Journey to IEC 61850 substations

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Technologist OT

/intro

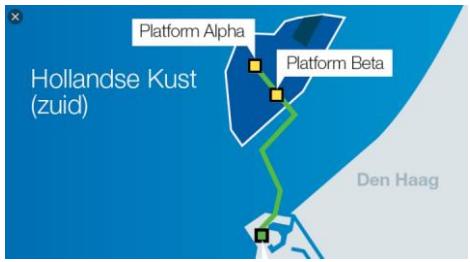
- Since 2005 involved in data communication, cyber security and OT
- Started in 2005 @ KEMA (later DNVGL)
- Technologist OT in TenneT since August 2020
- Involved in standardization

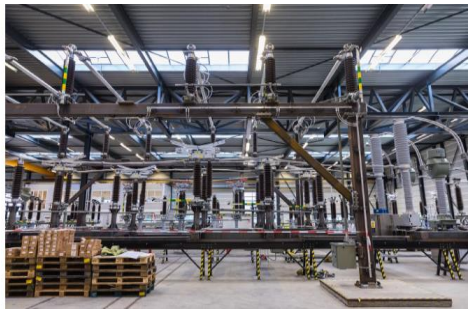
- Focus on
  - Substation automation,
  - data- and tele-communication,
  - IEC standards (61850, 60870-5, 62351),
  - Quality assurance and standardization.

IEC 61850 @ TenneT

- 2 major programs in NL :
  - Offshore grid in Northsea (AC – 700 MW)
  - Onshore replacement of 110/150 kV grid (Bay Replacement Program)

- 2 approaches
  - Turn key vendor lock-in
  - Open/Standardized TenneT approach





Bay Replacement

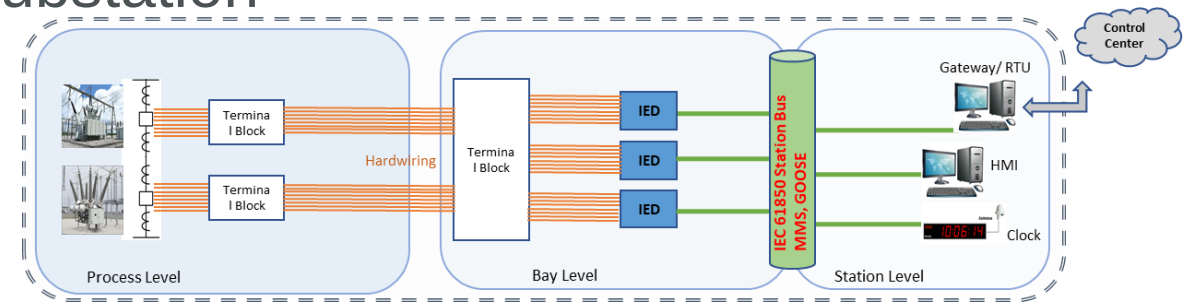
- European transmission system operator (TSO)

- Goal: Renovate at least 145 substations in the next 10 years
- 110 / 150 kV voltage level – decoupling from DSOs

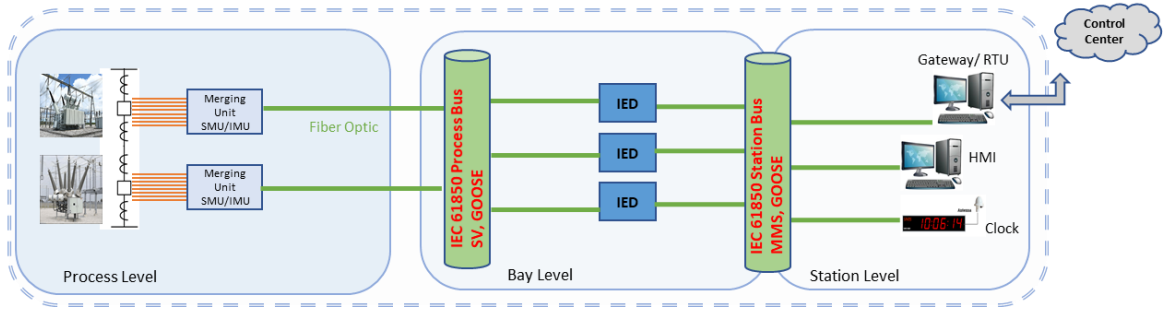
- Ambitions:
  - Maximize speed during replacement
  - Minimize cost during replacement
  - Minimize maintenance & personnel required on site
  - Maintaining the availability and secure supply of the Dutch grid

Bay Replacement

- Proof of Concept (PoC) within 6 HV (AIS and GIS) substations
- Staged approach to a full digital substation

