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Simplifying substation control engineering by using an IEC 61850 based Relion[®] solution

Overview

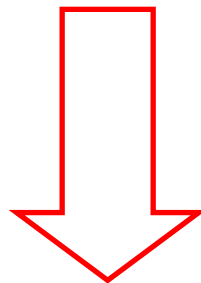
- IEC61850 Basics
- What is a GOOSE message?
- Digitizing copper in P&C applications

The Basics

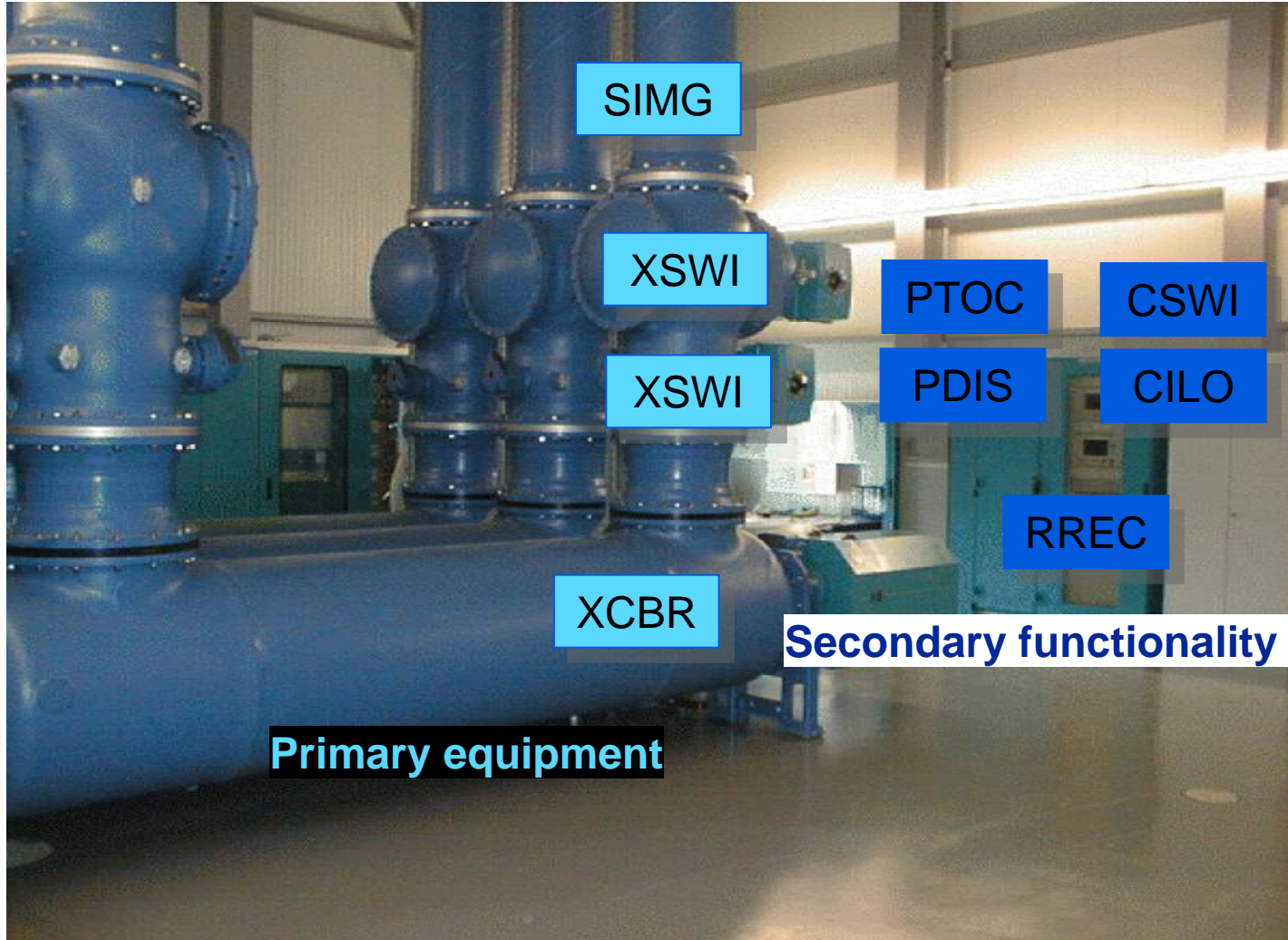
A way to model equipment/functions and document in a standard format for easy exchange

- Moving from a memory location driven data layout to one that is named and defined based on application

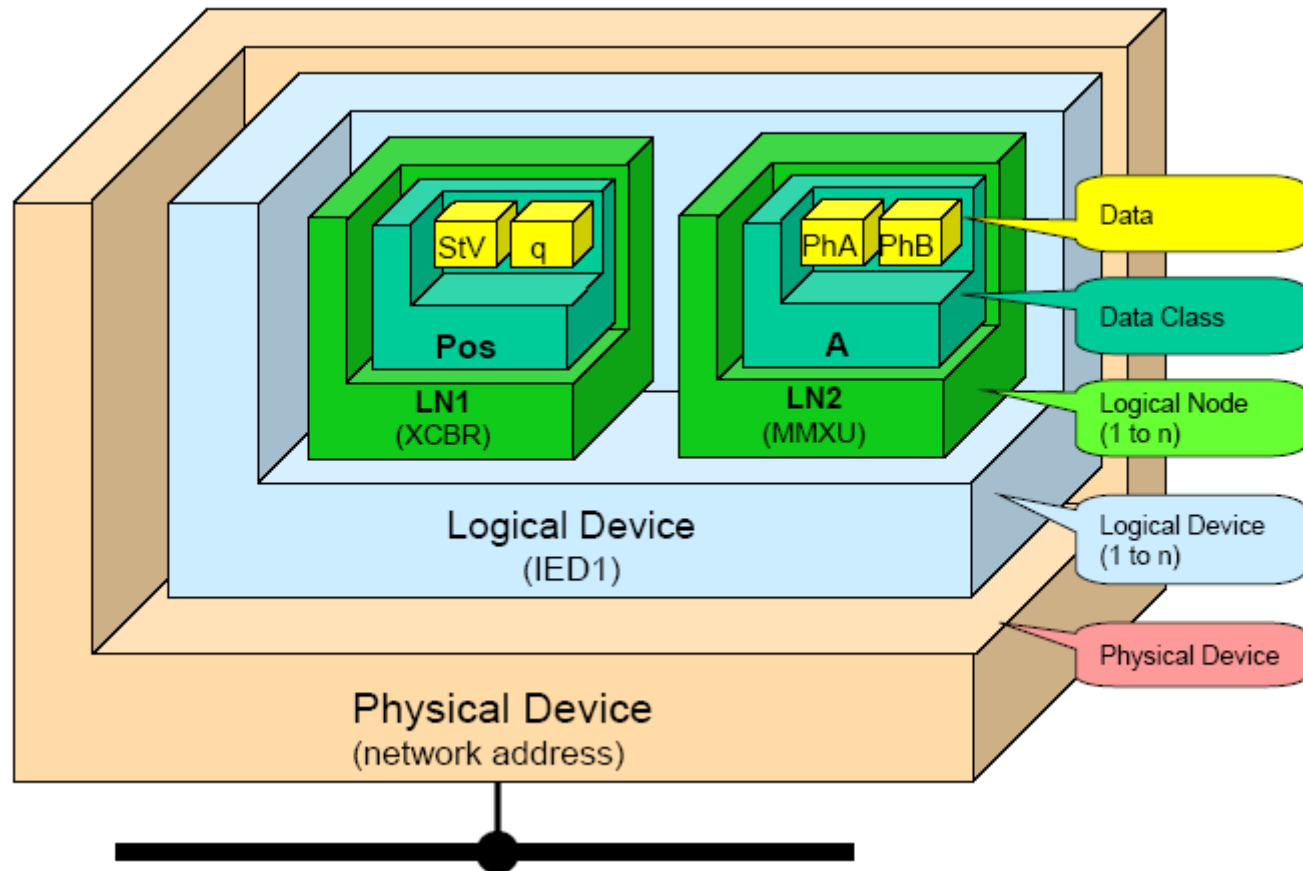
```
00001: <0> 00014: <0> 00027: <0> 00040: <0> 00053: <0> 00066: <0> 00079: <0> 00092: <0>
00002: <0> 00015: <0> 00028: <0> 00041: <0> 00054: <0> 00067: <0> 00080: <0> 00093: <0>
00003: <0> 00016: <0> 00029: <0> 00042: <0> 00055: <0> 00068: <0> 00081: <0> 00094: <0>
00004: <0> 00017: <0> 00030: <0> 00043: <0> 00056: <0> 00069: <0> 00082: <0> 00095: <0>
00005: <0> 00018: <0> 00031: <0> 00044: <0> 00057: <0> 00070: <0> 00083: <0> 00096: <0>
00006: <0> 00019: <0> 00032: <0> 00045: <0> 00058: <0> 00071: <0> 00084: <0> 00097: <0>
00007: <0> 00020: <0> 00033: <0> 00046: <0> 00059: <0> 00072: <0> 00085: <0> 00098: <0>
00008: <0> 00021: <0> 00034: <0> 00047: <0> 00060: <0> 00073: <0> 00086: <0> 00099: <0>
