Renesas Radiation Hardened GaN FET Screening and QCI Flow

This document outlines the production flow and lot assurance testing for Renesas Radiation Hardened GaN FET Products for space applications. Refer to the datasheet for each device for more information specific to that device.

Contents

1. Introduction

The production flow detailed in this document is in accordance with MIL-PRF-38535L. Products that refer to this document are produced, screened, and tested to MIL-PRF-38535L Class V standards, except for the wafer fabrication facility audit. The wafer fabrication facility audit is the only deviation from MIL-PRF-38535L Class V standards. Unless otherwise specified, this applies to hermetically sealed packaged products. Note: Renesas does not support source inspection (pre-cap or final) on die or packaged parts.

2. Production Flow

This section outlines the production flow that Renesas Radiation Hardened GaN FET parts receive after assembly. This production flow, group, and sub-group names are in accordance with MIL-PRF-38535L.

After parts have been assembled, all units go through the Production Screening Procedure, detailed further in Production Screening Procedure. After the FETs pass the Production Screening Procedure, sample selection for Quality Conformance Inspection (QCI) occurs, discussed further in Quality Conformance Inspection. The remaining FETs go on quality hold pending QCI recommendation. Finally, when QCI has passed, the FETs placed on quality hold move into inventory and become orderable. If the sampled FETs fail QCI, the FETs on quality hold are scrapped and can never be ordered.

The flowcharts in this document are used as a visual representation of the production screening and QCI flow. All tests shown are performed in accordance with MIL-PRF-38535L; however, the order of the tests is subject to change based on manufacturing needs.

