

The documentation and process conversion measures necessary to comply with this document shall be completed by 7 April 2025.

INCH-POUND

MIL-PRF-19500/534J
w/AMENDMENT 1
7 January 2025
SUPERSEDING
MIL-PRF-19500/534J
4 June 2019

PERFORMANCE SPECIFICATION SHEET

TRANSISTOR, NPN, SILICON, POWER, TYPES 2N5002 AND 2N5004,
ENCAPSULATED (CASE MOUNT PACKAGE) AND UNENCAPSULATED, RADIATION HARDNESS ASSURANCE,
QUALITY LEVELS JAN, JANTX, JANTXV, JANS, JANHC AND JANKC

This specification is approved for use by all Departments
and Agencies of the Department of Defense.

The requirements for acquiring the product described herein shall consist of
this specification sheet and [MIL-PRF-19500](#).

1. SCOPE

* 1.1 Scope. This specification covers the performance requirements for NPN, silicon, power transistors for use in high-speed power-switching applications. Four levels of product assurance (JAN, JANTX, JANTXV, and JANS) are provided for each encapsulated device type as specified in [MIL-PRF-19500](#). Two levels of product assurance (JANHC and JANKC) for each unencapsulated device type die. RHA level designators "M", "D", "P", "L", "R", "F", "G" and "H" are appended to the device prefix to identify devices, which have passed RHA requirements.

1.2 Physical dimensions.

1.2.1 Package outlines. The device package outline is a TO-210AA (formerly TO-59) in accordance with [figure 1](#) for all encapsulated device types.

1.2.2 Unencapsulated die. The dimensions and topography for JANHC and JANKC unencapsulated die are in accordance with [figure 2](#).

1.3 Maximum ratings. Unless otherwise specified $T_A = +25^{\circ}\text{C}$.

P_T (1) $T_A = 25^{\circ}\text{C}$	P_T (2) $T_C = 25^{\circ}\text{C}$	$R_{\theta JA}$	$R_{\theta JC}$ (3)	V_{CBO}	V_{CEO}	V_{EBO}	I_C	I_C (4)	Reverse pulse energy (5)	T_{stg} and T_J
<u>W</u>	<u>W</u>	<u>$^{\circ}\text{C/W}$</u>	<u>$^{\circ}\text{C/W}$</u>	<u>V dc</u>	<u>V dc</u>	<u>V dc</u>	<u>A dc</u>	<u>A dc</u>	<u>mJ</u>	<u>$^{\circ}\text{C}$</u>
2	58	88	3	100	80	5.5	5	10	15	-65 to +200

- (1) Derate linearly 11.4 mW/ $^{\circ}\text{C}$ for $T_A > 25^{\circ}\text{C}$.
- (2) For derating see [figure 3](#).
- (3) For thermal impedance see [figure 4](#).
- (4) This value applies for $P_w \leq 8.3$ ms, duty cycle ≤ 1 percent.
- (5) This rating is based on the capability of the transistors to operate safely in the unclamped inductive load energy test circuit [figure 5](#) herein.

Comments, suggestions, or questions on this document should be addressed to DLA Land and Maritime, ATTN: VAC, P.O. Box 3990, Columbus, OH 43218-3990, or emailed to Semiconductor@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

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1.4 Primary electrical characteristics. Unless otherwise specified $T_C = +25^\circ\text{C}$.

Limits	h_{FE2} (1) $V_{CE} = 5\text{ V}$ $I_C = 2.5\text{ A}$		$ h_{fe} $ $V_{CE} = 5\text{ V}$ $I_C = 500\text{ mA dc}$ $f = 10\text{ MHz}$		$V_{BE(sat)2}$ (1) $I_C = 5\text{ A dc}$ $I_B = 500\text{ mA dc}$	$V_{CE(sat)2}$ (1) $I_C = 5\text{ A dc}$ $I_B = 500\text{ mA dc}$	C_{obo} $V_{CB} = 10\text{ V dc}$ $I_E = 0$ $f = 1\text{ MHz}$
	2N5002	2N5004	2N5002	2N5004			
Min	30	70	6	7	<u>V dc</u>	<u>V dc</u>	<u>pF</u>
Max	90	200			2.2	1.5	250

(1) Pulsed (see 4.5.1).

1.5 Part or Identifying Number (PIN). The PIN is in accordance with MIL-PRF-19500, and as specified herein. See 6.4 for PIN construction example and 6.5 for a list of available PINs.

1.5.1 JAN brand and quality level designators for encapsulated devices. The quality level designators for encapsulated devices that are applicable for this specification sheet from the lowest to the highest level are follows: "JAN", "JANTX", "JANTXV" and "JANS".

1.5.2 Quality level designators for unencapsulated devices (die). The quality level designators for unencapsulated devices (die) that are applicable for this specification sheet from the lowest to the highest level are "JANHC" and "JANKC".

* 1.5.3 Radiation hardness assurance (RHA) designator. The RHA levels that are applicable for this specification sheet from lowest to highest are as follows: "M", "D", "P", "L", "R", "F", "G", and "H".

1.5.4 Device type. The designation system for the device types of transistors covered by this specification sheet are as follows.

1.5.4.1 First number and first letter symbols. The transistors of this specification sheet are identified by the first number and letter symbols "2N".

1.5.4.2 Second number symbols. The second number symbols for the transistor covered by this specification sheet are as follows: "5002" and "5004".

1.5.5 Die identifiers for unencapsulated devices. The manufacturer and critical interface die identifiers that are applicable for this specification sheet is "B" (see figure 2 and 6.4.2).

1.5.6 Lead finish. The lead finishes applicable to this specification sheet are listed on QML-19500.

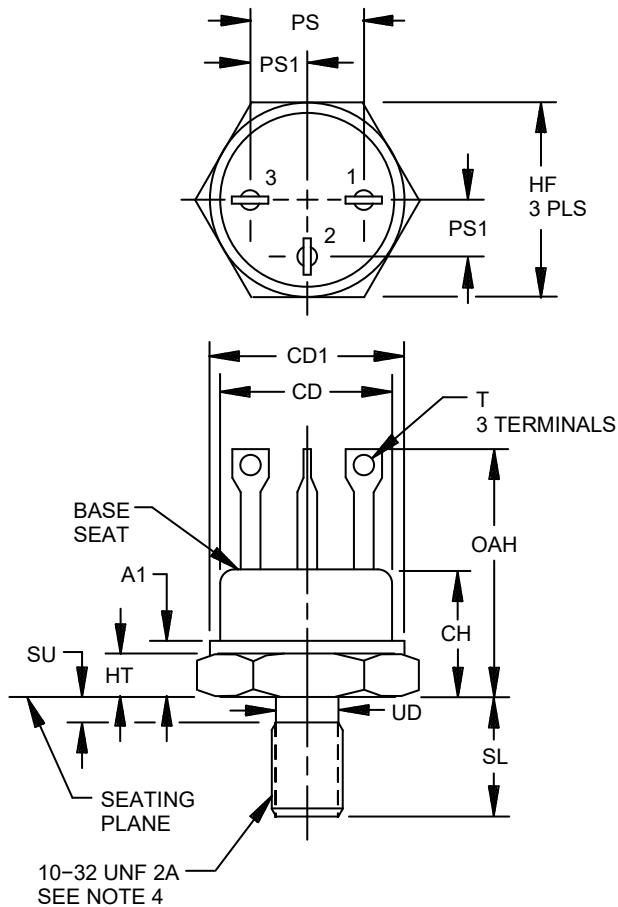
* 1.6 Radiation features. The following radiation features are applicable for RHA devices supplied to this specification sheet.

* 1.6.1 Maximum total ionizing dose (TID). The maximum TID that RHA devices were tested to in accordance with condition A (dose rate = 50 to 300 rad(Si)/s) of method 1019 of MIL-STD-750 are as follows:

For device type 2N5002, 2N5004: 300 Krad(Si) 1/

* 1/ The manufacturers supplying these device types have performed characterization testing in accordance with condition A (dose rate = 50 to 300 rad(Si)/s) of method 1019 of MIL-STD-750. The radiation end point limits are guaranteed only to a maximum TID level of 300 Krad(Si).