00009: <0> 00022: <0> 00035: <0> 00048: <0> 00061: <0> 00074: <0> 00087: <0> 00100: <0>
00010: <0> 00023: <0> 00036: <0> 00049: <0> 00062: <0> 00075: <0> 00088: <0>
00011: <0> 00024: <0> 00037: <0> 00050: <0> 00063: <0> 00076: <0> 00089: <0>
00012: <0> 00025: <0> 00038: <0> 00051: <0> 00064: <0> 00077: <0> 00090: <0>
00013: <0> 00026: <0> 00039: <0> 00052: <0> 00065: <0> 00078: <0> 00091: <0>
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Logical nodes



What is inside a Logical Node?

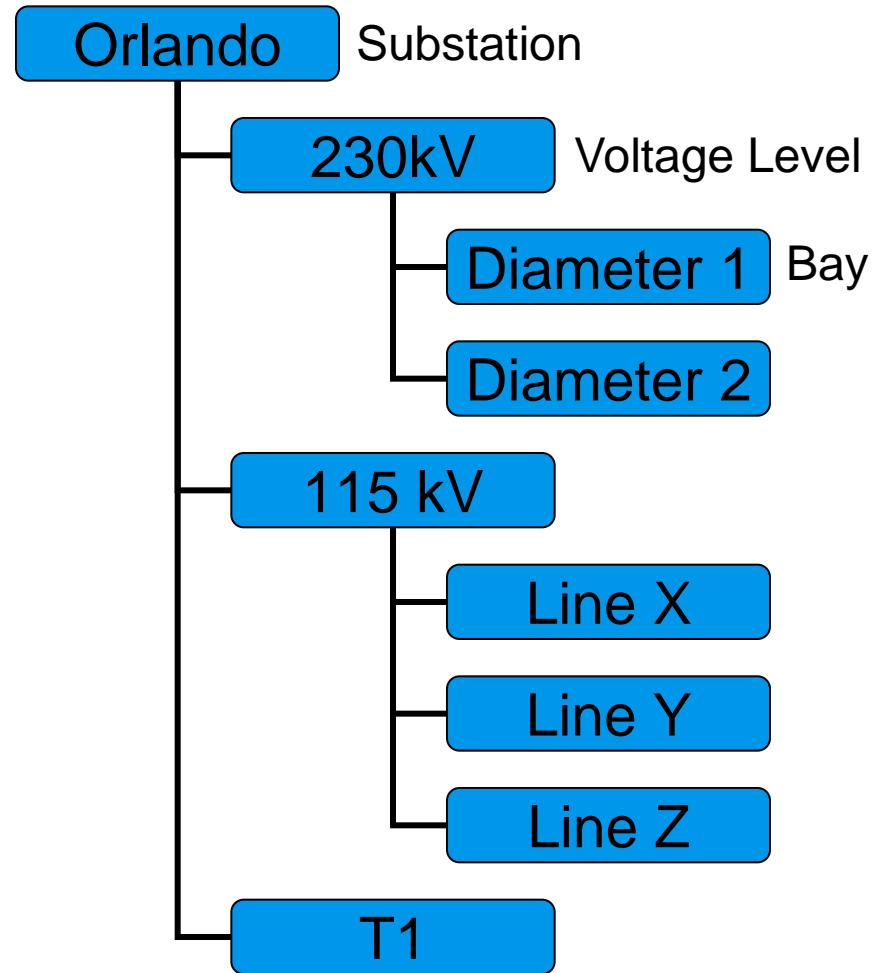
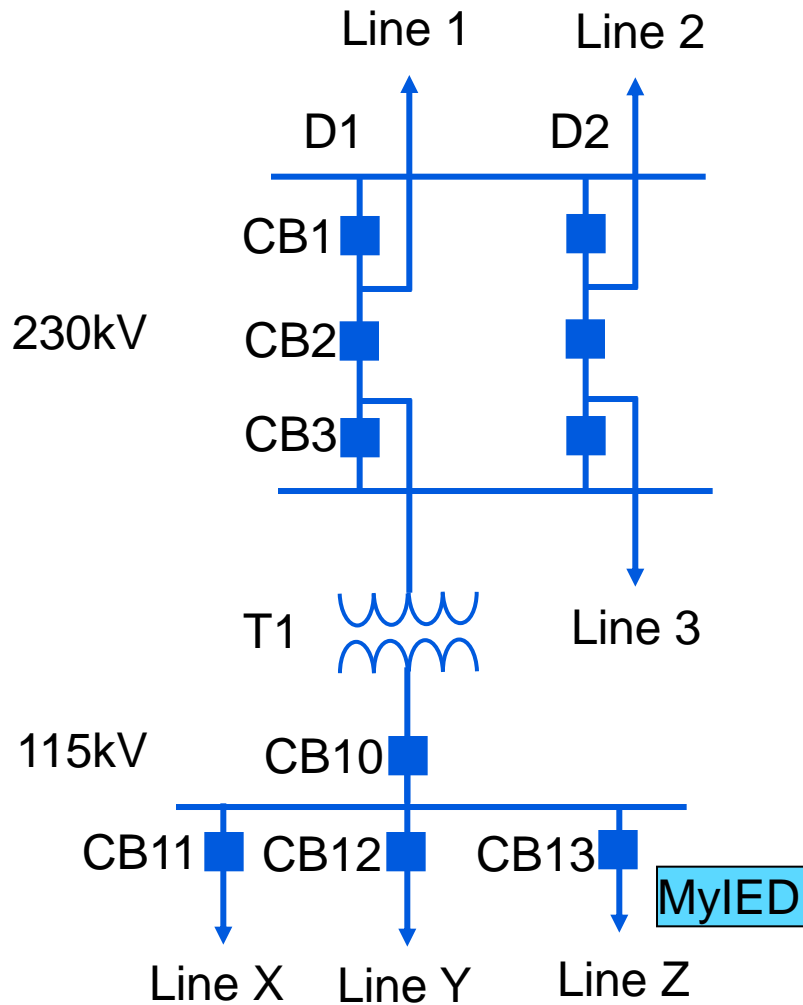


Different kinds of Logical Nodes

- LLN0, LPHD: IED and function management
- Pxxx: protection (PTOC, PIOC, PDIS, PDIF,.....) (28)
- Rxxx: protection related (RREC, RSYN, RDRx,) (10)
- Cxxx: control related (CSWI, CILO, CALH, CCGR, CPOW)
- Mxxx: measurements (MMXU, MMXN, MMTR, MHAI, MDIF, MSTA)
- Axxx: automatic functions (ATCC, ANCR, ARCO, AVCO)
- Gxxx: generic functions (GGIO, GAPC, GSAL)
- Sxxx: sensor/monitoring interface (SIMG, SIML, SARC, SPDC)
- Txxx: instrument transformer (TCTR, TVTR)
- Xxxx: switchgear process interface (XCBR, XSWI)
- Yxxx: transformer process if (YPTR, YLTC, YEFN, YPSH)
- Zxxx: further power related equipment (ZBAT, ZGEN, ZMOT,...)
