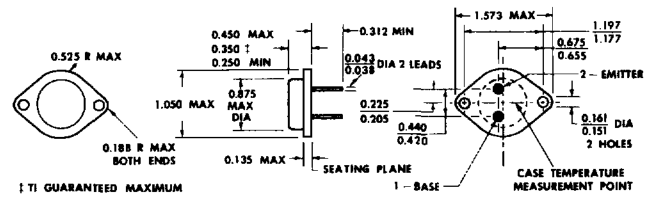
TYPE 2N1046
P-N-P ALLOY-DIFFUSED GERMANIUM POWER TRANSISTOR

HIGH-FREQUENCY POWER TRANSISTOR FOR MILITARY AND INDUSTRIAL APPLICATIONS

mechanical data

This transistor is in a precision-welded, hermetically sealed enclosure. The mounting base provides an excellent heat path from the collector junction to a heat sink. The mounting base and heat sink must be in intimate contact for maximum heat transfer. Extreme cleanliness during the assembly process prevents sealed-in contamination. The approximate weight of the unit is 18 grams.

*ALL JEDEC TO-3 DIMENSIONS AND NOTES ARE APPLICABLE.
*THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



‡ TI GUARANTEED MAXIMUM

DIMENSIONS ARE IN INCHES

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

Collector-Base Voltage	100 v*
Collector-Emitter Voltage (See Note 1)	50 v*
Emitter-Base Voltage	1.5 v* 2.0 v†
Continuous Collector Current	12 a*
Peak Collector Current (See Note 2)	20 a*
Base Current	3 a*
Safe Continuous Operating Region	See Figure 13*
Continuous Collector Dissipation at (or below) 75°C Case Temperature (See Note 3)	50 w
Continuous Collector Dissipation at (or below) 50°C Case Temperature (See Note 4)	50 w*
Peak Collector Power Dissipation at (or below) 25°C Case Temperature (See Notes 2 and 5)	600 w*
Operating Collector Junction Temperature	100°C*
Storage Temperature Range	−55°C to +100°C* −55°C to +110°C†
Lead Temperature, 1/8 inch ± 1/32 inch from case for 10 seconds	230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. This value applies for a rectangular waveshape, pulse width ≤ 270 μsec, duty cycle ≤ 10%. See figure 12 for other allowable pulse width and duty cycle combinations.
3. Derate linearly to 100°C case temperature at the rate of 2 w/C°.
4. Derate linearly to 100°C case temperature at the rate of 1 w/C°. This corresponds to the JEDEC registered maximum value of thermal resistance, $\theta_{J\text{-}C}$, 1.0 C°/w.
5. Derate linearly to 100°C case temperature at the rate of 8 w/C°.

*Indicates JEDEC registered data. †Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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

	PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = -10$ ma, $I_E = 0$	−100*		v
BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = -200$ ma, $I_B = 0$, See Note 6	−50*		v
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = -2$ ma, $I_C = 0$	−1.5*		v
		$I_E = -10$ ma, $I_C = 0$	−2.0		
I_{CBO}	Collector Cutoff Current	$V_{CB} = -3$ v, $I_E = 0$		−0.3*	ma
		$V_{CB} = -75$ v, $I_E = 0$		−2.0*	
		$V_{CB} = -75$ v, $I_E = 0$, $T_C = +70°C$		−12	
I_{CEX}	Collector Cutoff Current	$V_{CE} = -75$ v, $V_{BE} = +0.2$ v		−2.0	ma
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -0.5$ v, $I_C = 0$		−0.1*	ma
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1.5$ v, $I_C = -0.5$ a, See Note 7	40* 60†		
		$V_{CE} = -1.5$ v, $I_C = -5$ a, See Note 7	40* 60†	200†	
		$V_{CE} = -1.5$ v, $I_C = -5$ a, $T_C = -55°C$, See Note 7	60 See Fig. 4		
		$V_{CE} = -1.5$ v, $I_C = -5$ a, $T_C = +70°C$, See Note 7	40 See Fig. 4		
V_{BE}	Base-Emitter Voltage	$I_B = -50$ ma, $I_C = -0.5$ a, See Note 7		−0.4*	v
		$I_B = -500$ ma, $I_C = -5$ a, See Note 7		−0.7*	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -50$ ma, $I_C = -0.5$ a, See Note 7		−0.2*	v
		$I_B = -500$ ma, $I_C = -5$ a, See Note 7		−0.4*	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -15$ v, $I_C = -0.5$ a, $f = 10$ mc	1.0* 2.0†		

