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Application of ISO 26262:2011-2012 to semiconductors —

Part 2: Application of hardware qualification

*Application de l'ISO 26262:2011-2012 aux semi-conducteurs —
Partie 2: Application de la qualification du matériel*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

ISO/PAS 19451 consists of the following parts, under the general title *Road vehicles — Application of ISO 26262:2011-2012 to semiconductors*:

- *Part 1: Application of concepts*
- *Part 2: Application of hardware qualification*

Introduction

This document is an informative guideline which provides users of the ISO 26262:2011-2012 standard recommendations and best practices which can be utilized when applying ISO 26262 to semiconductor components and parts. This document was created by a group of industry experts including semiconductor developers, system developers, and vehicle manufacturers in order to clarify concerns seen after the initial release of the ISO 26262 standard and when possible to align on common interpretations of the standard.

This document serves to augment the existing normative and informative guidance in the ISO 26262 standard. The approach is similar to that taken in writing the ISO 26262-10:2012, Annex A, "ISO 26262 and microcontrollers," with extension to additional types of semiconductor technologies and relevant topics.

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Application of ISO 26262:2011-2012 to semiconductors —

Part 2: Application of hardware qualification

1 Scope

This document is applicable to developers who are evaluating the use of hardware qualification for semiconductor elements according to ISO 26262-8:2011, Clause 13.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 26262-1, *Road vehicles — Functional safety — Part 1: Vocabulary*

ISO 26262-4, *Road vehicles — Functional safety — Part 4: Product development at the system level*

ISO 26262-5:2011, *Road vehicles — Functional safety — Part 5: Product development at the hardware level*

ISO 26262-8:2011, *Road vehicles — Functional safety — Part 8: Supporting processes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 26262-1 apply.

4 Hardware qualification

Hardware qualification is a process in which it is determined if the hardware can fulfil the allocated requirements of a given design. There are multiple ways in which hardware qualification can be defined and applied. Unfortunately ISO 26262-1 does not include a formal definition of hardware qualification. Due to the variety of usages of the phrase “hardware qualification” there can be perceived ambiguity in ISO 26262-8:2011, Clause 13 dependent on the background of the reader.

Throughout the remainder of this document the phrase “hardware qualification” is used to reference “Qualification of Hardware Components” according to ISO 26262-8:2011, Clause 13. Activities used to qualify hardware for compliance to relevant automotive quality standards for safety related or non-safety related hardware components and parts are described as “standard qualification.”

5 How is “standard qualification” differentiated from ISO 26262 hardware qualification?

5.1 Standard qualification

ISO 26262-8:2011, Clause 13 does not specify a particular standard or set of standards which should be applied for standard qualification. Several examples are listed as understood to be relevant to current

state of the art. The user of the standard should take care to ensure that any standard or set of standards to be applied for hardware qualification are considered state of the art at the time of development.

ISO 16750-1 is one of the references suggested to carry out a standard qualification. It gives requirements to qualify suitability of a product for automotive applications. Tests proposed by ISO 16750-1 are meant to stress the product at the boundaries of an automotive scenario to ensure its robustness in terms of e.g. temperature and voltage ranges. Qualification according to ISO 16750-1 is meant for generic automotive usage.

AEC-Q100^[7] provides details of a number of accelerated test methods which could be applied to perform standard qualification. The main AEC-Q100 document is supplemented by multiple annexes which each focus on a specific test method for accelerated testing of particular failure modes. The Automotive Electronics Council provides other standards focusing on discrete semiconductors (AEC-Q101 series) and passive components (AEC-Q200 series) which may be relevant dependent on the type of element under consideration.

[Annex A](#) provides excerpts from an example standard qualification plan used by a supplier of semiconductors to the automotive market. Tests have been selected from a number of quality standards in order to demonstrate suitability for use in automotive applications. In this example qualification tests from AEC, JEDEC, and US military standards are referenced. Exact contents of a standard qualification plan will vary from supplier to supplier and should be based on testing of specific failure modes relevant to the type of circuitry implemented and the specific technology used.