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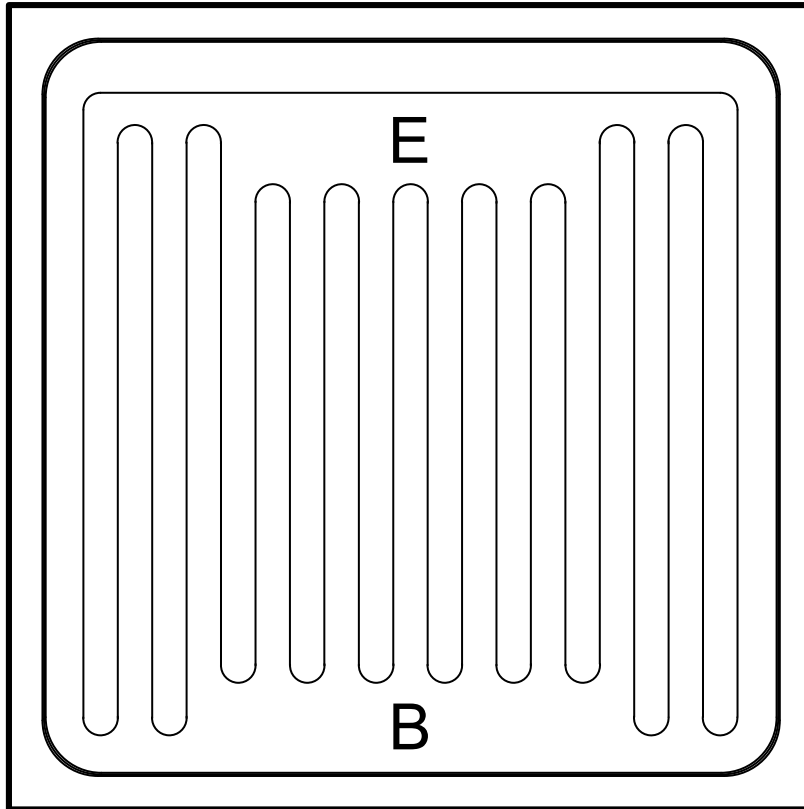
Ltr	Dimension				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
A1		.250		6.35	
CD	.330	.360	8.38	9.14	
CD1	.370	.437	9.40	11.10	
CH	.320	.468	8.13	11.89	
HF	.424	.437	10.77	11.10	
HT	.090	.150	2.29	3.81	
OAH	.575	.763	14.61	19.38	5
PS	.185	.215	4.70	5.46	6, 7, 8
PS1	.090	.110	2.29	2.79	6, 7, 8
SL	.400	.455	10.16	11.56	
SU		.078		1.98	9
T	.040	.065	1.02	1.65	
UD	.155	.189	3.94	4.80	

NOTES:

1. Dimensions are in inches. Millimeters are given for general information only.
2. Terminal 1 is emitter, terminal 2 is base, and terminal 3 is collector. The collector terminal shall be isolated from the case.
3. The case temperature may be measured anywhere on the seating plane within .125 inch (3.18 mm) of the stud.
4. Threads shall be 10-32 UNF-2A in accordance with FED-STD-H28. Maximum pitch diameter of plated threads shall be basic pitch diameter .1697 inch (4.31 mm).
5. All three terminals.
6. The angular orientation of the terminals in relation to the hex flats is not controlled.
7. This dimension applies to the location of the center line of the terminals.
8. Terminal spacing measured at the base seat only.
9. Maximum unthreaded dimension.

* FIGURE 1. Physical dimensions of TO-210AA (device types 2N5002 and 2N5004).

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NOTES:

1. Dimensions are in inches. Millimeters are given for general information only.
2. Unless otherwise specified, tolerance is ± 0.005 (0.13 mm).
3. The physical characteristics of the die are as follow:
 - a. Die size .120 inch (3.05 mm) x .120 inch (3.05 mm) ± 0.002 inch (± 0.05 mm).
 - b. Die thickness .014 inch (0.35 mm) ± 0.0015 inch nominal (± 0.04 mm).
 - c. Base pad (B): .060 x .012 inch (1.5 mm x 0.30 mm).
 - d. Emitter pad (E) .050 x .012 inch (1.27 mm x 0.30 mm).
 - e. Collector Backside.
 - f. Back metal Gold 6,000Å minimum, 8,000Å nominal.
 - g. Top metal Aluminum, 54,000Å minimum, 60,000Å nominal.

FIGURE 2. Physical dimensions of JANHC and JANKC (B-version) die.

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-19500 – Semiconductor Devices, General Specification for.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-750 – Test Methods For Semiconductor Devices.

* (Copies of these documents are available online at <https://quicksearch.dla.mil>).

2.3 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The individual item requirements shall be as specified in MIL-PRF-19500 and as modified herein.

3.2 Qualification. Devices furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.2 and 6.3).

3.3 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-PRF-19500.

3.4 Interface and physical dimensions. Interface and physical dimensions shall be as specified in MIL-PRF-19500, and on figures 1 and 2.

3.4.1 Lead finish. Lead finish shall be solderable in accordance with MIL-PRF-19500, MIL-STD-750, and herein. Where a choice of lead finish is desired, it shall be specified in the acquisition document (see 6.2).

3.5 Marking. Marking shall be in accordance with MIL-PRF-19500. The RHA designator (see 1.5.3) shall immediately precede (or replace) the device "2N" identifier (depending upon degree of abbreviation required).

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3.6 Electrical performance characteristics. Unless otherwise specified herein, the electrical performance characteristics shall be as specified in 1.3, 1.4, and table I.

3.7 Electrical test requirements. The electrical test requirements shall be as specified in table I herein.

3.8 RHA. RHA requirements and test levels shall be as defined in MIL-PRF-19500.

3.9 Workmanship. Semiconductor devices shall be processed in such a manner as to be uniform in quality and shall be free from other defects that will affect life, serviceability, or appearance.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

- a. Qualification inspection (see 4.2).
- b. Screening (see 4.3).
- c. Conformance inspection (see 4.4 and tables I and II).
- d. Element evaluation (see 4.6).

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-PRF-19500 and as specified herein.

4.2.1 JANHC and JANKC qualification. JANHC and JANKC qualification inspection shall be in accordance with MIL-PRF-19500.

4.2.2 Group E qualification. Group E inspection shall be performed for qualification or re-qualification only. In case qualification was awarded to a prior revision of the specification sheet that did not request the performance of table III tests, the tests specified in table III herein that were not performed in the prior revision shall be performed on the first inspection lot of this revision to maintain qualification.

* 4.3 Screening of quality levels JANTX and JANTXV and JANS. Screening of packaged devices shall be in accordance with table E-IV of MIL-PRF-19500 and as specified herein. The following measurements shall be made in accordance with table I herein. Devices that exceed the limits of table I herein shall not be acceptable.

Screen	Measurements for JANS level	Measurements for JANTX and JANTXV levels
(1) 3c	Thermal impedance (see 4.3.2)	Thermal impedance (see 4.3.2)
9	I_{CES1} and h_{FE2}	Not applicable
11	I_{CES1} and h_{FE2} $\Delta I_{CES1} = 100$ percent or 100 nA, whichever is greater; $\Delta h_{FE2} = \pm 20$ percent	I_{CES1} and h_{FE2}
12	See 4.3.1	See 4.3.1
13	Subgroups 2 and 3 of table I herein; $\Delta I_{CES1} = +100$ percent of initial value or 100 nA, whichever is greater. $\Delta h_{FE2} = \pm 20$ percent	Subgroup 2 of table I herein; $\Delta I_{CES1} = +100$ percent of initial value or 100 nA, whichever is greater. $\Delta h_{FE2} = \pm 20$ percent

- (1) Shall be performed anytime after temperature cycling, screen 3a; JANTX and JANTXV do not need to be repeated in screening requirements.