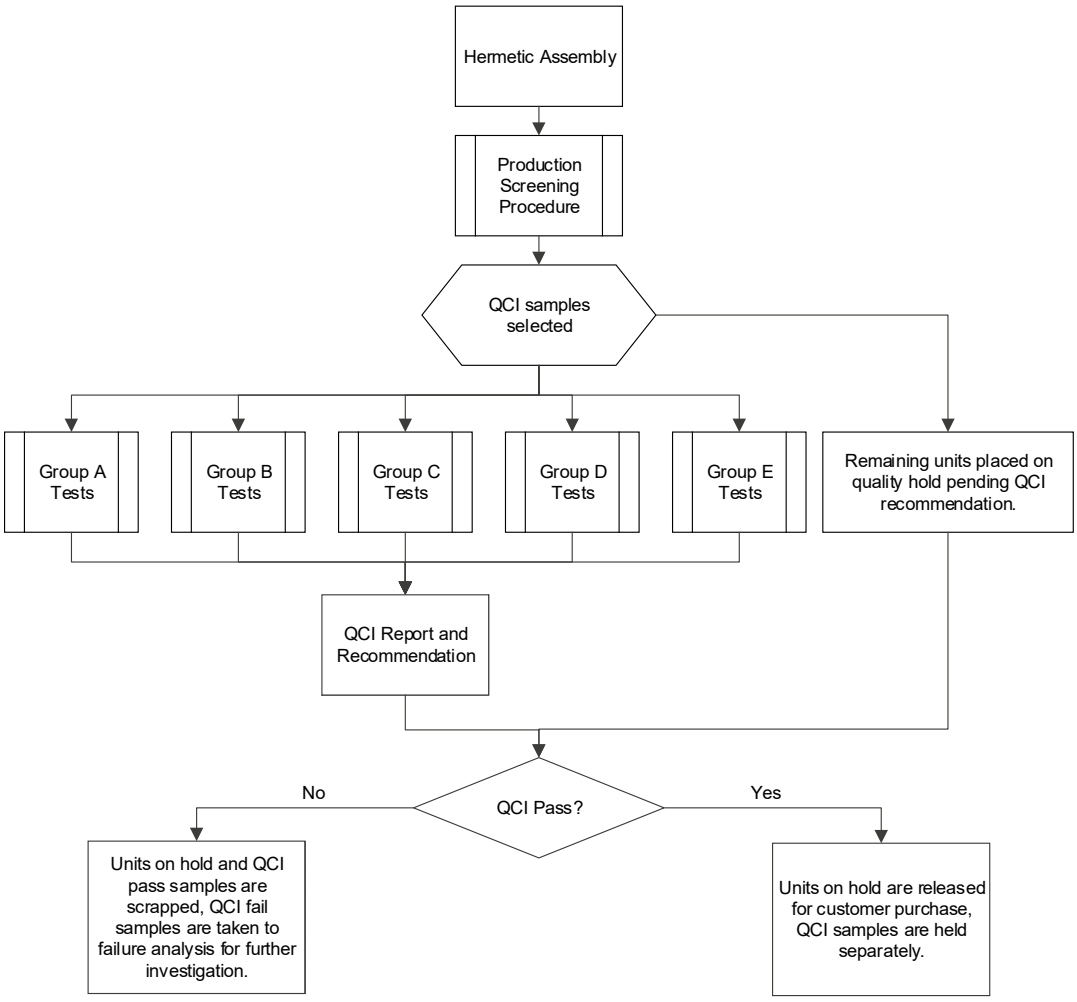

Figure 1. Radiation Hardened GaN FET Production Flow Chart

3. Production Screening Procedure

This section outlines the production screening that 100% of Renesas Radiation Hardened GaN FET units receive. This production screening follows MIL-PRF-38535L Table 1A.

