The documentation and process conversion measures necessary to comply with this revision shall be completed by 22 October 1999

INCH-POUND

MIL-PRF-19500/371D
23 July 1999
SUPERSEDING
MIL-S-19500/371C
27 March 1995

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, HIGH-POWER TYPES 2N3902 AND 2N5157 JAN AND JANTX

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 NPN silicon, high-power transistors. Two levels of product assurance are provided for each device type as specified in MIL-PRF-19500.

Datasheet.Live

1.2 Physical dimensions. See figure 1 (similar to TO-3), (see 3.3).

1.3 Maximum ratings.

Type	P_T 1/ T_A = +25°C	P_T 2/ T_C = +75°C	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_J and T_{STG}	$R_{\Theta JC}$
	W	W	V dc	V dc	V dc	A dc	A dc	°C	°C/W
2N3902	5.0	100	700	400	5.0	2.0	3.5	-65 to +200	1.25
2N5157	5.0	100	700	500	6.0	2.0	3.5	-65 to +200	1.25

1/ Derate linearly 29 mW/°C above T_A = +25°C.
2/ Derate linearly 0.8 W/°C above T_C = +75°C.

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-VAC, 3990 East Broad St., Columbus, OH 43216-5000, by using the addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5961

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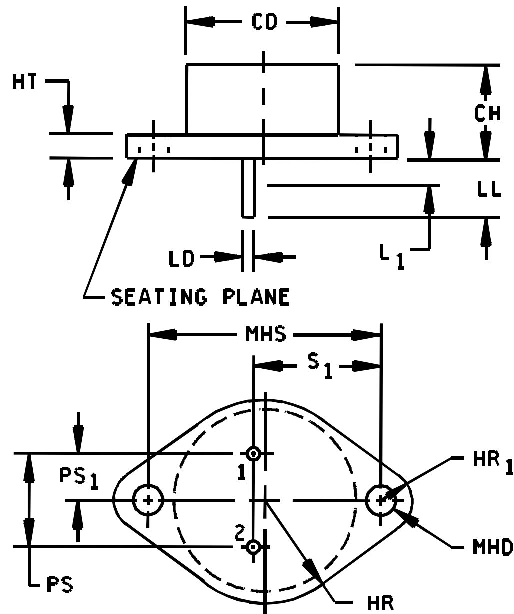


Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD		.875		22.22	
CH	.250	.328	6.35	8.33	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
HT	.060	.135	1.52	3.43	
LD	.038	.043	0.97	1.09	3,6
LL	.312	.500	7.92	12.70	3
L_1		.050		1.27	6
MHD	.151	.161	3.84	4.09	4
MHS	1.177	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	
PS_1	.205	.225	5.21	5.72	
s_1	.655	.675	16.64	17.15	

NOTES:

1. Dimensions are in inches. Lead 1 is emitter, lead 2 is base, and case is collector.
2. Metric equivalents 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_1.
7. In accordance with ANSI Y14.5M, diameters are equivalent to ϕx symbology.

FIGURE 1. Physical dimensions.

1.4 Primary electrical characteristics.

	h_{FE1} 1/	h_{FE2} 1/	$V_{BE(SAT)1}$	$V_{CE(SAT)1}$	C_{obo}	$\|h_{fe}\|$	Switching	
	V_{CE} = 5.0 V dc I_C = 0.5 A dc	V_{CE} = 5.0 V dc I_C = 1.0 A dc	I_C = 1.0 A dc I_B = 0.1 A dc	I_C = 1.0 A dc I_B = 0.1 A dc	V_{CB} = 10 V dc I_E = 0 100 kHz ≤ f ≤ 1 MHz	V_{CE} = 10 V dc I_C = 0.2 A dc f = 1 MHz	t_{on}	t_{off}
			V dc	V dc	pF		µs	µs
Min	25	30				2.5		
Max		90	1.5	0.8	250	25	0.8	1.7

1/ Pulsed (see 4.5.1).

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 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 Defense Automated Printing Service, 700 Robbins Avenue, Building 4D (DPM – DODSSP), 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 Associated specification. The individual item requirements shall be in accordance with MIL-PRF-19500 and as specified herein.

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

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

3.3.1 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).

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

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 the subgroups specified in table I herein.

3.7 Qualification. Devices furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.2 and 6.4).

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).

