The documentation and process conversion measures necessary to comply with this revision shall be completed by 1 October 1998

INCH-POUND

MIL-PRF-19500/433E
1 July 1998
SUPERSEDING
MIL-S-19500/433D
1 December 1993

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, TRANSISTOR, PNP, SILICON, HIGH-POWER TYPE 2N4399 AND 2N5745 JAN, JANTX, JANTXV, AND JANS

This Specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for PNP silicon, high-power transistors. Four 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. $R_{\theta JC}$ = 0.875°C/W, $R_{\theta JA}$ = 35°C/W.

	P_T 1/ T_A = +25°C	P_T 2/ T_C = +100°C	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_J and T_{STG}
	W	W	V dc	V dc	V dc	A dc	A dc	°C
2N4399	5	115	60	60	5	7.5	30	-55 to +200
2N5745	5	115	80	80	5	7.5	20	-55 to +200

1/ Derate linearly 28.57 mW/°C above T_A = +25°C.
2/ Derate linearly 1.15 W/°C above T_C = +100°C.

1.4 Primary electrical characteristics.

	H_{FE2} 1/	h_{FE2} 1/	$\|h_{FE}\|$	$V_{CE(sat)1}$ 1/		$V_{BE(sat)1}$ 1/		C_{obo}	Switching	
	V_{CE} = 2 V dc, I_C = 15 A dc	V_{CE} = 2 V dc, I_C = 10 A dc	V_{CE} = 10 V dc, I_C = 1 A dc, f = 1 MHz	I_C = 15 A dc, I_B = 1.5 A dc		I_C = 15 A dc, I_B = 1.5 A dc		V_{CB} = 10 V dc, I_E = 0, 100 kHz ≤ f ≤ 1 MHz	t_{on}	t_{off}
	2N4399	2N5745	V dc	2N4399 V dc	2N5745 V dc	2N4399	2N5745	pF	µs	µs
Min	25	25	4							
Max			40	1.0	1.5	1.8	2.0	1,000	1.2	2.5

|1/ Pulsed (see 4.5.1).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Defense Supply Center Columbus, ATTN: DSCC-VAT, 3990 East Broad Street, Columbus, OH 43216-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5961

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 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 documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2.1 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATION

DEPARTMENT OF DEFENSE

MIL-PRF-19500 - Semiconductor Devices, General Specification for.

STANDARD

MILITARY

MIL-STD-750 - Test Methods for Semiconductor Devices.

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available 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 (except for related associated specifications or specification sheets), 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 Qualification. Devices furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.4).

3.2 Associated specification. The individual item requirements shall be in accordance with MIL-PRF-19500 and as specified herein.

3.3 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-PRF-19500.

3.4 Interface requirements and physical dimensions. The interface requirements and physical dimensions shall be as specified in MIL-PRF-19500 and on figure 1 herein.

3.4.1 Lead finish. Unless otherwise specified, lead finish shall be solderable in accordance with MIL-STD-750, MIL-PRF-19500, and herein.

3.5 Marking. Devices shall be marked as specified in MIL-PRF-19500.

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

3.7 Electrical test requirements. The electrical test requirements shall be the subgroups specified in 4.4.2 and 4.4.3 herein.

