

JEDEC STANDARD

Temperature Range and Measurement Standards for Components and Modules

JESD402-1B

(Revision of JESD402-1A, March 2022)

September 2024

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION



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TEMPERATURE RANGE AND MEASUREMENT STANDARDS FOR COMPONENTS AND MODULES

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TEMPERATURE RANGE AND MEASUREMENT STANDARDS FOR COMPONENTS AND MODULES

Foreword

This standard has been prepared by JEDEC. The purpose of this standard is to provide specifications for operating temperature ranges as well as storage temperature ranges which may be referenced and utilized by other standards, specifications, or datasheets of devices or products when defining temperature related specifications.

Introduction

The initial version of this document is based on latest released version of the LPDDR5, DDR4, UFS v3.1 and GDDR6 specifications. However, the intent of this standard is to allow any standards, specifications, and/or datasheets developed by JEDEC, other standard bodies or individual manufacturers, to adopt this standard by way of referencing JESD402-1 if and when the responsible parties deem appropriate. Once the reference to JESD402-1 is included in these other specifications, the reference values and methods herein establish a required minimum specification. It is also expected that at the early adoption, some standards, specifications or datasheets may prefer to use a more traditional terminology of the temperature ranges. In such case, it is recommended that the standard terminology from JESD402-1 be also noted together with the traditional terminology.

This standard recognizes that some market segments prefer case temperature methods while other markets prefer an ambient temperature method. For example, media applications such as DRAM and managed NAND use package case temperature as the basis for temperature specifications which is widely used in device standards such as LPDDR5, DDR4, UFS v3.1, GDDR6, etc. Other applications, such as microcontrollers, NOR Flash, Serial Flash, and SLC NAND Flash prefer to apply ambient temperature measurement methods. When an emerging application arises which does not apply to existing market standards, the case temperature method is the preferred method due to reduced dependence on external factors such as barometric pressure, humidity, and so forth. Suppliers may also want to consider specifying both case and ambient methods and values, as well as methods specifying, measuring or calculating junction temperature directly. Newer devices such as GDDR7 and HBM4 incorporate temperature sensors on the device and therefore will use junction temperature as opposed to case or ambient temperature. Please refer to supplier datasheets for the supported method.

It is further recognized that many systems applications may mix components from different markets into unique solutions, for example a microcontroller with NOR Flash and DRAM. Since the various components may use different measurement approaches, case versus ambient, guidance is given in this specification regarding correlation of these different methods.

The distinction between case and ambient methods applies only to operating temperature ranges. Storage temperature range measurements apply to all components and assemblies.

This document outlines the full spectrum of temperature ranges defined and available for use. Individual device or product standards, specifications, and datasheets are expected to pick and choose a subset of available ranges as appropriate per the specific device or product being defined.

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TEMPERATURE RANGE and MEASUREMENT STANDARDS for COMPONENTS and MODULES

(From JEDEC Board Ballot JCB-24-28, formulated under the cognizance of the JC-42 Committee on Solid State Memories, item number 1885.01).

1 Scope

This document specifies standard temperature ranges that may be used, by way of referencing JESD402-1, in other standards, specifications, and datasheets when defining temperature related specifications.

2 Normative Reference

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For updated references, the latest edition of the normative document referred to applies.

- [UFS], JESD220, Universal Flash Storage (UFS),
- [DDR], JESD79-4, DDR4 SDRAM,
- [DDR], JESD79-5, DDR5 SDRAM,
- [LPDDR], JESD209-5, Low Power Double Data Rate 5/5X (LPDDR5/5X),
- [GDDR], JESD250, Graphics Double Data Rate (GDDR6) SGRAM STANDARD,
- [GDDR], JESD239, Graphics Double Data Rate (GDDR7) SGRAM STANDARD,
- [JESD51-1] Integrated circuit thermal measurement method – electrical test method (single semiconductor device), Dec 1995
- [JESD51-2A] Integrated circuits thermal test method environmental conditions – natural convection (still air), Jan 2007
- [AEC-Q100] Failure Mechanism Based Stress Test Qualification for Ics(base document), Rev H, Sept 2014, AEC(Automotive Electronics Council)
- [AEC-Q104] Failure Mechanism Based Stress Test Qualification For Multichip Modules (MCM) In Automotive Applications, Initial Version.

