

MIL-S-19500/102A

29 December 1966

SUPERSEDING

MIL-S-19500/102 (NAVY)

19 July 1962

(See 6.2)

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTORS, NPN, SILICON, HIGH-POWER

TYPES 2N1016B, 2N1016C, AND 2N1016D

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 high-power, NPN, silicon transistor.

1.2 Physical dimensions. See figure 1.

1.3 Maximum ratings.

| Type | $P_C \frac{1}{T_C = 45^\circ C}$ | V_{CBO} | V_{EBO} | V_{CEO} | I_C | T_{stg} | T_J |
|---------|----------------------------------|------------|------------|------------|------------|-------------|-----------|
| | <u>W</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Vdc</u> | <u>Adc</u> | <u>°C</u> | <u>°C</u> |
| 2N1016B | 150 | 100 | 25 | 100 | 7.5 | -65 to +150 | +150 |
| 2N1016C | 150 | 150 | 25 | 150 | 7.5 | -65 to +150 | +150 |
| 2N1016D | 150 | 200 | 25 | 200 | 7.5 | -65 to +150 | +150 |

^{1/} Derate linearly 1.428 W/°C for $T_C > 45^\circ C$.

1.4 Primary electrical characteristics.

| | h_{FE} $I_C = 2.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$ | h_{FE} $I_C = 5.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$ | h_{fe} $I_C = 5.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$ | $V_{CE(sat)}$ $I_C = 5.0 \text{ Adc}$ $I_B = 1.0 \text{ Adc}$ | f_{hfe} $I_C = 5.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$ | θ_{J-C} |
|------|---|---|---|---|--|----------------|
| | | | | <u>Vdc</u> | <u>kc</u> | <u>°C/W</u> |
| Min. | 20 | 10 | 5 | --- | 20 | --- |
| Max. | 80 | 35 | --- | 2.5 | --- | 0.7 |

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.

FSC 5961

MIL-S-19500/102A

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.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NATIONAL BUREAU OF STANDARDS

Handbook H28 - Screw-Thread Standards for Federal services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)

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. 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:

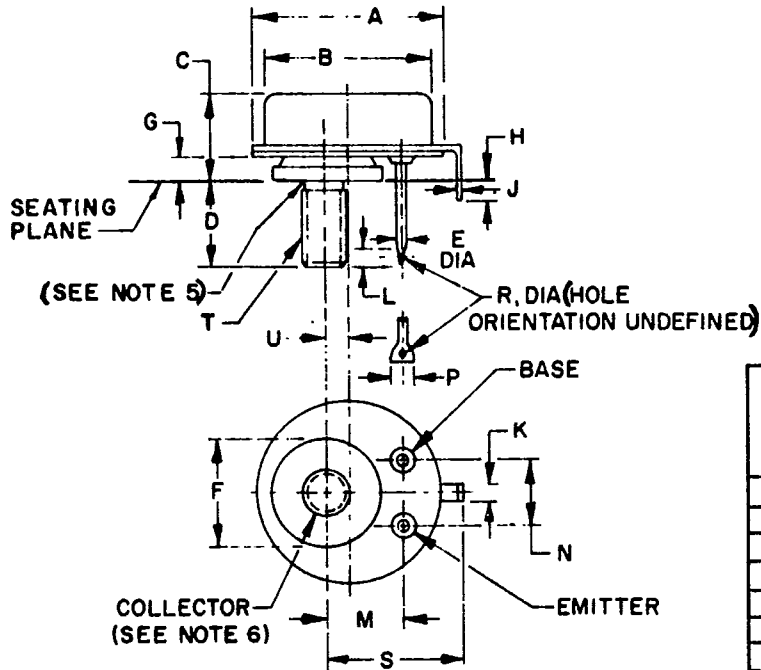
- (a) Country of origin.
- (b) Manufacturer's identification.