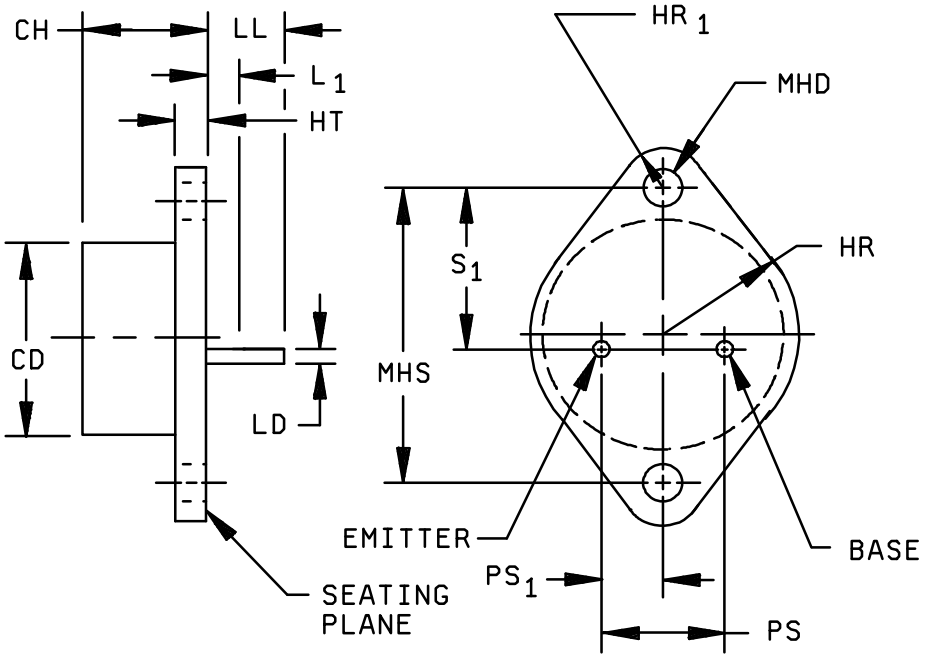


FIGURE 1. Physical dimensions TO-3.

Symbol	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD	- - -	.875	- - -	22.23	5
CH	.270	.380	6.86	9.65	
HT	.060	.135	1.52	3.43	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
LD	.038	.043	0.97	1.09	
LL	.312	.500	7.92	12.70	
L_1	- - -	.050	- - -	1.27	
MHD	.151	.161	3.84	4.09	
MHS	1.177	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	2, 3
PS_1	.205	.225	5.21	5.72	2, 3
S_1	.655	.675	16.64	17.15	2

NOTES:
1. Dimensions are in inches.
2. These dimensions should be measured at points .050 inch (1.27 mm) to .055 inch (1.40 mm) below seating plane. When gauge is not used, measurement will be made at the seating plane.
3. 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.
4. Collector shall be electrically connected to the case.
5. LD applies between L_1 and LL. Diameter is uncontrolled in L_1.

FIGURE 1. Physical dimensions. Continued.

4. VERIFICATION

4.1 Classification of and inspection. 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).

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-PRF-19500.

4.3 Screening (JANS, JANTX, and JANTXV levels only). Screening shall be in accordance with MIL-PRF-19500 (appendix E, table IV), 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 IV of MIL-PRF-19500)	Measurement	
	JANS level	JANTX and JANTXV levels
1/	Thermal response (see 4.3.2)	Thermal response (see 4.3.2)
9	I_{CEX1} and h_{FE2}	I_{CEX1}
11	I_{CEX1} and h_{FE2} $\Delta I_{CEX1} \leq$ 100 percent of initial value or 5 nA dc, whichever is greater. $\Delta h_{FE2} \leq \pm$ 15 percent of initial value	I_{CEX1} and h_{FE2}; $\Delta I_{CEX1} \leq$ 100 percent of initial value or 100 nA dc, whichever is greater.
12	See 4.3.1	See 4.3.1
13	Subgroup 2 of table I herein; $\Delta I_{CEX1} \leq$ 100 percent of initial value or 50 nA dc, whichever is greater; $\Delta h_{FE2} \leq \pm$ 15 percent of initial value	Subgroup 2 of table I herein; $\Delta I_{CEX1} \leq$ 100 percent of initial value or 100 nA dc, whichever is greater; $\Delta h_{FE2} \leq \pm$ 15 percent of initial value;

1/ This test shall be performed anytime after screen 3.

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

$T_J = 187.5 \pm 12.5°C$; V_{CE} = 25 V dc; T_A = room ambient as defined in the general requirements of MIL-STD-750.

