Тестирование цифровой подстанции – определения, требования, возможности.

Testing the digital substation. Definitions, requirements and possibilities

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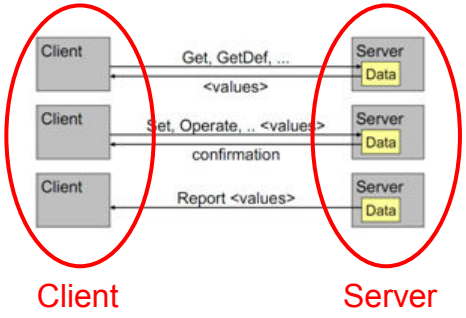
2017-10-03

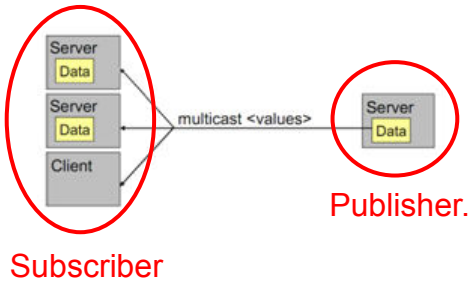
How to approach?

- Definitions in the standard
- Products
- Requirements

The standard: Different communication methods

Client / Server services	Real-Time services
> Control center ↔ field devices (SCADA) > Reports, Control, Setting Groups > Non-time-critical > One-to-one connection (Two-Party-Application-Association)	> Fast interdevice communication and transmission of sampled values > GOOSE and Sampled Values > Time-critical > One-to-many connection (Multicast-Application-Association)





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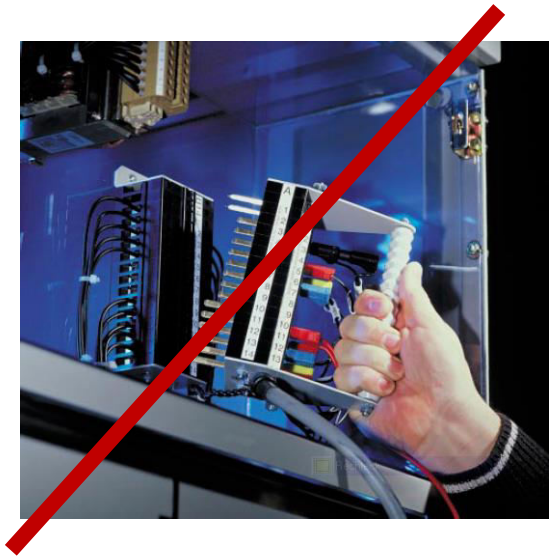
The Standard: No test plugs in IEC 61850

Test plugs:

Disconnect trip, short-circuit CTs, inject signals



IEC 61850:

- Many signals on one Ethernet cable
- Unplugging the cable not an option

Solution in IEC 61850

Complex but powerful solution

- Simulation/Test flag in GOOSE & SV
- LPHD.Sim switch in IED
- Test flag in data quality
- Mode/Behavior of LDs and LNs

