

This is a preview of "IEC/TR 61850-90-3 Ed...". [Click here to purchase the full version from the ANSI store.](#)



Edition 1.0 2016-05

# TECHNICAL REPORT



---

**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.**

## CONTENTS

FOREWORD.....	9
INTRODUCTION.....	11
1 Scope.....	12
2 Normative references.....	13
3 Terms, definitions, abbreviations, acronyms and conventions .....	13
3.1 Terms and definitions .....	13
3.2 Abbreviations, acronyms and conventions.....	14
4 Use cases .....	32
5 GIS (Gas Insulated Switchgear).....	32
5.1 Summary .....	32
5.2 GIS overview .....	33
5.3 GIS use case diagrams .....	34
5.3.1 Gas compartments.....	34
5.3.2 Circuit breaker and switches .....	38
5.3.3 Operating mechanism .....	42
5.3.4 Monitoring issues for POW (Point-on-wave switching controller).....	49
5.4 Preliminary modelling approach.....	53
5.4.1 GIS data modelling example.....	53
5.4.2 GIS gas modelling.....	53
5.4.3 Circuit breaker modelling.....	54
5.4.4 Switches modelling .....	55
5.4.5 PD monitoring by UHF method .....	55
6 Power transformer .....	56
6.1 Summary .....	56
6.2 Transformer overview.....	56
6.3 Transformer CMD use case diagram.....	57
6.3.1 Dissolved gas and moisture in oil supervision .....	57
6.3.2 Partial discharge (PD) supervision.....	59
6.3.3 Temperature supervision.....	61
6.3.4 Solid insulation aging supervision.....	63
6.3.5 Bubbling temperature supervision.....	66
6.3.6 Bushing supervision .....	67
6.3.7 Cooling supervision.....	69
6.3.8 Ancillary sensors supervision .....	72
6.4 Preliminary modelling approach.....	74
6.4.1 Dissolved gas and moisture in oil supervision .....	74
6.4.2 Partial discharge (PD) supervision.....	75
6.4.3 Transformer supervision.....	75
6.4.4 Solid insulation aging supervision.....	75
6.4.5 Bubbling temperature supervision (use SIML).....	75
6.4.6 Bushing supervision .....	76
6.4.7 Cooling supervision.....	76
6.4.8 Ancillary sensors supervision .....	76
7 Load tap changer (LTC).....	76
7.1 Summary .....	76

7.2	Load tap changer overview .....	77
7.3	Constraints/assumptions/design considerations .....	77
7.4	Data flow .....	79
7.5	Use case diagram .....	80
7.5.1	Monitoring LTC operation properties .....	81
7.5.2	Monitoring LTC operation counts .....	83
7.5.3	Monitoring contact abrasion .....	84
7.5.4	Monitoring LTC oil temperature and flow .....	86
7.5.5	Monitoring operation of oil filter unit .....	88
7.6	Data description table .....	89
7.6.1	Monitoring operation property .....	89
7.6.2	Monitoring operation counts .....	91
7.6.3	Monitoring contact abrasion .....	92
7.6.4	Monitoring LTC oil temperature and flow .....	92
7.6.5	Monitoring operation of oil filter unit .....	93
8	Underground cable (UGC) .....	94
8.1	Summary .....	94
8.2	Underground cable overview .....	94
8.2.1	General .....	94
8.2.2	XLPE (cross-linked polyethylene insulated) cable .....	94
8.2.3	OF (Oil Filled) cable .....	95
8.3	Constraints/assumptions/design considerations .....	95
8.4	Data flow .....	95
8.5	Use case diagram .....	97
8.5.1	General .....	97
8.5.2	Thermal aging supervision .....	97
8.5.3	Supervision of cable parts cracking .....	98
8.5.4	Insulation aging supervision .....	101
8.5.5	Water-tree supervision .....	102
8.5.6	Supervision of earth fault without circuit breaker trip .....	104
8.5.7	Oil aging supervision .....	106
8.5.8	Oil leak supervision .....	107
8.6	Data description table .....	109
8.6.1	Sensor items held in existing LNs .....	109
8.6.2	Sensor items requiring a new LN .....	109
8.6.3	Supervising items held in existing LNs .....	110
8.6.4	Supervising items requiring new DO's in an existing LN .....	110
8.6.5	Supervising items requiring a new LN .....	110
9	Transmission line (TL) .....	110
9.1	Summary .....	110
9.2	Transmission line overview .....	111
9.2.1	Overhead transmission line (OHTL) .....	111
9.2.2	Line sensor unit .....	112
9.3	TL CMD use case diagram .....	113
9.3.1	Line condition supervisor .....	113
9.3.2	Tower condition supervisor .....	114
9.3.3	Insulator condition supervisor .....	116
9.3.4	Surrounding area supervisor .....	118
9.4	Data description table .....	121

