The documentation and process conversion measures necessary to comply with this revision shall be completed by 25 November 1994

INCH-POUND

MIL-S-19500/464B
25 May 1994
SUPERSEDING
~~MIL-S-19500/464A~~
23 April 1992

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON POWER
TYPES 2N5685 AND 2N5686, 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, power transistors. Two levels of product assurance are provided for each device type as specified in MIL-S-19500.

1.2 Physical dimensions. See figure 1.

1.3 Maximum ratings. T_C = +125°C, unless otherwise specified.

	P_T 1/ T_C = +25°C	P_T 1/ T_C = +100°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
2N5685	300	171	60	60	5	15	50	-55 to +200	.584
2N5686	300	171	80	80	5	15	50	-55 to +200	.584

1/ Between T_C = +25°C and T_C = +200°C linear derating factor 1.715 W/°C.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Electronics Supply Center, DESC-ELD, 1507 Wilmington Pike, Dayton, Oh 45444-5765 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

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1.4 Primary electrical characteristics.

	h_{FE2} 1/		h_{FE3} 1/		$V_{BE(SAT)}$ 1/		$V_{CE(SAT)1}$ 1/		$V_{CE(SAT)2}$ 1/	
	V_{CE} = 2 V dc I_C = 25 A dc		V_{CE} = 5 V dc I_C = 50 A dc		I_C = 25 A dc I_B = 2.5 A dc		I_C = 25 A dc I_B = 2.5 A dc		I_C = 50 A dc I_B = 10 A dc	
	Min	Max	Min	Max	V dc Min	Max	V dc Min	Max	V dc Min	Max
2N5685	15	60				2.0		1.0		5.0
2N5686	15	60	5			2.0		1.0		5.0

	C_{obo}		h_{fe}		Switching (see table I and figure 2 herein)	
	V_{CB} = 10 V dc I_E = 0 .1 MHz ≤ f ≤ MHz		V_{CE} = 5 V dc I_C = 10 A dc f = 1 kHz		t_{on}	t_{off}
	Min	Max pF	Min	Max	Min Max µs	Min Max µs
2N5685		1,200	15		1.5	3.0
2N5686		1,200	15		1.5	3.0

1/ Pulsed (see 4.5.1).

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 Defense Printing Service Detachment Office, Building 4D (Customer Service), 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, 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.

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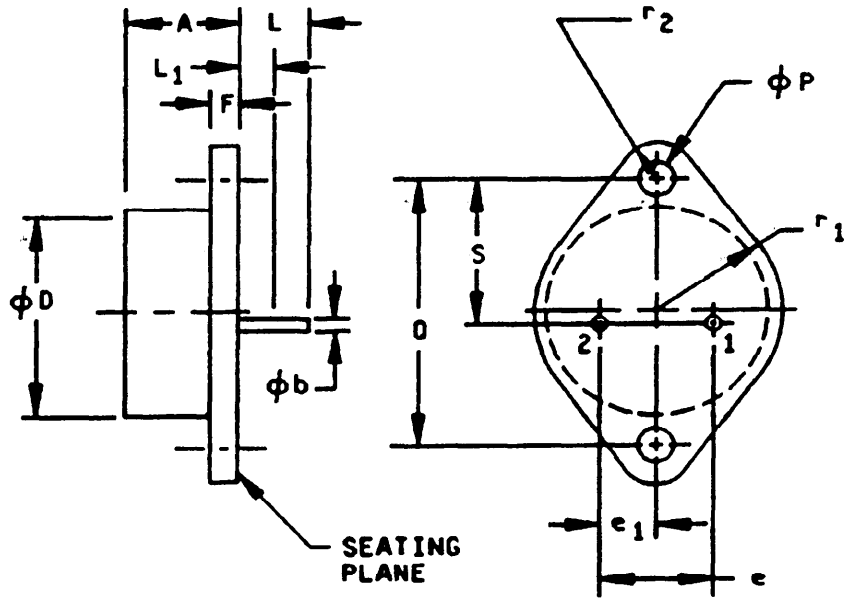

Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
A	.250	.450	6.35	11.43	
ϕb	.057	.063	1.45	1.60	4,6
ϕD		.875		22.23	
e	.420	.440	10.67	11.18	3
e_1	.205	.225	5.21	5.72	3
F	.060	.135	1.52	3.43	
L	.312	.500	7.92	12.70	4,6
L_1		.050		1.27	4,6
ϕP	.151	.165	3.84	4.19	
q	1.177	1.197	29.90	30.40	
r_1	.495	.525	12.57	13.34	
r_2	.131	.188	3.33	4.78	
S	.655	.675	16.64	17.15	3

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. 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 seating plane.
4. Two leads.
5. Collector shall be electrically connected to the case.
6. ϕb applies between L_1 and L. Diameter is uncontrolled in L_1.

FIGURE 1. Physical dimensions.

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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 finish. Lead finish shall be solderable in accordance with MIL-STD-750 and MIL-S-19500. 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-S-19500.

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.

4.3 Screening (JANTX and JANTXV levels). Screening shall be in accordance with table II of MIL-S-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 II of MIL-S-19500)	Measurement
	JANTX and JANTXV levels only
11	h_{FE2} and I_{CEX}
12	See 4.3.1
13	ΔI_{CEX} = 100 percent of initial value or 100 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_J = +187.5°C ±12.5°C; $V_{CB} \geq$ 20 V dc, $T_A \leq$ +100°C.

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

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4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table IVb (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 I, group A, subgroup 2 herein.

4.4.2.1 Group B inspection, table IVb (JANTX and JANTXV) of MIL-S-19500.

Subgroup	Method	Conditions
B3	1037	2,000 cycles, $V_{CE} \geq 10$ V dc, $P_T = 170$ W, ΔT_J between cycles $\geq 100°C$.
	2037	11 devices, ACC = 0.
B5	3131	See 4.5.2.

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 herein. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table I, group A, subgroup 2 herein.

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

Subgroup	Method	Conditions
C2	2036	Test condition A, weight = 10 lbs, t = 15 s.
C6	1037	6000 cycles, $V_{CE} \geq 10$ V dc, $P_T = 170$ W, ΔT_J between cycles $\geq 100°C$.

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. Collector current magnitude during power applications shall be 1 A dc.

b. Collector to emitter voltage magnitude shall be ≥ 5 V dc.

c. Reference temperature measuring point shall be the case.

d. Reference point temperature shall be $+25°C \leq T_R \leq +75°C$ and recorded before the test is started.

e. Mounting arrangement shall be with heat sink to header.

f. Maximum limit shall be $R_{\theta JC} = .584°C/W$.

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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 emitter	3011	Bias condition D; I_C = 100 mA dc, pulsed (pulsed 4.5.1)	$V_{(BR)CEO}$			
2N5685				60		V dc
2N5686				80		V dc
Collector to emitter cutoff current	3041	Bias condition D	I_{CEO}		500	µA dc
2N5685		V_{CE} = 30 V dc				
2N5686		V_{CE} = 40 V dc				
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = 1.5 V dc	I_{CEX1}		500	µA dc
2N5685		V_{CE} = 60 V dc				
2N5686		V_{CE} = 80 V dc				
Emitter to base cutoff current	3061	Bias condition D; V_{BE} = 5 V dc, I_C = 0	I_{EBO}		1	mA dc
Collector to base cutoff current	3036	Bias condition D	I_{CBO1}			
2N5685		V_{CB} = 60 V dc			2.0	mA dc
2N5686		V_{CB} = 80 V dc			2.0	mA dc
Base to emitter saturated	3066	Test condition A; I_C = 25 A dc, I_B = 2.5 A dc, pulsed (see 4.5.1)	$V_{BE(sat)}$		2.0	V dc
Base to emitter non-saturated	3066	Test condition B; I_C = 25 A dc, V_{CE} = 2 A dc, pulsed (see 4.5.1)	V_{BE}		2.0	V dc
Collector to emitter saturated voltage	3071	I_C = 25 A dc; I_B = 10 A dc, pulsed (see 4.5.1)	$V_{CE(sat)1}$		1.0	V dc
Collector to emitter saturated voltage	3071	I_C = 50 A dc; I_B = 10 A dc, pulsed (see 4.5.1)	$V_{CE(sat)2}$		5.0	V dc
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; I_C = 5 A dc, pulsed (see 4.5.1)	h_{FE1}	30		

See footnote at end of table.

