The documentation and process conversion measures necessary to comply with this revision shall be completed by 26 February 2015.

INCH-POUND

MIL-PRF-19500/374F
26 November 2014
SUPERSEDING
MIL-PRF-19500/374E
30 April 2009

PERFORMANCE SPECIFICATION SHEET

* TRANSISTOR, NPN, SILICON, POWER,
TYPES 2N3996 THROUGH 2N3999,
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 are provided for each encapsulated device (JAN, JANTX, JANTXV, and JANS). Two levels of product assurance are provided for the unencapsulated die (JANHC and JANKC).

* 1.2 Package outlines. The device package outlines are as follows: encapsulated device types 2N3996 and 2N3997, 4 lead stud package in accordance with figure 1, encapsulated device types 2N3998 and 2N3999, 3 lead stud package in accordance with figure 2, unencapsulated device types JANHC and JANKC, B-version, in accordance with figure 3 and figure 4, and JANHC and JANKC, C-version in accordance with figure 5).

1.3 Maximum ratings. Unless otherwise specified, $T_C$ = +25°C.

| $P_T$ (1) $T_A$ = +25°C | $P_T$ (2) $T_C$ = +100°C | $V_{EBO}$ | $V_{CBO}$ | $V_{CEO}$ | $I_B$ | $I_C$ | $I_C$ (3) | $T_{STG}$ and $T_J$ | $R_{\Theta JC}$ |
|---|---|---|---|---|---|---|---|---|---|
| W | W | V dc | V dc | V dc | A dc | A dc | A dc | °C | °C/W |
| 2 | 30 | 8 | 100 | 80 | 0.5 | 5.0 | 10 | -65 to +200 | 3.33 |

(1) Derate linearly, 11.4 mW/°C for $T_A \geq$ +25°C.
(2) Derate linearly, 300 mW/°C for $T_C \geq$ +100°C.
(3) This value applies for $t_p \leq 1$ ms, duty cycle ≤ 50percent.

* 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/.

AMSC N/A FSC 5961

1.4 Primary electrical characteristics at $T_C$ = +25°C.

| Limit | $h_{FE2}$ (1) $V_{CE}$ = 2 V dc; $I_C$ = 1 A dc | | $\|h_{fe}\|$ $V_{CE}$ = 5 V dc; $I_C$ = 1 A dc; f = 10 MHz | $V_{BE\ (sat)\ 2}$ (1) $I_C$ = 5 A dc; $I_B$ = 500 mA dc | $V_{CE\ (sat)\ 2}$ (1) $I_C$ = 5 A dc; $I_B$ = 500 mA dc | $C_{obo}$ $V_{CB}$ = 10 V dc $I_E$ = 0 100 kHz ≤ f ≤ 1 MHz |
|---|---|---|---|---|---|---|
| | 2N3996 2N3998 | 2N3997 2N3999 | | V dc | V dc | pF |
| Minimum | 40 | 80 | 3 | | | |
| Maximum | 120 | 240 | 12 | 1.6 | 2.0 | 150 |

(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 certification mark and quality level. The quality level designators for encapsulated devices that are applicable for this specification sheet from the lowest to the highest level are as 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 as follows: "JANHC" and "JANKC".

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

* 1.5.3.1 First number and first letter symbols. The transistors of this specification sheet use the first number and letter symbols "2N".

* 1.5.3.2 Second number symbols. The second number symbols for the transistors covered by this specification sheet are as follows: "3996", "3997", “3998” and "3999".

* 1.5.3.3 Suffix symbols. Suffix symbols are not applicable for this specification sheet.

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

* 1.5.5 Die identifiers for unencapsulated devices (manufacturers and critical interface identifiers). The manufacturer die identifiers that are applicable for this specification sheet are "A", “B”, and "C" (see figures 3, 4, and 5).

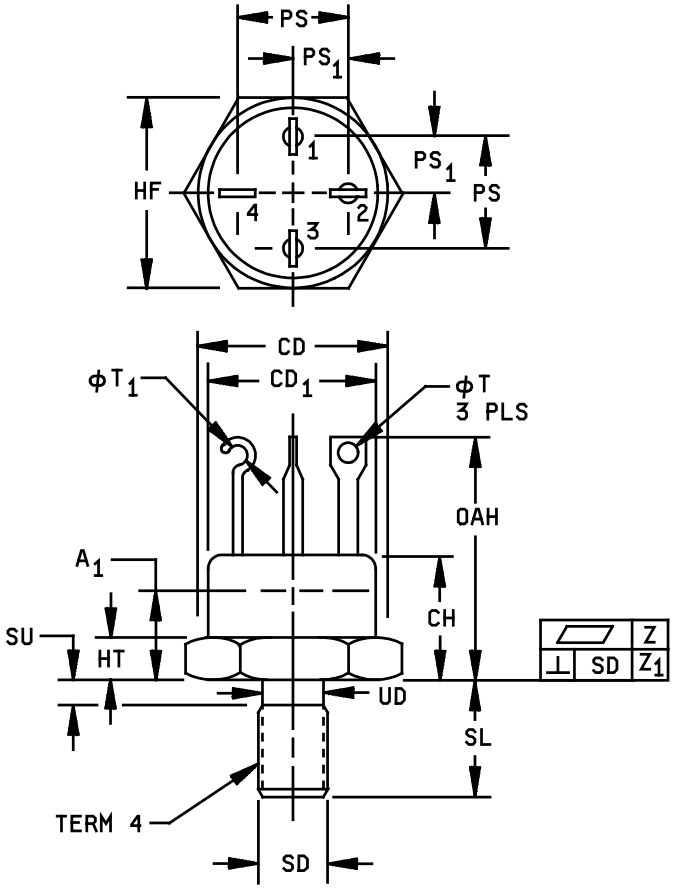



FIGURE 1. Physical dimensions for transistor types 2N3996 and 2N3997.

| Symbol | Dimensions | | | | Notes |
|---|---|---|---|---|---|
| | Inches | | Millimeters | | |
| | Min | Max | Min | Max | |
| CH | .345 | .400 | 8.76 | 10.16 | |
| $A_1$ | | .250 | | 6.35 | 3 |
| CD | .370 | .437 | 9.40 | 11.10 | 3 |
| $CD_1$ | .318 | .380 | 8.08 | 9.65 | |
| HF | .424 | .437 | 10.77 | 11.10 | |
| PS | .180 | .215 | 4.57 | 5.46 | 5 |
| $PS_1$ | .080 | .110 | 2.03 | 2.79 | 5 |
| HT | .090 | .140 | 2.29 | 3.56 | 2,6 |
| OAH | .575 | .675 | 14.61 | 17.15 | 1 |
| UD | .155 | .189 | 3.94 | 4.80 | |
| SL | .400 | .455 | 10.16 | 11.56 | |
| SU | | .078 | | 1.98 | 7 |
| $\phi T$ | .040 | .065 | 1.02 | 1.65 | |
| $\phi T_1$ | .040 | .065 | 1.02 | 1.65 | 4 |
| SD | .190-32 UNF-2A | | | | 8 |
| Z | | .002 | | 0.05 | |
| $Z_1$ | | .006 | | 0.15 | |

NOTES:

1. Terminal 1, emitter; terminal 2, base; terminal 3, collector; terminal 4, case.
2. Chamfer or undercut on one or both ends of hexagonal portion is optional.
3. The outline contour with the exception of the hexagon is optional within cylinder defined by $CD_1$ and $A_1$.
4. Terminal r can be flattened and pierced or hook type. A visual index is required when the flattened and pierced tab terminal contour (identical to the adjacent terminals) option is used. The case terminal (hook) is mechanically connected to the case. The other three terminals shall be electrically isolated from the case.
5. Angular orientation of terminals with respect to hexagon is optional.
6. HT dimension does not include sealing flanges.
7. SU is the length of incomplete or undercut threads.
8. SD is the pitch diameter of coated threads. Reference: Screw threads standards for Federal Service Handbook H28, part I.
9. Dimensions are in inches.
10. Millimeters are giving for general information only.
11. In accordance with ASME Y14.5M, diameters are equivalent to $\phi$x symbology.

