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TECHNICAL REPORT

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

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS CAPABILITY IN OPERATION –

Part 1: Temperature uprating

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

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

This first edition cancels and replaces IEC/TR 62240 published in 2005. This edition constitutes a technical revision.

This edition includes the following significant changes:

a) Document is revised from IEC/TR 62240 to IEC/TR 62240-1.
b) Revised wording in clauses/subclauses: Introduction and Clauses 1 to 4 including paragraph clarifications and corrections.

c) Removed all “shall” terms from document.

d) Updated paragraphs, including addition of references to the utilization of samples from a single lot, and the fact that performance of uprating is repeated if significant changes are implemented by device manufacturer, as well as the reference that the manufacturer’s warranty may be eliminated if uprating is performed.

e) Added an abbreviations subclause, 3.2.

f) Reworded 4.3.5, item b), reference pertaining to default margin of 20 °C below the absolute maximum junction temperature.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
107/199/DTR	107/203/RVC

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 publication 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.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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A bilingual version of this publication may be issued at a later date.

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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 equipment manufacturers to use devices at temperature ranges that are wider than those specified by the device manufacturer.

This technical report provides information to select semiconductor devices, to assess their capability to operate, and to assure 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 may result normally in loss of warranty by the device manufacturer.

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PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS CAPABILITY IN OPERATION –

Part 1: Temperature uprating

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1 Scope

This 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 components for circuit design.

This technical report describes the methods and processes for implementing this special case. 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.

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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 (e.g., 90 nm and less). This technical report does not imply that applications use the device to function beyond the absolute maximum rating limits of the device specified by the original device manufacturer and assumes that:

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- 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 equipment.

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.

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 abbreviations

3.1 Terms and definitions

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

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
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.

3.1.6
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

3.1.7
semiconductor device
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 piece part or component. Examples are diodes, integrated circuits, and transistors.

3.1.8
electronic equipment
any item, for example end item, sub-assembly, line-replaceable unit, shop-replaceable unit, or system produced by an electronic equipment manufacturer

3.1.9
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]

3.1.10
manufacturer-specified parameter limits
electrical parameter limits that are guaranteed by the device manufacturer when a device is used within the recommended operating conditions

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SEE: Rating.

3.1.11
manufacturer-specified temperature range
operating temperature range over which the component specifications, based on the component data sheet, are guaranteed by the component manufacturer

SEE: Rating.

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

3.1.12
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

3.1.13
parameter temperature characterisation
process of determining the specification values of electrical parameters by testing samples over the manufacturer's specified temperature range

3.1.14
parameter temperature re-characterisation
process for thermal uprating in which the device parameters are re-defined as a result of testing performed

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3.1.15
rating
value that establishes either a limiting capability or a limiting condition for a semiconductor device

3.1.16
recommended operating conditions
conditions for use of the component for which the component specifications, based on the component data sheet, are identified by the component manufacturer

SEE: Rating.

3.1.17
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

3.1.18
target temperature range
operating temperature range of the device in its required application

3.1.19
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.

3.1.20
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 Abbreviations

ADHP	Aerospace, defence and high performance
ATP	Acceptance test procedure
CAGE	Commercial and government entity
CMOS	Complementary metal-oxide-semiconductor
ECMP	Electronic components management plan
ESS	Environmental stress screening
ID	Identification
LRU	Line replaceable unit
PCN	Process change notice
SD	Sigma deviation
QA	Quality assurance

4 Selection provisions

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4.1 General

Selection provisions are described below.

Devices used outside the manufacturer's specified temperature range are selected (4.2), their capability assessed (4.3), their quality assured (4.4) and documented (4.5), as illustrated by the flow chart of Figure 1.

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

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

The 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 manufacturer's limits may 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.

4.2 Device selection, usage and alternatives

4.2.1 General

The equipment is designed so that, initially and throughout equipment life, no absolute maximum value for the intended service is exceeded for any device under the worst probable operating conditions.

Operating condition examples include the following: supply voltage variation, equipment device variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variation in characteristics of the device under consideration and of all other electronic devices in the equipment.

