MIL-S-19500/501A
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SUPERSEDING
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30 June 1975

MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, DARLINGTON TRANSISTOR, PNP, SILICON, POWER TYPES 2N6051, 2N6052 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 detail requirements for PNP, Darlington, silicon, power transistors for use in general purpose amplifier and high-power switching applications. Three 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.

Types	P_T 1/ T_C = 25°C	P_T 1/ T_C = 100°C	V_{CBO}	V_{EBO}	V_{CEO}	I_C	I_B	T_{stg} and T_{op}
	W	W	Vdc	Vdc	Vdc	Adc	Adc	°C
2N6051	150	75	-80	-5.0	-80	-12	-0.2	-65 to +175
2N6052	150	75	-100	-5.0	-100	-12	-0.2	-65 to +175

1/ Derate linearly at 1.00 W/°C for T_C > 25°C.

1.4 Primary electrical characteristics at T_C = 25° ±3°C.

Limit	θ_{J-C}	$V_{BE}(sat)$ I_C = -12 Adc, I_B = -120 mAdc	$V_{CE}(sat)$ I_C = -12 Adc, I_B = -120 mAdc	C_{obo} V_{CB} = -10 Vdc, I_E = 0, 100 kHz ≤ f ≥ 1 MHz	h_{fe} V_{CE} = -3 Vdc, I_C = -5 Adc, f = 1 kHz	h_{fe} V_{CE} = -3 Vdc, I_C = -5 Adc, f = 1 MHz
	°C/W	Vdc	Vdc	pF		
Min	---	---	---	---	1000	10
Max	1.00	-4.0	-3.0	300	---	250

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Rome Air Development Center (RBE-2), Griffiss AFB, NY 13441, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Limit	h_{FE} V_{CE} = -3 Vdc I_C = -12 Adc	h_{FE} V_{CE} = -3 Vdc I_C = -6 Adc	h_{FE} V_{CE} = -3 Vdc I_C = -1 Adc	Pulse response t_{on}	Pulse response t_{off}	$V_{CE}(sat)$ I_C = -6 Adc I_B = -24 mAdc
				µs	µs	Vdc
Min	150	1000	1000	---	---	---
Max	---	18000	---	2	10	-2.0

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATION

MILITARY

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

STANDARD

MILITARY

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

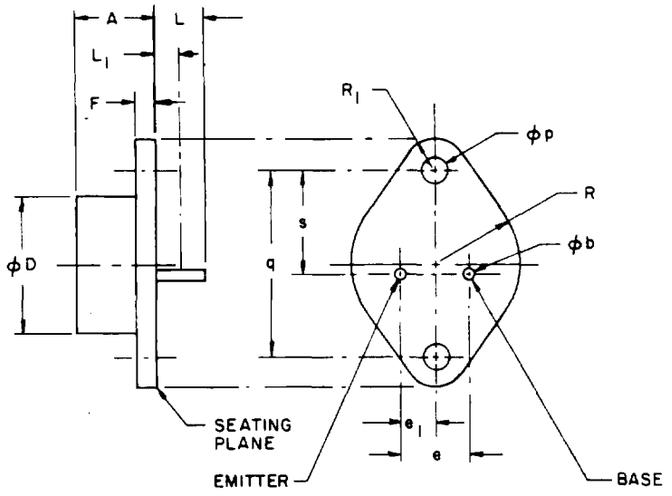
(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

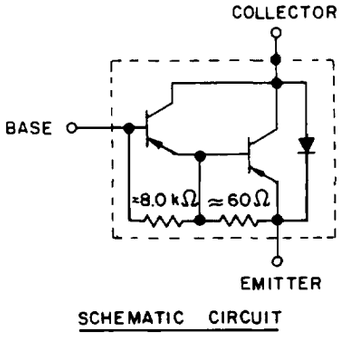
3. REQUIREMENTS

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

3.2 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined 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 figure 1 herein. No aluminum case shall be permitted.





