

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, PNP, GERMANIUM, LOW-POWER

TYPE 2N428

*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 PNP, germanium, low-power switching transistor.

1.2 Physical dimensions. See figure 1 (TO-5).

1.3 Maximum ratings.

| PT 1/ | V <sub>CB0</sub> | V <sub>CEO</sub> | V <sub>EB0</sub> | I <sub>C</sub> | T <sub>stg</sub> |
|-------|------------------|------------------|------------------|----------------|------------------|
| mW    | V <sub>dc</sub>  | V <sub>dc</sub>  | V <sub>dc</sub>  | mAdc           | °C               |
| 150   | -30              | -12              | -20              | 400            | -65 to +100      |

1/ Derate linearly 2 mW/°C for T<sub>A</sub> > 25° C.

1.4 Primary electrical characteristics.

| Limits | f <sub>hfb</sub><br><br>V <sub>CB</sub> = -5 V <sub>dc</sub><br>I <sub>C</sub> = -1 mAdc | h <sub>FE</sub><br><br>V <sub>CE</sub> = -0.25 V <sub>dc</sub><br>I <sub>B</sub> = -1 mAdc | h <sub>FE</sub><br><br>V <sub>CE</sub> = -0.35 V <sub>dc</sub><br>I <sub>B</sub> = -10 mAdc | V <sub>CE(sat)</sub><br><br>I <sub>C</sub> = -200 mAdc<br>I <sub>B</sub> = -10 mAdc |
|--------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|        | MHz                                                                                      |                                                                                            |                                                                                             | V <sub>dc</sub>                                                                     |
| Min    | 10                                                                                       | 60                                                                                         | 20                                                                                          | ...                                                                                 |
| Max    | ---                                                                                      | 250                                                                                        | ---                                                                                         | -0.25                                                                               |

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.

## **STANDARD**

### **MILITARY**

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.** Transistors shall be of the design, construction, and physical dimensions shown on figure 1.

**3.3.1 Terminal-lead length.** Terminal-lead length(s) other than that specified in figure 1 may be furnished when so stipulated under contract or order (see 6.2) where the devices covered herein are required directly for particular equipment-circuit installation or for automatic-assembly-technique programs. Where other lead lengths are required and provided, it shall not be construed as adversely affecting the qualified-product status of the device, or applicable JAN marking.