FIGURE 1. Physical dimensions for transistor types 2N3996 and 2N3997 - Continued.

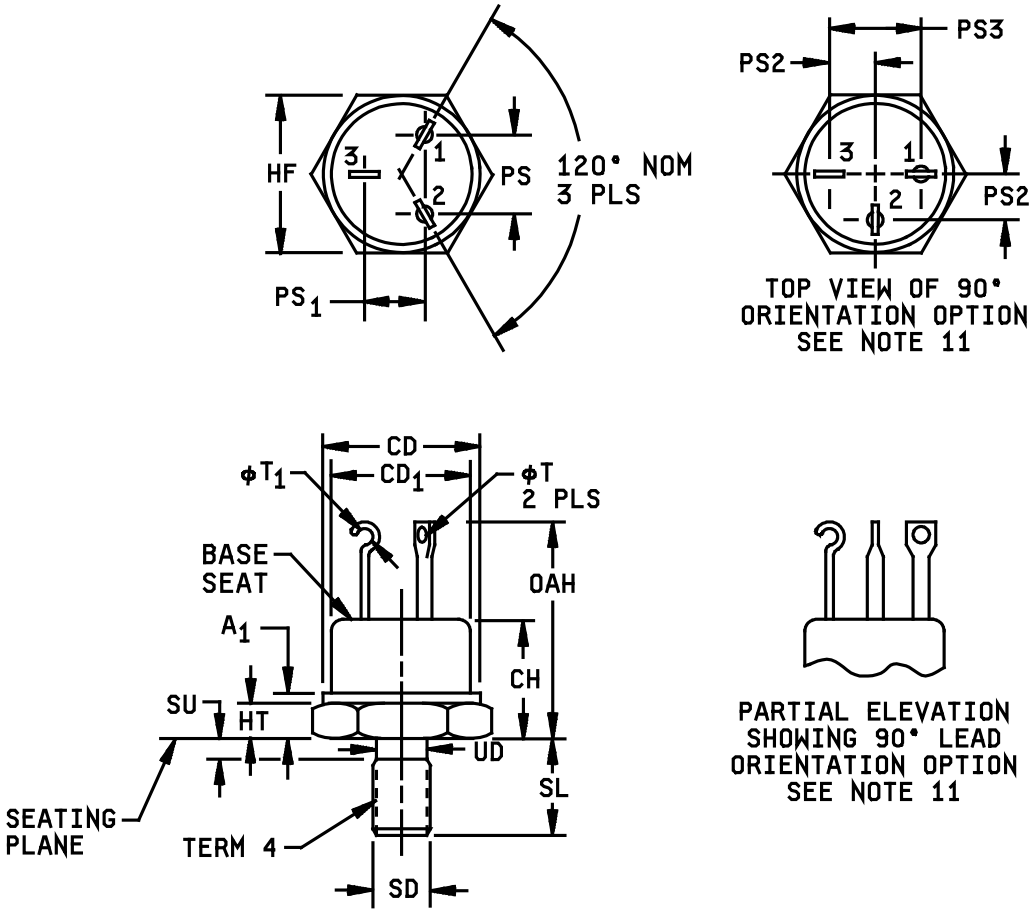
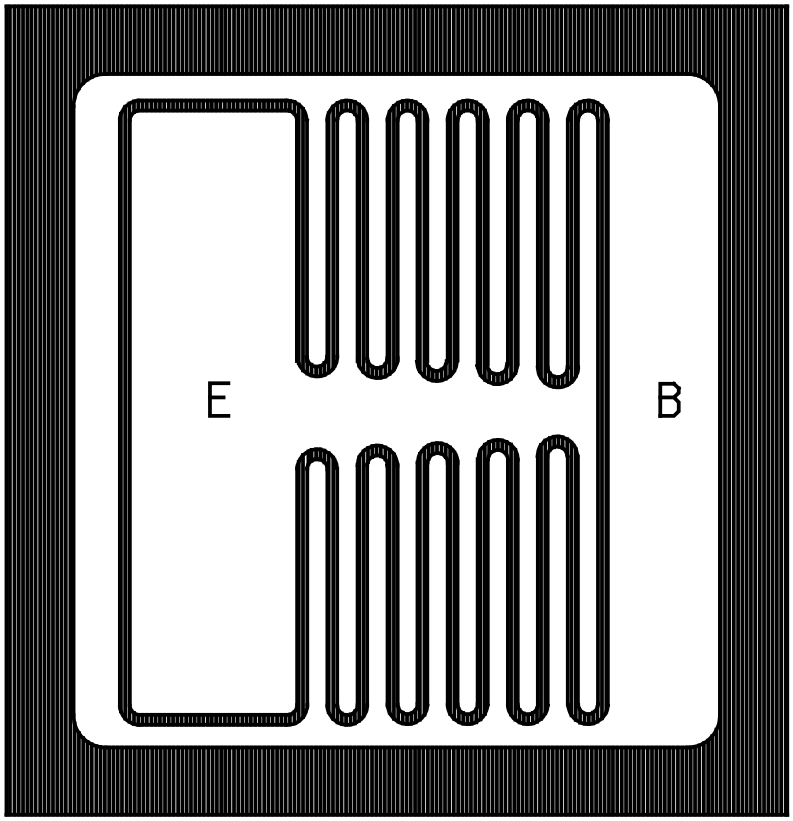



FIGURE 2. Physical dimensions for transistor types 2N3998 and 2N3999.

| Symbol | Dimensions | | | | Notes |
|---|---|---|---|---|---|
| | Inches | | Millimeters | | |
| | Min | Max | Min | Max | |
| | | | | | |
| CH | .345 | .400 | 8.76 | 10.16 | |
| $A_1$ | | .250 | | 6.35 | |
| $CD_1$ | .318 | .380 | 8.08 | 9.65 | |
| CD | .370 | .437 | 9.40 | 11.10 | |
| HF | .424 | .437 | 10.77 | 11.10 | |
| PS | .125 | .165 | 3.18 | 4.19 | 4,7,8 |
| $PS_1$ | .110 | .145 | 2.79 | 3.68 | 4,7 |
| $PS_2$ | .090 | .140 | 2.29 | 3.56 | 4,7,8 |
| $PS_3$ | .185 | .215 | 4.70 | 5.46 | 4,7,8 |
| HT | .090 | .140 | 2.29 | 3.56 | |
| OAH | .575 | .675 | 14.61 | 17.15 | 5 |
| UD | .155 | .189 | 3.94 | 4.80 | |
| SL | .400 | .455 | 10.16 | 11.56 | |
| SU | | .078 | | 1.98 | 9 |
| $\phi T$ | .040 | .065 | 1.02 | 1.65 | |
| $\phi T_1$ | .040 | .065 | 1.02 | 1.65 | |
| SD | .190-32 UNF-2A | | | | 3 |

