N-P-N TRIPLE-DIFFUSED PLANAR SILICON POWER TRANSISTORS

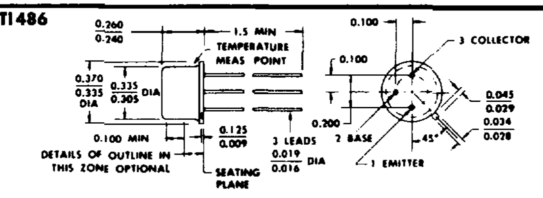
TYPES TI 486, TI 487
BULLETIN NO. DL-S 6910496, JANUARY 1969

HIGH-FREQUENCY INTERMEDIATE-POWER TRANSISTORS

- **15 Watts at 100°C Case Temperature**
- **Typ $V_{CE(sat)}$ of 0.2 V at 200 mA**
- **Typ V_{BE} of 0.8 V at 200 mA**
- **Typ f_T of 50 MHz at 10 V, 100 mA**

mechanical data

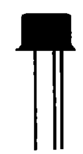
TI486



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

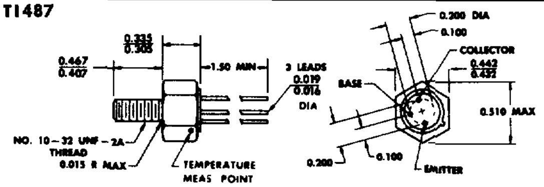
ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



CASE TEMPERATURE IS MEASURED 0.144 INCH ± 0.010 INCH DOWN FROM TOP OF CAN.

TI487



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

POSITION OF THE LEADS IN RELATION TO THE HEX IS NOT CONTROLLED

MAXIMUM RECOMMENDED MOUNTING TORQUE: 15 IN.-LB.

DIMENSIONS ARE IN INCHES

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

	TI486	TI487
Collector-Base Voltage	← 80 V →	
Collector-Emitter Voltage (See Note 1)	← 60 V →	
Emitter-Base Voltage	← 6 V →	
Continuous Collector Current	← 1 A →	
Peak Collector Current (See Note 2)	← 1.5 A →	
Safe Operating Region at (or below) 100°C Case Temperature	See Figure 8	
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	← 15 W →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	1 W	2 W
Operating Case Temperature Range	← −65°C to 200°C →	
Storage Temperature Range	← −65°C to 200°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 150 mW/deg.
4. Derate linearly to 200°C free-air temperature at the rate of 5.7 mW/deg for the TI 486 and 11.4 mW/deg for the TI487.

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	80			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 5	60			V
I_{CES}	Collector Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = 0$			3	μA
		$V_{CE} = 60$ V, $V_{BE} = 0$, $T_C = 150°C$			300	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 6$ V, $I_C = 0$			20	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 200$ mA, See Notes 5 and 6	20		80	
V_{BE}	Base-Emitter Voltage	$I_B = 20$ mA, $I_C = 200$ mA, See Notes 5 and 6		0.8	2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 20$ mA, $I_C = 200$ mA, See Notes 5 and 6		0.2	2	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 100$ mA, f = 10 MHz		5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz		30		pF

5

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.

thermal characteristics

PARAMETER		TI486 MAX	TI487 MAX	UNIT
θ_{J-C}	Junction-to-Case Thermal Resistance	6.67	6.67	deg/W
θ_{J-A}	Junction-to-Free-Air Thermal Resistance	175	87.5	deg/W

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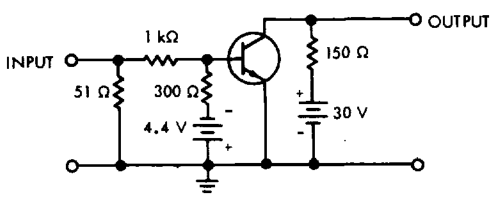
switching characteristics at 25°C case temperature

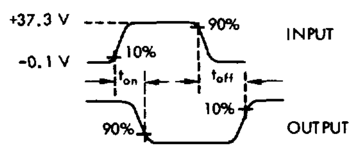
PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_{on} Turn-On Time	I_C = 200 mA, $I_{B(1)}$ = 20 mA, $I_{B(2)}$ = −20 mA,	0.14	μs
t_{off} Turn-Off Time	$V_{BE(off)}$ = −3.4 V, R_L = 150 Ω, See Figure 1	2.6	

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

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 Ω, t_p = 10 μs, duty cycle ≤ 2%.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.

c. Resistors must be noninductive types.

d. The d-c power supplies may require additional bypassing in order to minimize ringing.

