

JEDEC PUBLICATION

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

JEP30-T100A

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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-23-10 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)

JESD30J, *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 Thermal 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.

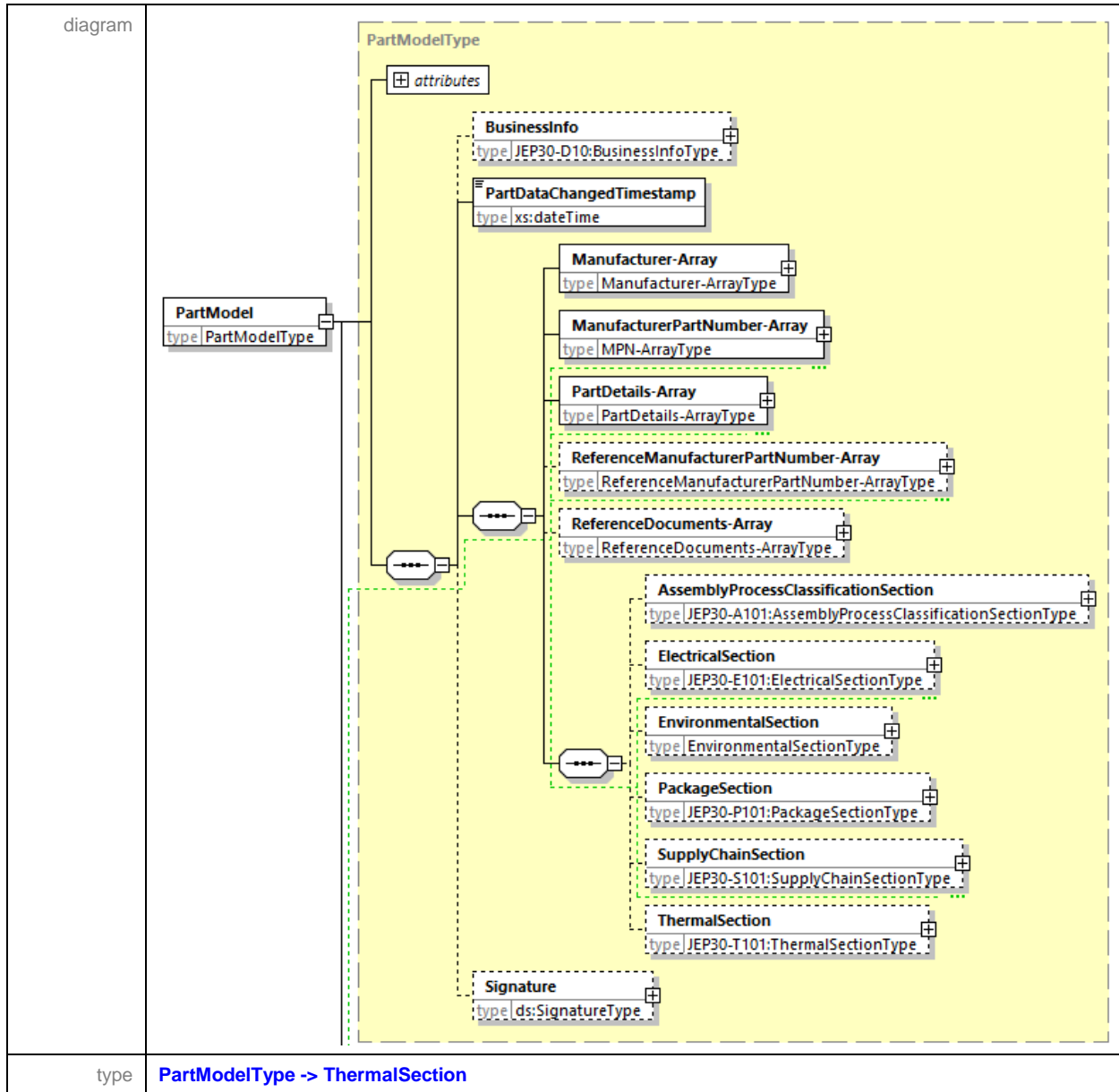
3.2 XML Schema Key Terms and Definitions

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 the JEP30 - Part Model Guidelines for Electronic-Device Packages – XML Requirements.

4.1 Part Model - Thermal Section (cont'd)

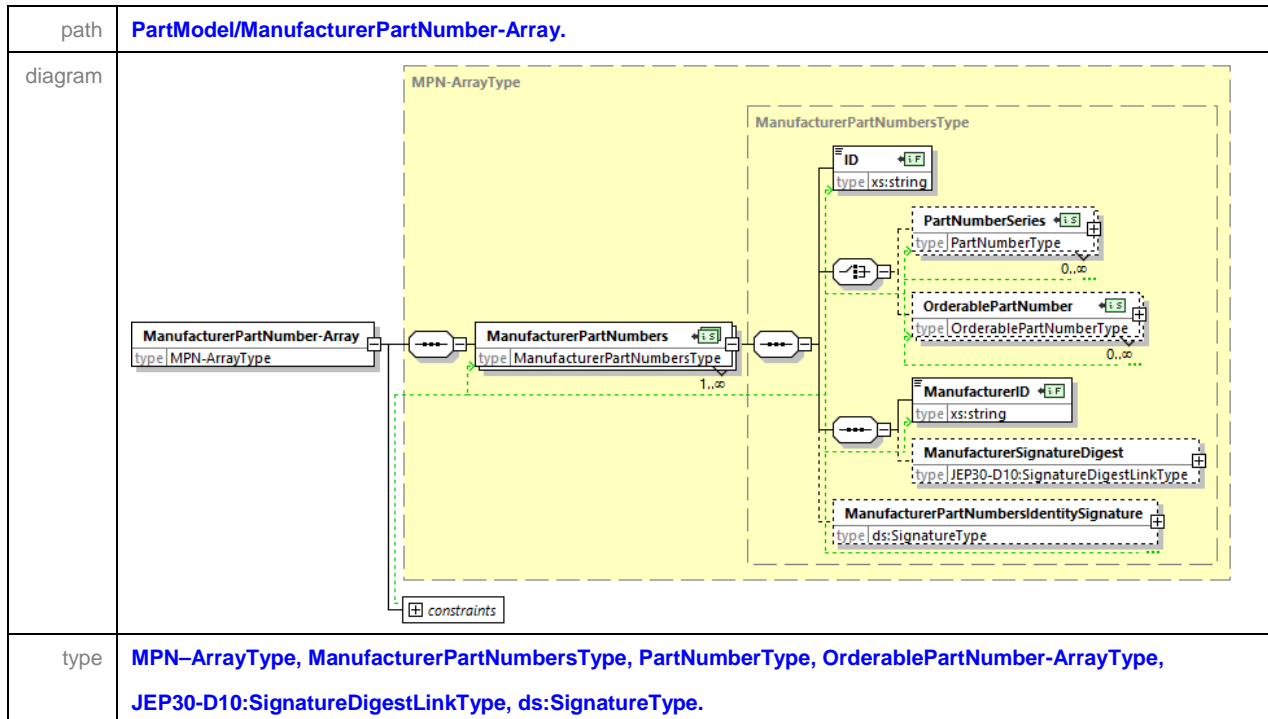
This document covers the *ThermalSection*, which is referenced from its parent's structure, the *PartModel*. The contents under the *ThermalSection* is tied to the Manufacturer's name and Manufacturer's part number.

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



The *ManufacturerPartNumber-Array* consists of a *ManufacturerPartNumbers* section that provide the definition of the part number, either via the *PartNumberSeries* or the *OrderablePartNumber*. All Parts via their Part Number families or via their Orderable Part Numbers are connected to the details in the *ThermalSection* via the *PartDetails-Array* section.

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

The linking of the Parts to its technical data is done via the *PartDetails-Array* section as outline in the JEP30 - Part Model Guidelines for Electronic-Device Packages – XML Requirements. This consists of two sections called *PartsSelection-Array* and *Association-Array* which defines the relationship between identifying the specific set of parts and how they are associated with the supply chain content. Reference the JEP30 parent document for more details on this association.

path	PartModel/PartDetails-Array/PartDetails/Association-Array/Association/Thermal-Array
diagram at the Association level	
type	ThermalFamilyAssociation-ArrayType , ThermalFamilyAssociationType , ThermalModelAssociationType .
diagram at the Thermal Section level	
type	ThermalSectionType , Thermal-ArrayType , ThermalType , ThermalModelType .

The thermal content is now sub-grouped into 2 major sections as shown in the diagram. This enables each section to be digitally signed independently of each other. The linkage between the 2 sections is shown below.

