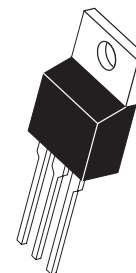


MJE13009*

*Motorola Preferred Device

**12 AMPERE
NPN SILICON
POWER TRANSISTOR
400 VOLTS
100 WATTS**



**CASE 221A-06
TO-220AB**

Designer's™ Data Sheet

SWITCHMODE Series

NPN Silicon Power Transistors

The MJE13009 is designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V switchmode applications such as Switching Regulators, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

SPECIFICATION FEATURES:

- $V_{CEO(sus)}$ 400 V and 300 V
- Reverse Bias SOA with Inductive Loads @ $T_C = 100^\circ\text{C}$
- Inductive Switching Matrix 3 to 12 Amp, 25 and 100°C
... t_C @ 8 A, 100°C is 120 ns (Typ).
- 700 V Blocking Capability
- SOA and Switching Applications Information.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	400	Vdc
Collector-Emitter Voltage	V_{CEV}	700	Vdc
Emitter Base Voltage	V_{EBO}	9	Vdc
Collector Current — Continuous	I_C	12	Adc
— Peak (1)	I_{CM}	24	
Base Current — Continuous	I_B	6	Adc
— Peak (1)	I_{BM}	12	
Emitter Current — Continuous	I_E	18	Adc
— Peak (1)	I_{EM}	36	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	2 16	Watts mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	100 800	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	62.5	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25	$^\circ\text{C}/\text{W}$
Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds	T_L	275	$^\circ\text{C}$

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

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.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage ($I_C = 10\text{ mA}$, $I_B = 0$)	$V_{CEO(sus)}$	400	—	—	Vdc
Collector Cutoff Current ($V_{CEV} = \text{Rated Value}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CEV} = \text{Rated Value}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	I_{CEV}	— —	— —	1 5	mAdc
Emitter Cutoff Current ($V_{EB} = 9\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	1	mAdc

SECOND BREAKDOWN

Second Breakdown Collector Current with base forward biased Clamped Inductive SOA with Base Reverse Biased	$I_{S/b}$ —	See Figure 1 See Figure 2			
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***ON CHARACTERISTICS**

DC Current Gain ($I_C = 5\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$) ($I_C = 8\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$)	h_{FE}	8 6	— —	40 30	
Collector–Emitter Saturation Voltage ($I_C = 5\text{ Adc}$, $I_B = 1\text{ Adc}$) ($I_C = 8\text{ Adc}$, $I_B = 1.6\text{ Adc}$) ($I_C = 12\text{ Adc}$, $I_B = 3\text{ Adc}$) ($I_C = 8\text{ Adc}$, $I_B = 1.6\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{CE(sat)}$	— — — —	— — — —	1 1.5 3 2	Vdc
Base–Emitter Saturation Voltage ($I_C = 5\text{ Adc}$, $I_B = 1\text{ Adc}$) ($I_C = 8\text{ Adc}$, $I_B = 1.6\text{ Adc}$) ($I_C = 8\text{ Adc}$, $I_B = 1.6\text{ Adc}$, $T_C = 100^\circ\text{C}$)	$V_{BE(sat)}$	— — —	— — —	1.2 1.6 1.5	Vdc

DYNAMIC CHARACTERISTICS

Current–Gain — Bandwidth Product ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1\text{ MHz}$)	f_T	4	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 0.1\text{ MHz}$)	C_{ob}	—	180	—	pF

SWITCHING CHARACTERISTICS

Resistive Load (Table 1)						
Delay Time	$(V_{CC} = 125\text{ Vdc}$, $I_C = 8\text{ A}$, $I_{B1} = I_{B2} = 1.6\text{ A}$, $t_p = 25\text{ }\mu\text{s}$, Duty Cycle $\leq 1\%$)	t_d	—	0.06	0.1	μs
Rise Time		t_r	—	0.45	1	μs
Storage Time		t_s	—	1.3	3	μs
Fall Time		t_f	—	0.2	0.7	μs
Inductive Load, Clamped (Table 1, Figure 13)						
Voltage Storage Time	$(I_C = 8\text{ A}$, $V_{clamp} = 300\text{ Vdc}$, $I_{B1} = 1.6\text{ A}$, $V_{BE(off)} = 5\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	t_{sv}	—	0.92	2.3	μs
Crossover Time		t_c	—	0.12	0.7	μs

*Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2%.

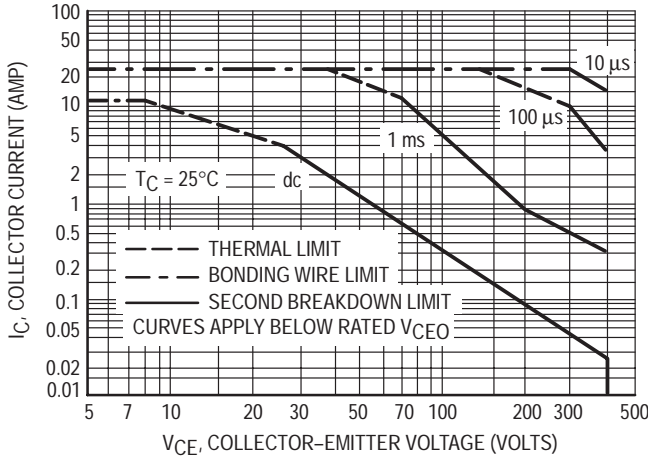


Figure 1. Forward Bias Safe Operating Area

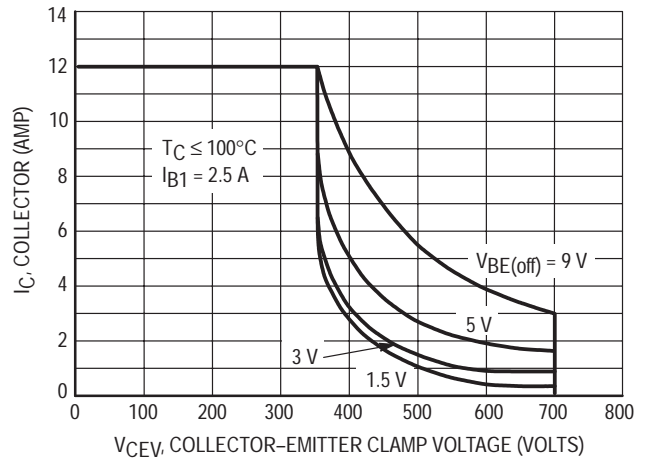


Figure 2. Reverse Bias Switching Safe Operating Area

The Safe Operating Area figures shown in Figures 1 and 2 are specified ratings for these devices under the test conditions shown.

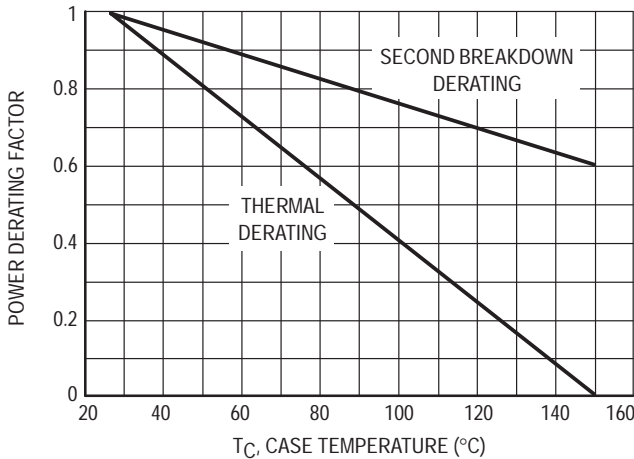


Figure 3. Forward Bias Power Derating

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 1 is based on $T_C = 25^\circ\text{C}$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25^\circ\text{C}$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 1 may be found at any case temperature by using the appropriate curve on Figure 3.

$T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Use of reverse biased safe operating area data (Figure 2) is discussed in the applications information section.

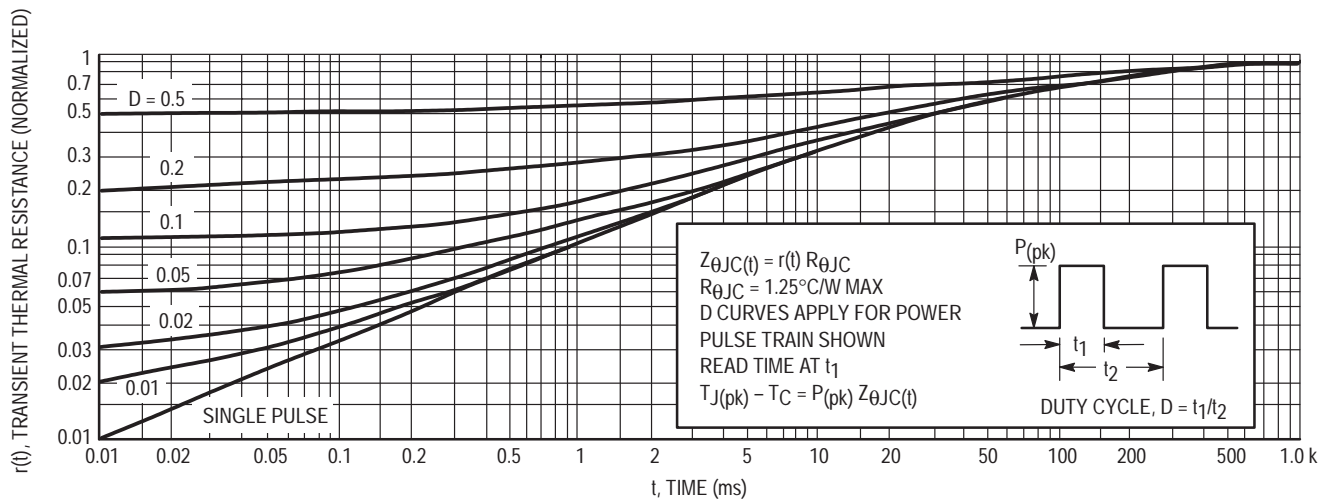


Figure 4. Typical Thermal Response [$Z_{\theta JC}(t)$]