TYPICAL CHARACTERISTICS

STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

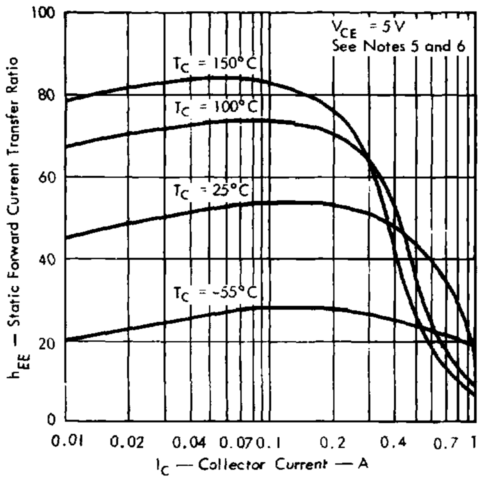


FIGURE 2

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

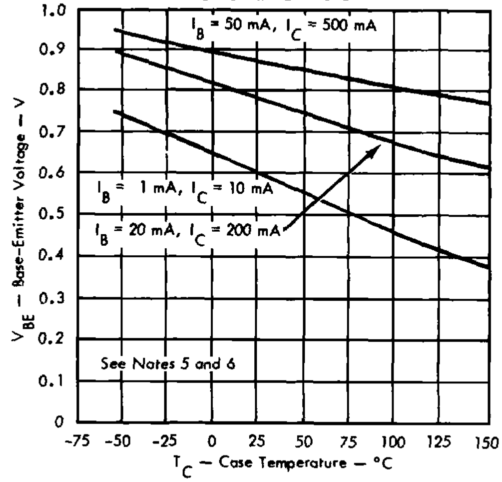


FIGURE 3

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

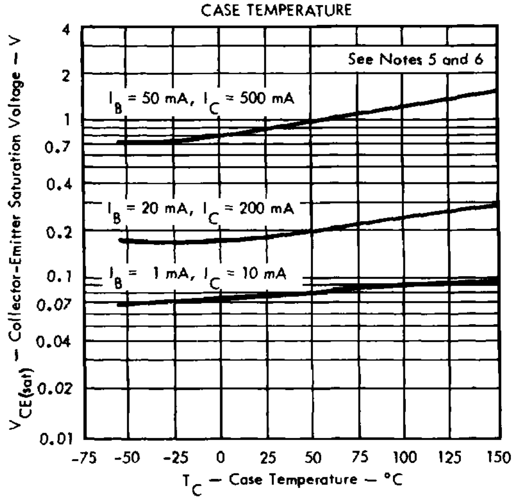


FIGURE 4

NORMALIZED COLLECTOR-EMITTER BREAKDOWN VOLTAGE
vs
BASE-EMITTER RESISTANCE

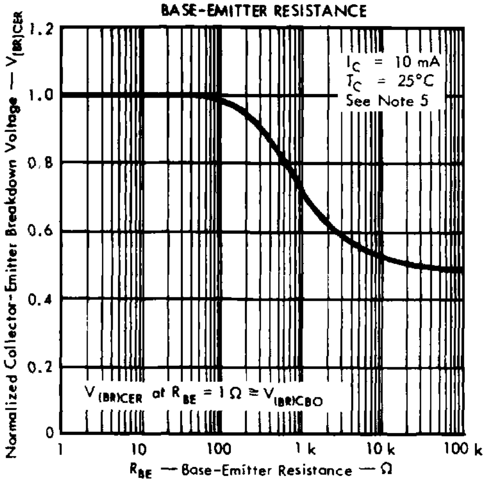


FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.

