Power System Protection Centre activities

Marjan Popov

Delft University of Technology

What is PSPC?

~~Public Services and Procurement Canada~~

Power System Protection Centre

~~Performance Standards for Protecting Coating~~

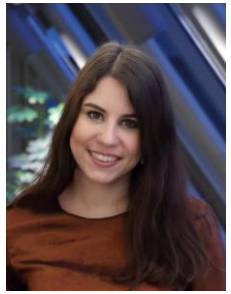
Power System Protection Centre

Ir. Evita Parabirsing, Stedin

Ir. Kees Koreman - TenneT

Dr. Dipl-Ing. M. Popov, TU Delft

Ing. Jacques van Ammers, GE



Dr. Dipl-Ing. A. Lekić, TU Delft

Ir. Maarten van Riet, Alliander

Ir. Frank Baldinger, Locamation

Prof. Mart van der Meijden,
TenneT/TU Delft

Ing. Corne de Hoogh, Siemens NL

www.tudelft.nl/pspc

Research Centre for Advanced Power System Protection

Vision

To advance the research, education and knowledge transfer in power system protection by applying current and future technologies and ideas.

Mission

To create a common platform among the utilities, manufacturers and academia by exchanging knowledge and results in order to improve existing solutions

On-going 5-year Project in the context of PSPC

- **Resilient Synchro-measurement-based Grid Protection Platform (ReSident)**

- Goal: The project deals with the design of a novel high-resolution synchronized measurement supported simulation platform, to reduce the risk of cascading events, as well as to classify and locate disturbances based on novel algorithms verified by actual data.

Partners: TenneT, Aliander, Enduris, Stedin, GE and VSL

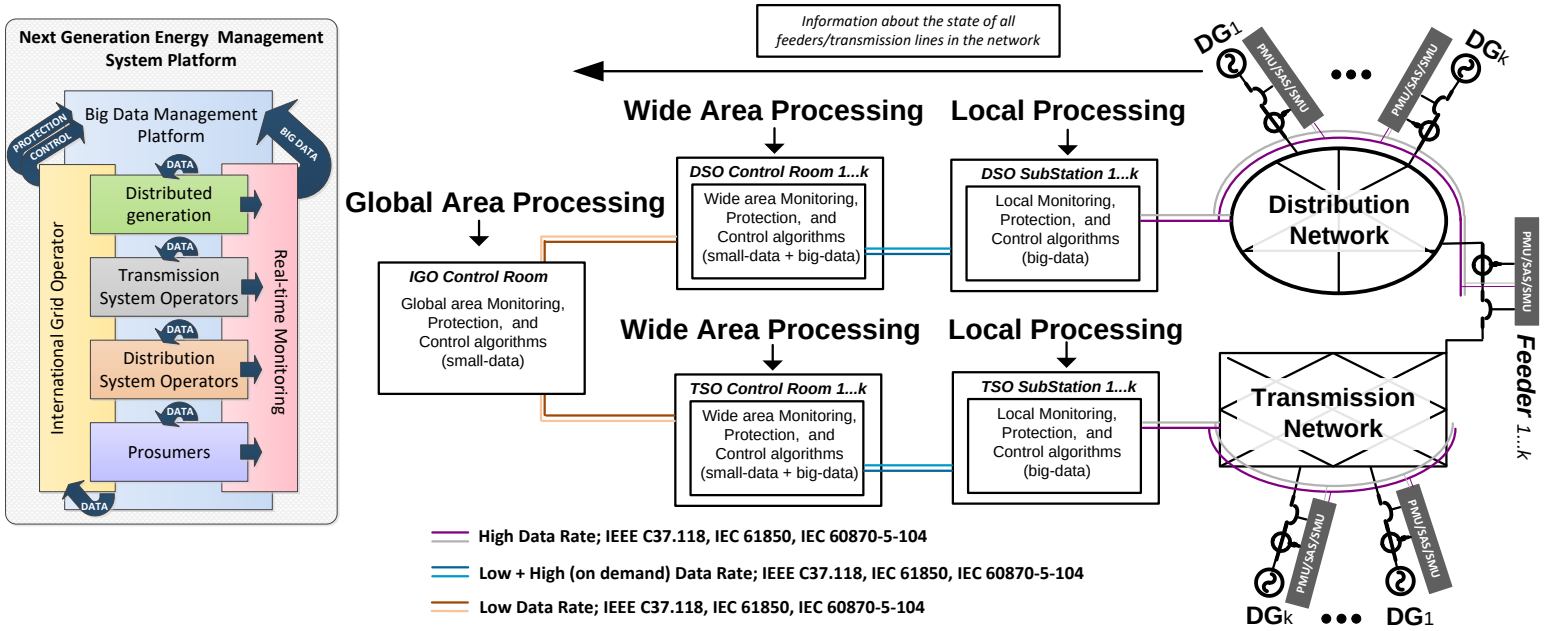
Composition of the research team and consortium

