Result of Research Project

SPECIFICATION

Submodel Semiconductor Datasheet

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Submodel Template of the

Asset Adminstration Shell

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2023-June-21	V 0.1	Initial Release of the Submodel template

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Foreword

This is the specification of a submodel for the Asset Administration Shell as result of a research project. It concerns the technical description of power semiconductors and is supposed to give addition details about a semiconductor in a common format and a common semantic that extends the technical product data sheet.

It was developed in the year 2023 by a group consisting of semiconductor vendors, PE-Systems, and the Ferdinand-Steinbeis-Institute. This working group has discussed and created the results under guidance from the Interopera project group.

We would like to thank the people who participated in the working group and who contributed to the results that have been accomplished.

1 General

1.1 About this document

This document is a part of a specification series. Each part specifies the contents of a Submodel template for the Asset Administration Shell (AAS). The AAS is described in [1-3] and [6]. First exemplary Submodel contents were described in [4], while the actual format of this document was derived by the "Administration Shell in Practice" [5]. The format aims to be very concise, giving only minimal necessary information for applying a Submodel template, while leaving deeper descriptions and specification of concepts, structures and mapping to the respective documents [1-6].

The target group of the specification are developers and editors of technical documentation and manufacturer information, which are describing assets in smart manufacturing by means of the Asset Administration Shell (AAS) and therefore need to create a Submodel instance with a hierarchy of SubmodelElements. This document especially details on the question, which SubmodelElements with which semantic identification shall be used for this purpose.

1.2 Scope of the Submodel

This Submodel template aims at interoperable provision of information describing power semiconductors in regard to the asset of the respective Asset Administration Shell. Central element is the provision of properties [7], ideally interoperable by the means of dictionaries such as ECLASS and IEC CDD (Common Data Dictionary). The purpose of this document is to make selected specifications of Submodels in such manner that information about assets can be exchanged in a meaningful way between partners in a value creation network. It targets the technical description (general, electrical, geometrical, and thermal properties) to enable a comparison of semiconductors during purchasing processes.

The intended use-case is the provision of a standardized property structure for power semiconductors, which enables a common definition of the aforementioned properties and the reduction of transaction costs during purchasing.

This concept can serve as a basis for standardizing the respective Submodel. The conception is based on existing norms, studies of common practices at enterprises, directives and standards so that a far-reaching acceptance can be achieved.

Beside standardized Submodel this template also introduces standardized SubmodelElementCollections (SMC) in order to improve the interoperability while modelling aspects of geometrical properties within other Submodels, i.e. we include a product model which can be used within the design of a mashine.

1.3 Relevant standards and sources of concepts for the Submodel template

According to [3], interoperable properties might be defined by standards, consortium specifications or manufacturer specifications. Useful standards providing sources of concepts are:

Table 1: List of examplary standards defining interoperable properties

IDTA Submodel “Digital Nameplate”	IDTA Submodel “Technical Data”
DIN EN IEC 60747 Norms	ECLASS

So called property dictionaries are used identify information elements (see Terms and Definitions of [6]). Such property dictionaries include:

- ECLASS, see: https://www.eclasscontent.com/
- IEC CDD, see: https://cdd.iec.ch/cdd/iec61987/iec61987.nsf and https://cdd.iec.ch/cdd/iec62683/cdddev.nsf

In this document, properties are aimed to be described by ECLASS.

2 Information set for Submodel Contact Information

While defining Submodels the following three aspects must be considered as suggested in [5]:

Use and economic relevance

The Submodel “Semiconductor Datasheet” is designed for the description of technical product properties that characterize a power semiconductor. Based on the well-defined semantics, the semiconductors can be described in similar terms with a similar meaning. This reduces the efforts that are needed during purchasing when customers need to compare semiconductors from different vendors. In addition, the digital description can be used as input for simulation tools that simulate the usage of the semiconductors.

Possible functions and interactions

Have not been part of the project.

Property specification

See section 3 Submodel and Collections.

