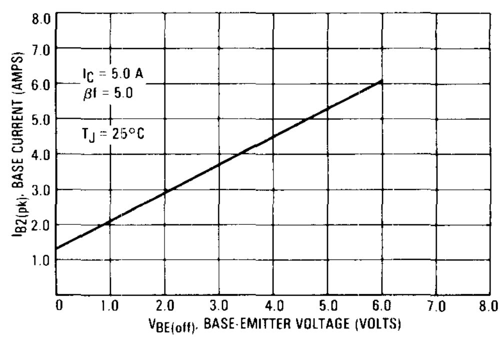


FIGURE 8 — PEAK REVERSE CURRENT



MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MJ13333
MJ13335

Designer's Data Sheet

SWITCHMODE SERIES
NPN SILICON POWER TRANSISTORS

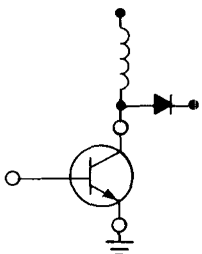
The MJ13333 and MJ13335 transistors are designed for high-voltage, high-speed, power switching in inductive circuits where fall time is critical. They are particularly suited for line operated switchmode applications such as:

- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Motor Controls
- Deflection Circuits

Fast Turn-Off Times
  200 ns Inductive Fall Time—25°C (Typ)
  1.8 μs Inductive Storage Time—25°C (Typ)

Operating Temperature Range −65 to +200°C

100°C Performance Specified for:
  Reversed Biased SOA with Inductive Loads
  Switching Times with Inductive Loads
  Saturation Voltages
  Leakage Currents



20 AMPERE

NPN SILICON POWER TRANSISTORS

400–500 VOLTS
175 WATTS

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit data — representing device characteristics boundaries — are given to facilitate "worst case" design.

3

MAXIMUM RATINGS

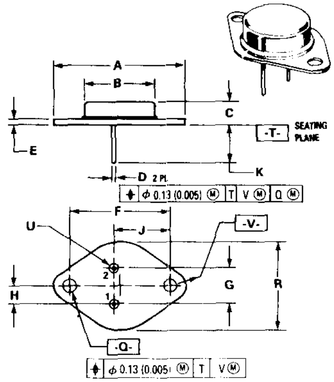
Rating	Symbol	MJ13333	MJ13335	Unit
Collector-Emitter Voltage	V_{CEO}	400	500	Vdc
Collector-Emitter Voltage	V_{CEV}	700	800	Vdc
Emitter Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous Peak (1)	I_C I_{CM}	20 30		Adc
Base Current — Continuous Peak (1)	I_B I_{BM}	10 15		Adc
Total Power Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	175 100 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T_L	275	°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

Similar device types available with lower V_{CEO} ratings, see the MJ13330 (200 V) and MJ13331 (250 V).



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 MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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	0.038	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)

SWITCHING TIMES NOTE

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

t_{sv} = Voltage Storage Time, 90% I_{B1} to 10% V_{clamp}
t_{rv} = Voltage Rise Time, 10−90% V_{clamp}
t_{fi} = Current Fall Time, 90−10% I_C
t_{ti} = Current Tail, 10−2% I_C
t_c = Crossover Time, 10% V_{clamp} to 10% I_C

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

$$P_{SWT} = 1/2\ V_{CC} I_C (t_c) f$$

In general, $t_{rv} + t_{fi} \simeq t_c$. However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at 25°C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds (t_c and t_{sv}) which are guaranteed at 100°C.

