

The documentation and process conversion measures necessary to comply with this document shall be completed by 10 December 2010.

INCH-POUND

MIL-PRF-19500/540E  
 10 September 2010  
 SUPERSEDING  
 MIL-PRF-19500/540D  
 12 August 2009

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, DARLINGTON TRANSISTOR, PNP SILICON, POWER, TYPES 2N6298 AND 2N6299, 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 is provided for each device type as specified in MIL-PRF-19500.

1.2 Physical dimensions. See figure 1 (similar to TO-66).

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

Type	$P_T$ (1)		$R_{\theta JC}$	$V_{CBO}$	$V_{CEO}$	$V_{EBO}$	$I_C$	$I_B$	$T_J$ and $T_{STG}$
	$T_C = 25^\circ\text{C}$	$T_C = +100^\circ\text{C}$							
	<u>W</u>	<u>W</u>	<u><math>^\circ\text{C/W}</math></u>	<u>V dc</u>	<u>V dc</u>	<u>V dc</u>	<u>A dc</u>	<u>mA dc</u>	<u><math>^\circ\text{C}</math></u>
2N6298	64	32	2.33	60	60	5	8	120	-65 to +175
2N6299	64	32	2.33	80	80	5	8	120	-65 to +175

(1) Derate linearly at 0.428 W/ $^\circ\text{C}$  above  $T_C > 25^\circ\text{C}$ .

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

Limits	$h_{FE2}$ (1)	$h_{FE3}$ (1)	$ h_{fe} $ $V_{CE} = 3\text{ V dc}$	$C_{obo}$ $100\text{ kHz} \leq f \leq 1\text{ MHz}$	Pulse response		$V_{BE(sat)}$ (1)	$V_{CE(sat)2}$ (1)	$h_{fe}$ $V_{CE} = 3\text{ V dc}$
	$V_{CE} = 3\text{ V dc}$ $I_C = 4\text{ A dc}$	$V_{CE} = 3\text{ V dc}$ $I_C = 8\text{ A dc}$	$I_C = 3\text{ A dc}$ $f = 1\text{ MHz}$	$V_{CB} = 10\text{ V dc}$ $I_E = 0$	$t_{on}$	$t_{off}$	$I_C = 8\text{ A dc}$ $I_B = 80\text{ mA dc}$	$I_C = 8\text{ A dc}$ $I_B = 80\text{ mA dc}$	$I_C = 3\text{ A dc}$ $f = 1\text{ kHz}$
Min	750	100	25	<u>pF</u>	<u><math>\mu\text{s}</math></u>	<u><math>\mu\text{s}</math></u>	<u>V dc</u>	<u>V dc</u>	300
Max	18,000		350	200	2.0	8.0	4.0	3.0	

(1) Pulsed (see 4.5.1).

\* 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@dsc.dla.mil](mailto: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 <https://assist.daps.dla.mil>.

## 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 <https://assist.daps.dla.mil/quicksearch> or <https://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. 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 manufacturers list 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. Interface and physical dimensions shall be as specified in MIL-PRF-19500, and on figure 1, (similar to TO-66).

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).

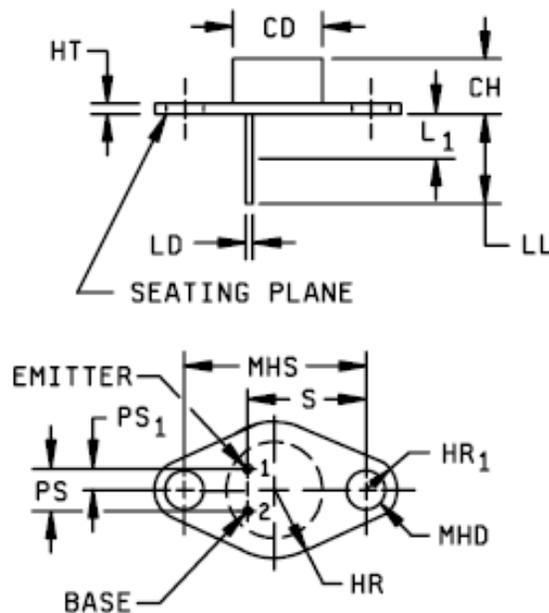
3.5 Marking. Marking shall be in accordance with MIL-PRF-19500.

3.6 Electrical performance characteristics. Unless otherwise specified herein, the electrical performance characteristics are as specified in 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.