4.3.2 Thermal response (ΔV_{BE} measurements). The ΔV_{BE} measurements shall be performed in accordance with MIL-STD-750., method 3131. The ΔV_{BE} conditions (I_H and V_H) and maximum limit shall be derived by each vendor. The chosen ΔV_{BE} measurement and conditions for each device in the qualification lot shall be submitted in the qualification report and a thermal response curve shall be plotted. The chosen ΔV_{BE} shall be considered final after the manufacturer has had the opportunity to test five consecutive lots. One hundred percent Safe Operating Area (SOA) testing may be performed in lieu of thermal response testing herein provided that the appropriate conditions of temperature, time, current, and voltage to achieve die attach integrity are submitted to the qualifying activity.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500, and as specified herein.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance appendix E, table V, MIL-PRF-19500 and 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 VIa (JANS) and table VIb (JANTX and JANTXV) of MIL-PRF-19500, and as follows. Electrical measurements (endpoints) and delta requirements shall be in accordance with the applicable steps of table I, subgroup 2 herein.

4.4.2.1 Group B inspection, appendix E, table VIa of MIL-PRF-19500.

Subgroup	Method	Conditions
B4	1037	V_{CE} = 20 V dc; P_T = 5 W at T_A = room ambient as defined in the general requirements of 4.5 of MIL-STD-750; $t_{on} = t_{off}$ = 3 minutes minimum for 2,000 cycles. No heat sink or forced-air cooling on devices shall be permitted.
B5	1027	V_{CB} = 20 V dc; T_A = +125°C ± 25°C for 96 hours; P_T = 5 W at T_A = +125°C or adjusted as required by the chosen T_A to give an average lot T_J = +275°C.

4.4.2.2 Group B inspection, appendix E, table VIb of MIL-PRF-19500.

Subgroup	Method	Conditions
B3	1037	V_{CB} = 20 V dc; ΔT_J between cycles ≥ +100°C. $t_{on} = t_{off}$ = 3 minutes minimum for 2,000 cycles. No heat sink or forced-air cooling on the devices shall be permitted.
B5	3053	Load condition C; (unclamped inductive load) (see figure 2); T_C = +25°C; duty cycle ≤ 10 percent; R_s = .01Ω; $t_r = t_f$ ≤ 500 ns. Test 1 - t_p = 5 ms (vary to obtain I_C); V_{BB2} = 0; R_{BB1} = 10Ω; L = 2 mH; V_{BB1} = 10 V dc; R_{BB2} = infinity; I_C = 10 A dc; V_{CC} = 15 V dc. Test 2 - t_p = 5 ms (vary to obtain I_C); V_{BB2} = 0; V_{BB1} = 10 V dc; R_{BB1} = 100Ω; L = 40 mH; R_{BB2} = infinity; I_C = 1 A dc; V_{CC} = 15 V dc.
B5	3053	Clamped switching destructive; V_{CC} = 55 V dc; T_A = +25°C; L = 20 mH; (see figures 3 and 4) 2N4399 - clamped voltage = 60 V dc; I_C = 30 A dc 2N5745 - clamped voltage = 80 V dc; I_C = 20 A dc

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 VII of MIL-PRF-19500, and as follows. Electrical measurements (endpoints) and delta requirements shall be in accordance with table I, subgroup 2 herein.

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

Subgroup	Method	Conditions
C6	1037	V_{CB} = 20 V dc; ΔT_J between cycles ≥ +100°C. $t_{on} = t_{off}$ = 3 minutes minimum for 6,000 cycles. No heat sink or forced-air cooling on device shall be permitted.

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 Thermal resistance. Thermal resistance measurements shall be conducted in accordance with test method 3131 of MIL-STD-750. The following details shall apply:

a. I_M measurement ..... 10 mA dc.

b. V_{CE} measurement voltage ..... 20 V dc.

c. I_H collector heating current ..... 2.5 A (minimum).

d. V_H collector emitter heating voltage ..... 20 V (minimum).

e. t_H heating time ..... Steady-state (see MIL-STD-750, method 2131).

f. t_{MD} measurement delay time ..... 20 µs.

g. t_{SW} sample window time..... 10 µs maximum.

TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	2/ Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical inspection	2071					
Subgroup 2						
Collector to base breakdown voltage	3011	Bias condition D; I_C = 200 mA dc; pulsed (see. 4.5.1)	$V_{(BR)CEO}$			
2N4399				60		
2N5745				80		
Collector to emitter cutoff current	3041	Bias condition D	I_{CEO}			
2N4399		V_{CE} = 60 V dc			100	µA dc
2N5745		V_{CE} = 80 V dc			100	µA dc
Emitter-base cutoff current	3061	Bias condition D; V_{EB} = 5 V dc	I_{EBO}		5.0	µA dc
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = 1.5 V dc	I_{CEX1}			
2N4399		V_{CE} = 60 V dc			5.0	µA dc
2N5745		V_{CE} = 80 V dc			5.0	µA dc
Base emitter saturated voltage	3066	Test condition A; I_C = 10 A dc; I_B = 1.0 A dc pulsed (see 4.5.1)	$V_{BE(sat)1}$		1.7	V dc
Base emitter saturated voltage	3066	Test condition A; ; I_C = 15 A dc; I_{BE} = 1.5 V dc, pulsed (see 4.5.1)	$V_{BE(sat)2}$			
2N4399					1.8	V dc
2N5745					2.0	V dc
Collector to emitter saturated voltage	3071	Pulsed (see 4.5.1); I_C = 5.0 A dc; I_B = 0.5 A dc	$V_{CE(sat)1}$		0.55	V dc
Collector to emitter saturated voltage	3071	I_C = 10 A dc; I_B = 1.0 A dc; pulsed (see 4.5.1)	$V_{CE(sat)2}$			
2N4399					0.75	V dc
2N5745					1.0	V dc
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; I_C = 1.0 A dc; pulsed (see 4.5.1)	h_{FE1}	40	425	

See footnote at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	2/ Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 2 - Continued						
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; pulsed (see 4.5.1)	h_{FE2}			
2N4399		I_C = 15 A dc		15	60	
2N5745		I_C = 10 A dc		15	60	
Forward-current transfer ratio	3076	V_{CE} = 5 V dc; pulsed (see 4.5.1)	h_{FE3}			
2N4399		I_C = 30 A dc		5		
2N5745		I_C = 20 A dc		5		
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}			
2N4399		V_{CE} = 60 V dc			10	mA dc
2N5745		V_{CE} = 80 V dc			10	mA dc
Low-temperature operation:		T_A = -55°C				
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; pulsed (see 4.5.1)	h_{FE4}			
2N4399		I_C = 15 A dc		7		
2N5745		I_C = 10 A dc		7		
Subgroup 4						
Pulse response transfer ratio	3251	Test condition A except test circuit and pulse requirement in accordance with figure 5.				
Pulse delay time		See figure 5	t_d		0.15	µs dc
Pulse rise time		See figure 5	t_r		0.4	µs dc
2N4399					0.85	
2N5745						
Pulse storage time		See figure 5	t_s		1.5	µs dc
Pulse fall time		See figure 5	t_f		1.0	µs dc

See footnote at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	2/ Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 4 - Continued						
Magnitude of common-emitter small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 10 V dc; I_C = 1.0 A dc; f = 1 MHz	$\|h_{fe}\|$	4	40	
Open circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0; 100 kHz ≤ f ≤ = 1 MHz	C_{obo}		1,000	pF
Small-signal short-circuit forward-current transfer ratio	3206	V_{CE} = 10 V dc; I_C = 1.0 A dc; f = 1.0 MHz	h_{fe}	40	425	
Subgroup 5						
Safe operating area (dc operation)	3051	T_C = +25°C; t = 1 s; 1 cycle, (see figure 6)				
Test 1 (Both device type)						
2N4399		V_{CE} = 6.67 V dc; I_C = 30 A dc				
2N5745		V_{CE} = 10 V dc; I_C = 20 A dc				
Test 2 (Both device types)		V_{CE} = 20 V dc; I_C = 10 A dc				
Test 3 (Both device types)		V_{CE} = 40 V dc; I_C = 3 A dc				
Test 4 (Both device type)						
2N4399		V_{CE} = 50 V dc; I_C = 600 mA dc				
2N5745		V_{CE} = 60 V dc; I_C = 600 mA dc				
Electrical measurements		See subgroup 2, herein for I_{CEX1} and h_{FE2}				
Subgroups 6 and 7						
Not applicable						

For sampling plan see MIL-PRF 19500.

