Complementary Silicon Plastic Power Transistors

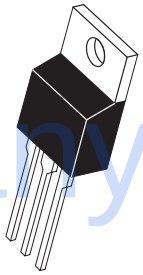
. . . designed for use in general–purpose amplifier and switching applications.

- DC Current Gain Specified to 15 Amperes —
  h_{FE} = 20–150 @ I_C = 5.0 Adc
  = 5.0 (Min) @ I_C = 15 Adc
- Collector–Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 60 Vdc (Min) – 2N6487, 2N6490
  = 80 Vdc (Min) – 2N6488, 2N6491
- High Current Gain — Bandwidth Product
  f_T = 5.0 MHz (Min) @ I_C = 1.0 Adc
- TO–220AB Compact Package

NPN
2N6487
2N6488*
PNP
2N6490
2N6491*

*Motorola Preferred Device

15 AMPERE
COMPLEMENTARY
SILICON
POWER TRANSISTORS
60–80 VOLTS
75 WATTS



CASE 221A–06
TO–220AB

MAXIMUM RATINGS (1)

Rating	Symbol	2N6487 2N6490	2N6488 2N6491	Unit
Collector–Emitter Voltage	V_{CEO}	60	80	Vdc
Collector–Base Voltage	V_{CB}	70	90	Vdc
Emitter–Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	15		Adc
Base Current	I_B	5.0		Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	75 0.6		Watts W/°C
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.8 0.014		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +150		°C

Datasheet.Company

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.67	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	70	°C/W

(1) Indicates JEDEC Registered Data.

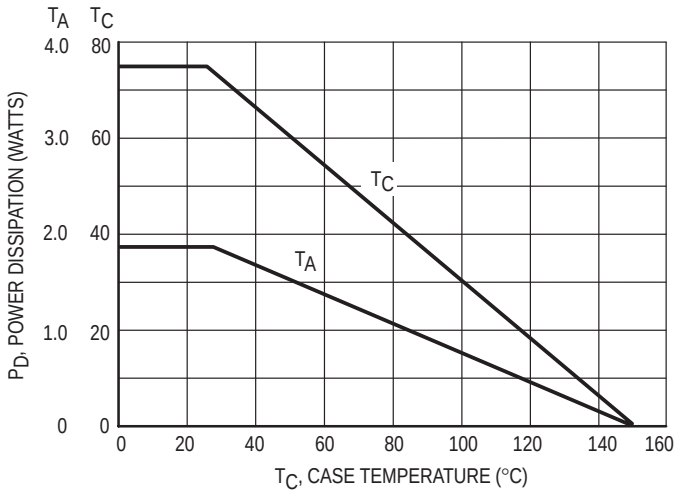


Figure 1. Power Derating

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

REV 7

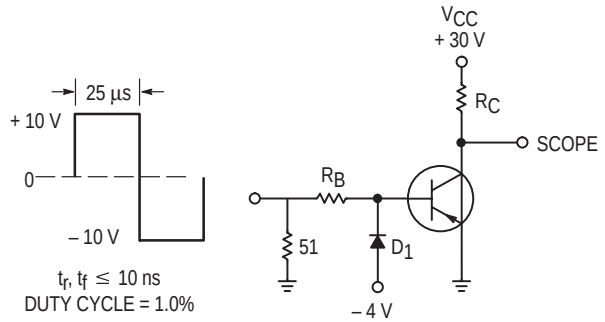
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	2N6487, 2N6490 2N6488, 2N6491	$V_{CEO(sus)}$	 60 80	—	Vdc
Collector–Emitter Sustaining Voltage (1) (I_C = 200 mAdc, V_{BE} = 1.5 Vdc)	2N6487, 2N6490 2N6488, 2N6491	VCEX	 70 90	— —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0)	 2N6487, 2N6490 2N6488, 2N6491	I_{CEO}	 — —	 1.0 1.0	mAdc
Collector Cutoff Current (V_{CE} = 65 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 85 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	 2N6487, 2N6490 2N6488, 2N6491 2N6487, 2N6490 2N6488, 2N6491	I_{CEX}	 — — — —	 500 500 5.0 5.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 15 Adc, V_{CE} = 4.0 Vdc)		h_{FE}	 20 5.0	 150 —	—
Collector–Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc) (I_C = 15 Adc, I_B = 5.0 Adc)		$V_{CE(sat)}$	 — —	 1.3 3.5	Vdc
Base–Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 15 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	 — —	 1.3 3.5	Vdc
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 1.0 MHz)		f_T	5.0	—	MHz
Small–Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	25	—	—

* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$.



R_B AND R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS.
FOR PNP, REVERSE ALL POLARITIES.

D_1 MUST BE FAST RECOVERY TYPE, e.g.:
1N5825 USED ABOVE $I_B \approx$ 100 mA
MSD6100 USED BELOW $I_B \approx$ 100 mA

