SIEMENS

Virtual Testing using SIPROTEC DigitalTwin

APN – C.009

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SIPROTEC 5 Compact Application

Virtual Testing using SIPROTEC DigitalTwin

APN-C.009, Edition 1

Content

1 Virtual testing using SIPROTEC DigitalTwin

1.1 Introduction

This document is only an extract from various test scenarios with the SIPROTEC DigitalTwin. The SIPROTEC DigitalTwin is the virtual digital twin of a real SIPROTEC 5 device, including algorithms, functions, and communication interfaces. The innovative cloud based SIPROTEC DigitalTwin provides comprehensive testing of your SIPROTEC 5 devices as part of the energy automation system with high efficiency, performance, security, and availability 24/7 from anywhere and without hardware.

A Digital twin is a digital representation of a tangible or intangible object or process from the real world in the digital world. It is irrelevant whether the counterpart already exists in the real world or will exist in the future. Digital twins enable an overarching exchange of data. They are more than just data and consist of models of the represented object or process and can also contain simulations, algorithms and services that describe or influence the properties or behavior of the represented object or process or offer services about it.

1.2 System requirements

The following hardware and software components are necessary:

- PC/Notebook or Tablet with actual browser (Microsoft Edge, Google Chrome, or Mozilla Firefox)
- Internet connection
- Login SIPROTEC Digital Twin (https://www.siprotec-digitaltwin.siemens.com)
    - Siemens ID Registration (for external users)
    - An ordered and active license (7XS70*)

Note: The configuration and any necessary changes are made exclusively in the engineering tool DIGSI 5.

1.3 Registration using Siemens ID

Siemens ID enables secure access to Siemens applications and services such as SIPROTEC DigitalTwin for Siemens customers, partners, and employees. Siemens ID supports three different options for two-factor authentication. This is necessary for:

1. Activation of the license
2. Login for SIPROTEC DigitalTwin

This usually takes about 5 minutes and is self-explanatory. Further information including password guidelines, activation, etc. can be found:

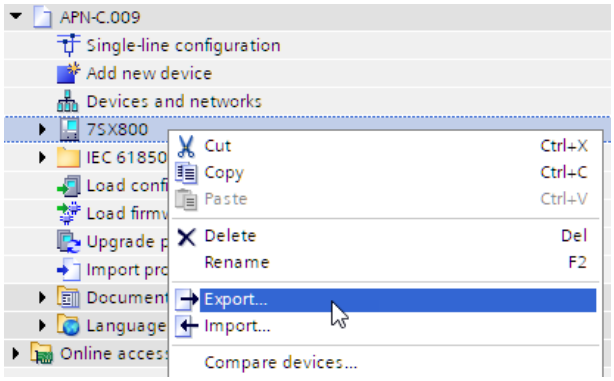
1.4 Export SIM-files in DIGSI 5 (Steps 1&2)

In general, either a single device or several devices from DIGSI 5 can be exported with the SIM data format and imported into SIPROTEC DigitalTwin.

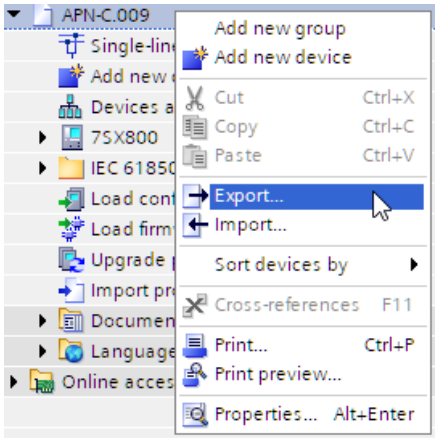
The abbreviation SIM stands for "SIMulation data format". This functionality in the DIGSI 5 engineering tool offers the possibility to export the simulation data and to simulate all devices in the DIGSI 5 project for test and commissioning requirements in SIPROTEC DigitalTwin.

Export the SIM- files in DIGSI5:

- At the device level if you only want to export and test a single device.



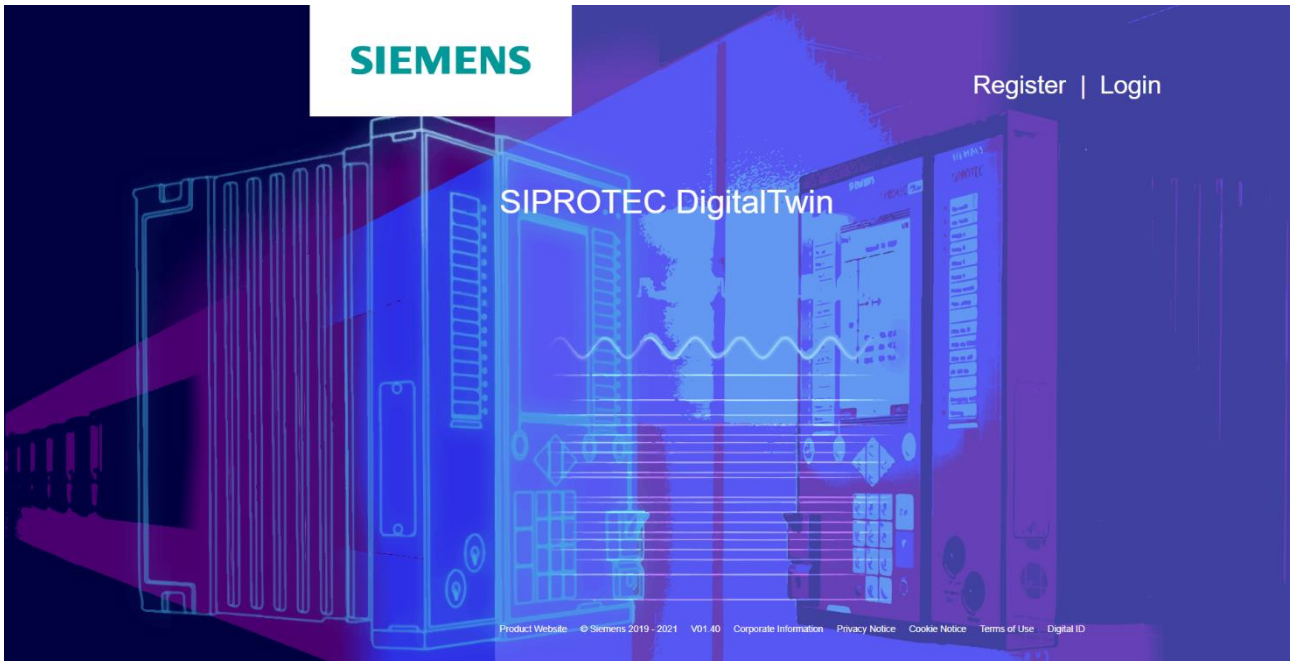
- At the project level if you want to export and test one or more devices.



