

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Interface de programmation d'application pour système de gestion d'énergie
(EMS-API) –**

Partie 301: Base de modèle d'information commun (CIM)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2022 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.



IEC 61970-301

Edition 7.1 2022-02
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Interface de programmation d'application pour système de gestion d'énergie
(EMS-API) –
Partie 301: Base de modèle d'information commun (CIM)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.200

ISBN 978-2-8322-5048-8

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

REDLINE VERSION

VERSION REDLINE



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

**Interface de programmation d'application pour système de gestion d'énergie
(EMS-API) –**

Partie 301: Base de modèle d'information commun (CIM)

IEC 61970-301-2020
015-ac0800becbc5/iec-61970-301-2020

CONTENTS

FOREWORD	35
INTRODUCTION	37
1 Scope	39
2 Normative references	39
3 Terms and definitions	40
4 CIM specification	40
4.1 Overview	40
4.2 CIM modelling notation	41
4.3 CIM packages	41
4.4 CIM classes and relationships	43
4.4.1 Classes	43
4.4.2 Generalization	44
4.4.3 Simple association	45
4.4.4 Aggregation	46
4.5 CIM model concepts and examples	46
4.5.1 Concepts	46
4.5.2 Containment, equipment hierarchies and naming	47
4.5.3 Names model	48
4.5.4 Connectivity model	49
4.5.5 Inheritance hierarchy	52
4.5.6 Transformer model	54
4.5.7 Transformer tap modelling	57
4.5.8 Phase wire modelling	70
4.5.9 Grounding devices modelling	72
4.5.10 Cuts, clamps and jumpers model	76
4.5.11 Measurements and controls	80
4.5.12 Regulating control models	85
4.5.13 DC model for CIM	87
4.5.14 Static Var Compensator Voltage Regulation	109
4.5.15 ICCP Configuration Model	110
4.5.16 Feeder Model	117
4.5.17 Control area modelling	117
4.6 Modelling guidelines	119
4.6.1 Modelling for change	119
4.6.2 Process for amendments to the CIM	119
4.6.3 Changes to the CIM UML model	120
4.6.4 Changes to the CIM standards documents	120
4.6.5 Deprecations	120
4.6.6 CIM profiles	120
4.7 Modelling tools	121
4.8 User implementation conventions	121
4.8.1 Conventions beyond UML	121
4.8.2 Number of terminals for ConductingEquipment objects	121
4.8.3 Nominal quantities	122
4.8.4 Datatypes	122
4.9 CIM modelling examples	122

5	Detailed model	122
5.1	Overview.....	122
5.2	Context.....	122
6	Package Base	124
6.1	General.....	124
6.2	Package Domain.....	124
6.2.1	General	124
6.2.2	ActivePower datatype	130
6.2.3	ActivePowerChangeRate datatype.....	131
6.2.4	ActivePowerPerCurrentFlow datatype.....	131
6.2.5	ActivePowerPerFrequency datatype	131
6.2.6	Admittance datatype	131
6.2.7	AngleDegrees datatype	132
6.2.8	AngleRadians datatype.....	132
6.2.9	ApparentPower datatype.....	132
6.2.10	Area datatype	132
6.2.11	Boolean primitive	133
6.2.12	Capacitance datatype	133
6.2.13	CapacitancePerLength datatype	133
6.2.14	Classification datatype.....	133
6.2.15	Conductance datatype	133
6.2.16	ConductancePerLength datatype.....	134
6.2.17	CostPerEnergyUnit datatype.....	134
6.2.18	CostPerHeatUnit datatype	134
6.2.19	CostPerVolume datatype	134
6.2.20	CostRate datatype	135
6.2.21	Currency enumeration	135
6.2.22	CurrentFlow datatype	139
6.2.23	Damping datatype.....	139
6.2.24	Date primitive	139
6.2.25	DateInterval compound.....	139
6.2.26	DateTime primitive.....	140
6.2.27	DateTimeInterval compound	140
6.2.28	Decimal primitive	140
6.2.29	DecimalQuantity compound	140
6.2.30	Displacement datatype	140
6.2.31	Duration primitive	141
6.2.32	Emission datatype	141
6.2.33	Float primitive.....	141
6.2.34	FloatQuantity compound.....	141
6.2.35	Frequency datatype	141
6.2.36	HeatRate datatype.....	142
6.2.37	Hours datatype	142
6.2.38	Impedance datatype	142
6.2.39	Inductance datatype	142
6.2.40	InductancePerLength datatype	143
6.2.41	Integer primitive.....	143
6.2.42	IntegerQuantity compound.....	143
6.2.43	KiloActivePower datatype	143

