



المؤتمر الدولي لإدارة الأصول والمرافق والصيانة في الدول العربية
International Asset, Facility and Maintenance Conference
in the Arab Countries

Digitization - Excellence - Sustainability



Ali Husain

Workshop
Digital Twin Relay Testing

28-26 January 2025

The Ritz-Carlton Jeddah, Kingdom of Saudi Arabia

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**Andrea
Bonetti**



**Niclas
Wetterstrand**



**Cedric
Harispuru**

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Workshop content

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Introduction

- What is a digital twin?

28-26 January 2025
The Abu Dhabi Global Region of Saudi Arabia

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Use cases and benefits

- In what cases can a digital twin be used?
- What benefits does it give?



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SIPROTEC DigitalTwin

- What has Siemens to offer?



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FREJA/SMRT Digital Twin

- What solutions has Megger to offer?



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Practical Demo

- Relay testing with digital twins
- Roleplay



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Conclusion

- A summary of the benefits in relay testing with digital twins



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Introduction

• What is a digital twin?

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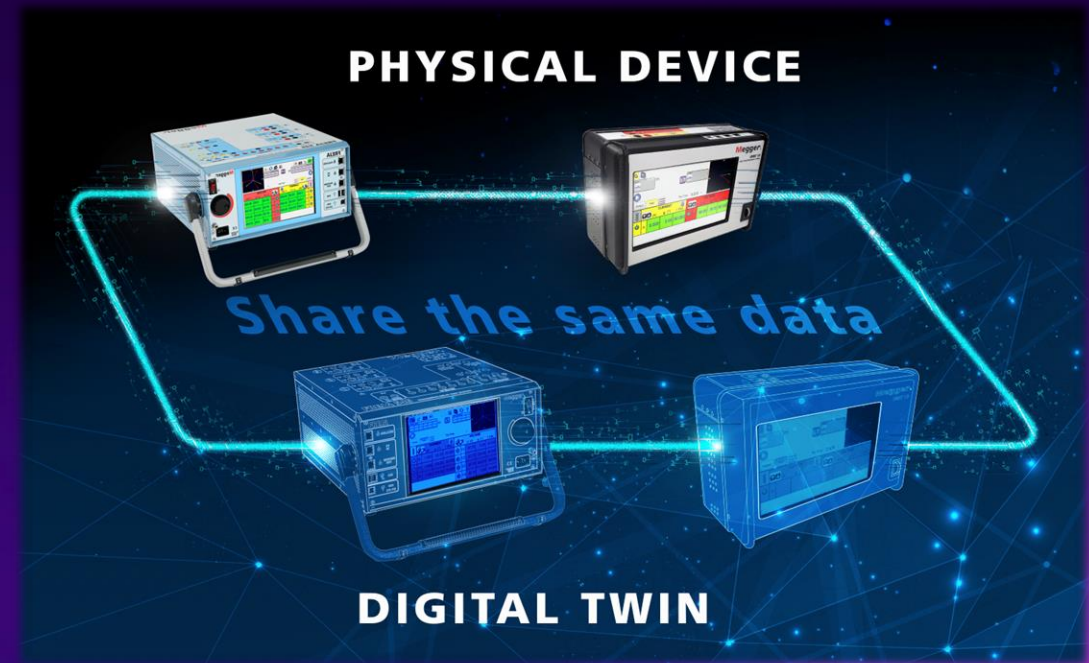
Digital twin definition

A digital twin is a *virtual representation of real-world entities and processes*

They *use* real-time and historical *data to* represent the past and present and *simulate predicted futures.*

Key elements

- Share the same data
- Get the same behavior

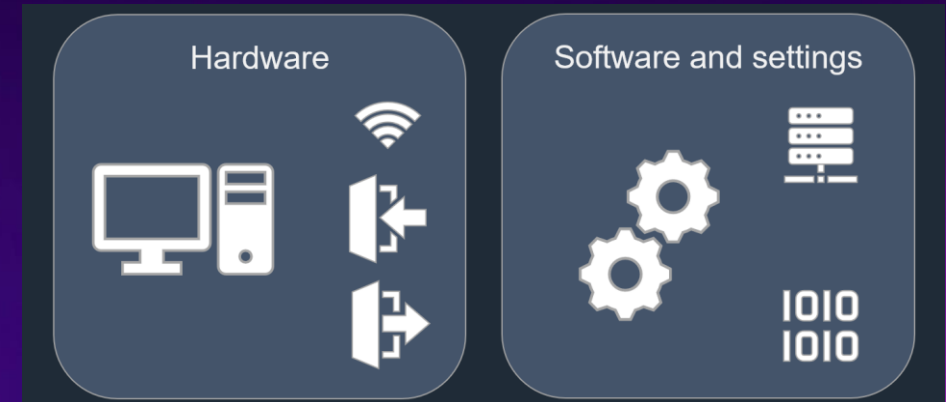


Protection relays and relay test sets suitable digital twins

- Devices consist of
 - Limited number of hardware inputs and outputs
 - Significant amount of software code
 - Algorithms
 - Settings

However, for functional digital twins ...

