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

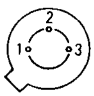
*Consult Motorola if a direct replacement is necessary.

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

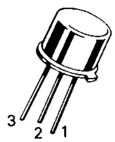
I_CCont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C
50	200	BUS51•		15 min	50					350
	400	MJ10015•##		10 min	40	2.5	1	20		250
	500	BUT34•##		15 min	32	3	1.5	32		250
		MJ10016•##		10 min	40	2.5	1	20		250
56	400	BUT33•##		20 min	36	3.3	1.6	36		250
60	60	MJ14000•	MJ14001•	15/100	50					300
	80	MJ14002•	MJ14003•	15/100	50					300
	200	MJ10020•##		75 min	15	3.5	0.5	30		250
	250	MJ10021•##		75 min	15	3.5	0.5	30		250
70	125	BUS50•		15 min	50					350

• Modified TO-3, 60 mil pins, # $|h_{fe}|$ @ 1 MHz, ## Darlington

TABLE 2 — METAL TO-205 (Formerly TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
(Pin 3 connected to case)



CASE 79-04 (TO-205AD)

I_CCont 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
0.5	300		MJ4646	20 min	0.5	0.72*		0.05	40	5
	400		MJ4647	20 min	0.5	0.72*		0.05	30	5
3	40		2N3719	25/180	1	0.4*		1	60	6
			2N3867	40/200	1.5	0.4*		1.5	60	6
	60		2N3720	25/180	1	0.4*		1	60	6
			2N3868	30/150	1.5	0.4*		1.5	60	6
	80		2N6303	30/150	1.5	0.4*		1.5	60	6
4	60	2N4877		20/100	4	1.5	0.5	4	4	10
5	80	2N5336	2N6190	30/120	2	2	0.2	2	30	6
		2N5337	2N6191	60/240	2	2	0.2	2	30	6
	100	2N5338		30/120	2	2	0.2	2	30	10
		2N5339	2N6193	60/240	2	2	0.2	2	30	6

JAN, JTX, JTXV Available

$^*t_{off}$

TABLE 12 — POWER DARLINGTONS (continued)

I_CCont Amps Max	$V_{CEO(sus)}$ 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			
50	90	MJ11030	MJ11031	400 min	50					300	TO-204/197
	120	MJ11032	MJ11033	400 min	50					300	TO-204/197
	400	MJ10015•		10 min	40	2.5	0.5	20	10	250	TO-204/197
	500	BUT34• MJ10016•		15 min 10 min	32 40	3 2.5	1.5 0.5	32 20	 10	250 250	TO-204/197 TO-204/197
56	400	BUT33•		20 min	36	3.3	1.6	36		250	TO-204/197
60	200	MJ10020•		75/1k min	15	3.5	0.5	30		250	TO-204/197
	250	MJ10021•		75/1k min	15	3.5	0.5	30		250	TO-204/197

• Darlington with speed-up diode.

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TABLE 13 — POWER SWITCHING TRANSISTORS

V_{CEO} < 200 V

I_CCont 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	Case JEDEC/MOT
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp			
0.8	40	MPS-U02	MPS-U52	30 min	0.5				150	10	—/152
1	120	MPS-U03		40 min	0.1				100	10	—/152
	180	MPS-U04		40 min	0.1				100	10	—/152
2	30	MPS-U01	MPS-U51	50 min	1				50	10	—/152
	40	MPS-U01A MPS-U45#	MPS-U51A MPS-U95#	50 min 4k min	1 1				50 100	10 10	—/152 —/152
	60	MPS-U05	MPS-U55	60 min	0.25				50	10	—/152
	80	MPS-U06	MPS-U56	60 min	0.25				50	10	—/152
	100	MPS-U07	MPS-U57	60 min	0.25				50	10	—/152
3	40		2N3719 2N3867	25/180 40/200	2 2	0.4* 0.4*		1 1	60 60	6 6	TO-205AA/31 TO-205AA/31
	60		2N3720 2N3868	25/180 30/150	2 2	0.4* 0.4*		1 1	60 60	6 6	TO-205AA/31 TO-205AA/31
	80		2N6303	30/150	2	0.4*		1	60	6	TO-205AA/31