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.



| Ltr | Dimensions in inches with metric equivalents (mm) in parentheses (see note 2) | | Notes |
|-----|---|---------------|-------|
| | Minimum | Maximum | |
| A | 1.24 (31.50) | 1.28 (32.51) | |
| B | | 1.130 (28.70) | |
| C | .50 (12.70) | .56 (14.22) | |
| D | .55 (13.97) | .58 (14.73) | |
| E | .045 (1.14) | .055 (1.40) | 4 |
| F | .73 (18.54) | .77 (19.56) | |
| G | .11 (2.79) | .14 (3.56) | |
| H | .13 (3.30) | .19 (4.83) | |
| J | .014 (.36) | .024 (.61) | |
| K | .14 (3.56) | .17 (4.32) | |
| L | .10 (2.54) | .14 (3.56) | |
| M | .48 (12.19) | .52 (13.21) | |
| N | .35 (8.89) | .40 (10.16) | |
| P | .09 (2.29) | .11 (2.79) | 4 |
| R | .050 (1.27) | .060 (1.52) | |
| S | .81 (20.57) | .85 (21.59) | |
| T | | | 3 |
| U | .14 (3.56) | .17 (4.32) | |

NOTES:

1. Dimensions are in inches.
2. Metric equivalents (to the nearest .01 mm) are given for general information only and are based upon 1 inch = 25.4 mm.
3. See NBS Handbook H28. 5/16 - 24 UNF-2A.
4. Two leads.
5. Reference point for temperature measurement.
6. Collector shall be internally connected to the mounting base.

FIGURE 1. Outline dimensions of transistor types 2N1016B, 2N1016C and 2N1016D.

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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. Upon failure of any Group C subgroups or upon determination by the inspector that Group C tests are not being met, the inspector shall require lot by lot inspection for a minimum of 3 consecutive lots on the failing Group C subgroups.

4.3.4 Group B and group C life-test samples. Samples that have been subjected to group B, 340-hour life-test, may be continued on test for 1,000-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, see 4.3.3.

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 Terminal strength (stud torque). Acceptance criteria after the stud torque test for external threaded parts (dimension "T" of figure 1) shall be in accordance with handbook H28.

4.4.2 Solderability. The solderability test shall apply to the two, lug-terminals only. The depth of immersion is to be within 1/4-inch of the seating plane. Acceptance criteria shall be that each termination is 95-percent covered by a continuous new solder coating to within 3/8-inch \pm 1/32-inch of the seating plane.

TABLE I. Group A inspection.

| Examination or test | MIL-STD-750 | | L T P D | 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; $I_C = 200 \text{ mAdc}$ | | BV_{CEO} | | | |
| 2N1016B | | | | | 100 | --- | Vdc |
| 2N1016C | | | | | 150 | --- | Vdc |
| 2N1016D | | | | | 200 | --- | Vdc |
| Collector to emitter cutoff current | 3041 | Bias cond. A; $V_{EB} = 1.5 \text{ Vdc}$ | | I_{CEX} | | | |
| 2N1016B | | $V_{CE} = 100 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016C | | $V_{CE} = 150 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016D | | $V_{CE} = 200 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| Collector to base cutoff current | 3036 | Bias cond. D | | I_{CBO} | | | |
| 2N1016B | | $V_{CB} = 100 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016C | | $V_{CB} = 150 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016D | | $V_{CB} = 200 \text{ Vdc}$ | | | --- | 1.0 | mAdc |