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

4.3 Screening (JANTX level). Screening shall be in accordance with table 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 IV of MIL-PRF-19500)	Measurement
	JANTX only
3	See 4.3.2
10	V_{CB} = 300 V
11	h_{FE2} and I_{CEX1}
12	See 4.3.1
13	ΔI_{CEX1} = 100 percent of initial value or 50 μA dc, whichever is greater. Δh_{FE2} = 25 percent of initial value; subgroup 2 of table I herein

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows: T_A = room ambient as defined in the general requirements of MIL-STD-750, paragraph 4.5; V_{CB} = 16-20 V dc; PT = 4.0 W.

4.3.2 Thermal response (ΔV_{BE} measurements). The ΔV_{BE} measurements shall be performed in accordance with MIL-STD-750, method 3131. The chosen ΔV_{BE} measurements 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 appropriate condition of temperature, time, current, voltage, circuit and procedure to achieve die attach integrity are approved by the qualifying activity. The following parameter measurements shall apply:

a. I_M measurement ....10 mA

b. V_{CE} measurement voltage ....20 V (same as V_H)

c. I_H collector heating current..................................2 A (minimum)

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

e. t_H heating time ....10 ms (minimum)

f. t_{MD} measurement delay time...............................30 μs to 60 μs

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

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

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table VIb (JAN and JANTX) of MIL-PRF-19500 and paragraph 4.4.2.1 herein. Electrical measurements (end-points) shall be in accordance with the applicable inspections of table I, group A, subgroup 2 herein. Delta measurements shall be in accordance with table II herein.

Subgroup	Method	Condition
B3	1037	Bias condition (see 4.3.1), $t_{on} = t_{off}$ = 3 minutes, 2,000 cycles.
B5	3131	V_{CE} = 20 V dc, I_C = 2.0 A, $R_{\theta JC}$ = 1.25°C/W maximum.

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

Subgroup	Method	Condition
C2	2036	test condition A, weight = 10 pounds, t = 15 s.
C6	1037	Bias condition (see 4.3.1), $t_{on} = t_{off}$ = 3 minutes, 6,000 cycles.

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.

TABLE I. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical examination	2071					
Subgroup 2						
Collector to emitter cutoff current	3041	Bias condition A; V_{CE} = 700 V dc; V_{BE} = 1.5 V dc	I_{CEX1}		500	μA dc
Emitter to base cutoff current	3061	Bias condition D;	I_{EBO1}			
2N3902		V_{EB} = 5.0 V dc			200	μA dc
2N5157		V_{EB} = 6.0 V dc			200	μA dc
Collector to emitter cutoff current	3041	Bias condition D;	I_{CEO}			
2N3902		V_{CE} = 325 V dc			250	μA dc
2N5157		V_{CE} = 400 V dc			250	μA dc
Base emitter voltage (saturated)	3066	Test condition A; I_C = 1.0 A dc; I_B = 0.1 A dc; pulsed (see 4.5.1)	$V_{BE(SAT)1}$		1.5	V dc
Base emitter voltage (saturated)	3066	Test condition A; I_C = 3.5 A dc; I_B = 0.7 A dc; pulsed (see 4.5.1)	$V_{BE(SAT)2}$		2.0	V dc
Collector to emitter saturated voltage	3071	I_C = 1.0 A dc; I_B = 0.1 A dc; pulsed (see 4.5.1)	$V_{CE(sat)1}$		0.8	V dc
Collector to emitter saturated voltage	3071	I_C = 3.5 A dc; I_B = 0.7 A dc; pulsed (see 4.5.1)	$V_{CE(sat)2}$		2.5	V dc
Forward-current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 0.5 A dc; pulsed (see 4.5.1)	h_{FE1}	25		

See footnote 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						
Forward-current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 1.0 A dc; pulsed (see 4.5.1)	h_{FE2}	30	90	
Forward-current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 2.5 A dc; pulsed (see 4.5.1)	h_{FE3}	10		
Forward-current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 3.5 A dc; pulsed (see 4.5.1)	h_{FE4}	5		
Collector to emitter sustaining voltage		I_C = 100 mA dc	$V_{CEO(SUS)}$			
2N3902				325		V dc
2N5157				400		V dc
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}			
2N3902		V_{CE} = 400 V dc		300		µA dc
2N5157		V_{CE} = 500 V dc		300		µA dc
Low-temperature operation:		T_A = -55°C				
Forward-current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 1.0 A dc; pulsed (see 4.5.1)	h_{FE5}	10		

