

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, HIGH-POWER TYPES 2N1487, 2N1488, 2N1489, AND 2N1490

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

1. SCOPE

1.1 Scope. This specification covers the detail requirements for a silicon, NPN, high-power transistor.

1.2 Physical dimensions. See figure 1 (TO-3).

1.3 Maximum ratings.

| P _C 1/ T _C = 25°C | V _{CBO} | | V _{EBO} | V _{CEO} | | V _{CEX} | | I _C | I _B | T _{stg} | θ _{J-C} | T _J |
|--------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|----------------|----------------|------------------|------------------|----------------|
| | 2N1487 2N1489 | 2N1488 2N1490 | | 2N1487 2N1489 | 2N1488 2N1490 | 2N1487 2N1489 | 2N1488 2N1490 | | | | | |
| <u>W</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Adc</u> | <u>Adc</u> | <u>°C</u> | <u>°C/W</u> | <u>°C</u> |
| 75 | 60 | 100 | 10 | 40 | 55 | 60 | 100 | 6 | 3 | -65 to +200 | 2.33 | +200 |

1/ Derate linearly 0.429 W/°C for T_C > 25°C.

1.4 Primary electrical characteristics.

| | h _{FE} 1/ V _{CE} = 4.0 Vdc I _C = 1.5 Adc | | V _{CE} (sat) 1/ I _C = 1.5 Adc | | V _{BE} 1/ V _{CE} = 4.0 Vdc I _C = 1.5 Adc | | I _{CBO} V _{CB} = 30 Vdc | I _{EBO} V _{EB} = 10 Vdc | f _{hfb} V _{CE} = 12 Vdc I _C = 100 mAdc |
|-----|-----------------------------------------------------------------------------|------------------|------------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------|------------------|----------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------|
| | 2N1487 2N1488 | 2N1489 2N1490 | I _B = 300 mAdc 2N1487 2N1488 | I _B = 100 mAdc 2N1489 2N1490 | 2N1487 2N1488 | 2N1489 2N1490 | | | |
| | | | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>μAdc</u> | <u>μAdc</u> | <u>kc</u> |
| Min | 15 | 25 | --- | --- | --- | --- | --- | --- | 500 |
| Max | 45 | 75 | 3.0 | 1.0 | 3.0 | 2.0 | 25 | 25 | --- |

1/ Pulsed (see 4. 4. 1).

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein.

SPECIFICATION

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for.

STANDARDS

MILITARY

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-750 - Test Methods for Semiconductor Devices.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 General. Requirements shall be in accordance with MIL-S-19500, and as specified herein.

3.2 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined in MIL-S-19500.

3.3 Design, construction, and physical dimensions. The transistors shall be of the design, construction, and physical dimensions shown on figure 1.

3.4 Performance characteristics. Performance characteristics shall be as specified in tables I, II, and III.

3.5 Marking. The following marking specified in MIL-S-19500 may be omitted from the body of the transistor at the option of the manufacturer:

- (a) Country of origin.
- (b) Manufacturer's identification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be in accordance with MIL-S-19500, and as specified herein.

4.2 Qualification inspection. Qualification inspection shall consist of the examinations and tests specified in tables I, II, and III.

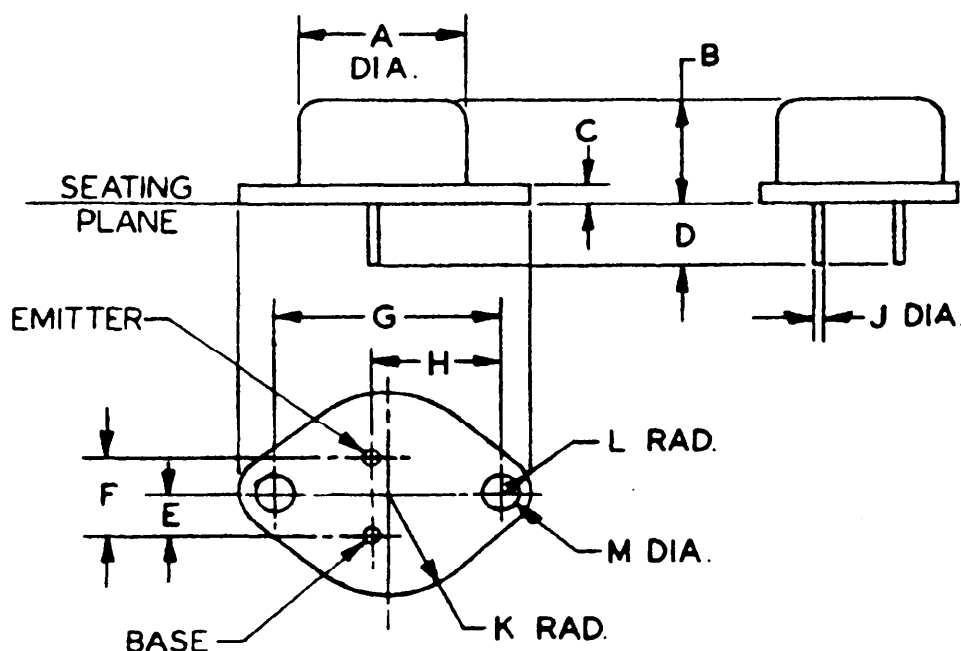
4.3 Quality conformance inspection. Quality conformance inspection shall consist of groups A, B, and C inspections.