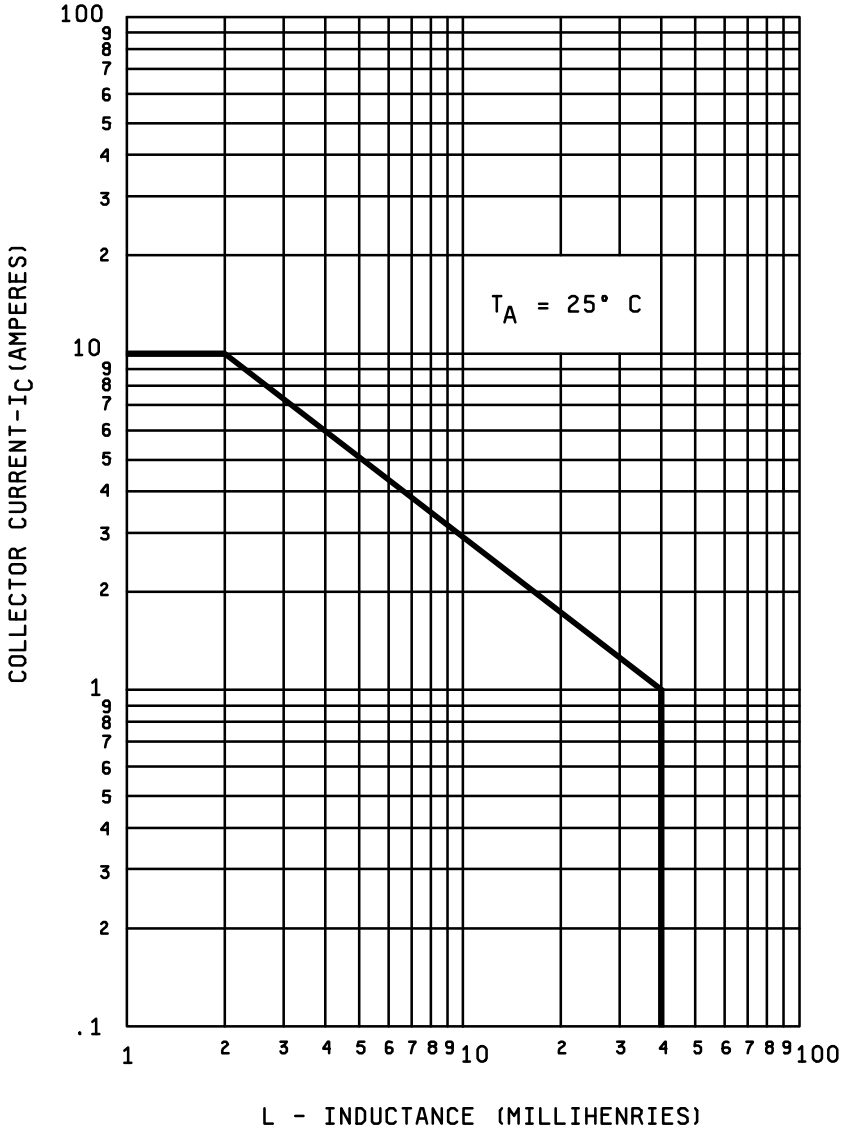
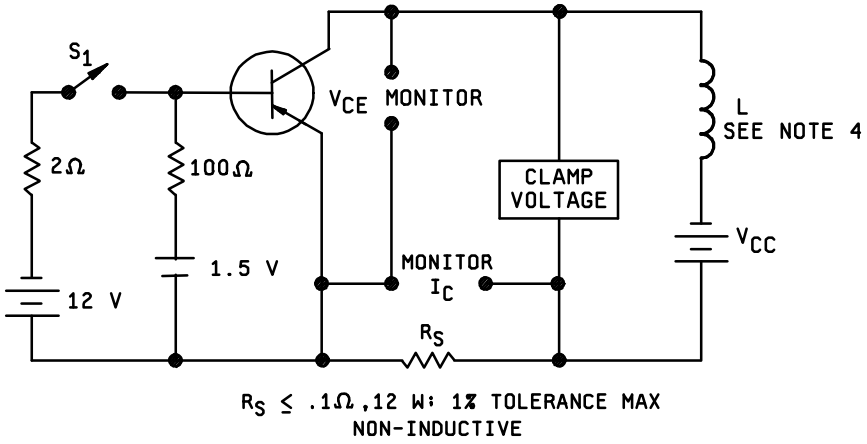