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TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 2 - Continued.						
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; I_C = 25 A dc, pulsed (see 4.5.1)	h_{FE2}	15	60	
Forward-current transfer ratio	3076	V_{CE} = 2 V dc; I_C = 50 A dc, pulsed (see 4.5.1)	h_{FE3}	2		
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}		5	mA dc
2N5685 2N5686		V_{CE} = 60 V dc V_{CE} = 80 V dc				
Low temperature operation:		T_A = -55°C				
Forward-current transfer ratio	3076	V_{CE} = 2.0 V dc; I_C = 25 A dc, pulsed (see 4.5.1)	h_{FE4}	7		
Subgroup 4						
Pulse response	3251	Test condition A except test circuit and pulse requirements (see figure 2 herein)				
Turn-on time		V_{CC} = 30 V dc; I_C = 25 A dc, I_{B1} = 2.5 A dc	t_{on}		1.5	µs
Turn-off time		V_{CC} = 30 V dc; I_C = 25 A dc, I_{B1} = $-I_{B2}$ = 2.5 A dc	t_{off}		3.0	µs
Storage time		V_{CC} = 30 V dc; I_C = 25 A dc, I_{B1} = $-I_{B2}$ = 2.5 A dc	t_s		2.0	µs
Magnitude of common emitter small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 10 V dc; I_C = 5 A dc, f = 1 MHz	$\|h_{fe}\|$	2.0	20	

See footnote at end of table.

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TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 4 - Continued.						
Small-signal short-circuit forward-current transfer ratio	3206	V_{CE} = 5 V dc; I_C = 10 A dc, f = 1 MHz	h_{fe}	15		
Open circuit output capacitance	3236	V_{CB} = 10 V dc; I_E = 0, 0.1 MHz ≤ f ≤ 1 MHz	C_{obo}		1200	pF
Subgroup 5						
Safe operating area (continuous dc)	3051	T_C = +25°C; t = 1 s, 1 cycle (see figures 3 and 4)				
Test 1		V_{CE} = 6 V dc; I_C = 50 A dc				
Test 2		V_{CE} = 30 V dc; I_C = 10 A dc				
Test 3		V_{CE} = 50 V dc; I_C = 560 mA dc				
2N5686		V_{CE} = 60 V dc; I_C = 640 mA dc				
Safe operating area (switching)	3053	Load condition C (unclamped inductive load) (see figure 5)				
		T_C = +25°C duty cycle ≤ 10 percent R_s = 0.1Ω; $t_r = t_f$ ≤ 500 ns				
Test 1		t_p approx 5 ms (vary to obtain I_C); R_{BB1} = 10Ω; V_{BB1} = 20 V dc; R_{BB2} = ∞ V_{BB2} = 0 V; V_{CC} = 50 V dc I_C = 20 A dc; L = 1 mH Sanford Miller CK - 50, 50 A .002 ohms (or equivalent)				
Test 2		t_p approx 5 ms, (vary to obtain I_C); R_{BB1} = 100Ω V_{BB1} = 10 V dc; R_{BB2} = ∞ V_{BB2} = 0 V dc; V_{CC} = 50 V dc I_C = 1.5 V dc; L = 80 mH (2 each signal transformer CH06, 6A) 0.4 ohms (or equivalent)				

See footnote at end of table.

