



DANE0 Control

Signal and Network Analyzer for Substation Automation Systems

▶ DANEØ Solution

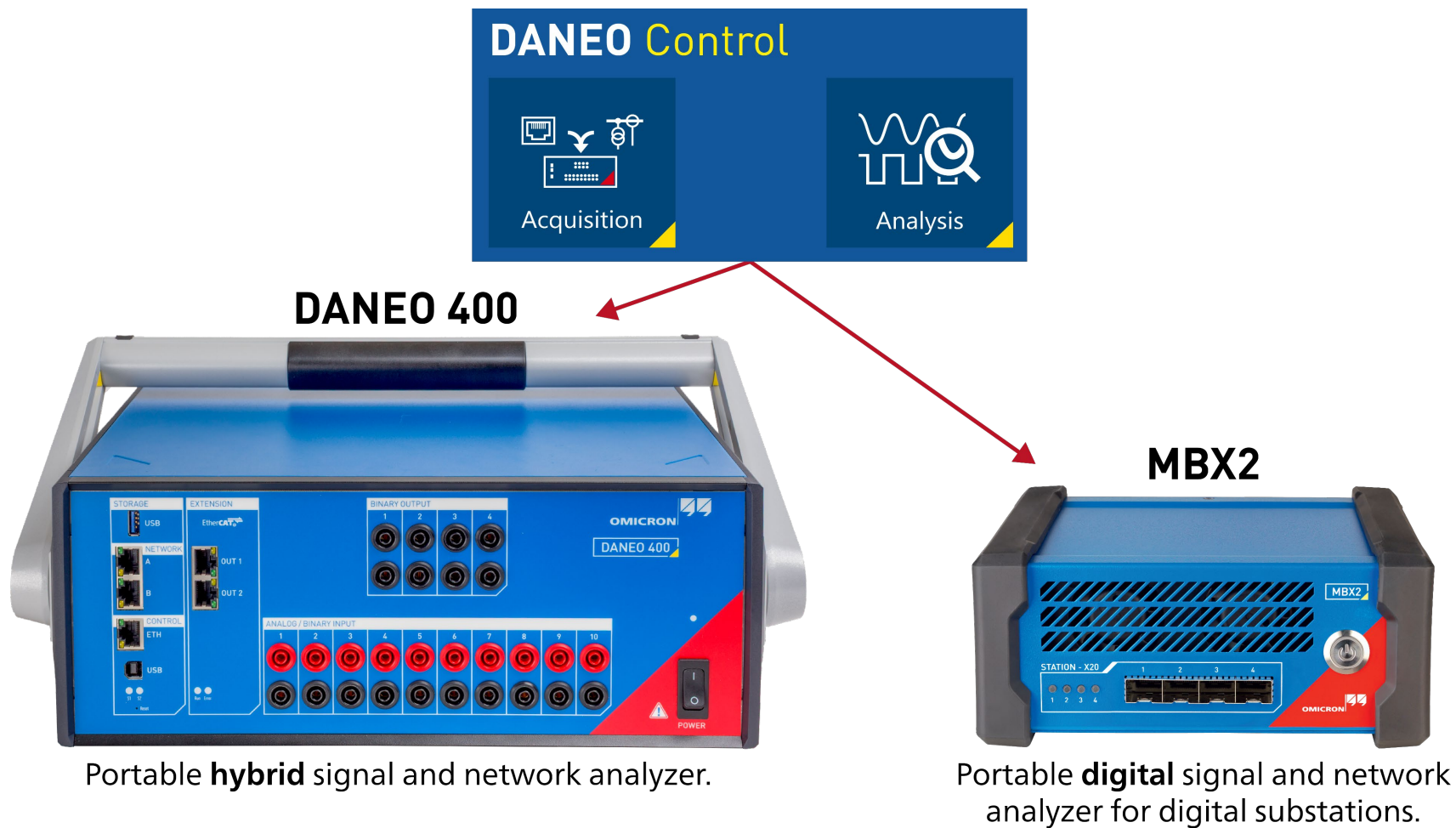
- ▶ Advanced **measurement and recording system**
 - ▶ **Hybrid** – conventional signals and messages on the communication network
 - ▶ **Digital** – sufficient performance for digital substations
 - ▶ **Distributed** – multiple time-synchronized units
- ▶ **Network traffic analyzer** for testing and troubleshooting substation communication networks



▶ Main applications

- ▶ Network traffic observation
- ▶ Verification of IEC 61850 process bus traffic based on SCL information
- ▶ Measurement and (virtual) wiring check
- ▶ Troubleshooting sporadic events with targeted supervision and recording
- ▶ Communication network testing and performance assessment
- ▶ PTP time synchronization testing
- ▶ Merging Unit and LPIT testing
- ▶ Sampled Values publishing

► One software – Multiple devices



► DANEQ 400: The hybrid device



► Your benefits with DANE0 400

- ▶ Simultaneous processing of analog signals and network communication traffic
 - ▷ Comparison of analog with digital signals (MU testing)
 - ▷ Binary outputs for trigger indication
 - ▷ Binary I/O accessory EXB1
- ▶ Distributed time-synchronized analog measurement and fault recording system
- ▶ IEC 61850 process bus testing in substations with limited number of SV streams



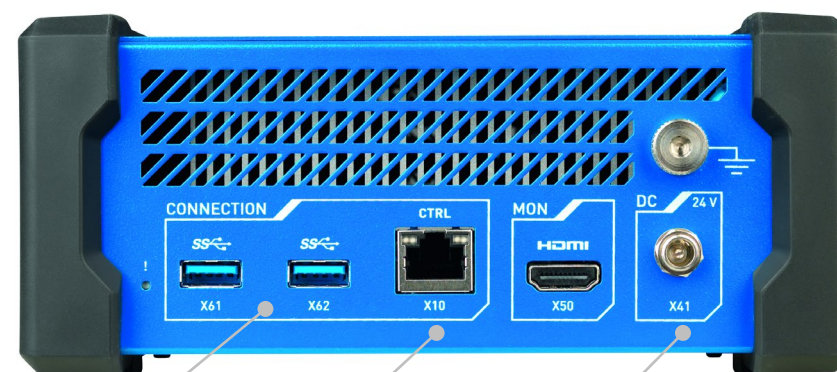
▶ DANE0 MBX2: The digital device



DIN-rail mounting



Secure cryptoprocessor



USB ports (not supported yet)

Control Ethernet port

DC input

► Your benefits with DANE0 MBX2

- ▶ Optimized for digital-only environments with sufficient performance for digital substations
 - ▶ More Sampled Value streams supported
 - ▶ More measurement signals for Phasor, RMS, and Harmonics
- ▶ Small and portable or installation with DIN-rail and DC power supply
- ▶ More network interfaces and flexibility with SFPs
 - ▶ 4 dedicated ports for connection to different segments of communication networks
 - ▶ High flexibility due to SFPs for media-specific transceiver (fiber-optic and copper)
- ▶ Cybersecurity
 - ▶ Future-proof and cybersecure device



► Comparison DANE0 400 and MBX2

Device	DANE0 400	MBX2
Analog/binary inputs	10	0
Network ports	3 x Ethernet (A, B, ETH) EMCON 200 accessory for fiber connections available	1 x Control Ethernet (CTRL) 4 x SFP slots (1,2,3,4) SFP transceiver module (copper, fiber) accessories available
Network TAP	Yes	Not supported yet
USB ports	1 x Control port 1 x External storage	Not supported yet
Internal storage	~ 60 GB	~ 240 GB
Binary I/O extension	Yes EXB1 accessory	No
Binary outputs	4	0
Built-in capabilities	Not designed for permanent installation; only with some workarounds and compromises	DIN-rail mounting accessory
Power supply	AC	AC 48-60 VDC 110-220 VDC

► License options

License	DANEO 400 Basic	DANEO 400 Standard	DANEO MBX2 Basic	DANEO MBX2 Standard
SV measurement and recording	n/a	5	8	24
SV supervision	n/a	10	16	32
Phasor, RMS, frequency measurements	34 channels	34 channels	64 channels	64 channels
Harmonics measurement	12 channels 25 th orders	12 channels 25 th orders	32 channels 64 th orders	32 channels 64 th orders
GOOSE input signals	n/a	244	512	512
SV quality attribute mappings	n/a	256	256	256
SV publishing (only 9-2 LE streams)	n/a	3	8	16
IED discover and server verification	n/a	yes	Not supported yet	Not supported yet