FIGURE 2. Safe operating area for switching between saturation and cutoff (unclamped inductive load).



NOTES:
1. With switch S1 closed, set the specified test conditions.
2. Open S1. Device fails if clamp voltage not reached.
3. Perform specified end-points tests.
4. L = 2.0 mH (2 each 1 mH, 50 A, .001Ω, Sanford Miller CK-50, or equivalent).

FIGURE 3. Clamped inductive sweep test circuit.

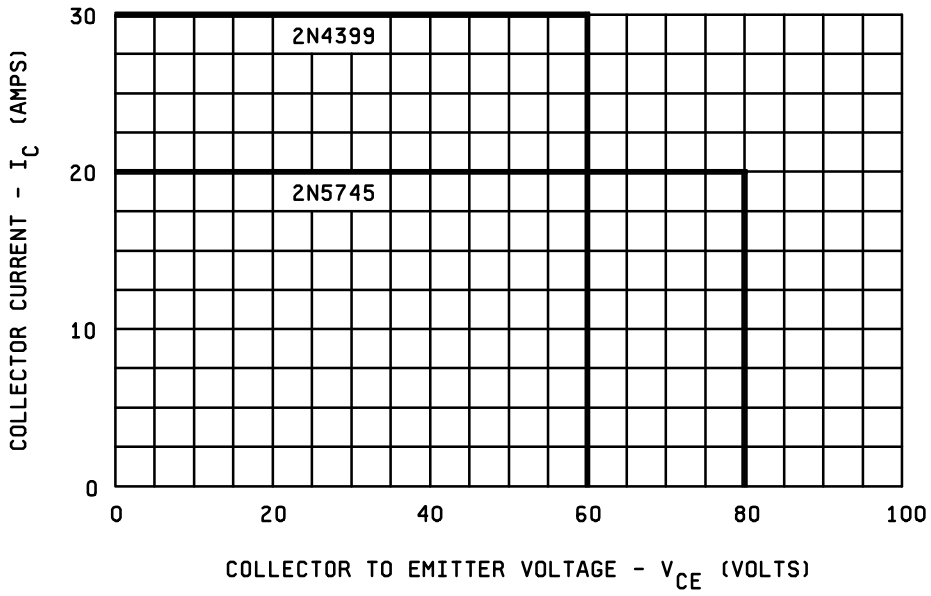
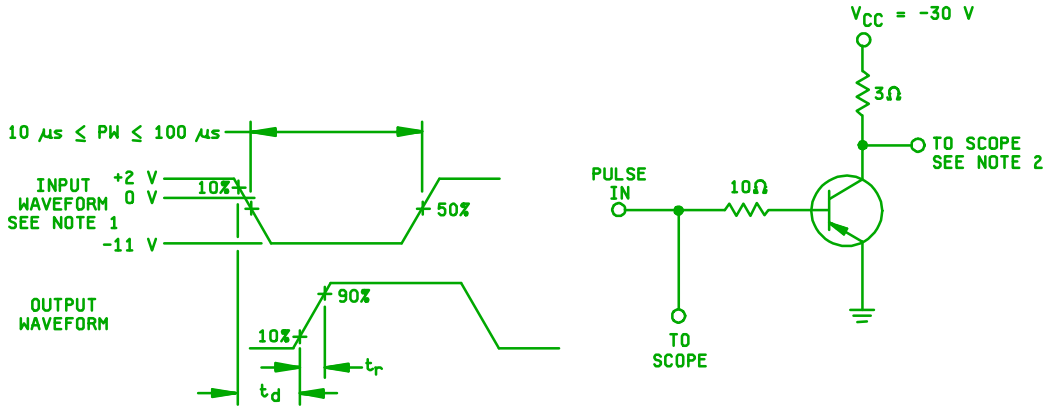
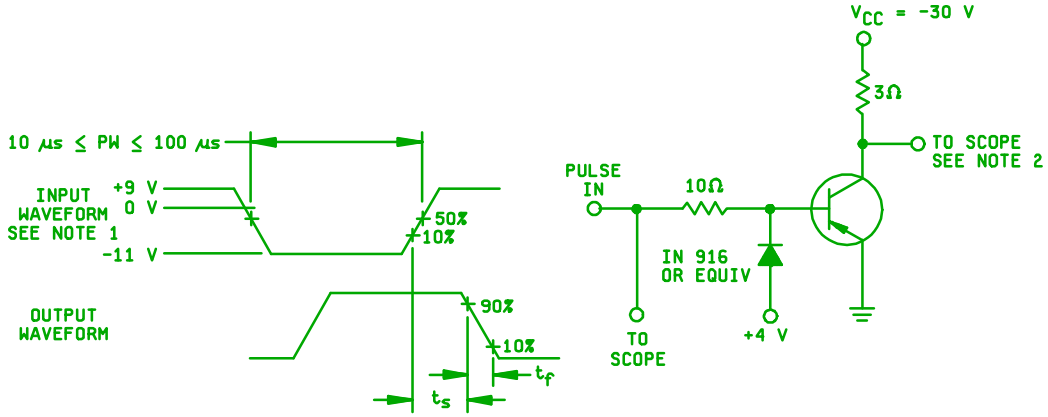


