INCH–POUND

The documentation and process conversion measures necessary to comply with this revision shall be completed by 30 March 2013.

MIL–PRF–19500/539F
30 December 2012
SUPERSEDING
MIL–PRF–19500/539E
22 August 2009

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, POWER DARLINGTON, TYPES 2N6300 AND 2N6301, 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 NPN silicon, power Darlington transistors. Three levels of product assurance are provided for each device type as specified in MIL–PRF–19500.

1.2 Physical dimensions. The device package style is TO–213AA (formerly TO–66) in accordance with figure 1.

1.3 Maximum ratings. Unless otherwise specified, T_C = +25°C.

Types	P_T (1)			$R_{\theta JC}$	V_{CBO}	V_{CEO}	V_{EBO}	I_C	I_B	T_J and T_{STG}
	T_C = 0°C		T_C = 100°C	(2)						
	W	W	W	°C/W	V dc	V dc	V dc	A dc	mA dc	°C
2N6300	75	65	37	2.66	60	60	5	8	120	–55 to +200
2N6301	75	65	37	2.66	80	80	5	8	120	–55 to +200

(1) See figure 2 for temperature-power derating curves.
(2) See figure 3 for thermal impedance curve.

Comments, suggestions, or questions on this document should be addressed DLA Land and Maritime ATTN: VAC, P.O. Box 3990, Columbus, OH 43218–3990, or emailed to semiconductor@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.dla.mil.

1.4 Primary electrical characteristics. Unless otherwise specified, T_C = +25°C.

Limit	h_{FE2} (1) V_{CE} = 3 V dc I_C = 4 A dc	h_{FE3} (1) V_{CE} = 3 V dc I_C = 8 A dc	$\lvert h_{fe} \rvert$ V_{CE} = 3 V dc I_C = 3 A dc f = 1 MHz	C_{obo} 100 kHz ≤ f ≤ 1 MHz V_{CB} = 10 V dc I_E = 0	Pulse response	
					t_{on}	t_{off}
				pF	µs	µs
Min	750	100	25			
Max	18,000		350	200	2.0	8.0

Limit	$V_{BE(sat)2}$ (1) I_C = 8 A dc I_B = 80 mA dc	$V_{CE(sat)2}$ (1) I_C = 8 A dc I_B = 80 mA dc	h_{fe} V_{CE} = 3 V dc I_C = 3 A dc f = 1 kHz
	V dc	V dc	
Min			300
Max	4.0	3.0	

(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.

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.dla.mil/quicksearch or https://assist.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.