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4.3.1 Power burn-in conditions. Power burn-in conditions shall be as follows: $V_{CB} = 10 - 30$ V dc. Power shall be applied to achieve $T_J = +175^\circ\text{C}$ minimum using a minimum $P_D = 75$ percent of P_T maximum, T_A ambient rated as defined in 1.3. $T_A \leq 35^\circ\text{C}$. With approval of the qualifying activity and preparing activity, alternate burn-in criteria (hours, bias conditions, T_J , and mounting conditions) may be used for JANTX and JANTXV quality levels. A justification demonstrating equivalence is required. In addition, the manufacturing site's burn-in data and performance history will be essential criteria for burn-in modification approval. Use method 3100 of MIL-STD-750 to measure T_J . NOTE: No heat sink or forced air cooling on the device shall be permitted.

4.3.2 Thermal impedance. The thermal impedance measurements shall be performed in accordance with method 3131 of MIL-STD-750 using the guidelines in that method for determining I_M , I_H , t_H , t_{MD} , t_{SW} (V_C and V_H where appropriate). The thermal impedance limit used in screen 3c of 4.3 and the subgroup 2 of table I herein shall comply with the thermal impedance graph in figure 4 (less than or equal to the curve value at the same t_H time) and shall be less than the process determined statistical maximum limit as outlined in method 3131. See table III, subgroup 4 herein.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500 and as specified herein. If the alternate procedure for screening is being performed in accordance with MIL-PRF-19500, a sample of screened devices shall be submitted to and pass the requirements of table I, subgroups 1 and 2 herein. The inspections of table E-VIB, subgroup 1 are not required to be performed again if group B has already been satisfied in accordance with 4.4.2.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with table E-V of MIL-PRF-19500 and table I herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with 4.4.2.1 for quality level JANS and 4.4.2.2 for quality levels JAN, JANTX, and JANTXV. Delta electrical measurements shall be in accordance with the steps of 4.7 herein.

4.4.2.1 Quality level JANS. Group B inspection for quality level JANS shall be conducted in accordance with the conditions specified for subgroup testing in table E-VIA of MIL-PRF-19500 and herein. For JANS, samples shall be selected from each inspection lot. See MIL-PRF-19500.

<u>Subgroup</u>	<u>Method</u>	<u>Condition</u>
B4	1037	$V_{CB} = 10$ V dc minimum, $P_T = 2.5$ W minimum, $T_A = +25^\circ\text{C} \pm 3^\circ\text{C}$; No heat sink or forced-air cooling on devices shall be permitted.
B5	1027	$V_{CB} = 20$ V dc, $T_J = +275^\circ\text{C}$ minimum for 96 hours; adjust the chosen T_A and P_T to give an average lot $T_J = +275^\circ\text{C}$. Marking legibility requirements shall not apply.
B6	3131	$R_{\theta JA}$ and $R_{\theta JC}$ only, as applicable (see 1.3) and in accordance with thermal impedance curves.

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4.4.2.2 Quality levels JAN, JANTX, and JANTXV. Group B inspection for quality levels JAN, JANTX, and JANTXV shall be conducted in accordance with the conditions specified in table E-VIC (small die flow) of [MIL-PRF-19500](#) and herein.

<u>Step</u>	<u>Method</u>	<u>Condition</u>
1	1026	Steady-state life: 1,000 hours minimum, $V_{CB} = 10$ V dc, power shall be applied to achieve $T_J = +150^\circ\text{C}$ minimum using a minimum of $P_D = 75$ percent of maximum rated P_T as defined in 1.3 . $n = 45$ devices, $c = 0$. The sample size may be increased and the test time decreased as long as the devices are stressed for a total of 45,000 device hours minimum, and the actual time of test is at least 340 hours.
2	1048	Blocking life, $T_A = +150^\circ\text{C}$, $V_{CB} = 80$ percent of rated voltage, 48 hours minimum. $n = 45$ devices, $c = 0$.
3	1032	High-temperature life (non-operating), $t = 340$ hours, $T_A = +200^\circ\text{C}$. $n = 22$, $c = 0$.

4.4.2.2.1 Group B sample selection. Samples selected for small die flow group B inspection shall be in accordance with all of the following requirements:

- Samples shall be chosen from an inspection lot that has been submitted to and passed [table I](#), subgroup 2 conformance inspection. See [MIL-PRF-19500](#).
- When the final lead finish is solder or any plating prone to oxidation at high temperature, the samples for life test may be selected prior to the application of final lead finish.
- Separate samples may be used for each step.

4.4.2.2.2 Failures. In the event of a lot failure, the resubmission requirements of [MIL-PRF-19500](#) shall apply. All catastrophic failures during small die flow group B inspection shall be analyzed to the extent possible to identify root cause and corrective action. Whenever a failure is identified as wafer lot or wafer processing related, the entire wafer lot and related devices assembled from the wafer lot shall be rejected unless an appropriate corrective action to eliminate the failure mode has been implemented and the devices from the wafer lot are screened to eliminate the failure mode.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the tests and conditions specified for subgroup testing in table E-VII of [MIL-PRF-19500](#) and in [4.4.3.1](#) (JANS) and [4.4.3.2](#) (JAN, JANTX, and JANTXV) herein. Delta electrical measurements shall be in accordance with the steps of [4.7](#) herein.

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4.4.3.1 Quality level JANS.

<u>Subgroup</u>	<u>Method</u>	<u>Condition</u>
C2	2036	Tension: Test condition A, weight = 7 pounds, ± 5 ounces (3.2 $\pm$ 0.16 kg), application time = 15 s. Terminal torque: Test condition D1, torque = 6 inch-ounce (42.4 mN-m), application time = 15 s. Stud torque: Test condition D2, torque = 15 inch-pounds (1.7 N-m), application time = 15 s.
C5	3131	R _{θJA} and R _{θJC} only, as applicable (see 1.3) and in accordance with thermal impedance curves.
C6	1026	1,000 hours at V _{CB} = 10 V dc; power shall be applied to achieve T _J = +175°C minimum and a minimum of P _D = 75 percent of maximum rated P _T as defined in 1.3 n = 45, c = 0. The sample size may be increased and the test time decreased as long as the devices are stressed for a total of 45,000 device hours minimum, and the actual time of test is at least 340 hours.

4.4.3.2 Quality levels JAN, JANTX, and JANTXV.

<u>Subgroup</u>	<u>Method</u>	<u>Condition</u>
C2	2036	Tension: Test condition A, weight = 7 pounds, ± 5 ounces (3.2 $\pm$ 0.16 kg), application time = 15 s. Terminal torque: Test condition D1, torque = 6 inch-ounce (42.4 mN-m), application time = 15 s. Stud torque: Test condition D2, torque = 15 inch-pounds (1.7 N-m), application time = 15 s.
C5	3131	R _{θJA} and R _{θJC} only, as applicable (see 1.3) and in accordance with thermal impedance curves.
C6		Not applicable.

4.4.3.3 Group C sample selection. Samples for subgroups in group C shall be chosen at random from any inspection lot containing the intended package type and lead finish procured to the same specification which is submitted to and passes [table I](#) tests herein for conformance inspection. When the final lead finish is solder or any plating prone to oxidation at high temperature, the samples for C6 life test may be pulled prior to the application of final lead finish. Testing of a subgroup using a single device type enclosed in the intended package type shall be considered as complying with the requirements for that subgroup.

4.4.4 Group D inspection. Conformance inspection for hardness assured JANS and JANKC types shall include the group D tests specified in [table II](#) herein. These tests shall be performed as required in accordance with [MIL-PRF-19500](#) and method 1019 of [MIL-STD-750](#), for total ionizing dose or method 1017 of [MIL-STD-750](#) for neutron fluence as applicable (see 6.2 herein), except group D, subgroup 2 may be performed separate from other subgroups. Alternate package options may also be substituted for the testing provided there is no adverse effects to the fluence profile.