SCHEMATIC CIRCUIT

LTR	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN	MAX	MIN	MAX	
A	.250	.328	6.35	8.33	
ϕb	.038	.043	.97	1.09	4,8
ϕD	---	.875	---	22.23	2
e	.420	.440	10.67	11.18	3, 9
e_1	.205	.225	5.21	5.72	3,4,9
F	.060	.135	1.52	3.43	
L	.312	.500	7.92	12.70	4
L_1	---	.050	---	1.27	4,8
ϕp	.151	.161	3.84	4.09	6
q	1.177	1.197	29.90	30.40	
R	.495	.525	12.57	13.34	
R_1	.131	.188	3.33	4.78	5
s	.655	.675	16.64	17.15	3

NOTES:
1. Metric equivalents are given for general information only and are based upon 1.00 inch = 25.4 mm.
2. Body contour is optional within zone defined by ØD.
3. These dimensions shall be measured at points .050 (1.27 mm) to .055 (1.40 mm) below seating plane. When gage is not used, measurement shall be made at seating plane.
4. Both terminals.
5. At both ends.
6. Two holes.
7. The collector shall be electrically connected to the case.
8. Øb applies between L_1 and L. Diameter is uncontrolled in L_1.
9. The seating plane of the header shall be flat within .001 inch (.03 mm) concave to .004 inch (.10 mm) convex inside a .930 inch (23.62 mm) diameter circle on the center of the header and flat within .001 inch (.03 mm) concave to .006 inch (.15 mm) convex overall.

FIGURE 1. Physical dimensions and schematic circuit.

3.3.1 Schematic circuit. The schematic circuit shall be as specified on figure 1.

3.4 Marking. Marking shall be in accordance with MIL-S-19500. At the option of the manufacturer, the following marking may be omitted from the body of the device:

a. Country of origin.
b. Manufacturer's identification.

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 only). 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
3	T(high) = +175°C, time at temperature extremes = 15 minutes (minimum)
9	I_{CEX1}
11	I_{CEX1}, h_{FE2}; ΔI_{CEX1} = 100% of initial value or 100 µAdc; whichever is greater.
12	See 4.3.1
13	Subgroup 2 of table I herein; ΔI_{CEX1} = 100% of initial value or 100 µAdc, whichever is greater; Δh_{FE2}= ±40% of initial value.

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows: T_J = +162.5°C ±12.5°C (see 4.5.2), $V_{CE} \geq$ 10 Vdc, $T_A \leq$ 100°C.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-19500.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-S-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 table IVb (JAN, JANTX, and JANTXV) of MIL-S-19500, and table II herein. Electrical measurements (end points) shall be in accordance with the applicable steps of table IV herein.

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 table III herein. Electrical measurements (end points) and delta requirements shall be in accordance with the applicable steps of table IV herein.

4.5 Methods of inspection. Methods of inspection shall be as specified in 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 Operating life-test conditions. Power shall be applied to the device to achieve a junction temperature (T_J) of +162.5° ±12.5°C.

T_J shall be determined as follows:

$T_J = P_D \theta_{JC} + T_C$;
$P_D = (V_{CE})(I_C)$;
$\theta_{JC} = 1.0$ C/W;
T_C = measured value at hottest point on case.

NOTE: For reference only. This test can be approximated by dissipating 5 watts at T_A = +25°C or 75 watts at T_C = +100°C.

4.5.3 Coil selection for safe operating area tests. In selecting coils for use in the clamped and unclamped inductive safe operating area 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 the wide tolerance of some commercially available coils (+100, -50%), it shall be the semiconductor manufacturer's responsibility, to prove upon request, compliance or equivalency of any coil used (commercial or in-plant designed) to be within (+20, -10%) of the specified inductance at the rated current and dc resistance.

4.5.4 Inspection conditions. Unless otherwise specified herein, all inspections shall be conducted at case temperature (T_C) of 25°C.

4.5.5 Group C life test. The Group C sample (T_C test conditions) shall be drawn from the devices which were drawn for the Group B sample (T_J test conditions).

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-19500.