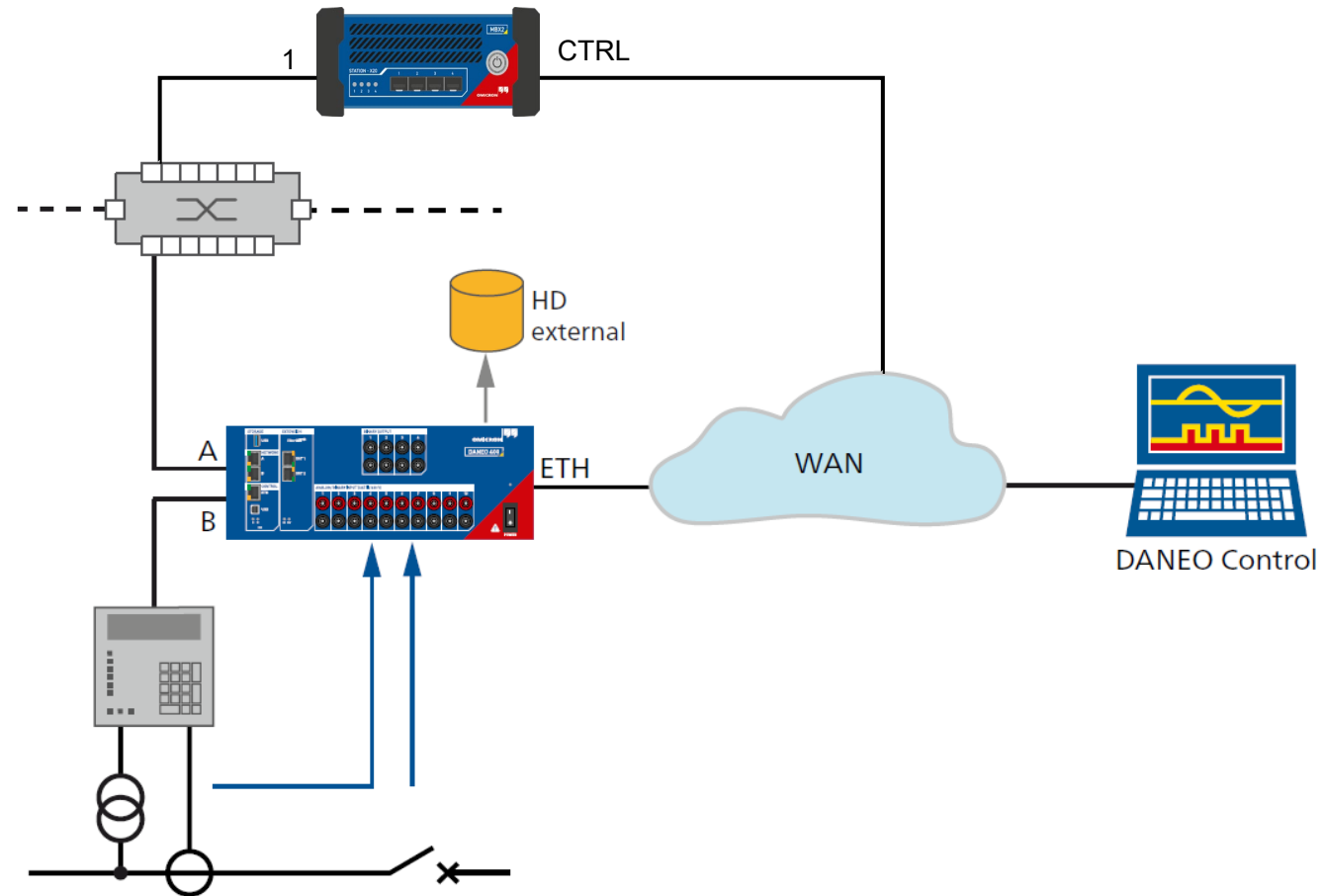
► One solution - Multiple use cases

- Measurement and recording
- Network testing
 - Verification IEC 61850 process bus traffic and redundancy check
 - Targeted supervision of network traffic
 - Assessment of network performance
- Merging Unit testing



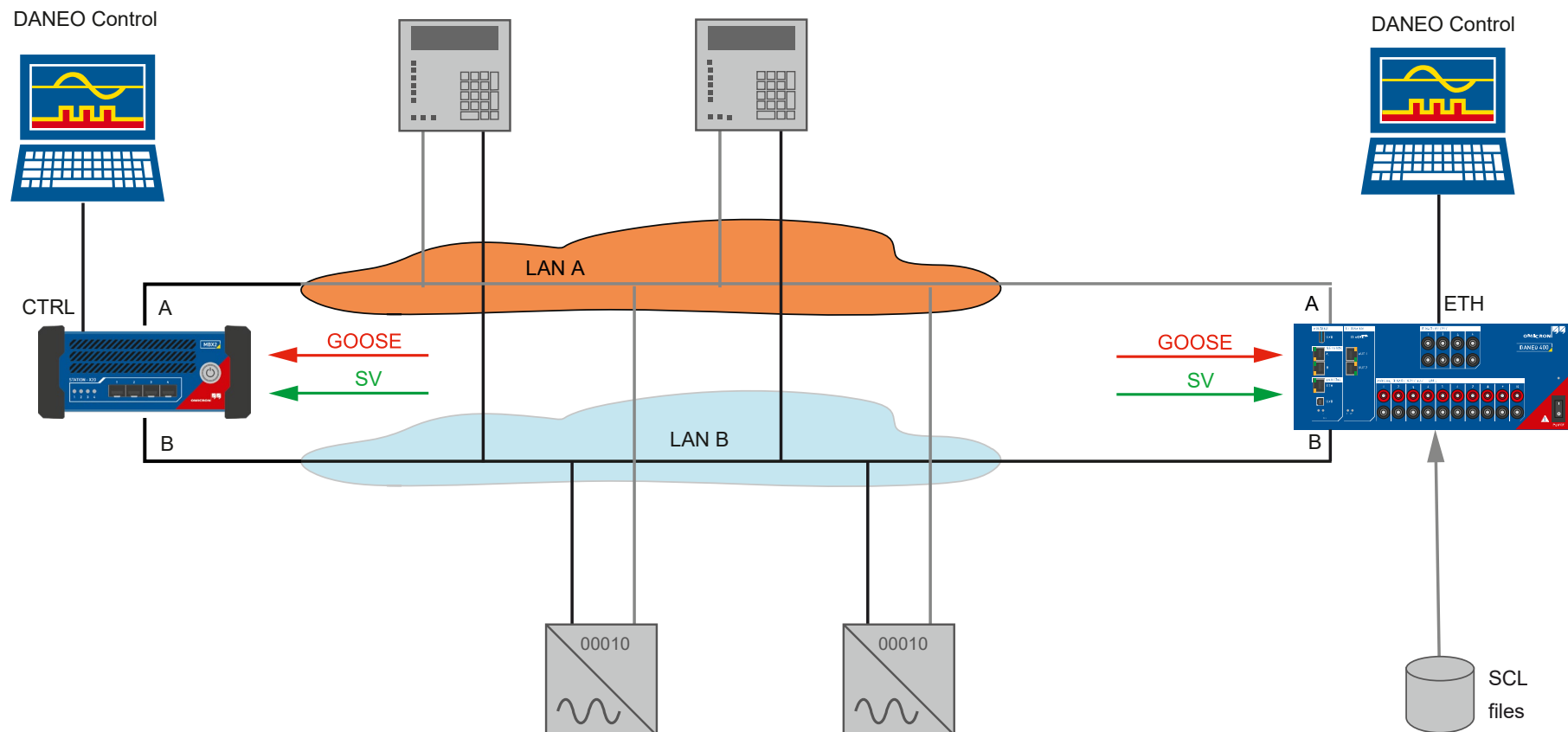
► Measurement and recording

- Conventional signals and messages on the communication network
- Unattended operation
- External storage option
(only for DANEO 400)
- Remote control



