

The documentation and process conversion measures necessary to comply with this revision shall be completed by 21 July 2008.

INCH-POUND

MIL-PRF-19500/501D
 21 April 2008
 SUPERSEDING
 MIL-PRF-19500/501C
 23 May 1997

* PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, DARLINGTON TRANSISTOR, PNP, SILICON, POWER,
 TYPES 2N6051 AND 2N6052, JAN, JANTX, AND JANTXV

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 PNP, Darlington, silicon, power transistors. Three levels of product assurance are provided for each device type as specified in MIL-PRF-19500.

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

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

Type	P_T (1) $T_C = +25^\circ\text{C}$	P_T (1) $T_C = +100^\circ\text{C}$	$R_{\theta JC}$	V_{CBO}	V_{CEO}	V_{EBO}	I_C	I_B	T_J and T_{STG}
	<u>W</u>	<u>W</u>	<u>$^\circ\text{C/W}$</u>	<u>V dc</u>	<u>V dc</u>	<u>V dc</u>	<u>A dc</u>	<u>A dc</u>	<u>$^\circ\text{C}$</u>
2N6051	150	75	1.0	80	80	5	12	0.2	-55 to +175
2N6052	150	75	1.0	100	100	5	12	0.2	-55 to +175

(1) Derate linearly at 1.00 W/ $^\circ\text{C}$ above $T_C > +25^\circ\text{C}$.

* Comments, suggestions, or questions on this document should be addressed to Defense Supply Center, Columbus, ATTN: DSCC-VAC, P.O. Box 3990, Columbus, OH 43218-3990, or emailed to Semiconductor@dsc.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil/>.

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

Limit	h_{FE2} (1)	h_{FE3} (1)	h_{FE}	$ h_{FE} $	C_{obo} 100 kHz $\leq f \leq$ 1 MHz $V_{CB} = 10$ V dc $I_E = 0$	Pulse response	
	$V_{CE} = 3$ V dc $I_C = 6$ A dc	$V_{CE} = 3$ V dc $I_C = 12$ A dc	$V_{CE} = 3$ V dc $I_C = 5$ A dc $f = 1$ kHz	$V_{CE} = 3$ V dc $I_C = 5$ A dc $f = 1$ MHz		t_{on}	t_{off}
Min	1,000	150		10	μF	μS	μS
Max	18,000		1,000	250	300	2	10

Limit	$V_{BE(sat)}$ $I_C = 12$ A dc $I_B = 120$ mA dc (1)	$V_{CE(sat)1}$ $I_C = 12$ A dc $I_B = 120$ mA dc (1)	$V_{CE(sat)2}$ $I_C = 6$ A dc $I_B = 24$ mA dc (1)
	<u>V dc</u>	<u>V dc</u>	<u>V dc</u>
Min	4.0	3.0	2.0
Max			

(1) Pulsed see 4.5.1.

2. APPLICABLE DOCUMENTS

* 2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 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, 4, or 5 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://assist.daps.dla.mil/quicksearch/> or <http://assist.daps.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Order of precedence. 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 and physical dimensions shall be as specified in MIL-PRF-19500 and on figure 1 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 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:

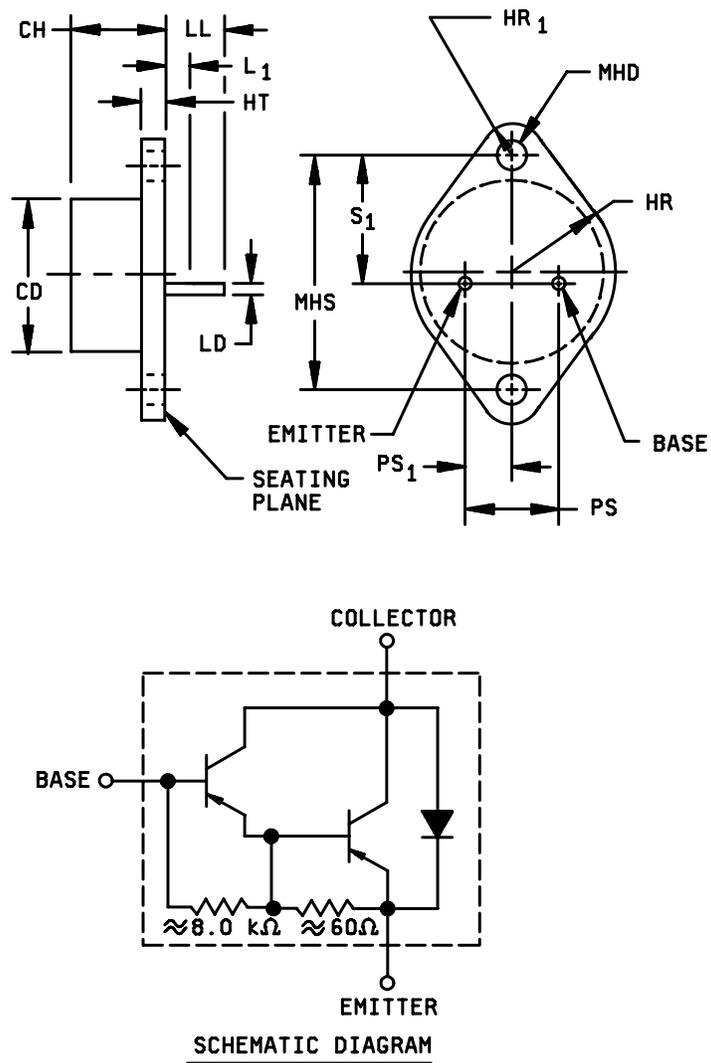
a. Qualification inspection (see 4.2).

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.



* FIGURE 1. Physical dimensions (TO-3) and schematic circuit.

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Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD		.875		22.23	3
CH	.250	.328	6.35	8.33	
HR	.495	.525	12.57	13.34	
HR ₁	.131	.188	3.33	4.78	6
HT	.060	.135	1.52	3.43	
LD	.038	.043	0.97	1.09	4, 5, 9
LL	.312	.500	7.92	12.70	4, 5, 9
L ₁		.050		1.27	5, 9
MHD	.151	.161	3.84	4.09	7
MHS	1.177	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	
PS ₁	.205	.225	5.21	5.72	5
S ₁	.655	.675	16.64	17.15	

NOTES:

1. Dimensions are in inches.
- *2. Millimeters are given for general information only.
3. Body contour is optional within zone defined by CD.
4. These dimensions shall be measured at points .050 inch (1.27 mm) to .055 inch (1.40 mm) below seating plane. When gauge is not used, measurement shall be made at seating plane.
5. Both terminals.
6. At both ends.
7. Two holes.
8. The collector shall be electrically connected to the case.
- * 9. LD applies between L₁ and LL. Lead diameter shall not exceed twice LD within L₁.
10. The seating plane of the header shall be flat within .001 inch (0.03 mm), concave to .004 inch (0.10 mm), convex inside a .930 inch (23.62 mm) diameter circle on the center of the header, and flat within .001 inch (0.03 mm) concave to .006 inch (0.15 mm), convex overall.
11. In accordance with ASME Y14.5M, diameters are equivalent to ϕ x symbology.

* FIGURE 1. Physical dimensions (TO-3) and schematic circuit - Continued.

* 4.3 Screening (JANTX and JANTXV levels). Screening 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 (see table E-IV of MIL-PRF-19500)	Measurement
	JANTX and JANTXV levels only
(1) 3c	Thermal impedance (see 4.3.2).
9	I_{CEX1}
11	I_{CEX1} , h_{FE2} . Subgroup 2 of table I herein; ΔI_{CEX1} = 100 percent of initial value or 2 μ A dc, whichever is greater.
12	See 4.3.1.
13	Subgroup 2 of table I herein; ΔI_{CEX1} = 100 percent of initial value or 2 μ A dc, whichever is greater; Δh_{FE2} = \pm 40 percent of initial value.

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

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows:

$$T_J = +162.5^\circ\text{C} \pm 12.5^\circ\text{C}; V_{CE} \geq 10 \text{ V dc}, T_A \leq +100^\circ\text{C}.$$

NOTE: No heat sink or forced air cooling on the devices shall be permitted.

