The documentation and process conversion measures necessary to comply with this revision shall be completed by 23 October 1999.

INCH-POUND

MIL-PRF-19500/528A
23 July 1999
SUPERSEDING
MIL-S-19500/528(USAF)
16 September 1977

PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN,
SILICON, POWER,
TYPES 2N6032 AND 2N6033
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 T0-3).

1.3 Maximum ratings.

Types	P_T 1/ T_C = +25°C	$R_{\theta JC}$	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_{OP} and T_{STG}
	W	°C/W	V dc	V dc	V dc	A dc	A dc	°C
2N6032	140	1.25	120	90	7.0	10	50	-65 to +200
2N6033	140	1.25	150	120	7.0	10	40	-65 to +200

1/ Between T_C = +25°C and T_C = +200, linear derating factor (average) = 800 mW/°C.

1.4 Primary electrical characteristics at T_A = +25°C.

Types	h_{FE1}				C_{obo}		$\|h_{fe}\|$	
	I_C = 50 A dc, V_{CE} = 2.6 V dc		I_C = 40 A dc, V_{CE} = 2.0 V dc		.1 MHz ≤ f ≤ 1 MHz, I_E = 0 A dc, V_{CB} = 10 V dc		f = 5 MHz, I_C = 2.0 A dc, V_{CE} = 10 V dc	
					pF			
	Min	Max	Min	Max	Min	Max	Min	Max
2N6032	10	50			---	1,000	10	40
2N6033			10	50	---	1,000	10	40

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.

1.4 Primary electrical characteristics at T_A = +25°C.

Type	$V_{BE(sat)}$		$V_{CE(sat)}$				switching			
	I_C = 50 A dc I_B = 5 A dc		I_C = 50 A dc I_B = 5 A dc		I_C = 40 A dc I_B = 4 A dc		t_{on}		t_{off}	
	V dc		V dc		V dc		(see table I and figure 4) µs			
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
2N6032	--	2.0	--	1.3	--	--	--	0.5	--	2.0
2N6033	--		--		--	1.0	--	0.5	--	2.0

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

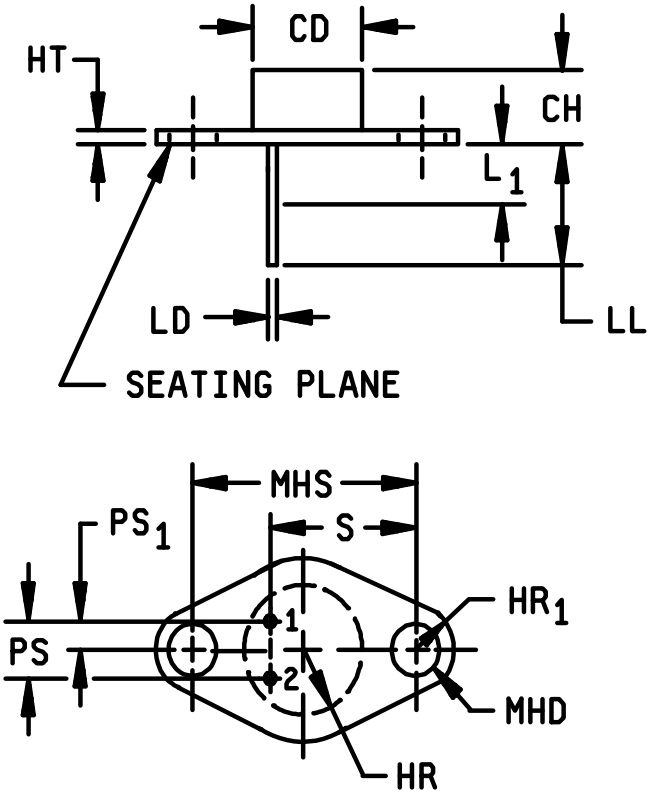
MILITARY

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, Building 4D (NPM-DODSSP), 700 Robbins Avenue, 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.

Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD		.875		22.22	3
CH	.250	.450	.635	11.43	
HR	.495	.525	12.57	13.34	
HR1	.131	.188	3.33	4.78	
HT	.050	.135	1.27	3.43	
L1		.050		1.27	5, 9
LD	.059	.061	1.50	1.55	5, 9
LL	.312	---	7.92	---	5
MHD	.151	.161	3.84	4.09	7
MHS	1.177	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	4
PS1	.205	.225	5.21	5.72	4, 5
S	.655	.675	16.64	17.14	4



Notes:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Body contour is optional within zone defined by CD
4. These dimensions shall be measured at points .050 (1.27 mm) to .055 (1.40 mm) below seating plane. When gauge is not used , measurement shall be made at seating plane.
5. Both terminals.
6. At both ends.
7. Two holes.
8. Terminal 1 is the emitter, terminal 2 is base. The collector shall be electrically connected to the case.
9. LD applies between L1 and LL. Diameter is uncontrolled in L1.
10. In accordance with ANSI Y14.5M, diameters are equivalent to ϕx symbology.

FIGURE 1. Physical dimensions (similar to T0-3).

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 herein.

3.3.1 Lead finish. Lead finish shall be solderable as defined in MIL-PRF-19500.

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

3.5 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).

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

3.7 Electrical test requirements. The electrical test requirements shall be the subgroups specified in table I.

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 and JANTXV levels only). Screening shall be in accordance with MIL-PRF-19500 (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 tableIV of MIL-PRF-19500)	Measurement JANTX and JANTXV levels
9	Not applicable
10	24 hours minimum
11	I_{CEX1} ,h_{FE1}
12	See 4.3.1; 168 hours minimum
13	Subgroup 2 of table I herein; ΔI_{CEX1} = ±100% of initial value or 3 mA dc, whichever is greater; Δh_{FE1} = ±25%

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows: T_J = +187.5°C ±12.5°C, $T_A \leq 35°C$

JANTX and JANTXV levels

2N6032 ---------- V_{CB} = 60 V dc.

2N6033 ---------- V_{CB} = 100 V dc.

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 with MIL-PRF-19500, and table I herein.

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

4.4.2.1 Group B inspection, table VIb (JAN, JANTX, and JANTXV) of MIL-PRF-19500.

Subgroup	Method	Condition
B3	1037	For solder die attach: $V_{CB} \geq 10$ V dc, 2000 cycles, $T_A \leq 35°C$. For eutectic die attach: $V_{CB} \geq 10$ V dc, $T_A \leq 35°C$, adjust P_T to achieve $T_J = 175°C$ min.
B5	3151	

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.

Subgroup	Method	Condition
C6	1037	For solder die attach: $V_{CB} \geq 10$ V dc, 6000 cycles, $T_A \leq 35°C$. For eutectic die attach: $V_{CB} \geq 10$ V dc, $T_A \leq 35°C$, adjust P_T to achieve $T_J = 175°C$ min.

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 Input capacitance. This test shall be conducted in accordance with method 3240 of MIL-STD-750, except the output capacitor shall be omitted.

4.5.3 Coil selection for safe operating area tests. In selecting coils for use in clamped and unclamped inductive SOAR tests, prime consideration should be given to the recommended commercially available coil. However, due to the extreme critical nature of the coil in these circuits and wide tolerance of some commercially available coils (+100, -50 percent), it shall be the semiconductor manufacturer's responsibility, to prove upon request, compliance or equivalency of any coil used (commercial or inplant designed) to be within (+20, -10 percent) of the specified inductance at the rated current and dc resistance.

