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SunSpec Device Information Model Specification

SunSpec Specification

Abstract

This document specifies the definition and usage of SunSpec Device Information Models.

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Revision History

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1.0	1-1-2019	Initial release

About the SunSpec Alliance

The SunSpec Alliance is a trade alliance of developers, manufacturers, operators, and service providers together pursuing open information standards for the distributed energy industry. SunSpec standards address most operational aspects of PV, storage, and other distributed energy power plants on the smart grid, including residential, commercial, and utility-scale systems, thus reducing cost, promoting innovation, and accelerating industry growth.

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SunSpec Interoperability Specifications follow a lifecycle pattern of: DRAFT, TEST, APPROVED, and SUPERSEDED.

For more information or to download a SunSpec Alliance specification, go to https://sunspec.org/about-sunspec-specifications/.

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1 Introduction

SunSpec Device Information Models provide a simple, standardized mechanism for specifying data sets supported by a device.

Device Information Models are used to structure device data for exchange across communications interfaces. The following figure shows the communication scenario and the responsibility of the SunSpec device to implement the Device Information Model.

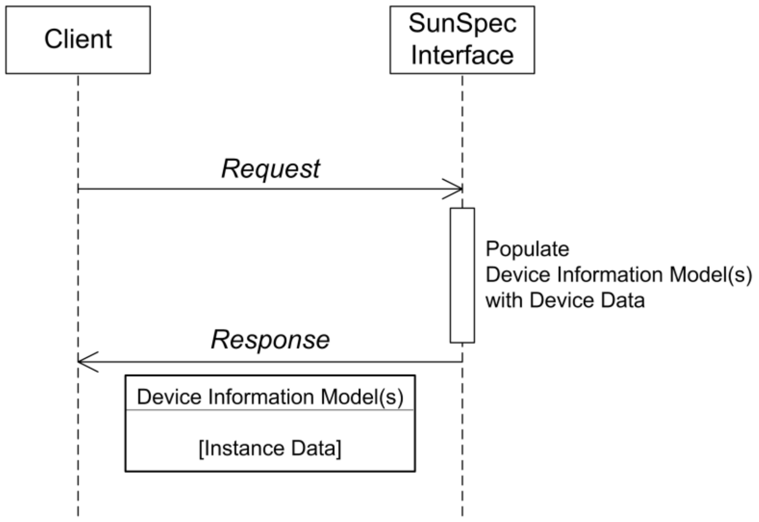

Client
SunSpec Interface
Request
Populate Device Information Model(s) with Device Data
Response
Device Information Model(s)
[Instance Data]

Figure 1: Device Information Model Communication and Implementation

This specification standardizes Device Information Model definition and specifies usage for two information representations:

- Modbus
- JSON encoded messages

1.1 Document Organization

Chapter 2 lists the standards documents that are normative references for this document.

Chapter 3 provides an introduction to Device Information Model concepts and structure used to define, implement, and use the model.

Chapter 4 provides a formal Device Information Model specification.

Chapter 5 specifies JSON and CSV model definition encoding.

Chapter 6 describes Device Information Model usage for the Modbus messaging structure.

Chapter 7 describes Device Information Model usage for JSON message encoding.

1.2 Terminology

Attribute	An attribute describes a definition element or provides additional information about the element. For example, an access attribute is a point element attribute that indicates if a point value is read/write or read-only. Attributes can be required or optional.
CSV	Comma-separated Values are plain text value fields separated by commas. CSV file formats can be opened by spreadsheet program and can be used as a format for data exchange between applications or devices.
Definition element	Definition elements are associated with a Device Information Model and describe the model data structure and usage. A definition element can have a value or provide a container for other elements. The Device Information Model defines the following elements: • model • point • point group • symbol • comment Definition elements have attributes that qualify or describe the element.
Device	A device is an entity that exchanges data across communications interfaces. A device has a data set, modeled by Device Information Models, that describes physical and state information about the device. The device data set is the set of logically-related data points specific to the device type. The collection of Device Information Models that describe the data set corresponds to the full set of device data points supported by the device.

Device Information Model	The Device Information Model is used to structure device data for exchange across communications interfaces. The model provides a mechanism for specifying the data set supported by a device, which consists of a set of standardized definition elements.
Device Information Model definition	A Device Information Model definition specifies the data points that make up the particular Device Information Model and the usage information associated with each data point. There is one definition for each Device Information Model. Device Information Model definitions represent collections of device data points. The canonical form of Device Information Model definitions is specified using JSON encoding.
Device Information Model instance	A Device Information Model instance is created from a Device Information Model definition. The instance includes data point values specified for each of the defined data points. There can be any number of instances of a Device Information Model.
JSON	JavaScript Object Notation is a lightweight format used for data exchange. The canonical form of Device Information Model definitions is specified using JSON encoding. This document specifies JSON encoding for Device Information Model instances.
Modbus	Modbus is a communication protocol for transmitting information between devices using a serial or TCP/IP communication interface. This document specifies Modbus encoding for Device Information Model instances.
Model	A Device Information Model *model* element defines a logical grouping of *points*. Each *model* has a unique model ID.
MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY, and OPTIONAL	The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this specification, are to be interpreted as described in IETF RFC 2119.
Point	A Device Information Model *point* element defines a device data point and has a value.
Point group	A Device Information Model *group* element contains a group of *points* and/or other *point groups*.
Point group, top-level	The top-level point group is the first element of a Device Information Model and contains all other elements.

RESTful web service	A RESTful web service is an architectural style that uses Representational State Transfer (REST) for web applications to access web service resources. REST HTTP methods for access resources include GET, PUT, POST, and DELETE.
Symbol	A Device Information Model *symbol* element defines a name-value pair. It is used to represent a constant value associated with the enumerated value or bit position of a *point*.
UTF-8	UTF-8 is a method for encoding Unicode characters using 8-bit sequences that can include one or more bytes.

2 Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3629] Yergeau, F., "UTF-8, a transformation format of ISO 10646", RFC 2279, DOI 10.17487/RFC2279, January 1998, <https://www.rfc-editor.org/info/rfc2279>.

[RFC8259] Bray, T., Ed., "The JavaScript Object Notation (JSON) Data Interchange Format", RFC 7159, DOI 10.17487/RFC7159, March 2014, <https://www.rfc-editor.org/info/rfc7159>.

Modbus IDA, MODBUS Application Protocol Specification v1.1b3, North Grafton, Massachusetts, (www.modbus.org/specs.php), April 26, 2012.

Modbus IDA, MODBUS/TCP Security Protocol Specification v21, North Grafton, Massachusetts, (www.modbus.org/specs.php), July 24, 2018.

IEEE 754-2008, IEEE Standard for Floating-Point Arithmetic, August 29, 2008, <https://ieeexplore.ieee.org/servlet/opac?punumber=4610933>.

3 Overview

This section introduces Device Information Model definition and usage.

