



# Virtual Testing using SIPROTEC DigitalTwin APN – C.009

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Virtual Testing of SIPROTEC 5 Compact using SIPROTEC DigitalTwin

# SIPROTEC 5 Compact Application Virtual Testing using SIPROTEC DigitalTwin

APN-C.009, Edition 1

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## **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 <u>Digital twin</u> 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 (<u>https://www.siprotec-digitaltwin.siemens.com</u>)
  - 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)

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SIEMENS			
		l Siemens ID Login Service	
	Log In		Sign Up
		vours@example.com	
		your password O	
		your given name	
		your family name	
		I agree to the terms and conditions	
		sigii op	
	D s	ign up with MyID (Employees)	

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.

												SIEM	ENS
No sel	lected device											lars schulzff	SIPROTEC DigitalTwin
	Project	Devi	ce List	Routing I	Matrix	Test Files							
	Device												Q
			Device	Name	Туре	Configuration Version	Device Firmware	COM Firmware	IP Address	Imported On	TEA-X	Upload TEA-X	
			7SX800	-Abgang	7SX80	V08.60 (Device)	V08.60		10.16.60.60/24 (Port J)	29.04.2021, 14:04:49		٢	
	instance		7SX800	-Einspeisung	7SX80	V08.60 (Device)	V08.60		10.16.60.60/24 (Port J)	29.04.2021, 14:04:49		٢	
	Test Result												

• Upload the SIM Files.

Upload Sin	1-Files	
Sim-File		
	Replace Update	
	$\checkmark$ $\bigotimes$	

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

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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.

										SIEM	ENS
											SIPROTEC DigitalTwin
No selected device										lara.schulzgz	semens.com 6 Semens 2019 - 2021
Project	Devic	e List Routir	g Matrix	Test Files							
Davisa							_				Q 🕄
Device		Device Name	Туре	Configuration Version	Device Firmware	COM Firmware	P Address	Imported On	TEA-X	Upload TEA-X	
lactance		7SX800-Abgang	7SX80	V08.60 (Device)	V08.60	V08.60	0.16.60.60/24 (Port J)	29.04.2021, 14:04:49	$\checkmark$	٢	
instance		7SX800-Einspeisu	ng 7SX80	V08.60 (Device)	V08.60	V08.60	0.16.60.60/24 (Port J)	29.04.2021, 14:04:49	$\checkmark$	٢	
Test Result											

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  $^{\circ}$ . Other values (e.g. -30  $^{\circ}$ ) are automatically converted (e.g. 330  $^{\circ}$ ). The SIPROTEC 5 device display displays values between -180 and 180  $^{\circ}$ . 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

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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.

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#### 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.

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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.

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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, ...

• •						SIEMENS SIPROTEC DigitalTwi
Project	Dev	rice List	Routing Matrix	Test Files		exist: hampuru@sement.com @ Severa 2019.20
Device		File Name		File Type	Import Date	
		NETWORK	_1kHz	COMTRADE	11/06/2020, 09:23:32 AM	
Instance		NETWORK	_8kHz	COMTRADE	11/06/2020, 09:22:50 AM	
		1_4920192	04451889_FRA00001_prim	COMTRADE	01/01/1, 12:00:00 AM	
Test Result						

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.

Upload COMTRADE / State Sequence										
CFG + DAT or XML										
$\checkmark$ $\bigotimes$										

Virtual Testing of SIPROTEC 5 Compact using SIPROTEC DigitalTwin

← → ∨ ↑ <mark> </mark> « (C:)	SYSTEM > UserData > nb227660 > DigitalTwin	> COMTRADE files > SIP5	(5) ~	Search SIP5
Organize  New folder	r			i≡ • □
the Original and the	Name	Date modified	Туре	Size
QUICK access	阈 175_31102017123751557_FRA00175.cfg	10/31/2017 2:39 PM	CFG File	2 KB
<ul> <li>Asymptotic Syncplicity</li> </ul>	🔊 175_31102017123751557_FRA00175.dat	10/31/2017 2:39 PM	DAT File	1,011 KB
🔄 This PC	😹 181_261020179732346_FRA00181.cfg	10/26/2017 12:34 PM	CFG File	2 KB
3D Objects	🔊 181_261020179732346_FRA00181.dat	10/26/2017 12:34 PM	DAT File	399 KB
	🙈 182_2610201792638406_FRA00182.cfg	10/26/2017 12:38 PM	CFG File	2 KB
	182_2610201792638406_FRA00182.dat	10/26/2017 12:38 PM	DAT File	400 KB
> 関 (C:) SYSTEM	🙈 Comtrade_8s.CFG	3/14/2016 3:14 PM	CFG File	1 KB
🥩 Network	Comtrade_8s.DAT	3/14/2016 3:14 PM	DAT File	824 KB
File nam	e: ["175_31102017123751557_FRA00175.dat" "175_3110201"	7123751557_FRA00175.cfg"	~	Custom Files (*.cfg;*.dat)
				Open Cancel