TABLE I. Group A inspection - Continued

| Examination or test | MIL-STD-750 | | L T P D | Symbol | Limits | | |
|--|-------------|--|------------------|---------------|--------|-----|-----------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 2 - Continued</u> | | | | | | | |
| Emitter to base cutoff current | 3061 | Bias cond. D; $V_{EB} = 25 \text{ Vdc}$ | | I_{EBO} | --- | 1.0 | mAdc |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 2 \text{ Adc}$ | | h_{FE} | 20 | 80 | --- |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 5 \text{ Adc}$ | | h_{FE} | 10 | 35 | --- |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 7.5 \text{ Adc}$ | | h_{FE} | 6 | 20 | --- |
| Small-signal short-circuit forward-current transfer ratio | 3206 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 5 \text{ Adc}$ | | h_{fe} | 5 | --- | --- |
| Small-signal short-circuit forward-current transfer-ratio cutoff frequency | 3301 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 5 \text{ Adc}$ | | f_{hfe} | 20 | --- | kc |
| <u>Subgroup 3</u> | | | | | | | |
| Collector to emitter voltage (saturated) | 3071 | $I_C = 5 \text{ Adc};$ $I_B = 1 \text{ Adc}$ | 5 | $V_{CE(sat)}$ | --- | 2.5 | Vdc |
| Base emitter voltage (saturated) | 3066 | Test cond. A; $I_C = 5 \text{ Adc};$ $I_B = 1 \text{ Adc}$ | | $V_{BE(sat)}$ | --- | 4.0 | Vdc |
| Pulse response | --- | $I_C = 5 \text{ Adc}; V_{EB} = 6 \text{ Vdc};$ $V_{CE} = 12 \text{ Vdc};$ $I_{B1} \text{ and } I_{B2} = 1.5 \text{ Adc}$ (see figure 2) | | $t_d + t_r$ | --- | 10 | μsec |
| Pulse response | --- | $I_C = 5 \text{ Adc}; V_{EB} = 6 \text{ Vdc};$ $V_{CE} = 12 \text{ Vdc};$ $I_{B1} \text{ and } I_{B2} = 1.5 \text{ Adc}$ (see figure 2) | | $t_s + t_f$ | --- | 15 | μsec |
| <u>Subgroup 4</u> | | | | | | | |
| High-temperature operation: Emitter to base cutoff current | 3061 | $T_C = +150 \pm 3^\circ \text{C}$ Bias cond. D; $V_{EB} = 25 \text{ Vdc}$ | | I_{EBO} | --- | 10 | mAdc |
| Collector to emitter cutoff current | 3041 | Bias cond. A; $V_{EB} = 1.5 \text{ Vdc}$ | | I_{CEX} | | | |
| 2N1016B | | $V_{CE} = 100 \text{ Vdc}$ | | | --- | 10 | mAdc |
| 2N1016C | | $V_{CE} = 150 \text{ Vdc}$ | | | --- | 10 | mAdc |
| 2N1016D | | $V_{CE} = 200 \text{ Vdc}$ | | | --- | 10 | mAdc |
| Low-temperature operation: Forward-current transfer ratio | 3076 | $T_C = -55 \pm 3^\circ \text{C}$ $V_{CE} = 4 \text{ Vdc};$ $I_C = 5 \text{ Adc}$ | | h_{FE} | 10 | 35 | --- |

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TABLE II. Group B inspection

| Examination or test | MIL-STD-750 | | L T P D | 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 (see 4.4.2) | | --- | --- | --- | --- |
| Thermal shock (temperature cycling) | 1051 | Test cond. F | | --- | --- | --- | --- |
| Thermal shock (glass strain) | 1056 | Test cond. A | | --- | --- | --- | --- |
| Terminal strength (tension) | 2036 | Test cond. A; weight = 5 lbs + 1 oz.; application time = 15 sec. to each terminal | | --- | --- | --- | --- |
| Terminal strength (terminal torque) | 2036 | Test cond. D1; torque = 5 oz.-in. to be applied to flat of each terminal for t = 15 sec. | | --- | --- | --- | --- |
| Terminal strength (stud torque) | 2036 | Test cond. D2; torque = 40 lb.-in. for t = 15 sec. (see 4.4.1) | | --- | --- | --- | --- |
| Seal (leak rate) | --- | Method 112, MIL-STD-202, 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: | | | | | | | |
| Collector to emitter cutoff current | 3041 | Bias cond. A; $V_{EB} = 1.5 \text{ Vdc}$ | | I_{CEX} | | | |
| 2N1016B | | $V_{CE} = 100 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016C | | $V_{CE} = 150 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| 2N1016D | | $V_{CE} = 200 \text{ Vdc}$ | | | --- | 1.0 | mAdc |
| Collector to emitter voltage (saturated) | 3071 | $I_C = 5 \text{ Adc};$ $I_B = 1 \text{ Adc}$ | | $V_{CE(sat)}$ | --- | 2.5 | Vdc |
| Forward-current transfer ratio | 3076 | $V_{CE} = 4 \text{ Vdc};$ $I_C = 5 \text{ Adc}$ | | h_{FE} | 10 | 35 | --- |
| <u>Subgroup 3</u> | | | 15 | | | | |
| Shock | | Nonoperating; 500 G; for 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 | | | --- | --- | --- | --- |