Device Information Model definitions represent collections of device data points. A device implementation based on the information models can use the model definitions to standardize the interface to device data points. This includes logically grouping the information to correspond to the data point grouping requirements of a device.

3.1 Device Information Model Structure

Device Information Models are defined using the following definition elements:

- model
- point
- point grouping
- symbol
- comment

The point definition element represents the Device Information Model data, and the other definition elements govern data structuring and usage. The following figure shows the primary definition elements structural relationship.

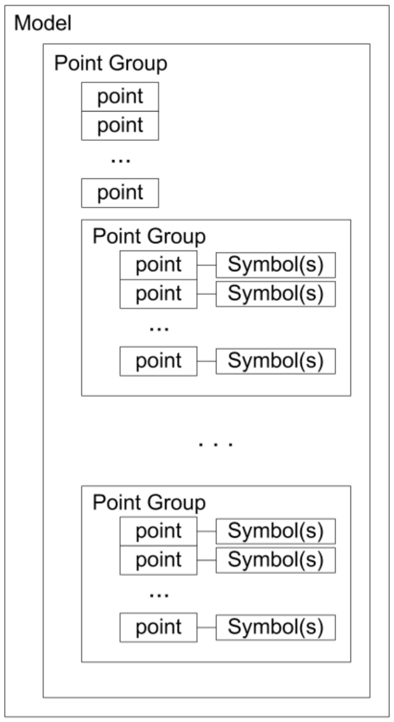


Figure 2: Device Information Model Elements

3.1.1 Model

The *model* definition element includes all of the definition elements. It is used as the container for the logically related set of device data points, for a particular model.

3.1.2 Point

The *point* definition element defines a Device Information Model data point. Point elements hold data values that correspond to a device property. There are typically multiple point definitions in the model definition. A point can be specified as repeating so it can be modeled and accessed as an array of points instead of as a single point.

3.1.3 Point Group

The *point group* definition element provides a way to logically group a set of points. There are three reasons to group points:

- The top-level model organization construct is always a point group. The first element in a model definition is the top-level point group and includes all of the point and point group definitions in the model.
- A repeating set of points can be grouped, creating multiple instances of the point group that can be accessed as an array of point groups.
- A set of points with synchronous operational requirements can be grouped, indicating that the points in the group must be read and written atomically.

3.1.4 Symbol

The *symbol* definition element assigns identifiers to values associated with a point definition element. Symbols define the set of valid values for the point and provide identifiers that can be used to represent the value.

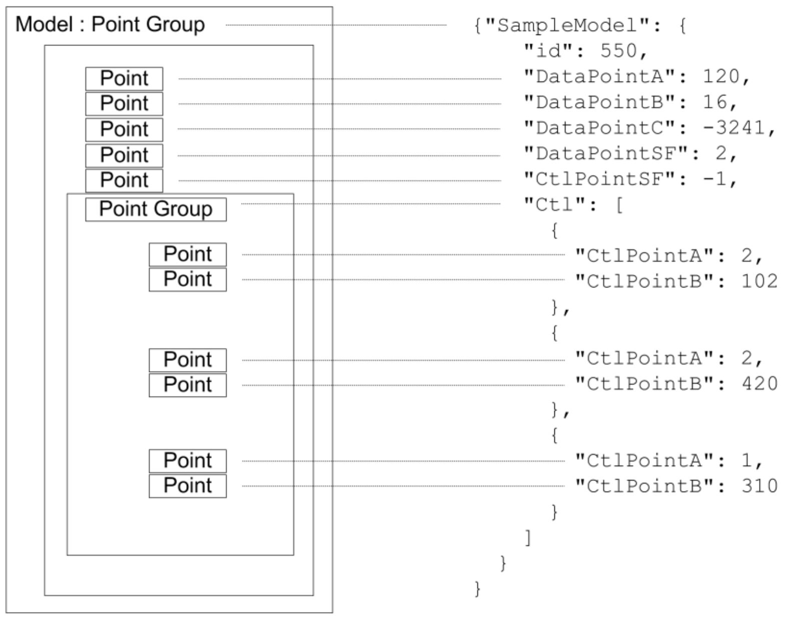
3.1.5 Comment

The *comment* definition element associates a comment string with any of the other definition elements. It can be used to document the element definition.

3.2 Device Information Model Definition and Instance Relationship

It is important to understand the relationship between a Device Information Model *definition* and a Device Information Model *instance*.

A Device Information Model *definition* specifies the data points that make up the particular Device Information Model and the usage information associated with each data point. There is one definition for each Device Information Model.



```
{"SampleModel": {
    "id": 550,
    "DataPointA": 120,
    "DataPointB": 16,
    "DataPointC": -3241,
    "DataPointSF": 2,
    "CtlPointSF": -1,
    "Ctl": [
      {
        "CtlPointA": 2,
        "CtlPointB": 102
      },
      {
        "CtlPointA": 2,
        "CtlPointB": 420
      },
      {
        "CtlPointA": 1,
        "CtlPointB": 310
      }
    ]
  }
}
```

Figure 3: Device Information Model Definition-Instance Map

A Device Information Model *instance* is created from a Device Information Model *definition*. The *instance* includes data point values specified for each of the defined data points. There can be any number of Device Information Model *instances*.

The canonical form of Device Information Model *definitions* is specified in a JSON encoding. For convenience, alternative Device Information Model definition representations can be used provided they preserve all of the Device Information Model definition content. In addition to the canonical JSON encoding, this specification standardizes a CSV encoding for Device Information Model definitions to support a spreadsheet presentation of the *definitions*.

3.3 Device Information Model Usage

Devices use the Device Information Model definitions that represent the data points supported by the device. Further, a device implementation includes the collection of Device Information Models that correspond to the full set of device data points.

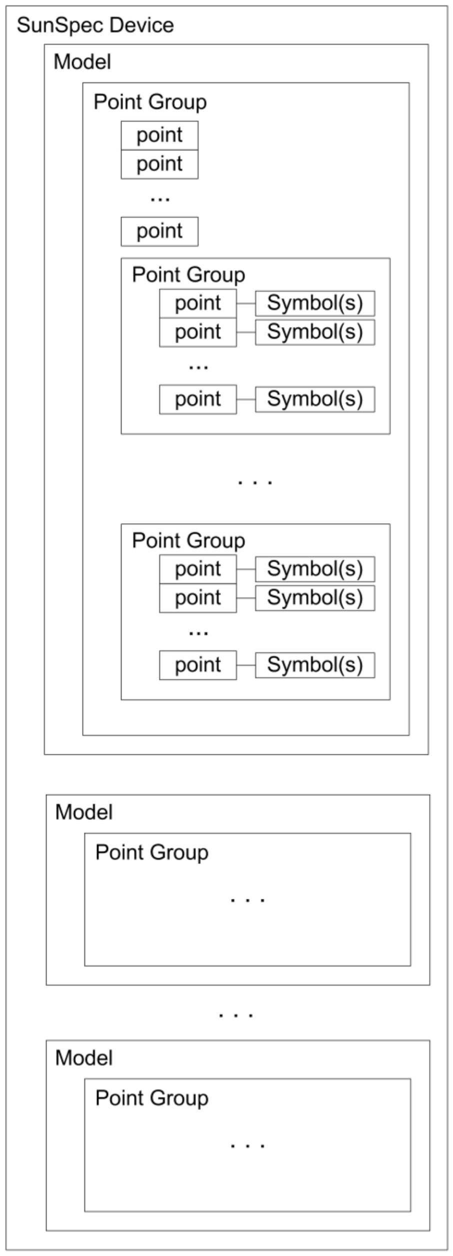


Figure 4: Device Information Model Instance

Information can be exchanged with a device by requesting some or all of the device data points, using a communication interface that implements the standardized Device Information Models. Device Information Model definitions are interface-independent. This specification standardizes Device Information Model usage for both Modbus, and JSON data representations.