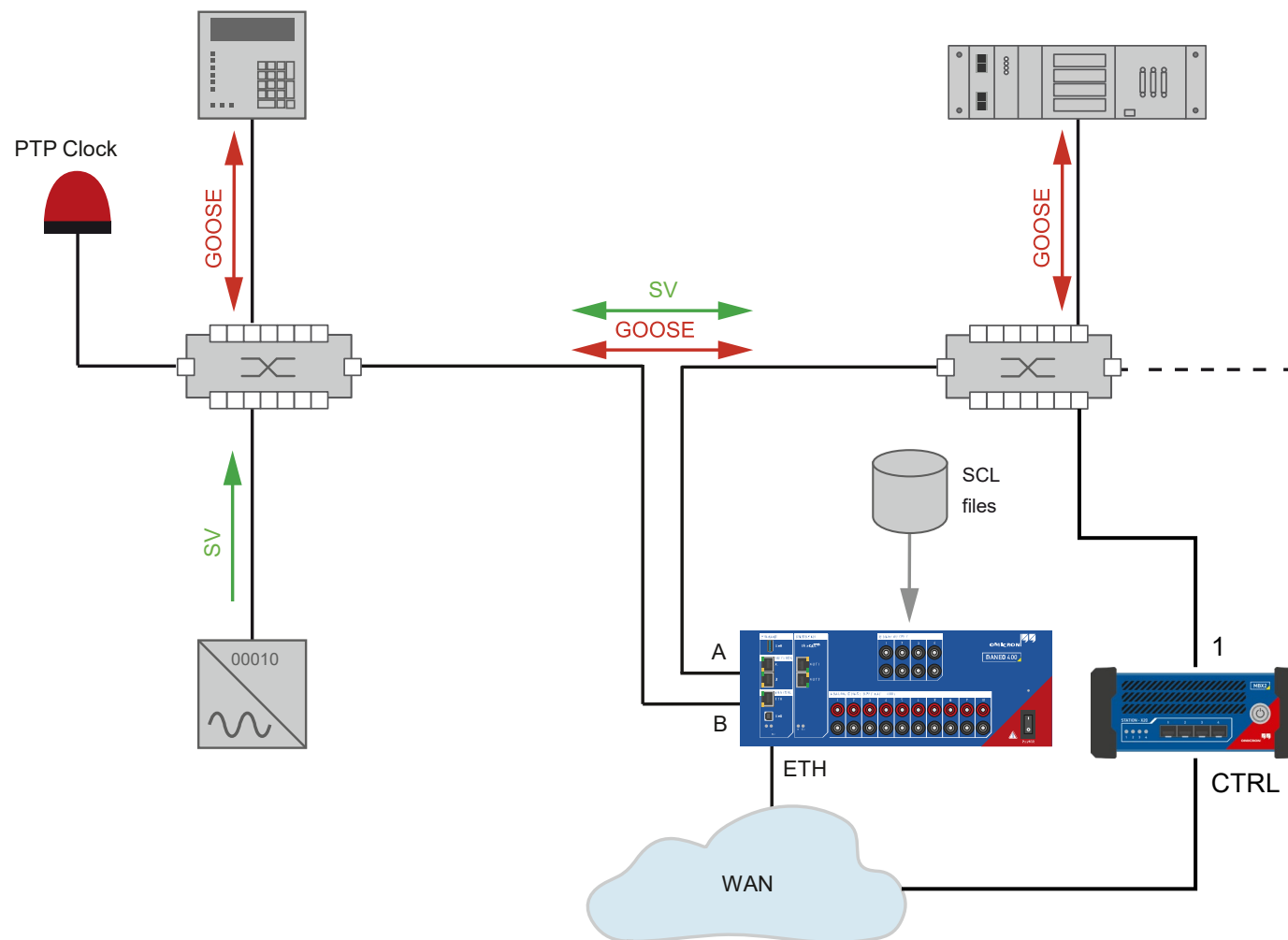
► Verification of IEC 61850 process bus traffic and redundancy check

- Verify process bus traffic based on SCL information
- PRP and HSR redundancy network topologies



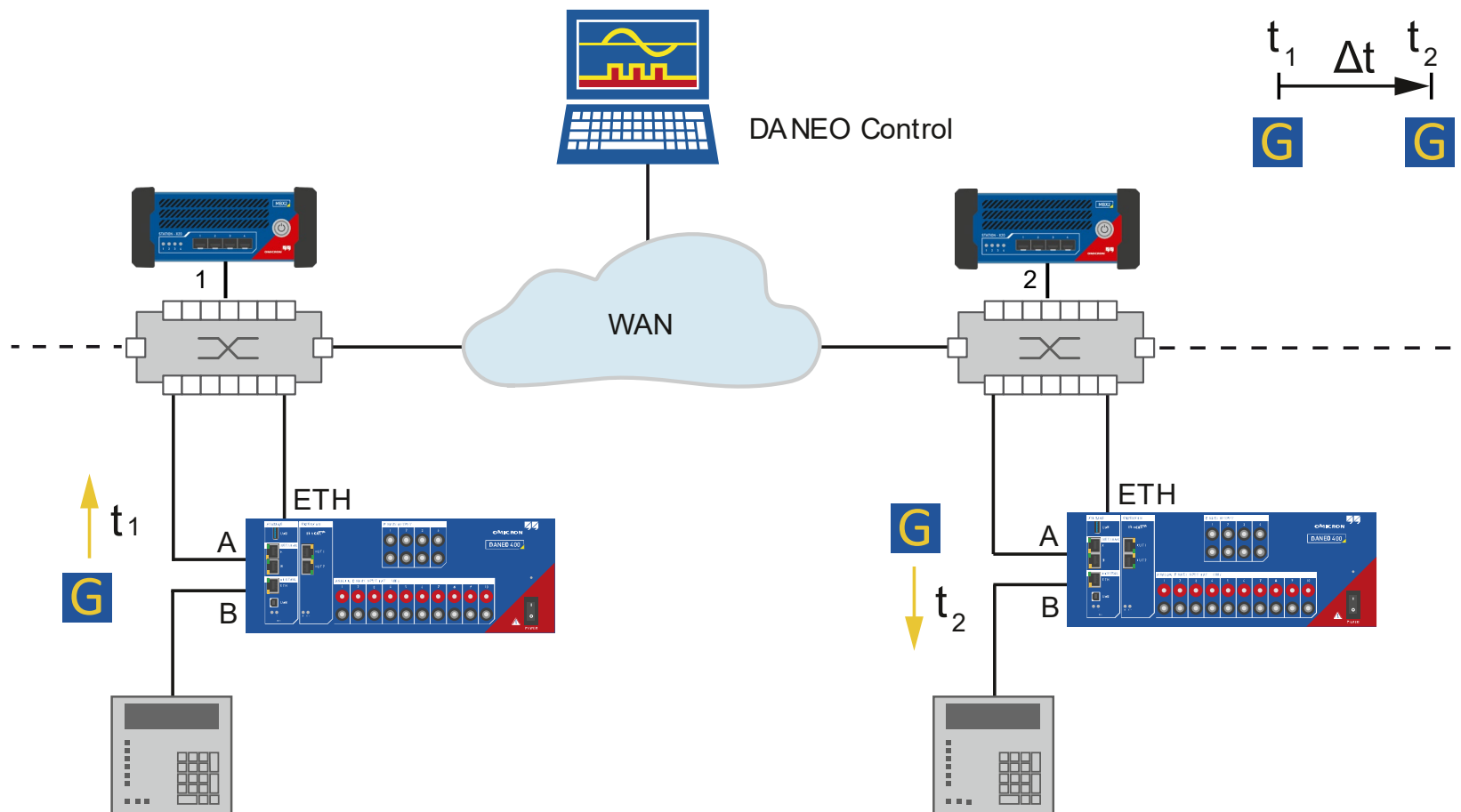
▶ Targeted supervision of network traffic

- ▶ Detection of GOOSE, R-GOOSE, Sampled Values, and PTP issues
- ▶ Actions for events
- ▶ Integrated Network TAP
(only for DANE0 400)