Darlington * t_{off} @ 1 MHz

(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 t_s μs Max	t_f μs Max	@ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C	Case JEDEC/MOT
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
	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

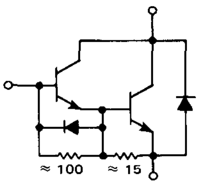
MJ10020
MJ10021

Designers Data Sheet

SWITCHMODE SERIES
NPN SILICON POWER DARLINGTON TRANSISTORS WITH BASE-EMITTER SPEEDUP DIODE

The MJ10020 and MJ10021 Darlington 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:

- AC and DC Motor Controls
- Switching Regulators
- Inverters
- Solenoid and Relay Drivers
- Fast Turn-Off Times
  150 ns Inductive Fall Time at 25°C (Typ)
  750 ns Inductive Storage Time at 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



60 AMPERE

NPN SILICON POWER DARLINGTON TRANSISTORS

200 and 250 VOLTS
250 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.

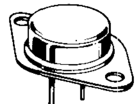
MAXIMUM RATINGS

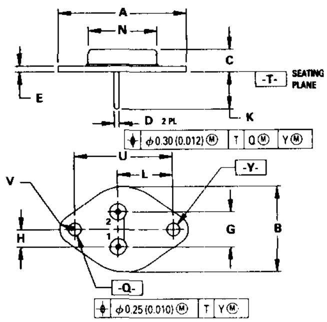
Rating	Symbol	MJ10020	MJ10021	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
Collector-Emitter Voltage	V_{CEV}	300	350	Vdc
Emitter Base Voltage	V_{EB}	8.0		Vdc
Collector Current — Continuous — Peak (1)	I_C I_{CM}	60 100		Adc
Base Current — Continuous — Peak (1)	I_B I_{BM}	20 30		Adc
Total Power Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	250 143 1.43		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	$R_{\theta JC}$	0.7	°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.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	38.86 REF		1.530 REF	
B	25.15	26.67	0.990	1.050
C	6.35	8.25	0.250	0.325
D	1.45	1.60	0.057	0.063
E	1.53	1.77	0.060	0.070
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
K	11.18	12.19	0.440	0.480
L	16.89 BSC		0.665 BSC	
N	19.31	21.08	0.760	0.830
Q	3.84	4.19	0.151	0.165
U	30.15 BSC		1.187 BSC	
V	3.33	4.77	0.131	0.188

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

CASE 197A-02
TO-204AE
(TO-3)