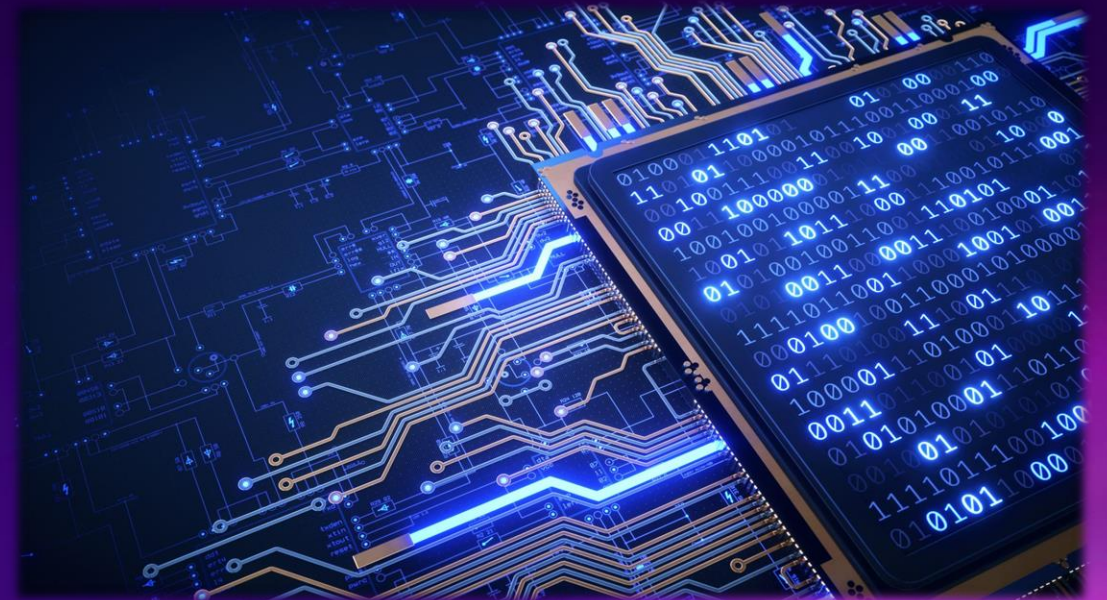
- Internal hardware processes need to be simulated



Ensures the same behaviour as the physical device

Function digital twin – High fidelity simulation

- Other simulations in the power industry
 - IEC 61850
 - Real time simulators
 - Network model simulation
- All in common that they do not verify real functionality and settings of the relay
- Functional digital twins made by OEM
 - Same functions
 - Same algorithms
 - Same behaviour



High fidelity simulation ONLY by OEM's

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Areas of responsibility are the same in the virtual and real world