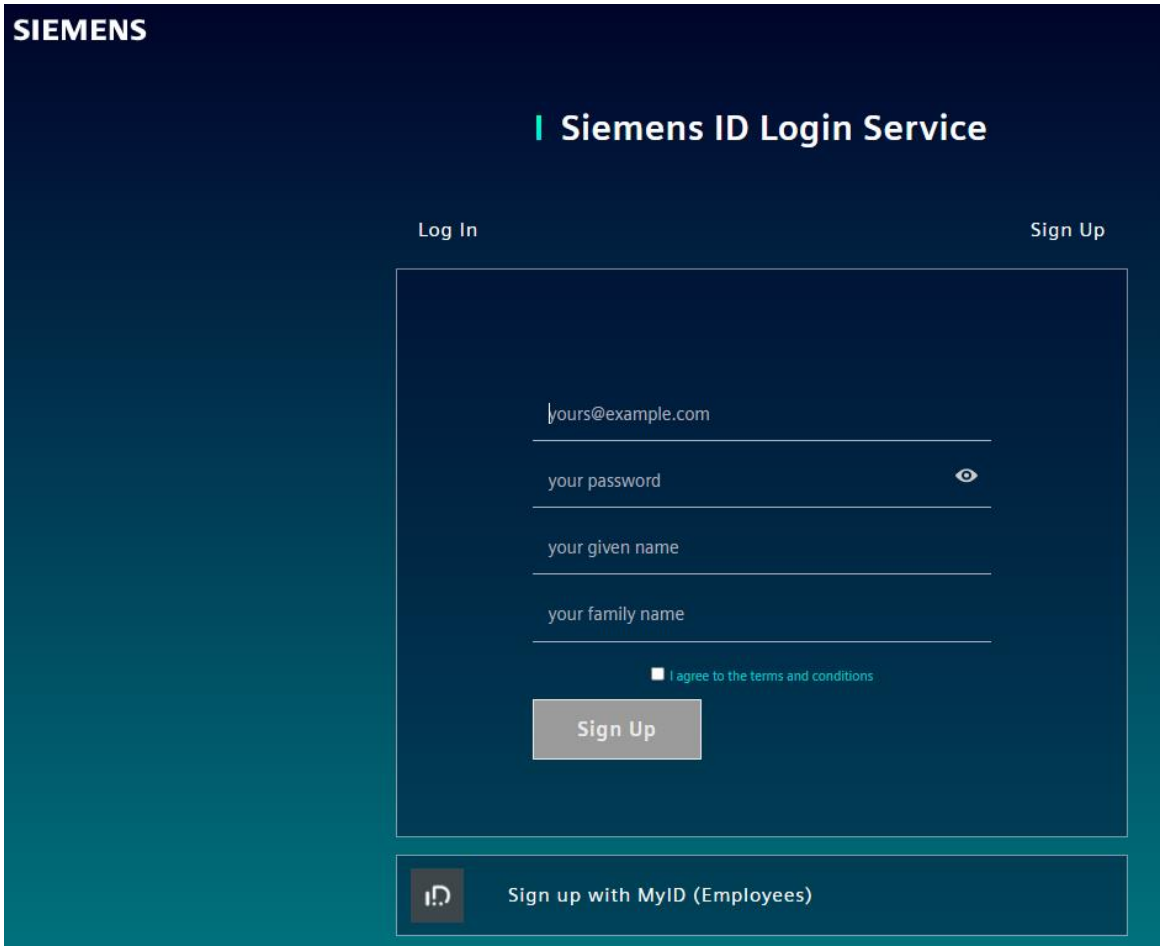
Uploading SIM files can also be done with connections at lower Internet speed, even when you are not in the office, e.g. in the hotel, in the home office or in the customer office via your mobile connection or even on the train before your customer visit.

1.5 Connection with SIPROTEC DigitalTwin (Step 3)

Start Web browser and login on SIPROTEC DigitalTwin with https://www.siprotec-digitaltwin.siemens.com



Enter your Login data (email and password)



For external users: Enter the one-time password that you receive via the Siemens ID app on your smartphone (iOS or Android).

Note: Multi-factor authentication (MFA) is a security measure to protect access to your uploaded data.

