



DPC: 24 / 30488090 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Title: BS IEC 62888-4 Railway applications - Energy measurement on board trains

Part 4: Communication

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Responsible Committee Secretary: Ms Bash Berry (BSI)

Direct tel: 0203 142 5620

E-mail: bash.berry@rssb.co.uk

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER: IEC 62888-4 ED2	
DATE OF CIRCULATION: 2024-02-23	CLOSING DATE FOR COMMENTS: 2024-05-17
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IEC TC 9 : ELECTRICAL EQUIPMENT AND SYSTEMS FOR RAILWAYS	
SECRETARIAT: France	SECRETARY: Mr Denis MIGLIANICO
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. ([See AC/22/2007](#) or [NEW GUIDANCE DOC](#)).

TITLE:

Railway applications – Energy measurement on board trains – Part 4: Communication

NOTE FROM TC/SC OFFICERS:

CONTENTS

<u>Toc156923693</u>	
FOREWORD	10
INTRODUCTION	12
1 Scope	15
2 Normative references	15
3 Terms, definitions and abbreviated terms	16
3.1 Terms and definitions	16
3.2 Abbreviated terms	19
4 Requirements	20
4.1 General	20
4.2 Communication between functions of the EMS	21
4.2.1 General	21
4.2.2 Communication protocols stack	22
4.2.3 Communication security	23
4.2.4 VMF/CMF to ECF Interface (VEI)	24
4.2.5 EMF to DHS interface (EMDI)	24
4.2.6 Maintenance/testing interfaces (DSI and ESI)	24
4.2.7 DHS to location function	24
4.2.8 DHS to UTC source	25
4.2.9 DHS to Consist Network digital interface (CNI)	25
4.3 Communication between the EMS and ground	25
4.3.1 General	25
4.3.2 EMS set-up	26
4.3.3 Application services (service layer)	28
4.3.4 Data structures (data layer)	29
4.3.5 Message mechanism (message layer)	77
4.3.6 Application protocols for supporting the message mechanism	88
4.3.7 Communication architecture	102
4.3.8 XML schema version control	106
4.3.9 Security	106
4.4 Access security	106
5 Conformance test	106
5.1 General	106
5.1.1 Introduction	106
5.1.2 Applicability	107
5.1.3 Methodology	107
5.2 PICS and PIXIT	107
5.2.1 General	107
5.2.2 PICS	107
5.2.3 PIXIT	107
5.3 Design review	108
5.4 Type test procedure	108
5.4.1 General	108
5.4.2 Testing the communication	108
5.4.3 Testing the on board interfaces	108
5.4.4 Testing the on board to ground interface	109

Annex A (informative) VEI–VMF/CMF to ECF interface implementation example.....	111
A.1 General.....	111
A.2 Payload format.....	111
A.3 Encryption	112
Annex B (informative) PICS structure and instruction	113
B.1 Structure.....	113
B.2 Instructions for completing the PICS pro-forma	113
B.2.1 PICS table structure	113
B.2.2 Abbreviations used in PICS	113
B.2.3 Ref. column	114
B.2.4 Subclause column	114
B.2.5 Capability column	114
B.2.6 Requirement column.....	114
B.2.7 Implementation column.....	114
B.2.8 Parameter values column	114
B.3 PICS pro-forma examples	115
B.3.1 Identification of PICS.....	115
B.3.2 Identification of the implementation under assessment	115
B.3.3 Identification of the IUA supplier	115
B.3.4 Identification of the standards.....	116
B.3.5 Global statement of conformity	116
B.3.6 Level of conformity	116
Annex C (informative) Access rights	118
Annex D (normative) XML schemas of the message mechanism	119
D.1 General.....	119
D.2 Message.xsd.....	119
Annex E (Normative) XML schemas of the mandatory data structures.....	121
E.1 General.....	121
E.2 62888_BaseTypes.xsd	121
E.3 IEC_CEMDBlock.xsd	123
E.4 IEC_EventSet.xsd.....	124
E.5 IEC_Heartbeat.xsd.....	124
Annex F (Normative) XML schemas of the optional data structures	126
F.1 General.....	126
F.2 62888_BaseTypes_Extension.xsd.....	126
F.3 IEC_ReadingBlock.xsd.....	127
F.4 IEC_CommunicationConfig.xsd	129
F.5 IEC_ChangeCommunicationConfig.xsd	134
F.6 IEC_AssetData.xsd	138
F.7 IEC_State.xsd.....	141
Annex G (informative) On board to ground communication XML examples	143
G.1 General.....	143
G.2 Examples of data structures	143
G.2.1 IEC_CEMDBlock.....	143
G.2.2 IEC_EventSet.....	146
G.2.3 IEC_Heartbeat.....	147
G.2.4 IEC_ReadingBlock.....	147

G.2.5	IEC_CommunicationConfig	151
G.2.6	IEC_ChangeCommunicationConfig	153
G.2.7	IEC_AssetData	155
G.2.8	IEC_State	158
G.3	Examples of application services	159
G.3.1	AutomaticTransferCEMDBlocks	159
G.3.2	AutomaticTransferEvents	159
G.3.3	AutomaticTransferHeartbeat	160
G.3.4	PeriodicTransferState	160
G.3.5	RequestCEMDBlocks	161
G.3.6	RequestAssetData	161
G.3.7	RequestEvents	162
G.3.8	ChangeCommunicationConfig	162
G.4	Example for the download of an IEC_CEMDBlock by means of Direct Connection	163
Annex H (informative)	Digital signature	166
H.1	General	166
H.2	Digital signature calculation	166
H.3	Digital signature verification	166
Annex I (informative)	Schema extension example	167
I.1	General	167
I.2	62888_CompanyExtensionExample schema	168
I.3	Modified IEC_ReadingBlock schema	168
I.4	IEC_ReadingBlock example	170
Annex J (informative)	Message with plain XML from application service	173
J.1	General	173
J.2	From application service to message	173
J.3	From message to application service	174
Bibliography		175
Figure 1	– EMS functional structure and dataflow diagram	14
Figure 2	– EMS block diagram and interfaces	21
Figure 3	– Communication components (example)	26
Figure 4	– Consumption point operational states	27
Figure 5	– Maintenance Commissioning states	27
Figure 6	– IEC_CEMDBlock structure	32
Figure 7	– IEC_EventSet structure	34
Figure 8	– IEC_Heartbeat structure	40
Figure 9	– IEC_ReadingBlock structure	41
Figure 10	– IEC_CommunicationConfig structure	47
Figure 11	– IEC_ChangeCommunicationConfig structure	57
Figure 12	– IEC_AssetData structure	65
Figure 13	– State structure	72
Figure 14	– Case of request from DCS to EMS	78
Figure 15	– Case of events from EMS to DCS	79

Figure 16 – RequestMessage structure	79
Figure 17 – ResponseMessage structure	79
Figure 18 – EventMessage structure	79
Figure 19 – Header structure	80
Figure 20 – Request structure	81
Figure 21 – Reply structure	82
Figure 22 – Payload structure	83
Figure 23 – HTTP request	89
Figure 24 – Successful HTTP response	90
Figure 26 – Example of procedure for the transmission of a RequestMessage using FTP with mailbox	98
Figure 26 – Example of procedure for the transmission of a ResponseMessage using FTP with mailbox	99
Figure 27 – Example of procedure for the transmission of an EventMessage using FTP with mailbox	99
Figure 28 – From EMS to DCS with encryption and compression	100
Figure 29 – From DCS to EMS with encryption and compression	100
Figure 30 – From EMS to DCS with encryption (no compression)	101
Figure 31 – From DCS to EMS with encryption (no compression)	101
Figure 32 – Communication architecture options	103
Figure 33 – Dedicated wireless connection	104
Figure 34 – Test bench for on board interface	108
Figure 35 – On board to ground test bench 1	110
Figure 36 – On board to ground test bench 2	110
Figure A.1 – Payload format	111
Figure I.1 – Reading block with two extensions: "co:XMLVersion" and "co:NewElement"	167
Table 1 – List of permitted protocol stacks	22
Table 2 – Types of user access rights	29
Table 3 – XML schema of each data structure	29
Table 4 – Definition of IEC_CEMDBlockType elements	32
Table 5 – Definition of EMSType elements (IEC_CEMDBlock)	33
Table 6 – Definition of CEMDType elements (IEC_CEMDBlock)	33
Table 7 – Definition of ChannelType elements (IEC_CEMDBlock)	33
Table 8 – Definition of EnergyType elements (IEC_CEMDBlock)	33
Table 9 – Definition of IEC_EventSetType elements	34
Table 10 – Definition of EMSType elements (IEC_EventSet)	34
Table 11 – Definition of EventType elements (IEC_EventSet)	35
Table 12 – Definition of EventDescriptionType elements	35
Table 13 – Variables for defining events	35
Table 14 – Value of variables for defining events	36
Table 15 – Hardware and software alarms	36
Table 16 – User management events	37

Table 17 – Measurement alarms	37
Table 18 – Synchronization alarms and events	38
Table 19 – Communication events	38
Table 20 – Configuration events	39
Table 21 – Definition of IEC_Heartbeat elements	40
Table 22 – Definition of IEC_ReadingBlockType elements	42
Table 23 – Definition of EMSType elements (IEC_ReadingBlock)	42
Table 24 – Definition of ReadingType elements (IEC_ReadingBlock)	42
Table 25 – Definition of ChannelType elements (IEC_ReadingBlock)	43
Table 26 – Definition of EnergyType elements (IEC_ReadingBlock)	43
Table 27 – Definition of Reactive4QType elements (IEC_ReadingBlock)	43
Table 28 – Definition of IndexEnergyType elements (IEC_ReadingBlock)	43
Table 29 – Definition of CurrentType elements (IEC_ReadingBlock)	44
Table 30 – Definition of VoltageType elements (IEC_ReadingBlock)	44
Table 31 – Definition of MinimumVoltageType elements (IEC_ReadingBlock)	44
Table 32 – Definition of EnhancedLocationType elements (IEC_ReadingBlock)	45
Table 33 – Definition of SpeedType elements (IEC_ReadingBlock)	45
Table 34 – Definition of TemperatureType elements (IEC_ReadingBlock)	45
Table 35 – Definition of InternalLoadType elements (IEC_ReadingBlock)	45
Table 36 – Value examples for kind in InternalLoadType (IEC_ReadingBlock)	45
Table 37 – Definition of IEC_CommunicationConfigType elements	47
Table 38 – Definition of UserType elements (IEC_CommunicationConfig)	48
Table 39 – Definition of UserMessageHeaderType elements (IEC_CommunicationConfig)	49
Table 40 – Definition of ServiceType (IEC_CommunicationConfig)	49
Table 41 – Definition of RequestType elements (IEC_CommunicationConfig)	49
Table 42 – Definition of AutomaticTransferType elements (IEC_CommunicationConfig)	50
Table 43 – Definition of ChangeType elements (IEC_CommunicationConfig)	50
Table 44 – Definition of ProtocolType elements (IEC_CommunicationConfig)	51
Table 45 – Definition of FTPMailboxType and SFTPMailboxType elements (IEC_CommunicationConfig)	51
Table 46 – Definition of HTTPType elements (IEC_CommunicationConfig)	51
Table 47 – Definition of DataGenerationType elements (IEC_CommunicationConfig)	52
Table 48 – Definition of CEMDBlockConfigType elements (IEC_CommunicationConfig)	52
Table 49 – Definition of HeartbeatConfigType elements (IEC_CommunicationConfig)	52
Table 50 – Definition of ReadingBlockConfigType elements (IEC_CommunicationConfig)	52
Table 51 – Definition of EventConfigType elements (IEC_CommunicationConfig)	53
Table 52 – Definition of LogType elements (IEC_CommunicationConfig)	53
Table 53 – Definition of StateConfigType elements (IEC_CommunicationConfig)	53
Table 54 – Definition of SignatureParameterType elements (IEC_CommunicationConfig)	53
Table 55 – Definition of MessageGenerationType elements (IEC_CommunicationConfig)	54

Table 56 – Definition of EMSMessageHeaderType elements (IEC_CommunicationConfig)	54
Table 57 – Definition of DedicatedWirelessConnectionType elements (IEC_CommunicationConfig)	54
Table 58 – Definition of MobileType elements (IEC_CommunicationConfig)	54
Table 59 – Definition of IPv4Type elements (IEC_CommunicationConfig)	55
Table 60 – Definition of IPv6Type elements (IEC_CommunicationConfig)	55
Table 61 – Definition of APNType elements (IEC_CommunicationConfig)	55
Table 62 – Definition of TelephoneNumberType elements (IEC_CommunicationConfig)	55
Table 63 – Definition of WIFIType elements (IEC_CommunicationConfig)	55
Table 64 – Definition of IEC61375DedicatedConnectionType elements (IEC_CommunicationConfig)	56
Table 65 – Definition of IEC61375SharedConnectionType elements (IEC_CommunicationConfig)	56
Table 66 – Definition of IEC_ChangeCommunicationConfigType elements	57
Table 67 – Definition of UserType elements (IEC_ChangeCommunicationConfig)	58
Table 68 – Definition of UserMessageHeaderType elements (IEC_ChangeCommunicationConfig)	58
Table 69 – Definition of ServiceType (IEC_ChangeCommunicationConfig)	59
Table 70 – Definition of RequestType elements (IEC_ChangeCommunicationConfig)	59
Table 71 – Definition of AutomaticTransferType elements (IEC_ChangeCommunicationConfig)	59
Table 72 – Definition of ChangeType elements (IEC_ChangeCommunicationConfig)	59
Table 73 – Definition of ProtocolType elements (IEC_ChangeCommunicationConfig)	59
Table 74 – Definition of FTPMailboxType and SFTPMailboxType elements (IEC_ChangeCommunicationConfig)	60
Table 75 – Definition of HTTPType elements (IEC_ChangeCommunicationConfig)	60
Table 76 – Definition of DataGenerationType elements (IEC_ChangeCommunicationConfig)	60
Table 77 – Definition of CEMDBlockConfigType elements (IEC_ChangeCommunicationConfig)	61
Table 78 – Definition of HeartbeatConfigType elements (IEC_CommunicationConfig)	61
Table 79 – Definition of ReadingBlockConfigType elements (IEC_ChangeCommunicationConfig)	61
Table 80 – Definition of EventConfigType elements (IEC_ChangeCommunicationConfig)	61
Table 81 – Definition of StateConfigType elements (IEC_ChangeCommunicationConfig)	61
Table 82 – Definition of SignatureParameterType elements (IEC_ChangeCommunicationConfig)	61
Table 83 – Definition of MessageGenerationType elements (IEC_ChangeCommunicationConfig)	62
Table 84 – Definition of EMSMessageHeaderType elements (IEC_ChangeCommunicationConfig)	62
Table 85 – Definition of DedicatedWirelessConnectionType elements (IEC_ChangeCommunicationConfig)	62
Table 86 – Definition of MobileType elements (IEC_ChangeCommunicationConfig)	62