Test equipment responsibility



- Test plans
- Test methods
- Test waveforms



Physical devices

Digital twins

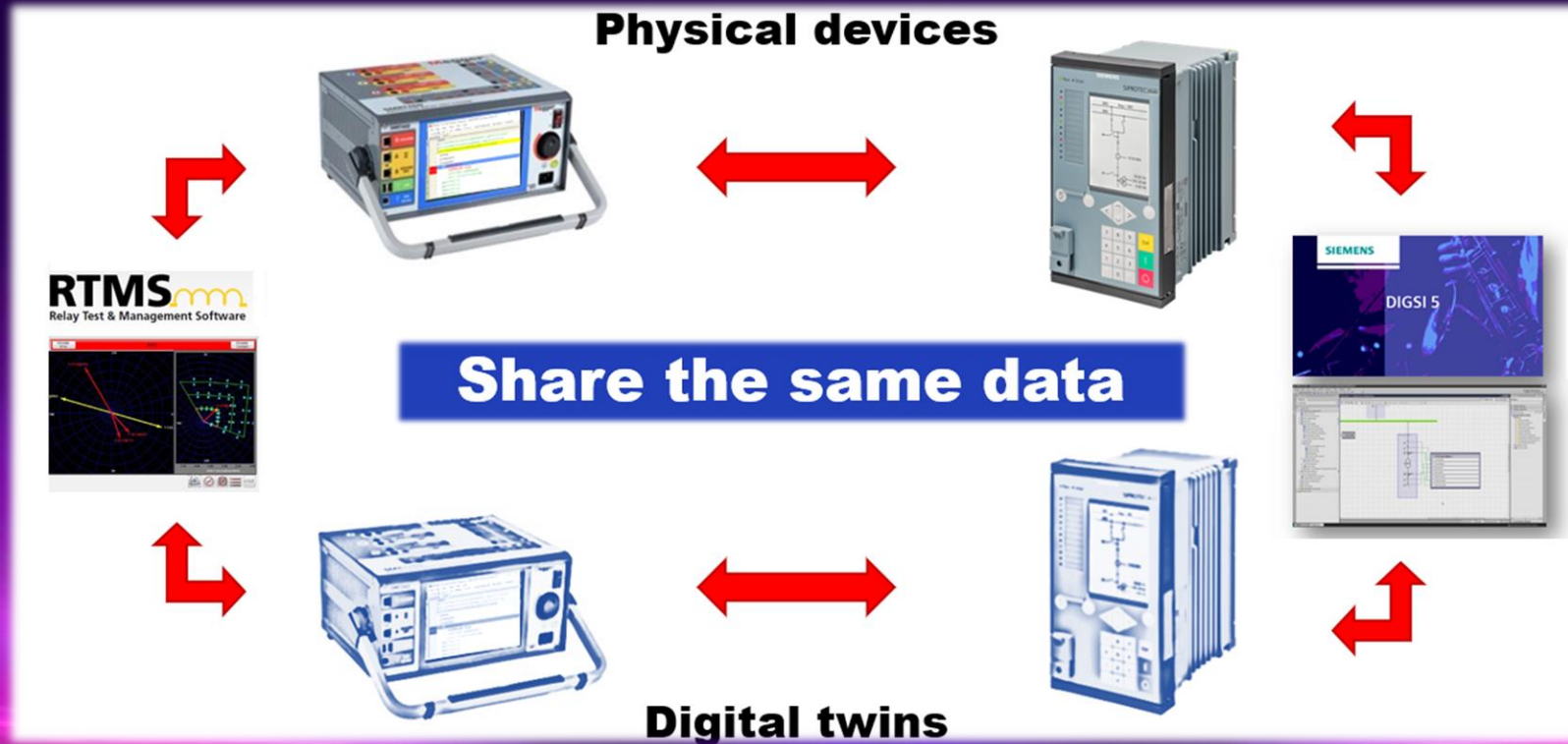
Relay responsibility



- Algorithms
- Settings
- Logics
- Protection scheme
- Communication

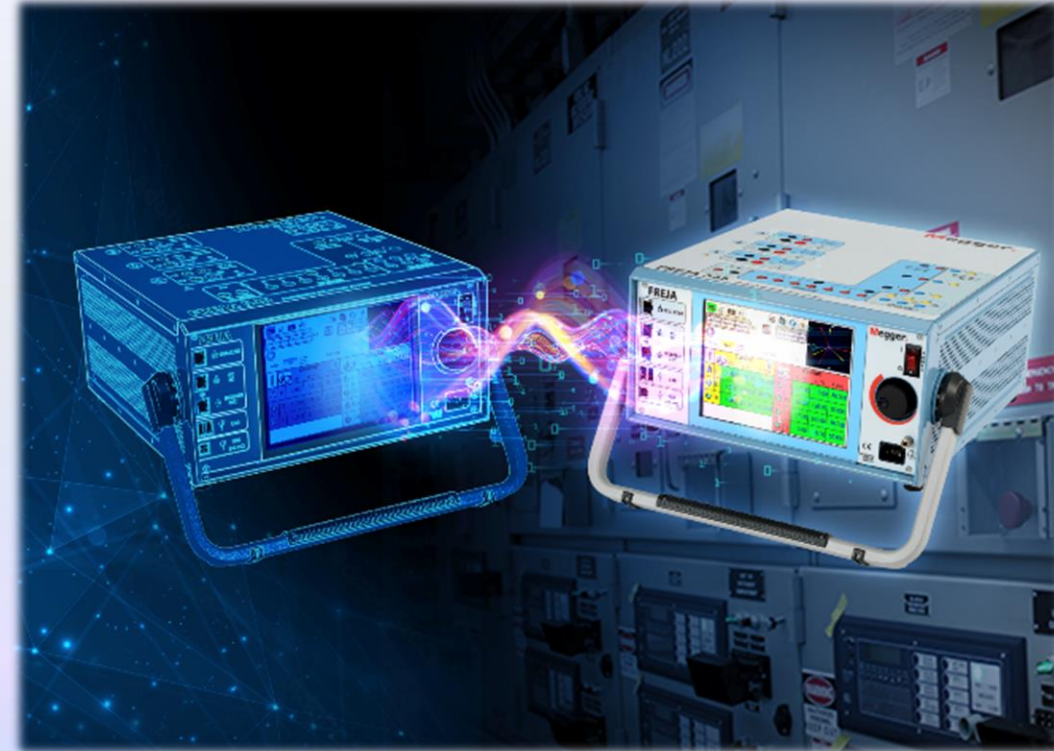


The physical device and the digital twin share the same data

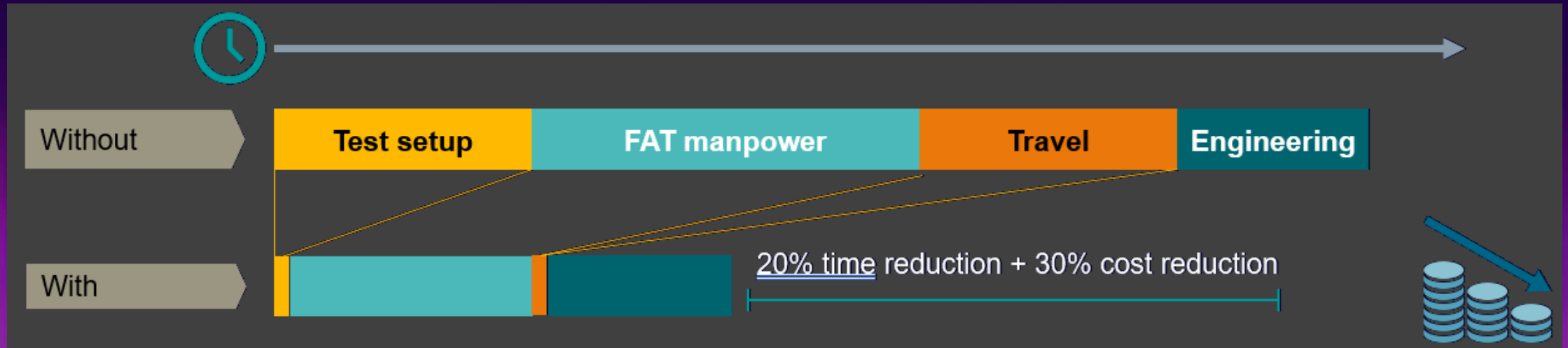


Use cases and benefits

- In what cases can a digital twin be used?
- What benefits does it give?



