



Comparison of Processes for Testing, Commissioning and Maintenance Methods - Digital Versus Conventional Substations

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Topics

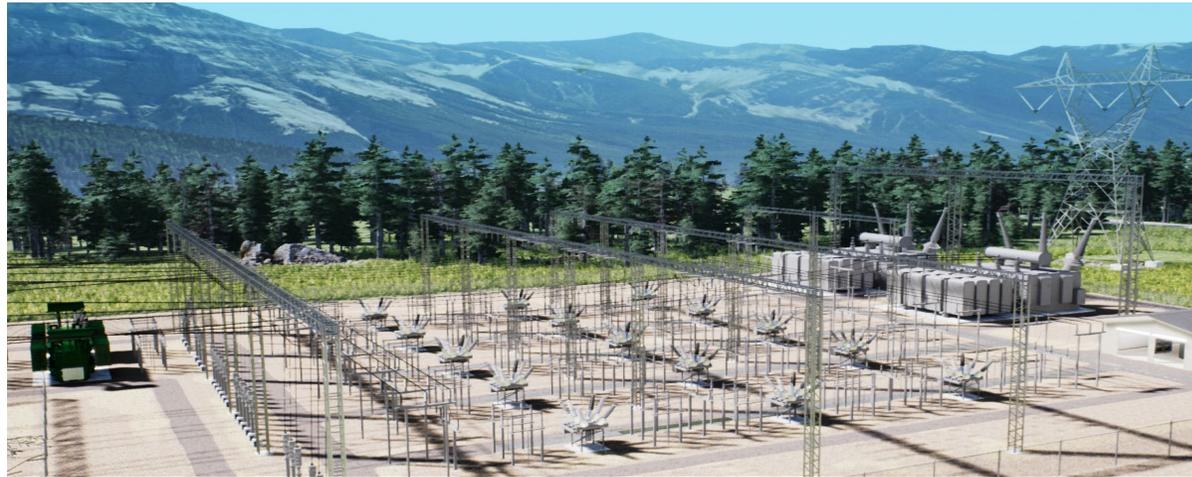
- Introduction
- Digital Substation Design and Documentation
- Configuration Testing / Verification
- Digital Substation System Testing / Verification
- Periodic / Maintenance Testing
- Troubleshooting Tools and Methods
- Conclusions

Introduction

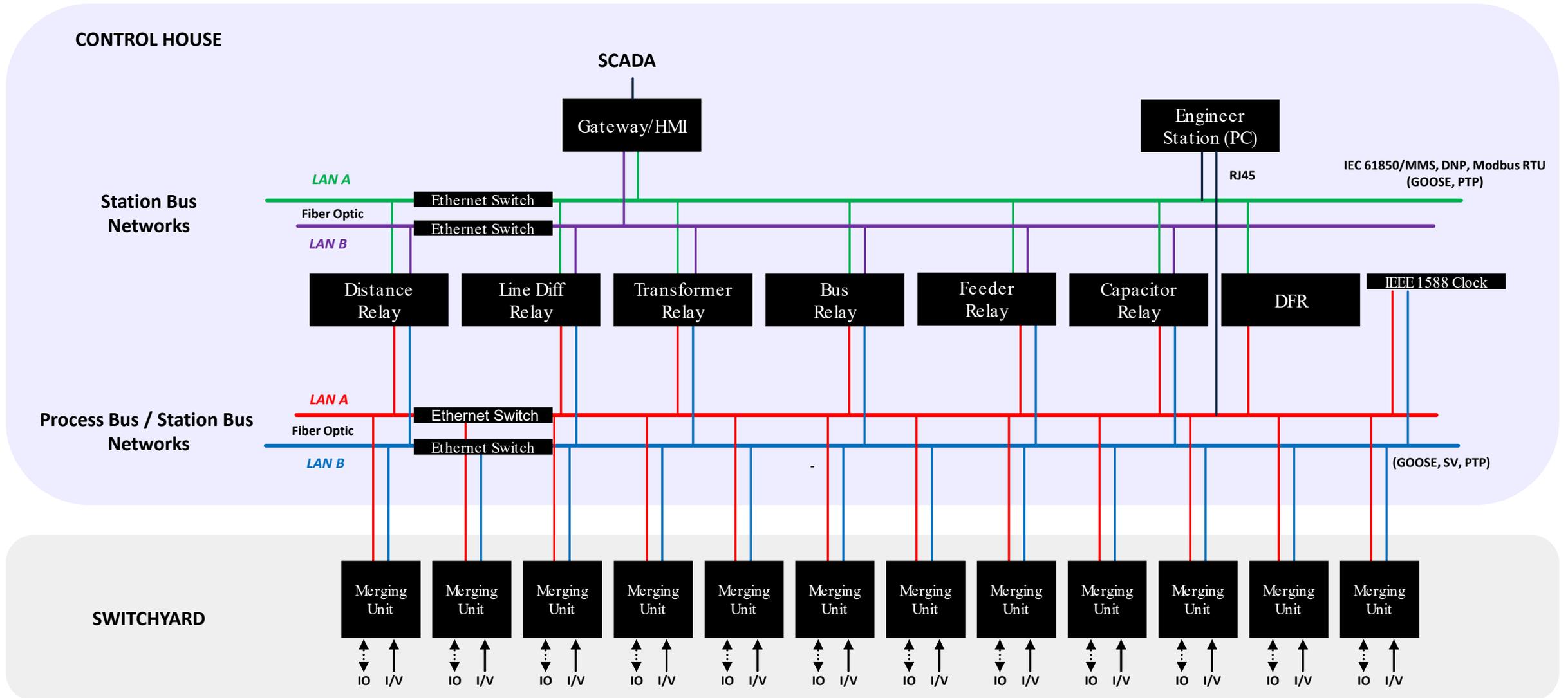
- Digital substation involve merging units (MUs) to connect to yard elements (CT, VT, 52, 89), digitizing the data, and communicating with relays/IEDs in control house over fiber optic Ethernet network
- The network providing this is called the *Process Bus*
 - Analog data (SV or sampled values), known as IEC 61850 9-2 LE for “light edition”, is published by MUs on the network
 - Published sampled values are synchronized by IEEE 1588 Precision Time Protocol (PTP) in the network
 - IEC 61850 9-2 LE profile for sampled values has a sampling rate of 80 samples/cycle
 - Dataset for IEC 61850 9-2 LE sampled values includes measurements for four currents (three phase and ground) and four voltages (three phase and auxiliary)
 - High-speed messaging (IEC 61850 GOOSE or Generic Object-Oriented Substation Event) is used for binary status and binary control on the network
- Inter-relay information used for interlocking, breaker failure, protection modification and other uses performed over *Station Bus* network
- The *Process Bus* and *Station Bus* can be separate Ethernet networks or same Ethernet network
- Redundant process bus / station bus Ethernet networks can be employed for high availability / reliability

Introduction

- Digital Substation benefits:
 - Elimination of wiring runs from yard elements to control house relay panels
 - Decrease in wire, terminations, trenching and conduit
 - Decrease in engineering and labor associated with wiring and relay panels
 - Large opportunity for *standardization* in design reducing engineering hours and construction time
 - Large opportunity for *standardization* in testing and for additional monitoring capabilities

