MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

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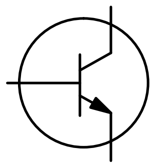
Designer's™ Data Sheet
SWITCHMODE™ NPN Silicon Planar Power Transistor

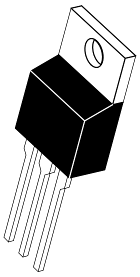
MJE18009
MJF18009

POWER TRANSISTORS
10 AMPERES
1000 VOLTS
50 and 150 WATTS

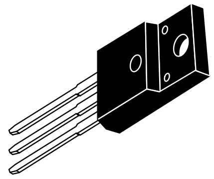


The MJE/MJF18009 has an application specific state–of–the–art die designed for use in 220 V line–operated Switchmode Power supplies and electronic ballast ("light ballast"). These high voltage/high speed transistors exhibit the following main features:

- Improved Efficiency Due to Low Base Drive Requirements:
  - — High and Flat DC Current Gain h_{FE}
  - — Fast Switching
  - — No Coil Required in Base Circuit for Turn–Off (No Current Tail)
- Full Characterization at 125°C
- Motorola "6 SIGMA" Philosophy Provides Tight and Reproducible Parametric Distributions
- Specified Dynamic Saturation Data
- Two Package Choices: Standard TO–220 or Isolated TO–220



CASE 221A–06
TO–220AB



CASE 221D–02
TO–220 FULLPACK

MAXIMUM RATINGS

Rating	Symbol	MJE18009	MJF18009	Unit
Collector–Emitter Sustaining Voltage	V_{CEO}	450		Vdc
Collector–Emitter Breakdown Voltage	V_{CES}	1000		Vdc
Collector–Base Breakdown Voltage	V_{CBO}	1000		Vdc
Emitter–Base Voltage	V_{EBO}	9		Vdc
Collector Current — Continuous — Peak (1)	I_C I_{CM}	10 20		Adc
Base Current — Continuous — Peak (1)	I_B I_{BM}	4 8		Adc
*Total Device Dissipation @ T_C = 25°C *Derate above 25°C	P_D	150 1.2	50 0.4	Watt W/°C
Operating and Storage Temperature	T_J, T_{stg}	–65 to 150		°C
RMS Isolation Voltage (2) Per Figure 22 (1s, 25°C, Humidity ≤ 30%) Per Figure 23 T_C = 25°C Per Figure 24	V_{ISOL1} V_{ISOL2} V_{ISOL3}		4500 3500 1500	V

THERMAL CHARACTERISTICS

Rating	Symbol	MJE18009	MJF18009	Unit
Thermal Resistance — Junction to Case — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	0.83 62.5	2.5 62.5	°C/W
Maximum Lead Temperature for Soldering Purposes: 1/8″ from Case for 5 Seconds	T_L	260		°C

(1) Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.
(2) Proper strike and creepage distance must be provided.

Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage (I_C = 100 mA, L = 25 mH)	$V_{CEO(sus)}$	450			Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	I_{CEO}			100	µAdc
Collector Cutoff Current (V_{CE} = Rated V_{CES}, V_{EB} = 0) @ T_C = 25°C @ T_C = 125°C (V_{CE} = 800 V, V_{EB} = 0) @ T_C = 125°C	I_{CES}			100 500 100	µAdc
Emitter–Cutoff Current (V_{EB} = 9 Vdc, I_C = 0)	I_{EBO}			100	µAdc
ON CHARACTERISTICS					
Base–Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)			0.8	1.1	
(I_C = 5 Adc, I_B = 1 Adc)			0.9	1.15	
(I_C = 7 Adc, I_B = 1.4 Adc)			0.9	1.25	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc) @ T_C = 25°C			0.3	0.6	
@ T_C = 125°C			0.3	0.65	
(I_C = 5 Adc, I_B = 1 Adc) @ T_C = 25°C			0.3	0.6	
@ T_C = 125°C			0.3	0.65	
(I_C = 7 Adc, I_B = 1.4 Adc) @ T_C = 25°C			0.35	0.7	
@ T_C = 125°C			0.4	0.9	
DC Current Gain	h_{FE}				—
(I_C = 1.5 Adc, V_{CE} = 5 Vdc) @ T_C = 25°C		14		34	
@ T_C = 125°C			29		
(I_C = 5 Adc, V_{CE} = 1 Vdc) @ T_C = 25°C		10	13		
@ T_C = 125°C		8	11.5		
(I_C = 7 Adc, V_{CE} = 1 Vdc) @ T_C = 25°C		7	10		—
@ T_C = 125°C		5	7.5		
(I_C = 10 mAdc, V_{CE} = 5 Vdc) @ T_C = 25°C		10	25		—
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1 MHz)	f_T		12		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}		150	200	pF
Input Capacitance (V_{EB} = 8 Vdc)	C_{ib}		2750	3500	pF

DYNAMIC SATURATION VOLTAGE

Dynamic Saturation Voltage: Determined 1 µs and 3 µs respectively after rising I_{B1} reaches 90% of final I_{B1}	I_C = 3 Adc I_{B1} = 300 mAdc V_{CC} = 300 V	@ 1 µs	@ T_C = 25°C	$V_{CE(dsat)}$		8		V
			@ T_C = 125°C			13.5		
		@ 3 µs	@ T_C = 25°C			4		
			@ T_C = 125°C			8		
	I_C = 7 Adc I_{B1} = 1.4 Adc V_{CC} = 300 V	@ 1 µs	@ T_C = 25°C			15		
			@ T_C = 125°C			21		
		@ 3 µs	@ T_C = 25°C			2		
			@ T_C = 125°C			2.7		

