The documentation and process conversion measures necessary to comply with this revision shall be completed by 12 September 2011.

INCH-POUND

MIL-PRF-19500/290P
12 August 2011
SUPERSEDING
MIL-PRF-19500/290N
20 September 2010

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, TRANSISTOR, PNP, SILICON, SWITCHING, TYPES, 2N2904, 2N2904A, 2N2904AL, 2N2905, 2N2905A, AND 2N2905AL, JAN, JANTX, JANTXV, JANS, JANTXVM, JANTXVD, JANTXVR, JANTXVH, JANSM, JANSD, JANSR, AND JANSH

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, silicon, switching transistors. Four levels of product assurance are provided for each device type as specified in MIL-PRF-19500. Provision for radiation hardness assurance (RHA) to four radiation test levels is provided for JANTXV and JANS product assurance levels for type 2N2905A. RHA level designators "M", "D", "R", and "H" are appended to the device prefix to identify devices which have passed RHA requirements.

1.2 Physical dimensions. See figure 1 herein (similar to TO-39).

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

Types	P_T = (1) T_A = +25°C	P_T = (2) T_C = +25°C	V_{CBO}	V_{CEO}	V_{EBO}	I_C	T_{STG} and T_J	$R_{\theta JA}$ (1) (2)	$R_{\theta JC}$ (1) (2)
	W	W	V dc	V dc	V dc	mA dc	°C	°C/W	°C/W
2N2904 (1)	0.8	3.0	60	40	5	600	-65 to +200	195	50
2N2905 (1)	0.8	3.0	60	40	5	600	-65 to +200	195	50
2N2904A, (2)	0.8	3.0	60	60	5	600	-65 to +200	195	50
2N2905A, (2)	0.8	3.0	60	60	5	600	-65 to +200	195	50
2N2904AL, (2)	0.8	3.0	60	60	5	600	-65 to +200	195	50
2N2905AL (2)	0.8	3.0	60	60	5	600	-65 to +200	195	50

(1) For derating, see figures 2 and 3.
(2) For thermal impedance, see figures 4 and 5.

* 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@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 .

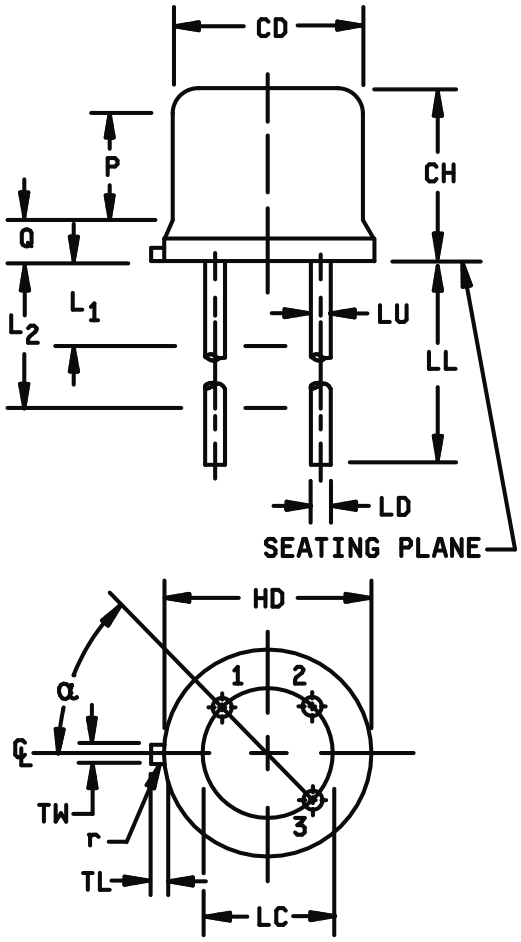
1.4 Primary electrical characteristics at T_A = +25°C.

	h_{FE} at V_{CE} = 10 V dc				
	h_{FE1} I_C = 0.1 mA dc	h_{FE2} I_C = 1 mA dc	h_{FE3} I_C = 10 mA dc	h_{FE4} (1) I_C = 150 mA dc	h_{FE5} (1) I_C = 500 mA dc
	2N2904	2N2904	2N2904	2N2904	2N2904
Min	20	25	35	40	20
Max		175		120	
	2N2905	2N2905	2N2905	2N2905	2N2905
Min	35	50	75	100	30
Max		450		300	
	2N2904A 2N2904AL	2N2904A 2N2904AL	2N2904A 2N2904AL	2N2904A 2N2904AL	2N2904A 2N2904AL
Min	40	40	40	40	40
Max		175		120	
	2N2905A 2N2905AL	2N2905A 2N2905AL	2N2905A 2N2905AL	2N2905A 2N2905AL	2N2905A 2N2905AL
Min	75	100	100	100	50
Max		450		300	

(1) Pulsed (see 4.5.1).

Types	$\|h_{fe}\|$	C_{obo}	Switching	
2N2904 2N2904A 2N2904AL 2N2905 2N2905A 2N2905AL	f = 100 MHz V_{CE} = 20 V dc I_C = 50 mA dc	100 kHz ≤ f ≤ 1 MHz V_{CB} = 10 V dc I_E = 0	t_{on} (see figure 6)	t_{off} (see figure 7)
		pF	ns	ns
Min	2.0			
Max		8	45	300

Symbol	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD	.305	.335	7.75	8.51	
CH	.240	.260	6.10	6.60	
HD	.335	.370	8.51	9.40	
LC	.200 TP		5.08 TP		6
LD	.016	.021	0.41	0.53	7, 8
LL	.500	.750	12.70	19.05	7, 8, 12
LU	.016	.019	.041	0.48	7, 8
L_1		.050		1.27	7, 8
L_2	.250		6.35		7, 8
P	.100		2.54		
Q		.050		1.27	5
TL	.029	.045	0.74	1.14	4
TW	.028	.034	0.71	0.86	3
r		.010		0.25	10
α	45° TP		45° TP		6



NOTES:
1. Dimension are in inches.
2. Millimeters are given for general information only.
3. Beyond r (radius) maximum, TW shall be held for a minimum length of .011 inch (0.28 mm).
4. Dimension TL measured from maximum HD.
5. Body contour optional within zone defined by HD, CD, and Q.
6. Leads at gauge plane .054 +.001, -.000 inch (1.37 +0.03, -0.00 mm) below seating plane shall be within .007 inch (0.18 mm) radius of true position (TP) at maximum material condition (MMC) relative to tab at MMC. The device may be measured by direct methods.
7. Dimension LU applies between L_1 and L_2. Dimension LD applies between L_2 and L minimum. Diameter is uncontrolled in L_1 and beyond LL minimum.
8. All three leads.
9. The collector shall be internally connected to the case.
10. Dimension r (radius) applies to both inside corners of tab.
11. In accordance with ASME Y14.5M, diameters are equivalent to ϕx symbology.
12. For "L" suffix devices, dimension LL is 1.50 (38.10 mm) minimum, 1.75 (44.45 mm) maximum.
13. Lead 1 = emitter, lead 2 = base, lead 3 = collector.