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	----	I_C = 200 mA dc; f = 30 - 60 Hz; L = 15 mH (see figure 2)	$V_{(BR)CEO}$			
2N6032				90		V dc
2N6033				120		V dc
Breakdown voltage, collector to emitter	----	I_C = 200 mA dc; f = 30 - 60 Hz; L = 15 mH (see figure 2)	$V_{(BR)CER}$			
2N6032				110		V dc
2N6033				140		V dc
Breakdown voltage, collector to emitter	----	I_C = 200 mA dc; f = 30 - 60 Hz; L = 2 mH (see figure 2)	$V_{(BR)CEX}$			
2N6032				120		V dc
2N6033				150		V dc
Emitter to base cutoff current	3061	Bias condition D V_{EB} = 7 V dc	I_{EBO}		10	mA dc
Collector to emitter cutoff Current	3041	Bias condition D V_{CE} = 80 V dc	I_{CEO}		10	mA dc
Collector to emitter cutoff Current	3041	Bias condition A; V_{BE} = -1.5 V dc	I_{CEX1}			
2N6032		V_{CE} = 110 V dc			12	mA dc
2N6033		V_{CE} = 135 V dc			10	mA dc
Collector to base cutoff Current	3036	Bias condition D;	I_{CBO}			
2N6032		V_{CB} = 120 V dc			25	mA dc
2N6033		V_{CB} = 150 V dc			25	mA dc
Forward-current transfer ratio	3076	V_{CE} = 2.6 V dc; I_C = 50 A dc (pulsed see 4.5.1)	h_{FE1}			
2N6032				10	50	
Forward-current transfer ratio	3076	V_{CE} = 2.0 V dc; I_C = 40 A dc (pulsed see 4.5.1)	h_{FE1}			
2N6033				10	50	

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						
Collector-emitter saturation voltage 2N6032	3071	I_C = 50 A dc; I_B = 5.0 A dc; pulsed (see 4.5.1)	$V_{CE(sat)}$		1.3	V dc
Collector-emitter saturation voltage 2N6033	3071	I_C = 40 A dc; I_B = 4.0 A dc pulsed (see 4.5.1)	$V_{CE(sat)}$		1.0	V dc
Base-emitter saturation voltage 2N6032	3306	Test condition A; I_B = 5.0 A dc; I_C = 50 A dc; pulsed (see 4.5.1)	$V_{BE(sat)}$		2.0	V dc
Base-emitter saturation voltage 2N6033	3306	Test condition A; I_B = 4.0 A dc; I_C = 40 A dc; pulsed (see 4.5.1)	$V_{BE(sat)}$		2.0	V dc
Subgroup 3						
High temperature operation		T_A = +150°C				
Collector to emitter cutoff current	3041	Bias condition D;V_{BE} = 1.5 V dc; V_{CE} = 100 V dc	I_{CEX2}			
2N6032					15	mA dc
2N6033					10	mA dc
Low temperature operation		T_A = -55°C				
Forward-current transfer ratio	3076	pulsed (see 4.5.1)	h_{FE2}			
2N6032		V_{CE} = 2.6 V dc; I_C = 50 A dc		5		
2N6033		V_{CE} = 2.0 V dc; I_C = 40 A dc		5		
Subgroup 4						
Magnitude of small-signal short- circuit forward current transfer ratio	3306	V_{CE} = 10 V dc; I_C = 2.0 A dc; f = 5.0 MHz	$\lvert h_{fe} \rvert$	10	40	
Open circuit Output capacitance	3236	V_{CB} = 10 V dc; I_E = 0; 100 kHz ≤ f ≤ 1 MHz	C_{obo}		1,000	pF

See footnote at end of table.

TABLE I. Group A inspection - continued.