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

Characteristic			Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS: Resistive Load (D.C. ≤ 10%, Pulse Width = 20 μs)							
Turn–on Time	I_C = 3 Adc, I_{B1} = 0.3 Adc I_{B2} = 1.5 Adc V_{CC} = 300 Vdc	@ T_C = 25°C @ T_C = 125°C	t_{on}		220 220	300	ns
Turn–off Time		@ T_C = 25°C @ T_C = 125°C	t_{off}		1.28 1.6	2.5	μs
Turn–on Time	I_C = 5 Adc, I_{B1} = 1 Adc I_{B2} = 2.5 Adc V_{CC} = 300 Vdc	@ T_C = 25°C @ T_C = 125°C	t_{on}		120 350	250	ns
Turn–off Time		@ T_C = 25°C @ T_C = 125°C	t_{off}		2.2 2.6	2.5	μs
Turn–on Time	I_C = 7 Adc, I_{B1} = 1.4 Adc I_{B2} = 3.5 Adc V_{CC} = 300 Vdc	@ T_C = 25°C @ T_C = 125°C	t_{on}		175 500	300	ns
Turn–off Time		@ T_C = 25°C @ T_C = 125°C	t_{off}		1.75 2.1	2.5	μs
SWITCHING CHARACTERISTICS: Inductive Load (V_{clamp} = 300 V, V_{CC} = 15 V, L = 200 μH)							
Fall Time	I_C = 3 Adc I_{B1} = 0.3 Adc I_{B2} = 1.5 Adc	@ T_C = 25°C @ T_C = 125°C	t_f		110 125	200	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s		2 2.6	2.75	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		250 300	350	ns
Fall Time	I_C = 5 Adc I_{B1} = 1 Adc I_{B2} = 2.5 Adc	@ T_C = 25°C @ T_C = 125°C	t_f		110 135	200	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s		2.4 3.1	3.5	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		260 300	350	ns
Fall Time	I_C = 7 Adc I_{B1} = 1.4 Adc I_{B2} = 3.5 Adc	@ T_C = 25°C @ T_C = 125°C	t_f		105 150	200	ns
Storage Time		@ T_C = 25°C @ T_C = 125°C	t_s		1.75 2.25	2.75	μs
Crossover Time		@ T_C = 25°C @ T_C = 125°C	t_c		225 300	350	ns

