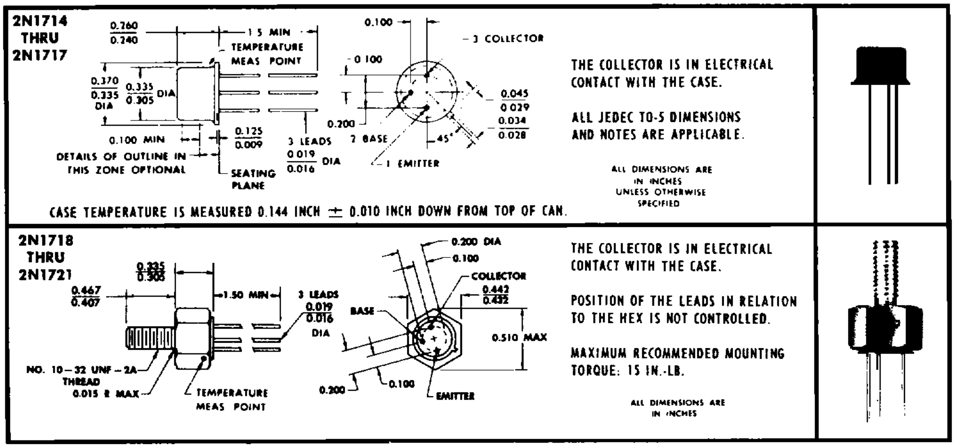
TYPES 2N1714 THRU 2N1721
N-P-N TRIPLE-DIFFUSED PLANAR SILICON POWER TRANSISTORS

TYPES 2N1714 THRU 2N1721
BULLETIN NO. DL-S 6810483, NOVEMBER 1968

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



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

	2N1714 2N1716	2N1715 2N1717	2N1718 2N1720	2N1719 2N1721
Collector-Base Voltage	90 V*	150 V*	90 V*	150 V*
Collector-Emitter Voltage (See Note 1)	60 V*	100 V*	60 V*	100 V*
Emitter-Base Voltage	← 6 V* →			
Continuous Collector Current	← {1 A†, 0.75 A*} →			
Peak Collector Current (See Note 2)	← {1.5 A†, 1 A*} →			
Continuous Emitter Current	← {1A†, 0.75 A*} →			
Safe Operating Region at (or below) 100°C Case Temperature	← See Figure 10 →			
Continuous Device Dissipation at (or below) 100°C Case Temperature (See Note 3)	← {15 W†, 10 W*} →			
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	← {1 W†, 0.8 W*} →		← 2 W* →	
Operating Collector Junction Temperature	← {200°C†, 175°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. For operation above 100°C case temperature refer to Dissipation Derating Curve, figure 13.
4. For operation above 25°C free-air temperature refer to Dissipation Derating Curves, figures 11 and 12.

