Current research work in large scale power system protection

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Projects

On-going projects in the field of protection

- MIGRATE – Protection of power systems with 100% penetration of Distribution Generation – 2016-2020
- URSES – Uncertainty Reduction of Sustainable Energy Systems -2014-2018
- CRC – Protection of HVDC Systems (2013-2017)
- DC Circuit breakers – Promotion 2016-2020
- Testing of Protective Relays (several master projects)

Migrate - Protection of power systems with 100% penetration of Distribution Generation (1)

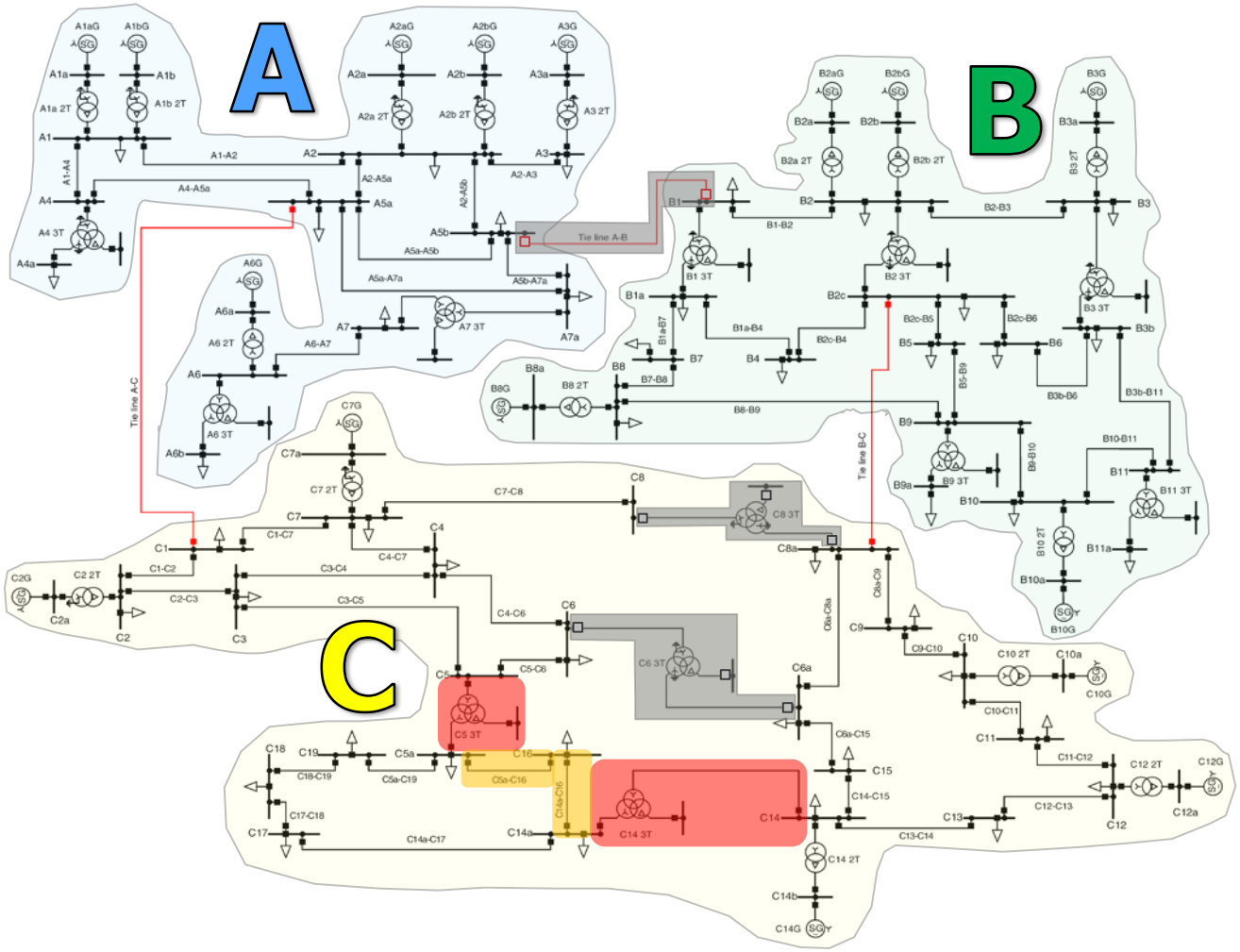
Protection difficulties are initiated by:

