MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, POWER
TYPES 2N6671, AND 2N6673, JAN, JANTX, AND JANTXV

This specification is approved for use by Rome Air Development Center, Department of the Air Force, and is available 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 for use in high-speed 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_A = +25°C	P_T 1/ T_C = +25°C	V_{CBO} and V_{CEX}	V_{CEO}	V_{EBO}	I_B	I_C	T_{STG} and T_{op}
	W	W	Vdc	Vdc	Vdc	Adc	Adc	°C
2N6671	6	150	450	300	8	4	8	-65 to +200
2N6673	6	150	650	400	8	4	8	-65 to +200

1/ Derate linearly 0.857 W/°C for T_C 25°C.
Derate linearly 34.2 mW/°C for T_A 25°C.

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

Limit	$R_{\theta JC}$	$V_{BE(sat)}$ I_C = 5 Adc I_B = 1 Adc	$V_{CE(sat)1}$ I_C = 5 Adc I_B = 1 Adc	C_{obo} V_{CB} = 10 Vdc I_E = 0 100 kHz f 1 MHz	h_{fe} V_{CE} = 10 Vdc I_C = 0.2 Adc f = 5 mHz
	°C/W	Vdc	Vdc	pF	
Min	---	---	---	50	3.0
Max	1.17	1.6	1.0	300	12

Limit	h_{FE1} V_{CE} = 3 Vdc I_C = 1 Adc 1/	h_{FE2} V_{CE} = 3 Vdc I_C = 5 Adc 1/	Switching parameters				
			t_d	t_r	t_s	t_f	t_c
			s	s	s	s	s
Min	10	10	--	--	--	--	--
Max	80	40	0.1	0.5	2.5	0.4	0.4

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: 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.

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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.

STANDARDS

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 and as follows:

$t_c = t_{off}$ cross over time. The time interval during which the collector voltage rises from 10 percent of its peak off state value and the collector current falls to 10 percent of its peak on state value (see figure 2).

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. Current density of internal conductors shall be as specified in 3.6.5 of MIL-S-19500. No aluminum case shall be permitted.

3.3.1 Lead material and finish. Lead material shall be Kovar or Alloy 52. Lead finish shall be gold plated, tin plated, or solder dipped. Where a choice of lead material or finish is desired, it shall be specified in the contract (see 6.2).

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

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 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
9	I_{CEX1}
11	I_{CEX1} and h_{FE2}; ΔI_{CEX1} = 100% of initial value or 50 µAdc, whichever is greater
12	See 4.2.1
13	Subgroup 2 of table I herein; ΔI_{CEX1} = 100% of initial value or 50 µAdc, whichever is greater; $\Delta h_{FE2} = \pm 20\%$ of initial value

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

T_J = +187.5 ±12.5°C; V_{CB} = 100 Vdc; $T_A \leq$ 100°C

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

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. End point electrical measurements shall be in accordance with the applicable steps of table IV herein.

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

4.5.1 Pulse measurement. 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 conditions apply:

a. Collector current magnitude during power applications shall be 2.5 Adc.
b. Collector to emitter voltage magnitude shall be 20 Vdc.
c. Reference temperature measuring point shall be the case.
d. Reference point temperature shall be 25°C to 75°C.
e. Mounting arrangement shall be with heat sink to case.
f. Maximum limit shall be 1.17°C/W.

4.5.3 Group C life test. If the option of "T_C" life test is conducted in group B inspection, the test sample may be continued as subgroup 6 of group C inspection in accordance with MIL-S-19500 and table III herein.

4.5.4 Inspection conditions. Unless otherwise specified in MIL-S-19500 or herein, all inspections shall be conducted at a case temperature (T_C) of 25° ±3°C.

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 should specify the following:

a. Lead material and finish (see 3.3.1).

Custodian:
Air Force - 17

Review activities:
Air Force - 11, 19, 85, 99
DLA - ES

Preparing activity:
Air Force - 17

Agent:
DLA - ES

(Project 5961-F777)