4.4.5 Group E inspection. Group E inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-IX of [MIL-PRF-19500](#) and as specified in [table III](#) herein. Delta electrical measurements shall be in accordance with the applicable steps of 4.7.

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4.5 Method of inspection. Methods of inspection shall be as specified in the appropriate tables and as follows.

4.5.1 Pulse measurements. Conditions for pulse measurement shall be as specified in section 4 of [MIL-STD-750](#).

4.5.2 Inspection conditions. Unless otherwise specified herein, all inspections shall be conducted at a case temperature (T_c) of +25°C.

4.6 Element evaluation of unencapsulated die (quality levels JANHC and JANKC). The element evaluation of unencapsulated die shall be in accordance with appendix G of [MIL-PRF-19500](#). For subgroup 4, the burn-in duration for the JANKC level shall follow the JANS requirements and the JANHC level shall follow the JANTX requirements.

4.7 Delta electrical measurements. Delta electrical measurements shall be as specified below: (1) (2) (3) (4) (5) (6)

Steps	Inspection	MIL-STD-750		Symbol	Limit	Limit	Unit
		Method	Conditions		Min	Max	
1.	Collector to emitter cutoff current	3041	Bias condition C, V _{CE} = 60 V dc	ΔI _{CES1}	100 percent of initial value or 100 nA, whichever is greater.		
2.	Forward - current transfer ratio	3076	I _C = 2.5 A dc V _{CE} = 5 V dc, pulsed (see 4.5.1)	Δh _{FE2}	±20 percent change from initial reading		

(1) See [MIL-PRF-19500](#) for sampling plan.

(2) Devices which exceed the [table I](#) limits for this test shall not be accepted.

(3) The delta electrical measurements for group B for quality level JANS are as follows:

a. Subgroup 3, steps 1 and 2.

b. Subgroup 4, steps 1 and 2.

(4) The delta electrical measurements for group B for quality levels JAN, JANTX, and JANTXV are as follows:
After each step in [4.4.2.2](#), steps 1 and 2.

(5) The delta electrical measurements for group C for all quality levels are as follows: Subgroup 6, steps 1 and 2.

(6) The delta electrical measurements for group E for all quality levels are as follows: Subgroups 1 and 2, steps 1 and 2.

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TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 1</u> 2/						
Visual and mechanical examination 3/	2071					
Solderability 3/ 4/	2026	n = 15 leads, c = 0				
Resistance to solvents 3/ 4/ 5/	1022	n = 15 devices, c = 0				
Salt atmosphere (corrosion) 4/ 6/		n = 6 devices, c = 0				
Temperature cycling 3/ 4/	1051	Test condition C, 25 cycles. n = 22 devices, c = 0				
Hermetic seal 4/ 7/ Fine leak Gross leak	1071	n = 22 devices, c = 0				
Electrical measurements 4/		Table I , subgroup 2				
Bond strength 3/ 4/	2037	Precondition T _A = +250°C at t = 24 hours or T _A = +300°C at t = 2 hours n = 11 wires, c = 0				
Decap internal visual (design verification) 4/	2075	n = 4 devices, c = 0				
<u>Subgroup 2</u>						
Thermal impedance 8/	3131	See 4.3.2	Z _{θJX}			°C/W
Breakdown voltage, collector to emitter	3011	Bias condition D, I _C = 100 mA, I _B = 0, pulsed (see 4.5.1)	V _{BR(CEO)}	80		V dc
Collector to emitter cutoff current	3041	Bias condition C, V _{CE} = 60 V dc, V _{BE} = 0	I _{CES1}		1.0	μA dc
Collector to emitter cutoff current	3041	Bias condition C, V _{CE} = 100 V dc, V _{BE} = 0	I _{CES2}		1.0	mA dc
Collector to emitter cutoff current	3041	Bias condition D, V _{CE} = 40 V dc, I _B = 0	I _{CEO}		50	μA dc
Emitter to base cutoff current	3061	Bias condition D, V _{EB} = 4 V dc, I _C = 0	I _{EBO1}		1.0	mA dc

See footnotes at end of table.

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TABLE I. Group A inspection. - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 2</u> - Continued						
Emitter to base cutoff current	3061	Bias condition D, $V_{EB} = 5.5$ V dc, $I_C = 0$	I_{EBO2}		1.0	mA dc
Forward - current transfer ratio	3076	$V_{CE} = 5$ V dc, $I_C = 50$ mA dc	h_{FE1}			
2N5002 2N5004				20 50		
Forward - current transfer ratio	3076	$V_{CE} = 5$ V dc, $I_C = 2.5$ A dc, pulsed (see 4.5.1)	h_{FE2}			
2N5002 2N5004				30 70	90 200	
Forward - current transfer ratio	3076	$V_{CE} = 5$ V dc, $I_C = 5$ A dc, pulsed (see 4.5.1)	h_{FE3}			
2N5002 2N5004				20 40		
Base-emitter voltage (non-saturated)	3066	Test condition B, $V_{CE} = 5$ V dc, $I_C = 2.5$ A dc, pulsed (see 4.5.1)	$V_{BE(on)}$		1.45	V dc
Base-emitter saturation voltage	3066	Test condition A, $I_C = 2.5$ A dc, $I_B = 250$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)1}$		1.45	V dc
Base-emitter saturation voltage	3066	Test condition A, $I_C = 5$ A dc, $I_B = 500$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)2}$		2.2	V dc
Collector-emitter saturation voltage	3071	$I_C = 2.5$ A dc, $I_B = 250$ mA dc, pulsed (see 4.5.1)	$V_{CE(sat)1}$		0.75	V dc
Collector-emitter saturation voltage	3071	$I_C = 5$ A dc, $I_B = 500$ mA dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		1.5	V dc
<u>Subgroup 3</u>						
High-temperature operation:		$T_C = +150^{\circ}\text{C}$				
Collector to emitter cutoff current	3041	Bias condition A; $V_{CE} = 60$ V dc, $V_{BE} = 0$	I_{CES3}		500	μA dc

See footnotes at end of table.

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TABLE I. Group A inspection. - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 3</u> - continued						
Low-temperature operation:		$T_C = -55^{\circ}\text{C}$				
Forward-current transfer ratio 2N5002 2N5004	3076	$V_{CE} = 5\text{ V dc}$, $I_C = 2.5\text{ A dc}$, pulsed (see 4.5.1)	h_{FE4}	15 25		
<u>Subgroup 4</u>						
Common-emitter, small-signal, short-circuit, forward-current transfer ratio 2N5002 2N5004	3206	$V_{CE} = 5\text{ V dc}$, $I_C = 100\text{ mA dc}$, $f = 1\text{ kHz}$	h_{fe}	20 50		
Magnitude of common-emitter, small-signal short-circuit, forward-current transfer ratio 2N5002 2N5004	3306	$V_{CE} = 5\text{ V dc}$, $I_C = 500\text{ mA dc}$, $f = 10\text{ MHz}$	$ h_{fe} $	6 7		
Open-circuit output capacitance	3236	$V_{CB} = 10\text{ V dc}$, $I_E = 0$, $f = 1\text{ MHz}$	C_{obo}		250	pF
Switching time		$I_C = 5\text{ A dc}$, $I_{B1} = 500\text{ mA dc}$, $I_{B2} = -500\text{ mA dc}$, $V_{BE(off)} = 3.7\text{ V}$, $R_L = 6\Omega$, (see figure 6)	t_{on} t_s t_r t_{off}		0.5 1.4 0.5 1.5	μs μs μs μs
<u>Subgroup 5</u>						
Safe operating area (dc)	3051	Pre-pulse condition for each test: $V_{CE} = 0$, $I_C = 0$, $T_C = +25^{\circ}\text{C}$. Pulse condition for each test, $t_p = 1\text{ sec}$. 1 cycle $T_C = +25^{\circ}\text{C}$, (see figure 7)				
Test #1		$V_{CE} = 12\text{ V dc}$, $I_C = 5\text{ A dc}$				
Test #2		$V_{CE} = 32\text{ V dc}$, $I_C = 1.7\text{ A dc}$				
Test #3		$V_{CE} = 80\text{ V dc}$, $I_C = 100\text{ mA dc}$				

See footnotes at end of table.