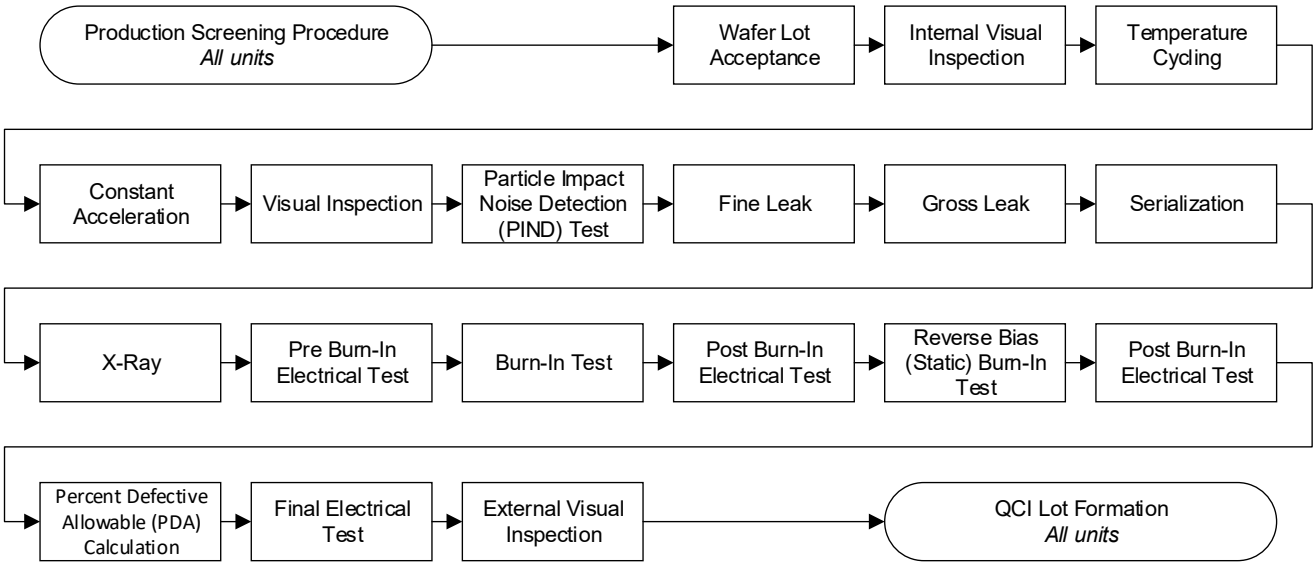

Figure 2. Production Screening Procedure Flow Chart

Table 1. Production Screening Test Procedure Method Descriptions

Test	Test Method	Notes
Wafer Lot Acceptance	MIL-STD-883 TM5007	
Internal Visual Inspection	MIL-STD-883 TM2010	Condition A, inspection for die cracking or chipping
Temperature Cycling	MIL-STD-883 TM1010	Condition C, 10 cycles
Constant Acceleration	MIL-STD-883 TM2001	Condition E (minimum), Y1 orientation only
Visual Inspection	100%	
Particle Impact Noise Detection (PIND) Test	MIL-STD-883 TM2020	Condition A on each device
Fine Leak	MIL-STD-883 TM1014	
Gross Leak	MIL-STD-883 TM1014	
Serialization	100%	
X-Ray	MIL-STD-883 TM2012	
Pre Burn-In Electrical Test	Per device specification, read and record	
Burn-In Test[1]	MIL-STD-883 TM1015	Condition D, 240 hours at 125°C or 180 hours at 135°C
Post Burn-In Electrical Test	Per device specification, read and record at 25°C	
Reverse Bias (Static) Burn-In Test[1]	MIL-STD-883 TM1015	Condition A, 144 hours at 125°C or 108 hours at 135°C
Percent Defective Allowable (PDA) Calculation	5% PDA, 3% PDA for functional parameters at 25°C including deltas	

Table 1. Production Screening Test Procedure Method Descriptions (Cont.)

Test	Test Method	Notes
Final Electrical Test	Per device specification	25°C, min., and max. operating temperatures
External Visual Inspection	MIL-STD-883 TM2009	

1. From *MIL-PRF-38535L Table 1A, Footnote 16*: The reverse bias burn-in is a requirement only when specified in the applicable device specification and is recommended only for a certain MOS, linear or other microcircuits where surface sensitivity may be a concern. When reverse bias burn-in is not required, interim post burn-in electrical parameter measurements shall be omitted. The order of performing the burn-in test and the reverse bias burn-in test may be inverted. Static burn-in may be substituted for high temperature reverse bias burn-in based on device technology and must be approved by the QA. Moreover, burn-in time-temperature regression table I of TM1015 of MIL-STD-883 can be used for determination of reverse bias burn-in time and temperature.

4. Quality Conformance Inspection

This section outlines the Quality Conformance Inspection testing that follows the production screening procedure.

After units undergo the production screening procedure outlined in Production Screening Procedure, samples are selected for Quality Conformance Inspection (QCI). The FETs not selected for QCI are held for customer purchase, pending QCI recommendation.

QCI testing is completed in accordance with MIL-PRF-38535L, which includes the test methods used, the number of samples selected, and the frequency of testing. Group and sub-group names are also in accordance with MIL-PRF-38535L.

Table 2. QCI Sampling Quantities and Frequencies

Test	Minimum Number of Samples (Allowed Fails)	Frequency
Group A Tests	116 (0)	Every inspection lot
Group B Tests (Subgroup 1)	3(0)	Every inspection lot
Group B Tests (Subgroup 3)	3(0)	Every inspection lot
Group C Tests	45(0)	Every wafer lot
Group D Tests (Subgroup 1)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 2)	3(0)	Per package type, every 6 months
Group D Tests (Subgroup 3)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 4)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 5)	15(0)	Per package type, every 6 months
Group D Tests (Subgroup 6)	3(0)	Per package type, every 6 months
Group E Tests (Subgroup 2)	4(0)	Every wafer

4.1 Group A Tests

As a part of QCI, Group A Tests (*Electrical Tests*) are performed, shown in Figure 3. These tests are in accordance with MIL-PRF-38535L Table 3.