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TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 5 - Continued.						
Safe operating area (switching)	3053	Clamped inductive load (see figures 6 and 7) T_A = +25°C; V_{CC} = 50 V dc				
2N5685		Clamp voltage = 60 V dc				
2N5686		Clamp voltage = 80 V dc				
Electrical measurements		See table I, subgroup 2				

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

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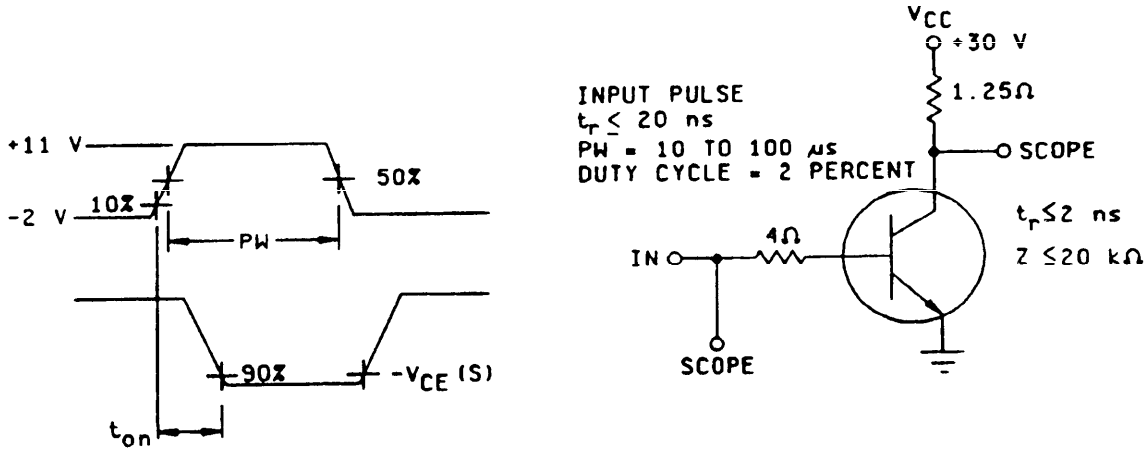
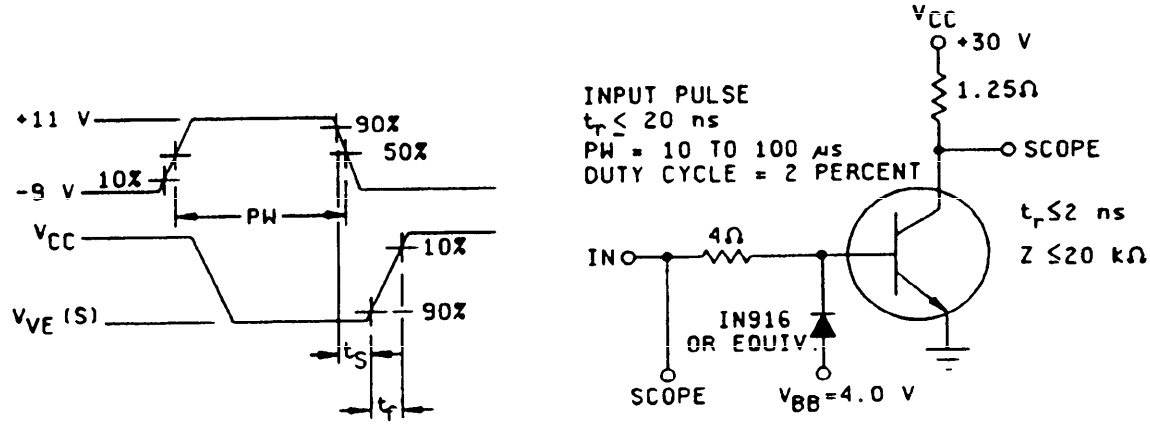


TURN-ON (t_{on}) TIME TEST CIRCUIT



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

FIGURE 2. Switching time test circuits.

