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Edition 3.0 2017-07

INTERNATIONAL STANDARD

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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 61970-452:2017-07(en-fr)

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

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

Part 452: CIM static transmission network model profiles

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61970-452 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The Equipment profile has been split into three separate profiles, CoreEquipment, Operation and ShortCircuit.
b) The HVDC model has been replaced with the new model defined in Edition 6 of 61970-301.
c) Added attribute IdentifiedObject.mRID.

d) Added class BusNameMarker.

e) Added attribute HydroPowerPlant.hydroPlantType.

f) Removed attribute HydroGeneratingUnit.energyConversionCapability.

g) Added classes related to grounding (PetersenCoil, GroundImpedance, GroundDisconnector, GroundSwitch, and Ground).

h) A number of changes have been made to whether specific attributes and associations are required or optional.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
57/1868/FDIS	57/1892/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 61970 is part of the IEC 61970 series that define an application program interface (API) for an energy management system (EMS).

The IEC 61970-3x series specifies 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) base* and draft standard IEC 61970-302[1], *Common Information Model (CIM) for Dynamics*.

This document 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 the IEC 61970-5x series.

This document 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 three profiles, the CoreEquipment Profile, the Operation Profile and the Short Circuit Profile, have been defined. A companion standard, IEC 61970-552, defines the CIM XML Model Exchange Format based on the Resource Description Framework (RDF) Schema specification language. IEC 61970-552 is the common industry approach and is recommended to be used to transfer power system model data for the IEC 61970-452 profile.

1 Under preparation. Stage at the time of publication: IEC/AFDIS 61970-302:2017.

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

Part 452: CIM static transmission network model profiles

1 Scope

This IEC document is one of the IEC 61970-450 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, such as power systems applications.

The purpose of this document is to 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 E. 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 6, 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.

Optional and required classes, attributes and associations must be imported if they are in the model file prior to import. If an optional attribute does not exist in the imported file, it does not have to be exported in case exactly the same data set is exported, i.e. the tool is not obliged to automatically provide this attribute. If any mandatory attribute or association is missing, the exchanged data is considered invalid. Specific business processes may relax restrictions of the profile, but such exchanges would not be considered to be compliant with the standard. Business processes governing different exchanges can also require mandatory exchange of certain optional attributes or associations.

Furthermore, 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 6.

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 6. 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 required (cardinality 1..1) or as optional (cardinality 0..1) 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 are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 IEC 60059, *International Electrotechnical Vocabulary*.

IEC 61968-13, *Application integration at electric utilities – System interfaces for distribution management – Part 13: CIM RDF Model exchange format for distribution*

IEC 61970-301:2016, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

IEC 61970-456, *Energy management system application program interface (EMS-API) – Part 456: Solved power system state profiles*

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

IEC 61970-552, *Energy management system application program interface (EMS-API) – Part 552: CIMXML Model exchange format*

Extensible Markup Language (XML) 1.0 (Second Edition), http://www.w3.org/TR/REC-xml

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Overview of data requirements

4.1 Overview

An extensive discussion of the model exchange use cases can be found in Annex A. In all cases, the purposes of this document are:

- 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 and specified in IEC 61970-456 represent the minimum subset of the full CIM model necessary to exchange sufficient power system data to support state estimation and power flow for HV(high voltage) and MV (medium voltage) networks. IEC 61968-13 describes the profiles used to exchange distribution MV/LV (low voltage) network models.

4.2 General requirements

The following requirements are general in nature or involve multiple classes. Additional requirements are defined in Subclauses 5.2.1 and 5.2.2 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.
- 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 attribute of IdentifiedObject, aliasName, is not required.
- The IdentifiedObject.mRID attribute should be used as the RDF ID. The RDF ID can not 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
- 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.
- All Equipment must be within a VoltageLevel except PowerTransformer, GeneratingUnit, HydroPump, Conductor, Switch and DCConductingEquipment. A PowerTransformer, GeneratingUnit or HydroPump should be contained in a substation; a Switch may be in a VoltageLevel or a Bay; and Conductor should be contained in a Line. For networks with HVDC the ACDCConverter will be in a DCConverterUnit and the associated PowerTransformer, Switches and SeriesCompensators will also be contained in a DCConverterUnit.