Table 87 – Definition of IPv4Type elements (IEC_ChangeCommunicationConfig)	62
Table 88 – Definition of IPv6Type elements (IEC_ChangeCommunicationConfig)	63
Table 89 – Definition of APNType elements (IEC_ChangeCommunicationConfig)	63
Table 90 – Definition of TelephoneNumberType elements (IEC_ChangeCommunicationConfig)	63
Table 91 – Definition of WIFIType elements (IEC_ChangeCommunicationConfig)	63
Table 92 – Definition of IEC61375DedicatedConnectionType elements (IEC_ChangeCommunicationConfig)	63
Table 93 – Definition of IEC61375SharedConnectionType elements (IEC_ChangeCommunicationConfig)	63
Table 94 – Definition of IEC_AssetData elements	65
Table 95 – Definition of EndDeviceInfoType elements (IEC_AssetData)	66
Table 96 – Definition of AssetModelType elements (IEC_AssetData)	66
Table 97 – Definition of HardwareVersionType elements (IEC_AssetData)	66
Table 98 – Definition of SoftwareVersionType elements (IEC_AssetData)	66
Table 99 – Definition of LifeCycleType elements (IEC_AssetData)	67
Table 100 – Definition of AcceptanceTestType elements (IEC_AssetData)	67
Table 101 – Definition of SensorType elements (IEC_AssetData)	67
Table 102 – Definition of MeterType elements (IEC_AssetData)	67
Table 103 – Definition of DeviceType elements (IEC_AssetData)	68
Table 104 – Definition of SealType elements (IEC_AssetData)	68
Table 105 – Definition of TractionUnitType elements (IEC_AssetData)	68
Table 106 – Definition of TractionSystemDataType elements (IEC_AssetData)	68
Table 107 – Definition of VehicleType elements (IEC_AssetData)	68
Table 108 – Definition of PhysicalPositionType elements (IEC_AssetData)	69
Table 109 – Definition of EMFType elements (IEC_AssetData)	69
Table 110 – Definition of ECFTType elements (IEC_AssetData)	69
Table 111 – Definition of CMFTType elements (IEC_AssetData)	69
Table 112 – Definition of VMFTType elements (IEC_AssetData)	70
Table 113 – Definition of FunctionType elements (IEC_AssetData)	70
Table 114 – Definition of StateType elements	72
Table 115 – Definition of SensorType elements (State)	73
Table 116 – Definition of MeterType elements (State)	73
Table 117 – Definition of DeviceType elements (State)	73
Table 118 – Definition of EMFType elements (State)	73
Table 119 – Definition of ECFTType elements (State)	73
Table 120 – Definition of CMFTType elements (State)	74
Table 121 – Definition of VMFTType elements (State)	74
Table 122 – Definition of FunctionType elements (State)	74
Table 123 – Definition of ActiveType elements	74
Table 124 – Definition of ReactiveType elements	75
Table 125 – Definition of CPIDType	75
Table 126 – Definition of DateTimeIntervalType	75

Table 127 – Definition of LocationType elements	75
Table 128 – Definition of simple types.....	75
Table 129 – Definition of BasicTemperatureType elements	76
Table 130 – Definition of BasicSpeedType elements	77
Table 131 – Definition of ActivePowerType elements	77
Table 132 – Additional simple types	77
Table 133 – Digital signature parameters	77
Table 134 – Definition of HeaderType elements	80
Table 135 – Definition of UserType elements	81
Table 136 – Definition of RequestType elements	81
Table 137 – Definition of ReplyType elements	82
Table 138 – Definition of ErrorType elements	82
Table 139 – Definition of Payload elements	83
Table 140 – Mapping of the service RequestCEMDBlocks	84
Table 141 – Mapping of the service AutomaticTransferCEMDBlocks	84
Table 142 – Mapping of the service RequestEvents	84
Table 143 – Mapping of the service AutomaticTransferEvents	85
Table 144 – Mapping of the service AutomaticTransferHeartbeat	85
Table 145 – Mapping of the service ReaquestReadingBlocks.....	85
Table 146 – Mapping of the service AutomaticTransferReadingBlocks	86
Table 147 – Mapping of the service RequestCommunicationConfig.....	86
Table 148 – Mapping of the service AutomaticTransferCommunicationConfig	86
Table 149 – Mapping of the service RequestAssetData.....	87
Table 150 – Mapping of the service AutomaticTransferCommunicationConfig	87
Table 151 – Mapping of the service RequestState	87
Table 152 – Mapping of the service PeriodicTransferState.....	87
Table 153 – Mapping of the service IEC_ChangeCommunicationConfig	88
Table 154 – HTTP parameters	90
Table B.1 – PICS table format.....	113
Table B.2 – PICS identification table	115
Table B.3 – IUA identification table	115
Table B.4 – IUA supplier identification table.....	116
Table B.5 – Applicable standards identification table	116
Table B.6 – Global statement table	116
Table B.7 – Level of conformity.....	117

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
ENERGY MEASUREMENT ON BOARD TRAINS –****Part 4: Communication****FOREWORD**

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International Standard IEC 62888-4 has been prepared by technical committee 9: Electrical equipment and systems for railways.

This standard is based on IEC 62888.

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

FDIS	Report on voting
xxx	xxx

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 62888 series, published under the general title *Railway applications – Energy measurement on board trains*, 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.

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INTRODUCTION

Three levels are introduced for categorising EMS as described in IEC 62888-1:202X in 4.1.

This part is Part 4 of the IEC 62888 series, which consists of the following parts, under the common title *Railway applications – Energy measurement on board trains*:

Part 1: General

Part 2: Energy measurement

Part 3: Data handling

Part 4: Communication

Part 5: Conformance test

Part 6: Requirements for purposes other than billing

This series of International Standards follows the functional guidelines description in Annex A, “Principles of conformity assessment”, of ISO/IEC 17000:2004 tailored to the Energy Measurement System (EMS).

The Energy Measurement System (EMS) provides measurement and data suitable for applications such as energy management, energy saving, billing and others.

This series of International Standards uses the functional approach to describe the EMS and on-ground Data Collecting System (DCS). These functions are implemented in one or more physical devices. The user of this series of standards is free to choose the physical implementation arrangements.

Structure and main contents of the IEC 62888 series

This series of International Standards is divided into six parts. The titles and brief descriptions of each part are given below:

IEC 62888-1 – General

The scope of IEC 62888-1 is the Energy Measurement System (EMS).

IEC 62888-1 provides system level requirements for the complete EMS and common requirements for all devices implementing one or more functions of the EMS.

IEC 62888-2 – Energy measurement

The scope of IEC 62888-2 is the Energy Measurement Function (EMF).

The EMF provides measurement of the consumed and regenerated active energy of a railway traction unit. If the traction unit is designed for use on AC electric traction systems, the EMF also provides measurement of reactive energy. The EMF provides the measured quantities via an interface to the Data Handling System.

The EMF consists of the three functions: Voltage Measurement Function, Current Measurement Function and Energy Calculation Function. For each of these functions, accuracy classes are specified and associated reference conditions are defined. IEC 62888-2 also defines all specific requirements for all functions of the EMF.

The Voltage Measurement Function measures the voltage of the contact line (CL) system and the Current Measurement Function measures the current taken from and returned to the CL system. These functions provide signal inputs to the Energy Calculation Function.

The Energy Calculation Function inputs the signals from the Current and Voltage Measurement Functions and calculates a set of values representing the consumed and regenerated energies. These values are transferred to the Data Handling System and are used in the creation of Compiled Energy Measured Data.

The document has been developed taking into account that in some applications, the EMF should be subjected to metrological principles. The relevant metrological aspects are covered in IEC 62888-2.

IEC 62888-2 also defines the conformance test of the functions of the EMF and the conformance evaluation of the EMF.

IEC 62888-3 – Data handling

The scope of IEC 62888-3 is the Data Handling System (DHS) and the associated requirements of the Data Collecting System (DCS).

The on-board DHS receives, produces and stores data, ready for transmission to any authorised receiver of data on board or on ground. The main goal of the DHS is to produce Compiled Energy Measured Data (CEMD) and transfer it to an on-ground Data Collecting System (DCS). The DHS can support other functions on board or on ground with data, as long as this does not conflict with the main goal.

The DCS on ground receives CEMD, stores the CEMD and transfer it to upstream servers such the settlement system.

IEC 62888-3 also defines the conformance test of the DHS and for the transfer of CEMD to an on-ground DCS.

IEC 62888-4 – Communication

The scope of IEC 62888-4 is the communication services.

IEC 62888-4 gives requirements and guidance regarding the data communication between the functions implemented within EMS as well as between such functions and other on-board units where data are exchanged using a communications protocol stack over a dedicated physical interface or a shared network.

It includes the board to ground and ground to board communication service and covers the requirements necessary to support data transfer between DHS and DCS.

IEC 62888-4 also defines the conformance test of the communications services.

IEC 62888-5 – Conformance test

The scope of IEC 62888-5 is the conformance test procedures for the EMS.

IEC 62888-5 also covers re-verification procedures and conformance test in the event of the replacement of a device of the EMS.

IEC 62888-6 – Requirements for purposes other than billing

The scope of IEC 62888-6 is to specify the requirements for EMS to be used for benchmarking, daily energy consumption monitoring, technical research and development.

IEC 62888-6 provides the requirements for monitoring consumed energy on board in daily services in an easy way and the measured data are applicable for general purposes in industry such as energy management, energy saving, etc. However, this part is not applicable for billing purposes.

EMS functional structure and dataflow

Figure 1 illustrates the functional structure of the EMS, the main sub-functions and the structure of the dataflow and is informative only. Only the main interfaces required by this standard are displayed by arrows.

Since the communication function is distributed throughout the EMS, it has been widely omitted for clarity, except for the train to ground communication. Not all interfaces are shown.

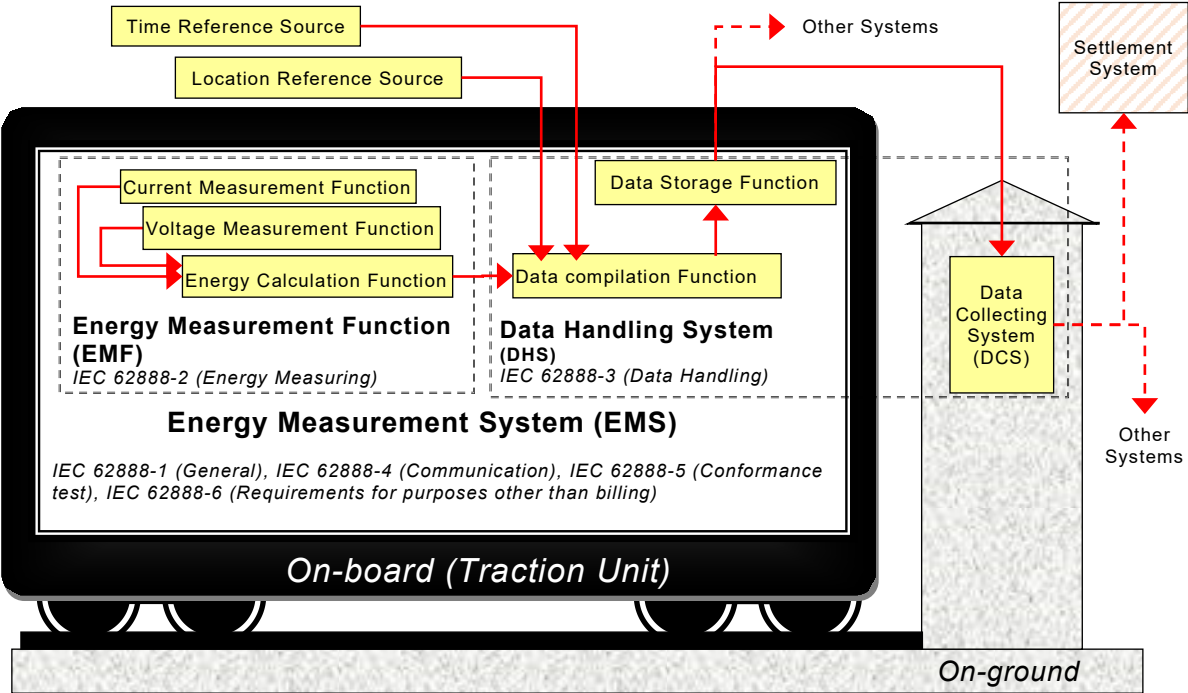
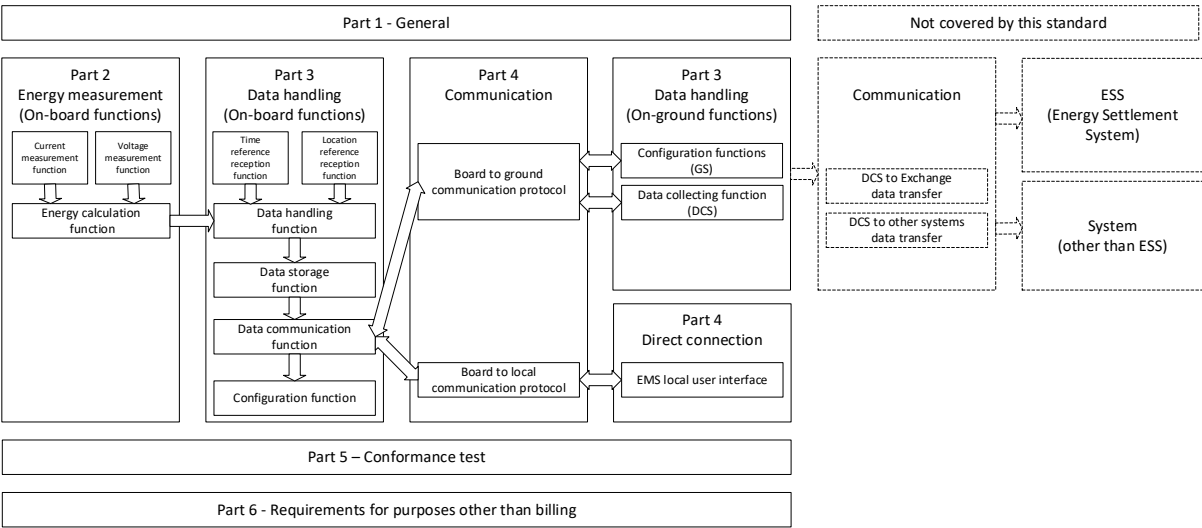


Figure 1 – EMS functional structure and dataflow diagram



RAILWAY APPLICATIONS – ENERGY MEASUREMENT ON BOARD TRAINS –

Part 4: Communication

1 Scope

This part of IEC 62888 applies to the on board and on board to ground communication services, i.e. it covers the data communication using digital interfaces:

- between functions implemented within the EMS;
- between EMS function and other on-board subsystems;
- between EMS and ground communication services.