FIGURE 1. Physical dimensions (similar to TO-39).

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 and as follows.

$R_{\theta JA}$ ..... Thermal resistance junction to ambient.
$R_{\theta JC}$ ..... Thermal resistance junction to case.

3.4 Interface and physical dimensions. Interface and physical dimensions shall be as specified in MIL-PRF-19500, and on figure 1.

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 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, II, and III).

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.

4.3 Screening (JANTX, JANTXV, and JANS 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	
	JANS level	JANTXV and JANTX level
1b	Required	Required (JANTXV only)
3b (1) 3c	Not applicable Required (see 4.3.2)	Not applicable Required (see 4.3.2)
5	Required	Not required
8	Required	Not required
9	I_{CBO2}, h_{FE4}	Not applicable
10	24 hours minimum	24 hours minimum
11	I_{CBO2}; h_{FE4}; ΔI_{CBO2} = 100 percent of initial value or 5 nA dc, whichever is greater. Δh_{FE4} = ±15 percent.	I_{CBO2}; h_{FE4}
12	See 4.3.1	See 4.3.1
13	Subgroups 2 and 3 of table I herein; ΔI_{CBO2} = 100 percent of initial value or 5 nA dc, whichever is greater. Δh_{FE4} = ±15 percent.	Subgroup 2 of table I herein; ΔI_{CBO2} = 100 percent of initial value or 5 nA dc, whichever is greater. Δh_{FE4} = ±15 percent.

(1) Shall be performed anytime after temperature cycling, screen 3a and does not need to be repeated in screening requirements. Record thermal impedance for JANS level devices in screen 13 or anytime after serialization.

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows: V_{CB} = 10 - 30 V dc. Power shall be applied to achieve T_J = +135°C minimum using a minimum P_D = 75 percent of P_T maximum, T_A ambient rated as defined in 1.3. With approval of the qualifying activity and preparing activity, an alternate burn-in flow may be used for JANTX and JANTXV quality levels. A justification demonstrating equivalence or adequacy is required. In addition, the manufacturing site's burn-in data and performance history will be essential criteria for burn-in modification approval.

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_{MD} (and V_C where appropriate). The thermal impedance limit used in screen 3c of 4.3 and the subgroup 2 of table I herein shall comply with the thermal impedance graph in figures 4 and 5 (less than or equal to the curve value at the same t_H time) and shall be less than the process determined statistical maximum limit as outlined in method 3131.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500, and as specified herein. If alternate screening is being performed in accordance with MIL-PRF-19500, a sample of screened devices shall be submitted to and pass the requirements of subgroups 1 and 2, of table I herein, inspection only (table E-VIb, group B, subgroup 1 is not required to be performed again if group B has already been satisfied in accordance with 4.4.2).

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.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VIa (JANS) of MIL-PRF-19500 and 4.4.2.1 herein. Electrical measurements (end-points) and delta requirements shall be in accordance with table I, subgroup 2 and 4.5.3 herein. See 4.4.2.2 for JAN, JANTX, and JANTXV group B testing. Electrical measurements (end-points) and delta requirements for JAN, JANTX, and JANTXV shall be after each step in 4.4.2.2 and shall be in accordance with table I, subgroup 2 and 4.5.3 herein.

4.4.2.1 Group B inspection (JANS), table E-VIa of MIL-PRF-19500.

Subgroup	Method	Condition
B4	1037	V_{CB} = 10 V dc.
B5	1027	V_{CB} = 10 V dc; $P_D \geq$ 100 percent of maximum rated P_T (see 1.3). (NOTE: If a failure occurs, resubmission shall be at the test conditions of the original sample.) Option 1: 96 hours minimum sample size in accordance with table E-VIA of MIL-PRF-19500, adjust T_A or P_D to achieve T_J = +275°C minimum. Option 2: 216 hours minimum, sample size = 45, c = 0; adjust T_A or P_D to achieve a T_J = +225°C minimum.

4.4.2.2 Group B inspection, (JAN, JANTX, and JANTXV). Separate samples may be used for each step. In the event of a lot failure, the resubmission requirements of MIL-PRF-19500 shall apply. In addition, all catastrophic failures during CI shall be analyzed to the extent possible to identify root cause and corrective action.

Step	Method	Condition
1	1026	Steady-state life: 1,000 hours minimum, V_{CB} = 10 V dc, power shall be applied to achieve T_J = +150°C minimum using a minimum of P_D = 75 percent of maximum rated P_T as defined in 1.3. n = 45 devices, c = 0. The sample size may be increased and the test time decreased as long as the devices are stressed for a total of 45,000 device hours minimum, and the actual time of test is at least 340 hours.
2	1048	Blocking life, T_A = +150°C, V_{CB} = 80 percent of rated voltage without exceeding max rated V_{CEO}, 48 hours minimum. n = 45 devices, c = 0.
3	1032	High-temperature life (non-operating), t = 340 hours, T_A = +200°C. n = 22, c = 0.