3.3.1 Modbus

Device Information Models can be mapped into a Modbus address space. A collection of Device Information Models can be used to create a Modbus map that corresponds to the data points supported by the device.

3.3.2 JSON

Device Information Model contents can be represented as JSON objects. Devices can access data points supported by the device through an interface that supports JSON objects, such as a RESTful web service.

4 Device Information Model Definition

Device Information Models are defined using standardized elements. Each Information Model Definition includes the definition elements specified in this section.

4.1 Definition Elements

A model definition MAY have the following elements:

Element	Description
model	A logical grouping of data points that are assigned a model id.
group	A group of *points* or point *groups*. A *model* can have multiple point groups and point groups can be nested. A *model* always has a top-level point group that includes all points and point groups in the model. A *model* can only have one top-level point group.
point	A data point that has a value.
symbol	A name-value pair used to represent a constant value associated with an enumerated value or bit position in a *point*.
comment	The text used to annotate the information model definition. Comments are associated with one of any definition element (*model*, *group*, *point*, or *symbol*) in the *model* definition.

Table 1: Model Definition Elements

4.1.1 Model Element

The *model* element includes all of the other definition elements associated with the model.

A model definition MUST have a top-level point group that includes all the points and point groups in the model.

A model definition MUST include the following two points as the first two element definitions inside the top-level point group:

- model ID with an identifier of `ID`
- model length with an identifier of `L`

The value of the `ID` point MUST be a SunSpec model ID which is a unique integer between 1 and 65535, inclusive. SunSpec model IDs are administered by the SunSpec Alliance.

The value of the model length `L` point MUST be 0 (zero) in the model definition. The model length point may not be used in some encodings. When the model length is used, as in a Modbus map, the length point (`L`) MUST be set to the length of that model instance. Some model definitions have elements that may vary in size, which causes the model instance length to vary.

The order of members of a model element is significant and MUST be maintained.

See Table 2: Element Attributes for the valid mandatory and optional element attributes for a model element definition.

4.1.2 Point Group Element

The point *group* element includes point elements or other point group elements.

The point group type MUST either be `group` or `sync`.

The group point group type is used to create a set of points and point groups. If the count for the point group is greater than one, the point group repeats the number of times specified by count. The count attribute can be defined as a constant in the point group definition or be specified as the value of another point in the model definition. If the point group count is specified in another point, that point MUST be defined in the top-level point group of the model before the point group definition.

The sync point group type is used to designate points and point groups that MUST be read and written atomically. Implementations MUST indicate an error if all the members of a sync group are not able to be read or written atomically.

The order of the point group members is significant and MUST be maintained.

All points in a point group MUST be defined before any point groups are defined.

See Table 2: Element Attributes for the valid mandatory and optional element attributes for a point group element definition.

4.1.3 Point Element

The *point* element defines a data point element.

The size of the data element MUST be specified for points that have a type of `string`.

If the count for the point is greater than one, the point repeats the number of times specified by the count. The count attribute can be defined as a constant in the point definition or be specified as a value of another point in the model definition. If the point count is specified in another point, that point MUST be defined in the top-level point group of the model before the point definition.

See Table 2: Element Attributes for the valid mandatory and optional element attributes for a point element definition.

4.1.4 Symbol Element

The *symbol* element associates an ID with a constant point value in a point definition.

The symbol element MUST be associated with a point definition. A point definition MAY have multiple symbols associated with it. Each symbol ID MUST be unique for that point definition. The symbol definitions for a point definition serve as a set of possible enumerated values that are valid for the point. If a point has associated symbols defined, all values not in the set of symbol definitions MUST be considered invalid by an implementation.

See Table 2: Element Attributes for the valid mandatory and optional element attributes for a symbol element definition.

4.1.5 Comment Element

The *comment* element is a single string and is associated with any valid definition element other than a *comment* element. A definition element MAY have multiple comments associated with it.

The *comment* element permits additional element definition annotation beyond the element definition attributes shown in Table 2: Element Attributes.

4.2 Element Attributes

Definition elements include attributes that qualify or describe the element. Table 2: Element Attributes shows the attributes associated with each element definition type. The table also uses the following notation to indicate which attributes are associated with each element type:

- Model
- Point Group
- Point
- Symbol

Additionally, for each element type, **R** indicates the attribute is required in an element definition and **O** indicates the attribute is optional.

Attribute	**Description**	**M**	**G**	**P**	**S**
ID	The element ID.	R	R	R	R
Points	An array of point definitions in a point group.		R		
Group	An array of point elements or other point group elements.	R			
Groups	An array of point group definitions in a point group.		O		
Value	If present, a constant value associated with the element.			O	R
Type	The element type.		R	R	
Count	The occurrence count of the element.		O	O	
Size	The element size. Mandatory when type is `string`.			O	
Scale Factor	If present, the scale factor point associated with the element.			O	
Units	If present, the units associated with the element.			O	
Access	Element access, read or read/write. If not present, defaults to read. (`R` or `RW`)			O	
Mandatory	Element is mandatory/optional. If not present, default to optional. (M or O)			O	
Label	Short label associated with the element.	R	R	O	O
Description	Description associated with the element.	O	O	O	O
Detailed Description	Addition description to provide more detail about the context and usage of the element.	O	O	O	O
Symbols	A name-value pair used to represent a constant value associated with an enumerated value or bit position in a point.	O	O	O	O

Table 2: Element Attributes

Optional attributes may have a default value and the default value may be different for different element types.

If an attribute does not have an entry in the table for an element type, the attribute MUST NOT be used in an element definition for that element type.

4.2.1 ID

The *ID* attribute is the element name and MUST be unique in the immediate group in which it is defined. An ID MUST consist of only alphanumeric characters and the underscore character. The *ID* attribute for a model element MUST be the numeric SunSpec model id.

4.2.2 Points

The *points* attribute is a point definition array of points contained in the point group.

4.2.3 Groups

The *groups* attribute is a point group definitions array of point groups contained in the point group.