6. NOTES

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

6.2 Ordering data. Procurement documents may specify the lead finish.

TABLE I. Group A inspection.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN JANTX JANTXV	Symbol	Limits Min	Limits Max	Unit
Subgroup 1			5				
Visual and mechanical examination	2071						
Subgroup 2			5				
Breakdown voltage, collector to emitter	3011	Bias condition D; I_C = 100 mAdc pulsed (see 4.5.1)		$V_{(BR)CEO}$			
2N6051					80	---	Vdc
2N6052					100	---	Vdc
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = +1.5 Vdc		I_{CEX1}	---	0.5	mAdc
2N6051		V_{CE} = 80 Vdc					
2N6052		V_{CE} = 100 Vdc					
Collector to emitter cutoff current	3041	Bias condition D;		I_{CEO}	---	1.0	mAdc
2N6051		V_{CE} = 40 Vdc					
2N6052		V_{CE} = 50 Vdc					
Emitter to base cutoff current	3061	Bias condition D; V_{EB} = -5 Vdc		I_{EBO}	---	2.0	mAdc
Base to emitter voltage (non-saturated)	3066	Test condition B; V_{CE} = 3 Vdc I_C = 6 Adc		V_{BE}	---	2.8	Vdc
Base to emitter voltage (saturated)	3066	Test condition A; I_B = 120 mAdc; I_C = 12 Adc; pulsed (see 4.5.1)		$V_{BE(sat)}$	---	4.0	Vdc
Collector to emitter voltage (saturated)	3071	I_C = 12 Adc I_B = 120 mAdc pulsed (see 4.5.1)		$V_{CE(sat)1}$	---	3.0	Vdc
Collector to emitter voltage (saturated)	3071	I_C = 6 Adc I_B = 24 mAdc pulsed (see 4.5.1)		$V_{CE(sat)2}$	---	2.0	Vdc
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc I_C = 1 Adc pulsed (see 4.5.1)		h_{FE1}	1000	---	---

TABLE I. Group A inspection - Continued.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN JANTX JANTXV	Symbol	Limits Min	Limits Max	Unit
Subgroup 2 -Continued							
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 6 Adc pulsed (see 4.5.1)		h_{FE2}	1000	18000	---
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 12 Adc pulsed (see 4.5.1)		h_{FE3}	150	---	---
Subgroup 3			7				
High temperature operation:		T_A = +150°C					
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = +1.5 Vdc		I_{CEX2}	---	5	mAdc
2N6051		V_{CE} = 80 Vdc					
2N6052		V_{CE} = 100 Vdc					
Collector to emitter voltage (saturated)	3071	I_C = 6 Adc; I_B = 24 mAdc pulsed (see 4.5.1)		$V_{CE(sat)}$	---	2.0	Vdc
Low temperature operation:		T_A = -55°C					
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 6 Adc pulsed (see 4.5.1)		h_{FE4}	300	---	---
Subgroup 4			7				
Small-signal short-circuit forward-current transfer ratio	3206	V_{CE} = 3 Vdc; I_C = 5 Adc		h_{fe}	1000	---	---
Magnitude of common-emitter small-signal short-circuit forward-current transfer-ratio	3306	V_{CE} = 3 Vdc; I_C = 5 Adc; f = 1 MHz		$\lvert h_{fe} \rvert$	10	250	---
Open circuit output capacitance	3236	V_{CB} = -10 Vdc; I_E = 0; 100 kHz $\leq$ f $\leq$ 1 MHz		C_{obo}	---	300	pF
Pulse response:							
Turn-on time	---	V_{CC} = 30 Vdc; I_C = 5 Adc; I_B = 20 mAdc (see figure 2)		t_{on}	---	2	µs

TABLE I. Group A inspection - Continued.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN JANTX JANTXV	Symbol	Limits Min	Limits Max	Unit
Subgroup 4 -Continued							
Turn-off time	---	V_{CC} = 30 Vdc; I_C = 5 Adc; $I_{B1} = -I_{B2}$ = 20 mAdc (see figure 2)		t_{off}	---	10	µs
Subgroup 5			10				
Safe operating area (dc)	3051	T_C = 25 +10, -0°C $t \geq 1$ s; 1 cycle (see figure 3)					
Test 1		V_{CE} = 12.5 Vdc; I_C = 12 Adc					
Test 2		V_{CE} = 30 Vdc; I_C = 5 Adc					
Test 3							
2N6051		V_{CE} = 70 Vdc; I_C = 200 mAdc					
2N6052		V_{CE} = 90 Vdc I_C = 155 mAdc					
End point electrical measurements		See table IV, steps 1 and 5					
Safe operating area (switching)	3053	Load condition B (clamped inductive load), T_A = +25°C $t_r + t_f$ < 1.0 µs Duty cycle <2%; $t_p \simeq$ 1 ms; (vary to obtain I_C) R_s = 0.10 ohms; R_{BB1} = 80 ohms; V_{BB1} = -16 Vdc; R_{BB2} = 100 ohms; V_{BB2} = -1.5 Vdc I_C = -12 Adc; V_{CC} = 20 Vdc $R_L \leq 2$ ohms; L = 10 mH (Stancor C-2688 or equivalent)					
2N6051		Clamp voltage = -80 +0, -5 Vdc					
2N6052		Clamp voltage = -100 +0, -5 Vdc Device fails if clamp voltage not reached					

TABLE I. Group A inspection - Continued.