* 4.3.2 Thermal impedance. The thermal impedance measurements shall be performed in accordance with method 3131 of MIL-STD-750 using the guidelines in that method for determining I_M , I_H , t_H , t_{SW} , (and V_H where appropriate). Measurement delay time (t_{MD}) = 70 μ s max. See table III, group E, subgroup 4 herein.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with appendix E, table E-V of MIL-PRF-19500, and table I herein. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in appendix E, table E-VIB (JAN, JANTX and JANTXV) of MIL-PRF-19500. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

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

Subgroup	Method	Conditions
B3	1037	$V_{CB} \geq 10 \text{ V dc}$; ΔT_J = between cycles $\geq +100^\circ\text{C}$. $t_{on} = t_{off} = 3$ minutes for 2,000 cycles. No heat sink or forced-air cooling on the devices shall be permitted.
* B5		Not applicable.

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4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in appendix E, table E-VII of MIL-PRF-19500. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

* 4.4.3.1. Group C inspection, appendix E, table E-VII of MIL-PRF-19500.

	<u>Subgroup</u>	<u>Method</u>	<u>Conditions</u>
*	C2	2036	Test condition A, weight = 10 pounds, t = 15 s.
*	C5	3131	See 4.3.2, $R_{\theta JC} = 1^{\circ}\text{C/W}$.
	C6	1037	$V_{CB} \geq 10\text{ V dc}$, ΔT_J between cycles $\geq +100^{\circ}\text{C}$, $t_{ON} = t_{OFF} = 3$ minutes for 6,000 cycles. No heat sink or forced-air cooling on the devices shall be permitted.

* 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 herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein. Delta measurements shall be in accordance with table II herein and applies to subgroup E1 and E2.

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

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

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* TABLE I. Group A inspection.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 1</u>						
Visual and mechanical examination	2071					
<u>Subgroup 2</u>						
* Thermal impedance <u>2/</u>	3131	See 4.3.2	$Z_{\theta JX}$			°C/W
Breakdown voltage collector to emitter 2N6051 2N6052	3011	Bias condition D; $I_C = 100$ mA dc, pulsed (see 4.5.1)	$V_{(BR)CEO}$	80 100		V dc V dc
* Collector to emitter cutoff current 2N6051 2N6052	3041	Bias condition A; $V_{BE} = 1.5$ V dc $V_{CE} = 80$ V dc $V_{CE} = 100$ V dc	I_{CEX1}		.01 .01	mA dc mA dc
Collector to emitter cutoff current 2N6051 2N6052	3041	Bias condition D $V_{CE} = 40$ V dc $V_{CE} = 50$ V dc	I_{CEO}		1	mA dc
Emitter to base cutoff current	3061	Bias condition D; $V_{BE} = 5$ V dc,	I_{EBO}		2	mA dc
Base to emitter non-saturated	3066	Test condition B; $I_C = 6$ A dc, $V_{CE} = 3$ V dc, pulsed (see 4.5.1)	V_{BE}		2.8	V dc
Base to emitter saturated	3066	Test condition A; $I_C = 12$ A dc, $I_B = 120$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)}$		4.0	V dc
Collector to emitter saturated voltage	3071	$I_C = 12$ A dc; $I_B = 120$ mA dc pulsed (see 4.5.1)	$V_{CE(sat)1}$		3.0	V dc
Collector to emitter saturated voltage	3071	$I_C = 6$ A dc; $I_B = 24$ A dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		2.0	V dc
Forward current transfer ratio	3076	$V_{CE} = 3$ V dc; $I_C = 1$ A dc, pulsed (see 4.5.1)	h_{FE1}	1,000		
Forward current transfer ratio	3076	$V_{CE} = 3$ V dc; $I_C = 6$ A dc, pulsed (see 4.5.1)	h_{FE2}	1,000	18,000	
Forward current transfer ratio	3076	$V_{CE} = 3$ V dc; $I_C = 12$ A dc, pulsed (see 4.5.1)	h_{FE3}	150		

