NTNU

Hardware in the loop relay testing in digital substation environment

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Outline

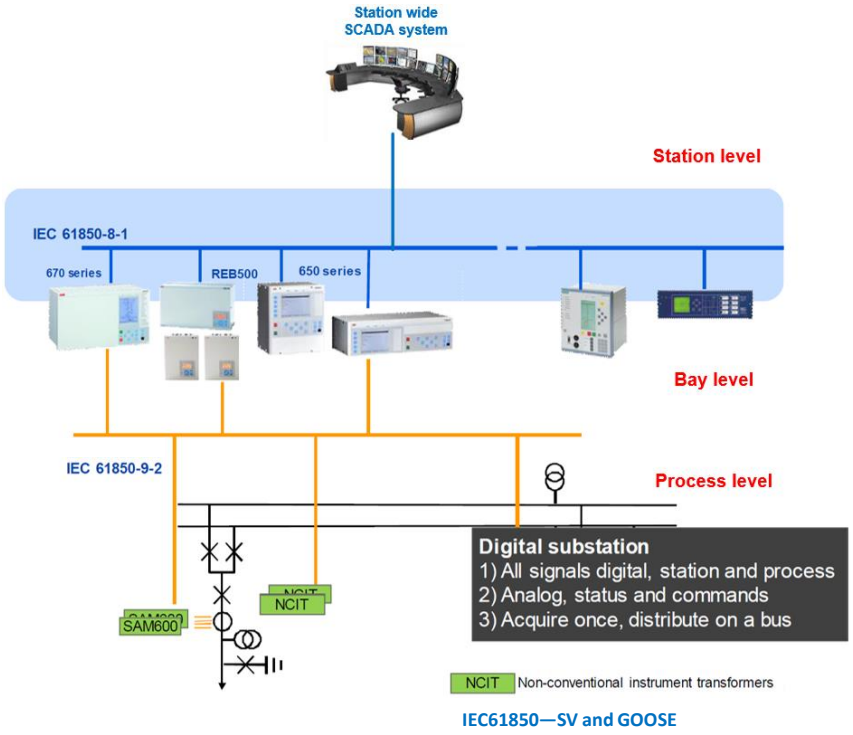
- **Background**
- Introduction of NTNU protection lab
- Show case

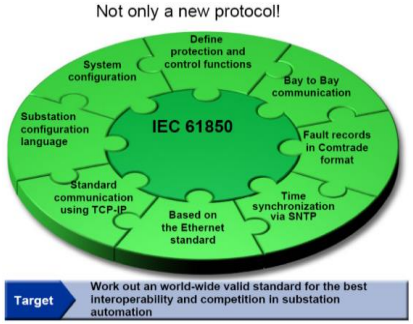
Digital substation

Power-system automation

Substation auto mation

IEC 61850 – "COMMUNICATION NETWORKS AND SYSTEMS IN SUBSTATIONS"