4.2.4 Type

The *type* attribute is the element type. Table 3: Point Element Type Attribute Values describes the possible type values for point elements and Table 4: Point Group Element Type Attribute Values specifies the possible type value for group elements.

4.2.5 Value

The *value* attribute is the constant value associated with the element. If the element does not have a constant value, the value attribute MUST be omitted.

If a point does not have a valid value, the unimplemented value MUST be used for the value. During device operation, the point value MAY change from the unimplemented value to a valid value or from a valid value to the unimplemented value at any time.

If the element contains a constant value, its model definition file encoding SHALL follow the conventions listed in Table 16: Point Type Mapping to JSON Type.

Type	Description
`int16`	Signed 16-bit integer
`int32`	Signed 32-bit integer
`int64`	Signed 64-bit integer
`raw16`	16-bit raw value
`uint16`	Unsigned 16-bit integer
`uint32`	Unsigned 32-bit integer
`uint64`	Unsigned 64-bit integer
`acc16`	Unsigned 16-bit accumulator (deprecated in favor of `uint16`)
`acc32`	Unsigned 32-bit accumulator (deprecated in favor of `uint32`)
`acc64`	Unsigned 64-bit accumulator (deprecated in favor of `uint64`)
`bitfield16`	16-bit bitfield
`bitfield32`	32-bit bitfield
`bitfield64`	64-bit bitfield
`enum16`	16-bit enumeration
`enum32`	32-bit enumeration
`float32`	32-bit floating-point
`float64`	642-bit floating-point
`string`	String (Latin-3 encoded)
`sunssf`	Scale factor – Signed power of 10 multiplier (+) or divider (-)
`pad`	16-bit pad used for alignment
`ipaddr`	IP Address as an unsigned 32-bit.
`ipv6addr`	16-byte IP V6 address
`eui48`	48-bit MAC address

Table 3: Point Element Type Attribute Values

Type	Description
`group`	Group
`sync`	Synchronization group

Table 4: Point Group Element Type Attribute Values

4.2.6 Count

The *count* attribute specifies the number of occurrences of the element in the model. The count is commonly used to specify the number of occurrences of a point group but it may also be used to specify a single repeating point.

The count MAY be specified as a constant value in the model definition, or by another point in the model that contains the count.

If the count is specified by another point in the model, the specifying point MUST be defined in the top-level point group before the element that the count applies to. The value of a point containing a count MUST be static and not change over time.

4.2.7 Size

The *size* attribute specifies the maximum element length in 16-bit words. The *size* attribute MUST be provided for the string point type and MAY be provided for the pad type. The *size* attribute MUST not be provided for any other type.

4.2.8 Scale Factor

As an alternative to floating-point format, values are represented by integer values with a signed scale factor applied. A negative scale factor explicitly shifts the decimal point to the left, and a positive scale factor shifts the decimal point to the right by the number of places specified in the scale factor value.

The *scale factor* attribute specifies a scale factor to be used with the point element. The scale factor may be another point defined in the model or a constant value. If the scale factor specifies another point defined in the model, the referenced point MUST be defined as a scale factor type (`sf`).

If a constant value is specified, the value MUST be a valid scale factor multiplier.

The value of a scale factor point MUST be static and MUST NOT change over time.

4.2.9 Units

The *units* attribute is a string that specifies the units associated with the element.

Units are defined as needed by specific models. Where units are shared across models, care is taken to ensure a common definition of those units.

4.2.10 Access

The *access* attribute specifies if the element is writable or read-only. If specified, the value MUST be read-only (`R`) or read/write (`RW`). If not specified, the default mode is read-only.

4.2.11 Mandatory

The *mandatory* attribute specifies whether the element is required to be implemented. If specified, the value MUST be either mandatory (`M`) or optional (`O`). If not specified, the default value is optional. Points specified as mandatory MUST always have a valid value. Points specified as optional may have the unimplemented value for the corresponding point type.

4.2.12 Label

The *label* attribute specifies a short label associated with the element.

4.2.13 Description

The *description* attribute provides a brief description of the element.

4.2.14 Detailed Description

The *detailed description* attribute specifies a more detailed description of the element.

4.2.15 Symbols

A name-value pair used to represent a constant value associated with an enumerated value or bit position in a point.

5 Device Information Model Definition Encoding

The canonical format used to define SunSpec Device Information Models is JSON.

An alternative CSV encoding is also specified in this document to support a spreadsheet presentation of Device Information Model definitions.

5.1 JSON Message Encoding

This section describes the method of representing Device Information Model definitions in JSON.

Model definitions defined in JSON MUST be encoded using UTF-8.

5.1.1 Element Types

Table 5: Definition Element JSON Encoding shows the JSON name and value type used for element type definitions.

Element	JSON Name	JSON Value
Model	`model`	Object of model elements
Point Group	`groups`	Object of group elements
Point	`points`	Object of point attributes
Symbol	`symbols`	Array of symbol objects
Comment	`comments`	Array of comment strings

Table 5: Definition Element JSON Encoding

5.1.2 Element Attribute Types

Table 6: JSON-encoded Element Attribute Types shows the JSON name and value type used for element attribute type definitions.

Attribute	JSON Name	JSON Values
ID	`id`	
Value	`value`	
Type	`type`	`int16, int32, int64, uint16, raw16, uint32, acc16, acc32, acc64, bitfield16, bitfield32, bitfield64, enum16, enum32, float32, string, sf, pad, ipaddr, ipv6addr, eui48, group, sync`
Count	`count`	
Size	`size`	
Scale Factor	`sf`	
Units	`units`	
Access (R/RW)	`access`	`R, RW`
Mandatory (M/O)	`mandatory`	`M, O`
Label	`label`	
Description	`desc`	
Detailed Description	`detail`	

Table 6: JSON-encoded Element Attribute Types

5.1.3 Model Encoding

A model definition MUST be represented as an object with a single property named model and an object as the value. See Appendix A for model definition examples.

The object value of `model` MUST have two properties: `id` and `group`. The value of the `id` property MUST be the SunSpec numeric model ID.

The value of the `group` property MUST be an object that includes the contents of the rest of the model definition. The `group` property represents the required single top-level point group in the model.

The `model` object MUST have a `label` property and MAY have `desc`, `detail`, and `comments` properties.

The following example shows the model element encoding.

```
{"model": {
"id": <model id>,
"group": {
      <rest of model content>
}
"label": <model label>,
"desc": <model description>,
"detail": <model detailed description>,
}
```

5.1.4 Point Group Encoding

A point group definition MUST be represented as an object with the required and optional properties for a point group.

A point group definition MUST have a property named `type` that has a group value identifying the object as a point group definition.

A point group definition MAY have a property named `comments` that is an array holding the comment strings associated with the point group.