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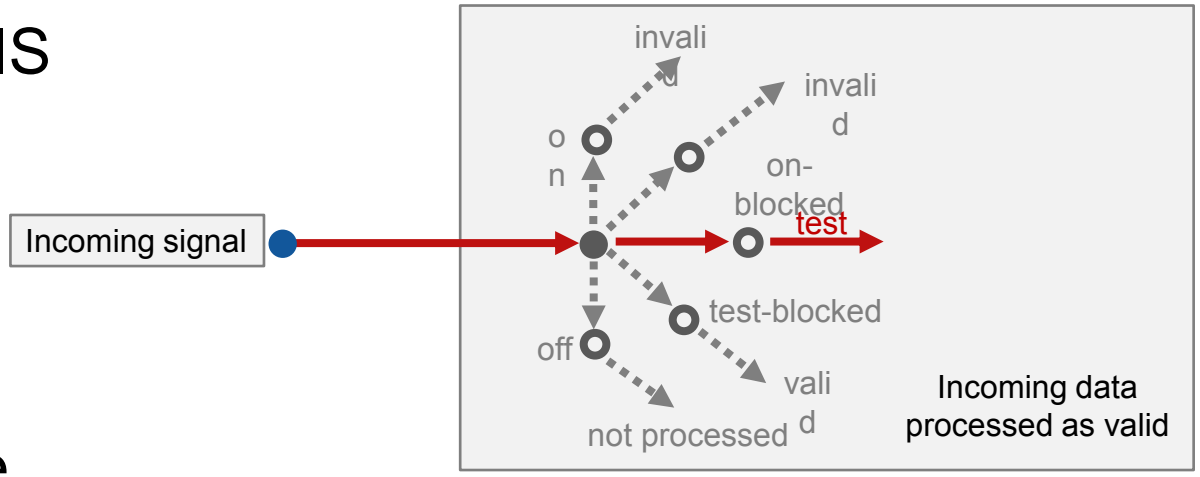
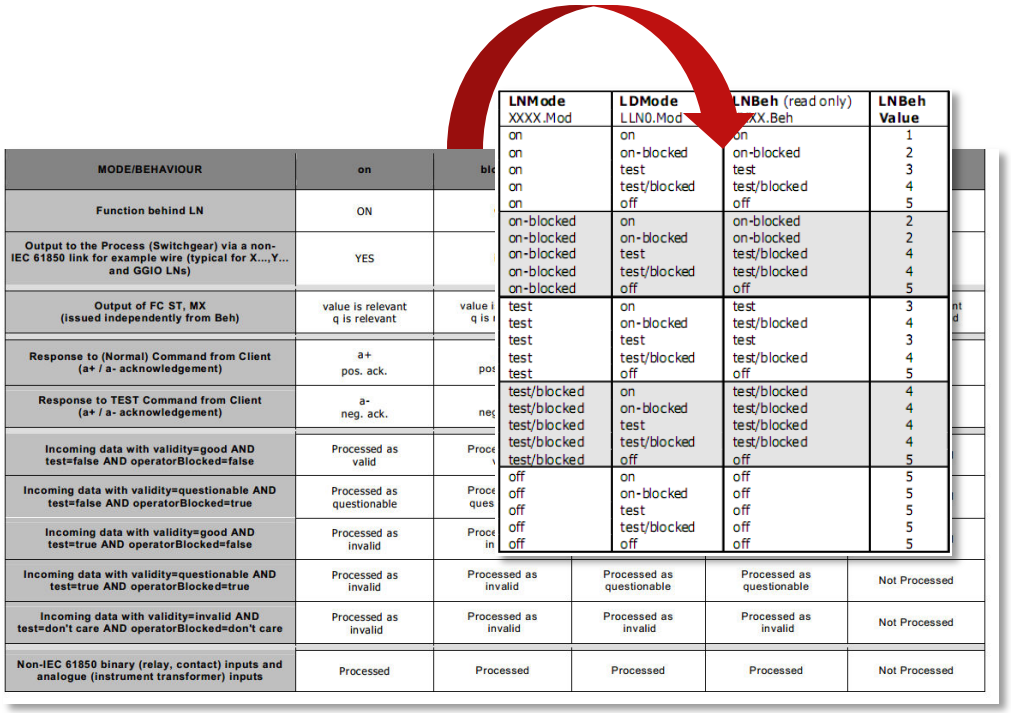
Solution: Test Mode

- Testing of every logical **node** like PROTECTION.PDIS 1
- Testing of every logical **device** like PROTECTION
- More than a simple „Test mode“:
  - on; on/blocked; test; test/ blocked; off



Complex dependencies defined in the standard



LNMode XXXX.Mod	LDMode LLN0.Mod	LNBeh (read only) XXX.Beh	LNBeh Value
on	on	on	1
on	on-blocked	on-blocked	2
on	test	test	3
on	test/blocked	test/blocked	4
on	off	off	5
on-blocked	on	on-blocked	2
on-blocked	on-blocked	on-blocked	2
on-blocked	test	test/blocked	4
on-blocked	test/blocked	test/blocked	4
on-blocked	off	off	5
test	on	test	3
test	on-blocked	test/blocked	4
test	test	test	3
test	test/blocked	test/blocked	4
test	off	off	5
test/blocked	on	test/blocked	4
test/blocked	on-blocked	test/blocked	4
test/blocked	test	test/blocked	4
test/blocked	test/blocked	test/blocked	4
test/blocked	off	off	5
off	on	off	5
off	on-blocked	off	5
off	test	off	5
off	test/blocked	off	5
off	off	off	5

