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TECHNICAL REPORT

colour inside

Process management for avionics – Electronic components capability in operation – Part 1: Temperature uprating

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS CAPABILITY IN OPERATION –

Part 1: Temperature uprating

FOREWORD

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IEC TR 62240-1, which is a Technical Report, has been prepared by IEC technical committee 107: Process management for avionics.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

a) Revised the wording in 4.1 and the corresponding Figure 1 to reflect current industry practices.

The text of this Technical Report is based on the following documents:

CDTR	Report on voting
107/313/DTR	107/322/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62240 series, published under the general title *Process management for avionics – Electronic components capability in operation*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Traditionally, industries that produced electronic equipment for ADHP (aerospace, defence and high performance) applications have relied on the military specification system for semiconductor device standards and upon manufacturers of military-specified devices as device sources. This assured the availability of semiconductor devices specified to operate over the temperature ranges required for electronic equipment in ADHP applications. In the past, several device manufacturers have exited the military market, resulting in the decreased availability of devices specified to operate over wide temperature ranges. Following are some typical ambient temperature ranges at which devices are marketed:

Military:	–55 °C to + 125 °C
Automotive:	–40 °C to + 125 °C
Industrial:	–40 °C to + 85 °C
Commercial:	0 °C to + 70 °C

If there are no reasonable or practical alternatives, then a potential response is for electronic equipment manufacturers to use devices at temperature ranges that are wider than those specified by the device manufacturer.

This document provides information on selecting semiconductor devices, assessing their capability to operate, and assuring their intended quality in the wider temperature ranges. It also reports the need for documentation of such usage.

This can be supported by exchanging technical information with the original device manufacturer.

Operation of the device beyond the manufacturer's limits can result normally in loss of warranty by the device manufacturer.

PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS CAPABILITY IN OPERATION –

Part 1: Temperature uprating

1 Scope

This part of IEC 62240, which is a technical report, provides information when using semiconductor devices in wider temperature ranges than those specified by the device manufacturer. The uprating solutions described herein are considered exceptions, when no reasonable alternatives are available; otherwise devices are utilized within the manufacturers' specifications.

The terms "uprating" and "thermal uprating" are being used increasingly in avionics industry discussions and meetings, and clear definitions are included in Clause 3. They were coined as shorthand references to a special case of methods commonly used in selecting electronic components for circuit design.

This document describes the methods and processes for implementing this special case of thermal uprating. All of the elements of these methods and processes employ existing, commonly used best engineering practices. No new or unique engineering knowledge is needed to follow these processes, only a rigorous application of the overall approach.

Even though the device is used at wider temperatures, the wider temperatures usage will be limited to those that do not compromise applications performance and reliability, particularly for devices with narrow feature size geometries (for example, 90 nm and less). This document does not imply that applications use the device to function beyond the absolute maximum rating limits specified by the original device manufacturer and assumes that:

– device usage outside the original device manufacturers' specified temperature ranges is done only when no reasonable alternative approach is available and is performed with appropriate justification;
– if it is necessary to use devices outside the original device manufacturers' specified temperature ranges, it is done with documented and controlled processes that assure integrity of the electronic equipment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62239-1, *Process management for avionics – Management plan – Part 1: Preparation and maintenance of an electronic components management plan*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
absolute maximum ratings
limiting values of operating and environmental conditions applicable to any semiconductor device of a specific type as defined by its published specification data, which should not be exceeded under the worst possible conditions

[SOURCE: IEC 60134:1961, Clause 4]

3.1.2
ambient temperature
temperature of the environment in which a semiconductor device is operating

3.1.3
case temperature
temperature of the surface of a semiconductor device package during operation

3.1.4
circuit element functional mode analysis
documented analysis that determines minimum ranges and maximums of all functional characteristics of the assembly with respect to the related functional parameters of devices being uprated

3.1.5
COTS product
commercial off-the-shelf product
one or more components, assembled and developed for multiple commercial consumers, whose design and/or configuration is controlled by the manufacturer's specification or industry standard

Note 1 to entry: COTS products can include electronic components, subassemblies or assemblies, or top level assemblies. Electronic COTS subassemblies or assemblies include circuit card assemblies, power supplies, hard drives, and memory modules. Top-level COTS assemblies include a fully integrated rack of equipment such as raid arrays, file servers to individual switches, routers, personal computers, or similar equipment.

[SOURCE: IEC TS 62668-1:2016, 3.1.3]

3.1.6
device capability assessment
process of demonstrating that the device design is capable of providing the specified functionality and operation over the wider temperature range, for the required length of time

Note 1 to entry: It assumes that the device has been qualified to operate within its specified temperature range, and includes additional testing or analysis to evaluate expected performance at the wider temperature range. Device capability assessment includes both performance and application-specific reliability.