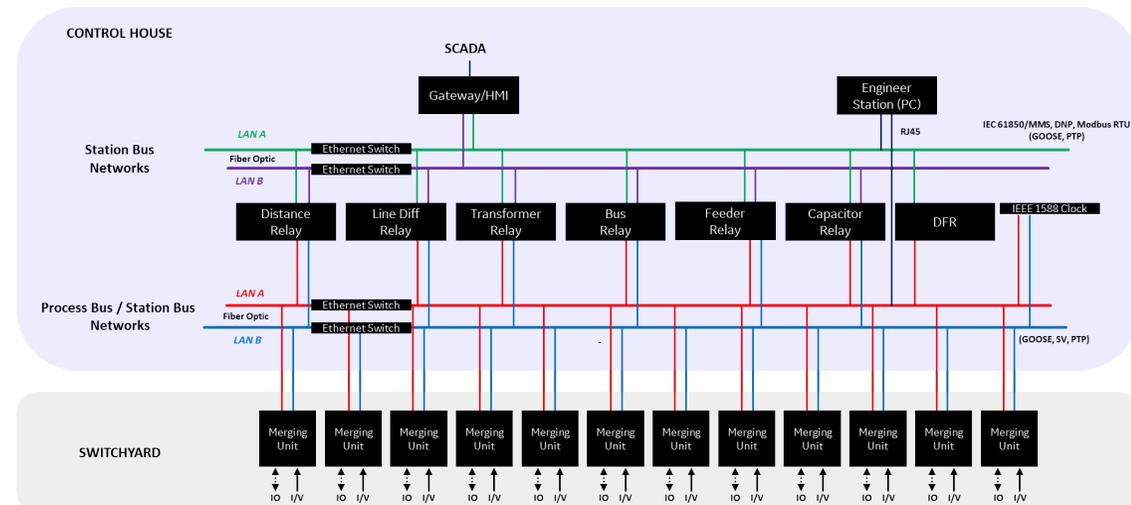
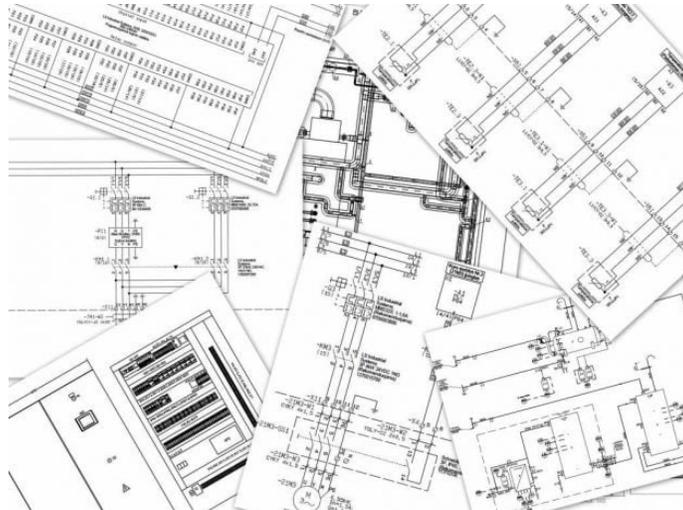


Digital Substation Ethernet Network Architecture with PRP



Digital Substation Design and Documentation

- Building blocks are MUs, Ethernet network switches and relay/IEDs
- Wiring of switchyard MU cabinets can be standardized and repeated for various installations (breaker, transformer)
- Wiring of substation control house relay/IED panels are reduced to DC control power and fiber optic Ethernet cabling
- Control house Ethernet network switches are “digital terminal blocks” for digital substation allowing IEC 61850 sampled values data and IEC 61850 GOOSE messages to be shared/distributed amongst switchyard MUs and control house relays/IEDs



Digital Substation Design and Documentation

- Publisher / subscriber table is useful and important in mapping IEC 61850 sampled values data and GOOSE messages amongst switchyard MUs and control house relays/IEDs
- These publisher / subscriber tables are similar to a conventional substation wiring table. Some utilities are placing publisher / subscriber information on their drawings.

VLAN CONFIGURATION PROCESS BUS				
VLAN	DESCRIPTION			
10	INTERNAL GOOSE INFORMATION FOR "A" PKG. PROT.			
14	V AND I SAMPLED FROM 115KV DEVICES			
LINE 6 P21A-LN6				
SMV IN	LOGICAL NODE / DO	PUBLISHER	VLAN	
R60 I Ph. A, B, C	TCTR.AmpSv	MUR60-1	14	
LN6 V Ph. A	TVTR.VolSv	MUR60-1	14	
WEST BUS V Ph. A, B, C, N	TVTR.VolSv	MUR60-1	14	
EAST BUS V Ph. A, B, C, N	TVTR.VolSv	MUR30-1	14	
GOOSE OUT	LOGICAL NODE / DO	SUBSCRIBER	VLAN	
R60 PROT. TRIP / INIT. BF	PTRC.Op	MUR60-1 BC6-1	10	
GOOSE IN	LOGICAL NODE / DO	PUBLISHER	VLAN	
LN6 V LOP	TVTR.FvFail	MUR60-1	10	
R60 STATUS 52a	XCBR.Pos	MUR60-1	10	
WEST BUS V LOP	TVTR.FvFail	MUR60-1	10	
EAST BUS V LOP	TVTR.FvFail	MUR30-1	10	
43RV-W EMER EAST BUS V - IN6	CSWI.LockKey	85A	10	

BAY 6 BC6-1				
SMV IN	LOGICAL NODE / DO	PUBLISHER	VLAN	
R60 I Ph. A, B, C	TCTR.AmpSv	MUR60-1	14	
LN6 V Ph. A	TVTR.VolSv	MUR60-1	14	
WEST BUS Ph. A, B, C, N	TVTR.VolSv	MUR60-1	14	
EAST BUS Ph. A, B, C, N	TVTR.VolSv	MUR30-1	14	
GOOSE OUT	LOGICAL NODE / DO	SUBSCRIBER	VLAN	
R60 EMS/MAN. CLOSE	CSWI.OpCls	MUR60-1	10	
R60 EMS/MAN. OPEN	CSWI.OpOpn	MUR60-1	10	
R60 RECLOSE	RREC.OpCls	MUR60-1	10	
R60 PROT. TRIP	RBRF.OpEx	MUR60-1	10	
R60 BF LO TRIP	RBRF.OpEx	MUR10-1 MUR30-1 85A	10	
R60 BF LO BLOCK	CIL0.EnaCls	BC1-1 BC3-1 85A	10	
GOOSE IN	LOGICAL NODE / DO	PUBLISHER	VLAN	
R60 LOW GAS PRESS. EMS ALARM	SIMG.InsAlm	MUR60-1	10	
R60 LOW GAS PRESS. TRIP	SIMG.InsTr	MUR60-1	10	
R60 LOW GAS PRESS. BLOCK	SIMG.InsBlk	MUR60-1	10	
R60 HEALTHY	XCBR.EEHealth	MUR60-1	10	
LN6 V LOP	TVTR.FvFail	MUR60-1	10	
R60 PROT. TRIP / INIT. BF	PTRC.Op	P21A-LN6	10	
WEST BUS V LOP	TVTR.FvFail	MUR60-1	10	
EAST BUS V LOP	TVTR.FvFail	MUR30-1	10	
R60 STATUS 52a	XCBR.Pos	MUR60-1	10	
R60 STATUS 52b	XCBR.Pos	MUR60-1	10	
R60 BLOCK CLOSE CONFIRM	XCBR.BlkCls	MUR60-1	10	
5/BUS & TB PROT. BLOCK R60 - IN2	CIL0.EnaCls	85A	10	

- Configuration/setting templates for MUs and relays/IEDs can be created **standardized** for a digital substation
- GOOSE IDs (or GO IDs) and sampled values IDs (or SV IDs) used by MUs and relays/IEDs will change in standard configuration templates based on publisher / subscriber table for particular digital substation design