3

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

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (Table 1) (I_C = 100 mA, I_B = 0)	MJ10020 MJ10021	$V_{CEO(sus)}$	200 250	— —	— —	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 = 150°C)		I_{CEV}	— —	— —	0.25 5.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEV}, R_{BE} = 50 Ω, T_C = 100°C)		I_{CER}	—	—	5.0	mAdc
Emitter Cutoff Current (V_{EB} = 2.0 V, I_C = 0)		I_{EBO}	—	—	175	mAdc
SECOND BREAKDOWN						
Second Breakdown Collector Current with base forward biased		$I_{S/b}$		See Figure 13		
Clamped Inductive SOA with Base Reverse Biased		RBSOA		See Figure 14		
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 15 Adc, V_{CE} = 5.0 V)		h_{FE}	75	—	1000	—
Collector-Emitter Saturation Voltage (I_C = 30 Adc, I_B = 1.2 Adc) (I_C = 60 Adc, I_B = 4.0 Adc) (I_C = 30 Adc, I_B = 1.2 Adc, T_C = 100°C)		$V_{CE(sat)}$	— — —	— — —	2.2 4.0 2.4	Vdc
Base-Emitter Saturation Voltage (I_C = 30 Adc, I_B = 1.2 Adc) (I_C = 30 Adc, I_B = 1.2 Adc, T_C = 100°C)		$V_{BE(sat)}$	— —	— —	3.0 3.5	Vdc
Diode Forward Voltage (I_F = 30 Adc)		V_f	—	2.5	5.0	Vdc
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f_{test} = 1.0 kHz)		C_{ob}	175	—	700	pF
SWITCHING CHARACTERISTICS						
Resistive Load (Table 1)						
Delay Time	(V_{CC} = 175 Vdc, I_C = 30 A, I_{B1} = 1.2 Adc, $V_{BE(off)}$ = 5.0 V, t_p = 25 μs Duty Cycle ≤ 2.0%).	t_d	—	0.02	0.2	μs
Rise Time		t_r	—	0.30	1.0	μs
Storage Time		t_s	—	1.0	3.5	μs
Fall Time		t_f	—	0.07	0.5	μs
Inductive Load, Clamped (Table 1)						
Storage Time	I_{CM} = 30 A(pk), V_{CEM} = 200 V, I_{B1} = 1.2 A, $V_{BE(off)}$ = 5 V, T_C = 100°C)	t_{sv}	—	1.2	3.5	μs
Crossover Time		t_c	—	0.45	2.0	μs
Storage Time	(I_{CM} = 30 A(pk), V_{CEM} = 200 V, I_{B1} = 1.2 A, $V_{BE(off)}$ = 5 V, T_C = 25°C)	t_{sv}	—	0.75	—	μs
Crossover Time		t_c	—	0.25	—	μs
Fall Time		t_{fi}	—	0.15	—	μs

