IEC TR 61850-90-3

Edition 1.0 2016-05

TECHNICAL REPORT

colour inside

Communication networks and systems for power utility automation – Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.200

ISBN 978-2-8322-3318-4

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 9
INTRODUCTION 11
1 Scope 12
1.1 General 12
1.2 Namespace name and version 12
1.3 Data model Namespace Code Component distribution 13
2 Normative references 14
3 Terms, definitions, abbreviations, acronyms and conventions 14
3.1 Terms and definitions 14
3.2 Abbreviations, acronyms and conventions 15
4 Use cases 33
5 GIS (Gas Insulated Switchgear) 34
5.1 Summary 34
5.2 GIS overview 35
5.3 GIS use case diagrams 36
5.3.1 Gas compartments 36
5.3.2 Circuit breaker and switches 40
5.3.3 Operating mechanism 44
5.3.4 Monitoring issues for POW (Point-on-wave switching controller) 51
5.4 Preliminary modelling approach 56
5.4.1 GIS data modelling example 56
5.4.2 GIS gas modelling 56
5.4.3 Circuit breaker modelling 57
5.4.4 Switches modelling 57
5.4.5 PD monitoring by UHF method 58
6 Power transformer 58
6.1 Summary 58
6.2 Transformer overview 59
6.3 Transformer CMD use case diagram 60
6.3.1 Dissolved gas and moisture in oil supervision 60
6.3.2 Partial discharge (PD) supervision 62
6.3.3 Temperature supervision 64
6.3.4 Solid insulation aging supervision 66
6.3.5 Bubbling temperature supervision 69
6.3.6 Bushing supervision 70
6.3.7 Cooling supervision 72
6.3.8 Ancillary sensors supervision 75
6.4 Preliminary modelling approach 77
6.4.1 Dissolved gas and moisture in oil supervision 77
6.4.2 Partial discharge (PD) supervision 78
6.4.3 Transformer supervision 78
6.4.4 Solid insulation aging supervision 78
6.4.5 Bubbling temperature supervision (use SIML) 78
6.4.6 Bushing supervision 79
6.4.7 Cooling supervision 79
6.4.8 Ancillary sensors supervision 79

7 Load tap changer (LTC) 79
7.1 Summary 79
7.2 Load tap changer overview 80
7.3 Constraints/assumptions/design considerations 80
7.4 Data flow 82
7.5 Use case diagram 83
7.5.1 Monitoring LTC operation properties 84
7.5.2 Monitoring LTC operation counts 86
7.5.3 Monitoring contact abrasion 87
7.5.4 Monitoring LTC oil temperature and flow 89
7.5.5 Monitoring operation of oil filter unit 91
7.6 Data description table 92
7.6.1 Monitoring operation property 92
7.6.2 Monitoring operation counts 94
7.6.3 Monitoring contact abrasion 95
7.6.4 Monitoring LTC oil temperature and flow 95
7.6.5 Monitoring operation of oil filter unit 96
8 Underground cable (UGC) 97
8.1 Summary 97
8.2 Underground cable overview 97
8.2.1 General 97
8.2.2 XLPE (cross-linked polyethylene insulated) cable 97
8.2.3 OF (Oil Filled) cable 98
8.3 Constraints/assumptions/design considerations 98
8.4 Data flow 98
8.5 Use case diagram 100
8.5.1 General 100
8.5.2 Thermal aging supervision 100
8.5.3 Supervision of cable parts cracking 101
8.5.4 Insulation aging supervision 104
8.5.5 Water-tree supervision 105
8.5.6 Supervision of earth fault without circuit breaker trip 107
8.5.7 Oil aging supervision 109
8.5.8 Oil leak supervision 110
8.6 Data description table 112
8.6.1 Sensor items held in existing LNs 112
8.6.2 Sensor items requiring a new LN 112
8.6.3 Supervising items held in existing LNs 113
8.6.4 Supervising items requiring new DO’s in an existing LN 113
8.6.5 Supervising items requiring a new LN 113
9 Transmission line (TL) 113
9.1 Summary 113
9.2 Transmission line overview 114
9.2.1 Overhead transmission line (OHTL) 114
9.2.2 Line sensor unit 115
9.3 TL CMD use case diagram 116
9.3.1 Line condition supervisor 116
9.3.2 Tower condition supervisor 117
9.3.3 Insulator condition supervisor 119

