

ALPHANUMERIC INDEX — CROSS-REFERENCE (Continued)

Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number	Industry Part Number	Motorola Direct Replacement	Motorola Similar Replacement	Page Number
MJ13090	MJ13090		3-688	MJ2802		2N5881	3-123
MJ13091		MJ16010	3-758	MJ2840		2N5877	3-120
MJ13100		MJ16016	3-774	MJ2841		2N5878	3-120
MJ13101		MJ16016	3-774	MJ2901		MJ15016	3-9
MJ13330	MJ13330		3-694	MJ2940		2N5875	3-120
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MJ14000	MJ14000		3-706	MJ3030	2N6545		3-221
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MJ15002	MJ15002		3-710	MJ3055A	2N3055A		3-9
MJ15003	MJ15003		3-713	MJ3237	MJE15031		3-972
MJ15004	MJ15004		3-713	MJ3238	MJE15031		3-972
MJ15011	MJ15011		3-716	MJ3247	MJE15030		3-972
MJ15012	MJ15012		3-716	MJ3248	MJE15030		3-972
MJ15015	MJ15015		3-9	MJ400		2N3739	3-37
MJ15016	MJ15016		3-9	MJ4030	2N6285		3-172
MJ15018	MJ15018		3-718	MJ4031	2N6286		3-172
MJ15019	MJ15019		3-718	MJ4032	2N6287		3-172
MJ15020	MJ15020		3-718	MJ4033	2N6282		3-172
MJ15021	MJ15021		3-718	MJ4034	2N6283		3-172
MJ15022	MJ15022		3-720	MJ4035	2N6284		3-172
MJ15023	MJ15023		3-723	MJ410	MJ410		3-522
MJ15024	MJ15024		3-720	MJ411	MJ411		3-522
MJ15025	MJ15025		3-723	MJ413	MJ413		3-524
MJ15026		MJ15024	3-720	MJ423	MJ423		3-524
MJ15027		MJ15025	3-723	MJ4237		MJ15012	3-716
MJ16002	MJ16002		3-726	MJ4238		MJ15012	3-716
MJ16002A	MJ16002A		3-734	MJ424		2N6308	3-181
MJ16004	MJ16004		3-726	MJ4247		MJ15011	3-716
MJ16006	MJ16006		3-742	MJ4248		MJ15011	3-716
MJ16006A	MJ16006A		3-750	MJ425		2N6545	3-221
MJ16008	MJ16008		3-742	MJ431	MJ431		3-524
MJ16010	MJ16010		3-758	MJ4360		MJE130C2	3-938
MJ16010A	MJ16010A		3-766	MJ4361		MJE130C3	3-938
MJ16012	MJ16012		3-758	MJ4380		MJE130C4	3-944
MJ16014	MJ16014		3-774	MJ4381		MJE130C5	3-944
MJ16016	MJ16016		3-774	MJ4400		MJE130C4	3-944
MJ16018	MJ16018		3-782	MJ4401		MJE130C5	3-944
MJ16020	MJ16020		—	MJ450		2N4398	3-68
MJ16022	MJ16022		—	MJ4502	MJ4502		3-536
MJ205		MJ12003	3-642	MJ4645	MJ4646		3-538
MJ2249		2N3766	3-44	MJ4646	MJ4646		3-538
MJ2250		2N3767	3-44	MJ4647	MJ4647		3-538
MJ2251		2N3738	3-37	MJ480		2N3055	3-6
MJ2252		2N3739	3-37	MJ481		2N3055	3-6
MJ2253		2N3740	3-41	MJ490		2N3789	3-56
MJ2254		2N3741	3-41	MJ491		2N3789	3-56
MJ2267		MJ15016	3-9	MJ6502	MJ6503		3-540
MJ2268		MJ2955	3-6	MJ6503	MJ6503		3-540
MJ2300		MJE270	3-874	MJ6700		2N6193	3-158
MJ2305		MJE271	3-874	MJ701		MJ12002	3-637
MJ2500	MJ2500		3-530	MJ702		MJ12002	3-637
MJ2501	MJ2501		3-530	MJ704		MJ12002	3-637
MJ2801		2N3055	3-6	MJ721		MJ12002	3-637

*Consult Motorola if a direct replacement is necessary.