4.4.2.3 Group B sample selection. Samples selected from group B inspection shall meet all of the following requirements:

a. For JAN, JANTX, and JANTXV samples shall be selected randomly from a minimum of three wafers (or from each wafer in the lot) from each wafer lot. For JANS, samples shall be selected from each inspection lot. See MIL-PRF-19500.

b. Shall be chosen from an inspection lot that has been submitted to and passed table I, subgroup 2, conformance inspection. When the final lead finish is solder, or any plating prone to oxidation at high temperature, the samples for life test (subgroups B4 and B5 for JANS, and group B for JAN, JANTX, and JANTXV) may be pulled prior to the application of final lead finish.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the test and conditions specified for subgroup testing in table E-VII of MIL-PRF-19500, and in 4.4.3.1 (JANS) and 4.4.3.2 (JAN, JANJ, JANTX, and JANTXV) herein for group C testing. Electrical measurements (end-points) and delta requirements shall be in accordance with table I, subgroup 2 and 4.5.3 herein; delta requirements only apply to subgroup C6.

4.4.3.1 Group C inspection (JANS), table VII of MIL-PRF-19500.

Subgroup	Method	Condition
C2	2036	Test condition E.
C5	3131	$R_{\theta JA}$ and $R_{\theta JC}$ only, as applicable (see 1.3) and applied thermal impedance curves.
C6	1026	1,000 hours at V_{CB} = 10 V dc; power shall be applied to achieve T_J = +150°C minimum and a minimum of P_D = 75 percent of maximum rated P_T as defined in 1.3 n = 45, c = 0. The sample size may be increased and the test time decreased as long as the devices are stressed for a total of 45,000 device hours minimum, and the actual time of test is at least 340 hours.

4.4.3.2 Group C inspection (JAN, JANTX, and JANTXV), table E-VII of MIL-PRF-19500.

Subgroup	Method	Condition
C2	2036	Test condition E.
C5	3131	$R_{\theta JA}$ and $R_{\theta JC}$ only, as applicable (see 1.3).
C6		Not applicable.

4.4.3.3 Group C sample selection. Samples for subgroups in group C shall be chosen at random from any inspection lot containing the intended package type and lead finish procured to the same specification which is submitted to and passes table I tests herein for conformance inspection. When the final lead finish is solder or any plating prone to oxidation at high temperature, the samples for C6 life test may be pulled prior to the application of final lead finish. Testing of a subgroup using a single device type enclosed in the intended package type shall be considered as complying with the requirements for that subgroup.

4.4.4 Group D inspection. Quality conformance inspection for hardness assured JANS and JANTXV types shall include the group D tests specified in table II. These tests shall be performed as required in accordance with MIL-PRF-19500 and method 1019 of MIL-STD-750 for total ionizing dose or method 1017 of MIL-STD-750 for neutron fluence as applicable.

4.4.5 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 in table III herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein; delta measurements shall be in accordance with the applicable steps of 4.5.3.

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.

4.5.2 Input capacitance. This test shall be conducted in accordance with method 3240 of MIL-STD-750, except the output capacitor shall be omitted.

4.5.3 Delta requirements. Delta requirements shall be as specified below:

Step	Inspection	MIL-STD-750		Symbol	Limit
		Method	Conditions		
1.	Collector-base cutoff current	3036	Bias condition D, V_{CB} = 50 V dc	ΔI_{CB02} (1)	100 percent of initial value or ±8 nA dc, whichever is greater.

(1) Devices which exceed the table I limits for this test shall not be accepted.

TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 1 2/						
Visual and mechanical examination 3/	2071	n = 45 devices, c = 0				
Solderability 3/ 4/	2026	n = 15 leads, c = 0				
Resistance to solvents 3/ 4/ 5/	1022	n = 15 devices, c = 0				
Temp cycling 3/ 4/	1051	Test condition C, 25 cycles. n = 22 devices, c = 0				
Hermetic seal 4/ 6/ Fine leak Gross leak	1071	n = 22 devices, c = 0				
Electrical measurements 4/		Table I, subgroup 2				
Bond strength 3/ 4/	2037	Precondition T_A = +250°C at t = 24 hours or T_A = +300°C at t = 2 hours n = 11 wires, c = 0				
Decap internal visual (design verification) 4/	2075	n = 4 devices, c = 0				
Subgroup 2						
Thermal impedance	3131	See 4.3.2	$Z_{\theta JX}$			°C/W
Collector to base cutoff current	3036	V_{CB} = 60 V dc	I_{CBO1}		10	µA dc
Emitter to base cutoff current	3061	V_{EB} = 5 V dc	I_{EBO1}		10	µA dc
Breakdown voltage, collector to emitter	3011	Bias condition D; I_C = 10 mA dc, pulsed (see 4.5.1)	$V_{(BR)CEO}$			
2N2904, 2N2905				40		V dc
2N2904A, 2N2905A				60		V dc
2N2904AL, 2N2905AL				60		V dc
Collector to base cutoff current	3036	Bias condition D; V_{CB} = 50 V dc	I_{CBO2}			
2N2904, 2N2905					20	nA dc
2N2904A, 2N2905A					10	nA dc
2N2904AL, 2N2905AL					10	nA dc
Emitter to base cutoff current	3061	Bias condition D; V_{EB} = 3.5 V dc	I_{EBO2}		50	nA dc

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 2 - Continued						
Collector to emitter cutoff current	3041	Bias condition C	I_{CES}			
2N2904, 2N2905		V_{CE} = 40 V dc			1	μA dc
2N2904A, 2N2904AL		V_{CE} = 60 V dc			1	μA dc
2N2905A, 2N2905AL		V_{CE} = 60 V dc			1	μA dc
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 0.1 mA dc	h_{FE1}			
2N2904				20		
2N2905				35		
2N2904A, 2N2904AL				40		
2N2905A, 2N2905AL				75		
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 1.0 mA dc	h_{FE2}			
2N2904				25	175	
2N2905				50	450	
2N2904A, 2N2904AL				40	175	
2N2905A, 2N2905AL				100	450	
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 10 mA dc	h_{FE3}			
2N2904				35		
2N2905				75		
2N2904A, 2N2904AL				40		
2N2905A, 2N2905AL				100		
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 150 mA dc, pulsed (see 4.5.1)	h_{FE4}			
2N2904				40	120	
2N2904A, 2N2904AL				40	120	
2N2905				100	300	
2N2905A, 2N2905AL				100	300	
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 500 mA dc, pulsed (see 4.5.1)	h_{FE5}			
2N2904				20		
2N2905				30		
2N2904A, 2N2904AL				40		
2N2905A, 2N2905AL				50		
Collector to emitter voltage (saturated)	3071	I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)1}$		0.4	V dc

