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Part Model Thermal Guidelines for Electronic-Device Packages – XML Requirements

JEP30-T100

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JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

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PART MODEL THERMAL GUIDELINE FOR ELECTRONIC-DEVICE PACKAGES - XML REQUIREMENTS

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PART MODEL THERMAL GUIDELINE FOR ELECTRONIC-DEVICE PACKAGES - XML REQUIREMENTS

(From JEDEC Board Ballots JCB-17-48 formulated under the cognizance of the JC-11 Committee on Mechanical Standardization.)

1 Scope

This standard establishes the requirements for exchanging part data between part manufacturers and their customers for electrical and electronic products. This standard applies to all forms of electronic parts. It forms part of the Part Model XML Schema, which covers the parental structure for the electrical, physical, thermal, assembly process classification data along with materials and substances that may be present in the supplied product or sub-products. This Guideline specifically focuses on the Thermal sub-section of the Part Model.

All releases of the *Thermal* sub-schema must be under the umbrella of the Part model Schema to ensure that the Part model schema is referencing the correct version of the thermal sub-schema. In addition, this will enable the *Thermal* sub-schema to connect to the Manufacturer Part Number and the Manufacturer of the Part.

1.1 Purpose

This standard is intended to benefit part manufacturers and their customers by providing consistency and efficiency to the transfer of part data from part manufacturer to customers. This standard specifically covers data applicable to the thermal modelling of the device.

2 Applicable Documents

The following documents form a part of this standard to the extent specified herein. The revision of the document in effect at the time of solicitation shall take precedence.

2.1 JEDEC (www.jedec.org)

JESD30H, *Descriptive Designation System for Electronic-device Packages*

JEP30, *Part Model Guidelines for Electronic-Device Packages – XML Requirements*

JEP30-10, *Part Model Schema*

JEP30-T101, *Part Model Package Schema*

JEP30-D10, *Part Model Schema Types Dictionary* (Required to support the Part Model Schema and each of its sectional sub-schemas.)

JESD15, *Thermal Modelling Overview*

JESD15-1, *Compact Thermal Model Overview*

JESD51, *Methodology for the Thermal Measurement of Component Packages (Single Semiconductor Device),* Dec. 1995

JESD51-1, *Integrated Circuits Thermal Measurement Method – Electrical Test Method (Single Semiconductor Device)*

2.1 JEDEC (www.jedec.org) (cont'd)

JESD51-2, *Integrated Circuit Thermal Test Method Environmental Conditions – Natural Convection (Still Air)*

JESD51-6, *Integrated Circuit Thermal Test Method Environmental Conditions – Forced Convection (Moving Air)*

JESD51-12, *Guidelines for Reporting and Using Electronic Package Thermal Information*

JESD51-13, *Glossary of Thermal Measurement Terms and Definitions*

JESD51-53, *Terms, Definitions and Units Glossary for LED Thermal Testing*

JESD99C, *Terms, Definitions, and Letter Symbols for Microelectronic Devices*

2.2 IPC (www.ipc.org)

IPC-T-50, *Terms and Definitions for Interconnecting and Packaging Electronic Circuits*

3 Requirements

The following terms and definitions are applicable to this XML Schema.

3.1 Terms and Definitions

All definitions and terms associated with the Thermal Data are defined in the JESD51 series of documents, as listed in the applicable documents section. The Thermal details of the part are defined in the *ThermalSection* of the XML Schema.

All common Terms and Definitions that are used by more than one sectional sub-schema, such as any of the Electrical, Package, Environmental, Assembly Process Classification, are defined in the "Part Model Schema Types Library".

All other definitions and terms necessary to define the schema, are defined by this document.

Part Model: A Part Model is a data representation described in an XML file that conforms to the rules and structure of the Part Model XML Schema.

NOTE 1 Companies who use the Part Model XML Files and claim compliance to JEDEC, must ensure that their Part Model XML file conforms to the specific released version of the Part Model XML Schema released by JEDEC.

NOTE 2 Section 4 will define the outline of the structure of the Thermal XML Schema. Specific components of the XML Schema and their hierarchy are specifically controlled by the JC-15 Standards Committee who retain the expertise for these structures.

NOTE 3 The *ThermalSection* of the schema forms part of the Part Model XML Schema and is not intended to act as a standalone schema. In addition, there is a "Part Model Schema Types Library" XML Schema, which is a common set of xml structures shared across the Part Model XML Schema and all of its sub-section schemas.

