The documentation and process conversion measures necessary to comply with this revision shall be completed by 26 October 2021.

INCH-POUND
MIL-PRF-19500/777
w/AMENDMENT 1
26 July 2021
MIL-PRF-19500/777
9 December 2020

PERFORMANCE SPECIFICATION SHEET

TRANSISTOR, FIELD EFFECT RADIATION HARDENED, N-CHANNEL,
SILICON, TYPES 2N7652 AND 2N7653, QUALITY LEVELS JANTXV AND JANS

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 and single event effects (SEE)), power transistor. Two levels of product assurance (JANTXV and JANS) are provided for each encapsulated device. Provisions for radiation hardness assurance (RHA) to two radiation levels ("R" and "F") are provided for JANTXV and JANS product assurance level.

1.2 Package outlines. The device package outlines are as follows: TO-254AA in accordance with figure 1 and surface mount (U2A) in accordance with figure 2 for all encapsulated device types.

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	$R_{\theta JC}$ (2)	V_{DS}	V_{DG}	V_{GS}	I_{D1} (3) (4) T_C = +25°C	I_{D2} T_C = +100°C	I_S	I_{DM} (5)	T_J and T_{STG}
	W	W	°C/W	V dc	V dc	V dc	A dc	A dc	A dc	A (pk)	°C
2N7652T1	208	2.60	0.60	60	60	±20	45	45	45	180	-55 to +150
2N7652U2A	250	2.50	0.50	60	60	±20	100	100	100	400	
* 2N7653U2A	250	2.50	0.50	100	100	±20	100	100	100	400	

(1) Derate linearly by 1.67 W/°C (T1), 2.00 W/°C (U2A) for T_C > +25°C.
(2) See figure 3, thermal impedance curves.
(3) 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:

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

(4) See figure 4, maximum drain current graph.
(5) I_{DM} = 4 X I_{D1}; I_{D1} as calculated by footnote (3).

Comments, suggestions, or questions on this document should be addressed to DLA Land and Maritime, ATTN: VAC, P.O. Box 3990, Columbus, OH 43218-3990, or emailed to Semiconductor@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/.

AMSC N/A
FSC 5961

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

Type	Min $V_{(BR)DSS}$ V_{GS} = 0 I_D = 1.0mA dc	$V_{GS(TH)1}$ $V_{DS} \geq V_{GS}$ I_D = 6.0 mA dc		Max I_{DSS1} V_{GS} = 0 V_{DS} = 80% of rated V_D	Max $r_{DS(on)}$ (1) V_{GS} = 12V, $I_D = I_{D2}$		E_{AS}
					T_J = +25°C	T_J = +150°C	
	V dc	V dc Min	Max	µA dc	Ω	Ω	mJ
2N7652T1	60	2.0	4.0	1.0	0.007	0.015	5600
2N7652U2A	60	2.0	4.0	1.0	0.004	0.009	4000
* 2N7653U2A	100	2.0	4.0	1.0	0.0065	0.014	3027

(1) Pulsed (see 4.5.1).

1.5 Part or Identifying Number (PIN). The PIN is in accordance with MIL-PRF-19500, and as specified herein. See 6.5 for PIN construction example and 6.6 for a list of available PINs.

1.5.1 JAN certification mark and quality level. The only quality level designators for encapsulated devices that are applicable for this specification sheet are the quality levels "JANTXV" and "JANS".

1.5.2 Radiation hardness assurance (RHA) designator. The RHA levels that are applicable for this specification sheet from lowest to highest are as follows: "R" and "F".

1.5.3 Device type. The designation system for the device types of transistors covered by this specification sheet are as follows.

1.5.3.1 First number and first letter symbols. The transistors of this specification sheet use the first number and letter symbols "2N".

* 1.5.3.2 Second number symbols. The second number symbols for the transistors covered by this specification sheet are as follows: "7652" and "7653".

1.5.4 Suffix letters. The following suffix letters are incorporated in the PIN for this specification sheet:

T1	Indicates a metal lidded 3 terminal leaded package similar to a TO-254AA (see figure 1)
U2A	Indicates a metal lidded 3 pad surface mount package (see figure 2).

1.5.5 Lead finish. The lead finishes applicable to this specification sheet are listed on QPDSIS-19500.

* 1.6 Radiation features:

Maximum total ionizing dose (TID) available (Dose rate = 50-300 rad(Si)/s)):

For device type 2N7652T1, 2N7652U2A, 2N7653U2A: ..... 300 krads(Si) 1/

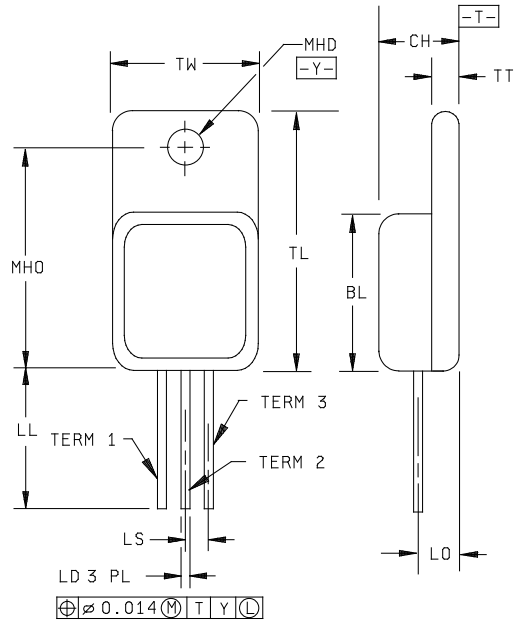
Heavy Ion Single Event Effect (SEE) SEB and SEGR test:

For device types 2N7652T1, 2N7652U2A:
No SEB and SEGR were observed at surface LET (see table IV) ..... ≤ 90 MeV·cm^2/mg 2/
(In-situ Bias V_{DS} = 60 V and V_{GS} = -1 V)

For device types 2N7653U2A:
No SEB and SEGR were observed at surface LET (see table IV) ..... ≤ 89.8 MeV-cm2/mg 2/
(In-situ Bias VDS = 100 V and VGS = -1 V)

1/ Manufacturer supplying device types 2N7652T1 2N7652U2A, and 2N7653U2A has performed characterization testing in accordance with MIL-STD-750, method 1019, condition A (dose rate = 50 - 300 rad(Si)/s). The radiation end point limits are guaranteed only for the conditions as specified in MIL-STD-750, method 1019, condition A to a maximum total ionizing dose level of 300 krads(Si).

