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Energy management system application program interface (EMS-API) –
Part 452: CIM Static transmission network model profiles

Interface de programmation d'application pour système de gestion d'énergie (EMS-API) –
Partie 452: Profils du modèle de réseau de transport statique CIM

IEC 61970-452:2013

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ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 452: CIM Static transmission network model profiles

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The text of this standard is based on the following documents:

FDIS	Report on voting
57/1366/FDIS	57/1384/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 61970 series, published under the general title *Energy management system application program interface (EMS-API)*, can be found on the IEC website.

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INTRODUCTION

This international standard is one of the IEC 61970 series that define an application program interface (API[1]) for an energy management system (EMS[2]).

The IEC 61970-3x series of documents specify a Common Information Model (CIM). The CIM is an abstract model that represents all of the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility. It provides the semantics for the IEC 61970 APIs specified in the IEC 61970-4x series of Component Interface Standards (CIS). The IEC 61970-3x series includes IEC 61970-301: Common Information Model (CIM[3]) base, and draft standard IEC 61970-302: Common Information Model (CIM) Financial, EnergyScheduling, and Reservation.

This standard is one of the IEC 61970-4x series of Compoment Interface Standards that specify the functional requirements for interfaces that a component (or application) shall implement to exchange information with other components (or applications) and/or to access publicly available data in a standard way. The component interfaces describe the specific message contents and services that can be used by applications for this purpose. The implementation of these messages in a particular technology is described in IEC 61970-5.

This standard specifies the specific profiles (or subsets) of the CIM for exchange of static power system data between utilities, security coordinators and other entities participating in a interconnected power system, such that all parties have access to the modeling of their neighbor's systems that is necessary to execute state estimation or power flow applications. Currently only one profile, the Equipment Profile, has been defined. A companion standard, 61970-552[4], defines the CIM XML Model Exchange Format based on the Resource Description Framework (RDF) Schema specification language which is recommended to be used to transfer power system model data for the 61970-452 profile.

1 Footnote 1 applies to the French version only.

2 Footnote 2 applies to the French version only.

3 Footnote 3 applies to the French version only.

4 To be published.

ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 452: CIM Static transmission network model profiles

1 Scope

This part of IEC 61970 forms part of the IEC 61907-450 to 499 series that, taken as a whole, defines at an abstract level the content and exchange mechanisms used for data transmitted between control centers and/or control center components.

The purpose of this document is to rigorously define the subset of classes, class attributes, and roles from the CIM necessary to execute state estimation and power flow applications. The North American Electric Reliability Council (NERC) Data Exchange Working Group (DEWG) Common Power System Modeling group (CPSM) produced the original data requirements, which are shown in Annex C. These requirements are based on prior industry practices for exchanging power system model data for use primarily in planning studies. However, the list of required data has been extended to facilitate a model exchange that includes parameters common to breaker-oriented applications. Where necessary this document establishes conventions, shown in Clause 5, with which an XML data file must comply in order to be considered valid for exchange of models.

This document is intended for two distinct audiences, data producers and data recipients, and may be read from two perspectives.

From the standpoint of model export software used by a data producer, the document describes a minimum subset of CIM classes, attributes, and associations which must be present in an XML formatted data file for model exchange. This standard does not dictate how the network is modelled, however. It only dictates what classes, attributes, and associations are to be used to describe the source model as it exists. All classes, attributes, and associations not explicitly labeled as recommended or conditionally required should be considered required with the following caveat. Consider, as an example, the situation in which an exporter produces an XML data file describing a small section of the exporter's network that happens to contain no breakers. The resulting XML data file should, therefore, not contain an instance of the Breaker class. On the other hand, if the section of the exporter's network does contain breakers, the resulting data file should contain instances of the Breaker class that include, at a minimum, the attributes and roles described herein for Breakers. Furthermore, it should be noted that an exporter may, at his or her discretion, produce an XML data file containing additional class data described by the CIM RDF Schema but not required by this document provided these data adhere to the conventions established in Clause 5.

From the standpoint of the model import used by a data recipient, the document describes a subset of the CIM that importing software must be able to interpret in order to import exported models. As mentioned above, data providers are free to exceed the minimum requirements described herein as long as their resulting data files are compliant with the CIM RDF Schema and the conventions established in Clause 5. The document, therefore, describes additional classes and class data that, although not required, exporters will, in all likelihood, choose to include in their data files. The additional classes and data are labeled as recommended or as not required to distinguish them from their required counterparts. Please note, however, that data importers could potentially receive data containing instances of any and all classes described by the CIM RDF Schema.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE For general glossary definitions, see the International Electrotechnical Vocabulary, IEC 60050.

IEC 61970-1, *Energy management system application program interface (EMS-API) – Part 1: Guidelines and general requirements*

IEC 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*

IEC 61970-301, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

IEC 61970-501, *Energy management system application program interface (EMS-API) – Part 501: Common Information Model Resource Description Framework (CIM RDF) schema*

3 Overview of data requirements

3.1 Overview

An extensive discussion of the model exchange use cases can be found in Annex A. In all cases, the purpose of this standard is:

- To improve the accuracy of power system models used in critical systems, particularly the representation of parts of the network outside the primary domain of the system in question.
- To achieve consistency among the models used by the various systems that play a role in operating or planning the interconnection.
- To reduce the overall cost of maintaining critical models used in operating or planning an interconnection.