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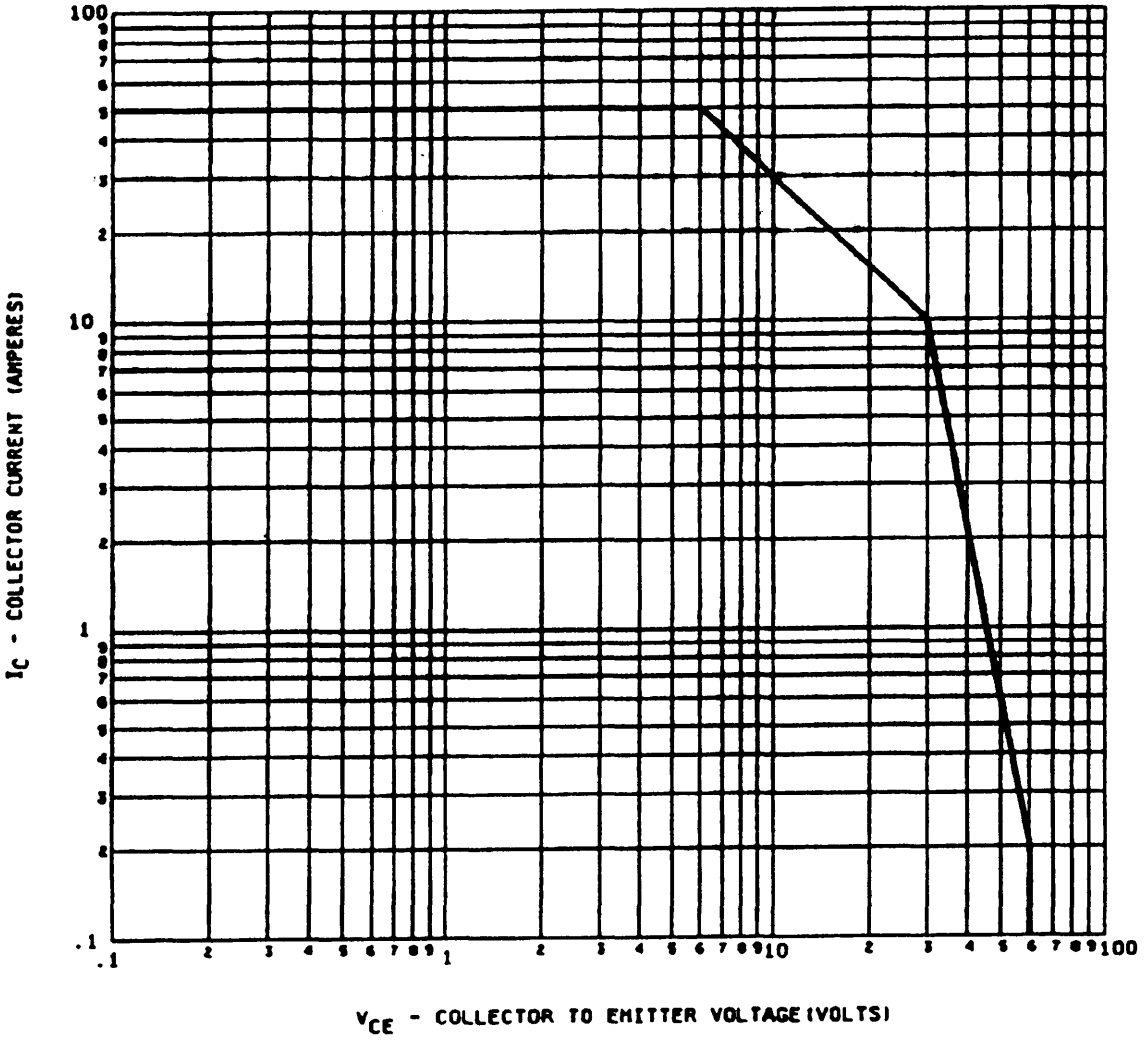

FIGURE 3. Maximum safe operating area graph continuous dc (2N5685).