Virtual Factory Acceptance Test (FAT)

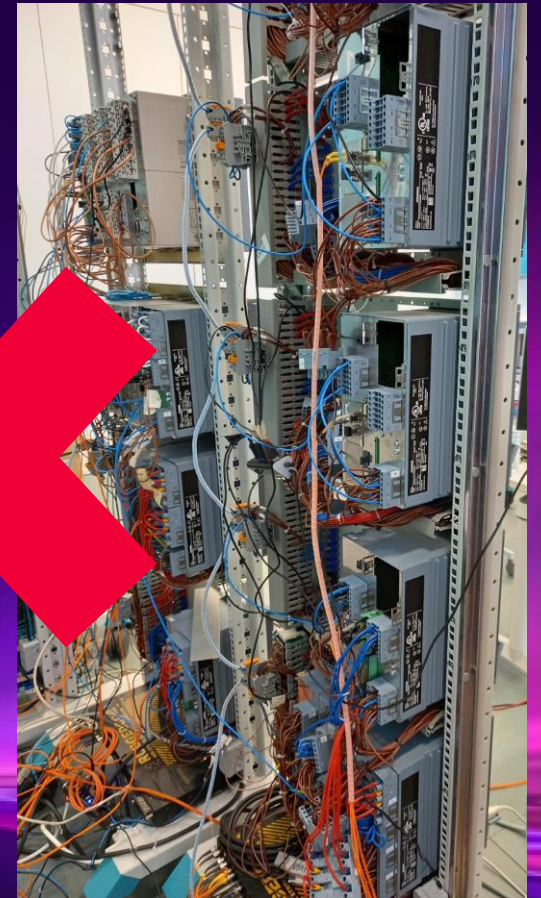


Save time and costs for system integration

Virtual FAT – at any place, at any time

- No logistics of devices
- No waiting for panel production
- No temporary installation and wirings
- No additional test hardware

- Virtual devices
- Virtual wirings
- Parallel work
- Remote



Practical experience in trainings with digital twins



Safety
aspect



Equipment
availability



Deja Vu

Digital Twins simplify complex tests

- Line differential
 - Long distance between test sites
 - Require time synchronised testing
 - Require two test systems
 - Require personnel at each end or a lot of time
- Large bus bar differential protection
 - Require many currents => huge test systems*
 - Impractical and costly

* This is possible through daisy-chain technology



Efficient remote support with digital twins

- Availability of specialists
- Availability of the system
- Work in office hours despite time zone differences

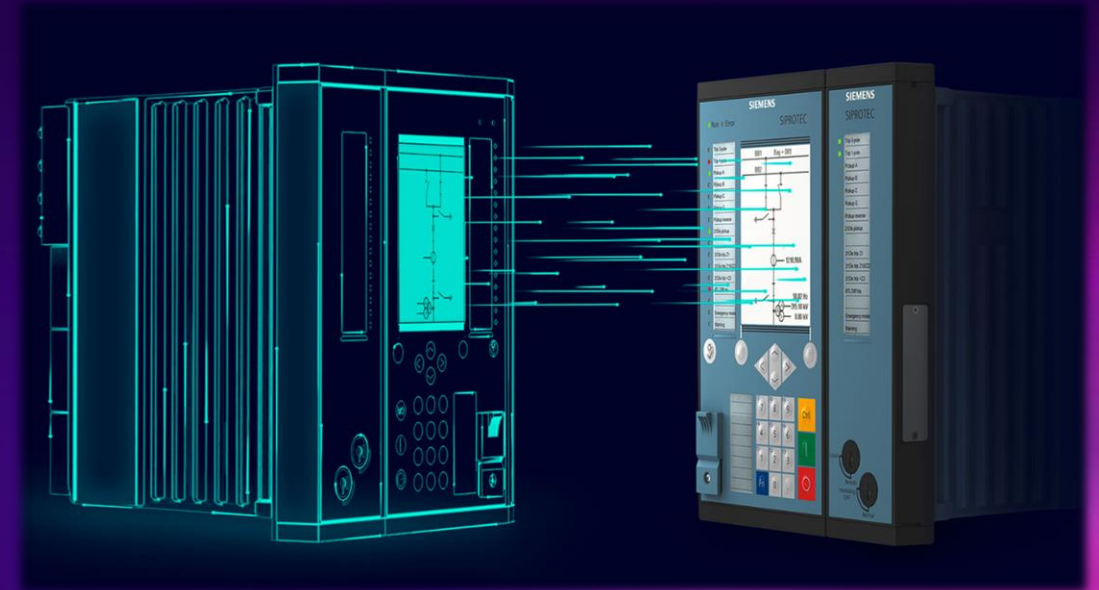
- Avoid mistakes
- Saves time
- No travel → saves costs and the environment

