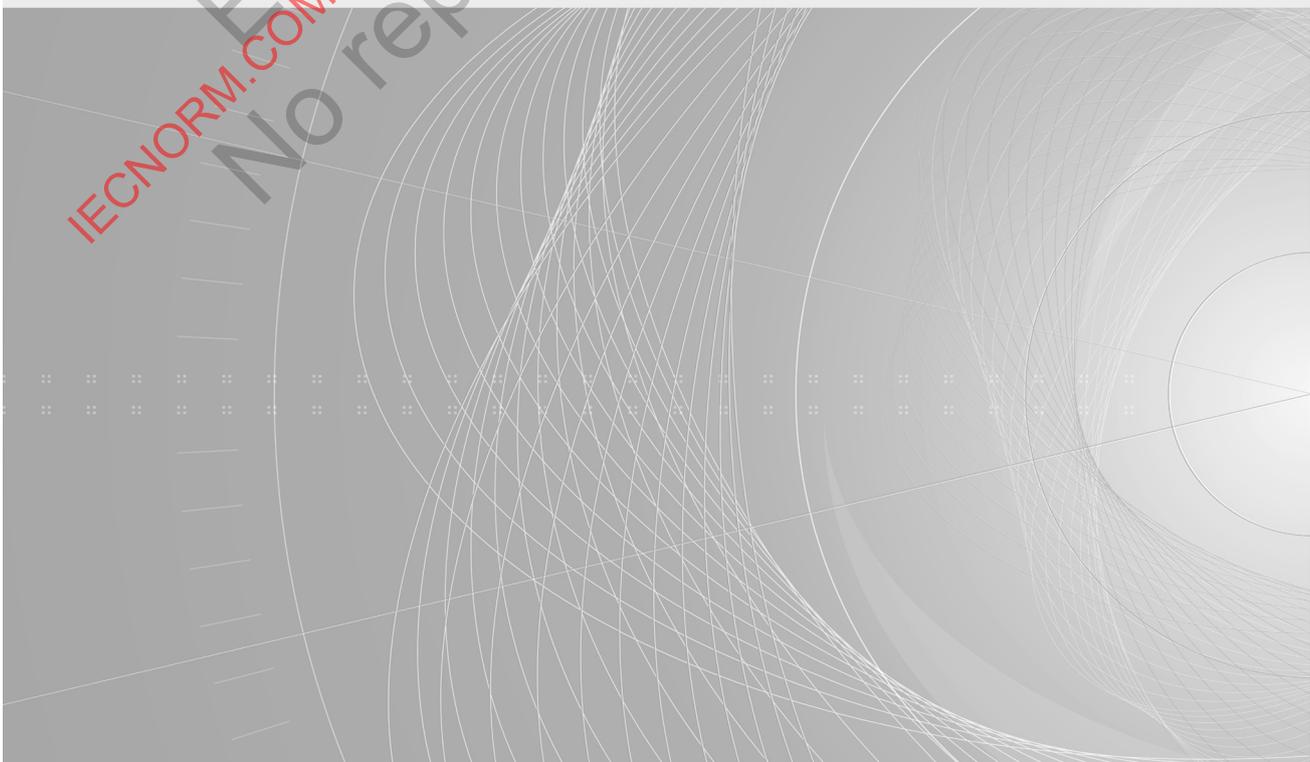


TECHNICAL REPORT



**Communication networks and systems for power utility automation –
Part 90-6: Use of IEC 61850 for Distribution Automation Systems**

Single user licence
EEESC WG on Smart Grid
IEC TR 61850-90-6 (WG):2018
No reproduction or circulation
May 2023
IECNORM.COM: Click to view the full PDF





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2018 IEC, Geneva, Switzerland

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

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

About the IEC

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

About IEC publications

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

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

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

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

Single user license for IEC Normative Publications
EESC WG on EMC (1685)-906 (WG)-2018
No reproduction or distribution without the explicit written permission of IEC
May 2018
IECNORM.COM: Click to view the full PDF file

TECHNICAL REPORT



Communication networks and systems for power utility automation –
Part 90-6: Use of IEC 61850 for Distribution Automation Systems

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-8322-6039-5

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

CONTENTS

| | |
|---|-----|
| FOREWORD..... | 9 |
| INTRODUCTION..... | 11 |
| 1 Scope..... | 13 |
| 1.1 General..... | 13 |
| 1.2 Namespace information | 13 |
| 1.3 Code components | 13 |
| 2 Normative references | 14 |
| 3 Terms, definitions, abbreviated terms and definitions of fault types | 15 |
| 3.1 Terms and definitions..... | 16 |
| 3.2 Abbreviated terms..... | 16 |
| 3.2.1 Proposed specifically for the data model part of the report..... | 16 |
| 3.2.2 Existing abbreviations used in the original IEC 61850 data object names model | 17 |
| 3.3 Definitions of fault types..... | 29 |
| 4 Common actors | 29 |
| 5 Requirements and use cases..... | 38 |
| 5.1 General..... | 38 |
| 5.2 Use case 1: Fault indication and report..... | 39 |
| 5.2.1 General | 39 |
| 5.2.2 Use case 1a: Generic use case – Not fault type specific | 39 |
| 5.2.3 Use case 1b: Overcurrent non directional Fault Localization and Indication (F1C/NC)..... | 58 |
| 5.2.4 Use case 1c: Phase to earth faults, non directional fault detection (F2) | 59 |
| 5.2.5 Use case 1d: Overcurrent and Phase to earth faults detection non directional (F3) | 59 |
| 5.2.6 Use case 1e: Overcurrent, directional and non directional, fault detection (F4)..... | 60 |
| 5.2.7 Use case 1f: Overcurrent, non directional, phase to earth faults, directional and non directional fault detection (F5)..... | 60 |
| 5.2.8 Use case 1g: Overcurrent and phase to earth faults, directional and non directional fault detection (F6) | 60 |
| 5.3 Use case 2: FLISR based on local control..... | 60 |
| 5.3.1 General | 60 |
| 5.3.2 Use case 2a: FLISR using sectionalizers detecting fault current | 60 |
| 5.3.3 Use case 2b: FLISR using sectionalizers detecting feeder voltage (SDFV) | 72 |
| 5.4 Use case 3: FLISR based on centralized control | 89 |
| 5.4.1 General | 89 |
| 5.4.2 Use case 3a: FLISR in a radial feeder based on centralized control | 89 |
| 5.4.3 Use case 3b: FLISR in an open loop feeder based on centralized control | 98 |
| 5.5 Use case 4: FLISR based on distributed control..... | 104 |
| 5.5.1 General | 104 |
| 5.5.2 Use case 4a: FLISR in an open loop network based on distributed control – Type A | 105 |
| 5.5.3 Use case 4b: FLISR based on distributed control – Type B..... | 129 |
| 5.6 Use case 5: Centralized Voltage and Var Control..... | 146 |
| 5.6.1 Description of the use case | 146 |

| | | |
|--------|---|-----|
| 5.6.2 | Diagrams of use case | 148 |
| 5.6.3 | Technical details..... | 149 |
| 5.6.4 | Step by step analysis of use case | 150 |
| 5.6.5 | Information exchanged | 152 |
| 5.7 | Use case 6: Anti-islanding protection based on communications | 152 |
| 5.7.1 | Description of the use case | 152 |
| 5.7.2 | Diagrams of use case | 154 |
| 5.7.3 | Technical details..... | 157 |
| 5.7.4 | Step by step analysis of use case..... | 158 |
| 5.7.5 | Information exchanged | 161 |
| 5.8 | Use Case 7: Automatic transfer switch..... | 161 |
| 5.8.1 | Description of the use case | 161 |
| 5.8.2 | Diagrams of use case | 162 |
| 5.8.3 | Technical details..... | 164 |
| 5.8.4 | Step by step analysis of use case..... | 164 |
| 5.8.5 | Information exchanged | 166 |
| 5.9 | Use Case 8: Monitor energy flows (Energy flow related Use cases)..... | 166 |
| 5.9.1 | Use case breakdown | 166 |
| 5.9.2 | Monitor Energy flows | 168 |
| 5.9.3 | Elaborate the direction of the energy flow | 169 |
| 5.10 | Use Case 9: Environment situation awareness..... | 172 |
| 5.10.1 | Description of the use case | 172 |
| 5.11 | Use case 10: Configuration of IEDs participating in distributed control..... | 175 |
| 5.11.1 | Description of the use case | 175 |
| 6 | Information models..... | 190 |
| 6.1 | Mapping of requirements on LNs | 190 |
| 6.1.1 | Mapping of the requirements of Fault Identification and report..... | 190 |
| 6.1.2 | Mapping of the requirements of FLISR based on local control – Type 2 | 192 |
| 6.1.3 | Mapping of the requirements of FLISR based on centralized control – Type 3 | 195 |
| 6.1.4 | Mapping of the requirements of FLISR based on distributed control – Type 4 | 196 |
| 6.1.5 | Mapping of the requirements of VVC use case – Type 5..... | 204 |
| 6.1.6 | Mapping of the requirements of anti-islanding protection use case – Type 6 | 206 |
| 6.1.7 | Mapping of the requirements of automatic transfer switch use case – Type 7 | 207 |
| 6.1.8 | Mapping of the requirements of Monitor energy flows related Use case – Type 8 | 209 |
| 6.1.9 | Mapping of Environment situation awareness use case – Type 9..... | 210 |
| 6.2 | Mapping summary of the set of UCs over the LNs (existing or new) | 213 |
| 7 | Logical node classes and data objects modelling..... | 214 |
| 7.1 | General..... | 214 |
| 7.2 | Logical node classes..... | 214 |
| 7.2.1 | General | 214 |
| 7.2.2 | Abstract LN of 90-6 namespace (Abstract90-6LNs)..... | 214 |
| 7.2.3 | LN of Group A (LNGroupA_90_6) | 219 |
| 7.2.4 | LN of Group D (LNGroupD_90_6)..... | 230 |
| 7.2.5 | LN of Group K (LNGroupK_90_6) | 232 |
| 7.2.6 | LN of Group M (LNGroupM_90_6) | 236 |

| | | |
|-----------------------|---|-----|
| 7.2.7 | LN from Group P (LNGroupP_90_6) | 249 |
| 7.2.8 | LN of Group R (LNGroupR_90_6) | 251 |
| 7.2.9 | LN of Group S (LNGroupS_90_6) | 253 |
| 7.3 | Data semantics | 265 |
| 7.4 | Enumerated data attribute types | 271 |
| 7.4.1 | General | 271 |
| 7.4.2 | Actual source (ActualSourceKind enumeration) | 272 |
| 7.4.3 | AffectedPhases90_6Kind enumeration | 273 |
| 7.4.4 | ATSAutoReturnModeKind enumeration | 273 |
| 7.4.5 | ATSSequenceResultKind enumeration | 274 |
| 7.4.6 | ATSSequenceStatusKind enumeration | 274 |
| 7.4.7 | FaultConfirmationModeKind enumeration | 275 |
| 7.4.8 | FaultPermanenceKind enumeration | 275 |
| 7.4.9 | FaultSourceTypeKind enumeration | 276 |
| 7.4.10 | GateStatusKind enumeration | 276 |
| 7.4.11 | IslandingStateKind enumeration | 277 |
| 7.4.12 | momentary close request in case of use of RFV automation (MomentaryCloseResultKind enumeration) | 277 |
| 7.4.13 | NormalSourceKind enumeration | 277 |
| 7.4.14 | RFVFuncTypeKind enumeration | 277 |
| 7.4.15 | Result of the latest restoration process (SequenceEndResultKind enumeration) | 278 |
| 7.4.16 | SequenceStatusKind enumeration | 278 |
| 7.5 | SCL enumerations (from DOEnums_90_6) | 279 |
| 8 | Communication and architectures | 281 |
| 8.1 | Types of communication architecture | 281 |
| 8.1.1 | General | 281 |
| 8.1.2 | Digital communication with remote monitoring | 281 |
| 8.1.3 | Digital communications with remote monitoring and control | 282 |
| 8.1.4 | Digital communication with distributed control | 282 |
| 8.2 | Architectures matching use cases | 283 |
| 8.3 | Cyber-security | 284 |
| 9 | Configuration | 284 |
| Annex A (informative) | Interpretation of logical node tables | 294 |
| A.1 | General interpretation of logical node tables | 294 |
| A.2 | Conditions for element presence | 294 |
| Annex B (informative) | Typical Grid topologies considered in this report | 297 |
| Bibliography | | 298 |
| Figure 1 | Actors top level hierarchy | 30 |
| Figure 2 | System Actors SGAM positioning (function) | 31 |
| Figure 3 | System Actors SGAM positioning (not function related) | 32 |
| Figure 4 | Fault indication – Main use case | 41 |
| Figure 5 | Fault indication for FPI – T1 | 42 |
| Figure 6 | Fault indication and report for FPI – T2 | 43 |
| Figure 7 | Fault indication for FPI – T3,T4 (with communication to HV/MV SS) in the context of FLISR as described in 5.4 | 44 |

| | |
|--|-----|
| Figure 8 – Fault indication for FPI – T3,T4 (without communication to HV/MV SS) in the context of FLISR as described in 5.4..... | 45 |
| Figure 9 – Voltage Presence/Absence | 59 |
| Figure 10 – FLISR use case breakdown..... | 63 |
| Figure 11 – Fault location sequence diagram..... | 64 |
| Figure 12 – Fault isolation sequence diagram..... | 65 |
| Figure 13 – Service restoration sequence diagram..... | 66 |
| Figure 14 – A distribution grid configuration in a multi-source network based on open loops | 73 |
| Figure 15 – The basic behavior of distribution feeder in FLISR using sectionalizers detecting feeder voltage | 75 |
| Figure 16 – FLISR-SDFV use case break down | 76 |
| Figure 17 – FLISR-SDFV Fault Location and Identification sequence diagram | 77 |
| Figure 18 – FLISR-SDFV Fault Location and Identification sequence diagram | 78 |
| Figure 19 – FLISR-SDFV Fault Location and Identification sequence diagram..... | 78 |
| Figure 20 – FLISR-SDFV Fault Location and Identification sequence diagram..... | 79 |
| Figure 21 – Auxiliary use cases for FLISR using SDFV | 79 |
| Figure 22 – FLISR-SDFV Set X specific time sequence diagram | 80 |
| Figure 23 – FLISR-SDFV Set Y specific time sequence diagram..... | 80 |
| Figure 24 – FLISR-SDFV Release blocking of closing sequence diagram | 80 |
| Figure 25 – FLISR-SDFV Set functional type sequence diagram..... | 81 |
| Figure 26 – FLISR-SDFV Set connection direction sequence diagram | 81 |
| Figure 27 – FLISR-SDFV Supervisory sequence diagram | 81 |
| Figure 28 – Common actors in a distribution system with FLISR using SDFV..... | 83 |
| Figure 29 – Centralized FLISR in a radial feeder – Use cases..... | 91 |
| Figure 30 – Centralized FLISR for radial feeder – Fault location sequence diagram | 92 |
| Figure 31 – Centralized FLISR for radial feeder – Fault isolation sequence diagram | 93 |
| Figure 32 – Centralized FLISR for radial feeder – Service restoration sequence diagram | 93 |
| Figure 33 – Centralized FLISR for open loop – Use case breakdown | 100 |
| Figure 34 – Centralized FLISR for open loop – Service restoration sequence diagram..... | 101 |
| Figure 35 – A distributed DAS for an open loop overhead feeder | 107 |
| Figure 36 – Distributed FLISR in an open loop network – Upstream use cases breakdown..... | 110 |
| Figure 37 – Distributed FLISR in an open loop network – Operation use cases breakdown..... | 111 |
| Figure 38 – Distributed FLISR in an open loop network – Topology discovery sequence diagram | 112 |
| Figure 39 – Distributed FLISR in an open loop network – FLISR operation sequence diagram | 114 |
| Figure 40 – Logical selectivity – FLI along the MV feeder | 131 |
| Figure 41 – Logical selectivity – FLI inside the EU plant | 132 |
| Figure 42 – Logical selectivity – FLI along the MV feeder and anti-islanding | 133 |
| Figure 43 – Distributed FLISR 4b – Use case breakdown..... | 134 |
| Figure 44 – Distributed FLISR 4b – For further analysis..... | 135 |
| Figure 45 – Volt-Var Control – Use case breakdown | 148 |

| | |
|---|-----|
| Figure 46 – Volt-Var Control – Sequence diagram | 149 |
| Figure 47 – Possible fault location on the feeder..... | 153 |
| Figure 48 – Anti-islanding protection – Use case breakdown..... | 154 |
| Figure 49 – Anti-islanding protection – Role diagram | 155 |
| Figure 50 – Anti-islanding protection – Sequence diagram..... | 156 |
| Figure 51 – Automatic transfer switch – Scenario flowchart..... | 163 |
| Figure 52 – Automatic transfer switch – Use cases breakdown | 163 |
| Figure 53 – Automatic transfer switch – Activity flowchart..... | 165 |
| Figure 54 – Monitor energy flows – use case breakdown | 167 |
| Figure 55 – Sequence diagram for the “Monitor energy flows” use case..... | 168 |
| Figure 56 – Environment situation awareness – Use cases breakdown | 173 |
| Figure 57 – Environment situation awareness – Sequence diagram | 174 |
| Figure 58 – The schematic diagram of remote configuration process | 178 |
| Figure 59 – Configuration of IEDs participating in distributed control – Use case diagram | 179 |
| Figure 60 – Configuration of IEDs participating in distributed control – Sequence diagram | 180 |
| Figure 61 – Possible arrangement of LNs to support fault passage indication | 192 |
| Figure 62 – Typical Arrangement of LNs to support FLISR using sectionalizers detecting fault current | 193 |
| Figure 63 – Typical Arrangement of LNs to support FLISR using SDFV | 194 |
| Figure 64 – Logical arrangement of LNs to support FLISR using SDFV..... | 194 |
| Figure 65 – Typical Arrangement of LNs to FLISR based on centralized control..... | 196 |
| Figure 66 – Typical arrangement of LNs to support distributed fault location (case 4a) | 197 |
| Figure 67 – Typical arrangement of LNs (between FeCtl) to support distributed fault location (case 4a) | 198 |
| Figure 68 – Typical arrangement of LNs to support distributed fault isolation (case 4a) | 199 |
| Figure 69 – Typical arrangement of LNs (between FeCtl) to support distributed fault isolation (case 4a) | 199 |
| Figure 70 – Possible arrangement to support distributed service restoration | 200 |
| Figure 71 – Break down of LNs and relationships to support distributed service restoration | 201 |
| Figure 72 – Possible LN arrangement of breakers related functions, contributing to distributed FLISR (case 4b) | 203 |
| Figure 73 – Possible LN arrangement of disconnectors related functions, contributing to distributed FLISR (case 4b) | 204 |
| Figure 74 – Possible LN arrangement for the mapping for tap changer control..... | 205 |
| Figure 75 – Possible LN arrangement for the mapping for capacitor bank control | 206 |
| Figure 76 – Breakdown of LNs and relationships to support unintentional islanding protection | 207 |
| Figure 77 – Possible arrangement of LNs to perform automatic transfer switch..... | 209 |
| Figure 78 – Possible arrangement of LNs to Monitor energy flows related Use cases | 210 |
| Figure 79 – Possible arrangement of LNs to support Environment situation awareness use cases | 212 |
| Figure 80 – Class diagram LogicalNodes_90_6::LogicalNodes_90_6..... | 214 |
| Figure 81 – Class diagram Abstract90-6LNs::LN AbstractLN 90_6..... | 215 |

| | |
|--|-----|
| Figure 82 – Statechart diagram LNGroupA_90_6::AATS Generic state-machine | 219 |
| Figure 83 – Statechart diagram LNGroupA_90_6::AATS Normal-Back-up | 220 |
| Figure 84 – Class diagram LNGroupA_90_6::LN GroupA 90_6 | 221 |
| Figure 85 – Class diagram LNGroupD_90_6::LN GroupD 90_6 | 231 |
| Figure 86 – Class diagram LNGroupK_90_6::LN GroupK 90_6 | 233 |
| Figure 87 – Class diagram LNGroupM_90_6::LN GroupM (1) 90_6 | 236 |
| Figure 88 – Class diagram LNGroupM_90_6::LN GroupM (2) 90_6 | 237 |
| Figure 89 – Class diagram LNGroupP_90_6::LN GroupP 90_6 | 249 |
| Figure 90 – Class diagram LNGroupR_90_6::LN GroupR 90_6 | 251 |
| Figure 91 – Class diagram LNGroupS_90_6::LN GroupS (1) 90_6 | 253 |
| Figure 92 – Class diagram LNGroupS_90_6::LN GroupS (2) 90_6 | 254 |
| Figure 93 – Class diagram DOEnums_90_6::DO Enumerations 90_6 | 272 |
| Figure 94 – Centralised distribution automation architecture with monitoring | 281 |
| Figure 95 – Centralised distribution automation architecture with monitoring and control | 282 |
| Figure 96 – Distributed control architecture | 282 |
| Figure 97 – Mixed distribution automation architecture combining distributed and centralised monitoring and control | 283 |
| Figure 98 – Distributed feeder automation system for an open loop overhead feeder | 285 |
| Figure 99 – Configuration process for the information exchange between substation automation and grid automation systems | 286 |
| Figure B.1 – Typical grid topologies | 297 |
| Table 1 – Normative abbreviations for data object names | 17 |
| Table 2 – Normative abbreviations for data object names | 17 |
| Table 3 – Time based Fault types | 29 |
| Table 4 – List of common actors | 33 |
| Table 5 – Mapping of Fault Identification and report use case 1 requirements onto LNs | 190 |
| Table 6 – Mapping of FLISR using sectionalizers detecting fault current use case 2a requirements onto LNs | 193 |
| Table 7 – Mapping of FLISR using SDFV use case 2b requirements onto LNs | 195 |
| Table 8 – Mapping of Distributed FLISR (fault location) use case 4a onto LNs | 196 |
| Table 9 – Mapping of Distributed FLISR (fault isolation) use case 4a onto LNs | 198 |
| Table 10 – Mapping of Distributed FLISR (service restoration) use case 4a onto LNs | 200 |
| Table 11 – Mapping of Distributed FLISR use case 4b requirements onto LNs | 202 |
| Table 12 – Mapping of anti-islanding use case requirements onto LNs | 206 |
| Table 13 – Mapping of automatic transfer switch use case requirements onto LNs | 208 |
| Table 14 – Energy flow related use case requirement mapping over LNs | 210 |
| Table 15 – Mapping of Environment situation awareness use cases to existing or new LNs | 211 |
| Table 16 – Data objects of AutomatedSequenceLN | 216 |
| Table 17 – Data objects of AutomaticSwitchingLN | 217 |
| Table 18 – Data objects of ASWI | 222 |
| Table 19 – Data objects of AATS | 224 |
| Table 20 – Data objects of AFSI | 226 |

| | |
|---|-----|
| Table 21 – Data objects of AFSL..... | 227 |
| Table 22 – Data objects of ASRC..... | 229 |
| Table 23 – Data objects of DISL | 232 |
| Table 24 – Data objects of KFIM..... | 234 |
| Table 25 – Data objects of KILL | 235 |
| Table 26 – Data objects of MENVExt | 238 |
| Table 27 – Data objects of MMETExt | 240 |
| Table 28 – Data objects of MMTNExt..... | 242 |
| Table 29 – Data objects of MMTRExt..... | 244 |
| Table 30 – Data objects of MMXNExt..... | 246 |
| Table 31 – Data objects of MMXUExt..... | 247 |
| Table 32 – Data objects of PTRCExt..... | 249 |
| Table 33 – Data objects of RRFV | 251 |
| Table 34 – Data objects of SCPI | 255 |
| Table 35 – Data objects of SFOD..... | 256 |
| Table 36 – Data objects of SFPI | 257 |
| Table 37 – Data objects of SFST | 259 |
| Table 38 – Data objects of SGPD | 260 |
| Table 39 – Data objects of SSMK | 262 |
| Table 40 – Data objects of SPSE | 263 |
| Table 41 – Data objects of SVPI | 264 |
| Table 42 – Attributes defined on classes of LogicalNodes_90_6 package | 265 |
| Table 43 – Literals of ActualSourceKind..... | 273 |
| Table 44 – Literals of AffectedPhases90_6Kind | 273 |
| Table 45 – Literals of ATSAutoReturnModeKind | 274 |
| Table 46 – Literals of ATSSequenceResultKind | 274 |
| Table 47 – Literals of ATSSequenceStatusKind | 275 |
| Table 48 – Literals of FaultConfirmationModeKind | 275 |
| Table 49 – Literals of FaultPermanenceKind..... | 276 |
| Table 50 – Literals of FaultSourceTypeKind..... | 276 |
| Table 51 – Literals of GateStatusKind..... | 276 |
| Table 52 – Literals of IslandingStateKind | 277 |
| Table 53 – Literals of MomentaryCloseResultKind | 277 |
| Table 54 – Literals of NormalSourceKind | 277 |
| Table 55 – Literals of RFVFuncTypeKind | 278 |
| Table 56 – Literals of SequenceEndResultKind..... | 278 |
| Table 57 – Literals of SequenceStatusKind..... | 278 |
| Table 58 – Distribution automation architecture matching the use cases..... | 283 |
| Table 59 – Mapping information models onto the protocol..... | 284 |
| Table A.1 – Interpretation of logical node tables | 294 |
| Table A.2 – Conditions for presence of elements within a context..... | 294 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**COMMUNICATION NETWORKS AND SYSTEMS
FOR POWER UTILITY AUTOMATION –****Part 90-6: Use of IEC 61850 for Distribution Automation Systems**

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 61850-90-6, 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 |
| 57/1929/DTR | 57/2008/RVDTR |

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

As a reminder a Joint Ad Hoc Group (JAHWG 51) had been set up between IEC Technical Committee 38 and IEC TC 57 in order to capture the requirements elaborated by the experts of the Fault Passage Indicators domain, which resulted in the publication of IEC TR 62689-100 in October 2016.

As agreed in the term of reference of this JAHWG 51, IEC TC 57 merged the conclusions of the above work within this document.

In return, it was agreed that IEC 62689-3, dealing with *Current and Voltage sensors or detectors, to be used for fault passage indication purposes – Part 3: Communication*, should be based on the content of IEC TR 61850-90-6.

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.

INTRODUCTION

IEC 61850 consists of the following parts, under the general title *Communication networks and systems for power utility automation* (all parts may have not been published yet).

- Part 1: Introduction and overview
- Part 2: Glossary
- Part 3: General requirements
- Part 4: System and project management
- Part 5: Communication requirements for functions and device models
- Part 6: Configuration description language for communication in electrical substations related to IEDs
- Part 7-1: Basic communication structure – Principles and models
- Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)
- Part 7-3: Basic communication structure – Common data classes
- Part 7-4: Basic communication structure – Compatible logical node classes and data classes
- Part 7-410: Hydroelectric power plants – Communication for monitoring and control
- Part 7-420: Basic communication structure – Distributed energy resources logical nodes
- Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- Part 80-1: Guideline to exchange information from a CDC based data model using IEC 60870-5-101/104
- Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3
- Part 90-1: Use of IEC 61850 for the communication between substations
- Part 90-2: Using IEC 61850 for the communication between substations and control centres¹
- Part 90-3: Using IEC 61850 for condition monitoring
- Part 90-4: Network Engineering Guidelines – Technical report
- Part 90-5: Using IEC 61850 to transmit synchrophasor information according to IEEE C37.118
- Part 90-7: Object models for power converters in distributed energy resources (DER) systems
- Part 90-8: Object model for E-mobility
- Part 10: Conformance testing

In addition to the above, the IEC 61850 basic communication structure for Wind Turbines has been published as IEC 61400-25, *Wind turbines – Communications for monitoring and control of wind power plants*.

IEC 61850-1 is an introduction and overview of the IEC 61850 series. It describes the philosophy, work approach and contents of the other parts.

Distribution Automation (DA) is a concept which emerged in the 1970s to promote the application of computer and communication technologies for the betterment of distribution system operating performance. It is in general used as an umbrella term to capture the deployment of automation technologies for protection, control, monitoring, and operation of distribution systems. These technologies enable electric utilities to monitor, control, and

¹ Under preparation. Stage at the time of publication: IEC/PWI 61850-90-2:2018.

operate distribution components in a real-time or non-real-time mode. The industry is also pushing towards smart and active distribution networks which support the high penetration of Distributed Energy Resources (DERs) and have better supply reliability and operation efficiency. As a result, DA concepts are also being extended in the form of Advanced Distribution Automation (ADA), which includes automation of DERs and demand response programs.

A widely-recognized instance of a DA project involves utilization of communication and information technology to enable real-time monitoring and control of switching devices including circuit breakers, line reclosers, automatic sectionalizers as well as capacitor banks and line regulators in MV networks. This control can be achieved in local, distributed, and central means. Local control is implemented inside a device based on local measurements. Distributed control involves peer-to-peer communication among relevant field devices. Central control is SCADA-like and is implemented in a substation or control room. This category of DA is also referred to as Feeder Automation (FA). Before the deployment of FA, the switching operations have to be done by the field crew, requiring physical patrolling of the feeder route to locate faults and manual verification of every switching action. Evidently, this practice prolongs the switching time and gives rise to extended outage times and system inefficiencies. With the application of data collection and real-time control through FA, these switching tasks are accomplished in an automated fashion giving rise to accelerated restoration times which are much less than those offered by the legacy systems.

Single user license
EESC WG on Smart Grids
No reproduction or circulation
May 2023
IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6:2018

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-6: Use of IEC 61850 for Distribution Automation Systems

1 Scope

1.1 General

The contents of Distribution Automation (DA) vary between different countries, regions, even between different utilities in the same country. DA may cover HV/MV substations, MV networks, LV networks, distributed energy resources, as well as demand sides. This part of IEC 61850, which is a technical report, provides basic aspects that need to be considered when using IEC 61850 for information exchange between systems and components to support Distribution Automation applications, within MV network automation, as presented in Annex B.

In particular, this document:

- defines use cases for typical DA applications that require information exchange between two or more components/systems
- provides modelling of components commonly used in DA applications
- proposes new logical nodes and the extensions to the existing logical nodes that can be used in typical DA applications.
- provides guidelines for the communication architecture and services to be used in DA applications
- provides configuration methods for IEDs to be used in DA systems.

Its content also results from the merge of the preparatory work exposed in IEC TR 62689-100 – *Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 100: Requirements and proposals for the IEC 61850 series data model extensions to support fault passage indicators applications.*

1.2 Namespace information

The parameters which identify this new release of this namespace are:

- Namespace Version: 2018
- Namespace Revision: A
- UML model file which reflects this namespace edition: wg10uml02v20draft20-wg18uml02v11b-wg17uml02v22-jwg25uml02v04c-tc17umlv0-tc38umlv0.eap, UML model version WG10UML02v20draft20
- Namespace release date: 2018-05-20
- Namespace name: "(Tr)IEC61850-90-6:2018A"

The name space "(Tr)IEC61850-90-6:2018A" is considered as "transitional" since the models are expected to be included in IEC 61850-7-4xx Edition 2. Potential extensions/modifications may happen if/when the models are moved to the International Standard status.

1.3 Code components

This IEC standard includes Code Components i.e. components that are intended to be directly processed by a computer. Such content is any text found between the markers <CODE BEGINS> and <CODE ENDS>, or otherwise is clearly labelled in this standard as a Code Component.

The purchase of this IEC standard carries a copyright license for the purchaser to sell software containing Code Components from this standard to end users either directly or via distributors, subject to IEC software licensing conditions, which can be found at: www.iec.ch/CCv1.

In this document, code components are contained in the tables and XML code lines located within Clause 7.

A separate file contains the electronic version of these code components.

The Code Components included in this IEC document are also available in a light version (without the description textual elements) as electronic machine readable file at:

http://www.iec.ch/tc57/supportdocuments/IEC_61850-90-6.NSD.2018A.light.zip

The Code Component(s) included in this IEC standard are potentially subject to maintenance works and the user shall select the latest release in the repository located at: <http://www.iec.ch/tc57/supportdocuments>.

The latest version/release of the document will be found by selecting the file of name: IEC_61850-90-6.NSD.{VersionStateInfo}.light.zip with the filed VersionStateInfo of the highest value.

In case of any differences between the code components available at the address given above and the IEC pdf published content, the code component(s) published on the IEC web site (see above) is(are) valid; they may be subject to updates. See history files of these code components.

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 TS 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

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

IEC 61850-6:2009, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-6:2009/AMD1:2018²

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

IEC 61850-7-2:2010/AMD1:2018²

IEC 61850-7-3:2010, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-3:2010/AMD1:2018³

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 61850-7-4:2010/AMD1:2018⁴

IEC 61850-8-1:2011, *Communication networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

² Under preparation. Stage at the time of publication: IEC/AFDIS 61850-7-2/AMD1:2018.

³ Under preparation. Stage at the time of publication: IEC/AFDIS 61850-7-3/AMD1:2018.

⁴ Under preparation. Stage at the time of publication: IEC/AFDIS 61850-7-3/AMD1:2018.

IEC 61850-8-2⁵, *Communication networks and systems for power utility automation – Part 8-2: Specific Communication Service Mapping (SCSM) – Mapping to Extensible Messaging Presence Protocol (XMPP)*

IEC TS 61850-80-1, *Communication networks and systems for power utility automation – Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104*

IEC TR 61850-90-2, *Communication networks and systems for power utility automation – Part 90-2: Using IEC 61850 for communication between substations and control centres*

IEC 62689-1:2016, *Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 1: General principles and requirements*

IEC 62689-2, *Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 2: System aspects*

IEC 62559-2, *Use case methodology – Part 2: Definition of the templates for use cases, actor list and requirements list*

3 Terms, definitions, abbreviated terms and definitions of fault types

For the purposes of this document, the terms and definitions given in IEC 61850-2 and IEC 61850-7-2 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>

⁵ Under preparation. Stage at the time of publication: IEC/CFDIS 61850-8-2:2017.

3.1 Terms and definitions

3.1.1

fault passage indicator

FPI

device able to detect faults providing indications about their localization (upstream or downstream from the FPI's location) and/or about the direction of fault current (usually referred as the direction of load current, i.e. from the HV/MV transformer towards end of MV feeders in a radial operated network)

[SOURCE: IEC 62689-1:2016, 3.1.1]

3.1.2

substation

substation of a power system

part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines, switchgear and housing and which may also include transformers

Note 1 to entry: This generally includes facilities necessary for system security and control (e.g. the protective devices).

Note 2 to entry: Applies equally to overhead and underground equipment.

[SOURCE: IEC 62689-1:2016, 3.1.3, modified (addition of Note 2 to entry)]

3.1.3

distribution substation unit

DSU

device (or a combination of devices and/or functions) able to perform, in addition to specific FPI's functionalities, additional features, not strictly related to fault detection (for instance remote communication/commands, Switch control or Breaker control, Network Automation, Distributed Energy Resources monitoring and control, etc.)

Note 1 to entry: Could also be named Distribution Automation Unit.

[SOURCE: IEC 62689-1:2016, 3.1.4]

3.2 Abbreviated terms

3.2.1 Proposed specifically for the data model part of the report

Table 1 shows normative terms that are combined to create data object names.

Table 1 – Normative abbreviations for data object names

| Term | Description | Term | Description |
|-------|---------------------------|-------|---|
| Abc | Absence | Nph | Not phase related |
| Alwd | Allowed | Pm | Permanent |
| Ani | Animal | Q | Quadrant |
| Ats | Automatic transfer switch | Q1 | Refer to the quadrant Q1 of the P/Q diagram |
| Cfm | Confirm | Q2 | Refer to the quadrant Q2 of the P/Q diagram |
| Drn | Drone | Q3 | Refer to the quadrant Q3 of the P/Q diagram |
| Evo | Evolution, Evolutive | Q4 | Refer to the quadrant Q4 of the P/Q diagram |
| Fght | Fighting | Rsto | Restoration |
| Frz | Freezing | Rtn | Return |
| Hmn | Human | Seism | seism |
| Illum | Illumination | Sfx | Self-extinguishing |
| Imd | Immediate | Sht | Shutter |
| Inf | Information | Spm | Semi-permanent |
| Isld | island, islanding | Tfr | Transfer |
| Itm | Intermittent | Uxp | Unexpected |
| Mmnt | Momentary | | |
| Nml | Normal | | |

3.2.2 Existing abbreviations used in the original IEC 61850 data object names model

Table 2 shows normative terms that are combined to create data object names.

Table 2 – Normative abbreviations for data object names

| Term | Description | Term | Description |
|-------|---|-------|--|
| A | Current; phase A (L1) | Admin | Administrative |
| AC | AC, alternating current | Adp | Adapter, adaptation |
| AGC | Automatic generation control | Aff | Affected |
| ASG | Analogue setting CDC | Age | Ageing |
| AWatt | Wattmetric component of current | Ahr | Ampere hours |
| Abr | Abrasion | Air | Air |
| Abs | Absolute | Alg | Algorithm |
| Absb | Absorbing | Alm | Alarm |
| Acc | Accuracy; acceleration (deprecated: use Accl instead) | Als | Alarm set |
| Accl | Acceleration | Alt | Altitude |
| Accm | Accumulated | Altn | Alternate |
| Ack | Acknowledgement, acknowledge | Amnt | Amount |
| Acs | Access | Amp | Ampere, current DC or non-phase-related AC |
| Act | Action, activity, active, activate | An | Analogue |
| Actr | Actuator | Anc | Ancillary |
| Acu | Acoustic | Ane | Anemometer |
| Addr | Address | Ang | Angle |
| Adj | Adjustment | Ap | Access point |
| | | Apc | Analogue point control |

| Term | Description |
|------|-------------------------------------|
| App | Apparent |
| Ar | Amperes reactive (reactive current) |
| Arc | Arc |
| Area | Area |
| Arr | Array |
| Asyn | Asynchronous |
| At | At |
| Auth | Authorisation |
| Auto | Automatic |
| Aux | Auxiliary |
| Av | Average |
| Avl | Availability |
| Ax | Axial |
| Azi | Azimuth |
| B | Bushing; phase B (L2) |
| BG | Before Gain |
| Bac | Binary-controlled analogue value |
| Bar | Barrier |
| Base | Base |
| Bat | Battery |
| Bck | Backup |
| Bec | Beacon |
| Beh | Behaviour |
| Ber | Bit error rate |
| Bias | Bias |
| Bl | Blade |
| Blb | Bulb |
| Blk | Block, blocked |
| Blow | Blowby |
| Bnd | Band, bandwidth |
| Boil | Boiler |
| Bot | Bottom |
| Brcb | Buffered report control block |
| Brg | Bearing |
| Brk | Brake |
| Bsc | Binary status control |
| Bst | Boost |
| Bt | Heartbeat |
| Bub | Bubbling |
| Bus | Bus |
| Byp | Bypass |
| C | Carbon; phase C (L3) |
| C2H2 | Acetylene |
| C2H4 | Ethylene |

| Term | Description |
|-------|--|
| C2H6 | Ethane |
| CB | Circuit breaker |
| CE | Cooling equipment (see also CI) |
| CG | Core ground |
| CH4 | Methane |
| CHP | Combined heat and power |
| CO | Carbon monoxide |
| CO2 | Carbon dioxide |
| Cab | Cable |
| Cal | Calorie, caloric |
| Cam | Cam, e.g. rotating non-circular disk |
| Can | Cancel |
| Cap | Capability, capacity |
| Capac | Capacitance |
| Car | Carrier |
| Cbr | Calibration |
| Ccw | Counter clockwise |
| Ccy | Currency |
| Cds | Condensation |
| Ceil | Ceiling |
| Cel | Cell |
| Cf | Crest factor |
| Cff | Coefficient |
| Cfg | Configuration |
| Cg | Combusted Gas |
| Ch | Channel |
| Cha | Charger |
| Chg | Change |
| Chk | Check |
| Chr | Characteristic |
| Chs | Chassis |
| Circ | Circulating, circuit |
| CI | Cooling, coolant, cooling system (see also CE) |
| Clc | Calculate, calculated |
| Clip | Clip |
| Clk | Clock |
| Cloud | Cloud |
| Clr | Clear |
| Cls | Close, closed |
| Cm | Centimetres |
| Cmbu | Combustible, combustion |
| Cmd | Command |
| Cmpl | Completed, completion, complete |

| Term | Description |
|---------|---|
| Cmut | Commute, commutator |
| Cndct | Conductivity, Conducting |
| Cnt | Counter |
| Cntt | Contractual |
| Cnv | Converter |
| Col | Coil |
| Comm | Communication |
| Comp | Compensation |
| ConfRev | Configuration revision (confRev from IEC 61850-7-2) |
| Conn | Connected, connections |
| Cons | Constant (general) |
| Cor | Correction |
| Core | Core |
| Cost | Cost |
| Crank | Crank |
| Crd | Coordination |
| Crit | Critical |
| Crl | Correlation |
| Crp | Creeping, slow movement |
| Crv | Curve |
| Csmp | Consumption, consumed |
| Ctl | Control |
| Ctr | Center |
| Cum | Cumulative |
| Cur | Current |
| Cut | Cut, cut-out, cut-in |
| Cvr | Cover, cover level |
| Cw | Clockwise |
| Cwb | Crowbar |
| Cyc | Cycle |
| D | Derivate |
| DC | DC, direct current |
| DER | Distributed energy resource |
| DExt | De-excitation |
| DPCSO | Double point controllable status output |
| DQ0 | Direct, quadrature, and zero axis quantities |
| DS | Device state |
| DT | Daylight saving time |
| Dam | Dam |
| Damp | Damping |
| Date | Date, date and time of action |
| Day | Day |
| Db | Deadband |

| Term | Description |
|---------|-------------------------------------|
| Dcl | DC-link |
| Dct | Direct |
| De | De (prefix) |
| Dea | Dead |
| Dec | Decrease |
| Deg | Degrees |
| Dehum | De-humidifier |
| Del | Delta |
| Den | Density |
| Dep | Dependent |
| Desc | Description |
| Det | Detected |
| Detun | Detuning |
| Dev | Device |
| Dew | Dew |
| Dff | Diffuse |
| Dfl | Deflector (used in Pelton turbines) |
| Dft | Default |
| Dia | Diaphragm |
| Diag | Diagnostics |
| Dif | Differential, difference |
| Dig | Digital |
| Dip | Dip |
| Dir | Direction |
| Dis | Distance |
| Dist | Distribution |
| Dith | Dither |
| DI | Delay |
| Dlt | Delete |
| Dlv | Delivery |
| Dmd | Demand |
| Dn | Down, downstream |
| Dpc | Double point control |
| Dpt | Departure |
| Drag | Drag hand |
| Dropout | Dropout |
| Drp | Droop |
| Drt | Derate |
| Drtb | Draft tube |
| Drv | Drive |
| Dsa | Disable, disabled |
| Dsc | Discrepancy |
| Dsch | Discharge |
| Dscon | Disconnected |

| Term | Description |
|------|---|
| Dsp | Displacement |
| Dtc | Detection |
| Dur | Duration |
| Dust | Dust |
| Dv | Deviation |
| Dw | Delta Omega |
| Dyn | Dynamic |
| EE | External equipment |
| EF | Earth fault |
| EFN | Earth-fault neutraliser (Petersen coil) |
| EMA | E-mobility Account |
| ENG | Enumerated status setting CDC |
| ENS | Enumerated status CDC |
| EPC | Emergency Power Control |
| EV | Electrical Vehicle |
| EVSE | EV Supply Equipment |
| Echo | Echo |
| Ecp | Electrical connection point |
| Edt | Edit, edited |
| Efc | Efficiency |
| EI | Elevation |
| Ela | Elasticity |
| Em | Emission |
| Emg | Emergency |
| En | Energy |
| Ena | Enabled, enable, allow operation |
| Enc | Enumerated control |
| Encl | Enclosure |
| End | End |
| Eng | Engine |
| Ent | Entity, entities |
| Entr | Entry, entries |
| Env | Environment |
| Eq | Equalization, equal, equivalent |
| Err | Error |
| Est | Estimated |
| Ev | Evaluation |
| Evn | Even |
| Evt | Event |
| Ex | External |
| ExIm | Export/import |
| Exc | Exceeded |
| Excl | Exclusion |
| Exp | Expired |

| Term | Description |
|---------|-------------------------------------|
| Exps | Expansion |
| Expt | Export |
| Ext | Excitation |
| F | Float |
| FA | Fault arc |
| FPM | Fuel processing module |
| Fa | "Fire all" sequence (to thyristors) |
| Fact | Factor |
| Fail | Failure |
| Fan | Fan |
| Fbc | Field breaker configuration |
| Fer | Frame error rate |
| Fil | Filter, filtration system |
| Fire | Fire |
| Fish | Fish |
| Fix | Fixed |
| Fld | Field |
| Flk | Flicker |
| Fll | Fall |
| Fllm | Flame |
| Flood | Flood |
| Flsh | Flash, flashing |
| Flt | Fault |
| Flush | Flush |
| Flw | Flow, flowing |
| Fol | Follower, following |
| Forc | Forced |
| Fu | Fuse |
| Fuel | Fuel |
| Full | Full |
| Fun | Function |
| Fwd | Forward |
| Gain | Gain |
| Gas | Gas |
| Gbx | Gearbox |
| Gdv | Guide vane |
| Gen | General |
| Glob | Global |
| Gm | Grand master |
| Gn | Generator |
| Gnd | Ground |
| GoCBRef | GOOSE control block reference |
| Gocb | GOOSE control block |

| Term | Description |
|--------|---|
| Gr | Group |
| Gra | Gradient |
| Grd | Guard |
| Gri | Grid |
| Gross | Gross |
| Gs | Grease |
| Gte | Gate |
| Gust | Gust |
| H | Harmonics (phase-related) |
| H2 | Hydrogen |
| H2O | Water (chemical aspect: liquid, steam, etc.) |
| HP | Hot point |
| HPh | Harmonics phase |
| Ha | Harmonics (non-phase-related AC) |
| Har | Harmonic |
| Hb | Harmonic bin |
| Hd | Head |
| Health | Health |
| Heat | Heater, heating, heat (see also Ht) |
| Hello | Hello signal, Live signal, "I am alive" signal |
| Hi | High, highest |
| Hif | Half |
| Hold | Hold |
| Hor | Horizontal |
| Horn | Horn |
| Ht | Heating, heating system (see also Heat) |
| Htex | Heat-exchanger |
| Hub | Hub |
| Hum | Humidity |
| Hy | Hydraulic, hydraulic system |
| Hyd | Hydrological, hydro, water |
| Hys | Hysteresis |
| Hz | Frequency |
| Hz1 | Frequency at side 1 |
| Hz2 | Frequency at side 2 |
| I | Integral, integration |
| ING | Integer status setting CDC |
| INS | Integer status CDC |
| ISCSO | Integer status controllable status output |
| Ia | Information available |
| Iafm | Information available force majeure |
| Iano | Information available non-operative |
| Ianof | Information available non-operative forced outage |

| Term | Description |
|----------|---|
| Ianopca | Information available non-operative planned corrective action |
| Ianos | Information available non-operative suspended |
| Ianosm | Information available non-operative scheduled maintenance |
| Iao | Information available operative |
| Iaog | Information available operative generating |
| Iaogfp | Information available operative generating with full performance |
| Iaogpp | Information available operative generating with partial performance |
| Iaong | Information available operative non-generating |
| Iaongel | Information available operative non-generating out of electrical specification |
| Iaongen | Information available operative non-generating out of environment specification |
| Iaongrs | Information available operative non-generating requested shutdown |
| Iaongts | Information available operative non-generating technical standby |
| Ice | Ice |
| Id | Identity, identifier |
| Ieee | IEEE definition |
| IeeeKH | Proportional gain HF (High Frequency). Defined in IEEE 421.5 |
| IeeeKH1 | Proportional gain HF positive. Defined in IEEE 421.5 |
| IeeeKH11 | Lead gain HF positive. Defined in IEEE 421.5 |
| IeeeKH17 | Lead gain HF negative. Defined in IEEE 421.5 |
| IeeeKH2 | Proportional gain HF negative. Defined in IEEE 421.5 |
| IeeeKI | Proportional gain IF (Intermediate Frequency). Defined in IEEE 421.5 |
| IeeeKI1 | Proportional gain IF positive. Defined in IEEE 421.5 |
| IeeeKI11 | Lead gain IF positive. Defined in IEEE 421.5 |
| IeeeKI17 | Lead gain IF negative. Defined in IEEE 421.5 |
| IeeeKI2 | Proportional gain IF negative. Defined in IEEE 421.5 |
| IeeeKL | Proportional gain LF (Low Frequency). Defined in IEEE 421.5 |
| IeeeKL1 | Proportional gain LF positive. Defined in IEEE 421.5 |
| IeeeKL11 | Lead gain LF positive. Defined in IEEE 421.5 |
| IeeeKL17 | Lead gain LF negative. Defined in IEEE 421.5 |
| IeeeKL2 | Proportional gain LF negative. Defined in IEEE 421.5 |

| Term | Description |
|-----------|---|
| leeeKs1 | Gain Ks1. Defined in IEEE 421.5 |
| leeeKs2 | Gain Ks2. Defined in IEEE 421.5 |
| leeeKs3 | Gain Ks3. Defined in IEEE 421.5 |
| leeeM | Ramtrack lowpass degree M. Defined in IEEE 421.R |
| leeeN | Ramtrack overall degree N. Defined in IEEE 421.5 |
| leeeT1 | Time constant T1. Defined in IEEE 421.5 |
| leeeT10 | Time constant T10. Defined in IEEE 421.5 |
| leeeT11 | Time constant T11. Defined in IEEE 421.5 |
| leeeT2 | Time constant T2. Defined in IEEE 421.5 |
| leeeT3 | Time constant T3. Defined in IEEE 421.5 |
| leeeT4 | Time constant T4. Defined in IEEE 421.5 |
| leeeT7 | Time constant T7. Defined in IEEE 421.5 |
| leeeT8 | Time constant T8. Defined in IEEE 421.5 |
| leeeT9 | Time constant T9. Defined in IEEE 421.5 |
| leeeTH1 | Time constant TH1 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH1 0 | Time constant TH10 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH1 1 | Time constant TH11 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH1 2 | Time constant TH12 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH2 | Time constant TH2 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH3 | Time constant TH3 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH4 | Time constant TH4 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH5 | Time constant TH5 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH6 | Time constant TH6 (High frequency positive). Defined in IEEE 421.5 |
| leeeTH7 | Time constant TH7 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH8 | Time constant TH8 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH9 | Time constant TH9 (High frequency negative). Defined in IEEE 421.5 |
| leeeT11 | Time constant T11 (Intermediate frequency positive). Defined in IEEE 421.5 |
| leeeT110 | Time constant T110 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT111 | Time constant T111 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT112 | Time constant T112 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT12 | Time constant T12 (Intermediate frequency positive). Defined in IEEE 421.5 |
| leeeT13 | Time constant T13 (Intermediate frequency positive). Defined in IEEE 421.5 |

| Term | Description |
|------------|--|
| leeeT14 | Time constant T14 (Intermediate frequency positive). Defined in IEEE 421.5 |
| leeeT15 | Time constant T15 (Intermediate frequency positive). Defined in IEEE 421.5 |
| leeeT16 | Time constant T16 (Intermediate frequency positive). Defined in IEEE 421.5 |
| leeeT17 | Time constant T17 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT18 | Time constant T18 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT19 | Time constant T19 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeTL1 | Time constant TL1 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL1 0 | Time constant TL10 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL1 1 | Time constant TL11 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL1 2 | Time constant TL12 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL2 | Time constant TL2 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL3 | Time constant TL3 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL4 | Time constant TL4 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL5 | Time constant TL5 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL6 | Time constant TL6 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL7 | Time constant TL7 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL8 | Time constant TL8 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL9 | Time constant TL9 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTw1 | Time constant wash out Tw1. Defined in IEEE 421.5 |
| leeeTw2 | Time constant wash out Tw2. Defined in IEEE 421.5 |
| leeeTw3 | Time constant wash out Tw3. Defined in IEEE 421.5 |
| leeeTw4 | Time constant wash out Tw4. Defined in IEEE 421.5 |
| leeeVHM ax | Maximum limit set-point HF. Defined in IEEE 421.5 |
| leeeVHM in | Minimum limit set-point HF. Defined in IEEE 421.5 |
| leeeVIM ax | Maximum limit set-point IF. Defined in IEEE 421.5 |
| leeeVIMi n | Minimum limit set-point IF. Defined in IEEE 421.5 |
| leeeVLM ax | Maximum limit set-point LF. Defined in IEEE 421.5 |
| leeeVLMi n | Minimum limit set-point LF. Defined in IEEE 421.5 |

| Term | Description |
|--------------|--|
| IEEEVsi1 Max | Input High Limit 1. Defined in IEEE 421.5 |
| IEEEVsi1 Min | Input Low Limit 1. Defined in IEEE 421.5 |
| IEEEVsi2 Max | Input High Limit 2. Defined in IEEE 421.5 |
| IEEEVsi2 Min | Input Low Limit 2. Defined in IEEE 421.5 |
| IEEEVstMax | Output High Limit. Defined in IEEE 421.5 |
| IEEEVstMin | Output Low Limit. Defined in IEEE 421.5 |
| Imb | Imbalance |
| Imp | Impedance non-phase-related AC |
| Impact | Impact |
| Impt | Import |
| In | Input |
| Ina | Inactivity |
| Inc | Integer control |
| Incl | Inclination |
| Incr | Increment, increase |
| Ind | Indication |
| Indp | Independent |
| Iner | Inertia |
| Inh | Inhibit |
| Inl | Inline |
| Inlet | Inlet |
| Inn | Inner |
| Ins | Insulation |
| Insol | Insolation |
| Inst | Instantaneous |
| Int | Integer |
| Intm | Intermediate |
| Intrn | Internal |
| Intr | Interrupt, interruption |
| Intv | Interval |
| Inv | Inverter, inverted, inverse |
| Isc | Integer status control |
| Isld | Islanded |
| Iso | Isolation |
| Iu | Information unavailable |
| Ix | Index |
| Jmp | Jump |
| Jnt | Joint |
| K | Constant (regulation) |
| K0Fact | Zero-sequence (residual) compensation factor |

| Term | Description |
|-------|-----------------------------------|
| KFact | K factor (harmonics) |
| Kck | Kicker |
| Key | Key, physical control device |
| L | Lower (action) |
| LDC | Line drop compensation |
| LDCR | Line drop compensation resistance |
| LDCX | Line drop compensation reactance |
| LDCZ | Line drop compensation impedance |
| LED | Light-emitting diode |
| LTC | Load tap changer |
| Last | Last |
| Ld | Lead |
| Ldp | Link discovery protocol |
| Leap | Leap (second) |
| Len | Length |
| Lev | Level |
| Lft | Lifting, lift |
| Lg | Lag |
| Life | Lifetime |
| Lim | Limit |
| Lin | Line |
| Liv | Live |
| Lkd | Locked |
| Lkg | Leakage |
| LI | Last long (interval) |
| Lo | Low (state or value) |
| Loc | Local |
| Locb | Log control block |
| Lod | Load, loading |
| Log | Log |
| Lok | (use Lkd instead) Locked |
| Loop | Loop |
| Los | Loss |
| Ls | Last short (interval) |
| Lst | List |
| Lub | Lubrication |
| Lum | Luminosity |
| M | Minutes |
| MV | Measured value CDC |
| Mac | Media access control, MAC-address |
| Made | Made |
| Mag | Magnetic, magnitude |
| Maint | Maintenance |
| Man | Manual |

| Term | Description |
|--------|--|
| Mat | Material |
| Mau | Medium access unit |
| Max | Maximum |
| Mbr | Membrane |
| Md | Motor drive |
| Mdul | Module |
| Meas | Measurement |
| Mech | Mechanical |
| Media | Media |
| Mem | Memory |
| Min | Minimum |
| Mir | Mirror |
| Mlt | Multiple |
| Mns | Mains |
| Mod | Mode |
| Mot | Motor |
| Mrg | Margin |
| Mrk | Market |
| Mst | Moisture |
| Msv | Main signaling voltage |
| Msvcb | Multicast sampled values control block |
| Mth | Method |
| Mult | Multiplier |
| Mvm | Movement, moving |
| N2 | Nitrogen |
| NOx | Nitrogen oxide |
| NQS | Average partial discharge current |
| Nam | Name |
| Name | Name (reserved for use in data objects EENAME and LNName only) |
| Ndl | Needle (used in Pelton turbines) |
| NdsCom | Needs commissioning |
| Neut | Neutral |
| Ng | Negative |
| Ngt | Negotiation |
| Nhd | Net head |
| Night | Night |
| No | No, not |
| Nom | Nominal, normalising |
| Num | Number |
| Nxt | Next |
| O2 | Oxygen |
| O3 | Ozon, trioxygen |
| Obl | Obligation |

| Term | Description |
|---------|---------------------------------------|
| Oc | Open circuit |
| Odd | Odd |
| Of | Offline |
| Off | Off, device disengaged, not running |
| Ofs | Offset |
| Oil | Oil |
| On | On, device applied, running |
| Oo | Out of |
| Op | Operate, operating, operation |
| Operate | Operate order to any device |
| Opn | Open, opened |
| Ord | Order |
| Out | Output |
| Ov | Over, override, overflow |
| Ovl | Overload |
| Ox | Oxidant |
| P | Proportional |
| PF | Power factor |
| PH | Acidity, value of pH |
| PNV | Phase-to-neutral voltage |
| POW | Point on wave switching |
| PP | Phase to phase |
| PPV | Phase to phase voltage |
| PT1 | Low-pass exponential time rate filter |
| Pa | Partial |
| Pair | Pair, paired |
| Pap | Paper |
| Par | Parallel |
| Pas | Passive |
| Path | Path |
| Pcb | Power quality classifier bin |
| Pct | Percent, percentage |
| Pdm | Power quality demodulation |
| Pe | Electric Power |
| Per | Periodic, period |
| Ph | Phase to reference |
| Phs | Phase |
| Phy | Physical |
| Pi | Instantaneous real power |
| Pin | Pin |
| Pipe | Pipe |
| Pk | Peak |
| Pl | Plant |
| Plg | Plug |

| Term | Description | Term | Description |
|--------|---------------------------------------|-------|---|
| Pls | Pulse | React | Reactance, reactive |
| Plt | Plate; long-term flicker severity | Rec | Reclose |
| Pmp | Pump | Rec1 | Reclose after single phase fault |
| Po | Polar | Rec13 | Reclose after evolving fault |
| Pol | Polarizing | Rec3 | Reclose after three phase fault |
| Polytr | Polytropic | Recha | Recharge, recharging |
| Port | Port | Rect | Rectifier |
| Pos | Position | Red | Redundant; (deprecated meaning) reduction |
| Pot | Potentiometer | Ref | Reference |
| Prc | Price, pricing | Reg | Regulation |
| Pre | Pre- | Rel | Release |
| Prec | Precondition, initial status | Req | Requested |
| Pres | Pressure | Res | Residual |
| Prg | Progress, in progress | Reso | Resonance |
| Prim | Primary | Reuse | Reuse |
| Prio | priority | Rf | Refreshment |
| Prm | Permissive | Rin | Reinsertion |
| Pro | Protection | Ris | Resistance |
| Proc | Process | RI | Relation, relative |
| Proxy | Proxy | Rm | Mutual resistance |
| Prs | Presence | Rmp | Ramping, ramp |
| Prt | Parts, part | Rms | Root mean square |
| Ps | Positive | Rn | Rain |
| Psk | Penstock | Rnbk | Runback |
| Pss | PSS, power system stabiliser function | Rng | Range |
| Pst | Post, short-term flicker severity | Rod | Rod |
| Pt | Point | Root | Root |
| Pth | Pitch | Rot | Rotation, rotor |
| Pwr | Power | Rpt | Repeat, repetition |
| Qty | Quantity | Rs | Reset, resettable |
| Qu | Queue | Rsl | Result |
| Qud | Quad | Rst | Restraint, restriction |
| R | Raise, increase | Rsv | Reserve |
| Rad | Radiation | Rt | Ride-through |
| Ral | Rail | Rte | Rate |
| Ramp | Ramp | Rtg | Rating |
| Rat | Ratio | Rub | Run-up/back |
| Rb | Runner blade | Run | Run |
| Rcd | Record, recording | Rv | Reverse |
| Rch | Reach | Rvc | Rapid voltage change |
| Rcl | Reclaim | Rvrt | Revert |
| Rct | Reaction | Rwy | Runaway, e.g. in runaway speed |
| Rdy | Ready | Rx | Receive, received |
| Re | Retry | S10 | Coefficient S1.0 |

| Term | Description |
|-------|---|
| S12 | Coefficient S1.2 |
| SM | Servo, servo-motor |
| SNL | Speed-no-load, connected but not generating |
| SOx | Sulphur oxide |
| SPCSO | Single point controllable status output |
| SPG | Single point setting CDC |
| SPS | Single point status CDC |
| SPI | Single pole/phase |
| ST | Standard time |
| Saf | Safety |
| Sag | Sag |
| Sar | Surge arrestor |
| Sat | Saturation |
| Sc | Short circuit |
| Scale | Scale |
| Schd | Schedule |
| Scnd | Secondary |
| Sco | Supply change over |
| Sec | Security |
| Sel | Select |
| Self | Self |
| Seq | Sequence |
| Ser | Series, serial |
| Set | Setting |
| Sgcb | Setting group control block |
| Sh | Shunt |
| Shar | Shared |
| Shft | Shaft |
| Shld | Shielded |
| Sig | Signal |
| Sign | Sign |
| Sim | Simulation, simulated |
| Sld | Solidity |
| Slnt | Salinity, saline content |
| Slp | Sleep; slip |
| Smok | Smoke |
| Smp | Sampling |
| Snd | Sound pressure |
| Snpt | Snapshot |
| Snr | Signal to noise ratio |
| Snw | Snow |
| Soc | State of charge |
| Sof | Switch on to fault |

| Term | Description |
|---------|---|
| Spc | Single point control |
| Spcf | Specific |
| Spd | Speed |
| Spec | Spectra |
| Spir | Spiral |
| Spt | Setpoint |
| Sq | Square |
| Src | Source |
| Srfc | Surface |
| St | Status, state |
| Sta | Station, function at plant level |
| Stab | Stabilizer |
| Stat | Statistics |
| Stc | Stack |
| Std | Standard |
| Stdby | Standby |
| Step | Step |
| Stk | Stroke |
| Stl | Still, not moving |
| Stnd | Stand, standing |
| Sto | Storage, e.g. activity of storing data |
| Stop | Stop |
| Storm | Storm |
| Stow | Stow |
| Str | Start |
| Strg | String |
| Stt | Stator |
| Stuck | Stuck, cannot move |
| Sub | Sub |
| Sum | Sum |
| Sup | Supply |
| Sv | Sampled value |
| SvCBRef | SV control block reference |
| Svc | Service |
| Sw | Switch, switched |
| Swg | Swing |
| Swl | Power quality event swell |
| Syn | Synchronisation, synchronous, synchronism, synchrocheck |
| Sys | System |
| TP | Three pole/phase |
| Ta | Armature time constant |
| Tag | Tag (maintenance work in progress) |
| Tap | Tap |

| Term | Description | Term | Description |
|------|---------------------------------------|-------|--|
| Task | Task | Trp | Transient Performance Class |
| Td | Transformer derating | Trs | Transient |
| Td0p | Td0' | Trunk | Trunk |
| Td0s | Td0'' | Ts | Total signed |
| Tdd | Total demand distortion | Tu | Total unsigned |
| Tdf | Transformer derating factor | Tun | Tuning |
| Tdp | Td' | Tur | Turbine |
| Tds | Td'' | Tx | Transmit, transmitted |
| Tech | Technology | Typ | Type |
| Term | Termination | UPS | Uninterruptible power supply |
| Test | Test | UTC | Coordinated Universal Time |
| Tgt | Target | Uhf | Ultra-high-frequency |
| Thd | Total harmonic distortion | Un | Un-; under |
| Thm | Thermal | Unav | Unavailable |
| Ti | Telephone influence | Unb | Unbalanced |
| Tilt | Tilt | Unld | Unload |
| Tm | Time | Unt | Unit, production unit |
| Tm1 | Time constant 1 | Up | Up, upstream |
| Tm2 | Time constant 2 | Ups | Uninterruptible Power Supply |
| Tm3 | Time constant 3 | Urcb | Unbuffered report control block |
| Tmh | Time in h | Use | Use |
| Tmm | Time in min | Used | Used |
| Tmms | Time in ms | Usvcb | Unicast sampled values control block |
| Tmp | Temperature (°C) | Util | Utility |
| Tms | Time in s | V | Voltage |
| Tnk | Tank | V1 | Voltage at side 1 |
| Tns | Tension (stress) | V2 | Voltage at side 2 |
| Top | Top (position) | VA | Apparent power (volt amperes) |
| Topo | Topology | VAh | Apparent energy |
| Torq | Torque | VAR | Reactive power (volt amperes reactive) |
| Tot | Total | VARh | Reactive energy |
| Tow | Power | Va | Variation |
| Tp | Test Point | Vac | Vacuum |
| Tpc | Teleprotection | Val | Value |
| Tpy | Temporarily | Vbr | Vibration |
| Tq0p | Tq0' | Ver | Vertical |
| Tq0s | Tq0'' | Viol | Violation |
| Tqp | Tq' | Vis | Visibility |
| Tqs | Tq'' | Visc | Viscosity |
| Tr | Trip (electrical protection function) | Vlan | VLAN |
| Trf | Transformer | Vld | Valid, validate, validated |
| Trg | Trigger | Vlm | Volume |
| Trip | Trip (non-electrical function) | Vlv | Valve |
| Trk | Track, tracking | Vol | Voltage DC or non-phase-related AC |

| Term | Description |
|---------|---|
| VolAmpr | Non-phase-related AC reactive power |
| Vss | Steady state voltage |
| W | Active power |
| W200 | Watts peak at 200 W/m ² |
| Wac | Watchdog |
| Wash | Washout |
| Watt | Active power non-phase-related AC |
| Wav | Wave, waveform |
| Wd | Wind |
| Week | Week |
| Wei | Weak end infeed |
| Wet | Wet |
| Wgt | Weight |
| Wh | Watt hours |
| Wid | Width |
| Win | Window |
| Wkup | Wake up |
| Wld | Welding |
| Wnd | Winding |
| Wrm | Warm |
| Wrn | Warning |
| Wrs | Warning set |
| Wtr | Water (physical aspect: river, cooling, etc.) |
| Wup | Windup |

| Term | Description |
|------|---|
| X | Reactance (imaginary part of impedance) |
| X0 | Zero sequence reactance |
| X1 | Positive sequence reactance |
| X2 | Negative sequence reactance X2 |
| Xd | Synchronous reactance Xd |
| Xdir | X-direction |
| Xdp | Transient synchronous reactance Xd' |
| Xds | Subtransient reactance Xd'' |
| Xm | Mutual reactance |
| Xq | Synchronous reactance Xq |
| Xqp | Transient synchronous reactance Xq' |
| Xqs | Subtransient reactance Xq'' |
| Xsec | Cross-section |
| Ydir | Y-direction |
| Yw | Yaw |
| Z | Impedance |
| Zer | Zero |
| Zero | (use 'Zer' instead) Zero |
| Zm | Mutual impedance |
| Zn | Zone |
| Zro | Zero sequence |
| km | Kilometre |
| ppm | Parts per million |

Simple user license for circulation
 EESC VVG on 2018-05-20
 No reproduction or full PDF of IEC TR 61850-90-6 (WG):2018
 May 2018

3.3 Definitions of fault types

Table 3 describes the fault classification referred to in this document. It contains the categorization of faults according to their clearance together with the fault source types.

Table 3 – Time based Fault types

| Fault type | Description | Notes |
|--|---|--|
| Intermittent | Short fault (<20ms) appearing every 100 to 200ms | Given durations are only here as example |
| Self extinguishing | Duration < protection response time (no tripping) | |
| Transient | Eliminated by the fast cycle of recloser (cycle 1) | |
| Semi-permanent | Eliminated by the slow cycles of recloser (cycle 2 or cycle 3) | |
| Permanent | Not eliminated by the recloser cycles | |
| Evolving | Same as permanent fault but the phases in Str Data Object at the end of the fault are not the same as the phases recorded at the beginning of the fault | |
| Unknown | Unknown type | Different from the above classification |
| <p>NOTE These definitions are aligned with the conventional usage of "Transient" in textbooks relating to Network protection and Automation and with:</p> <ul style="list-style-type: none"> [IEC 60050-614:2016, 614-02-09] transient fault an insulation fault which only temporarily affects a device's dielectric properties which are restored after a short time [IE C 60050-614:2016, 614-02-12] intermittent fault a transient fault which recurs repeatedly in the same place and due to the same cause [IEC 60050-614:2016, 614-02-08] permanent fault a fault which affects a device and prevents its restoration into service until action has been taken at the point of the fault [IEC 60050-614:2016, 614-02-10] self-extinguishing fault an insulation fault where the arc extinguishes without it being necessary to disconnect the device from the system for its essential dielectric properties to be restored | | |

4 Common actors

Table 4 contains the list of the actors commonly used in this document. If additional (and specific) actors are needed in the description of the use case, they will be described in the corresponding subclause dedicated to the given use case.

Figure 1 to Figure 3 help to better understand the global hierarchy of the proposed list of actors. The figures also help to discriminate between high level actors such as system, persons, devices and application type of actors.