10	Auxiliary power system .....	121
10.1	Summary .....	121
10.2	Auxiliary power system overview .....	122
10.2.1	General .....	122
10.2.2	Legend of diagrams .....	122
10.2.3	Secured DC system from AC input power .....	122
10.2.4	Secured AC system from DC input with AC backup .....	123
10.2.5	Secured AC system from AC input with AC backup .....	123
10.3	Data flow .....	124
10.4	Use case diagram .....	124
10.5	Data modelling .....	126
10.5.1	Functional breakdown .....	126
11	Communication Requirements.....	128
11.1	General issues .....	128
11.2	Response behaviour requirements (6.4 of IEC 61850-5:2013) .....	129
11.3	Requirements for data integrity (Clause 14 of IEC 61850-5:2013).....	129
11.4	Communication requirements for the WAN.....	129
11.5	Performance issue .....	130
11.6	Plug and Play.....	130
12	Asset Management.....	130
12.1	Definition .....	130
12.2	Comparison of asset management to other systems.....	130
12.3	IEC 61850 services for Asset Management.....	131
12.3.1	General .....	131
12.3.2	Data set.....	132
12.3.3	Log.....	132
12.3.4	Report .....	132
12.3.5	Polling .....	133
12.3.6	SCSM.....	133
12.4	CMD .....	133
12.5	Conclusion.....	133
12.6	Maintenance .....	133
12.7	ERP Update .....	136
13	Logical node classes .....	139
13.1	General.....	139
13.2	Abstract Logical Nodes (AbstractLNs_90_3) .....	140
13.2.1	General .....	140
13.2.2	<<abstract>> LN: Battery Charger Name: BatteryChargerLN.....	141
13.3	Logical nodes for tanks (LNGroupK) .....	143
13.3.1	General .....	143
13.3.2	LN: Tank Name: KTNKExt.....	145
13.3.3	LN: Tower Name: KTOW .....	146
13.4	Logical nodes for metering and measurement (LNGroupM) .....	147
13.4.1	General .....	147
13.4.2	LN: Meteorological information Name: MMETExt.....	148
13.5	Logical nodes for supervision and monitoring (LNGroupS) .....	150
13.5.1	General .....	150
13.5.2	LN: Battery Name: SBAT.....	153

13.5.3	LN: Circuit breaker supervision Name: SCBRExt.....	155
13.5.4	LN: Cooling Group Supervision Name: SCGR.....	156
13.5.5	LN: Equipment Ageing Model Name: SEAM.....	158
13.5.6	LN: Fire Supervision Name: SFIR.....	159
13.5.7	LN: Insulation medium supervision (liquid) Name: SIMLExt.....	160
13.5.8	LN: Insulation moisture supervision (solid) Name: SIMS.....	165
13.5.9	LN: Tap changer supervision Name: SLTCExt.....	167
13.5.10	LN: Power Transformer supervision Name: SPTRExt.....	169
13.5.11	LN: Saturation temperature supervision Name: SSTP.....	171
13.6	Logical nodes for instrument transformers and sensors (LNGroupT).....	172
13.6.1	General.....	172
13.6.2	LN: Density Sensor Name: TDEN.....	173
13.6.3	LN: Torque Name: TTRQ.....	174
13.6.4	LN: UHF Sensor Name: TUHF.....	175
13.7	Logical nodes for power transformers (LNGroupY).....	176
13.7.1	General.....	176
13.7.2	LN: Power Transformer Supervision Name: YPTRExt.....	177
13.8	Logical nodes for further power system equipment (LNGroupZ).....	179
13.8.1	General.....	179
13.8.2	LN: Auxiliary network Name: ZAXNExt.....	182
13.8.3	LN: Battery Name: ZBATExt.....	183
13.8.4	LN: Bushing Name: ZBSHExt.....	185
13.8.5	LN: Battery Charger Name: ZBTC.....	186
13.8.6	LN: Power cable Name: ZCABExt.....	187
13.8.7	LN: Converter Name: ZCONExt.....	189
13.8.8	LN: Generator Name: ZGENExt.....	190
13.8.9	LN: Power overhead line Name: ZLINExt.....	192
13.8.10	LN: UPS (Uninterruptable Power Supply) Name: ZUPS.....	194
14	Data object name semantics and enumerations.....	196
14.1	Data semantics.....	196
14.2	Enumerated data attribute types.....	204
14.2.1	General.....	204
14.2.2	BatteryChargerType90_3Kind enumeration.....	204
14.2.3	BatteryTestResult90-3Kind enumeration.....	205
14.2.4	BatteryType90_3Kind enumeration.....	205
14.2.5	ChargerOperationKind enumeration.....	205
14.2.6	ExternalDeviceModeKind enumeration.....	206
14.2.7	OperationFailureModeKind enumeration.....	206
14.2.8	SystemOperationModeKind enumeration.....	206
15	SCL enumerations (from DOEnums_90_3).....	207
Annex A (informative) Usage of "T" logical node and "S" logical node in CMD application.....		209
Bibliography.....		210
Figure 1 – CMD Modelling Concept.....		32
Figure 2 – GIS CMD Overview.....		34
Figure 3 – GIS use case diagram.....		35
Figure 4 – Abrasion monitoring use case.....		39