Research team:

- Matija Naglic 1.09.2018 – 1.09.2019, postdoc (completed) (ICT platform)
- Ilya Tyuryukanov 1.03.2019 – 1.03.2021, postdoc (control islanding/out of step protection)
- Aleksandar Boricic 1.06.2019 – 1.6.2023, PhD student (voltage control/vulnerability analysis)
- Nidarshan Veera Kumar 1.09.2019-1.09.2023 PhD student (disturbance detection/classification)
- Marko Tealane 1.10.2019-1.10.2020 (out of step protection)

Supervision: M. Popov / J. Rueda
Consortium: TenneT, Alliander, Stedin, Enduris, GE,VSL

Work done so far



The novel NGEMS platform

M. Naglic, M. Popov, M. A. M. M. van der Meijden and V. Terzija, "Synchronized Measurement Technology Supported Online Generator Slow Coherency Identification and Adaptive Tracking," in *IEEE Transactions on Smart Grid*.

Other realization in 2019/2020

PhD theses:

Lian Liu: Protection of Multi-terminal HVDC Systems Algorithm Development and Performance Verification By EMT Simulations, CRC – scholar, December 2019

Ilya Tyuryukanov: Graph Partitioning Algorithms For Control Of Ac Transmission Grids, Generator Slow Coherency, Intentional Controlled Islanding and Secondary Voltage Control, NWO-URSES program, to be defended March 2020

Matija Naglic: On Power System Automation – Synchronised Measurements Technology Supported Power System Situational Awareness, NWO-URSES program, to be defended March 2020.

Projects realized

PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

WP6 – modeling DC CBs

- SciBreak DC CB (TU Delft/SciBreak/Kema Lbs/TenneT)
- Surge arresters modeling (TU Delft/Kema Lbs)

WP9 – Protection of DC

- Defining procedures and guidelines for testing DC protection

Kema laboratories 2018

S. Liu, M. Popov, S.S. Mirhosseini, S. Nee, T. Modeer, L. Ängquist, N. Belda, K. Koreman and M. van der Meijden, "Modelling, Experimental Validation and Application of VARC HVDC Circuit Breakers," in *IEEE Transactions on Power Delivery*

Last Year !

We have successfully organized post-academic education in protection:

Cigre C4 colloquium

We have successfully hosted international colloquium on lightning:

cigre
For power system expertise
21, rue d'Artois, F-75008 PARIS
https://www.cigre.org

International Colloquium on
Lightning and Power Systems

Delft 2019

On-going research projects supported and partly financed by PSPC

Tanumay Karmokar

Industrial Ph.D. Researcher | TU Delft
Faculty of EEMCS | IEPG

Specialist Engineer for HVDC Cables
TenneT TSO GmbH
Bayreuth, Germany

Industrial Doctoral Research *(Partner: TenneT TSO)*

- **Topic** — Characterisation of Dynamic Stresses on HVDC Cables upon DC Current Interruption in Meshed Grid Applications *(Project Start: Dec 2021)*
- **Promotors** — Dr.ir. Marjan Popov, Dr. Armando Rodrigo Mor
- **Research Goal**
  - Define a sustainable electrical interface between HVDC cables and DCCB up to 525 kV for different operational modes of DCCB.
  - Experimentally investigate the impact of representative cable stresses in comparison to

➢ Initial Findings

- Challenge is practice-based detailed impedance modelling of HVDC cables for investigating its transient behaviour.
- Voltage simulated at open end of 100 km long cable *(see Fig 1)*.
- Damping of reflections is mainly caused by screen resistance *(see Fig 2).*