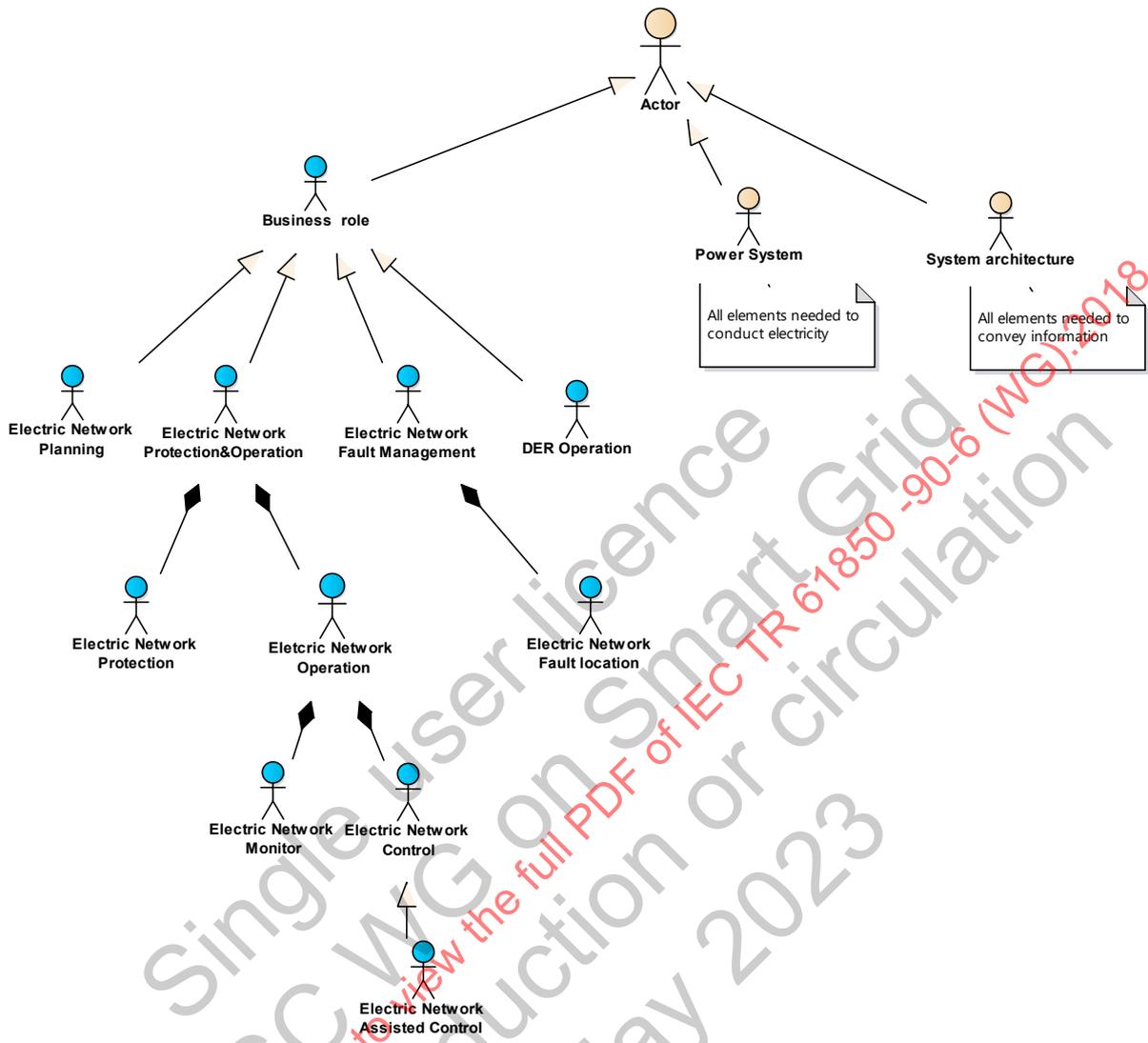


Figure 1 – Actors top level hierarchy

Single User licence
EESC WG on Smart Grid
No reproduction or circulation
IEC TR 61850-90-6 (WG) 2018
IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG) 2018
May 2023

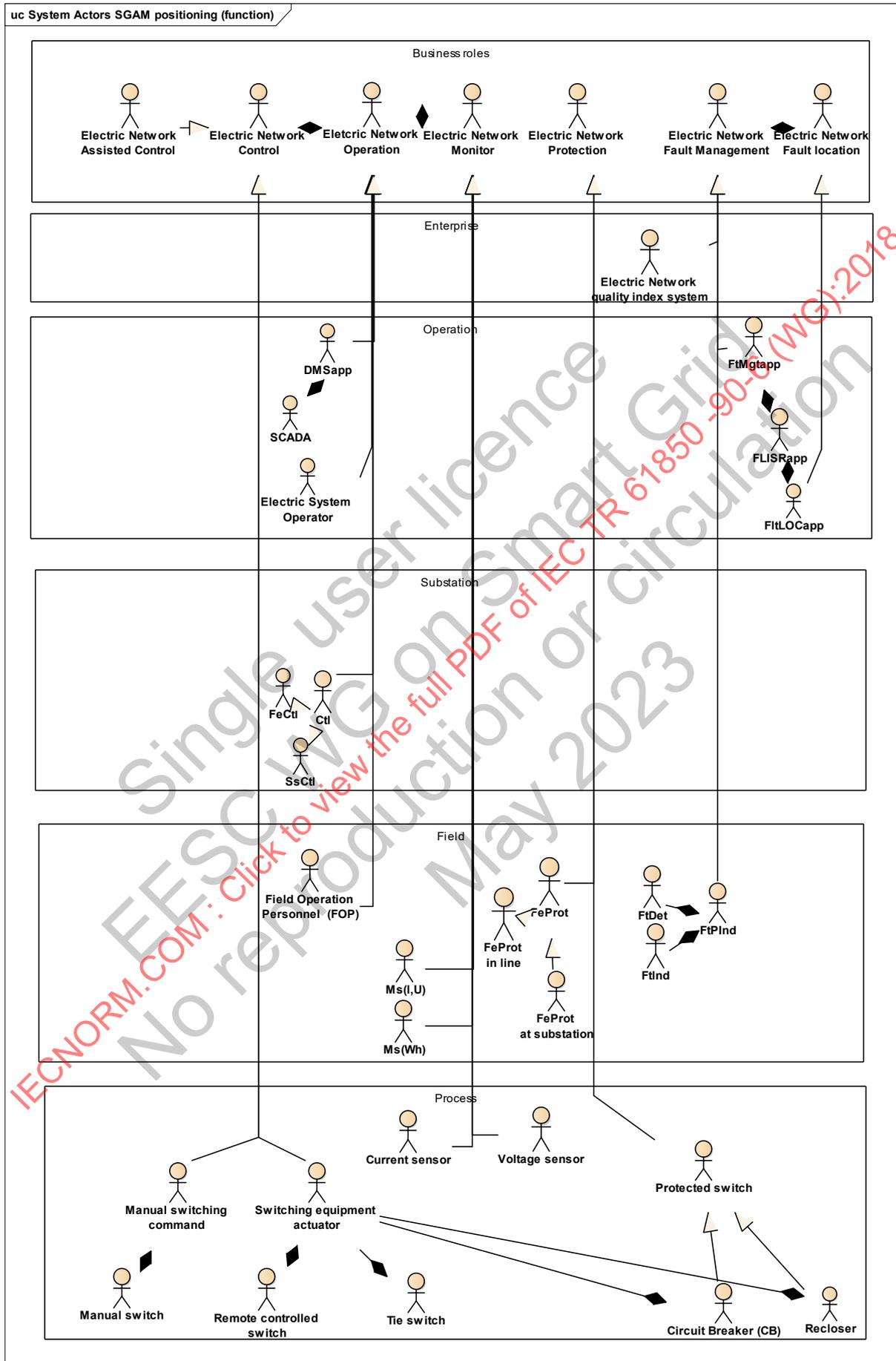


Figure 2 – System Actors SGAM positioning (function)

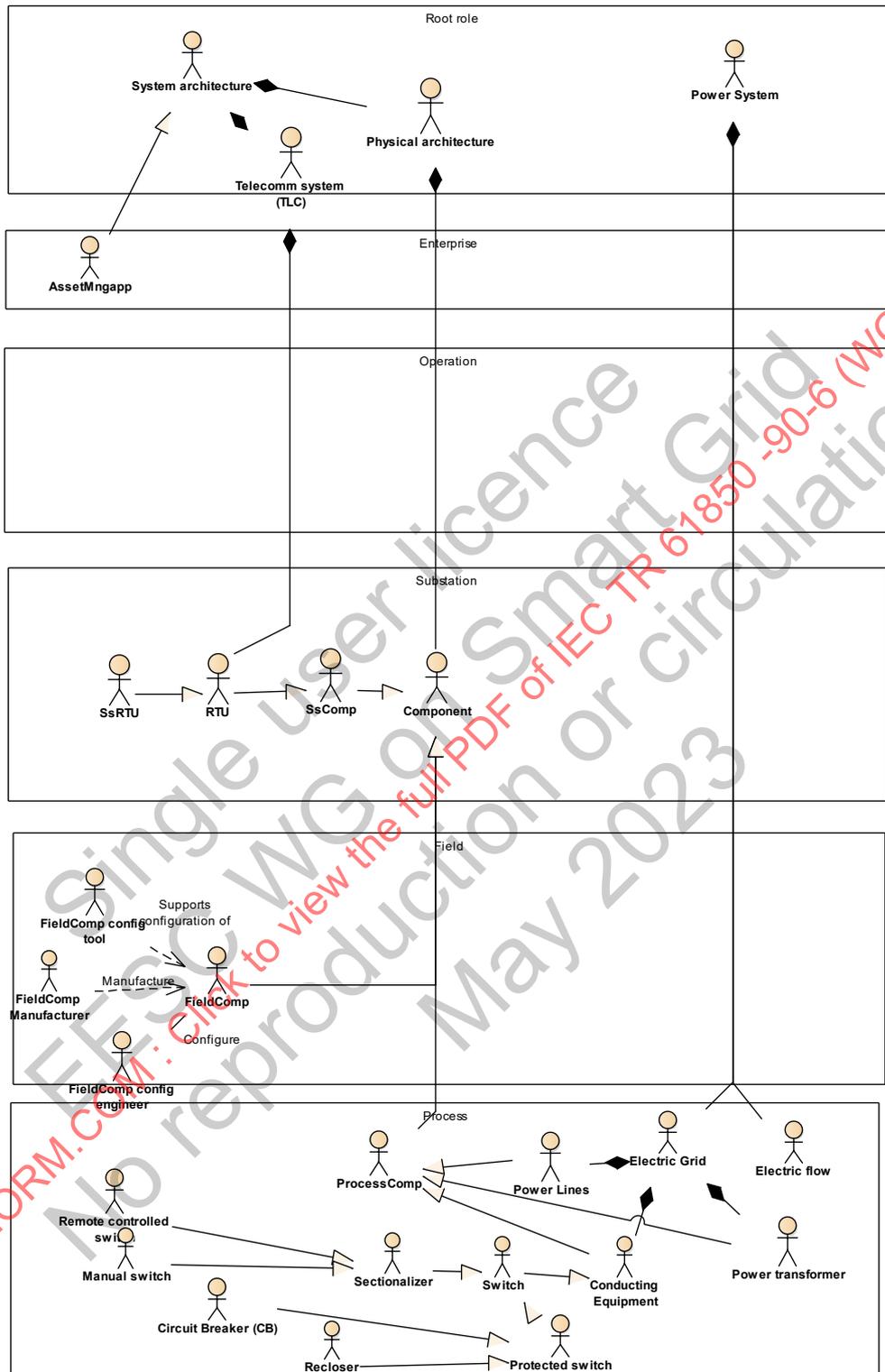


Figure 3 – System Actors SGAM positioning (not function related)

The “system architecture” tree designates the “boxes” and “wires” which are used to make the system running. These boxes host a set of functions described in Figure 2, and “wires” support “exchanges” between boxes.

In our case, we focus mostly of components located in the field. For a selected geographical area, a first class at substation level “Component” designates the upper parent class of any of

such component (hosting for example the longitude/latitude/altitude, etc.). Then they are sorted into three sub-families:

- SsComp -> the one located at “substation zone” such as RTU, Substation controller
- FieldComp -> the one located at “field zone” such as protection relay, power meters, etc.
- ProcessComp -> the one located at “process zone” such as switchgear, breakers, transformers, lines, etc.

Table 4 – List of common actors

| Actors | | | |
|---------------------------------------|-------------------|---|---|
| Actor name | Actor type | Actor description | Further information |
| Autorecloser (AR) | System field | Function which is located in the field along the feeder to protect the downstream assets by eliminating fault current and having communicating capability to indicate trip conditions to upper levels. This device includes the protection detection function and the recloser function. It also has the ability to be remotely controlled to re-energize the protected feeder. | Electric Network Protection & Operation [field-process]...autorecloser |
| Controller at distribution substation | System substation | Controller function installed at the substation level which communicates with both the field devices and the control center. FLISRapp may be implemented at the substation computer as an option. | Electric Network Assisted Control [substation]...controller ... substation ... distribution |
| DER Management System (DER MS) | System | The DER MS provides the DER-type-independent communication interface for the communication to the DMS. It forwards the information coming from the DER unit and executes the commands from the DMS. | DER Operation [operation-field] |
| DER Unit | System process | Distributed energy resources. A DER Unit consists of the physical equipment to generate, store and consume electrical power. | Power system [process]/DER [process] |
| DER Unit Controller (DERCTL) | System Field | Distributed energy resources. A DER Unit consists of the physical equipment to generate, store and consume electrical power. | DER Operation [field] |
| SysOp | People | Person who monitors network and identifies the need for and performs or contributes to perform remote operation such as required switching using the FLISRapp Application, or triggering VVC. | Electric Network Operation [Operation]...distribution grid |
| DMS application module (DMSapp) | System Operation | Refer to IRM. It represents the aggregation of Network Operation, Fault Management, and many others. DMS System feature hosted at control center level that monitors continuously the Grid network and based on a given network topology reflects the energy path and flows. | Electric Network Operation [operation] |
| Electric Grid | System process | Represent the set of equipment of a distribution feeder including lines, DER, loads, interconnections, switching equipment and voltage transformers. | Power system [process]... distribution ... feeder |
| Electric Network Fault management | System operation | Refer to IRM. | Electric Network Fault Management [operation] |

| Actors | | | |
|---|-------------------|--|--|
| Actor name | Actor type | Actor description | Further information |
| Electric Network Planning (Planning) | System enterprise | Refer to IRM. | Electric Network Planning [enterprise] |
| Electric Network quality index system (QIS) | System enterprise | System which collects outage data for reporting to Utility Commissions. | Electric Network Fault Management [enterprise]...Network quality logger |
| Electric System operator (SysOp) | People | Person who monitors network and identifies the need for and performs or contributes to perform required switching using the FLISRApp Application. | Electric Network Operation [operation] |
| Electrical measurement(Ms(I,U)) | System field | Function that elaborates electrical measurement such as I, U, P, Q, PF, | Electric Network Protection/Electric Network Operation [field-process]...Electrical measurement |
| Energy counting for operation (Ms(Wh)) | System field | Function that elaborates energy counting (for operational purpose). | Electric Network Protection/Electric Network Operation [field-process]...Energy counting |
| Power Flow direction computation(Ms(power flow direction)) | System field | Function that elaborates the direction of power flow: forward – from supply or backward – to supply (for operational purpose). | Electric Network Protection/Electric Network Operation [field-process]... Power Flow direction computation |
| Fault Indicator(FtInd) | System field | Function that identifies the presence of a fault on the Grid. | Electric Network Protection/Electric Network Operation [field-process]...Fault indication |
| Fault location application module (FtLOCapp) | System operation | Fault location module of a FLISRapp. | Electric Network Fault location [operation]...FLISR application module ... fault location |
| Fault passage indicator at feeder level (FtPInd) | System field | Function located along the feeder and capable of detecting and indicating a fault. It includes the needed sensors to perform the function. | Electric Network Fault location [field-process]...fault detector ... feeder |
| Fault signature detection (FtDet) | System field | Function that detects and reports on fault presence (including the update of concerned statistics). | Electric Network Protection/Electric Network Operation [field-process]...Fault signature detection |
| Electric Network Fault management application module (FtMgtapp) | System operation | Application module which manages or help managing network faults impact and resolution (usually part of an Outage Management application module). | Electric Network Fault Management [operation]...Fault Management application module |
| Feeder equipment controller (FeCtl) | System substation | Feeder equipment controller located along a feeder which helps to control either the feeder switching equipment and possibly a set of equipment connected to the feeder at this connection point (such as a MV/LV transformer, and a LV switchgear). | Electric Network Operation [substation-field]...feeder substation, feeder equipment |

| Actors | | | |
|---|-------------------|---|---|
| Actor name | Actor type | Actor description | Further information |
| Substation controller (SsCtl) | System substation | Substation controller which helps to control any equipment located in a selected substation (such as a HV/MV transformer, HV incomers, MV feeders). | Electric Network Operation [substation-field]... substation, substation equipment |
| External environment | System | Groups many external elements such as weather conditions, flooding conditions, live presence status, geographical perimeter status (doors, etc.). | |
| Adjacent feeder equipment controller (Adjacent FeCtl) | System substation | Feeder equipment controller located adjacent to another specific feeder equipment controller, i.e., its attached switching equipment are sharing a same line segment. | Electric Network Operation [substation-field]... feeder substation, feeder equipment...adjacent to() |
| Feeder equipment controller downstream to fault (Downstream FeCtl) | System substation | Feeder equipment controller located along a feeder and specifically located downstream to a fault. | Electric Network Operation [substation-field]...feeder substation, feeder equipment...downstream to fault |
| Feeder equipment controller upstream to fault (Upstream FeCtl) | System substation | Feeder equipment controller located along a feeder and specifically located upstream to a fault. | Electric Network Operation [substation-field]...feeder substation, feeder equipment...upstream to fault |
| Feeder Protection equipment at feeder end substation (FeProt at end substation) | System field | A Feeder Protection equipment located at the other end of the feeder. | Power system [process]/Electric Network Protection [field-process]...Protection equipment .. Feeder protection equipment... at feeder end substation |
| Feeder In Line Protection equipment (FeProt in line) | System field | A Feeder Protection equipment located within the feeder. | Power system [process]/Electric Network Protection [field-process]...Protection equipment .. Feeder protection equipment... in line |
| Feeder Protection equipment at main substation (FeProt at main substation) | System field | A breaker-type equipment associated with a protection function, located at the main substation to protect an outgoing feeder. It may have communication capability to indicate trip conditions to upper levels. It may also have the ability to be remotely controlled (closed) to re-energize the feeder. It may as well have an autoreclosing function. | Power system [process]/Electric Network Protection /Electric Network Operation[field-process]...Protection equipment .. Feeder protection equipment... at main substation |
| Feeder Protection function at substation (FeProt at substation) | System field | A function located in the substation that trips a breaker to eliminate fault current in a feeder. It may also reclose the breaker when a preconfigured delay time is expired after the breaker is tripped. | Electric Network Protection /Electric Monitor & control[field]...Protection function ... Feeder Protection function |

| Actors | | | |
|---|-------------------|--|---|
| Actor name | Actor type | Actor description | Further information |
| General Protection function at end-user side (GeneralProt-eu) | System field | A function located at the connecting point of the End User in charge of clearing faults inside its premise. | Electric Network Protection /Electric Monitor & control[field]...Protection function ... Feeder Protection function |
| Generator Interface protection function (GeneratorInterfaceProt-eu) | System field | A function(s) which are located inside the End User power plant in charge of tripping to disconnect the generators in case of faults in the Distribution Network. | Electric Network Protection /Electric Monitor & control[field]...Protection function ... Feeder Protection function |
| Generator Interface disconnection function (GeneratorInterfaceDisconnect-eu) | System field | A function(s) which are located inside the End User power plant in charge of disconnecting the generators when the GeneratorInterfaceProt -eu trips. | Electric Network Protection /Electric Monitor & control[field]...Protection function ... Feeder Protection function |
| Field level physical component (FieldComp) | System substation | IEC 61850 physical component of a selected system. | System Architecture.. Components [substation-process].. Physical component .. Field |
| Field level physical component configuration engineer (FieldComp config engineer) | People | Person who is in charge of using a Field level physical component configurator. | System Architecture.. Components [substation-process].. Physical component configurator .. Configuration engineer |
| Field level physical component configurator (FieldComp config tool) | System substation | Configurator of an IEC 61850 physical component of a selected system. | System Architecture.. Components [substation-process].. Physical component configurator .. Field |
| Field level physical component setting tool (FieldComp setting tool) | System substation | Tool used to enter field parameter settings for an IEC 61850 physical component of a selected system. | System Architecture.. Components [substation-process].. Physical component setting tool .. Field |
| Field level physical feeder sub-system configurator (FieldSyst config tool) | System operation | Configurator of a subsystem made of IEC 61850 physical components including potentially many substation/equipment of a selected feeder or a set of feeders. | System Architecture.. Feeder sub-system [operation-process] |
| Field Operation Personnel (FOP) | People | Person who is activated by people/systems in charge of monitoring network. He performs the required switching operation in field using the outcome of an overall FLISRapp. | Electric Network Operation [substation-process] |
| FLISR application module (FLISRapp) | System operation | Application module that performs Fault Location, Isolation and Service Restoration at network operation level. | Electric Network Fault location [operation]...FLISR application module |
| New Field level physical component | System substation | New IEC 61850 physical component of a selected system. | System Architecture.. Components [substation-process].. Physical component .. Field ..new |

| Actors | | | |
|--|-------------------|---|---|
| Actor name | Actor type | Actor description | Further information |
| ProcessComp | System process | Any physical component (asset, such as switch, breaker, transformer, lines, ...) located at "process zone level". It enables hosting the common properties such physical asset has, such as a physical nameplate, a volume, a location, an age, etc., | System Architecture.. Components [substation-process].. Physical component .. Process |
| Power Transformer Tap | System process | Taps actuator on transformer windings that change the turns ratio of the transformer. | Power system [process] Electric Network Operation process]... Power transformer... Tap |
| Remote terminal at Substation (Substation RTU) | System substation | Gateway function with the capability of receiving or sending data/control from or to an external source (for example, electronic multifunction meters, digital relays, controllers), ensuring the interface of a substation of field equipment to the remote world. This device may be either a function included in other devices and/or a specific device including also the so-called Remote Terminal Units. | Electric Network Operation [substation].. gateway ... remote terminal |
| Sectionalizer | System process | Function located along the feeder – sectionalizers/sectionalizing autoreclosers, and switches. | Power system [process]/Electric Network Protection&Operation [process]...sectionalizer |
| Service Restoration Controller (SRC) | System operation | The function that controls the service restoration of downstream healthy sections of a fault. This function internally gets the support of the role "Operation Planning – switching action scheduling" to establish the switching sequence – this may have been predefined at configuration. | Electric Network Assisted Control [operation] ... |
| Shunt Capacitor Switching equipment | System process | Switches associated with shunt capacitors. They can operate automatically through remote communications from the control center, or manually by the field crew. | Power system [process]/Electric Network Operation [field-process]...switching equipment ... capacitor shunt |
| Switching equipment actuator | System process | Primary equipment switches which are located along the grid lines to enable the operator or the system to isolate the faulty section. They can be manually operated or remotely/locally operated through the FSCs. In this use case we will restrict our analysis to remotely controllable switches. | Power system /Electric Network Operation [process]...switching equipment ...actuator |
| Switching equipment as Tie switch | System process | A special normally open tie point device function, which is able to sense voltage presence on both sides of its current interrupting mechanism. It also includes the logic to close the interrupting mechanism either automatically upon loss of voltage on one side, or through communication control command. This function can be implemented with recloser, sectionalizer or switch. | Power system [process]...switching equipment (Tie) |

| Actors | | | |
|----------------------------------|------------------|--|--|
| Actor name | Actor type | Actor description | Further information |
| Tie switch equipment actuator | System process | Actuator of a switching equipment operated as a Tie switch. | Power system /Electric Network Operation [process]...switching equipment (Tie) ...actuator |
| Voltage presence indicator (VPI) | System field | A device that indicates the presence of voltage over a certain limit on the measured point. It includes the needed sensors to perform the function. | Electric Network Fault location [field-process]...voltage detector |
| VVC application module (VVCapp) | System operation | Application that performs voltage and var control. It determines optimal settings for capacitors and voltage regulators, and either applies them directly to the devices or recommends them to the DSO for approval. | Electric Network Assisted control [operation]... VVC application module |

5 Requirements and use cases

5.1 General

The objective of this clause is to go down to the general high level requirements of information exchanges of Distribution Automation Systems (DASs) as a starting point for proposing the new LNs, the extension of new LNs, new communication services, communication profiles and configuration methods.

The following use cases for basic DA functions that may require the definition of new LNs and the extension of existing LNs are described hereafter:

- Fault Passage Indication:** This is the main purpose of proper devices indicated as Fault Passage Indicator (FPI) or Distribution Substation Unit (DSU), depending on their performances, which are, respectively, a device or a device/combination of devices and/or functions able to detect faults and provide indications about their localization.
- FLISR (Fault Location, Isolation and Service Restoration):** This includes the FLISR using auto reclosers and auto-sectionalizers, the FLISR based on the centralized control of the master station and the FLISR based on the distributed control scheme in which field IEDs exchange fault and control information through a peer-to-peer communication network. These are the main typical implementation/architecture for supporting the FLISR. The reality may be a mix of all these three modes.
- VVC (Voltage and Var Control):** The objective of VVC is to minimize the power losses in the network, improve the voltage profile, or both, using the settings of LTC substation transformers, bus/feeder voltage regulators and switching shunt capacitors. More advanced VVC applications may also use the active and reactive power injection by DER units as well as distribution FACTS devices such as D-STATCOM and D-SVC. Only the basic VVC scenario which involves the control of voltage regulators and switching shunt capacitors is considered in this document.
- Anti-Islanding Protection Based on Communications:** If the feeder circuit breaker opens, an unintentional islanding may have been created. The involved DERs in the island have to be forced to stop energizing the feeder for workers' safety, system security and power quality reasons. Whilst the islanding detection methods using local measurements at intertie may have none-detection zone, the anti-islanding protection can be improved through detecting the tripping of substation breakers and transmitting this information down to the DERs.
- Automatic Switch Transfer:** When a voltage loss occurs on the primary source, the system decides under specific conditions to transfer the load to the backup source.

- **Monitoring Energy Flow:** Active or reactive or net cumulated energy either per quadrant, or globally delivered or received at the point of measurement, based on the energy flows direction conventions.
- **Environment Situation Awareness:** Manages a set of specific sensors related to environment situations such as weather conditions, flooding conditions, live presence status, geographical perimeter status (doors, etc.) and elaborates from these raw measurements warnings and alarms based on pre-defined thresholds and other criteria.

A Distribution Automation System (DAS) can have up to tens of thousands of IEDs spreading over a wide area distribution network. From time to time, the new IEDs may be introduced, and the configuration of the existing IEDs may need to be modified. The current configuration method for substation automation systems may not be adequate to DASs, and a new configuration method may be needed. Therefore, a use case for introducing new IEDs and updating the configuration of existing IEDs will also be described in this clause.

5.2 Use case 1: Fault indication and report

5.2.1 General

Fault indication and report are fundamental functions for the fault management of distribution networks. The seven use cases in this clause will describe the general high level requirements of information exchanges between a Fault Passage Indicator, as defined in IEC 62689-1 and IEC 62689-2 and the rest of the Distribution Automation Systems (DASs).

These requirements are expressed under the form of use cases as recommended by IEC 62559-2. F1, F2 ... Fn refer to FPI function classes as defined in 62689-1.

In this document the meanings of the following terms are:

- **Fault Indication:** fault detection (no intra/extra-substation communication directly managed from FPI, only local indication to system operator, usually via the DMS application module);
- **Report:** following the fault identification, remote communication concerning the fault may be present and managed either by other devices, or directly from the DSU, client-server mode and/or peer-to-peer mode.

When a fault occurs on the network, the fault passage indicator needs to identify such fault. Once the fault is identified and possibly confirmed, the fault passage indicator needs to report to the external local or remote components information related to this fault. This is to allow fault clearing and possible supply restoration, as well as counting fault occurrence based on different criteria.

5.2.2 Use case 1a: Generic use case – Not fault type specific

5.2.2.1 Description of the use case

5.2.2.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|---------------------------------|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Fault identification and report |

5.2.2.1.2 Version Management

| Version management | | | | | | |
|--------------------------------------|----------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management changes / version | Date | Name author(s) or committee | Domain expert | Area of expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| First version in IEC template | 24/08/15 | JAHWG51 | | | | Draft |

5.2.2.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Related business case | Distribution System Operation |
| Scope | The Distribution Automation (DA) system with the help (or not) of the Operator identifies and locates a fault in a feeder of a radially operated network. |
| Objective | Contribute to minimize the duration of the supply interruptions. Improve the continuity of service for users connected in MV or LV, by reducing the overall process of fault isolation thanks to automation, therefore reducing the number of customer minutes lost due to outages. |

5.2.2.1.4 Narrative of use case – Short description

The fault detection process (and possible FLISR) is described considering both only local fault indication and different kinds of extra-substation communication, according to FPIs communication classes described in IEC 62689-1.

Different types of faults (short circuits, earth faults, etc.) are not considered explicitly, the fault is a generic one.

Possible automatic reclosing cycles are not considered in this generic use case

5.2.2.1.5 Narrative of use case – Complete description

The Fault Detection and indication functionalities are (optionally) preliminary set (e.g. by the Field Operation Personnel).

The monitoring of the power system is constantly performed also by the FPIs located on the radially operated power system under focus.

A fault on the power grid can be Permanent or Fugitive. The involved FPIs (located upstream to the fault) detect the fault signature and indicates to the Field Operation Personnel or/and to the FtMgtapp (fault management application), according to its communication class, the information that such fault signature was observed.

The Field Operator and the FtMgtapp have the information to perform further (out of the scope) fault isolation and service restoration actions.

The fault event may be reported to the Quality index system (refer to Clause 0) to contribute to the quality index calculation

5.2.2.1.6 General remarks

This use case describes the function of fault identification, location and report in a network which feeders are radially operated without any MV/MV autotransformer.

Currently the use case does not consider the presence of DER.

This use case assumes that the feeder has at least one FPI located upstream to the fault. The use case applies to feeders with sections of overhead line or underground cable or a mixture of both types

5.2.2.2 Diagrams of use case

For the sake of simplifying the diagram, the Quality index system (refer to Clause 4) is not represented on the sequence diagram shown in Figures 4 to 8. Basically any fault event received by the FtMgtapp should also be received by the Quality index system (refer to Clause 4).

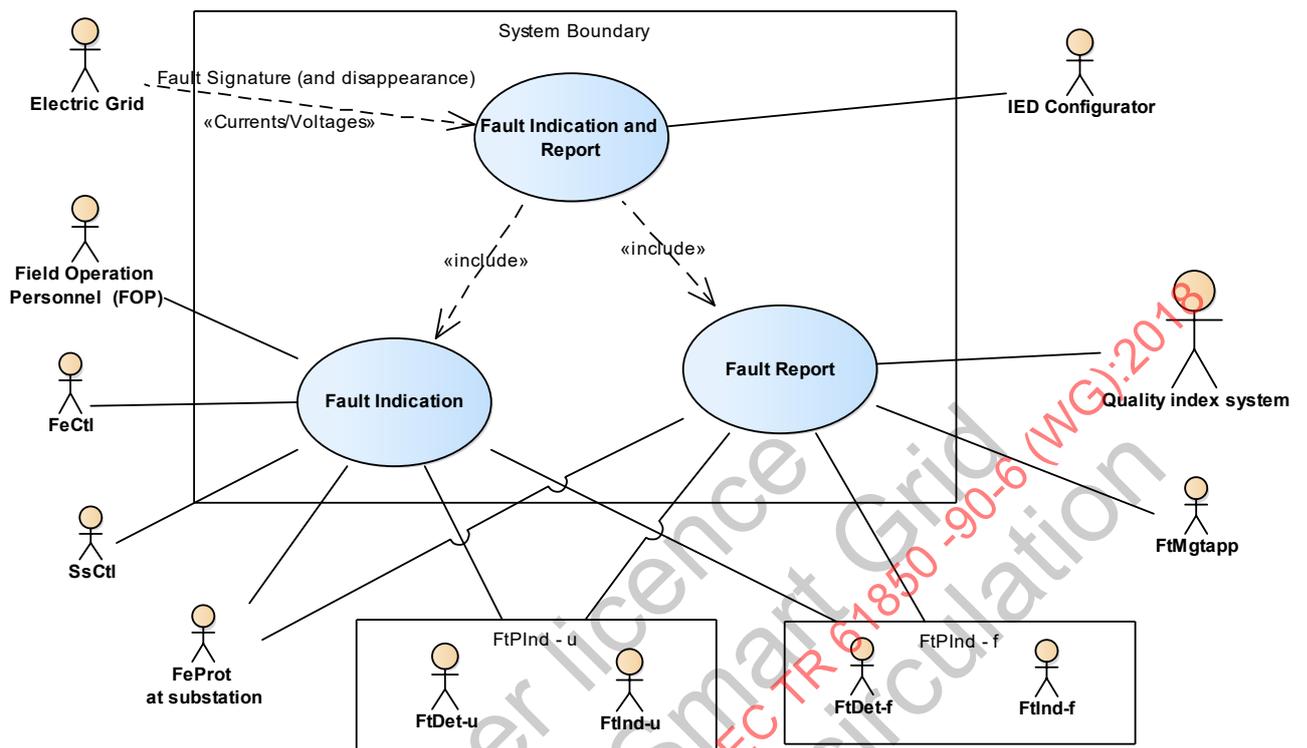


Figure 4 – Fault indication – Main use case

Single User License on Smart Grid
 EESC WG on Smart Grid
 No reproduction or circulation
 IEC NORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
 May 2023

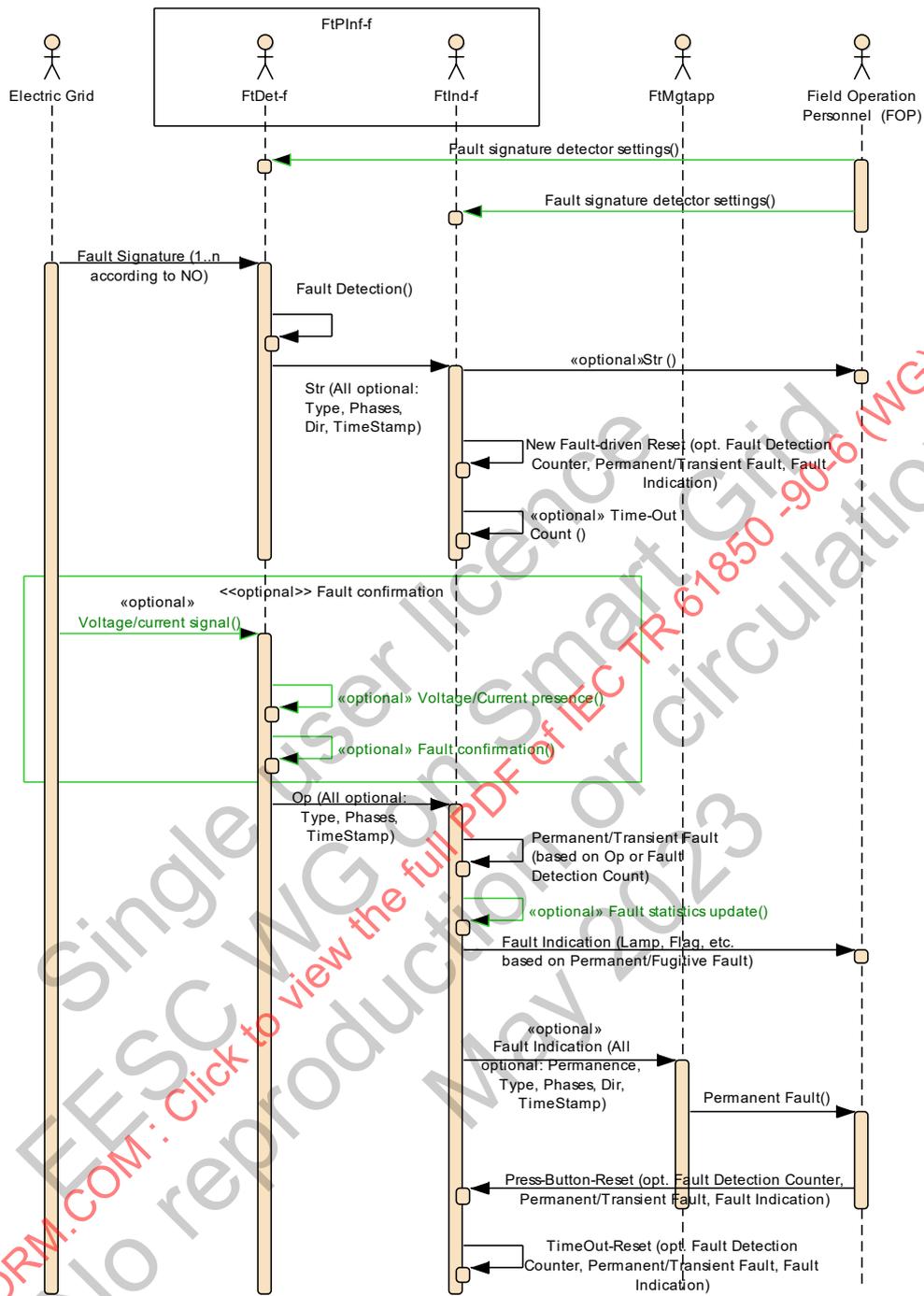


Figure 5 – Fault indication for FPI – T1

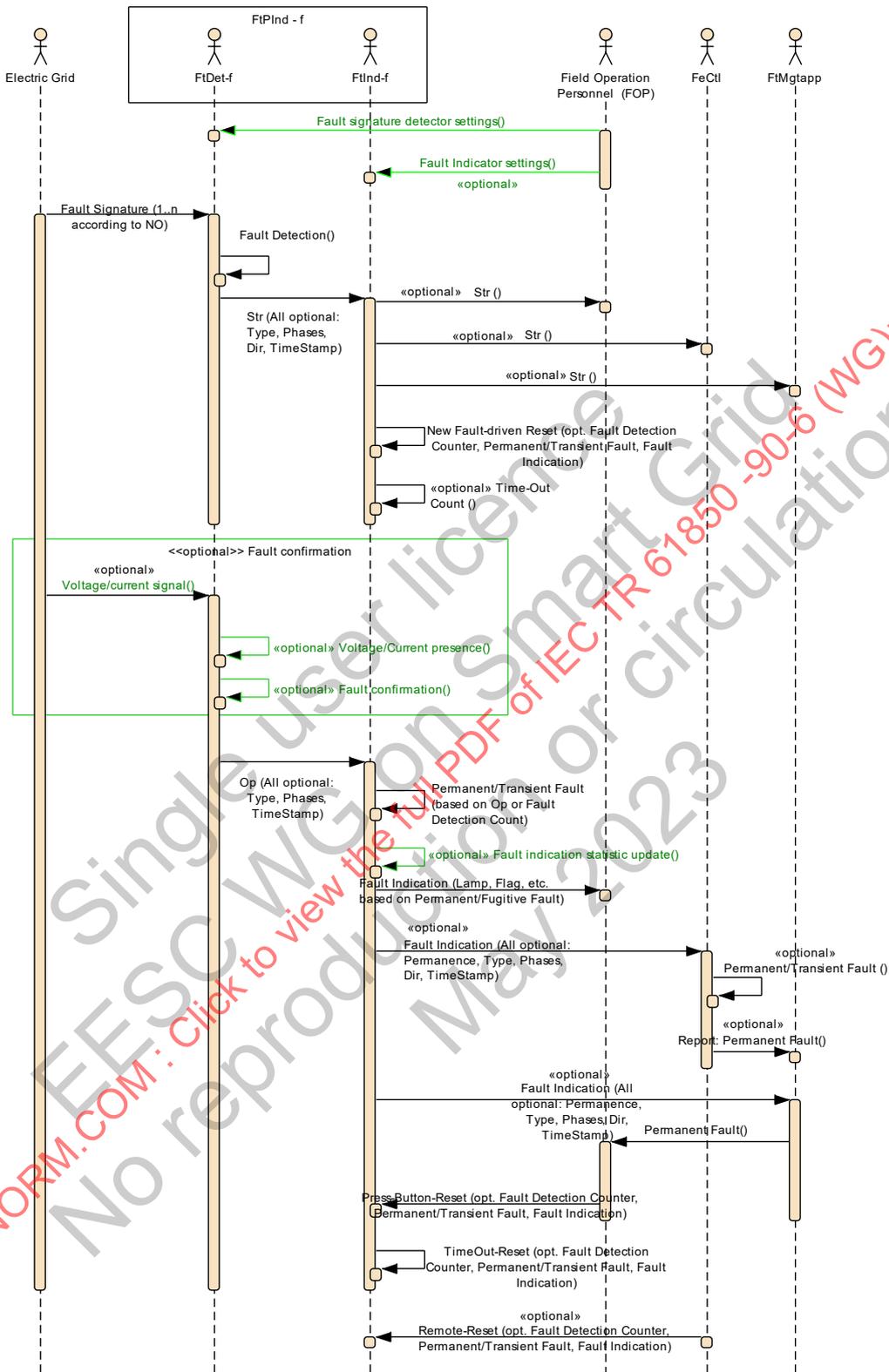


Figure 6 – Fault indication and report for FPI – T2

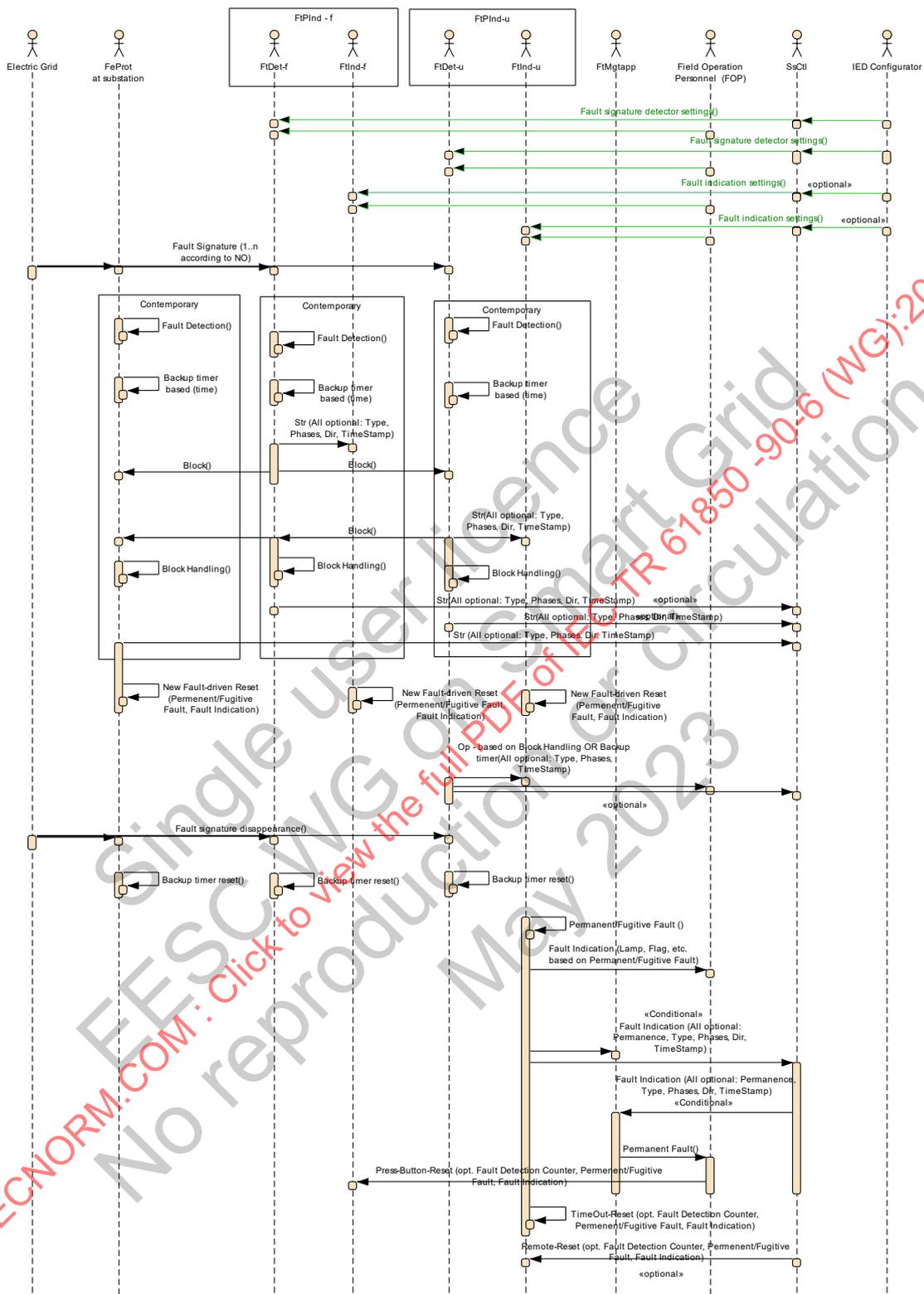


Figure 7 – Fault indication for FPI – T3,T4 (with communication to HV/MV SS) in the context of FLISR as described in 5.4

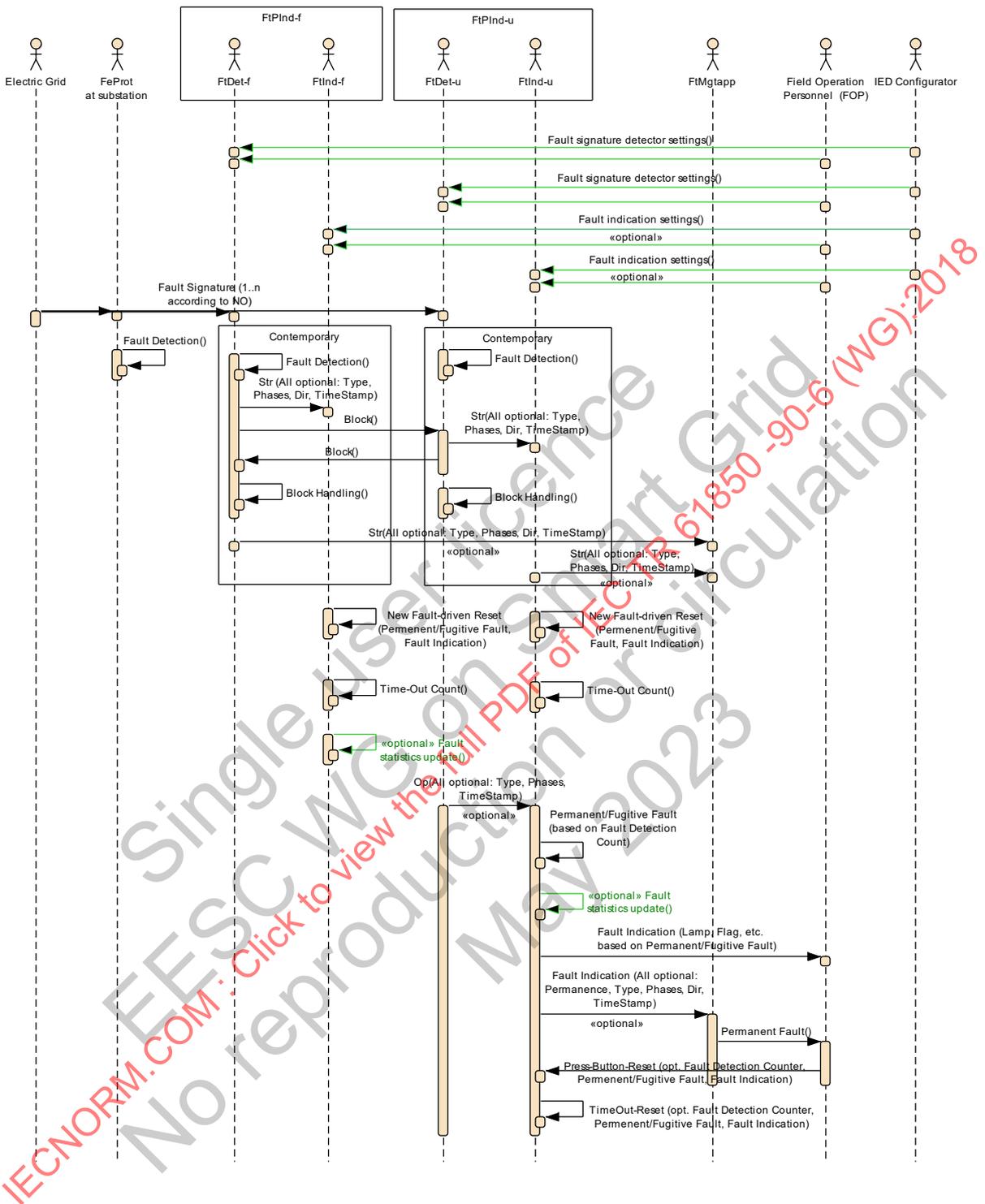


Figure 8 – Fault indication for FPI – T3,T4 (without communication to HV/MV SS) in the context of FLISR as described in 5.4

5.2.2.3 Technical details

5.2.2.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|---------------------------------|------------------------------|-------------------------------------|---|
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Electric Grid | System | Refer to Clause 4. | |
| FeProt at main substation | Device | Refer to Clause 4. | |
| FtPInd | Device | Refer to Clause 4. | |
| FtInd | Device | Refer to Clause 4. | |
| FtDet | Device | Refer to Clause 4. | |
| Field Operation Personnel (FOP) | Person | Refer to Clause 4. | |
| RTU | Device | Refer to Clause 4. | |
| DMSapp | (System) Application | Refer to Clause 4. | |
| Quality index system | (System) Application | Refer to Clause 4. | |
| FtMgtapp | (System) Application | Refer to Clause 4. | |
| Fault Location | (System) Application | Refer to Clause 4. | |

5.2.2.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|--|--|----------------|--|
| Actor/System/ Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | Continuous | | The Grid is continuously monitored The Grid topology is known and reflects the real topology The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches). |
| Grid | Fault | | The Grid is reacting in presence of the fault. |
| FtLOCapp | Fault Detection Autorecloser Operation | | The application that performs Fault Indication and Reporting (Location), is activated by the fault detection. The application may operate autonomously using local signals or/and with the support of communication network (Client-server or peer-to-peer). If communication is used, enough energy storage shall be available. |
| FeProt at main substation | Fault Detection | | The application that performs Fault Location for the Indication and Reporting is activated by the fault detection. The application may operate autonomously using local signals or/and with the support of communication network (Client-server or peer-to-peer). It is assumed that enough energy storage is available. |
| FtPInd | Overcurrent/earth faults/over-voltage, etc. | | Backup power/battery shall be available for operation and communications. |
| Optionality of information exchange and/or processes/functions | N.A. | | If no optionality is reported in the Sequence Diagrams and "Step by Step Analysis of Use Case", the information/function/process is assumed as mandatory. |
| Setting for Directional Detection | N.A. | | These parameters are included in the Protection settings. |

5.2.2.3.3 References / Issues

| References | | | | | | |
|------------|-----------------|-----------|--------|--------------------|---------------------------|------|
| No. | References type | Reference | Status | Impact on use case | Originator / Organization | Link |
| | | | | | | |

5.2.2.4 Step by step analysis of use case

5.2.2.4.1 General

| Scenario conditions | | | | | |
|---------------------|---|-----------------------------|--------------------------|---------------|--|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 5.1.1.4.1 | Fault Indication for FtPInd – T1 | FtPInd | Fault Signature handling | | The distribution system stakeholders are aware of the fault and its characteristics (type, location, etc.) |
| 5.1.1.4.2 | Fault Indication for FtPInd – T2 | FtPInd | Fault Signature handling | | The distribution system stakeholders are aware of the fault and its characteristics (type, location, etc.) |
| 5.1.1.4.3 | Fault Indication for FtPInd – T3,T4 (with communication to HV/MV SS) | FtPInd, HV/MV SS protection | Fault Signature handling | | The distribution system stakeholders are aware of the fault and its characteristics (type, location, etc.) |
| 5.1.1.4.4 | Fault Indication for FtPInd – T3,T4 (without communication to HV/MV SS) | | Fault Signature handling | | The distribution system stakeholders are aware of the fault and its characteristics (type, location, etc.) |

5.2.2.4.2 Steps – Fault indication for FtPInd – T1

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Fault Detection handling, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

Single User Licence
 IEC NORM.COM
 No reproduction or circulation
 Click to view the full PDF of IEC TR 61850-90-6 (WG12018)
 May 2023

| Scenario | | | | | | | | |
|----------------|-----------------|------------------------------|-----------------------------------|------------------|------------------------------|---|------------------------------|--|
| Scenario name: | | Fault Indication FtPInd – T1 | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1 | Fault on feeder | Fault Detection | Fault detection | | Electric Grid | FtDet | Fault Signature | Internal process (fault type analysis) |
| 2 | | | Fault Analysis | | FtDet | FtInd | Protection Str | Internal process |
| 2a | | | Fault Analysis | | FtDet | Field Operation Personnel | Protection Str | Optional |
| 2b | | | Fault Analysis | | FtInd | Internal F handling data initialization | | |
| 3 | | Fault confirmation | Voltage/current presence analysis | | Electric Grid | FtDet | Voltage / Current signal | Optional Process |
| 3a | | | Voltage/current presence analysis | | FtDet | | | Internal optional process |
| 3b | | | Fault confirmation | | FtDet | FtInd | Protection Op | Internal process |
| 4 | | Fault Indication | Fault statistics and indication | | FtInd | | | Internal counters update and heuristic's related to fault type |
| 4a | | | Fault Indication | | FtInd | Field Operation Personnel | Fault indication | Local HMI |
| 4b | | | Fault Indication | IEC 61850 Report | FtInd | FtMgtapp | Fault Indication | Optional |
| 5 | | | Fault Indication | | FtMgtapp | Field Operation Personnel | Permanent Fault notification | |
| 6 | | | Fault Indication | | Field Operation Personnel | FtInd | Fault Indication Reset | Optionally, the fault Detection Counter could be reset |
| 7 | | | Fault Indication | | FtInd | | Fault Indication Reset | Internal process after timeout without operator intervention Optionally, the fault Detection Counter could be reset |

5.2.2.4.3 Steps – Fault indication for FtPInd – T2

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Fault Detection handling, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|--|---|-------------------------------------|--|------------------------------|--|---|---|
| Scenario name: | | Fault Indication FtPInd – T2 | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1 | Equipment settings/Network maintenance | Fault Detection and Indication Settings | Fault Signature detection settings | File Transfer or/and Client/Server interactions and/or proprietary interface | Field Operation Personnel | FtDet | Protection settings (Thresholds, curves, direction, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 1a | | | Fault Signature Indication settings | File Transfer or/and Client/Server interactions and/or proprietary interface | Field Operation Personnel | FtInd | Parameter settings (timers, counters, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2 | Fault on feeder | Fault Detection | Fault detection | | Electric Grid | FtDet | Fault Signature | Internal process (fault type analysis) |
| 3 | | | Fault Analysis | | FtDet | FtInd | Protection Str | Internal process |
| 3a | | | Fault Analysis | | FtDet | Field Operation Personnel | Protection Str | Optional |
| 3b | | | Fault Analysis | | FtInd | Internal F. handling data initialization | | |
| 4 | | Fault confirmation | Voltage/current presence analysis | | Electric Grid | FtDet | Voltage / Current signal | Optional Process |
| 4a | | | Voltage/current presence analysis | | FtDet | | | Internal optional process |
| 4b | | | Fault confirmation | | FtDet | FtInd | Protection Op | Internal process |

| Scenario | | | | | | | | |
|----------------|-------|------------------------------|----------------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|--|
| Scenario name: | | Fault Indication FtPInd – T2 | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 5 | | Fault Indication | Fault statistics and indication | | FtInd | | | Internal counters update and heuristic's related to fault type |
| 5a | | | Fault Indication | | FtInd | Field Operation Personnel | Fault indication | Local HMI |
| 5b | | Fault Reporting | Fault Reporting | IEC 61850 Report | FtInd | HV/MV SS RTU | Fault Indication | Optional |
| 5c | | | Fault Reporting | | HV/MV SS RTU | FtMgtapp | Fault Type Report | Optional Internal process (fault type analysis) |
| 5d | | | Fault Reporting | | HV/MV SS RTU | Quality index system | Fault Type Report | Optional Internal process (fault type analysis) |
| 6 | | Fault Indication | Fault Indication | | FtInd | FtMgtapp | Fault Indication | Optional |
| 6a | | | Fault Indication | | FtInd | Quality index system | Fault Indication | Optional |
| 7 | | | Fault Indication | | FtMgtapp | Field Operation Personnel | Permanent Fault notification | |
| 8 | | | Fault Indication | | Field Operation Personnel | FtInd | Fault Indication Reset | Optionally, the fault Detection Counter could be reset |
| 9 | | | Fault Indication | | FtInd | | Fault Indication Reset | Internal process after timeout without operator intervention Optionally, the fault Detection Counter could be reset |
| 10 | | | Fault Indication | IEC 61850 Client/Server Set | HV/MV SS RTU | FtInd | Fault Indication Reset | Optionally, the fault Detection Counter could be reset |

5.2.2.4.4 Steps – Fault indication for FtPInd T3,T4 feeders radially operated (with communication to HV/MV SS)

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Fault Detection handling, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|--|--|-------------------------------------|--|---|------------------------------|--|---|
| Scenario name: | | Fault Indication FtPInd – T3,T4 (with communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1a | Equipment settings/Network maintenance | Fault Detection and Indication Settings | Fault Signature detection settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool via HV/MV SS RTU and/or Field Operation Personnel | FtDet-u | Protection settings (Thresholds, curves, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-f |
| 2a | | | Fault Signature Indication settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool via HV/MV SS RTU and/or Field Operation Personnel | FtInd-u | Parameter settings (timers, counters, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-f |
| 1b | | | Fault Signature detection settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool via HV/MV SS RTU and/or Field Operation Personnel | FtDet-f | Protection settings (Thresholds, curves, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-u |
| 2b | | | Fault Signature Indication settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool via HV/MV SS RTU and/or Field Operation Personnel | FtInd-f | Parameter settings (timers, counters, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-u |

| Scenario | | | | | | | | |
|----------------|-----------------|--|--------------------------------------|------------------|------------------------------|------------------------------|-----------------------|---|
| Scenario name: | | Fault Indication FtPInd – T3,T4 (with communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 3a | Fault on feeder | Fault Detection | Fault detection | | Electric Grid | FeProt at main substation | Fault Signature | Internal process (fault type analysis and any action backup handling) |
| 3b | | | Fault detection | | Electric Grid | FtDet-u | Fault Signature | Internal process (fault type analysis and any action backup handling) |
| 3c | | | Fault detection | | Electric Grid | FtDet-f | Fault Signature | Internal process (fault type analysis and any action backup handling) |
| 4a | | | Fault Analysis | | FtDet-u | FtInd-u | Protection Str | Internal process |
| 5a | | Logical Selectivity | Blocking of Upstream FPI/Protections | GOOSE | FtDet-u | Other FtDet-u | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique unblocked IED will handle the Fault |
| 4b | | Fault Detection | Fault Analysis | | FtDet-f | FtInd-f | Protection Str | Internal process |
| 5b | | Logical Selectivity | Blocking of Upstream FPI/Protections | GOOSE | FtDet-f | FtDet-u | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique unblocked IED will handle the Fault |
| 6a | | Fault Reporting | Fault Analysis | IEC 61850 Report | FeProt at main substation | HV/MV SS RTU | Protection Str | Optional |
| 6b | | | Fault Analysis | IEC 61850 Report | FtDet-u | HV/MV SS RTU | Protection Str | Optional |
| 6c | | | Fault Analysis | IEC 61850 Report | FtDet-f | HV/MV SS RTU | Protection Str | Optional |

| Scenario | | | | | | | | |
|----------------|----------------------------|--|----------------------------------|------------------|------------------------------|------------------------------|-------------------------------|---|
| Scenario name: | | Fault Indication FtPInd – T3,T4 (with communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 7a | | Fault Indication | Fault Indication | | FeProt at main substation | | | Internal counters update and heuristics related to fault type |
| 7b | | | Fault Indication | | FtInd-u | | | Internal counters update and heuristics related to fault type |
| 7c | | | Fault Indication | | FtInd-f | | | Internal counters update and heuristics related to fault type |
| 8a | | | Fault confirmation | | FtDet-f | FtInd-f | Protection Op | Internal process |
| 8b | | | Fault Indication | | FtInd-f | Field Operation Personnel | Protection Op | Local HMI |
| 8c | | | Fault confirmation | IEC 61850 Report | FtDet-f | HV/MV SS RTU | Protection Op | Optional |
| 9a | Fault on feeder disappears | Fault Detection | Fault detection | | Electric Grid | HV/MV SS Protection | Fault Signature Disappearance | Internal process (any action backup handling reset) |
| 9b | | | Fault detection | | Electric Grid | FtDet-u | Fault Signature Disappearance | Internal process (any action backup handling reset) |
| 9c | | | Fault detection | | Electric Grid | FtDet-f | Fault Signature Disappearance | Internal process (any action backup handling reset) |
| 10a | | Fault Indication | Fault Indication | | FtInd-f | Field Operation Personnel | Permanent Fault Indication | Including local HMI |
| 10b | | | Fault Indication | | FtInd-f | HV/MV SS RTU | Permanent Fault Indication | Conditional: at least one between 9b or (9c+10) |
| 10c | | Fault Reporting | Fault Indication | | FtInd-f | FtMgtapp | Permanent Fault Indication | Conditional: at least one between 9b or (9c+10) |

| Scenario | | | | | | | | |
|----------------|-------|--|----------------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|--|
| Scenario name: | | Fault Indication FtPInd – T3,T4 (with communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 10d | | | Fault Indication | | FtInd-f | Quality index system | Permanent Fault Indication | Conditional: at least one between 9b or (9c+10) |
| 11 | | | Fault Analysis | | HV/MV SS RTU | FtMgtapp | Permanent Fault notification | Conditional: at least one between 9b or (9c+10) |
| 12 | | Fault Indication | Fault Indication | | Outage Management System | Field Operation Personnel | Permanent Fault notification | |
| 13 | | | Fault Indication | | Field Operation Personnel | FtInd | Fault Indication Reset | “Press-Button”. Optionally, the fault Detection Counter could be reset |
| 14 | | | Fault Indication | | FtInd | | Fault Indication Reset | Internal process after timeout without operator intervention Optionally, the fault Detection Counter could be reset |
| 15 | | | Fault Indication | IEC 61850 Client/Server Set | HV/MV SS RTU | FtInd | Fault Indication Reset | Optionally, the fault Detection Counter could be reset |

5.2.2.4.5 Steps – Fault indication for FPI T3,T4 feeders radially operated (without communication to HV/MV SS)

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Fault Detection handling, according to 5.2.3, 5.2.4, 5.2.5,5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|--|--|-------------------------------------|--|--|------------------------------|--|---|
| Scenario name: | | Fault Indication FPI – T3,T4 (without communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1a | Equipment settings/Network maintenance | Fault Detection and Indication Settings | Fault Signature detection settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool and/or Field Operation Personnel | FtDet-u | Protection settings (Thresholds, curves, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-f |
| 2a | | | Fault Signature Indication settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool and/or Field Operation Personnel | FtInd-u | Parameter settings (timers, counters, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-f |
| 1b | | | Fault Signature detection settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool and/or Field Operation Personnel | FtDet-f | Protection settings (Thresholds, curves, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-u |
| 2b | | | Fault Signature Indication settings | File Transfer or/and Client/Server interactions and/or proprietary interface | FieldComp config tool and/or Field Operation Personnel | FtInd-f | Parameter settings (timers, counters, etc.) | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange Same info as for FPI/DSU-u |
| 3a | Fault on feeder | Fault Detection | Fault detection | | Electric Grid | FeProt at main substation | Fault Signature | Internal process (fault type analysis) |
| 3b | | | Fault detection | | Electric Grid | FtDet-u | Fault Signature | Internal process (fault type analysis) |

| Scenario | | | | | | | | |
|----------------|-------|--|--------------------------------------|------------------|------------------------------|------------------------------|----------------------------|---|
| Scenario name: | | Fault Indication FPI – T3,T4 (without communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 3c | | | Fault detection | | Electric Grid | FtDet-f | Fault Signature | Internal process (fault type analysis) |
| 4a | | | Fault Analysis | | FtDet-u | FtInd-u | Protection Str | Internal process |
| 5a | | Logical Selectivity | Blocking of Upstream FPI/Protections | GOOSE | FtDet-u | Other FtDet-u | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique unblocked IED will handle the Fault |
| 4b | | Fault Detection | Fault Analysis | | FtDet-f | FtInd-f | Protection Str | Internal process |
| 5b | | Logical Selectivity | Blocking of Upstream FPI/Protections | GOOSE | FtDet-f | FtDet-u | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique unblocked IED will handle the Fault |
| 6a | | Fault Reporting | Fault Analysis | IEC 61850 Report | FtDet-u | HV/MV SS RTU | Protection Str | Optional |
| 6b | | | Fault Analysis | IEC 61850 Report | FtDet-f | HV/MV SS RTU | Protection Str | Optional |
| 7a | | Fault Indication | Fault Indication | | FtInd-u | | | Internal counters update and heuristics related to fault type |
| 7b | | | Fault Indication | | FtInd-f | | | Internal counters update and heuristics related to fault type |
| 8 | | | Fault confirmation | | FtDet-f | FtInd-f | Protection Op | Optional Internal process |
| 9a | | Fault Indication | Fault Indication | | FtInd-f | Field Operation Personnel | Permanent Fault Indication | Including local HMI |

| Scenario | | | | | | | | |
|----------------|-------|--|----------------------------------|---------|------------------------------|------------------------------|------------------------------|--|
| Scenario name: | | Fault Indication FPI – T3,T4 (without communication to HV/MV SS) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 9b | | | Fault Indication | | FtInd-f | FtMgtapp | Permanent Fault Indication | Optional |
| 10 | | | Fault Indication | | FtMgtapp | Field Operation Personnel | Permanent Fault notification | |
| 11 | | | Fault Indication | | Field Operation Personnel | FtInd | Fault Indication Reset | “Press-Button”. Optionally, the fault Detection Counter could be reset |
| 12 | | | Fault Indication | | FtInd | | Fault Indication Reset | Internal process after timeout without operator intervention Optionally, the fault Detection Counter could be reset |

Single user licence
 EESC WG on Smart Grids
 No reproduction or circulation
 May 2023
 IECNORM.COM : Click to view the full PDF of IEC TR 61850-90-6 (WG) 2018

5.2.2.5 Information exchanged

| Information exchanged | | |
|---|--|--|
| Name of Information exchanged | Description of Information exchanged | Requirements to information data R-ID |
| Str | Start – Protection dependent (directionality, general or per single phase and/or neutral, ...) | Only if new DO/DA or new P-Type LN |
| Op | Operate – Protection dependent (general or per single phase and/or neutral, ...) | Only if new DO/DA or new P-Type LN |
| Fault Indication | Fault presence with type of fault, impacted phase, time tagging, and fault direction (possibly) | New LN |
| Fault Statistical Details | Counters per fault type per given time periods. | New LN |
| Voltage Presence/absence | Status and settings | New LN |
| Current Presence/absence | Status and settings | New LN |
| Protection Settings | Thresholds, timers, curves, etc. | Only if new DO/DA or new P-Type LN |
| Fault indicator parameter settings | Timers, counters, etc. | New LN |
| Fault Indication Reset | Remote Fault Indication reset (counters, etc.) | New LN |
| Block | Status of Block request and Topological information for logical selectivity execution | New DO/DA or new LN |
| Forward/backward direction convention setting | (possibly) Set the expected relationship between the direction of the current and the notions of backward/forward. Usually the closest busbar is the reference, but this may be an issue in case of contiguous line sections | Such setting shall affect in the same way all P-Type nodes involved in the fault signature detection |

NOTE In IEC 62689-1 the term Fault Detection is used instead of Fault Localization and Indication (FLI).

5.2.3 Use case 1b: Overcurrent non directional Fault Localization and Indication (F1C/NC)

5.2.3.1 General

This use case is relevant to the overcurrent non directional Fault Localization and Indication (phase to earth fault on solid earthed systems) with or without confirmation (see IEC 62689-1, F1C/NC etc.). It relies on the generic one described in 5.2.2, and has the following specificities.

5.2.3.2 F1(C/NC) for T1 and T2 application

5.2.3.2.1 Fault Detection

To detect the phase to earth fault on solid earthed systems an Overcurrent Function and, if necessary, a confirmation based on Voltage Presence/Absence or Current Presence/Absence, is required. For communication and Data exchange purposes, IEC 61850-7-4 already foresees the following LNs for which DOs and DAs are sufficient for the purpose:

PTOC, PTUC, PTUV, PTOV.

The confirmation may be based on:

- **Voltage Presence/Absence** (see Figure 9) – in this case PTUV and PTOV LNs shall be used to indicate a 2 values information (Vprs) whose calculation is based on the following criteria:
 - the Voltage Presence is determined when at least on one phase the relevant PTOV operates (StrVal = Vp and OpDITmms=Tp are reached)

- the Voltage Absence is determined when on all phases the relevant PTUVs operate (StrVal = Va and OpDITmms=Ta are reached).

The specific semantic of the Vprs requires a **new LN** (refer to Clause 7).

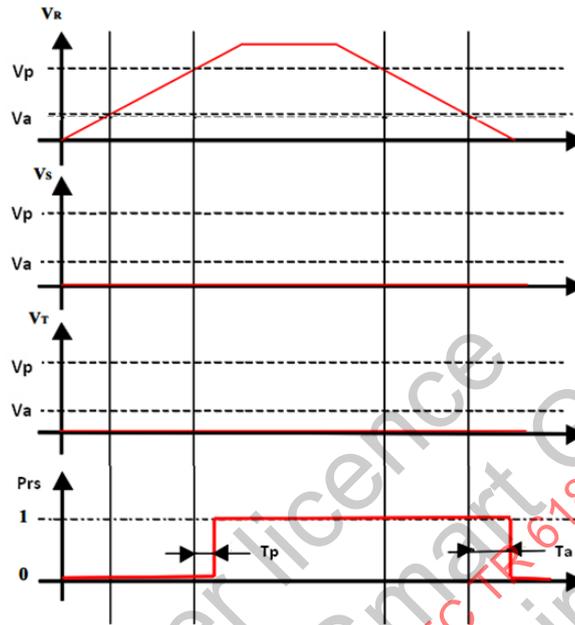


Figure 9 – Voltage Presence/Absence

- **Current Presence/Absence** – in this case PTOC and PTUC LNs shall be used to indicate a 2 values information (Cprs) whose calculation is based on the following criteria (similar to the Vprs evaluation):

- the Current Presence is determined when at least on one phase the relevant PTOC operates
- the Current Absence is determined when on all phases the relevant PTUCs operate.

The specific semantic of the Cprs requires a **new LN** (refer to Clause 7).

5.2.3.2.2 Fault Indication

To indicate a phase to earth fault on solid earthed systems it is required to communicate the following information:

- (optional) the Str DO of the PTOC LN, detailing optionally the relevant phase and the Time Stamp
- the Indication of the event to the Field Operation Personnel and (optional) to Outage Management System for T1 and T2 and (opt.) to the MV/LV SS RTU for T2.

The specific semantic of the Fault Indication requires a **new LN** including all the related parameters (refer to Clause 7).

5.2.4 Use case 1c: Phase to earth faults, non directional fault detection (F2)

This use case relies on the generic one described in 5.2.2, but fault signature detection is assumed to be capable of detecting phase to earth faults, non directional faults.

5.2.5 Use case 1d: Overcurrent and Phase to earth faults detection non directional (F3)

This case is just the concatenation of the two previous one (F1 + F2).

5.2.6 Use case 1e: Overcurrent, directional and non directional, fault detection (F4)

This use case relies on the generic one described in 5.2.2, but fault signature detection is assumed to be capable of detecting overcurrent, directional and non directional, faults. It will request to handle directionality of fault in the information exchange.

5.2.7 Use case 1f: Overcurrent, non directional, phase to earth faults, directional and non directional fault detection (F5)

This use case relies on the generic one described in 5.2.2, but fault signature detection is assumed to be capable of detecting overcurrent, non directional, phase to earth faults, directional and non directional faults. It will request to handle directionality of fault in the information exchange.

5.2.8 Use case 1g: Overcurrent and phase to earth faults, directional and non directional fault detection (F6)

This case is just the concatenation of the two previous one (F4 + F5).

5.3 Use case 2: FLISR based on local control

5.3.1 General

FLISR based on local control is achieved by autonomous open/close operations of sectionalizers in a feeder according to local overcurrent or voltage measurements. This subclause will describe two use cases of FLISR based on local control. Use case 2a is for the application detecting and counting overcurrent signatures which is widely use in North America. Use case 2b is for the application detection the loss and presence of voltage on feeders which is widely uses in East Asia typically in Japan and China.

In these kinds of FLISR, the circuit breaker and sectionalizers in a feeder operate in a pre-determined sequence, not requiring information from any other device during their protection process. However, the data can be exchanged between the master station and the IEDs of sectionalizers include some configuration values such as overcurrent and voltage settings, operation mode as well as monitoring data such as the lock mode of the sectionalizer.

5.3.2 Use case 2a: FLISR using sectionalizers detecting fault current

5.3.2.1 Description of the use case

5.3.2.1.1 Name of use case

| Use Case Identification | | |
|-------------------------|-------------------------|---|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Fault Location, Isolation, and Service Restoration (FLISR) using sectionalizers detecting fault current |

5.3.2.1.2 Version management

| Version management | | | | | | |
|--------------------------------------|---------------|-------------------------------------|---------------|-----------------------------------|-------|--|
| Version management changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| 1.0 | Sept. 2, 2014 | Dmitry Ishchenko, Salman Mohagheghi | | | | Draft |
| 1.1 | Jan 12, 2015 | Dmitry Ishchenko | | | | |
| 1.2 | Feb 14, 2015 | Dmitry Ishchenko | | | | |

5.3.2.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Related business case | Distribution System Operation |
| Scope | Fault location, Isolation and Service Restoration scheme operates in automated, semi-automated or manual mode to help the distribution system operator to isolate faults and reconfigure the network to re-energize as many unaffected feeder sections as possible. |
| Objective | Isolate faults in the power system to maintain safety and to minimize the duration of power interruptions in order to improve the overall reliability of the power grid. |

5.3.2.1.4 Narrative of use case – Short description

FLISR logic alters the topological structure of distribution feeder systems by changing the open/close status of switches under abnormal operating conditions. In particular, when a permanent fault occurs and the upstream recloser changes to lockout status after the reclosing sequence is complete, FLISR can selectively change switch statuses to isolate a fault and restore power to as much load as possible. This process can be fully automatic or supervised by the distribution system operator from the Control Centre.

5.3.2.1.5 Narrative of use case – Complete description

The FLISR function with autoreclosers and sectionalizers in open loop system is described as follows.

In an open loop configuration, the system can potentially be energized from two sources/distribution substations. For normal operating mode one part of the circuit is energized from one substation, another part of the system is energized from the second substation, and the two parts are electrically isolated from one another by a normally open tie-point recloser or a switch. The IED controlling this type of switch must be capable of sensing the voltages on both sides of the recloser mechanism. Most simple form of open loop system includes only one normally open tie.

When a fault occurs in the electrical power system, it must be cleared by a protection device, which in the context of distribution system protection can be either substation breaker, field recloser or a fuse. In a typical distribution system with autoreclosers there are two general concepts for selectivity to be considered. The fuse blowing principle utilizes extended autorecloser trip times in order to allow the downstream fuse to clear the fault. Second concept, fuse saving, is to minimize the trip time of an autorecloser or reclosing breaker so as to try to prevent the downstream fuse from blowing in case the fault is temporary. The use case described here applies to fuse blowing concept.

A special switch called a sectionalizer may also be used by the DA schemes to provide better fault isolation granularity in systems with autoreclosers. Sectionalizers are capable of breaking the electrical connections under no load or alternatively under normal loading conditions but cannot interrupt full fault currents, particularly in four-wire grounded distribution systems. Sectionalizers have basic current sensing capabilities and can recognize the fault as an overcurrent event. In some cases, sectionalizer function can also be implemented in the recloser control logic. This is referred to as a “sectionalizer recloser”.

In case of a fault, the sectionalizer will register overcurrent event and increment its counter. If the mid-point recloser upstream clears the fault, successfully recloses and no further fault is detected within the configurable sectionalizer reset time period, the sectionalizer returns to the previous state. Otherwise, if the fault is still present and again cleared by the recloser, the sectionalizer will register second overcurrent event. This sequence will continue until the configurable trip count setting of the sectionalizer is reached. It will then open during autorecloser open interval and isolate the faulted part of the circuit. This will allow the autorecloser to successfully reclose and maintain power supply to the unaffected part of the system upstream of the sectionalizer.

In a system with multiple sectionalizers or sectionalizing reclosers, when a first fault is cleared by the autorecloser, the sectionalizer at the end of the faulty feeder section will open

first. If the recloser closes back and the fault is not isolated, the recloser will again clear it, and the second from the end sectionalizer will open during the second reclose interval. This sequence will continue until the faulty segment is disconnected from the source, thus completing the auto-sectionalizing sequence. Then the mid-point autorecloser will successfully reclose and re-energize the healthy section of the feeder upstream of the last open sectionalizer.

The next step is to isolate the fault. If DA scheme contains more than two sectionalizers, this step is typically more conveniently accomplished at the substation computer or DMS (distribution management system) level. The decision to open a sectionalizer in the disconnected feeder section can be made based on the observations that some sectionalizers in the previous stage have reported zero voltage and current without having reported the fault current. In addition, Fault Detectors can also be incorporated into the scheme for better granularity.

Then tie-point recloser or switch will detect loss of voltage on one of its sides and close once the pre-determined loss of voltage timer expires. The loss of voltage timer of the tie recloser must be coordinated with the time-current curves of the mid-line reclosers, as well as with recloser open intervals. Alternatively, the signal to reclose the tie-point switch can be sent by the substation computer or DMS operator. In this case, the capacity check can also be run in order to confirm switching some part of the load from one feeder to another will not overload lines and transformers and will not cause voltage issues.

5.3.2.1.6 General remarks

This use case describes the function of Fault Location, Isolation and Service Restoration ("FLISR") system with autoreclosers and sectionalizers operated in an "open loop" topology. Currently the use case does not consider the impact of DER.

However, with the increase of the number of mid-line reclosers, coordination and design of such a scheme without centralized communications become increasingly difficult. Additionally, configurations with multiple normally open tie reclosers or switches, classified as multi back-feed circuits, can also exist. Implementation of FLISR functionality in such a system will only be feasible when implemented as centralized Control Centre function or decentralized peer-to-peer scheme.

