ALPHANUMERIC INDEX — CROSS-REFERENCE (Continued)

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KSC2334		MJE15028	3-972
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MJ10009	MJ10009		3-588
MJ1001	MJ1001		3-528
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MJ10012	MJ10012		3-596
MJ10013	MJ10014		3-600
MJ10014	MJ10014		3-600
MJ10015	MJ10015		3-606
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MJ10020	MJ10020		3-611
MJ10021	MJ10021		3-611
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MJ11022	MJ11022		3-631
MJ11028	MJ11028		3-635
MJ11029	MJ11029		3-635
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MJ11031	MJ11031		3-635
MJ11032	MJ11032		3-635
MJ11033	MJ11033		3-635
MJ1200		2N6300	3-147
MJ12002	MJ12002		3-637
MJ12003	MJ12003		3-642
MJ12004	MJ12004		3-644
MJ12005	MJ12005		3-650
MJ12005D	MJ12005D		3-652
MJ1201		2N6301	3-147
MJ12010	MJ12010		3-658
MJ12020	MJ12020		3-660
MJ12021	MJ12021		3-660
MJ12022	MJ12022		3-660
MJ13010		2N6547	3-225
MJ13014	MJ13014		3-670
MJ13015	MJ13015		3-670
MJ13018		MJ13330	3-694
MJ13019		MJ13331	3-694
MJ13070	MJ13070		3-676
MJ13071		MJ16002	3-726
MJ13080	MJ13080		3-682
MJ13081		MJ16006	3-742

*Consult Motorola if a direct replacement is necessary.

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

I_{C}Cont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	f_T MHz Min	P_D (Case) Watts @ 25°C
25	60	2N5885	2N5883	20/100	10	1	0.8	10	4	200
	80	2N5886	2N5884 2N6436	20/100 30/120	10 10	1 1	0.8 0.25	10 10	4 40	200 200
	100	2N6338	2N6437	30/120	10	1	0.25	10	40	200
	120	2N6339	2N6438	30/120	10	1	0.25	10	40	200
	125	BUV10 BUV10N		10 min 10 min	20 20	1.2 1.55	0.25 0.45	20 15	8 10	150 175
	140	2N6340		30/120	10	1	0.25	10	40	200
	150	2N6341		30/120	10	1	0.25	10	40	200
	500	BUT14##		15 min	16	2.8	0.8	16		175
28	400	BUT13##		20 min	20	2.6	0.8	18		175
30	40	2N3771 2N5301	 2N4398	15/60 15/60	15 15	 2	 1	 10	2 2	150 200
	60	2N5302 MJ11012##	2N4399 MJ11011##	15/60 1k min	15 20	2	1	10	2 4#	200 200
	90	BUX39 MJ11014##	 MJ11013##	8 min 1k min	20 20	1	0.25	20	8 4#	120 200
	100	2N6328 MJ802	 MJ4502	6/30 25/100	30 7.5				3 2	200 200
	120	MJ11016##	MJ11015##	1k min	20				4#	200
	325	BUV23•		8 min	16	1.8	0.4	16	8	250
	400	BUS98• BUX98		8 min	20	2.3 3	0.4 0.8	20 20		250 250
	450	BUS98A• BUX98A MJ16020• MJ16022•		8 min 5 min 7 min	16 30 30	2.3 3 1.8 1.5	0.4 0.8 0.2 0.15	16 16 20 20		250 250 250 250
40	160	BUV21N•		10 min	40	1	0.2	40	8	250
	200	BUV21•		10 min	25	1.8	0.4	25	8	150
	250	BUS52• BUV22•		15 min 10 min	40 20	 1.1	 0.35	 20	 8	350 250
	350	MJ10022•##		50/600	120	2.5	0.9	20		250
	400	MJ10023•##		50/600	10	2.5	0.9	20		250
	700	BUT35•##		15 min	24	4	1.2	24		250
50	60	2N5685• MJ11028•##	2N5683• MJ11029•##	15/60 400 min	25 50	0.5 typ	0.3 typ	25	2	300 300
	80	2N5686•	2N5684• 2N6377•	15/60 30/120	25 20	0.5 typ 0.8	0.3 typ 0.25	25 20	2 30	300 250
	90	MJ11030•##	MJ11031•##	400 min	50					300
	100	2N6274•	2N6378•	30/120	20	0.8	0.25	20	30	250
	120	2N6275• MJ11032•##	2N6379• MJ11033•##	30/120 400 min	20 50	0.8	0.25	20	30	250 300
	125	BUV20•		10 min	50	1.2	0.25	50	8	250
	150	2N6277•		30/120	20	0.8	0.25	20	30	250

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

(continued)

☐ JAN, JTX, JTXV Available

TABLE 12 — POWER DARLINGTONS (continued)