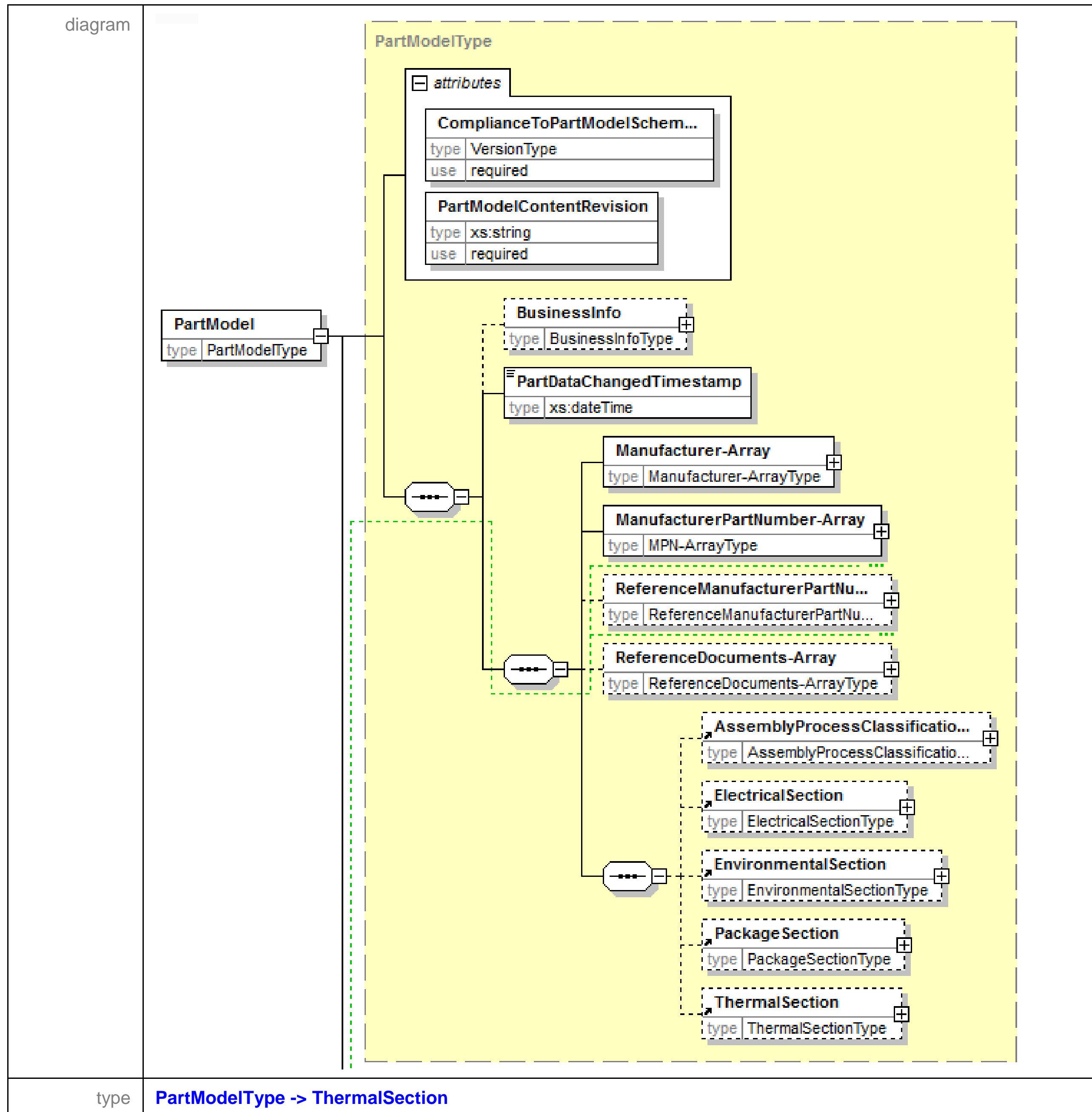
3.2 XML Schema Key Terms and Definitions

Reference the JEP30 publication for details of the "XML Schema Key Terms and Definitions".

4 Part Model Schema Definition

The following section describes the XML Schema structure.

4.1 Part Model - Thermal Section



The *PartModelType* belongs to the “Part Model XML Schema”. The *ThermalSection* belongs to the “Part Model Thermal XML Schema”. The primary purpose of the Part Model Schema is to provide the structure for identifying unique parts (Manufacturer and MPN), and the structure to include the sub schemas which define the part details, as outline in clause 1 of JEP30.

4.1 Part Model - Thermal Section (cont'd)

This document covers the *ThermalSection*, which is referenced from its parent's structure, the *PartModel*. The contents under the *ThermalSection* is tied to the Manufacturer's name and Manufacturer's part number.

The *ComplianceToPartModelSchemaVersion* indicates the version of the Schema to which the XML file is to be validated against. All new releases to this document or XML Schema is governed by the rules outlined in JEP30, and must be released in sync with the Part Model.

> *"Each time that a Sub-schema gets updated, then the part model version also gets updated in order to release that Sub-schema under the umbrella of the Part model. This is because the Part Model must now reference the new version of Sub-schema, since all subschemas have their own version number. The parent schema includes them by referring to a precise version, so a version bump in the subschema requires a version bump in the parent only at the time of release of the Parent."*

The *PartModelContentRevision* indicates the revision of the data for the Part that is submitted in the XML file. This enables the Component Manufacturer to provide a new XML file for a Part each time they wish to upgrade a new set of data for a part, in any of the sub-sections such as this *ThermalSection*.

