

CIGRE-483 Virtual testing lab for digital substation

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Market – Major factors driving the revolution of energy systems ...



Decarbonization

“All electric world” – Fluctuating infeed – e-Mobility



Power production from renewables

Increases by over 300% between 2010 and 2030
Share of renewables goes up to 40% in 2030

Decentralization

Distributed generation – Microgrids – Energy autonomy



New installations distributed power generation

Increases by over 150% between 2010 and 2030
Share of distributed goes up to 67% in 2030

Digitalization

Connectivity – Edge computing – End-to-end



Major industrial companies will use virtual avatars

By 2021, half of the major industrial companies will be using virtual avatars, resulting in productivity gains of up to 10 %

Major Challenges



Time and Costs

- Complexity of the protection system,
- Implementation is time consuming,
- Considerable efforts for testing & commissioning



Outage Management

- Faster energization (green field)
- Shorter outages (planned & unplanned)
- Substation extensions (brown field)



Agility and Flexibility

- Validation of new products,
- Implementation of new protection schemes,
- Fault analysis very complicated



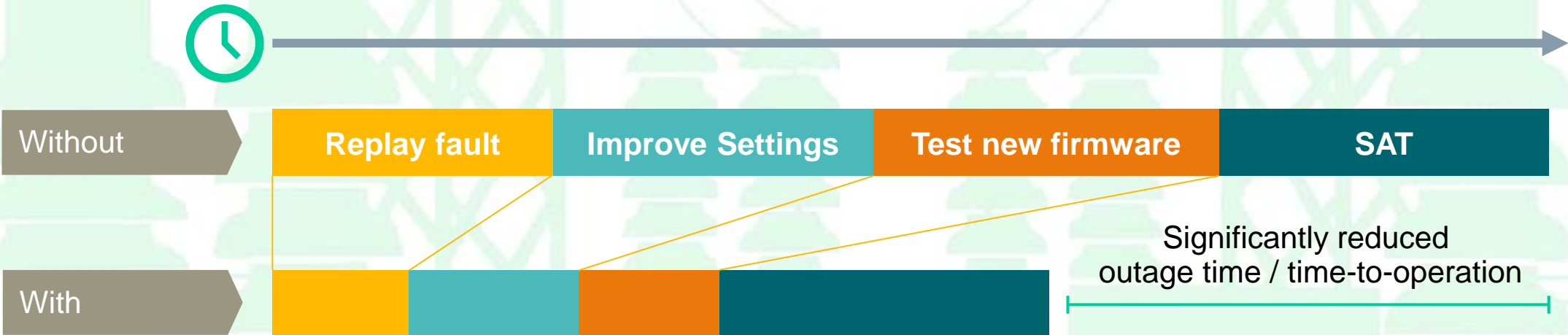
Training and maintenance

- Training costs very high,
- Test lab assets (costly)
- Efficiency of maintenance

Benefits

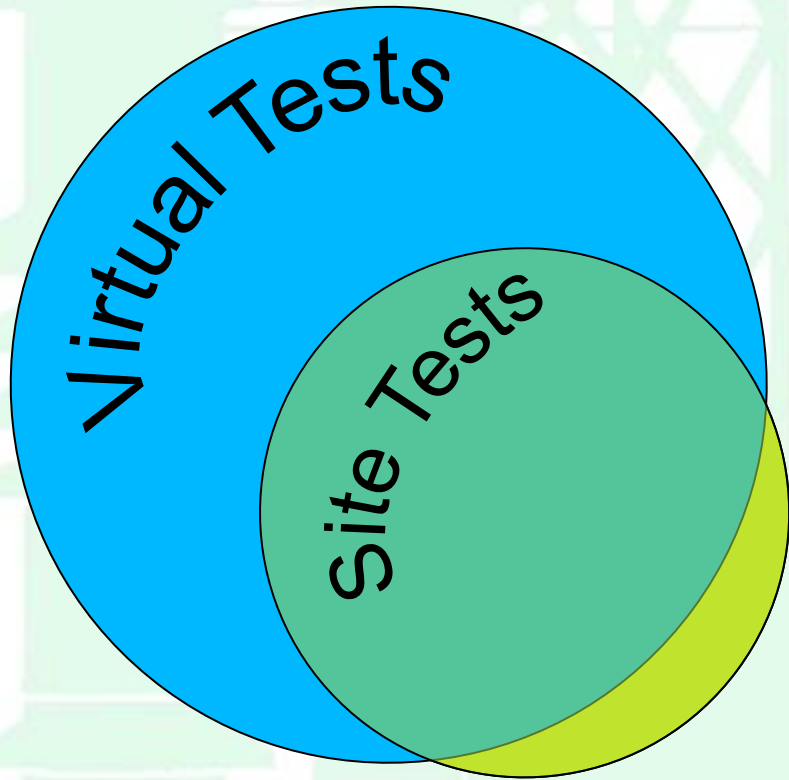
Save time & increase quality throughout the system lifecycle