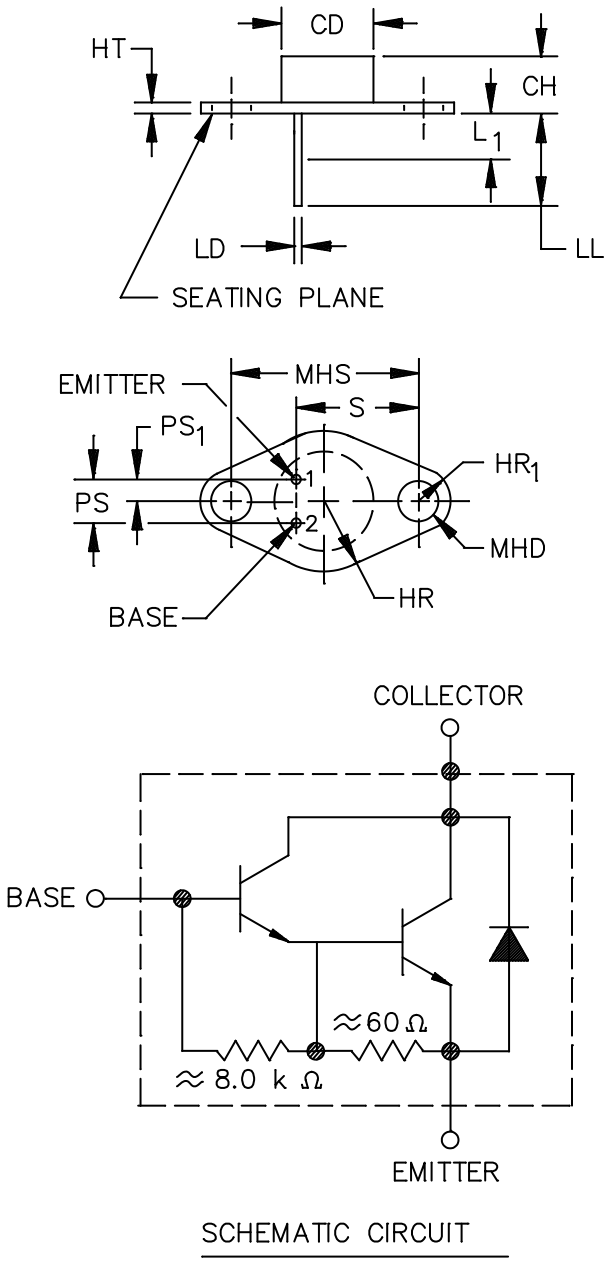


FIGURE 1. Physical dimensions and schematic (TO–213AA, formerly TO–66).

Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD	.470	.620	11.94	15.74	3
CH	.250	.340	6.35	8.64	
HR		.350		8.89	
HR_1	.115	.145	2.92	3.68	4
HT	.050	.075	1.27	1.91	3, 5
LD	.028	.034	0.71	0.86	6, 7
LL	.360	.500	9.14	12.70	6
L_1		.050		1.27	8
MHD	.142	.152	3.61	3.86	4
MHS	.958	.962	24.33	24.43	
PS	.190	.210	4.83	5.33	9
PS_1	.093	.107	2.37	2.71	9
S	.570	.590	14.48	14.99	9

NOTES:

1. Dimensions are in inches. Millimeters are given for general information only.
2. Terminal 1 is the emitter and terminal 2 is the base. The collector shall be electrically connected to the case.
3. Body contour is optional within zone defined by dimension CD.
4. Applies to two holes, at both ends.
5. Dimension HT does not include sealing flanges.
6. Applies to both terminals.
7. Dimension LD applies between dimensions L_1 and LL. Diameter is uncontrolled in dimension L_1.
8. Within this zone the lead diameter may vary to allow for lead finishes and irregularities.
9. 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.
10. The seating plane of header shall be flat within .001 inch (0.03 mm), concave to .004 inch (0.10 mm), convex inside a .520 inch (13.20 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 Φx symbology.

FIGURE 1. Physical dimensions and schematic (TO–213AA, formerly TO–66) – Continued.

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 and as follows:

I_M – The measurement current applied to forward bias the junction for measurement of V_{BE}.
I_H – The collector current applied to the device under test during the heating period.
t_H – The duration of the applied heating power pulse.
t_{SW} – Sample window time during which final V_{BE} measurement is made.

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. The 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).

3.4.2 Polarity. The polarity of the device types shall be as shown on figure 1.

3.5 Electrical performance characteristics. Unless otherwise specified herein, the electrical performance characteristics are as specified in 1.3, 1.4, and table I.

3.6 Electrical test requirements. The electrical test requirements shall be as specified in table I.

3.7 Marking. Marking shall be in accordance with MIL–PRF–19500.

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 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)	Measurement
	JANTX and JANTXV levels
3c (1)	Thermal impedance, see 4.3.1
9	I_{CEX1} and h_{FE2}
11	I_{CEX1} and h_{FE2} ΔI_{CEX1} = ±100 percent of initial value or 100 nA dc, whichever is greater. Δh_{FE2} = ±40 percent of initial value.
12	See 4.3.2
13	See table I, subgroup 2 herein. ΔI_{CEX1} = 100 percent of initial value or 100 nA dc, whichever is greater. Δh_{FE2} = ±40 percent of initial value.

(1) Thermal impedance shall be performed anytime after temperature cycling (screen 3a) and does not need to be repeated in screening requirements.

4.3.1 Thermal impedance. The thermal impedance measurements shall be performed in accordance with test method 3131 of MIL–STD–750 using the guidelines in that method for determining I_H, I_M, t_H, t_{SW} (and V_H where appropriate). The thermal impedance limit used in screen 3c and table I, subgroup 2 herein shall be set statistically by the supplier. Measurement delay time (t_{MD}) = 70 μs maximum. See table II, subgroup 4 (group E) herein.

4.3.2 Power burn-in conditions. Power burn-in conditions shall be as follows: T_J = +162.5°C ±12.5°C, V_{CE} ≥ 10 V dc. NOTE: No heat sink or forced air cooling on the devices shall be permitted.

