Outcomes and Results
Smart beats Copper
TA Project

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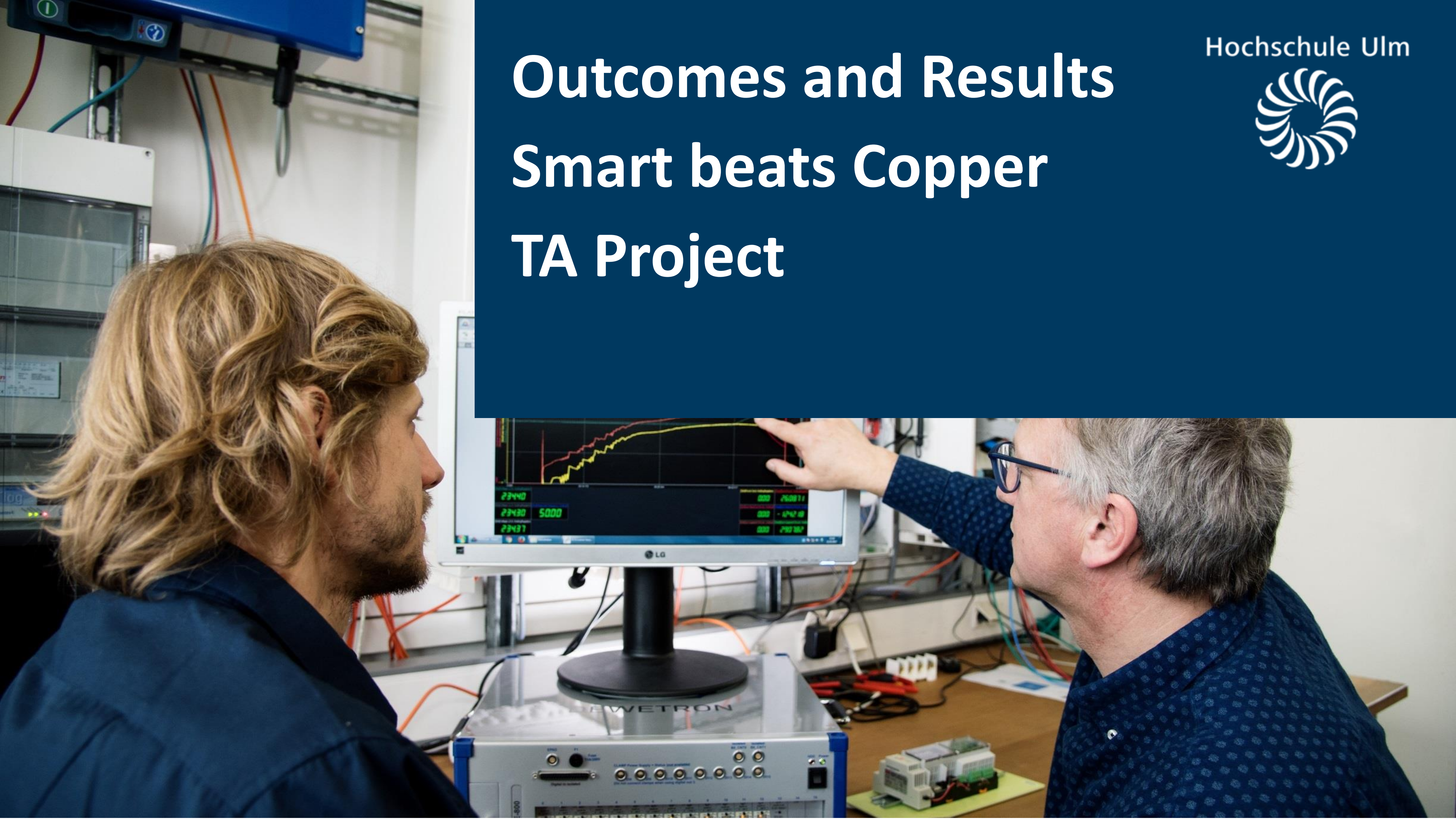
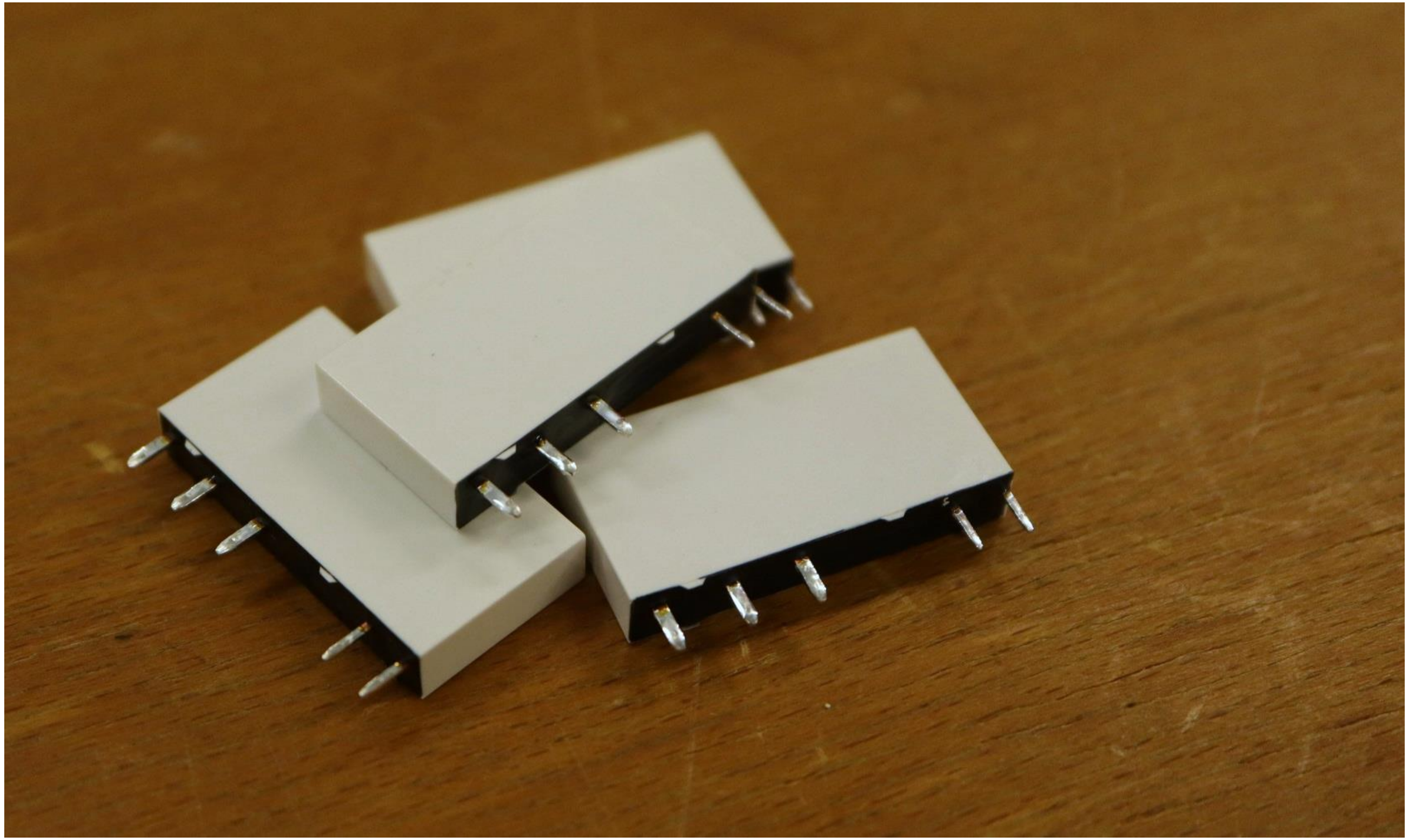


Agenda

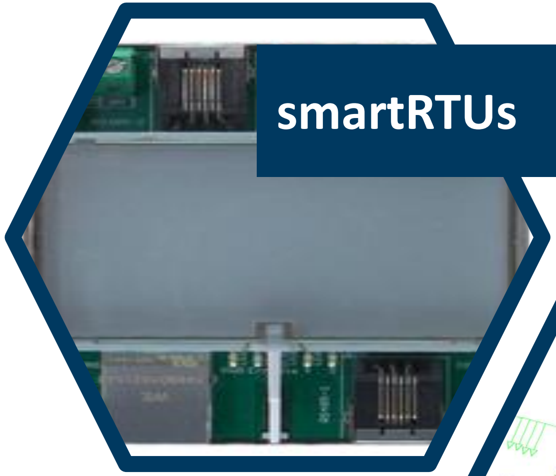
- Introduction
- System Setups
- Comparison of System Setups
- Case Study
- Conclusion & Outlook

Digitalisation of the German Energy Sector

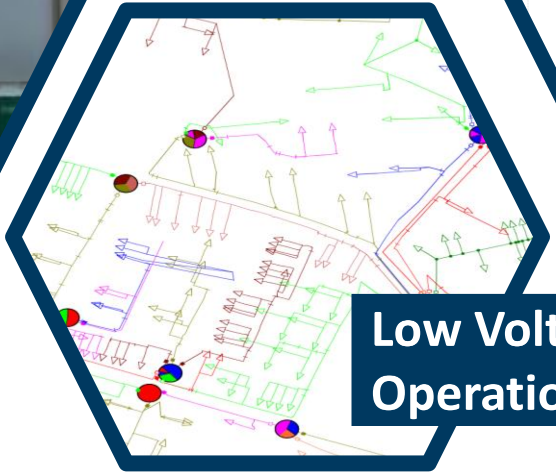


Challenges for DSO

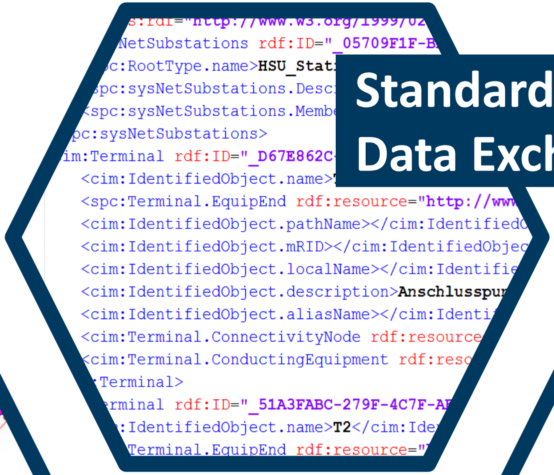
Changes caused by decentralisation and digitalisation:



smartRTUs



Low Voltage Grid Operation



Standards and Data Exchange

(partly) Automated Operation

Key Question

How can one **test** and **validate** systems which are performing a **smart grid control strategy**?