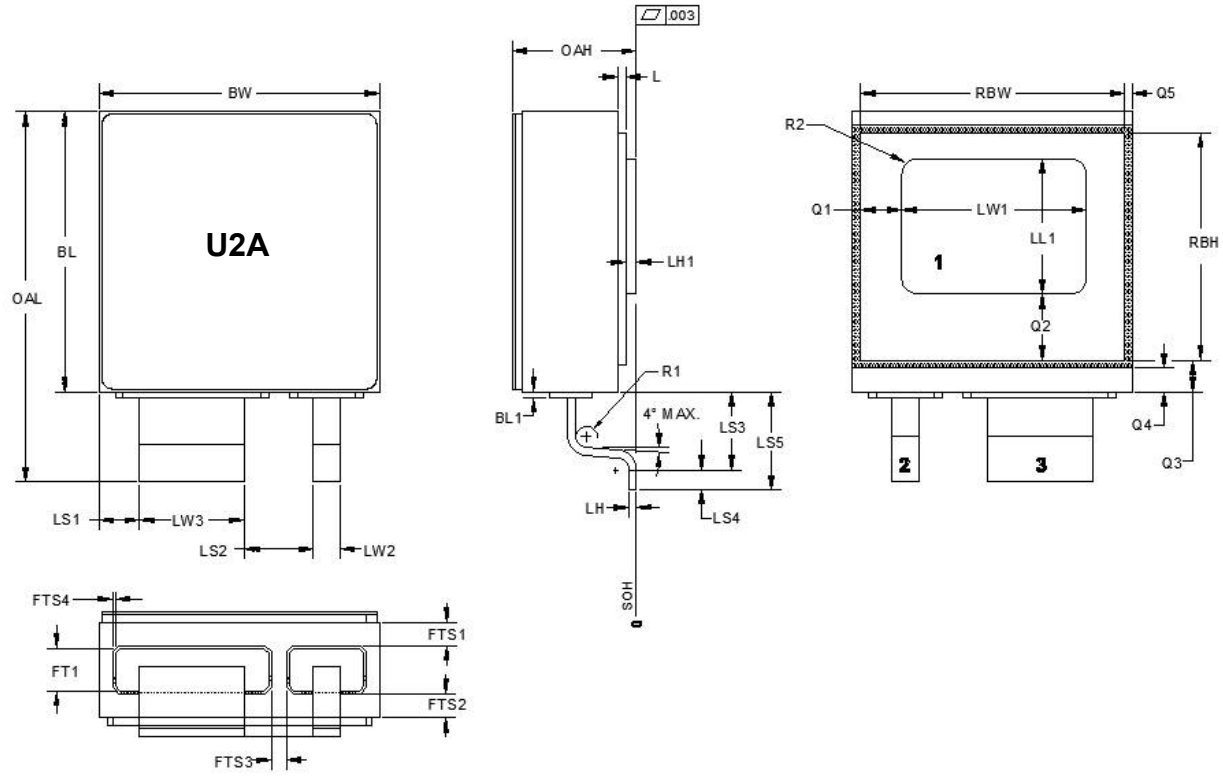
2/ Manufacturer also performed heavy ion SEB and SEGR test at TAMU Radiation Effects Facility for the MOSFET technology devices in accordance with TM1080 of MIL-STD-750. Limits are characterized at initial qualification and after any design or process changes which may affect the SEE (SEB/SEGR) characteristics. For more information on SEE (SEB/SEGR) test results, customers are requested to contact the manufacturer.



Ltr	Dimensions				Notes
	Inches		Millimeters		
	Min	Max	Min	Max	
BL	.535	.545	13.59	13.84	
CH	.249	.260	6.33	6.60	
LD	.035	.045	0.89	1.14	
LL	.510	.570	12.95	14.48	3
LO	.150 BSC		3.81 BSC		
LS	.150 BSC		3.81 BSC		
MHD	.139	.149	3.53	3.79	
MHO	.665	.685	16.89	17.40	
TL	.790	.800	20.07	20.32	4
TT	.040	.050	1.02	1.27	
TW	.535	.545	13.59	13.84	4
Term 1	Drain				
Term 2	Source				
Term 3	Gate				

NOTES:
1. Dimensions are in inches.
2. Millimeters are given for general information only.
3. Protrusion thickness of ceramic eyelets included in dimension LL.
4. All terminals are isolated from case.
5. In accordance with ASME Y14.5, diameters are equivalent to ϕx symbology.

* FIGURE 1. Physical dimensions for TO-254AA (2N7652T1).



* FIGURE 2. Physical dimensions, U2A surface mount (2N7652U2A and 2N7653U2A).

Symbol	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
BL	.524	.536	13.31	13.61
BL1	.005	.015	0.13	0.38
BW	.524	.536	13.31	13.61
FT1	.075	.085	1.91	2.16
FTS1	.036		0.91	
FTS2	.036		0.91	
FTS3	.030		0.76	
FTS4	.005 TYP		0.127 TYP	
L	.013	.017	0.33	0.43
LH	.013	.017	0.33	0.43
LH1	.02	.024	0.51	0.58
LL1	.25	.26	6.35	6.60
LS1	.07	.08	1.78	2.03
LS2	.125	.135	3.18	3.43
LS3	.125	.145	3.18	3.68
LS4	.040	.050	1.02	1.27
LS5	.170	.190	4.32	4.83
LW1	.345	.355	8.76	9.02
LW2	.045	.055	1.14	1.4
LW3	.195	.205	4.95	5.21
OAH	.26 TYP		6.60 TYP	
OAL		.71		18.03
Q1	.073	.083	1.85	2.11
Q2	.12	.13	3.05	3.3
Q3	.055	.065	1.4	1.65
Q4	.04		1.02	
Q5	.010	.020	.25	.51
RBH	.425	.435	10.8	11.05
RBW	.495	.505	12.57	12.83
R1	.02		0.51	
R2	.025	.035	0.635	0.889
TERM 1	Drain			
TERM 2	Gate			
TERM 3	Source			

NOTES:
1. Dimensions are in inches.
2. Millimeters are given for general information only.
3. Lid is isolated.

* FIGURE 2. Physical dimensions, U2A surface mount (2N7652U2A and 2N7653U2A) − continued.

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 of 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 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.
MIL-STD-883 - Test Method Standard Microcircuits

(Copies of these documents are available online at https://quicksearch.dla.mil/).

2.3 Order of precedence. Unless otherwise noted herein or in the contract, 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.

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 manufacturer's list (QML) 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.

3.4 Interface and physical dimensions. Interface and physical dimensions shall be as specified in MIL-PRF-19500 and on figures 1 (T1, TO-254AA), and 2 (U2A surface mount) herein. Methods used for the electrical isolation of the terminals shall employ materials that contain a minimum of 90 percent Al_2O_3 (ceramic).

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

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

3.4.3 Silicone die coat. The use of a silicone die coat requires a successful completion of MIL-STD-883, method 5011 on each silicone lot for its intended applications, and as part of the full MIL-PRF-19500 qualification process.

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

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

3.7 Electrostatic discharge sensitive (ESDS). The devices covered by this specification sheet have been classified as ESDS. The devices shall be handled in accordance with the ESD program established to comply with the requirements of MIL-PRF-19500 to avoid damage due to the accumulation of static charge. The following handling practices shall be followed:

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 shall be terminated to source, R ≤ 100 kΩ, whenever bias voltage is to be applied drain to source.

3.8 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 and as specified herein.

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.