9.3.4 Surrounding area supervisor 121
9.4 Data description table 123
10 Auxiliary power system 124
10.1 Summary 124
10.2 Auxiliary power system overview 124
10.2.1 General 124
10.2.2 Legend of diagrams 125
10.2.3 Secured DC system from AC input power 125
10.2.4 Secured AC system from DC input with AC backup 126
10.2.5 Secured AC system from AC input with AC backup 126
10.3 Data flow 126
10.4 Use case diagram 127
10.5 Data modelling 129
10.5.1 Functional breakdown 129
11 Communication Requirements 131
11.1 General issues 131
11.2 Response behaviour requirements (6.4 of IEC 61850-5:2013) 132
11.3 Requirements for data integrity (Clause 14 of IEC 61850-5:2013) 132
11.4 Communication requirements for the WAN 132
11.5 Performance issue 133
11.6 Plug and Play 133
12 Asset Management 133
12.1 Definition 133
12.2 Comparison of asset management to other systems 133
12.3 IEC 61850 services for Asset Management 134
12.3.1 General 134
12.3.2 Data set 135
12.3.3 Log 135
12.3.4 Report 135
12.3.5 Polling 136
12.3.6 SCSM 136
12.4 CMD 136
12.5 Conclusion 136
12.6 Maintenance 136
12.7 ERP Update 139
13 Logical node classes 142
13.1 General 142
13.2 Abstract Logical Nodes (AbstractLNs_90_3) 143
13.2.1 General 143
13.2.2 <<abstract>> LN: Battery Charger Name: BatteryChargerLN 144
13.3 Logical nodes for tanks (LNGroupK) 146
13.3.1 General 146
13.3.2 LN: Tank Name: KTNKExt 148
13.3.3 LN: Tower Name: KTOW 149
13.4 Logical nodes for metering and measurement (LNGroupM) 150
13.4.1 General 150
13.4.2 LN: Meteorological information Name: MMETExt 151
13.5 Logical nodes for supervision and monitoring (LNGroupS) 153

13.5.1 General 153
13.5.2 LN: Battery Name: SBAT 156
13.5.3 LN: Circuit breaker supervision Name: SCBRExt 157
13.5.4 LN: Cooling Group Supervision Name: SCGR 159
13.5.5 LN: Equipment Ageing Model Name: SEAM 160
13.5.6 LN: Fire Supervision Name: SFIR 161
13.5.7 LN: Insulation medium supervision (liquid) Name: SIMLExt 162
13.5.8 LN: Insulation moisture supervision (solid) Name: SIMS 167
13.5.9 LN: Tap changer supervision Name: SLTCExt 169
13.5.10 LN: Power Transformer supervision Name: SPTRExt 171
13.5.11 LN: Saturation temperature supervision Name: SSTP 173
13.6 Logical nodes for instrument transformers and sensors (LNGroupT) 174
13.6.1 General 174
13.6.2 LN: Density Sensor Name: TDEN 175
13.6.3 LN: Torque Name: TTRQ 176
13.6.4 LN: UHF Sensor Name: TUHF 177
13.7 Logical nodes for power transformers (LNGroupY) 178
13.7.1 General 178
13.7.2 LN: Power Transformer Supervision Name: YPTRExt 179
13.8 Logical nodes for further power system equipment (LNGroupZ) 181
13.8.1 General 181
13.8.2 LN: Auxiliary network Name: ZAXNExt 184
13.8.3 LN: Battery Name: ZBATExt 185
13.8.4 LN: Bushing Name: ZBSHExt 187
13.8.5 LN: Battery Charger Name: ZBTC 188
13.8.6 LN: Power cable Name: ZCABExt 189
13.8.7 LN: Converter Name: ZCONExt 191
13.8.8 LN: Generator Name: ZGENExt 192
13.8.9 LN: Power overhead line Name: ZLINExt 194
13.8.10 LN: UPS (Uninterruptable Power Supply) Name: ZUPS 196
14 Data object name semantics and enumerations 198
14.1 Data semantics 198
14.2 Enumerated data attribute types 206
14.2.1 General 206
14.2.2 BatteryChargerType90_3Kind enumeration 206
14.2.3 BatteryTestResult90-3Kind enumeration 207
14.2.4 BatteryType90_3Kind enumeration 207
14.2.5 ChargerOperationKind enumeration 208
14.2.6 ExternalDeviceModeKind enumeration 208
14.2.7 OperationFailureModeKind enumeration 209
14.2.8 SystemOperationModeKind enumeration 209
Annex A (informative) Usage of “T” logical node and “S” logical node in CMD application 210
Bibliography 211