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

Project	Devi	ice List	Г	Routin	ng Matrix	ĸ	Testfiles										
Davies	Source: 182_2610201792		926384	06_FRA	00182 🤜	Destination:	7SJ82-Publisher	•	Filter:	Voltage	•		Device 1	Device 2	Device 3		
Device			1.1	1.2	1.3								Device 4	8			
	MPV3p1	:VA											_				ſ
Instance	MPV3p1	VB		$\checkmark$													
	MPV3p1	V C			~												

• For currents

Project	Dev	Device List Routing Matrix		ĸ	Testfiles											
	Source:	182_26	102017	926384	06_FRA	00182	Destination:	7SJ82-Publisher	•	Filter:	Voltage	•		Device 1	Device 2	Device
Device			1.1	1.2	1.3								Device 4	8		
	MPV3p1	:VA											-			
Instance	MPV3p1	:V B														
	MPV3p1	:V C			~											

Once the device is up and running, you can:

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

<b>()</b>	$\otimes \sim \otimes$	$\sim$	NETWORK	_1kHz		•		0
7SJ85-Incomer-Subscriber		_	NETWORK NETWORK	_1kHz _8kHz				Manual Tes
Project	Voltage/Current	В	inary	Tran	sducer			
		V 1.1	0 V		0 °		50	Hz
Device		V 1.2	0 V	8	0 °	8	50	Hz
		V 1.3	0 V		0 °		50	Hz
Instance								

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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://172.16.60.60:4443)
- 8. Cyber Security functionality, e.g., with Radius Server
- ...

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## 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.

No	selected device					S simone kact	IEMENS SIPROTEC DigitalTwin refriess@siemens.com @Siemens 2019 - 2021
	Project	Google Chrome	Comtrade Viewer	DIGSI 5	IEC Browser	IEC 61850 System Configurator	SIGRA 4
	Device						
	Instance						
	Test Result						
	Apps						

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.

	) 🕐					SIEMENS	
753080	0				Manual Test	SimKOTEC Lagitari Wit simone kachekiess@siemens.com @Survuss.2019-2021	
	Project	TestResu	lt List				
						(*3)	
	Device					$\sim$	
			Simulation Start	Simulation Stop	Devices		
		$\checkmark$	10.05.2021, 16:28:02	10.05.2021, 16:44:34	7SX800		
	Instance		07.05.2021, 08:15:15	07.05.2021, 08:54:49	7SJ82-Feeder-Publisher, PrimaryEquipmentSimulator		

#### SIPROTEC DigitalTwin Test Report

er: sinoe kacheliest@siemers.com ert time: \$7/0/2021 22402 PM op time: \$7/0/2021 24434 PM								
Name	Product Code	Config Version	Firmware Version	IP Address (Port Name)	Imported On			
75X800	75X80-DAAA-AA0-0AAAA0-AH0611-94114A-AYCO00-000AD0-000BF4	Device: V08.70 COM:	Device: V08.70 COM:	192.168.100.101/24 (Port J)	5/10/2021 10:02:50 AM			

## Virtual Testing of SIPROTEC 5 Compact using SIPROTEC DigitalTwin

Proces	s Data								
Data from user							Data from simulation		
DeviceId	Name	SignalName	InternalName	Value	Angle	Frequency		2021-05-10 10:04:17.3870528	
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		11.1	0.2	0	50			
7SX800	IB		11.2	0.2	240	50			
7SX800	IC		I 1.3	0.2	120	50			
7SX800	IN		11.4	0	180	50			
DeviceId	Name	SignalName				Valu	lue		
7SX800	BI 1.1	Circuit breaker 1.Circuit bre	Circuit breaker 1.Circuit breakPosition - OH False						
7SX800	BI 1.2	Circuit breaker 1.Circuit bre	Circuit breaker 1.Circuit breakPosition - CH True				Je		

## 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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Our Customer Support Center provides a 24-hour service. Siemens AG Smart Infrastructure – Digital Grid Customer Support Center E-Mail: energy.automation@siemens.com For all products using security features of OpenSSL the following shall apply:

This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit. (http://www.openssl.org)

This product includes cryptographic software written by Eric Young (eay@cryptsoft.com)

This product includes software written by Tim Hudson (tjh@cryptsoft.com)

This product includes software developed by Bodo Moeller.