4.3 Transformer modeling

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

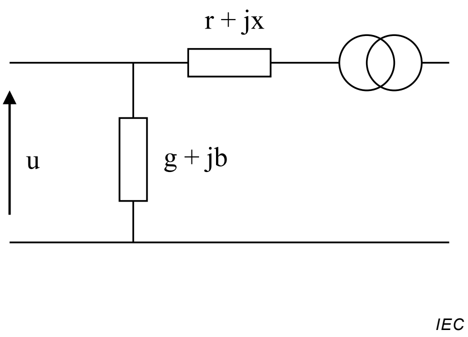

Figure 1 – Two winding transformer impedance

A three winding PowerTransformer has three PowerTransformerEnds. The equivalent pi-model corresponds to three ends 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 ends 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.

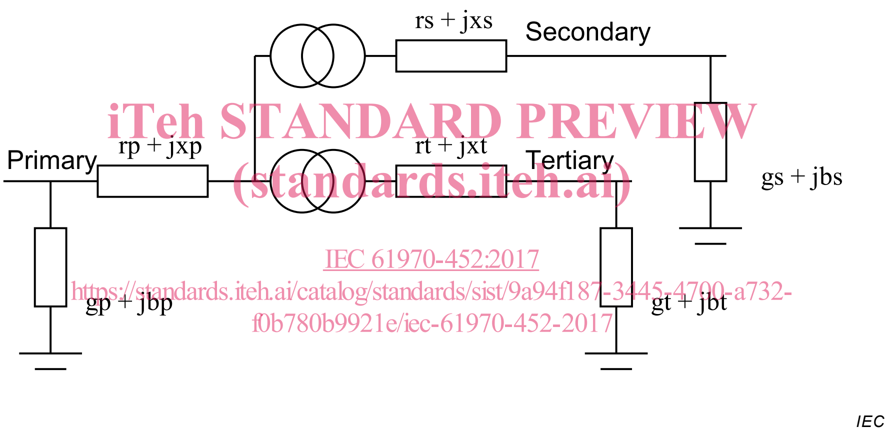

Figure 2 – Three winding transformer impedance

Additional requirements related to transformer modeling are listed below.

- Each PowerTransformer and its associated PowerTransformerEnds and tap changers (RatioTapChanger, PhaseTapChangerLinear, PhaseTapChangerSymetrical, and PhaseTapChangerAsymetrical) shall be contained within one substation. For the case of a transformer that connects two substations, however, the terminal of one of the PowerTransformerEnds can be connected to a ConnectivityNode defined in another substation. In this case, the PowerTransformer, the PowerTransformerEnds, the tap changers are still all defined in one substation.
- A PowerTransformer shall be contained by a Substation. A PowerTransformerEnd shall be contained by a PowerTransformer. A RatioTapChanger, PhaseTapChangerLinear, PhaseTapChangerSymetrical, and PhaseTapChangerAsymetrical shall be contained by a PowerTransformerEnd.
- Each PowerTransformer shall have at least two and no more than three PowerTransformerEnds. Each PowerTransformerEnd can have at most one tap changer (RatioTapChanger, PhaseTapChangerLinear, PhaseTapChangerSymetrical, or PhaseTapChangerAsymetrical). If a PowerTransformerEnd does not have an associated tap changer, the end 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 the RatioTapChanger class, PhaseTapChangerLinear class, PhaseTapChangerSymetrical class, or PhaseTapChangerAsymetrical class. Each of these classes are subtypes of the TapChanger class. The use of the various subtypes is explained in IEC 61970-301.

4.4 Modeling authorities

From the use cases for model exchange detailed in Annex A, it is clear that most situations involve multiple entities that shall 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 we use the concepts of ModelingAuthority and ModelingAuthoritySet. ModelingAuthority and ModelingAuthoritySet are not defined as classes in the normative portion of the CIM. 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. When using the concept of ModelingAuthoritySets, a single file shall contain only data objects associated with a single ModelingAuthoritySet.

4.5 Use of measurement classes

4.5.1 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 tap changer (RatioTapChanger, PhaseTapChangerLinear, PhaseTapChangerSymetrical or PhaseTapChangerAsymetrical). 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, PowerTransformer, 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
	SwitchPosition
Discrete	

4.5.2 ICCP data exchange

In the context of this data exchange profile, ICCP Data Exchange is only for the purpose of defining input measurements for use by State Estimator. It is not meant to be used to configure bidirectional ICCP exchange.