Configuration Testing / Verification

- Many electric utilities have protection and control (P&C) labs to test and validate new P&C schemes with their associated settings/configuration before schemes are implemented into field/substation
- Digital substations can be considered as new P&C scheme and treated similar to conventional P&C scheme with regards to benefits of lab testing or factory acceptance testing (FAT)
- Results of lab/FAT testing for a particular digital substation P&C scheme are:
 - Verification of configuration template(s) for MU cabinet(s)
 - Verification of various relay/IED protection setting configuration templates
 - Verification of protection and control logic within and amongst the various relays/IEDs and MUs
 - Verification of publisher and subscriber configuration of SV datasets and GOOSE messages of relay/IEDs and MUs
 - Verification of Ethernet network switch configurations (such as VLANs and MAC address filtering)
- Use IEC 61850 testing tools during lab testing to aid in validation of SV datasets, GOOSE messages and communication links of digital substation P&C scheme



Digital Substation Merging Unit – Factory Acceptance Tests

- MU cabinet should be factory installed by substation equipment manufacturer
- Load generic/standard configuration into MUs (IOs, SV datasets and GOOSE messages) for particular MU cabinet wiring design
- MU cabinet testing/verification should be performed by MU cabinet manufacturer
- *FAT will verify wiring to merging unit is correct and generic/standard configuration of merging unit is correct for particular P&C scheme for which MU will be implemented*
- Current/voltage/IO interface testing of merging unit is similar to testing conventional digital relay by injecting currents & voltages using standard relay testing tools to verify current / voltage analog measurements and digital inputs / outputs operation
- Use MU's interface software to verify current / voltage measurements and states of digital inputs and outputs being tested or use IEC 61850 testing tool to read the information



Digital Substation Merging Unit – Site Acceptance Tests

- Load specific configuration (IOs, SV datasets, GOOSE messages and current/voltage settings) of each MU for particular P&C scheme at site during commissioning / site acceptance tests (SAT)
- ***SAT of each MU will verify specific configuration of IOs, CT settings, PT settings, phase rotation, SV dataset(s) configuration and GOOSE messages configuration***
- Use MU's interface software to:
 - Monitor status of GOOSE inputs subscribed by MU and on-line/off-line GOOSE subscriber status
 - Verify current & voltage measurements and verify states of digital inputs & outputs being tested
- IEC 61850 testing tools
 - Can be used to confirm configuration of SV dataset(s) and GOOSE messages of each MU during commissioning / site acceptance tests (SAT) and as needed during maintenance/troubleshooting
 - Can be configured to subscribe to SV/GOOSE data published by MU and publish GOOSE messages to MU
 - Benefit from information contained in SCL file to automate creation of test cases and minimize manual configuration by user
 - Can be used to read MU data (GOOSE states, measurements/SV data, GOOSE subscription status)



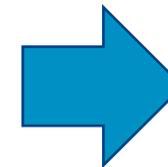
Digital Substation Protective Relay/IED Panel – Factory Acceptance Tests

- Substation control house relay/IED panels wiring reduced to DC control power and fiber optic Ethernet network communications (station bus & process bus) for each relay/IED
- *Panel assembly FAT tests reduced to power up test and verification of self -test alarm contact for each relay/IED prior to shipping assembled panel*
- Factory acceptance testing of each relay/IED generic P&C configuration should be done in lab described previously
- Not required to have settings loaded in relay/IEDs for panel assembly tests to be performed
- Assume only IO on relay/IED is self-test alarm contact and all IO come from switchyard connected MUs

Traditionally wired relay panel



Digital substation relay panel



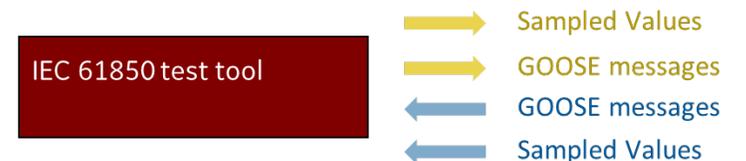
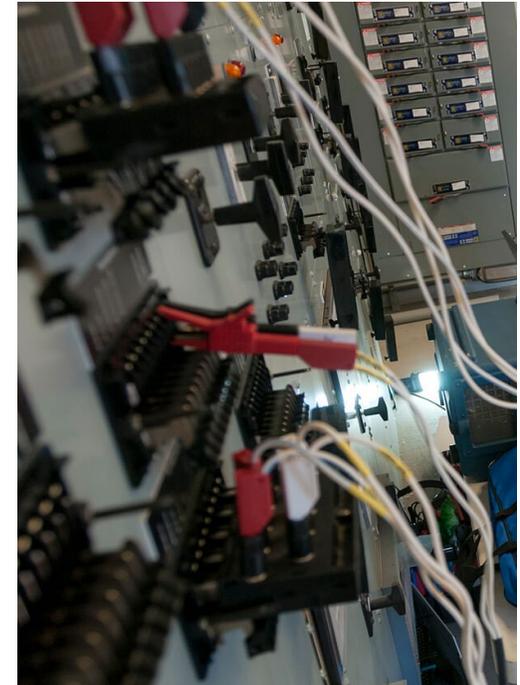
Digital Substation Protective Relay/IED Panel – Site Acceptance Tests

- Load specific configuration (P&C elements, SV datasets and GOOSE messages) to each relay/IED for particular digital substation P&C scheme at site during commissioning / SAT
- ***SAT of each relay/IED will verify specific configuration of CT settings, PT settings, phase rotation, SV dataset(s) configuration and GOOSE messages configuration***
- Use relay/IED's interface software to:
 - Monitor status of GOOSE inputs subscribed by relay/IED and on-line/off-line GOOSE subscriber status
 - Verify current and voltage measurements simulated by IEC 61850 testing tools or directly from various connected switchyard MUs
- IEC 61850 testing tools
 - Can be used to validate SV/GOOSE mappings of relay/IED when IEC 61850 tool is configured to simulate SV/GOOSE data being subscribed by relay/IED and when IEC 61850 tool is configured to subscribe to messages being published by relay/IED
 - Benefit from information contained in SCL file to automate creation of test cases and minimize manual configuration by user
 - Can be used to read relay/IED data (GOOSE states, measurements/SV data, SV/GOOSE subscription status)