X-in-the-Loop for Smart Grid System Testing

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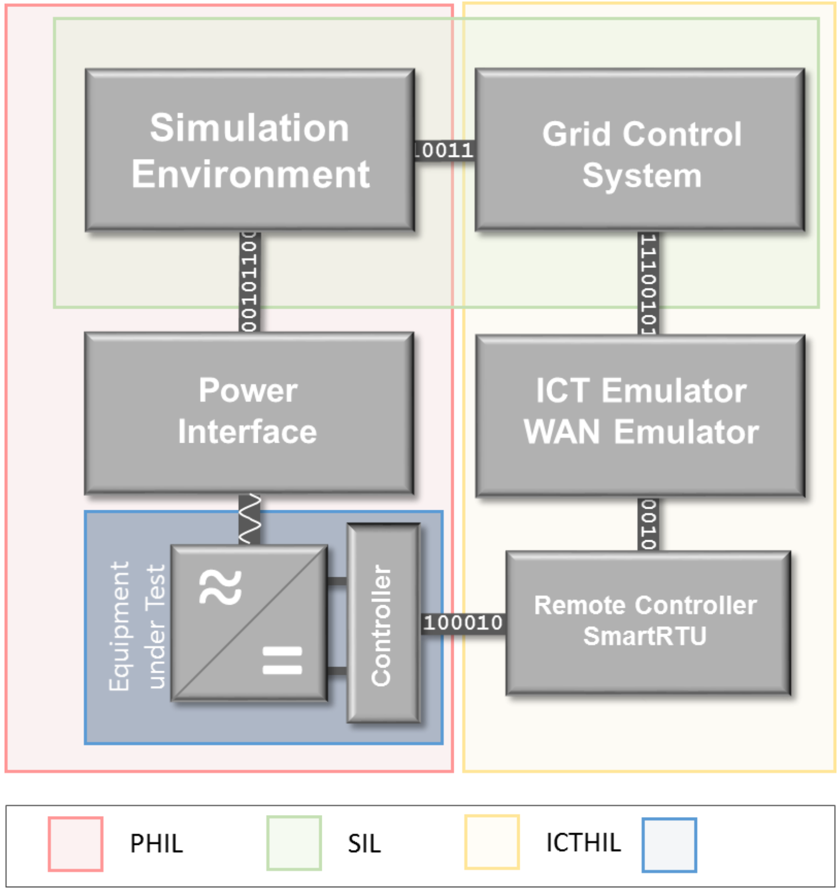
- Combination and Usage:
  - Power-Hardware-in-the-Loop (PHIL)
  - Software-in-the-Loop (SIL)
  - Controller-in-the-Loop (CHIL)
  - Communication-in-the-Loop (ICTHIL)



Requirements: Testbed

Category	Domain	Requirement
Systems Properties	Involved Domains	SGAM Domain *Distribution*, *Decentralized Energy Resource* or *Customer Premise*
	Communication	communication over WAN (e.g., BPL or Mobil 4G)
	Communication	multiple communication protocols are used and converter
	Control	central and decentralised control
	Control	autonomous or partially autonomous control of multiple systems
	Timing	update and control cycles $> 30s$
Requirements	Timing	PHIL cycle time $t_{PHIL} \leq 1s$
	Accuracy	only sinusoidal waveform
	Accuracy	low voltage deviation $\Delta U \leq 1V_{RMS}$

EriGrid TA: Smart Beats Copper

Key Facts for the TA:

- Host Facility: AIT – SmartTest Lab
- User Group: Smart Grid Resarch Group @ Ulm University of Applied Science
- 2 Stays (November 2017 / March 2018)
- 5 Members visited AIT
- 2 Publications
  - 1 Confernce Paper
  - 1 Journal Paper

Smart Grid Lab @ HSU

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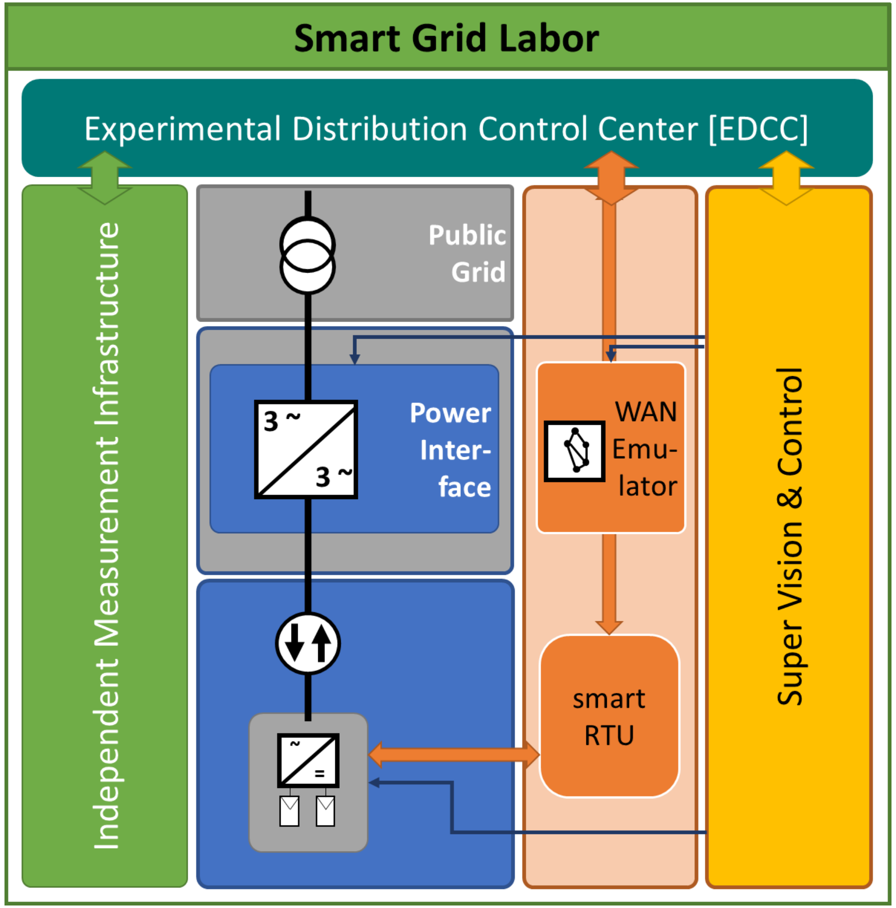
Test of Smart Grid Systems and Components

Key Components:

- Power Interface
  - Regatron Top.Con ACS
- Independent Measurement Device
  - Dewetron Dewe-800
- ICT- Infrastructure
  - IWL KMAX WAN-Emulator
- SmartMeter Infrastructure
  - CLS Management
  - Smart Meter Gateway Admin
- Utility Grade SCADA
  - Siemens Spectrum Power 5



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EDCC – Experimental Distribution Control Center

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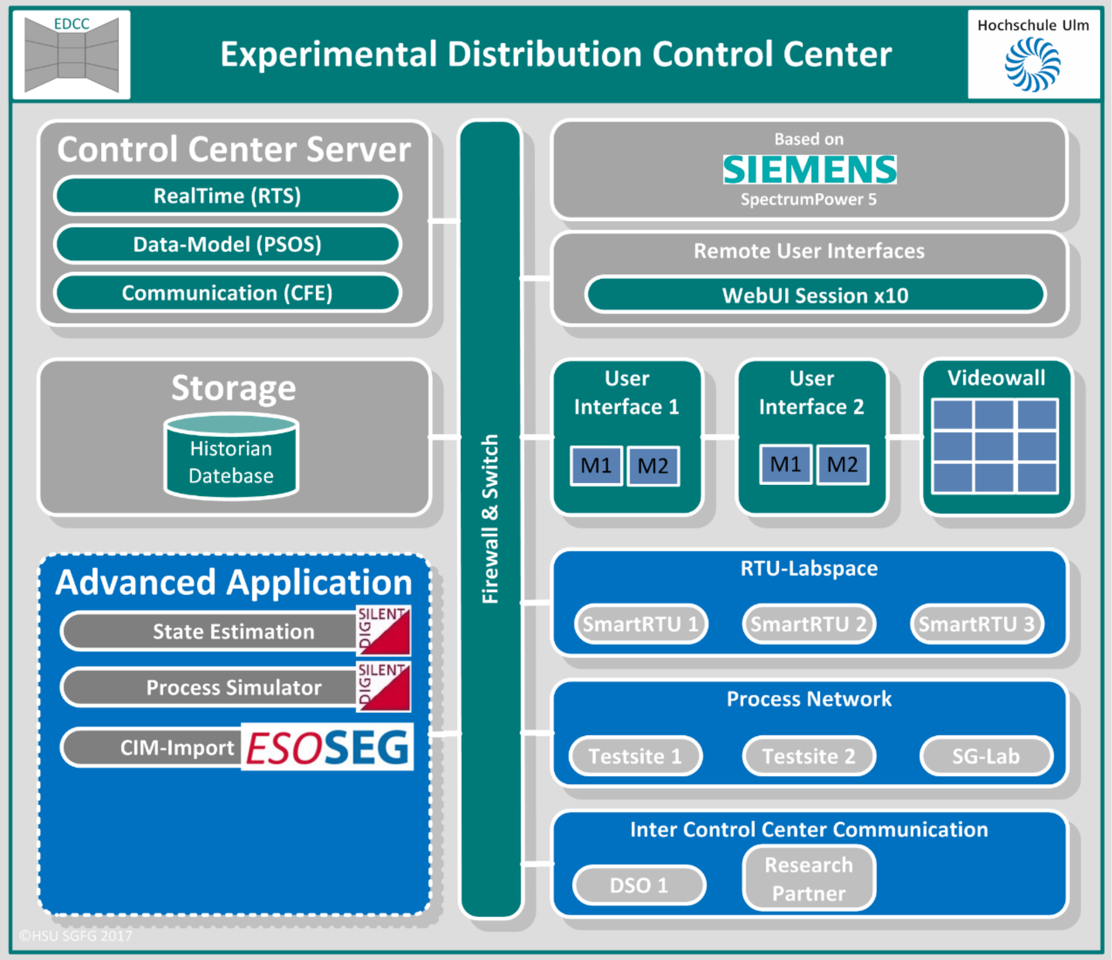
Test of Smart Grid Communication and Strategies