TABLE I. Group A inspection.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN TX TXV	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 = 200 mAdc; pulsed (see 4.5.1)		$V_{(BR)CEO}$			
2N6671					300	---	Vdc
2N6673					400	---	Vdc
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = -1.5 Vdc		I_{CEX1}			
2N6671		V_{CE} = 450 Vdc			---	0.1	mAdc
2N6673		V_{CE} = 650 Vdc			---	0.1	mAdc
Collector to base, cutoff current	3036	Bias condition D;		I_{CBO}			
2N6671		V_{CB} = 450 Vdc			---	1.0	mAdc
2N6673		V_{CB} = 650 Vdc			---	1.0	mAdc
Emitter to base cutoff current	3061	Bias condition D; V_{EB} = -8 Vdc		I_{EBO}	---	2.0	mAdc
Base emitter voltage (saturated)	3066	Test condition A; I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)		$V_{BE(sat)}$	---	1.6	Vdc
Collector to emitter voltage (saturated)	3071	I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)		$V_{CE(sat)1}$	---	1.0	Vdc
Collector to emitter voltage (saturated)	3071	I_C = 8 Adc; I_B = 4 Adc; 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}	10	80	---
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; pulsed (see 4.5.1); I_C = 5 Adc		h_{FE2}	10	40	---
Subgroup 3			7				
High-temperature operation:		T_A = 125°C					
Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = -1.5 Vdc;		I_{CEX2}			
2N6671		V_{CE} = 450 Vdc			---	1.0	mAdc
2N6673		V_{CE} = 650 Vdc			---	1.0	mAdc
Collector to emitter voltage (saturated)	3071	I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)		$V_{CE(sat)3}$	---	2.0	Vdc
Switching parameters:		T_A = +125°C					
Pulse delay time		See figure 2		t_d	---	0.1	µs
Pulse rise time		See figure 2		t_r	---	0.8	µs
Pulse storage time		See figure 2		t_s	---	4.0	µs
Pulse fall time		See figure 2		t_f	---	0.8	µs
Cross-over time		See figure 2		t_c	---	0.8	µs
Low temperature operation:		T_A = -55°C					

TABLE I. Group A inspection - Continued.

Inspection	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN TX TXV	Symbol	Limits Min	Limits Max	Unit
Subgroup 3 - continued							
Forward-current transfer ratio	3076	V_{CE} = 3 Vdc; pulsed (see 4.5.1); I_C = 5 Adc		h_{FE3}	4	---	---
Subgroup 4			7				
Magnitude of small signal short circuit forward current transfer ratio	3306	V_{CE} = 10 Vdc; I_C = 0.2 Adc; f = 5 MHz		$\|h_{fe}\|$	3	12	
Open circuit output capacitance	3236	V_{CB} = 10 Vdc; I_E = 0; 100 kHz $<$ f $<$ 1 MHz		C_{obo}	50	300	pF
Switching parameters:							
Pulse delay time		See figure 2		t_d	---	0.1	µs
Pulse rise time		See figure 2		t_r	---	0.5	µs
Pulse shortage time		See figure 2		t_s	---	2.5	µs
Pulse fall time		See figure 2		t_f	---	0.4	µs
Cross-over time		See figure 2		t_c	---	0.4	µs
Subgroup 5			10				
Safe operating area (continuous dc)	3051	T_C = 25°C; power application time = 1 sec, 1 cycle (see figure 3)					
Test 1							
2N6671, 2N6673		V_{CE} = 18.75 Vdc; I_C = 8 Adc					
Test 2							
2N6671, 2N6673		V_{CE} = 25 Vdc; I_C = 6 Adc					
Test 3							
2N6671, 2N6673		V_{CE} = 100 Vdc; I_C = 0.25 Adc					
Test 4							
2N6671		V_{CE} = 300 Vdc; I_C = 38 mAdc					
2N6673		V_{CE} = 400 Vdc; I_C = 23 mAdc					
Safe operating area (clamped switching)		T_A = 25°C; V_{CC} = 15 Vdc (see figures 5 and 6)					
2N6671		clamp voltage = 350 Vdc; I_C = 5 Adc					
2N6671		clamp voltage = 200 Vdc; I_C = 8 Adc					
2N6673		clamp voltage = 450 Vdc; I_C = 5 Adc					
2N6673		clamp voltage = 300 Vdc; I_C = 8 Adc					
End point electrical measurements		See table IV, steps 1, 4, and 6					
Subgroups 6 and 7							
Not applicable							

TABLE II. Group B inspection (all quality levels).

Inspection	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 1			15
Solderability	2026		
Resistance to solvents	1022		
Subgroup 2			10
Thermal shock (temperature cycling)	1051		
Hermetic seal a. Fine leak b. Gross leak	1071		
Electrical measurements		See table IV, steps 1 and 3	
Subgroup 3			5
Steady-state operation life (LTPD)	1027	T_J = 187.5 ±12.5°C; V_{CB} = 100 Vdc; $T_A \leq$ 100°C	
Electrical measurements		See table IV, steps 1, 6, 7, and 8	
Subgroup 4			
Decap internal visual design verification	2075		1 device/ 0 failure 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	3131	See 4.5.3	
Subgroup 6			7
High temperature non-operating life (LTPD)	1032	T_A = 200°C	
Electrical measurements		See table IV, steps 1, 3, 6, and 8	
Subgroup 7			10
Safe operating area	3053	Load condition C; (unclamped inductive load) (see figure 4); T_A = 25°C; duty cycle $\leq$ 10%; R_S = 0.1Ω ; $t_r = t_f \leq$ 500 ns	
Test 1		t_p = 5 ms (vary to obtain I_C); R_{BB1} = 2Ω ; V_{BB1} = 10 Vdc; R_{BB2} = 50Ω ; V_{BB2} = -4 Vdc; V_{CC} = 20 Vdc; I_C = 8 Adc; L = 10 µH (approximately 10 turns, 1 row of #16 ASG wire on an air core 2 7/8" @ ID). .0007 ohms or equivalent	

TABLE II. Group B inspection (all quality levels) - Continued.