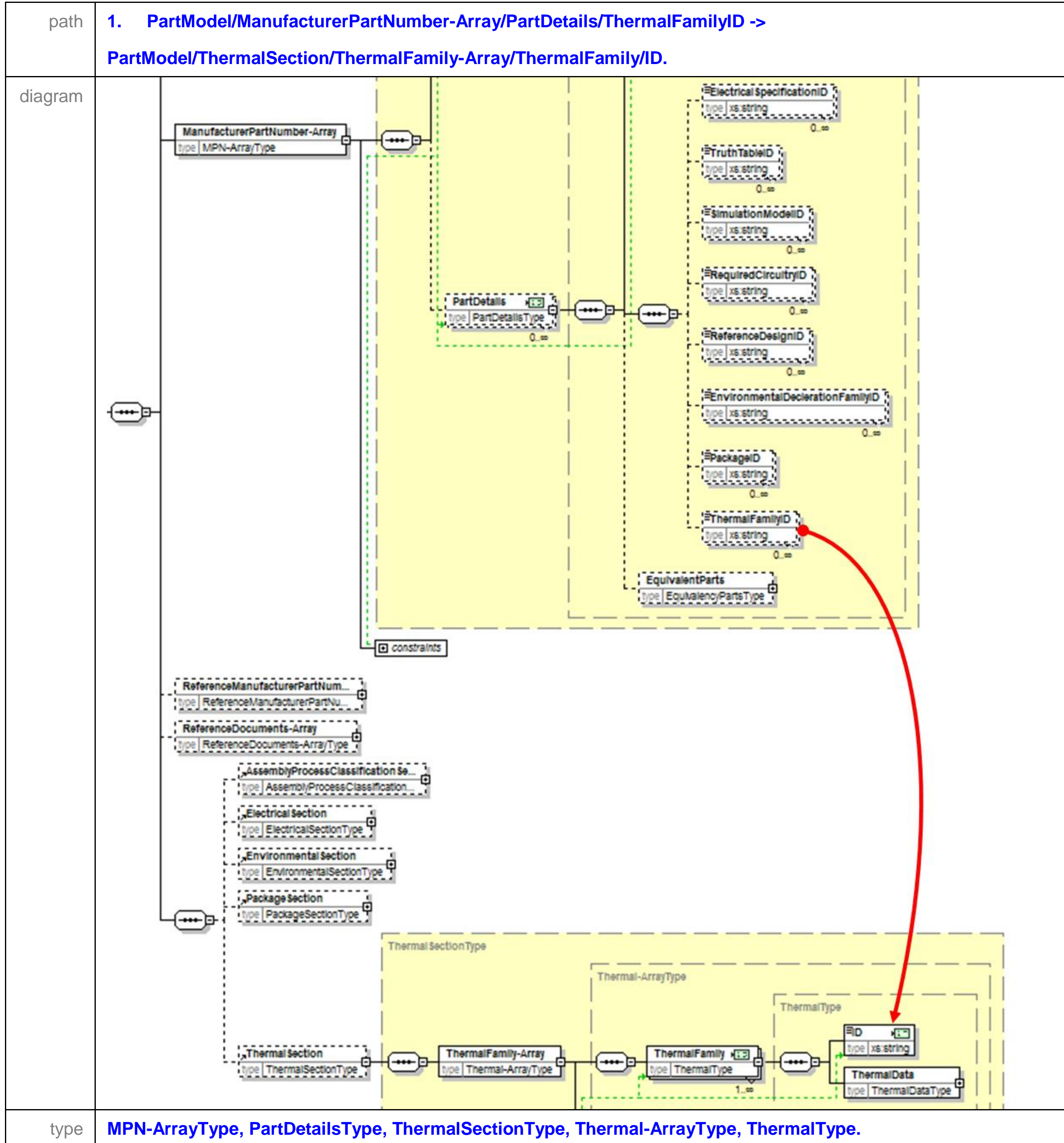
4.2 Manufacturer Part Number-Array

path	**PartModel/ManufacturerPartNumber-Array.**
diagram	MPN-ArrayType; ManufacturerPartNumber-Array (type MPN-ArrayType); PartNumberConstruction (type PartNumberType) 0..∞; OrderablePartNumber-Array (type OrderablePartNumber-ArrayType); PartDetails (type PartDetailsType) 0..∞; constraints
type	**MPN–ArrayType, PartNumberType, OrderablePartNumber-ArrayType, PartDetailsType.**