- Siemens SpectrumPower 5
  - IEC104
  - IEC61850
  - TASE.2
- Tele Control Lab
- IEC61850 Test Environment
  - Omicron IEDScout
  - SystemCorp ICDDesginer

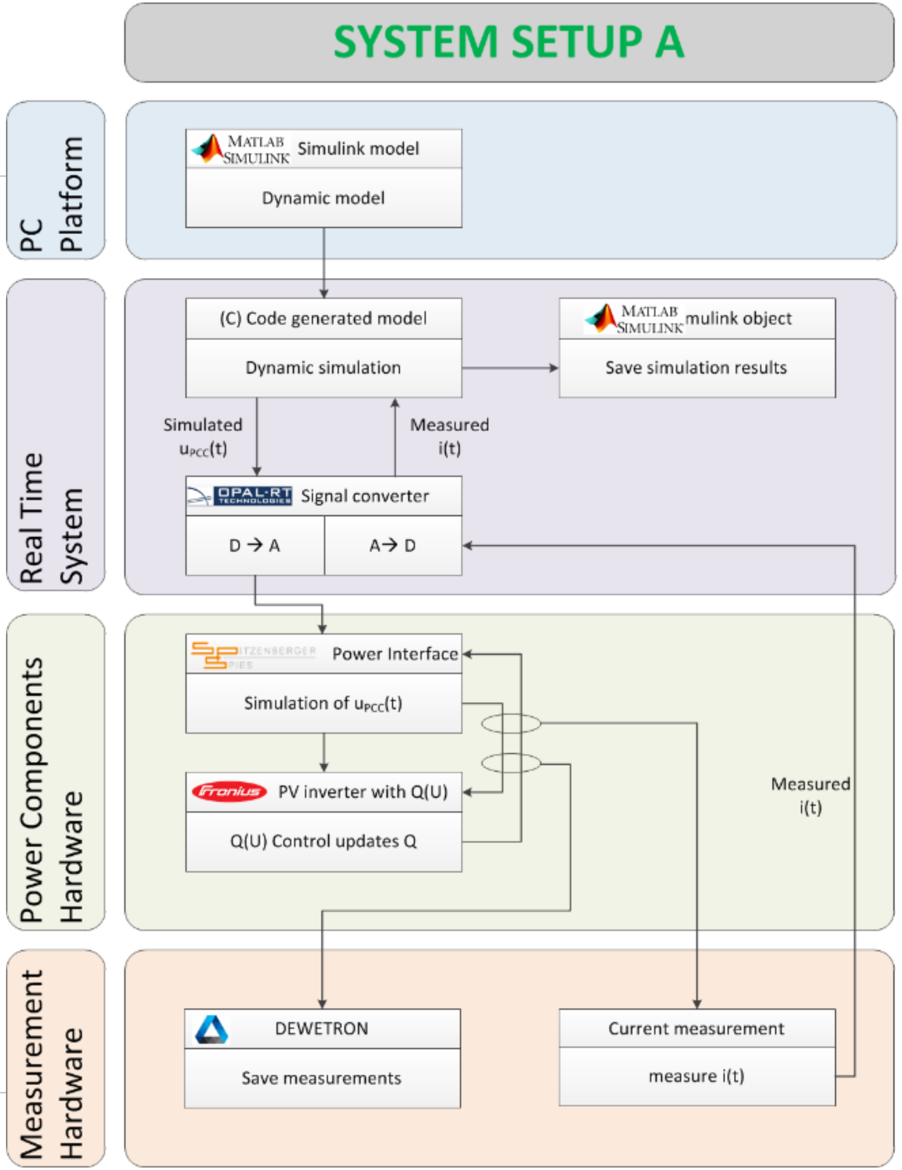


PHIL Setup

Classic Approach

Key Components:

- Power Interface
  - Spitzenberg Spies PAS
  - (Linear Amplifier)
- Simulation System
  - Opal-RT