Dimensions					
Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
CD		.620		15.76	
CH	.250	.340	6.35	8.64	
HR		.350		8.89	
HT	.050	.075	1.27	1.91	
HR <sub>1</sub>	.115	.145	2.92	3.68	4
LD	.028	.034	.71	.86	4, 6
LL	.360	.500	9.14	12.70	
L <sub>1</sub>		.050		1.27	6
MHD	.142	.152	3.61	3.86	4
MHS	.958	.962	24.33	24.43	
PS	.190	.210	4.83	5.33	3
PS <sub>1</sub>	.093	.107	2.36	2.73	3
S	.570	.590	14.48	14.99	
Notes	1, 2, 5, 7				



## NOTES:

1. Dimensions are in inches.
2. Millimeters are given for general information only.
3. These dimensions should be measured at points .050 inch (1.27 mm) +.005 inch (0.13 mm) -.000 inch (0.00 mm) below seating plane. When gauge is not used, measurement will be made at the seating plane.
4. Two places.
5. 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.
6. Lead diameter shall not exceed twice LD within L<sub>1</sub>.
7. Lead number 1 is the emitter, lead 2 is the base, case is the collector.
8. In accordance with ASME Y14.5M, diameters are equivalent to  $\varnothing$ x symbology.

FIGURE 1. Physical dimensions (similar to TO-66).

## 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 tables 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 II tests, the tests specified in table II herein that were not performed in the prior revision shall be performed on the first inspection lot of this revision to maintain qualification.

4.3 Screening (JANTX and JANTXV levels only). 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)	Measurements
	JANTX and JANTXV levels only
(1) 3c	Thermal impedance (see 4.3.2).
9	$I_{CEX1}$ and $h_{FE2}$
11	$I_{CEX1}$ and $h_{FE2}$
12	See 4.3.1
13	Subgroup 2 of table I herein; $\Delta I_{CEX1} = 100$ percent of initial value or $2 \mu\text{A dc}$ , whichever is greater. $\Delta h_{FE2} = \pm 40$ percent.

(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:  $V_{CE} \geq 10$  V dc;  $T_J = +162.5^\circ\text{C} \pm 12.5^\circ\text{C}$ .  
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). See table II, group E, subgroup 4 herein. Measurement delay time ( $t_{MD}$ ) = 70  $\mu\text{s}$  max.

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 table E-V of MIL-PRF-19500 and table I herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

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4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VIB (JAN, JANTX, and JANTXV) of MIL-PRF-19500. Electrical measurements (end-points) shall be in accordance with the table I, subgroup 2 herein.

<u>Subgroup</u>	<u>Method</u>	<u>Condition</u>
B3	1037	$V_{CE} \geq 10 \text{ V dc}$ ; $\Delta T_J$ 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.

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

<u>Subgroup</u>	<u>Method</u>	<u>Condition</u>
C2	2036	Test condition A, weight = 10 pounds, time = 15 seconds.
C5	3151	$R_{\theta JC} = 2.33^\circ\text{C/W}$ .
C6	1037	$V_{CE} \geq 10 \text{ V dc}$ ; $\Delta T_J$ 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 device 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.

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	Limits		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	$Z_{\theta JC}$			$^{\circ}C/W$
Breakdown voltage, collector to emitter 2N6298 2N6299	3011	Bias condition D, $I_C = 100$ mA dc; pulsed (see 4.5.1)	$V_{(BR)CEO}$	60 80		V dc V dc
Collector to emitter cutoff current 2N6298 2N6299	3041	Bias condition A, $V_{BE} = 1.5$ V dc  $V_{CE} = 60$ V dc $V_{CE} = 80$ V dc	$I_{CEX1}$		10 10	$\mu A$ dc $\mu A$ dc
Collector to emitter cutoff current 2N6298 2N6299	3041	Bias condition D  $V_{CE} = 30$ V dc $V_{CE} = 40$ V dc	$I_{CEO}$		0.5 0.5	mA dc mA dc
Emitter to base cutoff current	3061	Bias condition D, $V_{EB} = 5$ V dc	$I_{EBO}$		2.0	mA dc
Forward-current transit ratio	3076	$V_{CE} = 3$ V dc, $I_C = 1$ A dc, pulsed (see 4.5.1)	$h_{FE1}$	500		
Forward-current transit ratio	3076	$V_{CE} = 3$ V dc, $I_C = 4$ A dc, pulsed (see 4.5.1)	$h_{FE2}$	750	18000	
Forward-current transit ratio	3076	$V_{CE} = 3$ V dc, $I_C = 8$ A dc, pulsed (see 4.5.1)	$h_{FE3}$	100		
Base emitter voltage (nonsaturated)	3066	Test condition B, $V_{CE} = 3$ V dc, $I_C = 4$ A dc, pulsed (see 4.5.1)	$V_{BE(on)}$		2.8	V dc
Base emitter voltage (saturated)	3066	Test condition A, $I_C = 8$ A dc, $I_B = 80$ mA dc, pulsed (see 4.5.1)	$V_{BE(sat)1}$		4.0	V dc
Collector - emitter voltage (saturated)	3071	$I_C = 4$ A dc, $I_B = 16$ mA dc, pulsed (see 4.5.1)	$V_{CE(sat)1}$		2.0	V dc
Collector - emitter voltage (saturated)	3071	$I_C = 8$ A dc, $I_B = 80$ mA dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		2.0	V dc