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 3</u>						
High temperature operation:		$T_A = +150^\circ\text{C}$				
Collector to emitter cutoff current 2N6051 2N6052	3041	Bias condition A, $V_{BE} = 1.5 \text{ V dc}$ $V_{CE} = 80 \text{ V dc}$ $V_{CE} = 100 \text{ V dc}$	I_{CEX2}		5.0 5.0	 mA dc mA dc
Low temperature operation:		$T_A = -55^\circ\text{C}$				
Forward current transfer ratio	3076	$V_{CE} = 3 \text{ V dc}$, $I_C = 6 \text{ A dc}$, pulsed (see 4.5.1)	h_{FE4}	300		
<u>Subgroup 4</u>						
Small signal short circuit forward current transfer ratio	3206	$V_{CE} = 3 \text{ V dc}$; $I_C = 5 \text{ A dc}$; $f = 1 \text{ kHz}$	h_{fe}	1,000		
Magnitude of small-signal short-circuit forward-current transfer ratio	3306	$V_{CE} = 3 \text{ V dc}$, $I_C = 5 \text{ A dc}$, $f = 1.0 \text{ MHz}$	$ h_{fe} $	10	250	
Open circuit output capacitance	3236	$V_{CB} = 10 \text{ V dc}$; $I_E = 0$; $100 \text{ kHz} \leq f \leq 1 \text{ MHz}$	C_{obo}		300	pF
Pulse response		(See figure 2)				
Turn-on time		$V_{CC} = 30 \text{ V dc}$, $I_C = 5 \text{ A dc}$, $I_{B1} = 20 \text{ mA dc}$	t_{on}		2.0	μs
Turn-off time		$V_{CC} = 30 \text{ V dc}$, $I_C = 5 \text{ A dc}$, $I_{B1} = I_{B2} = 20 \text{ mA dc}$	t_{off}		10	μs

See footnote at end of table.

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* TABLE I. Group A inspection - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 5</u>						
Safe operating area (dc)	3051	$T_C = +25^\circ\text{C} +10^\circ\text{C}, -0^\circ\text{C}, t \geq 1\text{s}, 1$ cycle, (see figure 3)				
Test 1		$V_{CE} = 12.5\text{ V dc}, I_C = 12\text{ A dc}$				
Test 2		$V_{CE} = 30\text{ V dc}, I_C = 5\text{ A dc}$				
Test 3 2N6051 2N6052		$V_{CE} = 70\text{ V dc}, I_C = 200\text{ mA dc}$ $V_{CE} = 90\text{ V dc}, I_C = 155\text{ mA dc}$				
Safe operating area (switching) 2N6051 2N6052	3053	Load condition B, (clamped inductive load), $T_A = +25^\circ\text{C}$, $t_r + t_f \leq 1.0\ \mu\text{s}$ duty cycle ≤ 2 percent, $t_p = 1\text{ ms}$, (vary to obtain I_C), $R_s = 0.1\text{ ohms}$, $R_{BB1} = 80\text{ ohms}$, $V_{BB1} = 16\text{ V dc}$, $R_{BB2} = 100\text{ ohms}$, $V_{BB2} = 1.5\text{ V dc}$, $V_{CC} = 20\text{ V dc}$, $I_C = 12\text{ A dc}$, $R_L \leq 2\text{ ohms}$, $L = 1\text{ mH}$ (Stancor C-2688 or equivalent); clamp voltage = $80 +0, -5\text{ V dc}$, clamp voltage = $100 +0, -5\text{ V dc}$. Device fails if clamp voltage not reached (see figure 4).				
Electrical measurements		See table I, subgroup 2.				
<u>Subgroups 6 & 7</u>						
Not applicable						