NOTES:
1. Dimensions are in inches. Millimeters are given for general information only.
2. Collector shall be electrically connected to the case. This terminal may be flattened and pierced only when the 90 degree option is used.
3. SD is the pitch diameter of coated threads. Reference: Screw thread standards for Federal Service Handbook H28, part I.
4. The orientation of the terminals in relation to the hex flats is not controlled.
5. All three terminals.
6. The case temperature may be measured anywhere on the seating plane within .125 (3.18 mm) of the stud.
7. Terminal spacing measured at the base seat only.
8. Dimensions PS, $PS_1$, $PS_2$, and $PS_3$ are measured from the centerline of terminals.
9. Maximum unthreaded dimension.
10. This dimension applies to the location of the center line of the terminals.
11. A 90 degree angle lead orientation as shown may be used at the option of the manufacturer. All dimensions of the basic outline except PS, $PS_1$, and the 120°lead angle apply to this option.
12. Terminal 1, emitter; terminal 2, base; terminal 3, collector.
13. A slight chamfer or undercut on one or both ends of the hexagonal is optional.
14. In accordance with ASME Y14.5M, diameters are equivalent to $\phi$x symbology.

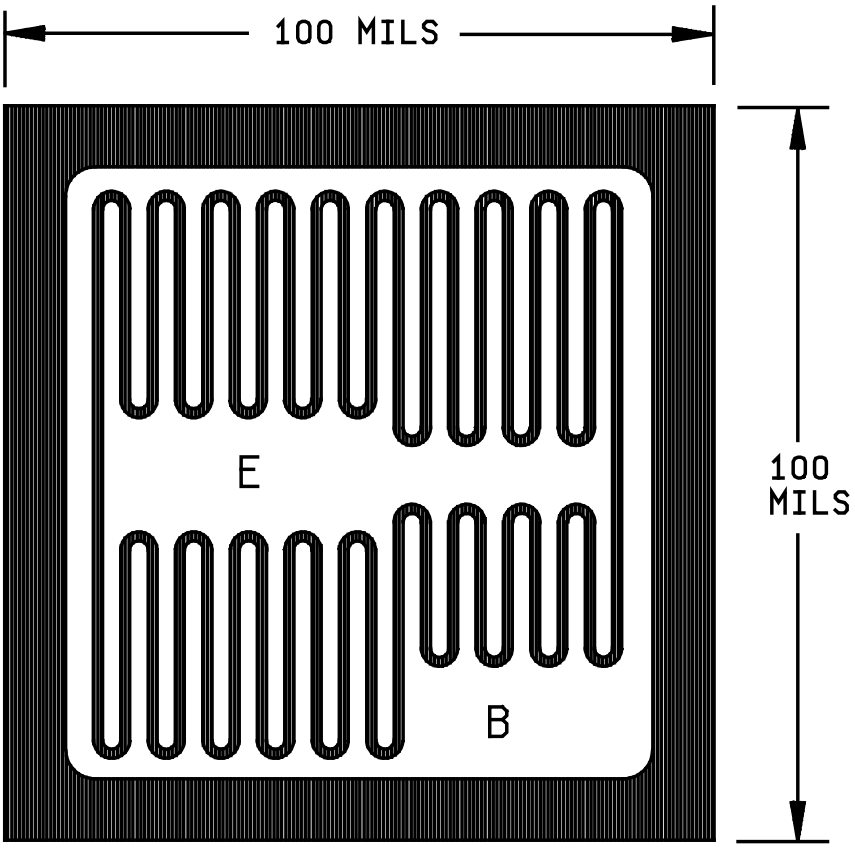
FIGURE 2. Physical dimensions for transistor types 2N3998 and 2N3999 - Continued.




NOTES:

1. Chip size..... 82 X 82 mils
2. Chip thickness..... 6 to 12 mils
3. Top metal ..... Aluminum 25,000 Å minimum, 30,000 Å nominal
4. Back metal..... Gold 2,500 Å minimum, 3,000 Å nominal
5. Backside..... Collector
6. Bonding pad ..... B = 8 x 60 mils, E = 8 x 50 mils

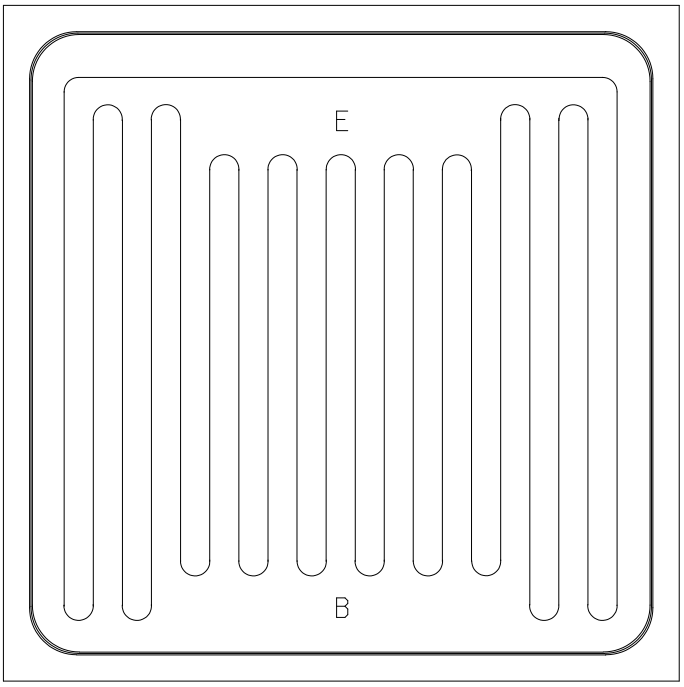
FIGURE 3. JANHC and JANKC (A-versions) die dimensions.




NOTES:

1. Chip size..... 100 X 100 mils
2. Chip thickness..... 6 to 12 mils
3. Top metal ..... Aluminum 25,000 Å minimum, 33,000 Å nominal
4. Back metal..... Gold 1,500 Å minimum, 2,500 Å nominal
5. Backside..... Collector
6. Bonding pad ..... 12 x 30 mils

FIGURE 4. JANHC and JANKC (B-versions) die dimensions.




