cigre Nederland

15 april 2025

Beveiliging ontrafeld

Uitgelegd wat je altijd al wilde weten

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Process bus based multivendor busbar protection, a proof of concept

Agenda

- Background & benchmark system
- System IED characteristics & limitations
- Engineering process & considerations
- Merging unit related tests
- Busbar protection specific test

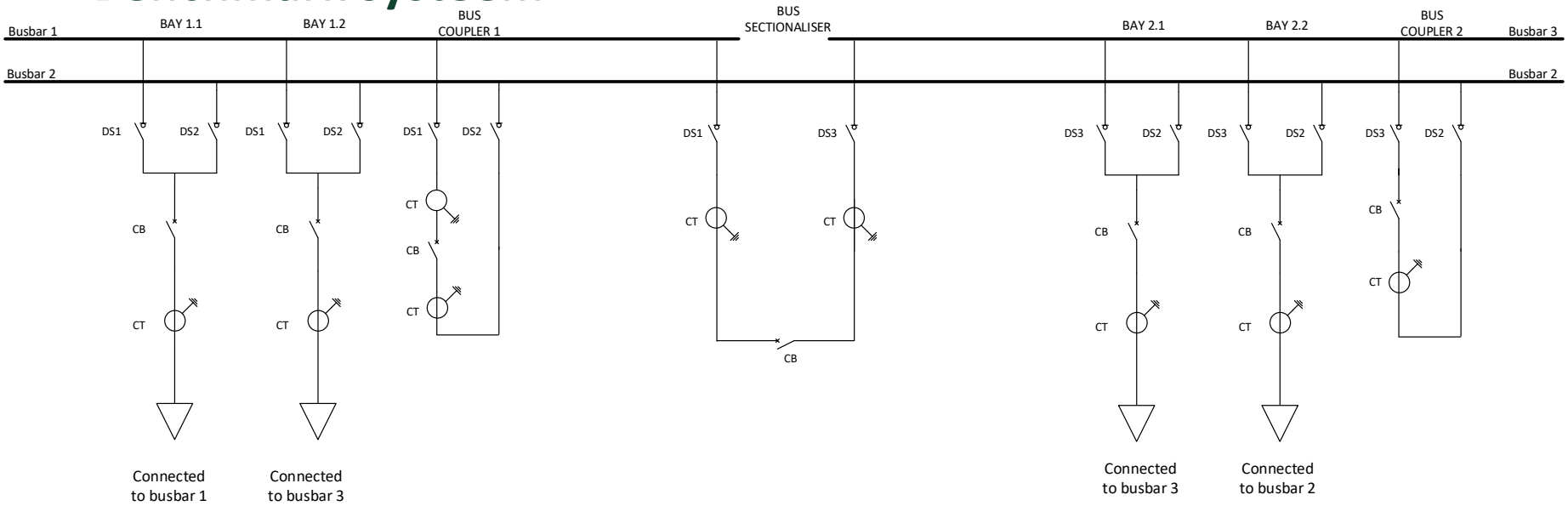
Introduction

- Sindhu V
- Afdelingshoofd, Stationsautomatisering, SPIE
- Lid van CIGRE B5.74 Busbar Protection Considerations When Using IEC 61850 Process Bus

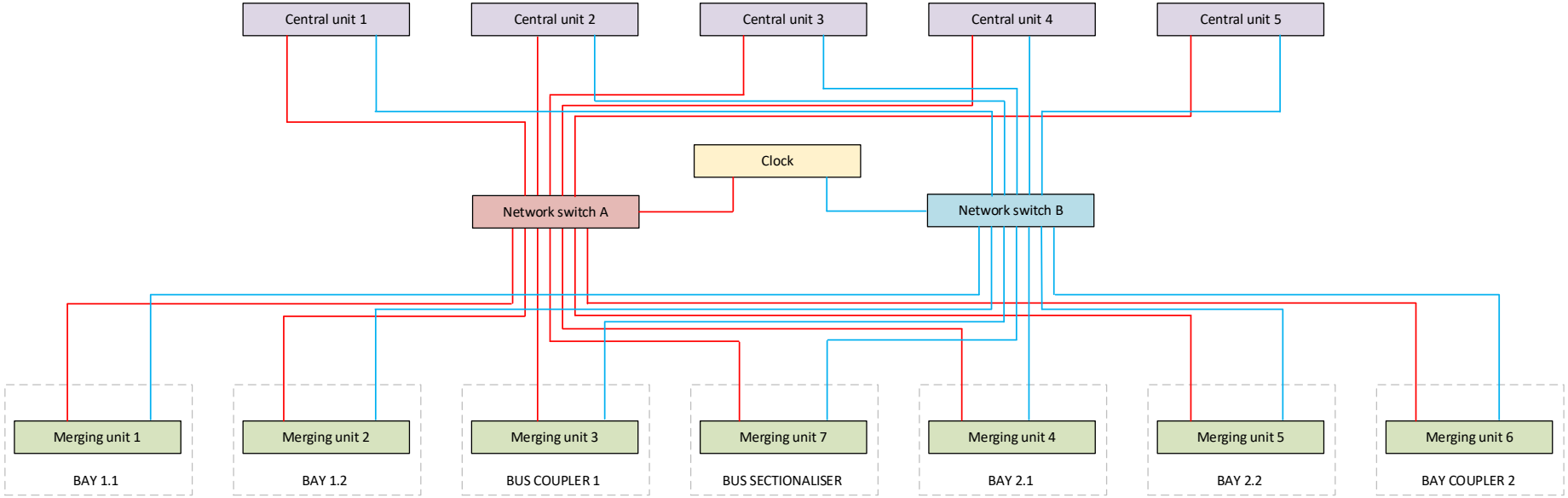
Background

- Not fully understood due to limited number of implementations worldwide
- Advantages: Interoperability & interchangeability
- No vendor dependance (line & busbar)
- Proof of concept as a viability (2024 & 2025)