The following example shows the point group element encoding.

```
{
 "id": <point group id>,
 "type": <point group type>,
 "count": <point group count>,
 "label": <point group label>,
 "desc": <point group description>,
 "detail": <point group detailed description>,
 "points": [<points>],
 "groups": [<point groups>],
 "comments": [<comment strings>]
}
```

5.1.5 Point Encoding

A point definition MUST be represented as an object with the required and optional point properties for a point.

A point definition MUST have a property named `type` that has a value of `point` identifying the object as a point definition.

A point definition MAY have a property named `symbols` that is an array holding the symbols associated with the point.

A point definition MAY have a property named `comments` that is an array holding the comment strings associated with the point.

The following example shows the point element encoding.

```
{
 "id": <point id>,
 "value": <point value>,
 "type": <point type>,
 "count": <point count>,
 "size": <point size>,
 "sf": <point scale factor>,
 "units": <point units>,
 "access": <point access>,
 "mandatory": <point mandatory>,
 "label": <point label>,
 "desc": <point description>,
 "detail": <point detailed description>,
 "symbols": [<symbols>],
 "comments": [<comment strings>]
}
```

5.1.6 Symbol Encoding

A symbol definition MUST be represented as an object with the required and optional properties for a symbol.

A symbol definition MAY have a property named `comments` that is an array holding the comment strings associated with the symbol.

The following example shows the symbol element encoding.

```
{
 "id": <symbol id>,
 "value": <point value>,
 "label": <point label>,
 "desc": <point description>,
 "detail": <point detailed description>,
 "comments": [<comment strings>]
}
```

5.1.7 Comment Encoding

A comment definition MUST be represented as a string. Comments are associated with other elements as an array of comments in the element definition.

5.2 CSV Encoding

There is a one-to-one mapping between CSV model definition attributes and the JSON definition. The JSON encoding is the canonical form of a Device Information Model, and the CSV encoding is supported for convenience in creating and inspecting model definitions using a spreadsheet application.

A spreadsheet renders the encoding as a row and column matrix. Each row in the spreadsheet defines a model definition element. Each column represents an element attribute. The CSV encoding could be instantiated in several ways, such as an Excel spreadsheet.

The CSV encoding is defined such that a JSON encoding can be generated from the CSV encoding.

5.2.1 Columns

The column names in Table 7: Spreadsheet Column Encoding specified as mandatory MUST be used as the column names in the spreadsheet encoding. Other columns MAY be included in the encoding at any column location. The names specified as optional in the table are included for convenience.

Column Name	Mandatory/Optional
ID	Mandatory
Value	Mandatory
Type	Mandatory
Count	Mandatory
Size	Mandatory
Scale Factor	Mandatory
Units	Mandatory
Access (R/RW)	Mandatory
Mandatory (M/O)	Mandatory
Label	Mandatory
Description	Mandatory
Detailed Description	Mandatory
Address Offset	Optional. Offset of the element from the beginning of the Information Model, if known. Typically generated from definition information.
Group Offset	Optional. Offset of the element from the beginning of the immediate containing group. Typically generated from definition information.

Table 7: Spreadsheet Column Encoding

The **ID**, **Value**, and **Type** fields are used to determine the definition element type. The following rules specify how to interpret each element when a spreadsheet is used to define a model.

Model	**Model** is the model id as represented in the value of the point **ID**.
Point group	**Type** is a point group type. Because point groups can be nested, point group IDs reflect the hierarchy of the point groups. A dot (**.**) delimits hierarchical levels.
Point	**Type** is a point type.
Symbol	The symbol is a key-value pair associated with the last point defined.
Comment	Any line with no **Type** and no **Value** values. The comment only consists of the contents of the first column value in the row. A comment is associated with the next defined element. An element may have more than one comment associated with it.
Blank line	Any row with no value in any column. Blank lines are not preserved in the model definition.

5.2.2 Rows

Rows in the spreadsheet MUST consist of all of the point group, point, symbol, and comment elements included in the model definition. The sequence of ordered elements MUST be preserved.

The name strings specified in the JSON encoding MUST be used for all type and type value representations.

Either:

It is assumed that any point or point group definition resides inside the last defined point group. If it is necessary to end the current point group to permit the next element to be defined at a higher level in the point group hierarchy, a definition with only the type specified with a value of end MUST be used to end the current point group. Multiple point group end indications can be used in succession to end multiple point groups. This convention is only used in the spreadsheet encoding due to the lack of hierarchical representation in the row information.

Or:

To represent the point group hierarchy, the ID of any point or point group not defined in the top-level point group MUST have each point group to which the element belongs below the top-level point group prepend to its ID using a period (.) as a separator between IDs.

6 Device Information Model Usage for Modbus

This section specifies Modbus Device Information Model instance encoding. An Information Model instance includes the values associated with the defined content of a model.

6.1 Device Modbus Map

Device Information Models are used to construct a device Modbus map. The Information Models that represent the functionality implemented in the device are placed contiguously in the Modbus address space at a defined location as specified in this section.

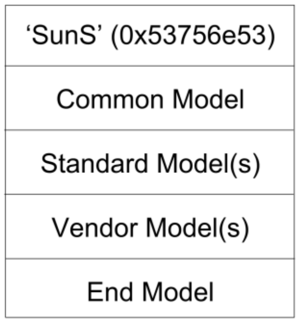


Figure 5: Device Modbus Map

All SunSpec Device Information Model maps MUST begin with the `SunS` identifier. The identifier is followed sequentially by common, standard, and vendor Device Information Models, as needed. An end model terminates the map.

6.1.1 Modbus Address Location

All Modbus device maps MUST be located in the holding register address space.

The beginning of the device Modbus map MUST be located at one of three Modbus addresses in the Modbus holding register address space: 0, 40000 (0x9C40) or 50000 (0xC350). These Modbus addresses are the full 16-bit, 0-based addresses in the Modbus protocol messages.

The first two Modbus registers at the start address MUST have the following well-known constant values as a marker: 0x5375, 0x6E53 (hexadecimal values of the ASCII string `SunS`).

6.1.2 Information Models

The Device Information Models MUST be placed contiguously, beginning immediately after the `SunS` marker registers. Each Information Model MUST have registers corresponding to all of the points in the Information Model, including those specified as optional or unimplemented. Points in a model MUST be placed such that there are not additional Modbus registers between points specified in the model definition. Points that are not supported or have no valid value MUST be assigned the appropriate unimplemented value based on the point type. There MUST NOT be additional Modbus registers between Information Models in the device Modbus map.

The length point (`L`) in an information model instance MUST be set to the remaining number of Modbus registers in the model following the length point.

A Modbus register map representing a Device Information Model MUST preserve the order of points and groups defined within the model. Such Modbus register maps MUST have group point elements placed before group elements, at lower register indices, and all instances of repeated point or group element MUST be consecutive.

6.1.3 End Model

The last Information Model in the device Modbus map MUST be a two-register empty model with a model id of 0xFFFF and a model length of 0.

6.2 Device Information Model Discovery

A discovery mechanism can be employed to determine the type and location of each of the Information Models in the device map.