... back to this later

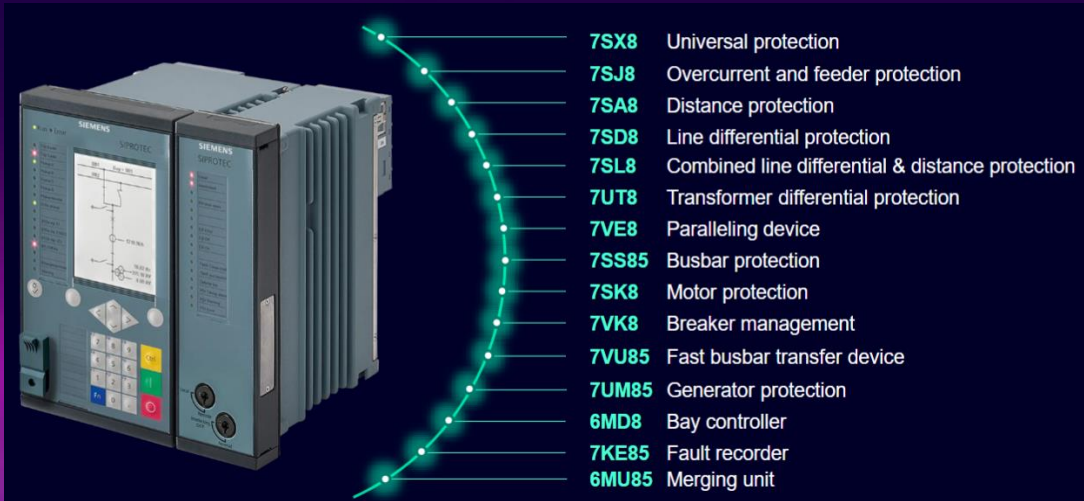


SIPROTEC DigitalTwin

- What has Siemens to offer?



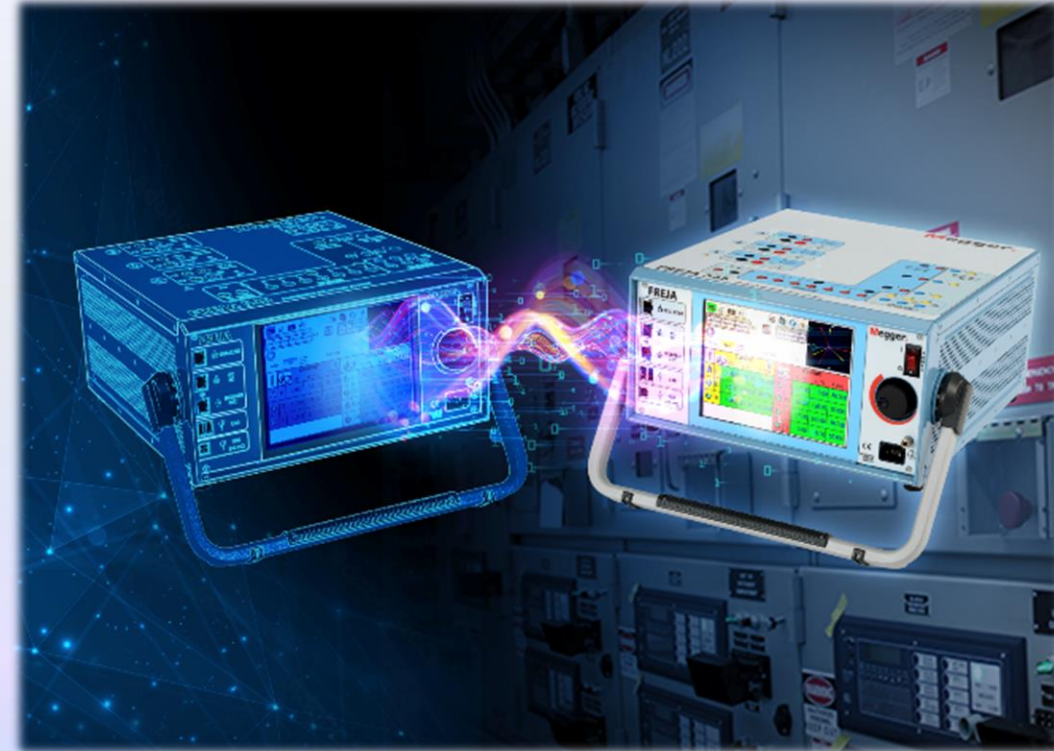
Siemens SIPROTEC DigitalTwin offering



- All SIPROTEC 5 relays have their DT
- All analog inputs supported:
Conventional, LPIT and IEC 61850 SMV
- Full system simulation
with up to 20 relays for L license
- Hybrid testing with physical RTU / HMI as
well as 3rd party IEDs for Ethernet
substation communication
(e.g. IEC 61850 MMS and GOOSE)
- Closed-loop testing with partner test
companies

FREJA/SMRT Digital Twin

- What solutions has Megger to offer?



FREJA and SMRT Digital Twins

- Connect RTMS to suitable Digital Twin
- Virtual machine installed at your PC
- Available models
 - FREJA 546 and 549
 - SMRT 1, 46, and 410
 - SUPER DT
 - A test set with 12 currents and 12 voltages
 - Voltage can be converted to currents → 24 currents
 - Possible to replicate with daisy-changing
- Available through subscription