4.2.1.1 Single event effects (SEE). SEE (SEB/SEGR) shall be performed in accordance with TM1080 of MIL-STD-750 at initial qualification and after process or design changes which may affect radiation hardness (see table III and table IV). Upon qualification, manufacturers shall provide the verification test conditions from section 5 of method 1080 of MIL-STD-750 that were used to qualify the device for inclusion into section 6 of the slash sheet. End-point measurements shall be in accordance with table II. SEE characterization data shall be made available upon request of the qualifying or acquiring activity.

4.3 Screening of encapsulated devices. Screening of packaged devices shall be in accordance with table E-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 (1) (2)	Measurement	
	JANS	JANTXV
(3)	Gate stress test (see 4.3.1)	Gate stress test (see 4.3.1)
(3)	Method 3470 of MIL-STD-750, E_{AS} (see 4.3.2)	Method 3470 of MIL-STD-750, E_{AS} (see 4.3.2)
(3) 3c	Method 3161 of MIL-STD-750, thermal impedance, (see 4.3.3)	Method 3161 of MIL-STD-750, thermal impedance, (see 4.3.3)
5	Method 2052 of MIL-STD-750, PIND (see MIL-PRF-19500 and 4.3.5)	Not applicable
9	Subgroup 2 of table I herein	Not applicable
10	Method 1042 of MIL-STD-750, test condition B	Method 1042 of MIL-STD-750, test condition B
11	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} = ±500 nA dc or ±100 percent of initial value, whichever is greater.	Subgroup 2 of table I herein.
12	Method 1042 of MIL-STD-750, test condition A	Method 1042 of MIL-STD-750, test condition A
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} = ±500 nA 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.	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} = ±500 nA 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.

(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 after temperature cycling, screen 3a; JANTXV does not need to be repeated in screening requirements.

4.3.1 Gate stress test. Apply V_{GS} = 24 V minimum for t = 250 µs minimum.

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

a. Peak current ..... $I_{AS} = I_{D2}$.

b. Inductance: ..... $\left[\frac{2E_{AS}}{(I_{D2})^2}\right]\left[\frac{V_{BR} - V_{DD}}{V_{BR}}\right]$ mH minimum.

c. Gate to source resistor (R_{GS})..... $25 \leq R_{GS} \leq 200\ \Omega$.

d. Supply voltage (V_{DD})..... V_{DD} = 25 V dc, up to rated V_{DS}.

* e. Peak gate voltage (V_{GS}) ..... 20 V, up to maximum rated V_{GS}.

f. Initial case temperature ..... T_C = +25°C +10°C, −5°C.

g. Number of pulses to be applied..... 1 pulse minimum.

4.3.3 Thermal impedance. The thermal impedance measurements shall be performed in accordance with method 3161 of MIL-STD-750 using the guidelines in that method for determining I_M, I_H, t_H, t_{MD}, t_{SW}, (and V_H where appropriate). See table III, group E, subgroup 4 herein.

4.3.4 Dielectric withstanding voltage.

a. Magnitude of test voltage……900V dc (T1 package), 1,200V dc (U2A package).

b. Duration of application of test voltage……...15 seconds (min).

c. Points of application of test voltage……All leads to case (bunch connection).

d. Method of connection……Mechanical

e. Kilovolt-ampere rating of high voltage source……..1,200 V, 1.0 mA (min).

f. Maximum leakage current……...1.0 mA.

g. Voltage ramp up time……500 V/second

4.3.5 PIND. Not applicable in screening when devices are processed using alternative method and flow requirements approved by the qualifying activity, that includes incorporating the use of certified clean processing and silicone die coat. Instead, the PIND test performance shall be performed in group B3 and group C3, on a lot sample basis. PIND failures detected in group B or C will represent lot jeopardy and shall be evaluated for root cause and lot integrity.

4.4 Conformance inspection. Conformance inspection shall be in accordance with MIL-PRF-19500.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with table E-V of 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 table E-VIA (JANS) and table E-VIB (JANTXV) of MIL-PRF-19500, and as follows.

4.4.2.1 Quality level JANS (table E-VIA of MIL-PRF-19500).

Subgroup	Method	Condition
B3	1051	Test condition G, 100 cycles.
B3	2077	Scanning electron microscope (SEM).
B3	2052	PIND, required if not performed in screening. (22 devices, c = 0 for large lots, 12 devices, c = 0 for small lots).
B4	1042	Intermittent operation life, condition D, t_{on} = 30 seconds minimum.
B5	1042	Accelerated steady-state gate bias, condition B, V_{GS} = rated; T_A = +175°C, t = 24 hours minimum; or T_A = +150°C, t = 48 hours minimum.
B5	1042	Accelerated steady-state reverse bias, condition A, V_{DS} = rated; T_A = +175°C, t = 120 hours minimum; or T_A = +150°C, t = 240 hours minimum.
B5	2037	Test condition D.

4.4.2.2 Quality level JANTXV (table E-VIB of MIL-PRF-19500).

Subgroup	Method	Condition
B2	1051	Test condition G, 25 cycles.
B3	1042	Intermittent operation life, condition D, t_{on} = 30 seconds minimum.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table E-VII of MIL-PRF-19500 and as follows.

Subgroup	Method	Condition
C2	2036	Terminal strength is not applicable to the U2A package
C3	2052	PIND, required if not performed in screening. (22 devices, c = 0 for large lots, 12 devices, c = 0 for small lots).
C5	3161	See 4.3.3, $R_{\theta JC}$ = 0.60 °C/W (T1 package) , $R_{\theta JC}$ = 0.50 °C/W (U2A package) .
C6	1042	Intermittent operation life, condition D, t_{on} = 30 seconds minimum.

4.4.4 Group D inspection. Group D inspection shall be conducted in accordance with table E-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 E-IX of MIL-PRF-19500 and as specified in table III 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.

TABLE I. Group A inspection.

	Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
		Method	Condition		Min	Max	
	Subgroup 1						
	Visual and mechanical inspection	2071					
	Subgroup 2						
	Thermal impedance 2/	3161	See 4.3.3	$Z_{\theta JC}$			°C/W
	Breakdown voltage drain to source	3407	Bias condition C, V_{GS} = 0 V, I_D = 1 mA dc				
	2N7652T1, U2A			$V_{(BR)DSS}$	60		V dc
*	2N7653U2A			$V_{(BR)DSS}$	100		V dc
	Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 6 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 V	I_{GSSF1}		+100	nA dc
	Gate current	3411	V_{GS} = -20 V dc, bias condition C, V_{DS} = 0 V	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}		1.0	µA dc
	Static drain to source on-state resistance	3421	V_{GS} = 12 V dc, condition A, pulsed (see 4.5.1), $I_D = I_{D2}$	$r_{DS(ON)1}$			
	2N7652T1					0.007	Ω
	2N7652U2A					0.004	Ω
*	2N7653U2A					0.0065	Ω
	Forward voltage	4011	V_{GS} = 0 V dc, condition A, $I_D = I_{D1}$	V_{SD}		1.2	V dc

