The documentation and process conversion measures necessary to comply with this revision shall be completed by 28 October 2004.

INCH POUND

MIL-PRF-19500/606B
28 July 2004
SUPERSEDING
MIL-PRF-19500/606A
6 February 1998

* PERFORMANCE SPECIFICATION SHEET

SEMICONDUCTOR DEVICE, FIELD EFFECT RADIATION HARDENED (TOTAL DOSE ONLY)
TRANSISTORS, N-CHANNEL, SILICON, TYPES 2N7291, 2N7293, 2N7295, AND 2N7297,
JANTXVM, D, AND R, AND JANSM, D, AND R

This specification is approved for use by all Departments and Agencies of the Department of Defense.

* The requirements for acquiring the product described herein shall consist of this specification sheet and MIL-PRF-19500.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for an N-Channel, enhancement-mode, MOSFET, radiation hardened (total dose only), power transistor. Two levels of product assurance are provided for each device type specified in MIL-PRF-19500.

1.2 Physical dimensions. See figure 1, TO-204AA and TO-204AE (similar to TO-3).

* 1.3 Maximum ratings. Unless otherwise specified, T_A= +25°C.

Type	P_T (1) T_C = +25°C	P_T T_A = +25°C	V_{DS}	V_{DG}	V_{GS}	I_{D1} (2) (3) T_C = +25°C	I_{D2} (2) (3) T_C = +100°C	I_S 2/	I_{DM}	T_J and T_{STG}	V_{ISO} 70,000 feet altitude
	W	W	V dc	V dc	V dc	A dc	A dc	A dc	A (pk)	°C	V dc
2N7291	150	4	100	100	±20	40.0	25.0	40.0	100	-55	N/A
2N7293			200	200		27.0	17.0	27.0	81	to	N/A
2N7295			250	250		20.0	12.0	20.0	60	+150	N/A
2N7297			500	500		10.0	6.0	10.0	30		500

(1) Derate linearly 1.2 W/°C for T_C > +25°C.
(2) The following formula derives the maximum theoretical I_D limit. I_D is limited by package and internal wires and may be limited by pin diameter:

$$I_D = \sqrt{\frac{T_{JM} - T_C}{(R_{\theta JC}) \times (R_{DS}(on) \text{ at } T_{JM})}}$$

(3) See figure 2, maximum drain current graphs.

* Comments, suggestions, or questions on this document should be addressed to Defense Supply Center, Columbus, ATTN: DSCC-VAC, P.O. Box 3990, Columbus, OH 43218-3990, or emailed to Semiconductor@dscc.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://www.dodssp.daps.mil/.

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

Type	Min $V_{(BR)DSS}$ V_{GS} = 0 I_D = 1.0 mA dc	$V_{GS(th)1}$ $V_{DS} \geq V_{GS}$ I_D = 1.0 mA dc	Max I_{DSS1} V_{GS} = 0 V_{DS} = 80 percent of rated V_{DS}	Max $r_{DS(on)}$ (1) V_{GS} = 10 V dc		$R_{\theta JC}$ max	I_{AS} = I_{DM}	E_{AS} at I_{AS}
				T_J = +25°C at I_{D2}	T_J = +125°C at I_{D2}			
	V dc	V dc Min Max	µA dc	ohm	ohm	°C/W	A(pk)	mJ
2N7291	100	2.0 4.0	25	0.055	0.110	0.83	100	500
2N7293	200			0.10	0.220		81	328
2N7295	250			0.17	0.408		60	180
2N7297	500			0.60	1.56		30	45

(1) Pulsed (see 4.5.1).

2. APPLICABLE DOCUMENTS

* 2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 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 of documents cited in sections 3, 4, or 5 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 cited in the solicitation or contract.

* DEPARTMENT OF DEFENSE SPECIFICATIONS

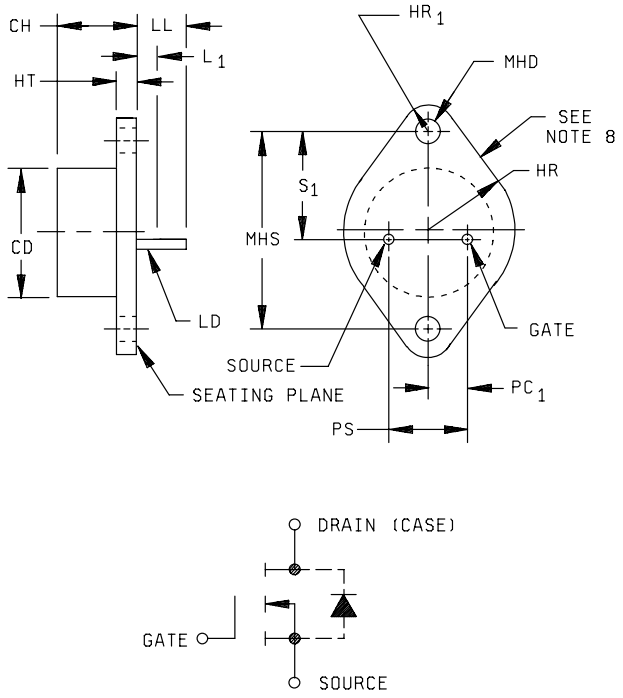
MIL-PRF-19500 - Semiconductor Devices, General Specification for.

* DEPARTMENT OF DEFENSE STANDARDS

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

* (Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://www.dodssp.daps.mil/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, 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, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.



Symbol	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
CD		.875		22.23	
CH	.250	.360	6.35	9.15	
HR	.495	.525	12.57	13.34	
HR_1	.131	.188	3.33	4.78	
HT	.060	.135	1.52	3.43	
LD	.057	063	1.45	1.60	5
LD	.038	.043	0.97	1.10	6
LL	.312	.500	7.92	12.70	
L_1		.050		1.27	
MHD	.151	.161	3.84	4.09	
MHS	1.117	1.197	29.90	30.40	
PS	.420	.440	10.67	11.18	1, 7
PC_1	.205	.225	5.21	5.72	1, 7
S_1	.655	.675	16.64	17.15	

NOTES:

1. Dimensions are in inches.
* 2. Millimeters are given for general information only.
3. These dimensions should be measured at points .050 inch (1.27 mm) and .055 inch (1.40 mm) below seating plane. When gauge is not used, measurements will be made at the seating plane.
4. The seating plane of the header shall be flat within .001 inch (0.03 mm) concave to .004 inch (0.10 mm) convex inside a .930 inch (23.62 mm) diameter circle on the center of the header and flat within .001 inch (0.03 mm) concave to .006 inch (0.15 mm) convex overall.
5. These dimensions pertain to the 2N7291 and 2N7293 types.
6. These dimensions pertain to the 2N7295 and 2N7297 types.
7. Mounting holes shall be deburred on the seating plane side.
8. Drain is electrically connected to the case.
* 9. In accordance with ASME Y14.5M, diameters are equivalent to ϕx symbology.