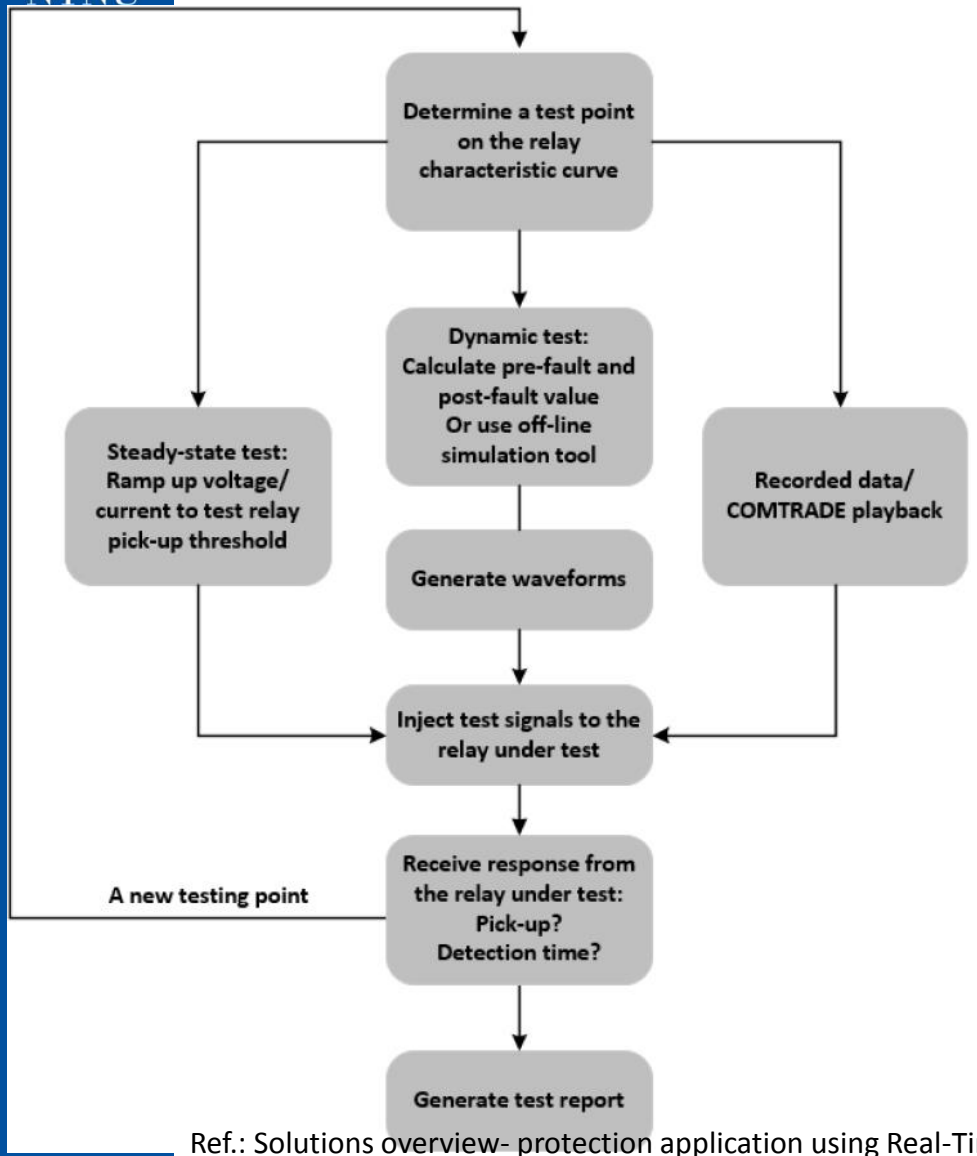


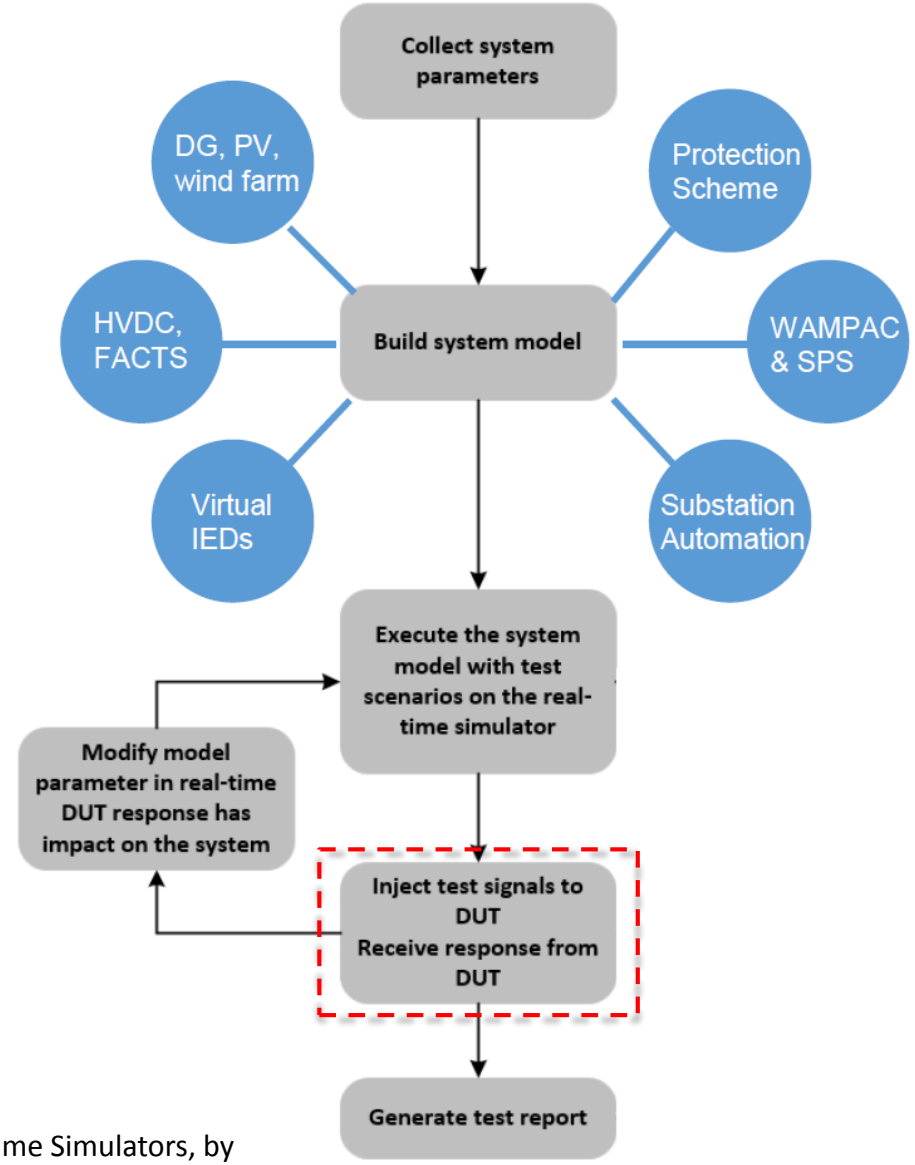
Pros and **cons** of IEC 61850 based digital substation:

- *Standard Ethernet-based communications systems*
- *No "spaghetti" mess behind*
- *Easy system expansion*
- *Increased system reliability*
- *Interoperability*
- *Increased safety for personnel*

- *More expensive implementation*
- *Training required*
- *Modifications from traditional automation system*
- *Cyber security*

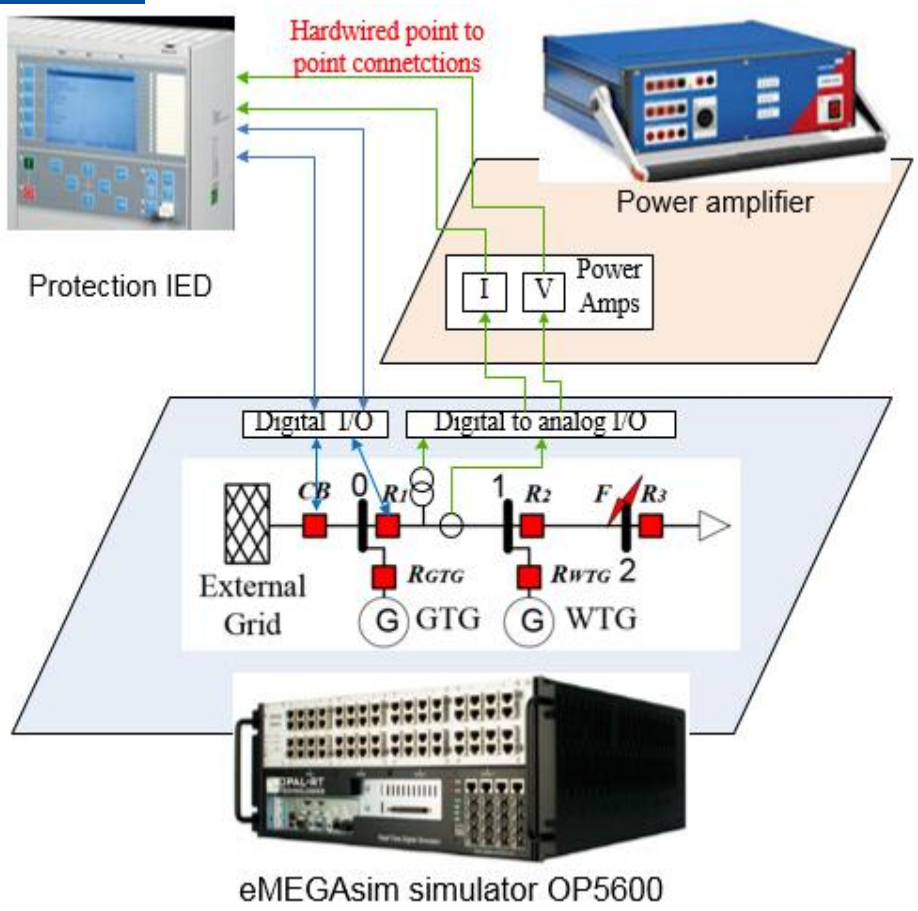
Conventional relay testing VS HIL

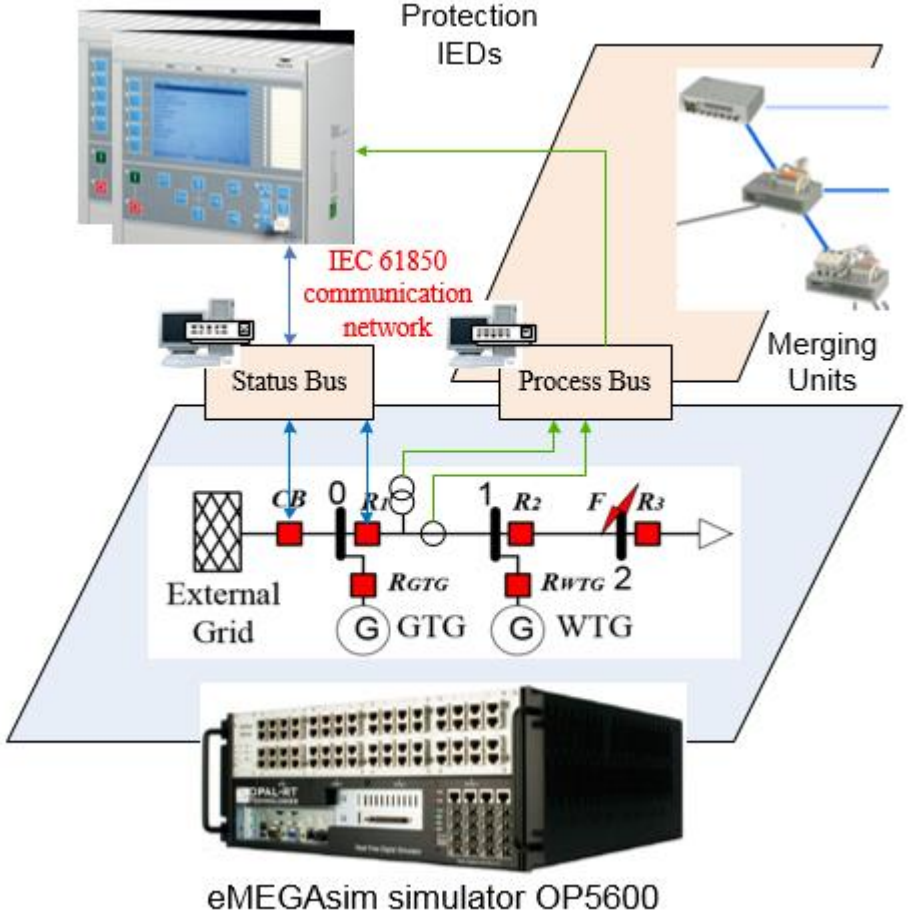




Ref.: Solutions overview- protection application using Real-Time Simulators, by Francois Berthelot & Shijia Li, OPAL-RT.

Relay testing in HIL way





Electrical Interface VS IEC 61850 interface

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New updates-1. Communication network modelling for HIL protection testing