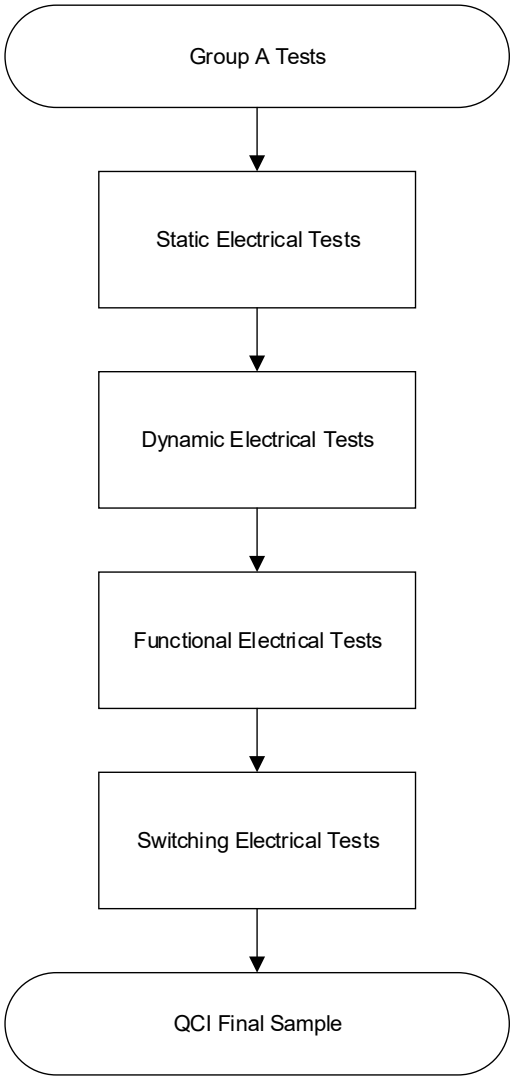

Figure 3. Group A Testing Flow Chart

Table 3. Group A Test Method Descriptions

Test	Test Method	Notes
Static Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Dynamic Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Functional Electrical Tests	Per device specification	25°C, min., and max. operating temperatures
Switching Electrical Tests	Per device specification	25°C, min., and max. operating temperatures

4.2 Group B Tests

As a part of QCI, Group B Tests (*Mechanical and Environmental Tests*) are performed, shown in Figure 4. These tests are in accordance with MIL-PRF-38535L Table 2.

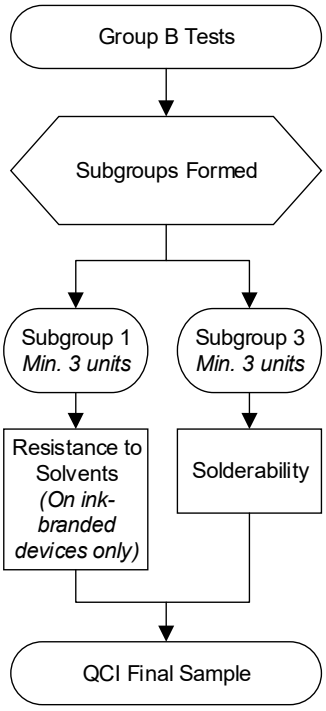

Figure 4. Group B Testing Flow Chart

Table 4. Group B Test Methods

Test	Test Method	Notes
Resistance to Solvents	MIL-STD-883 TM2015	
Solderability	MIL-STD-883 TM2003	22 leads from a min. of 3 devices, solder temperature +245°C ± 5°C

4.3 Group C Tests

As a part of QCI, Group C Tests (*Life Tests*) are performed, shown in Figure 5. These tests are in accordance with MIL-PRF-38535L Table 4.