4.3.1 Linking the Manufacturing Part Number to Thermal Family Content

path	PartModel/PartDetails-Array/PartDetails/Association-Array/Association/Thermal-Array/ThermalFamily
diagram at the Electrical Parameters Association level	<p>The diagram shows a dashed box representing <code>ThermalFamilyAssociationType</code>. Inside, there is a <code>ThermalFamily</code> element (type <code>ThermalFamilyAssociationType</code>) with a cardinality of <code>0..∞</code>. To its right is a <code>ThermalFamilyID</code> element (type <code>xs:string</code>) and a <code>ThermalFamilySignature</code> element (type <code>JEP30-D10:SignatureDigestLinkType</code>). A red arrow points from the <code>ThermalFamilyID</code> element to the <code>ID</code> element in the diagram below.</p>
type	ThermalFamilyAssociationType , JEP30-D10:SignatureDigestLinkType .
path	PartModel/ThermalSection/Thermal-Array/ThermalFamily
diagram at the Electrical Parameters-Array level	<p>The diagram shows a dashed box representing <code>ThermalType</code>. Inside, there is a <code>ThermalFamily</code> element (type <code>ThermalType</code>) with a cardinality of <code>1..∞</code>. To its right is an <code>ID</code> element (type <code>xs:string</code>), a <code>ThermalData</code> element (type <code>ThermalDataType</code>), and a <code>ThermalFamilySignature</code> element (type <code>ds:SignatureType</code>). A red arrow points from the <code>ID</code> element to the <code>ThermalFamilyID</code> element in the diagram above.</p>
type	ThermalType , ThermalDataType , ds:SignatureType .

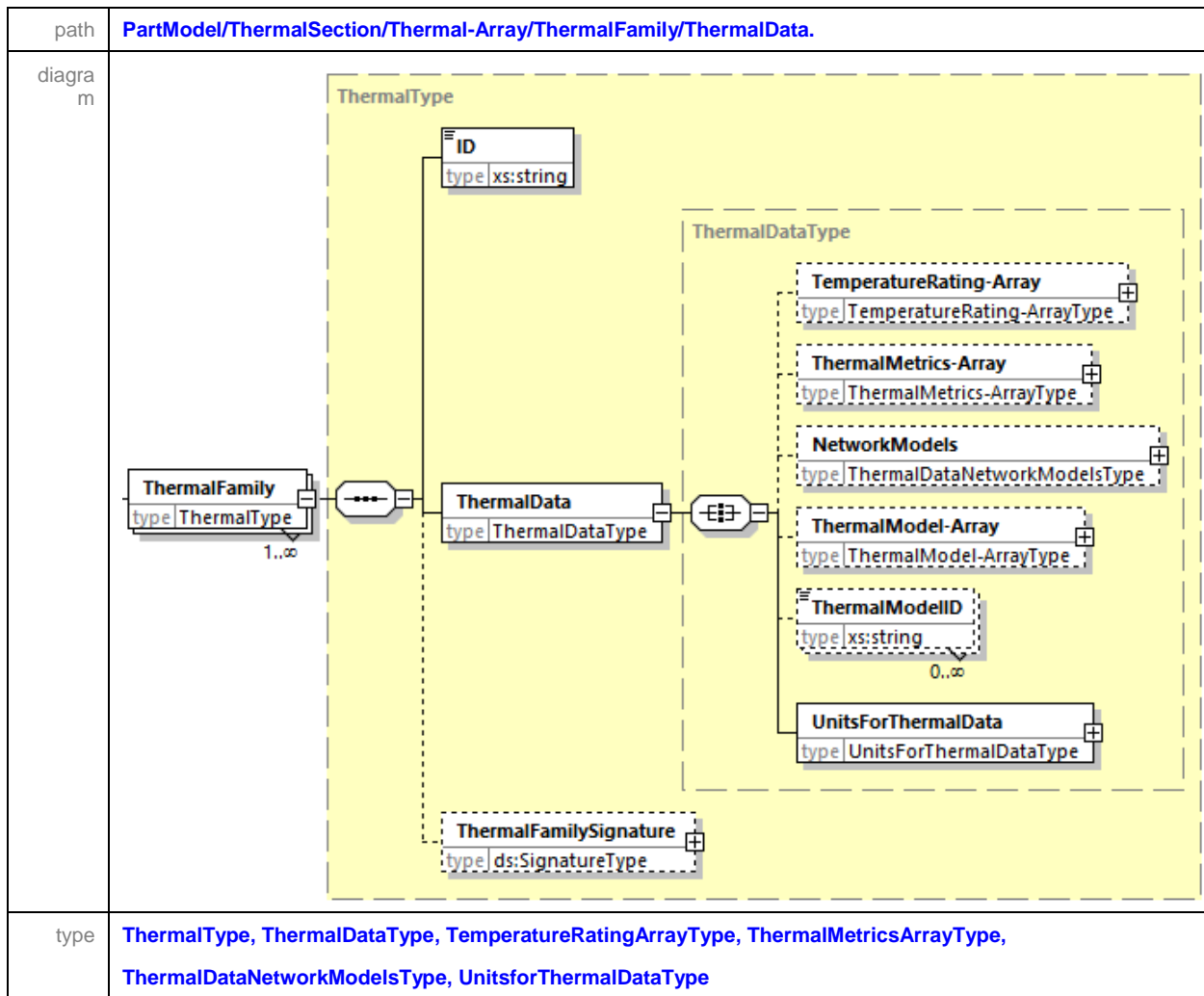
The [ThermalFamilyID](#) references the [ThermalFamily/ID](#) under the [ThermalSection/Thermal-Array](#). This is enforced by the key named as [ThermalFamilyKey](#) that is assigned to the [ThermalFamily/ID](#) element, which is referenced by the [ThermalFamilyID](#) which has a Keyref that refers to the [JEP30-T101: ThermalFamilyKey](#).

4.3.2 Linking the Manufacturing Part Number to Thermal Model Content

path	PartModel/PartDetails-Array/PartDetails/Association-Array/Association/ThermalFamily-Array/ThermalModel
diagram at the Electrical Parameters Association level	<p>The diagram shows a dashed box representing the ThermalModel element, with a type of <code>ThermalModelAssociationType</code> and a cardinality of <code>0..∞</code>. This is connected to a larger dashed box representing the ThermalModelAssociationType element. Inside this box, there are two sub-elements: ThermalModelID (type <code>xs:string</code>) and ThermalModelSignature (type <code>JEP30-D10:SignatureDigestLinkType</code>). A red arrow points from the ThermalModelID element to the ID element in the diagram below.</p>
type	ThermalModelAssociationType , JEP30-D10:SignatureDigestLinkType .
path	PartModel/ThermalSection/Thermal-Array/ThermalModel
diagram at the Electrical Parameters-Array level	<p>The diagram shows a dashed box representing the ThermalModel element, with a type of <code>ThermalModelType</code> and a cardinality of <code>0..∞</code>. This is connected to a larger dashed box representing the ThermalModelType element. Inside this box, there are several sub-elements: ID (type <code>xs:string</code>), SPICE-Thermal (type <code>JEP30-D10:EmptyType</code>), VHDL-AMS (type <code>JEP30-D10:EmptyType</code>), FMU (type <code>JEP30-D10:EmptyType</code>), MTX (type <code>JEP30-D10:EmptyType</code>), Other (type <code>xs:string</code>), Model (type <code>xs:string</code>), ModelDescription (type <code>xs:string</code>, cardinality <code>0..∞</code>), and ThermalModelSignature (type <code>ds:SignatureType</code>). A red arrow points from the ID element to the ThermalModelID element in the diagram above.</p>
type	ThermalModelType , JEP30-D10:EmptyType , ds:SignatureType .

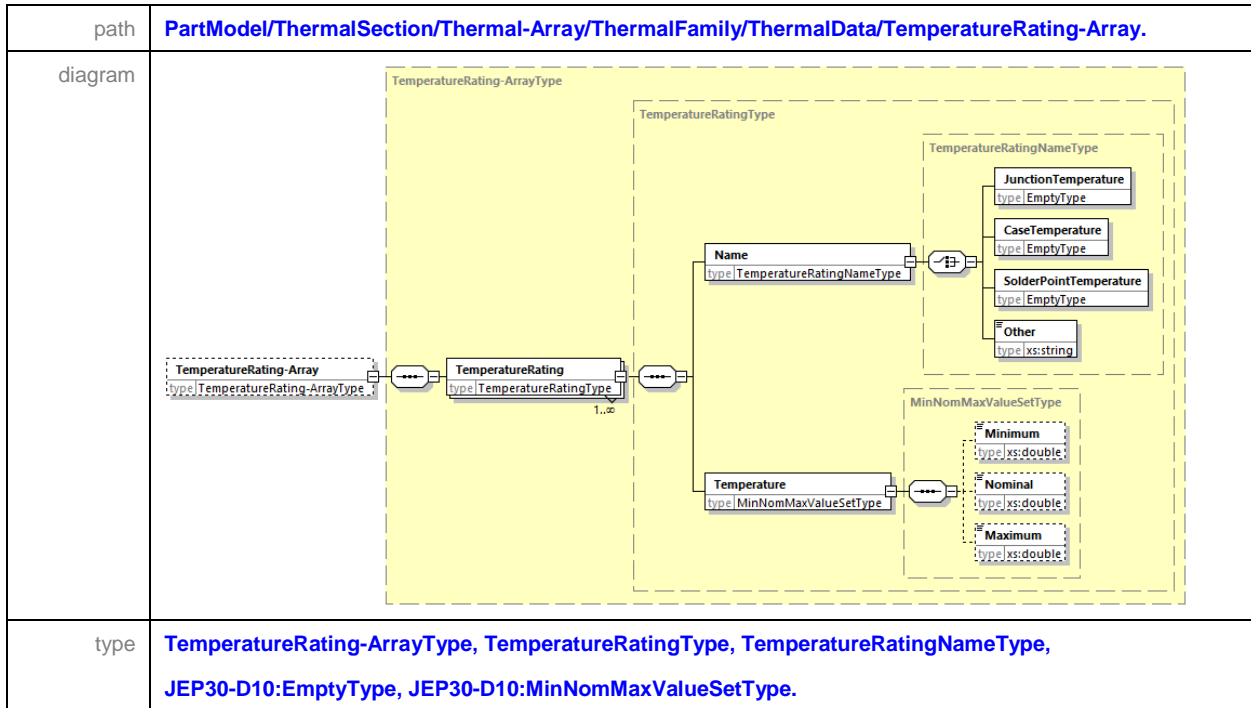
The *ThermalModelID* references the *ThermalModel/ID* under the *ThermalSection/Thermal-Array*. This is enforced by the key named as *ThermalModelKey* that is assigned to the *ThermalModel/ID* element, which is referenced by the *ThermalModelID* which has a Keyref that refers to the *JEP30-T101:ThermalModelKey*.