I_C Cont Amps Max	$V_{CEO(sus)}$ Volts Min	Device Type NPN	Device Type PNP	h_{FE} Min/Max	@ I_C Amp	Resistive Switching t_s μs Max	Resistive Switching t_f μs Max	Resistive Switching @ I_C Amp	$\|h_{fe}\|$ @ 1 MHz Min	P_D (Case) Watts @ 25°C	Case JEDEC/MOT
10	400	MJ10012		100/2k	6	15	15	6		175	TO-204/1
	600	MJ10014•		10/250	10	2.5	0.8	10		175	TO-204/1
12	60	2N6057	2N6050	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	80	2N6058	2N6051	750/18k	6	1.6 typ	1.5 typ	6	4	150	TO-204/1
	100	2N6059	2N6052	750/18k	6	1.6 typ	1.5 typ	6		150	TO-204/1
	1000	BUT16•		5 min	8	3.3	1.5	8		150	TO-204/1
15	60	2N6576		2k/20k	4	2	7	10	10/200	120	TO-204/1
	90	2N6577		2k/20k	4	2	7	10	10/200	120	TO-204/1
	120	2N6578		2k/20k	4	2	7	10	10/200	120	TO-204/1
	150	MJ11018 MJH11018	MJ11017 MJH11017	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	200	MJ11020 MJH11020	MJ11019 MJH11019	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	250	MJ11022 MJH11022	MJ11021 MJH11021	100 min 100 min	15 15				3 3	175 150	TO-204/1 TO-218/340
	500	BUT51P		40 min	5	1.1	0.16	10		125	TO-218/340D
20	60	2N6282 MJH6282	2N6285 MJH6285	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	80	2N6283 MJH6283	2N6286 MJH6286	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	100	2N6284 MJH6284	2N6287 MJH6287	750/18k 750/18k	10 10	2.5 typ 2.5 typ	2.5 typ 2.5 typ	10 10	4 4	160 125	TO-204/1 TO-218/340
	350	MJ10000 MJ10004•		40/400 40/400	10 10	3 1.5	1.8 0.5	10	10 10	175 175	TO-204/1 TO-204/1
	400	MJ10001 MJ10005•		40/400 40/400	10 10	3 1.5	1.8 0.5	10	10 10	175 175	TO-204/1 TO-204/1
	450	MJ10008•		30/300	10	2	0.6	10	8	175	TO-204/1
	500	MJ10009•		30/300	10	2	0.6	10	8	175	TO-204/1
	700	BUT15•		15 min	12	2.5	0.8	12		175	TO-204/1
	750	MJ10024•		50/600	5	5	1.8	10		250	TO-204/1
	850	MJ10025•		50/600	5	5	1.8	10		250	TO-204/1
25	500	BUT14•		15 min	16	2.8	0.8	16		175	TO-204/1
28	400	BUT13•		20 min	20	2.6	0.8	18		175	TO-204/1
30	60	MJ11012	MJ11011	1k min	20				4	200	TO-204/1
	90	MJ11014	MJ11013	1k min	20				4	200	TO-204/1
	120	MJ11016	MJ11015	1k min	20				4	200	TO-204/1
40	350	MJ10022•		50/600	10	2.5	0.9	20		250	TO-204/197
	400	MJ10023•		50/600	10	2.5	0.9	20		250	TO-204/197
	700	BUT35•		15 min	24	4	1.2	24		250	TO-204/197
50	60	MJ11028	MJ11029	400 min	50					300	TO-204/197

• Darlington with speed-up diode.

(continued)

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

PNP	NPN
MJ11011	MJ11012
MJ11013	MJ11014
MJ11015	MJ11016

HIGH-CURRENT COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain h_{FE} = 1000 (Min) @ I_C = 20 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor
- Junction Temperature to +200°C

30 AMPERE

DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60-120 VOLTS
200 WATTS

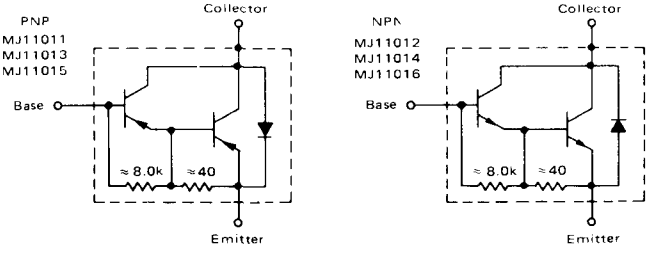
MAXIMUM RATINGS

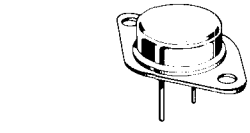
Rating	Symbol	MJ11011 MJ11012	MJ11013 MJ11014	MJ11015 MJ11016	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	120	Vdc
Collector-Base Voltage	V_{CB}	60	90	120	Vdc
Emitter-Base Voltage	V_{EB}	5			Vdc
Collector Current	I_C	30			Adc
Base Current	I_B	1			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C @ T_C = 100°C	P_D	200 1.15			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200			°C