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 2 - Continued						
Collector to emitter voltage (saturated)	3071	I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		1.6	V dc
Base emitter voltage (saturated)	3066	Test condition A, I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{BE(sat)1}$		1.3	V dc
Base emitter voltage (saturated)	3066	Test condition A, I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{BE(sat)2}$		2.6	V dc
Subgroup 3						
High temperature operation:		T_A = +150°C				
Collector to base cutoff current	3036	Bias condition D, V_{CB} = 50 V dc	I_{CBO3}			
2N2904, 2N2905					20	µA dc
2N2904A, 2N2904AL					10	µA dc
2N2905A, 2N2905AL					10	µA dc
Low temperature operation:		T_A = -55°C				
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 1.0 mA dc	h_{FE6}			
2N2904				15		
2N2905				30		
2N2904A, 2N2904AL				20		
2N2905A, 2N2905AL				50		
Subgroup 4						
Small-signal short-circuit forward-current transfer ratio	3206	V_{CE} = 10 V dc, I_C = 1 mA dc, f = 1 kHz	h_{fe}			
2N2904				25		
2N2905				50		
2N2904A, 2N2904AL				40		
2N2905A, 2N2905AL				100		

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 4 – Continued.						
Small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 20 V dc, I_C = 50 mA dc, f = 100 MHz	$\|h_{fe}\|$	2.0		
Open circuit output capacitance	3236	V_{CB} = 10 V dc, I_E = 0, 100 kHz ≤ f ≤ 1 MHz	C_{obo}		8	pF
Input capacitance (output open-circuited)	3240	V_{EB} = 2.0 V dc, I_C = 0, 100 kHz ≤ f ≤ 1 MHz (see 4.5.2)	C_{ibo}		30	pF
Turn-on time		(See figure 6)	t_{on}		45	ns
Turn-off time		(See figure 7)	t_{off}		300	ns
Subgroups 5 and 6						
Not applicable						

1/ For sampling plan, see MIL-PRF-19500.
2/ For resubmission of failed test in subgroup 1 of table I, double the sample size of the failed test or sequence of tests. A failure in table I, subgroup 1 shall not require retest of the entire subgroup. Only the failed test shall be rerun upon submission.
3/ Separate samples may be used.
4/ Not required for JANS devices.
5/ Not required for laser marked devices.
6/ This hermetic seal test is an end-point to temp-cycling in addition to electrical measurements.

TABLE II. Group D inspection and end-point limits.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Neutron irradiation	1017					
Collector to base cutoff current	3036	V_{CB} = 60 V dc	I_{CBO1}		20	µA dc
Collector to base cutoff current	3036	Bias condition D	I_{CBO2}			
2N2904, 2N2905		V_{CB} = 50 V dc			40	nA dc
2N2904A, 2N2905A					20	nA dc
2N2904AL, 2N2905AL					20	nA dc
Forward current transfer ratio	3076	V_{CE} = 10 V dc; I_C = 0.1 mA dc	[h_{FE1}]			
2N2904				[10]		
2N2905				[17.5]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[37.5]		
D2N2905A, D2N2905AL				[37.5]		
R2N2905A, R2N2905AL				[37.5]		
H2N2905A, H2N2905AL				[37.5]		
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 1.0 mA dc	[h_{FE2}]			
2N2904				[12.5]	175	
2N2905				[25]	450	
2N2904A, 2N2904AL				[20]	175	
M2N2905A, M2N2905AL				[50]	450	
D2N2905A, D2N2905AL				[50]	450	
R2N2905A, R2N2905AL				[50]	450	
H2N2905A, H2N2905AL				[50]	450	
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 10 mA dc, pulsed (see 4.5.1)	[h_{FE3}]			
2N2904				[17.5]		
2N2905				[37.5]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[50]		
D2N2905A, D2N2905AL				[50]		
R2N2905A, R2N2905AL				[50]		
H2N2905A, H2N2905AL				[50]		

See footnotes at end of table.

TABLE II. Group D inspection and end-point limits - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 1 - Continued						
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 150 mA dc	[h_{FE4}]			
2N2904				[20]	120	
2N2905				[50]	300	
2N2904A, 2N2904AL				[20]	120	
M2N2905A, M2N2905AL				[50]	300	
D2N2905A, D2N2905AL				[50]	300	
R2N2905A, R2N2905AL				[50]	300	
H2N2905A, H2N2905AL				[50]	300	
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 500 mA dc	[h_{FE5}]			
2N2904				[10]		
2N2905				[15]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[25]		
D2N2905A, D2N2905AL				[25]		
R2N2905A, R2N2905AL				[25]		
H2N2905A, H2N2905AL				[25]		
Collector to emitter voltage (saturated)	3071	I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)1}$			
2N2904					0.46	V dc
2N2905					0.46	V dc
2N2904A, 2N2904AL					0.46	V dc
M2N2905A, M2N2905AL					0.46	V dc
D2N2905A, D2N2905AL					0.46	V dc
R2N2905A, R2N2905AL					0.46	V dc
H2N2905A, H2N2905AL					0.46	V dc
Collector to emitter voltage (saturated)	3071	I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$			
2N2904					1.84	V dc
2N2905					1.84	V dc
2N2904A, 2N2904AL					1.84	V dc
M2N2905A, M2N2905AL					1.84	V dc
D2N2905A, D2N2905AL					1.84	V dc
R2N2905A, R2N2905AL					1.84	V dc
H2N2905A, H2N2905AL					1.84	V dc
Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 5 V dc	I_{EBO1}		20	µA

See footnotes at end of table

TABLE II. Group D inspection - Continued.