4.3.1 Group A inspection. Group A inspection shall consist of the examinations and tests specified in table I.

4.3.2 Group B inspection. Group B inspection shall consist of the examinations and tests specified in table II.

4.3.3 Group C inspection. Group C inspection shall consist of the examinations and tests specified in table III. This inspection shall be conducted on the initial lot and thereafter every 6 months during production.

4.3.4 Group B and group C life-test samples. Samples that have been subjected to group B, 340-hours life-test, may be continued on test to 1000-hours in order to satisfy group C life-test requirements. These samples shall be predesignated, and shall remain subjected to the group C 1,000-hour acceptance evaluation after they have passed the group B, 340-hour acceptance criteria. The cumulative total of failures found during 340-hour test and during the subsequent interval up to 1,000 hours shall be computed for 1,000-hour acceptance criteria.



NOTES:

1. Metric equivalents (to the nearest .01 mm) are given for general information only and are based upon 1 inch = 25.4 mm.
2. This dimension should be measured at points .050 (1.27 mm) to .055 (1.40 mm) below seating plane. When gage is not used, measurement will be made at seating plane.
3. Two leads.
4. Collector shall be electrically connected to the case.

| DIMENSIONS | | | | | NOTES |
|------------|--------|-------|-------------|-------|-------|
| LTR | INCHES | | MILLIMETERS | | |
| | MIN | MAX | MIN | MAX | |
| A | | .875 | | 22.23 | |
| B | .250 | .450 | 6.35 | 11.43 | |
| C | | .135 | | 3.43 | |
| D | .312 | | 7.92 | | 3 |
| E | .205 | .225 | 5.21 | 5.72 | |
| F | .420 | .440 | 10.67 | 11.18 | |
| G | 1.177 | 1.197 | 29.90 | 30.40 | |
| H | .665 | .675 | 16.64 | 17.15 | 2 |
| J | .038 | .043 | .97 | 1.09 | 3 |
| K | | .525 | | 13.34 | |
| L | | .188 | | 4.78 | |
| M | .151 | .161 | 3.84 | 4.09 | |

FIGURE 1. Physical dimensions of transistor types 2N1487, 2N1488, 2N1489 and 2N1490 (TO-3).

4.4 Methods of examination and test. Methods of examination and test shall be as specified in tables I, II, and III.

4.4.1 Pulse measurements. Conditions for pulse measurement shall be as specified in section 4 of MIL-STD-750.

4.4.2 Interval for end-point test measurements. End-point tests shall be completed within the following time limitations, after completion of the last test in the subgroup:

- (a) Qualification inspection: within 24 hours.
- (b) Quality conformance inspection: within 96 hours.