This use case assumes that the feeder has a remotely controlled breaker at the main substation and several remotely monitored field reclosers operating in either traditional recloser mode, sectionalizer or tie modes located along the feeder. The use case applies to feeders with sections of overhead line or underground cable or a mixture of both types.

5.3.2.2 Diagrams of use case

The primary use case is shown and broken down in Figure 10 and sequence diagrams of secondary use cases are respectively presented in Figure 11 to Figure 13:

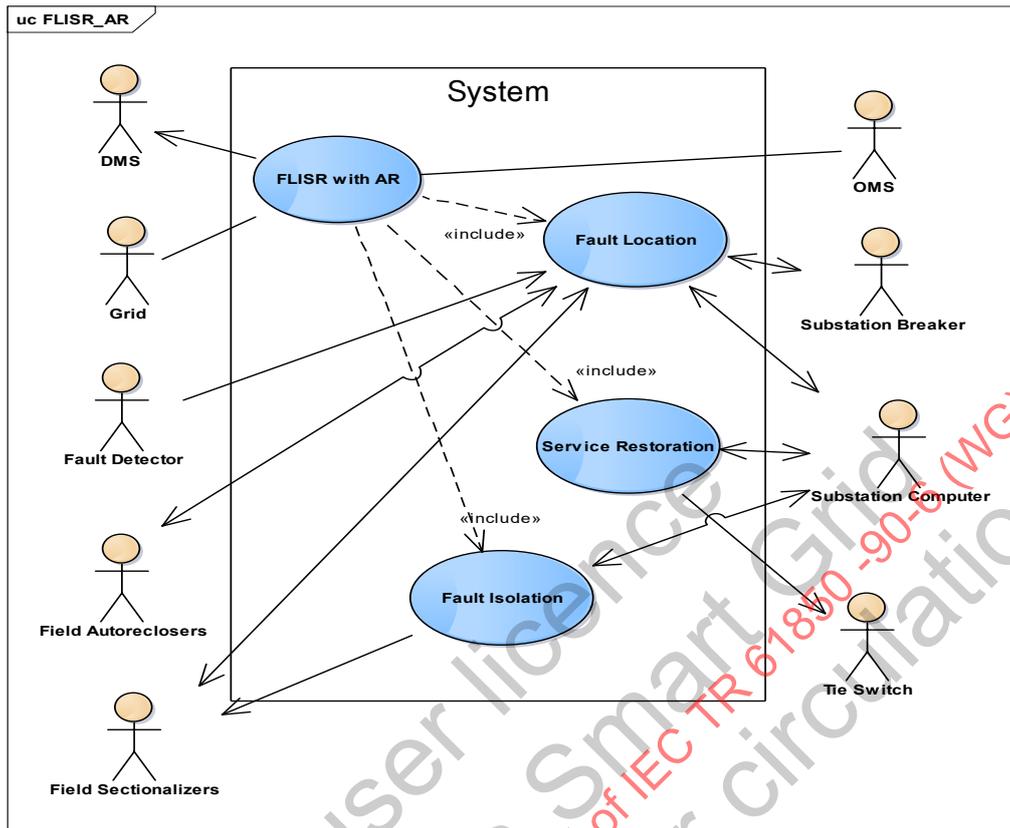


Figure 10 – FLISR use case breakdown

Single user license
 EESC WG on Smart Grids
 IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
 No reproduction or circulation
 May 2023

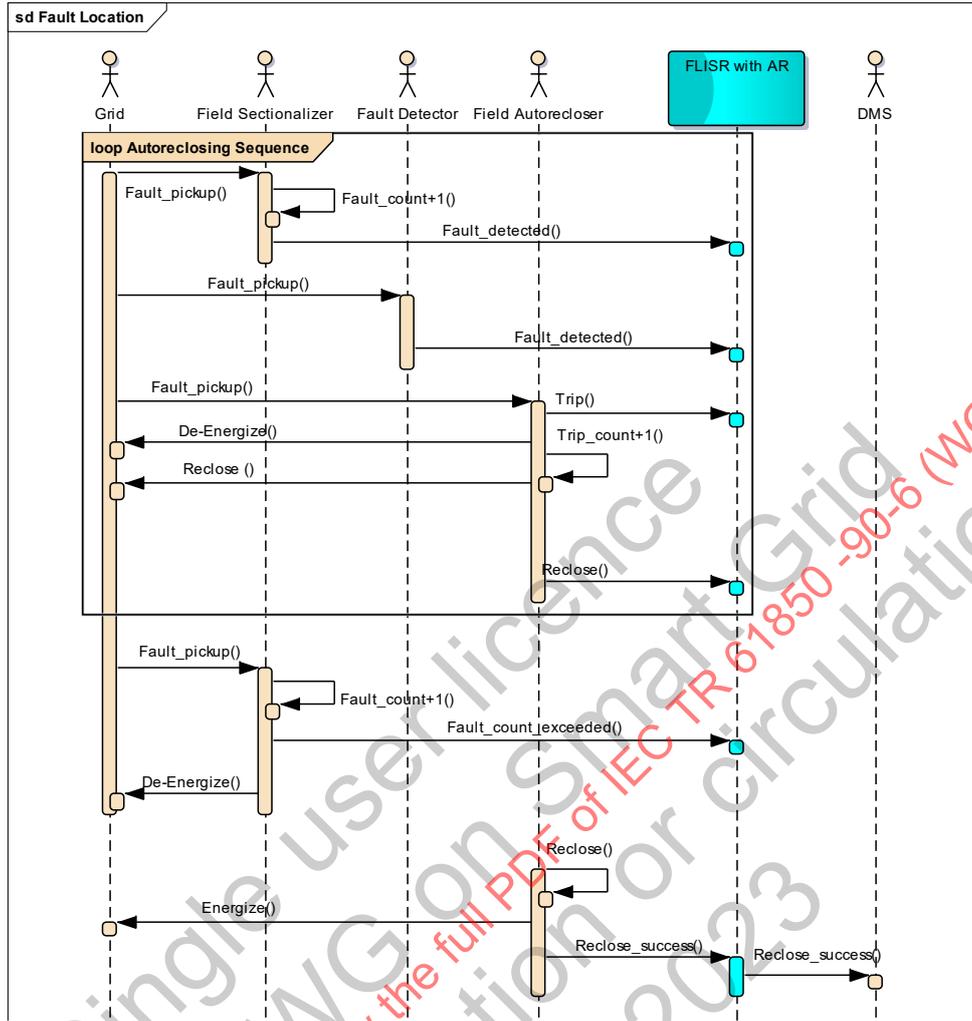


Figure 11 – Fault location sequence diagram

Single user license on Smart Grid
EESC WG on Circulation
No reproduction or circulation
IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
May 2023

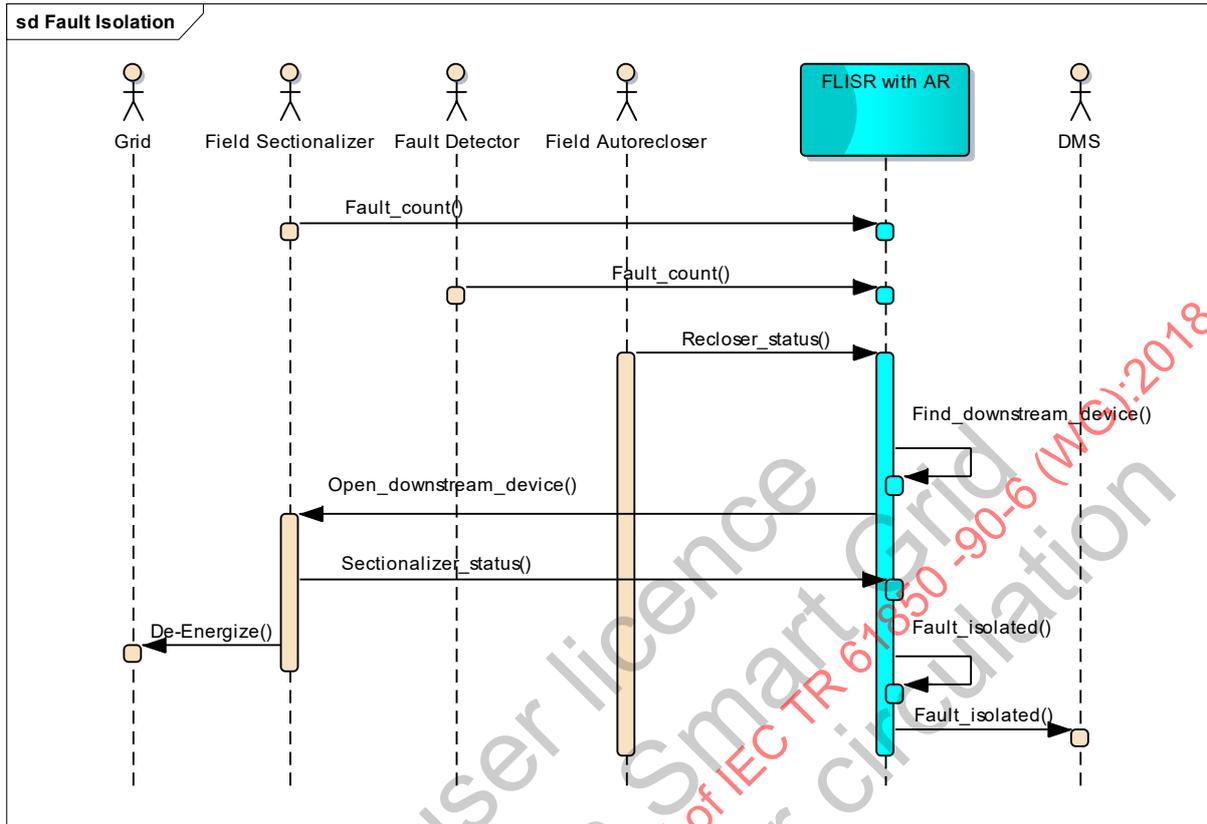


Figure 12 – Fault isolation sequence diagram

Single user licence
 EEESC WG on Smart Grid
 No reproduction or circulation
 May 2023
 IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018

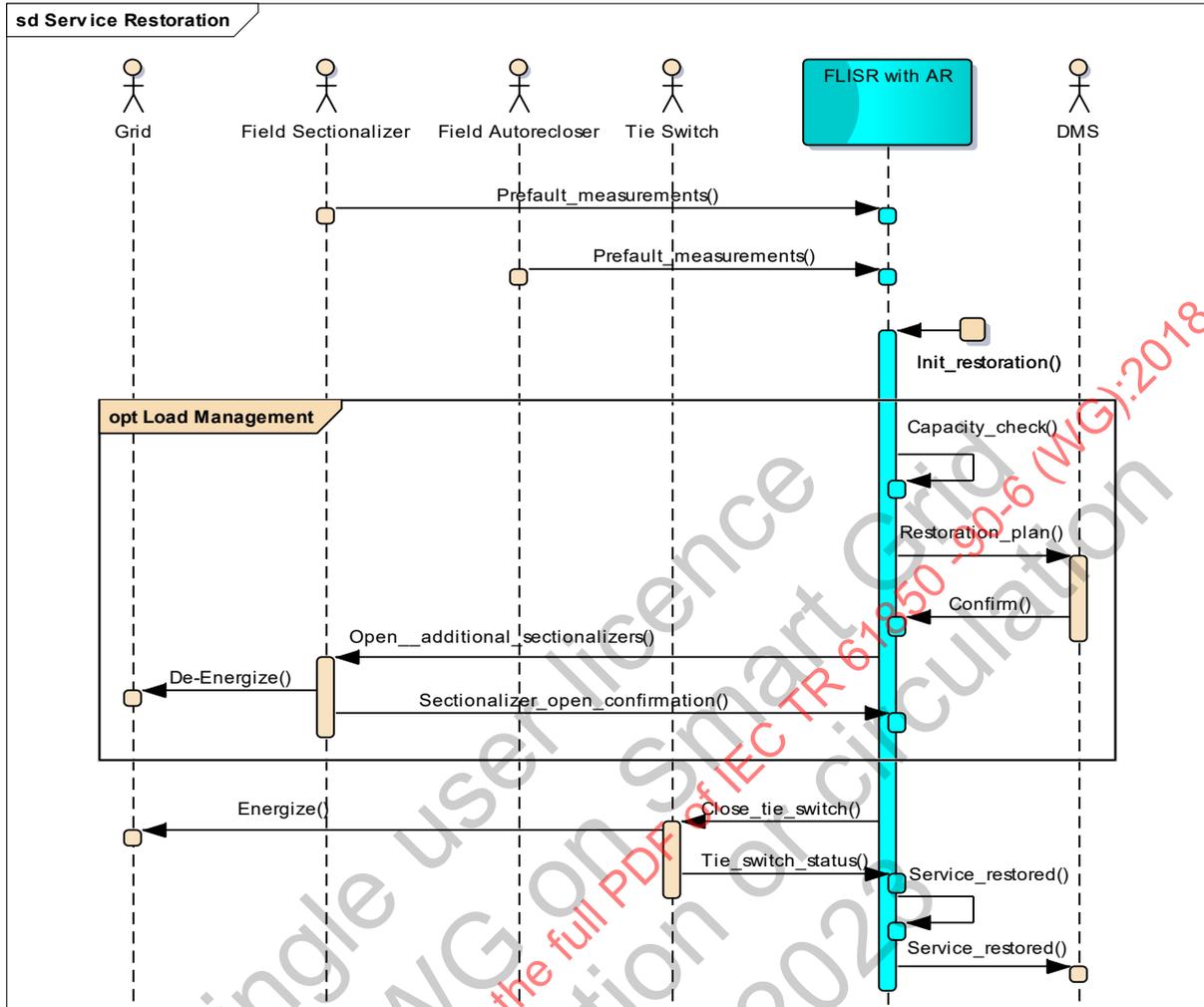


Figure 13 – Service restoration sequence diagram

Single user licence
EESC WG on Smart Grids
No reproduction of IEC TR 61850-90-6 (WG):2018
May 2022

5.3.2.3 Technical details

5.3.2.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|------------------------------|------------------------------|--|---|
| Grouping (community) | | Group description | |
| Actor name see Actor list | Actor type see Actor list | Actor description see Actor list | Further information specific to this use case |
| Electric Grid | System | Refer to Clause 4 | |
| Field Autorecloser | System | Device which is located in the field along the feeder to protect the downstream assets by eliminating fault current and having communicating capability to indicate trip conditions to upper levels. This device includes the protection detection function and the recloser function. It also has the ability to be remotely controlled to re-energize the protected feeder. | |
| Field Sectionalizer | System | Devices which are located along the feeder – sectionalizers/sectionalizing autoreclosers, and switches. | |
| Tie Switch | System | A special normally open tie point device function, which is able to sense voltage presence on both sides of its current interrupting mechanism. It also includes the logic to close the interrupting mechanism either automatically upon loss of voltage on one side, or through communication control command. This function can be implemented with recloser, sectionalizer or switch. | |
| Fault Detector | System | Device located along the feeder and capable of detecting a fault | |
| FeProt at main substation | System | Refer to Clause 4 | |
| Substation Computer | System | Computer installed at the substation which communicates with both the field devices and the control center. FLISRapp may be implemented at the substation computer as an option. | |
| SysOp | Person | Refer to Clause 4 | |
| DMSapp | System | Refer to Clause 4 | |
| FtMgtapp | System | Refer to Clause 4 | |
| FLISRapp | Application | Refer to Clause 4 | |

5.3.2.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|---------------------------|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | Continuous | | The Grid is continuously monitored The Grid topology is known and reflects the real topology The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches) |
| Grid | | | |
| FLISRapp | Autorecloser Operation | | Communication system between generic architectural component and control center where FLISRapp is hosted is operational |
| Field Sectionalizers | Continuous | | Enough energy is stored and available for communicating |
| Field Autoreclosers | Overcurrent/ undervoltage | | Backup power/ battery is available for operation and communications |
| Switching equipment actuators | Control command from IED | | Backup power is stored and available for remote control of the actuators in absence of power |

5.3.2.4 Step by step analysis of use case

| Scenario conditions | | | | | |
|---------------------|---------------|---------------|------------------|---------------|----------------|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 1 | Normal | | | | |
| 2 | Alternative | | | | |

IECNORM.COM : Click to view the full PDF of IEC TR 61850-90-6:2018
 No reproduction or circulation permitted
 May 2023

5.3.2.4.1 Steps – Normal

| Scenario | | | | | | | | |
|----------------|--------------------------|---|---|---------|------------------------------|------------------------------|------------------------------|---|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| | | Fault detection and location "sub-use case" | | | | | | |
| 1a | Fault occurs on the Grid | Report Fault | Protection function of an IED detects a fault | | Electric Grid | Protection device | Fault Detected | |
| 1b | Fault occurs on the Grid | Sectionalizer Count Event | Sectionalizer registers fault event | | Sectionalizer | FLISRapp | Fault detected | Note: fault condition can be detected based on either current (North American scheme) or voltage (Asian scheme) |
| 1c | Fault occurs on the Grid | Fault Detector Event | Fault detector detects a fault | | Fault Detector | FLISRapp | Fault detected | |
| 1d | Fault occurs on the Grid | Initial Trip | Autorecloser or FeProt at main substation trips | | Protection device | Electric Grid | Trip | |
| 1e | | | Information transfer | | Protection device | FLISRapp | Trip | Start of trip/reclose cycle |
| 2a | | | Information transfer | | Protection device | FLISRapp | Reclosing cycle start | Reclosing cycle |
| 2b | Recloser timer expires | First Reclose Attempt | First autorecloser reclosing operation | | Protection device | Electric Grid | Re-energize | |
| 3a | Fault reoccurs | Report Fault | Autorecloser or reclosing breaker trips | | Protection device | Protection Device | Fault Detected | |
| 3b | Fault reoccurs | Sectionalizer Count Event | Sectionalizer registers second overcurrent event | | Sectionalizer IED | FLISRapp | Fault Detected | |
| 3c | Recloser trip | Second recloser Trip | Autorecloser or reclosing breaker trips | | Protection device | Electric Grid | Trip | |
| 3d | Sectionalizer opens | Auto-sectionalizing | Sectionalizer opens during recloser open interval | | Sectionalizer | FLISRapp | Sectionalizer Open operation | |
| 3e | | | Information transfer | | Protection device | FLISRapp | Trip | Second Trip |

| Scenario | | | | | | | | |
|----------------|---|----------------------------------|---|---------|------------------------------|------------------------------|---|----------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 3f | | | Information transfer | | Sectionalizer | FLISRapp | Status, voltage and current measurements | Second Trip |
| 4a | | | Information transfer | | Protection device | FLISRapp | Second Reclosing interval start | Reclosing cycle |
| 4b | Recloser timer expires | Second autoreclosing attempt | Second autoreclosing operation | | Protection device | FLISRapp | Successful autoreclosing | |
| 4c | | | Information transfer | | Protection device | FLISRapp | Trip | Second Trip |
| | | Fault isolation sub use case | | | | | | |
| 5a | Isolation Timer expires | Initiate Isolation | Substation computer analyses data from sectionalizers and autoreclosers and determines the first switch downstream of the fault that should be opened | | FLISRapp | Sectionalizer IED | Autoreclosing and sectionalizer status and measurements | |
| 5b | Sectionalizer downstream of the fault opens | Isolate Fault | Sectionalizer IED controlling the first downstream switch opens | | Sectionalizer IED | Electric Grid | Sectionalizer Status | |
| 5c | | | Information transfer | | Sectionalizer IED | FLISRapp | Status | |
| 5d | | | Information transfer | | Sectionalizer IED | Substation Computer | Status | |
| | | Service restoration sub use case | | | | | | |
| 6a | Re-energization conditions check | Capacity check | Use voltage and current information send by field IEDs prior to the fault to confirm restoration will not violate operational constraints | | Substation Computer | FLISRapp | Voltage and Current measurements | |
| 6b | | | Information transfer | | FLISRapp | DMSapp | Status | |

| Scenario | | | | | | | | |
|----------------|------------------------------------|-------------------------------|--|---------|------------------------------|------------------------------|---|----------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 6c | | | Information transfer | | DMSapp | FLISRapp | Control | Optional confirmation from DSO |
| 7a | Re-energization conditions not met | Capacity check | If de-energized part of the feeder cannot be fully energized, open additional sectionalizers | | Substation computer | FLISRapp | Sectionalizer control | |
| 7b | Sectionalizer opens | Manage load | Sectionalizer opens to reduce the load transferred to alternative source | | Sectionalizer IED | Electric Grid | | |
| 7c | | | Information transfer | | Sectionalizer | FLISRapp | Status | |
| 8a | Load management complete | Restore from alternate source | Close Tie Switch | | Tie Switch | FLISRapp | Control Tie Switch | |
| 8b | Tie Switch closed | Restoration complete | Tie Switch reports closing | | Tie Switch | FLISRapp | Tie Switch Status | |
| 8c | | | | | FLISRapp | DMSapp | Recloser, sectionalizer and tie switch status | |

Single user
 EESC WG on Smart Grid
 No reproduction or circulation
 May 2022
 IECNORM.COM : Click to view the full PDF of IEC TR 61850-9-6 (WG12018)

5.3.2.5 Information exchanged

| Information exchanged | | |
|-------------------------------|---|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| Pre-fault measurements | Voltage and current measurements reported to FLISRapp for optional capacity check | |
| Fault count | Sectionalizer fault counts for all downstream sectionalizers | |
| Autorecloser position | Reclosing sequence and lockout status of autoreclosers | |
| Sectionalizer position | Sectionalizer opens to isolate the fault or to manage load | |
| Substation breaker position | Status of the substation breaker | |
| Fault detector status | Fault detection status and/or optional voltage and current measurements from fault detectors located along the feeder | |
| Switching plan | List of sectionalizers to open and close | |
| Tie switch position | Tie autorecloser or sectionalizer position | |
| Close command | Command to close tie-recloser or sectionalizer | |

5.3.3 Use case 2b: FLISR using sectionalizers detecting feeder voltage (SDFV)

5.3.3.1 Description of the use case

5.3.3.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|---|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Fault Location, Isolation, and Service Restoration (FLISR) using sectionalizers detecting feeder voltage (SDFV) |

5.3.3.1.2 Version management

| Version management | | | | | | |
|--------------------------------------|---------------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management Changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| 1.0 | June 19, 2015 | Tetsuo Otani | | | | Draft |
| 1.1 | July 10, 2015 | Tetsuo Otani | | | | Draft |
| 1.2 | Jun 14, 2016 | Tetsuo Otani | | | | Draft |
| 1.3 | Jul 21, 2016 | Tetsuo Otani | | | | Draft |

5.3.3.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Distribution System Operation |
| Scope | The Fault Location, Isolation and Service restoration scheme operates in automated mode to help the distribution system operator isolate faults and reconfigure the network to re-energize as many unaffected feeder sections as possible. |
| Objective | Isolate faults in the power system to maintain safety and minimize the duration of power interruptions to improve overall power grid reliability. |

5.3.3.1.4 Narrative of use case – Short description

This FLISR logic automatically alters the topological structure of distribution feeder systems by changing the open/close status of switches according to feeder voltage detection. In particular, when a permanent fault occurs and the upstream sectionalizer changes to lockout status after the fault section is identified, FLISR can selectively change switch statuses to isolate a fault and restore power to as much load as possible.

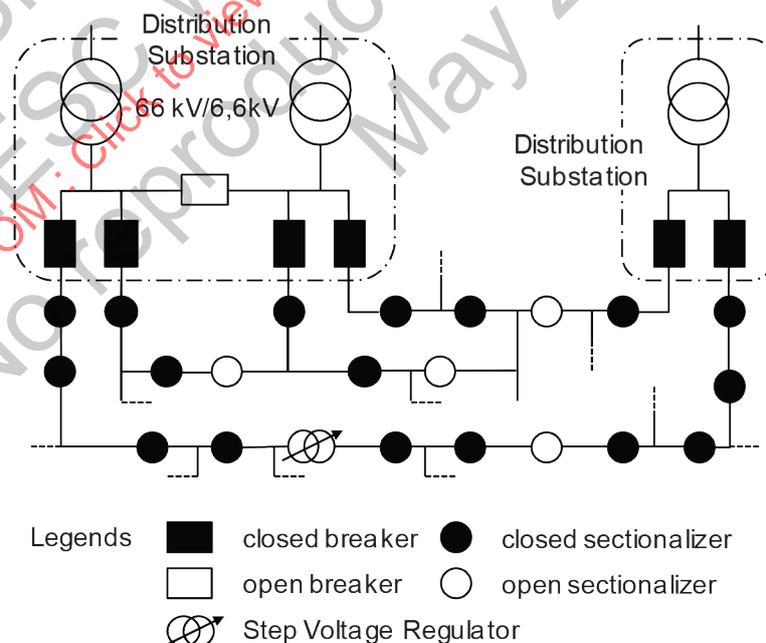
5.3.3.1.5 Narrative of use case – Complete description

A. Distribution Grid Configuration

Figure 14 shows a typical configuration of the distribution grid in urban areas. Feeders dendritically run from distribution substations and link up with a tie-sectionalizer, which normally opens and is thus known as an open loop configuration.

Feeders vary from about 3 km in urban areas to 60 km in rural areas and all have each kilometer segmented with a sectionalizer that is normally closed. A recloser is installed on a long feeder instead of a sectionalizer, to protect the feeder against faults that the feeder circuit breaker (FCB) is unable to isolate. A step voltage regulator (SVR) is installed on a long feeder to prevent voltage drop.

The distribution grids are constructed as an insulated neutral system. Accordingly, protective relays are built taking the characteristics of insulated neutral systems into consideration.



Note: A recloser is installed instead of a sectionalizer in some cases.

IEC

Figure 14 – A distribution grid configuration in a multi-source network based on open loops

B. FLISR procedure

The FLISR procedure provided in the DAS is illustrated in Figure 15 and assumes a permanent fault in the section between sectionalizers S2 and S3 (step 1). When a protective relay in the distribution substation detects the fault, it trips the FCB to interrupt the fault current (step 2). Each IED connected to a sectionalizer on the feeder detects no-voltage at the corresponding sectionalizer and opens it (step 3). The FCB is reclosed after a specific interval has elapsed to restore the power supply (step 4). The IED of S1 closes the sectionalizer S1 after a specific delay (X specific delay) since it detects that the section near the distribution substation is charged (step 5). The IED of S2 does the same as the IED of S1 (step 6). At this time, the protective relay in the distribution substation detects the fault again and trips the FCB (step 7). All the IEDs connected to the closed sectionalizers re-open them. The IED of S2 detects no-voltage within another (Y specific) delay and locks the sectionalizer S2 open (step 8). The fault is then located and isolated at this step.

The FCB is reclosed again after the time interval for the FCB has elapsed (step 9) and the IED of S1 closes the sectionalizer S1 after the reclose-delay-time (step 10). These operations restore power to the sections between the distribution substation and sectionalizer S2. The IED of S2 does not close the sectionalizer S2 because it is locked, meaning the fault does not recur. Note that the operations between steps 1 to 10 do not require communications between the master unit and the IEDs.

S4 is closed to supply power to the section between S3 and S4 from substation 2. It is executed by either of two schemes; autonomous IED control (non-communication-based scheme) or command issued by the master unit (communication-based scheme).

The FLISR procedure is completed and power is restored to all sound sections in step 11.

If a fault is temporary, the second trip of FCB (step 7) does not occur and power to all sections is restored.

Supervisory data acquired by the IEDs of sectionalizers is sent to the master station to analyze the fault.

To identify a fault point more precisely, the master unit can issue a command to the IED of S2 to close the sectionalizer S2 within a short period not to trip the FCB, which is known as a momentary charge.

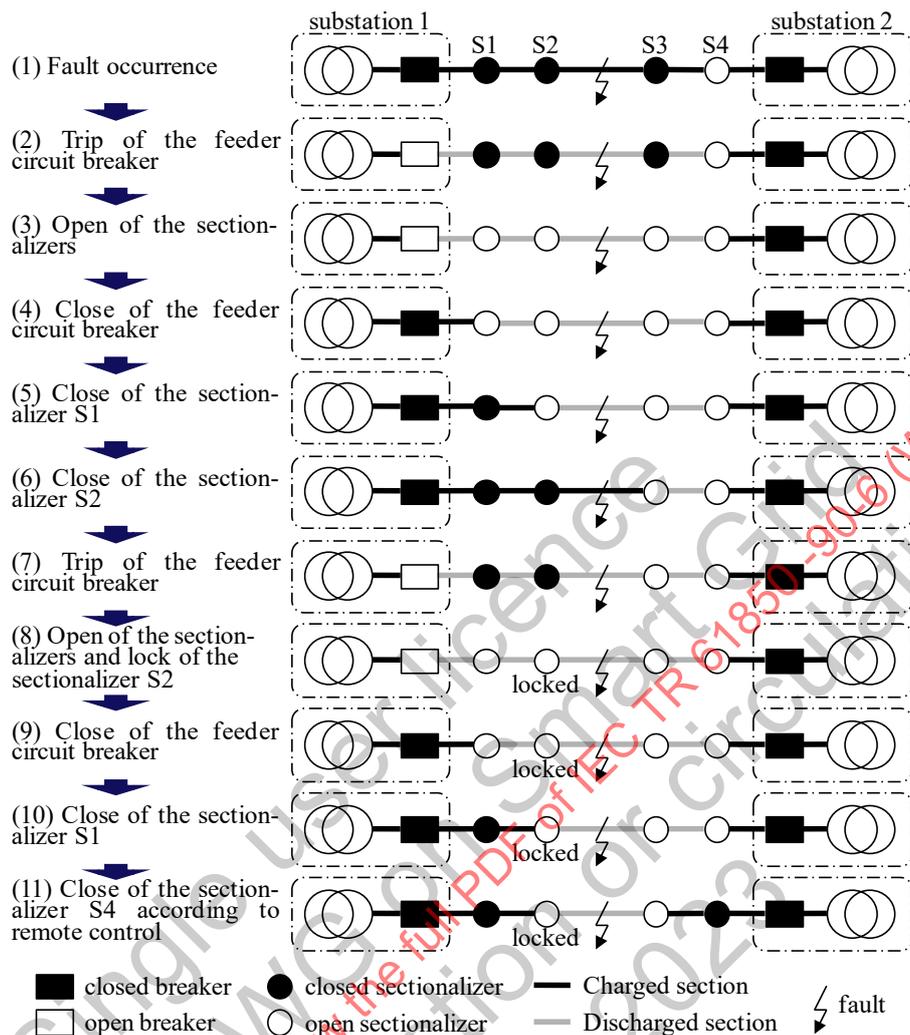


Figure 15 – The basic behavior of distribution feeder in FLISR using sectionalizers detecting feeder voltage

C. Configuration

The master station communicates with the IEDs to set parameters for the FLISR procedure such as X specific delay and connection direction. The X specific delay is used to close the sectionalizer in the step 5 of the FLISE procedure. The connection direction indicates which side of sectionalizer is connected to the substation side.

5.3.3.1.6 General remarks

This Use Case describes the function of the Fault Location, Isolation and Service Restoration (FLISR) system with sectionalizers operated in an “open loop” topology. The FLISR process differs from that described in Section 5.1. Currently the use case does not consider the impact of DER.

Each sectionalizer needs to have some time delay configurations used for reclosing. Configuration values should be sent via communications between the DMSapp and sectionalizers. The DMSapp also monitors the statuses of sectionalizers to understand the distribution grid topology

5.3.3.2 Diagrams of use case

Figure 16 to Figure 27 show the main sub-use cases and associated sequence diagrams of FLISR using SDFV.

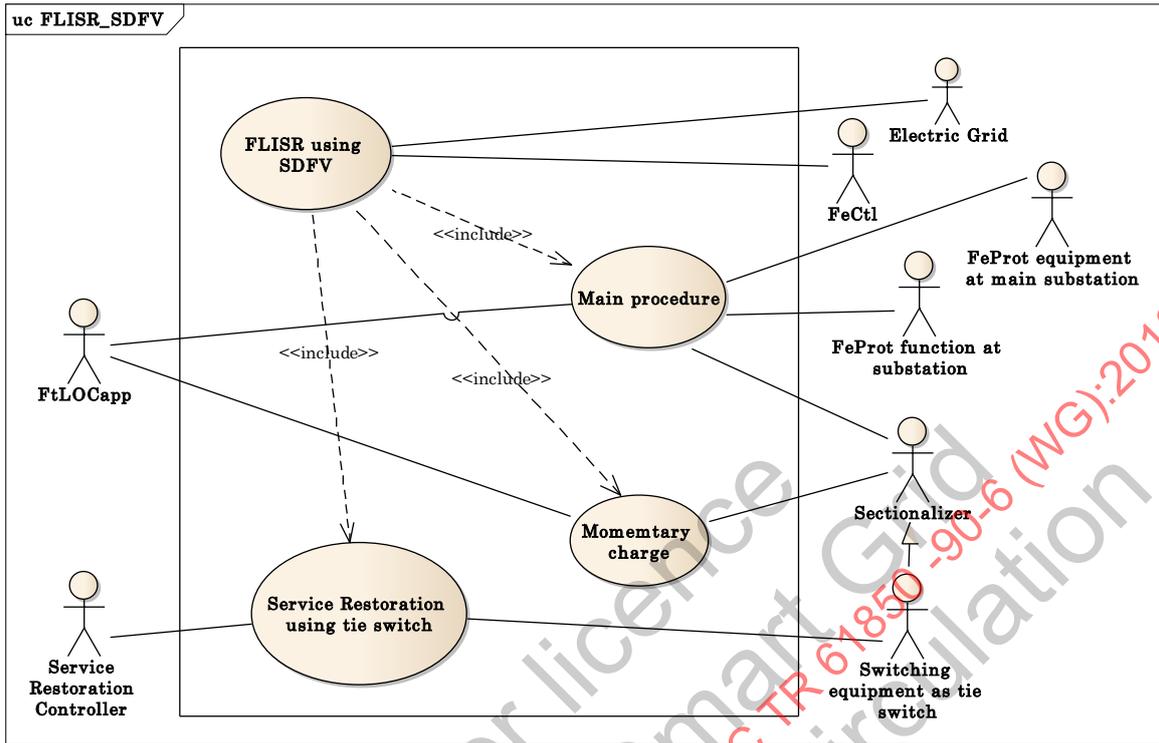


Figure 16 – FLISR-SDFV use case break down

Single user license
EESC WG on Smart Grid
IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
No reproduction or circulation
May 2023

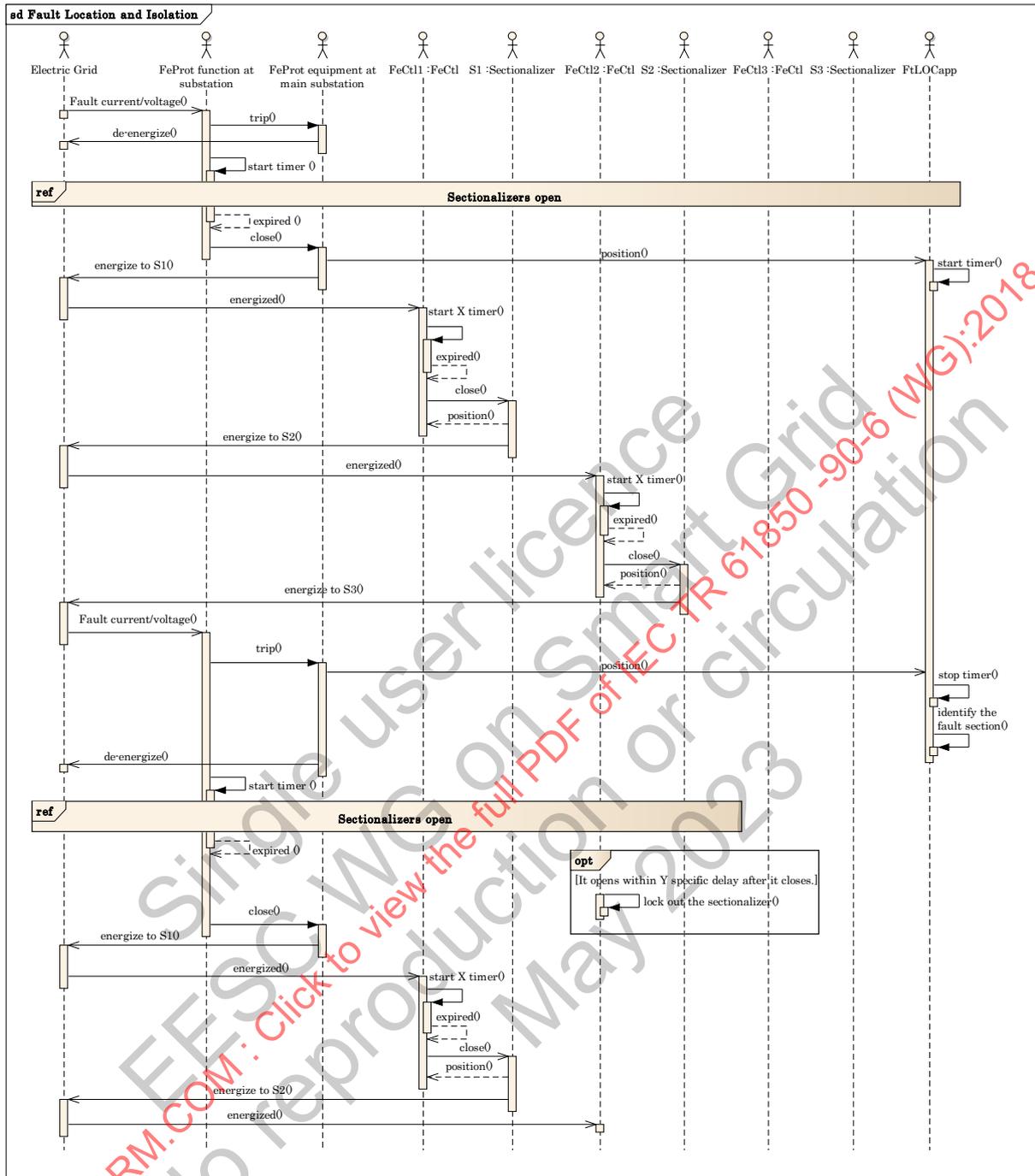


Figure 17 – FLISR-SDFV Fault Location and Identification sequence diagram

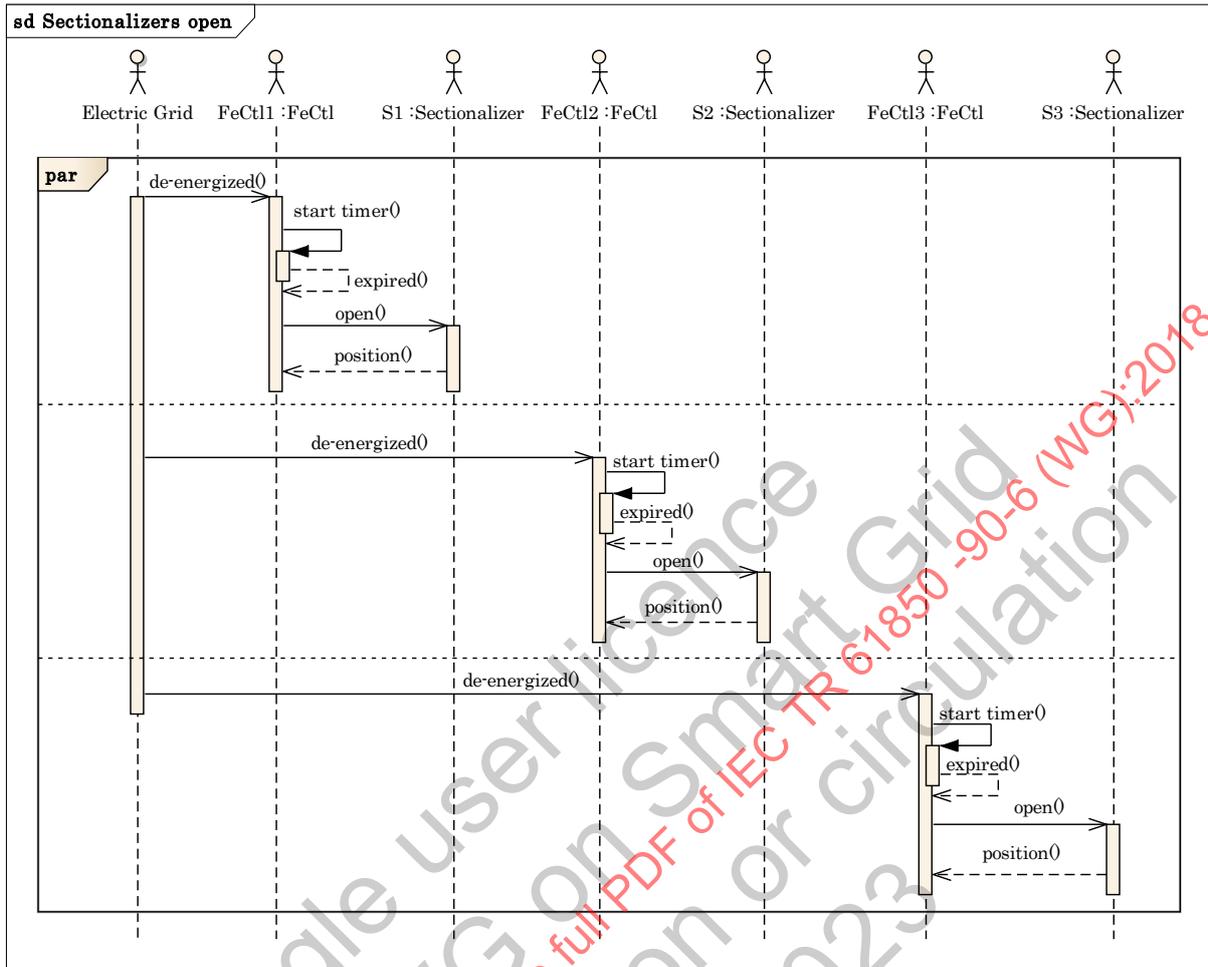


Figure 18 – FLISR-SDFV Fault Location and Identification sequence diagram

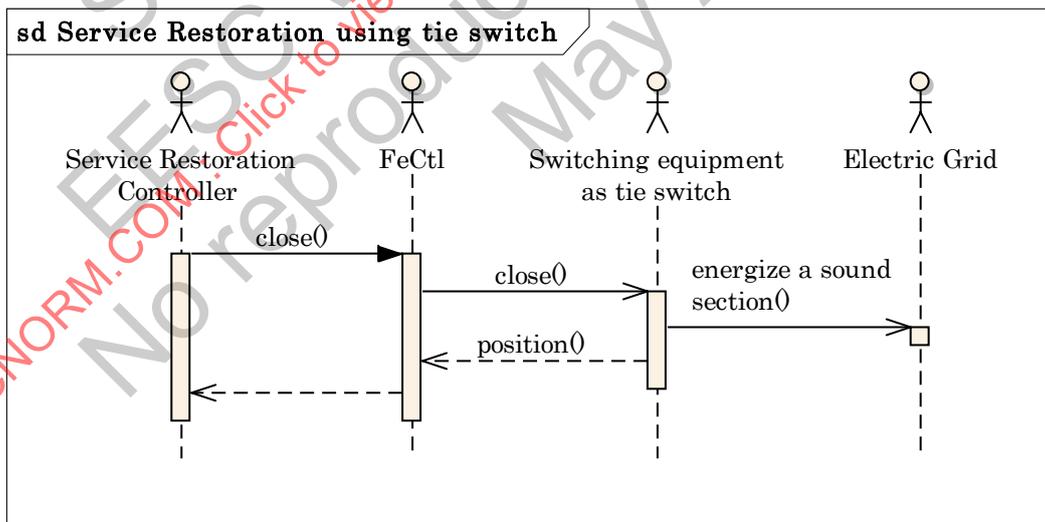


Figure 19 – FLISR-SDFV Fault Location and Identification sequence diagram

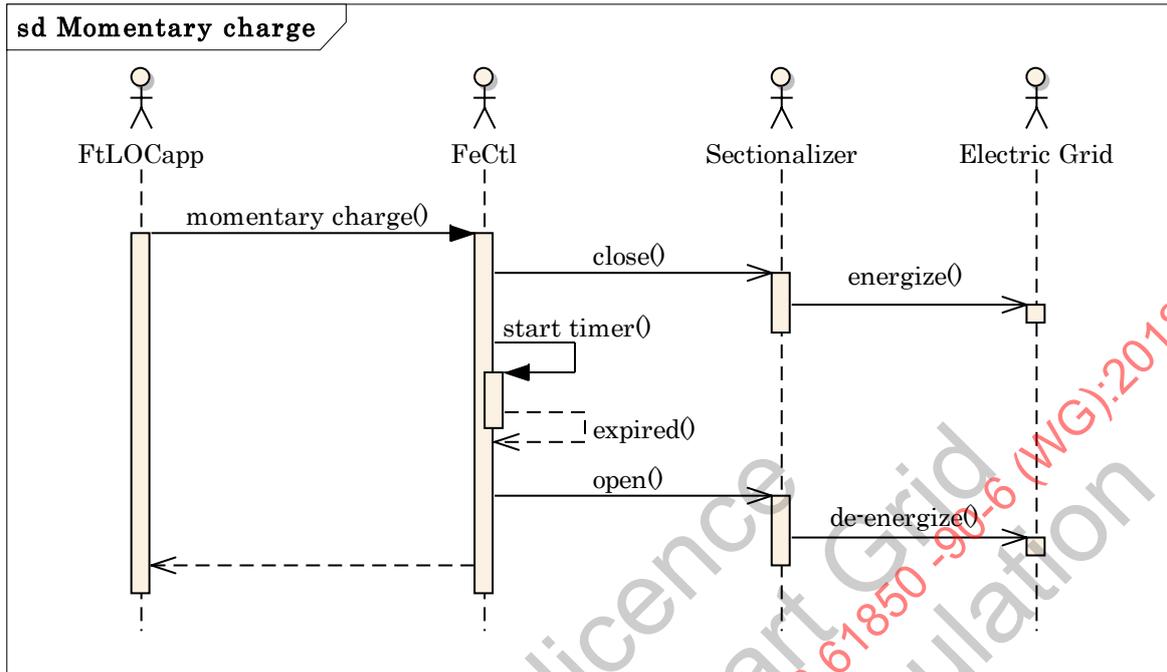


Figure 20 – FLISR-SDFV Fault Location and Identification sequence diagram

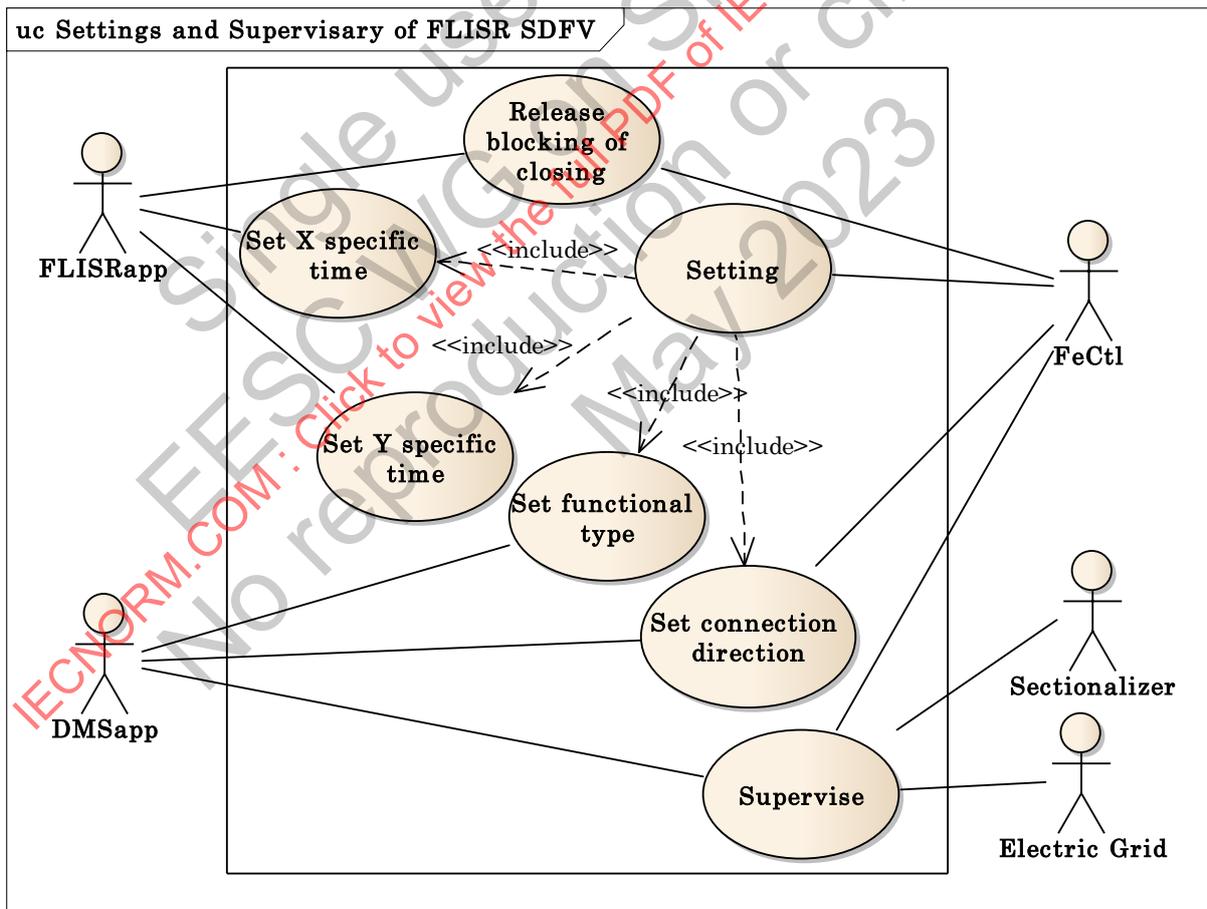


Figure 21 – Auxiliary use cases for FLISR using SDFV

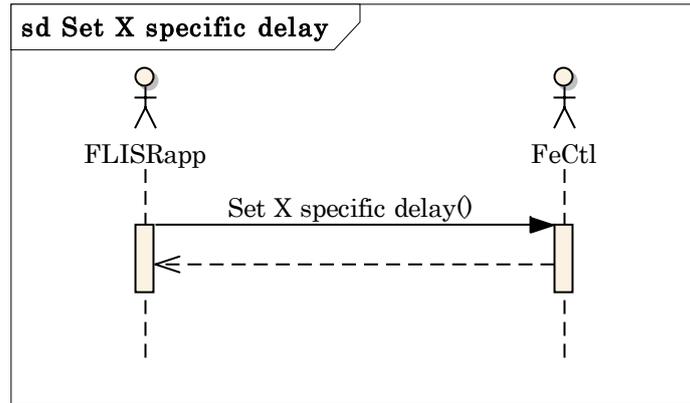


Figure 22 – FLISR-SDFV Set X specific time sequence diagram

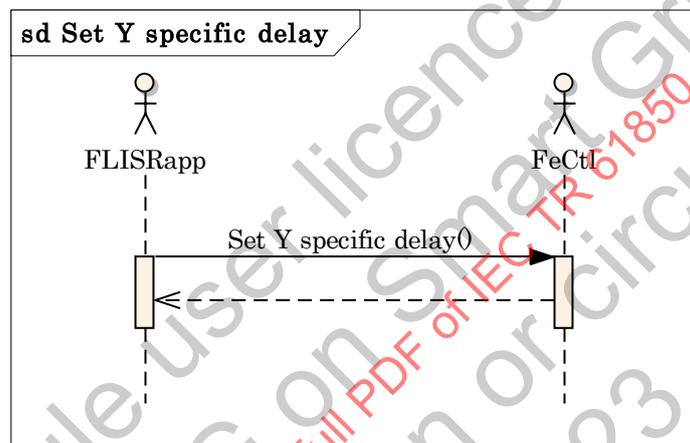


Figure 23 – FLISR-SDFV Set Y specific time sequence diagram

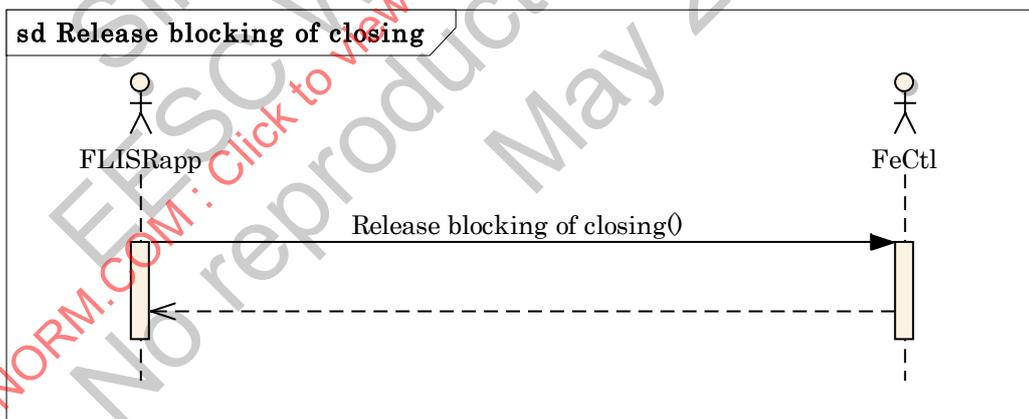


Figure 24 – FLISR-SDFV Release blocking of closing sequence diagram

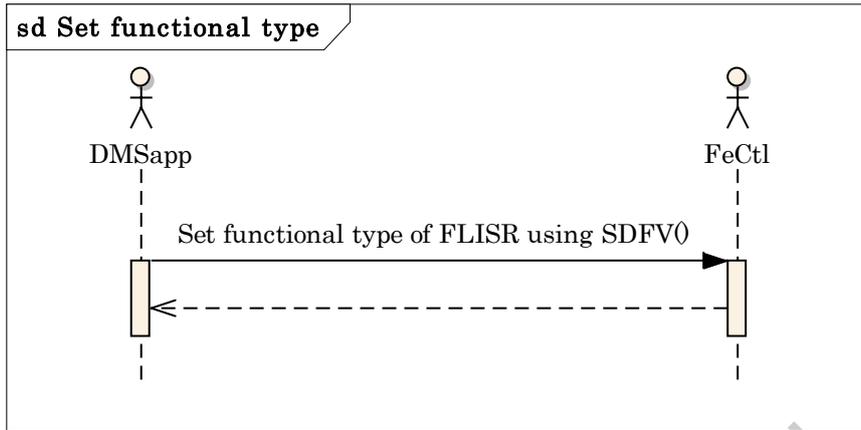


Figure 25 – FLISR-SDFV Set functional type sequence diagram

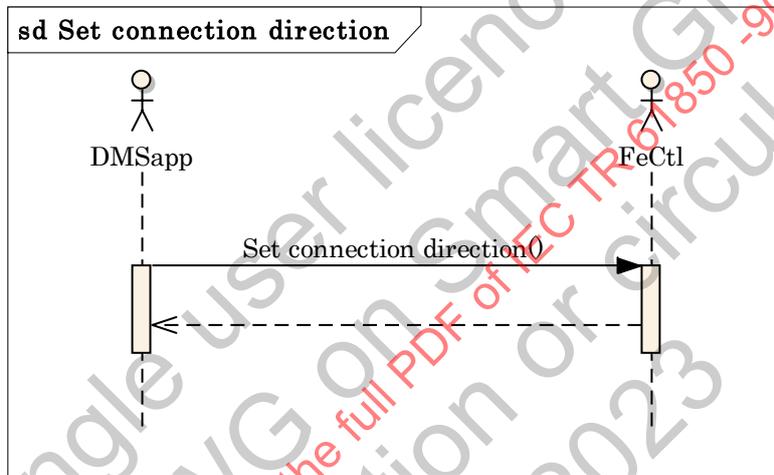


Figure 26 – FLISR-SDFV Set connection direction sequence diagram

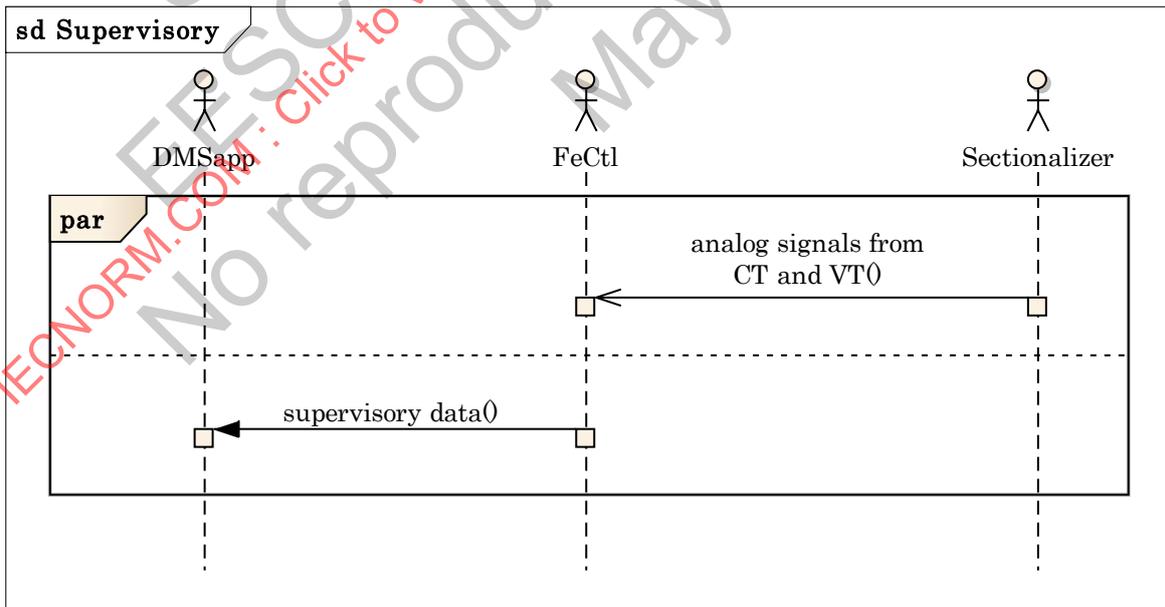


Figure 27 – FLISR-SDFV Supervisory sequence diagram

5.3.3.3 Technical details

5.3.3.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|--|------------------------------|-------------------------------------|---|
| Grouping (Community) | | Group description | |
| Actor name see Actor list | Actor type see Actor list | Actor description see Actor list | Further information specific to this use case |
| Electric Grid | System process | Refer to Clause 4 | |
| Sectionalizer | System process | Refer to 4.1 | |
| Switching equipment as tie Switch | System process | Refer to 4.1 | |
| FeCtl | System field | Refer to 4.1 | |
| FeProt (equipment) at main substation | System | Refer to Clause 4 | |
| FeProt (function) at substation | System field | Refer 4.1 | |
| DMSapp | System | Refer to Clause 4 | |
| FtMgtapp | System | Refer to Clause 4 | |
| FLISRapp | Application | Refer to Clause 4 | |
| FtLOCapp | System operation | Refer to 4.1 | |
| Service Restoration Controller | System operation | Refer to 4.1 | |

5.3.3.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|--|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | Continuous | | The Grid is continuously monitored The Grid topology is known and reflects the real topology The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches) |
| Electric Grid | | | The Grid is reacting in presence of the fault. |
| FLISRapp | Detection of fault and trip by FeProt at main substation | | It can calculate when a tie-switch should be closed according to the situation of the grid and fault. |
| Sectionalizers | Continuous | | All sectionalizers are configured for the FLISRapp in advance. |
| FeProt (function) at substation | Continuous | | It is configured to detect a fault according to the feeder characteristics. |

5.3.3.3 Further information to the use case for classification / mapping

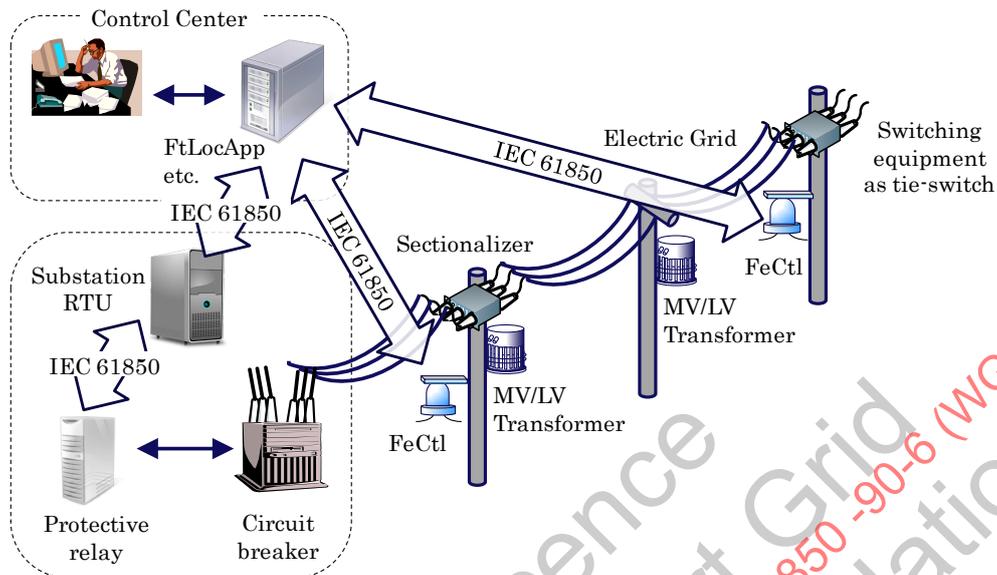


Figure 28 – Common actors in a distribution system with FLISR using SDFV

Figure 28 illustrates some of the common actors in a distribution automation system with FLISR using SDFV.

5.3.3.4 Step by step analysis of use case

5.3.3.4.1 General

| Scenario conditions | | | | | |
|---------------------|--|---------------|------------------|---------------|----------------|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 1 | FLISR using SDFV | | | | |
| 2 | Settings and Supervisory of FLISR using SDFV | | | | |

5.3.3.4.2 Steps – FLISR using SDFV

| Scenario | | | | | | | | |
|----------------|---|-----------------------------|---|---------|-------------------------------|-------------------------------------|-----------------------|--|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| | | Main procedure sub-use-case | | | | | | |
| 1a | A fault occurs on the grid | | A short circuit or earth fault occurs on the grid. | | Electric Grid | FeProt function at substation | Fault current/voltage | |
| 1b | A fault occurs on the grid. | | The protective relay at substation (FeProt function at substation) detects the fault on the grid. | | FeProt function at substation | FeProt equipment at main substation | Trip command | All the sections are de-energized. A timer in the protective relay starts. |
| 1c | A fault occurs on the grid. | | All sections of feeder are de-energized. | | Electric Grid | Field Sectionalizers | De-energized | All the sectionalizers open by detecting zero-voltage state on the feeder. The details are described in the Sectionalizers open sub-use-case |
| 2a | The first service restoration procedure | | The timer in the protective relay (FeProt function at substation) expires. The circuit breaker (FeProt at equipment at main substation) is closed. | | FeProt function at substation | FeProt equipment at main substation | Close command | The section between the substation and S1 is energized. The FeCtl1 starts the timer for X specific delay. The FtLOCapp recognizes that the CB is closed. |
| 2b | The first service restoration procedure | | The timer for X specific delay expires in FeCtl1 | | FeCtl1 | Sectionalizer S1 | Close command | The sections to S2 are energized. The FeCtl2 starts the timer for X specific delay. |
| 2c | The first service restoration procedure | | X specific delay expires in FeCtl2 | | FeCtl2 | Sectionalizer S2 | Close command | The sections to S3 are energized |
| 3a | A fault recurs on the grid. | | The fault recurs on the grid because it is permanent. | | Electric Grid | FeProt function at substation | Fault current/voltage | |
| 3b | A fault recurs on the grid. | | The protective relay at substation detects the fault on the grid. | | FeProt function at substation | FeProt at main substation | Trip command | All the sections are de-energized. The timer in the protective relay starts. The FtLOCapp recognizes that the CB is opened and stops the timer. |
| 3c | A fault recurs on the grid. | | All sections are de-energized. | | Electric Grid | Sectionalizers | De-energized | All the sectionalizers open by detecting zero-voltage state on the feeder. The details are described in the Sectionalizers open sub-use-case |

| Scenario | | | | | | | | |
|----------------|---|---|---|---------|--------------------------------|-------------------------------------|----------------------------|---|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 4a | Location and isolation of the fault section | | SectionalizerS2 within Y specific delay | | FeCtl2 | FeCtl2 | Lock out command | Sectionalizer S2 is locked to open. |
| 4b | Location and isolation of the fault section | | FtLOCapp identifies the fault section | | FtLOCapp | FtLOCapp | Identify the fault section | |
| 5a | The second service restoration procedure | | The timer in the protective relay (FeProt function at substation) expires. The circuit breaker (FeProt at equipment at main substation) is closed. | | FeProt function at substation | FeProt equipment at main substation | Close command | The section to S1 is energized. The FeCtl1 starts the timer for X specific delay. |
| 5b | The second service restoration procedure | | The timer for X specific delay expires in FeCtl1 | | FeCtl1 | Sectionalizer S1 | Close command | The sections to S2 are energized. The FeCtl2 starts the timer for X specific delay. |
| | | Sectionalizers open sub-use-case | | | | | | |
| 1c-1 3c-1 | Non-voltage on the Electric Grid | | The Electric Grid is de-energized. | | Electric Grid | FeCtl | de-energized | A FeCtl starts the timer for opening the sectionalizer connected to it. |
| 1c-2 3c-2 | Expiration of the timer in FeCtl | | FeCtl opens the sectionalizer connected to it. | | FeCtl | Sectionalizer | open command | The FeCtl confirms the position of sectionalizer. |
| | | Service Restoration using tie switch sub-use-case | | | | | | |
| 6 | Service restoration for the sound sections away from the fault section. | | The tie switch is closed due to a command from the Service Restoration Controller. | | Service Restoration Controller | FeCtl | Close command | FeCtl closes the switching equipment as tie switch, so the section close to the tie-switch is energized. Req of transfer time = TT1 (1000 ms) |
| | | Momentary charge sub-use-case | | | | | | |

| Scenario | | | | | | | | |
|----------------|------------------|---------------------------|--|---------|------------------------------|------------------------------|--------------------------|---|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 7a | Momentary charge | | FtLOCapp sends a request of momentary charge to the FeCtl | | FtLOCapp | FeCtl | Momentary charge command | The field sectionalizer closes at moment and opens. Req of transfer time = TT1 (1000 ms) |
| 7b | Momentary charge | | The sectionalizer close to the fault section is closed | | FeCtl | Sectionalizer | close command | The fault section on the electric grid is energized. |
| 7c | Momentary charge | | The sectionalizer close to the fault section is opened within a short period not to trip the substation breaker. | | FeCtl | Sectionalizer | open command | |

Single user license
 EEESC WG on Smart Grids
 No reproduction or circulation
 May 2023
 IECNORM.COM : Click to view the full PDF of IEC TR 61850-90-6 (WG):2018

5.3.3.4.3 Settings and supervisory of FLISR using SDFV

| Scenario | | | | | | | | |
|----------------|---|---------------------------------------|--|---------|------------------------------|------------------------------|---|--------------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| | | Set X specific delay sub-use-case | | | | | | |
| 1 | Set of X specific delay | | The X specific delay in a FeCtl is set. | | FLISRapp | FeCtl | Set X specific delay | Req of transfer time = TT1 (1000 ms) |
| | | Set Y specific delay sub-use-case | | | | | | |
| 2 | Set of Y specific delay | | The Y specific delay in a FeCtl is set. | | FLISRapp | FeCtl | Set Y specific delay | Req of transfer time = TT1 (1000 ms) |
| | | Release blocking of closing use case | | | | | | |
| 3 | Release blocking of closing | | The block closing set by FLISR using SDFV in a FeCtl is released to enable the sectionalizer close. | | FLISRapp | FeCtl | Release blocking of closing | Req of transfer time = TT1 (1000 ms) |
| | | Set functional type use case | | | | | | |
| 4 | Set functional type of FLISR using SDFV | | The functional type of FLISR using SDFV in FeCtl is changed according to distribution grid topology. | | DMSapp | FeCtl | Set functional type of FLISR using SDFV | Req of transfer time = TT1 (1000 ms) |
| | | Set connection direction sub-use-case | | | | | | |

| Scenario | | | | | | | | |
|----------------|--|--------------------------|---|---------|------------------------------|------------------------------|--|---|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 5 | Set of connection direction of sectionizer | | The connection direction of a sectionizer is set to forward or reverse. | | DMSapp | FeCtl | Set connection direction | Req of transfer time = TT1 (1000 ms) |
| | | Supervisory sub-use-case | | | | | | |
| 6 | Sampling | | CTs and VTs in the sectionizer sample current and voltage respectively. | | Sectionalizer | FeCtl | | |
| 7 | Fault recognition by FeCtl | | FeCtIs send monitoring data related to the fault. | | FeCtl | DMSapp | Supervisory data related to the fault such as relay activation | Some relay elements are installed in the FeCtl. Req of transfer time = TT1 (1000 ms) |

5.3.3.5 Information exchanged

| Information exchanged | | |
|-------------------------------|--|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| Fault current/voltage | The current and voltage values on zero-phase caused by the fault, because the distribution grid is an insulated neutral system. | |
| Trip command | A command issued by the protective relay to open the substation breaker. | |
| Energize | A feeder is energized by closing switchgear such as sectionizer or circuit breaker. | |
| De-energize | No voltage on a feeder. | |
| Start timer | A FeCtl start a timer in it. | |
| Expired | A timer in FeCtl expires according the preset duration. | |
| Position | A device such as FeCtl or application recognizes that the switchgear under control such as sectionizer or circuit breaker is open or closed. | |
| Open command | A command issued by a device such as FeCtl to open the sectionizer. For some types of sectionizers automatically open itself. | |
| Close command | A command issued by the protective relay to close the substation breaker. A command issued by the FeCtl to close the sectionizer. | |
| Lock out command | A command issued by the FeCtl to keep the sectionizer open. | |

| Information exchanged | | |
|-------------------------------|--|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| Supervisory data | Data acquired by the FeCtl related to the fault, e.g. direction of fault, detection of over current, open/close status of sectionalizer. | |
| Momentary charge command | A command to close the sectionalizer within a short period not to trip the substation breaker. | |
| Set X specific delay | A command to set X specific delay in a FeCtl. | |
| Set Y specific delay | A command to set Y specific delay in a FeCtl. | |
| Control the relay mode | A command to switch over the relay mode to operated or blocked. | |
| Set connection direction | A command to set the direction of a sectionalizer to forward or reverse. | |
| Analog signals from CT and VT | Analog signals to show current and voltage on the feeder on which the sectionalizer is mounted. | |
| Supervisory data | A data set representing status and alarms such as protective relay activation. | |

5.4 Use case 3: FLISR based on centralized control

5.4.1 General

FLISR based on centralized control applies to the feeder that has a remotely controlled breaker at the main substation and several remotely monitored fault passage indicators located at suitable points along the feeder, as well as remotely controllable switches along the feeder to isolate the faulty section. The fault passage indication information is sent to the control center so that the system and/or operator can decide where the fault is located and send commands to the appropriate remotely controlled switches to isolate the faulty section. If the fault is successfully isolated, then the final step is to send commands to restore power to the healthy sections. Two use cases for the FLISR based on centralized control are described in this section. Use case 3a for the application in a radial feeder, and use case 3b is for the application in an open loop.

5.4.2 Use case 3a: FLISR in a radial feeder based on centralized control

5.4.2.1 Description of the use case

5.4.2.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|---|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | FLISR in a radial feeder based on centralized control |

5.4.2.1.2 Version management

| Version management | | | | | | |
|--------------------------------------|-------------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management Changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| First version in IEC template | 1- Aug-2014 | Laurent Guise, Tom Berry | | | | Draft |

5.4.2.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Network Operation |
| Scope | The Distribution Automation (DA) system with the help (or not) of the Operator identifies, locates, isolates a fault in a network operated radially and restores the healthy section of the feeder |
| Objective | Minimize the duration of power interruptions |

5.4.2.1.4 Narrative of use case – Short description

When a permanent fault occurs on a feeder, the main breaker will trip and reclose one or more times but then remains open.

Fault passage indication information is sent to the control center so that the system and/or operator can decide where the fault is located and send commands to isolate the faulty section. If the fault is successfully isolated, then the final step is to send a command to reclose the feeder breaker and restore power to the upstream healthy section.

5.4.2.1.5 Narrative of use case – Complete description

The following steps describe how the Function works:

The health of the power delivery system is constantly monitored, by Fault Passage Indicators (FtPInd) located on the radially operated power system under focus.

When a fault occurs on the power grid, the Feeder Protection equipment at main substation (where the fault appears) tries first to eliminate the fault current and to eliminate the reason of fault mostly by making one or many attempts of reclose.

Then when a “permanent” fault is confirmed on the power grid, the main breaker has de-energized the faulty part of the feeder. Communication to the control center is used for warning the System Operator (SysOp) and the FLISR application module (FLISRapp).

The concerned remote FtPInds located on the power system, which have detected the fault signature, communicate to the FLISRapp the information that such fault signature was observed. This can be event-driven communication by the FtPInds, or under the initiative of the remote system or both.

Based on the received information (which may be partly faulty, i.e. the signature of the fault may have been observed by devices not directly concerned by the fault, especially in presence of high rate of capacitive current), the FLISRapp with or without the System Operator identifies the smaller faulty section

Once the faulty section is identified, the FLISRapp determines and notifies the System Operator of the various valid switching options to be used to isolate the faulty section i.e. the two remotely operated opening points.

Next the System Operator or the FLISRapp selects the best switching option (based on multiple criteria, among which the compliance with grid codes rules) and uses the FLISRapp to execute the switching procedure to open the switches on each side of the fault location to "Isolate" the faulty section.

Finally, the System Operator or the FLISRapp re-energizes the feeder which has become healthy by switching on the main Protection device.

Conditions of power unavailability are logged into the system depending on consumer impact.

5.4.2.1.6 General remarks

The targeted system with the help (or not) of the Operator identifies, locates, isolates a fault in a network radially operated and restore the healthy section of the feeder.

This use case describes how Fault Identification, Location, Isolation and Service Restoration function may run in a network radially operated. Currently the use case does not consider the impact of DER.