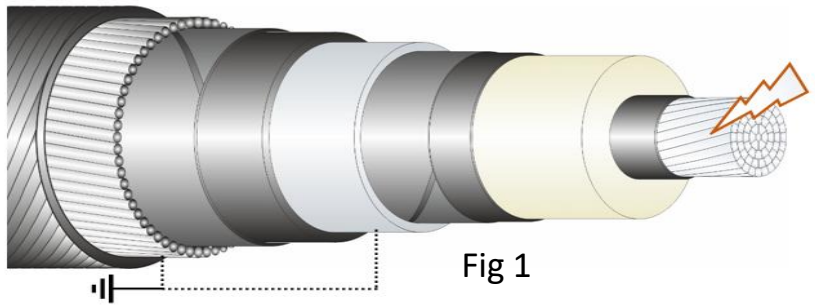


Fig 1

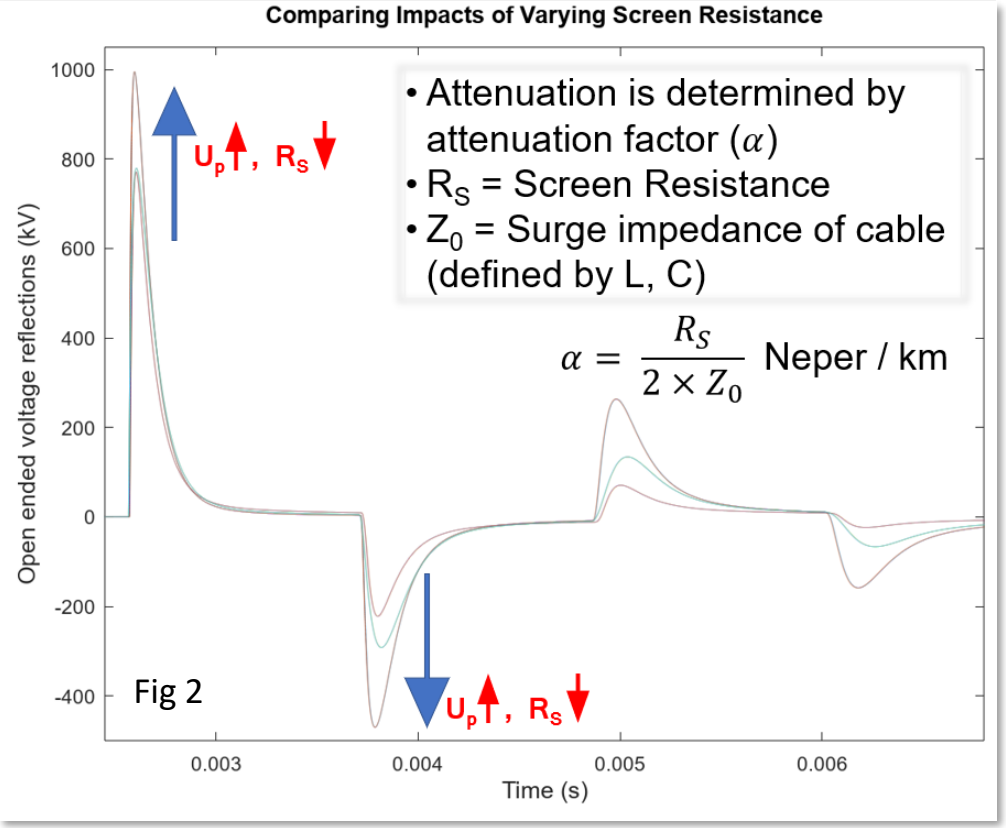


Fig 2

Three-phase high frequency power transformer modelling

Phd candidate: Farzad Nasirpour,
Promotors: Marjan Popov, Mohamad Ghaffarian Niasar (2021-2025)

Research aims:

- Three-phase broad-frequency transformer modelling;
- Detailed studies of phenomena taking place in transformers;
- Developing a framework to obtain the model for different transformers with different sizes;
- Implementation of the model in EMTP environment for further studies regarding interaction of transformers with other parts of system;
- Defining protection solutions.

