Automotive Electronics Council
Component Technical Committee

ATTACHMENT 9

AEC - Q100-009 REV-B

ELECTRICAL DISTRIBUTIONS ASSESSMENT

Automotive Electronics Council

Component Technical Committee

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Change Notification

The following summary details the changes incorporated into AEC-Q100-009 Rev-B:

- **Section 1, Scope: Added statement regarding data sheet limits for new parts.**
- **Section 3.1, Cpk and Ppk: Added new definition.**
- **Section 3.2, Electrical Characterization: Modified definition term to add "Electrical", deleted the first sentence, added wording to define AC and DC parameters per the supplier datasheet or customer specification, and added new Note regarding Process Characterization (AEC-Q003).**
- **Section 3.3, Electrical Distribution: Replaced "application" with "customer specification or supplier datasheet".**
- **Section 3.4, Key Significant/Critical Electrical Parameter: Added new definition.**
- **Section 3.6, Parametric Drift: Added example regarding use of drift of individuals.**
- **Section 4.2, Parameters: Added wording "significant/critical" to electrical parameters, added reference to user application range, and added reference to sample list of parameters.**
- **Section 4.3, Procedure: Added new section.**
- **Section 4.3.1, Sample Size: Added statement on use of larger sample size.**
- **Section 4.3.2, Testing of Samples: Added reference to Section 4.2; modified Note to require a statistically significant number of parts (deleted 20 part minimum) and added wording on use of gage repeatability and reproducibility data.**
- **Section 4.3.4, Processes with One-Sided Specifications or Non-Normal Distributions: Added new section.**
- **Section 4.3.5, Setting LTL and UTL: Added wording advising when to calculate LTL and UTL; modified equations to replace "3" with "g", and added definition of term "g".**
- **Section 5, Evaluation Criteria: Modified section title; complete revision of section.**
- **Section 6, Summary: Modified wording to state details shall be provided to the user; modified item b, and added new item c.**

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METHOD - 009

ELECTRICAL DISTRIBUTIONS ASSESSMENT

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

1. SCOPE

This specification describes test methods for assessing electrical parameter characterization, distributions (e.g., to AC, DC and timing, etc.) and parametric shifts of integrated circuits which have established supplier datasheet limits. For new parts, these datasheet limits are determined through application of the Characterization procedure AEC-Q003 as referenced in the AEC-Q100. The results are used to determine the capability to meet the performance requirements of the device specification. The results can also be used to set device test limits (e.g., LTL and UTL).

2. PURPOSE

The purpose of this test method is to define methods for obtaining characterization, electrical distribution and parametric shift data for electrical parameters on integrated circuits. The intent of this method is to assess the part's capability to function within the specification parameters over normal process variations, time, and/or the anticipated application environment (e.g., operating temperature range, voltage, etc.).

3. DEFINITIONS

3.1 Cpk and Ppk

A measure of the relationship between the specification limits and the capability (Cpk) or potential (Ppk). Reference: PPAP Manual Fourth Edition, see SPC Manual.

3.2 Electrical Characterization

The determination of the functional robustness (e.g., the effect of one parameter on another, etc.) of the part. These parameters usually involve measurement of electrical parameters with the device at operating extremes with respect to voltage, frequency and temperature, but could also include various loading conditions and other inputted AC and DC parameters per the supplier datasheet or customer specification.

Note: This is different from Process Characterization as described in AEC-Q003, where material is deliberately manufactured at process corner (limit) values and tested to determine and establish the “sweet spot” of the manufacturing process.

3.3 Electrical Distribution

The statistical distribution of an electrical parameter taken from a random sample of parts in a normal production population at a given temperature, frequency, and voltage for the purpose of determining the capability of the part to meet the customer specification or supplier datasheet parametric requirements.

3.4 Key Significant/Critical Electrical Parameter

A measurable electrical parameter that can reasonably expect to affect the quality and/or reliability of the part if it violates a specification limit for that parameter. Also, a measurable electrical parameter designated in conjunction with the user that is important in the function of the user's intended application.