Figure 2. Switching Time Test Circuit

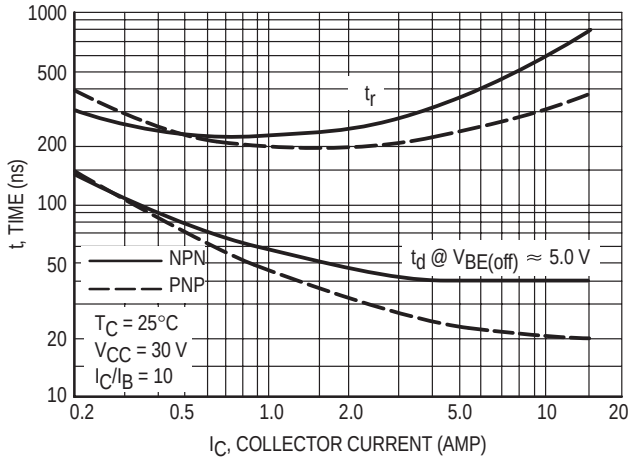


Figure 3. Turn–On Time

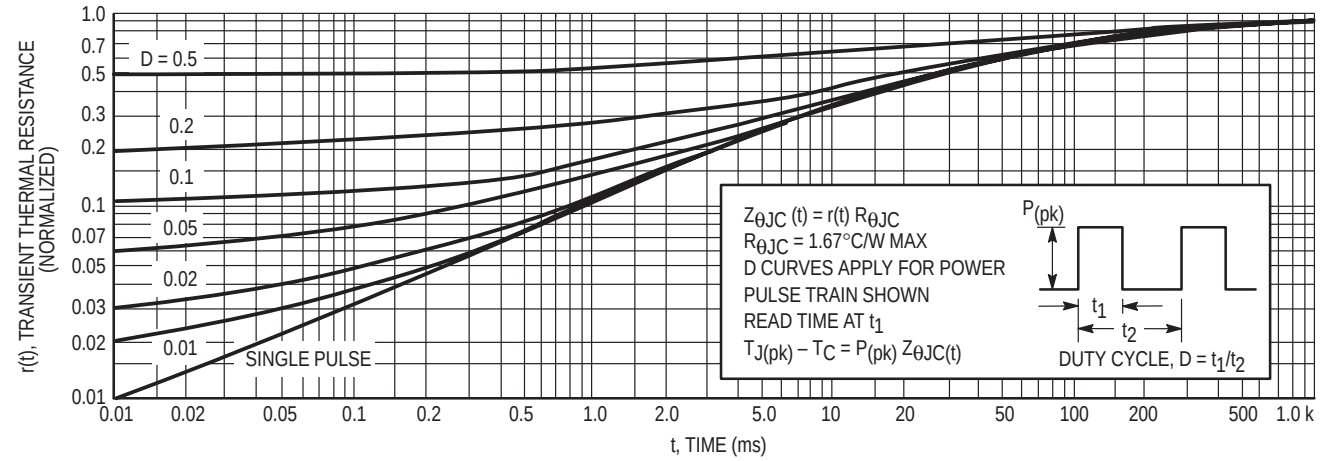


Figure 4. Thermal Response

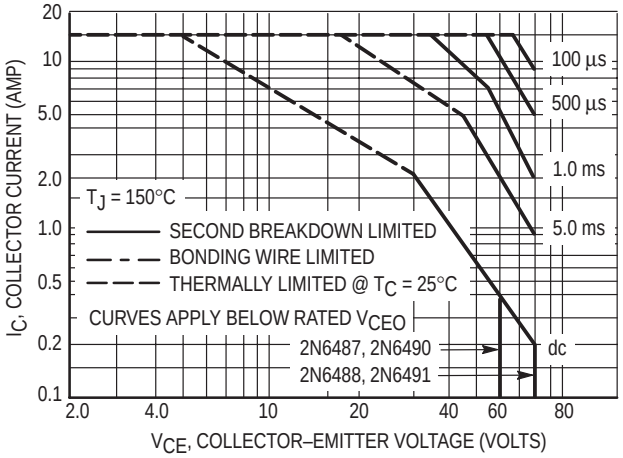


Figure 5. Active–Region Safe Operating Area

There are two limitations on the power handling ability of a transistors 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 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ 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

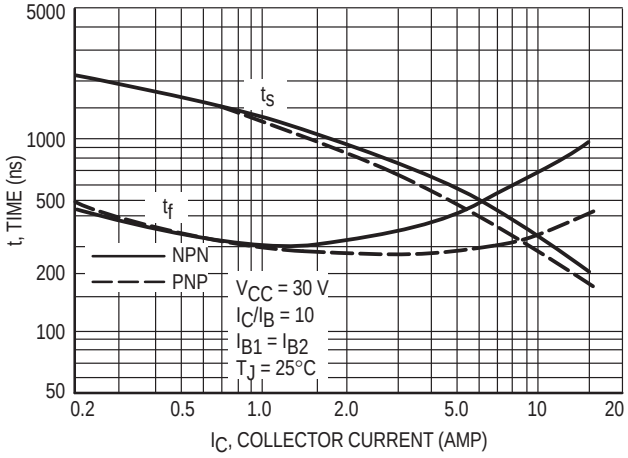


Figure 6. Turn–Off Time

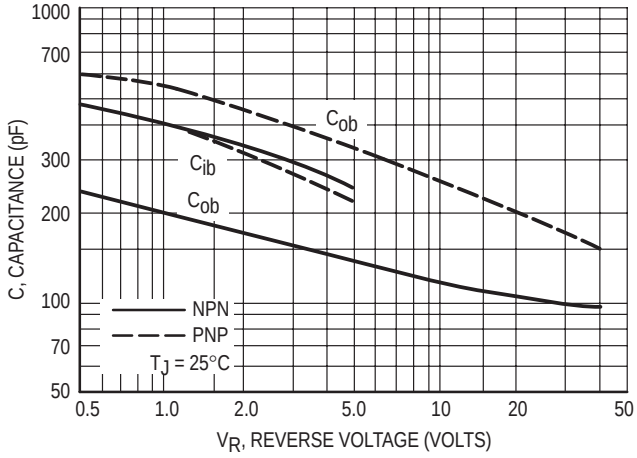
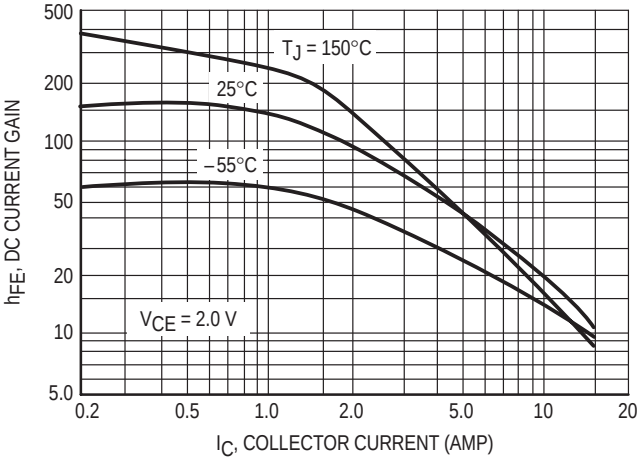


Figure 7. Capacitances

NPN
2N6487, 2N6488



PNP
2N6490, 2N6491

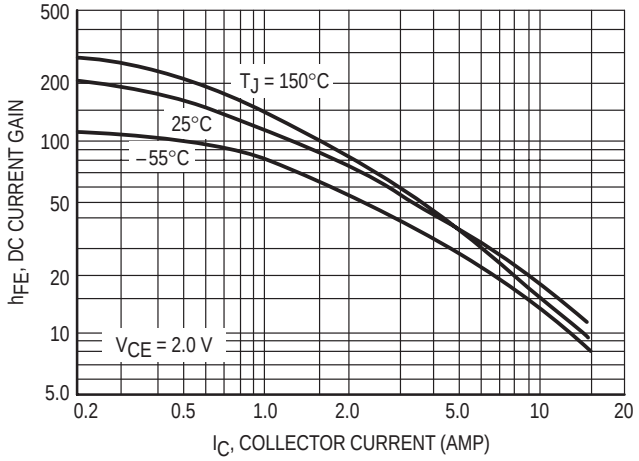
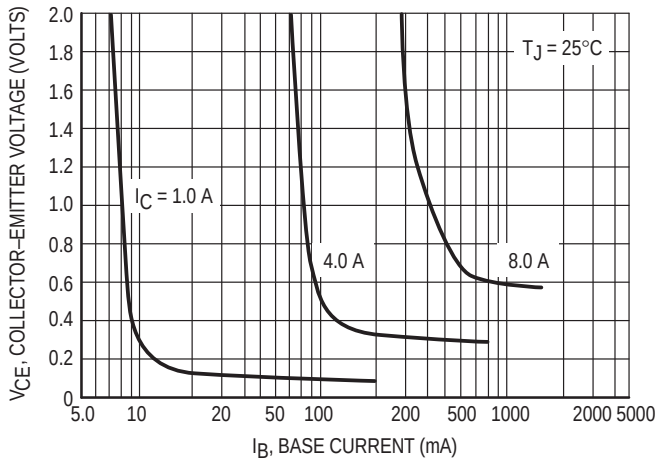


Figure 8. DC Current Gain



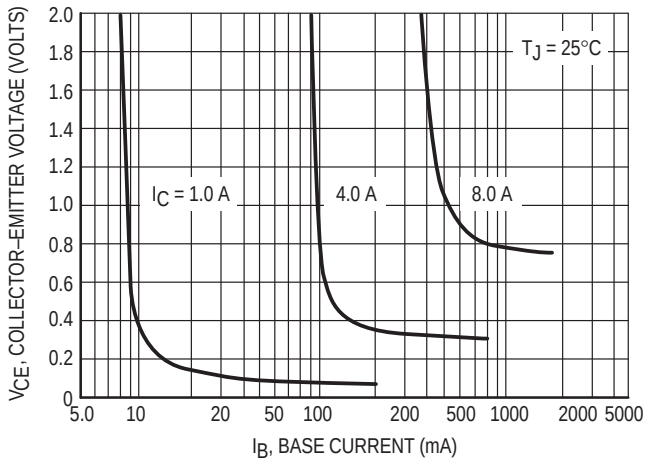
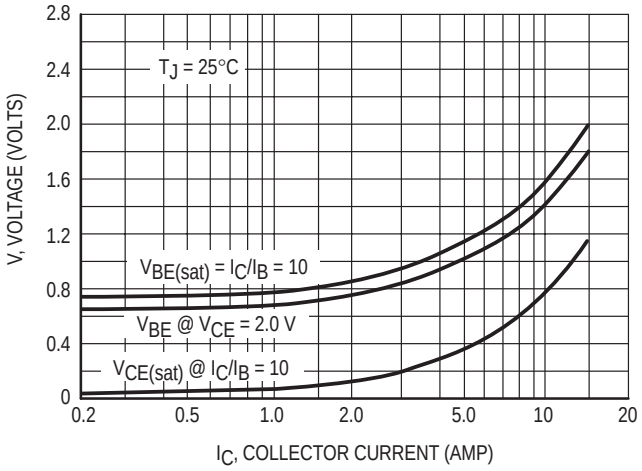