The on-board data communication services of the EMS cover the data exchange between functions of the EMS and the data exchange between EMS and other on-board units, where data are exchanged using a communications protocol stack over a dedicated physical interface or a shared communication network.

The on board to ground communication services cover the wireless data communication between the DHS and the on-ground server. Furthermore, this document includes conformance test requirements.

Specific requirements for EMS Level 2 and Level 3 are specified in IEC 62888-6.

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.

IEC 60870-5 (all parts), *Telecontrol equipment and systems – Part 5: Transmission protocols*

IEC 61158-2:2014, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61375-1:2012, *Electronic railway equipment — Train communication network (TCN) — Part 1: General architecture*

IEC 61375-2-6:202X, *Electronic railway equipment — Train communication network — Part 2-6: On-board to ground communication*

IEC 61375-3-1:2012, *Electronic railway equipment — Train communication network (TCN) — Part 3-1: Multifunction Vehicle Bus (MVB)*

IEC 61375-3-3:2012, *Electronic railway equipment — Train communication network (TCN) — Part 3-3: CANopen Consist Network (CCN)*

IEC 61375-3-4:2014, *Electronic railway equipment — Train communication network (TCN) — Part 3-4: Ethernet Consist Network (ECN)*

IEC 62680-2-1:2015, *Universal Serial Bus interfaces for data and power - Part 2-1: Universal Serial Bus Specification*

IEC 62888-1:202X, *Railway applications – Energy measurement on board trains – Part 1: General*

IEC 62888-2:202X, *Railway applications – Energy measurement on board trains – Part 2: Energy measurement*

IEC 62888-3:202X, *Railway applications – Energy measurement on board trains – Part 3: Data handling*

IEC 62888-5:202X, *Railway applications – Energy measurement on board trains – Part 5: Conformance test*

IEC 62888-6:202X, *Railway applications – Energy measurement on board trains – Part 6: Requirements for purposes other than billing*

ISO 3166-1:2013, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

ISO/IEC 8482:1993, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections*

ISO 8601:2004, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO/IEC/IEEE 8802-3:2017, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

ISO/IEC 9646-1:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 1: General concepts*

ISO 11898-1:2015, *Road vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signalling*

ISO 11898-2:2016, *Road vehicles – Controller area network (CAN) – Part 2: High-speed medium access unit*

RFC 1321:1992, *The MD5 Message-Digest Algorithm*

RFC 1952:1996, *GZIP file format specification*

RFC 2616:1999, *Hypertext Transfer Protocol – HTTP/1.1*

RFC 3275:2002, *XML-Signature Syntax and Processing*

RFC 3986:2005, *Uniform Resource Identifier (URI): Generic Syntax*

RFC 4001:2005, *Textual Conventions for Internet Network Addresses*

RFC 4051:2005, *Additional XML Security Uniform Resource Identifiers (URIs)*

RFC 4648:2006, *The Base16, Base32, and Base64 Data Encodings*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62888-1:202X and the following apply.

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>

3.1.1**Board to Ground Interface****BGI**

interface used for the communication between the train and the ground

3.1.2**consist**

single vehicle or a group of vehicles which are not separated during normal operation

Note 1 to entry: A consist can contain no, one or several consist networks.

Note 2 to entry: A consist can contain one or more traction units.

[SOURCE: IEC 60050-811:2017, 811-37-20, modified: Note 2 to entry has been added]

3.1.3**consist network****CN**

bus connecting equipment within a consist, e.g. the MVB, and which conforms or adapts to the TCN real-time protocols

[SOURCE: IEC 60050-811:2017, 811-37-21]

3.1.4**Consist Network Interface****CNI**

interface to an on board consist network used by the EMS and by other on board devices interfacing with the EMS

3.1.5**DHS to MCF Interface****DMI**

interface between the DHS and the MCF; it may be dedicated or shared on CNI

3.1.6**DHS to Service Interface****DSI**

interface between the DHS and a maintenance/administration tool

3.1.7**EMF to DHS Interface****EMDI**

interface between the EMF and the DHS

3.1.8**EMF to Service Interface****ESI**

interface between the EMF and a maintenance/administration tool

3.1.9**entity in charge of the test**

organisation responsible for conformance testing

3.1.10**Fully Qualified Domain Name****FQDN**

domain name which specifies its exact location in the tree hierarchy of the Domain Name System (DNS)

Note 1 to entry: It specifies all domain levels, starting from the host name up to the top-level domain.

3.1.11**Ground Station****GS**

any station on ground which is able to communicate with the EMS

226 Note 1 to entry: A GS may host different services such as DCS or any EMS management service.

227 **3.1.12**

228 **Integrity <of information>**

229 state in which information is complete and not altered

230 [SOURCE: IEC 60050-821:2017, 821-11-26]

231 **3.1.13**

232 **Internet Engineering Task Force**

233 **IETF**

234 organised activity of the Internet Society in charge of producing technical documents relevant
235 to the design, use and management of the Internet

236 **3.1.14**

237 **location data**

238 data describing the geographical position of the traction unit

239 **3.1.15**

240 **Location Function to DHS Interface**

241 **LFDI**

242 interface linking the location function to the DHS

243 Note 1 to entry: The location function can be interfaced with the DHS via a CNI.

244 **3.1.16**

245 **Mobile Communication Function**

246 **MCF**

247 function performing the EMS to on ground communication

248 Note 1 to entry: It includes the sub-function(s) for the wireless link between the train and ground and the sub-
249 functions that execute the communication protocols up to the application interface.

250 **3.1.17**

251 **Mobile Communication Gateway**

252 **MCG**

253 device that implements the MCF

254 Note 1 to entry: It may be embedded into the DHS, shared on CNI or connected as a dedicated device by means
255 of the DMI.

256 **3.1.18**

257 **non-voluntary change**

258 accidental or unintentional change

259 Note 1 to entry: Accidental change is caused by unpredictable physical influences, and unintentional change is the
260 effect caused by user functions and residual defects of the software even though the best efforts in development
261 techniques have been applied.

262 **3.1.19**

263 **Payload <of the message>**

264 part of the message containing the useful data produced by the source application and used by
265 the destination application

266 **3.1.20**

267 **protective interface**

268 interface which permits intended data to be exchanged, and prevents unintended data being
269 exchanged

270 **3.1.21**

271 **Protocol Analyser**

272 **PA**

273 instrument which is used to record and analyse the frames produced by the IUA during the
274 protocol testing

3.1.22**Protocol Frame Generator****PFG**

instrument which is used to inject the testing frames into the interface of the IUA

3.1.23**Protocol Implementation Conformity Statement****PICS**

document containing the information of the claim of conformity of the IUA in respect of the specification

3.1.24**Protocol Implementation Extra Information for Testing****PIXIT**

document used when testing the user defined aspects of the protocol for the IUA

3.1.25**test bench**

arrangement of test equipment for testing an IUA

Note 1 to entry: Test equipment may include oscilloscopes, signal generators and other instruments.

3.1.26**Train Control and Monitoring System****TCMS**

set of interrelated objects providing on board control and monitoring of the train

3.1.27**UTC source to DHS interface****TFDI**

dedicated interface of the UTC Source to the DHS

Note 1 to entry: The UTC source can be interfaced with the DHS via a CNI.

3.1.28**verdict**

statement of “pass”, “fail”, or “inconclusive”, as specified in an abstract test case, concerning conformity of an IUA with respect to the test case when it is executed

3.1.29**VMF/CMF to ECF Interface****VEI**

interface between a VMF/CMF and an ECF

Note 1 to entry: It may be a combined interface for VMF and CMF or two separated interfaces.

3.1.30**voluntary change**

intentional change consisting in a modification of software elements and/or modification, loading or swapping of the memory

3.2 Abbreviated terms

For the purpose of this document, the abbreviated terms given in IEC 62888-1:202X and the following apply.

APN	Access Point Name
BGI	Board to Ground Interface
CHAP	Challenge Handshake Authentication Protocol
CNI	Consist Network Interface
CRC	Cyclic Redundancy Check
DHCP	Dynamic Host Configuration Protocol
DMI	DHS interface to Mobile Communication Function

324	DNS	Domain Name System
325	DSI	Data Handling System to service interface
326	ECN	Ethernet Consist Network
327	EMDI	EMF to DHS interface
328	ESI	Energy Measuring Function to service interface
329	FIP	Factory Instrumentation Protocol
330	FQDN	Fully Qualified Domain Name
331	FTP	File Transfer Protocol
332	GNSS	Global Navigation Satellite System
333	GPRS	General Packet Radio Service
334	GS	Ground Station
335	HTTP	Hyper-Text Transfer Protocol
336	IETF	Internet Engineering Task Force
337	IP	Internet Protocol
338	LFDI	Location Function to DHS interface
339	MCC	Mobile Country Code
340	MCF	Mobile Communication Function
341	MCG	Mobile Communication Gateway
342	MNC	Mobile Network Code
343	MVB	Multifunction Vehicle Bus
344	PA	Protocol Analyser
345	PAP	Password Authentication Protocol
346	PICS	Protocol Implementation Conformity Statement
347	PIN	Personal Identification Number
348	PIXIT	Protocol Implementation Extra Information for Testing
349	PUK	PIN Unlock
350	SIM	Subscriber Identity Module
351	TCMS	Train Control and Monitoring System
352	TCN	Train Communication Network
353	TCP	Transmission Control Protocol
354	TFDI	UTC Source to DHS interface
355	URI	Uniform Resource Identifier
356	USB	Universal Serial Bus
357	VEI	VMF/CMF to ECF interface
358	XML	eXtensible Markup Language
359	XSD	XML Schema Definition

360 **4 Requirements**

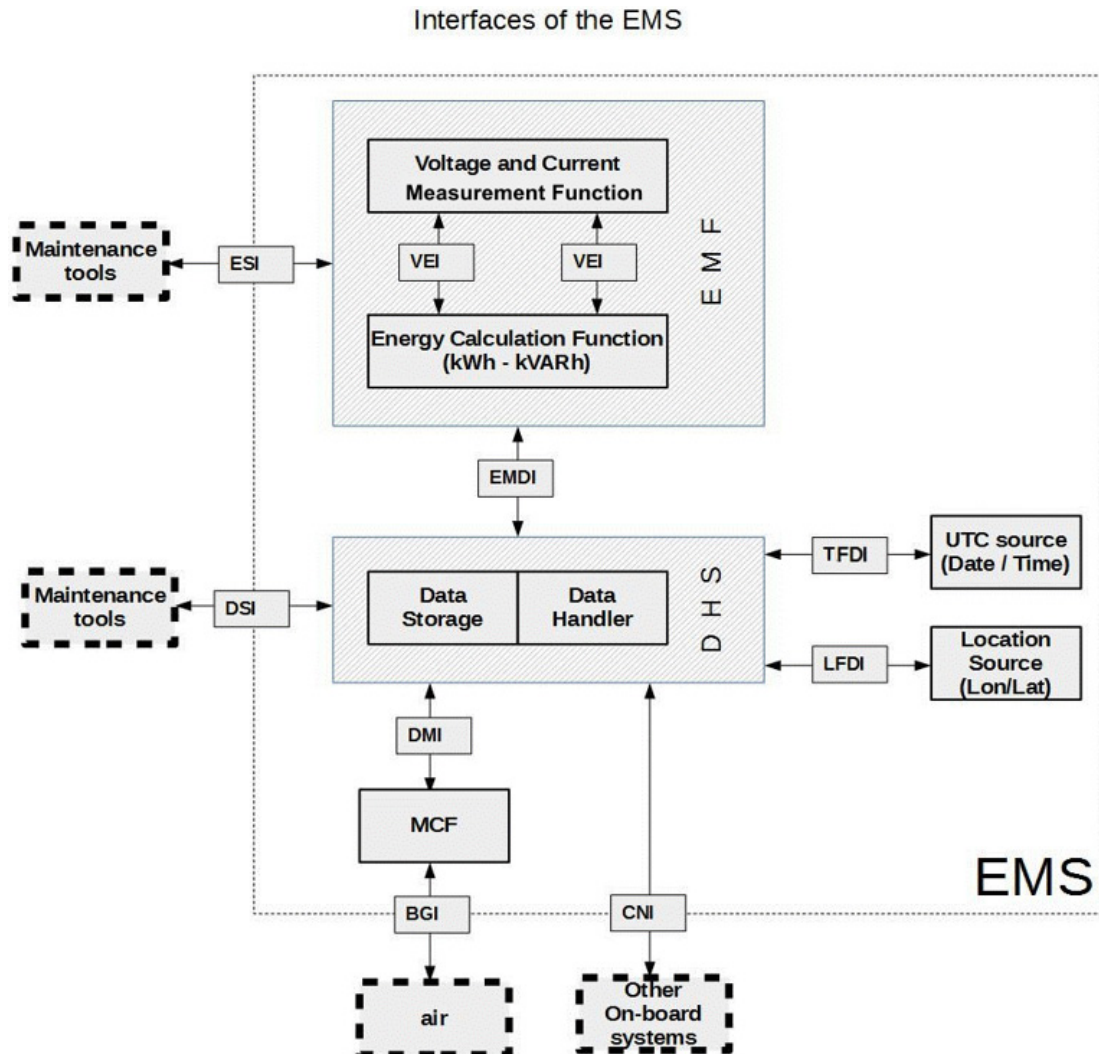
361 **4.1 General**

362 The requirements in IEC 62888-1:202X, Clause 4, apply to any device containing one or more
363 implementation of the communication services where applicable. IEC 62888-4 defines
364 additional requirements specific to the communication services.