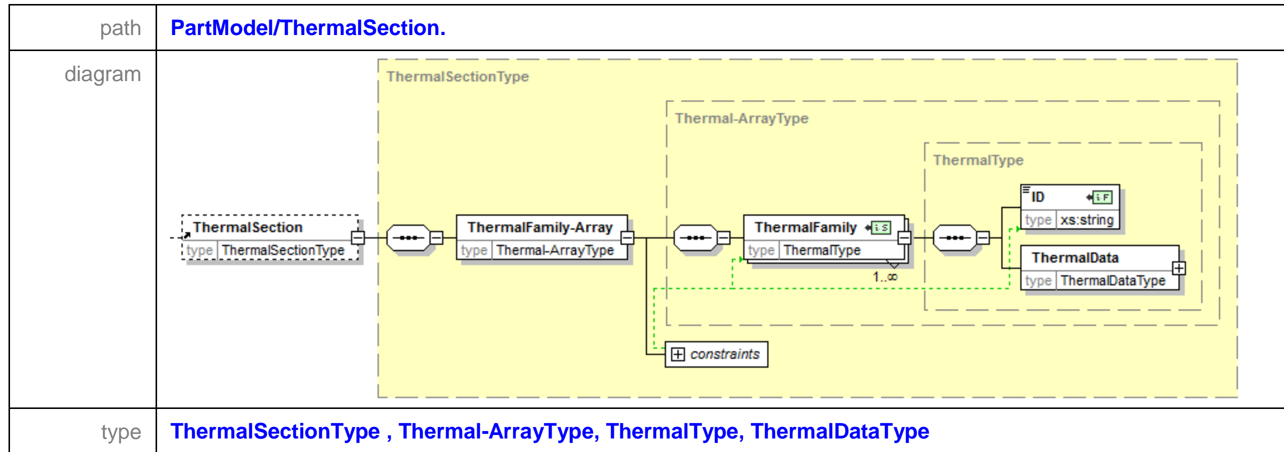
The *ManufacturerPartNumber-Array* consists of 3 sections that provide the definition of the part number, and how it can be connected to the technical specification. All Parts via their Orderable Part Numbers or Part Number families are connected to the details in the *ThermalSection* via the *PartDetails* section.

4.3. Linking the Manufacturing Part Number to a specific Thermal Data set

1. The *PartDetails/ThermalFamilyID* references the *ThermalFamily/ID* under the *ThermalSection/ ThermalFamily -Array*.

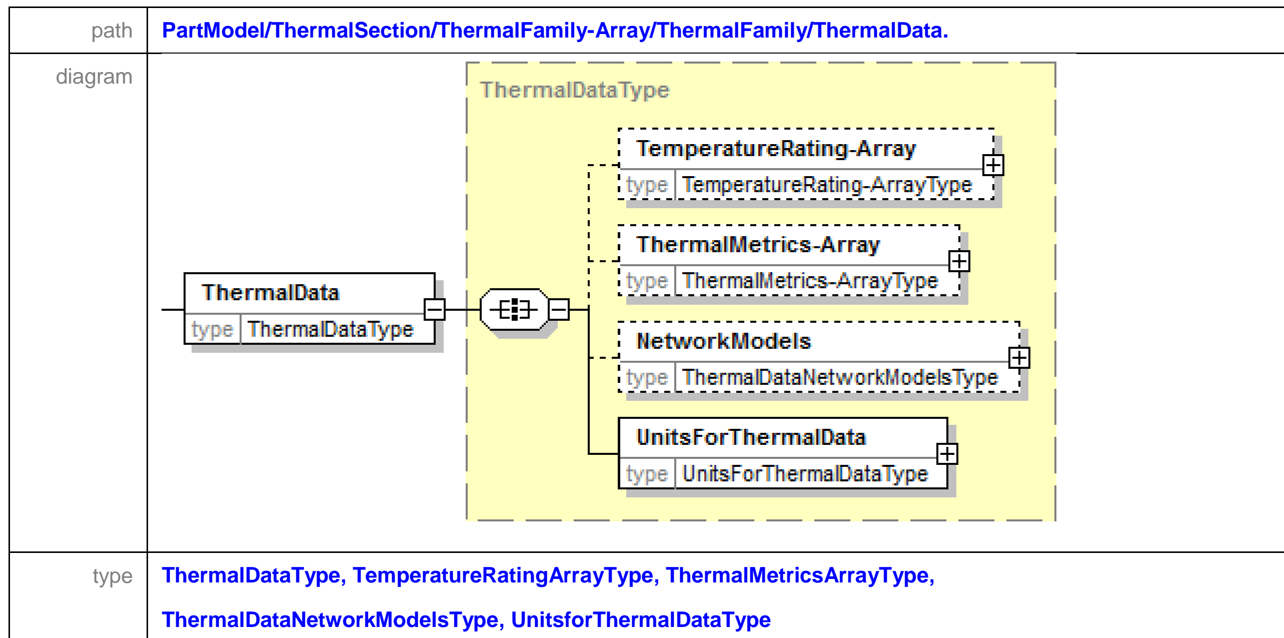
<table>
<tr><td>path</td><td>1. PartModel/ManufacturerPartNumber-Array/PartDetails/ThermalFamilyID ->
PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ID.</td></tr>
<tr><td>diagram</td><td>
</td></tr>
<tr><td>type</td><td>MPN-ArrayType, PartDetailsType, ThermalSectionType, Thermal-ArrayType, ThermalType.</td></tr>
</table>

4.4. Thermal Family-Array

path	**PartModel/ThermalSection.**
diagram	
type	**ThermalSectionType , Thermal-ArrayType, ThermalType, ThermalDataType**

The *ThermalSection* allows for the definition of an *ID*, along with its *ThermalData*, which is described in the following sections.