Benchmark systeem



Netwerk architectuur (2024)



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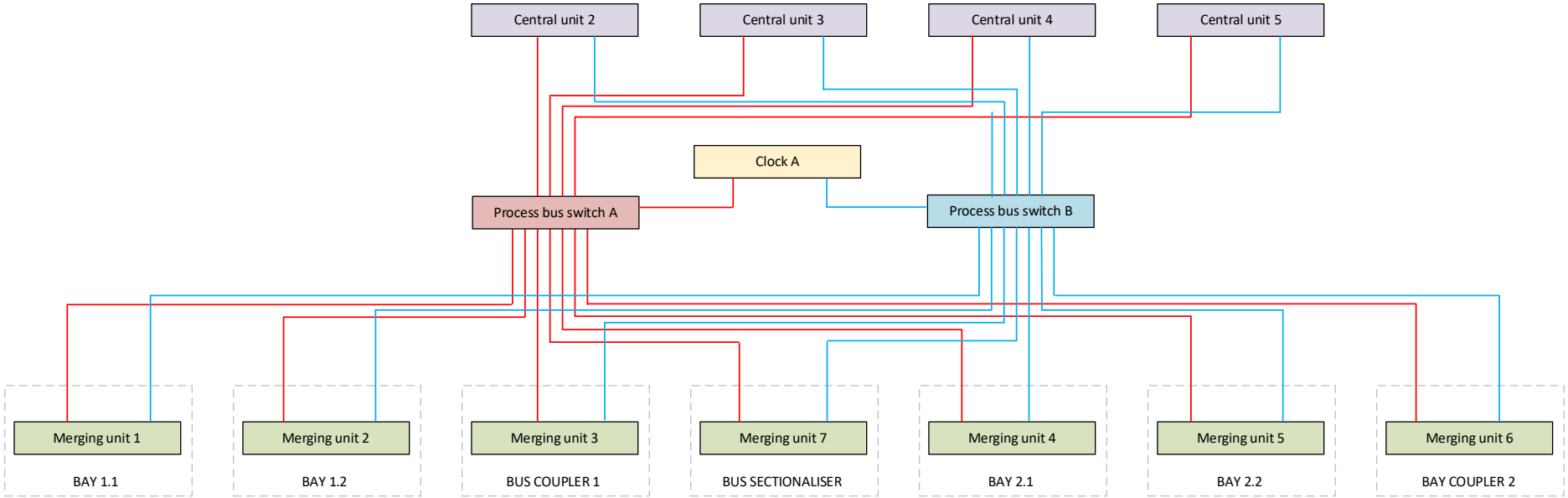


Leveranciers

Ingeteam

Schneider Electric

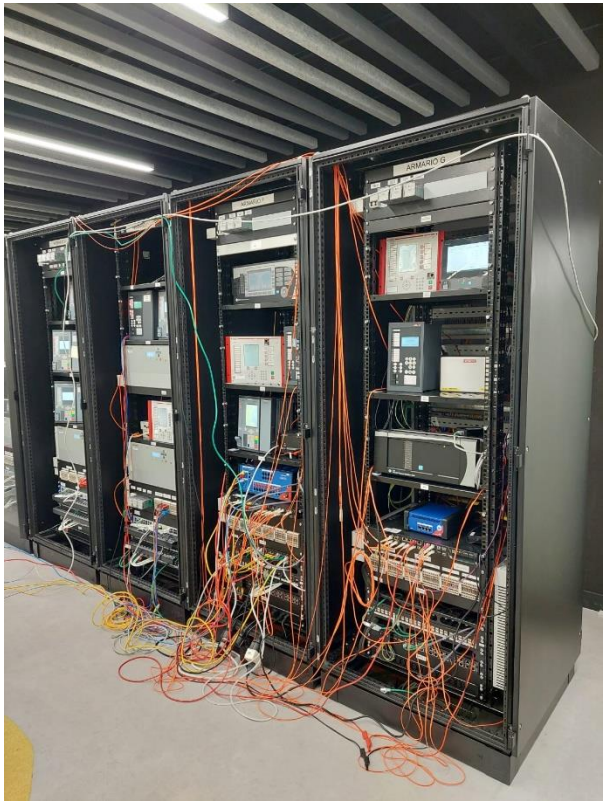
ZIV

General Electric

HITACHI

SIEMENS

Test opstelling



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System IED characteristics (2024)

IED	BAY	VENDOR	SV Edition	SV Stream	Variant
MU1	1.1	A	2.1	IEC 61869-9	F4800S2I4U4
MU2	1.2	B	2.1	IEC 61869-9	F4800S2I4U0
MU3	BC1	C	2.1	IEC 61869-9	F4800S2I4U0
MU4	2.1	D	2.0	9-2 LE	F4800S1I4U4
MU5	2.2	E	2.0	IEC 61869-9	F4800S2I4U0
MU6	BC2	F	2.0	IEC 61869-9	F4800S2I3U0
MU7	BS	A	2.1	IEC 61869-9	F4800S2I4U4
CU1	BB	C	2.0	IEC 61869-9	NA
CU2	BB	A	2.1	IEC 61869-9	NA
CU3	BB	F	2.0	IEC 61869-9	NA
CU4	BB	E	2.0	IEC 61869-9	NA
CU5	BB	D	2.0	IEC 61869-9	NA