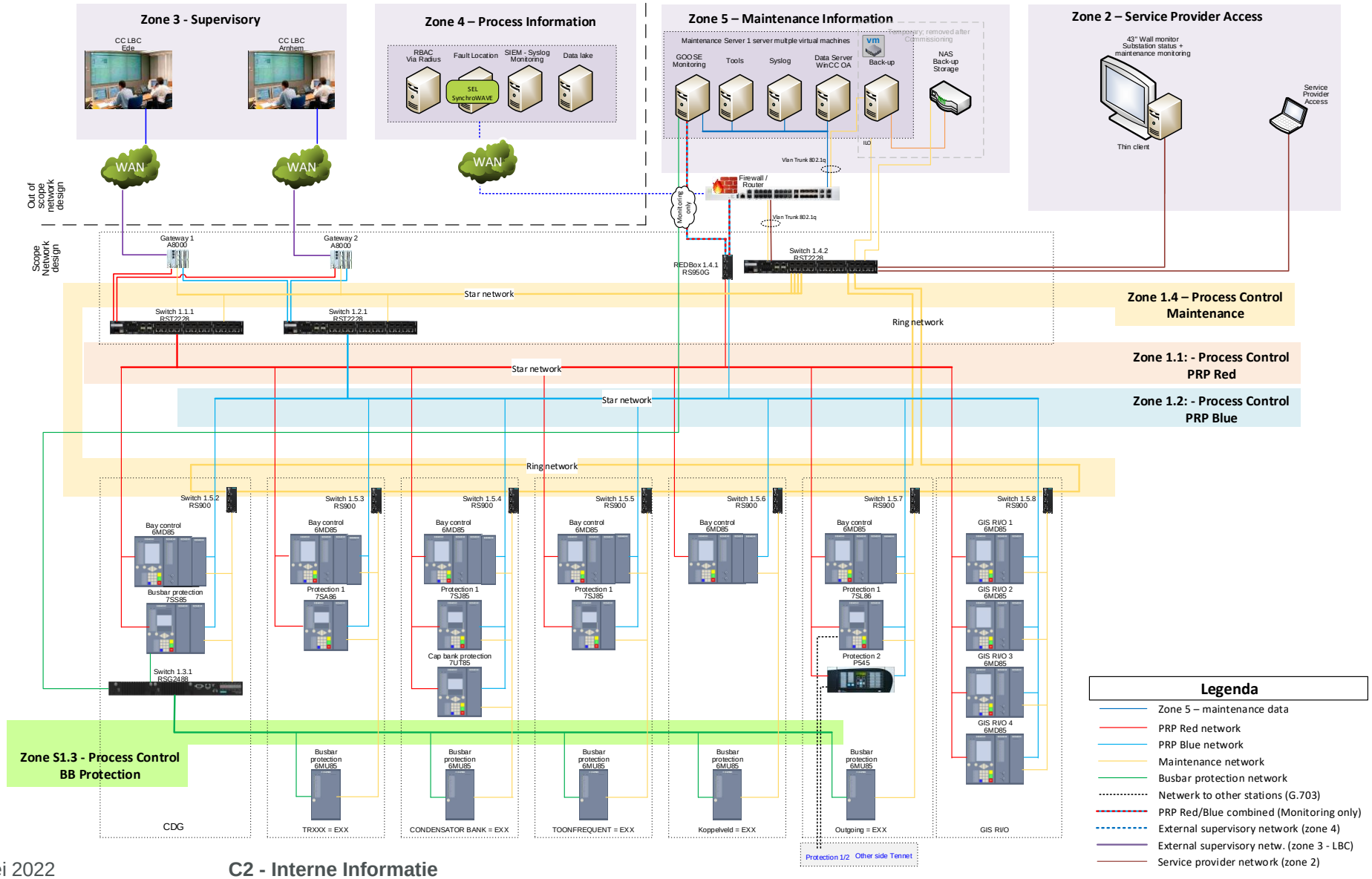


- Goals PAC system
  - Vendor independence
  - Top-down engineering
  - Getting to know GOOSE
  - Easy monitoring



