IEC TR 61850-90-6

Edition 1.0 2018-09

TECHNICAL REPORT

colour inside

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

IEC TR 61850-90-6:2018-09(en)

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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

FOREWORD

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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- withdrawn,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 centres[1]
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.

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.

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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/AMD1:2018

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/AMD1:2018[2]

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/AMD1:2018[3]

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/AMD1:2018[4]

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*

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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 61850-8-2 [5], *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
Abc	Absence
Alwd	Allowed
Ani	Animal
Ats	Automatic transfer switch
Cfm	Confirm
Drn	Drone
Evo	Evolution, Evolutive
Fght	Fighting
Frz	Freezing
Hmn	Human
Illum	Illumination
Imd	Immediate
Inf	Information
Isld	island, islanding
Itm	Intermittent
Mmnt	Momentary
Nml	Normal
Nph	Not phase related
Pm	Permanent
Q	Quadrant
Q1	Refer to the quadrant Q1 of the P/Q diagram
Q2	Refer to the quadrant Q2 of the P/Q diagram
Q3	Refer to the quadrant Q3 of the P/Q diagram
Q4	Refer to the quadrant Q4 of the P/Q diagram
Rsto	Restoration
Rtn	Return
Seism	seism
Sfx	Self-extinguishing
Sht	Shutter
Spm	Semi-permanent
Tfr	Transfer
Uxp	Unexpected

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
A	Current; phase A (L1)
AC	AC, alternating current
AGC	Automatic generation control
ASG	Analogue setting CDC
AWatt	Wattmetric component of current
Abr	Abrasion
Abs	Absolute
Absb	Absorbing
Acc	Accuracy; acceleration (deprecated: use Accl instead)
Accl	Acceleration
Accm	Accumulated
Ack	Acknowledgement, acknowledge
Acs	Access
Act	Action, activity, active, activate
Actr	Actuator
Acu	Acoustic
Addr	Address
Adj	Adjustment
Admin	Administrative
Adp	Adapter, adaptation
Aff	Affected
Age	Ageing
Ahr	Ampere hours
Air	Air
Alg	Algorithm
Alm	Alarm
Als	Alarm set
Alt	Altitude
Altn	Alternate
Amnt	Amount
Amp	Ampere, current DC or non-phase-related AC
An	Analogue
Anc	Ancillary
Ane	Anemometer
Ang	Angle
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 Cl)
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
Cl	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
Dl	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
El	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
Flm	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
GoCBRe f	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
Hlf	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
Ianofo	Information available non-operative forced outage
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
IeeeKH1 1	Lead gain HF positive. Defined in IEEE 421.5
IeeeKH1 7	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
IeeeKL1 1	Lead gain LF positive. Defined in IEEE 421.5
IeeeKL1 7	Lead gain LF negative. Defined in IEEE 421.5
IeeeKL2	Proportional gain LF negative. Defined in IEEE 421.5

Term	Description
IeeeKs1	Gain Ks1. Defined in IEEE 421.5
IeeeKs2	Gain Ks2. Defined in IEEE 421.5
IeeeKs3	Gain Ks3. Defined in IEEE 421.5
IeeeM	Ramptrack lowpass degree M. Defined in IEEE 421.R
IeeeN	Ramptrack overall degree N. Defined in IEEE 421.5
IeeeT1	Time constant T1. Defined in IEEE 421.5
IeeeT10	Time constant T10. Defined in IEEE 421.5
IeeeT11	Time constant T11. Defined in IEEE 421.5
IeeeT2	Time constant T2. Defined in IEEE 421.5
IeeeT3	Time constant T3. Defined in IEEE 421.5
IeeeT4	Time constant T4. Defined in IEEE 421.5
IeeeT7	Time constant T7. Defined in IEEE 421.5
IeeeT8	Time constant T8. Defined in IEEE 421.5
IeeeT9	Time constant T9. Defined in IEEE 421.5
IeeeTH1	Time constant TH1 (High frequency positive). Defined in IEEE 421.5
IeeeTH10	Time constant TH10 (High frequency negative). Defined in IEEE 421.5
IeeeTH11	Time constant TH11 (High frequency negative). Defined in IEEE 421.5
IeeeTH12	Time constant TH12 (High frequency negative). Defined in IEEE 421.5
IeeeTH2	Time constant TH2 (High frequency positive). Defined in IEEE 421.5
IeeeTH3	Time constant TH3 (High frequency positive). Defined in IEEE 421.5
IeeeTH4	Time constant TH4 (High frequency positive). Defined in IEEE 421.5
IeeeTH5	Time constant TH5 (High frequency positive). Defined in IEEE 421.5
IeeeTH6	Time constant TH6 (High frequency positive). Defined in IEEE 421.5
IeeeTH7	Time constant TH7 (High frequency negative). Defined in IEEE 421.5
IeeeTH8	Time constant TH8 (High frequency negative). Defined in IEEE 421.5
IeeeTH9	Time constant TH9 (High frequency negative). Defined in IEEE 421.5
IeeeTI1	Time constant TI1 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI10	Time constant TI10 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI11	Time constant TI11 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI12	Time constant TI12 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI2	Time constant TI2 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI3	Time constant TI3 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI4	Time constant TI4 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI5	Time constant TI5 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI6	Time constant TI6 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI7	Time constant TI7 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI8	Time constant TI8 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI9	Time constant TI9 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTL1	Time constant TL1 (Low frequency positive). Defined in IEEE 421.5
IeeeTL10	Time constant TL10 (Low frequency negative). Defined in IEEE 421.5
IeeeTL11	Time constant TL11 (Low frequency negative). Defined in IEEE 421.5
IeeeTL12	Time constant TL12 (Low frequency negative). Defined in IEEE 421.5
IeeeTL2	Time constant TL2 (Low frequency positive). Defined in IEEE 421.5
IeeeTL3	Time constant TL3 (Low frequency positive). Defined in IEEE 421.5
IeeeTL4	Time constant TL4 (Low frequency positive). Defined in IEEE 421.5
IeeeTL5	Time constant TL5 (Low frequency positive). Defined in IEEE 421.5
IeeeTL6	Time constant TL6 (Low frequency positive). Defined in IEEE 421.5
IeeeTL7	Time constant TL7 (Low frequency negative). Defined in IEEE 421.5
IeeeTL8	Time constant TL8 (Low frequency negative). Defined in IEEE 421.5
IeeeTL9	Time constant TL9 (Low frequency negative). Defined in IEEE 421.5
IeeeTw1	Time constant wash out Tw1. Defined in IEEE 421.5
IeeeTw2	Time constant wash out Tw2. Defined in IEEE 421.5
IeeeTw3	Time constant wash out Tw3. Defined in IEEE 421.5
IeeeTw4	Time constant wash out Tw4. Defined in IEEE 421.5
IeeeVHMax	Maximum limit set-point HF. Defined in IEEE 421.5
IeeeVHMin	Minimum limit set-point HF. Defined in IEEE 421.5
IeeeVIMax	Maximum limit set-point IF. Defined in IEEE 421.5
IeeeVIMin	Minimum limit set-point IF. Defined in IEEE 421.5
IeeeVLMax	Maximum limit set-point LF. Defined in IEEE 421.5
IeeeVLMin	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
IeeeVstM ax	Output High Limit. Defined in IEEE 421.5
IeeeVstM in	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
Intn	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
Ll	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	Nogotiation
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
Pls	Pulse
Plt	Plate; long-term flicker severity
Pmp	Pump
Po	Polar
Pol	Polarizing
Polytr	Polytropic
Port	Port
Pos	Position
Pot	Potentiometer
Prc	Price, pricing
Pre	Pre-
Prec	Precondition, initial status
Pres	Pressure
Prg	Progress, in progress
Prim	Primary
Prio	priority
Prm	Permissive
Pro	Protection
Proc	Process
Proxy	Proxy
Prs	Presence
Prt	Parts, part
Ps	Positive
Psk	Penstock
Pss	PSS, power system stabiliser function
Pst	Post, short-term flicker severity
Pt	Point
Pth	Pitch
Pwr	Power
Qty	Quantity
Qu	Queue
Qud	Quad
R	Raise, increase
Rad	Radiation
Ral	Rail
Ramp	Ramp
Rat	Ratio
Rb	Runner blade
Rcd	Record, recording
Rch	Reach
Rcl	Reclaim
Rct	Reaction
Rdy	Ready
Re	Retry

Term	Description
React	Reactance, reactive
Rec	Reclose
Rec1	Reclose after single phase fault
Rec13	Reclose after evolving fault
Rec3	Reclose after three phase fault
Recha	Recharge, recharging
Rect	Rectifier
Red	Redundant; (deprecated meaning) reduction
Ref	Reference
Reg	Regulation
Rel	Release
Req	Requested
Res	Residual
Reso	Resonance
Reuse	Reuse
Rf	Refreshment
Rin	Reinsertion
Ris	Resistance
Rl	Relation, relative
Rm	Mutual resistance
Rmp	Ramping, ramp
Rms	Root mean square
Rn	Rain
Rnbk	Runback
Rng	Range
Rod	Rod
Root	Root
Rot	Rotation, rotor
Rpt	Repeat, repetition
Rs	Reset, resettable
Rsl	Result
Rst	Restraint, restriction
Rsv	Reserve
Rt	Ride-through
Rte	Rate
Rtg	Rating
Rub	Run-up/back
Run	Run
Rv	Reverse
Rvc	Rapid voltage change
Rvrt	Revert
Rwy	Runaway, e.g. in runaway speed
Rx	Receive, received
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
SPl	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
Task	Task
Td	Transformer derating
Td0p	Td0'
Td0s	Td0''
Tdd	Total demand distortion
Tdf	Transformer derating factor
Tdp	Td'
Tds	Td''
Tech	Technology
Term	Termination
Test	Test
Tgt	Target
Thd	Total harmonic distortion
Thm	Thermal
Ti	Telephone influence
Tilt	Tilt
Tm	Time
Tm1	Time constant 1
Tm2	Time constant 2
Tm3	Time constant 3
Tmh	Time in h
Tmm	Time in min
Tmms	Time in ms
Tmp	Temperature (°C)
Tms	Time in s
Tnk	Tank
Tns	Tension (stress)
Top	Top (position)
Topo	Topology
Torq	Torque
Tot	Total
Tow	Tower
Tp	Test Point
Tpc	Teleprotection
Tpy	Temporarily
Tq0p	Tq0'
Tq0s	Tq0''
Tqp	Tq'
Tqs	Tq''
Tr	Trip (electrical protection function)
Trf	Transformer
Trg	Trigger
Trip	Trip (non-electrical function)
Trk	Track, tracking
Trp	Transient Performance Class
Trs	Transient
Trunk	Trunk
Ts	Total signed
Tu	Total unsigned
Tun	Tuning
Tur	Turbine
Tx	Transmit, transmitted
Typ	Type
UPS	Uninterruptible power supply
UTC	Coordinated Universal Time
Uhf	Ultra-high-frequency
Un	Un-; under
Unav	Unavailable
Unb	Unbalanced
Unld	Unload
Unt	Unit, production unit
Up	Up, upstream
Ups	Uninterruptible Power Supply
Urcb	Unbuffered report control block
Use	Use
Used	Used
Usvcb	Unicast sampled values control block
Util	Utility
V	Voltage
V1	Voltage at side 1
V2	Voltage at side 2
VA	Apparent power (volt amperes)
VAh	Apparent energy
VAr	Reactive power (volt amperes reactive)
VArh	Reactive energy
Va	Variation
Vac	Vacuum
Val	Value
Vbr	Vibration
Ver	Vertical
Viol	Violation
Vis	Visibility
Visc	Viscosity
Vlan	VLAN
Vld	Valid, validate, validated
Vlm	Volume
Vlv	Valve
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

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

NOTE These definitions are aligned with the conventional usage of “Transient” in textbooks relating to Network protection and Automation and with:

- [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.

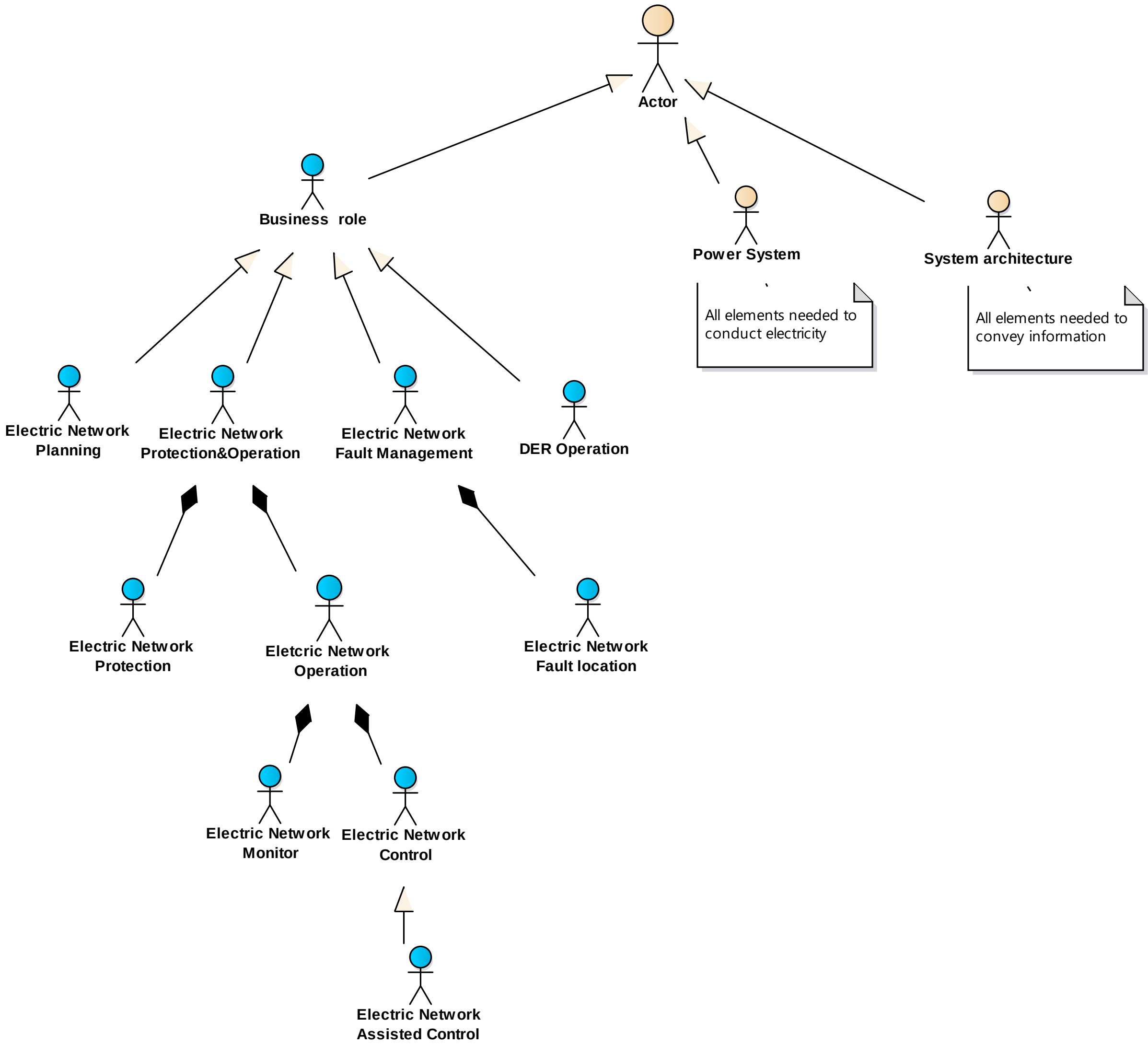


Figure 1 – Actors top level hierarchy

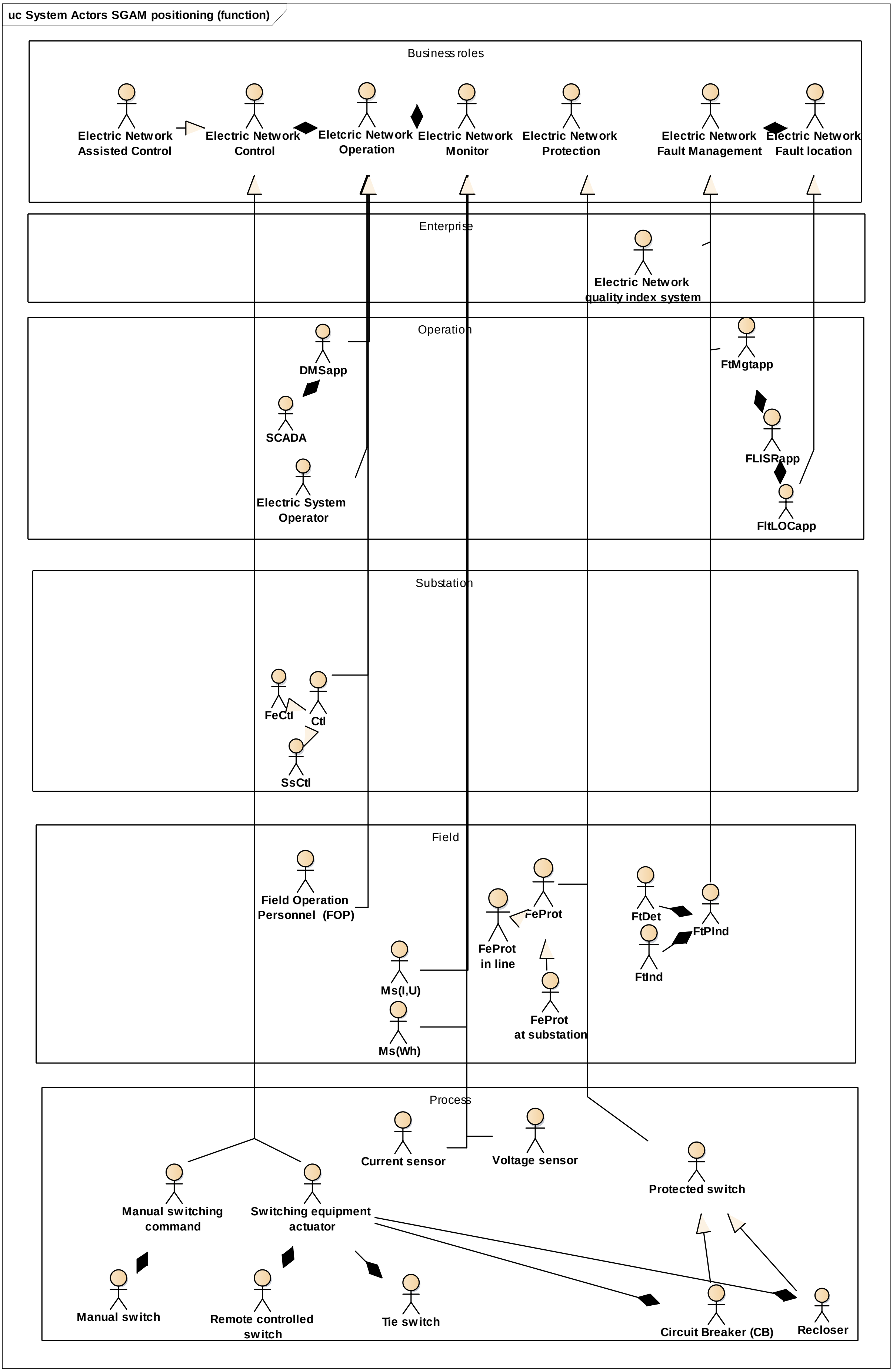


Figure 2 – System Actors SGAM positioning (function)

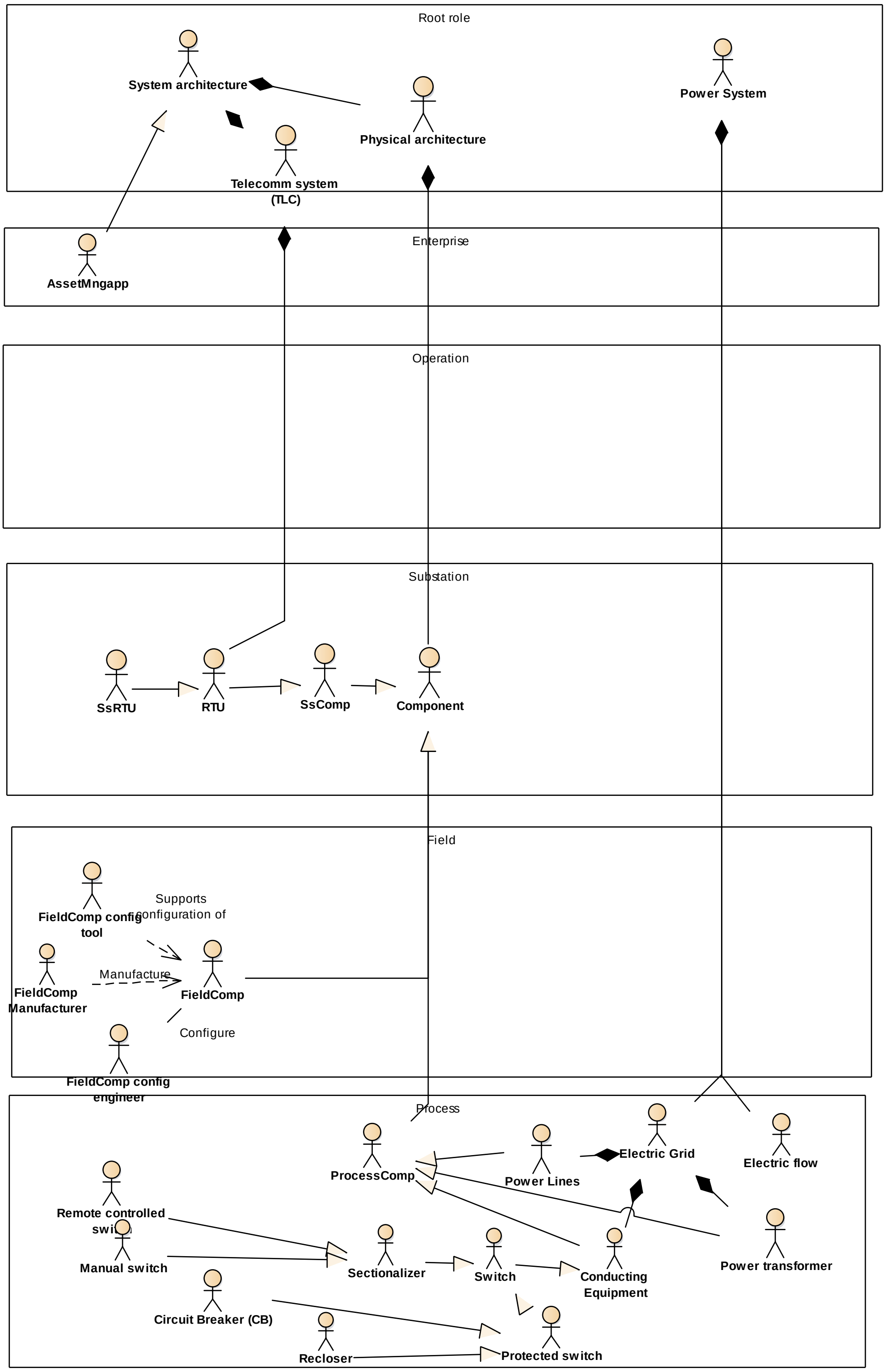


Figure 3 – System Actors SGAM positioning (not function related)

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 filed 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).

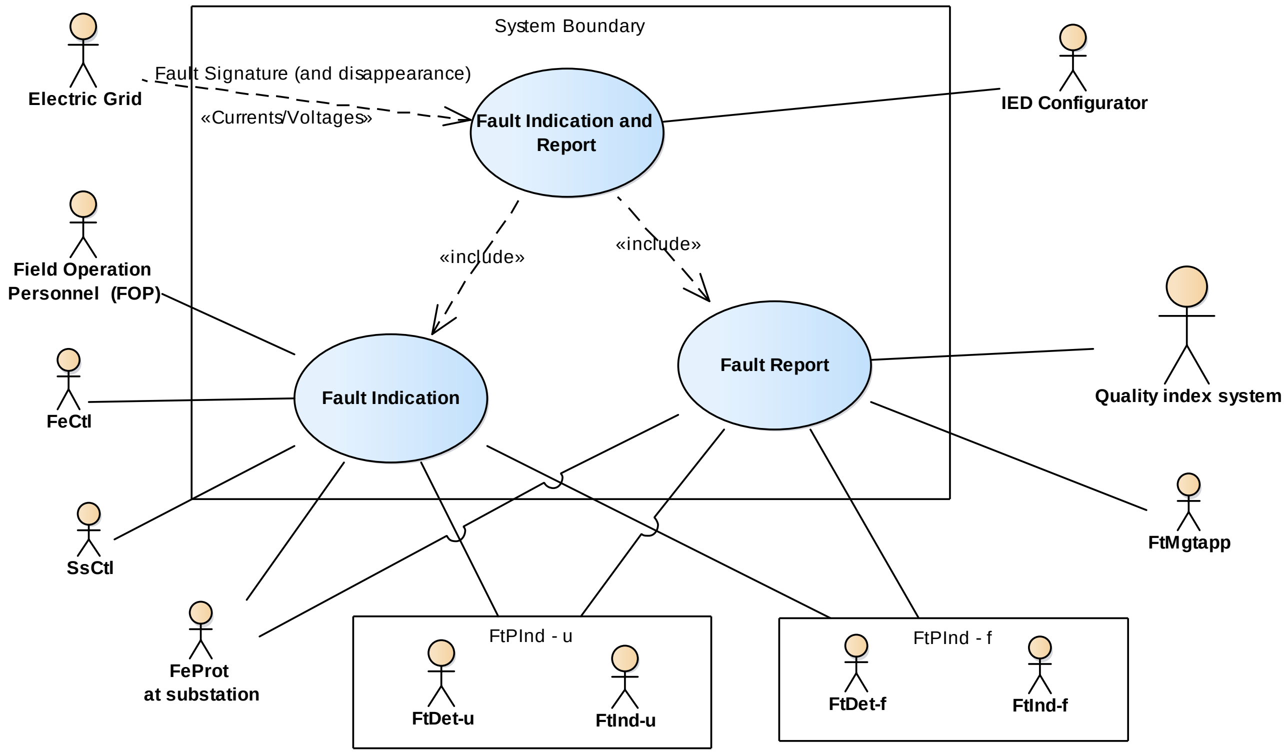


Figure 4 – Fault indication – Main use case

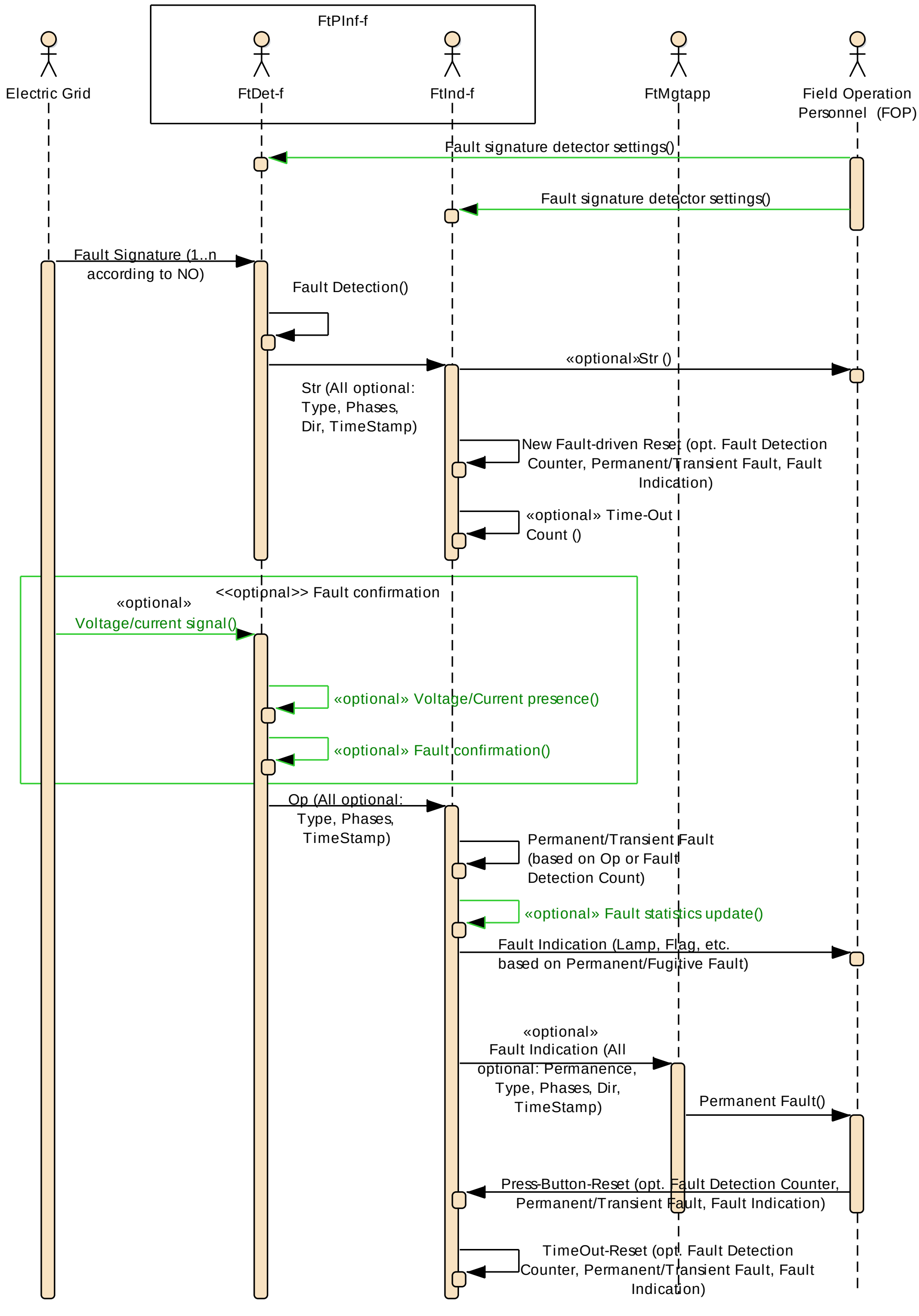


Figure 5 – Fault indication for FPI – T1

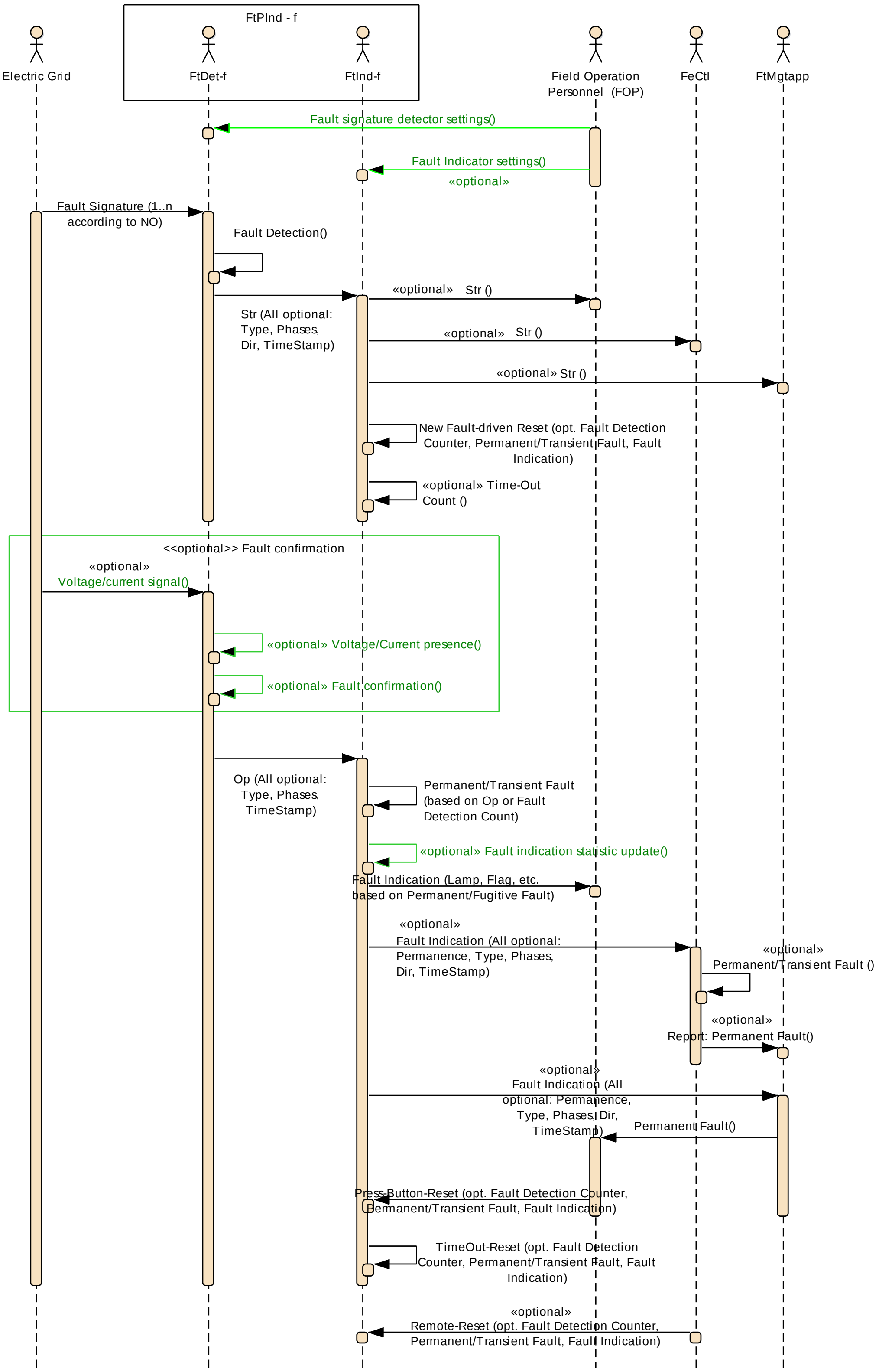


Figure 6 – Fault indication and report for FPI – T2

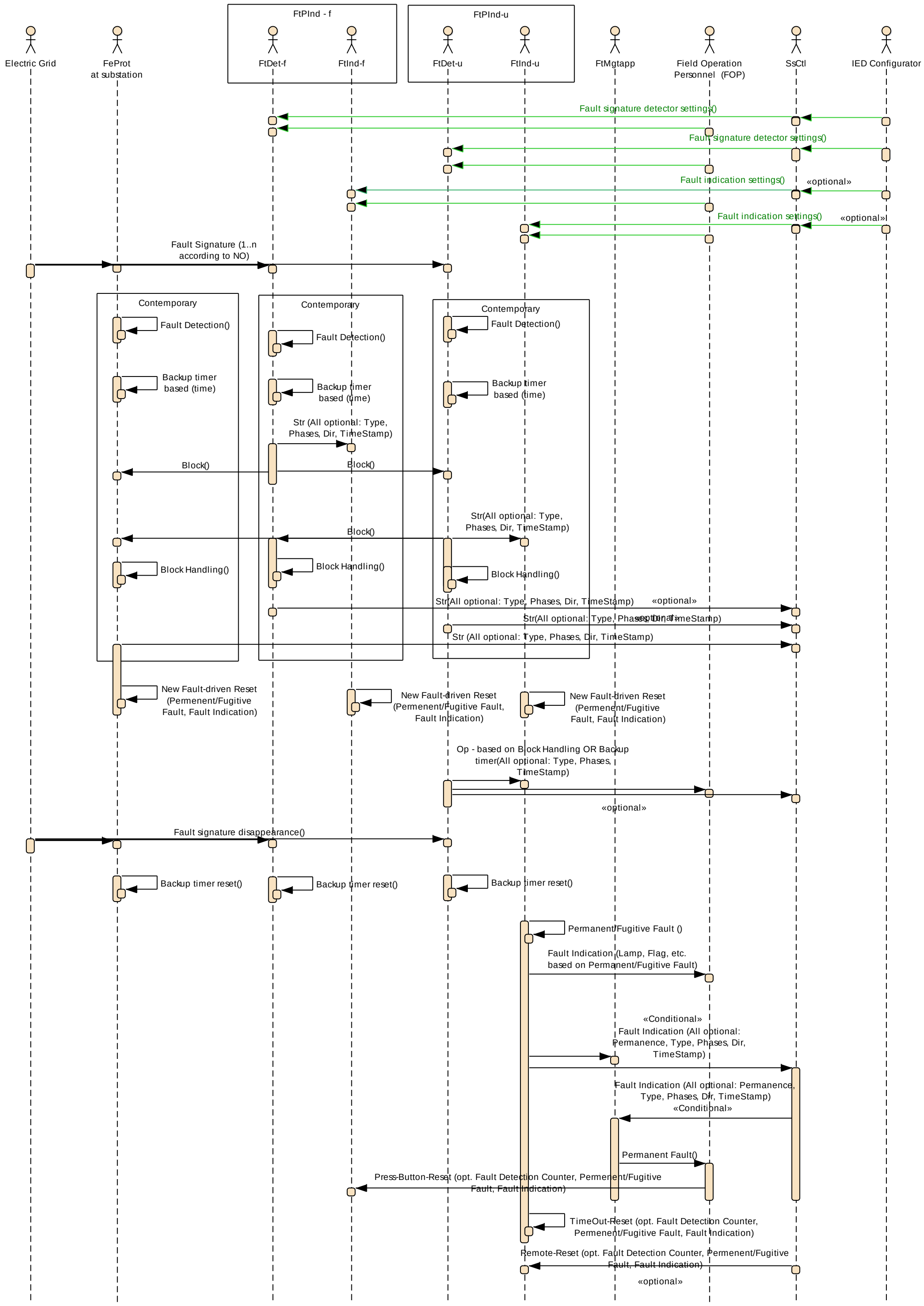


Figure 7 – Fault indication for FPI – T3,T4 (with communication to HV/MV SS) in the context of FLISR as described in 5.4

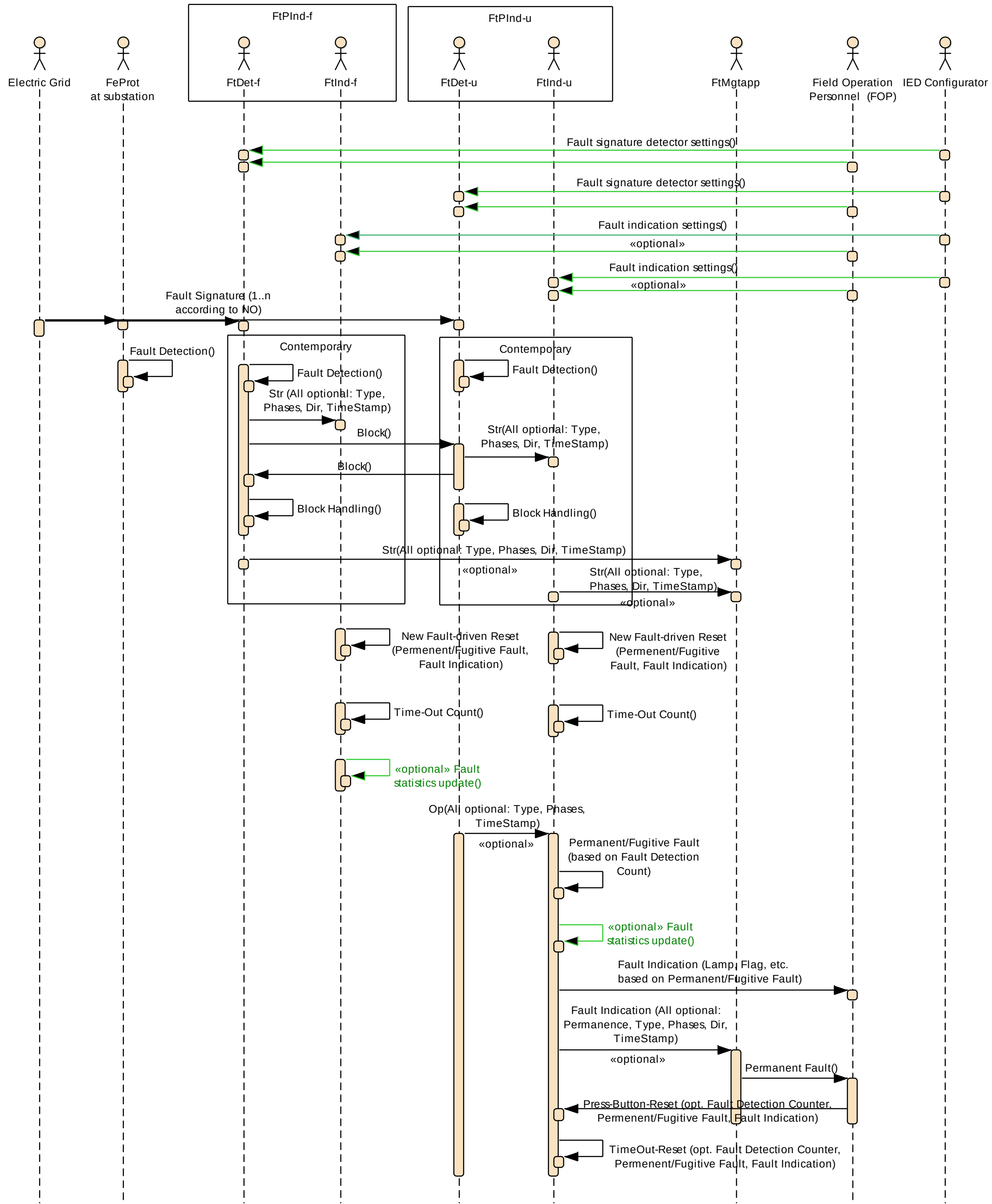


Figure 8 – Fault indication for FPI – T3,T4 (without communication to HV/MV SS) in the context of FLISR as described in 5.4

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 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-undervoltage, 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.

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

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 OpDlTmms=Tp are reached)

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

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

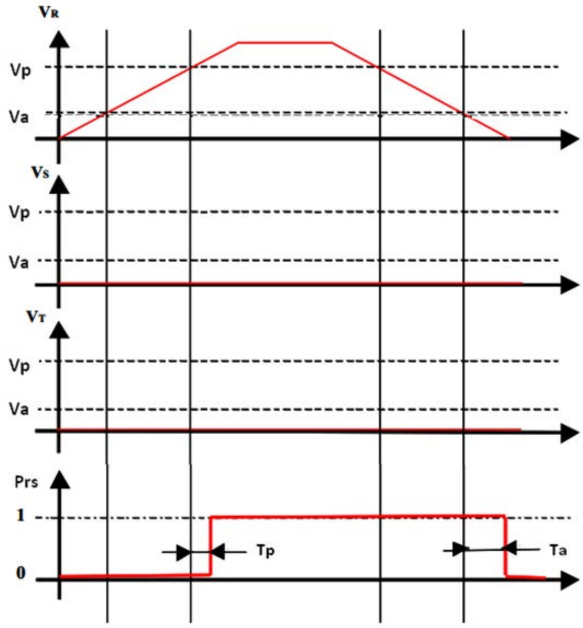


Figure 9 – Voltage Presence/Absence

- **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 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:

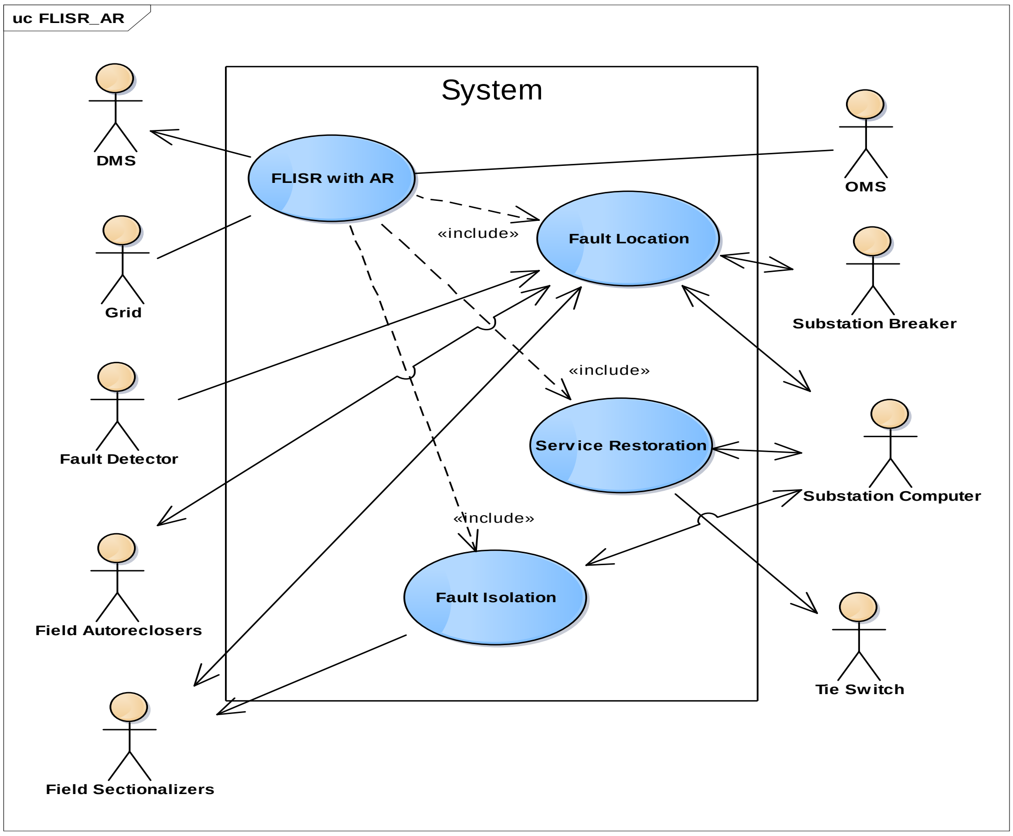


Figure 10 – FLISR use case breakdown

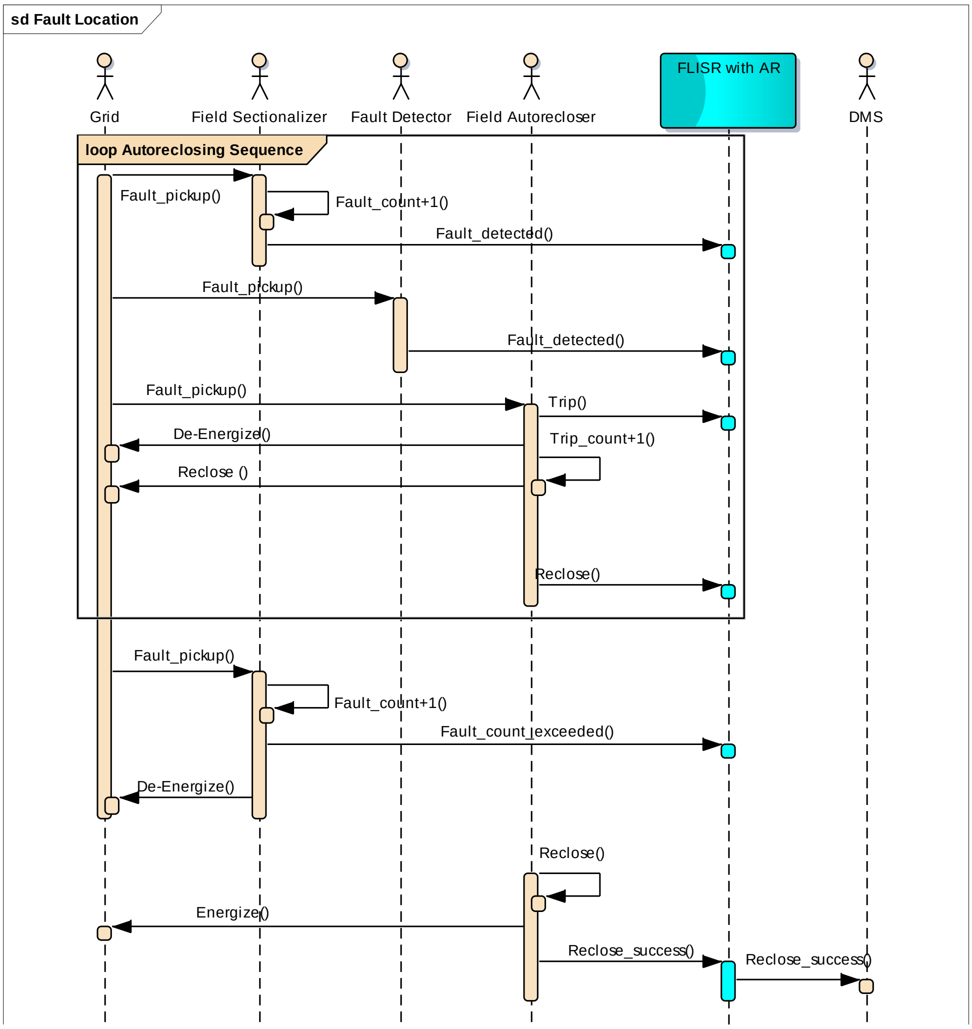


Figure 11 – Fault location sequence diagram

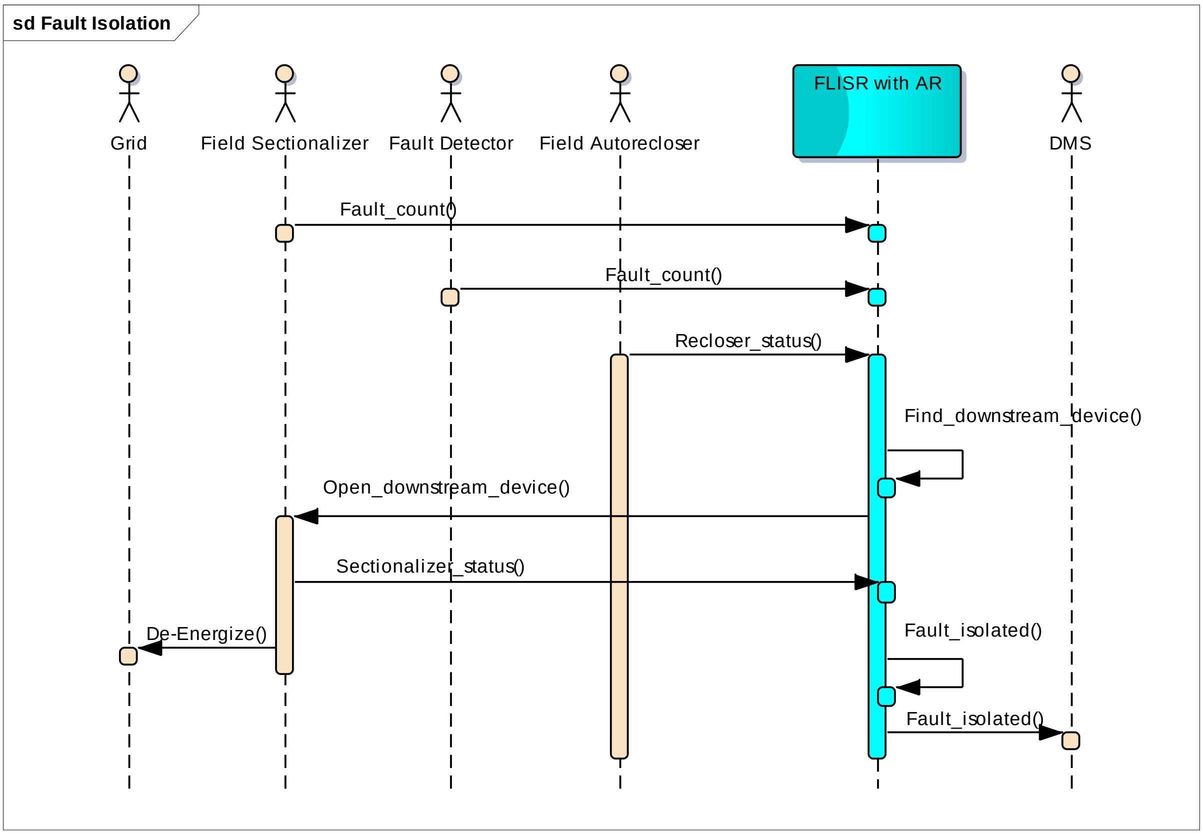


Figure 12 – Fault isolation sequence diagram

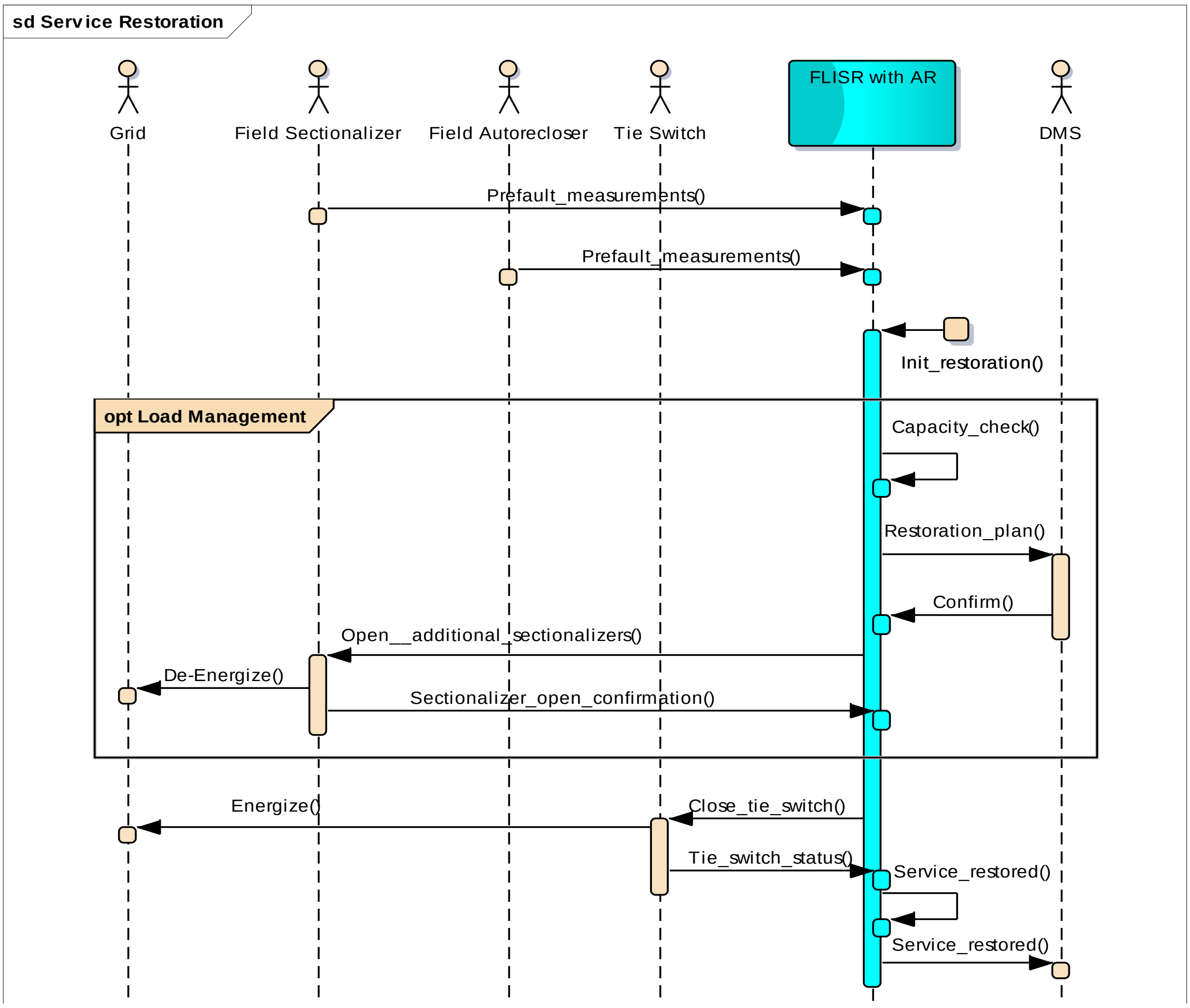


Figure 13 – Service restoration sequence diagram

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				

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	

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.