See footnote at end of table.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 4						
Pulse response	3251	Test condition A except test circuit and pulse requirements in accordance with figure 2 herein.				
Turn-on time		V_{CC} = 125 V dc; I_C = 1.0 A dc; I_{B1} = 0.1 A dc	t_{on}		0.8	µs
Turn-off time		V_{CC} = 125 V dc; I_C = 1.0 A dc; I_{B1} = 0.1 A dc; $-I_{B2}$ = 0.50 A dc	t_{off}		1.7	µs
Small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 10 V dc; I_C = 0.2 A dc; f = 1 MHz	$\|h_{fe}\|$	2.5	25	
Open circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0; 100 kHz $\leq$ f $\leq$ 1 MHz	C_{obo}		250	pF
Subgroup 5						
Safe operating area (continuous dc)	3051	T_C = 25°C; t $\geq$ 1 s; (see figure 3)				
Test 1		V_{CE} = 28.6 V dc; I_C = 3.5 A dc				
Test 2		V_{CE} = 70 V dc; I_C = 1.43 A dc				
Test 3						
2N3902		V_{CE} = 325 V dc; I_C = 55 mA dc				
2N5157		V_{CE} = 400 V dc; I_C = 35 mA 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 5 continued						
Safe operating area (switching)	3053	Load condition C (unclamped inductive load) (see figure 4) T_C = 25°C; duty cycle ≤ 10 percent, R_S = 0.1Ω (see 4.5.1)				
Test 1		t_p approximately 3 ms (vary to obtain I_C); R_{BB1} = 20Ω; V_{BB1} = 10 V dc; R_{BB2} = 3 kΩ; V_{BB2} = 1.5 V dc; I_C = 3.5 A dc; V_{CC} = 50 V dc; L = 60 mH; R = 3 Ω; R_L ≤ 14 Ω.				
Test 2		t_p approximately 3 ms (vary to obtain I_C); R_{BB1} = 100Ω; V_{BB1} = 10 V dc; R_{BB2} = 3 kΩ; V_{BB2} = 1.5 V dc; I_C = 0.6 A dc; V_{CC} = 50 V dc; L = 200 mH; R = 8 Ω; R_L ≤ 83 Ω.				
Safe operating area (switching)	3053	Clamped inductive load (see figure 5); T_C = +25°C; duty cycle ≤ 10 percent; t_p = approximately 30 ms (vary to obtain I_C); R_S = 0.1Ω; R_{BB1} = 20Ω; V_{BB1} = 10 V dc; R_{BB2} = 100 ohms; V_{BB2} = 1.5 V dc; V_{CC} = 50 V dc; I_C = 3.5 A dc; (see figure 5); R_L ≥ 0 Ω; L = 60 mH; R = 3 Ω A suitable clamping circuit or diode can be used. (see 4.5.1).				
2N3902		Clamp voltage = 400 +0, -5 V dc				
2N5157		Clamp voltage = 500 +0, -5 V dc				
		(Clamped voltage must be reached)				
Electrical measurements		See table II, steps 1 and 2				

1/ For sampling plan, see MIL-PRF-19500.

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

Step	Inspection	MIL-STD-750		Symbol	Limit		Unit
		Method	Conditions		Min	Max	
1.	Forward current transfer ratio	3076	V_{CE} = 5.0 V dc; I_C = 1.0 A dc; pulsed (see 4.5.1)	Δh_{FE1}	±25 percent change from previously measured value		
2.	Thermal response 3/	3131	See 4.3.2	ΔV_{BE}			4/

1/ The delta measurements for table VIb (JAN, JANTX) of MIL-PRF-19500 are as follows:

a. Subgroup 3, see table II herein, steps 1 and 2.

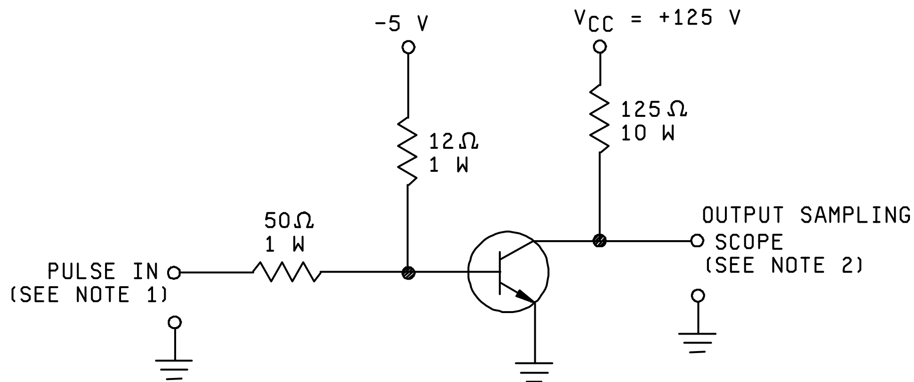
b. Subgroup 6, see table II herein, step 1.