Inspection 1/ 2/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 1 – Continued						
Emitter to base cutoff current	3061	Bias condition D; V_{EB} = 3.5 V dc	I_{EBO2}		100	nA
Base to emitter voltage (saturated)	3066	Test condition A, I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{BE\ (sat)1}$		1.5	V dc
Base to emitter voltage (saturated)	3066	Test condition A, I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{BE\ (sat)2}$		3.0	V dc
Breakdown voltage, Collector to emitter	3011	Bias condition D; I_C = 10 mA dc, pulsed (see 4.5.1)	$V_{(BR)CEO}$			
2N2904, 2N2905 2N2904A, 2N2905A 2N2904AL, 2N2905AL				40 60 60		V dc V dc V dc
Collector to emitter cutoff current	3041	Bias condition C	I_{CES}			
2N2904, 2N2905 2N2904A, 2N2905A 2N2904AL, 2N2905AL		V_{CE} = 40 V dc V_{CE} = 60 V dc V_{CE} = 60 V dc			2.0 2.0 2.0	µA µA µA
Subgroup 2	1019					
Steady-state total dose Irradiation						
2N2904, 2N2905 2N2904A, 2N2905A 2N2904AL, 2N2905AL		Gamma exposure V_{ECS} = 32 V Gamma exposure V_{ECS} = 48 V Gamma exposure V_{ECS} = 48 V				
Collector to base cutoff current	3036	V_{CB} = 60 V dc	I_{CBO1}		20	µA
Collector to base cutoff current	3036	Bias condition D V_{CB} = 50 V dc	I_{CBO2}			
2N2904, 2N2905 2N2904A, 2N2905A 2N2904AL, 2N2905AL					40 20 20	nA nA nA

See footnotes at end of table

TABLE II. Group D inspection - Continued.

Inspection 1/ 2/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 2 – Continued						
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 0.1 mA dc	[h_{FE1}]			
2N2904				[10]		
2N2905				[17.5]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[37.5]		
D2N2905A, D2N2905AL				[37.5]		
R2N2905A, R2N2905AL				[37.5]		
H2N2905A, H2N2905AL				[37.5]		
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 1 mA dc	[h_{FE2}]			
2N2904				[12.5]	175	
2N2905				[25]	450	
2N2904A, 2N2904AL				[20]	175	
M2N2905A, M2N2905AL				[50]	450	
D2N2905A, D2N2905AL				[50]	450	
R2N2905A, R2N2905AL				[50]	450	
H2N2905A, H2N2905AL				[50]	450	
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 10 mA dc, pulsed (see 4.5.1)	[h_{FE3}]			
2N2904				[17.5]		
2N2905				[37.5]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[50]		
D2N2905A, D2N2905AL				[50]		
R2N2905A, R2N2905AL				[50]		
H2N2905A, H2N2905AL				[50]		
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 150 mA dc	[h_{FE4}]			
2N2904				[20]	120	
2N2905				[50]	300	
2N2904A, 2N2904AL				[20]	120	
M2N2905A, M2N2905AL				[50]	300	
D2N2905A, D2N2905AL				[50]	300	
R2N2905A, R2N2905AL				[50]	300	
H2N2905A, H2N2905AL				[50]	300	

See footnotes at end of table.

TABLE II. Group D inspection - Continued.

Inspection 1/ 2/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 2 – Continued						
Forward current transfer ratio	3076	V_{CE} = 10 V dc, I_C = 500 mA dc	[h_{FE5}]			
2N2904				[10]		
2N2905				[15]		
2N2904A, 2N2904AL				[20]		
M2N2905A, M2N2905AL				[25]		
D2N2905A, D2N2905AL				[25]		
R2N2905A, R2N2905AL				[25]		
H2N2905A, H2N2905AL				[25]		
Collector to emitter voltage (saturated)	3071	I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)\ 1}$			
2N2904					0.46	V dc
2N2905					0.46	V dc
2N2904A, 2N2904AL					0.46	V dc
M2N2905A, M2N2905AL					0.46	V dc
D2N2905A, D2N2905AL					0.46	V dc
R2N2905A, R2N2905AL					0.46	V dc
H2N2905A, H2N2905AL					0.46	V dc
Collector to emitter voltage (saturated)	3071	I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{CE(sat)\ 2}$			
2N2904					1.84	V dc
2N2905					1.84	V dc
2N2904A, 2N2904AL					1.84	V dc
M2N2905A, M2N2905AL					1.84	V dc
D2N2905A, D2N2905AL					1.84	V dc
R2N2905A, R2N2905AL					1.84	V dc
H2N2905A, H2N2905AL					1.84	V dc
Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 5 V dc	I_{EBO1}		20	µA
Emitter to base cutoff current	3061	Bias condition D; V_{EB} = 3.5 V dc	I_{EBO2}		100	nA
Base to emitter voltage (saturated)	3066	Test condition A, I_C = 150 mA dc, I_B = 15 mA dc, pulsed (see 4.5.1)	$V_{BE\ (sat)1}$		1.5	V dc;

See footnotes at end of table.