Figure 5 – Switch monitoring use case .....	41
Figure 6 – Operating mechanism monitoring use case .....	43
Figure 7 – Maintenance planning use case .....	48
Figure 8 – CB operating time monitoring use case .....	50
Figure 9 – GIS internal structure .....	53
Figure 10 – Example of 3 phases compartment modelling .....	54
Figure 11 – Example of 3 phases CB modelling .....	54
Figure 12 – Example of 3 phases switch modelling .....	55
Figure 13 – Example of PD monitoring modelling .....	55
Figure 14 – Transformer principle .....	56
Figure 15 – Typical power transformer .....	57
Figure 16 – Use case for oil supervision .....	58
Figure 17 – Partial discharge (PD) use case .....	60
Figure 18 – Use case for temperature supervision .....	62
Figure 19 – Use case for solid insulation aging supervision .....	64
Figure 20 – Use case for bubbling temperature supervision .....	66
Figure 21 – Use case for bushing supervision .....	68
Figure 22 – Use case for cooling supervision .....	70
Figure 23 – Use case for ancillary sensors supervision .....	73
Figure 24 – Structure of load tap changer .....	77
Figure 25 – Configuration of LTC CMD system .....	78
Figure 26 – Data flows for LTC CMD (part 1) .....	79
Figure 27 – Data flows for LTC CMD (part 2) .....	80
Figure 28 – Data flows for LTC CMD (part 3) .....	80
Figure 29 – Use case for monitoring LTC operation properties .....	81
Figure 30 – Use case for monitoring LTC operation counts .....	83
Figure 31 – Use case for monitoring contact abrasion .....	84
Figure 32 – Use case for monitoring LTC oil temperature and flow .....	86
Figure 33 – Use case for monitoring operation of oil filter unit .....	88
Figure 34 – An online system monitoring OF (Oil Filled) cable conditions .....	94
Figure 35 – Cable cross-section drawing .....	95
Figure 36 – Supervisions of UGC and their data flows .....	96
Figure 37 – Supervisions of OF cables and their data flows .....	97
Figure 38 – Use case for thermal aging supervision .....	97
Figure 39 – A sensor detecting cable positions in 3 dimensions .....	99
Figure 40 – Use case for supervision of cable parts cracking .....	99
Figure 41 – Use case for insulation aging supervision .....	101
Figure 42 – Use case for water-tree supervision .....	102
Figure 43 – Use case for supervision of earth fault without circuit breaker trip .....	104
Figure 44 – Use case for oil aging supervision .....	106
Figure 45 – Use case for oil leak supervision .....	107
Figure 46 – Example configuration of OHTL tower cluster .....	112
Figure 47 – Line sensor unit .....	112