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TABLE I. Group A inspection. - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 5</u> - Continued. Safe operating area (unclamped inductive) End-point electrical measurements <u>Subgroups 6 and 7</u> Not applicable	3053	$T_C = +25^{\circ}\text{C}$, $R_{BB1} = 10\Omega$, $R_{BB2} = 100\Omega$, $L = 0.3 \text{ mH}$, $R_L = 0.1\Omega$, $V_{CC} = 10 \text{ V dc}$, $V_{BB1} = 10 \text{ V dc}$, $V_{BB2} = 4 \text{ V dc}$, $I_{CM} = 10 \text{ A dc}$ (see figure 7) See subgroup 2 of table I				

1/ For sampling plan, see [MIL-PRF-19500](#).

2/ For resubmission of failed in subgroup 1 of [table I](#), double the sample size of the failed test or sequence of tests. A failure in [table I](#), subgroup 1 shall not require retest of the entire subgroup. Only the failed test shall be rerun upon submission.

3/ Separate samples may be used.

4/ Not required for JANS devices.

5/ Not required for laser marked devices.

6/ Required only for laser marked devices with corrosion prone base metals.

7/ This hermetic seal test is an end-point to temperature-cycling in addition to electrical measurements.

8/ For end-point measurements, this test is required for the following subgroups:

Group B, subgroups 3, 4, and 5 (JANS).

Group B, step 1 of [4.4.2.2](#) herein (JAN, JANTX, and JANTXV).

Group C, subgroups 2 and 6.

Group E, subgroups 1 and 2.

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* TABLE II. Group D inspection.

Inspection 1/ 2/ 3/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 1</u> 4/						
Neutron irradiation	1017	Neutron exposure $V_{CES} = 0$ V				
Breakdown voltage, collector to emitter	3011	Bias condition D, $I_C = 100$ mA, $I_B = 0$, pulsed (see 4.5.1)	$V_{BR(CEO)}$	80		V dc
Collector to emitter cutoff current	3041	Bias condition C, $V_{CE} = 60$ V dc, $V_{BE} = 0$	I_{CES1}		2.0	μ A dc
Collector to emitter cutoff current	3041	Bias condition C, $V_{CE} = 100$ V dc, $V_{BE} = 0$	I_{CES2}		2.0	mA dc
Collector to emitter cutoff current	3041	Bias condition D, $V_{CE} = 40$ V dc, $I_B = 0$	I_{CEO}		100	μ A dc
Emitter to base cutoff current	3061	Bias condition D, $V_{EB} = 4$ V dc, $I_C = 0$	I_{EBO1}		2.0	mA dc
Emitter to base cutoff current	3061	Bias condition D, $V_{EB} = 5.5$ V dc, $I_C = 0$	I_{EBO2}		2.0	mA dc
Forward - current transfer ratio 2N5002 2N5004	3076	$V_{CE} = 5$ V dc, $I_C = 50$ mA dc	$[h_{FE1}]$ 5/	[10] [25]		
Forward - current transfer ratio 2N5002 2N5004	3076	$V_{CE} = 5$ V dc, $I_C = 2.5$ A dc, pulsed (see 4.5.1)	$[h_{FE2}]$ 5/	[15] [35]	90 200	
Forward - current transfer ratio 2N5002 2N5004	3076	$V_{CE} = 5$ V dc, $I_C = 5$ A dc, pulsed (see 4.5.1)	$[h_{FE3}]$ 5/	[10] [20]		
Base-emitter voltage (nonsaturated)	3066	Test condition B, $V_{CE} = 5$ V dc, $I_C = 2.5$ A dc, pulsed (see 4.5.1)	V_{BE}		1.67	V dc
Base-emitter saturation voltage	3066	Test condition A, $I_C = 2.5$ A dc, $I_B = 250$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)1}$		1.67	V dc
Base-emitter saturation voltage	3066	Test condition A, $I_C = 5$ A dc, $I_B = 500$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)2}$		2.53	V dc

See footnotes at end of table.

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* TABLE II. Group D inspection - Continued.

Inspection 1/ 2/ 3/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 1</u> - Continued.						
Collector-emitter saturation voltage	3071	I _C = 2.5 A dc, I _B = 250 mA dc, pulsed (see 4.5.1)	V _{CE(sat)1}		.86	V dc
Collector-emitter saturation voltage	3071	I _C = 5 A dc, I _B = 500 mA dc, pulsed (see 4.5.1)	V _{CE(sat)2}		1.73	V dc
<u>Subgroup 2</u>						
Total dose irradiation	1019	Gamma exposure V _{CES} = 64 V Condition A for High dose rate,				
Breakdown voltage, collector to emitter	3011	Bias condition D, I _C = 100 mA, I _B = 0, pulsed (see 4.5.1)	V _{BR(CEO)}	80		V dc
Collector to emitter cutoff current	3041	Bias condition C, V _{CE} = 60 V dc, V _{BE} = 0	I _{CES1}		2.0	μA dc
Collector to emitter cutoff current	3041	Bias condition C, V _{CE} = 100 V dc, V _{BE} = 0	I _{CES2}		2.0	mA dc
Collector to emitter cutoff current	3041	Bias condition D, V _{CE} = 40 V dc, I _B = 0	I _{CEO}		100	μA dc
Emitter to base cutoff current	3061	Bias condition C, V _{EB} = 4 V dc, I _C = 0	I _{EB01}		2.0	mA dc
Emitter to base cutoff current	3061	Bias condition C, V _{EB} = 5.5 V dc, I _C = 0	I _{EB02}		2.0	mA dc
Forward - current transfer ratio	3076	V _{CE} = 5 V dc, I _C = 50 mA dc	[h _{FE1}] 5/			
2N5002 2N5004				[10] [25]		
Forward - current transfer ratio	3076	V _{CE} = 5 V dc, I _C = 2.5 A dc, pulsed (see 4.5.1)	[h _{FE2}] 5/			
2N5002 2N5004				[15] [35]	90 200	
Forward - current transfer ratio	3076	V _{CE} = 5 V dc, I _C = 5 A dc, pulsed (see 4.5.1)	[h _{FE3}] 5/			
2N5002 2N5004				[10] [20]		

See footnotes at end of table.

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* TABLE II. Group D inspection - Continued.

Inspection <u>1/</u> <u>2/</u> <u>3/</u>	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 2</u> - Continued.						
Base-emitter voltage (non-saturated)	3066	Test condition A, $V_{CE} = 5 \text{ V dc}$, $I_C = 2.5 \text{ A dc}$, pulsed (see 4.5.1)	V_{BE}		1.67	V dc
Base-emitter saturation voltage	3066	Test condition B, $I_C = 2.5 \text{ A dc}$, $I_B = 250 \text{ mA dc}$, pulsed (see 4.5.1)	$V_{BE(sat)1}$		1.67	V dc
Base-emitter saturation voltage	3066	Test condition B, $I_C = 5 \text{ A dc}$, $I_B = 500 \text{ mA dc}$, pulsed (see 4.5.1)	$V_{BE(sat)2}$		2.53	V dc
Collector-emitter saturation voltage	3071	$I_C = 2.5 \text{ A dc}$, $I_B = 250 \text{ mA dc}$, pulsed (see 4.5.1)	$V_{CE(sat)1}$		.86	V dc
Collector-emitter saturation voltage	3071	$I_C = 5 \text{ A dc}$, $I_B = 500 \text{ mA dc}$, pulsed (see 4.5.1)	$V_{CE(sat)2}$		1.73	V dc

1/ Tests to be performed on all devices receiving radiation exposure.

