The documentation and process conversion measures necessary to comply with this revision shall be completed by 30 June 1993

INCH-POUND

MIL-S-19500/413B
24 March 1993
SUPERSEDING
MIL-S-19500/413A
3 January 1983

MILITARY SPECIFICATION
SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, HIGH-POWER
TYPES 2N3771 AND 2N3772, JANTX, AND JANTXV

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 detail requirements for NPN silicon, high-power transistors for use in high-speed power-switching applications. Two levels of product assurance are provided for each device type as specified in MIL-S-19500.

1.2 Physical dimensions. See figure 1 (TO-3).

1.3 Maximum ratings. $R_{\theta JC}$ = 1.17°C/W, $R_{\theta JA}$ = 29.2°C/W.

	P_T							
	T_A = +25°C 1/	T_C = +25°C 2/	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_{STG} and T_J
	W	W	V dc	V dc	V dc	V dc	A dc	°C
2N3771	6	150	50	40	7	7.5	30	-65 to +200
2N3772	6	150	100	60	7	5.0	20	-65 to +200

1/ Derate linearly 34.2 mW/°C for T_A > +25°C.
2/ Derate linearly 857 mW/°C for T_C > +25°C.

1.4 Primary electrical characteristics.

	h_{FE2} at V_{CE} = 4 V dc				$V_{CE(SAT)}$ 1/		$V_{CE(SAT)}$ 1/	
	I_C = 15 A dc		I_C = 10 A dc		I_C = 15 A dc, I_B = 1.5 A dc		I_C = 10 A dc, I_B = 1.5 A dc	
	Min	Max	Min	Max	Min	Max	Min	Max
2N3771	15	60				1.5		
2N3772			15	60				1.2

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: NASA/ Parts Project Office (NPPO), NASA Goddard Space Flight Center, Code 310.A, Greenbelt, MD 20771 by using the self-addressed Standardization Document Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 5961

DISTRIBUTION STATEMENT A Approved for public release; distribution is unlimited

Limits	$\lvert h_{fe} \rvert$	C_{obo}	Switching (see figure 2)			
	V_{CE} = 4 V dc I_C = 1 A dc f = 100 kHz	V_{CB} = 10 V dc I_E = 0 100 kHz ≤ f ≤ 1 MHz	t_{on}, t_{off} 2N3771		t_{on}, t_{off} 2N3772	
			µs	µs	µs	µs
Min	6					
Max	30	1200 pF	10	12	8	10

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 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

MILITARY

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

STANDARD

MILITARY

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

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for associated detail specifications, specification sheets, or MS standards), the text of this document shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Associated detail specification. The individual item requirements shall be in accordance with MIL-S-19500, and as specified herein.

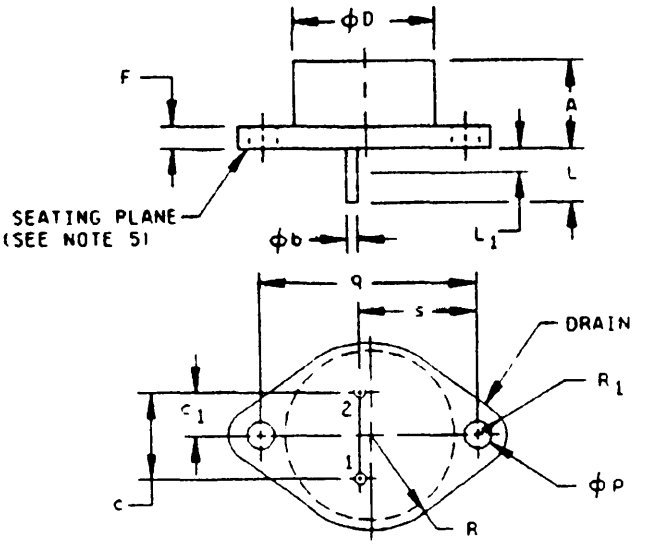
3.2 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-S-19500.