3 Terms and Definitions

For the purpose of this standard, the terms and definitions given in section 2 “Normative Reference” and the following apply.

3.1 Terms

UFS	Universal Flash Storage
DDR	Double Data Rate
LPDDR	Low Power Double Data Rate
GDDR	Graphics Double Data Rate
HBM	High Bandwidth Memory
MCP	Multichip Packages

3.2 Keywords

Several keywords are used to differentiate levels of requirements and options, as follow:

Can - A keyword used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

Expected - A keyword used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented.

Ignored - A keyword that describes bits, bytes, quadlets, or fields whose values are not checked by the recipient.

Mandatory - A keyword that indicates items required to be implemented as defined by this standard.

May - A keyword that indicates a course of action permissible within the limits of the standard (*may* equals *is permitted*).

Must - The use of the word *must* be deprecated and shall not be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

Optional - A keyword that describes features which are not required to be implemented by this standard. However, if any optional feature defined by the standard is implemented, it shall be implemented as defined by the standard.

Reserved - A keyword used to describe objects—bits, bytes, and fields—or the code values assigned to these objects in cases where either the object or the code value is set aside for future standardization. Usage and interpretation may be specified by future extensions to this or other standards. A reserved object shall be zeroed or, upon development of a future standard, set to a value specified by such a standard. The recipient of a reserved object shall not check its value. The recipient of a defined object shall check its value and reject reserved code values.

3.2 Keywords (cont'd)

Shall - A keyword that indicates a mandatory requirement strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*). Designers are required to implement all such mandatory requirements to assure interoperability with other products conforming to this standard.

Should - A keyword used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is deprecated but not prohibited (*should* equals *is recommended that*).

Will - The use of the word *will* be deprecated and shall not be used when stating mandatory requirements; *will* is only used in statements of fact.

3.3 Abbreviations

etc. - And so forth (Latin: et cetera)

e.g. - For example (Latin: exempli gratia)

i.e. - That is (Latin: id est)

3.4 Conventions

Temperatures shall be defined in degrees Celsius.

4 Temperature Definitions

4.1 Package Case Surface Temperature

Unless explicitly stated otherwise, “Package Case Surface Temperature”¹ shall be the basis of device temperature specifications using the case method. Additional details may be provided in individual standards, specifications, or datasheets of the devices.

4.2 Operating Case Temperature

Unless explicitly stated otherwise, “Operating case temperature” is defined as “the package case surface temperature of the device when the device is operating”. Additional details may be provided in individual standards, specifications, or datasheets of the devices.

4.3 Package Ambient Temperature

Unless explicitly stated otherwise, “Package ambient Temperature”² shall be the basis of device temperature specifications using the ambient method. Additional details may be provided in individual standards, specifications, or datasheets of the devices.

4.4 Operating Ambient Temperature

Unless explicitly stated otherwise, “Operating ambient temperature” is defined as “the package ambient temperature of the device when the device is operating”. Additional details may be provided in individual standards, specifications, or datasheets of the devices.

4.5 Operating Junction Temperature

Unless explicitly stated otherwise, “Operating junction temperature” is defined as “the junction temperature of the device when the device is operating”. Additional details may be provided in individual standards, specifications, or datasheets of the devices.

¹ The “Package Case Surface Temperature” is the temperature measured in package case surface per JESD51-2A, and does not refer to nor represent junction temperature or ambient temperature. Note that the temperature range specification in this JEDEC standard is defined based on Package Case Surface Temperature, while AEC-Q100 specification is defined based on ambient temperature and AEC-Q104 specification defers the temperature range to be defined by suppliers.

² The “Package Ambient Temperature” is the ambient temperature measured per JESD51-1.

4.6 Storage Temperature

Unless explicitly stated otherwise, “Storage temperature” is defined as “the package case surface temperature or package ambient temperature of the device or assembly when power is not supplied”. Additional details such as data preservation may be provided in individual standards, specifications, or datasheets of the devices.

5 Operating Temperature Ranges and Abbreviations

Table 5-1 defines operating temperature ranges, generic terminology, and abbreviations for devices supporting the case temperature method. It is recommended that device standards, specifications, and datasheets refer to this table when defining temperature ranges and detailed naming in their standards, specifications, or datasheets.