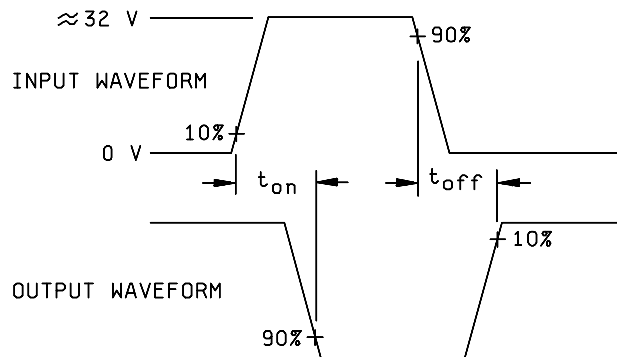
2/ The delta measurements for table VII of MIL-PRF-19500 are as follows:

a. Subgroup 1, see table II herein, steps 1 and 2.

3/ Safe operating area (SOA) may be performed in lieu of thermal response testing herein provided that the appropriate conditions of temperature, time, current, voltage, procedure and circuit to achieve die attach integrity, are approved by the qualifying activity.

4/ Twenty percent degradation in group B is permitted; 30 percent degradation in group C is permitted.





NOTES:

1. The rise time (t_r) and fall time (t_f) of the applied pulse shall be each ≤ 20 ns; duty cycle ≤ 5 percent; generator source impedance shall be 50Ω; pulse width = 5 μs.
2. Output sampling oscilloscope: Z_{in} ≥ 100 kΩ; C_{in} ≤ 50 pF; rise time ≤ 2.0 ns.

FIGURE 2. Pulse response test circuit.