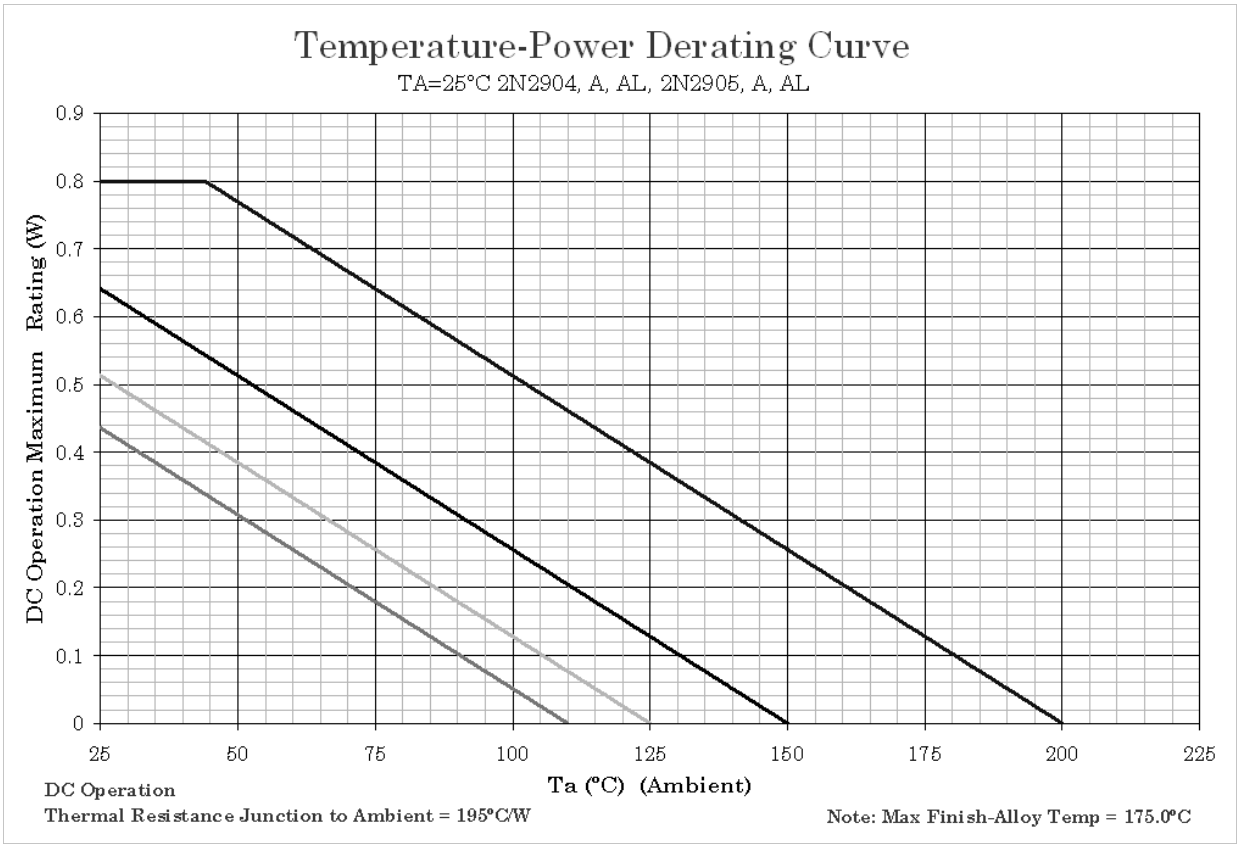
TABLE II. Group D inspection - Continued.

Inspection 1/ 2/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 2 – Continued						
Base to emitter voltage (saturated)	3066	Test condition A, I_C = 500 mA dc, I_B = 50 mA dc, pulsed (see 4.5.1)	$V_{BE\ (sat)2}$		3.0	V dc
Breakdown voltage, collector to emitter	3011	Bias condition D; I_c = 10 mA dc, pulsed (see 4.5.1)	$V_{(BR)CEO}$			
2N2904, 2N2905				40		V dc
2N2904A, 2N2905A				60		V dc
2N2904AL, 2N2905AL				60		V dc
Collector to emitter cutoff current	3041	Bias condition C	I_{CES}			
2N2904, 2N2905		V_{CE} = 40 V dc			2.0	µA
2N2904A, 2N2905A		V_{CE} = 60 V dc			2.0	µA
2N2904AL, 2N2905AL		V_{CE} = 60 V dc			2.0	µA

1/ Tests to be performed on all devices receiving radiation exposure.
2/ For sampling plan, see MIL-PRF-19500.
3/ Electrical characteristics apply to the corresponding A and AL suffix versions unless otherwise noted.
4/ See 6.2.e herein.
5/ See method 1019 of MIL-STD-750 for how to determine [h_{FE}] by first calculating the delta ($1/h_{FE}$) from the pre- and post-radiation h_{FE}. Notice the [h_{FE}] is not the same as h_{FE} and cannot be measured directly. The [h_{FE}] value can never exceed the pre-radiation minimum h_{FE} that it is based upon.

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

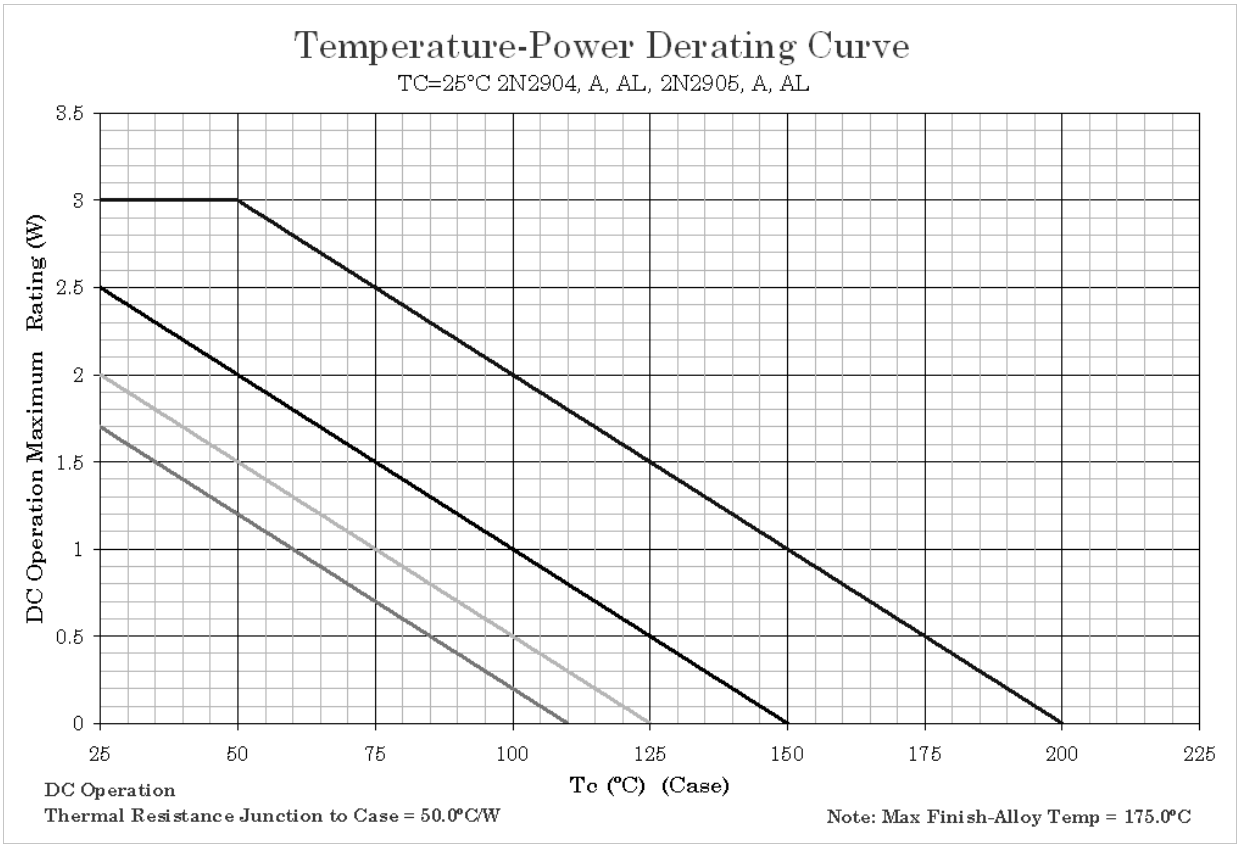
Inspection	MIL-STD-750		Qualification
	Method	Conditions	
Subgroup 1			45 devices c = 0
Temperature cycling (air to air)	1051	Test condition C, 500 cycles.	
Hermetic seal	1071		
Fine leak Gross leak			
Electrical measurements		See table I, subgroup 2 and 4.5.3 herein.	
Subgroup 2			45 devices c = 0
Intermittent life	1037	Intermittent operation life: V_{CB} = 10 V dc, 6,000 cycles.	
Electrical measurements		See table I, subgroup 2 and 4.5.3 herein.	
Subgroup 4			
Thermal impedance curves		See table E-IX of MIL-PRF-19500, group E, subgroup 4.	
Subgroup 5			
Not applicable			
Subgroup 6			11 devices
Electrostatic discharge (ESD)	1020		
Subgroup 8			45 devices c = 0
Reverse stability	1033	Condition B.	