* FIGURE 1. Physical dimensions for TO-204 (similar to TO-3).

3. REQUIREMENTS

3.1 General. The individual item requirements shall be as specified in MIL-PRF-19500 and as modified herein.

* 3.2 Qualification. Devices furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.2 and 6.3).

* 3.3 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-PRF-19500 and as follows:

I_{AS} .....Rated avalanche current, non-repetitive.
nC .....nano coulomb.

* 3.4 Interface and physical dimensions. The interface and physical dimensions shall be as specified in MIL-PRF-19500 and on figure 1 (TO-204).

* 3.4.1 Lead material and finish. Lead material shall be Kovar or Alloy 52; a copper core or plated core is permitted. Lead finish shall be solderable in accordance with MIL-PRF-19500 and herein. Where a choice of lead finish is desired, it shall be specified in the acquisition requirement (see 6.2).

* 3.4.2 Internal construction. Multiple chip construction is not permitted to meet the requirements of this specification.

3.5 Electrostatic discharge protection. The devices covered by this specification require electrostatic discharge protection.

3.5.1 Handling. MOS devices must be handled with certain precautions to avoid damage due to the accumulation of static charge. However, the following handling practices are recommended (see 3.5).

a. Devices should be handled on benches with conductive handling devices.

b. Ground test equipment, tools, and personnel handling devices.

c. Do not handle devices by the leads.

d. Store devices in conductive foam or carriers.

e. Avoid use of plastic, rubber, or silk in MOS areas.

f. Maintain relative humidity above 50 percent if practical.

g. Care should be exercised during test and troubleshooting to apply not more than maximum rated voltage to any lead.

h. Gate must be terminated to source, $R \leq 100\ k\Omega$, whenever bias voltage is to be applied drain to source.

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

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

* 3.8 Marking. Marking shall be in accordance with MIL-PRF-19500.

* 3.9 Workmanship. Semiconductor devices shall be processed in such a manner as to be uniform in quality and shall be free from other defects that will affect life, serviceability, or appearance.

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 and tables I and II).

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

* 4.2.1 Group E qualification. Group E inspection shall be performed for qualification or re-qualification only. In case qualification was awarded to a prior revision of the specification sheet that did not request the performance of table III tests, the tests specified in table III herein that were not performed in the prior revision shall be performed on the first inspection lot of this revision to maintain qualification.

* 4.3 Screening (JANS, JANTXV levels only). Screening shall be in accordance with 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 table IV of MIL-PRF-19500) (1) (2)	Measurement	
	JANS level	JANTXV levels
(3)	Gate stress test (see 4.3.1)	Gate stress test (see 4.3.1)
(3)	Method 3470 of MIL-STD-750, (see 4.3.2)	Method 3470 of MIL-STD-750, (see 4.3.2)
(3) 3c	Method 3161 of MIL-STD-750, (see 4.3.3)	Method 3161 of MIL-STD-750, (see 4.3.3)
7	Optional.	Optional.
9	I_{GSSF1}, I_{GSSR1}, I_{DSS1}, subgroup 2 of table I herein	Subgroup 2 of table I herein
10	Method 1042 of MIL-STD-750, test condition B	Method 1042 of MIL-STD-750, test condition B
11	I_{GSSF1}, I_{GSSR1}, I_{DSS1}, $r_{DS(on)1}$, $V_{GS(th)1}$ Subgroup 2 of table I herein; ΔI_{GSSF1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{GSSR1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{DSS1} = ± 10 μA dc or ± 100 percent of initial value, whichever is greater.	I_{GSSF1}, I_{GSSR1}, I_{DSS1}, $r_{DS(on)1}$, $V_{GS(th)1}$ Subgroup 2 of table I herein
12	Method 1042 of MIL-STD-750, test condition A	Method 1042 of MIL-STD-750, condition A or T_A = +175°C and t = 48 hours min (4)
13	Subgroups 2 and 3 of table I herein; ΔI_{GSSF1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{GSSR1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{DSS1} = ± 10 μA dc or ± 100 percent of initial value, whichever is greater. $\Delta r_{DS(on)1}$ = ± 20 percent of initial value. $\Delta V_{GS(th)1}$ = ± 20 percent of initial value.	Subgroups 2 and 3 of table I herein; ΔI_{GSSF1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{GSSR1} = ± 20 nA dc or ± 100 percent of initial value, whichever is greater. ΔI_{DSS1} = ± 10 μA dc or ± 100 percent of initial value, whichever is greater. $\Delta r_{DS(on)1}$ = ± 20 percent of initial value. $\Delta V_{GS(th)1}$ = ± 20 percent of initial value.
14	Required.	Required.

(1) At the end of the test program, I_{GSSF1}, I_{GSSR1}, and I_{DSS1}, are measured.
(2) An out-of-family program to characterize I_{GSSF1}, I_{GSSR1}, I_{DSS1}, and $V_{GS(th)1}$ shall be invoked.
(3) Shall be performed anytime before screen 9.
(4) Use of this accelerated screening option requires a 1,000-hour life test in accordance with the applicable group E, subgroup 2 life test, and end-points specified herein to be provided to the qualifying activity for review and acceptance.

* 4.3.1 Gate stress test. Apply V_{GS} = -30 V minimum for t = 250 µs minimum.

* 4.3.2 Single pulse avalanche energy (E_{AS}).

a. $I_{AS} = I_{DM}$.

b. L = .1 mH.

c. $E_{AS} = .5\ LI_{AS}^2$.

d. Initial junction temperature = +25°C +10°C, -5°C.