TYPICAL STATIC CHARACTERISTICS

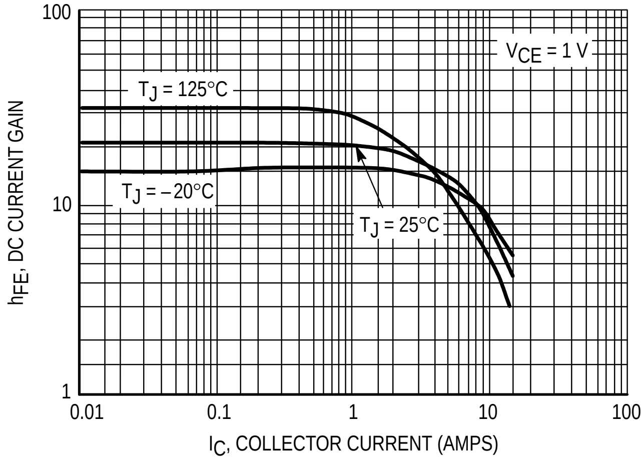


Figure 1. DC Current Gain @ 1 Volt

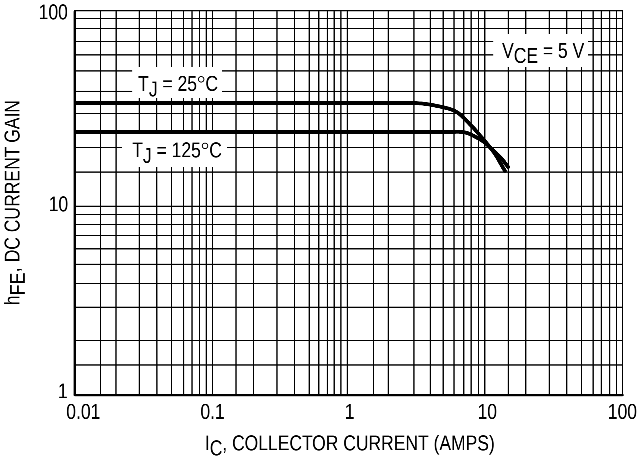


Figure 2. DC Current Gain @ 5 Volt

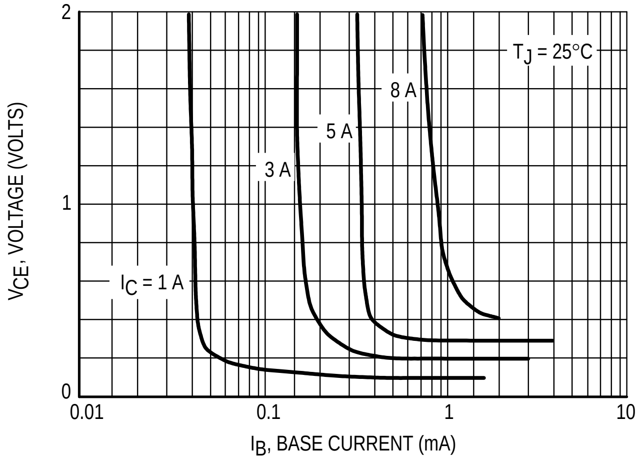


Figure 3. Collector Saturation Region

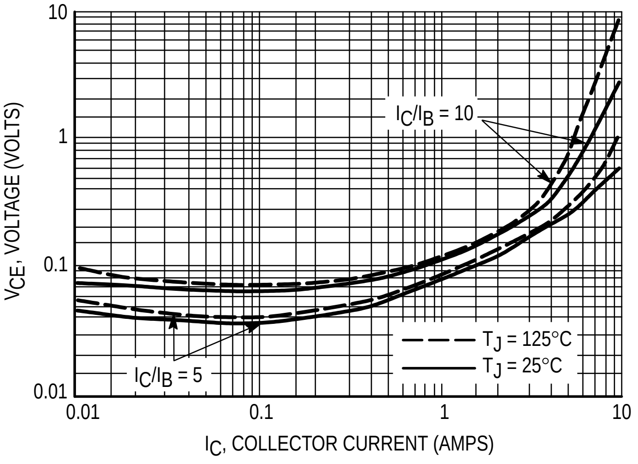


Figure 4. Collector–Emitter Saturation Voltage

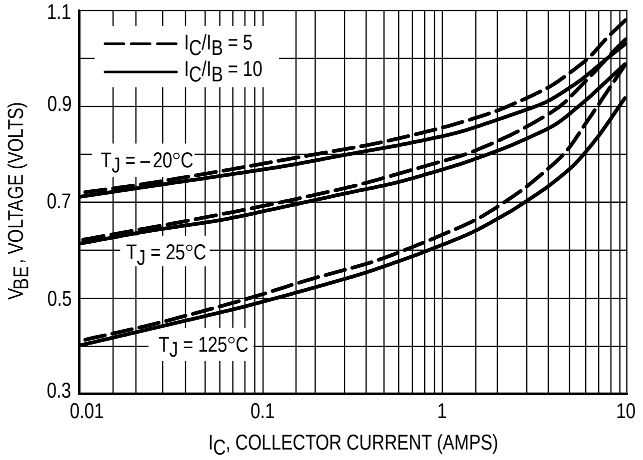


Figure 5. Base–Emitter Saturation Region

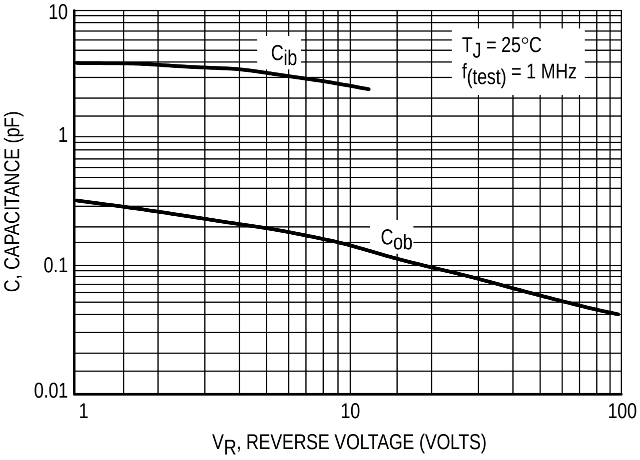


Figure 6. Capacitance

TYPICAL SWITCHING CHARACTERISTICS

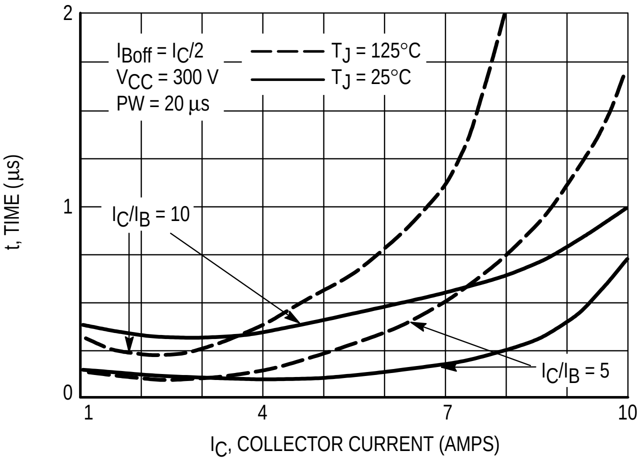