In this first approach, the feeder is not part of an open loop, then as the fault location is closer to the primary substation, the higher number of consumers will be impacted by the fault.

The function can be improved in case of an open loop topology, by re-energizing the healthy section downstream of the fault by the other part of the loop. This is considered as an alternative to the main use case.

This use case assumes that the feeder has a remotely controlled breaker at the main substation and several remotely monitored fault passage indicators located at suitable points along the feeder. The use case applies to feeders with sections of overhead line or underground cable or a mixture of both types.

5.4.2.2 Diagrams of use case

Figures 29 to 32 present the use case diagrams.

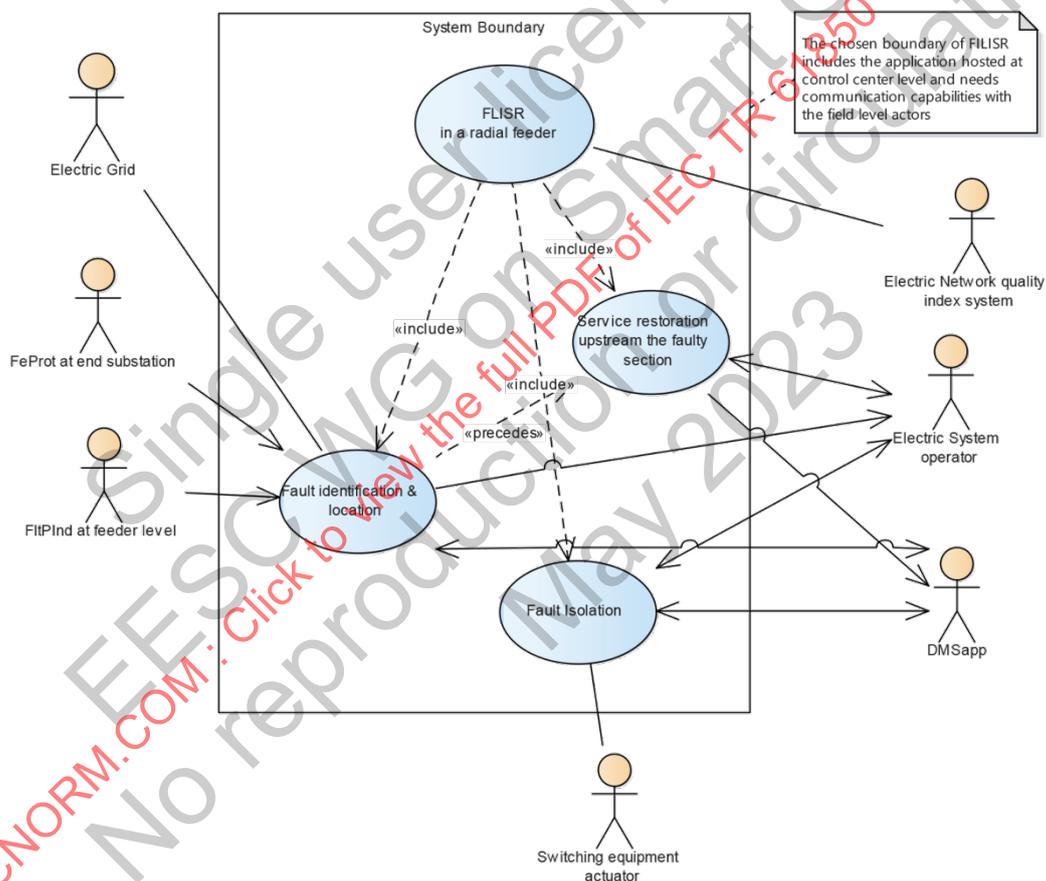


Figure 29 – Centralized FLISR in a radial feeder – Use cases

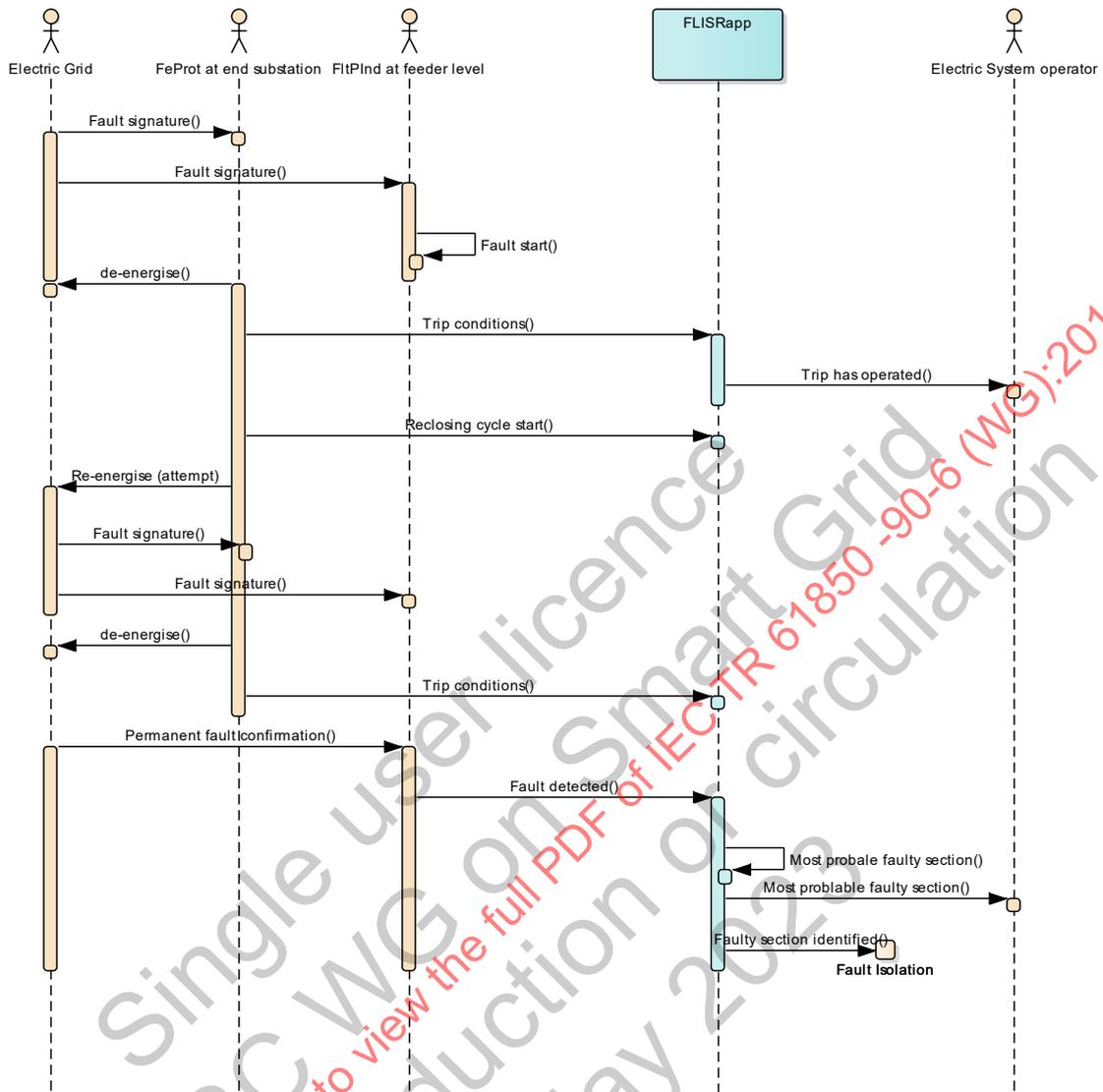


Figure 30 – Centralized FLISR for radial feeder – Fault location sequence diagram

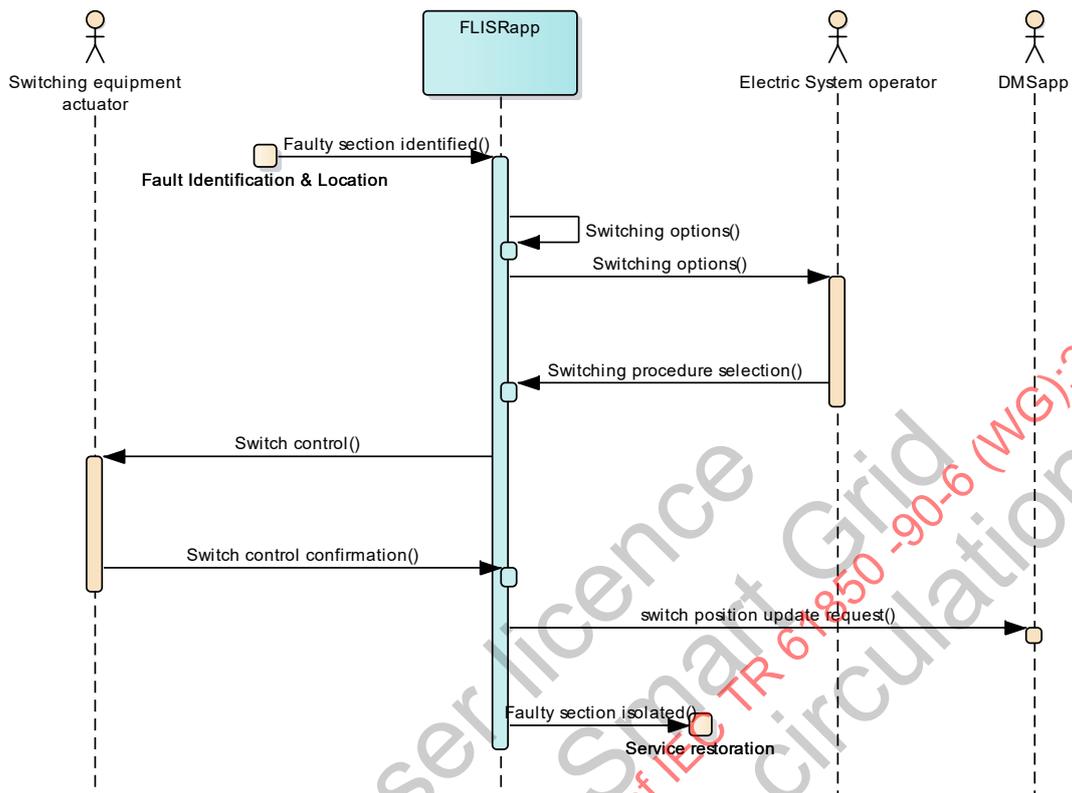


Figure 31 – Centralized FLISR for radial feeder – Fault isolation sequence diagram

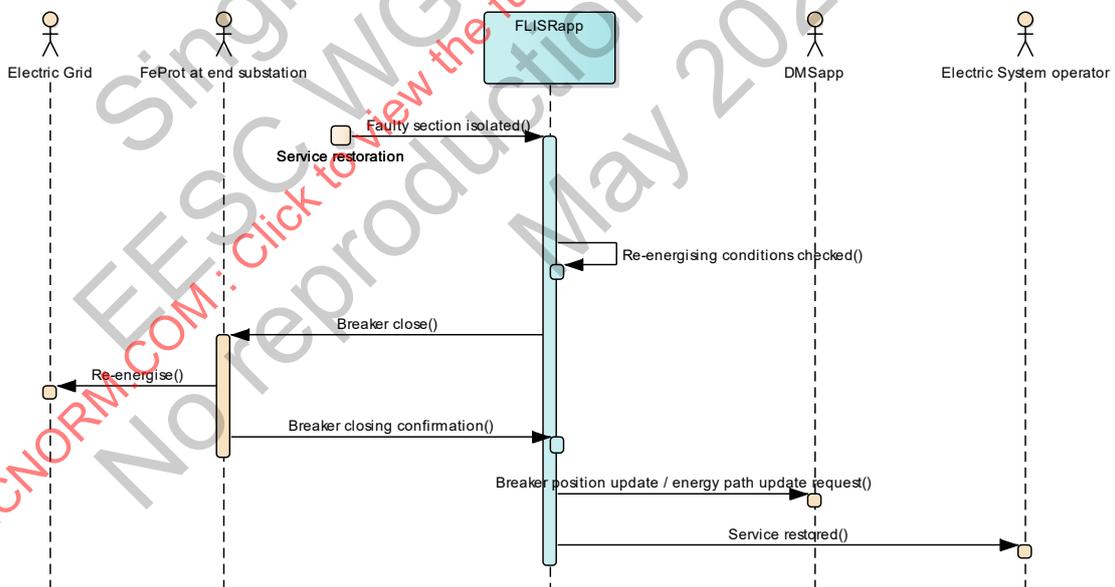


Figure 32 – Centralized FLISR for radial feeder – Service restoration sequence diagram

5.4.2.3 Technical details

5.4.2.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|------------------------------|------------------------------|-------------------------------------|---|
| Grouping (Community) | | Group description | |
| Actor name see Actor list | Actor type see Actor list | Actor description see Actor list | Further information specific to this use case |
| Electric Grid | System | Refer to Clause 4 | |
| FeProt at main substation | System | Refer to Clause 4 | |
| FtPInd | System | Refer to Clause 4 | |
| Switching equipment actuator | System | Refer to Clause 4 | |
| SysOp | Person | Refer to Clause 4 | |
| DMSapp | System | Refer to Clause 4 | |
| Quality index system | System | Refer to Clause 4 | |
| FLISRapp | System | Refer to Clause 4 | |

5.4.2.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|------------------|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | | | The Grid is continuously monitored The Grid topology is known and reflects the real topology The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches) |
| Electric Grid | | | The Grid is reacting in presence of the fault. |
| FLISRapp | | | Communication system between generic architectural component and control center where FLISR is hosted is operational |
| FeProt at main substation | | | Enough energy is stored and available for communicating |
| FtPInds | | | Enough energy is stored and available for communicating in absence of power |
| Switching equipment actuators | | | Enough energy is stored and available for remotely control the selected switches in absence of power |

5.4.2.4 Step by step analysis of use case

5.4.2.4.1 General

| Scenario conditions | | | | | |
|---------------------|--|---------------|-----------------------|---------------|---|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 5.3.4.1 | Radial Feeder | | Circuit breaker trips | | Fault is isolated by opening a switch "upstream" of the fault. Circuit breaker is reclosed. |
| 5.3.4.2 | Open-loop Feeder | | Circuit breaker trips | | Fault is isolated by opening one switch "upstream" of the fault, and another "downstream" of the fault. The circuit breaker is reclosed. The normal open switch is closed. |
| 5.3.4.3 | Open-loop Feeder with load restriction | | Circuit breaker trips | | Fault is isolated by opening one switch "upstream" of the fault, and another "downstream" of the fault. The circuit breaker is reclosed. Another switch downstream of the fault is opened to reduce the load before the normal open switch is closed. |

5.4.2.4.2 Steps – Radial Feeder

| Scenario | | | | | | | | |
|----------------|------------------------------------|-------------------------------|--|---------|------------------------------|------------------------------|-----------------------|----------------------------------|
| Scenario name: | | Radial Feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| | | Fault location "sub use case" | | | | | | |
| 1a | Fault occurs on the Grid | | Protection function detects a fault | | Electric Grid | FeProt at main substation | "fault signature" | |
| 1b | Fault occurs on the Grid | | Circuit breaker trips and clears the fault current | | FeProt at main substation | Electric Grid | De-energized feeder | |
| 1c | | | Information transfer | | FeProt at main substation | FLISRapp | Trip | Start of trip/reclose cycle |
| 2a | | | Information transfer | | FeProt at main substation | FLISRapp | Reclosing cycle start | Optional reclosing cycle |
| 2b | Fault current cleared + time delay | | First reclosing operation | | FeProt at main substation | Electric Grid | Re-energize | |
| 2c | Fault re-occurs on the Grid | | FeProt at main substation trips | | FeProt at main substation | Electric Grid | De-energize | |
| 2d | | | Information transfer | | FeProt at main substation | FLISRapp | Trip | Final trip |

| Scenario | | | | | | | | |
|----------------|---|---|--|---------|------------------------------|-------------------------------|---|--|
| Scenario name: | | Radial Feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 3 | Fault occurs on the Grid (same as 1) | | FtPInd detects « permanent » fault passage | | FtPInd | FtPInd | Start of fault detection | |
| 5a | End of timeout after fault start with absence of voltage or current | | Confirmation of a permanent fault (thanks to absence of voltage or current) | | FtPInd | FtPInd | “permanent fault” confirmation | |
| 5b | “Permanent” trip confirmation | | Reports « permanent » fault passage to FLISRapp | | FtPInd | FLISRapp | Fault detected with fault conditions | |
| 6 | Field (substation and detection) information received | | Uses FtPInd fault reports and CIM electrical network system model to determine the most probable faulty section of the faulty feeder | | FLISRapp | FLISRapp | “most probable” faulty section Between two controllable switches (Switching equipment actuators) | Outage Management System may also notify the SysOp |
| | | Fault upstream isolation “sub use case” | | | | | | |
| 7 | Faulty section identified | | Display valid switching options and their impact on the system | | FLISRapp | FLISRapp or Operator | List of switching options | |
| 8 | Switching options available | | Select desired switching procedures | | FLISRapp or Operator | FLISRapp | Selected switching procedure | |
| 9 | Controllable points to isolate the faulty section selected | | Transmit switching commands | | FLISRapp | Switching equipment actuators | Switch control | Secured control |
| 10 | Switches have operated | | confirm switching operations | | Field actuators | FLISRapp | Switching control confirmation | Faulty section is considered isolated |
| 11 | Position update received | | Updates system model and line status information | | FLISRapp | DMS – Network monitoring | Request for switch positions/ energy flow update | |
| | | Service restoration “sub use case” | | | | | | |

| Scenario | | | | | | | | |
|----------------|----------------------------------|--------------------------|---|---------|------------------------------|-------------------------------|--|---|
| Scenario name: | | Radial Feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 12a | Re-energizing conditions checked | | Transmits switching command to FeProt at main substation to reclose the breaker | | FLISRapp or Operator | FeProt at main substation | Breaker close control | |
| 12b | Re-energizing is confirmed | | Report breaker status | | FeProt at main substation | FLISRapp | Breaker closing confirmation | |
| 12c | Breaker Position update received | | FLISRapp updates system model and line status information | | FLISRapp | DMS – Network monitoring | Request for breaker positions/energy flow update | |
| 12 | Re-energizing is confirmed | | Start and duration of non-availability of power is logged from the time the fault occurred and per consumer | | FLISRapp | Network quality Logger system | Outage characterization | For power quality assessment (SAIDI, SAIFI calculation) |

Notes for Steps

1a – FeProt are located at main substations. If any, Distributed Energy Resources are automatically disconnected to avoid islanding mode, e.g. triggered on under voltage protection type protection.

2b – Fault and reason for fault can be automatically eliminated by the short circuit, and then very often the FeProt at main substation will engage an automatic reclosing cycle, especially in case of overhead lines protection, and check if re-energizing can be done immediately. If yes, this means that reason for fault has disappeared.

Depending on the recloser configuration Operation 2b to 2d can be repeated several times (typically 3), separated with defined time delays.

3 – Non-permanent faults (i.e. fault which either temporary – such as lightning, or which have been eliminated through the reclosing cycle) are ignored by FLISRapp (not transmitted in this procedure) but logged locally by the FPI.

Fault signature detection will depend on:

- Nature of the fault (phase to earth, phase to phase, single phase, multiple phases)
- Earthing method (intensity of the fault current)
- Ability to discriminate fault current from capacitive current (can done using directional fault detection)
- Presence of Distributed generation on the line

In order to optimize the FPI power consumption and battery duration, as well as to avoid overloading of the control center by un-needed messages, the FPI will consider a “permanent” fault only if the main breaker “FeProt at main substation” will do so. This condition is usually implemented where the network can't be operated with a leaving fault, by the checking of absence of voltage and/or current on the line.

5b – Could be « event-driven », under the initiative of each concerned field devices, or polled by the FLISRapp, on selected devices, or both.

Depending on the device the information can be:

- Passage signaled
- Idem above + the nature of fault
- Idem above + the direction of the fault location (downstream or upstream)

5.4.2.4.3 Information exchanged

| Information exchanged | | |
|-------------------------------|---|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| Fault signature | The set of fault passage indications reported for a feeder | |
| Energized status | Voltage presence / absence | |
| Trip / Breaker Open | Breaker open status – reason is tripping | |
| Breaker closed | Breaker closed status | |
| Reclose cycle start/end | Status of automatic reclosing controller | |
| Fault detection start | Start of fault detection calculation | |
| Permanent fault indication | Fault detection status latched after start of fault detection and confirmed by voltage or current absence for a time period | |
| Fault type / conditions | Earth fault, Phase fault etc. | |
| Fault summary | Fault summary including fault time, duration, the current and voltage magnitudes during and before fault | |
| Faulty section identifier | Identification of a section of network, maybe by identification of start and end points | |
| Switching options | List of switching device identifiers and operations | |
| Switch control | Open command | |
| Switch control confirmation | Isolating switch position | |
| Breaker control confirmation | Breaker position | |
| Outage characterization | Counters for different types of outage. Depends on utility reporting requirements | |

5.4.3 Use case 3b: FLISR in an open loop feeder based on centralized control

5.4.3.1 Description of the use case

5.4.3.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|---|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | FLISR of an open loop feeder based on centralized control |

5.4.3.1.2 Version management

| Version management | | | | | | |
|--------------------------------------|------------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management Changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| V1 | 1-Jan-2015 | Laurent Guise, Tom Berry | | | | Draft |

5.4.3.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Network Operation |
| Scope | The Distribution Automation (DA) system with the help (or not) of the Operator identifies, locates, isolates a fault in an open-loop network, operated radially and restores the healthy section of the feeder |
| Objective | Minimize the duration of power interruptions |

5.4.3.1.4 Narrative of use case – Short description

When a permanent fault occurs on a feeder, the main breaker will trip and may reclose one or more times but then remains open.

Fault passage indication information is sent to the control center so that the system and/or operator can decide where the fault is located. The operator, possibly aided partly or fully by the system, can send commands to isolate the faulty section. If the fault is successfully isolated, then the final step is to send commands to close the feeder breaker and the tie switch to restore power to the healthy sections upstream and downstream of the faulty section.

5.4.3.1.5 Narrative of use case – Complete description

This use case complements the use case “FLISR based on centralized control in a radially operated feeder”: Not only, the SysOp or the FLISRApp re-energizes the feeder which has become healthy by switching on the switching equipment controlled by the FeProt at main substation, but re-energizes under conditions the sections located downstream of the faulty section.

Conditions of power unavailability are logged into the system depending on consumer impact.

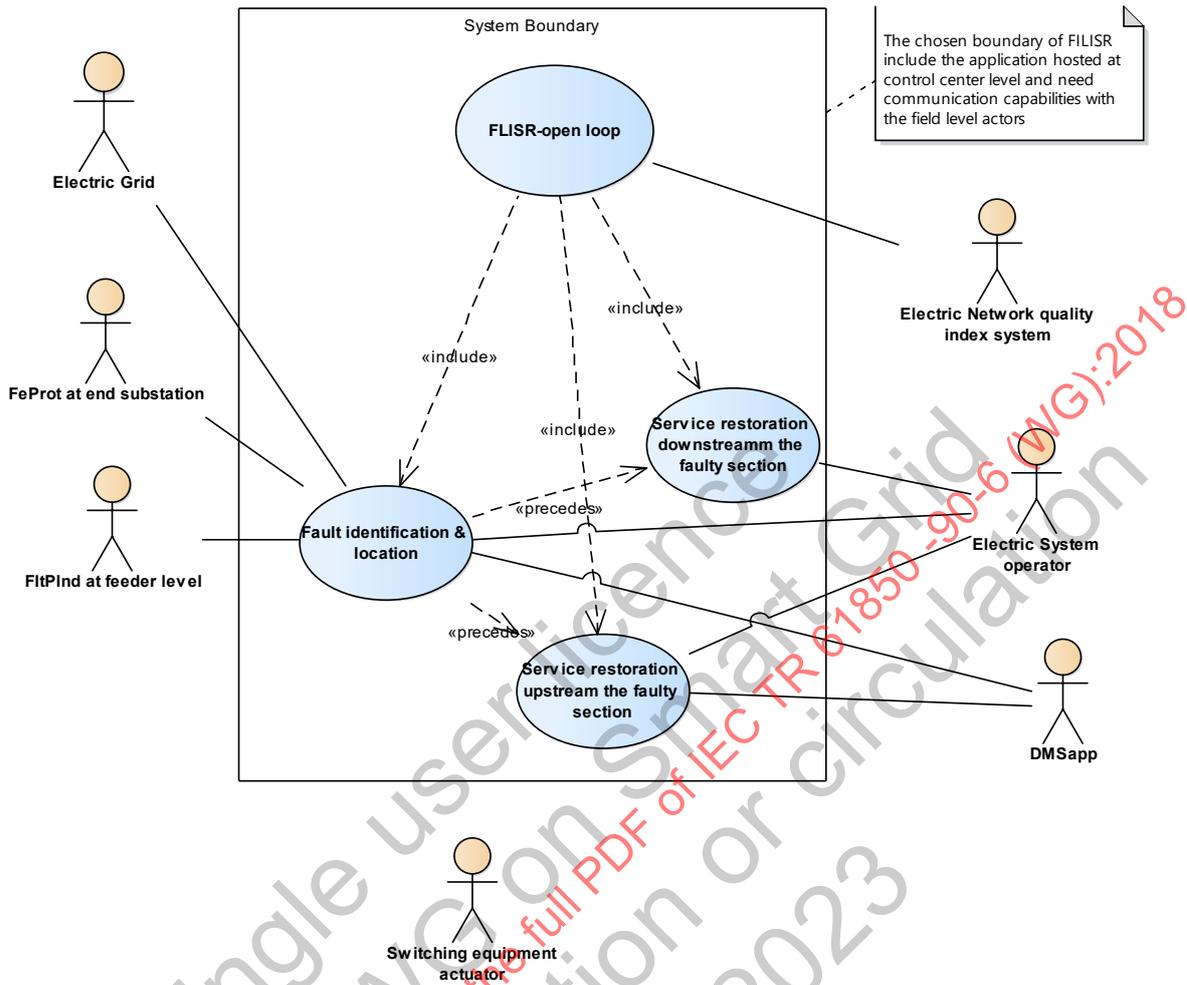
5.4.3.1.6 General remarks

This use case complements and improves the use case “FLISR based on centralized control in a radially operated feeder”: Currently the use case does not consider the impact of DER.

This use case assumes that the feeder has remotely controlled breakers at both ends of the open-loop located at the main substations and several remotely monitored fault passage indicators as well as remotely controlled switches located at suitable points along the both part of feeder. A Tie switch separates the feeders into two parts, which are individually radially operated. The position of the Tie Switch along the feeder may vary during the life of the feeder, however, in all cases, the assumption is made that both parts are never electrically connected during normal and abnormal operation. The use case applies to feeders with sections of overhead line or underground cable or a mixture of both types.

5.4.3.2 Diagrams of use case

Figures 33 and 34 present the use case diagrams.



NOTE Compared to the FLISR Radial use-case, the Fault isolation needs to perform the isolation of both ends of the faulty section. Thus the sequence diagram is slightly modified.

Figure 33 – Centralized FLISR for open loop – Use case breakdown

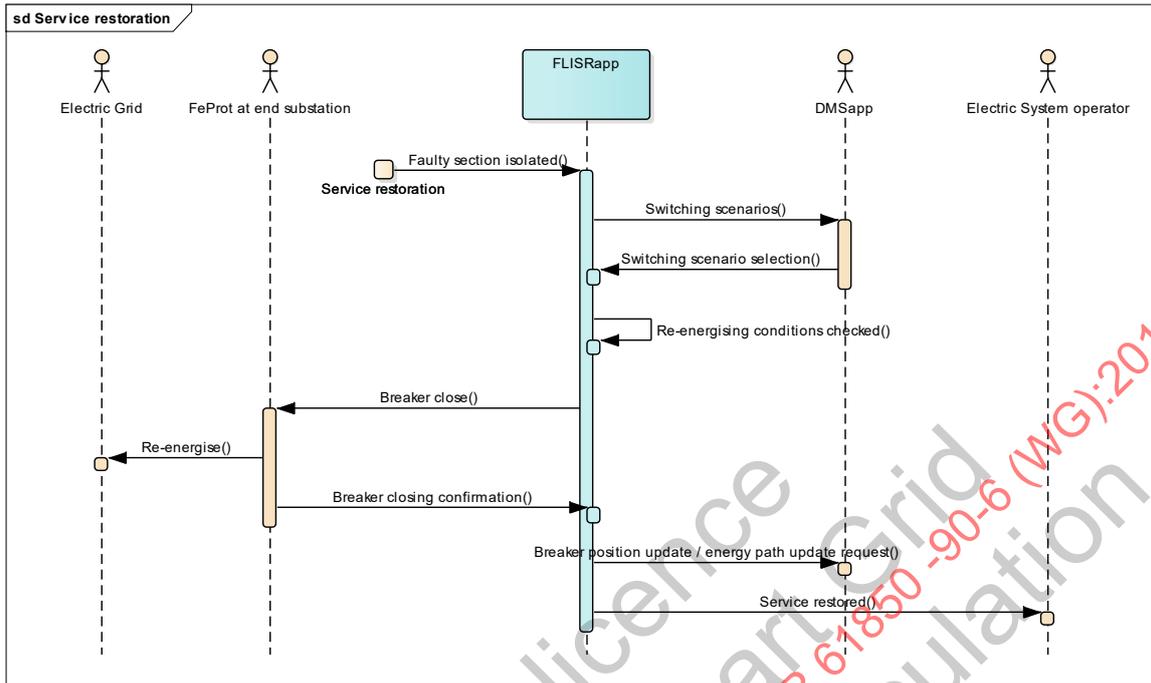


Figure 34 – Centralized FLISR for open loop – Service restoration sequence diagram

5.4.3.3 Technical details

5.4.3.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|-------------------------------|------------------------------|-------------------------------------|--|
| Grouping (Community) | | Group description | |
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Electric Grid | System | Refer to 4 | |
| FeProt at main substation | System | Refer to 4 | |
| FtPInd | System | Refer to 4 | |
| Switching equipment actuator | System | Refer to 4 | |
| Tie switch equipment actuator | System | Refer to 4 | |
| SysOp | Person | Refer to 4 | |
| DMSapp | System | Refer to 4 | |
| Quality Index system | System | Refer to 4 | |
| FLISRapp | System | Refer to 4 | |

5.4.3.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|------------------|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| All FLISRApp conditions | | | Conditions met |
| Feeder | | | Feeder is designed for an open-loop operation, i.e. can support the energizing of the healthy section located downstream a faulty section on the other half of the feeder. |

5.4.3.3.3 References / Issues

| References | | | | | | |
|------------|-----------------|-----------|--------|--------------------|---------------------------|------|
| No. | References Type | Reference | Status | Impact on Use Case | Originator / Organization | Link |
| | | | | | | |

5.4.3.4 Step by step analysis of use case

5.4.3.4.1 General

| Scenario conditions | | | | | |
|---------------------|--|---------------|-----------------------|---------------|---|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 5.3.4.2 | Open-loop Feeder | | Circuit breaker trips | | Fault is isolated by opening one switch “upstream” of the fault, and another “downstream” of the fault. The circuit breaker is reclosed. The normal open switch is closed. |
| 5.3.4.3 | Open-loop Feeder with load restriction | | Circuit breaker trips | | Fault is isolated by opening one switch “upstream” of the fault, and another “downstream” of the fault. The circuit breaker is reclosed. Another switch downstream of the fault is opened to reduce the load before the normal open switch is closed. |

5.4.3.4.2 Steps – Open-Loop Feeder

In this scenario, two radial feeders are connected by the Tie switch (a normally open switch). When a fault is detected on one of the feeders, there are two sets of steps for fault location, isolation and restoration. On the “upstream”, i.e. circuit breaker side of the fault, the steps are as above. On the “downstream” side of the fault, towards the Tie switch normal open point, the second set of steps are as follows. Step 18 closes the tie switch (normally open switch) in the same way as step 12 above.

| Scenario | | | | | | | | |
|---|--|--------------------------|---|---------|------------------------------|-------------------------------|---|---|
| Scenario name: | | Open-loop Feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Requirements, R-ID |
| 1 to 12 | | | As for FLISRApp | | | | | |
| Fault downstream isolation "sub use case" | | | | | | | | |
| 13 | Faulty section identified | | Display valid switching options and their impact on the system | | FLISRApp | FLISRApp or Operator | List of switching options | |
| 14 | Switching options available | | Select desired switching procedures | | FLISRApp or Operator | FLISRApp | Selected switching procedure | |
| 15 | Controllable points to isolate the faulty section selected | | Transmit switching commands | | FLISRApp | Switching equipment actuators | Switch control | Secured control |
| 16 | Switches have operated | | confirm switching operations | | Field actuators | FLISRApp | Switching control confirmation | Faulty section is considered isolated |
| 17 | Position update received | | Updates system model and line status information | | FLISRApp | DMS – Network monitoring | Request for switch positions/energy flow update | |
| Service restoration downstream "sub use case" | | | | | | | | |
| 18a | Re-energizing conditions checked | | Transmits switching command to close the Tie switch | | FLISRApp or Operator | Tie switch | Tie switch close control | |
| 18b | Re-energizing is confirmed | | Report breaker status | | Field actuators | FLISRApp | Switching control confirmation | |
| 18c | Tie Switch Position update received | | FLISRApp updates system model and line status information | | FLISRApp | DMS – Network monitoring | Request for switch positions/energy flow update | |
| 19 | Re-energizing is confirmed | | Start and duration of non-availability of power is logged from the time the fault occurred and per consumer | | FLISRApp | Network quality Logger system | Outage characterization | For power quality assessment (SAIDI, SAIFI calculation) |

5.4.3.4.3 Steps – Open Loop Feeder with load transfers

This scenario is similar to the Open Loop Feeder scenario above, except that the feeders do not have sufficient capacity to support the full load of both feeders. In this case, before

reclosing the normally open switch, the system or operator must make a check that the transfer will not overload the feeder.

| Scenario | | | | | | | | |
|----------------|-----------------------|--------------------------------------|---|---------|------------------------------|-------------------------------|------------------------------|---------------------|
| Scenario name: | | Open-loop Feeder with load transfers | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Requirements , R-ID |
| 1 to 17 | | As for open loop feeder | | | | | | |
| 18 | Load check | | The load to be transferred is compared with the spare capacity on the second feeder | | DMS | FLISRapp or Operator | | |
| 19 | Load transfer options | | Identify sequences of switching operations to reduce the load on the second feeder | | FLISRapp or Operator | FLISRapp | Selected switching procedure | |
| 20 | Load transfer (1) | | Transmit switching command | | FLISRapp or Operator | Switching equipment actuators | Switch open control | |
| 21 | Load transfer (2) | | Transmit switching command | | FLISRapp or Operator | Switching equipment actuators | Switch close control | |
| | | | The remaining steps are the same as steps 18 to 19 in the open loop feeder scenario | | | | | |

Notes for Steps

In addition to FLISR Radial Use case:

12a – The control center has to check compliance with grid codes and security of re-energizing the feeder before sending the control (details not described in this use case).

FeProt is located at the main substation, and will usually to get the control order directly from the control center.

5.4.3.5 Information exchanged

| Information exchanged | | |
|-------------------------------|--|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| In addition to FLISR Radial | | |
| Switch control | Close command | |
| Feeder load | Real time or estimated load on each feeder | |
| Feeder capacity | Load carrying capacity of each feeder | |

5.5 Use case 4: FLISR based on distributed control

5.5.1 General

FLISR based on distributed control is achieved through information exchanges among IEDs controlling the main breaker in the substation and sectionalizer switches in the feeders. Two types of FLISR based on distributed control are described in this subclause. Use case 4a is

for the application implemented in China, and use case 4b is for the application implemented in ENEL Italy.

5.5.2 Use case 4a: FLISR in an open loop network based on distributed control – Type A

5.5.2.1 Description of the use case

5.5.2.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|--|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | FLISR in an open loop network based on distributed control |

5.5.2.1.2 Version management

| Version management | | | | | | |
|--------------------------------------|-------------|--|---------------|-----------------------------------|-------|--|
| Version management Changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| V 1.0 | Sept.1,2014 | Xu Bingyin Zhu Zhengyi Fan Kaijun Chen Yu | | | | |
| V1.1 | Dec.2,2014 | Xu Bingyin Zhu Zhengyi | | | | |
| V1.2 | Feb.2, 2015 | Xu Bingyin Liu Dong | | | | |
| V1.3 | Jun 2,2016 | Xu Bingyin T Yip Ren Yanming | | | | |

5.5.2.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Network Operation |
| Scope | In a distributed feeder automation system, the feeder equipment controller (FeCtl) in an open loop feeder recognizes the real time topology of the network, locates, isolates a fault and restores the service of healthy sections through exchanging fault and control information with each other. |
| Objective | Minimize the duration of power interruptions within a second without the involvement of DMS. |

5.5.2.1.4 Narrative of use case – Short description

In the distributed distribution automation system (DAS) of an open loop feeder, the service restoration controller recognizes the real time topology of the feeder by polling its neighboring FeCtIs, and controls the service restoration of downstream healthy sections of a fault. Having detected a permanent fault, the FeCtIs on the concerned feeder will exchange fault detection and control information with each other through a peer-to-peer communication network, recognize and isolate the faulty section, and then restore the service of healthy sections.

5.5.2.1.5 Narrative of use case – Complete description

The following steps describe how the function works.

The recognition of real time topology of an open loop feeder by the service restoration controller

In the distributed DAS of an open loop feeder, the main breaker is monitored by a feeder protection equipment (FeProt) at the main substation. Each sectionalizing switch, including pole top switch, ring main unit (RMU) or pad mounted switchgear (PMS), is monitored by the feeder equipment controller (FeCtl). The FeProt at main substation and the FeCtIs are all collectively designated as FeCtIs. The attributes of the switches monitored (main breakers in substation or sectionalizing switches in the feeder) as well as the name and communication address of the adjacent FeCtIs can be extracted from the configuration file of FeCtIs.

The service restoration controller recognizes the real time topology of the feeder by polling its neighboring FeCtIs and controls the service restoration of the downstream healthy sections of a fault. Although any FeCtl in the feeder can be assigned as a service restoration controller, it is preferred to assign this role to the tie switch controller as service restoration is always involved with the closing of the tie switch.

The service restoration controller will start polling the other FeCtIs in the feeder after its powering on. It will first send a polling request to its adjacent FeCtl in one side. The adjacent FeCtl will send back the status of the monitored switch after the polling request is received. If the monitored equipment is a RMU or a PMS, the name and status of two incoming switches will be sent back. The adjacent FeCtl will notice the service restoration controller if the monitored switch is a main breaker, otherwise the name and communication address of its next adjacent FeCtl will also be sent. This allows the service restoration controller to poll the next FeCtl along the feeder. This polling process will continue until the polled FeCtl is a FeProt at main substation, which will complete the topology recognition in this side of the network. In case there is no reply from the FeCtl polled, the service restoration controller will send a polling request again after a preset time until the needed information has been returned.

Having obtained the real time topology information in one side of the feeder, the service restoration controller will poll the neighboring FeCtIs in another side in the same way.

The real time topology of the feeder will be established after the service restoration controller completes the polling on both sides. The identity of tie switch will be confirmed if a switch is in an open position and all switches between it and main breakers (including main breakers) on both sides are in closed position.

Taking the system shown in Figure 35 as an example, the tie-switch controller FeCtl3 is assigned as the service restoration controller. FeCtl3 will send a polling request to FeCtl4, the adjacent FeCtl in its right-hand side, with a preset time delay after its powering on. FeCtl4 will return following information to FeCtl3 : the status of switch S4, the name and communication address of FeCtl4's right-hand adjacent FeCtl i.e. FeCtl5. Having received all information from FeCtl4, FeCtl3 will then send a polling request to FeCtl5. The information returned by FeCtl5 is similar to the information returned by FeCtl4. They are the status of switch S5, the name and communication address of FeCtl5's next adjacent FeCtl, i.e. FeProt2 at end substation. Next step, FeCtl3 will send a polling request to FeProt2 at end substation. SPR2 will return the status of CB2 and notice the FeCtl3 that CB2 is a main breaker. FeCtl3 will complete the polling to its right hand FeCtIs after receiving the information from FeProt2 at end substation. Then FeCtl3 will begin to poll the neighboring FeCtIs in its left side in the same way. The entire real time topology of the feeder will be established after the FeCtl3 completes the polling on both sides.

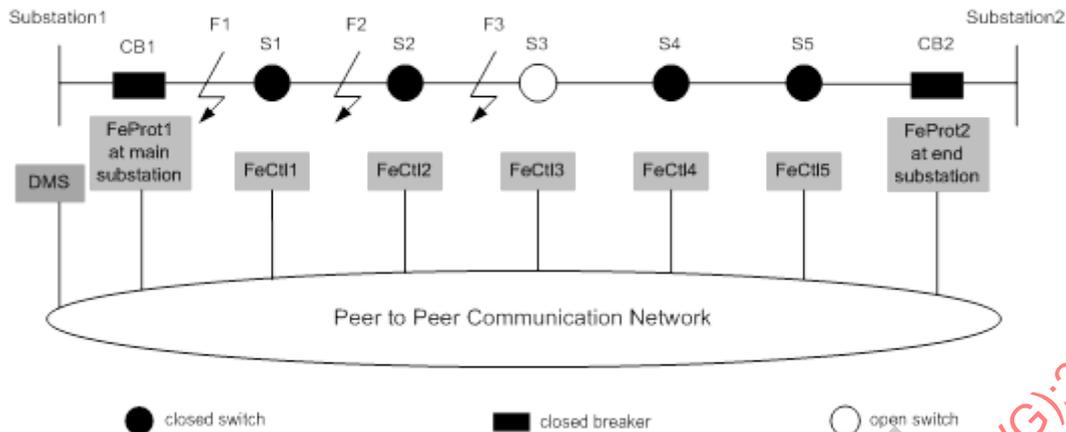


Figure 35 – A distributed DAS for an open loop overhead feeder

The real time topology stored in the service restoration controller will be refreshed whenever the status of any switch in the network changes. The status change of a switch will be detected by its FeCtl and will be broadcasted to all FeCtIs in the feeder.

If the configuration of an FeCtl in the network changes, the FeCtl will broadcast a notice message to the other FeCtIs in the network. The service restoration controller will re-recognize the topology of the feeder after receiving the notice message.

The service restoration controller will periodically check if the configuration of any FeCtl in the feeder has been updated during normal operations after its identity is confirmed. The stored real time topology will be updated if the configuration of any related FeCtl changes.

Fault location, isolation and service restoration

When a permanent fault occurs on an open loop feeder, the main breaker at the substation will trip to clear the fault. If the feeder is an overhead line, the main breaker will reclose N times according to the setting of the FeProt at main substation, but then will remain open. For a cable feeder, the main breaker remains open after its first trip.

The FeCtIs on the feeder will confirm the occurring of a permanent fault when they have detected “ $N+1$ ” times of over-current signatures. Having detected a permanent fault, the FeCtIs will communicate with its adjacent FeCtIs to request their fault detection results. The FeCtl that finds out its adjacent FeCtl has not detected the fault will confirm the fault is in the section in between.

If the fault is in the first section after the main breaker, the main breaker FeProt at main substation will recognize that the fault is in its adjacent feeder section and send a trip command to its adjacent FeCtl to isolate the fault. The adjacent FeCtl will send an acknowledgement message to the FeProt at main substation after it has tripped the downstream end switch of the faulty section. Having received the acknowledgement message, the FeProt at main substation will broadcast a “fault isolated” message to the service restoration controller to start the service restoration of the healthy sections. The main breaker will remain open as the fault is in its adjacent section. Having received the “fault isolated” message, the service restoration controller will request the current margin of the remote main breaker, which is the difference between its rated current and the actual load current, and the pre-fault load current I_{ds1} flowing through the first downstream switch of the fault from the FeCtIs installed there. Then it will compare the current margin I_{marg} of the remote main breaker with the I_{ds1} . If I_{marg} is larger than I_{ds1} , it means that the remote main breaker has enough current margin to restore the services of all downstream healthy sections of the fault. The service restoration controller will then close the tie switch to restore the service of these sections. Otherwise, the service restoration controller will request the pre-fault load current of the rest downstream switches of the fault and compare I_{marg} with the returned current one by

one till the condition that I_{marg} is larger than the compared current is met or the switch adjacent to the tie switch is reached. The service restoration controller will open the switch if its prefault current is less than the current margin, and then close the tie switch to restore its downstream healthy sections. Otherwise no actions will be taken by the service restoration controller as the current margin is not sufficient to restore the service of any healthy sections.

For example, assuming a fault occurs in F1 in the section between CB1 and S1 as shown in Figure 35. Only FeProt1 at main substation detects overcurrent. It will communicate with the adjacent FeCtl1 to check if FeCtl1 has detected overcurrent. FeProt1 at main substation recognizes the fault is in its adjacent downstream section as FeCtl1 has not detected overcurrent, and then send a tripping command to FeCtl1 to open the adjacent switch S1 to isolate the fault. Having received acknowledgement message FeProt1 at main substation will broadcast "fault isolated" message to the service restoration controller to start service restoration of downstream healthy sections after fault, provided that the tie-switch controller FeCtl3 is assigned as the service restoration controller. Having received "fault isolated" message, FeCtl3 will send a message to FeProt2 at end substation to request the current margin I_{marg} of the remote main breaker CB2, and to FeCtl1 to request the prefault load current I_{S1} of the downstream adjacent switch S1 of the fault which represent the total load current to be restored. If I_{marg} is greater than I_{S1} , it means that the remote main breaker has sufficient current margin to restore the service of all downstream switches of the fault. FeCtl3 then closes S3 to complete the service restoration operation. If I_{marg} is less than I_{S1} , FeCtl3 will request the prefault load current I_{S2} of S2 and compare I_{marg} with I_{S2} . FeCtl3 will open S2 and close S3 to restore the service to the downstream section S2 which is also the adjacent section of tie switch S3 if I_{marg} is larger than I_{S2} . Otherwise, the current margin is not enough to restore the service to the adjacent section of S3 and no further action is taken by FeCtl3.

If the fault is in the section which is neither adjacent to the main breaker or tie switch, the upstream end FeCtl of the faulty section will confirm that the fault is in its adjacent downstream section, and send a trip command to its downstream end FeCtl to isolate the fault. The downstream FeCtl will send an acknowledgement message to the upstream FeCtl after it has tripped the downstream end switch of the faulty section. The upstream FeCtl will then broadcast a "fault isolated" message to both the main breaker FeProt1 at main substation and the service restoration controller to start service restoration of the healthy sections after receiving the acknowledge message from the downstream FeCtl. Having received the "fault isolated" message, the main breaker FeProt1 at main substation will close the breaker to restore the services of all healthy sections before the fault after, and the service restoration controller will restore the service of downstream healthy sections of the fault using same method for the fault adjacent to the main breaker as described above.

For example, assuming a fault occurs in F2 in the section between S1 and S2 as shown in Figure 35, FeCtl1 will recognize the fault is in its adjacent downstream section. Then FeCtl1 will open S1 and send a tripping command to FeCtl2 to open its downstream adjacent switch S2 to isolate the fault. FeCtl1 will send "fault isolated" message to FeProt1 at main substation and FeCtl3 to start service restoration of all healthy sections after receiving the acknowledge message from FeCtl2. FeProt1 at main substation will close CB1 to restore the service to S1, the upstream section of fault. FeCtl3 will control the restoration of two downstream switches of the fault (S2 and S3) following similar steps as described above for the fault in F1.

If the fault is in the section adjacent to the tie-switch, the downstream end switch of the faulty section is the tie-switch. Therefore the FeCtl of the upstream end switch of the faulty section will get an "I am a tie-switch" response from tie-switch FeCtl. The upstream FeCtl of the fault will then confirm the fault is in its adjacent downstream section, trip the upstream end switch of the faulty section, and send a "fault isolated" message to the FeProt at main substation to start service restoration of all healthy sections. The tie switch will not be closed as the fault is in its adjacent section.

For example, assuming a fault occurs in F3 in the section between S2 and S3 as shown in figure1, FeCtl2 will recognize the fault is in its adjacent downstream section, open S2, and send a tripping command to FeCtl3 to open its downstream adjacent switch S3 to isolate the fault. FeCtl2 will send “fault isolated” message to FeProt1 at main substation to start service restoration of all healthy sections after an acknowledge message is received from FeCtl3. FeProt1 at main substation will close CB1 to restore the service to the upstream section of fault. The tie switch S3 will not be closed as the fault is in its adjacent section.

During FLISR process, the upstream FeCtIs of the fault will report fault location and isolation results to the DMS. The FeProt at main substation of main breaker and the service restoration controller will report service restoration results to the DMS.

5.5.2.1.6 General remarks

In the distribution automation systems, the FeCtIs in a feeder exchange fault and control information with each other through peer-to-peer communication networks and achieve fault location, isolation and service restoration (FLISR) without the intervention of master stations.

This use case describes the function of Fault Location, Isolation and Service Restoration (FLISR) based on distributed control for an overhead or cable feeder which operates in an open loop with dual power sources backing up mutually. Currently the use case does not consider the impact of DER.

Auto-reclosing function is not applied to the outlet protection for cable lines while predefined times of auto-reclosing is needed to operate for overhead lines.

This use case describes the process after a fault occurs on the trunk feeder between switches. Faults occurring on the busbar or outlets of a RMU or on a lateral of an overhead feeder are not considered.

Each pole-top switch is monitored with an overhead FeCtl. Each RMU is assumed to be equipped with a FeCtl which could monitor the inlet and outlet switches in real-time in this use case, substation outlet breaker is monitored by a FeProt at main substation.

Service restoration process is divided into upstream and downstream service restoration in this use case. Before the upstream healthy sections of a fault are restored, whether the faulty section is the adjacent section of the main breaker needs to be considered; before the downstream healthy sections are restored, whether the fault occurs in the adjacent section of the tie-switch must be considered, and whether there is enough reserve capacity of the remote substation to achieve load transfer must be checked.

The neighbor information of a switch is provided by configuration files of associated FeCtIs. The identity of the tie-switch is recognized by the associated FeCtIs through the recognition of real time feeder topology. The service restoration controller stores the real time feeder topology information to support the operation of service restoration for healthy sections. The recognition of real time feeder topology and tie-switch will be described in the use case of “real time recognition of tie-switch”.

5.5.2.2 Diagrams of Use Case

Figures 36 to 39 present the use case diagrams.

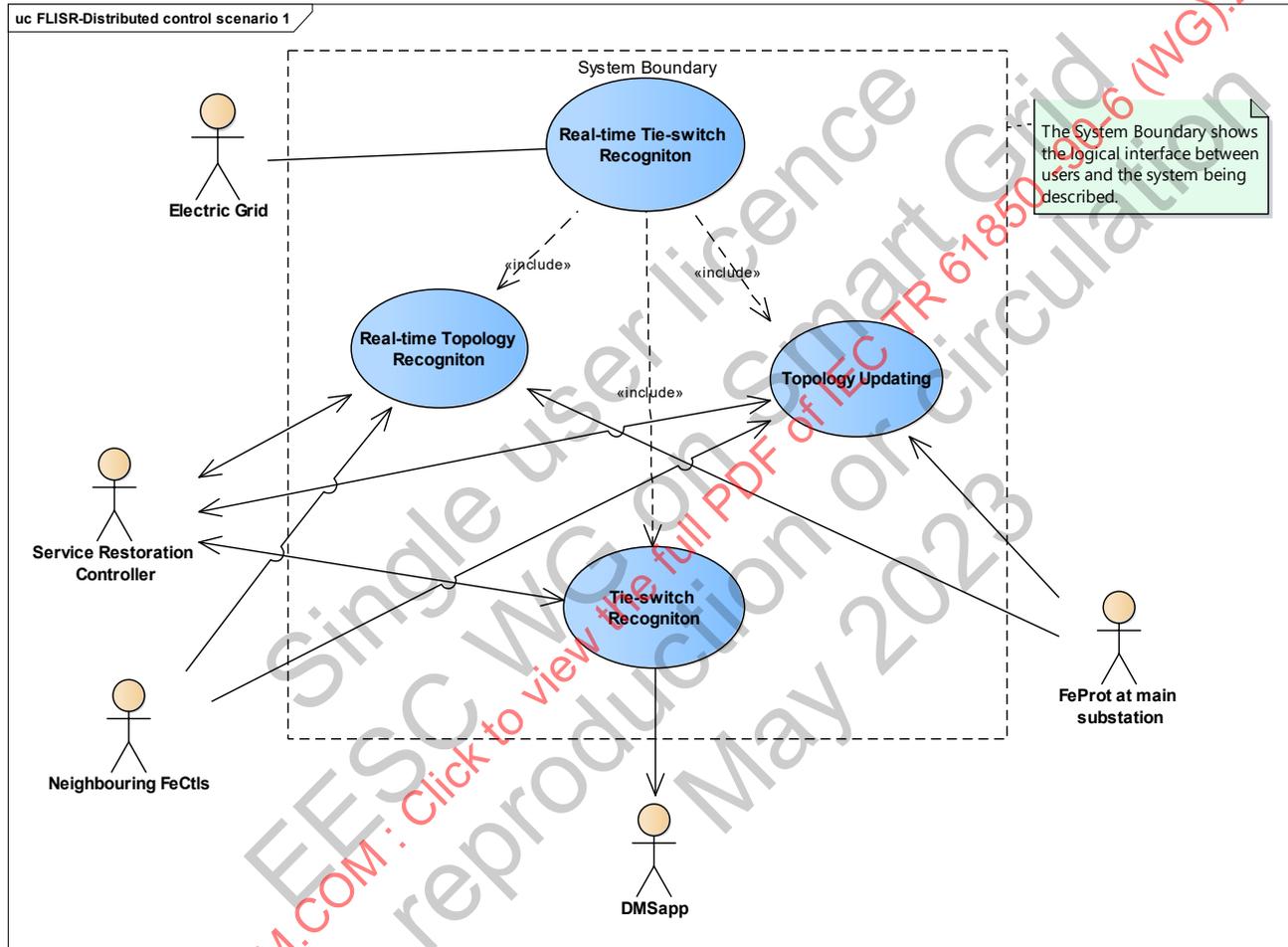


Figure 36 – Distributed FLISR in an open loop network – Upstream use cases breakdown

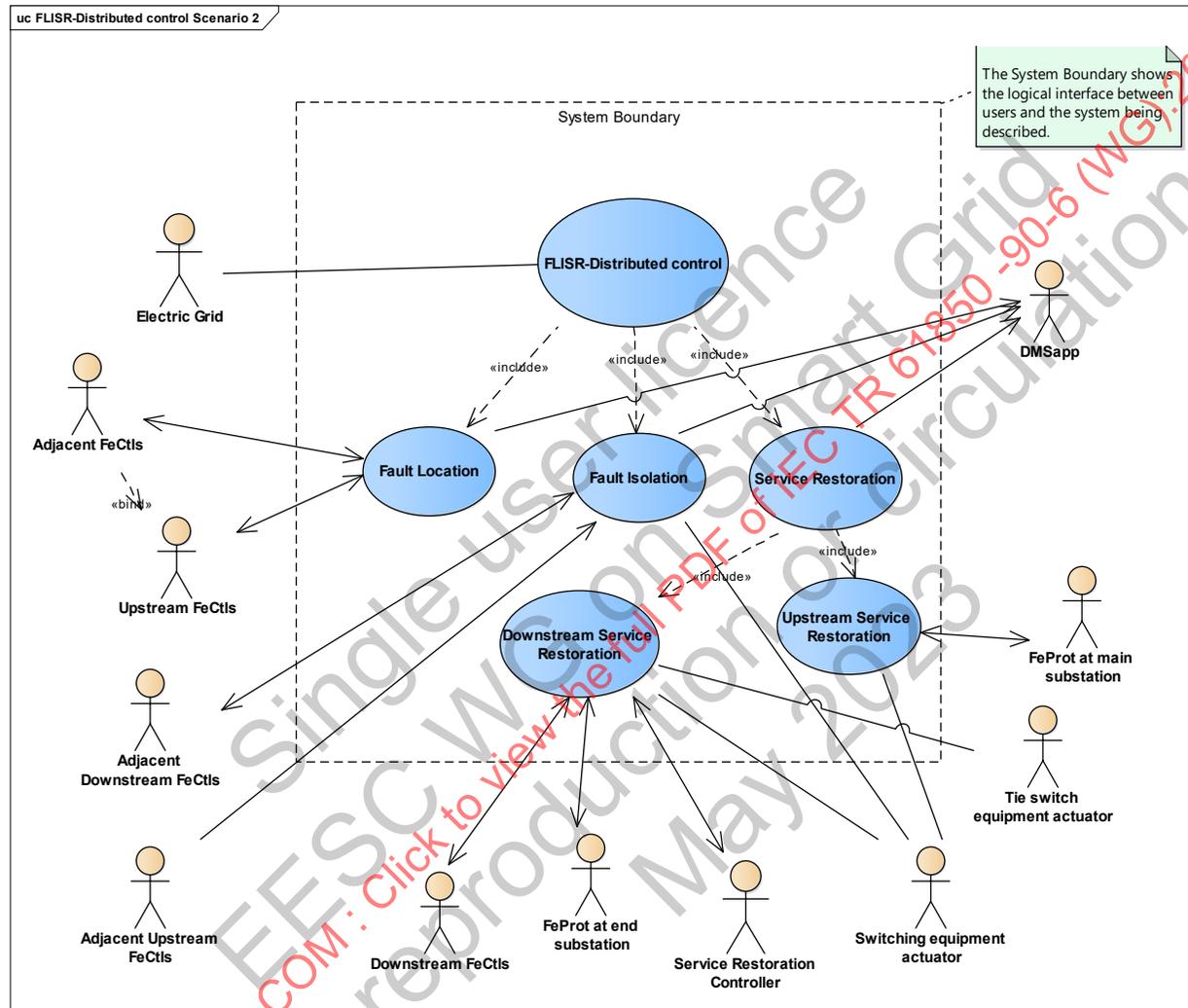


Figure 37 – Distributed FLISR in an open loop network – Operation use cases breakdown

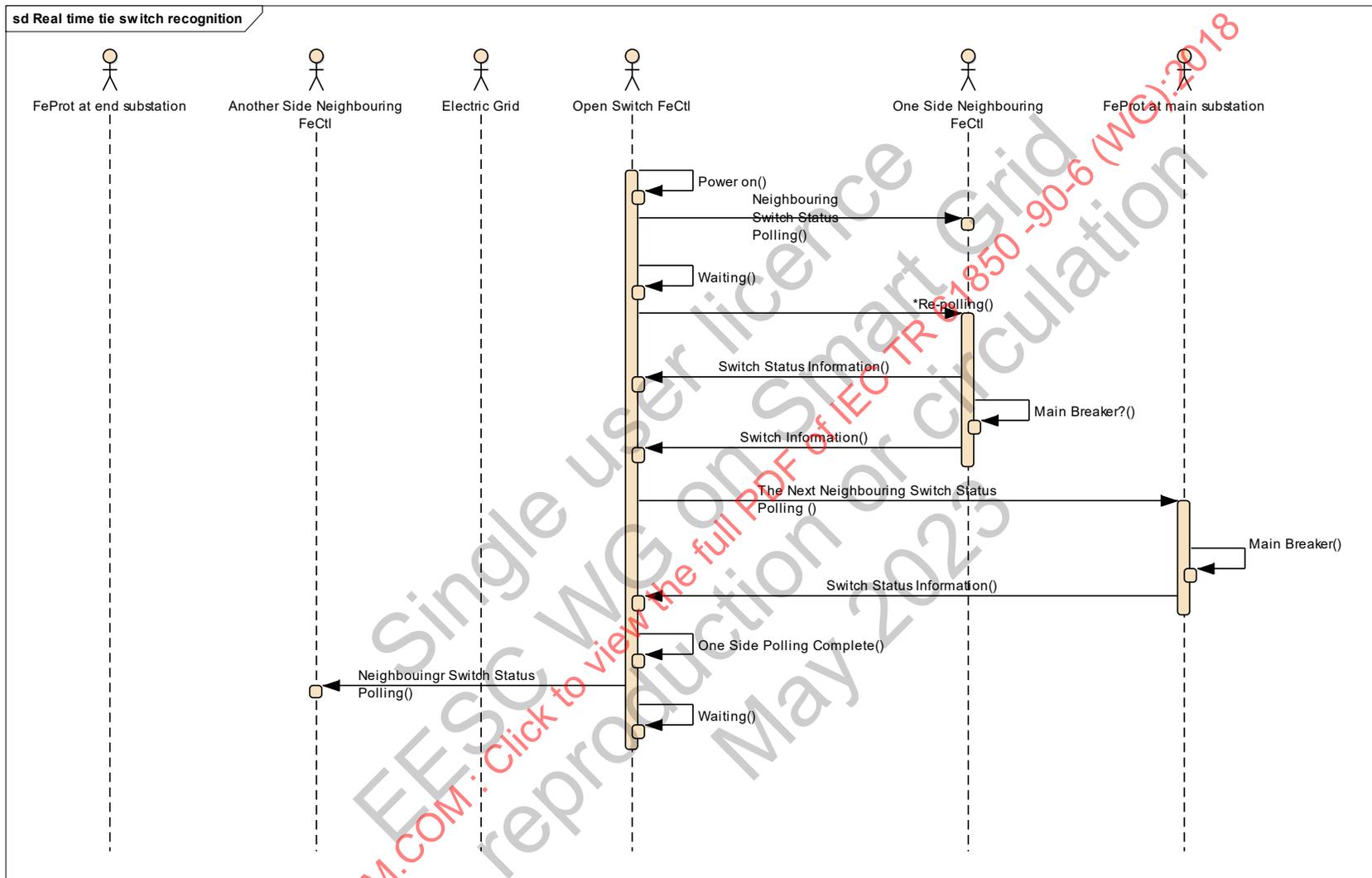


Figure 38 – Distributed FLISR in an open loop network – Topology discovery sequence diagram (1 of 2)

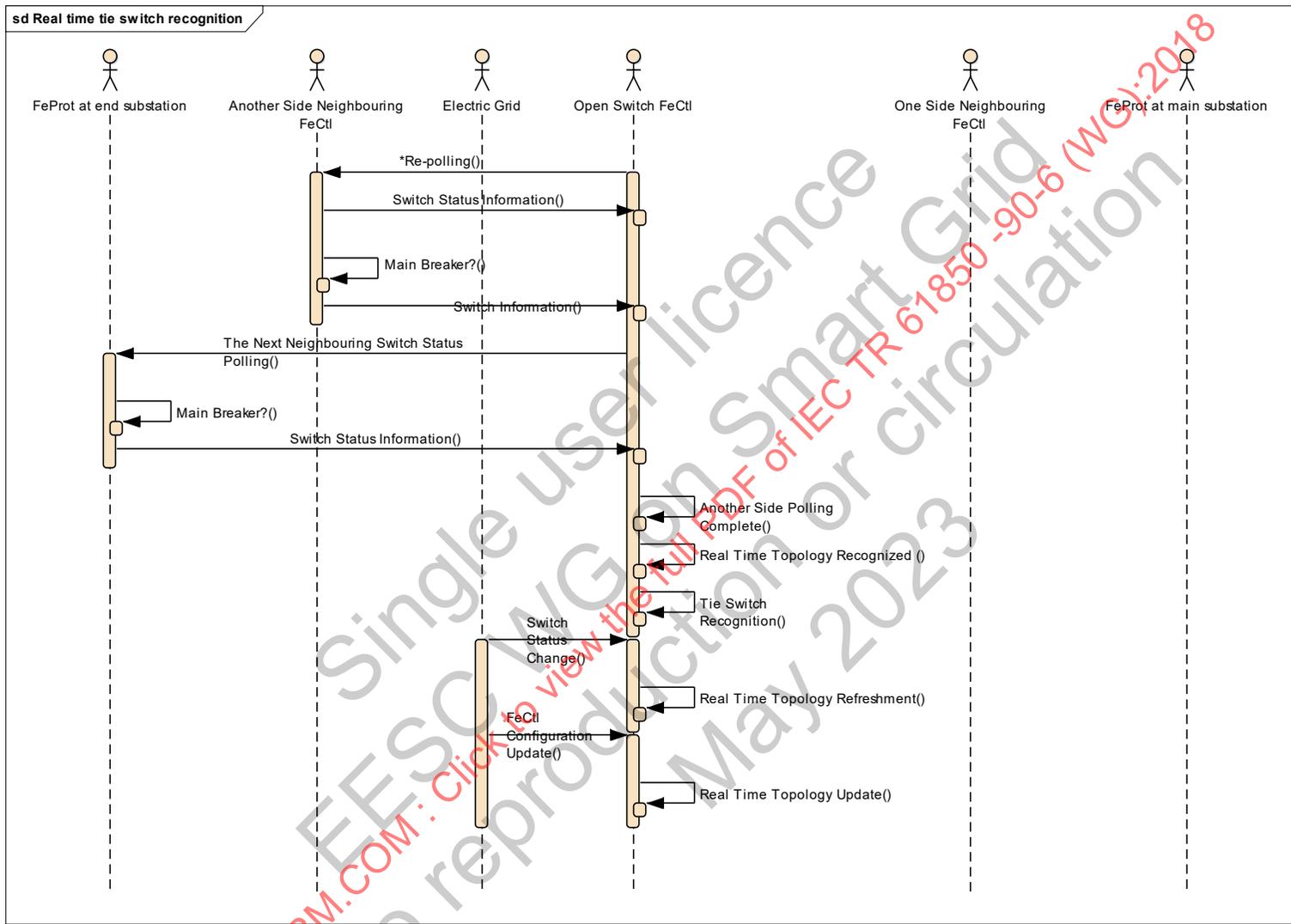


Figure 38 (2 of 2)

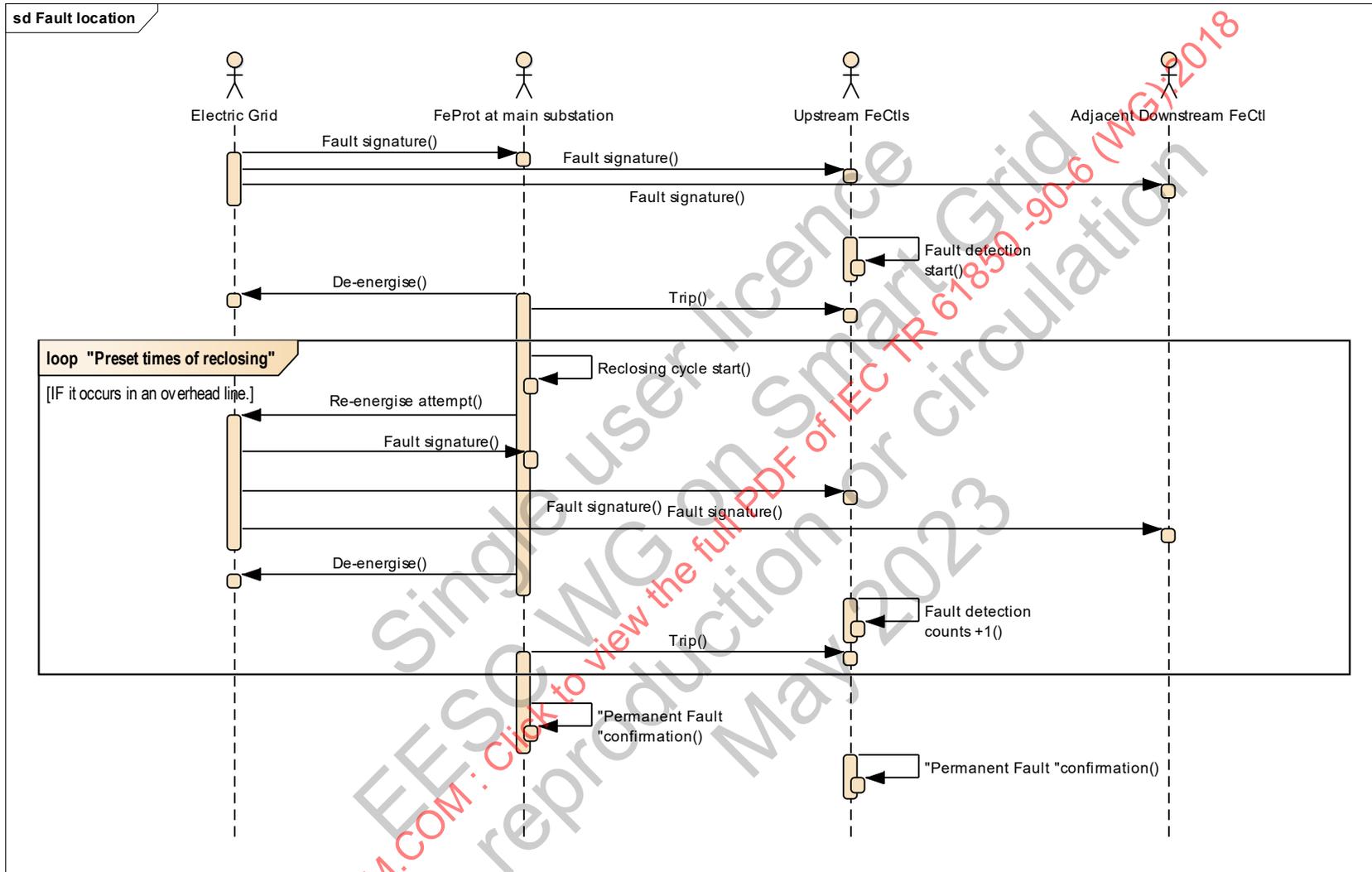


Figure 39 – Distributed FLISR in an open loop network – FLISR operation sequence diagram (1 of 5)

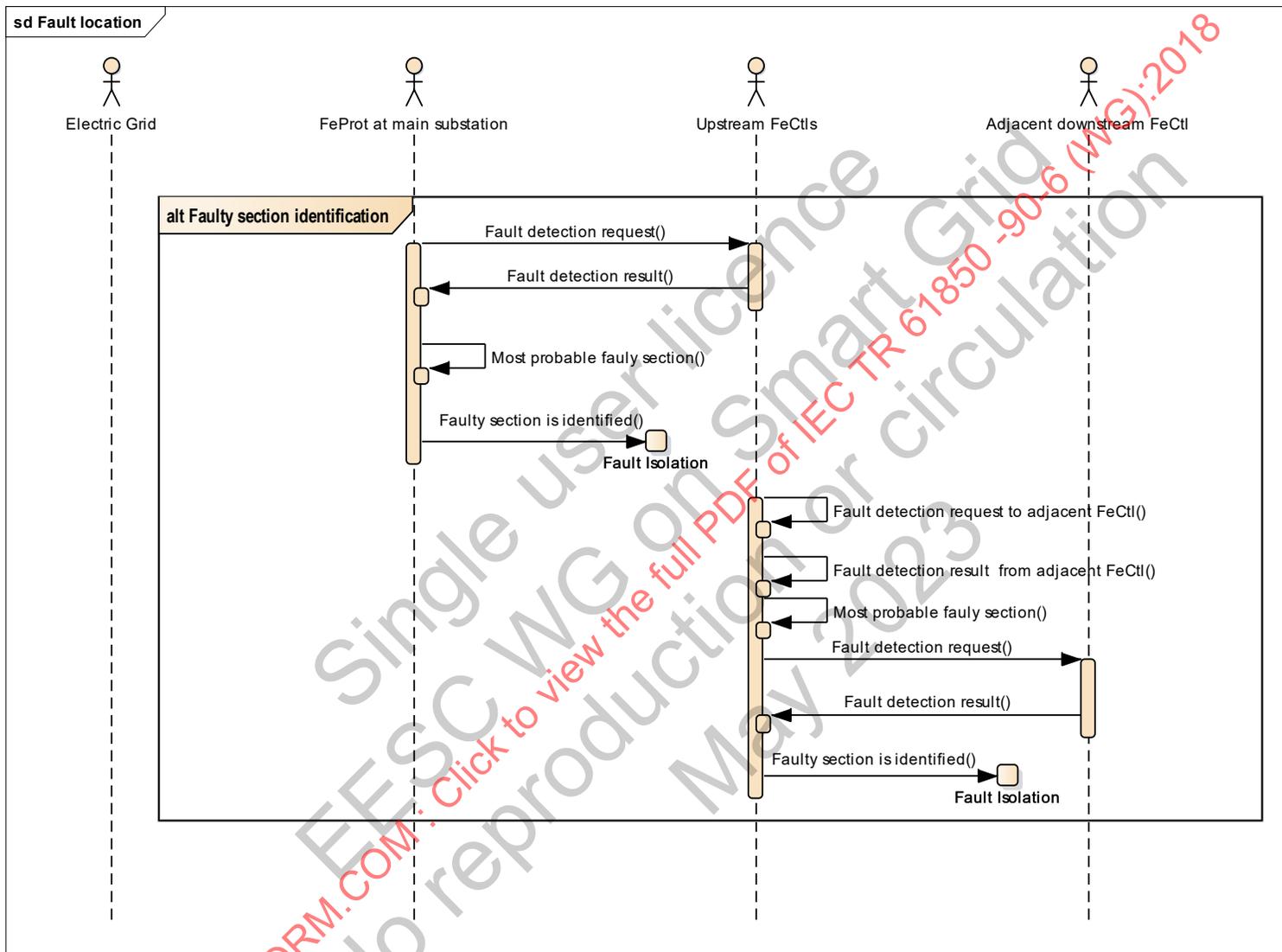


Figure 39 (2 of 5)