4.2 Communication between functions of the EMS

4.2.1 General

Figure 2 shows the EMS functions which communicate through interfaces. The BGI interface is specified in 4.3.



Key

- BGI Board to Ground interface
- CNI Consistent Network interface between DHS and other on board subsystems
- DMI interface between DHS and MCF
- EMDI interface between EMF and DHS
- ESI interface between EMF and the maintenance tools
- DSI interface between DHS and the maintenance tools
- LFDI interface between the DHS and location device
- TFDI interface between the DHS and UTC source
- VEI interface between VMF and/or CMF and ECF

Figure 2 – EMS block diagram and interfaces

ESI and DSI are exposed interfaces which are intended to be used for:

- a) maintenance;
- b) EMF and/or DHS administration;
- c) testing.

More than one interface, dedicated to this purpose, may exist according to the structure of the EMS implementation, e.g. if the EMF and DHS are implemented in two separate devices, it is possible to implement one interface attached to EMF and one attached to DHS.

The interface LFDI is required if the data are exchanged between DHS and a dedicated location function. Alternatively, the location function may be interfaced with the DHS via the CNI.

The interface TFDI is required if the data are exchanged between DHS and a dedicated UTC source device. Alternatively, the UTC source may be interfaced with the DHS via the CNI.

The interface DMI is required if the data are exchanged between DHS and a dedicated Mobile Communication Function. Alternatively, the Mobile Communication Function may be interfaced with the DHS via the CNI.

The interface CNI is required if the data are exchanged between DHS and external TCMS subsystems or non-embedded EMS function, e.g. TCMS subsystems attached to the consist network or location device linked to DHS via the shared consist network.

4.2.2 Communication protocols stack

The communication protocol stack executed by each on board physical interface shall be one of those listed in Table 1. A different protocol stack may be used for each interface.

NOTE Internal embedded interfaces (e.g. for VEI, TFDI, LFDI or DMI) don't have to comply to the protocol stack.

Table 1 – List of permitted protocol stacks

Protocol stack	Physical layer Reference standard	Link layer Reference standard	Upper layer Reference standard
RS232	ITU-T Recommendation V.24	User defined.	User defined
RS485	ISO/IEC 8482	IEC 60870-5 (all parts)	Application specific using the following services: S1 (send/no reply) S2 (send/confirm) S3 (request/respond)
RS422	TIA/EIA-422-B, May 1994	IEC 60870-5 (all parts)	Application specific using the following services: S1 (send/no reply) S2 (send/confirm) S3 (request/respond)
CANopen	ISO 11898-2:2016	ISO 11898-1:2015	IEC 61375-3-3
ETHERNET	ISO/IEC/IEEE 8802-3:2017	IEC 61375-3-4	IEC 61375-3-4
MVB	IEC 61375-3-1	IEC 61375-3-1	IEC 61375-3-1
FIP	IEC 61158-2	IEC 61158-2	IEC 61158-2
USB	IEC 62680-2-1	IEC 62680-2-1	IEC 62680-2-1
user defined	user defined	user defined	user defined
NOTE 1 The RS232 is listed but is used with care because it is not sufficiently robust for the demanding electromagnetic environment found typically on board of trains.			

Irrespective of the chosen protocol and in order to execute the conformity design review and the conformance test procedure, the IUA Supplier shall provide the PICS relevant to this protocols stack and the mapping to the specifications stated in the clauses relevant to the design review and to the conformance module test procedure.

4.2.3 Communication security

4.2.3.1 General

Subclause 4.2.3 specifies the requirements for achieving the proper level of communication security of the interface. The communication security shall ensure the integrity and authenticity of the exchanged payload data.

Referring to integrity, it shall be ensured that the risk of accepting exchanged information containing unintentional or accidental changes and/or intentional changes is reduced to an acceptable level.

Referring to authenticity, it shall be ensured that the risk of accepting exchanged data transmitted by a wrong source function/sub-function and received by the wrong consumer function/sub-function is reduced to an acceptable level.

In order to reach an acceptable level, two cases are considered:

- a) data transfer is protected by physical means;
- b) data transfer is protected by software means.

The protection by physical means is specified in IEC 62888-1:202X, 4.3.5.2 and 4.3.5.3.

4.2.3.2 Security implemented by software

4.2.3.2.1 General

If the physical means cannot ensure an adequate security level, the security shall be ensured by a dedicated software layer that shall be added to the communication protocol stack of the relevant interface.

The protection by software shall respect the general requirements specified in IEC 62888-1:202X, 4.3.4.3, 4.3.4.4, 4.3.4.5, 4.3.4.6 and 4.3.5.4.

The software security layer shall provide:

- a) the data integrity at application level;
- b) the authenticity to ensure data transfer over the interface only occurs between the correct devices. This is optional if the requirement a) adequately covers the detection of data changes (caused by intentional and unintentional actions).

NOTE Binding is one method for ensuring authenticity.

When the secrecy of data is required by the purchaser and agreed with the supplier, the software security layer may provide encryption of the transferred data.

4.2.3.2.2 Data integrity

The integrity of the data shall be ensured by an error detecting code applied at application level on the payload data.

The type of error detecting code and its length shall be chosen considering the payload length in order to ensure at a reasonable level that any change in the payload data is detected.

NOTE CRC is one method for communication error detecting.

4.2.3.2.3 Binding procedure and data AES

This subclause is informative.

The binding procedure is applied in order to generate a secret key that is transferred under controlled condition between the two units that communicate throughout the interface. The key is generated by the master unit and transferred in a controlled environment to the slave unit. This key is used to encrypt the payload by the transmitting unit and to decrypt the payload extracted from the received frame by the receiving unit.

This procedure is executed attaching the maintenance tool (e.g. personal computer) to the maintenance interface of the master unit and activating the procedure after a successful authentication based on User ID and password owned only by the authorised personnel.

As soon as the binding procedure is started, the following events occur:

- a) The master unit generates a key and stores it in a dedicated memory cell that cannot be accessed in the future except by the software that decrypts the payload.
- b) The key is transmitted to the slave unit that stores it in a dedicated memory cell that cannot be accessed in the future except by the software that has to encrypt the payload.
- c) The encryption and decryption of a known payload is transmitted from the master unit to the slave unit and vice-versa to check that the two are correctly bound.
- d) The procedure is closed.

4.2.4 VMF/CMF to ECF Interface (VEI)

If this interface is digital, it shall be implemented according to IEC 62888-2:202X, 4.3 and 4.4, and the requirements listed in this document under 4.2.2 and 4.2.3.

An example of implementation is given in informative Annex B.

VEI may be implemented as a shared interface like CNI provided that the performance, safety and security level is adequate and comparable with the level of a direct and exclusive interface.

4.2.5 EMF to DHS interface (EMDI)

This shall be a protective interface.

This interface shall be implemented according to one of the following options:

- a) a direct and exclusive serial interface between EMF and DHS;
- b) a shared interface like CNI provided that the security level is adequate and comparable with the level of a direct and exclusive interface.

The interface shall transfer at least the data in accordance with IEC 62888-2 and IEC 62888-3.

4.2.6 Maintenance/testing interfaces (DSI and ESI)

This shall be a protective interface.

This is an interface to be used by the tools dedicated to the EMS maintenance and testing.

If the EMF and DHS functions are implemented in a single device, at least one interface shall be provided for the maintenance and testing purposes.

If the EMF and DHS functions are implemented in two separate devices, one of the two cases shall apply:

Case 1: there is only one maintenance/testing interface that shall be controlled by the main processing unit of the DHS. In this case, a software module, called the agent, is in charge of routing the information relevant to the maintenance/testing of EMF through the EMDI interface invoking a software module, called the manager, which is in charge of executing the maintenance/testing tasks in the EMF.

Case 2: there are two interfaces dedicated to maintenance/testing, one attached to the device implementing the DHS function and one attached to the device implementing the EMF function.

NOTE The above statements give maintenance/testing interfaces requirements when the implementation of an EMS is done with multiple devices.

The access shall be controlled according to the requirements specified in IEC 62888-1:202X, 4.3.2.2.1 and 4.3.2.3.

4.2.7 DHS to location function

Two interfaces are possible:

- a) the LFDI interface;
- b) the CNI interface that connects the DHS to the location function by means of the consist network digital interface.

If case a) applies, the interface shall be a direct and exclusive interface to the location function.

If case b) applies, requirements are given in 4.2.9.

The interface shall transfer location information in accordance with IEC 62888-3:202X, 4.4.

If this interface is able to provide UTC information compliant to the specification given in IEC 62888-3:202X, 4.2, it can be used as UTC source interface.

4.2.8 DHS to UTC source

Two interfaces are possible:

- a) the TFDI interface;
- b) the CNI interface that connects the DHS to the UTC source by means of the consist network digital interface.

If case a) applies, the interface shall be a direct and exclusive interface between a UTC source and the DHS. No other on-board subsystem shall be attached to this time function by any means or interface.

If case b) applies, requirements are given in 4.2.9.

The information from UTC source is used to synchronise the internal DHS clock. This interface may be an interface that is transmitting date and time or an interface plus a pulse per second line.

The communication shall ensure that the synchronisation error, due to the communication itself, is less than 500 ms.

If the UTC source does not provide a UTC date and time updated according to the leap second adjustment, it shall provide the information of the offset of its own date and time to the UTC date and time with leap second adjustment.

4.2.9 DHS to Consist Network digital interface (CNI)

This interface shall be compliant to IEC 61375-3-1 (MVB) or IEC 61375-3-4 (ECN).

4.3 Communication between the EMS and ground

4.3.1 General

This subclause sets out the specification of the on board to ground communication subsystem. The basic requirements are set in IEC 62888-1 and IEC 62888-3.

In order to achieve the communication between the EMS and a user on ground (e.g. DCS, traction unit owner or energy management system), this clause defines:

- the EMS set-up;
- the application services between EMS and a user on ground (service layer);
- the data structures that the application services use (data layer);
- the message mechanism for implementing the application services (message layer);
- the application protocols for supporting the message mechanism;
- the communication architecture for supporting the application protocols;
- a set of security mechanisms for securing the application services.

The user on ground connects to the EMS through a GS.

NOTE 1 More than one user could have the role of DCS.

NOTE 2 A system connected to the EMS local interface or other traction unit subsystems could use this protocol.

4.3.2 EMS set-up

A train includes a number of networked devices that are involved in some services like passenger information, train identification, fleet management and energy measuring for billing and saving purposes. The train is connected to the Ground Station with a set of wireless connections and is capable of switching between them “on the fly” according to the requirement of bandwidth requested by the “service”.

Figure 3 shows one example of a communication scenario. The following clauses cover the interaction between the network’s elements existing between the Ground Station and the on-board mobile communication gateway (MCG). The behaviour of the MCG is transparent for the linkage of the EMS to ground, independent from the MCG architecture option, but the implementation can depend, for example:

- in case of a shared MCG, it acts as a proxy, representing the train functional structure to the ground network;
- in case of a dedicated MCG, it acts as an IP sub domain allowing each function/service to be reached through its functional address.

Considering the existing network structures and services of the railway operators, key points are the interoperability of the system and the communication protocols of the applications.

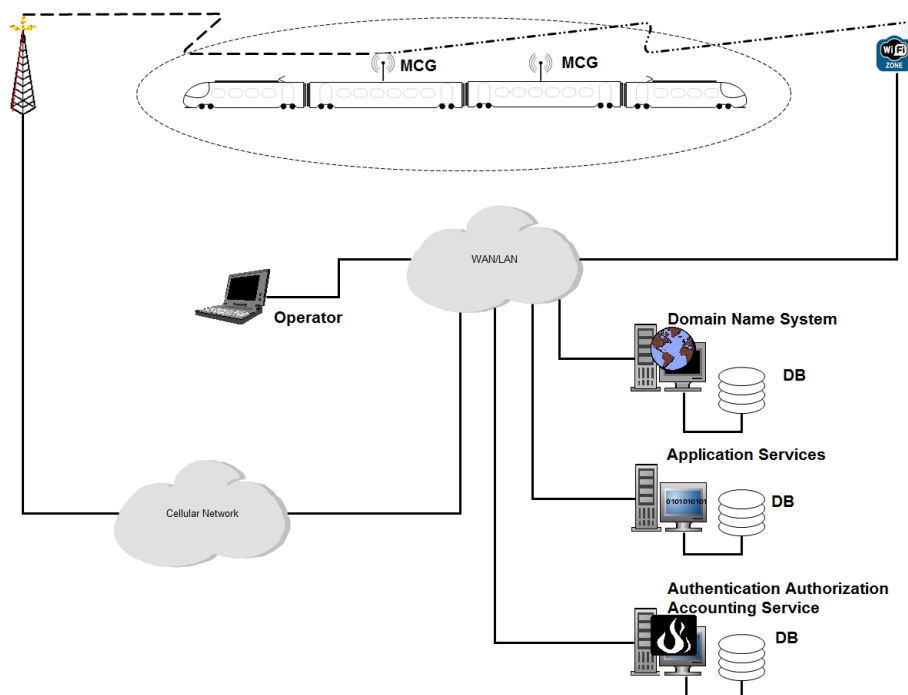


Figure 3 – Communication components (example)

The EMS, during its power-up sequence, can have different states as illustrated in Figure 4. The binding process to set-up the consumption point (EMS installed on the traction unit type) is managed in the Maintenance/Commissioning state. The exchange of CEMDs between the consumption point and DCS and the retrieve of the consumption point information (e.g. EMS configuration, Traction unit information, actual DCS address) are managed in the Normal Operation state.

