The documentation and process conversion measures necessary to comply with this revision shall be completed by 5 November 1997

INCH-POUND

MIL-PRF-19500/464C
5 August 1997
SUPERSEDING
MIL-S-19500/464B
25 May 1994

PERFORMANCE SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON POWER
TYPES 2N5685 AND 2N5686, JAN, 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 performance requirements for NPN silicon, power transistors. Three levels of product assurance are provided for each device type as specified in MIL-PRF-19500.

1.2 Physical dimensions. See figure 1, similar to TO-3.

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	60	60	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.

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	Min	Max	Min	Max	Min Max
	pF				µs		µs
2N5685		1,200	15			1.5	3.0
2N5686		1,200	15			1.5	3.0

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.

2. APPLICABLE DOCUMENTS

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

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-PRF-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.

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 6.3).

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.

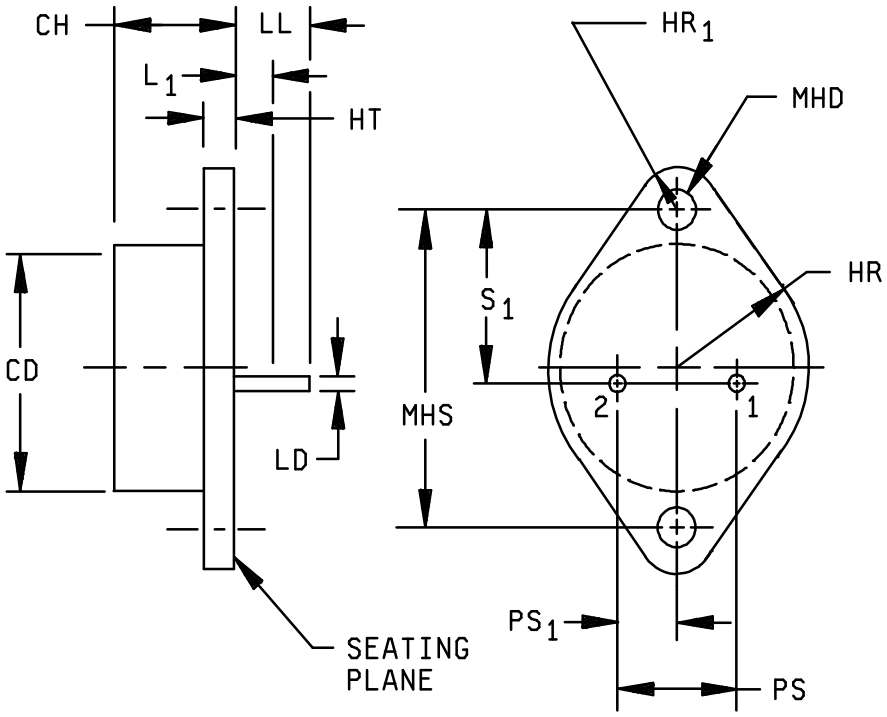
3.4 Interface requirements and physical dimensions. The interface requirements and physical dimensions shall be as specified in MIL-PRF-19500, and figure 1 herein.

3.4.1 Lead finish. Lead finish shall be solderable in accordance with MIL-STD-750 and MIL-PRF-19500. Where a choice of lead finish is desired, it shall be specified in the acquisition document (see 6.2).

3.5 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 4.4.2 and 4.4.3.



Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
CH	.250	.450	6.35	11.43	
LD	.057	.063	1.45	1.60	4, 6
CD	---	.875	---	22.23	
PS	.420	.440	10.67	11.18	3
PS_1	.205	.225	5.21	5.72	3
HT	.060	.135	1.52	3.43	
LL	.312	.500	7.92	12.70	4, 6
L_1	---	.050	---	1.27	4, 6
MHD	.151	.165	3.84	4.19	
MHS	1.177	1.197	29.90	30.40	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
S_1	.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. LD applies between L_1 and LL. Diameter is uncontrolled in L_1.

FIGURE 1. Physical dimensions.

4. VERIFICATION

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

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).

b. Screening (see 4.4).

c. Conformance inspection (see 4.5).

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

4.4 Screening (JANTX and JANTXV levels). Screening shall be in accordance with appendix E, 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 appendix E, table IV of MIL-PRF-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 or100 μA dc, whichever is greater; Δh_{FE2} = 25 percent of initial value; subgroup 2 of table I herein.