Inspection	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 7 - continued			
Test 2		t_p = 5 ms (vary to obtain I_C); R_{BB1} = 100Ω; ; V_{BB1} = 10 Vdc; R_{BB2} = 50Ω; ; V_{BB2} = -4 Vdc; V_{CC} = 20 Vdc; I_C = 100 mAdc; L = 1 mH (1 each Miller type 7827 in parallel with 2 each series strung Miller type 7825 and this in series with 2 each series strung Miller type 7827) .45 ohms or equivalent	
Safe operating area (clamped switching) (destructive)	3053	T_A = 25°C (see figures 5 and 6)	
Test 1		V_{CC} = 125 Vdc; I_C = 5 Adc	
2N6671		Clamp voltage = 350 Vdc	
2N6673		Clamp voltage = 450 Vdc	
Test 2		V_{CC} = 200 Vdc; I_C = 8 Adc	
2N6671		Clamp voltage = 200 Vdc	
2N6673		Clamp voltage = 300 Vdc	
End point electrical measurements		See table IV, steps 1, 4, and 6	

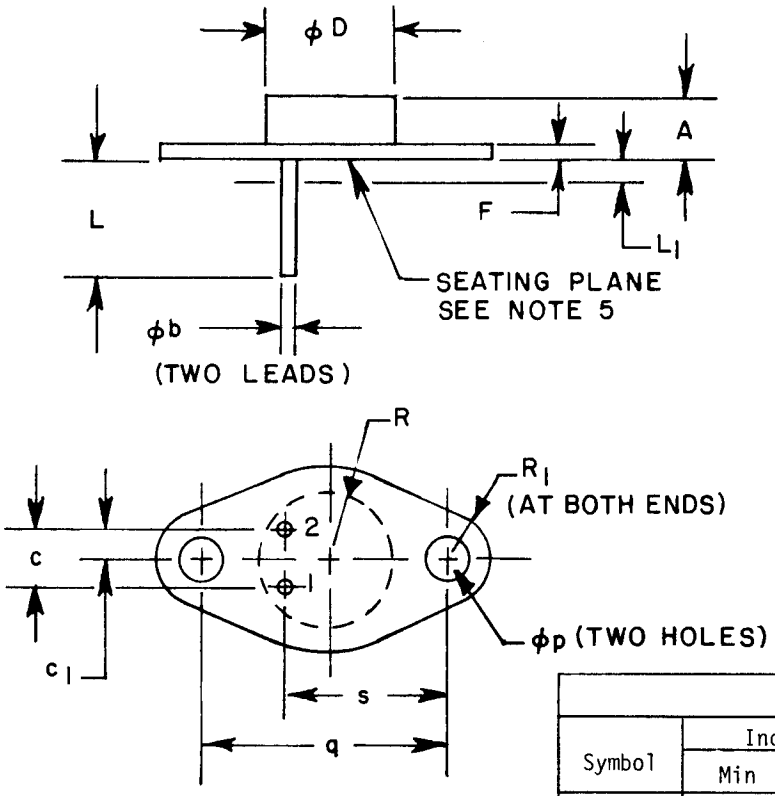
TABLE III. Group C inspection (all quality levels).

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; time = 15 s	
Hermetic seal	1071		
a. Fine leak b. Gross leak			
Moisture resistance	1021		
External visual	2071		
Electrical measurements		See table IV, steps 1 and 7	
Subgroup 3			10
Shock	2016		
Vibration, variable frequency	2056		
Constant acceleration	2006		
Electrical measurements		See table IV, steps 1 and 7	
Subgroup 4			15
Salt atmosphere (corrosion)	1041		
Subgroup 5			
Not applicable			
Subgroup 6			10
Steady-state operation life	1027	V_{CB} = 20 Vdc; P_T = 85 W @ 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 a T_J = 187.5° $\pm$12.5°C (see 4.5.3 and 4.5.4)	
Electrical measurements		See table IV, steps 1, 2, 3, 5, 7, 8 and 9	

TABLE IV. Groups A, B, and C electrical measurements.

