ATTACHMENT 6

AEC - Q100-006 REV-D

ELECTRO-THERMALLY INDUCED PARASITIC GATE LEAKAGE TEST (GL)
Acknowledgment

Any document involving a complex technology brings together experience and skills from many sources. The Automotive Electronics Counsel would especially like to recognize the following significant contributors to the development of this document:

Mark A. Kelly    Delphi Delco Electronics Systems
Change Notification

The following summary details the changes incorporated into AEC-Q100-006 Rev-D:

- **Sections 3.5, 3.5.1, and 3.5.2**: Deleted section title 3.5, Detailed Procedure. Changed section 3.5.1 to section 3.5 and section 3.5.2 to section 3.6.
METHOD - 006

ELECTRO-THERMALLY INDUCED PARASITIC GATE LEAKAGE (GL) TEST

Text enhancements and differences made since the last revision of this document are shown as underlined areas.

1. SCOPE

1.1 Description

The purpose of this specification is to establish a reliable and repeatable procedure for determining surface mount integrated circuit susceptibility to Electro-Thermally Induced Parasitic Gate Leakage (GL). This specification may also be used as an evaluation tool for determining the susceptibility of circuit designs, molding compounds, fabrication processes, and post mold cure processes to GL.

1.2 Reference Documents

Not applicable.

1.3 Terms and Definitions

The terms used in this specification are defined as follows:

1.3.1 Device Failure

A condition in which a device does not meet all the requirements of the acceptance criteria, as specified in section 5, following the GL test.

1.3.2 DUT

An electronic device being evaluated for its sensitivity to GL.

1.3.3 Electro-Thermally Induced Parasitic Gate Leakage (GL)

A trapped-charge phenomenon affecting plastic encapsulated integrated circuits in varying degrees depending upon circuit design, fabrication technology, molding compound, and post mold cure profile. The phenomena occurs at high temperature when an electric field (E-field) is present. GL results in yield losses during high temperature processes, especially those with heated air flow (e.g., high temperature handling and IR reflow solder operations). The phenomena can be detected as an increase in Icc, input leakage, pin parametrics degradation, or functional failure. GL does not cause permanent damage and can be reversed by a 4 hour unbiased bake at a temperature of 125 °C (or 2 hours at 150 °C).
1.3.4 Electro-Thermally Induced Parasitic Gate Leakage (GL) Sensitivity

A GL level resulting in device failure. Sensitivity will vary depending upon the design, layout, process, and materials used.

2. EQUIPMENT

2.1 Test Apparatus

The apparatus required for this test consists of a GL test fixture, high voltage power supply, and thermal chamber. Figure 1 shows an equivalent test setup.

![GL Test Fixture and Set-up](image)

**Figure 1: GL Test Fixture and Set-up**

2.1.1 GL Test Fixture

A test fixture as illustrated in Figure 1 and Appendix A. Other equivalent test fixture configurations may be used, but the actual fixture must meet the following requirements:

1. The tungsten probe must be at a height of $2.5 \pm 0.5$ inches above the conductive base plate surface and allow for vertical movement to facilitate voltage adjustment.

2. To ensure consistent test results, all test devices must be able to be repeatably placed with leads in contact with the conductive base plate surface by using milled recesses or equivalent markings and shall be equidistant from the high voltage tungsten probe.
2.1.2 High Voltage Power Supply

A high voltage DC power supply capable of generating 20,000 volts at both positive (+) and negative (-) polarities.

2.1.3 Thermal Chamber

An oven (Thermotron oven Model 51.C-B or equivalent) capable of controlled heating to a temperature of 155 °C and having adequate space to accommodate the GL test fixture.

2.2 Measurement Equipment

Equipment shall include a digital voltmeter and high voltage probe to verify conformance of the GL test fixture and resulting electric field (E-field) to the requirements of this document as specified in Figure 2, section 3.4, and Appendix A.

2.2.1 Digital Voltmeter

Digital voltmeter capable of accurately measuring 0 to 20,000 volts DC with a minimum sensitivity of ± 1 mV.

2.2.2 High Voltage Probe

High voltage probe capable of accurately measuring 0 to 20,000 volts DC with input resistance of 1000 MΩ and ± 2% accuracy (Fluke Model 80 K-40 or equivalent).

3. TEST PROCEDURE

3.1 Sample Size

A total of six (6) devices shall be evaluated for GL sensitivity: a sample of three (3) devices shall be stressed at a positive (+) GL exposure and a new sample of three (3) devices shall be stressed at a negative (-) GL exposure. The use of a new sample group of three (3) devices for each GL exposure polarity is required. Test samples must be representative of the normal process for deliverable devices; samples shall not be subjected to any additional testing or preconditioning (e.g., burn-in, etc.). Devices used for GL testing shall be discarded and shall not be retested or considered as deliverable product. GL is typically a non-destructive phenomena; however, the process of GL testing and the post-test bake, used to verify recovery, often results in changes to the molding compound and/or lead solderability characteristics rendering the devices unsatisfactory for shipment.