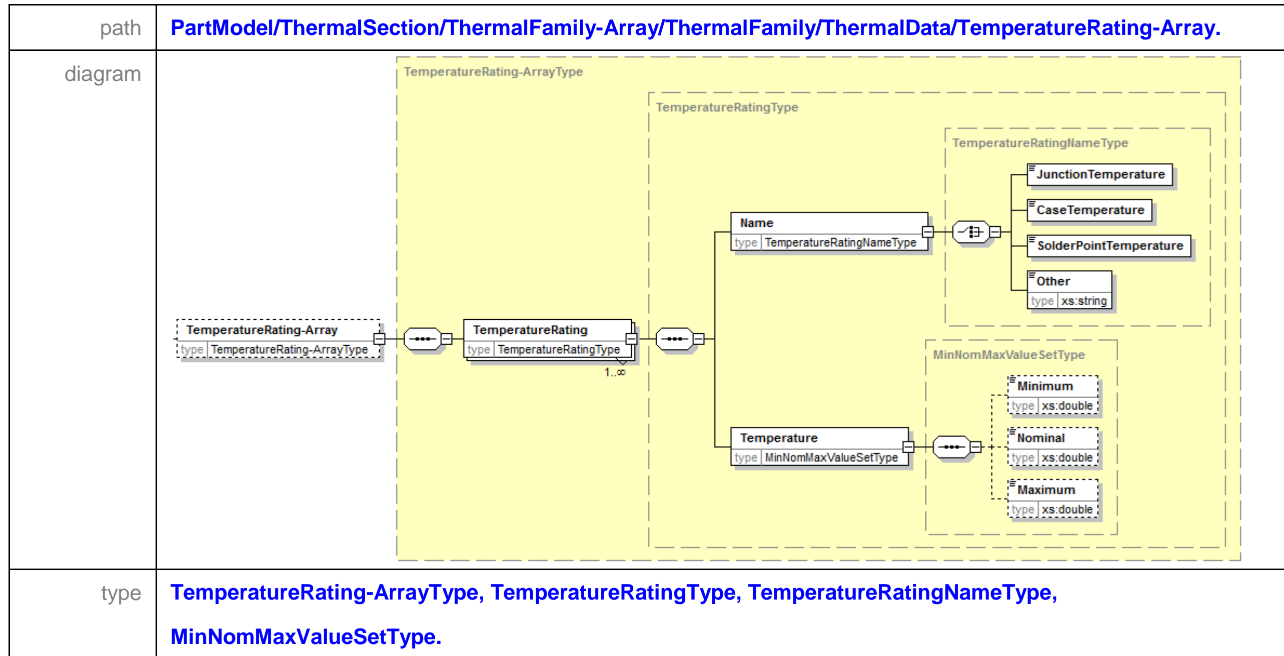
4.5. Thermal Data

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData.**
diagram	
type	**ThermalDataType, TemperatureRatingArrayType, ThermalMetricsArrayType, ThermalDataNetworkModelsType, UnitsforThermalDataType**

ThermalData allows for the definition of temperature ratings (via the *TemperatureRating-Array*), thermal metrics (via the *ThermalMetrics-Array* and intended for part comparison purposes) and thermal models (via the *NetworkModels* and intended for simulation purposes). The *UnitsForThermalData* apply to all of the previous respective branches where applicable.

4.6. Temperature Rating - Array

<table>
<tr><td>path</td><td>PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/TemperatureRating-Array.</td></tr>
<tr><td>diagram</td><td>