FIGURE 4. Safe operating area for switching between saturation and cutoff (clamped inductive load).



TURN-ON (t_{on}) TIME TEST CIRCUIT A



TURN-OFF (t_{off}) TIME TEST CIRCUIT B

NOTES:

1. The input waveform is supplied by a pulse generator with the following characteristics:

   $t_r \leq 20$ µs, $t_f \leq 1$µ:s, 10µs ≤ PW ≤ 100µs, $Z_{OUT} = 50\Omega$, duty cycle ≤ 2 percent.

2. Output waveforms are monitored on an oscilloscope with the following characteristics:

   $t_r \leq 2$ µs, $Z_{IN} \geq 100$ kΩ, $C_{IN} \leq 12$ pF.

3. Test circuit A for t_d and t_r; test circuit B for t_s and t_f.

FIGURE 5. Pulse response test circuit.

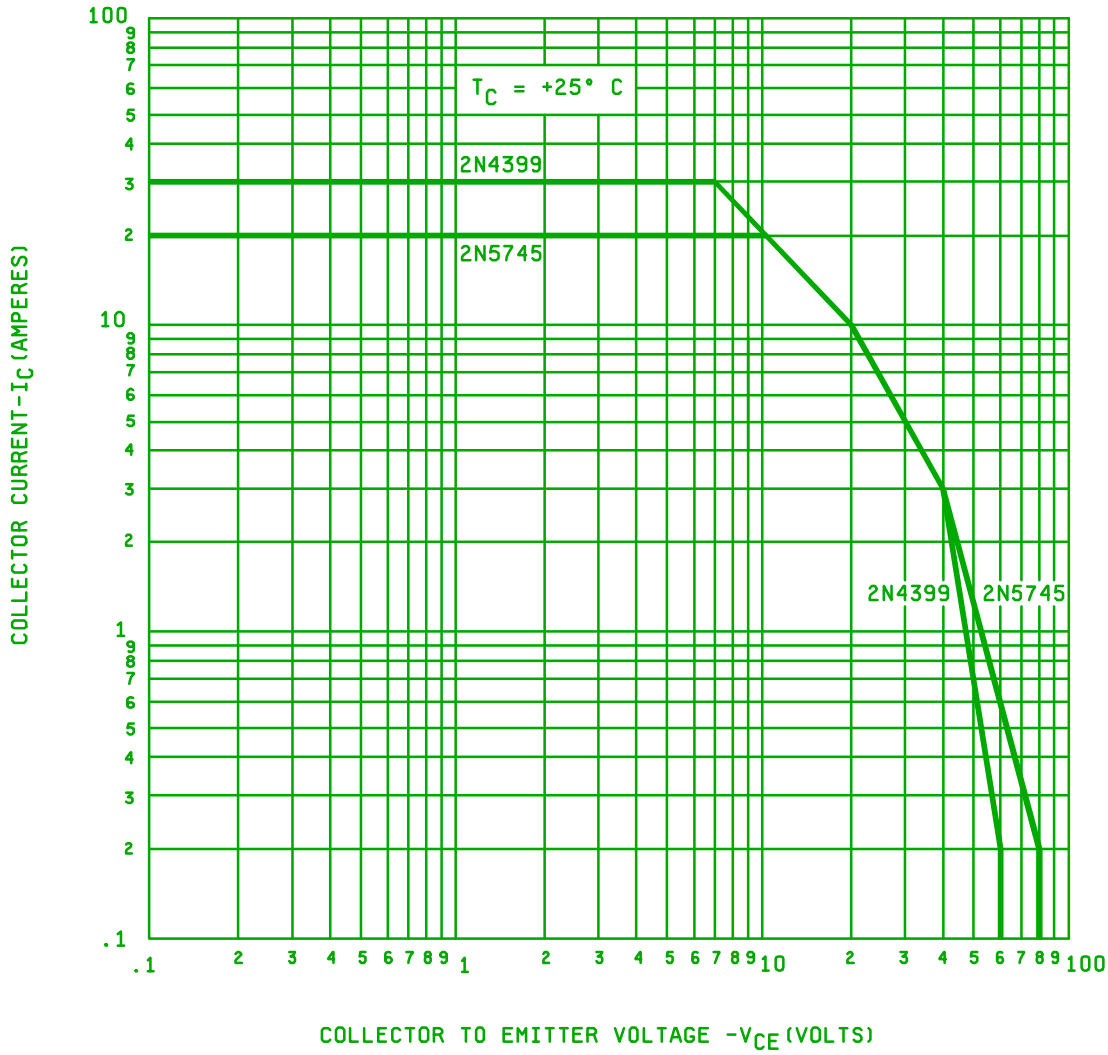


FIGURE 6. Maximum safe operating area graph (continuous dc).

5. PACKAGING

5.1 Packaging. Packaging shall prevent mechanical damage of the devices during shipping and handling and shall not be detrimental to the device. When actual packaging of material is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Points' packaging activity within the Military Department or Defense Agency, or within the Military Departments' System Command. Packaging data retrieval is available from the managing Military Departments' or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