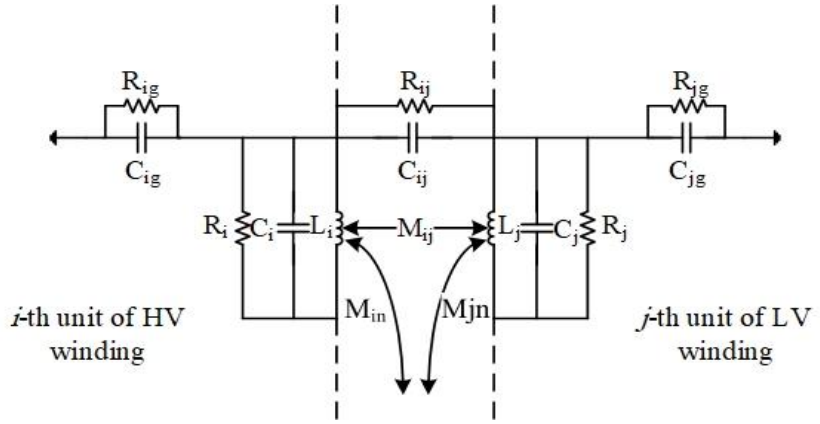


Fig. 1. The detailed model of a transformer.

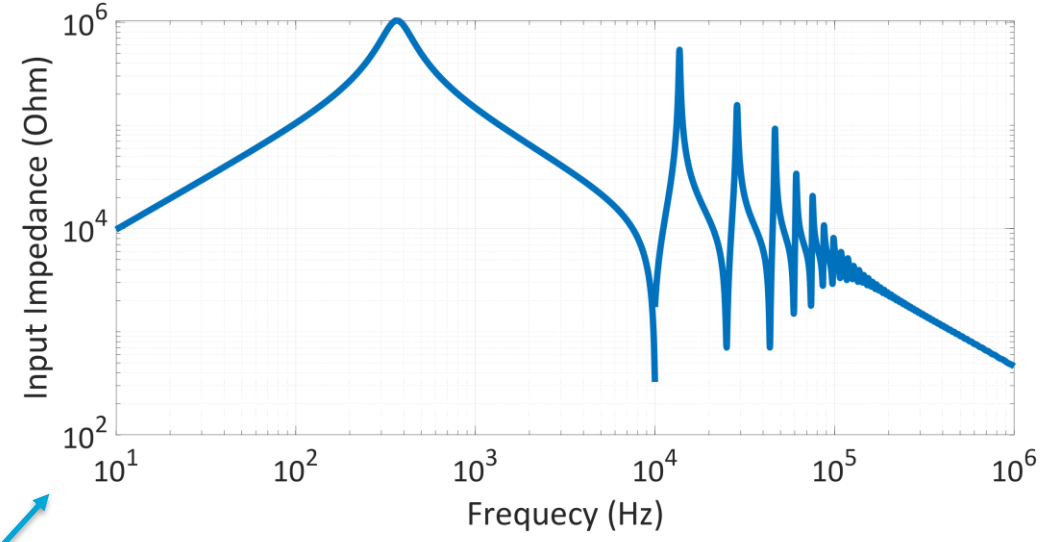


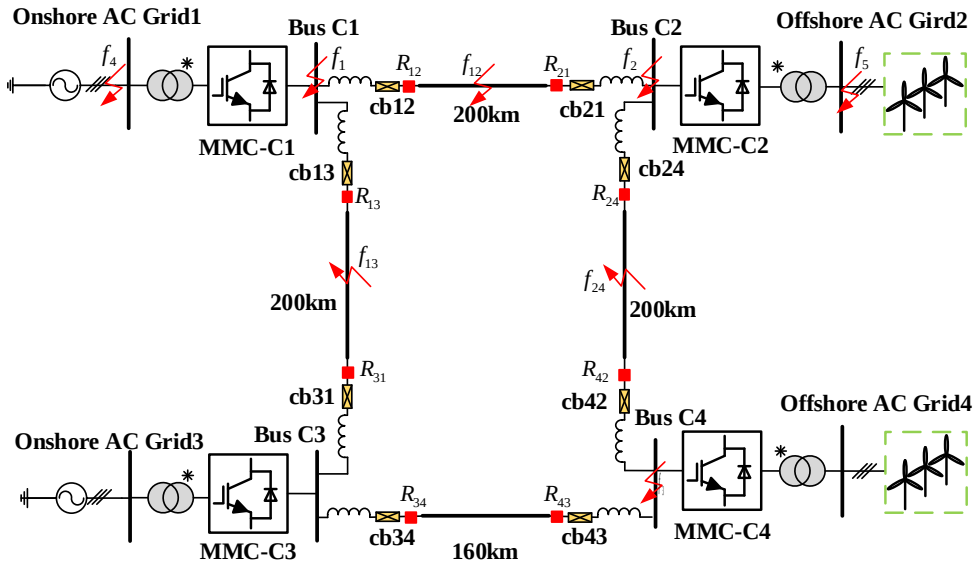
Fig. 2. Input impedance of an HV winding of a transformer obtained using the detailed model.