- Ixxx: interfacing and archiving (IHMI, ITCI, IARC, ITMI)

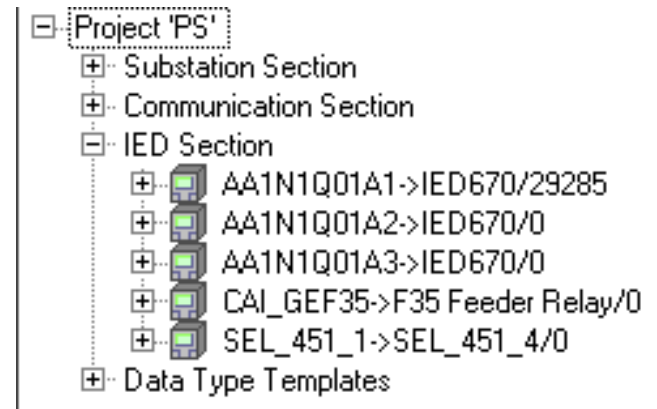
Modeling – Substation structure

Orlando Substation



SCD and Modeling in 61850

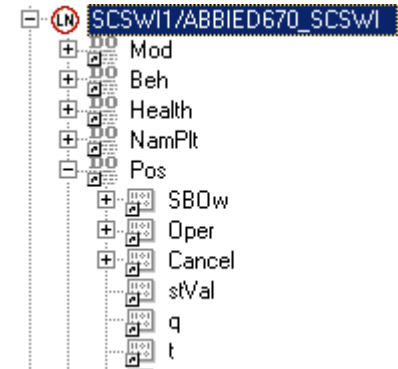
- 61850 defines a common language where all compliant manufacturers can exchange information regarding the “functions” (Logical Nodes) and related data available inside their equipment.
- Substation Configuration Language
- Offers 4 file formats (Ed. 1)
 - SSD: Substation Specification Description
 - ICD: IED Capabilities Description
 - CID: Configured IED Description
 - SCD: Substation Configuration Description



The Basics (cont.)

Client-Server interactions

- Get information from relays and meters
- Higher resolution of information
- Lower integration costs
 - Drag and drop process thanks to SCL file
 - All manufacturers with same naming convention
 - Less chances for mistakes
 - Faster integration



Point#	Refer#	Variable	Class
0	0	Ia (Load Currents)	03
1	2	Ib	03
2	4	Ic	03
3	6	In	03
4	9	KVan (Mag) (*1000)	03
5	11	KVbn (Mag) (*1000)	03
Point#	Refer#	Variable	Class
0	9	KVan (Mag) (*1000)	03
1	11	KVbn (Mag) (*1000)	03
2	13	KVcn (Mag) (*1000)	03
3	0	Ia (Load Currents)	03
4	2	Ib	03
5	4	Ic	03
6	6	In	03
7	15	KWan	0

SXSWI: 3.OPENPOS	CircuitSwitch, Apparatus open position
SXSWI: 3.CLOSEPOS	CircuitSwitch, Apparatus closed position
VNMMXU: 3.V_C	VoltagePhasors, V_C Amplitude, magnitude of reported value
VNMMXU: 3.V_B	VoltagePhasors, V_B Amplitude, magnitude of reported value
VNMMXU: 3.V_A	VoltagePhasors, V_A Amplitude, magnitude of reported value
CMSQI: 3.3I0	CurrentSequenceComponents, 3I0 magnitude of reported value

The Basics (cont.)

Digitize copper (GOOSE + SMV)

- Thanks to Ethernet technology and previously mentioned data model we are able to digitize copper:
 - Binary signals
 - Analog signals

What is a GOOSE message?

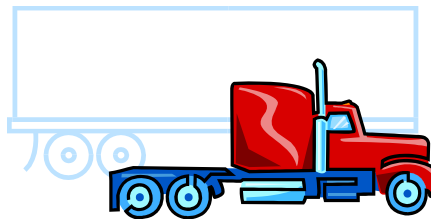
- Generic Object Oriented Substation Event
- Fast and reliable distribution of information
 - Status (breaker position, trip, pickup, alarms, etc.)
 - Analog (voltage, current, counter values, etc.)
- Performance
 - Fast messages Type 1A (Class P2/P3) received within 3ms.
 - This includes transmission time into the other IEDs (similar to an output to input connection between 2 relays)
- In P&C it represents a way to exchange status points similar to inputs and outputs

What is a GOOSE message?

- GOOSE messages are based on change event
- GOOSE messages include diagnostic functions (a “heart beat” to all devices subscribed is sent periodically)
- GOOSE messages are managed by GCBs (GOOSE control block) inside IEDs
- GOOSE messages send “Data Sets” upon changes of state



Data set
(information)



GCB



Network

What is a GOOSE message?

- GOOSE messages enable the connection of functions rather than inputs and outputs
- This principle results in more intuitive documentation of control diagrams
- Fast deployment and testing of changes

The screenshot displays the configuration for a Protection Function (PHPIOC1) in an IED. The interface is divided into several sections:

- Tree View (Left):** Shows the hierarchy of the IED, including Mod, Beh, Health, NamPlt, Op, and various data points like general, phsA, phsB, phsC, q, and t.
- Data Sets (Middle-Left):** Lists available data sets such as StatUrg, StatNmI, MeasFlt, StatUrg_B, raw_ID, cntrl_ID, trip_stat, resets, metered_data, and PROTEC.
- Data Set Entries (Middle-Right):** Shows the selected data set entries for LD0.PHPIOC1.Op.general, including phsA, phsB, phsC, q, and t.
- IED Data Model (Right):** Shows the selected IED (LD0.PHPIOC1) and its configuration, including the selected data set and the 'Func. Constraint' set to 'ST'.
- Inputs Table (Bottom-Left):** Lists the inputs for the selected IED, including various protection and control signals.
- Client IED Table (Bottom-Right):** Lists the client IEDs connected to the selected IED, including their identifiers and order numbers.