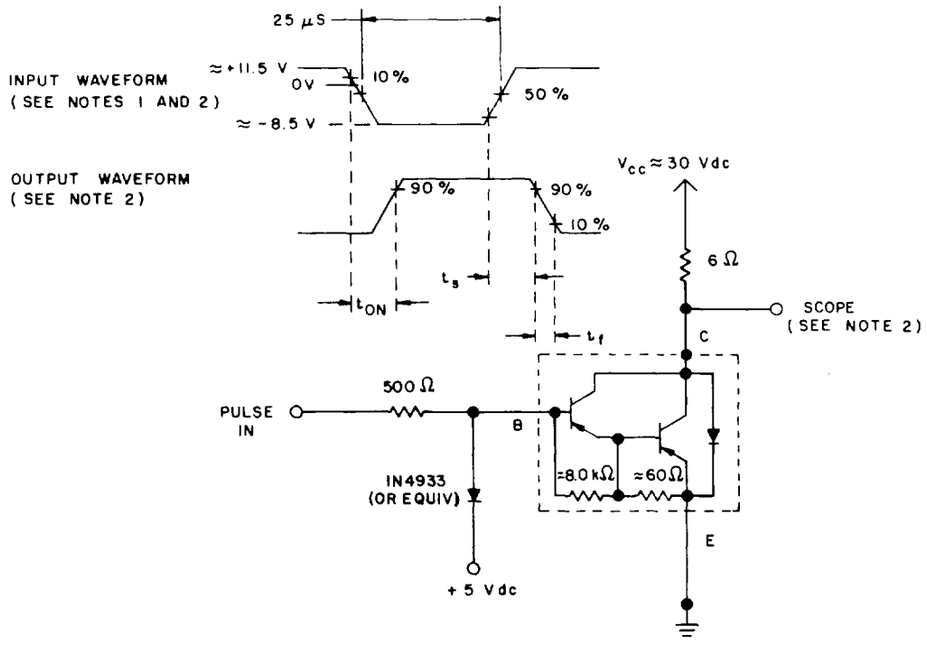
Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN JANTX JANTXV	Symbol	Limits Min	Limits Max	Unit
End point electrical measurements		See table IV, steps 1 and 5					
Subgroups 6 and 7							
Not applicable							

TABLE II. Group B inspection for JAN, JANTX, and JANTXV devices.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD
Subgroup 1			15
Solderability	2026		
Resistance to solvents	1022		
Subgroup 2			10
Thermal shock (temperature cycling)	1051	T(high) = +175°C time at temperature extremes = 15 minutes (minimum)	
Hermetic seal a. Fine leak b. Gross leak	1071		
Electrical measurements		See table IV, steps 1 and 5	
Subgroup 3			5
Steady-state operation life	1027	T_J = +162.5 ±12.5°C; V_{CE} > 10 Vdc; $T_A \leq$ 100°C (see 4.5.2)	
Electrical measurements		See table IV, steps 2, 4, and 5	
Subgroup 4			
Decap internal visual	2075		1 device/0 failures for each lot
Bond strength	2037	Test condition A; all internal wires for each device shall be pulled separately	20 (c = 0)
Subgroup 5			15
Thermal resistance	3151	$R_{\theta JC}$ = 1°C/W (max)	
Subgroup 6			7
High temperature life (nonoperating)	1032	T_A = +175°C	
Electrical measurements		See table IV, steps 2 and 5	

TABLE II. Group B inspection for JAN, JANTX, and JANTXV devices - Continued.