Device architects may choose to implement different collections of Information Models in arbitrary order. In any implementation, after the Modbus address of a particular model is determined, the Modbus location of the points in the model are then known based on the model definition.

All Information Models start with an id register and a length register. This information is used to step through or scan the Information Models even if the ID and contents of an Information Model are not understood by the scanning application. This permits implementations to find and use the Device Information Model(s) it understands and ignores those whose definitions are unknown.

The following procedure is used for Information Model discovery:

1. Read the contents of addresses 0, 40000, and 50000 until the well-known marker is found.
2. Repeat the following steps until a model id of 0xFFFF is found:
    1) Read the next two registers to get the id and length of the next Information Model.
    2) Add the length to the Modbus address of the next register after the length register to determine the starting address of the subsequent Information Model
3. When this process is complete, the Modbus address and id of each Information Model is known.

6.3 Modbus Functions

The Modbus interface MUST comply with the Modbus standard for the functionality specified in this section.

The interface MUST support function code 3 (Read Holding Registers) and function code 16 (0x10) (Write Multiple Registers).

The interface MAY support function code 6 (Write Single Register).

If Modbus support is provided in the device, it MUST support a Modbus serial interface and/or a Modbus TCP/IP interface.

6.4 Value Representation

Values are stored in big-endian order and MUST be compliant with the Modbus specification. All integer values are documented as signed or unsigned. All signed values are represented using a two's-compliment format.

6.4.1 16-bit Integer Values

16-bit integers are stored using one register in big-endian order.

Modbus Register	1															
Byte	0								1							
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Table 8: Modbus 16-bit Integer Value Register

int16 Range: -32767... 32767	NOT IMPLEMENTED value: 0x8000
uint16 Range: 0 ... 65534	NOT IMPLEMENTED value: 0xFFFF
raw16 Range:	
acc16 Range: 0 ... 65535	NOT ACCUMULATED value: 0x0000
enum16 Range: 0 ... 65534	NOT IMPLEMENTED value:0xFFFF
bitfield16 Range: 0 ... 0x7FFF	NOT IMPLEMENTED value:0xFFFF
Pad Range: 0x8000	Always returns 0x8000

6.4.2 32-bit Integer Values

32-bit integers are stored using two registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits	31 … 24	23 … 16	15 … 8	7 … 0

Table 9: Modbus 32-bit Integer Value Registers

int32 Range: -2147483647 ... 2147483647	NOT IMPLEMENTED value: 0x80000000
uint32 Range: 0 ... 4294967294	NOT IMPLEMENTED value: 0xFFFFFFFF
acc32 Range: 0 ... 4294967295	NOT ACCUMULATED value: 0x00000000
enum32 Range: 0 ... 4294967294	NOT IMPLEMENTED value: 0xFFFFFFFF
bitfield32 Range: 0 ... 0x7FFFFFFF	NOT IMPLEMENTED value: 0xFFFFFFFF
ipaddr 32 bit IPv4 address	NOT CONFIGURED value: 0x00000000

6.4.3 48-bit Integer Values

48-bit integers are stored using four registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits			47 … 40	39 … 32

Table 10: Modbus 64-bit Integer Value High Registers

Modbus Register	3		4	
Byte	4	5	6	7
Bits	31 … 24	23 … 16	15 … 8	7 … 0

Table 11: Modbus 64-bit Integer Value Low Registers

int48 Range:	NOT IMPLEMENTED value:
TBD	NOT ACCUMULATED value:

6.4.4 64-bit Integer Values

64-bit integers are stored using four registers in big-endian order.

Modbus Register	1		2	
Byte	0	1	2	3
Bits	63 … 56	55 … 48	47 … 40	39 … 32

Table 12: Modbus 64-bit Integer Value High Registers

Modbus Register	3		4	
Byte	4	5	6	7
Bits	31 … 24	23 … 16	15 … 8	7 … 0

Table 13: Modbus 64-bit Integer Value Low Registers

int64 Range: -9223372036854775807 ... 9223372036854775807	NOT IMPLEMENTED value: 0x8000000000000000
uint64 Range: 0 ... 18,446,744,073,709,551,615	NOT IMPLEMENTED value:
acc64 Range: 0 ... 9223372036854775807	NOT ACCUMULATED value: 0

6.4.5 128-bit Integer Values

128-bit integers are stored using eight registers in big-endian order.

ipv6addr 128 bit IPv6 address	Not Configured: 0

Table 14: Modbus 128-bit Integer Value Registers

ipv6addr 128 bit IPv6 address	NOT CONFIGURED value: 0

Note: (TBD) review use of 0 as unimplemented value for ipaddr.

6.4.6 String Values

Store variable length string values in a fixed size register range using a NULL (0 value) to terminate or pad the string. For example, up to 16 characters can be stored in 8 contiguous registers as follows.

Modbus Register	1		2		3		4		5		6		7		8	
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Character	E	X	A	M	P	L	E	spc	S	T	R	I	N	G	!	NULL

Table 15: Modbus String Value Registers

NOT_IMPLEMENTED value: all registers filled with `NULL`, or 0x0000

It is recommended that an empty string be represented with the first register, with a value of 0x0080.

6.4.7 32-bit Floating-point Values

Floating-point 32-bit values are encoded according to the IEEE 754 floating-point standard.

Modbus Register	1															
Byte	0								1							
Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IEEE 754	sign	Exponent							Fraction							

Table 16: Modbus 32-bit Floating-point Value High Register

Modbus Register	2															
Byte	2								3							
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IEEE 754	Fraction least															

Table 17: Modbus 32-bit Floating-point Value Low Register

float32 Range: see IEEE 754 NOT IMPLEMENTED value: 0x7FC00000 (NaN)

6.4.8 64-bit Floating-point Values

Floating-point 64-bit values are encoded according to the IEEE 754 floating-point standard.

Modbus Register	1															
Byte	0								1							
Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IEEE 754	sign	Exponent							Fraction							

Table 18: Modbus 64-bit Floating-point Value High Register

Modbus Register	2															
Byte	2								3							
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IEEE 754	Fraction least															

Table 19: Modbus 64-bit Floating-point Value Low Register

float64 Range: see IEEE 754 NOT IMPLEMENTED value:

6.4.9 sunssf

TBD

Modbus Register	1															
Byte	0								1							
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Table 20: Modbus sunssf Value Registers

sunssf signed range: -10 ... 10 NOT IMPLEMENTED value: 0x8000

6.5 Modbus Error Handling

This section describes the required Modbus error handling procedures.

6.5.1 Unimplemented Registers

When reading an unimplemented register, the unimplemented value for the data point type MUST be returned.

When writing an unimplemented register, a Modbus exception MUST be generated. The Modbus exception MUST be either exception code `2`, `3`, or `4`.

6.5.2 Writing Invalid Value

When writing an invalid value to a register, a Modbus exception MUST be generated. The Modbus exception MUST be either exception code `2`, `3`, or `4`.