2/ For sampling plan, see MIL-PRF-19500.

3/ Electrical characteristics apply to all device types unless otherwise noted.

4/ See 6.2.e.

5/ See method 1019 of MIL-STD-750 for how to determine $[h_{FE}]$ by first calculating the delta ($1/h_{FE}$) from the pre- and post-radiation h_{FE} . Notice the $[h_{FE}]$ is not the same as h_{FE} and cannot be measured directly. The $[h_{FE}]$ value can never exceed the pre-radiation minimum h_{FE} that it is based upon.

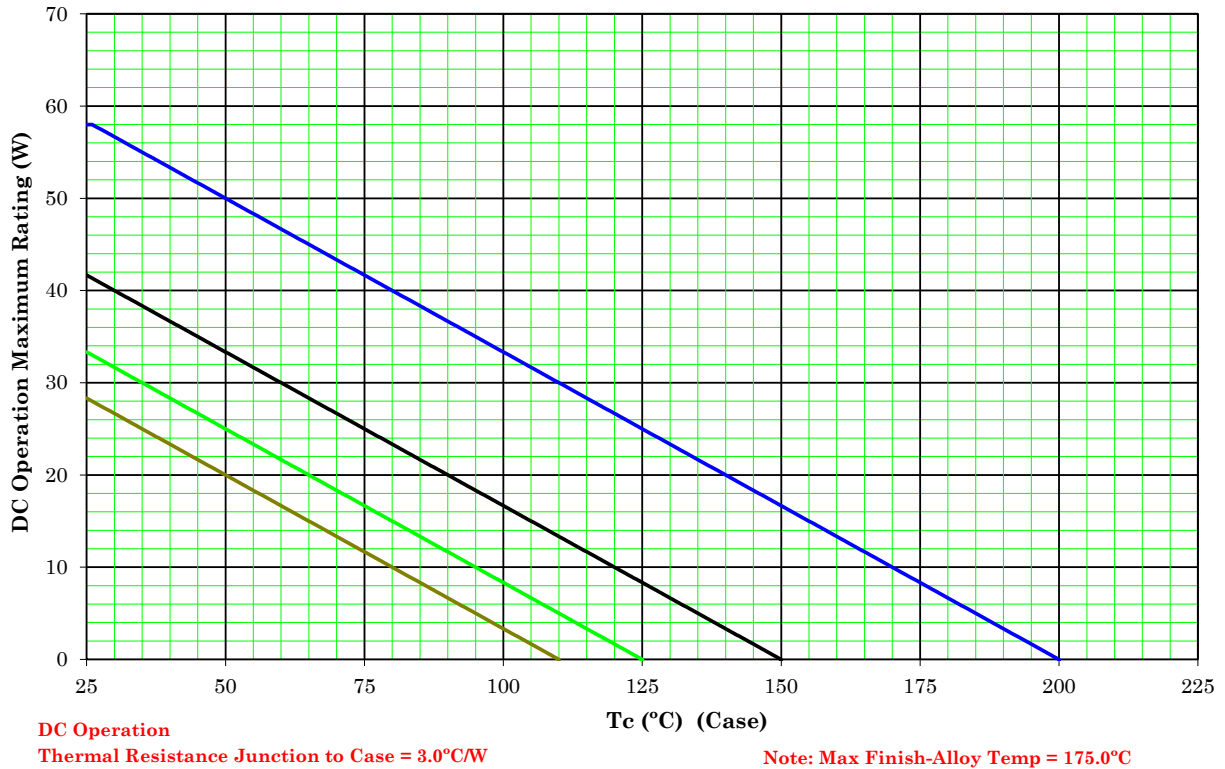
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TABLE III. Group E inspection (all quality levels) - for qualification or re-qualification only.

Inspection	MIL-STD-750		Sample plan
	Method	Conditions	
<u>Subgroup 1</u>			45 devices c = 0
Temperature cycling (air to air)	1051	Test condition C, 500 cycles	
Hermetic seal Fine leak Gross leak	1071		
Electrical measurements		See table I , subgroup 2 and 4.7 herein	
<u>Subgroup 2</u>			45 devices c = 0
Intermittent life	1037	Intermittent operation life: $V_{CB} = 10$ V dc, 6,000 cycles. Adjust device current, or power, to achieve a minimum ΔT_J of +100°C	
Electrical measurements		See table I , subgroup 2 and 4.7 herein	
<u>Subgroup 4</u>			Sample size N/A
Thermal impedance curves		See table E-IX of MIL-PRF-19500 , subgroup 4	
<u>Subgroup 5</u>			
Not applicable			
<u>Subgroup 8</u>			45 devices c = 0
Reverse stability	1033	Condition B	

Temperature-Power Derating Curve

2N5002, 2N5004



NOTES:

1. Top curve is thermal runaway loci and cannot be used as a derate design curve since it exceeds the maximum ratings for this part. Operating under this curve using these mounting conditions assures the device will not have a thermal runaway. This is the true inverse of the worst case thermal resistance value extrapolated out to the thermal runaway point.
2. Derate design curve constrained by the maximum junction temperature ($T_J \leq +200^\circ\text{C}$) and power rating specified (see 1.3 herein).
3. Derate design curve chosen at $T_J \leq +150^\circ\text{C}$, where the maximum temperature of electrical test is performed.
4. Derate design curve chosen at $T_J \leq +125^\circ\text{C}$, and $+110^\circ\text{C}$ to show power rating where most users want to limit T_J in their application.

* FIGURE 3. Temperature-power derating for ($R_{\theta JC}$) for 2N5002 and 2N5004 (similar to TO-59).