Example scenario: Fault analysis, system optimization and upgrade



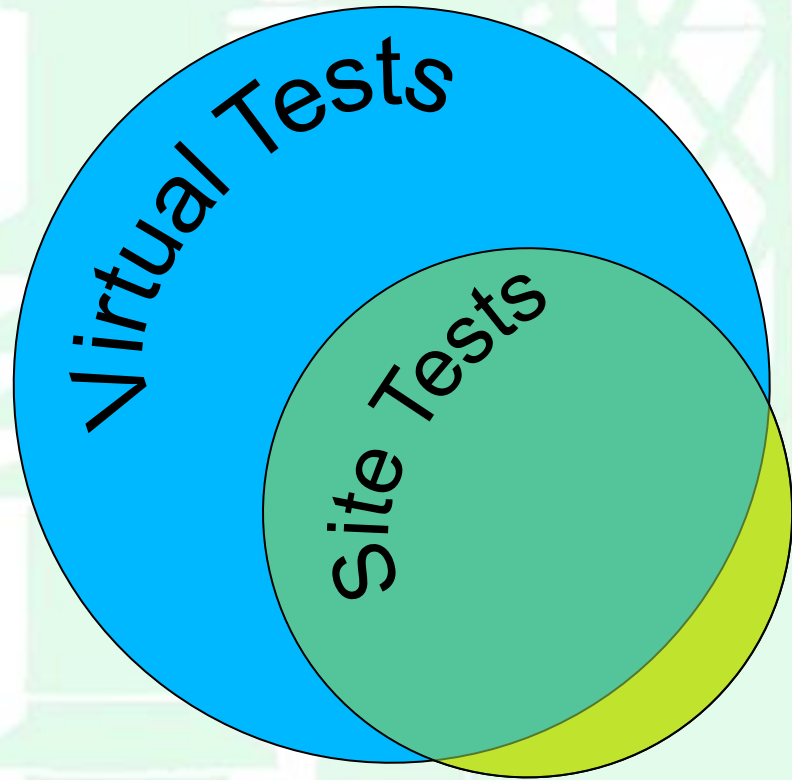
... and all this with **higher quality, flexibility and more customer confidence** in our products and systems

Introduction – Virtual testing of protection relay



- ☐ Verification of parameter settings in relay
- ☐ Current injection to check CT/VT configuration
- ☐ Fault current injection to check protection function operation
- ☐ Operation of CB and lockout with every protection function
- ☐ Verify the logs and fault records on protection operation
- ☐ Verify the signals generates for automation
- ☐ Verify the execution of logics
- ☐ Operation of BOs of execution of logics

Introduction – Virtual testing of protection relay



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Advantages – Virtual testing of protection relay

Once relay configuration and tests et files are validated, it can be re-used in substation



Virtual test can be performed from remote, practically anywhere in the world. Easy to get experts involved from any location.