PRoteuS

TU Delft

PhD candidate: Le Liu, Promotors: Marjan Popov, Aleksandra Lekic (2020-2024)

Robust Protection and Control Algorithms for MTDC System



Topology of the studied ±525kV MTDC system

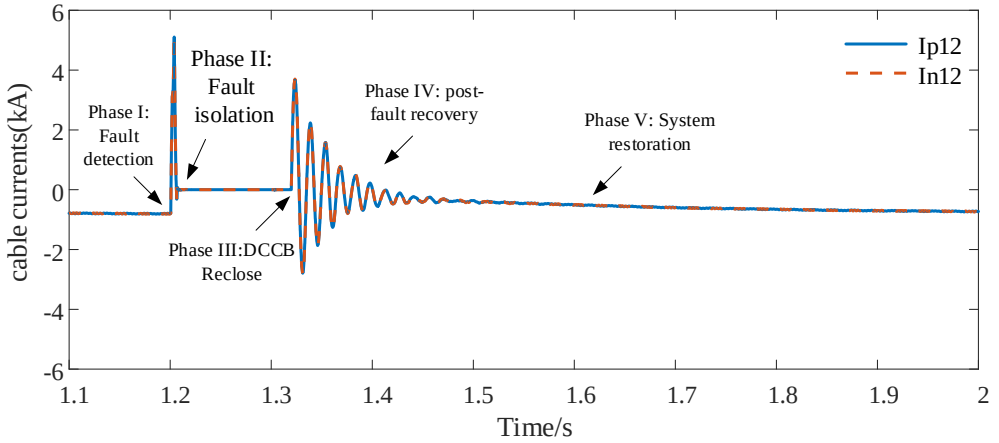
Research targets

- Detect dc faults, interrupt fault currents with different types of DC circuit breakers(VARC, Hybrid, Mechanical cbs)
- Optimize the system transient performance under large disturbance from the perspective of MMC control strategy

Research topics

- Develop robust protection algorithms and advanced MMC control strategies for ±525kV MTDC system
- Hardware-in-the-loop-test in RTDS platform of the applications of protection and control algorithms (future work)

How can protection, dc cb and MMC controllers enhance the system performance in the post-fault stage?