- Two system integrator with IEC 61850 experience

Bay Replacement



Bay Replacement

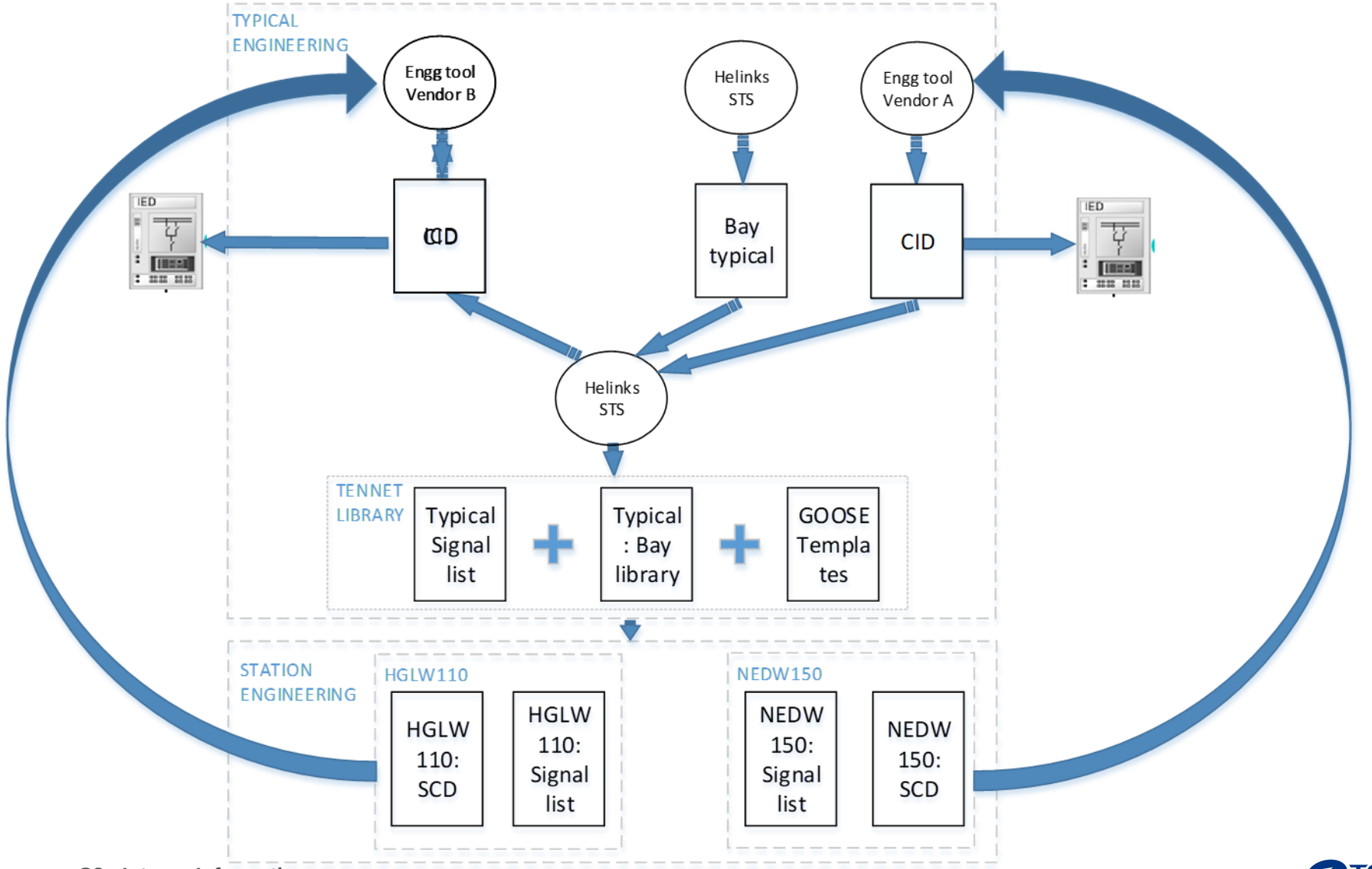
MGU by-night

Bay Replacement

Hierboven enkele foto's van de Tijdelijke Diensten Containers welke in Oldenzaal staan en getest gaan worden.

Bay Replacement

IEC 61850 Engineering workflow PoC



Engineering building blocks

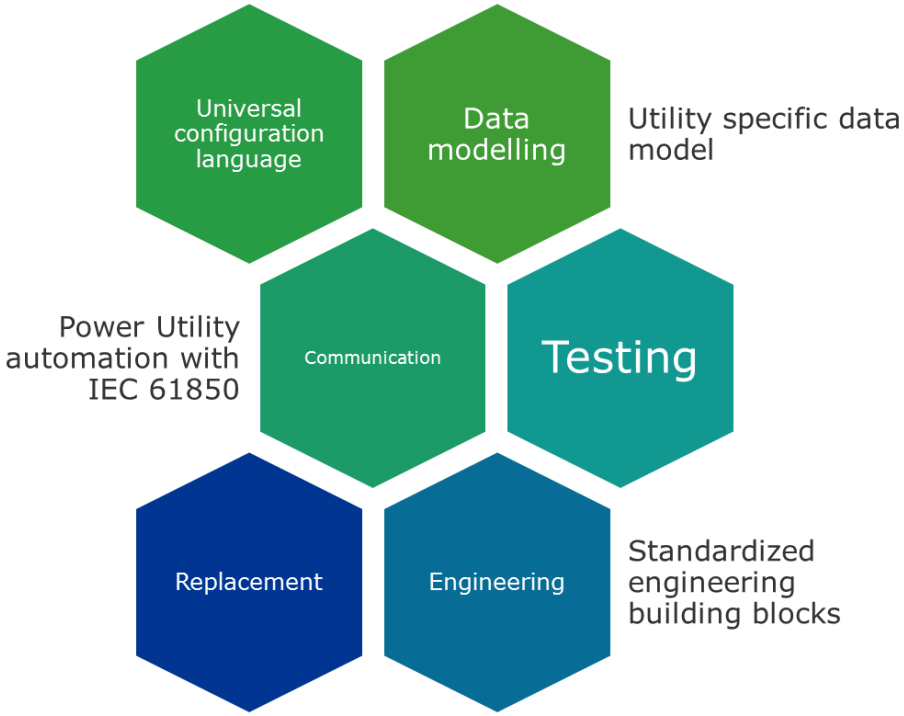
- Bay templates
  - Bays are saved to the library
  - IED roles, logical devices and logical nodes are saved
  - Bay signal list is saved as well and no further configuration for MMS
  - If the bay must be used in the new project/substation, all that must be done is to instantiate it
- GOOSE templates
  - Subscriber and publisher are saved within logical devices as role
  - GOOSE links can be instantiated by a checkbox



Digital substation is more than a stationbus

- Digital substation means teamwork
- Digital substations breaks with existing paradigms
- Vendor selection based upon functions is key

- Substation to control center integration
  - IEC 61850-80-1 to configure gateways
  - IEC 61850-80-6 to integrate with EMS/SCADA
  - Phase out of CS101/104
  - Teamwork! Early interaction!



Alternative sensing equipment

Advantages and disadvantages

		Conven-tional	LPIT
Safety	1. Risk for explosion	😞	🙂
Safety	2. Touch safety	😞	🙂
Quality of supply	3. Risk of failure	😐	🙂
Financial	4. Costs	🙂	😐
Financial	5. Revenue / benefits	😐	🙂
Reputation	6. Loss of functionality	🙂	😐
Environment	7. Leakage (oil/SF_6)	😞	🙂
Environment	8. Scarce materials	😞	🙂
Compliance	9. Proven technology	🙂	😐
Compliance	10. Compliancy to regulation	🙂	😐
Compliance	11. Required knowledge	🙂	😐
Compliance	12. Flexibility of application	😐	🙂

With pilots, studies and investment of time all points can turn green!

Figure 1 – Comparison of example, with left: conventional, right: LPIT

Alternative sensing equipment

PRODUCT FAMILY STANDARDS		PRODUCT STANDARD IEC	PRODUCTS	OLD STANDARD IEC
IEC 61869-1 GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS	IEC 61869-6 ADDITIONAL GENERAL REQUIREMENTS FOR LOW-POWER INSTRUMENT TRANSFORMERS	61869-2	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS	60044-1 60044-6
		61869-3	ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS	60044-2
		61869-4	ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS	60044-3
		61869-5	ADDITIONAL REQUIREMENTS FOR CAPACITOR VOLTAGE TRANSFORMERS	60044-5
		61869-7	ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS	60044-7
		61869-8	ADDITIONAL REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS	60044-8
		61869-9	DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS	
		61869-10	ADDITIONAL REQUIREMENTS FOR LOW-POWER PASSIVE CURRENT TRANSFORMERS	
		61869-11	ADDITIONAL REQUIREMENTS FOR LOW-POWER PASSIVE VOLTAGE TRANSFORMERS	60044-7
		61869-12	ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMER OR COMBINED PASSIVE TRANSFORMERS	
		61869-13	STAND ALONE MERGING UNIT	
		61869-14	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS FOR DC APPLICATIONS	
		61869-15	ADDITIONAL REQUIREMENTS FOR DC VOLTAGE TRANSFORMERS FOR DC APPLICATIONS	