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

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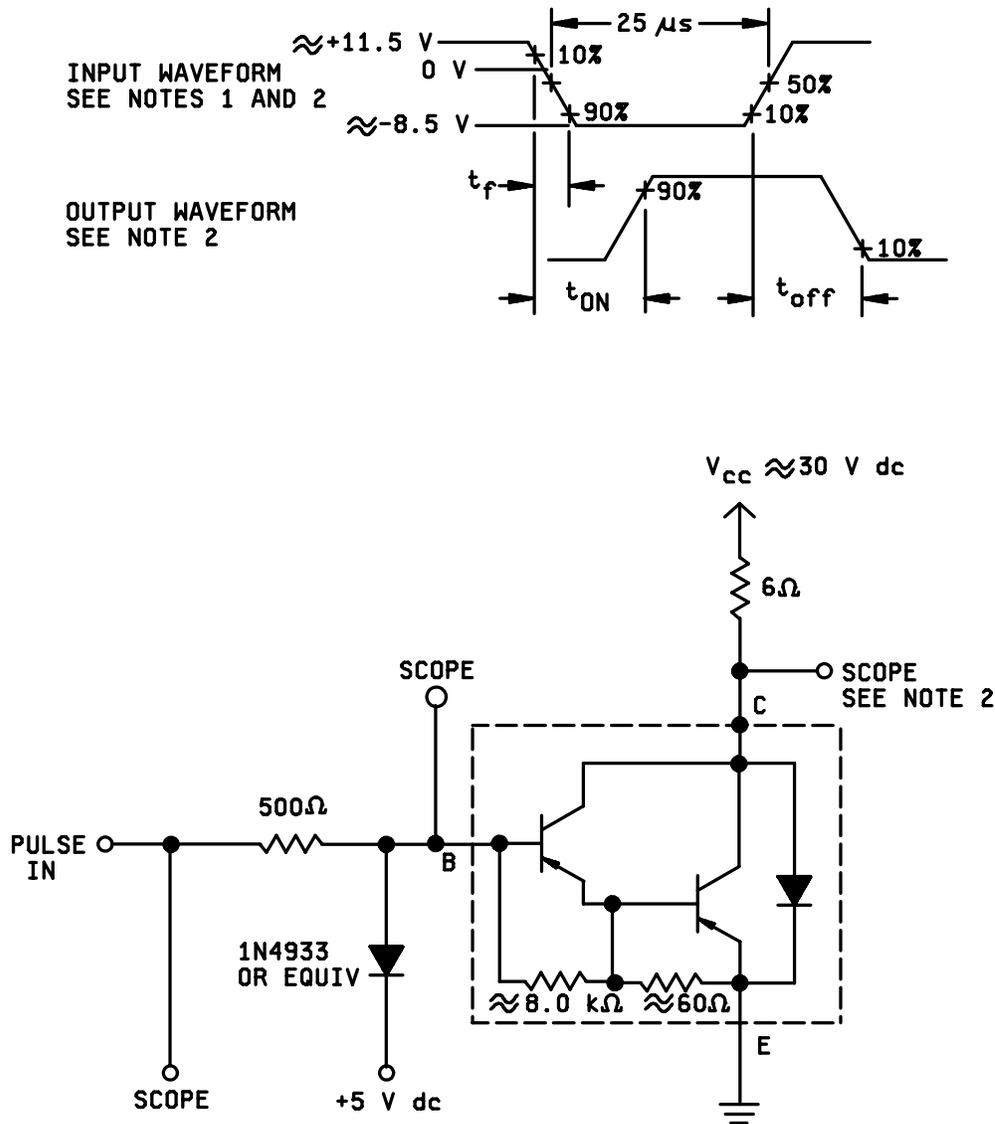
* TABLE II. Groups B, C, and E delta measurements. 1/ 2/ 3/

Step	Inspection	MIL-STD-750		Symbol	Limit		Unit
		Method	Conditions		Min	Max	
1	Forward - current transfer ratio	3076	$V_{CE} = 3 \text{ V dc}$, $I_C = 6 \text{ A dc}$, pulsed (see 4.5.1)	Δh_{FE2}	± 40 percent		

- 1/ The delta measurements for table E-VIB (JAN, JANTX, and JANTXV) of MIL-PRF-19500 are subgroups 3 and 6, see table II herein, step 1.
 2/ The delta measurements for table E-VII of MIL-PRF-19500 are subgroup 6, see table II herein, step 1.
 3/ The delta measurements for table E-IX of MIL-PRF-19500 are subgroup 1 and 2, see table II herein, step 1.

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

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



NOTES:

1. The input waveform is supplied by a pulse generator with the following characteristics: $t_r \leq 20$ ns, $t_f \leq 20$ ns, $Z_{out} = 50 \Omega$, $PW = 2.0 \mu s$, duty cycle ≤ 2 percent.
2. Output wave forms are monitored on an oscilloscope with the following characteristics: $t_r \leq 2.0$ ns, $Z_{in} \geq 20$ k Ω , $C_{in} \leq 11.5$ pF.
3. Resistors shall be noninductive types.
4. The dc power supplies may require additional by-passing in order to minimize ringing.