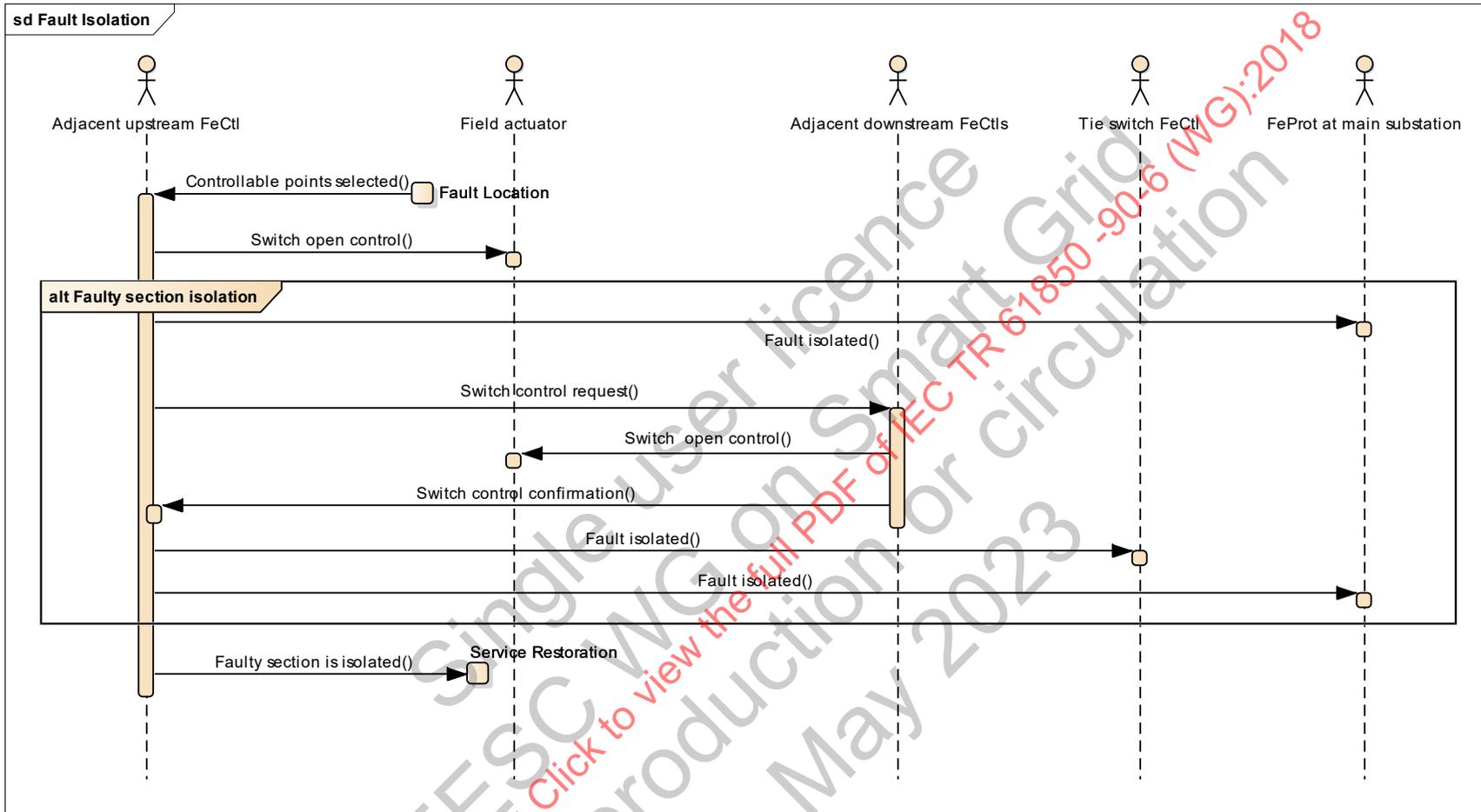


Figure 39 (3 of 5)

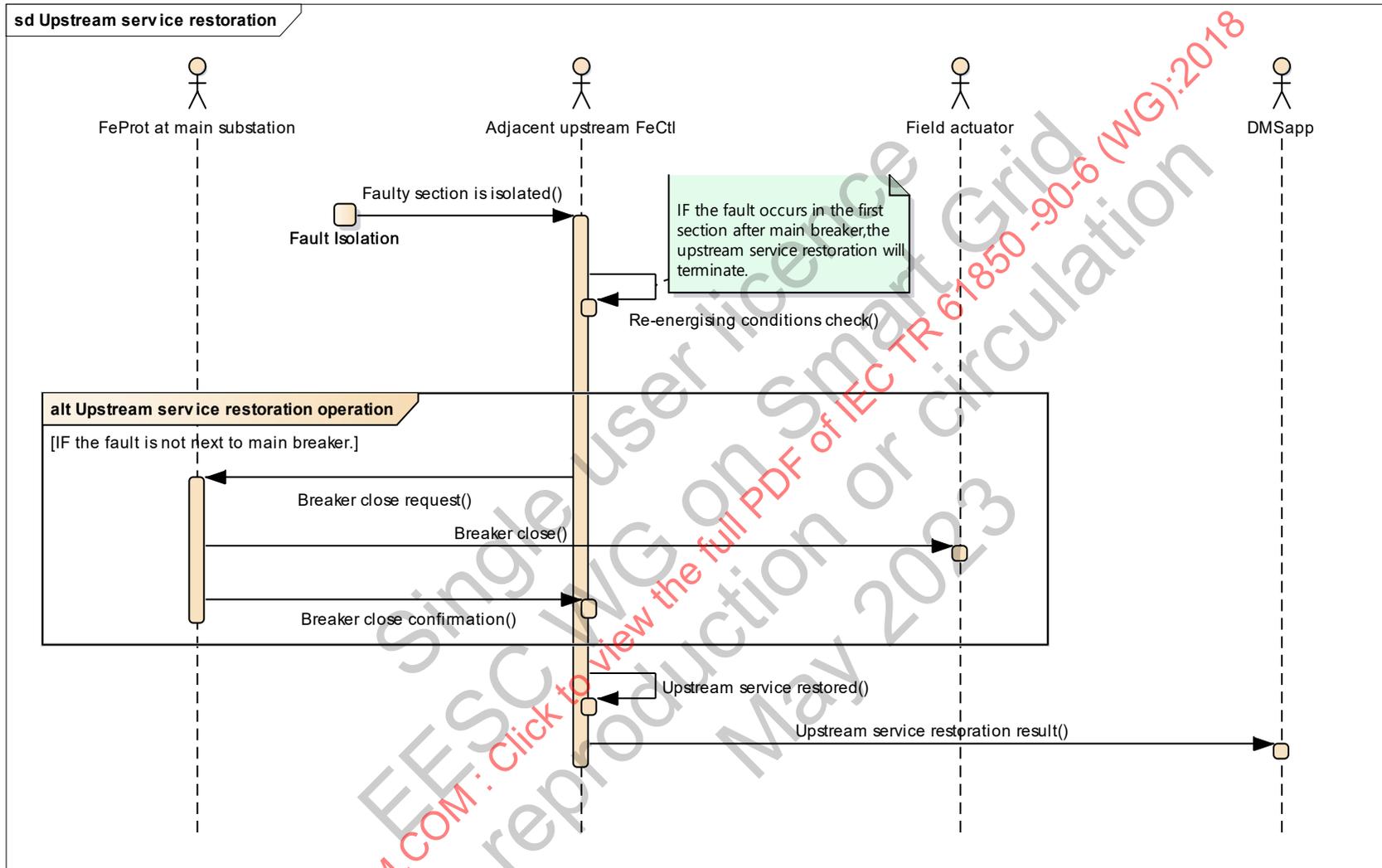


Figure 39 (4 of 5)

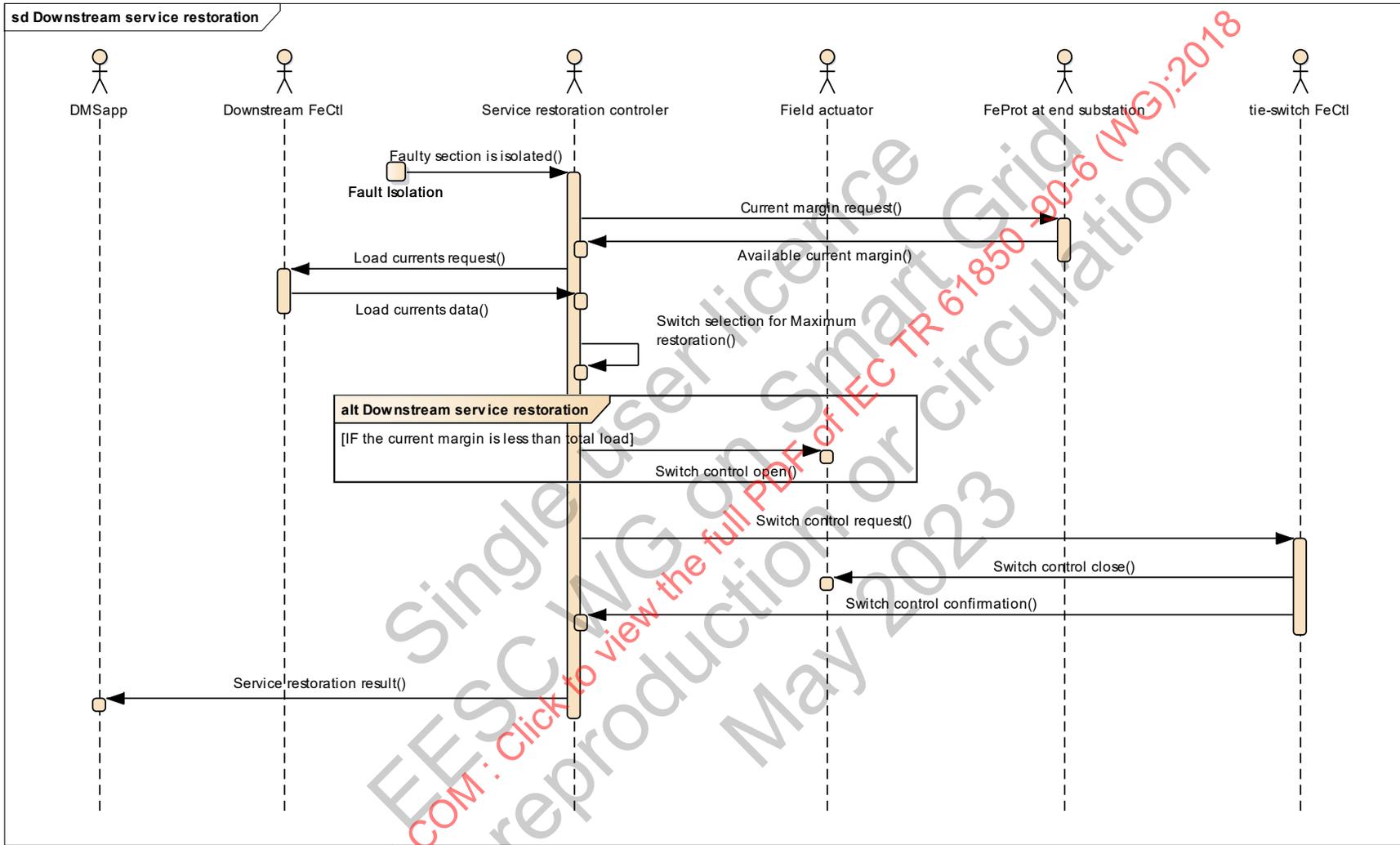


Figure 39 (5 of 5)

5.5.2.3 Technical details

5.5.2.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|---|------------------------------|-------------------------------------|--|
| Grouping (community) | | Group description | |
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Electric Grid | System process | Refer to Clause 4 | |
| Feeder Protection equipment at main substation (FeProt at main substation) | System field | Refer to Clause 4 | |
| Feeder Protection equipment at feeder end substation (FeProt at end substation) | System field | Refer to Clause 4 | |
| Switching equipment actuator | System process | Refer to Clause 4 | |
| DMSapp | System | Refer to Clause 4 | |
| Tie switch equipment actuator | System process | Refer to Clause 4 | |
| Feeder equipment controller (FeCtl) | System substation | Refer to Clause 4 | |
| adjacent Feeder equipment controller (Adjacent FeCtl) | System substation | Refer to Clause 4 | |
| Feeder equipment controller downstream to fault (Downstream FeCtl) | System substation | Refer to Clause 4 | |
| Feeder equipment controller upstream to fault (Upstream FeCtl) | System substation | Refer to Clause 4 | |
| Service Restoration Controller | System operation | Refer to Clause 4 | Though any FeCtl in the network can be assigned as a service restoration controller, it is preferred to choose the tie switch FeCtl as the service restoration controller, |
| DMSapp | System | Refer to Clause 4 | |

5.5.2.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|------------------|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | | | <p>The Grid is continuously monitored.</p> <p>The Grid topology is known and reflects the real topology.</p> <p>The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches).</p> |
| FeProt at main substation | | | <p>Enough energy is stored and available for communication.</p> <p>Communication with feeder switch FeCtl is available.</p> |
| Switching equipment actuator | | | <p>Enough energy is stored and available for remotely control the selected switches in absence of power.</p> |
| Tie switch equipment actuator | | | <p>Enough energy is stored and available for remotely control the selected switches in absence of power.</p> |
| FeCtl | | | <p>Enough energy is stored and available for communicating.</p> <p>Communication system for FeCtl is interaction is operational</p> |
| Adjacent FeCtl | | | <p>Enough energy is stored and available for communicating.</p> |

5.5.2.4 Step by step analysis of use case

5.5.2.4.1 General

| Scenario conditions | | | | | |
|---------------------|---------------|---------------|------------------|---------------|----------------|
| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
| 4.1 | Normal | | | | |
| 4.2 | Alternative | | | | |

5.5.2.4.2 Steps – Normal

| Scenario | | | | | | | | |
|----------------|---------------------------------------|-------------------------------|---|---------|--|--|--|-----------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| | | Fault location "sub use case" | | | | | | |
| 1a | Fault occurs on the Grid | | Protection function detects a fault | | Electric Grid | Main breaker FeProt at main substation | "fault signature" | |
| 1b | Fault occurs on the Grid | | FeCtlS at the upstream side of faulty section detects a fault | | Electric Grid | Upstream FeCtlS of fault | "fault signature" | fault start |
| 1c | Fault occurs on the Grid | | Circuit breaker trips and clears the fault current | | Main breaker FeProt at main substation | Electric Grid | De-energized feeder | |
| 1d | | | Information transfer | | Main breaker FeProt at main substation | Feeder switch FeCtl | Trip | trip/start of reclose cycle |
| 1e | | | If it is for an overhead line | | Feeder switch FeCtl | Feeder switch FeCtl | Application procedure: The application goes to step 2a. | |
| 1f | | | If it is for a cable line | | Feeder switch FeCtl | Feeder switch FeCtl | Application procedure: The application goes to step 3a. | |
| 2a | Fault current cleared + time delay | | First reclosing operation | | Main breaker FeProt at main substation | Electric Grid | Re-energize | |
| 2b | Fault re-occurs on the Grid | | Main breaker trips | | Main breaker FeProt at main substation | Electric Grid | De-energize | |
| 2c | | | Information transfer | | Main breaker FeProt at main substation | Feeder switch FeCtl | Trip | Final trip |
| 2d | Fault occurs on the Grid (same as 1a) | | Feeder monitoring FeCtlS detect a "permanent" fault | | Upstream end FeCtl of faulty section | Upstream end FeCtl of faulty section | Start of fault detection | |

| Scenario | | | | | | | | |
|----------------|--|--------------------------------|--|---------|--|--|-------------------------------------|------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 2e | End of timeout after fault start with several times of over-current or under voltage detection | | Confirmation of a permanent fault (based on under voltage or over-current detection) | | Upstream end FeCtl of the faulty section | Upstream end FeCtl of the faulty section | Confirmation | Fault location start |
| 3a | "permanent fault" confirmed | | FeCtIs confirming a "permanent fault", request fault detection information from their Adjacent FeCtIs | | Upstream FeCtl of the fault | Adjacent FeCtl | Fault detection information request | |
| 3b | | | Adjacent FeCtIs return their fault detection information | | Adjacent FeCtl | Upstream FeCtl of the fault | Fault detection result | |
| 3c | Receive fault detection information from Adjacent FeCtIs. | | The FeCtl determines which section the fault is located based on the fault detection result of its own and the adjacent FeCtIs. | | Upstream FeCtl of the fault | Upstream FeCtl of the fault | "most probable faulty section" | Faulty section is identified |
| | | Fault isolation "sub use case" | | | | | | |
| 4a | Controllable switches to isolate the faulty section identified | | The upstream end FeCtl of the faulty section trips the local switch. If the fault occurred in the substation outlet section, the circuit breaker has been tripped already. | | Upstream end FeCtl of the faulty section | Switching equipment actuator | Switch control | Secured control |
| 4b | | | Upstream end FeCtl of faulty section send trip command to the downstream end FeCtl of the faulty section. | | Upstream end FeCtl of the faulty section | Downstream end FeCtl of faulty section | Switch control request | Secured control |
| 5a | Switch control command is received from its adjacent FeCtIs. | | Adjacent FeCtl trips the monitored switch | | Adjacent FeCtl | Switching equipment actuator | Switch control | Secured control |

| Scenario | | | | | | | | |
|----------------|---|---|--|---------|--|--|--------------------------------|---------------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 5b | Switches have operated and been open | | Confirm switching operations | | Adjacent FeCtl | Upstream end FeCtl of faulty section | Switching control confirmation | Faulty section is considered isolated |
| | | restoration "sub use case" | | | | | | |
| 6a | Re-energizing conditions checked : If the fault is located in the substation outlet section, the circuit breaker is not allowed to close, there is no healthy upstream feeder section needing to be restored. | | Transmits switching command to main breaker FeProt at main substation to close the breaker | | Upstream end FeCtl of the faulty section | Main breaker FeProt at main substation | Breaker close request | |
| 6b | Breaker closing command is received by the SPR | | Close the main breaker. | | Main breaker FeProt at main substation | Main breaker | Breaker closing command | |
| 6c | Re-energizing is confirmed | | Report breaker status | | Main breaker FeProt at main substation | Upstream end FeCtl of faulty section | Breaker closing confirmation | Upstream service is restored |
| | | Downstream service restoration "sub use case" | | | | | | |
| 7 | Service restoration conditions check: the fault does not occur in section next to the tie switch. | | Upstream end FeCtl of the faulty section notifies the service restoration controller to start service restoration. | | Upstream end FeCtl of the faulty section | Service restoration controller | Start service restoration | |

| Scenario | | | | | | | | |
|----------------|--|---------------------------|---|---------|---|---|--|---------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 8a | Service restoration notification is received by the service restoration controller | | The service restoration controller requests rated current and actual current value of the remote substation outlet breaker from remote FeProt at main substation | | Service restoration controller | Remote main breaker FeProt at main substation | Current data request | |
| 8b | | | The service restoration controller requests load current value from all downstream FeCtIs of faulty section. | | Service restoration controller | Upstream end FDA of the faulty section | Current data request | |
| 9 | Current data request is received by remote main breaker FeProt at main substation | | Current data returned. | | Remote main breaker FeProt at main substation | Service restoration controller | Rated current value and actual current value | |
| 10 | Request is received by all downstream FeCtIs of faulty section | | Load current data returned. | | Each downstream FeCtl of fault | Service restoration controller | Pre-fault load current | |
| 11a | Current data is received by the service restoration controller | | Maximum restoration decision : the service restoration controller will compare the acquired available current margin and each load current of downstream FeCtl. | | Service restoration controller | Service restoration controller | The comparison results. | |
| 11b | | | If the current margin is larger than the total load current of all downstream healthy sections of the fault which is the pre-fault load current flowing through the first downstream switch of fault. | | Service restoration controller | Service restoration controller | Application procedures: the application goes directly to step 13a. | |

| Scenario | | | | | | | | |
|----------------|---|---|--|---------|---|---|--|--------------------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 11c | | | Else conditions of step 11b | | Service restoration controller | Service restoration controller | Application procedure: the application goes to step 11d. | |
| 11d | The furthest upstream end switch of the section(s) to be restored is selected | | Service restoration controller commands to trip the furthest end switch. | | Service restoration controller | The furthest end FeCtl of the section(s) to be restored | Switch control request() | Secured control |
| 12a | | | The furthest end switch trips to open | | The furthest end FeCtl of the section(s) to be restored | Switching equipment actuator | Trip command | Secured control |
| 12b | | | Switch control confirmation | | The furthest end FeCtl of the section(s) to be restored | Service restoration controller | Switch position | |
| 13a | Close the tie switch | | Switching command | | Service restoration controller | Switching equipment actuator | Switch control | Secured control |
| 13b | Switches have operated and been closed | | Confirming switching operations | | Service restoration controller | FeCtl at the upstream side of faulty section. | Switching control confirmation | Service is considered restored |
| 14 | Service is restored | | Fault information report by FeCtl. | | FeCtl at the upstream side of faulty section. | DMSapp | Fault information | |
| 15a | Topology changing occurs on the grid | Topology changed | The changes of Grid leading to the topology changes | | Electric Grid | Maintenance tool | Topology changed | |
| 15b | Topology changing occurs on the grid | Report changing | The FeCtl produces a report when a topology change occurs | | FeCtl | Maintainer | Topology changed | |
| 15c | Topology changing occurs on the grid | Maintainer confirms report and record information of new topology | Maintainer confirms the specific information of topology from the report and sends to maintenance tool | | Maintainer | Maintainer tool | Topology information | |

| Scenario | | | | | | | | |
|----------------|-----------------------|--|--|---------|--------------------------------------|--|--|---------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 16a | Topology modelling | Operate topology modelling progress on the newly changed topology | Maintenance tool confirms the report from maintainer and revises the current topology according to the step of topology modelling progress | | Maintenance tool | Topology modelling | Topology changing information | |
| 16b | Topology modelling | Confirmed topological changes to Maintenance tool | Maintainer checked the newly constructed topology model and confirmed | | Maintainer | Maintenance tool | Newly constructed topology model | |
| 16c | Topology modelling | Return topology model to FeCtl | Modelling system returns the newly constructed topology model to the changed FeCtl | | Topology modelling | FeCtl need topology updating | Newly constructed topology model | |
| 17a | Modelling recognition | FeCtl configures topology information | The FeCtl configure basic topology information and parameter | | FeCtl | FeCtl | Topology information | |
| 17b | Modelling recognition | FeCtl recognizes topology information | The FeCtl recognizes the topology information and return the validity of the model | | FeCtl that needs topology updating | Maintainer | The validity of the newly constructed topology model | |
| 17c | Modelling recognition | Maintainer commands FeCtl for recognition with adjacent FeCtIs | The Maintainer confirms the validity information from the FeCtl and asks the FeCtl for recognition with its adjacent FeCtIs | | Maintainer | FeCtl that completes the topology updating | Command for FeCtl to recognize topology information with adjacent FeCtIs | |
| 17d | Modelling recognition | FeCtl sending switch change signals to adjacent FeCtIs for recognition | The FeCtl receive Maintainer's command and send switch change signals to its adjacent FeCtIs for mutual recognition | | FeCtl with renewed topology model | Adjacent FeCtIs | Renewed topology information | |
| 17e | Modelling recognition | React to save station | FeCtl sends renewed information to slave station | | FeCtl that completes topology update | Slave station | Topology information | |

| Scenario | | | | | | | | |
|----------------|-----------------------|---------------------------|--|---------|--|------------------------------|-----------------------|---------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 17f | Modelling recognition | React to master station | Slave station recognizes the topology information and send it to the master substation | | Slave station that receives the update information | Master station | Topology information | |

IECNORM.COM : Click to view the full PDF of IEC TR 61850-90-6 (WG 2018)
 Single user licence
 EESC WG on Smart Grid
 No reproduction or circulation
 May 2023

5.5.2.4.3 Steps – Alternative, error management, and/or maintenance/backup scenario

| Scenario | | | | | | | | |
|----------------|-------|---------------------------|----------------------------------|---------|-----------------------------|------------------------------|-----------------------|---------------------|
| Scenario name: | | | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| | | | | | | | | |

Notes for Steps

1b – Fault signature detected by FeCtlS could be overcurrent or undervoltage, “FLISR -Distributed control” is an application of FeCtlS.

1e-1g – The reclosing times of overhead lines is preset, one cycle of reclosing is described here, multiple reclosing is similar to this.

2a – The timing of timeout for “permanent fault” detection begins as soon as fault detection start.

2b – Whether there is a permanent fault or not depends on the preset times of over-current or under-voltage signals detected within the timeout. Once a fault signature detected on cable line, it is considered to be a permanent fault.

4a – If fault occurs on the substation outlet section, the main breaker is already open before fault isolation.

4b – The FeCtl determines the fault section by comparing the fault detection result of the upstream end switch with the downstream end switch.

6a – If fault occurs on the substation outlet section, service restoration for upstream healthy sections of faulty section will not proceed. In this use case, fault is assumed not in that position, so FLISR function could continue.

7 – If the fault occurs in the section adjacent to tie switch, the tie switch cannot be closed and will not be notified to restore downstream service in process of fault isolation.

11a – In restoration of downstream service, the reserve capacity and load should be compared to decide the maximum sections to be restored and select the furthest upstream end switch of the section.

5.5.2.5 Information exchanged

| Information exchanged | | |
|-------------------------------|--|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| Fault signature | The set of fault passage indications reported for a feeder | fast messages 10ms time tagging |
| Energized status | Voltage presence / absence | fast messages 10ms |
| Trip / Breaker Open | Breaker open status – reason is tripping | fast messages 10ms time tagging |
| Fault detection | The FeCtl detects the overcurrent or under voltage to determine a fault. | fast messages 10ms time tagging |
| Fault detection request | FeCtl issues fault detection information request to its adjacent FeCtlS. | fast messages 10ms |
| Fault detection information | Fault detection information returned by adjacent FeCtlS. | fast messages 10ms time tagging |
| Switch control | Open or close command | fast messages 10ms |
| Switch control request | Open or close command to actors controlled by other FeCtlS | fast messages 10ms |
| Switch control confirmation | Switches position | fast messages 10ms |
| Breaker close request | close command from Feeder monitoring FeCtlS to the FeProt at main substation | fast messages 10ms |
| Breaker close confirmation | Breaker position | fast messages 10ms |

| Information exchanged | | |
|---|--|--|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| FLISR information | Processing results of faulty section, fault isolation, service restoration etc. | fast messages 10ms |
| Current data | Rated current value, actual current value and load current value which are stored in respective FeCtIs. | medium speed message 100ms Raw data messages time tagging 20ms time tagging Bandwidth: bits*frequency |
| Information of the change from bay and voltage level | The voltage level and bay numbers in the renewed topology | Low speed messages time tagging 1s |
| Newly added and removed equipment and connective node objects | The name of equipment that has been removed from the old topology and equipment that is newly added to the topology; the information of newly added terminals and connective nodes | low speed messages time tagging 1s |

5.5.3 Use case 4b: FLISR based on distributed control – Type B

5.5.3.1 Description of the use case

5.5.3.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|--|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Fault Localization and Isolation (with related info reporting) in a feeder radially operated, built with distributed protection breaker capabilities |

5.5.3.1.2 Version Management

| Version management | | | | | | |
|--------------------------------------|-------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management Changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| v2 | 14/11 | IEC 61850-90-6 TF | L. Guise | (inclusion of Spanish comments) | | Draft |
| First version in IEC | | JAHWG51 | | | | Draft |

5.5.3.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Distribution System Operation |
| Scope | The Fault Location and Isolation operates in automated mode to help the distribution system operator isolate faults and reconfigure the network to re-energize as many unaffected feeder sections as possible. |
| Objective | Isolate faults in the power system to maintain safety and minimize the duration of power interruptions to improve overall power grid reliability. |

5.5.3.1.4 Narrative of use case – Short description

The main purpose of this use case is, by the usage of breakers along the feeder and telecommunication, to not only ensure the automatic isolation of earth faults, but also to prevent as well unwanted islanding conditions.

The Transfer Trip without fault has not been considered in this version of the document. If required a new section will be added accordingly.

For a better comprehension, the complete use case has been split into three different sub-cases, according to the fault location:

- Fault along MV feeder (Figure 40)
- Fault inside End User's plant (Figure 41)
- Fault along MV feeder with presence of DER and consequent need of transfer trip to avoid possible uncontrolled islanding (Figure 42)

5.5.3.1.5 Fault located along MV feeder – Long description

Refer to Figure 40.

All FtPInds upstream from the fault location detect the fault, as well as the Protection Device in the HV/MV substation.

Without the fault, a broadcast and repeated GOOSE message is sent periodically from every FtPInd to all the other ones.

After the fault occurrence, all the FtPInds upstream from the fault change the message payload indicating the fault detection. This information acts as a block for every FPI receiving it (being a broadcast signal, all the FtPInds receive this signal, but only those ones upstream from the closest to the fault will subscribe to it, while all the FtPInds downstream from the closest (upstream) from the fault will ignore the signal with different payload). Therefore, only the FPI closest (upstream) to the fault may act (it does not receive any blocking signal contemporaneously to the fault detection).

A further refinement has been added in order to:

- consider possibly time-based backup protection (chronologic selectivity)
- consider the case where the feeder is equipped of both breakers and sectionaliser along the feeder. In that case, a second process will happen, when de-energised, to used the sectionaliser to isolate the faulty section

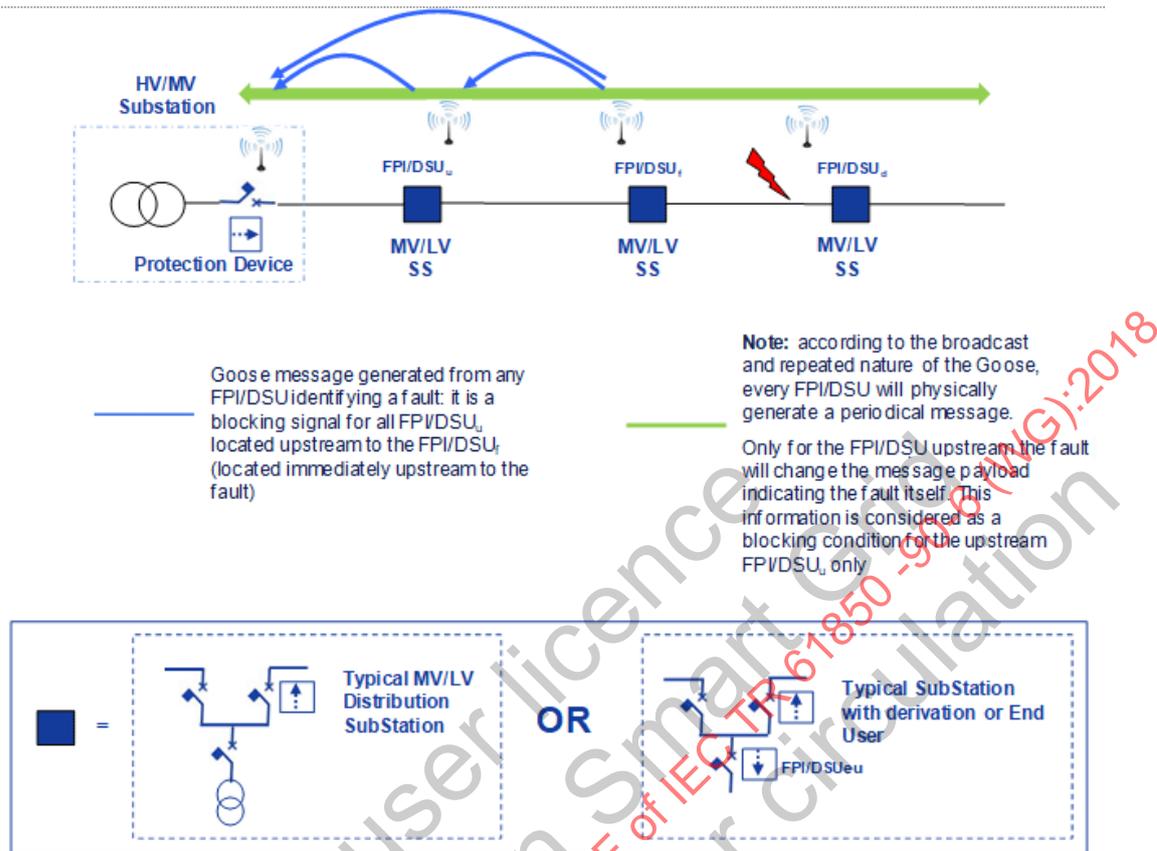


Figure 40 – Logical selectivity – FLI along the MV feeder

5.5.3.1.6 Fault located inside the End User plant – Long description

Refer to Figure 41:

All FPIs along MV feeder behaves like in the previous situation.

In this case, the FPI closest (upstream) to the fault cannot act because it receives the blocking signal from the End User General Protection.

All protections inside the End User Plant are enabled to communicate only with the FPI_{eu} on a local telecommunication network managed from the FPI_{eu}. GOOSE messages with different payload, used as blocking signals, are always subscribed from FPI_{eu}, being confined in the local network.

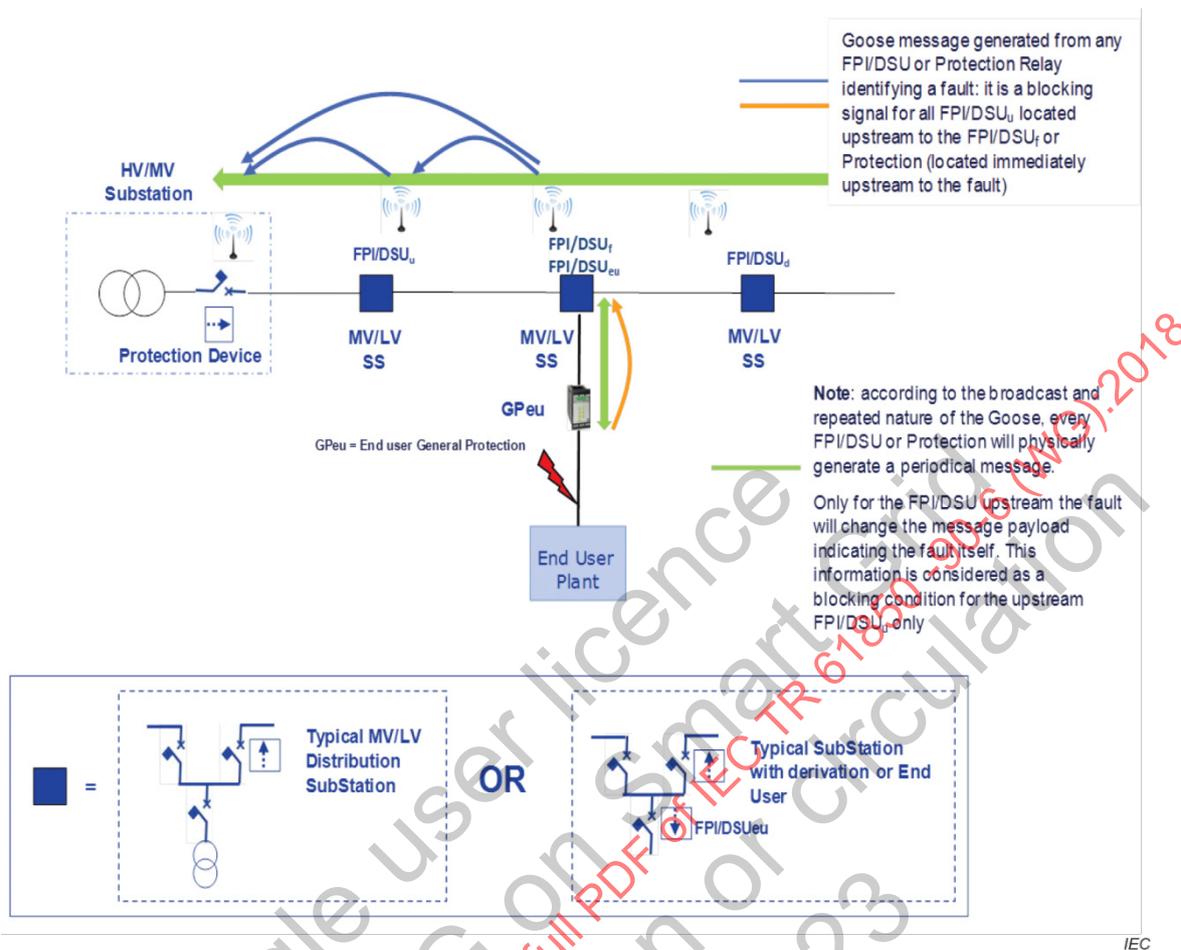


Figure 41 – Logical selectivity – FLI inside the EU plant

5.5.3.1.7 Fault along MV feeder with presence of DER and consequent need of transfer trip to avoid possible uncontrolled islanding – Long description

Refer to Figure 42:

All FPIs behave as in the first situation.

In addition, the FPI closest (upstream) to the fault, the only one enabled to act, send a GOOSE message to all FPI_{eu} downstream from it after the completion of its action.

All protections inside the End User Plant are enabled to communicate only with the FPI_{eu} on a local telecommunication network managed from the FPI_{eu}.

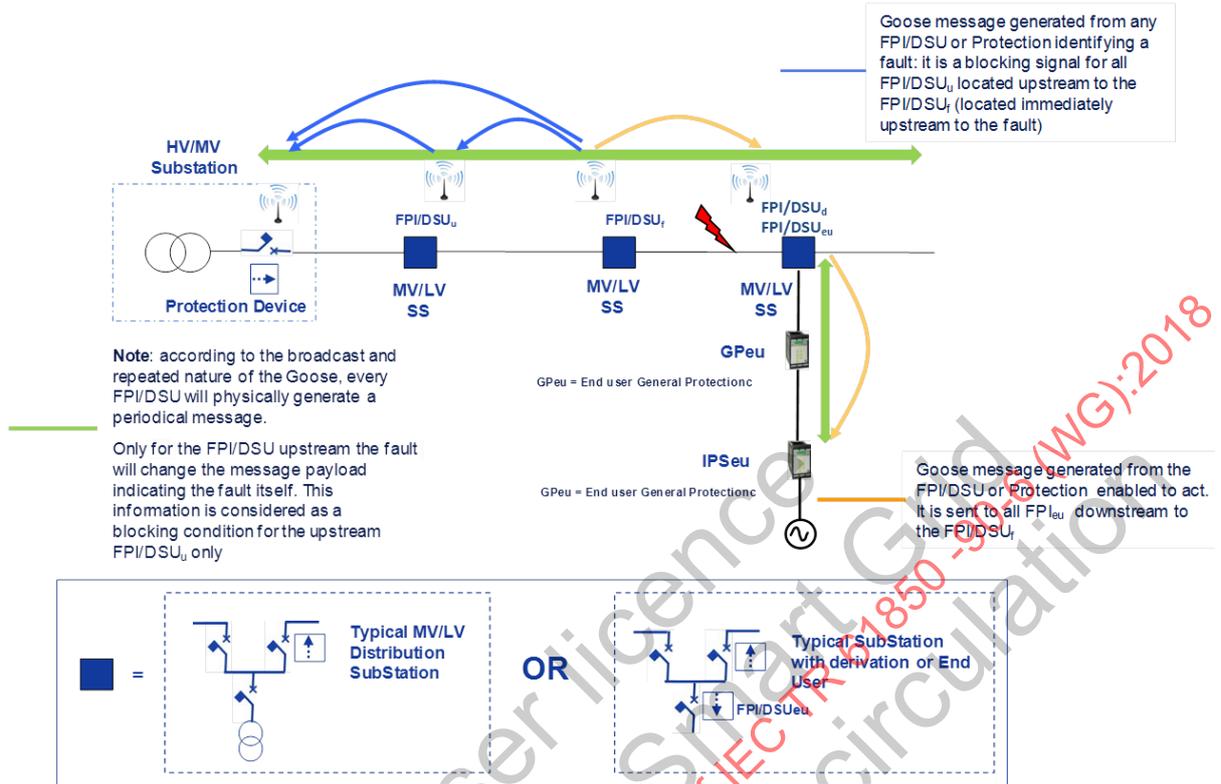


Figure 42 – Logical selectivity – FLI along the MV feeder and anti-islanding

5.5.3.2 Diagrams of use case

Figures 43 and 44 present the use case diagrams.

Single user licence for EESC WG on Smart Grids (WG):2018
 No reproduction or circulation of IEC TR 61850-90-6:2018
 May 2023

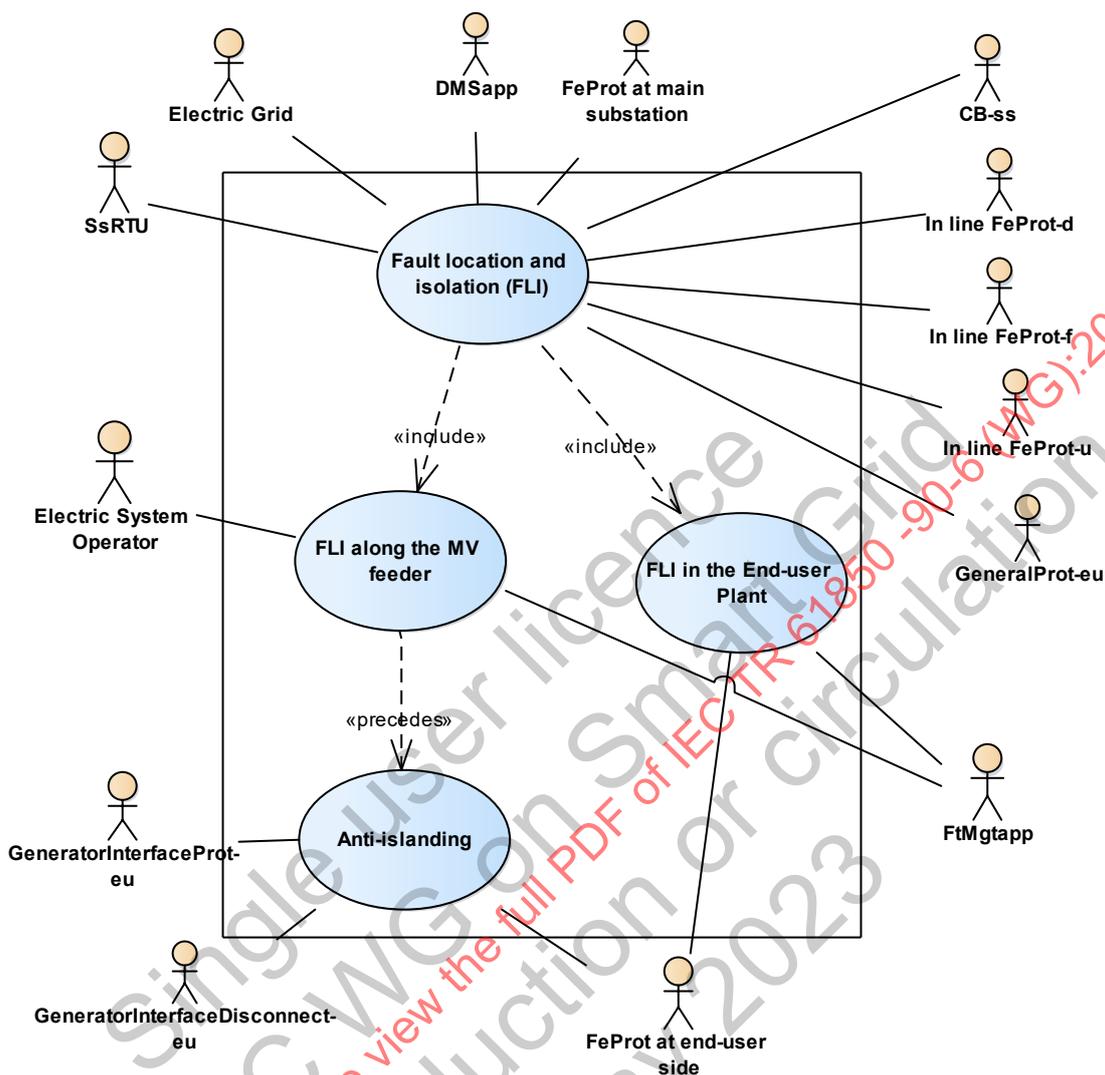


Figure 43 – Distributed FLISR 4b – Use case breakdown

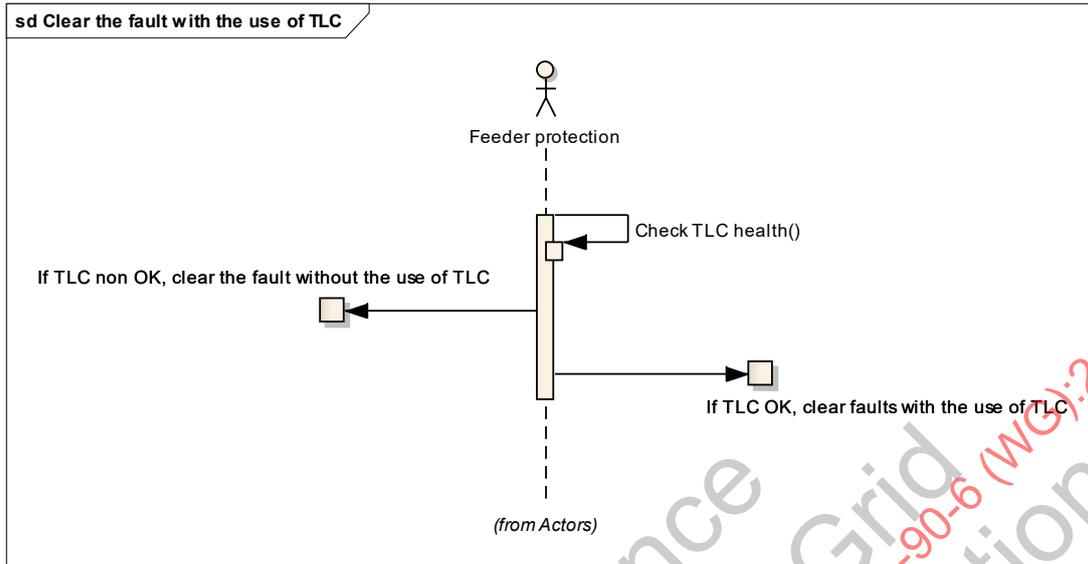


Figure 44 – Distributed FLISR 4b – For further analysis

5.5.3.3 Technical details

5.5.3.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|---------------------------------|------------------------------|---|---|
| Grouping (community) | | Group description | |
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Feeder In Line Protection | Device | Refer to Clause 4 | An index can be added for distinguishing different instances of actor |
| GeneralProt-eu | Device | Refer to Clause 4 | |
| GeneralProt-eu | Device | Refer to Clause 4 | |
| GeneratorInterfaceDisconnect-eu | Device | Refer to Clause 4 | |
| Grid | System | Refer to Clause 4 | |
| FeProt at main substation | Device | Refer to Clause 4 | |
| FtPInd | Device | Refer to Clause 4. | An index can be added for distinguishing different instances of actor |
| In line FeProt-u | Device | A feeder protection equipment (FeProt – Refer to 4.) located upstream to a fault, but not the closest one – see Figure 40 | An index can be added for distinguishing different instances of actor |
| In line FeProt-f | Device | A feeder protection equipment (FeProt – Refer to 4.) located upstream the closest to a fault, – see Figure 40 | An index can be added for distinguishing different instances of actor |

| Actors | | | |
|---------------------------------|------------------------------|---|---|
| Grouping (community) | | Group description | |
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| In line FeProt-d | Device | A feeder protection equipment (FeProt – Refer to Clause 4.) located downstream to a fault,– see Figure 40 | An index can be added for distinguishing different instances of actor |
| GeneralProt-eu | Person | Refer to Clause 4. | |
| Fault Operation Personnel (FOP) | Person | Refer to Clause 4. | |
| RTU | Device | Refer to Clause 4. | |
| DMSapp | System | Refer to Clause 4 | |
| FtMgtapp | System | Refer to Clause 4. | |
| FLISRapp | Application | Refer to Clause 4 | |

5.5.3.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|------------------------|----------------|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | Continuous | | The Grid is continuously monitored The Grid topology is known and reflects the real topology The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches) |
| FLISRapp | Autorecloser Operation | | Communication system between generic architectural component and control center where FILISR is hosted is operational |
| Feeder protection | | | Backup power/ battery is available for operation and communications |

5.5.3.4 Step by step analysis of use case

5.5.3.4.1 General

| Scenario conditions | | | | | |
|---------------------|---|---------------|--------------------------|---------------|---|
| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
| 5.2.5.4.1 | Logical Selectivity – FLI along the MV feeder | | Fault Signature handling | | The distribution system stakeholders collaborate to handle the fault occurred in a feeder |
| 5.2.5.4.2 | Logical Selectivity – FLI in the EU plant | | Fault Signature handling | | The distribution system stakeholders collaborate to handle the fault occurred in a feeder |
| 5.2.5.4.3 | Anti Islanding in case of FLI along the MV feeder | | Fault Signature handling | | The distribution system stakeholders collaborate to handle the fault occurred in a feeder |

5.5.3.4.2 Steps – Logical selectivity – FLI along the MV feeder

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Protection handling the fault, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|--|---|--|--|---|------------------------------|-------------------------------|---|
| Scenario name: | | Logical Selectivity – FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1 | Equipment settings/Network maintenance | Fault Localization and Isolation Settings | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | DMS (FieldComp config tool functionality) | HV/MV SS RTU | Ntw Topological Configuration | Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |

| Scenario | | | | | | | | |
|----------------|---------------------------------------|---|--|--|------------------------------|------------------------------|-------------------------------|---|
| Scenario name: | | Logical Selectivity – FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 2a | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-d | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2b | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-f | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2c | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-u | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2d | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | HV/MV SS Protection | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 3a | Fault signature (fault on the feeder) | Fault Detection | Fault detection | | Electric Grid | HV/MV SS Protection | Fault Signature | Internal process (fault type analysis) |
| 3a1 | | | (option) Internal timer starts for backup protection | | FltStr | HV/MV SS Protection | HV/MV SS Protection | Internal process (backup time-based protection start) |
| 3b | | | Fault detection | | Electric Grid | FeProt-u, FeInd-u | Fault Signature | Internal process (fault type analysis) |

| Scenario | | | | | | | | |
|----------------|-------|---|---|---------|------------------------------|------------------------------|-----------------------|---|
| Scenario name: | | Logical Selectivity – FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 3b1 | | | (option) Internal timer starts for backup protection | | FltStr | FeProt-u, FeInd-u | FeProt-u | Internal process (backup time-based protection start) |
| 3c | | | Fault detection | | Electric Grid | FeProt-f, FeInd-f | Fault Signature | Internal process (fault type analysis) |
| 3c1 | | | (option) Internal timer starts for backup protection | | FltStr | FeProt-f, FeInd-f | FeProt-f | Internal process (backup time-based protection start) |
| 4a | | Logical Selectivity | Blocking of Upstream FPIs/Protections | GOOSE | FeProt-u, FeInd-u | Other FeProt-u, FeInd-u | Block | Relevant for UPSTREAM FeProt-u, FeInd-u only (handling the received blocks). Only the unique unblocked FeProt-u will handle the Fault |
| 4b | | | Blocking of Upstream FPI/Protections | GOOSE | FeProt-f | FeProt-u, FeInd-u | Block | Relevant for UPSTREAM FeProt-u, FeInd-u only (handling the received blocks). Only the unique unblocked FeProt-u will handle the Fault |
| 4c | | | Releasing of back-up protection of Upstream FPI/Protections | GOOSE | FeProt-f | FeProt-u, FeInd-u | Block | Relevant for UPSTREAM FeProt-u, FeInd-u only (handling the received blocks). Upon reception internal timer is stopped to avoid backup operation |

IECNORM.COM · Click to view the full PDF of IEC TR 61850-90-6 (MC) 2018
 No reproduction or circulation allowed without user licence
 May 2023

| Scenario | | | | | | | | |
|----------------|-------|---|---|------------------|------------------------------|------------------------------|-----------------------|--|
| Scenario name: | | Logical Selectivity – FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 4d | | | Isolating the faulty section | GOOSE | FeProt-u, FeInd-u | other FeProt-u, FeInd-u | Block | Relevant for UPSTREAM FeProt-u, FeInd-u only (handling the received blocks). If 4c information is not received, for FeProt-u which internal timer expires operates the breaker and send unblocking /Breaker Operated information |
| 5a | | Fault Indication | Fault Analysis | IEC 61850 Report | HV/MV SS Protection | HV/MV SS RTU | Fault Information | Protection Str |
| 5b | | | Fault Analysis | IEC 61850 Report | FeProt-u, FeInd-u | HV/MV SS RTU | Fault Information | Protection Str |
| 5c | | | Fault Analysis | IEC 61850 Report | FeProt-f, FeInd-f | HV/MV SS RTU | Fault Information | Protection Str |
| 6 | | Fault Isolation | Fault Analysis | | FeProt-f | | | Internal process to trip the controlled CB which has not been blocked by downstream fault detector(s) |
| 7 | | | Fault Solution | GOOSE | FeProt-f | CB-f | Op | Trip the MV/LV SS CB to isolate the fault |
| 7a | | | (optional) further Fault isolation in case of mixed CBs and disconnectors | GOOSE | FeInd-f | other FeInd-f, FeInd-u | Block | Trip the MV/LV SS CB to isolate the fault |
| 7b | | | (optional) wait for OpDITmms of the selectivity mechanism between disconnectors | | FeInd-f, FeInd-u | | | given time to receive blocking signal from other feeder disconnectors |

| Scenario | | | | | | | | |
|----------------|-------|---|---|------------------|------------------------------|------------------------------|-----------------------|---|
| Scenario name: | | Logical Selectivity – FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 7c | | | (optional) further Fault isolation in case of mixed CBs and disconnectors | GOOSE | FeInd-f | Switch actuator | Open | Open the MV/LV disconnectors to isolate the fault more accurately than the closest CB |
| 7d | | | (optional) re-energize the upstream not faulty section | GOOSE | FeProt-f | CB | Close | |
| 8 | | | Fault Solution | GOOSE | FeProt-f | Anti-Islanding Function | Remote Disconnection | Ref. to 5.5.3.4.4 |
| 9 | | Fault Reporting | Fault Solution | IEC 61850 Report | FeProt-f | HV/MV SS RTU | Permanent Fault | Protection Op |
| 10a | | | Fault Solution | | HV/MV SS RTU | FtMgtapp | Fault Localization | On the base of the reports from all the Protections and FtPInd on the faulted feeder |
| 10b | | | Fault Solution | | HV/MV SS RTU | DMSapp | Fault Localization | On the base of the reports from all the Protections and FtPInd on the faulted feeder |
| 11 | | Fault Indication | Fault Indication | | Outage Management System | Field Operation Personnel | Fault Localization | Permanent Fault notification |
| 12 | | System Restoration | Feeder Re-energization | | DMSapp | System restoration Function | TBD | Utility based, TBD |

5.5.3.4.3 Steps – Logical selectivity – FLI in the EU plant

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Protection handling the fault, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|--|---|--|--|---|------------------------------|-------------------------------|---|
| Scenario name: | | Logical Selectivity – FLI in the EU plant | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1 | Equipment settings/Network maintenance | Fault Localization and Isolation Settings | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | DMS (FieldComp config tool functionality) | HV/MV SS RTU | Ntw Topological Configuration | Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2a | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-d | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2b | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-eu | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2c | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-f | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 2d | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | FeProt-u | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |

| Scenario | | | | | | | | |
|----------------|---|---|--|--|------------------------------|------------------------------|-------------------------------|---|
| Scenario name: | | Logical Selectivity – FLI in the EU plant | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 2e | | | Ntw Topological Configuration settings | File Transfer or/and Client/Server interactions and/or proprietary interface | HV/MV SS RTU | HV/MV SS Protection | IED Topological Configuration | Optional, Utility Policy dependent. Could be proprietary or IEC 61850 information exchange |
| 3a | Fault signature (fault in the End User plant) | Fault Detection | Fault detection | | Electric Grid | HV/MV SS Protection | Fault Signature | Internal process (fault type analysis) |
| 3b | | | Fault detection | | Electric Grid | FeProt-u | Fault Signature | Internal process (fault type analysis) |
| 3c | | | Fault detection | | Electric Grid | FeProt-eu | Fault Signature | Internal process (fault type analysis) |
| 3d | | | Fault detection | | Electric Grid | GP-eu | Fault Signature | Internal process (fault type analysis) |
| 4a | | Logical Selectivity | Blocking of Upstream FPIs/Protections | GOOSE | FeProt-eu | Broadcast | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique unblocked IED will handle the Fault |
| 5 | | | General Protection Start | GOOSE | GP-eu | FeProt-eu | Protection Str | TBD – For relevant FPI-eu local logics |
| 5b | | | Blocking of Upstream FPI/Protections | GOOSE | FeProt-u | Broadcast | Block | Relevant for UPSTREAM IEDs only (handling the received blocks). Only the unique not blocked IED will handle the Fault |
| 6a | | Fault Indication | Fault Analysis | IEC 61850 Report | FeProt at main substation | HV/MV SS RTU | Fault Information | Protection Str |
| 6b | | | Fault Analysis | IEC 61850 Report | FeProt-u | HV/MV SS RTU | Fault Information | Protection Str |

| Scenario | | | | | | | | |
|----------------|-------|---|----------------------------------|------------------|------------------------------|------------------------------|-----------------------|--|
| Scenario name: | | Logical Selectivity – FLI in the EU plant | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 7 | | Fault Isolation | Fault Analysis | | GeneralProt -eu | | | Internal process to trip the controlled CB as not blocked by downstream fault detector(s) |
| 8 | | | Fault Solution | GOOSE | GeneralProt -eu | CB-eu | Op | Trip the MV/LV SS CB to isolate the fault |
| 9 | | Fault Reporting | Fault Solution | IEC 61850 Report | GeneralProt -eu | HV/MV SS RTU | Permanent Fault | Protection Op |
| 10a | | | Fault Solution | | HV/MV SS RTU | FtMgtapp | Fault Localization | On the base of the reports from all the Protections and FtPInd on the feeder with faulted EU plant |
| 10b | | | Fault Solution | | HV/MV SS RTU | DMSapp | Fault Localization | On the base of the reports from all the Protections and FtPInd on the feeder with faulted EU plant |
| 11 | | Fault Indication | Fault Indication | | FtMgtapp | Field Operation Personnel | Fault Localization | Permanent Fault notification |
| 12 | | System Restoration | Feeder Re-energization | | DMSapp | System restoration Function | TBD | Utility based, TBD |

5.5.3.4.4 Steps – Anti Islanding in case of FLI along the MV feeder

The details of the Str and Op information (directionality, general or per single phase and/or neuter) depends on the type of Protection handling the fault, according to 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and 5.2.8.

| Scenario | | | | | | | | |
|----------------|----------------------|---|----------------------------------|---------|----------------------------------|----------------------------------|-------------------------------|--|
| Scenario name: | | Anti Islanding in case of FLI along the MV feeder | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1 | Remote Disconnection | Anti Islanding | Anti islanding | GOOSE | FeProt-f | GeneralProt -eu | Remote Trip | In general to all the Interface Protections of the Distributed Generation downstream the fault |
| 2 | | | Anti islanding | GOOSE | GeneralProt -eu | GeneratorInterfaceProt -eu | Transfer Trip | |
| 3 | | | Anti islanding | GOOSE | GeneratorInterfaceProt -eu | GeneratorInterfaceDisconnect -eu | Op | |
| 4 | | | Anti islanding | GOOSE | GeneratorInterfaceDisconnect -eu | GeneralProt -eu | GeneratorInterfaceProt Status | Optional TBD – For relevant FPI-eu local logics |

Single user licence
 EESC WG on Smart Grids
 No reproduction or circulation
 May 2023
 IEC NORM.COM : Click to view the full PDF of IEC TR 61850-90-6 (M0) 2018

5.5.3.5 Information exchanged

| Information exchanged | | |
|---|--|--|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| IED Topological Information (for configuration) | Topological Addressing (Structured information) of IEDs involved in DA on the Feeder; dynamical definition of the relationship with neighbor IEDs (up/down-stream) | New DO in new LN |
| Remote Disconnection | Disconnection of a feeder section (potentially blocked by neighboring breakers and switches) | New DO/DA or new LN |
| GP Start | Protection dependent (directionality, general or per single phase and/or neutral, ...) | Will be mapped over Str of the appropriate P-Type LN |
| Remote Trip | Anti-Islanding of a MV feeder trunk affected by a fault | New DO/DA or new LN |
| Transfer Trip | To open the ICB | New DO/DA or new LN |

5.6 Use case 5: Centralized Voltage and Var Control

5.6.1 Description of the use case

5.6.1.1 General

Traditional VVC application adjusts the settings of the online load tap changer (OLTC) substation transformers, bus/feeder voltage regulating transformers (voltage regulators) and switching shunt capacitors to regulate the voltage profile and the reactive power across the power system. More advanced VVC applications may also use the active and reactive power injection by the DER units as well as distribution FACTS devices such as D-STATCOM and D-SVC. The objective of VVC can be to minimize the power losses in the network, to reduce the total demand, to improve the voltage profile, to perform conservation voltage reduction (CVR), to improve power quality in the system, and/or to remove imbalance. VVC can be applied to both the LV network and the MV network. The problem of VVC is often formulated as an optimization problem and is solved subject to (a) network constraints, e.g. voltage limits, current limits, reactive power and/or PF constraint at the main substation, and (b) operational constraints, e.g. maximum allowable operations for capacitors and regulators. If VVC regulates both active and reactive power, it may be referred to as Voltage, Var and Watt Control (VVWC).

5.6.1.2 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|-------------------------------------|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Centralized Voltage and Var Control |

5.6.1.3 Version management

| Version management | | | | | | |
|--------------------------------------|--------------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management changes / Version | Date | Name author(s) or committee | Domain expert | Area of expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| V1.0 | 14-Sept-2014 | Salman Mohagheghi | | | | Draft |
| V1.1 | 2-Feb-2015 | Salman Mohagheghi | | | | |

5.6.1.4 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Distribution System Operation |
| Scope | VVC can be used in automated, semi-automated or manual mode to allow the operator to improve the performance of the system in the form of minimizing the losses, reducing the demand, flattening the voltage profile at various nodes, improving power quality, removing imbalance, and suchlike. It can be performed in a centralized or a decentralized (distributed) fashion. |
| Objective | One or more of the following: Minimize the power losses across the system, flatten the voltage profile (deviation of node voltages with respect to the desired voltage level), reduce the voltage level to as close to ANSI low as possible (conservation voltage reduction), minimize voltage imbalance in the system, etc. |

5.6.1.5 Narrative of use case – Short description

VVC manages the status of switching shunt capacitors, voltage regulating transformers and substation OLTC in order to direct the power system towards an operating condition with minimum power losses and/or as flat of a voltage profile as possible, among other things. The application can be active throughout the day, and can be triggered by the operator or another DMSapp application. It can operate in a fully automated way, or it can be designed to provide recommended settings for capacitors and transformers, only to be confirmed by the operator at the control center.

5.6.1.6 Narrative of use case – Complete description

The main objective of VVC is to control reactive power and voltage in the power system. This is very important for ensuring the security and efficiency of the network. An efficient control scheme for regulating the reactive power can ensure that the voltage profile in the system is optimized, which will lead to minimal losses and maximum net savings in terms of consumed power and energy. Effective voltage control on the other hand ensures that different equipment in the system will perform with the highest efficiency possible.

Generally speaking, various control variables exist in a distribution system that can be used by the system operator to achieve the above goals. These normally include:

A transformer with OLTC installed at the main distribution substation in order to regulate the secondary bus voltage at a certain level despite changes in the load,

Voltage regulating transformers along the main distribution feeder or sometimes the lateral branches (sub-feeders) to help regulate the voltage magnitude,

Switched shunt capacitors that are alternatively switched on and off to be able to respond to the temporary reactive power needs of the distribution system. These may be installed at the secondary of the main distribution transformer, along the main feeder or along the lateral branches.

The problem of controlling the above components in a power system is often referred to as VVC. The main objective here is to advise a control policy for regulating the shunt capacitors and transformer tap positions in order to minimize the peak hour demand, reduce losses, release the congestion of the system, while all the voltages are kept within the permissible range. Peripheral objectives may also be accounted for, such as reducing the reactive power flow through the main distribution transformer, flattening the voltage profile, and reducing the total number of switching/tap operations on the capacitors and/or the transformers.

5.6.1.7 General remarks

This use case describes the function of Voltage and Var Control system with shunt capacitors, OLTC transformers and voltage regulating transformers.

However, in the modern power system, distributed energy resources and energy storage systems can also be incorporated into the problem, known as VVWC (voltage, var and watt control) which is tied in closely with the concept of generation dispatch. Here, similar to VVC, the objective would be to achieve optimal system performance in terms of voltage profile and/or losses by regulating the tap positions, capacitor switch statuses, and the output of DER and ESS.

It is also possible to combine VVC with conservation voltage reduction (CVR). Here, the objective would be to reduce the distribution feeder service voltage (although above ANSI low limits) in order to reduce energy consumption and peak demand. The goal would be to reduce the voltages at various nodes by regulating the tap positions and capacitor switch statuses.

Finally, VVC can be performed in an autonomous (decentralized) fashion. Under this scenario, the command and/or computation of settings would not be provided by the utility control center, and will instead be calculated based on the information shared between neighboring IEDs and their knowledge on the local system model.

5.6.2 Diagrams of use case

Figures 45 and 46 present the use case diagrams.

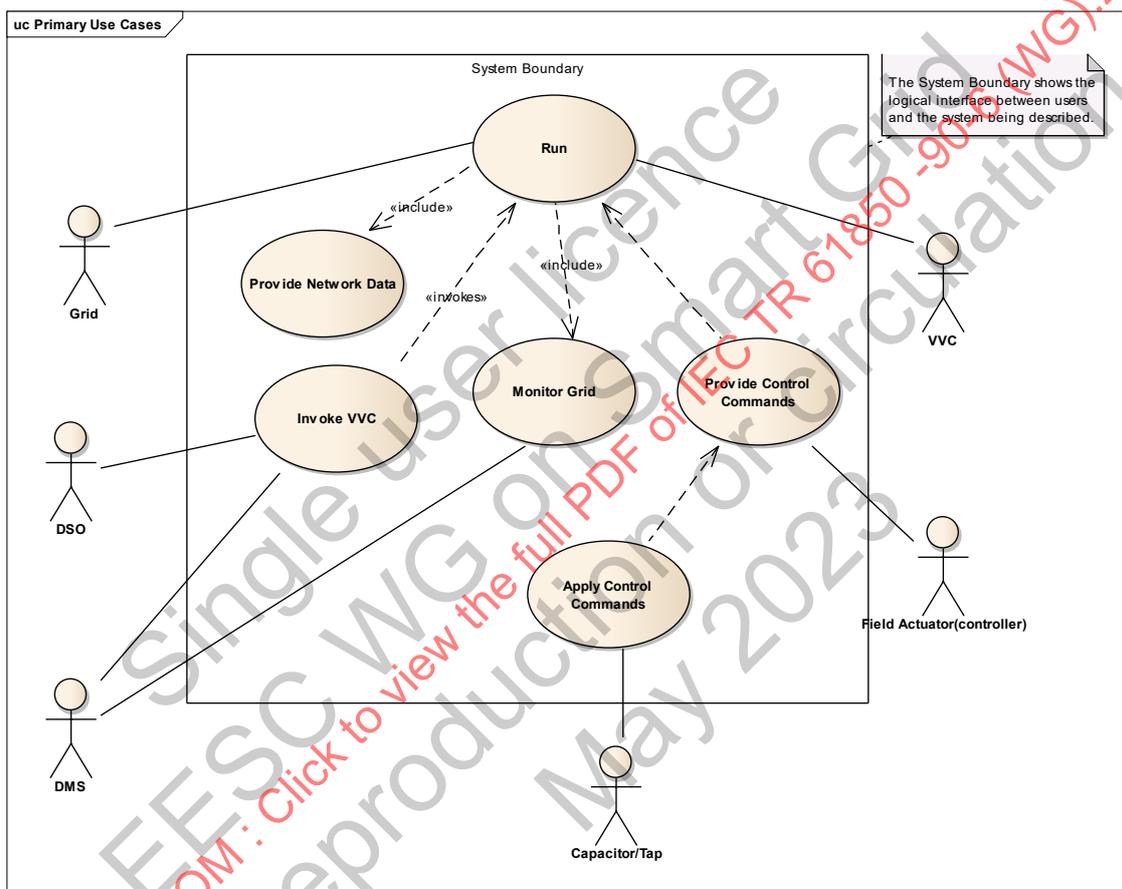


Figure 45 – Volt-Var Control – Use case breakdown

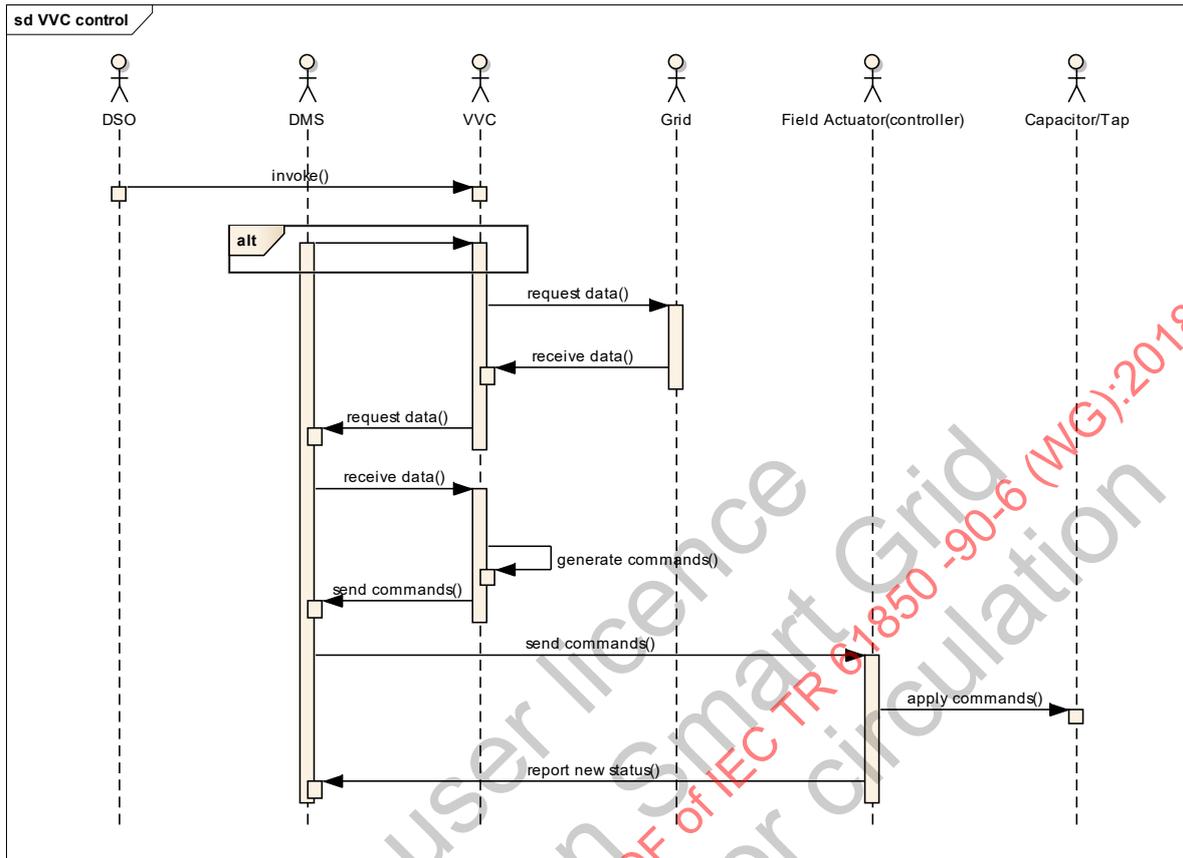


Figure 46 – Volt-Var Control – Sequence diagram

5.6.3 Technical details

5.6.3.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|----------------------------------|------------------------------|---|---|
| Grouping (community) | | Group description | |
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Electric Grid | System | Refer to 4 | |
| SysOp | Person | Refer to 4 | |
| Switching equipment actuators | Device | Refer to 4 | |
| DMSapp | System | Refer to 4 | |
| Shunt Capacitor Switch | Device | Switches associated with shunt capacitors. They can operate automatically through remote communications from the control center, or manually by the field crew. | |
| Transformer Tap | Device | Taps on transformer windings that change the turns ratio of the transformer | |
| VVC | Application | Application that performs voltage and var control. It determines optimal settings for capacitors and voltage regulators, and either applies them directly to the devices or recommends them to the DSO for approval. | |

5.6.3.2 Preconditions, assumptions, post condition, events

| Use case conditions | | | |
|-----------------------------------|---|--|--|
| Actor/System/Information/Contract | Triggering event | Pre-conditions | Assumption |
| DMSapp | Continuous | The Grid energy path is known and reflects the true flow of power as well as the status of remote monitored and controllable switches. | The Grid is continuously monitored The Grid topology is known and reflects the real topology |
| VVC | DSO or other DMS | | Communication system between generic architectural component and control center where VVC is hosted is operational |
| Switching equipment actuators | Control command from control center (through SCADA) | | Backup power is stored and available for remote control of the actuators in absence of power |

5.6.3.3 References / Issues

| References | | | | | | |
|------------|-----------------|-----------|--------|--------------------|---------------------------|------|
| No. | References Type | Reference | Status | Impact on Use Case | Originator / Organization | Link |
| | | | | | | |

5.6.4 Step by step analysis of use case

5.6.4.1 General

| Scenario conditions | | | | | |
|---------------------|---------------|---------------|--|--|---|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| | Normal | DSO, VVC | DSO initiates VVC, or another application within control center invokes VVC. | Distribution SCADA, distribution network model, capability to monitor voltage and power across all or a portion of the distribution grid, capability to control all or some of voltage regulators and shunt capacitors across the grid in the closed-loop mode | Optimal settings have been sent to voltage regulators and shunt capacitor switches. Power quality is enhanced. Distribution facilities are better utilized. Power losses are reduced and (if applicable) voltage profile is enhanced. Peak load is reduced. |

5.6.4.2 Steps – Normal

| Scenario | | | | | | | | |
|----------------|---|---------------------------|---|---------|-------------------------------|--|-----------------------|----------------------------------|
| Scenario name: | | Normal | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1a | VVC is invoked | Initial Trigger | DSO (or other DMSapp) triggers VVC | | DSO | VVC | Initiate | |
| 1b | VVC is invoked | Retrieve network data | Measurement and status data (powers, voltages, switch status, tap position) are retrieved by VVC | | DMSapp/Electric Grid | VVC | Network data | |
| 2 | VVC executes and creates control commands | Generate command signals | Command signals (capacitor status and tap positions) are generated and provided to DMSapp | | VVC | DMSapp | Control commands | |
| 3 | Information sent to field device actuators | Send command signals | DMSapp sends the control command signals to the field actuators (controllers) for capacitors and transformers | | DMSapp | Switching equipment actuators | Control commands | |
| 4 | Commands are applied to the corresponding devices | Commands performed | Field actuators apply the control commands to their controlled devices (shunt capacitors and transformers) | | Switching equipment actuators | Shunt Capacitor Switches/ Transformer Taps | | |
| 5 | New status reported back | Status report | The new status data (capacitor switch status and transformer tap position) reported back to the DMSapp | | Switching equipment actuators | DMSapp | New status data | |

5.6.5 Information exchanged

| Information exchanged | | |
|-------------------------------|--------------------------------------|---------------------------------------|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| | | |

5.7 Use case 6: Anti-islanding protection based on communications

5.7.1 Description of the use case

5.7.1.1 Name of use case

| Use case identification | | |
|-------------------------|--|---|
| ID | Area / Domain(s)/ Zone(s) | Name of use case |
| 0101 | Area: Distribution Network Domains: Distribution, DER, Zones: Process, Field, Station, Operation | Anti-islanding protection based on communications |

5.7.1.2 Version management

| Version management | | | | |
|--------------------|----------|-------------------|--|-----------------|
| Version No. | Date | Name of author(s) | Changes | Approval status |
| 0.1 | 20.06.14 | Henry Dawidczak | Creation | Draft |
| 0.11 | 03.12.14 | HD | Continued | Draft |
| 0.12 | 07.01.15 | HD | Incorrect manual operation to open CB (can also cause an unintentional island) | draft |
| 0.13 | 03.02.15 | HD | Changes acc. Golden meeting (e.g. Topology picture with possible faults) | Draft |

5.7.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Scope | Detection of unintentional islanding, islanding protection and de-energizing of involved feeder |
| Objective(s) | |
| Related business case(s) | Distribution automation and operation of feeder with DER |

5.7.1.4 Narrative of use case – Short description

The feeder and the connected equipment (loads and DERs) are not designed to work in an islanding mode. In case of the feeder circuit breaker opens, an unintentional islanding may have been created and then has to be detected. The auto-recloser function has to be blocked. The involved DER has to be forced to stop energizing the feeder.