NEN-EN-IEC 61869-6
(en)

Instrument transformers - Part 6: Additional general requirements for low-power instrument transformers (IEC 61869-6:2016,IDT)

3.2.14
low-power instrument transformer
LPIT
instrument transformer with no rated output power

38/653/CDV – IEC 61869-99 ED1

Note 1 to entry: A general block diagram of an LPIT is the following Figure 1, where some blocks may be not present, according to the specific technology of the LPIT under consideration.

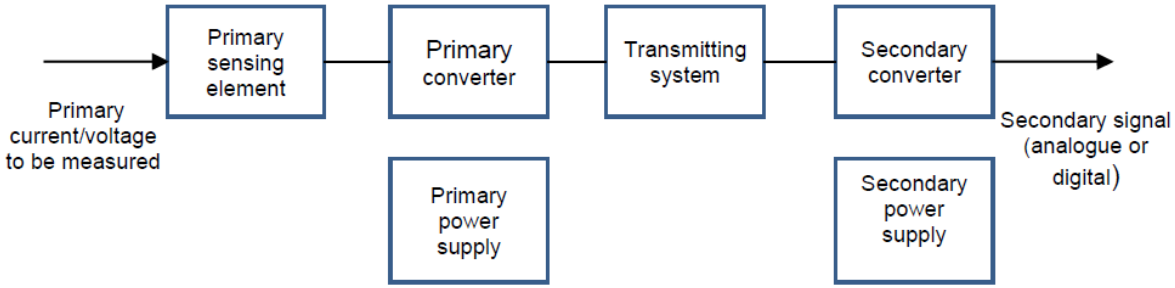
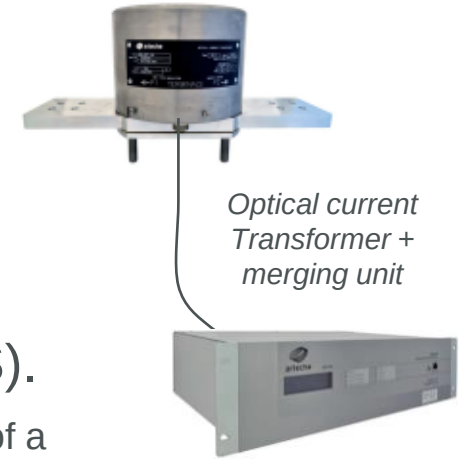


Figure 1 – Example block diagram of an LPIT

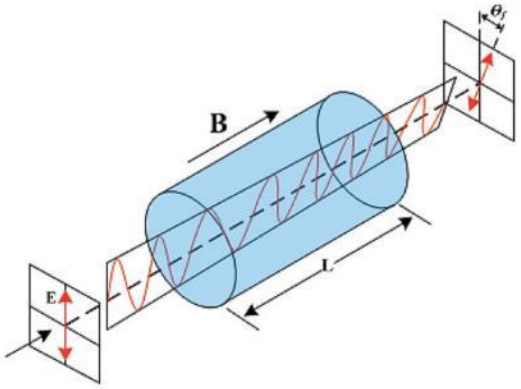
Alternative sensing equipment



Optical current Transformer + merging unit

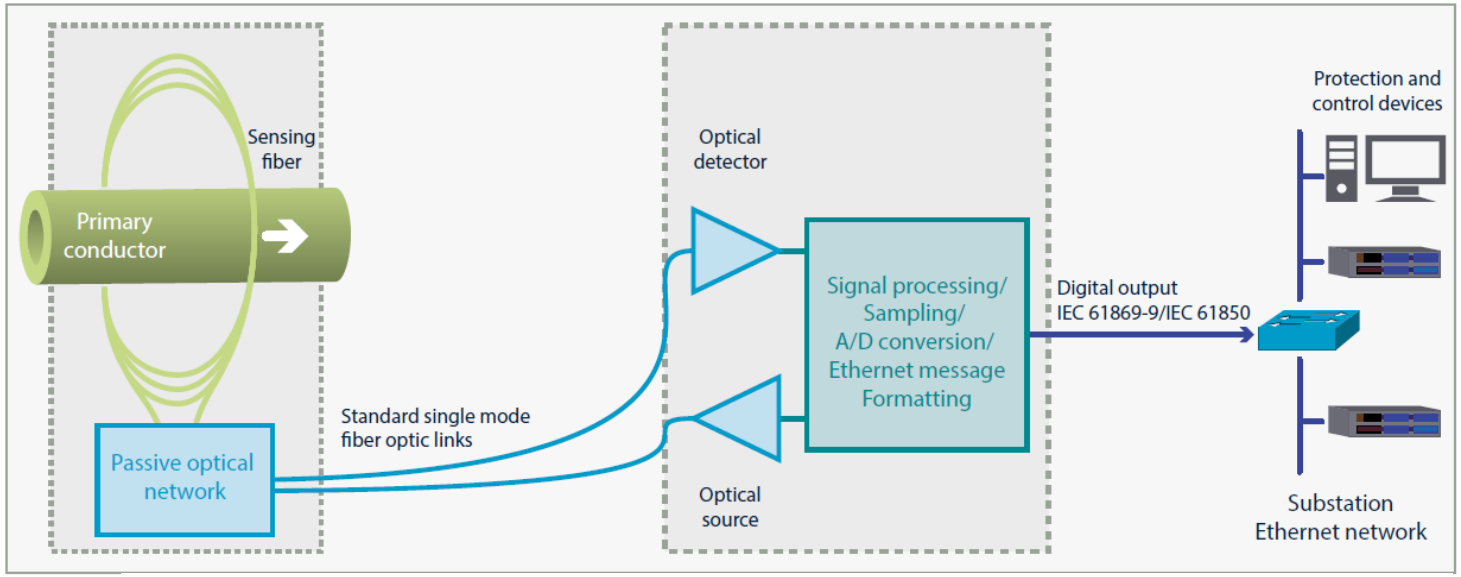
Measurement technique for current, option 1: Faraday effect (typically AIS).