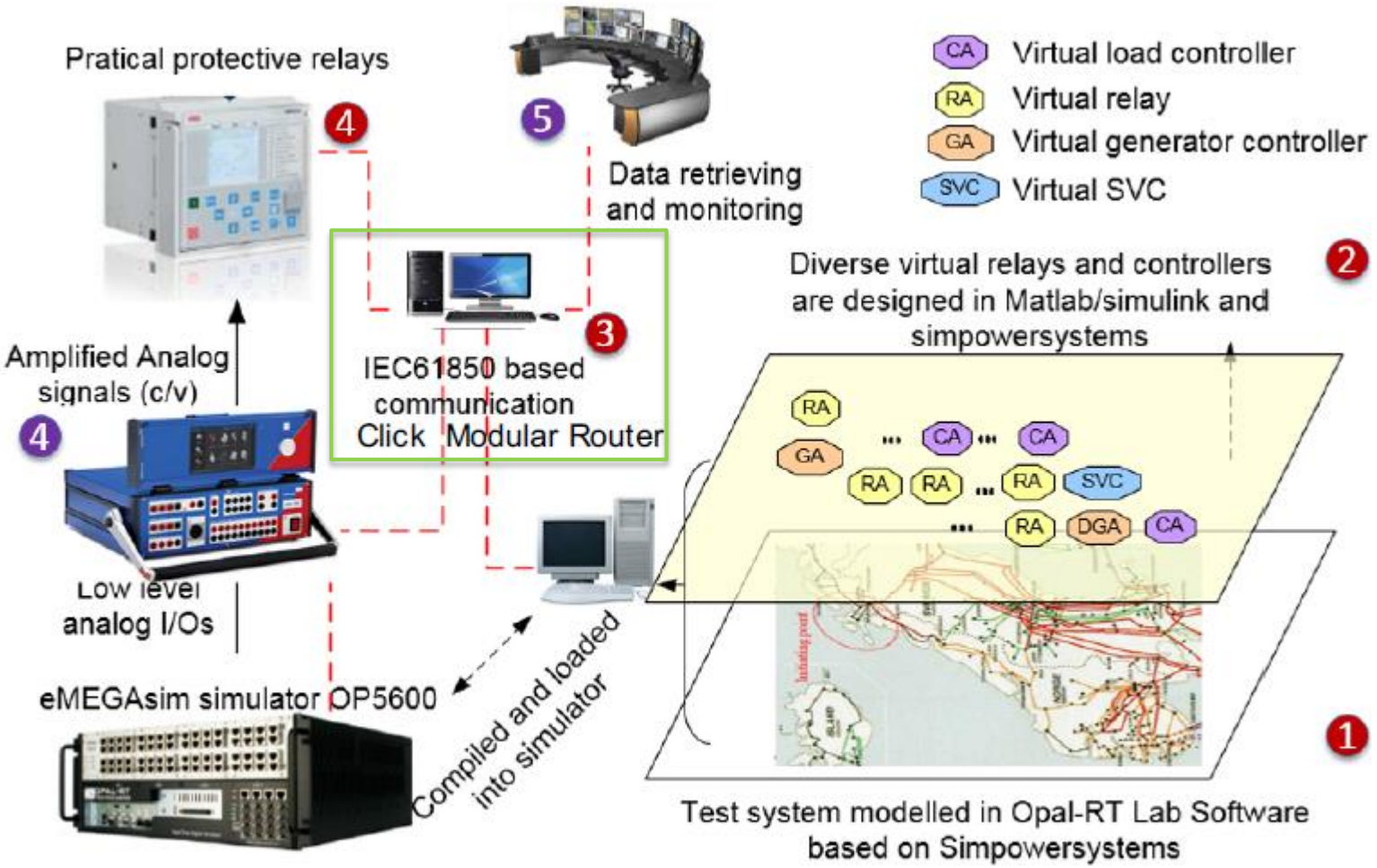


Fig. 1: Network emulator integrated with HIL Setup.