6.2.44	Length datatype.....	144
6.2.45	Mass datatype.....	144
6.2.46	Minutes datatype.....	144
6.2.47	Money datatype.....	144
6.2.48	MonthDay primitive.....	145
6.2.49	MonthDayInterval compound.....	145
6.2.50	PU datatype.....	145
6.2.51	PerCent datatype.....	145
6.2.52	Pressure datatype.....	145
6.2.53	Reactance datatype.....	146
6.2.54	ReactancePerLength datatype.....	146
6.2.55	ReactivePower datatype.....	146
6.2.56	RealEnergy datatype.....	146
6.2.57	Resistance datatype.....	147
6.2.58	ResistancePerLength datatype.....	147
6.2.59	RotationSpeed datatype.....	147
6.2.60	Seconds datatype.....	148
6.2.61	Speed datatype.....	148
6.2.62	String primitive.....	148
6.2.63	StringQuantity compound.....	148
6.2.64	Susceptance datatype.....	148
6.2.65	SusceptancePerLength datatype.....	149
6.2.66	Temperature datatype.....	149
6.2.67	Time primitive.....	149
6.2.68	TimeInterval compound.....	149
6.2.69	UnitMultiplier enumeration.....	150
6.2.70	UnitSymbol enumeration.....	151
6.2.71	Voltage datatype.....	156
6.2.72	VoltagePerReactivePower datatype.....	156
6.2.73	Volume datatype.....	156
6.2.74	VolumeFlowRate datatype.....	157
6.2.75	WaterLevel datatype.....	157
6.3	Package Core.....	157
6.3.1	General.....	157
6.3.2	ACDCTerminal.....	162
6.3.3	BaseFrequency.....	163
6.3.4	BasePower.....	164
6.3.5	BaseVoltage.....	164
6.3.6	BasicIntervalSchedule.....	165
6.3.7	Bay.....	165
6.3.8	BreakerConfiguration enumeration.....	166
6.3.9	BusbarConfiguration enumeration.....	167
6.3.10	ConductingEquipment.....	167
6.3.11	ConnectivityNode.....	168
6.3.12	ConnectivityNodeContainer.....	169
6.3.13	Curve.....	169
6.3.14	CurveData root class.....	170
6.3.15	CurveStyle enumeration.....	171
6.3.16	Equipment.....	171

6.3.17	EquipmentContainer	172
6.3.18	Feeder	173
6.3.19	GeographicalRegion	174
6.3.20	IdentifiedObject root class	175
6.3.21	IrregularIntervalSchedule.....	176
6.3.22	IrregularTimePoint root class	176
6.3.23	Name root class.....	177
6.3.24	NameType root class	177
6.3.25	NameTypeAuthority root class	178
6.3.26	OperatingParticipant.....	178
6.3.27	OperatingShare root class	179
6.3.28	PSRType	179
6.3.29	PhaseCode enumeration	180
6.3.30	PowerSystemResource.....	181
6.3.31	RegularIntervalSchedule.....	181
6.3.32	RegularTimePoint root class	182
6.3.33	ReportingGroup	183
6.3.34	ReportingSuperGroup.....	183
6.3.35	SubGeographicalRegion	184
6.3.36	Substation	185
6.3.37	Terminal	186
6.3.38	VoltageLevel.....	187
6.4	Package Wires.....	188
6.4.1	General	188
6.4.2	AsynchronousMachineKind enumeration.....	203
6.4.3	ACLineSegment.....	204
6.4.4	ACLineSegmentPhase.....	205
6.4.5	AsynchronousMachine.....	206
6.4.6	Breaker.....	208
6.4.7	BusbarSection	210
6.4.8	Clamp.....	211
6.4.9	CompositeSwitch.....	212
6.4.10	Conductor.....	213
6.4.11	Connector.....	214
6.4.12	CoolantType enumeration.....	215
6.4.13	Cut	215
6.4.14	Disconnecter	217
6.4.15	DisconnectingCircuitBreaker.....	218
6.4.16	EarthFaultCompensator	219
6.4.17	EnergyConnection	220
6.4.18	EnergyConsumer	221
6.4.19	EnergyConsumerPhase	223
6.4.20	EnergySchedulingType	224
6.4.21	EnergySource.....	224
6.4.22	EnergySourcePhase	226
6.4.23	ExternalNetworkInjection	227
6.4.24	FrequencyConverter	229
6.4.25	Fuse	230
6.4.26	Ground	231