* 4.3.3 Thermal response ΔV_{SD} measurement). The ΔV_{SD} measurement shall be performed in accordance with method 3161 of MIL-STD-750. The ΔV_{SD} conditions (I_H and V_H) and maximum limit shall be derived by each vendor from the thermal response curves (see figure 3) and shall be specified in the certificate of conformance prior to qualification. The following parameter measurements shall apply:

a. Measuring current (I_M) ..... 10 mA.

b. Drain heating current (I_H) ..... 4 A minimum.

c. Heating time (t_H) ..... 10 ms.

d. Drain-source heating voltage (V_H) ..... 25 V.

e. Measurement time delay (t_{MD}) ..... 30 to 60 µs.

f. Sample window time (t_{SW}) ..... 10 µs maximum.

* 4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500 and as specified herein. Alternate flow is allowed for JANTXV level conformance inspection in accordance with MIL-PRF-19500.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with appendix E, table V of MIL-PRF-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 in appendix E, table VIa (JANS) and table VIb (JANTXV) of MIL-PRF-19500, and herein. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table IV herein.

* 4.4.2.1 Group B inspection, table VIa (JANS) of MIL-PRF-19500.

	Subgroup	Method	Conditions
*	B3	2077	SEM
*	B5	1042	V_{DS} = rated; T_A = +175°C; t = 240 hours min. Read and record $V_{BR(DSS)}$ (pre and post) at I_D = 1 mA. Read and record I_{DSS} (pre and post) in accordance with table IV.
	B5	1042	Condition B, V_{GS} = rated; T_A = +175°C, t = 24 hours.
	B5	2037	Test condition A, all internal wires for each device shall be pulled separately.
	B5	3161	See 4.5.2.

* 4.4.2.2 Group B inspection, table VIb (JANTXV) of MIL-PRF-19500.

Subgroup	Method	Conditions
B2	1051	Test condition G, 25 cycles.

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

	Subgroup	Method	Conditions
	C2	1056	Condition B.
	C2	2036	Test condition A, weight = 10 pounds; t = 15 s.
*	C5	3161	See 4.5.2.
	C6	1042	Test condition D, 6,000 cycles; a cycle shall be 30 seconds minimum.

4.4.4 Group D Inspection. Group D inspection shall be conducted in accordance with appendix E, table VIII of MIL-PRF-19500 and table II herein.

* 4.4.5 Group E inspection. Group E inspection shall be conducted in accordance with the conditions specified for subgroup testing in table IX of MIL-PRF-19500 and as specified in table III herein. Electrical measurements (end-points) shall be in accordance with table I, subgroup 2 herein.

4.5 Methods 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 performed in accordance with method 3161 of MIL-STD-750. The maximum limit of $R_{\theta JC(max)}$ = 0.83°C/W. The following parameter measurements shall apply.

a. Measuring current (I_M) ..... 10 mA.

b. Drain heating current (I_H) ..... 4 A.

c. Heating time (t_H) ..... Steady-state (see method 3161 of MIL-STD-750 for definition).

d. Drain-source heating voltage (V_H) ..... 25 V.

e. Measurement time delay (t_{MD}) ..... 30 to 60 μs.

f. Sample window time (t_{SW}) ..... 10 μs maximum.

* TABLE I. Group A inspection.

	Inspection 1/	MIL-STD-750		Symbol	Limits		Units
		Method	Conditions		Min	Max	
	Subgroup 1						
	Visual and mechanical inspection	2071					
	Subgroup 2						
	Breakdown voltage, drain to source	3407	V_{GS} = 0 V; I_D = 1 mA dc, bias condition C	$V_{(BR)DSS}$			
	2N7291				100		V dc
	2N7293				200		V dc
	2N7295				250		V dc
	2N7297				500		V dc
	Gate to source voltage (threshold)	3403	$V_{DG} \geq V_{GS}$, I_D = 1 mA dc	$V_{GS(th)1}$	2.0	4.0	V dc
*	Gate current	3411	V_{GS} = +20 V dc, bias condition C, V_{DS} = 0	I_{GSSF1}		+100	nA dc
*	Gate current	3411	V_{GS} = -20 V dc, bias condition C, V_{DS} = 0	I_{GSSR1}		-100	nA dc
	Drain current	3413	V_{GS} = 0 V dc, bias condition C, V_{DS} = 80 percent of rated V_{DS}	I_{DSS1}		25	µA dc
	Static drain to source on-state resistance	3421	V_{GS} = 10 V dc, condition A, pulsed (see 4.5.1), I_D = I_{D2}	$r_{DS(on)1}$			
	2N7291					0.055	Ω
	2N7293					0.10	Ω
	2N7295					0.17	Ω
	2N7297					0.60	Ω
	Static drain to source on-state resistance	3421	V_{GS} = 10 V dc, condition A, pulsed (see 4.5.1), I_D = I_{D1}	$r_{DS(on)2}$			
	2N7291					0.058	Ω
	2N7293					0.105	Ω
	2N7295					0.179	Ω
	2N7297					0.630	Ω
	Forward voltage	4011	Pulsed (see 4.5.1), Id = Id1, V_{GS} = 0 V dc	V_{SD}		1.8	V dc

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Units
	Method	Conditions		Min	Max	
Subgroup 3						
High temperature operation:		$T_C = T_J = +125°C$				
Gate current	3411	V_{GS} = +20 V dc and -20 V dc, bias condition C, V_{DS} = 0	I_{GSS2}		± 200	nA dc
Drain current	3413	V_{GS} = 0 V dc, bias condition C, V_{DS} = 100 percent of rated V_{DS}	I_{DSS2}		1.0	mA dc
		V_{DS} = 80 percent of rated V_{DS}	I_{DSS3}		0.25	mA dc
Static drain to source on-state resistance	3421	V_{GS} = 10 V dc, pulsed (see 4.5.1), $I_D = I_{D2}$	$r_{DS(on)3}$			
2N7291					0.110	Ω
2N7293					0.220	Ω
2N7295					0.408	Ω
2N7297					1.56	Ω
Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 1 mA dc	$V_{GS(th)2}$	1.0		V dc
Low temperature operation:		$T_C = T_J = -55°C$				
Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 1 mA dc	$V_{GS(th)3}$		5.0	V dc
Subgroup 4						
Switching time test	3472	$I_D = I_{D1}$, V_{GS} = 10 V dc, R_G = 25Ω, V_{DD} = 50 percent of rated V_{DS}				
Turn-on delay time			$t_{d(on)}$			
2N7291					170	ns
2N7293					170	ns
2N7295					150	ns
2N7297					160	ns
Rise time			t_r			
2N7291					1,120	ns
2N7293					600	ns
2N7295					450	ns
2N7297					260	ns