Table 5-1 — JEDEC Operating Case Temperature Ranges

Temperature Range (Unit: °C)		Generic Terminology and Abbreviation	
Min	Max	Terminology	Abbreviation
-40	125	Operating Case Temperature Range A1T	T _{OPRA1T}
-40	105	Operating Case Temperature Range A2T	T _{OPRA2T}
-40	85	Operating Case Temperature Range A3T	T _{OPRA3T}
-40	95	Operating Case Temperature Range IT	T _{OPRIT}
-25	105	Operating Case Temperature Range ET	T _{OPRET}
-25	85	Operating Case Temperature Range ST	T _{OPRST}
-5	95	Operating Case Temperature Range XT2	T _{OPRXT2}
0	95	Operating Case Temperature Range XT	T _{OPRXT}
0	85	Operating Case Temperature Range NT	T _{OPRNT}
0	45	Operating Case Temperature Range RT	T _{OPRRT}
NOTE 1 Operating Case Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.			
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.			

Historically, these temperature ranges used terminology derived from a variety of sources. These historical names are shown in Table 5-2 with the newer preferred names.

5 Operating Temperature Ranges and Abbreviations (cont'd)

Table 5-2 — Historical Case Temperature Range Names and Preferred Names

Historical Terminology	Preferred Terminology
Automotive_Grade1_Operating_Temperature	Operating Case Temperature Range A1T
Automotive_Grade2_Operating_Temperature	Operating Case Temperature Range A2T
Automotive_Grade3_Operating_Temperature	Operating Case Temperature Range A3T
Industrial_Operating_Temperature	Operating Case Temperature Range IT
Elevated_Operating_Temperature	Operating Case Temperature Range ET
Standard_Operating_Temperature	Operating Case Temperature Range ST
Extended_Operating_Temperature	Operating Case Temperature Range XT
Normal_Operating_Temperature	Operating Case Temperature Range NT
Reduced_Operating_Temperature	Operating Case Temperature Range RT

Table 5-3 defines operating temperature ranges, generic terminology, and abbreviations for devices supporting the ambient temperature method. It is recommended that device standards, specifications, and datasheets refer to this table when defining temperature ranges and detailed naming in their standards, specifications, or datasheets.

Table 5-3 — JEDEC Operating Ambient Temperature Ranges

Temperature Range (Unit: °C)		Generic Terminology and Abbreviation	
Min	Max	Terminology	Abbreviation
0	+70	Operating Ambient Temperature Range CT	TA _{OPR} CT
-40	+85	Operating Ambient Temperature Range IOT	TA _{OPR} IOT
-40	+105	Operating Ambient Temperature Range IPT	TA _{OPR} IPT
-40	+125	Operating Ambient Temperature Range IXT	TA _{OPR} IXT
-40	+85	Operating Ambient Temperature Range AO3T	TA _{OPR} AO3T
-40	+105	Operating Ambient Temperature Range AO2T	TA _{OPR} AO2T
-40	+125	Operating Ambient Temperature Range AO1T	TA _{OPR} AO1T
NOTE 1 Operating Ambient Temperature is the ambient temperature measured per JESD51-1.			

Historically, these temperature ranges used terminology derived from a variety of sources. These historical names are shown in Table 5-4 with the newer preferred names.

5 Operating Temperature Ranges and Abbreviations (cont'd)

Table 5-4 — Historical Ambient Temperature Range Names and Preferred Names

Historical Terminology	Preferred Terminology
Commercial operating temperature	Operating Ambient Temperature Range CT
Industrial operating temperature Industrial Grade (I)	Operating Ambient Temperature Range IOT
Industrial Plus operating temperature Industrial Grade (J)	Operating Ambient Temperature Range IPT
Extended industrial operating temperature Industrial Grade (K)	Operating Ambient Temperature Range IXT
Automotive operating temperature level 1 Automotive Grade 1 (Q)	Operating Ambient Temperature Range AO1T
Automotive operating temperature level 2 Automotive Grade 1 (R)	Operating Ambient Temperature Range AO2T
Automotive operating temperature level 3	Operating Ambient Temperature Range AO3T

The Abbreviation, for example, can be used as a part of product identification string to indicate the supporting temperature range of a product. Usage of the Abbreviation is not limited to this example.