MODE/BEHAVIOUR	on	bl			
Function behind LN	ON				
Output to the Process (Switchgear) via a non-IEC 61850 link for example wire (typical for X...,Y... and GGIO LNs)	YES				
Output of FC ST, MX (issued independently from Beh)	value is relevant q is relevant	value i q is			
Response to (Normal) Command from Client (a+ / a- acknowledgement)	a+ pos. ack.	pos			
Response to TEST Command from Client (a+ / a- acknowledgement)	a- neg. ack.	neg			
Incoming data with validity=good AND test=false AND operatorBlocked=false	Processed as valid	Proce			
Incoming data with validity=questionable AND test=false AND operatorBlocked=true	Processed as questionable	Proce ques			
Incoming data with validity=good AND test=true AND operatorBlocked=false	Processed as invalid	Proce in			
Incoming data with validity=questionable AND test=true AND operatorBlocked=true	Processed as invalid	Processed as invalid	Processed as questionable	Processed as questionable	Not Processed
Incoming data with validity=invalid AND test=don't care AND operatorBlocked=don't care	Processed as invalid	Processed as invalid	Processed as invalid	Processed as invalid	Not Processed
Non-IEC 61850 binary (relay, contact) inputs and analogue (instrument transformer) inputs	Processed	Processed	Processed	Processed	Not Processed

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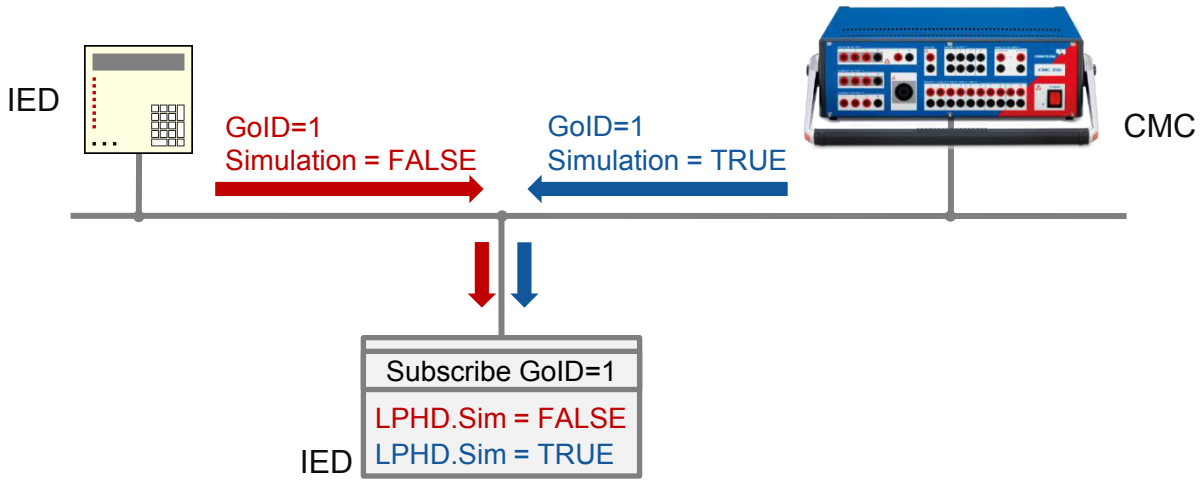
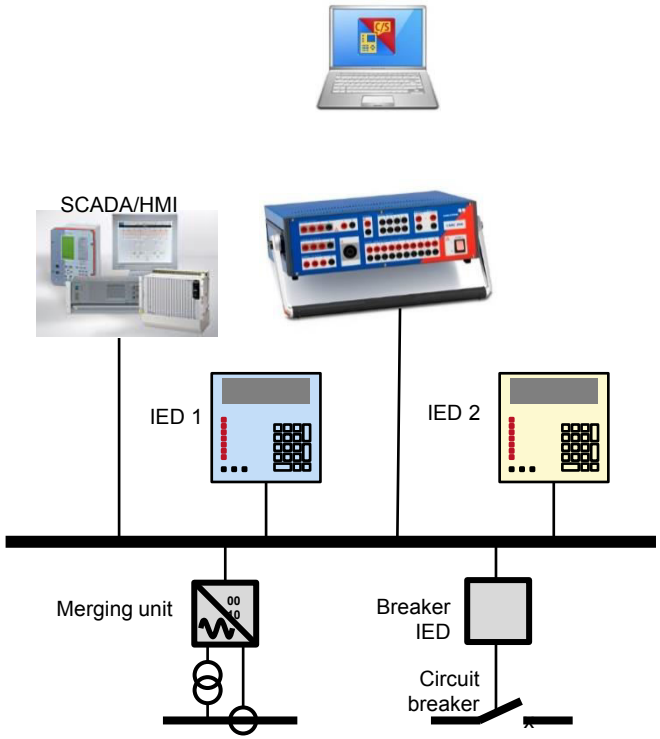
Simulation indication with GOOSE & Sampled Values

- How to distinguish between “real” signals and simulated one?
- Sets the entire IED (“physical device”) in simulation mode LPHD.Sim = True



