# PNP Silicon High-Power Transistors

- . . . designed for use in power amplifier and switching circuits.
- Low Collector–Emitter Saturation Voltage —
   IC = 15 Adc, VCE(sat) = 1.0 Vdc (Max) 2N4398,99
   = 1.5 Vdc (Max) 2N5745
- DC Current Gain Specified 1.0 to 30 Adc
- Complements to NPN 2N5301, 2N5302, 2N5303

#### \*MAXIMUM RATINGS

Rating	Symbol	2N4398	2N4399	2N5745	Unit
Collector–Emitter Voltage	VCEO	40	60	80	Vdc
Collector-Base Voltage					Vdc
Emitter–Base Voltage	VEB	5.0			Vdc
Collector Current — Continuous Peak	lC	30 50	30 50	20 50	Adc
Base Current — Continuous Peak	ΙB	7.5 15			Adc
Total Device Dissipation  @ T <sub>A</sub> = 25°C**  Derate above 25°C	PD	5.0 28.6			Watts mW/°C
Total Device Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	PD	200 1.15			Watts W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-65 to +200			°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	0.875	°C/W
Thermal Resistance, Junction to Ambient	$\theta$ JA	35	°C/W

<sup>\*</sup> Indicates JEDEC Registered Data.

<sup>\*\*</sup> Motorola guarantees this data in addition to JEDEC Registered Data.

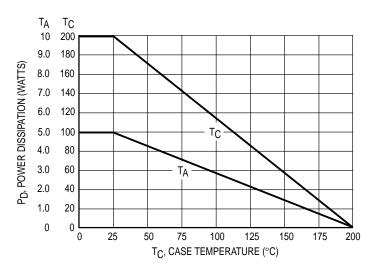


Figure 1. Power-Temperature Derating Curve

Safe Area Curves are indicated by Figure 13. All limits are applicable and must be observed.

# 2N4347 (See 2N3442)

2N4398 2N4399 2N5745

20, 30 AMPERE
POWER TRANSISTORS
PNP SILICON
40-60-180 VOLTS
200 WATTS



# 2N4398 2N4399 2N5745

# **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage (1) (I <sub>C</sub> = 200 mAdc, I <sub>B</sub> = 0)	2N4398 2N4399 2N5745	VCEO(sus)	40 60 80	_ _ _	Vdc
Collector Cutoff Current (VCE = 40 Vdc, IB = 0) (VCE = 60 Vdc, IB = 0) (VCE = 80 Vdc, IB = 0)	2N4398 2N4399 2N5745	ICEO		5.0 5.0 5.0	mAdc
Collector Cutoff Current (VCE = 40 Vdc, VBE(off) = 1.5 Vdc) (VCE = 60 Vdc, VBE(off) = 1.5 Vdc) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc) (VCE = 30 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C) (VCE = 80 Vdc, VBE(off) = 1.5 Vdc, T <sub>C</sub> = 150°C)	2N4398 2N4399 2N5745 2N4398, 2N4399 2N5745	<sup>I</sup> CEX	11111	5.0 5.0 5.0 10	mAdc
Collector Cutoff Current (V <sub>CB</sub> = 40 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0) (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)	2N4398 2N4399 2N5745	СВО	111	1.0 1.0 1.0	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 5.0 Vdc, I <sub>C</sub> = 0)		I <sub>EBO</sub>	_	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)  (IC = 1.0 Adc, VCE = 2.0 Vdc)  (IC = 10 Adc, VCE = 2.0 Vdc)  (IC = 15 Adc, VCE = 2.0 Vdc)  (IC = 20 Adc, VCE = 2.0 Vdc)  (IC = 30 Adc, VCE = 4.0 Vdc)	All Types 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	hFE	40 15 15 5.0 5.0	 60 60  	_
Collector–Emitter Saturation Voltage (1) ( $I_C = 10$ Adc, $I_B = 1.0$ Adc) ( $I_C = 15$ Adc, $I_B = 1.5$ Adc) ( $I_C = 20$ Adc, $I_B = 2.0$ Adc) ( $I_C = 20$ Adc, $I_B = 4.0$ Adc) ( $I_C = 30$ Adc, $I_B = 6.0$ Adc)	2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	VCE(sat)		0.75 1.0 1.0 1.5 2.0 2.0 4.0	Vdc
Base–Emitter Saturation Voltage (1) (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 1.0 Adc)**  (I <sub>C</sub> = 15 Adc, I <sub>B</sub> = 1.5 Adc)  (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 2.0 Adc)** (I <sub>C</sub> = 20 Adc, I <sub>B</sub> = 4.0 Adc)	2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745	VBE(sat)	- - - - -	1.6 1.7 1.85 2.0 2.5 2.5	Vdc
Base–Emitter On Voltage (1)  (IC = 10 Adc, VCE = 2.0 Vdc)  (IC = 15 Adc, VCE = 2.0 Vdc)  (IC = 20 Adc, VCE = 4.0 Vdc)  (IC = 30 Adc, VCE = 4.0 Vdc)  *Indicates_IEDEC_Registered_Data	2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	VBE(on)	_ _ _ _	1.5 1.7 2.5 3.0	Vdc