3.2 Test Temperature

Each sample group shall be subjected to a GL exposure at 155 °C.

3.3 Measurements

Prior to GL testing, complete initial DC parametric and functional testing (initial ATE verification) shall be performed per applicable device specification. If the applicable part drawing specifies an allowable parametric shift as failure criteria, a data log of each device shall be made listing the applicable parameter measurement values (e.g., supply current, pin leakages, etc.). The data log will be compared to the parameters measured during final ATE verification to determine the failure criteria of section 4.
3.4 GL Stress Conditions

Each sample shall be subjected to an E-field voltage potential of positive (+) or negative (-) 400 volts. A new sample of three (3) devices shall be used for each E-field voltage polarity.

3.5 Fixture Preparation

a. Place the GL test fixture in the thermal chamber and verify both are at room temperature (see Figure 1 and Appendix A).

b. Ensure the high voltage power supply is OFF and connect the positive lead to the high voltage tungsten probe. Set the height of the tungsten probe to a level of 2.5 ± 0.5 inches above the conductive base plate surface.

c. Connect the negative lead of the high voltage power supply to the conductive base plate.

d. Place a setup device in the fixture (located where the actual test samples will be placed) such that the device leads are in contact with the conductive base plate surface.

e. Make sure the voltage control is set to the minimum level. Turn the high voltage power supply to the ON position.

f. Place the positive lead of the high voltage probe at the center of, and in direct contact with, the top surface of the setup device. Connect the negative lead of the high voltage probe to the conductive base plate. The high voltage probe body should extend at a 45° ± 5° angle away from the conductive base plate surface (as depicted in Figure 2). This angle is critical to the measuring of the E-field voltage potential. As the high voltage probe body is raised (exceeding the 45° angle requirement) or lowered (falling below the 45° angle requirement), the measured E-field voltage potential will vary significantly.

g. Monitor the setup device’s E-field voltage potential using the digital voltmeter. Adjust the voltage setting on the high voltage power supply to provide a positive (+) 400 volt E-field voltage potential, or negative (-) 400 volt E-field voltage potential depending on the desired GL exposure, measured at the center of the setup device’s top surface.

h. Turn the high voltage power supply switch to the OFF position.

i. Verify that the high voltage power supply is at zero (0) volts before touching the GL test fixture.

j. Remove the setup device from the GL test fixture.
3.6 Detailed Test Procedure

a. Ensure the high voltage power supply is OFF. Place a sample group of three (3) devices in the GL test fixture such that the device leads are in contact with the conductive base plate surface. All devices must be at the same distance from the high voltage tungsten probe as the setup device used in section 3.5.1.

b. Set the thermal chamber temperature to 155 °C. The use of a thermocouple placed in direct contact with the GL test fixture conductive base plate surface may be used to monitor the temperature of the sample group devices.

c. Verify the test sample devices are at the specified temperature. Allow the test fixture and sample group of three (3) devices to stabilize at the specified temperature for 15 minutes.

d. Turn the high voltage power supply switch to the ON position.

e. Allow the devices and GL test fixture (with the E-field voltage applied) to soak for a 2 minute dwell time as indicated in Figure 3.

f. After 2 minutes of the total dwell time have elapsed, begin reducing the thermal chamber temperature to 100 °C or less with the E-field voltage still applied. This can be accomplished by opening the thermal chamber door while the circulating fans are operating. Thermal chamber heating and cooling times will vary and a longer ramp-down time may be required when reducing the thermal chamber temperature. The total ramp-down time (155 °C to 100 °C) shall not exceed 10 minutes (see Figure 3).
g. Once the sample group of three (3) devices reaches a temperature of 100 °C, turn the high voltage power supply switch to the OFF position. A thermocouple placed in direct contact with the GL test fixture conductive base plate surface may be used to monitor the temperature of the sample group devices.

h. Verify the high voltage power supply is at zero (0) volts before touching the GL test fixture.

i. After cooling to room temperature, remove the sample group of three (3) devices from the GL test fixture.

j. Submit the devices for complete DC parametric and functional testing (final ATE verification) per applicable device specification within 96 hours of GL exposure and determine whether the devices meet the acceptance criteria requirements specified in section 5. The storage temperature between GL exposure and final ATE verification shall not exceed 30 °C.

k. Subject all failing devices to an unbiased bake of 4 hours at a temperature of 125 °C (or 2 hours at 150 °C) and then submit for complete DC parametric and functional testing (ATE re-verification). GL failures will always recover when subjected to a 4 hour unbiased bake at 125 °C (or 2 hours at 150 °C). If the failing devices do not recover following the unbiased bake, then the devices may have been damaged (due to handling, EOS, ESD, etc.). Failing devices that do not recover shall be eliminated from the GL data.

l. Record pass/fail and any other pertinent observations for each device.

m. Reverse the high voltage power supply polarity, verify the E-field voltage potential (as specified in section 3.5.1), and repeat steps (a) through (l) above using a new sample group of three (3) devices.