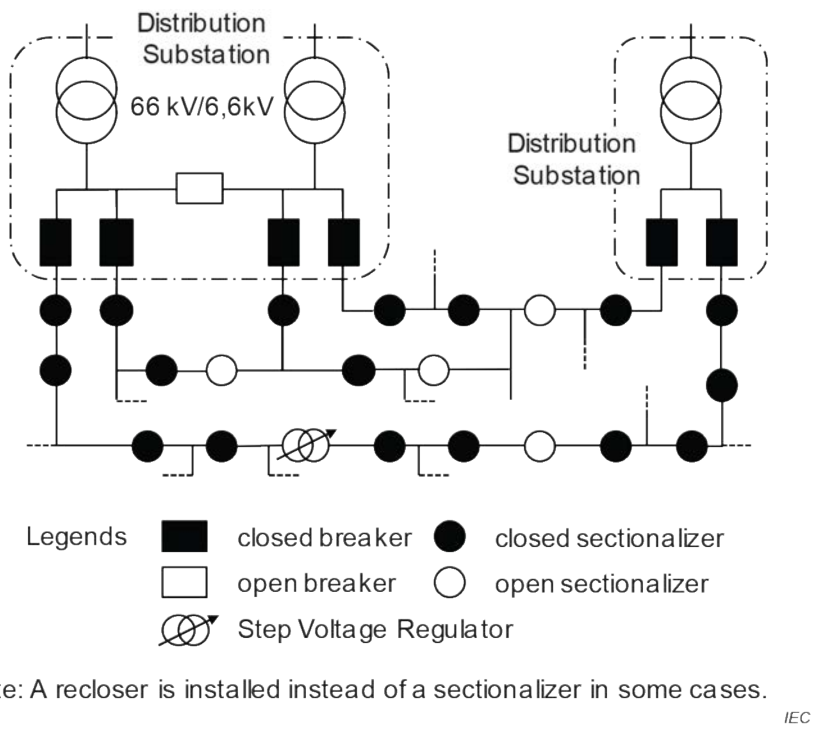


Figure 14 – A distribution grid configuration in a multi-source network based on open loops

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.

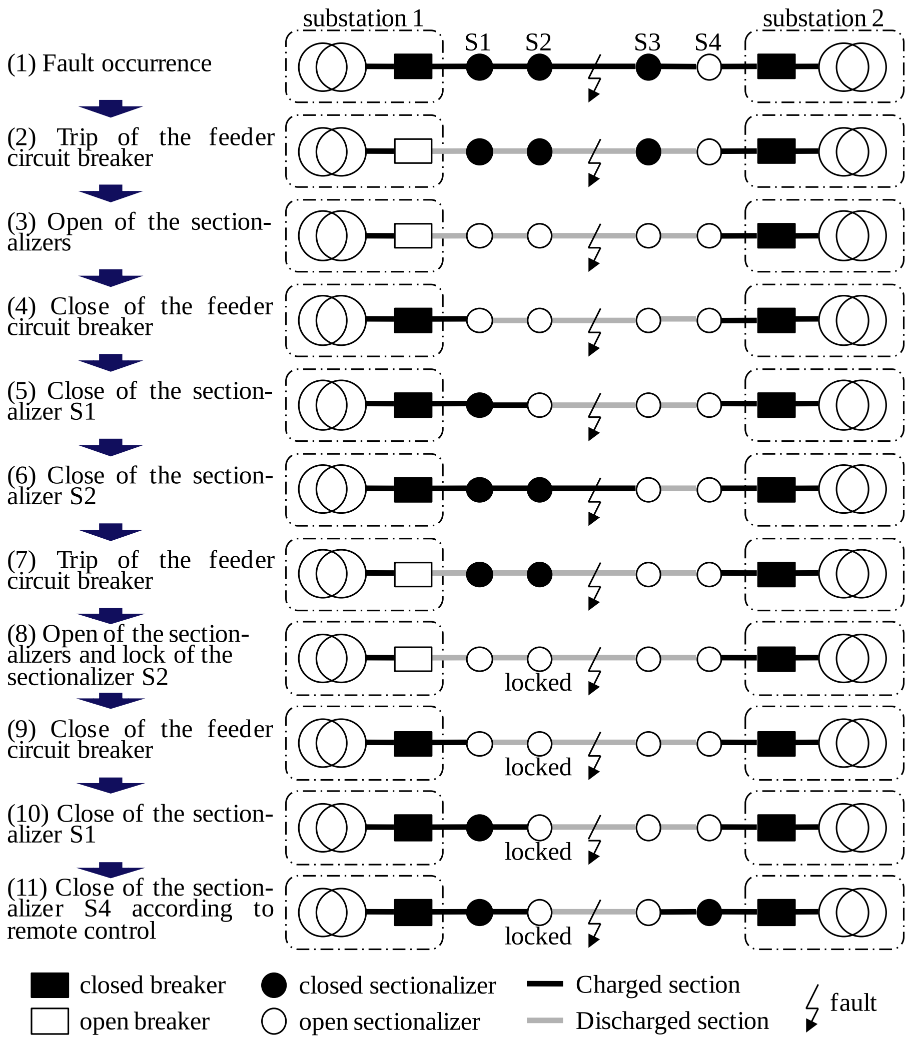


Figure 15 – The basic behavior of distribution feeder in FLISR using sectionalizers detecting feeder voltage

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.

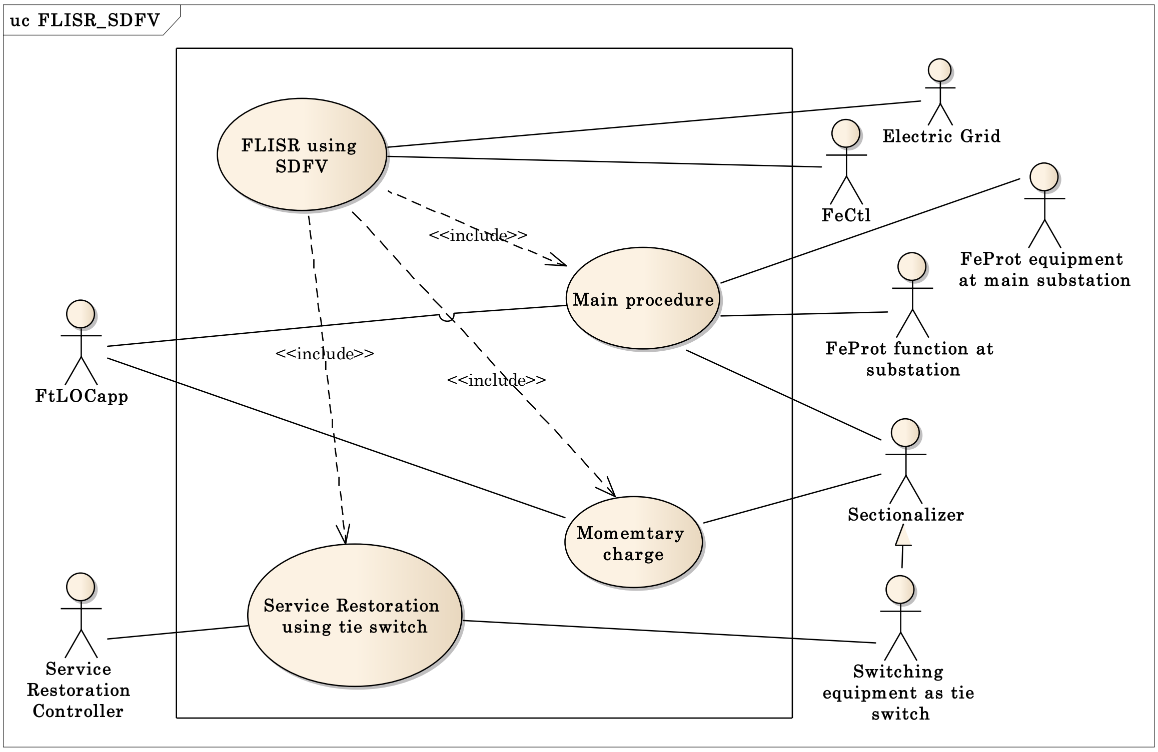


Figure 16 – FLISR-SDFV use case break down

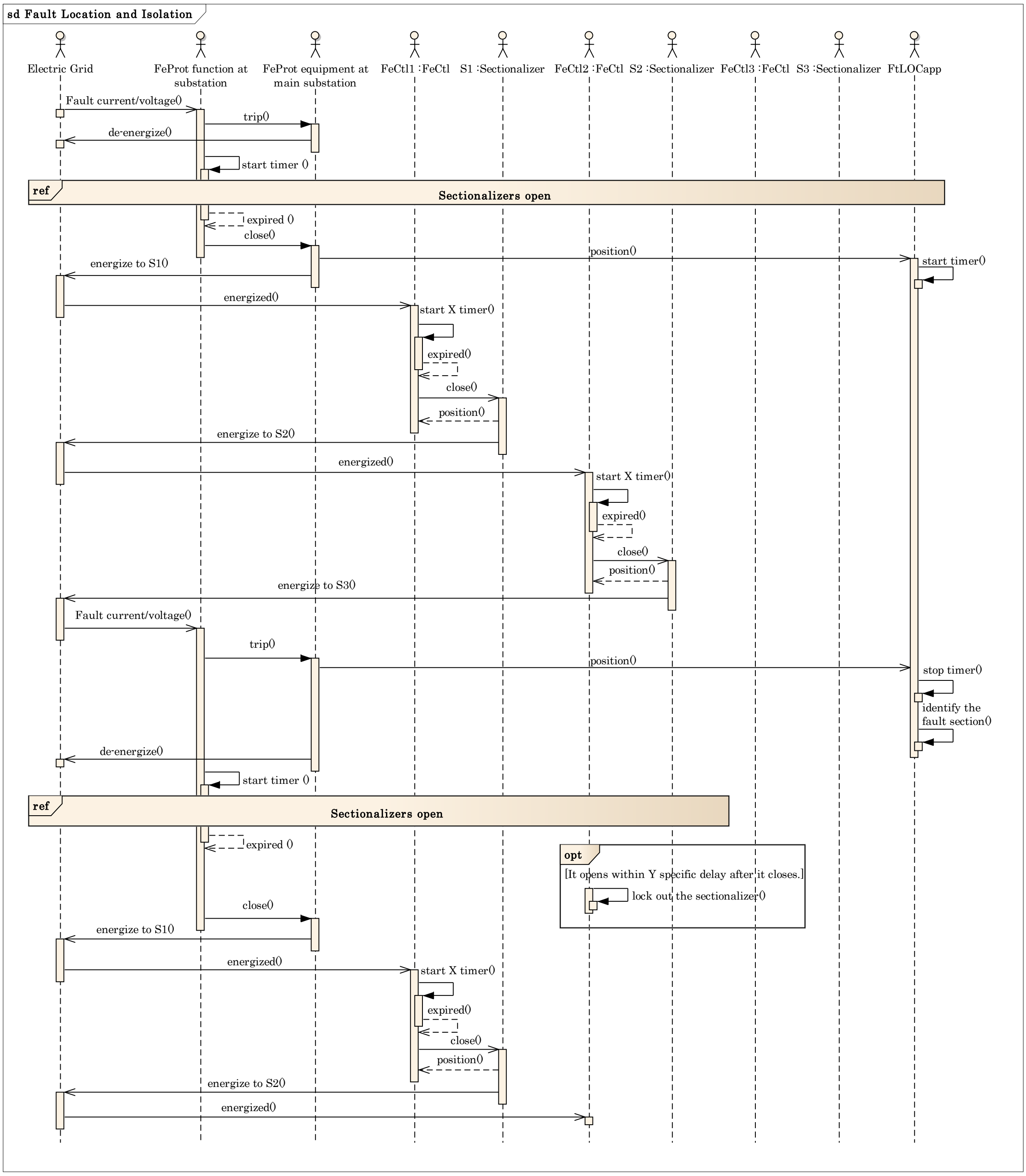


Figure 17 – FLISR-SDFV Fault Location and Identification sequence diagram

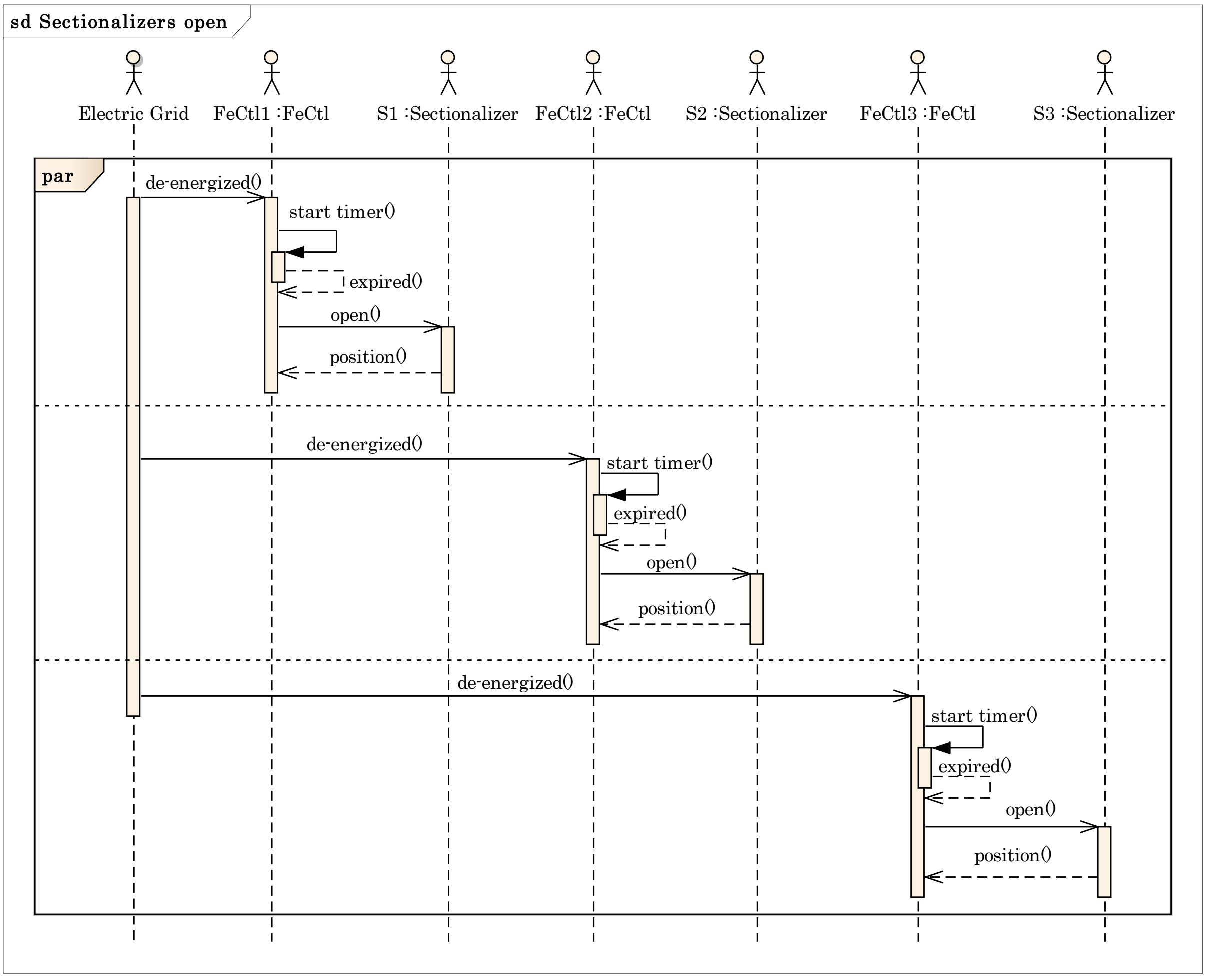


Figure 18 – FLISR-SDFV Fault Location and Identification sequence diagram

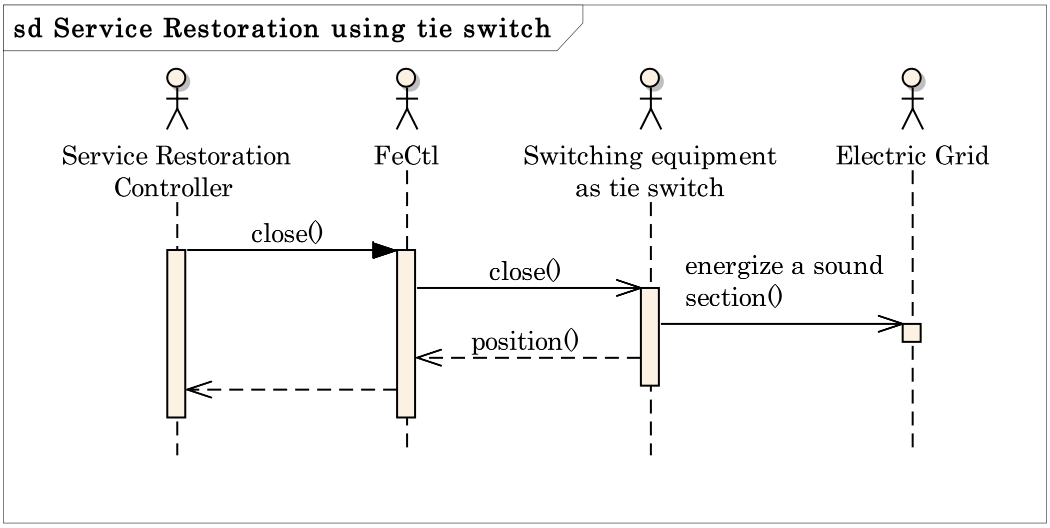


Figure 19 – FLISR-SDFV Fault Location and Identification sequence diagram

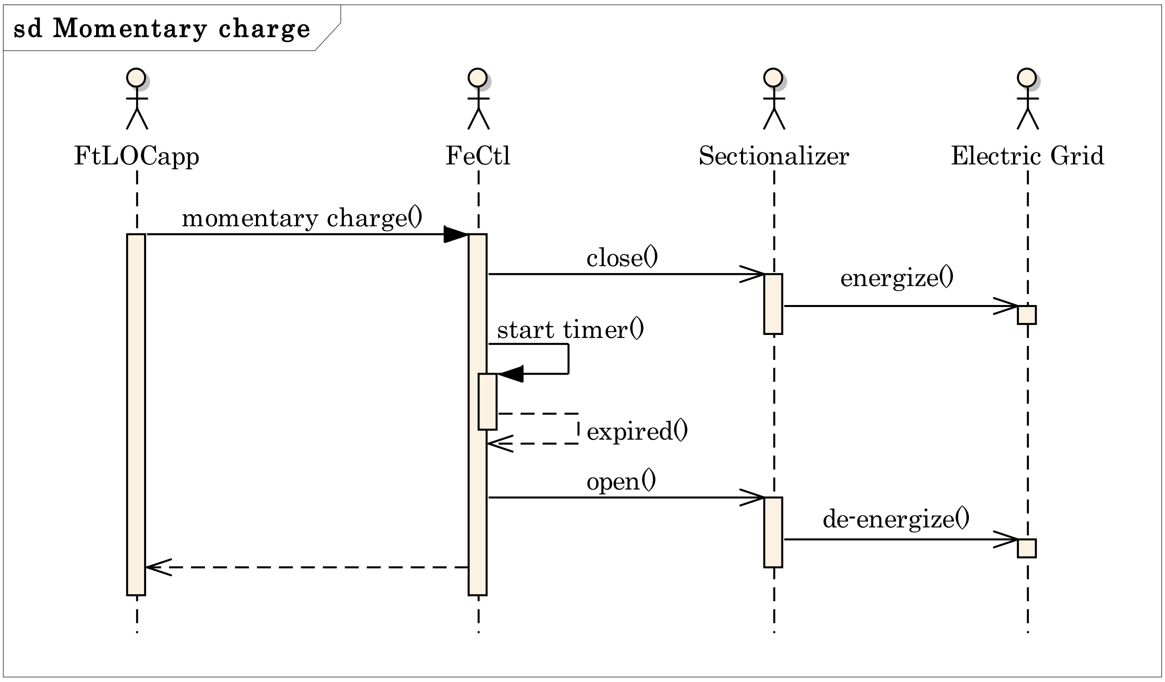


Figure 20 – FLISR-SDFV Fault Location and Identification sequence diagram

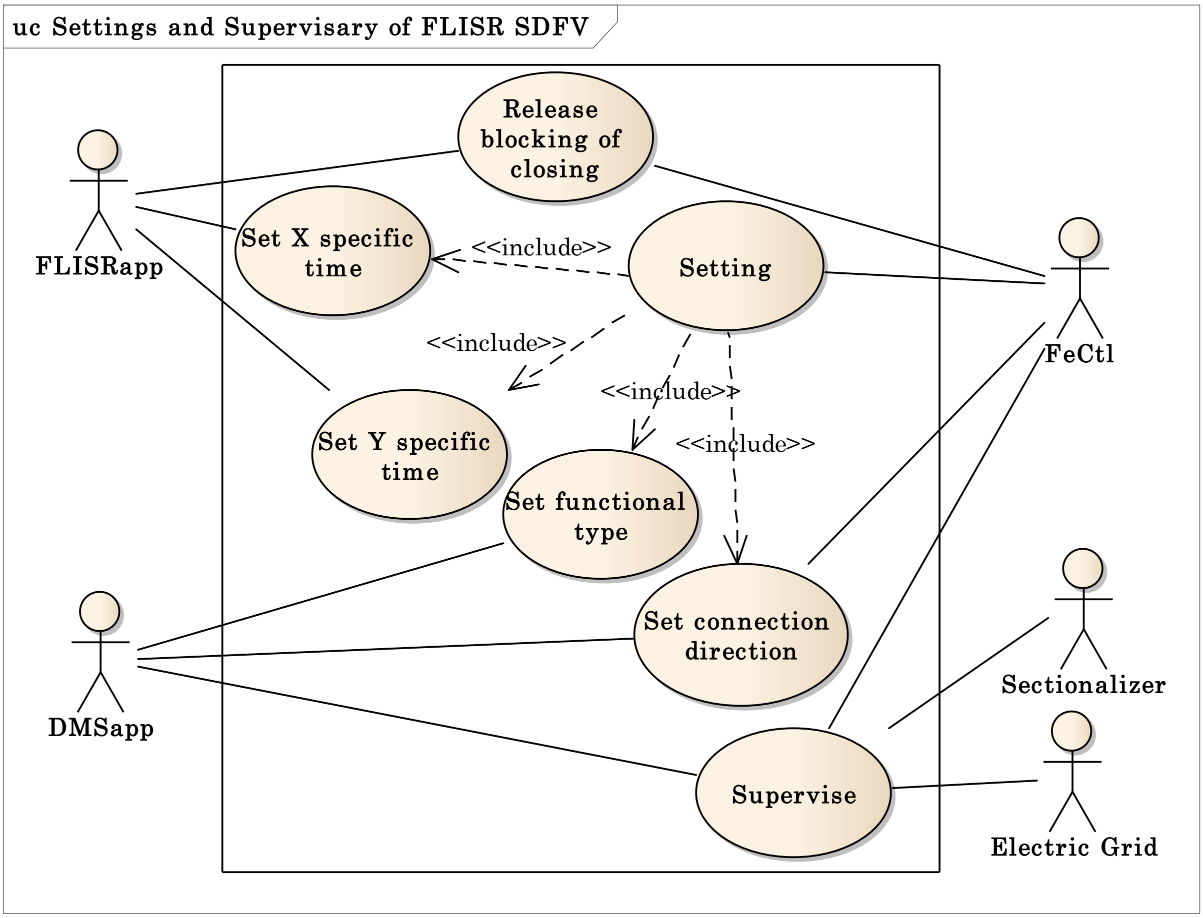


Figure 21 – Auxiliary use cases for FLISR using SDFV

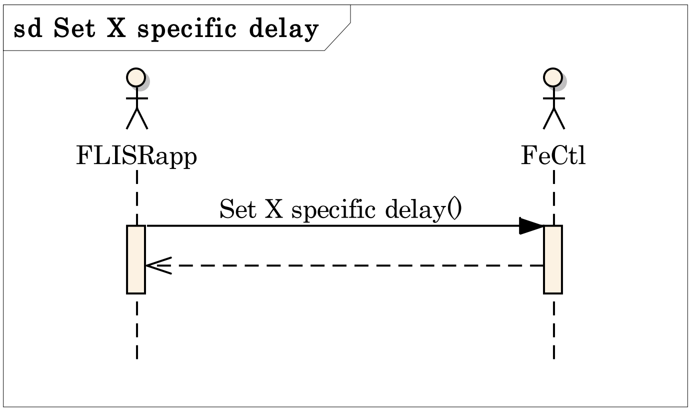


Figure 22 – FLISR-SDFV Set X specific time sequence diagram

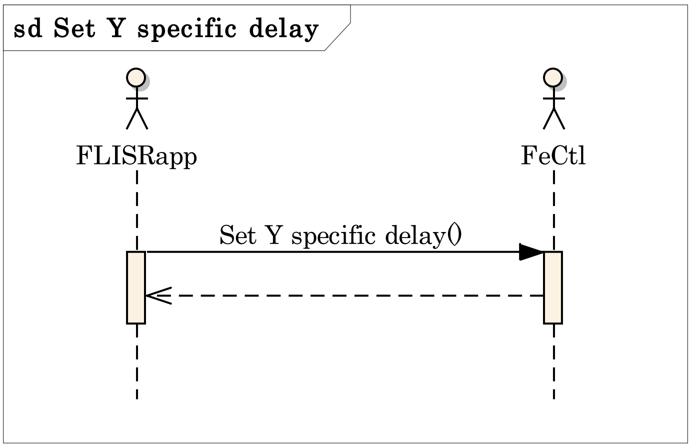


Figure 23 – FLISR-SDFV Set Y specific time sequence diagram

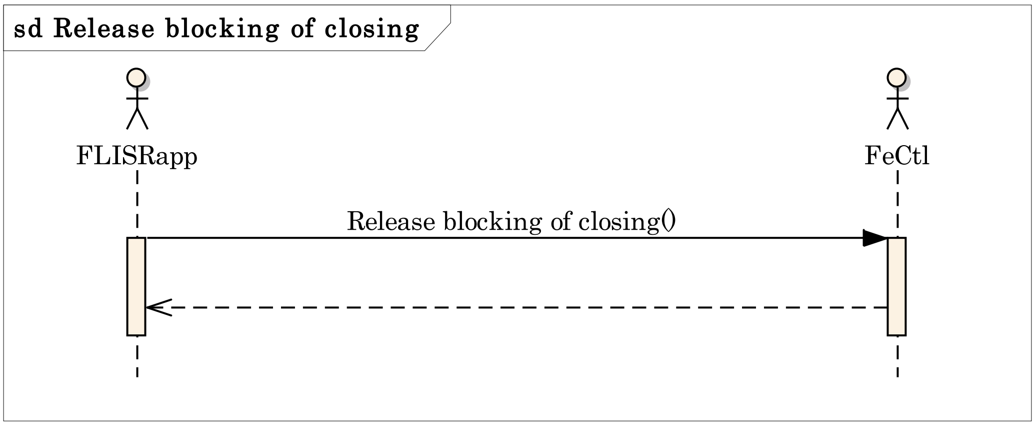


Figure 24 – FLISR-SDFV Release blocking of closing sequence diagram

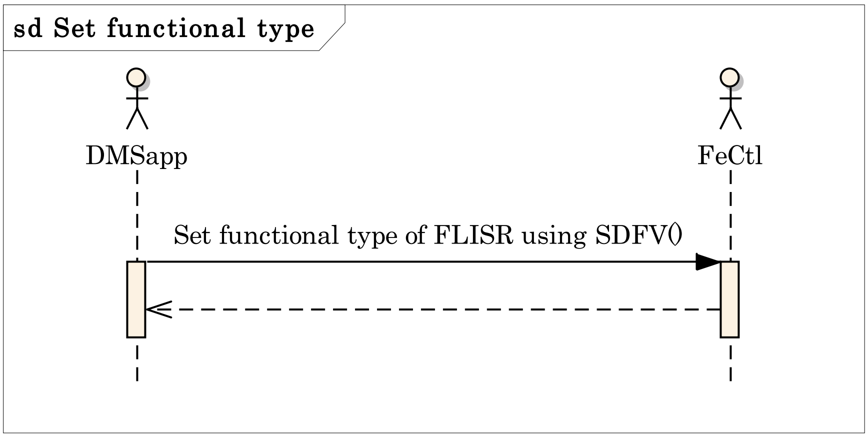


Figure 25 – FLISR-SDFV Set functional type sequence diagram

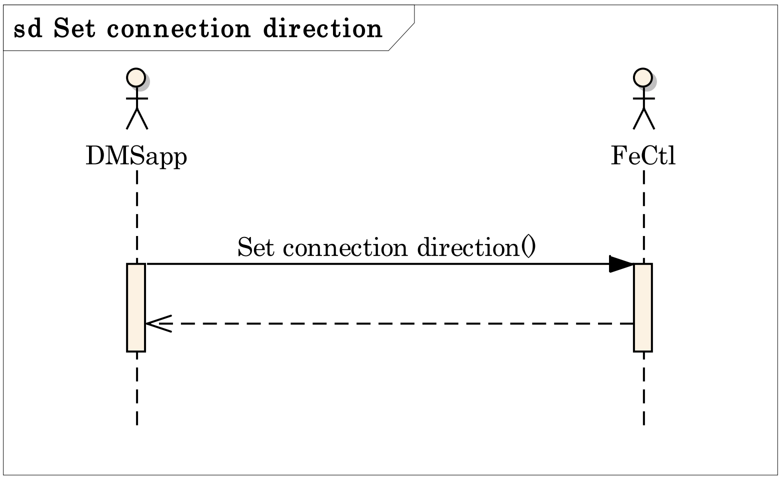


Figure 26 – FLISR-SDFV Set connection direction sequence diagram

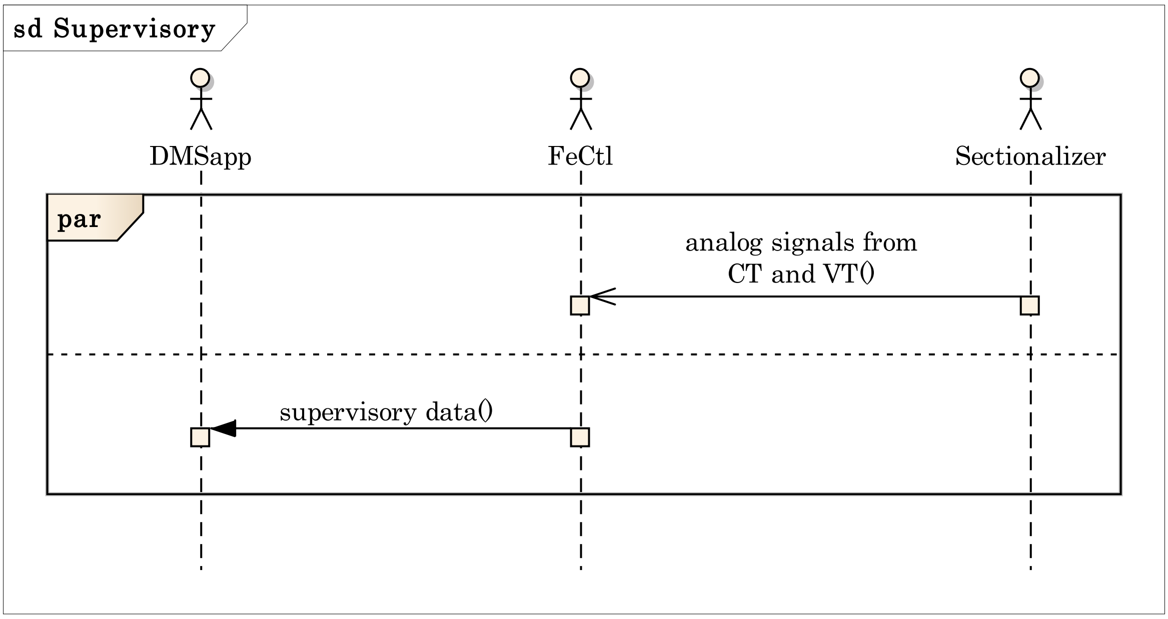


Figure 27 – FLISR-SDFV Supervisory sequence diagram

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.

5.3.3.3.3 Further information to the use case for classification / mapping

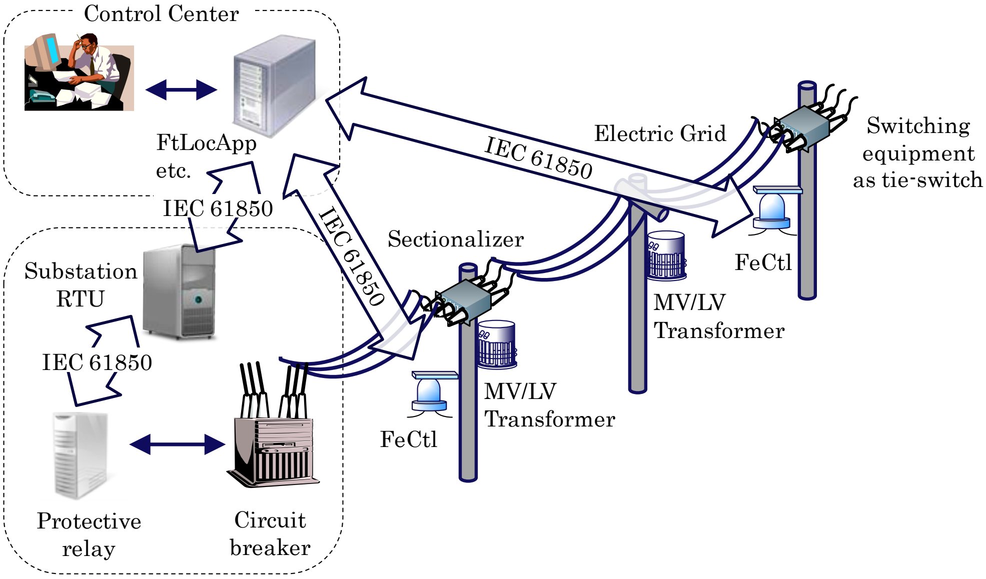


Figure 28 – Common actors in a distribution system with FLISR using SDFV

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	

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 sectionalizer		The connection direction of a sectionalizer 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 sectionalizer sample current and voltage respectively.		Sectionalizer	FeCtl		
7	Fault recognition by FeCtl		FeCtls 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 sectionalizer 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 sectionalizer or circuit breaker is open or closed.	
Open command	A command issued by a device such as FeCtl to open the sectionalizer. For some types of sectionalizers 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 sectionalizer.	
Lock out command	A command issued by the FeCtl to keep the sectionalizer 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 case3b 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.

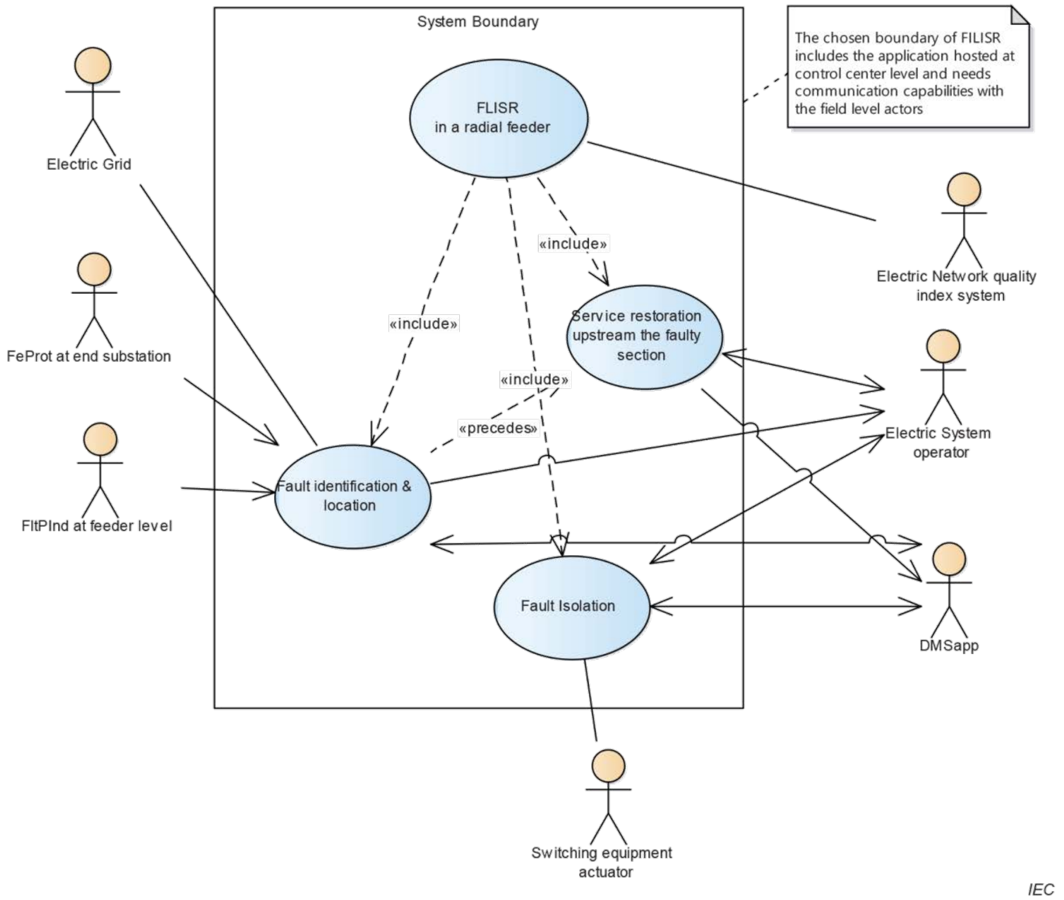


Figure 29 – Centralized FLISR in a radial feeder – Use cases

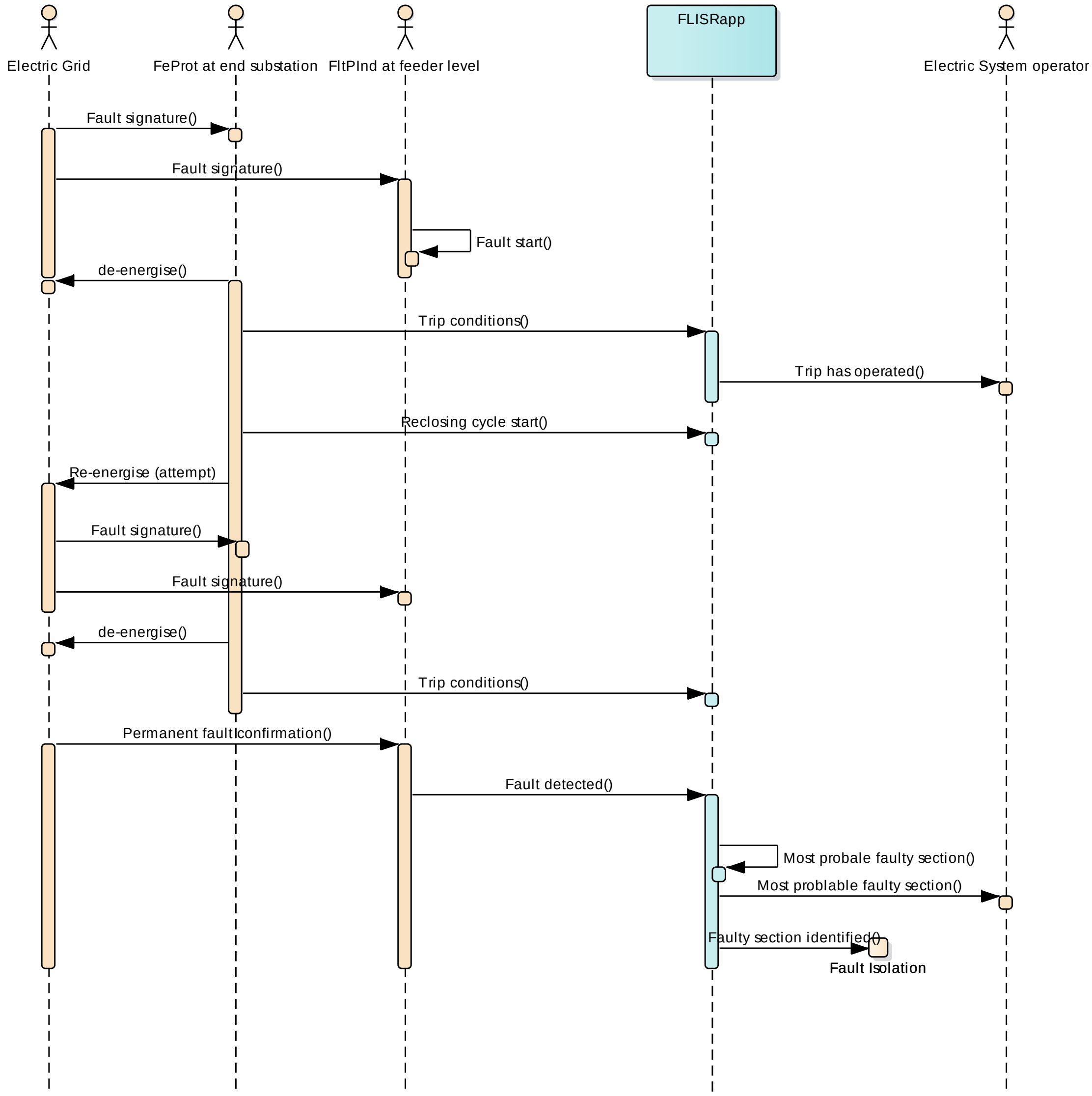


Figure 30 – Centralized FLISR for radial feeder – Fault location sequence diagram

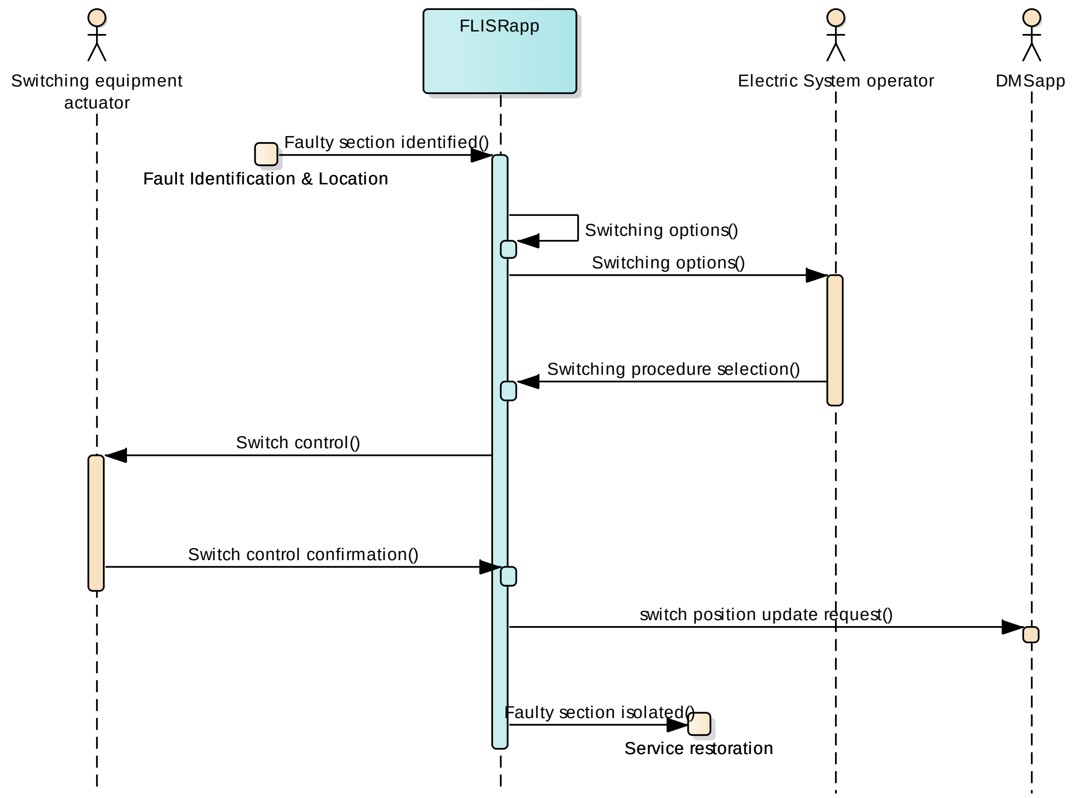


Figure 31 – Centralized FLISR for radial feeder – Fault isolation sequence diagram

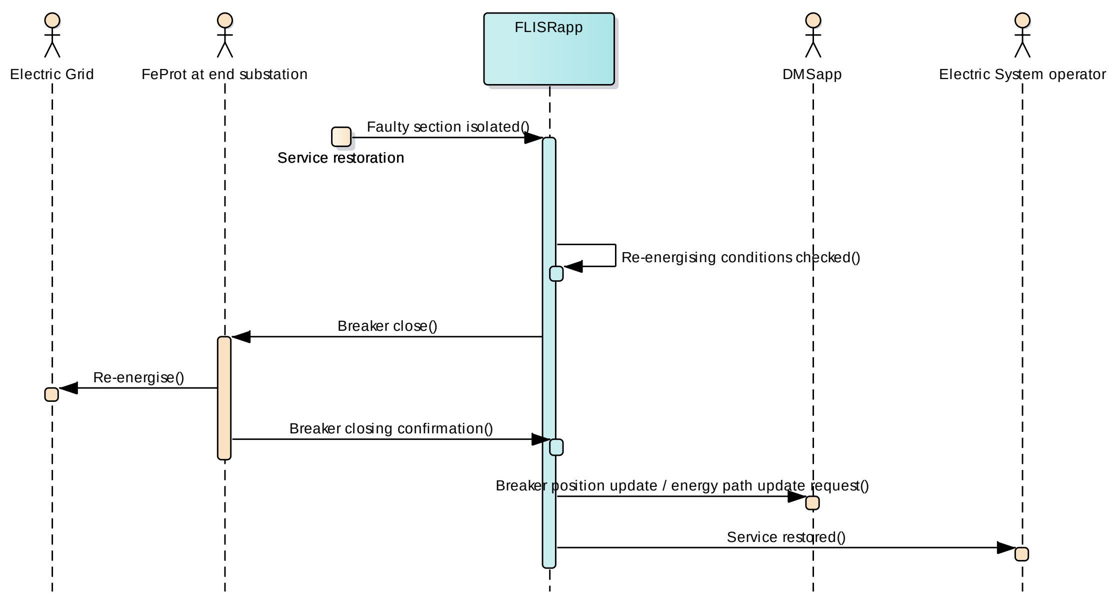


Figure 32 – Centralized FLISR for radial feeder – Service restoration sequence diagram

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 DER device	“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 down stream 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.

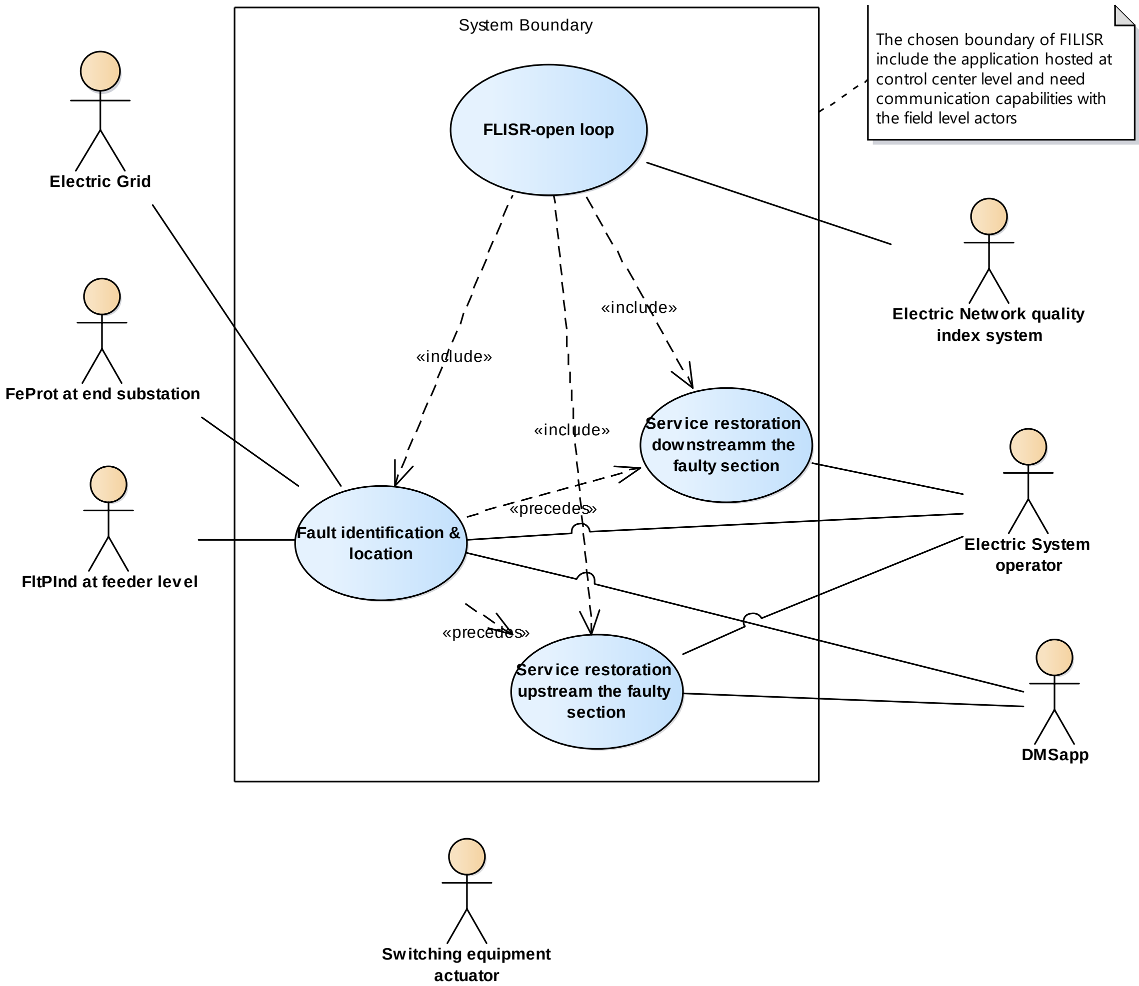
5.4.3.1.6 General remarks

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

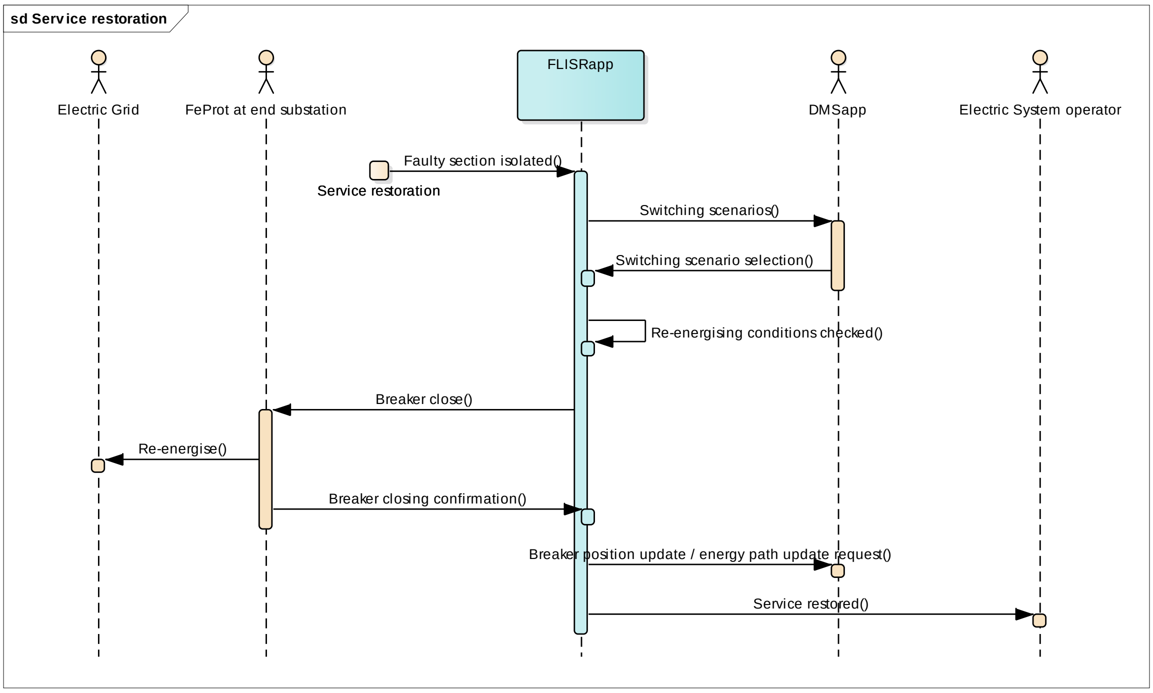


Figure 34 – Centralized FLISR for open loop – Service restoration sequence diagram

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 FeCtls, and controls the service restoration of downstream healthy sections of a fault. Having detected a permanent fault, the FeCtls 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 FeCtls are all collectively designated as FeCtls. 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 FeCtls can be extracted from the configuration file of FeCtls.

The service restoration controller recognizes the real time topology of the feeder by polling its neighboring FeCtls 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 FeCtls 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 FeCtls 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 FeCtls after receiving the information from FeProt2 at end substation. Then FeCtl3 will begin to poll the neighboring FeCtls 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.