- The operation of an optical current transformer is based on the Faraday Effect. The polarization state of a linearly polarized optical signal is rotated as it travels through a magnetic field. For an optical signal which travels along a closed path, the angle of rotation is proportional to the current enclosed by the path.
- The rotation of the polarization state of the light is measured interferometrically as the phase difference between circularly polarized optical signals which travel in opposite directions around a coil of fiber that encloses the primary.



Phase shift of polarized light (Faraday effect)

*Simplified block diagram **

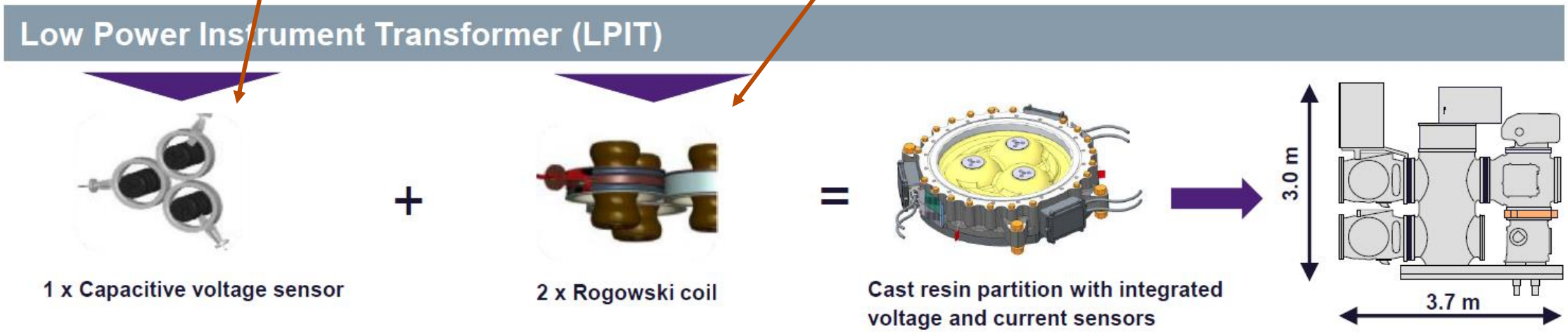


** In this example the passive optical network is in the sensor head, this may also be placed in the merging unit.*

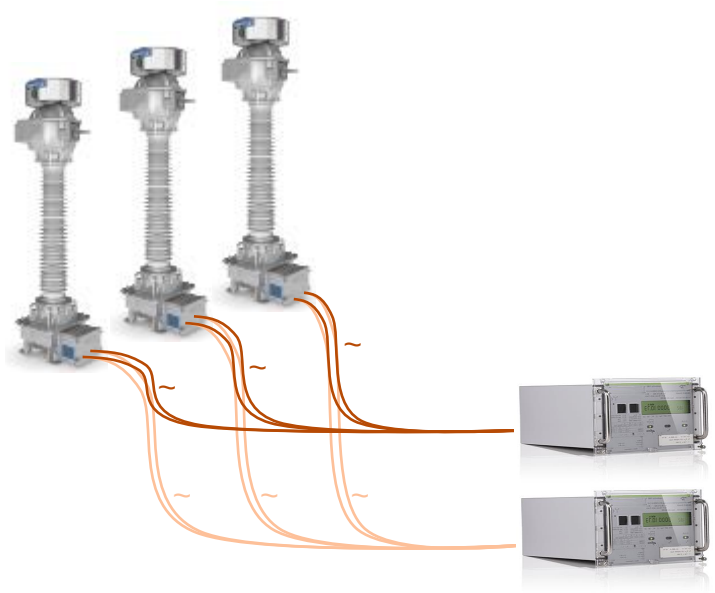
Alternative sensing equipment

Measurement technique for voltage, option 1: capacitive divider (typically GIS).

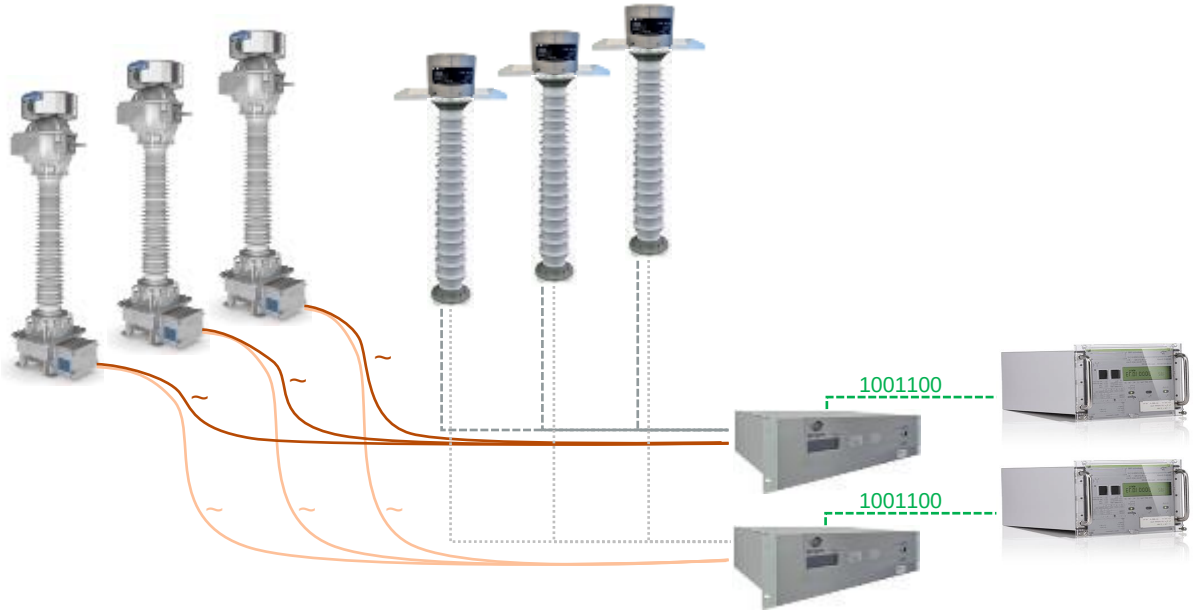
Measurement technique for current, option 2: Rogowski (typically GIS).