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

	Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
		Method	Condition		Min	Max	
	Subgroup 3						
	High temperature operation		$T_C = T_J = +125°C$				
	Gate current	3411	$V_{GS} = \pm 20$ V dc, bias condition C, $V_{DS} = 0$ V	I_{GSS2}		±200	nA dc
	Drain current	3413	$V_{GS} = 0$ V dc, bias condition C, V_{DS} = 80 percent of rated V_{DS}	I_{DSS2}		25	µA dc
	Static drain to source on-state resistance	3421	V_{GS} = 12 V dc, condition A, pulsed (see 4.5.1), $I_D = I_{D2}$	$r_{DS(ON)3}$			
	2N7652T1					0.011	Ω
	2N7652U2A					0.0068	Ω
*	2N7653U2A					0.011	Ω
	Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 6.0 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	$V_{DS} \geq V_{GS(TH)3}$, I_D = 6.0 mA dc	$V_{GS(TH)3}$		5.0	V dc
	Subgroup 4						
	Forward transconductance	3475	$I_D = I_{D2}$, V_{DD} = 15 V dc (see 4.5.1)	g_{FS}			
	2N7652T1				42		S
	2N7652U2A				50		S
*	2N7653U2A				68		S
*	Switching Time Tests	3472	$I_D = I_{D1}$, V_{GS} = 12 V dc, R_G = 2.35 Ω, V_{DD} = 50 percent rated V_{DS}				
	Turn-On Delay Time			td(on)			
	2N7652T1					36	ns
	2N7652U2A					30	ns
*	2N7653U2A					41	ns
	Rise Time			tr			
	2N7652T1					93	ns
	2N7652U2A					180	ns
*	2N7653U2A					101	ns
	Turn-Off Delay Time			td(off)			
	2N7652T1					131	ns
*	2N7652U2A					113	ns
	2N7653U2A					98	ns
	Fall Time			tf			
	2N7652T1					66	ns
	2N7652U2A					66	ns
*	2N7653U2A					28	ns

See footnotes at end of table.

TABLE I. Group A inspection - Continued.

	Inspection 1/	MIL-STD-750		Symbol	Limits		Unit
		Method	Condition		Min	Max	
	Subgroup 5						
	Safe operating area test	3474	See figure 5, tp = 10 ms min. V_{DS} = 80 percent of max. rated V_{DS}				
	Electrical measurements		See table I, subgroup 2				
	Subgroup 6						
	Not applicable						
	Subgroup 7						
	Gate charge	3471	Condition B, $I_D = I_{D1}$, V_{GS} = 12 V dc V_{DD} = 50 percent of rated V_{DS}				
	On-state gate charge and turn-off gate charge			Q_G			
	2N7652T1					194	nC
	2N7652U2A					194	nC
*	2N7653U2A					195	nC
	Gate to source charge (turn-on and turn-off)			Q_{GS}			
	2N7652T1					50	nC
	2N7652U2A					50	nC
*	2N7653U2A					67	nC
	Gate to drain charge (turn-on and turn-off)			Q_{GD}			
	2N7652T1					69	nC
	2N7652U2A					69	nC
*	2N7653U2A					52	nC
	Reverse recovery time	3473	Condition A, di/dt = -100 A/µs, $V_{DD} \leq$ 25 V, $I_D = I_{D1}$	t_{rr}			
	2N7652T1					165	ns
	2N7652U2A					165	ns
*	2N7653U2A					252	ns

1/ For sampling plan, see MIL-PRF-19500.
2/ For end-point measurements, this test is required for the following subgroups:
Group B, subgroups 2 and 3 (JANTXV).
Group B, subgroups 3 and 4 (JANS).
Group C, subgroup 2 and 6.
Group E, subgroup 1.

TABLE II. Group D inspection.

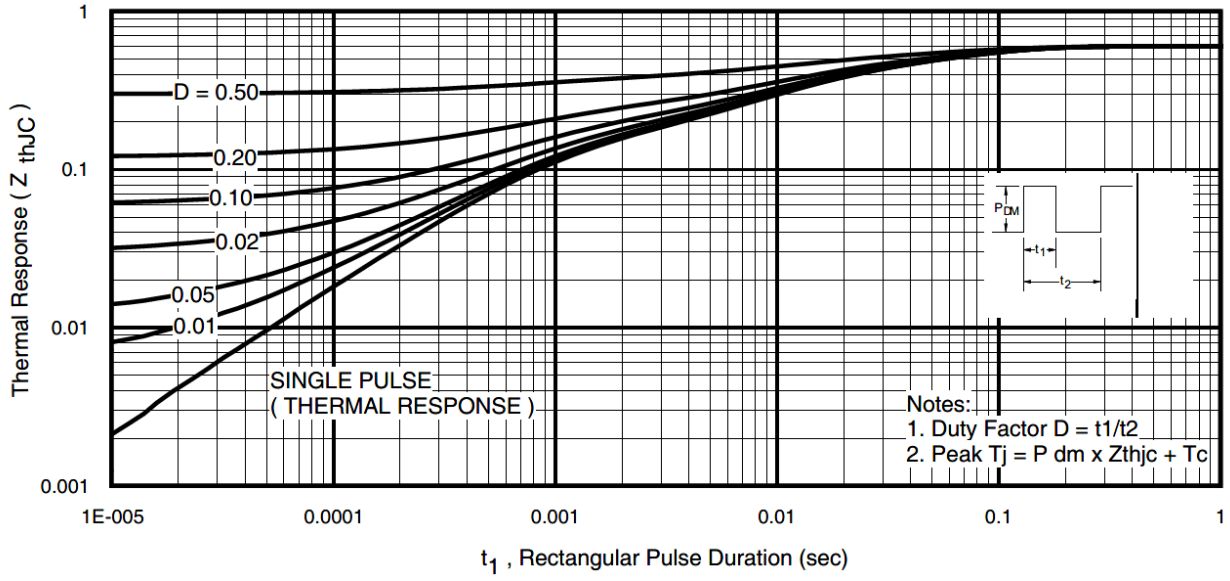
	Inspection 1/ 2/ 3/	MIL-STD-750		Symbol	Pre-irradiation limits		Post-irradiation limits		Unit
		Method	Conditions		R and F		R and F		
					Min	Max	Min	Max	
	Subgroup 1 Not applicable								
	Subgroup 2		T_C = + 25°C						
	Steady-state total dose irradiation (V_{GS} bias) 4/	1019	Condition A, V_{GS} = 12 V; V_{DS} = 0						
	Steady-state total dose irradiation (V_{DS} bias) 4/	1019	Condition A, V_{GS} = 0; V_{DS} = 80 percent of rated V_{DS}(pre-irradiation)						
	End-point electricals:								
	Breakdown voltage, drain to source	3407	Bias condition C, V_{GS} = 0; I_D = 1 mA	$V_{(BR)DSS}$					
	2N7652T1, U2A				60		60		V dc
*	2N7653U2A				100		100		V dc
	Gate to source voltage (threshold)	3403	$V_{DS} \geq V_{GS}$, I_D = 6 mA	$V_{GS(th)1}$	2.0	4.0	2.0	4.0	V dc
	Gate current	3411	Bias condition C, V_{GS} = +20 V; V_{DS} = 0	I_{GSSF1}		100		100	nA dc
	Gate current	3411	Bias condition C, V_{GS} = -20 V; V_{DS} = 0	I_{GSSR1}		-100		-100	nA dc
	Drain current	3413	Bias condition C, V_{GS} = 0 V_{DS} = 80 percent of rated V_{DS} (pre-irradiation)	I_{DSS}		1.0		1.0	µA dc
	Static drain to source on-state voltage	3405	V_{GS} = 12 V; I_D = I_{D2} condition A, pulsed (see 4.5.1)	$V_{DS(on)}$					
	2N7652T1 5/					0.315		0.315	V dc
	2N7652U2A 5/					0.400		0.400	V dc
*	2N7653U2A 5/					0.605		0.605	V dc
	Forward voltage source drain diode 5/	4011	Bias condition A, V_{GS} = 0; I_D = I_{D1}	V_{SD}		1.2		1.2	V dc