NOTES:

| | | |
|---|---|---|
| 1. | Die size | .120 inch (3.05 mm) x .120 inch (3.05 mm) ±.002 inch (±0.05 mm). |
| 2. | Die thickness | .014 inch (0.35 mm) ±.0015 inch nominal (±0.04 mm). |
| 3. | Top metal | Aluminum, 54,000Å minimum, 60,000Å nominal. |
| 4. | Back metal | Gold 6,000Å minimum, 8,000Å nominal. |
| 5. | Backside | Collector |
| 6. | Bonding pad | B = .060 x .012 inch (1.5 mm x 0.30 mm).<br>E = .050 x .012 inch (1.27 mm x 0.30 mm). |

FIGURE 5. JANHC and JANKC (C-versions) die dimensions.

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 http://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 manufacturer's list (QML) 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. The Interface requirements and physical dimensions shall be as specified in MIL-PRF-19500, and figures1, 2, 3, 4, and 5 herein.

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.

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

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

3.8 Electrostatic discharge protection. The devices covered by this specification require electrostatic discharge protection.

3.8.1 Handling. MOS devices must be handled with certain precautions to avoid damage due to the accumulation of static charge. However, the following handling practices are recommended.

a. Devices should be handled on benches with conductive handling devices.

b. Ground test equipment, tools, and personnel handling devices.

c. Do not handle devices by the leads.

d. Store devices in conductive foam or carriers.

e. Avoid use of plastic, rubber, or silk in MOS areas.

f. Maintain relative humidity above 50 percent if practical.

g. Care should be exercised during test and troubleshooting to apply not more than maximum rated voltage to any lead.

h. Gate must be terminated to source, $R \leq 100\ k\Omega$, whenever bias voltage is to be applied drain to source.

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 table I and II).

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

4.2.1 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.

4.2.2 JANHC and JANKC devices. Qualification for JANHC and JANKC devices shall be in accordance with appendix G of MIL-PRF-19500. This testing may be performed utilizing a TO-5 package in lieu of the TO-59 or the TO-111.

* 4.3 Screening.

* 4.3.1 Screening (JANS, JANTX, and JANTXV levels only). Screening of encapsulated 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 | Measurement | |
|---|---|---|
| | JANS level | JANTX and JANTXV levels |
| (1) 3c | Thermal impedance (see 4.3.1.1) | Thermal impedance (see 4.3.1.1) |
| 9 | $I_{CES1}$ and $h_{FE2}$ | $I_{CES1}$ |
| 11 | $I_{CES1}$ and $h_{FE2}$; $\Delta I_{CES1}$ = 100 percent of initial value or 100 nA dc, whichever is greater; $\Delta h_{FE2}$ = +15 percent, -10 percent | $I_{CES1}$ and $h_{FE2}$; $\Delta I_{CES1}$ = 100 percent of initial value or 100 nA dc; whichever is greater. |
| 12 | See 4.3.1.2 | See 4.3.1.2 |
| 13a | Subgroups 2 and 3 of table I herein; $\Delta I_{CES1}$ = 100 percent of initial value or 100 nA dc, whichever is greater; $\Delta h_{FE2}$ = +15 percent, -10 percent | Subgroup 2 of table I herein, $\Delta I_{CES1}$ = 100 percent of initial value or 200 nA dc, whichever is greater; $\Delta h_{FE2}$ = +20 percent, -10 percent |
| 13b | Insulation resistance (terminal to case) method 1016 of MIL-STD-750 (types 2N3996 and 2N3997 only); test condition B (short collector, emitter, and base terminals together); $R_{iso}$ = $10^9$ Ω minimum | Insulation resistance (terminal to case) method 1016 of MIL-STD-750 (types 2N3996 and 2N3997 only); test condition B (short collector, emitter, and base terminals together); $R_{iso}$ = $10^9$ Ω minimum. |

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

4.3.1.1 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 $I_M$, $I_H$, $t_H$, $t_{SW}$, (and $V_H$ where appropriate). Measurement delay time ($t_{MD}$) = 70 μs max. See table III, group E, subgroup 4 herein.

4.3.1.2 Power burn-in conditions. Power burn-in conditions for all levels are as follows: $V_{CE}$ = 25 V dc, ±5 V dc; $T_J$ = 187.5°C, ±12.5°C; $T_A$ = 35°C. max.

* 4.3.2 Screening of unencapsulated die (JANHC and JANKC). Screening of JANHC and JANKC unencapsulated die shall be in accordance with appendix G of MIL-PRF-19500.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500 and as specified herein. Group A inspection shall be performed on each sublot.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-PRF-19500, and table I herein. Electrical measurements (end-points) shall be in accordance with the applicable inspections of table I, group A, subgroup 2 herein.

* 4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in tables E-VIA (JANS) and E-VIB (JAN, JANTX, and JANTXV) of MIL-PRF-19500 and 4.4.2.1 and 4.4.2.2 herein. Delta measurements shall be in accordance with table II herein.

* 4.4.2.1 Group B inspection, table E-VIA (JANS) of MIL-PRF-19500.

| Subgroup | Method | Condition |
|---|---|---|
| * B4 | 1037 | $V_{CE} \geq 10$ V dc. |
| B5 | 1027 | $V_{CE}$ = 20 V dc ±1.0 V dc; 96 hours. Adjusted as required by the chosen $T_A$ to give an average lot $T_J$ = +275°C. |
| B7 | 3053 | Load condition C (unclamped inductive) (see figure 6), $T_A$ = +25°C ±3°C, duty cycle ≤ 10 percent; $R_S = 0.1\Omega$.<br><br>Test 1 - $t_p$ = 640 µs; $R_{BB1} = 39\Omega$; $V_{BB1}$ = 20 V dc; $R_{BB2} = \infty$; $V_{BB2}$ = 0; $V_{CC}$ = 10 V dc; $I_C$ = 4.3 A dc; L = 1 mH (0.5Ω, 5A) (Tower #7870 or equivalent).<br><br>Test 2 - $t_p$ = 2.88 mS; $R_{BB1} = 120\Omega$; $V_{BB1}$ = 20 V dc; $R_{BB2} = \infty$; $V_{BB2}$ = 0; $V_{CC}$ = 10 V dc; $I_C$ = 1.4 A dc; L = 10 mH (0.11 Ω, 12.5A) (Stancor C-2688 or equivalent). |
| B7 | 3053 | Safe operating area (switching) (destructive); load condition B (clamped inductive) $T_A$ = +25°C; $I_B$ = 0.5 A dc, $I_C$ = 5 A dc; $V_{CC}$ = 55 V dc, L = 1.0 mH, $V_{BB2}$ = 3.0 V, $R_{BB2}$ = 20 Ω. |

* 4.4.2.2 Group B inspection, table E-VIB (JAN, JANTX and JANTXV) of MIL-PRF-19500.