NOTES: 6. This parameter must be measured using pulse techniques. PW = 300 μsecs; Duty Cycle ≤ 2%.
7. If these parameters are measured without a heat sink, d-c collector current must not be applied longer than 250 msec.

switching characteristics at 25°C case temperature

PARAMETER	TEST CONDITIONS‡	TYPICAL	UNIT
t_d Delay Time	$I_C = -5a$, $I_{B(1)} = -0.5a$, $I_{B(2)} = 0.5a$, $V_{BE(off)} = 2$ v, $R_L = 4\Omega$, See Figure 1	0.1	μsec
t_r Rise Time		0.2	μsec
t_s Storage Time		2.0	μsec
t_f Fall Time		0.4	μsec
t_T Total Switching Time		2.7	μsec

‡Voltage and current values are nominal; exact values vary slightly with device parameters.

PARAMETER MEASUREMENT INFORMATION

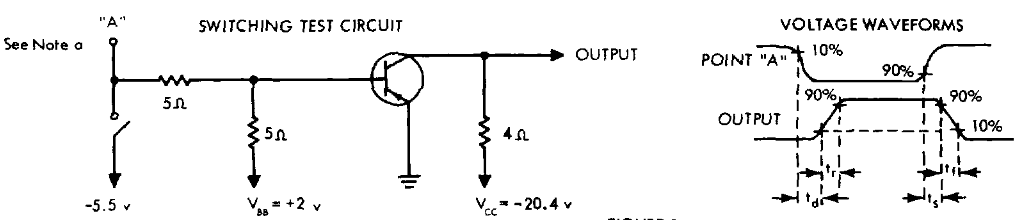

FIGURE 1

NOTES: (a) The pulse at point "A" has the following characteristics: $t_r \leq 20$ nsec, $t_f \leq 20$ nsec, PW = 5 μsec, duty cycle ≤ 5%.
(b) The waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ nsec., $R_{in} \geq 1$ MΩ, $C_{in} \leq 20$ pf.
*Indicates JEDEC registered data.
†Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TYPICAL CHARACTERISTICS

COMMON-EMITTER COLLECTOR CHARACTERISTICS
(Low-Voltage Region)

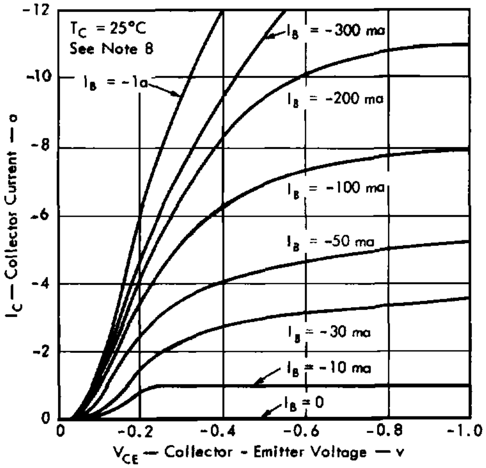

FIGURE 2

COMMON-EMITTER COLLECTOR CHARACTERISTICS
(High-Voltage Region)