1/ For sampling plan, see MIL-PRF-19500.
2/ Group D qualification may be performed prior to lot formation. Wafers qualified to these group D QCI requirements may be used for any other specification sheets utilizing the same die design.
3/ At the manufacturer's option, group D samples need not be subjected to the screening tests, and may be assembled in its qualified package or in any qualified package that the manufacturer has data to correlate the performance to the designated package.
4/ Separate samples shall be pulled for each bias. Devices supplied to this specification sheet have been characterized through levels R and F of irradiation. Pre and Post irradiation values are identical unless otherwise specified in Table II. When performing post irradiation electrical measurements for any RHA level, TA = +25°C (see 1.6 herein).
5/ Group D samples are built and tested in T0-3 packages. The equivalent pre-radiation and post radiation limit for $V_{DS(on)}$ in the T0-3 package is 0.257Vdc (at I_D = 45A) for the 2N7652T1, 0.450Vdc (at I_D = 75A) for the 2N7652U2A, and 0.75Vdc (at 75A) for the 2N7653U2A.

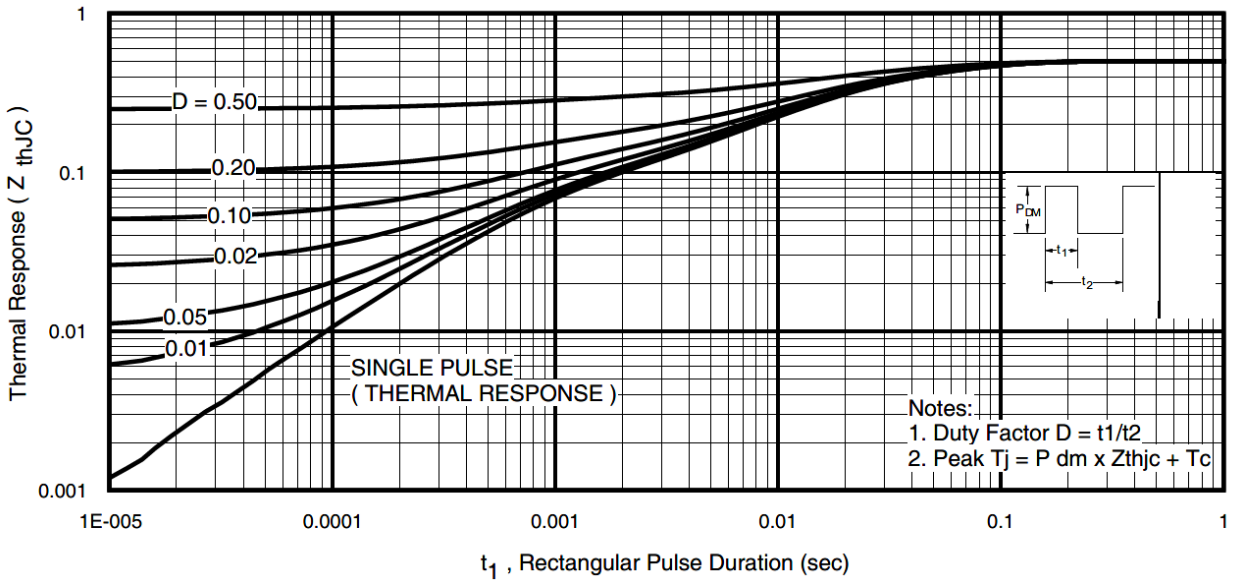
TABLE III. Group E inspection (all quality levels) for qualification or re-qualification only.

Inspection	MIL-STD-750		Sample plan
	Method	Conditions	
Subgroup 1			45 devices c = 0
Temperature cycling	1051	Condition G, -55°C to +150°C, 500 cycles	
Hermetic seal Fine leak Gross leak	1071	As applicable.	
Electrical measurements		See table I, subgroup 2 herein.	
Subgroup 2 1/			45 devices c = 0
Steady-state gate bias	1042	Condition B, 1,000 hours.	
Electrical measurements		See table I, subgroup 2 herein.	
Steady-state reverse bias	1042	Condition A, 1,000 hours.	
Electrical measurements		See table I, subgroup 2 herein.	
Subgroup 3			n = 45, c = 0
Not applicable			
Subgroup 4			Sample size N/A
Thermal impedance curves		See MIL-PRF-19500.	
Subgroup 5 Not applicable			
Subgroup 10			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		
Subgroup 11			3 devices
SEE 2/ 3/	1080	See MIL-STD-750 method 1080 and 6.2.	

1/ A separate sample for each test shall be pulled.
2/ Group E qualification of SEE testing may be performed prior to lot formation. Qualification may be extended to other specification sheets utilizing the same structurally identical die design.
3/ Device qualification to a higher level linear energy transfer (LET) is sufficient to qualify all lower level LETs.