Figure 7. Resistive Switching, t_{on}

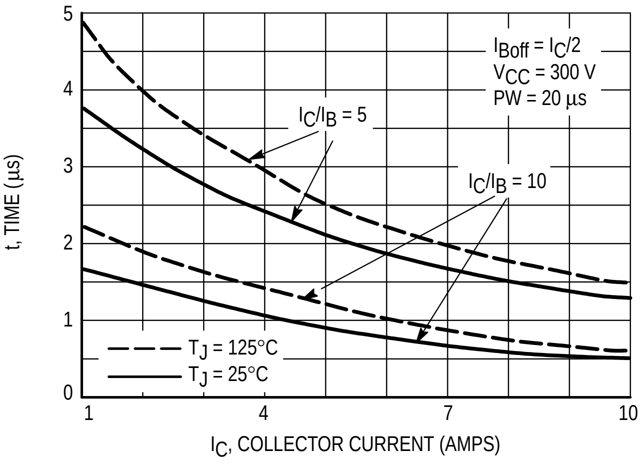


Figure 8. Resistive Switching, t_{off}

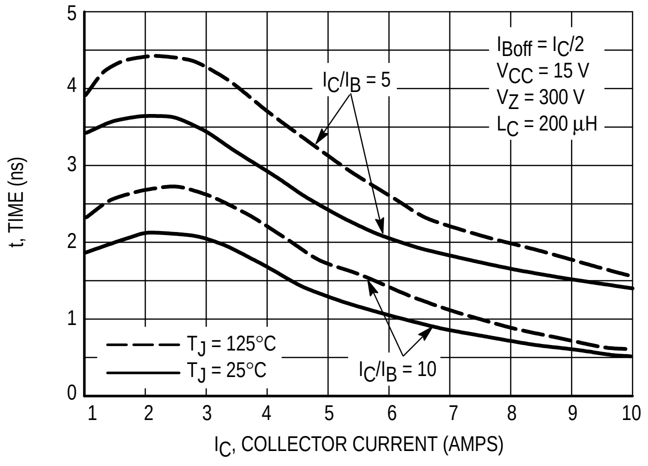


Figure 9. Inductive Storage Time, t_{si}

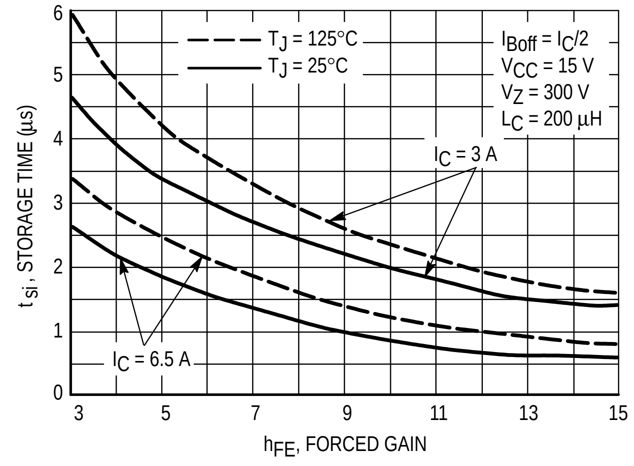


Figure 10. Inductive Storage Time

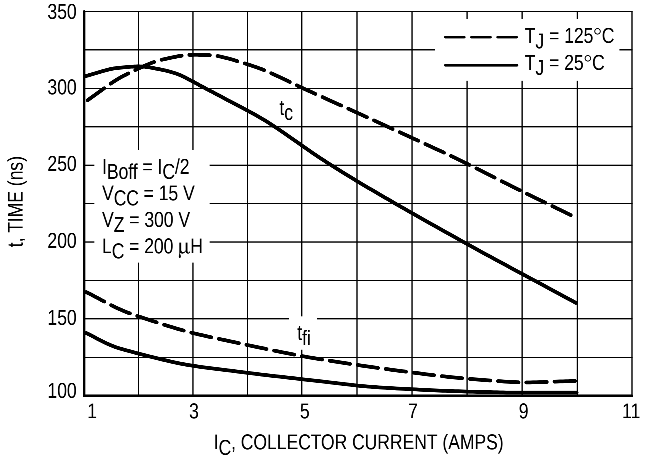


Figure 11. Inductive Switching, t_c & t_{fi} @ $I_C/I_B = 5$

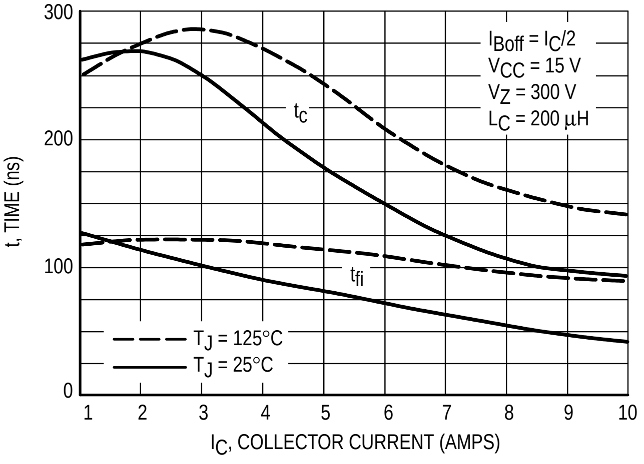


Figure 12. Inductive Switching, t_c & t_{fi} @ $I_C/I_B = 10$

TYPICAL SWITCHING CHARACTERISTICS

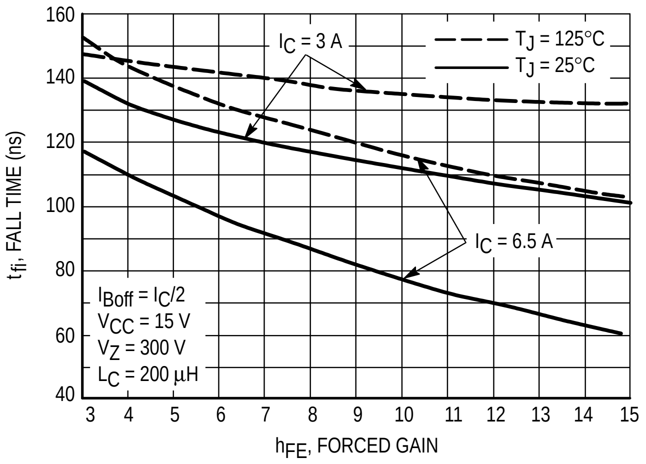