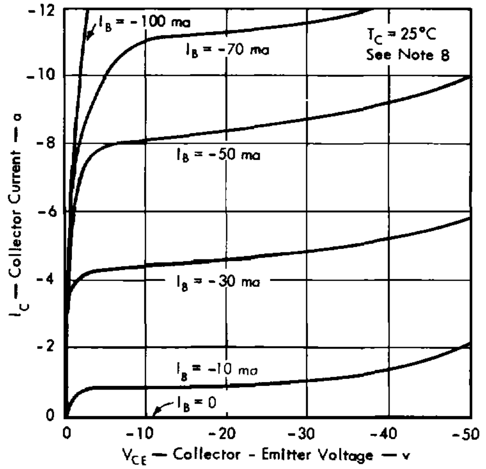

FIGURE 3

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

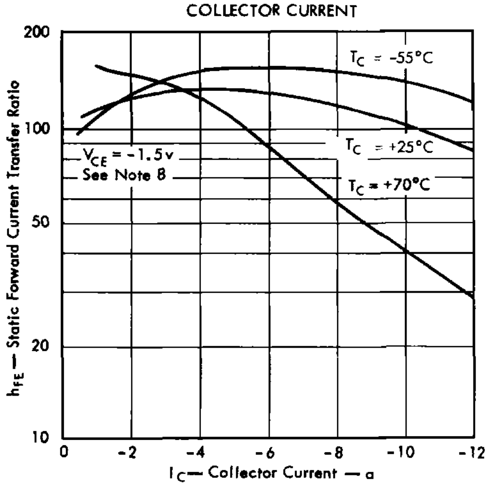

FIGURE 4

BASE-EMITTER VOLTAGE
vs
COLLECTOR CURRENT

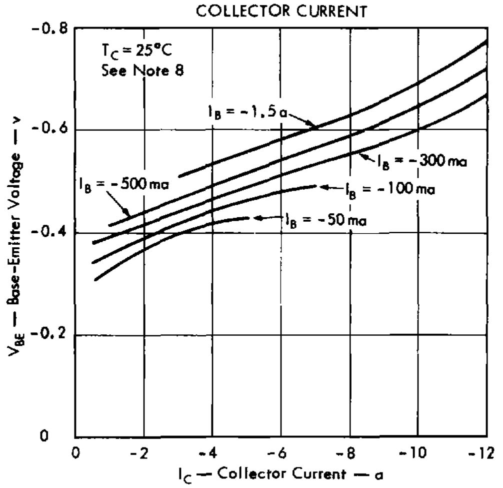

FIGURE 5

NOTE 8: These characteristics were measured using pulse techniques. PW = 300μsec, Duty Cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