Inspection	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 7			10
Safe operating area (clamped inductive) (destructive)	3053	Load condition B T_A = +25°C $t_r + t_f \leq 1.0$ µs Duty cycle <2%; $t_p \approx 1$ ms; (vary to obtain I_C) R_s = 0.10 ohms; R_{BB1} = 80 ohms; V_{BB1} = -16 Vdc; R_{BB2} = 100 ohms; V_{BB2} = -1.5 Vdc I_C = -12 Adc; V_{CC} = -79 Vdc $R_L \leq 2$ ohms; $L \approx 10$ mH (Stancor C-2688 or equivalent)	
2N6051		Clamp voltage = -80 +0, -5 Vdc	
2N6052		Clamp voltage = -100 +0, -5 Vdc Device fails if clamp voltage not reached	
Safe operating area (switching, unclamped) (inductive)	3053	Load condition C; T_A = +25°C; duty cycle < 2%; R_s = 0.1 ohm; $t_r = t_f \leq 15$ ns (see figure 4)	
Test 1		$t_p \approx 80$ µs; (vary to obtain I_C); R_{BB1} = 80 ohms; $V_{BB1} \geq 12$ Vdc; R_{BB2} = ∞; V_{BB2} = 0; $V_{CC} \geq 40$ Vdc; I_C = 12 mAdc; The coil used shall provide a minimum inductance of 1 mH at 12 Adc (see 4.5.3)	
Test 2		$t_p \approx 1$ ms; (vary to obtain I_C); R_{BB1} = 80 ohms; $V_{BB1} \geq 12$ Vdc; R_{BB2} = ∞; V_{BB2} = 0; $V_{CC} \geq 40$ Vdc; I_C = 300 mAdc; The coil used shall provide a minimum inductance of 100 mH at 300 mAdc (see 4.5.3)	
End point electrical measurements		See table IV, steps 1 and 5	



NOTES:
1. The input waveform is supplied by a pulse generator with the following characteristics: $t_r \leq 20$ ns, $t_f \leq 20$ ns, $Z_{out} = 50\Omega$, PW = 25 μs, duty cycle $\leq 2\%$.
2. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 20$ ns, $Z_{in} \geq 20$ kΩ, $C_{in} \leq 11.5$ pF.
3. Resistors shall be noninductive types.
4. The dc power supplies may require additional by-passing in order to minimize ringing.

FIGURE 2. Pulse response test circuit.