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Units
	Method	Conditions		Min	Max	
Subgroup 4 - Continued						
Turn-off delay time			$t_{d(off)}$			
2N7291					420	ns
2N7293					580	ns
2N7295					650	ns
2N7297					750	ns
Fall time			t_f			
2N7291					380	ns
2N7293					300	ns
2N7295					260	ns
2N7297					180	ns
Subgroup 5						
Safe operating area test	3474	See figure 4, t_p = 10 ms minimum, V_{DS} = 80 percent of max rated V_{DS} ($V_{DS} \leq$ 200)				
Electrical measurements		See table IV, steps 1, 2, 3, 4, 5, 6, and 7				
Subgroup 6						
Not applicable						
Subgroup 7						
Gate charge	3471	Condition B				
On-state gate charge		V_{DD} = 0.5 B, V_{DSS}, $I_D = I_{D1}$ $V_{GS} \leq$ 20V, $I_{GS1} = I_{GS2}$	$Q_{g(on)}$			
2N7291					230	nC
2N7293					244	nC
2N7295					252	nC
2N7297					258	nC

See footnote at end of table.

* TABLE I. Group A inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Limits		Units
	Method	Conditions		Min	Max	
Subgroup 7 - Continued						
Gate to source charge			Q_{gs}			
2N7291					63	nC
2N7293					53	nC
2N7295					48	nC
2N7297					34	nC
Gate to drain charge			Q_{gd}			
2N7291					123	nC
2N7293					125	nC
2N7295					126	nC
2N7297					123	nC
Reverse recovery time	3473	di/dt = 100 A/µs, $V_{DD} \leq 30$ V, $I_d = I_{d1}$	T_{rr}			
2N7291					1,400	ns
2N7293					1,700	ns
2N7295					2,000	ns
2N7297					2,300	ns

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

TABLE II. Group D inspection.

Inspection 1/	MIL-STD-750		Symbol	Preirradiation limits		Preirradiation limits		Units
	Method	Conditions		M, D, and R		M, D, and R		
				Min	Max	Min	Max	
Subgroup 1								
Not applicable								
Subgroup 2		T_C = +25°C						
Steady state total dose irradiation	1019	2/ 3/						
End-point electricals								
Breakdown voltage, drain to source	3407	V_{GS} = 0; I_D = 1 mA; bias condition C	$V_{BR(DSS)}$					
2N7291				100		100		V dc
2N7293				200		200		V dc
2N7295				250		250		V dc
2N7297				500		500		V dc
Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 1 mA	$V_{GS(th)1}$					
2N7291				2.0	4.0	2.0	4.0	V dc
2N7293				2.0	4.0	2.0	4.0	V dc
2N7295				2.0	4.0	2.0	4.0	V dc
2N7297				2.0	4.0	2.0	4.0	V dc
Gate current	3411	V_{GS} = 20 V; V_{DS} = 0, bias condition C	I_{GSSF1}		100		100	nA dc
Gate current	3411	V_{GS} = 20 V; V_{DS} = 0, bias condition C	I_{GSSR1}		-100		-100	nA dc
Drain current	3413	V_{GS} = 0, bias condition C V_{DS} = 80 percent of rated V_{DS} (preirradiation)	I_{DSS1}					
2N7291					25		25	µA dc
2N7293					25		25	µA dc
2N7295					25		25	µA dc
2N7297					25		25	µA dc

See footnotes at end of table.

TABLE II. Group D inspection - Continued.

Inspection 1/	MIL-STD-750		Symbol	Preirradiation limits		Preirradiation limits		Units
	Method	Conditions		M, D, and R		M, D, and R		
				Min	Max	Min	Max	
Subgroup 2 - Continued								
Static drain to source on-state resistance	3421	V_{GS} = 10 V; condition A, pulsed (see 4.5.1), $I_D = I_{D2}$	$R_{DS(on)1}$					
2N7291					0.055		0.055	Ω
2N7293					0.100		0.100	Ω
2N7295					0.170		0.170	Ω
2N7297					0.600		0.600	Ω
Drain source on-state voltage	3405	V_{GS} = 10 V; $I_D = I_{D1}$; condition A; pulsed (see 4.5.1), $I_D = I_{D1}$	$V_{DS(on)}$					
2N7291					2.32		2.32	V dc
2N7293					2.70		2.70	V dc
2N7295					3.58		3.58	V dc
2N7297					6.30		6.30	V dc

1/ For sampling plan, see MIL-PRF-19500.
2/ Inspection requires all subgroup 2 (group D) measurements after exposure to both of the following insitu bias conditions: V_{GS} = 10 V; V_{DS} = 0; V_{GS} = 0 V; V_{DS} = 80 percent of rated V_{DS}.
3/ Each bias condition requires a separate total dose sample.

* TABLE III. Group E inspection (all quality levels) for qualification or re-qualification only.

Inspection	MIL-STD-750		Qualification and large lot quality conformance inspection
	Method	Conditions	
Subgroup 1			12 devices c = 0
Temperature cycling	1051	-55°C to +150°C, 500 cycles	
Hermetic seal Fine leak Gross leak	1071	 Test conditions G or H Test conditions C or D	
Electrical measurements		See table IV, steps 1, 2, 3, 4, 5, 6, and 7	
Subgroup 2 1/			12 devices c = 0
Steady-state gate bias	1042	Condition B, 1,000 hours.	
Electrical measurements		See table IV, steps 1, 2, 3, 4, 5, 6, and 7	
Steady-state reverse bias	1042	Condition A, 1,000 hours.	
Electrical measurements		See table IV, steps 1, 2, 3, 4, 5, 6, and 7	
Subgroup 3			3 devices c = 0
DPA	2102		
Subgroup 4			Sample size N/A
Thermal impedance curves		Each supplier shall submit their qual-lot average and design maximum thermal impedance curves. In addition, the optimal test conditions and $Z_{\theta JX}$ limit shall be provided to the qualifying activity in the qualification report	
Subgroup 5			15 devices c = 0
Barometric pressure (reduced) (2N7297 only)	1001		
Subgroup 6			3 devices
ESD	1020		
Subgroup 8			22 devices c = 0
Commutating diode for safe operating area test procedure for measuring dv/dt during reverse recovery of power MOSFET transistors or insulated gate bipolar transistors	3476		

1/ A separate sample for each test shall be pulled.