Figure 9. Collector Saturation Region



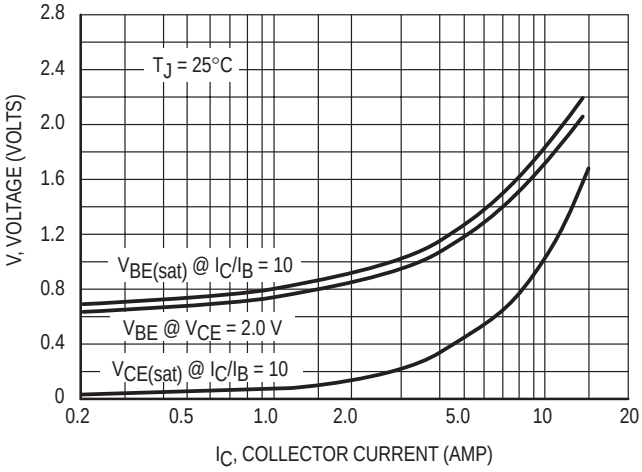
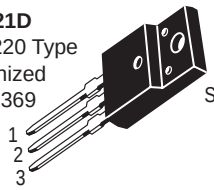


Figure 10. “On” Voltages

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



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

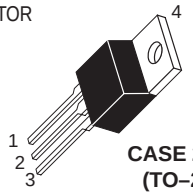
Table 1. Plastic (Isolated TO–220 Type)

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	45
	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



CASE 221A–06
(TO–220AB)

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 $V_{CEO(sus)}/V_{CES}$.

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		
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

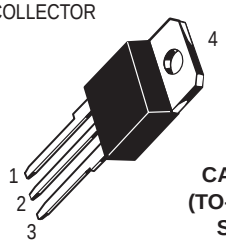
(1)$|h_{FE}|$ @ 1 MHz
(2)Darlington
(3)Switching tests performed w/special application simulator circuit. See data sheet for details.
(7)V_{CEO} = 375 V
(8)When 2 voltages are given, the format is $V_{CEO(sus)}/V_{CES}$.
(9)Self protected Darlington

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	***BDX33C***(2)	***BDX34C***(2)	750 min	3				3	70
	450/1000	***MJE18009***		14/34	1.5	2.75(3)	0.2(3)	3	12	150
12	400/700	***MJE13009***		6/30	8	3	0.7	8	4	100
15	80	***2N6488***	***2N6491***	20/150	5	0.6 typ	0.3 typ	5	5	75
		D44VH10	***D45VH10***	20 min	4	0.5	0.09	8	50 typ	83
	100	***BDW42***(2)	***BDW47***(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	***MJH16006A***		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	***BDV65B***(2)	***BDV64B***(2)	1k min	5					125
		TIP33C	TIP34C	20/100	3				3	80
		TIP142(2)	***TIP147***(2)	500 min	10	2.5 typ	2.5 typ	5	4(1)	125
	400	***BU323AP***(2)		150/100	6	15	15	6		125
		MJH10012(2)		100/2k	6	15	15	6		118

(1)$|h_{FE}|$ @ 1 MHz
(2)Darlington
(8)When 2 voltages are given, the format is $V_{CEO(sus)}/V_{CES}$.

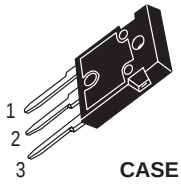
Devices listed in bold, italic are Motorola preferred devices.

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

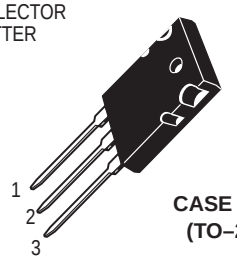
I_C Cont Amps Max	$V_{CEO(sus)}$ Volts Min	V_{CES} Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
			NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
10	650	1500	***MJW16212***		4/10	10	4(3)	0.5(3)	5.5		150
	800	1500	***MJW16018***		4 min	5	4.5 typ	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)

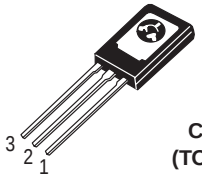
Table 5. Large Plastic TO–264

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	***MJL3281A***	***MJL1302A***	60/175	0.1				30 typ	200
	650/1500	***MJL16218***		4/11	12				2.5 typ	170
16	250	***MJL21194***	***MJL21193***	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		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		
0.3	350	***MJE3439***		40/160	0.02				15	15
0.5	150	MJE341		25/200	0.05				15	20.8
	200	***MJE344***		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	***BD158***		30/240	0.05					20
		MJE340	***MJE350***	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)

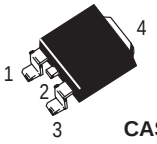
I_C Cont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s μs Max	t_f μs Max	@ I_C Amp		
0.5	350	***2N5657***		30/250	0.1	3.5 typ	0.24 typ	0.1	10	20
		BD159		30/240	0.05					20
1	40	2N4921	2N4918	20/100	0.5	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.

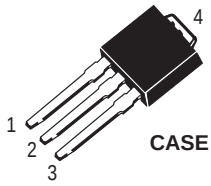
Table 6. Plastic TO–225AA Type (Formerly TO–126 Type) (continued)

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	***BD779***(2)	***BD780***(2)	750 min	2				20	15
		MJE802(2)	MJE702(2)	750 min	1.5				1(1)	40
		MJE803(2)	***MJE703***(2)	750 min	2				1(1)	40
		2N6039(2)	***2N6036***(2)	750/18k	2	1.7 typ	1.2 typ	2	25	40
	100	***BD681***(2)	***BD682***(2)	750 min	1.5					40
		BD791	***BD792***	10 min	2				40	15
		MJE243	***MJE253***	40/120	0.2	0.15 typ	0.07 typ	2	40	15
5	25	***MJE200***	***MJE210***	45/180	2	0.13 typ	0.035 typ	2	65	15



CASE 369A(13)

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



CASE 369(12)

Table 7. DPAK – Surface Mount Power Packages

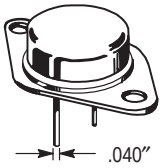
I_C Cont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
0.5	300	***MJD340***	***MJD350***	30/240	0.05					15
1	250	MJD47		30/150	0.3	2	0.2	0.3	10	15
	375		***MJD5731***	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	400	***MJD50***		30/150	0.3	2	0.2	0.3	10	15
1.5	400	***MJD13003***		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.

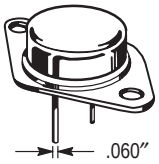
Devices listed in bold, italic are Motorola preferred devices.