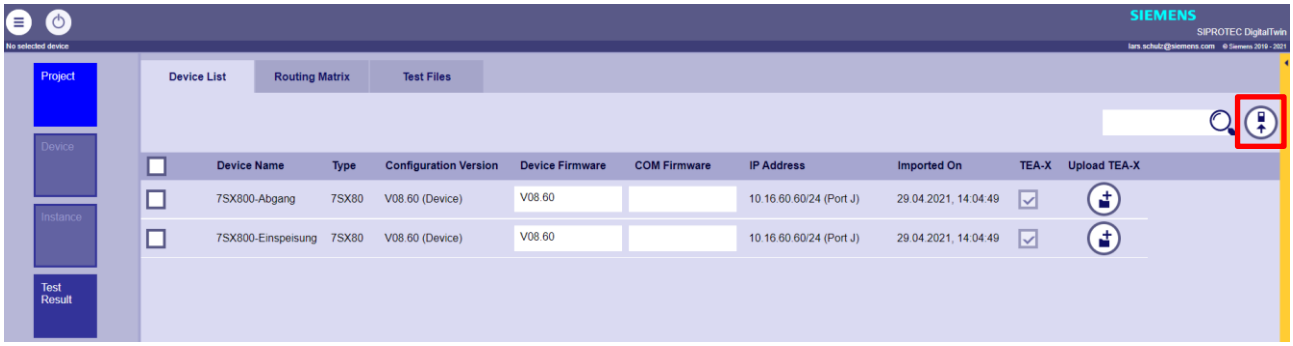
1. For Siemens users: Click on "Login with MyID (Employee)".

If you cannot use the PKI card (e.g. no smart card reader on the computer):

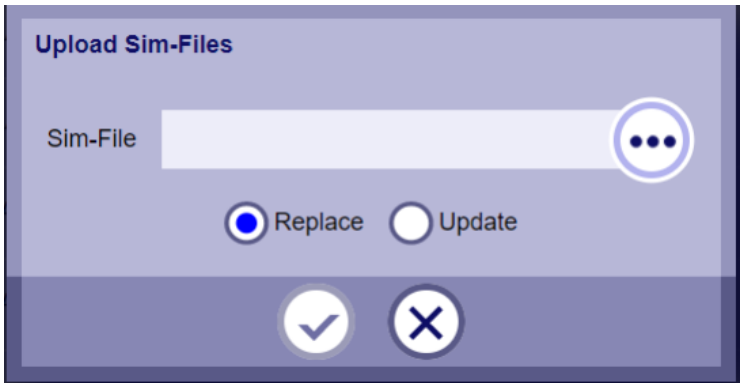
2. Select "Email", enter your Windows login details (only required if you are not connected to the company network)
3. Select 'Mobile

1.6 Import your SIM file and start the simulation

- Click the SIM- Upload button.



- Upload the SIM Files.



You can select a single SIM file or upload multiple SIM files for different applications:

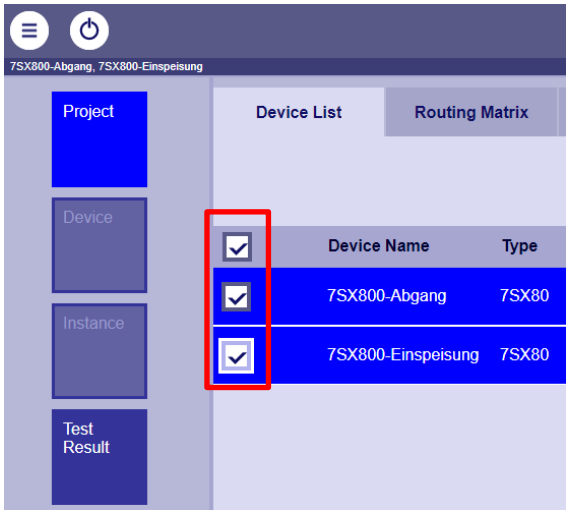
1. where devices were exported individually from DIGSI 5
2. where you need another SIM file, e.g., a simulator for the primary plant (circuit breaker, disconnector or earthing switch)

Select "Replace" to use only the devices you exported from DIGSI 5, or "Update" to expand/update a list of previously uploaded devices.

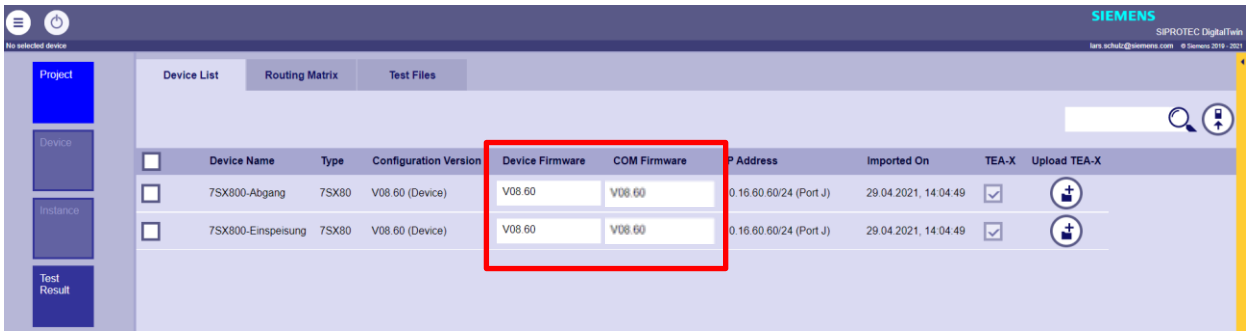
Note: The "Update" option is particularly useful not only to update individual devices (faster than re-exporting a full SIM file with many devices), but also to add more devices to the existing simulation project.

Imported devices are listed with name, device type, configuration versions used, selected firmware versions, IP addresses, and import date.

1. Select the devices to simulate



The devices are simulated with the displayed firmware, which by default is the latest DDD version and must be higher than or equal to the configuration version.

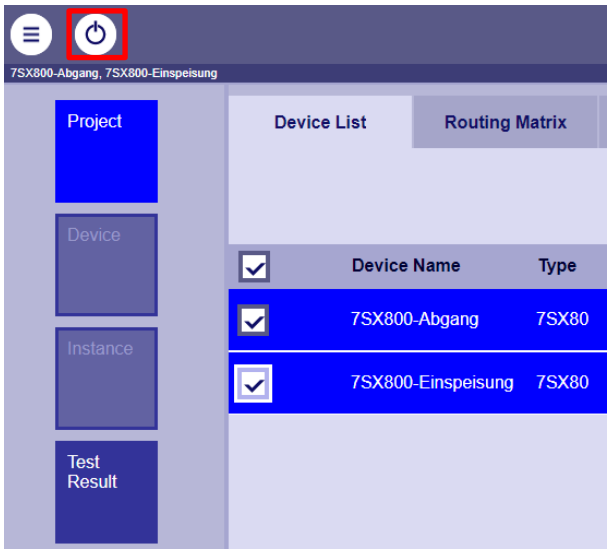


Remarks:

• Depending on your license type (e.g., with M license) you can choose a different firmware version (e.g. a newer version with improvements).

