2N5304 (SILICON)

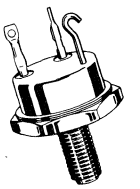
RADIATION-RESISTANT
NPN SILICON POWER TRANSISTOR

. . . designed for high-speed switching and wide-band amplifier applications in radiation environments.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) @ I_C = 100 mAdc
- DC Current Gain –
  h_{FE} = 30-120 @ I_C = 2.0 Adc
  = 25 (Min) @ I_C = 5.0 Adc
  = 12 (Min) @ I_C = 10 Adc
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 2.0 Adc
  = 0.8 Vdc (Max) @ I_C = 5.0 Adc
  = 1.2 Vdc (Max) @ I_C = 10 Adc
- Current-Gain – Bandwidth Product–
  f_T = 100 MHz (Min) @ I_C = 0.5 Adc
- Collector Cutoff Current, DC Current Gain and Collector-Emitter Saturation Voltage Limits Guaranteed After Exposure to 1 x 10^{14} Fast Neutron/cm^2.

10 AMPERE
POWER TRANSISTOR
NPN SILICON

40 VOLTS
25 WATTS



GUARANTEED RADIATION RESISTANCE CAPABILITIES
After 1 x 10^{14} n/cm^2 Fast Neutron (E > 10 keV) Exposure (Fission Spectrum)

Characteristic	Symbol	Min	Max	Unit
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	5.0	–	–
Collector Cutoff Current (V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc	I_{CEX}	–	50	μAdc
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$	–	1.5	Vdc

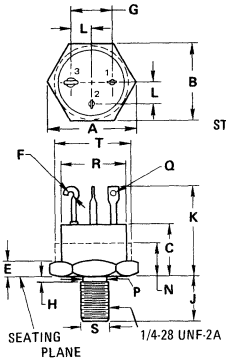
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	10	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @T_C = 125°C Derate above 125°C	P_D	25 0.333	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C
Fast Neutron Radiation Level	–	1x10^{14}	n/cm^2

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	°C/W

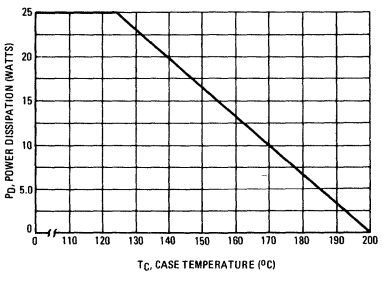
*Indicates JEDEC Registered Data



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	19.30	20.07	0.760	0.790
B	16.94	17.45	0.667	0.687
C	8.26	11.68	0.325	0.460
E	2.29	3.81	0.090	0.150
F	1.17	1.96	0.046	0.077
G	8.64	10.54	0.340	0.415
H	–	2.29	–	0.090
J	10.72	11.56	0.422	0.455
K	16.26	22.23	0.640	0.875
L	4.32	5.41	0.170	0.213
N	–	6.86	–	0.270
P	5.59	6.32	0.220	0.249
Q	1.19	1.83	0.047	0.072
R	14.48	15.49	0.570	0.610
S	5.651	5.761	0.2225	0.2268
T	15.49	17.45	0.610	0.687

Collector connected to case
All JEDEC dimensions and notes apply
CASE 9
TO-61

FIGURE 1 – POWER DERATING



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

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	–	200	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	10	μAdc
(V_{CE} = 25 Vdc, $V_{EB(off)}$ = 1.5 Vdc T_C = 150°C)		–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	25	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		30	120	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		25	–	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)		12	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		–	0.4	
(I_C = 5.0 Adc, I_B = 500 mAdc)		–	0.8	
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		–	1.2	
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.8	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	300	pF
SWITCHING CHARACTERISTICS				
Rise Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_r	–	100	ns
Storage Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc, I_{B2} = 100 mAdc)	t_s	–	700	ns
Fall Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc, I_{B2} = 100 mAdc)	t_f	–	100	ns