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

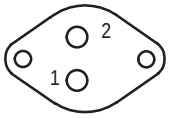
I_C Cont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type		h_{FE} Min/Max	@ I_C Amp	Resistive Switching			f_T MHz Min	P_D (Case) Watts @ 25°C
		NPN	PNP			t_s µs Max	t_f µs Max	@ I_C Amp		
2	100	***MJD112***(2)	***MJD117***(2)	1000 min	2	1.7	1.3	2	25(1)	20
3	40	MJD31	MJD32	10 min	1	0.6	0.3	1	3	15
	100	***MJD31C***	***MJD32C***	10 min	1	0.6	0.3	1	3	15
4	80	***MJD6039***(2)	***MJD6036***(2)	1k/12k	2	1.7	1.2	2	25	20
	100	***MJD243***	***MJD253***	40/180	0.2	0.16	0.04	1	40	12.5
5	25	***MJD200***	***MJD210***	45/180	2	0.15	0.04	2	65	12.5
6	100	***MJD41C***	***MJD42C***	15/75	3	0.4	0.15	3	3	20
8	80	***MJD44H11***	***MJD45H11***	40 min	4	0.5	0.14	5	50 typ	20
	100	***MJD122***(2)	***MJD127***(2)	1k/12k	4	1.5	2	4	4(1)	20
10	60	***MJD3055***	***MJD2955***	20/100	4	1.5	1.5	3	2	20
	80	***MJD44E3***(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	***MJ15020***	***MJ15021***	30 min	1				20	150
5	700/1500	***BU208A***		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	***MJ1001***(2)		1k min	3					90
		2N6056(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	150
		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	200
	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

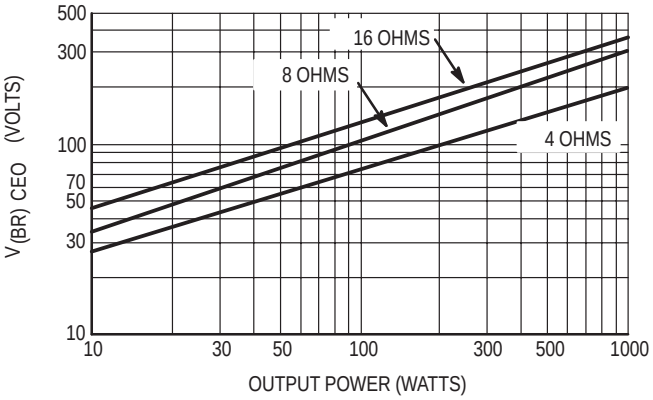
(1)$|h_{FE}|$ @ 1 MHz
(2)Darlington
(8)When 2 voltages are given, the format is $V_{CEO(sus)}$ / V_{CES}.
(16)Case 197A–03 (TO–204AE)

Devices listed in bold, italic are Motorola preferred devices.

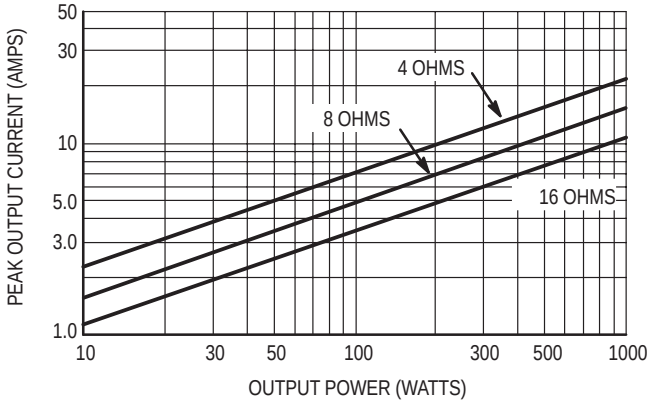
Audio

GENERAL DESIGN CURVES FOR POWER AUDIO OUTPUT STAGES

$V_{(BR)CEO}$ Required on Output and Driver Transistor versus Output Power for 4, 8 and 18 Ohm Loads



Output Transistor Peak Collector Current versus Output Power for 4, 8 and 16 Ohm Loads



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

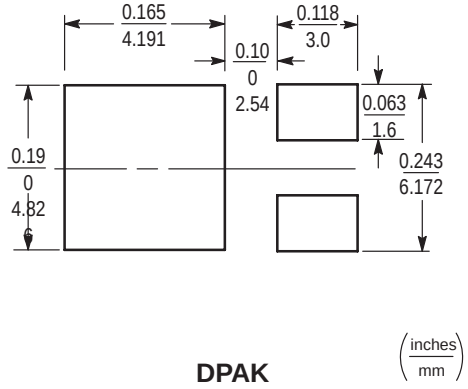
RMS Power Output	NPN	PNP	Case	P_D Watts @ 25°C	V_{CEO}	h_{FE} @ Min/Max	I_C Amps	f_T MHz Typ	ISB Volts/Amps
To 25W	MJE15030	MJE15031	TO–220	50	150	20 min	4	30	14/3.6
	MJE15032	MJE15033	TO–220	50	250	50 min	1	40	50/1
25 to 50W	2N3055A	MJ2955A	TO–204	120	120	20/70	4	3	60/2
	MJ15001	MJ15002	TO–204	200	140	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.

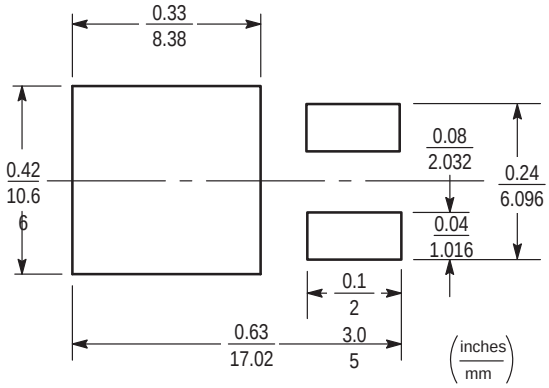
INFORMATION FOR USING SURFACE MOUNT PACKAGES

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.



DPAK



D2PAK

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.

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

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.

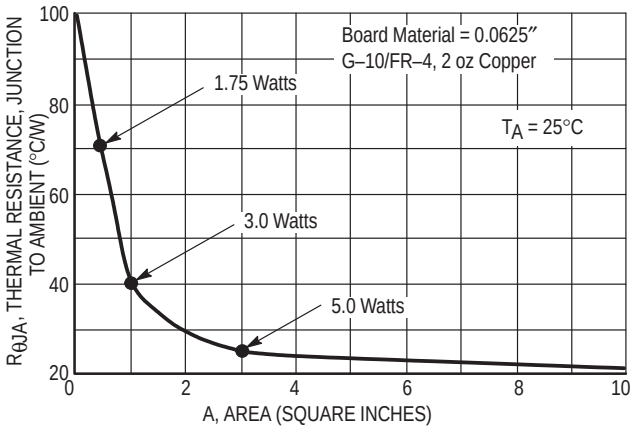


Figure 1. Thermal Resistance versus Drain Pad Area for the DPAK Package (Typical)

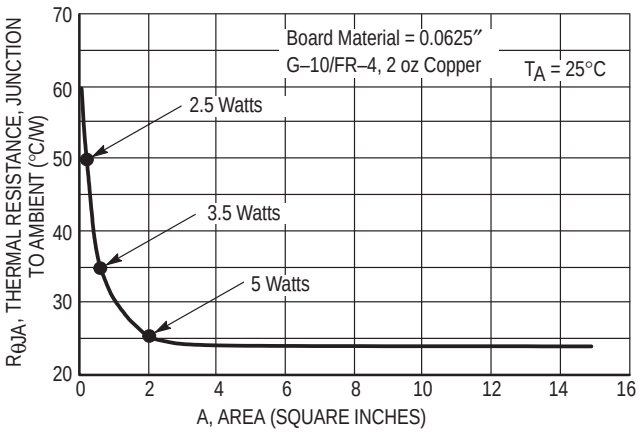


Figure 2. Thermal Resistance versus Drain Pad Area for the D2PAK Package (Typical)

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 D^2PAK 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 D^2PAK 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.