| Subgroup | Method | Condition |
|---|---|---|
| * B3 | 1037 | For solder die attach; $V_{CE} \geq 10$ V dc. |
| B3 | 1027 | For eutectic die attach $T_A$ = +35°C max, $P_T$ adjusted to achieve $T_J$ = +175°C min, $V_{CE} \geq 10$ V dc. |
| B5 | | Not applicable. |
| B7 | 3053 | Load condition C (unclamped inductive) (see figure 6), $T_A$ = +25°C, duty cycle ≤ 10 percent; $R_S$ = 0.1 Ω.<br><br>Test 1 - $t_p$ = 640 µs; $R_{BB1} = 39\Omega$; $V_{BB1}$ = 20 V dc; $R_{BB2} = \infty$; $V_{BB2}$ = 0; $V_{CC}$ = 10 V dc; $I_C$ = 4.3 A dc; L = 1 mH (0.5 Ω, 5A) (Tower #7870 or equivalent).<br><br>Test 2 - $t_p$ = 2.88 mS; $R_{BB1} = 120\Omega$; $V_{BB1}$ = 20 V dc; $R_{BB2} = \infty$; $V_{BB2}$ = 0; $V_{CC}$ = 10 V dc; $I_C$ = 1.4 A dc; L = 10 mH (0.11 Ω, 12.5A) (Stancor C-2688 or equivalent) |
| B7 | 3053 | Safe operating area (switching) (destructive); load condition B (clamped inductive) $T_A$ = 25°C; $I_B$ = 0.5 A dc, $I_C$ = 5 A dc; $V_{CC}$ = 55 V dc, L = 1.0 mH, $V_{BB2}$ = 3.0 V, $R_{BB2}$ = 20 Ω. |

* 4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VII of MIL-PRF-19500, and as follows. Delta measurements shall be in accordance with table II herein.

| Subgroup | Method | Condition |
|---|---|---|
| C2 | 2036 | Test condition A; weight = 7 pounds ±5 ounce, application time = 15 s, tubulated leads only.<br>Test condition D2; torque = 15 inch-pound; application time = 15 s.<br>Test condition D1; torque = 8 in-oz; application time = 15 s; tubulated leads only. |
| C5 | 3131 | See 4.5.4, $R_{\theta JC}$ = 5°C/W. |
| C6 | 1037 | For solder die attach; $V_{CE} \geq 10$ V dc, 6,000 cycles |
| C6 | 1026 | For eutectic die attach $T_A$ = +35°C max, $P_T$ adjusted to achieve $T_J$ = +175°C min, $V_{CE} \geq 10$ V dc |

4.4.4 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. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

4.5 Methods 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 Case-temperature control for $h_{fe}$ test. To maintain the case temperature at less than +40°C for this test, the specified dc collector current should be applied for not longer than 10 seconds without employing a heat sink.

4.5.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be conducted as a case temperature ($T_C$) of +25°C.

4.5.4 Thermal resistance. Thermal resistance measurement shall be performed in accordance with method 3131 of MIL-STD-750 using the guidelines in that method for determining $I_M$, $I_H$, and $t_H$. Measurement delay time $t_{MD}$ = 70 ms max. Forced moving air or draft shall not be permitted across the devices during test.

* TABLE I. Group A inspection.

| Inspection 1/ | MIL-STD-750 | | Symbol | Limits | | Unit |
|---|---|---|---|---|---|---|
| | Method | Conditions | | Min | Max | |
| Subgroup 1 | | | | | | |
| Visual and mechanical examination | 2071 | | | | | |
| Subgroup 2 | | | | | | |
| Thermal impedance 2/ | 3131 | See 4.3.3 | $Z_{\theta JX}$ | | | °C /W |
| Breakdown voltage, collector to base | 3001 | Bias condition D, $I_C$ = 10 μA dc, $I_B$ = 0 | $V_{(BR)CBO}$ | 100 | | V dc |
| Breakdown voltage, collector to emitter | 3011 | Bias condition D, $I_C$ = 50 mA dc, pulsed (see 4.5.1) | $V_{(BR)CEO}$ | 80 | | V dc |
| Collector to emitter cutoff current | 3041 | Bias condition C, $V_{CE}$ = 80 V dc, $V_{BE}$ = 0 | $I_{CES1}$ | | 200 | nA dc |
| Collector to emitter cutoff current | 3041 | Bias condition D, $V_{CE}$ = 60 V dc, $I_B$ = 0 | $I_{CEO}$ | | 10 | μA dc |
| Emitter to base cutoff current | 3061 | Bias condition D, $V_{EB}$ = 5 V dc, $I_C$ = 0 | $I_{EBO1}$ | | 200 | nA dc |
| Emitter to base cutoff current | 3061 | Bias condition D, $V_{EB}$ = 8 V dc, $I_C$ = 0 | $I_{EBO2}$ | | 10 | μA dc |
| Base-emitter voltage (saturated) | 3066 | Test condition A, $I_C$ = 1 A dc, $I_B$ = 0.1 A dc, pulsed (see 4.5.1) | $V_{BE(sat)1}$ | 0.6 | 1.2 | V dc |
| Base-emitter voltage (saturated) | 3066 | Test condition A, $I_C$ = 5 A dc, $I_B$ = 0.5 A dc, pulsed (see 4.5.1) | $V_{BE(sat)2}$ | | 1.6 | V dc |
| Collector to emitter voltage (saturated) | 3071 | $I_C$ = 1 A dc; $I_B$ = 0.1 A dc, pulsed (see 4.5.1) | $V_{CE(sat)1}$ | | 0.25 | V dc |
| Collector to emitter voltage (saturated) | 3071 | $I_C$ = 5 A dc; $I_B$ = 0.5 A dc, pulsed (see 4.5.1) | $V_{CE(sat)2}$ | | 2 | V dc |

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

| Inspection 1/ | MIL-STD-750 | | Symbol | Limits | | Unit |
|---|---|---|---|---|---|---|
| | Method | Conditions | | Min | Max | |
| Subgroup 2 - Continued | | | | | | |
| Forward-current transfer ratio | 3076 | $V_{CE}$ = 2 V dc; $I_C$ = 50 mA dc, pulsed (see 4.5.1) | $h_{FE1}$ | | | |
| 2N3996, 2N3998 | | | | 30 | | |
| 2N3997, 2N3999 | | | | 60 | | |
| Forward-current transfer ratio | 3076 | $V_{CE}$ = 2 V dc; $I_C$ = 1 A dc, pulsed (see 4.5.1) | $h_{FE2}$ | | | |
| 2N3996, 2N3998 | | | | 40 | 120 | |
| 2N3997, 2N3999 | | | | 80 | 240 | |
| Forward-current transfer ratio | 3076 | $V_{CE}$ = 5 V dc; $I_C$ = 5 A dc, pulsed (see 4.5.1) | $h_{FE3}$ | | | |
| 2N3996, 2N3998 | | | | 15 | | |
| 2N3997, 2N3999 | | | | 20 | | |
| Subgroup 3 | | | | | | |
| High temperature operation | | $T_C$ = +150°C | | | | |
| Collector to emitter cutoff current | 3041 | Bias Condition C, $V_{CE}$ = 80 V dc, $V_{BE}$ = 0 | $I_{CES2}$ | | 50 | µA dc |
| Low-temperature operation | | $T_C$ = -55°C | | | | |
| Forward-current transfer ratio | 3076 | $V_{CE}$ = 2 V dc; $I_C$ = 1 A dc, pulsed (see 4.5.1) | $h_{FE4}$ | | | |
| 2N3996, 2N3998 | | | | 10 | | |
| 2N3997, 2N3999 | | | | 20 | | |