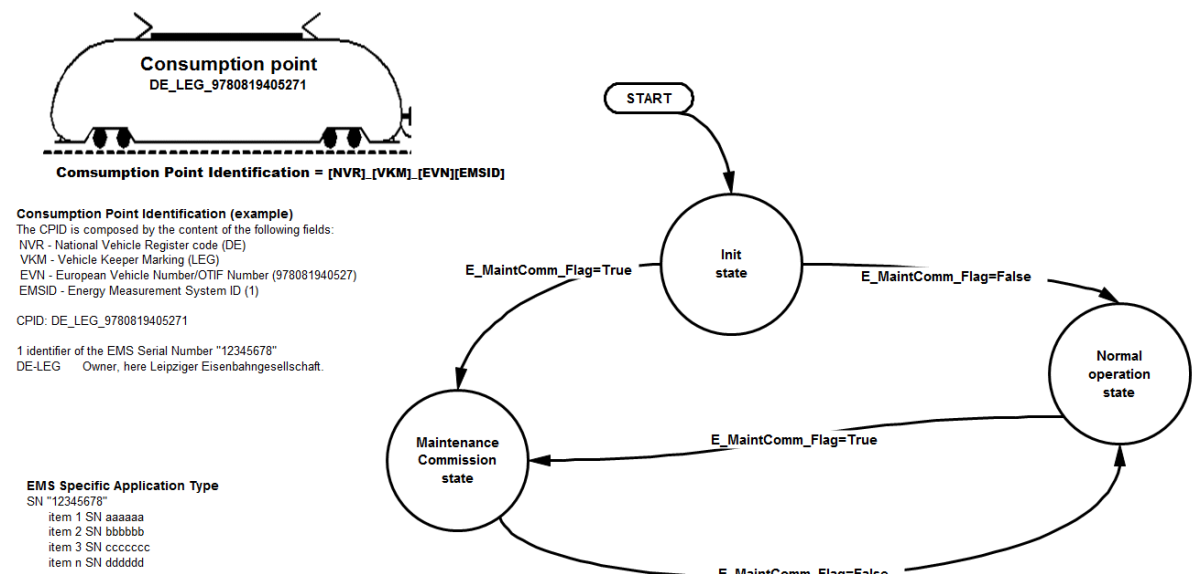


Figure 4 – Consumption point operational states

The binding process to set-up the consumption point (EMS installed on the traction unit type) in the Maintenance/Commissioning state could be either managed through the communication interface or by the service interface/manual procedure. In any case the main states of the binding process are illustrated in Figure 5. The transition between the Normal Operation state and the Maintenance Commissioning state should only be possible in accordance with a documented procedure, taking into account the need for authentication and authorization.

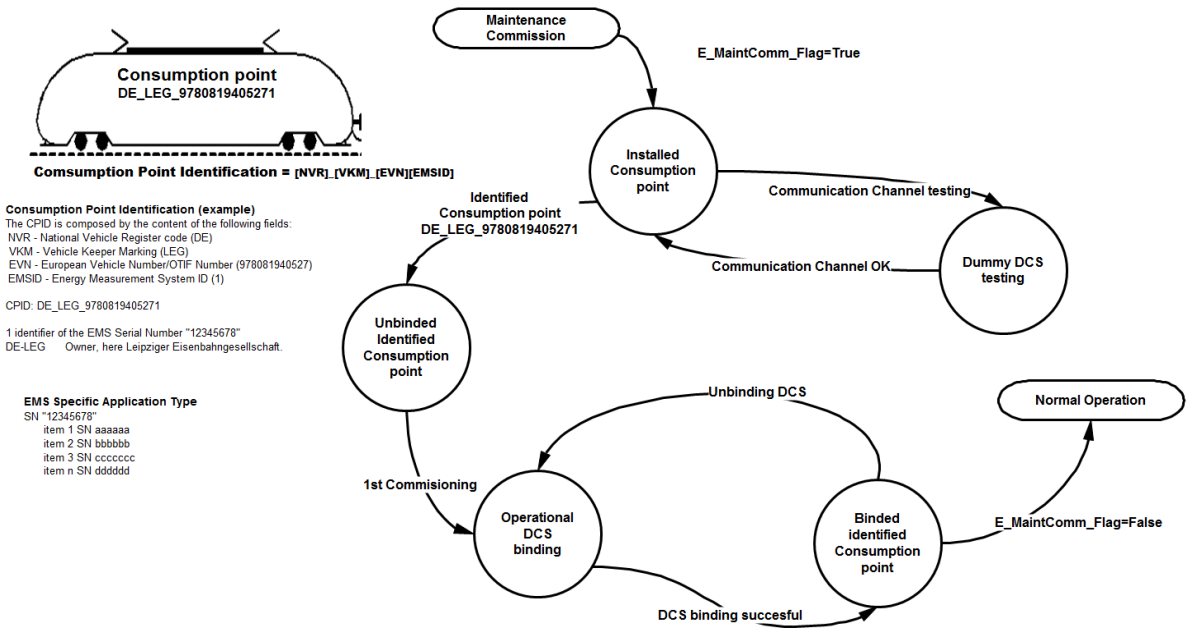


Figure 5 – Maintenance Commissioning states

The maintenance commissioning state and the binding process shall be described and agreed between by the relevant parties. The binding process includes the definition of the options of the communication.

4.3.3 Application services (service layer)

4.3.3.1 Services related with the transfer of CEMDs from EMS to a user on ground

All EMS and DCS shall support these services:

- automatic transfer of CEMD blocks (AutomaticTransferCEMDBlocks);
- request CEMD blocks (RequestCEMDBlocks);
- automatic transfer of a heartbeat (AutomaticTransferHeartbeat).

The tag name of the application service appears between parentheses.

Other users on ground may be supported.

A CEMD block is a sequence of CEMDs with additional information, e.g. EMS identification.

A heartbeat is a message sent from an EMS to a user on ground that facilitates the EMS discovery.

4.3.3.2 Other services

All EMS shall support these services.

- request EMS events (RequestEvents);

The following services are optional:

- request reading blocks (RequestReadingBlocks);
- request EMS communication configuration (RequestCommunicationConfig);
- change EMS communication configuration (ChangeCommunicationConfig);
- request EMS asset data (RequestAssetData);
- request EMS state (RequestState);
- automatic transfer of reading blocks (AutomaticTransferReadingBlocks);
- automatic transfer of a new asset configuration (AutomaticTransferAssetData);
- automatic transfer of a new communication configuration (AutomaticTransferCommunicationConfig);
- automatic transfer of events (AutomaticTransferEvents);
- periodic transfer of EMS state (PeriodicTransferState);

If any of these optional services are implemented, they shall comply with the requirements in this standard.

A reading block is a sequence of readings, e.g. energy measurements with its own time period, and can be used for energy management, e.g. energy saving or losses calculation.

Other services (e.g. software update) which are not listed above are not standardized in this standard.

4.3.3.3 User access rights to the application services

In order to fulfill the IEC 62888-1 access security requirements and the communication requirements, Table 2 defines the types of user access rights and their available application services, from the point of view of communication between the EMS and a user on ground.

611

Table 2 – Types of user access rights

Type of user access right	Available application services
CanNotChange	RequestCEMDBlocks AutomaticTransferCEMDBlocks AutomaticTransferHeartbeat RequestEvents AutomaticTransferEvents (if available) RequestReadingBlocks (if available) AutomaticTransferReadingBlocks (if available) RequestAssetData (if available) AutomaticTransferAssetData (if available) RequestState (if available) PeriodicTransferState (if available) RequestCommunicationConfig (if available) AutomaticTransferCommunicationConfig (if available)
ChangeOwn	Same as NotChange with this additional application service if it's available: ChangeCommunicationConfig restricted to the communication configuration data of the user.
ChangeAll	All available services without user restriction.

612

613 NOTE A user with access right "CanNotChange" is typically a basic user. A user with access right "ChangeAll"
614 is typically an administrator.

615 A user who does not have ChangeAll access rights shall not receive data about other users.

616 If the EMS includes the ChangeCommunicationConfig service, it shall implement, at least, one
617 user with the user access right ChangeOwn. If the scope of the ChangeCommunicationConfig
618 is more than the user communication configuration, the EMS shall implement, at least, one user
619 with the user access right ChangeAll.

620 In the case of more than one user on ground, that shares application services affected by
621 confidentiality and management restriction, the use of these types of user access rights is
622 recommended. Nevertheless, the rules for the on-ground management of user access rights is
623 outside the scope of this standard.

624 4.3.4 Data structures (data layer)

625 4.3.4.1 General

626 Data structures used by application services shall comply with the XML schema indicated by
627 Table 3. The M/O/C column defines whether the data structure is mandatory ("M"), or optional
628 ("O") or conditional ("C"). The value C is an indication that a condition exists for this data
629 structure, given under the table. C may have an index to handle multiple conditions. The column
630 Annex indicates the annex where to find the normative XML schema.

631 NOTE The data structure defined in this IEC 62888-4 differs from the data structures defined in EN 50463-4.
632 Some schemas from EN 50463 are mandatory in Europe. The schemas in IEC 62888 are built in such a way that
633 an implementer can adjust easily and to offer products compliant to IEC 62888 and also to EN 50463.

Table 3 – XML schema of each data structure

Data structure name (XML schema name)	Application services using this data structure	M/O/C	Description	Annex
IEC_CEMDBlock (IEC_CEMDBlock.xsd)	RequestCEMDBlocks AutomaticTransferCEMDBlocks	M	See 4.3.4.2	E

IEC_EventSet (IEC_EventSet.xsd)	RequestEvents AutomaticTransferEvents	M	See 4.3.4.3	E
IEC_Heartbeat (IEC_Heartbeat.xsd)	AutomaticTransferHeartbeat	M	See 4.3.4.4	E
IEC_ReadingBlock (IEC_ReadingBlock.xsd)	RequestReadingBlocks AutomaticTransferReadingBlocks	C1	See 4.3.4.5	F
IEC_CommunicationConfig (IEC_CommunicationConfig.xsd)	RequestCommunicationConfig AutomaticTransferCommunicationConfig	C2	See 4.3.4.6	F
IEC_ChangeCommunicationConfig (IEC_ChangeCommunicationConfig.xsd)	ChangeCommunicationConfig	C3	See 4.3.4.7	F
IEC_AssetData (IEC_AssetData.xsd)	RequestAssetData AutomaticTransferAssetData	C4	See 4.3.4.8	F
IEC_State (IEC_State.xsd)	RequestState PeriodicTransferState	C5	See 4.3.4.9	F

Condition C1: Data structure and schema are mandatory if the EMS supports the service RequestReadingBlocks or AutomaticTransferReadingBlocks.

Condition C2: Data structure and schema are mandatory if the EMS supports the service RequestCommunicationConfig or AutomaticTransferCommunicationConfig.

Condition C3: Data structure and schema are mandatory if the EMS supports the service ChangeCommunicationConfig.

Condition C4: Data structure and schema are mandatory if the EMS supports the service RequestAssetData or AutomaticTransferAssetData.

Condition C5: Data structure and schema are mandatory if the EMS supports the service RequestState or PeriodicTransferState.

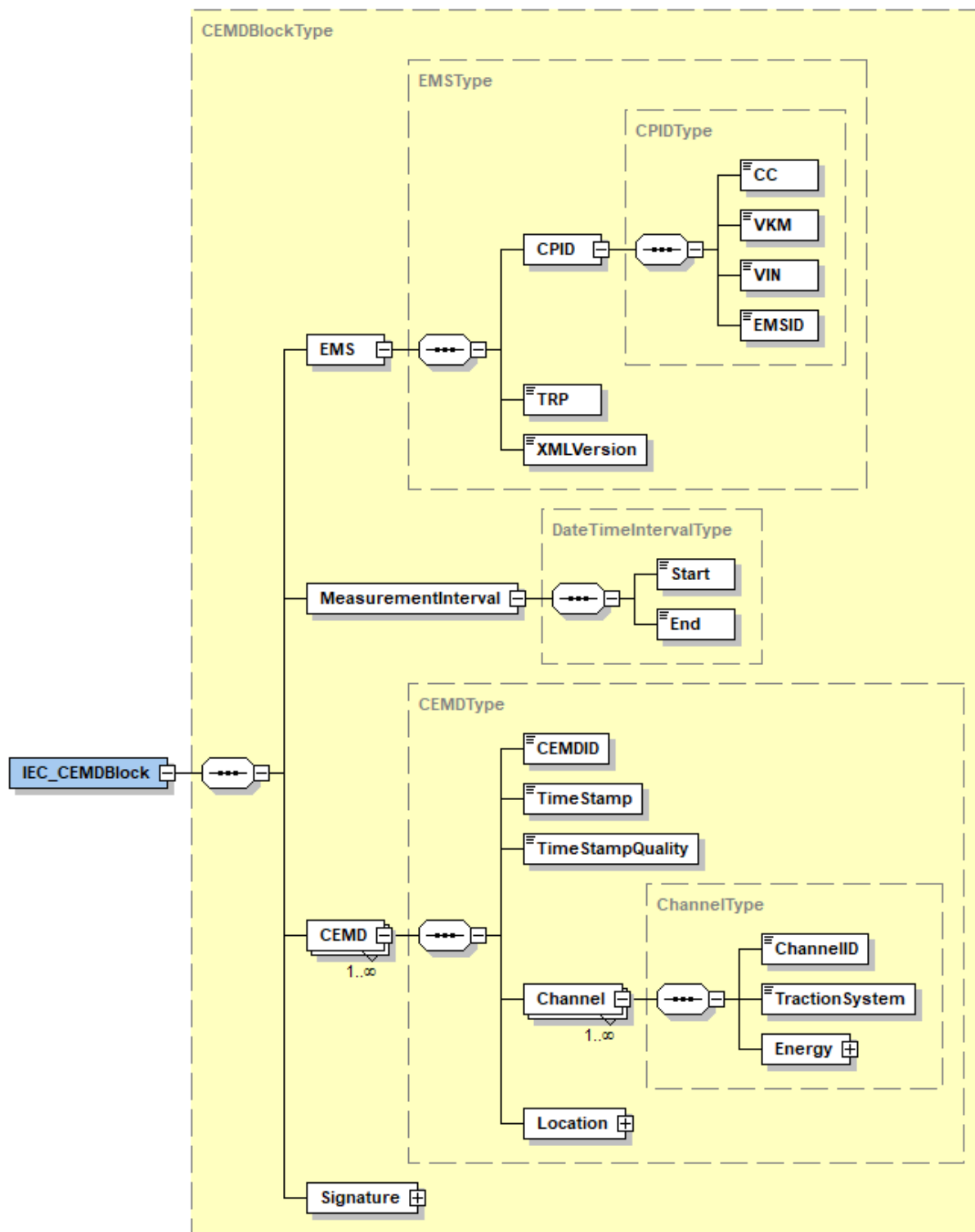
NOTE Annex G provides XML examples of the data structures.

The data structures IEC_ReadingBlock, IEC_CommunicationConfig, IEC_ChangeCommunicationConfig, IEC_AssetData and IEC_State use optional elements.

The following subclauses describes the data structures using graphics. The graphical conventions used are explained in 4.3.4.2.

4.3.4.2 IEC_CEMDBlock

The IEC_CEMDBlock is a sequence of CEMDs with additional information. Figure 6 describes the structure of IEC_CEMDBlock.