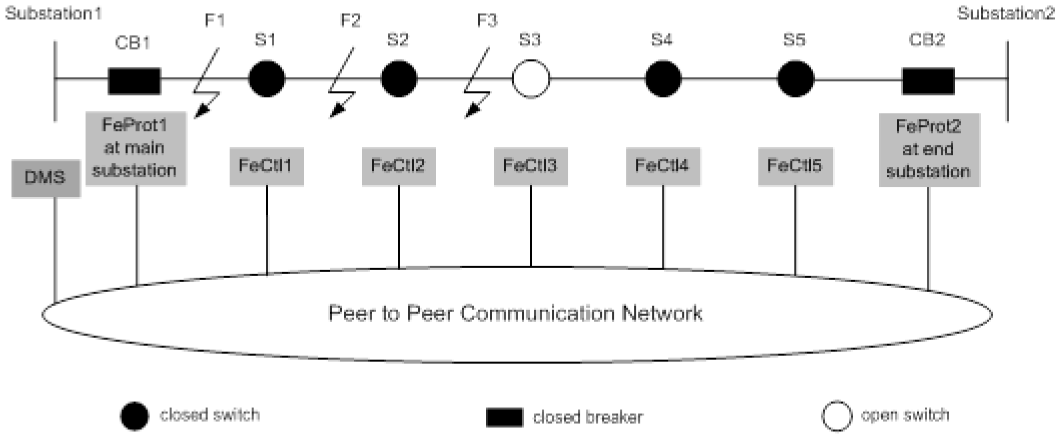


Figure 35 – A distributed DAS for an open loop overhead feeder

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 FeCtls in the feeder.

If the configuration of an FeCtl in the network changes, the FeCtl will broadcast a notice message to the other FeCtls 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 FeCtls 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 FeCtls will communicate with its adjacent FeCtls 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 FeCtls 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 substation1 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. Therefor 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 heathy 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 FeCtls 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 FeCtls 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 occuring 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 FeCtls. The identity of the tie-switch is recognized by the associated FeCtls 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.

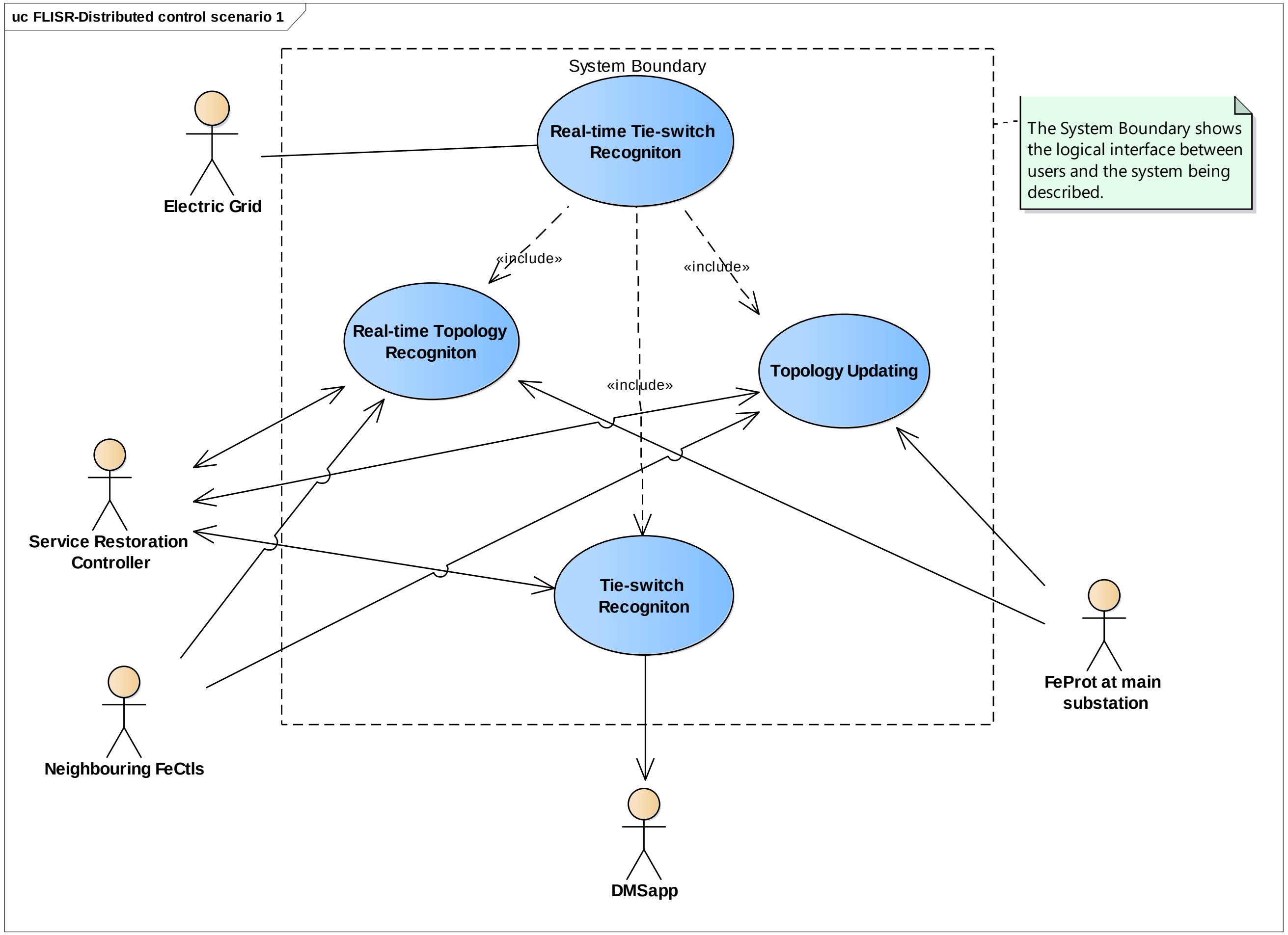


Figure 36 – Distributed FLISR in an open loop network – Upstream use cases breakdown

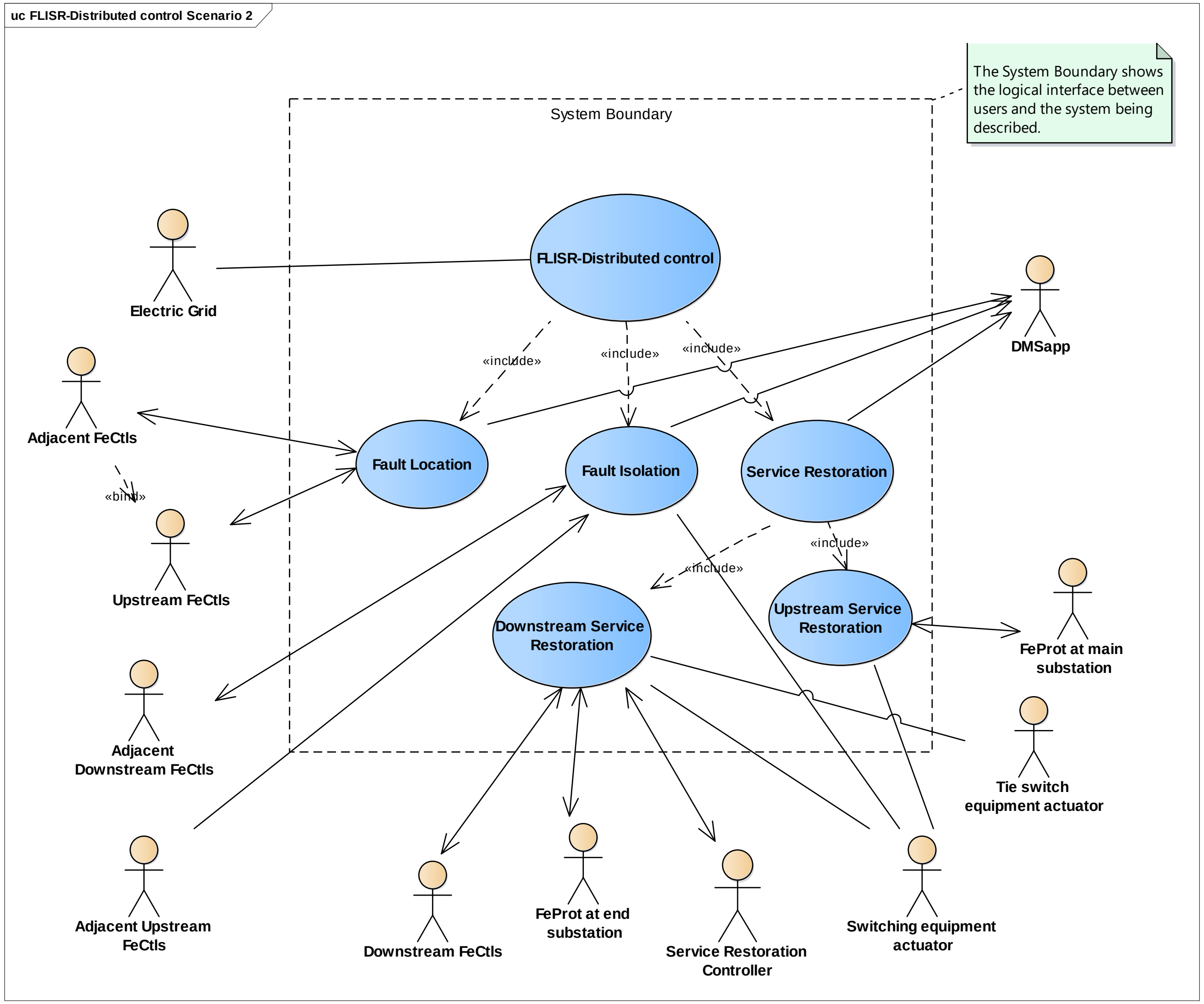


Figure 37 – Distributed FLISR in an open loop network – Operation use cases breakdown

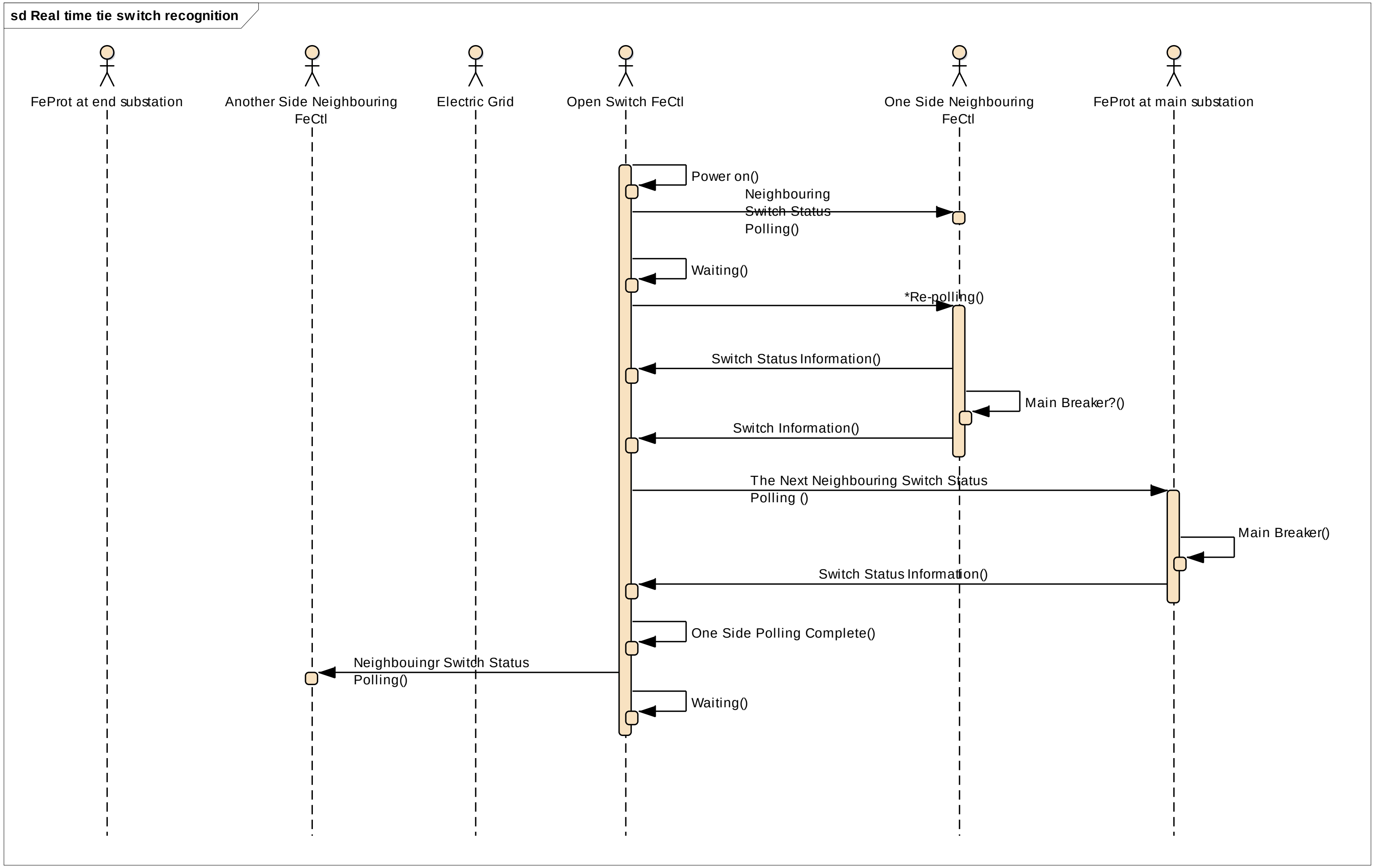


Figure 38 – Distributed FLISR in an open loop network – Topology discovery sequence diagram *(1 of 2)*

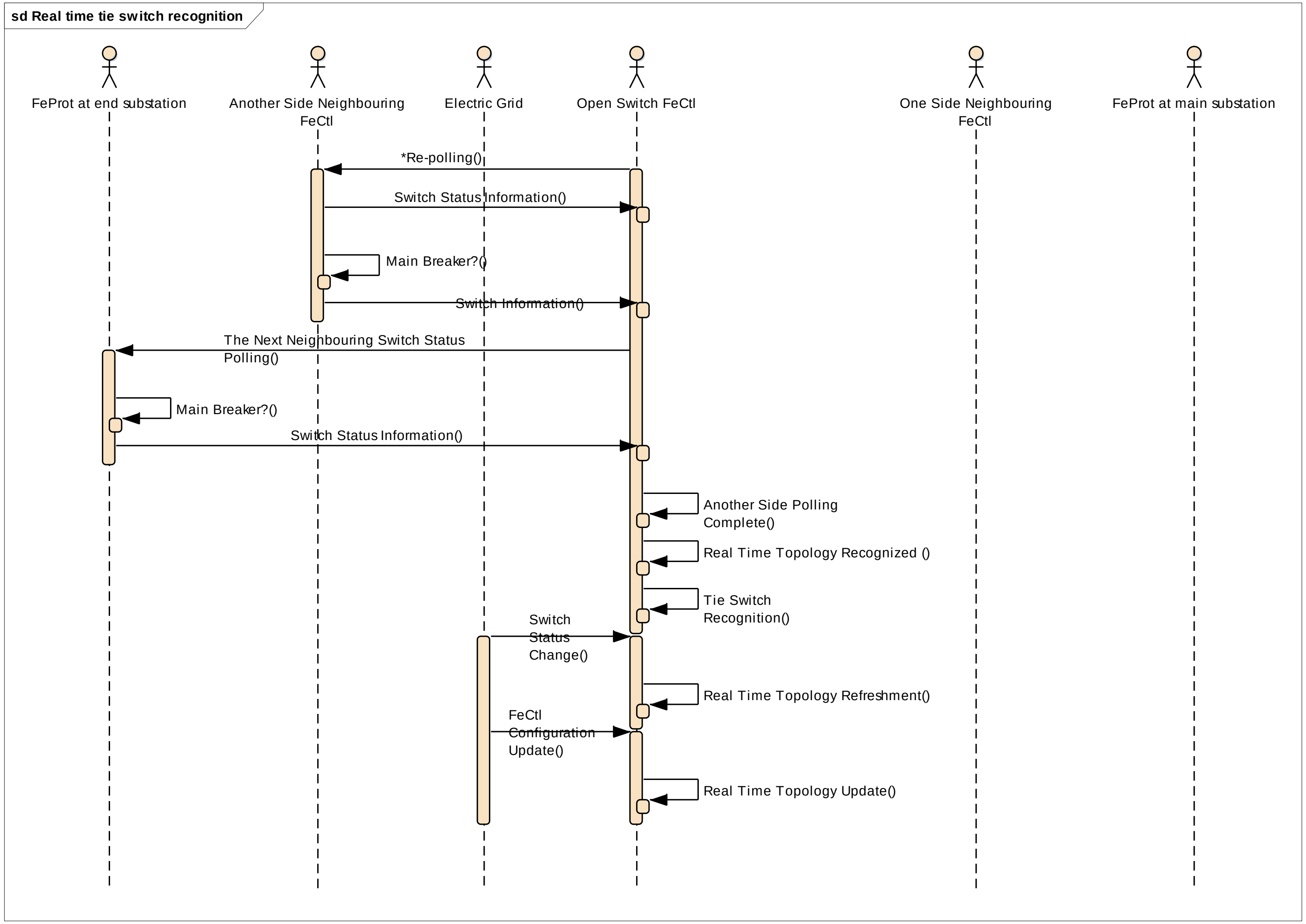


Figure 38 *(2 of 2)*

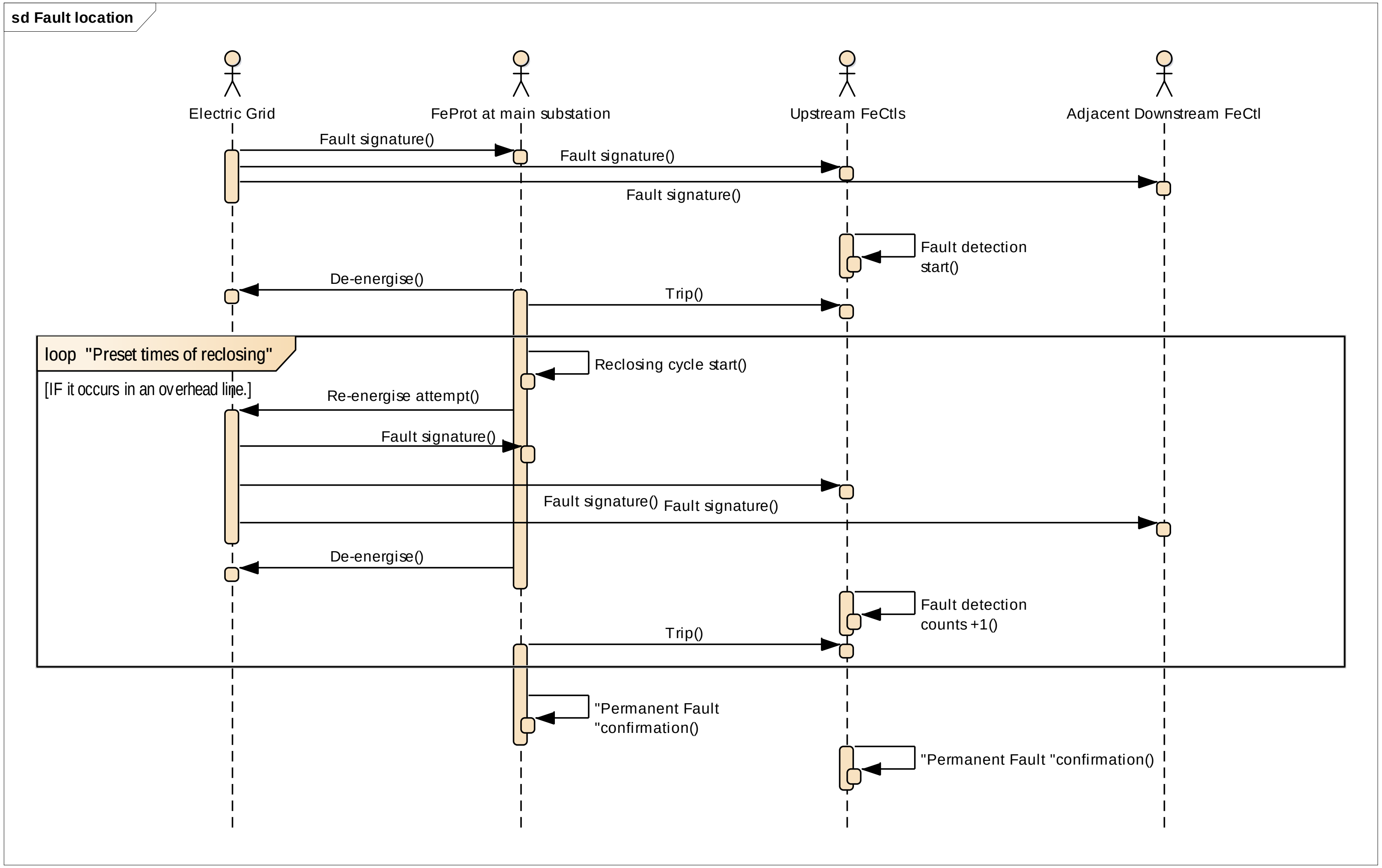


Figure 39 – Distributed FLISR in an open loop network – FLISR operation sequence diagram *(1 of 5)*

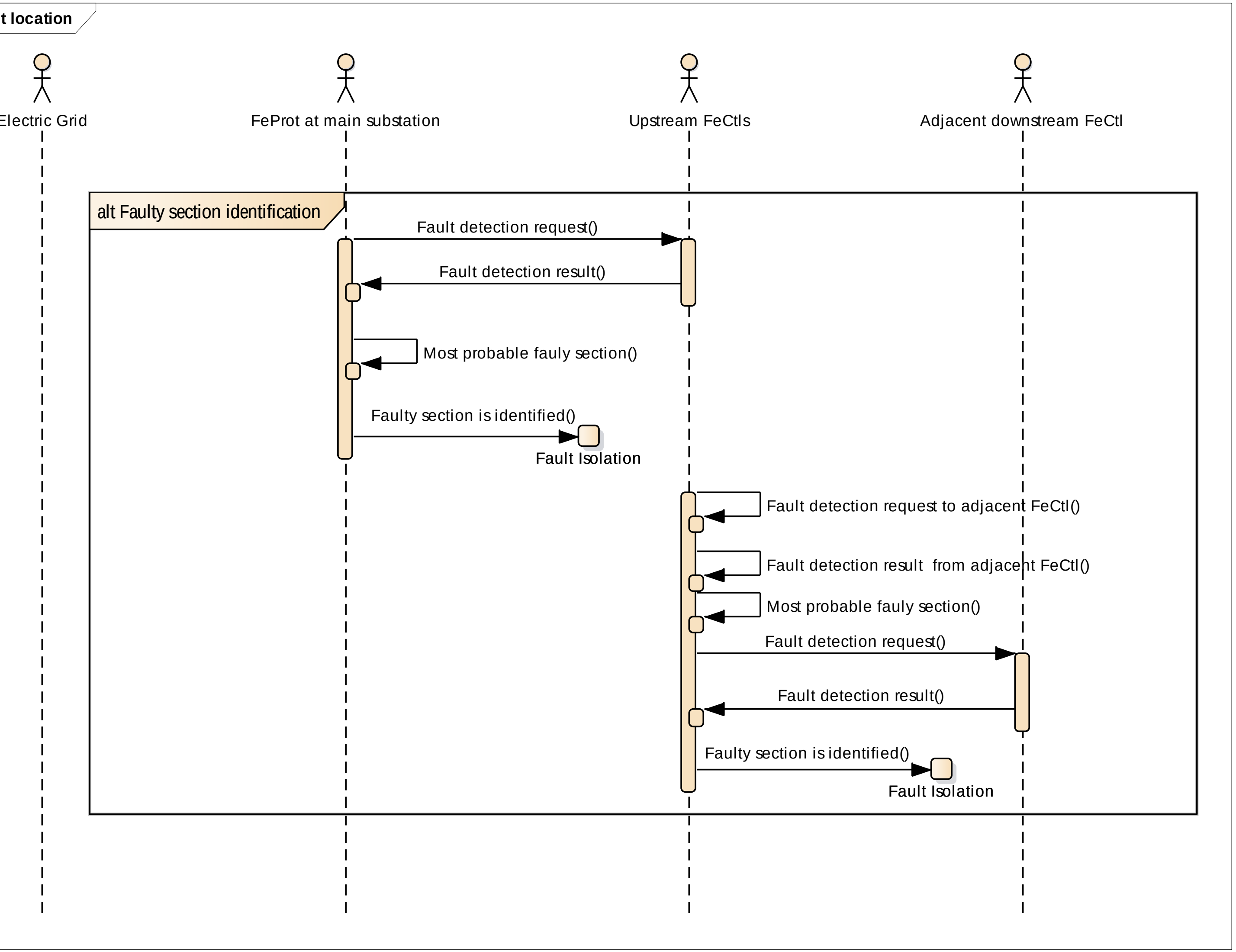


Figure 39 *(2 of 5)*

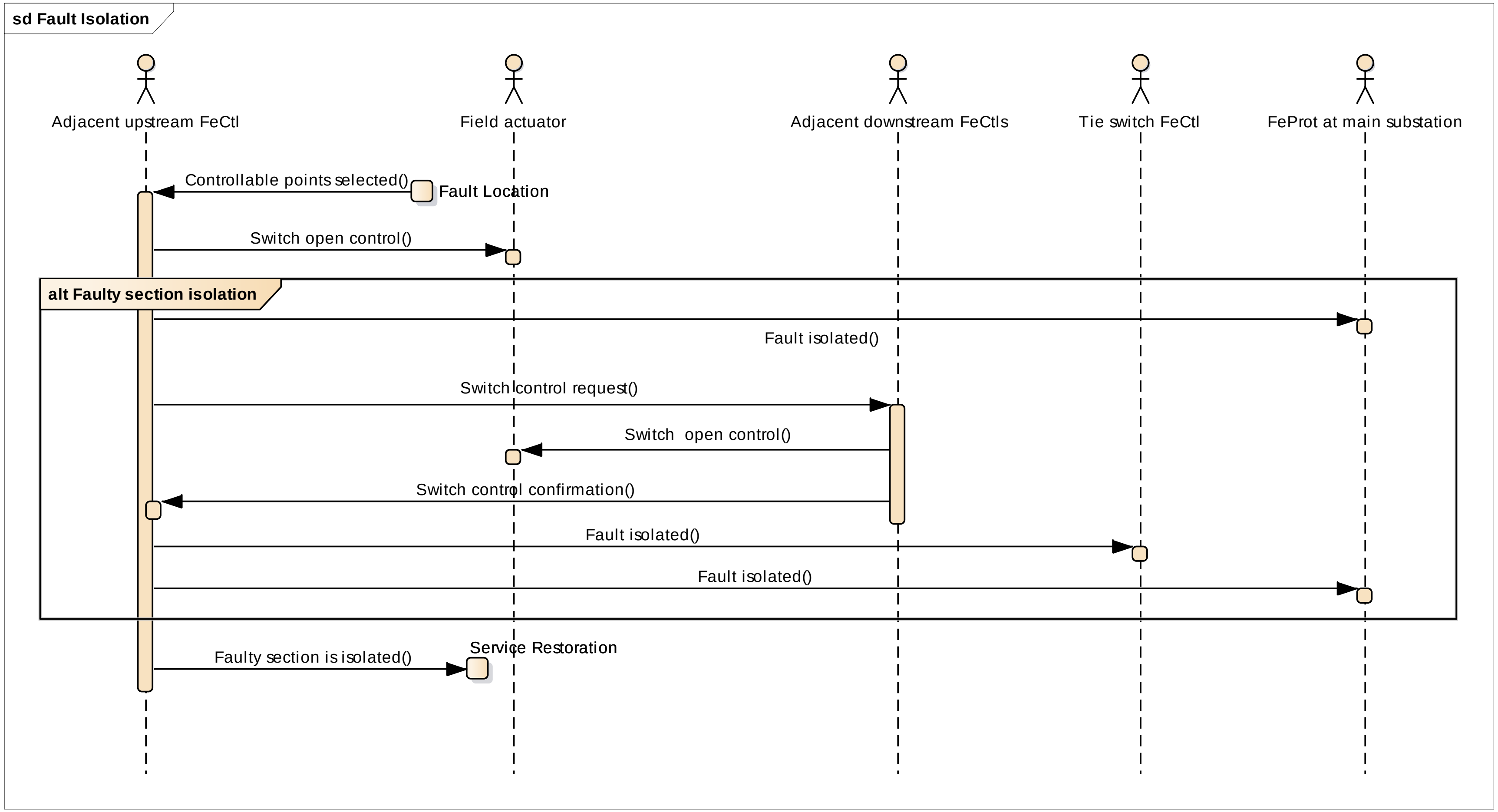


Figure 39 *(3 of 5)*

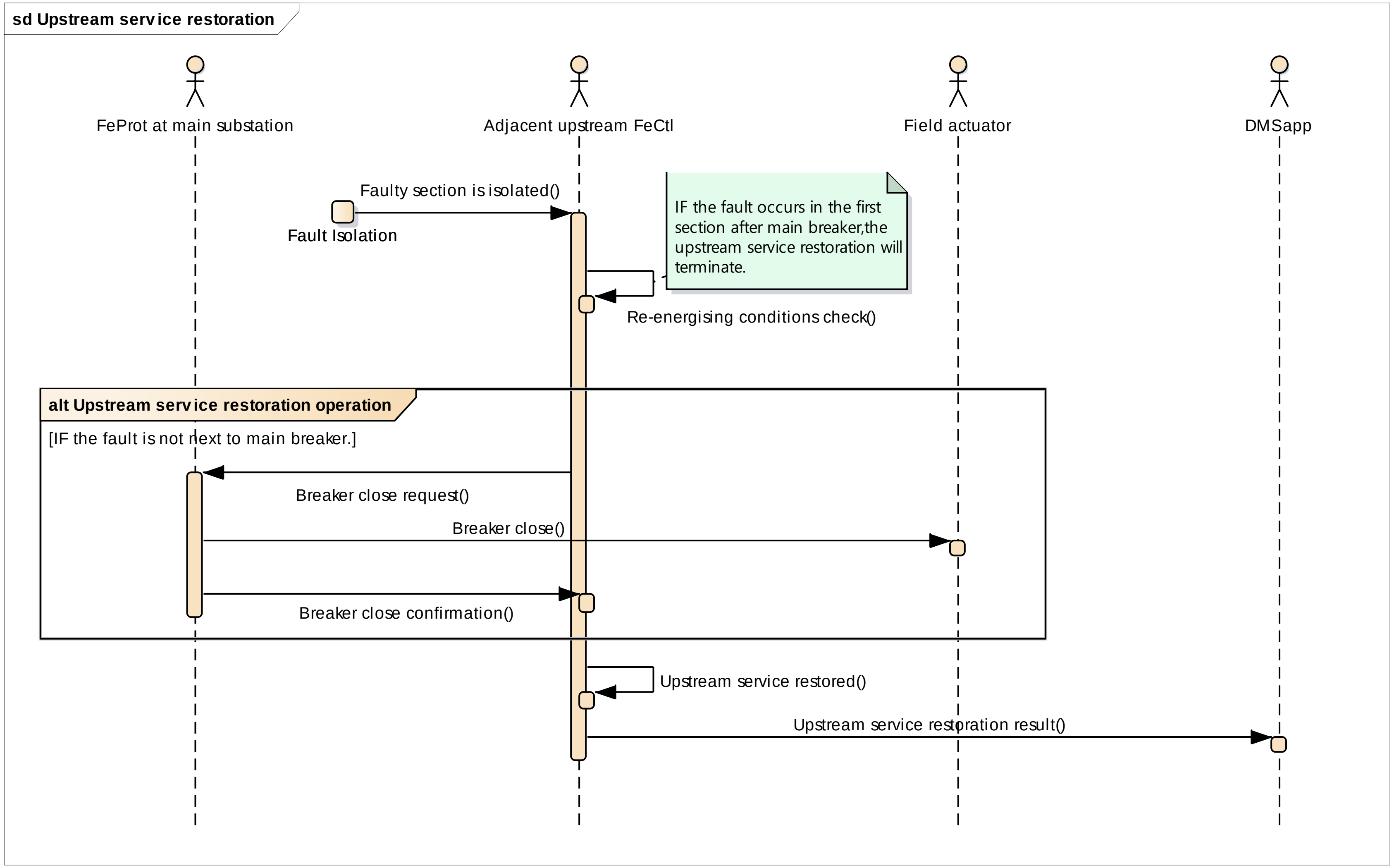


Figure 39 *(4 of 5)*

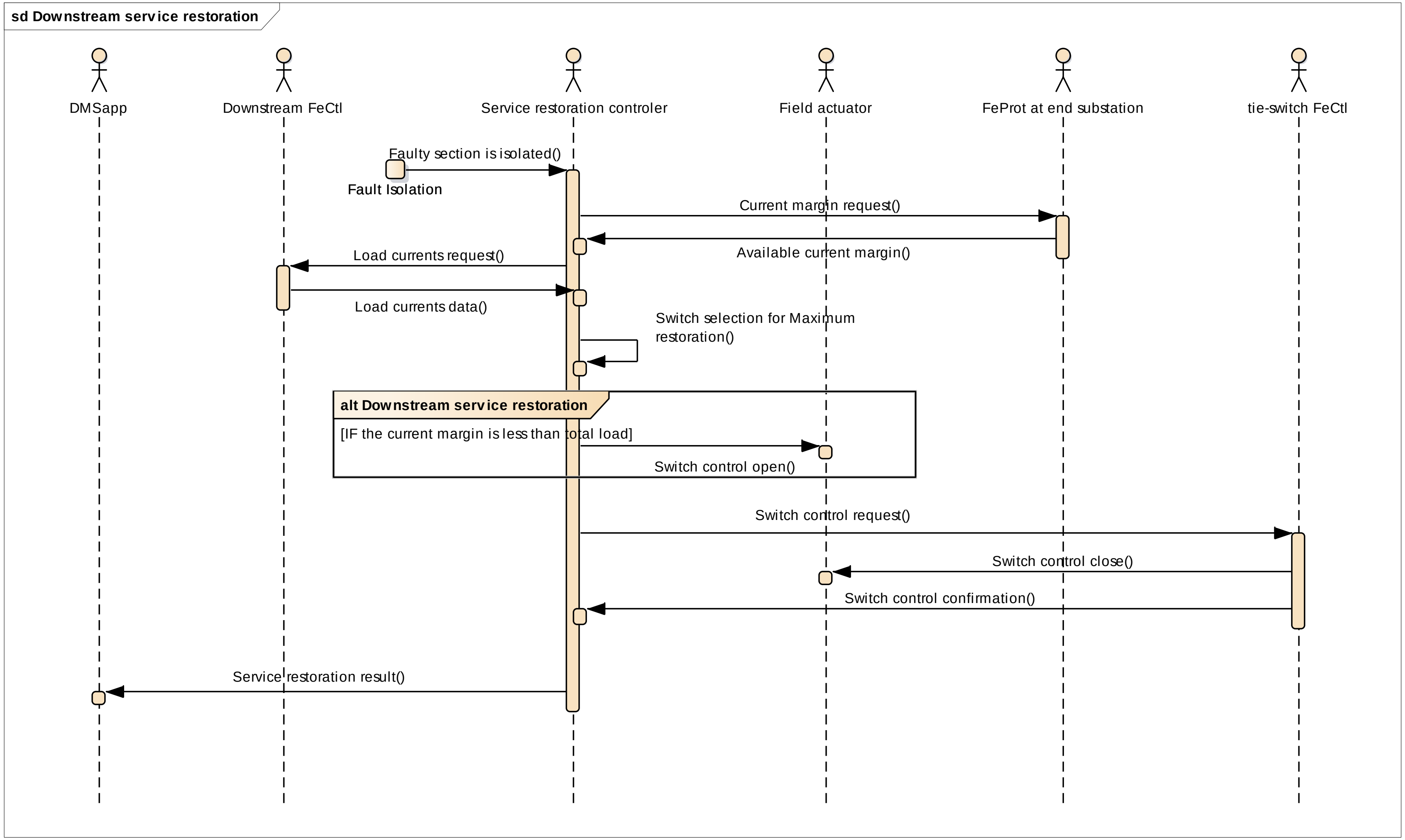


Figure 39 *(5 of 5)*

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 FeCtls 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			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).
FeProt at main substation			Enough energy is stored and available for communication. Communication with feeder switch FeCtls is available.
Switching equipment actuator			Enough energy is stored and available for remotely control the selected switches in absence of power.
Tie switch equipment actuator			Enough energy is stored and available for remotely control the selected switches in absence of power.
FeCtl			Enough energy is stored and available for communicating. Communication system for FeCtls interaction is operational
Adjacent FeCtl			Enough energy is stored and available for communicating.

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		FeCtls confirming a “permanent fault”, request fault detection information from their Adjacent FeCtls		Upstream FeCtl of the fault	Adjacent FeCtl	Fault detection information request	
3b			Adjacent FeCtls return their fault detection information		Adjacent FeCtl	Upstream FeCtl of the fault	Fault detection result	
3c	Receive fault detection information from Adjacent FeCtls.		The FeCtl determines which section the fault is located based on the fault detection result of its own and the adjacent FeCtls.		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 FeCtls.		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 FeCtls 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 FeCtls 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 directly goes 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 FeCtls	The Maintainer confirms the validity information from the FeCtl and asks the FeCtl for recognition with its adjacent FeCtls		Maintainer	FeCtl that completes the topology updating	Command for FeCtl to recognize topology information with adjacent FeCtls	
17d	Modelling recognition	FeCtl sending switch change signals to adjacent FeCtls for recognition	The FeCtl receive Maintainer’s command and send switch change signals to its adjacent FeCtls for mutual recognition		FeCtl with renewed topology model	Adjacent FeCtls	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	

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 FeCtls.	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 uptream 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 usptream from the closest to the fault will subsbribe to it, while all the FtPInds dowstream from the closest (upstream) from the fault will ignore the signal with different payload). Therefore, only the FPI closest (uspream) 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 equiped 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

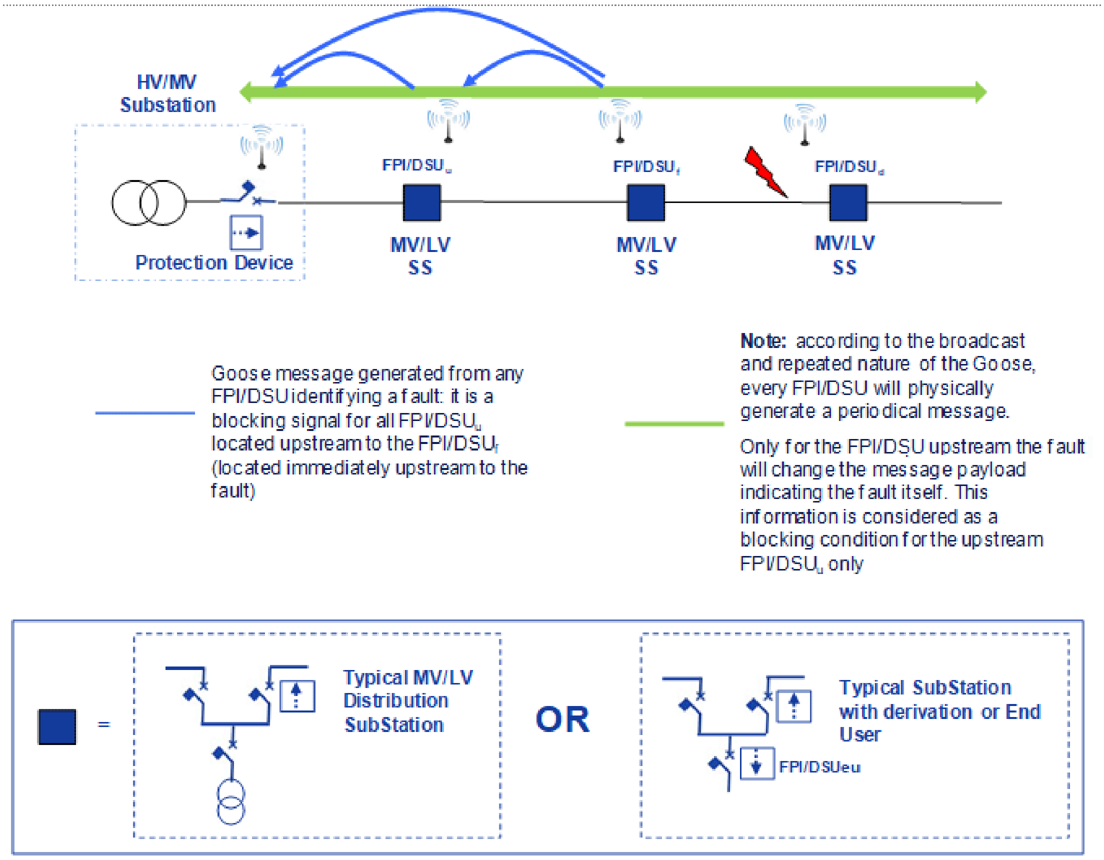


Figure 40 – Logical selectivity – FLI along the MV feeder

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 (usptream) 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.

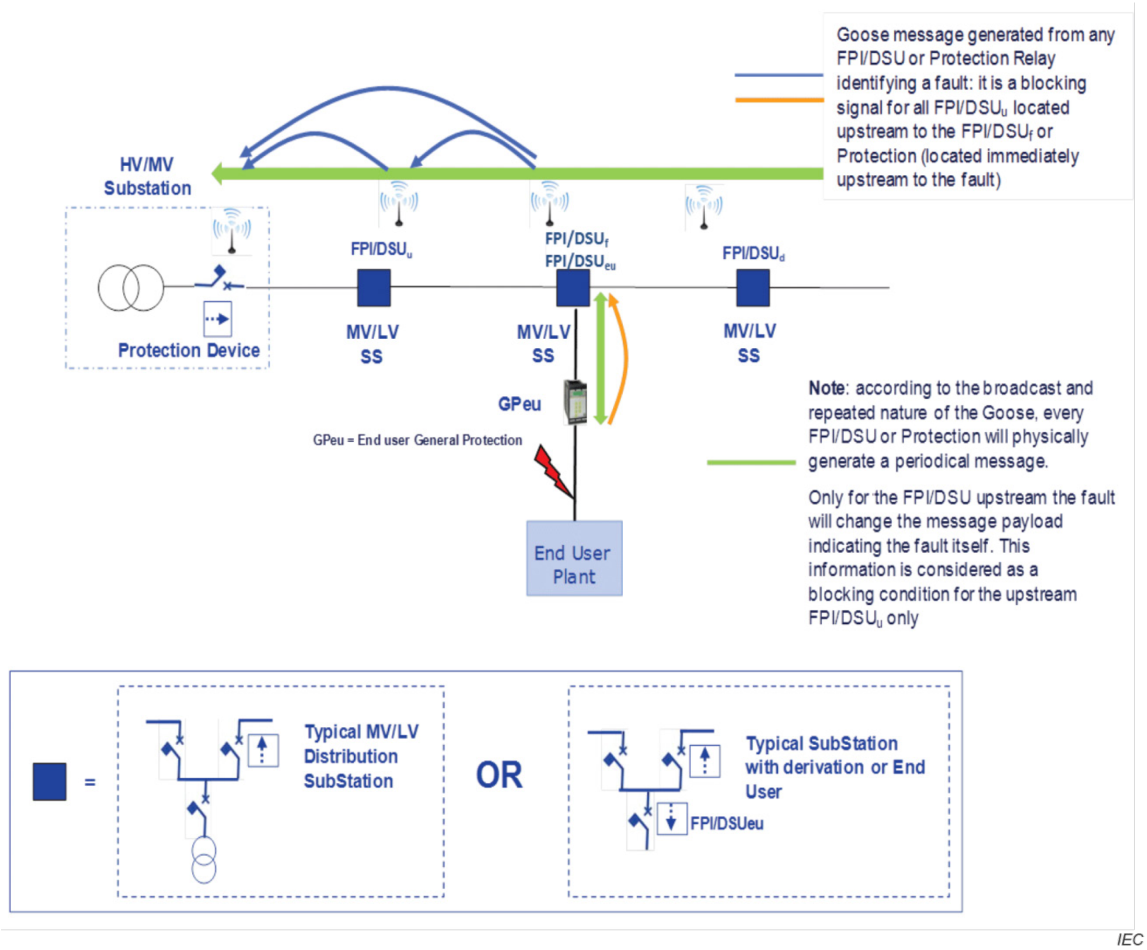


Figure 41 – Logical selectivity – FLI inside the EU plant

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 (usptream) 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$_{eu}$.

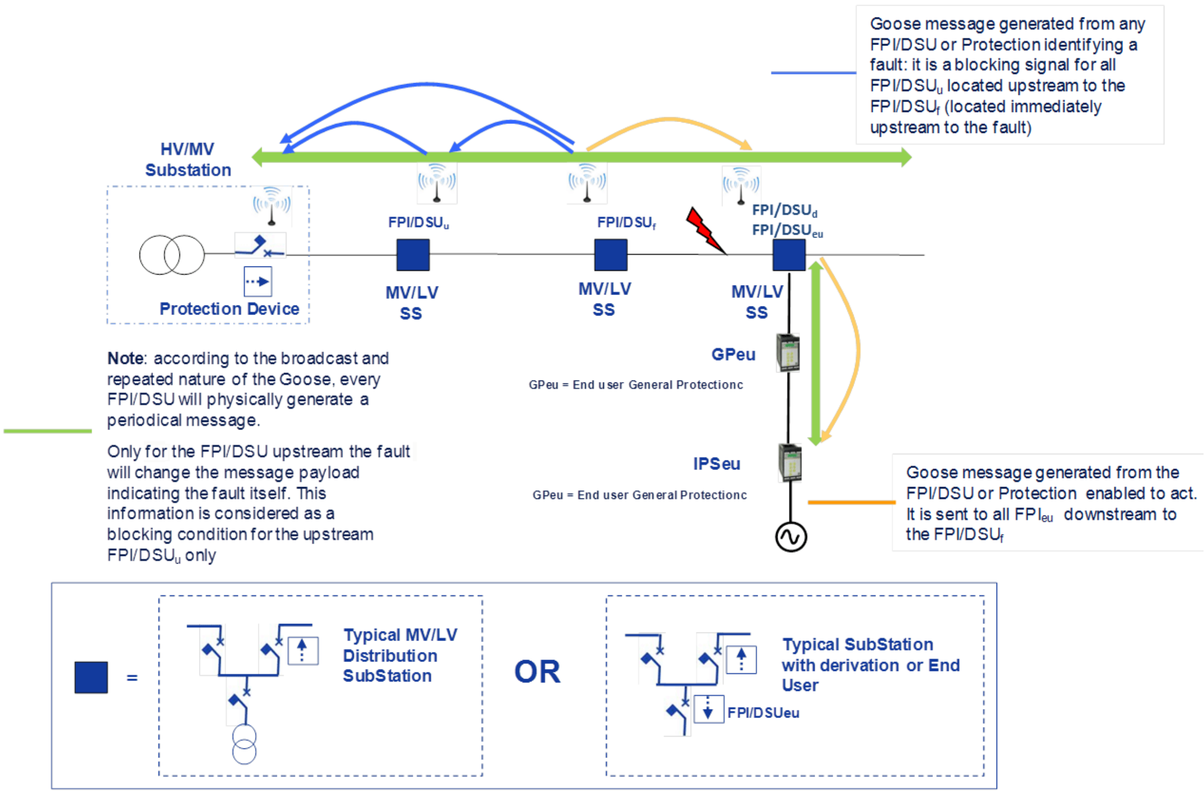


Figure 42 – Logical selectivity – FLI along the MV feeder and anti-islanding

5.5.3.2 Diagrams of use case

Figures 43 and 44 present the use case diagrams.

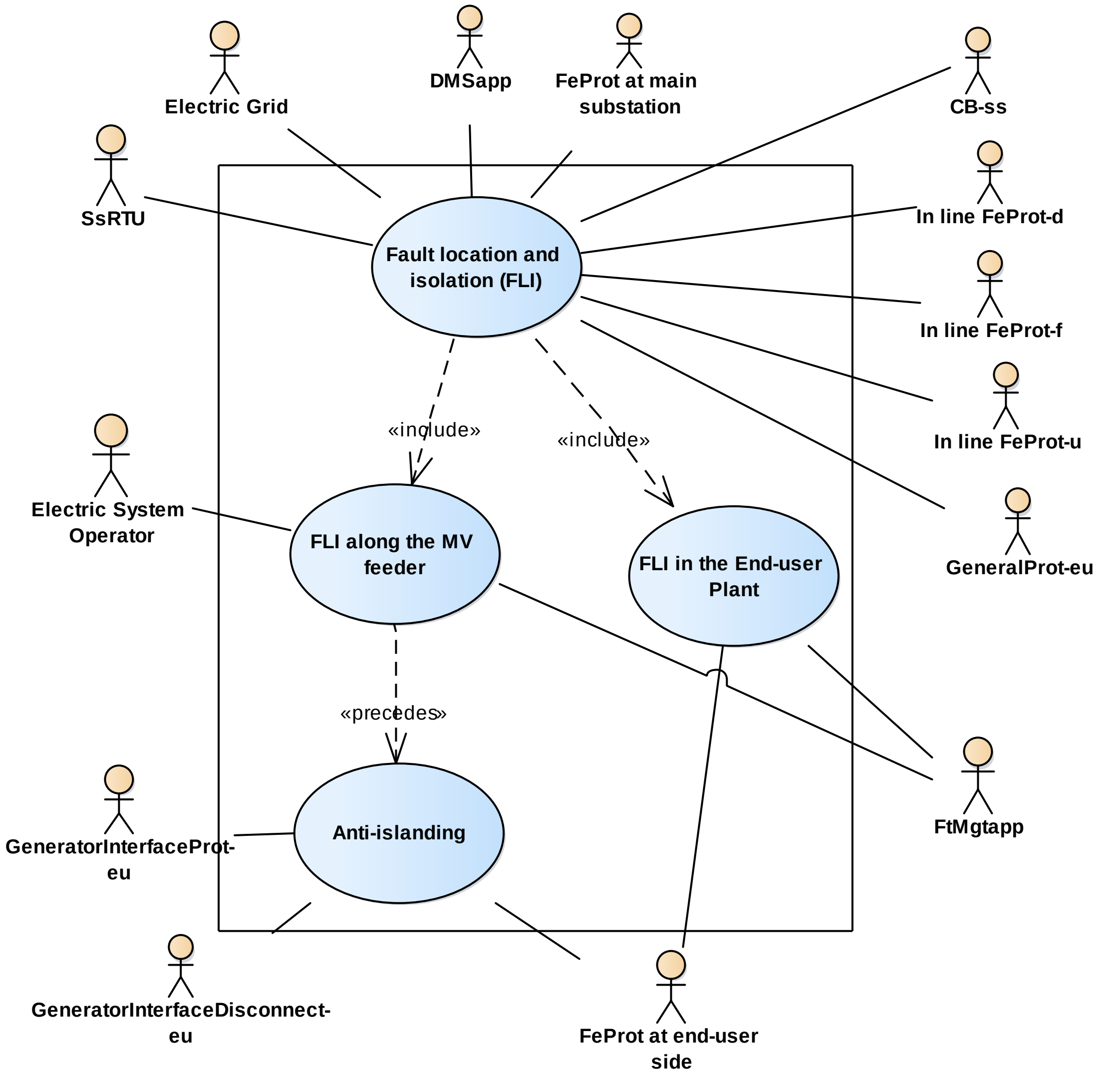


Figure 43 – Distributed FLISR 4b – Use case breakdown

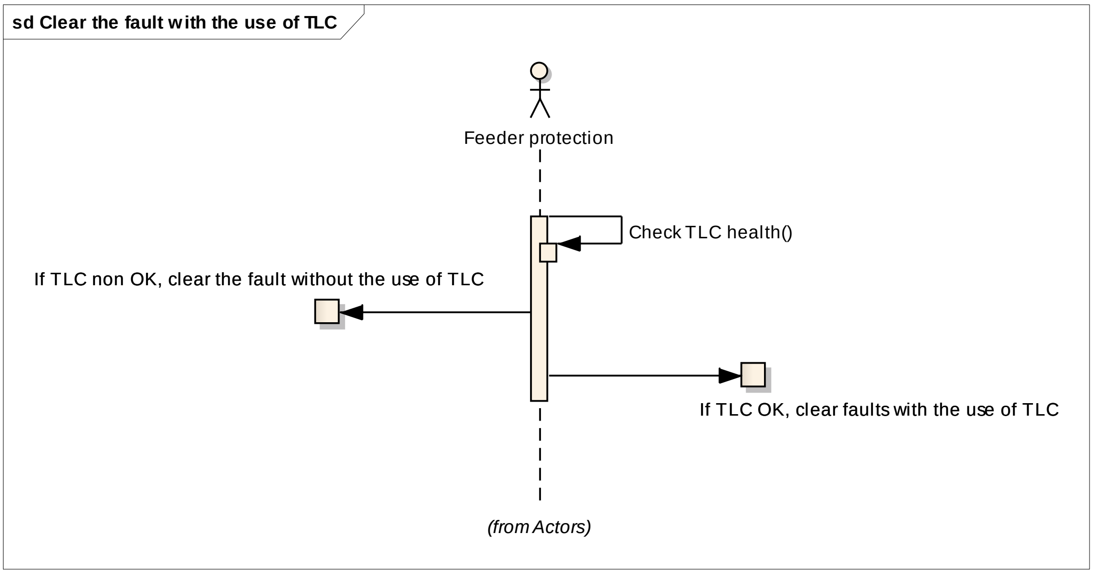


Figure 44 – Distributed FLISR 4b – For further analysis

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

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 disconnector 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	GeneratorInterfacеProt -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

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.