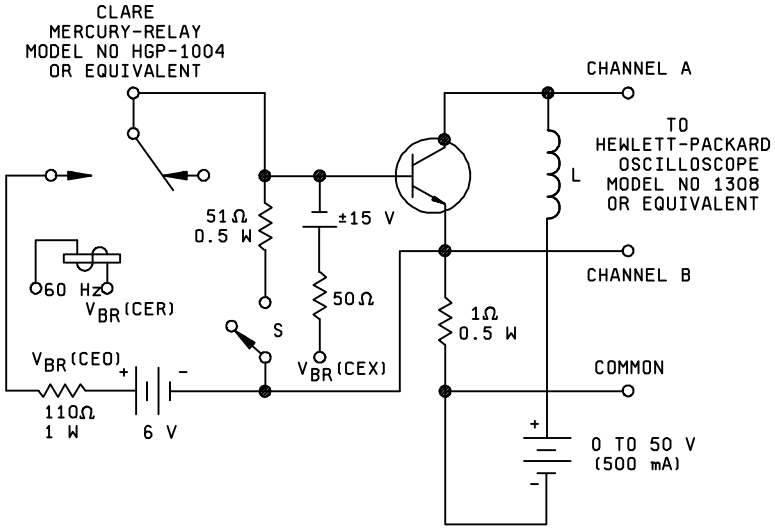
Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
Subgroup 4 - Continued						
Pulse response:	3251	Test condition A except test circuit and pulse requirements in accordance with figure 3.				
Turn-on time			t_{on}		0.5	µs
2N6032		V_{CC} = 30 V dc ±2; I_C = 50 A dc; I_{B1} = 5.0 A dc				
2N6033		V_{CC} = 30 V dc ±2; I_C = 40 A dc; I_{B1} = 4.0 A dc				
Turn-off time			t_{off}		2.0	µs
2N6032		V_{CC} = 30 V dc ±2; I_C = 50 A dc; I_{B2} = 5.0 A dc, I_{B2} = -5.0 A dc				
2N6033		V_{CC} = 30 V dc ±2; I_C = 40 A dc; I_{B1} = 4.0 A dc, I_{B2} = -4.0 A dc				
Subgroup 5						
Safe operating area (continuous dc)	3051	T_C = +25°C; t = 1 s; 1 cycle; (see figure 4)				
Test 1 2N6032 only		I_C = 50 A dc; V_{CE} = 2.8 V dc				
Test 2 2N6033 only		I_C = 40 A dc; V_{CE} = 3.5 V dc				
Test 3		I_C = 5.8 A dc; V_{CE} = 24 V dc				
Test 4		I_C = 0.9 A dc; V_{CE} = 40 V dc				
Test 5 2N6032 only		I_C = 0.18 A dc; V_{CE} = 90 V dc				
Test 6 2N6033 only		I_C = 0.1 A dc; V_{CE} = 120 V dc				

See footnote at end of table.

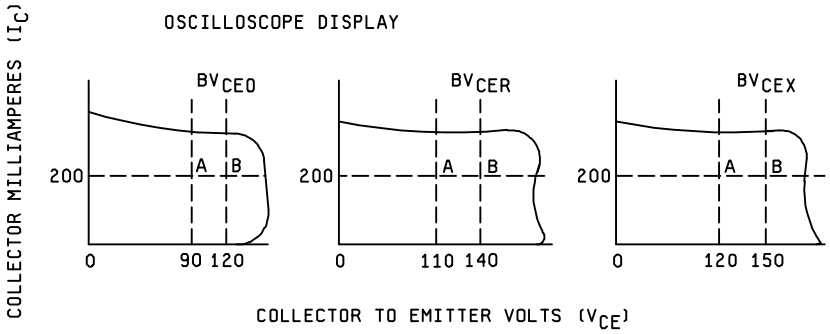
TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
	Method	Conditions		Min	Max	
Subgroup 5 - Continued						
Safe operating area (switching)	3053	Load condition C; (unclamped inductive lead) (see figure 5); T_C = +25°C; Duty cycle ≤ 10 percent; R_S = 0.1 ohm;				
Test 1		$t_p \approx 10$ ms; $R_{BB1} = 1\Omega$; V_{BB1} = 10 V dc max; $R_{BB2} = 20\Omega$; V_{BB2} = 4 V dc;				
2N6032		I_C = 50 A dc;				
2N6033		I_C = 40 A dc; V_{CC} = 10 V dc L = 50 μH, 0.1 Ω;				
Test 2		$t_p \approx 10$ ms; $R_{BB1} = 10\Omega$; V_{BB1} = 10 V dc max; $R_{BB2} = 20\Omega$; V_{BB2} = 4 V dc; I_C = 10 A dc; V_{CC} = 10 V dc L = 500 μH, 0.1 Ω				
Electrical measurements		See table I, group A, subgroup 2				
Safe operating area (switching)	----	T_A = +25°C; duty cycle ≤ 10 percent. $t_p \approx 10$ ms (vary to obtain I_C); $R_S \leq 1\ \Omega$; $V_{CC} \geq 50$ V dc; L = 50 μH, 0.1 Ω				
2N6032		I_C = 50 A dc;				
2N6033		I_C = 40 A dc;				
2N6032 2N6033		clamp voltage = 90 V dc; clamp voltage = 120 V dc; (see figure 6)				
Electrical measurements		See table I, group A, subgroup 2				
Subgroups 6 and 7						
Not applicable						