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

I _C Cont Amps Max	V _{CEO} (sus) Volts Min	Device Type		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	250	MJ15011	MJ15012	20/100	2					200
	300	MJ3041##		250 min	2.5					175
	325	MJ413 MJ423 MJ431		20/80 30/90 15/35	0.5 1 2.5				2.5 2.5 2.5	125 125 125
	350	BU323## MJ3042## MJ13014 MJ10002## MJ10006##		150 min 250 min 8/20 3/300 30/300	6 2.5 5 5 5	7.5 typ 2 2.5 1.5	5.2 typ 0.5 1 0.5	6 5 5 5	10# 10#	175 175 150 150 150
	400	BU323A## MJ10007## MJ10012## MJ13015		150 min 30/300 100/2k 8/20	6 5 6 5	7.5 typ 1.5 15 2	5.2 typ 0.5 15 0.5	6 5 6 5	10#	175 150 175 150
	600	MJ10014##		10/250	10	2.5	0.8	10		175
	700	MJ8504		7.5 min	1.5	4	2	5		175
	800	MJ8505 MJ16018		7.5 min 4 min	1.5 5	4 4.5 typ	2 0.2 typ	5 5		175 150
	950*	MJ12010		4.2 min	5		1	5		100
12	60	2N6057##	2N6050##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
	80	2N6058##	2N6051##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
	100	2N6059##	2N6052##	750/18k	6	1.6 typ	1.5 typ	6	4#	150
15	60	2N3055 2N3055A 2N6576## 2N5881	MJ2955 MJ2955A 2N5879	20/70 20/70 2k/20k 20/100	4 4 4 6	0.7 typ 2 1	0.3 typ 7 0.8	4 10 6	2.5 0.8 10-200# 4	115 115 120 160
	80	2N5882	2N5880	20/100	6	1	0.8	6	4	160
	90	2N6577##		2k/20k	4	2	7	10	10-200#	120
	120	MJ15015 2N6578##	MJ15016	20/70 2k/20k	4 4	2	7	10	1 10-200#	180 120
	140	MJ15001	MJ15002	25/150	4				2	200
	150	MJ11018##	MJ11017##	100 min	15				3#	175
	200	BUX41 2N6249 MJ11020##	MJ11019##	8 min 10/50 100 min	8 10 15	1.5 3.5	0.4 1	8 10	8 2.5 3#	120 175 175
	250	MJ11022##	MJ11021##	100 min	15				3#	175
	275	2N6250		8/50	10	3.5	1	10	2.5	175
	300	2N6546		6/30	10	4	0.7	10	6 to 24	175
	325	BUX13		8 min	8	2.5	0.8	8	8	150
	400	BUX48 2N6547 MJ13090 MJ16110		8 min 6/30 8 min 6/20	10 10 10 15	2 4 2.5 0.8 typ	0.4 0.7 0.5 0.1 typ	10 10 10	6 to 24	175 175 175 175
	450	BUX48A MJ16010		8 min 5 min	8 15	2 1.2 typ	0.4 0.2 typ	10 10		175 175

* V(BR)CEX. # |h_{FE}| @ 1 MHz, ## Darlington

(continued)

 JAN, JTX, JTXV Available

**COMPLEMENTARY SILICON
HIGH-POWER TRANSISTORS**

... PowerBase complementary transistors designed for high power audio, stepping motor and other linear applications. These devices can also be used in power switching circuits such as relay or solenoid drivers, dc-to-dc converters, inverters, or for inductive loads requiring higher safe operating area than the 2N3055 and MJ2955.