Requirement: Client integrated in protection test

- LPHD.Sim and Mode handling
- Access to information from IED
- Test SCADA signals while protection testing



Standard: Setting Groups

SIP • Data Model • Ln1_5051OC3phA1 • II_PTOC1

LN II_PTOC1 Time overcurrent

Name		Description	Value
▸ DO TmACrv		Operating curve type	IEC Normal Inverse
◢ DO StrVal		Start value	1500 A
▸ DA units	[CF]	Units of the attribute(s) representing the value of the data	A
▸ DA minVal	[CF]	Defines together with maxVal the setting range for ctlVal (CDC INC, BSC, ISC), setVal (C...	30 A
▸ DA maxVal	[CF]	Defines together with minVal the setting range for ctlVal (CDC INC, BSC, ISC), setVal (C...	35000 A
▸ DA stepSize	[CF]	Defines the step between individual values that ctlVal (CDC INC, APC, BAC), setVal (CD...	0 A
▸ DA setMag	[SG]	The value of an analogue setting or set point	1500 A
◢ DA setMag	[SE]	The value of an analogue setting or set point	
DA f	[SE]	Floating point value	

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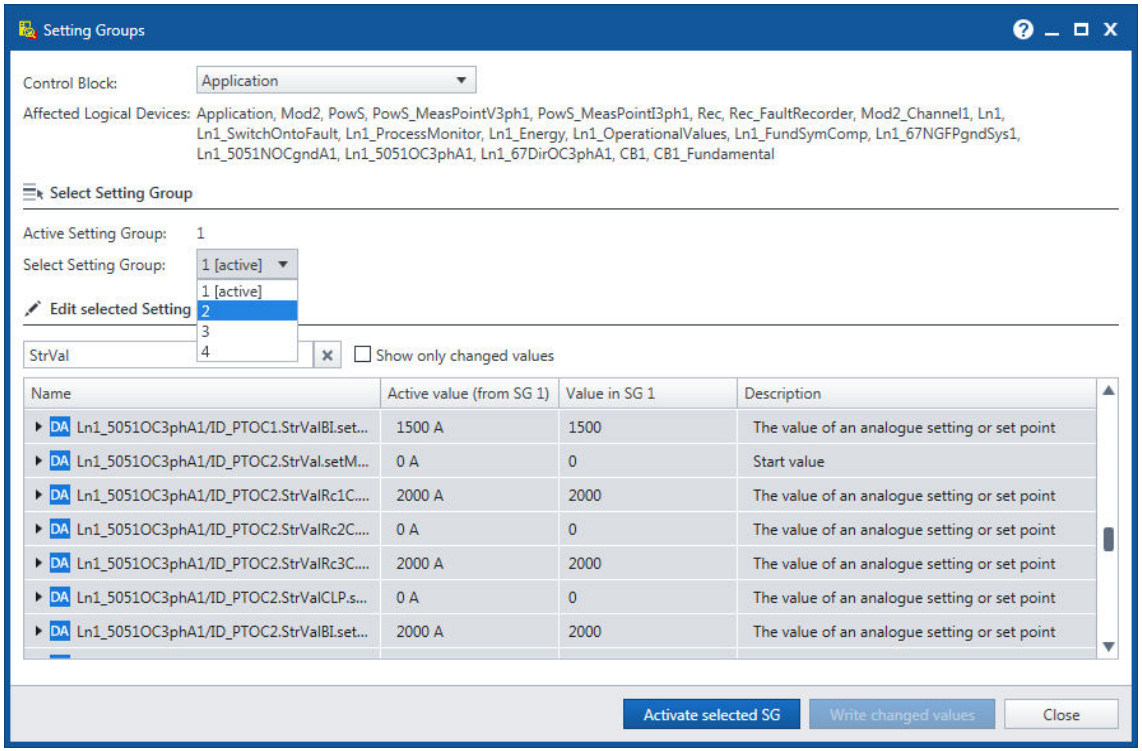
Requirements: Setting Group Service