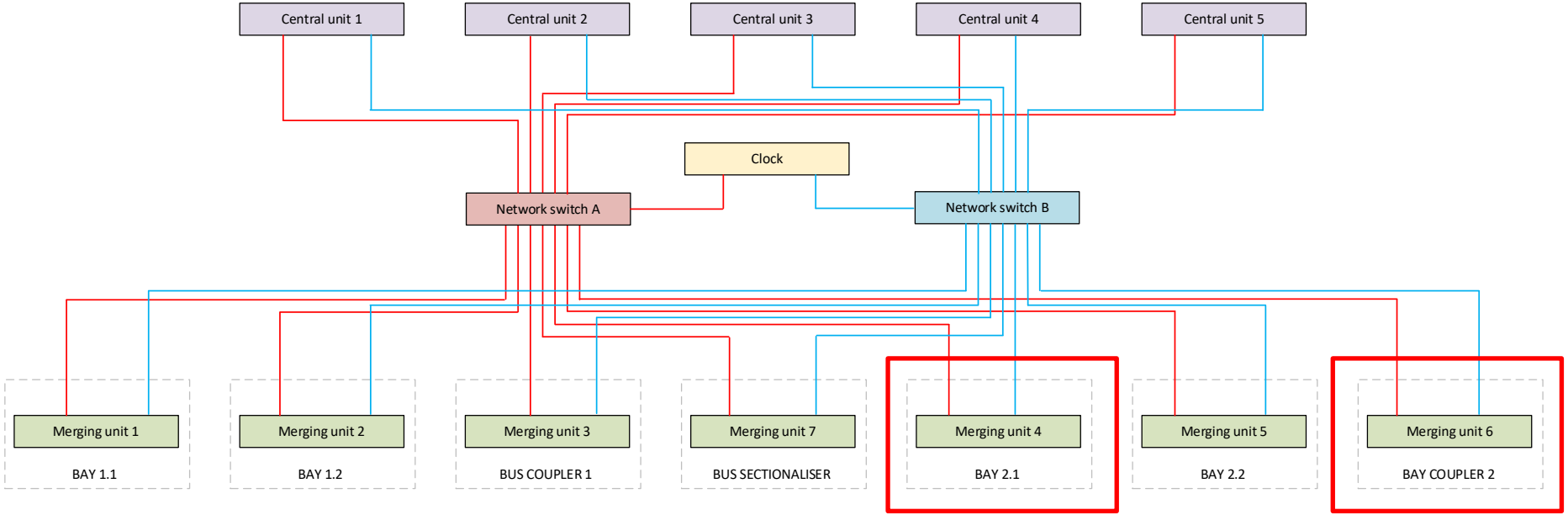
Profile related limitations

- 9-2 LE
  - No customised dataset, always composed of 4 voltages and 4 currents
  - smpRate="80" & smpMod="SmpPerPeriod"
- IEC 61869-9
  - F4000S1I4U4 and F4800S1I4U4 for 50Hz & 60Hz respectively
  - smpRate="4800" & smpMod="SmpPerSec"

Profile related limitations – possible solutions

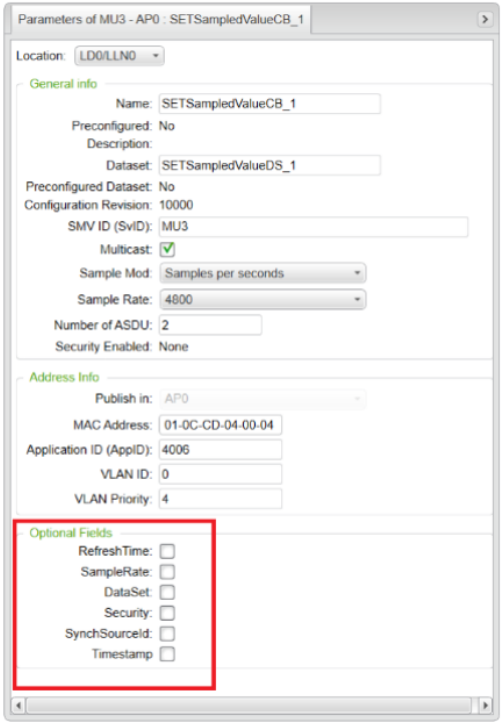
- Manually changing the 9-2 LE IED capabilities as if it was capable of 4800 samples per second

Simulated IEDs (2024)



IEC 61850 edition related limitations

- SynchSrcID
- Optional fields



System IED characteristics (2025)

IED	BAY	VENDOR	SV Edition	SV Stream	Variant
MU1	1.1	A	2.1	IEC 61869-9	F4800S2I4U4
MU2	1.2	B	2.1	IEC 61869-9	F4800S2I4U0
MU3	BC1	C	2.1	IEC 61869-9	F4800S2I4U0
MU4	2.1	D	2.1	IEC 61869-9	F4800S2I4U0
MU5	2.2	E	2.0	IEC 61869-9	F4800S2I4U0
MU6	BC2	F	2.0	IEC 61869-9	F4800S2I4U0
MU7	BS	A	2.1	IEC 61869-9	F4800S2I4U4
~~CU1~~	~~BB~~	~~C~~	~~2.0~~	~~IEC 61869-9~~	~~NA~~
CU2	BB	A	2.1	IEC 61869-9	NA
CU3	BB	F	2.0	IEC 61869-9	NA
CU4	BB	E	2.0	IEC 61869-9	NA
CU5	BB	D	2.0	IEC 61869-9	NA