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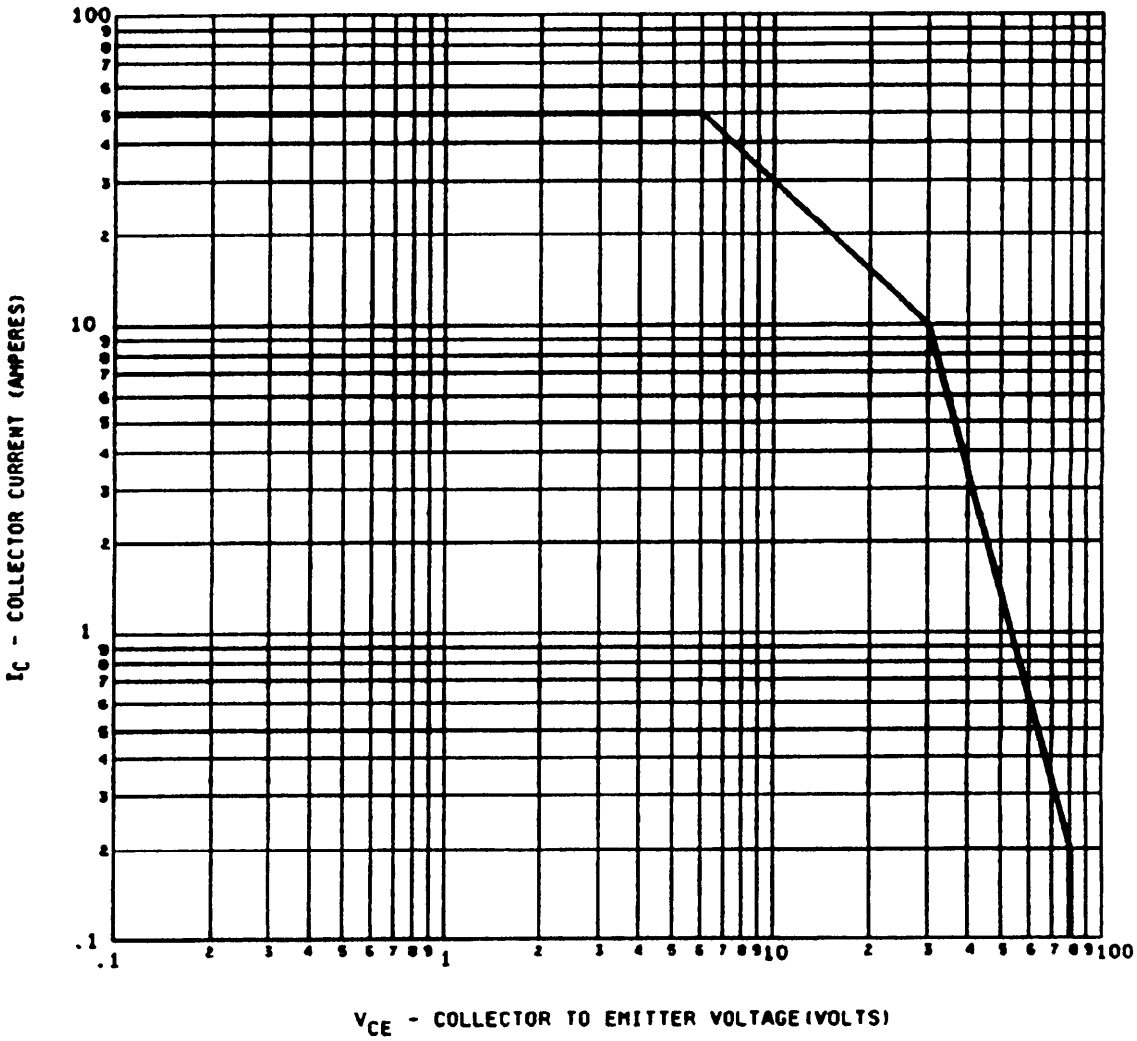

FIGURE 4. Maximum safe operating area graph continuous dc (2N5686).