Maximum Thermal Impedance

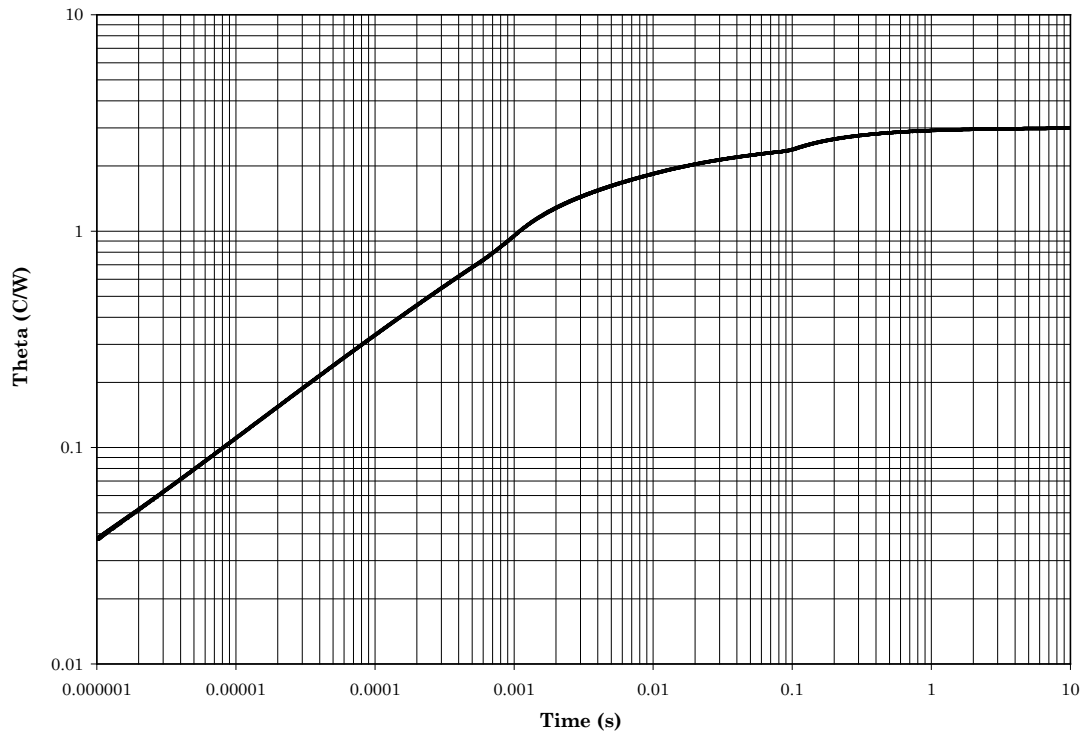
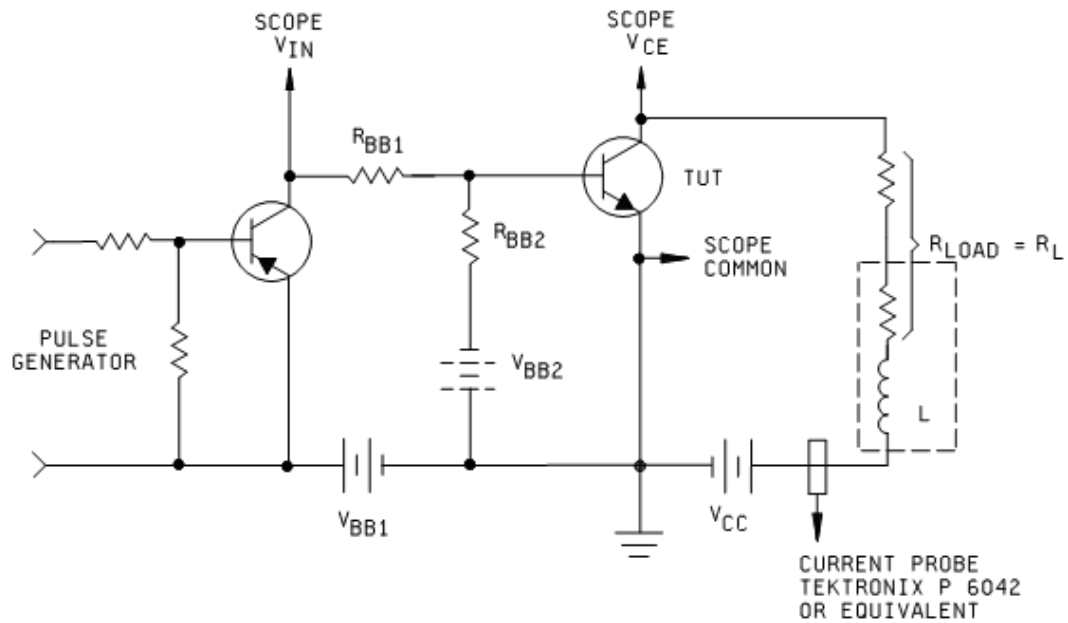


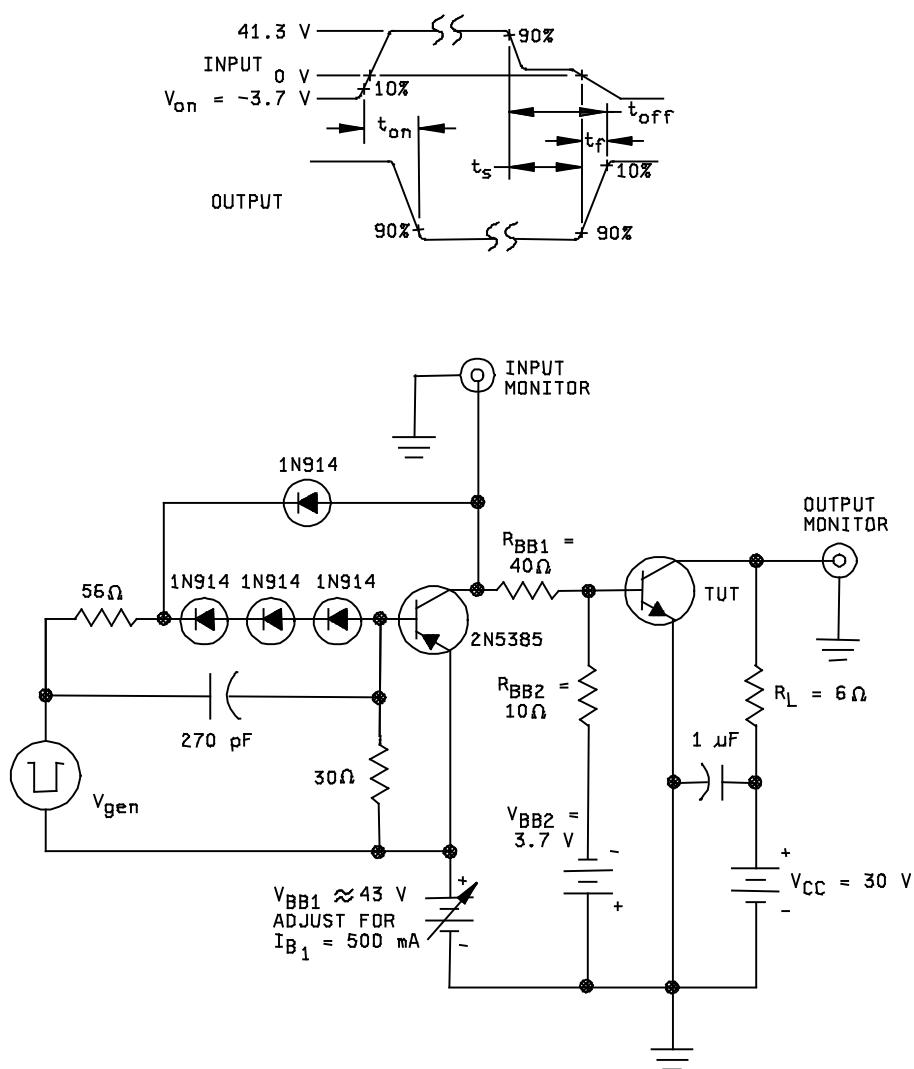
FIGURE 4. Thermal impedance graph ($R_{\theta JC}$) for 2N5002 and 2N5004 (similar to TO-59).



$R_{BB1} = 10 \Omega$	$V_{CC} = 10 \text{ V dc}$
$R_{BB2} = 100 \Omega$	$I_C = 10 \text{ A}$
$L = 0.3 \text{ mH}$	$V_{BB1} = 10 \text{ V dc}$
$R_L = 0.1 \Omega$	$V_{BB2} = 4 \text{ V dc}$

* FIGURE 5. Unclamped inductive load energy test circuit.

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NOTES:

1. V_{gen} is a -30 pulse (from 0 V) into a 50 ohm termination.
2. The V_{gen} waveform is supplied by a generator with the following characteristics:
 $t_r \leq 15$ ns, $t_f \leq 15$ ns,
 $Z_{out} = 50$ ohm, duty cycle ≤ 2 percent.
3. Waveforms are monitored on an oscilloscope with the following characteristics:
 $t_r \leq 15$ ns, $R_{in} \geq 10$ M Ω ,
 $C_{in} \leq 11.5$ pF.
4. Resistors must be non-inductive types.
5. The dc power supplies may require additional bypassing in order to minimize ringing.
6. An equivalent circuit may be used.

* FIGURE 6. Switching time test circuit.