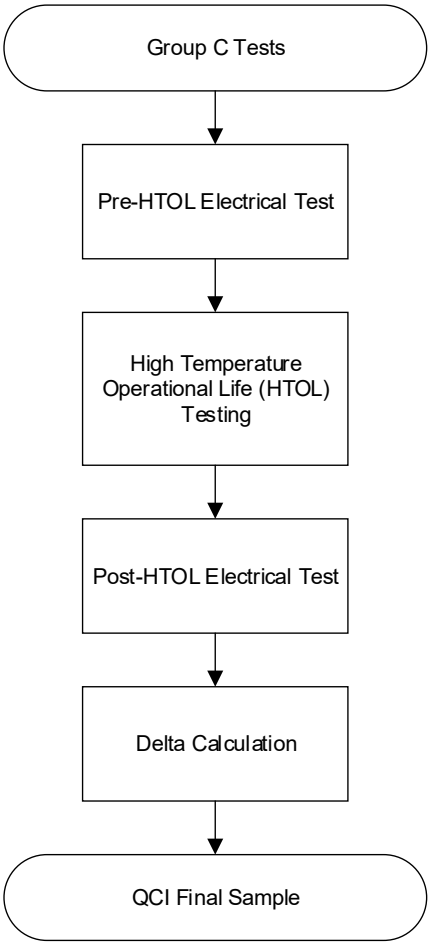

Figure 5. Group C Testing Flow Chart

Table 5. Group C Test Method Descriptions

Test	Test Method	Notes
Pre-HTOL Electrical Test	Per device specification	25°C, min., and max. operating temperatures
High Temperature Operational Life (HTOL) Testing	MIL-STD-883 TM1005	Condition D, T_A = 125° C, 1000 hours min. or T_A = 135° C, 800 hours min.
Post-HTOL Electrical Test	Per device specification	25°C, min., and max. operating temperatures
Delta Calculation		25°C

4.4 Group D Tests

As a part of QCI, Group D Tests (*Package Related Tests*) are performed, shown in Figure 6. These tests are in accordance with MIL-PRF-38535L Table 5.