3 Submodel and Collections

3.1 Overview of the Submodel "Semiconductor Datasheet"

The figure below shows the UML-diagram defining the relevant properties which need to be set. Figure 1 describes the details of the Submodel structure combined with examples.

Figure 1: UML-Diagram for Submodel "Semiconductor Datasheet"

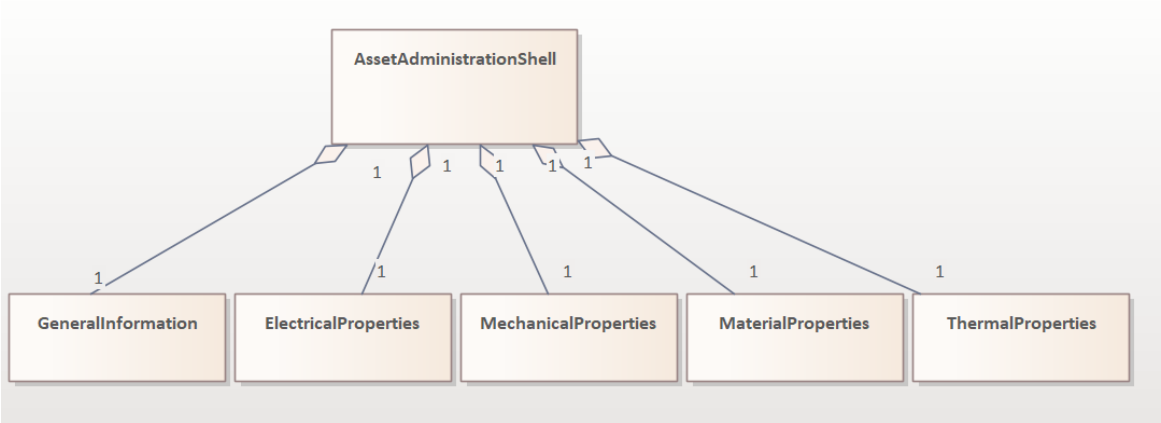

Table 2: Properties of Submodel "SemiconductorDatasheet"

idShort	SemiconductorDatasheetTemplate *Note: the above idShort shall always be as stated.*		
Class	Submodel		
semanticId	---		
Parent	---		
Explanation	The Submodel "SemiconductorDatasheet" is the collection for various properties of power semiconductors, including mechanical, electrical, material, and thermal properties.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	

3.2 Properties of the SMC "GeneralInformation"

The GeneralInformation is specified according to the IDTA submodel template "Digital Nameplate". The following table describes the details of the SMC structure combined with examples.

Table 3: Properties of SMC "GeneralInformation"

idShort	SemiconductorDatasheetTemplate.GeneralInformation *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId	--		
isCaseOf	--		
AllowDuplicates	True		
Parent	SemiconductorDatasheetTemplate		
Explanation	The Submodel "GeneralInformation" is the collection for various general details about the semiconductor, such as vendor, model, contact details.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[File] ManufacturerLogo	Logo	[File] 	[0..1]
[Property] ManufacturerOrderCode	Order Code	[Integer] 12345	[0..1]
[Property] ManufacturerPartNumber	Part Number	[Integer] 54321	[0..1]
[Property] ManufacturerProductDesignation	Product Designation	[string] Some Power Semiconductor	[0..1]
[File} ProductImage	Foto of the product	[File] --	[0..*]
[SubmodelElementCollection] ProductClassification	Details about the product the product classification	--	[0..*]
[Property] ClassificationSystemVersion	Verison of the Classification System	[String] 13.0	[0..1]