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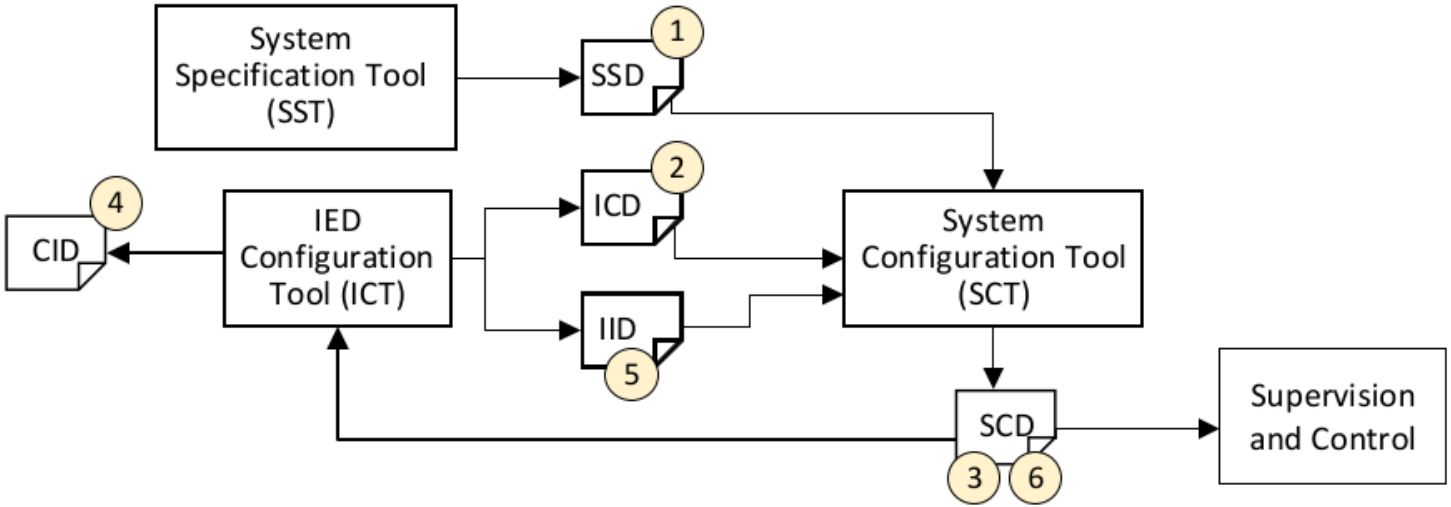
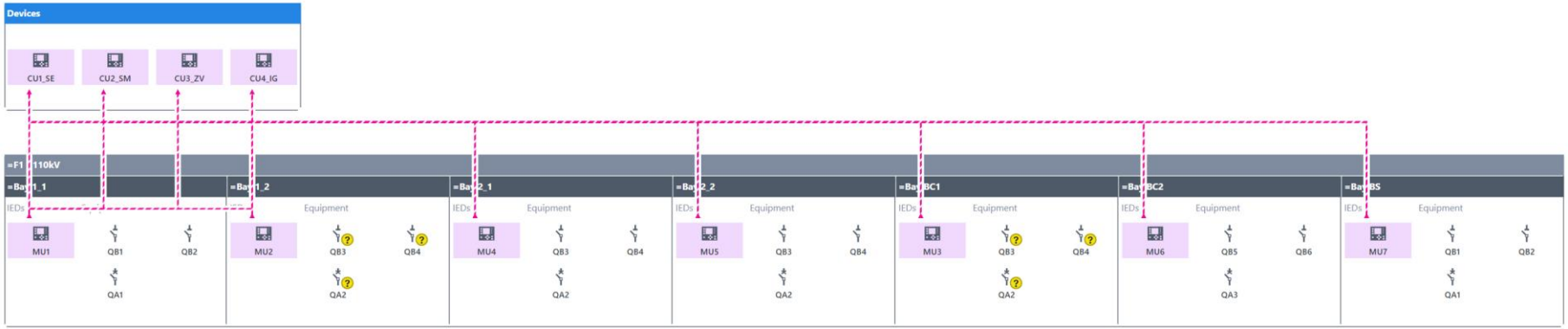
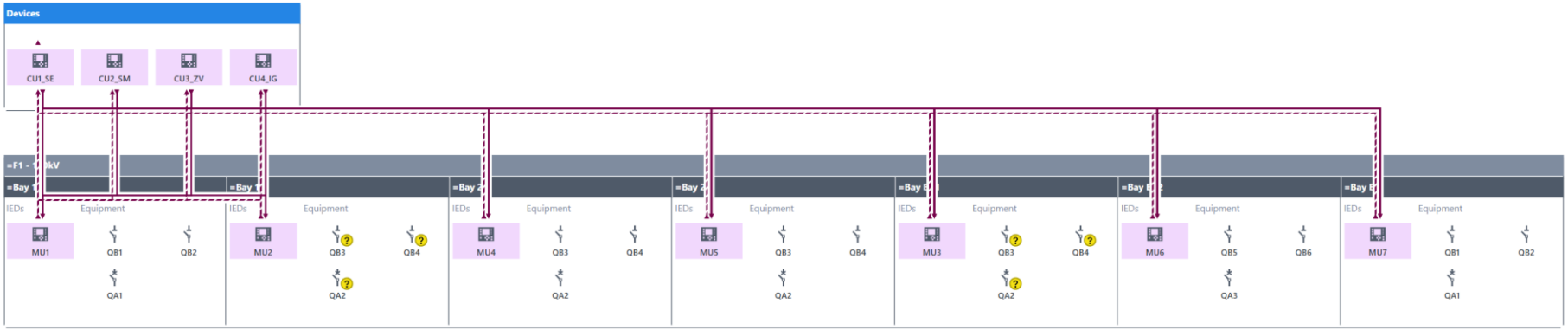
System engineering – Top down



Communication configuration



Communication configuration



Merging unit considerations

- GOOSE subscription not using an ExtRef
- Multiple service sections
- SMV settings