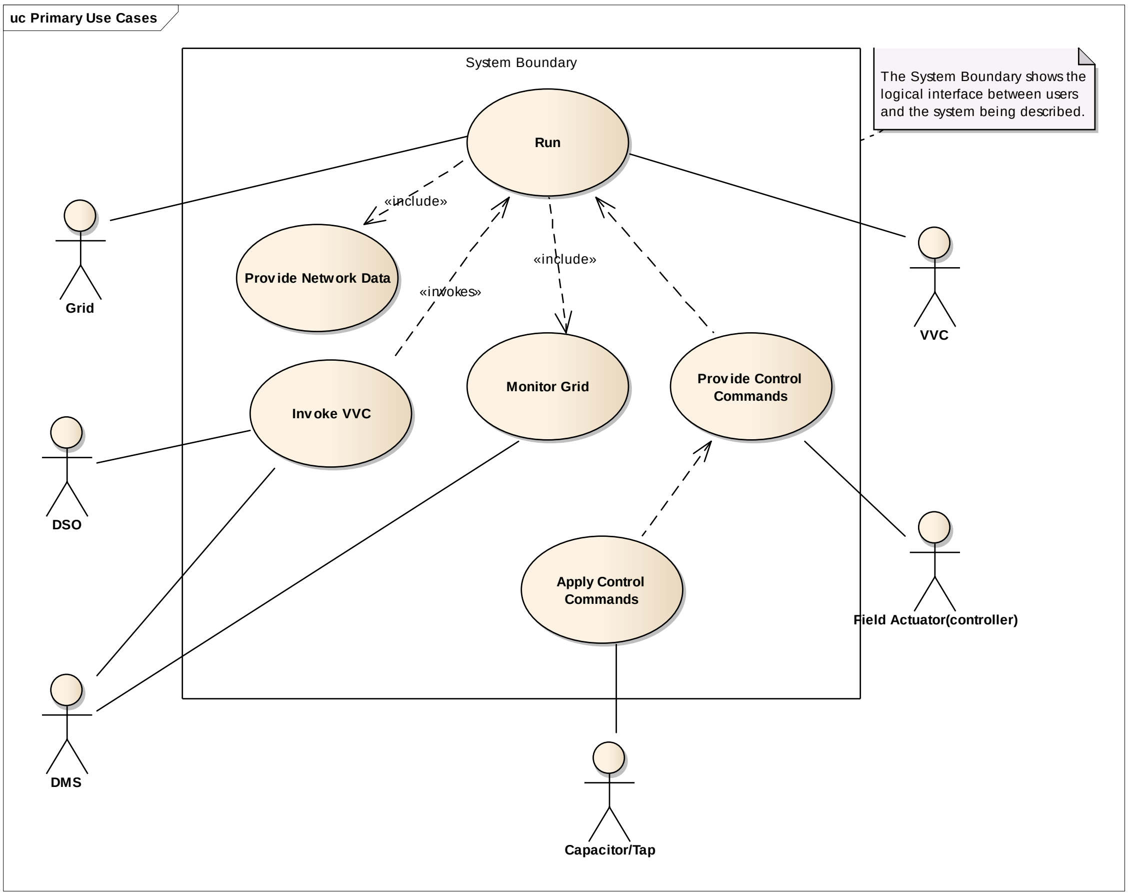


Figure 45 – Volt-Var Control – Use case breakdown

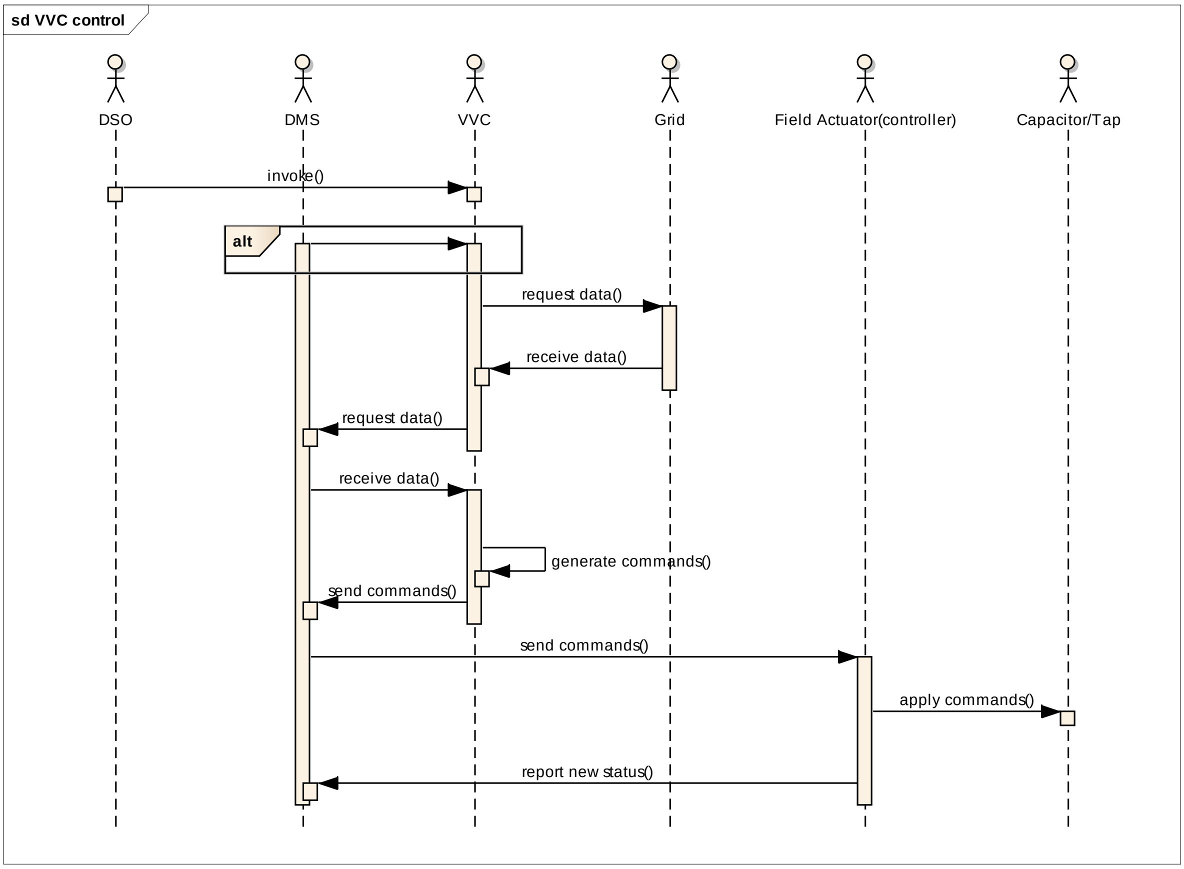


Figure 46 – Volt-Var Control – Sequence diagram

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 been 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.

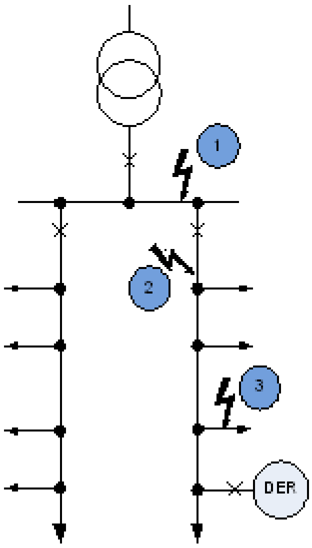


Figure 47 – Possible fault location on the feeder

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.

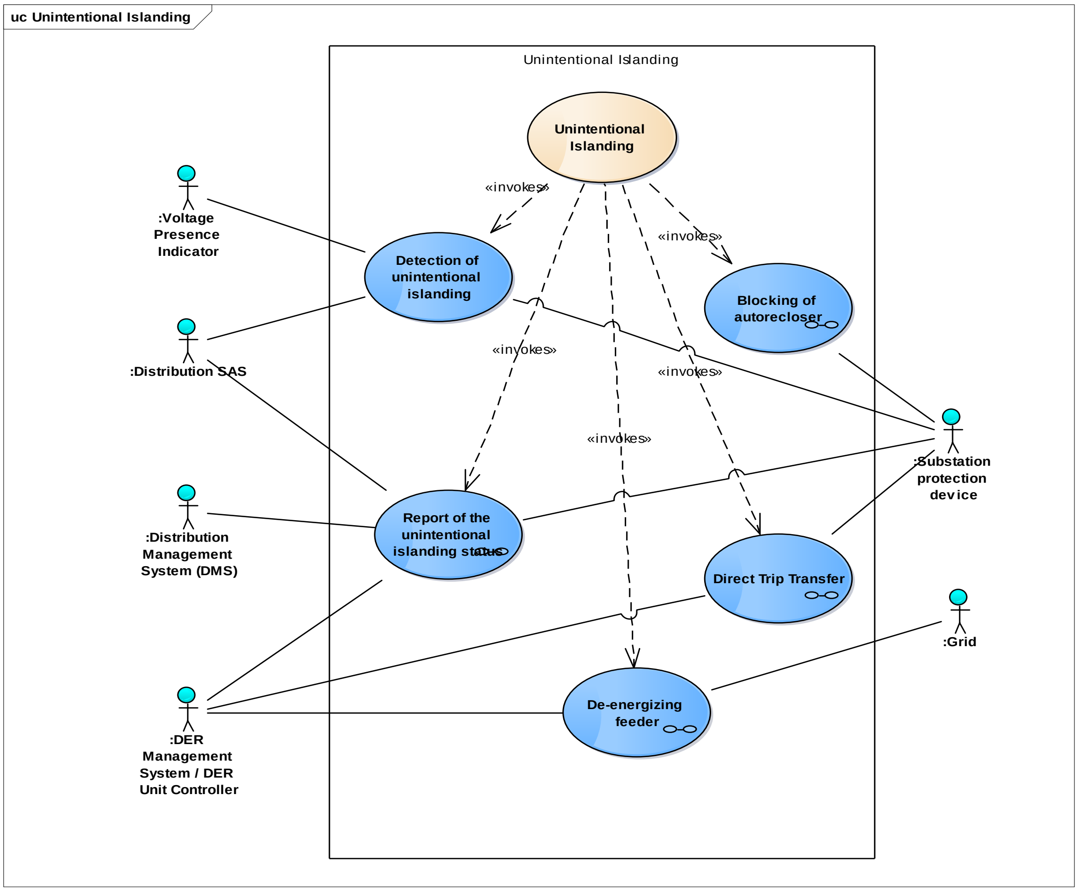


Figure 48 – Anti-islanding protection – Use case breakdown

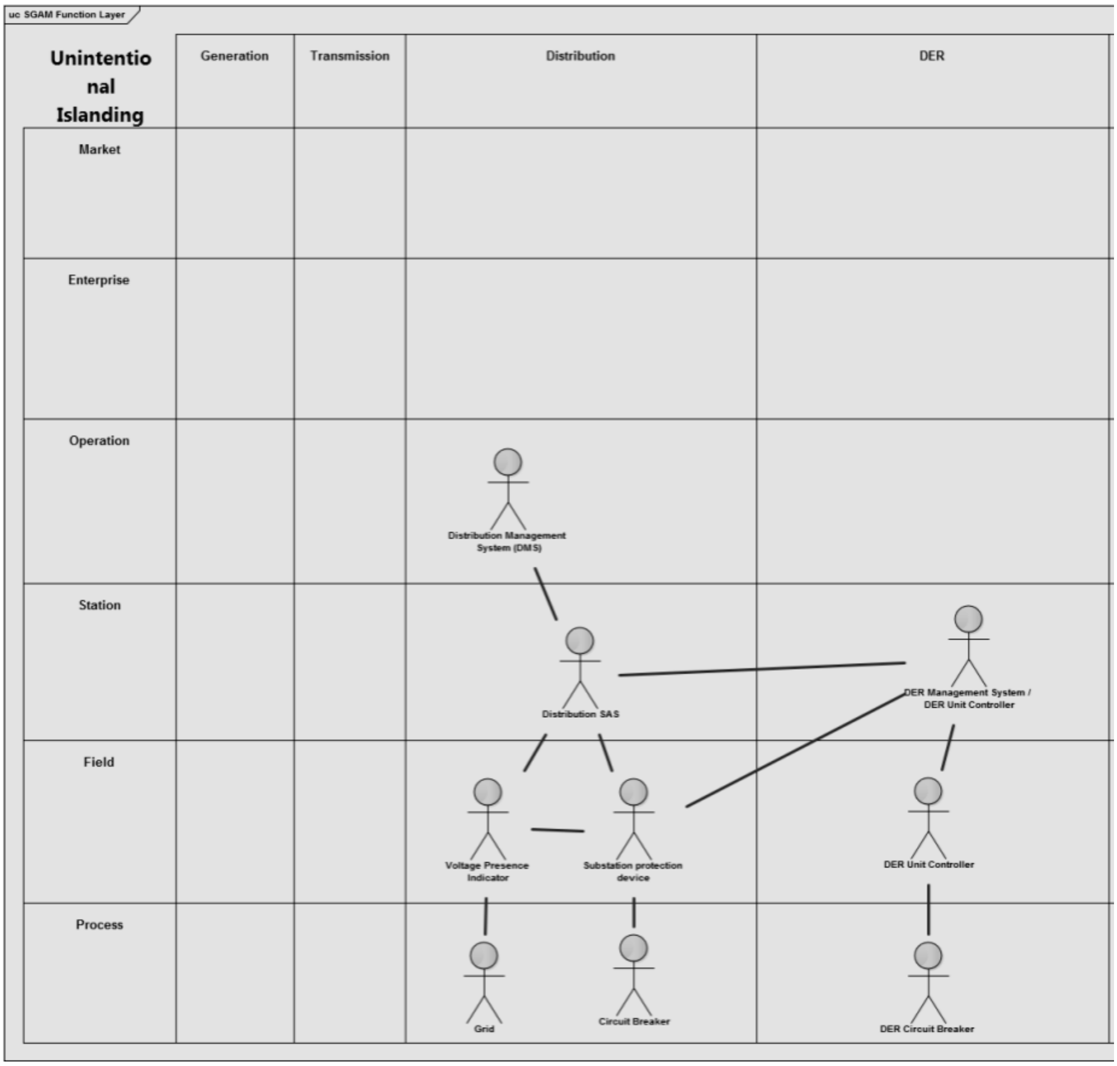


Figure 49 – Anti-islanding protection – Role diagram

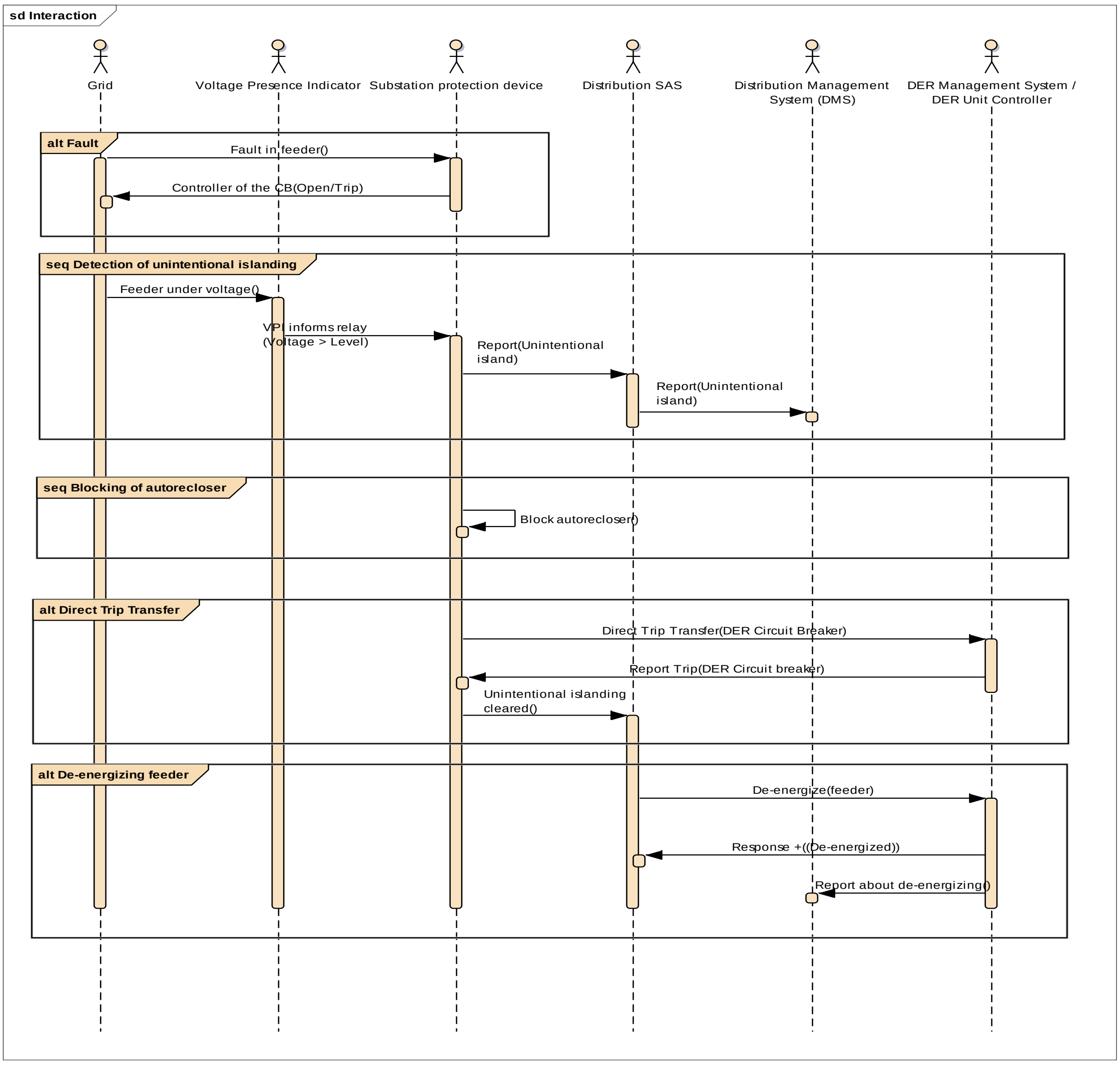


Figure 50 – Anti-islanding protection – Sequence diagram

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	Require-ments , 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/SAS	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	Require-ments , 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	Require-ments , R-ID
1		Substation protection device blocks recloser	Relay processes blocking signal and blocks recloser function		Substation protection device	Autorecloser function	RREC.Blk	

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	Require-ments , R-ID
1		Creation of status Unintentio nal Islanding	Relay derives about unintentiona l islanding		Substation protection device	SAS	Status Unintention al islanding	
2		Reports to DMSapp about Unintentio nal islanding	SAS reports the status		SAS	DMSapp	Status Unintention al 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	Require-ments , 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.TxT R)	
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 unintentiona l islanding cleared		Substation protection device	SAS; DMSapp	Status unintention al 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	Require-ments , R-ID
1		Emergenc y 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	Require-ments , 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.

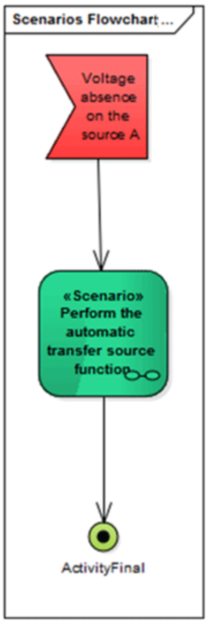


Figure 51 – Automatic transfer switch – Scenario flowchart

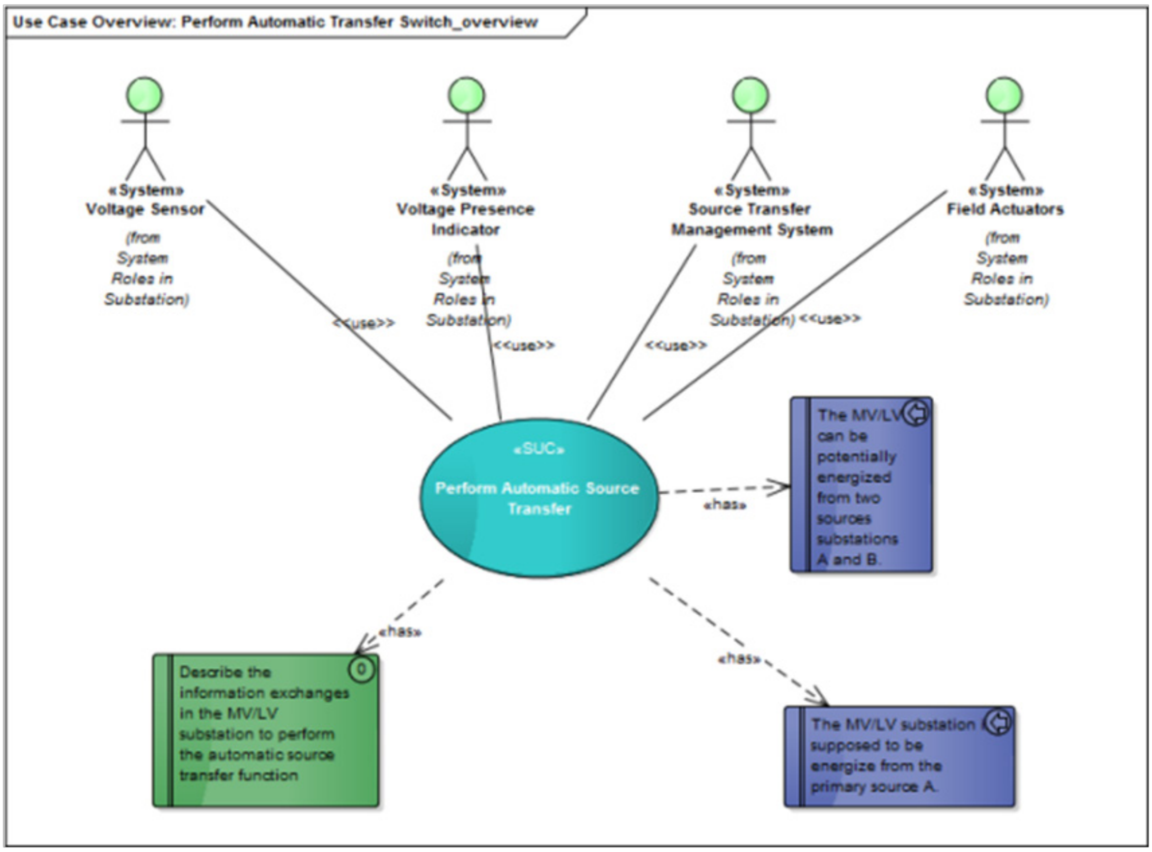


Figure 52 – Automatic transfer switch – Use cases breakdown

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.

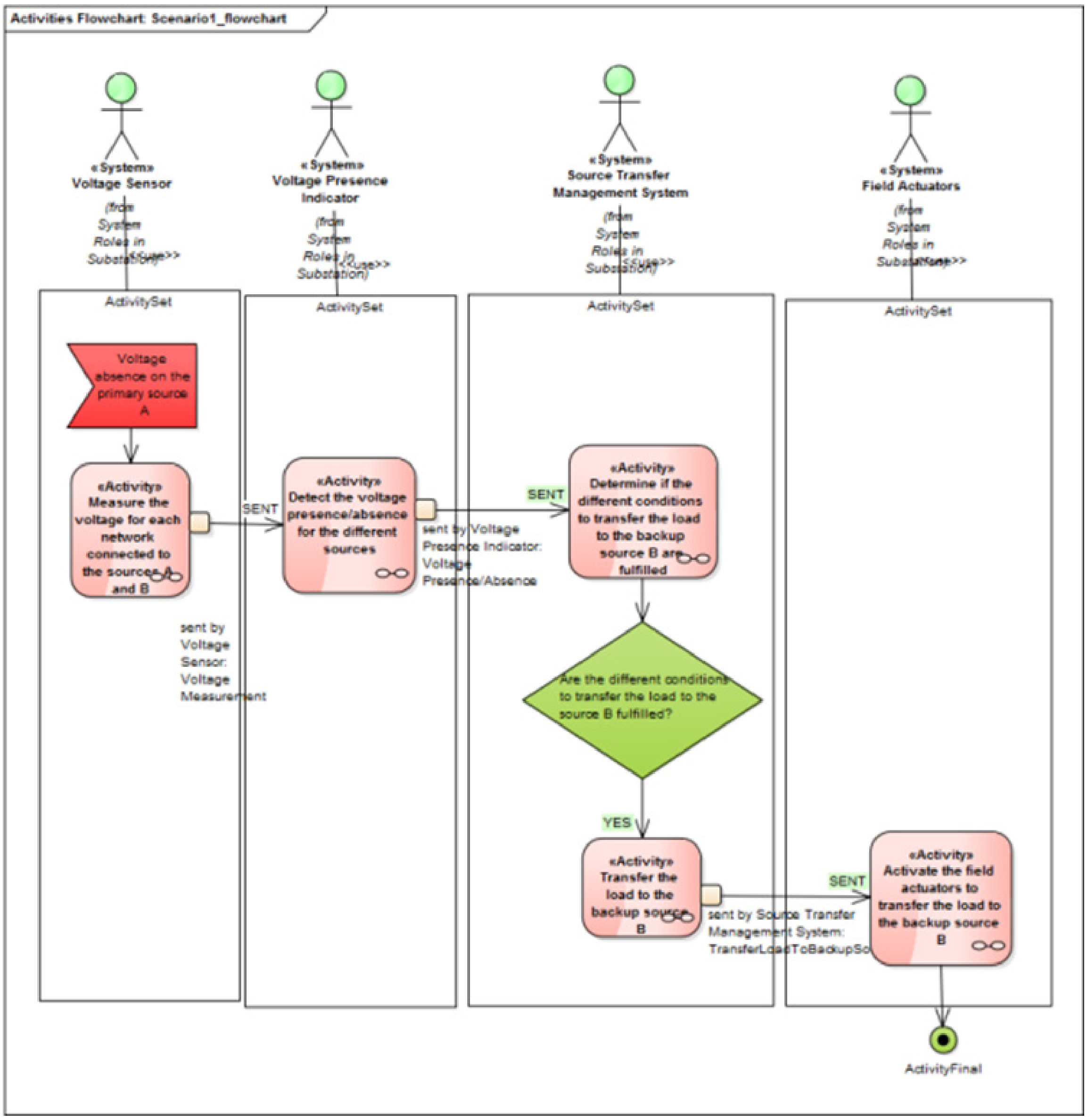


Figure 53 – Automatic transfer switch – Activity flowchart

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.

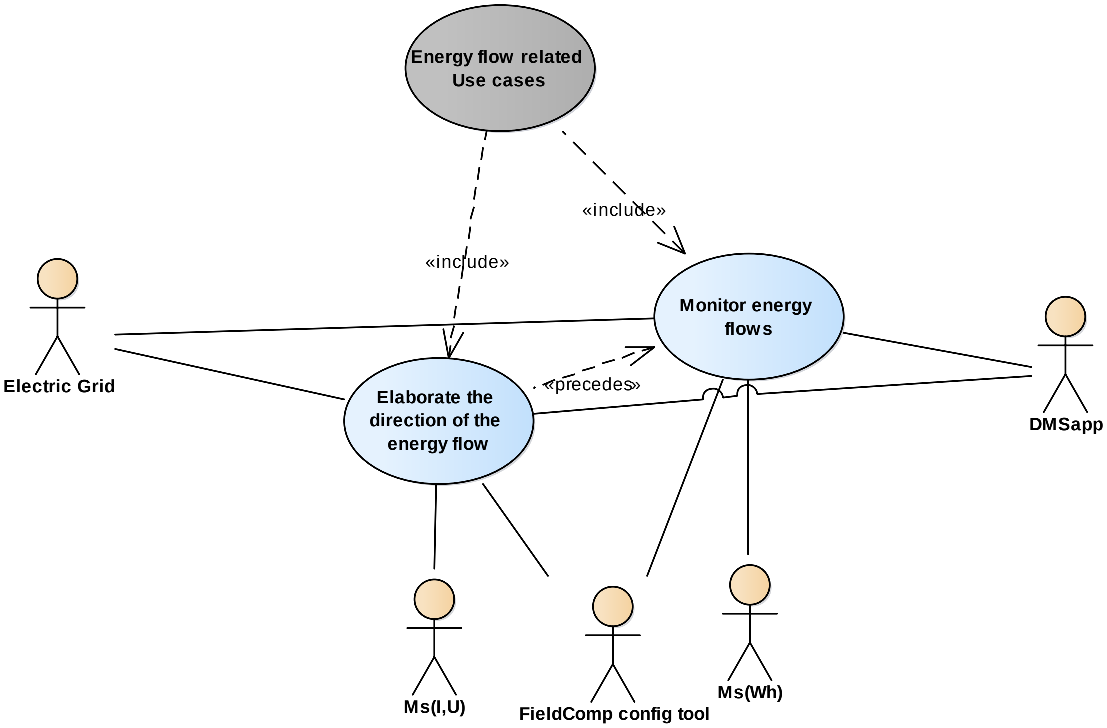


Figure 54 – Monitor energy flows – use case breakdown

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

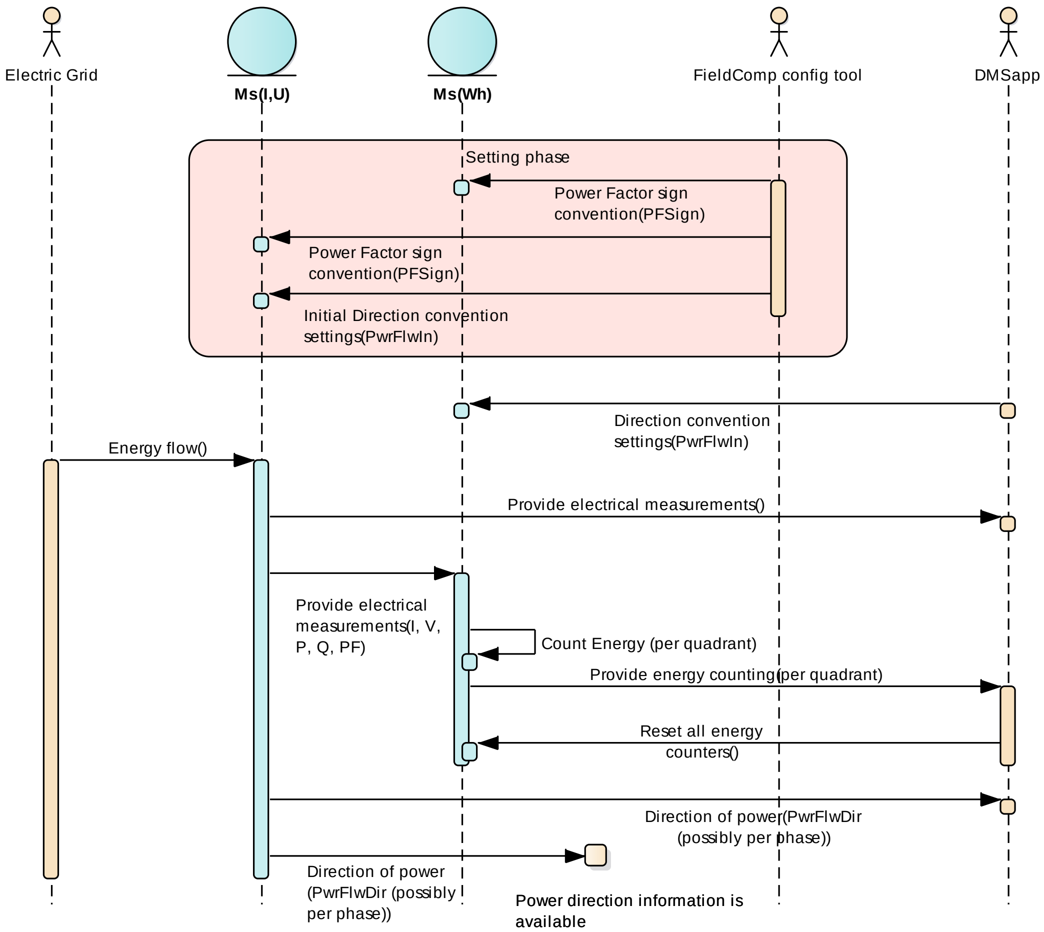


Figure 55 – Sequence diagram for the "Monitor energy flows" use case

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 measuremen t	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.

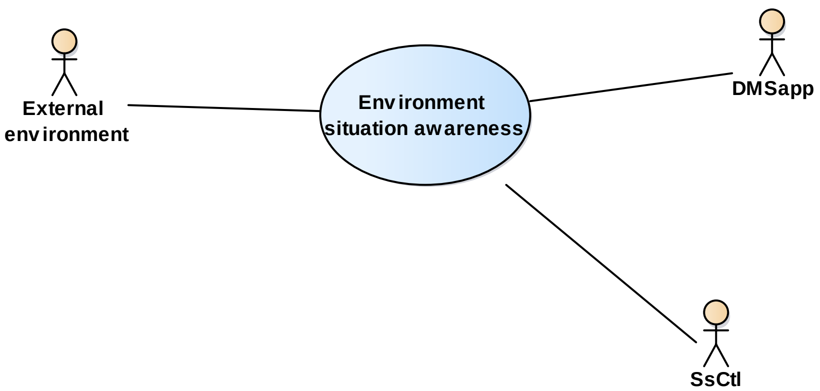


Figure 56 – Environment situation awareness – Use cases breakdown

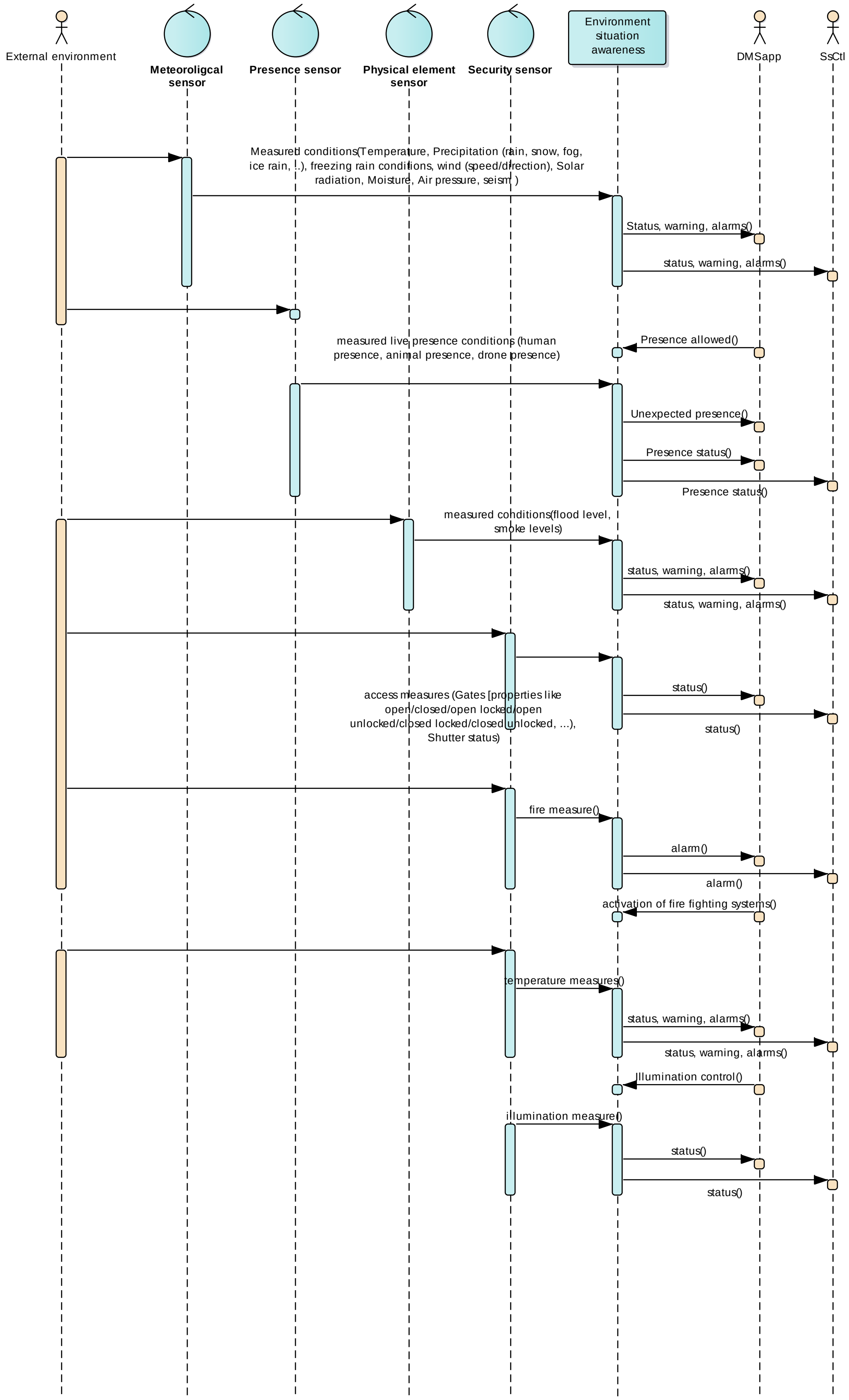


Figure 57 – Environment situation awareness – Sequence diagram

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.

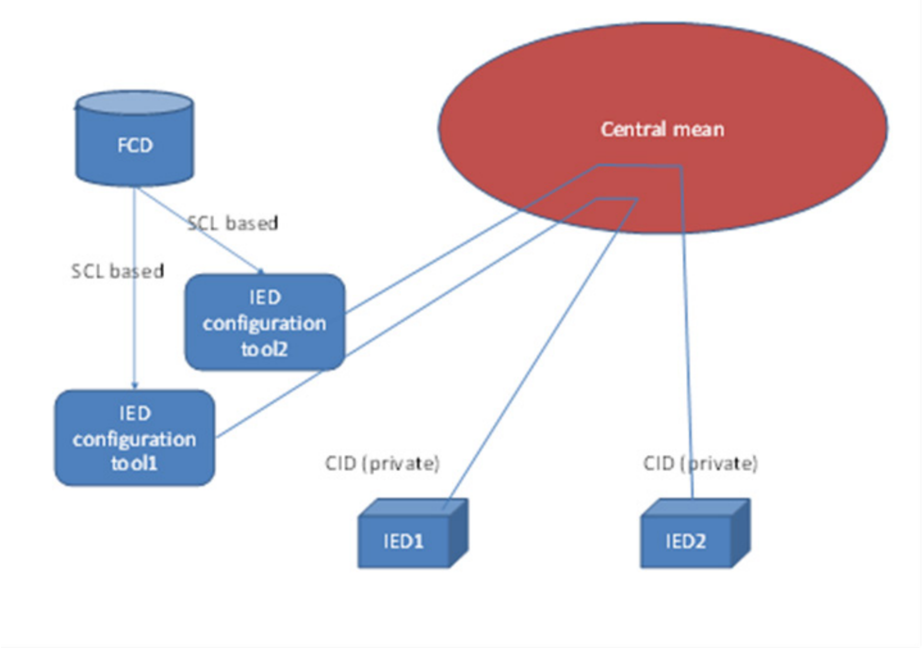


Figure 58 – The schematic diagram of remote configuration process

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.

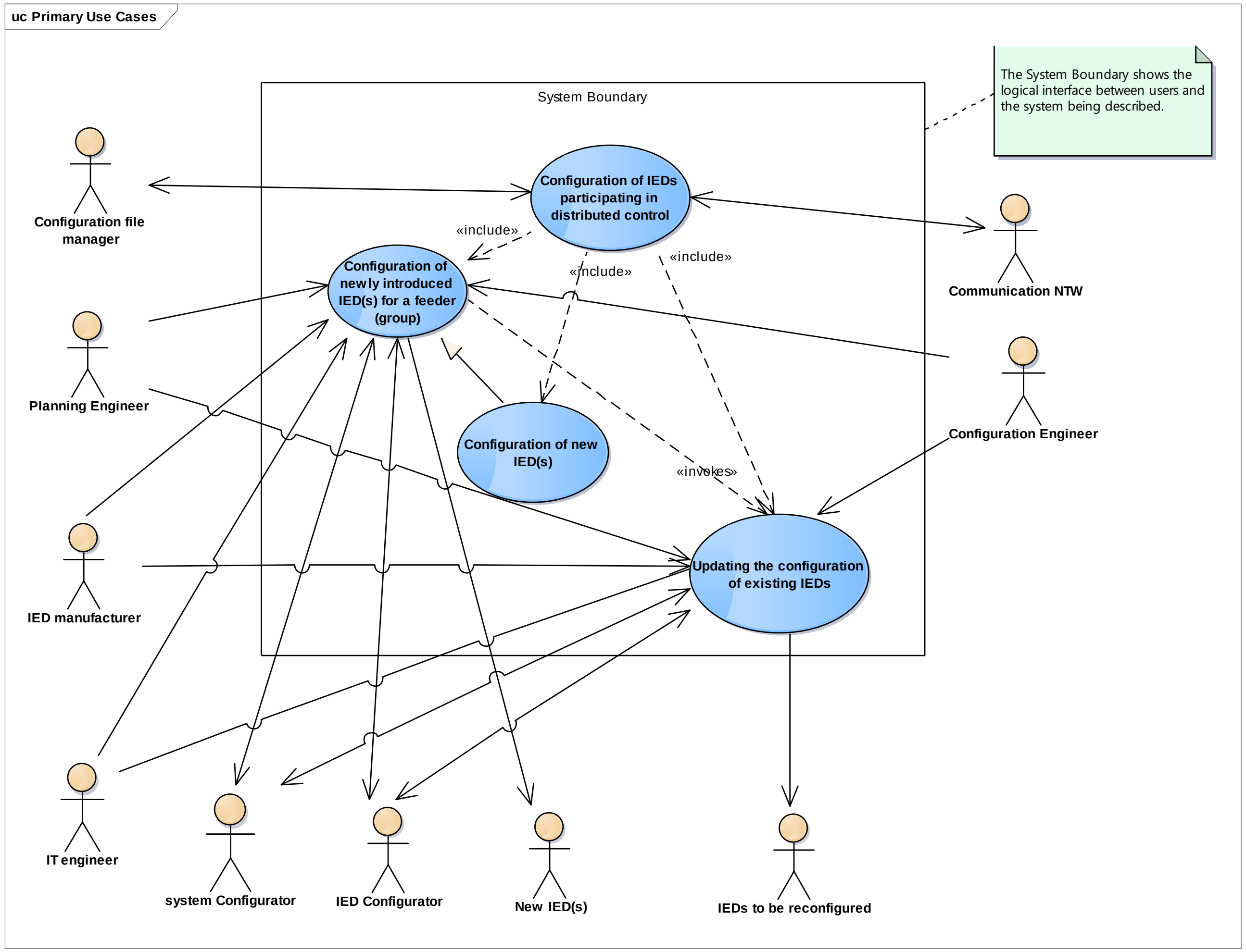


Figure 59 – Configuration of IEDs participating in distributed control – Use case diagram

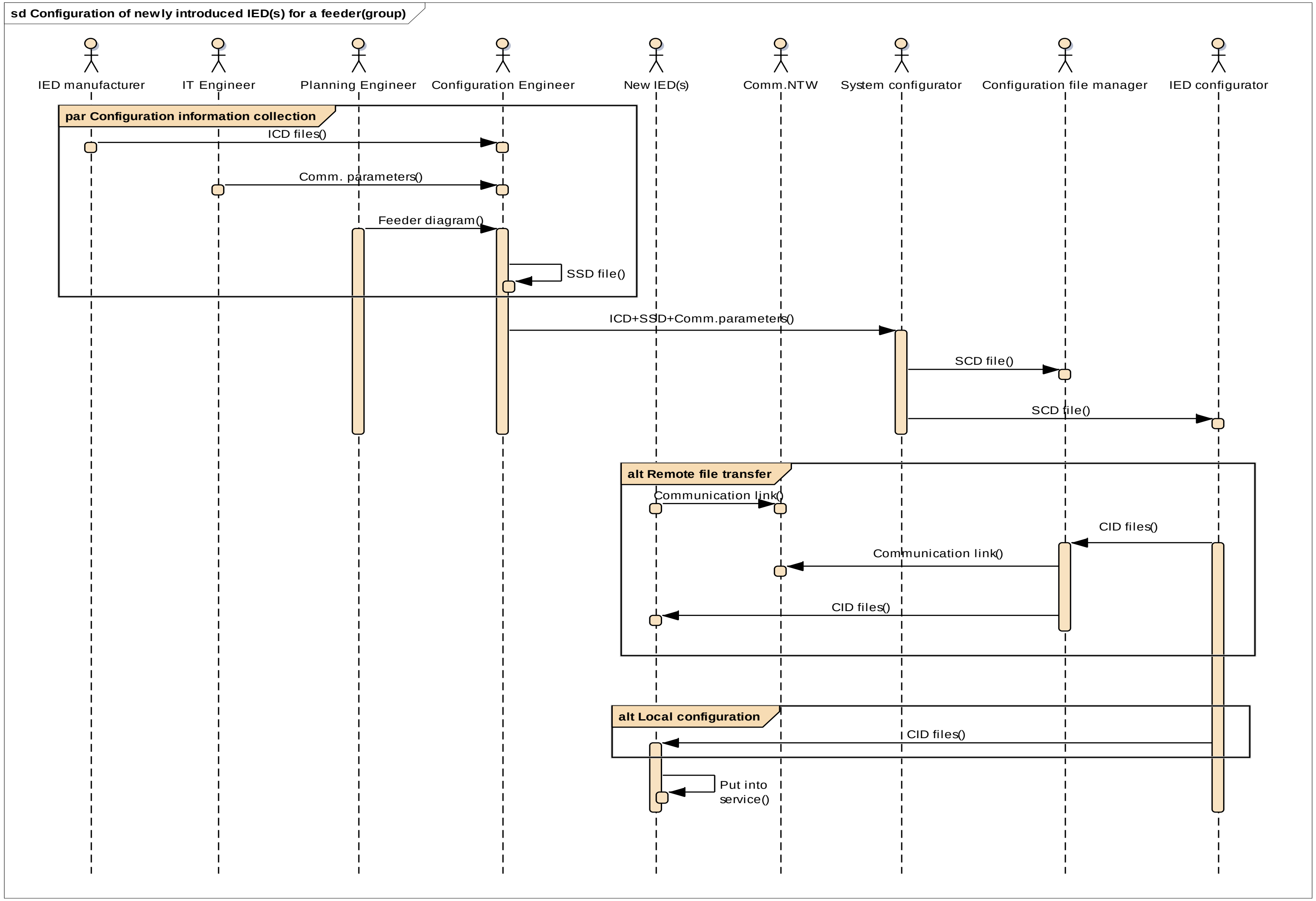


Figure 60 – Configuration of IEDs participating in distributed control – Sequence diagram *(1 of 2)*

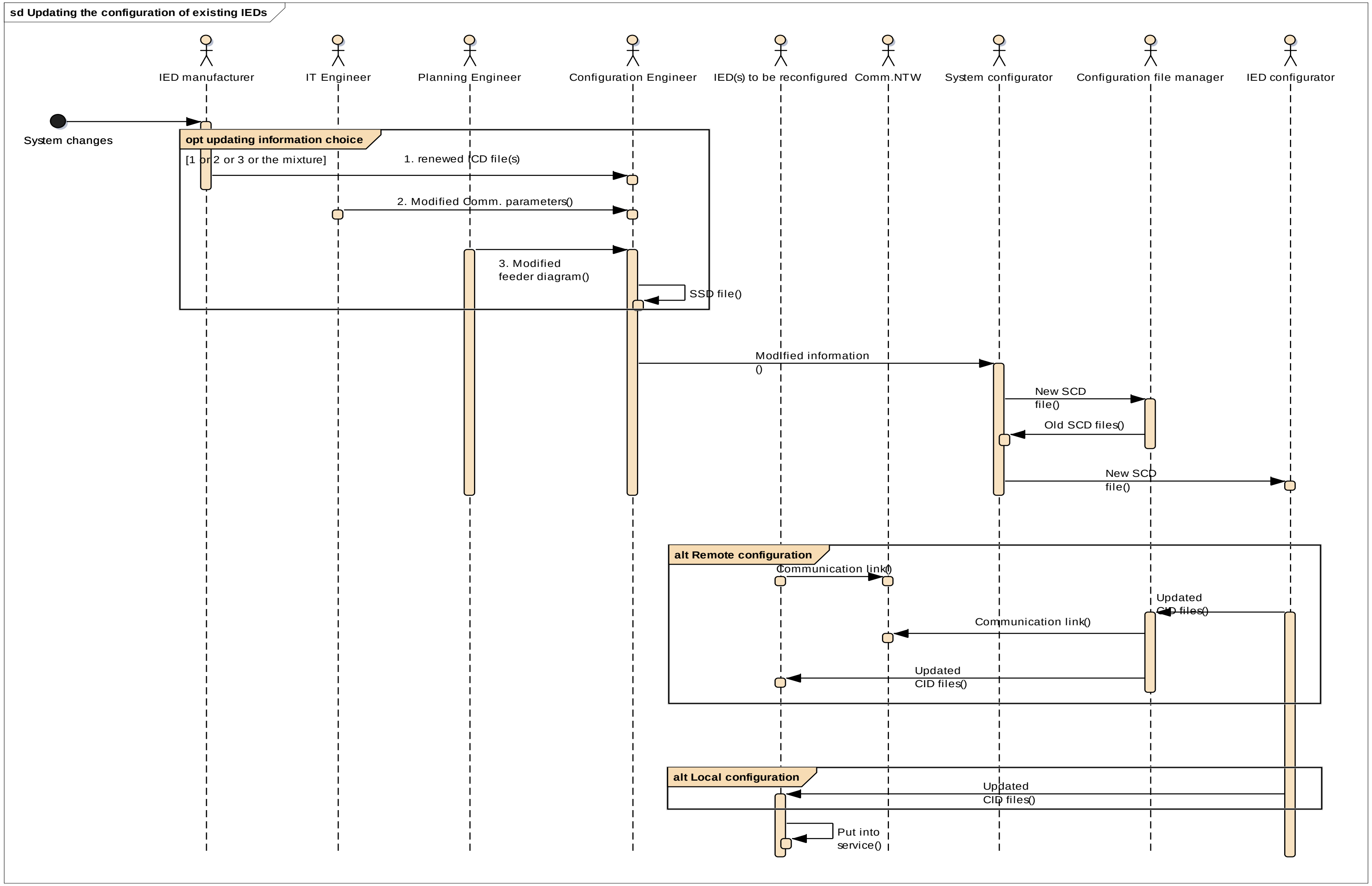


Figure 60 *(2 of 2)*

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	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. 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.	
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.	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. 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.
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	The exchange method depends on utility and/or manufacturer's polices. The local communication for the data transfer is beyond the scope of this technical report. 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 1000 ms.
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 work-station, 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 work-station, 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.	

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
SVPI -> Voltage presence indicator function which produces a persistent “presence” signal and an “absence” signal based on inputs from PTOV, PTUV In general, Absence is set by PTUV.Op and is reset when PTUV.Str resets Presence is set by PTOV.Op and is reset when PTOV.Str resets 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. A SVPI logical node can also be used to provide the same common outputs to feed an automatic transfer between different sources.	SVPI New. Especially elaborate the presence and absence signals, from each of the 3 phases indications 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.
SCPI -> Current presence indicator function which produces a persistent “presence” signal and an “absence signal” based on inputs from PTOC, PTUC 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.	SCPI New 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. In addition SCPI presence will indicate per phase the direction of the power flow, based on the forward/backward convention (as for protection)
SFST -> Computation statistics on fault presence for a given period.	SFST New 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.)
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	TCTR needs to be extended in order to support the logical association between the connected wire and the associated Phase/Neutral

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

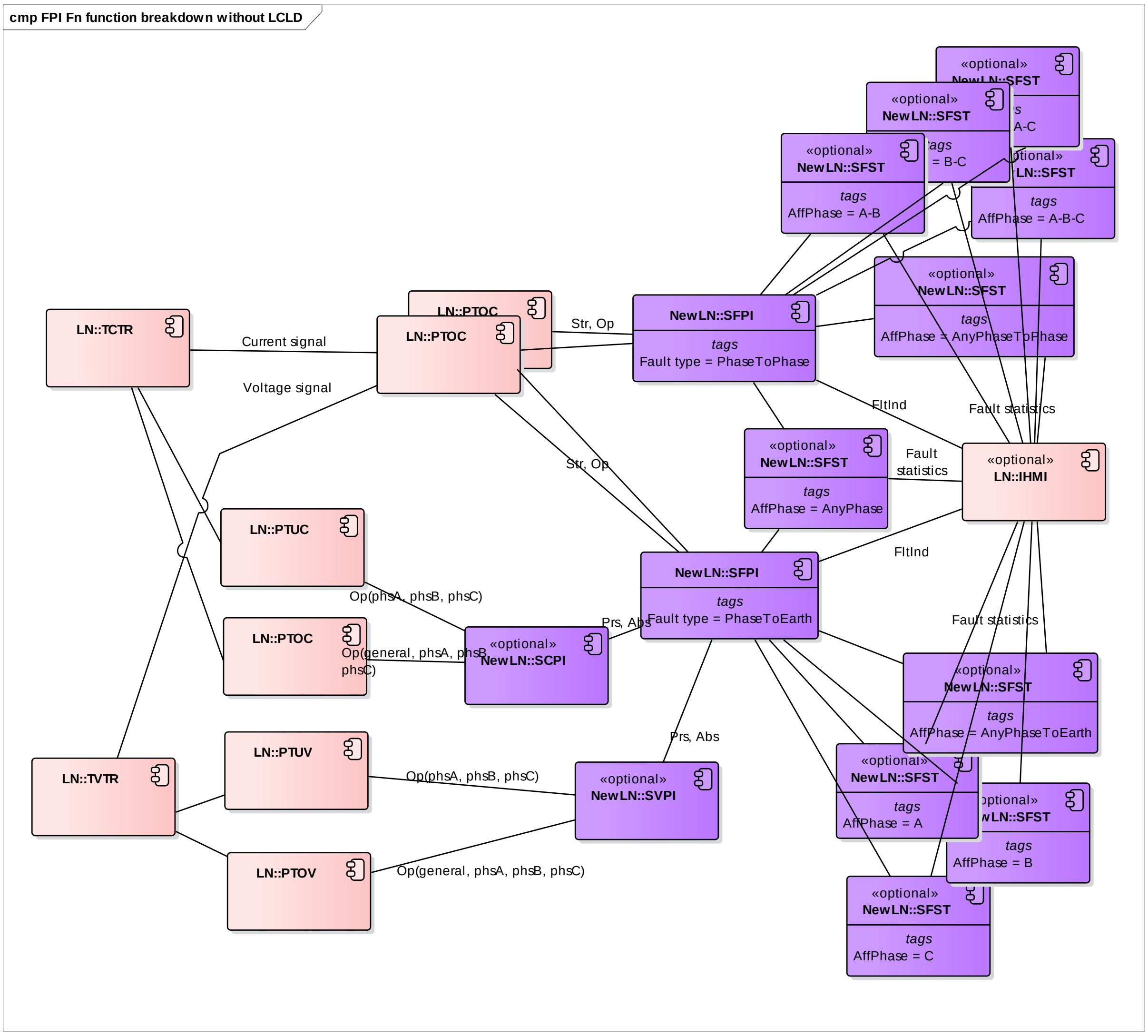


Figure 61 – Possible arrangement of LNs to support fault passage indication

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.