[Property] ProductClassID	Reference of Class ID	[Integer] 27261790	[0..1]
[Property] ProductClassificationSystem	Which Classification System was used	[Integer] ECLASS	[0..1]
[Property] RoleOf Contact Person	Role of Contact Person	[String] Support	[0..1]
[MLP][1] NationalCode	National Code	[String] DE	[0..1]
[Property] Language	Language	[String] EN	[0..1]
[Property] TimeZone	Time Zone of Point of Contact	[String] GMT+01	[0..1]
[MLP] CityTown	City or Town	[String] Stuttgart	[0..1]
[MLP] Company	Company Name	[String] Ferdinand-Steinbeis-Institut	[0..1]
[MLP] Department	Department	[String] Ferdinand-Steinbeis-Institut Stuttgart	[0..1]
[Submodel ElementCollection] Phone	Phone Number of Point of Contact	[String] +49 711 49065 795	[0..1]
[Submodel ElementCollection] Fax	Fax Number of Point of Contact	[String] +49 711 685 74183	[0..1]
[Submodel ElementCollection] Email	E-Mail of Point of Contact	[String] info@ferdinand-steinbeis-institut.de	[0..1]
[SubmodelElementCollection] IPCommunication{00}			[0..1]
[MLP] Street	Adress - Street	[String] Filderhaupstr. 142	[0..1]

[1] Recommendation: property declaration as MLP is required by its semantic definition. As the property value is language independent, users are recommended to provide maximal 1 string in any language of the user's choice.

[MLP][1] Zipcode	Adress – Zipcode	[Integer] 70599	[0..1]
[MLP] POBox	Adress - POBox	[String]	[0..1]
[MLP] [1] ZipCodeOf POBox	Adress - ZipCodeOfPOBox	[String]	[0..1]
[MLP] StateCounty	State	[String] Baden-Württemberg	[0..1]
[MLP] NameOfContact	Name of individual Contact Person	[String] Lachenmaier	[0..1]
[MLP] FirstName	First Name of individual Contact Person	[String] Jens	[0..1]
[MLP] MiddleNames	Middle Names of individual Contact Person	[String] F.	[0..1]
[MLP] Title	Title of individual Contact Person	[String] Mr.	[0..1]
[MLP] AcademicTitle	Academic Title of individual Contact Person	[String] Dr.	[0..1]
[MLP] FurtherDetails OfContact	Further address details of individual Contact Person	[String]	[0..1]
[Property] AddressOfAdditionalLink	Link to Webpage	[String] https://ferdinand-steinbeis-institut.de/	[0..1]

3.3 Properties of the SMC “MechanicalProperties”

The figure below shows the UML-diagram defining the relevant properties which need to be set. Figure 2 describes the details of the Submodel structure combined with examples.

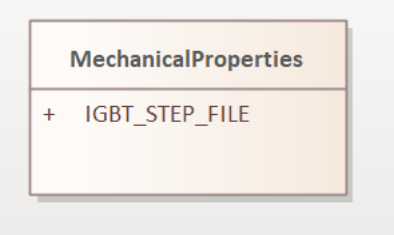

Figure 2: UML-Diagram for SMC "MechanicalProperties"

Table 4: Properties of SMC “MechanicalProperties"

idShort	SemiconductorDatasheetTemplate.MechanicalProperties *Note: the above idShort shall always be as stated.*

Class	MechanicalProperties		
semanticId	---		
Parent	SemiconductorDatasheetTemplate		
Explanation	The Submodel “MechanicalProperties” is the collection for the mechanical properties of a power semiconductor.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[File] IGBT_STEP_FILE	Digital Product Model as a STEP File	[File] --	[0..1]

3.4 Properties of the SMC “MaterialProperties”

The figure below shows the UML-diagram defining the relevant properties which need to be set. Figure 3 describes the details of the Submodel structure combined with examples.