654

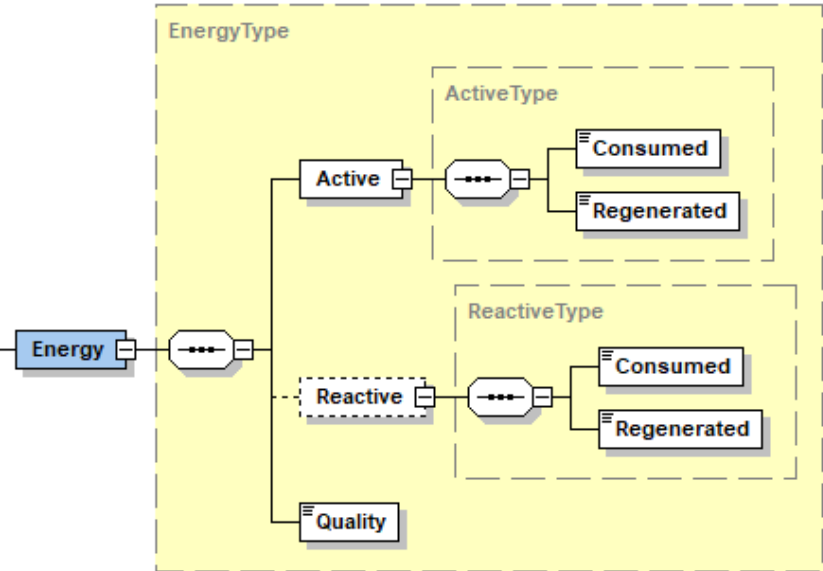


Figure 6 – IEC_CEMDBlock structure

The graphical representation used in this document (see Figure 6 for example) uses the convention set out below:

- white or blue rectangle indicates an element;
- symbol – indicates that the element contains child elements. The graphic shows the child elements on the right;
- symbol + indicates that the element contains child elements. The graphic does not show the child elements;
- white or blue rectangle with solid border indicates that the element is mandatory;
- white or blue rectangle with dashed border indicates that the element is optional;
- symbol 1..∞ indicates one or more elements;
- symbol 0..∞ indicates zero or more elements;
- yellow rectangle with dashed border indicates that element has been defined as a complex type;
- symbol  indicates a sequence of elements.

Table 4 to Table 8 define the IEC_CEMDBlock elements. The multiplicity of the elements is set out in the normative schema.

Table 4 – Definition of IEC_CEMDBlockType elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 5)	EMS that has calculated the IEC_CEMDBlock.
MeasurementInterval	M	DateTimeIntervalType (see Table 126)	Measurement interval for which the sequence of CEMDs has been produced. Start is the date and time at the beginning of the time period for which the first CEMD of the sequence is produced. End is the date and time at the end of the time period for which the last CEMD of the sequence is produced.
CEMD	M	CEMDType (see Table 6)	Sequence of CEMDs.

Signature	M	ds:SignatureType (see 4.3.4.12)	Digital signature of the IEC_CEMDBlock
-----------	---	------------------------------------	--

The element End of the element MeasurementInterval and the element TimeStamp of the last CEMD of the sequence shall have the same value.

Table 5 – Definition of EMSType elements (IEC_CEMDBlock)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
TRP	M	xs:duration	Time Reference Period. The value is fixed to “PT5M” (5 min).
XMLVersion	M	XMLVersionType (see Table 128)	IEC 62888–4 XML schema version.

Table 6 – Definition of CEMDType elements (IEC_CEMDBlock)

Element	M/O/C	XSD Type	Description
CEMDID	M	NumericID (see Table 128)	Sequential number to identify each CEMD.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time at the end of the time reference period.
TimeStampQuality	M	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Channel	M	ChannelType (see Table 7)	Channels in which the CEMD measurement is placed.
Location	M	LocationType (see Table 127)	Location at the end of the time reference period.

Table 7 – Definition of ChannelType elements (IEC_CEMDBlock)

Element	M/O/C	XSD Type	Description
ChannelID	M	NumericID (see Table 128)	Unique identifier for the channel.
TractionSystem	M	StandardTractionSystemType (see Table 128)	Type of traction system that the channel is connected to at the end of the time reference period.
Energy	M	EnergyType (see Table 8)	Energy consumed/regenerated measured by the channel during the time reference period.

Table 8 – Definition of EnergyType elements (IEC_CEMDBlock)

Element	M/O/C	XSD Type	Description
Active	M	ActiveType (see Table 123)	Active energy delta values.
Reactive	C1	ReactiveType (see Table 124)	Reactive energy delta values.
Quality	M	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement

Condition C1: Mandatory if the channel is measuring an AC traction system.

4.3.4.3 IEC_EventSet

The IEC_EventSet is a set of events with additional information. Figure 7 describes the structure of IEC_EventSet.

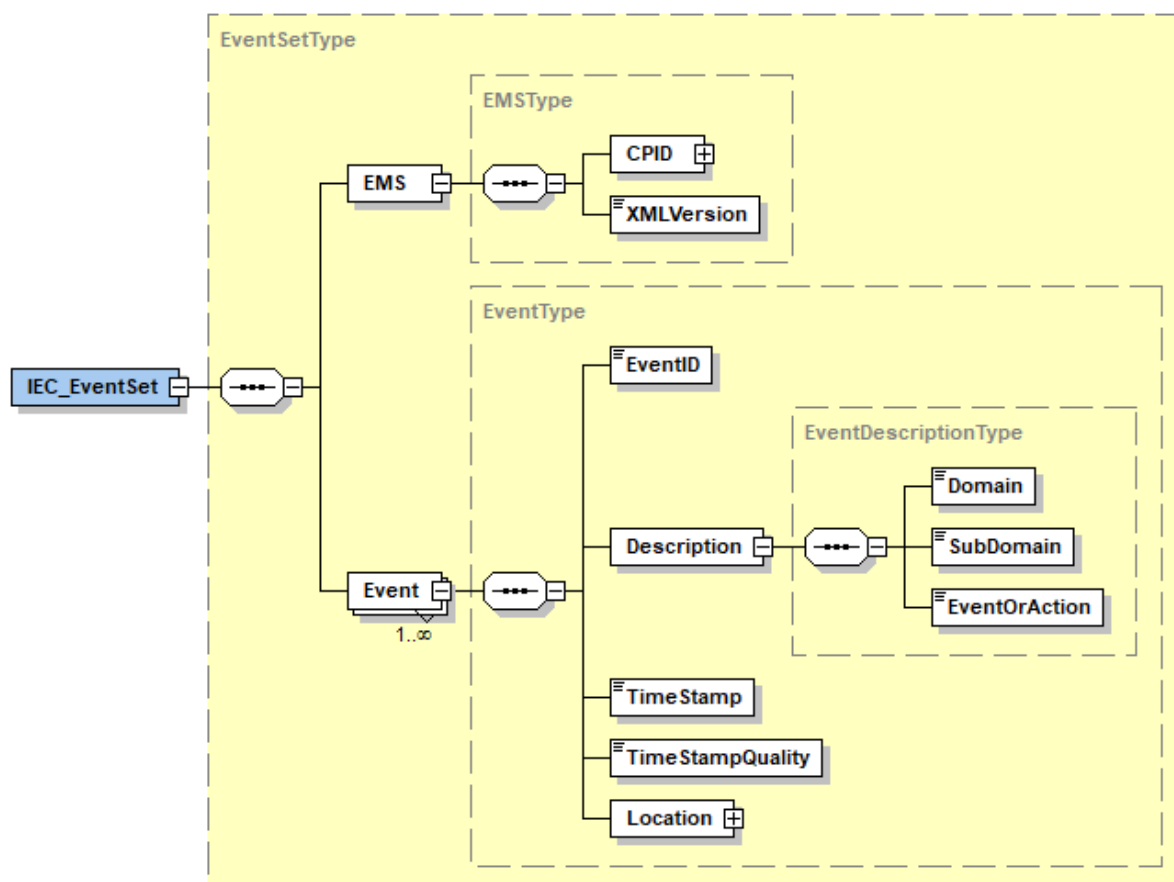


Figure 7 – IEC_EventSet structure

Table 9 to Table 12 define the IEC_EventSet elements.

Table 9 – Definition of IEC_EventSetType elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 10)	EMS that has generated the events.
Event	M	EventType (see Table 11)	Set of events.

Table 10 – Definition of EMSType elements (IEC_EventSet)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
XMLVersion	M	XMLVersionType (see Table 128)	IEC 62888-4 XML schema version.

NOTE IEC_EventSet uses a slightly different definition of EMSType than IEC_CEMDBlock.

Table 11 – Definition of EventType elements (IEC_EventSet)

Element	M/O/C	XSD Type	Description
EventID	M	NumericID (see Table 128)	Sequential number to identify each event
Description	M	EventDescriptionType (see Table 12)	Event description.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when the event has been processed.
TimeStampQuality	M	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Location	M	LocationType (see Table 127)	Location where the event has been processed.

Table 12 –Definition of EventDescriptionType elements

Element	M/O/C	XSD Type	Description
Domain	M	LongRestrictedStringType (see Table 128)	High-level nature of the event. By properly classifying events by a small set of domain codes, a system can more easily run reports based on the types of events that have occurred or been received. In the case of EMS it indicates the EMS functionality or EMS component where the event has appeared.
SubDomain	M	LongRestrictedStringType (see Table 128)	More specific nature of the event, as a further sub-categorization of 'domain'.
EventOrAction	M	ShortRestrictedStringType (see Table 128)	The most specific part of this event type. It is mainly in the form of a verb that gives action to the event which has occurred.

Table 13 describes the used variables for defining the values of Domain and SubDomain.

Table 13 – Variables for defining events

Variable	Description
UserName	Unique identifier for each user who connects to the EMS
ECFID	Unique identifier for each ECF.
VMFID	Unique identifier for each VMF.
CMFID	Unique identifier for each CMF.
FunctionID	Unique identifier for each EMS function that is not ECF type or VMF type or CMF type.
SensorID	Unique identifier for each physical sensor of the EMS.
MeterID	Unique identifier for each device containing one or more ECFs.
DeviceID	Unique identifier for each device of the EMS that is not sensor type or meter type.
ParameterID	Unique identifier for each configurable parameter of the EMS.
SoftwareID	Unique identifier for each software component of the EMS.

If the EMS is using the application services related with asset data and communication configuration, the variables of Table 13 shall use the values defined by Table 14.

698

Table 14 – Value of variables for defining events

Variable	Value
UserName	UserID of the user in IEC_CommunicationConfig
ECFID	ECFID of the ECF in IEC_AssetData
VMFID	VMFID of the VMF in IEC_AssetData
CMFID	CMFID of the ECF in IEC_AssetData
FunctionID	FunctionID of the Function in IEC_AssetData
SensorID	SensorID of the Sensor in IEC_AssetData
MeterID	MeterID of the Meter in IEC_AssetData
DeviceID	DeviceID of the Device in IEC_AssetData
ParameterID	Path in IEC_CommunicationConfig to the element using xxxID if it is necessary. Examples: “IEC_CommunicationConfig.DataGeneration.ReadingBlockConfig.TimePeriod” “IEC_CommunicationConfig.User_[UserID].Protocol.HTTP.Web”
SoftwareID	SoftwareID of the Software in IEC_AssetData

699

700 Table 15 to Table 20 define the values of Domain, SubDomain and EventOrAction for different
 701 types of events. “[x]” indicates the expression shall be replaced by the value of the indicated
 702 variable. The CEMD column indicates if the event is a CEMD related event.

703

Table 15 – Hardware and software alarms

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
EMS	Status	Error	M	Y	Critical error.
EMS	Status	Normal	M	Y	Recovered from a critical error.
EMS	Power	Up	M	Y	Power up.
EMS	Power	Down	M	Y	Power down.
DHS	Status	Error	M	Y	Internal error.
DHS	Status	Normal	M	Y	Recovered from internal error.
DHS	Memory	Full	M	Y	Memory full. Free memory is exhausted or under mandatory minimum free space.
DHS	Memory	Error	M	C1	Memory error.
DHS	Memory	Normal	M	C1	Recovered from memory error.
DHS	Logs	Cleared	M	Y	Event logs cleared.
Device_[DeviceID]	Status	Error	O	C2	Internal error in the EMS device defined by [DeviceID].
Device_[DeviceID]	Status	Normal	O	C2	Recovered from internal error.
Function_[FunctionID]	Status	Error	O	C3	Internal error in the EMS function defined by [FunctionID].
Function_[FunctionID]	Status	Normal	O	C3	Recovered from internal error.
EMS	Enclosure	Open	O	C4	An enclosure is open.
EMS	Enclosure	Closed	O	C4	An enclosure is closed.
EMS	TerminalCover	Open	O	C5	A terminal cover is open.
EMS	TerminalCover	Closed	O	C5	A terminal cover is closed.

Condition C1: Yes if the memory stores CEMDs.

Condition C2: Yes if the device is involved in the CEMD.

Condition C3: Yes if the function is involved in the CEMD.

Condition C4: Yes if opening the enclosure might indicate a threat to the integrity of the CEMD.

Condition C5: Yes if opening the cover might indicate a threat to the integrity of the CEMD.

Table 16 – User management events

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
DHS	Passwords	Reset	M	N	Initialization of user names and passwords with default values.
User_[UserName]	Remote	Login	M	N	Remote login of the user defined by [UserName].
User_[UserName]	Remote	Logout	M	N	Remote user logout.
User_[UserName]	Remote	Failed	M	N	Remote user login failure: e.g wrong password.
User_[UserName]	Local	Login	M	N	Local user login.
User_[UserName]	Local	Logout	M	N	Local user logout.
User_[UserName]	Local	Failed	M	N	Local user login failure: e.g invalid password.
DHS	Communication	InvalidMessage	M	N	The EMS has received an invalid message
User_[UserName]	Communication	InvalidRequest	M	N	The EMS has received from this user an invalid request.

An InvalidMessage shall be generated when a failure in the decryption of the message, or invalid origin of the message or invalid user ID occurs.

Table 17 – Measurement alarms

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
ECF_[ECFID]	Status	Error	M	Y	Internal error of the ECF defined by [ECFID].
ECF_[ECFID]	Status	Normal	M	Y	Recovered from internal error.
VMF_[VMFID]	Status	Error	O	Y	Internal error.
VMF_[VMFID]	Status	Normal	O	Y	Recovered from internal error.
VMF_[VMFID]	SignalStatus	Error	O	Y	Signal is wrong.
VMF_[VMFID]	SignalStatus	Normal	O	Y	Recovered from signal error.
CMF_[CMFID]	Status	Error	O	Y	Internal error.
CMF_[CMFID]	Status	Normal	O	Y	Recovered from internal error.
CMF_[CMFID]	SignalStatus	Error	O	Y	Signal is wrong.
CMF_[CMFID]	SignalStatus	Normal	O	Y	Recovered from signal error.
Sensor_[SensorID]	Status	Error	O	C1	Internal error.