3.3 Design, construction, and physical dimensions. The design, construction, and physical dimensions shall be as specified in MIL-S-19500, and on figure 1 herein.

3.3.1 Lead material and finish. Lead material shall be Kovar or Alloy 52. Lead finish shall be gold or tin or solder as specified in MIL-S-19500. Where a choice of lead finish is desired, it shall be specified in the contract or purchase order (see 6.2).

3.4 Marking. Marking shall be in accordance with MIL-S-19500. At the option of the manufacturer, the country of origin marking may be omitted from the body of the transistor.

Symbol	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
A	.270	.380	6.86	9.65	
ϕb	.038	.053	0.97	1.35	7
ϕD		.875		22.22	
c	.420	.440	10.67	11.18	4
c_1	.205	.225	5.21	5.72	4
F	.060	.135	1.52	3.43	
L	.312	.500	7.92	12.70	
L_1		.050		1.27	
ϕP	.151	.165	3.84	4.19	
q	1.177	1.197	29.90	30.40	
R	.495	.525	12.57	13.33	
R_1	.131	.188	3.33	4.78	
s	.655	.675	16.64	17.15	



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Terminal 1 is base; terminal 2 is emitter; case is collector.
4. These dimensions should be measured at points .050 - .055 inch (1.27 mm - 1.40 mm) below seating plane. When gauge is not used, measurement will be made at seating plane.
5. The seating place of the header shall be flat within .004 inch (0.03 mm) inside a .930 inch (23.62 mm) diameter circle on the center of the header and flat within .004 inch (0.03 mm) concave to .006 inch (0.15 mm) convex overall.
6. Collector shall be electrically connected to the case.
7. Dimension ϕb applies to the length of the leads beyond L_1. Diameter is uncontrolled in L_1.

FIGURE 1. Physical dimensions.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be in accordance with MIL-S-19500 and as specified herein.

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-S-19500 and as specified herein.

4.3 Screening (JANTXV and JANTX levels). Screening shall be in accordance with MIL-S-19500 (table II) 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 II of MIL-S-19500)	Measurement
	JANTX and JANTXV levels
9	I_{CEX1}
11	I_{CEX1} and h_{FE2}; ΔI_{CEX1} = 100 percent of initial value or 200 µA dc, whichever is greater.
12	Burn-in (see 4.3.1)
13	ΔI_{CEX1} = 100 percent of initial value or 500 µA dc, whichever is greater; Δh_{FE2} = ±25 percent of initial reading. Subgroup 2 of table I herein.

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

$T_A \leq +100°C$; V_{CB} = 25 V dc ±5 V dc; T_J = +187.5°C ±12.5°C

Note: No heat sink or forced air cooling on the devices shall be permitted.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-19500 and as specified herein.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-S-19500 and table I herein. End-point electrical measurements shall be in accordance with the applicable steps of table II herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table IVb (JAN, JANTX, and JANTXV) of MIL-S-19500 and as follows. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

4.4.2.1 Group B inspection, table IVb of MIL-S-19500.

a. Subgroup 2: Temperature cycling; method 1051; test condition A.

b. Subgroup 3: Intermittent operation life; method 1037; 2,000 cycles; $V_{CB} \geq 10$ V dc; ΔT_J between cycles $\geq 100°$; $t_{on} = t_{off} \geq 1$ minute. Bond strength; method 2037; Test condition A or C as applicable. All internal leads for each device shall be pulled separately.

c. Subgroup 6: High-temperature life (nonoperating); method 1031; $T_{STG} = 200°C$.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table V of MIL-S-19500 and as follows. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table II herein.

4.4.3.1 Group C inspection, table V of MIL-S-19500.

a. Subgroup 2: Thermal shock; method 1056; test condition A. Terminal strength (tension); method 2036; test condition A, weight = 10 lbs., t = 15 s.

b. Subgroup 5: Not applicable.

c. Subgroup 6: Intermittent operation life; method 1037; 6,000 cycles; $V_{CB} \geq 10$ V dc; ΔT_J between cycles $\geq 100°$; $t_{on} = t_{off} \geq 1$ minute.