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

| Inspection 1/ | MIL-STD-750 | | Symbol | Limits | | Unit |
|---|---|---|---|---|---|---|
| | Method | Conditions | | Min | Max | |
| Subgroup 4 | | | | | | |
| Open circuit output capacitance | 3236 | $V_{CB}$ = 10 V dc; $I_E$ = 0; 100 kHz ≤ f ≤ 1 MHz | $C_{obo}$ | | 150 | pF |
| Magnitude of common emitter small-signal short circuit forward current transfer ratio | 3306 | $V_{CE}$ = 5 V dc; $I_C$ = 1 A dc; f = 10 MHz, (see 4.5.2) | $h_{fe}$ | 3 | 12 | |
| Switching parameters: | | | | | | |
| 2N3996 and 2N3998 | | | | | | |
| Pulse delay time | | See figure 7 | $t_d$ | | 100 | ns |
| Pulse rise time | | See figure 7 | $t_r$ | | 240 | ns |
| Pulse storage time | | See figure 7 | $t_s$ | | 1.4 | µs |
| Pulse fall time | | See figure 7 | $t_f$ | | .3 | µs |
| $t_{on}$ | | $t_d + t_r$ | $t_{on}$ | | .3 | µs |
| $t_{off}$ | | $t_s + t_f$ | $t_{off}$ | | 1.5 | µs |
| 2N3997 and 2N3999 | | | | | | |
| Pulse delay time | | See figure 7 | $t_d$ | | 100 | ns |
| Pulse rise time | | See figure 7 | $t_r$ | | 240 | ns |
| Pulse storage time | | See figure 7 | $t_s$ | | 1.75 | µs |
| Pulse fall time | | See figure 7 | $t_f$ | | .3 | µs |
| $t_{on}$ | | $t_d + t_r$ | $t_{on}$ | | .3 | µs |
| $t_{off}$ | | $t_s + t_f$ | $t_{off}$ | | 2.0 | µs |
| Subgroup 5 | | | | | | |
| Safe operating area (DC) | 3051 | $T_C$ = 100°C; power application time = 1.0 sec. (see figure 8) | | | | |
| Test 1 | | $V_{CE}$ = 80 V dc; $I_C$ = .080 A dc | | | | |
| Test 2 | | $V_{CE}$ = 20 V dc; $I_C$ = 1.5 A dc | | | | |

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

| Inspection 1/ | MIL-STD-750 | | Symbol | Limits | | Unit |
|---|---|---|---|---|---|---|
| | Method | Conditions | | Min | Max | |
| Subgroup 5 - continued | | | | | | |
| * Safe operating area (clamped inductive) | 3053 | (See figures 9 and 10); (clamped inductive load) $T_A$ = 25°C; $I_B$ = 0.5 A dc; $I_C$ = 5 A dc; $V_{CC}$ = 15 V dc: Load condition C | | | | |
| Electrical measurements | | See table I, subgroup 2 herein. | | | | |
| Subgroup 6 and 7 | | | | | | |
| Not applicable | | | | | | |

1/ For sampling plan, see MIL-PRF-19500.
2/ This test required for the following end-point measurements only:
Group B, subgroups 3, 4, and 5 (JANS).
Group B, subgroups 2 and 3 (JAN, JANTX, and JANTXV).
Group C, subgroup 2 and 6.
Group E, subgroup 1.

TABLE II. Groups A, B, C, and E delta measurements. 1/ 2/ 3/ 4/ 5/

| Step | Inspection | MIL-STD-750 | | Symbol | Limits | | Unit |
|---|---|---|---|---|---|---|---|
| | | Method | Conditions | | Min | Max | |
| 1. | Forward-current transfer ratio | 3076 | $V_{CE}$ = 2 V dc, $I_C$ = 1 A dc pulsed (see 4.5.1) | $\Delta h_{FE2}$ | | ±20 percent change from initial reading. | |
| 2. | Collector to emitter cutoff current | 3041 | Bias condition D; $V_{CE}$ = 60 V dc $I_B$ = 0 | $\Delta I_{CEO}$ | | 100 percent of initial value or 100 nA dc, whichever is greater. | |
| 3. | Collector to emitter voltage (saturated) | 3071 | $I_C$ = 1 A dc $I_B$ = 0.1 A dc pulsed (see 4.5.1) | $\Delta V_{CE(SAT)1}$ | | ±50 mV dc change from previously measured value. | |
| 4. | Thermal impedance | 3131 | See 4.3.3 | $\Delta Z_{\theta JX}$ | | 3.3 | °C/W |

1/ The devices which exceed the group A limits for this test shall not be acceptable.
2/ The delta measurements for table E-VIA (JANS) of MIL-PRF-19500 are as follows:
   a. Subgroups 4 and 5, see table II herein, steps 1 and 4.
   b. Subgroup 7, see table II herein, step 1.
3/ The delta measurements for table E-VIB (JAN, JANTX, and JANTXV) of MIL-PRF-19500 are as follows:
   a. Subgroup 3, see table II herein, steps 1 and 4.
   b. Subgroup 6, see table II herein, step 2.
   c. Subgroup 7, see table II herein, step 1.
4/ The delta measurements for table E-VII of MIL-PRF-19500 are as follows:
   a. Subgroup 2, see table II herein, step 3 for JANS.
   b. Subgroup 6, see table II herein, steps 1, 2, and 4 for JANS and steps 1 and 4 for JAN, JANTX, and JANTXV.
5/ The delta measurements for table E-IX of MIL-PRF-19500 are: Subgroup 1, see table II herein, all steps.

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

| Inspection | MIL-STD-750 | | Sample plan |
|---|---|---|---|
| | Method | Conditions | |
| Subgroup 1 | | | 45 devices<br>c = 0 |
| Temperature cycling | 1051 | 500 cycles minimum | |
| Hermetic seal<br>Fine leak<br>Gross leak | 1071 | | |
| Electrical measurements | | Table I, subgroup 2 and table II herein. | |
| Subgroup 2 | | | 45 devices<br>c = 0 |
| Blocking life | 1048 | Test temperature = +125°C, $V_{CB}$ = 80 percent of rated, T = 1,000 hours. | |
| Electrical measurements | | Table I, subgroup 2. | |
| Subgroup 4 | | | Sample size<br>N/A |
| Thermal impedance curves | | See MIL-PRF-19500. | |
| Subgroup 8 | | | 22 devices<br>c = 0 |
| Reverse stability | 1033 | Condition B | |