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection <u>1/</u>	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 2N6298 2N6299	3041	Bias condition A, $V_{BE} = 1.5\text{ V dc}$ $V_{CE} = 60\text{ V dc}$ $V_{CE} = 80\text{ V dc}$	$I_{CEX2}$		5.0 5.0	mA dc mA dc
Low temperature operation:		$T_A = -55^\circ\text{C}$				
Forward current transfer ratio	3076	$V_{CE} = 3\text{ V dc}$ , $I_C = 4\text{ A dc}$ , pulsed (see 4.5.1)	$h_{FE4}$	200		
<u>Subgroup 4</u>						
Small signal short circuit forward current transfer ratio	3206	$V_{CE} = 3\text{ V dc}$ ; $I_C = 3\text{ A dc}$ ; $f = 1\text{ kHz}$	$h_{fe}$	300		
Magnitude of small-signal short-circuit forward-current transfer ratio	3306	$V_{CE} = 3\text{ V dc}$ , $I_C = 3\text{ A dc}$ , $f = 1.0\text{ MHz}$	$ h_{fe} $	25	350	
Pulse response	3251					
Turn-on time		See figure 2; $V_{CC} = 30\text{ V dc}$ ; $I_C = 4\text{ A dc}$ ; $I_{B1} = 16\text{ mA dc}$	$t_{on}$		2.0	$\mu\text{s}$
Turn-off time		See figure 3; $V_{CC} = 30\text{ V dc}$ ; $I_C = 4\text{ A dc}$ ; $I_{B1} = 16\text{ mA dc}$	$t_{off}$		8.0	$\mu\text{s}$
Open circuit output capacitance	3236	$V_{CB} = 10\text{ V dc}$ ; $I_E = 0$ ; $100\text{ kHz} \leq f \leq 1\text{ MHz}$	$C_{obo}$		200	pF

See footnotes at end of table.

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	$T_C = 25^\circ\text{C} + 10^\circ\text{C}$ , $t = 1$ s; 1 cycle; see figure 4; $V_{CE} = 8$ V dc; $I_C = 8$ A dc				
Test 1						
Test 2		$V_{CE} = 20$ V dc; $I_C = 2.0$ A dc				
Test 3		$I_C = 100$ mA dc				
2N6298 2N6299		$V_{CE} = 60$ V dc $V_{CE} = 80$ V dc				
Safe operating area (switching)	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 $\leq 10$ percent, $t_p = 1$ ms; (vary to obtain $I_C$ ); $R_S = 0.1$ ohms; $R_{BB1} = 80$ ohms; $V_{BB1} = 16$ V dc; $R_{BB2} = 100$ ohms; $V_{BB2} = 1.5$ V dc; $V_{CC} = 50$ V dc; $I_C = 8$ A dc; $R_L \leq 2$ ohms; $L = 1$ mH; clamp voltage				
2N6298 2N6299			60 V dc 80 V dc			
Safe operation area (switching)	3053	Load condition C; (unclamped inductive load) See figure 5, $T_A = +25^\circ\text{C}$ ; duty cycle $\leq 10$ percent $R_S = 0.1$ ohms				
Test 1		$t_p = 1$ ms; (vary to obtain $I_C$ ); $R_{BB1} = 80$ ohms; $V_{BB1} \geq 12$ V dc; $R_{BB2} = \infty$ ; $V_{CC} \geq 30$ V dc; $I_C = 8$ A dc; $R_L \leq 0.5$ ohms; $L = 1$ mH at 8 A dc				