Figure 13. Inductive Fall Time

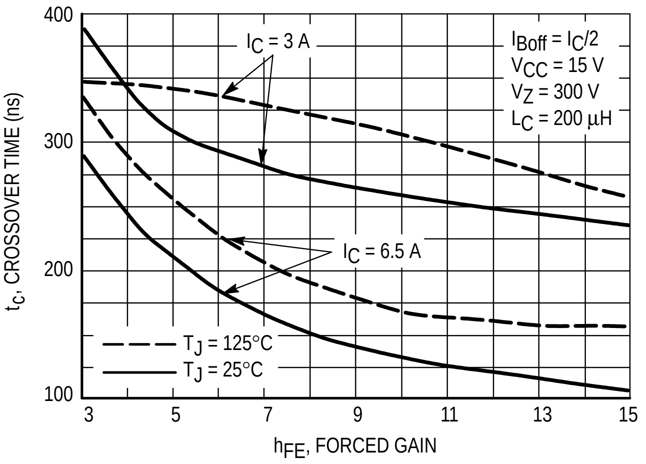


Figure 14. Inductive Crossover Time

TYPICAL CHARACTERISTICS

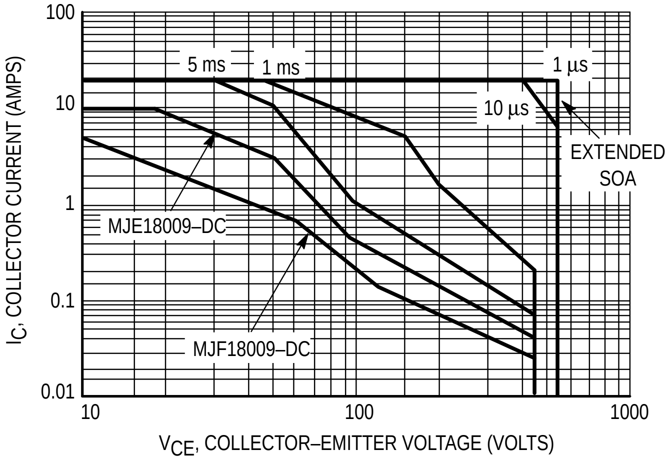


Figure 15. Forward Bias Safe Operating Area

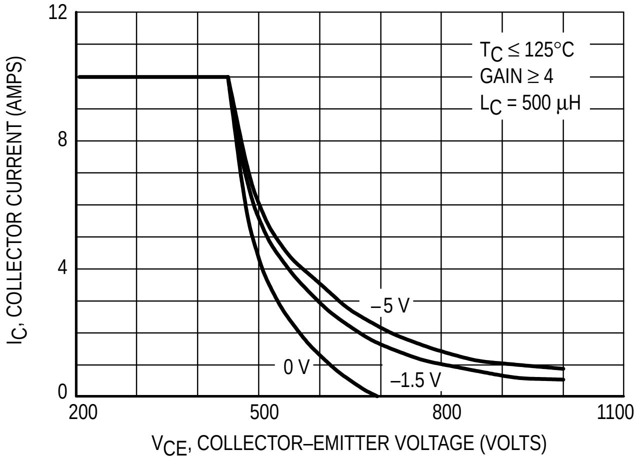


Figure 16. Reverse Bias Switching Safe Operating Area

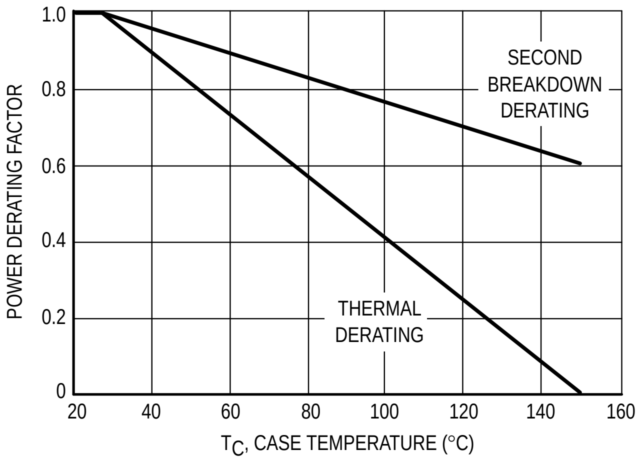


Figure 17. Forward Bias Power Derating

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 15 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 > 25°C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 17.