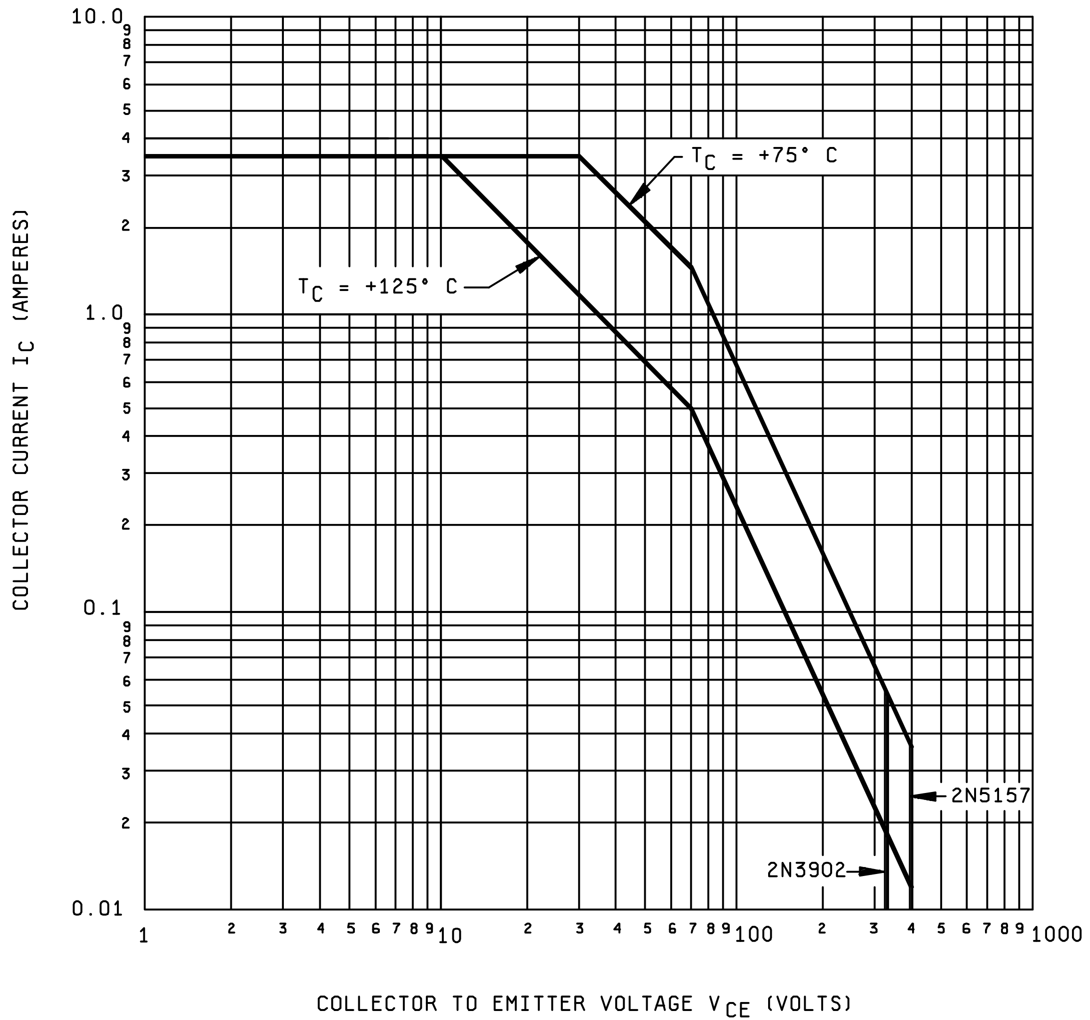


FIGURE 3. Maximum safe operating graph (continuous dc).