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.

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

Subgroup	Method	Conditions
B3	1037	V_{CE} ≥ 10 V dc, 2,000 cycles, adjust device current, or power, to achieve a minimum ΔT_J of +100°C.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the tests and conditions specified for subgroup testing in table E–VII of MIL–PRF–19500 and as follows. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

Subgroup	Method	Conditions
C2	2036	Test condition A; weight = 10 pounds (4.54 Kg); time = 15 s.
C5	3131	See 4.3.1, $R_{\theta JC}$ = 2.66°C/W.
C6	1037	V_{CE} ≥ 10 V dc, 6,000 cycles, adjust device current, or power, to achieve a minimum ΔT_J of +100°C.

4.4.4 Group E inspection. Group E inspection shall be conducted in accordance with the tests and conditions specified for subgroup testing in appendix E, table E–IX of MIL–PRF–19500 and as specified in table II 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 response measurements. The conditions for pulse response measurement shall be as specified in section 4 of MIL–STD–750.

TABLE I. Group A inspection.

Inspection 1/	MIL–STD–750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical examination	2071					
Subgroup 2						
Thermal impedance 2/	3131	See 4.3.1	$Z_{\theta JX}$			°C/W
Breakdown voltage, collector to emitter	3011	Bias condition D, I_C = 100 mA dc; pulsed (see 4.5.1)	$V_{(BR)CEO}$			
2N6300				60		V dc
2N6301				80		V dc
Collector to emitter cutoff current	3041	Bias condition A, V_{BE} = –1.5 V dc	I_{CEX1}			
2N6300		V_{CE} = 60 V dc			10	µA dc
2N6301		V_{CE} = 80 V dc			10	µA dc
Collector to emitter cutoff current	3041	Bias condition D	I_{CEO}			
2N6300		V_{CE} = 30 V dc			0.5	mA dc
2N6301		V_{CE} = 40 V dc			0.5	mA dc
Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 5 V dc	I_{EBO}		2.0	mA dc
Forward-current transfer ratio	3076	V_{CE} = 3 V dc; I_C = 1 A dc; pulsed (see 4.5.1)	h_{FE1}	500		
Forward-current transfer ratio	3076	V_{CE} = 3 V dc; I_C = 4 A dc; pulsed (see 4.5.1)	h_{FE2}	750	18000	
Forward-current transfer 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);	$V_{BE(SAT)1}$		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);	$V_{BE(SAT)2}$		4.0	V dc
Saturation voltage; collector to emitter	3071	I_C = 4 A dc; I_B = 16 mA dc; pulsed (see 4.5.1)	$V_{CE(SAT)1}$		2.0	V dc
Saturation voltage; collector to emitter	3071	I_C = 8 A dc; I_B = 80 m A dc; pulsed (see 4.5.1)	$V_{CE(SAT)2}$		3.0	V dc

See footnotes at end of table.

TABLE I. Group A inspection – Continued.

Inspection 1/	MIL–STD–750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 3						
High-temperature operation:		T_A = +150°C				
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = –1.5 V dc	I_{CEX2}			
2N6300		V_{CE} = 60 V dc			1.0	mA dc
2N6301		V_{CE} = 80 V dc			1.0	mA dc
Low-temperature operation:		T_A = –55°C				
Forward-current transfer ratio	3076	V_{CE} = 3 V dc I_C = 4 A dc; pulsed (see 4.5.1)	h_{FE4}	200		
Subgroup 4						
Small-signal, short-circuit forward-current transfer ratio	3206	V_{CE} = 3 V dc; I_C = 3 A dc; f = 1 kHz	h_{fe}	300		
Magnitude of small-signal, short-circuit forward-current transfer ratio	3306	V_{CE} = 3 V dc; I_C = 3 A dc; f = 1.0 MHz	$\|h_{fe}\|$	25	350	
Pulse response transfer ratio	3251	Test condition A, except test circuit and pulse requirements in accordance with figures 4 and 5 herein				
Turn-on time		V_{CC} = 30 V dc, (see figure 4), I_C = 4 A dc, I_{B1} = 16 mA dc	t_{on}		2.0	µs
Turn-off time		V_{CC} = 30 V dc, (see figure 5), I_C = 4 A dc, I_{B1} = – I_{B2} = 16 mA dc	t_{off}		8.0	µs
Open-circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0, 100 kHz ≤ f ≤ 1 MHz	C_{obo}		200	pF
Subgroup 5						
Safe operating area (continuous dc)	3051	T_C = +25°C +10°C, t = 1s, 1 cycle (see figure 6)				
Test 1						
All device types		V_{CE} = 8.0 V dc; I_C = 8 A dc				

See footnotes at end of table.