T_J(pk) may be calculated from the data in Figures 20 and 21. At any case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn–off with the base–to–emitter junction reverse biased. The safe level is specified as a reverse–biased safe operating area (Figure 16). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

TYPICAL SWITCHING CHARACTERISTICS
($I_B = I_C/2$ FOR ALL CURVES)

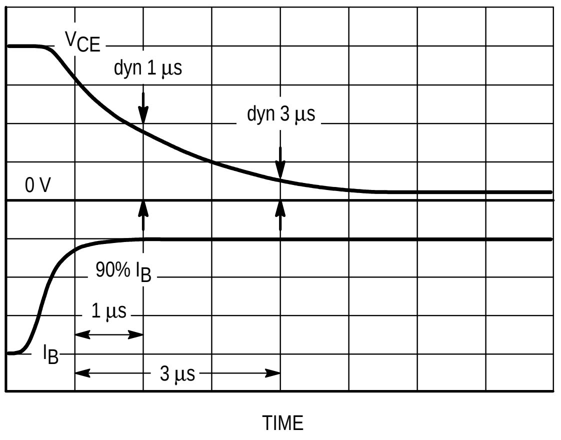


Figure 18. Dynamic Saturation Voltage Measurements

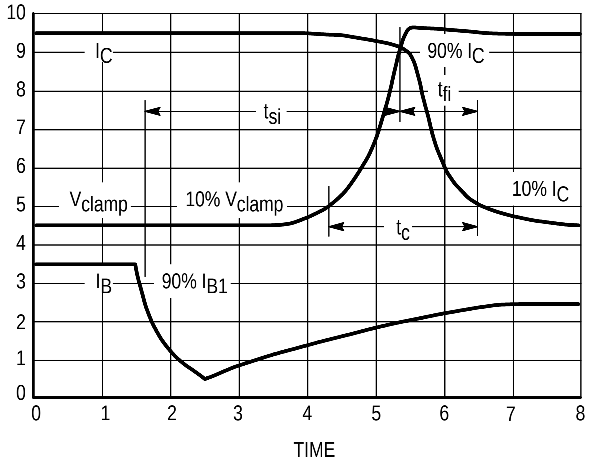
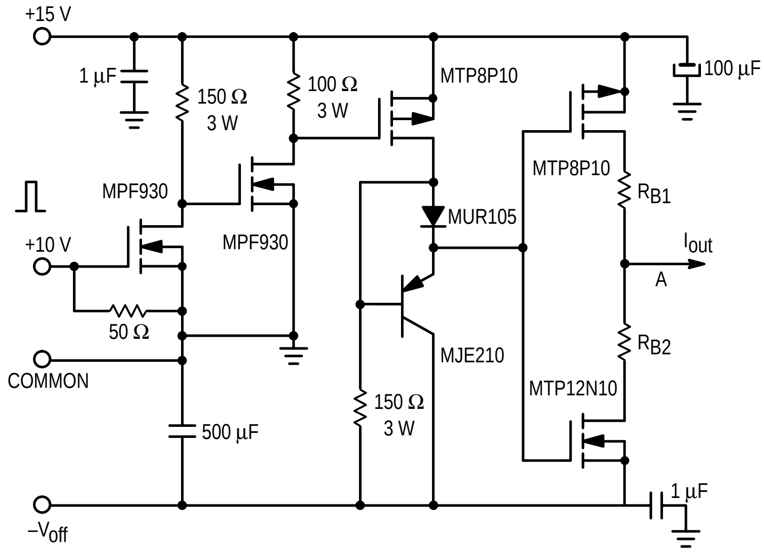
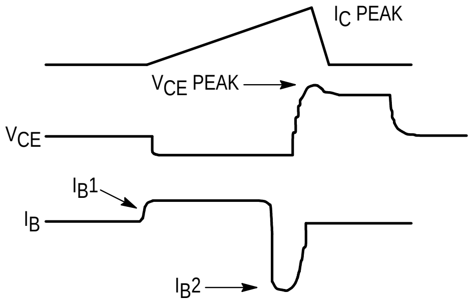


Figure 19. Inductive Switching Measurements

Table 1. Inductive Load Switching Drive Circuit





$V_{(BR)CEO(sus)}$	Inductive Switching	RBSOA
L = 10 mH	L = 200 µH	L = 500 µH
$R_{B2} = \infty$	$R_{B2} = 0$	$R_{B2} = 0$
V_{CC} = 20 Volts	V_{CC} = 15 Volts	V_{CC} = 15 Volts
$I_{C(pk)}$ = 100 mA	R_{B1} selected for desired I_{B1}	R_{B1} selected for desired I_{B1}

TYPICAL THERMAL RESPONSE
($I_B = I_C/2$ FOR ALL CURVES)