* TABLE IV. Groups A, B, C, and E electrical and delta measurements.

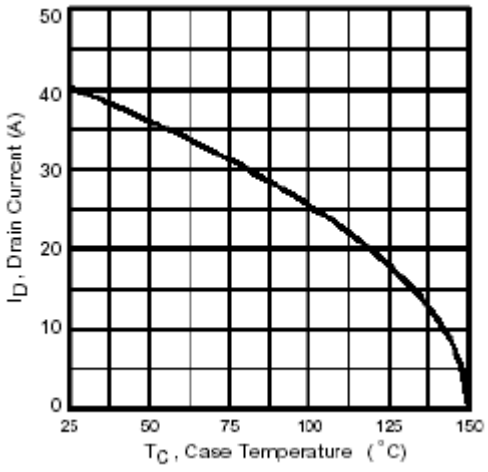
Step	Inspection 1/ 2/ 3/ 4/	MIL-STD-750		Symbol	Limits		Units
		Method	Conditions		Min	Max	
1.	Breakdown voltage drain to source	3407	V_{GS} = 0 V; I_D = 1 mA dc; bias condition C	$V_{(BR)DSS}$			
	2N7291				100		V dc
	2N7293				200		V dc
	2N7295				250		V dc
	2N7297				500		V dc
2.	Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$; I_D = 1 mA dc	$V_{GS(th)1}$	2.0	4.0	V dc
3.	Gate current	3411	V_{GS} = +20 and -20 V dc; V_{DS} = 0 V; bias condition C	I_{GSS1}		±100	nA dc
4.	Drain current	3413	V_{GS} = 0 V dc; bias condition C, V_{DS} = 80 percent of rated V_{DS}	I_{DSS1}		25	µA dc
5.	Static drain to source on-state resistance	3421	V_{GS} = 10 V dc; condition A, pulsed (see 4.5.1), $I_D = I_{D2}$	$r_{DS(on)1}$			
	2N7291					0.055	Ω
	2N7293					0.100	Ω
	2N7295					0.170	Ω
	2N7297					0.600	Ω
6.	Static drain to source on-state resistance	3421	V_{GS} = 10 V dc; condition A, pulsed (see 4.5.1), $I_D = I_{D1}$	$r_{DS(on)2}$			
	2N7291					0.058	Ω
	2N7293					0.105	Ω
	2N7295					0.179	Ω
	2N7297					0.630	Ω
7.	Forward-voltage (source drain diode)	4011	Pulsed (see 4.5.1), V_{GS} = 0 V dc, $I_D = I_{D1}$	V_{SD}		1.8	V dc
8.	Thermal response	3161	See 4.3.3	ΔV_{SD}			

1/ The electrical measurements for appendix E, table VIa (JANS) of MIL-PRF-19500 are as follows:
   a. Subgroup 3, see table IV herein, steps 1, 2, 3, 4, 5, 6, and 7.
   b. Subgroup 4, see table IV herein, steps 1, 2, 3, 4, 5, 6, 7, and 8.
   c. Subgroup 5, see table IV herein, steps 1, 2, 3, 4, 5, 6, and 7.

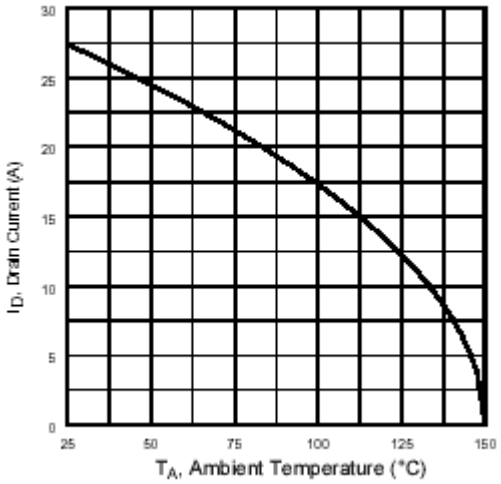
2/ The electrical measurements for appendix E, table VIb (JANTXV) of MIL-PRF-19500 are as follows:
   a. Subgroup 2, see table IV herein, steps 1, 2, 3, 4, 5, 6, and 7.
   b. Subgroup 3 see table IV herein, steps 1, 2, 3, 4, 5, 6, 7, and 8.

3/ The electrical measurements for appendix E, table VII of MIL-PRF-19500 are: Subgroups 2, 3, and 6, see table IV herein, steps 1, 2, 3, 4, 5, 6, and 7.

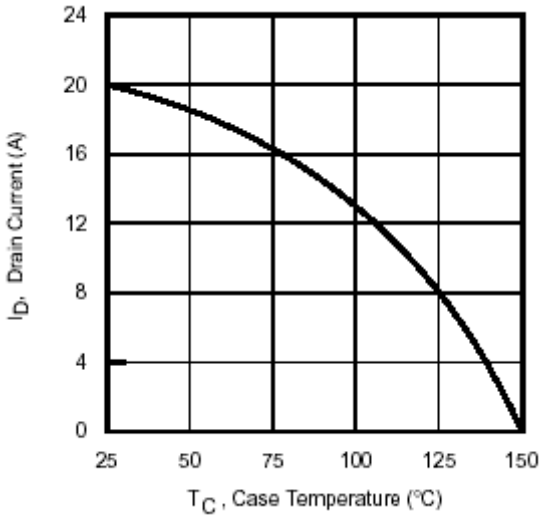
4/ The electrical measurements for table IX of MIL-PRF-19500 are: Subgroups 1 and 2, see table IV herein, steps 1, 2, 3, 4, 5, 6, and 7.