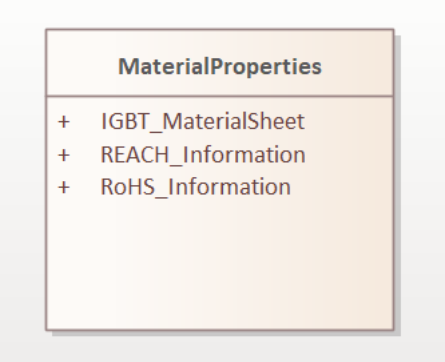

Figure 3: UML-Diagram for SMC "MaterialProperties"

Table 5: Properties of SMC “MaterialProperties"

idShort	SemiconductorDatasheetTemplate.MateriallProperties *Note: the above idShort shall always be as stated.*		
Class	Submodel		
semanticId	MateriallProperties		
Parent	SemiconductorDatasheetTemplate		
Explanation	The Submodel “MaterialProperties” is the collection for various material related documentation.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[File] IGBT_MaterialSheet	Data about the material that the vendor provides	[File] --	[1..*]

[File] RoHS_Information	Information according to RoHS	[File] --	[1..*]
[File] REACH_Information	Information according to REACH	[File] --	[1..*]

3.5 Properties of the SMC “ThermalProperties”

The figure below shows the UML-diagram defining the relevant properties which need to be set. Figure 4 describes the details of the Submodel structure combined with examples.

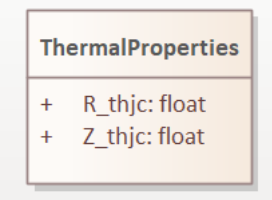

Figure 4: UML-Diagram for SMC "ThermalProperties"

Table 6: Properties of SMC “ThermalProperties"

idShort	SemiconductorDatasheetTemplate.ThermalProperties *Note: the above idShort shall always be as stated.*		
Class	Submodel		
semanticId	ThermalProperties		
Parent	SemiconductorDatasheetTemplate		
Explanation	The Submodel “ThermalProperties” is the collection for various thermal properties of power semiconductors.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[property] R_thjc	Thermal resistance junction to case in K/W	[float] 0.234	[0..1]
[properties] Z_thjc	Transient thermal impedance junction to case in K/W	[float] 1.734	[0..1]

3.6 Properties of the SMC “ElectricalProperties”

The figure below shows the UML-diagram defining the relevant properties which need to be set. Figure 5 describes the details of the Submodel structure combined with examples. The template also includes the variables that are needed to calculate the values as qualifiers, which are not depicted here.

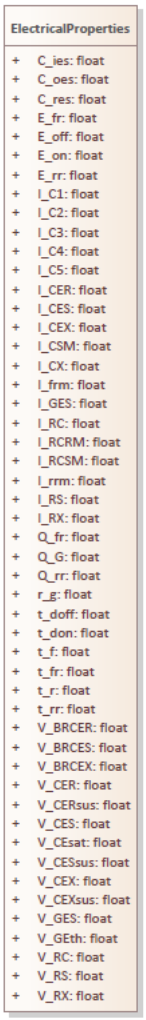

Figure 5: UML-Diagram for SMC "ElectricalProperties"

Table 7: Properties of SMC “ElectricalProperties"

idShort	SemiconductorDatasheetTemplate.ElectricalProperties *Note: the above idShort shall always be as stated.*
Class	Submodel
semanticId	ElectricalProperties
Parent	SemiconductorDatasheetTemplate
Explanation	The Submodel “ElectricalProperties” is the collection for various electrical properties of power semiconductors.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
C_(ies)	Input capacitance in F	[float] 1.234	[0..1]
C_(oes)	Output capacitance in F	[float] 1.234	[0..1]
C_(res)	Reverse transfer capacitance in F	[float] 1.234	[0..1]
E_(fr)	Forward recovery energy in J	[float] 1.234	[0..1]
E_(off)	Turn-off Energy in J	[float] 1.234	[0..1]
E_(on)	Turn-on Energy in J	[float] 1.234	[0..1]
E_(rr)	Reverse recovery energy in J	[float] 1.234	[0..1]
I_(C)	Maximum reverse biased safe operating area (RBSOA) in A	[float] 1.234	[0..1]
I_(C)	Maximum short-circuit safe operating area 1 (SCSOA1) in A	[float] 1.234	[0..1]
I_(C)	Maximum short-circuit safe operating area 2 (SCSOA2) in A	[float] 1.234	[0..1]
I_(C)	Inductive load turn-off current in A	[float] 1.234	[0..1]
I_(C)	Forward biased safe operating area (FBSOA) in A	[float] 1.234	[0..1]
I_(CER)	Collector cut-off current in A	[float] 1.234	[0..1]
I_(CES)	Collector cut-off current in A	[float] 1.234	[0..1]
I_(CEX)	Collector cut-off current in A	[float] 1.234	[0..1]
I_(CRM)	Repetitive peak collector current in A	[float] 1.234	[0..1]
I_(CSM)	Non-repetitive peak collector current in A	[float] 1.234	[0..1]
I_(CX)	Continous (direct) collector current in A	[float] 1.234	[0..1]