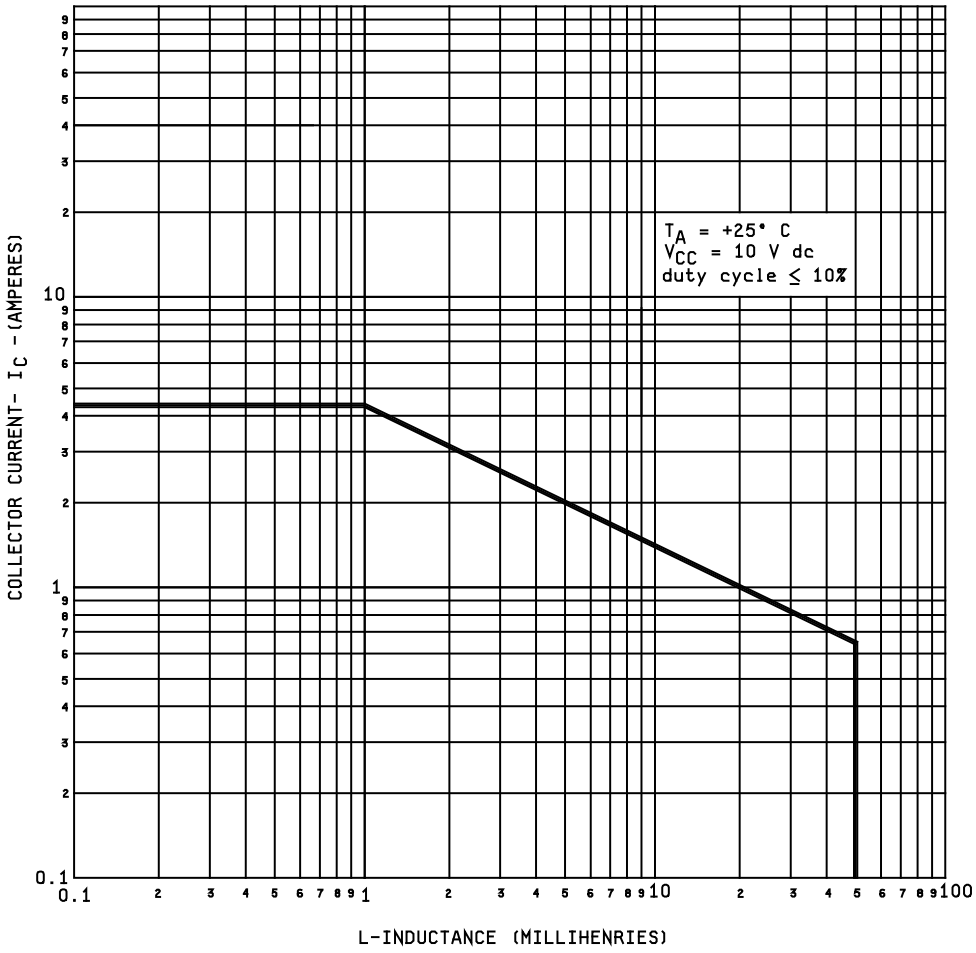
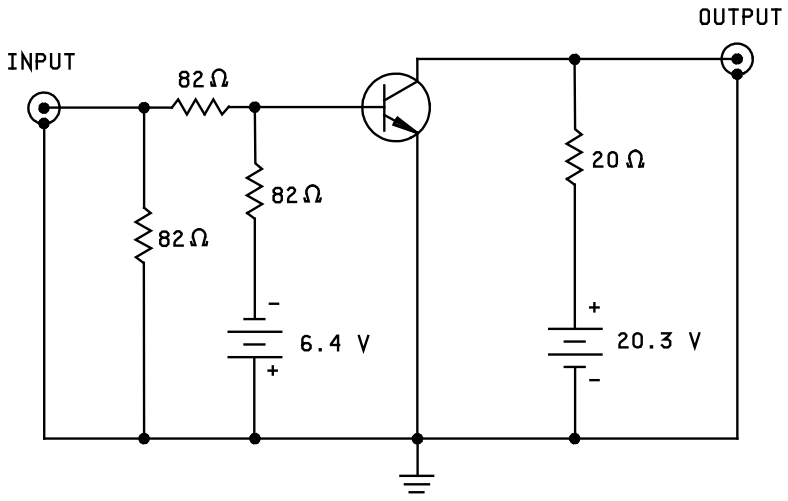
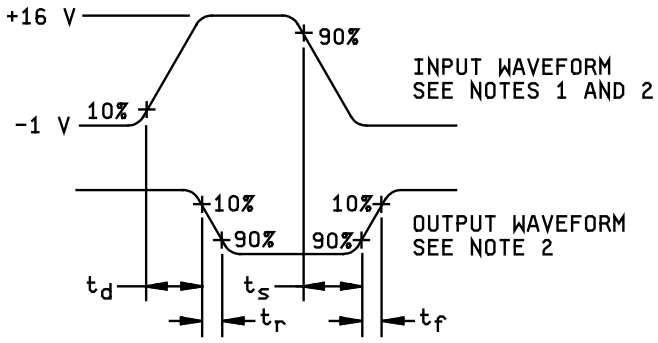



FIGURE 6. Safe operating area for switching between saturation and cutoff - unclamped inductive load.




NOTES:

1. The input waveform is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\ \Omega$, pW = 2 μs, duty cycle ≤ 2 percent.
2. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 10\ M\Omega$, $C_{in} \leq 11.5$ pF.
3. Resistors must be non-inductive types.
4. The d-c power supplies may require additional by-passing in order to minimize ringing.

FIGURE 7. Pulse response test circuit.

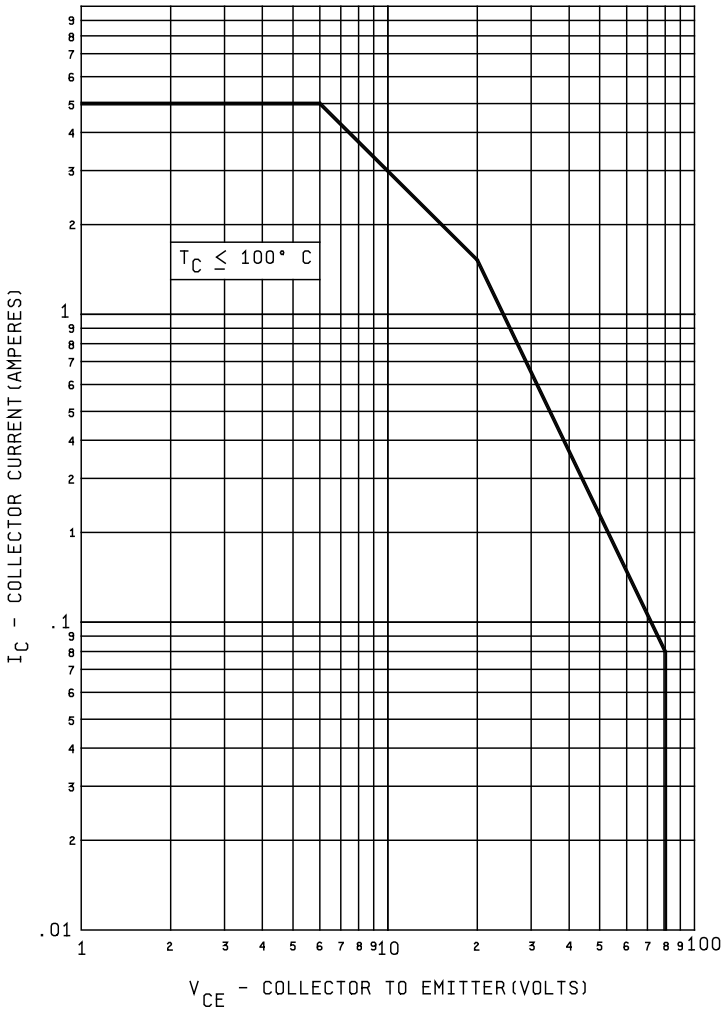
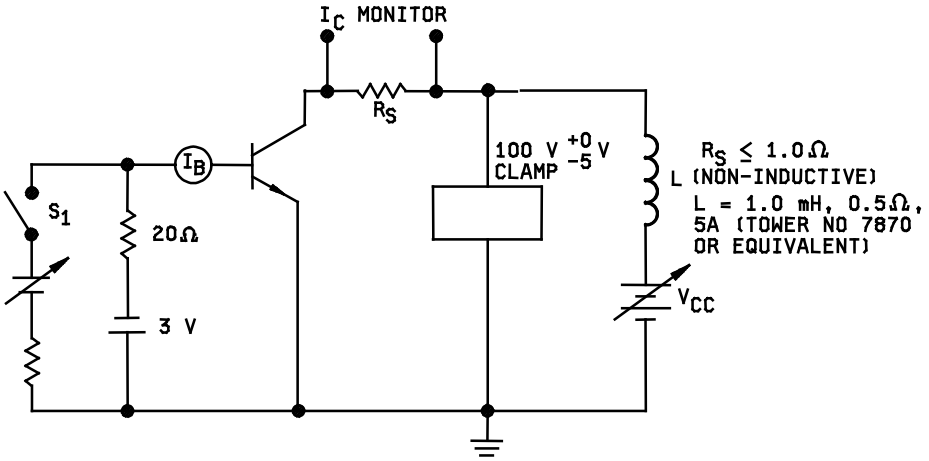