6.4.27	GroundingImpedance	232
6.4.28	GroundDisconnector	233
6.4.29	Jumper	234
6.4.30	Junction	236
6.4.31	Line	236
6.4.32	LinearShuntCompensator	237
6.4.33	LinearShuntCompensatorPhase	239
6.4.34	LoadBreakSwitch	239
6.4.35	MutualCoupling	241
6.4.36	NonlinearShuntCompensator	242
6.4.37	NonlinearShuntCompensatorPhase	243
6.4.38	NonlinearShuntCompensatorPhasePoint root class	244
6.4.39	NonlinearShuntCompensatorPoint root class	245
6.4.40	PerLengthImpedance	245
6.4.41	PerLengthLineParameter	246
6.4.42	PerLengthPhaseImpedance	246
6.4.43	PerLengthSequenceImpedance	247
6.4.44	PetersenCoil	248
6.4.45	PetersenCoilModeKind enumeration	249
6.4.46	PhaseImpedanceData root class	249
6.4.47	PhaseShuntConnectionKind enumeration	250
6.4.48	PhaseTapChanger	251
6.4.49	PhaseTapChangerAsymmetrical	252
6.4.50	PhaseTapChangerLinear	253
6.4.51	PhaseTapChangerNonLinear	254
6.4.52	PhaseTapChangerSymmetrical	256
6.4.53	PhaseTapChangerTable	257
6.4.54	PhaseTapChangerTablePoint	257
6.4.55	PhaseTapChangerTabular	258
6.4.56	Plant	259
6.4.57	PowerElectronicsConnection	260
6.4.58	PowerElectronicsConnectionPhase	261
6.4.59	PowerTransformer	262
6.4.60	PowerTransformerEnd	264
6.4.61	ProtectedSwitch	266
6.4.62	RatioTapChanger	268
6.4.63	RatioTapChangerTable	269
6.4.64	RatioTapChangerTablePoint	269
6.4.65	ReactiveCapabilityCurve	270
6.4.66	Recloser	271
6.4.67	RegulatingCondEq	272
6.4.68	RegulatingControl	273
6.4.69	RegulatingControlModeKind enumeration	275
6.4.70	RegulationSchedule	275
6.4.71	RotatingMachine	276
6.4.72	Sectionaliser	278
6.4.73	SeriesCompensator	279
6.4.74	ShortCircuitRotorKind enumeration	280
6.4.75	ShuntCompensator	280

6.4.76	ShuntCompensatorPhase	282
6.4.77	SinglePhaseKind enumeration	283
6.4.78	StaticVarCompensator	284
6.4.79	SVCControlMode enumeration	285
6.4.80	Switch	285
6.4.81	SwitchPhase	287
6.4.82	SwitchSchedule	288
6.4.83	SynchronousMachine	289
6.4.84	SynchronousMachineOperatingMode enumeration	292
6.4.85	SynchronousMachineKind enumeration	292
6.4.86	TapChanger	292
6.4.87	TapChangerControl	294
6.4.88	TapChangerTablePoint root class	295
6.4.89	TapSchedule	296
6.4.90	TransformerControlMode enumeration	297
6.4.91	TransformerCoreAdmittance	297
6.4.92	TransformerEnd	298
6.4.93	TransformerMeshImpedance	299
6.4.94	TransformerStarImpedance	300
6.4.95	TransformerTank	301
6.4.96	TransformerTankEnd	301
6.4.97	VoltageControlZone	302
6.4.98	WireSegment	303
6.4.99	WireSegmentPhase	304
6.4.100	WindingConnection enumeration	305
6.5	Package LoadModel	305
6.5.1	General	305
6.5.2	ConformLoad	306
6.5.3	ConformLoadGroup	308
6.5.4	ConformLoadSchedule	308
6.5.5	DayType	309
6.5.6	EnergyArea	310
6.5.7	LoadArea	310
6.5.8	LoadGroup	311
6.5.9	LoadResponseCharacteristic	311
6.5.10	NonConformLoad	313
6.5.11	NonConformLoadGroup	314
6.5.12	NonConformLoadSchedule	315
6.5.13	PowerCutZone	316
6.5.14	Season	316
6.5.15	SeasonDayTypeSchedule	317
6.5.16	StationSupply	317
6.5.17	SubLoadArea	319
6.6	Package Generation	319
6.6.1	General	319
6.6.2	Package GenerationTrainingSimulation	320
6.6.3	Package Production	336
6.7	Package DC	388
6.7.1	General	388