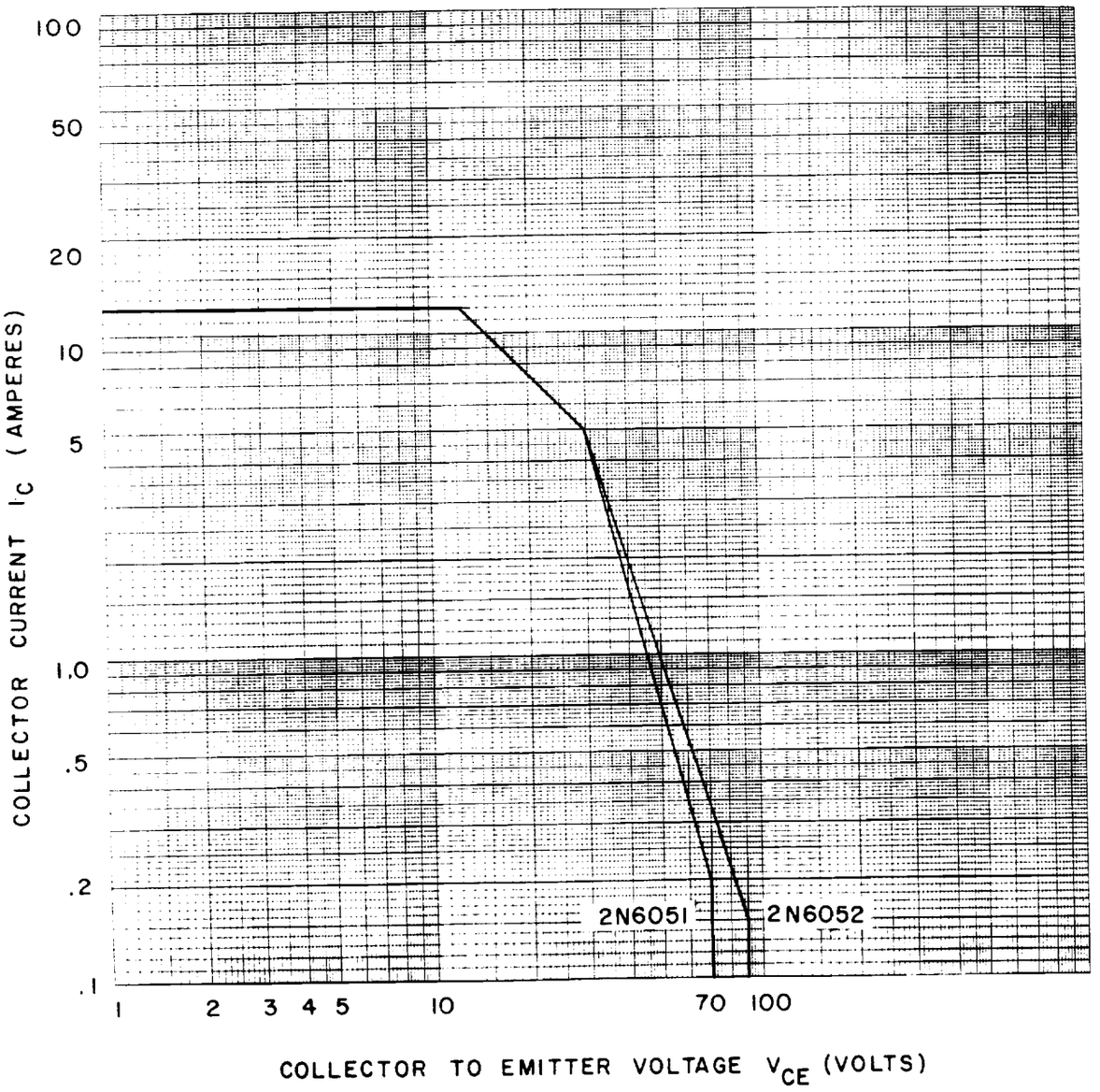


FIGURE 3. Maximum safe operating area graph (continuous dc).