• This displayed firmware version is also displayed on the device display (at startup or in the menus).

1. Activate the simulation for the selected devices.



1.7 Testing of the devices

When you start the selected devices for the first time, it takes about three minutes for the devices to be fully initialized. Each further start of the simulation in this session then takes only about a minute.

During this time, you can e.g.:

1. Prepare the Routing Matrix before you start the simulation (see Section 1.XX)
2. the process input values while the simulation starts. This will be described in the next steps.

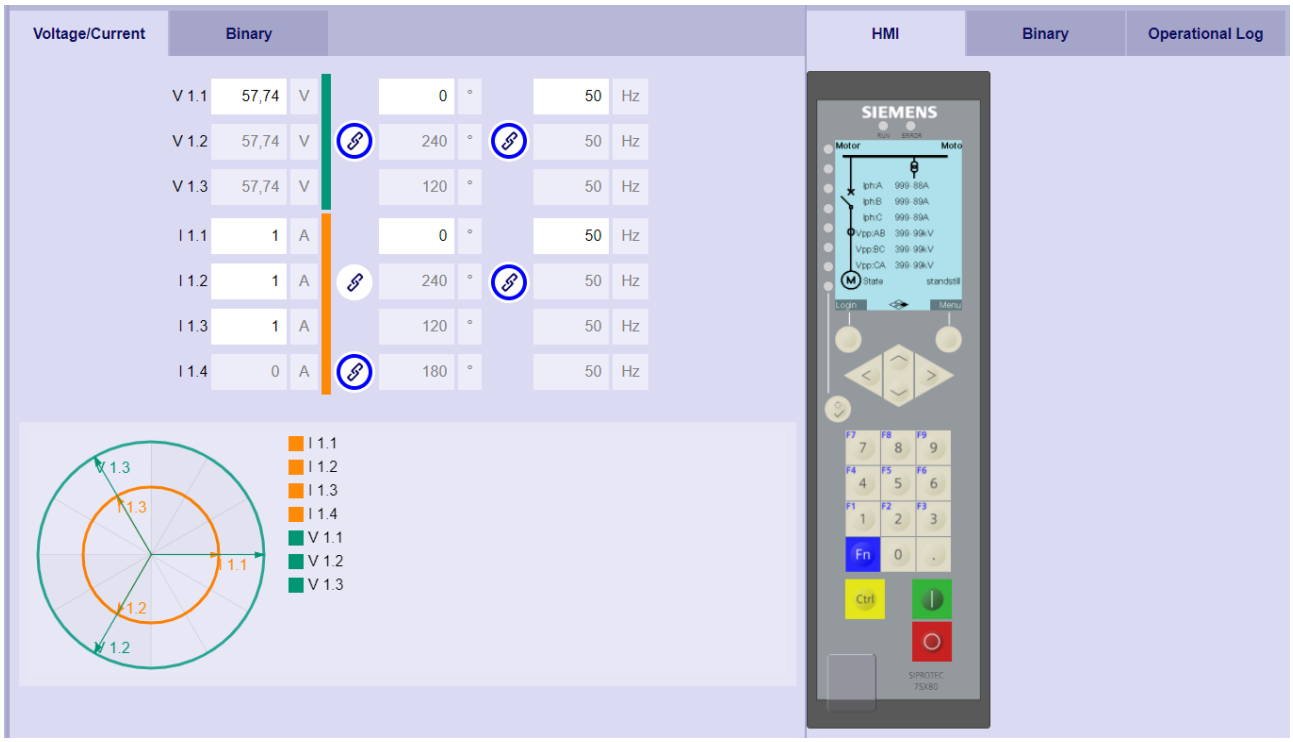
You have various possibilities to simulate current and voltage curves in the devices. The next section describes the feeding of static values for current and voltage.

1.7.1 Inject of static currents and voltages

After the device start, the following interface appears. Here, secondary values for current, voltage, phase angle or frequency can be entered. If a device has several measuring points, the name is displayed via the green/orange bar. This button links the measured values to a symmetric system.

When logging in, the measured values from the last session are restored.

Angles are displayed between 0 and 360 °. Other values (e.g. -30 °) are automatically converted (e.g. 330 °). The SIPROTEC 5 device display displays values between -180 and 180 °. The vector diagram can be used to visualize the angles and amplitudes.



Once all measured values have been prepared for the test case, the measured values can be fed in two ways. The corresponding buttons can be found at the top of the screen.

1. Any change in the values is implemented immediately

2. One-time change of values

Other functions of the buttons:

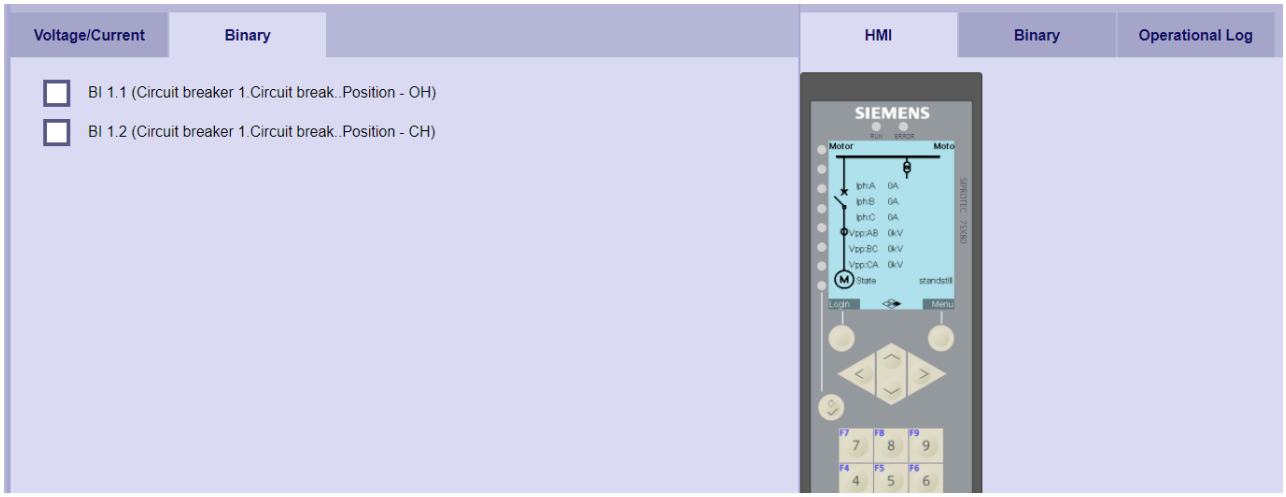
3. Reset all measured values (even during ongoing simulation)

4. Pausing the feed (UI is still active)

5. Save the current settings

1.7.2 Simulation of binary inputs

You can set the states of all parameterized binary inputs.

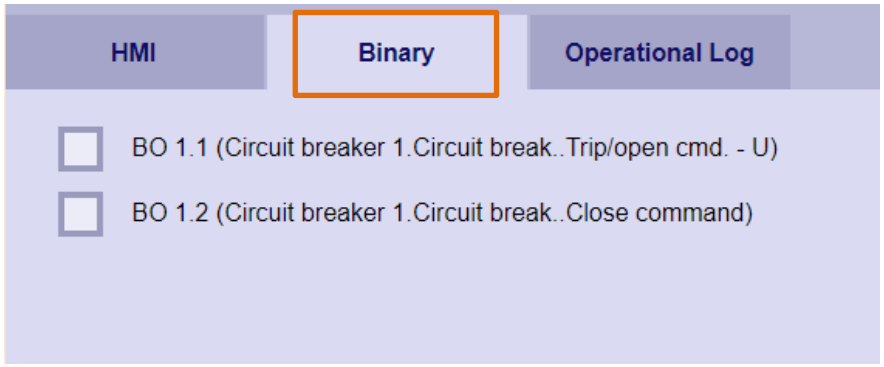


The same designations are displayed as on the front display. Either the full hierarchical or the alternative terms. The suffixes OH (open), CH (closed), H (high) or L (low) are automatically inserted according to the information ranking of the DIGSI 5 project. The states of the last simulation are preset.

Note: Opening the circuit breaker has no effect on the static measured values fed in.

1.7.3 Simulation of binary outputs

The states of the binary outputs can be viewed under the following button.



The labeling of the binary outputs is done in the same way as described in the previous chapter. In contrast to the binary inputs, the states cannot be changed here. The states are displayed as the contacts are controlled by the protection device.

1.7.4 Front Display

The front display of the virtual device behaves exactly like a physical device. All configured display pages are available. The navigation through these pages and the submenus works like in the real device.

You can access all the functionalities in the menus, such as:

- menus with different logs (Operation, Fault, User defined, etc.)
- modification and confirmation of new protection parameters
- operation of the function keys

Navigation can be done by clicking on the corresponding keys but can also be done directly from the keyboard or from the Windows on-screen keyboard.

The key assignment can be seen in the following figure.

Note: By pressing the 'c' key, screenshots can be taken in bitmap format.

1.8 Testing of protection functions

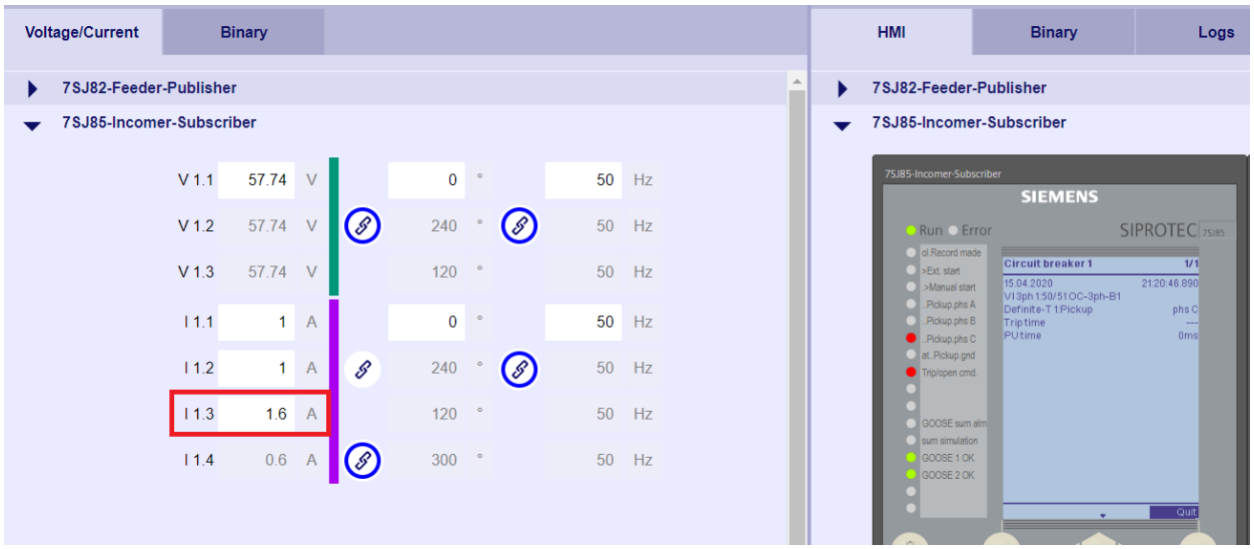
To test protection functions, there are several possibilities to simulate measured values in the device and to check the correct functioning of the parameterized protection mechanisms.