**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.

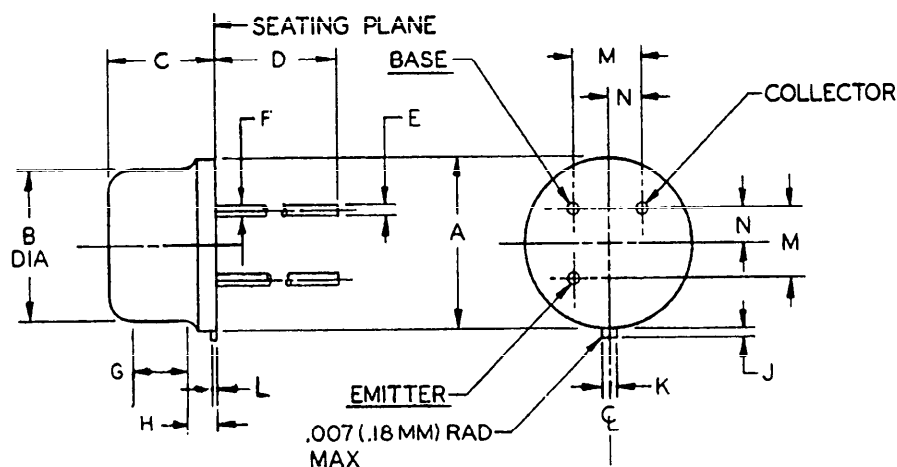
## **4. QUALITY ASSURANCE PROVISIONS**

**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 group 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.

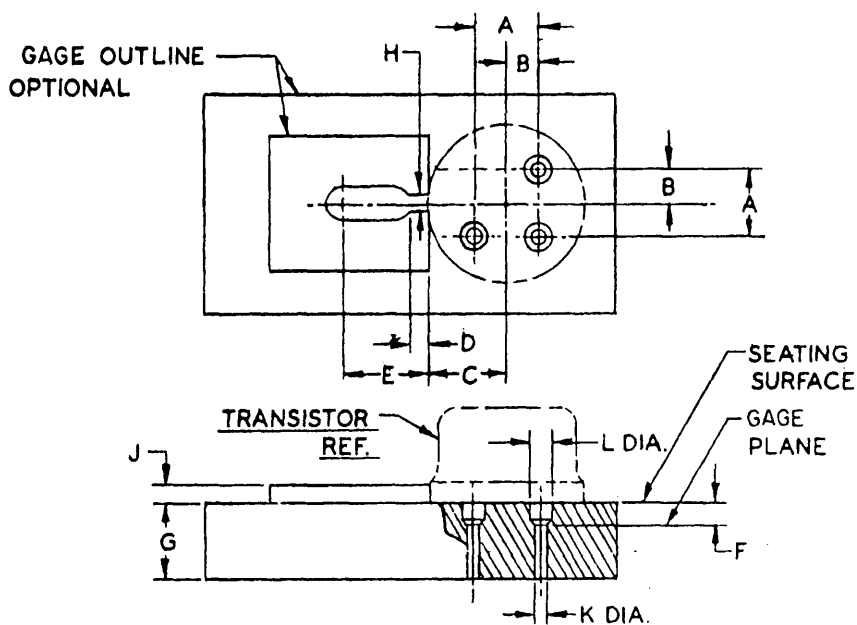


| DIMENSIONS |           |       |             |       | NOTES |
|------------|-----------|-------|-------------|-------|-------|
| LTR        | INCHES    |       | MILLIMETERS |       |       |
|            | MIN       | MAX   | MIN         | MAX   |       |
| A          | .335      | .370  | 8.51        | 9.40  | --    |
| B          | .305      | .335  | 7.75        | 8.51  | --    |
| C          | .240      | .260  | 6.10        | 6.60  | --    |
| D          | 1.500     | 1.750 | 38.10       | 44.45 | 9     |
| E          | .016      | .021  | .41         | .53   | 2,9   |
| F          | .016      | .019  | .41         | .48   | 3,9   |
| G          | .100      | --    | 2.54        | --    | 4     |
| H          | --        | --    | --          | --    | 5     |
| J          | .029      | .045  | .74         | 1.14  | 8     |
| K          | .028      | .034  | .71         | .86   | --    |
| L          | .009      | .125  | .23         | 3.18  | --    |
| M          | .1414 Nom |       | 3.59 Nom    |       | 6     |
| N          | .0707 Nom |       | 1.90 Nom    |       | 6     |

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. Measured in the zone beyond .250 (6.35 mm) from the seating plane.
3. Measured in the zone .050 (1.27 mm) and .250 (6.35 mm) from the seating plane.
4. Variations on dimension B in this zone shall not exceed .010 (.25 mm).
5. Outline in this zone is not controlled.
6. When measured in a gaging plane .054 +.001, -.000 (1.37 +.03, -.00 mm) below the seating plane of the transistor maximum diameter leads shall be within .007 (.18 mm) of their true location relative to a maximum width tab. Smaller diameter leads shall fall within the outline of the maximum diameter lead tolerance. Figure 2 preferred measured method.
7. All leads shall be electrically insulated from the case.
8. Measured from the maximum diameter of the actual device.
9. All 3 leads.

FIGURE 1. Physical dimensions of transistor type 2N428 (TO-5).



| LTR | DIMENSIONS |       |             |      |
|-----|------------|-------|-------------|------|
|     | INCHES     |       | MILLIMETERS |      |
|     | MIN        | MAX   | MIN         | MAX  |
| A   | .1409      | .1419 | 3.58        | 3.60 |
| B   | .0702      | .0712 | 1.78        | 1.81 |
| C   | .182       | .199  | 4.62        | 5.05 |
| D   | .009       | .011  | .23         | .28  |
| E   | .125 Nom   |       | 3.18 Nom    |      |
| F   | .054       | .055  | 1.37        | 1.40 |
| G   | .372       | .378  | 9.45        | 9.60 |
| H   | .0350      | .0355 | .89         | .90  |
| J   | .150 Nom   |       | 3.81 Nom    |      |
| K   | .0325      | .0335 | .83         | .85  |
| L   | .0595      | .0605 | 1.51        | 1.54 |