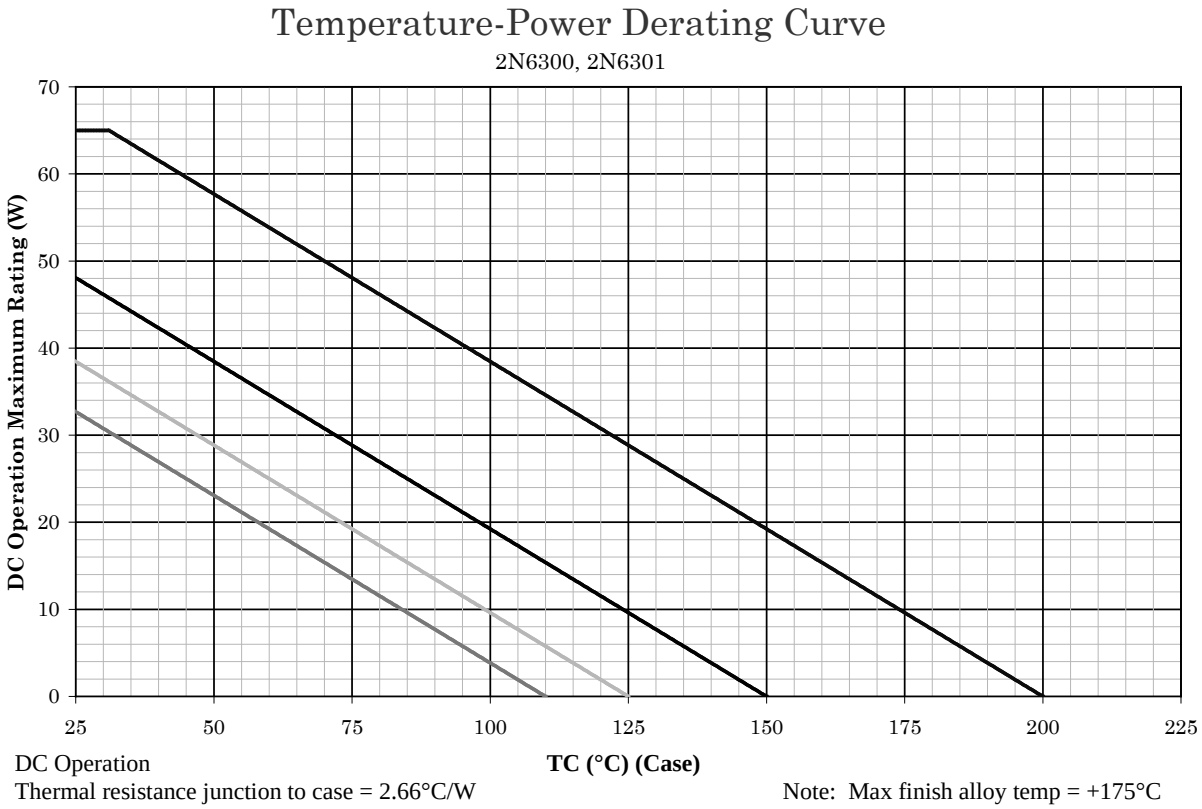
TABLE I. Group A inspection – Continued.