4.4 Thermal Family



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.

4.4.1 Temperature Rating - Array



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.

4.4.2 Thermal Metrics - Array

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array.
diagram	
type	ThermalMetrics-ArrayType , ThermalMetricsTestConditionType , ThermalMetricsType , ThermalMetricGraphType

4.4.2.1 Test Condition

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/TestCondition.
diagram	
type	ThermalMetricsTestConditionType , ThermalMetricsTestConditionUnitsType , JEP30-D10:Current UOM Type , JEP30-D10:Frequency UOM Type , JEP30-D10:Power UOM Type , JEP30-D10:Temperature UOM Type , JEP30-D10:Voltage UOM Type .

An example *TestCondition* ($T_a = 25\text{ }^\circ\text{C}$) is shown below in its XML representation. The use of the `_{}_` parentheses indicate that subscript formatting is applied to the string within those parentheses.

4.4.2.1 Test Condition (cont'd)

```

<TestCondition>
  <Symbol>T_{a}</Symbol>
  <SymbolDescription>Ambient Temperature</SymbolDescription>
  <Value>25</Value>
  <Units>
    <Temperature>DegC</Temperature>
  </Units>
</TestCondition>

```

The enumerated list of values for each of the UOM's specified above are identified in Table 1 – Test Condition Units UOM Enumerated Lists

Table 1 – Test Condition Units UOM Enumerated Lists

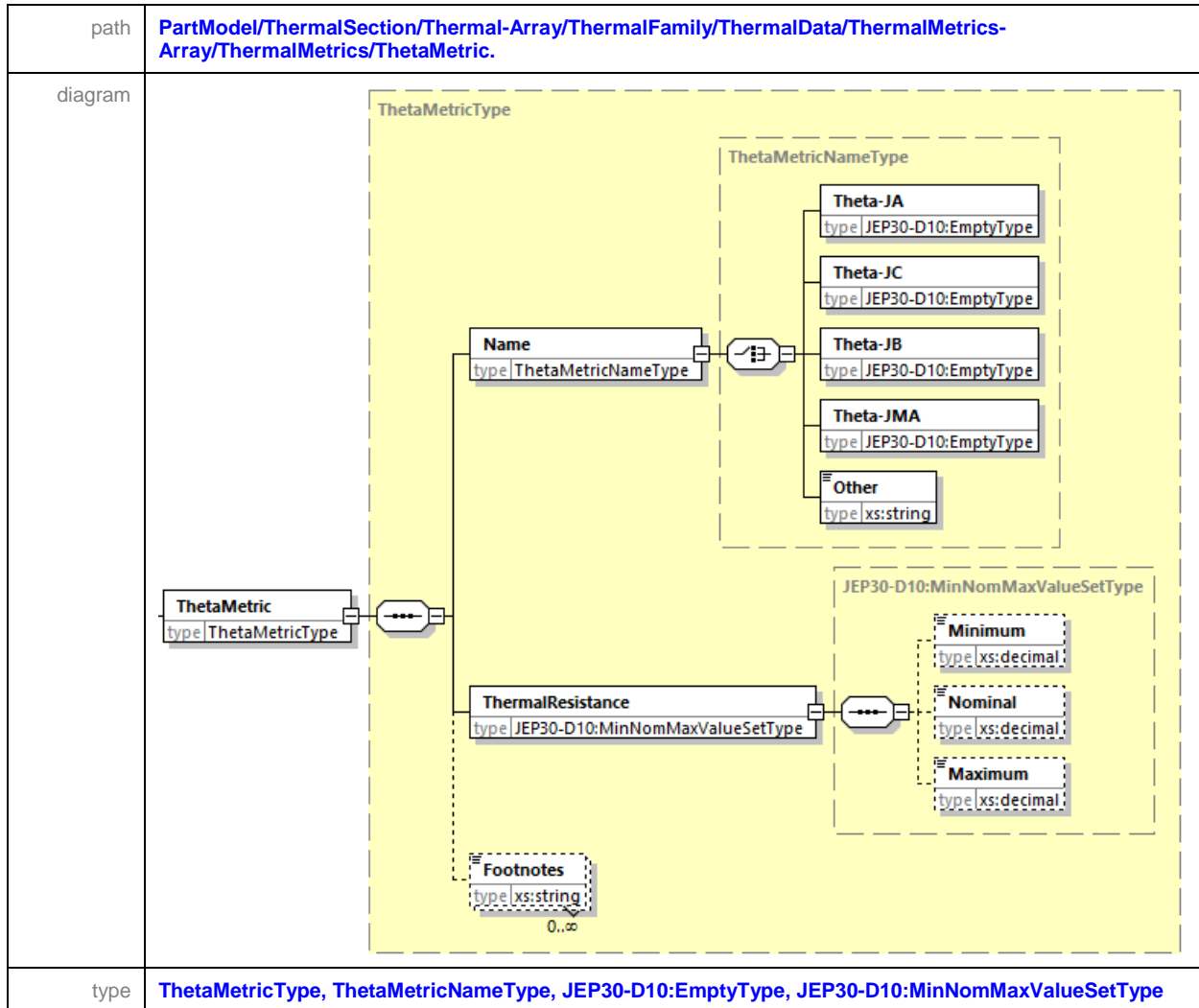
Current	Frequency	Power	Temperature	Voltage
uA	Hz	mW	DegC	mV
mA	KHz	W	DegF	V
A	MHz	kW	K	
	GHz			

4.4.2.2 Thermal Metrics

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/ThermalMetrics.
diagram	<p>The diagram illustrates the XSD structure for ThermalMetrics. The root element is ThermalMetrics (type <code>ThermalMetricsType</code>) with a cardinality of <code>1..∞</code>. It contains two child elements: ThetaMetric (type <code>ThetaMetricType</code>) and PSI-Metric (type <code>PSI-MetricType</code>). Both <code>ThetaMetricType</code> and <code>PSI-MetricType</code> are complex types containing: <ul style="list-style-type: none"> Name (type <code>ThetaMetricNameType</code>) for <code>ThetaMetricType</code> and PSI-MetricName (type <code>PSI-MetricNameType</code>) for <code>PSI-MetricType</code>. ThermalResistance (type <code>JEP30-D10:MinNomMaxValueType</code>). Footnotes (type <code>xs:string</code>) with a cardinality of <code>0..∞</code>. </p>
type	ThermalMetricsType, ThetaMetricType, ThetaMetricNameType, JEP30-D10:MinNomMaxValueType, PSI-MetricType, PSI-MetricNameType.