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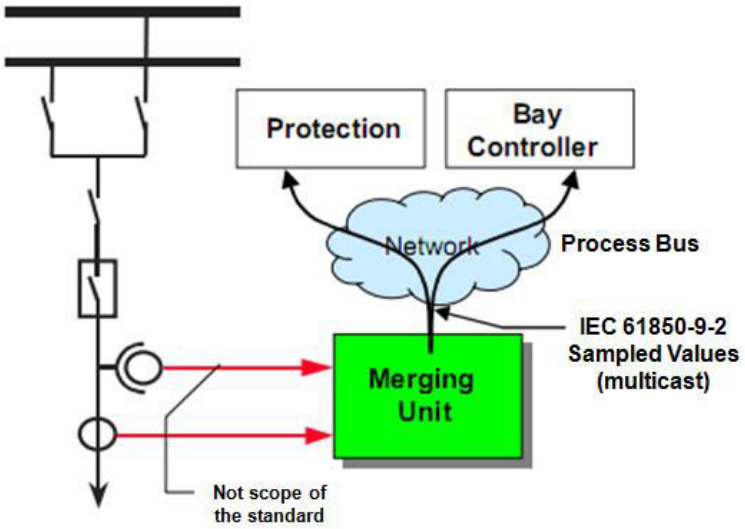
Standard definitions: Sampled Values



IEC 61850-9-2

Sampling Frequency	Samples per Packet	Packet Frequency	
4000Hz (80SPC @ 50Hz)	1	4000Hz	9-2LE
4800Hz (80SPC @ 60Hz)	1	4800Hz	
12800Hz (256SPC @ 50Hz)	8	1600Hz	
15360Hz (256SPC @ 60Hz)	8	1920Hz	
4800Hz	2	2400Hz	New preferred
14400Hz	6	2400Hz	
5760Hz	1	5760Hz	96SPC @ 60Hz

IEC 61869-9

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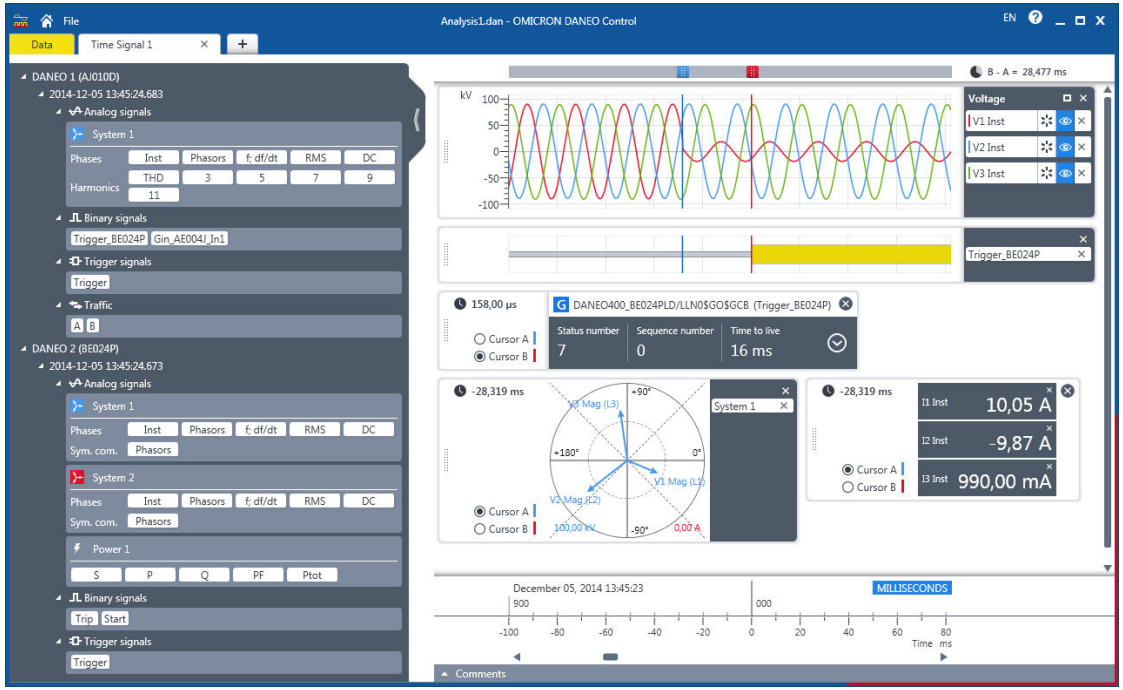
Requirement

- Handle sampled values and conventional signals



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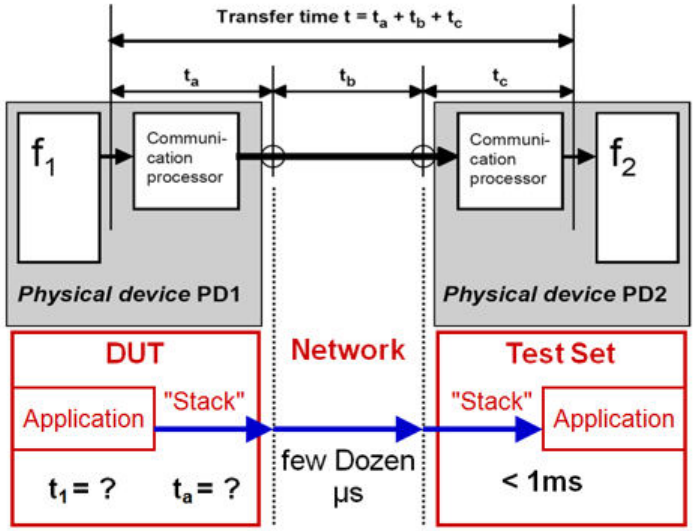
Standard definitions: Performance