4.4.1 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.

4.5 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500 appendix E, table V, and table I herein.

4.5.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-PRF-19500, appendix E table V, and table I herein. Electrical measurements (end-points) shall be in accordance with the applicable steps of table II, herein.

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

4.5.2.1 Group B inspection, appendix E, table VIb (JANTX and JANTXV) of MIL-PRF-19500.

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

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

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

Subgroup	Method	Conditions
C2	2036	Test condition A, weight = 10 pounds, t = 15 s.
C6	1037	6,000 cycles, $V_{CE} \geq 10$ V dc, $P_T = 170$ W, ΔT_J between cycles $\geq +100°C$.

4.6 Method of inspection. Methods of inspection shall be as specified in the appropriate tables and as follows.

4.6.1 Pulse measurements. Conditions for pulse measurement shall be as specified in section 4 of MIL-STD-750.

4.6.2 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 $R_{\theta JC} = .584°C/W$.

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

See footnote at end of table.

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		V_{CE} = 60 V dc				
2N5686		V_{CE} = 80 V dc				
Low temperature operation:						
Forward current transfer ratio	3076	T_A = -55°C	h_{FE4}	7		
Subgroup 4		V_{CE} = 2.0 V dc; I_C = 25 A dc, pulsed (see 4.5.1)				
Pulse response	3251					
Turn-on time		Test condition A, except test circuit and pulse requirements (see figure 2 herein)	t_{on}		1.5	µs
Turn-off time		V_{CC} = 30 V dc; I_C = 25 A dc, I_{B1} = 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_{CC} = 30 V dc; I_C = 25 A dc, I_{B1} = - I_{B2} = 2.5 A dc; V_{CE} = 10 V dc; I_C = 5 A dc, f = 1 MHz	$\|h_{fe}\|$	2.0	20	

See footnote 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						
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}		1,200	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)				
Test 1		T_C = +25°C duty cycle ≤ 10 percent R_S = 0.1 Ω; $t_r = t_f \leq$ 500 ns t_p approximately 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 Ω (or equivalent)				
Test 2		t_p approximately 5 ms (vary to obtain I_C); R_{BB1} = 100 Ω; V_{BB1} = 10 V dc; R_{BB2} = ∞; V_{BB2} = 0 V; V_C = 50 V dc; I_C = 1.5 V dc; L = 80 mH; (2 each signal transformer CH06, 6A) 0.4 Ω (or equivalent)				

See footnote at end of table.

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 II, steps 1 and 3.				

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

TABLE II. Groups A, B, and C electrical end-point measurements. 1/ 2/

Step	Inspection	MIL-STD-750		Symbol	Limit		Unit
		Method	Conditions		Min	Max	
1.	Collector to emitter cutoff current 2N5685 2N5686	3041	Bias condition A, V_{BE} = 1.5 V dc V_{CE} = 60 V dc V_{CE} = 80 V dc	I_{CEX1}		500	µA dc
2.	Collector to emitter cutoff current 2N5685 2N5686	3041	Bias condition A, V_{BE} = 1.5 V dc T_A = +150°C V_{CE} = 60 V dc V_{CE} = 80 V dc	I_{CEX2}		5	mA dc
3.	Forward-current transfer ratio	3076	V_{CE} = 2.0 V dc I_C = 25 A dc pulsed (see 4.5.1)	h_{FE2}	15	60	
4.	Forward-current transfer ratio	3076	V_{CE} = 2.0 V dc I_C = 25 A dc pulsed (see 4.5.1)	Δh_{FE2}	± 25 percent of initial value.		
5.	Thermal response	3131	I_C = 25 A dc,	V_{BE}			

1/ The electrical measurements for appendix E, table VIb (JANTX and JANTXV) of MIL-PRF-19500 are as follows:

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

b. Subgroup 3, see table II herein, steps 2, 4, and 5.