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

4.4.2.2.1 Theta Metric

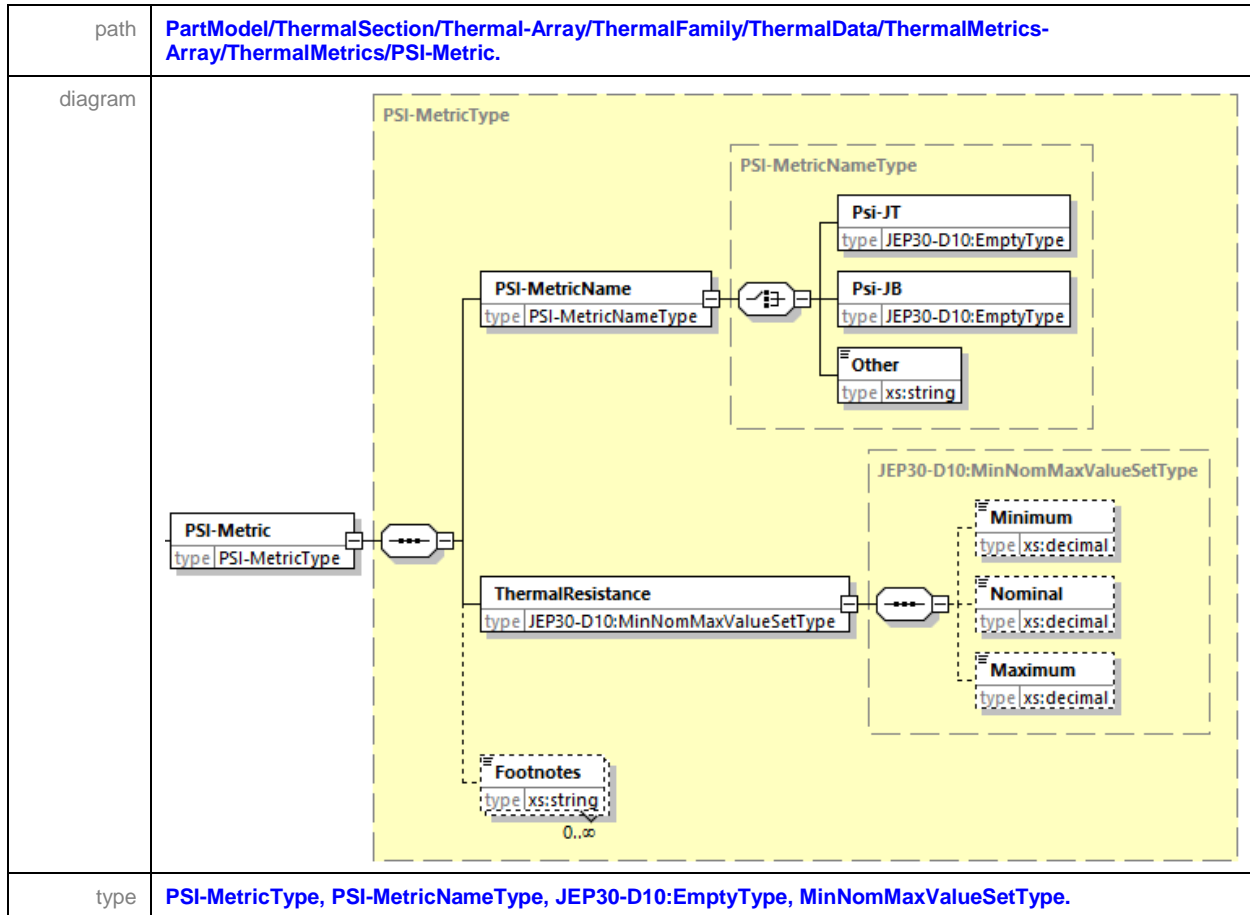


Minimum, nominal or maximum values of thermal resistance can be defined for each *ThetaMetric*:-

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.

4.4.2.2.2 PSI-Metric



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.

4.4.2.3 Thermal Metric Graph

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/ThermalMetricGraph.
diagram	
type	<p>ThermalMetricsType, ThermalMetricGraphChartXAxisType, ThermalMetricGraphChartYAxisType, ThermalMetricGraphData-ArrayType, JEP30-D10:GraphFormattingType, ThermalMetricGraphUnitsType, JEP30-D10:GraphChartXAxisFormattingType, JEP30-D10:GraphChartYAxisFormattingType</p>

A *ThermalMetricGraph* has 2 axis that are defined by the *TestConditionDefinition* (The X-axis definition), and the *ParameterDefinition* (The Y-axis definition). Each axis is labelled by the *AxisTitle*. When possible, the *Symbol* which represents the *AxisTitle* should be added to the PartModel file and should represent a standards-based symbol as defined in the appropriate Terms and Definitions standards. If appropriate, a more detailed *Description* can be used to describe the definition of the *AxisTitle*. Each axis will also have a pre-defined set of *Units* but can be optionally excluded for those axis' which are unitless.

4.4.2.3 Thermal Metric Graph (cont'd)

Note that the *ParameterDefinition* is unbounded whereas the *TestConditionDefinition* is bounded to a single instance. This is to cater for those graphs in which there are 2 or more y-axis, each with their own definition.

The graph can either be captured under the *Data-Array* or represented via a *GraphFormula* (A string representing the equation of the *ParameterDefinition* relationship to the Test *TestConditionDefinition*).

4.4.2.3.1 Thermal Metrics Graph Units

path	<p>PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/ThermalMetricGraph/TestConditionDefinition/Units.</p> <p>PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/ThermalMetricGraph/ParameterDefinition/Units.</p>
diagram	<pre> classDiagram class ThermalMetricGraphUnitsType { +DimensionUOM +NodalMassUOM +PowerUOM +SpecificHeatCapacityUOM +ThermalCapacitanceUOM +ThermalResistanceUOM +TemperatureUOM +Time } class DimensionUOM { +type JEP30-D10:DimensionUOMType } class NodalMassUOM { +type JEP30-D10:MassUOMType } class PowerUOM { +type JEP30-D10:PowerUOMType } class SpecificHeatCapacityUOM { +type SpecificHeatCapacityUOMType } class ThermalCapacitanceUOM { +type ThermalCapacitanceUOMType } class ThermalResistanceUOM { +type JEP30-D10:ThermalResistanceUOMType } class TemperatureUOM { +type JEP30-D10:TemperatureUOMType } class Time { +type JEP30-D10:Time-in-pSec-to-Years-UOMType } ThermalMetricGraphUnitsType < -- DimensionUOM ThermalMetricGraphUnitsType < -- NodalMassUOM ThermalMetricGraphUnitsType < -- PowerUOM ThermalMetricGraphUnitsType < -- SpecificHeatCapacityUOM ThermalMetricGraphUnitsType < -- ThermalCapacitanceUOM ThermalMetricGraphUnitsType < -- ThermalResistanceUOM ThermalMetricGraphUnitsType < -- TemperatureUOM ThermalMetricGraphUnitsType < -- Time </pre>
type	<p>JEP30-D10:DimensionUOMType, JEP30-D10:MassUOMType, JEP30-D10:PowerUOMType, SpecificHeatCapacityUOMType, ThermalCapacitanceUOMType, JEP30-D10:ThermalResistanceUOMType, JEP30-D10:TemperatureUOMType, JEP30-D10:Time-in-pSec-to-Years-UOMType</p>

The enumerated list of values for each of the UOM's specified above are identified in Table 1 - UOM Enumerated Lists

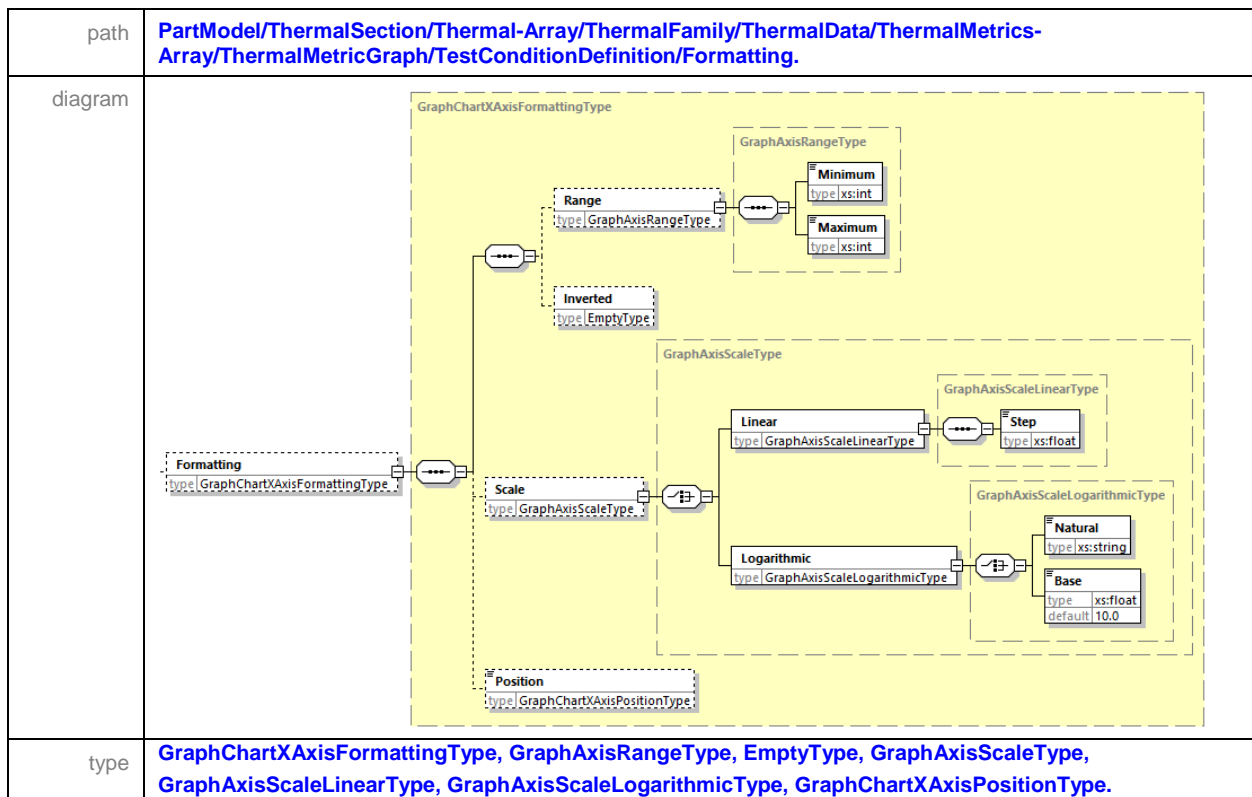
4.4.2.3.1 Thermal Metric Graph Units (cont'd)