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 5</u> - Continued						
Test 2		$t_D = 1 \text{ ms}$ ; (vary to obtain $I_C$ ); $R_{BB1} = 80 \text{ ohms}$ ; $V_{BB1} \geq 12 \text{ V dc}$ ; $R_{BB2} = \infty$ ; $V_{BB2} = 0 \text{ V dc}$ ; $V_{CC} = 30 \text{ V dc}$ ; $I_C = 0.2 \text{ A dc}$ ; $R_L \leq 0.5 \text{ ohms}$ ; $L = 100 \text{ mH}$ ; at $0.2 \text{ A dc}$				
End point electrical measurements:						
Collector to emitter cutoff current	3041	Bias condition A; $V_{BE} = 1.5 \text{ V dc}$	$I_{CEX1}$			
2N6298		$V_{CE} = 60 \text{ V dc}$			0.5	mA dc
2N6299		$V_{CE} = 80 \text{ V dc}$			0.5	mA dc
Forward-current transfer ratio	3076	$V_{CE} = 3 \text{ V dc}$ ; $I_C = 4 \text{ A dc}$ ; pulsed (see 4.5.1)	$h_{FE2}$	750	18,000	

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, subgroup 2 and 6.

Group E, subgroup 1.

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

Inspection	MIL-STD-750		Sample plan
	Method	Conditions	
<u>Subgroup 1</u>			
Temperature cycling	1051	500 cycles.	45 devices c = 0
Hermetic seal	1071		
Fine leak Gross leak			
Electrical measurements		See table I, subgroup 2 herein.	
<u>Subgroup 2</u>			
Blocking life	1048	Test temperature = +125°C; V <sub>CB</sub> = 80 percent rated; T = 1,000 hours.	45 devices c = 0
Electrical measurements		See table I, subgroup 2 herein.	
<u>Subgroup 4</u>			
Thermal impedance curves		See table E-IX of MIL-PRF-19500, group E, subgroup 4.	Sample size N/A
<u>Subgroup 6</u>			
ESD	1020	Testing is not required for class 3 listing. Testing is required for a nonsensitive listing to prove capability.	3 devices
<u>Subgroup 8</u>			
Reverse stability	1033	Condition B.	45 devices c = 0

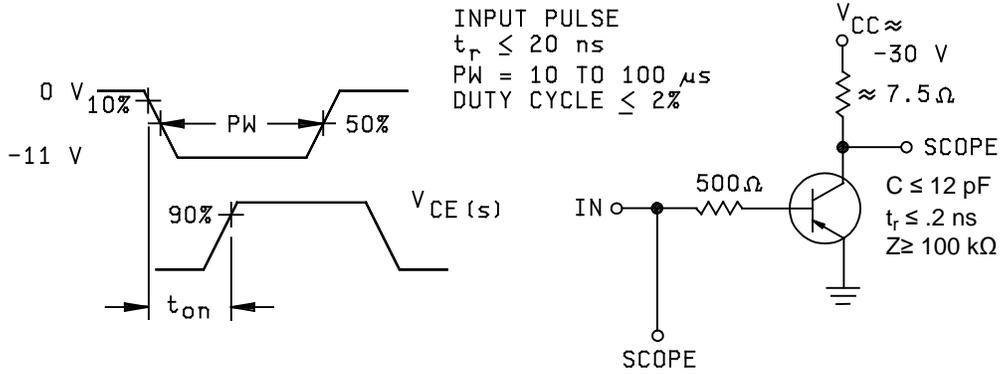
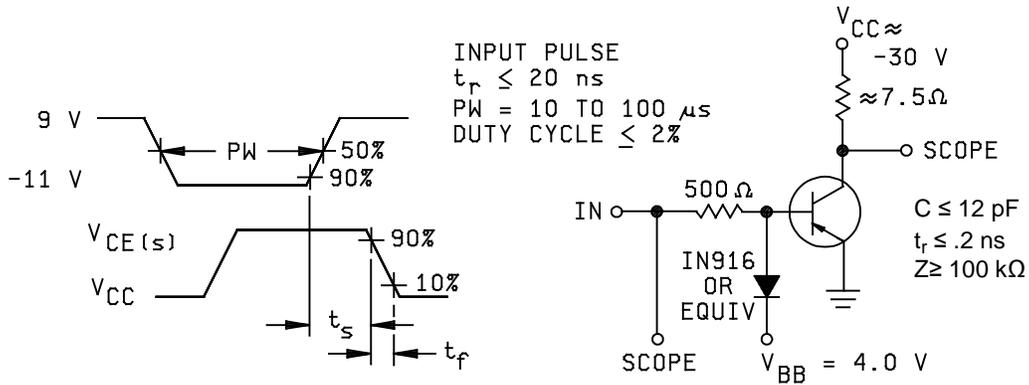


FIGURE 2. Turn-on time test circuit.