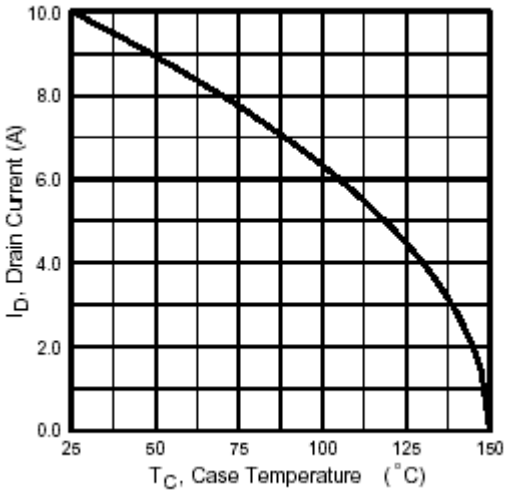
2N7291



2N7293

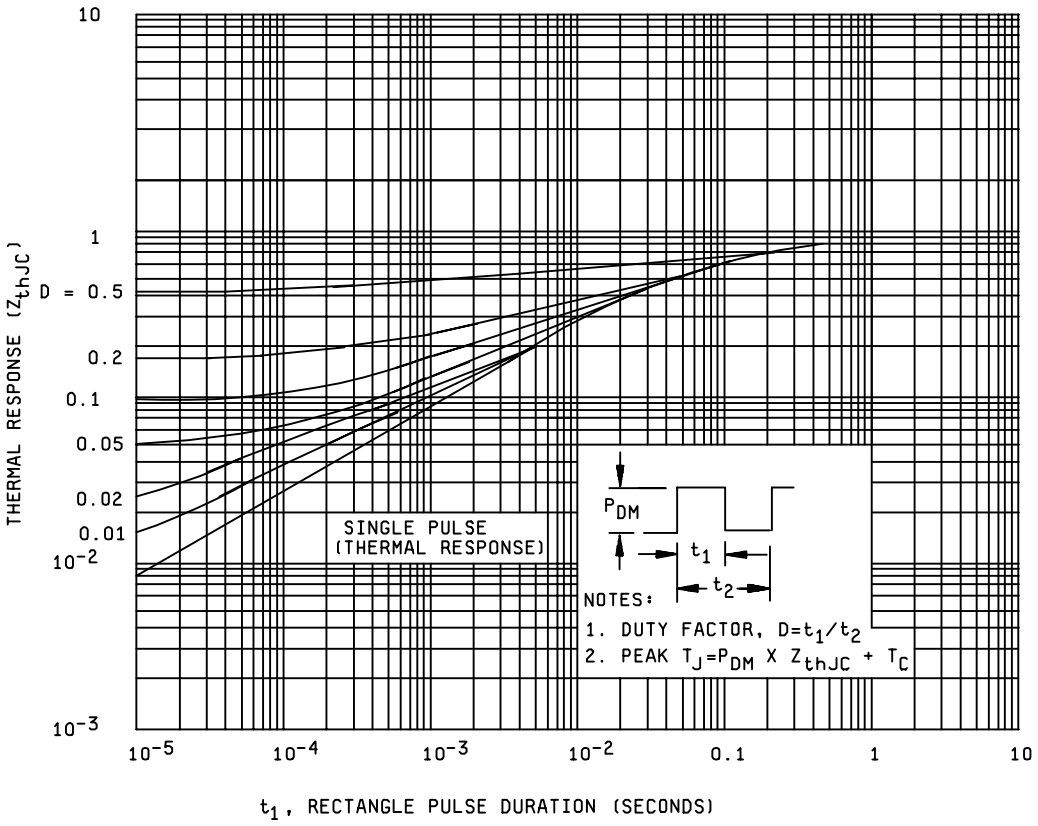


2N7295



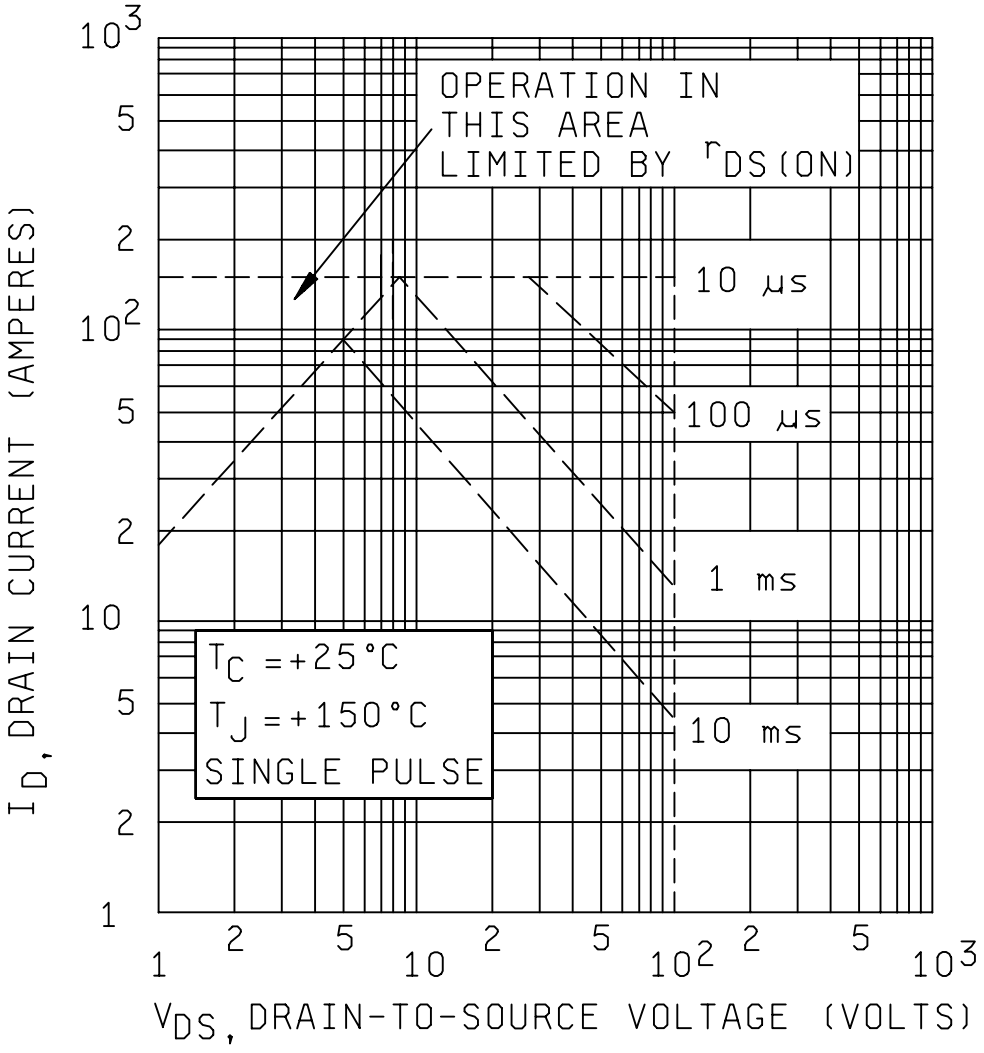
2N7297

* FIGURE 2. Maximum drain current vs case temperature graphs.