Table 2 – Thermal Metrics Graph Units UOM Enumerated Lists

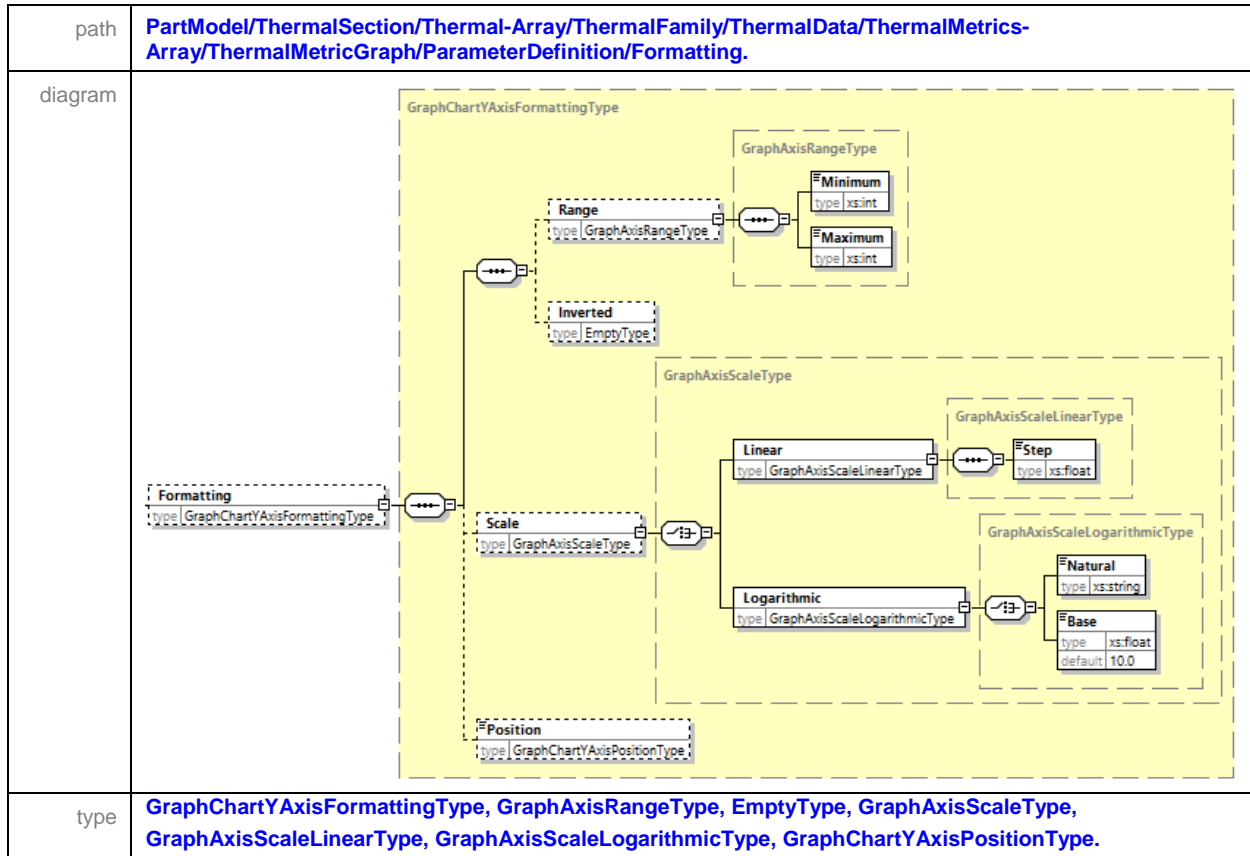
Dimension UOM	Nodal Mass UOM	Power UOM	Specific Heat Capacity UOM	Thermal Capacitance UOM	Thermal Resistance UOM	Temperature UOM	Time
nm	ug	mW	J/kgK	J/K	K/W	DegC	ps
um	mg	W	Cal/gK	mJ/K	DegC/W	DegF	ns
mm	g	kW	BTU/lb DegF			K	us
m	kg						ms
Mil	oz						s
in	lb						min
							h
							d
							wk
							y

4.4.2.3.2 Formatting

The Formatting is an optional set of data that enables the user to re-create the graph for visualization purposes. Formatting applies to the following



4.4.2.3.2 Formatting (cont'd)



The axis range which is usually defined from minimum to maximum can be inverted to show a graph going from maximum to minimum. The scale can be defined in either a linear step amount, a natural logarithm, or a logarithm of the specified base. The *Base* log is set to a default of *Base 10* but can be defined to any base number.

The *Position* enumerated list for the *GraphChartXAxisPositionType* is

- Top
- Bottom

And for the *GraphChartYAxisPositionType*, the enumerated values are

- Left
- Right

4.4.2.3.2 Formatting (cont'd)

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/ThermalMetrics-Array/ThermalMetricGraph/Formatting.
diagram	<pre> classDiagram class GraphFormattingType { +DisplayType +Legend } class DisplayType { +type GraphDisplayType } class Legend { +type GraphLegendType } class GraphLegendType { +Location +VerticalPosition +HorizontalPosition } class GraphLegendLocationType { +type GraphLegendLocationType } class GraphLegendVerticalPositionType { +type GraphLegendVerticalPositionType } class GraphLegendHorizontalPositionType { +type GraphLegendHorizontalPositionType } GraphFormattingType --> DisplayType GraphFormattingType --> Legend GraphLegendType --> GraphLegendLocationType GraphLegendType --> GraphLegendVerticalPositionType GraphLegendType --> GraphLegendHorizontalPositionType </pre>
type	GraphFormattingType , GraphDisplayType , GraphLegendType , GraphLegendLocationType , GraphLegendVerticalPositionType , GraphLegendHorizontalPositionType .

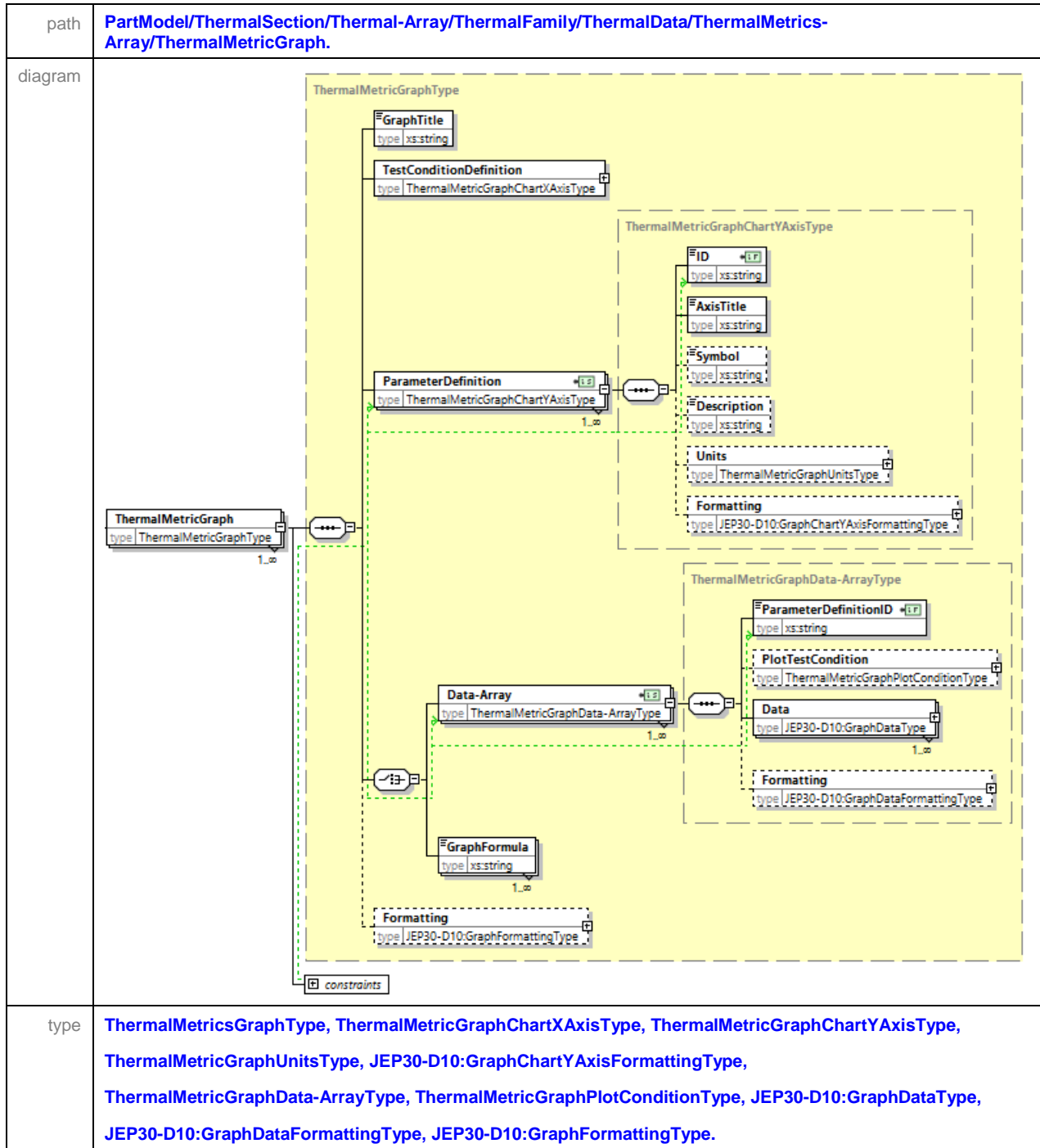
The body of the graph can be formatted under the [GraphFormattingType](#). The [DisplayType](#) enumerated list is