Practical Demo

- Relay testing with digital twins
- Roleplay



Roleplay and duties



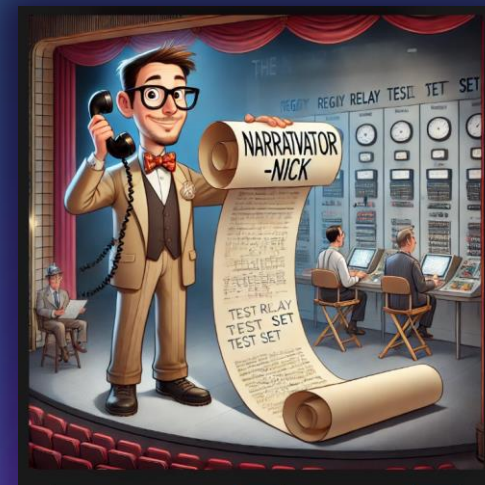
Relay-Bob
Cedric Harispu



Test-Tony
Andrea Bonetti



Commissioning-Ken
Ali Hussain



Narrator-Nick
Niclas Wetterstrand

Storyline

- **Relay-Bob** configures the relay, shares the SIM-file on the shared folder
- **Test-Tony** retrieves the file, uploads it in Siemens DT
- **Test-Tony** opens the Megger DT test kit, creates a test file and runs the tests.
- **Test-Tony** identifies a setting mistake, calls **Relay-Bob** who confirms the mistake
- **Test-Tony** gets permission to change the setting, re-tests and confirms that the issue is resolved
- **Test-Tony** extracts the updated and tested **DIGSI file** from the DT relay, saves it on the shared folder
- **Test-Tony** saves the **test file** and uploads it in on the shared folder
- **Relay-Bob** shares the files with **Commissioning-Ken**
- **Commissioning-Ken** gets the files, writes the settings in the relay and repeat the tests by re-using the setting file and the test file
- **All tests work as expected**
- **Success!!! Commissioning ready prior to deadline by using the property that the twins can share the same data**

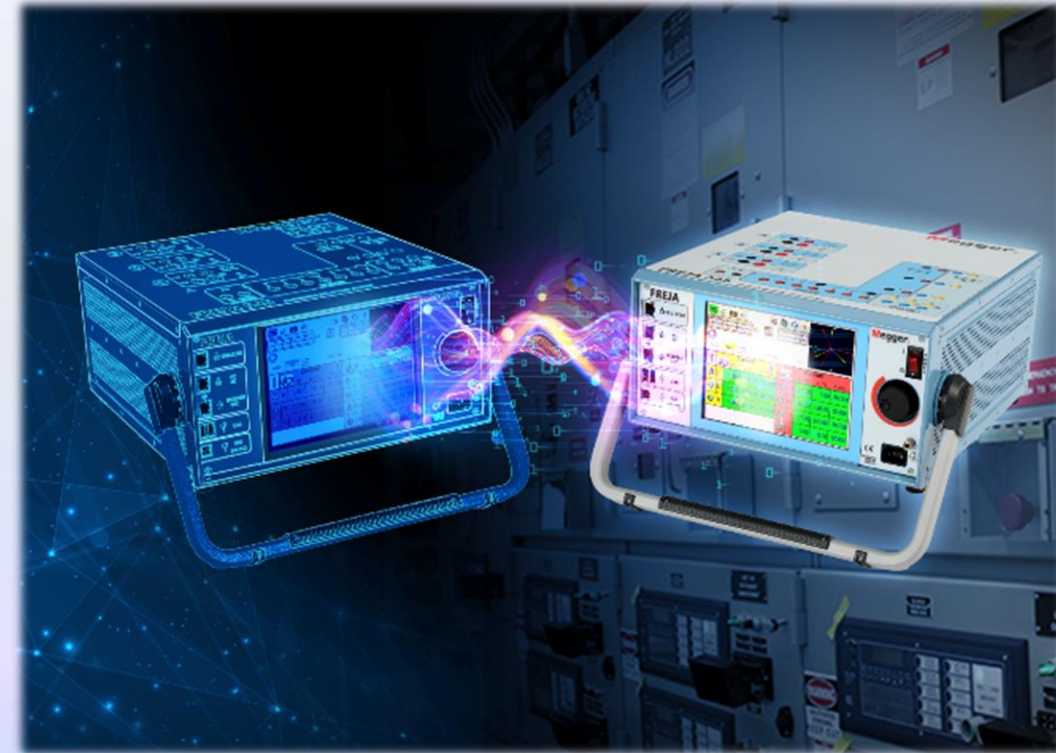


Narrativator-Nick
Niclas Wetterstrand



Conclusion

- A summary of the benefits in relay testing with digital twins



Conclusions – Benefits

- Interacting digital twin relays and digital twin test systems enable benefits:
 - Save time and costs
 - Removes uncertainties and avoids mistakes
 - Improve certainty to meet deadlines
 - Reduce environmental footprint
 - Enable challenging or impossible tests





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THANK YOU!

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References

FREJA and SMRT Digital Twin high fidelity simulator





High fidelity software simulator for use with the FREJA and SMRT relay testers

<https://www.megger.com/en-us/products/freja-and-smrt-digital-twin-high-fidelity-simulator>

Realising the potential of digital twin technology in power system protection

November 2023

Conference: MATPOST 2023 · At: Lyon, France

 Andrea Bonetti ·  Ronald Kubelec ·  Mehdi Zeyeni · [Show all 5 authors](#) ·  Niclas Wetterstrand

<https://www.researchgate.net/publication/376002111> Realising the potential of digital twin technology in power system protection

Digital Twins: Revolutionizing Testing of Protection Relays (Transformer Technology Magazine)

Article Full-text available April 2022

 Andrea Bonetti ·  Niclas Wetterstrand



<https://www.researchgate.net/publication/360973780> Digital Twins Revolutionizing Testing of Protection Relays Transformer Technology Magazine

Virtual Testing of Protection Systems using Digital Twin Technology

Publisher: IEEE

Cite This

PDF

Sughosh Kuber ; Mohit Sharma ; Andrea Bonetti ; Cédric Harispuru ; Amir Soroush [All Authors](#)

<https://ieeexplore.ieee.org/document/9776572>

Functional digital twins of relay protection and relay test equipment enabling benefits in training and remote support

Conference Paper

Full-text available

March 2022 · DPSP 2022

 Abdul Raqeeb ·  Andrea Bonetti ·  Andreas Carlsson · [...] ·  Niclas Wetterstrand







https://www.researchgate.net/publication/359159893_FUNCTIONAL_DIGITAL_TWINS_OF_RELAY_PROTECTION_AND_RELAY_TEST_EQUIPMENT_ENABLING_BENEFITS_IN_TRAINING_AND_REMOTE_SUPPORT