- Low Inertia
- Low fault current amplitude
- Difficulty to detect
- Possible protection mal operations
- Low critical clearing times

URSES - Uncertainty Reduction of Sustainable Energy Systems -2014-2018

- Developing Real Time PMU Platform for online monitoring
- Developing an efficient algorithm for control islanding

Simulation example: Blackout scenario



Stage 0

- 1 Transformer (690 MVA) is on maintenance

Stage 1

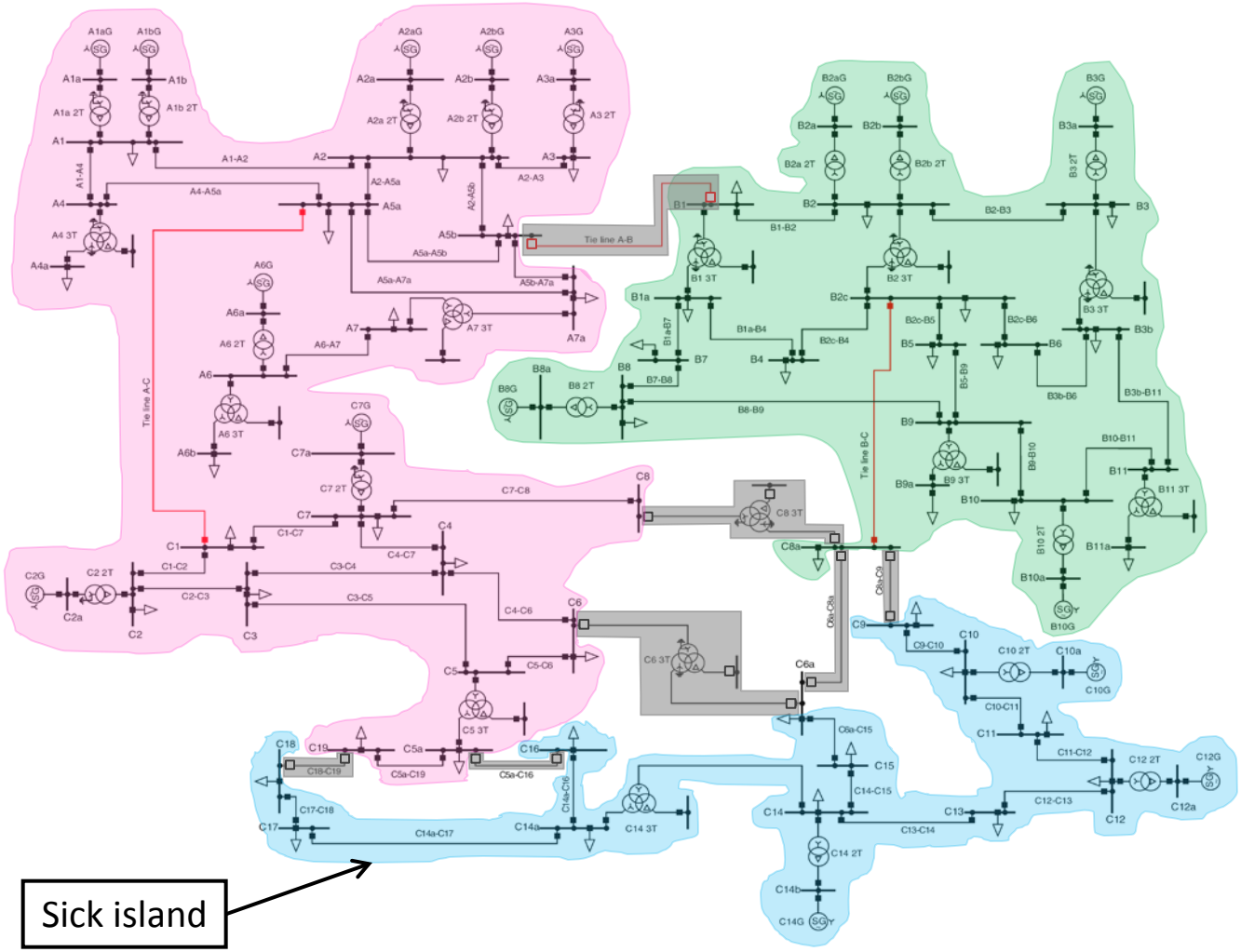
- TL A-B with 800 MVA flowing from A to B trips
- 2nd transformer gets overloaded