An incorrect manual operation that opens the circuit breaker could also cause an unintentional island.

5.7.1.5 Narrative of use case – Complete description

A fault in a MV network can lead to an unintentional island of the involved feeder. This case happens if the feeder circuit breaker trips to solve the fault and in the same time connected DERs continue to in-feed power.

An additional reason of an unintentional island is an incorrect manual operation to open the circuit breaker (rare case). In that case the auto-recloser function in the protection relay will not be activated and therefore it must not be blocked. The resolution of the unintentional islanding is the same like after a fault.

For the discussion about unintentional islanding, the feeder topology and the location of the fault is important.

Figure 47 shows three possible locations of a radial feeder (example):

- The fault occurs in the busbar. The complete feeder can create an island.
- The fault occurs in a feeder. It can happen that a complete or a part of it will create an island.
- The fault occurs in a section of the feeder.

It is relevant if the fault can be isolated with a selected section (see FLISR) or if the feeder will be switch off completely.

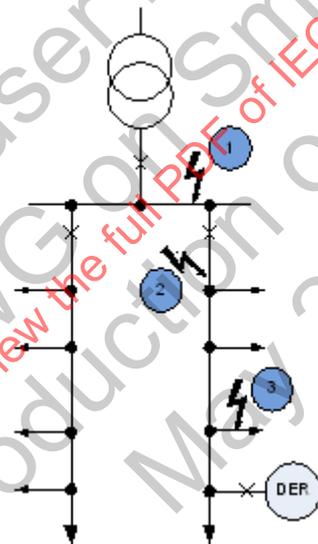


Figure 47 – Possible fault location on the feeder

For a short or longer period of time a balance of energy generation and consumption can exist in the islanded feeder. This causes a continuous and dangerous operation of the feeder under voltage conditions.

Measures have to be taken to detect and prevent unintentional islanding, i.e. blocking of auto-recloser in the distribution substation to prevent unsynchronized closing for a short time after trip. This can be achieved by:

- direct transfer trip (DTT) to DER systems
- or exchanging the status disconnection of unintentional islanding to DER System to de-energize the feeder (shutdown the in-feed of power).

Pre-requisite: There is a configured group of possible DERs to be involved in DTT. The group of DERs may change dynamically (refer to use case in chapter feeder configuration/engineering).

5.7.1.6 General remarks

There are different methods (active and passive, with and without communication) to detect unintentional islanding.

For example, some inverters of DER have the capability trying to push system frequency. In normal operation they are not able to change frequency. In case of an unintentional island with relatively big amount of in-feed power of this DER system, inverters detect by the ability changing the frequency that they are not in a normal operation and can disconnect from the network.

In this use case, methods using communication will be handled.

Intentional islanding and its operation will not be described here.

Other methods use impedance measurement, three phase monitoring, or oscillating circuit tests (e.g. German regulation VDE 0126-1-1).

NOTE The topology of the feeder (radial, open-loop etc.) has a big impact of the concept of detection of an unintentional islanding.

IEEE-1547-2003 and IEEE 1547a-2014 define compliance as ceasing to energize the Area EPS within 2 seconds of the formation of the unintentional island.

5.7.2 Diagrams of use case

Refer to Figure 48, Figure 49 and Figure 50.

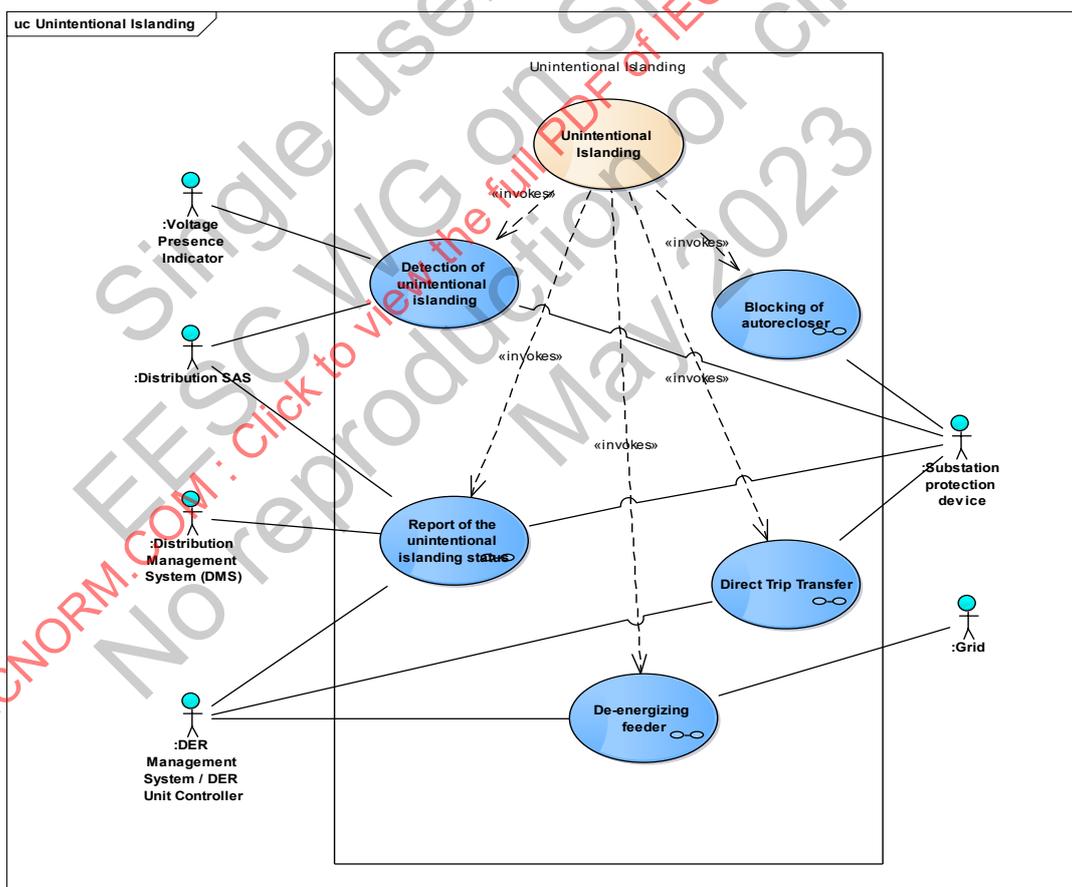


Figure 48 – Anti-islanding protection – Use case breakdown

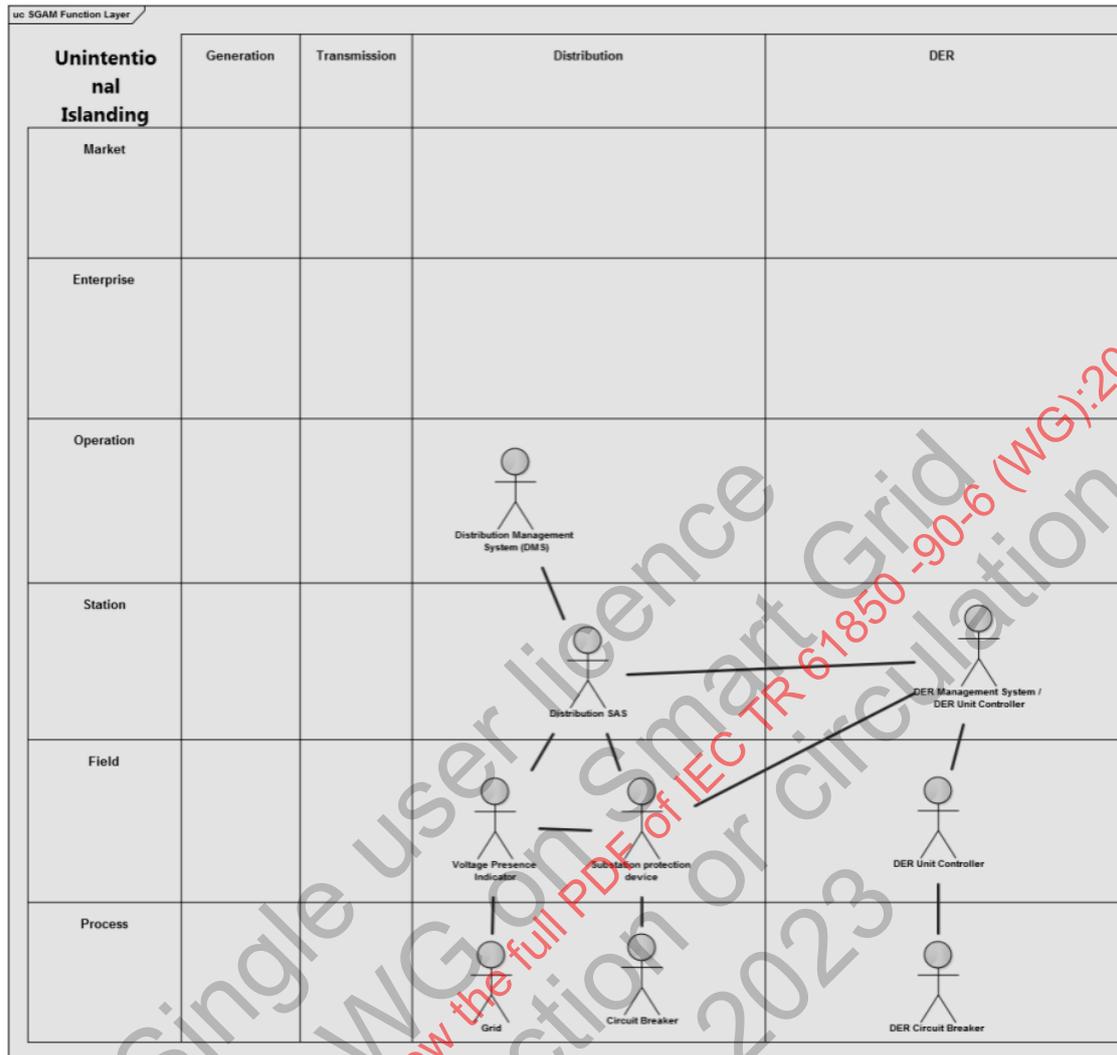


Figure 49 – Anti-islanding protection – Role diagram

IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
 No reproduction or circulation
 May 2023

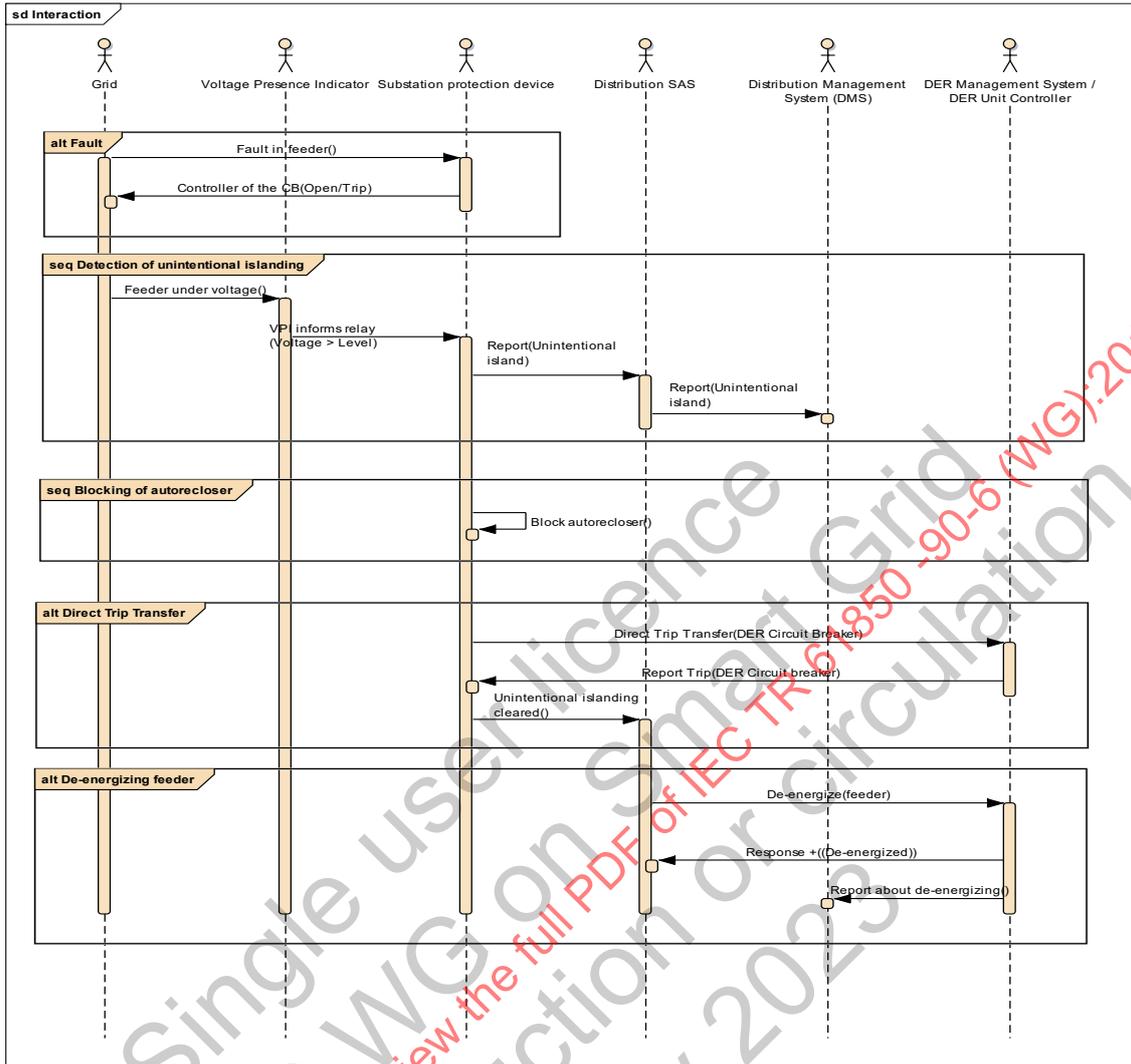


Figure 50 – Anti-islanding protection – Sequence diagram

IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG).2018
 Single user licence
 EESC WG on Smart Grid
 No reproduction or circulation
 May 2023

5.7.3 Technical details

5.7.3.1 Actors

| Actors | | | |
|--|------------------------------|--|---|
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| Electric Grid | System | Refer to 4. | |
| Voltage presence indicator (VPI) | Device | A device that indicates the presence of voltage over a certain limit on the measured point. | |
| DER Unit Controller | Device | Controller of DER with control and data acquisition function | The DER Unit Controller executes the controls from the higher level (DER MS) and fulfills the electrical grid codes. |
| DER Unit | Device | Distributed energy resources. A DER Unit consists of the physical equipment to generate, store and consume electrical power. | For the application of unintentional islanding the most powerful DER have to be taken into account. What must be achieved is that the power goes into an unbalance state by disconnecting a number of big DER. After that, the smaller DER reacts as a result of voltage and frequency deviations. |
| DER Management System | Application | The DER MS provides the DER-type- independent communication interface for the communication to the DMSapp. It forwards the information coming from the DER unit and executes the commands from the DMSapp. | Here the DER MS at the lowest level will be considered. That means it provides the status of the PCC of the DER System – the electrical connection point that can be impacted by DSO. |
| Substation protection device | Application | Substation protection device application with anti-islanding protection function | For fast transmission of trip signals (DTT) the protection relay provides the communication service UDP-Goose to DER MS. |
| Distribution Substation Automation System (SAS)(Substation controller) | Application | The Substation controller is part of the Distribution Substation Automation System and acts as a gateway for the signals from the feeder. | Distribution SAS has been connected by communication links according to IEC 61850-8-2 |
| DMSapp | Application | Refer to 4. | Only the DMS has the information about the topology (electrical connection points), the operational status and communication means of the DER systems in its area. |

5.7.3.2 Triggering event, preconditions, assumptions

| Use case conditions | | | |
|---------------------------------------|------------------|------------------------------|---|
| Actor/System/Information/ Contract | Triggering event | Pre-conditions | Assumption |
| Unintentional islanding | Protection trip | Feeder with DER in operation | DERs in-feed so much power that a balance between generation and consumption has been established |

5.7.4 Step by step analysis of use case

5.7.4.1 Overview of scenarios

| Scenario conditions | | | | | |
|---------------------|---------------------------------------|---|--|---|--|
| No. | Scenario name | Primary actor | Triggering event | Pre-condition | Post-condition |
| 001 a | Fault | Substation protection device | Fault | Feeder is in operation | Trip has cleared the fault |
| 001 b | Incorrect manual open operation of CB | Bay Controller in SAS | Open operation | Feeder is in operation | CB has been opened |
| 002 | Detection of unintentional islanding | Substation protection device, Voltage presence indicator(VPI) | The VPI detects the presence of voltage after tripping | Trip in the feeder | Substation protection device states an unintentional islanding |
| 003 | Blocking of auto-recloser | Substation protection device / auto-recloser function | Unintentional islanding | | Autorecloser is blocked |
| 004 | Report about unintentional islanding | Substation protection device | Unintentional islanding | Communication link to SAS/DMSapp | SAS and DSM got report |
| 005 | Direct trip transfer | Substation protection device | Activation of DTT | Link to DER MS of big units | DTT has been sent, DER MS trips its CB |
| 006 | De-energizing of feeder | SAS | SAS decides to de-energize feeder | SAS got information about unintentional islanding, communication link to DER MS available | DER has been shutdowned, feeder is de-energized |

5.7.4.2 Steps – Scenarios

| Scenario | | | | | | | | |
|----------------|-------|---|---------------------------------|---------|------------------------------|------------------------------|-----------------------|---------------------|
| Scenario name: | | S01a – Fault S01b– Incorrect manual open operation of CB | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1a | | Fault in feeder | In feeder occurs network fault | | Feeder | Substation protection device | Pick-up PTRC.Str | |
| 2a | | Clear fault (Trip) | The relay trips the CB | | Substation protection device | | Trip PTRC.Tr | |
| 1b | | Manual open operation | Operator opens manually the CB | | DMSapp/S AS | Bay controller | XCBR.Pos | |

| Scenario | | | | | | | | |
|----------------|-------|--|--|---------|------------------------------|-----------------------------------|------------------------|---------------------|
| Scenario name: | | S02 – Detection of unintentional islanding | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1 | | Voltage presence | Continuously detection of voltage presence | | Voltage presence Indicator | Substation protection device, SAS | Phase voltage MMXU.PhV | |

| Scenario | | | | | | | | |
|----------------|-------|--|--|---------|------------------------------|------------------------------|-----------------------|---------------------|
| Scenario name: | | S03 – Blocking of auto-recloser | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1 | | Substation protection device blocks recloser | Relay processes blocking signal and blocks recloser function | | Substation protection device | Autorecloser function | RREC.Bik | |

| Scenario | | | | | | | | |
|----------------|-------|---|---|---------|------------------------------|------------------------------|--------------------------------|---------------------|
| Scenario name: | | S04 – Report about unintentional islanding | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1 | | Creation of status Unintentional Islanding | Relay derives about unintentional islanding | | Substation protection device | SAS | Status Unintentional islanding | |
| 2 | | Reports to DMSapp about Unintentional islanding | SAS reports the status | | SAS | DMSapp | Status Unintentional islanding | |

| Scenario | | | | | | | | |
|----------------|-------|---|--|---------|------------------------------|------------------------------|--|---------------------|
| Scenario name: | | S05 – Direct trip transfer (Alternative to S06) | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1 | | Direct trip transfer | Relay sends a DDT signal to DER MS | | Substation protection device | DER MS of big units | Signal to trip CB (PSCH.TxTR) | |
| 2 | | Response of tripping | After tripping by DER MS, it sends positive response | | DER MS | Substation protection device | XCBR.Pos=open | |
| 3 | | Report to SAS, DMSapp | Report that unintentional islanding cleared | | Substation protection device | SAS; DMSapp | Status unintentional islanding cleared | |

| Scenario | | | | | | | | |
|----------------|-------|--|---|---------|------------------------------|------------------------------|--------------------------------------|---------------------|
| Scenario name: | | S06 – De-energizing of feeder (Alternative to S05) | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements , R-ID |
| 1 | | Emergency direct control | SAS sends an emergency direct control command to one or more big DER systems to shut-down their in-feed and therefore to bring the island into a unbalanced state | | SAS | DER MS | Shut-down DER and de-energize feeder | |

| Scenario | | | | | | | | |
|----------------|-------|---|---|---------|------------------------------|------------------------------|-----------------------|--------------------|
| Scenario name: | | S06 – De-energizing of feeder (Alternative to S05) | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information Exchanged | Requirements, R-ID |
| 2 | | Shut-down of in-feed by DER Systems | DER Systems shuts-down its in-feed | | DER MS | DER Units | | |
| 3 | | Reaction on unbalanced state by other (smaller) DER Systems | Protection of DER Systems reacts on frequency deviation on its electrical connection point and disconnect from the feeder | | DER MS | DER Units | | |
| 4 | | Report about disconnection by DER systems | The solved unintentional islanding will be reported to the DMSapp. | | DER MS | SAS | | |

5.7.5 Information exchanged

| Information exchanged | | |
|--------------------------------------|--|----------------------------------|
| Name of information (ID) | Description of Information exchanged | Requirements to information data |
| Voltage presence | Voltage presence of feeder | |
| Trip signal | Trip signal to clear fault in the feeder by protection in the distribution substation | |
| State of unintentional islanding | Information of the feeder to indicate unintentional islanding state | |
| DTT | Direct trip signal from feeder protection | |
| Command to shutdown in-feed of power | SAS/DMSapp controls DER MS with high priority to shutdown in-feed of power to de-energize the feeder | |

5.8 Use Case 7: Automatic transfer switch

5.8.1 Description of the use case

5.8.1.1 Name of use case

| Use case identification | | |
|-------------------------|---------------------------|-----------------------------------|
| ID | Area(s)/Domain(s)/Zone(s) | Name of use case |
| | | Perform Automatic Source Transfer |

5.8.1.2 Version management

| Version management | | | | |
|--------------------|------------|-------------------|---------|-----------------|
| Version No. | Date | Name of author(s) | Changes | Approval status |
| 0.1 | 2015-12-02 | Clement Paris | | |

5.8.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Scope | The automatic source transfer function is supposed to be used in a MV/LV substation |
| Objective(s) | Describe the information exchanges in the MV/LV substation to perform the automatic source transfer function |
| Related business case(s) | |

5.8.1.4 Narrative of use case – Short description

This system use case describes the automatic transfer switch function. When a voltage loss occurs on the primary source, the system decides under specific conditions to transfer the load to the backup source.

5.8.1.5 Narrative of use case – Complete description

The MV/LV substation can potentially be energized from two sources substations A and B.

The MV/LV substation is supposed to be energized from the primary source A.

When a voltage loss occurs on the primary source A, the automatic source transfer management system will try to transfer the load to the backup source B.

The source transfer management system will switch the source A with the source B if:

- The source transfer function is active (not blocked because of a fault presence)
- A voltage absence on the source A has been detected
- At least one of the field actuators associated to the source A is closed
- A voltage presence on the backup source B has been detected
- All the field actuators associated to the source B are open
- The transfer direction is authorized
- The command voltage is valid

5.8.1.6 Use case conditions

| Prerequisites | |
|---------------|--|
| 1 | The MV/LV can be potentially energized from two sources substations A and B. |
| 2 | The MV/LV substation is supposed to be energize from the primary source A. |

5.8.2 Diagrams of use case

Figures 51 and 52 present the use case diagrams.

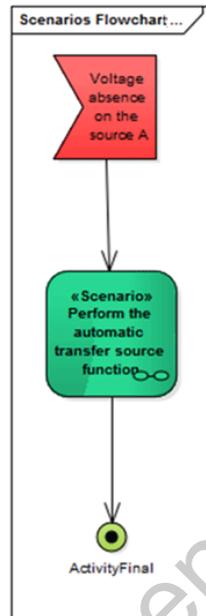


Figure 51 – Automatic transfer switch – Scenario flowchart

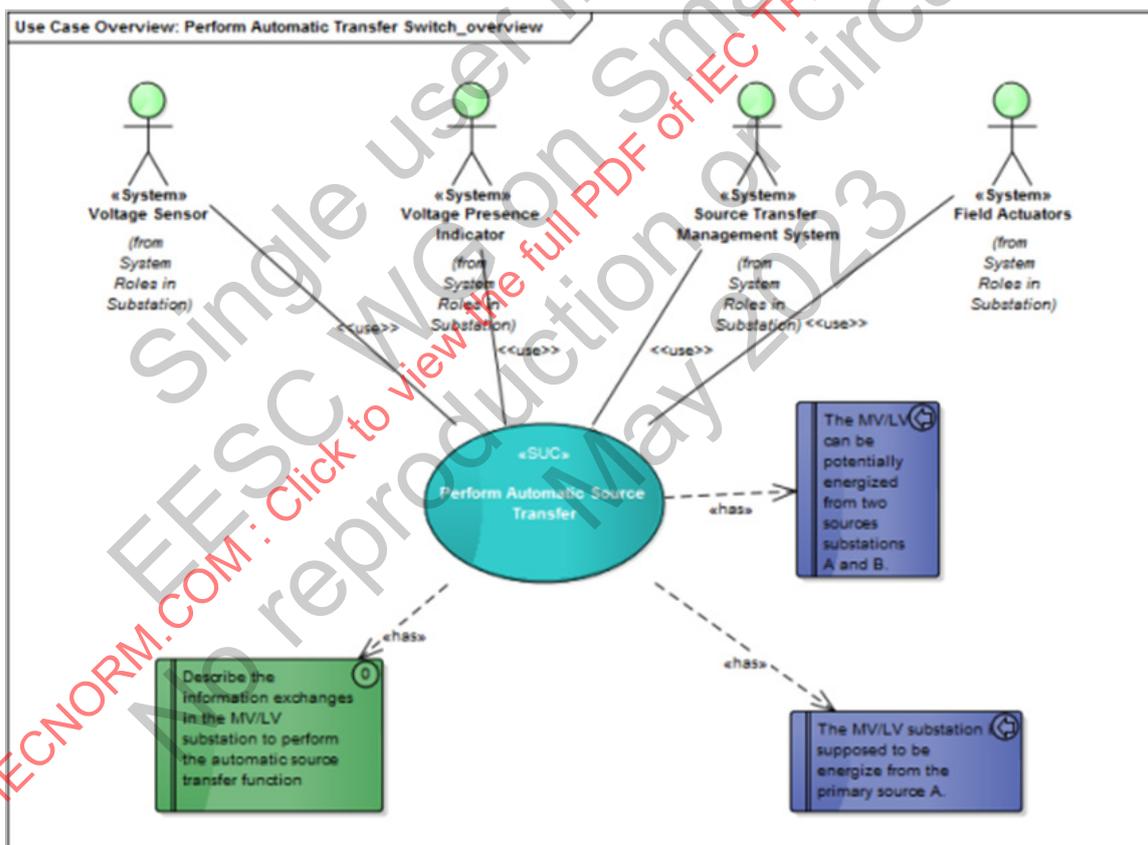


Figure 52 – Automatic transfer switch – Use cases breakdown

5.8.3 Technical details

5.8.3.1 Actors

| Actor name | Actor type | Actor description | Further information specific to this use case |
|-----------------------------------|------------|---|---|
| Field Actuators | System | Primary equipment switches which are located along the network to enable the operator or the system to isolate faulty section. They can be operated automatically or manually through remote communications | |
| Source Transfer Management System | System | When a voltage loss occurs on the primary source, the Source Transfer Management System decides, under specific conditions, to transfer the load to the backup source | |
| Voltage Presence Indicator | System | This system indicates the voltage presence/absence on a specific point of the network | |
| Voltage Sensor | System | System which measures the voltage on a network | |

5.8.4 Step by step analysis of use case

5.8.4.1 Overview of scenarios

| Scenario conditions | | | | | | |
|---------------------|--|----------------------|---------------|---------------------------------|---------------|----------------|
| No. | Scenario name | Scenario description | Primary actor | Triggering event | Pre-condition | Post-condition |
| 1 | Perform the automatic transfer source function | | | Voltage absence on the source A | | |

5.8.4.2 Steps – Scenarios

5.8.4.2.1 Perform the automatic transfer source function

Figure 53 shows the associated activity flowchart.

IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
 No reproduction or circulation
 May 2023

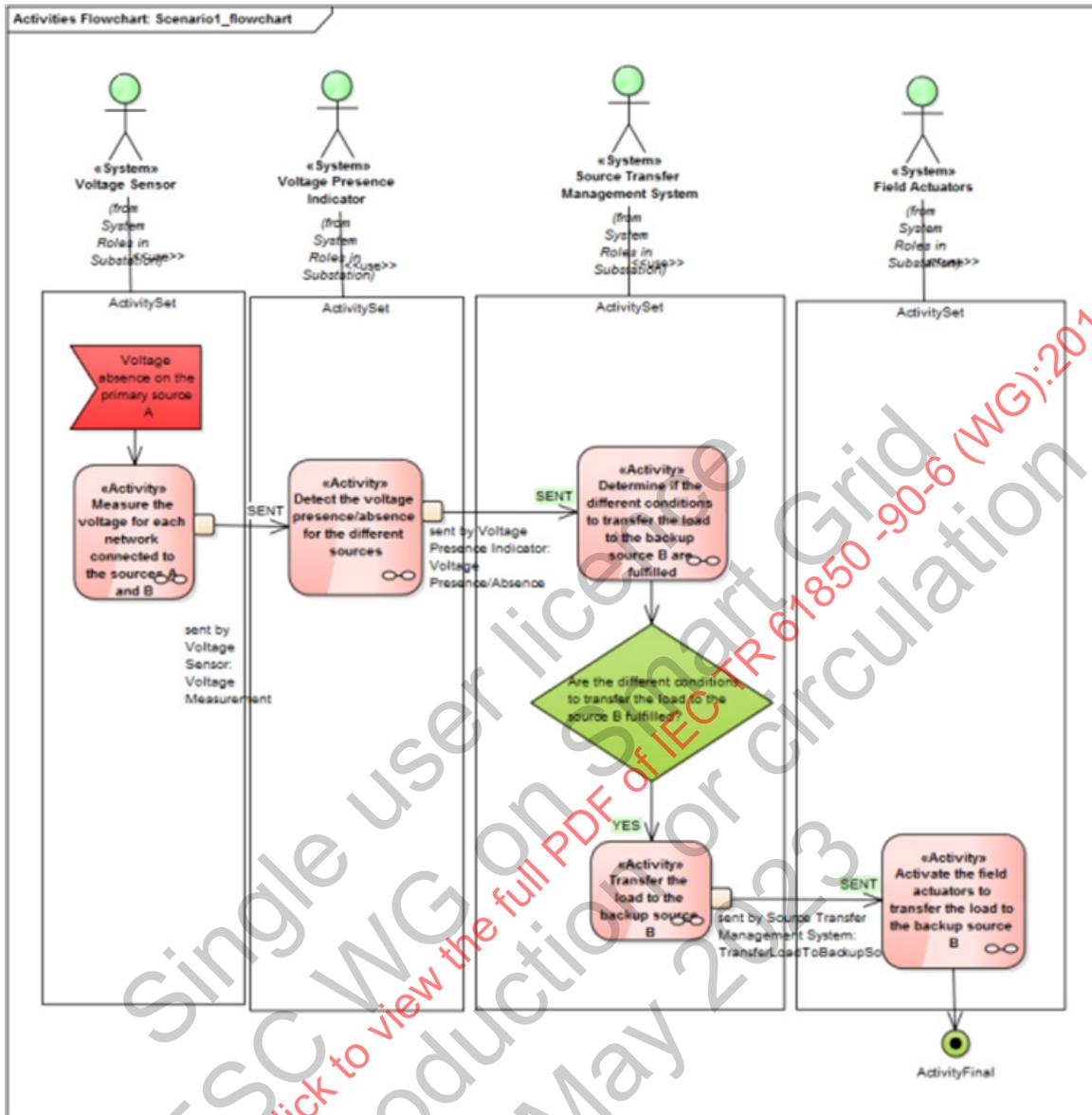


Figure 53 – Automatic transfer switch – Activity flowchart

Step by step analysis:

| Scenario | | | | | | | | |
|---------------|-------|---|---------------------------------|---------|-----------------------------------|-----------------------------------|---|--------------------|
| Scenario name | | Perform the automatic transfer source function | | | | | | |
| Step No | Event | Name of process/activity | Description of process/activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged (IDs) | Requirement, R-IDs |
| 1.1 | | Detect the voltage presence/absence for the different sources | | SENT | Voltage Presence Indicator | Source Transfer Management System | Info1-sent by Voltage Presence Indicator | |
| 1.2 | | Determine if the different conditions to transfer the load to the backup source B are fulfilled | | | Source Transfer Management System | | | |
| 1.3 | | Measure the voltage for each network connected to the sources A and B | | SENT | Voltage Sensor | Voltage Presence Indicator | Info2-sent by Voltage Sensor | |
| 1.4 | | Transfer the load to the backup source B | | SENT | Source Transfer Management System | Field Actuators | Info3-sent by Source Transfer Management System | |
| 1.5 | | Activate the field actuators to transfer the load to the backup source B | | | Field Actuators | | | |

5.8.5 Information exchanged

| Name of information (ID) | Description of information exchanged | Requirement, R-IDs |
|----------------------------|---|--------------------|
| Voltage Presence/Absence | sent by Voltage Presence Indicator | |
| Voltage Measurement | sent by Voltage Sensor | |
| TransferLoadToBackupSource | sent by Source Transfer Management System | |

5.9 Use Case 8: Monitor energy flows (Energy flow related Use cases)

5.9.1 Use case breakdown

The parent use case is broken down into sub use cases as presented in Figure 54.

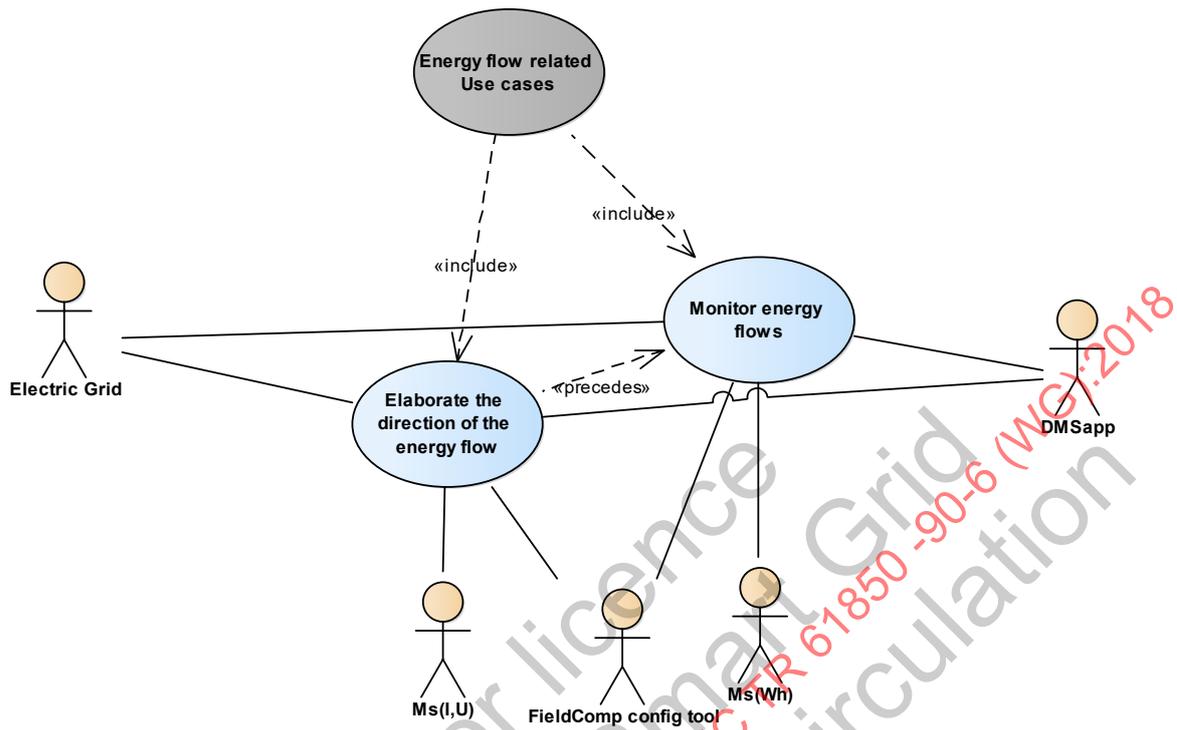


Figure 54 – Monitor energy flows – use case breakdown

Figure 55 shows a generic sequence diagram which covers both sub use cases.

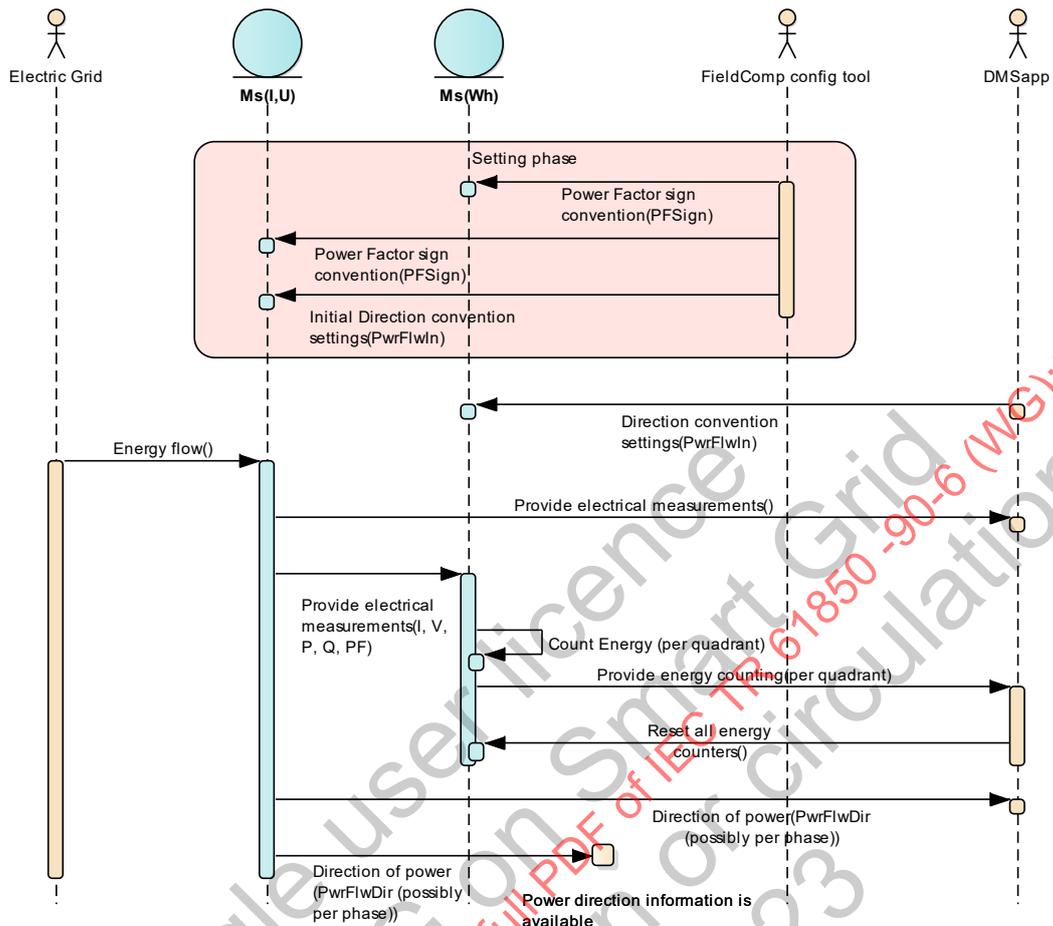


Figure 55 – Sequence diagram for the “Monitor energy flows” use case

5.9.2 Monitor Energy flows

5.9.2.1 Description of the use case

5.9.2.1.1 General

At the current time the main use case considered for energy measurement is for billing metering purpose, expecting the count of a number of pulses, each pulse representing a quantity of energy. The purpose of this use case is for operation, to provide all needed information relating to active, reactive and net energy, supplied/delivered or demanded/received, or even per quadrant (Q1 to Q4).

5.9.2.1.2 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|----------------------|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Monitor Energy flows |

5.9.2.1.3 Version management

| Version management | | | | | | |
|--------------------------------------|------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| First version | | JAHWG51 | | | | Draft |

5.9.2.1.4 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Scope | Monitor energy flows for operation purpose. |
| Objective | Enable to measure active, reactive and net power and energy supplied/delivered to or demanded/received out, or even per quadrant (Q1 to Q4) at the point of measurement, for operation purpose. |

5.9.2.1.5 Narrative of use case – Short description

Provides detailed active or reactive or net cumulated energy either per quadrant, or globally delivered or received at the point of measurement, based on the energy flows direction conventions.

5.9.2.1.6 Narrative of use case – Complete description

Provides detailed active or reactive or net cumulated energy globally for the three phases or per phase. Provides energy metering per quadrant, or delivered or received (based on forward/backward convention) at the point of measurement. The calculation context (period duration & automatic reset, max, min etc.) is set prior to the calculation. All energy counters are resettable synchronously.

5.9.2.2 Diagrams of use case

Refer to Figure 55.

5.9.3 Elaborate the direction of the energy flow**5.9.3.1 Description of the use case****5.9.3.1.1 General**

Host/spread the convention (setting type) which allows other functions to define the “normal energy flow” and then whether a measured energy is supplied/delivered downstream or demanded/received out of downstream.

This setting will be used further either for protection direction information or for counting cumulated energy based on its direction. It also elaborates dynamically a tag indicating both for active and reactive power the direction of the energy flow (forward or backward).

5.9.3.1.2 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|--|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Elaborate the direction of the energy flow |

5.9.3.1.3 Version management

| Version management | | | | | | |
|--------------------------------------|-----------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version management changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
| First version | 19/3/2015 | JAHG 51 | | | | Draft |

5.9.3.1.4 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Scope | Elaborate the direction of energy flows. |
| Objective | Allows other functions (such as protection or energy measurement) to define whether the energy is supplied/delivered to or demanded/received out. |

5.9.3.1.5 Narrative of use case

5.9.3.1.5.1 Narrative of use case – Short description

Based on given conventions, elaborate the direction of power flows.

5.9.3.1.5.2 Narrative of use case – Complete description

Based on given conventions on power factor sign, and direction convention, elaborate the direction of active and reactive power.

5.9.3.1.6 Diagrams of use case

Refer to Figure 55.

5.9.3.1.7 Technical details – Actors

| Actors | | | |
|------------------------------|------------------------------|-------------------------------------|---|
| Actor Name see Actor List | Actor Type see Actor List | Actor Description see Actor List | Further information specific to this Use Case |
| Electric Grid | System | Refer to Clause 4. | |
| DMSapp | System | Refer to Clause 4. | |
| FieldComp config tool | (System) Application | Refer to Clause 4. | |
| Ms(I,U) | (Device) Function | Refer to Clause 4. | |
| Ms(Wh) | (Device) Function | Refer to Clause 4. | |
| Ms(power flow direction) | (Device) Function | Refer to Clause 4. | |

5.9.3.1.8 Step by step analysis of use case

| Scenario | | | | | | | | |
|----------------|------------------------------------|--|---|------------------------------|------------------------------|------------------------------|--|----------------------------------|
| Scenario name: | | Elaborate the direction of the energy flow | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information producer (actor) | Information receiver (actor) | Information exchanged | Additional notes or requirements |
| 1a | Equip settings/Network maintenance | Setting phase | Power Factor Sign setting | Parameter setting | FieldComp config tool | Ms(I,U) | PFSign | |
| 1b | Equip settings/Network maintenance | Setting phase | Definition of the "supply/demand convention" | Parameter setting | FieldComp config tool | Ms(Wh) | RvPwrFlwSgn | |
| 2 | Topology change | Setting update phase | (optional)RE-Definition of the "supply/demand convention" | Parameter setting | DMSapp | Ms(I,U) | RvPwrFlwSgn | |
| 3 | Continuous | Running | Electrical measurement" | Real-time measurement | Ms(I,U) | Ms(power flow direction) | Per phase signed P, Q, PF. Power flow direction (forward – from supply or backward – to supply) | |
| 4 | Continuous | Running | Electrical measurement" | Per quadrant energy counting | Ms(Wh) | Ms(power flow direction) | Per quadrant Wh, VARh, VAh. Real, reactive and apparent supplied energy, or demand energy, or difference or addition of both | |

5.9.3.1.9 Information exchanged

| Information exchanged | | |
|--|---|---|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| PFSign | Power Factor Sign – needed to cope with different convention all around the world. This settings guarantee that all concerned functions work with the same convention – Typically IEC based or IEEE based | See PFSign as designed in MMXU of IEC 61850-7-4, however it shall be located at a place it will affect all measurements and associated functions the same way. Existing DO in new LN |
| PwrFlwIn | Enable the definition of the “supply/demand convention” – it may affect simultaneously multiple functions | New DO in new LN. Must be aligned with CIM convention |
| I, U, P, Q, PF | Per phase signed. | Existing MMXU |
| PwrFlwDir | Powerflow direction (from supply or to supply), including per phase | New DO |
| Active, reactive, apparent Energy measurements: Wh, VARh, VAh | (3 phase or single phase) per quadrant Wh, VARh, VAh. Real, reactive and apparent supplied energy, or demand energy, or difference or addition of both | New DOs |

5.10 Use Case 9: Environment situation awareness

5.10.1 Description of the use case

5.10.1.1 General

The main purpose of this use case is to make remote systems (here the DMSapp) aware of local environment situation, and to enable the local systems to log these for archiving purpose (and possibly post-mortem analysis).

5.10.1.2 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|---------------------------------|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Environment situation awareness |

5.10.1.3 Version management

| Version management | | | | | | |
|--------------------------------------|------|-----------------------------|---------------|-----------------------------------|-------|--|
| Version Management Changes / Version | Date | Name Author(s) or Committee | Domain Expert | Area of Expertise / Domain / Role | Title | Approval Status draft, for comments, for voting, final |
| First version | | L. Guise | | | | Draft |

5.10.1.4 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|---|
| Scope | Environment situation awareness for operation purpose. |
| Objective | Provides to local and remote system measurement, warning and alarms on many external situation elements like weather conditions, flooding conditions, live presence status, geographical perimeter status (doors, etc.) for operation and logging purpose |

5.10.1.5 Narrative of use case

5.10.1.5.1 Narrative of use case – Short description

Manages a set of specific sensors related to environment situations such as weather conditions, flooding conditions, live presence status, geographical perimeter status (doors, etc.) and elaborates from these raw measurement warnings and alarms based on pre-defined threshold and other criteria.

5.10.1.5.2 Narrative of use case – Complete description

Same as above. The considered situations are:

- Exceptional weather conditions (temperature, rain, snow, wind)
- Exceptional flooding conditions
- Live presence conditions (presence of human or animals)
- Geographical perimeter changes (doors unlocked, opened, etc.)

Once measured, and based on predefined criteria (threshold, information is made available (sent) to local and remote systems (SsCtl, DMSapp) and to local logging (SsCtl).

5.10.1.6 Diagrams of Use Case

Figures 56 and 57 present the use case diagrams.

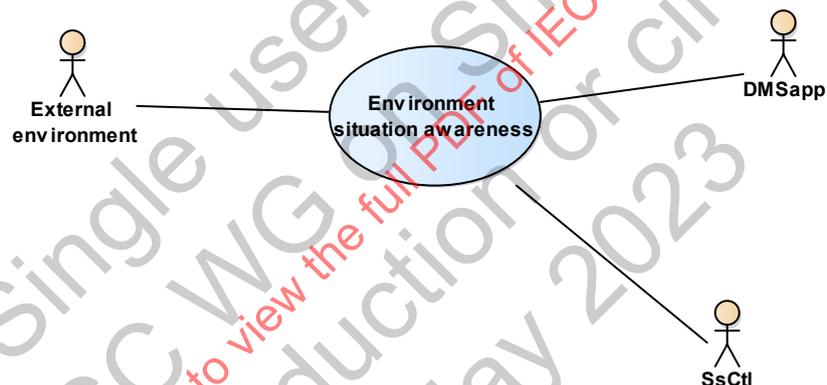


Figure 56 – Environment situation awareness – Use cases breakdown

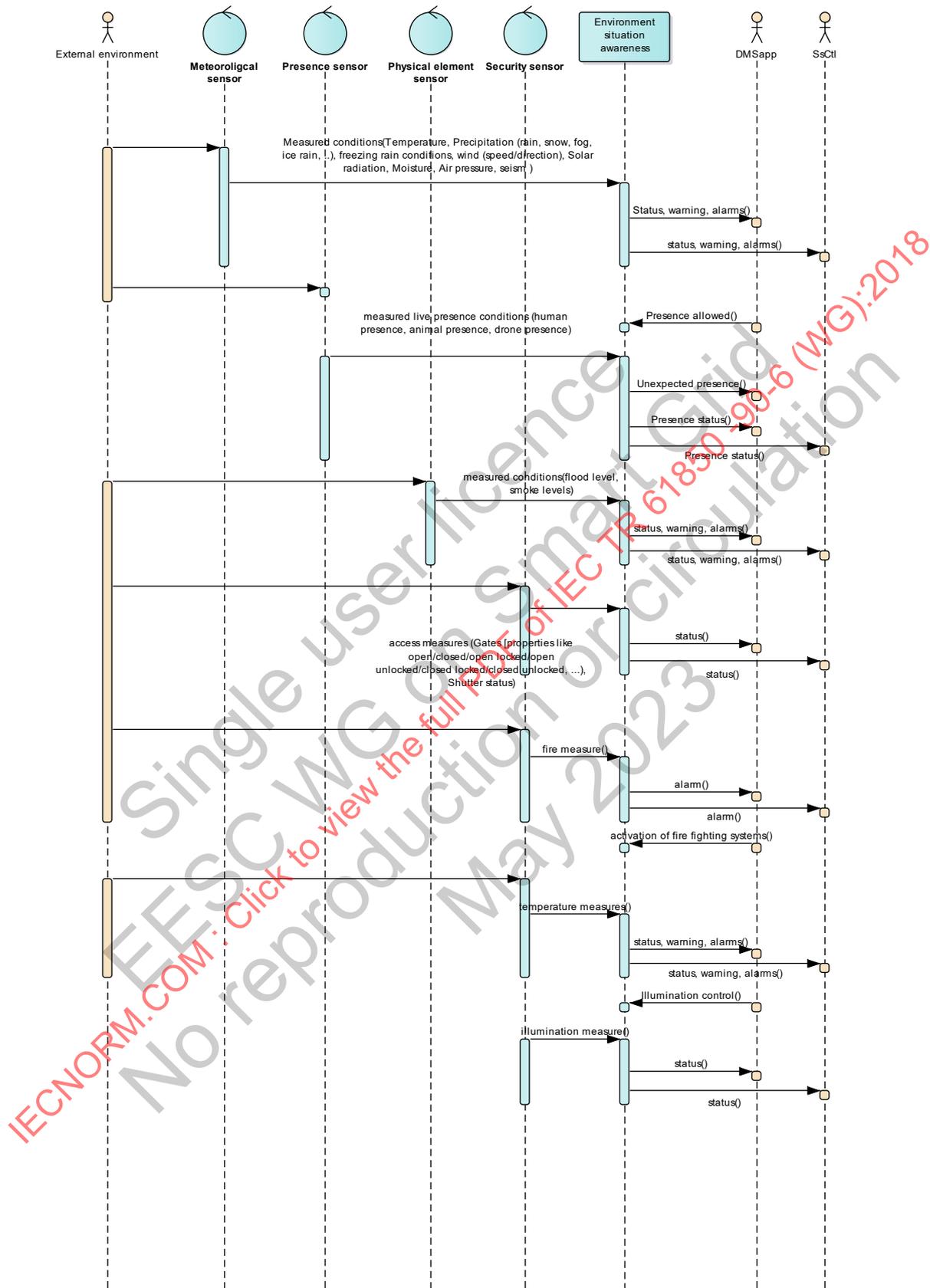


Figure 57 – Environment situation awareness – Sequence diagram

5.10.1.7 Technical details – Actors

| Actors | | | |
|------------------------------|------------------------------|-------------------------------------|---|
| Actor Name see Actor List | Actor Type see Actor List | Actor Description see Actor List | Further information specific to this Use Case |
| External environment | System | Refer to 4. | |
| DMSapp | System | Refer to 4. | |
| SsCtl | | Refer to 4 | |

5.10.1.8 Step by step analysis of use case

Step by step analysis does not really fit this case, because most of the activities presented here are continuous monitoring activities

5.10.1.9 Information exchanged

| Information exchanged | | |
|-------------------------------|---|---------------------------------------|
| Name of Information exchanged | Description of Information exchanged | Requirements to information data R-ID |
| refer to Table 15 | Status, alarm, warning: Temperature, Precipitation (rain, snow, fog, ice rain, ..), wind (speed/direction), Solar radiation, Moisture, Air pressure | |
| (to be defined) | Presence is allowed (control) | |
| (to be defined) | Status: Human presence, animal presence, unexpected object presence, drone presence | |
| refer to Table 15 | Status, alarm, warning: ice level, snow level, flood level, radiation, earthquake | |
| (to be defined) | Not allowed presence summary | |
| (to be defined) | Status, alarm, warning: Access (Gates status [open/closed/open locked/open unlocked/closed locked/closed unlocked, Fences position, ...]) | |
| (to be defined) | Status, alarm, warning: fire measure | |
| (to be defined) | Activation of fire fighting systems | |
| refer to Table 15 | Status, alarm, warning: Temperature measures | |
| (to be defined) | Illumination activation (control) | |
| (to be defined) | Status, alarm, warning: illumination measure | |

5.11 Use case 10: Configuration of IEDs participating in distributed control

5.11.1 Description of the use case

5.11.1.1 Name of use case

| Use case identification | | |
|-------------------------|-------------------------|--|
| ID | Domain(s) | Name of use case |
| | Distribution Automation | Configuration of IEDs participating in distributed control |

5.11.1.2 Version management

| Version management changes / Version | Date | Name author(s) or committee | Domain expert | Area of Expertise / Domain / Role | Title | Approval status draft, for comments, for voting, final |
|--------------------------------------|------|--|---------------|-----------------------------------|-------|--|
| V1.0 | | Zhu, Zhengyi, Xu Bingyin Han Guozheng | | | | draft |
| V2.0 | | Zhu Zhengyi Xu Bingyin | | | | |
| V3.0 | | Xu Bingyin Zhu zhengyi Laurent Guise Liu Dong | | | | |

5.11.1.3 Scope and objectives of use case

| Scope and objectives of use case | |
|----------------------------------|--|
| Related business case | Network Operation |
| Scope | Configuration of newly introduced IEDs or the updating of the configuration of existing IEDs participating in a distributed control automation such as the FLISR-Distributed control. The configuration data includes topological information. |
| Objective | Make seamless and dynamic configuration of these IEDs, helping the distributed control to adapt to topological changes |

5.11.1.4 Narrative of use case

5.11.1.4.1 Narrative of use case – Short description

By running this use case, each IED located along the feeder and participating in a distributed automation function related to this given feeder, will receive adequate information, including communication interface and topology information, possibly provided to other entities.

5.11.1.4.2 Narrative of use case – Complete description

The following steps describe how the configuration process works, assuming the architecture described in Figure 58.

Configuration of newly introduced IEDs for a feeder or feeder group

A DAS may cover up to tens of thousands equipment, and the configuration of the primary systems may change from time by time. It is not practical and unrealistic to configure the entire network as a single project. Therefore, in the current assumption, the IEDs in the system are configured based on the automation system of a radial feeder, or a group of connected feeders. The objective system (project) shall depend on the real topological connection of feeders, which may be designed as a radial feeder or a group of connected feeders for the loads in one sub-geographical area.

When a new feeder or a group of connected feeders (called a feeder group for short) is introduced, firstly a SSD (System Specification Description) file related to that line shall be created, using the SCL schemes. It includes the single line diagram of the line (i.e. the feeders and distribution substations), and the associated functions such as fault passage indicators, FLISR, protection, control, monitoring and so on.

Then a SCD (System Configuration Description) file is generated from the SSD file, the communication related parameters, and the ICD (IED Capability Description) files of the IEDs at the feeder or feeder group. According to the implemented DA functions, the functions listed in the SSD file are mapped to LNs hosted by selected IEDs.

A SSD/SCD file is seen as needed for the first establishment of the feeder or feeder group with the distributed automation function. SCD content will be de facto further updated through the services depicted below.

In case of mapping a FLISR based on distributed control, the information enables the system to identify the main "device" roles, such as:

- The "feeder switch IED"
- The "Main breaker IED"
- Information related to "adjacent IEDs"
- The "service restoration controller"
- The "Tie-switch IED"

Next, a "SCL configuration payload", e.g., CID (Configured IED Description) file for each IED will be derived from the SCD file. Besides the project specific communication parameters, LD instances, LN instances and DataTypeTemplates, the "SCL configuration payload" also contains the needed local topology information as well as the communication information of adjacent IEDs. This is because in distributed automation, the leading unit requires the topology information in order to recognize the coordinating units and their communication parameters, so that it can establish the control strategy and assign tasks to the coordinating units. For example, as discussed previously in use case 4, the Fault Locating Unit of the distributed FLISR must decipher the fault information from its local breaker and the neighboring breakers in order to determine the fault region.

In practical engineering, the IED can be configured either locally or remotely. If the IEDs are configured remotely, the IEDs are firstly configured with authentication parameters, communication parameters, and a communication link to the new IED and the remote configuration tool are established using registration and discovery mechanism. Then the "SCL configuration payload" is sent to each IED through a configuration file manager (see Figure 58).

If the IEDs are configured locally in the field, the "SCL configuration payload" is uploaded to the IED directly from the local configuration tool.

Each concerned IED (configured locally or remotely) registers as a member of the distributed feeder automation function. This application is regularly checked, in order to adapt to any configuration changes.

Configuration of a single newly introduced IED

If a new IED is introduced to a feeder some of whose equipment are already monitored by existing IEDs, a new SCD file shall be created by the system configurator according to the newly imported DA functions, dataflow to other IEDs, communication related parameters, and topological information. That is, the existing SCD file and the new individual ICD file is integrated to create a new SCD file, then the CID file specific for this new IED will be extracted and uploaded to it remotely or locally. If the new IED is introduced with an addition of primary devices, the new SSD file shall also be needed to recreate the SCD file.

Updating the configuration of existing IEDs

The configuration of an existing IED may need to be updated if the system change is influential on its configuration, such as its implemented functions and/or its communication parameters, the associated primary apparatus, or the dataflow associated with the other IEDs.

In this case, the new SCD file shall be updated using all the information that leads to the system change upon the existing SCD file. Then the updated CID files for all the influenced IEDs will be generated and uploaded to them in a local or remote way. The information that leads to the system change may be carried by IID (Instantiated IED Description) file, SED (System Exchange Description) file, SSD file, ICD file or other private type files.

According to IEC 61850-6:2009, the IID file is defined to allow the updating of IED data within a system. It describes the project specific configuration of an IED. In the case that this IED does not exist in the SCD file, it can be imported completely and instantiated as a project specific IED, without any reference to other IEDs. In the case that the IED exists already, the data model part inclusive any values can replace the appropriate parts existing in the system configurator. If the configuration of a feeder group consists of different projects for respective feeders, the SED files are optionally needed when we exchange data between system configurators of those projects. The function and handling of SED file are basically same as the rules defined in IEC 61850-6:2009.

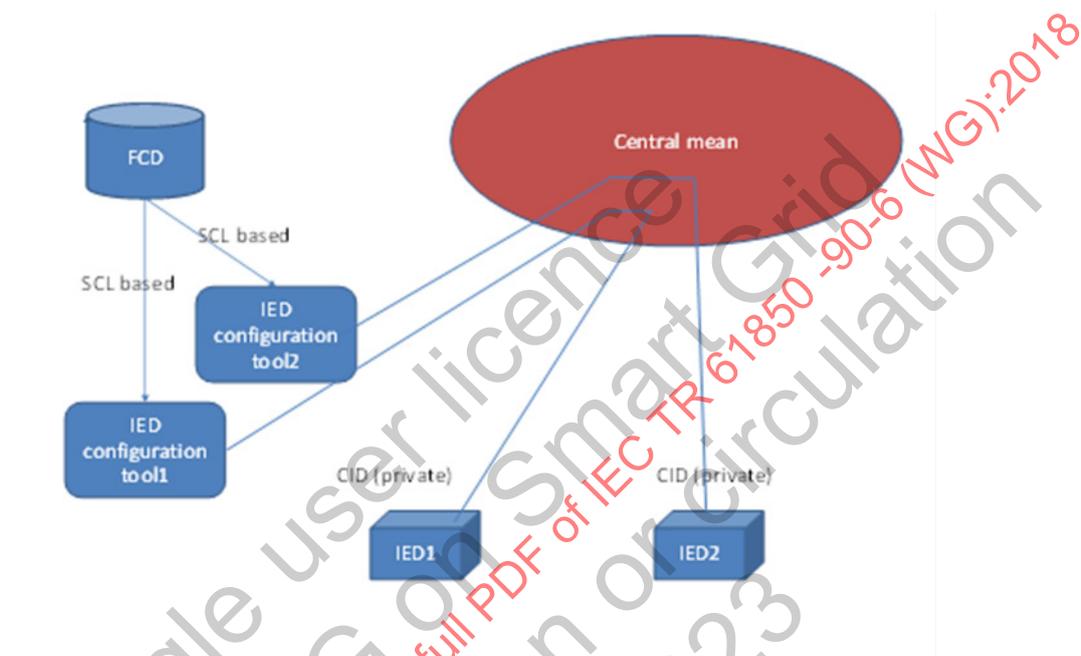


Figure 58 – The schematic diagram of remote configuration process

System managements

In order to ensure the consistency of the distributed function, means are available to suspend or resume the distributed function.

5.11.1.5 General remarks

Configuration work can be done at a remote file manager (e.g. the control center) or locally in the field by the configuration engineer.

If the configuring work is at a remote file manager, the basic communication parameters have to be configured before installation. So, the IED can connect to the communication network and establish the link to the configuration file manager.

If the primary system of a feeder or feeder group changes, the grid status and topology information (e.g. the SSD file) of the feeder shall be modified.

The IED configurator collects all the required information to process the CID file for each IED.

Generally, some manual operations bring about the changes on relevant CID file, SCD file and/or SSD file. This use case assumes the configuration engineer will be informed of the changes in time so that the configuration can be started to update manually.

5.11.1.6 Diagrams of use case

Figures 59 and 60 present the use case diagrams.