Typical cable currents during post-fault stage

Nidarshan Kumaar
PhD Candidate

TU Delft
Faculty of EEMCS

Intelligent Electrical Power Grids

June 2019 - June 2023

Promotors:
Dr. ir. Marjan Popov,
Dr. ir. Jose L. R. Torres

Vision: Incremental learning of disturbance events with transforming power grid

RTDS Module for initial training

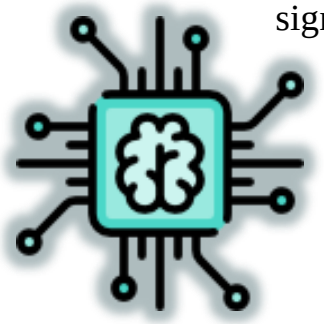
Real world labelled event data

Concept drifted real-world labelled event signatures

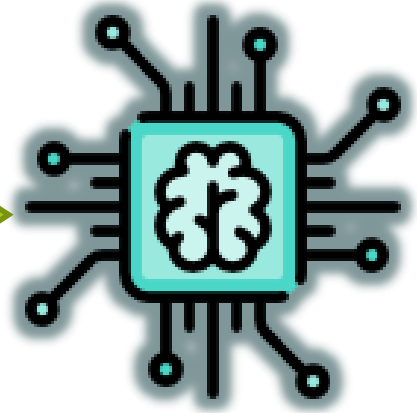
New set of unknown event signatures

Trained algorithm by RTDS grid model data at lab

Algorithm updating incrementally for grid specific event signatures



Algorithm adapting incrementally for concept shift of event signatures



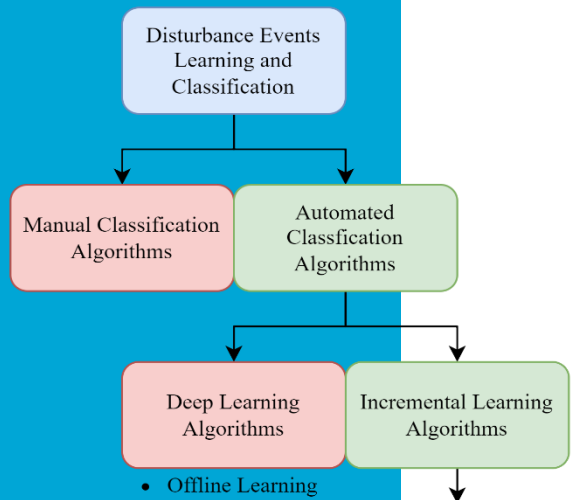
Algorithm adapting for new event class signatures without forgetting of old events

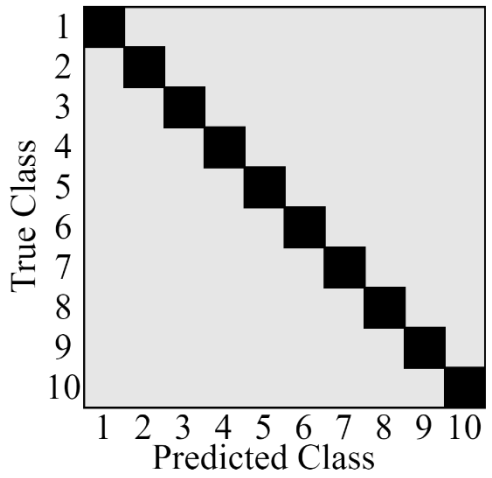
Real-time event detection, classification and localization

Mission: In order to prevent large blackouts, timely detection and classification of disturbances are needed. The application of AI algorithms for real-time detection and classification by using IED (intelligent electric devices) data is needed.

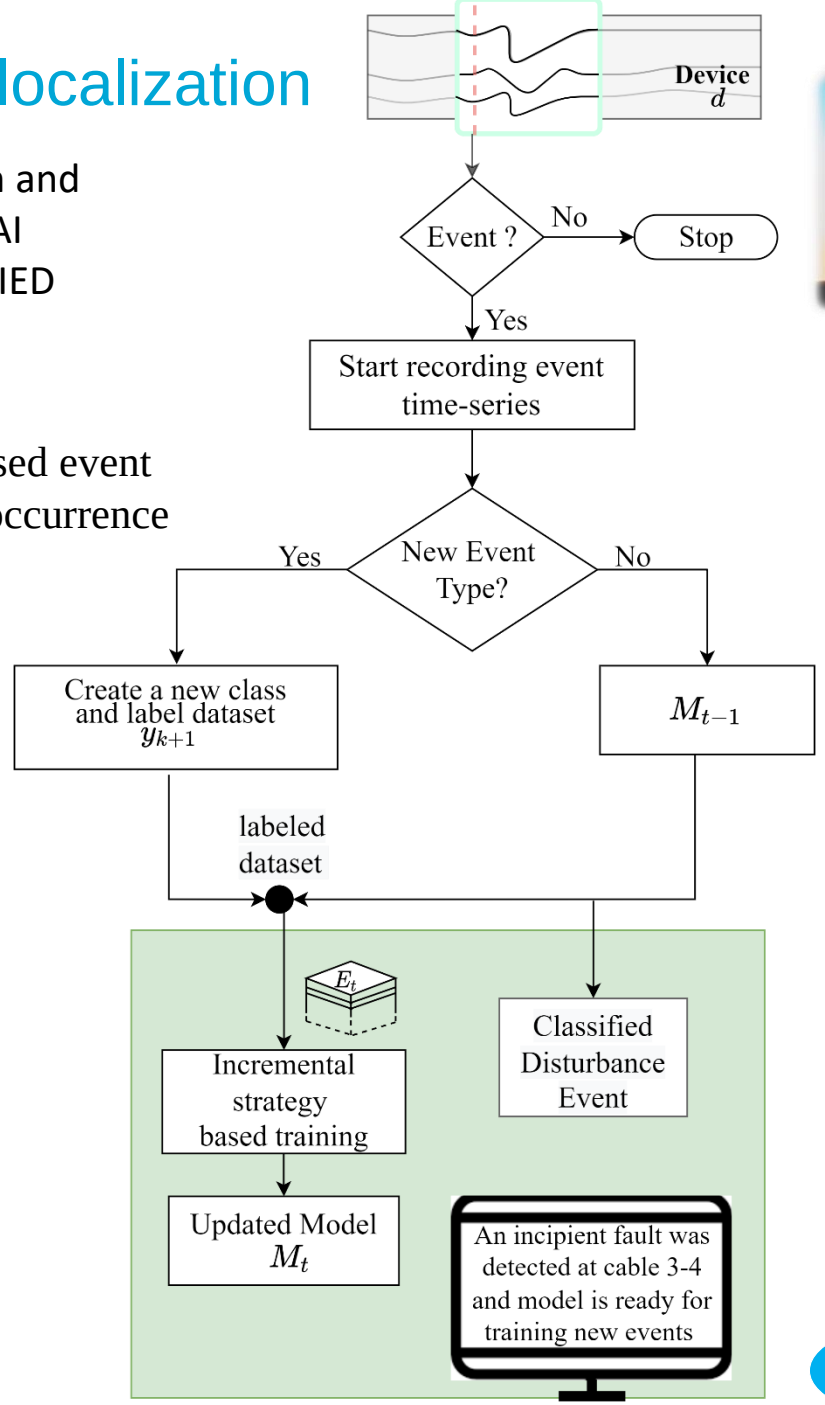
Goal: To develop a real-time expert system scheme by AI-based event detection, location, and classification in order to prevent the occurrence of severe faults and cascading events.