Stage 2

- 2nd Transformer (690 MVA) trips

- ~100% overload
- ~50% overload
- switched off, out of service

Simulation example: Islanding solution



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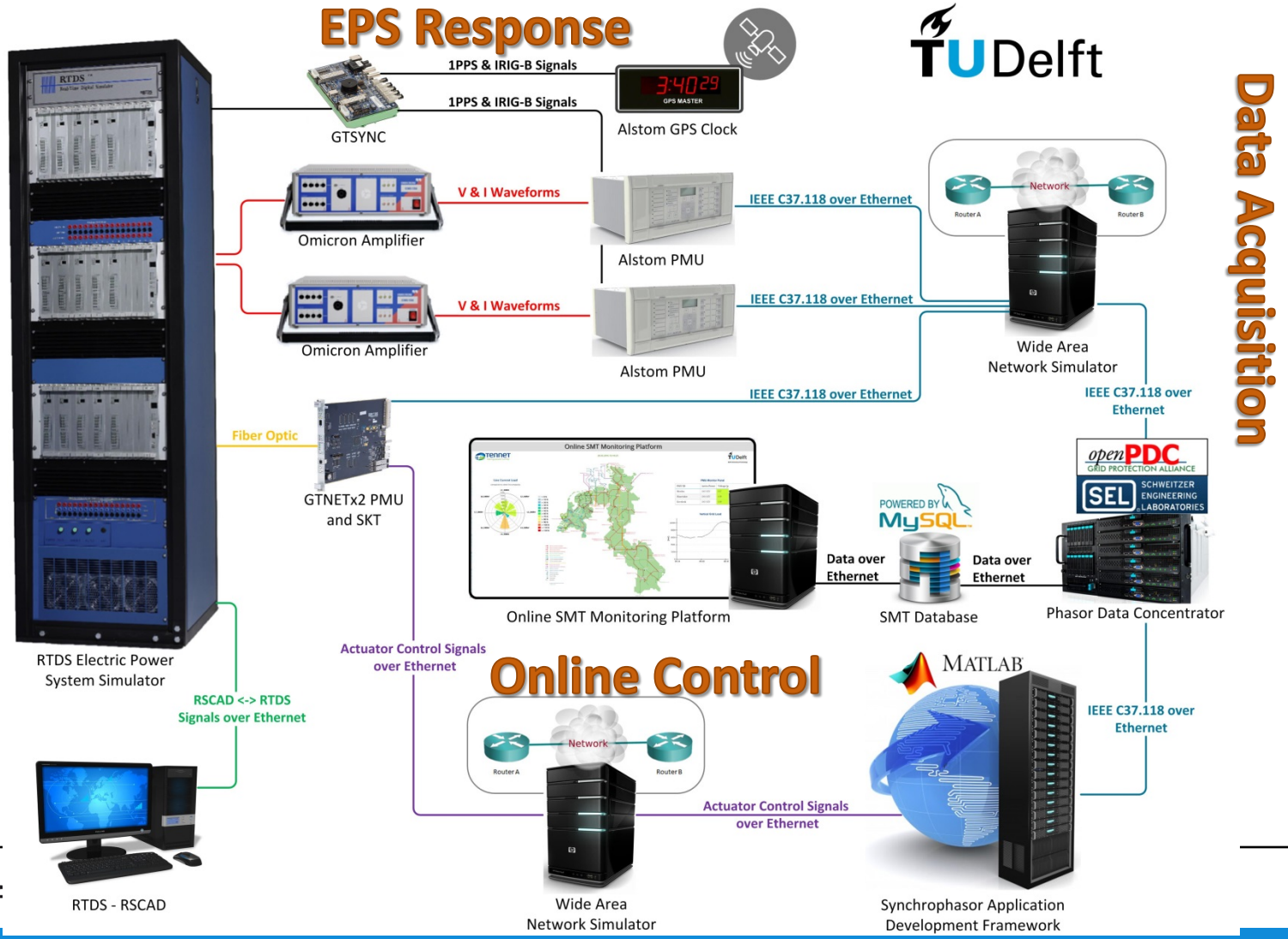
Stage ICI