3.5 Lower Test Limit (LTL)

A test limit that is tighter than the lower spec limit (LSL) to guardband for measurement error.

3.6 Parametric Drift

The change of an electrical parameter from its original value because of time and environmental conditions. The form of the change may be a shift from the original value of a device or in the statistical distribution of a group of devices. When changes are to be studied on an individual device basis the study is called Parametric Drift of individuals (serialization of individual units is required). An example of when drift of individuals might be requested is when one or more key significant/critical electrical parameters are specified by the user as important to their intended application. When changes are studied on a group of devices the study is referred to as Parametric Drift of distributions (serialization of individual units is not required). The cause of the change may be time and/or environmental conditions (during real life application or as simulated by accelerated stress testing).

3.7 Upper Test Limit (UTL)

A test limit that is tighter than the upper spec limit (USL) to guardband for measurement error.

4. PROCEDURE

4.1 Requirements

The performance of Electrical Distributions for each user part qualification is required by Q100. The use of generic data is not allowed. The performance of Electrical Characterization and Parametric Drift is not required but should be available based on the suppliers own evaluations or determined by mutual agreement between the user and supplier based on need.

4.2 Parameters

The supplier is not required to perform Electrical Distributions on every electrical parameter detailed in the supplier's data sheet. The parameters tested should be those whose variation may impact outgoing quality and/or reliability, or those essential to the successful operation of the device. This list of parameters is usually called key significant/critical electrical parameters. This list of parameters may be established by the supplier based on knowledge of the technology, process, design, and user application range, or could be negotiated between the user and supplier, usually through a user device specification if a set of parameters are important to the intended user application. A sample list of key significant/critical electrical parameters can be found in the AEC-Q001 Part Average Testing specification. If a list of parameters does not exist, the default list is the set of measurable electrical parameters defined in the supplier datasheet.

4.3 Procedure

4.3.1 Sample Size

Select a random set of parts from a given population, the sample size of which is specified in AEC-Q100. Parts must come from the production process and must be manufactured on production tooling with all processing as product to be delivered to the user (i.e., burn-in, if used, etc.). If parametric drift is to be determined on individuals, serialize each part. This will enable determining the absolute part-specific drift as well as the sample (Distribution) drift. The supplier can use a larger sample size if statistical significance is a concern for a given measurement or parameter.

4.3.2 Testing of Samples

Run these parts through the production tester using a program that enables variables data to be taken on each part or a group of parts for each parameter determined in Section 4.2. Begin the first run at room temperature, with subsequent runs at hot and cold temperature extremes as detailed in the device specification. If Characterization is to be performed, repeat this step as many times as there are changed parameters.

Note: Before testing samples, if the standard deviation of the measurement error needs to be determined, a statistically significant number of parts shall be tested at least twice per tester per temperature to estimate the standard deviation of the measurement (stdevm) error. Otherwise, use the gage repeatability and reproducibility data generated from the measurement system analysis of the test equipment to be used in testing these parts.

4.3.3 Data Analysis

Once the data is collected, it should be tabulated in a format where capability can be easily analyzed. The data fields should include parameter, unit of measure, mean, standard deviation, minimum and maximum values, minimum and maximum specification limits, and Cpk/Ppk for each different combination of temperature, frequency and/or voltage. The supplier has the option of including the detailed part data in any report to the user, but the data should be available upon request.

4.3.4 Processes with One-Sided Specifications or Non-Normal Distributions (Reference: PPAP Manual Fourth Edition)

Use of Cpk and/or Ppk process capability indices are only intended for evaluation of stable processes, assuming normality and two-sided specifications (target in the center). Rigid application of Cpk/Ppk indices to electrical distributions (ED) data assessment may yield unreliable information when applied to one-sided specifications and/or non-normal (non-"Gaussian") distributions resulting from highly sorted (e.g., speed sorting of memory devices) production material (e.g., population sorting by read speed of a memory device).