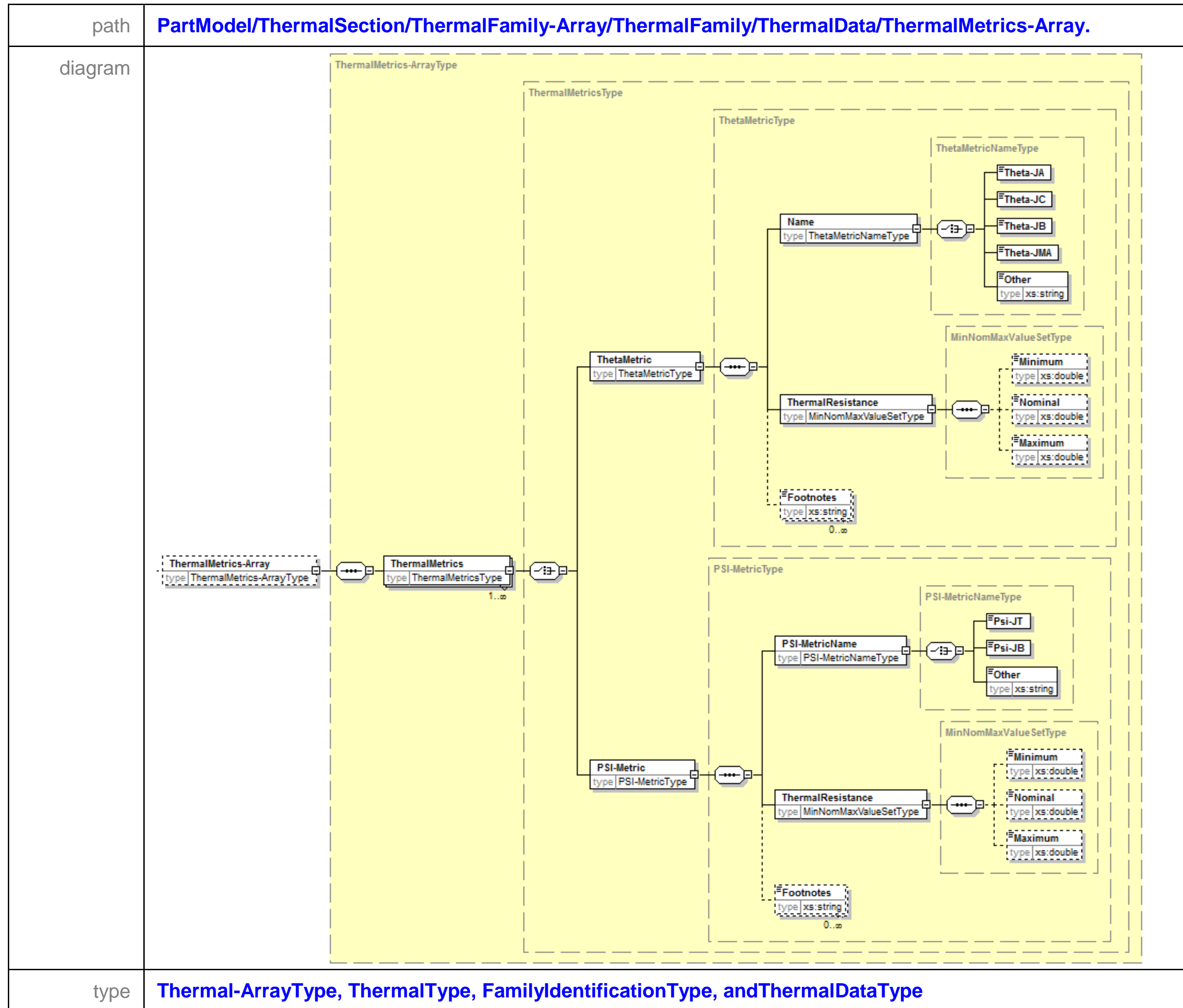
</td></tr>
<tr><td>type</td><td>TemperatureRating-ArrayType, TemperatureRatingType, TemperatureRatingNameType, MinNomMaxValueSetType.</td></tr>
</table>

Minimum, nominal or maximum temperature rating values can be defined for:

1. *JunctionTemperature*,
2. *CaseTemperature*,
3. *SolderPointTemperature*.

Or any other user defined string(s) indicating the location at which the temperature is rated at.

4.7. Thermal Metrics

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/ThermalMetrics-Array.**
diagram	
type	**Thermal-ArrayType, ThermalType, FamilyIdentificationType, andThermalDataType**

Two types of thermal metrics are supported; Theta (Θ) metrics and Psi (Ψ) metrics, as defined in JESD51-2, JESD51-6 and JESD51-12.

4.8. Theta Metrics

Minimum, nominal or maximum values of thermal resistance can be defined for each *ThetaMetric*:-

1. *Theta-JA*,
2. *Theta-JC*,
3. *Theta-JB*,
4. *Theta-JMA*.

Or any other user defined string(s) indicating the name of the Theta metric.

4.9. Psi Metrics

Minimum, nominal or maximum values of thermal resistance can be defined for each *PSI-Metric*:-

1. *Psi-JT*,
2. *Psi-JB*.

Or any other user defined string(s) indicating the name of the Psi metric.

4.10. Network Models

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels.**
diagram	ThermalDataNetworkModelsType NetworkModels type ThermalDataNetworkModelsType 1..∞ DELPHI-Model type DELPHI-ModelType 1..∞ TwoResistorModel type TwoResistorModelType 1..∞
type	**ThermalDataNetworkModelsType, DELPHI-ModelType, TwoResistorModelType**

Two types of thermal *NetworkModels* are supported; *DELPHI-Model*, as defined in JESD15-4 and *2-ResistorModel*, as defined in JESD15-3. Both models involve the definition of a nodal thermal network. Any number of 2-resistor or DELPHI Network Models may be defined.