TABLE II. Group B inspection - Continued

| Examination or test | MIL-STD-750 | | L T P D | Symbol | Limits | | |
|---|-------------|---|------------------|----------------------|--------|-----|------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 3 - Continued</u> | | | | | | | |
| Constant acceleration | 2006 | 5000 G; in each orientation: X ₁ , Y ₁ , Y ₂ , and Z ₁ | | --- | --- | --- | --- |
| End points: (Same as subgroup 2) | | | 15 | | | | |
| <u>Subgroup 4</u> | | | | | | | |
| Salt atmosphere (corrosion) | 1041 | | | --- | --- | --- | --- |
| End points: (Same as subgroup 2) | | | 10 | | | | |
| <u>Subgroup 5</u> | | | | | | | |
| High-temperature life (nonoperating) | 1031 | T _{stg} = 150° C; t = 340 hours (see 4.3.4) | | --- | --- | --- | --- |
| End points: | | | | | | | |
| Collector to emitter cutoff current | 3041 | Bias cond. A; V _{EB} = +1.5 Vdc | | I _{CEX} | | | |
| 2N1016B | | V _{CE} = 100 Vdc | | | --- | 2.0 | mAdc |
| 2N1016C | | V _{CE} = 150 Vdc | | | --- | 2.0 | mAdc |
| 2N1016D | | V _{CE} = 200 Vdc | | | --- | 2.0 | mAdc |
| Collector to emitter voltage (saturated) | 3071 | I _C = 5 Adc; I _B = 1 Adc | | V _{CE(sat)} | --- | 2.5 | Vdc |
| Forward-current transfer ratio | 3076 | V _{CE} = 4 Vdc; I _C = 5 Adc | | h _{FE} | 8 | 42 | --- |
| <u>Subgroup 6</u> | | | | | | | |
| Steady state operation life | 1026 | T _C = +100° C; V _{CB} = 30 Vdc; I _C = 2.39 Adc; t = 340 hrs (see 4.3.4) | | --- | --- | --- | --- |
| End points: (Same as subgroup 5) | | | 10 | | | | |

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TABLE III. Group C inspection

| Examination or test | MIL-STD-750 | | L T P D | Symbol | Limits | | |
|---|-------------|---|------------------|----------------|--------|-----|---------------|
| | Method | Details | | | Min | Max | Unit |
| <u>Subgroup 1</u> | | | 15 | | | | |
| Barometric pressure, reduced (altitude operation) | 1001 | Normal mounting; pressure = 8 mm Hg for 60 sec min. | | --- | --- | --- | --- |
| Measurement during test: | | | | | | | |
| Collector to base cutoff current | 3036 | Bias cond. D; | | I_{CBO} | | | |
| 2N1016B | | $V_{CB} = 100$ Vdc | | | --- | 1.0 | mAdc |
| 2N1016C | | $V_{CB} = 150$ Vdc | | | --- | 1.0 | mAdc |
| 2N1016D | | $V_{CB} = 200$ Vdc | | | --- | 1.0 | mAdc |
| Thermal resistance, junction to case | 3151 | | | θ_{J-C} | --- | 0.7 | $^{\circ}C/W$ |
| <u>Subgroup 2</u> | | | $\lambda = 10$ | | | | |
| High-temperature life (nonoperating) | 1031 | $T_{stg} = +150^{\circ}C$ (see 4.3.4) | | --- | --- | --- | --- |
| End points: (Same as subgroup 5 of Group B) | | | | | | | |
| <u>Subgroup 3</u> | | | $\lambda = 10$ | | | | |
| Steady state operation life | 1026 | $T_C = +100^{\circ}C$; $V_{CB} = 30$ Vdc; $I_C = 2.39$ Adc (see 4.3.4) | | --- | --- | --- | --- |
| End points: (Same as subgroup 5 of Group B) | | | | | | | |

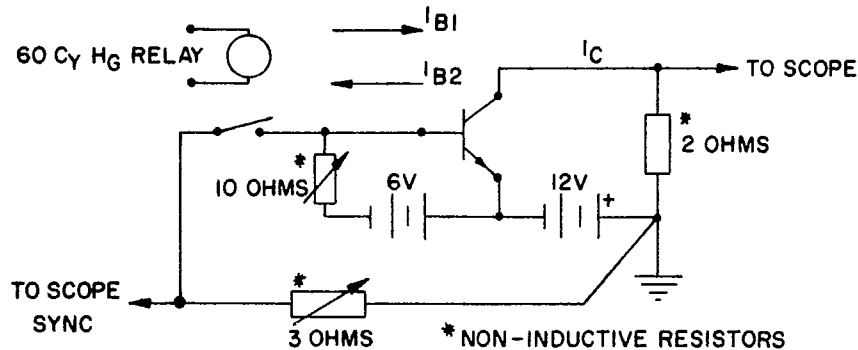


FIGURE 2. Switching-time test circuit.

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 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 - 11Preparing activity:
Navy - SH

(Project 5961-0002-28)

Review activities:

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

Code "C"

User activities:

Army - EL, SM
Navy - CG, MC, AS, OS
Air Force - 14, 19