Inspection 1/	MIL–STD–750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 5 – Continued						
Test 2						
All device types		V_{CE} = 20 V dc; I_C = 2.0 A dc				
Test 3						
2N6300		V_{CE} = 60 V dc; I_C = 100 mA dc				
2N6301		V_{CE} = 80 V dc; I_C = 100 mA dc				
Safe operating area (switching)	3053	Load condition B, (clamped inductive load), T_A = +25°C, tr + tf ≤ 1.0 μs duty cycle ≤ 10%, 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 ≤ 2 ohms, L = 1 mH				
2N6300		Clamp voltage = 60 V dc				
2N6301		Clamp voltage = 80 V dc				
Safe operating area (switching)	3053	Load condition C, (unclamped inductive load) (see figure 7), T_A = +25°C, duty cycle ≤ 10%, R_s ≤ 0.1 ohms				
Test 1		t_p = 1 ms (vary to obtain I_C), R_{BB1} = 80 ohms, V_{BB1} ≥ 12 V dc, R_{BB2} = ∞, V_{CC} ≥ 30 V dc, I_C = 8 A dc, R_L ≤ 0.5 ohms, L = 1 mH at 8 A dc				
Test 2		t_p = 1 ms (vary to obtain I_C), R_{BB1} = 80 ohms, V_{BB1} ≥ 12 V dc, R_{BB2} = ∞, V_{BB2} = 0 V dc, V_{CC} ≥ 30 V dc, I_C = 0.2 A dc, R_L ≤ 0.5 ohms, L = 100 mH at 0.2 A dc				
Electrical measurements		See subgroup 2 of this table				
Subgroups 6 and 7						
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, subgroups 1 and 2.

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

Inspection	MIL–STD–750		Qualification sample plan
	Method	Conditions	
Subgroup 1			45 devices; c = 0
Temperature cycling (air to air)	1051	500 cycles.	
Hermetic seal	1071		
Fine leak Gross leak			
Electrical measurements		See table I, subgroup 2 herein.	
Subgroup 2			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 herein.	
Subgroup 4			Sample size N/A
Thermal impedance curves		See MIL–PRF–19500.	
Subgroup 5			3 devices; c = 0
Barometric pressure (reduced)	1001	Test condition C. See 1.3.	
Subgroup 6			11 devices
Electrostatic discharge sensitivity classification	1020		
Subgroup 8			45 devices; c = 0
Reverse voltage leakage stability	1033	Condition B for all device types.	

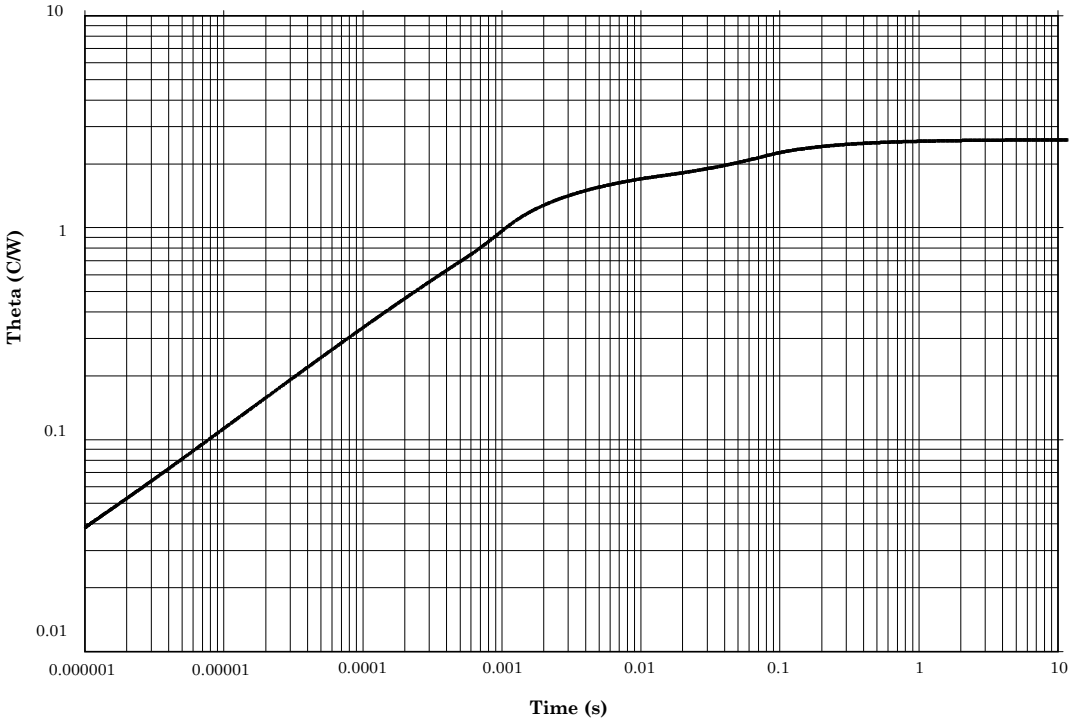


NOTES:

1. All devices are capable of operating at ≤ T_J specified on this curve. Any parallel line to this curve will intersect the appropriate power for the desired maximum T_J allowed.
2. Derate design curve constrained by the maximum junction temperature (T_J ≤ +200°C) and power rating specified (see 1.3 herein.)
3. Derate design curve chosen at T_J ≤ +150°C where the maximum temperature of electrical test is performed.
4. Derate design curves chosen at T_J ≤ +125°C and +110°C to show power rating where most users want to limit T_J in their application.