Sensor_[SensorID]	Status	Normal	O	C1	Recovered from internal error.
Meter_[MeterID]	Status	Error	O	Y	Internal error.
Meter_[MeterID]	Status	Normal	O	Y	Recovered from internal error.
DHS	CEMDMemory	Cleared	M	Y	CEMD memory cleared.
ECF_[ECFID]		CurrentWithoutVoltage	O	Y	Current without voltage.

Condition C1: Yes if the sensor can detect a critical error and it can compromise the CEMD.

Table 18 – Synchronization alarms and events

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
Clock	Status	Error	M	Y	Internal error.
Clock	Status	Normal	M	Y	Recovered from internal error.
Clock	TimeSync	Reset	M	Y	Clock synchronization out of the automatic synchronization process (e.g. manual synchronization)
Clock	TimeSync	Failed	M	Y	More than the maximum time between synchronizations.
Clock	TimeSync	MajorCorrection	M	Y	A change of the time exceeding the maximum permitted deviation.

Table 19 – Communication events

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
EMS	IPAddress	[New value]	M	N	New IP value. Example: "130.24.24.133"
IEC61375SharedConnection	Communication	Error	C3	N	Ground communication failure.
IEC61375SharedConnection	Communication	Normal	C3	N	Recovered from ground communication failure.
IEC61375DedicatedConnection	Communication	Error	C2	N	Ground communication failure.
IEC61375DedicatedConnection	Communication	Normal	C2	N	Recovered from ground communication failure.
DedicatedWirelessConnection	Communication	Error	C1	N	Ground communication failure.
DedicatedWirelessConnection	Communication	Normal	C1	N	Recovered from ground communication failure.
Function_[FunctionID]	Communication	Error	O	N	Function communication error. The function is related with ground communications.
Function_[FunctionID]	Communication	Normal	O	N	Recovered from function communication error.

User_[UserName]	ReceivedCEMD	[Interval start]_[Interval end]	M	N	The user has received the specific interval of new CEMD.
User_[UserName]	ReceivedReading	[Interval start]_[Interval end]	O	N	The user has received the specific interval of new Readings.

Condition C1: Mandatory if the EMS is using the DedicatedWirelessConnection.

Condition C2: Mandatory if the EMS is using the IEC61375DedicatedConnection.

Condition C3: Mandatory if the EMS is using the IEC61375SharedConnection.

A “Ground communication failure” event represents failures in the level of the communication architecture or in the associated application protocol.

[Interval start] and [Interval end] shall use the same format as ZuluDateTimeType (Table 128).

[Interval end] shall be greater than [Interval start].

Table 20 – Configuration events

Domain	SubDomain	EventOrAction	M/O/C	CEMD	Description
User_[UserName]	[ParameterID]	[New value]	M	C1	The user has changed the value of the element referred by ParameterID and the new value is indicated. In the case of passwords or keys [New value] is substituted by the word “Changed”.
User_[UserName]	[SoftwareID].Version	[New version]	M	C2	New version of the software referred by SoftwareID.
User_[UserName]	Sensor_[SensorID]	Changed	M	C3	Sensor changed
User_[UserName]	CMF_[CMFRID].kfactor	[New value]	M	Y	New k-factor
User_[UserName]	VMF_[VMFRID].kfactor	[New value]	M	Y	New k-factor
User_[UserName]	[ParameterID]	Wrong	M	N	The EMS has received a configuration value out of range or the field doesn't exist
User_[UserName]	[ParameterID]	InsufficientRights	M	N	The user does not have the necessary rights to change this field.

Condition C1: Yes if the parameter is involved in the CEMD.

Condition C2: Yes if the software is involved in the CEMD.

Condition C3: Yes if the sensor is involved in the CEMD.

The event list may be extended with extra events depending on implementation following the same structure.

4.3.4.4 IEC_Heartbeat

Figure 8 describes the structure of IEC_Heartbeat elements.

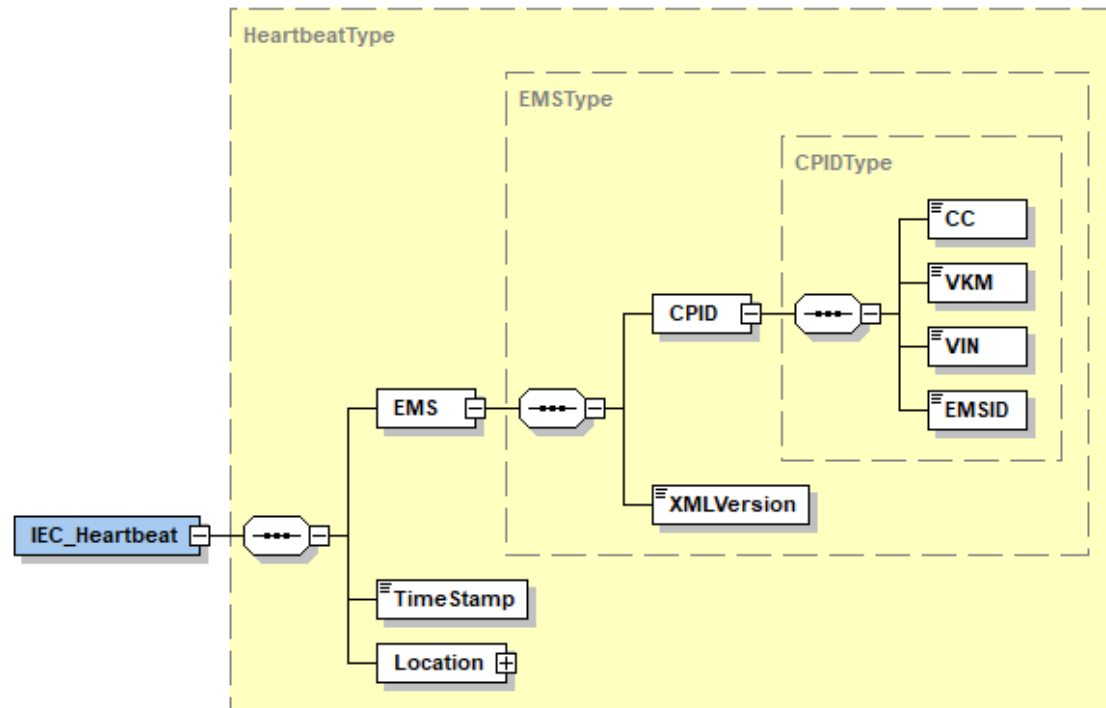


Figure 8 – IEC_Heartbeat structure

Table 21 defines the IEC_Heartbeat elements.

Table 21 – Definition of IEC_Heartbeat elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 10)	The EMS which has generated the heartbeat.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when the heartbeat has been generated.
Location	M	LocationType (see Table 127)	Location where the heartbeat has been generated.

4.3.4.5 IEC_ReadingBlock

The IEC_ReadingBlock is a sequence of readings with additional information. Figure 9 describes the main structure of the IEC_ReadingBlock.

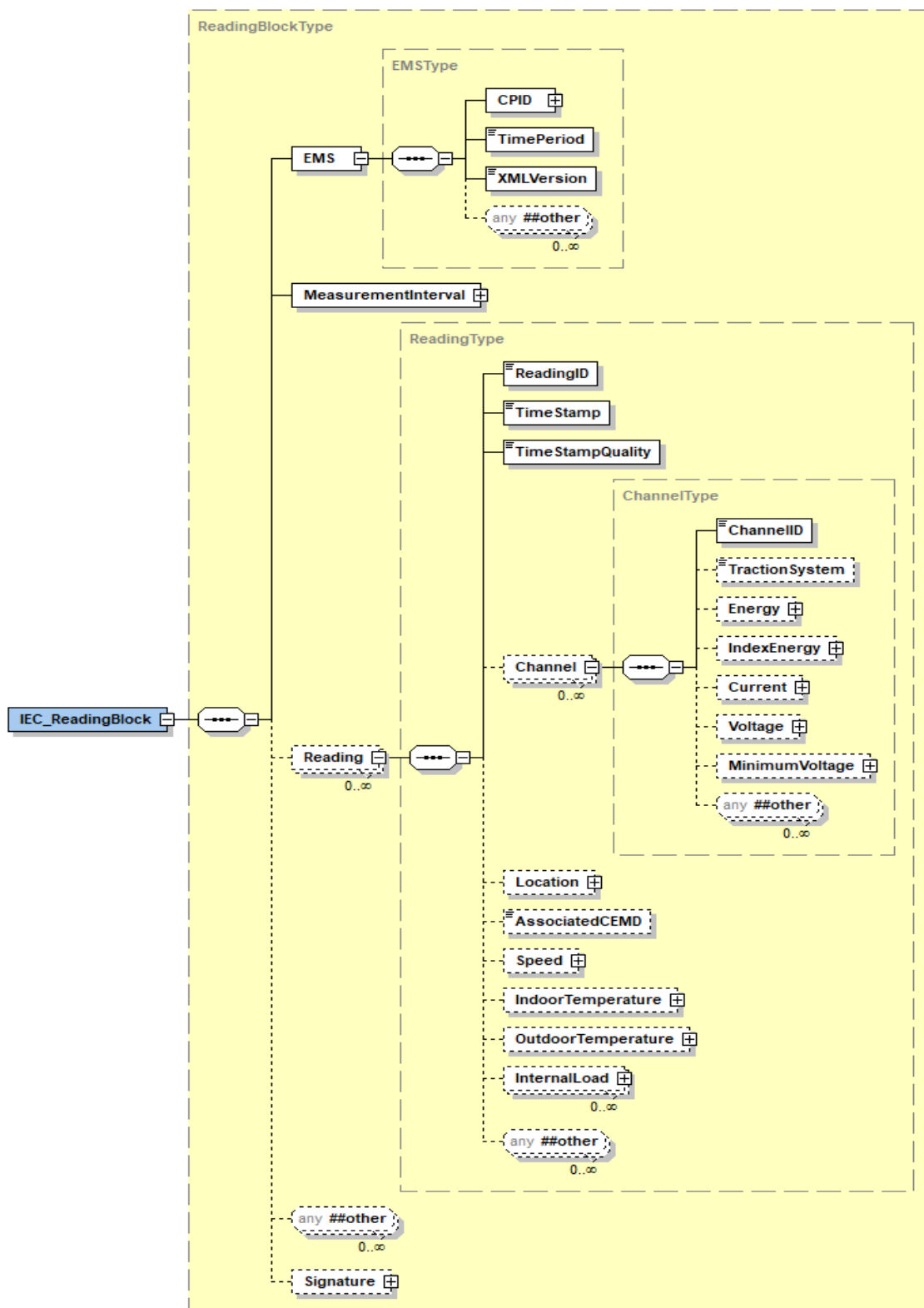


Figure 9 – IEC_ReadingBlock structure

Table 22 to Table 36 define the IEC_ReadingBlock elements.

The production of the optional elements related with measurement (four-quadrant reactive energy, current, voltage, minimum voltage, speed, indoor temperature, outdoor temperature and internal load) is not addressed in the IEC 62888 series.

NOTE 1 The inclusion of these optional elements in this part of the IEC 62888 series, does not necessarily imply an intention to specify them more extensively in future.

748

Table 22 – Definition of IEC_ReadingBlockType elements

Element	M/O/C	XSD Type	Description
EMS	M	EMSType (see Table 23)	EMS that has calculated the IEC_ReadingBlock.
MeasurementInterval	M	DateTimeIntervalType (see Table 126)	Measurement interval for which the sequence of Readings has been produced. Start is the date and time at the beginning of the time period for which the first Reading of the sequence is produced. End is the date and time at the end of the time period for which the last Reading of the sequence is produced.
Reading	O	ReadingType (see Table 24)	Sequence of Readings.
any	O	other	Used to allow custom extensions.
Signature	O	ds:SignatureType (see 4.3.4.12)	Digital signature of the IEC_ReadingBlock.

749

750 The element End of MeasurementInterval and the element TimeStamp of the last Reading of
 751 the sequence shall have the same value.

752

Table 23 – Definition of EMSType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID.
TimePeriod	M	xs:duration	Period of time for which Reading is produced. Value examples: "PT1M" (1 min), "PT30S" (30 s).
XMLVersion	M	XMLVersionType (see Table 128)	IEC 62888-4 XML schema version.
any	O	other	Used to allow custom extensions

753 NOTE 2 IEC_ReadingBlock uses a slightly different definition of EMSType than IEC_CEMDBlock.

754

Table 24 – Definition of ReadingType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
ReadingID	M	NumericID (see Table 128)	Sequential number to identify each Reading.
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time at the end of the time period. In this section 'time period' refers to the time period for which Reading is produced.
TimeStampQuality	O	TimeQualityCodeType (see Table 128)	Quality of the TimeStamp value.
Channel	O	ChannelType (see Table 25)	Channel in which the measurement is placed.
Location	O	EnhancedLocationType (see Table 32)	Location at the end of the time period.
AssociatedCEMD	O	NumericID (see Table 128)	The Reading could be associated to a CEMD (the value is the CEMDID of the associated CEMD)
Speed	O	SpeedType (see Table 33)	Train speed data in the time period.
IndoorTemperature	O	TemperatureType (see Table 34)	Indoor train temperature at the end of time period.

OutdoorTemperature	O	TemperatureType (see Table 34)	Outdoor train temperature at the end of time period.
InternalLoad	O	InternalLoadType (see Table 35)	Energy consumed by internal loads of the train during the time period.
any	O	other	Used to allow custom extensions.

755

Table 25 – Definition of ChannelType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
ChannelID	M	NumericID (see Table 128)	Number to identify each channel.
TractionSystem	O	StandardTractionSystemType (see Table 128)	Type of traction system that the channel is connected to at the end of the time period.
Energy	O	EnergyType (see Table 26)	Energy consumed/regenerated measured by the channel during the time period.
IndexEnergy	O	IndexEnergyType (see Table 28)	Index energy values at the end of the time period.
Current	O	CurrentType (see Table 29)	Current data during the time period.
Voltage	O	VoltageType (see Table 30)	Voltage data during the time period.
MinimumVoltage	O	MinimumVoltageType (see Table 31)	Information related with the minimum voltage value during the time period.
any	O	other	Used to allow custom extensions.