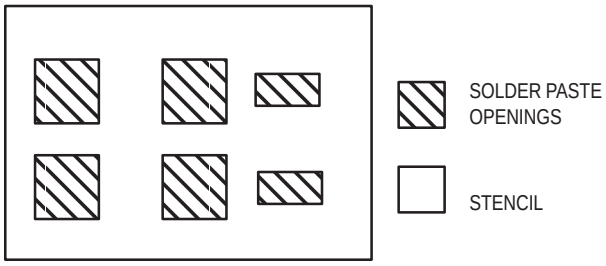


Figure 3. Typical Stencil for DPAK and D^2PAK Packages

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 D^2PAK 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.

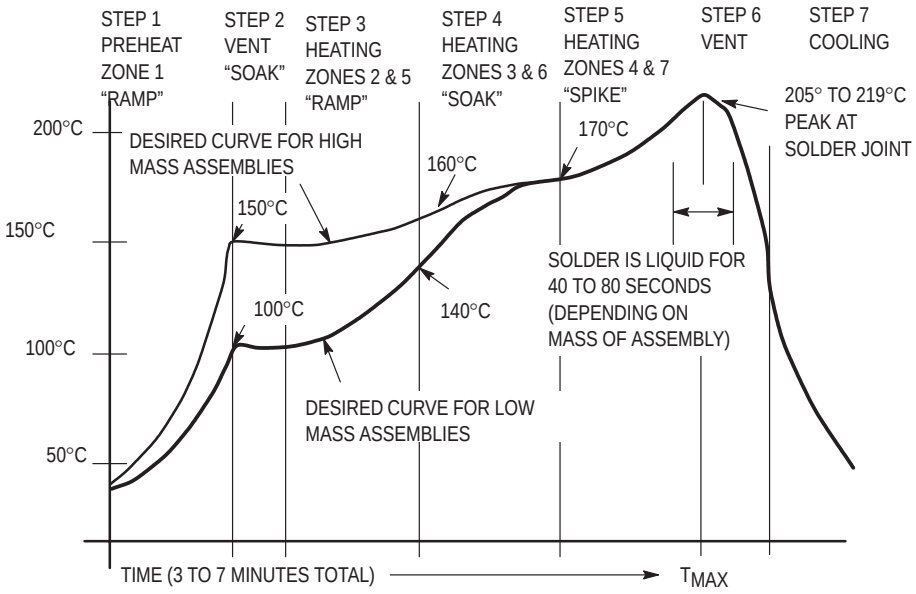


Figure 4. Typical Solder Heating Profile

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	—	—	—	—
Astrodynamics	X	—	—	—	—	—	—	—	X	—
Delbert Blinn	—	—	X	—	X	X	X	X	X	—
IERC	X	—	—	—	—	—	—	—	X	—
Staver	—	—	—	—	—	—	—	—	X	—
Thermalloy	X	X	X	X	X	X	X	X	X	X
Tran-tec	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

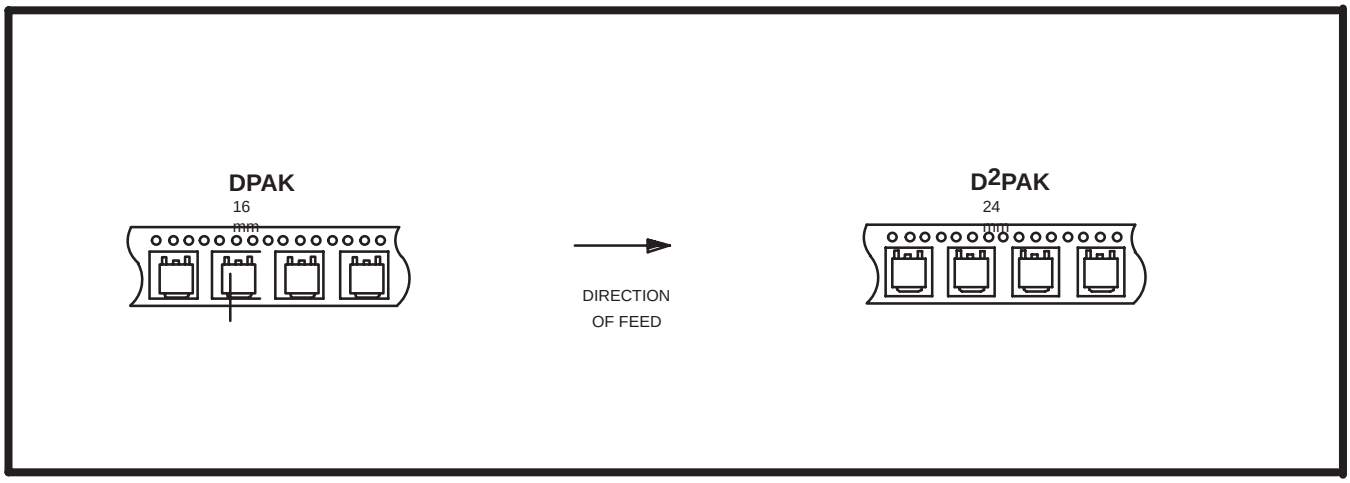
Wakefield Engineering, Inc., Wakefield, Massachusetts 01880 (617) 245-5900

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.

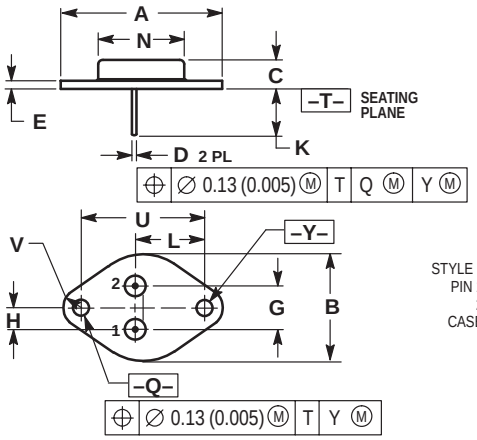
- Two Reel Sizes Available (7″ and 13″)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, –1, –2
- DPAK SO–14, in 16 mm Tape
- D^{2}PAK in 24 mm Tape

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

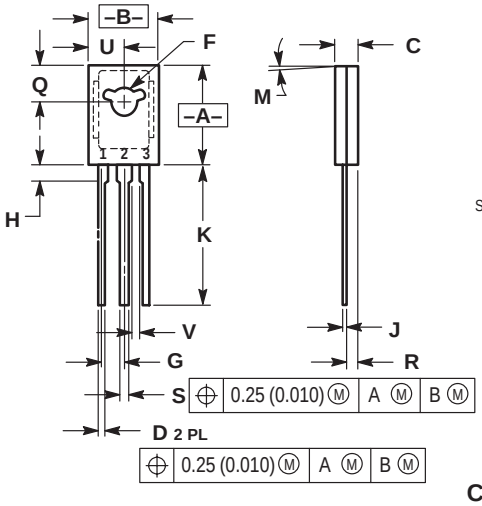


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

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.