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

TYPES 2N1714 THRU 2N1721
N-P-N TRIPLE-DIFFUSED PLANAR SILICON POWER TRANSISTORS

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

	PARAMETER	TEST CONDITIONS	2N1714 2N1718 MIN	2N1714 2N1718 MAX	2N1715 2N1719 MIN	2N1715 2N1719 MAX	2N1716 2N1720 MIN	2N1716 2N1720 MAX	2N1717 2N1721 MIN	2N1717 2N1721 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 5	60		100		60		100		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 3$ V, $I_E = 0$		1		1		1		1	μA
I_{CEO}	Collector Cutoff Current	$V_{CE} = 50$ V, $I_B = 0$		50				50			μA
		$V_{CE} = 90$ V, $I_B = 0$				50				50	
I_{CES}	Collector Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = 0$		2		2		2		2	μA
		$V_{CE} = 90$ V, $V_{BE} = 0$		50				50			
		$V_{CE} = 150$ V, $V_{BE} = 0$				50				50	
		$V_{CE} = 60$ V, $V_{BE} = 0$, $T_C = 170°C$		500		500		500		500	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V, $I_C = 0$		10		10		10		10	μA
		$V_{EB} = 6$ V, $I_C = 0$		10		10		10		10	
$V_{EB(fl)}$	Emitter-Base Floating Potential	$V_{CB} = 60$ V, $I_E = 0$		1				1			V
		$V_{CB} = 100$ V, $I_E = 0$				2				2	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 5	10		10		20		20		
		$V_{CE} = 5$ V, $I_C = 200$ mA, See Notes 5 and 6	20	60	20	60	40	120	40	120	
		$V_{CE} = 5$ V, $I_C = 200$ mA, See Notes 5 and 6, $T_C = -55°C$	10		10		20		20		
V_{BE}	Base-Emitter Voltage	$I_B = 20$ mA, $I_C = 200$ mA, See Notes 5 and 6		1.6		1.6		1.6		1.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 20$ mA, $I_C = 200$ mA, See Notes 5 and 6		2		2		2		2	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 100$ mA, $f = 16$ MHz	1		1		1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz		50		50		50		50	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300$ μs, duty cycle $\leq 2\%$.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

thermal characteristics

	PARAMETER	2N1714, 2N1715 2N1716, 2N1717 MAX	2N1718, 2N1719 2N1720, 2N1721 MAX	UNIT
$\theta_{J\text{-}C}$	Junction-to-Case Thermal Resistance	6.67† 7.5*	6.67† 7.5*	deg/W
$\theta_{J\text{-}A}$	Junction-to-Free-Air Thermal Resistance	175† 187.5*	75*	deg/W

*Indicates JEDEC registered data

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

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

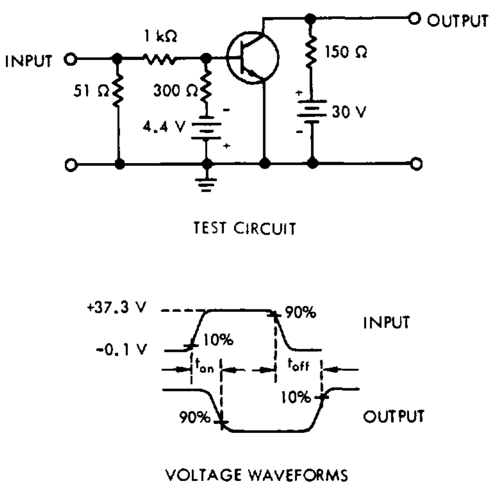


FIGURE 1

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

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 15$ ns, $R_{in} \ge 10\ M\Omega$, $C_{in} \le 11.5$ pF.

c. Resistors must be noninductive types.

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

TYPICAL CHARACTERISTICS

2N1714, 2N1715, 2N1718, 2N1719
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

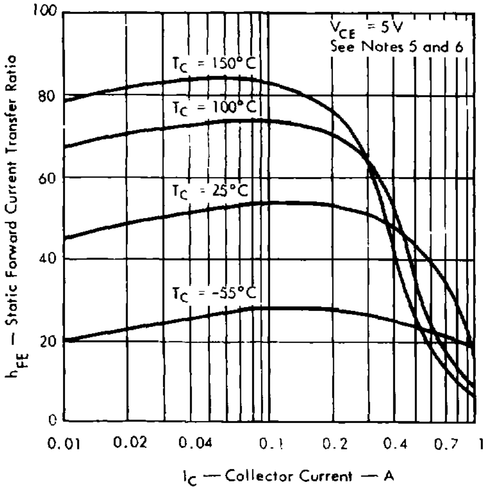


FIGURE 2

2N1716, 2N1717, 2N1720, 2N1721
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