Digital twins and the smart grid (e-tech Magazine, IEC)

Article

Full-text available

March 2022

 Catherine Bischofberger ·  Andrea Bonetti ·  Laurent Guise ·  François Coallier



https://www.researchgate.net/publication/361004727_Digital_twins_and_the_smart_grid_e-tech_Magazine_IEC

Digital twin technology for virtual testing of power system relay protection





Publisher: IEEE [Cite This](#) [PDF](#)

Andrea Bonetti ; Cédric Harispuru ; Marius Pitzer ; Mark Pustejovsky ; Niclas Wetterstrand ; Simone Kachelrieß [All Authors](#)

<https://ieeexplore.ieee.org/document/9587869>

Special Electrical Tester 003-2021 - Virtual testing of protection relays is real!

Article [Full-text available](#) July 2021

 Andrea Bonetti ·  Cédric Harispuru ·  Niclas Wetterstrand ·  Marius Pitzer



https://www.researchgate.net/publication/356411989_Special_Electrical_Tester_003-2021_-_Virtual_testing_of_protection_relays_is_real

Expert Workshop - Digital Twins for Energy Automation

February 8, 2022

<https://www.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/webinars/protection-relay-siprotec-digitaltwin-2202.html>

Workshop – practical part



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6) Andrea sparar testplanen (testfilen) för den digitala tvilling-testutrustningen, så att den kan (åter)användas i stationen med en fysisk testutrustning från idrifttagningens ägare för att

Virtual commissioning with Digital Twins / demo

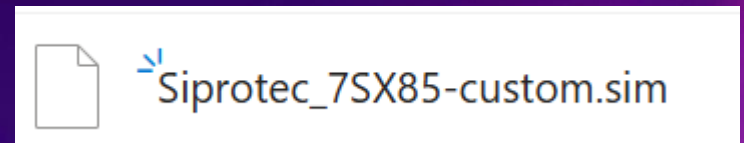
1) Relay-Bob is the relay engineer.

He prepares his settings/configuration file with DIGSI 5 but does not test the relay himself. Once he's done, Relay-Bob saves the Digital Twin file (SIM file) for the relay and sends it to Test-Tony for virtual testing.



Relay-Bob
Cedric Harispuru

To Test-Tony...



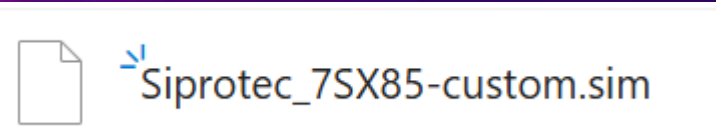
(SIEMENS FILE ".SIM")

Virtual commissioning with Digital Twins / demo

2) Test-Tony will test... virtually.

He creates the digital twin relay in his Siemens SIPROTEC Digital Twin environment.

FROM Relay-Bob

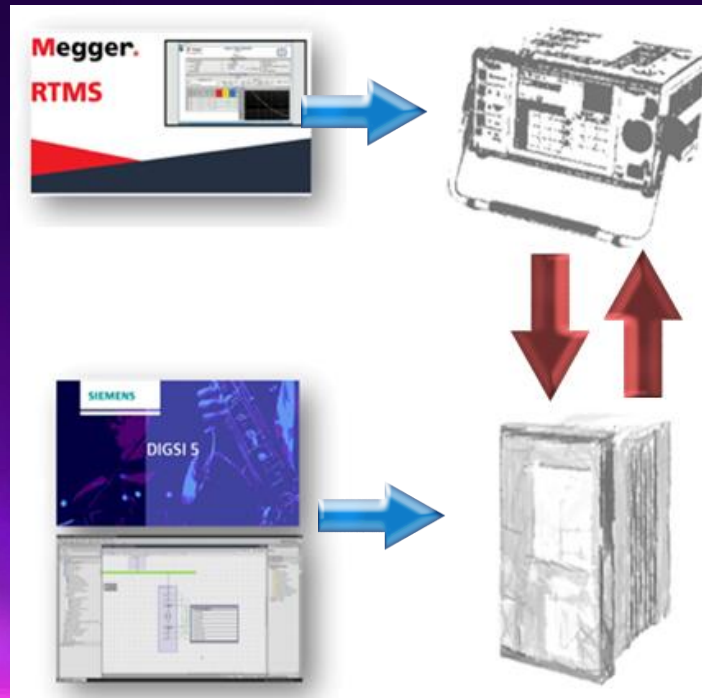


(SIEMENS FILE ".SIM")



Virtual commissioning with Digital Twins / demo

3) Test-Tony tests the protection relay using the digital twin test equipment, "connected" to the digital twin relay.



Virtual commissioning with Digital Twins / demo

4) Test-Tony can change or not change certain settings in the relay, depending on the test results. He can use the relay's front HMI for simple adjustments or use virtual DIGSI for more complex changes.

Test-Tony can agree on these changes with Relay-Bob.



Virtual commissioning with Digital Twins / demo

5) Test-Tony exports the relay information from the digital twin relay and sends the DIGSI file (.TCF) and the TEST FILE to Relay-Bob, so that he can provide them to Commissioning-Ken

To Relay-Bob



TESTFILE.PdbXml
(MEGGER POWERDB TEST FILE)



CORRECT_PROJECT.TCF
(SIEMENS DIGSI FILE PROJECT)



Virtual commissioning with Digital Twins / demo

6) Relay-Bob sends the DIGSI FILE and the TEST FILE to Commissioning-Ken so that it can be (re)used in the station with physical test equipment from the Commissioning-Ken to ensure that everything is still Ok (sharing the same data).