## NOTES:

1. The following gaging procedure shall be used: The use of a pin straightener prior to insertion in the gage is permissible. The device being measured shall be inserted until its seating plane is  $.125 \pm .010$  (3.18  $\pm$  .25 mm) from the seating surface of the gage. A spacer may be used to obtain the .125 (3.18 mm) distance from the gage seat prior to force application. A force of 8 oz  $\pm$  .05 oz shall then be applied parallel and symmetrical to the device's cylindrical axis. When examined visually after the force application (the force need not be removed) the seating plane of the device shall be seated against the gage.
2. The location of the tab locator, within the limits of dim C, will be determined by the tab and flange dimension of the device being checked.
3. Metric equivalents (to the nearest .01 mm) are given for general information only and are based upon 1 inch = 25.4 mm.

FIGURE 2. Gage for lead and tab location for transistor type 2N428.

TABLE I. Group A inspection

| Examination or test                                                        | MIL-STD-750 |                                                                                          | LTPD | Symbol                  | Limits |       | Unit            |
|----------------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------|------|-------------------------|--------|-------|-----------------|
|                                                                            | Method      | Details                                                                                  |      |                         | Min    | Max   |                 |
| Subgroup 1                                                                 |             |                                                                                          | 10   |                         |        |       |                 |
| Visual and mechanical examination                                          | 2071        |                                                                                          |      | ---                     | ---    | ---   | ---             |
| Subgroup 2                                                                 |             |                                                                                          | 5    |                         |        |       |                 |
| Breakdown voltage, emitter to base                                         | 3026        | Bias cond. D; $I_E = -25 \mu\text{Ade}$                                                  |      | $BV_{EBO}$              | -20    | ---   | Vdc             |
| Breakdown voltage, collector to emitter                                    | 3011        | Bias cond. D; $I_C = -1 \mu\text{Ade}$                                                   |      | $BV_{CEO}$              | -12    | ---   | Vdc             |
| Breakdown voltage, collector to base                                       | 3001        | Bias cond. D; $I_C = -25 \mu\text{Ade}$                                                  |      | $BV_{CBO}$              | -30    | ---   | Vdc             |
| Collector to base cutoff current                                           | 3036        | Bias cond. D; $V_{CB} = -1.5 \text{ Vdc}$                                                |      | $I_{CBO}$               | ---    | -3    | $\mu\text{Ade}$ |
| Emitter to base cutoff current                                             | 3061        | Bias cond. D; $V_{EB} = -1.5 \text{ Vdc}$                                                |      | $I_{EBO}$               | ---    | -3    | $\mu\text{Ade}$ |
| Subgroup 3                                                                 |             |                                                                                          | 5    |                         |        |       |                 |
| Base emitter voltage (nonsaturated)                                        | 3066        | Test cond. B; $V_{CE} = -0.25 \text{ Vdc}$ ; $I_B = -1 \text{ mAde}$                     |      | $V_{BE}$                | ---    | 0.45  | Vdc             |
| Base emitter voltage (nonsaturated)                                        | 3066        | Test cond. B; $V_{CE} = -0.35 \text{ Vdc}$ ; $I_B = -10 \text{ mAde}$                    |      | $V_{BE}$                | ---    | -0.8  | Vdc             |
| Collector to emitter voltage (saturated)                                   | 3071        | $I_C = -200 \text{ mAde}$ ; $I_B = -10 \text{ mAde}$                                     |      | $V_{CE}^{(\text{sat})}$ | ---    | -0.25 | Vdc             |
| Forward-current transfer ratio                                             | 3076        | $V_{CE} = -0.25 \text{ Vdc}$ ; $I_B = -1 \text{ mAde}$                                   |      | $h_{FE}$                | 60     | 250   | ---             |
| Forward-current transfer ratio                                             | 3076        | $V_{CE} = -0.35 \text{ Vdc}$ ; $I_B = -10 \text{ mAde}$                                  |      | $h_{FE}$                | 20     | ---   | ---             |
| Small-signal short-circuit forward-current transfer-ratio cutoff frequency | 3301        | $V_{CB} = -5 \text{ Vdc}$ ; $I_C = -1 \text{ mAde}$                                      |      | $f_{hfb}$               | 10     | ---   | MHz             |
| Base-spreading resistance                                                  | ---         | $V_{CB} = -5 \text{ Vdc}$ ; $I_C = -1 \text{ mAde}$ ; $f = 2 \text{ MHz}$ (see figure 3) |      | $r_b$                   | ---    | 160   | ohms            |
| Open-circuit output capacitance                                            | 3236        | $V_{CB} = -5 \text{ Vdc}$ ; $I_E = 0$ ; $100 \text{ kHz} \leq f \leq 1 \text{ MHz}$      |      | $C_{obo}$               | ---    | 20    | pf              |
| Subgroup 4                                                                 |             |                                                                                          | 10   |                         |        |       |                 |
| Switching parameters:                                                      |             |                                                                                          |      |                         |        |       |                 |
| Turn-on time                                                               | 3251        | Test cond. A; $R_B = 6,900 \text{ ohms}$ (see figure 4)                                  |      | $t_{on}$                | ---    | .85   | $\mu\text{sec}$ |
| Turn-off time                                                              | 3251        | Test cond. A; $R_B = 6,000 \text{ ohms}$ (see figure 4)                                  |      | $t_{off}$               | ---    | 1.10  | $\mu\text{sec}$ |
| Subgroup 5                                                                 |             |                                                                                          | 10   |                         |        |       |                 |
| High-temperature operation:                                                |             | $T_A = +70^\circ\text{C}$                                                                |      |                         |        |       |                 |
| Collector to base cutoff current                                           | 3036        | Bias cond. D; $V_{CB} = -1.5 \text{ Vdc}$                                                |      | $I_{CBO}$               | ---    | -70   | $\mu\text{Ade}$ |
| Forward-current transfer ratio                                             | 3076        | $V_{CE} = -0.25 \text{ Vdc}$ ; $I_B = -1 \text{ mAde}$                                   |      | $h_{FE}$                | 50     | ---   | ---             |

