

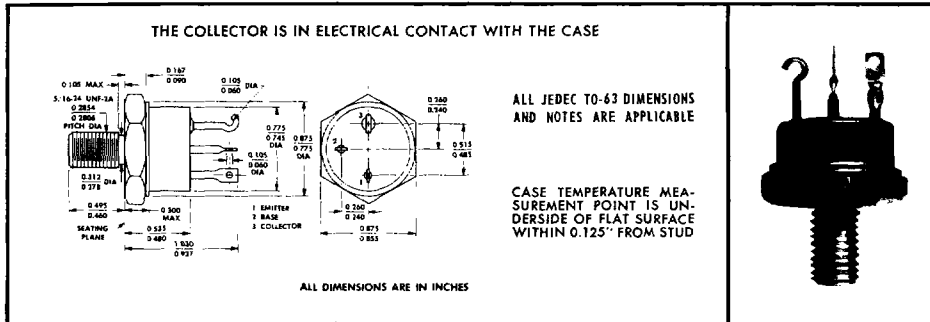
TYPES 2N4002, 2N4003 N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

TYPES 2N4002, 2N4003
BULLETIN NO. DL-5-688606, MAY 1966
REVISED MAY 1968

FOR POWER-AMPLIFIER AND HIGH-SPEED-SWITCHING APPLICATIONS

- 30-A Rated Continuous Collector Current
- 100 Watts at 100°C Case Temperature
- Maximum $V_{CE(sat)}$ of 1.2 V at 30 A
- Maximum V_{BE} of 1.8 V at 30 A
- Maximum t_{on} of 1 μs at 15 A

***mechanical data**



***absolute maximum ratings at 25°C case temperature (unless otherwise noted)**

	2N4002	2N4003
Collector-Base Voltage	100 V	120 V
Collector-Emitter Voltage (See Note 1)	80 V	100 V
Emitter-Base Voltage	← 8 V →	
Continuous Collector Current	← 30 A →	
Peak Collector Current (See Note 2)	← 40 A →	
Continuous Base Current	← 10 A →	
Continuous Emitter Current	← 30 A →	
Safe Operating Region at (or below) 100°C Case Temperature	See Figure 7	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	← 100 W →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← 4 W →	
Operating Collector Junction Temperature Range	-65°C to 200°C	
Storage Temperature Range	-65°C to 200°C	
Terminal Temperature 1/8 Inch from Case for 10 Seconds	← 230°C →	

- NOTES: 1. These values apply when the base-emitter diode is open-circuited.
 2. This value applies for $t_p \leq 0.3$ ms, duty cycle $\leq 10\%$.
 3. Derate linearly to 200°C case temperature at the rate of 1 W/deg.
 4. Derate linearly to 200°C free-air temperature at the rate of 22.9 mW/deg.

*Indicates JEDEC registered data.

TYPES 2N4002, 2N4003

N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	2N4002		2N4003		UNIT
		MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$ Collector-Emitter Breakdown Voltage	$I_C = 30 \text{ mA}$, $I_B = 0$, See Note 5	80		100		V
I_{CEO} Collector Cutoff Current	$V_{CE} = 40 \text{ V}$, $I_B = 0$	2				mA
	$V_{CE} = 50 \text{ V}$, $I_B = 0$			2		
I_{CES} Collector Cutoff Current	$V_{CE} = 90 \text{ V}$, $V_{BE} = 0$	1				mA
	$V_{CE} = 110 \text{ V}$, $V_{BE} = 0$			1		
	$V_{CE} = 90 \text{ V}$, $V_{BE} = 0$, $T_C = 150^\circ\text{C}$	2				
	$V_{CE} = 110 \text{ V}$, $V_{BE} = 0$, $T_C = 150^\circ\text{C}$			2		
I_{EBO} Emitter Cutoff Current	$V_{EB} = 5 \text{ V}$, $I_C = 0$	100		100		μA
	$V_{EB} = 8 \text{ V}$, $I_C = 0$	50		50		mA
h_{FE} Static Forward Current Transfer Ratio	$V_{CE} = 4 \text{ V}$, $I_C = 30 \text{ A}$, See Notes 5 and 6	10		10		
	$V_{CE} = 4 \text{ V}$, $I_C = 15 \text{ A}$, See Notes 5 and 6	20	80	20	80	
V_{BE} Base-Emitter Voltage	$V_{CE} = 4 \text{ V}$, $I_C = 30 \text{ A}$, See Notes 5 and 6	1.8		1.8		V
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = 4 \text{ A}$, $I_C = 30 \text{ A}$, See Notes 5 and 6	1.2		1.2		V
h_{fo} Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4 \text{ V}$, $I_C = 1 \text{ A}$, $f = 1 \text{ kHz}$	30		30		
$ h_{fe} $ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10 \text{ V}$, $I_C = 1 \text{ A}$, $f = 10 \text{ MHz}$	3		3		

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300 \mu\text{s}$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

*thermal characteristics

PARAMETER	MAX	UNIT
θ_{J-C} Junction-to-Case Thermal Resistance	1	deg/W
θ_{J-A} Junction-to-Free-Air Thermal Resistance	43.7	deg/W

*Indicates JEDEC registered data.