Figure 1 – CMD Modelling Concept 34
Figure 2 – GIS CMD Overview 36
Figure 3 – GIS use case diagram 37

Figure 4 – Abrasion monitoring use case 41
Figure 5 – Switch monitoring use case 43
Figure 6 – Operating mechanism monitoring use case 45
Figure 7 – Maintenance planning use case 50
Figure 8 – CB operating time monitoring use case 53
Figure 9 – GIS internal structure 56
Figure 10 – Example of 3 phases compartment modelling 56
Figure 11 – Example of 3 phases CB modelling 57
Figure 12 – Example of 3 phases switch modelling 58
Figure 13 – Example of PD monitoring modelling 58
Figure 14 – Transformer principle 59
Figure 15 – Typical power transformer 60
Figure 16 – Use case for oil supervision 61
Figure 17 – Partial discharge (PD) use case 63
Figure 18 – Use case for temperature supervision 65
Figure 19 – Use case for solid insulation aging supervision 67
Figure 20 – Use case for bubbling temperature supervision 69
Figure 21 – Use case for bushing supervision 71
Figure 22 – Use case for cooling supervision 73
Figure 23 – Use case for ancillary sensors supervision 76
Figure 24 – Structure of load tap changer 80
Figure 25 – Configuration of LTC CMD system 81
Figure 26 – Data flows for LTC CMD (part 1) 82
Figure 27 – Data flows for LTC CMD (part 2) 83
Figure 28 – Data flows for LTC CMD (part 3) 83
Figure 29 – Use case for monitoring LTC operation properties 84
Figure 30 – Use case for monitoring LTC operation counts 86
Figure 31 – Use case for monitoring contact abrasion 87
Figure 32 – Use case for monitoring LTC oil temperature and flow 89
Figure 33 – Use case for monitoring operation of oil filter unit 91
Figure 34 – An online system monitoring OF (Oil Filled) cable conditions 97
Figure 35 – Cable cross-section drawing 98
Figure 36 – Supervisions of UGC and their data flows 99
Figure 37 – Supervisions of OF cables and their data flows 100
Figure 38 – Use case for thermal aging supervision 100
Figure 39 – A sensor detecting cable positions in 3 dimensions 102
Figure 40 – Use case for supervision of cable parts cracking 102
Figure 41 – Use case for insulation aging supervision 104
Figure 42 – Use case for water-tree supervision 105
Figure 43 – Use case for supervision of earth fault without circuit breaker trip 107
Figure 44 – Use case for oil aging supervision 109
Figure 45 – Use case for oil leak supervision 110
Figure 46 – Example configuration of OHTL tower cluster 115