TABLE I. Group A inspection - Continued

| Examination or test            | MIL-STD-750 |                                                       | LTPD | Symbol          | Limits |     | Unit |
|--------------------------------|-------------|-------------------------------------------------------|------|-----------------|--------|-----|------|
|                                | Method      | Details                                               |      |                 | Min    | Max |      |
| Subgroup 5 - Continued         |             |                                                       |      |                 |        |     |      |
| Low-temperature operation:     |             | T <sub>A</sub> = -55°C                                |      |                 |        |     |      |
| Forward-current transfer ratio | 3076        | V <sub>CE</sub> = -0.25 Vdc; I <sub>B</sub> = -1 mAdc |      | h <sub>FE</sub> | 45     | --- | ---  |

TABLE II. Group B inspection

| Examination or test                    | MIL-STD-750 |                                                                                                 | LTPD | Symbol    | Limits |                    | Unit          |
|----------------------------------------|-------------|-------------------------------------------------------------------------------------------------|------|-----------|--------|--------------------|---------------|
|                                        | Method      | Details                                                                                         |      |           | Min    | Max                |               |
| Subgroup 1                             |             |                                                                                                 | 20   |           |        |                    |               |
| Physical dimensions                    | 2066        | (See figure 1)                                                                                  |      | ---       | ---    | ---                | ---           |
| Subgroup 2                             |             |                                                                                                 | 15   |           |        |                    |               |
| Solderability                          | 2026        |                                                                                                 |      | ---       | ---    | ---                | ---           |
| Thermal shock<br>(temperature cycling) | 1051        | Test cond. B except<br>T (max) = +100°C                                                         |      | ---       | ---    | ---                | ---           |
| Thermal shock (glass strain)           | 1056        | Test cond. A                                                                                    |      | ---       | ---    | ---                | ---           |
| Moisture resistance                    | 1021        |                                                                                                 |      | ---       | ---    | ---                | ---           |
| End points:                            |             |                                                                                                 |      |           |        |                    |               |
| Collector to base cutoff current       | 3036        | Bias cond. D; $V_{CB} = -30$ Vdc                                                                |      | $I_{CBO}$ | ---    | .25                | $\mu$ Adc     |
| Emitter to base cutoff current         | 3061        | Bias cond. D; $V_{EB} = -20$ Vdc                                                                |      | $I_{EBO}$ | ---    | .25                | $\mu$ Adc     |
| Forward-current transfer ratio         | 3076        | $V_{CE} = -0.25$ Vdc; $I_B = -1$ mAdc                                                           |      | $h_{FE}$  | 60     | 250                | ---           |
| Subgroup 3                             |             |                                                                                                 | 20   |           |        |                    |               |
| Shock                                  | 2016        | Nonoperating; 500 G, 1 msec;<br>5 blows in each orientation:<br>$X_1$ , $Y_1$ , $Y_2$ and $Z_1$ |      | ---       | ---    | ---                | ---           |
| Vibration, variable frequency          | 2056        | 10 G                                                                                            |      | ---       | ---    | ---                | ---           |
| Constant acceleration                  | 2006        | 20,000 G; in each orientation:<br>$X_1$ , $Y_1$ , $Y_2$ , and $Z_1$                             |      | ---       | ---    | ---                | ---           |
| End points:<br>(Same as subgroup 2)    |             |                                                                                                 |      |           |        |                    |               |
| Subgroup 4                             |             |                                                                                                 | 20   |           |        |                    |               |
| Terminal strength (lead fatigue)       | 2036        | Test cond. E                                                                                    |      | ---       | ---    | ---                | ---           |
| End points:                            |             |                                                                                                 |      |           |        |                    |               |
| Seal (leak-rate)                       | 1071        | Test cond. G or H for fine leaks;<br>test cond. A, C, D or F for gross leaks                    |      | ---       | ---    | $1 \times 10^{-7}$ | atm<br>cc/sec |