3.1.7
device quality assurance over the wider temperature range
additional testing or analysis required to assure that each individual device is capable of operating successfully in the required wider temperature range

3.1.8
device
component
material element or assembly of such elements intended to perform a required function

Note 1 to entry: A device may form part of a larger device.

[SOURCE: IEC 60050-151:2001, 151-11-20, modified – The term "component" has been added as a synonym to "device".]

3.1.8.1

semiconductor device
electrical or electronic device that is not subject to disassembly without destruction or impairment of design use

Note 1 to entry: It is sometimes called electronic part or electronic piece part or component or electronic component. Examples are diodes, integrated circuits, and transistors.

3.1.9
electronic equipment
any item, for example end item, sub-assembly, line-replaceable unit, shop-replaceable unit, or system produced by an electronic equipment manufacturer

3.1.10
environmental stress screening
ESS
highly accelerated stress screening
HASS
set of production process tasks consisting in applying to the equipment concerned, within the limits permitted by its design, particular environmental stresses in order – during manufacturing – to reveal and eliminate the largest possible number of extrinsic defects which, in all probability, would have appeared once utilisation had begun (early life failures)

[Source: IEC TS 62500:2008, 2.8, modified – The second term, HASS, has been added.]

3.1.11
highly accelerated test
HAT
highly accelerated life test
HALT
test during which the product or some of its component parts are subjected to environmental and/or operating stresses that are increased progressively to values far in excess of the specified values, up to the operating and/or destruction limits of the product

NOTE The rise in exposure time or number of cycles, whether or not associated with a combination of certain stresses raised to values close to or equal to the specification (or stresses whose nature is not specified) may meet the same targets as those of the highly accelerated tests, as defined in this document.

[Source: IEC TS 62500:2008, 2.10, modified – The second term, HALT, has been added and in the note "technical specification" has been replaced by "document".]

3.1.12
junction temperature
temperature of the active region of the device in which the major part of the heat is generated

[SOURCE: SEMATECH Dictionary of Semiconductor Terms:2012]

3.1.13
manufacturer-specified parameter limits
electrical parameter limits that are guaranteed by the device manufacturer when a device is used within the recommended operating conditions

3.1.14
manufacturer-specified temperature range
operating temperature range over which the component specifications, based on the component data sheet, are guaranteed by the electronic component manufacturer

Note 1 to entry: Manufacturer-specified temperature range is a subset of the recommended operating conditions.

3.1.15
parameter conformance assessment
process for thermal uprating in which devices are tested to assess their conformance to the manufacturer-specified parameter limits over the target wider temperature range

3.1.16
parameter temperature characterisation
process of determining the specification values of electrical parameters by testing samples over the manufacturer's specified temperature range

3.1.17
parameter temperature re-characterisation
process for thermal uprating in which the device parameters are re-defined as a result of testing performed

3.1.18
PCB assembly uprating
CCA uprating
uprating of a printed circuit board or circuit card assembly populated with individual components, some or all of which are operated at temperatures beyond their data sheet parameters

3.1.19
rating
value that establishes either a limiting capability or a limiting condition for a semiconductor device

3.1.20
recommended operating conditions
conditions for use of the component for which the component specifications, based on the component data sheet, are identified by the electronic component manufacturer

3.1.21
stress balancing
process for thermal uprating in which at least one of the device's electrical parameters is kept below its maximum allowable limit to reduce heat generation, thereby allowing operation at a higher ambient temperature than that specified by the device manufacturer

3.1.22
target temperature range
operating temperature range of the device in its required application

3.1.23
thermal uprating
uprating
process to assess the capability of a part to meet the performance requirements of the application in which the device is used outside the manufacturer's specified temperature range

Note 1 to entry: Terms such as "upscreening", "retest", "up-temperature testing" and other similar variations are subsets of or encompassed by the overall uprating process.

3.1.24
wider temperature range
target temperature range outside the manufacturer-specified temperature range

Note 1 to entry: It may include temperatures that are higher or lower than the manufacturer-specified temperature range, or both.

3.2 Abbreviated terms

ADHP	aerospace, defence and high performance
AQEC	aerospace qualified electronic component
ATP	acceptance test procedure
CAGE	commercial and government entity
CCA	circuit card assembly
COTS	commerical off-the-shelf
CMOS	complementary metal-oxide-semiconductor
ECMP	electronic components management plan
ESD	electro-static discharge
ESS	environmental stress screening
HALT	highly accelerated life testing
HAT	highly accelerated test
HASS	highly accelerated stress screening
ID	Identification
PCB	printed circuit board
PCN	process change notice
PPM	parts per million
SD	sigma deviation
QA	quality assurance

4 Selection provisions

4.1 General

Selection provisions are described below.

The flow chart of Figure 1 describes a typical approach for using devices outside the electronic component manufacturer's specified temperature range, by considering their selection (4.2), their capability assessment (4.3), their quality assurance (4.4 and 4.5) and their documentation (4.7).