Alternate acceptance criteria for processes with one-sided specifications and/or non-normal distributions shall be per agreement between user and supplier.

4.3.5 Setting LTL and UTL

If the supplier desires to set a lower and upper test limit based on the electrical distributions data, the LTL and UTL maybe arrived at as follows:

LTL = LSL + g*(stdevm)
UTL = USL – g*(stdevm)

where:
stdevm = the standard deviation of the measurement error from Section 4.3.2.
g = multiplier determining the degree of measurement error (a minimum of g=3).

4.3.6 Parametric Drift Testing

If Parametric Drift is to be performed, repeat the above steps after stress testing (usually HTOL) is completed on the parts under consideration (If the study is on individuals on the serialized parts).

5. EVALUATION CRITERIA

A parameter requires evaluation if it fails the requirements of the device specification or any statistical acceptance criteria agreed to between the user and supplier (e.g., Cpk/Ppk to the part specification or datasheet parametric limits for Gaussian-distributed electrical parameters, metrics for one-sided or non-Gaussian distributions, degree of parametric drift, etc.). For example, a typical gauge historically used for key significant/critical electrical parameters on high reliability parts is a Cpk greater than 1.33, and/or a Ppk greater than 1.67.

Supplier's qualification summary report shall include clarification of data **for the parameter(s) in question**, with respect to applicability of statistical analysis techniques (if and when they apply, and/or do not apply to the data presented for qualification approval by the customer). For example, statistical analysis may not be applicable to sorted or selected parameters, non-normal distributions that do not have an acceptable transformation, etc. Supplier can provide the distribution in a histogram format, showing that the product will not be out of spec, and is capable of meeting the user's requirements.

If the assessment indicates that there may be a potential problem with device application, the following actions can be considered by the user and/or supplier (following order recommended, with the understanding that some actions may affect availability and/or cost of the qualified device/technology):

a. Ensure that the gage repeatability and reproducibility of the measurement system used is acceptable, for the data being evaluated.

b. Prove that the parameter is inherently non-normal, and re-assess applicability (i.e., significant differences in mean, mode and/or median, non-negligible skew and/or kurtosis), keeping in mind that these are essentially discrete distributions that will likely not be perfectly Gaussian in shape.

c. Supplier to assure the user that the electrical parameter(s) in question do not adversely affect the user's application. Conversely, the user should show the supplier that the parameter(s) in question are important enough to the application to require action.

d. If the above assessment does not resolve qualification data anomalies, and it is mutually determined the user's application is affected, a screen may be implemented if one does not already exist for the key significant/critical electrical parameter in question.

e. If a screen for the key significant/critical electrical parameter in question is already in place, the test and/or specification limits for the incapable parameter may be tightened to eliminate failures, or the screen should be inspected for efficiency and effectiveness.

f. Re-center the parameter by a combination of possible specification changes, process re-centering, and/or component redesign.

6. SUMMARY

The following details shall be provided to the user:

a. The type of study: Electrical Distributions and, if performed, Parametric Shift (individuals or distributions).

b. List of key significant/critical electrical parameters to be measured, with supplier clarification of applicability of statistical analysis techniques, and additional parameters as agreed upon by the user and supplier. The default list is the set of measurable electrical parameters defined in the supplier datasheet.

c. The metrics (e.g., Cpk, degree of drift, etc.) that the electrical parameters are to be evaluated against.

d. Minimum and maximum operating voltages.

e. Minimum and maximum operating frequencies or at the specified frequency of the IC.

f. Hot, room, and cold temperatures.

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Revision History

Rev #	Date of change	Brief summary listing affected sections
-	Oct. 8, 1998	Initial Release.
A	July 18, 2003	Minor revisions to correct formatting errors.
B	Aug. 27, 2007	Complete Revision. Revised Acknowledgment section and added Notice Statement. Revised sections 1, 2, 3.1, 3.2, 3.3, 3.4, 3.5, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 5, and 6. Added new sections 3.1, 3.4, 4.3, and 4.3.4.