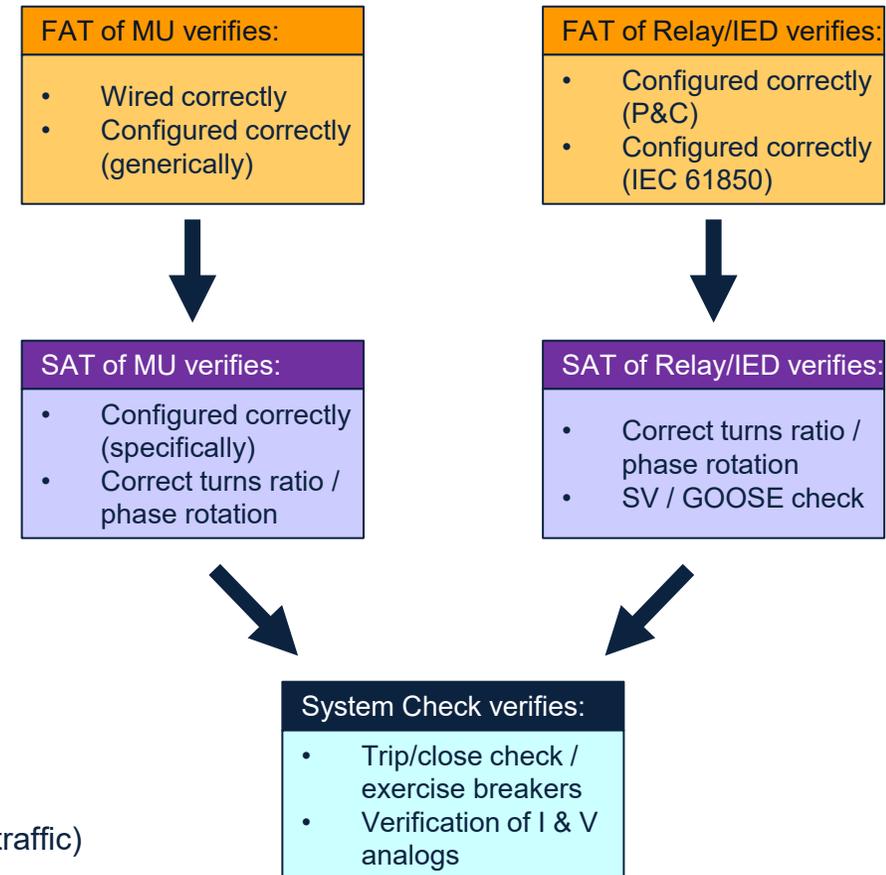
Digital Substation System Testing / Verification

- Commission testing of substation verifies:
 - Protection system is installed correctly
 - All devices are operating correctly
 - Devices are configured correctly for application
- Commissioning a digital substation is more *efficient* than commissioning a conventional substation because testing can be done in parts or modules and IEC 61850 tools are available
 - MU cabinets and relay/IED panels can be commissioned separately
 - Most of testing is already done as part of lab testing or factory acceptance tests (FAT)
 - Lab and factory acceptance tests proved the particular digital substation protection and control scheme and have individually tested main components of digital substation such as MU cabinets and relay/IED panels
 - IEC 61850 testing tool can be configured to read MU or relay/IED data (GOOSE states, measurements/SV data, GOOSE/SV subscription status) and simulate SV/GOOSE data of MU and/or relay/IED on process bus / station bus Ethernet network



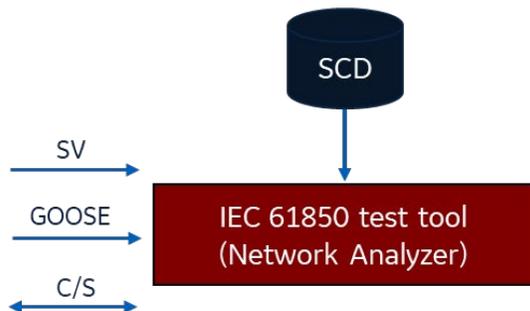
Digital Substation System Testing / Verification Commissioning Process

- **Factory acceptance tests (FAT) of each MU verifies:**
 - Wiring to merging unit is correct
 - Generic/standard configuration (IOs, SV datasets, GOOSE messages) is correct
- **Factory acceptance tests (FAT) of each relay/IED verifies**
 - P&C scheme (all protection element settings, logic)
 - SV dataset(s) configuration and GOOSE messages configurations
- **Site acceptance tests (SAT) of each installed MU verifies:**
 - Specific configuration of IOs, CT settings, PT settings, phase rotation, SV dataset(s)
 - GOOSE messages configuration
- **Site acceptance tests (SAT) of each installed relay/IED verifies:**
 - Specific configuration of CT settings, PT settings, phase rotation, SV dataset(s)
 - GOOSE messages configuration
 - Subscribing to correct SV datasets and correct GOOSE messages
 - Subscribed SV datasets and subscribed GOOSE publishers are in
 - SV / GOOSE checks performed using IEC 61850 testing tools (analysis of SCD file and network traffic)
- **Final system checkouts**
 - Exercise switchyard breakers by performing trip and close check using HMI of each control house relay/IED- verifies particular relay/IED operates correct breaker(s)
 - Verify particular relay/IED has correct SV analog data from each switchyard MU using IEC 61850 testing tool or by injecting currents and voltages at MU using relay test set

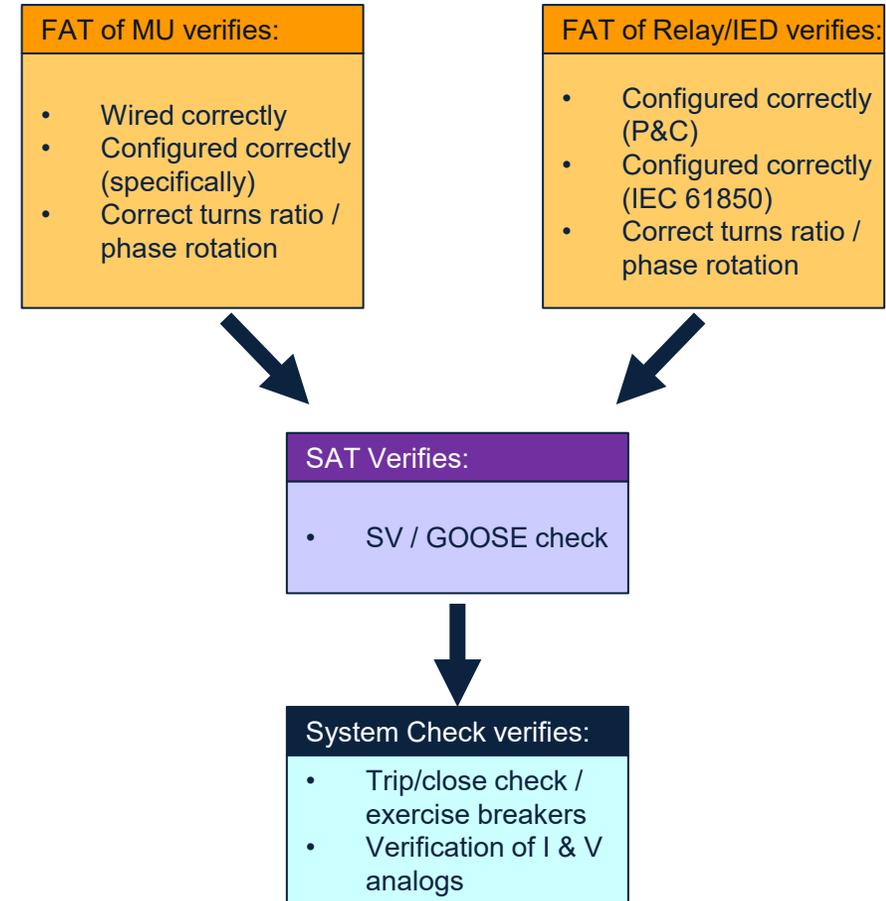


Digital Substation System Testing / Verification

- Using specific project MU configurations (if available) and specific project relay/IED configurations (if available) during factory acceptance tests (FAT) is best and ~~reduce~~ site acceptance tests
- Specific project settings/configuration of MUs and relay/IEDs, and specific communication (SV and GOOSE) mappings could be tested at FAT
- This would reduce on-site work to:
 - Fiber optic Ethernet cabling to primary equipment
 - SV/ GOOSE checks performed using IEC 61850 testing tools (analysis of SCD file and network traffic)
 - Final system checks