Step	Inspection	MIL-STD-750		Symbol	Limits		Unit
		Method	Conditions		Min	Max	
1	Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = -1.5 Vdc	I_{CEX1}			
	2N6671		V_{CE} = 450 Vdc		---	0.1	mAdc
	2N6673		V_{CE} = 650 Vdc		---	0.1	mAdc
2	Collector to emitter voltage (saturated)	3071	I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)	$V_{CE(sat)1}$	---	1.0	Vdc
3	Base emitter voltage (saturated)	3066	Test condition A; I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)	$V_{BE(sat)}$	---	1.6	Vdc
4	Breakdown voltage collector to emitter	3011	Bias condition D; I_C = 200 mAdc	$V_{(BR)CEO}$			
	2N6671				300	---	Vdc
	2N6673				400	---	Vdc
5	Forward current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 1 Adc pulsed (see 4.5.1)	h_{FE1}	10	80	---
6	Forward current transfer ratio	3076	V_{CE} = 3 Vdc; pulsed (see 4.5.1) I_C = 5 Adc	h_{FE2}	10	40	---
7	Collector to emitter cutoff current	3041	Bias condition A; V_{BE} = -1.5 Vdc	ΔI_{CEX1} 1/		100% of initial value or	
	2N6671		V_{CE} = 450 Vdc		---	50 µAdc;	
	2N6673		V_{CE} = 650 Vdc		---	whichever is greater	
8	Forward current transfer ratio	3076	V_{CE} = 3 Vdc; I_C = 5 Adc pulsed (see 4.5.1)	Δh_{FE2} 1/	---	±25% change from previously measured value	
9	Collector to emitter voltage (saturated)	3071	I_C = 5 Adc; I_B = 1 Adc; pulsed (see 4.5.1)	$\Delta V_{CE(sat)}$ 1/		±100 mV change from previously measured value	

1/ Devices which exceed the group A limits for this test shall not be acceptable.



Dimensions					
Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
A	.270	.380	6.86	9.65	
Øb	.038	.043	.97	1.09	
ØD	---	.875	---	22.22	
c	.420	.440	10.67	11.18	4,5
c_1	.205	.225	5.21	5.72	4,5
F	.060	.135	1.52	3.43	
L	.312	.500	7.92	12.70	
L_1	---	.050	---	1.27	
Øp	.151	.161	3.84	4.09	
q	1.177	1.197	29.90	30.40	
R	.495	.525	12.57	13.34	
R_1	.131	.188	3.33	4.78	
s	.655	.675	16.64	17.14	

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only and are based upon 1.00 inch = 25.4 mm.
3. Terminal 1, base; terminal 2, emitter; case, collector.
4. These dimensions should be measured at points .050-.055 (1.27-1.40 mm) below seating plane. When gage is not used, measurement will be made at the seating plane.
5. The seating plane of the header shall be flat within .001 (.03 mm) concave to .004 (.10 mm) convex inside a .930 (23.62 mm) diameter circle on the center of the header and flat within .001 (.03 mm) concave to .006 (.15 mm) convex overall.
6. Collector shall be electrically connected to the case.

FIGURE 1. Physical dimensions of transistor types 2N6671 and 2N6673.