Properties | Signals | Inputs | History

Property	Value
Cb Name	Conf
Dat Set	Conf
KDA Participant	false
Nof ASDU	Conf
Opt Fields	Conf
Pdc Time Stamp	false
Samples Per Sec	4800
Samples Per Sec1	true
Sec Per Samples	
Smp Rate	4800
Smp Rate1	Conf
Sv ID	Conf
Synch Src Id	false

Central unit considerations

- SV subscription not using an ExtRef
- Instrument transformer parameters, ratio as a part of IID file

Table 905 – Extensions to the TCTR class

TCTR class extensions with nameplate information				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
NamAccRtg	VSD	the accuracy class rating in the format described in 5.6, e.g. "0,5S/5P20"		M
NamARtg	VSD	a semicolon separated list of the rated primary currents (I_{Pr}) in amperes, e.g. "200;400;800"		M
NamClipRtg	VSD	the ratio of the clipping limit of the instantaneous current to the rated primary current multiplied with a square root of two, e.g. "20"		M
Key M = Mandatory O = Optional C = Conditional				

System engineering

IED	Completely Top-Down	Observations
MU1	Yes	No
MU2	Yes	No
MU3	Yes	No
MU4	No	9-2 Dataset and 80 Samples per Cycle
MU5	No	
MU6	No	Only allows 3 currents on the dataset
MU7	Yes	No
CU1	No	Requires additional configuration at ICT
CU2	Yes	Takes the CT's parameters from the SCD with an option to be filled manually
CU3	No	Requires additional configuration at ICT
CU4	No	Requires additional configuration at ICT
CU5	No	Private SV Subscription need to be done on the ICT

IED	Completely Top-Down	Observations
MU1	Yes	No
MU2	Yes	No
MU3	Yes	No
MU4	No	Needs to be completely configured by ICT
MU5	No	Requires additional configuration at ICT
MU6	Yes	No
MU7	Yes	No
CU2	Yes	Takes the CT's parameters from the SCD with an option to be filled manually
CU3	No	Requires additional configuration at ICT
CU4	Yes	No
CU5	No	Private SV Subscription need to be done on the ICT

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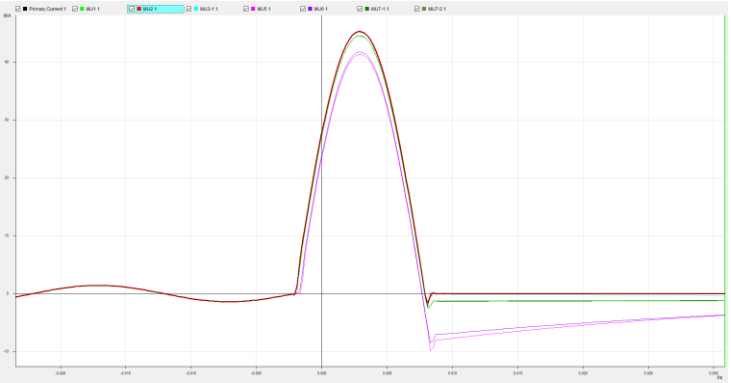
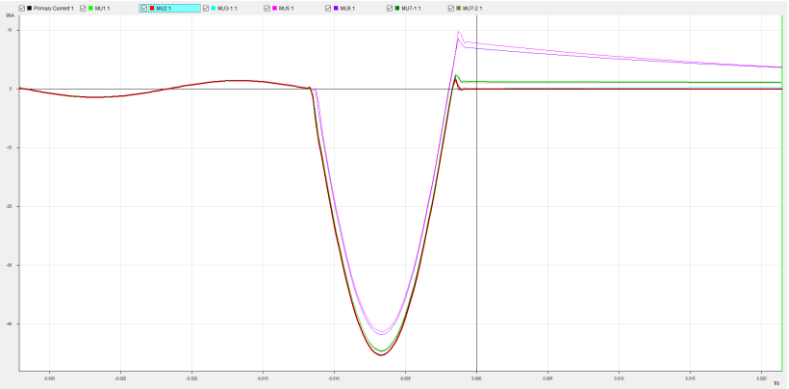
Comparing merging units against each other





PTP related test

- Steady state

IED	With GNSS	Without GNSS	No-PTP
MU1	Global (2)	None (0)	None (0)
MU2	Global (2)	Local (1)	None (0)
MU3	Global (2)	Local (1)	None (0)
MU4	-	-	-
MU5	Global (2)	Local (1)	None (0)
MU6	Global (2)	Local (1)	None (0)
MU7	Global (2)	None (0)	None (0)

- Complete loss of PTP

IED:	Event:	Delta t [s]
PTPv2	GPS switched OFF from 100ns accuracy	0.000
MU3	Global -> None	5.216
MU1, MU7	Global -> None	25.215
MU2	Global -> None	34.206
MU6	Global -> None	61.035
MU5	Global -> None	160.21

PTP related test

- Recovery of PTP (without GNSS)

IED:	Event:	Delta t [s]
PTPv2	None -> Local Oscillator	0.000
MU6	None -> Local	7.020
MU3	None -> Local	7.973
MU2	None -> Local	24.976
MU5	None -> Local	39.973
MU1, MU7	No Reaction / Change	

- Recovery of PTP(with GNSS)

IED:	Event:	Delta t [s]
PTPv2	GPS switched ON with 25ms accuracy	0.000
PTPv2	PTP with 2.5us accuracy	2.935
MU3	Local -> None	4.804
MU5	Local -> None	5.262
MU6	Local -> Global	5.950
MU2	Local -> None	30.804
MU3	None -> Global	40.279
MU1, MU7	None -> Local	55.278
MU5	None -> Global	58.279
MU1, MU7	Local -> Global	66.278
MU2	None -> Global	68.824