Figure 48 – Use case for line condition supervisor .....	113
Figure 49 – Use case for tower condition supervisor .....	115
Figure 50 – Use case for insulator condition supervisor .....	117
Figure 51 – Use case for surrounding area supervisor .....	119
Figure 52 – Legend of diagrams .....	122
Figure 53 – Secured DC system from AC input power .....	123
Figure 54 – Secured AC system from DC input with AC backup .....	123
Figure 55 – Secured AC system from AC input with AC backup.....	124
Figure 56 – Data flow of auxiliary power system .....	124
Figure 57 – Use case for auxiliary power system .....	125
Figure 58 – Secured DC system from AC input power .....	127
Figure 59 – Secured AC system from DC input with AC backup .....	127
Figure 60 – Secured AC system from AC input with AC backup.....	128
Figure 61 – Communication architecture for CMD .....	129
Figure 62 – Reporting and logging model (conceptual) from IEC 61850-7-1.....	132
Figure 63 – Use case for maintenance .....	134
Figure 64 – Use case for ERP update.....	137
Figure 65 – Class diagram LogicalNodes_90_3::LogicalNodes_90_3 .....	140
Figure 66 – Class diagram AbstractLNs_90_3::AbstractLNs_90_3 .....	141
Figure 67 – Class diagram LNGroupK::LNGroupK .....	144
Figure 68 – Class diagram LNGroupM::LNGroupM .....	148
Figure 69 – Class diagram LNGroupS::LNGroupS1 .....	151
Figure 70 – Class diagram LNGroupS::LNGroupS2.....	152
Figure 71 – Class diagram LNGroupT::LNGroupT .....	173
Figure 72 – Class diagram LNGroupY::LNGroupY .....	177
Figure 73 – Class diagram LNGroupZ::LNGroupZ1 .....	180
Figure 74 – Class diagram LNGroupZ::LNGroupZ2 .....	181
Figure 75 – Class diagram DOEnums_90_3::DOEnums_90_3.....	204
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) .....	209
Table 1 – Normative abbreviations for data object names .....	14
Table 2 – Data objects of BatteryChargerLN.....	142
Table 3 – Data objects of KTNKExt .....	145
Table 4 – Data objects of KTOW .....	146
Table 5 – Data objects of MMETExt .....	149
Table 6 – Data objects of SBAT .....	154
Table 7 – Data objects of SCBRExt .....	155
Table 8 – Data objects of SCGR.....	157
Table 9 – Data objects of SEAM.....	158
Table 10 – Data objects of SFIR.....	160
Table 11 – Data objects of SIMLExt .....	161
Table 12 – Data objects of SIMS .....	166

This is a preview of "IEC/TR 61850-90-3 Ed...". [Click here to purchase the full version from the ANSI store.](#)

Table 13 – Data objects of SLTCExt.....	167
Table 14 – Data objects of SPTRExt .....	170
Table 15 – Data objects of SSTP.....	171
Table 16 – Data objects of TDEN .....	174
Table 17 – Data objects of TTRQ .....	175
Table 18 – Data objects of TUHF .....	176
Table 19 – Data objects of YPTRExt .....	178
Table 20 – Data objects of ZAXNExt .....	182
Table 21 – Data objects of ZBATExt.....	183
Table 22 – Data objects of ZBSHExt .....	185
Table 23 – Data objects of ZBTC.....	186
Table 24 – Data objects of ZCABExt .....	188
Table 25 – Data objects of ZCONExt.....	190
Table 26 – Data objects of ZGENExt .....	191
Table 27 – Data objects of ZLINExt .....	193
Table 28 – Data objects of ZUPS .....	195
Table 29 – Attributes defined on classes of LogicalNodes_90_3 package.....	196
Table 30 – Literals of BatteryChargerType90_3Kind .....	204
Table 31 – Literals of BatteryTestResult90-3Kind .....	205
Table 32 – Literals of BatteryType90_3Kind .....	205
Table 33 – Literals of ChargerOperationKind .....	206
Table 34 – Literals of ExternalDeviceModeKind .....	206
Table 35 – Literals of OperationFailureModeKind .....	206
Table 36 – Literals of SystemOperationModeKind.....	207



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.

This is a preview of "IEC/TR 61850-90-3 Ed...". [Click here to purchase the full version from the ANSI store.](#)

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.

A bilingual version of this publication may be issued at a later date.

**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.**

This is a preview of "IEC/TR 61850-90-3 Ed...". [Click here to purchase the full version from the ANSI store.](#)

## 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

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.

The parameters which are identifying this new namespace are:

- Namespace Version: 2015
- Namespace Revision: A
- UML model file which reflects this namespace edition: wg10uml02v18a-wg18uml02v11b-wg17uml02v17c-jwg25uml02v04c.eap, UML model version WG10UML02v18
- Namespace release date: 2015-10-05
- Namespace name: "(Tr)IEC61850-90-3:A"

The namespace "(Tr)IEC61850-90-3:A" is considered as "transitional" since the models are expected to be included in next editions of IEC 61850-7-4xx International Standards (IS). Potential extensions/modifications may happen if/when the models are moved to the International Standard status. Only the new data objects and CDCs which are not said to be inherited from existing LNs will be tagged with this namespace name. The others should still refer to the namespace where they are primarily defined."

Clauses 13 through 15 and their subclauses including XML enumerations are automatically generated from the UML model.

## **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*