4.11. DELPHI-Model

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model.**
diagram	DELPHI-ModelType; DELPHI-Model type DELPHI-ModelType 1..∞; Name type xs:string; Description type xs:string; PackageBodyCenterOffset-to-O... type PositionCoordinateType; PositionCoordinateType: x type xs:double, y type xs:double, z type xs:double; CoreNetwork type DELPHI-ModelCoreNetworkType; DELPHI-ModelCoreNetworkType: Node-Array type Node-ArrayType, ThermalResistance-Array type ThermalResistanceBetweenNo..., ThermalCapacitance-Array type ThermalCapacitanceNodal-Arra...; ConnectionNetwork-Array type DELPHI-ModelConnectionNetw...; DELPHI-ModelConnectionNetwork-ArrayType: ConnectionNetwork type DELPHI-ModelConnectionNetw... 1..∞; DELPHI-ModelConnectionNetworkType: Node-Array type Node-ArrayType, ThermalResistance-Array type ThermalResistanceBetweenNo..., ThermalCapacitance-Array type ThermalCapacitanceNodal-Arra...; OverlappingPolicy type OverlappingPolicy default PrecedenceByHierarchy
type	**DELPHI-ModelType, PositionCoordinateType, DELPHI-ModelCoreNetworkType,** **DELPHI-ModelConnectionNetwork-ArrayType, DELPHI-ModelConnectionNetworkType,** **Node-ArrayType, ThermalResistanceBetweenNodes-ArrayType, ThermalCapacitanceNodal-ArrayType,** **OverlappingPolicy.**

A *DELPHI-Model* is defined by a *Name*, an optional *Description*, its *PackageBodyCenterOffset-to-Origin*, a single *CoreNetwork* and optional *ConnectionNetworks* representing level 2 interconnects or sockets (unless those were considered part of the package when the DELPHI-Model was extracted).

In order to connect the Thermal Model to the Package Model, a reference for the position of the Node Array to the Origin is specified, via the *PackageBodyCenterOffset-to-Origin*. Since the Node Array Position is in respect to the Origin, specifying the offset here from the Package Body Center to the Origin will enable the alignment of the Thermal Model to the Physical Model that is defined under the *PackageSection*.

The *CoreNetwork* and *ConnectionNetwork* are defined in the same way, and is similar for a Two Resistor Model Network apart from the ability to define nodal thermal capacitances.

4.11 DELPHI Model (cont'd)

If two *RectangularNodeFaces* (see section 4.14 below) are defined as spatially overlapping, as is commonly the case for 'top inner' and 'top outer' nodal areas, then an *OverlappingPolicy* may be set to one of the following:

1. Precedence By Hierarchy
2. Precedence By Size

PrecedenceByHierarchy indicates that the Rectangular Node Face defined first in the sequence of the xml file will be interpreted as being overwritten by the overlapping *RectangularNodeFace* defined after. *PrecedenceByHierarchy* is the default setting.

PrecedenceBySize indicates that, regardless of the order in which the *RectangularNodeFaces* are defined in the xml, the smaller one (by area) will be interpreted as overwriting the larger one (by area).

4.12. 2-Resistor Model

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel.**
diagram	TwoResistorModel (type TwoResistorModelType, 1..∞); TwoResistorModelType: Name (type xs:string), Description (type xs:string), PackageBodyCenterOffset-to-O... (type PositionCoordinateType; PositionCoordinateType: x (type xs:double), y (type xs:double), z (type xs:double)), Network (type TwoResistorModelNetworkType; TwoResistorModelNetworkType: Node-Array (type Node-ArrayType), ThermalResistance-Array (type ThermalResistanceBetweenNo...))
type	**TwoResistorModelType, PositionCoordinateType, TwoResistorModelNetworkType, Node-ArrayType, ThermalResistanceBetweenNodes-ArrayType.**

A *TwoResistorModel* is defined by a *Name*, an optional *Description,* its *PackageBodyCenterOffset-to-Origin*, and a *Network*. The Network is defined by a *Node-Array* and a *Thermal Resistance-Array*.

4.13. Node-Array

path	1. **PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array,** 2. **PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array** 3. **PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/Node-Array.**
diagram	
type	**Nodal–ArrayType, NodeType, NodeFace–ArrayType, NodeVolume–ArrayType, RectangularNodeFaceType, CuboidalNodeVolumeType, PositionCoordinateType, xyPlaneType, yzPlaneType, xzPlaneType, SizeType.**

The *Node-Array* should consist of at least 2 named *Node* elements. One or more *Nodes* may have a *Power* value defined.

Such a nodal thermal model could be used for thermal or electro-thermal circuit simulation. However, if the model is to be used as part of a 3D simulation it is required to have a 3D physical definition. This is achieved by defining the following shapes:

1. Rectangular Node Face
2. Cuboidal Node Volume

4.14. Rectangular Node Face

path	**1. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array/Node/NodeFace-Array/RectangularNodeFace,** **2. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array/Node/NodeFace-Array/RectangularNodeFace,** **3. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/Node-Array/Node/NodeFace-Array/RectangularNodeFace.**
diagram	RectangularNodeFaceType RectangularNodeFace type RectangularNodeFaceType 1..∞ Position type PositionCoordinateType PositionCoordinateType: x type xs:double; y type xs:double; z type xs:double xyPlane type xyPlaneType xyPlaneType: dx type xs:double; dy type xs:double yzPlane type yzPlaneType yzPlaneType: dy type xs:double; dz type xs:double xzPlane type xzPlaneType xzPlaneType: dx type xs:double; dz type xs:double
type	**RectangularNodeFaceType, PositionCoordinateType, xyPlaneType, yzPlaneType, xzPlaneType**

The *RectangularNodeFace* is a 2D rectangular shape defined by an x, y, and z *Position*, a xy or yz or xz plane orientation and the dimension of the rectangle in that plane. When defined as a child of a Node, it nominates that node to be peripheral in that it will act as a fixed temperature thermal connection to the surrounding 3D simulation space. One or more Rectangular Node Face shapes can be defined as children of a Node.