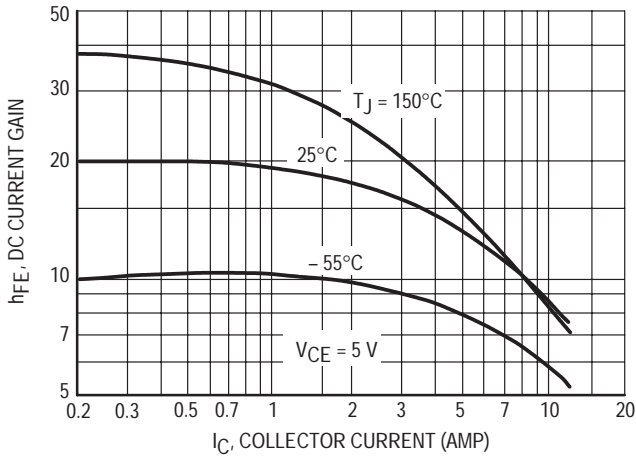


Figure 5. DC Current Gain

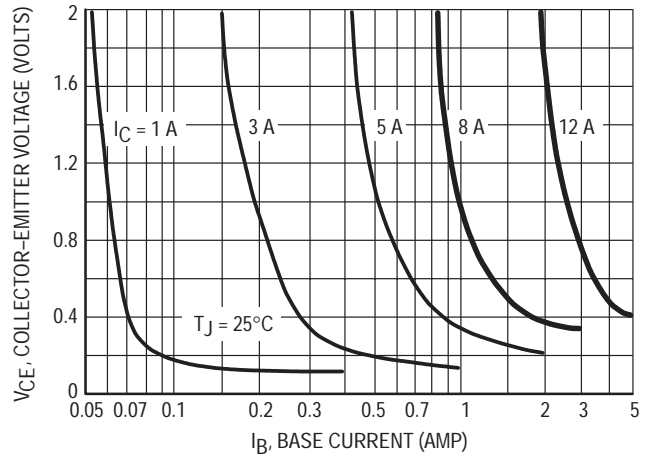


Figure 6. Collector Saturation Region

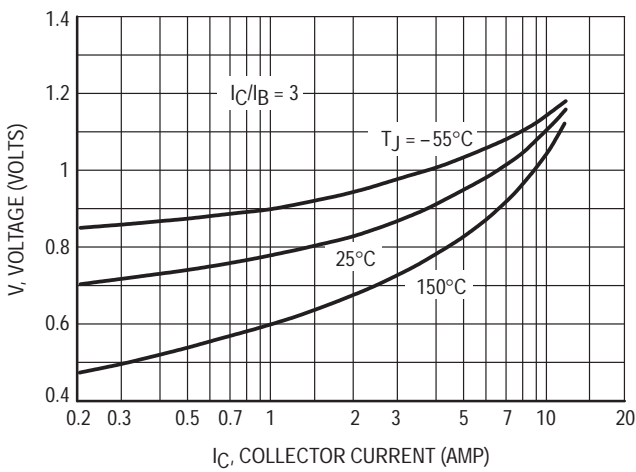


Figure 7. Base-Emitter Saturation Voltage

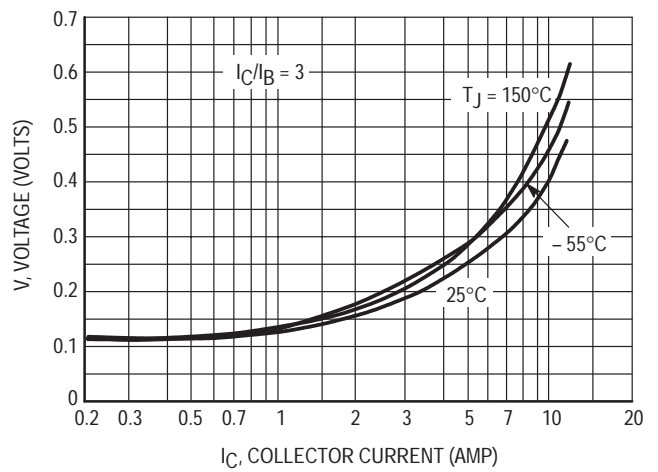


Figure 8. Collector-Emitter Saturation Voltage

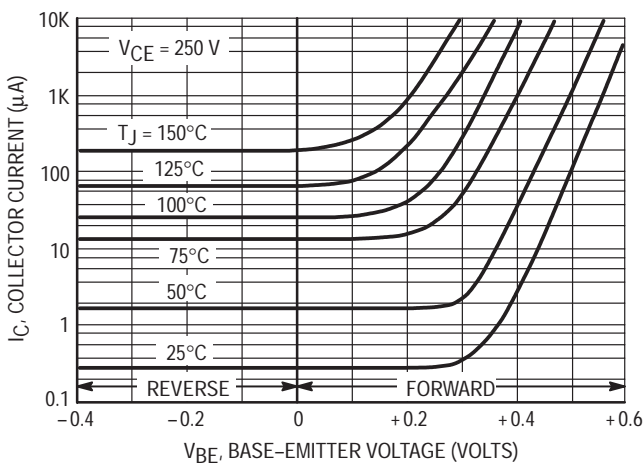


Figure 9. Collector Cutoff Region

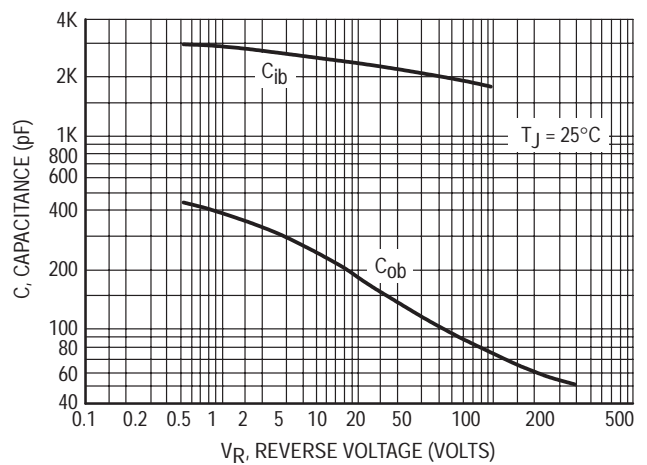


Figure 10. Capacitance

Table 1. Test Conditions for Dynamic Performance

REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING		RESISTIVE SWITCHING
TEST CIRCUITS	<p>DUTY CYCLE $\leq 10\%$ $t_r, t_f \leq 10$ ns</p> <p>NOTE PW and V_{CC} Adjusted for Desired I_C R_B Adjusted for Desired I_{B1}</p>	
CIRCUIT VALUES	<p>Coil Data: Ferroxcube Core #6656 Full Bobbin (~16 Turns) #16</p> <p>GAP for 200 $\mu H/20$ A $L_{coil} = 200 \mu H$</p> <p>$V_{CC} = 20$ V $V_{clamp} = 300$ Vdc</p>	<p>$V_{CC} = 125$ V $R_C = 15 \Omega$ D1 = 1N5820 or Equiv. $R_B = \Omega$</p>
TEST WAVEFORMS	<p>OUTPUT WAVEFORMS</p> <p>t_1 ADJUSTED TO OBTAIN I_C $t_1 \approx \frac{L_{coil}(I_{CM})}{V_{CC}}$</p> <p>$t_2 \approx \frac{L_{coil}(I_{CM})}{V_{clamp}}$</p> <p>Test Equipment Scope-Tektronics 475 or Equivalent</p>	<p>$t_r, t_f < 10$ ns Duty Cycle = 1.0% R_B and R_C adjusted for desired I_B and I_C</p>

APPLICATIONS INFORMATION FOR SWITCHMODE SPECIFICATIONS

INTRODUCTION

The primary considerations when selecting a power transistor for SWITCHMODE applications are voltage and current ratings, switching speed, and energy handling capability. In this section, these specifications will be discussed and related to the circuit examples illustrated in Table 2.(1)

VOLTAGE REQUIREMENTS

Both blocking voltage and sustaining voltage are important in SWITCHMODE applications.

Circuits B and C in Table 2 illustrate applications that require high blocking voltage capability. In both circuits the switching transistor is subjected to voltages substantially higher than V_{CC} after the device is completely off (see load line diagrams at $I_C = I_{leakage} \approx 0$ in Table 2). The blocking capability at this point depends on the base to emitter conditions and the device junction temperature. Since the highest device capability occurs when the base to emitter junction is reverse biased (V_{CEV}), this is the recommended and specified use condition. Maximum I_{CEV} at rated V_{CEV} is specified at a relatively low reverse bias (1.5 Volts) both at 25°C and

100°C. Increasing the reverse bias will give some improvement in device blocking capability.

The sustaining or active region voltage requirements in switching applications occur during turn-on and turn-off. If the load contains a significant capacitive component, high current and voltage can exist simultaneously during turn-on and the pulsed forward bias SOA curves (Figure 1) are the proper design limits.

For inductive loads, high voltage and 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 a Reverse Bias Safe Operating Area (Figure 2) which represents voltage-current conditions that can be sustained during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

(1) For detailed information on specific switching applications, see Motorola Application Notes AN-719, AN-767.

VOLTAGE REQUIREMENTS (continued)

In the four application examples (Table 2) load lines are shown in relation to the pulsed forward and reverse biased SOA curves.

In circuits A and D, inductive reactance is clamped by the diodes shown. In circuits B and C the voltage is clamped by the output rectifiers, however, the voltage induced in the primary leakage inductance is not clamped by these diodes and could be large enough to destroy the device. A snubber network or an additional clamp may be required to keep the turn-off load line within the Reverse Bias SOA curve.

Load lines that fall within the pulsed forward biased SOA curve during turn-on and within the reverse bias SOA curve during turn-off are considered safe, with the following assumptions:

- (1) The device thermal limitations are not exceeded.
- (2) The turn-on time does not exceed 10 μ s (see standard pulsed forward SOA curves in Figure 1).
- (3) The base drive conditions are within the specified limits shown on the Reverse Bias SOA curve (Figure 2).

CURRENT REQUIREMENTS

An efficient switching transistor must operate at the required current level with good fall time, high energy handling

capability and low saturation voltage. On this data sheet, these parameters have been specified at 8 amperes which represents typical design conditions for these devices. The current drive requirements are usually dictated by the $V_{CE(sat)}$ specification because the maximum saturation voltage is specified at a forced gain condition which must be duplicated or exceeded in the application to control the saturation voltage.

SWITCHING REQUIREMENTS

In many switching applications, a major portion of the transistor power dissipation occurs during the fall time (t_{fi}). For this reason considerable effort is usually devoted to reducing the fall time. The recommended way to accomplish this is to reverse bias the base-emitter junction during turn-off. The reverse biased switching characteristics for inductive loads are discussed in Figure 11 and Table 3 and resistive loads in Figures 13 and 14. Usually the inductive load component will be the dominant factor in SWITCHMODE applications and the inductive switching data will more closely represent the device performance in actual application. The inductive switching characteristics are derived from the same circuit used to specify the reverse biased SOA curves, (See Table 1) providing correlation between test procedures and actual use conditions.

RESISTIVE SWITCHING PERFORMANCE

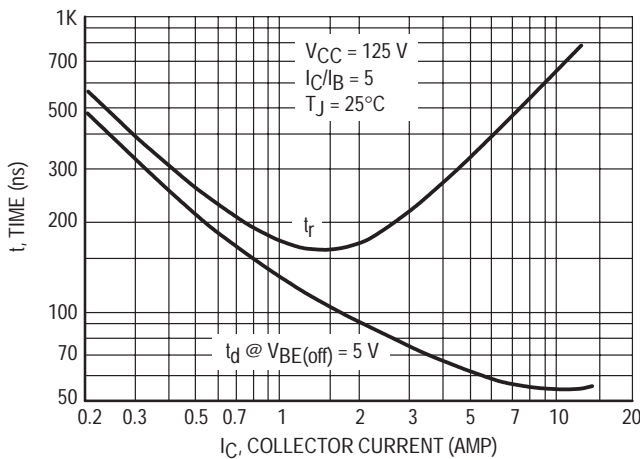


Figure 11. Turn-On Time

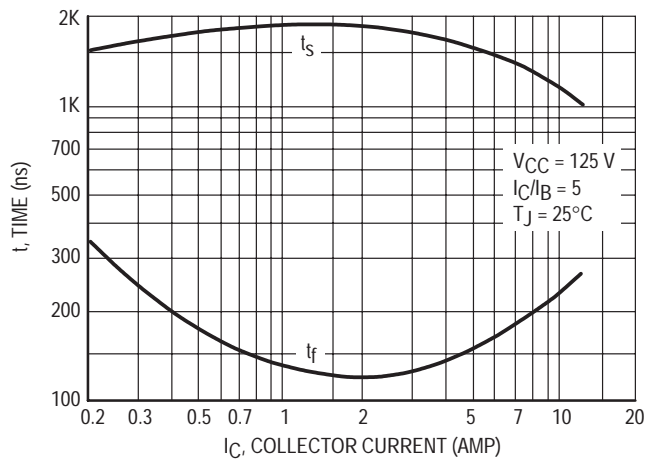


Figure 12. Turn-Off Time

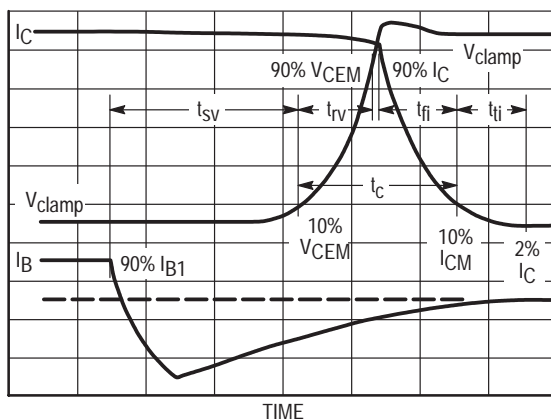


Figure 13. Inductive Switching Measurements

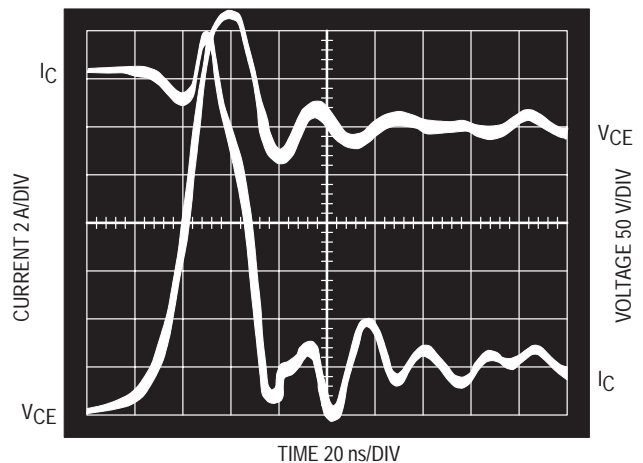


Figure 14. Typical Inductive Switching Waveforms (at 300 V and 12 A with $I_{B1} = 2.4$ A and $V_{BE(off)} = 5$ V)