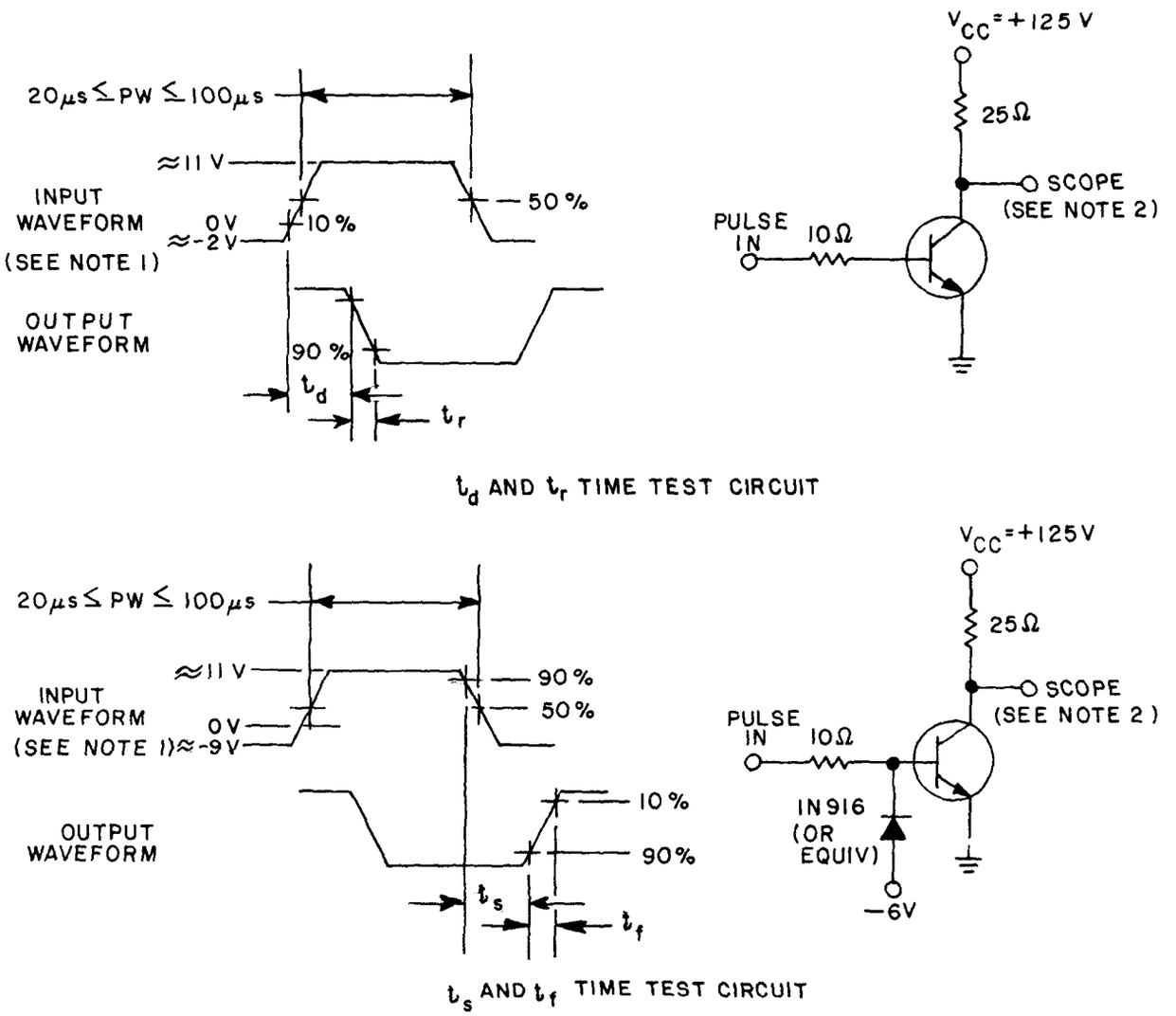
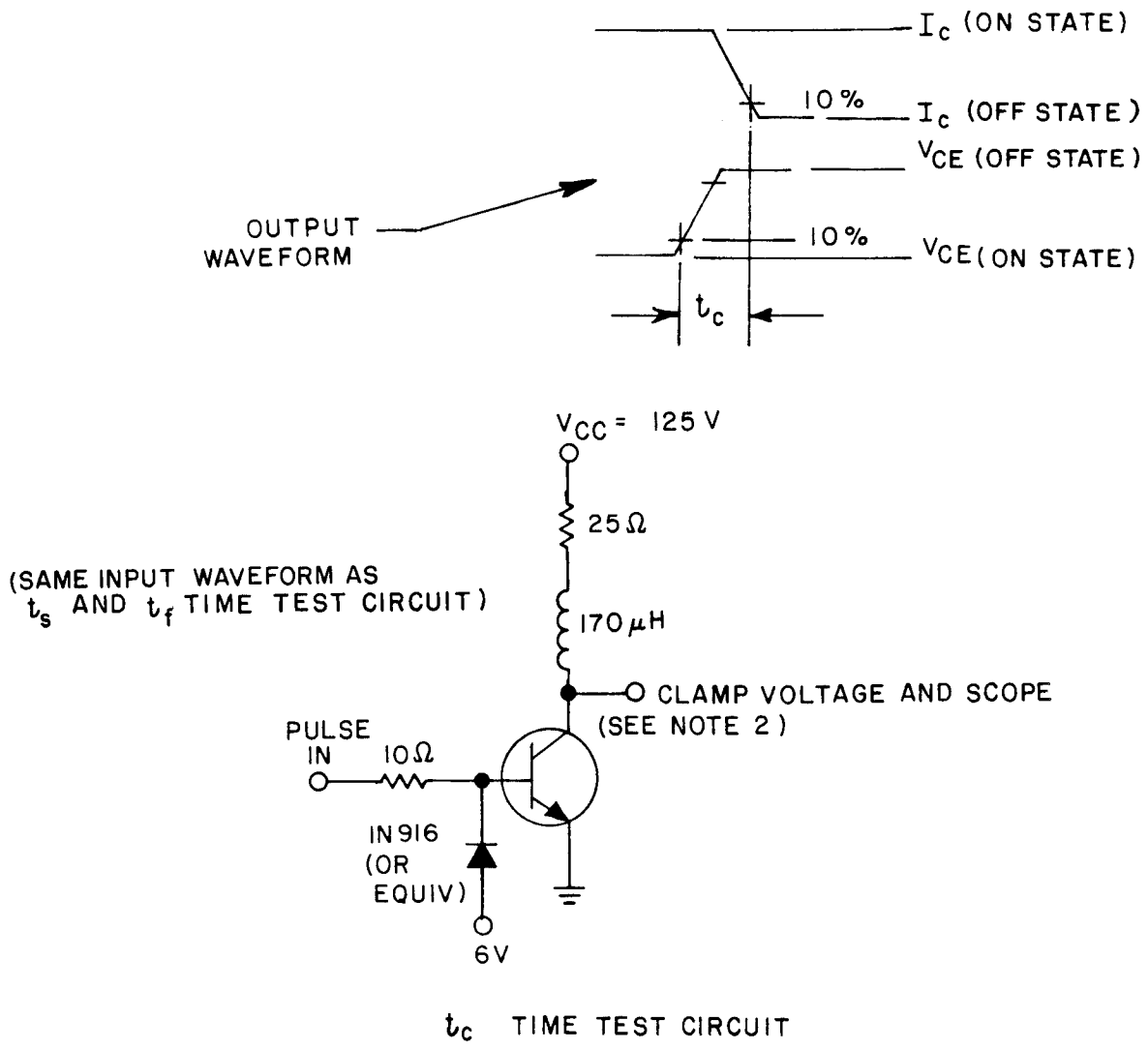