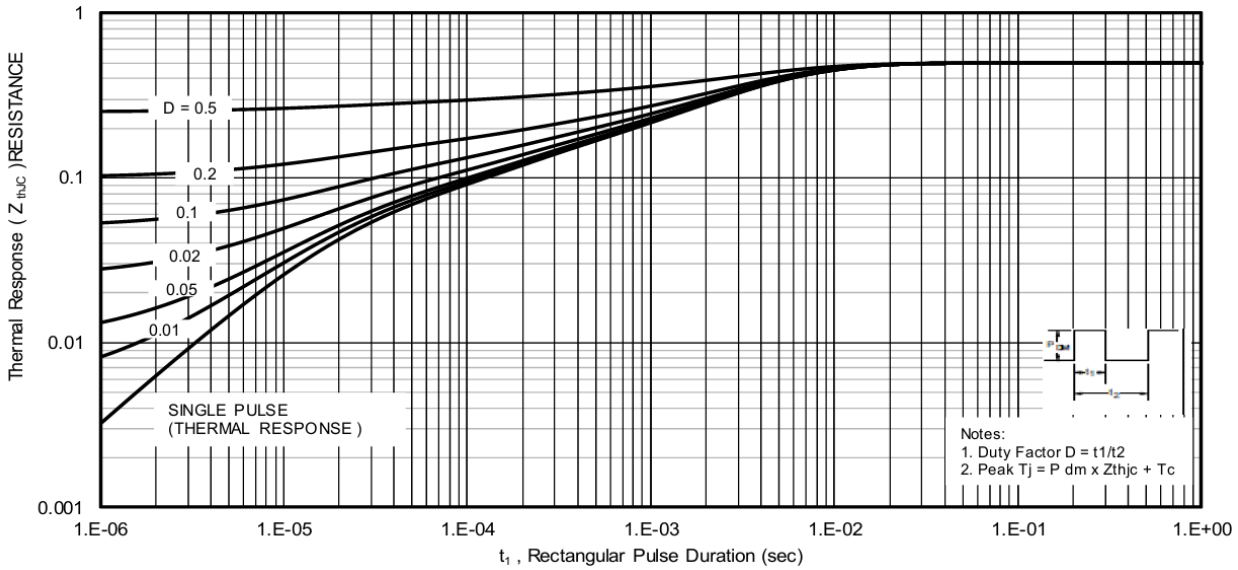


2N7652T1



2N7652U2A

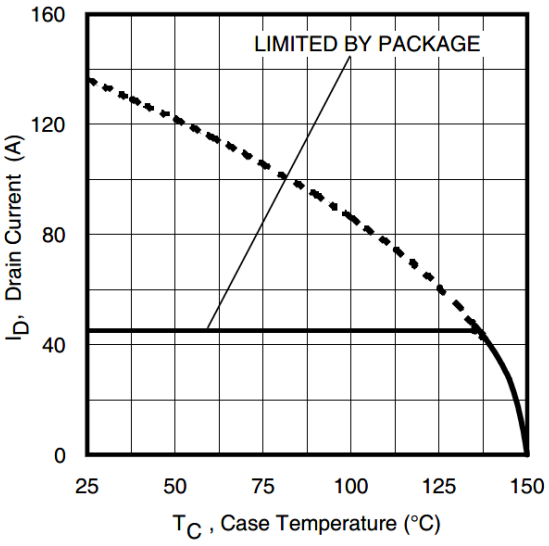
FIGURE 3. Thermal response curve.



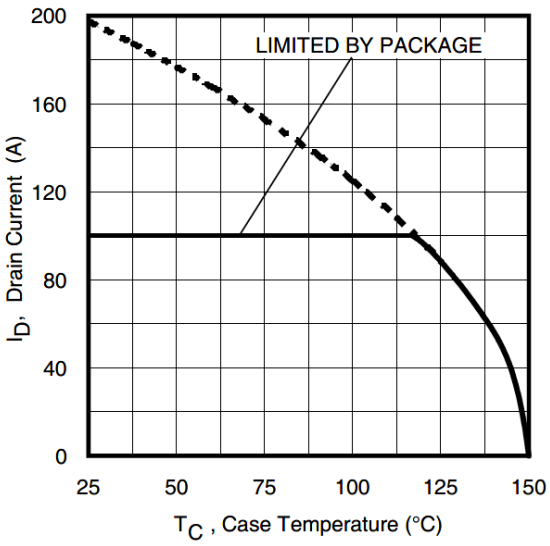
2N7653U2A

* FIGURE 3. Thermal response curve – Continued

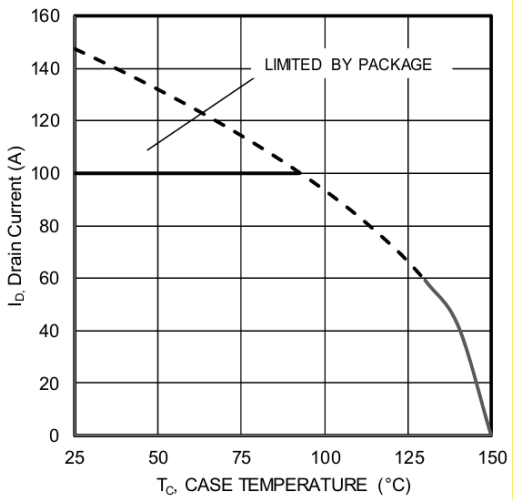
Maximum Current Rating



2N7652T1

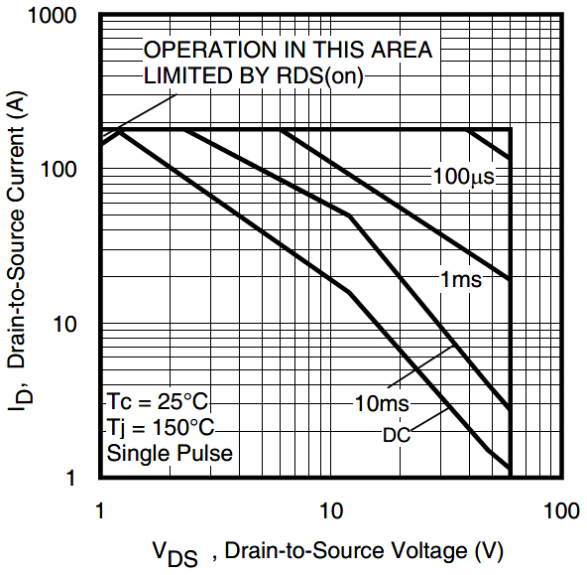


2N7652U2A

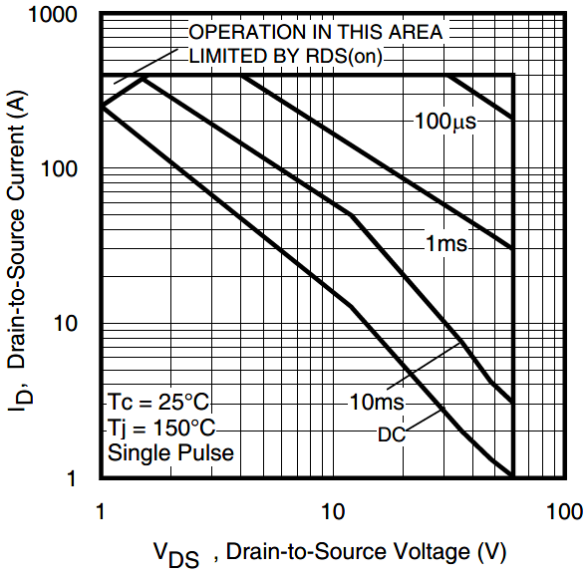


2N7653U2A

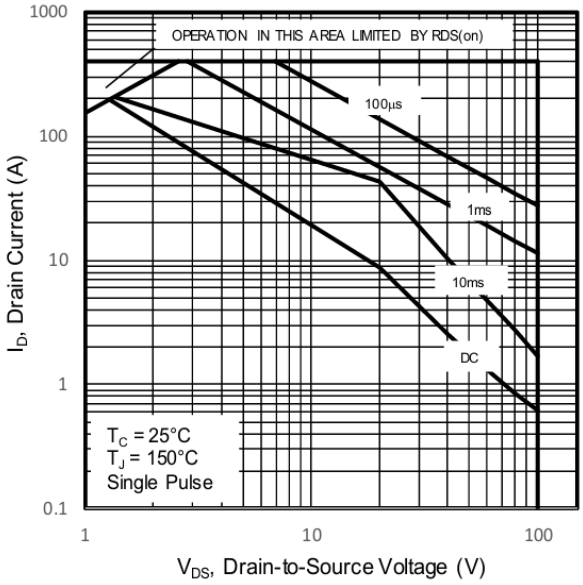
* FIGURE 4. Maximum drain current versus case temperature graphs.