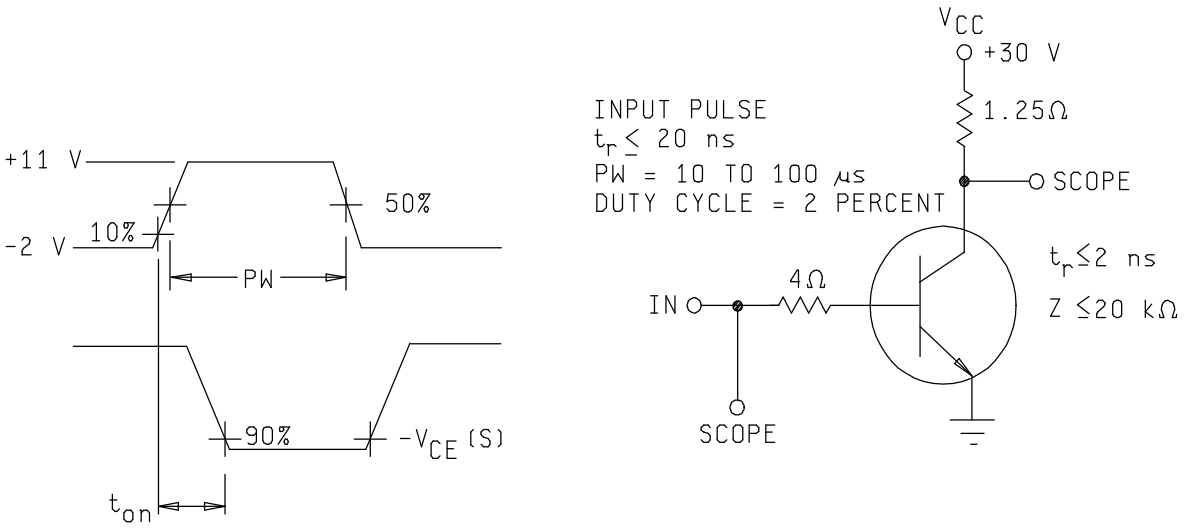
c. Subgroup 6, see table II herein, steps 2 and 4.

2/ The electrical measurements for appendix E, table VII of MIL-PRF-19500 are as follows:

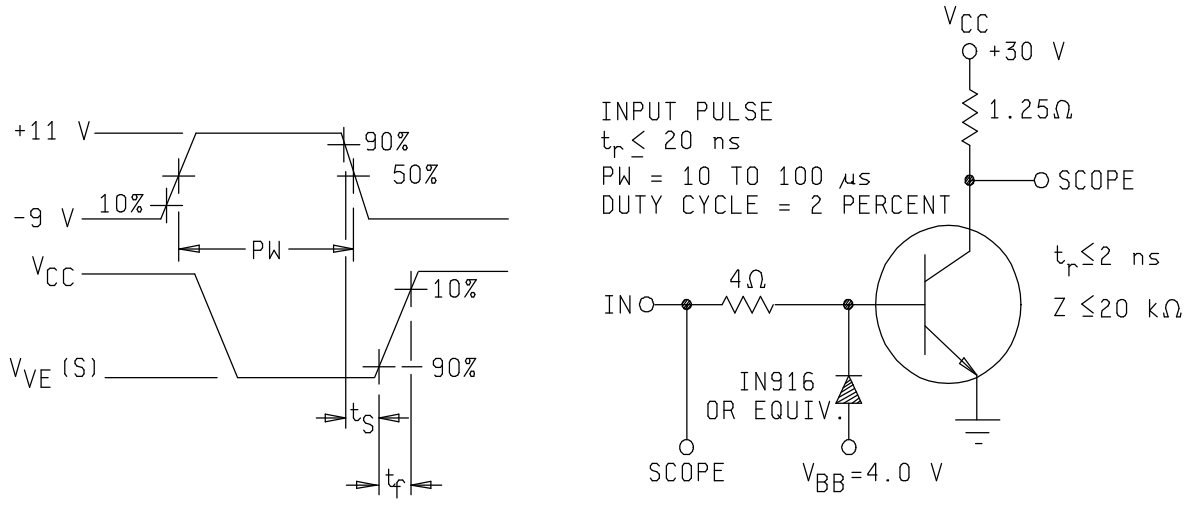
a. Subgroup 2, see table II herein, steps 1 and 3.

b. Subgroup 3, see table II herein, steps 1 and 3.

c. Subgroup 6, see table II herein, steps 2, 4, and 5."



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



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

FIGURE 2. Switching time test circuits.