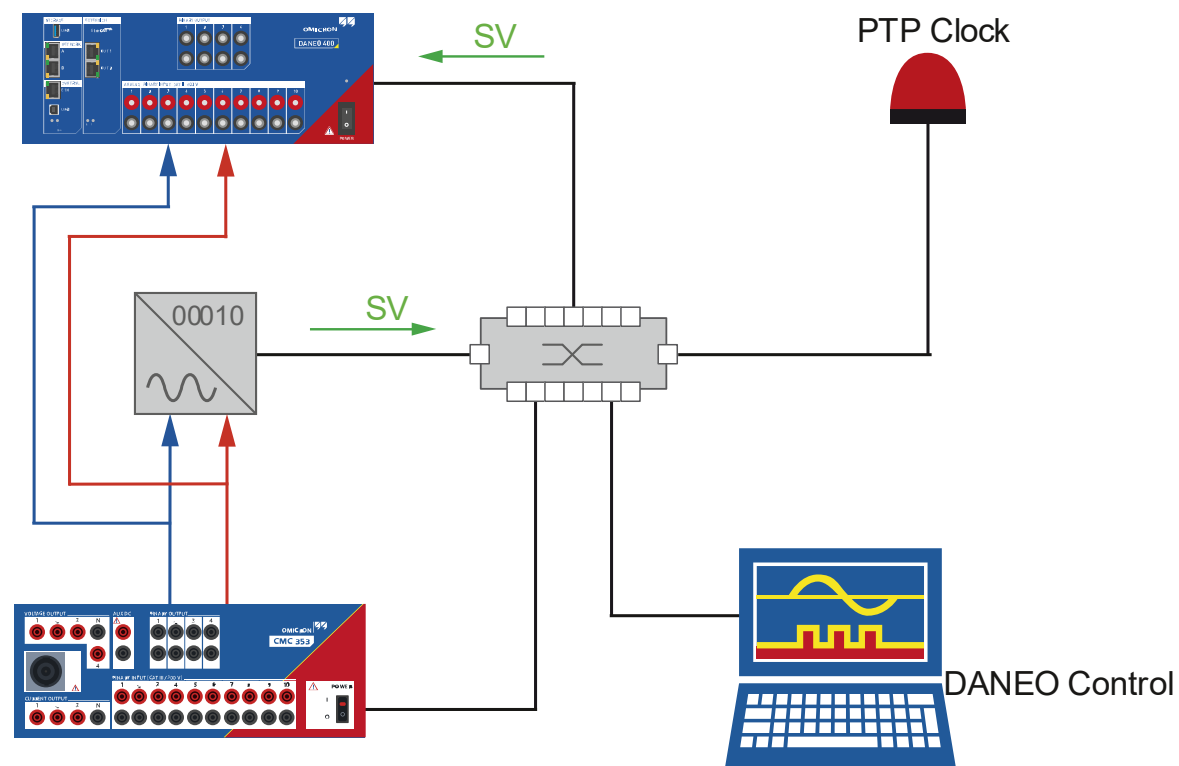
▶ Network performance assessment

- ▶ Bandwidth usage
- ▶ Packet propagation delays

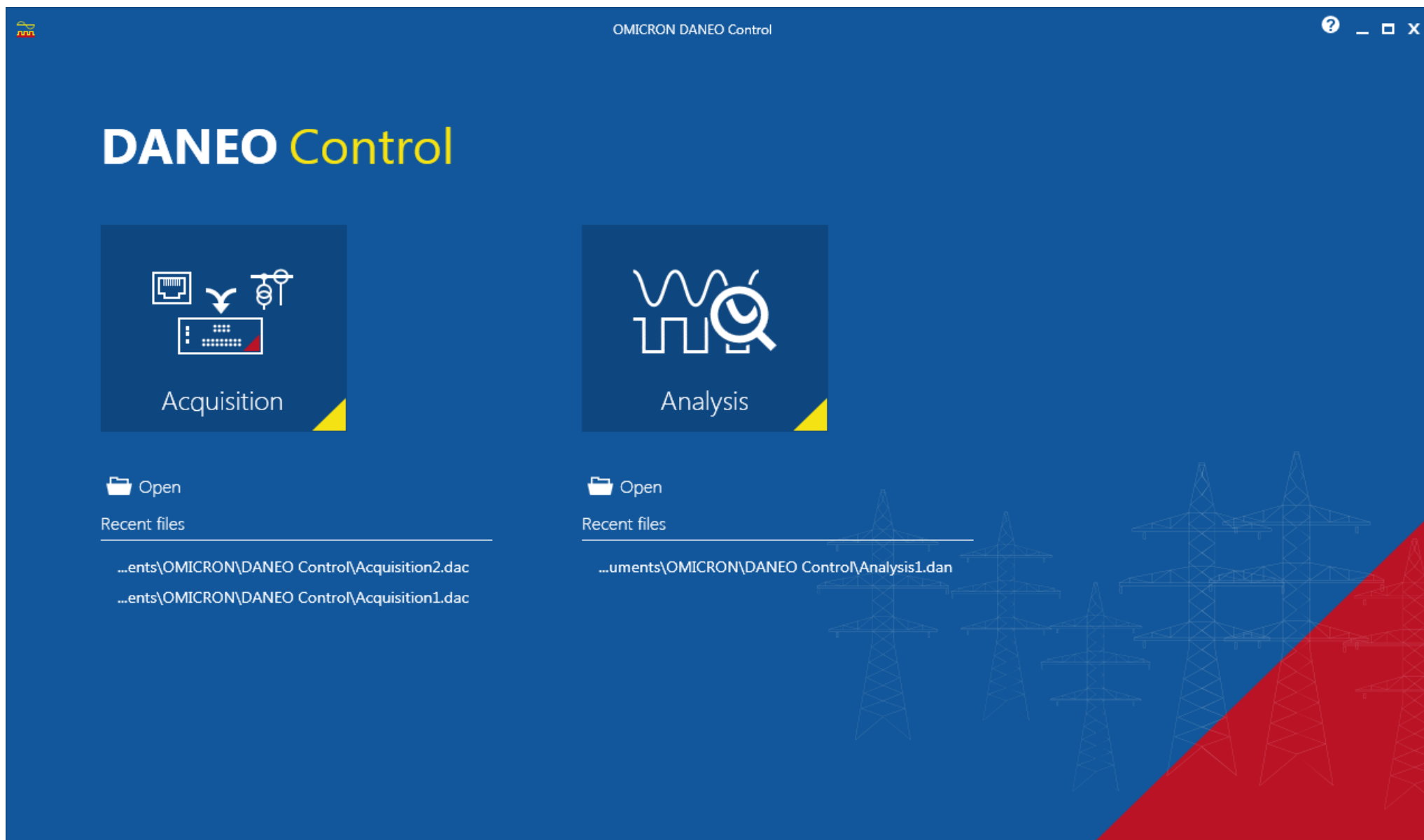


► Merging Unit testing

- Comparison of inputs with outputs
- Performance analysis (packet intervals, packet delays)
- Troubleshooting of data anomalies, packets dropped, synchronization or quality problems



▶ DANE0 Control - data acquisition and analysis



Configuration

Observation

Verification

Supervision

Recording

Analysis

Documentation

► Configuration

► Measurement system

- Device connections, time source, and inputs
- Harmonics, phase and power systems, calculated signals

► System under test

- Import IEDs from SCL files
- Map GOOSE, R-GOOSE, and SV data to signal pool

Analog settings				
Sampling frequency	40 kHz			
Nominal frequency	50,000 Hz			
Inputs				
1	2	3	4	5
Name	Name	Name	Name	Name
V1	V2	V3	I1	Bin1
Range	Range	Range	Range	
100 V	100 V	100 V	10 V	
Factor	Factor	Factor	Factor	
1,10 kV/V	1,10 kV/V	1,10 kV/V	1,00 kA/V	

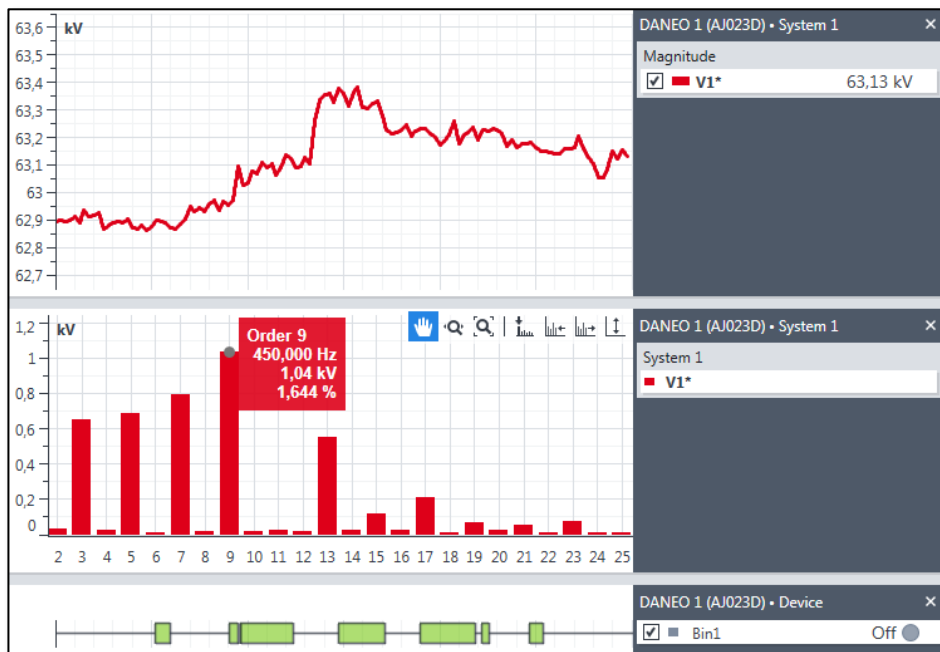
Analog and binary input configuration

Phases			
V1	RMS	AC	DC
V2	RMS	AC	DC
V3	RMS	AC	DC

Signal pool

Observation

- ▶ Measurement of live values and most recent history
- ▶ Instantaneous values
- ▶ Phasor diagrams and harmonics spectrum
- ▶ GOOSE, R-GOOSE, and SV values and statistics