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 method 3131 of MIL-STD-750. The following details shall apply:

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

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

c. I_H collector heating current . . . . . 2.6 A (minimum)

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

e. t_H heating time . . . . . Steady-state (see MIL-STD-750, method 3131).

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	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 1						
Visual and mechanical examination	2071					
Subgroup 2						
Breakdown voltage, collector to base	3011	Bias condition D, pulsed (see 4.5.1), I_C = 200 mA dc	$V_{(BR)CEO}$			
2N3771				40		V dc
2N3772				60		V dc
Breakdown voltage, collector to emitter	3011	Bias condition B, I_C = 200 mA dc, R_{BE} = 100Ω, pulsed (see 4.5.1)	$V_{(BR)CER}$			
2N3771				45		V dc
2N3772				70		V dc
Breakdown voltage, collector to emitter	3011	Bias condition A, I_C = 200 mA dc, V_{BE} = -1.5 V dc, pulsed (see 4.5.1)	$V_{(BR)CEX}$			
2N3771				50		V dc
2N3772				90		V dc
Collector-emitter cutoff current	3041	Bias condition D	I_{CEO}			
2N3771		V_{CE} = 30 V dc			5	mA dc
2N3772		V_{CE} = 50 V dc			5	mA dc
Emitter to base cutoff current	3061	Bias condition D, V_{BE} = 7.0 V dc	I_{EBO}		2.0	mA dc
Collector-emitter cutoff current	3041	Bias condition A, V_{BE} = 1.5 V dc	I_{CEX1}			
2N3771		V_{CE} = 50 V dc			500	µA dc
2N3772		V_{CE} = 100 V dc			500	µA dc
Base emitter voltage (nonsaturated)	3066	Test condition B, pulsed (see 4.5.1), V_{CE} = 4 V dc	V_{BE}			
2N3771		I_C = 15 A dc			2.3	V dc
2N3772		I_C = 10 A dc			2.0	V dc
Collector to emitter voltage (saturated)	3071	Pulsed (see 4.5.1)	$V_{CE(sat)1}$			
2N3771		I_C = 15 A dc, I_B = 1.5 A dc			1.5	V dc
2N3772		I_C = 10 A dc, I_B = 1 A dc			1.2	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 4 - Continued						
Magnitude of common emitter small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 4 V dc I_C = 1.0 A dc f = 100 kHz	$\|h_{fe}\|$	6	30	
Small-signal short circuit forward current transfer ratio	3206	V_{CE} = 10 V dc I_C = 1.0 A dc f = 1 kHz	h_{fe}	40		
Output capacitance (open circuit)	3236	V_{CB} = 10 V dc, I_E = 0, 100 kHz ≤ f ≤ 1 MHz	C_{obo}		1200	pF
Subgroup 5						
Safe operating area (dc operation)	3051	T_C = +25°C, t = 1 s, 1 cycle, see figure 3				
Test 1 (2N3771 only)		I_C = 30 A dc V_{CE} = 5 V dc				
Test 2 (2N3771 only)		I_C = 3.75 A dc V_{CE} = 40 V dc				
Test 3 (2N3772 only)		I_C = 20 A dc V_{CE} = 7.5 V dc				
Test 4 (2N3772 only)		I_C = 2.5 A dc V_{CE} = 60 V dc				
Safe operating area (clamped inductive)	3053	Load condition B, T_C = +25°C, duty cycle ≤ 10 percent, (vary pulse width to achieve I_C), R_s = 0.1Ω, (see figure 5)				
Test 1 (2N3771 only)		R_{BB1} = 2Ω, V_{BB1} ≤ 14 V dc, R_{BB2} = 100Ω, V_{BB2} = 1.5 V dc, I_C = 30 A dc, V_{CC} = 20 ±5 V dc, R_L ≤ .67Ω, L = 5 mH, 0.01Ω (Signal transformer Co. CH-30 or equivalent), CR = 1N1186A, clamp voltage = 50 +0, -5 V dc, (device fails if clamp voltage not reached)				

See footnotes at end of page.

TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 5 - Continued						
Test 2 (2N3772 only)		R_{BB1} = 2Ω, V_{BB1} ≤ 10 V dc, R_{BB2} = 100Ω, V_{BB2} = 1.5 V dc, I_C = 20 A dc, V_{CC} = 40 ±5 V dc, R_L ≤ 2Ω, L = 5 mH, 0.01Ω (Signal transformer Co. CH-30 or equivalent), CR = 1N1186A, clamp voltage = 90 +0, -5 V dc, (device fails if clamp voltage not reached)				
End point electrical measurements		See table II, steps 1, and 3				
Subgroup 6						
Safe operating area (unclamped inductive)	3053	Load condition C (unclamped inductive load) see figure 4 herein; T_C = 25°C; duty cycle ≤ 10%; R_S = 0.1Ω; R_{BB2} = 100Ω; V_{BB2} = 1.5 V dc; V_{CC} ≤ 15 V dc.				
Test 1 (2N3771 only)		R_{BB1} = 1Ω; V_{BB1} ≤ 12 V dc; I_C = 30 A dc; L = 1 mH, 0.005Ω (Signal transformer Co. CH-100 or equivalent); t_p ≈ 5 ms.				
Test 2 (2N3772 only)		R_{BB1} = 2Ω; V_{BB1} ≤ 12 V dc; I_C = 20 A dc; L = 2 mH, 0.01Ω (Signal transformer Co. CH-50 or equivalent); t_p ≈ 5 ms.				
Test 3 (both types)		R_{BB1} ≤ 30Ω; V_{BB1} ≤ 10 V dc; I_C = 5 A dc; L = 40 mH, 0.3Ω (Signal transformer Co. CH-8 or equivalent); t_p ≈ 20 ms.				
Safe operating area (clamped inductive) (destructive)	3053	Load condition B; T_C = 25°C; duty cycle ≤ 10%; R_S = 0.1Ω; (see figure 5).				

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

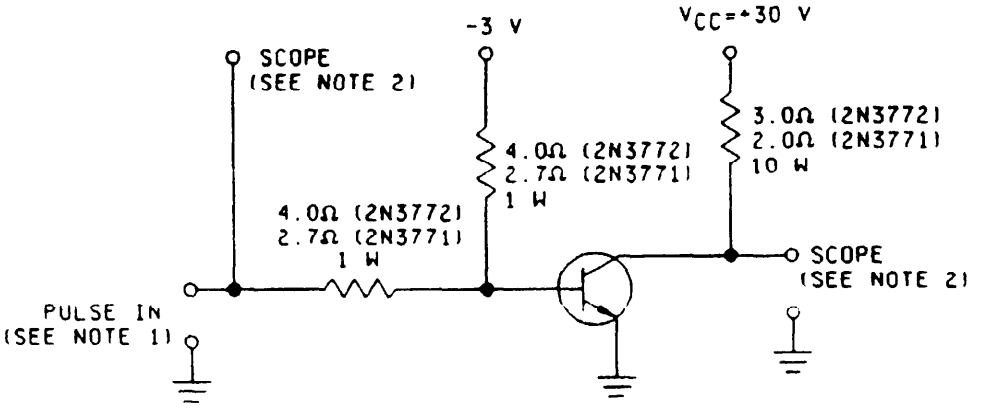
Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 6 - Continued						
Test 1 (2N3771 only)		R_{BB1} = 2Ω; V_{BB1} ≤ 14 V dc; R_{BB2} = 100Ω; V_{BB2} = 1.5 V dc; I_C = 30 A dc; V_{CC} = 50 +0,-5 V dc; R_L = 1.67Ω; L = 5 mH, 0.01Ω (Signal transformer Co. CH-30 or equivalent); CR = 1N1186A; Clamp voltage = 50 +0, -5 V dc.				
Test 2 (2N3772 only)		R_{BB1} = 2Ω; V_{BB1} ≤ 10 V dc; R_{BB2} = 100Ω; V_{BB2} = 1.5 V dc; I_C = 20 A dc; V_{CC} = 90 +0,-5 V dc; R_L = 4.5Ω; L = 5 mH, 0.01Ω (Signal transformer Co. CH-30 or equivalent); CR = 1N1186A; Clamp voltage = 90 +0, -5 V dc.				
Electrical measurements		See table II, steps 2, and 4				