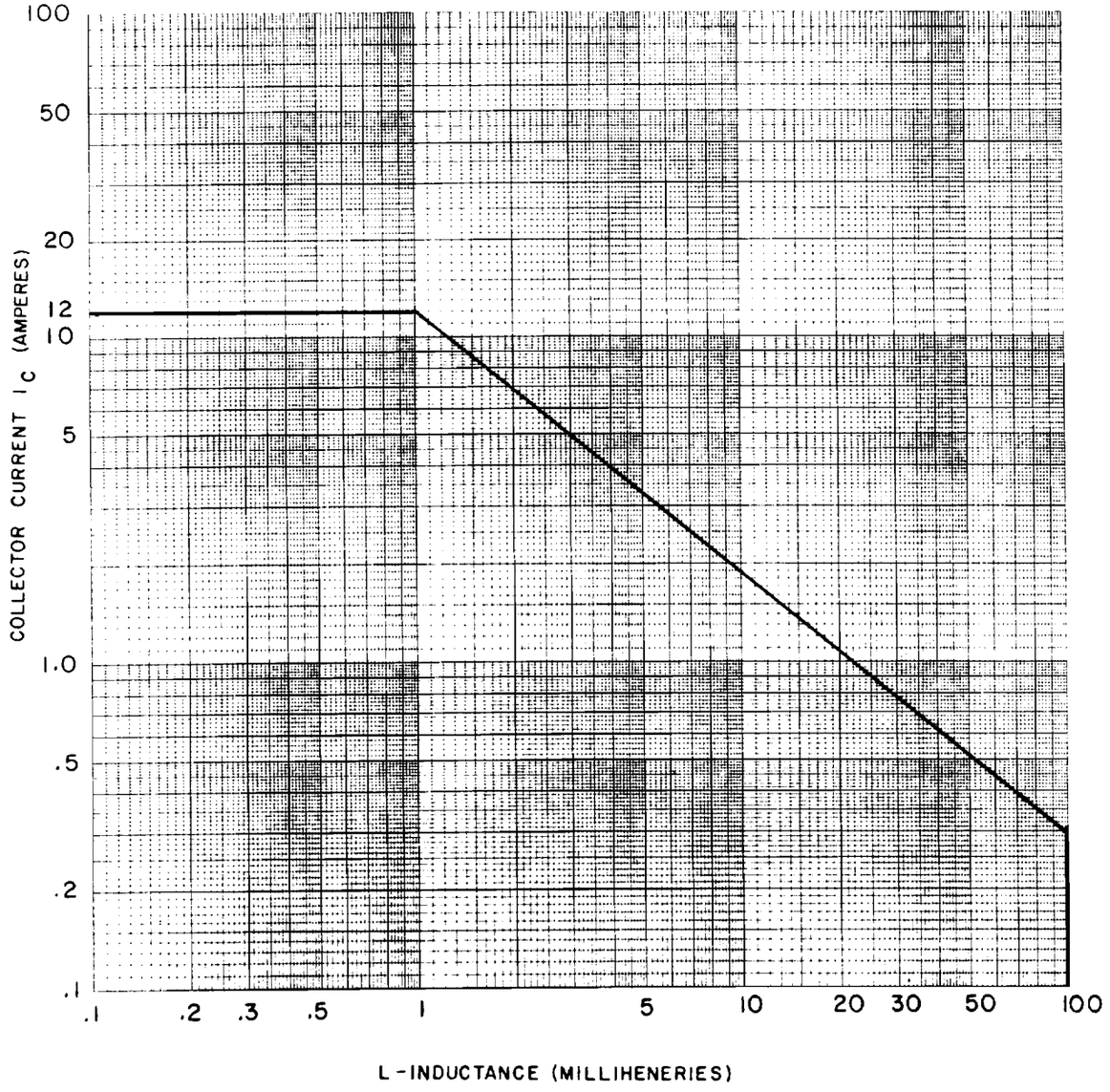


FIGURE 4. Safe operating area for switching between saturation and cutoff (Unclamped inductive load).

TABLE III. Group C inspection (all quality levels).

Inspection	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 1			15
Physical dimensions	2066	See figure 1	
Subgroup 2			10
Thermal shock (glass strain)	1056	Test condition B	
Terminal strength (tension)	2036	Test condition A; Weight = 10 lbs; t = 15 s	
Hermetic seal a. Fine leak b. Gross leak	1071		
Moisture resistance	1021		
External visual	2071		
Electrical measurements		See table IV, steps 1 and 5	
Subgroup 3			10
Shock	2016		
Vibration, variable frequency	2056		
Constant acceleration	2006		
Electrical measurements		See table IV, steps 1 and 5	
Subgroup 4			15
Salt atmosphere (corrosion)	1041		
Subgroup 5			
Not applicable			
Subgroup 6			λ=10
Steady-state operation life	1026	$V_{CE} \geq$ 10 Vdc; P_T = 75 W at T_C = 100°C or 100°C $\leq T_C \leq$ 125°C with P_T varied; according to the chosen T_C, to achieve T_J = 162.5 ±12.5°C (see 4.5.2 and 4.5.5) (for qualifications only)	
Steady-state operation life	1026	T_J = +162.5 ±12.5°C; $V_{CE} \geq$ 10 Vdc; $T_A \leq$ 100°C (see 4.5.2)	
Electrical measurements		See table IV, steps 2,3,4 and 5	

TABLE IV. Groups 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 2N6051 2N6052	3041	Bias condition A; V_{BE} = +1.5 Vdc V_{CE} = 80 Vdc V_{CE} = 100 Vdc	I_{CEX1}	---	0.5	mAdc
2	Collector to emitter cutoff current 2N6051 2N6052	3041	Bias condition A; V_{BE} = +1.5 Vdc V_{CE} = 80 Vdc V_{CE} = 100 Vdc	I_{CEX1}	---	1.0	mAdc
3	Base to emitter voltage (saturated)	3066	Test condition A; I_C = 12 Adc; I_B = 120 mAdc pulsed (see 4.5.1)	$V_{BE(sat)}$	---	4.0	Vdc
4	Collector to emitter voltage (saturated)	3071	I_C = 12 Adc; I_B = 120 mAdc pulsed (see 4.5.1)	$V_{CE(sat)}$	---	3.0	Vdc
5	Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 6 Adc pulsed (see 4.5.1)	h_{FE2}	1000	18000	---

6.3 Design and application guidance. The following NPN type transistors are complementary to the PNP devices listed herein:

Transistor PNP	Complementary NPN transistors types
2N6051	2N6058
2N6052	2N6059

6.4 Substitutability. Transistors covered by this specification are substitutable for the following commercial device types:

JAN types	Commercial types
2N6051	MJ2501
2N6052	MJ2502

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

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

Review activities:
Air Force - 11,19,99,85
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User activities:
Air Force - 13, 15

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(Project 5961-0795)

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