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

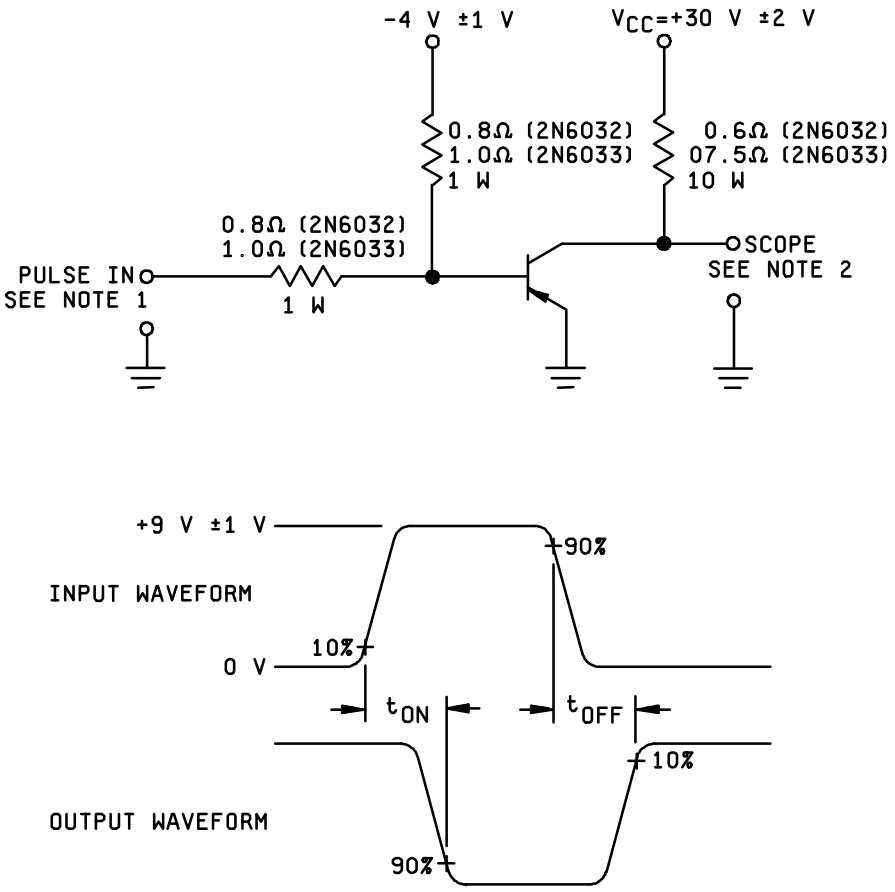


L=15 mH FOR $V_{BR(CEO)}$, $V_{BR(CER)}$ MEASUREMENTS
L=2 mH FOR $V_{BR(CEX)}$ MEASUREMENTS



NOTE: $V_{(BR)CEO}$, $V_{(BR)CER}$, $V_{(BR)CEX}$ is acceptable when the trace falls to the right and above point "A" for type 2N6032. The trace shall fall to the right and above point "B" for type 2N6033

FIGURE 2. $V_{(BR)CEO}$, $V_{(BR)CER}$, $V_{(BR)CEX}$ measurement circuit.