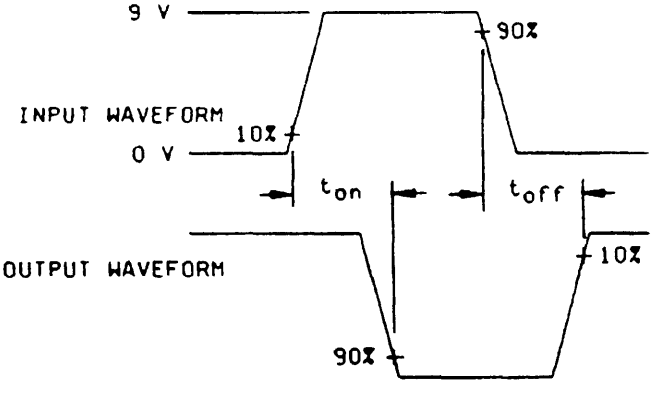
1/ For sampling plan, see MIL-S-19500.

TABLE II. Group A, B, and C electrical measurements.

Step	Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	Symbol	Limits Min	Limits Max	Unit
1.	Collector to emitter cutoff current	3041	Bias condition A, V_{BE} = -1.5 V dc	I_{CEX1}			
	2N3771		V_{CE} = 50 V dc			500	µA dc
	2N3772		V_{CE} = 100 V dc			500	µA dc
2.	Collector to emitter cutoff current	3041	Bias condition A, V_{BE} = -1.5 V dc	I_{CEX2}			
	2N3771		V_{CE} = 50 V dc			1.5	mA dc
	2N3772		V_{CE} = 100 V dc			1.5	mA dc
3.	Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 7 V dc	I_{EBO}		2	mA dc
4.	Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 7 V dc	I_{EBO}		4	mA dc
5.	Forward-current transfer ratio	3076	V_{CE} = 4 V dc	h_{FE2}			
	2N3771		I_C = 15 V dc		15	60	
	2N3772		I_C = 10 V dc		15	60	
6.	Forward-current transfer ratio	3076	V_{CE} = 4 V dc	h_{FE2}			
	2N3771		I_C = 15 V dc		12	75	
	2N3772		I_C = 10 V dc		12	75	
7.	Collector to emitter voltage (saturated)	3071	Pulsed (see 4.5.1)	$V_{CE(sat)1}$			
	2N3771		I_C = 15 A dc, I_B = 1.5 A dc			1.5	V dc
	2N3772		I_C = 15 A dc, I_B = 1.0 A dc			1.2	V dc
8.	Forward-current transfer ratio	3076	V_{CE} = 4 V dc, pulsed (see 4.5.1)	Δh_{FE2} 1/			±25% change from previously measured value
	2N3771		I_C = 15 V dc				
	2N3772		I_C = 10 V dc				

1/ Devices which exceed the group A limits for this test shall not be acceptable.
2/ The electrical measurements for table IVb, (JANTX and JANTXV) of MIL-S-19500 are as follows:
   a. Subgroup 2, see table II herein, step 1.
   b. Subgroup 3, see table II herein, steps 2, 4, 6, and 8.
   c. Subgroup 6, see table II herein, steps 2, 6, and 8.
3/ The electrical measurements for table V of MIL-S-19500 are as follows:
   a. Subgroup 2, see table II herein, steps 1, 5, 7, and 8.
   b. Subgroup 3, see table II herein, steps 1, 3, 5, and 7.
   c. Subgroup 6, see table II herein, steps 2, 4, 6, and 8.