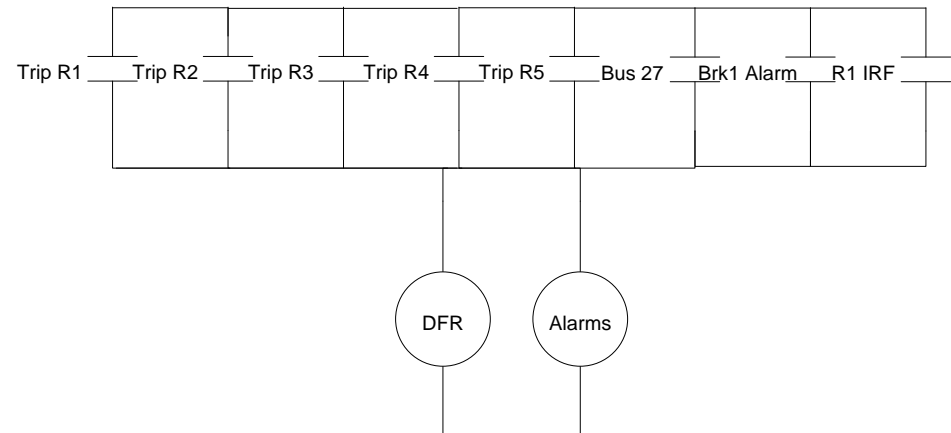
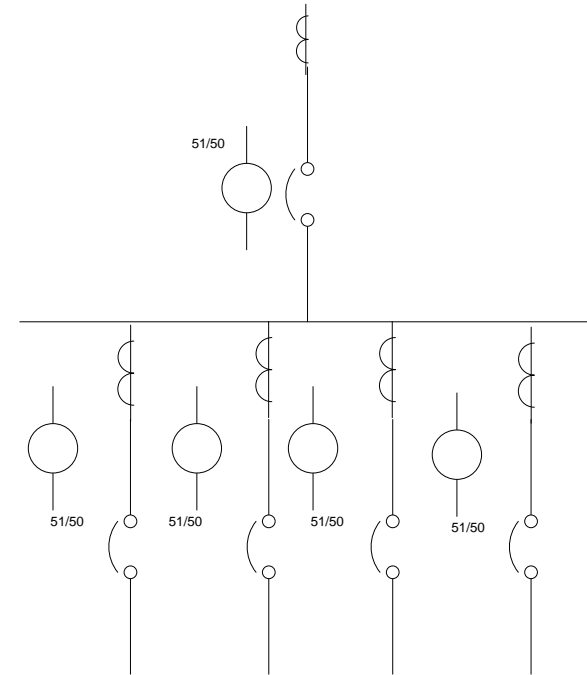
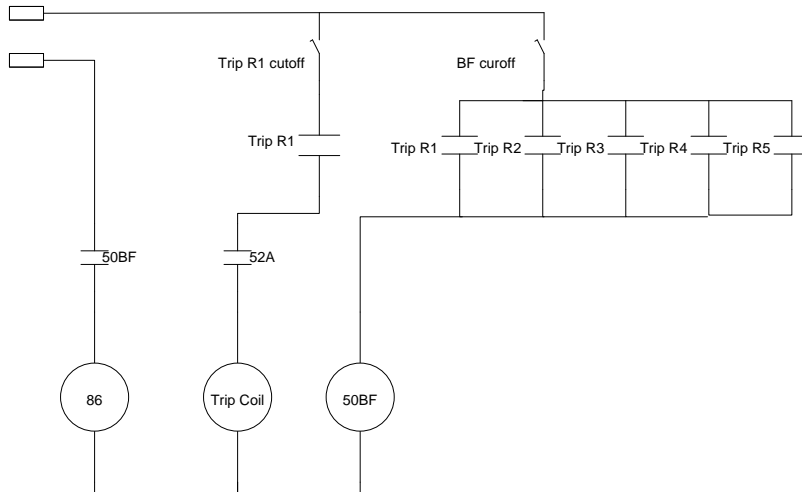
Descr.	DataSet	Name	Identifier.
POS	POS	POS	001

Client IED		Order
AA1D1Q01A2		0
AA1F1Q01A1		1
AA1F1Q01A2		2
AA1F1Q02A1		3

Applying GOOSE messages

Define an application

- Anything that requires the exchange of information within relays (done today via hardwired connections)
- Breaker Failure (**VERIFY DROPOUT REQUIREMENTS**)
- DFR
- Transfer Scheme
- Reclosing in multi breaker arrangements



Applying GOOSE messages

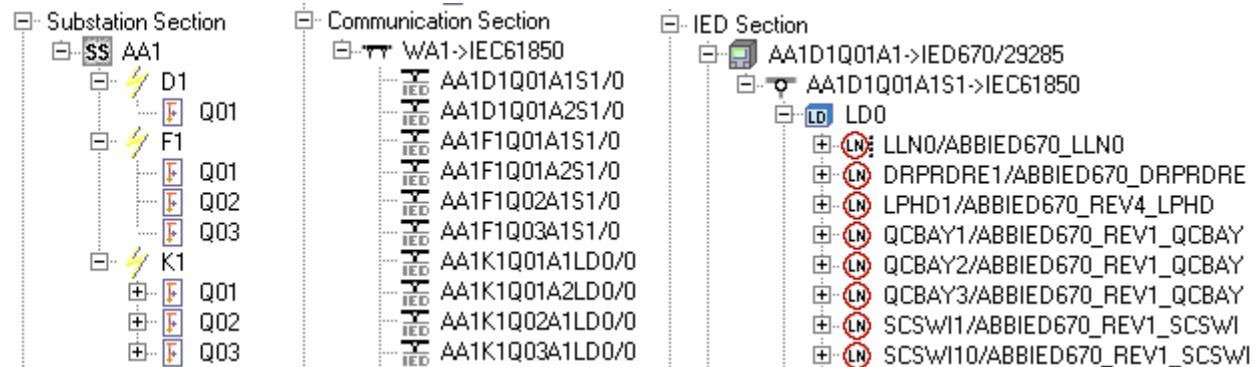
How about the network?

- Depending on the application of GOOSE messages the network infrastructure now becomes part of the P & C team
- Switches must comply to the same quality and performance standards as other electronic P & C equipment (Dielectric, SWC, RFI, etc).