4.2.2 Alternatives

A review of alternatives is to be performed prior to using a device outside the manufacturer's specified temperature range. If an alternative can be shown to be reasonable and practical then it is selected. The results of this evaluation are then documented.

Examples of potential alternatives include:

– using a device specified over the required temperature range, with the identical function, but from a different manufacturer;
– using a device specified over the required temperature range, with the identical function, but a wider specified temperature range;
– using a device specified over the required temperature range, with the identical function, but a different package;
– using a device specified over the required temperature range, that has slightly different specified parameter limits, but which still meets the equipment design goals;
– using a device with the identical function, but a specified temperature range that still meets the application requirement;
– using a device specified over the required temperature range, but a different function, and compensating by making changes elsewhere in the equipment design;
– modifying the device's local operating environment, for example, adding cooling, etc.;
– modifying the equipment specified ambient temperature requirement, in co-operation with the customer;
– modifying the equipment operating or maintenance procedures, in co-operation with the customer; and
– negotiating with the device manufacturer to provide assurance over the wider temperature range.

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For most applications, the preferred device for use in a wider temperature range is the one for which the extension beyond the specified range is the least, i.e., upon making the decision to uprate a given manufacturer's part and if the manufacturer offers the device in various temperature ranges, then the widest temperature range is selected. For example, given the choice to uprate a manufacturer part available in commercial temperature range (0 °C to 70 °C) versus the same device available in industrial grade (–40 °C to 85 °C) or automotive grade (–40 °C to 125 °C), then the device having the widest range is selected.

4.2.3 Device technology

The technology of a device and its package are to be identified and understood in sufficient detail to assess the likelihood and consequences of potential failure mechanisms. If available, manufacturer data, information and/or guidance are collected at the onset.

4.2.4 Compliance with the electronic component management plan

All devices considered for use in wider temperature ranges are to be compliant with the equipment manufacturer's ECMP.

NOTE IEC/TS 62239-1 is a resource for an ECMP.

4.3 Device capability assessment

4.3.1 General

The assessment of device capability needs to assure that not only are device parameters acceptable, but also that device functionality and functionality of the related circuit application are acceptable as well. Therefore, functional testing at the application or higher levels is recommended.

4.3.2 Device package and internal construction capability assessment

Device qualification test data and other applicable data when available are to be analysed to assure that:

a) They support the operation of the device over the end use temperature range and that the package and internal construction type used in device qualification is the same as that to be used in the end application.

b) The package and internal construction can withstand the stresses resulting from wider temperature cycling ranges, and that the package materials do not undergo deleterious phase changes or changes in material properties in the wider temperatures.

If data are not available, then relevant testing based on the application is to be considered.

4.3.3 Risk assessment (assembly level)

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A preliminary risk assessment is to be performed to help guide decisions regarding the method(s) of capability assessment to be used, as well as how and when they are applied. Understanding the risks on an application-specific basis enables "risk informed" decision-making and thereby a prediction of the impact of critical decisions.

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The process for assessing risks considers applicable factors associated with the use of devices beyond the manufacturer's specified temperature range. Risk factors in this assessment may include:

– application criticality into which the device will be used;

– consequences of failure at device, circuit assembly and system level;

– type or technology of device under consideration – manufacturer data available for the device;

– quality/reliability monitors employed by the manufacturer including lot-to-lot variation;

– comprehensiveness of production assembly-level screens performed at extended temperature;

– identification of both managed and unmanaged risks.

Details about the likelihood of occurrence, consequences of occurrence, and acceptable mitigation approaches for each identified risk are generated. Each risk normally falls into one of the following categories:

– functionality risks: risks for which the consequences of occurrence are loss of equipment, loss of mission, or unacceptable performance. Functionality risks impair the product's capability to operate to the customer's specification;

– "productibility" risks: risks for which the consequences of occurrence are schedule impacts. "Productibility" risks determine the probability of successfully manufacturing/fabricating the product (where "successfully" refers to some combination of schedule, manufacturing yield, quantity and other factors).

Several approaches are possible, and each approach constitutes a unique mixture of risk mitigation factors. The results of a preliminary risk assessment should provide insight and assistance to the selection of a viable approach or approaches for establishing the capability of devices being used outside the manufacturer's specified temperature range.