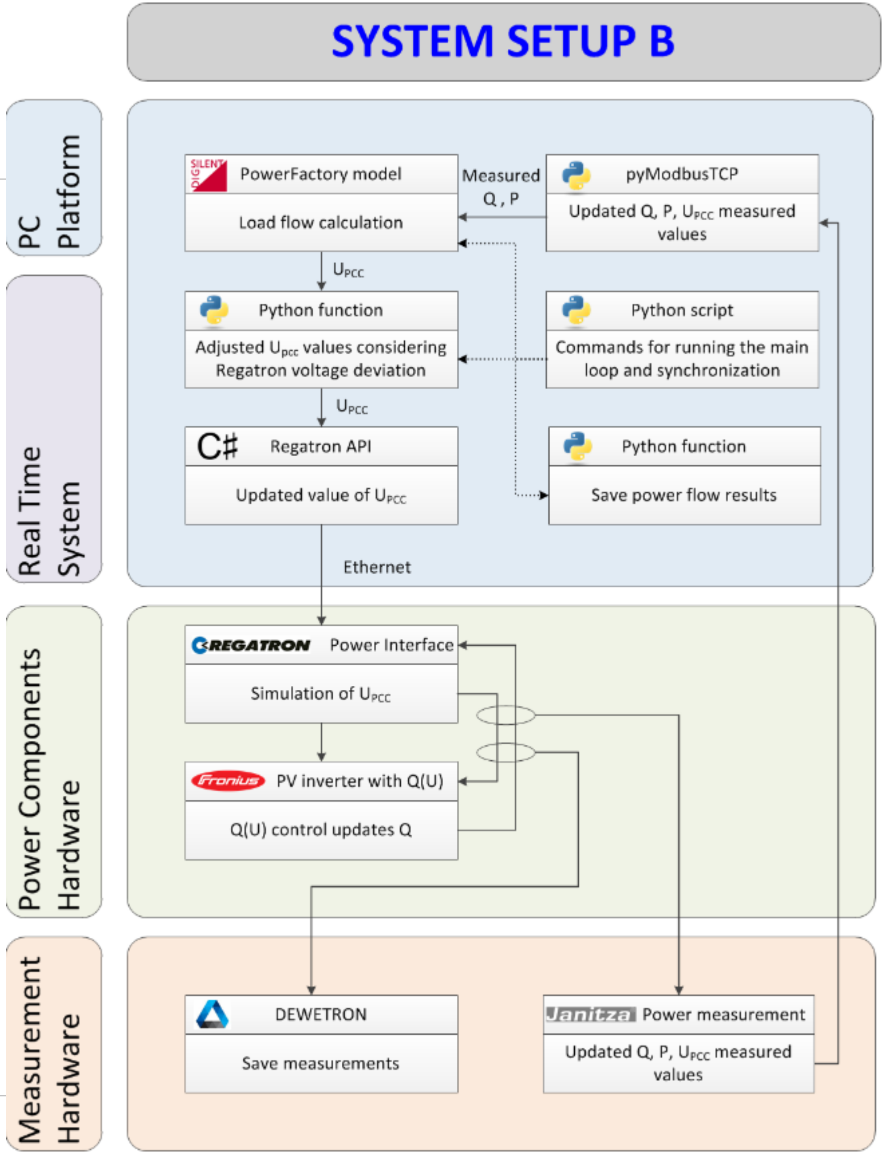


PHIL Setup

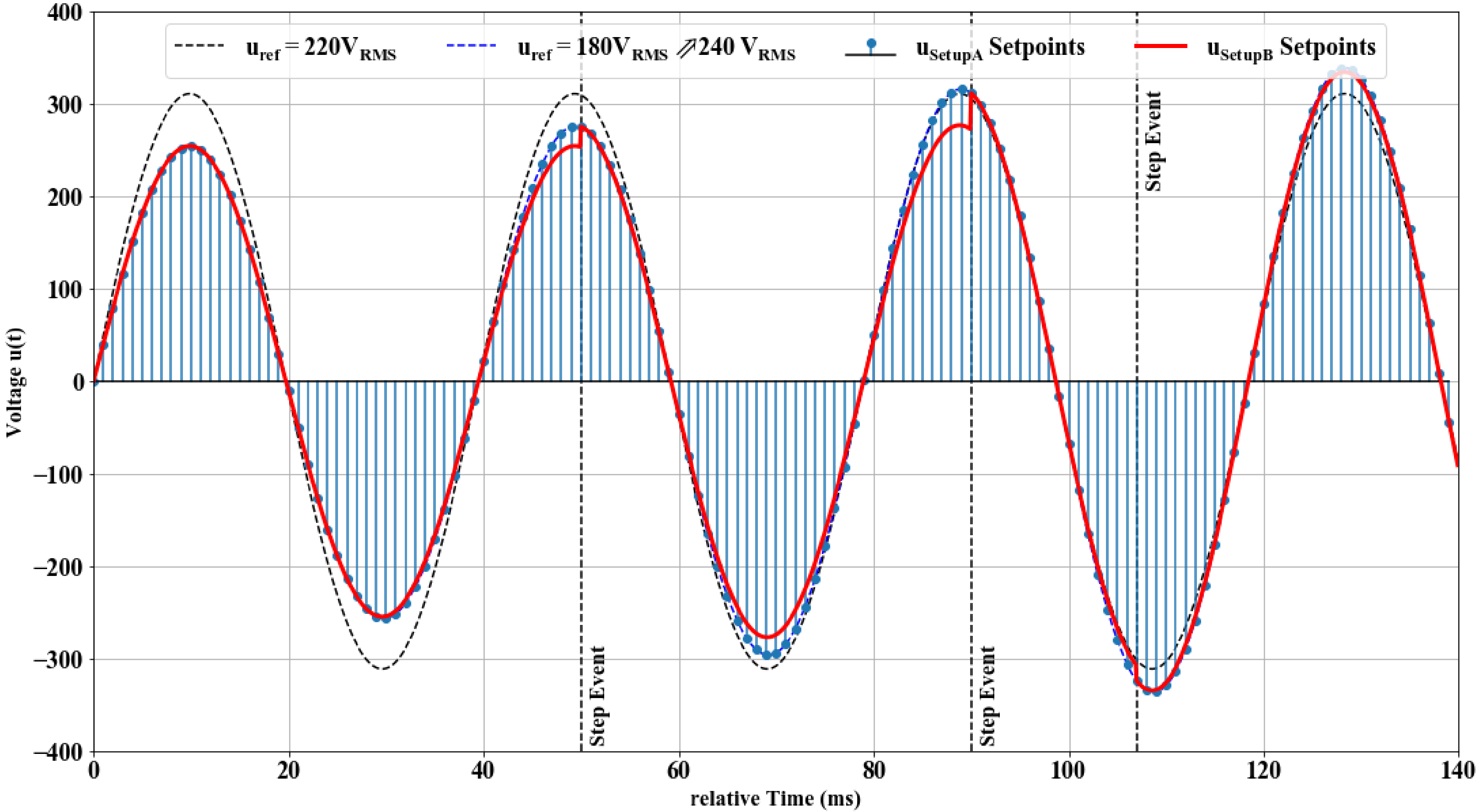
RMS - Approach

Key Components:

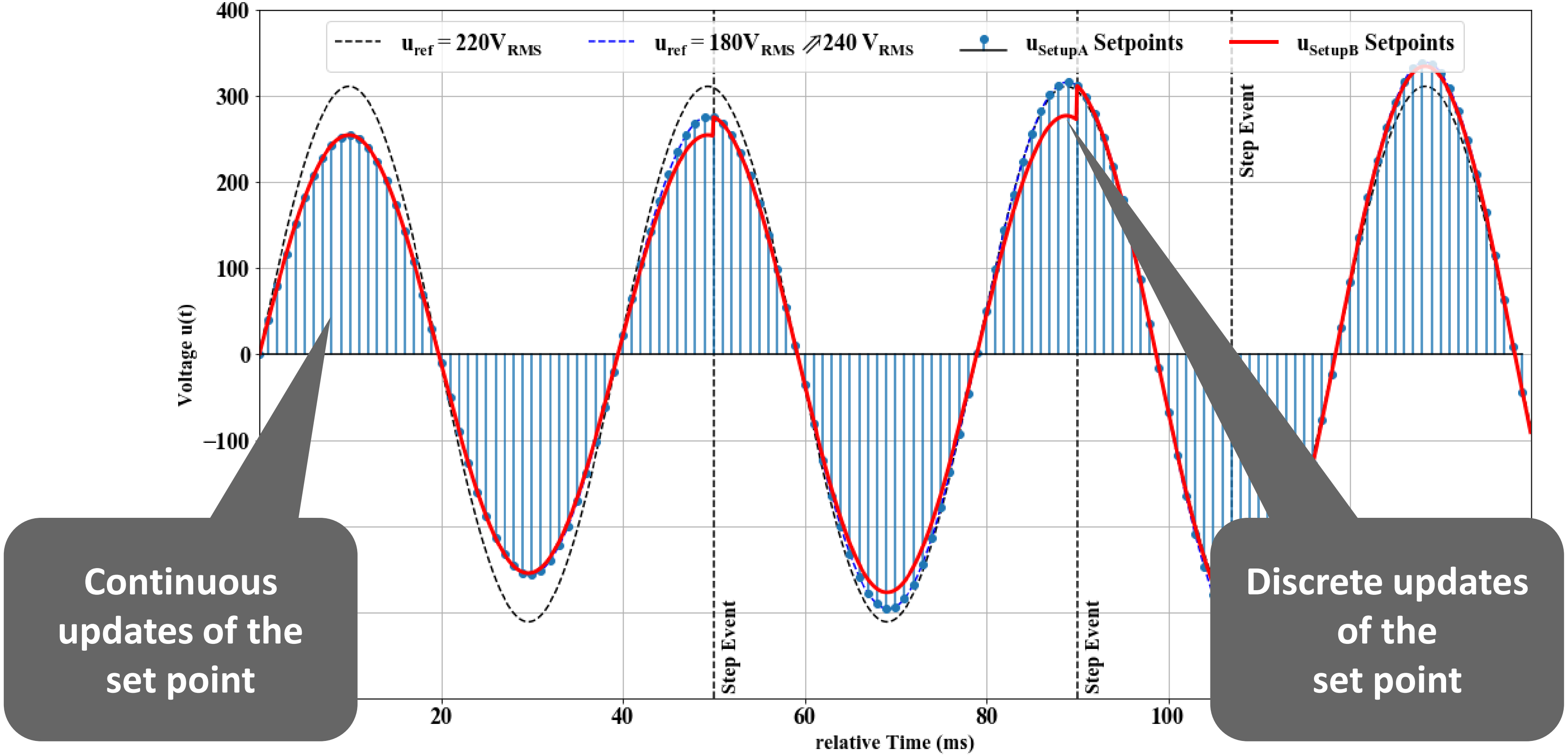
- Power Interface
  - Regatron Top.Con ACS
  - (Switch Mode Amplifier)
- Simulation System
  - Digsilent PowerFactory 2018