In the following, with the help of static measured values and Comtrade, the O/C protection function, as well as the restart inhibit function for motor protection can tested.

1.8.1 Test with statistic measured values

For a test of the overcurrent time protection function, a current above the set protection threshold can be set in one of the phases (e.g., 1.6A). This can be done for all phases at the same time as well as for individual phases. After feeding in the current, the reaction of the device can be observed, and the parameterization carried out can be checked.

In this example, the secondary current was raised to 1.6A, which should lead to a triggering. As can be seen in the display of the protection device, all three phases respond, and the trigger command was passed on to the circuit breaker.

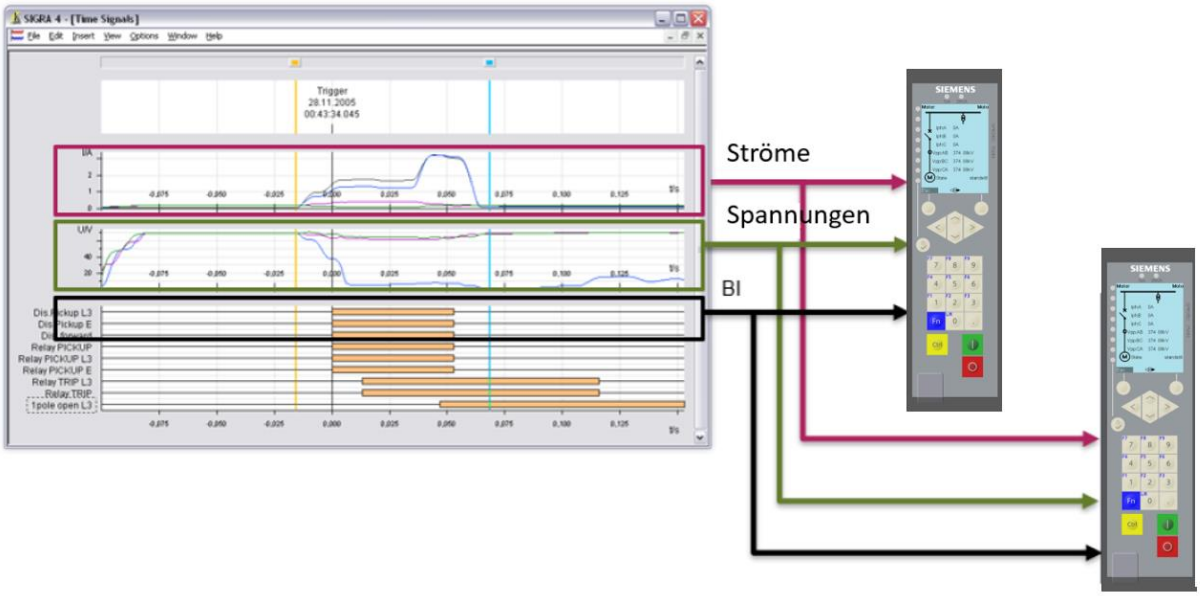


Analogously, the single-phase triggering can be tested. Here only the current of L3 was raised. This was also detected by the device which tripped accordingly.

In this way, various protection algorithms and device configurations can be tested. However, this static feeding of measured values does not reflect all cases that can occur in practice. How these cases can be simulated is described in more detail in the following section.

1.8.2 Testing with Comtrade files

To simulate more complex error cases, it is possible to use current and voltage curves of COMTRADE files from the M license onwards. For this purpose, the corresponding files are uploaded in the Digital Twin and the voltage curves are assigned to the measuring inputs of the device. Any number of currents / voltages can be reproduced.



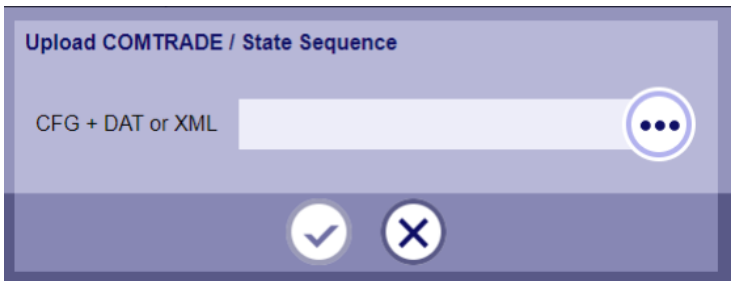
Upload your standard COMTRADE files (according to IEEE C37.111/ IEC 60255-24), with either primary or secondary values from the following sources:

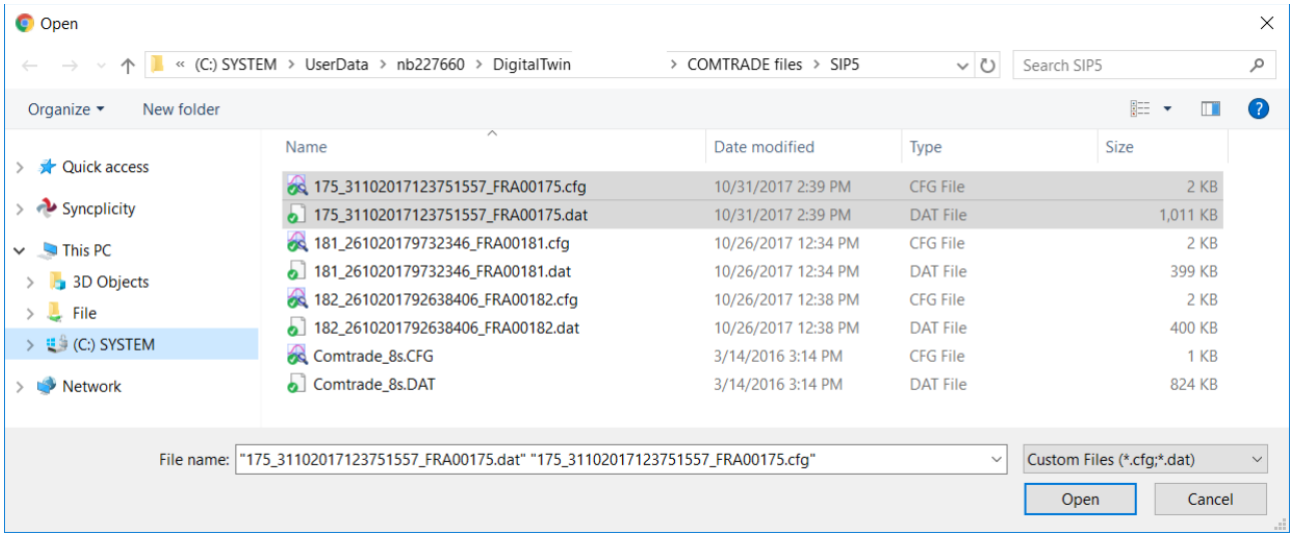
1. From a real failure case (from a SIPROTEC 5 Compact or another protective device
2. As an export from a test software, e.g.
    1. Network calculation: SIEMENS PSS SINCAL, CAPE, RTDS RSCAD, Opal-RT Hypersim, ...
    2. Protection test software: Omicron Test Universe, Doble Protection Suite, Megger Power DB, ...

Note: If the upload button is still not displayed, please try to zoom out in the web browser.

You can delete test files that are no longer needed if you no longer need them. This improves the clarity in the areas "Test Files" and "Routing Matrix".

The CFG and DAT file types should be uploaded with the same names at the same time.





Several COMTRADE files can be uploaded at the same time.

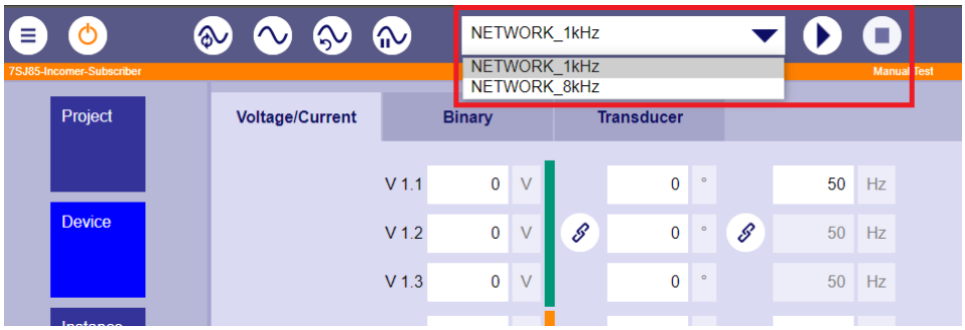
Then you can assign the measuring inputs of the protection devices to the channels of Comtrade playback:

- For voltages

- For currents

Once the device is up and running, you can:

- Select the file to play.
- Pause or stop the playback of the COMTRADE file.

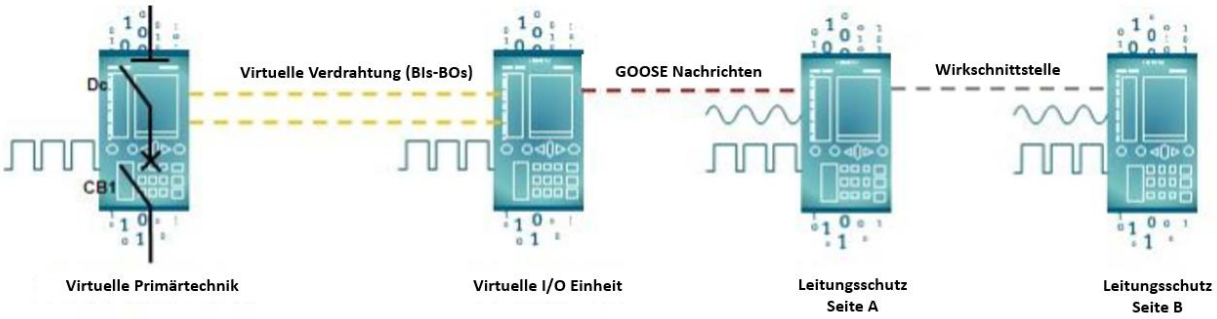


Only test files that have been connected to the devices via the Routing Matrix can be selected.

Applications

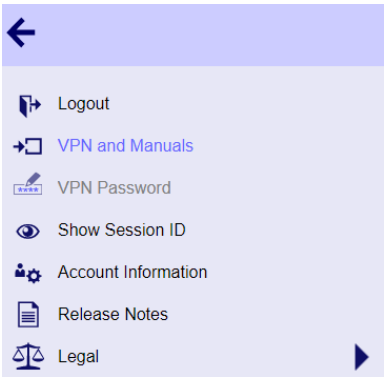
1. The behavior between two device configurations can be compared, e.g., with
   - Different settings
   - Different protection algorithms
2. expand the device configuration to get more binary tracks, restore error recording, and improve protection parameters

This can also be used in combination with virtual cabling and GOOSE functionality to test the effects of a COMTRADE incident on the entire configuration.



1.9 Further test applications

A variety of test options for protection, automation, and PQ functions, as well as integration into station automation and IoT applications available, details can be found in the document "Guideline and Test Cases Digital Twin", which you can download after registration.



The following tests are possible:

1. Communication with real, e.g., SIPROTEC 3/4/5/Compact or also third-party devices and virtual devices
2. Ethernet-based communication to control technology (SICAM A8000, PAS, SCC or third-party systems)
3. PQ/PMU functionality with PQ applications SICAM PQS, PQ Analyzer, SIGUARD PDP
4. Connection to the IoT applications SICAM GridEdge and SICAM Dashboard
5. IEC 61850 GOOSE Communication
6. DIGSI 5 Test suite and CFC Online debugging
7. SIPROTEC 5 WebUI (Default https https://172.16.60.60:4443)
8. Cyber Security functionality, e.g., with Radius Server

- ...