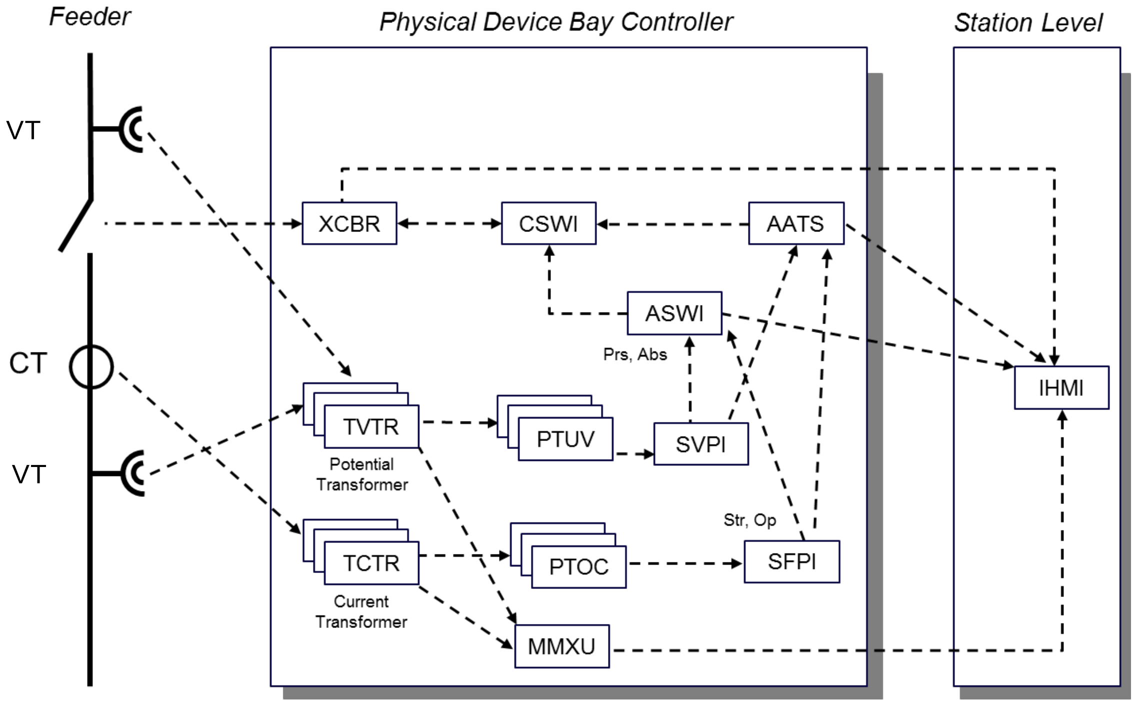


Figure 62 – Typical Arrangement of LNs to support FLISR using sectionalizers detecting fault current

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.

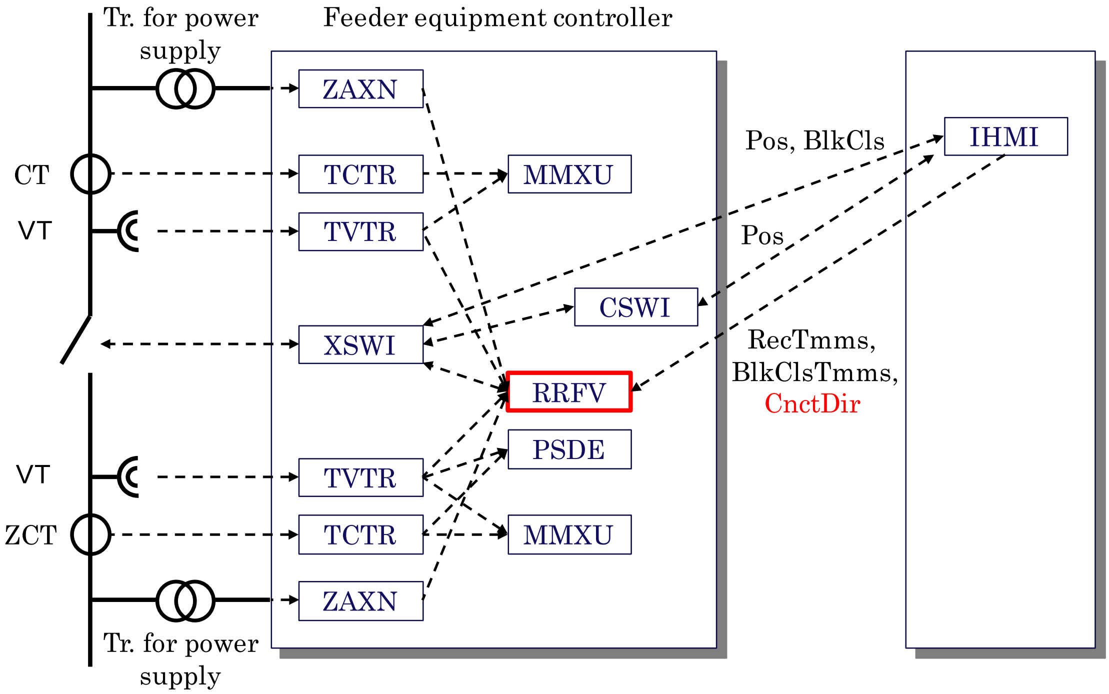
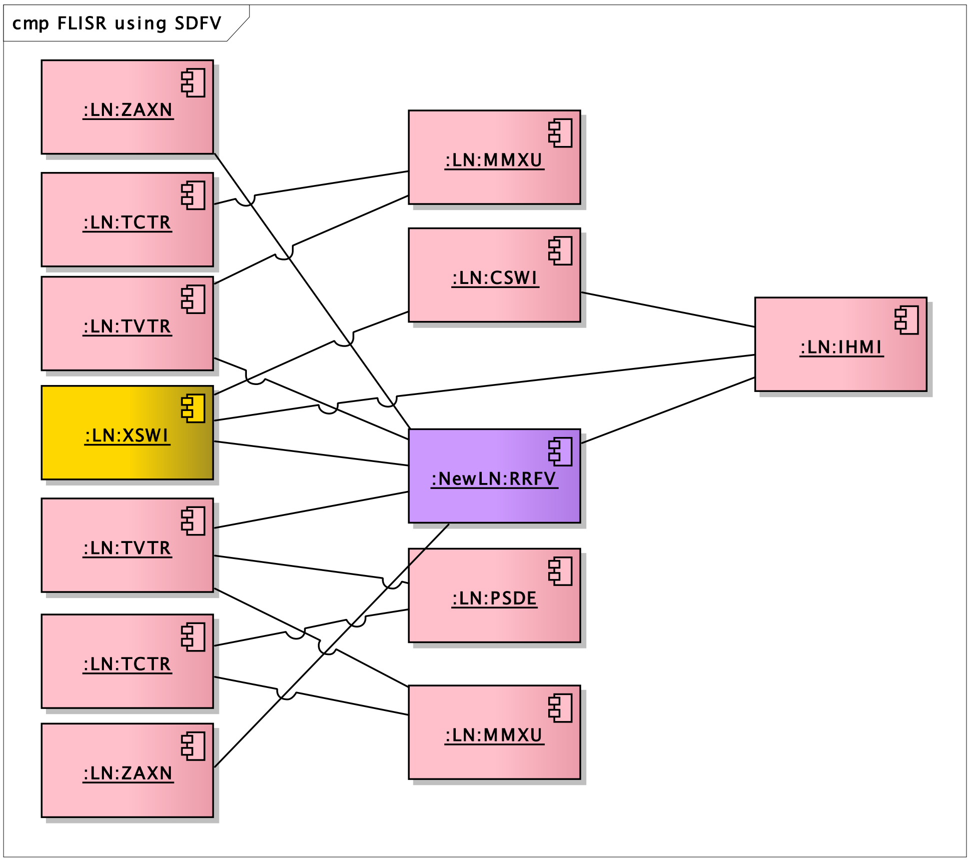


Figure 63 – Typical Arrangement of LNs to support FLISR using SDFV



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.

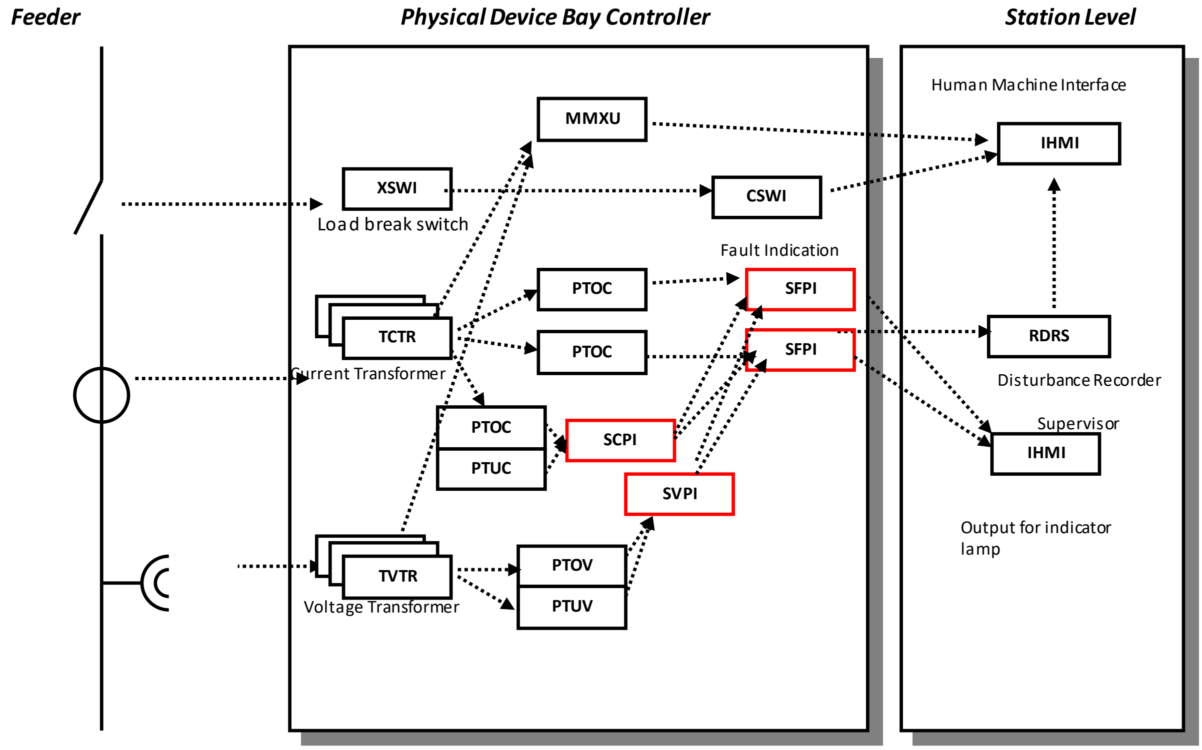
6.1.3 Mapping of the requirements of FLISR based on centralized control – Type 3

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.

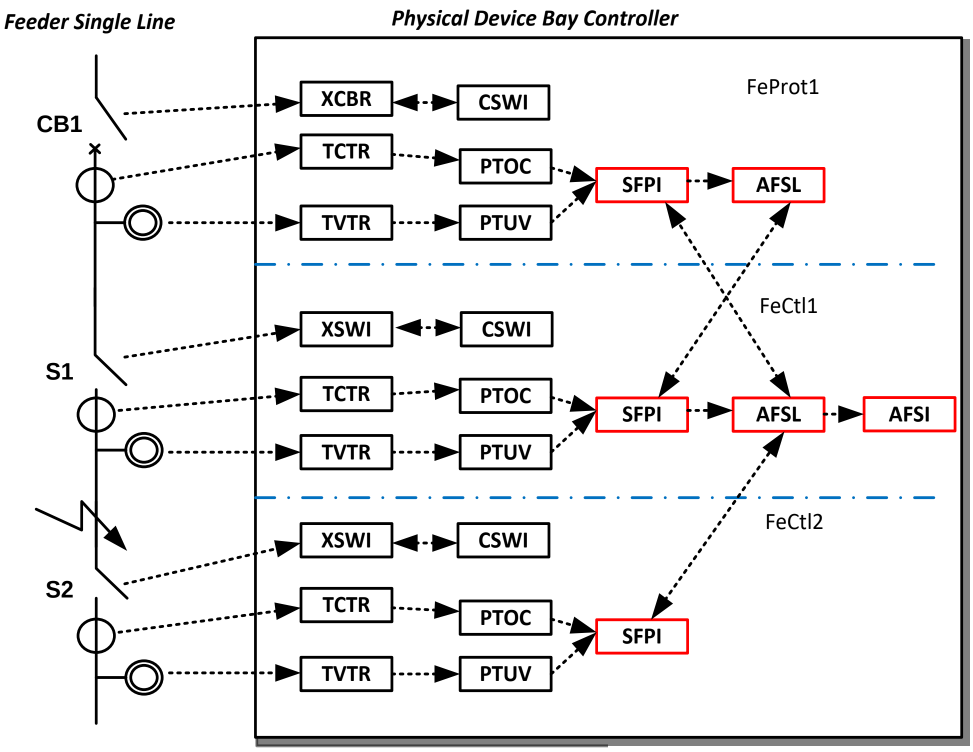


Figure 66 – Typical arrangement of LNs to support distributed fault location (case 4a)

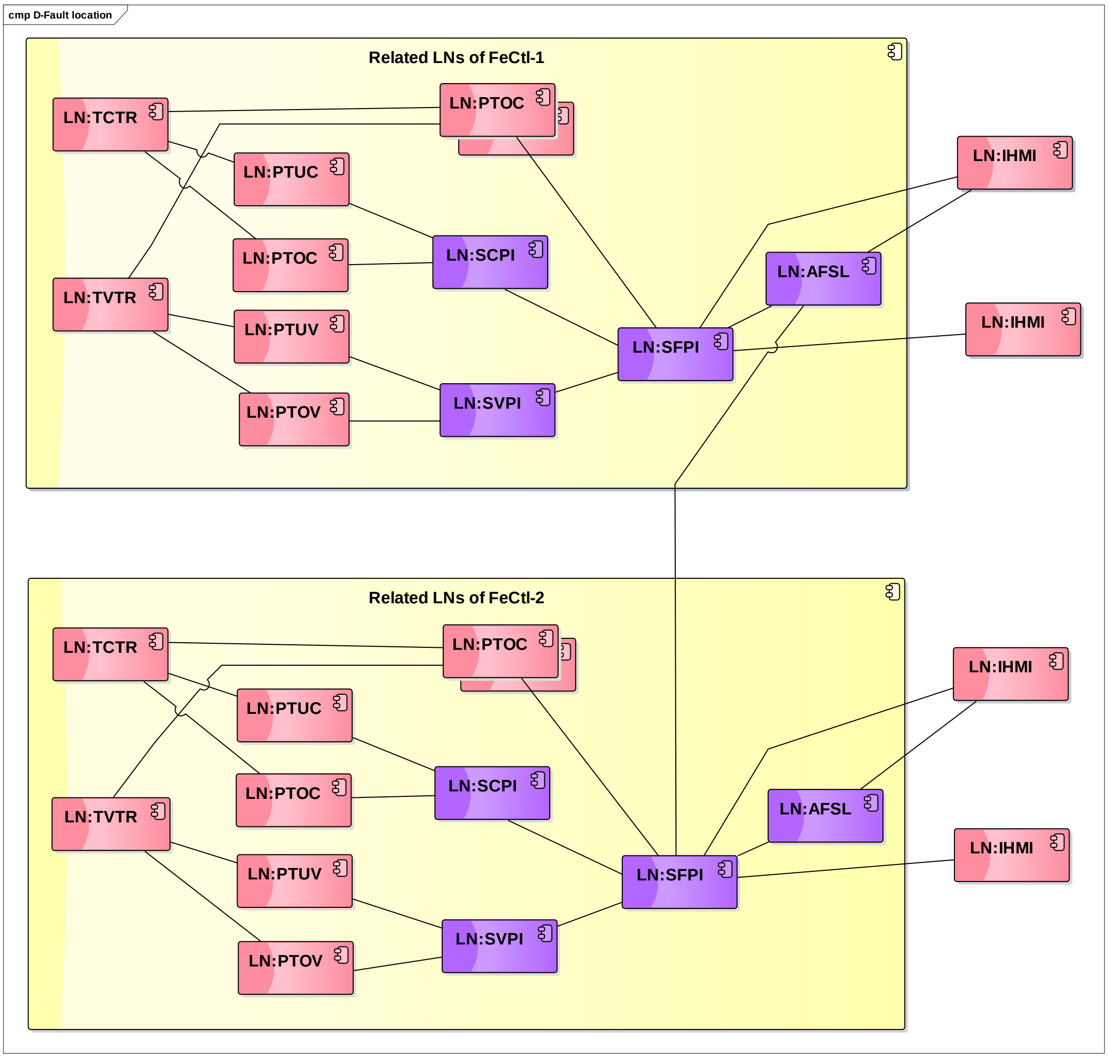


Figure 67 – Typical arrangement of LNs (between FeCtl) to support distributed fault location (case 4a)

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 introduce 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.

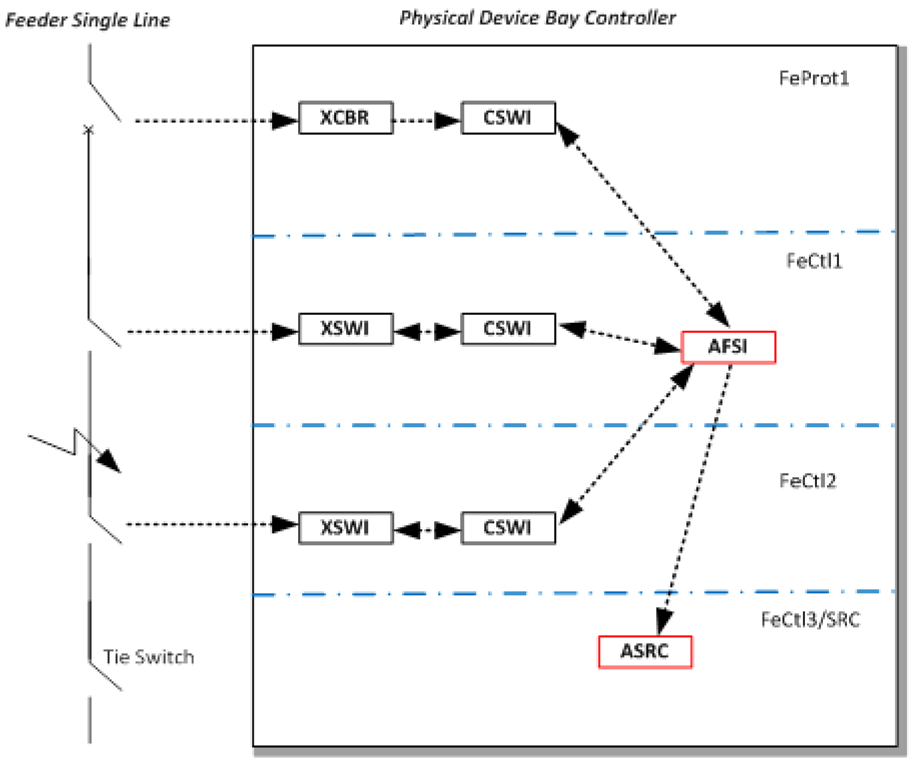


Figure 68 – Typical arrangement of LNs to support distributed fault isolation (case 4a)

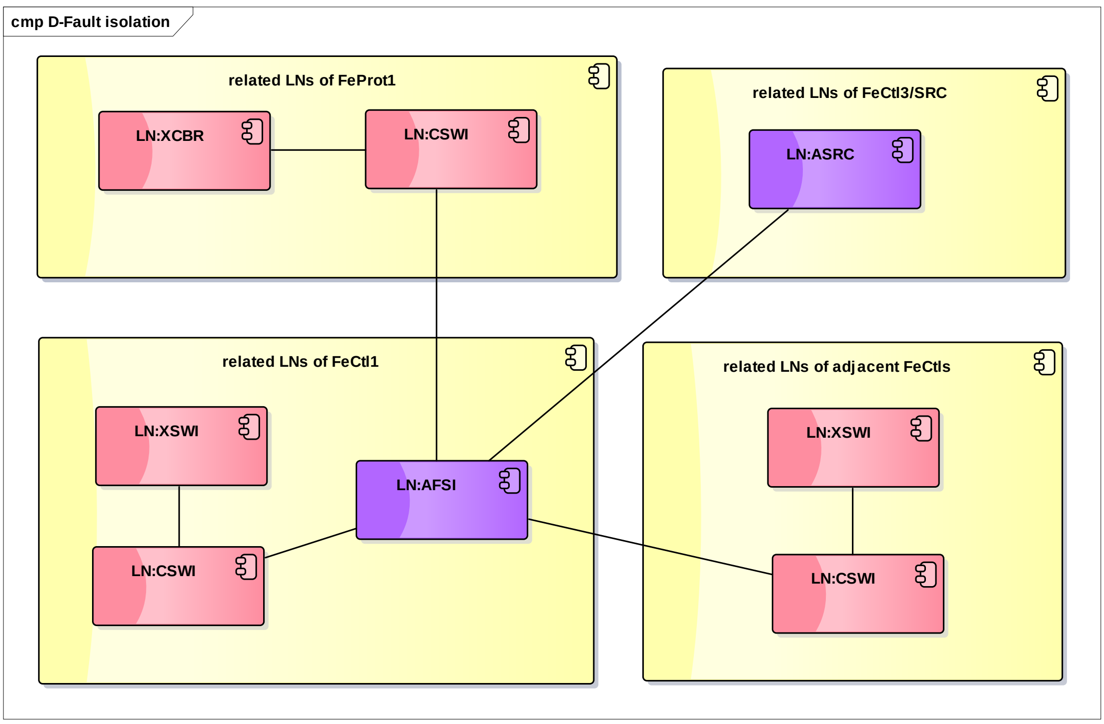


Figure 69 – Typical arrangement of LNs (between FeCtl) to support distributed fault isolation (case 4a)

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.

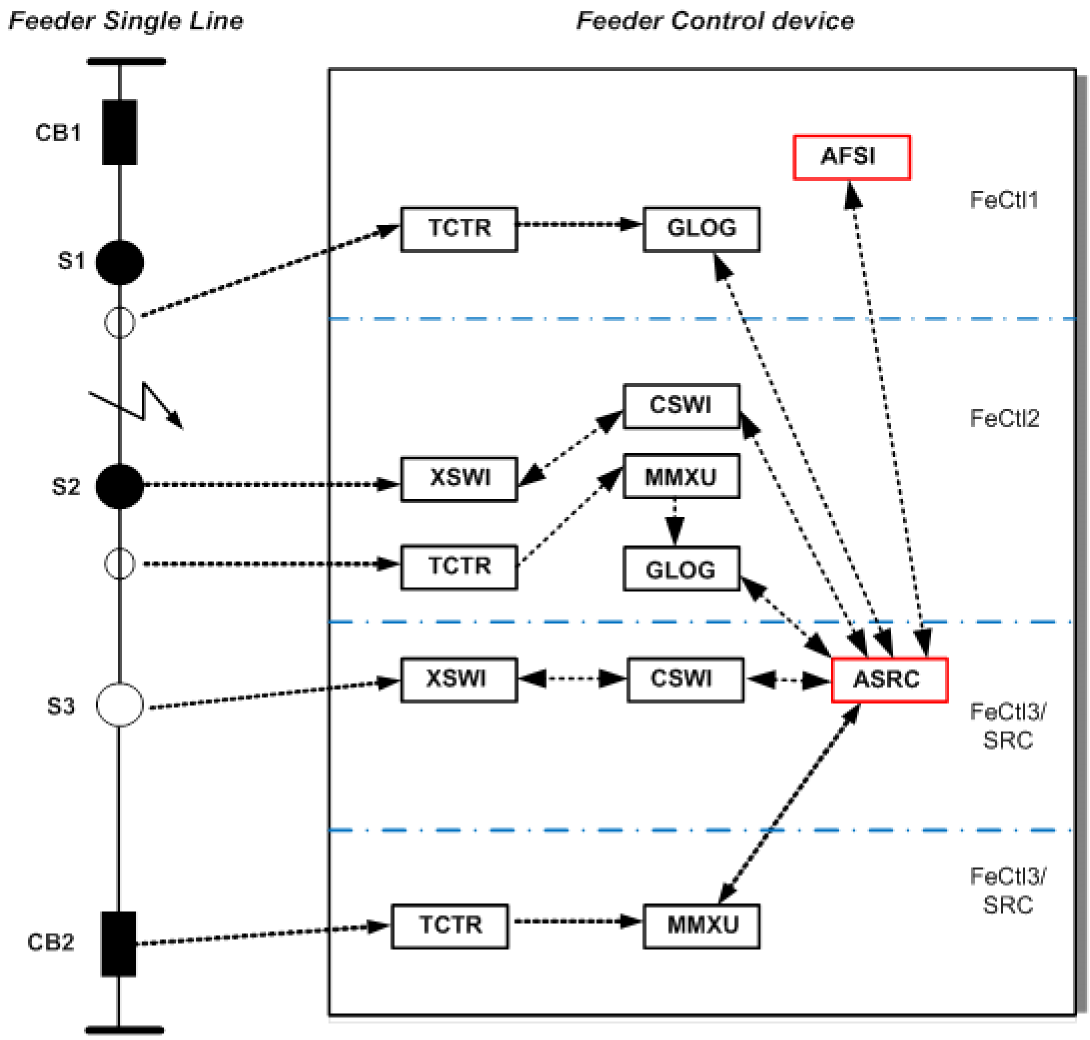


Figure 70 – Possible arrangement to support distributed service restoration

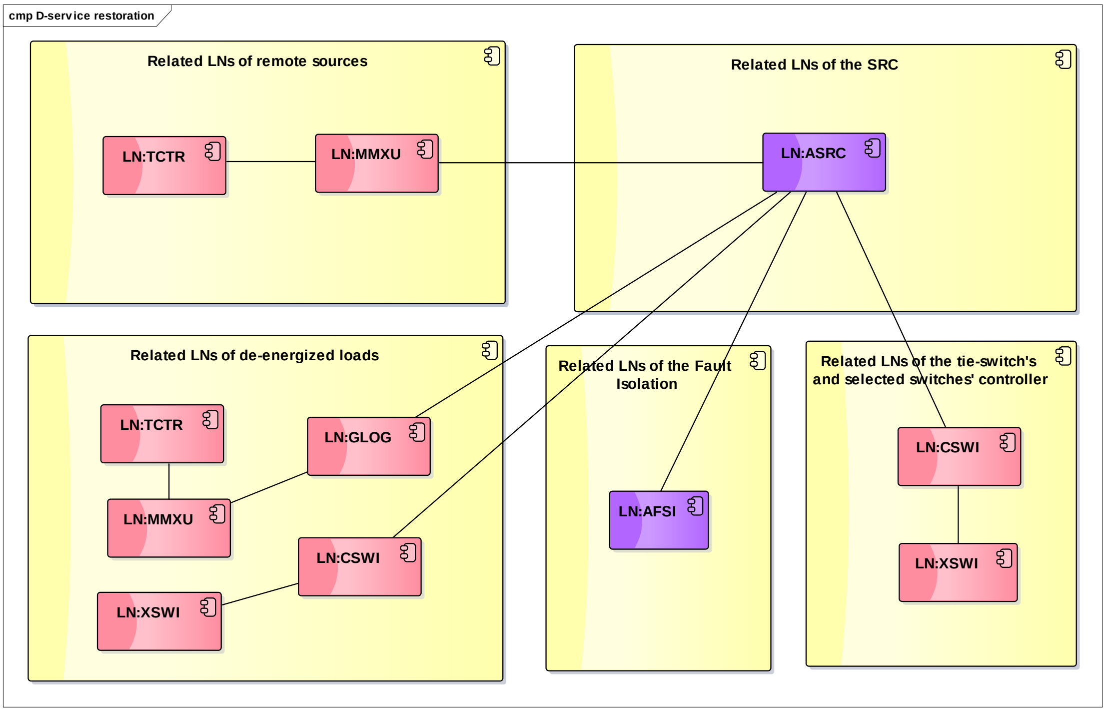


Figure 71 – Break down of LNs and relationships to support distributed service restoration

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)	The proposed approach relies on way to inhibit by settings blocking information. 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. 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. In case of feeder reconfiguration, these setting values would be changed to reflect the new topology. Model impact: Addition of BlkRefInh as an optional setting with multiple instances (as many as BlkRef one) at PTRC and CSWI level.
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.

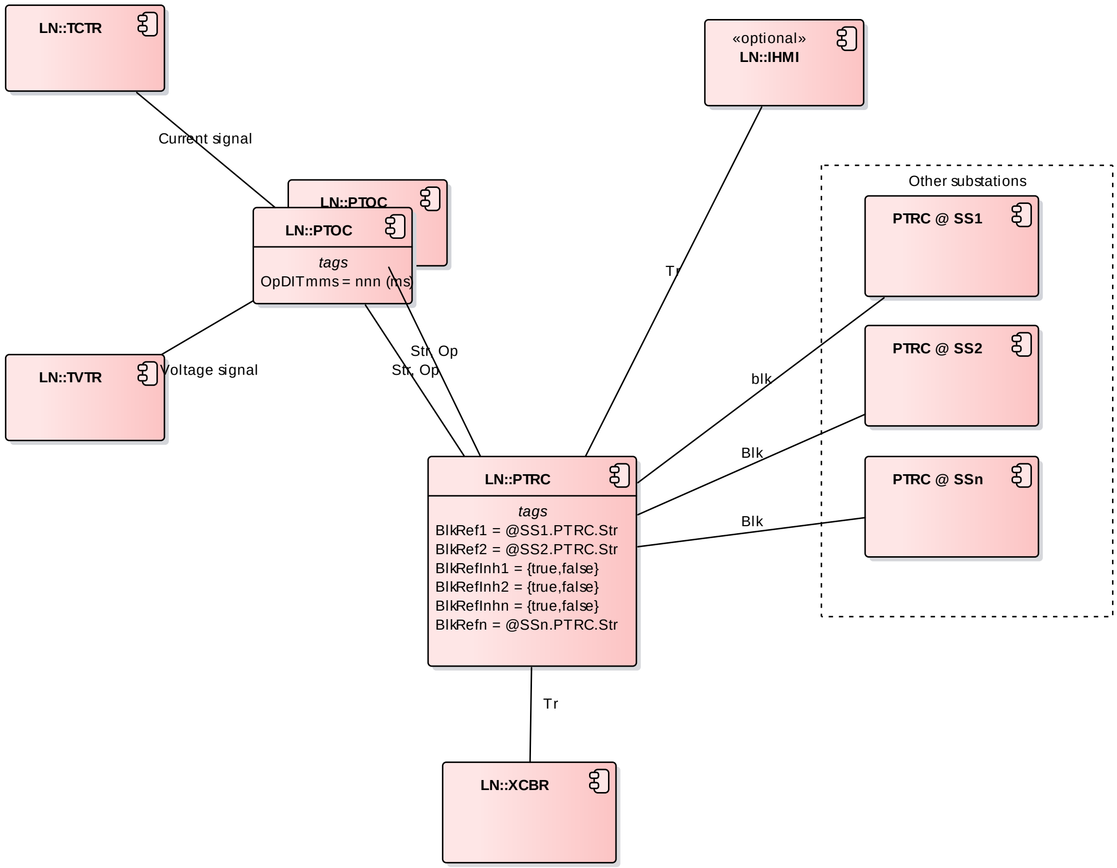


Figure 72 – Possible LN arrangement of breakers related functions, contributing to distributed FLISR (case 4b)

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 (OpDlTmms – which will indicate how long the LN needs to wait until sending the control to the switch, or being blocked).

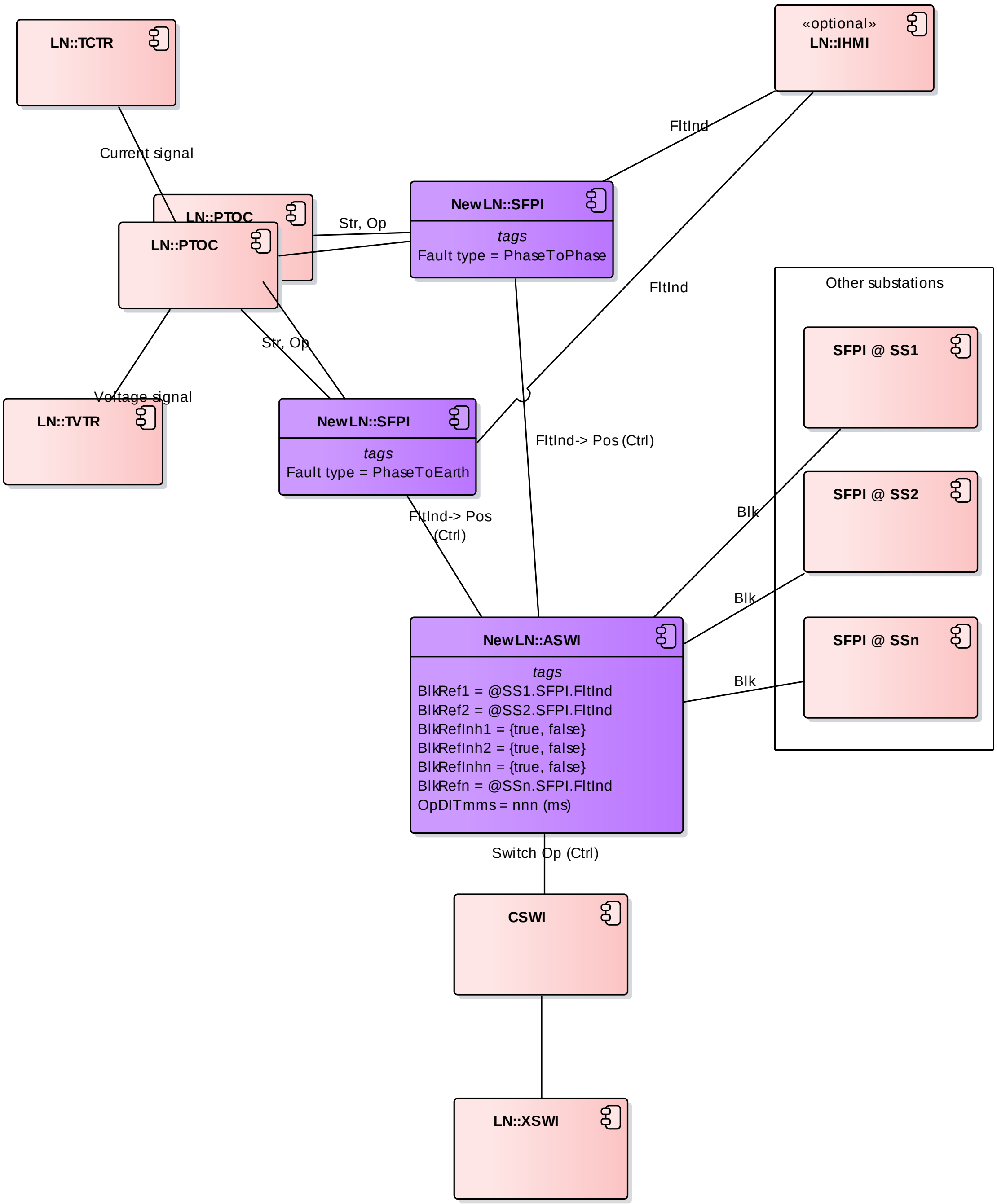


Figure 73 – Possible LN arrangement of disconnectors related functions, contributing to distributed FLISR (case 4b)

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.

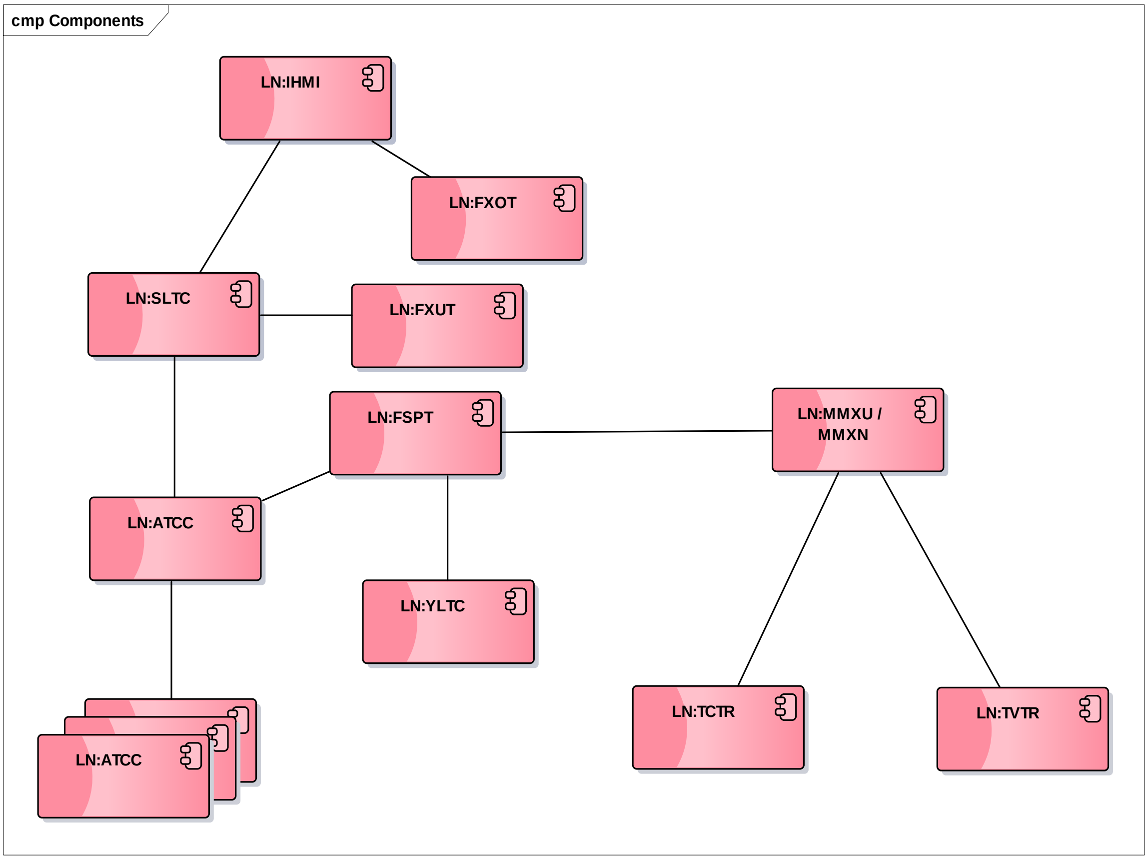


Figure 74 – Possible LN arrangement for the mapping for tap changer control

6.1.5.2 Mapping for capacitor bank control

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

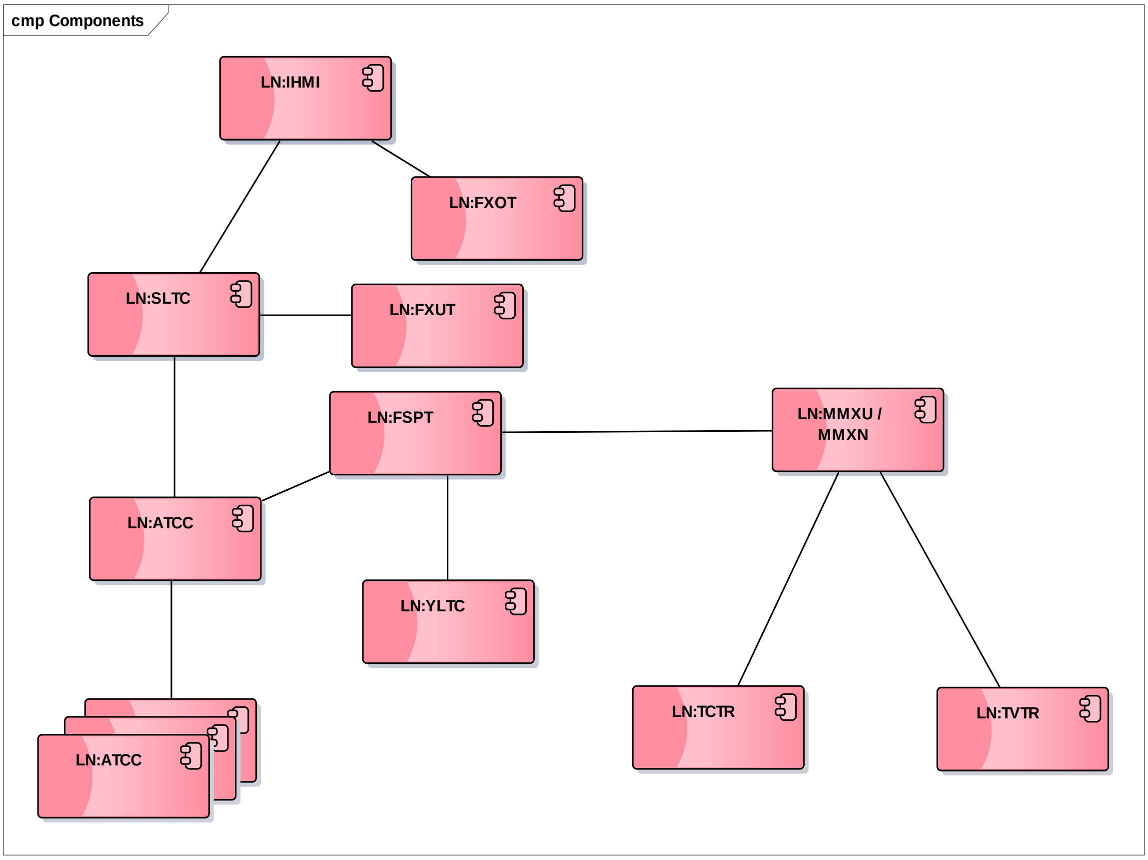


Figure 75 – Possible LN arrangement for the mapping for capacitor bank control

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.

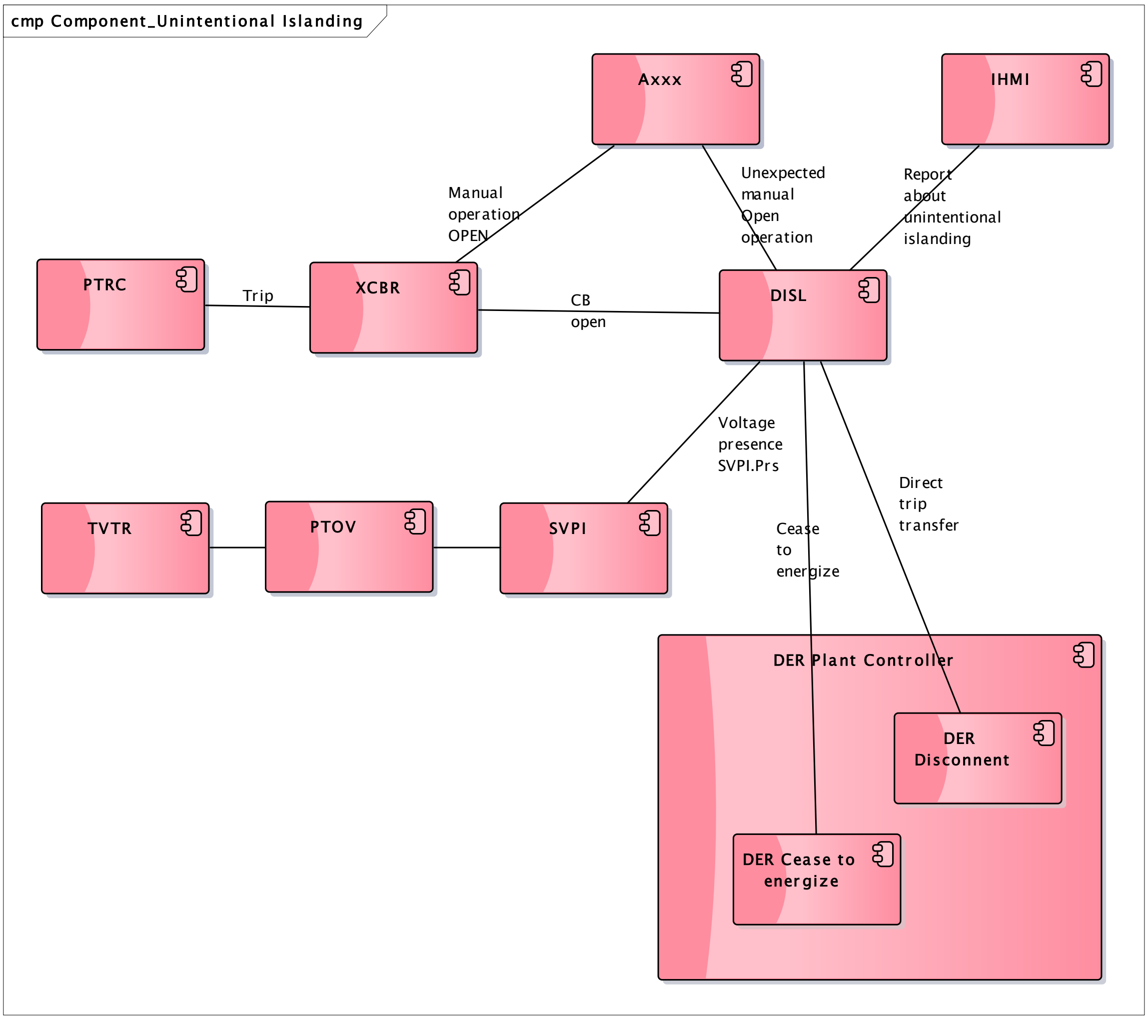


Figure 76 – Breakdown of LNs and relationships to support unintentional islanding protection

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.

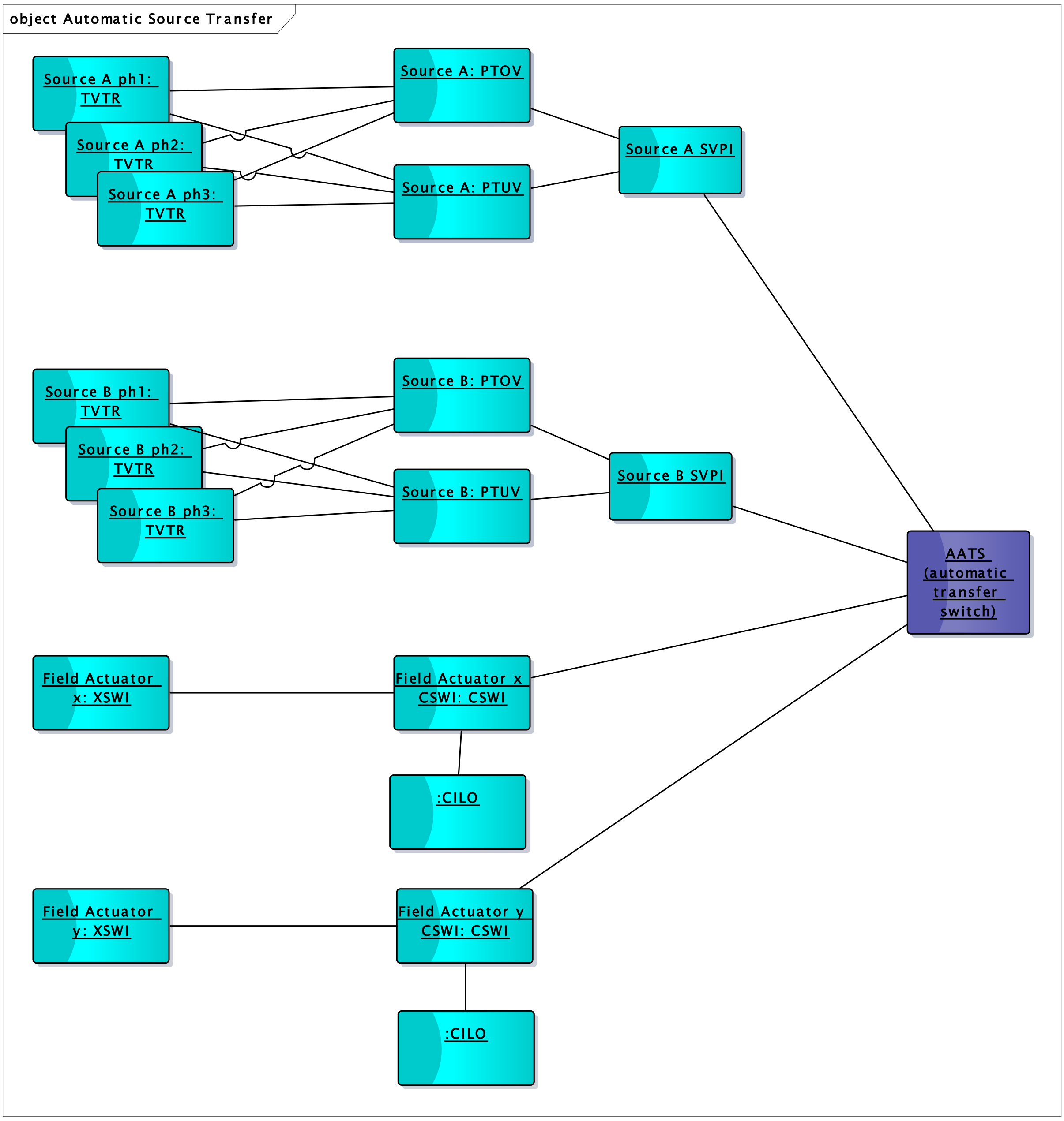


Figure 77 – Possible arrangement of LNs to perform automatic transfer switch

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.

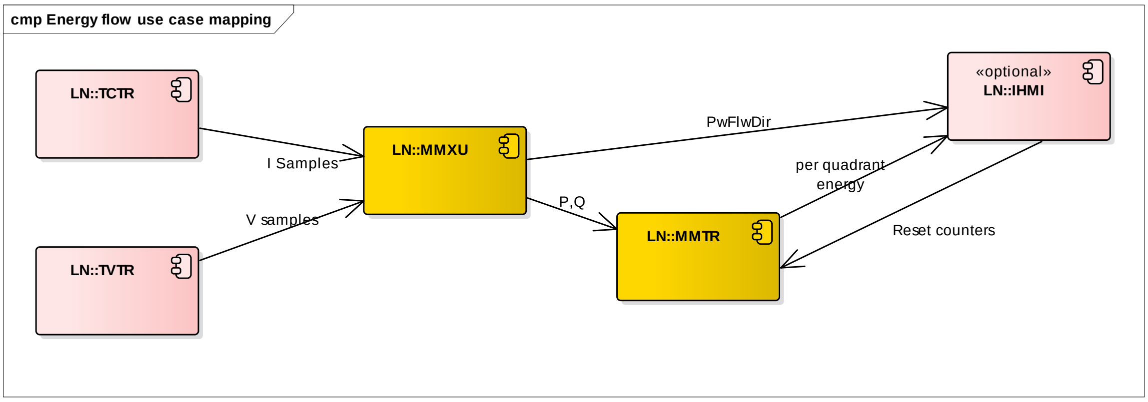


Figure 78 – Possible arrangement of LNs to Monitor energy flows related Use cases

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

<table>
<tr><th>Requirement</th><th>IEC 61850 LN mapping</th></tr>
<tr><td>Status, alarm, warning:
Temperature,
Precipitation (rain, snow, fog, ice rain...),
wind (speed/direction), Solar radiation, Moisture, Air pressure</td><td>MMET<table>
<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></td></tr>
<tr><td>Status, alarm, warning: ice level, snow level, flood level, earthquake
Radiation measurement,</td><td><table>
<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></td></tr>
<tr><td>Presence is allowed (control)</td><td>SPSE (NEW)</td></tr>
<tr><td>Status: Human presence, animal presence, unexpected object presence, drone presence</td><td>SPSE (NEW)</td></tr>
<tr><td>Not allowed presence summary</td><td>SPSE (NEW)</td></tr>
<tr><td>Status: Access (Gates status [open/closed/open locked/open unlocked/closed locked/closed unlocked), Shutter position, ...)</td><td>SPSE (NEW)</td></tr>
<tr><td>Fire alarm.</td><td>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<table>
<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></td></tr>
<tr><td>Activation of fire fighting systems</td><td>KFIM (NEW)</td></tr>
</table>

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.

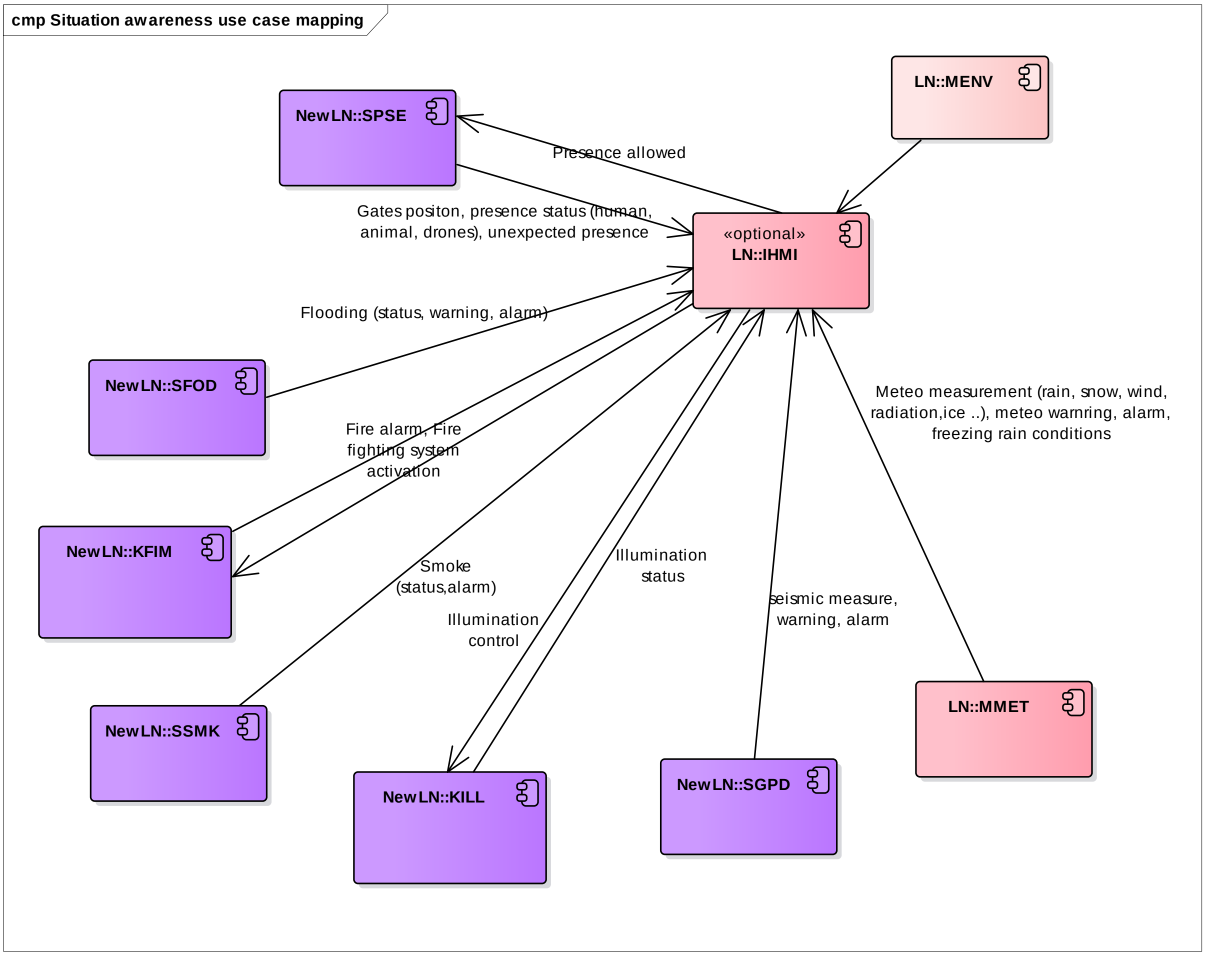


Figure 79 – Possible arrangement of LNs to support Environment situation awareness use cases

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					x	x	x				
2a	FLISR using sectionalizers detecting fault current					x			x					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		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.