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

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TYPICAL CHARACTERISTICS

COMMON-BASE OPEN-CIRCUIT INPUT AND OUTPUT CAPACITANCE vs REVERSE BIAS VOLTAGE

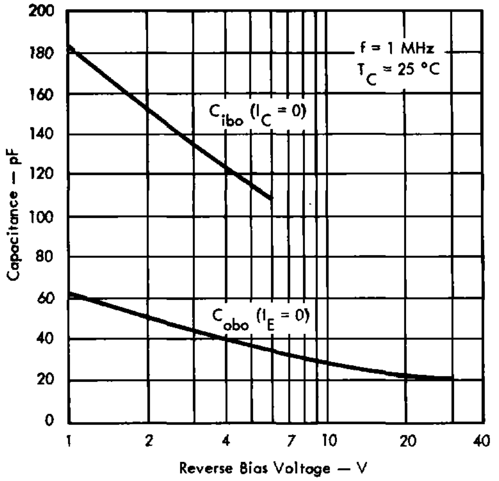

FIGURE 6

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO vs FREQUENCY

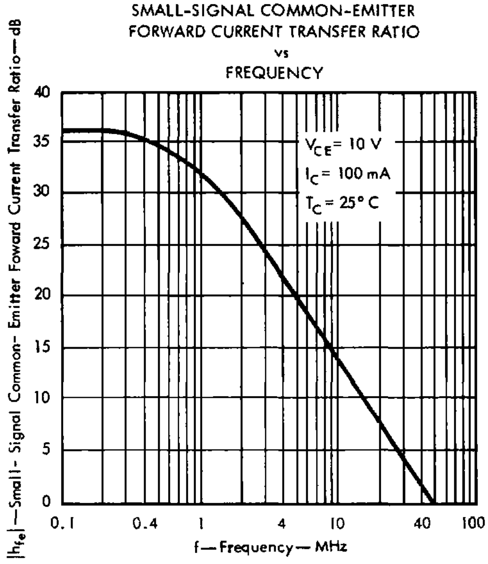

FIGURE 7

MAXIMUM SAFE OPERATING REGION

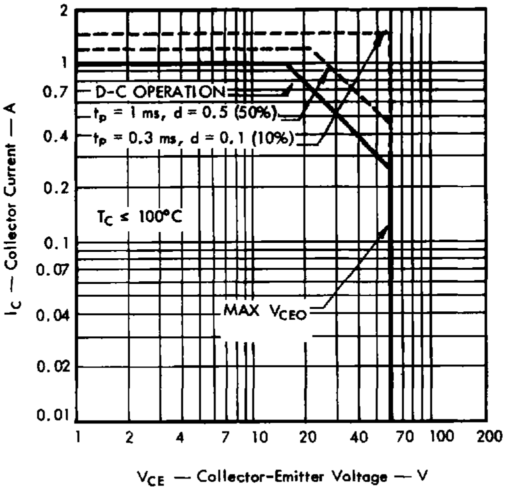

FIGURE 8

THERMAL INFORMATION

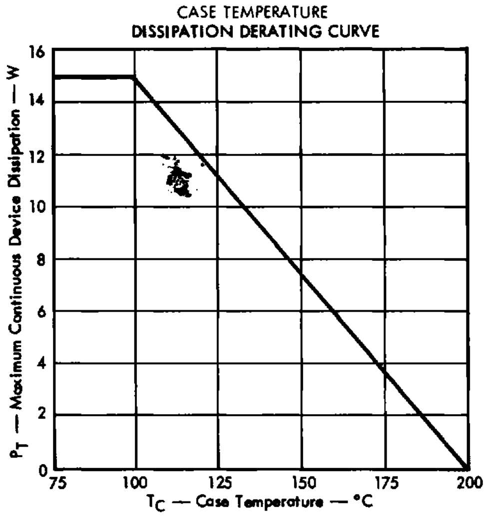

FIGURE 9

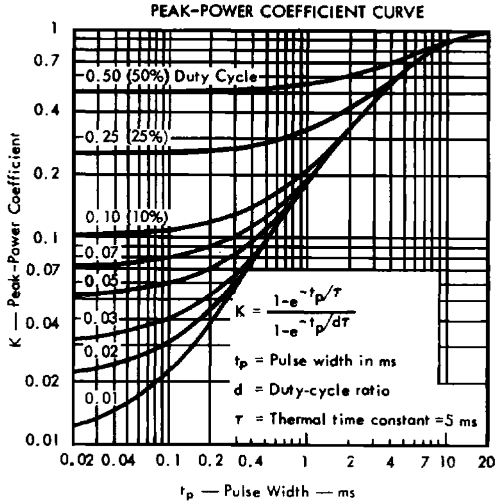

FIGURE 10

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE TI486	VALUE TI487	UNIT
$P_{T(av)}$	Average Power Dissipation			W
$P_{T(max)}$	Peak Power Dissipation			W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	175	87.5	deg/W
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	6.67	6.67	deg/W
$\theta_{C\text{-}A}$	Case-to-Free-Air Thermal Resistance	168	81	deg/W
$\theta_{C\text{-}HS}$	Case-to-Heat-Sink Thermal Resistance			deg/W
$\theta_{HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance			deg/W
T_A	Free-Air Temperature			°C
T_C	Case Temperature			°C
$T_{J(av)}$	Average Junction Temperature	$\leq$ 200		°C
$T_{J(max)}$	Peak Junction Temperature	$\leq$ 200		°C
K	Peak-Power Coefficient	See Figure 10		
t_p	Pulse Width			ms
t_x	Pulse Period			ms
d	Duty-Cycle Ratio (t_p/t_x)			

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

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 100°C \leq T_C \leq 200°C \text{ as in Figure 9}$$

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

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}A}} \quad \text{for } 25°C \leq T_A \leq 200°C$$

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

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

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

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

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

OPERATING CONDITIONS:

$\theta_{C\text{-}HS} + \theta_{HS\text{-}A} = 7$ deg/W (From information supplied with heat sink.)

$T_{J(av)}$ (design limit) $= 200°C$

$T_A = 50°C$

$d = 10\%$ (0.1)

$t_p = 0.1$ ms

Solution:

From Figure 10, Peak-Power Coefficient

K = 0.11 and by use of equation No. 3

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

$$P_{T(max)} = \frac{200 - 50}{0.1\,(7) + 0.11\,(6.67)} = 105 \text{ W}$$

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