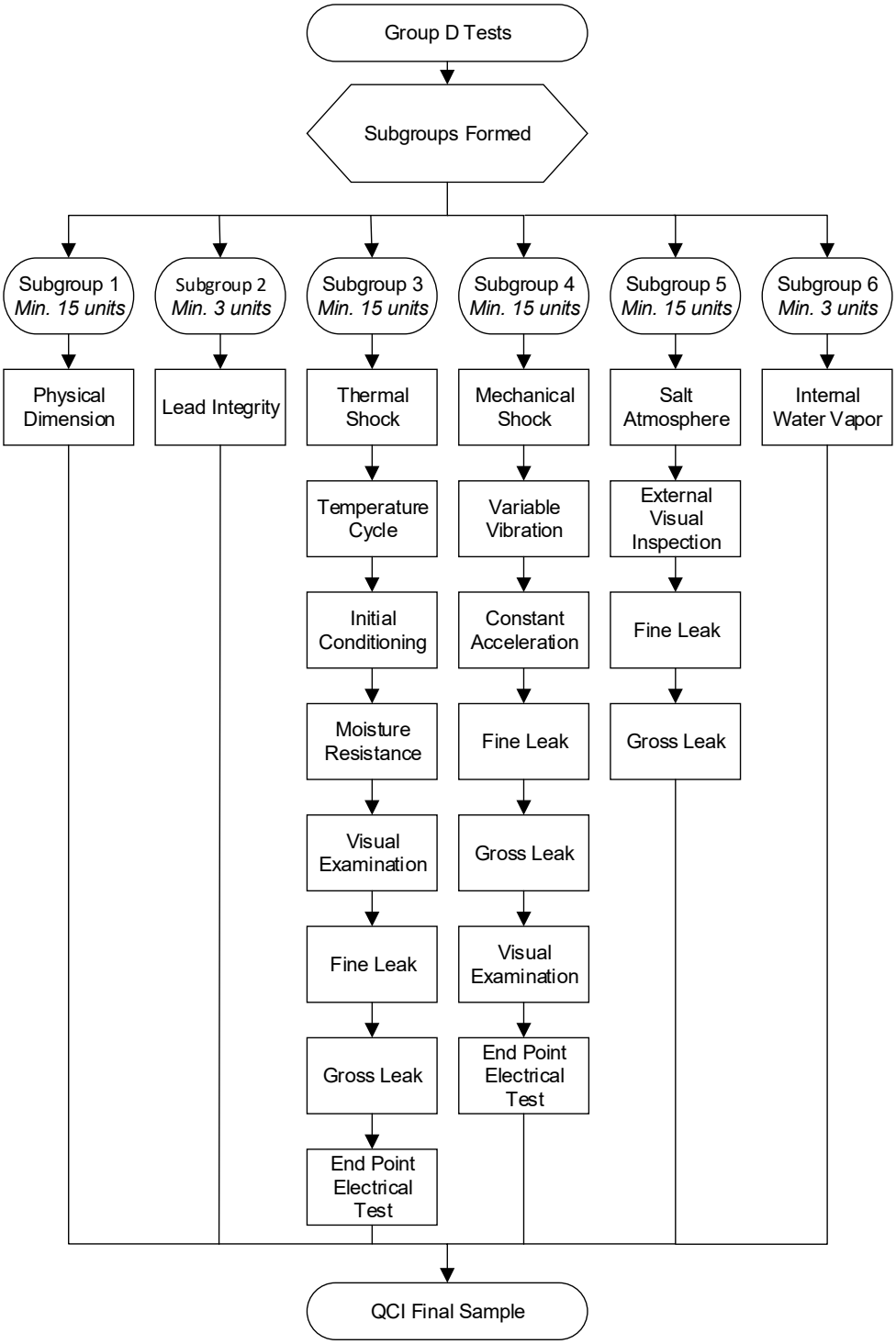

Figure 6. Group D Testing Flow Chart

Table 6. Group D Test Method Descriptions

Test	Test Method	Notes
Physical Dimension	MIL-STD-883 TM2016	
Lead Integrity	MIL-STD-883 TM2004 and/or MIL-STD-883 TM2028	Sample size is 45 leads with zero failure from a minimum of 3 devices. For LLC packages only, sample size is 15 leads from a minimum of 3 devices.
Thermal Shock	MIL-STD-883 TM1011	Condition B, 15 cycles, -55°C to 125°C
Temperature Cycle	MIL-STD-883 TM1010	Condition C, 100 cycles
Moisture Resistance	MIL-STD-883 TM1004	
Visual Examination (*Subgroup 3*)	MIL-STD-883 TM1004 or MIL-STD-883 TM1010	
End Point Electrical Test	Per device specification	
Mechanical Shock	MIL-STD-883 TM2002	Condition B (min.)
Variable Vibration	MIL-STD-883 TM2007	Condition A (min.), 20-2kHz
Constant Acceleration	MIL-STD-883 TM2001	Condition E (min.), Y1 orientation only
Visual Examination (*Subgroup 4*)	MIL-STD-883 TM2007	
Salt Atmosphere	MIL-STD-883 TM1009	Condition A (min.)
Fine Leak	MIL-STD-883 TM1014	
Gross Leak	MIL-STD-883 TM1014	
External Visual Inspection	MIL-STD-883 TM1009	
Internal Water Vapor	MIL-STD-883 TM1018	5000 ppm max. water content at 100°C

4.5 Group E Tests

As a part of QCI, Group E Tests (*Radiation Hardness Assurance Tests*) are performed, shown in Figure 7. These tests are in accordance with MIL-PRF-38535L Table C-1.

For Group E tests, the radiation levels a given device is qualified to can be found on its respective datasheet and radiation reports.