6.5.3 Writing a Read-Only Register

When writing a read-only register, a Modbus exception MUST be generated. The Modbus exception MUST be either exception code `2`, `3`, or `4`.

6.6 Security

Modbus/TCP security SHALL be compliant with the Modbus/TCP Security specification (http://modbus.org/docs/MB-TCP-Security-v21_2018-07-24.pdf).

7 Device Information Model Usage for JSON

This section specifies JSON Information Model instance encoding. An Information Model instance contains the values associated with the defined content of a model.

The following rules apply for mapping Information Model content to a JSON encoded object:

- A Model element is represented as a JSON object.
- A Point Group element is represented as a JSON object.
- A Point element is represented as a JSON number or a JSON string. The mapping of each point type is shown in Table 21: Point Type Mapping to JSON Type.
- Repeating elements are represented as a JSON array containing the repeated elements.
- Unimplemented values are omitted.

Type	JSON Encoding
`int16`	number
`int32`	number
`int64`	number
`raw16`	number
`uint16`	number
`raw16`	number
`uint32`	number
`uint64`	number
`acc16`	Unsigned 16-bit accumulator (deprecated in favor of uint16)
`acc32`	number
`acc64`	number
`bitfield16`	number
`bitfield32`	number
`bitfield64`	number
`enum16`	number
`enum32`	number
`float32`	number
`float64`	number
`string`	string
`sf`	number
`pad`	N/A
`ipaddr`	number or hexadecimal string or convert to IP address string (x.x.x.x)
`ipv6addr`	hexadecimal string or convert to IP address string
`eui48`	number or hexadecimal string or convert to MAC string (xx:xx:xx:xx:xx:xx)

Table 21: Point Type Mapping to JSON Type

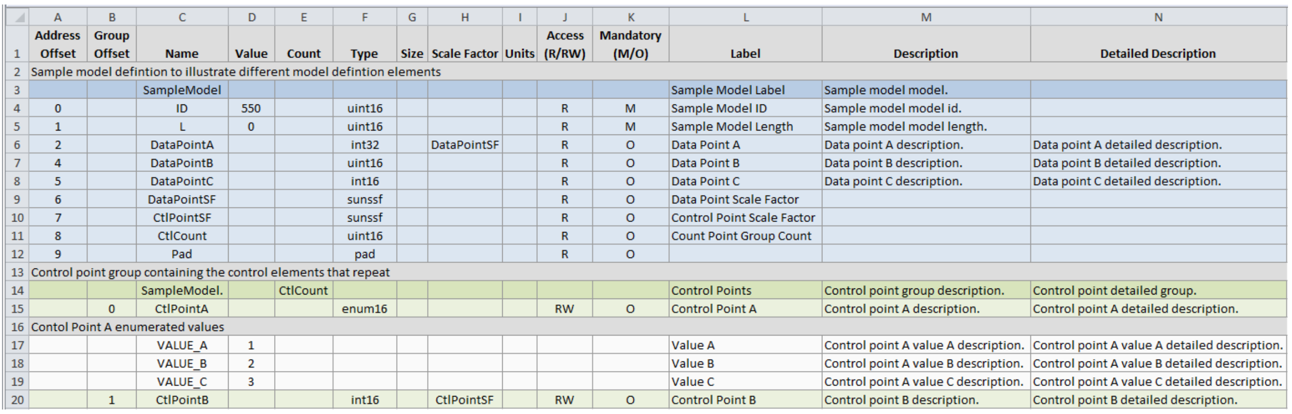
Appendix A: Model Definition Examples

This appendix contains examples of model definitions using both CSV encoding and canonical JSON encoding. The same, simple sample model definition is used throughout the document for both model definition and instance examples.

The example model definition is a simple model containing three points and a point group that contains two points. The point group count is contained as a data point. The model is 550 and the name of the model point group is *SampleModel*.

Spreadsheet Model Definition Example

The spreadsheet encoding provides a convenient mechanism for easily viewing the contents of a device information model. The basis of the spreadsheet visualization is CSV encoding. This example shows the CVS representation of the sample model definition and an example of the information in spreadsheet form:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Address Offset	Group Offset	Name	Value	Count	Type	Size	Scale Factor	Units	Access (R/RW)	Mandatory (M/O)	Label	Description	Detailed Description
2	Sample model defintion to illustrate different model defintion elements													
3			SampleModel									Sample Model Label	Sample model model.	
4	0		ID	550		uint16				R	M	Sample Model ID	Sample model model id.	
5	1		L	0		uint16				R	M	Sample Model Length	Sample model model length.	
6	2		DataPointA			int32		DataPointSF		R	O	Data Point A	Data point A description.	Data point A detailed description.
7	4		DataPointB			uint16				R	O	Data Point B	Data point B description.	Data point B detailed description.
8	5		DataPointC			int16				R	O	Data Point C	Data point C description.	Data point C detailed description.
9	6		DataPointSF			sunssf				R	O	Data Point Scale Factor		
10	7		CtlPointSF			sunssf				R	O	Control Point Scale Factor		
11	8		CtlCount			uint16				R	O	Count Point Group Count		
12	9		Pad			pad				R	O			
13	Control point group containing the control elements that repeat													
14			SampleModel.		CtlCount							Control Points	Control point group description.	Control point detailed group.
15		0	CtlPointA			enum16				RW	O	Control Point A	Control point A description.	Control point A detailed description.
16	Contol Point A enumerated values													
17			VALUE_A	1								Value A	Control point A value A description.	Control point A value A detailed description.
18			VALUE_B	2								Value B	Control point A value B description.	Control point A value B detailed description.
19			VALUE_C	3								Value C	Control point A value C description.	Control point A value C detailed description.
20		1	CtlPointB			int16		CtlPointSF		RW	O	Control Point B	Control point B description.	Control point B detailed description.

In the example, visual cues, such as color-coding point groups, are added for clarity. A spreadsheet representation should not add to the model definition contents but may use visual elements to help understand the model definition contents.