I_(frm)	Peak forward recovery current in A	[float] 1.234	[0..1]
I_(GES)	Gate leakage current in A	[float] 1.234	[0..1]
I_(RC)	Continous (direct) reverse-conducting current of a reverse-conducting IGBT in A	[float] 1.234	[0..1]
I_(RCRM)	Repetitive peak reverse-conducting current of a reverse-conducting IGBT in A	[float] 1.234	[0..1]
I_(RCSM)	Non-repetitive peak reverse-conducting current of a reverse-conducting IGBT in A	[float] 1.234	[0..1]
I_(rrm)	Peak reverse recovery current in A	[float] 1.234	[0..1]
I_(RS)	Reverse current of a reverse-blocking IGBT in A	[float] 1.234	[0..1]
I_(RX)	Reverse current of a reverse-blocking IGBT in A	[float] 1.234	[0..1]
Q_(fr)	Forward recoverd charge in C	[float] 1.234	[0..1]
Q_(G)	Gate Charge in C	[float] 1.234	[0..1]
Q_(rr)	Reverse recovered charge in C	[float] 1.234	[0..1]
r_(g)	Internal gate resistance in Ohm	[float] 1.234	[0..1]
t_(d(off))	Turn-off delay in s	[float] 1.234	[0..1]
t_(d(on))	Turn-on delay in s	[float] 1.234	[0..1]
t_(f)	Fall time in s	[float] 1.234	[0..1]
t_(fr)	Forward recovery time in s	[float] 1.234	[0..1]
t_(r)	Rise time in s	[float] 1.234	[0..1]
t_(rr)	Reverse recovery time in s	[float] 1.234	[0..1]

V_(BR)CER	Collector-emitter breakdown voltage, termination with a resistor in V	[float] 1.234	[0..1]
V_(BR)CES	Collector-emitter breakdown voltage, termination with a short-circuit in V	[float] 1.234	[0..1]
V_(BR)CEX	Collector-emitter breakdown voltage, termination with specified gate-emitter voltage in V	[float] 1.234	[0..1]
V_(CER)	Collector-emitter voltage, termination with a resistor in V	[float] 1.234	[0..1]
V_(CES)	Collector-emitter voltage, termination with a short-circuit in V	[float] 1.234	[0..1]
V_(CEsat)	Collector-emitter saturation voltage in V	[float] 1.234	[0..1]
V_(CEX)	Collector-emitter voltage, termination with specified gate-emitter voltage in V	[float] 1.234	[0..1]
V_(GE(th))	Gate-emitter threshold voltage in V	[float] 1.234	[0..1]
V_(GES)	Gate-emitter voltage with collector-emitter short-circuit in V	[float] 1.234	[0..1]
V_(RC)	Reverse-conducting voltage of a reverse-conducting IGBT in V	[float] 1.234	[0..1]
V_(RS)	Reverse voltage of a reverse-blocking IGBT, termination with a short-circuit in V	[float] 1.234	[0..1]
V_(RX)	Reverse voltage of a reverse-blocking IGBT, termination with specified gate-emitter voltage in V	[float] 1.234	[0..1]
V_CERsus	Collector-emitter sustaining voltage, termination with a resistor in V	[float] 1.234	[0..1]
V_CESsus	Collector-emitter sustaining voltage, termination with a short-circuit in V	[float] 1.234	[0..1]
V_CEXsus	Collector-emitter sustaining voltage, termination with	[float] 1.234	[0..1]

	specified gate-emitter voltage in V		

Annex A: Explanations on used table formats

General
The used tables in this document try to outline information as concise as possible. They do not convey all information on Submodels and SubmodelElements. For this purpose, the definitive definitions are given by a separate file in form of an AASX file of the Submodel template and its elements.