FIGURE 2. Pulse response test circuit.

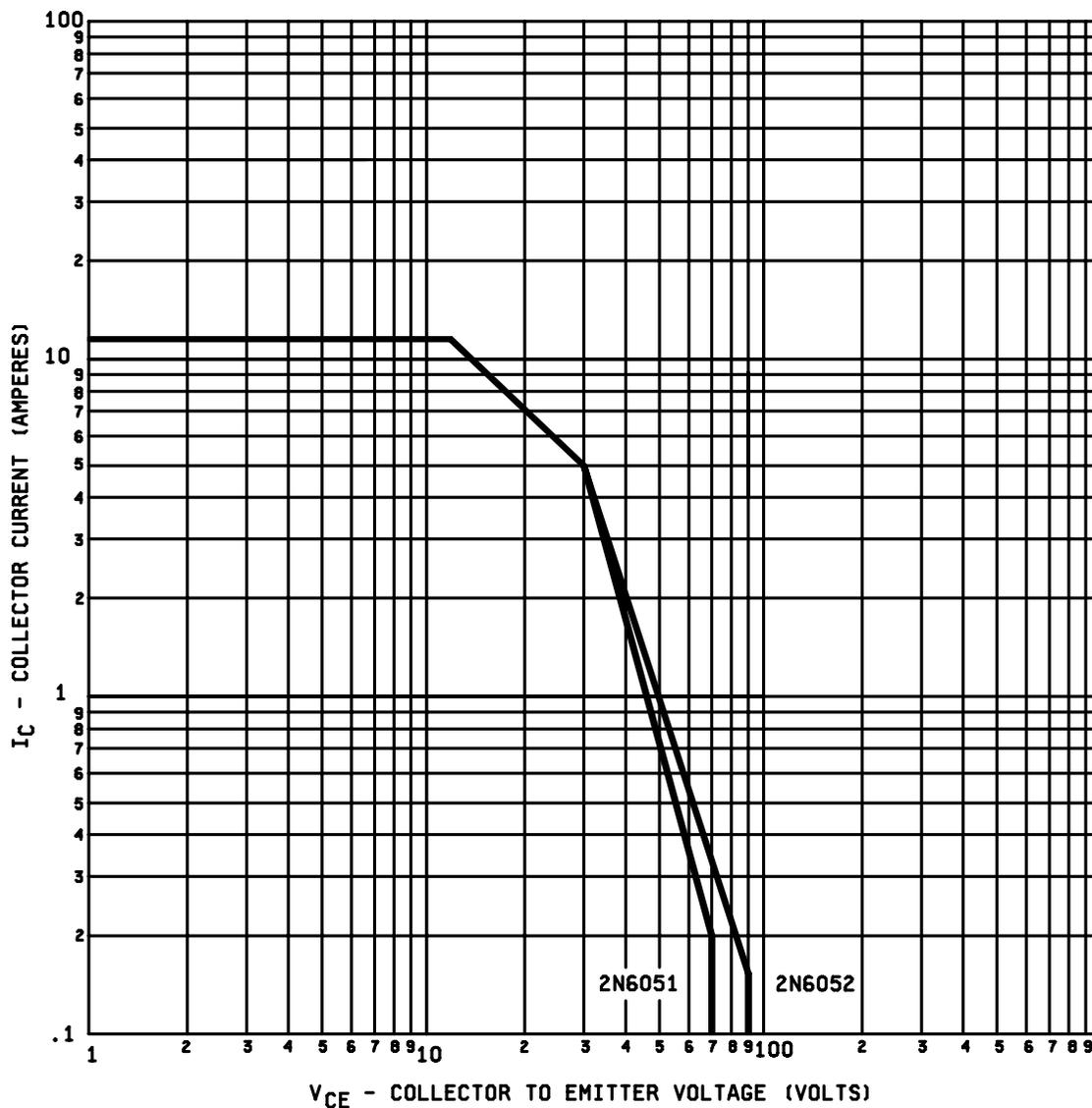


FIGURE 3. Maximum safe operating area graph (continuous dc).