2N7652T1



2N7652U2A



2N7653U2A

* FIGURE 5. Safe operating area graph.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When 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. The notes specified in MIL-PRF-19500 are applicable to this specification.)

6.1 Intended use. Semiconductors conforming to this specification are intended for original equipment design applications and logistic support of existing equipment.

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 finish (see 3.4.1).

d. The complete PIN, see 1.5 and 6.6.

e. For acquisition of RHA designated devices, table II, subgroup 1 testing of group D herein is optional. If subgroup 1 is desired, it should be specified in the contract or order.

f. If SEE testing data is desired, it should be specified in the contract or order.

g. If specific SEE characterization conditions are desired (see section 6.7 and table IV), manufacturer's cage code should be specified in the contract or order.

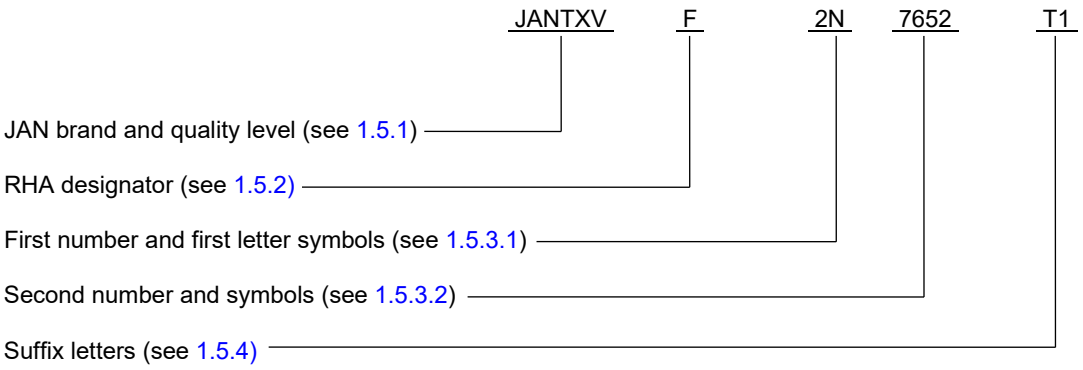
6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Manufacturers List (QML 19500) whether or not such products have actually been so listed by that date. The attention 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 DLA Land and Maritime, ATTN: VQE, P.O. Box 3990, Columbus, OH 43218-3990 or e-mail vqe.chief@dla.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://qpldocs.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) (without JAN and RHA prefix). This information in no way implies that manufacturer's PINs are substitutable for the military PIN.

Preferred types military PIN	Commercial PIN
2N7652T1	IRHMS9A7064
2N7652U2A	IRHNS9A7064
2N7653U2A	IRHNS9A7160

*

6.5 PIN construction example. The PINs for encapsulated devices are constructed using the following form.



* 6.6 List of PINs. The following is a list of possible PINs (without JAN brand) available on this specification sheet.

PINs for devices of the "TXV" quality level	PINs for devices of the "S" quality level
JANTXVF2N7652T1	JANSF2N7652T1
JANTXVR2N7652T1	JANSR2N7652T1
JANTXVF2N7652U2A	JANSF2N7652U2A
JANTXVR2N7652U2A	JANSR2N7652U2A
* JANTXVF2N7653U2A	JANSF2N7653U2A
* JANTXVR2N7653U2A	JANSR2N7653U2A

1/ The PIN is also available without an RHA designator.
2/ DLA Land and Maritime maintains an online database of all current sources of supply at https://landandmaritimeapps.dla.mil/Downloads/QPLQML/19500/QPDSIS_19500.pdf/

6.7 Application data.

6.7.1 Manufacturer specific irradiation data. Each manufacturer qualified to this specification sheet has characterized its devices to the requirements of MIL-STD-750 method 1080 and as specified herein. Since each manufacturer's characterization conditions can be different and can vary by the version of method 1080 qualified to, the MIL-STD-750 method 1080 revision version date and conditions used by each manufacturer for characterization have been listed here (see table IV) for information only. SEE (SEB and SEGR) conditions and figures listed in section 6 are current of the date of this specification sheet, please contact the manufacturer for the most recent conditions.

TABLE IV. Manufacturers characterization conditions.

Manufacturers CAGE	Inspection	MIL-STD-750		Sample plan
		Method	Conditions	
69210	SEE 1/	1080	See MIL-STD-750 method 1080 and figure 6	3 devices
	Pre SEB/SEGR Electrical measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	
	SEE irradiation		Fluence = 3E5 ions/cm^2 Flux = 4E3 to 4E4 ions/cm^2/sec, temperature = 25 ±5°C	
	2N7652T1, 2N7652U2A		Surface LET = 38 MeV-cm2/mg, range = 43 µm, Kr ion beam energy = 355 MeV In-situ bias conditions: V_{DS} = 60 V and V_{GS} = -10 V (Typical 4.23 MeV/Nucleon at Texas A & M Cyclotron)	
*	2N7653U2A		Surface LET = 37 MeV-cm2/mg, range = 50 µm, Kr ion beam energy = 417 MeV In-situ bias conditions: V_{DS} = 100 V and V_{GS} = -10 V (Typical 4.97 MeV/Nucleon at Texas A & M Cyclotron)	
	Post SEB/SEGR Electrical measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	
	SEE 1/	1080	See MIL-STD-750 method 1080	3 devices
	Pre SEB/SEGR Electrical measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	
	SEE irradiation		Fluence = 3E5 percent ions/cm^2 Flux = 4E3 to 4E4 ions/cm^2/sec, temperature = 25 ±5°C	
	2N7652T1, 2N7652U2A		Surface LET = 60 MeV-cm2/mg, range = 60 µm, energy = 753MeV In-situ bias conditions: V_{DS} = 60 V and V_{GS} = -10 V; (Typical 5.84 MeV/Nucleon at Texas A & M Cyclotron)	
*	2N7653U2A		Surface LET = 59.8 MeV-cm2/mg, range = 60 µm, Xe ion beam energy = 753MeV In-situ bias conditions: V_{DS} = 100 V and V_{GS} = -10 V; (Typical 5.84 MeV/Nucleon at Texas A & M Cyclotron)	
	Post SEB/SEGR Electrical Measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	

See footnote at end of table.