FIGURE 2. Temperature-power derating graph for device types 2N6300 and 2N6301.

Maximum Thermal Impedance



$R_{\theta JC}$ = 2.66 °C/W

FIGURE 3. Thermal impedance graph.

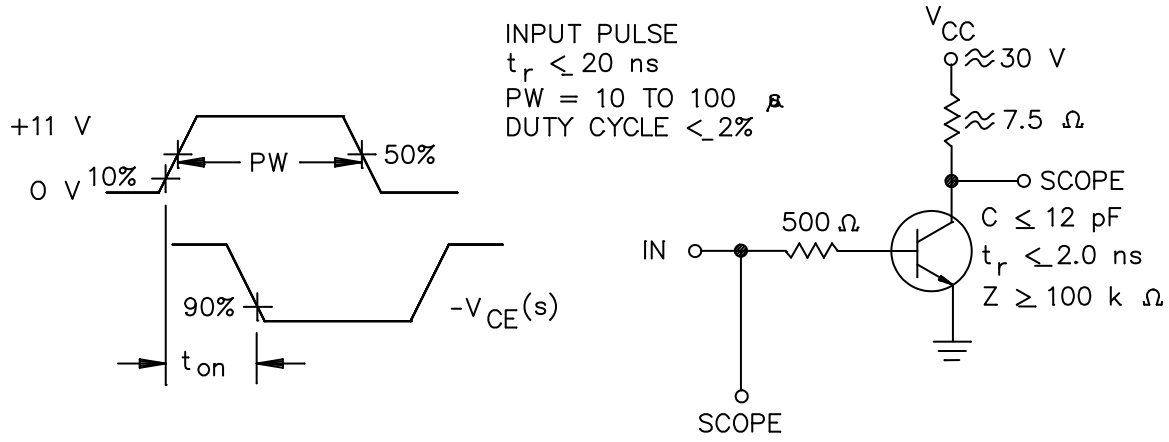
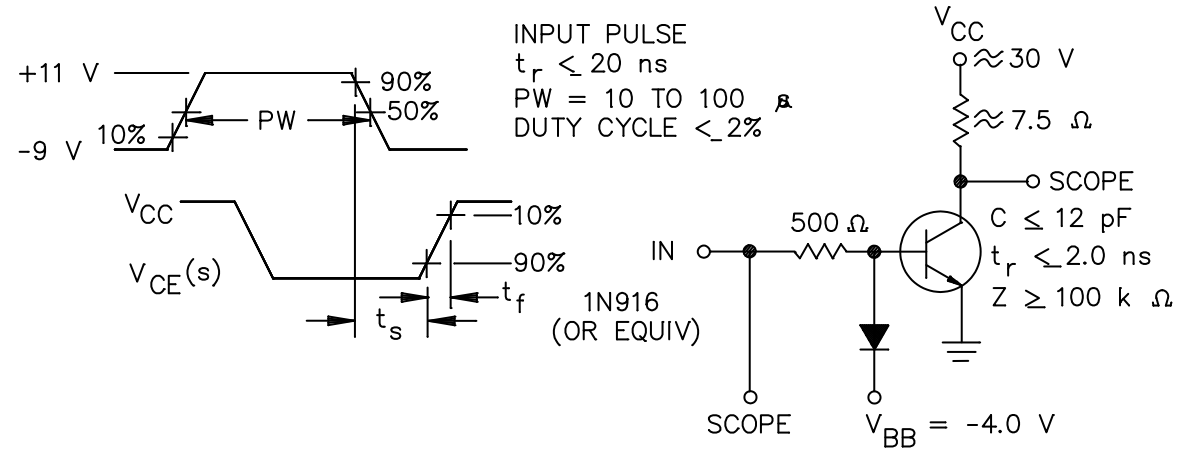


FIGURE 4. Turn on (t_{on}) time test circuit.