5.2 Marking. Unless otherwise specified (see 6.2), marking shall be in accordance with MIL-PRF-19500.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Notes. The notes specified in MIL-PRF-19500 are applicable to this specification.

6.2 Acquisition requirements. See MIL- PRF-19500.

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 Products List QPL No.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 purchase 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, 3990 East Broad Street, Columbus, OH 43216-5000.

6.4 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

Custodians:
Army - CR
Navy - EC
Air Force - 17
NASA - NA

Review activities:
Army - AR, MI, SM
Navy - AS, CG, MC
Air Force - 13, 19, 99

Preparing activity:
DLA - CC

(Project 5961-1969)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-PRF-19500/433E	**2. DOCUMENT DATE (YYMMDD)** 980701

3. DOCUMENT TITLE
SEMICONDUCTOR DEVICE, TRANSISTOR, PNP, SILICON, HIGH-POWER, TYPES 2N4399 AND 2N5745 JAN, JANTX, JANTXV, AND JANS

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) Commercial DSN FAX EMAIL	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. Point of contact: Alan Barone	b. TELEPHONE Commercial 614-692-0510 DSN 850-0510 FAX 614-692-6939 EMAIL alan_barone@dscc.dla.mil
c. ADDRESS: Defense Supply Center Columbus, ATTN: DSCC-VAT, 3990 East Broad Street, Columbus, OH 43216-5000	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 DSN 289-2340