TABLE I. Group A inspection

| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|-----------------------------------------|-------------|---------------------------------------------------------------------------|------|------------|--------|-----|-----------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 1</u> | | | 10 | | | | |
| Visual and mechanical examination | 2071 | | | --- | --- | --- | --- |
| <u>Subgroup 2</u> | | | 5 | | | | |
| Breakdown voltage, collector to emitter | 3011 | Bias cond. D; $I_C = 100 \text{ mAdc}$; pulsed (see 4.4.1) | | BV_{CEO} | | | |
| 2N1487, 2N1489 | | | | | 40 | --- | Vdc |
| 2N1488, 2N1490 | | | | | 55 | --- | Vdc |
| Breakdown voltage, collector to base | 3001 | Bias cond. D; $I_C = 200 \mu\text{Adc}$ | | BV_{CBO} | | | |
| 2N1487, 2N1489 | | | | | 60 | --- | Vdc |
| 2N1488, 2N1490 | | | | | 100 | --- | Vdc |
| Breakdown voltage, collector to emitter | 3011 | Bias cond. A; $V_{EB} = 1.5 \text{ Vdc}$; $I_C = 0.5 \text{ mAdc}$ | | BV_{CEX} | | | |
| 2N1487, 2N1489 | | | | | 60 | --- | Vdc |
| 2N1488, 2N1490 | | | | | 100 | --- | Vdc |
| Collector to base cutoff current | 3036 | Bias cond. D; $V_{CB} = 30 \text{ Vdc}$ | | I_{CBO} | --- | 25 | μAdc |
| Emitter to base cutoff current | 3061 | Bias cond. D; $V_{EB} = 10 \text{ Vdc}$ | | I_{EBO} | --- | 25 | μAdc |
| <u>Subgroup 3</u> | | | 5 | | | | |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4.0 \text{ Vdc}$; $I_C = 1.5 \text{ Adc}$; pulsed (see 4.4.1) | | h_{FE} | | | |
| 2N1487, 2N1488 | | | | | 15 | 45 | --- |
| 2N1489, 2N1490 | | | | | 25 | 75 | --- |

TABLE I. Group A inspection - Continued

| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|----------------------------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------|--------|-----|-----------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 3 - Continued</u> | | | | | | | |
| Collector to emitter voltage (saturated) | 3071 | | | $V_{CE}^{(sat)}$ | | | |
| 2N1487, 2N1488 | | $I_C = 1.5 \text{ Adc}; I_B = 300 \text{ mAdc};$ pulsed (see 4.4.1) | | | --- | 3.0 | Vdc |
| 2N1489, 2N1490 | | $I_C = 1.5 \text{ Adc}; I_B = 100 \text{ mAdc};$ pulsed (see 4.4.1) | | | --- | 1.0 | Vdc |
| Base emitter voltage (nonsaturated) | 3066 | Test cond. B, $V_{CE} = 4.0 \text{ Vdc}; I_C = 1.5 \text{ Adc};$ pulsed (see 4.4.1) | | V_{BE} | | | |
| 2N1487, 2N1488 | | | | | --- | 3.0 | Vdc |
| 2N1489, 2N1490 | | | | | --- | 2.0 | Vdc |
| <u>Subgroup 4</u> | | | | | | | |
| Small-signal short-circuit forward-current transfer-ratio cutoff frequency | 3301 | $V_{CB} = 12 \text{ Vdc}; I_C = 100 \text{ mAdc};$ | 10 | f_{hfb} | 500 | --- | kc |
| Open-circuit output capacitance | 3236 | $V_{CB} = 10 \text{ Vdc}; I_E = 0;$ $100 \text{ kHz} \leq f \leq 1 \text{ MHz}$ | | C_{obo} | --- | 700 | pf |
| Pulse response | 3251 | Test cond. A; $V_{CC} = 12 \text{ Vdc};$ $I_B^{(0)} = I_B^{(2)} = 150 \text{ mAdc};$ $I_B^{(1)} = 300 \text{ mAdc};$ $R_C = 7.8 \text{ ohms}$ | | $t_{on} + t_{off}$ | --- | 25 | μsec |
| <u>Subgroup 5</u> | | | | | | | |
| High-temperature operation: | | $T_A = +175^\circ\text{C}$ | 15 | | | | |
| Collector to base cutoff current | 3036 | Bias cond. D; $V_{CB} = 30 \text{ Vdc}$ | | I_{CBO} | --- | 1.0 | mAdc |
| Low-temperature operation: | | $T_A = -55^\circ\text{C}$ | | | | | |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4.0 \text{ Vdc}; I_C = 1.5 \text{ Adc};$ pulsed (see 4.4.1) | | h_{FE} | | | |
| 2N1487, 2N1488 | | | | | 10 | --- | --- |
| 2N1489, 2N1490 | | | | | 15 | --- | --- |