FIGURE 2. Pulse response test circuits.



t_c TIME TEST CIRCUIT

NOTES:
1. The rise time (t_r) of the applied pulse shall be $\leq$ 20 ns; duty cycle $\leq$ 2%; generator source impedance shall be 50Ω.
2. Output sampling oscilloscope: $Z_{in} \geq$ 100 kΩ; $C_{in} \leq$ 12 pF; rise time $\leq$ 20 ns.

FIGURE 2. Pulse response test circuits - Continued.

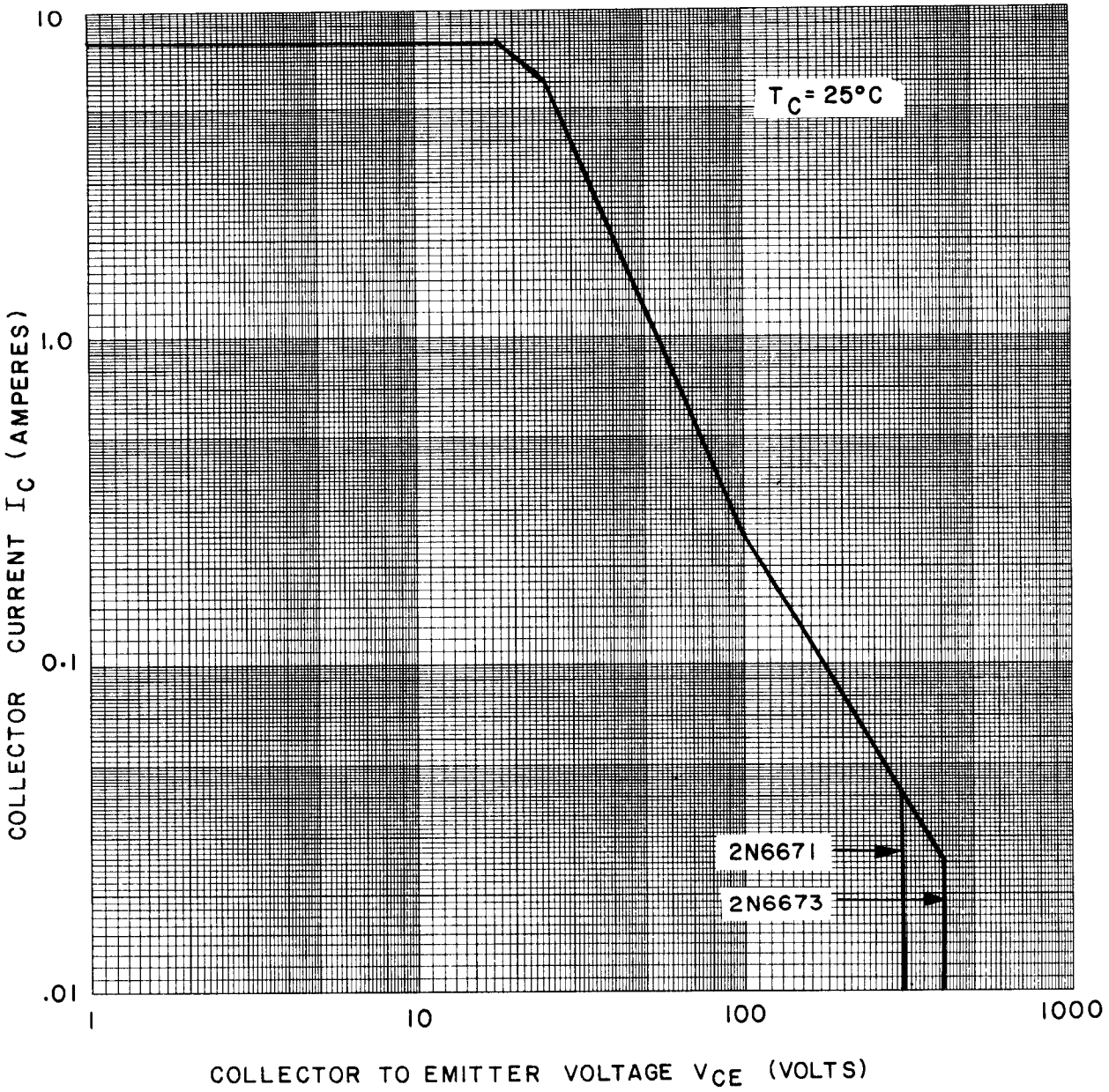


FIGURE 3. Maximum safe operating graph (DC).