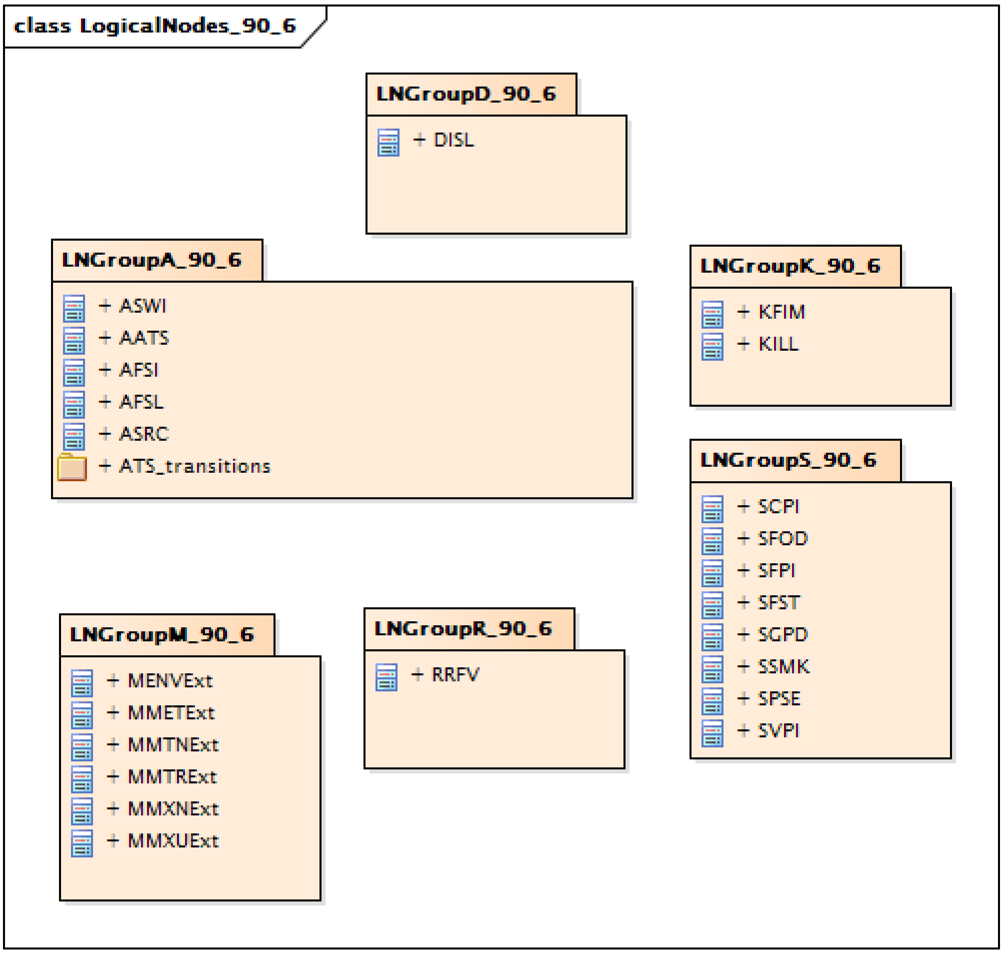


Figure 80 – Class diagram LogicalNodes_90_6::LogicalNodes_90_6

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

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

7.2.2.1 General

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

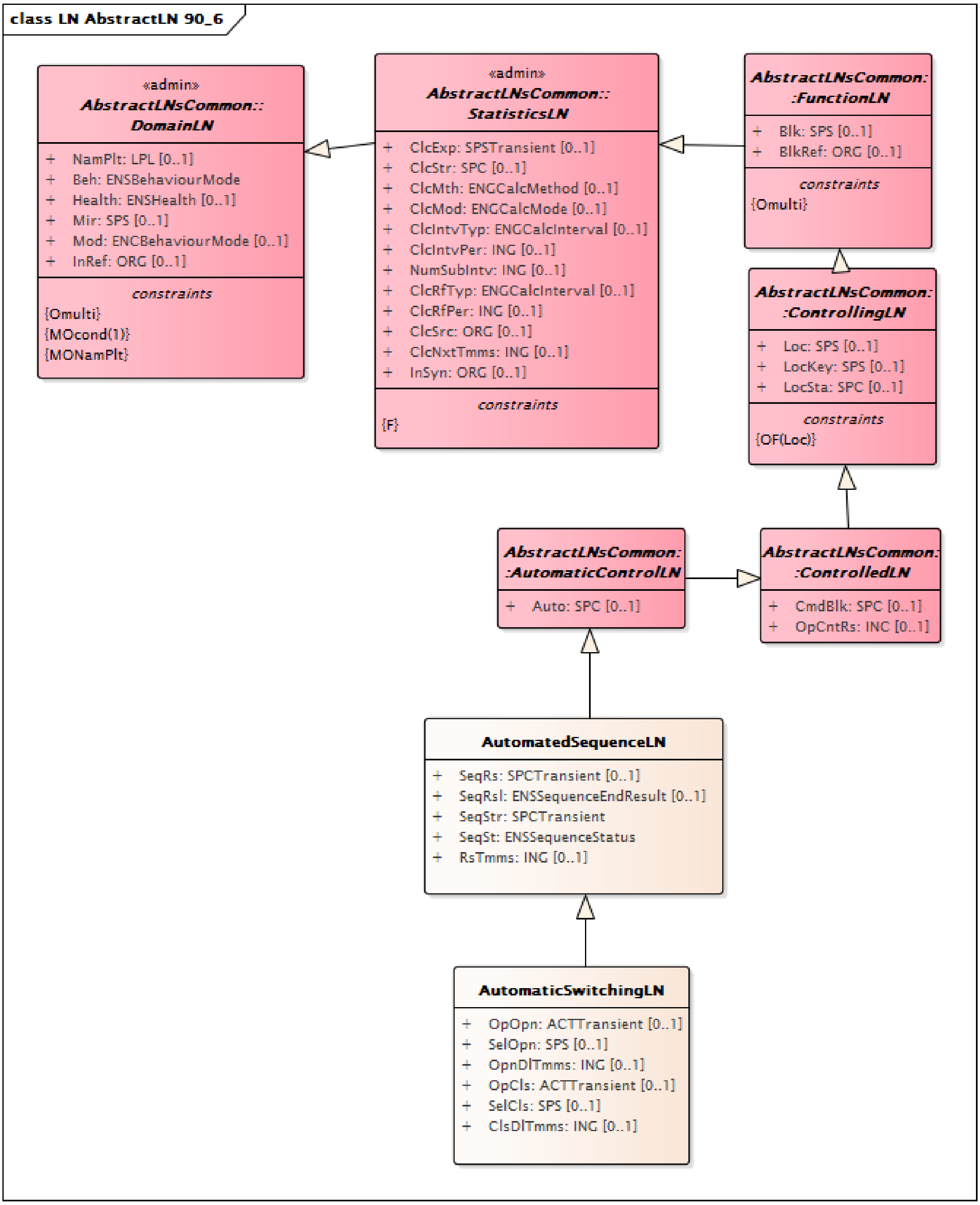


Figure 81 – Class diagram Abstract90-6LNs::LN AbstractLN 90_6

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**	**PresCond nds/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**	**PresCond nds/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
ClcNxtTmms	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**	**PresCond nds/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**	**PresCond nds/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				
OpnDlTmms	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
ClsDlTmms	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.

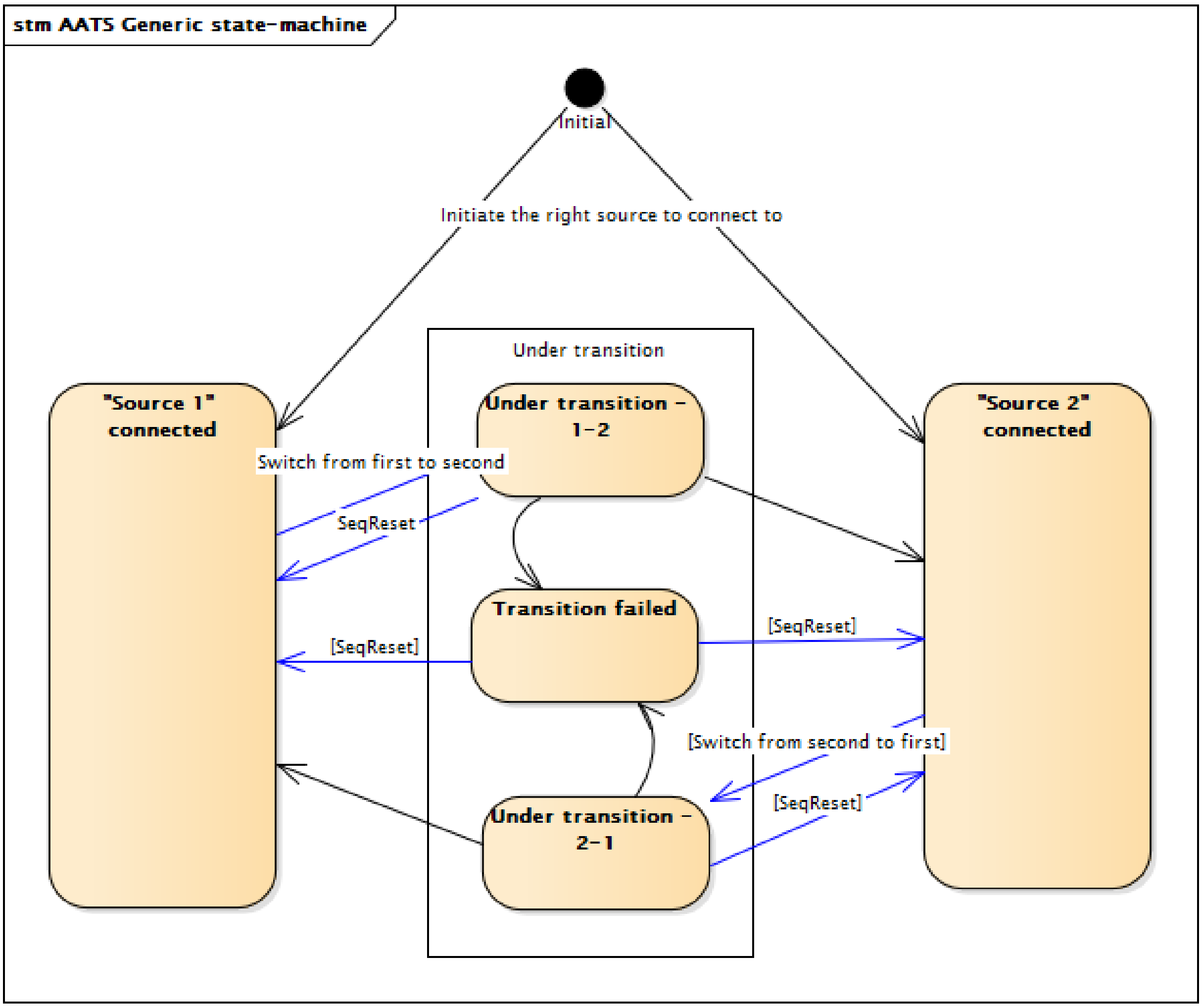


Figure 82 – Statechart diagram LNGroupA_90_6::AATS Generic state-machine

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

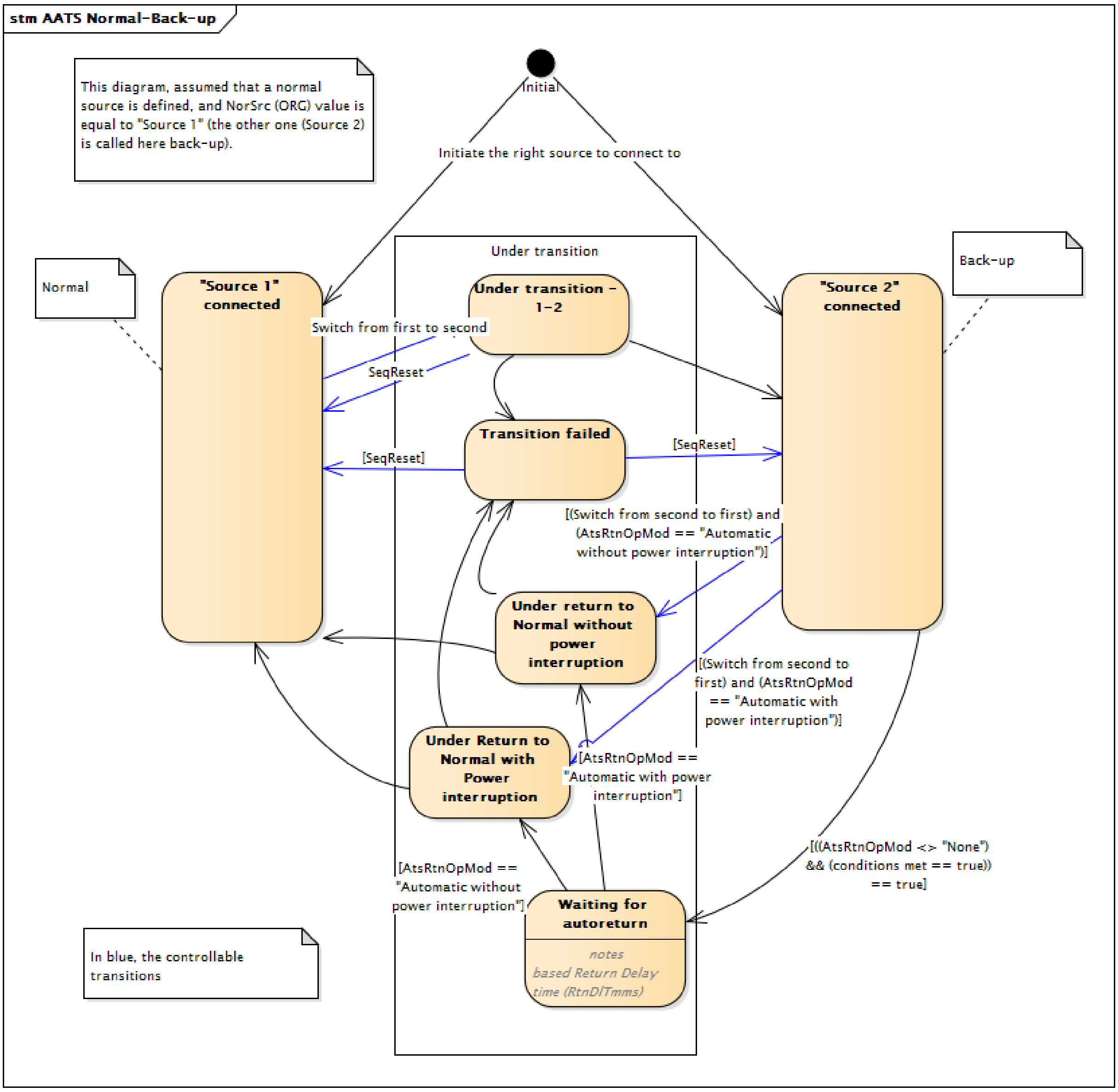


Figure 83 – Statechart diagram LNGroupA_90_6::AATS Normal-Back-up

Figure 83: Generic State machine diagram for automatic transfer source, when one source is designated as normal.

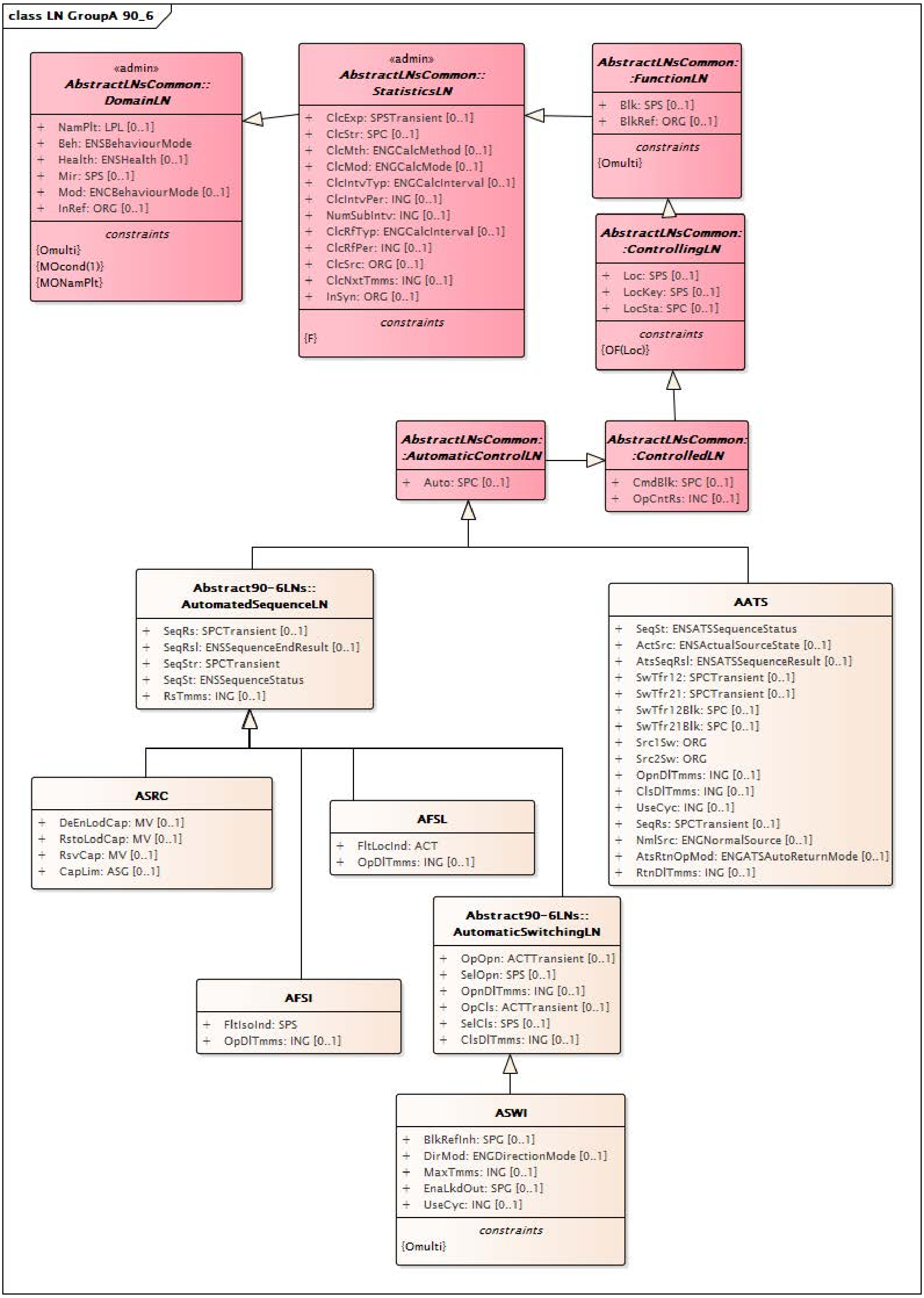


Figure 84 – Class diagram LNGroupA_90_6::LN GroupA 90_6

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**	**PresCond nds/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**	**PresCond nds/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
OpnDlTmms	ING		inherited from: AutomaticSwitchingLN	O / F
ClsDlTmms	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
ClcNxtTmms	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**	**PresCond nds/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**	**PresCond nds/ds**
			and monitoring of the connection/disconnection of Source2	
OpnDlTmms	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
ClsDlTmms	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
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
RtnDlTmms	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**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
FltIsoInd	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 FltIsoRs, 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				
OpDlTmms	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

AFSI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
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

7.2.3.5 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**	**PresCond nds/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**	**PresCond nds/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				
OpDlTmms	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**	**PresCond nds/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**	**PresCond nds/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
ClcNxtTmms	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 transistions 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

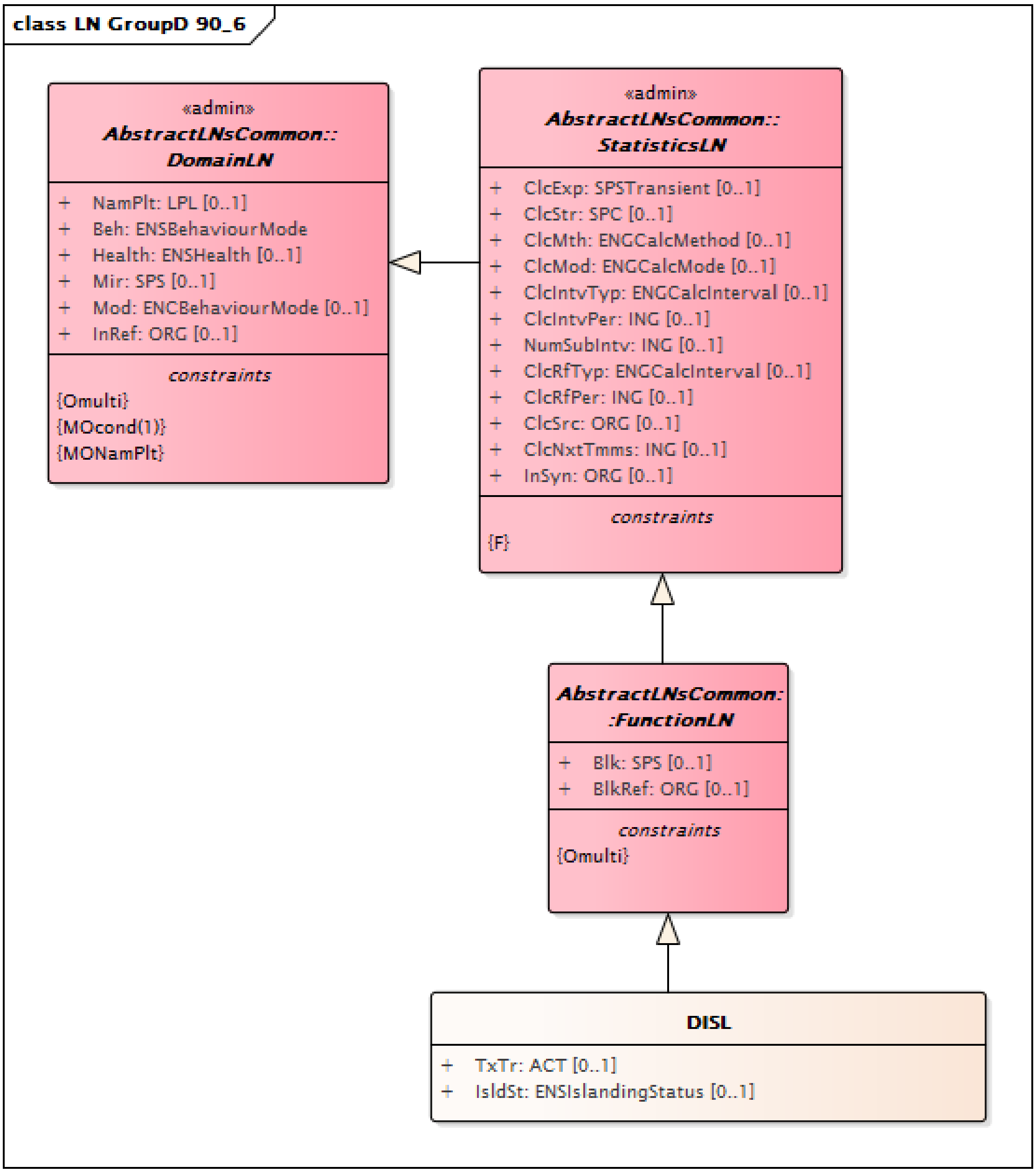


Figure 85 – Class diagram LNGroupD_90_6::LN GroupD 90_6

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**	**PresCond nds/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
ClcNxtTmms	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.

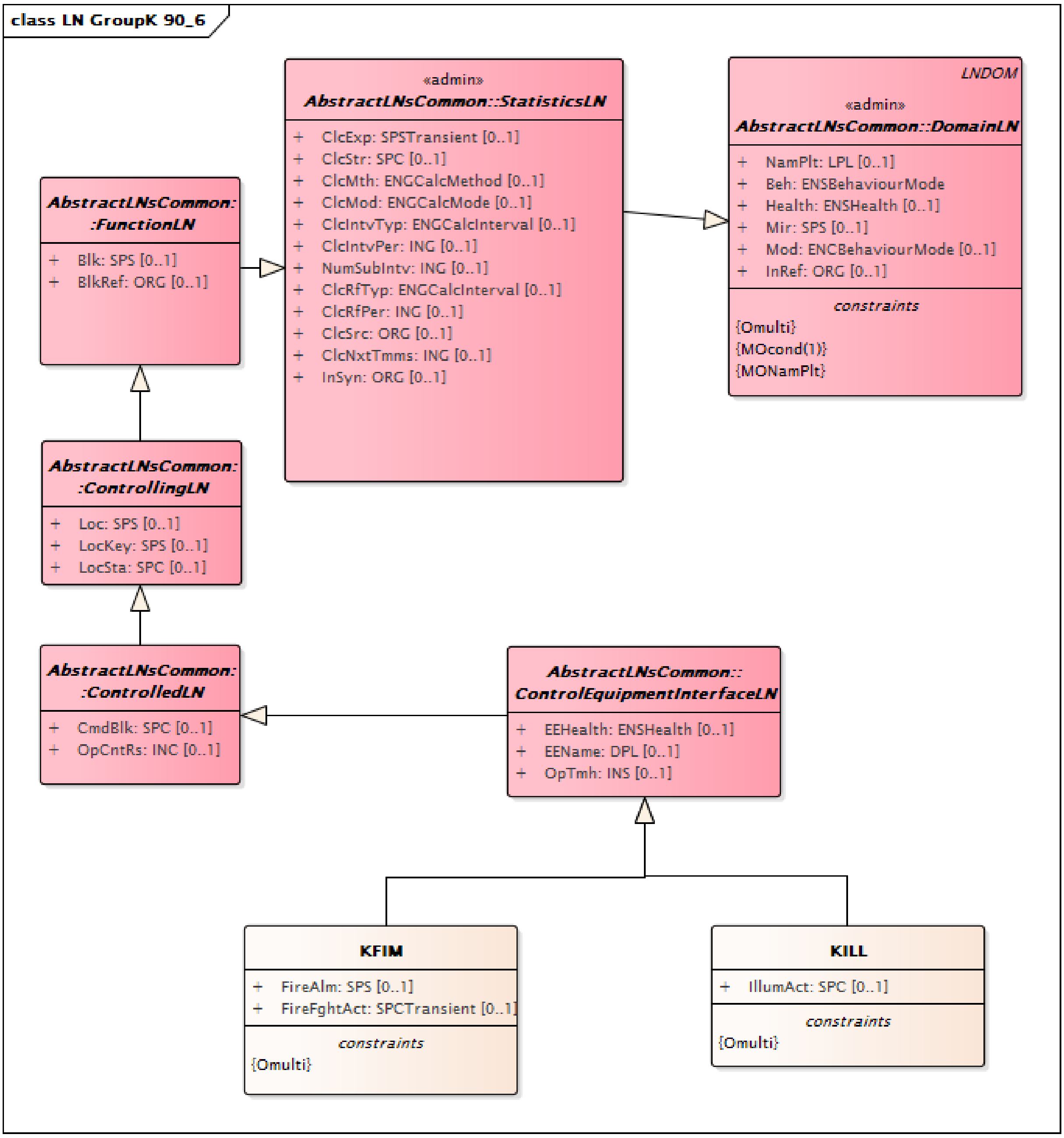


Figure 86 – Class diagram LNGroupK_90_6::LN GroupK 90_6

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**	**PresCond nds/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	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
ClcNxtTmms	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**	**PresCond nds/ds**
Descriptions				
EEName	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 disactivated.	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
ClcNxtTmms	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.

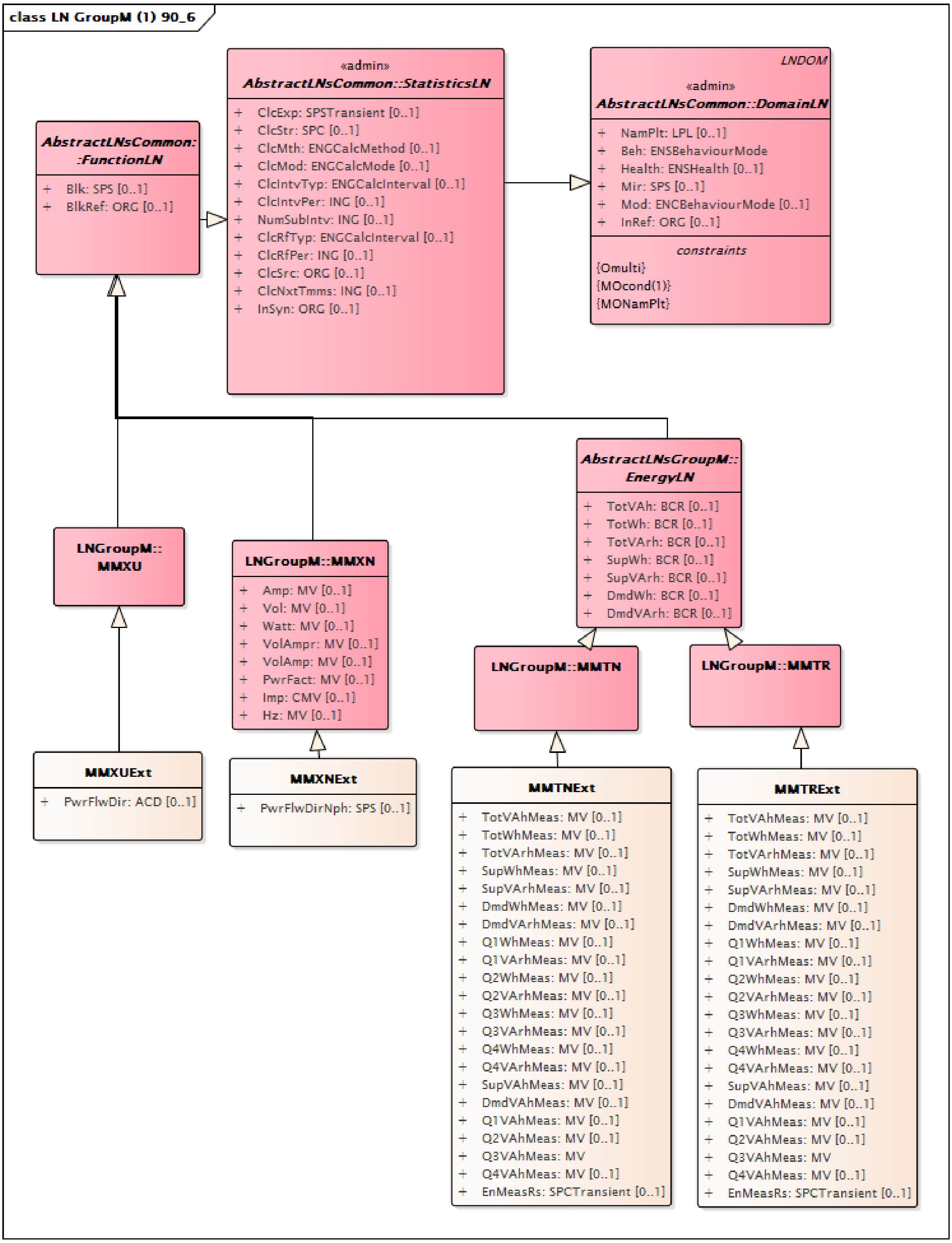


Figure 87 – Class diagram LNGroupM_90_6::LN GroupM (1) 90_6

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.

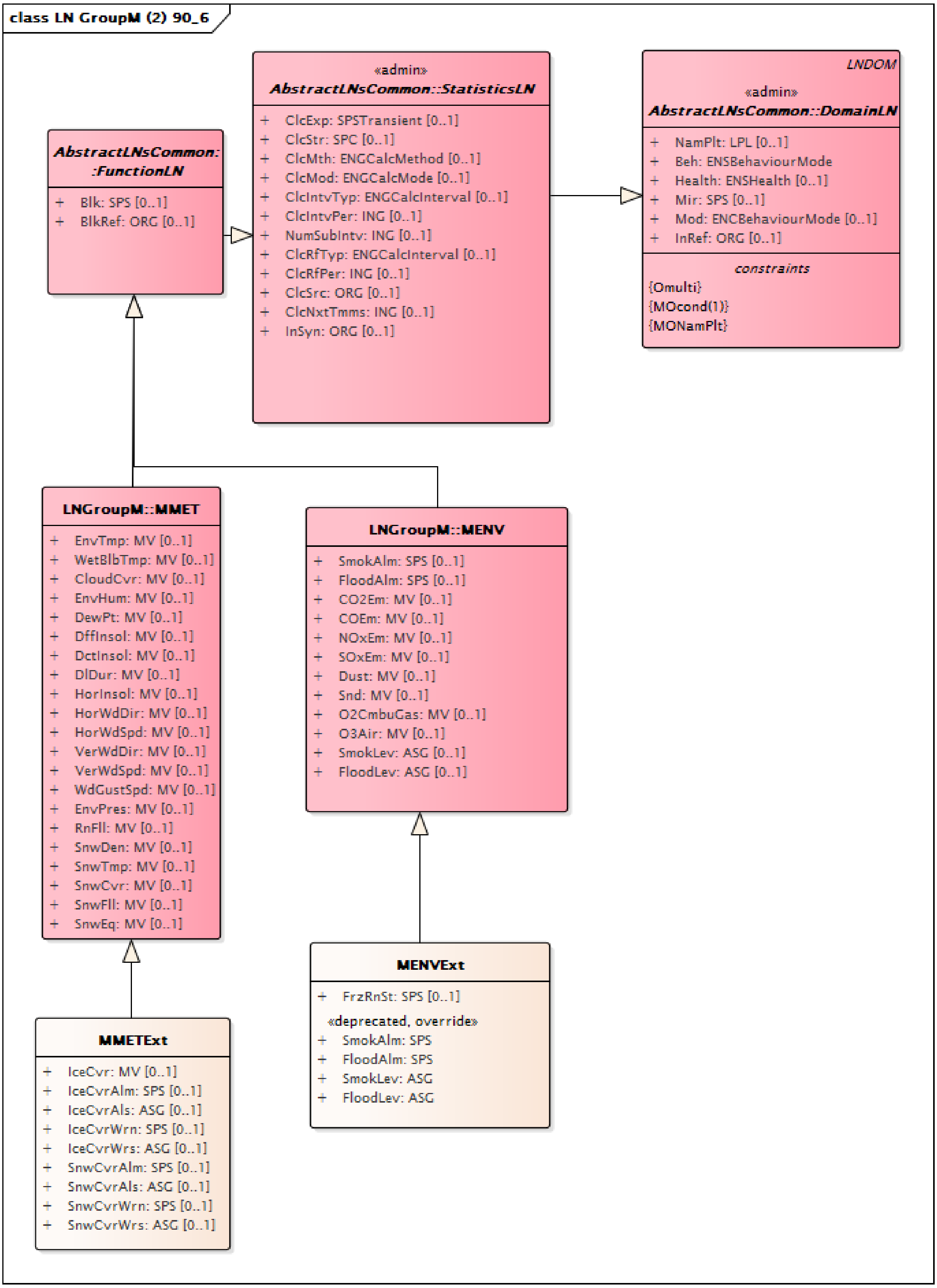


Figure 88 – Class diagram LNGroupM_90_6::LN GroupM (2) 90_6

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**	**PresCond nds/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**	**PresCond nds/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
ClcNxtTmms	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.

Table 27 – Data objects of MMETExt

MMETExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
IceCvrAlm	SPS		If true, the ice cover exceeds the alarming threshold level defined in IceCvrAls.	O / F
IceCvrWrn	SPS		If true, the ice cover exceeds the warning threshold level defined in IceCvrWrs.	O / F
SnwCvrAlm	SPS		If true, the snow cover exceeds the alarming threshold level defined in SnwCvrAls.	O / F
SnwCvrWrn	SPS		If true, the snow cover exceeds the warning threshold level defined in SnwCvrWrs.	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				
IceCvr	MV		Ice cover (typically in mm – length SIUnit [m]).	O / O
EnvTmp	MV		inherited from: MMET	O / O
WetBlbTmp	MV		inherited from: MMET	O / O
CloudCvr	MV		inherited from: MMET	O / O
EnvHum	MV		inherited from: MMET	O / O
DewPt	MV		inherited from: MMET	O / O
DffInsol	MV		inherited from: MMET	O / O
DctInsol	MV		inherited from: MMET	O / O
DlDur	MV		inherited from: MMET	O / O
HorInsol	MV		inherited from: MMET	O / O
HorWdDir	MV		inherited from: MMET	O / O
HorWdSpd	MV		inherited from: MMET	O / O
VerWdDir	MV		inherited from: MMET	O / O
VerWdSpd	MV		inherited from: MMET	O / O
WdGustSpd	MV		inherited from: MMET	O / O
EnvPres	MV		inherited from: MMET	O / O
RnFll	MV		inherited from: MMET	O / O
SnwDen	MV		inherited from: MMET	O / O
SnwTmp	MV		inherited from: MMET	O / O
SnwCvr	MV		inherited from: MMET	O / O
SnwFll	MV		inherited from: MMET	O / O
SnwEq	MV		inherited from: MMET	O / O
Controls				
ClcStr	SPC		inherited from: StatisticsLN	O / O

MMETExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
IceCvrAls	ASG		Ice cover alarming threshold	O / F
IceCvrWrs	ASG		Ice cover warning threshold	O / F
SnwCvrAls	ASG		Snow cover alarming threshold	O / F
SnwCvrWrs	ASG		Snow cover warning threshold	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

7.2.6.4 LN: Non Phase related energy measurement extension Name: MMTNExt

Set of information objects to extend the MMTN LN.

This logical node represents calculation of energy measurement in a single-phase system. Originally MMTN was exclusively set for billing purpose. The main objectives of these extensions are for operative applications purpose where DOs are based on the MV CDC, and a suffix Meas indicates this difference with the original BCR-typed one.

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

Table 28 shows all data objects of MMTNExt.

Table 28 – Data objects of MMTNExt

MMTNExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
TotVAh	BCR		inherited from: EnergyLN	O / O
TotWh	BCR		inherited from: EnergyLN	O / O
TotVArh	BCR		inherited from: EnergyLN	O / O
SupWh	BCR		inherited from: EnergyLN	O / O
SupVArh	BCR		inherited from: EnergyLN	O / O
DmdWh	BCR		inherited from: EnergyLN	O / O
DmdVArh	BCR		inherited from: EnergyLN	O / O
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				
TotVAhMeas	MV		Net apparent energy reported as MV	O / O
TotWhMeas	MV		Net real energy reported as MV	O / O
TotVArhMeas	MV		Net reactive energy reported as MV	O / O
SupWhMeas	MV		Real energy supply (default direction: forward based on RvPwrFlwSign convention) reported as MV	O / O
SupVArhMeas	MV		Reactive energy supply (default direction: foreward based on RvPwrFlwSign convention) reported as MV	O / O
DmdWhMeas	MV		Real energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV	O / O
DmdVArhMeas	MV		Reactive energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV	O / O
Q1WhMeas	MV		Real energy supply in quadrant 1 reported as MV	O / O
Q1VArhMeas	MV		Reactive energy supply in quadrant 1 reported as MV	O / O
Q2WhMeas	MV		Real energy supply in quadrant 2 reported as MV	O / O
Q2VArhMeas	MV		Reactive energy supply in quadrant 2 reported as MV	O / O
Q3WhMeas	MV		Real energy supply in quadrant 3 reported as MV	O / O
Q3VArhMeas	MV		Reactive energy supply in quadrant 3 reported as MV	O / O
Q4WhMeas	MV		Real energy supply in quadrant 4 reported as MV	O / O
Q4VArhMeas	MV		Reactive energy supply in quadrant 4 reported as MV	O / O
SupVAhMeas	MV		Supplied apparent energy reported as MV	O / O
DmdVAhMe	MV		Demand apparent energy reported as MV	O / O

MMTNExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
as				
Q1VAhMeas	MV		Quadrant 1 apparent energy reported as MV	O / O
Q2VAhMeas	MV		Quadrant 2 apparent energy reported as MV	O / O
Q3VAhMeas	MV		Quadrant 3 apparent energy reported as MV	M / O
Q4VAhMeas	MV		Quadrant 4 apparent energy reported as MV	O / O
Controls				
EnMeasRs	SPC	T	Operating with value true performs the reset of all (operation) energy counters of this LN – not the one based on BCR type. Operating with value false is ignored. The change of its status value is a local issue	O / 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
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.6.5 LN: Three phases related energy measurement extension Name: MMTRExt

Set of information objects to extend the MMTR LN.

This logical node represents calculation of energy measurement in a three-phases system. Originally MMTN was exclusively set for billing purpose. The main objectives of these extensions are for operative applications where DOs are based on the MV CDC, and a suffix Meas indicates this difference with the original BCR-typed one.

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

Table 29 shows all data objects of MMTRExt.

Table 29 – Data objects of MMTRExt

MMTRExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
TotVAh	BCR		inherited from: EnergyLN	O / O
TotWh	BCR		inherited from: EnergyLN	O / O
TotVArh	BCR		inherited from: EnergyLN	O / O
SupWh	BCR		inherited from: EnergyLN	O / O
SupVArh	BCR		inherited from: EnergyLN	O / O
DmdWh	BCR		inherited from: EnergyLN	O / O
DmdVArh	BCR		inherited from: EnergyLN	O / O
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				
TotVAhMeas	MV		Net apparent energy reported as MV	O / O
TotWhMeas	MV		Net real energy reported as MV	O / O
TotVArhMeas	MV		Net reactive energy reported as MV	O / O
SupWhMeas	MV		Real energy supply (default direction: forward based on RvPwrFlwSign convention) reported as MV	O / O
SupVArhMeas	MV		Reactive energy supply (default direction: foreward based on RvPwrFlwSign convention) reported as MV	O / O
DmdWhMeas	MV		Real energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV	O / O
DmdVArhMeas	MV		Reactive energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV	O / O
Q1WhMeas	MV		Real energy supply in quadrant 1 reported as MV	O / O
Q1VArhMeas	MV		Reactive energy supply in quadrant 1 reported as MV	O / O
Q2WhMeas	MV		Real energy supply in quadrant 2 reported as MV	O / O
Q2VArhMeas	MV		Reactive energy supply in quadrant 2 reported as MV	O / O
Q3WhMeas	MV		Real energy supply in quadrant 3 reported as MV	O / O
Q3VArhMeas	MV		Reactive energy supply in quadrant 3 reported as MV	O / O
Q4WhMeas	MV		Real energy supply in quadrant 4 reported as MV	O / O
Q4VArhMeas	MV		Reactive energy supply in quadrant 4 reported as MV	O / O
SupVAhMeas	MV		Supplied apparent energy reported as MV	O / O
DmdVAhMe	MV		Demand apparent energy reported as MV	O / O

MMTRExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
as				
Q1VAhMeas	MV		Quadrant 1 apparent energy reported as MV	O / O
Q2VAhMeas	MV		Quadrant 2 apparent energy reported as MV	O / O
Q3VAhMeas	MV		Quadrant 3 apparent energy reported as MV	M / O
Q4VAhMeas	MV		Quadrant 4 apparent energy reported as MV	O / O
Controls				
EnMeasRs	SPC	T	Operating with value true performs the reset of all (operation) energy counters of this LN – not the one based on BCR type. Operating with value false is ignored. The change of its status value is a local issue	O / 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
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.6.6 LN: Non Phase related electric measurement extension Name: MMXNExt

Set of information objects to extend the MMXN LN.

This logical node represents calculation of electric measurement such as currents, voltages, powers and impedances in a non-phase-related system. The main use is for operative applications.

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

Table 30 shows all data objects of MMXNExt.

Table 30 – Data objects of MMXNExt

MMXNExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
PwrFlwDirNph	SPS		True value indicates power is flowing into the related PowerSystemResource.(also called "supply"). False indicates power is flowing out of the related PowerSystemResource (alaso called 'demand"). Supply and demand are refering to the setting PsFlwIn indicating the relationship between these notions and the sign of the measured power.	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				
Amp	MV		inherited from: MMXN	O / O
Vol	MV		inherited from: MMXN	O / O
Watt	MV		inherited from: MMXN	O / O
VolAmpr	MV		inherited from: MMXN	O / O
VolAmp	MV		inherited from: MMXN	O / O
PwrFact	MV		inherited from: MMXN	O / O
Imp	CMV		inherited from: MMXN	O / O
Hz	MV		inherited from: MMXN	O / O
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
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O

MMXNExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.6.7 LN: Three phases related electric measurement extension Name: MMXUExt

Set of information objects to extend the MMXU LN.

This logical node represents calculation of electric measurement such as currents, voltages, powers and impedances in a three-phase system. The main use is for operative applications.

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

Table 31 shows all data objects of MMXUExt.

Table 31 – Data objects of MMXUExt

MMXUExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
PwrFlwDir	ACD		True value indicates power is flowing into the related PowerSystemResource.(also called "supply"). False indicates power is flowing out of the related PowerSystemResource (alaso called 'demand"). This information is also available per phase. Supply and demand are refering to the setting PsFlwIn indicating the relationship between these notions and the sign of the measured power.	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				
TotW	MV		inherited from: MMXU	O / O
TotVAr	MV		inherited from: MMXU	O / O
TotVA	MV		inherited from: MMXU	O / O
TotPF	MV		inherited from: MMXU	O / O
Hz	MV		inherited from: MMXU	O / O
PPV	DEL		inherited from: MMXU	O / O
PNV	WYE		inherited from: MMXU	O / O
PhV	WYE		inherited from: MMXU	O / O
A	WYE		inherited from: MMXU	O / O
W	WYE		inherited from: MMXU	O / O
VAr	WYE		inherited from: MMXU	O / O
VA	WYE		inherited from: MMXU	O / O
PF	WYE		inherited from: MMXU	O / O
Z	WYE		inherited from: MMXU	O / O
AvAPhs	MV		inherited from: MMXU	O / O

MMXUExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
AvPPVPhs	MV		inherited from: MMXU	O / O
AvPhVPhs	MV		inherited from: MMXU	O / O
AvWPhs	MV		inherited from: MMXU	O / O
AvVAPhs	MV		inherited from: MMXU	O / O
AvVArPhs	MV		inherited from: MMXU	O / O
AvPFPhs	MV		inherited from: MMXU	O / O
AvZPhs	MV		inherited from: MMXU	O / O
MaxAPhs	MV		inherited from: MMXU	O / O
MaxPPVPhs	MV		inherited from: MMXU	O / O
MaxPhVPhs	MV		inherited from: MMXU	O / O
MaxWPhs	MV		inherited from: MMXU	O / O
MaxVAPhs	MV		inherited from: MMXU	O / O
MaxVArPhs	MV		inherited from: MMXU	O / O
MaxPFPhs	MV		inherited from: MMXU	O / O
MaxZPhs	MV		inherited from: MMXU	O / O
MinAPhs	MV		inherited from: MMXU	O / O
MinPPVPhs	MV		inherited from: MMXU	O / O
MinPhVPhs	MV		inherited from: MMXU	O / O
MinWPhs	MV		inherited from: MMXU	O / O
MinVAPhs	MV		inherited from: MMXU	O / O
MinVArPhs	MV		inherited from: MMXU	O / O
MinPFPhs	MV		inherited from: MMXU	O / O
MinZPhs	MV		inherited from: MMXU	O / O
HzRte	MV		inherited from: MMXU	O / O
Controls				
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
ClcTotVA	ENG (STotalCalcMethodKind)		inherited from: MMXU	O / F
PFSign	ENG (PFSignKind)		inherited from: MMXU	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

7.2.7 LN from Group P (LNGroupP_90_6)

7.2.7.1 General

This group of logical nodes refers to modelling of protection and protection related functions

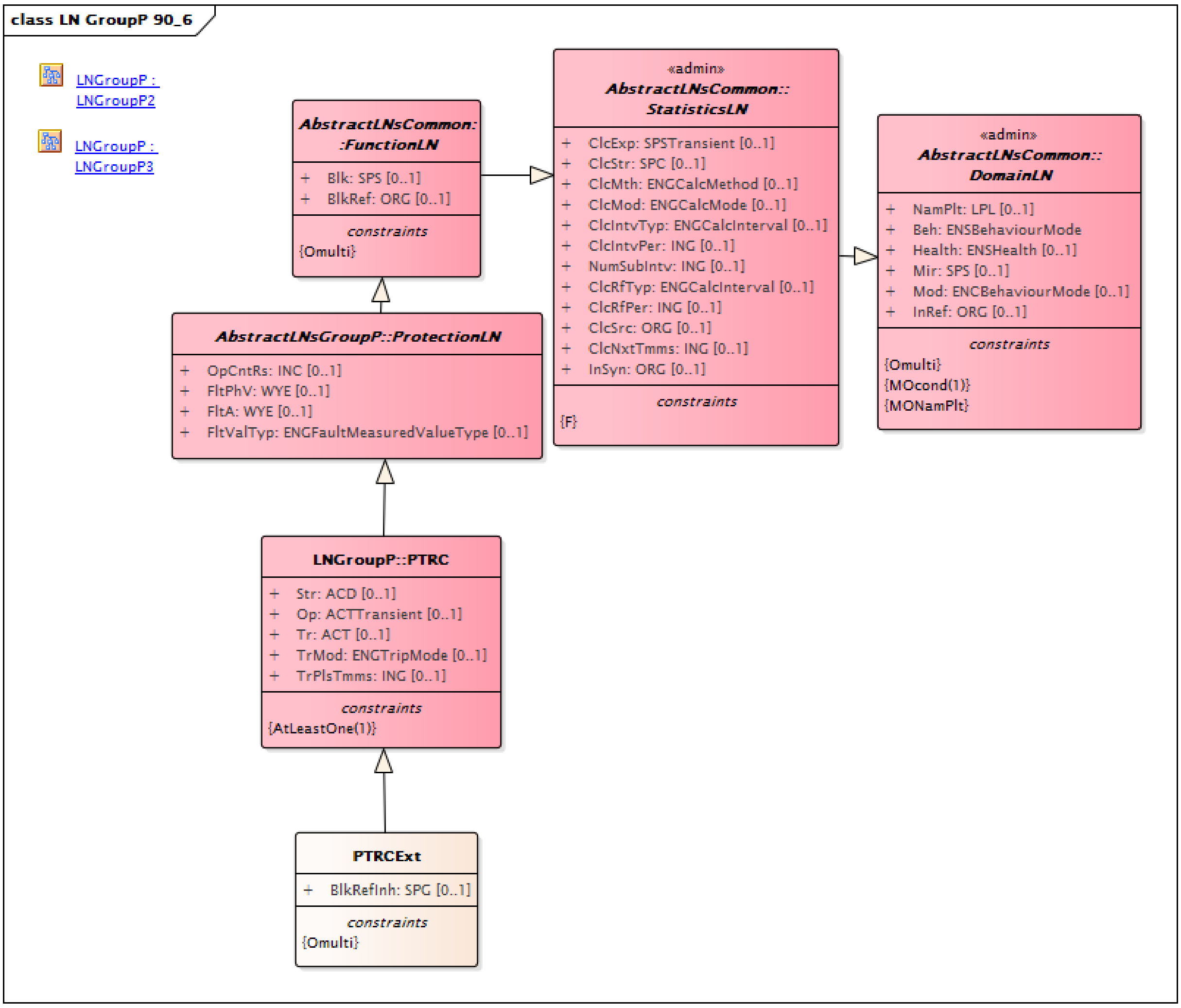


Figure 89 – Class diagram LNGroupP_90_6::LN GroupP 90_6

Figure 89: This diagram shows the first part of concrete logical nodes of this group, with the supertypes that factor their common attributes.

7.2.7.2 LN: Trip conditioning extension Name: PTRCExt

Set of information objects to extend the PTRC LN.

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

Table 32 shows all data objects of PTRCExt.

Table 32 – Data objects of PTRCExt

PTRCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt

PTRCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Status information				
Str	ACD		inherited from: PTRC	AtLeastOne(1) / F
Op	ACT	T	inherited from: PTRC	AtLeastOne(1) / F
Tr	ACT		inherited from: PTRC	AtLeastOne(1) / 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				
FltPhV	WYE		inherited from: ProtectionLN	O / O
FltA	WYE		inherited from: ProtectionLN	O / O
Controls				
OpCntRs	INC		inherited from: ProtectionLN	O / O
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
TrMod	ENG (TripModeKind)		inherited from: PTRC	O / F
TrPlsTmms	ING		inherited from: PTRC	O / F
FltValTyp	ENG (FaultMeasuredValueTypeKind)		inherited from: ProtectionLN	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

7.2.8 LN of Group R (LNGroupR_90_6)

7.2.8.1 General

This set of LNs proposed extensions to existing IEC 61850 namespaces to support protection-related functions (they contribute to, but do not do protection).