	INCHES		MILLIMETERS	
DIM	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)

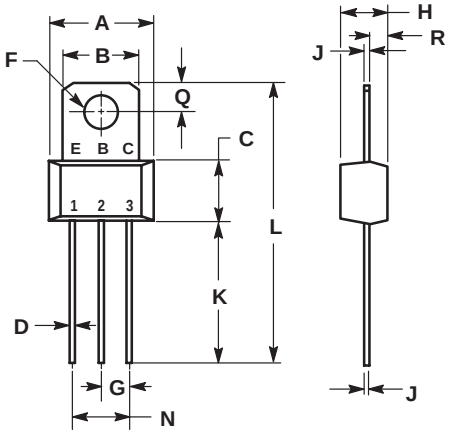


STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

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

	INCHES		MILLIMETERS	
DIM	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)



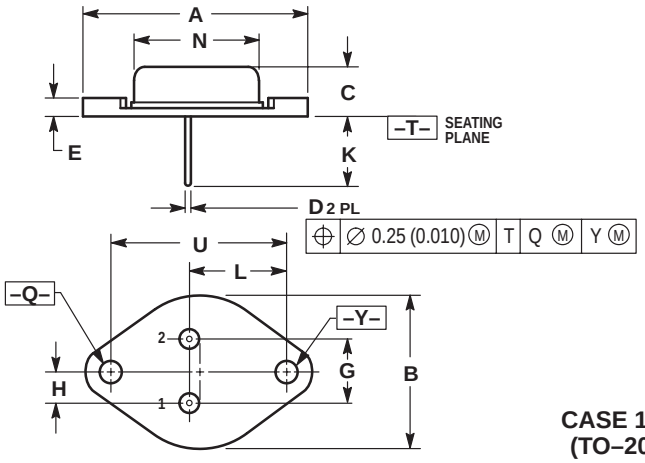
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
(COLLECTOR CONNECTED TO TAB)

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

	MILLIMETERS		INCHES	
DIM	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)

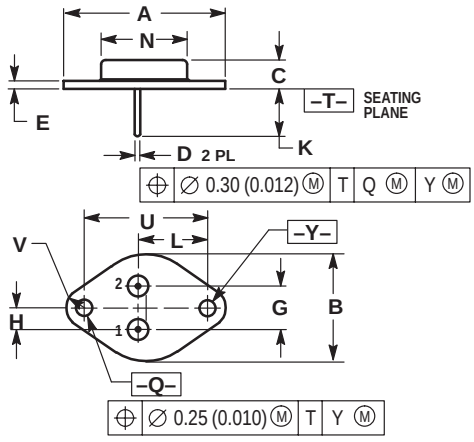


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

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

	INCHES		MILLIMETERS	
DIM	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

CASE 197–05
(TO–204AE)

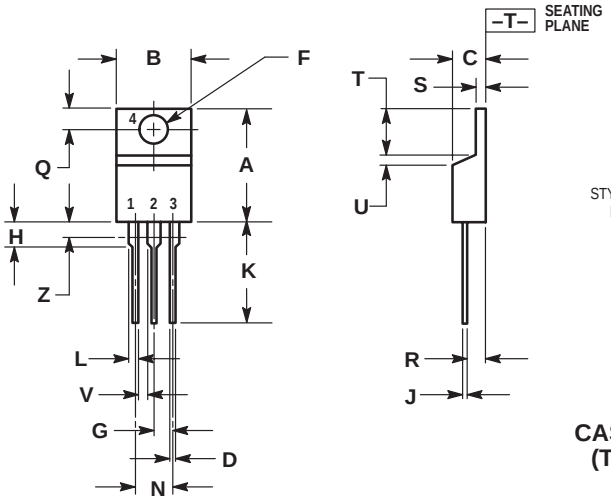


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

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

	INCHES		MILLIMETERS	
DIM	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

CASE 197A–05
(TO–204AA)



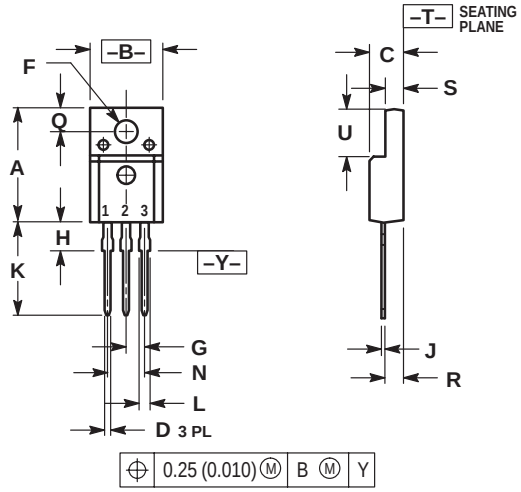
STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

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.

	INCHES		MILLIMETERS	
DIM	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

CASE 221A–06
(TO220–AB)

Outline Dimensions (continued)

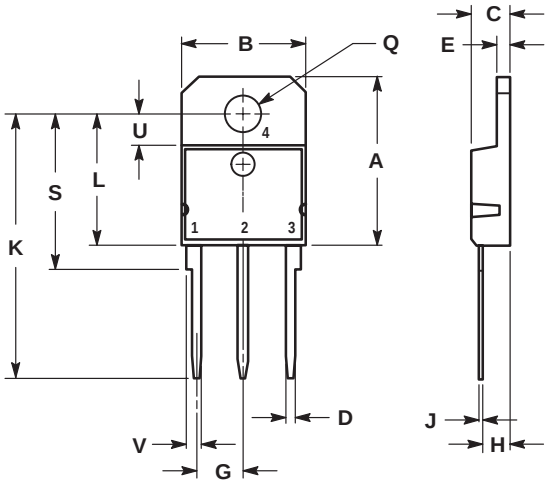


STYLE 2:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

CASE 221D–02
(TO–220)

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

	INCHES		MILLIMETERS	
DIM	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

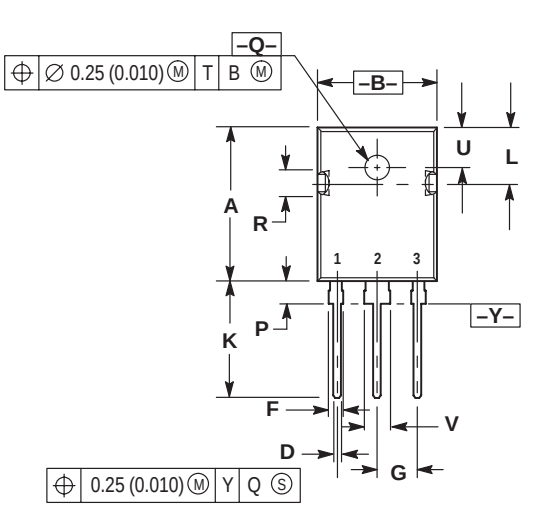


STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

CASE 340D–01
(TO–218)

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

	MILLIMETERS		INCHES	
DIM	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



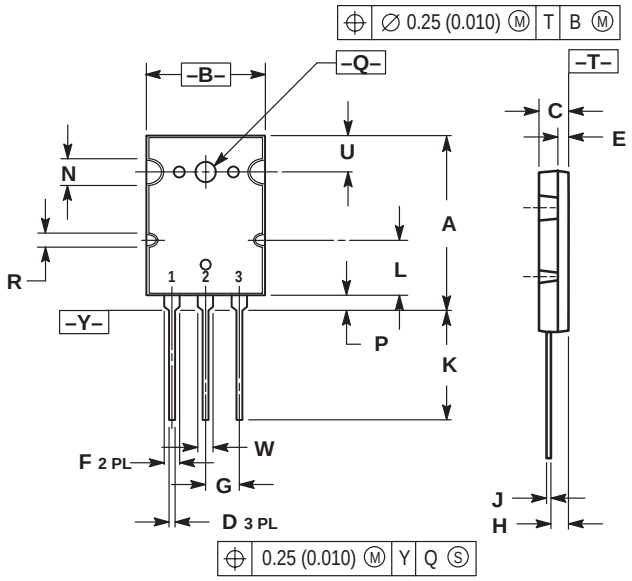
STYLE 3:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

CASE 340F–03
(TO–247AE)

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

	MILLIMETERS		INCHES	
DIM	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)