Table 2. Applications Examples of Switching Circuits

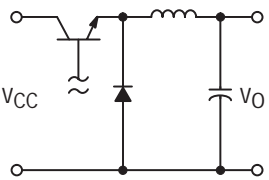
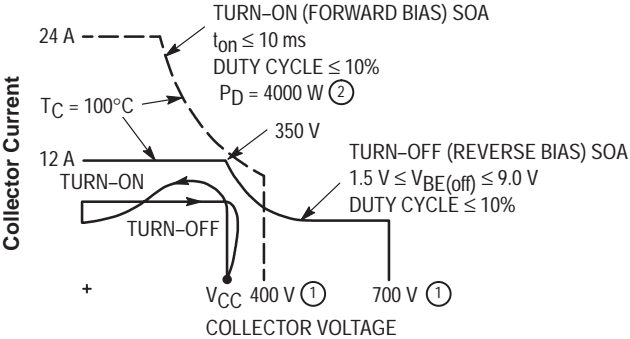
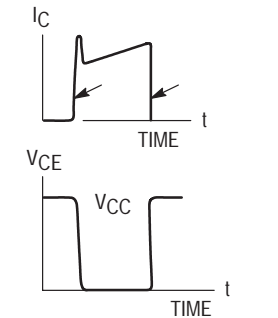
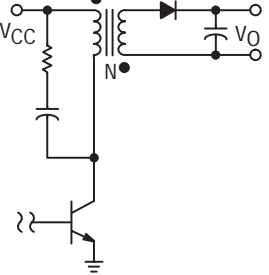
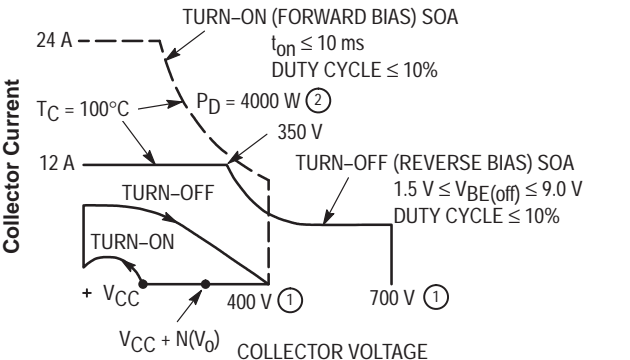
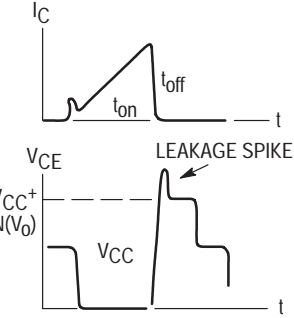
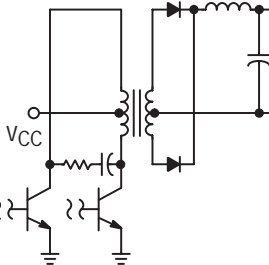
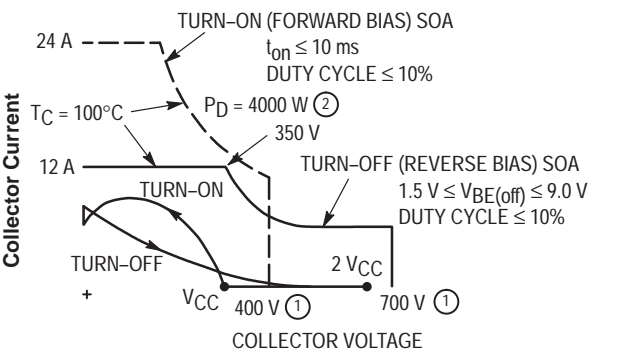
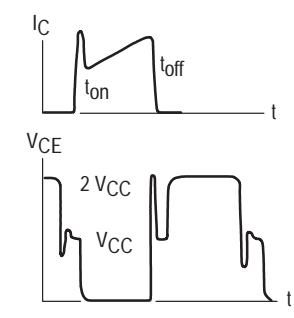
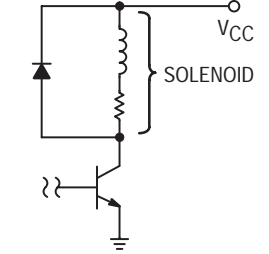
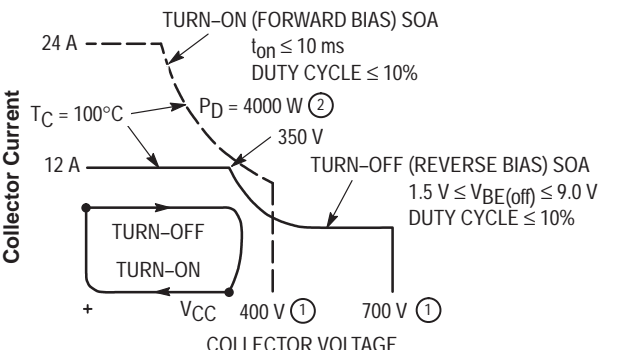
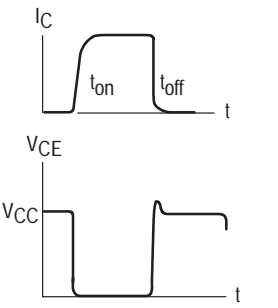
CIRCUIT	LOAD LINE DIAGRAMS	TIME DIAGRAMS
<p>SERIES SWITCHING REGULATOR</p> 		
<p>RINGING CHOKE INVERTER</p> 		
<p>PUSH-PULL INVERTER/CONVERTER</p> 		
<p>SOLENOID DRIVER</p> 		

Table 3. Typical Inductive Switching Performance

I _C AMP	T _C °C	t _{sv} ns	t _{rv} ns	t _{fi} ns	t _{tj} ns	t _c ns
3	25	770	100	150	200	240
	100	1000	230	160	200	320
5	25	630	72	26	10	100
	100	820	100	55	30	180
8	25	720	55	27	2	77
	100	920	70	50	8	120
12	25	640	20	17	2	41
	100	800	32	24	4	54

NOTE: All Data recorded In the Inductive Switching Circuit In Table 1.

SWITCHING TIME NOTES

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_{tj} = Current Tail, 10–2% I_{CM}

t_c = Crossover Time, 10% V_{CEM} to 10% I_{CM}

An enlarged portion of the turn-off waveforms is shown in Figure 13 to aid in the visual identity of these terms.

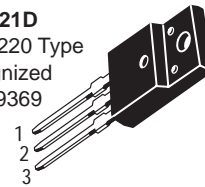
For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

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

Typical inductive switching waveforms are shown in Figure 14. In general, t_{rv} + t_{fi} ≈ 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.

CASE 221D
Isolated TO-220 Type
UL Recognized
File #E69369



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

Table 1. Plastic (Isolated TO-220 Type)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min	V _{CES} 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		
1	250		MJF47		30/150	0.3	2 typ	0.17 typ	0.3	10	28
2	400	700	BUL44F		14/34	0.2	2.75 ⁽³⁾	0.2 ⁽³⁾	1	13 typ	25
		1000	MJF18002		14/34	0.2	2.75 ⁽³⁾	0.175 ⁽³⁾	1	13 typ	25
3	100		MJF31C	MJF32C	10 min	1	0.6	0.3	1	3	28
5	100		MJF122 ⁽²⁾	MJF127 ⁽²⁾	2000 min	3	1.5 typ	1.5 typ	3	4 ⁽¹⁾	28
	400	700	BUL45F		14/34	0.3	1.7 ⁽³⁾	0.15 ⁽³⁾	1	12 typ	35
	450	1000	BUT11AF		10 min	.005	4	0.8	2.5		40
		1000	MJF18004		14/34	0.3	1.7 ⁽³⁾	0.15 ⁽³⁾	1	13 typ	35
550	1200	MJF18204		18/35	0.5	2.75 ⁽³⁾	0.2 ⁽³⁾	2	12	35	
6	400	700	BUL146F		14/34	0.5	2.5 ⁽³⁾	0.15 ⁽³⁾	3	14 typ	40
	450	1000	MJF18006		14/34	0.5	3.2 ⁽³⁾	0.15 ⁽³⁾	3	14 typ	40
8	80			MJF6107	30/90	2	0.5 typ	0.13 typ	2	4	35
	150		MJF15030	MJF15031	40 min	3	1 typ	0.15 typ	3	30	35
	400	700	MJF13007		5/30	5	3	0.7	5	4	40
				BUL147F		14/34	1	2.5 ⁽³⁾	0.18 ⁽³⁾	2	14 typ
450	1000	MJF18008		16/34	1	2.75 ⁽³⁾	0.18 ⁽³⁾	2	13 typ	45	
10	60		MJF3055	MJF2955	20/100	4	—	—	—	2	40
	80		MJF44H11	MJF45H11	40/100	4	0.5 typ	0.14 typ	5	40	35
	100		MJF6388 ⁽²⁾	MJF6668 ⁽²⁾	3k/20k	3	1.5 typ	1.5 typ		20 ⁽¹⁾	40
	450	1000	MJF18009		14/34	1.5	2.75 ⁽³⁾	0.2 ⁽³⁾	3	12	50
12	400	700	MJF13009		6/30	8	3	0.7	8	8	40

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(3)Switching tests performed w/special application simulator circuit. See data sheet for details.

Devices listed in bold, italic are Motorola preferred devices.

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

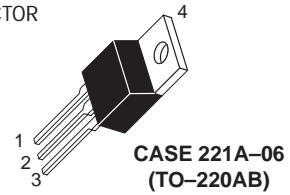


Table 2. Plastic TO-220AB

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
0.5	350	MJE2360T		15 min	0.1				10 typ	30
		MJE2361T		40 min	0.1				10 typ	30
1	100	TIP29C	TIP30C	15/75	1	0.6 typ	0.3 typ	1	3	30
	250	TIP47		30/150	0.3	2 typ	0.18 typ	0.3	10	40
	300	TIP48	MJE5730	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	350	TIP49	MJE5731	30/150	0.3	2 typ	0.18 typ	0.3	10	40
	400	TIP50	MJE5731A⁽⁷⁾	30/150	0.3	2 typ	0.18 typ	0.3	10	40
2	100	TIP112⁽²⁾	TIP117⁽²⁾	500 min	2	1.7 typ	1.3 typ	2	25 ⁽¹⁾	50
	400/700	BUL44		14/36	0.4	2.75 ⁽³⁾	0.175 ⁽³⁾	1	13 typ	50
	450/1000	BUX85		30	0.1	3.5	1.4	1	4	50
	450/1000	MJE18002		14/34	0.2	3 ⁽³⁾	0.17 ⁽³⁾	1	12 typ	40
	900/1800	MJE1320		3 min	1	4 typ	0.8 typ	1		80
3	80	BD241B	BD242B	25 min	1				3	40
	100	BD241C	BD242C	25 min	1				3	40
		TIP31C	TIP32C	25 min	1	0.6 typ	0.3 typ	1	3	40
	150		MJE9780	50/200	0.5				5 typ	40

(1)|h_{FE}| @ 1 MHz
 (2)Darlington
 (3)Switching tests performed w/special application simulator circuit. See data sheet for details.
 (7)V_{CEO} = 375 V
 (8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
4	40		MJE1123	45/100	4				5	75
	60	MJE800 ⁽²⁾	MJE700 ⁽²⁾	750 min	1.5				1 ⁽¹⁾	40
	80	D44C12	D45C12	40/120	0.2			1	40 typ	30
	400/700	MJE13005		6/30	3	3	0.7	3	4	60
5	100	TIP122 ⁽²⁾	TIP127 ⁽²⁾	1k min	3	1.5 typ	1.5 typ	4	4 ⁽¹⁾	75
	250	2N6497		10/75	2.5	1.8	0.8	2.5	5	80
	300	2N6498		10/75	2.5	1.8	0.8	2.5	5	80
	400/700	BUL45		14/34	0.3	1.7 ⁽³⁾	0.15 ⁽³⁾	1	12 typ	75
	450/1000	MJE16002		5 min	5	3	0.3	3		80
	450/850	MJE16004		7 min	5	2.7	0.35	3		80
	450/1000	MJE18004		14/34	0.3	1.7	0.15	1.0	13	75
	550/1200	MJE18204		18/35	0.5	2.75 ⁽³⁾	0.2 ⁽³⁾	2	12	75
6	80	BD243B	BD244B	15 min	3	0.4 typ	0.15 typ	3	3	65
	100	BD243C	BD244C	15 min	3	0.4 typ	0.15 typ	3	3	65
		TIP41C	TIP42C	15/75	3	0.4 typ	0.15 typ	3	3	65
	250/550	MJE16204		5 min	6	1.5 ⁽²⁾	0.15 ⁽²⁾	1	10	80
	400/700	BUL146		14/34	0.5	1.75 ⁽³⁾	0.15 ⁽³⁾	3	14 typ	100
	450/1000	MJE18006		14/34	0.5	3.2 ⁽³⁾	0.13 ⁽³⁾	3	14 typ	100
7	30	2N6288	2N6111	30/150	3	0.4 typ	0.15 typ	3	4	40
	50		2N6109	30/150	2.5	0.4 typ	0.15 typ	3	4	40
	70	2N6292	2N6107	30/150	2	0.4 typ	0.15 typ	3	4	40
	100	BD801	BD802	15 min	3				3	65
	150	BU407		30 min	1.5		0.75	5	10	60
	200	BU406		30 min	1.5		0.75	5	10	60
	450	BU522B ⁽²⁾		250 min	2.5				7.5	75

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(3)Switching tests performed w/special application simulator circuit. See data sheet for details.