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

3

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

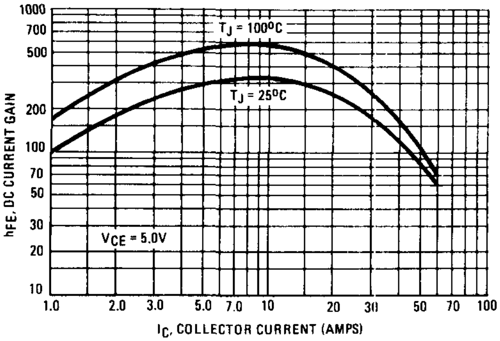


FIGURE 2 – COLLECTOR SATURATION REGION

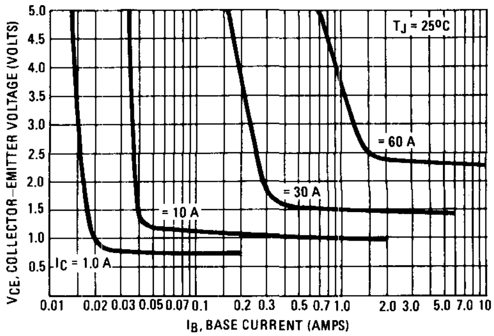


FIGURE 3 – COLLECTOR–EMITTER SATURATION VOLTAGE

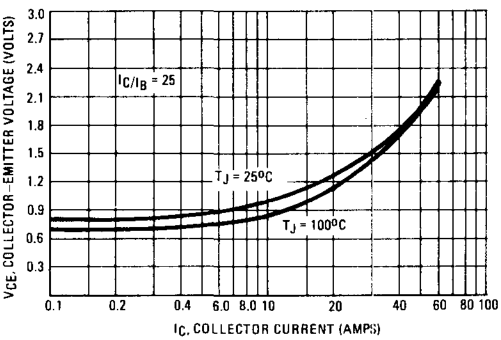


FIGURE 4 – BASE–EMITTER VOLTAGE

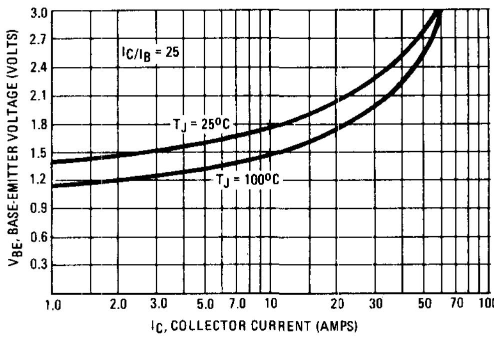


FIGURE 5 – COLLECTOR CUTOFF REGION

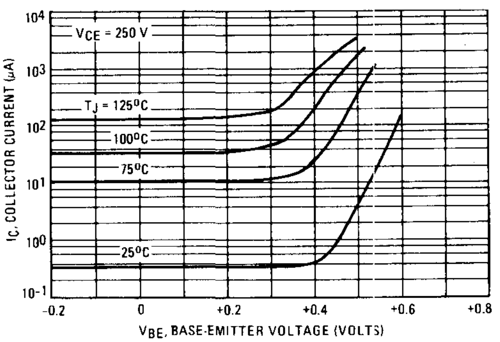


FIGURE 6 – OUTPUT CAPACITANCE

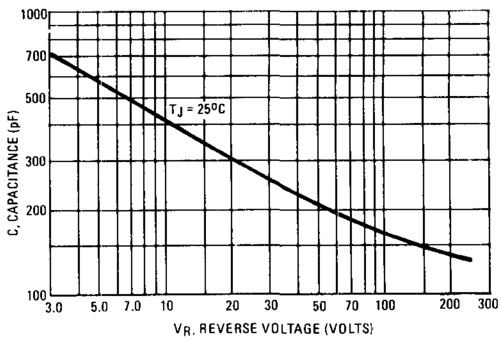


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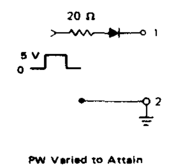
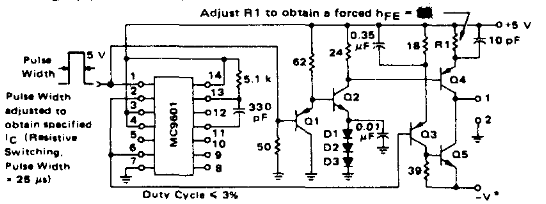
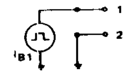
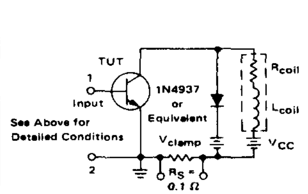
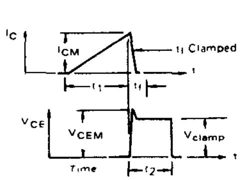
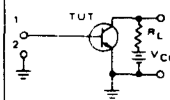
TABLE 1 – TEST CONDITIONS FOR DYNAMIC PERFORMANCE

	$V_{CEO(sus)}$	RBSOA AND INDUCTIVE SWITCHING	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain I_C = 100 mA		TURN-ON TIME  I_{B1} adjusted to obtain the forced h_{FE} desired. TURN-OFF TIME: Use inductive switching circuit as the input to the resistive test circuit.
CIRCUIT VALUES	L_{coil} = 10 mH, V_{CC} = 10 V, R_{coil} = 0.7 Ω, V_{clamp} = $V_{CEO(sus)}$	L_{coil} = 180 μH, R_{coil} = 0.05 Ω, V_{CC} = 20 V; Q1 2N2907, Q2 2N2222, Q3 2N3762, Q4 MJE15029, Q5 MJE15028, D1 1N914, D2 1N914, D3 1N914	V_{CC} = 175 V, R_L = 5.6 Ω, Pulse Width = 25 μs
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT 	OUTPUT WAVEFORMS  t_1 Adjusted to Obtain I_C; $t_1 \approx \frac{L_{coil}(I_{CM})}{V_{CC}}$; $t_2 \approx \frac{L_{coil}(I_{CM})}{V_{clamp}}$; Test Equipment Scope – Tektronix 475 or Equivalent	RESISTIVE TEST CIRCUIT 

*Adjust – V such that $V_{BE(off)}$ = 5 V except as required for RBSOA (Figure 14).