Live values and recent history

G ISIO_AM174KCB/LLN0\$GO\$GCB			
Details			
Statistics			
	A	B	ETH
Receive time			2017-02-01 16:09:12.054
Packet count			656
Status changes seen			136
Status changes missed			3
Retransmissions missed			12
Duplicates seen			0
Time to live expired			False
Time to live expired count			2
Packet delay:			
Minimum			2,60 ms
Maximum			4,09 s
Average			32,93 ms
DataSet - ISIO_AM174KCB/LLN0\$GooseDataSet1			
Name	Type	Value	Ports
DA XCBR1.Pos.stVal	Dbpos	01	A B ETH
DA XCBR1.Pos.q	Quality	Good	A B ETH
DA XCBR2.Pos.stVal	Dbpos	00	A B ETH
DA XCBR2.Pos.q	Quality	Good	A B ETH

GOOSE data values and statistics

► Verification of IEC 61850 process bus traffic

- Verify process bus traffic based on SCL information
- List all GOOSE, R-GOOSE and SV orphans
- Check differences and missing IEDs

System Verification				
☒ IEDs	☒ Server	☒ G & SV	Result	
☒ IED1	✓	✓	✓	
☒ IED2	⚠	✓	⚠	
☒ IED3	✗	✗	✗	
☒ IED4	⚠	⚠	⚠	
☒ IED5	⚠	✗	⚠	
☒ IED6	—	✗	✗	
☒ IED7	✓	✗	⚠	

Start Clear Stop Close

Verification overview

Orphans	
GOOSE (18)	
✓ AA1J1Q01A1LD0/LLN0\$GO\$gcbGeneralTrip	
✓ AA1J1Q01A1LD0/LLN0\$GO\$gcbGGIOPos	
✓ AA1J1Q01A1LD0/LLN0\$GO\$gcbOC1	
✓ AA1J1Q01A1LD0/LLN0\$GO\$gcbSwitchPos	
✓ BRAHMA_1234567890__brahmaBX/LLN0\$GO\$GCB	
✓ IED_000000009MU01/LLN0\$GO\$Control_DataSet	
✓ ISIO_AE005JBX/LLN0\$GO\$GCB	
✓ ISIO_AM174KBX/LLN0\$GO\$GCB	
✓ ISIO_AM193KPROT/LLN0\$GO\$GCB	
✓ ISIO_BF279KSW/LLN0\$GO\$GCB	
✓ ISIO_BF288KBX/LLN0\$GO\$GCB	
✓ OMIC1CB/LLN0\$GO\$gcST	
✓ OMIC2CB/LLN0\$GO\$gcST	
✓ Q1_SCB/LLN0\$GO\$gcST	
✓ Q2_SCB/LLN0\$GO\$gcST	
✓ RIO1LD0/LLN0\$GO\$RIO600	
✓ S7SJ86Ln1_5051NOCgndA1/LLN0\$GO\$Control_DataSet	
✓ S7SJ86Ln1_5051OC3phA1/LLN0\$GO\$Control_DataSet	
SV Sampled Values (1)	
✓ SIEMENSMU0101	

00:00:14 Close

GOOSE and SV orphans list

► Process bus network redundancy check

- Compare raw traffic and IEC 61850 GOOSE, R-GOOSE, Sampled Values
- Automatic detection of issues in PRP trailers and HSR headers or incorrect cabling of IEDs

Network Redundancy Check				
MBX2 - Digital	A PRP_A	B PRP_B		Result
Raw traffic	1,6 MB/s	1,6 MB/s		0,0 B/s
SV Sampled Values	2	2		✓
	MU0001 A	MU0001 B		✓
	MU0002 A	MU0002 B		✓
R-G R-GOOSE	1	1		✓
	RTUBinIO_BinaryInputs/LLN0\$RG\$Control_DataSet A	RTUBinIO_BinaryInputs/LLN0\$RG\$Control_DataSet B		✓
SV Sampled Values simulated	1	1		✓
	OMICRON_CMC_SV1 A	OMICRON_CMC_SV1 B		✓
G GOOSE	4	4		✗ 1
	AA1_Bay1_M1Master/LLN0\$GO\$Trip A	AA1_Bay1_M1Master/LLN0\$GO\$Trip B		✓
	ISIO_123456789CB/LLN0\$GO\$GCB B	ISIO_123456789CB/LLN0\$GO\$GCB A		✗
	LPUSystem/LLN0\$GO\$gcb01 A	LPUSystem/LLN0\$GO\$gcb01 B		✓
	TFPULine1_CB_QA1/LLN0\$GO\$SETGooseCB_1 A	TFPULine1_CB_QA1/LLN0\$GO\$SETGooseCB_1 B		✓

▶ Start ↖ Clear ■ Stop Close

Targeted supervision

- ▶ Live view of supervisor event list
- ▶ Select GOOSE, R-GOOSE and Sampled Values for supervision
- ▶ Define actions for triggering recordings

Event list			
	Date and Time	Device	Category
✖	2015-10-16 15:49:35.049	DANEO 1 (AJ023D)	GOOSE
i	2015-10-16 15:48:44.576	DANEO 1 (AJ023D)	Device
✖	2015-10-16 15:48:43.109	DANEO 1 (AJ023D)	GOOSE
i	2015-10-16 15:48:34.576	DANEO 1 (AJ023D)	Device
i	2015-10-16 15:45:56.572	DANEO 1 (AJ023D)	Device
i	2015-10-16 15:45:47.571	DANEO 1 (AJ023D)	Device
i	2015-10-16 15:45:27.099	DANEO 1 (AJ023D)	Recording
i	2015-10-16 15:45:23.672	DANEO 1 (AJ023D)	PTP
i	2015-10-16 15:45:23.672	DANEO 1 (AJ023D)	Device
i	2015-10-16 15:45:21.950	DANEO 1 (AJ023D)	Recording
i	2015-10-16 15:45:18.663	DANEO 1 (AJ023D)	PTP

Details	
Severity	Error
Date and Time	2015-10-16 15:49:35.049
Device	DANEO 1 (AJ023D)
Category	GOOSE
Type	Out of sequence
Port	B
Control block reference	ISIO_AM174KBX/LLN0\$GO\$GCB
Destination MAC address	01-0C-CD-01-00-00
Source MAC address	20-B7-C0-00-3E-89
Application ID	1
GOOSE ID	GoID
DataSet reference	ISIO_AM174KBX/LLN0\$GooseDataSet1
Simulation/Test	False
Status number	1 (previous: 1)
Sequence number	0 (previous: 34)