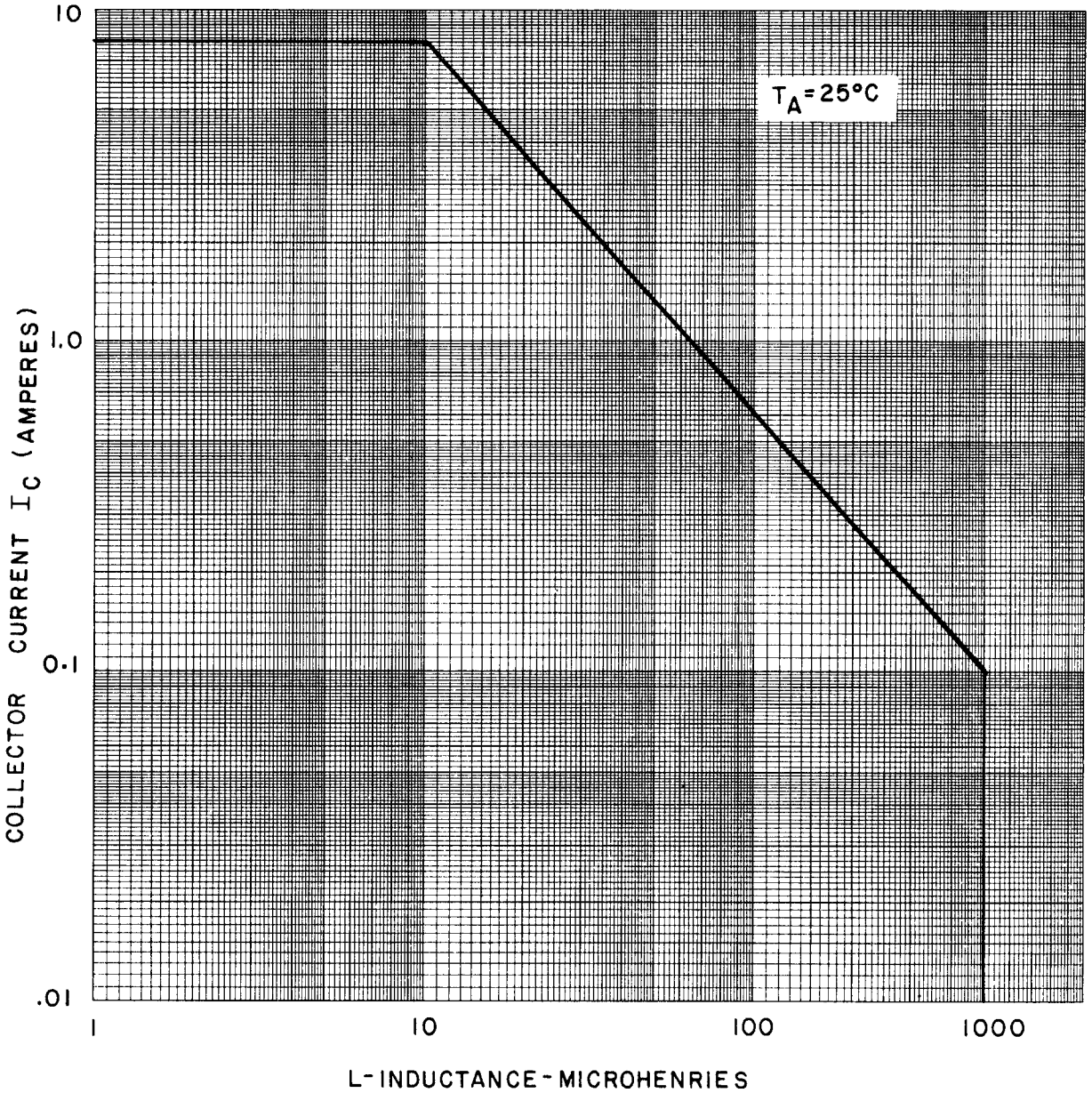


FIGURE 4. Safe operating area for switching between saturation and cutoff (unclamped inductive load).