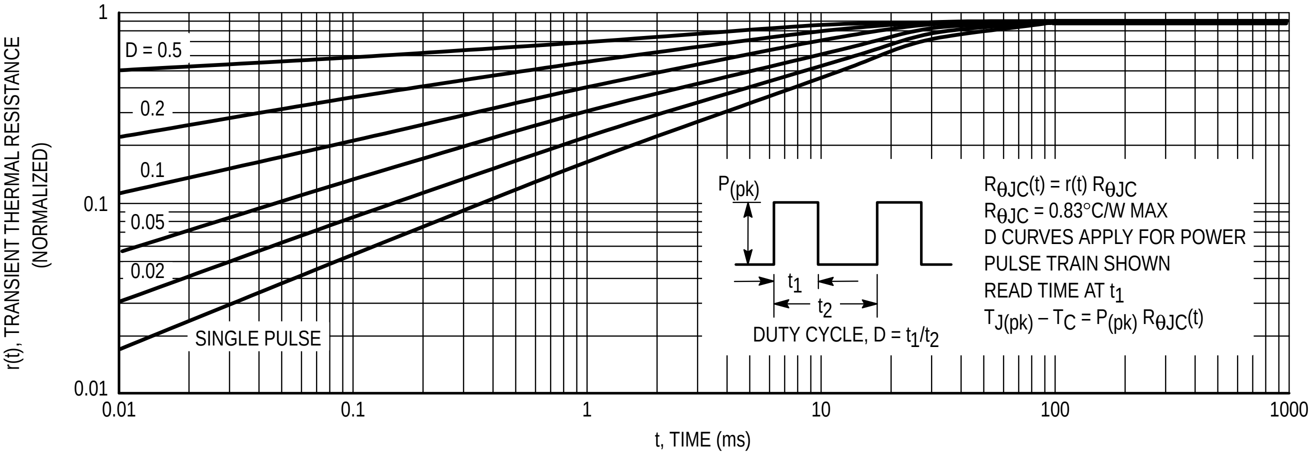


Figure 20. Typical Thermal Response ($Z_{\theta JC}(t)$) for MJE18009

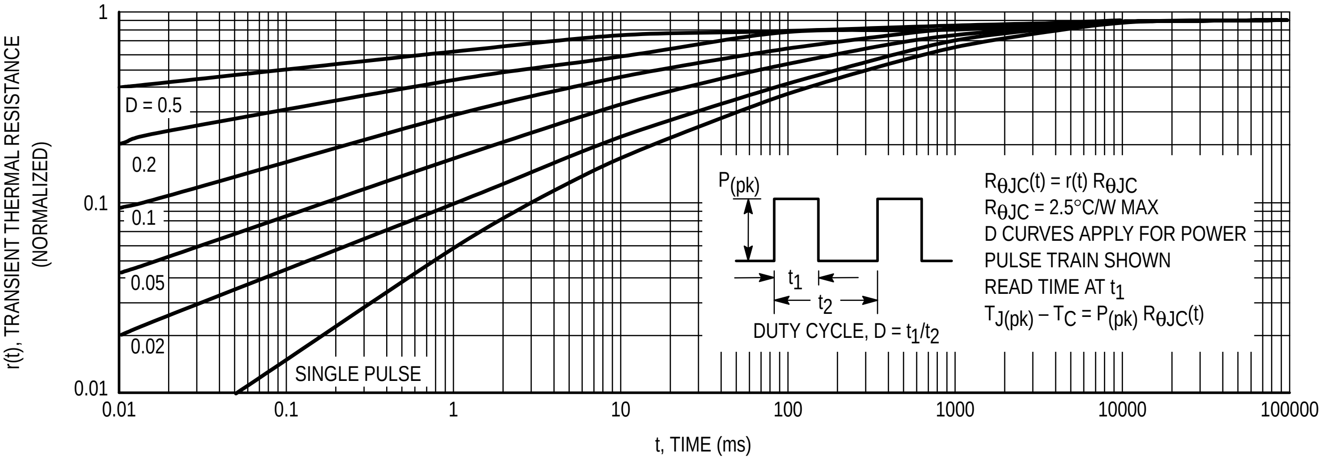


Figure 21. Typical Thermal Response ($Z_{\theta JC}(t)$) for MJF18009

TEST CONDITIONS FOR ISOLATION TESTS*

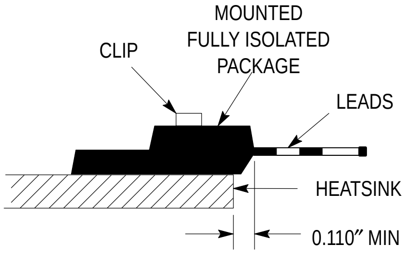


Figure 22. Clip Mounting Position for Isolation Test Number 1

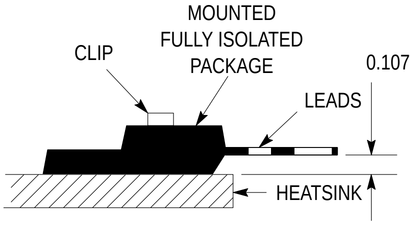


Figure 23. Clip Mounting Position for Isolation Test Number 2

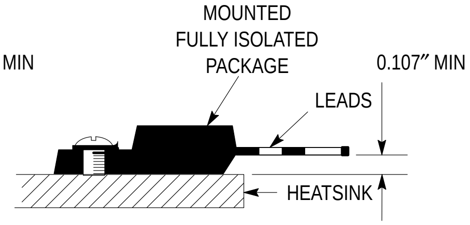


Figure 24. Screw Mounting Position for Isolation Test Number 3

* Measurement made between leads and heatsink with all leads shorted together

MOUNTING INFORMATION**

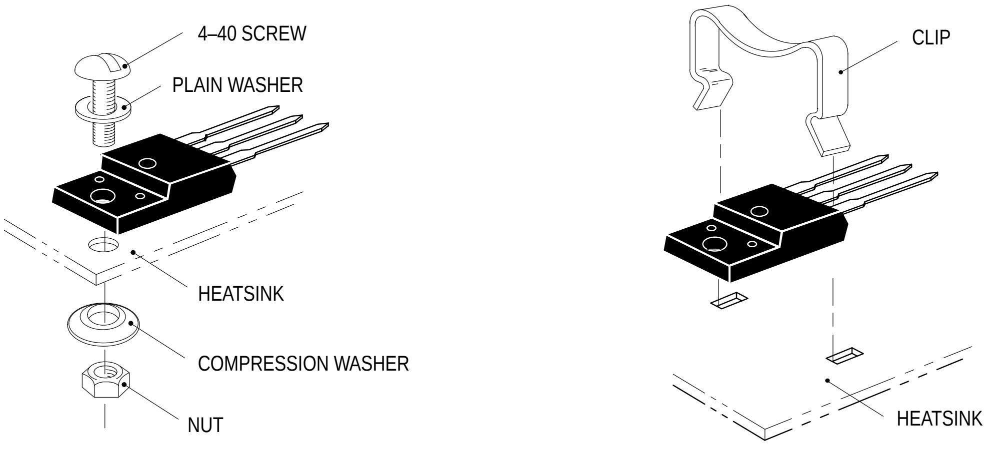


Figure 25a. Screw–Mounted

Figure 25b. Clip–Mounted

Figure 25. Typical Mounting Techniques for Isolated Package

Laboratory tests on a limited number of samples indicate, when using the screw and compression washer mounting technique, a screw torque of 6 to 8 in · lbs is sufficient to provide maximum power dissipation capability. The compression washer helps to maintain a constant pressure on the package over time and during large temperature excursions.

Destructive laboratory tests show that using a hex head 4–40 screw, without washers, and applying a torque in excess of 20 in · lbs will cause the plastic to crack around the mounting hole, resulting in a loss of isolation capability.