INDUCTIVE SWITCHING

FIGURE 9 — STORAGE TIME

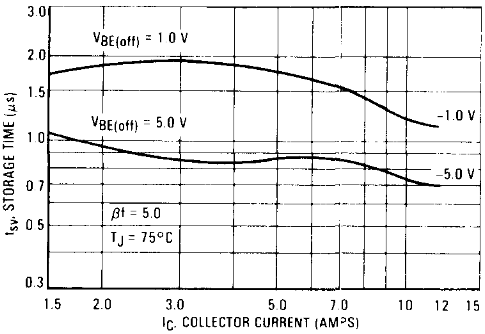


FIGURE 10 — CROSSOVER AND FALL TIMES

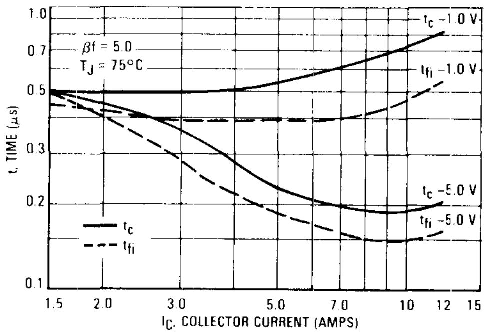


FIGURE 11 — THERMAL RESPONSE

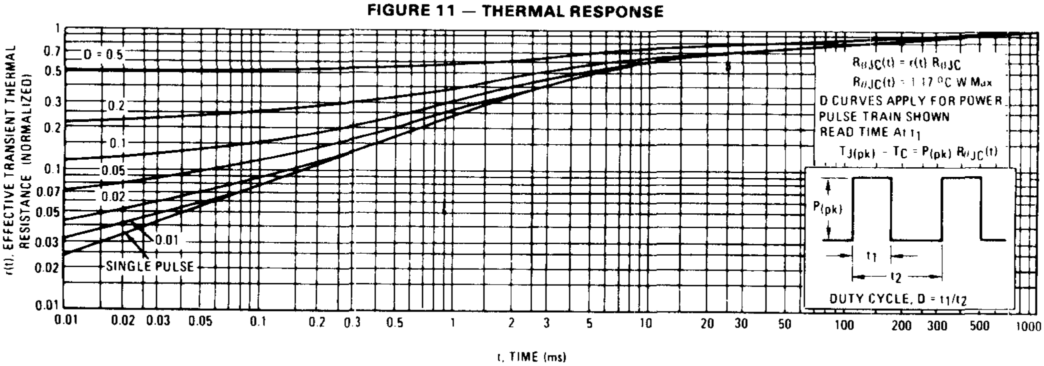


TABLE 1 — TEST CONDITIONS FOR DYNAMIC PERFORMANCE

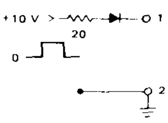
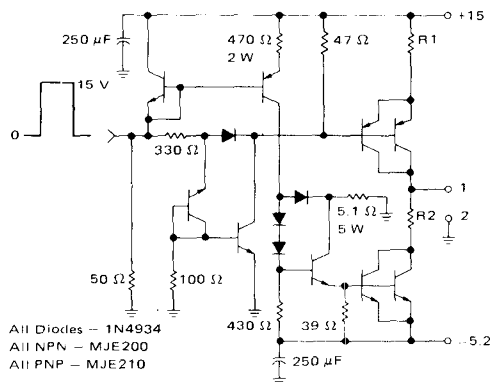
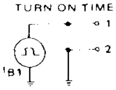
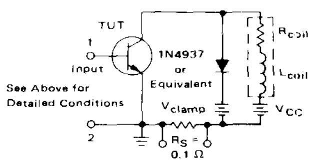
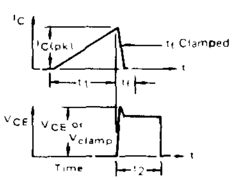
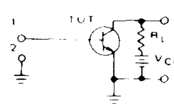
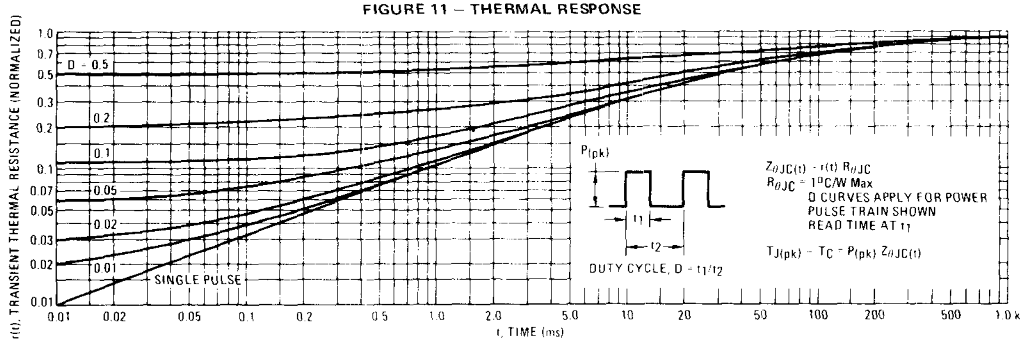
	$V_{CEO(sus)}$	RBSOA AND INDUCTIVE SWITCHING	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain I_C = 100 mA	 All Diodes — 1N4934 All NPN — MJE200 All PNP — MJE210 Adjust R1 to obtain I_{B1} For switching and RBSOA, R2 = 0 For $V_{CEO(sus)}$, R2 = ∞	TURN ON TIME  I_{B1} adjusted to obtain the forced h_{FE} desired TURN OFF TIME Use inductive switching driver as the input to the resistive test circuit.
CIRCUIT VALUES	L_{coil} = 80 mH V_{CC} = 10 V R_{coil} = 0.7 Ω	L_{coil} = 180 µH R_{coil} = 0.05 Ω V_{CC} = 20 V V_{clamp} = 200 V	V_{CC} = 175 V R_L = 17.5 Pulse Width = 25 µs
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT  See Above for Detailed Conditions	OUTPUT WAVEFORMS  t_1 Adjusted to Obtain I_C $t_1 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{CC}}$ $t_2 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{clamp}}$ Test Equipment Scope — Tektronix 475 or Equivalent	RESISTIVE TEST CIRCUIT 

FIGURE 11 — THERMAL RESPONSE



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The Safe Operating Area figures shown in Figures 12 and 13 are specified for these devices under the test conditions shown.

FIGURE 12 — FORWARD BIAS SAFE OPERATING AREA

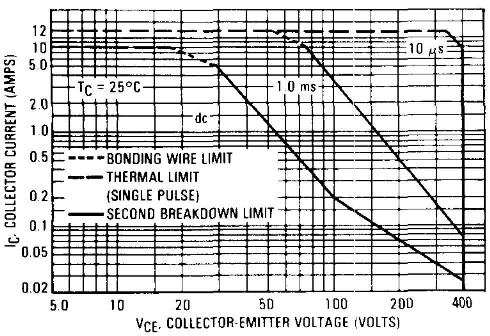
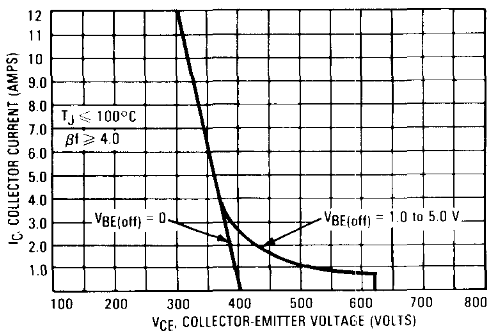


FIGURE 13 — REVERSE BIAS SAFE OPERATING AREA



SAFE OPERATING AREA INFORMATION

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 12 is based on $T_C = 25^oC$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25^oC$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 12 may be found at any case temperature by using the appropriate curve on Figure 14.

$T_{J(pk)}$ may be calculated from the data in Figure 11. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

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 13 gives RBSOA characteristics.

3

FIGURE 14 — POWER DERATING