- Redundancy (Parallel Redundancy Protocol) to ensure high availability and dependability of the system

Applying GOOSE messages

System tool approach

- Thanks to common file format engineering of the SAS system can be performed under a single tool
- This provides a single point of interaction with the configuration files of all devices regardless of manufacturer
- End result (SCD file) must be part of the final system documentation just like DC and AC elementary are

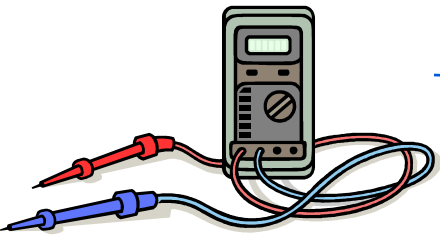


Applying GOOSE messages

Test and verification

- Digitizing copper requires new testing techniques and tools
- These tools are available now from different manufacturers
- Visualization of results are important
 - See that application works: GOOD
 - See and record network traffic: BETTER
- Network analyzers allow us to quickly diagnose and evaluate the status of the system

Applying GOOSE messages



ITT600 - Explore Ethernet

File View Tools Help

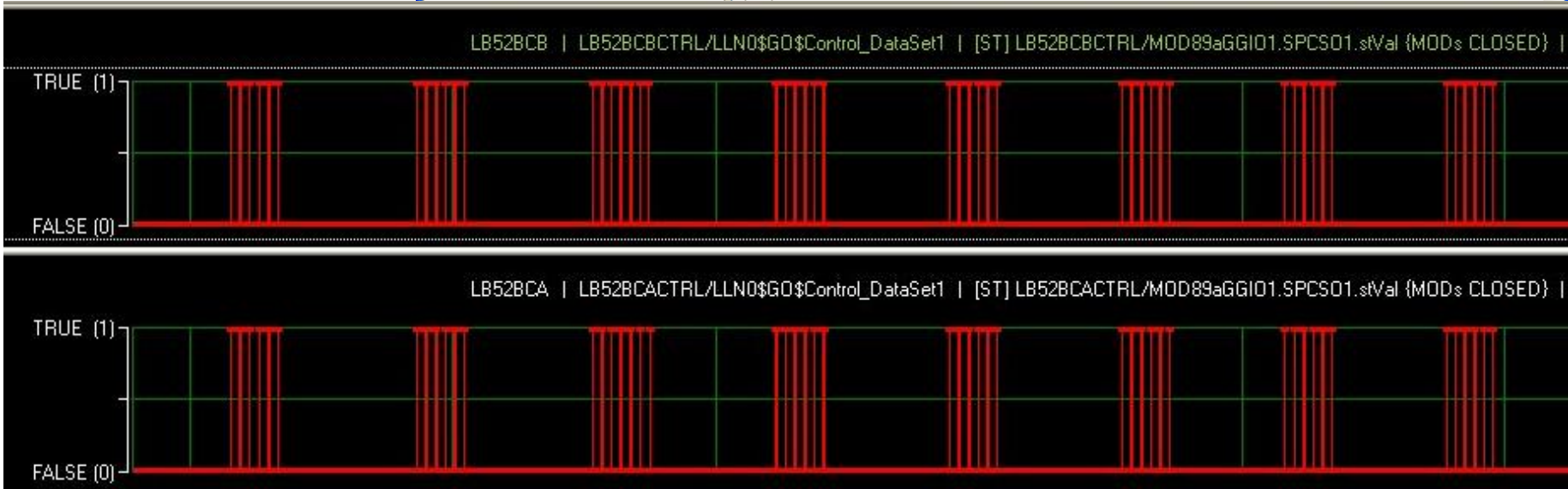
No.	SourceS	DestinationSer	RecTime	SourceIP	Destinat	SourceM	Destination	Dat	Applicati	Details	Transport
5	Not found	Not found	20.10.2008 2	0.0.0.0	0.0.0.0	00:0A:DC:	01:80:C2:00:	60	Spanning_	Spanning T	Ethernet
6	Not found	Not found	20.10.2008 2	0.0.0.0	0.0.0.0	00:80:82:7	01:0C:CD:01	184	GOOSE	GOOSE A	Ethernet