- Line
- Bar

The graph Legend can also be positioned around the graph in any of the following locations:

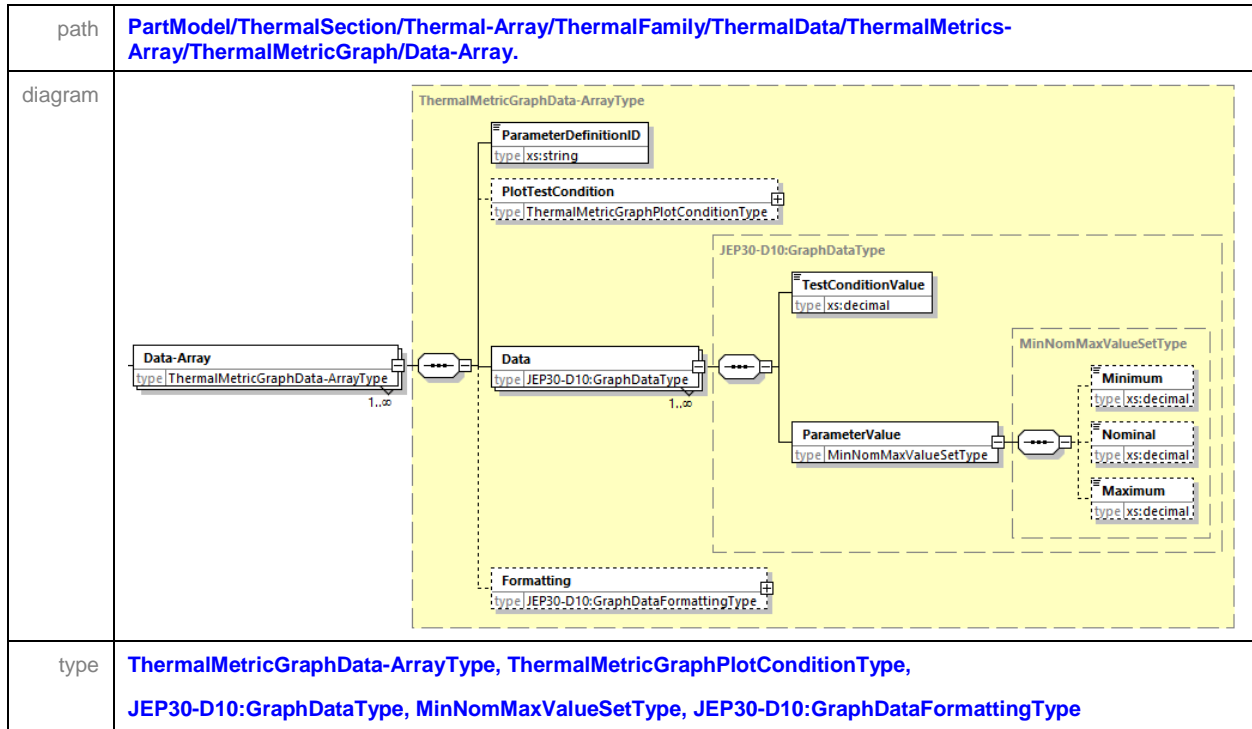
- Location
 - Inside Graph,
 - Outside Graph,
- Vertical Position
 - Top,
 - Center,
 - Bottom,
- Horizontal Position
 - Left,
 - Center,
 - Right.

4.4.2.3.3 Linking the Data-Array to the Appropriate Parameter Definition



When populating the *Data-Array* for a given graph, the set of data is referenced to the specific *ParameterDefinition* via the *ParameterDefinitionID*. The process is replicated for each *ParameterDefinition* if there are 2 or more vertical *ParameterDefinition* axis defined. Each set of data captured under the *Data-Array* is now tied to the appropriate *ParameterDefinition* axis.

4.4.2.3.4 Data-Array



Each data set consisting of the *TestConditionValue* and the *ParameterValue*, represents one point of a piecewise linear graph. A Z_{th} thermal impedance response example of the *ThermalMetricGraph* is shown and represented in the xml data below.

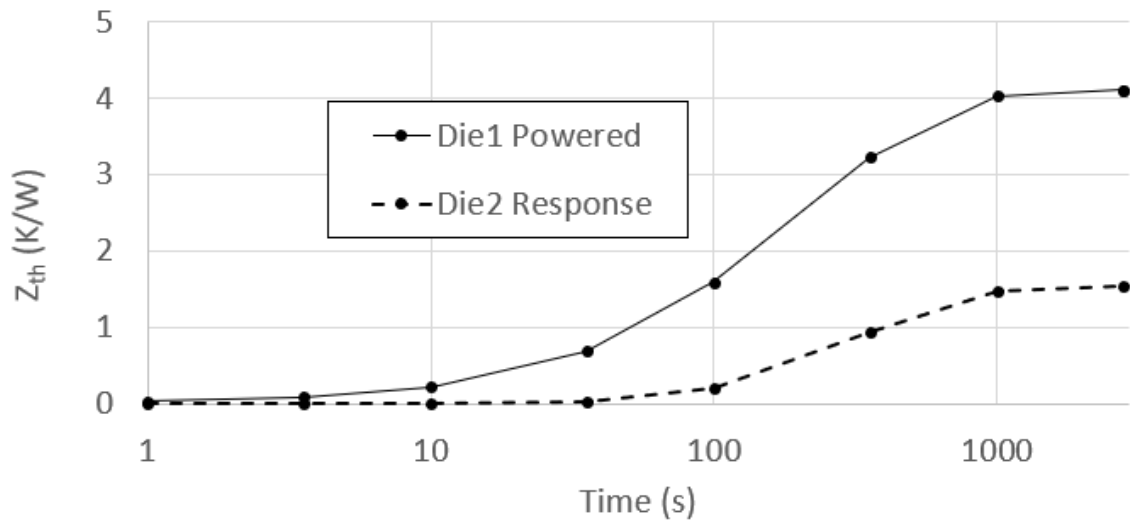
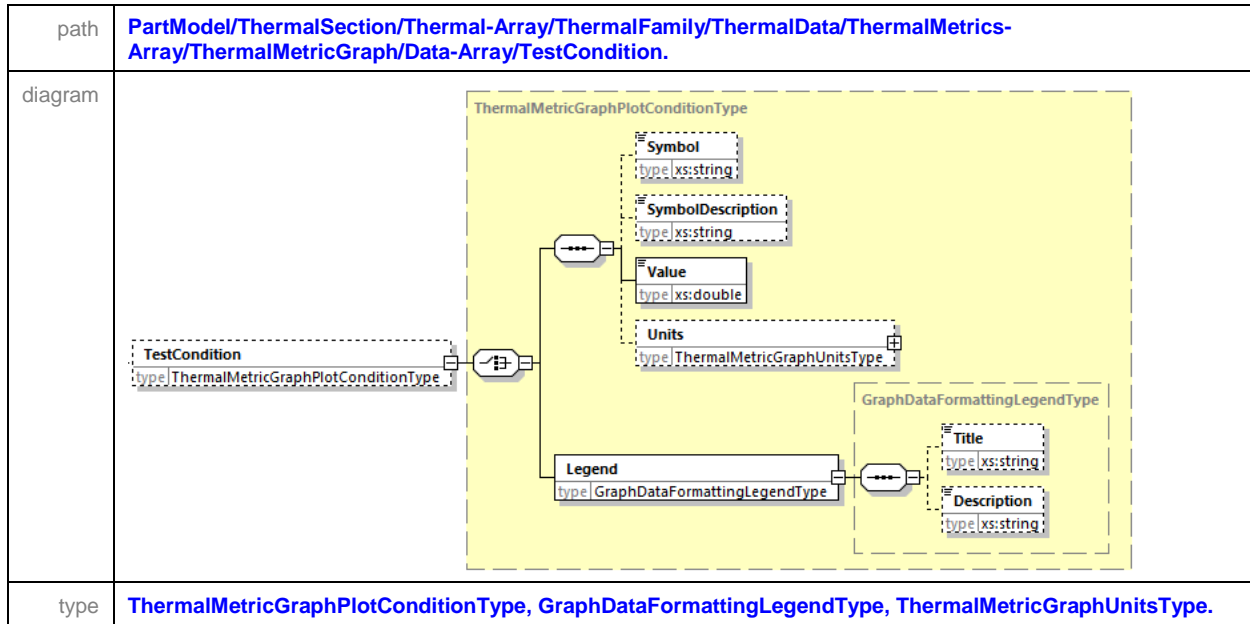