(7)V_{CEO} = 375 V

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Table 2. Plastic TO-220AB (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
8	60	2N6043 ⁽²⁾	2N6040 ⁽²⁾	1k/10k	4	1.5 typ	1.5 typ	3	4 ⁽¹⁾	75
	80	2N6044 ⁽²⁾	2N6041 ⁽²⁾	1k/10k	4	1.5 typ	1.5 typ	3	4 ⁽¹⁾	75
		BDX53B ⁽²⁾	BDX54B ⁽²⁾	750 min	3				4 ⁽¹⁾	60
	100	2N6045 ⁽²⁾	2N6042 ⁽²⁾	1k/10k	3	1.5 typ	1.5 typ	3	4 ⁽¹⁾	75
		BDX53C ⁽²⁾	BDX54C ⁽²⁾	750 min	3					
		TIP102 ⁽²⁾	TIP107 ⁽²⁾	1k/20k	3	1.5 typ	1.5 typ	3	4 ⁽¹⁾	80
	120	MJE15028	MJE15029	20 min	4				30	50
	150	MJE15030	MJE15031	20 min	4				30	50
	200	BU806 ⁽²⁾		100 min	5	0.55 typ	0.2 typ	5		60
	300/600	MJE5740 ⁽²⁾		200 min	4	8 typ	2 typ	6	4	80
			MJE5850	15 min	2	2	0.5	4		80
	350	MJE5741 ⁽²⁾		200 min	4	8 typ	2 typ	6		80
			MJE5851	15 min	2	2	0.5	4		80
		MJE5742 ⁽²⁾		200 min	4	8 typ	2 typ	6		80
		MJE13007		5/30	5	3	0.7	5		80
			MJE5852	15 min	2	2	0.5	4		80
400/650	MJE16106		6/22	8	2 typ	0.1 typ	5		100	
400/700	BUL147		14/34	1	2.5 ⁽³⁾	0.18 ⁽³⁾	2	14 typ	125	
450/1000	MJE18008		16/34	1	2.75 ⁽³⁾	0.18 ⁽³⁾	2	13 typ	125	
10	20		BD808	15 min	4				1.5	90
	60	D44H8	D45H8	40 min	4					50
		MJE3055T	MJE2955T	20/70	4					75
		2N6387 ⁽²⁾	2N6667 ⁽²⁾	1k/20k	5				20 ⁽¹⁾	65
	80	BDX33B ⁽²⁾	BDX34B ⁽²⁾	750 min	3				3	70
		BD809	BD810	15 min	4				1.5	90
		2N6388 ⁽²⁾	2N6668 ⁽²⁾	1k/20k	5				20 ⁽¹⁾	65
		D44H10	D45H10	20 min	4	0.5 typ	0.14 typ	5	50 typ	50
D44H11		D45H11	40 min	4	0.5 typ	0.14 typ	5	50 typ	50	

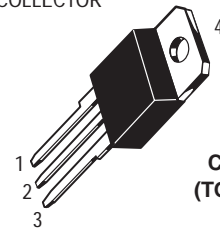
(1)h_{FE} @ 1 MHz
 (2)Darlington
 (3)Switching tests performed w/special application simulator circuit. See data sheet for details.
 (7)V_{CEO} = 375 V
 (8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.
 (9)Self protected Darlington

Devices listed in bold, italic are Motorola preferred devices.

Table 2. Plastic TO-220AB (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min(8)	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	100	<i>BDX33C</i> (2)	<i>BDX34C</i> (2)	750 min	3				3	70
	450/1000	<i>MJE18009</i>		14/34	1.5	2.75(3)	0.2(3)	3	12	150
12	400/700	<i>MJE13009</i>		6/30	8	3	0.7	8	4	100
15	80	<i>2N6488</i>	<i>2N6491</i>	20/150	5	0.6 typ	0.3 typ	5	5	75
		<i>D44VH10</i>	<i>D45VH10</i>	20 min	4	0.5	0.09	8	50 typ	83
	100	<i>BDW42</i> (2)	<i>BDW47</i> (2)	1k min	5	1 typ	1.5 typ	5	4	85

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



CASE 340D
(TO-218 Type,
SOT-93)

Table 3. Plastic TO-218 Type

I _C Cont Amps Max	V _{CEO(sus)} Volts Min(8)	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		
8	500/1000	<i>MJH16006A</i>		5 min	8	2.5	0.25	5		125
10	60	TIP140(2)	TIP145(2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
		TIP141(2)	TIP146(2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
	100	<i>BDV65B</i> (2)	<i>BDV64B</i> (2)	1k min	5					125
		TIP33C	TIP34C	20/100	3				3	80
		<i>TIP142</i> (2)	<i>TIP147</i> (2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
	400	<i>BU323AP</i> (2)		150/100	6	15	15	6		125
<i>MJH10012</i> (2)			100/2k	6	15	15	6		118	

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

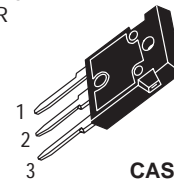
Table 3. Plastic TO-218 Type (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
15	60	TIP3055	TIP2955	5 min	10				2.5	80
	150	MJH11018 ⁽²⁾	MJH11017 ⁽²⁾	400/15k	10				3	150
	200	MJH11020 ⁽²⁾	MJH11019 ⁽²⁾	400/15k	10				3	150
	250	MJH11022⁽²⁾	MJH11021⁽²⁾	400/15k	10				3	150
	400	BUV48		8 min	10	2	0.4	10		150
	450	BUV48A		8 min	8	2	0.4	10		150
16	140	MJE4342	MJE4352	15 min	8	1.2 typ	1.2 typ	8	1	125
	160	MJE4343	MJE4353	15 min	8	1.2 typ	1.2 typ	8	1	125
20	60	MJH6282 ⁽²⁾	MJH6285 ⁽²⁾	750/18k	10				4	125
	100	MJH6284⁽²⁾	MJH6287⁽²⁾	750/18k	10				4	125
25	80	TIP35A	TIP36A	15/75	15	0.6 typ	0.3 typ	10	3	125
	100	BD249C	BD250C	10 min	15				3	125
		TIP35C	TIP36C	15/75	15	0.6 typ	0.3 typ	10	3	125

⁽²⁾Darlington

⁽⁸⁾When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

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



CASE 340F
(TO-247 Type)

Table 4. Isolated Mounting Hole — Plastic TO-247 Type

I _C Cont Amps Max	V _{CEO(sus)} Volts Min	V _{CES} 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	650	1500	MJW16212		4/10	10	4 ⁽³⁾	0.5 ⁽³⁾	5.5		150
	800	1500	MJW16018		4 min	5	4.5 typ	0.2 typ	5	3 typ	150
12	500	1200	MJW16206		5/13	10	2.25	0.25	6.5	3 typ	150
15	450	850	MJW16010		5 min	15	1.2 typ	0.2 typ	10		150
		850	MJW16012		7 min	15	0.9 typ	0.15 typ	10		150
	500	1000	MJW16010A		5 min	15	3	0.4	10		150

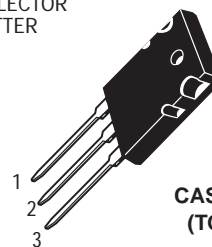
⁽³⁾Switching tests performed w/special application simulator circuit. See data sheet for details.

⁽¹⁰⁾Tested in Applications simulator: see Data Sheet.

Devices listed in bold, italic are Motorola preferred devices.

New Product New Product New Product New Product

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



CASE 340G
(TO-264)

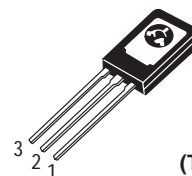
Table 5. Large Plastic TO-264

I _C Cont Amps Max	V _{CEO(sus)} Volts Min	Device Type		hFE 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		
15	200	<i>MJL3281A</i>	<i>MJL1302A</i>	60/175	0.1				30 typ	200
	650/1500	<i>MJL16218</i>		4/11	12				2.5 typ	170
16	250	<i>MJL21194</i>	<i>MJL21193</i>	25/75	8				4	200

New Product New Product New Product New Product

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

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



CASE 77
(TO-225AA)

Table 6. Plastic TO-225AA Type (Formerly TO-126 Type)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min	Device Type		hFE 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		
0.3	350	<i>MJE3439</i>		40/160	0.02				15	15
0.5	150	MJE341		25/200	0.05				15	20.8
	200	<i>MJE344</i>		30/300	0.05				15	20.8
	250	2N5655		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
		BD157		30/240	0.05					20
	300	<i>BD158</i>		30/240	0.05					20
		<i>MJE340</i>	<i>MJE350</i>	30/240	0.05					20.8
2N5656			30/250	0.1	3.5 typ	0.24 typ	0.1	10	20	

Devices listed in bold, italic are Motorola preferred devices.

Table 6. Plastic TO-225AA Type (Formerly TO-126 Type) (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		
0.5	350	2N5657		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
		BD159		30/240	0.05					20
1	40	2N4921	2N4918	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	60	2N4922	2N4919	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
	80	2N4923	2N4920	20/100	0.5	0.6 typ	0.3 typ	0.5	3	30
1.5	45	BD165	BD166	15 min	0.5				6	20
		BD135	BD136	40/250	0.15					12.5
	60	BD137	BD138	40/250	0.15					12.5
	80	BD169		15 min	0.5				6	20
		BD139	BD140	40/250	0.15					12.5
			BD140-10	63/160	0.15					12.5
	300	MJE13002 ⁽¹¹⁾		5/25	1	4	0.7	1	5	40
	400	MJE13003 ⁽¹¹⁾		5/25	1	4	0.7	1	5	40
2	80	BD237	BD238	25 min	1				3	25
	100	MJE270 ⁽²⁾⁽¹¹⁾	MJE271 ⁽²⁾⁽¹¹⁾	1.5k min	0.12				6	15
3	60	MJE181	MJE171	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	80	BD179	BD180	40/250	0.15				3	30
		MJE182	MJE172	50/250	0.1	0.6 typ	0.12 typ	0.1	50	12.5
	200	BUY49P		30 min	0.5				25	20
4	40	MJE521	MJE371	40 min	1					40
	45	BD437	BD438	40 min	2				3	36
			BD776 ⁽²⁾	750 min	2				20	15
	60		BD440	25 min	2				3	36
		BD677 ⁽²⁾	BD678 ⁽²⁾	750 min	1.5					40
		BD677A ⁽²⁾	BD678A ⁽²⁾	750 min	2					40
		BD787	BD788	20 min	2				50	15
		BD777 ⁽²⁾	BD778 ⁽²⁾	750 min	2				20	15
		2N5191	2N5194	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		MJE800 ⁽²⁾	MJE700 ⁽²⁾	750 min	1.5				1 ⁽¹⁾	40
		2N6038 ⁽²⁾	2N6035 ⁽²⁾	750/18k	2	1.7 typ	1.2 typ	2	25	40
	80	2N5192	2N5195	25/100	1.5	0.4 typ	0.4 typ	1.5	2	40
		BD441	BD442	15 min	2				3	36
		BD679 ⁽²⁾	BD680 ⁽²⁾	750 min	1.5					40
BD679A ⁽²⁾		BD680A ⁽²⁾	750 min	2					40	
BD789		BD790	10 min	2				40	15	

(1) |h_{FE}| @ 1 MHz

(2) Darlington

(11) Case 77, Style 3

Devices listed in bold, italic are Motorola preferred devices.

Table 6. Plastic TO–225AA Type (Formerly TO–126 Type) (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		
4	80	<i>BD779</i> (2)	<i>BD780</i> (2)	750 min	2				20	15
		MJE802(2)	MJE702(2)	750 min	1.5				1(1)	40
		<i>MJE803</i> (2)	<i>MJE703</i> (2)	750 min	2				1(1)	40
		<i>2N6039</i> (2)	<i>2N6036</i> (2)	750/18k	2	1.7 typ	1.2 typ	2	25	40
	100	<i>BD681</i> (2)	<i>BD682</i> (2)	750 min	1.5					40
		<i>BD791</i>	<i>BD792</i>	10 min	2				40	15
<i>MJE243</i>		<i>MJE253</i>	40/120	0.2	0.15 typ	0.07 typ	2	40	15	
5	25	<i>MJE200</i>	<i>MJE210</i>	45/180	2	0.13 typ	0.035 typ	2	65	15



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

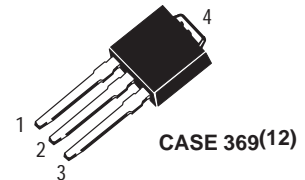


Table 7. DPAK – Surface Mount Power Packages

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		
0.5	300	<i>MJD340</i>	<i>MJD350</i>	30/240	0.05					15
1	250	MJD47		30/150	0.3	2	0.2	0.3	10	15
	375		<i>MJD5731</i>	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	400	<i>MJD50</i>		30/150	0.3	2	0.2	0.3	10	15
1.5	400	<i>MJD13003</i>		5/25	1	4	0.7	1	4	15

(1)|h_{FE}| @ 1 MHz

(2)Darlington

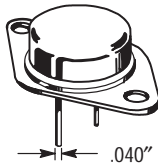
(12)Case 369–07 may be ordered by adding –1 suffix to part number.

(13)Case 369A–13 may be ordered as tape and reel by adding a “T4” suffix; 2500 units/reel.

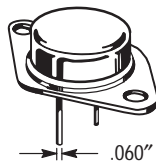
Devices listed in bold, italic are Motorola preferred devices.

Table 7. DPAK – Surface Mount Power Packages (continued)

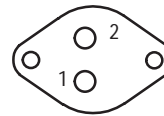
I _C Cont Amps Max	V _{CEO(sus)} Volts Min	Device Type		h _{FE} Min/Max	@ I _C Amp	Resistive Switching			f _T MHz Min	P _D (Case) Watts @ 25°C
		NPN	PNP			t _s μs Max	t _f μs Max	@ I _C Amp		
2	100	<i>MJD112</i> (2)	<i>MJD117</i> (2)	1000 min	2	1.7	1.3	2	25(1)	20
3	40	MJD31	MJD32	10 min	1	0.6	0.3	1	3	15
	100	<i>MJD31C</i>	<i>MJD32C</i>	10 min	1	0.6	0.3	1	3	15
4	80	<i>MJD6039</i> (2)	<i>MJD6036</i> (2)	1k/12k	2	1.7	1.2	2	25	20
	100	<i>MJD243</i>	<i>MJD253</i>	40/180	0.2	0.16	0.04	1	40	12.5
5	25	<i>MJD200</i>	<i>MJD210</i>	45/180	2	0.15	0.04	2	65	12.5
6	100	<i>MJD41C</i>	<i>MJD42C</i>	15/75	3	0.4	0.15	3	3	20
8	80	<i>MJD44H11</i>	<i>MJD45H11</i>	40 min	4	0.5	0.14	5	50 typ	20
	100	<i>MJD122</i> (2)	<i>MJD127</i> (2)	1k/12k	4	1.5	2	4	4(1)	20
10	60	<i>MJD3055</i>	<i>MJD2955</i>	20/100	4	1.5	1.5	3	2	20
	80	<i>MJD44E3</i> (2)		1k min	5	2	0.5	10		20



CASE 1-07
TO-204AA



CASE 197A TO-204AE
(Used for high current types at end of
table. See types w/footnote(16).)