- Current-Gain — Bandwidth-Product @ $I_C = 1.0 \text{ A dc}$
 $f_T = 0.8 \text{ MHz (Min) — NPN}$
 $= 2.2 \text{ MHz (Min) — PNP}$
- Safe Operating Area — Rated to 60 V and 120 V, Respectively

***MAXIMUM RATINGS**

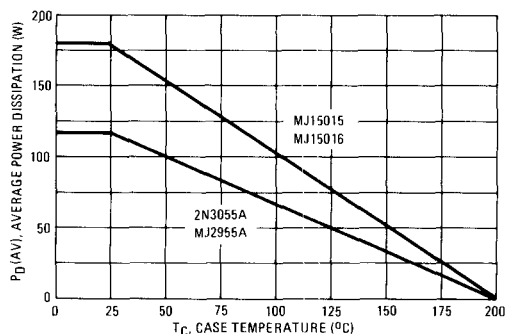
Rating	Symbol	2N3055A MJ2955A	MJ15015 MJ15016	Unit
Collector-Emitter Voltage	V_{CE0}	60	120	Vdc
Collector-Base Voltage	V_{CBO}	100	200	Vdc
Collector-Emitter Voltage Base Reversed Biased	V_{CEV}	100	200	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	15		Adc
Base Current	I_B	7.0		Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	115 0.65	180 1.03	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	0.98	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data (2N3055A)

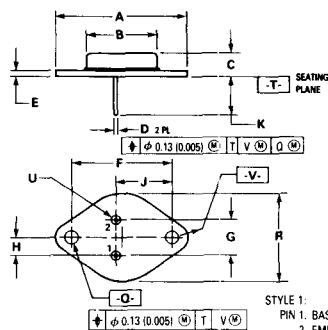
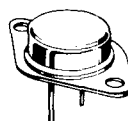
FIGURE 1 — POWER DERATING



15 AMPERE

**COMPLEMENTARY SILICON
POWER TRANSISTORS**

**60, 120 VOLTS
115, 180 WATTS**



STYLE 1:
PN 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	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	8.25	0.250	0.325
D	0.97	1.09	0.038	0.043
E	1.40	1.77	0.055	0.070
F	30.15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	11.18	12.19	0.440	0.480
Q	3.84	4.19	0.151	0.165
R	—	26.67	—	1.050
U	4.83	5.33	0.190	0.210
V	3.84	4.19	0.151	0.165

**CASE 1-06
TO-204AA
(TO-3)**

NPN 2N3055A, MJ15015
PNP MJ2955A, MJ15016

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS (1)					
*Collector-Emitter Sustaining Voltage ($I_C = 200 \text{ mAdc}$, $I_B = 0$)	2N3055A, MJ2955A MJ15015, MJ15016	$V_{CE(sus)}$	60 120	— —	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 0 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 0 \text{ Vdc}$)	2N3055A, MJ2955A MJ15015, MJ15016	I_{CEO}	— —	0.7 0.1	mAdc
*Collector Cutoff Current ($V_{CEV} = \text{Rated Value}$, $V_{BE(off)} = 1.5 \text{ Vdc}$)	2N3055A, MJ2955A MJ15015, MJ15016	I_{CEV}	— —	5.0 1.0	mAdc
Collector Cutoff Current ($V_{CEV} = \text{Rated Value}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	2N3055A, MJ2955A MJ15015, MJ15016	I_{CEV}	— —	30 6.0	mAdc
*Emitter Cutoff Current ($V_{EB} = 7.0 \text{ Vdc}$, $I_C = 0$)	2N3055A, MJ2955A MJ15015, MJ15016	I_{EBO}	— —	5.0 0.2	mAdc
*SECOND BREAKDOWN					
Second Breakdown Collector Current with Base Forward Biased ($t = 0.5 \text{ s non-repetitive}$) ($V_{CE} = 60 \text{ Vdc}$)	2N3055A, MJ2955A MJ15015, MJ15016	$I_{S/b}$	1.95 3.0	— —	Adc
*ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 4.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 4.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$) ($I_C = 10 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)		h_{FE}	10 20 5.0	70 70 —	—
Collector-Emitter Saturation Voltage ($I_C = 4.0 \text{ Adc}$, $I_B = 400 \text{ mAdc}$) ($I_C = 10 \text{ Adc}$, $I_B = 3.3 \text{ Adc}$) ($I_C = 15 \text{ Adc}$, $I_B = 7.0 \text{ Adc}$)		$V_{CE(sat)}$	— — —	1.1 3.0 5.0	Vdc
Base-Emitter On Voltage ($I_C = 4.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)		$V_{BE(on)}$	0.7	1.8	Vdc
*DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	2N3055A, MJ15015 MJ2955A, MJ15016	f_T	0.8 2.2	6.0 18	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)		C_{ob}	60	600	pF
*SWITCHING CHARACTERISTICS (2N3055A only)					
RESISTIVE LOAD					
Delay Time	$(V_{CC} = 30 \text{ Vdc}$, $I_C = 4.0 \text{ Adc}$, $I_{B1} = I_{B2} = 0.4 \text{ Adc}$, $t_p = 25 \mu\text{s Duty Cycle} \leq 2\%$)	t_d	—	0.5	μs
Rise Time		t_r	—	4.0	μs
Storage Time		t_s	—	3.0	μs
Fall Time		t_f	—	6.0	μs