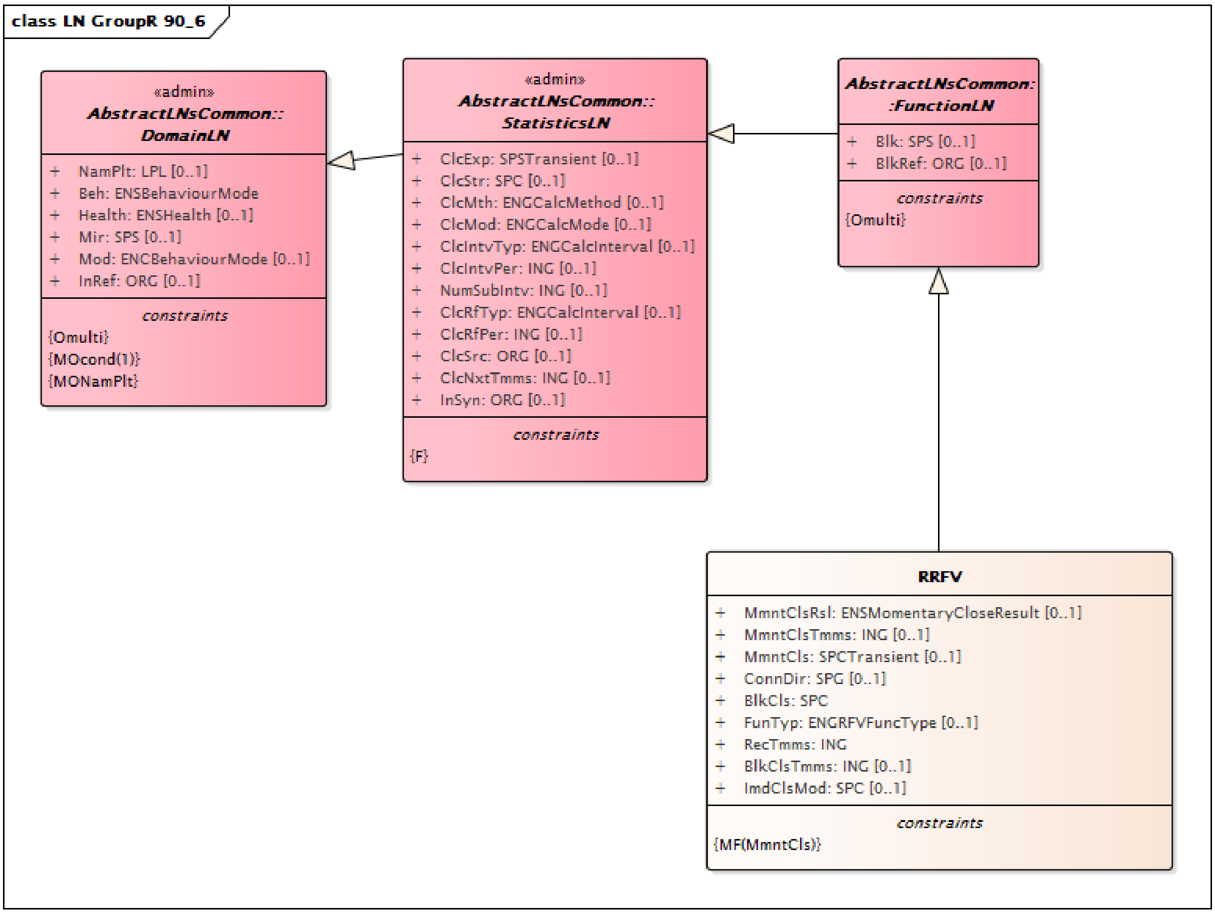


Figure 90 – Class diagram LNGroupR_90_6::LN GroupR 90_6

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

7.2.8.2 LN: Reclosing by feeder voltage detection Name: RRFV

This LN models a function for reclosing a sectionalizer according to feeder voltage presence/absence.

Table 33 shows all data objects of RRFV.

Table 33 – Data objects of RRFV

RRFV				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
MmntClsRsl	ENS (MomentaryCloseResultKind)		The result of momentary close	MF(MmntCls) / F

RRFV				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
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				
MmntCls	SPC	T	(controllable) To execute a momentary close. If its stVal = true, a signal is sent from a field controller to close a sectionalizer. The change of its status value to false is local issue according to the end of the signal. So, its stVal does not represent the result of momentary charge, but the MmntClsRsl does.	O / F
BlkCls	SPC		(controllable) if true closing of sectionalizer by this FLISR function is blocked, otherwise unblocked..	M / F
ImdClsMod	SPC		(controllable) If true, the sectionalizer controlled by the RRFV will close soon after the feeder on the substation side is energized, otherwise it will close after the RecTmms delay after the feeder on the substation is energized	O / F
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
MmntClsTmms	ING		Momentary close duration time in ms	O / F
ConnDir	SPG		Connection direction indicating the side to a primary substation based on the physical sectionalizer installation. true = forward, false = reverse. The “forward” means that a primary substation is on the head side of sectionalizer.	O / F
FunTyp	ENG (RFVFuncTypeKind)		The functional type of Voltage detection based FLISR	O / F
RecTmms	ING		Reclose delay time (ms) i.e. time between detecting voltage presence and closing the sectionalizer	M / F
BlkClsTmms	ING		Block closing time (ms), i.e. time to wait for voltage absence after the sectionalizer is closed. If no voltage is detected, then BlkCls is set true to prevent subsequent reclosing	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

RRFV				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
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

7.2.9 LN of Group S (LNGroupS_90_6)

7.2.9.1 General

This group of logical nodes represents proposed extensions to existing IEC 61850 namespaces to support supervision and monitoring functions.

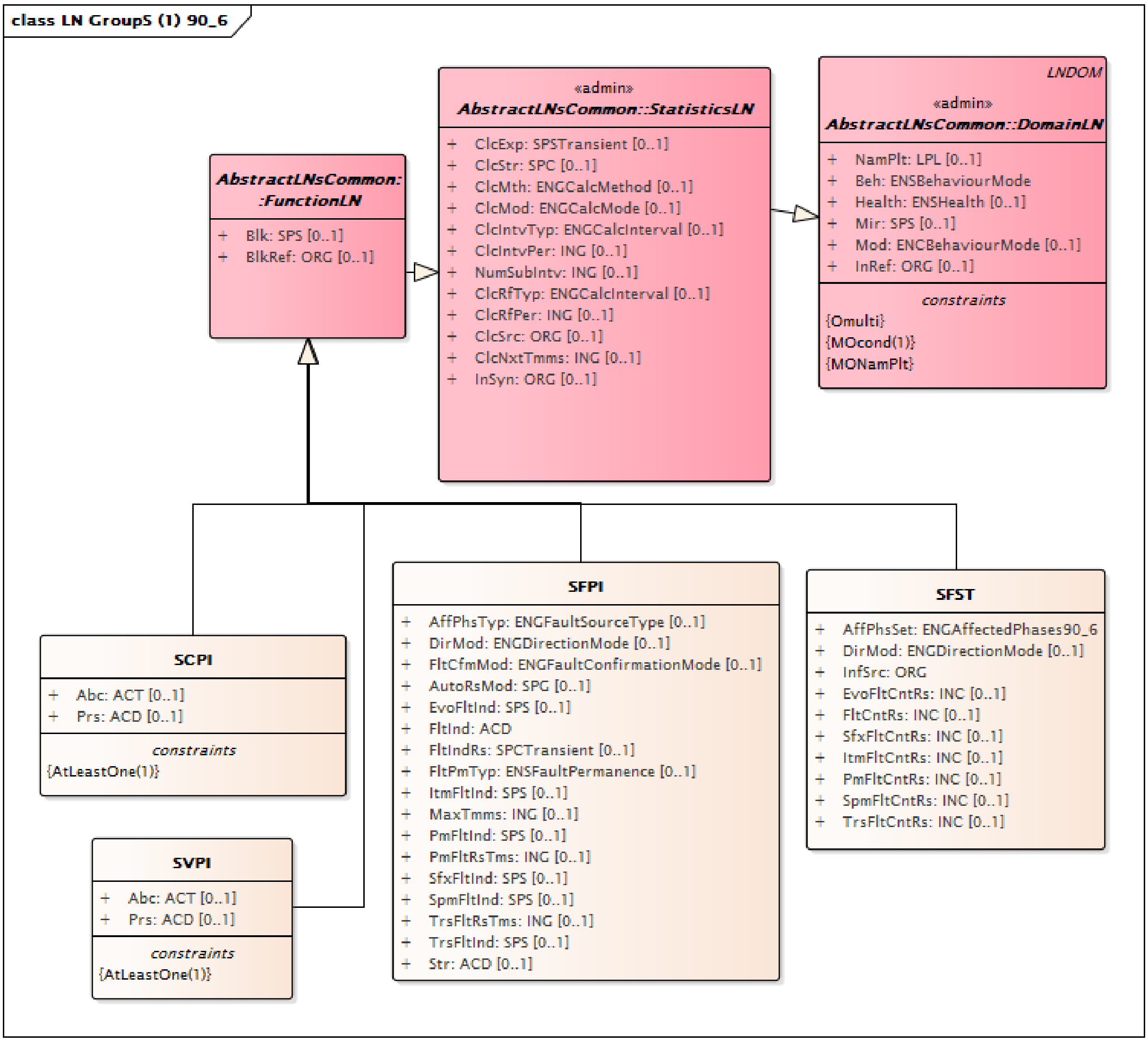


Figure 91 – Class diagram LNGroupS_90_6::LN GroupS (1) 90_6

Figure 91: List (1 out of 2) of proposed new LNs to extend the Group S of LNs to support the IEC TR 61850-90-6 domain.

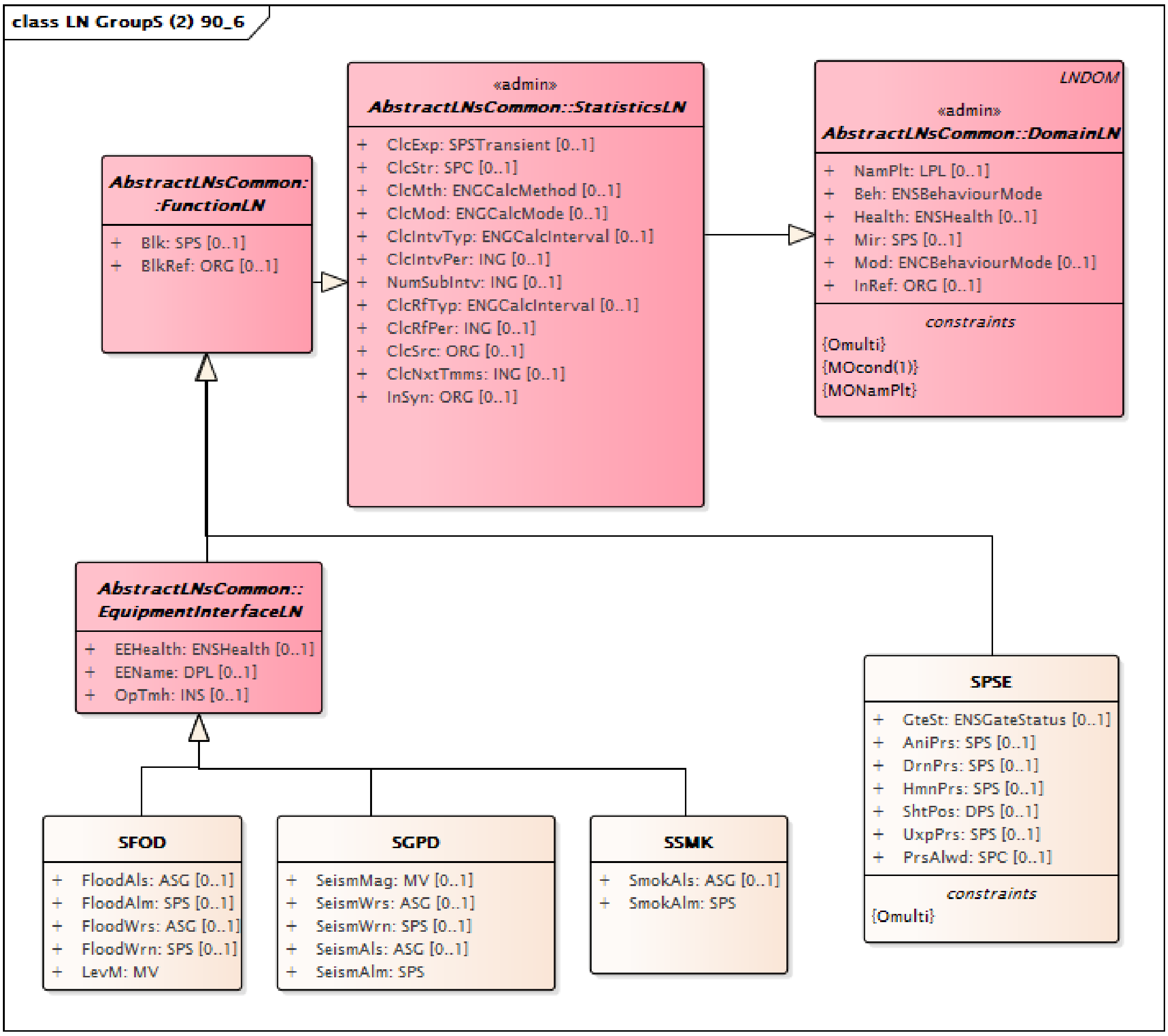


Figure 92 – Class diagram LNGroupS_90_6::LN GroupS (2) 90_6

Figure 92: List (2 out of 2) of proposed new LNs to extend the Group S of LNs to support the IEC TR 61850-90-6 domain.

7.2.9.2 LN: Current Presence Indication Name: SCPI

The LN contains all data objects to reflect current presence.

Table 34 shows all data objects of SCPI.

Table 34 – Data objects of SCPI

SCPI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
Abc	ACT		Expose current absence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for absence are met for the considered phase, otherwise set to false. The attribute "general" is true if all Phase absence signals are true, otherwise set to false. Neutral "neut" attribute is meaningless for absence	AtLeastOne(1) / F
Prs	ACD		Expose current presence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for presence are met for the considered phase, otherwise set to false. The attribute "general" is true if at least presence is true on at least one phase, otherwise set to false. In case of presence, the direction of the current for the considered phase Phase A, PhaseB, Phase C may be expressed using respectively dirPhsA, dirPhsB, dirPhsC. Neutral "neut" attribute is potentially reflecting the presence of residual current, and the "dirNeut" attribute may be present and will just reflect the sign of the residual current .	AtLeastOne(1) / 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

SCPI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.9.3 LN: Flooding conditions monitoring Name: SFOD

The LN contains all data objects to monitor flooding conditions

Table 35 shows all data objects of SFOD.

Table 35 – Data objects of SFOD

SFOD				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		inherited from: EquipmentInterfaceLN	O / F
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
FloodAlm	SPS		If true, the flood alarm is active.	O / F
FloodWrn	SPS		if true, the flood level exceeds the warning level defined in FloodWrs	O / F
EEHealth	ENS (HealthKind)		inherited from: EquipmentInterfaceLN	O / F
OpTmh	INS		inherited from: EquipmentInterfaceLN	O / O
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				
LevM	MV		Water level at the point of measuring [m]	M / O
Controls				
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
FloodAls	ASG		Threshold setting for flood alarm 'FloodAlm' (in m)	O / F
FloodWrs	ASG		Flood level warning threshold (in m)	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

SFOD				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/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
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.9.4 LN: Fault Passage Indication Name: SFPI

The LN contains all data objects to support fault passage indication. It aims to provide indications related to a fault occurrence.

Table 36 shows all data objects of SFPI.

Table 36 – Data objects of SFPI

SFPI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
EvoFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Evolving, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured	O / F
FltInd	ACD		Expose fault presence status, globally ("general" attribute) and on each phases ("phsA", "phsB", "phsC") or between phases (corresponding phase attributes should be set to true). "phsA", "phsB", "phsC" attributes are respectively set to true if a fault is detected on the considered phase or between phases, otherwise set to false. "general" is true if at least one of the attribute "phsA", "phsB", "phsC" is true.	M / F
FltPmTyp	ENS (FaultPermanenceKind)		Fault permanence type: a classification of the current fault based on how it was cleared. The value of this enumerated status should be consistent with the corresponding indication e.g. TrsFltInd, PmFltInd.	O / F
ItmFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Intermittent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured	O / F
PmFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Permanent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (PmFltRsTms) has occured	O / F
SfxFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Self-extinguishing, The signal will remain true, until, either a manual reset (through	O / F

SFPI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			FltIndRs) or a default timeout (TrFltRsTms) has occured	
SpmFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Semi-permanent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured	O / F
TrsFltInd	SPS		The raising edge of the signal means the occurence of a fault of type Transient, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured	O / F
Str	ACD		If its ‘general’=true, a fault has been detected and its direction may be available in its ‘dirGeneral'. It remains true until all faults have been cleared.	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				
FltIndRs	SPC	T	(controllable) Operating with value true initiates all active fault indicators to be resetted; operating with value false is ignored. The change of its status value is a local issue.	O / F
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
AffPhsTyp	ENG (FaultSourceTypeKind)		Set a possible limited set of types of faults under focus by the considered LN	O / F
DirMod	ENG (DirectionModeKind)		Directional mode setting, used to preselect faults when the directional conditions are met. If set to 'forward' or 'reverse', the statistics operates only if the fault detected is in that direction.	O / F
FltCfmMod	ENG (FaultConfirmationModeKind)		FPI fault confirmation mode	O / F
AutoRsMod	SPG		If set to true, Automatic Reset of fault indication is activated, otherwise is not activated	O / F
MaxTmms	ING		Maximum time after fault detection during which auto-reclosing is permitted	O / F
PmFltRsTms	ING		Timeout in seconds for automatic reset of permanent fault indications	O / F
TrsFltRsTms	ING		Timeout in seconds for automatic reset of transient and semi-permanent fault indications	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

SFPI				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
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

7.2.9.5 LN: Fault indication statistic calculation Name: SFST

The LN contains all data objects to to support fault indication statistic calculation. The SFST logical node contains a set of counters for faults classified by permanence type e.g. transient or permanent, all with the same fault type e.g. phase-earth, phase-phase, any. To manage counters based on fault type or direction type, use several instances of SFST.

Table 37 shows all data objects of SFST.

Table 37 – Data objects of SFST

SFST				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
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				
EvoFltCntRs	INC		(controllable) Evolving faults count, can be reset to a value different than 0.	O / O
FltCntRs	INC		(controllable) Faults count (whatever the type), can be reset to a value different than 0. By nature the value of FltCnt is higher than the sum of all detailed counters per permanence type (EvoFltCntRs, ItmFltCntRs, SfxFltCntRs, TrsFltCntRs, SPmFltCntRs, PmFltCntRs if they are implemented). Thus resetting it, leads to reset all present counters of this LN. Setting its value to a value different from shall be ignored.	O / O
SfxFltCntRs	INC		(controllable) Self-extinguishing faults count, can be reset to a value different than 0.	O / O
ItmFltCntRs	INC		(controllable) Intermittent faults count, can be reset to a value different than 0.	O / O
PmFltCntRs	INC		(controllable) Permanent faults count, can be reset	O / O

SFST				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			to a value different than 0.	
SpmFltCntRs	INC		(controllable) Semi-permanent faults count, can be reset to a value different than 0.	O / O
TrsFltCntRs	INC		(controllable) Transient faults count, can be reset to a value different than 0.	O / O
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
AffPhsSet	ENG (AffectedPhases90_6Kind)		Setting which preselects the type of faults counted by the SFST LN.	M / F
DirMod	ENG (DirectionModeKind)		Directional mode setting, used to enable statistics operation when the directional conditions are met. If set to 'forward' or 'reverse', the statistics operates only if the fault detected is in that direction.	O / F
InfSrc	ORG		Reference of the information source (typically a SFPI node) to elaborate the counting of faults. The use of ClcRsc (for conventional statistics) and InfSrc (for the first step of counting) are exclusive.	M / 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

7.2.9.6 LN: Geo-physical information supervision Name: SGPD

The LN contains all data objects related to supporting the supervision of geo-physical information such as seism

Table 38 shows all data objects of SGPD.

Table 38 – Data objects of SGPD

SGPD				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		inherited from: EquipmentInterfaceLN	O / F

SGPD				
Data object name	**Common data class**	**T**	**Explanation**	**PresConds/ds**
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
SeismWrn	SPS		If true, the seism magnitude has exceeded the warning threshold level defined in SeismWrs.	O / F
SeismAlm	SPS		If true, the seism magnitude has exceeded the alarming threshold level defined in SeismAls.	M / F
EEHealth	ENS (HealthKind)		inherited from: EquipmentInterfaceLN	O / F
OpTmh	INS		inherited from: EquipmentInterfaceLN	O / O
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				
SeismMag	MV		Measurement of earthquake magnitude (actually the amplitude (height) of the largest recorded wave of an earthquake) expressed under the Richter scale.	O / O
Controls				
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (BehaviourModeKind)		inherited from: DomainLN	O / O
Settings				
SeismWrs	ASG		Seism magnitude warning threshold (under Richter scale)	O / F
SeismAls	ASG		Seism magnitude alarming threshold (under Richter scale)	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

7.2.9.7 LN: Smoking conditions supervision Name: SSMK

The LN contains all data objects to monitor smoking conditions

Table 39 shows all data objects of SSMK.

Table 39 – Data objects of SSMK

SSMK				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		inherited from: EquipmentInterfaceLN	O / F
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
SmokAlm	SPS		If true, the smoke level has gone over the threshold SmokAls and the alarm is considered as active.	M / F
EEHealth	ENS (HealthKind)		inherited from: EquipmentInterfaceLN	O / F
OpTmh	INS		inherited from: EquipmentInterfaceLN	O / O
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				
SmokAls	ASG		Smoke level alarm threshold (measured as the density of particule, i.e number of particule per volume unit)	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

7.2.9.8 LN: Presence monitoring Name: SPSE

This LN includes all data objects to control and measure the presence of human, animals or objects, unexpected or not.

Table 40 shows all data objects of SPSE.

Table 40 – Data objects of SPSE

SPSE				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
GteSt	ENS (GateStatusKind)		Status of a gate to the facility such as window, door	Omulti / F
AniPrs	SPS		Animal presence sensor indication. If true, indicates that aa animal is present on the considered area.	Omulti / F
DrnPrs	SPS		Drone presence sensor indication. If true, indicates that a drone is present on the considered area.	Omulti / F
HmnPrs	SPS		Human presence sensor indication. If true, indicates that a human is present on the considered area.	O / F
ShtPos	DPS		Shutter position	Omulti / F
UxpPrs	SPS		Unexpected presence summary. If true, indicates that an unexpected presence is detected.	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				
PrsAlwd	SPC		(controllable) If set to true, indicates that human presence is allowed in the considered area, otherwise unexpected.	O / 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	ING		inherited from: StatisticsLN	O / O

SPSE				
Data object name	Common data class	T	Explanation	PresCond nds/ds
s				
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.2.9.9 LN: Voltage presence indicator Name: SVPI

The LN contains all data objects to reflect voltage presence indication.

Table 41 shows all data objects of SVPI.

Table 41 – Data objects of SVPI

SVPI				
Data object name	Common data class	T	Explanation	PresCond nds/ds
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt
Status information				
Abc	ACT		Expose voltage absence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for absence are met for the considered phase, otherwise set to false. The attribute "general" is true if all Phase absence signals are true, otherwise set to false.	AtLeastOne(1) / F
Prs	ACD		Expose voltage presence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for presence are met for the considered phase, otherwise set to false. The attribute "general" is true if at least presence is true on at least one phase, otherwise set to false. Directionality is not used here.	AtLeastOne(1) / 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

SVPI				
Data object name	Common data class	T	Explanation	PresCond nds/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
ClcNxtTmms	ING		inherited from: StatisticsLN	O / O
InSyn	ORG		inherited from: StatisticsLN	O / O
InRef	ORG		inherited from: DomainLN	Omulti / Omulti

7.3 Data semantics

Table 42 shows all attributes defined on classes of LogicalNodes_90_6 package.

Table 42 – Attributes defined on classes of LogicalNodes_90_6 package

Name	Type	(Used in) Description
Abc	ACT	(SCPI) Expose current absence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for absence are met for the considered phase, otherwise set to false. The attribute "general" is true if all Phase absence signals are true, otherwise set to false. Neutral "neut" attribute is meaningless for absence (SVPI) Expose voltage absence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for absence are met for the considered phase, otherwise set to false. The attribute "general" is true if all Phase absence signals are true, otherwise set to false.
ActSrc	ENS (ActualSourceKind)	(AATS) Active source currently in use
AffPhsSet	ENG (AffectedPhases90_6Kind)	(SFST) Setting which preselects the type of faults counted by the SFST LN.
AffPhsTyp	ENG (FaultSourceTypeKind)	(SFPI) Set a possible limited set of types of faults under focus by the considered LN
AniPrs	SPS	(SPSE) Animal presence sensor indication. If true, indicates that aa animal is present on the considered area.
AtsRtnOpMod	ENG (ATSAutoReturnModeKind)	(AATS) Define the automatic "return to normal" operation mode
AtsSeqRsl	ENS (ATSSequenceResultKind)	(AATS) Expose the result of the latest transition attempt of the state machine related to the Automatic Transfer Source
AutoRsMod	SPG	(SFPI) If set to true, Automatic Reset of fault indication is activated, otherwise is not activated
BlkCls	SPC	(RRFV) (controllable) if true closing of sectionalizer by this FLISR function is blocked, otherwise unblocked..
BlkClsTmms	ING	(RRFV) Block closing time (ms), i.e. time to wait for voltage absence after the sectionalizer is closed. If no voltage is detected, then BlkCls is set true to prevent subsequent reclosing
BlkRefInh	SPG	(ASWI) if set to true, the value provided through the BlkRef DO instance of

Name	Type	(Used in) Description
		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) (PTRCExt) 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)
CapLim	ASG	(ASRC) Capacity limit of the standby power source in VA, determined by the power system conditions
ClsDlTmms	ING	(AutomaticSwitchingLN) Operation delay time (in ms)- time between the triggering condition and sending the command to close the switch (AATS) 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
ConnDir	SPG	(RRFV) Connection direction indicating the side to a primary substation based on the physical sectionalizer installation. true = forward, false = reverse. The “forward” means that a primary substation is on the head side of sectionalizer.
DeEnLodCap	MV	(ASRC) Total capacity (in VA) of the de-energised load in healthy sections before service restoration
DirMod	ENG (DirectionModeKind)	(ASWI) 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 (SFPI) Directional mode setting, used to preselect faults when the directional conditions are met. If set to 'forward' or 'reverse', the statistics operates only if the fault detected is in that direction. (SFST) Directional mode setting, used to enable statistics operation when the directional conditions are met. If set to 'forward' or 'reverse', the statistics operates only if the fault detected is in that direction.
DmdVAhMeas	MV	(MMTNExt) Demand apparent energy reported as MV (MMTRExt) Demand apparent energy reported as MV
DmdVArhMeas	MV	(MMTNExt) Reactive energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV (MMTRExt) Reactive energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV
DmdWhMeas	MV	(MMTNExt) Real energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV (MMTRExt) Real energy demand (direction: backward based on RvPwrFlwSign convention) reported as MV
DrnPrs	SPS	(SPSE) Drone presence sensor indication. If true, indicates that a drone is present on the considered area.
EnMeasRs	SPC (T)	(MMTNExt) Operating with value true performs the reset of all (operation) energy counters of this LN – not the one based on BCR type. Operating with value false is ignored. The change of its status value is a local issue (MMTRExt) Operating with value true performs the reset of all (operation) energy counters of this LN – not the one based on BCR type. Operating with value false is ignored. The change of its status value is a local issue
EnaLkdOut	SPG	(ASWI) True means enable lockout on switch operation failure. False means the ASWI will send another open command during the next reclose dead time.
EvoFltCntRs	INC	(SFST) (controllable) Evolving faults count, can be reset to a value different than 0.
EvoFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of type Evolving, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured
FireAlm	SPS	(KFIM) if true, a fire is present
FireFghtAct	SPC (T)	(KFIM) (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.

Name	Type	(Used in) Description
FloodAlm	SPS	(SFOD) If true, the flood alarm is active. (MENVExt) (deprecated)
FloodAls	ASG	(SFOD) Threshold setting for flood alarm 'FloodAlm' (in m)
FloodLev	ASG	(MENVExt) (deprecated)
FloodWrn	SPS	(SFOD) if true, the flood level exceeds the warning level defined in FloodWrs
FloodWrs	ASG	(SFOD) Flood level warning threshold (in m)
FltCfmMod	ENG (FaultConfirmationModeKind)	(SFPI) FPI fault confirmation mode
FltCntRs	INC	(SFST) (controllable) Faults count (whatever the type), can be reset to a value different than 0. By nature the value of FltCnt is higher than the sum of all detailed counters per permanence type (EvoFltCntRs, ItmFltCntRs, SfxFltCntRs, TrsFltCntRs, SPmFltCntRs, PmFltCntRs if they are implemented). Thus resetting it, leads to reset all present counters of this LN. Setting its value to a value different from shall be ignored.
FltInd	ACD	(SFPI) Expose fault presence status, globally ("general" attribute) and on each phases ("phsA", "phsB", "phsC") or between phases (corresponding phase attributes should be set to true). "phsA", "phsB", "phsC" attributes are respectively set to true if a fault is detected on the considered phase or between phases, otherwise set to false. "general" is true if at least one of the attribute "phsA", "phsB", "phsC" is true.
FltIndRs	SPC (T)	(SFPI) (controllable) Operating with value true initiates all active fault indicators to be resetted; operating with value false is ignored. The change of its status value is a local issue.
FltIsoInd	SPS	(AFSI) If true, the faulty section located in the direction of the circuit is now isolated. It remains true until it has been reset through FltIsoRs, or the RsTmms timeout has operated.
FltLocInd	ACT	(AFSL) 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.
FltPmTyp	ENS (FaultPermanenceKind)	(SFPI) Fault permanence type: a classification of the current fault based on how it was cleared. The value of this enumerated status should be consistent with the corresponding indication e.g. TrsFltInd, PmFltInd.
FrzRnSt	SPS	(MENVExt) Freezing rain status. If true conditions are met for having
FunTyp	ENG (RFVFuncTypeKind)	(RRFV) The functional type of Voltage detection based FLISR
GteSt	ENS (GateStatusKind)	(SPSE) Status of a gate to the facility such as window, door
HmnPrs	SPS	(SPSE) Human presence sensor indication. If true, indicates that a human is present on the considered area.
IceCvr	MV	(MMETExt) Ice cover (typically in mm – length SIUnit [m]).
IceCvrAlm	SPS	(MMETExt) If true, the ice cover exceeds the alarming threshold level defined in IceCvrAls.
IceCvrAls	ASG	(MMETExt) Ice cover alarming threshold
IceCvrWrn	SPS	(MMETExt) If true, the ice cover exceeds the warning threshold level defined in IceCvrWrs.
IceCvrWrs	ASG	(MMETExt) Ice cover warning threshold
IllumAct	SPC	(KILL) (controllable) If true, illumination is activated; otherwise illumination is disactivated.

Name	Type	(Used in) Description
ImdClsMod	SPC	(RRFV) (controllable) If true, the sectionalizer controlled by the RRFV will close soon after the feeder on the substation side is energized, otherwise it will close after the RecTmms delay after the feeder on the substation is energized
InfSrc	ORG	(SFST) Reference of the information source (typically a SFPI node) to elaborate the counting of faults. The use of ClcRsc (for conventional statistics) and InfSrc (for the first step of counting) are exclusive.
IsldSt	ENS (IslandingStateKind)	(DISL) Reflects the islanding status of the considered grid area
ItmFltCntRs	INC	(SFST) (controllable) Intermittent faults count, can be reset to a value different than 0.
ItmFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of type Intermittent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured
LevM	MV	(SFOD) Water level at the point of measuring [m]
MaxTmms	ING	(ASWI) 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) (SFPI) Maximum time after fault detection during which auto-reclosing is permitted
MmntCls	SPC (T)	(RRFV) (controllable) To execute a momentary close. If its stVal = true, a signal is sent from a field controller to close a sectionalizer. The change of its status value to false is local issue according to the end of the signal. So, its stVal does not represent the result of momentary charge, but the MmntClsRsl does.
MmntClsRsl	ENS (MomentaryCloseResultKind)	(RRFV) The result of momentary close
MmntClsTmms	ING	(RRFV) Momentary close duration time in ms
NmlSrc	ENG (NormalSourceKind)	(AATS) Definition of the source which is considered as normal
OpCls	ACT (T)	(AutomaticSwitchingLN) 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.
OpDlTmms	ING	(AFSI) Operation delay time in ms between the triggering condition (end of fault location) and sending the control(s) to perform the isolation (AFSL) Operation delay time in ms between the triggering condition (e.g voltage absence) and calculating FltLocInd
OpOpn	ACT (T)	(AutomaticSwitchingLN) 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.
OpnDlTmms	ING	(AutomaticSwitchingLN) 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 (AATS) 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
PmFltCntRs	INC	(SFST) (controllable) Permanent faults count, can be reset to a value different than 0.
PmFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of type Permanent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (PmFltRsTms) has occured
PmFltRsTms	ING	(SFPI) Timeout in seconds for automatic reset of permanent fault indications
Prs	ACD	(SCPI) Expose current presence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for presence are met for the considered phase, otherwise set to false. The

Name	Type	(Used in) Description
		attribute "general" is true if at least presence is true on at least one phase, otherwise set to false. In case of presence, the direction of the current for the considered phase Phase A, PhaseB, Phase C may be expressed using respectively dirPhsA, dirPhsB, dirPhsC. Neutral "neut" attribute is potentially reflecting the presence of residual current, and the "dirNeut" attribute may be present and will just reflect the sign of the residual current . (SVPI) Expose voltage presence status, globally ("general" attribute) and possibly on each phases ("phsA", "phsB", "phsC"). The attributes "phsA", "phsB", "phsC" are respectively set to true if the considered criteria for presence are met for the considered phase, otherwise set to false. The attribute "general" is true if at least presence is true on at least one phase, otherwise set to false. Directionality is not used here.
PrsAlwd	SPC	(SPSE) (controllable) If set to true, indicates that human presence is allowed in the considered area, otherwise unexpected.
PwrFlwDir	ACD	(MMXUExt) True value indicates power is flowing into the related PowerSystemResource.(also called "supply"). False indicates power is flowing out of the related PowerSystemResource (alaso called 'demand"). This information is also available per phase. Supply and demand are refering to the setting PsFlwIn indicating the relationship between these notions and the sign of the measured power.
PwrFlwDirNph	SPS	(MMXNExt) True value indicates power is flowing into the related PowerSystemResource.(also called "supply"). False indicates power is flowing out of the related PowerSystemResource (alaso called 'demand"). Supply and demand are refering to the setting PsFlwIn indicating the relationship between these notions and the sign of the measured power.
Q1VAhMeas	MV	(MMTNExt) Quadrant 1 apparent energy reported as MV (MMTRExt) Quadrant 1 apparent energy reported as MV
Q1VArhMeas	MV	(MMTNExt) Reactive energy supply in quadrant 1 reported as MV (MMTRExt) Reactive energy supply in quadrant 1 reported as MV
Q1WhMeas	MV	(MMTNExt) Real energy supply in quadrant 1 reported as MV (MMTRExt) Real energy supply in quadrant 1 reported as MV
Q2VAhMeas	MV	(MMTNExt) Quadrant 2 apparent energy reported as MV (MMTRExt) Quadrant 2 apparent energy reported as MV
Q2VArhMeas	MV	(MMTNExt) Reactive energy supply in quadrant 2 reported as MV (MMTRExt) Reactive energy supply in quadrant 2 reported as MV
Q2WhMeas	MV	(MMTNExt) Real energy supply in quadrant 2 reported as MV (MMTRExt) Real energy supply in quadrant 2 reported as MV
Q3VAhMeas	MV	(MMTNExt) Quadrant 3 apparent energy reported as MV (MMTRExt) Quadrant 3 apparent energy reported as MV
Q3VArhMeas	MV	(MMTNExt) Reactive energy supply in quadrant 3 reported as MV (MMTRExt) Reactive energy supply in quadrant 3 reported as MV
Q3WhMeas	MV	(MMTNExt) Real energy supply in quadrant 3 reported as MV (MMTRExt) Real energy supply in quadrant 3 reported as MV
Q4VAhMeas	MV	(MMTNExt) Quadrant 4 apparent energy reported as MV (MMTRExt) Quadrant 4 apparent energy reported as MV
Q4VArhMeas	MV	(MMTNExt) Reactive energy supply in quadrant 4 reported as MV (MMTRExt) Reactive energy supply in quadrant 4 reported as MV
Q4WhMeas	MV	(MMTNExt) Real energy supply in quadrant 4 reported as MV (MMTRExt) Real energy supply in quadrant 4 reported as MV
RecTmms	ING	(RRFV) Reclose delay time (ms) i.e. time between detecting voltage presence and closing the sectionalizer
RsTmms	ING	(AutomatedSequenceLN) Timeout in ms, after which the grid automation function is automatically reset
RstoLodCap	MV	(ASRC) Restored capacity (in VA) after service restoration.

Name	Type	(Used in) Description
RsvCap	MV	(ASRC) 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.
RtnDlTmms	ING	(AATS) Automatic return delay time (ms) between conditions are met for switching back to normal and the start of the sequence for returning to normal
SeismAlm	SPS	(SGPD) If true, the seism magnitude has exceeded the alarming threshold level defined in SeismAls.
SeismAls	ASG	(SGPD) Seism magnitude alarming threshold (under Richter scale)
SeismMag	MV	(SGPD) Measurement of earthquake magnitude (actually the amplitude (height) of the largest recorded wave of an earthquake) expressed under the Richter scale.
SeismWrn	SPS	(SGPD) If true, the seism magnitude has exceeded the warning threshold level defined in SeismWrs.
SeismWrs	ASG	(SGPD) Seism magnitude warning threshold (under Richter scale)
SelCls	SPS	(AutomaticSwitchingLN) If true, the switching equipment has been selected for closing operation.
SelOpn	SPS	(AutomaticSwitchingLN) If true, the switching equipment has been selected for opening operation.
SeqRs	SPC (T)	(AutomatedSequenceLN) (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. (AATS) (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.
SeqRsl	ENS (SequenceEndResultKind)	(AutomatedSequenceLN) Express the result of the latest sequence handling.
SeqSt	ENS (SequenceStatusKind), ENS (ATSSequenceStatusKind)	(AutomatedSequenceLN) Automatic sequence state – see details in SequenceStatusKind enumeration (AATS) automatic transfer switching state – see details in ATSSequenceStatusKind enumeration
SeqStr	SPC (T)	(AutomatedSequenceLN) (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.
SfxFltCntRs	INC	(SFST) (controllable) Self-extinguishing faults count, can be reset to a value different than 0.
SfxFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of type Self-extinguishing, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured
ShtPos	DPS	(SPSE) Shutter position
SmokAlm	SPS	(SSMK) If true, the smoke level has gone over the threshold SmokAls and the alarm is considered as active. (MENVExt) (deprecated)
SmokAls	ASG	(SSMK) Smoke level alarm threshold (measured as the density of particule, i.e number of particule per volume unit)
SmokLev	ASG	(MENVExt) (deprecated)
SnwCvrAlm	SPS	(MMETExt) If true, the snow cover exceeds the alarming threshold level defined in SnwCvrAls.
SnwCvrAls	ASG	(MMETExt) Snow cover alarming threshold
SnwCvrWrn	SPS	(MMETExt) If true, the snow cover exceeds the warning threshold level defined in SnwCvrWrs.
SnwCvrWrs	ASG	(MMETExt) Snow cover warning threshold
SpmFltCntRs	INC	(SFST) (controllable) Semi-permanent faults count, can be reset to a value different than 0.
SpmFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of

Name	Type	(Used in) Description
		type Semi-permanent, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured
Src1Sw	ORG	(AATS) Reference to the physical entity enabling the control and monitoring of the connection/disconnection of Source1
Src2Sw	ORG	(AATS) Reference to the physical entity enabling the control and monitoring of the connection/disconnection of Source2
Str	ACD	(SFPI) If its ‘general’=true, a fault has been detected and its direction may be available in its ‘dirGeneral'. It remains true until all faults have been cleared.
SupVAhMeas	MV	(MMTNExt) Supplied apparent energy reported as MV (MMTRExt) Supplied apparent energy reported as MV
SupVArhMeas	MV	(MMTNExt) Reactive energy supply (default direction: foreward based on RvPwrFlwSign convention) reported as MV (MMTRExt) Reactive energy supply (default direction: foreward based on RvPwrFlwSign convention) reported as MV
SupWhMeas	MV	(MMTNExt) Real energy supply (default direction: forward based on RvPwrFlwSign convention) reported as MV (MMTRExt) Real energy supply (default direction: forward based on RvPwrFlwSign convention) reported as MV
SwTfr12	SPC (T)	(AATS) (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.
SwTfr12Blk	SPC	(AATS) (controllable) if true, transition from Source1 to Source2 is blocked, otherwise enabled
SwTfr21	SPC (T)	(AATS) (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.
SwTfr21Blk	SPC	(AATS) (controllable) if true, transition from Source2 to Source1 is blocked, otherwise enabled.
TotVAhMeas	MV	(MMTNExt) Net apparent energy reported as MV (MMTRExt) Net apparent energy reported as MV
TotVArhMeas	MV	(MMTNExt) Net reactive energy reported as MV (MMTRExt) Net reactive energy reported as MV
TotWhMeas	MV	(MMTNExt) Net real energy reported as MV (MMTRExt) Net real energy reported as MV
TrsFltCntRs	INC	(SFST) (controllable) Transient faults count, can be reset to a value different than 0.
TrsFltInd	SPS	(SFPI) The raising edge of the signal means the occurence of a fault of type Transient, The signal will remain true, until, either a manual reset (through FltIndRs) or a default timeout (TrFltRsTms) has occured
TrsFltRsTms	ING	(SFPI) Timeout in seconds for automatic reset of transient and semi-permanent fault indications
TxTr	ACT	(DISL) If its ‘general’=true, the function is to transmit teleprotection direct trip signal to the other side.
UseCyc	ING	(ASWI) Actual number of reclose cycles to count before triggering the ASWI sequence to open the sectionalizer (AATS) Number of reclose cycles before triggering an automatic transfer switch sequence
UxpPrs	SPS	(SPSE) Unexpected presence summary. If true, indicates that an unexpected presence is detected.

7.4 Enumerated data attribute types

7.4.1 General

This subclause contains explicit definition of enumerated types used in 61850-90-6.

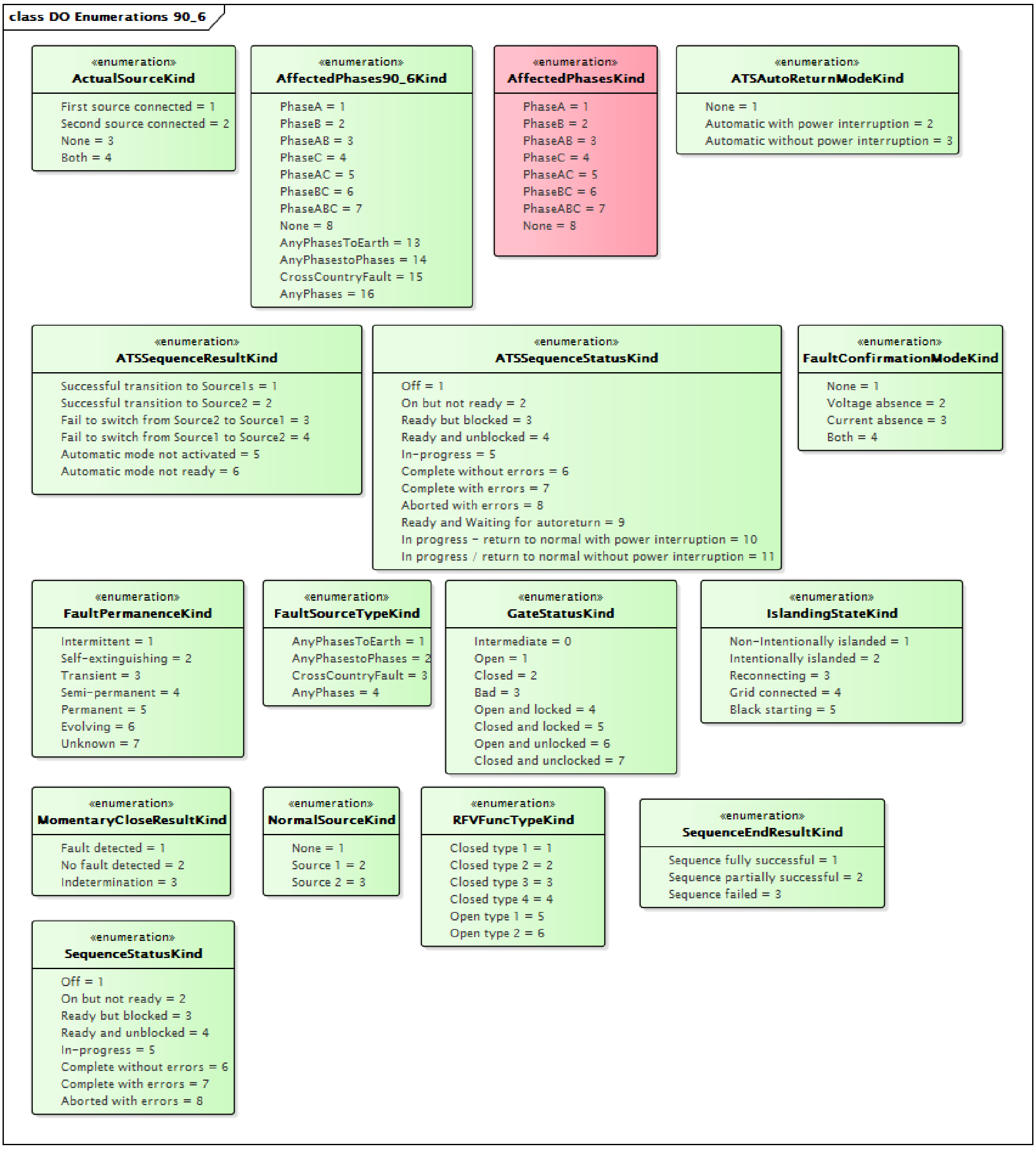


Figure 93 – Class diagram DOEnums_90_6::DO Enumerations 90_6

Figure 93: List of the Enumeration lists used in the namespace included in IEC TR 61850-90-6.

7.4.2 Actual source (ActualSourceKind enumeration)

This enumeration lists the actual connectivity state of both sources of a source transfer automation (between two sources).

Table 43 shows all enumeration items of ActualSourceKind.

Table 43 – Literals of ActualSourceKind

ActualSourceKind		
enumeration item	**value**	**description**
First source connected	1	The first source (as indicated in the hosting LN) is connected.
Second source connected	2	The second source (as indicated in the hosting LN) is connected.
None	3	None of them are connected.
Both	4	Both sources are connected

7.4.3 AffectedPhases90_6Kind enumeration

Extends the AffectedPhase Enumeration from IEC 61850-7-4 to also cover statistical functions related to faults, knowing that IEC TR 61850-90-17 already extends this enumeration with values from 9 to 12.

Table 44 shows all enumeration items of AffectedPhases90_6Kind.

Table 44 – Literals of AffectedPhases90_6Kind

AffectedPhases90_6Kind		
enumeration item	**value**	**description**
PhaseA	1	
PhaseB	2	
PhaseAB	3	
PhaseC	4	
PhaseAC	5	
PhaseBC	6	
PhaseABC	7	
None	8	
AnyPhasesToEarth	13	Phase A to Earth, or Phase B to Earth, or Phase C to Earth
AnyPhasestoPhases	14	Phase A to Phase B, or Phase B to Phase C, or Phase C to Phase A, or Full 3 Phases jointly faulty
CrossCountryFault	15	
AnyPhases	16	

7.4.4 ATSAutoReturnModeKind enumeration

This enumeration lists the possible automatic "return to normal" operation modes.

Table 45 shows all enumeration items of ATSAutoReturnModeKind.

Table 45 – Literals of ATSAutoReturnModeKind

ATSAutoReturnModeKind		
enumeration item	**value**	**description**
None	1	Automatic return to normal is neither meaningless or not allowed
Automatic with power interruption	2	Automatic return to normal is allowed with power interruption
Automatic without power interruption	3	Automatic return to normal is allowed without power interruption

7.4.5 ATSSequenceResultKind enumeration

This enumeration lists the different results (successful or faulty, with the detail of the error which may have occurred) of the latest transition of the state machine related to the Automatic Transfer Source LN.

Table 46 shows all enumeration items of ATSSequenceResultKind.

Table 46 – Literals of ATSSequenceResultKind

ATSSequenceResultKind		
enumeration item	**value**	**description**
Successful transition to Source1s	1	The first source (as indicated in the hosting LN) is connected.
Successful transition to Source2	2	The second source (as indicated in the hosting LN) is connected.
Fail to switch from Source2 to Source1	3	
Fail to switch from Source1 to Source2	4	Under transition between two sources. None of them are connected.
Automatic mode not activated	5	
Automatic mode not ready	6	

7.4.6 ATSSequenceStatusKind enumeration

This enumeration lists the different states of the automatic transfer source "machine". It extends the SequenceStatusKind enumeration for the specific purpose of automatic transfer switch sequence.

Table 47 shows all enumeration items of ATSSequenceStatusKind.

Table 47 – Literals of ATSSequenceStatusKind

ATSSequenceStatusKind		
enumeration item	**value**	**description**
Off	1	
On but not ready	2	At least one condition is not met to get to the ready state, whatever the blocking command status
Ready but blocked	3	All automatic sequence ready conditions are met, but the sequence is blocked due to manual mode sequence status
Ready and unblocked	4	All conditions are met and the sequence is in mode auto, thus the automatic sequence can be performed. The connected source is exposed in the ActSrc DO.
In-progress	5	Automatic sequence has started
Complete without errors	6	The automatic sequence has reached its normal end without errors. If autoreturn is activated, the sequence is ended at the end of the auto return
Complete with errors	7	The sequence has gone to its normal end, however some errors have been found
Aborted with errors	8	The sequence has not gone to its normal end due to errors
Ready and Waiting for autoreturn	9	
In progress – return to normal with power interruption	10	
In progress / return to normal without power interruption	11	This enumeration refines the SequenceStatusKind one, in the specific case of AutomaticTransferSwitch

7.4.7 FaultConfirmationModeKind enumeration

This enumeration lists the possible modes of confirmation of faults.

Table 48 shows all enumeration items of FaultConfirmationModeKind.

Table 48 – Literals of FaultConfirmationModeKind

FaultConfirmationModeKind		
enumeration item	**value**	**description**
None	1	Fault doesn't need confirmation
Voltage absence	2	Fault confirmation relies on Voltage absence (from voltage presence indicator)
Current absence	3	Fault confirmation relies on Current absence (from current presence indicator)
Both	4	Fault confirmation relies both on Voltage and current absence (from voltage presence and current presence indicators)

7.4.8 FaultPermanenceKind enumeration

This enumeration lists the possible categories of electrical faults permanence.

Table 49 shows all enumeration items of FaultPermanenceKind.

Table 49 – Literals of FaultPermanenceKind

FaultPermanenceKind		
enumeration item	**value**	**description**
Intermittent	1	short fault (<20ms) appearing every 100 to 200ms. Given durations are only here as example
Self-extinguishing	2	Duration < protection response time (no tripping)
Transient	3	Eliminated by the fast cycle (cycle 1)
Semi-permanent	4	Eliminated by the low cycles of recloser (cycle 2 or cycle 3)
Permanent	5	Not eliminated by the recloser cycles
Evolving	6	Same as permanent fault but phases in Start data object at the end of the fault are not the same as the phases recorded at the beginning of the fault.
Unknown	7	Unknown type (different from the above)

7.4.9 FaultSourceTypeKind enumeration

This enumeration lists the possible sources of electrical faults.

Table 50 shows all enumeration items of FaultSourceTypeKind.

Table 50 – Literals of FaultSourceTypeKind

FaultSourceTypeKind		
enumeration item	**value**	**description**
AnyPhasesToEarth	1	Phase A to Earth, or Phase B to Earth, or Phase C to Earth
AnyPhasestoPhases	2	Phase A to Phase B, or Phase B to Phase C, or Phase C to Phase A, or Full 3 Phases jointly faulty
CrossCountryFault	3	
AnyPhases	4	

7.4.10 GateStatusKind enumeration

This enumeration lists the different status a gate to the facility (windows, doors, ...) may have. If a lock mechanism is available on the gate, then the enumeration 4 to 7 shall be used.

Table 51 shows all enumeration items of GateStatusKind.

Table 51 – Literals of GateStatusKind

GateStatusKind		
enumeration item	**value**	**description**
Intermediate	0	
Open	1	
Closed	2	
Bad	3	sensor provide a wrong information
Open and locked	4	
Closed and locked	5	
Open and unlocked	6	
Closed and unclocked	7	

7.4.11 IslandingStateKind enumeration

This enumeration lists the different states of an islandable branch of the grid.

Table 52 shows all enumeration items of IslandingStateKind.

Table 52 – Literals of IslandingStateKind

IslandingStateKind		
enumeration item	**value**	**description**
Non-Intentionally islanded	1	The first source (as indicated in the hosting LN) is connected.
Intentionally islanded	2	The second source (as indicated in the hosting LN) is connected.
Reconnecting	3	Under transition between two sources. None of them are connected.
Grid connected	4	
Black starting	5	

7.4.12 momentary close request in case of use of RFV automation (MomentaryCloseResultKind enumeration)

This enumeration lists the possible result of a momentary close request, in case of use of RFV automation

Table 53 shows all enumeration items of MomentaryCloseResultKind.

Table 53 – Literals of MomentaryCloseResultKind

MomentaryCloseResultKind		
enumeration item	**value**	**description**
Fault detected	1	A fault is detected on the load side when a sectionalizer is momentarily closed
No fault detected	2	No fault is detected on the load side when a sectionalizer is momentarily closed
Indetermination	3	It cannot be determined whether a cause of fault on the load side has been eliminated or not

7.4.13 NormalSourceKind enumeration

This enumeration lists the possible cases of definition of the source which is considered as "normal"

Table 54 shows all enumeration items of NormalSourceKind.

Table 54 – Literals of NormalSourceKind

NormalSourceKind		
enumeration item	**value**	**description**
None	1	None of the sources is considered as normal
Source 1	2	Source 1 is considered as normal
Source 2	3	Source 2 is considered as normal

7.4.14 RFVFuncTypeKind enumeration

This enumeration lists the possible types of RFV automation function.

Table 55 shows all enumeration items of RFVFuncTypeKind.

Table 55 – Literals of RFVFuncTypeKind

RFVFuncTypeKind		
enumeration item	**value**	**description**
Closed type 1	1	A sectionalizer is closed in the seconds set by the RecTmms of RRFV after the primary substation side of the sectionalizer is energized. It is not closed in case where the opposite side of sectionalizer is energized.
Closed type 2	2	In addition to the behaviours of the Closed type 1, a sectionalizer is closed immediately when either side of sectionalizer is energized within a certain period after the both side are de-energized
Closed type 3	3	A sectionalizer is closed in a period for reclosing after it isolates a fault on the load side. It behaves the same as the Closed type 1 except for the case mentioned in the previous item
Closed type 4	4	A sectionalizer is closed in the seconds set by the RecTmms of RRFV after either side of the sectionalizer is energized
Open type 1	5	A sectionalizer is NOT closed even though either or both sides of it are energized
Open type 2	6	A sectionalizer is NOT closed in the case where either side of it is energized after its both sides are de-energized. It is closed in the case where either side of it is de-energized after its both sides are energized

7.4.15 Result of the latest restoration process (SequenceEndResultKind enumeration)

This enumeration expresses the end result of an automated sequence.