New updates-2. GPS sync. Spectracom installation

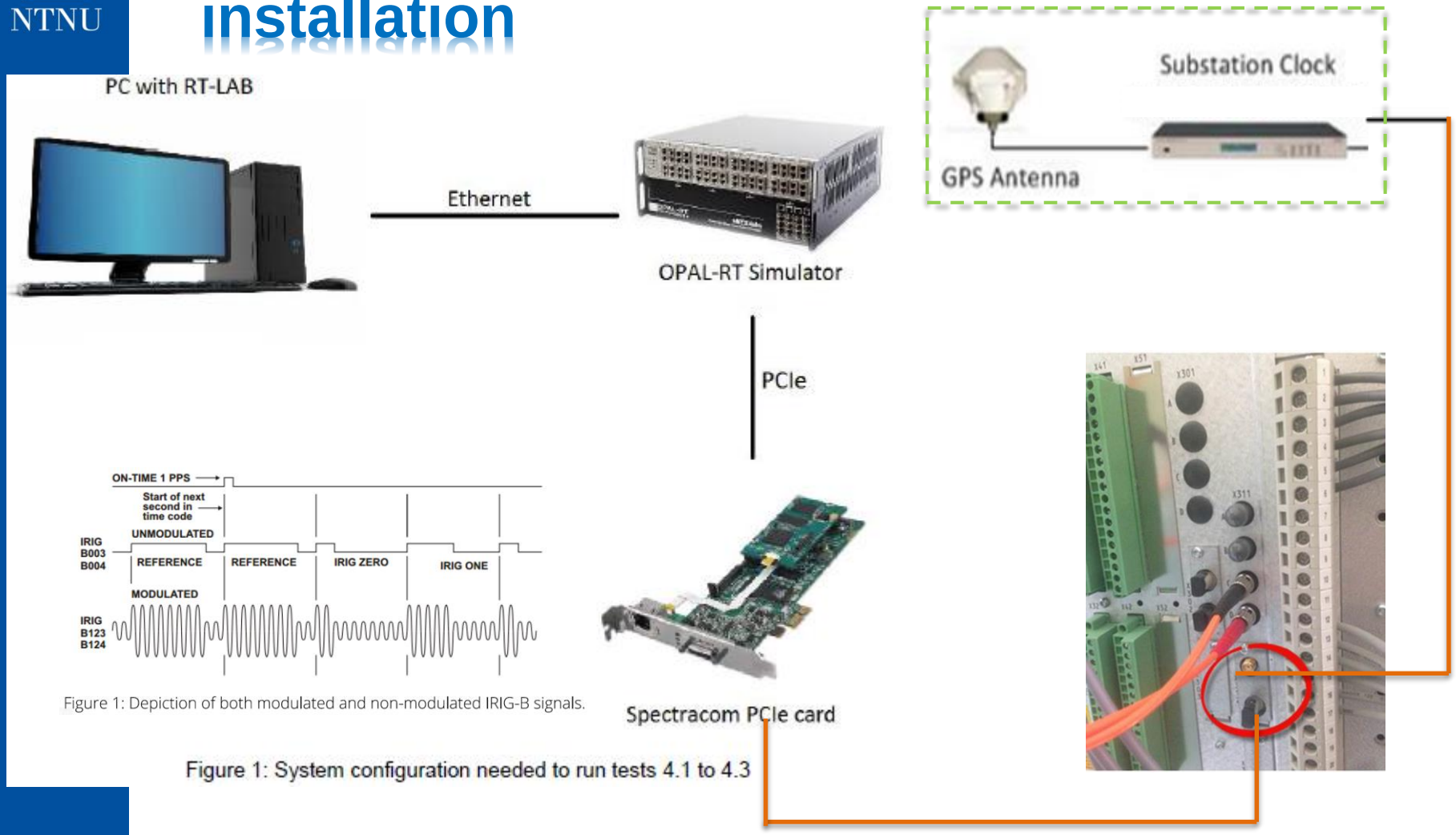