Several people can work in parallel, for example wiring test at site and function test at remote



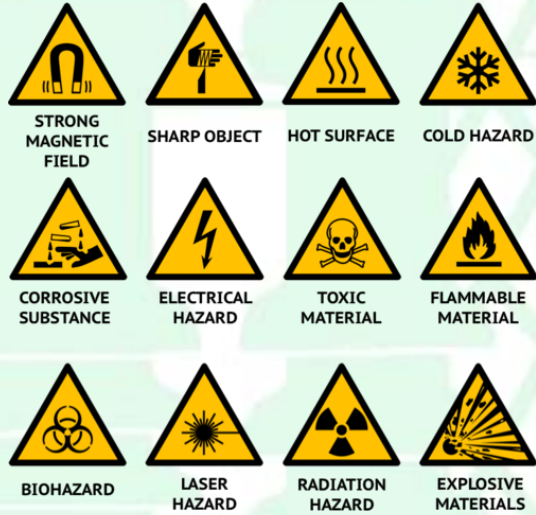
Less time pressure on site and increased quality of the performed tests on site.



Time reduced at site, its very helpful in case of far remote locations. Reduced cost of commissioning hence



Advantages beyond project – Virtual testing of protection relay



It's safe

Convenient training

Revisit the conventional testing lab – Virtual testing of protection relay

Several type of relays required to perform tests on various application according to field requirements

Workforce must be available in lab location, physical wiring changes, making connections per test required

Different software and licenses may be needed

Infrastructure to maintain the costly lab equipment's,

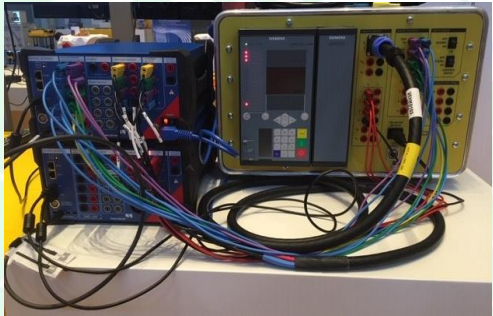
Maintenance expenses like, calibration



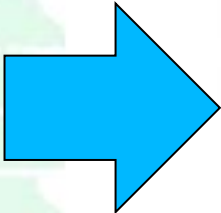
Introduction SIPROTEC Digital Twin – Virtual testing of protection relay



Relay configuration software



Relay test kit Relay to test



Introduction SIPROTEC Digital Twin – Virtual testing of protection relay



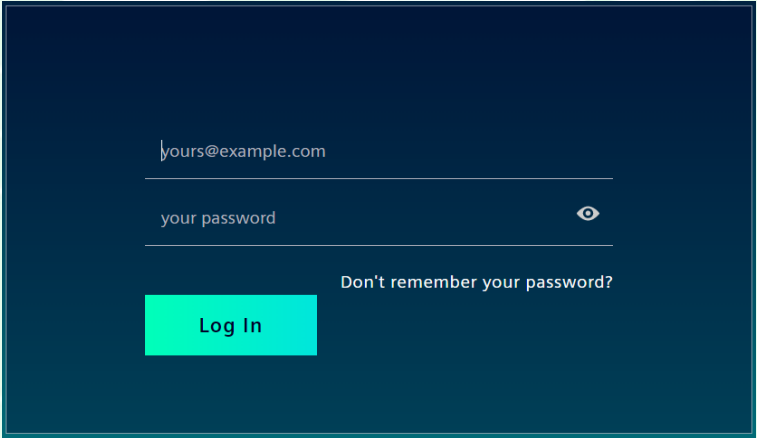
Pilot digital substation with IEC61850 process bus at 72kV Sullivan Lake substation (ATCO)

Station bus upgrade with IEC61850 at 240kV Louise Creek Substation (ATCO)