Figure 1 – Z_{th} Thermal Impedance Curves

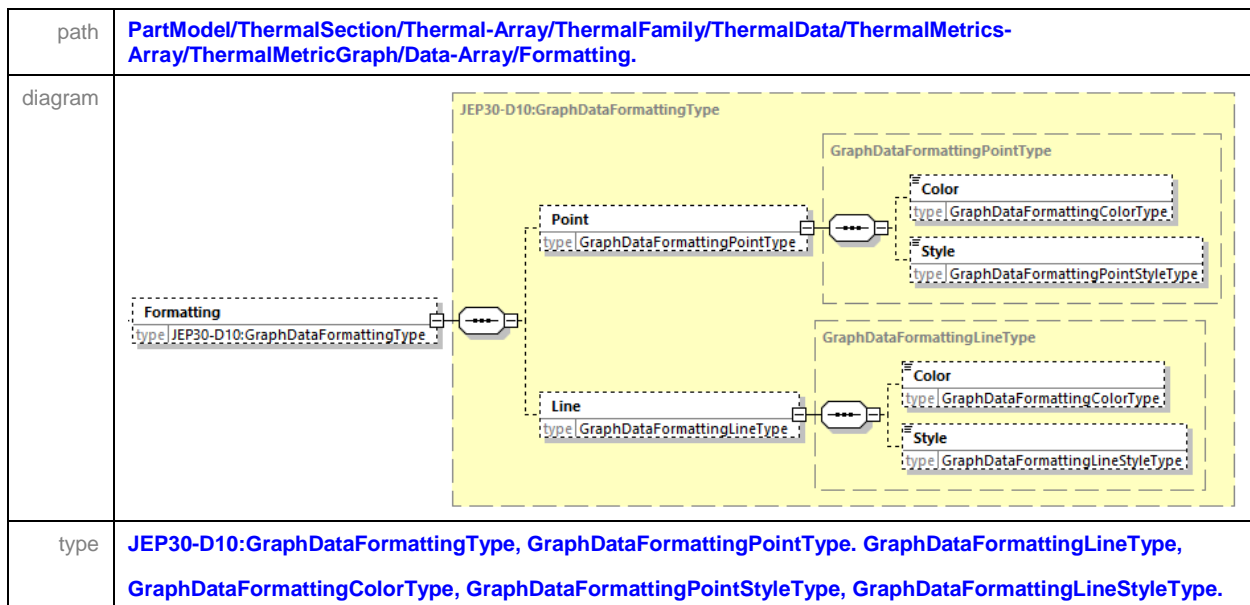
The *TestCondition* represents different plots on the same graph, as shown in Figure 1 - Z_{th} Thermal Impedance Curves . The Z_{th} curves representing ‘Die1 Powered’ and ‘Die2 Response’ are captured with their own *TestCondition* as shown in the below XML file (first 2 points only shown for brevity).

4.4.2.3.4 Data-Array (cont'd)



Depending upon the type of test condition, its value may be a string or label that describes the *TestCondition*, in which case the value is populated under the *Legend* branch.

When possible, the *Symbol* which represents the *TestCondition* should be added to the PartModel file and should represent a standards-based symbol as defined in the appropriate Terms and Definitions standards. If appropriate, a more detailed *SymbolDescription* can be defined to describe the definition of the *TestCondition*. The *Symbol* can have a pre-defined set of *Units* but can be optionally excluded for those *TestCondition* which are unitless.



4.4.2.3.4 Data-Array (cont'd)

The data points can also be formatted. Individual data points can have the following styles

- Point Styles are
 - Circle,
 - Square,
 - Triangle,
 - None.
- Line Style are
 - Solid,
 - Dash,
 - Dot,
 - Dash-dot,
 - Dash-dash-dot,
 - None.
- Colors are
 - Red,
 - Green,
 - Blue,
 - Orange,
 - Brown,
 - Pink,
 - Purple,
 - Yellow,
 - Black.

The xml fragment shown below represents the data plotted in Figure 1 – Zth Thermal Impedance Curves.

```
< ThermalMetricGraph>  
  <GraphTitle>Zth Thermal Impedance Curves</GraphTitle>  
  <TestConditionDefinition>  
    <AxisTitle>Time (s)</AxisTitle>  
    <Symbol>t</Symbol>  
    <Description>Time since power step</Description>  
    <Units>  
      <Time>s</Time>  
    </Units>  
    <Formatting>  
      <Range>  
        <Minimum>1</Minimum>  
        <Maximum>10000</Maximum>  
      </Range>  
      <Scale>  
        <Logarithmic>  
          <Base>10</Base>  
        </Logarithmic>  
      </Scale>  
      <Position>Bottom</Position>  
    </Formatting>  
  </TestConditionDefinition>
```

4.4.2.3.4 Data-Array (cont'd)

```
<ParameterDefinition>
  <ID>Y1</ID>
  <AxisTitle>Z_{th} (K/W)</AxisTitle>
  <Symbol>Z_{th}Symbol</Symbol>
  <Description>Thermal Impedance Response</Description>
  <Units>
    <ThermalResistanceUOM>K/W</ThermalResistanceUOM>
  </Units>
  <Formatting>
    <Range>
      <Minimum>0</Minimum>
      <Maximum>5</Maximum>
    </Range>
    <Scale>
      <Linear>
        <Step>1</Step>
      </Linear>
    </Scale>
    <Position>Left</Position>
  </Formatting>
</ParameterDefinition>
<Data-Array>
  <ParameterDefinitionID>Y1</ParameterDefinitionID>
  <TestCondition>
    <Legend>
      <Title>Die1 Powered</Title>
    </Legend>
  </TestCondition>
  <Data>
    <TestConditionValue>1</TestConditionValue>
    <ParameterValue>
      <Nominal>0.026</Nominal>
    </ParameterValue>
  </Data>
  <Data>
    <TestConditionValue>3.55</TestConditionValue>
    <ParameterValue>
      <Nominal>0.085</Nominal>
    </ParameterValue>
  </Data>
  ...
  ...
</Data-Array>
<Data-Array>
  <ID>Y1</ID>
  <TestCondition>
    <Legend>
      <Title>Die2 Response</Title>
    </Legend>
  </TestCondition>
  <Data>
    <TestConditionValue>1</TestConditionValue>
    <ParameterValue>
      <Nominal>9.7e-7</Nominal>
    </ParameterValue>
  </Data>
</Data-Array>
```

4.4.2.3.4 Data-Array (cont'd)

```

        </ParameterValue>
    </Data>
    <Data>
        <TestConditionValue>3.55</TestConditionValue>
        <ParameterValue>
            <Nominal>4.4e-5</Nominal>
        </ParameterValue>
    </Data>
    ...
    ...
    <Formatting>
        <Point>
            <Color>Blue</Color>
            <Style>Circle</Style>
        </Point>
        <Line>
            <Color>Black</Color>
            <Style>Solid</Style>
        </Line>
    </Formatting>
</Data-Array>
<Formatting>
    <DisplayType>Line</DisplayType>
    <Legend>
        <Location>Inside Graph</Location>
        <VerticalPosition>Center</VerticalPosition>
        <HorizontalPosition>Center</HorizontalPosition>
    </Legend>
</Formatting>
</ThermalMetricGraph>

```

4.4.3 Network Models

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels.
diagram	
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.

4.4.3.1 DELPHI-Model

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model.
diagram	
type	<p>DELPHI-ModelType, PositionCoordinateType, DELPHI-ModelCoreNetworkType, DELPHI-ModelConnectionNetwork-ArrayType, DELPHI-ModelConnectionNetworkType, Node-ArrayType, ThermalResistanceBetweenNodes-ArrayType, ThermalCapacitanceNodal-ArrayType, OverlappingPolicy.</p>

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.

4.5.3.1 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).

4.4.3.2 2-Resistor Model

path	PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel.
diagram	
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*.