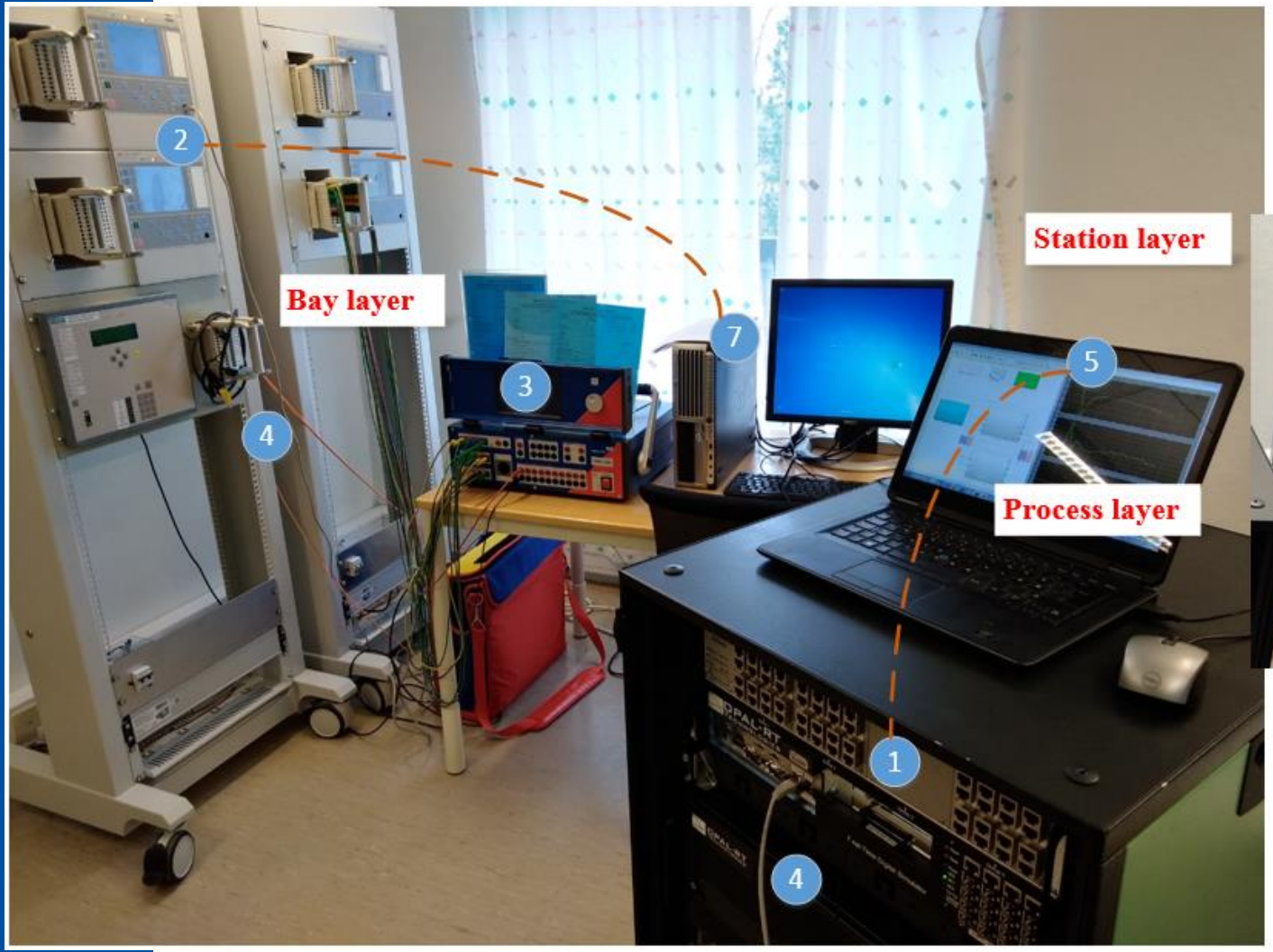


Figure 1: Depiction of both modulated and non-modulated IRIG-B signals.