NOTE If experimental data from standard qualification is to be used as a source for failure rates in calculation of functional safety metrics according to ISO 26262-5:2011, 8.4.3 then appropriate failure mechanisms and sample sizes are considered.

5.2 ISO 26262 hardware qualification

Qualification according to ISO 26262-8:2011, Clause 13 requires that a dedicated qualification argument (report) should be provided for the hardware component or part with respect to the allocated safety requirements. The qualification argument demonstrates that the applied analyses and tests provide sufficient evidence of compliance with the allocated safety requirement(s). The relevant failure modes and failure mode distributions are also included in order to evaluate the validity of the argument.

Some results of standard qualification may satisfy the requirements of the hardware qualification activity. A gap analysis could be performed to identify requirements of hardware qualification which are not satisfied by standard qualification. If no gap is identified, this analysis should be a sufficient argument to claim compliance with ISO 26262-8:2011, Clause 13. This is supported by ISO 26262-8:2011, 13.4.5.

In some cases data generated from standard qualification activities can be used to provide failure rates and failure distributions for a part or component. If this approach is taken, it is done in accordance with ISO 26262-5:2011, 8.4.3. If additional testing is used to develop failure rates for safety analysis the developer can consult a relevant industry publication such as the ZVEI or SAE Handbook of Robustness Validation of Semiconductor Devices in Automotive Applications^{[9][10]} for suggestions in the selection and application of relevant tests.

The qualification according to ISO 26262-8:2011, Clause 13 may also include verification and testing plans for the functional aspects of the hardware component and part. These verification activities are not always performed by the supplier, particularly in the case of COTS or SEooC parts or components. If performed, these activities are part of the qualification and safety case argumentation.

6 Why is ISO 26262 hardware qualification applied?

6.1 Hardware qualification as a method of design verification of allocated safety requirements

As stated in the NOTE of ISO 26262-4:2011, 7.4.5.2, hardware qualification according to ISO 26262-8:2011, Clause 13 may provide evidence of compliance to allocated safety requirements.

In this context the output of the hardware qualification activity can be used as an input to the item integration and test activity.

ISO 26262-5:2011, 6.4.6 states that hardware qualification is an accepted method for design verification of the hardware of the item or element, including environmental conditions, specific operational environment, and component specific requirements.

As stated in ISO 26262-5:2011, 10.2, hardware qualification and associated testing is not the same as hardware integration and testing.

As both ISO 26262-5:2011, Clause 10 and ISO 26262-4:2011, Clause 8 have as an objective to ensure by testing the compliance of the developed hardware and integrated elements with the (allocated) safety requirements, qualification is an alternative or specific means to testing. It can be used for hardware components and parts lower in the design hierarchy and in cases where it can be a sufficient means to provide evidence of the compliance to the allocated safety requirements, while further integration tests may be needed at higher levels in the design hierarchy.

[Figure 1](#) illustrates how hardware qualification interacts with other verification activities in the context of ISO 26262. According to ISO 26262-5:2011, 6.4.6 there are multiple options to provide design verification, including by hardware qualification (see ISO 26262-8:2011, Clause 13) and by hardware integration and testing (see ISO 26262-5:2011, Clause 10). The planning of the verification activity is illustrated as occurring before initiation of the hardware design (see ISO 26262-5:2011, Clause 7). The results of the hardware qualification activity then become inputs to the hardware integration and testing activity (see ISO 26262-5:2011, Clause 10) or the item integration and testing activity (ISO 26262-4:2011, Clause 8), dependent on the level of hierarchy of the element under qualification. The standard qualification report, though not directly a work product of hardware qualification according to ISO 26262-8:2011, Clause 13, is used as an input to the initiation of product development at the hardware level (ISO 26262-5:2011, Clause 5) if available when product development at hardware level is initiated.