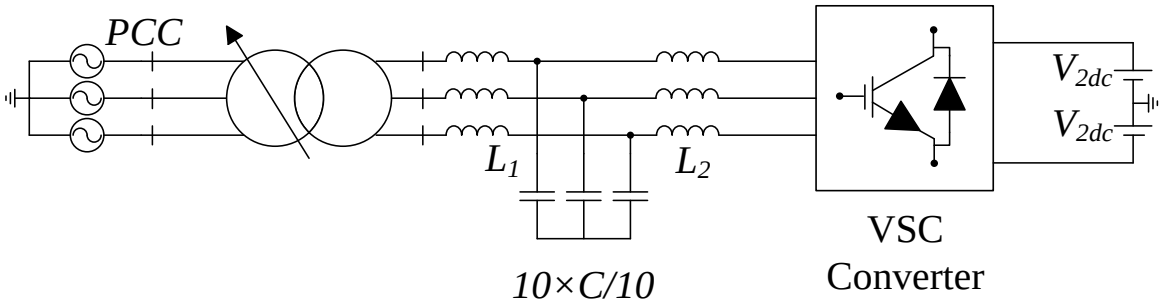
- Calculate system splitting boundary in max. 1–2 s after the initiating event. Also consider gen. coherency.

- 3 islands obtained
- No angle instability after islanding
- No significant overloads
- Some voltages are low, but isolated in the smallest island

WAMPAC-ready platform for online evaluation of corrective control algorithms

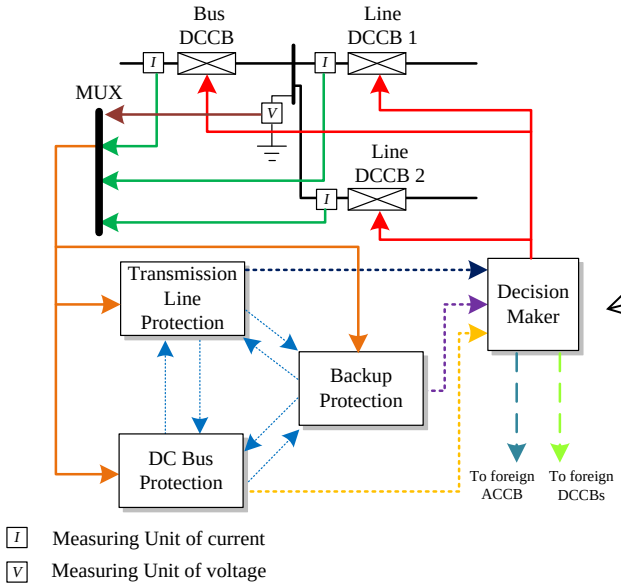


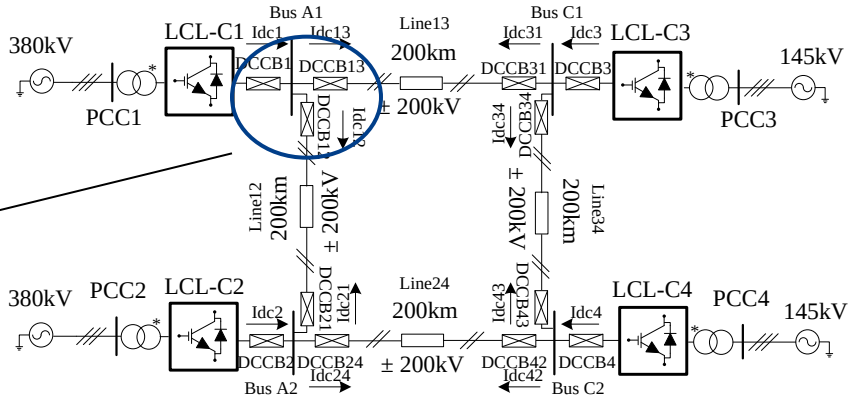
CRC - Protection of HVDC Systems



- The LCL-converter can limit DC fault current.
- The LCL-converter could be controlled under partial loads condition, for the sake of minimizing the power losses.