The use of devices that operate outside the temperature ranges specified by the device manufacturer is discouraged; however, such usage can occur if other options prove to be impossible, unreasonable, or impractical. Justification for such usage can be based on availability, functionality, or other relevant criteria.

Such operation is not cause for unstable part operation or loss of electronic equipment function nor is the device to be operated beyond its absolute maximum data sheet ranges (for example maximum junction temperature).

The electronic equipment manufacturer uprating the component utilizes a process to demonstrate that the component will meet reliability and lifetime requirements of the ADHP application.

Additionally, operation of the device beyond the electronic component manufacturer's limits can result normally in loss of warranty by the device manufacturer.

NOTE The headings of Clause 4 are keyed to the actions and decisions of Figure 1.

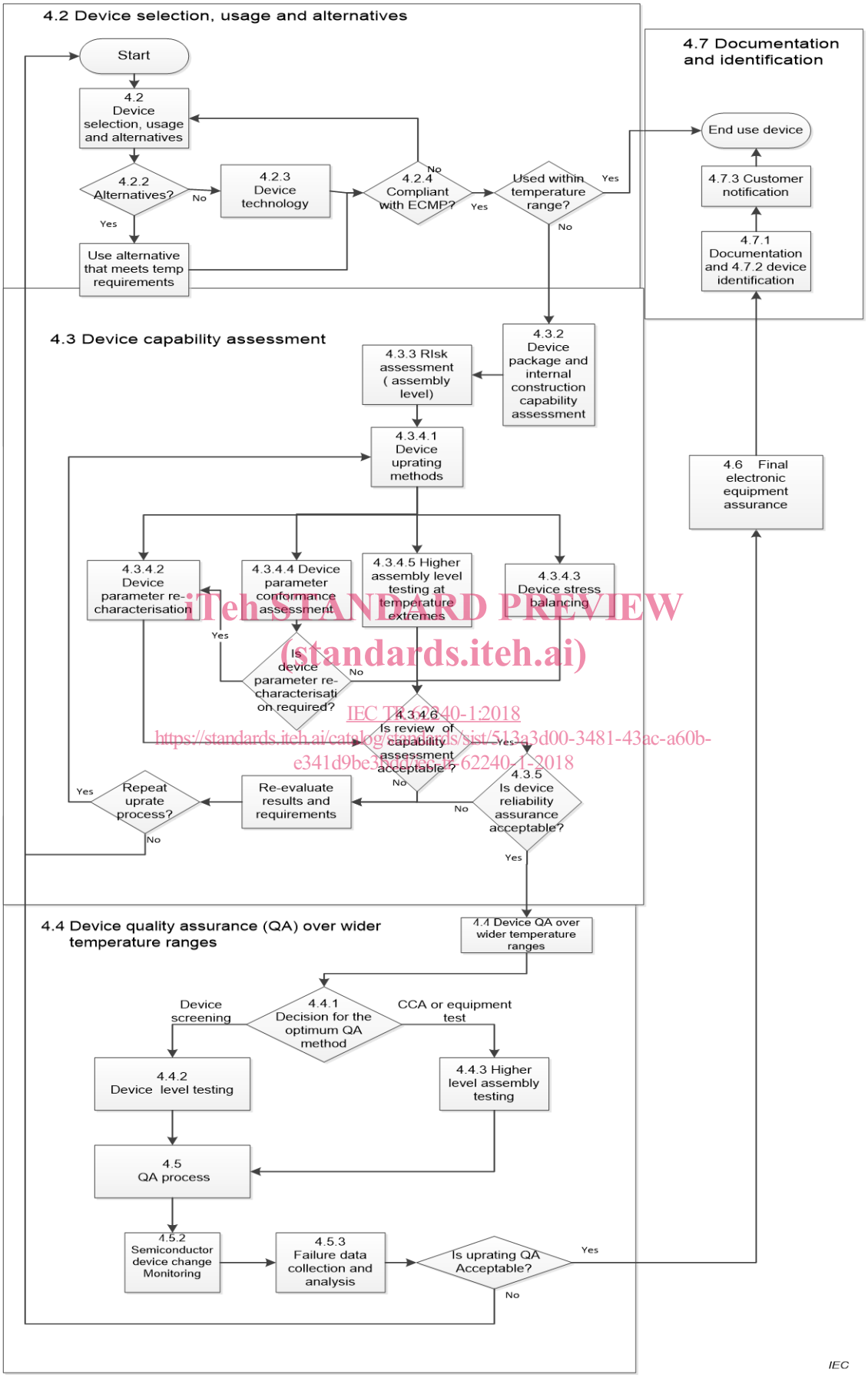

Figure 1 – Flow chart for semiconductor devices over wider temperature ranges