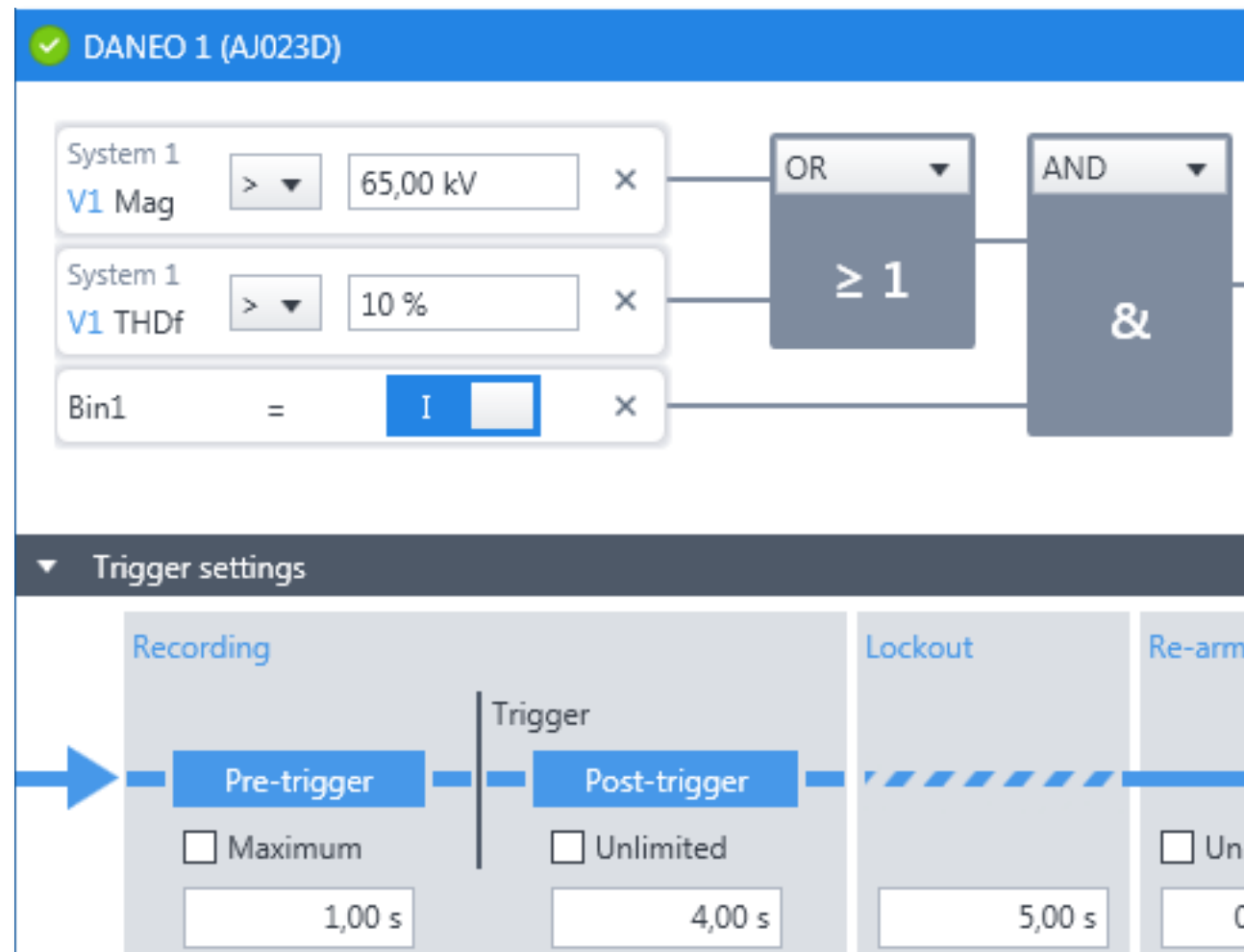
Event list

Action	
Name	My Action
Binary	☒ ☐
Name	GOOSE_Error
Hold time	2,00 s
Filter	
Devices	Severity
☒ ▶ DANEO 1 (AJ023D)	☒ ✖ Error
	☐ ⚠ Warning
	☐ i Information
Advanced	
☒ GOOSE	☐ Sampled Values
☒ ✖ Time to live expired	☐ ✖ Timeout
☒ ✖ Out of sequence	☐ ✖ Out of sequence
☒ ✖ Parsing error	☐ ✖ Parsing error
☐ ⚠ Never seen	☐ ⚠ Never seen
☐ ⚠ Validity not 'Good'	☐ ⚠ Validity not 'Good'
☐ i Quality Test changed	☐ i Quality Test changed
☐ PTP	☐ Device
☐ ✖ Synchronization lost	☐ ✖ Operation error
☐ ⚠ Grandmaster accuracy changed	☐ ⚠ Operation warning

Supervisor action

Recording

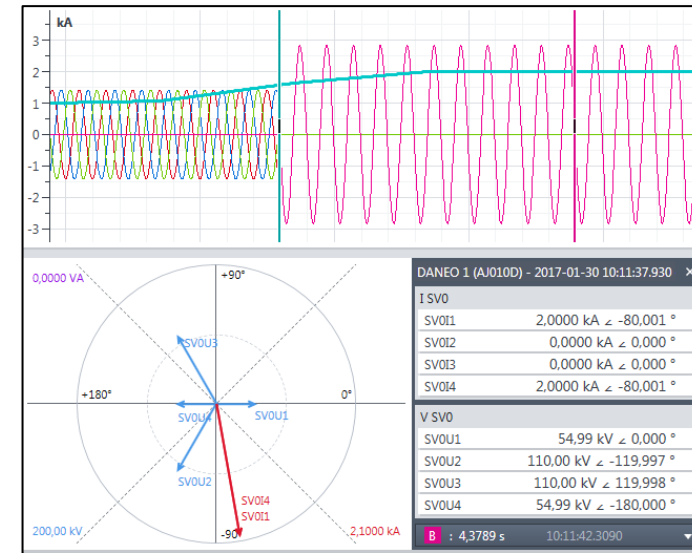
- ▶ Select signals from the signal pool
- ▶ Configure network traffic capture with filter options
- ▶ Define trigger conditions
- ▶ Store recordings on the internal disc or external USB storage



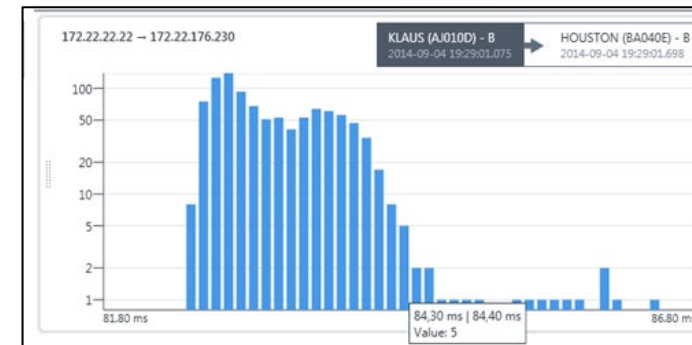
Trigger conditions

► Analysis

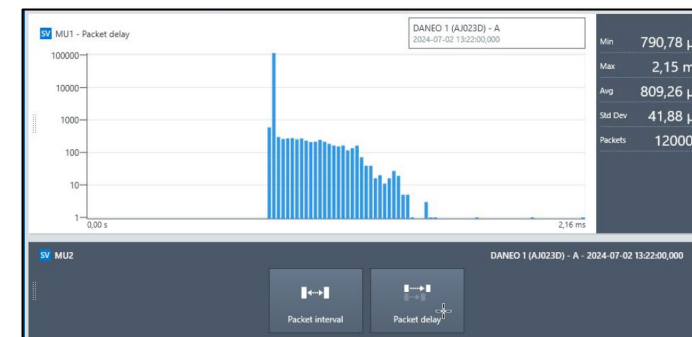
- Analyze signals in aggregated time-aligned view
- Check network traffic and analyze hidden circumstances on the network
- Analyze timing of Merging Units
- Measure propagation delay of network packets
- Browse supervisor events archive
- Export data in COMTRADE or PCAP format



Time Signal view



Packet propagation delay



Sampled Values timing

► Documentation

- Measurement system configuration
- Test results and analysis of recordings
- Export reports as MS Word