5 Operating Temperature Ranges and Abbreviations (cont'd)

Table 5-5 — JEDEC Operating Junction Temperature Ranges

Temperature Range (Unit: °C)		Generic Terminology and Abbreviation	
Min	Max	Terminology	Abbreviation
-40	135	Operating Junction Temperature Range A135	TJ _{OPR} A135
-40	130	Operating Junction Temperature Range A130	TJ _{OPR} A130
-40	125	Operating Junction Temperature Range A125 / A1T	TJ _{OPR} A125 / TJ _{OPR} A1T
-40	120	Operating Junction Temperature Range A120	TJ _{OPR} A120
-40	115	Operating Junction Temperature Range A115	TJ _{OPR} A115
-40	110	Operating Junction Temperature Range A110	TJ _{OPR} A110
-40	105	Operating Junction Temperature Range A105 / A2T	TJ _{OPR} A105 / TJ _{OPR} A2T
-40	100	Operating Junction Temperature Range A100	TJ _{OPR} A100
-40	95	Operating Junction Temperature Range A95	TJ _{OPR} A95
-40	90	Operating Junction Temperature Range A90	TJ _{OPR} A90
-40	85	Operating Junction Temperature Range A85 / A3T	TJ _{OPR} A85 / TJ _{OPR} A3T
-40	135	Operating Junction Temperature Range LT135	TJ _{OPR} LT135
-40	130	Operating Junction Temperature Range LT130	TJ _{OPR} LT130
-40	125	Operating Junction Temperature Range LT125	TJ _{OPR} LT125
-40	120	Operating Junction Temperature Range LT120	TJ _{OPR} LT120
-40	115	Operating Junction Temperature Range LT115	TJ _{OPR} LT115
-40	110	Operating Junction Temperature Range LT110	TJ _{OPR} LT110
-40	105	Operating Junction Temperature Range LT105	TJ _{OPR} LT105
-40	100	Operating Junction Temperature Range LT100	TJ _{OPR} LT100
-40	95	Operating Junction Temperature Range LT95 / IT	TJ _{OPR} LT95 / TJ _{OPR} IT
-40	90	Operating Junction Temperature Range LT90	TJ _{OPR} LT90
-40	85	Operating Junction Temperature Range LT85	TJ _{OPR} LT85
-25	120	Operating Junction Temperature Range ET120	TJ _{OPR} ET120
-25	115	Operating Junction Temperature Range ET115	TJ _{OPR} ET115
-25	110	Operating Junction Temperature Range ET110	TJ _{OPR} ET110
-25	105	Operating Junction Temperature Range ET105 / ET	TJ _{OPR} ET105 / TJ _{OPR} ET

Table 5 5 — JEDEC Operating Junction Temperature Ranges (cont'd)

Temperature Range (Unit: °C)		Generic Terminology and Abbreviation	
Min	Max	Terminology	Abbreviation
-25	100	Operating Junction Temperature Range ET100	TJ _{OPR} ET100
-25	100	Operating Junction Temperature Range ET95	TJ _{OPR} ET95
-25	90	Operating Junction Temperature Range ET90	TJ _{OPR} ET90
-25	85	Operating Junction Temperature Range ET85 / ST	TJ _{OPR} ET85 / TJ _{OPR} ST
0	120	Operating Junction Temperature Range 120	TJ _{OPR} 120
0	115	Operating Junction Temperature Range 115	TJ _{OPR} 115
0	110	Operating Junction Temperature Range 110	TJ _{OPR} 110
0	105	Operating Junction Temperature Range 105	TJ _{OPR} 105
0	100	Operating Junction Temperature Range 100	TJ _{OPR} 100
0	95	Operating Junction Temperature Range 95 / XT	TJ _{OPR} 95 / TJ _{OPR} XT
0	90	Operating Junction Temperature Range 90	TJ _{OPR} 90
0	85	Operating Junction Temperature Range 85 / NT	TJ _{OPR} 85 / TJ _{OPR} NT
0	45	Operating Case Temperature Range RT	T _{OPR} RT
NOTE 1 Operating Junction Temperature is the temperature reported by the temperature sensor of the device. See device specifications for the procedure to read the temperature sensor or sensors in a device.			
NOTE 2 A1T, A2T, A3T, IT, ET, ST, XT, and NT provided for specifications that prefer to use legacy terminology.			

5.1 Examples of Operating Case Temperature

Table 5-6 through Table 5-10 show examples of temperature range and naming applied to JEDEC LPDDR5, UFS, DDR4, and DDR5 component and SODIMM specifications. Note that other device or product standards, specifications, and datasheets may follow similar format if and/or when they adopt this standard, JESD402-1, as the reference for their operating temperature range definitions.