Courtesy: Siemens





Confusion matrix representing event classification accuracy.



Aleksandar Boričić
PhD Candidate

TU Delft
Faculty of EEMCS

Intelligent Electrical Power Grids

June 2019 - June 2023

Promotors:
Dr. ir. Marjan Popov,
Dr. ir. Jose L. R. Torres

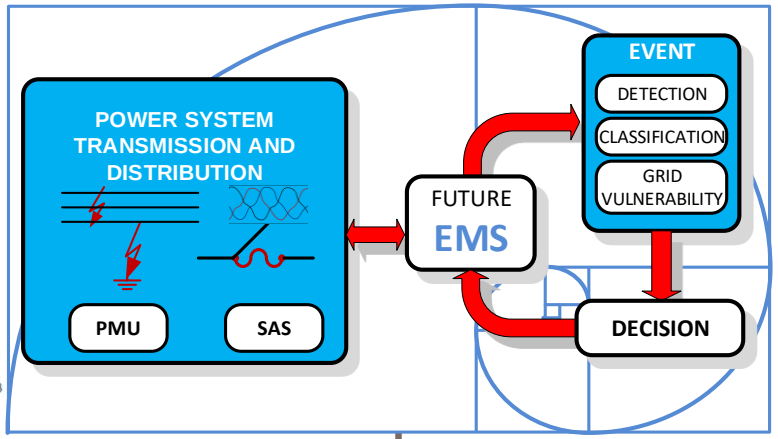
Vulnerability Assessment of Power Systems with High Penetration of Renewable Energy Sources

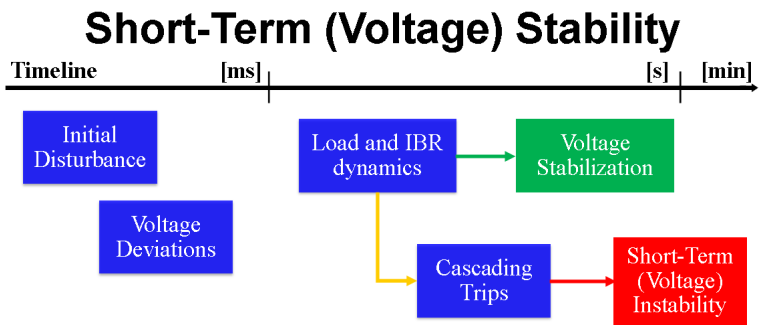
IEPG Intelligent Electrical Power Grids
http://iepg.ewi.tudelft.nl/