Export a Report

Configurations

☒ Network Diagram

☒ Measurement System

☒ Recording

☒ Supervision

Test results

☒ System Verification

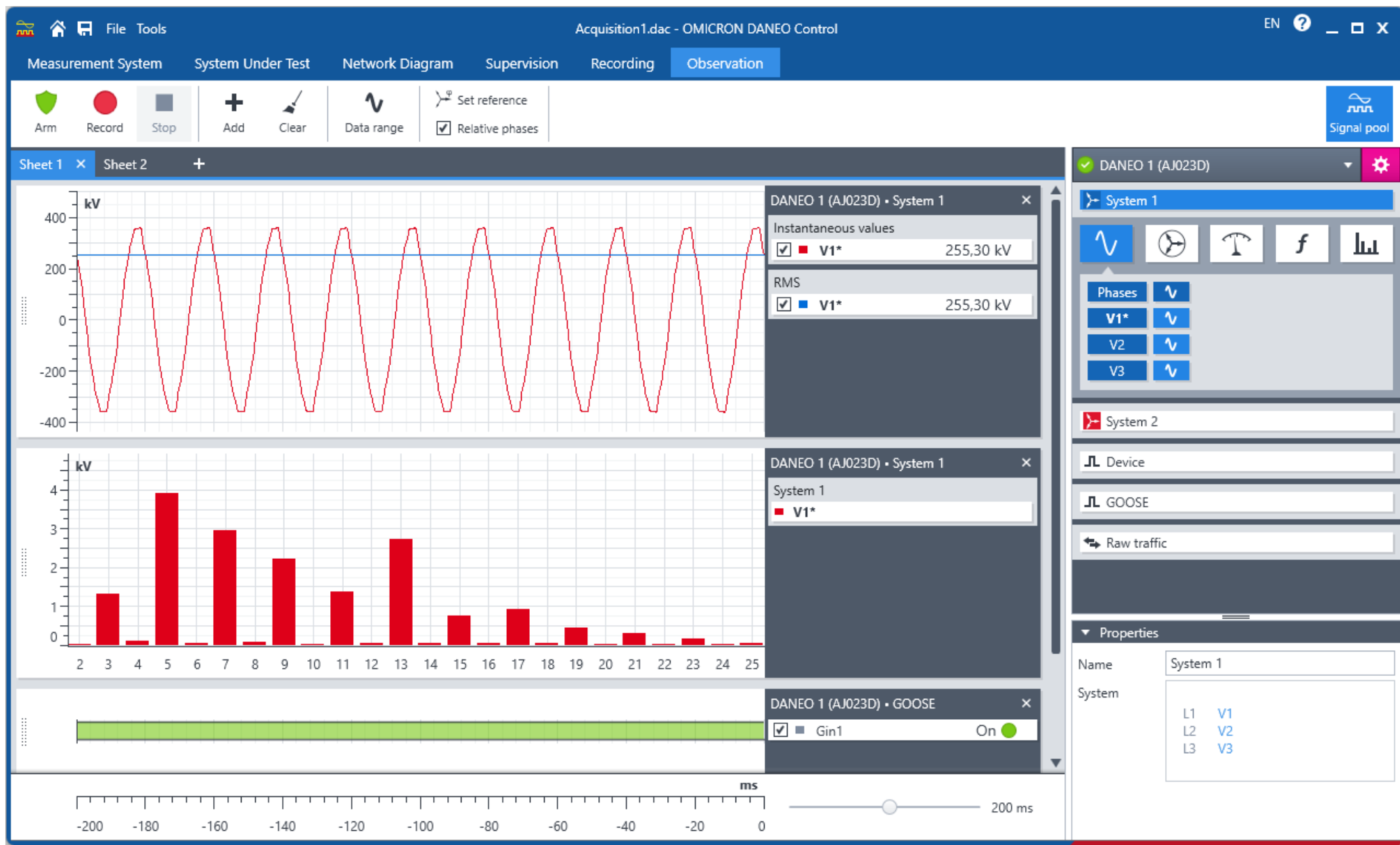
☒ System Under Test

☒ Network Redundancy Check

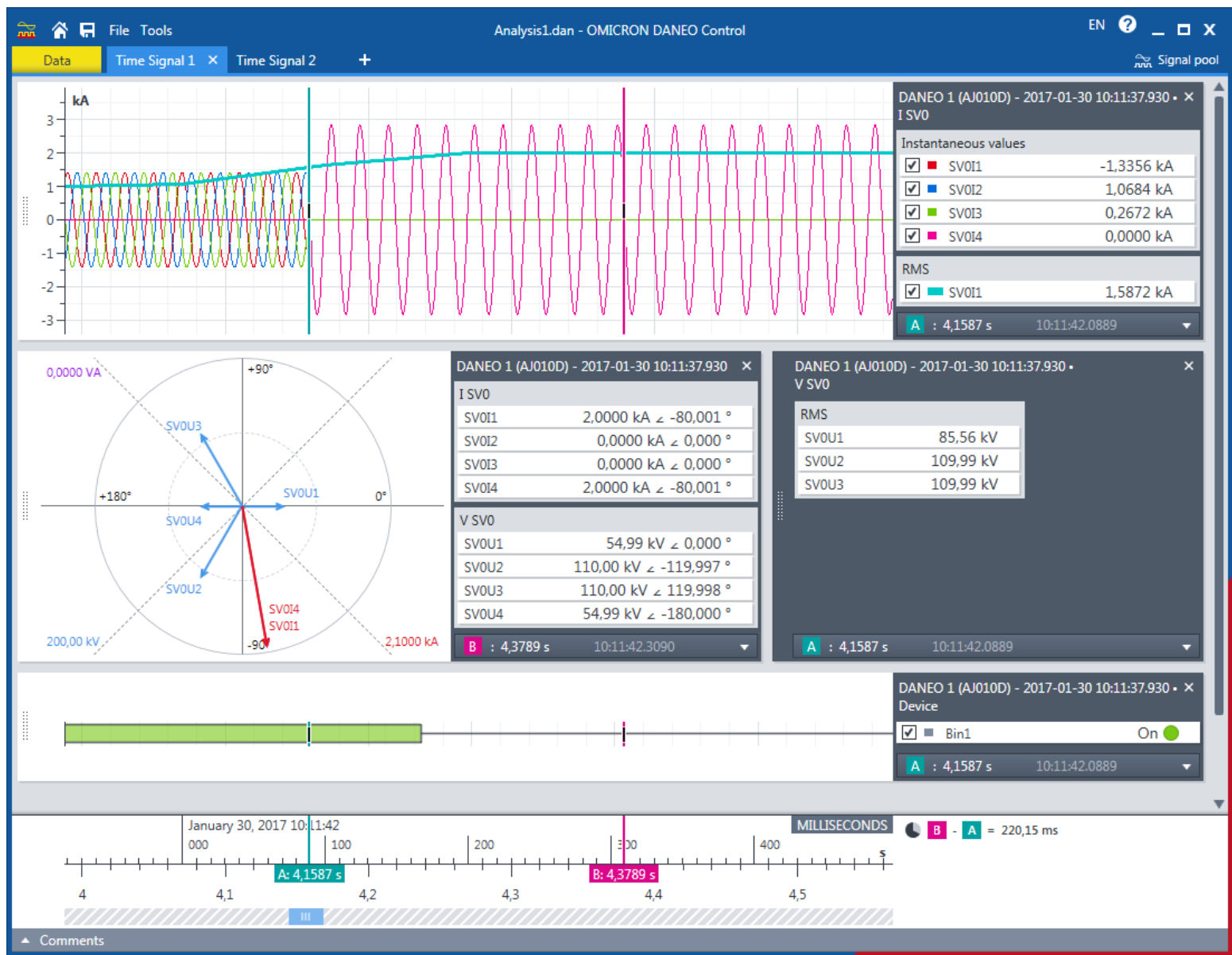
Export to Word **Close**

Report content selection

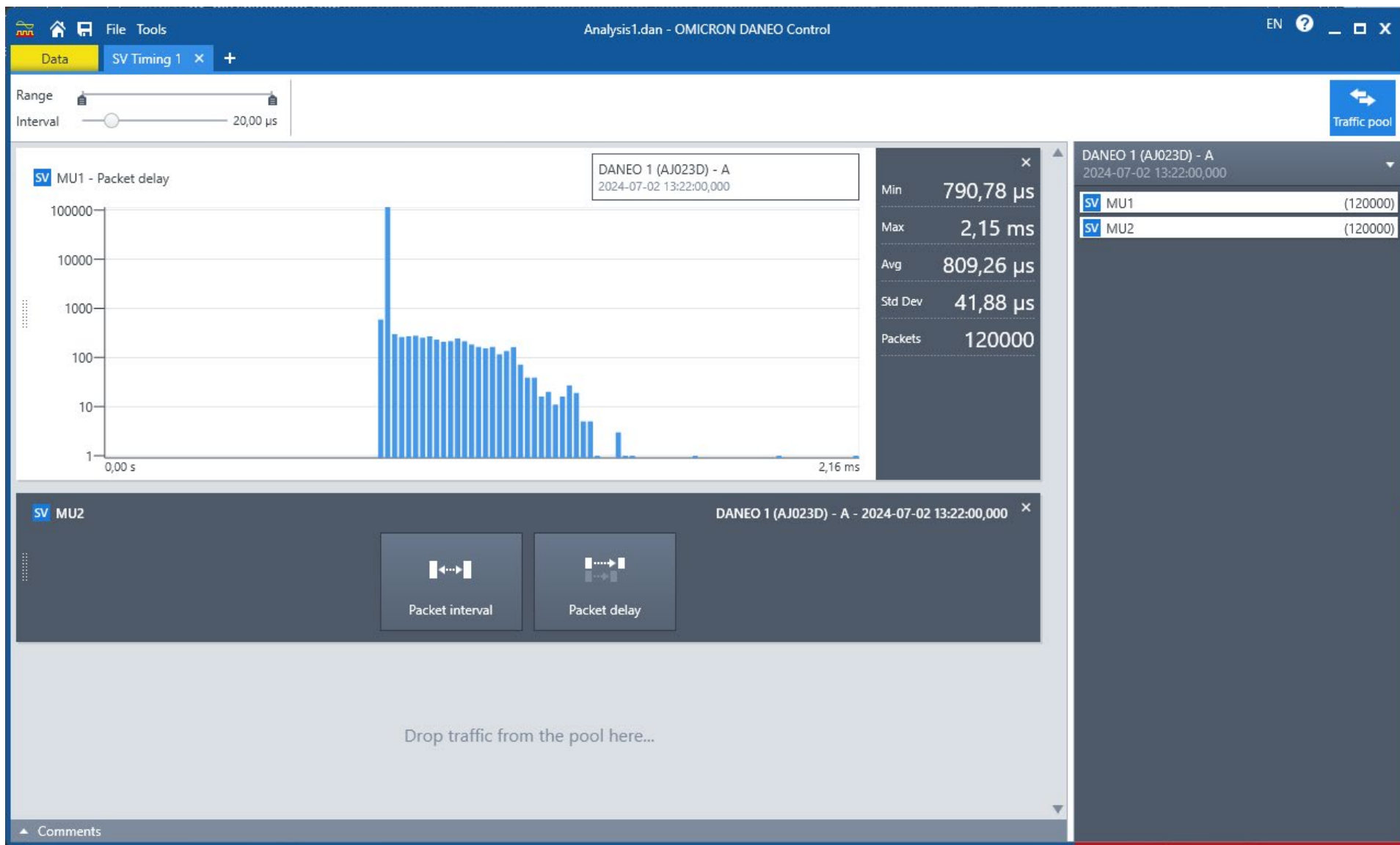
► Observation of actual values and recent history