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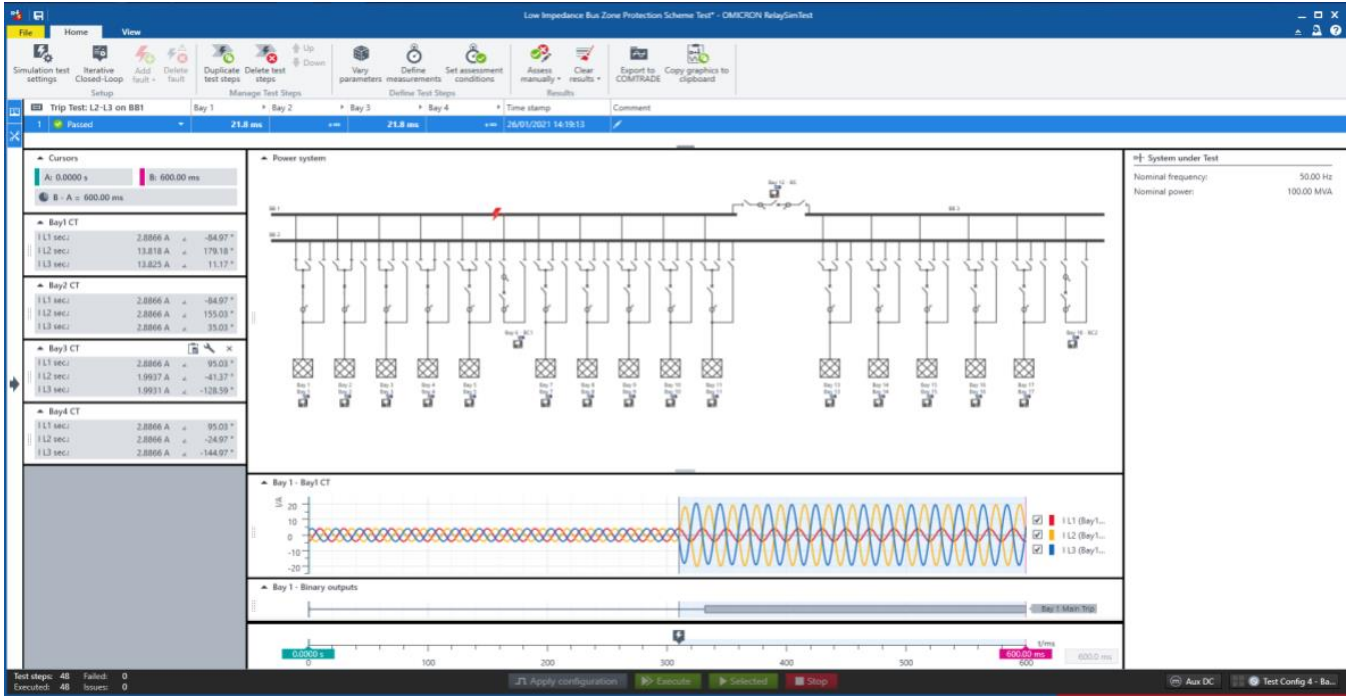
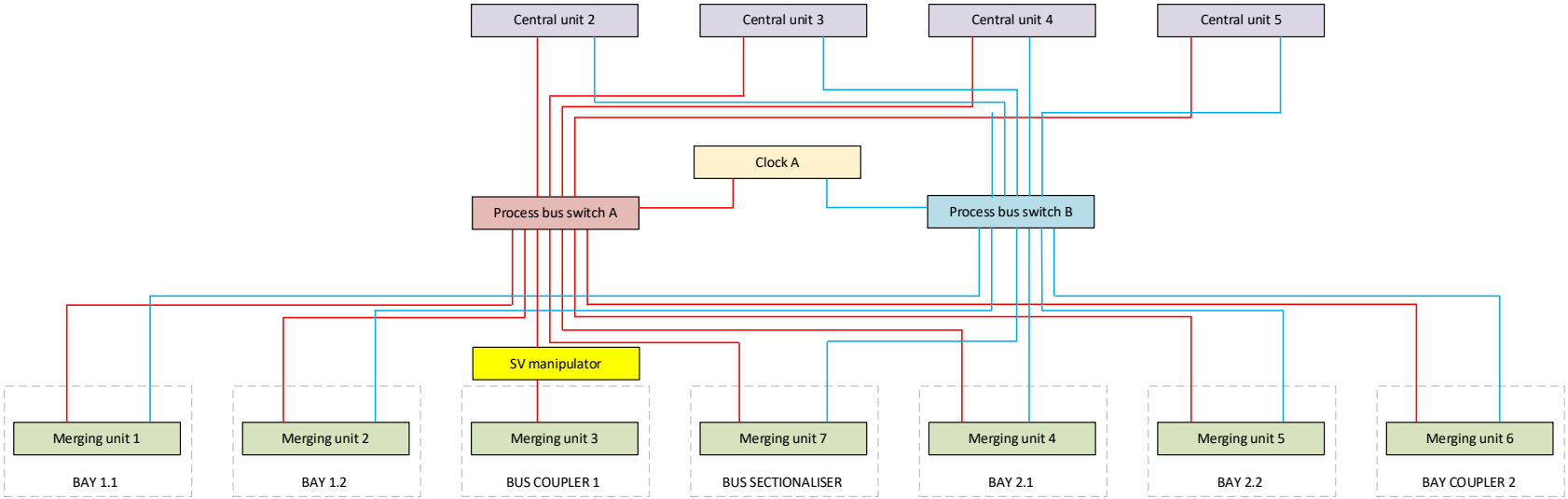
- Busbar protection specific test