4.15. Cuboidal Node Volume

path	**1. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array/Node/NodeVolume-Array/CuboidalNodeVolume,** **2. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array/Node/NodeVolume-Array/CuboidalNodeVolume.**
diagram	
type	**CuboidalNodeVolumeType, PositionCoordinateType, SizeType.**

The *CuboidalNodeVolume* is a 3D cuboidal shape defined by an x, y, z *Position* and x, y, z Size. It is intended to block out the physical space occupied by the Part within the 3D simulation context. One or more Cuboidal Node Volume shapes can be defined as children of a Node.

4.16. Thermal Resistance Between Nodes - Array

path	**1. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/ThermalResistance-Array,** **2. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/ThermalResistance-Array,** **3. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/ThermalResistance-Array**
diagram	ThermalResistanceBetweenNodes-ArrayType ThermalResistanceBetweenNodesType ThermalResistance-Array type ThermalResistanceBetweenNo... ThermalResistance type ThermalResistanceBetweenNo... 1..∞ FromNode type xs:string ToNode type xs:string ThermalResistance type xs:double
type	**ThermalResistanceBetweenNodes–ArrayType, ThermalResistanceBetweenNodesType**

The *ThermalResistance-Array* lists the thermal links of the Network by specifying the *FromNode* name, the *ToNode* name and the *ThermalResistance* value linking them.

4.17. Thermal Capacitance - Array

path	**1. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/ThermalCapacitance-Array,** **2. PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/ThermalCapacitance-Array**
diagram	ThermalCapacitanceNodal-ArrayType ThermalCapacitanceNodalType ThermalCapacitance-Array type ThermalCapacitanceNodal-Arra... ThermalCapacitance type ThermalCapacitanceNodalType 1..∞ FromNode type xs:string ToNode type xs:string NodalMass type xs:double NodalSpecificHeatCapacity type xs:double ThermalCapacitance type xs:double
type	**ThermalCapacitanceNodal-ArrayType, ThermalCapacitanceNodalType**

ThermalCapacitance are defined by a *ThermalCapacitance-Array* by specifying the *FromNode* name, an optional *ToNode* name and a *ThermalCapacitance* value. If no *ToNode* name is defined, then the thermal capacitance will be assumed to be connected to the thermal ground, e.g., as in a Cauer type network.

4.18. Units

path	**PartModel/ThermalSection/ThermalFamily-Array/ThermalFamily/ThermalData/UnitsForThermalData.**
diagram	UnitsForThermalDataType UnitsForThermalData type UnitsForThermalDataType DimensionUOM type DimensionUOMType NodalMassUOM type MassUOMType PowerUOM type PowerUOMType SpecificHeatCapacityUOM type SpecificHeatCapacityUOMType ThermalCapacitanceUOM type ThermalCapacitanceUOMType ThermalResistanceUOM type ThermalResistanceUOMType TemperatureUOM type TemperatureUOMType
type	**UnitsForThermalDataType, ThermalResistanceUOMType, TemperatureUOMType, ThermalCapacitanceUOMType, DimensionUOMType, PowerUOMType, SpecificHeatCapacityUOMType, MassUOMType**

4.18 Units (cont'd)

The following are the units of measure used throughout the Thermal section of the schema.

1. Dimension UOM Type,
    a. nm
    b. um
    c. mm
    d. m
    e. in
    f. mil
2. Mass UOM Type
    a. ug
    b. mg
    c. g
    d. kg
    e. oz
    f. lb
3. Power UOM Type,
    a. mW
    b. W
    c. kW
4. Specific Heat Capacity UOM Type,
    a. J/kgK
    b. Cal/gK
    c. BTU/lb DegF
5. Thermal Capacitance UOM Type,
    a. J/K
    b. mJ/K
6. Thermal Resistance UOM Type,
    a. K/W
    b. DegC/W
7. Temperature UOM Type,
    a. DegC
    b. DegF
    c. K

Annex A (informative) Differences between JEP30-T100 and its predecessors

This table briefly describes most of the changes made to entries that appear in this standard, JEP30-T100, compared to its predecessor; Punctuation changes may or may not be included.

Initial Issue: A	Date: N/A	Item Number: 11.2-938

Change Record History

Issue: A	Date:	Item Number:
Description of changes		
Revised Table of Contents		

Standard Improvement Form JEDEC ____________________

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).

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☐ Test method number __________ Clause number __________

The referenced clause number has proven to be:

☐ Unclear ☐ Too Rigid ☐ In Error

☐ Other ____________________

2. Recommendations for correction:

____

____

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____

3. Other suggestions for document improvement:

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