NOTES:

1. All devices are capable of operating at $\leq T_J$ 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 ($T_J \leq 200°C$) and power rating specified. (See 1.3 herein.)
3. Derate design curve chosen at $T_J \leq 150°C$, where the maximum temperature of electrical test is performed.
4. Derate design curves chosen at $T_J \leq 125°C$, and 110°C to show power rating where most users want to limit T_J in their application.

FIGURE 2. Derating for 2N2904, 2N2904A, 2N2904AL, 2N2905, 2N2905A, 2N2905AL, ($R_{\theta JA}$) PCB (TO-39).

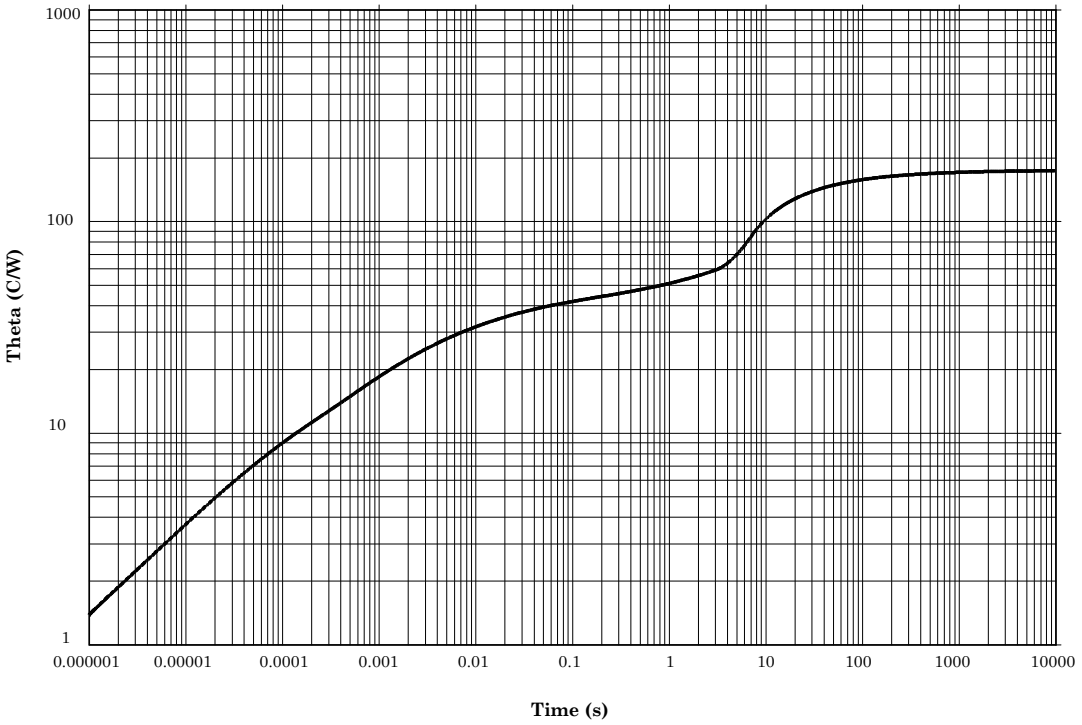


NOTES:

1. All devices are capable of operating at $\leq T_J$ 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 ($T_J \leq 200°C$) and power rating specified. (See 1.3 herein.)
3. Derate design curve chosen at $T_J \leq 150°C$, where the maximum temperature of electrical test is performed.
4. Derate design curves chosen at $T_J \leq 125°C$, and 110°C to show power rating where most users want to limit T_J in their application.

FIGURE 3. Derating for 2N2904, 2N2904A, 2N2904AL, 2N2905, 2N2905A, 2N2905AL, ($R_{\theta JC}$) PCB (TO-39).