TYPES 2N4002, 2N4003 N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

*switching characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS†	MAX	UNIT
t_{on} Turn-On Time	$I_C = 15 \text{ A}$, $I_{B(1)} = 1.5 \text{ A}$, $I_{B(2)} = -1.5 \text{ A}$,	1	μs
t_{off} Turn-Off Time	$V_{BE(off)} = -2 \text{ V}$, $R_L = 3 \Omega$, See Figure 1	3	

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

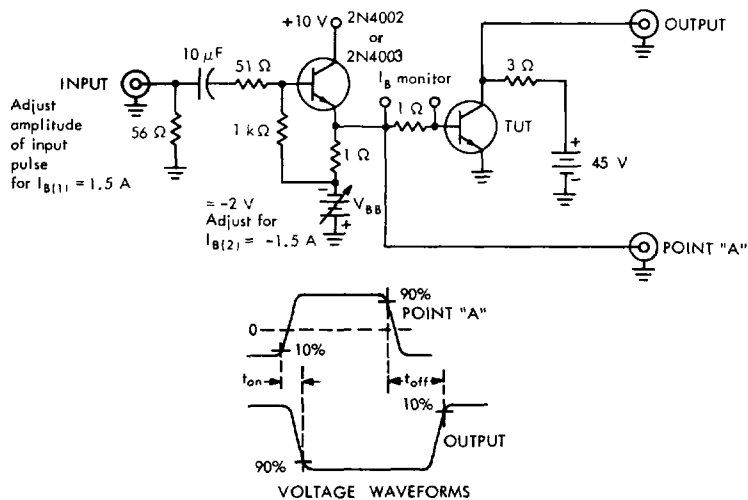


FIGURE 1

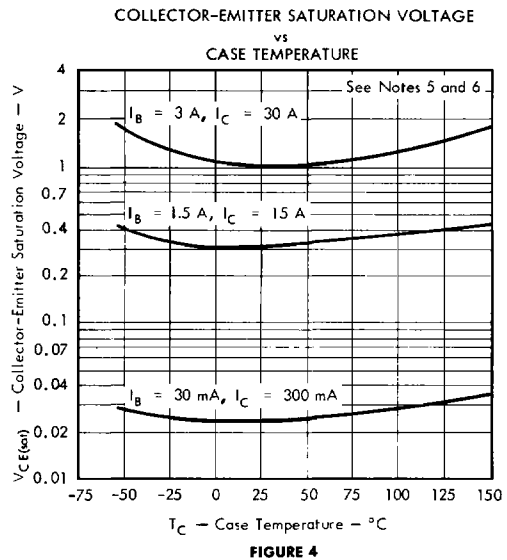
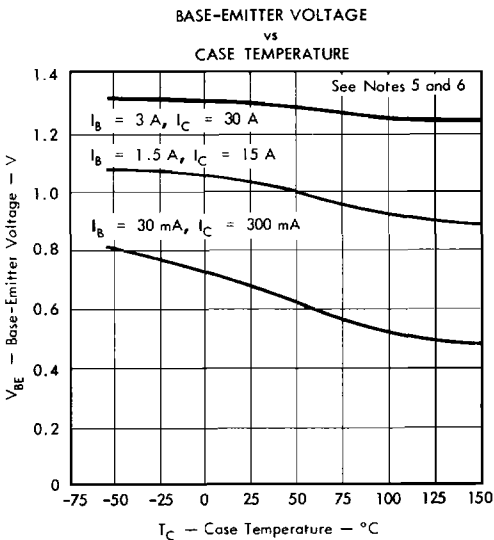
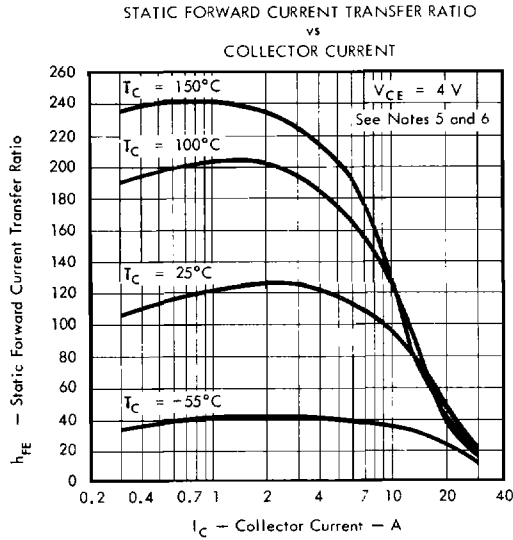
- NOTES: a. The input waveform at point "A" has the following characteristics: $t_r \leq 100 \text{ ns}$, $t_f \leq 100 \text{ ns}$, $t_p = 20 \mu\text{s}$, duty cycle $\leq 0.2\%$.
 b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5 \text{ ns}$, $R_{in} \geq 1 \text{ M}\Omega$, $C_{in} \leq 5 \text{ pF}$.
 c. Resistors must be noninductive types.
 d. The d-c power supplies may require additional bypassing in order to minimize ringing.