(continued)

<sup>\*</sup>Indicates JEDEC Registered Data.
\*\*Motorola Guarantees this Data in Addition to JEDEC Registered Data.

<sup>(1)</sup> Pulse Test: Pulse Width  $\leq 300 \,\mu s$ , Duty Cycle  $\leq 2.0\%$ 

# **ELECTRICAL CHARACTERISTICS** — continued

Characteristic			Symbol	Min	Max	Unit
DYNAMIC CHARACTERIST	ics					•
Current–Gain Bandwidth P (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10 f = 1.0 MHz)		2N4398, 2N4399 2N5745	fΤ	4.0 2.0		MHz
Small–Signal Current Gain (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 10	Vdc, f = 1.0 kHz)		h <sub>fe</sub>	40	_	_
SWITCHING CHARACTERS	STICS					
Rise Time		2N4398, 2N4399 2N5745	t <sub>r</sub>	_	0.4 1.0	μs
Storage Time	(V <sub>C</sub> C = 30 Vdc, I <sub>C</sub> = 10 Adc, I <sub>R1</sub> = I <sub>R2</sub> = 1.0 Adc)	2N4396, 2N4399 2N5745	t <sub>S</sub>	_	1.5 2.0	μs
Fall Time		2N4398, 2N4399 2N5746	t <sub>f</sub>	_	0.6 1.0	μs

<sup>(2)</sup> f<sub>T</sub> is defined as the frequency at which |h<sub>fe</sub>| extrapolates to unity.