*Indicates JEDEC Registered Data

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

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

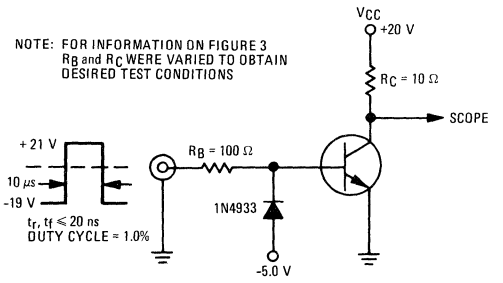


FIGURE 3 – SWITCHING TIMES

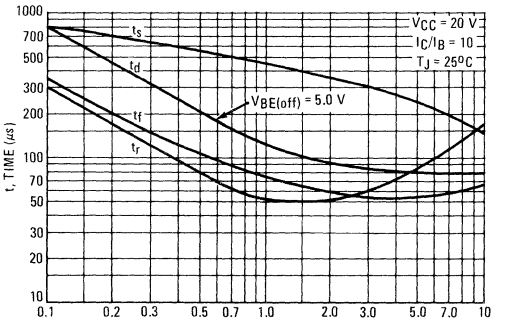


FIGURE 4 – THERMAL RESPONSE

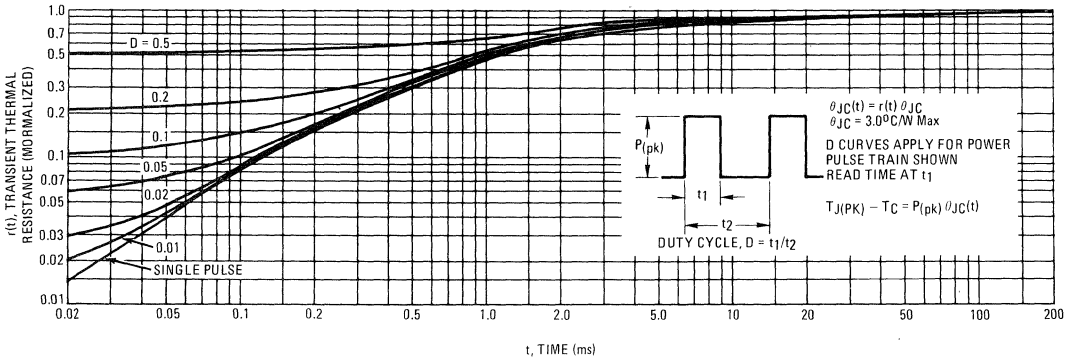
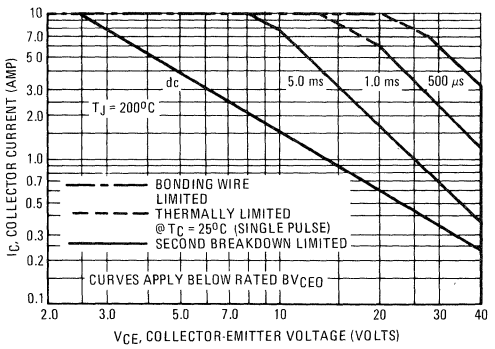
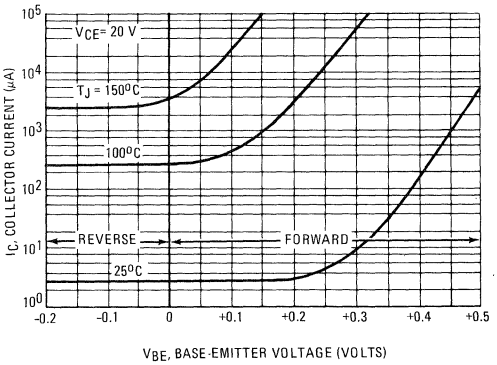


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



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.

FIGURE 6 – COLLECTOR CUTOFF REGION



The data of Figure 5 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 $T_{J(pk)} < 200^{\circ}C$. $T_{J(pk)}$ 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. (See AN-415).