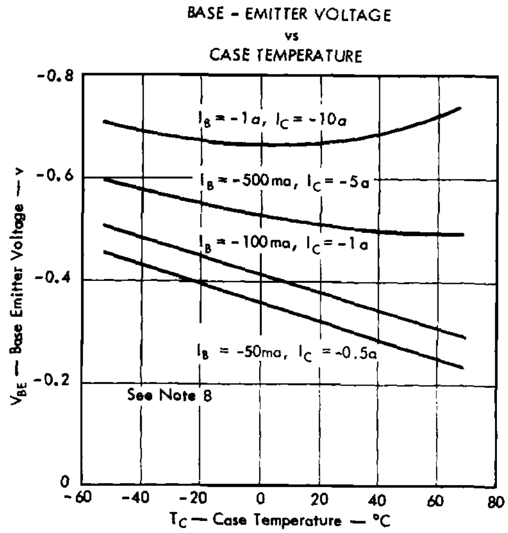

FIGURE 6

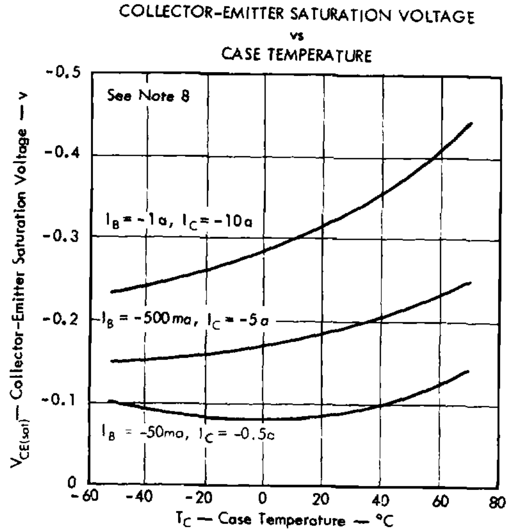

FIGURE 7

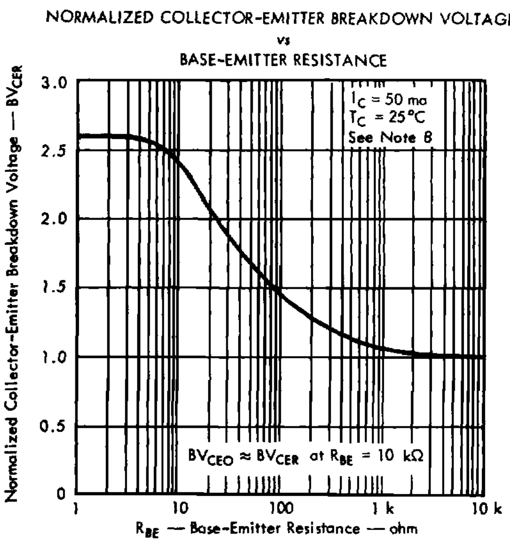

FIGURE 8

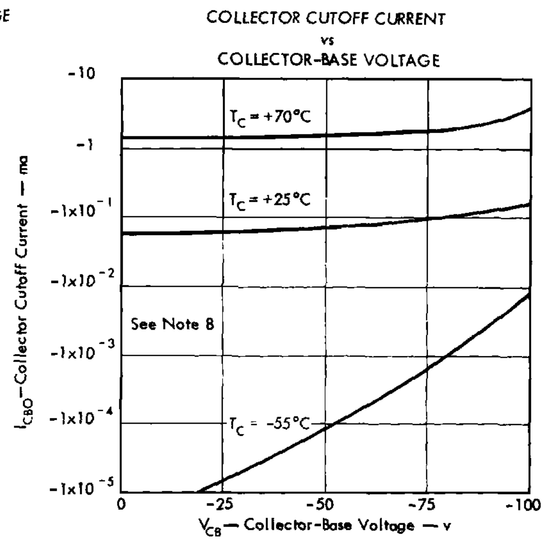

FIGURE 9

NOTE 8: These characteristics were measured using pulse techniques. PW = 300μsec, Duty Cycle ≤ 2%.

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THERMAL CHARACTERISTICS

CASE TEMPERATURE
DISSIPATION DERATING CURVES

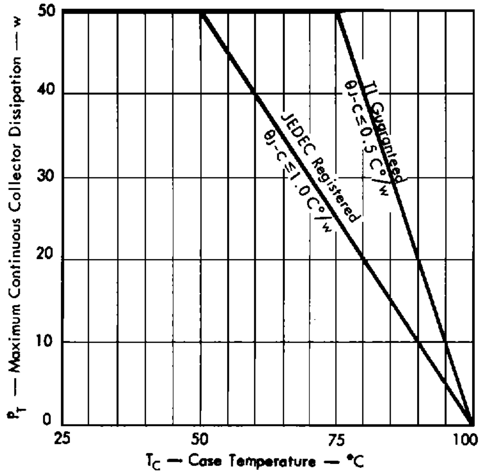

FIGURE 10

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

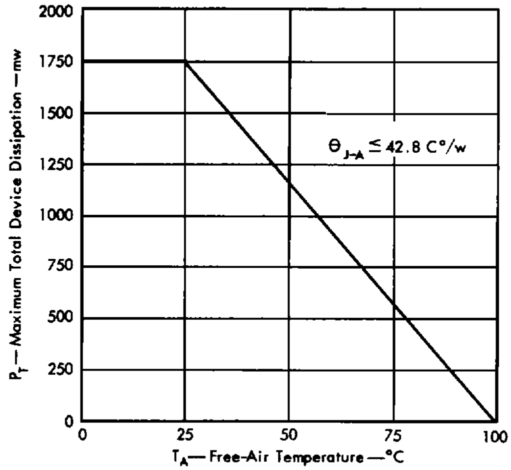

FIGURE 11

PEAK - POWER COEFFICIENT

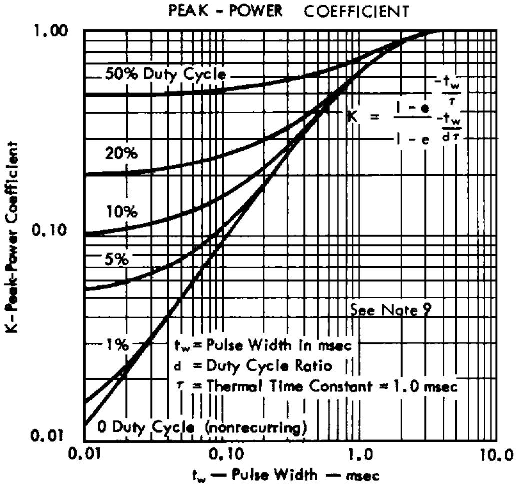

FIGURE 12

MAXIMUM SAFE CONTINUOUS
OPERATING REGION

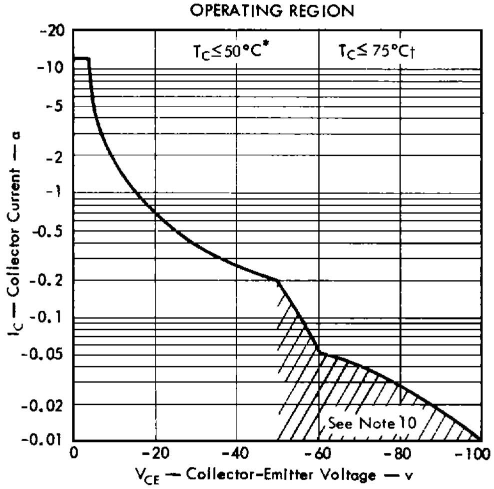

FIGURE 13

NOTES: 9. When $t_w > 3.0$ msec or $d > 0.5$ (50%), operation must be confined to the continuous operating region of Figure 13.
10. Operation in this region is permissible when base-emitter resistance $R_{BE} \leq 5\,\Omega$