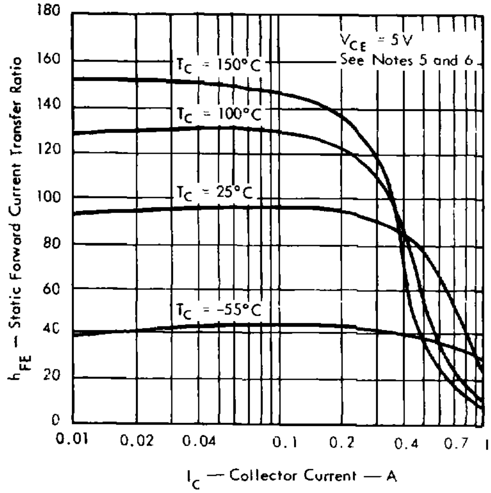


FIGURE 3

BASE-EMITTER VOLTAGE
vs
CASE TEMPERATURE

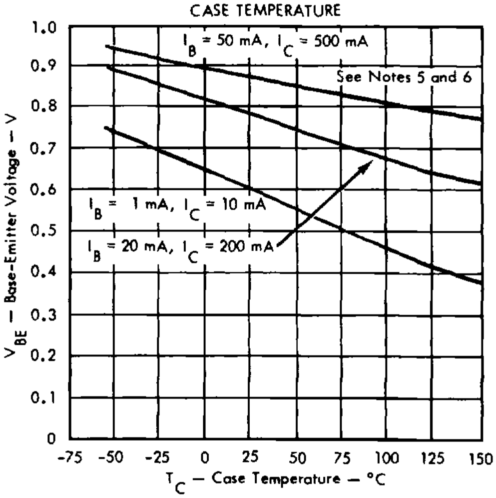


FIGURE 4

COLLECTOR-EMITTER SATURATION VOLTAGE
vs
CASE TEMPERATURE

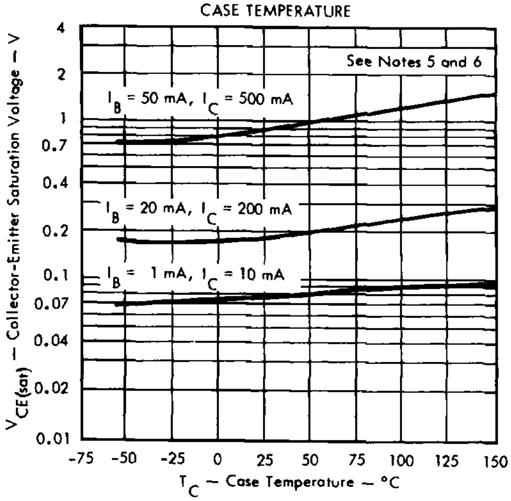


FIGURE 5

NOTES: 5. These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle $\leq$ 2%.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

TYPICAL CHARACTERISTICS

NORMALIZED COLLECTOR-EMITTER BREAKDOWN VOLTAGE
vs
BASE-EMITTER RESISTANCE

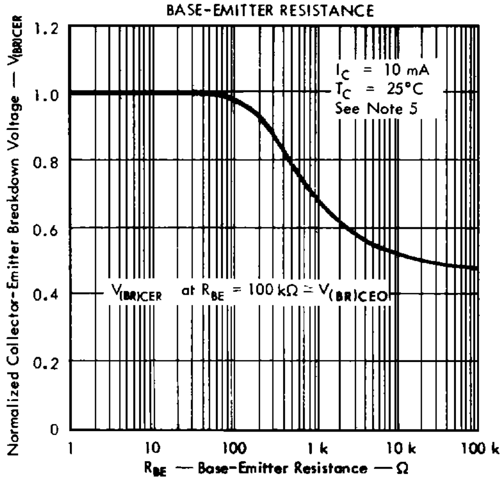


FIGURE 6

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

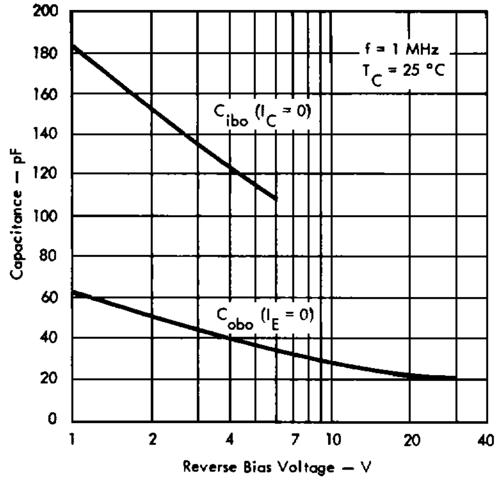


FIGURE 7

2N1714, 2N1715,
2N1718, 2N1719
SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
FREQUENCY