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**Figure 3: Dwell Time and Ramp-Down Time for GL Test**
4. **FAILURE CRITERIA**

A device will be defined as a failure if, after exposure to GL, the device fails any of the following criteria:

1. The device exceeds the allowable shift value. Specific parameters and allowable shift values shall be as defined in the applicable device specification. During initial ATE verification, a data log shall be made for each device listing the applicable parameter measurement values. The data log will be compared to the parameters measured during final ATE verification to determine the shift value. Devices exceeding the allowable shift value will be defined as a failure.

2. The device no longer meets the device specification requirements. Complete DC parametric and functional testing shall be performed per applicable device specification.

5. **ACCEPTANCE CRITERIA**

A device passes a GL exposure level if all devices in the sample group stressed at that GL level pass. All the devices and sample groups used must pass the measurement requirements specified in section 3 and the failure criteria requirements specified in section 4 following both positive (+) and negative (-) 400 volt E-field exposures in order for the devices to be considered acceptable.
Appendix A

(suggested GL test fixture)

This appendix provides suggested general construction features of the GL test fixture. Other equivalent test fixture configurations may be used, but the actual fixture must meet the requirements of section 2.1.1. The dimensions shown are approximate and are not critical to the test fixture construction. Figures A1 through A5 illustrate the GL test fixture assembly and major components.

Note:
Attach High Voltage Warning Label to test fixture

Figure A1: GL Test Fixture Assembly
The base plate is constructed from electrically conductive material (e.g., .125 - .250 inch aluminum stock). The plate is approximately 6 inches square and serves to support and locate the devices under test and as one pole of the test voltage. Milled recesses may be used for repeatable device placement during GL testing (see Figures A1 and A2). The suggested recesses may be milled directly into the plate to ensure consistent device placement and orientation with respect to the tungsten probe center-line. The recesses, large enough to accommodate the largest device to be tested, are located 120 degrees apart and equidistant from the center of the base plate. The absolute distance from center (approximately one inch) is not critical.

The lower left hand corner (dashed line section) is cut off on a diagonal to facilitate device handling and to reduce thermal mass. A lower post section, or leg, is added to the diagonal side for stability (see Figure A1).

Note: The aluminum plate should be alodine coated for protection against corrosion and to retain electrical quality.
The top insulating plate serves to support and locate the tungsten probe at the center of the GL test fixture. It establishes and maintains the probe to device distance during set-up and test. The top plate is fabricated from a triangular piece of .250 inch Teflon, Delrin, or other insulating material which is capable of withstanding an environment of 200 °C and ± 20,000 volts.

A .049 inch diameter hole, used to position the tungsten probe, is centered on the diagonal side so as to be directly above the base plate center point after assembly. Clearance holes are drilled at each corner for assembly screws.
Grind a 60 degree point on a 4 inch length of 0.049 inch diameter tungsten wire (or a diameter of tungsten wire that is readily available; the diameter of the wire is not critical). This will provide an E-field potential at the specified test voltage, as measured on the top surface of the device approximately 2 inches from the tungsten probe point.

Figure A4: Tungsten Probe

Two pieces of 0.250" Teflon or Delrin rod are drilled for a tight fit on the tungsten probe. Set screws may be added.

These pieces clamp the tungsten probe and allow for vertical movement to facilitate voltage adjustment.

Figure A5: Tungsten Probe Clamping Mechanism
## Revision History

<table>
<thead>
<tr>
<th>Rev #</th>
<th>Date of change</th>
<th>Brief summary listing affected sections</th>
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<tr>
<td>-</td>
<td>June 9, 1994</td>
<td>Initial Release</td>
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<tr>
<td>A</td>
<td>May 15, 1995</td>
<td>Added Copyright statement. Revised the following: Foreword; Sections 2.1.2, 3.1, 3.2.2 (d, f, and g), and 3.2.3 (a, b, c, f, g, and l); Figures 1, 2, and 3; Appendix A.</td>
</tr>
<tr>
<td>B</td>
<td>Sept. 6, 1996</td>
<td>Deleted old Sections 1.3.3, 1.3.4, 1.3.5, 1.3.6, 1.3.7, 2.1.1, 3.1, 3.2.1, 3.3, 3.4, 3.5, and 3.6. Added new Sections 1.3.1, 1.3.4, 2.2, 2.2.1, 2.2.2, 3.1, 3.2, 3.3, 3.4, and 5.0. Revised the following: Sections 1.1, 1.3, 1.3.2, 1.3.3, 2.1, 2.1.1, 2.1.2, 3.5.1 (a, e, f, g, h, and i), 3.5.2 (a, b, c, e, f, g, h, i, j, k, l, and m), 4.0, and Appendix A; Figures 1, 2, 3, A1, and A2.</td>
</tr>
<tr>
<td>C</td>
<td>Oct. 8, 1998</td>
<td>Revised the following: Sections 3.4, 3.5.1 (g), 5; Figure 1. Revisions reflect a change in E-field requirement from ±700 volt to ±400 volt.</td>
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<tr>
<td>D</td>
<td>July 18, 2003</td>
<td>Revised the following: Sections 3.5, 3.5.1, and 3.5.2.</td>
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