Introduction SIPROTEC Digital Twin – Virtual testing of protection relay



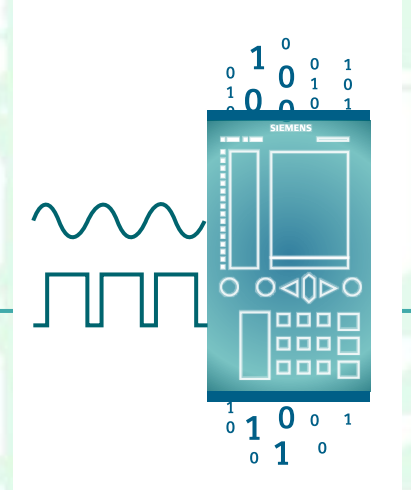
PC Internet Login Credentials



Supported
by all major
Web browsers

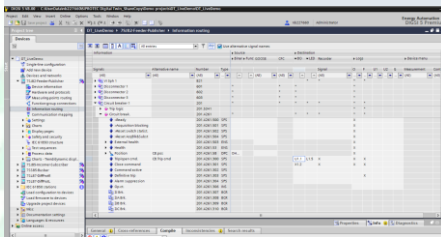


Access your SIPROTEC Digital twin in 5 steps– Virtual testing of protection relay



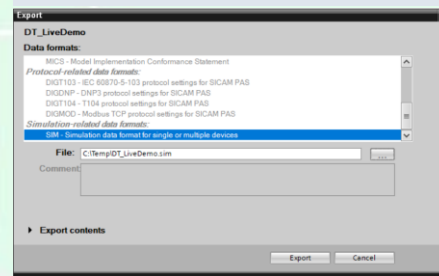
1

Open DIGSI 5 project



2

Export SIM file



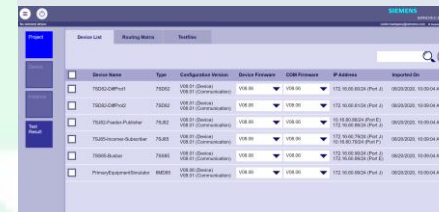
3

Connection to the Cloud



4

Import SIM





5

SIPROTEC DigitalTwin



Testing of transformer protection – Virtual testing of protection relay



2043S 701T_87TA_51_50BF_7UT86_R0, Test Breaker and GOOSE Sim

SIEMENS

SIPROTECH

ashutosh.s@siemens.com

Project

Device List

Routing Matrix

Test Files

Files for Apps

Device

Test Result

Apps

Migration Tool

<input type="checkbox"/>	Device Name	Type	Configuration Version	Device Firmware	COM Firmware	IP Address
<input type="checkbox"/>	7UT86 - TR	7UT86	V08.40 (Device) V08.40 (Communication)	V08.40	V08.40	172.16.60.60/24 (Port J) 10.0.242.148/22 (Port E)
<input type="checkbox"/>	7SX800	7SX80	V08.84 (Device)	V08.84		10.16.60.60/24 (Port F)
<input checked="" type="checkbox"/>	2043S 701T_87TA_51_50BF_7UT86_R0	7UT86	V08.83 (Device) V08.83 (Communication)	V08.83	V08.84	172.16.28.129/16 (Port E)
<input checked="" type="checkbox"/>	Test Breaker and GOOSE Sim	7UT86	V08.83 (Device) V08.83 (Communication)	V08.83	V08.84	172.16.60.60/24 (Port J) 172.16.28.200/16 (Port E)

Import SIM files to portal
and switch on the devices

Testing of transformer protection – Virtual testing of protection relay

2043S 701T_87TA_51_50BF_7UT86_R0, Test Breaker and GOOSE Sim

Select Routing Matrix Preset

Project

Device

Test Result

Apps

Migration Tool

Device List

Routing Matrix

Test Files

Files for Apps

Type: Binary Source: 2043S 701T_87TA_51_50BF_7UT... Destination: Test Breaker and GOOSE Sim