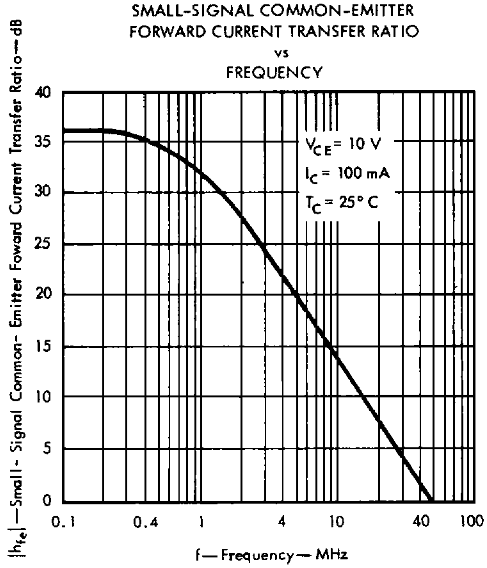


FIGURE 8

2N1716, 2N1717,
2N1720, 2N1721
SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
FREQUENCY

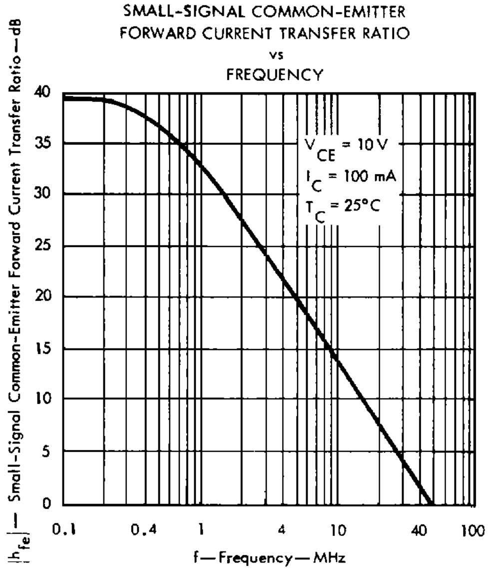


FIGURE 9

NOTE 5: This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5

MAXIMUM SAFE OPERATING REGION

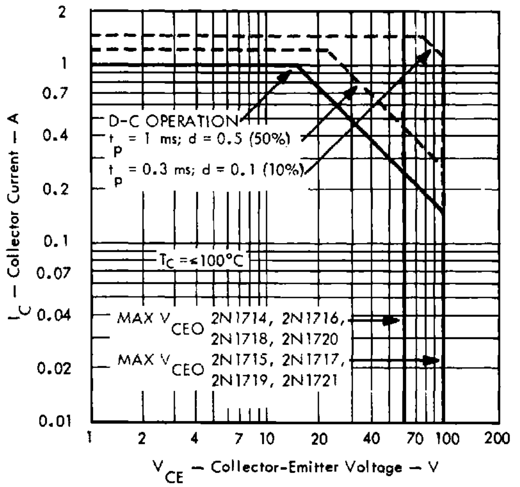


FIGURE 10

THERMAL INFORMATION

2N1714 THRU 2N1717
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

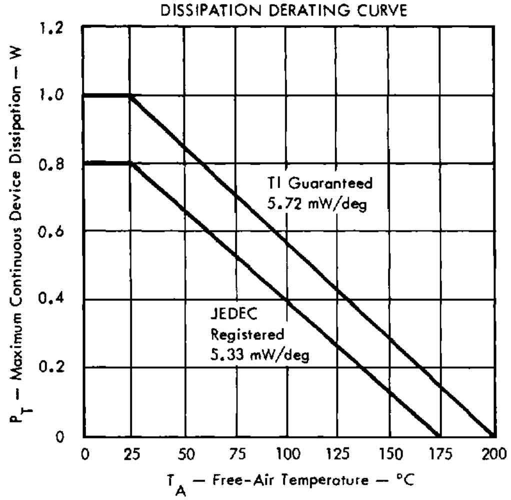


FIGURE 11

2N1718 THRU 2N1721
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

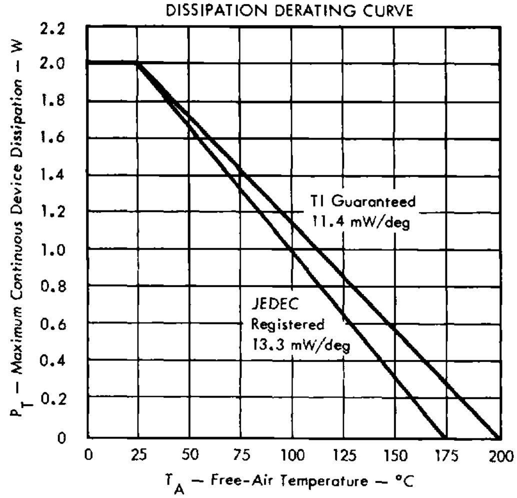


FIGURE 12

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THERMAL INFORMATION

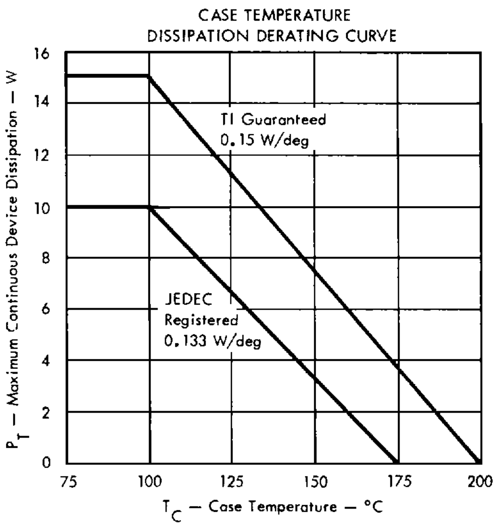

FIGURE 13

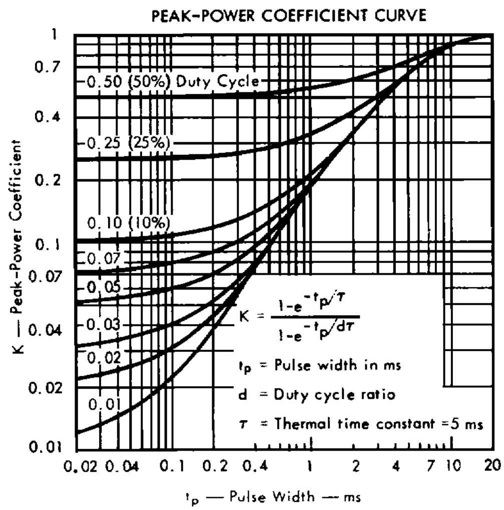

FIGURE 14

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE 2N1714 THRU 2N1717	VALUE 2N1718 THRU 2N1721	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	75	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	68	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	≤ 200		°C
$T_{J(max)}$	Peak Junction Temperature	≤ 200		°C
K	Peak-Power Coefficient	See Figure 14		
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.

$$P_{T(av)} = \frac{T_{J(av)} - T_A}{\theta_{J\text{-}C} + \theta_{C\text{-}HS} + \theta_{HS\text{-}A}} \quad \text{for } 100°C \leq T_C \leq 200°C \text{ as in Figure 13}$$

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 14, 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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