FIGURE 7 – CAPACITANCE

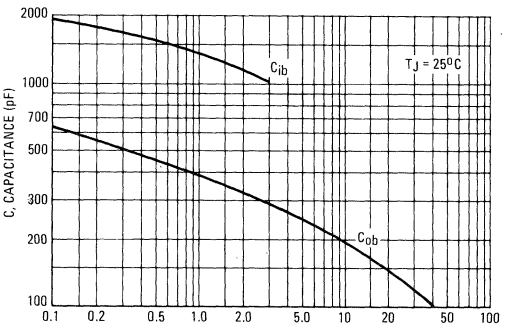


FIGURE 8 – BASE CUTOFF REGION

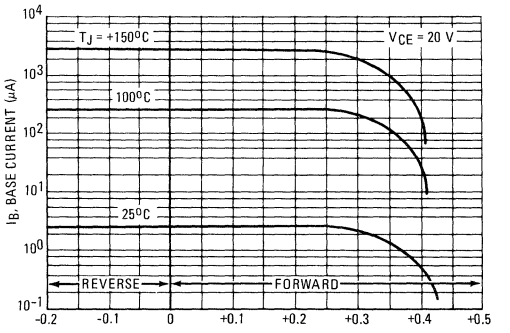


FIGURE 9 – DC CURRENT GAIN

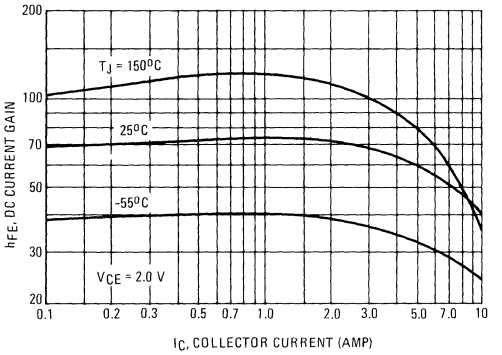


FIGURE 10 – COLLECTOR SATURATION REGION

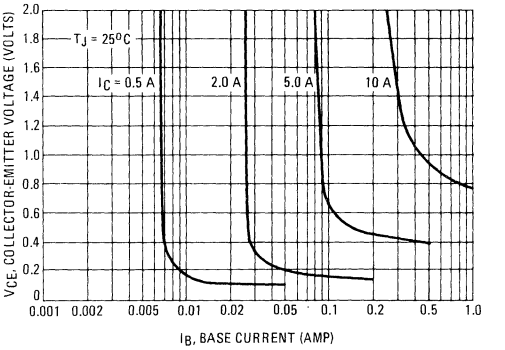


FIGURE 11 – "ON" VOLTAGES

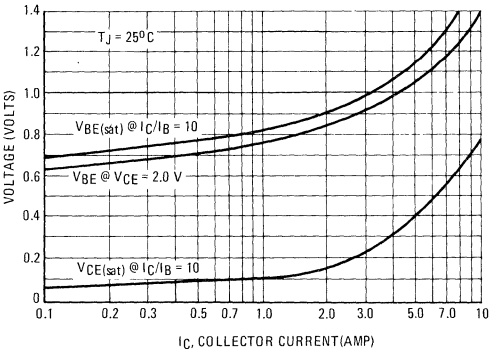
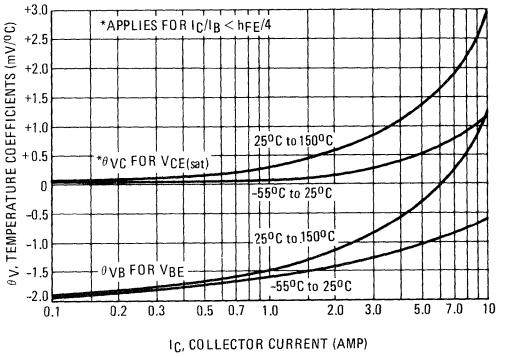


FIGURE 12 – TEMPERATURE COEFFICIENTS



EFFECTS OF FAST NEUTRON DOSAGE

FIGURE 13 – DC CURRENT GAIN

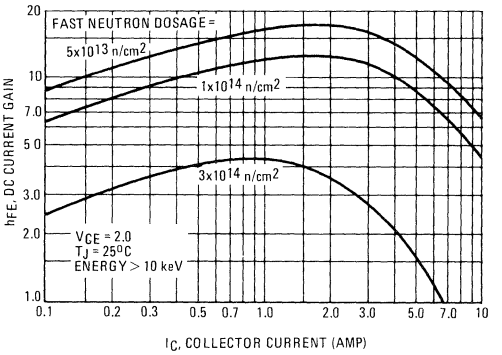


FIGURE 14 – COLLECTOR-EMITTER SATURATION VOLTAGE