TenneT NL – Soest 150kV

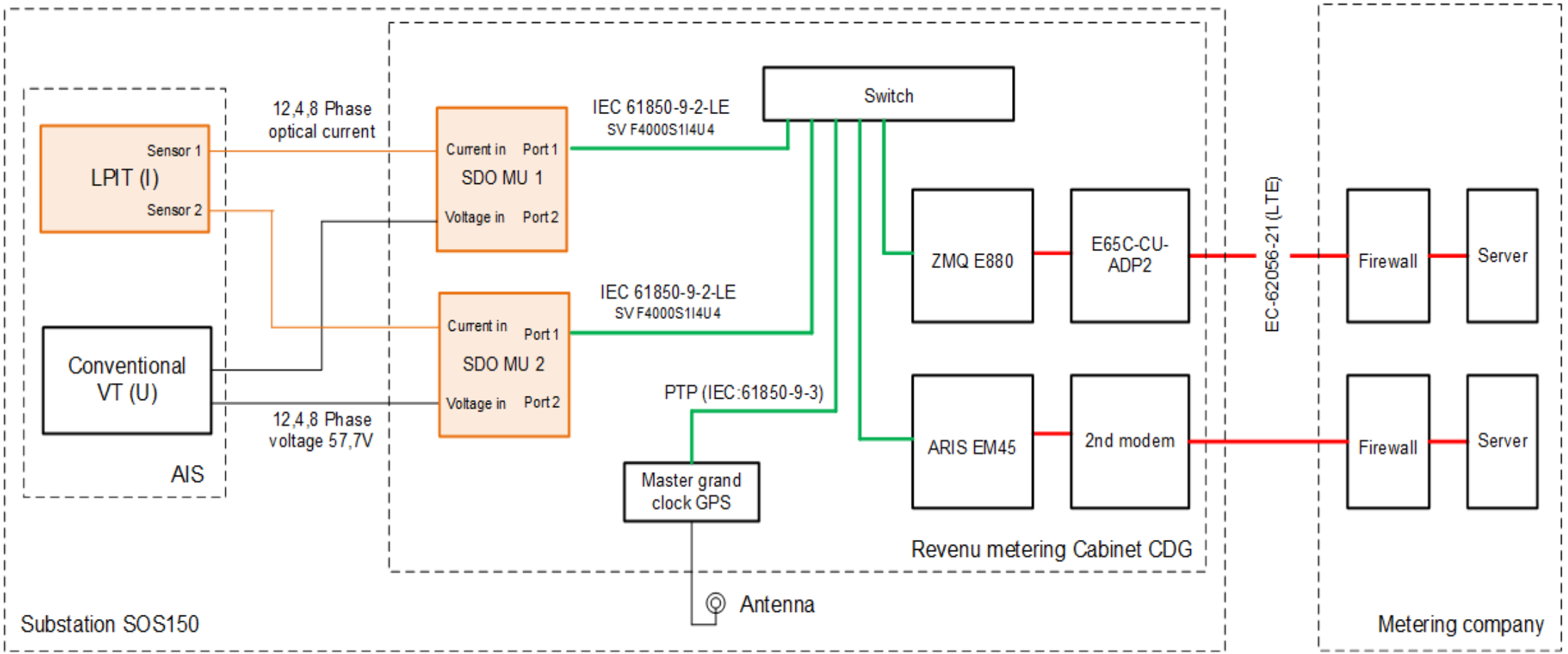


Conventional setup with combined transformer



Conventional voltage transformer and current LPIT + MU

TenneT NL – Soest 150kV



Tested by supplier

TenneT NL – Soest 150kV

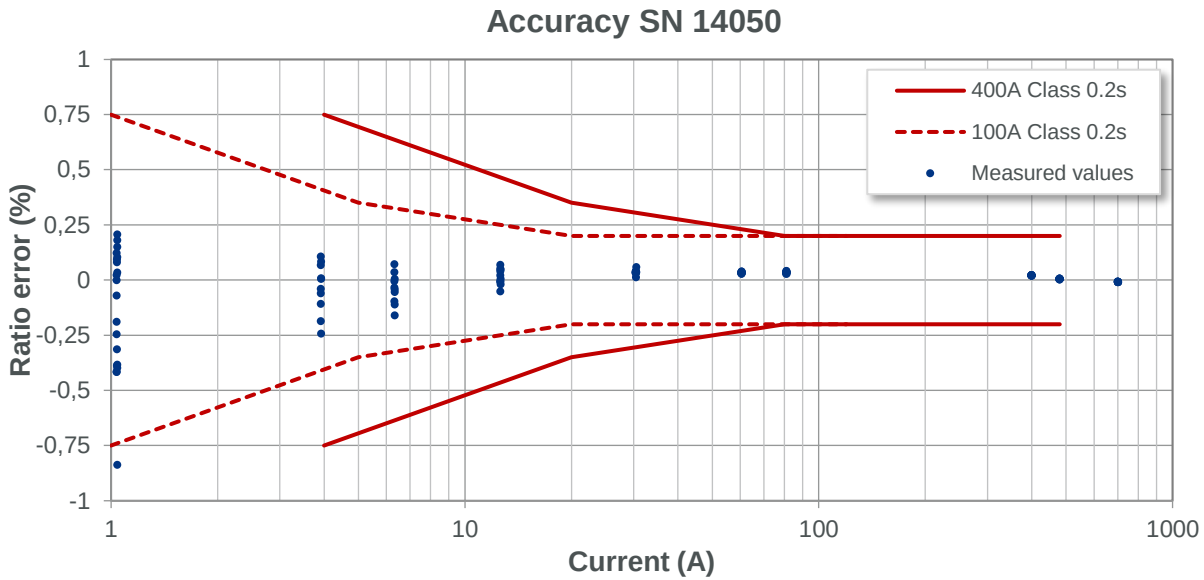
Accuracy of 1 from 6 sensors using 200ms integration time