6.7.2	ACDCConverter	392
6.7.3	ACDCConverterDCTerminal	395
6.7.4	CsConverter	396
6.7.5	DCTopologicalNode	398
6.7.6	CsOperatingModeKind enumeration	399
6.7.7	CsPpccControlKind enumeration	399
6.7.8	DCBaseTerminal	399
6.7.9	DCBreaker	400
6.7.10	DCBusbar	401
6.7.11	DCChopper	402
6.7.12	DCConductingEquipment	403
6.7.13	DCConverterOperatingModeKind enumeration	404
6.7.14	DCConverterUnit	404
6.7.15	DCDisconnecter	405
6.7.16	DCEquipmentContainer	406
6.7.17	DCGround	407
6.7.18	DCLine	408
6.7.19	DCLineSegment	409
6.7.20	DCNode	410
6.7.21	DCPolarityKind enumeration	411
6.7.22	DCSeriesDevice	411
6.7.23	DCShunt	412
6.7.24	DCSwitch	413
6.7.25	DCTerminal	414
6.7.26	DCTopologicalIsland	415
6.7.27	PerLengthDCLineParameter	415
6.7.28	VsCapabilityCurve	416
6.7.29	VsConverter	416
6.7.30	VsPpccControlKind enumeration	419
6.7.31	VsQpccControlKind enumeration	419
6.8	Package Equivalents	420
6.8.1	General	420
6.8.2	EquivalentBranch	421
6.8.3	EquivalentEquipment	424
6.8.4	EquivalentInjection	425
6.8.5	EquivalentNetwork	427
6.8.6	EquivalentShunt	428
6.9	Package AuxiliaryEquipment	429
6.9.1	General	429
6.9.2	AuxiliaryEquipment	430
6.9.3	CurrentTransformer	431
6.9.4	FaultIndicator	432
6.9.5	PostLineSensor	433
6.9.6	PotentialTransformer	434
6.9.7	PotentialTransformerKind enumeration	435
6.9.8	Sensor	436
6.9.9	SurgeArrester	437
6.9.10	WaveTrap	437
6.10	Package Meas	438

6.10.1	General	438
6.10.2	Accumulator	442
6.10.3	AccumulatorLimit	443
6.10.4	AccumulatorLimitSet	443
6.10.5	AccumulatorReset	444
6.10.6	AccumulatorValue	445
6.10.7	Analog	446
6.10.8	AnalogControl	446
6.10.9	AnalogLimit	447
6.10.10	AnalogLimitSet	448
6.10.11	AnalogValue	448
6.10.12	Command	449
6.10.13	Control	450
6.10.14	Discrete	451
6.10.15	DiscreteValue	452
6.10.16	IOPoint	453
6.10.17	Limit	454
6.10.18	LimitSet	454
6.10.19	Measurement	455
6.10.20	MeasurementValue	456
6.10.21	MeasurementValueQuality	457
6.10.22	MeasurementValueSource	458
6.10.23	Quality61850 root class	458
6.10.24	RaiseLowerCommand	459
6.10.25	SetPoint	460
6.10.26	StringMeasurement	461
6.10.27	StringMeasurementValue	462
6.10.28	Validity enumeration	462
6.10.29	ValueAliasSet	463
6.10.30	ValueToAlias	464
6.11	Package Topology	464
6.11.1	General	464
6.11.2	BusNameMarker	466
6.11.3	TopologicalIsland	466
6.11.4	TopologicalNode	467
6.12	Package DiagramLayout	468
6.12.1	General	468
6.12.2	Diagram	469
6.12.3	DiagramObject	470
6.12.4	DiagramObjectGluePoint root class	471
6.12.5	DiagramObjectPoint root class	472
6.12.6	DiagramObjectStyle	472
6.12.7	DiagramStyle	473
6.12.8	OrientationKind enumeration	473
6.12.9	TextDiagramObject	474
6.12.10	VisibilityLayer	475
6.13	Package OperationalLimits	475
6.13.1	General	475
6.13.2	ActivePowerLimit	477