Figure 1: System configuration needed to run tests 4.1 to 4.3

Real time Hardware in the loop (HIL) protection lab at NTNU

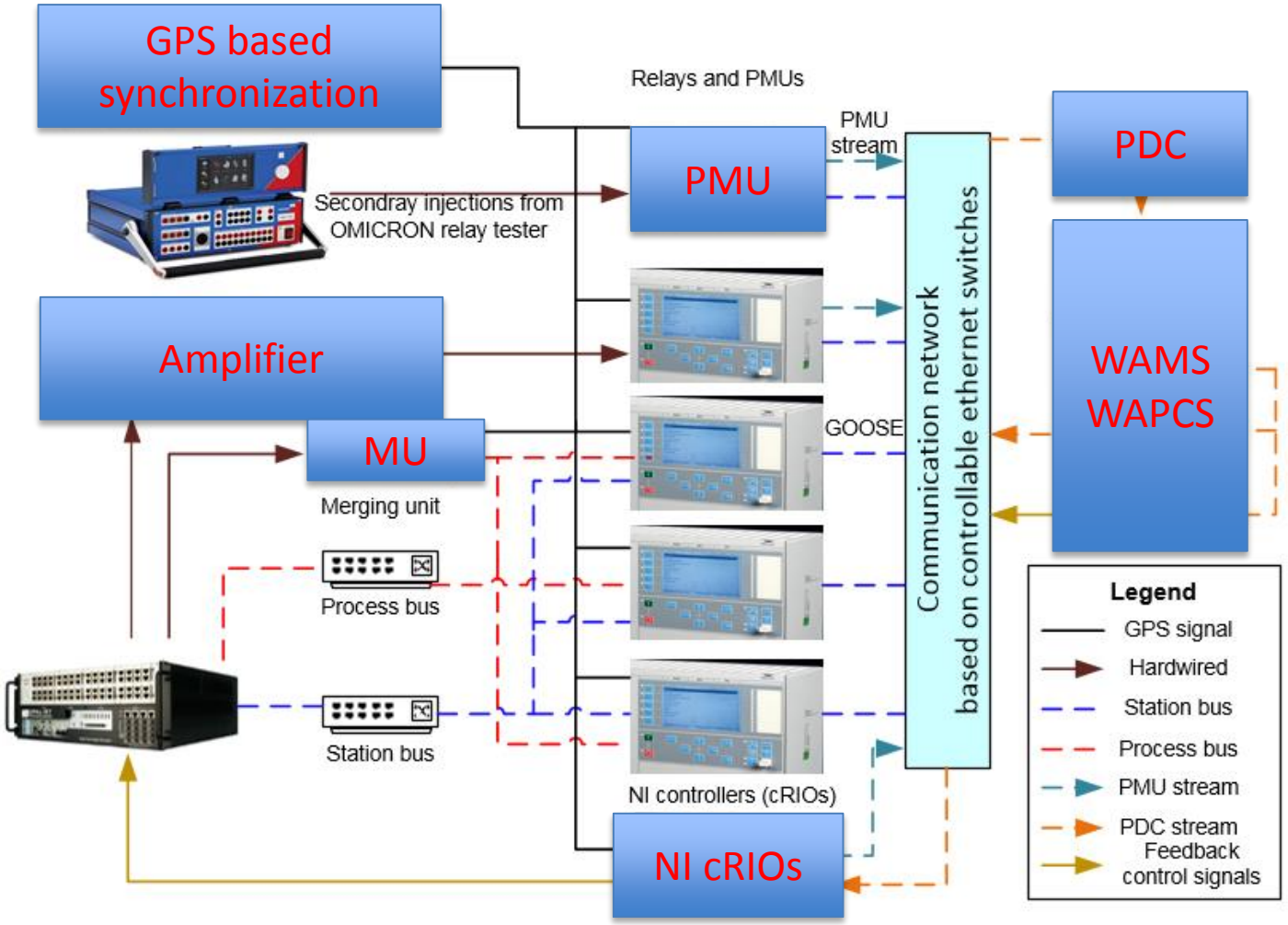


1. Opal-RT simulator
2. ABB Relion 670 relays
3. OMICRON CMC 356
4. IEC61850 based communication network

5. Host PC and HMI for Opal simulator and network analyzer
6. Communication switch emulator-Click and Network analyzer-Wireshark
7. Host PC and HMI for PCM 600 and ABB relays