IED	Server	GOOSE & SV	Result
CNEWHAR1	✓	✓	✓
AA1D1Q02FN1	✓	⚠	⚠
R841BUP	✓	✓	✓
AA1D1Q02KF2	✓	✓	✓
R546FFPM	✓	✓	✓
AA1D1Q02KF3	✓	-	✓
AA1D1Q02FN2	✓	✓	✓
AA1D1Q02KF1	✓	⚠	⚠
RREDFPSM	✓	✓	✓
GTWM	⚠	-	⚠
OISERVN	✓	-	✓
MER1UNIT320	-	⚠	⚠
MERUNIT320	-	✓	✓



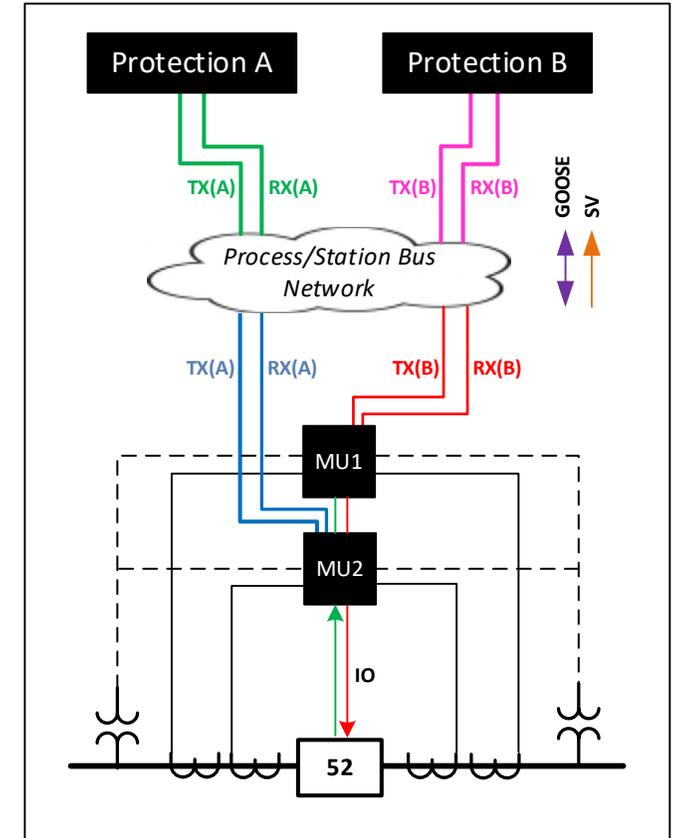
Periodic / Maintenance Testing

- Maintenance or inservice testing of P&C system proves devices are still operating with defined performance parameters or when changes to device configuration or protection element settings are made
- *For a digital substation, only MUs may require regular maintenance testing*
- Relay/IEDs are fully digital device with complete self-monitoring and do not require maintenance / periodic testing. Only require maintenance testing if protection or control element settings are altered due to changing system conditions.
- Periodic testing of digital substation verifies:
 - Settings in relays/IEDs have not changed
 - Settings in MUs have not changed
 - Digital I/O of MUs are operational
 - Analog measurements of MUs are within specifications
 - SV dataset(s) and GOOSE messages configuration have not changed using IEC 61850 testing tool
 - SV and GOOSE communication links have not changed using IEC 61850 testing tool



In-Service Maintenance Testing

- Most digital substations will have redundant relay/IEDs and redundant MUs used for protection and control of a particular transformer, transmission line, capacitor bank or bus
- With redundant protection and control schemes, one of the P&C systems (relay/IED and associated MU) could be put into various IEC 61850 test modes for in-service maintenance testing
- *Caution should be taken to isolate relay/IED or MU under test to avoid any accidental breaker trip or undesired exchange of IEC 61850 messages between IEDs due to the testing*



In-Service Maintenance Testing

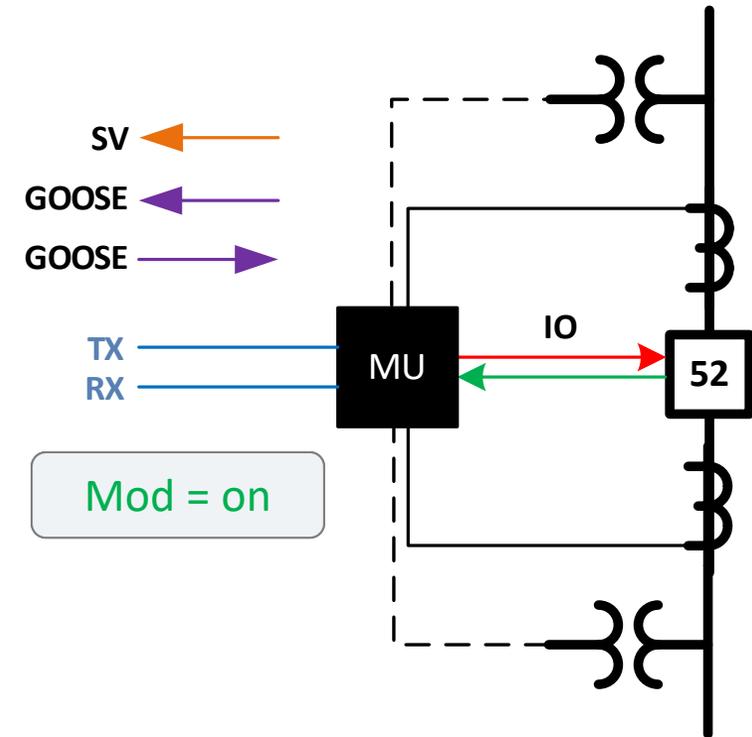
- Edition 2 of IEC 61850 has two features available to accomplish isolation during testing
- **Capability to put a device/IED in test mode using IEC 61850 data object mode (Mod) (such as LLN0.Mod)**
 - IED manufacturers usually have simple implementation to set entire IED in test mode, such as ON, TEST-BLOCKED and TEST
 - Important - quality of data items of GOOSE message is configured in device for IEC 61850 data object mode (Mod) to function properly
 - **ON** mode: Normal in-service operation. P&C functionality and I/O functionality of device are normal.
 - **TESTBLOCKED** mode: All IEC 61850 data published by device will be test data and will be processed but not used by in-service devices in ON mode. All physical contact outputs of device are blocked. Test bit of quality attribute of values sent via IEC 61850 services (SV and GOOSE) will be set to TRUE.
 - **TEST** mode: All IEC 61850 data published by device will be test data and will be processed but not used by in-service devices in ON mode. Test bit of quality attribute of values sent via IEC 61850 services (SV and GOOSE) will be set to TRUE.
- **Capability to use simulation flag (LPHD.Sim) in subscribing device for IEC 61850 GOOSE & sampled values**
 - LPHD.Sim serves as switch between messages coming from real IEC 61850 devices and simulated IEC 61850 messages coming from relay test sets or IEC 61850 testing tools
 - When device is in SIMULATION mode, received GOOSE messages and/or received SV data with "simulation" flag/bit set are used in place of normal messages in subscribing device

SETTING	PARAMETER
TT6DataSet03 name	TT6DataSet3
TT6DataSet03 shared by	
TT6DataSet03 Member1	Master.GGIO1.ST.Ind001.stVal
TT6DataSet03 Member2	Master.GGIO1.ST.Ind001.q
TT6DataSet03 Member3	Master.GGIO1.ST.Ind002.stVal
TT6DataSet03 Member4	Master.GGIO1.ST.Ind002.q
TT6DataSet03 Member5	Master.GGIO1.ST.Ind003.stVal
TT6DataSet03 Member6	Master.GGIO1.ST.Ind003.q
TT6DataSet03 Member7	Master.GGIO1.ST.Ind004.stVal
TT6DataSet03 Member8	Master.GGIO1.ST.Ind004.q
TT6DataSet03 Member9	Master.GGIO1.ST.Ind005.stVal
TT6DataSet03 Member10	Master.GGIO1.ST.Ind005.q
TT6DataSet03 Member11	Master.GGIO1.ST.Ind006.stVal
TT6DataSet03 Member12	Master.GGIO1.ST.Ind006.q