NOTE: $t_s + t_f = t_{off}$

FIGURE 5. Turn off (t_{off}) time test circuit.

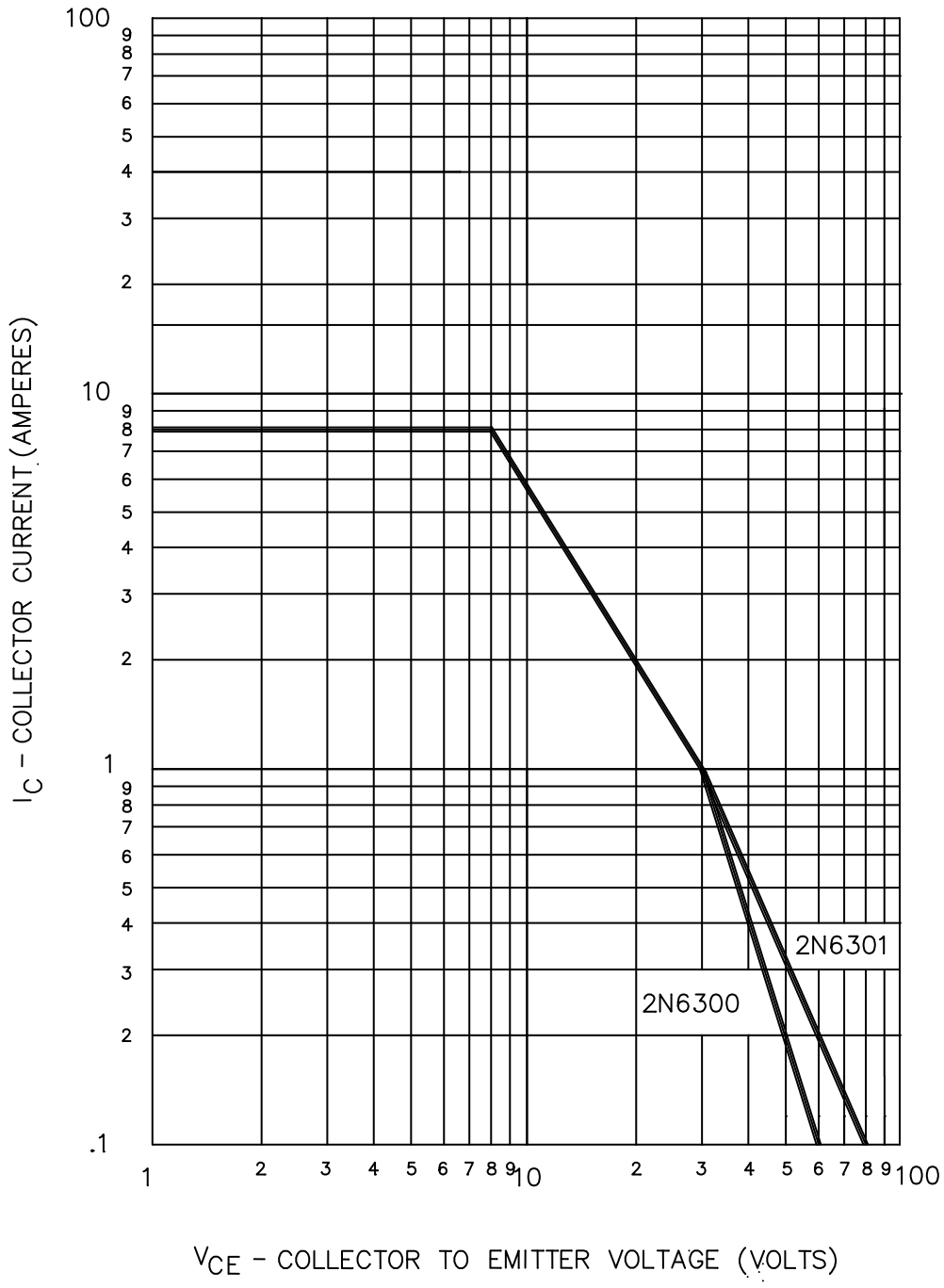


FIGURE 6. Maximum safe operating graph (dc).