4.4.3.3 Node-Array

path	<ol style="list-style-type: none"> 1. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array, 2. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array 3. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/Node-Array.
diagram	
type	Node-ArrayType , NodeType , NodeFace-ArrayType , NodeVolume-ArrayType , RectangularNodeFaceType , CuboidalNodeVolumeType

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, which includes their respective *Name*, *Position* and *Size* as shown below:

1. Rectangular Node Face
2. Cuboidal Node Volume

4.4.3.3.1 Rectangular Node Face

<p>path</p>	<ol style="list-style-type: none"> 1. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array/Node/NodeFace-Array/RectangularNodeFace, 2. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array/Node/NodeFace-Array/RectangularNodeFace, 3. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/Node-Array/Node/NodeFace-Array/RectangularNodeFace.
<p>diagram</p>	<pre> classDiagram class RectangularNodeFace { type RectangularNodeFaceType } class RectangularNodeFaceType { Name : type xs:string Position : type PositionCoordinateType xyPlane : type xyPlaneType yzPlane : type yzPlaneType xzPlane : type xzPlaneType } class PositionCoordinateType { x : type xs:decimal y : type xs:decimal z : type xs:decimal } class xyPlaneType { dx : type xs:decimal dy : type xs:decimal } class yzPlaneType { dy : type xs:decimal dz : type xs:decimal } class xzPlaneType { dx : type xs:decimal dz : type xs:decimal } RectangularNodeFace "1..∞" -- "1" RectangularNodeFaceType RectangularNodeFaceType -- "1" PositionCoordinateType RectangularNodeFaceType -- "1" xyPlaneType RectangularNodeFaceType -- "1" yzPlaneType RectangularNodeFaceType -- "1" xzPlaneType PositionCoordinateType -- "1" x PositionCoordinateType -- "1" y PositionCoordinateType -- "1" z xyPlaneType -- "1" dx xyPlaneType -- "1" dy yzPlaneType -- "1" dy yzPlaneType -- "1" dz xzPlaneType -- "1" dx xzPlaneType -- "1" dz </pre>
<p>type</p>	<p>RectangularNodeFaceType, PositionCoordinateType, xyPlaneType, yzPlaneType, xzPlaneType</p>

4.4.3.3.1 Rectangular Node Face (cont'd)

The *RectangularNodeFace* is a 2D rectangular shape defined by a *Name*, an *x*, *y*, and *z Position*, a *xyPlane* or *yzPlane* or *xzPlane* orientation and the dimension of the rectangle in that plane, *dx*, *dy*, *dz*. 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.

4.4.3.3.2 Cuboidal Node Volume

path	<ol style="list-style-type: none"> 1. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/Node-Array/Node/NodeVolume-Array/CuboidalNodeVolume, 2. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/Node-Array/Node/NodeVolume-Array/CuboidalNodeVolume.
diagram	<pre> classDiagram class CuboidalNodeVolumeType { Name xs:string Position PositionCoordinateType Size SizeType } class PositionCoordinateType { x xs:decimal y xs:decimal z xs:decimal } class SizeType { dx xs:decimal dy xs:decimal dz xs:decimal } CuboidalNodeVolumeType "1..∞" --> PositionCoordinateType CuboidalNodeVolumeType "1..∞" --> SizeType PositionCoordinateType --> x PositionCoordinateType --> y PositionCoordinateType --> z SizeType --> dx SizeType --> dy SizeType --> dz </pre>
type	CuboidalNodeVolumeType, PositionCoordinateType, SizeType.

The *CuboidalNodeVolume* is a 3D cuboidal shape defined by a *Name*, an *x*, *y*, *z Position* and *dx*, *dy*, *dz 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.

4.4.3.4 Thermal Resistance Between Nodes - Array

path	<ol style="list-style-type: none"> 1. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/ThermalResistance-Array, 2. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/ThermalResistance-Array, 3. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/TwoResistorModel/Network/ThermalResistance-Array
diagram	
type	ThermalResistanceBetweenNodes-ArrayType , ThermalResistanceBetweenNodesType

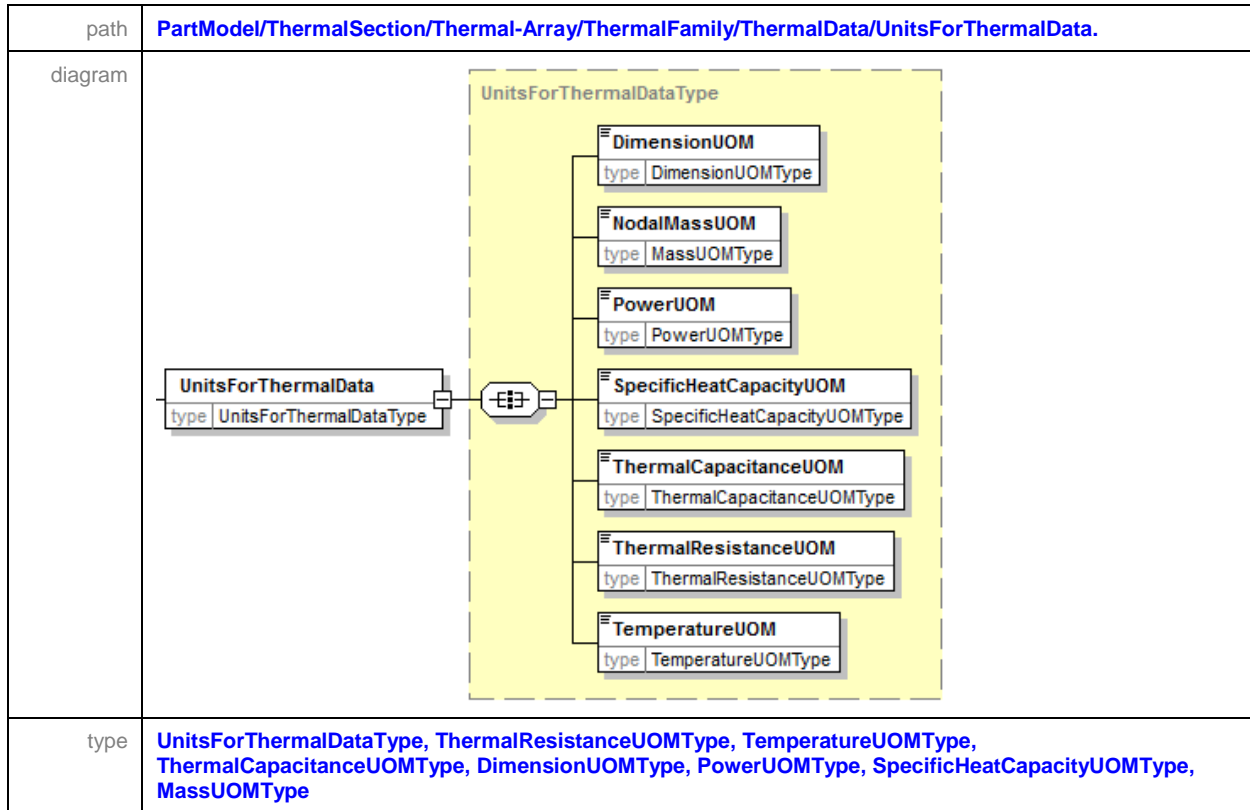
The *ThermalResistance-Array* lists the thermal links of the Network by specifying the *FromNode* name, the *ToNode* name and the *ThermalResistance* value linking them.

4.4.3.5 Thermal Capacitance - Array

path	<ol style="list-style-type: none"> 1. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/CoreNetwork/ThermalCapacitance-Array, 2. PartModel/ThermalSection/Thermal-Array/ThermalFamily/ThermalData/NetworkModels/DELPHI-Model/ConnectionNetwork-Array/ConnectionNetwork/ThermalCapacitance-Array
diagram	
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.

4.4.4 Units for Thermal Data



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

4.4.4 Units for Thermal Data (cont'd)

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

4.5 Thermal Model

path	PartModel/ThermalSection/Thermal-Array/ThermalModel
diagram	
type	ThermalModelType, JEP30-D10:EmptyType, ds:SignatureType.

One or more references to external thermal simulation model files can be defined by the *ThermalModel* section. The *Model* element can refer to either a file name of a file that is provided together with the corresponding JEP30 xml archive or a URL definition. *ThermalModel* enables a standardized thermal simulation file format to be defined so that the importing tool can correctly interpret that file format. An *Other* file format is accommodated to account for non-standard formats where it is advised that the optional *ModelDescription* element is used to describe the format and its intended usage.

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:	Date: N/A	Item Number: 11.2-938
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Change Record History

Issue: A	Date:	Item Number:
Description of changes		
Section 4.5 Thermal Data: Added new section for <i>External Model-Array</i> .		
Sections 4.5.1, 4.5.2.2.1, 4.5.2.2.2, :Added "Empty Type" for several elements through schema that did not have types.		
Section 4.5.2 Thermal Metrics: Re-labelled the section title to Thermal Metrics-Array. Added in a new section for "Thermal Metric Graph". Also added in "Test Conditions" that can be applied to either the "Thermal Metrics" or the "Thermal Metrics Graph".		
Section 4.5.2.1 Test Condition: Added new "Test Condition" section		
Section 4.5.2.3 Thermal Metric Graph: Added new section to represent thermal parametric data in graph form.		
Section 4.5.3.3: Update descriptive text on the Rectangular Node Face and the Cuboidal Node Volume		
Section 4.5.3.3.1 RectangularNodeFace: Added in "Name" element in under "RectangularNodeFace"		
Section 4.5.3.3.2 CuboidalNodeVolume: Added in "Name" element in under "CuboidalNodeVolume"		
Section 4.5.4 External Model-Array: Added new section to capture external models		



Standard Improvement Form

JEDEC JEP30-T100A

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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1. I recommend changes to the following:

Requirement, clause number _____

Test method number _____ Clause number _____

The referenced clause number has proven to be:

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Other _____

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