TABLE II. Group B inspection

| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|-------------------------------------|-------------|-----------------------------------------------------------------------------------------------|------|-----------|--------|--------------------|------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 1</u> | | | 20 | | | | |
| Physical dimensions | 2066 | (See figure 1) | | --- | --- | --- | --- |
| <u>Subgroup 2</u> | | | 15 | | | | |
| Solderability | 2026 | Omit aging; dwell time = 10 ± 1 sec | | --- | --- | --- | --- |
| Thermal shock (temperature cycling) | 1051 | Test cond. C | | --- | --- | --- | --- |
| Thermal shock (glass strain) | 1056 | Test cond. B | | --- | --- | --- | --- |
| Terminal strength (tension) | 2036 | Test cond. A; weight = 10 lbs; time = 15 sec | | --- | --- | --- | --- |
| Terminal strength (lead torque) | 2036 | Test cond. D1; torque = 6 in-oz; time = 15 sec | | --- | --- | --- | --- |
| Seal (leak-rate) | --- | MIL-STD-202, method 112, test cond. C, procedure III; test cond. A for gross leaks | | --- | --- | 5×10^{-7} | atm cc/sec |
| Moisture resistance | 1021 | Omit initial conditioning | | --- | --- | --- | --- |
| End points: (See 4.4.2.) | | | | | | | |
| Collector to base cutoff current | 3036 | Bias cond. D; $V_{CB} = 30$ Vdc | | I_{CBO} | --- | 25 | μ Adc |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4.0$ Vdc; $I_C = 1.5$ Adc | | h_{FE} | | | |
| 2N1487, 2N1488 | | | | | 15 | 45 | --- |
| 2N1489, 2N1490 | | | | | 25 | 75 | --- |
| <u>Subgroup 3</u> | | | 10 | | | | |
| Shock | 2016 | Nonoperating; 500 G, 1.0 msec, 5 blows in each orientation: X_1 , Y_1 , Y_2 , and Z_1 | | --- | --- | --- | --- |
| Vibration fatigue | 2046 | Nonoperating | | --- | --- | --- | --- |
| Vibration, variable frequency | 2056 | | | --- | --- | --- | --- |
| Constant acceleration | 2006 | 5000 G in each orientation: X_1 , Y_1 , Y_2 , and Z_1 | | --- | --- | --- | --- |
| End points: | | | | | | | |
| (Same as for subgroup 2) | | | | | | | |