FIGURE 7 – INDUCTIVE SWITCHING MEASUREMENTS

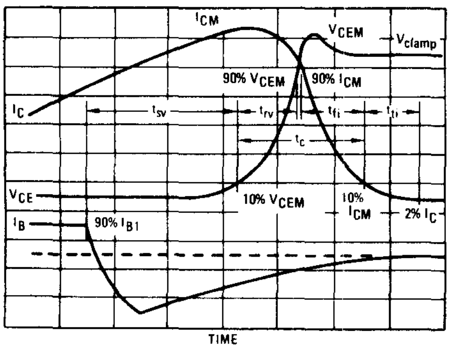


FIGURE 8 – TYPICAL PEAK REVERSE BASE CURRENT

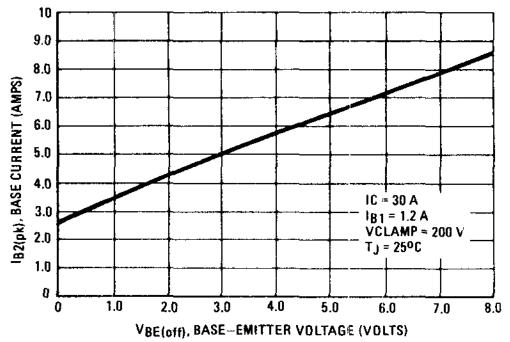
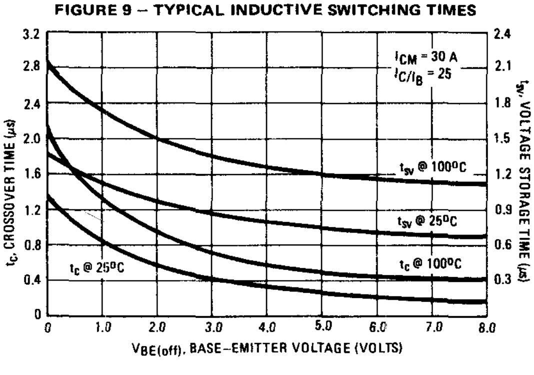


FIGURE 9 – TYPICAL INDUCTIVE SWITCHING TIMES



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_{CEM}
t_{rv} = Voltage Rise Time, 10 – 90% V_{CEM}
t_{fi} = Current Fall Time, 90 – 10% I_{CM}
t_{ti} = Current Tail, 10 – 2% I_{CM}
t_c = Crossover Time, 10% V_{CEM} to 10% I_{CM}

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-222A:

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

In general, $t_{rv} + t_{fi} \cong t_c$*. 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.