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

FIGURE 2. Pulse response test circuit.

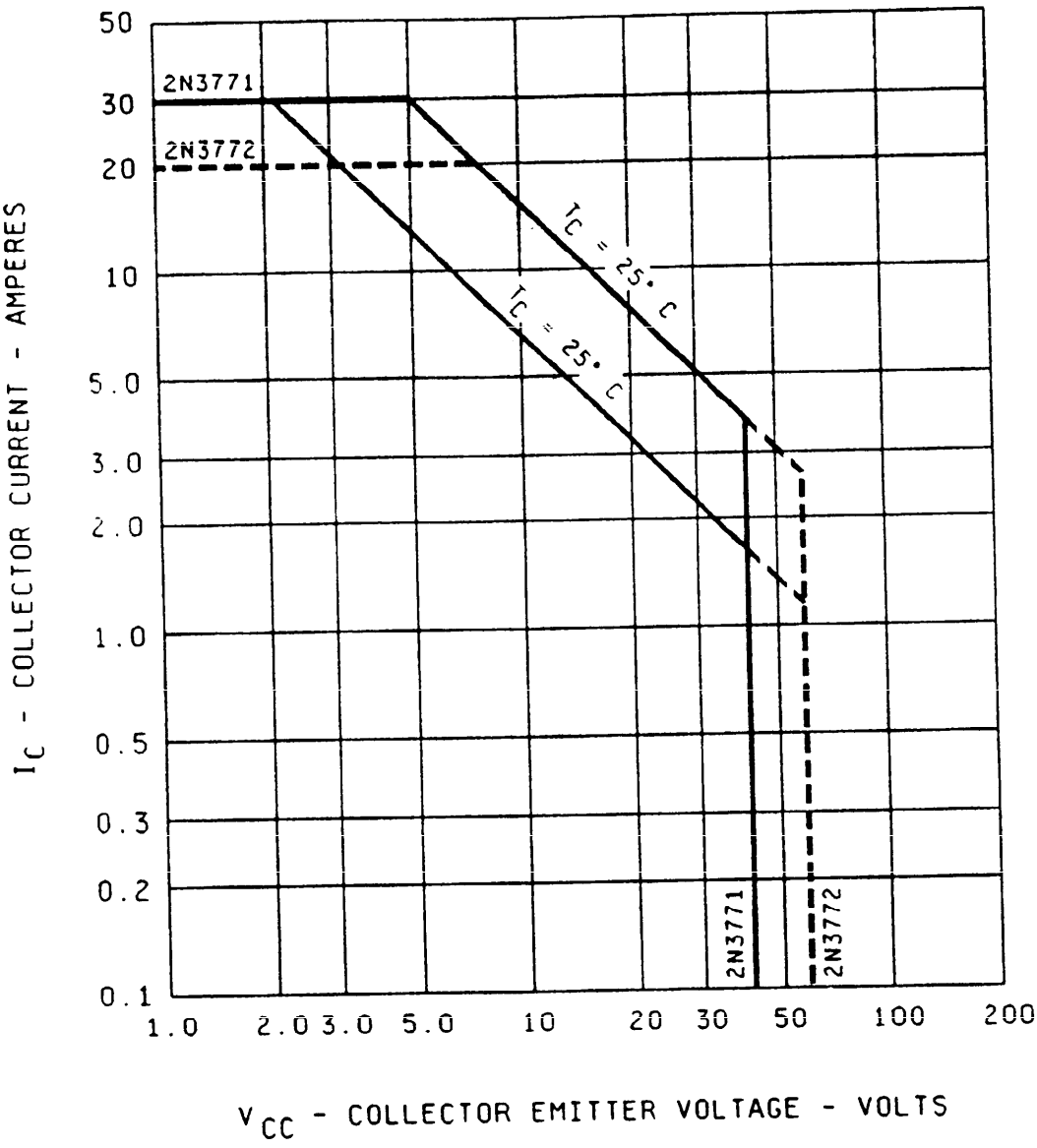


FIGURE 3. Maximum save operating area graph (continuous dc).