Message Type	Description	Performance Class	Max. overall time
Type 1A "Trip"	Fast message	P1	10ms
		P2/P3	3ms
Type 1B "Others"	Fast message	P1	100ms
		P2/P3	20ms
Type 2	Medium speed	-	100ms

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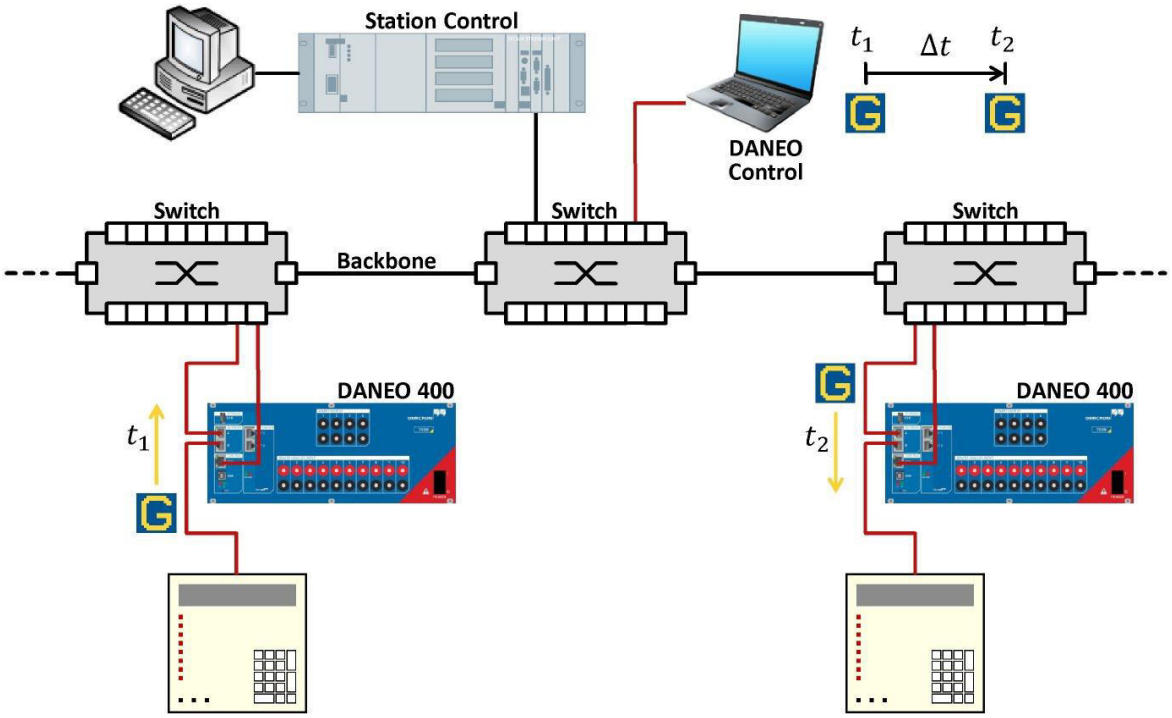
FAT or SAT scenarios in substations