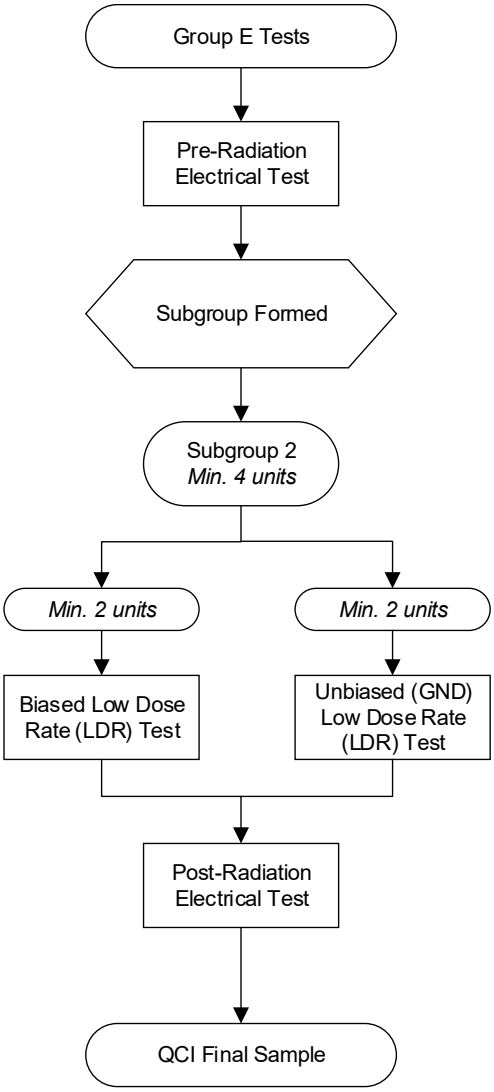

Figure 7. Group E Testing Flow Chart

Table 7. Group E Test Method Descriptions

Test	Test Method	Notes
Pre-Radiation Electrical Test	Per device specification, read and record	
Biased Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Unbiased (GND) Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Post-Radiation Electrical Test	Per device specification, read and record	

5. Up-Front Characterization and Qualification

This section outlines the one-time, up-front characterization and qualification that products receive. These tests are only performed during initial qualification or after any major design and/or process change, and are in accordance with MIL-PRF-38535L. These tests are performed in addition to the standard production screening flow and quality conformance inspection.

Table 8. Up-Front Characterization Samples

Test Group	Test	Minimum Number of Samples
Package Related Tests	All Tests	3(0)
Device Related Tests	Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Test	3(0)
Device Related Tests	Charge Device Model (CDM) Electrostatic Discharge (ESD) Sensitivity Test	3(0)
Radiation Related Tests	Biased Low Dose Rate (LDR) Test	10(0)
Radiation Related Tests	Unbiased (GND) Low Dose Rate (LDR) Test	10(0)
Radiation Related Tests	Single Event Burnout (SEB) Test	4(0)

5.1 Package Related Tests

As a part of one-time, up-front characterization, certain package related tests are performed, as shown in Figure 8. These tests are in accordance with MIL-PRF-38535L Table 5, Subgroup 9. Refer to *MIL-PRF-38535L Table A-1* for further information.

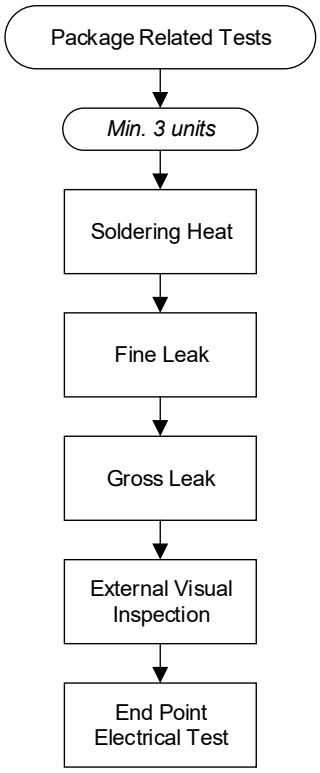

Figure 8. Up-Front Characterization Package Related Tests Flowchart

Table 9. Up-Front Characterization Package Related Test Descriptions

Test	Test Method	Notes
Soldering Heat	MIL-STD-883 TM2036	
Fine Leak	MIL-STD-883 TM1014	
Gross Leak	MIL-STD-883 TM1014	
External Visual Inspection	MIL-STD-883 TM2009	
End Point Electrical Test	Per device specification	

5.2 Device Related Tests

As a part of one-time, up-front characterization, certain device related tests are performed, as shown in Figure 9. These tests are in accordance with MIL-PRF-38535L Appendixes A and H.