7	Not found	Not found	20.10.2008 2	0.0.0.0	0.0.0.0	00:80:82:7	01:0C:CD:01	184	GOOSE	GOOSE A	Ethernet
8	Not found	Not found	20.10.2008 2	0.0.0.0	0.0.0.0	00:0A:DC:	01:80:C2:00:	60	Spanning_	Spanning T	Ethernet
9	Not found	Not found	20.10.2008 2	192.168.1.13	192.168.1.1	00:80:82:7	00:1C:2F:18:	60	MMS	TCP Keep	TCP

GOOSE Frame Header

- APPID: 0x0001
- GoCBRef: REL670LD0/LLN0\$GO\$Pos
- TimeAllowedToLive: 1100
- DataSetRef: REL670LD0/LLN0\$Positions
- GoID: REL670LD0/LLN0\$GO\$Pos
- Timestamp: 11.10.2008 23:45:31.946
- StateChangeNumber: 32
- SequenceNumber: 35
- TestMode: False
- ConfigurationRevision: 2

General

- IsComplete: True
- messageCount: 1
- MessageDescript: GOOSE APPID: 0x0001



Applications for Smart Substation Design

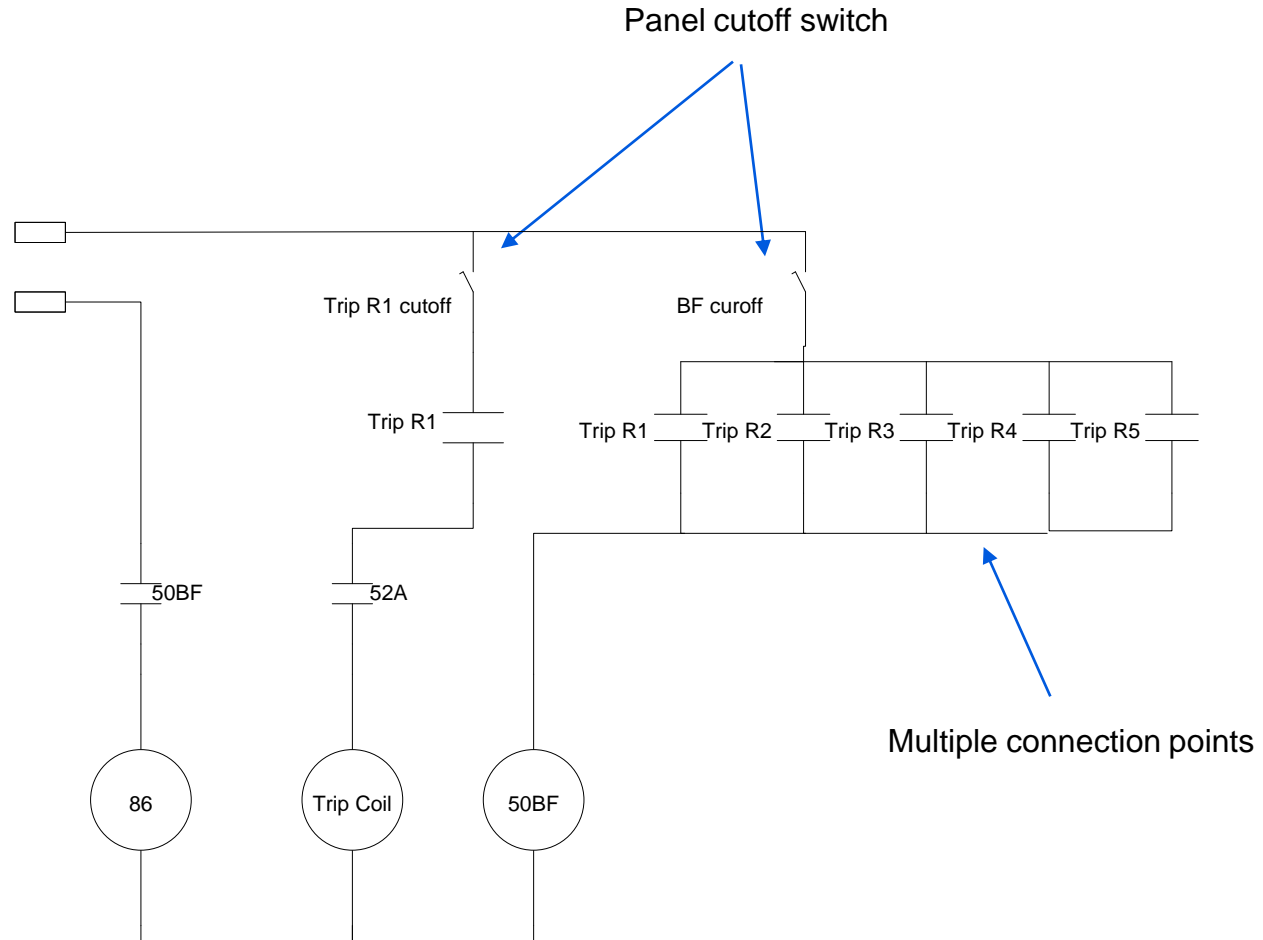
New substation design based on IEC61850 takes full advantage of microprocessor relay features saving/reducing:

- Panel Space
- Hard wired connection points
- Equipment
- Points of failure
- Testing
- Documentation

Sample applications:

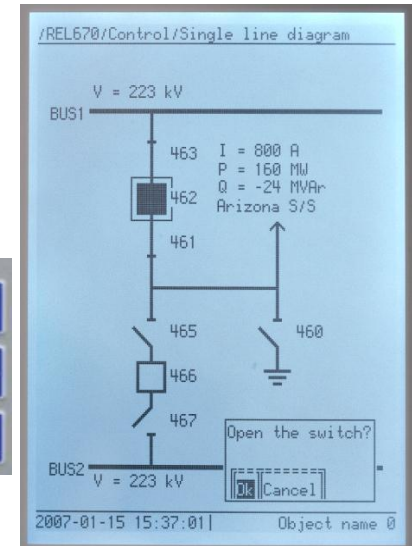
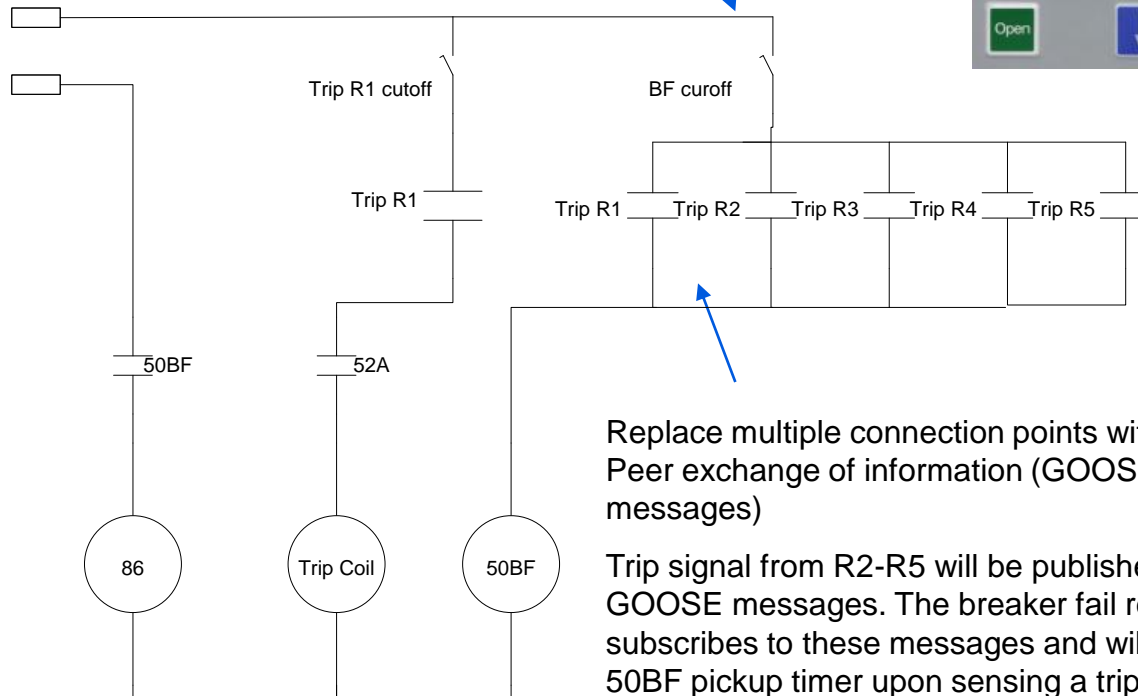
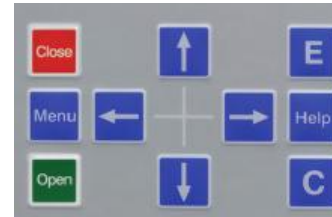
- Breaker failure
- Bus fault protection
- Alarms & Station DFR
- Transfer schemes
- Reclosing
- Sharing of status

Conventional Breaker Fail Scheme