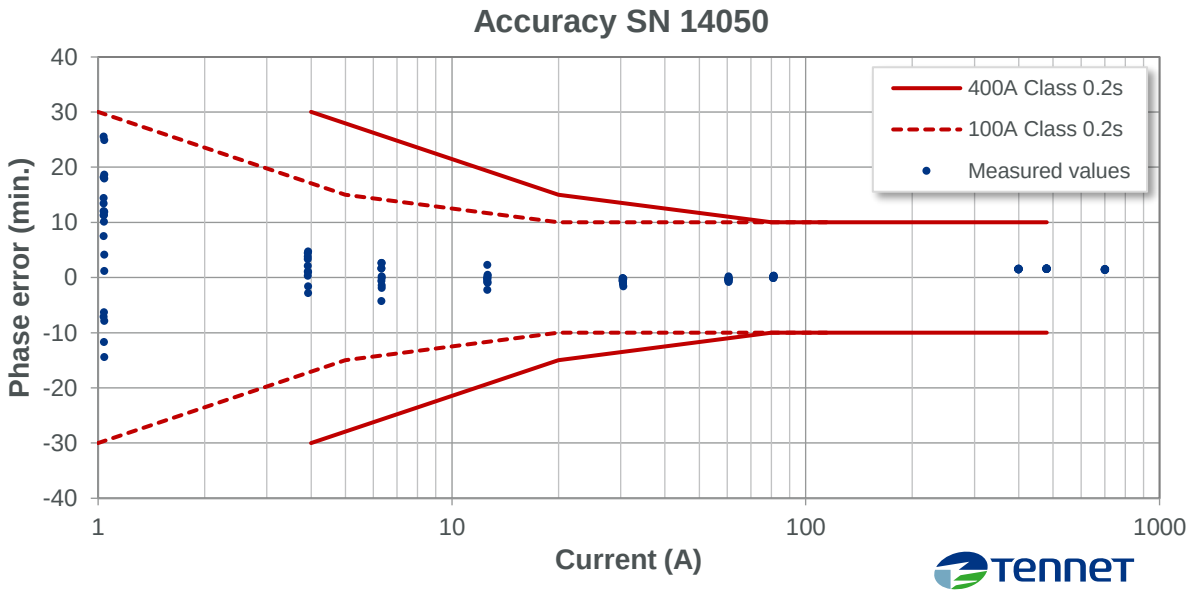
- Amplitude
- Fase

Ratio = 400/1

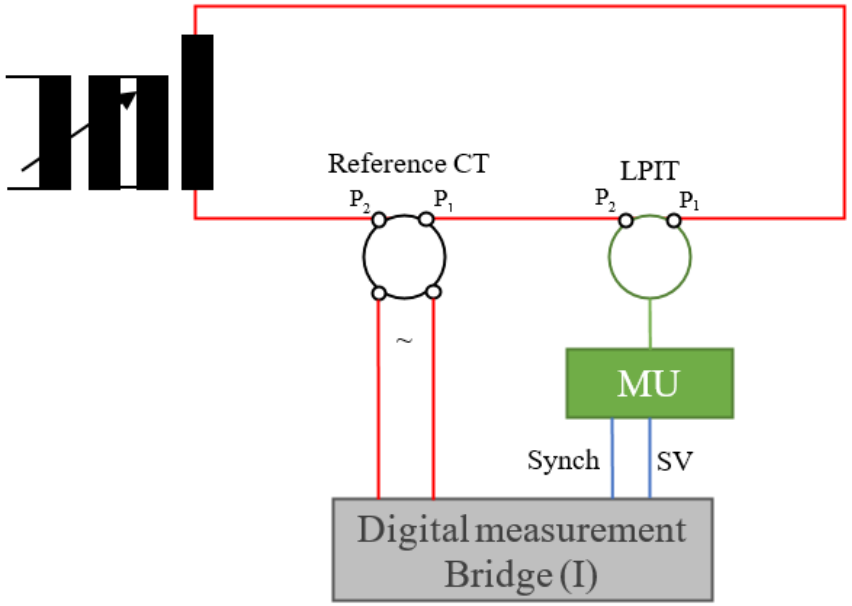
For ratio 100/1 it is still well within IEC accuracy limits