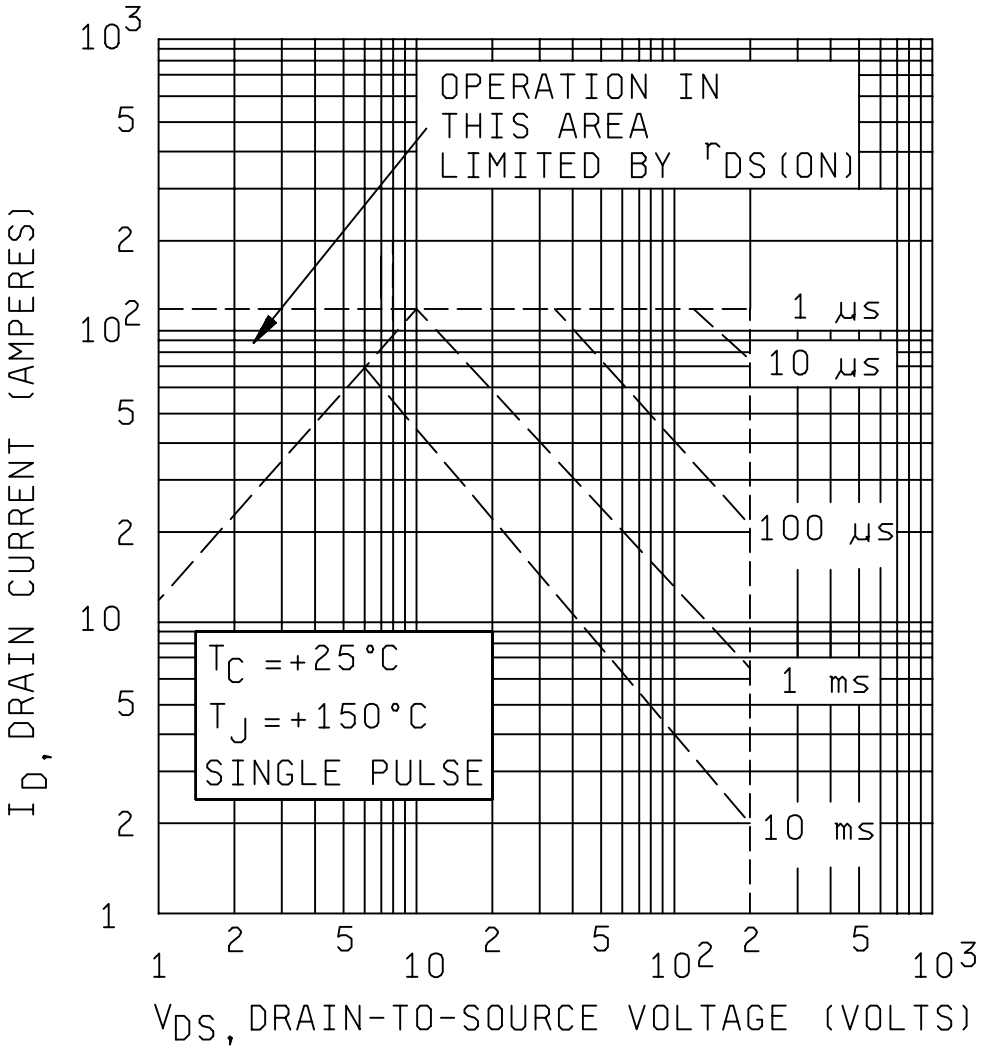


* FIGURE 3. Thermal response curves.