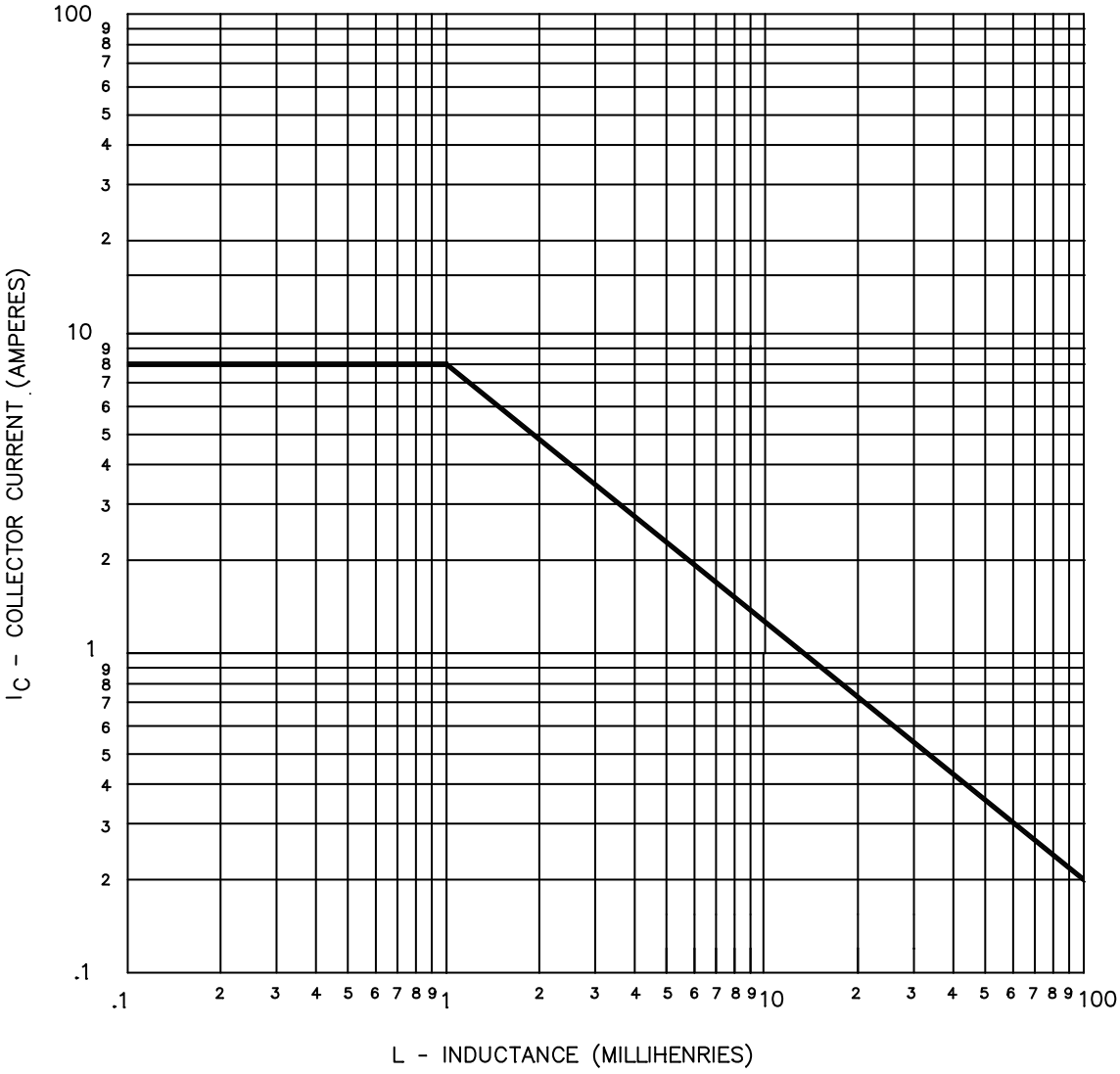


FIGURE 7. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

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. The complete Part or Identifying Number (PIN), see section 1.

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. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.dla.mil.

6.4 Changes from previous issue. The margins of this specification are marked with vertical lines 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 – 85
NASA – NA
DLA – CC

Review activities:
Army – AR, MI
Air Force – 19, 99

Preparing activity:
DLA – CC

(Project 5961–2012–081)

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.dla.mil.