CRC - Protection of HVDC Systems





Transmission line protection

$$Threshold = k \cdot \sum_{i=1}^{n} w_i \cdot \max\left[WT(I_{dc})_{Level\_i}\right]$$

$(n = 2,3,4...)$

DC bus protection

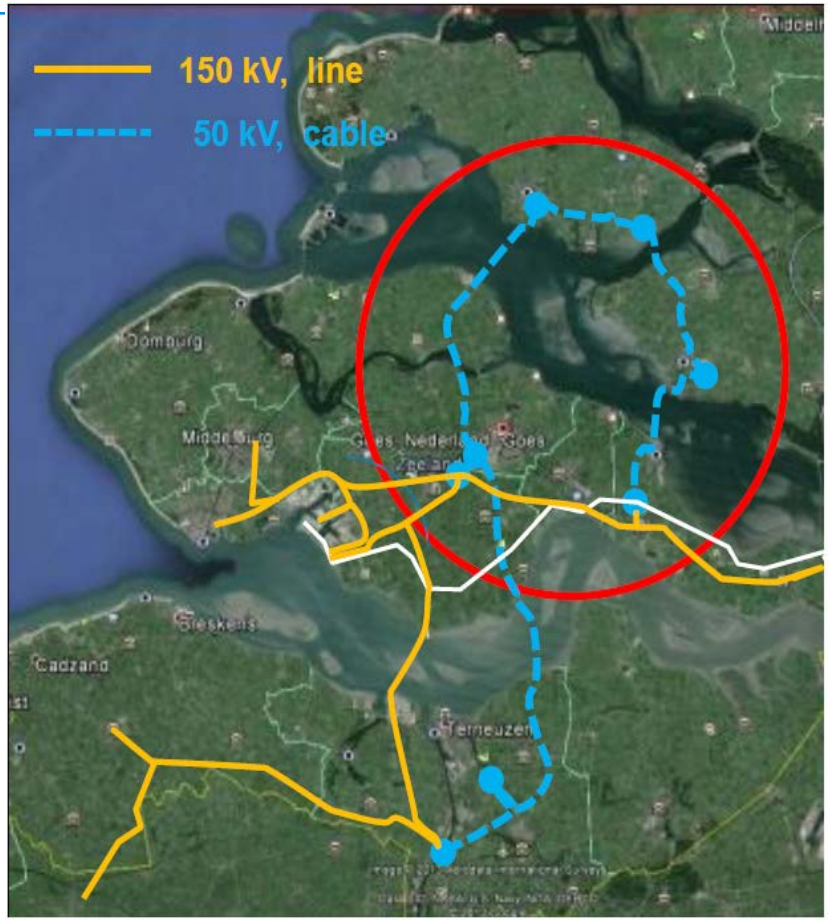
$$Idiff = Idci - \sum Idcij(i, j = 1,2,3,4, i \neq j)$$

Backup protection

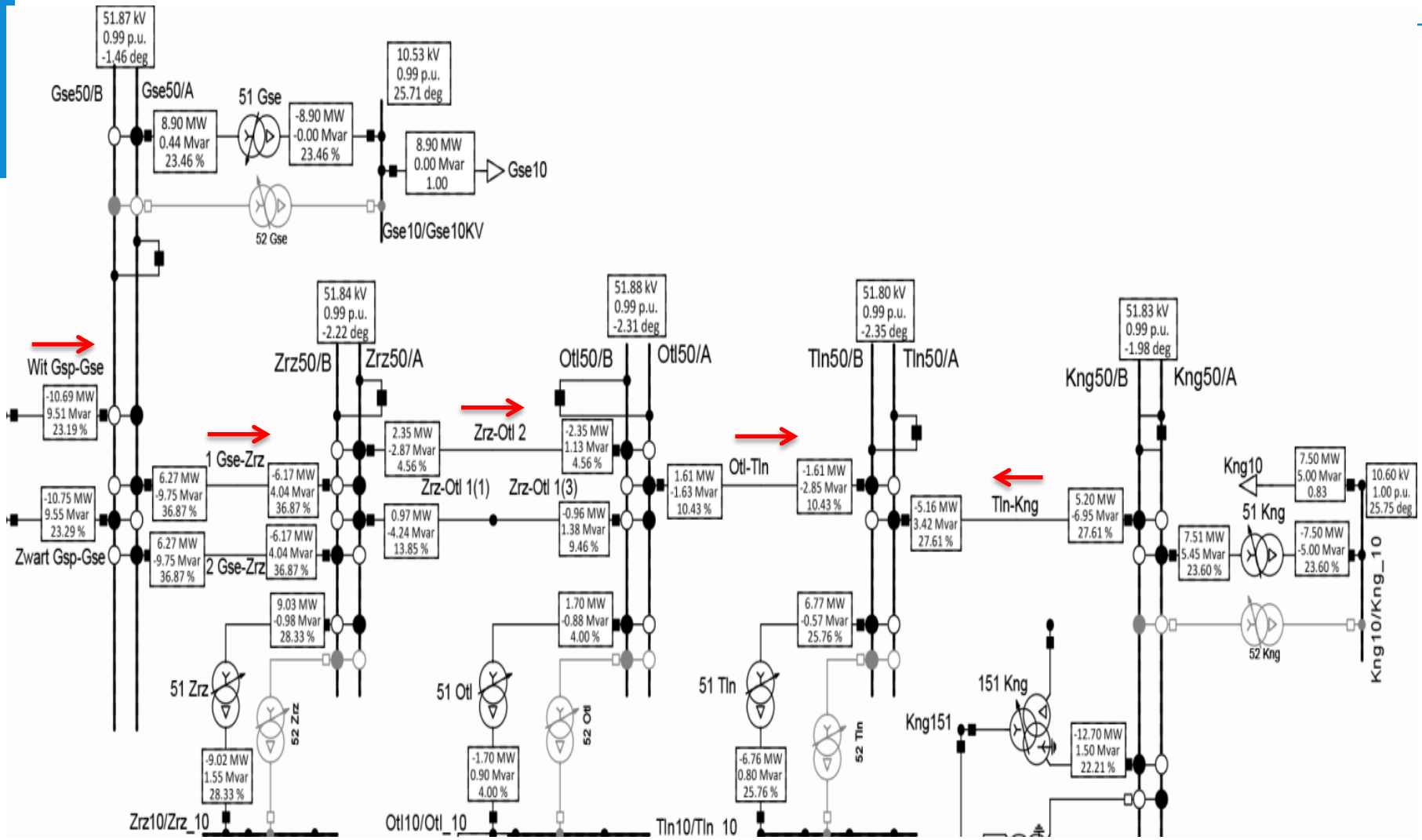
1. The local information is adequate for the fault detection using wavelet transform;
2. The selectivity can be ensured between different protections at one bus;
3. The communication is necessary for the relays in a MTDC network, and the reliability can be enhanced.
4. More criteria could be introduced, but the response time may increase.