ICCP (known officially as IEC 60870-6 TASE.2) data is exchanged using the Measurement classes (Analog, Discrete, and Accumulator), the MeasurementValue classes (AnalogValue, DiscreteValue, and AccumulatorValue), and the MeasurementValueSource class. The MeasurementValueSource class is used to define the control center supplying the ICCP data. The MeasurementValueSource shall be associated with an instance of Name where the attribute Name.name holds the name of the supplying control center. The instance of NameType associated with the control center Name shall have the NameType.name attribute set to “ICCP Provider ID”.

The MeasurementValue classes are used to specify the ICCP ID. The MeasurementValue shall be associated with an instance of Name where the attribute Name.name holds the ICCP ID. The instance of NameType associated with the ICCP ID Name shall have the NameType.name attribute set to “ICCP ID”. The MeasurementValue.name attribute holds the SCADA point name. Each MeasurementValue will be associated with one Measurement. Each MeasurementValue being supplied via ICCP shall also have an association to a MeasurementValueSource.

To clearly specify the point in the system being measured, the Measurement should be associated with a Terminal. For a switch status measurement, however, the association to the appropriate PowerSystemResource representing the switch would be sufficient.

4.6 Voltage or active power regulation

To use CIM to define how a piece of equipment regulates a point in the system, an association is defined between the regulating conducting equipment (SynchronousMachine, LinearShuntCompensator, NonLinearShuntCompensator, StaticVarCompensator, RatioTapChanger, PhaseTapChangerLinear, PhaseTapChangerSymetrical, PhaseTapChangerAsymetrical, PhaseTapChangerTabular or ExternalNetworkInjection) and an instance of RegulatingControl or TapChangerControl. The RegulatingControl or TapChangerControl shall be associated with a Terminal. The control for a piece of regulating equipment can refer to a Terminal associated with another PowerSystemResource. For instance, for voltage regulation purposes the control for a SynchronousMachine could refer to a Terminal associated with a BusbarSection. The Terminal defines the point of regulation. The association between RegulatingControl or TapChangerControl and Terminal is required to define regulation of voltage or active power. For a piece of equipment that is not regulating, the association to RegulatingControl or TapChangerControl is not required.

4.7 Use of curves

4.7.1 General

The use of the Curve and CurveData attributes will differ for the different types of curves derived from Curve. To define a Y value that does not change, the curveStyle attribute should be set to “constantYValue”. In this case, only one instance of CurveData should be included defining the single point for the curve. Because the Y value is constant, the CurveData.xvalue value will be ignored, if it is supplied at all. A curve should never have multiple instances of CurveData where the xvalue value is repeated.

4.7.2 Generating unit reactive power limits

Generating unit reactive power limits shall be included in data exchange, but may be specified differently depending on the characteristics of the generating unit being represented. In most cases, a SynchronousMachine should be associated with a default ReactiveCapabilityCurve using the SynchronousMachine.InitialReactiveCapabilityCurve association.

If the reactive power limits of the generating unit do not vary with the real power output, the reactive power limit attributes on the SynchronousMachine class, minQ and maxQ, can be used. If the reactive power output of the generating unit is fixed, the reactive power limits should both be set to the fixed reactive output value.

4.8 Definition of schedules

The use of the RegularIntervalSchedule and RegularTimePoint attributes will differ for the different types of schedules derived from RegularIntervalSchedule. To specify a relative time for a schedule, the date portion of the dateTime format can be eliminated, which leaves the ISO 8601 time of day format “hh:mm:ss”. In this format, hh is the number of complete hours that have passed since midnight, mm is the number of complete minutes since the start of the hour, and ss is the number of complete seconds since the start of the minute.

The earliest allowed time used in a schedule (BasicIntervalSchedule.startTime) is “00:00:00”. The latest allowed time used in a schedule (RegularIntervalSchedule.endTime) is “24:00:00”. The point in time specified by the endTime is not included in the period of the schedule.

A schedule defining a day shall be defined with multiple RegularTimePoints associated with the same RegularIntervalSchedule. It shall not be defined with multiple schedules.

For schedules that are associated with Season and DayType, the associations to Season and DayType are not required. If a schedule does not have an associated Season, the schedule will be considered valid for all Seasons. Similarly, if a schedule does not have an association to a DayType, the schedule will be considered to apply to all days of the week.

When SeasonDayTypeSchedules are defined for a given entity, such as ConformLoadSchedules for a given ConformLoadGroup, only one schedule can be defined for a given combination of Season and DayType.

5 CIM Static Transmission Network Model Profiles

5.1 CIM Static Transmission Network Model Profiles General

This clause lists the profiles that will be used for data exchange and the classes, attributes, and associations that are a part of each profile. Included are all the classes that a data