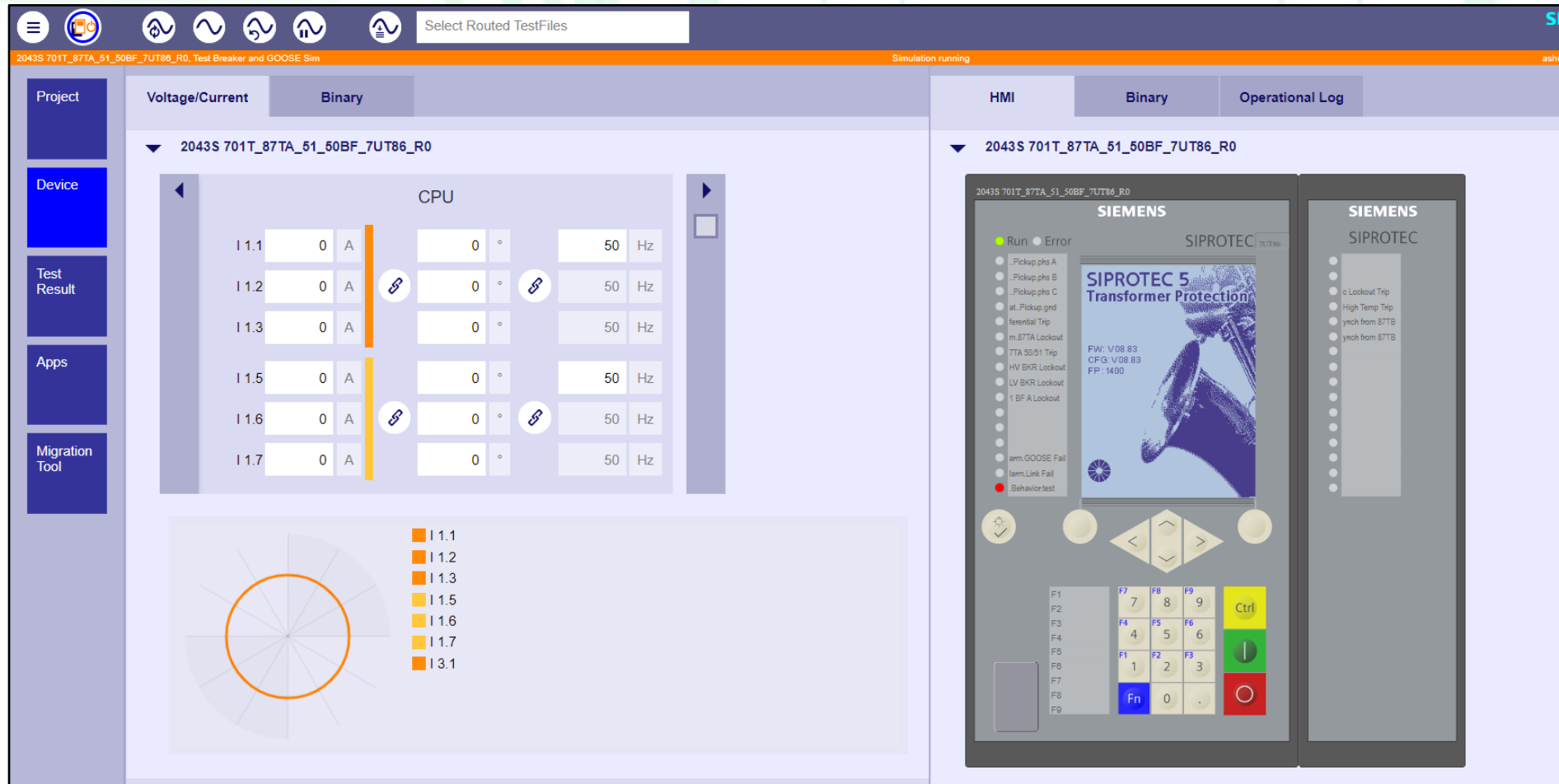
Output (Source) \ Input (Destination)	1.1	1.2	3.1	3.2	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10
BO 2.2 (E:ETH-BB-2FO.Channel 1.PRP.both channel fail - U)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BO 3.1 (CB701.Circuit break..Trip/open cmd. - U)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BO 3.2 (CB701.Circuit break..Trip/open cmd. - U)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BO 3.3 (CB501.Circuit break..Trip/open cmd. - U)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BO 3.7 (CB701.Circuit break..Close command)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BO 3.8 (CB501.Circuit break..Close command)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
LifeContact	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Routing Overview (Type: Binary)