To Commissioning-Ken



TESTFILE.PdbXml
(MEGGER POWERDB TEST FILE)



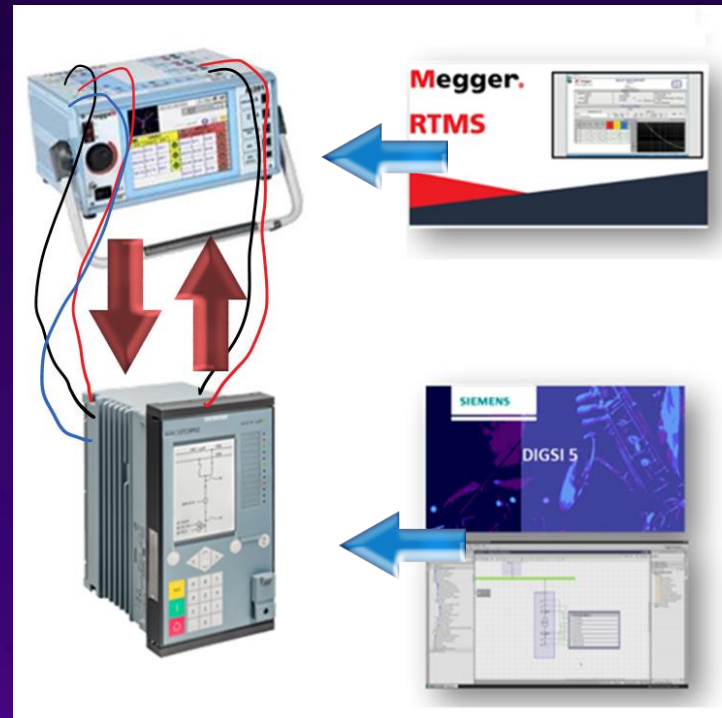
CORRECT_PROJECT.TCF
(SIEMENS DIGSI FILE PROJECT)

Virtual commissioning with Digital Twins / demo

7) Commissioning-Ken will download the DIGSI file into the physical relay and use the test plan files to test the physical relay with the physical test set in the substation... SHARING THE SAME DATA!



Commissioning-Ken
Ali Hussain



TESTFILE.PdbXml



CORRECTPROJECT.TCF



Virtual commissioning with Digital Twins / demo

Some important comments.

The example given is just ONE of the many possible workflows. A few other methods we have experience with are the followings:

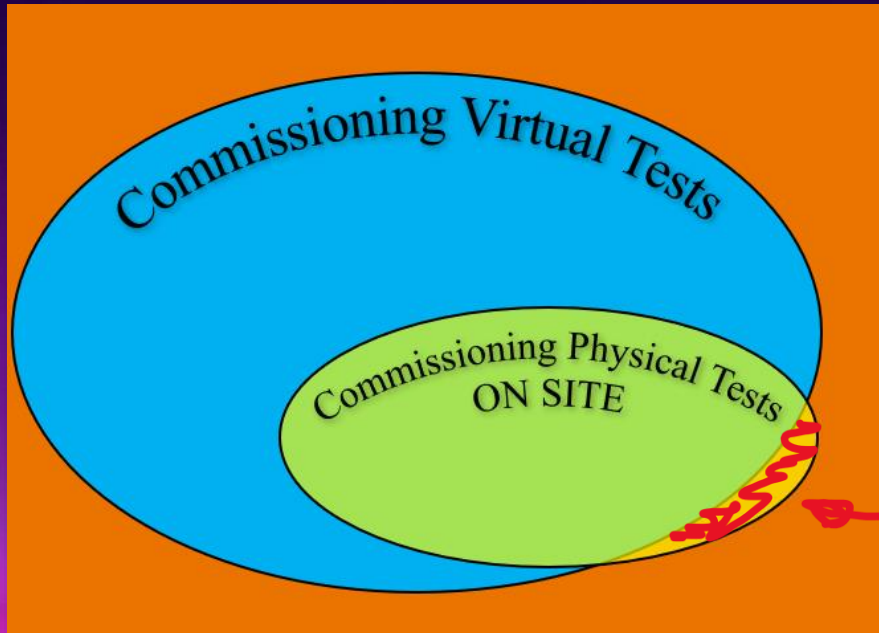
- a) Relay-Bob and Test-Tony could be the same person from the engineering company. The DIGSI relay file and FREJA/SMRT test file from the virtual tests are then handed over to the Commissioning-engineer (Commissioning-Ken) at the substation.
- b) Test-Tony could be at the substation and needs assistance. Relay-Bob is a specialist in the company and helps out..

When working in this way, **only a few files are transferred**. There is NO need to create a new project in DIGSI for the "physical relay." **Simply use the same file that was created in the virtual environment.**

There is **no need to recreate a new test file** for the FREJA/SMRT "physical test equipment." **Simply use the same file.**

Virtual commissioning with Digital Twins / demo

Of course, errors can still occur, but this helps to minimize them.



Some new tests may still be needed at the substation to verify certain hardware functionality, connections, etc.

AND NOW... THE DEMO

VIRTUAL RELAY TESTING WITH DIGITAL TWINS



VIRTUAL
TESTING
ACTION

PROTECTION
RELAY

DIGITAL
TWINNING
IN ACTION



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