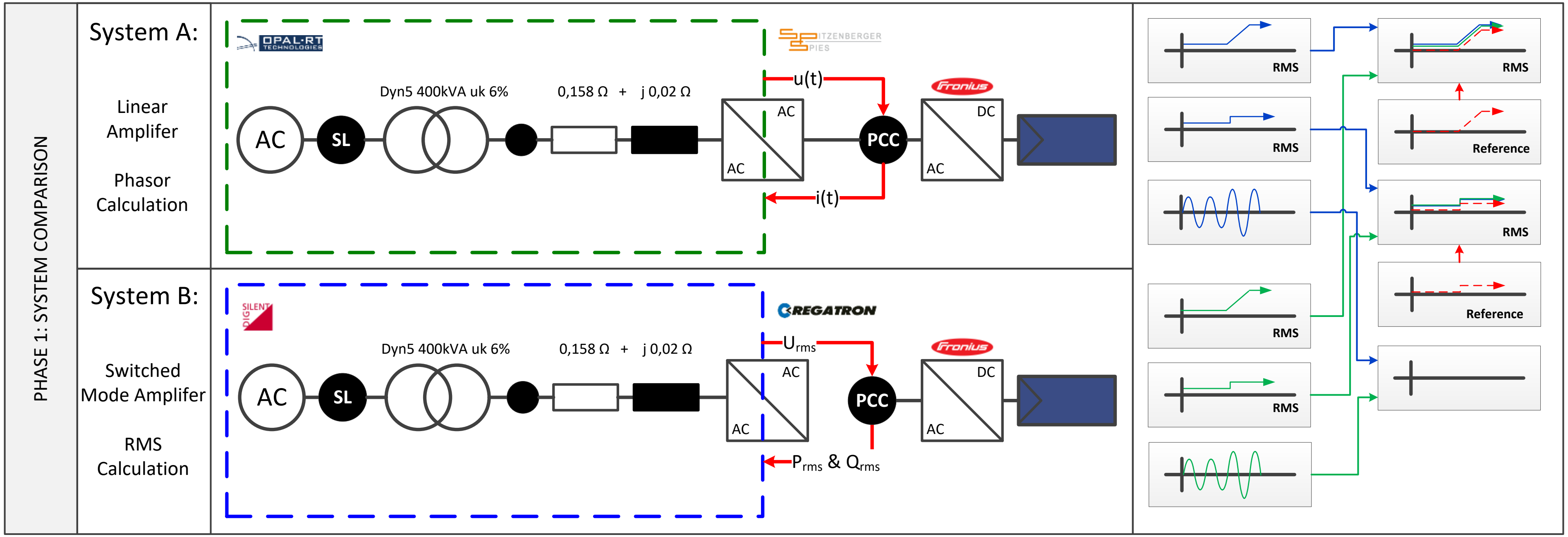
PHIL Setup - Comparison



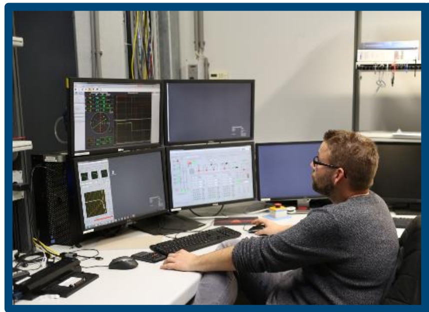
PHIL Setup - Comparison



Test Phase 1 – Comparison of Systems Setups



Test Phase 1 - Setup



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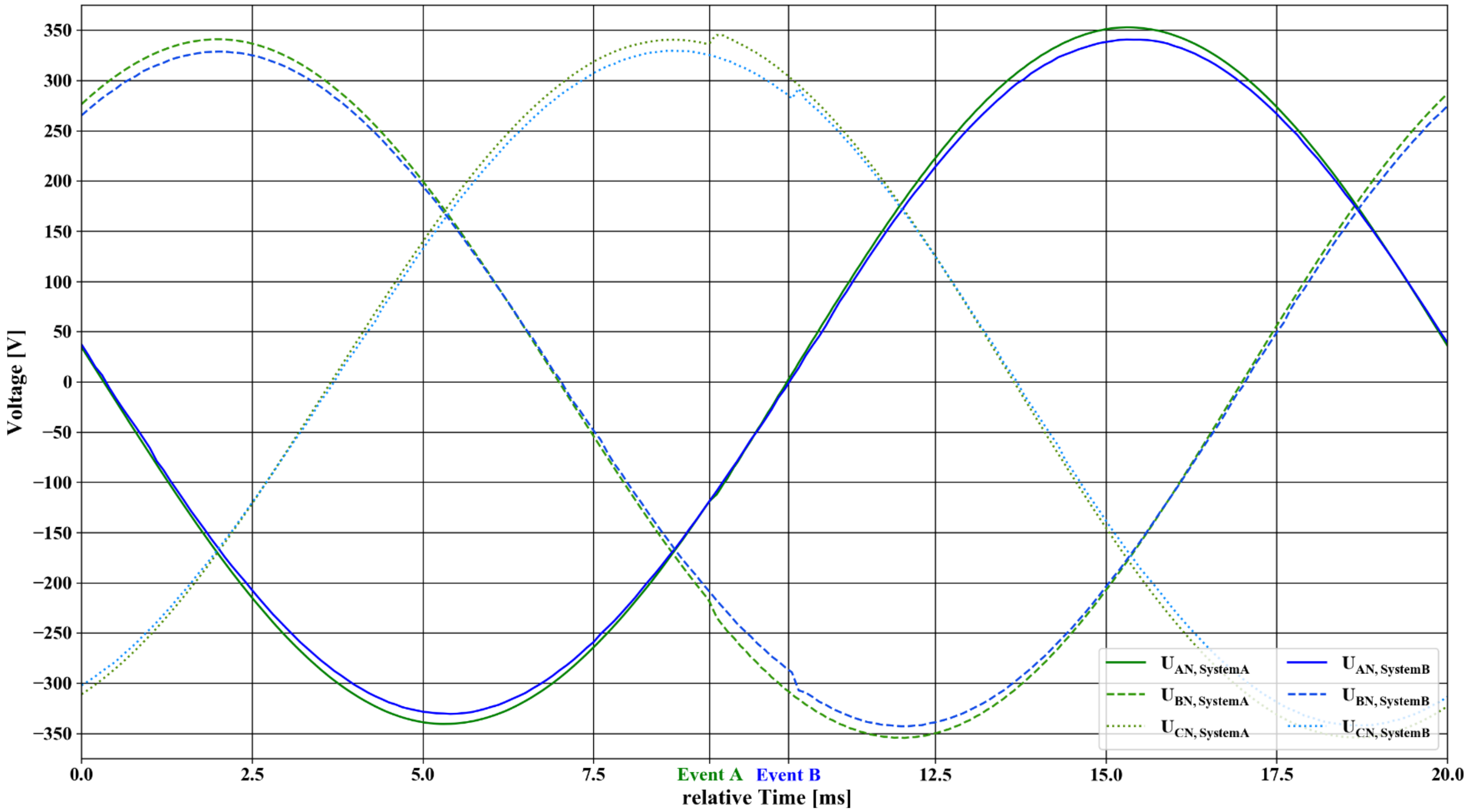
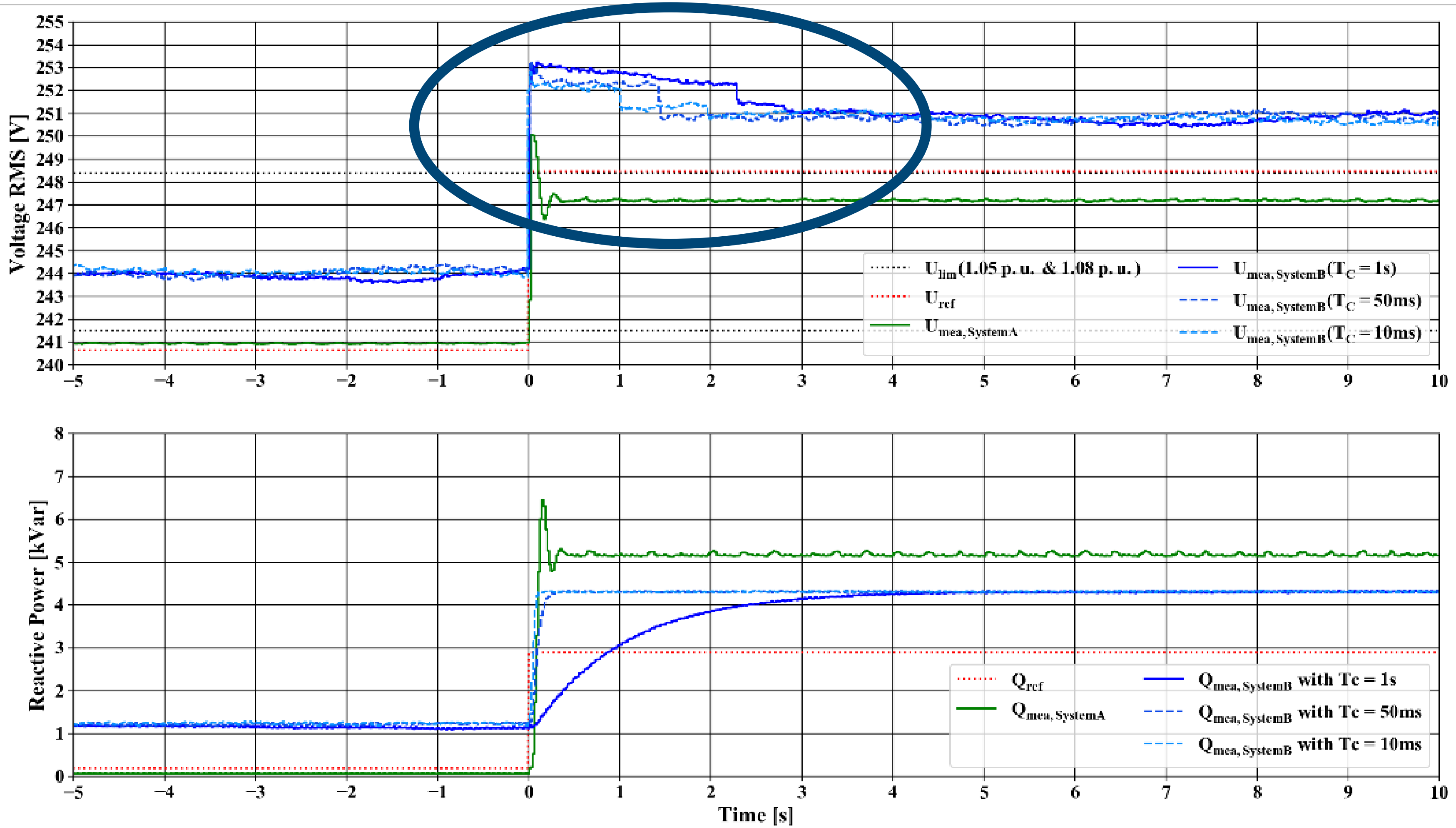
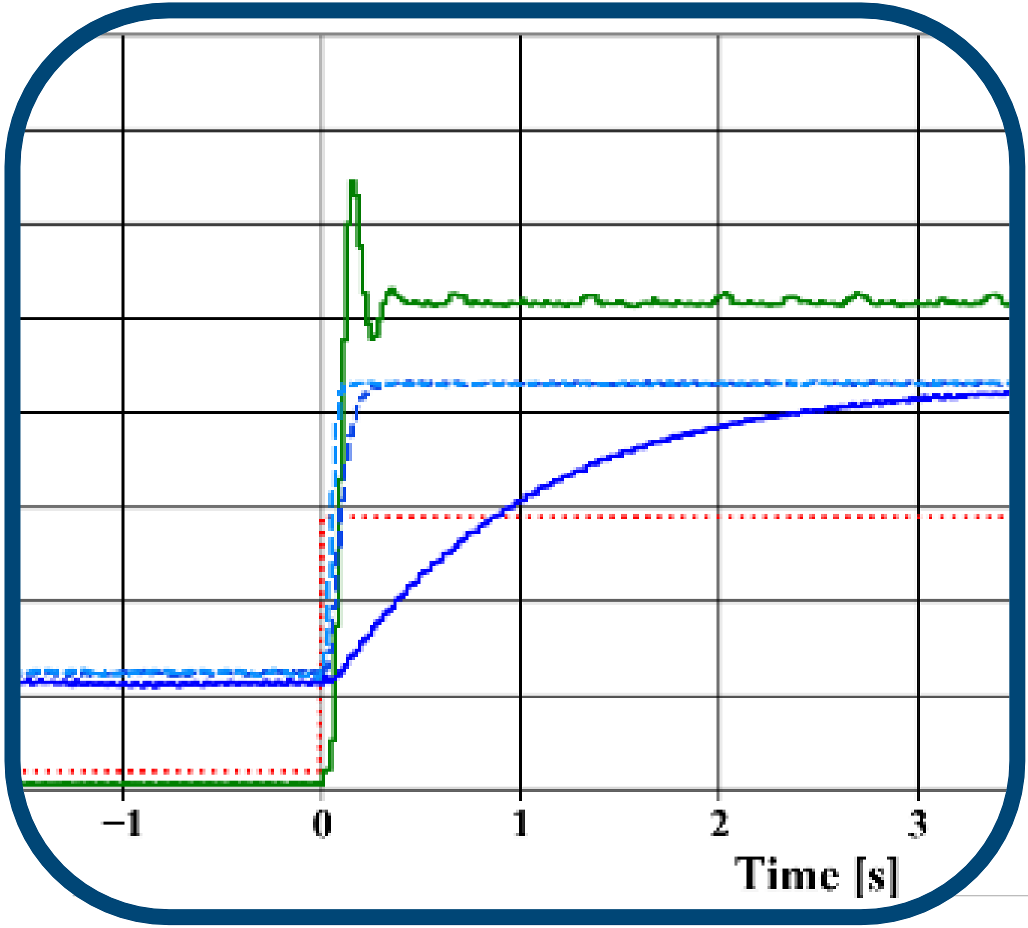
Test Phase 1- Transient Voltage Step