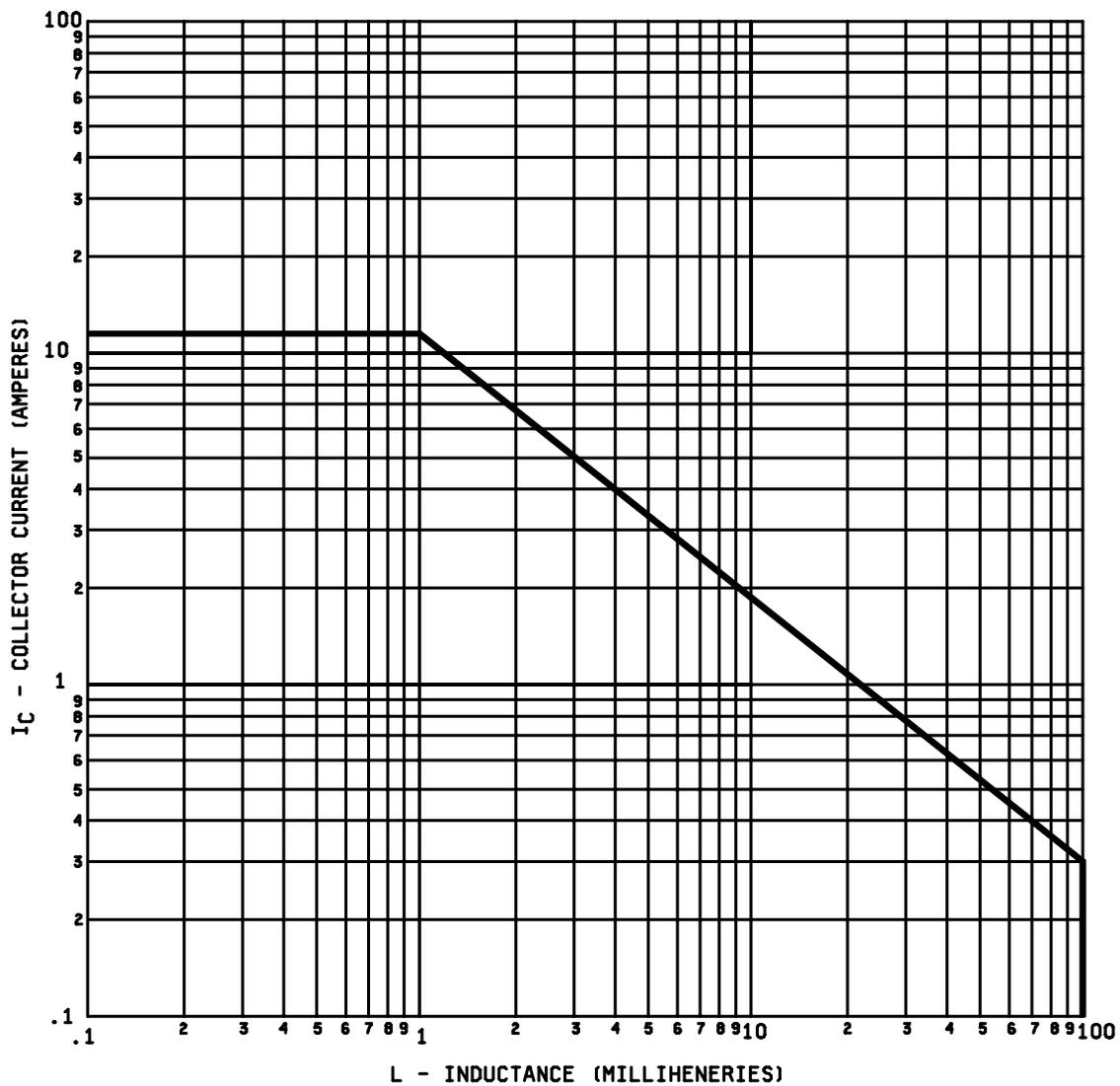


FIGURE 4. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

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. Product assurance level and type designator.

* 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 Defense Supply Center, Columbus, ATTN: DSCC/VQE, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail vqe.chief@dla.mil.

* 6.4 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.

Custodians:
Army - CR
Navy - EC
Air Force - 11
NASA - NA
DLA - CC

Preparing activity:
DLA - CC
(Project 5961-2007-047)

Review activities:
Air Force - 19, 99

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