MU In-Service Maintenance Test

The steps for testing are:

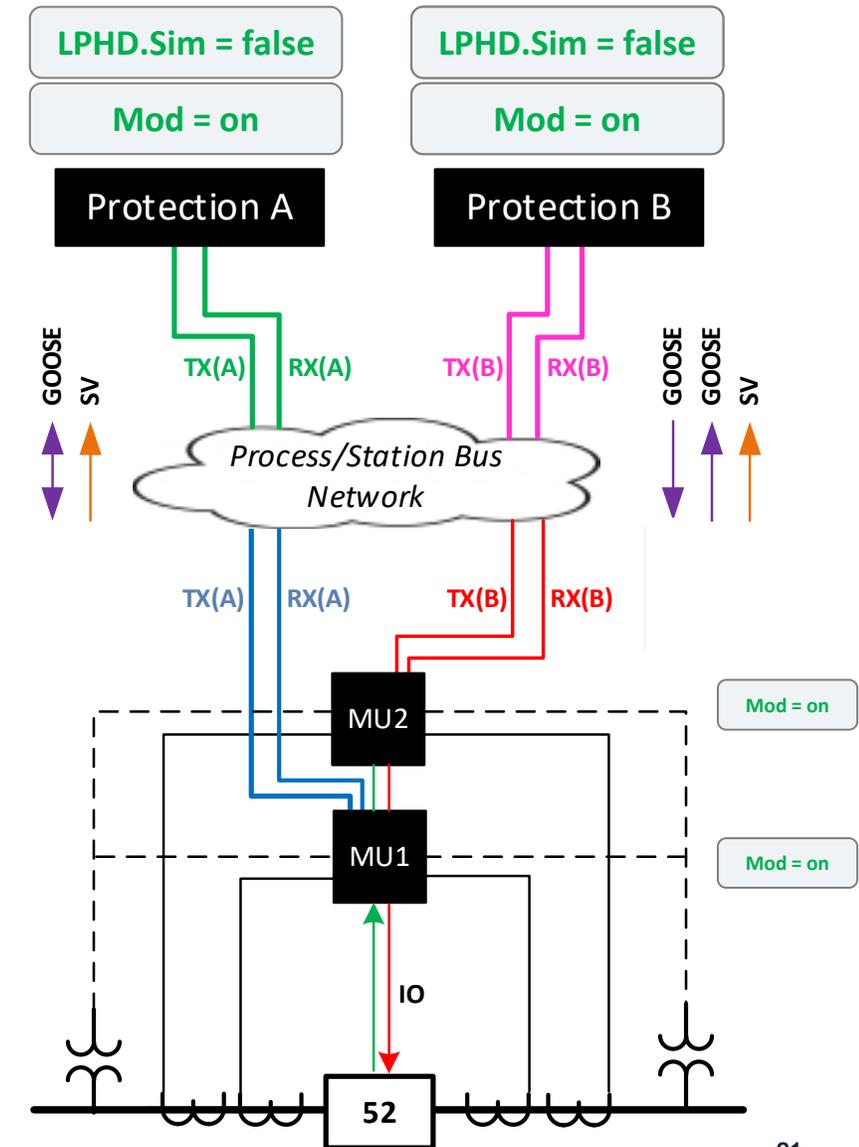
1. Place MU into **TEST** mode. All IEC 61850 data published (SV data and GOOSE messages) by MU will be test data and will be processed but not used by in-service devices in ON mode.
2. Perform contact I/O and I/V analog injection using relay test set and associated MU test switches to verify digital I/O of MU are operational and analog measurements of MUs are within specifications
 - Caution should be taken to isolate MU I/O under test to avoid any accidental breaker operation
 - Use IEC 61850 testing tools to verify configuration of IEC 61850 SV dataset(s) and GOOSE messages of MU
 - MU could be left connected to process bus/station bus Ethernet network, since MU is in IEC 61850 TEST mode, for IEC 61850 SV dataset(s) and GOOSE messages verifications by IEC 61850 testing tools
3. After testing is complete, place MU into **ON** mode for normal in-service operation and re-connect to equipment using associated MU test switches



Relay/IED In-Service Maintenance Test

The steps for testing are:

1. Place relay/IED to be tested into **TEST** mode. All IEC 61850 data published (GOOSE messages) by relay/IED in TEST mode will be test data and will be processed but not used by in-service devices in ON mode.
2. Place relay/IED under test into **SIMULATION** mode so it will accept simulated SV and simulated GOOSE messages. Relay/IED in SIMULATION mode will use live process data for every subscribed SV dataset and subscribed GOOSE message until it receives simulated SV or GOOSE data (a message where simulation bit is TRUE) for a specific message. Then for this message only, device will only accept simulated data.
3. Testing is performed by having the IEC 61850 testing tool simulate fault events, publishing simulated SV and simulated GOOSE messages, and verifying protection element settings of relay/IED under test
4. Once the testing is complete, place the device into normal operation:
 - Relay/IED under test is taken out of SIMULATION mode to only use live received GOOSE messages and live received SV data
 - Relay/IED under test is returned to normal in-service operation by placing to **ON** mode



Relay/IED In-Service Maintenance Test – Detailed IEC 61850 Test Process

Set relay/IED

- Mode = test
- LPHD.Sim = true

Configure Sampled Values in IEC 61850 test tool

- Voltages and currents published as Sampled Values
- Simulation flag = true

Configure GOOSE messages in IEC 61850 test tool

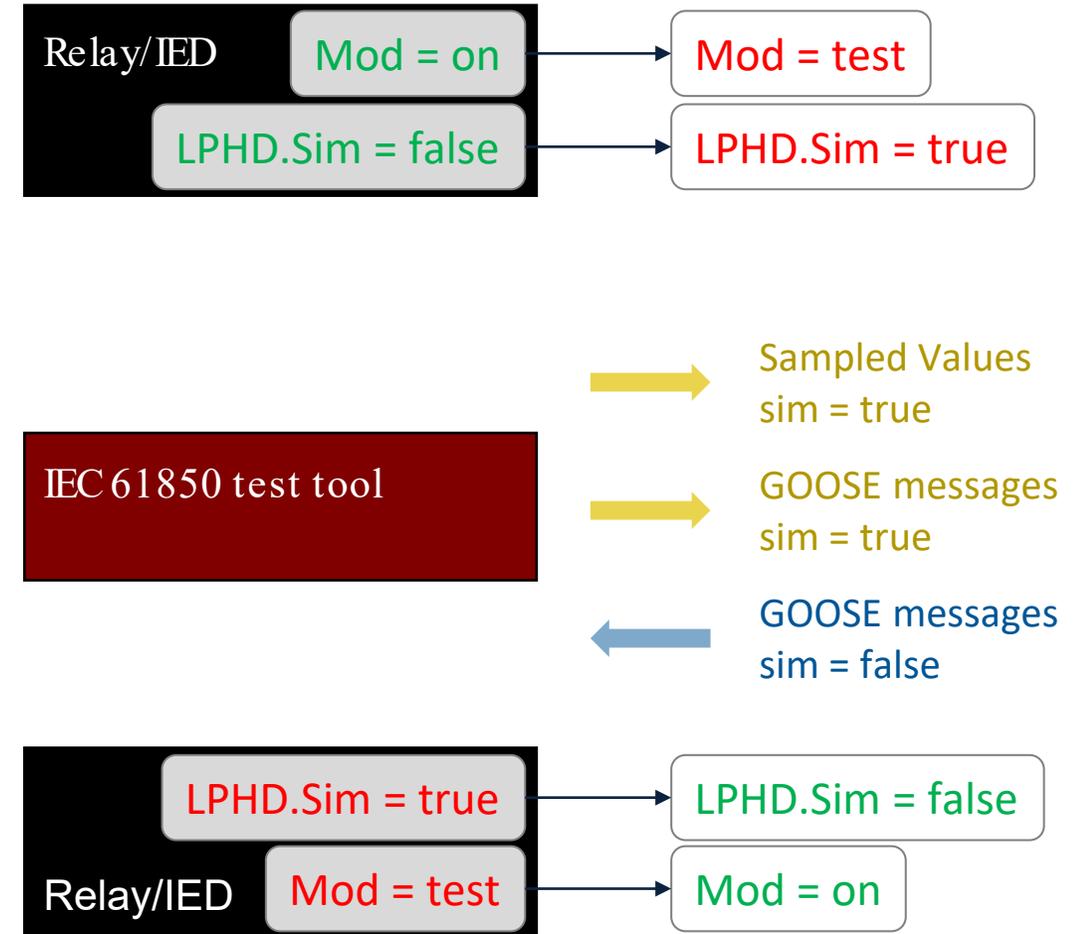
- Publish GOOSE messages to send information to relay/IED under test
- Simulation flag = true
- Subscribe to GOOSE messages from relay/IED under test