The classes, attributes, and associations identified in this document represent the minimum subset of the full CIM model necessary to exchange sufficient power system data to support state estimation and power flow.

3.2 General requirements

The following requirements are general in nature or involve multiple classes. Additional requirements are defined in the sections for the individual classes.

– The cardinality defined in the CIM model shall be followed, unless a different cardinality is explicitly defined in this document. For instance, the cardinality on the association between VoltageLevel and BaseVoltage indicates that a VoltageLevel shall be associated with one and only one BaseVoltage, but a BaseVoltage can be associated with zero to many VoltageLevels.

– Associations between classes referenced in this document and classes not referenced here are not required regardless of cardinality. For instance, the CIM requires that a HydroGeneratingUnit be associated with a HydroPowerPlant. Because the HydroPowerPlant class is not included in this document the association to HydroPowerPlant is not considered mandatory in this context.

– The attribute “name” inherited by many classes from the abstract class IdentifiedObject is not required to be unique. The RDF ID defined in the data exchange format is the only unique and persistent identifier used for this data exchange. The attribute

IdentifiedObject.name is, however, always required. The additional attributes of IdentifiedObject (aliasName, description, and pathName) are not required. If the pathName attribute is supplied it shall be constructed from the names in the GeographicalRegion / SubGeographicalRegion / Substation / VoltageLevel / … hierarchy. A forward slash, "/", shall be used as the separator between names.

– Although not defined within this profile, the IdentifiedObject.mRID attribute should be used as the RDF ID. The RDF ID cannot begin with a number. An underscore should be added as the first character if necessary. The RDF ID shall be globally unique. A prefix may be added, if necessary, to ensure global uniqueness, but the RDF ID including the prefix shall be within the maximum character limit specified below.
– The maximum character length of names and identifiers are listed below.
  - rdf:ID – 60 characters maximum
  - IdentifiedObject.name – 32 characters maximum
  - IdentifiedObject.aliasname – 40 characters maximum
  - IdentifiedObject.description – 256 characters maximum
– To maintain a consistent naming hierarchy, each Substation shall be contained by a SubGeographicalRegion and each SubGeographicalRegion shall be contained by one and only one GeographicalRegion.
– Equipment defined without connectivity, because the associated Terminal(s) are not connected to ConnectivityNodes is allowed, for instance a ShuntCompensator whose Terminal is not associated to a ConnectivityNode.
– UTF-8 is the standard for file encoding. UTF-16 is not supported.
– Instance data to be exchanged shall make use of the most detailed class possible. The classes GeneratingUnit, Switch, and EnergyConsumer should only be used if the information to determine the more detailed class (ThermalGeneratingUnit, HydroGeneratingUnit, Breaker, Disconnector, etc.) is not available.

3.3 Transformer modeling

A two winding PowerTransformer has two TransformerWindings. This gives the option to specify the impedance values for the equivalent pi-model completely at one of the windings or split them over the two windings. The impedances shall be specified at the primary voltage side as shown in Figure 1.

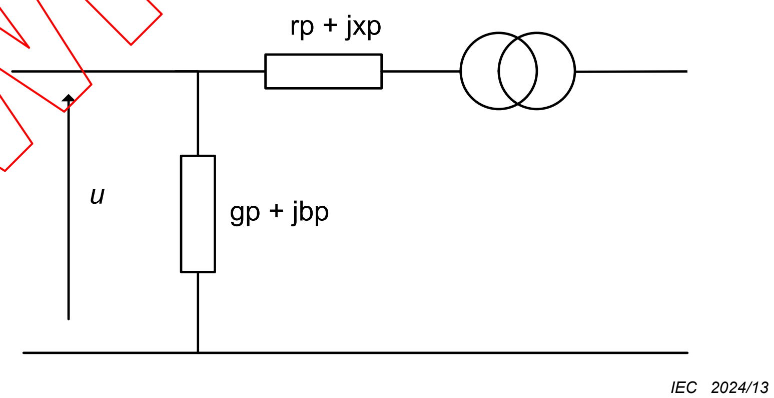

Figure 1 – Two winding transformer impedance

A three winding PowerTransformer has three TransformerWindings. The equivalent pi-model corresponds to three TransformerWindings connected in wye configuration as shown below. The impedance values for a three winding transformer are specified on each of the three TransformerWindings. Each of the windings has series impedances rn+jxn and shunt gn+jbn where n is: p for primary, s for secondary and t for tertiary as shown in Figure 2.