*Indicates JEDEC registered data.

5

TYPES 2N4002, 2N4003 N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS



NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300 \mu s$, duty cycle $\leq 2\%$.

6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

TYPES 2N4002, 2N4003 N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

TYPICAL CHARACTERISTICS

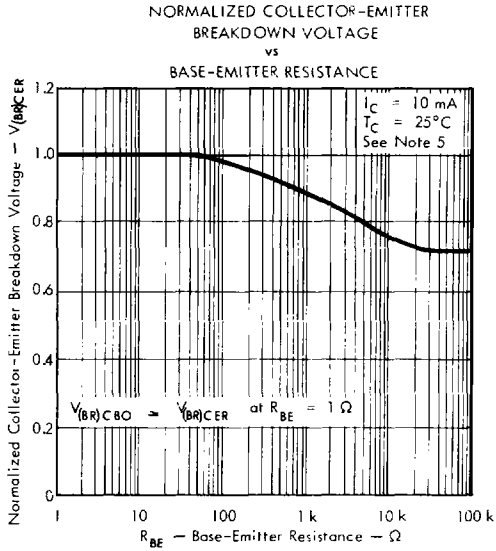


FIGURE 5

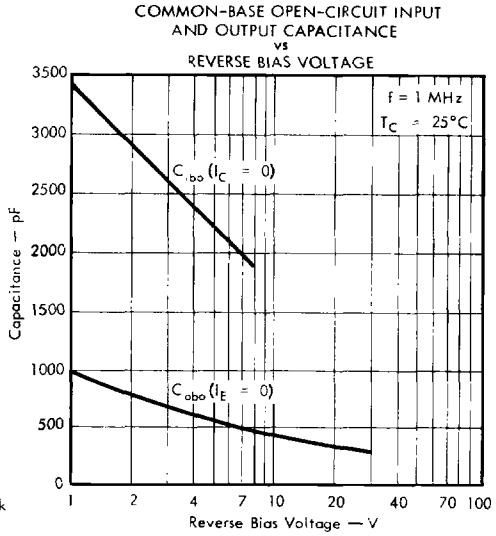


FIGURE 6

NOTE 5: These parameters must be measured using pulse techniques. $t_p = 300 \mu\text{s}$, duty cycle $\leq 2\%$.