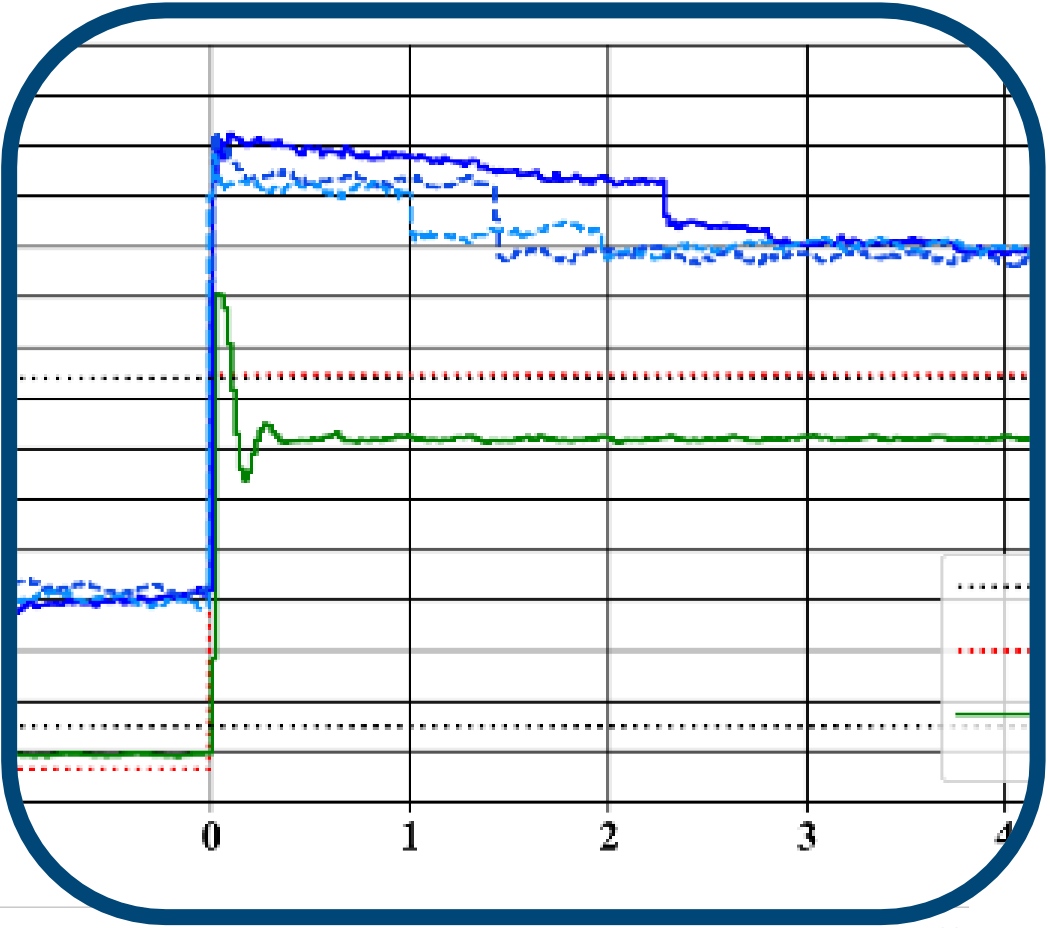


Test Phase 1 – Voltage Step



Test Phase 1 – Voltage Step





Test Phase 1 – Voltage Ramp

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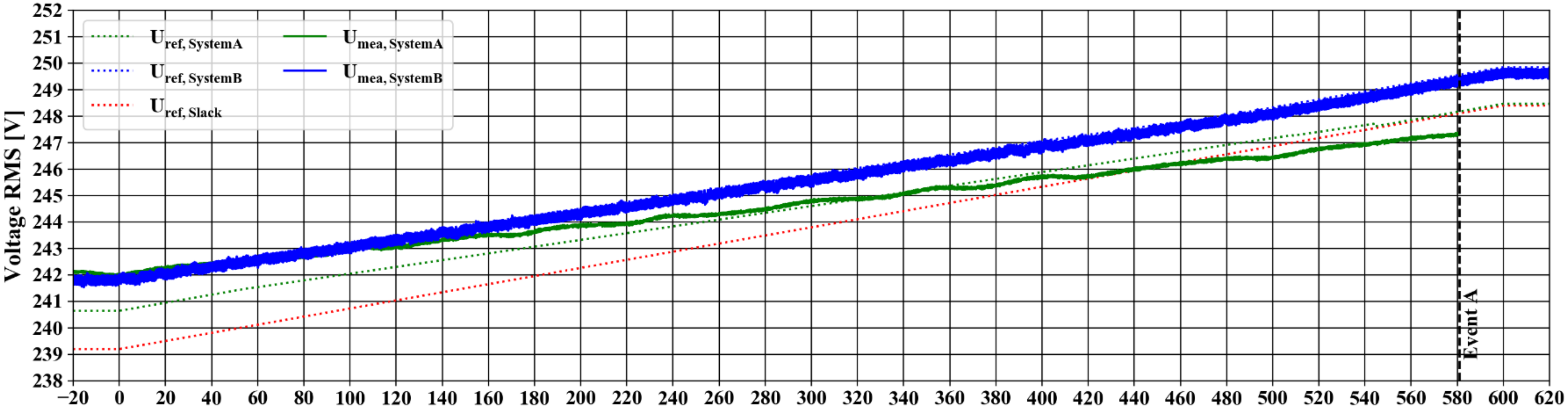

Test Phase 1 – Conclusions

	System Setup A	System Setup B
Pros (+)	small cycle time ($\leq 50\mu s$) multiple calculation methods (phasor simulation, transient simulation) low immanent impedance	regenerates energy during the test
Neutral (#)	specific usage of the simulation tool	sufficient cycle time ($\leq 1s$) variation in cycle time (STD xxx s)
Cons (-)	over heating occurs dissipates energy during test run	one calculation method (steady state) high immanent impedance

Test Phase 2 -Case Study

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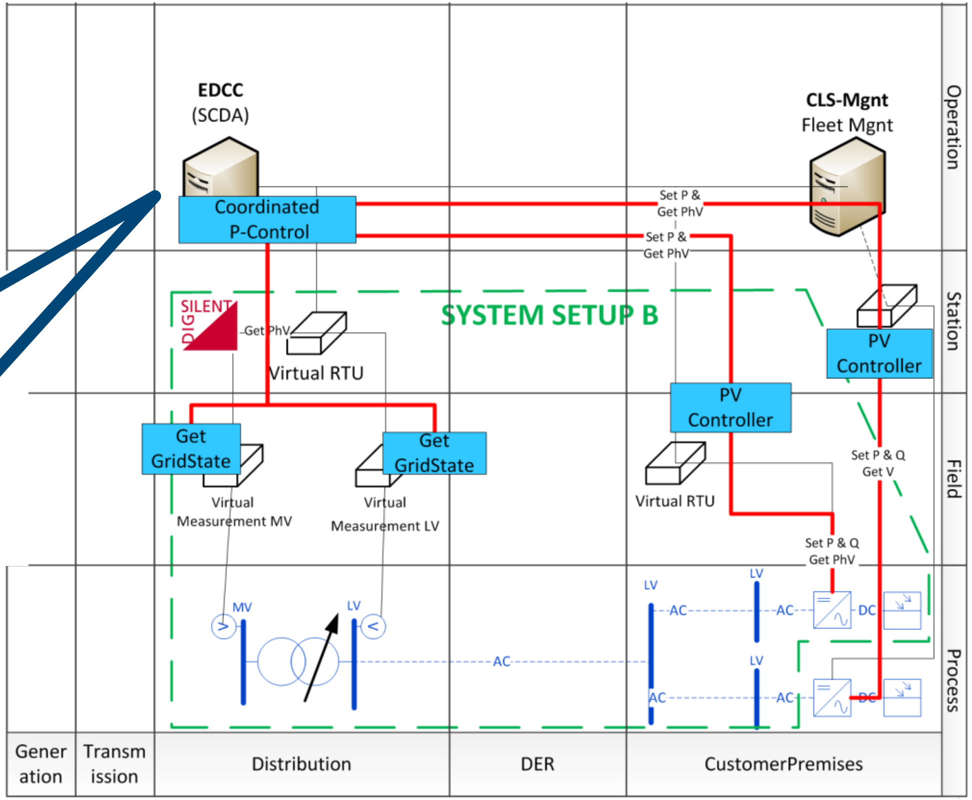
Voltage Control due to Curtailment and decentralised Volt/Var Control