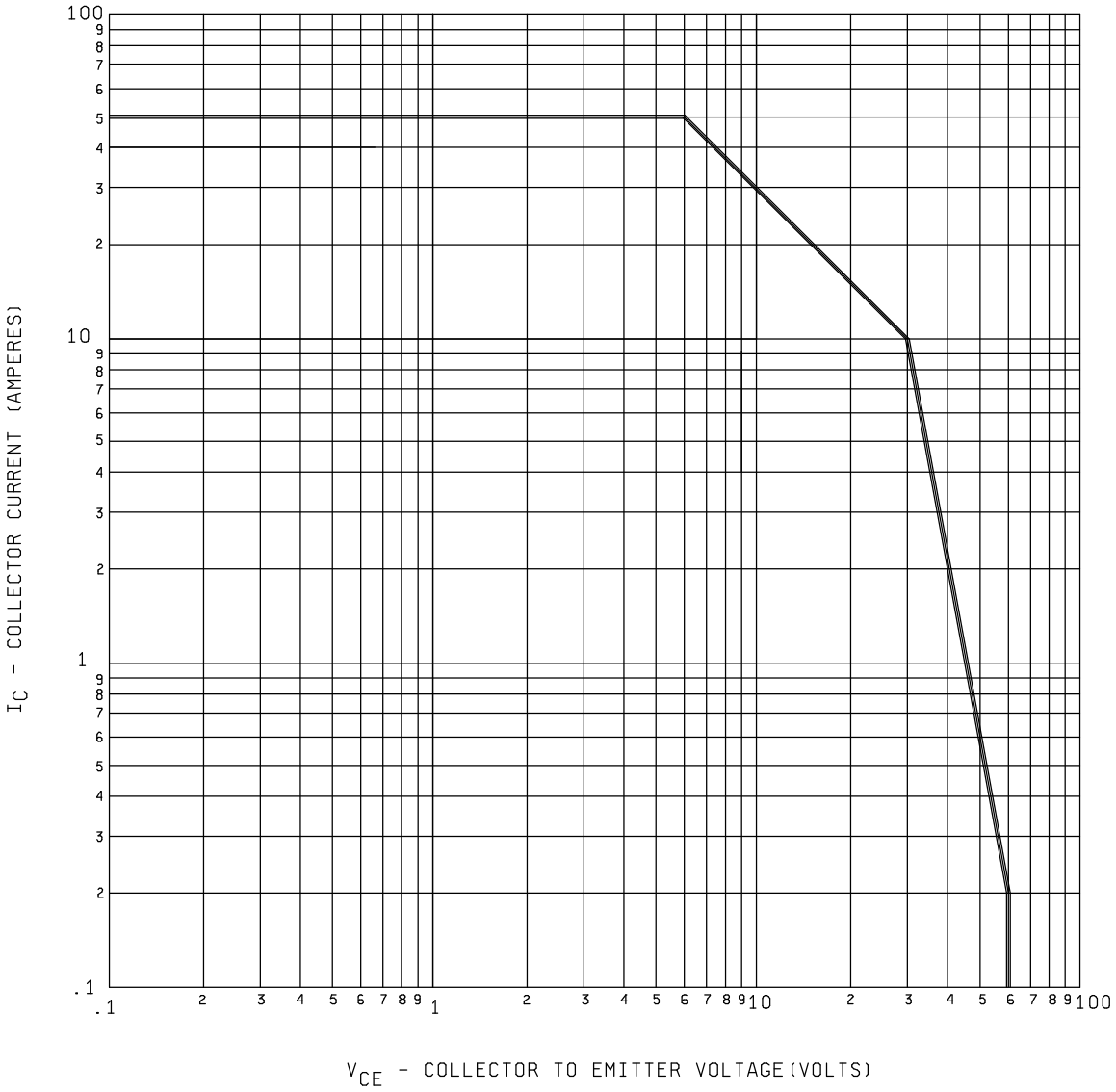


FIGURE 3. Maximum safe operating area graph continuous dc (2N5685).