Table 5-6 — (Example) Operating Case Temperature Applied to JEDEC LPDDR5 Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Operating Case Temperature)	Notes
	Min	Max		
T _{OPR}	-40	125	T _{OPR} A1T	1,2
	-40	105	T _{OPR} A2T	1,2
	-40	85	T _{OPR} A3T	1,2
	-25	105	T _{OPR} ET	1,2
	-25	85	T _{OPR} ST	1,2
NOTE 1 Operating Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.				

Table 5-7 — (Example) Operating Case Temperature Applied to UFS Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Operating Case Temperature)	Notes
	Min	Max		
T _{OPR}	-40	105	T _{OPR} A2T	1,2,3
	-25	85	T _{OPR} ST	1,2
NOTE 1 Operating Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.				
NOTE 3 In JESD220 (Universal Flash Storage (UFS)), this temperature range uses the terminology “Extended”. Note that it is not the same as the “Extended” defined in this specification, JESD402-1.				

5.1 Examples of Operating Case Temperature (cont'd)

Table 5-8 — (Example) Operating Case Temperature Applied to JEDEC DDR4 Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Operating Case Temperature)	Notes
	Min	Max		
T _{OPR}	0	95	T _{OPR} ET	1
	0	85	T _{OPR} NT	1
	0	45	T _{OPR} RT	1
NOTE 1 Operating Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				

Table 5-9 — (Example) Operating Case Temperature Applied to JEDEC DDR5 Component Standard

Symbol	Parameter	Temperature Range (Unit: °C)		Grade	Notes
		Min	Max		
T _{oper_normal}	Normal Operating Temperature	0	85	NT	1,2,3,4
T _{oper_normal}	Extended Operating Temperature	0	95	XT	1,2,3,4,5
NOTE 1 All operating temperature symbols, ranges, acronyms are referred from JESD402-1.					
NOTE 2 Operating Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD51-2 standard.					
NOTE 3 All DDR5 SDRDAMs are required to operate in NT and XT temperature ranges.					
NOTE 4 When operating above 85 °C, the host shall provide appropriate Refresh mode controls associated with the increased temperature range. The full description of these settings are defined in Table 68 in section 4.13.5					
NOTE 5 Operating Temperature for 3DS needs to be derated by the number of DRAM dies as: [TOPER – (2.5°C × log2N)], where N is the number of the stacked dies.					

5.1 Examples of Operating Case Temperature (cont'd)

Table 5-10 — (Example) Operating Case Temperature Applied to JEDEC DDR5 SODIMM Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Operating Case Temperature)	Notes
	Min	Max		
T _{OPR}	0	95	T _{OPRXT}	1
NOTE 1 Operating temperature applies to the case temperature of all SDRAM components on the module. All other support components on the module must remain within their respective operating temperature ranges when the case temperature of the SDRAMs are at the minimum and maximum values. For the measurement conditions for each component, please refer to JESD51-2A.				

5.2 Examples of Operating Ambient Temperature

Table 5-11 shows examples of temperature range and naming applied to JEDEC NOR flash specifications. Note that other device or product standards, specifications, and datasheets may follow similar format if and/or when they adopt this standard, JESD402-1, as the reference for their operating ambient temperature range definitions.

Table 5-11 — (Example) Operating Ambient Temperature Applied to NOR Flash Devices

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Operating Ambient Temperature)	Notes
	Min	Max		
TA _{OPR}	-40	125	TA _{OPR} IXT	1,2
	-40	105	TA _{OPR} IP	1,2
	-40	85	TA _{OPR} IOT	1,2
	-40	125	TA _{OPR} A01T	1,2
	-40	105	TA _{OPR} A02T	1,2
NOTE 1 Operating Ambient Temperature as measured per JESD51-1.				
NOTE 2 In the case of MCP where multiple components are combined, for example NOR flash and SLC NAND flash, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.				

5.3 Examples of Operating Junction Temperature

GDDR7 defines the Operating Junction Temperature as vendor specific. The GDDR7 specification (JESD239) includes example tables on how the device can apply the JESD402-1 junction temperature ranges as shown in the following tables.