Table 56 shows all enumeration items of SequenceEndResultKind.

Table 56 – Literals of SequenceEndResultKind

SequenceEndResultKind		
enumeration item	**value**	**description**
Sequence fully successful	1	
Sequence partially successful	2	Load partially restored
Sequence failed	3	

7.4.16 SequenceStatusKind enumeration

This enumeration lists the possible states of an automated sequence.

Table 57 shows all enumeration items of SequenceStatusKind.

Table 57 – Literals of SequenceStatusKind

SequenceStatusKind		
enumeration item	**value**	**description**
Off	1	
On but not ready	2	At least one condition is not met to get to the ready state, whatever the blocking command status
Ready but blocked	3	All automatic sequence ready conditions are met, but the sequence is blocked due to manual mode sequence status

SequenceStatusKind		
enumeration item	**value**	**description**
Ready and unblocked	4	All conditions are met and the sequence is in mode auto, thus the automatic sequence can be performed
In-progress	5	Automatic sequence has started
Complete without errors	6	The automatic sequence has reached its normal end without errors
Complete with errors	7	The sequence has gone to its normal end, however some errors have been found
Aborted with errors	8	The sequence has not gone to its normal end due to errors

7.5 SCL enumerations (from DOEnums_90_6)


```
<EnumType id="ActualSourceKind">
   <EnumVal ord="1">First source connected</EnumVal>
   <EnumVal ord="2">Second source connected</EnumVal>
   <EnumVal ord="3">None</EnumVal>
   <EnumVal ord="4">Both</EnumVal>
</EnumType>
<EnumType id="AffectedPhases90_6Kind">
   <EnumVal ord="1">PhaseA</EnumVal>
   <EnumVal ord="2">PhaseB</EnumVal>
   <EnumVal ord="3">PhaseAB</EnumVal>
   <EnumVal ord="4">PhaseC</EnumVal>
   <EnumVal ord="5">PhaseAC</EnumVal>
   <EnumVal ord="6">PhaseBC</EnumVal>
   <EnumVal ord="7">PhaseABC</EnumVal>
   <EnumVal ord="8">None</EnumVal>
   <EnumVal ord="13">AnyPhasesToEarth</EnumVal>
   <EnumVal ord="14">AnyPhasestoPhases</EnumVal>
   <EnumVal ord="15">CrossCountryFault</EnumVal>
   <EnumVal ord="16">AnyPhases</EnumVal>
</EnumType>
<EnumType id="ATSAutoReturnModeKind">
   <EnumVal ord="1">None</EnumVal>
   <EnumVal ord="2">Automatic with power interruption</EnumVal>
   <EnumVal ord="3">Automatic without power interruption</EnumVal>
</EnumType>
<EnumType id="ATSSequenceResultKind">
   <EnumVal ord="1">Successful transition to Source1s</EnumVal>
   <EnumVal ord="2">Successful transition to Source2</EnumVal>
   <EnumVal ord="3">Fail to switch from Source2 to Source1</EnumVal>
   <EnumVal ord="4">Fail to switch from Source1 to Source2</EnumVal>
   <EnumVal ord="5">Automatic mode not activated</EnumVal>
   <EnumVal ord="6">Automatic mode not ready</EnumVal>
</EnumType>
<EnumType id="ATSSequenceStatusKind">
   <EnumVal ord="1">Off</EnumVal>
   <EnumVal ord="2">On but not ready</EnumVal>
   <EnumVal ord="3">Ready but blocked</EnumVal>
   <EnumVal ord="4">Ready and unblocked</EnumVal>
   <EnumVal ord="5">In-progress</EnumVal>
   <EnumVal ord="6">Complete without errors</EnumVal>
   <EnumVal ord="7">Complete with errors</EnumVal>
   <EnumVal ord="8">Aborted with errors</EnumVal>
```

```
    <EnumVal ord="9">Ready and Waiting for autoreturn</EnumVal>
    <EnumVal ord="10">In progress – return to normal with power interruption</EnumVal>
    <EnumVal ord="11">In progress / return to normal without power interruption</EnumVal>
  </EnumType>
  <EnumType id="FaultConfirmationModeKind">
    <EnumVal ord="1">None</EnumVal>
    <EnumVal ord="2">Voltage absence</EnumVal>
    <EnumVal ord="3">Current absence</EnumVal>
    <EnumVal ord="4">Both</EnumVal>
  </EnumType>
  <EnumType id="FaultPermanenceKind">
    <EnumVal ord="1">Intermittent</EnumVal>
    <EnumVal ord="2">Self-extinguishing</EnumVal>
    <EnumVal ord="3">Transient</EnumVal>
    <EnumVal ord="4">Semi-permanent</EnumVal>
    <EnumVal ord="5">Permanent</EnumVal>
    <EnumVal ord="6">Evolving</EnumVal>
    <EnumVal ord="7">Unknown</EnumVal>
  </EnumType>
  <EnumType id="FaultSourceTypeKind">
    <EnumVal ord="1">AnyPhasesToEarth</EnumVal>
    <EnumVal ord="2">AnyPhasestoPhases</EnumVal>
    <EnumVal ord="3">CrossCountryFault</EnumVal>
    <EnumVal ord="4">AnyPhases</EnumVal>
  </EnumType>
  <EnumType id="GateStatusKind">
    <EnumVal ord="0">Intermediate</EnumVal>
    <EnumVal ord="1">Open</EnumVal>
    <EnumVal ord="2">Closed</EnumVal>
    <EnumVal ord="3">Bad</EnumVal>
    <EnumVal ord="4">Open and locked</EnumVal>
    <EnumVal ord="5">Closed and locked</EnumVal>
    <EnumVal ord="6">Open and unlocked</EnumVal>
    <EnumVal ord="7">Closed and unclocked</EnumVal>
  </EnumType>
  <EnumType id="IslandingStateKind">
    <EnumVal ord="1">Non-Intentionally islanded</EnumVal>
    <EnumVal ord="2">Intentionally islanded</EnumVal>
    <EnumVal ord="3">Reconnecting</EnumVal>
    <EnumVal ord="4">Grid connected</EnumVal>
    <EnumVal ord="5">Black starting</EnumVal>
  </EnumType>
  <EnumType id="MomentaryCloseResultKind">
    <EnumVal ord="1">Fault detected</EnumVal>
    <EnumVal ord="2">No fault detected</EnumVal>
    <EnumVal ord="3">Indetermination</EnumVal>
  </EnumType>
  <EnumType id="NormalSourceKind">
    <EnumVal ord="1">None</EnumVal>
    <EnumVal ord="2">Source 1</EnumVal>
    <EnumVal ord="3">Source 2</EnumVal>
  </EnumType>
  <EnumType id="RFVFuncTypeKind">
    <EnumVal ord="1">Closed type 1</EnumVal>
    <EnumVal ord="2">Closed type 2</EnumVal>
    <EnumVal ord="3">Closed type 3</EnumVal>
    <EnumVal ord="4">Closed type 4</EnumVal>
    <EnumVal ord="5">Open type 1</EnumVal>
```

```
    <EnumVal ord="6">Open type 2</EnumVal>
</EnumType>
<EnumType id="SequenceEndResultKind">
    <EnumVal ord="1">Sequence fully successful</EnumVal>
    <EnumVal ord="2">Sequence partially successful</EnumVal>
    <EnumVal ord="3">Sequence failed</EnumVal>
</EnumType>
<EnumType id="SequenceStatusKind">
    <EnumVal ord="1">Off</EnumVal>
    <EnumVal ord="2">On but not ready</EnumVal>
    <EnumVal ord="3">Ready but blocked</EnumVal>
    <EnumVal ord="4">Ready and unblocked</EnumVal>
    <EnumVal ord="5">In-progress</EnumVal>
    <EnumVal ord="6">Complete without errors</EnumVal>
    <EnumVal ord="7">Complete with errors</EnumVal>
    <EnumVal ord="8">Aborted with errors</EnumVal>
</EnumType>
```

<CODE ENDS>

8 Communication and architectures

8.1 Types of communication architecture

8.1.1 General

Three types of architecture are considered as support for the above use cases, and are compared in regards to their ability to support them.

NOTE Clause 7.2 describes some typical communication architectures. This doesn't set any limitations neither on the configurations of controlled and monitored distribution grid nor on the distribution automation system itself.

8.1.2 Digital communication with remote monitoring

An architecture (see Figure 94) that relies on central supervisory control and data acquisition (SCADA) software and related components (such as advanced distribution management system (ADMS)) enables an operator to know the status of equipment such as sectionalizer and/or functions in a field component such as FPI remotely. Control is still performed manually on the field, but maintenance activities may be optimized by immediately focusing the field crew on the faulty section.

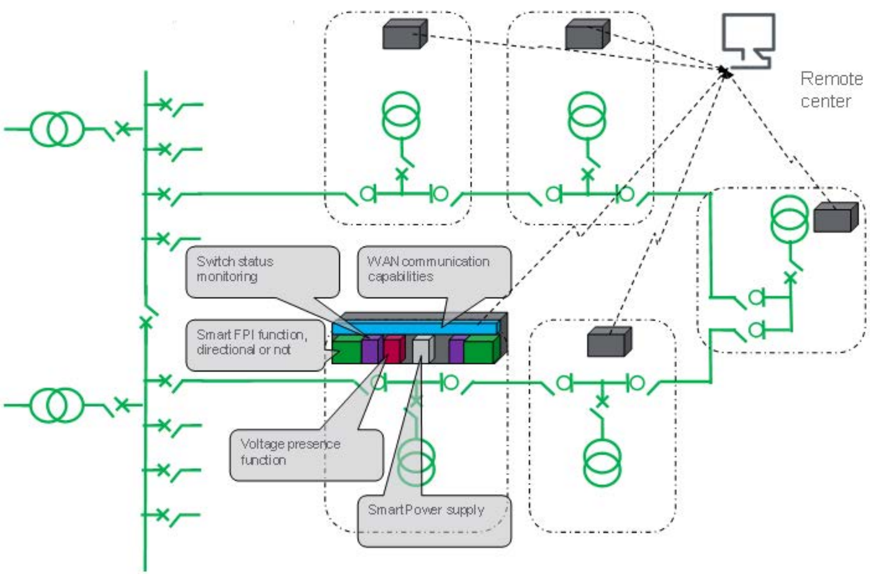


Figure 94 – Centralised distribution automation architecture with monitoring

8.1.3 Digital communications with remote monitoring and control

This architecture (see Figure 95) presents all the advantages of the previous one plus the ability to control remotely. It also offers the possibility of optimizing the reconfiguration process based on the topology as well as load and generation status.

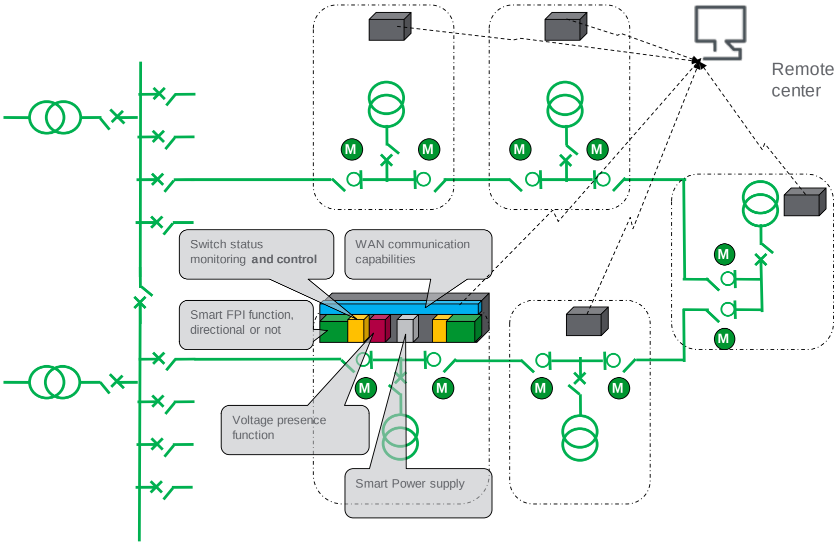


Figure 95 – Centralised distribution automation architecture with monitoring and control

8.1.4 Digital communication with distributed control

This architecture with digital communication supporting distributed control (see Figure 96) offers stand-alone capabilities that have very often faster reactions than architectures based on central means. Each smart component located along the feeder can benefit from communicating with its neighbors to perform distributed automation such as fault location, fault isolation, or Volt-VAR control without been requested to communicate with a remote control center.

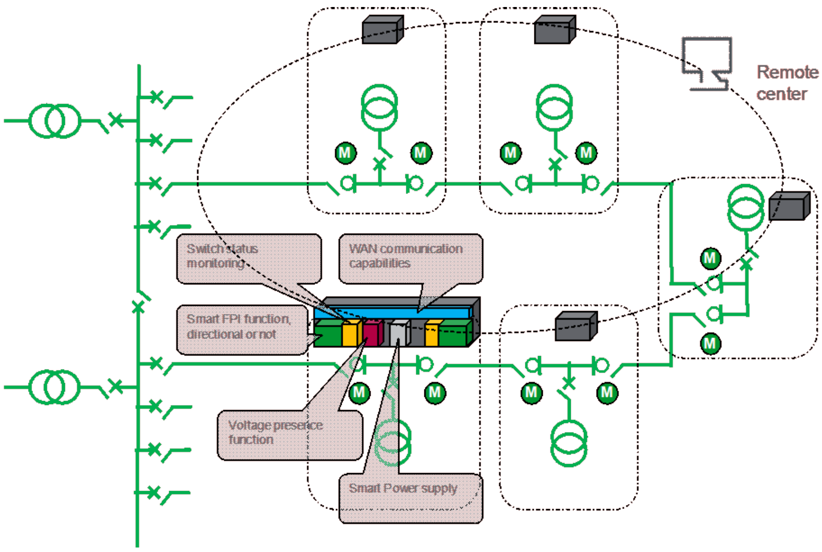


Figure 96 – Distributed control architecture

A variant of the distributed control architecture may be considered by mixing it with centralised monitoring and control features as shown in Figure 97.

Such an architecture relies on the principle that FLISR may be executed locally (under certain conditions) while monitoring and back-up FLISR (in case where local decision is not possible) is performed remotely.

Such a mixed architecture, assuming a suitable alignment of the local and remote data, may provide better response time and higher availability, especially in case of loss of the communication chanel with the remote center. In the mixed architecture a kind of semi-decentralized application like for FLISR function can be provided for multiple rings or even for meshed networks in open ring configuration.

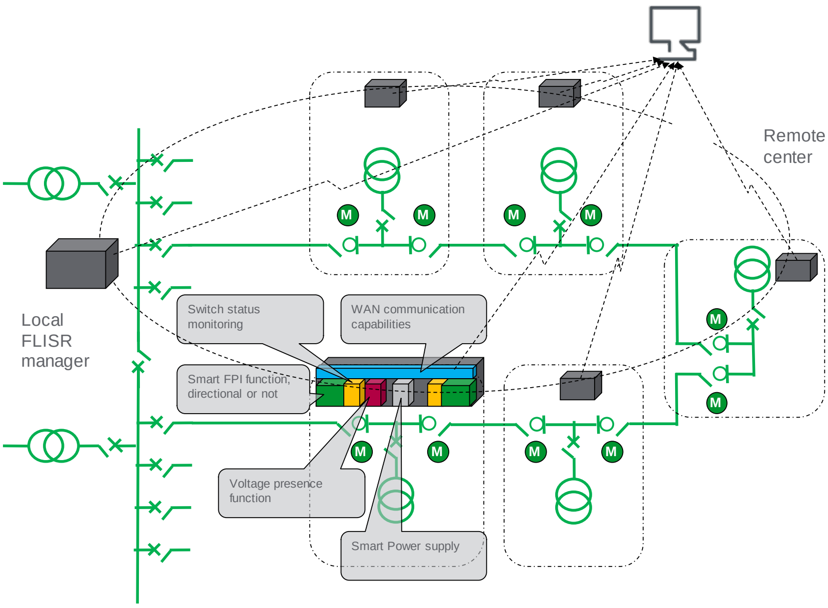


Figure 97 – Mixed distribution automation architecture combining distributed and centralised monitoring and control

8.2 Architectures matching use cases

Table 58 tries to map the use cases identified in the previous sections to the architectures.

Table 58 – Distribution automation architecture matching the use cases

Architecture	Use case support abilities
Digital communication with centralised monitoring – more observability	Use case 1: Fault indication and report Use case 2a : FLISR using sectionalizers detecting fault current Use case 2b: FLISR using sectionalizers detecting feeder voltage Use case 8: Monitor energy flow (Energy flow related Use cases) Use case 9: Environment situation awareness
Digital communication with centralised monitoring and control – more controllability	The above plus: Use case 3a: FLISR in a radial feeder based on centralized control Use case 3b : FLISR in an open loop feeder based on centralized control Use case 5: Centralized Voltage and Var Control Use case 7: Automatic transfer switch
Digital communication with distributed control or mixed architecture	The above plus: Use case 4a: FLISR in an open loop network based on distributed control-Type A Use case 4b : FLISR based on distributed control----Type B Use case 6: Anti-islanding protection based on communications

When looking to match the appropriate communication technologies to the different architectures, it is important to differentiate the communication layer (protocol specification) from the information layer (i.e., data model and semantics). See Table 59.

Table 59 – Mapping information models onto the protocol

<table>
<tr><th rowspan="2">Architecture</th><th rowspan="2">Communication layer</th><th rowspan="2">Mapping technology to support the data model over the protocol</th><th colspan="2">Information layer</th></tr>
<tr><th>Information type</th><th>Main information semantic namespaces</th></tr>
<tr><td rowspan="3">Digital communication with remote monitoring
&
Digital communication with remote monitoring and control</td><td>IEC 60870-5-101 or 104</td><td>Mapping at CDC level
IEC 61850-80-1</td><td rowspan="11">IEC 61850-7-3</td><td rowspan="11">(including but not limited to)
IEC 61850-7-4
IEC 61850-7-420
IEC TR 61850-90-6 (this document)
IEC TR 61850-90-2
IEC TR 61850-90-3
IEC 62271-3
IEC 61869-9</td></tr>
<tr><td>DNP3 (IEEE 1815)</td><td>Mapping at CDC level
IEEE 1815-1</td></tr>
<tr><td>IEC 61850-8-1
In future IEC 61850-8-2 for public networks
IEC TR 61850-90-2</td><td>Native support through
IEC 61850-7-2</td></tr>
<tr><td rowspan="8">Digital communication with distributed control
Or
Mixed</td><td colspan="2">For specific peer-to-peer communication:</td></tr>
<tr><td>IEC 61850-8-1 or
IEC 61850-90-5
(Included in IEC 61850-8-1:2011)</td><td>Native support through
IEC 61850-7-2</td></tr>
<tr><td colspan="2">For (client-server) observability and control</td></tr>
<tr><td>IEC 60870-5-101 or 104</td><td>Mapping at CDC level
IEC 61850-80-1</td></tr>
<tr><td>DNP3 (IEEE 1815)</td><td>Mapping at CDC level
IEEE 1815-1</td></tr>
<tr><td>IEC 61850-8-1
In future IEC 61850-8-2 for public networks
IEC TR 61850-90-2</td><td>Native support through
IEC 61850-7-2</td></tr>
</table>

8.3 Cyber-security

As mentioned in IEC TR 62357, cyber-security aspects rely on the IEC 62351 series.

9 Configuration

Configuration will be covered in detail as part of the coming IEC TR 61850-90-16 on system management. For illustration purpose only, an example of the SCL files required for configuring use case 4a is given in Figure 98.

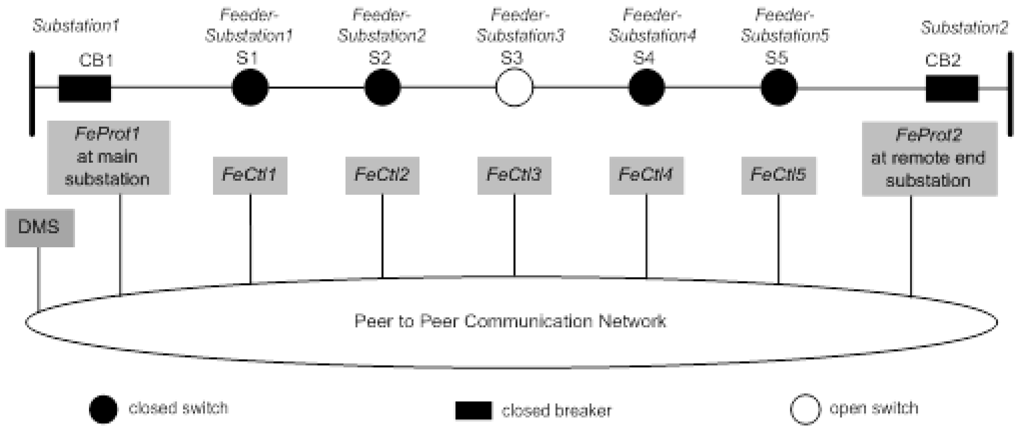


Figure 98 – Distributed feeder automation system for an open loop overhead feeder

With reference to use case 4a in 5.5.2.1.4, Figure 98 represents a FLISR scheme for an open-loop feeder with distributed control. During configuration, the logical nodes and the primary circuit's relationship is written using SCL (System Configuration Language).

The configuration of the two primary substations, Substation1 and Substation2, is represented by two SCD (System Configuration Description) files, namely SCD_SUB1.scd and SCD_SUB2.scd. They should have been available already for the existing digital primary substations.

To newly introduce a feeder automation scheme, a "grid structured" configuration file needs to be created, which includes feeder substations S1 to S5. This is represented by the SCD file SCD_GRID.scd.

Feeder automation needs to gain access to CB1 and CB2 to perform fault location, isolation and service restoration. Therefore, there is a need to provide information exchange between the SCD files of the two primary substations and the "grid" SCD file. This can be achieved by means of the SED (System Exchange Description) files in the following steps.

1) The SED_SUB1.sed and SED_SUB2.sed are created as subsets from SCD_SUB1.scd and SCD_SUB2.scd. They contain the CB1 and CB2 information respectively.
2) The SED_SUB1.sed and SED_SUB2.sed are imported into SCD_GRID.scd to create a new version named SCD_GRID.scd (ver. 2), which now contains the CB1 and CB2 information.
3) SED_SUB1.sed and SED_SUB2.sed are also updated with the feeder automation's logical nodes from SCD_GRID.scd. They are then imported back into SCD_SUB1.scd and SCD_SUB2.scd to create SCD_SUB1.scd (ver.2) and SCD_SUB2.scd (ver.2) respectively. These new SCD files now contain the data exchange description with the feeder automation system.

This process is shown in Figure 99. SCD_GRID.scd (ver.2) is now all-inclusive by including the relevant components and logical nodes from Substation1 and Substation2. Similarly, SCD_SUB1.scd (ver.2) and SCD_SUB2.scd (ver.2) for the two primary substations are now equipped to exchange information with the feeder automation system.

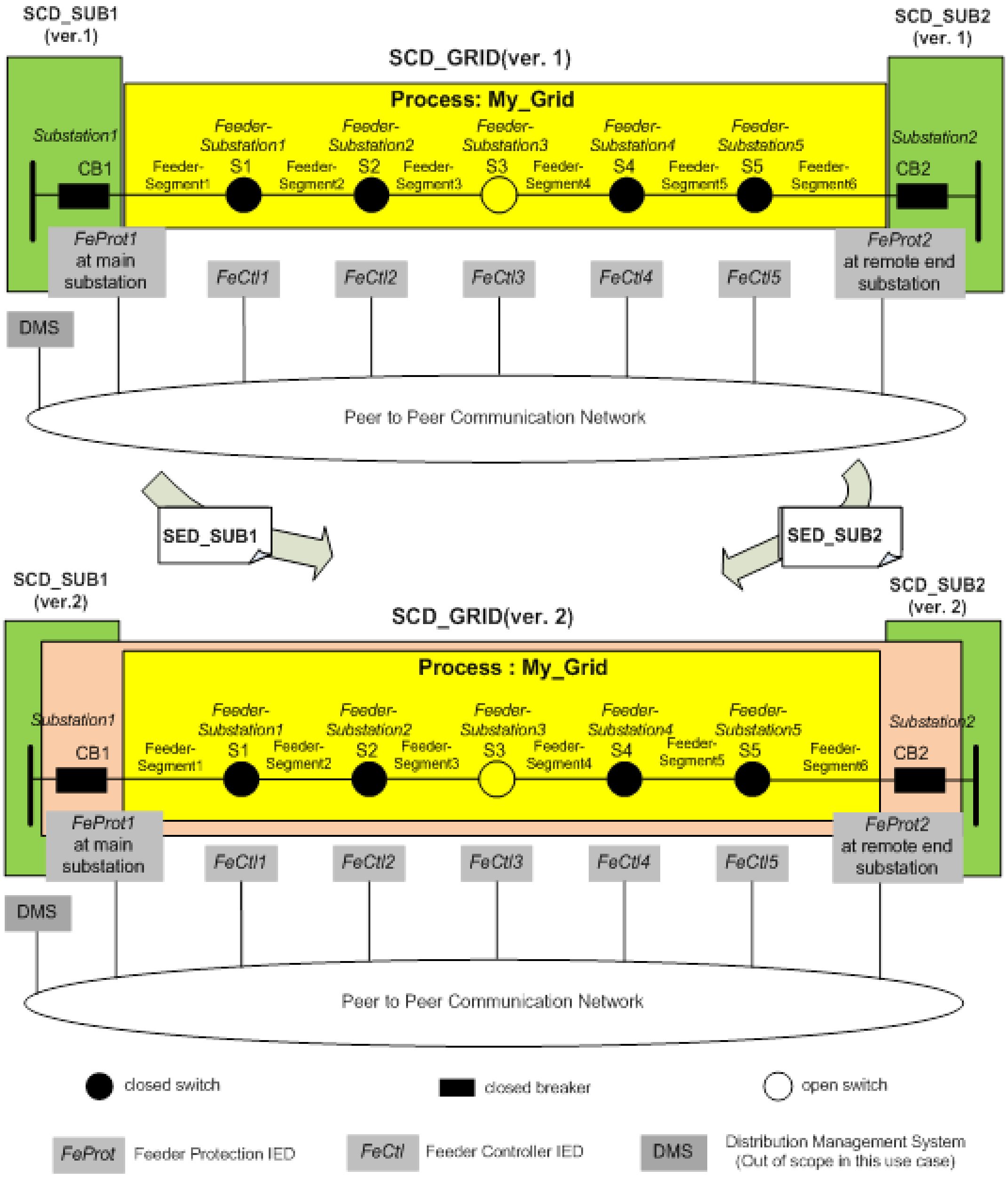


Figure 99 – Configuration process for the information exchange between substation automation and grid automation systems

According to the SCL schema from the latest IEC 61850-6:2009, the structures of the following files are shown. The Version 2 files are the results of information exchange between the substation scd files and the grid scd files. The SCD_GRID.scd (ver. 2) is also shown in more details at the end.

1) SCD_SUB1.scd (ver.1)
2) SED_SUB1.sed (ver.1)
3) SCD_SUB2.scd (ver.1)
4) SED_SUB2.sed (ver.1)
5) SCD_GRID.scd (ver.1)
6) SCD_SUB1.scd (ver.2)
7) SCD_SUB2.scd (ver.2)
8) SCD_GRID.scd (ver.2)

Structure of SCD_SUB1.scd (ver.1)

```
 < Substation name="Substation1" >
    < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <ConductingEquipment name=CB1>
             <LNode lnclass=CSWI>
         <ConductingEquipment />
    </ Bay>
    < Bay name="Q2" />
    < Bay name="Q3" />
</ Substation >
    …………
    < IED name="FeProt1" />
    < IED name="Prot2" />
    < IED name="Prot3" />
    …………
```

Structure of SED_SUB1.sed (ver.1)

```
 < Substation name="Substation1" >
    < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <ConductingEquipment name=CB1>
                   <LNode ldInst="LD1" lnclass=CSWI  lnInst="1" IedName="FeProt1>
         <ConductingEquipment />
    </ Bay>
</ Substation >
<IED name="FeProt1" engRight="dataflow" owner="Substation1_Proj" >
   <AccessPoint name="s1">
      <Server>
         <LD Name=”LD1”>
            <LN0>
             <DataSet name=”CB1_Pos”>
               <FCDA ldInst="LD1" prefix="FeProt1" lnClass="CSWI"  lnInst="1" doName="Pos"
               daName="stVal" fc="ST"/>
             </DataSet>
            </LN0>
            <LN class=”CSWI” inst =”1”/>
         </LD>
      </Server>
   </AccessPoint>
</IED>
```

Structure of SCD_SUB2.scd (ver.1)

```
 < Substation name="Substation2" >
    < Bay name="Q1" >
          <LNode lnClass=PTOC>
          <LNode lnClass=PTUV>
          <ConductingEquipment name=CB2>
             <LNode lnClass=CSWI>
         <ConductingEquipment />
    </ Bay>
    < Bay name="Q2">
    < Bay name="Q3">
    …………
    < IED name="FeProt2">
    < IED name="Prot4">
    < IED name="Prot5">
    …………
</ Substation>
```

Structure of SED_SUB2.sed (ver.1)

```
 < Substation name="Substation2" >
    < Bay name="Q1" >
          <LNode lnClass=PTOC>
          <LNode lnClass=PTUV>
          <ConductingEquipment name=CB2>
```

```
            <LNode Inclass=CSWI ldInst="LD1"  lnInst="1" ledName ="FeProt2” >
      </ Bay>
   </ Substation >
   <IED name="FeProt2" engRight="dataflow" owner="Substation2_Proj" >
      <AccessPoint name="s1">
         <Server>
            <LDname =”LD1”>
               <LN0>
                   <DataSet name=”CB2_Pos”>
                     <FCDA ldInst="LD1" prefix="FeProt1" lnClass="CSWI"  lnInst="1" doName="Pos"
                     daName="stVal" fc="ST"/>
                   </DataSet>
               </LN0>
               <LN class=”CSWI” inst=”1”/>
            </LDevice>
         </Server>
      </AccessPoint>
   </IED>
```

Structure of SCD_GRID.scd (ver.1)

```
 < Process name="My_Grid" >

      <Function name=”My_feeder_service_restoration” >
         <LNode Inclass=ASRC />
      </Function>

      <Line name="FeederSegment1">
         <ConductingEquipment name="Segment-CB1-S1" type="LIN">
            <Terminal connectivityNode="Substation1/D1/Q2/L1" substationName="Substation1"
                 voltageLevelName="D1" bayName="Q2" cNodeName="L1"/>
            <Terminal connectivityNode="Feeder-Substation1/D1/Q1/L1" substationName="Feeder-
                 Substation1" voltageLevelName="D1" bayName="Q1" cNodeName="L1"/>
         </ConductingEquipment>
      </Line>

      <Substation name="Feeder_Substation1" >
         < Bay name="Q1" >
            <LNode lnClass=PTOC />
            <LNode lnClass=PTUV />
            <LNode lnClass=SFPI />
            <LNode lnClass=AFSL />
            <LNode lnClass=AFSI />
            <ConductingEquipment name=S1 />
         </ Bay>
     </Substation >

     <Line name="FeederSegment2">
         <ConductingEquipment name="Segment-S1-S2" type="LIN">
            <Terminal connectivityNode="Feeder-Substation1/D1/Q1/L2" substationName="Feeder-
                 Substation1" voltageLevelName="D1" bayName="Q1" cNodeName="L2"/>
            <Terminal connectivityNode="Feeder-Substation2/D1/Q1/L1" substationName="Feeder-
                 Substation2" voltageLevelName="D1" bayName="Q1" cNodeName="L1"/>
         </ConductingEquipment>
     </Line>

     < Substation name="Feeder-Substation2" >
         < Bay name="Q1" >
            <LNode lnClass=PTOC />
            <LNode lnClass=PTUV />
            <LNode lnClass=SFPI />
            <LNode lnClass=AFSL />
            <LNode lnClass=AFSI />
            <ConductingEquipment name=S2 />
         </ Bay>
     </Substation >

     <Line name="FeederSegment3">
         ……similar to Feeder-Segment2……
```

```
    </Line>

    < Substation name="Feeder_Substation3" >
       < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <LNode lnClass=SFPI />
          <LNode lnClass=AFSL />
          <LNode lnClass=AFSI />
          <ConductingEquipment name=S3 />
       </Bay>
    </Substation >

    <Line name="FeederSegment4">
       …… similar to Feeder-Segment2……
    </Line>

    < Substation name="Feeder_Substation4" >
       < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <LNode lnClass=SFPI />
          <LNode lnClass=AFSL />
          <LNode lnClass=AFSI />
          <ConductingEquipment name=S4 />
       </ Bay>
    </ Substation >

    <Line name="FeederSegment5">
       ……similar to Feeder-Segment2……
    </Line>

    < Substation name="Feeder_Substation5" >
       < Bay name="Q1">
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <LNode lnClass=SFPI />
          <LNode lnClass=AFSL />
          <LNode lnClass=AFSI />
          <ConductingEquipment name=S5 />
       </Bay>
    </Substation >

    <Line name="FeederSegment6">
       <ConductingEquipment name="Segment-S5-CB2" type="LIN">
          <Terminal connectivityNode="Feeder-Substation5/D1/Q1/L2" substationName="Feeder-
            Substation5" voltageLevelName="D1" bayName="Q1" cNodeName="L2"/>
          <Terminal connectivityNode="Substation2/D1/Q2/L1" substationName="Substation2"
            voltageLevelName="D1" bayName="Q2" cNodeName="L1"/>
       </ConductingEquipment>
    </Line>
< /Process>
```

Structure of SCD_SUB1.scd (ver.2)

```
 < Substation name="Substation1" >
    < Bay name="Q1" >
       <LNode lnClass=PTOC />
       <LNode lnClass=PTUV />
       <LNode lnClass=SFPI />
       <LNode lnClass=AFSL />
       <LNode lnClass=AFSI />
       <ConductingEquipment name=CB1>
           <LNode lnClass=CSWI />
         </ConductingEquipment>
    </Bay>
    …………
 </Substation >
```

Structure of SCD_SUB2.scd (ver.2)

```
 < Substation name="Substation2" >
    < Bay name="Q1" >
       <LNode lnClass=PTOC />
       <LNode lnClass=PTUV />
       <LNode lnClass=SFP />
       <LNode lnClass=AFS />
       <LNode lnClass=AFS />
       <ConductingEquipment name=CB2>
             <LNode lnClass=CSWI />
         </ConductingEquipment>
    </Bay >
    …………
  </Substation >
```

Structure of SCD_GRID.scd (ver.2)

```
< Substation name="Substation1" >
    < Bay name="Q1" >
       <LNode lnClass=PTOC />
       <LNode lnClass=PTUC />
       <LNode lnClass=SFPI />
       <LNode lnClass=AFSL />
       <LNode lnClass=AFSI />
       <ConductingEquipment name=CB1>
          <LNode lnClass=CSWI />
         </ConductingEquipment>
    </Bay >
    …………
</ Substation >

< Process name="My_Grid" >

    <Function name="My_feeder_service_restoration" >
       <LNode Inclass=ASRC />
    </Function>

    <Line name="FeederSegment1">
       <ConductingEquipment name="Segment-CB1-S1" type="LIN">
          <Terminal connectivityNode="Substation1/D1/Q2/L1" substationName="Substation1"
               voltageLevelName="D1" bayName="Q2" cNodeName="L1"/>
          <Terminal connectivityNode="Feeder-Substation1/D1/Q1/L1" substationName="Feeder-
               Substation1" voltageLevelName="D1" bayName="Q1" cNodeName="L1"/>
       </ConductingEquipment>
    </Line>

    < Substation name="Feeder_Substation1" >
       < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <LNode lnClass=SFPI />
          <LNode lnClass=AFSL />
          <LNode lnClass=AFSI />
          <ConductingEquipment name=S1 />
       < /Bay >
     </ Substation >

     <Line name="FeederSegment2">
       ……similar to Feeder-Segment1……
     </Line>

    < Substation name="Feeder_Substation2" >
       < Bay name="Q1" >
          <LNode lnClass=PTOC />
          <LNode lnClass=PTUV />
          <LNode lnClass=SFPI />
          <LNode lnClass=AFSL />
          <LNode lnClass=AFSI />
          <ConductingEquipment name=S2 />
```

```
    </Bay >
  </Substation >

  <Line name="FeederSegment3">
    ……similar to Feeder-Segment1……
  </Line>

 < Substation name="Feeder_Substation3" >
   < Bay name="Q1" >
     <LNode lnClass=PTOC />
     <LNode lnClass=PTUV />
     <LNode lnClass=SFPI />
     <LNode lnClass=AFSL />
     <LNode lnClass=AFSI />
     <ConductingEquipment name=S3 />
   < / Bay >
  </ Substation >

  <Line name="FeederSegment4">
    ……similar to Feeder-Segment1……
  </Line>

 < Substation name="Feeder_Substation4" >
   < Bay name="Q1" >
     <LNode lnClass=PTOC />
     <LNode lnClass=PTUV />
     <LNode lnClass=SFPI />
     <LNode lnClass=AFSL />
     <LNode lnClass=AFSI />
     <ConductingEquipment name=S4 />
   </Bay >
  </Substation >

  <Line name="FeederSegment5">
    ……similar to Feeder-Segment1……

  </Line>

 < Substation name="Feeder_Substation5" >
   < Bay name="Q1" >
     <LNode lnClass=PTOC />
     <LNode lnClass=PTUV />
     <LNode lnClass=SFPI />
     <LNode lnClass=AFSL />
     <LNode lnClass=AFSI />
     <ConductingEquipment name=S5 />
   < / Bay >
  </ Substation >

  <Line name="FeederSegment6">
    <ConductingEquipment name="Segment-S5-CB2" type="LIN">
      <Terminal connectivityNode="Feeder-Substation5/D1/Q1/L2" substationName="Feeder-
        Substation5" voltageLevelName="D1" bayName="Q1" cNodeName="L2"/>
      <Terminal connectivityNode="Substation2/D1/Q2/L1" substationName="Substation2"
        voltageLevelName="D1" bayName="Q2" cNodeName="L1"/>
    </ConductingEquipment>
  </Line>

< /Process >

< Substation name="Substation2" >
  < Bay name="Q1" >
     <LNode lnClass=PTOC />
     <LNode lnClass=PTUV />
     <LNode lnClass=SFPI />
     <LNode lnClass=AFSL />
     <LNode lnClass=AFSI />
     <ConductingEquipment name=CB2 />
```

```
  < / Bay >
</ Substation >
```


Details from SCD_GRID.scd (ver.2)


```
<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSpy v2013 (http://www.altova.com)-->
<scl:SCL version="2007" revision="B"
release="3"xmlns:scl="http://www.iec.ch/61850/2003/SCL"xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<scl:Header id="Feeder SCD_v2  file example" version="" revision=""toolID=""nameStructure="IEDName"/>
<scl:Substation name="Substation1">
        <scl:VoltageLevel name="D1">
                <scl:Voltage multiplier="k" unit="V">10</scl:Voltage>
                <scl:Bay name="Q1"desc=" ">
                        <scl:LNode  lnInst="1" lnClass="PTOC" ldInst="Prot1"iedName="FeProt1"/>
                        <scl:LNode lnInst="1" lnClass="PTUV"ldInst="Prot1"iedName="FeProt1"/>
                        <scl:LNode lnInst="1" lnClass="PTRC"ldInst="Prot1"iedName="FeProt1"/>
                        <scl:LNode lnInst="1" lnClass="SFPI"ldInst="FA"iedName="FeProt1"/>
                        <scl:LNode lnInst="1" lnClass="AFSL"ldInst="FA"iedName="FeProt1"/>
                        <scl:LNode lnInst="1" lnClass="AFSI"ldInst="FA"iedName="FeProt1"/>
                        <scl:ConductingEquipment name="CB1" type="CBR">
                                <scl:LNode lnInst="1" lnClass="CSWI"ldInst="Ctrl1"iedName="FeProt1"/>
                                <scl:LNode lnInst="1" lnClass="XCBR"ldInst="Proc1"iedName="FeProt1"/>
<scl:TerminalconnectivityNode="Substation1/D1/Q2/B1"substationName="Substation1"voltageLevelName="D1"bayName="Q2"
cNodeName="B1"/>
<scl:TerminalconnectivityNode="Substation1/D1/Q1/L1"substationName="Substation1"voltageLevelName="D1"bayName="Q1"
cNodeName="L1"/>
                        </scl:ConductingEquipment>
                        <scl:ConnectivityNode name="L1"pathName="Substation1/D1/Q1/L1"/>
                </scl:Bay>
        </scl:VoltageLevel>
</scl:Substation>

<scl:Process name="My-grid">
    <scl:Function name="My_feeder_service_restoration”>
        <scl:LNode lnInst="1" lnClass="ASRC"ldInst="FA"iedName="FeCtl3"/>
    </scl:Function>
    <scl:Substation name="Feeder-Substation1">
        <scl:VoltageLevel name="D1">
                <scl:Voltage multiplier="k" unit="V">10</scl:Voltage>
                <scl:Bay name="Q1">
                        <scl:LNode lnInst="1" lnClass="PTOC"ldInst="Prot1"iedName="FeCtl1"/>
                        <scl:LNode lnInst="1" lnClass="PTUV"ldInst="Prot1"iedName="FeCtl1"/>
                        <scl:LNode lnInst="1" lnClass="SFPI"ldInst="FA"iedName="FeCtl1"/>
                        <scl:LNode lnInst="1" lnClass="AFSL"ldInst="FA"iedName="FeCtl1"/>
                        <scl:LNode lnInst="1" lnClass="AFSI"ldInst="FA"iedName="FeCtl1"/>
                        <scl:ConductingEquipment name="S1" type="DIS">
                                <scl:LNode lnInst="1" lnClass="CSWI"ldInst="Ctrl1"iedName="FeCtl1"/>
                                <scl:LNode lnInst="1" lnClass="XSWI"ldInst="Proc1"iedName="FeCtl1"/>
    <scl:TerminalconnectivityNode="Feeder-Substation1/D1/Q1/L1"substationName="Feeder-Substation1"voltageLevelName="D1"
bayName="Q1"cNodeName="L1"/>
<scl:TerminalconnectivityNode="Feeder-Substation1/D1/Q1/L2"substationName="Feeder-Substation1"voltageLevelName="D1"
bayName="Q1"cNodeName="L2"/>
                        </scl:ConductingEquipment>
                        <scl:ConnectivityNode name="L1"pathName="Feeder-Substation1/D1/Q1/L1"/>
                        <scl:ConnectivityNode name="L2"pathName="Feeder-Substation1/D1/Q1/L2"/>
                </scl:Bay>
        </scl:VoltageLevel>
    </scl:Substation>
    <scl:Substation name="Feeder-Substation2">
        <!-- Similar to Feeder-Substation1, not repeated here.-->
    </scl:Substation>
    <scl:Substation name="Feeder-Substation3">
        <!-- Similar to Feeder-Substation1 except with the addition of ASRC logical node, not repeated here.-->
    </scl:Substation>
    <scl:Substation name="Feeder-Substation4">
        <!-- Similar to Feeder-Substation1, not repeated here.-->
    </scl:Substation>
    <scl:Substation name="Feeder-Substation5">
        <!-- Similar to Feeder-Substation1, not repeated here.-->
    </scl:Substation>
    </scl:Substation>
    <scl:Line name="FeederSegment1">
        <scl:ConductingEquipment name="Segment-CB1-S1" type="LIN">
    <scl:TerminalconnectivityNode="Substation1/D1/Q2/L1"substationName="Substation1"voltageLevelName="D1"bayName="Q2"
cNodeName="L1"/>
    <scl:TerminalconnectivityNode="Feeder-Substation1/D1/Q1/L1"substationName="Feeder-
```

```
Substation1"voltageLevelName="D1"bayName="Q1"cNodeName="L1"/>
            </scl:ConductingEquipment>
    </scl:Line>
    <scl:Line name="FeederSegment2">
            <!-- Similar to Feeder_Segment1, not repeated here.-->
    </scl:Line>
    <scl:Line name="FeederSegment3">
            <!-- Similar to Feeder_ Segment1, not repeated here.-->
    </scl:Line>
    <scl:Line name="FeederSegment4">
            <!-- Similar to Feeder_ Segment1, not repeated here.-->
    </scl:Line>
    <scl:Line name="FeederSegment5">
            <!-- Similar to Feeder_ Segment1, not repeated here.-->
    </scl:Line>
    <scl:Line name="FeederSegment6">
            <scl:ConductingEquipment name="Segment-S5-CB2" type="LIN">
                    <scl:Terminal connectivityNode="Feeder-Substation5/D1/Q1/L2" substationName="Feeder-Substation5"
voltageLevelName="D1" bayName="Q1" cNodeName="L2"/>
                    <scl:Terminal connectivityNode="Substation2/D1/Q2/L1" substationName="Substation2"
voltageLevelName="D1" bayName="Q2" cNodeName="L1"/>
            </scl:ConductingEquipment>
    </scl:Line>
</scl:Process>

<scl:Substation name="Substation2">
            <!-- Similar to Substation1, not repeated here.-->
</scl:Substation>
</scl:SCL>
```

Annex A
(informative)

Interpretation of logical node tables

A.1 General interpretation of logical node tables

Table A.1 shows how to interprete LN tables included in Clause 7 (extracted from IEC 61850-7-4).

Table A.1 – Interpretation of logical node tables

Column heading	Description
Data object name	Name of the data object
Common data class	Common data class that defines the structure of the data object. See IEC 61850-7-3. For common data classes regarding the service tracking logical node (LTRK), see IEC 61850-7-2.
Explanation	Explanation of the data object and how it is used.
T	Transient data objects – the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state. Some T may be only valid on a modelling level. The TRANSIENT property of DATA OBJECTS only applies to BOOLEAN process data attributes (FC=ST) of that DATA OBJECTS. A transient DATA OBJECT is identical to normal DATA OBJECT, except that for the process state change from TRUE to FALSE no event may be generated for reporting and for logging. For transient data objects, the falling edge is not reported if the transient attribute is set to true in the SCL-ICD file[6]. It is recommended to report both states (TRUE to FALSE, and FALSE to TRUE), i.e. not to set the transient attribute in the SCL-ICD file for those DOs, and that the clients filter the transitions that are not "desired". For GOOSE or SMV services this attribute does not apply.
PresCond nds / ds	This column defines whether a data object is mandatory (M), optional (O) or has some other presence condition for a non-derived-statistics (nds) and derived-statistics (ds) instance of a logical node. When a data object is marked mandatory (M), it shall be contained in the instance of the logical node. When a data object is marked optional (O), it may be contained in the instance of the logical node; the decision if the data object is contained or not is outside the scope of this standard. Other more complex presence conditions all have their semantic defined in IEC 61850-7-2 and for the convenience of the reader they are also reprinted (as informative) below. In case of a condition that is not machine processable, the text of the condition is given outside the LN table. NOTE1 Procurement specifications may require specific data objects marked optional to be provided for a particular project. The amount of optional information to be provided needs to be negotiated. NOTE 2 The attributes for data objects that are instantiated may also be mandatory or optional based on the CDC (attribute type) definition in IEC 61850-7-3.

A.2 Conditions for element presence

This clause introduces conditions that specify presence of elements in a given context (one LN, or one CDC, or one data attribute type, or one data object for dataNs).

Table A.2 shows presence conditions.

Table A.2 – Conditions for presence of elements within a context

Condition name	Definition
M	Element is mandatory.
O	Element is optional.

6 Transient is an attribute of the element DO of the LnodeType of the SCL (IEC 61850-6).

Condition name	Definition
F	Element is forbidden.
na	Element is not applicable.
Mmulti	At least one element shall be present; all instances have an instance number >0.
Omulti	Zero or more elements may be present; all instances have an instance number >0.
AtLeastOne(n)	Parameter n: group number (>0). At least one of marked elements of a group n shall be present.
AtMostOne	At most one of marked elements shall be present.
AllOrNonePerGroup(n)	Parameter n: group number (>0). All or none of the elements of a group n shall be present.
AllOnlyOneGroup(n)	Parameter n: group number (>0). All elements of only one group n shall be present.
MF(sibling)	Parameter sibling: sibling element name. Mandatory if sibling element is present, otherwise forbidden.
MO(sibling)	Parameter sibling: sibling element name. Mandatory if sibling element is present, otherwise optional.
OM(sibling)	Parameter sibling: sibling element name. Optional if sibling element is present, otherwise mandatory.
FM(sibling)	Parameter sibling: sibling element name. Forbidden if sibling element is present, otherwise mandatory.
MOcond(condID)	Parameter condID: condition number (>0). Textual presence condition (non-machine processable) with reference condID to context specific text. If satisfied, the element is mandatory, otherwise optional.
MFcond(condID)	Parameter condID: condition number (>0). Textual presence condition (non-machine processable) with reference condID to context specific text. If satisfied, the element is mandatory, otherwise forbidden.
OFcond(condID)	Parameter condID: condition number (>0). Textual presence condition (non-machine processable) with reference condID to context specific text. If satisfied, the element is optional, otherwise forbidden.
MmultiRange(min, max)	Parameters min, max: limits for instance number (>0). One or more elements must be present; all instances have an instance number within range [min, max] (see Part 7-1).
OmultiRange(min, max)	Parameters min, max: limits for instance number (>0). Zero or more elements may be present; all instances have an instance number within range [min, max] (see Part 7-1).
MFsubst	Element is mandatory if substitution is supported (for substitution, see IEC 61850-7-2), otherwise forbidden.
MOln0	Element is mandatory in the context of LLN0; otherwise optional.
MFln0	Element is mandatory in the context of LLN0; otherwise forbidden.
MOlnNs	Element is mandatory if the name space of its logical node deviates from the name space of the containing logical device, otherwise optional. See IEC 61850-7-1 for use of name space.
MOdataNs	Element is mandatory if the name space of its data object deviates from the name space of its logical node, otherwise optional. See IEC 61850-7-1 for use of name space.
MOcdcNs	Element is mandatory if the name space of its CDC deviates from the name space of its data object, otherwise optional. See IEC 61850-7-1 for use of name space.
MFscaledAV	Element is mandatory* if any sibling elements of type AnalogueValue include 'i' as a child, otherwise forbidden. *Even though devices without floating point capability cannot exchange floating point values through ACSI services, the description of scaling remains mandatory for their (SCL) configuration.

Condition name	Definition
MFscaledMagV	Element is mandatory* if any sibling elements of type Vector include 'i' as a child of their 'mag' attribute, otherwise forbidden. *See MFscaledAV.
MFscaledAngV	Element is mandatory* if any sibling elements of type Vector include 'i' as a child of their 'ang' attribute, otherwise forbidden. *See MFscaledAV.
MOrms	Element is mandatory if the harmonic values in the context are calculated as a ratio to RMS value (value of data attribute 'hvRef' is 'rms'), optional otherwise.
MOrootLD	Element is mandatory in the context of a root logical device; otherwise it is optional.
MOoperTm	Element is mandatory if at least one controlled object on the IED supports time activation service; otherwise it is optional.
MmultiF(sibling)	Parameter sibling: sibling element name. One or more elements must be present if sibling element is present, otherwise forbidden.
MFsbo	Element is mandatory if declared control model supports 'sbo-with-normal-security' or 'sbo-with-enhanced-security', otherwise forbidden.
MFenhanced	Element is mandatory if declared control model supports 'direct-with-enhanced-security' or 'sbo-with-enhanced-security', otherwise forbidden.

Annex B
(informative)

Typical Grid topologies considered in this report

The proposed scope of the network to be considered is the light blue area delimited by the black triangle shown in Figure B.1.

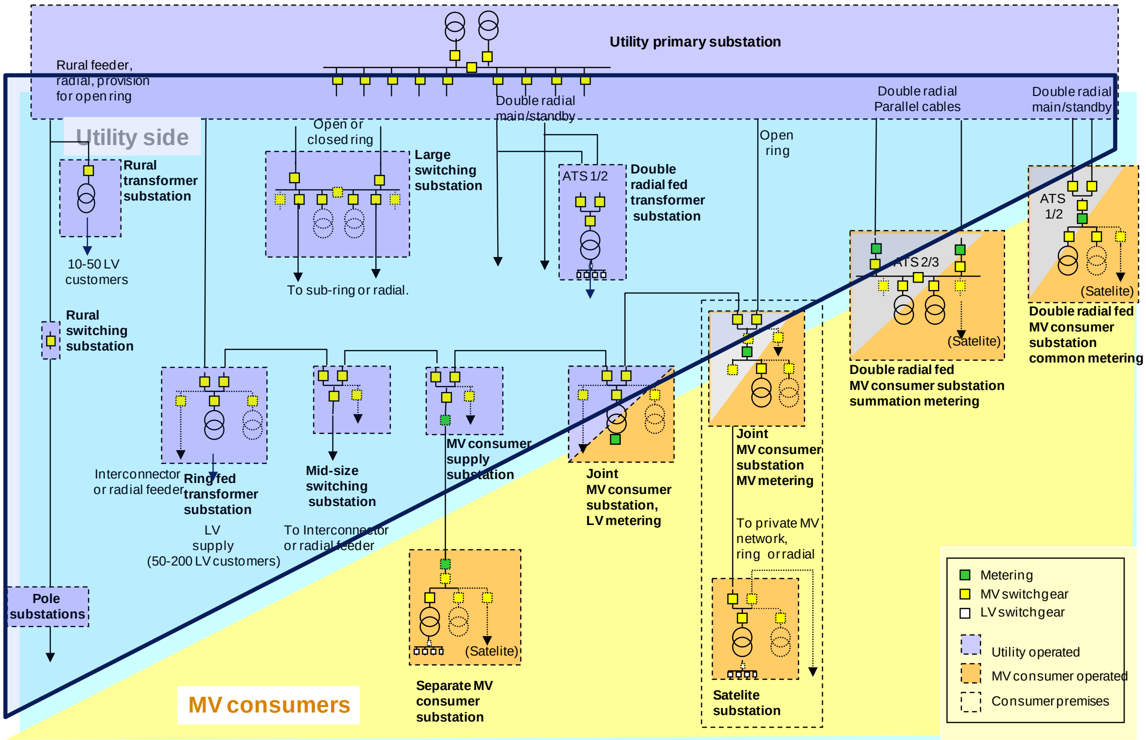


Figure B.1 – Typical grid topologies

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

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