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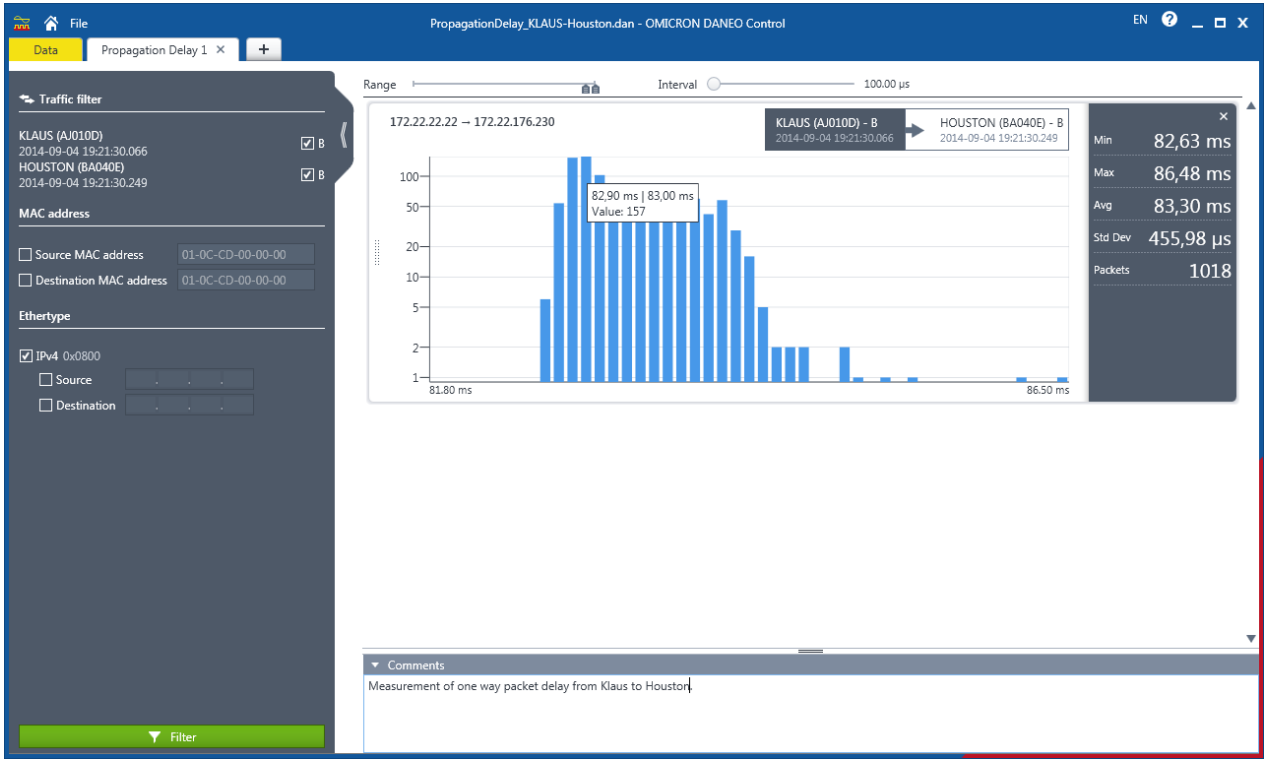
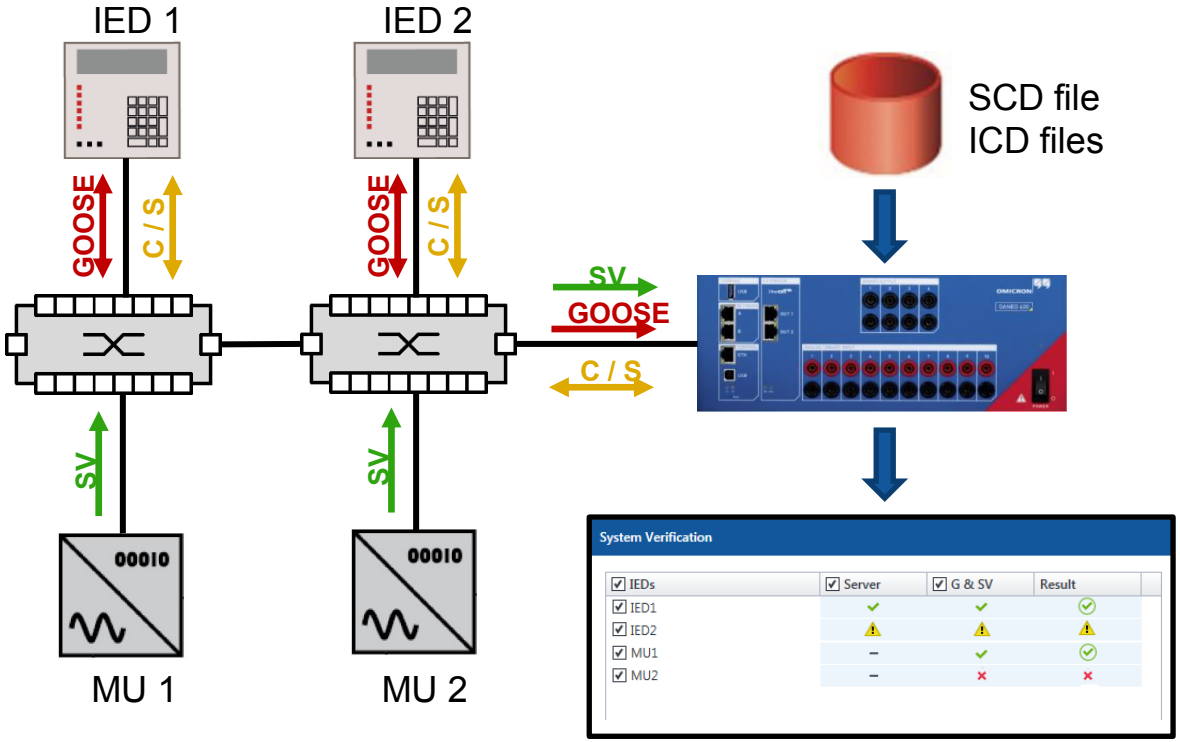
Requirement – Propagation delays measurement