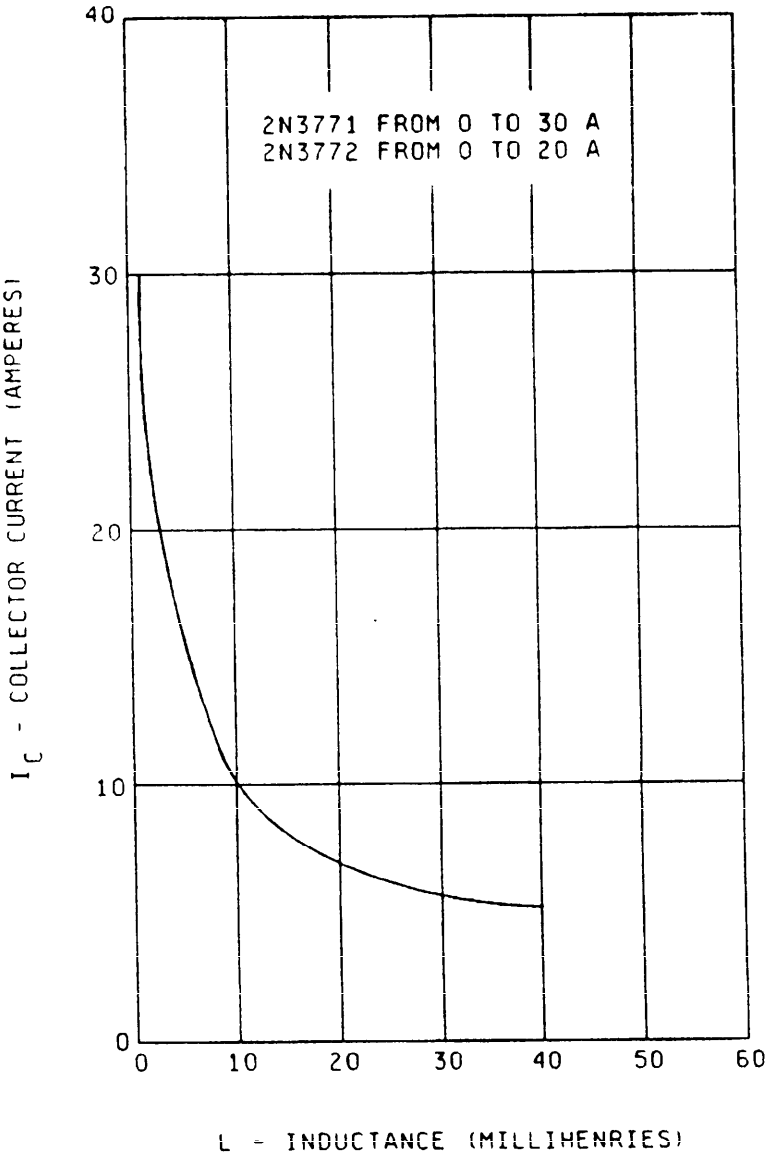


FIGURE 4. Save operating area switching between saturation and cutoff (unclamped inductive load).