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

*Indicates JEDEC Registered Data (2N3055A)

NPN 2N3055A, MJ15015
PNP MJ2955A, MJ15016

FIGURE 8 – TURN-OFF TIMES

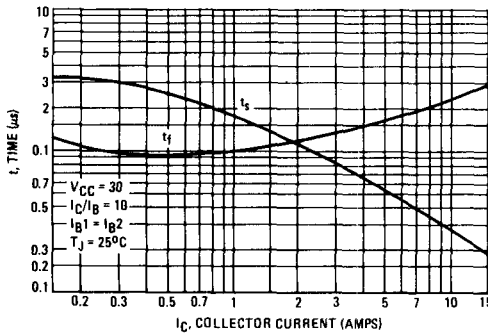
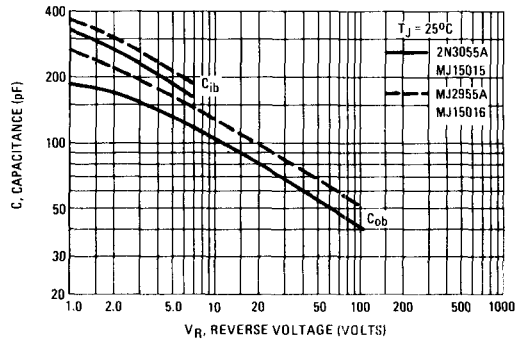
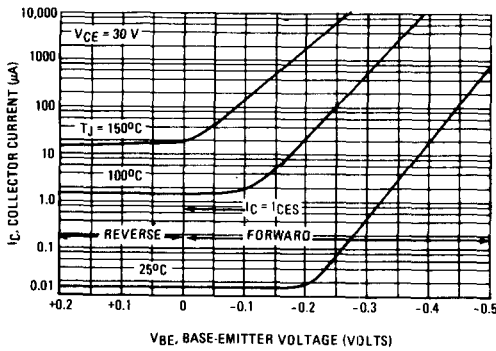