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 50 Ω; pulse width : 20 ns.
2. Output sampling oscilloscope: Z_{in} > 100 kΩ; C_{in} < 50 pF; rise time < 20 nanoseconds.

FIGURE 3. Pulse response test circuit.

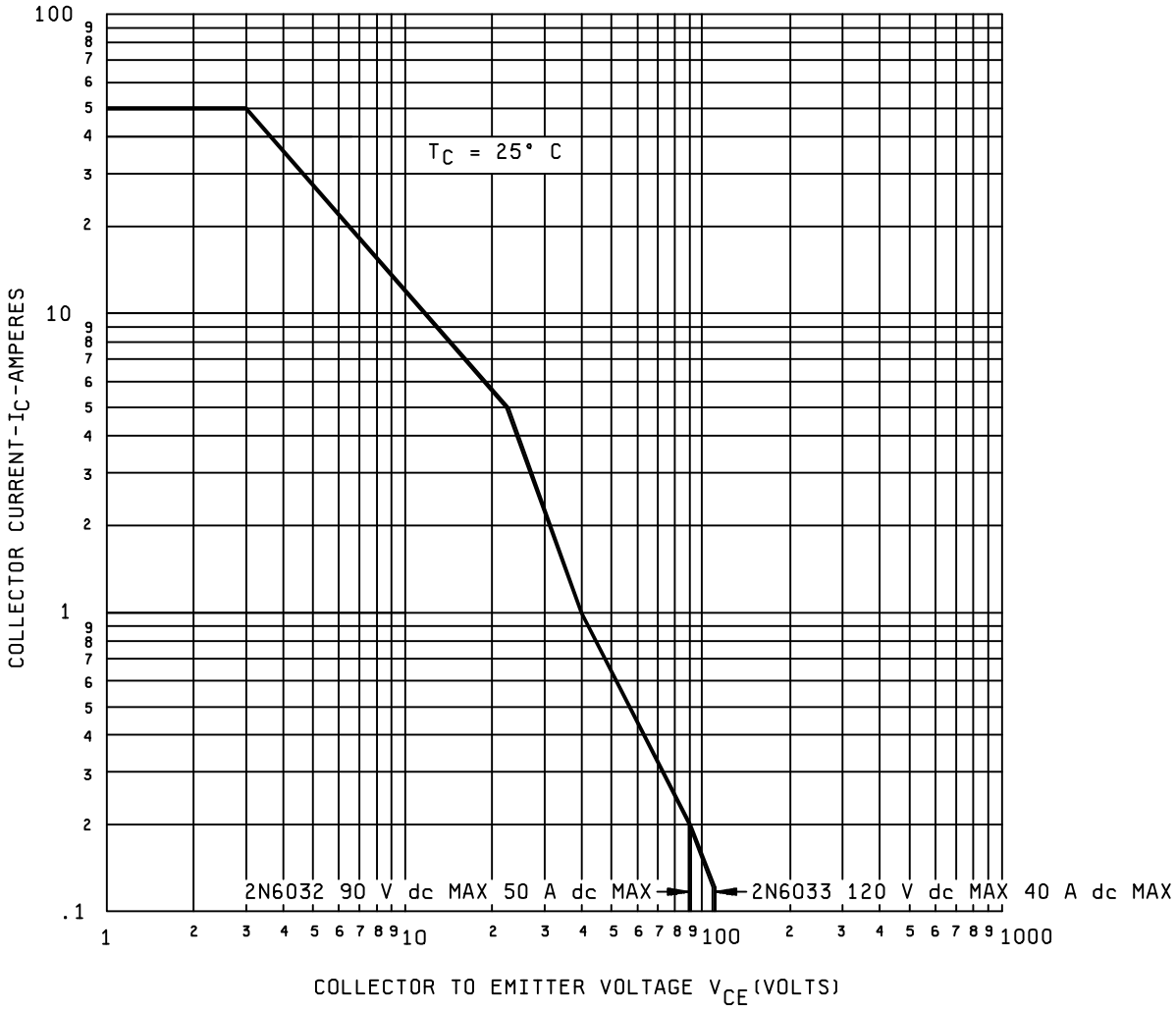


FIGURE 4 Maximum safe operating area graph (continuous DC).

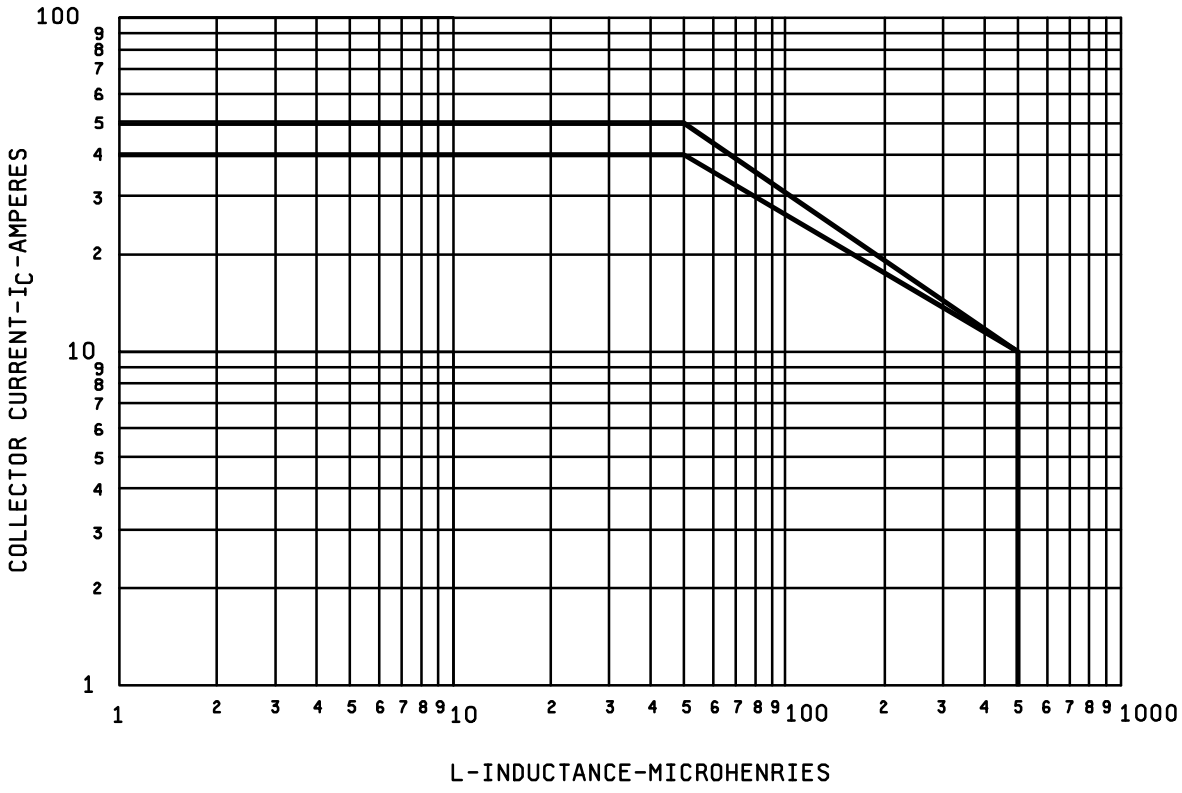
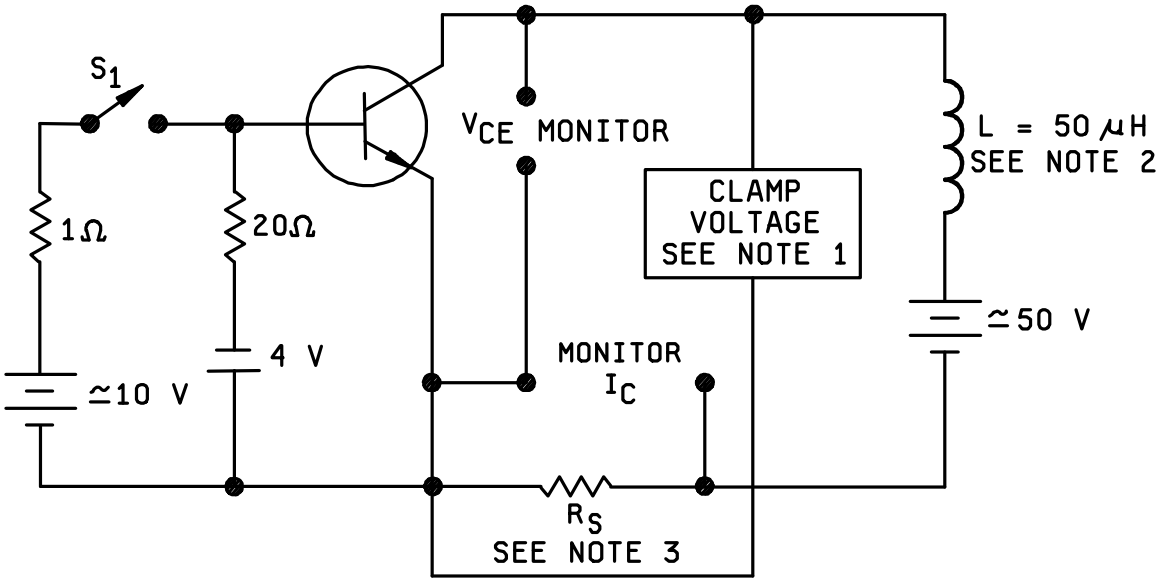