MAXIMUM SAFE OPERATING REGION

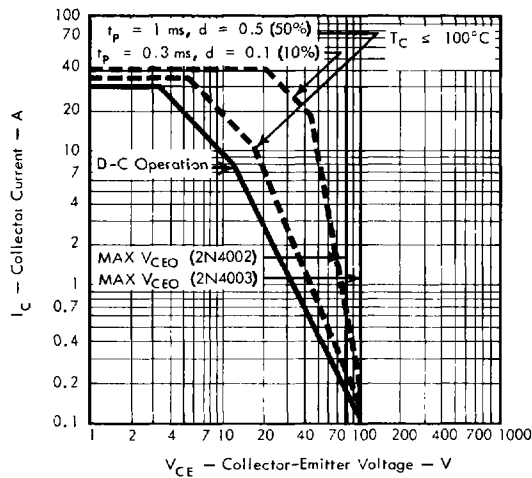


FIGURE 7

5

TYPES 2N4002, 2N4003 N-P-N EPITAXIAL PLANAR SILICON POWER TRANSISTORS

THERMAL INFORMATION

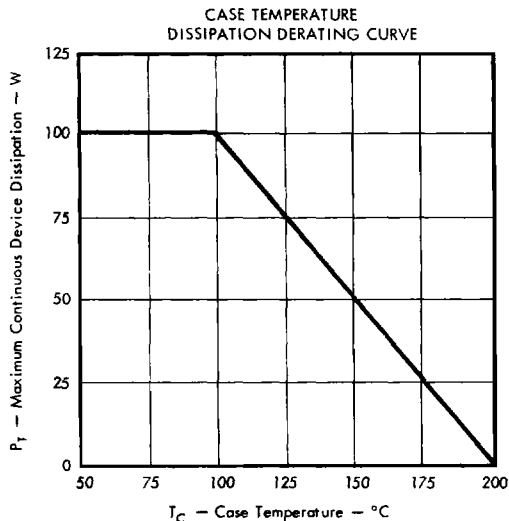


FIGURE 8

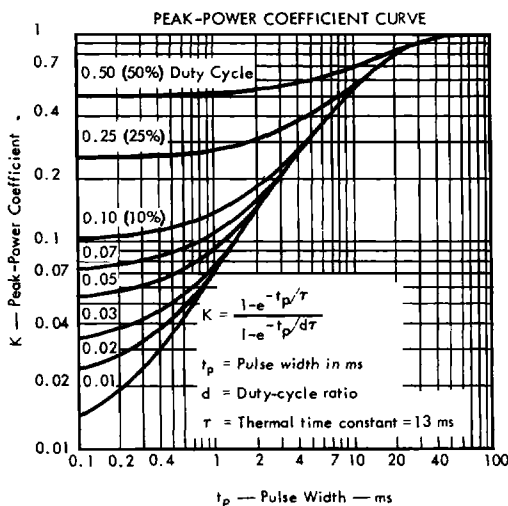


FIGURE 9

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
$P_{T(avg)}$	Average Power Dissipation		W
$P_{T(max)}$	Peak Power Dissipation		W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	43.7	deg/W
θ_{J-C}	Junction-to-Case Thermal Resistance	1	deg/W
θ_{C-A}	Case-to-Free-Air Thermal Resistance	42.7	deg/W
θ_{C-HS}	Case-to-Heat-Sink Thermal Resistance		deg/W
θ_{HS-A}	Heat-Sink-to-Free-Air Thermal Resistance		deg/W
T_A	Free-Air Temperature		°C
T_C	Case Temperature		°C
$T_{J(avg)}$	Average Junction Temperature	≤ 200	°C
$T_{J(max)}$	Peak Junction Temperature	≤ 200	°C
K	Peak-Power Coefficient	See Figure 9	
t_p	Pulse Width		ms
t_x	Pulse Period		ms
d	Duty-Cycle Ratio (t_p/t_x)		

Example — Find $P_{T(max)}$ (design limit)

OPERATING CONDITIONS:

$$\theta_{C-HS} + \theta_{HS-A} = 2.5 \text{ deg/W (From information supplied with heat sink.)}$$

$$T_{J(avg)} \text{ (design limit)} = 200^\circ\text{C}$$

$$T_A = 50^\circ\text{C}$$

$$d = 10\% (0.1)$$

$$t_p = 0.1 \text{ ms}$$

Equation No. 1 — Application: d-c power dissipation, heat sink used.

$$P_{T(avg)} = \frac{T_{J(avg)} - T_A}{\theta_{J-C} + \theta_{C-HS} + \theta_{HS-A}} \text{ for } 100^\circ\text{C} \leq T_C \leq 200^\circ\text{C}, \text{ as in Figure 8}$$

Equation No. 2 — Application: d-c power dissipation, no heat sink used.

$$P_{T(avg)} = \frac{T_{J(avg)} - T_A}{\theta_{J-A}} \text{ for } 25^\circ\text{C} \leq T_A \leq 200^\circ\text{C}$$

Equation No. 3 — Application: Peak power dissipation, heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C-HS} + \theta_{HS-A}) + K\theta_{J-C}} \text{ for } 100^\circ\text{C} \leq T_C \leq 200^\circ\text{C}$$

Equation No. 4 — Application: Peak power dissipation, no heat sink used.

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d\theta_{C-A} + K\theta_{J-C}} \text{ for } 25^\circ\text{C} \leq T_A \leq 200^\circ\text{C}$$

Solution:

From Figure 9, Peak-Power Coefficient

$$K = 0.1 \text{ and by use of equation No. 3}$$

$$P_{T(max)} = \frac{T_{J(max)} - T_A}{d(\theta_{C-HS} + \theta_{HS-A}) + K\theta_{J-C}}$$

$$P_{T(max)} = \frac{200 - 50}{0.1(2.5) + 0.1(1)} = 428 \text{ W}$$