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

Table 8. Metal TO-204AA (Formerly TO-3), TO-204AE

I _C Cont Amps Max	V _{CEO(sus)} Volts Min(8)	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		
4	200	MJ15018		30 min	1				20	150
	250	<i>MJ15020</i>	<i>MJ15021</i>	30 min	1				20	150
5	700/1500	<i>BU208A</i>		2.5 min	4.5	8 typ	0.4 typ	4.5	4 typ	90
8	60	MJ1000(2)		1k min	3					90
		2N6055(2)		750/18k	4	1.5 typ	1.5 typ	4	4(1)	100
	80	<i>MJ1001</i> (2)		1k min	3					90
		<i>2N6056</i> (2)		750/18k	4	1.5 typ	1.5 typ	4	4(1)	100

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}

(12)Case 369 may be ordered by adding -1 suffix to part number.

(13)Case 369A may be ordered as tape and reel by adding a "T4" suffix; 2500 units/reel.

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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	60	2N3715	2N3791	30 min	3	0.3 typ	0.4 typ	5	4	150
		MJ3000 ⁽²⁾	MJ2500 ⁽²⁾	1k min	5					150
	80	2N3716	2N3792	30 min	3	0.3 typ	0.4 typ	5	4	150
		2N5878		20/100	4	1	0.8	4	4	150
		MJ3001 ⁽²⁾	MJ2501⁽²⁾	1k min	5					150
	140	2N3442		20/70	4					117
	250	MJ15011	MJ15012	20/100	2					200
	325	MJ413		20/80	0.5				2.5	125
		MJ423		30/90	1				2.5	125
	400	BU323A⁽²⁾		150 min	6	7.5 typ	5.2 typ	6		175
MJ10007⁽²⁾			30/300	5	1.5	0.5	5	10 ⁽¹⁾	150	
MJ10012⁽²⁾			100/2k	6	15	15	6		175	
12	60	2N6057 ⁽²⁾	2N6050 ⁽²⁾	750/18k	6	1.6 typ	1.5 typ	6	4 ⁽¹⁾	150
	80	2N6058 ⁽²⁾	2N6051 ⁽²⁾	750/18k	6	1.6 typ	1.5 typ	6	4 ⁽¹⁾	150
	100	2N6059⁽²⁾	2N6052⁽²⁾	750/18k	6	1.6 typ	1.5 typ	6	4 ⁽¹⁾	150
15	60	2N3055	MJ2955	20/70	4	0.7 typ	0.3 typ	4	2.5	115
		2N3055A	MJ2955A	20/70	4				0.8	115
		2N6576 ⁽²⁾		2k/20k	4	2	7	10	10–200 ⁽¹⁾	120
		2N5881	2N5879	20/100	6	1	0.8	6	4	160
	80	2N5882	2N5880	20/100	6	1	0.8	6	4	160
	90	2N6577 ⁽²⁾		2k/20k	4	2	7	10	10–200 ⁽¹⁾	120
	120	MJ15015	MJ15016	20/70	4	0.7 typ	0.3 typ	4	1	180
		2N6578⁽²⁾		2k/20k	4	2	7	10	10–200 ⁽¹⁾	120
	140	MJ15001	MJ15002	25/150	4				2	200
	150	MJ11018 ⁽²⁾	MJ11017 ⁽²⁾	100 min	15				3 ⁽¹⁾	175
	200	MJ11020 ⁽²⁾		100 min	15				3 ⁽¹⁾	175
		MJ3281A	MJ1302A	60/175	0.1				30 typ	250
	250	MJ11022⁽²⁾	MJ11019 ⁽²⁾	100 min	15				3 ⁽¹⁾	175
			MJ11021⁽²⁾	6/30	10	4	0.7	10	6 to 24	175
	400/850	BUX48		8 min	10	2	0.4	10		175
		2N6547		6/30	10	4	0.7	10	6 to 24	175
	400/650	MJ16110		6/20	15	0.8 typ	0.1 typ	10		175
450/1000	BUX48A		8 min	8	2	0.4	10		175	

(1)|h_{FE}| @ 1 MHz

(2)Darlington

(8)When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
15	450/850	MJ16010		5 min	15	1.2 typ	0.2 typ	10		175
		MJ16012		7 min	15	0.9 typ	0.15 typ	10		175
16	140	2N3773	2N6609	15/60	8	1.1 typ	1.5 typ	8	4	150
		2N5631	2N6031	15/60	8	1.2 typ	1.2 typ	8	1	200
	200	MJ15022	MJ15023	15/60	8				5	250
	250	MJ15024	MJ15025	15/60	8				5	250
		MJ21194	MJ21193	25/75	8				4	250
	20	60	2N3772		15/60	10				2
2N6282 ⁽²⁾			2N6285 ⁽²⁾	750/18k	10	2.5 typ	2.5 typ	10	4 ⁽¹⁾	160
75		2N5039		20/100	10	1.5	0.5	10	60	140
80		2N6283 ⁽²⁾	2N6286 ⁽²⁾	750/18k	10	2.5 typ	2.5 typ	10	4 ⁽¹⁾	160
90		2N5038		20/100	12	1.5	0.5	12	60	140
100		2N6284 ⁽²⁾	2N6287 ⁽²⁾	750/18k	10	2.5 typ	2.5 typ	10	4 ⁽¹⁾	160
140		MJ15003	MJ15004	25/150	5				2	250
200		BUV11		10 min	12	1.8	0.4	12	8	150
350		MJ10000 ⁽²⁾		40/400	10	3	1.8	10	10 ⁽¹⁾	175
400		MJ10005 ⁽²⁾		40/400	10	1.5	0.5	10	10 ⁽¹⁾	175
		MJ13333		10/60	5	4	0.7	10		175
500		MJ10009 ⁽²⁾		30/300	10	2	0.6	10	8 ⁽¹⁾	175
25		60	2N5885	2N5883	20/100	10	1	0.8	10	4
	80	2N5886	2N5884	20/100	10	1	0.8	10	4	200
			2N6436	30/120	10	1	0.25	10	40	200
	100	2N6338	2N6437	30/120	10	1	0.25	10	40	200
	120	2N6339	2N6438	30/120	10	1	0.25	10	40	200
	140	2N6340		30/120	10	1	0.25	10	40	200
150	2N6341		30/120	10	1	0.25	10	40	200	
30	40	2N3771		15/60	15				2	150
		2N5301	2N4398	15/60	15	2	1	10	2	200
	60	2N5302	2N4399	15/60	15	2	1	10	2	200
		MJ11012 ⁽²⁾	MJ11011 ⁽²⁾	1k min	20				4 ⁽¹⁾	200
	90	MJ11014 ⁽²⁾	MJ11013 ⁽²⁾	1k min	20				4 ⁽¹⁾	200
	100	2N6328		6/30	30				3	200
		MJ802	MJ4502	25/100	7.5				2	200
	120	MJ11016 ⁽²⁾	MJ11015 ⁽²⁾	1k min	20				4 ⁽¹⁾	200

(1) |h_{FE}| @ 1 MHz

(2) Darlington

(8) When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

Devices listed in bold, italic are Motorola preferred devices.

Table 8. Metal TO–204AA (Formerly TO–3), TO–204AE (continued)

I _C Cont Amps Max	V _{CEO(sus)} Volts Min ⁽⁸⁾	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		
30	325	BUV23		8 min	16	1.8	0.4	16	8	250
	400/1000	BUS98		8 min	20	2.3	0.4	20		250
		BUX98		8 min	20	3	0.8	20		250
	450/850	MJ16020 ⁽¹⁶⁾		5 min	30	1.8	0.2	20		250
		MJ16022 ⁽¹⁶⁾		7 min	30	1.5	0.15	20		250
	450/1000	BUS98A		8 min	16	2.3	0.4	16		250
		BUX98A		8 min	16	3	0.8	16		250
40	200	BUV21 ⁽¹⁶⁾		10 min	25	1.8	0.4	25	8	150
	250	BUV22 ⁽¹⁶⁾		10 min	20	1.1	0.35	20	8	250
	350	MJ10022 ⁽²⁾ ⁽¹⁶⁾		50/600	10	2.5	0.9	20		250
	400	MJ10023 ⁽²⁾ ⁽¹⁶⁾		50/600	10	2.5	0.9	20		250
50	60	2N5685 ⁽¹⁶⁾		15/60	25	0.5 typ	0.3 typ	25	2	300
	80	2N5686 ⁽¹⁶⁾	2N5684 ⁽¹⁶⁾	15/60	25	0.5 typ	0.3 typ	25	2	300
	90	MJ11030 ⁽²⁾ ⁽¹⁶⁾	MJ11031 ⁽²⁾ ⁽¹⁶⁾	400 min	50					300
	100	2N6274 ⁽¹⁶⁾		30/120	20	0.8	0.25	20	30	250
	120	2N6275 ⁽¹⁶⁾	2N6379 ⁽¹⁶⁾	30/120	20	0.8	0.25	20	30	250
		MJ11032 ⁽²⁾ ⁽¹⁶⁾	MJ11033 ⁽²⁾ ⁽¹⁶⁾	400 min	50					300
	125	BUV20 ⁽¹⁶⁾		10 min	50	1.2	0.25	50	8	250
		BUV60 ⁽¹⁶⁾		10 min	80	1.1	0.25	80		250
	150	2N6277 ⁽¹⁶⁾		30/120	20	0.8	0.25	20	30	250
	400	MJ10015 ⁽²⁾ ⁽¹⁶⁾		10 min	40	2.5	1	20		250
	500	BUT34 ⁽²⁾ ⁽¹⁶⁾		15 min	32	3	1.5	32		250
MJ10016 ⁽²⁾ ⁽¹⁶⁾			10 min	40	2.5	1	20		250	
56	400	BUT33 ⁽²⁾ ⁽¹⁶⁾		20 min	36	3.3	1.6	36		250
60	60		MJ14001 ⁽¹⁶⁾	15/100	50					300
	80	MJ14002 ⁽¹⁶⁾	MJ14003 ⁽¹⁶⁾	15/100	50					300
	200	MJ10020 ⁽²⁾ ⁽¹⁶⁾		75 min	15	3.5	0.5	30		250
	250	MJ10021 ⁽²⁾ ⁽¹⁶⁾		75 min	15	3.5	0.5	30		250
70	125	BUS50 ⁽¹⁶⁾		15 min	50	1.5	0.3	70		350
80	100	BUV18A ⁽¹⁶⁾		10 min	80	1.1	0.25	80		250

(1) |h_{FE}| @ 1 MHz

(2) Darlington

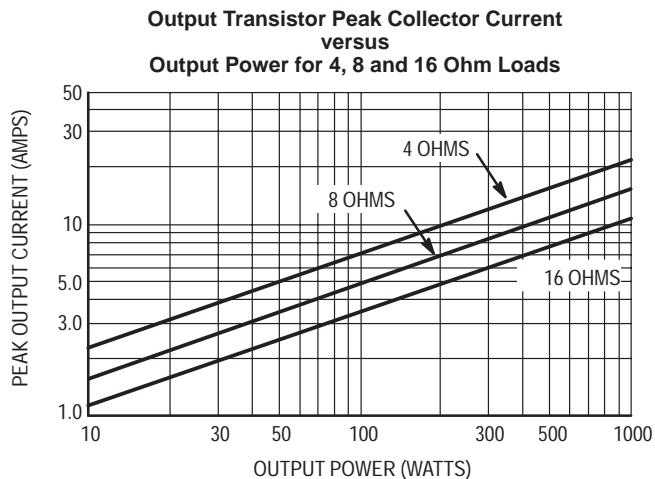
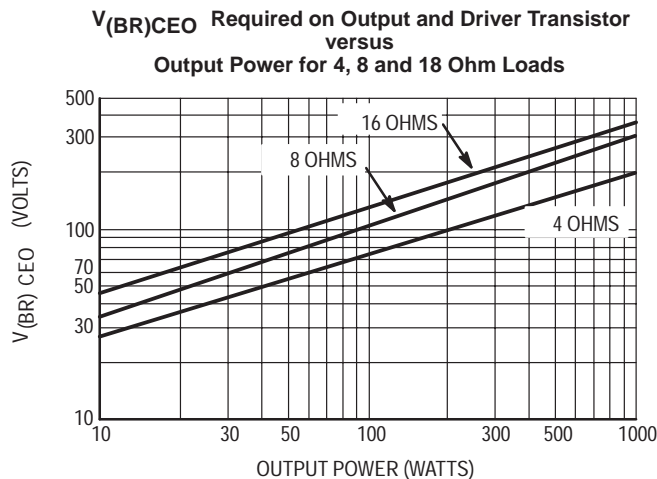
(8) When 2 voltages are given, the format is V_{CEO(sus)}/V_{CES}.