KEMA reported very similar results

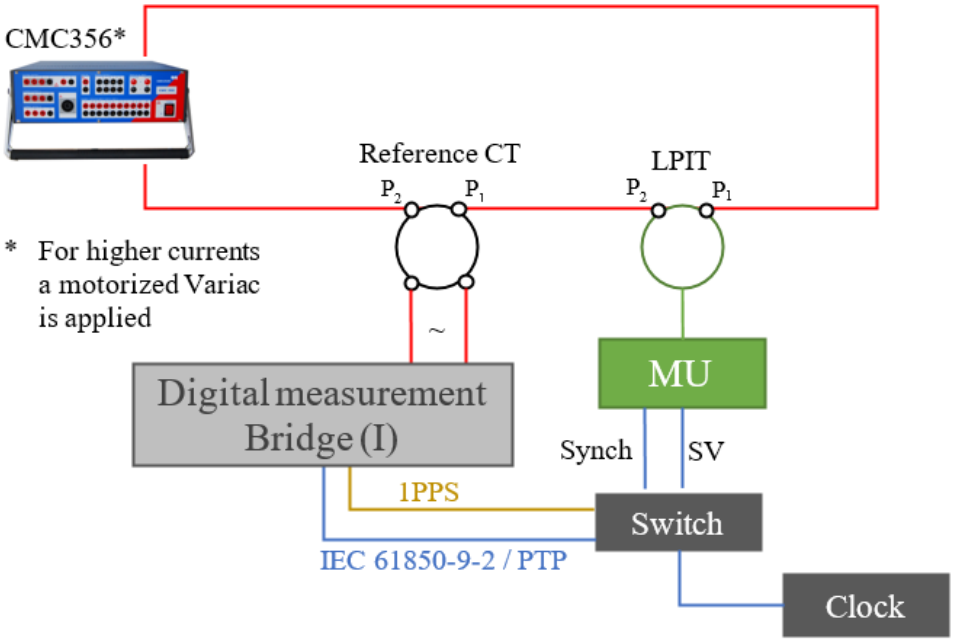




TenneT NL – Soest 150kV



Setup of supplier

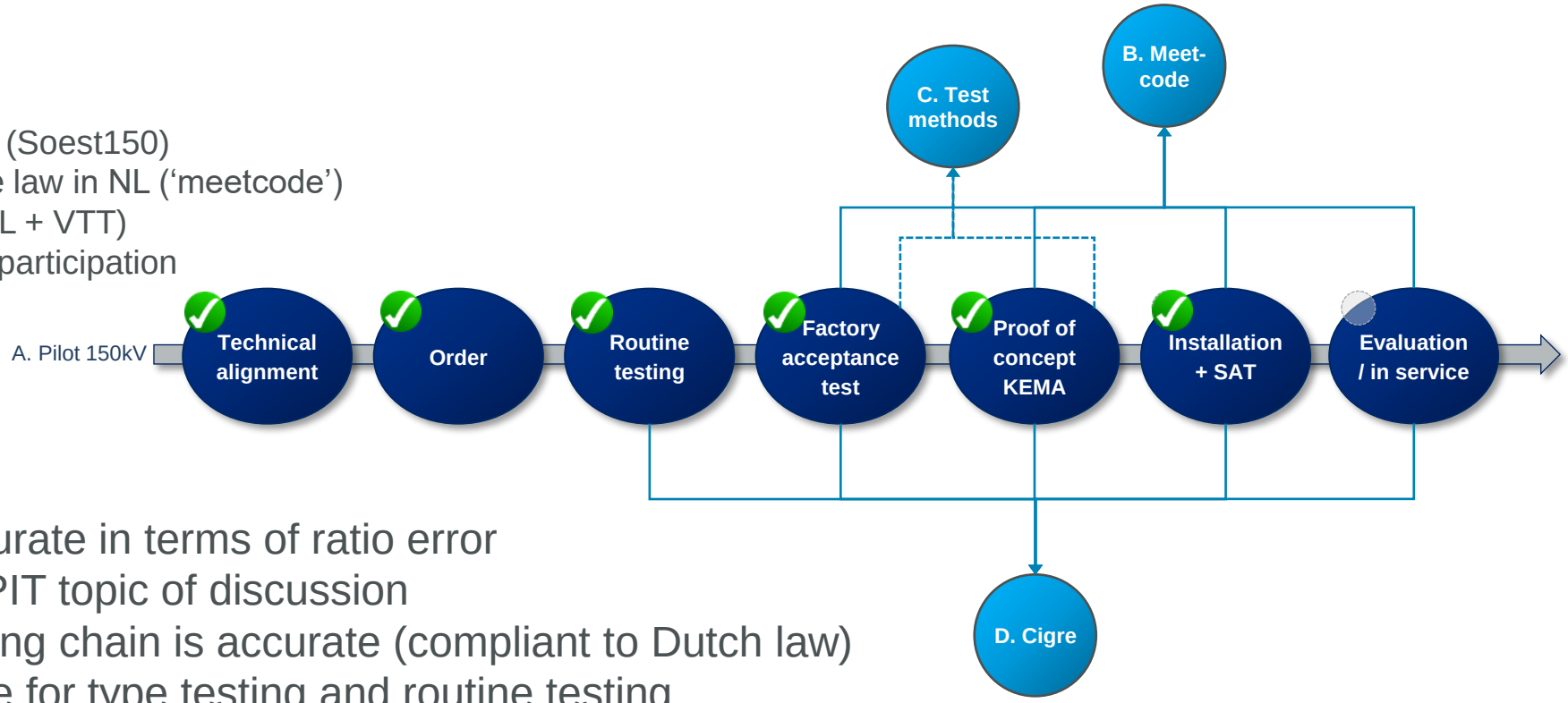


Setup of laboratory

TenneT NL – Soest 150kV

Overview of initiatives

A. Pilot for metering (Soest150)
B. Adjustment of the law in NL (‘meetcode’)
C. DigIT project (VSL + VTT)
D. Cigre WG B5.76 participation



Lessons learned:

1. LPIT is very accurate in terms of ratio error
2. Angle error of LPIT topic of discussion
3. Complete metering chain is accurate (compliant to Dutch law)
4. IEC not complete for type testing and routine testing
5. Limited services in market for:
   a) System integration
   b) Type testing
   c) Calibration / certification of setup

Questions?

Thank you very much for your attention!

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