Busbar protection scheme specific tests



Sample specific tests



Sample specific tests – behaviour of central units

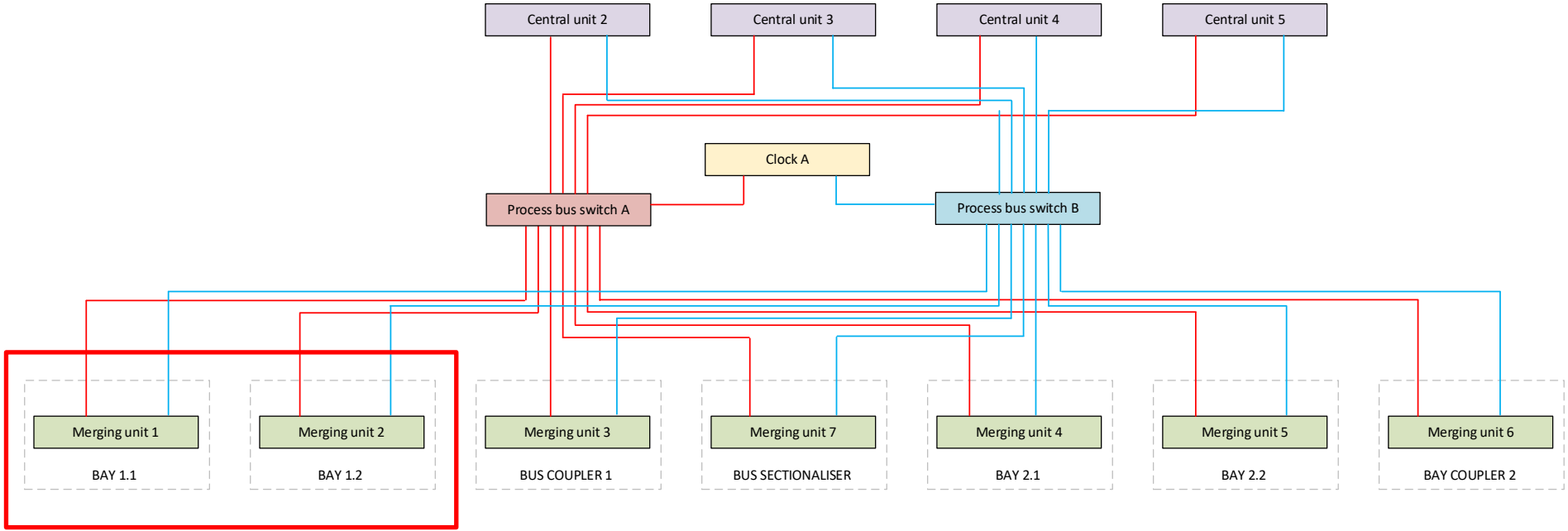
- < Three packets dropped

IED:	Behaviour:
CU2	Not blocked
CU3	Not blocked
CU4	Not blocked
CU5	Not blocked

- > Three packets dropped

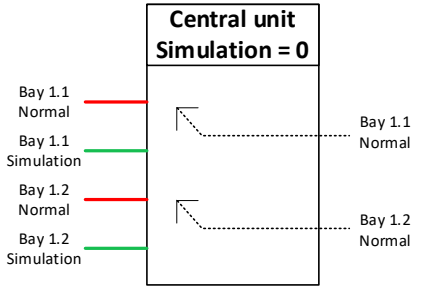
IED:	Behaviour:
CU2	Blocked
CU3	Not blocked
CU4	Blocked
CU5	Blocked