Figure 47 – Line sensor unit 115
Figure 48 – Use case for line condition supervisor 116
Figure 49 – Use case for tower condition supervisor 118
Figure 50 – Use case for insulator condition supervisor 120
Figure 51 – Use case for surrounding area supervisor 122
Figure 52 – Legend of diagrams 125
Figure 53 – Secured DC system from AC input power 125
Figure 54 – Secured AC system from DC input with AC backup 126
Figure 55 – Secured AC system from AC input with AC backup 126
Figure 56 – Data flow of auxiliary power system 127
Figure 57 – Use case for auxiliary power system 128
Figure 58 – Secured DC system from AC input power 130
Figure 59 – Secured AC system from DC input with AC backup 130
Figure 60 – Secured AC system from AC input with AC backup 131
Figure 61 – Communication architecture for CMD 132
Figure 62 – Reporting and logging model (conceptual) from IEC 61850-7-1 135
Figure 63 – Use case for maintenance 137
Figure 64 – Use case for ERP update 140
Figure 65 – Class diagram LogicalNodes_90_3::LogicalNodes_90_3 143
Figure 66 – Class diagram AbstractLNs_90_3::AbstractLNs_90_3 144
Figure 67 – Class diagram LNGroupK::LNGroupK 147
Figure 68 – Class diagram LNGroupM::LNGroupM 151
Figure 69 – Class diagram LNGroupS::LNGroupS1 154
Figure 70 – Class diagram LNGroupS::LNGroupS2 155
Figure 71 – Class diagram LNGroupT::LNGroupT 175
Figure 72 – Class diagram LNGroupY::LNGroupY 179
Figure 73 – Class diagram LNGroupZ::LNGroupZ1 182
Figure 74 – Class diagram LNGroupZ::LNGroupZ2 183
Figure 75 – Class diagram DOEnums_90_3::DOEnums_90_3 206
Figure A.1 – Decomposition of functions into interacting LN on different levels: Examples for generic function with tele control interface, protection function and measuring/metering function (from IEC 61850-5:2003) 210

Table 37 – Attributes of (Tr)IEC61850-90-3:2015B namespace 13
Table 1 – Normative abbreviations for data object names 16
Table 2 – Data objects of BatteryChargerLN 145
Table 3 – Data objects of KTNKExt 148
Table 4 – Data objects of KTOW 149
Table 5 – Data objects of MMETExt 152
Table 6 – Data objects of SBAT 156
Table 7 – Data objects of SCBRExt 157
Table 8 – Data objects of SCGR 159
Table 9 – Data objects of SEAM 160
Table 10 – Data objects of SFIR 162

Table 11 – Data objects of SIMLExt 163
Table 12 – Data objects of SIMS 168
Table 13 – Data objects of SLTCExt 169
Table 14 – Data objects of SPTRExt 172
Table 15 – Data objects of SSTP 173
Table 16 – Data objects of TDEN 176
Table 17 – Data objects of TTRQ 177
Table 18 – Data objects of TUHF 178
Table 19 – Data objects of YPTRExt 180
Table 20 – Data objects of ZAXNExt 184
Table 21 – Data objects of ZBATExt 185
Table 22 – Data objects of ZBSHExt 187
Table 23 – Data objects of ZBTC 188
Table 24 – Data objects of ZCABExt 190
Table 25 – Data objects of ZCONExt 192
Table 26 – Data objects of ZGENExt 193
Table 27 – Data objects of ZLINExt 195
Table 28 – Data objects of ZUPS 197
Table 29 – Attributes defined on classes of LogicalNodes_90_3 package 198
Table 30 – Literals of BatteryChargerType90_3Kind 207
Table 31 – Literals of BatteryTestResult90-3Kind 207
Table 32 – Literals of BatteryType90_3Kind 208
Table 33 – Literals of ChargerOperationKind 208
Table 34 – Literals of ExternalDeviceModeKind 209
Table 35 – Literals of OperationFailureModeKind 209
Table 36 – Literals of SystemOperationModeKind 209

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 61850-90-3, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1522/DTR	57/1654/RVC

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

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

A list of all parts in the IEC 61850 series, published under the general title *Communication networks and systems for power utility automation*, can be found on the IEC website.

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

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

The contents of the corrigendum of November 2020 have been included in this copy.

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

INTRODUCTION

The CMD (Condition Monitoring Diagnosis) which diagnoses power grid health status has been one of the major issues to improve the reliability of the power system by preventing a potential failure in advance. Since too many different information modelling, information exchange, and configuration techniques for CMD in various forms from many vendors are currently used, they need to be standardized within the IEC.

IEC 61850 is intended to be used to communicate with the condition monitoring equipment. A seamless communication with the sensor network is also desirable.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis

1 Scope

1.1 General

Since the outcome of this work will affect several parts of IEC 61850, in a first step, this technical report has been prepared to address the topic from an application specific viewpoint across all affected parts of IEC 61850. This approach is similar to what is done as an example with IEC 61850-90-1 for the communication between substations. Once this technical report has been approved, the affected parts of the standard will be amended with the results from the report.