Perform testing as usual

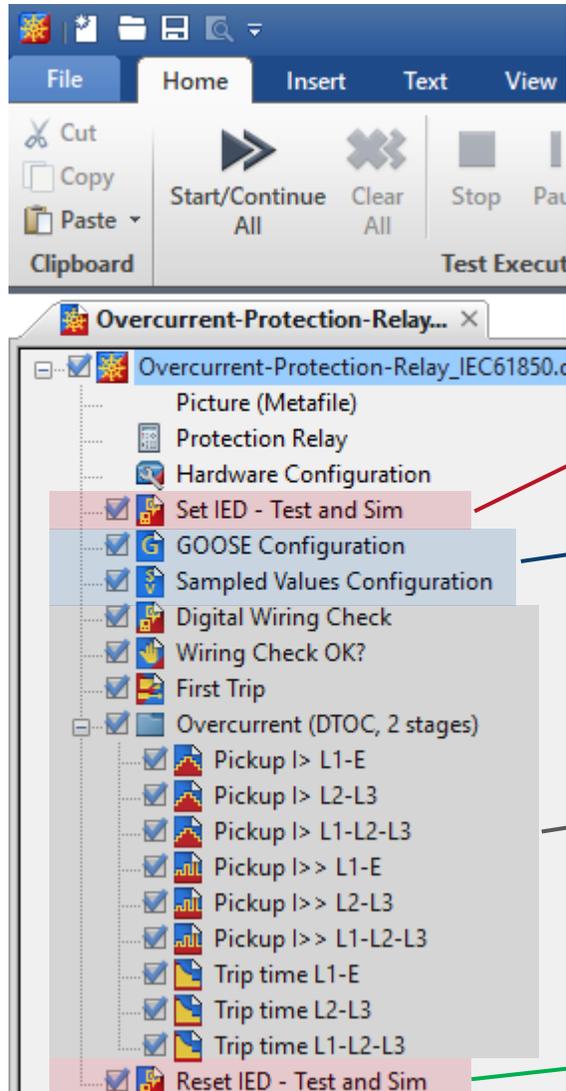
Return relay/IED to normal operation

- LPHD.Sim = false
- Mode = on

Testing completed



Relay/IED In-Service Maintenance Test Plan



Set Relay/IED
(IEC 61850 Client/Server)

Configure test set
(GOOSE messages and Sampled Values)

Protection Testing
(as usual)

Reset Relay/IED to normal operation
(IEC 61850 Client/Server)

Troubleshooting Tools and Methods



- **LGOS**(logical node for GOOSE subscription) can be used for monitoring status of GOOSE subscriptions in device
- **LSVS**(logical node for sampled values subscription) can be used to monitor status of SV subscriptions in device
- Use HMI screens on relay/IED, substation gateway/HMI, or IEC 61850 testing/monitoring tools to show online connection status using LGOS and LSVS statuses:
 - Relay/IED
 - On-line status of connected sampled value(s) from MU(s)
 - On-line status of subscribed MUs publishing GOOSE messages
 - On-line status of subscribed relays/devices publishing GOOSE messages
 - Merging Units (MUs)
 - On-line status of subscribed relays/devices or MUs publishing GOOSE messages
- P&C technician can easily determine which device is off-line and take appropriate action

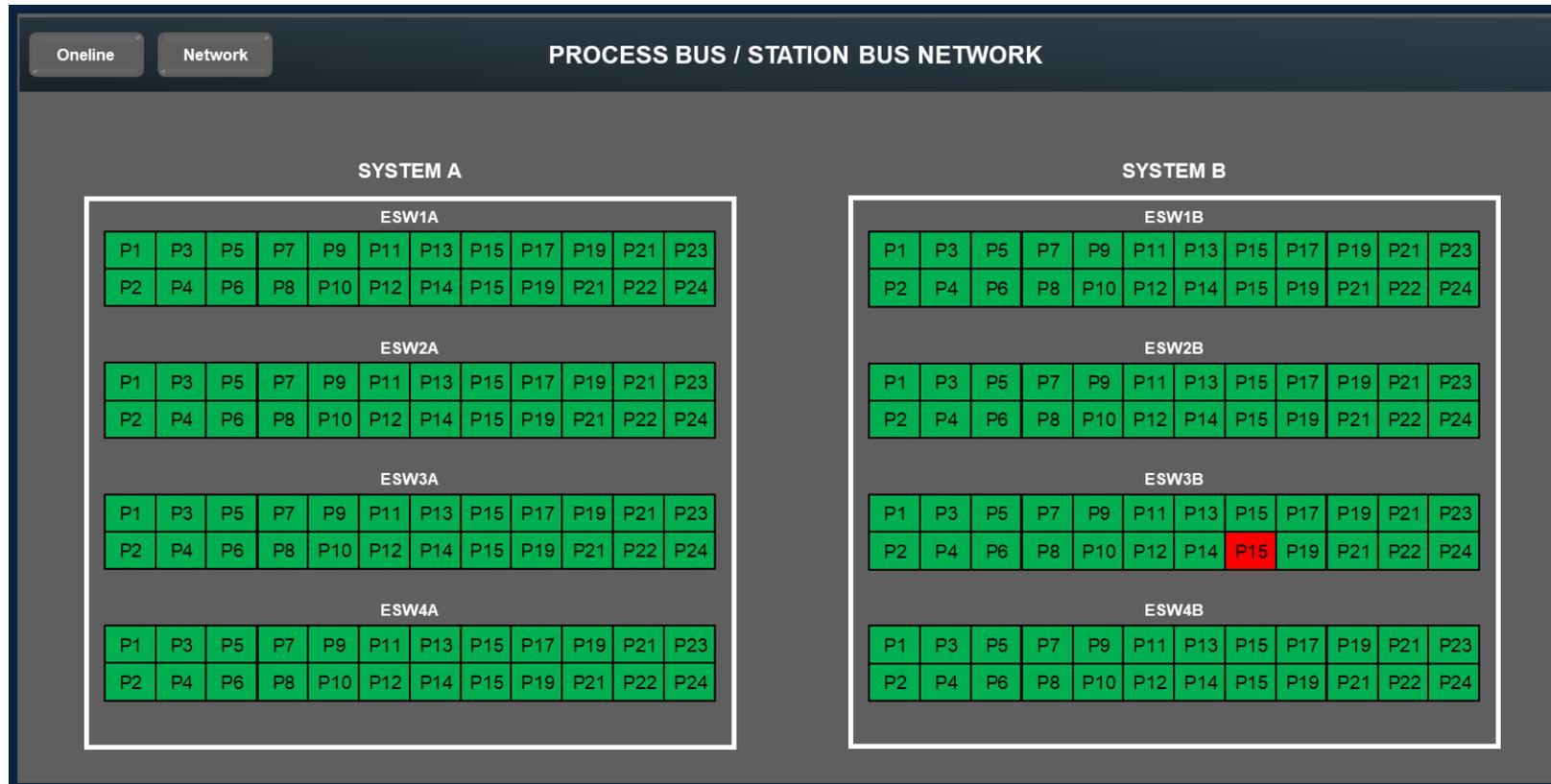
453 TRIP PHASE A	453 TRIP PHASE B	453 TRIP PHASE C	453 TIME OC FAULT	453 INST OC FAULT			MU1 SV1 & SV2 ON-LINE
496 TRIP PHASE A	496 TRIP PHASE B	496 TRIP PHASE C	496 TIME OC FAULT	496 INST OC FAULT	496 RECLOSING READY	496 RECLOSING LOCKOUT	MU2 SV1 & SV2 ON-LINE
476 TRIP PHASE A	476 TRIP PHASE B	476 TRIP PHASE C	476 TIME OC FAULT	476 INST OC FAULT	476 RECLOSING READY	476 RECLOSING LOCKOUT	MU3 SV1 & SV2 ON-LINE
486 TRIP PHASE A	486 TRIP PHASE B	486 TRIP PHASE C	486 TIME OC FAULT	486 TIME OC FAULT	486 RECLOSING READY	486 RECLOSING LOCKOUT	MU1 GOOSE ON-LINE
466 TRIP PHASE A	466 TRIP PHASE B	466 TRIP PHASE C	466 TIME OC FAULT	466 INST OC FAULT	466 RECLOSING READY	466 RECLOSING LOCKOUT	MU2 GOOSE ON-LINE
BUS TRIP PHASE A	BUS TRIP PHASE B	BUS TRIP PHASE C	BUS PERCENT DIFF TRIP	BUS INST DIFF TRIP	BUS CT SAT DETECTED	BUS DIR FAULT DETECTED	MU3 GOOSE ON-LINE