Table 5-12 — (Example 1) Operating Junction Temperature Applied to GDDR7 Devices

Parameter	Symbol	Min	Max	Unit	Notes
Operating Temperature Range	TJopr115	0	115	°C	

Table 5-13 — (Example 2) Operating Junction Temperature Applied to GDDR7 Devices

Parameter	Symbol	Min	Max	Unit	Notes
Operating Temperature Range Standard	TJopr90	0	90	°C	
Operating Temperature Range Extended	TJopr100	0	100	°C	

Table 5-14 — (Example 3) Operating Junction Temperature Applied to GDDR7 Devices

Parameter	Symbol	Min	Max	Unit	Notes
Operating Temperature Range A105	TJoprA105	-40	105	°C	
Operating Temperature Range A85	TJoprA85	-40	85	°C	
Operating Temperature Range Extended	TJopr110	0	110	°C	
Operating Temperature Range Standard	TJopr95	0	95	°C	

5.3 Examples of Operating Junction Temperature (cont'd)

Table 5-15 — (Example) Operating Junction Temperature Applied to HBM4 Devices

Parameter		Symbol	JESD402-1 Operating Junction Temperature Range	Minimum	Maximum	Unit	Notes
Operating Temperature	Standard	T _N				°C	1, 3
Operating Temperature (Optional)	Extended	T _E				°C	1, 2, 3
<p>NOTE 1 The operating temperature refers to the junction temperature of all memory die(s) and the optional logic die of the HBM4 DRAM. The host is required to monitor the operating temperature via the IEEE1500 test port instructions TEMPERATURE and CHANNEL_TEMPERATURE. The host is also required to monitor the CATTRIP output that signals if the junction temperature of any die in the HBM4 DRAM exceeds a catastrophic trip-point level that could result in permanent damage of the device.</p> <p>NOTE 2 HBM4 DRAM may require additional Refresh cycle. Refer to vendor datasheet.</p> <p>NOTE 3 HBM4 operating temperatures are vendor specific. Please see JESD402-1B or later for the TJopr ranges that can be supported and vendor specifications for the specific ranges supported.</p>							

6 Storage Temperature Ranges and Abbreviations

Table 6-1 defines storage temperature ranges, generic terminology and abbreviations. It is recommended that device standards, specifications, and datasheets refer this table when defining temperature ranges and detailed naming in their standards, specifications, or datasheets.

Table 6-1 — Storage Temperature Ranges

Temperature Range (Unit: °C)		Generic Terminology and Abbreviation	
Min	Max	Terminology	Abbreviation
-55	125	Storage Temperature Range 2	T _{STG2}
-55	100	Storage Temperature Range 1B	T _{STG1B}
-40	105	Storage Temperature Range 1A	T _{STG1A}
-40	85	Storage Temperature Range ST	T _{STGST}
NOTE 1 Storage Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.			
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.			

Historically, these temperature ranges used terminology derived from a variety of sources. These historical names are shown with the newer preferred names.

Table 6-2 — Historical Range Names and Preferred Names

Historical Terminology	Preferred Terminology
Extended2_Storage_Temperature	Storage Temperature Range 2
Extended1B_Storage_Temperature	Storage Temperature Range 1B
Extended1A_Storage_Temperature	Storage Temperature Range 1A
Standard_Storage_Temperature	Storage Temperature Range ST

6.1 Examples of Storage Temperature

Table 6-3 through Table 6-7 show examples of storage temperature ranges and naming applied to JEDEC LPDDR5, GDDR6, DDR4, and UFS v3.1 specifications. Note that other device or product standards, specifications, and datasheets may follow similar format if and/or when they adopt this standard, JESD402-1, as the reference for their storage temperature range definitions.

Table 6-3 — (Example) Storage Temperature Applied to JEDEC LPDDR5 Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Storage Temperature)	Notes
	Min	Max		
T _{STG}	-55	125	T _{STG2}	1,2
NOTE 1 Storage Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.				

Table 6-4 — (Example) Storage Temperature Applied to JEDEC GDDR6 Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Storage Temperature)	Notes
	Min	Max		
T _{STG}	-55	125	T _{STG2}	1
NOTE 1 Storage Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				

Table 6-5 — (Example) Storage Temperature Applied to JEDEC DDR4 SDRAM Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Storage Temperature)	Notes
	Min	Max		
T _{STG}	-55	100	T _{STG1B}	1
NOTE 1 Storage Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				

6.1 Examples of Storage Temperature (cont'd)

Table 6-6 — (Example) Storage Temperature Applied to JEDEC UFS 3.1 Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Storage Temperature)	Notes
	Min	Max		
T_{STG}	-40	105	T_{STG1A}	1,2
	-40	85	T_{STGST}	1,2
NOTE 1 Storage Temperature is the case surface temperature on the center-top side of the device. For the measurement conditions, please refer to JESD51-2A.				
NOTE 2 In case of MCP, when multiple components, for example LPDDR and UFS, are used to make one product, it is recommended that the temperature range be defined per the temperature ranges commonly supported by all of those multiple components.				