1.10 Remote App

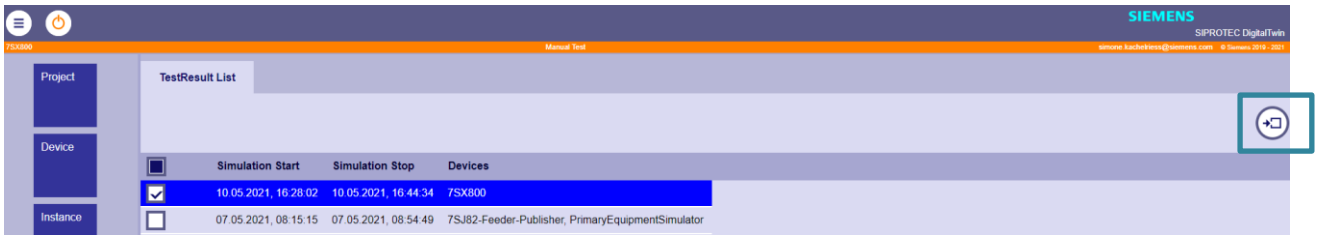
Some of the most common scenarios can now be fully tested within the web browser with the help of the included remote apps without establishing an additional VPN connection.

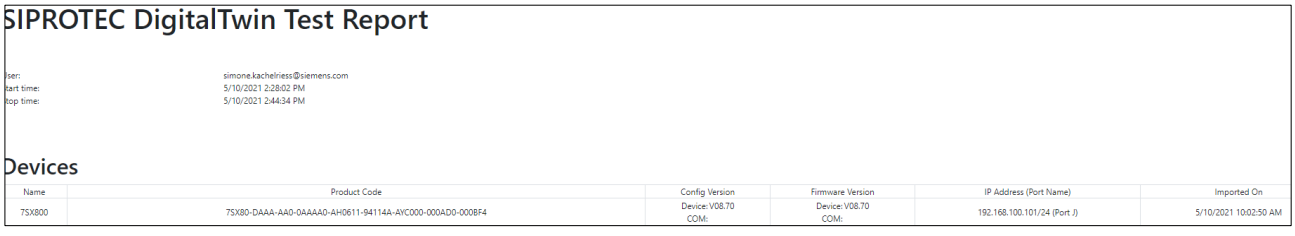
These can be found in the "Apps" tab and are generally available for ALL users/licenses except in the DemoUI license.

Further details can also be found in the document "Guideline and Test Cases Digital Twin", which you can download after registration.

1.11 Test reports

After a simulation, a test report is available with information about day and time, as well as the simulated devices. The implementation is in progress and is continuously updated based on your requirements.

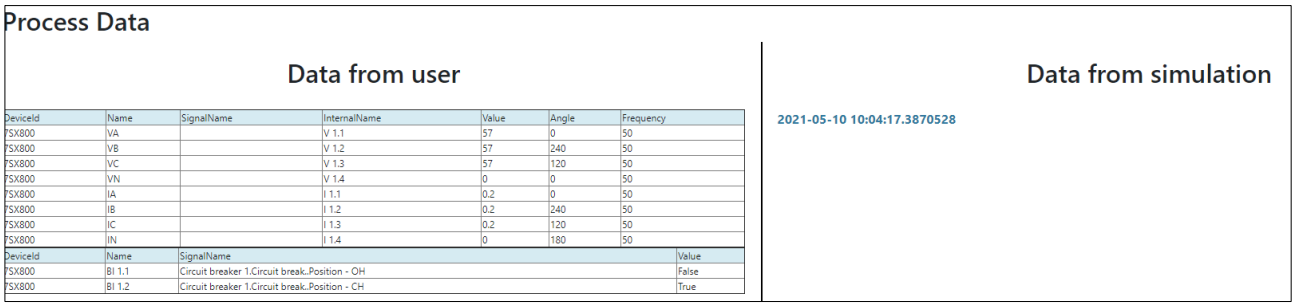



SIPROTEC DigitalTwin Test Report

simone.kachelriess@siemens.com
5/10/2021 2:28:02 PM
5/10/2021 2:44:34 PM

Devices

Name	Product Code	Config Version	Firmware Version	IP Address (Port Name)	Imported On
7SX800	7SX80-DAAA-AA0-0AAAA0-AH0611-94114A-AYC000-000AD0-000BF4	Device: V08.70 COM:	Device: V08.70 COM:	192.168.100.101/24 (Port J)	5/10/2021 10:02:50 AM



Process Data

Data from user

DeviceId	Name	SignalName	InternalName	Value	Angle	Frequency
7SX800	VA		V 1.1	57	0	50
7SX800	VB		V 1.2	57	240	50
7SX800	VC		V 1.3	57	120	50
7SX800	VN		V 1.4	0	0	50
7SX800	IA		I 1.1	0.2	0	50
7SX800	IB		I 1.2	0.2	240	50
7SX800	IC		I 1.3	0.2	120	50
7SX800	IN		I 1.4	0	180	50

DeviceId	Name	SignalName	Value
7SX800	BI 1.1	Circuit breaker 1.Circuit break..Position - OH	False
7SX800	BI 1.2	Circuit breaker 1.Circuit break..Position - CH	True

Data from simulation

2021-05-10 10:04:17.3870528

1.12 Conclusion

SIPROTEC DigitalTwin saves you time and increases quality throughout the entire life cycle of your system. Protection, automation, and PQ functions can be tested, as well as the integration into station automation and IoT applications without a real device and without additional effort for logistics, wiring and location independent.

SIPROTEC DigitalTwin fully supports you in the digital transformation.

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