The major part of the work will consist in defining new logical nodes that contain the information for condition monitoring. It is important that the existing standards are analyzed with regard to information that is already available today. The information available in these logical nodes can as well be useful for asset management systems.

Another important aspect is a homogenous modelling approach that is to be used as well by other domains with a similar scope. Therefore, this technical report will include a chapter that describes the basic modelling approach that was used.

This technical report will address communication aspects related to specific sensor networks that are widely used as well as information exchange towards asset management systems where the IEEE PC37.239 is applicable, but it is not specific for the Condition Based Monitoring.

Several IEC technical committees cooperate to achieve harmonized (unified) models for CMD applications. Other areas of IEC work affected by the information contained in this technical report are: Overhead lines; Power transformers; Switchgear and controlgear; Electrical cables; Instrument transformers; and Wind turbines.

1.2 Namespace name and version

Table 37 shows all attributes of (Tr)IEC61850-90-3:2015B namespace.

Table 37 – Attributes of (Tr)IEC61850-90-3:2015B namespace

Attribute	Content
Namespace nameplate	
Namespace Identifier	(Tr)IEC61850-90-3
Version	2015
Revision	B
Release	1
Full Namespace Name	(Tr)IEC61850-90-3:2015B
Namespace Type	transitional
Namespace dependencies	
extends	IEC 61850-7-4:2007B version :2007 revision :B
Namespace transitional status	
Future handling of namespace content	The name space (Tr)IEC61850-90-3:2015B is considered as "transitional" since the models are expected to be included in further editions IEC 61850-7-4xx. Potential extensions/modifications may happen if/when the models are moved to the International Standard status

The table below provides an overview of all published versions of this namespace.

Edition	Publication date	Webstore	Namespace
Edition 1.0	2016-05	IEC TR 61850-90-3:2016	(Tr) IEC61850-90-3:2015
Corrigendum 1	2020-10	IEC TR 61850-90-3:2016 Cor1	(Tr) IEC61850-90-3:2015B

1.3 Data model Namespace Code Component distribution

The Code Components are in light and full version:

- The full version is named: *IEC_TR_61850-90-3.NSD.2015B.Full*. It contains definition of the whole data model defined in this standard with the documentation associated and access is restricted to purchaser of this part

- The light version is named: *IEC_TR_61850-90-3.NSD.2015B.Light*. It does not contain any documentations but contains the whole data model as per full version, and this light version is freely accessible on the IEC website for download at : http://www.iec.ch/tc57/supportdocuments, but the usage remains under the licensing conditions.

The Code Components for IEC 61850 data models are formatted in compliance with the NSD format defined by the standard IEC 61850-7-7. Each Code Component is a ZIP package containing:

- the electronic representation of the Code Component itself (possibly multiple files),

- the grammar files (XSD) enabling to check the consistency of the associated files against the defined version of NSD, but as well against the IEC 61850 flexibility rules in case of private extensions

- a file describing the content of the package (IECManifest.xml).

The IECManifest contains different sections giving information on:

- The copyright notice
- The identification of the code component
- The publication related to the code component
- The list of the electronic files which compose the code component
- An optional list of history files to track changes during the evolution process of the code component

The life cycle of a code component is not restricted to the life cycle of the related publication. The publication life cycle goes through two stages, Version (corresponding to an edition) and Revision (corresponding to an amendment). A third publication stage (Release) allows publication of Code Component in case of urgent fixes of InterOp Tissues, thus without need to publish an amendment.

Consequently new release(s) of the Code Component may be released, which supersede(s) the previous release, and will be distributed through the IEC TC57 web site at: http://www.iec.ch/tc57/supportdocuments.

The latest version/release of the document will be found by selecting the file named *IEC_TR_61850-90-3.NSD.{VersionStateInfo}.Light* with the filed VersionStateInfo of the highest value.

2 Normative references

The following referenced documents are indispensable for the application 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 TS 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-5:2013, *Communication networks and systems for power utility automation – Part 5: Communication requirements for functions and devices models 3*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*