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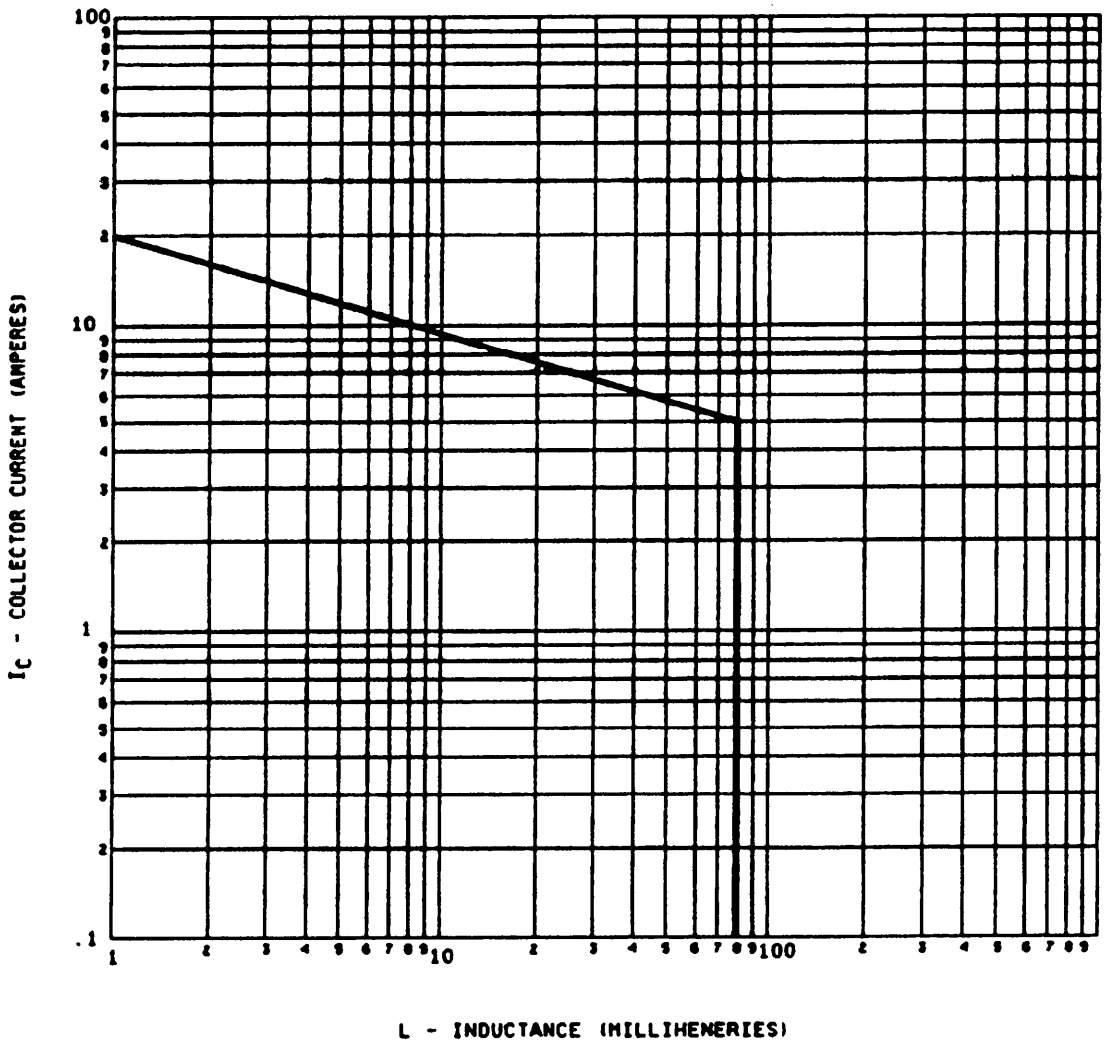

FIGURE 5. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

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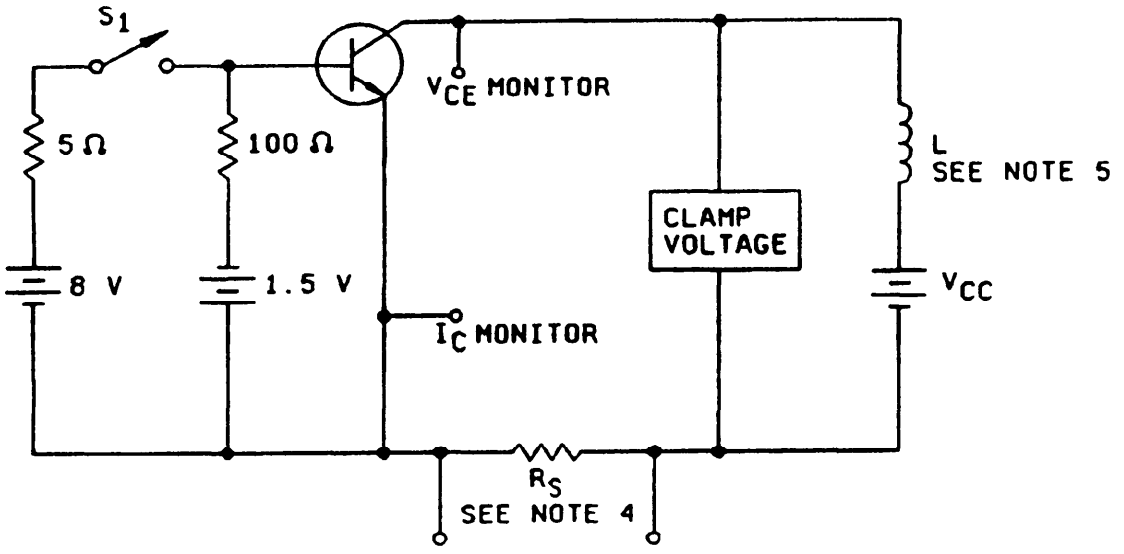