CSV Model Definition Encoding Example

The CSV encoding is the basis of the spreadsheet representation. As specified in the CSV encoding section, the group hierarchy is represented by including the group hierarchy in the group name. In this example, the `Ctl` group has the name of `SampleModel.Ctl` to explicitly indicate the group hierarchy.

```
Address Offset,Group Offset,Name,Value,Count,Type,Size,Scale
Factor,Units,Access (R/RW),Mandatory (M/O),Label,Description,Detailed
Description
Sample model definition to illustrate different model definition
elements,,,,,,,,,,,,,
,,SampleModel,,,,,,,,,Sample Model Label,Sample model model.,
0,,ID,550,,uint16,,,,R,M,Sample Model ID,Sample model model id.,
1,,L,0,,uint16,,,,R,M,Sample Model Length,Sample model model length.,
2,,DataPointA,,,int32,,DataPointSF,,R,O,Data Point A,Data point A
description.,Data point A detailed description.
4,,DataPointB,,,uint16,,,,R,O,Data Point B,Data point B description.,Data
point B detailed description.
5,,DataPointC,,,int16,,,,R,O,Data Point C,Data point C description.,Data
point C detailed description.
6,,DataPointSF,,,sunssf,,,,R,O,Data Point Scale Factor,,
7,,CtlPointSF,,,sunssf,,,,R,O,Control Point Scale Factor,,
8,,CtlCount,,,uint16,,,,R,O,Count Point Group Count,,
Control point group containing the control elements that repeat,,,,,,,,,,,,,
,,SampleModel.Ctl,,CtlCount,,,,,,,Control Points,Control point group
description.,Control point detailed group.
,0,CtlPointA,,,enum16,,,,RW,O,Control Point A,Control point A
description.,Control point A detailed description.
Contol Point A enumerated values,,,,,,,,,,,,,
,,VALUE_A,1,,,,,,,,Value A,Control point A value A description.,Control point
A value A detailed description.
,,VALUE_B,2,,,,,,,,Value B,Control point A value B description.,Control point
A value B detailed description.
,,VALUE_C,3,,,,,,,,Value C,Control point A value C description.,Control point
A value C detailed description.
,1,CtlPointB,,,int16,,CtlPointSF,,RW,O,Control Point B,Control point B
description.,Control point B detailed description.
```

JSON Model Definition Encoding Example

This example shows the canonical JSON encoding of the device information model definition.

```
{
  "id": 550
  "group": {
    "id": "SampleModel",
    "points": [
      {
        "id": "ID",
        "type": "uint16",
        "label": "Sample Model ID",
        "desc": "Sample model model id.",
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "true",
        "detail": null,
        "symbols": [],
        "comments": [],
        "value": 550
      },
      {
        "id": "L",
        "type": "uint16",
        "label": "Sample Model Length",
        "desc": "Sample model model length.",
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "true",
        "detail": null,
        "symbols": [],
        "comments": [],
        "value": 0
      },
      {
        "id": "DataPointA",
        "type": "int32",
        "label": "Data Point A",
        "desc": "Data point A description.",
        "sf": "DataPointSF",
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": "Data point A detailed description.",
        "symbols": [],
        "comments": []
      },
      {
        "id": "DataPointB",
        "type": "uint16",
        "label": "Data Point B",
        "desc": "Data point B description.",
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": "Data point B detailed description.",
        "symbols": [],
        "comments": []
      },
      {
        "id": "DataPointC",
        "type": "int16",
        "label": "Data Point C",
        "desc": "Data point C description.",
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": "Data point C detailed description.",
        "symbols": [],
        "comments": []
      },
      {
        "id": "DataPointSF",
        "type": "sunssf",
        "label": "Data Point Scale Factor",
        "desc": null,
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": null,
        "symbols": [],
        "comments": []
      },
      {
        "id": "CtlPointSF",
        "type": "sunssf",
        "label": "Control Point Scale Factor",
        "desc": null,
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": null,
        "symbols": [],
        "comments": []
      },
      {
        "id": "CtlCount",
        "type": "uint16",
        "label": "Count Point Group Count",
        "desc": null,
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": null,
        "symbols": [],
        "comments": []
      },
      {
        "id": "Pad",
        "type": "pad",
        "label": null,
        "desc": null,
        "sf": null,
        "units": null,
        "access": "r",
        "mandatory": "false",
        "detail": null,
        "symbols": [],
        "comments": []
      }
    ],
    "groups": [
      {
        "id": "Ctl",
      "points": [
        {
          "id": "CtlPointA",
          "type": "enum16",
          "label": "Control Point A",
          "desc": "Control point A description.",
          "sf": null,
          "units": null,
          "access": "rw",
          "mandatory": "false",
          "detail": "Control point A detailed description.",
          "symbols": [
            {
              "id": "VALUE_A",
              "value": 1,
              "label": "Value A",
              "desc": "Control point A value A description.",
              "detail": "Control point A value A detailed description.",
              "comments": [
                "Contol Point A enumerated values"
              ]
            },
            {
              "id": "VALUE_B",
              "value": 2,
              "label": "Value B",
              "desc": "Control point A value B description.",
              "detail": "Control point A value B detailed description.",
              "comments": []
            },
            {
              "id": "VALUE_C",
              "value": 3,
              "label": "Value C",
              "desc": "Control point A value C description.",
              "detail": "Control point A value C detailed description.",
              "comments": []
            }
          ],
          "comments": []
        },
        {
          "id": "CtlPointB",
          "type": "int16",
          "label": "Control Point B",
          "desc": "Control point B description.",
          "sf": "CtlPointSF",
          "units": null,
          "access": "rw",
          "mandatory": "false",
          "detail": "Control point B detailed description.",
          "symbols": [],
          "comments": []
        }
      ],
      "groups": [],
      "label": "Control Points",
      "desc": "Control point group description.",
      "detail": "Control point detailed group.",
      "comments": [
        "Control point group containing the control elements that repeat"
      ],
      "count": "CtlCount"
    }
  ],
  "label": "Sample Model Label",
    "desc": "Sample model model.",
    "detail": null,
    "comments": [
      "Sample model defintion to illustrate different model defintion elements"
    ]
  }
}
```

Appendix B: Model Instance Examples

This appendix contains examples of a model instance based on the sample model definition shown in Appendix A. The model instance examples show the contents of the model definition with the current values associated with each data point.

JSON Message Encoding Example

This example shows a JSON encoding of the sample model with associated values.

```
{"SampleModel": {
   "id": 550,
   "DataPointA": 120,
   "DataPointB": 16,
   "DataPointC": -3241,
   "DataPointSF": 2,
   "CtlPointSF": -1,
   “CtlCount”: 3,
   "Ctl": [
     {
       "CtlPointA": 2,
       "CtlPointB": 102
     },
     {
       "CtlPointA": 2,
       "CtlPointB": 420
     },
     {
       "CtlPointA": 1,
       "CtlPointB": 310
     }
   ]
  }
}
```

MODBUS Message Encoding Example

The example shows a simplified Modbus map that contains the initial marker, sample model, and end model. This shows the general Modbus map structure but is not complete because an actual Modbus map contains additional models.

Modbus Address	Register Contents	Description
40000	'Su'	Beginning of models marker
40001	'nS'	
40002	550	ID
40003	14	L
40004	0	DataPointA (high order word)
	120	DataPointA (low order word)
40006	16	DataPointB
40007	-3241	DataPointC
40008	2	DataPointSF
40009	-1	CtlPointSF
40010	3	CtlCount
40011	0	Pad
40012	2	CtlPointA[0]
40013	102	CtlPointB[0]
40014	2	CtlPointB[1]
40015	420	CtlPointB[1]
40016	1	CtlPointC[2]
40017	310	CtlPointC[2]
40018	0	Pad
40019	0xFFFF	End Model ID