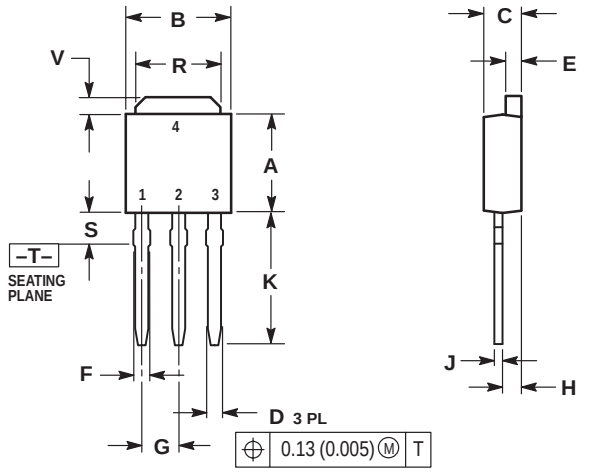


STYLE 2:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

CASE 340G–02
(TO–3PBL)

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

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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

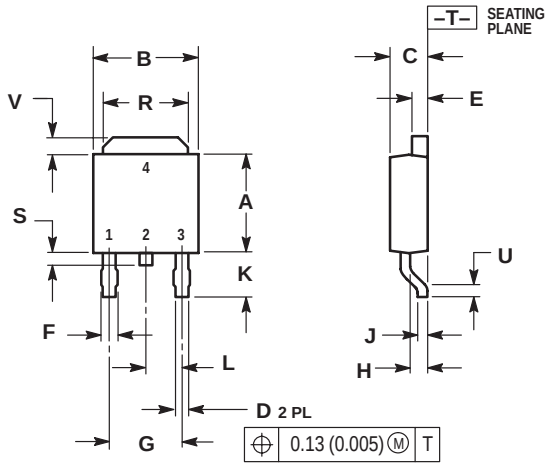


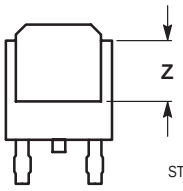
STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

CASE 369–07

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

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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





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

CASE 369A–13

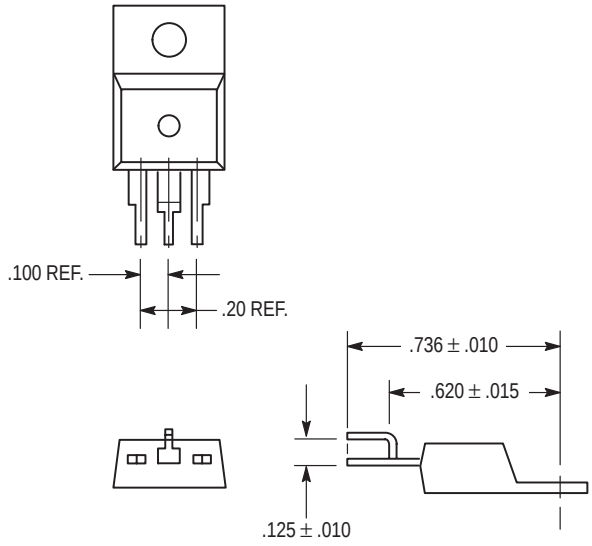
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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	—

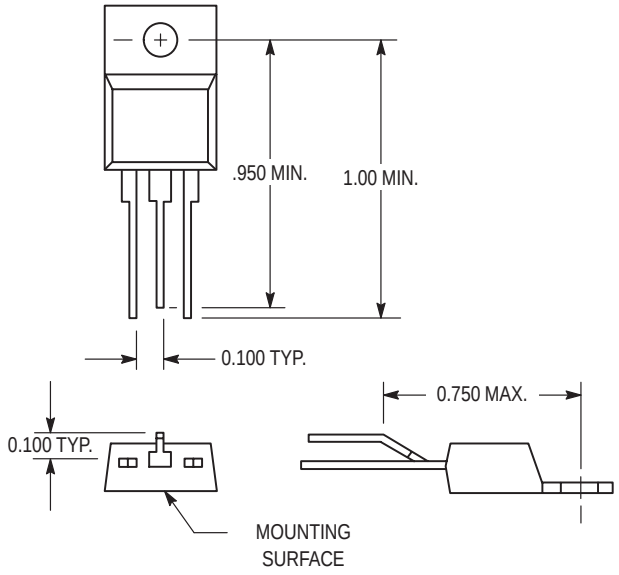
Leadform Options — TO–220 (Case 221A)

- **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.**

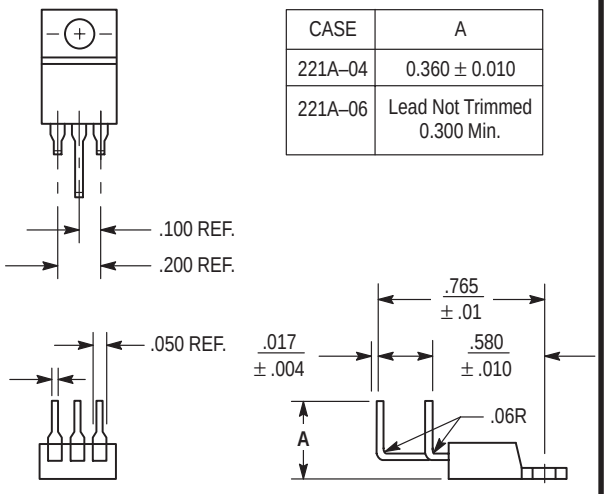
LEADFORM AS



LEADFORM BC



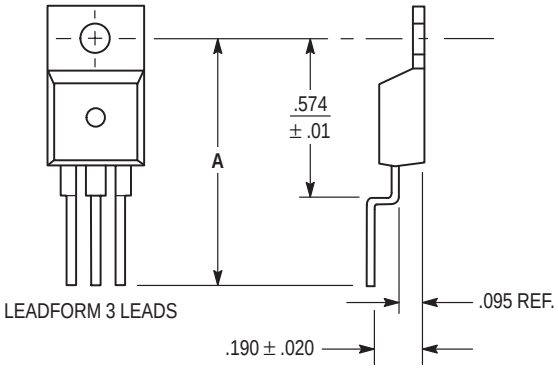
LEADFORM AJ



CASE	A
221A–04	0.360 ± 0.010
221A–06	Lead Not Trimmed 0.300 Min.

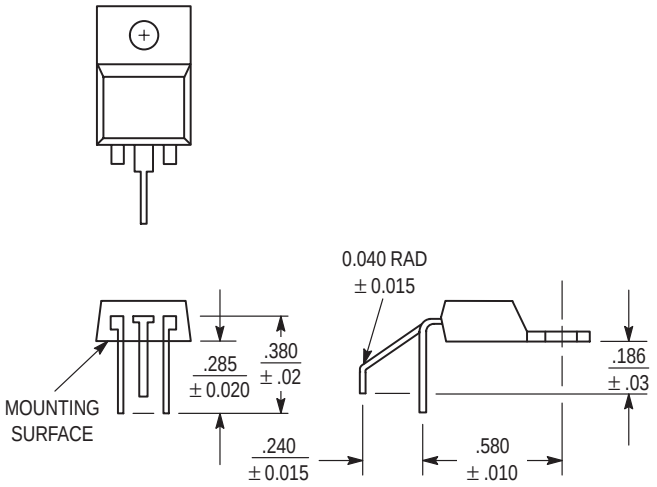
LEADFORM AU

CASE	A
221A–04	0.920 Min.
221A–06	0.885 Min.