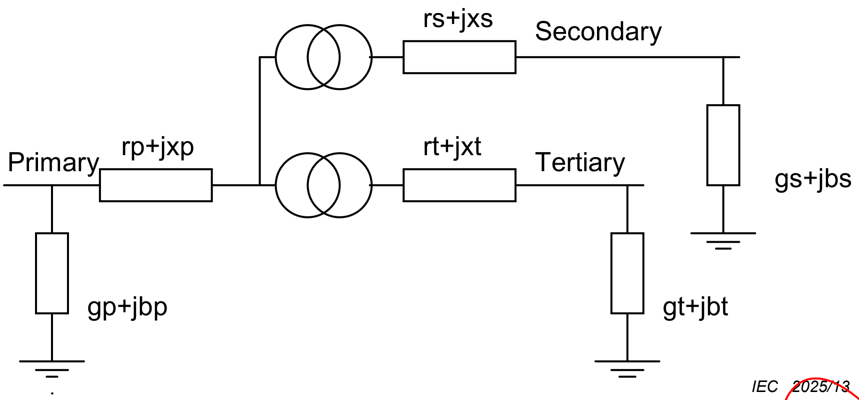

Figure 2 – Three winding transformer impedance

Additional requirements related to transformer modeling are listed below.

– Each PowerTransformer and its associated TransformerWindings, RatioTapChangers and PhaseTapChangers shall be contained within one substation. For the case of a transformer that connects two substations, however, the terminal of one of the TransformerWindings can be connected to a ConnectivityNode defined in another substation. In this case, the PowerTransformer, the TransformerWindings, the RatioTapChangers and the PhaseTapChangers are still all defined in one substation.

– A PowerTransformer shall be contained by a Substation. A TransformerWinding shall be contained by a PowerTransformer. A RatioTapChanger and a PhaseTapChanger shall be contained by a TransformerWinding.

– Each PowerTransformer shall have at least two and no more than three TransformerWindings. Each TransformerWinding can have at most one RatioTapChanger or PhaseTapChanger. If a TransformerWinding does not have an associated RatioTapChanger or PhaseTapChanger, the winding should be considered to have a fixed tap.

Multiple types of regulating transformers are supported by the CIM model. Depending on the regulation capabilities, the effects of tap movement will be defined using either the RatioTapChanger class or the PhaseTapChanger class. Both of these classes are subtypes of the TapChanger class. The use of the various subtypes is explained in IEC 61970-301.

3.4 Modeling authorities

From the use cases for model exchange detailed in Annex A, it is clear that most situations involve multiple entities that must cooperate. In these situations, it is very important to establish which entity has the authority for modeling each region or set of data objects. For this purpose the CIM includes classes called ModelingAuthority and ModelingAuthoritySet. When multiple modeling entities are involved, each modeled object is assigned to a ModelingAuthoritySet. A ModelingAuthority can be responsible for one or more ModelingAuthoritySets. A more detailed description of the use ModelingAuthorities and ModelingAuthoritySets can be found in Annex B.

For purposes of data exchange, the use of explicit associations between ModelingAuthoritySets and the objects in the model would create an unnecessary burden because of the potential file sizes and additional processing necessary. To avoid this situation, when using ModelingAuthoritySets, a single file shall contain only data objects associated with a single ModelingAuthoritySet.

3.5 Use of measurement classes

3.5.1 General

Use of the CIM Measurement classes (Analog, Accumulator, and Discrete) is frequently misunderstood and has changed over time. Previously in addition to the use representing points in the system where telemetry is available, the classes had been used to associate Limits with a piece of Equipment and to define regulated points. Measurements are now only used to define where telemetry is available and to facilitate exchange of ICCP data.

A Measurement shall be associated with a PowerSystemResource to convey containment information for the Measurement. Transmission line measurements should be associated with an ACLineSegment, not with a Line. Transformer measurements should be associated with a PowerTransformer, not with a Transformer Winding. Voltage measurements should be associated with a piece of equipment, not with a VoltageLevel. A TapPosition measurement shall be associated with a RatioTapChanger or with a PhaseTapChanger. A SwitchPosition measurement shall be associated with a Switch or a subtype of Switch.

The Measurement may also be associated with one of the Terminals associated with a piece of equipment. For measurements representing actual telemetered points, it is especially important that the association to a Terminal defines the specific topological point in the network that is measured. A Measurement can be associated with at most one Terminal. Each flow measurement (active power, reactive power, or current) shall be associated with a terminal. This association is particularly important for State Estimation. The measurement shall be associated with the correct terminal of the piece of conducting equipment that is being measured (SynchronousMachine, EnergyConsumer, ACLineSegment, TransformerWinding, etc.) Associating the measurement with a terminal of the wrong equipment or the terminal on the wrong end of the correct piece of equipment will cause problems for State Estimation. Only two types of measurement, TapPosition and SwitchPosition, do not require an association to a Terminal.

Three subtypes of Measurement are included in this profile, Analog, Accumulator, and Discrete. To describe what is being measured, the attribute Measurement.measurementType is used, but only particular measurementTypes are valid for each of the subtypes of Measurement. The valid associations are defined in Table 1.

Table 1 – Valid measurementTypes

Measurement subclass	measurementType
Analog	ThreePhasePower
	ThreePhaseActivePower
	ThreePhaseReactivePower
	LineCurrent
	PhaseVoltage
	LineToLineVoltage
	Angle
	TapPosition
Accumulator	ApparentEnergy
	ReactiveEnergy
	ActiveEnergy
Discrete	SwitchPosition