	1	2	3	4
1 - 7UT86 - TR				
2 - 7SX800				
3 - 2043S 701T_87TA_51_50BF_7U...				
4 - Test Breaker and GOOSE Sim				

Make connections between devices in soft as you make wiring between devices in field or lab

Testing of transformer protection – Virtual testing of protection relay



Now relay and supporting device like CB is ready for analog and BI injection

Testing of transformer protection – Virtual testing of protection relay



Apply the current, voltage or BI needed to apply fault to the relay from injection module. Relay will be trip as per the configuration

Testing of transformer protection – Virtual testing of protection relay

SIPROTEC DigitalTwin Test Report

User: ashutosh.s@siemens.com
Start time:
Stop time:



Devices

Name	Product Code	Config Version	Firmware Version	IP Address (Port Name)	Imported On
2043S 701T_87TA_51_50BF_7UT86_R0	7UT86-DAAA-AA0-0AAAA0-AV0111-23121B-BAA000-000AC0-CC1BA1-CH1	Device: V08.83 COM: V08.83	Device: V08.83 COM: V08.84	172.16.28.129/16 (Port E)	8/31/2022 1:09:31 PM
Test Breaker and GOOSE Sim	7UT86-DAAA-AA0-0AAAA0-AV0111-33121B-BAA000-000AC0-CC1BA1-CH1CD0	Device: V08.83 COM: V08.83	Device: V08.83 COM: V08.84	172.16.60.60/24 (Port J) 172.16.28.200/16 (Port E)	8/31/2022 1:09:31 PM

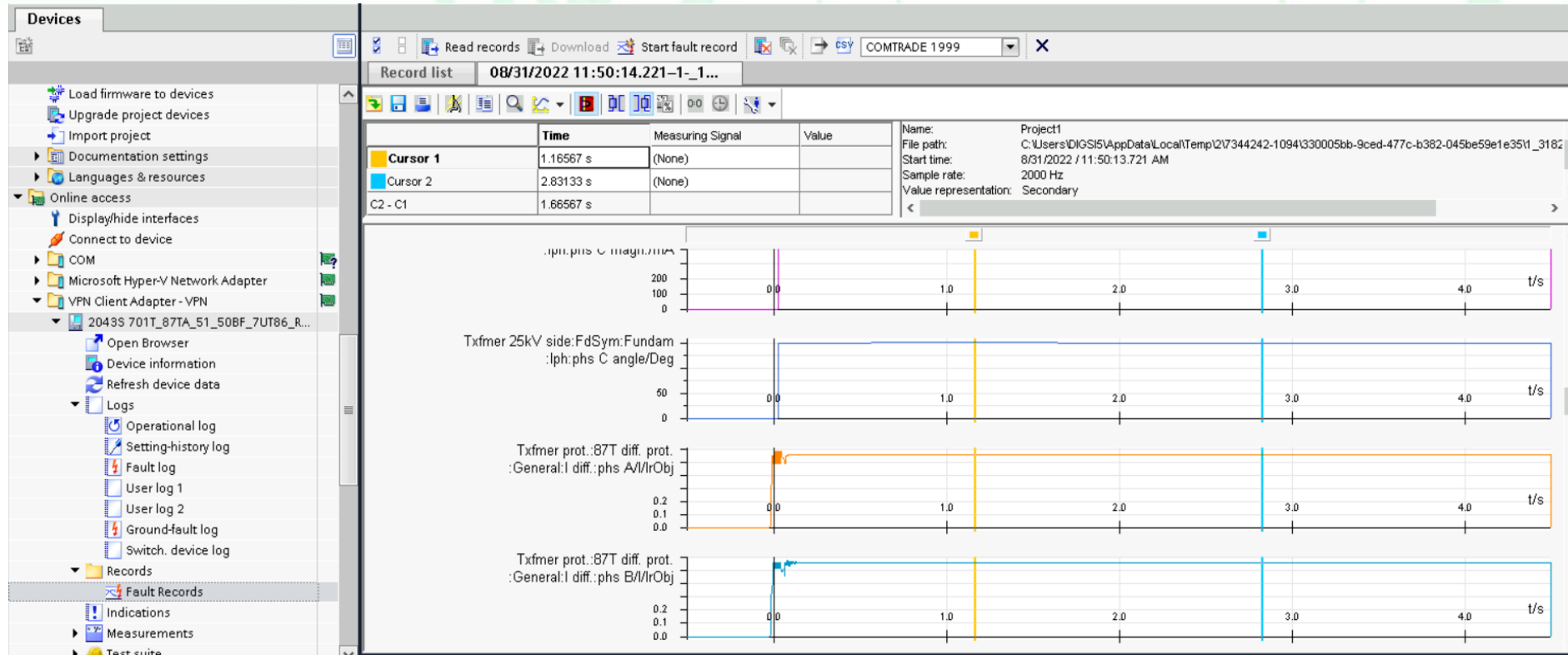
Report will be available from SIPROTEC digital twin