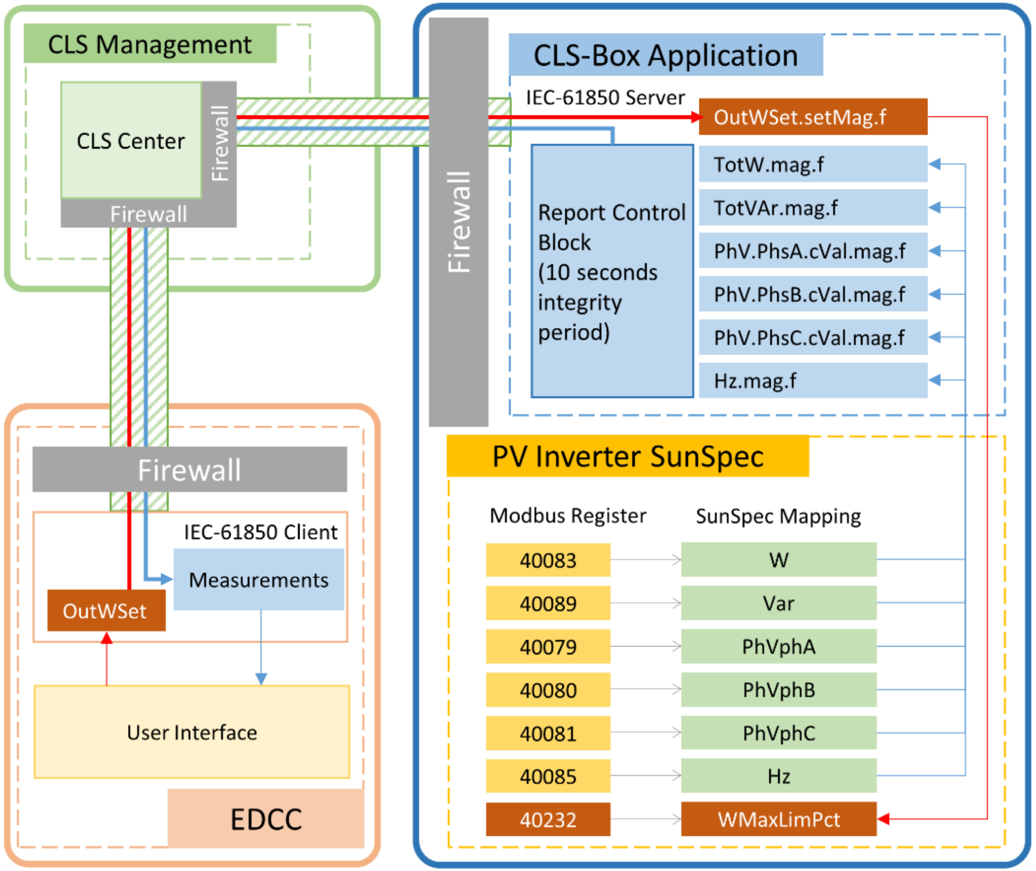
$$P_{Limit} = P_{nominal} * f_{curtailment}(U_{PCC}) \begin{cases} f = 0.0 & U_{PCC} \geq 1.080\ p.u. \\ f = 0.1 & U_{PCC} \geq 1.075\ p.u. \\ & \vdots \\ f = 0.9 & U_{PCC} \geq 1.055\ p.u. \\ f = 1.0 & U_{PCC} \leq 1.050\ p.u. \end{cases}$$



Test Phase 2- Implemented Solution for the PV-Curtailment

Hochschule Ulm

- Protocol Conversion from SunSpec to IEC61850 (MMS)
- Utilization of the “FNN Steuerbox” and Smart Meter Gateway Concept
- Direct Control of the Inverter from the EDCC



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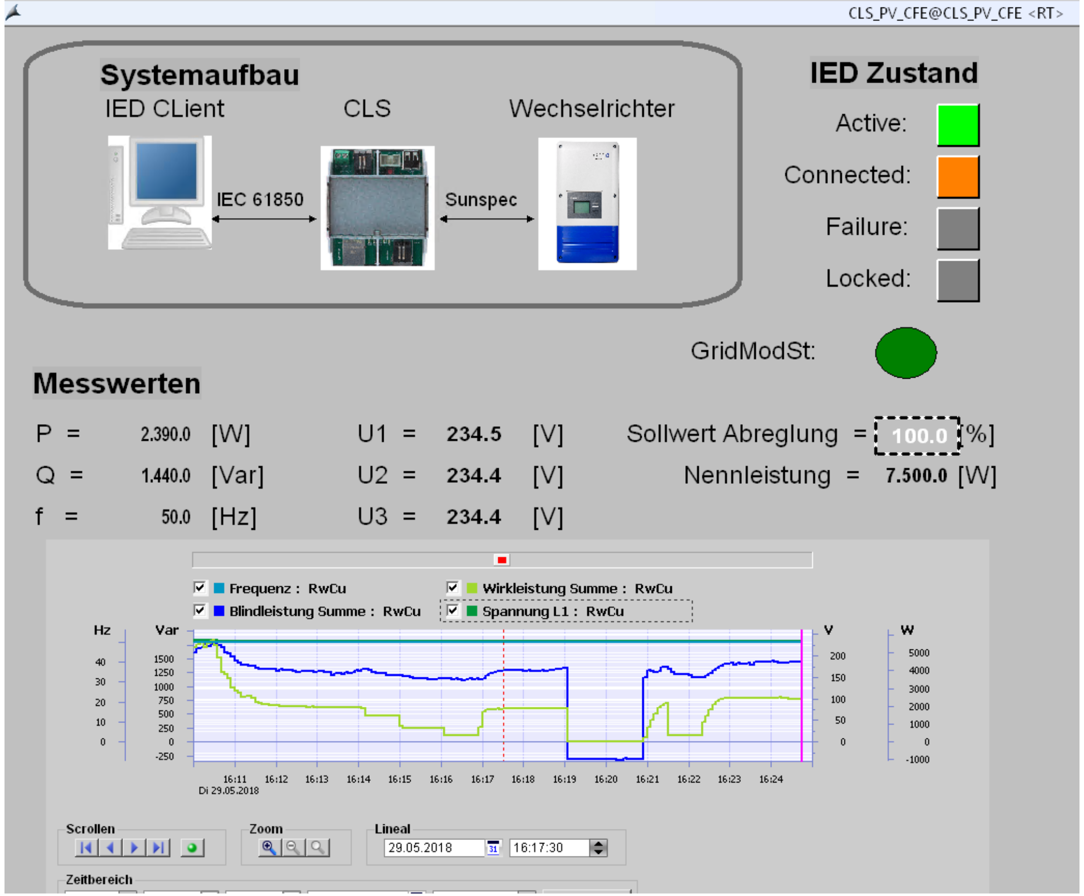
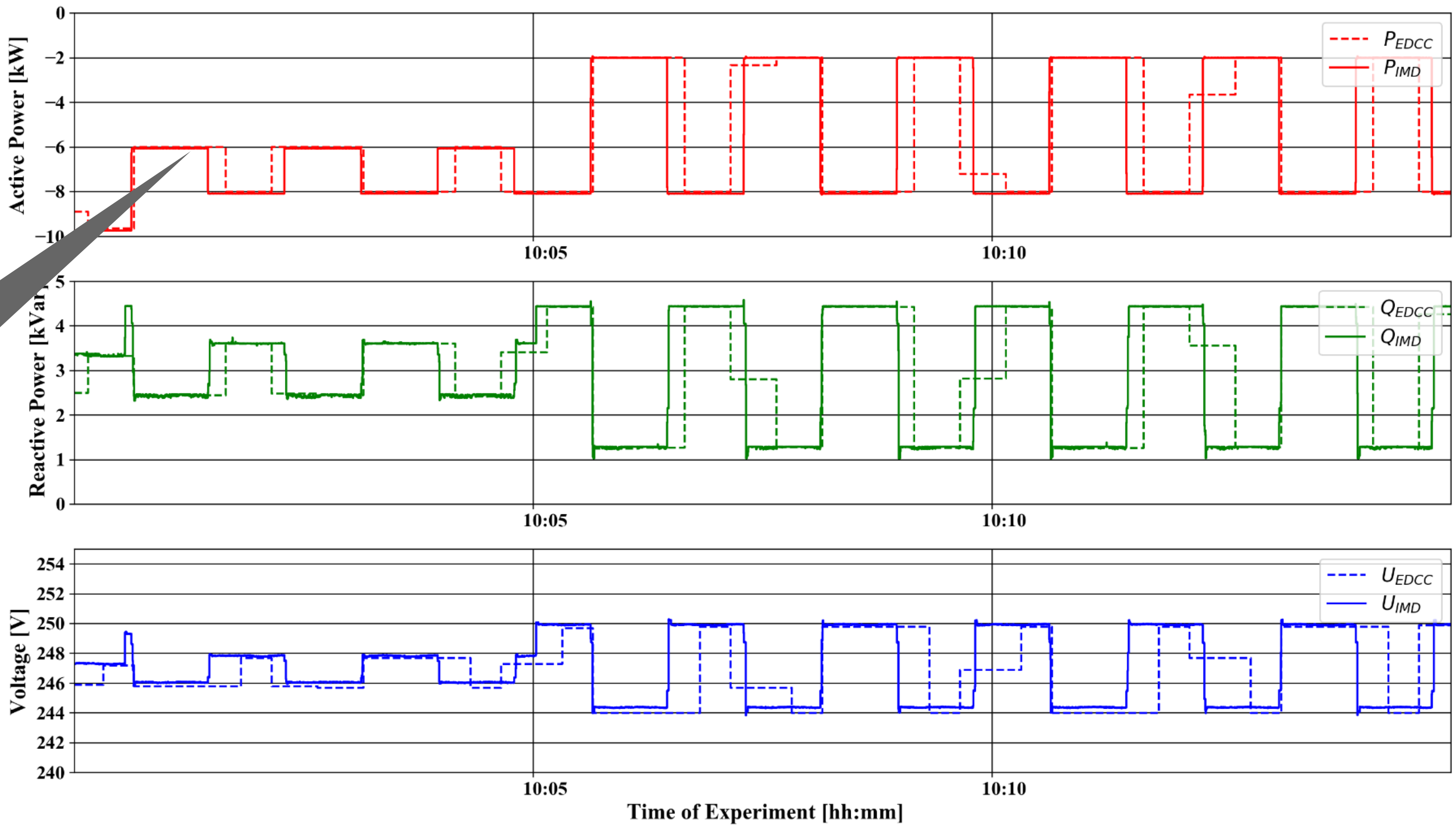
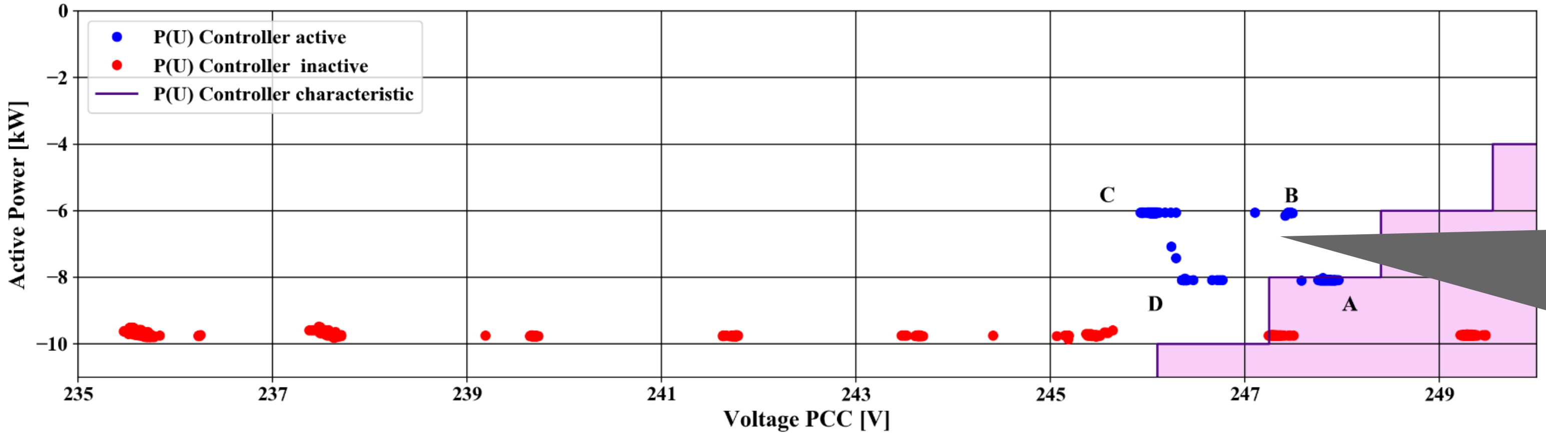