Delta Network 50 kV distribution grid

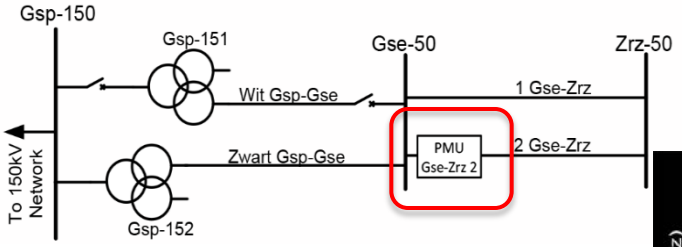
- 50 kV distribution grid.
- Operated by the DNWG – Delta Network Group (hereinafter referred to as Delta)
- Located in the province of Zeeland in the southwestern part of the Netherlands near the North Sea.
- Ideal for DG penetration affecting the distribution grid.
- Hence, the decision to use PMU technology for grid monitoring.

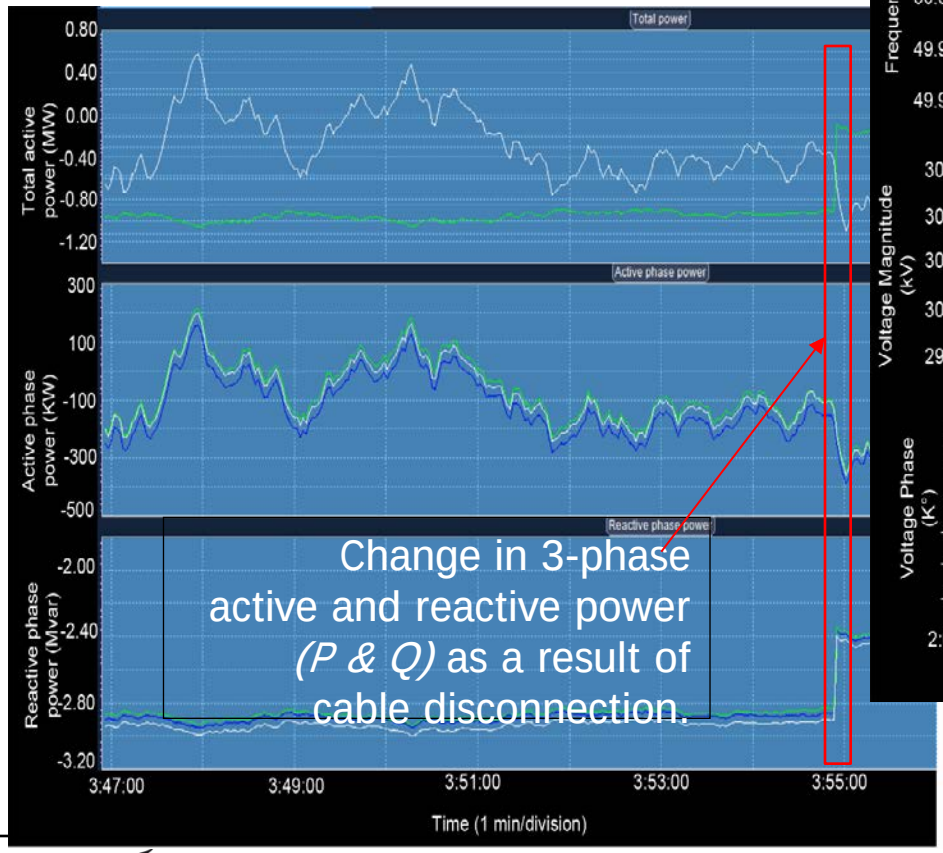


Results showing a snapshot of the 50 kV distribution grid

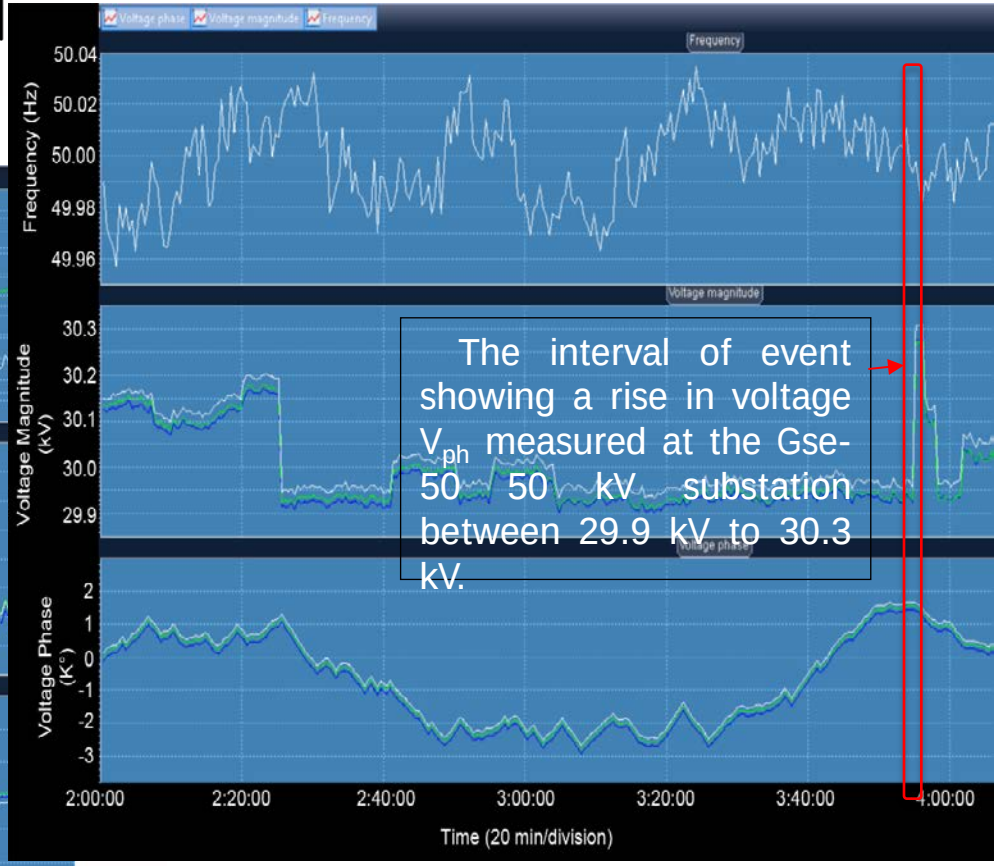


Event logged by Gse-Zrz-2 PMU at Gse-50 50 kV substation





Change in 3-phase active and reactive power *(P & Q)* as a result of cable disconnection.



The interval of event showing a rise in voltage V_{ph} measured at the Gse-50 50 kV substation between 29.9 kV to 30.3 kV.

RTDS