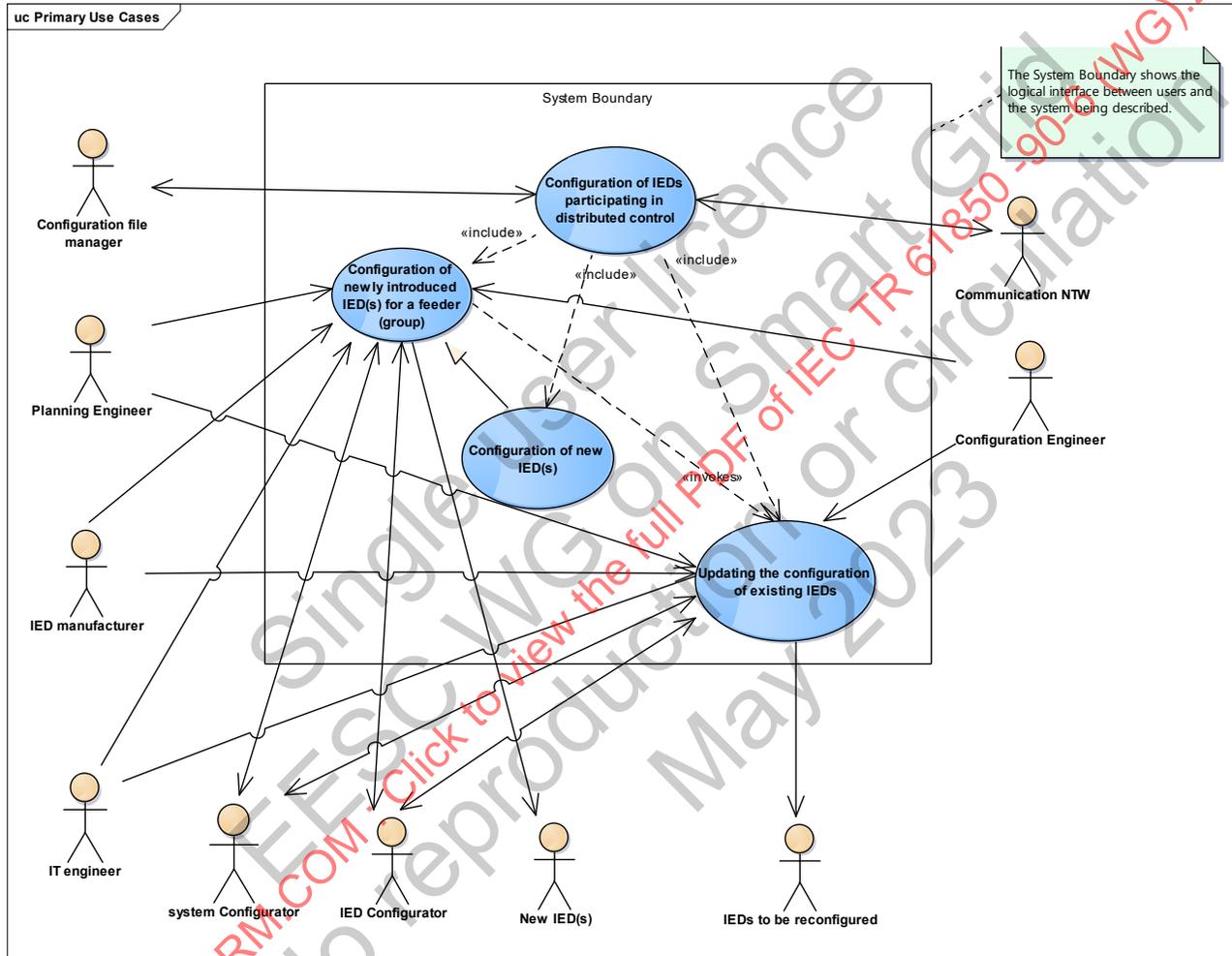


Figure 59 – Configuration of IEDs participating in distributed control – Use case diagram

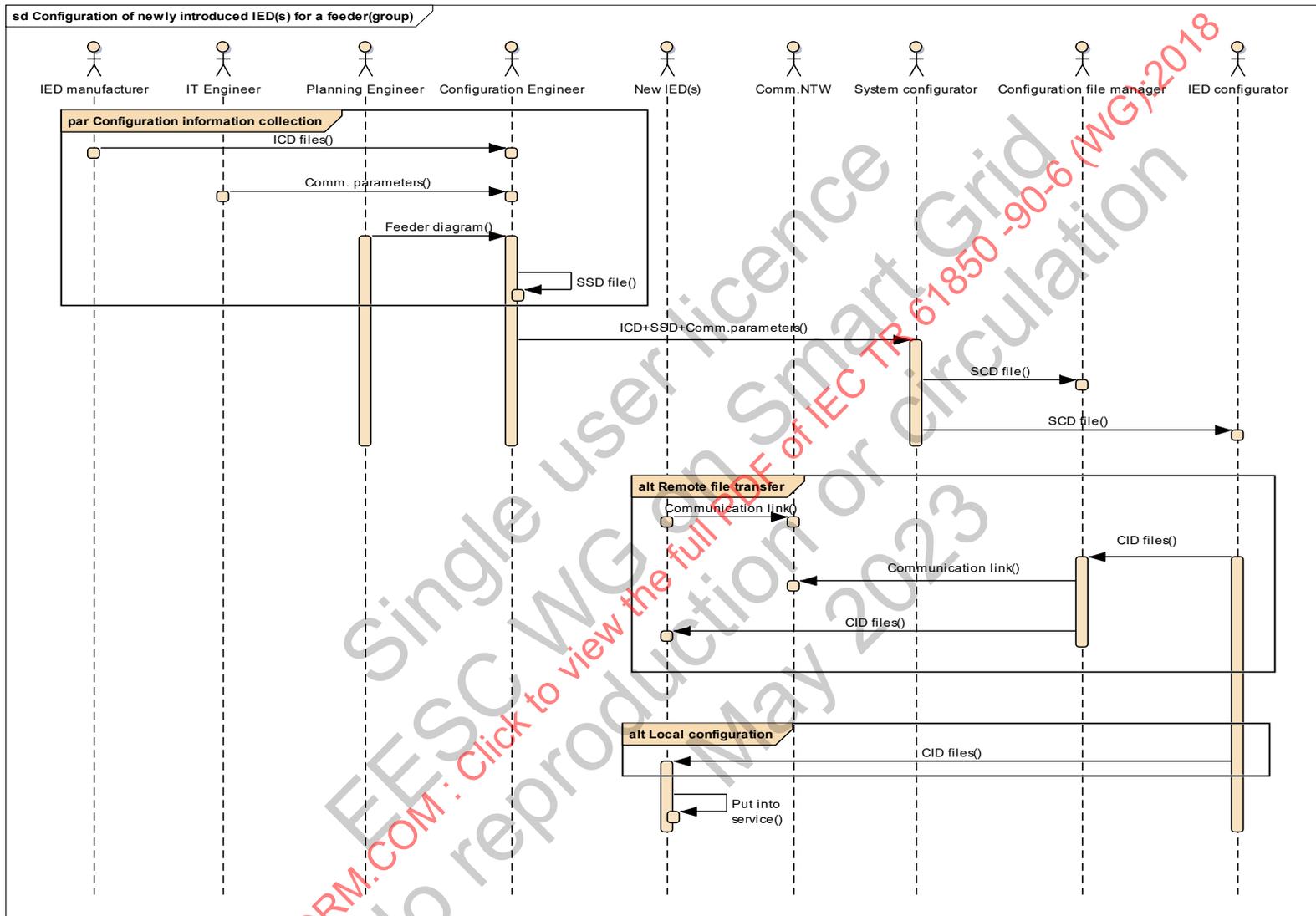


Figure 60 – Configuration of IEDs participating in distributed control – Sequence diagram (1 of 2)

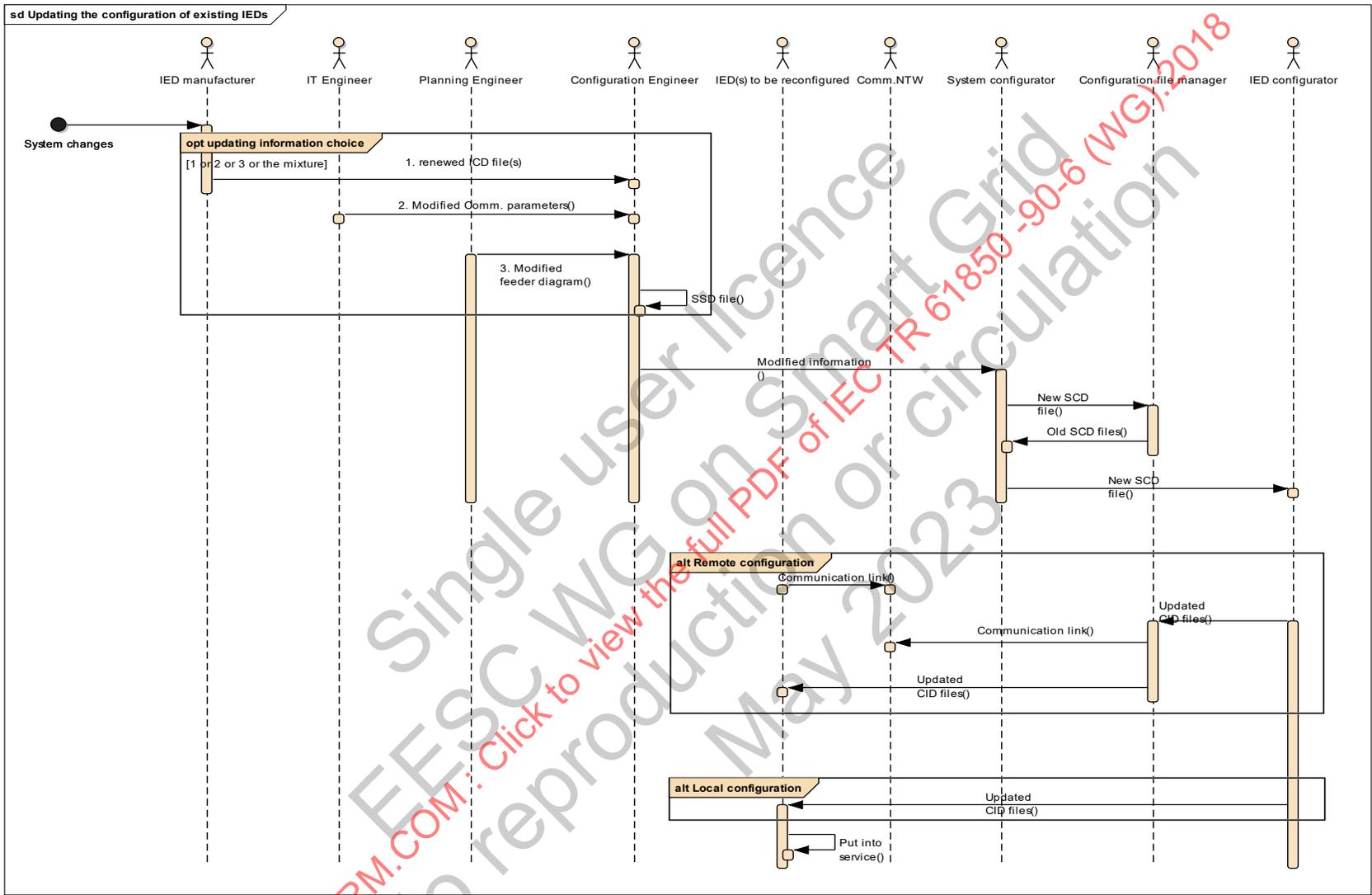


Figure 60 (2 of 2)

5.11.1.7 Technical details

5.11.1.7.1 Actors: People, systems, applications, databases, the power system, and other stakeholders

| Actors | | | |
|------------------------------|------------------------------|--|--|
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| FieldComp | System substation | IEC 61850 physical component of a selected system, i.e., the field IEDs participating in the DA system. | |
| New FieldComp | System substation | One or more new IEDs assigned to be configured in a DA project for the first time. New IEDs will mainly be associated with a feeder or a feeder group while a single new IED will be assigned to one feeder device or substation. | |
| FieldComp to be reconfigured | System substation | IEDs whose CID file has to be reconfigured because of changes on the related contents. | |
| FieldComp manufacturer | People | Manufacturer of the field IED | |
| IT Engineer | People | Personnel that manages the communication infrastructure for the DA, providing all the related parameters for the configuration of the FPI/DSU. | |
| Planning Engineer | People | Personnel that manage at the SCADA the Distribution Grid structure and therefore the connectivity diagram of the equipment in the MV feeder. | |
| FieldComp Config engineer | People | Personnel that manage the configuration of the IED at the control center (optionally on the field). | |
| FieldSyst Config tool | System operation | The FieldSyst Config tool is an IED independent system level tool that shall be able to import or export configuration files defined by this part of use case. It shall be able to import configuration files from several IEDs, as needed for system level engineering, and used by the configuration engineer to add system information shared by different IEDs. Then the system configurator shall generate a substation-related configuration file as defined by this part of use case, which is fed back to the FieldComp config tool for system-related IED configuration. The System Configurator should also be able to read a System specification file for example as a base for starting system engineering, or to compare it with an engineered system for the same substation. | |

| Actors | | | |
|------------------------------|------------------------------|---|---|
| Actor name see actor list | Actor type see actor list | Actor description see actor list | Further information specific to this use case |
| FieldComp config tool | System substation | <p>The FieldComp config tool is a central mean which has the capability to output CID file (one form of SCL configuration payload) for each IED of the feeder group with an integrated information input.</p> <p>It is a manufacturer-specific, may be even IED specific, tool that shall be able to import or export the files defined by this part of use case. The tool then provides IED-specific settings and generates IED-specific configuration files, or it downloads the IED configuration file into the IED.</p> | |
| Configuration file manager | System substation | A system for generation, storage and delivery of configuration files using dedicate or common communication networks. Remote exchange of information and files must adapt the appropriate safety and security measures to protect against cyber attack. | <p>Regarding the local communication from a configuration file manager connected locally to the IED, the data transfer is beyond the scope of this technical report.</p> <p>For the remote file transfer, for example, by the file transfer method of IEC 61850-7-2. The file format is not defined within this technical report, but SCL format is a possible choice at least of a part of the configuration data.</p> |
| Communication NTW | System | Secondary networks in the power distribution system supporting all the configuration, automation and statistical tasks of an utility | Both LAN and WAN |

5.11.1.8 Step by step analysis of use case

5.11.1.8.1 General

| Scenario conditions | | | | | |
|---------------------|---------------|---------------|------------------|---------------|----------------|
| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
| 4.1 | Normal | | | | |
| 4.2 | Alternative | | | | |

5.11.1.8.2 Steps – Normal

| Scenario | | | | | | | | |
|----------------|---|--|---|---------|-----------------------------|------------------------------|---|--|
| Scenario name: | | Configuration of new IED(s) for a feeder (group) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 1 | Introduce new IED to a feeder or feeder group | | IED's manufacturer provides an ICD file | | FieldComp manufacturer | FieldComp Config engineer | ICD file | <p>The exchange method depends on utility and/or manufacturer's polices.</p> <p>The local communication for the data transfer is beyond the scope of this technical report.</p> <p>If a remote file transfer is used, the transfer time is not critical and there are no specific limits according to IEC 61850-5.</p> <p>Typically, the time requirements are equal to or greater than 1000 ms.</p> |
| 2 | | | Configuration engineer gets the line diagram where the IED will be installed from the planning engineer | | Planning engineer | FieldComp Config engineer | Single line diagram of the feeder or feeder group | Same as the above |
| 3 | | | Configuration engineer generates the SSD file according to the diagram | | FieldComp Config engineer | | SSD file, internal activity | |
| 4 | | | Configuration engineer gets the communication parameters which will be assigned the IEDs from the IT engineer | | IT engineer | FieldComp Config engineer | communication parameters | Same as the above |

| Scenario | | | | | | | | |
|----------------|--|--|---|---------|-----------------------------|------------------------------|--|---------------------|
| Scenario name: | | Configuration of new IED(s) for a feeder (group) | | | | | | |
| Step No. | Event | Name of process/activity | Description of process/activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 5a | | | The SSD, ICD files and communication parameters are imported into the system configurator | | FieldComp Config engineer | Fieldsyst config tool | SSD,ICD files and communication parameters, and/or IID files | Same as the above |
| 5b | | | system configurator generates SCD file for the feeder or feeder group system | | Fieldsyst config tool | Configuration file manager | SCD file | Same as the above |
| 6a | | | system configurator sends SCD file to the FieldComp config tool | | Fieldsyst config tool | FieldComp config tool | SCD file | Same as the above |
| 6b | | | IED configurator generates CID files for each IED requirement | | FieldComp config tool | Configuration file manager | CID file | Same as the above |
| 7 | Configuration engineer has got the CID files | | If the IED is configured at the remote workstation, it will jump to step 8a, else if configured locally in the field, it will jump to step 9. | | FieldComp Config engineer | | Internal activity | |
| 8a | | | Configuration file manager establishes a communication link to the NTW; Configuration engineer imports the CID files into the file manager | | FieldComp config tool | Configuration file manager | CID files | Same as the above |
| 8b | | | The new IED establishes a communication link to the NTW; Configuration file manager uploads the CID files to the IED. | | Configuration file manager | New FieldComp | CID files | Same as the above |

| Scenario | | | | | | | | |
|----------------|-------|--|---|---------|-----------------------------|------------------------------|-----------------------|---------------------|
| Scenario name: | | Configuration of new IED(s) for a feeder (group) | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 9 | | | Configuration engineer uploads the CID files to new IEDs directly in the field. | | FieldComp config tool | New FieldComp | CID files | Same as the above |
| 10 | | | Configuration process is accomplished. | | | | | |

5.11.1.8.3 Steps – Alternative, error management, and/or maintenance/backup scenario

| Scenario | | | | | | | | |
|----------------|--|--|---|---------|-----------------------------|------------------------------|--|--|
| Scenario name: | | Updating the configuration for existing IEDs | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 1 | System changes are alternatively combined of primary topology, IED communication parameters and IED capability | | IED's manufacturer provides an ICD file | | FieldComp manufacturer | FieldComp Config engineer | ICD file | The exchange method depends on utility and/or manufacturers polices. If a remote file transfer is used, the transfer time is not critical and there are no specific limits according to IEC 61850-5. Typically, the time requirements are equal to or greater than 1 000 ms. |
| 2a | | | Configuration engineer gets the line diagram where the IED will be installed from the planning engineer | | Planning engineer | FieldComp Config engineer | Line diagram of the feeder or feeder group | Same as the above |

| Scenario | | | | | | | | |
|----------------|-------|--|---|---------|-----------------------------|------------------------------|--|---------------------|
| Scenario name: | | Updating the configuration for existing IEDs | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 2b | | | Configuration engineer generates the SSD file according to the diagram | | FieldComp Config engineer | | Internal activity | |
| 3 | | | Configuration engineer gets the communication parameters which will be assigned the IEDs from the IT engineer | | IT engineer | FieldComp Config engineer | Communication parameters | Same as the above |
| 4 | | | The old SCD file is got from the database of configuration file manager | | Configuration file manager | FieldComp Config engineer | Old(current) SCD file | Same as the above |
| 5a | | | The SSD, ICD files, old SCD file, and communication parameters are imported into the system configurator | | FieldComp Config engineer | Fieldsyst config tool | The SSD, ICD files, old SCD file, and communication parameters, and/or IID files | Same as the above |
| 5b | | | System configurator generates the new SCD file for the feeder or feeder group system | | Fieldsyst config tool | Configuration file manager | New SCD file | Same as the above |
| 6a | | | System configurator sends new SCD file to the FieldComp config tool | | Fieldsyst config tool | FieldComp config tool | New SCD file | Same as the above |
| 6b | | | IED configurator generates new CID files for IEDs to be configured | | FieldComp Config tool | Configuration file manager | New CID file | Same as the above |

| Scenario | | | | | | | | |
|----------------|--|--|---|---------|-----------------------------|------------------------------|-----------------------|---------------------|
| Scenario name: | | Updating the configuration for existing IEDs | | | | | | |
| Step No. | Event | Name of process/ activity | Description of process/ activity | Service | Information Producer(Actor) | Information Receiver (Actor) | Information exchanged | Requirements , R-ID |
| 7 | Configuration engineer has got the CID files | | If the IED is configured at the remote workstation, it will jump to step 8a, else if configured locally in the field, it will jump to step 9. | | FieldComp Config engineer | FieldComp Config engineer | | |
| 8a | | | Configuration file manager establishes a communication link to the NTW; Configuration engineer imports the new CID files into the file manager | | FieldComp config tool | Configuration file manager | New CID file | Same as the above |
| 8b | | | The reconfiguration needed IEDs establishes a communication link to the NTW; Configuration file manager uploads the new CID files to the reconfiguration needed IEDs. | | Configuration file manager | | New CID file | Same as the above |
| 9 | | | Configuration engineer uploads the new CID files to reconfiguration needed IEDs directly in the field. | | FieldComp config tool | FieldComp to be reconfigured | New CID file | Same as the above |
| 10 | | | Configuration updating process is accomplished. | | | | | |

5.11.1.8.4 Information exchanged

| Information exchanged | | |
|-------------------------------|---|--|
| Name of information exchanged | Description of information exchanged | Requirements to information data R-ID |
| ICD file | It describes the basic data models and communication services to support. | |
| SSD file | It describes the topological information of the feeder and the related LNs of DA functionalities. It is created according to the feeder diagram provided by the planning department. | |
| CID file | It includes the instantiated data models and configuration of topological and communicational parameters. | |
| SCD file | It contains the connectivity information of the primary equipment it monitors, the IDs and communication addresses of its adjacent IEDs, the adjacent switches monitored by neighboring IEDs and the connectivity information between local equipment terminals and the adjacent monitored switches. | |
| New CID file | The CID file that has been reconfigured to correctly describe the modified information (functional, topological and communicational) which is relevant to the affected IED. | |
| IID file | It describes the project specific configuration of an IED. In the case that this IED does not exist in the SCD file, it can be imported completely and instantiated as a project specific IED, without any references to other IEDs. In the case that the IED exists already, the data model part inclusive any values can replace the appropriate parts existing in the system configurator. | |

IECNORM.COM : Click to view the PDF of IEC TR 61850-90-6 (WG1/2018)
 No reproduction or circulation
 May 2023

6 Information models

6.1 Mapping of requirements on LNs

6.1.1 Mapping of the requirements of Fault Identification and report

6.1.1.1 Modelling remarks

This section is intended to describe the proposed modelling of fault detector and voltage presence functions for the purposes of FLISR requirements as described in use case 1.

It proposes a number of additional logical nodes and data objects.

Fault passage indication shares some common characteristics with fault detection for protection. In the case of protection systems, the aim is to produce an operate signal that will trip a circuit breaker. By definition any operate and trip signals are transient as they will be reset when the fault is cleared.

In the case of fault passage indication systems, the basic aim is to provide persistent indication of the presence or absence of a fault. In addition, there are supervisory functions to determine whether the fault is transient or permanent and to count the number of different fault types.

6.1.1.2 Mapping of required LN on LN classes

Table 5 shows how LNs could be arranged to support the considered use case.

Table 5 – Mapping of Fault Identification and report use case 1 requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|---|--|
| Time over-current detection May be phase current or earth current. May be directional | PTOC -> Time over-current "Protection" Or any P-type LN Provides transient signals of fault start with operation (confirmation) after a time delay Note: even if P node have been designed for protecting equipment, most of this nodes are currently only providing a fault signature detection, which is exactly what is expected here. |
| (per phase) Voltage under or over a threshold, within a given timing | PTUV, PTOV Provides (per phase) status (start) and transient signals needed to elaborate voltage presence and absence status. |
| (per phase) Current below or over a threshold, , within a given timing | PTUC, PTOC Provides (per phase) status (start) and transient signals needed to elaborate current presence and absence status |
| Fault indication e.g. phase fault or earth fault Computation of fault passage indication based on fault signature detection (P LN series) and SVPI and/or SCPI. Elaborate as well its type (transient, semi-permanent, permanent etc.) | SFPI New. In some ways, similar to PTRC, with two main differences -> Semantic differences -> expected to provide an indication of fault and not a Trip Logic -> sort the faults per types |

| Requirement | IEC 61850 LN mapping |
|--|--|
| <p>SVPI -> Voltage presence indicator function which produces a persistent “presence” signal and an “absence” signal based on inputs from PTOV, PTUV</p> <p>In general, Absence is set by PTUV.Op and is reset when PTUV.Str resets</p> <p>Presence is set by PTOV.Op and is reset when PTOV.Str resets</p> <p>It can be a stand-alone function, but may also be used (as depicted in the use cases above) for feeding the SFPI LN, by providing evidence that a detected fault was cleared and/or that supply has been restored.</p> <p>A SVPI logical node can also be used to provide the same common outputs to feed an automatic transfer between different sources.</p> | <p>SVPI</p> <p>New. Especially elaborate the presence and absence signals, from each of the 3 phases indications</p> <p>Presence and absence are not always opposed – there are some situations where none of the indicators could be true, depending on the choices of the thresholds.</p> |
| <p>SCPI -> Current presence indicator function which produces a persistent “presence” signal and an “absence signal” based on inputs from PTOC, PTUC</p> <p>This logical node is analogous to the SVPI for voltage presence, except that its inputs are based on PTOC and PTUC logical nodes configured for current detection.</p> | <p>SCPI</p> <p>New</p> <p>Presence and absence are not always opposed – there are some situations where none of the indicators could be true, depending on the choices of the thresholds.</p> <p>In addition SCPI presence will indicate per phase the direction of the power flow, based on the forward/backward convention (as for protection)</p> |
| <p>SFST -> Computation statistics on fault presence for a given period.</p> | <p>SFST</p> <p>New</p> <p>Can benefit from the statistical model of IEC 61850 in order to provide nested statistics (average, max, min, max avg, min avg, max max, min min etc.)</p> |
| <p>Hosting a setting which will wire logically the Phase Current transformer to the right phase (avoiding rewiring the cubicle to get this match, and then saving time of the Field Operation Personnel</p> | <p>TCTR needs to be extended in order to support the logical association between the connected wire and the associated Phase/Neutral</p> |

6.1.1.3 Possible arrangement of LNs to support fault passage indication

The schema shown in Figure 61 is assumed to meet the here-below requirements:

- produce fault detection for Phase-to-Phase and for Phase-to-Earth types of faults
- produce statistics for each phase-to-phase and each phase-to-earth types of faults, as well as aggregated statistic for all phase-to-phase and all phase-to-earth types of faults

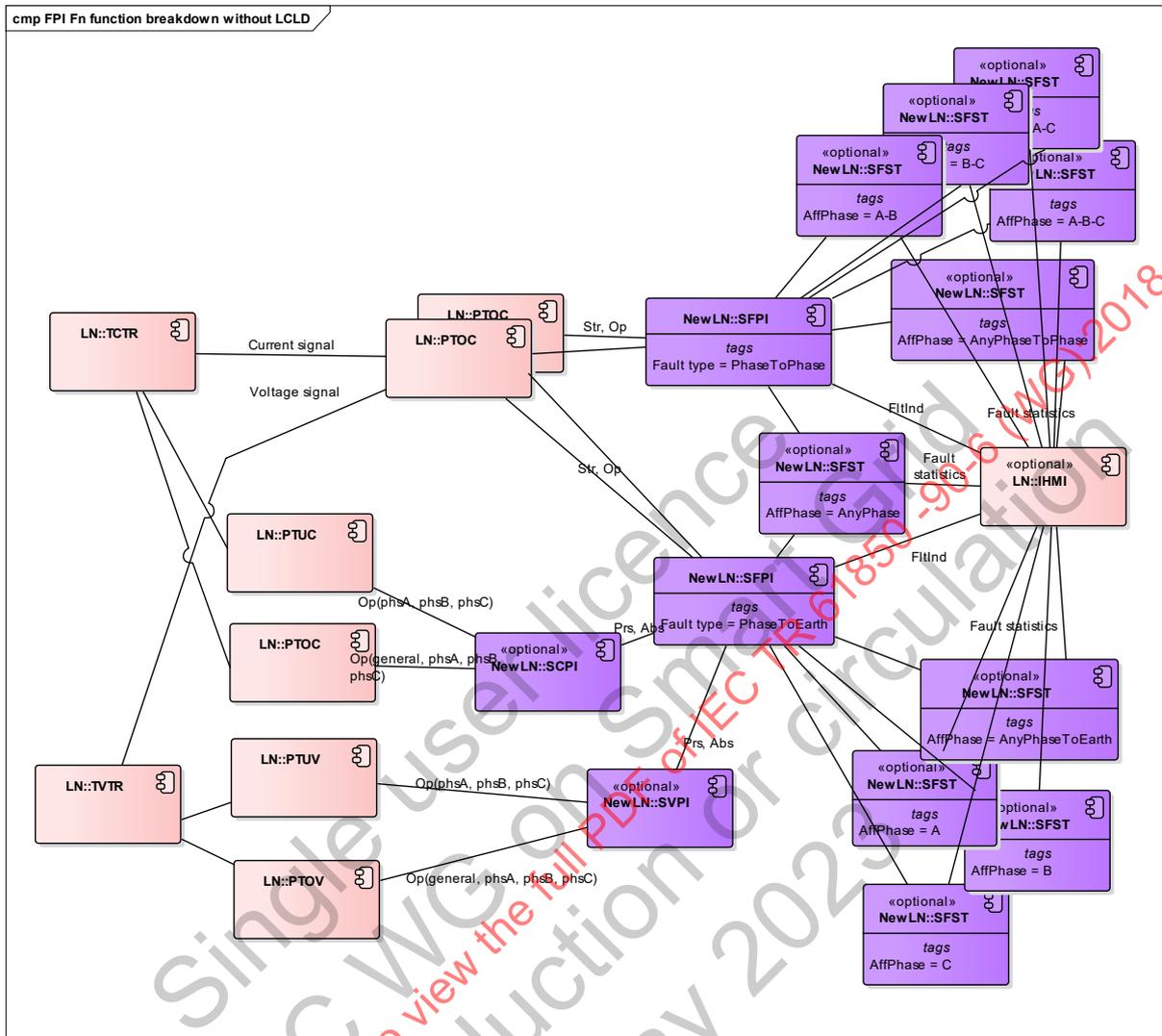


Figure 61 – Possible arrangement of LNs to support fault passage indication

6.1.2 Mapping of the requirements of FLISR based on local control – Type 2

6.1.2.1 Modelling principles of FLISR using sectionalizers detecting fault current – Type 2a

6.1.2.1.1 General

The model is built with voltage and current instrument Logical Nodes providing measurement samples to instances of overcurrent and undervoltage LNs. Fault passage indicator data is used to count the number of overcurrent events observed by an IED. Automated switching LN ASWI executes the logic to operate a sectionalizer according to basic principles outlined in 5.3.2.1. For sectionalizers operating in tie mode, automatic transfer between two sources LN AATS takes input from the fault passage indicator LN SFPI and voltage presence indicator LN SVPI in order to determine the conditions suitable for closing the tie sectionalizer. Once the conditions are satisfied, tie sectionalizer is closed. The specific role of an IED, i.e. mid-point sectionalizer or tie-point sectionalizer, is defined by enabling or disabling corresponding logical nodes. For example, if the function is applied to a sectionalizer, the AATS LN can be de-activated.

6.1.2.1.2 Possible arrangement of LNs to FLISR with AR

Figure 62 shows how LNs could be arranged to support the considered use case. The figure uses the example of an XCBR but XSWI may also be used.

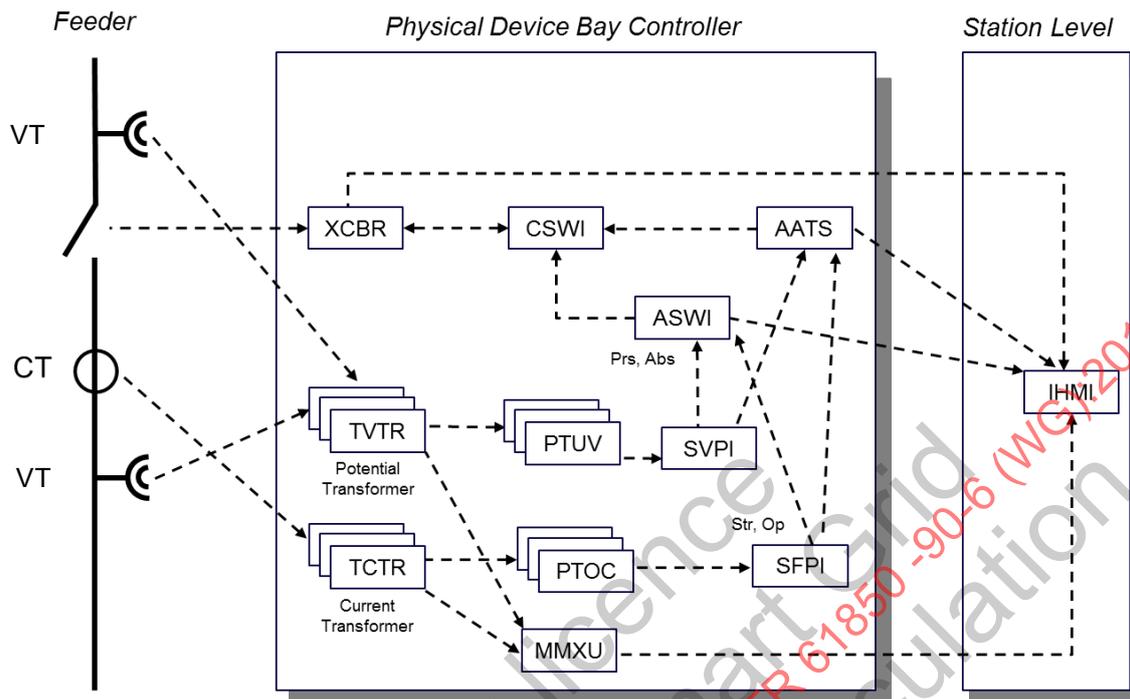


Figure 62 – Typical Arrangement of LNs to support FLISR using sectionalizers detecting fault current

6.1.2.1.3 Mapping of required LN and LN classes

Table 6 shows how LNs could be arranged to support the considered use case.

Table 6 – Mapping of FLISR using sectionalizers detecting fault current use case 2a requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|---|---|
| A field sectionalizer, detector, and autorecloser shall detect a fault on a feeder based on either over current or under voltage. | Automatic switching LN ASWI can implement logic to operate a switch CSWI based on the information received from SFPI and SVPI |
| A sectionalizer operating as tie shall detect loss of voltage on one side and close. | AATS Logical Node can be used to detect loss off voltage on Source 1 or Source 2 sides and control CSWI switch. |
| A Field autorecloser shall trip and reclose the circuit breaker it connects. | PTRC and RREC can be used. |
| A field sectionalizer and detector shall measure load before a fault occurs. | MMXU can be used. |

6.1.2.2 Modelling principles of FLISR using sectionalizers detecting feeder voltage (SDFV) – Type 2b

6.1.2.2.1 General

The most important thing for modelling of FLISR using SDFV is how to represent control and monitored items specific to it. The items are especially shown the settings and supervisory use case described in 5.3.2. In addition, the functions for this FLISR in FeCtl shall work independently from other functions. Therefore, these items and functions should be consolidated into one or small number of logical nodes.

6.1.2.2.2 Possible arrangement of LNs to FLISR using SDFV

Figure 63 and Figure 64 show how LNs could be arranged to support the considered use case: These figures use the example of an XSWI but XCBR may also be used.

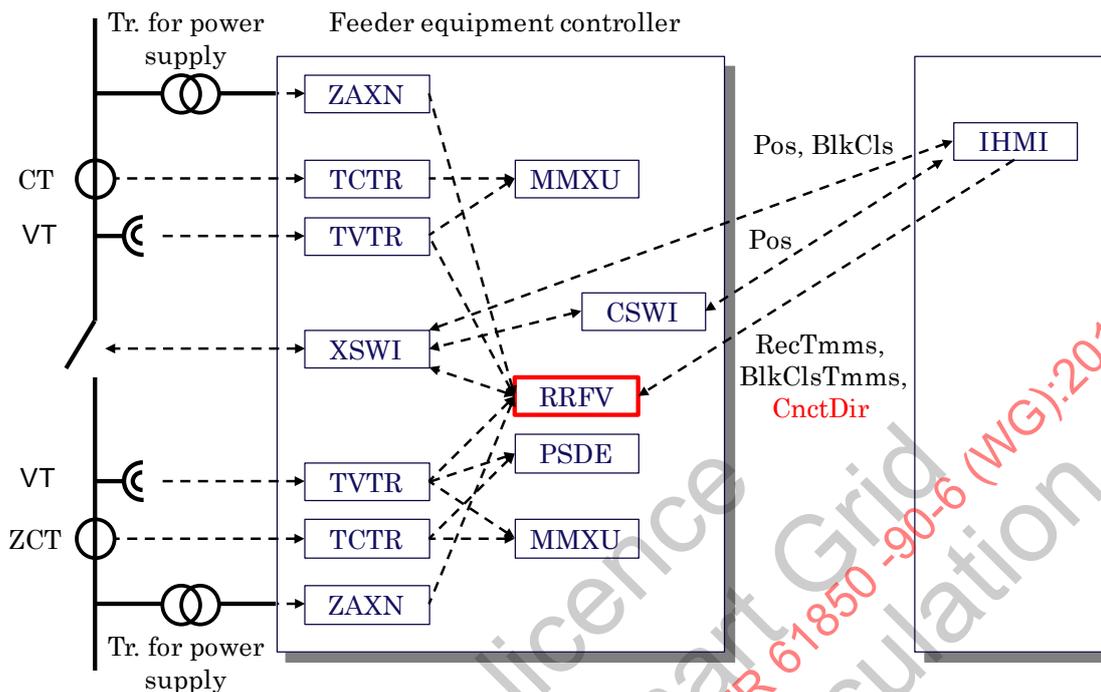
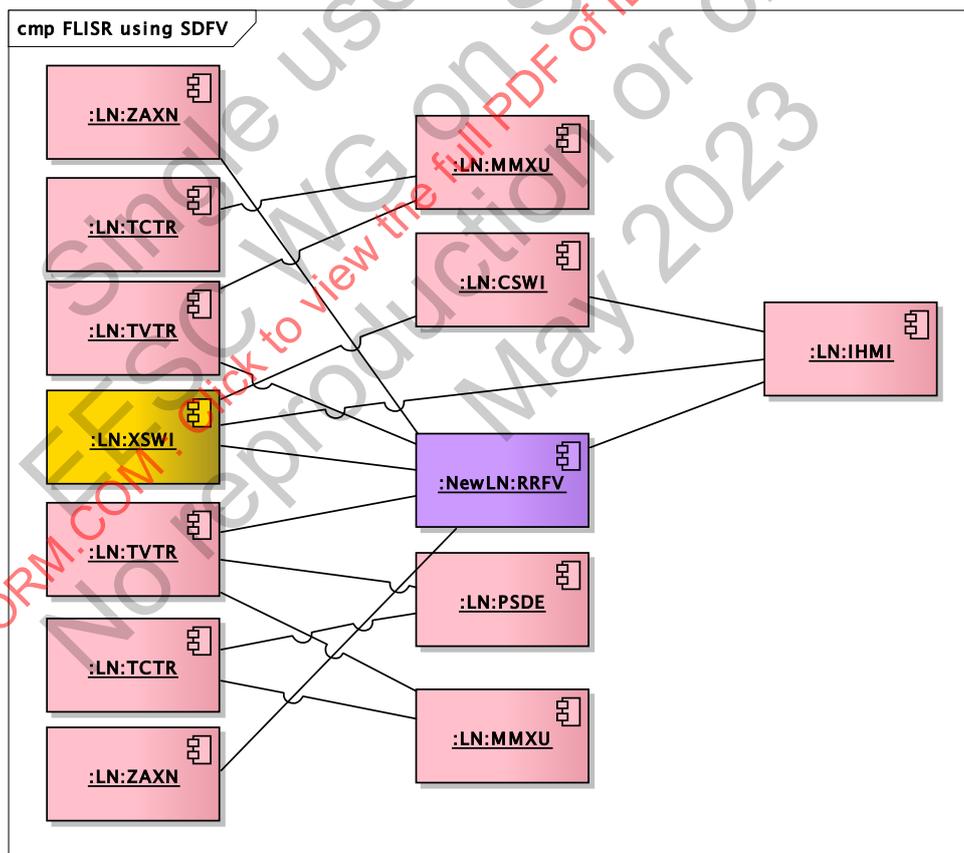


Figure 63 – Typical Arrangement of LNs to support FLISR using SDFV



NOTE The logic for determining the open/close of the sectionalizer is contained in the new logical node named RRFV, and it is outside the scope of this document. RRFV receives data about feeder voltage from either TVTR or ZAXN.

Figure 64 – Logical arrangement of LNs to support FLISR using SDFV

6.1.2.2.3 Mapping of required LN and LN classes

Table 7 shows how LNs could be arranged to support the considered use case.

Table 7 – Mapping of FLISR using SDFV use case 2b requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|---|---|
| FLISR using SDFV opens the sectionalizer when no voltage is detected on the both side of the sectionalizer. It closes the sectionalizer at the expiration of reclose-delay-time after voltage is detected on substation side. It blocks closing of the sectionalizer if no voltage is detected within block-closing-time. | RRFV New. The function requirement is a combination of automatic switching and reclosing. The automatic switching is specific to the FLISR using SDFV so CSWI providing a generic switching control cannot realize this switching. In addition, the behavior of RREC is generic and does not have some parameters for the FLISR using SDFV so a new LN should be assigned to meet the requirement. This function can be regarded as a kind of protection related function, so this new LN should have its name starting with "R". The following letters "RFV" come from "Reclosing by Feeder Voltage". |
| It configures reclose-delay-time and block-closing-time It switches over selector devices such as one for relay mode. | RRFV New. According the reason mentioned above, RRFV should be assigned to meet the requirement. |
| A FeCtl provides fault data. | PSDE (relay operation) TCTR, TVTR (instantaneous values) |
| FLISR using SDFV configures the connection direction of sectionalizer | RRFV New. The connection direction of sectionalizer is used for the FLISR using SDFV and XSWI does not have a corresponding data object. Therefore, RRFV provides a data object for controlling the connection direction because it is designated for the FLISR using SDFV. |
| A FeCtl Indicates block closing status of the sectionalizer. | RRFV New. The block closing status of the sectionalizer is set by the function of FLISR using SDFV in FeCtl. It is different from BlkCls function in XSWI. |
| Momentary charge on the fault section. | RRFV New. The momentary charge is not general for other controls, so CSWI does not provide it but RRFV does. |

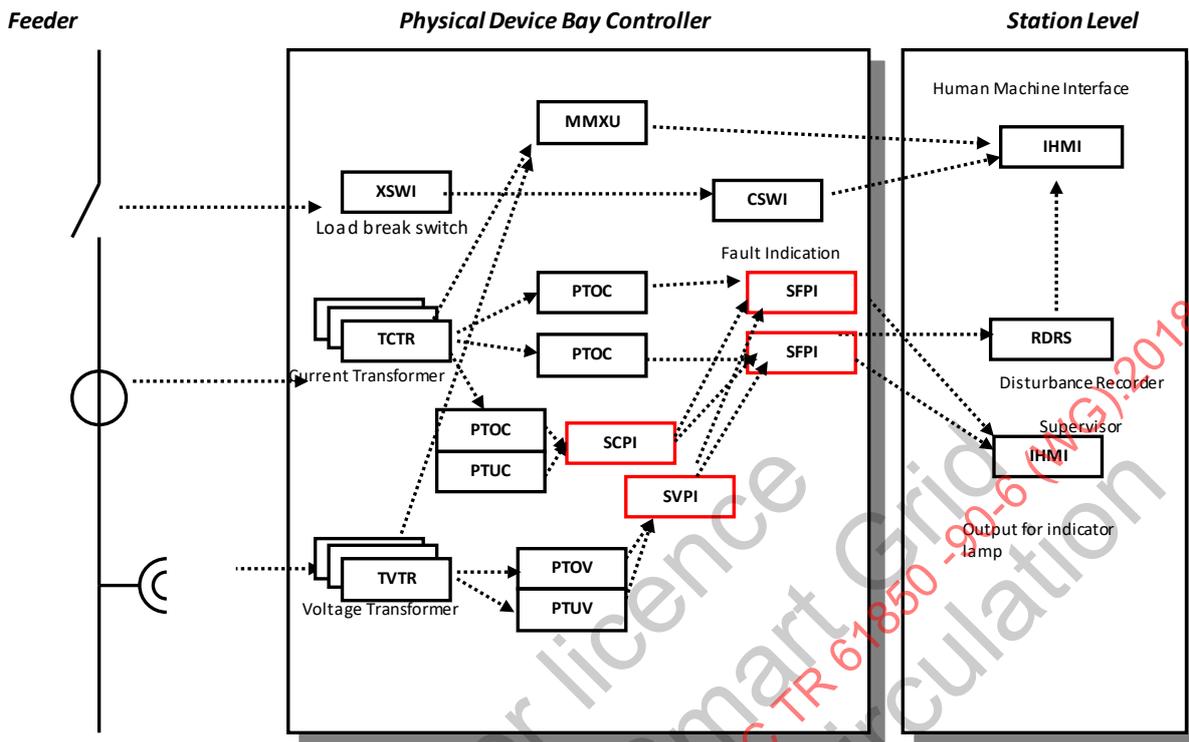
6.1.3 Mapping of the requirements of FLISR based on centralized control – Type 3

6.1.3.1 Mapping of required LN on LN classes

This mapping mostly relies on the mapping of the fault passage indicators related use cases as described in 6.1.1. The upper level of function (the centralized functions) is not the primary objective of mapping because this "client side" is very commonly a SCADA DMS, mapped over the CIM.

6.1.3.2 Possible arrangement of LNs to FLISR based on centralized control

Refer to Figure 65.



NOTE The logic for determining the on/off pattern for an indicator lamp is vendor specific, i.e. outside the scope of this standardisation proposal.

Figure 65 – Typical Arrangement of LNs to FLISR based on centralized control

6.1.4 Mapping of the requirements of FLISR based on distributed control – Type 4

6.1.4.1 Mapping for distributed FLISR – Type 4a

6.1.4.1.1 Mapping for fault location

6.1.4.1.1.1 Mapping of required LN on LN classes

Table 8 shows how LNs could be arranged to support the considered use case.

Table 8 – Mapping of Distributed FLISR (fault location) use case 4a onto LNs

| Requirement | IEC 61850 LN mapping |
|--|---|
| Fault indication | Refer to 6.1.1 |
| Indication of the faulty section location. The fault location indication indicates the immediate faulty section plus the fault direction. | AFSL A new LN is needed to host the computation for identifying a faulty section |

6.1.4.1.1.2 Possible LN arrangement to support distributed fault location

Figure 66 and Figure 67 show how LNs could be used and arranged to map the considered set of use cases.

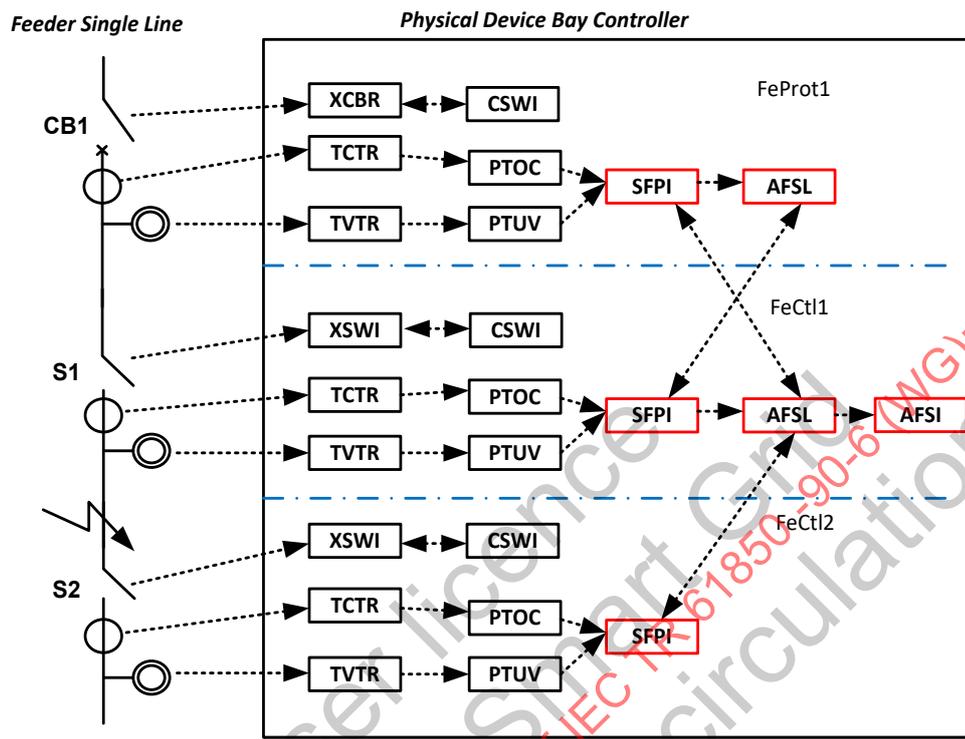


Figure 66 – Typical arrangement of LNs to support distributed fault location (case 4a)

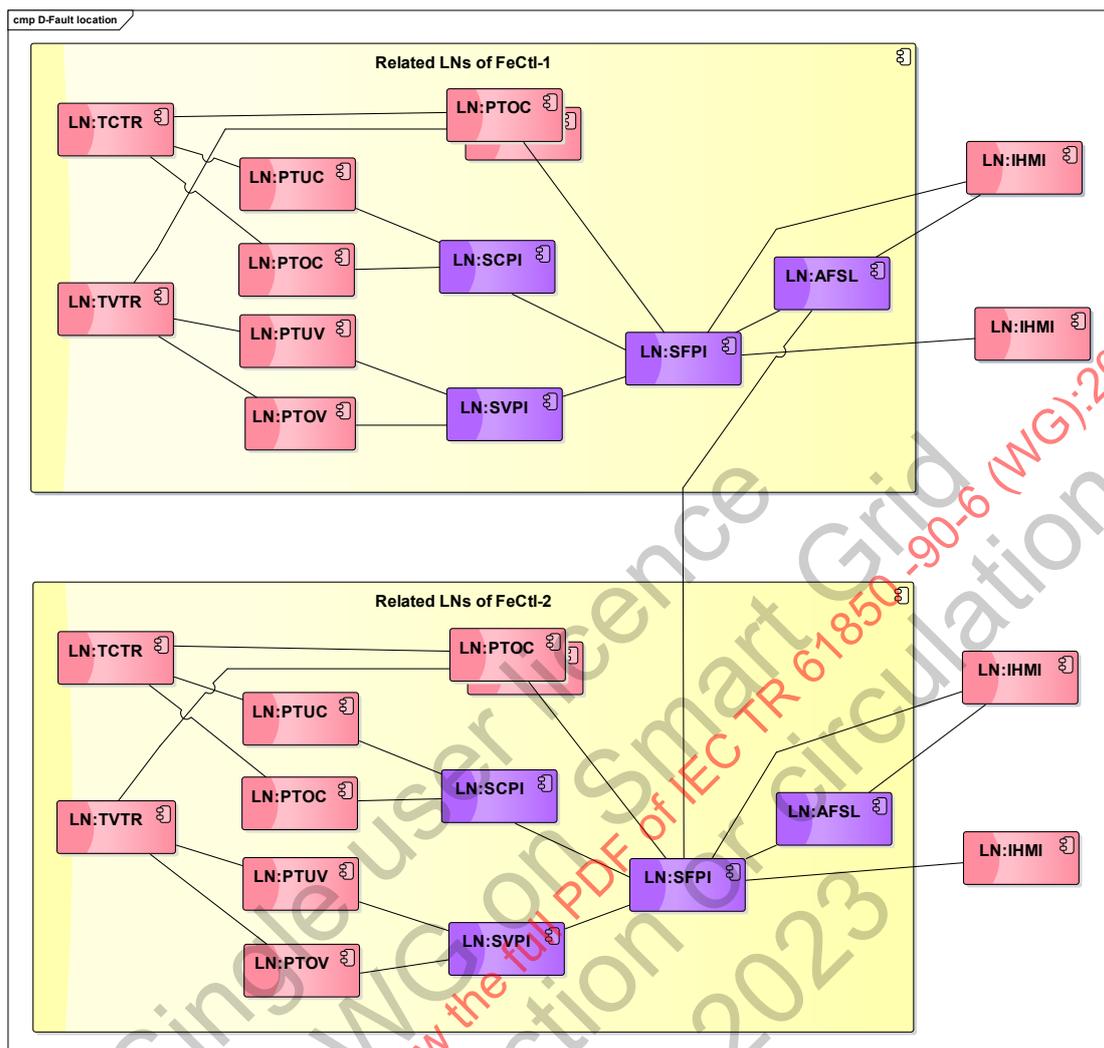


Figure 67 – Typical arrangement of LNs (between FeCtl) to support distributed fault location (case 4a)

6.1.4.1.2 Mapping for fault isolation

6.1.4.1.2.1 Mapping of required LN on LN classes

Table 9 shows how LNs could be arranged to support the considered use case.

Table 9 – Mapping of Distributed FLISR (fault isolation) use case 4a onto LNs

| Requirement | IEC 61850 LN mapping |
|--|--|
| Substation circuit breaker and sectionalizing switch control | CSWI, XCBR, XSWI |
| Indication of the completion of faulty isolation. A signal to notify the substation FeProt and SRC to start service restoration | AFSI A new LN is needed to host the computation for isolating a faulty section Fault restoration will be introduced in 6.1.4.1.3 |

6.1.4.1.2.2 Possible LN arrangement to support distributed fault isolation

Figure 68 and Figure 69 show how LNs could be used and arranged to map the considered set of use cases.

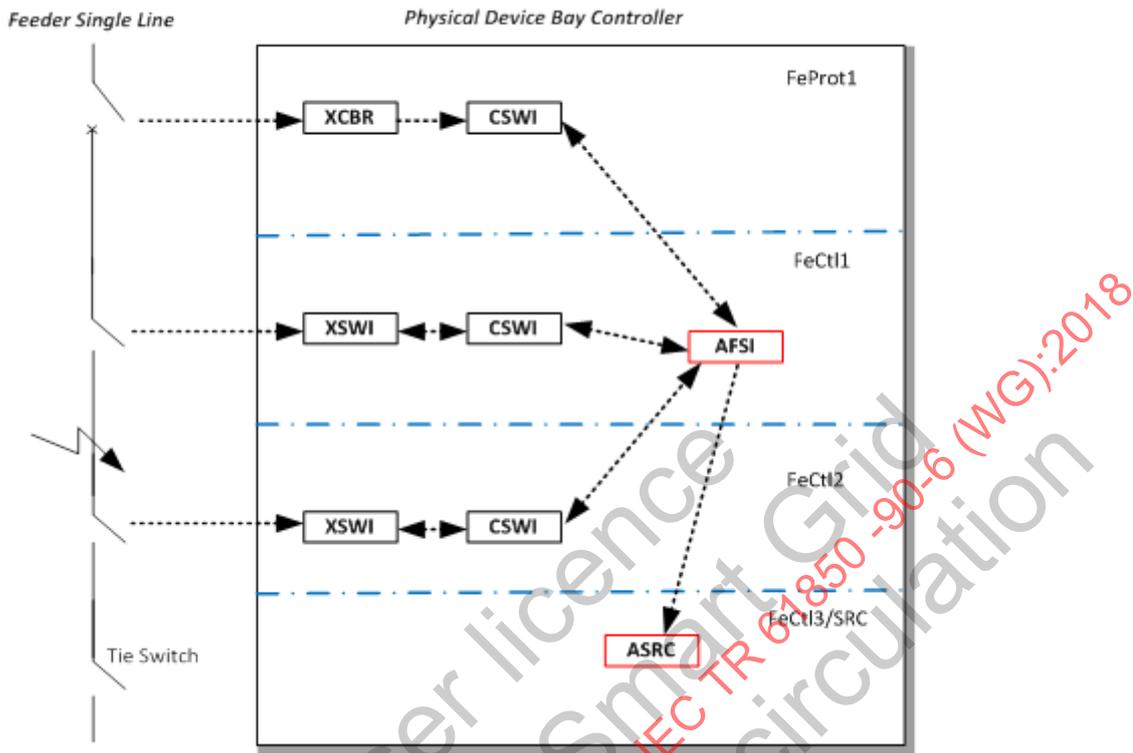


Figure 68 – Typical arrangement of LNs to support distributed fault isolation (case 4a)

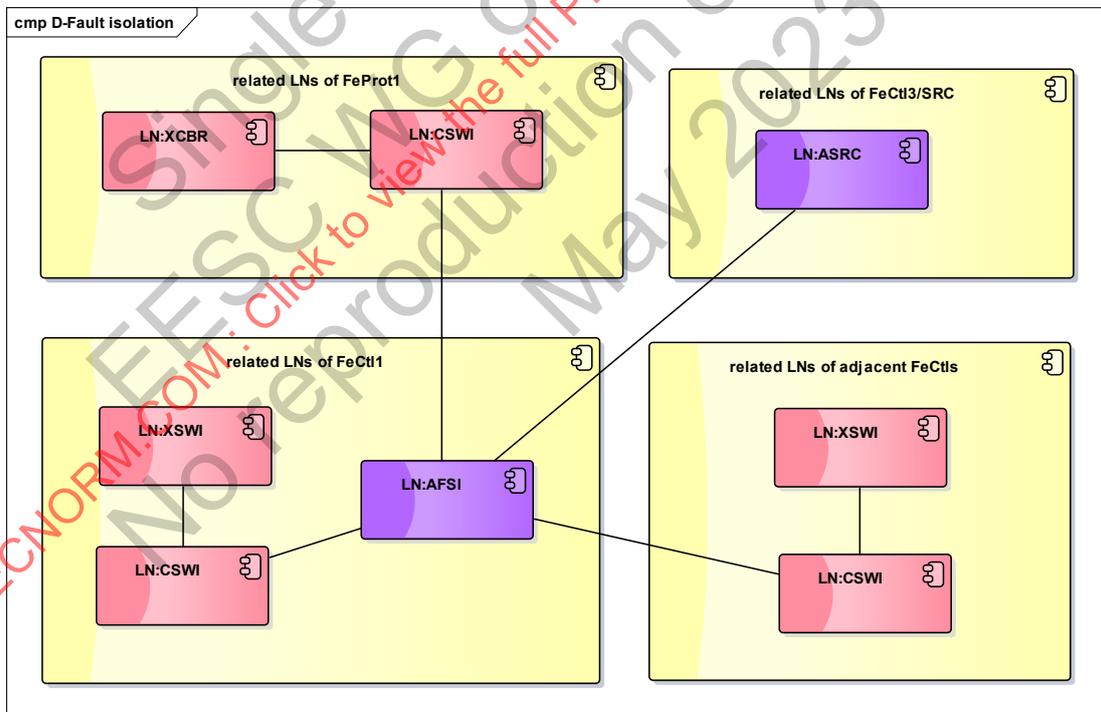


Figure 69 – Typical arrangement of LNs (between FeCtl) to support distributed fault isolation (case 4a)

6.1.4.1.3 Mapping for distributed service restoration

6.1.4.1.3.1 Mapping of required LN on LN classes

Table 10 shows how LNs could be arranged to support the considered use case.

Table 10 – Mapping of Distributed FLISR (service restoration) use case 4a onto LNs

| Requirement | IEC 61850 LN mapping |
|---|--|
| Substation circuit breaker, tie switch and sectionalizing switch control | CSWI,XCBR,XSWI |
| Load current measurement of backup source feeder SRC also needs to get load current of backup source feeder (the remote end feeder) to evaluate its capacity margin available for service restoration of the downstream sections to the fault. | TCTR,MMXU |
| The control of service restoration process | ASRC A new LN is needed to host the computation for service restoration |

6.1.4.1.3.2 Possible LN arrangement to support distributed service restoration

Figure 70 and Figure 71 show how LNs could be used and arranged to map the considered set of use cases.

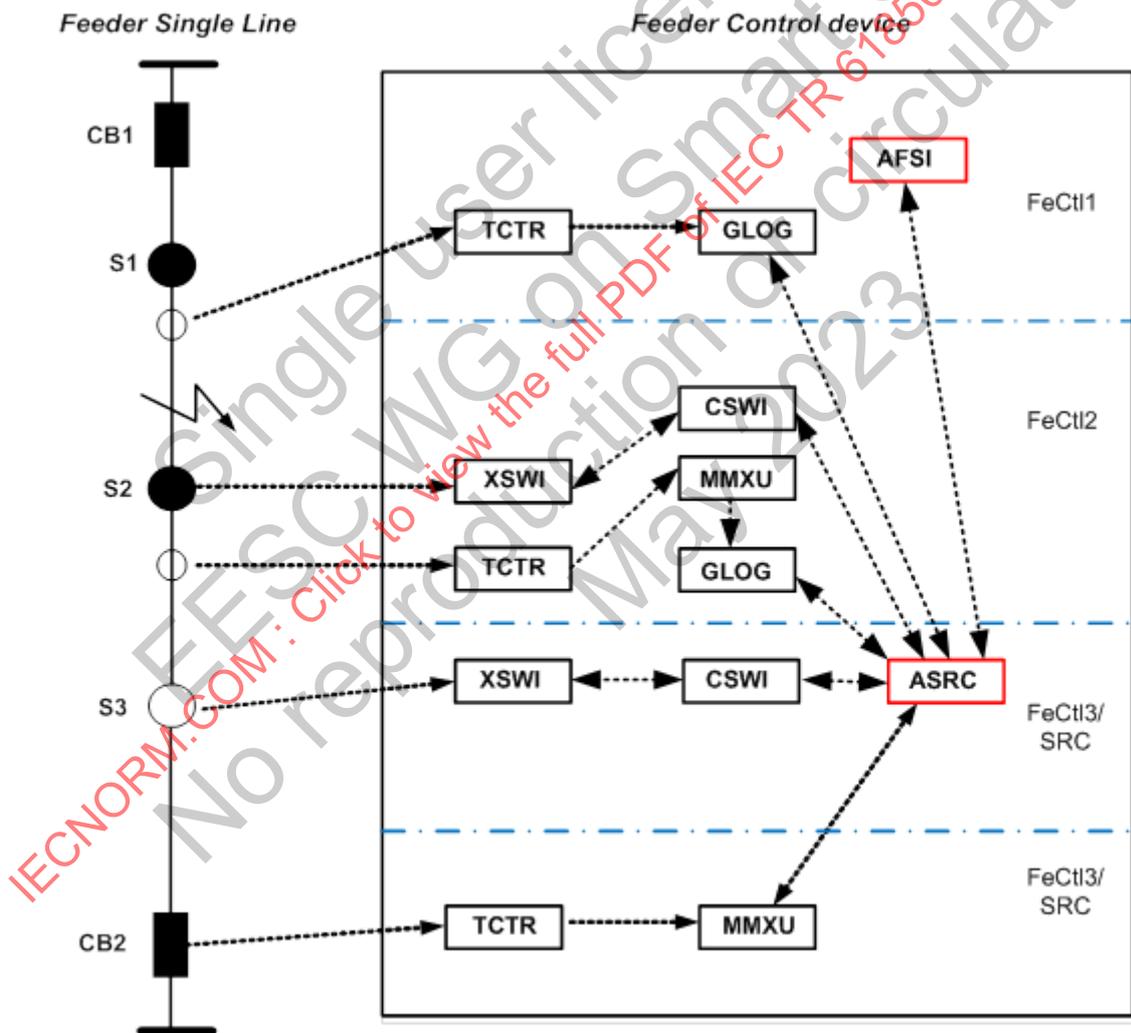


Figure 70 – Possible arrangement to support distributed service restoration

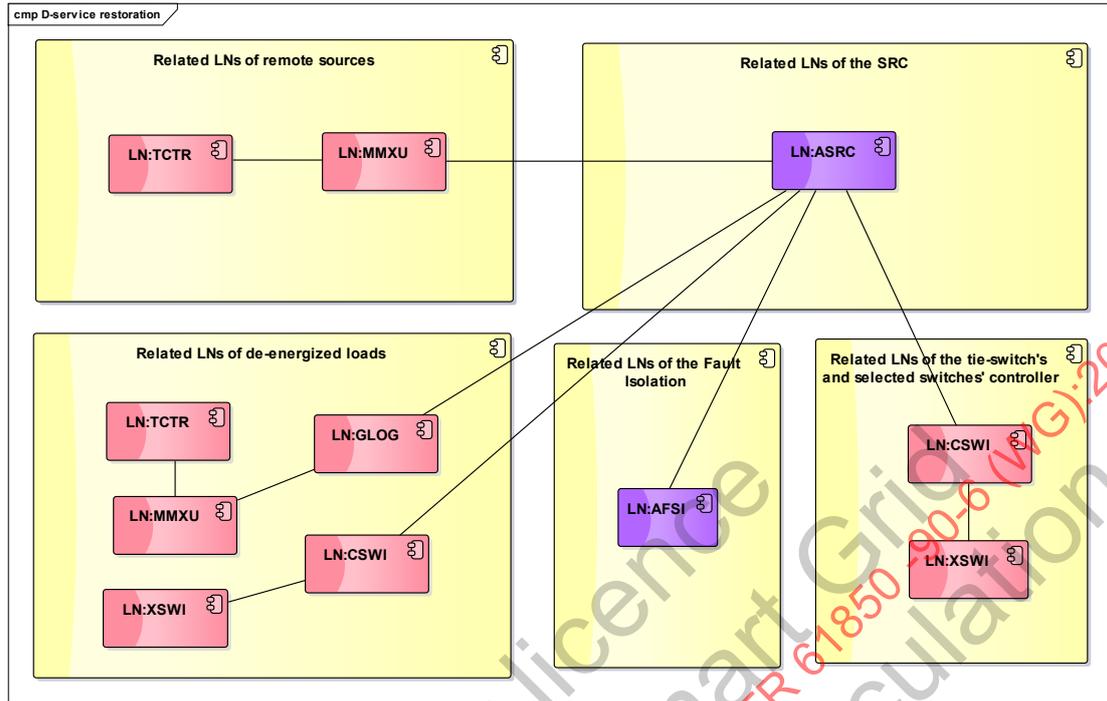


Figure 71 – Break down of LNs and relationships to support distributed service restoration

6.1.4.2 Mapping for distributed FLISR – Type4b

6.1.4.2.1 Mapping on LN (existing or new)

| | | |
|---|--|--|
| IED Topological Information (for configuration) | Topological Addressing (Structured information) of IEDs involved in DA on the Feeder; dynamical definition of the relationship with neighbor IEDs (up/down-stream) | New DO in new LN |
| Remote Disconnection | Anti-Islanding of a MV feeder trunk affected by a fault | New DO/DA or new LN |
| GP Start | Protection dependent (directionality, general or per single phase and/or neuter, ...) | Will be mapped over Str of the appropriate P-Type LN |
| Remote Trip | Anti-Islanding of a MV feeder trunk affected by a fault | New DO/DA or new LN |
| Transfer Trip | To open the ICB | New DO/DA or new LN |

Table 11 shows how LNs could be arranged to support the considered use case.

Table 11 – Mapping of Distributed FLISR use case 4b requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|--|--|
| Topological Addressing (Structured information) of IEDs involved in DA on the Feeder; dynamical definition of the relationship with neighbor IEDs (up/down-stream) | <p>The proposed approach relies on way to inhibit by settings blocking information.</p> <p>Assumption: Each potential blocking elements of the whole feeder would have a BlkRef entry point in the PTRC or CSWI control LN of the considered switching equipment.</p> <p>In addition, new setting objects (as many objects as BlkRef instances) enable the LN to discard blocking request information if not provided by downstream elements.</p> <p>In case of feeder reconfiguration, these setting values would be changed to reflect the new topology.</p> <p>Model impact: Addition of BlkRefInh as an optional setting with multiple instances (as many as BlkRef one) at PTRC and CSWI level.</p> |
| Anti-Islanding of a MV feeder trunk affected by a fault | DISL (islanding management) |
| Protection dependent (directionality, general or per single phase and/or neuter, ...) | Group P node |
| To open the ICB | CSWI |

6.1.4.2.2 Possible LN arrangement to support distributed FLISR (case 4b)

Figure 72 shows how LNs could be used and arranged to map the considered set of use cases, as far as breakers are concerned. This appears to be a quite conventional blocking schema, except the fact that the blocking signals may be inhibited by settings.

Single User License
 EEESC WG on Smart Grids
 IEC TR 61850-90-6:2018
 No reproduction or circulation
 May 2023
 IECNORM.COM: Click to view the full PDF

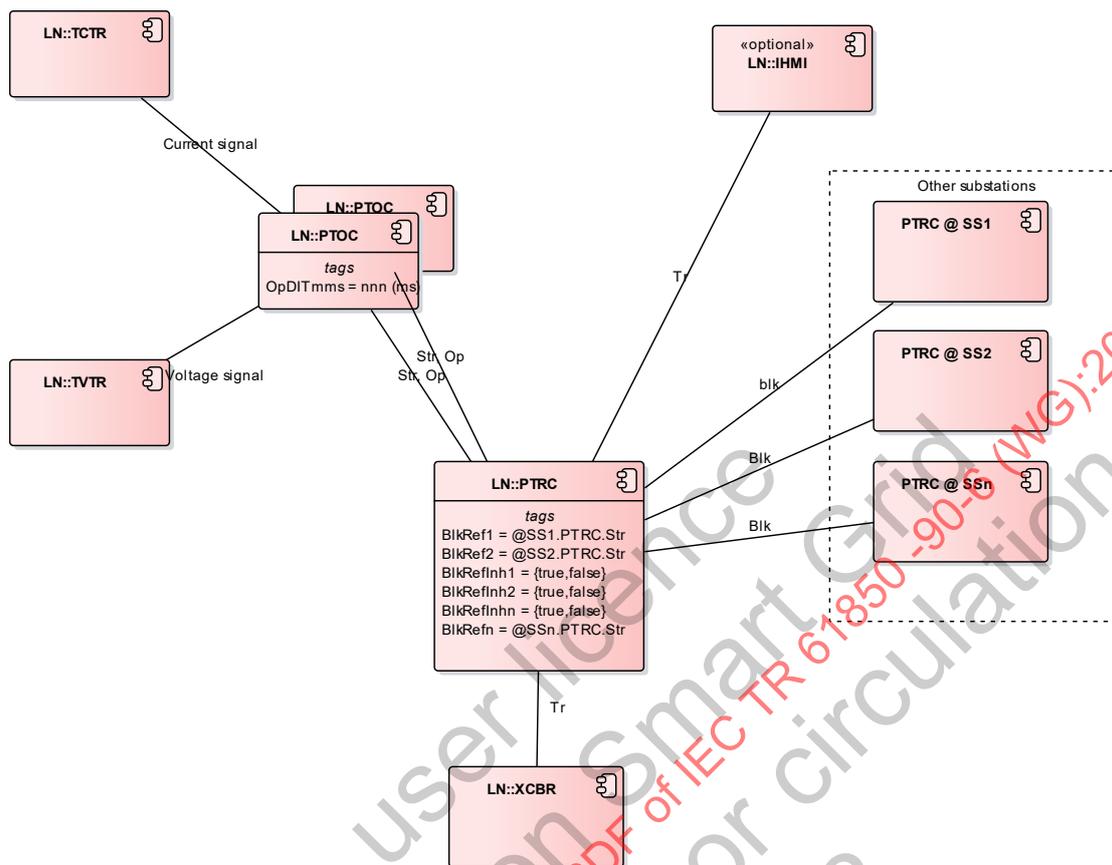


Figure 72 – Possible LN arrangement of breakers related functions, contributing to distributed FLISR (case 4b)

Figure 73 shows how LNs could be used and arranged to map the considered set of use cases, as far as switches (disconnectors) are concerned. A specific NEW automation switching LN needs to be introduced to handle the logic occurring between the occurrence of the fault, the reception of potential blocking signals from other CBs and FPIs (potentially inhibited by settings – same as above), and the final possible operation of the associated switch. The Open operation resulting from this sequence will be handled by the CSWI LN attached to the LN, as any other controls possibly sent by other functions. The CSWI will in particular verify the conditions (local/remote, interlocking etc.) for sending the order to the associated equipment.

In order to operate as expected, the new LN needs to expose at least a Start (SPS – indicating the occurrence of a fault, and True until blocked or operate), an Operate (SPC Transient to ask for opening the considered switch), and a delay Setting (OpDITmms – which will indicate how long the LN needs to wait until sending the control to the switch, or being blocked).

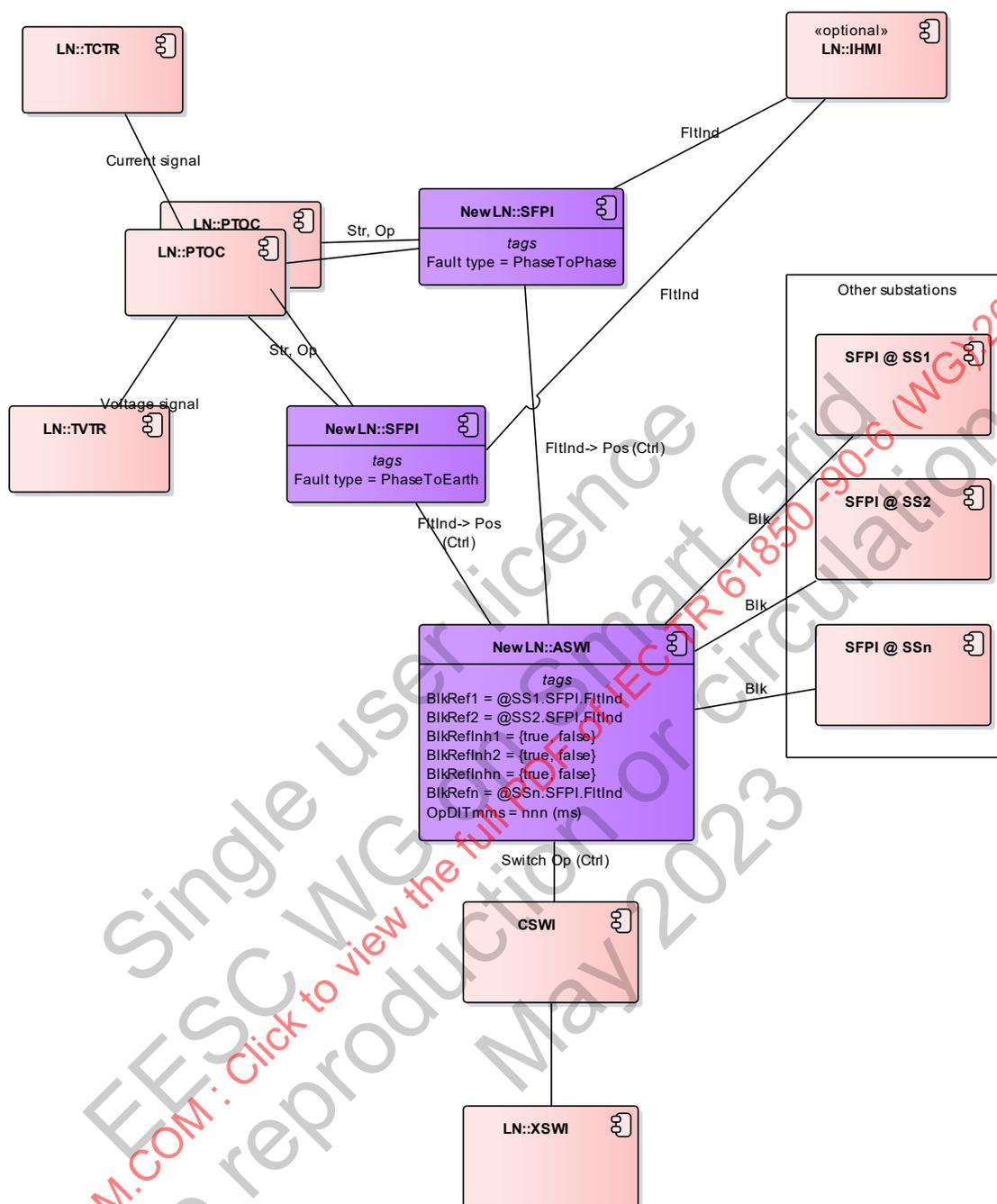


Figure 73 – Possible LN arrangement of disconnectors related functions, contributing to distributed FLISR (case 4b)

6.1.5 Mapping of the requirements of VVC use case – Type 5

6.1.5.1 Mapping for tap changer control

As presented in Figure 74, no new LN is needed.

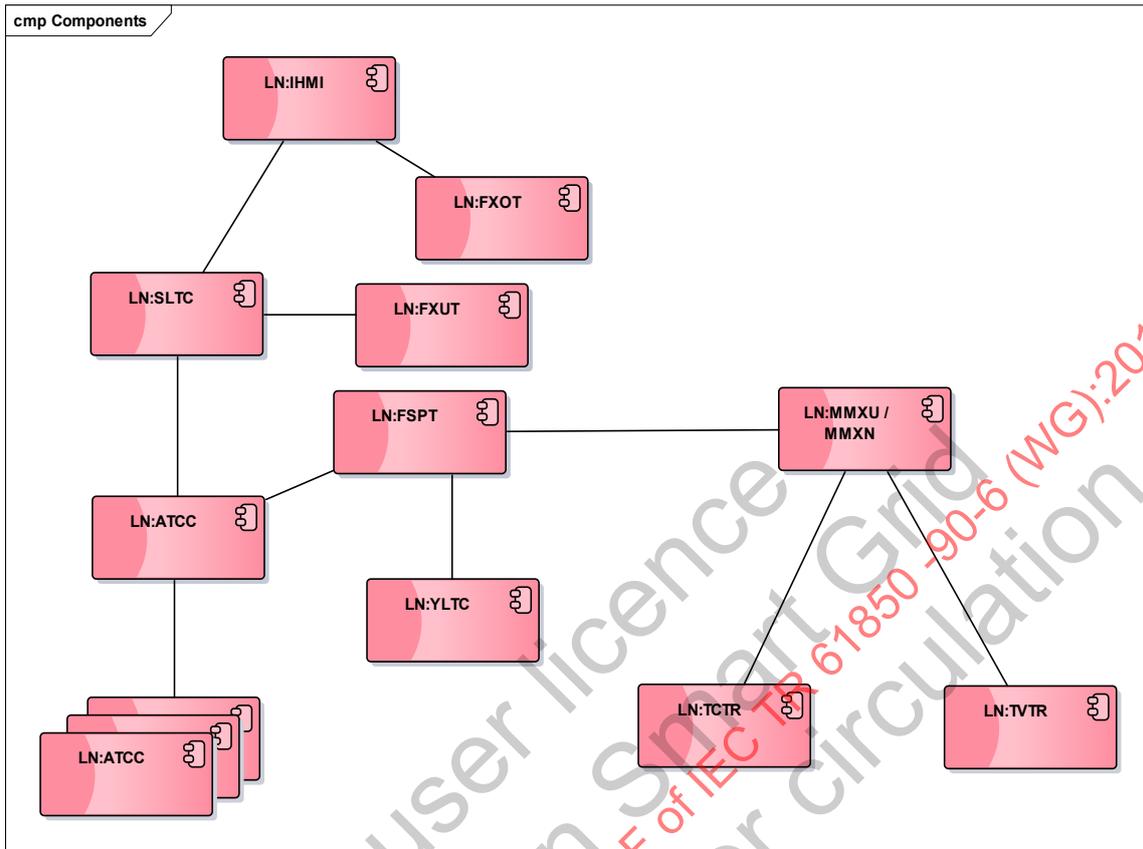


Figure 74 – Possible LN arrangement for the mapping for tap changer control

6.1.5.2 Mapping for capacitor bank control

As presented in Figure 75, no new LN is needed.

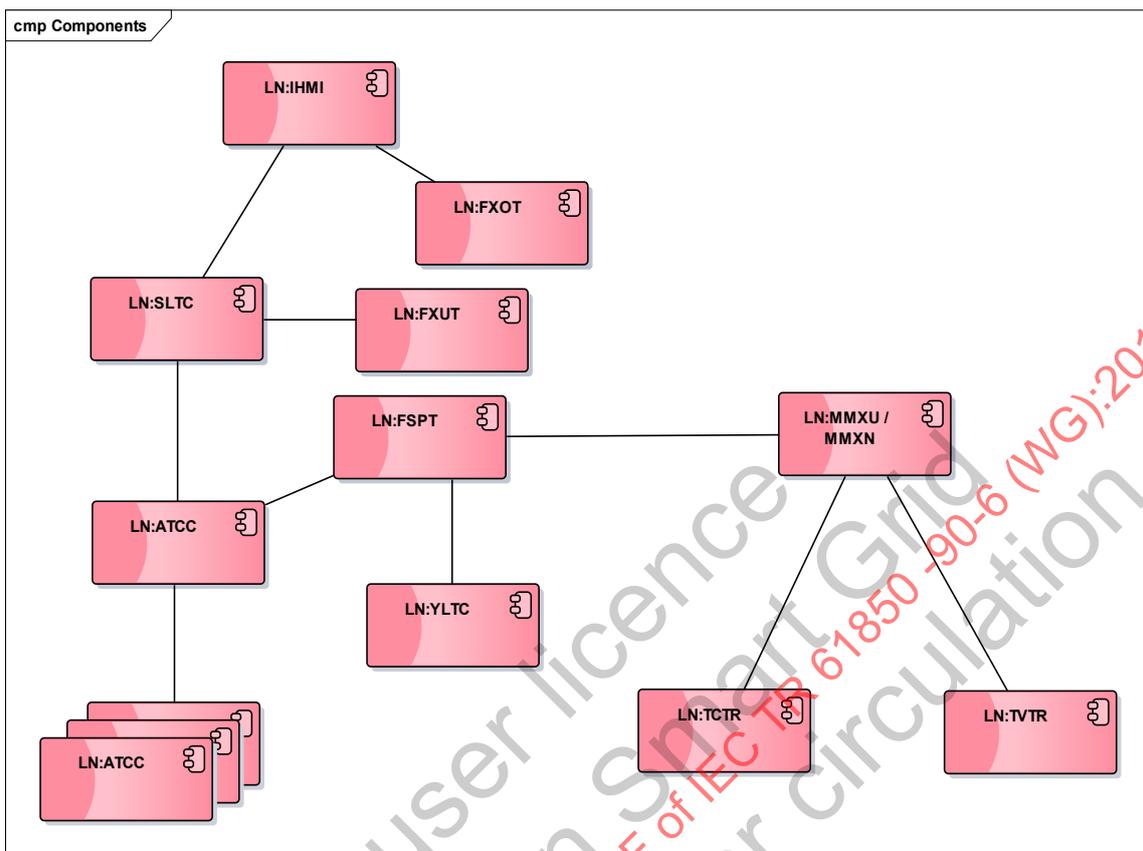


Figure 75 – Possible LN arrangement for the mapping for capacitor bank control

6.1.6 Mapping of the requirements of anti-islanding protection use case – Type 6

6.1.6.1 Mapping of required LN on existing LN classes

Table 12 shows how LNs could be arranged to support the considered use case.

Table 12 – Mapping of anti-islanding use case requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|--|---|
| Voltage presence | SVPI.Prs Provides voltage presence indication (CDC ACT) |
| Trip signal of feeder protection function | PTRC.Tr (If 'general'=true, the function has issued a trip.) |
| State of abnormal manual OPEN operation | Axxx.abnormal manual OPEN operation (SPS) |
| State of unintentional islanding | DISL.StIsld – State of Islanding CDC ENS (1=unintentional island) |
| Direct trip transfer for tripping breaker at DER | DISL.TxTr (If 'general'=true, the function is to transmit teleprotection direct trip signal to the other side.) |
| Command to shutdown-infeed of power/cease to energize / DER Disconnect | See IEC 61850-7-420 (cease to energize), Dxxx.Cease, Dxxx.Cease/ DER Disconnect |

6.1.6.2 Possible arrangement of LNs to support anti-islanding protection

Figure 76 shows how LNs could be arranged to support the considered use case.