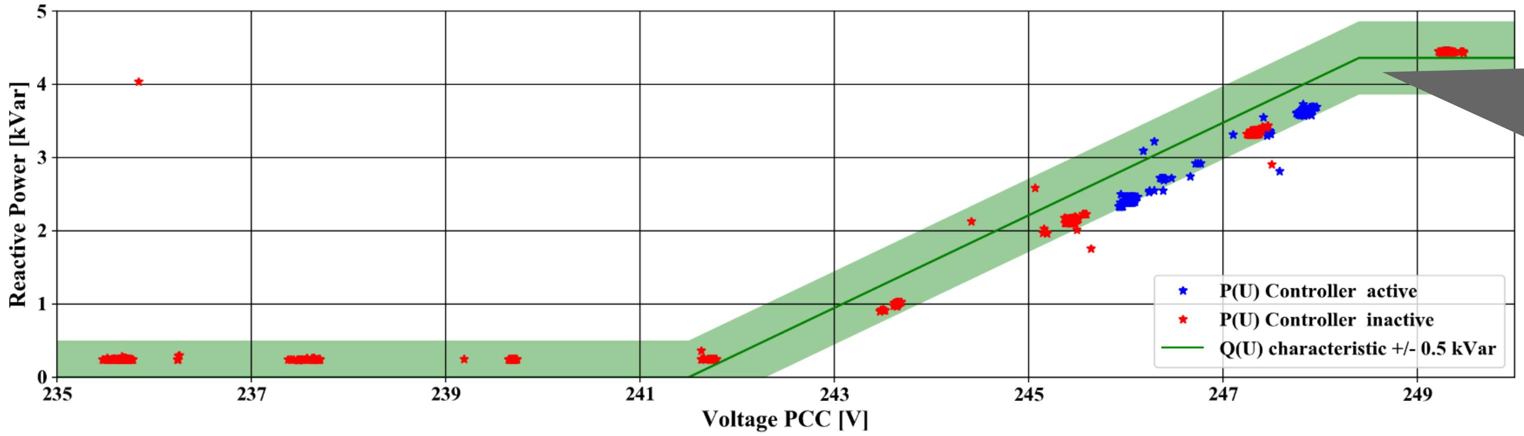
Test Phase 2 – Time Series



Oscillation caused by the controller as intended at the design of the experiment

Test Phase 2 – P/V & Q/V Plot





Clusters for the different Stages of the PHIL Setup visible.

Volt/Var Controller acts independtly

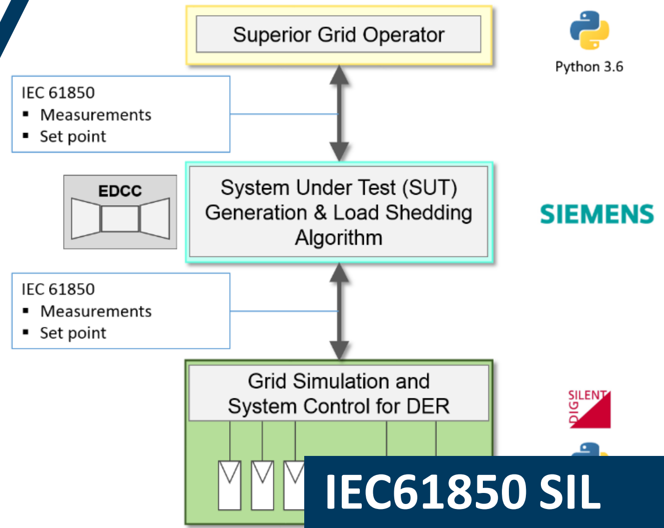
Conclusion

Just a nice trip or …. ?

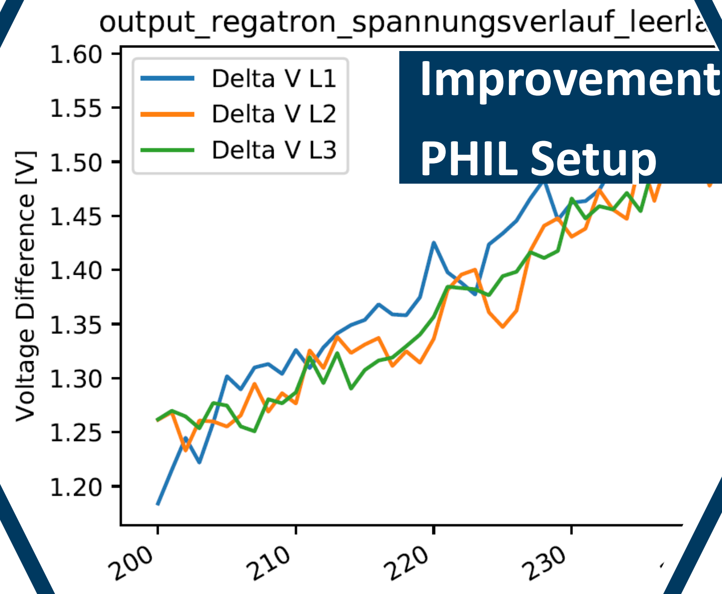
- For the planned examinations the System Setup B is suitable.
- The System Setup B is also implemented at the Ulm University of Applied Science
- New ideas who to improve the lab
- Got insight on the usage of a OpalRT system
- Offset of the PI has to be further examined

Outlook

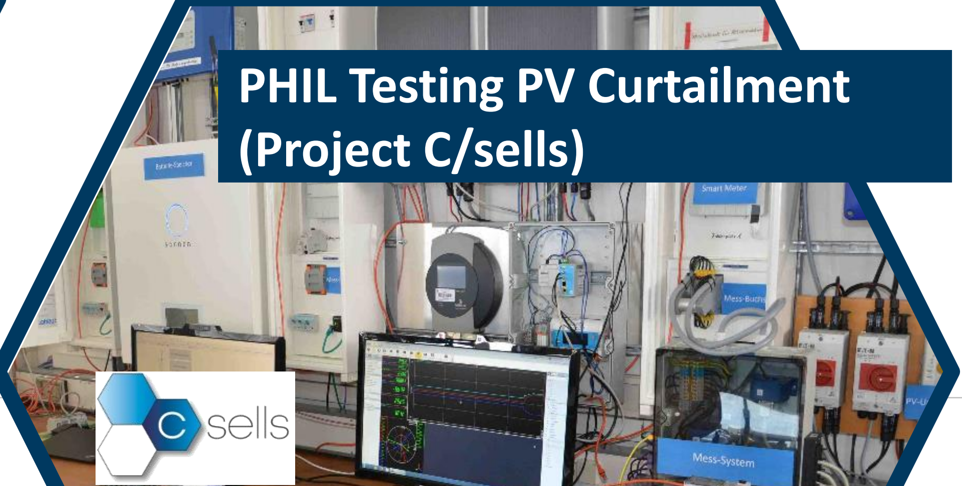
What‘s Next ?



IEC61850 SIL Environment



Improvement PHIL Setup



PHIL Testing PV Curtailment (Project C/sells)

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Outlook - A more detailed Look:

MDPI Energies Journal - Speciel Issue:
“Methods and Concepts for Designing
and Validating Smart Grid Systems”

Comparison of Power Hardware-in-the-Loop Approaches for the Testing of Smart Grid Controls

(in preparation)

CIRED Workshop 2018

AN APPROACH FOR VALIDATING AND TESTING MICRO GRID AND CELL-BASED CONTROL CONCEPTS

Research Project

EriGrid TA:

Smart beats Copper

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ERIGrid
Connecting European Smart Grid Infrastructure

Research Project

C/sells

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Das Energiesystem der Zukunft

Gefördert durch:
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aufgrund eines Beschlusses des Deutschen Bundestages

SINTEG
SCHAUFENSTER INTELLIGENTE ENERGIE

Research Project

ESOSEG

esoseg.in.tum.de

ESOSEG
Environment for Simulation, Operation and Optimization of Smart Energy Grids

Gefördert durch:
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STROMNETZE
Forschungsinitiative der Bundesregierung

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