\* FIGURE 3. Turn-off time test circuit.

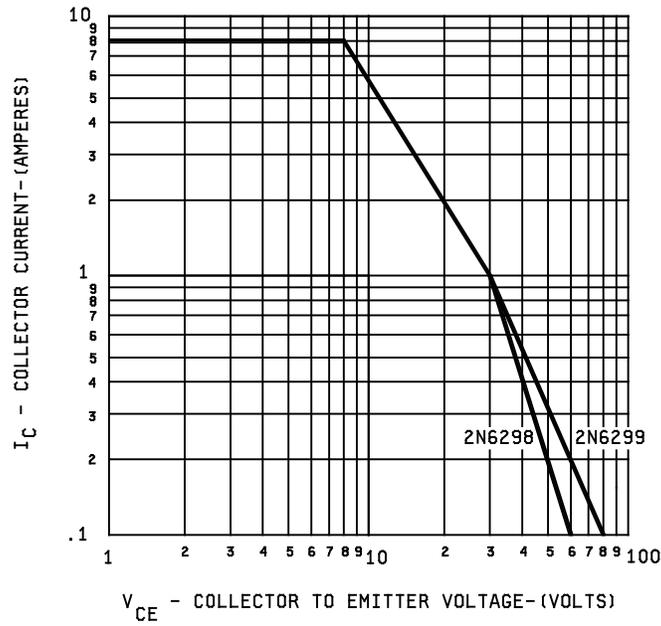


FIGURE 4. Maximum safe operating graph (dc).

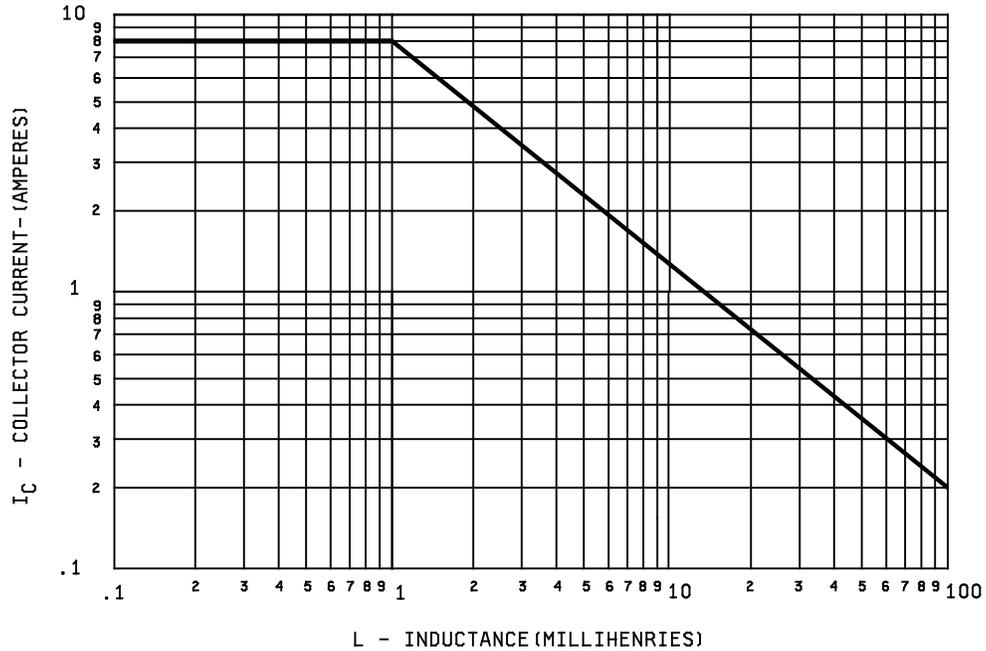


FIGURE 5. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

## 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 DLA Land and Maritime, ATTN: VQE, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail [vqe.chief@dla.mil](mailto: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.daps.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.

Custodian:  
Army - CR  
Air Force - 85  
DLA - CC

Preparing activity:  
DLA - CC

Review activities:  
Army - AR  
Air Force - 19, 71, 99

(Project 5961-2010-055)

\* NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.daps.dla.mil>.