(16) Case 197A–03 (TO–204AE)

Devices listed in bold, italic are Motorola preferred devices.

Audio

GENERAL DESIGN CURVES FOR POWER AUDIO OUTPUT STAGES



Another important parameter that must be considered before selecting the output transistors is the safe-operating area these devices must withstand. For a complete discussion see Application Note AN485.

Table 9. Recommended Power Transistors for Audio/Servo Loads

RMS Power Output	NPN	PNP	Case	P_D Watts @ 25°C	V_{CEO}	h_{FE} @ Min/Max	I_C Amps	f_T MHz Typ	ISB Volts/Amps
To 25W	MJE15030	MJE15031	TO-220	50	150	20 min	4	30	14/3.6
	MJE15032	MJE15033	TO-220	50	250	50 min	1	40	50/1
25 to 50W	2N3055A	MJ2955A	TO-204	120	120	20/70	4	3	60/2
	MJ15001	MJ15002	TO-204	200	140	25/150	4	3	40/5
50 to 100W	MJ15015	MJ15016	TO-204	180	120	20/70	4	3	60/3
	MJ15003	MJ15004	TO-204	250	140	25/150	5	3	100/1
	MJ15020	MJ15021	TO-204	150	250	30 min	1	20	50/3
Over 100W	MJ15024	MJ15025	TO-204	250	250	15/60	8	8	80/2.2
	MJ3281A	MJ1302A	TO-204	250	200	60/175	7	30	50/4
	MJL3281A	MJL1302A	340G-01	150	200	60/175	7	30	40/4
	MJ21194	MJ21193	TO-204	250	250	25/75	8	7	100/2
	MJL21194	MJL21193	340G-01	200	200	25/75	8	7	100/2

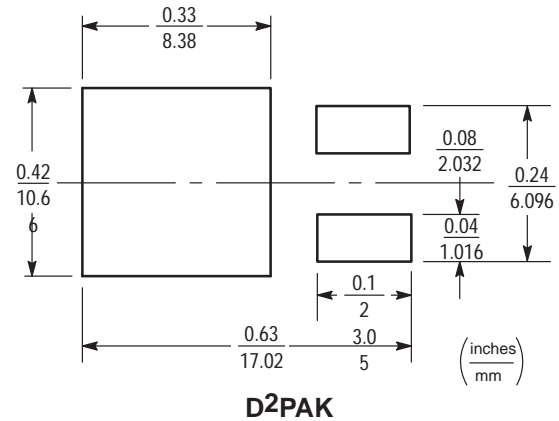
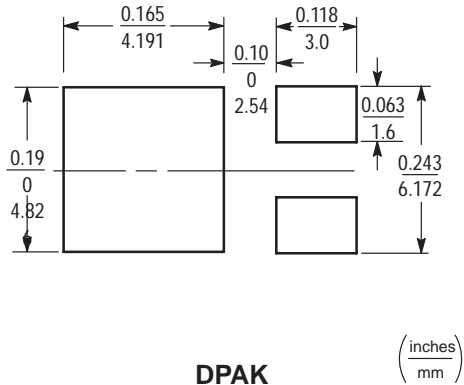
The Power Transistors shown are provided for reference only and show device capability. The final choice of the Power Transistors used is left to the circuit designer and depends upon the particular safe-operating area required and the mounting and heat sinking configuration used.

INFORMATION FOR USING SURFACE MOUNT PACKAGES

RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct

pad geometry, the packages will self align when subjected to a solder reflow process.



POWER DISSIPATION FOR A SURFACE MOUNT DEVICE

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°C, one can calculate the power dissipation of the device. For example, for a D2PAK, P_D is calculated as follows.

$$P_D = \frac{150^\circ\text{C} - 25^\circ\text{C}}{50^\circ\text{C/W}} = 2.5 \text{ watts}$$

The 50 °C/W for the D2PAK package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 2.5 watts. There are other alternatives to achieving higher power dissipation from the surface mount packages. One is to increase the area of the drain/collector pad. By increasing the area of the drain/collector pad, the power dissipation can be increased.

Although the power dissipation can almost be doubled with this method, area is taken up on the printed circuit board which can defeat the purpose of using surface mount technology. For example, a graph of $R_{\theta JA}$ versus drain pad area is shown in Figures 1 and 2.

Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

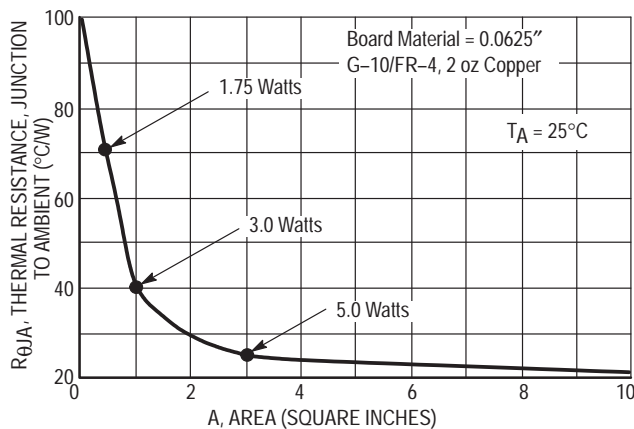


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

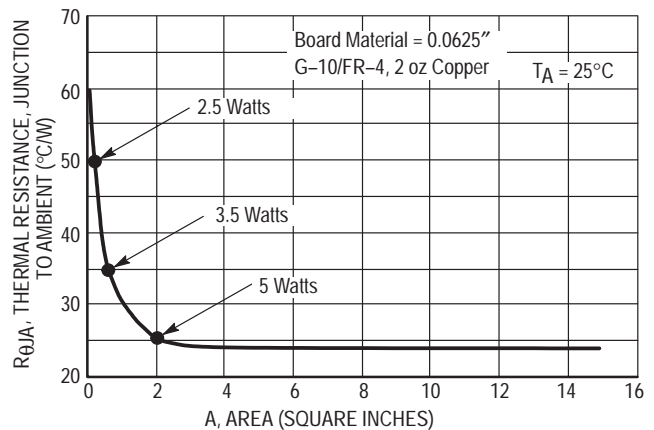


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. Solder stencils are used to screen the optimum amount. These stencils are typically 0.008 inches thick and may be made of brass or stainless steel. This is not the case with the DPAK and D²PAK packages. If a 1:1 opening is used to screen solder onto the drain pad, misalignment and/or “tombstoning” may occur due to an excess of solder. For these two packages, the opening in the stencil for the paste should be approximately 50% of the tab area. The opening for the leads is still a 1:1 registration. Figure 3 shows a typical stencil for the DPAK and D²PAK packages. The pattern of the opening in the stencil for the drain pad is not critical as long as it allows approximately 50% of the pad to be covered with paste.

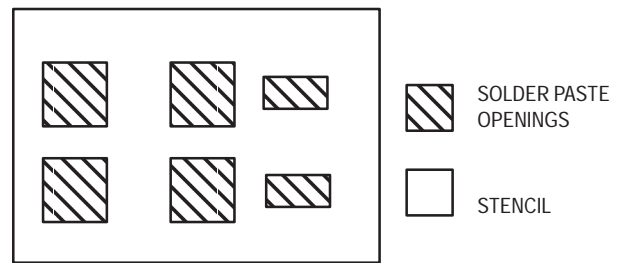


Figure 3. Typical Stencil for DPAK and D²PAK Packages

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference should be a maximum of 10°C.
- The soldering temperature and time should not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.

- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used since the use of forced cooling will increase the temperature gradient and will result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

* Due to shadowing and the inability to set the wave height to incorporate other surface mount components, the D²PAK is not recommended for wave soldering.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 5 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems, but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the

actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

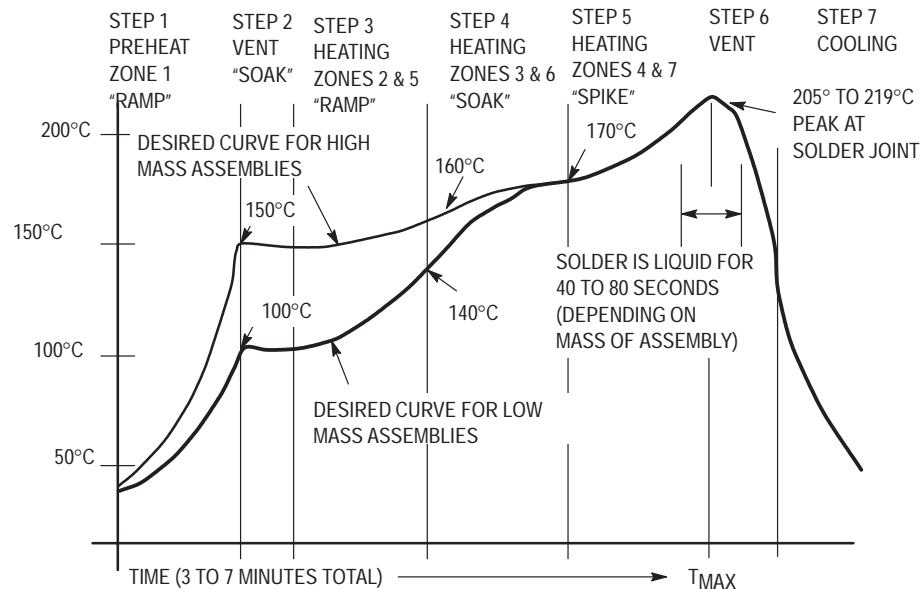


Figure 4. Typical Solder Heating Profile

Mounting Hardware and Techniques

There are many methods available and options possible for installing power semiconductors. A complete discussion of mounting is contained in Motorola Application Note AN1040, "Mounting Considerations for Power Semiconductors," reprinted in Section 6 of this data book. Various suppliers of mounting hardware, listed below, may be contacted for their catalogs which contain considerable technical information.

Sources for Mounting Hardware

Manufacturer	Joint Compound	Adhesives	Insulators						Heatsinks	Clips	
			BeO	AlO ₂	Anodize	Mica	Plastic Film	Silicone Rubber			
Aavid Eng.	—	—	—	—	—	—	—	X	X	X	X
AHAM-TOR	—	—	—	—	—	—	—	—	—	X	—
Asheville-Schoonmaker	—	—	—	—	—	—	X	—	—	—	—
Astroynamics	X	—	—	—	—	—	—	—	—	X	—
Delbert Blinn	—	—	X	—	X	X	X	X	X	X	—
IERC	X	—	—	—	—	—	—	—	—	X	—
Staver	—	—	—	—	—	—	—	—	—	X	—
Thermalloy	X	X	X	X	X	X	X	X	X	X	X
Tran-tec	X	—	X	X	X	X	X	—	X	X	—
Wakefield Eng.	X	X	X	—	X	—	—	—	X	X	X

Other sources for silicone rubber pads: Chomerics, Berquist

Suppliers Addresses

Aavid Engineering, Inc., P.O. Box 400, Laconia, New Hampshire 03247 (603) 528-1478

AHAM-TOR Heatsinks, 27901 Front Street, Rancho, California 92390 (714) 676-4151

Asheville-Schoonmaker, 900 Jefferson Ave., Newport News, VA 23607 (804) 244-7311

Astro Dynamics, Inc., 2 Gill St., Woburn, Massachusetts 01801 (617) 935-4944

Berquist, 5300 Edina Industrial Blvd., Minneapolis, Minnesota 55435 (612) 835-2322

Chomerics, Inc., 16 Flagstone Drive, Hudson, New Hampshire 03051 1-800-633-8800

Delbert Blinn Company, P.O. Box 2007, Pomona, California 91769 (714) 623-1257

International Electronic Research Corporation, 135 West Magnolia Boulevard, Burbank, California 91502 (213) 849-2481

The Staver Company, Inc., 41-51 Saxon Avenue, Bay Shore, Long Island, New York 11706 (516) 666-8000

Thermalloy, Inc., P.O. Box 34829, 2021 West Valley View Lane, Dallas, Texas 75234 (214) 243-4321

Tran-tec Corporation, P.O. Box 1044, Columbus, Nebraska 68601 (402) 564-2748

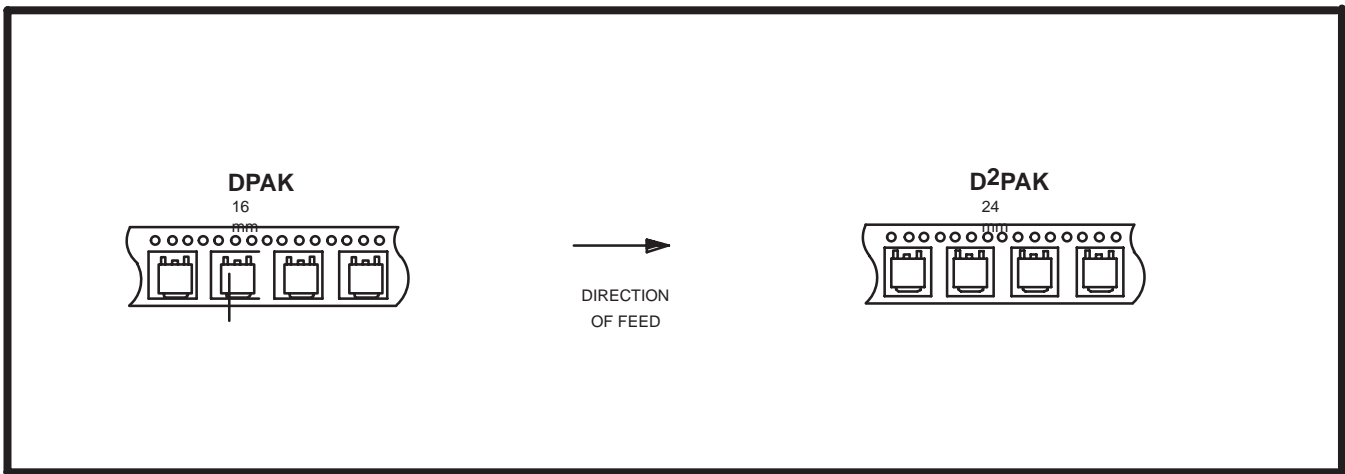
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

Tape and Reel Specifications and Packaging Specifications

Embossed Tape and Reel is used to facilitate automatic pick and place equipment feed requirements. The tape is used as the shipping container for various products and requires a minimum of handling. The antistatic/conductive tape provides a secure cavity for the product when sealed with the “peel-back” cover tape.