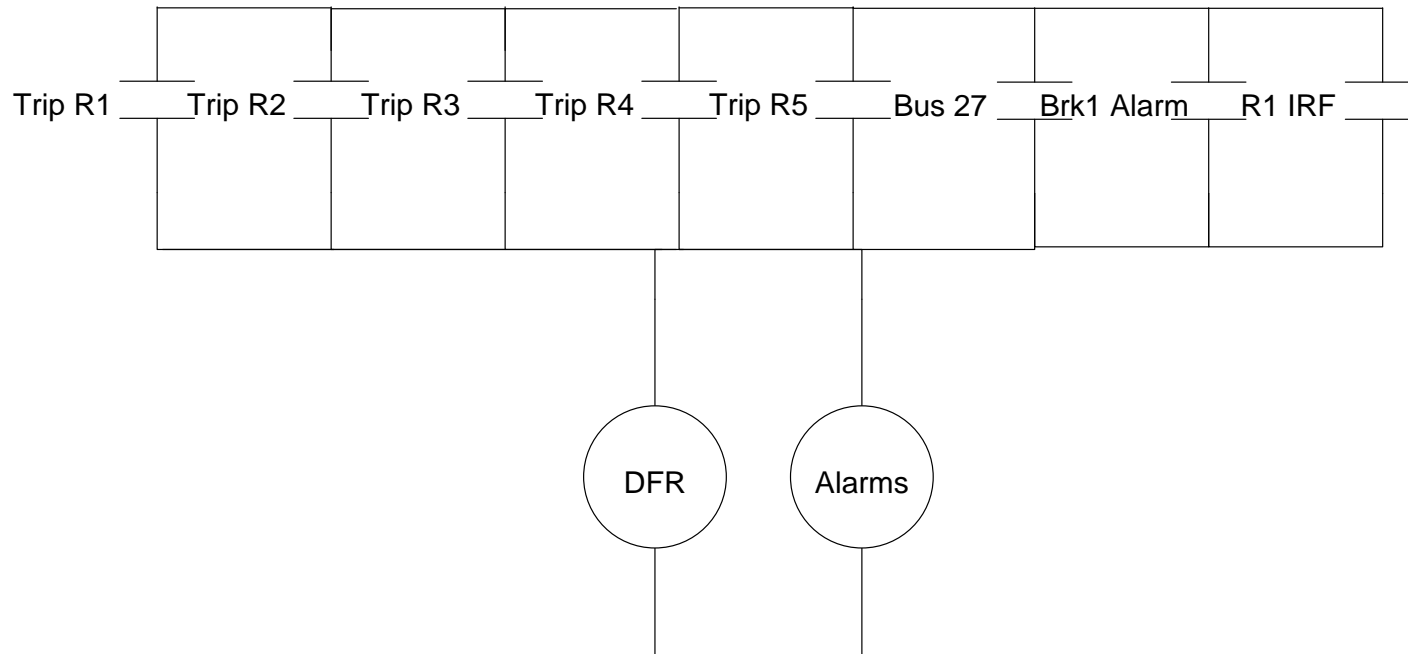


Smart Breaker Fail Scheme

Utilize Relay's HMI to enable/disable protection elements instead of hard wired switches



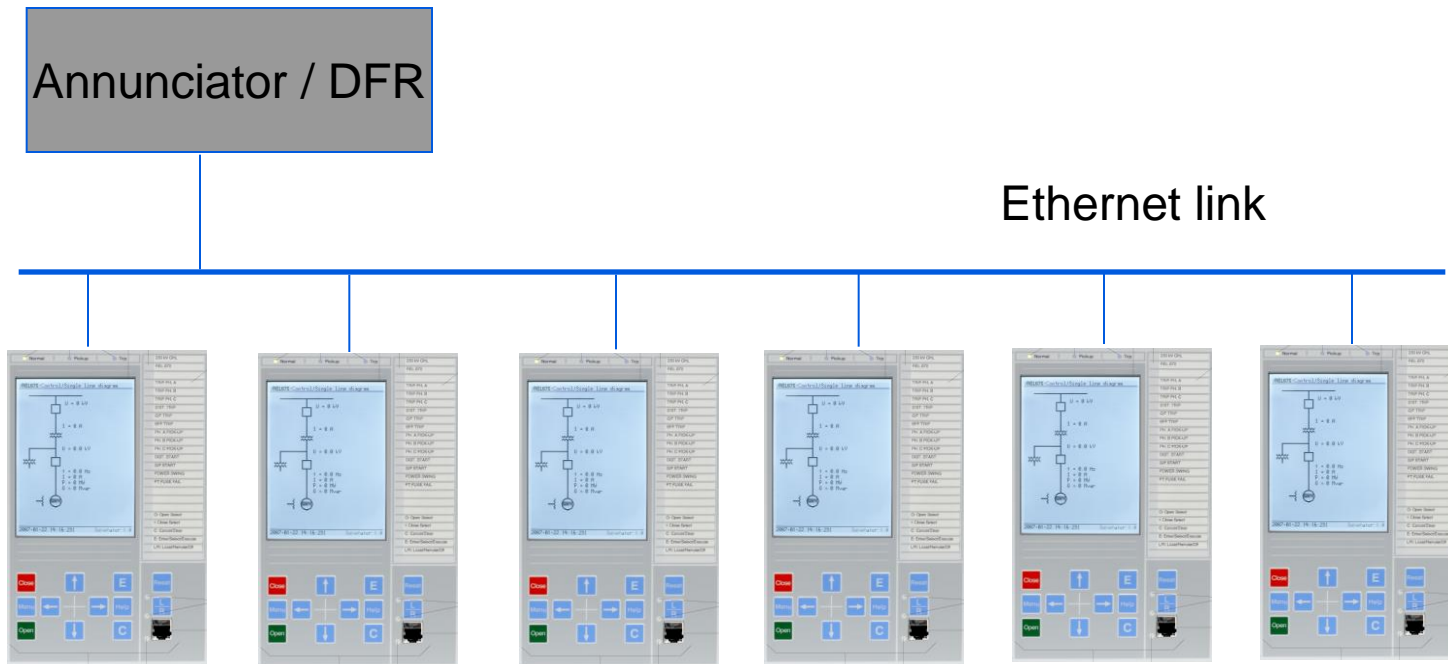
Conventional Alarms and Station DFR



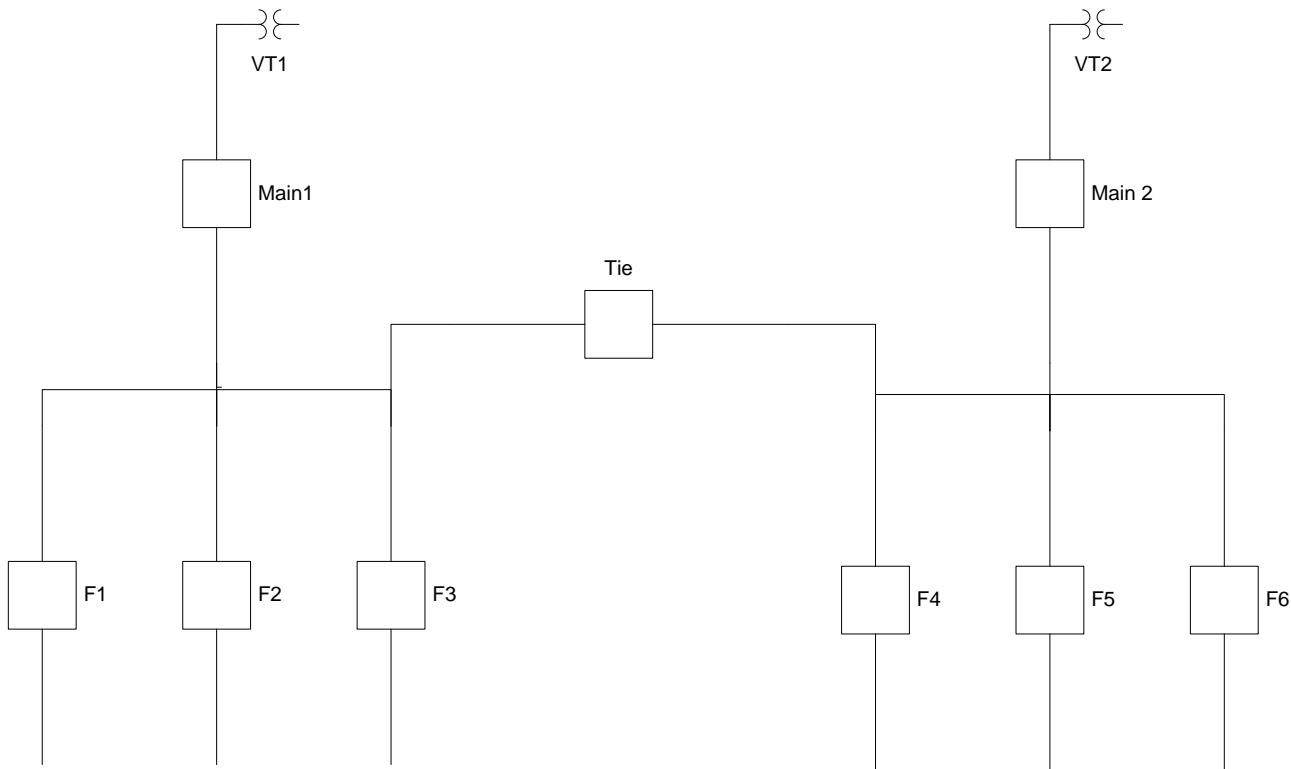
- Several connection points (costs)
- Often signals are combined to reduce amount of connections points resulting in lack of depth of information (e.g. Relay IRF)
- Rigorous documentation
- Changes require manual labor (connection points, relabeling of terminations, etc)

Smart Alarms and Station DFR

- Utilization of GOOSE messages instead of hard wired output contacts for:
 - Alarms
 - Trigger signal for DFR
 - Peer based IRF schemes

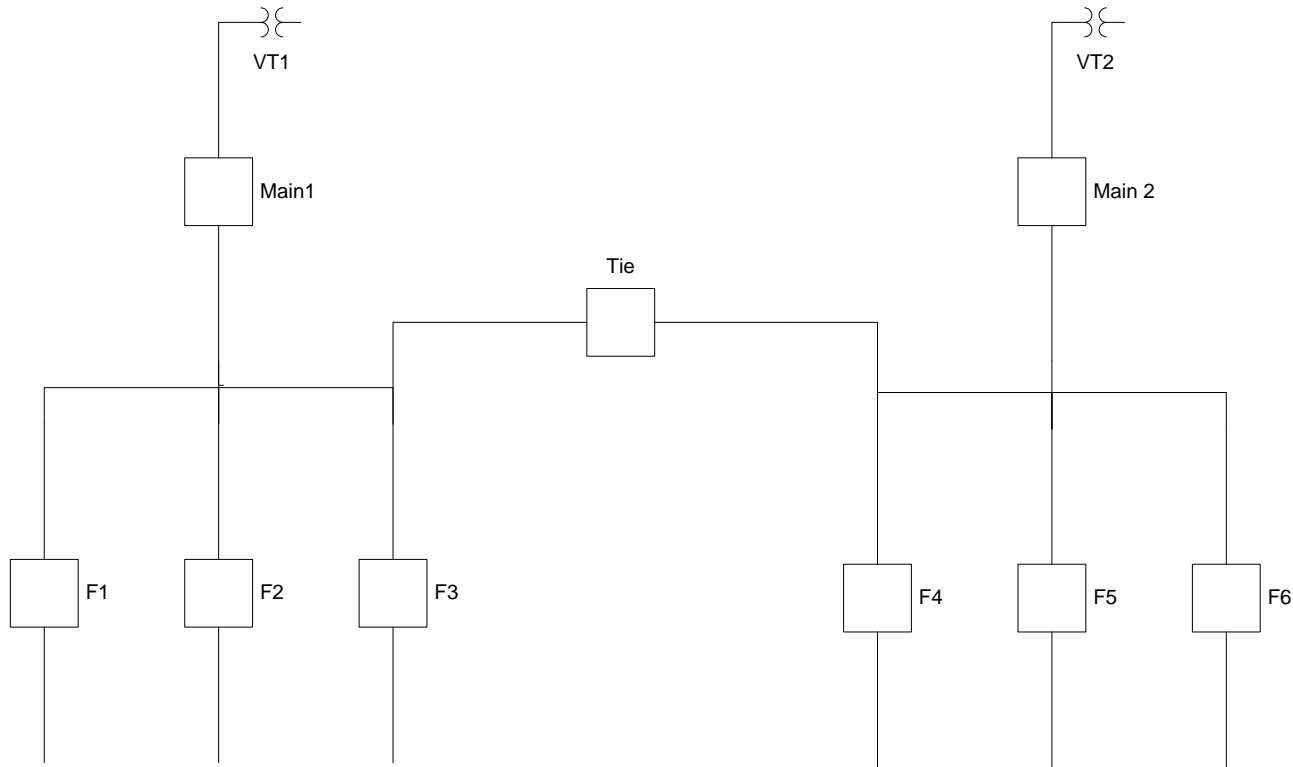


Conventional Transfer Scheme



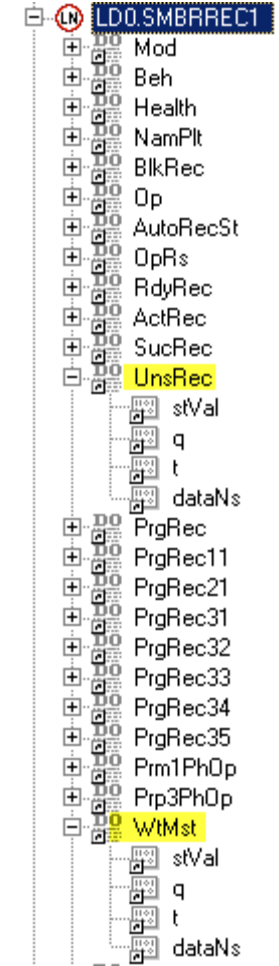
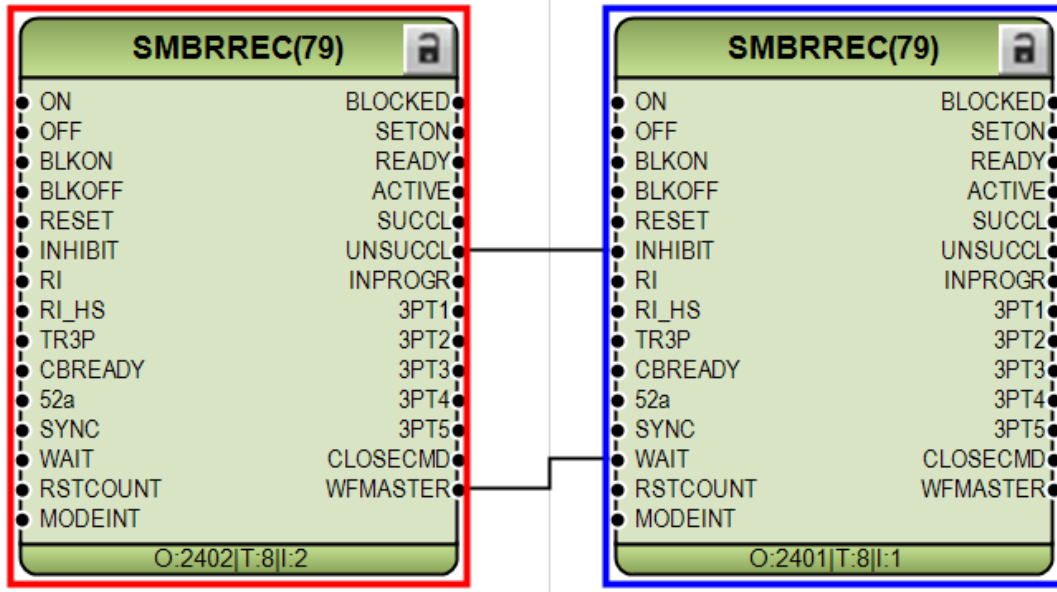
- 9 Relays needed for Feeder P&C
- 1 Transfer scheme relay
- Hardwired signals:
 - Main1 Pos
 - Main2 Pos
 - Tie Pos
 - VT1
 - VT2

Smart Transfer Scheme



- 9 Relays needed for Feeder P&C
- Tie relay executes transfer scheme logic
- Hardwired signals:
 - Tie Pos
 - VT1
 - VT2
- Signals via GOOSE:
 - Main1 Pos
 - Main2 Pos
- Advanced logic to determine load prior to transfer and determine if sources can handle combined load without equipment/apparatus failure

Reclosing in multi breaker arrangements



Relion® family products

- **670** - Optimized for transmission applications
- **650** - Optimized for transmission and subtransmission applications
- **620** - Optimized for High end distribution applications
- **615** - Standard series for distribution applications

Relion® family products

Family Highlights



- One common tool for all Relion® products, Protection and Control Manager PCM600
- Covers all applications, from interconnected transmission grids to secondary distribution networks
- The performance of Relion protection and control IEDs meet the comprehensive IEC 61850 communication tasks, for example, GOOSE messaging for peer-to-peer communication
- The Relion IEDs utilize ABB's unique connectivity package concept
- The Relion product family provides configured, pre-configured or fully customized IEDs

The value of implementing 61850

- Cost reduction
 - Reduction of copper hardwires wires
 - Eliminate terminations/terminal blocks
 - Reduce testing intervals due to self monitoring
 - Reduce documentation e.g. DC elementary
 - Faster integration
- Improved performance:
 - Faster than conventional binary inputs and outputs
 - Increased reliability due to repetitive messages

QUESTIONS?