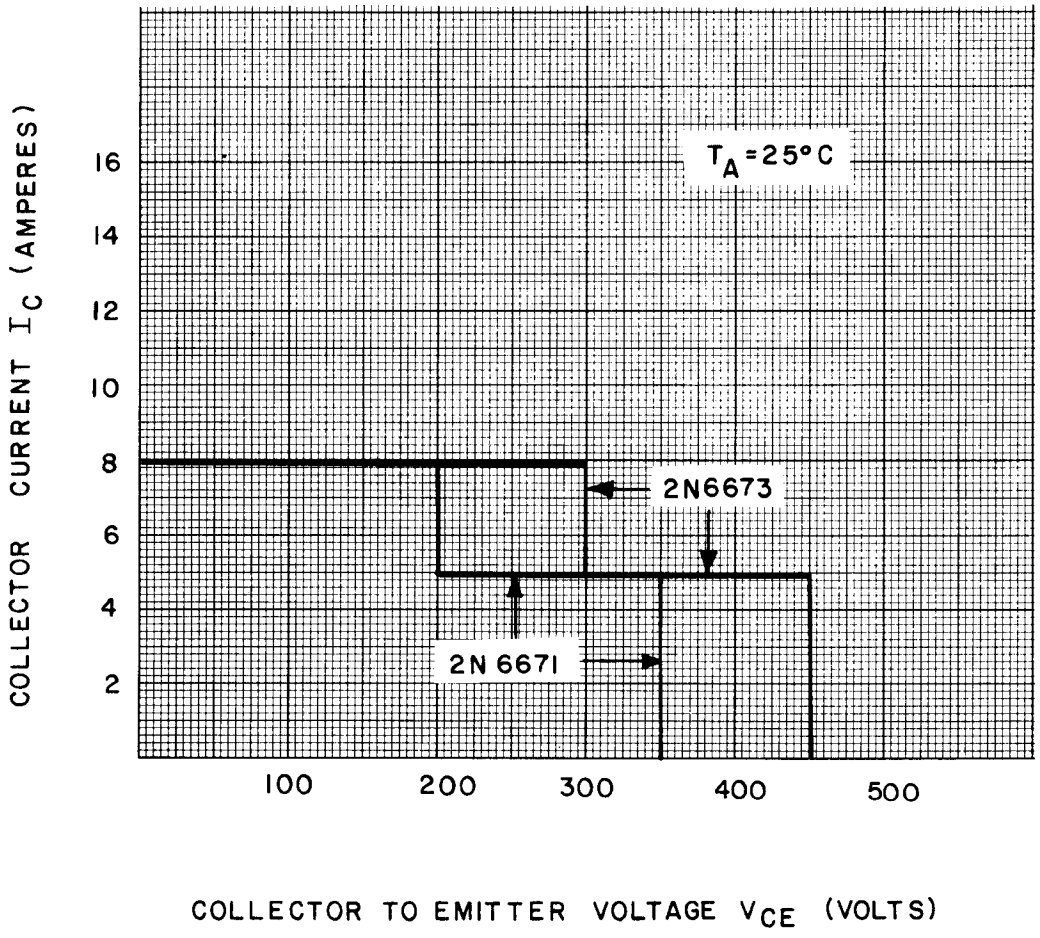
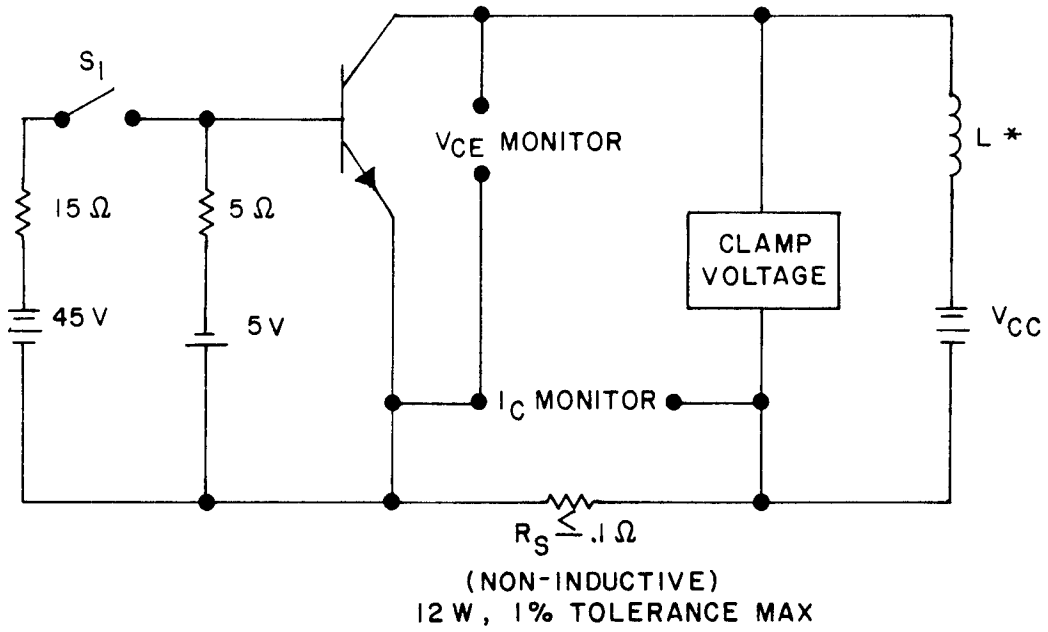


FIGURE 5. Safe operating area for switching between saturation and cutoff (clamped inductive load).



* L = 170 μH, .05Ω, 8 A.

Procedure:
1. With switch S_1 closed, set the specified test conditions.
2. Open S_1. Device fails if clamp voltage not reached.
3. Perform specified end point tests.

FIGURE 6. Clamped inductive sweep test circuit.