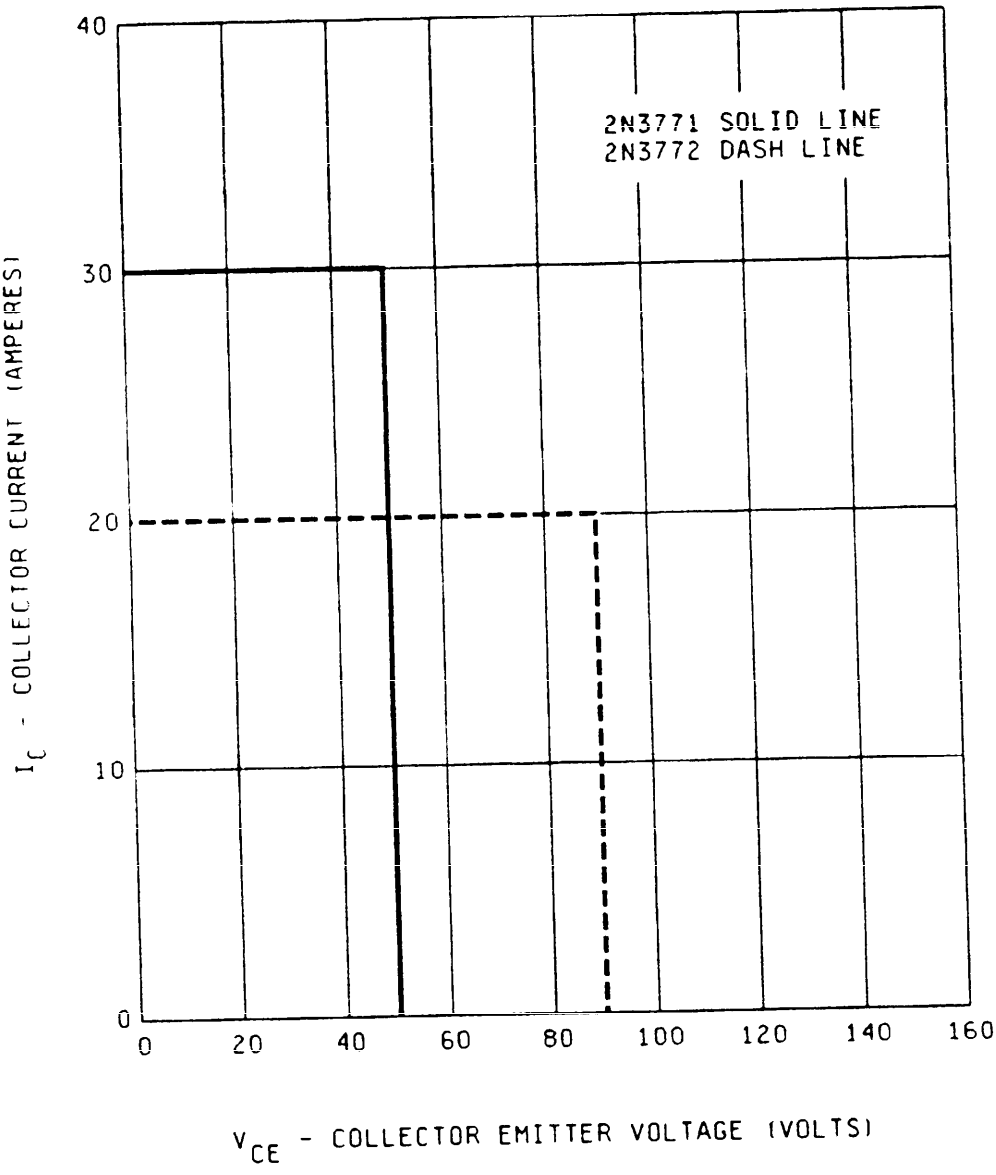


FIGURE 5. Safe operating area for switching between saturation and cutoff (clamped inductive load).

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-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-S-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.

b. Lead finish as specified (see 3.3.1).

c. Type designation and product assurance (JAN) level.

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 extensiveness of the changes.

CONCLUDING MATERIAL

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

Review activity:
Air Force - 19, 85, 99
DLA - ES

Preparing activity:
NASA - NA

Agent:
DLA - ES

(Project 5961-1407)

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.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-S-19500/413B	2. DOCUMENT DATE (YYMMDD)

3. DOCUMENT TITLE SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, HIGH-POWER, TYPES 2N3771 AND 2N3772, JANTX AND JANTXV

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) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY	
a. NAME NASA Parts Project Office	b. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (301) 731-8680
c. ADDRESS (Include Zip Code) Manager (310.A), NASA Parts Project Office Goddard Space Flight Center Greenbelt, MD 20771	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 AUTOVON 289-2340

DD Form 1426, OCT 89 — Previous editions are obsolete. — '98.29(