# **SWITCHING TIME EQUIVALENT TEST CIRCUITS**

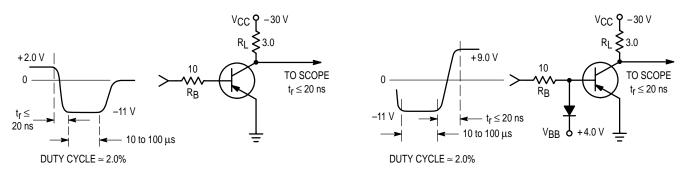


Figure 2. Turn-On Time

Figure 3. Turn-Off Time

# **TYPICAL "ON" REGION CHARACTERISTICS**

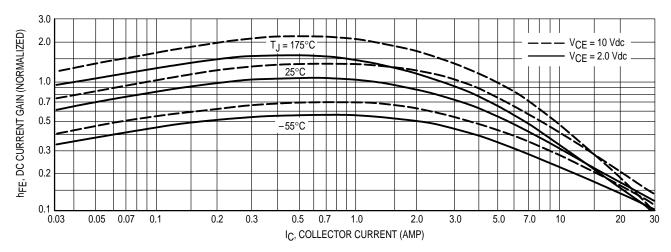


Figure 4. DC Current Gain

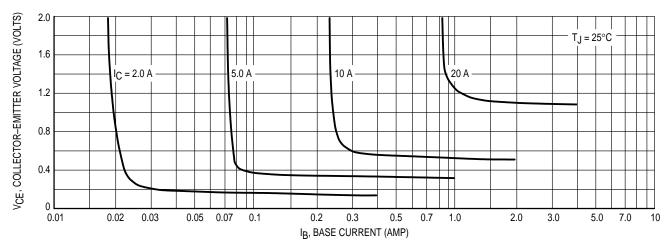


Figure 5. Collector Saturation Region

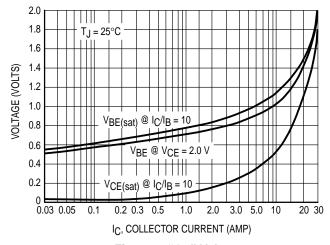
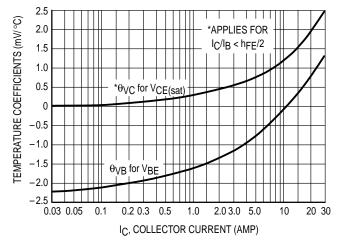


Figure 6. "On" Voltages



**Figure 7. Temperature Coefficients** 

#### **RATINGS AND THERMAL DATA**

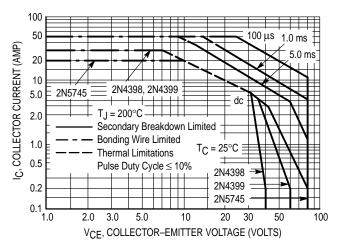


Figure 8. Active Region Safe Operating Area

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 8 is based on  $T_{J(pk)} = 200^{\circ}C$ ;  $T_{C}$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \le 200^{\circ}C$ .  $T_{J(pk)}$  may be calculated from the data in Figure 9. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

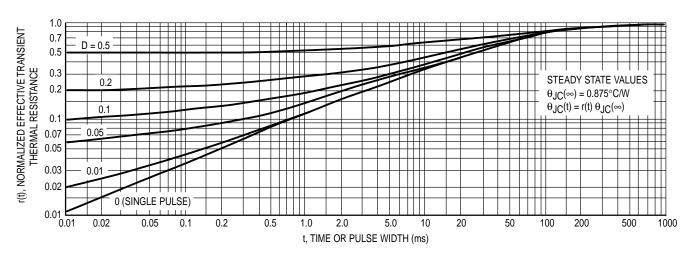
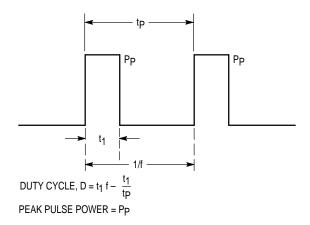


Figure 9. Thermal Response

### **DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA**



A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 9 was calculated for various duty cycles.

To find  $\theta_{JC}(t)$ , multiply the value obtained from Figure 9 by the steady state value  $\theta_{JC}(\infty)$ .

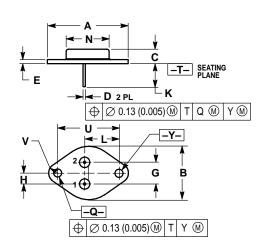
#### Example:

The 2N4398 is dissipating 100 watts under the following conditions:  $t_1 = 1.0$  ms,  $t_P = 5.0$  ms. (D = 0.2)

Using Figure 9, at a pulse width of 1.0 ms and D = 0.2, the reading of r (t) is 0.28.

The peak rise in junction temperature is therefore  $T = r(t) \times Pp \times \theta_{JC}(\infty) = 0.28 \times 100 \times 0.875 = 24.5^{\circ}C$ 

#### PACKAGE DIMENSIONS



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

- ALL RULES AND NOTES ASSOCIATED WITH
   REFERENCED TO-204AA OUTLINE SHALL APPLY.

	INCHES		MILLIN	IETERS	
DIM	MIN	MAX	MIN	MAX	
Α	1.550	REF	39.37	39.37 REF	
В		1.050		26.67	
С	0.250	0.335	6.35	8.51	
D	0.038	0.043	0.97	1.09	
Е	0.055	0.070	1.40	1.77	
G	0.430	BSC	10.92 BSC		
Н	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		
٧	0.131	0.188	3.33	4.77	

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

**CASE 1-07** TO-204AA (TO-3) **ISSUE Z** 

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