FIGURE 8. Maximum safe operating area graph (dc).




Procedure:

1. With switch $S_1$ closed, set the specified test conditions.
2. Open $S_1$. Device fails if clamp voltage not reached.
3. Perform specified end point test.

FIGURE 9. Clamped inductive sweep test circuit.

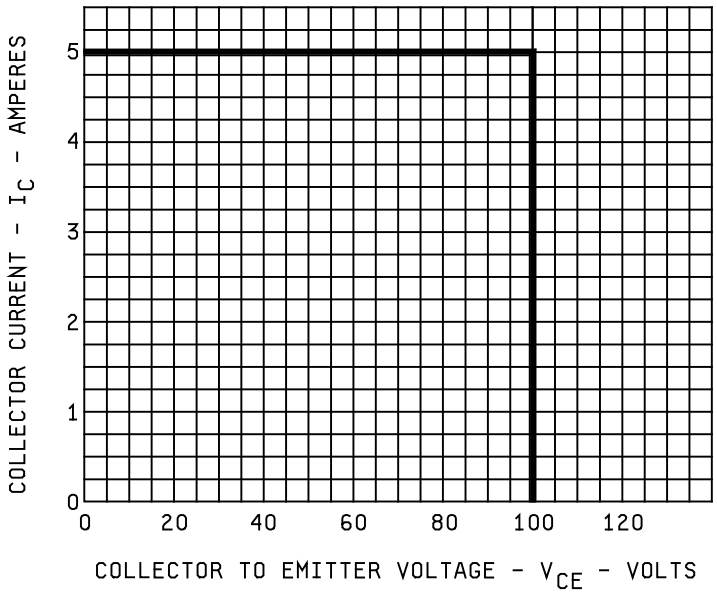



FIGURE 10. Safe operating area for switching between saturation and cutoff - clamped inductive load.

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).

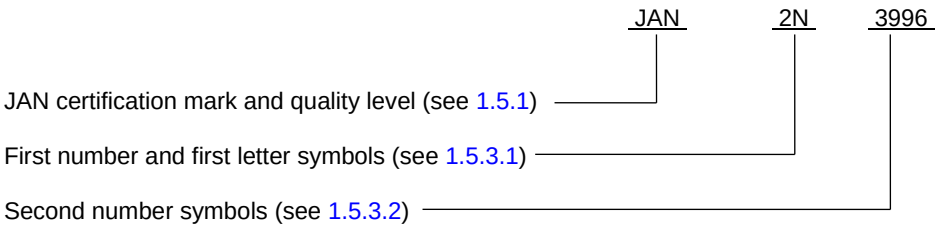
c. Lead finish (see 3.4.1).

* d. The complete Part or Identifying Number (PIN), see 1.5.

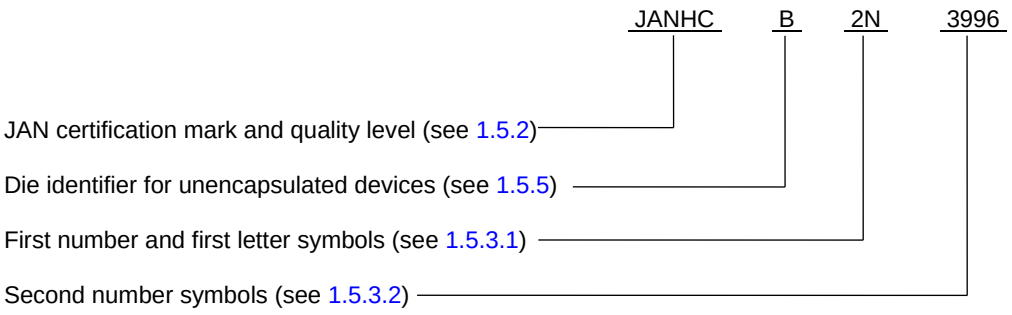
* 6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Manufacturers List (QML 19500) whether or not such products have actually been so listed by that date. The attention 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://assist.dla.mil .

* 6.4 PIN construction example.

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



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




* 6.5 List of PINs.

* 6.5.1 List of PINs for unencapsulated devices. The following is a list of possible PINs for encapsulated devices 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 |
|---|---|---|---|
| JAN2N3996 | JANTX2N3996 | JANTXV2N3996 | JANS2N3996 |
| JAN2N3997 | JANTX2N3997 | JANTXV2N3997 | JANS2N3997 |
| JAN2N3998 | JANTX2N3998 | JANTXV2N3998 | JANS2N3998 |
| JAN2N3999 | JANTX2N3999 | JANTXV2N3999 | JANS2N3999 |

* 6.5.2 PINs for unencapsulated devices (die). The following is a list of possible PINs for unencapsulated devices available on this specification sheet. The qualified JANHC and JANKC suppliers with the applicable letter version (example JANHCB2N3996) will be identified on the QML.

| Die ordering information | | | |
|---|---|---|---|
| Pin | Manufacturer | | |
| | 33178 (1) | 34156 | 43611 |
| 2N3996 | JANHCA2N3996 | JANHCB2N3996<br>JANKCB2N3996 | JANHCC2N3996 |
| 2N3997 | JANHCA2N3997 | JANHCB2N3997<br>JANKCB2N3997 | JANHCC2N3997 |
| 2N3998 | JANHCA2N3998 | JANHCB2N3998<br>JANKCB2N3998 | JANHCC2N3998 |
| 2N3999 | JANHCA2N3999 | JANHCB2N3999<br>JANKCB2N3999 | JANHCC2N3999 |

(1) This die version is no longer manufactured.

6.6 Changes from previous issue. The margins of this specification are marked with asterisks to indicate where changes from the previous issue were made. 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 last previous issue.

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(Project 5961-2014-108)

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