FIGURE 9 – CAPACITANCES



NPN
FIGURE 10 – 2N3055A, MJ15015



PNP
FIGURE 11 – MJ2955A, MJ15016

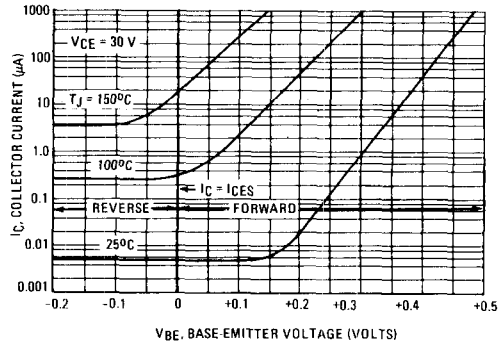


FIGURE 12 – FORWARD BIAS SAFE OPERATING AREA
2N3055A, MJ2955A

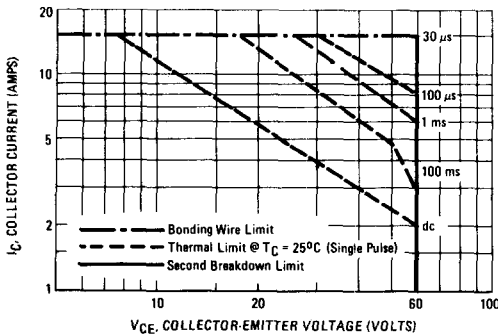
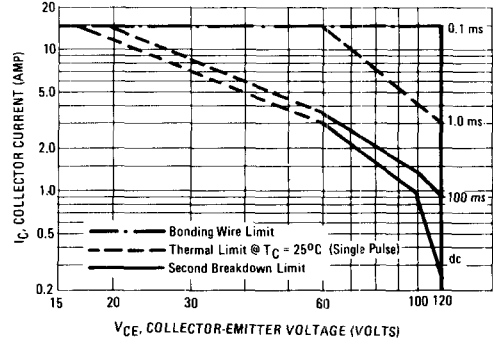


FIGURE 13 – FORWARD BIAS SAFE OPERATING AREA
MJ15015, MJ15016



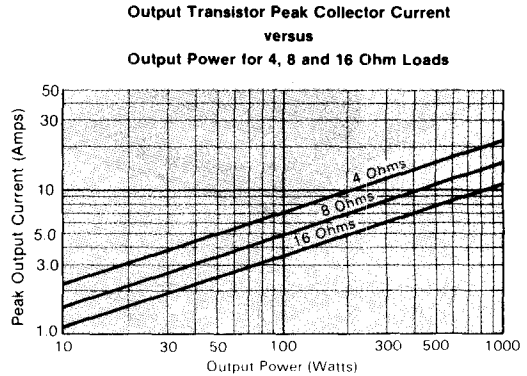
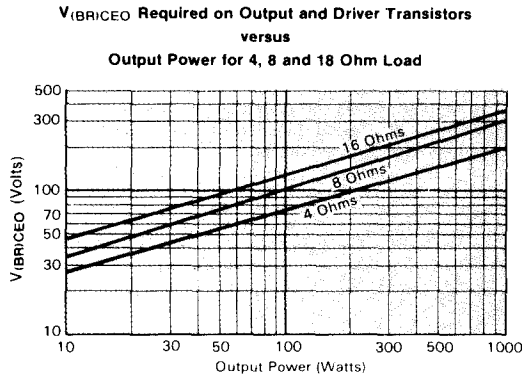
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater

dissipation than the curves indicate.

The data of Figures 12 and 13 is based on $T_C = 25^\circ\text{C}$; $T_J(\text{pk})$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 1.

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 on these see Application Notes AN484A and AN485.

TABLE 1 — RECOMMENDED POWER TRANSISTORS FOR AUDIO/SERVO LOADS

RMS Power Output	NPN	PNP	Case	P _D Watts @ 25°C	V _{CEO}	h _{FE} α Min/Max	I _C Amps	f _T MHz Typ	ISB Volts/Amps
To 25W	MJE15030	MJE15031	TO-220	50W	150 V	20 min	4A	70	14/3.6
25 to 50W	2N3055A MJ15001	MJ2955A MJ15002	TO-204	120W	120 V	20/70	4A	3	60/2
			TO-204	200W	140 V	25/150	4A	3	40/5
50 to 100W	MJ15015 MJ15003 MJ15018 MJ15020	MJ15016 MJ15004 MJ15019 MJ15020	TO-204	180W	120 V	20/70	4A	3	60/3
			TO-204	250W	140 V	25/150	5A	3	100/1
			TO-204	150W	200	30 min	1A	20	50/3
			TO-204	150W	250	30 min	1A	20	50/3
Over 100W	MJ15024	MJ15025	TO-204	250W	250 V	15/60	8A	8	80/2.2

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.