TABLE II. Group B inspection - Continued

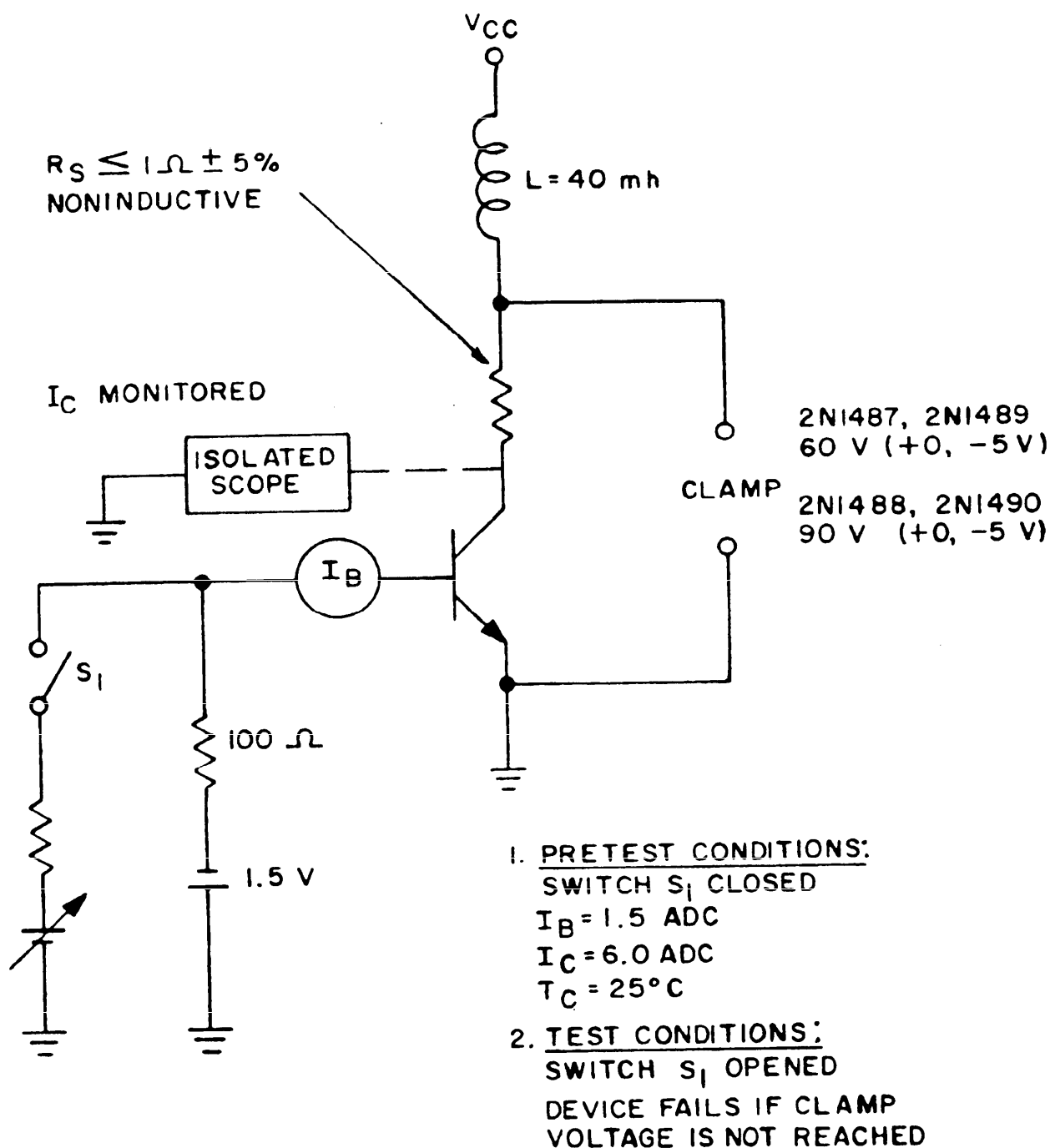
| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|-----------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------|--------|-----|-----------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 4</u> | | | 20 | | | | |
| Salt atmosphere (corrosion) | 1041 | | | --- | --- | --- | --- |
| End points: (Same as for subgroup 2) | | | | | | | |
| <u>Subgroup 5</u> | | | 10 | | | | |
| Burnout by pulsing | 3005 | Prepulse cond.: $T_A = 25^\circ\text{C}$; $V_{CE} = 0$; $I_C = 0$ Pulse cond.: $T_A = 25^\circ\text{C}$; $t_p = 1$ sec; test cycles = 1 | | | | | |
| Test #1 (All types) | | $V_{CE} = 12.5$ Vdc; $I_C = 6.0$ Adc | | --- | --- | --- | --- |
| Test #2 2N1487, 2N1489 | | $V_{CE} = 40$ Vdc; $I_C = 1.875$ Adc | | --- | --- | --- | --- |
| Test #3 2N1488, 2N1490 | | $V_{CE} = 55$ Vdc; $I_C = 1.36$ Adc | | --- | --- | --- | --- |
| End points: (Same as for subgroup 2) | | | | | | | |
| <u>Subgroup 6</u> | | | 10 | | | | |
| Clamped-inductive sweep test | --- | (See figure 2) | | --- | --- | --- | --- |
| Unclamped-inductive sweep test | --- | (See figure 3 and 4) | | --- | --- | --- | --- |
| End points: (Same as for subgroup 2) | | | | | | | |
| <u>Subgroup 7</u> | | | 7 | | | | |
| High-temperature life (nonoperating) | 1031 | $T_{stg} = +200^\circ\text{C}$; time = 340 hours (see 4.3.4) | | --- | --- | --- | --- |
| End points: (See 4.4.2.) | | | | | | | |
| Collector to base cutoff current | 3036 | Bias cond. D; $V_{CB} = 30$ Vdc | | I_{CBO} | --- | 50 | μAdc |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4.0$ Vdc; $I_C = 1.5$ Adc | | h_{FE} | | | |
| 2N1487, 2N1488 | | | | | 10 | 70 | --- |
| 2N1489, 2N1490 | | | | | 18 | 115 | --- |