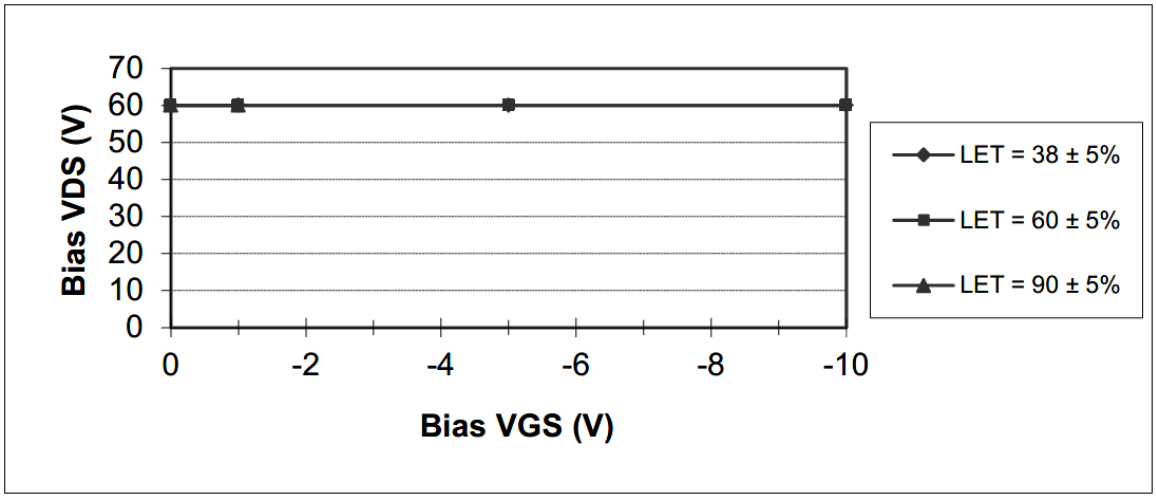
TABLE IV. Manufacturers characterization conditions - continued.

Manufacturer CAGE	Inspection	MIL-STD-750		Sample plan
		Method	Conditions	
69210	SEE 1/	1080	See MIL-STD-750 method 1080 and figure 6	3 devices
	Pre SEB/SEGR Electrical measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	
	SEE irradiation		Fluence = 3E5 percent ions/cm^2 Flux = 4E3 to 4E4 ions/cm^2/sec, temperature = 25 ±5°C	
	2N7652T1, 2N7652U2A		Surface LET = 90 MeV-cm2/mg, range = 82 µm, energy = 1515 MeV In-situ bias conditions: V_{DS} = 60 V and V_{GS} = -1 V (Typical 7.7 MeV/Nucleon at Texas A & M Cyclotron)	
*	2N7653U2A		Surface LET = 89.8 MeV-cm2/mg, range = 82 µm, Au ion beam energy = 1515 MeV In-situ bias conditions: V_{DS} = 100 V and V_{GS} = -1 V (Typical 7.7 MeV/Nucleon at Texas A & M Cyclotron)	
	Post SEB/SEGR Electrical measurements		I_{GSSF1}, I_{GSSR1}, and I_{DSS1} in accordance with table I, subgroup 2	
Upon qualification, all manufacturers will provide the verification test conditions to be added to this table.				

1/ I_{GSSF1}, I_{GSSR1}, and I_{DSS1} parameters were examined before and following SEE irradiation to determine acceptability for each bias conditions. Other test conditions in accordance with table I, subgroup 2, may be performed at the manufacturer's option.

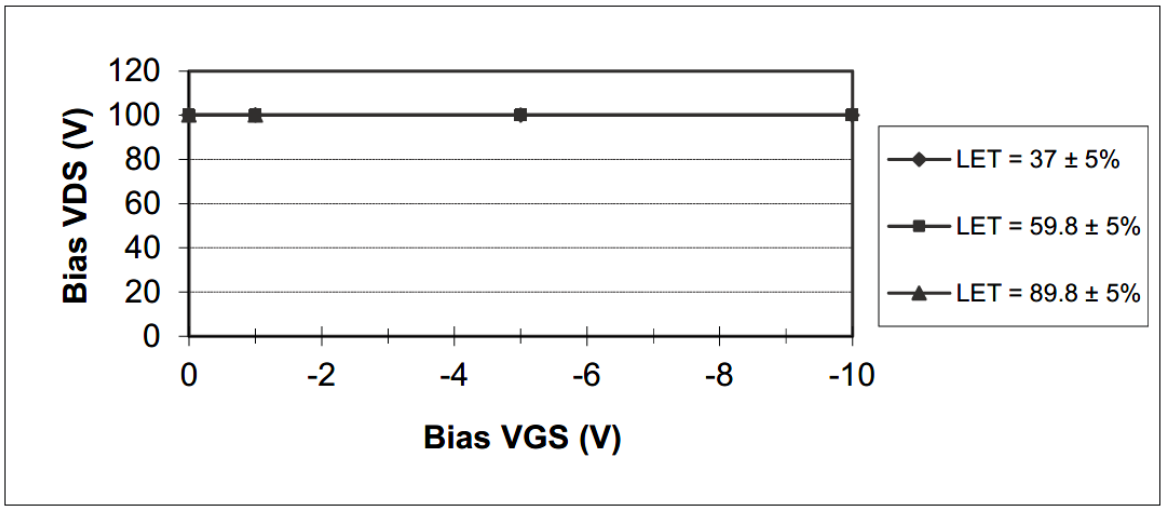
2/ Manufacturer performed heavy ion SEE(SEB/SEGR) test at TAMU Radiation Effects Facility for the MOSFET technology devices in accordance with TM1080 of MIL-STD-750. No single event burnout (SEB) and Single event gate rupture (SEGR) were observed to surface LET as stated above table IV and safe operating area (see figure 5). Limits are characterized at initial qualification and after any design or process changes which may affect the SEE(SEB/SEGR) characteristics. For more information on SEE (SEB/SEGR) test results, customers are requested to contact the manufacturer.

Typical SEB/SEGR RESPONSE



2N7652T1, 2N7652U2A

Single-Event-Effects RESPONSE



2N7653U2A

* FIGURE 6. SEE safe operating area graph.

6.8 Request for new types and configurations. Requests for new device types or configurations for inclusions in this specification sheet should be submitted to: DLA Land and Maritime, ATTN: VAC, Post Office Box 3990, Columbus, OH 43218-3990 or by electronic mail at Semiconductor@dla.mil or by facsimile (614) 692-6939 or DSN 850-6939.

* 6.9 Amendment notations. The margins of this specification are marked with asterisks to indicate modifications generated by this amendment. 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 - SH
Air Force - 85
NASA - NA
DLA - CC

Review activity:
Army - AV, MI
Air force - 19

Preparing activity:
DLA - CC

(Project 5961-2021-058)

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 https://assist.dla.mil/.