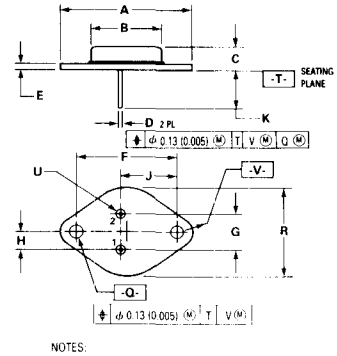
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.87	°C/W
Maximum Lead Temperature for Soldering Purposes for ≤ 10 Seconds.	T_L	275	°C

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC







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 MIN	MILLIMETERS MAX	INCHES MIN	INCHES 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

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

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

3

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

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = 100 mAdc, I_B = 0)	MJ11011,MJ11012		60	–	
	MJ11013,MJ11014		90	–	
	MJ11015,MJ11016		120	–	
Collector Emitter Leakage Current		I_{CER}			mAdc
(V_{CE} = 60 Vdc, R_{BE} = 1 k ohm)	MJ11011,MJ11012		–	1	
(V_{CE} = 90 Vdc, R_{BE} = 1 k ohm)	MJ11013,MJ11014		–	1	
(V_{CE} = 120 Vdc, R_{BE} = 1 k ohm)	MJ11015,MJ11016		–	1	
(V_{CE} = 60 Vdc, R_{BE} = 1 k ohm, T_C = 150°C)	MJ11011,MJ11012		–	5	
(V_{CE} = 90 Vdc, R_{BE} = 1 k ohm, T_C = 150°C)	MJ11013,MJ11014		–	5	
(V_{CE} = 120 Vdc, R_{BE} = 1 k ohm, T_C = 150°C)	MJ11015,MJ11016		–	5	
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	–	5	mAdc
Collector Emitter Leakage Current (V_{CE} = 50 Vdc, I_B = 0)		I_{CEO}	–	1	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			–
(I_C = 20 Adc, V_{CE} = 5 Vdc)			1000	–	
(I_C = 30 Adc, V_{CE} = 5 Vdc)			200	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 200 mAdc)			–	3	
(I_C = 30 Adc, I_B = 300 mAdc)			–	4	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
I_C = 20 Adc, I_B = 200 mAdc)			–	3.5	
I_C = 30 Adc, I_B = 300 mAdc)			–	5	
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short Circuit Forward Current Transfer Ratio (I_C = 10 Adc, V_{CE} = 3 Vdc, f = 1 MHz)		h_{fe}	4	–	MHz

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

FIGURE 2 – DC CURRENT GAIN (1)

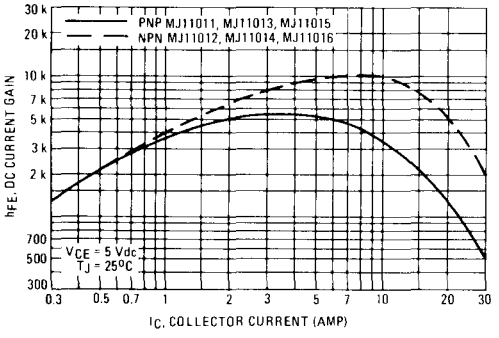


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

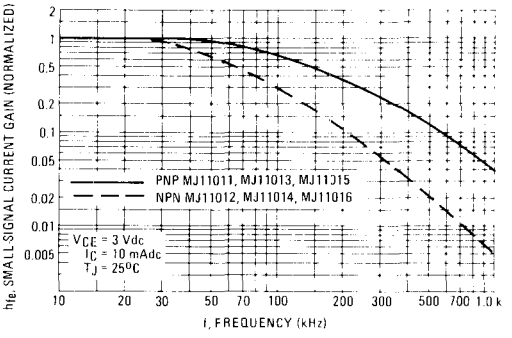


FIGURE 4 – "ON" VOLTAGES (1)

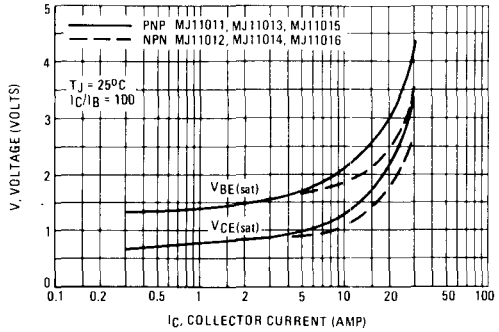
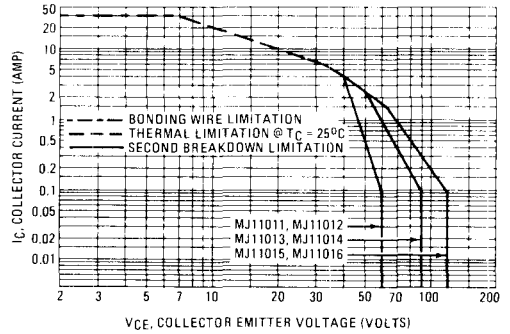


FIGURE 5 – ACTIVE REGION DC SAFE OPERATING AREA



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

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.