TABLE II. Group B inspection - Continued

| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|-------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------|--------|-----|------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 8</u> Steady-state operation life End points: (Same as for subgroup 7) | 1026 | $100^{\circ} \text{C} \leq T_C \leq 125^{\circ} \text{C};$ $V_{CE} = 24 \text{ Vdc};$ $P_C = 32 \text{ W} + \frac{125^{\circ} \text{C} - T_C}{2.33^{\circ} \text{C/W}}$ time = 340 hours (see 4.3.4) | 10 | --- | --- | --- | --- |

TABLE III. Group C inspection

| Examination or test | MIL-STD-750 | | LTPD | Symbol | Limits | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|--------|------|----------------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 1</u> Barometric pressure, reduced (altitude operation) Measurement during above test: Collector to base cutoff current 2N1487, 2N1489 2N1488, 2N1490 Thermal resistance (junction to case) | 1001 | Pressure = 8 mm Hg, normal mounting; time = 1 minute | 20 | --- | --- | --- | --- |
| | 3036 | Bias cond. D $V_{CB} = 60 \text{ Vdc}$ $V_{CB} = 100 \text{ Vdc}$ | $\lambda = 10$ | I_{CBO} | --- | 200 | μAdc |
| | | | | | --- | 200 | μAdc |
| | 3151 | | | θ_{J-C} | --- | 2.33 | $^{\circ}\text{C/W}$ |
| <u>Subgroup 2</u> High-temperature life (nonoperating) End points: (See 4.4.2.) Collector to base cutoff current Forward-current transfer ratio 2N1487, 2N1488 2N1489, 2N1490 | 1031 | $T_{stg} = +200^{\circ} \text{C}$ (see 4.3.4) | $\lambda = 10$ | | | | |
| | 3036 | Bias cond. D; $V_{CB} = 30 \text{ Vdc}$ | | I_{CBO} | --- | 50 | μAdc |
| | 3076 | $V_{CE} = 4.0 \text{ Vdc}; I_C = 1.5 \text{ Adc}$ | | h_{FE} | 10 | 70 | --- |
| | | | | | 18 | 115 | --- |
| <u>Subgroup 3</u> Steady-state operation life End points: (Same as for subgroup 2) | 1026 | $100^{\circ} \text{C} \leq T_C \leq 125^{\circ} \text{C};$ $V_{CE} = 24 \text{ Vdc};$ $P_C = 32 \text{ W} + \frac{125^{\circ} \text{C} - T_C}{2.33^{\circ} \text{C/W}}$ (see 4.3.4) | $\lambda = 10$ | --- | --- | --- | --- |

FIGURE 2. Clamped-inductive sweep test circuit.