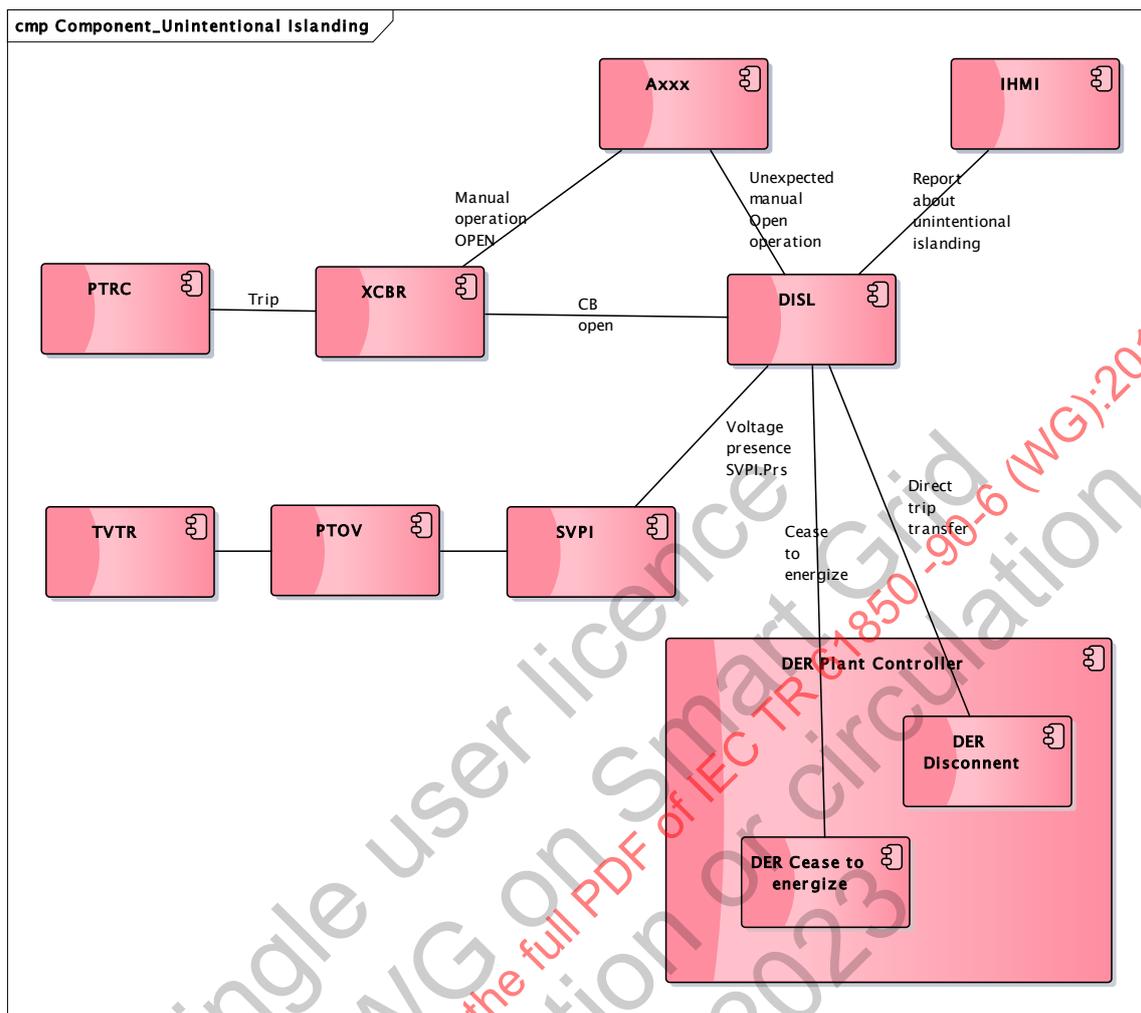


Figure 76 – Breakdown of LNs and relationships to support unintentional islanding protection

6.1.7 Mapping of the requirements of automatic transfer switch use case – Type 7

6.1.7.1 Mapping of required LN on LN classes

Table 13 shows how LNs could be arranged to support the considered use case.

Table 13 – Mapping of automatic transfer switch use case requirements onto LNs

| Requirement | IEC 61850 LN mapping |
|---|---|
| Voltage measure | TVTR Provides sampled values of voltage |
| Voltage under or over a threshold, within a given timing | PTUV, PTOV Provides (per phase) status (start) and transient signals needed to elaborate voltage presence and absence status. |
| SVPI -> Voltage presence indicator function which produces a persistent “presence” signal and an “absence” signal based on inputs from PTOV, PTUV | SVPI Presence and absence are not always opposed there are some situations where none of the indicators could be true, depending on the choices of the thresholds. |
| Management of the automatic source transfer function | AATS New. |
| Command Field Actuators | CSWI |
| Field Actuators | XSWI |
| Interlocking | CILO |

6.1.7.2 Possible arrangement of LNs to perform Automatic transfer switch

Figure 77 shows how LNs could be arranged to support the considered use case.

Single user license
 EEESC WG on Smart Grid
 IEC TR 61850-90-6 (WG) 2018
 No reproduction or circulation
 May 2023
 IECNORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG) 2018

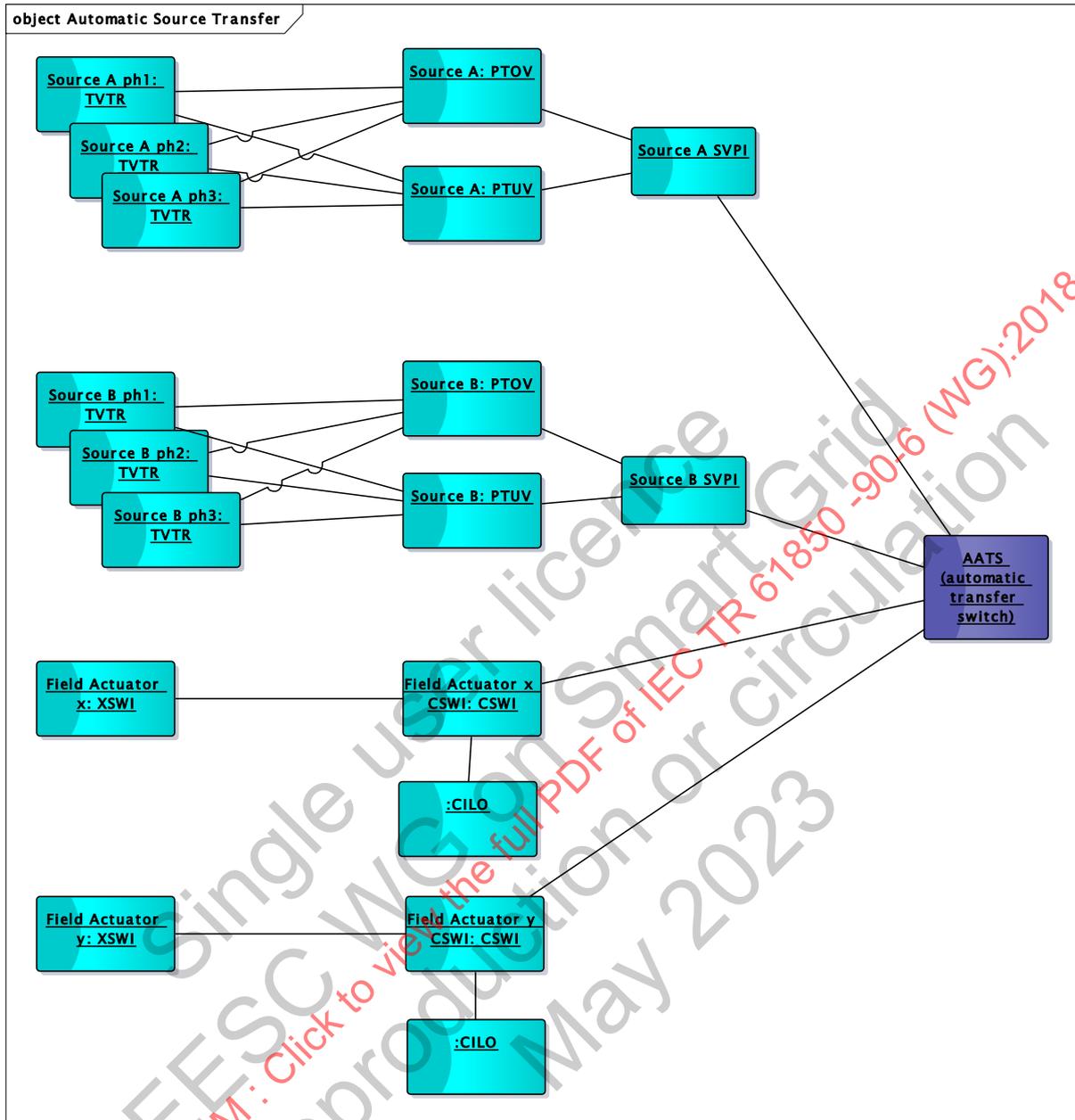


Figure 77 – Possible arrangement of LNs to perform automatic transfer switch

6.1.8 Mapping of the requirements of Monitor energy flows related Use case – Type 8

6.1.8.1 Mapping of required LN on LN classes

Table 14 shows how LNs could be arranged to support the considered use case.

The Use cases under scope are defined in 5.9.

Table 14 – Energy flow related use case requirement mapping over LNs

| Requirement | IEC 61850 LN mapping |
|---|--|
| Hosting the sign convention which determines supply vs demand direction | Finally it seems that such requirement is not managed dynamically, and sign convention is de facto established at the commissioning of concerned measurement functions, and thus doesn't need to be reflected through the data model |
| Elaborate the direction supply/demand of the energy flow in real time | MMXU can be extended for this purpose |
| Provide Energy measurement for operation with reset capabilities | MMTR can be extended for this purpose (currently only hold BCR type measurement for revenue purpose) |
| Provide per quadrant Energy measurement for operation with reset capabilities | MMTR can be extended for this purpose |

6.1.8.2 Possible arrangement of LNs to support Monitor energy flows related Use cases

Figure 78 shows a possible arrangement of Logical Nodes to fulfill the information exchange expressed in clause 5.9.

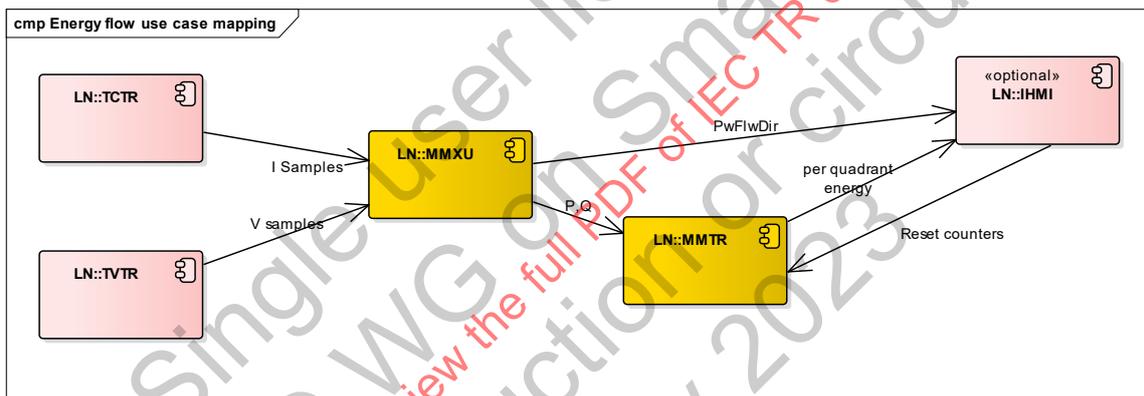


Figure 78 – Possible arrangement of LNs to Monitor energy flows related Use cases

6.1.9 Mapping of Environment situation awareness use case – Type 9

6.1.9.1 Mapping of required LN on LN classes

Table 15 shows a mapping of required exchanged information onto existing or new models. The use case under scope is defined in 5.10.

Table 15 – Mapping of Environment situation awareness use cases to existing or new LNs

| Requirement | IEC 61850 LN mapping | | | | | | | | | | | | | | | | | | | | | |
|---|--|--|-------------|---|-----------------------------|----------------------------------|-------------|--|-----------|--------|-----------------------------|------------|------------|---|----------------|---|------------------|---|-----------|---|--------------|---|
| Status, alarm, warning: Temperature, Precipitation (rain, snow, fog, ice rain...), wind (speed/direction), Solar radiation, Moisture, Air pressure | MMET <table border="1"> <tr> <td>Temperature</td> <td>✓</td> </tr> <tr> <td>rain</td> <td>✓</td> </tr> <tr> <td>snow</td> <td>✓</td> </tr> <tr> <td>fog</td> <td></td> </tr> <tr> <td>ice/freezing rain (boolean)</td> <td>(extended)</td> </tr> <tr> <td>wind speed</td> <td>✓</td> </tr> <tr> <td>wind direction</td> <td>✓</td> </tr> <tr> <td>Solar radiation,</td> <td>✓</td> </tr> <tr> <td>Moisture,</td> <td>✓</td> </tr> <tr> <td>Air pressure</td> <td>✓</td> </tr> </table> | | Temperature | ✓ | rain | ✓ | snow | ✓ | fog | | ice/freezing rain (boolean) | (extended) | wind speed | ✓ | wind direction | ✓ | Solar radiation, | ✓ | Moisture, | ✓ | Air pressure | ✓ |
| Temperature | ✓ | | | | | | | | | | | | | | | | | | | | | |
| rain | ✓ | | | | | | | | | | | | | | | | | | | | | |
| snow | ✓ | | | | | | | | | | | | | | | | | | | | | |
| fog | | | | | | | | | | | | | | | | | | | | | | |
| ice/freezing rain (boolean) | (extended) | | | | | | | | | | | | | | | | | | | | | |
| wind speed | ✓ | | | | | | | | | | | | | | | | | | | | | |
| wind direction | ✓ | | | | | | | | | | | | | | | | | | | | | |
| Solar radiation, | ✓ | | | | | | | | | | | | | | | | | | | | | |
| Moisture, | ✓ | | | | | | | | | | | | | | | | | | | | | |
| Air pressure | ✓ | | | | | | | | | | | | | | | | | | | | | |
| Status, alarm, warning: ice level, snow level, flood level, earthquake Radiation measurement, | <table border="1"> <tr> <td>ice level</td> <td>MMET (extended)</td> </tr> <tr> <td>snow level</td> <td>MMET ✓ (no alarming, warning)</td> </tr> <tr> <td>flood level</td> <td>To be deprecated in MENV and moved and expanded to a dedicated LN SFOD (NEW)</td> </tr> <tr> <td>radiation</td> <td>MENV ✓</td> </tr> <tr> <td>earthquake</td> <td>SGPD (NEW)</td> </tr> </table> | | ice level | MMET (extended) | snow level | MMET ✓ (no alarming, warning) | flood level | To be deprecated in MENV and moved and expanded to a dedicated LN SFOD (NEW) | radiation | MENV ✓ | earthquake | SGPD (NEW) | | | | | | | | | | |
| ice level | MMET (extended) | | | | | | | | | | | | | | | | | | | | | |
| snow level | MMET ✓ (no alarming, warning) | | | | | | | | | | | | | | | | | | | | | |
| flood level | To be deprecated in MENV and moved and expanded to a dedicated LN SFOD (NEW) | | | | | | | | | | | | | | | | | | | | | |
| radiation | MENV ✓ | | | | | | | | | | | | | | | | | | | | | |
| earthquake | SGPD (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Presence is allowed (control) | SPSE (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Status: Human presence, animal presence, unexpected object presence, drone presence | SPSE (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Not allowed presence summary | SPSE (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Status: Access (Gates status [open/closed/open locked/open unlocked/closed locked/closed unlocked), Shutter position, ...) | SPSE (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Fire alarm. | <p>One scenario could have been to extend MENV, but it appears that first smoke measurement and fire alarm should be treated in different way. Smoke level monitoring remains a supervision and moved to a dedicated LN (SSMK). Fire management system is an external system and thus is associated to a new LN from group K (KFIM). It may also include actions to fight against fire, attached to a potential subsystem of equipment. This requests to deprecate the corresponding data objects in MENV</p> <table border="1"> <tr> <td>smoke level</td> <td>deprecated in MENV and moved/extended in SSMK (NEW)</td> </tr> <tr> <td>smoke alarm and alarm level</td> <td>created in SSMK (NEW)</td> </tr> <tr> <td>fire alarm</td> <td>KFIM (NEW)</td> </tr> </table> | | smoke level | deprecated in MENV and moved/extended in SSMK (NEW) | smoke alarm and alarm level | created in SSMK (NEW) | fire alarm | KFIM (NEW) | | | | | | | | | | | | | | |
| smoke level | deprecated in MENV and moved/extended in SSMK (NEW) | | | | | | | | | | | | | | | | | | | | | |
| smoke alarm and alarm level | created in SSMK (NEW) | | | | | | | | | | | | | | | | | | | | | |
| fire alarm | KFIM (NEW) | | | | | | | | | | | | | | | | | | | | | |
| Activation of fire fighting systems | KFIM (NEW) | | | | | | | | | | | | | | | | | | | | | |

| Requirement | IEC 61850 LN mapping |
|--|--|
| Status, alarm, warning: Temperature measures | STMP |
| Illumination activation (control) | One scenario could have been to extend MENV, but it appears that Illumination is not only measurement but may also include actions, attached to a potential subsystem of equipment. A specific LN of Group Z (KILL) is proposed to be created, |
| Illumination status | KILL (NEW) |

6.1.9.2 Possible arrangement of LNs to support Environment situation awareness use cases

Figure 79 shows a possible arrangement of Logical Nodes to fulfill the information exchange expressed in 5.10.

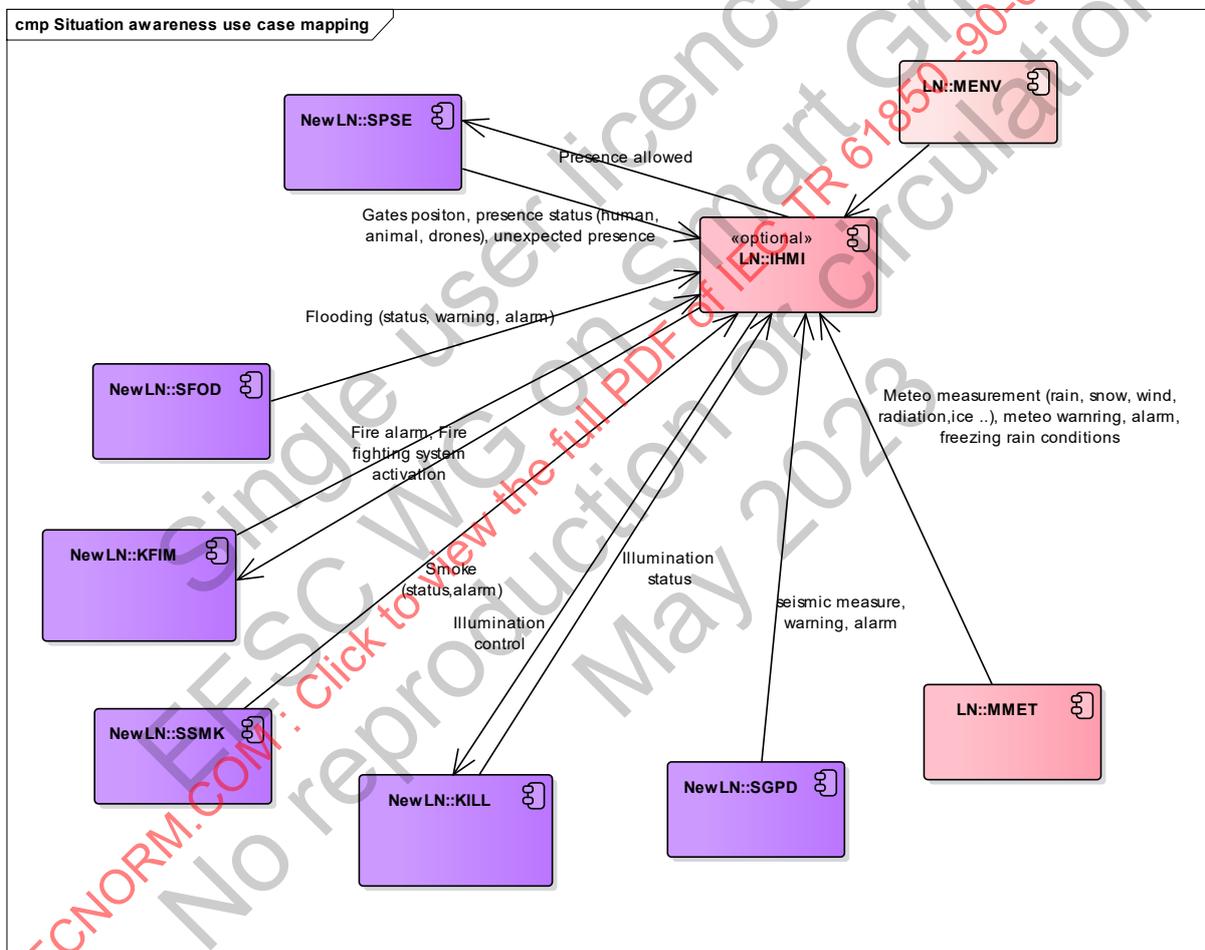


Figure 79 – Possible arrangement of LNs to support Environment situation awareness use cases

6.2 Mapping summary of the set of UCs over the LNs (existing or new)

| | | AATS | AFSI | AFSL | ASRC | ASWI | ATCC | CILO | CSWI | DISL | FSPT | FXOT | FXUT | IHMI | KFIN | KILL | MENV | MMET | MMTR | MMXU | PTOC | PTOV | PTRC | PTUC | PTUV | RREC | RRFV | SCPI | SFOD | SFPI | SFST | SGPD | SPSE | SSMK | SLTC | SVPI | TCTR | TVTR | XCBR | XSWI | YLTC | ZAXN | | | | | |
|-----------|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--|--|--|--|--|
| 1 | Fault indication and report | | | | | | | | | | | | | X | | | | | | | X | X | | X | X | | | | | | | | | X | X | X | | | | | | | | | | | |
| 2a | FLISR using sectionalizers detecting fault current | | | | X | | | X | | | | | | X | | | | | X | X | | X | | | | X | | | | | | | | | X | X | X | X | | | | | | | | | |
| 2b | FLISR using sectionalizers detecting feeder voltage | | | | | | | X | | | | | | X | | | | | X | | | | | | | X | | | | | | | | | | | X | X | | X | | | | | | | |
| 3a/ 3b | FLISR in a radial feeder based on centralized control | | | | | | | X | | | | | | X | | | | | | X | X | | X | X | | | X | | X | X | | | | | X | X | X | | | | | | | | | | |
| 4a | FLISR in an open loop network based on distributed control----Type A | X | X | X | | | | X | | | | | | | | | | | X | X | X | | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| 4b | FLISR based on distributed control----Type B | | | | X | | | X | | | | | | X | | | | | X | | | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Centralized Voltage and Var Control | | | | | X | | | | | X | X | X | X | | | | | X | | | | | | | | | | | | | | | | X | | | | | | X | | | | | | |
| 6 | Anti-islanding protection based on communications | | | | | | | | | X | | | | X | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Automatic transfer switch | X | | | | | | X | X | | | | | | | | | | | | | X | | | X | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Monitor energy flow (Energy flow related Use cases) | | | | | | | | | | | | | X | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Environment situation awareness | | | | | | | | | | | | | X | X | X | X | X | X | | | | | | | | | X | | | X | X | X | | | | | | | | | | | | | | |

<CODE BEGINS>

7 Logical node classes and data objects modelling

7.1 General

The tables and element presence conditions included in clause 7 shall be interpreted as explained in Annex A.

7.2 Logical node classes

7.2.1 General

This clause specifies logical nodes defined in IEC TR 61850-90-6.

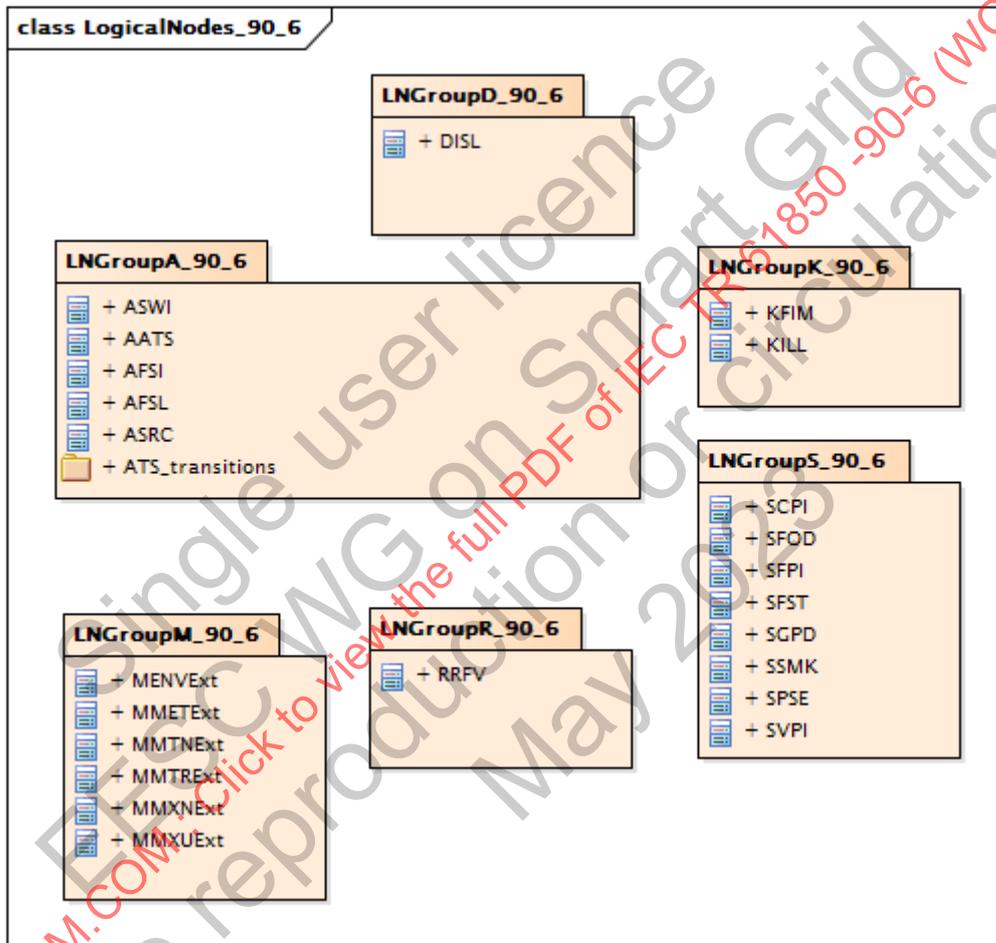


Figure 80 – Class diagram LogicalNodes_90_6::LogicalNodes_90_6

Figure 80: Logical Nodes created or extended within IEC TR 61850-90-6.

7.2.2 Abstract LN of 90-6 namespace (Abstract90-6LNs)

7.2.2.1 General

This includes all abstract logical LNs used further to build LNs of the 61850-90-6 namespace

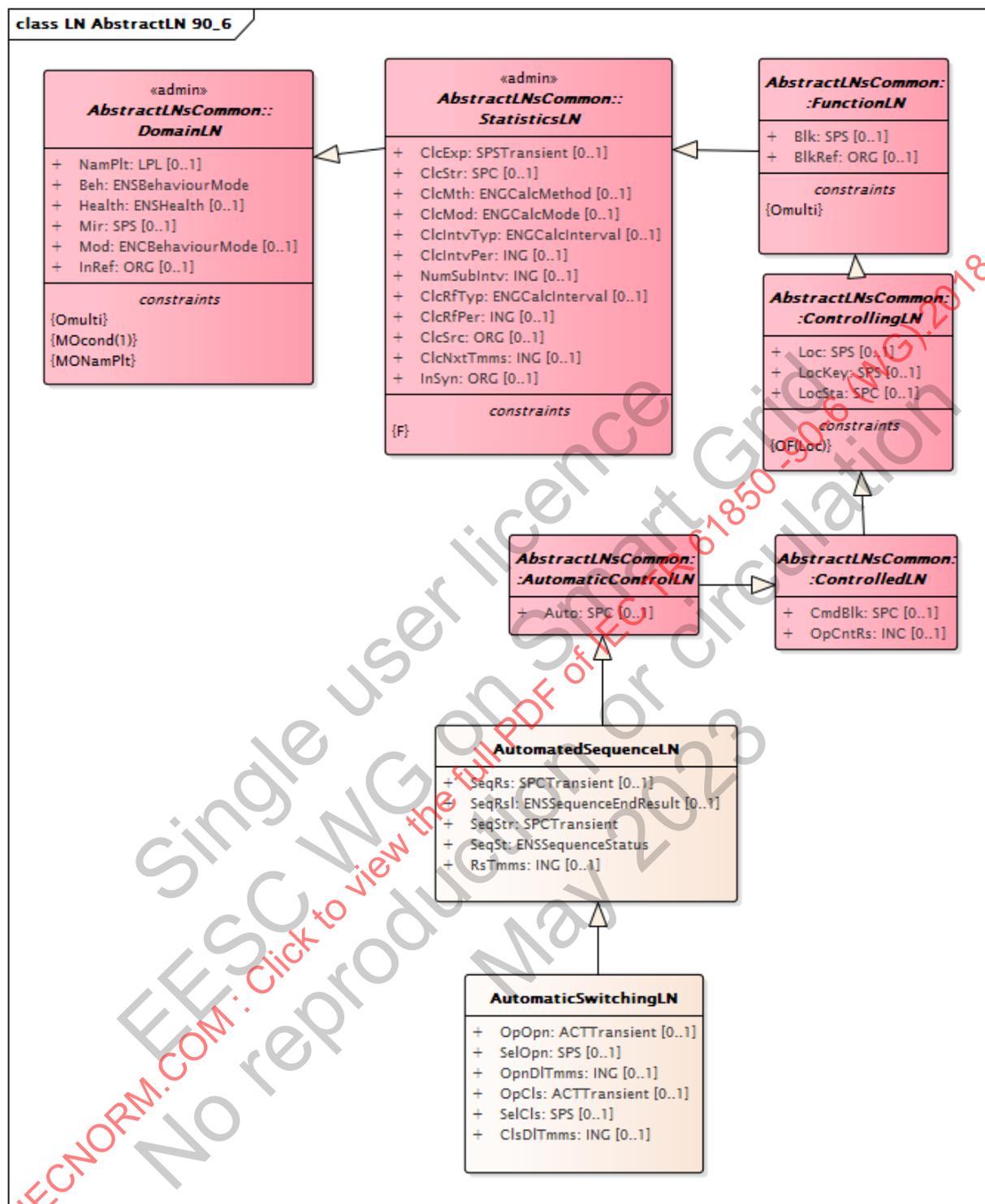


Figure 81 – Class diagram Abstract90-6LNs::LN AbstractLN 90_6

Figure 81: List of proposed new abstract LNs to support the IEC TR 61850-90-6 domain.

7.2.2.2 LN: Automatic sequence Name: AutomatedSequenceLN

This logical node host the data objects to support an automated sequence.

Its relies on a very simple state machine which can be extended with new states and new controlled transitions, and/or new sequence end results cases .

Any new controlled transition shall be of SPCTransient type defined in a private or standard namespace.

Any new states shall be expressed through the enumeration SequenceStatusKind, either by private values (negative) or standard one (positive).

Any new w sequence end results cases shall be expressed through the enumeration SequenceEndresultKind, either by private values (negative) or standard one (positive).

Table 16 shows all data objects of AutomatedSequenceLN.

Table 16 – Data objects of AutomatedSequenceLN

| AutomatedSequenceLN | | | | |
|---------------------------|-----------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| SeqRsl | ENS (SequenceEndResultKind) | | Express the result of the latest sequence handling. | O / F |
| SeqSt | ENS (SequenceStatusKind) | | Automatic sequence state – see details in SequenceStatusKind enumeration. | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SeqRs | SPC | T | (controllable) Operating with value true initiates the reset of the sequence; operating with value false is ignored. The change of its status value is a local issue. | O / F |
| SeqStr | SPC | T | (controllable) Operating with value true initiates the start of the sequence; operating with value false is ignored. The change of its status value is a local issue. | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| RsTmms | ING | | Timeout in ms, after which the grid automation function is automatically reset | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG | | inherited from: StatisticsLN | O / O |

| AutomatedSequenceLN | | | | |
|---------------------|---------------------------|---|------------------------------|--------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| | (CalcIntervalKind) | | | |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.2.3 LN: Automatic switching logical operation Name: AutomaticSwitchingLN

Automatic switching logical node is designed to operate a certain logic to operate a switch, close to what the LN PTRC is doing to trip a breaker under certain conditions.

The way Goose can be used to transfer information to CSWI is explained in IEC TR 61850-7-500.

OpCntRs can be used to count the number of times the automatic sequence has been executed

Table 17 shows all data objects of AutomaticSwitchingLN.

Table 17 – Data objects of AutomaticSwitchingLN

| AutomaticSwitchingLN | | | | |
|---------------------------|--------------------------------|---|---|------------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| OpOpn | ACT | T | If its 'general' is true, the switching automation logic or sequence has decided to open the switching equipment. Note that the state must last long enough that the subscriber can detect it. | O / F |
| SelOpn | SPS | | If true, the switching equipment has been selected for opening operation. | O / F |
| OpCls | ACT | T | If its 'general' is true, the switching automation logic or sequence has decided to close the switching equipment. Note that the state must last long enough that the subscriber can detect it. | O / F |
| SelCls | SPS | | If true, the switching equipment has been selected for closing operation. | O / F |
| SeqRsl | ENS (SequenceEndResultKind) | | inherited from: AutomatedSequenceLN | O / F |
| SeqSt | ENS (SequenceStatusKind) | | inherited from: AutomatedSequenceLN | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |

| AutomaticSwitchingLN | | | | |
|----------------------|-------------------------|---|--|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SeqRs | SPC | T | inherited from: AutomatedSequenceLN | O / F |
| SeqStr | SPC | T | inherited from: AutomatedSequenceLN | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| OpnDITmms | ING | | Operation delay time (in ms)- time between the triggering condition (e.g. voltage absence or reclose cycle N) and sending the command to open the switch | O / F |
| ClsDITmms | ING | | Operation delay time (in ms)- time between the triggering condition and sending the command to close the switch | O / F |
| RsTmms | ING | | inherited from: AutomatedSequenceLN | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmms | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3 LN of Group A (LNGroupA_90_6)

7.2.3.1 General

This group of logical nodes proposed extensions to existing IEC 61850 namespaces to support the automatic functions mentioned in this report.

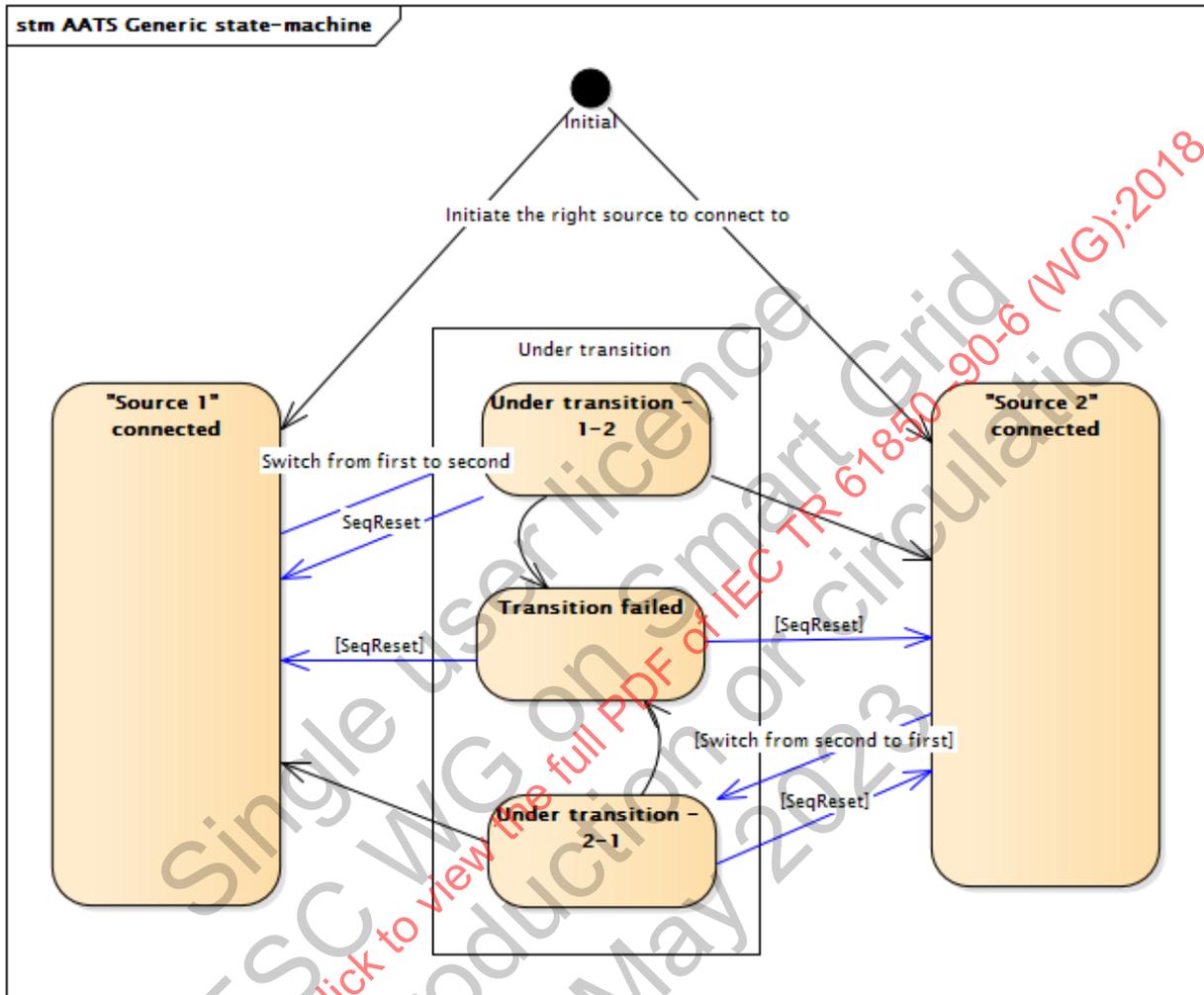


Figure 82 – Statechart diagram LNGroupA_90_6::AATS Generic state-machine

Figure 82: Generic State machine diagram for automatic transfer source, with balanced roles sources

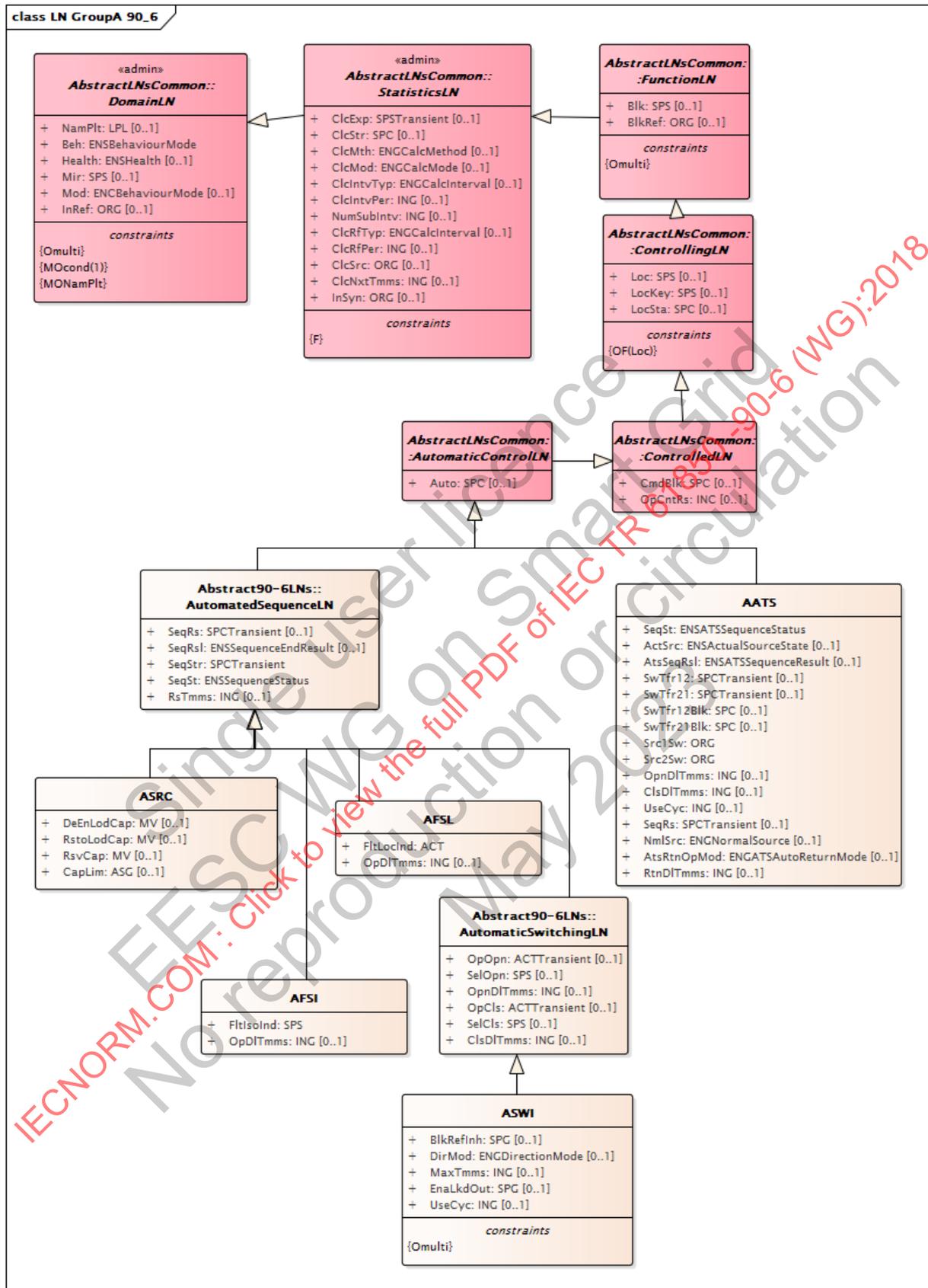


Figure 84 – Class diagram LNGroupA_90_6::LN GroupA 90_6

Figure 84: List of proposed new LNs or extended LNs to extend the Group A of LNs to support the IEC TR 61850-90-6 domain.

7.2.3.2 LN: Automatic switching sequence Name: ASWI

This logical node supports the implementation of an automated sequence having as consequence the switching (open/close) of a single equipment controlled by the CSWI LN, such as switch (XSWI) or breaker (XCBR)

Table 18 shows all data objects of ASWI.

Table 18 – Data objects of ASWI

| ASWI | | | | |
|---------------------------|-----------------------------|---|--|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| OpOpn | ACT | T | inherited from: AutomaticSwitchingLN | O / F |
| SelOpn | SPS | | inherited from: AutomaticSwitchingLN | O / F |
| OpCls | ACT | T | inherited from: AutomaticSwitchingLN | O / F |
| SelCls | SPS | | inherited from: AutomaticSwitchingLN | O / F |
| SeqRsl | ENS (SequenceEndResultKind) | | inherited from: AutomatedSequenceLN | O / F |
| SeqSt | ENS (SequenceStatusKind) | | inherited from: AutomatedSequenceLN | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SeqRs | SPC | T | inherited from: AutomatedSequenceLN | O / F |
| SeqStr | SPC | T | inherited from: AutomatedSequenceLN | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| BlkRefInh | SPG | | if set to true, the value provided through the BlkRef DO instance of same suffix is ignored, and its potential blocking effect inhibited (i.e for example BlkRefInh5 will inhibit the blocking effect of value of the signal referenced by BlkRef5) | Omulti / F |
| DirMod | ENG (DirectionModeKind) | | Used to enable operation when the fault directional conditions are met. If set to 'forward' or 'reverse', the sectionalizer operates only if the fault detected is in that direction | O / F |

| ASWI | | | | |
|------------------|---------------------------|---|---|--------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| MaxTmms | ING | | Maximum time (ms) after fault detection during which auto-reclosing is expected (should be configured with the same value as RREC.MaxTmms in the main substation) | O / F |
| EnaLkdOut | SPG | | True means enable lockout on switch operation failure. False means the ASWI will send another open command during the next reclose dead time. | O / F |
| UseCyc | ING | | Actual number of reclose cycles to count before triggering the ASWI sequence to open the sectionalizer | O / F |
| OpnDITmms | ING | | inherited from: AutomaticSwitchingLN | O / F |
| ClsDITmms | ING | | inherited from: AutomaticSwitchingLN | O / F |
| RsTmms | ING | | inherited from: AutomatedSequenceLN | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3.3 LN: Automatic transfer between two sources Name: AATS

AATS logical node is the one which performs an automatic transfer between two sources controlled through their respective switch (or breaker)

Table 19 shows all data objects of AATS.

Table 19 – Data objects of AATS

| AATS | | | | |
|---------------------------|-----------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| SeqSt | ENS (ATSSequenceStatusKind) | | automatic transfer switching state – see details in ATSSequenceStatusKind enumeration | M / F |
| ActSrc | ENS (ActualSourceKind) | | Active source currently in use | O / F |
| AtsSeqRsl | ENS (ATSSequenceResultKind) | | Expose the result of the latest transition attempt of the state machine related to the Automatic Transfer Source | O / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SwTfr12 | SPC | T | (controllable) Operating with value true initiates a transition aiming at switching from Source1 to Source2; operating with value false is ignored. The change of its status value is a local issue. | O / F |
| SwTfr21 | SPC | T | (controllable) Operating with value true initiates a transition aiming at switching from Source2 (as identified in the setting) to Source1 (as identified by the settings); operating with value false is ignored. The change of its status value is a local issue. | O / F |
| SwTfr12Blk | SPC | | (controllable) if true, transition from Source1 to Source2 is blocked, otherwise enabled | O / F |
| SwTfr21Blk | SPC | | (controllable) if true, transition from Source2 to Source1 is blocked, otherwise enabled. | O / F |
| SeqRs | SPC | T | (controllable) Operating with value true initiates the reset of the sequence; operating with value false is ignored. The change of its status value is a local issue. | O / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| Src1Sw | ORG | | Reference to the physical entity enabling the control and monitoring of the connection/disconnection of Source1 | M / F |
| Src2Sw | ORG | | Reference to the physical entity enabling the control | M / F |

| AATS | | | | |
|------------------|--------------------------------|---|---|-----------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| | | | and monitoring of the connection/disconnection of Source2 | |
| OpnDITmms | ING | | Open command delay time (ms) of between the triggering condition (e.g absence of voltage) and the open command for the switch of the current source | O / F |
| ClsDITmms | ING | | Close command delay time (ms) of between the end of the open command of the current source and the close command for the switch of the new source | O / F |
| UseCyc | ING | | Number of reclose cycles before triggering an automatic transfer switch sequence | O / F / F |
| NmlSrc | ENG (NormalSourceKind) | | Definition of the source which is considered as normal | O / F |
| AtsRtnOpMod | ENG (ATSAutoReturnModeKind) | | Define the automatic "return to normal" operation mode | O / F |
| RtnDITmms | ING | | Automatic return delay time (ms) between conditions are met for switching back to normal and the start of the sequence for returning to normal | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmms | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3.4 LN: Automatic faulty section isolation Name: AFSI

The AFSI logical node is designed to host automatic faulty section isolation function.

Table 20 shows all data objects of AFSI.

Table 20 – Data objects of AFSI

| AFSI | | | | |
|---------------------------|-----------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| FItlsoInd | SPS | | If true, the faulty section located in the direction of the circuit is now isolated. It remains true until it has been reset through FItlsoRs, or the RsTmms timeout has operated. | M / F |
| SeqRsl | ENS (SequenceEndResultKind) | | inherited from: AutomatedSequenceLN | O / F |
| SeqSt | ENS (SequenceStatusKind) | | inherited from: AutomatedSequenceLN | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SeqRs | SPC | T | inherited from: AutomatedSequenceLN | O / F |
| SeqStr | SPC | T | inherited from: AutomatedSequenceLN | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| OpDITmms | ING | | Operation delay time in ms between the triggering condition (end of fault location) and sending the control(s) to perform the isolation | O / F |
| RsTmms | ING | | inherited from: AutomatedSequenceLN | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |

| AFSL | | | | |
|------------------|-------------------|---|------------------------------|--------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3.5 LN: Automatic faulty section location Name: AFSL

The AFSL logical node is designed to host automatic faulty section location function

Table 21 shows all data objects of AFSL.

Table 21 – Data objects of AFSL

| AFSL | | | | |
|---------------------------|--------------------------------|---|---|--------------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| FltLocInd | ACT | | If true, indicates that this AFSL instance is the closest to the faulty section (as the result of the faulty section location process). Forward means the fault is in the direction of the circuit(From CT to circuit) It supposes that many AFSL LNs instance captures the fault along the feeder , but only this one, actually positioned the closest to the fault operates. It remains true until it has been reset through FltLocRs, or the RsTmms timeout has operated. | M / F |
| SeqRsl | ENS (SequenceEndResultKind) | | inherited from: AutomatedSequenceLN | O / F |
| SeqSt | ENS (SequenceStatusKind) | | inherited from: AutomatedSequenceLN | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| SeqRs | SPC | T | inherited from: AutomatedSequenceLN | O / F |
| SeqStr | SPC | T | inherited from: AutomatedSequenceLN | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |

| AFSL | | | | |
|------------------|----------------------------|---|--|-----------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| OpDITmms | ING | | Operation delay time in ms between the triggering condition (e.g. voltage absence) and calculating FltLocInd | O / F |
| RsTmms | ING | | inherited from: AutomatedSequenceLN | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmms | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3.6 LN: Automatic service restoration control Name: ASRC

ASRC is the logical node hosting automatic service restoration control function.

OpCntRs can be used to count the number of times the restoration sequence has been executed

Table 22 shows all data objects of ASRC.

Table 22 – Data objects of ASRC

| ASRC | | | | |
|------------------------------------|-----------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| SeqRsl | ENS (SequenceEndResultKind) | | inherited from: AutomatedSequenceLN | O / F |
| SeqSt | ENS (SequenceStatusKind) | | inherited from: AutomatedSequenceLN | M / F |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Measured and metered values | | | | |
| DeEnLodCap | MV | | Total capacity (in VA) of the de-energised load in healthy sections before service restoration | O / O |
| RstoLodCap | MV | | Restored capacity (in VA) after service restoration. | O / O |
| RsvCap | MV | | Reserve capacity of the standby power source, i.e., the remote substation which can be connected by the tie switch. It is calculated by subtracting the load from the CapLim setting. | O / O |
| Controls | | | | |
| SeqRs | SPC | T | inherited from: AutomatedSequenceLN | O / F |
| SeqStr | SPC | T | inherited from: AutomatedSequenceLN | M / F |
| Auto | SPC | | inherited from: AutomaticControlLN | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| CapLim | ASG | | Capacity limit of the standby power source in VA, determined by the power system conditions | O / F |
| RsTmms | ING | | inherited from: AutomatedSequenceLN | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |

| ASRC | | | | |
|------------------|---------------------------|---|------------------------------|--------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.3.7 Package holding the transitions for the Automatic transfer switch sequence (ATS_transitions)

7.2.4 LN of Group D (LNGroupD_90_6)

7.2.4.1 General

This set of LNs proposed extensions to existing IEC 61850 namespaces to support DER-based systems

Single user licence
 EESC WG on Smart Grid
 IEC NORM.COM: Click to view the full PDF of IEC TR 61850-90-6 (WG):2018
 No reproduction or circulation
 May 2023

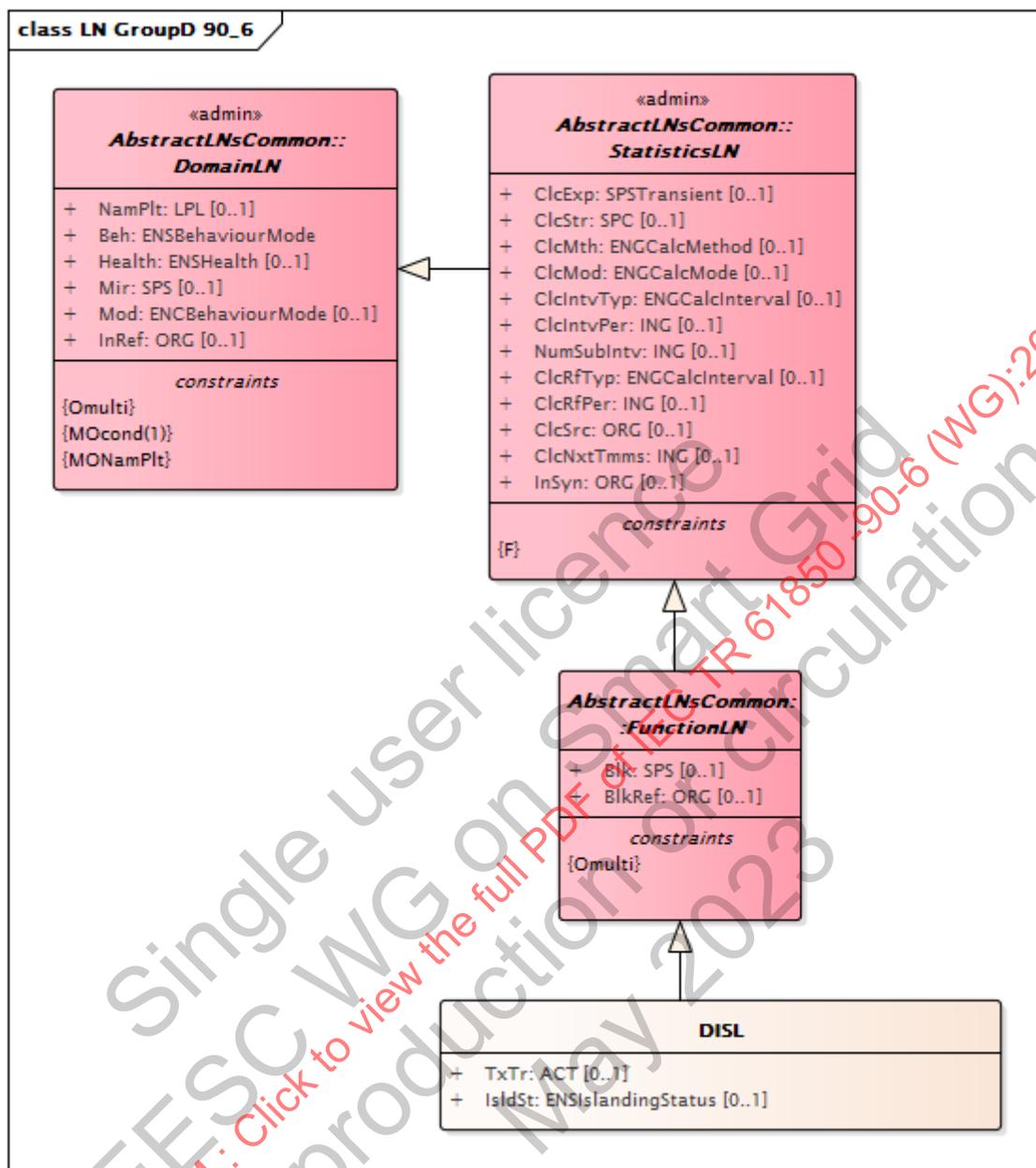


Figure 85 – Class diagram LNGroupD_90_6::LN GroupD_90_6

Figure 85: List of proposed new LNs or extended LNs to extend the Group D of LNs to support the IEC TR 61850-90-6 domain.

7.2.4.2 LN: Islanding management Name: DISL

This LN models a function related to the management of an islanded branch of the grid (intentional or not intentional).

Table 23 shows all data objects of DISL.

Table 23 – Data objects of DISL

| DISL | | | | |
|---------------------------|--------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| TxTr | ACT | | If its 'general'=true, the function is to transmit teleprotection direct trip signal to the other side. | O / F |
| IsldSt | ENS (IslandingStateKind) | | Reflects the islanding status of the considered grid area | O / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.5 LN of Group K (LNGroupK_90_6)

7.2.5.1 General

This group of logical nodes represents various devices that can be supervised, controlled or operated but that are not primarily of electrical nature.

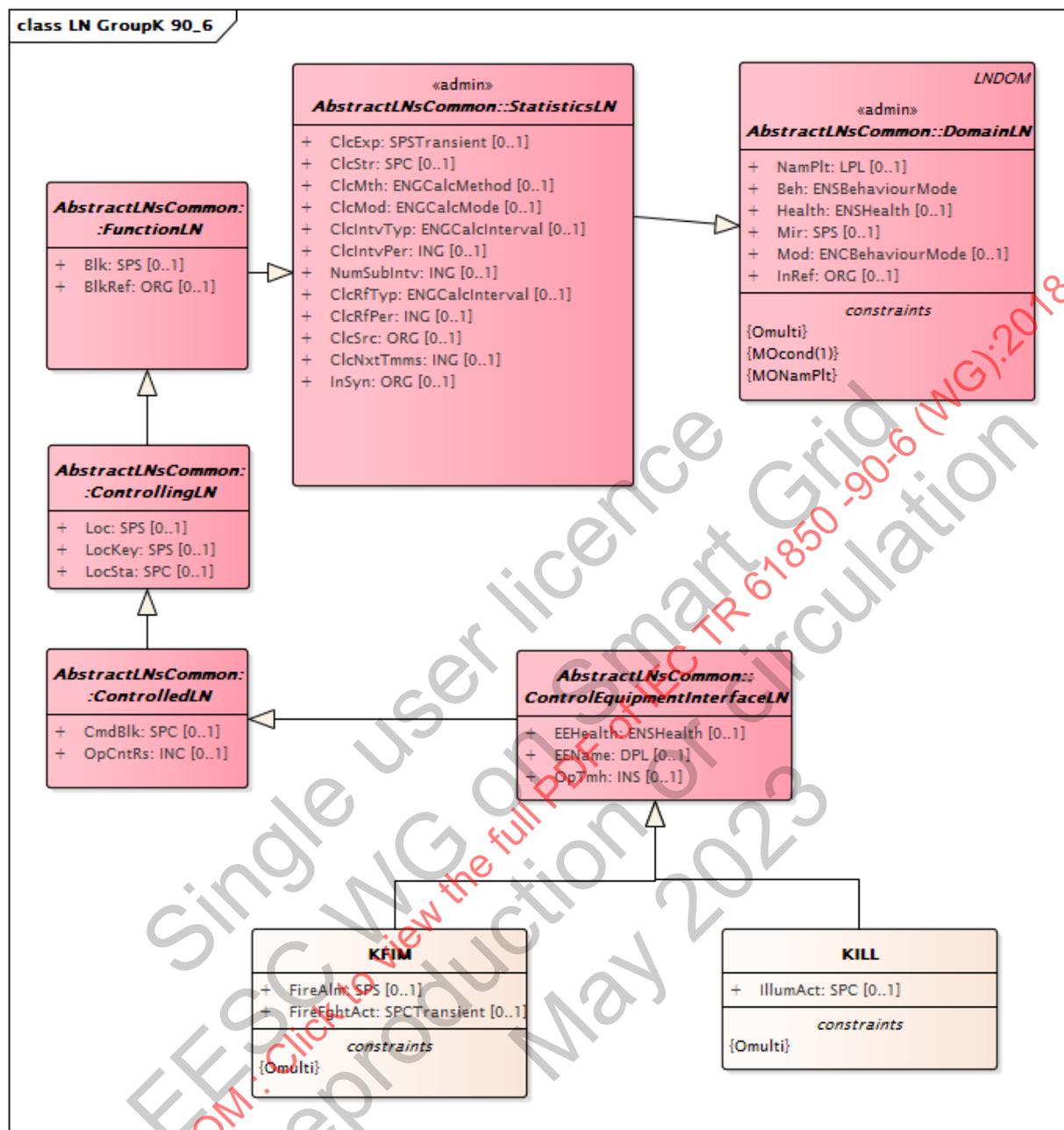


Figure 86 – Class diagram LNGroupK_90_6::LN GroupK 90_6

Figure 86: List of proposed new LNs or extended LNs to extend the Group K of LNs to support the IEC TR 61850-90-6 domain.

7.2.5.2 LN: Fire situation management Name: KFIM

This LN includes all data objects to manage fire situation, and possibly monitor fire detectors and activate fire fighting systems.

Table 24 shows all data objects of KFIM.

Table 24 – Data objects of KFIM

| KFIM | | | | |
|---------------------------|-------------------------|---|--|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| EEName | DPL | | inherited from: ControlEquipmentInterfaceLN | O / F |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| FireAlm | SPS | | if true, a fire is present | O / F |
| EEHealth | ENS (HealthKind) | | inherited from: ControlEquipmentInterfaceLN | O / F |
| OpTmh | INS | | inherited from: ControlEquipmentInterfaceLN | O / O |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| FireFghtAct | SPC | T | (controllable) Operating with value true initiates the activation of the fire fighting system; operating with value false is ignored. The change of its status value is a local issue. | O / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENG (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.5.3 LN: Illumination system monitoring and control Name: KILL

This LN includes all data objects to monitor and control illumination (could be lamps of any kind (halogen, led, ...)). Such illumination is not supposed to be used for power grid operation purpose.

Table 25 shows all data objects of KILL.

Table 25 – Data objects of KILL

| KILL | | | | |
|---------------------------|-------------------------|---|---|--------------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| EENam | DPL | | inherited from: ControlEquipmentInterfaceLN | O / F |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| EEHealth | ENS (HealthKind) | | inherited from: ControlEquipmentInterfaceLN | O / F |
| OpTmh | INS | | inherited from: ControlEquipmentInterfaceLN | O / O |
| Loc | SPS | | inherited from: ControllingLN | O / F |
| LocKey | SPS | | inherited from: ControllingLN | OF(Loc) / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Controls | | | | |
| IllumAct | SPC | | (controllable) If true, illumination is activated; otherwise illumination is deactivated. | Omulti / F |
| CmdBlk | SPC | | inherited from: ControlledLN | O / F |
| OpCntRs | INC | | inherited from: ControlledLN | O / O |
| LocSta | SPC | | inherited from: ControllingLN | OF(Loc) / F |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.6 LN of Group M (LNGroupM_90_6)

7.2.6.1 General

This group of logical nodes represents proposed extensions to existing IEC 61850 namespaces to support metering and measuring functions requested through the Use cases defined in this report.

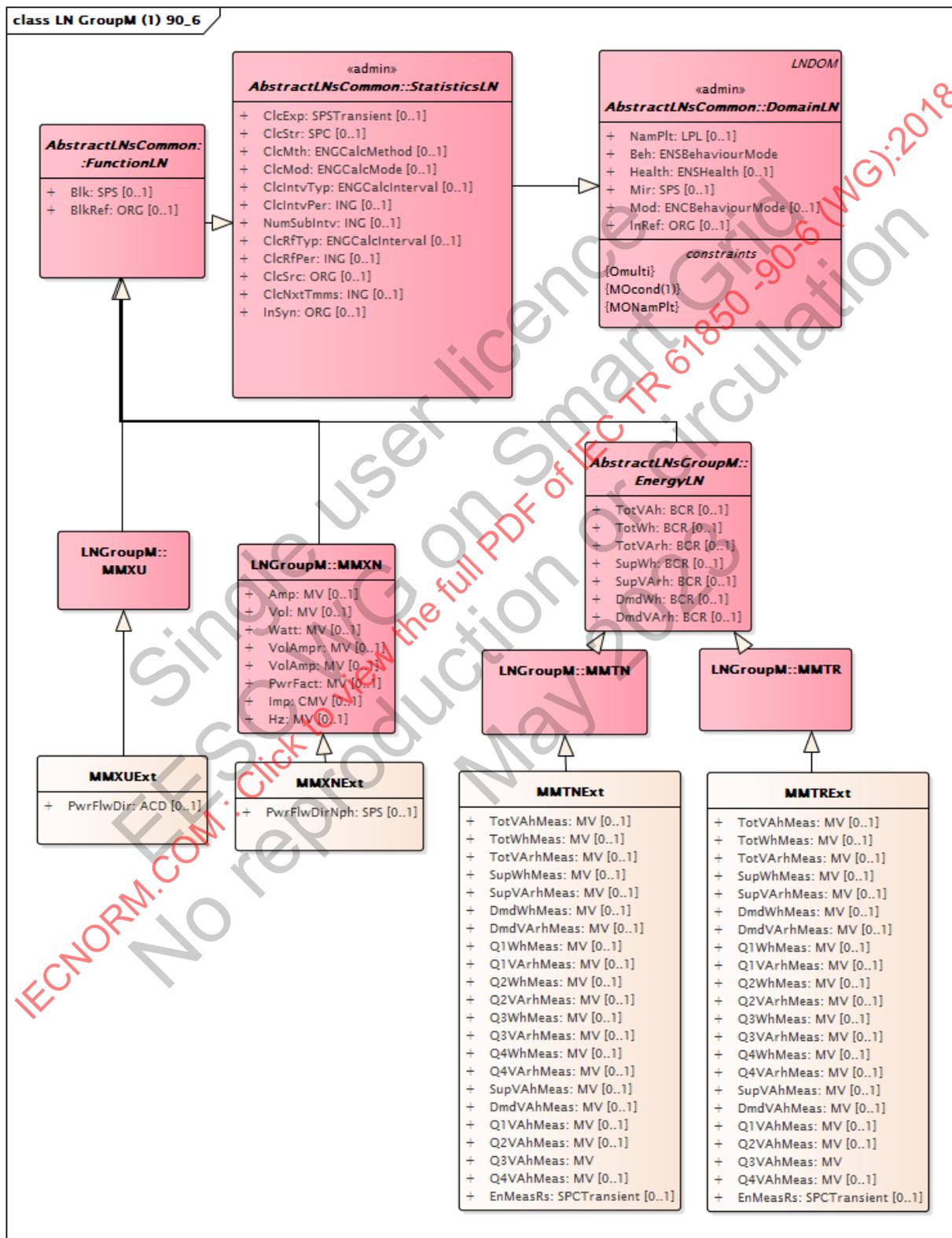


Figure 87 – Class diagram LNGroupM_90_6::LN GroupM (1) 90_6

Figure 87: List (1 out of 2) of proposed new LNs or extended LNs to extend the Group M of LNs to support the IEC TR 61850-90-6 domain.

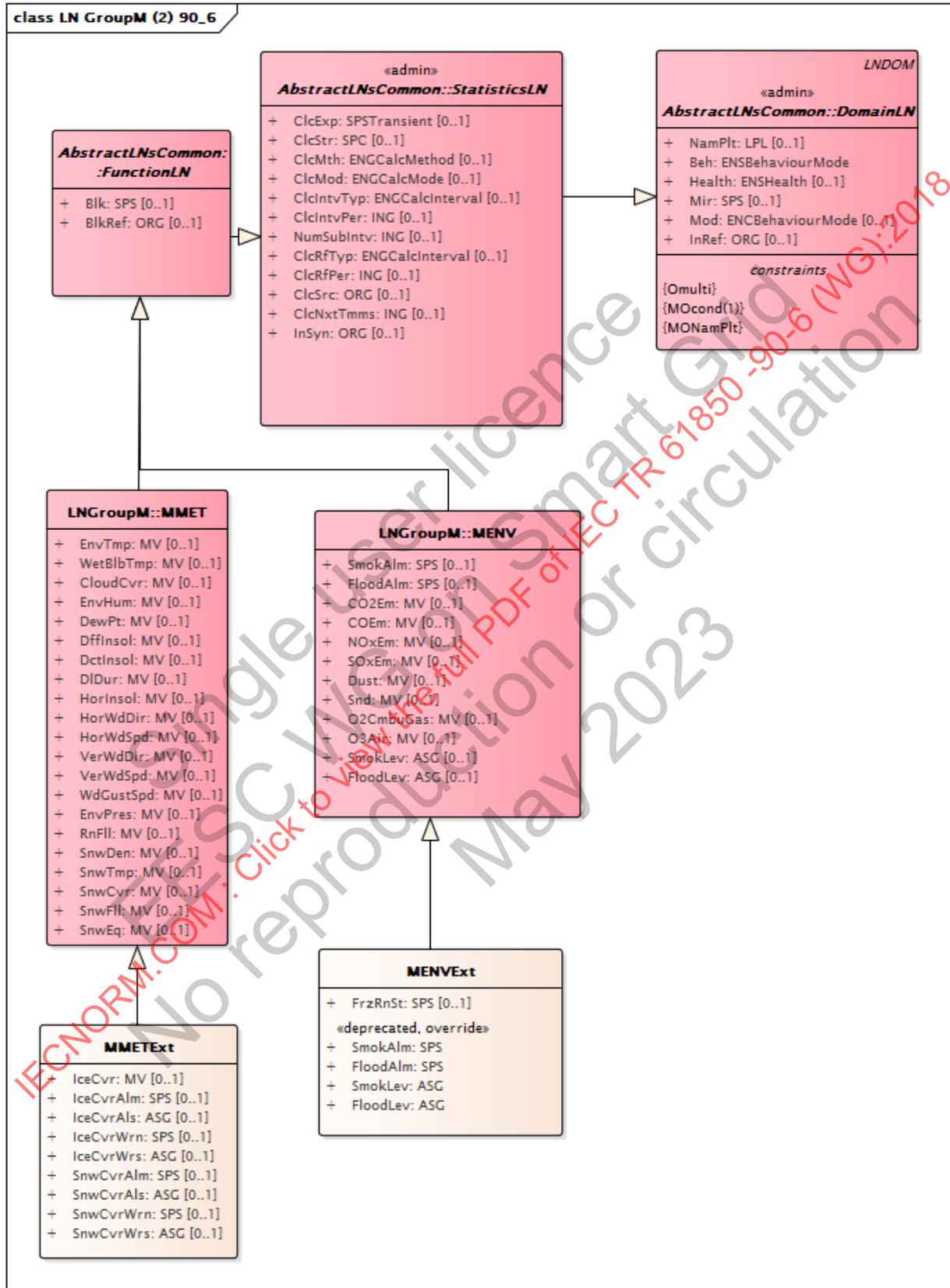


Figure 88 – Class diagram LNGroupM_90_6::LN GroupM (2) 90_6

Figure 88: List (2 out of 2) of proposed new LNs or extended LNs to extend the Group M of LNs to support the IEC TR 61850-90-6 domain.

7.2.6.2 LN: Environnement monitoring extension Name: MENVExt

Set of information objects to extend the MENV LN.

This logical node models the characteristics of environmental conditions such as emissions, and other key environmental data objects. In addition, many of the environmental sensors may be located remotely from the instantiated logical node. This logical node may therefore represent a collection of environmental information from many sources. It does, however, not include basic meteorological and hydrological data objects that are modelled with MHYD and MMET.

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model.

NOTE Flooding and smoking related information are proposed to be deprecated and moved to dedicated LNs.

Table 26 shows all data objects of MENVExt.

Table 26 – Data objects of MENVExt

| MENVExt | | | | |
|------------------------------------|-------------------------|---|---|-----------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Descriptions | | | | |
| NamPlt | LPL | | inherited from: DomainLN | MONamPlt / MONamPlt |
| Status information | | | | |
| FrzRnSt | SPS | | Freezing rain status. If true conditions are met for having | O / F |
| SmokAlm | SPS | | (deprecated) | M / F |
| FloodAlm | SPS | | (deprecated) | M / F |
| SmokAlm | SPS | | inherited from: MENV | O / F |
| FloodAlm | SPS | | inherited from: MENV | O / F |
| Blk | SPS | | inherited from: FunctionLN | O / F |
| ClcExp | SPS | T | inherited from: StatisticsLN | O / O |
| Beh | ENS (BehaviourModeKind) | | inherited from: DomainLN | M / M |
| Health | ENS (HealthKind) | | inherited from: DomainLN | O / O |
| Mir | SPS | | inherited from: DomainLN | MOcond(1) / MOcond(1) |
| Measured and metered values | | | | |
| CO2Em | MV | | inherited from: MENV | O / O |
| COEm | MV | | inherited from: MENV | O / O |
| NOxEm | MV | | inherited from: MENV | O / O |
| SOxEm | MV | | inherited from: MENV | O / O |
| Dust | MV | | inherited from: MENV | O / O |
| Snd | MV | | inherited from: MENV | O / O |
| O2CmbuGas | MV | | inherited from: MENV | O / O |
| O3Air | MV | | inherited from: MENV | O / O |
| Controls | | | | |
| ClcStr | SPC | | inherited from: StatisticsLN | O / O |

| MENVExt | | | | |
|------------------|----------------------------|---|------------------------------|--------------------|
| Data object name | Common data class | T | Explanation | PresConds/ds |
| Mod | ENC (BehaviourModeKind) | | inherited from: DomainLN | O / O |
| Settings | | | | |
| SmokLev | ASG | | (deprecated) | M / F |
| FloodLev | ASG | | (deprecated) | M / F |
| SmokLev | ASG | | inherited from: MENV | O / F |
| FloodLev | ASG | | inherited from: MENV | O / F |
| BlkRef | ORG | | inherited from: FunctionLN | Omulti / F |
| ClcMth | ENG (CalcMethodKind) | | inherited from: StatisticsLN | O / M |
| ClcMod | ENG (CalcModeKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcIntvPer | ING | | inherited from: StatisticsLN | O / O |
| NumSubIntv | ING | | inherited from: StatisticsLN | O / O |
| ClcRfTyp | ENG (CalcIntervalKind) | | inherited from: StatisticsLN | O / O |
| ClcRfPer | ING | | inherited from: StatisticsLN | O / O |
| ClcSrc | ORG | | inherited from: StatisticsLN | F / M |
| ClcNxtTmm s | ING | | inherited from: StatisticsLN | O / O |
| InSyn | ORG | | inherited from: StatisticsLN | O / O |
| InRef | ORG | | inherited from: DomainLN | Omulti / Omulti |

7.2.6.3 LN: Meteorological information monitoring Name: MMETExt

Set of information objects to extend the MMET LN.

It represents meteorological information, which can come from a meteorological station information or be a collection of meteorological information from many sources, that is, from sensors located at different places

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model

Table 27 shows all data objects of MMETExt.