Project tree: Online access > VPN Client Adapter - VPN > 2043S 701T_87TA_51_50BF_7UT86_R0 (Assigned) > Logs > Fault log (<Unknown>)

Time stamp	Relative time	try number	Functions structure	Name	Value	Quality	Cause
08/31/2022 11:50:14.221			(All)	(All)	(All)	(All)	(All)
				Fault log			
	00:00:00:00.105		CB501:Circuit break.	Break-current phs C	202 A	good (process/test)	Data update
	00:00:00:00.619		CB501:Circuit break.	Definitive trip	off	good (process/test)	Data change
	00:00:00:00.119		CB501:Circuit break.	Definitive trip	on	good (process/test)	Data change
	00:00:00:00.105		CB501:Circuit break.	Break-current 3I0/IN	0 A	good (process/test)	Data update
	00:00:00:00.093		CB501:Circuit break.	Trip/open cmd.	on	good (process/test)	Data change
	00:00:00:00.105		CB501:Circuit break.	Break-current phs B	200 A	good (process/test)	Data update
	00:00:00:00.105		CB501:Circuit break.	Break-current phs A	197 A	good (process/test)	Data update
	00:00:00:00.269		CB701:50BF Ad.CBF 1	CB failure pole	phs A phs B ph...	good (process/test)	Data change
	00:00:00:00.269		CB701:50BF Ad.CBF 1	Trip T2	on	good (process/test)	Data change
	00:00:00:00.189		CB701:50BF Ad.CBF 1	Retrip T1	on	good (process/test)	Data change
	00:00:00:00.093		CB701:50BF Ad.CBF 1	Pickup	on	good (process/test)	Data change
	00:00:00:00.093		CB701:Circuit break.	Trip/open cmd.	on	good (process/test)	Data change
	00:00:00:00.105		CB701:Circuit break.	Break-current phs A	80.0 A	good (process/test)	Data update
	00:00:00:00.619		CB701:Circuit break.	Definitive trip	off	good (process/test)	Data change
	00:00:00:00.105		CB701:Circuit break.	Break-current phs C	80.9 A	good (process/test)	Data update
	00:00:00:00.105		CB701:Circuit break.	Break-current 3I0/IN	0 A	good (process/test)	Data update
	00:00:00:00.119		CB701:Circuit break.	Definitive trip	on	good (process/test)	Data change
	00:00:00:00.105		CB701:Circuit break.	Break-current phs B	78.8 A	good (process/test)	Data update

A report also can be derived from logs retrieved from configuration software which is DIGSI5 in this case

Testing of transformer protection – Virtual testing of protection relay



Please note fault record in comtrade format is also available to download just like a lab test or actual fault

Future use – Virtual testing of protection relay

Replay of the faults occurred at site in SIPROTEC digital twin

Tests of complicated protections schemes like multi-terminal line differential

Communication testing with substation automation system on IEC61850

Thank You

Questions?

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CIGRE-483 Virtual testing lab for digital substation

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Time		Thursday, November 3, 2022		
08:00	12:00		Tutorial 2 — Eau Claire	
			Siemens Canada Digital Twins and the Energy System – Interactive Tutorial Session	