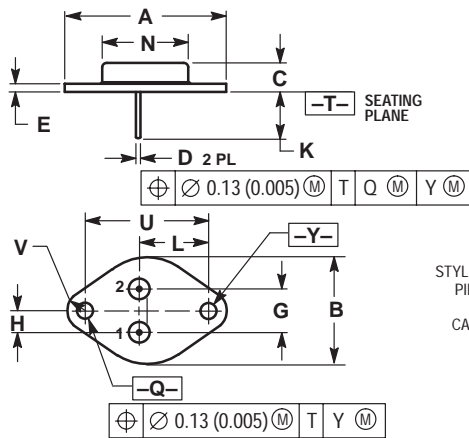
- Two Reel Sizes Available (7” and 13”)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, -1, -2
- DPAK SO-14, in 16 mm Tape
- D²PAK in 24 mm Tape

Use the standard device title and add the required suffix as listed in the option table on the following page. Note that the individual reels have a finite number of devices depending on the type of product contained in the tape. Also note the minimum lot size is one full reel for each line item, and orders are required to be in increments of the single reel quantity.



Package	Tape Width (mm)	Reel Size (inch)				
DPAK	16	8.0 ± 0.1 (.315 ± .004)	330	(13)	2,500	T4
D ² PAK	24	16.0 ± 0.1 (.630 ± .004)	330	(13)	800	T4

Outline Dimensions

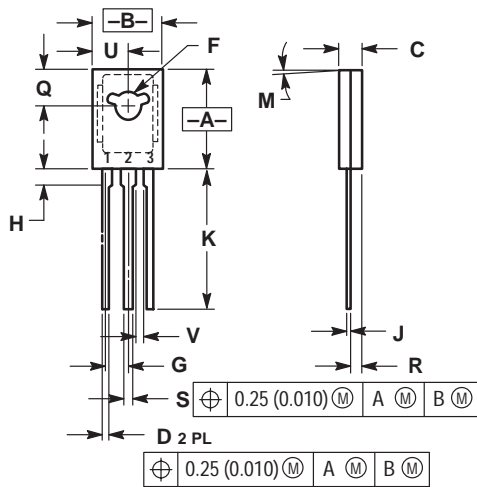


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

- 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	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.550 REF	---	39.37 REF	---
B	---	1.050	---	26.67
C	0.250	0.335	6.35	8.51
D	0.038	0.043	0.97	1.09
E	0.055	0.070	1.40	1.77
G	0.430 BSC	---	10.92 BSC	---
H	0.215 BSC	---	5.46 BSC	---
K	0.440	0.480	11.18	12.19
L	0.665 BSC	---	16.89 BSC	---
N	---	0.830	---	21.08
Q	0.151	0.165	3.84	4.19
U	1.187 BSC	---	30.15 BSC	---
V	0.131	0.188	3.33	4.77

**CASE 1-07
(TO-204AA)**

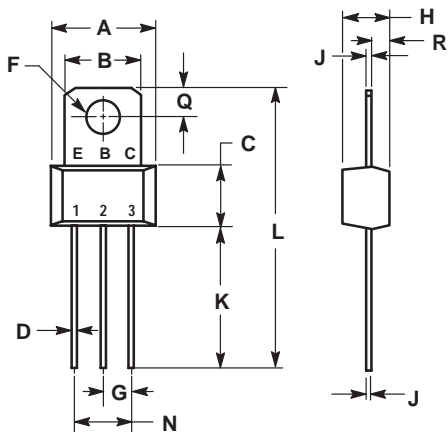


STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.425	0.435	10.80	11.04
B	0.295	0.305	7.50	7.74
C	0.095	0.105	2.42	2.66
D	0.020	0.026	0.51	0.66
F	0.115	0.130	2.93	3.30
G	0.094 BSC	---	2.39 BSC	---
H	0.050	0.095	1.27	2.41
J	0.015	0.025	0.39	0.63
K	0.575	0.655	14.61	16.63
M	5° TYP	---	5° TYP	---
Q	0.148	0.158	3.76	4.01
R	0.045	0.055	1.15	1.39
S	0.025	0.035	0.64	0.88
U	0.145	0.155	3.69	3.93
V	0.040	---	1.02	---

**CASE 77-08
(TO-225AA)**



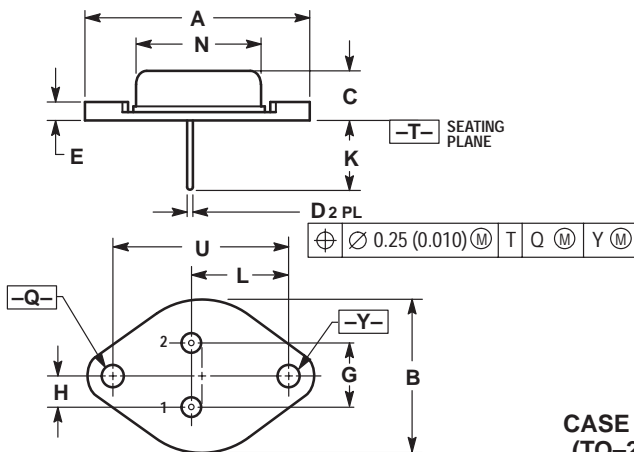
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
(COLLECTOR CONNECTED TO TAB)

- NOTES:
1. LEADS WITHIN 0.15 (0.006) TOTAL OF TRUE POSITION AT CASE, AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC	---	0.100 BSC	---
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	11.63	12.70	0.458	0.500
L	24.58	25.53	0.968	1.005
N	5.08 BSC	---	0.200 BSC	---
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

Outline Dimensions (continued)

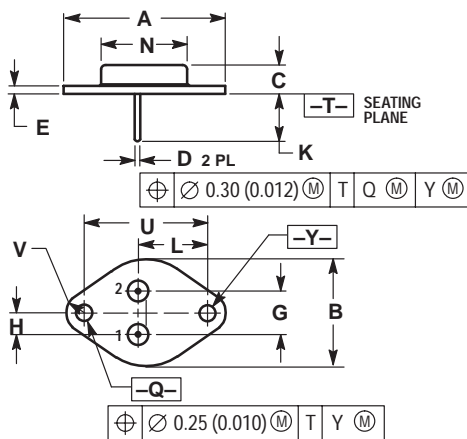


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

**CASE 197-05
(TO-204AE)**

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.510	1.550	38.35	39.37
B	0.980	1.050	24.89	26.67
C	0.250	0.335	6.35	8.51
D	0.057	0.063	1.45	1.60
E	0.060	0.135	1.52	3.43
G	0.420	0.440	10.67	11.18
H	0.205	0.225	5.21	5.72
K	0.440	0.480	11.18	12.19
L	0.655	0.675	16.64	17.15
N	0.760	0.830	19.30	21.08
Q	0.151	0.175	3.84	4.19
U	1.177	1.197	29.90	30.40

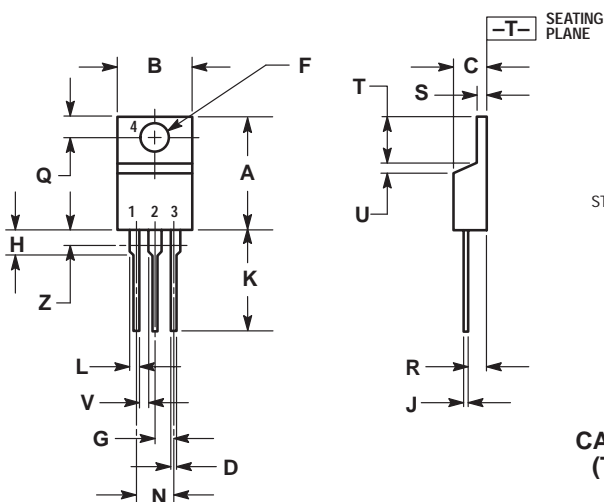


STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

**CASE 197A-05
(TO-204AA)**

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.530 REF		38.86 REF	
B	0.990	1.050	25.15	26.67
C	0.250	0.335	6.35	8.51
D	0.057	0.063	1.45	1.60
E	0.060	0.070	1.53	1.77
G	0.430 BSC		10.92 BSC	
H	0.215 BSC		5.46 BSC	
K	0.440	0.480	11.18	12.19
L	0.665 BSC		16.89 BSC	
N	0.760	0.830	19.31	21.08
Q	0.151	0.165	3.84	4.19
U	1.187 BSC		30.15 BSC	
V	0.131	0.188	3.33	4.77



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

**CASE 221A-06
(TO220-AB)**

- 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

Outline Dimensions (continued)

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

**CASE 221D-02
(TO-220)**

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. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

**CASE 340D-01
(TO-218)**

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.00	19.60	0.749	0.771
B	14.00	14.50	0.551	0.570
C	4.20	4.70	0.165	0.185
D	1.00	1.30	0.040	0.051
E	1.45	1.65	0.058	0.064
G	5.21	5.72	0.206	0.225
H	2.60	3.00	0.103	0.118
J	0.40	0.60	0.016	0.023
K	28.50	32.00	1.123	1.259
L	14.70	15.30	0.579	0.602
Q	4.00	4.25	0.158	0.167
S	17.50	18.10	0.689	0.712
U	3.40	3.80	0.134	0.149
V	1.50	2.00	0.060	0.078

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

**CASE 340F-03
(TO-247AE)**

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	20.40	20.90	0.803	0.823
B	15.44	15.95	0.608	0.628
C	4.70	5.21	0.185	0.205
D	1.09	1.30	0.043	0.051
E	1.50	1.63	0.059	0.064
F	1.80	2.18	0.071	0.086
G	5.45 BSC		0.215 BSC	
H	2.56	2.87	0.101	0.113
J	0.48	0.68	0.019	0.027
K	15.57	16.08	0.613	0.633
L	7.26	7.50	0.286	0.295
P	3.10	3.38	0.122	0.133
Q	3.50	3.70	0.138	0.145
R	3.30	3.80	0.130	0.150
U	5.30 BSC		0.209 BSC	
V	3.05	3.40	0.120	0.134

Outline Dimensions (continued)

$\oplus \varnothing 0.25 (0.010) \text{ (M) T B (M)}$
 $\oplus 0.25 (0.010) \text{ (M) Y Q (S)}$

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

CASE 340G-02 (TO-3PBL)

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

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.8	2.9	1.102	1.142
B	19.3	20.3	0.760	0.800
C	4.7	5.3	0.185	0.209
D	0.93	1.48	0.037	0.058
E	1.9	2.1	0.075	0.083
F	2.2	2.4	0.087	0.102
G	5.45 BSC		0.215 BSC	
H	2.6	3.0	0.102	0.118
J	0.43	0.78	0.017	0.031
K	17.6	18.8	0.693	0.740
L	11.0	11.4	0.433	0.449
N	3.95	4.75	0.156	0.187
P	2.2	2.6	0.087	0.102
Q	3.1	3.5	0.122	0.137
R	2.15	2.35	0.085	0.093
U	6.1	6.5	0.240	0.256
W	2.8	3.2	0.110	0.125

$\oplus 0.13 (0.005) \text{ (M) T}$

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

CASE 369-07

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.090 BSC		2.29 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.350	0.380	8.89	9.65
R	0.175	0.215	4.45	5.46
S	0.050	0.090	1.27	2.28
V	0.030	0.050	0.77	1.27