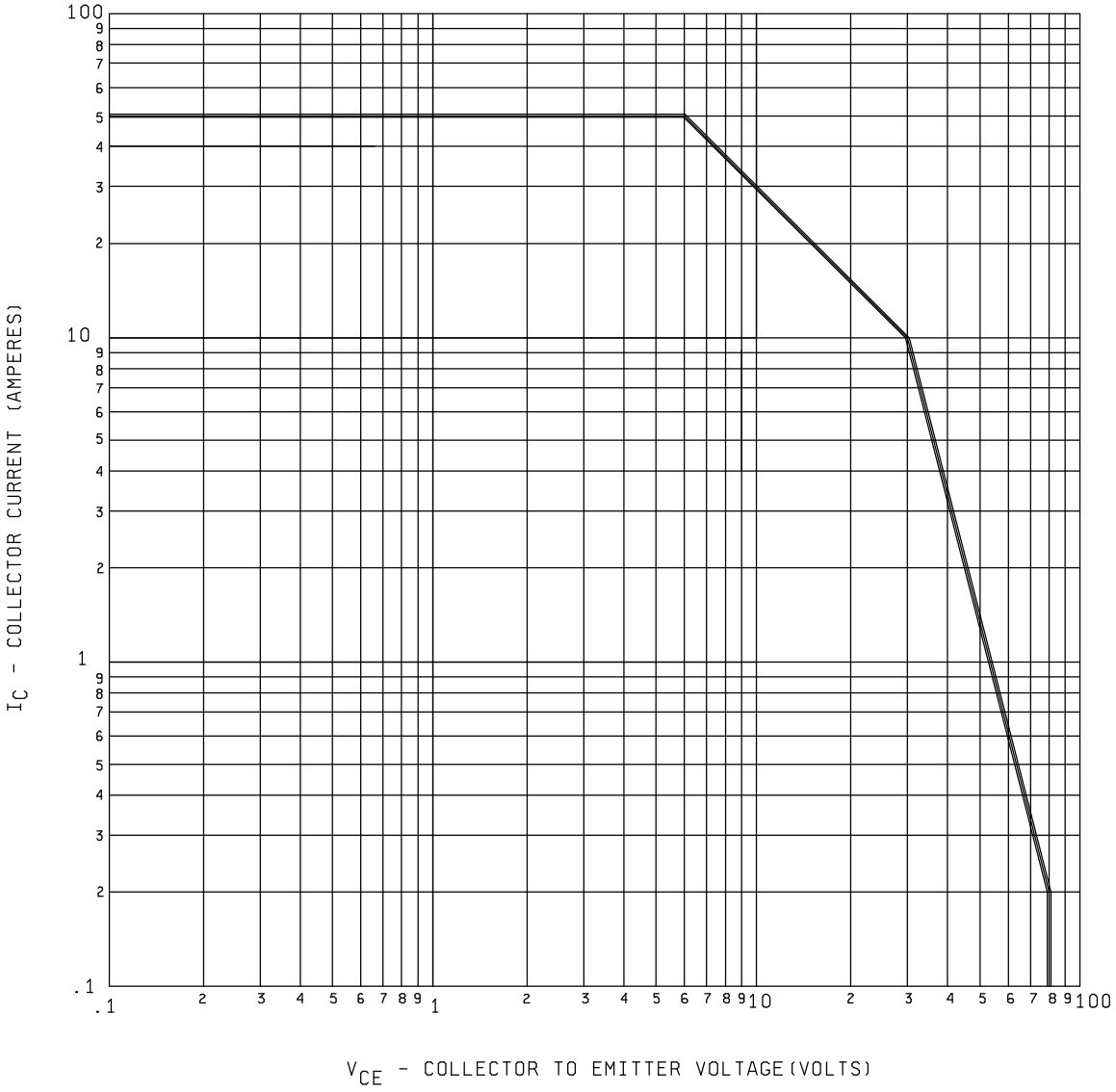


FIGURE 4. Maximum safe operating area graph continuous dc (2N5686).