Example relay/IED status screen indicating an issue with merging unit (MU2)

- Publishing device (i.e., MU) is not powered up?
- Ethernet network switch issue?
- Fiber optic cable / connector issue?
- Publishing MU configuration (SV and GOOSE) has changed?

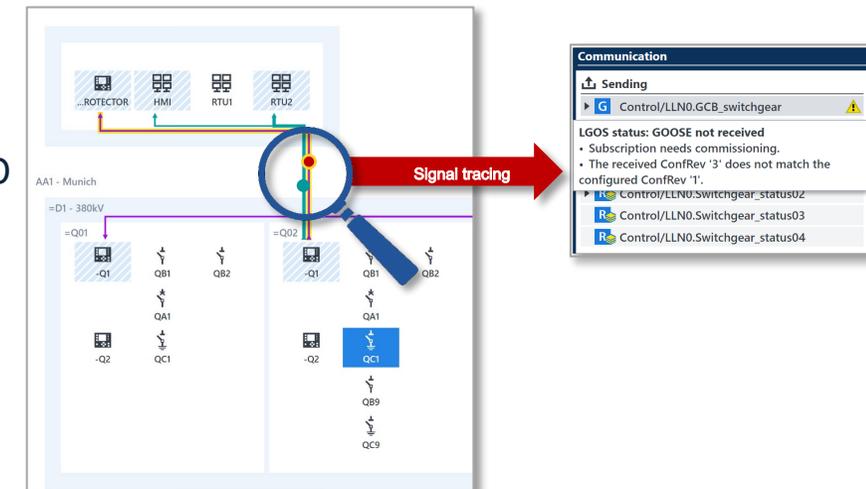
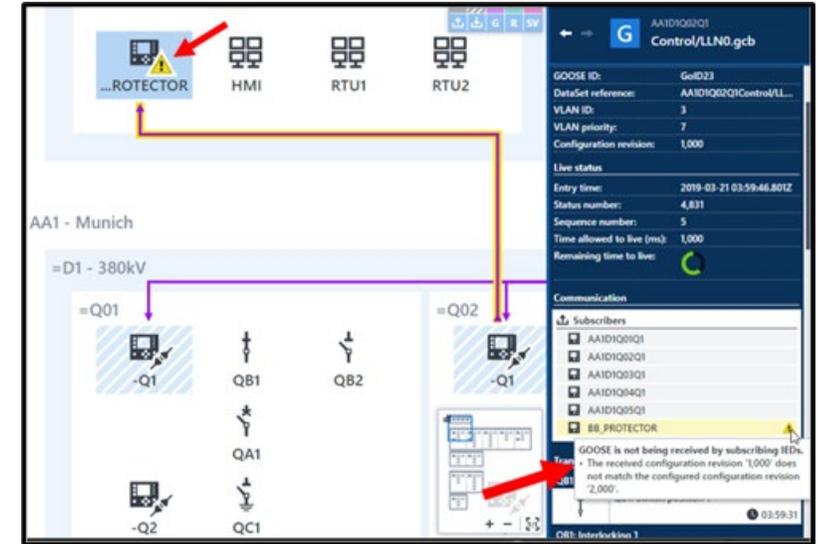
Troubleshooting Tools and Methods

- Substation HMI can provide extremely useful communication information for digital substation to identify Ethernet network hardware communication issues with various MUs and relays/IEDs



Troubleshooting Tools and Methods - IEC 61850 Testing Tools

- Aid in all stages of digital substation implementation and operation
- Use System Configuration Description (SCD) file containing all IED configurations (SV and GOOSE) and communication configuration between relay/IEDs and MUs
- Entire digital substation scheme can be visualized similar to a single line diagram or HMI
- IEC 61850 testing tool can:
 - Validate SV and GOOSE signals of each device, report communication links by accessing Ethernet network traffic and device MMS connections. Identify issues:
 - GOOSE mismatch using control block settings
 - GOOSE publisher errors by sniffing the Ethernet network and comparing against SCD file
 - GOOSE subscription errors by verifying LGOS states at each subscribing IED
 - Simulate and publish SV dataset(s) mimic one or many merging units
 - Simulate GOOSE messages (both publisher and subscriber) of relay/IEDs or merging units
 - Simulate relay/IED data model and associated SCADA (MMS) related services for testing of gateways, HMI, and SCADA systems



Conclusions

- Advantages of digital substation P&C system include faster implementation with fewer errors, a more reliable and repeatable final product, and significant cost savings from efficiencies in design, testing/commissioning, maintenance and operation
- Documentation of a digital substation P&C design is important and aids in testing and operation
- Efficient implementation of testing processes of a digital substation is achieved by lab testing, factory acceptance tests, site acceptance tests and system checks
- Maintenance testing can be performed by placing the device/IED in test mode or test and simulation modes
- IEC 61850 testing tools and use of LGOS and LSVS aid in testing and troubleshooting a digital substation P&C scheme

Thanks for the time

Questions ?