FIGURE 5. Safe operating area for switching between saturation and cutoff (unclamped inductive load).



NOTES:
1. Either a clamping circuit or clamping diode may be used.
2. The coil used shall provide a minimum inductance of 50 µH with a maximum dc resistance of .1 ohm.
3. $R_S \leq .1\ \Omega$, 12 W, 1% tolerance maximum (non-inductive).

Procedure
1. With switch S1 closed, set the specified test conditions.
2. Open S_1. Device fails if clamp voltage not reached and maintained until the current returns to zero.
3. Perform specified endpoint tests.

FIGURE 6. Clamped inductive sweep test circuit.

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 Departments' or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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. Acquisition documents should specify the following:

a. Lead formation and finish may be specified (see 3.3.1).

b. Type designation and product assurance level.

c. 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 extensiveness 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.

CONCLUDING MATERIAL

Custodians:
Air Force - 11
DLA - CC

Preparing activity:
DLA - CC

(Project 5961-F161)

Review activities:
Air Force - 19

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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-19500/528A	**2. DOCUMENT DATE** 99/07/23

3. DOCUMENT TITLE SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, POWER, TYPES 2N6032 AND 2N6033 JAN, 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) Commercial DSN FAX EMAIL	7. DATE SUBMITTED

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-VAC Columbus, OH 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 Belvior, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888			

DD FORM 1426, FEB 99 (EG) PREVIOUS EDITIONS ARE OBSOLETE WHS/DIOR, Feb 99