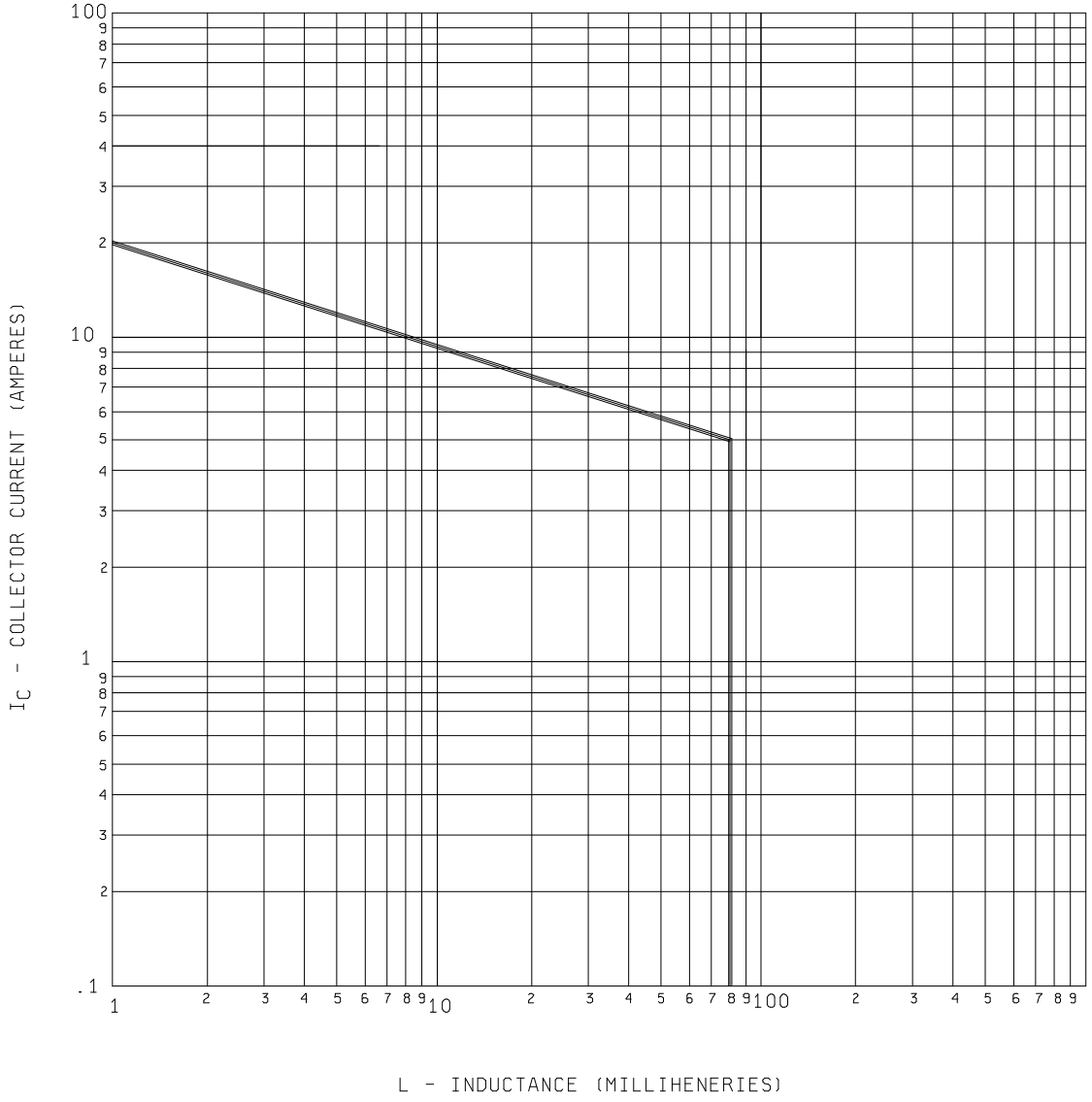
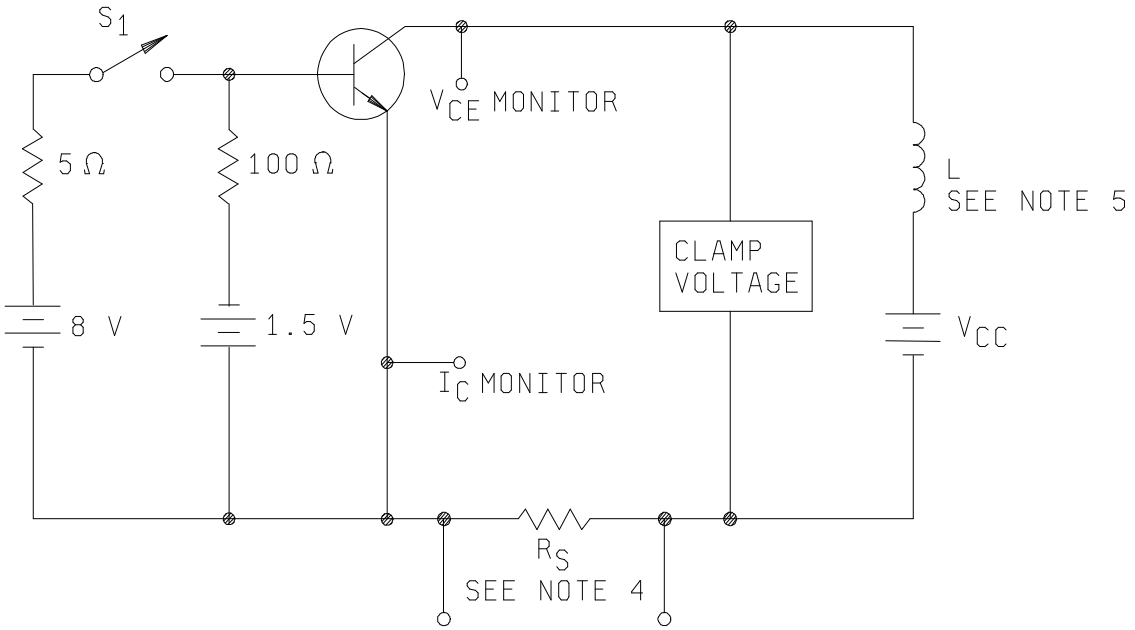