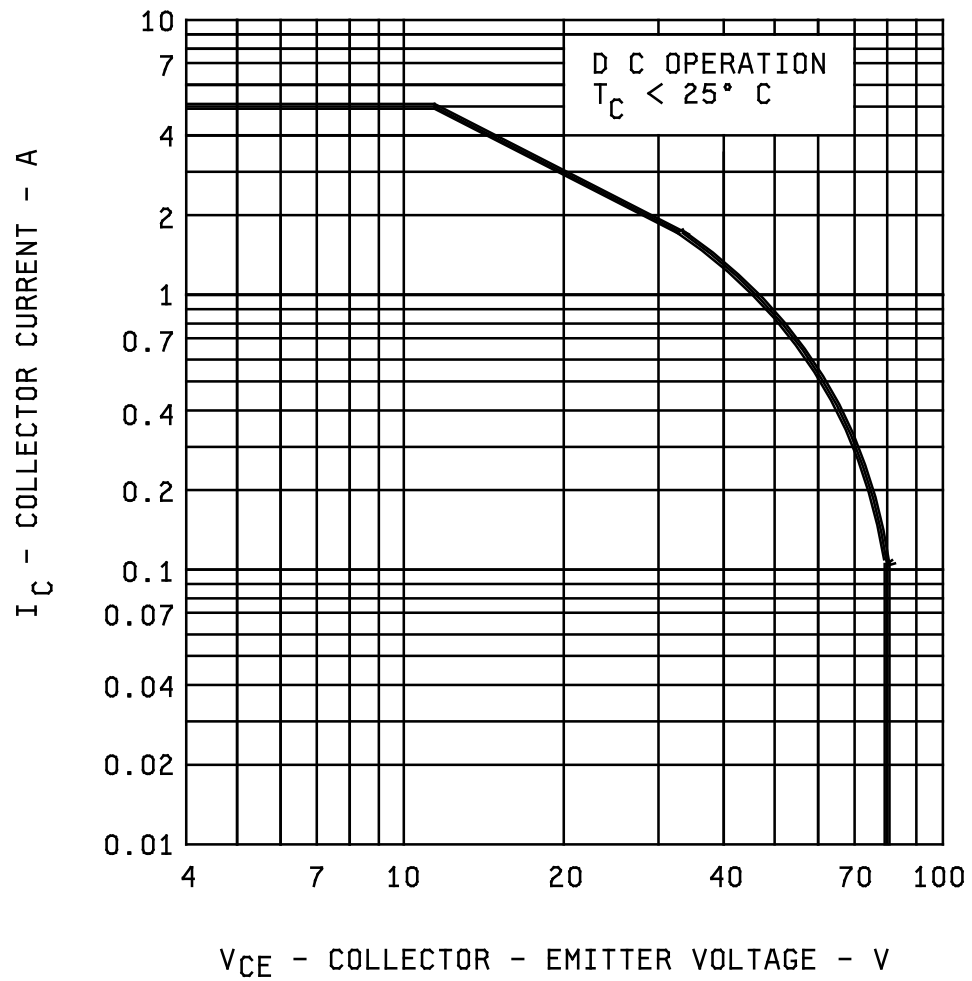


FIGURE 7. Maximum safe operating area.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the Military Service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory. The notes specified in [MIL-PRF-19500](#) are applicable to this specification.)

6.1 Intended use. Semiconductors conforming to this specification are intended for original equipment design applications and logistic support of existing equipment.

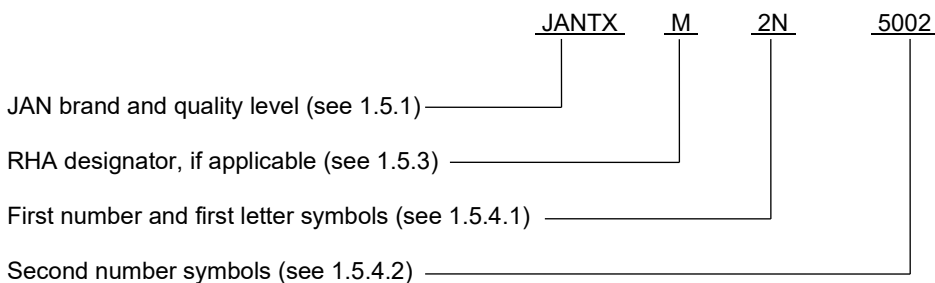
6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Packaging requirements (see 5.1).
- c. Lead finish (see [3.4.1](#)).
- d. The complete PIN, see [1.5](#) and [6.4](#).
- e. For acquisition of RHA designated devices, [table II](#), subgroup 1 testing of group D herein is optional. If [table II](#), subgroup 1 is desired, it should be specified in the contract.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Manufacturers List ([QML 19500](#)) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from DLA Land and Maritime, ATTN: VQE, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail vqe.chief@dla.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at <https://qpldocs.dla.mil>.

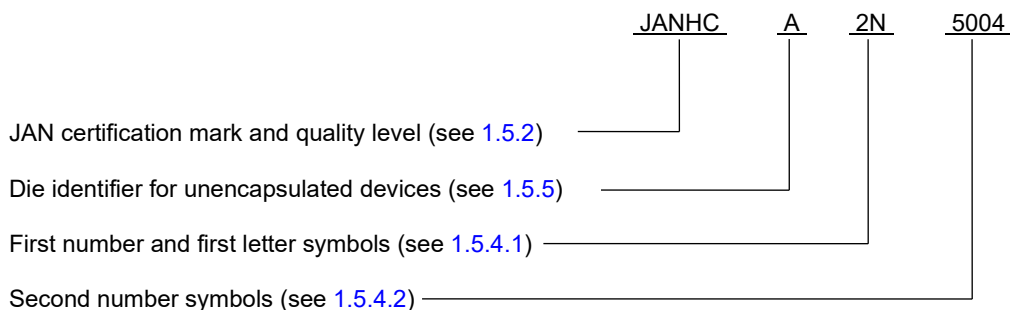
6.4 PIN construction examples.

6.4.1 Encapsulated devices. The PINs for encapsulated devices are constructed using the following form.



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6.4.2 Unencapsulated devices. The PINs for un-encapsulated devices are constructed using the following form.



6.5 List of PINs.

6.5.1 List of PINs. The following is a list of possible PINs available on this specification sheet.

PINs for devices of the base quality level	PINs for devices of the "TX" quality level	PINs for devices of the "TXV" quality level	PINs for devices of the "S" quality level
JAN2N5002	JANTX2N5002	JANTXV#2N5002	JANS#2N5002
JAN2N5004	JANTX2N5004	JANTXV#2N5004	JANS#2N5004

(#) The number sign (#) represent one of eight RHA designators available (M, D, P, L, R, F, G, of H).

6.5.2 PINs for unencapsulated die. The following is a list of possible PINs for unencapsulated devices available on this specification sheet.

Quality level HC	Quality level HC w/ RHA	Quality level KC	Quality level KC w/ RHA
JANHCB2N5002	JANHCB#2N5002	JANKCB2N5002	JANKHCB#2N5002
JANHCB2N5004	JANHCB#2N5004	JANKCB2N5004	JANKHCB#2N5004

(#) The number sign (#) represent one of eight RHA designators available (M, D, P, L, R, F, G, of H).

6.6 Suppliers of JANHC and JANKC die. The qualified JANHC and JANKC die suppliers with the applicable letter version (example JANHCB2N5002) will be identified on the QML.

Die ordering information (1)	
PIN	Manufacturer
	43611
2N5002	JANHCB2N5002
2N5004	JANHCB2N5004

(1) For JANKC level, replace JANHC with JANKC.

6.7 Complementary use. The devices specified herein are designed for complementary use with the 2N5003 and 2N5005 of MIL-PRF-19500/535.

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6.8 Interchangeability information. An alternate package configuration for the devices covered by this specification sheet is available on [MIL-PRF-19500/613](#). MIL-PRF-19500/613 covers device type 2N7373, which is a TO-254 package version of the device types covered by this specification sheet. The military 2N7373 contains the same die as the military 2N5002 and 2N5004.

6.9 Request for new types and configurations. Requests for new device types or configurations for inclusions in this specification sheet should be submitted to: DLA Land and Maritime, ATTN: VAC, Post Office Box 3990, Columbus, OH 43218-3990 or by electronic mail at Semiconductor@dla.mil or by facsimile (614) 693-1642 or DSN 850-6939.

* 6.10 Amendment notations. The margins of this specification are marked with asterisks to indicate modifications generated by this amendment. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the previous issue.

Custodians:

- Army - MI
- * Navy - SH
- Air Force - 85
- * NASA - NA
- DLA - CC

Preparing activity:
DLA - CC

(Project 5961-2024-085)

Review activities:

Air Force - 19

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.dla.mil>.