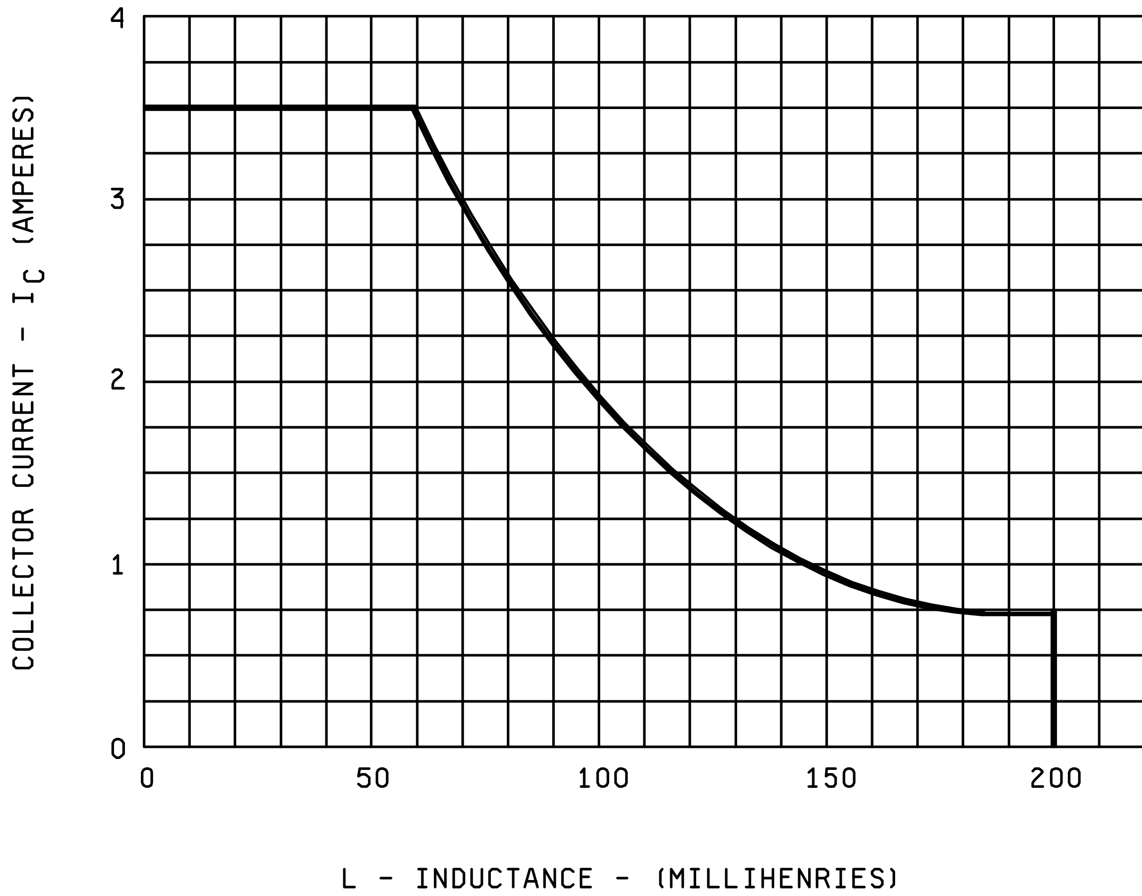


FIGURE 4. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

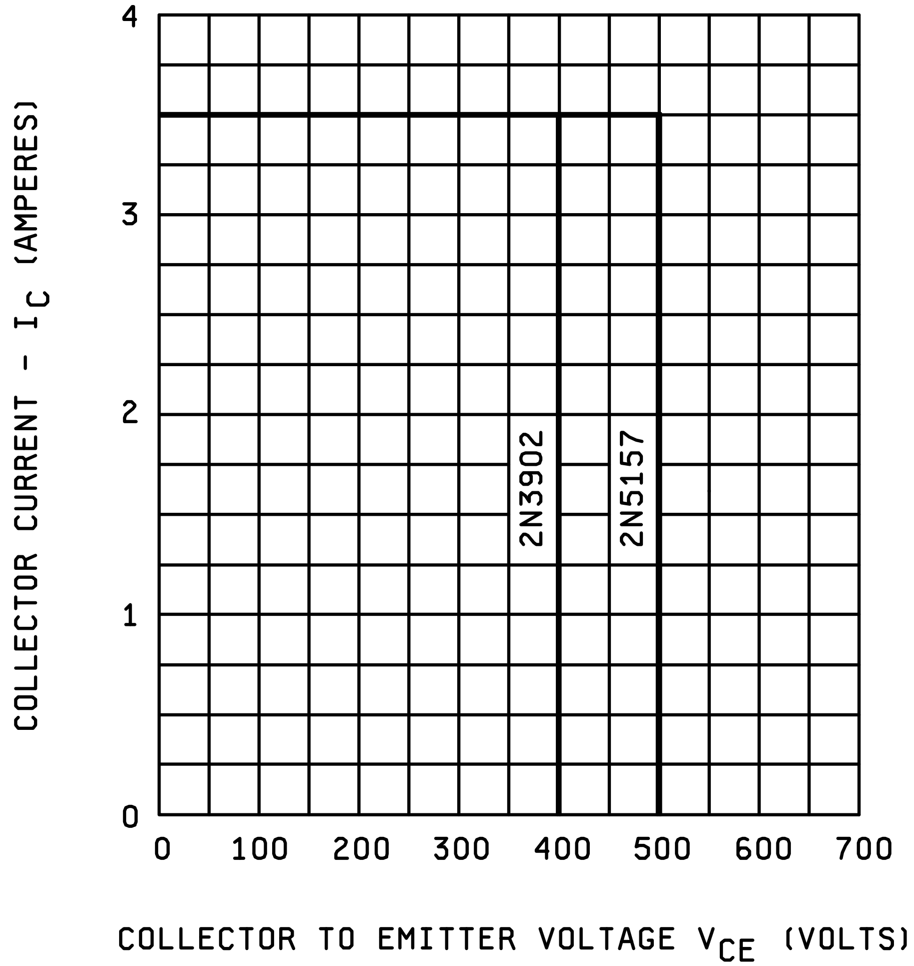


FIGURE 5. Safe operating area for switching between saturation and cutoff (clamped inductive load).

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When 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 Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Issue of DODISS to be cited in the solicitation and, if required, the specific issue of individual documents referenced (see 2.2.1).

b. Lead finish (see 3.3.1).

c. Type designation and product assurance level.

d. Packaging requirements (see 5.1).

6.3 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.

6.4 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 purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Defense Supply Center Columbus, DSCC-VQE, Columbus, OH 43216.

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

Review activities:
Air Force - 19, 99
Navy - AS, CG, MC

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(Project 5961-2165)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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3. DOCUMENT TITLE
SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, HIGH-POWER TYPES 2N3902 AND 2N5157, JAN AND JANTX

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)* (1) Commercial (2) DSN *(If applicable)*	7. DATE SUBMITTED *(YYYYMMDD)*

8. PREPARING ACTIVITY

a. NAME Al Barone	b. TELEPHONE *(Include Area Code* (1) Commercial 614-692-0510 (2) DSN 850-0510
c. ADDRESS *(Include Zip Code)* DSCC-VAT 3990 East Broad Street Columbus, Ohio 43216-5000	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703)767-6888 DSN 427-6888

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