Requirement: Engineering (SCD)



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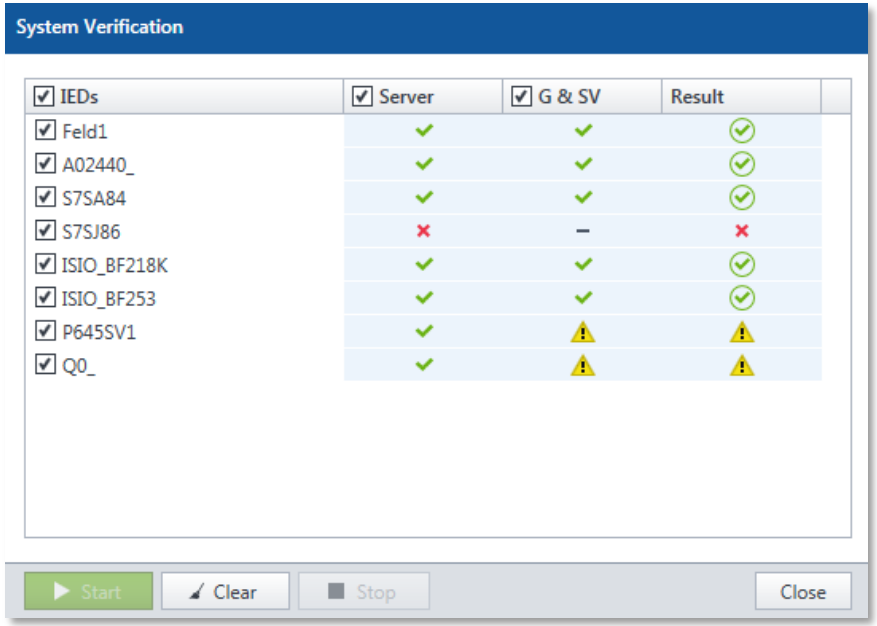
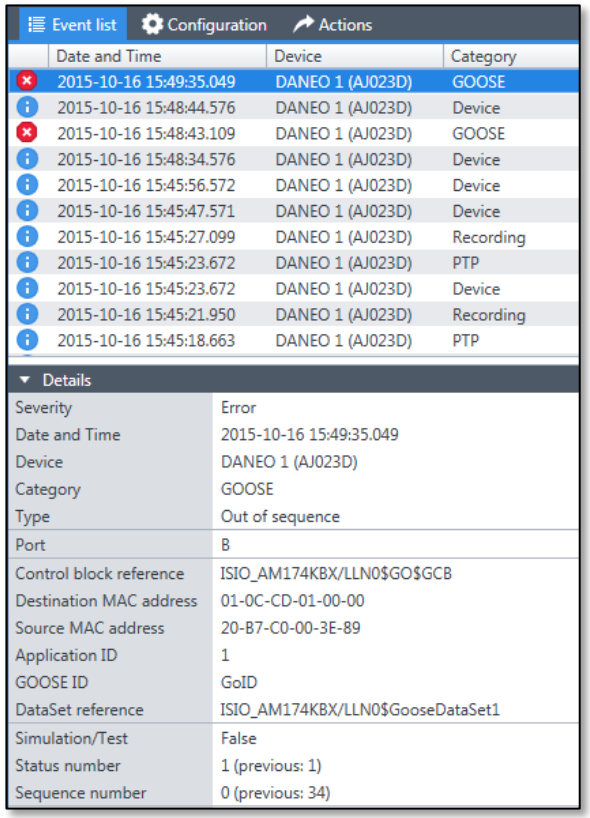
Requirement Verification & Supervision





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Summary

- different possibilities in the standard require modern testing tools with new capabilities
- Clients become important
- Test equipment to be used in conventional and digital substations
- Time synchronization

Thanks for your attention!

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