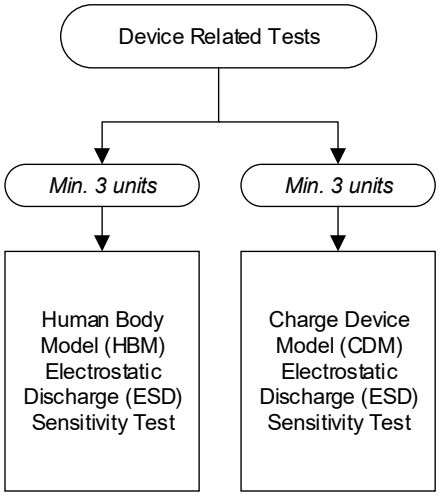

Figure 9. Up-Front Characterization Device Related Tests Flowchart

Table 10. Up-Front Characterization Device Related Test Descriptions

Test	Test Method	Notes
Human Body Model (HBM) Electrostatic Discharge (ESD) Sensitivity Test	MIL-STD-883 TM3015 or JEDEC Test Standard JS-001	Assembly and test areas use JESD625 specification controls
Charge Device Model (CDM) Electrostatic Discharge (ESD) Sensitivity Test	MIL-STD-883 TM3015 or JEDEC Test Standard JS-002	

5.3 Radiation Related Tests

As a part of one-time, up-front characterization, certain radiation-related tests are performed, as shown in Figure 10. Refer to *MIL-PRF-38535L Table C-1* for further information.

The radiation levels that a given device is qualified to can be found on its respective datasheet and radiation test reports.

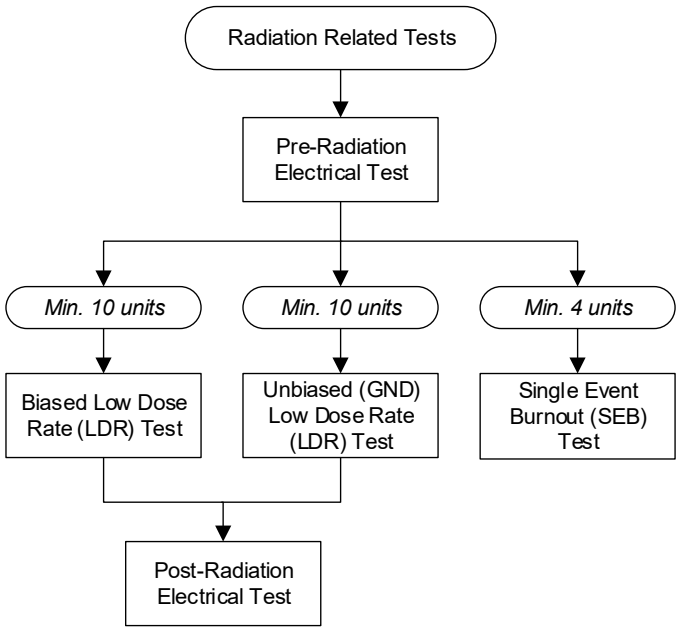

Figure 10. Up-Front Characterization Radiation Related Tests Flowchart

Table 11. Up-Front Characterization Radiation Related Tests

Test	Test Method	Notes
Pre-Radiation Electrical Test	Per device specification, read and record	25°C
Biased Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Unbiased (GND) Low Dose Rate (LDR) Test	MIL-STD-883 TM1019	Radiation level as per device specification
Post-Radiation Electrical Test	Per device specification, read and record	25°C
Single Event Burnout (SEB)	JEDEC Test Standard JESD57A, per device specification	Radiation level as per device specification to assess burnout and latch-up in a heavy ion environment

6. Revision History

Revision	Date	Description
1.00	Feb 13, 2023	Initial release.

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