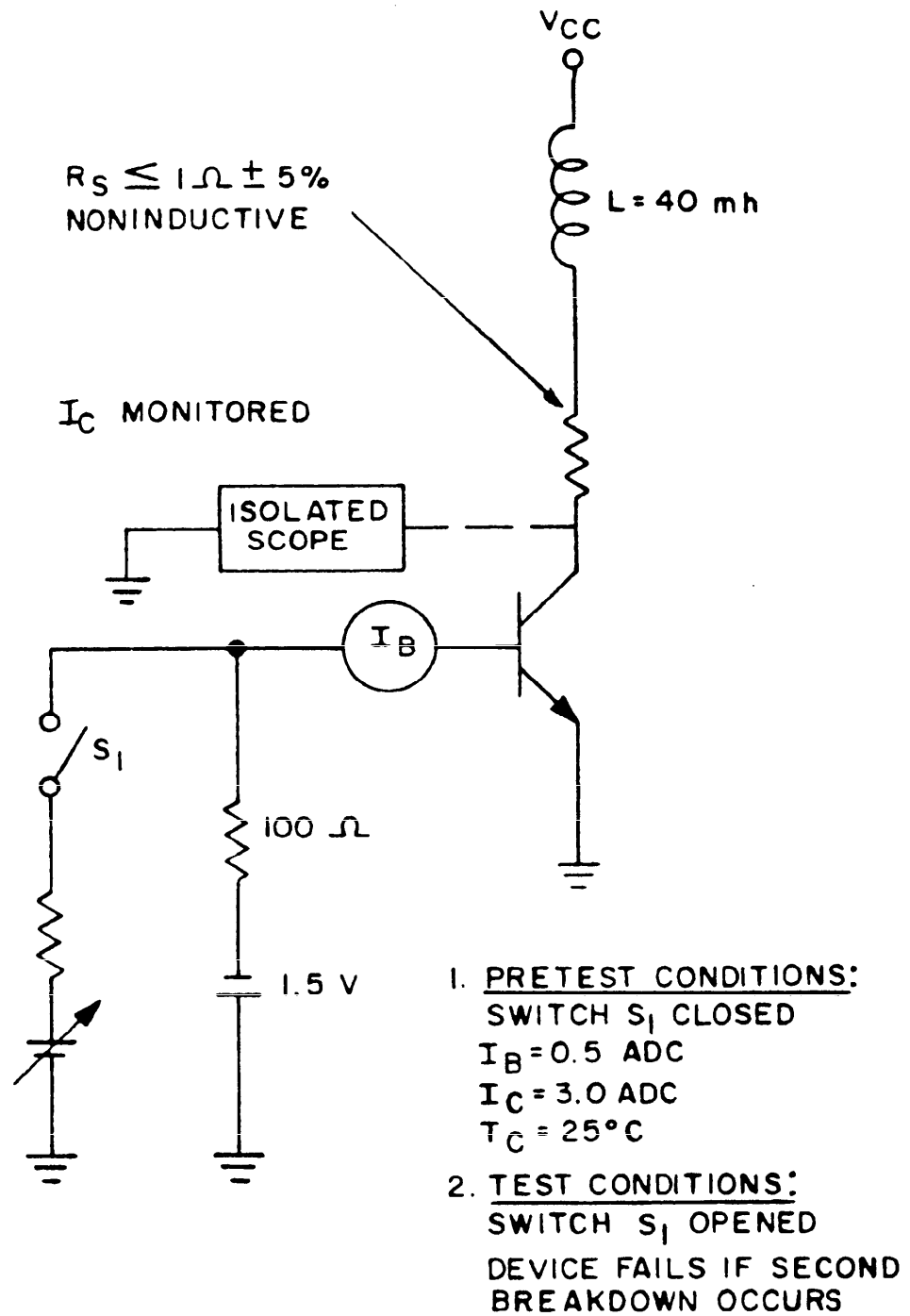
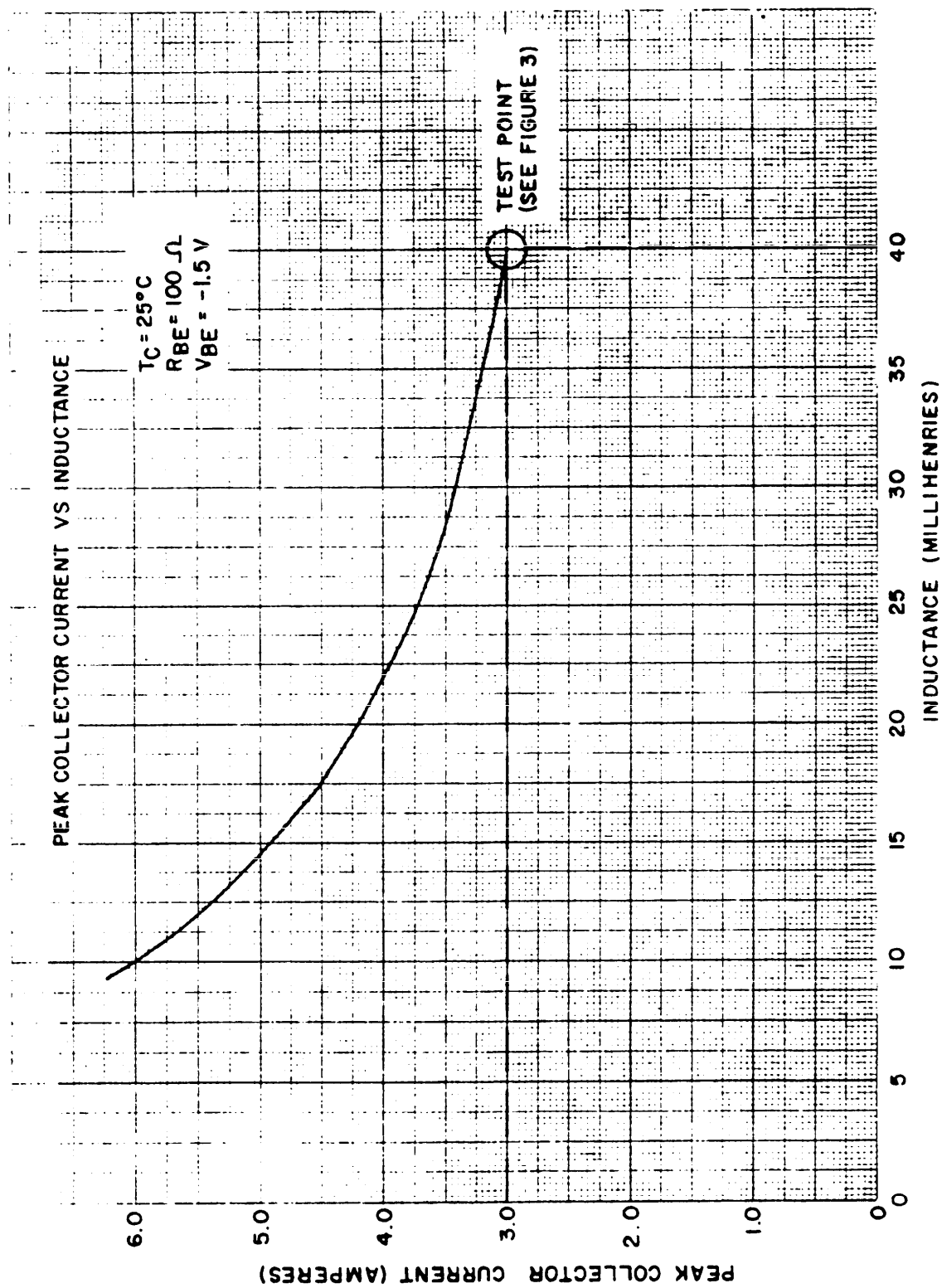