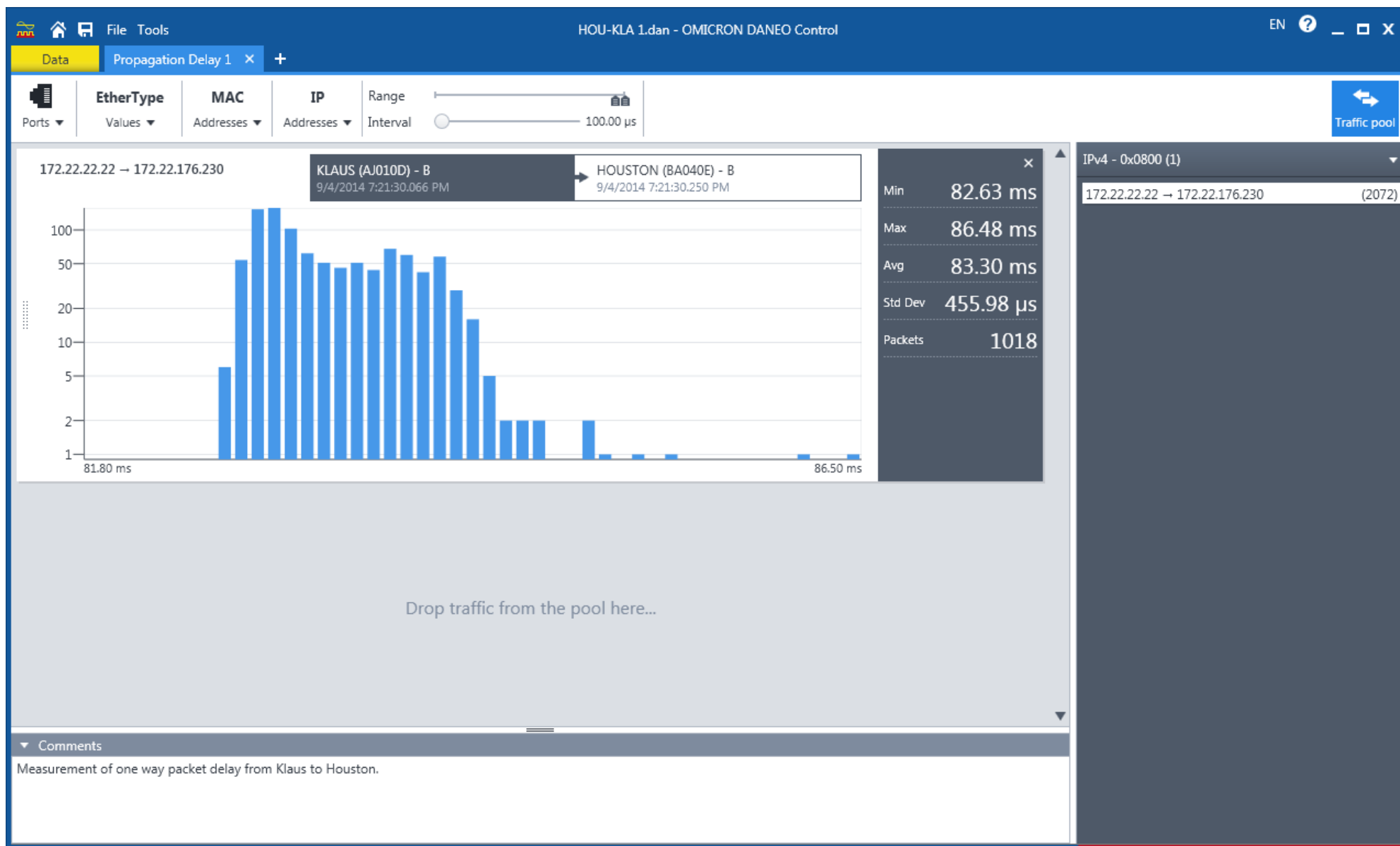
Time Signal analysis



► Sampled Values timing analysis



► Propagation delay measurement



PTP Sniffer

PTP Sniffer - DANE0 1 (AJ023D)

PTP sources

Status	Port	Protocol	Domain
✓	B	IEEE 802.3	0
✓	ETH	IEEE 802.3	11
✓	ETH	IEEE 802.3	0

PTP source details

Delay mechanism	Peer-to-Peer
Announce interval	1 s
Sync interval	1 s
Other peers	1
Best master available	True
Packet errors	0

PTP masters

1@20-B7-C0-FF-FE-00-39-42 (Best master)

Power profile GM Id	3
Power profile version	1
MAC address	20-B7-C0-00-39-42
VLAN ID	not present
VLAN priority	not present
GM identity	20-B7-C0-FF-FE-00-39-42
GM priority 1	128
GM priority 2	128
GM clock accuracy	WITHIN_100_NS (0x21)
GM clock class	PRIMARY_REF_PTP (6)
GM clock variance	18465
Qualified	Yes
Alternate	No
TLV count	2
UTC offset	35
UTC offset valid	True
Leap 59	False
Leap 61	False
Time traceable	True
Frequency traceable	True
PTP time scale	True
Time source	GPS (0x20)

Restart

Ok

Cancel

▶ Sampled Values publishing

- ▶ Easy configuration in DANEO Control
- ▶ Up to 16 SV streams (IEC 61850 9-2LE) per device
- ▶ Nominal static values or single-phase fault injection

Sampled Values

Network portA

Sampling rate4800 Hz

Number of ASDUs2

Synchronization offset150 µs

SV OMICRON_SV1

+

Configuration	Values
SV IDOMICRON_SV1	Nominal frequency50 Hz
Use simulation flag ☒	Primary voltage100,00 kV
Synchronization statusLocally synchronized (1)	Primary current1,00 kA
Destination MAC address01:0C:CD:04:00:00	Quality0x0000
Source MAC addressFrom device	Fault type (L1-E) ☒
Application ID (hex)4000	Fault voltage50 %
Enable VLAN ☒	Fault current200 %
VLAN ID0	Fault angle80 °
VLAN priority4	
Configuration revision1	

Optimize zoom

▶ IEEE 1588 / PTP grandmaster clock accessory

- ▶ If no PTP present on the network
 - ▶ Dedicated clock delivers time for the DANE0 400
 - ▶ Integrated GPS receiver
 - ▶ Power Profile IEEE C37.238
-
- ▶ OMICRON PTP grandmaster clocks
 - ▶ CMGPS 588 – „the blue egg“
dedicated accessory for DANE0 that uses the power profile
 - ▶ OTMC 100p – „the red egg“
generic configurable clock with power profile support



▶ EXB1 – binary I/O extension accessory

- ▶ Only for DANE0 400
- ▶ Each EXB1 adds 8 binary inputs and outputs to the measurement system
- ▶ Connected via EtherCAT extension interface
 - ▶ EXB1 devices powered with PoE
 - ▶ Daisy chaining of multiple EXB1 units



▶ DANEØ Solution

- ▶ Measurement in power systems
- ▶ Distributed time synchronized recordings
- ▶ Understands IEC 61850 GOOSE, R-GOOSE, Sampled Values
- ▶ Analyzing communication networks and their performance



Thank you for your attention.