*Indicates JEDEC registered data. †Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

THERMAL INFORMATION

TABLE I

HEAT SINK Type	HEAT SINK Dimensions	†θ_{HS-A}
Bright Copper	4" x 4" x 1/8"	3.8 C°/w
	6" x 6" x 1/8"	2.2 C°/w
	8" x 8" x 1/8"	1.8 C°/w
	10" x 10" x 1/8"	1.4 C°/w
Bright Aluminum	4" x 4" x 1/8"	6.5 C°/w
	6" x 6" x 1/8"	4.5 C°/w
	8" x 8" x 1/8"	3.5 C°/w
	10" x 10" x 1/8"	2.8 C°/w
Delbert Blinn #113 or Modine 1E1155B, Unfinished (or Equivalents)		3.7 C°/w
Delbert Blinn #113 or Modine 1E1155B, Black Anodized (or Equivalents)		3.2 C°/w

†θ_{HS-A} are typical values based on convection cooling; plates and fins mounted in vertical position.

‡All transistors mounted in the center of the heat sink with two 6-32 screws at 6 inch-pounds of torque.

TABLE II

SYMBOL	DEFINITION	UNIT	VALUE
$P_{T(avg)}$	Average Power Dissipation	w	
$P_{T(max)}$	Peak Power Dissipation	w	
θ_{J-C}	Junction-to-Case Thermal Resistance	C°/w	0.5
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	C°/w	42.8
θ_{C-A}	Case-to-Free-Air Thermal Resistance	C°/w	42.3
‡θ_{C-HS}	Case-to-Heat-Sink Thermal Resistance Typical with Dry Mounting Base	C°/w	0.65
	Typical with DC-11 Silicone Grease		0.45
θ_{HS-A}	Heat-Sink-to-Free-Air Thermal Resistance	C°/w	see Table 1
T_A	Free-Air Temperature	°C	
$T_{J(avg)}$	Average Junction Temperature	°C	≤100
$T_{J(max)}$	Peak Junction Temperature	°C	≤100
T_C	Case Temperature	°C	
K	Peak-Power Coefficient		see Fig. 12
t_w	Pulse Width	msec	
t_p	Pulse Period	msec	
d	Duty Cycle Ratio (t_w/t_p)		

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For d-c operation these transistors are voltage limited as well as thermally limited. Figure 10 or 11 and Figure 13 are recommended as a guide for selecting safe voltage and current combinations.

These transistors have a very low thermal resistance that may be fully utilized in a pulse-power application provided the pulse width is equal to (or less than) 3 milliseconds. If the power pulse is longer than 3 milliseconds, then the operating path is limited to the safe operating region described by Figure 10 or 11 and Figure 13.

The PEAK-POWER-COEFFICIENT CURVE shows the ratio of maximum instantaneous junction-to-case temperature rise for any pulse width and duty cycle to the rise which occurs at 100% duty cycle. Use of this curve is best explained by the equations and example below. See Table II for a definition of terms.

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

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

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

$$P_{T(avg)} = \frac{T_{J(avg)} - T_A}{\theta_{J-A}}$$

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

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

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

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

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

OPERATING CONDITIONS:

Heat Sink = 8" x 8" x 1/8" copper,

$\theta_{HS-A} = 1.8$ C°/w

with DC-11 grease, $\theta_{C-HS} = 0.45$ C°/w

$T_{J(max)}$ (design limit) = 100°C

$T_A = 35$°C

d = 20% (0.2)

$t_w = 0.1$ msec

SOLUTION:

From Figure 12, Peak-Power Coefficient,

K = 0.24, and by use of equation No. 3

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

$$P_{T(max)} = \frac{100 - 35}{0.2\,(0.45 + 1.8) + 0.24\,(0.5)} = 114 \text{ w}$$

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