Procedure:

1. With switch S1 closed, set the specified test conditions.
2. Open S1. Device fails if clamp voltage not reached.
3. Perform specified end-point tests.
4. $R_S \leq 0.1\Omega$, 12 W; 1% tolerance max; (noninductive)
5. L = 2.0 Mh (2 each 1 mH.
   Sanford Miller CK-50, 50 A).
   R = .002Ω.

FIGURE 6. Clamp inductive sweep test circuit.

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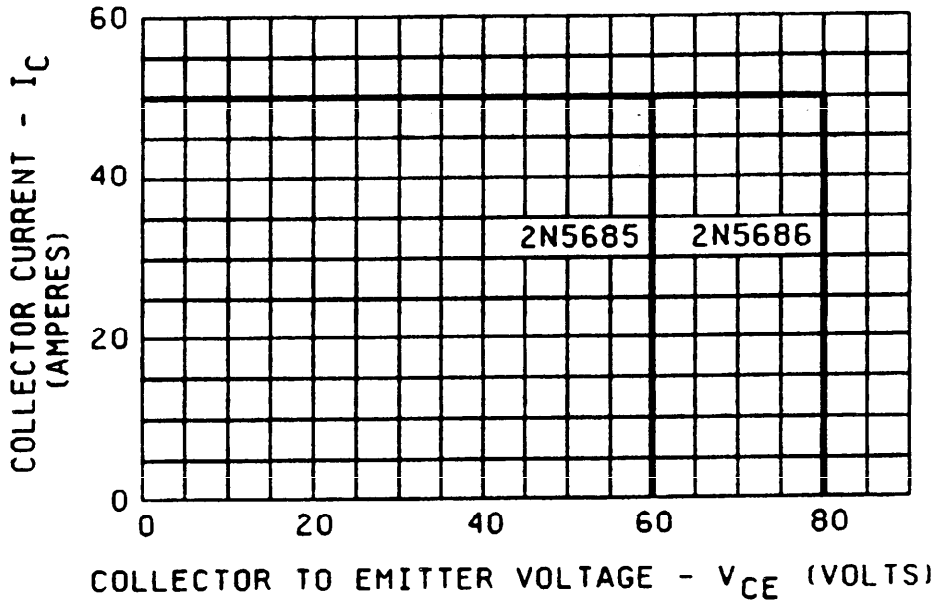

FIGURE 7. Safe operating area for switching between saturation and cutoff (clamped inductive load).

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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 quality (JAN) level.

6.3 JANTX substitution. JANTX devices are a oneway substitute for JAN devices (example JANTX2N5685 for JAN2N5685).

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 extensiveness of the changes.

CONCLUDING MATERIAL

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

Review activities:
Army - MI
Air Force - 13, 19, 70, 80, 85

Preparing activity:
DLA - ES

(Project 5961-1561)

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-S-19500/464B	2. DOCUMENT DATE (YYMMDD) 940525

3. DOCUMENT TITLE SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON POWER, TYPES 2N5685 AND 2N5686, 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	b. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON
c. ADDRESS (Include Zip Code)	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

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