Perspective and Shortages for the future

Test bed for research and advanced applications—Phase 2&3



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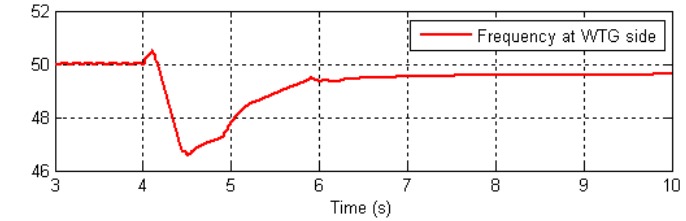
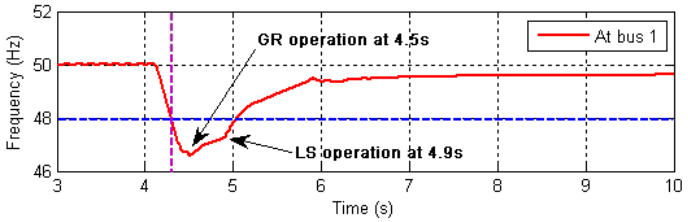
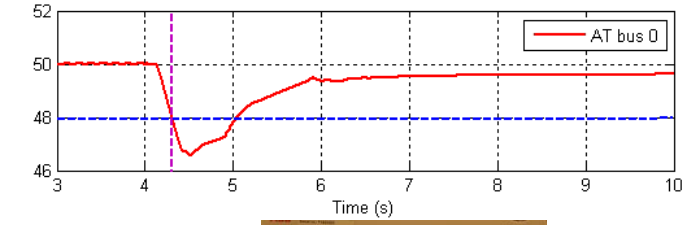
HIL relay testing in NTN

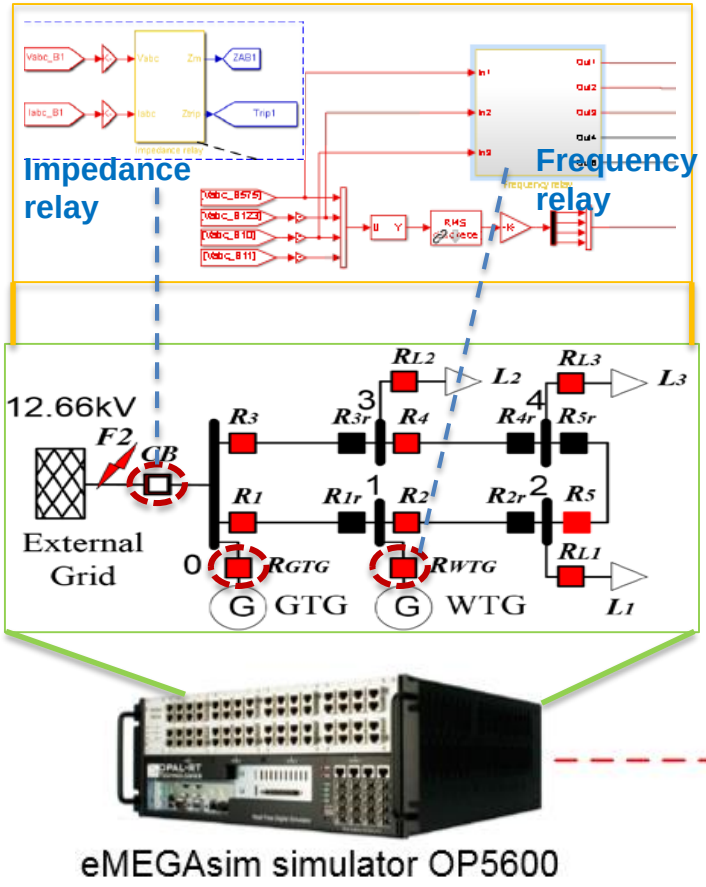


Case 1:

F2 induced islanding and cascading trips







RED 670

Setting group 1

Setting group 2

eMEGAsim simulator OP5600

IEC61850 based communication

REG 670 or **other controllers**

Z. Liu, H. K. Høidalen, M. M. Saha, "A protection and control coordination scheme for distribution network with wind power integration", PACWorld 2016, Ljubljana, Slovenia, 2017.

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Thank you for your attention!