FIGURE 5. Safe operating area for switching between saturation and cutoff (unclamped inductive load).



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; 1percent tolerance maximum; (noninductive)
5. L = 2.0 mH (2 each 1 mH.
   Sanford Miller CK-50, 50 A).
   R = .002 Ω.

FIGURE 6. Clamp inductive sweep test circuit.

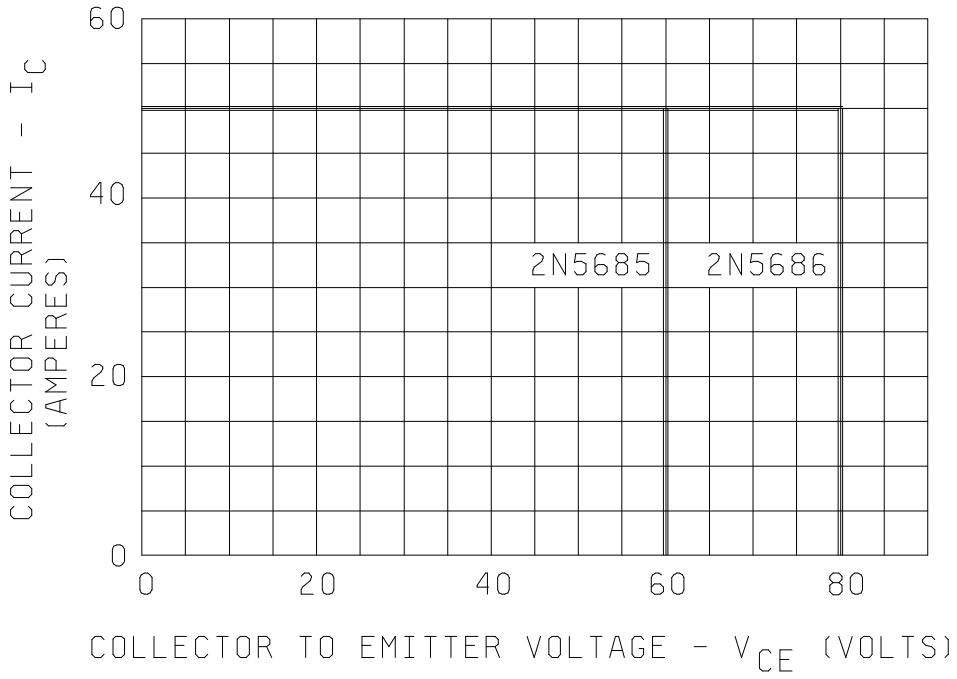


FIGURE 7. Safe operating area for switching between saturation and cutoff (clamped inductive load).

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-STD-129.

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

Review activities:
Army - MI
Air Force - 13, 19, 70, 80, 85, 99

Preparing activity:
DLA - CC

(Project 5961-1829)

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-19500/464C**	**2. DOCUMENT DATE (YYMMDD)** **970805**

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 Alan Barone	b. TELEPHONE (Include Area Code) (1) Commercial (614)692-0510 (2) AUTOVON 850-0510
c. ADDRESS (Include Zip Code) , 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 AUTOVON 289-2340