RESISTIVE SWITCHING

FIGURE 10 — TYPICAL TURN-ON SWITCHING TIMES

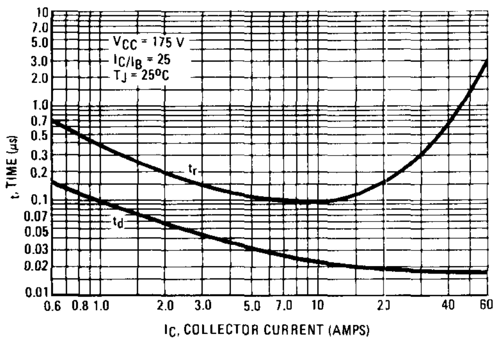


FIGURE 11 — TYPICAL TURN-OFF SWITCHING TIMES

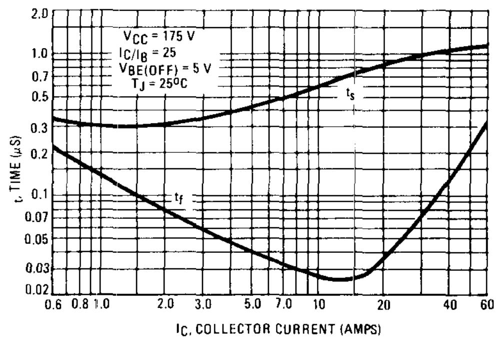
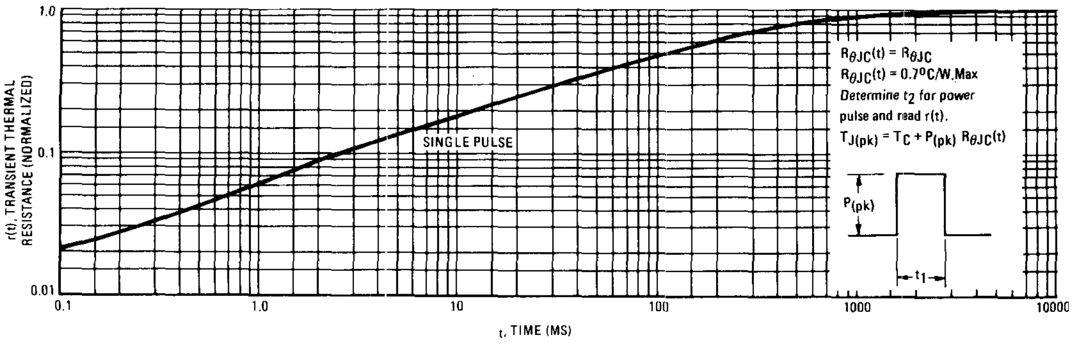


FIGURE 12 — THERMAL RESPONSE



The Safe Operating Area figures shown in Figures 13 and 14 are specified for these devices under the test conditions shown.

FIGURE 13 — MAXIMUM FORWARD BIAS SAFE OPERATING AREA

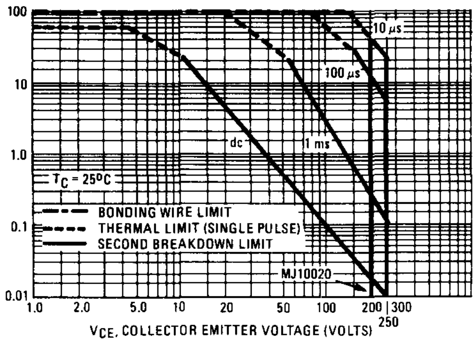
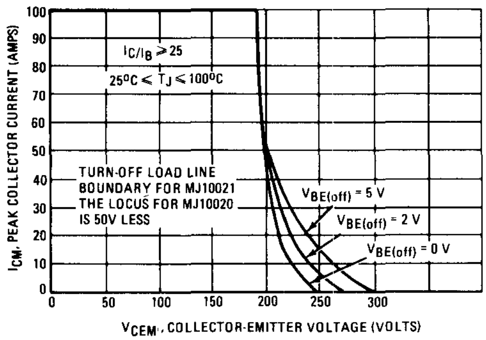


FIGURE 14 — MAXIMUM RBSOA, REVERSE BIAS SAFE OPERATING AREA



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.

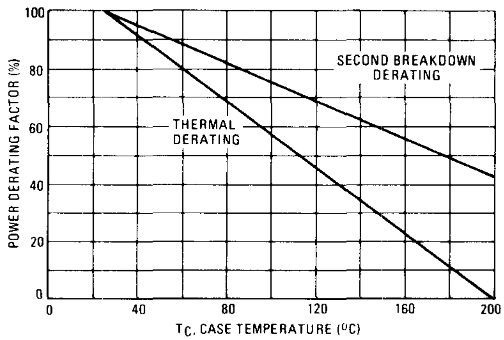
The data of Figure 13 is based on T_C = 25°C; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq$ 25° C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 13 may be found at any case temperature by using the appropriate curve on Figure 15.

$T_{J(pk)}$ may be calculated from the data in Figure 12. 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 condition allowable during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 14 gives the RBSOA characteristics.

FIGURE 15 — POWER DERATING



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