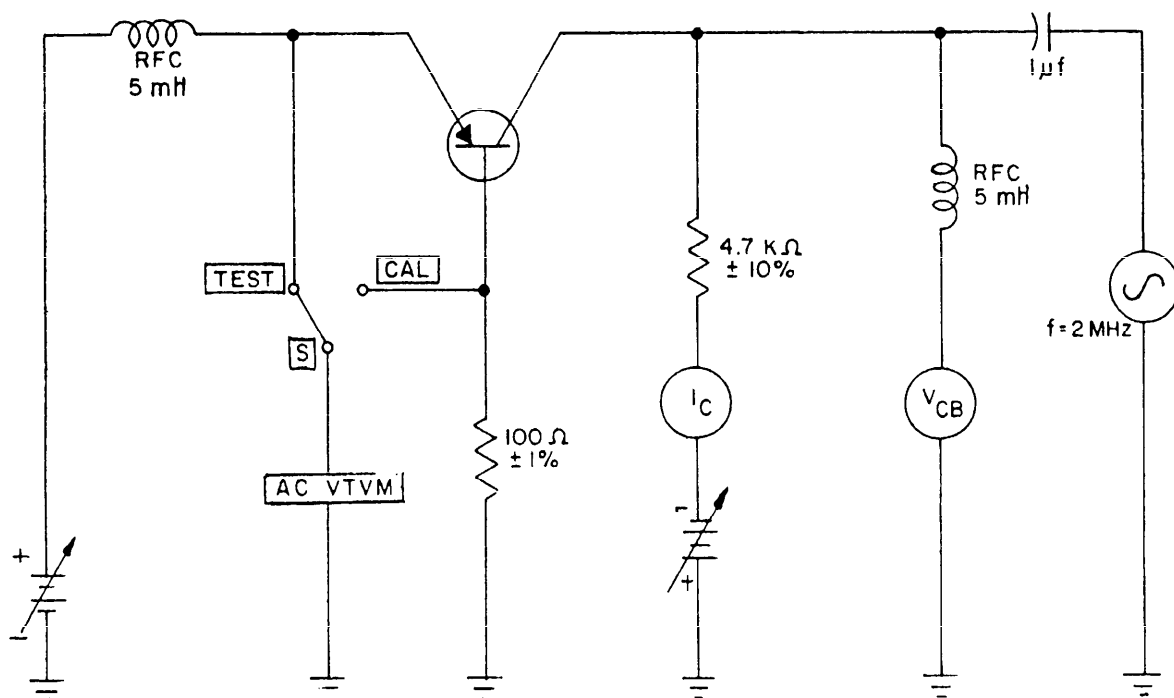
TABLE II. Group B inspection - Continued