Tables on Submodels and SubmodelElements
For clarity and brevity, a set of rules is used for the tables for describing Submodels and SubmodelElements.

- The tables follow in principle the same conventions as in [5].
- The table heads abbreviate 'cardinality' with 'card'.
- The tables often place two informations in different rows of the same table cell. In this case, the first information is marked out by sharp brackets [] form the second information. A special case are the semanticIds, which are marked out by the format: (type)(local)[idType]value.
- The types of SubmodelElements are abbreviated: SME

SME type Submodel	Element type
Property	Property
MLP	MultiLanguageProperty
Range	Range
File	File
Blob	Blob
Ref	ReferenceElement
Rel	RelationshipElement
SMC	SubmodelElementCollection

- If an idShort ends with '{00}', this indicates a suffix of the respective length (here: 2) of decimal digits, in order to make the idShort unique. A different idShort might be choosen, as long as it is unique in the parent's context.
- The Keys of semanticId in the main section feature only idType and value, such as: [IRI]https://admin-shell.io/vdi/2770/1/0/DocumentId/Id. The attributes "type" and "local" (typically "ConceptDescription" and "(local)" or "GlobalReference" and (no-local)") need to be set accordingly; see [6].
- If a table does not contain a column with "parent" heading, all represented attributes share the same parent. This parent is denoted in the head of the table.
- Multi-language strings are represented by the text value, followed by '@'-character and the ISO 639 language code: example@de.
- The [valueType] is only given for Properties.

Bibliography

[1] “Recommendations for implementing the strategic initiative INDUSTRIE 4.0”, acatech, April 2013. [Online]. Available: https://www.acatech.de/Publikation/recommendations-for-implementing-the-strategic-initiative-industrie-4-0-final-report-of-the-industrie-4-0-working-group/

[2] “Implementation Strategy Industrie 4.0: Report on the results of the Industrie 4.0 Platform”; BITKOM e.V. / VDMA e.V., /ZVEI e.V., April 2015. [Online]. Available: https://www.bitkom.org/noindex/Publikationen/2016/Sonstiges/Implementation-Strategy-Industrie-40/2016-01-Implementation-Strategy-Industrie40.pdf

[3] “The Structure of the Administration Shell: TRILATERAL PERSPECTIVES from France, Italy and Germany”, March 2018, [Online]. Available: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/hm-2018-trilaterale-coop.html

[4] “Beispiele zur Verwaltungsschale der Industrie 4.0-Komponente – Basisteil (German)”; ZVEI e.V., Whitepaper, November 2016. [Online]. Available: https://www.zvei.org/presse-medien/publikationen/beispiele-zur-verwaltungsschale-der-industrie-40-komponente-basisteil/

[5] “Verwaltungsschale in der Praxis. Wie definiere ich Teilmodelle, beispielhafte Teilmodelle und Interaktion zwischen Verwaltungsschalen (in German)”, Version 1.0, April 2019, Plattform Industrie 4.0 in Kooperation mit VDE GMA Fachausschuss 7.20, Federal Ministry for Economic Affairs and Energy (BMWi), Available: https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/2019-verwaltungsschale-in-der-praxis.html

[6] “Details of the Asset Administration Shell; Part 1 - The exchange of information between partners in the value chain of Industrie 4.0 (Version 3.0RC01)”, November 2020, [Online]. Available: https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/Details-of-the-Asset-Administration-Shell-Part1.html

[7] “Semantic interoperability: challenges in the digital transformation age”; IEC, International Electronical Commission; 2019. [Online]. Available:https://basecamp.iec.ch/download/iec-white-paper-semantic-nteroperability-challenges-in-the-digital-transformation-age-en/