Additional tests on slotted 4–40 screws indicate that the screw slot fails between 15 to 20 in · lbs without adversely affecting the package. However, in order to positively ensure the package integrity of the fully isolated device, Motorola does not recommend exceeding 10 in · lbs of mounting torque under any mounting conditions.

** For more information about mounting power semiconductors see Application Note AN1040.

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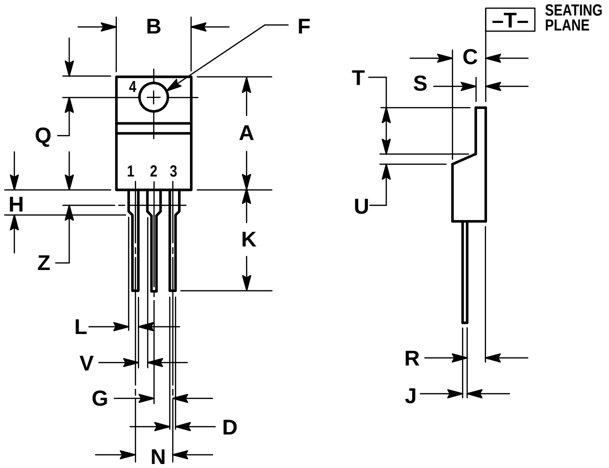
PACKAGE DIMENSIONS

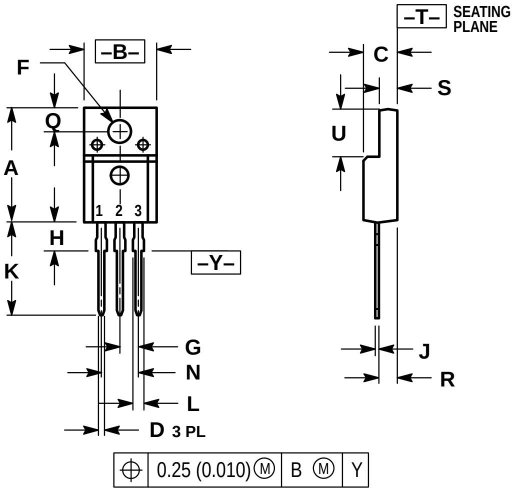


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	——	1.15	——
Z	——	0.080	——	2.04

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

CASE 221A–06
TO–220AB
ISSUE Y



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.621	0.629	15.78	15.97
B	0.394	0.402	10.01	10.21
C	0.181	0.189	4.60	4.80
D	0.026	0.034	0.67	0.86
F	0.121	0.129	3.08	3.27
G	0.100 BSC		2.54 BSC	
H	0.123	0.129	3.13	3.27
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.14	1.52
N	0.200 BSC		5.08 BSC	
Q	0.126	0.134	3.21	3.40
R	0.107	0.111	2.72	2.81
S	0.096	0.104	2.44	2.64
U	0.259	0.267	6.58	6.78

STYLE 1:
PIN 1. GATE
2. DRAIN
3. SOURCE

CASE 221D–02
(ISOLATED TO–220 TYPE)
UL RECOGNIZED: FILE #E69369
ISSUE D

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