6.13.3	ApparentPowerLimit	478
6.13.4	BranchGroup	478
6.13.5	BranchGroupTerminal root class	479
6.13.6	CurrentLimit	480
6.13.7	OperationalLimit	480
6.13.8	OperationalLimitDirectionKind enumeration	481
6.13.9	OperationalLimitSet	481
6.13.10	OperationalLimitType	482
6.13.11	VoltageLimit	483
6.14	Package ControlArea	483
6.14.1	General	483
6.14.2	AltGeneratingUnitMeas	485
6.14.3	AltTieMeas	486
6.14.4	ControlArea	487
6.14.5	ControlAreaGeneratingUnit	488
6.14.6	ControlAreaTypeKind enumeration	489
6.14.7	TieFlow	489
6.15	Package Contingency	490
6.15.1	General	490
6.15.2	Contingency	490
6.15.3	ContingencyElement	491
6.15.4	ContingencyEquipment	491
6.15.5	ContingencyEquipmentStatusKind enumeration	492
6.16	Package StateVariables	492
6.16.1	General	492
6.16.2	StateVariable root class	493
6.16.3	SvInjection	493
6.16.4	SvPowerFlow	494
6.16.5	SvShuntCompensatorSections	494
6.16.6	SvStatus	495
6.16.7	SvSwitch	495
6.16.8	SvTapStep	496
6.16.9	SvVoltage	496
6.17	Package Protection	497
6.17.1	General	497
6.17.2	CurrentRelay	498
6.17.3	ProtectionEquipment	499
6.17.4	RecloseSequence	500
6.17.5	SynchrocheckRelay	501
6.18	Package Faults	502
6.18.1	General	502
6.18.2	EquipmentFault	503
6.18.3	Fault	503
6.18.4	FaultCauseType	504
6.18.5	FaultImpedance compound	504
6.18.6	LineFault	505
6.18.7	PhaseConnectedFaultKind enumeration	505
6.19	Package SCADA	506
6.19.1	General	506

6.19.2	CommunicationLink	507
6.19.3	RemoteControl	508
6.19.4	RemotePoint.....	508
6.19.5	RemoteSource.....	509
6.19.6	RemoteUnit	510
6.19.7	RemoteUnitType enumeration.....	510
6.19.8	Source enumeration	511
6.20	Package ICCPConfiguration.....	511
6.20.1	General	511
6.20.2	ApplicationSecurityKind enumeration.....	513
6.20.3	BilateralExchangeActor	514
6.20.4	BilateralExchangeAgreement.....	514
6.20.5	ICCPAccessPrivilegeKind enumeration.....	515
6.20.6	ICCPInformationMessage	515
6.20.7	ICCPPointKind enumeration	516
6.20.8	ICCPProvidedPoint.....	516
6.20.9	ICCPQualityKind enumeration	517
6.20.10	ICCPScopeKind enumeration.....	518
6.20.11	ICCPVCC	518
6.20.12	ICCPVirtualControlCentre.....	519
6.20.13	IOPointSource	520
6.20.14	IPAccessPoint	521
6.20.15	IPAddressKind enumeration.....	522
6.20.16	ISOUpperLayer.....	522
6.20.17	ProvidedBilateralPoint	523
6.20.18	PublicX509Certificate root class	523
6.20.19	TASE2BilateralTable	524
6.20.20	TCPAccessPoint.....	525
Annex A	(normative) Custom extensions.....	527
A.1	Overview.....	527
A.2	European extensions	527
A.2.1	General	527
A.2.2	Package ExtEuCore.....	527
A.2.3	Package ExtEuOperationalLimits	531
A.2.4	Package ExtEuGeneration	533
Annex B	(Informative) Examples of PST transformer modelling.....	536
B.1	General.....	536
B.2	Detailed calculations and examples	536
B.2.1	Symmetrical phase shifters with two cores.....	536
B.2.2	Quadrature boosters	540
B.2.3	Asymmetrical phase shifter.....	544
Annex C	(informative) Use cases HVDC representation	551
C.1	Overview.....	551
C.2	Back-to-back installations	551
C.3	Monopole with ground return.....	552
C.4	Monopole with metallic return	553
C.5	Voltage source converter	554
Bibliography	556