FIGURE 3. Unclamped-inductive sweep test circuit.

FIGURE 4. Unclamped inductive sweep test curve.

5. PREPARATION FOR DELIVERY

5.1 See MIL-S-19500, section 5.

6. NOTES

6.1 Notes. The notes specified in MIL-S-19500 are applicable to this specification.

6.2 Types covered by superseded specification. Transistor types 2N1511 through 2N1514 have been deleted from this specification. These types (TO-36 case) are no longer manufactured. Transistor types 2N1487 through 2N1490, respectively, are electrically interchangeable with the deleted types and, with suitable mounting modifications, may be used as replacement items. Types having the "USA" prefix are interchangeable with those of corresponding type designation.

6.2.1 Disposition of deleted types. Types 2N1511 through 2N1514, as specified in the superseded specification, may be issued until present stock is depleted.

6.3 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians:

Army - EL
Navy - SH
Air Force - 11

Preparing activity:

Army - EL

(Project 5961-0009-3)

Review activities:

Army - EL, MU, MI
Navy - SH
Air Force - 11, 17, 85

Code "C"

User activities:

Army - EL, SM
Navy - CG, MC, AS, OS
Air Force - 19

| SPECIFICATION ANALYSIS SHEET | | Form Approved Budget Bureau No. 119-R004 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------|
| <p style="text-align: center;">INSTRUCTIONS</p> <p>This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity.</p> | | |
| SPECIFICATION | | |
| ORGANIZATION | CITY AND STATE | |
| CONTRACT NO. | QUANTITY OF ITEMS PROCURED | DOLLAR AMOUNT \$ |
| MATERIAL PROCURED UNDER A | | |
| <input type="checkbox"/> DIRECT GOVERNMENT CONTRACT <input type="checkbox"/> SUBCONTRACT | | |
| <p>1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?</p> <p style="margin-left: 40px;">A. GIVE PARAGRAPH NUMBER AND WORDING.</p> | | |
| <p style="margin-left: 40px;">B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES</p> | | |
| 2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID | | |
| <p>3. IS THE SPECIFICATION RESTRICTIVE?</p> <p style="margin-left: 40px;"> <input type="checkbox"/> YES <input type="checkbox"/> NO IF "YES", IN WHAT WAY? </p> | | |
| <p>4. REMARKS (Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)</p> | | |
| SUBMITTED BY (Printed or typed name and activity) | | DATE |

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