$\oplus 0.13 (0.005) \text{ (M) T}$

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

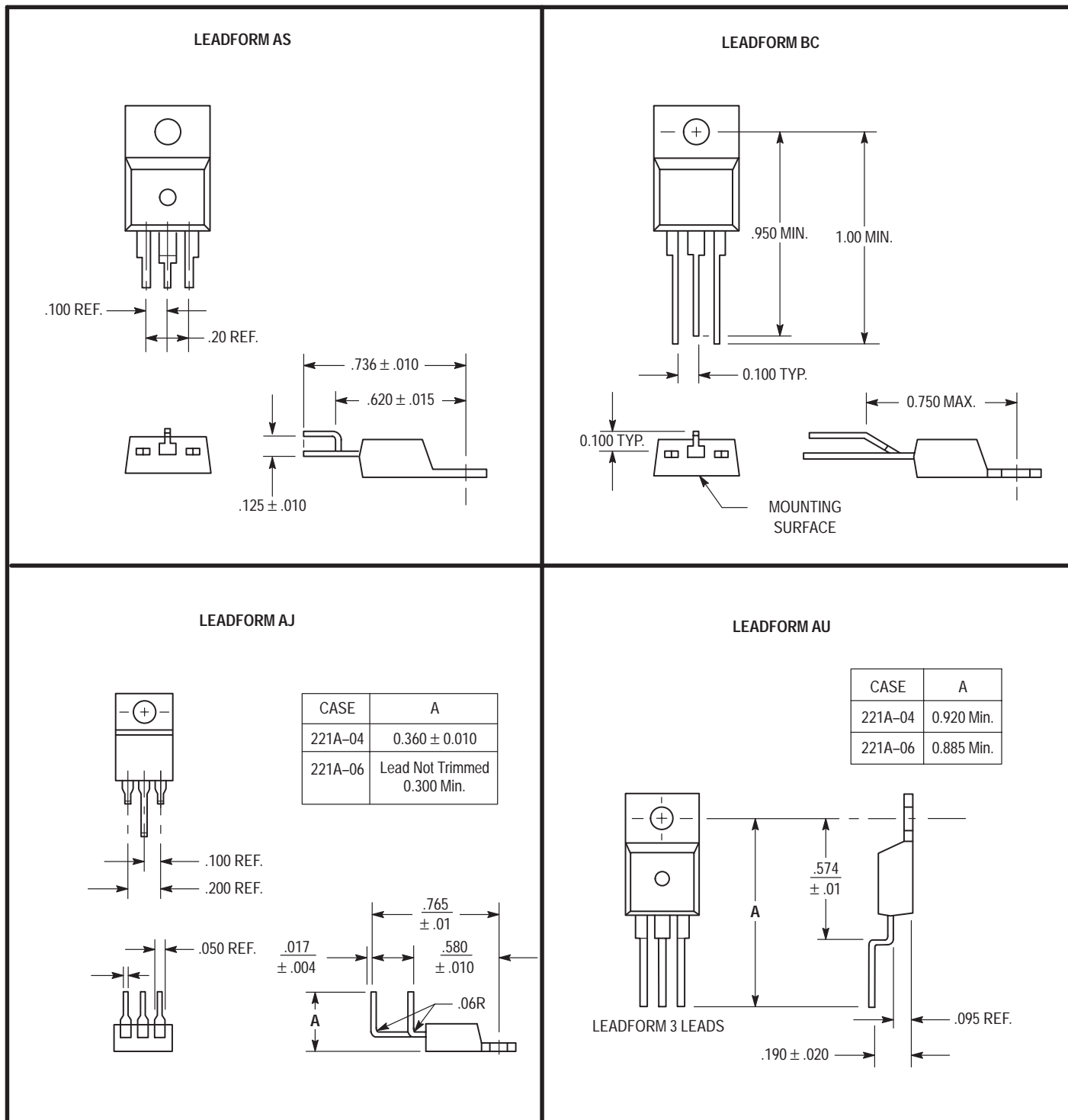
CASE 369A-13

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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.175	0.215	4.45	5.46
S	0.020	0.050	0.51	1.27
U	0.020	---	0.51	---
V	0.030	0.050	0.77	1.27
Z	0.138	---	3.51	---

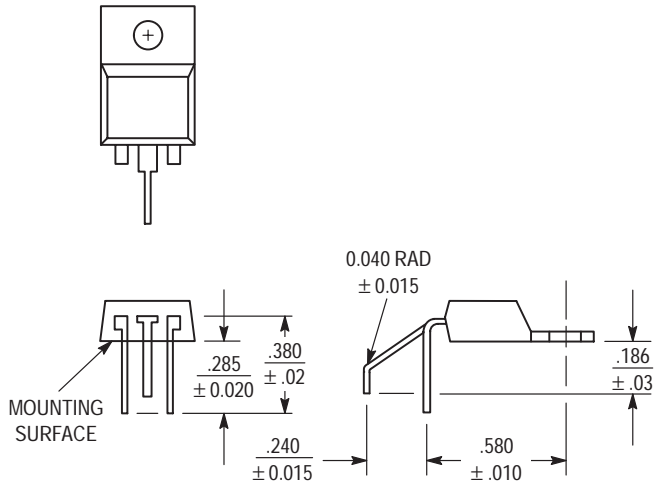
Leadform Options — TO-220 (Case 221A)

- Leadform options require assignment of a special part number before ordering.
- Contact your local Motorola representative for special part number and pricing.
- 10,000 piece minimum quantity orders are required.
- Leadform orders are non-cancellable after processing.
- Leadforms apply to both Motorola Case 221A-04 and 221A-06 except as noted.

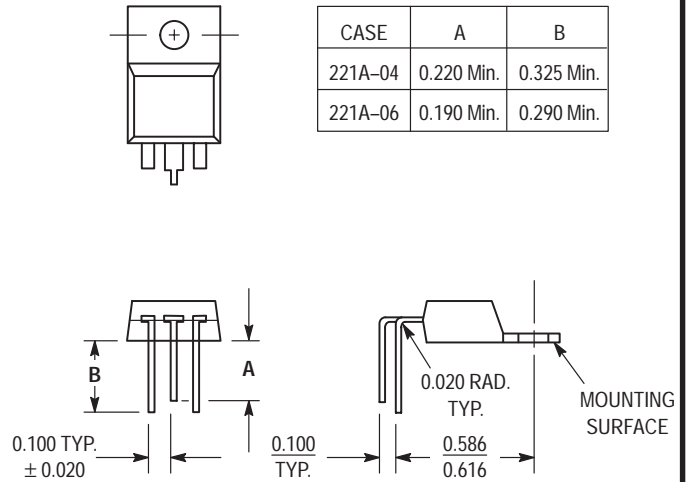


TO-220 Leadform Options (continued)

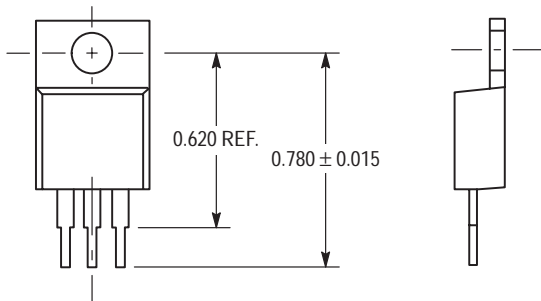
LEADFORM AN



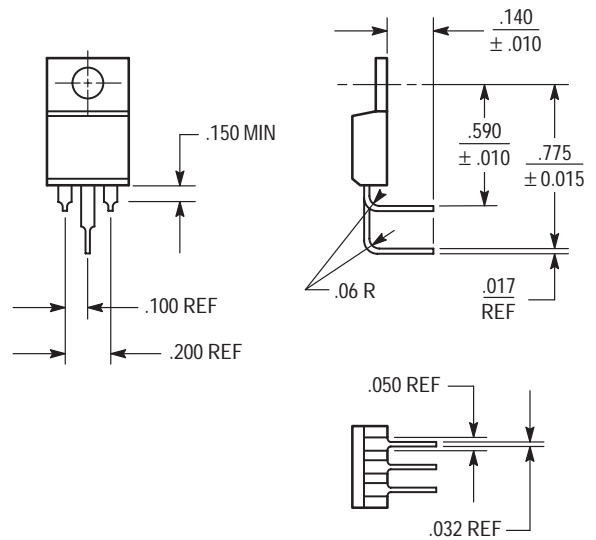
LEADFORM BA



LEADFORM BG

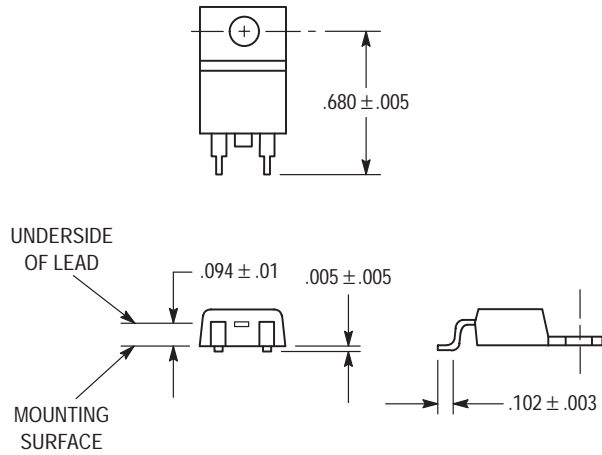


LEADFORM AK

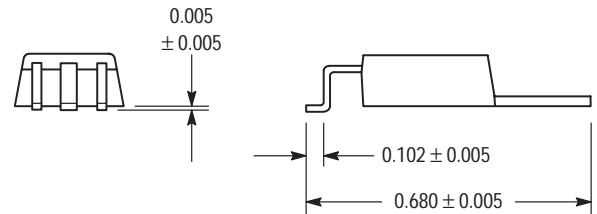


TO-220 Leadform Options (continued)

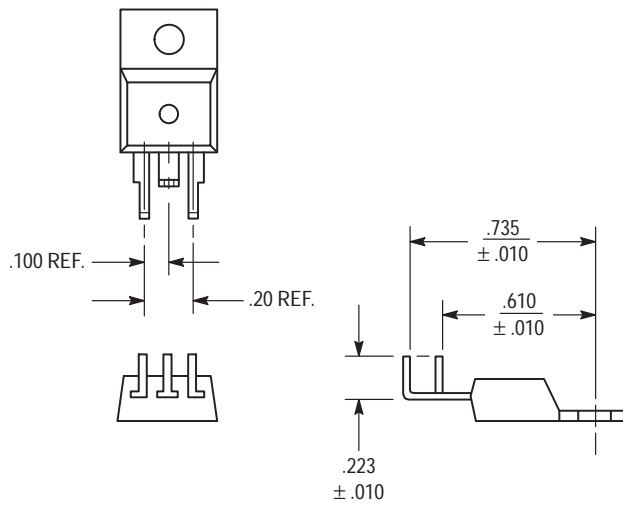
LEADFORM BU



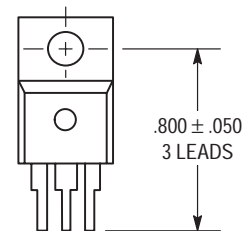
LEADFORM BV



LEADFORM BD

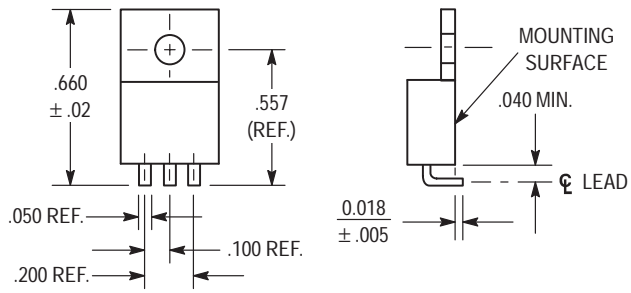


LEADFORM DW

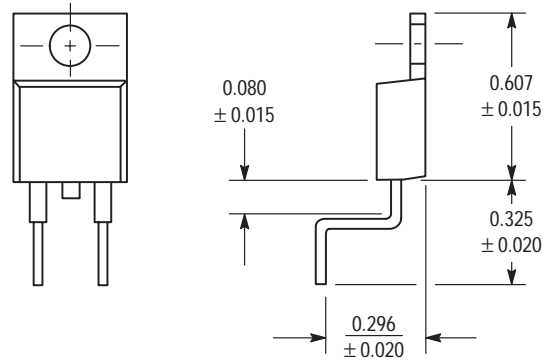


TO-220 Leadform Options (continued)

LEADFORM AF



LEADFORM BS



INDEX AND CROSS REFERENCE

The following table represents an index and cross-reference guide for all low-frequency power transistors which are either manufactured directly by Motorola or for which Motorola manufactures a suitable equivalent. Where the Motorola part number differs from the industry part number, the Motorola device is a "form, fit and function" replacement for the industry type number — however, subtle differences in characteristics and/or specifications may exist. Where multiple replacement parts appear for a given industry part number, the page number represents the first replacement device listed.

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number	Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
40251		2N3055	3-2	2N3055H		2N3055A	3-5
40325		2N3055	3-2	2N3055SD		2N3055A	3-5
40363		2N5878	3-74	2N3055UB		2N3055A	3-5
40369		2N5878	3-74	2N3076		BUV23	3-388
40411		MJ802	3-421	2N3171		2N3792	3-25
40513		MJE3055T	3-628	2N3172		2N3792	3-25
40514		MJE3055T	3-628	2N3173		2N3792	3-25
40542		MJE3055T	3-628	2N3174		MJ15016	3-5
40543		MJE3055T	3-628	2N3183		2N3792	3-25
40613		TIP31B	3-873	2N3184		2N3792	3-25
40618		TIP31B	3-873	2N3185		2N3792	3-25
40621		TIP31B	3-873	2N3186		MJ15016	3-5
40622		TIP31B	3-873	2N3195		2N3792	3-25
40624		TIP41B	3-883	2N3196		2N3792	3-25
40627		TIP41B	3-883	2N3198		MJ15016	3-5
40629		TIP31B	3-873	2N3232		2N5878	3-74
40630		TIP31B	3-873	2N3233		2N5882	3-77
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