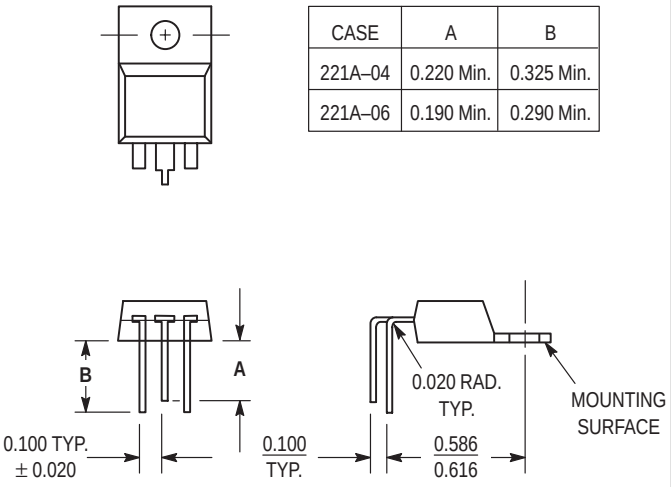


TO–220 Leadform Options (continued)

LEADFORM AN

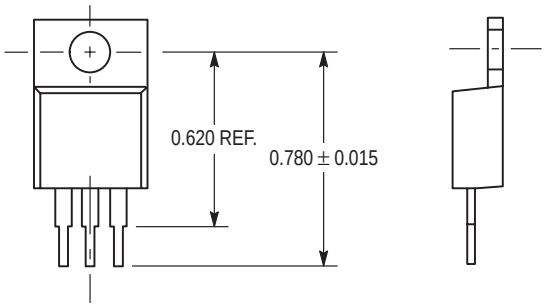


LEADFORM BA

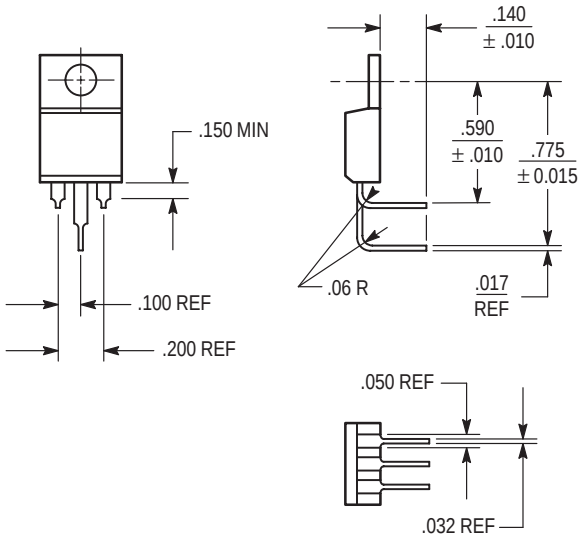


CASE	A	B
221A–04	0.220 Min.	0.325 Min.
221A–06	0.190 Min.	0.290 Min.

LEADFORM BG

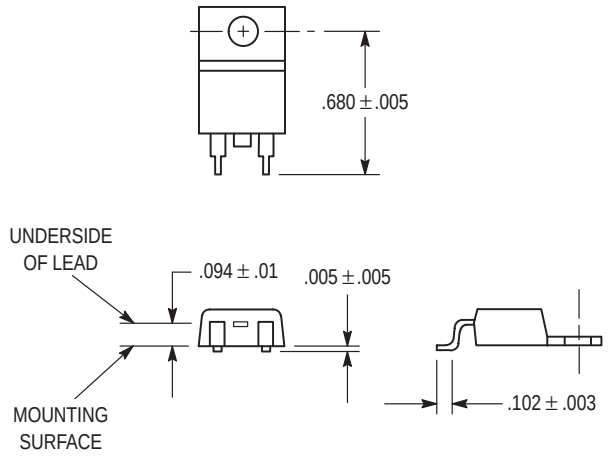


LEADFORM AK

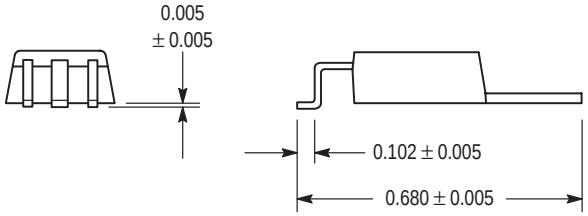


TO–220 Leadform Options (continued)

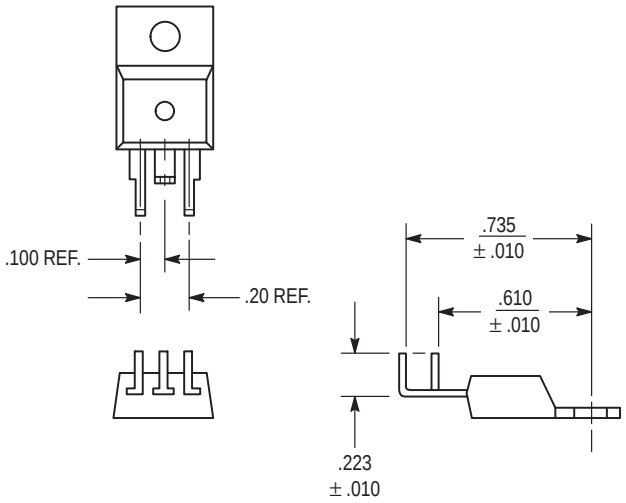
LEADFORM BU



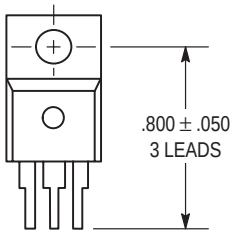
LEADFORM BV



LEADFORM BD

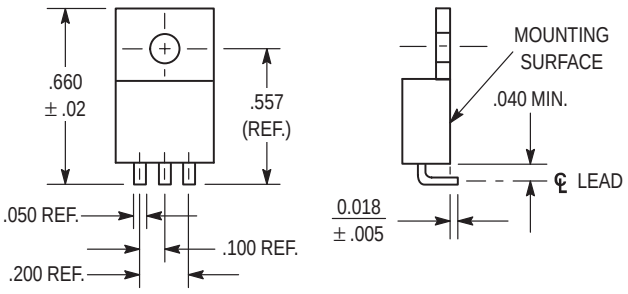


LEADFORM DW

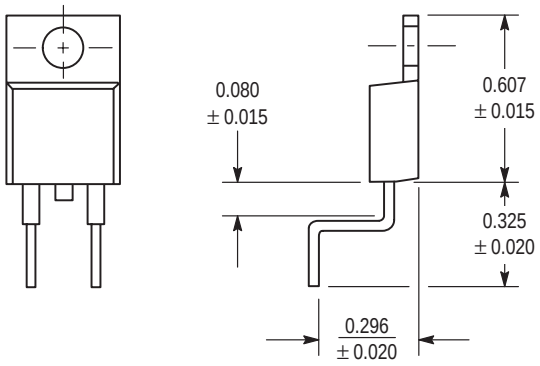


TO–220 Leadform Options (continued)

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
40251		2N3055	3–2
40325		2N3055	3–2
40363		2N5878	3–74
40369		2N5878	3–74
40411		MJ802	3–421
40513		MJE3055T	3–628
40514		MJE3055T	3–628
40542		MJE3055T	3–628
40543		MJE3055T	3–628
40613		TIP31B	3–873
40618		TIP31B	3–873
40621		TIP31B	3–873
40622		TIP31B	3–873
40624		TIP41B	3–883
40627		TIP41B	3–883
40629		TIP31B	3–873
40630		TIP31B	3–873
40631		TIP31B	3–873
40632		TIP41B	3–883
40636		2N5878	3–74
40853		2N6547	3–140
40854		2N6547	3–140
40871		TIP41C	3–883
40872		TIP42C	3–883
40873		TIP41B	3–883
40874		TIP41B	3–883
40875		TIP41C	3–883
40876		TIP41B	3–883
40887		MJE340	3–602
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