MIL-S-19500/44D

| Examination or test                  | MIL-STD-750 |                                                                                                                                               | LTPD | Symbol           | Limits |     | Unit            |
|--------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------|------------------|--------|-----|-----------------|
|                                      | Method      | Details                                                                                                                                       |      |                  | Min    | Max |                 |
| <i>Subgroup 5</i>                    |             |                                                                                                                                               | 20   |                  |        |     |                 |
| Salt atmosphere (corrosion)          | 1041        |                                                                                                                                               |      | ---              | ---    | --- | ---             |
| End points:<br>(Same as subgroup 2)  |             |                                                                                                                                               |      |                  |        |     |                 |
| <i>Subgroup 6</i>                    |             |                                                                                                                                               | 5    |                  |        |     |                 |
| High-temperature life (nonoperating) | 1032        | $T_{\text{sig}} = +100^{\circ}\text{C}$ ; time = 340 hours<br>(see 4.3.4)                                                                     |      | ---              | ---    | --- | ---             |
| End points:                          |             |                                                                                                                                               |      |                  |        |     |                 |
| Collector to base cutoff current     | 3036        | Bias cond. D; $V_{\text{CB}} = -30\text{ Vdc}$                                                                                                |      | $I_{\text{CBO}}$ | ---    | 40  | $\mu\text{Ade}$ |
| Emitter to base cutoff current       | 3061        | Bias cond. D; $V_{\text{EB}} = -20\text{ Vdc}$                                                                                                |      | $I_{\text{EBO}}$ | ---    | 40  | $\mu\text{Ade}$ |
| Forward-current transfer ratio       | 3076        | $V_{\text{CE}} = -0.25\text{ Vdc}$ ; $I_{\text{B}} = -1\text{ mAde}$                                                                          |      | $h_{\text{FE}}$  | 42     | 300 | ---             |
| <i>Subgroup 7</i>                    |             |                                                                                                                                               | 5    |                  |        |     |                 |
| Steady-state operation life          | 1027        | $T_{\text{A}} = +25^{\circ}\text{C}$ ; $V_{\text{CB}} = -15\text{ Vdc}$ ;<br>$P_{\text{T}} = 150\text{ mW}$ ; time = 340 hours<br>(see 4.3.4) |      | ---              | ---    | --- | ---             |
| End points:<br>(Same as subgroup 6)  |             |                                                                                                                                               |      |                  |        |     |                 |

TABLE III. Group C inspection

| Examination or test                               | MIL-STD-750 |                                                                                                                         | LTPD          | Symbol | Limits |     | Unit |
|---------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------|---------------|--------|--------|-----|------|
|                                                   | Method      | Details                                                                                                                 |               |        | Min    | Max |      |
| <i>Subgroup 1</i>                                 |             |                                                                                                                         | $\lambda = 7$ |        |        |     |      |
| High-temperature life<br>(nonoperating)           | 1031        | $T_{\text{sig}} = +100^{\circ}\text{C}$ (see 4.3.4)                                                                     |               | ---    | ---    | --- | ---  |
| End points:<br>(Same as subgroup 6 of<br>group B) |             |                                                                                                                         |               |        |        |     |      |
| <i>Subgroup 2</i>                                 |             |                                                                                                                         | $\lambda = 7$ |        |        |     |      |
| Steady-state operation life                       | 1026        | $T_{\text{A}} = +25^{\circ}\text{C}$ ; $V_{\text{CB}} = -15\text{ Vdc}$ ;<br>$P_{\text{T}} = 150\text{ mW}$ (see 4.3.4) |               | ---    | ---    | --- | ---  |
| End points:<br>(Same as subgroup 6 of<br>group B) |             |                                                                                                                         |               |        |        |     |      |