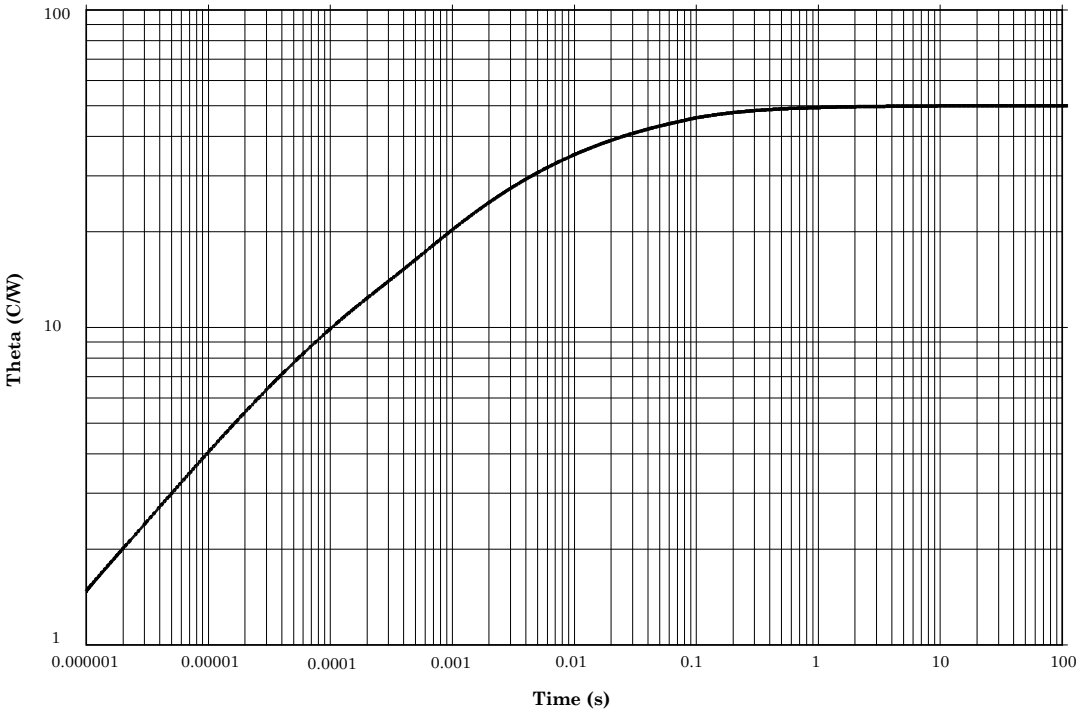
Maximum Thermal Impedance



Ambient free air cooled T_A = +25°C, 800mW, thermal resistance $R_{\theta JA}$ = 175°C/W.

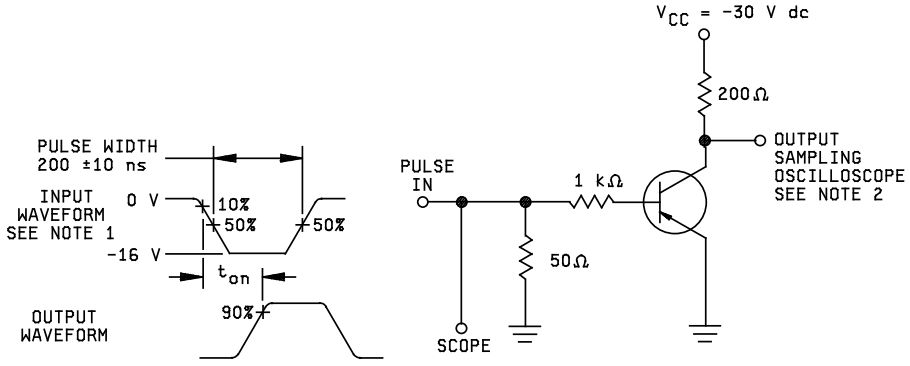
FIGURE 4. Thermal impedance graph ($R_{\theta JA}$) for all 2N2904, and 2N2905 devices (TO-39).

Maximum Thermal Impedance



Ambient case mounted T_C = +25°C, thermal resistance $R_{\theta JC}$ = 50°C/W.

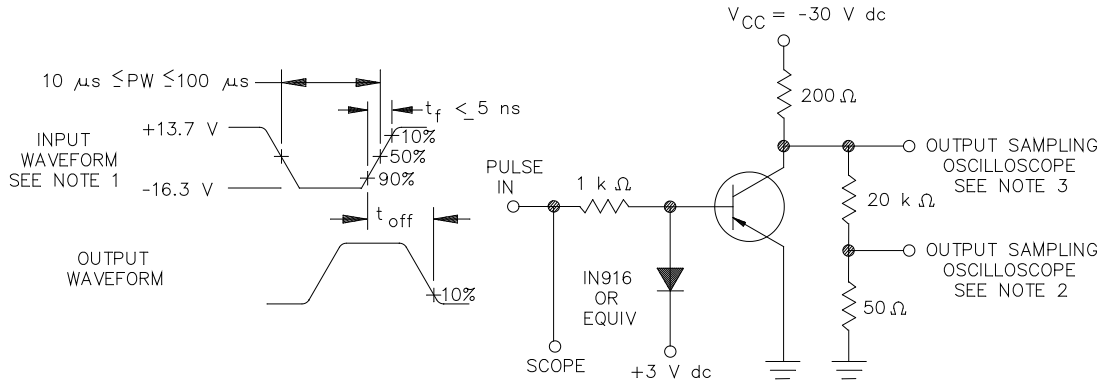
FIGURE 5. Thermal impedance graph ($R_{\theta JC}$) for all 2N2904, and 2N2905 devices (TO-39).



NOTES:

1. The rise time (t_r) of the applied pulse shall be ≤ 2.0 ns, duty cycle ≤ 2 percent, and the generator source impedance shall be 50 Ω.
2. Sampling oscilloscope: Z_{in} ≥ 100 kΩ, C_{in} ≤ 12 pF, rise time ≤ 5 ns.

FIGURE 6. Saturated turn-on switching time test circuit.



NOTES:

1. The rise time (t_r) of the applied pulse shall be ≤ 2.0 ns, duty cycle ≤ 2 percent, and the generator source impedance shall be 50Ω.
2. Sampling oscilloscope: Z_{in} ≥ 100 kΩ, C_{in} ≤ 12 pF, rise time ≤ 5 ns.
3. Alternate test point for high impedance attenuating probe.

FIGURE 7. Saturated turn-off switching time test circuit.

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.

e. For acquisition of RHA designated devices, table II, subgroup 1 testing of group D herein is optional. If subgroup 1 is desired, it shall be specified in the contract.

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.daps.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
DLA - CC

Preparing activity:
DLA - CC

(Project 5961-2011-012)

Review activities:
Army - AR, MI, SM
Navy - AS
Air Force - 19, 99

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