Table 6-7 — (Example) Storage Temperature Applied to JEDEC DDR5 SODIMM Standard

Symbol	Temperature Range (Unit: °C)		Generic Abbreviation (Storage Temperature)	Notes
	Min	Max		
T_{STG}	-55	100	T_{STG1B}	1
NOTE 1 Storage temperature applies to the case temperature of all components on the module.				
NOTE 2 Storage Temperature is the case surface temperature on the center-top side of each device. For the measurement conditions, please refer to JESD51-2A.				
NOTE 3 This is a stress rating only, and device functional operation at or above the conditions indicated is not implied. Exposure to absolute maximum ratings for extended periods may affect reliability.				

Annex A — (Informative) Differences between JESD402-1A and JESD402-1

JESD402-1A consists of addition of Ambient Temperature Ranges for markets that prefer that measurement system, as developed by the Automotive task Group. Specific changes are as follows:

1. Document name changed from “Temperature Grade and Measurement Specifications for Components and Modules” to “Temperature Range and Measurement Standards for Components and Modules”.
2. Changes made to the following clauses:
 - Clause 4.2: From “Operating Temperature” to “Operating Case Temperature”
 - Clause 4.3: Package Ambient Temperature added
 - Clause 4.4: Operating Ambient Temperature added
3. Clause 2 added the following normative documents:
 - JESD51-1: Integrated circuit thermal measurement method - electrical test method (single semiconductor device), Dec 1995
 - JESD51-2A: Integrated circuits thermal test method environmental conditions - natural convection (still air), Jan 2007
4. Changes made to the following clauses:
 - Clause 5: Tables 5.5 through 5.9 added
 - Clause 6: Tables 6.6 and 6.7 added
 - All table captions were changed
 - Headers and entries were changed on all tables

Annex B — (Informative) Differences between JESD402-1B and JESD402-1A

JESD402-1B consists of:

- (1) addition of Operating Junction Temperature and
- (2) HBM4 example for TJ, DDR5 component example for TC, and TOPRXT2 operating case temperature range.

Editorial changes were also done to include the cover pages and the Standard Improvement Form. Detailed changes are as follows:

Page	Clause	Description of change
iii	Introduction	Added statement in paragraph 2 for GDDR7 and HBM4
1	2	Additional normative reference documents, such as JESD79-5
2	3.1	Added HBM to “Terms”
4	4.5	New clause “Operating Junction Temperature”
6	Table 5-1	Added row for Operating Case Temperature Range XT2
9	Table 5-5	New table “JEDEC Operating Junction Temperature Ranges”
11	5.1	Modification of 1 st paragraph
11	Table 5-7	Removed the “3.1” version from the table caption for UFS standard
12	Table 5-9	New table “(Example) Operating Case Temperature applied to JEDEC DDR5 Component Standard
13	Table 5-10	Changed abbreviation for Operating Case Temperature from T _{OPRT} to T _{OPREXT}
15	5.3	New clause “Examples of Operating Junction Temperature”
15	Table 5-12	New table “(Example 1) Operating Junction Temperature Applied to GDDR7 Devices”
15	Table 5-13	New table “(Example 2) Operating Junction Temperature Applied to GDDR7 Devices”
15	Table 5-14	New table “(Example 3) Operating Junction Temperature Applied to GDDR7 Devices”
16	Table 5-15	New table “(Example) Operating Junction Temperature Applied to HBM4 Devices”

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Standard Improvement Form

JEDEC Standard **JESD402-1B**

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

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1. I recommend changes to the following:

☐ Requirement, clause number _____

☐ Test method number _____ Clause number _____

The referenced clause number has proven to be:

☐ Unclear ☐ Too Rigid ☐ In Error

☐ Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by

Name: _____

Company: _____

Address: _____

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Phone: _____

E-mail: _____

Date: _____