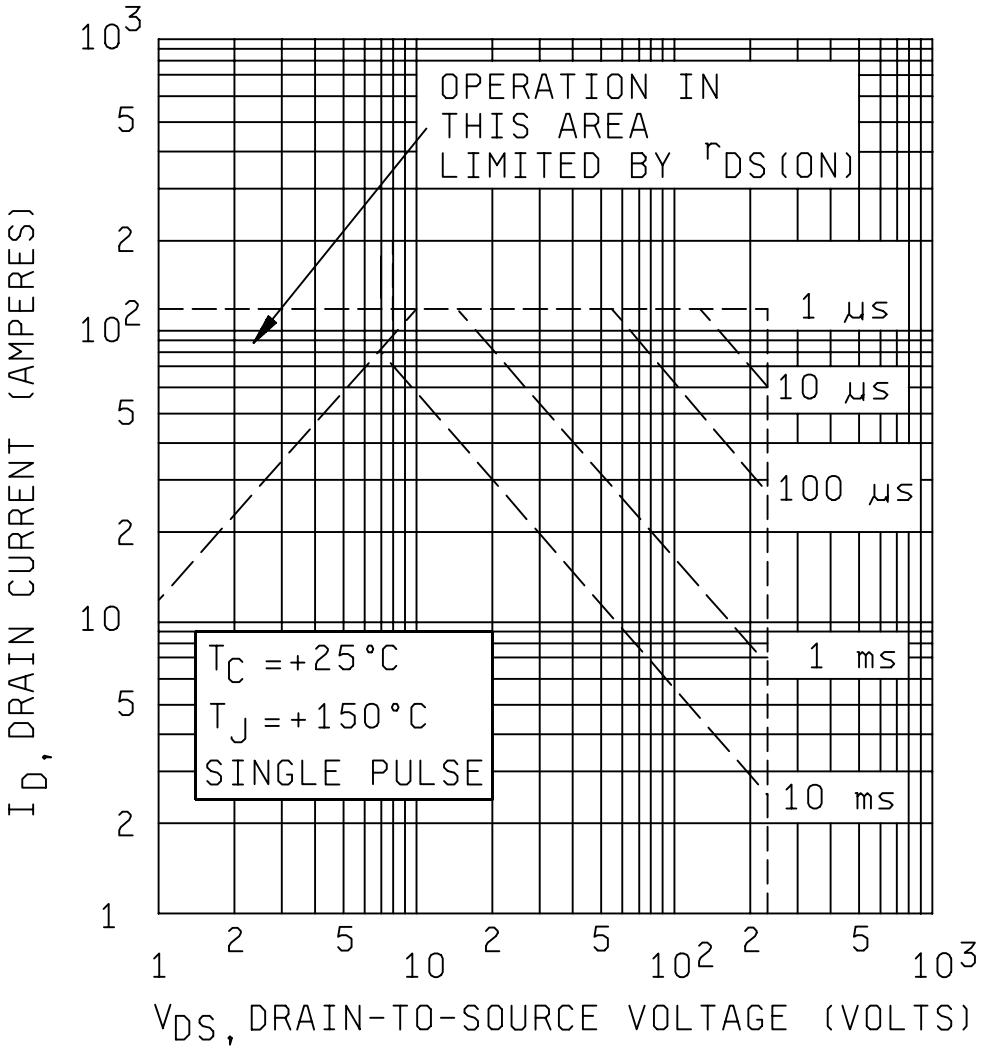
2N7291



* FIGURE 4. Safe operating area graphs.

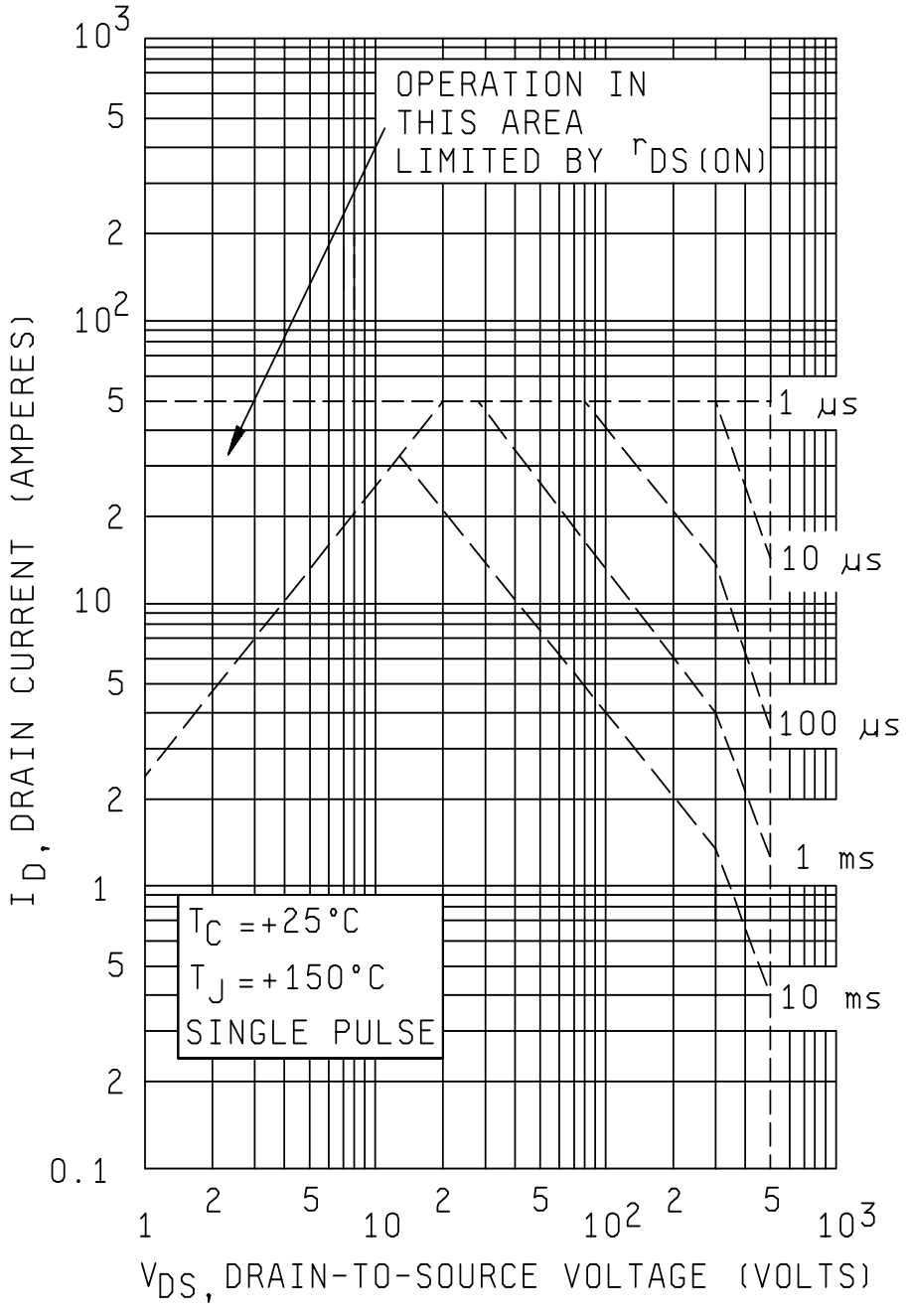


* FIGURE 4. Safe operating area graphs - Continued.



* FIGURE 4. Safe operating area graphs - Continued.

2N7297



* FIGURE 4. Safe operating area graphs - Continued.

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 materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the Military Service's system commands. Packaging data retrieval is available from the managing Military Department's 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 Intended use. The notes specified in MIL-PRF-19500 are applicable to this specification.

* 6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Packaging requirements (see 5.1).

c. Lead material and finish (see 3.4.1).

d. Type designation and product assurance level.

* 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 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 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, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail vqe.chief@dla.mil.

6.4 Substitution information. Devices covered by this specification are substitutable for the manufacturer's and user's Part or Identifying Number (PIN). This information in no way implies that manufacturer's PIN's are suitable for the military PIN.

Preferred types	Commercial types
2N7291	FRK150 (1)
2N7293	FRK250 (1)
2N7295	FRK254 (1)
2N7297	FRK450 (2)

(1) FRKxxxM, FRKxxxD, FRKxxxR, 3 k, 10 k, 100 k RAD(Si).
(2) FRM450M, FRM450D, FRM450R, 3 k, 10 k, 100 k RAD(Si).

* 6.5 Changes from previous issue. The margins of this specification are marked with asterisks to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

Custodians:
Army - CR
Navy - EC
Air Force - 11
DLA - CC

Review activities:
Navy - TD
Air Force - 19, 70

Preparing activity:
DLA - CC

(Project 5961-2840)

* NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://www.dodssp.daps.mil/ .