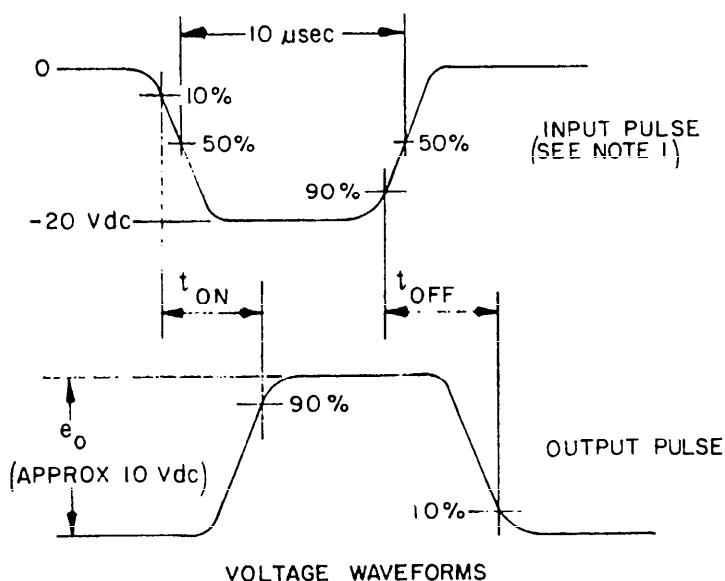
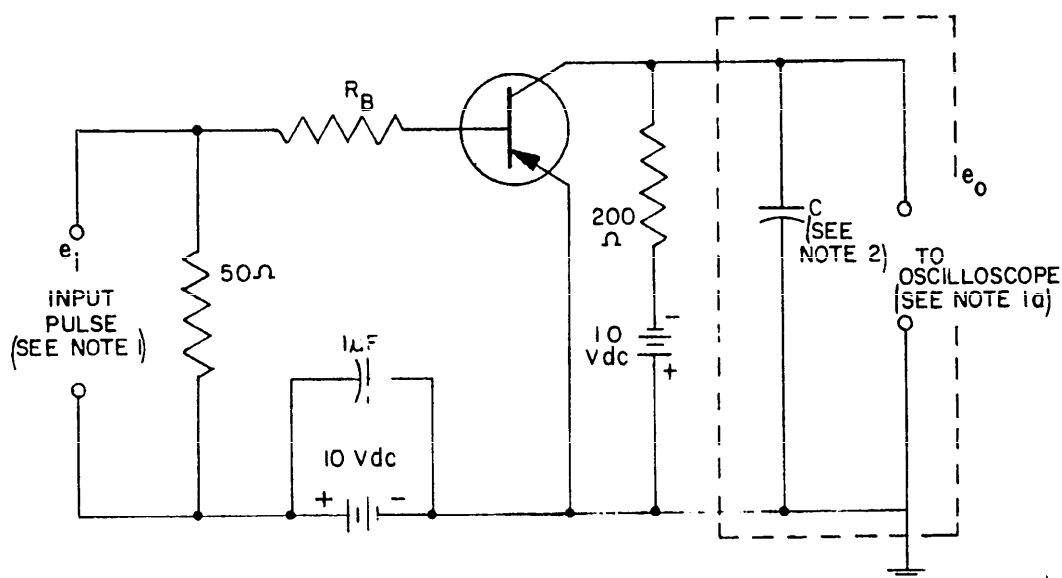
## NOTES:

1. Test computation shall be based upon the following formula:

$$r_b = 100 \times \frac{\text{Reading of AC VTVM with switch S in test position}}{\text{Reading of AC VTVM with switch S in CAL. position}} - 100$$

2. An equivalent test circuit may be used.

FIGURE 3. Base spreading resistance ( $r_b$ ) test circuit.



## NOTES:

1. Input pulse:
  - a. The rise and fall times of the input pulse and the oscilloscope used to view the output voltage should be less than  $0.03\text{ }\mu\text{sec}$ .
  - b. Repetition rate = 500 Hz.
2. Oscilloscope and wiring capacitance = 15 pf.
3. An equivalent test circuit may be used.

FIGURE 4. Test circuit and waveforms for measuring  $t_{on}$  and  $t_{off}$  times.

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-hour life-test, may be continued on test to 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.

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

## 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 *Ordering data.* Procurement documents should specify the following: Terminal-lead length if other than specified in figure 1 (see 3.3.1).

### Custodians:

Army - EL  
Navy - EC  
Air Force - 85

### Review activities:

Army - MU, MI  
Navy - SH  
Air Force - 11, 17  
DSA - ES

### User activities:

Army - SM  
Navy - CG, MC, OS, AS  
Air Force - 13, 15, 19, 70, 80

### Preparing activity:

Army - EL

### Agent:

DSA - ES

(Project 5961-0158)