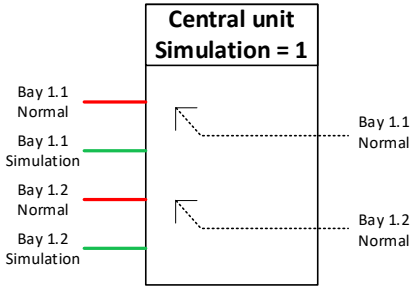
Simulation mode

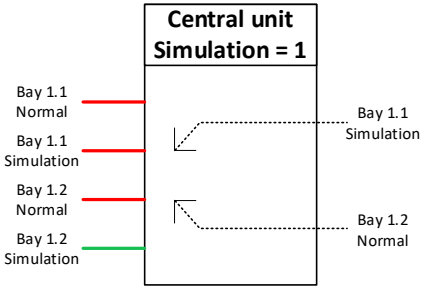


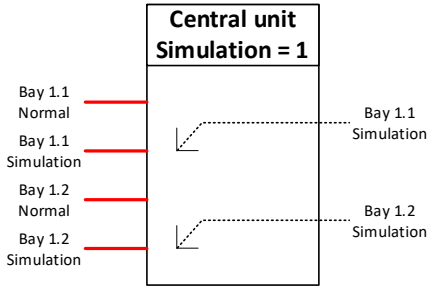
Not published

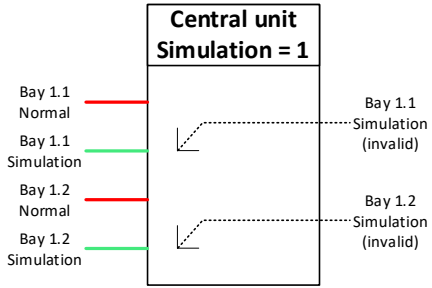
Simulation mode

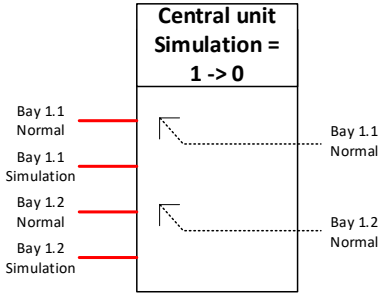








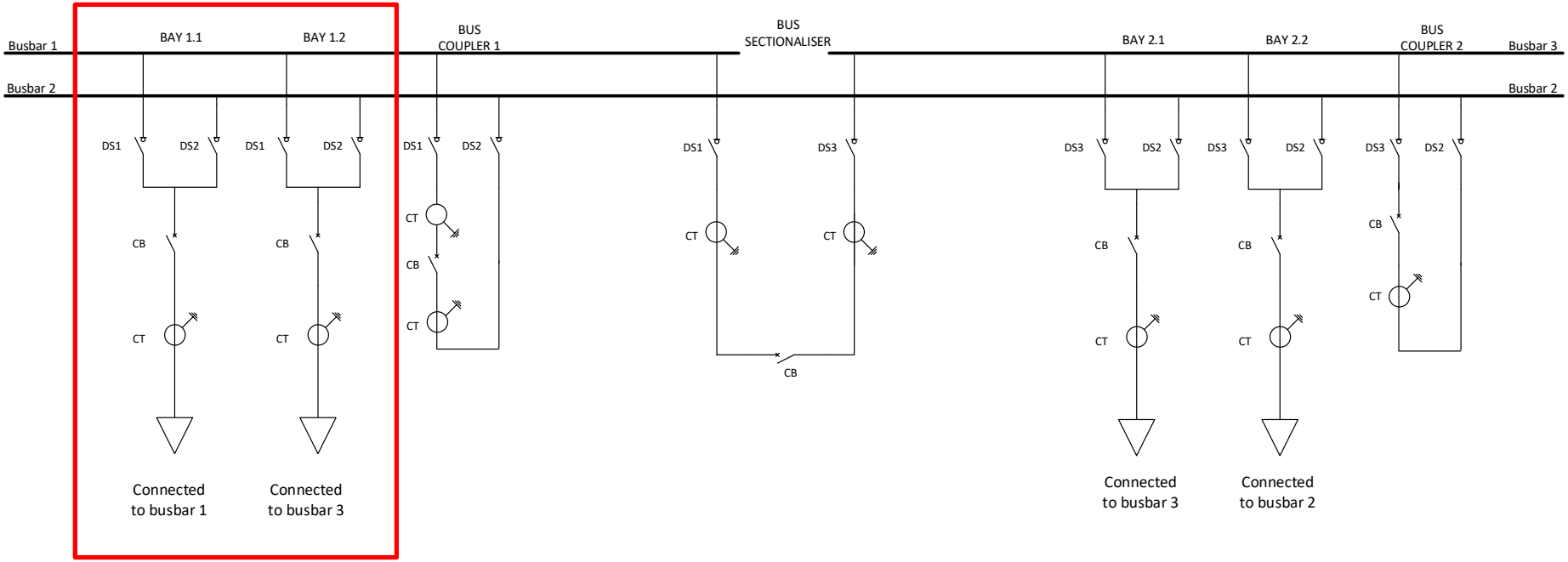




Simulation mode – behaviour of central units

IED:	Behaviour:
CU2	As expected
CU3	As expected
CU4	No simulation available
CU5	As expected

Test mode


Busbar 1
Busbar 2
BAY 1.1
BAY 1.2
BUS COUPLER 1
BUS SECTIONALISER
BAY 2.1
BAY 2.2
BUS COUPLER 2
Busbar 3
Busbar 2
DS1
DS2
DS3
CB
CT
Connected to busbar 1
Connected to busbar 3
Connected to busbar 3
Connected to busbar 2

Test mode – Expected behaviour

Table A.2 – Definition of mode and behaviour

MODE/BEHAVIOUR	on	on-blocked	test	test/blocked	off
Function behind LN	ON	ON	ON	ON	OFF
Output to the Process (Switchgear) via a non-IEC 61850 link for example wire (typical for X...,Y... and GGIO LNs)	YES	NO	YES	NO	NO
Output of FC ST, MX (issued independently from Beh)	value is relevant q is relevant	value is relevant q = operatorBlocked	value is relevant q = test	value is relevant q = test +operator-Blocked	value is irrelevant q = invalid
Response to (Normal) Command from Client (a+ / a- acknowledgement)	a+ pos. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.
Response to TEST Command from Client (a+ / a- acknowledgement)	a- neg. ack.	a- neg. ack.	a+ pos. ack.	a+ pos. ack.	a- neg. ack.
Incoming data with q=normal	Processed as valid	Processed as valid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=operatorBlocked	Processed as blocked	Processed as blocked	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=test	Processed as valid	Processed as invalid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=test+operatorBlocked	Processed as invalid	Processed as invalid	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=invalid	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

NOTE A precondition of the use of different modes (Mod/Beh) is the processing of the quality status (q) of the receiving information.

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Test mode – Behaviour

IED:	Behaviour:
CU2	Process & issued trip with quality test
CU3	Process & issued trip with quality test
CU4	Process & issued trip with quality test
CU5	Process & issued trip with quality test

IED:	Behaviour:
MU1 & MU7	Blocked, setting
MU2	Blocked
MU3	Tripped
MU4	Blocked
MU5	Blocked
MU6	Blocked

Recommendations

- Use IEC 61869-9 Ed.1 for flexibility
- Specification is the key, this includes SMV settings as well (example: F4800S2I4U0)
- Optional fields only when absolutely necessary
- Engineering process: If the vendor supports a full top down engineering approach(including ExtRef) this can help significantly reduce time & errors
- Thorough testing in a lab environment

The minds behind the working group…

Take aways

- SMVs begint te leven
- Bouwen dan allen spreken
- Hoe gaan wij verder in de praktijk?
- U4 voor het testen

BEDANKT VOOR UW AANDACHT

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