756

Table 26 – Definition of EnergyType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Active	O	ActiveType (see Table 123)	Active energy delta values.
Reactive	O	ReactiveType (see Table 124)	Reactive energy delta values.
Reactive4Q	O	Reactive4QType (see Table 27)	Reactive energy delta values (four quadrants).
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement.
any	O	other	Used to allow custom extensions.

757

Table 27 – Definition of Reactive4QType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Q1	M	BasicReactiveType (see Table 128)	Reactive quadrant 1.
Q2	M	BasicReactiveType	Reactive quadrant 2.
Q3	M	BasicReactiveType	Reactive quadrant 3.
Q4	M	BasicReactiveType	Reactive quadrant 4.

758

Table 28 – Definition of IndexEnergyType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Active	O	ActiveType (see Table 123)	Active energy index value.

Reactive	O	ReactiveType (see Table 124)	Reactive energy index value.
Reactive4Q	O	Reactive4QType (see Table 27)	Reactive energy index values (four quadrants).
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the energy measurement.
any	O	other	Used to allow custom extensions.

759

Table 29 – Definition of CurrentType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicCurrentType (see Table 132)	Minimum rms AC or DC current during the time period.
Average	O	BasicCurrentType	Average rms AC or DC current during the time period.
Maximum	O	BasicCurrentType	Maximum rms AC or DC current during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the current measurement.
any	O	other	Used to allow custom extensions.

760

Table 30 – Definition of VoltageType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicVoltageType (see Table 132)	Minimum rms AC or DC voltage during the time period.
Average	O	BasicVoltageType	Average rms AC or DC voltage during the time period.
Maximum	O	BasicVoltageType	Maximum rms AC or DC voltage during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the voltage measurement.
any	O	other	Used to allow custom extensions.

761

Table 31 – Definition of MinimumVoltageType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
TimeStamp	M	ZuluDateTimeType (see Table 128)	Date and time when rms AC or DC voltage is minimum.
Voltage	M	BasicVoltageType (see Table 132)	rms AC or DC voltage value.
VoltageQuality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the voltage measurement
Current	O	BasicCurrentType (see Table 132)	rms AC or DC current value at the minimum voltage.
CurrentQuality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the current measurement.
Energy	O	EnergyType (see Table 26)	Energy consumed and/or regenerated from the beginning of the time period to the instant where the minimum voltage has been detected.

Location	O	EnhancedLocationType (see Table 32)	Location where the minimum voltage has been detected.
any	O	other	Used to allow custom extensions.

Table 32 – Definition of EnhancedLocationType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Latitude	M	LatitudeType (see Table 128)	Latitude.
Longitude	M	LongitudeType (see Table 128)	Longitude.
Quality	O	LocationQualityCodeType (see Table 128)	Quality of location data.
any	O	other	Used to allow custom extensions.

Table 33 – Definition of SpeedType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Minimum	O	BasicSpeedType (see Table 130)	Minimum speed during the time period.
Average	O	BasicSpeedType	Average speed during the time period.
Maximum	O	BasicSpeedType	Maximum speed during the time period.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the speed measurement.
any	O	other	Used to allow custom extensions.

Table 34 – Definition of TemperatureType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Value	M	BasicTemperatureType (see Table 129)	Measurement value.
Quality	O	MeasurementQualityCodeType (see Table 128)	Quality code of the temperature measurement value.

Table 35 – Definition of InternalLoadType elements (IEC_ReadingBlock)

Element	M/O/C	XSD Type	Description
Kind	M	ShortRestrictedStringType (see Table 128)	Kind of internal load. Table 36 shows possible values.
Value	M	xs:decimal	Active energy value.
Unit	M	ShortRestrictedStringType	Value unit.
Quality	O	MeasurementQualityCodeType (see Table 128)	Measurement quality code.

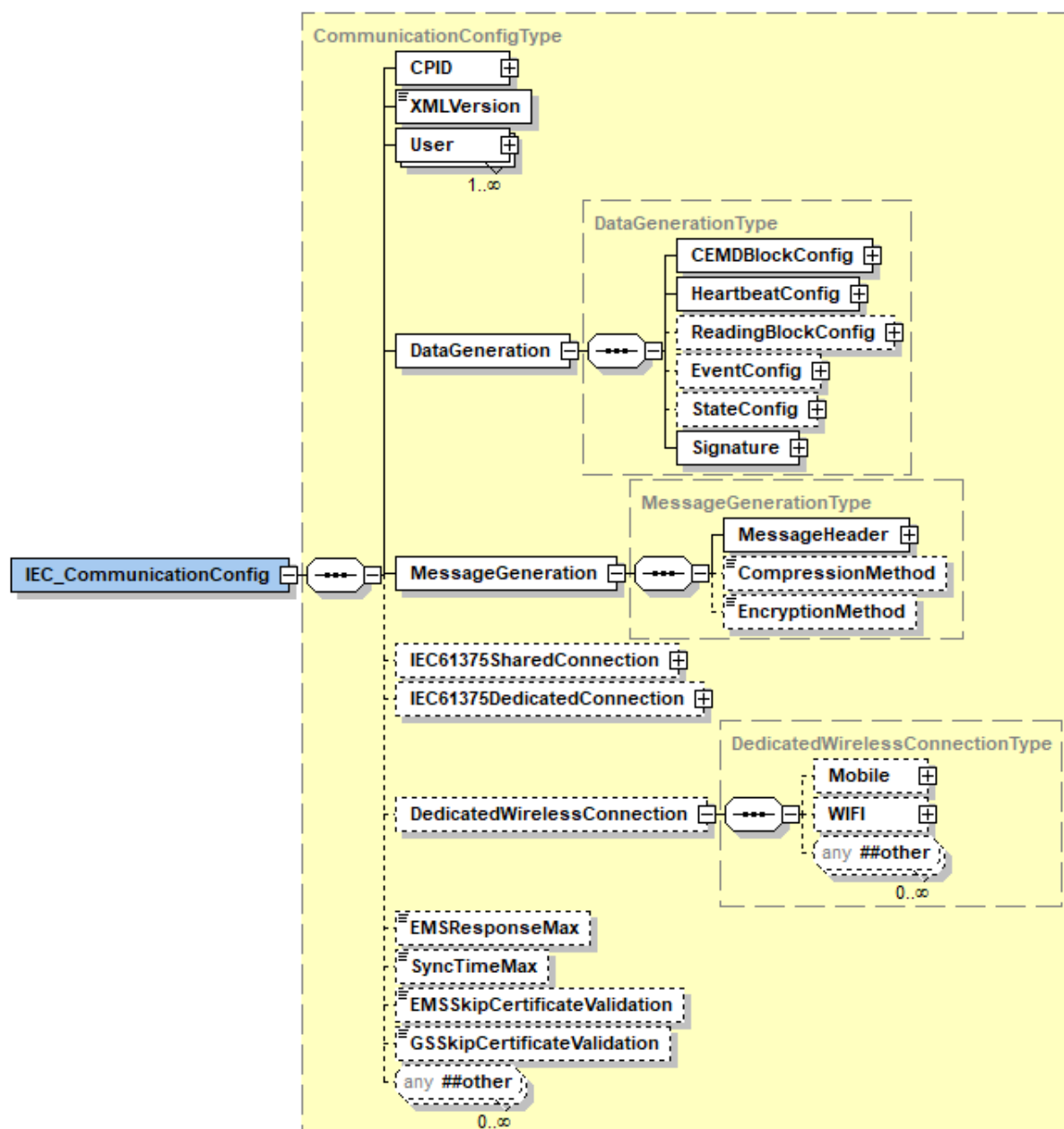
Table 36 – Value examples for kind in InternalLoadType (IEC_ReadingBlock)

Value	Description
Lighting	Lighting
HVAC	HVAC
ElectricHeating	Electrical heating
TractionConverterConsumedActive	Energy active consumption for traction converters.

TractionConverterConsumedReactive	Energy reactive consumption for traction converters.
TractionConverterRegeneratedActive	Energy active regenerated for traction converters.
TractionConverterRegeneratedReactive	Energy reactive regenerated for traction converters.
AuxConverterConsumedActive	Energy active consumption for auxiliary converters.
AuxConverterConsumedReactive	Energy reactive consumption for auxiliary converters.
BreakResistorConsumedActive	Energy active consumption for brake resistors.

4.3.4.6 IEC_CommunicationConfig

The IEC_CommunicationConfig defines the communication configuration of the EMS. Figure 10 describes the structure of IEC_CommunicationConfig.



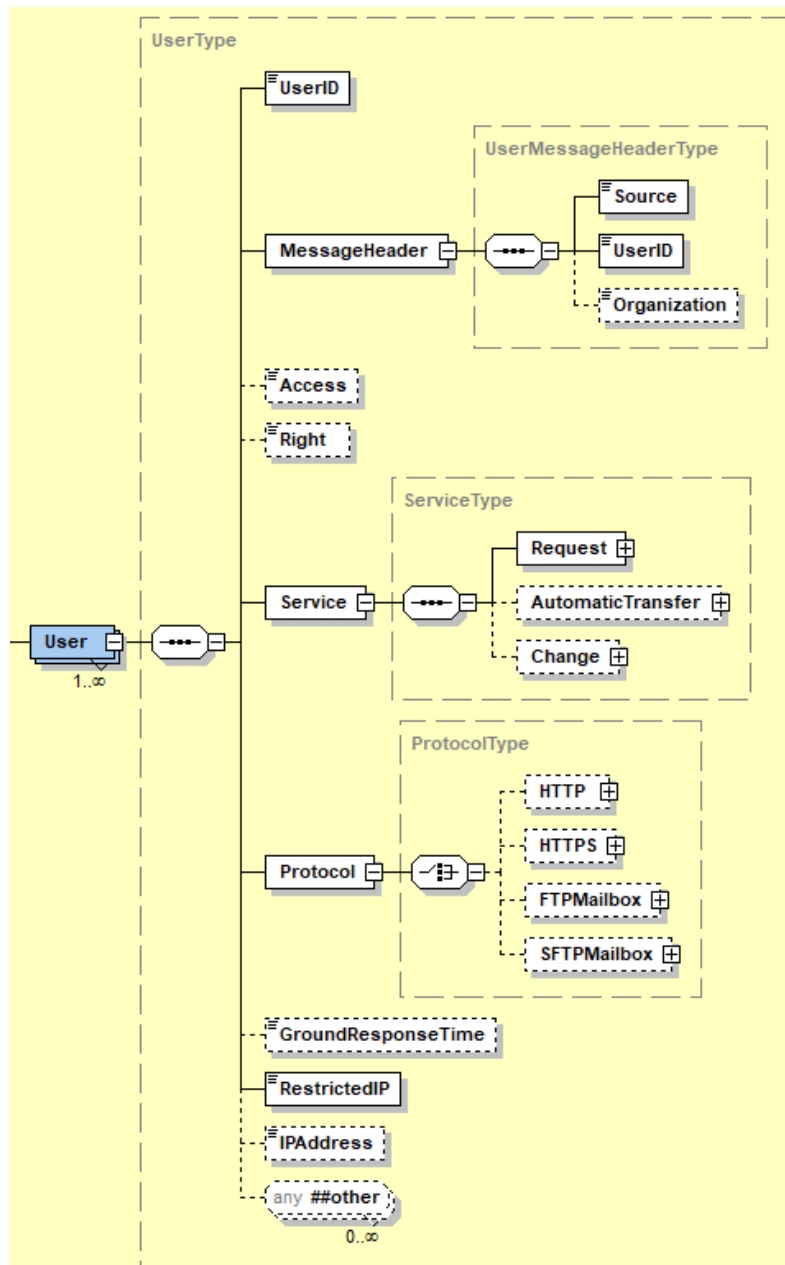


Figure 10 – IEC_CommunicationConfig structure

Table 37 to Table 65 define the IEC_CommunicationConfig elements.

Table 37 – Definition of IEC_CommunicationConfigType elements

Element	M/O/C	XSD Type	Description
CPID	M	CPIDType (see Table 125)	Consumption Point ID
XMLVersion	M	XMLVersionType (see Table 128)	IEC 62888-4 XML schema version
User	M	UserType (see Table 38)	EMS user communication configuration
DataGeneration	M	DataGenerationType (see Table 47)	Data generation parameters
MessageGeneration	M	MessageGenerationType (see Table 55)	Message generation parameters

IEC61375SharedConnection	C1	IEC61375SharedConnectionType (see Table 65)	Configuration of the EMS to ground communication using a shared communication unit based on IEC 61375–2-6
IEC61375DedicatedConnection	C1	IEC61375DedicatedConnectionType (see Table 64)	Configuration of the EMS to ground communication using a dedicated communication unit based on IEC 61375–2-6
DedicatedWirelessConnection	C1	DedicatedWirelessConnectionType (see Table 57)	Configuration of the EMS to ground communication using a dedicated wireless connection
EMSResponseMax	O	xs:duration	Maximum time that the EMS needs for responding to a ground request, if the communication system is available.
SyncTimeMax	O	xs:duration	Maximum allowable time between two synchronizations with an external reference.
EMSSkipCertificateValidation	C2	xs:boolean	If true, EMS shall skip GS certificate validation (see 4.3.6.3.1)
GSSkipCertificateValidation	C2	xs:boolean	If true, GS shall skip EMS certificate validation (see 4.3.6.3.2)
any	O	other	Used to allow custom extensions.

776 Condition C1: At least, one of the three elements shall appear.

777 Condition C2: Mandatory in case of partial implementation of HTTPS (see 4.3.6.3).

778 **Table 38 – Definition of UserType elements (IEC_CommunicationConfig)**

Element	M/O/C	XSD Type	Description
UserID	M	AlphanumericID	EMS unique identifier for the user. The value cannot be changed.
MessageHeader	M	UserMessageHeaderType (see Table 39)	Information for checking the message header. When the EMS receives a message from this user, it checks that header meets this data.
Access	O	UserAccessType xs:string	Available access for the user. Values: “OnlyLocal” (only local access) “OnlyRemote” (only remote access) “RemoteAndLocal” (remote and local access).
Right	O	UserRightType xs:string	User right (see Table 2). Values: “ChangeAll” “ChangeOwn” “CanNotChange”
Service	M	ServiceType (see Table 40)	User available services. If a service element does not exist, the user can never use this service.