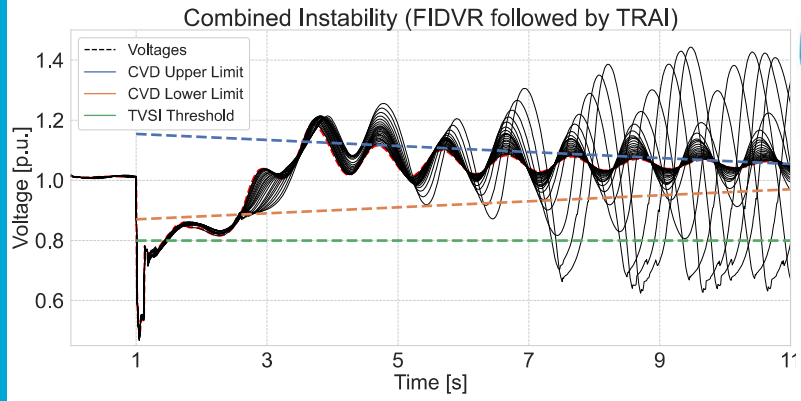
Goals of the research:

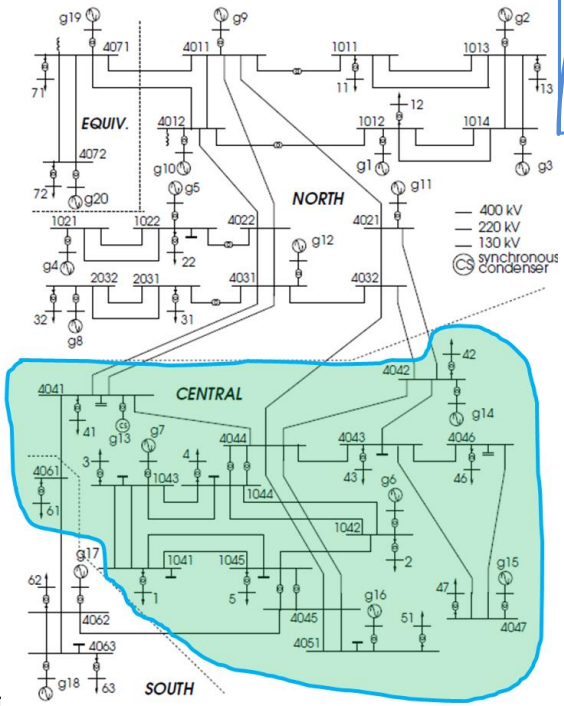
- Improve the understanding of modern power system dynamics, stability, and resilience with a high integration of renewables
- Develop novel vulnerability evaluation methods to support stable operation (prevent cascading) with a high integration of renewables

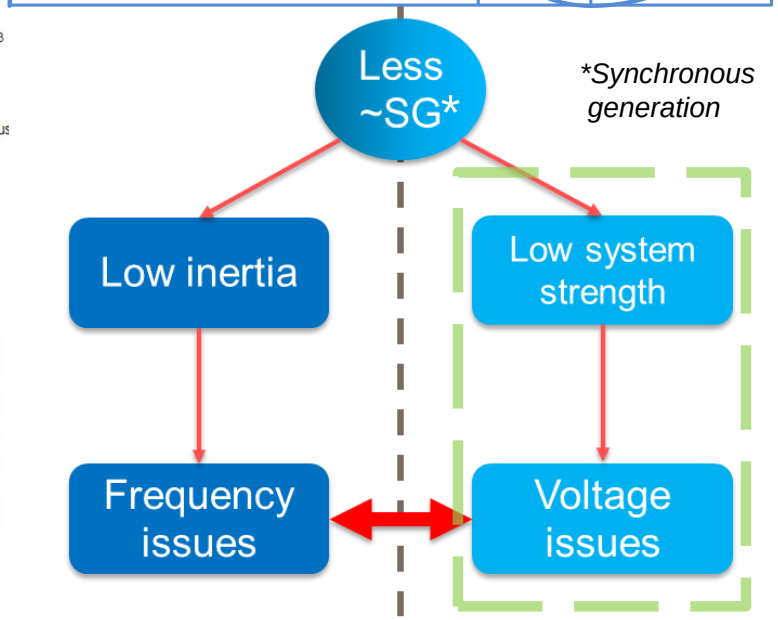
Part of the Resilient Synchromeasurement-based Grid Protection Platform project (ReSident)











Milan Jankovski

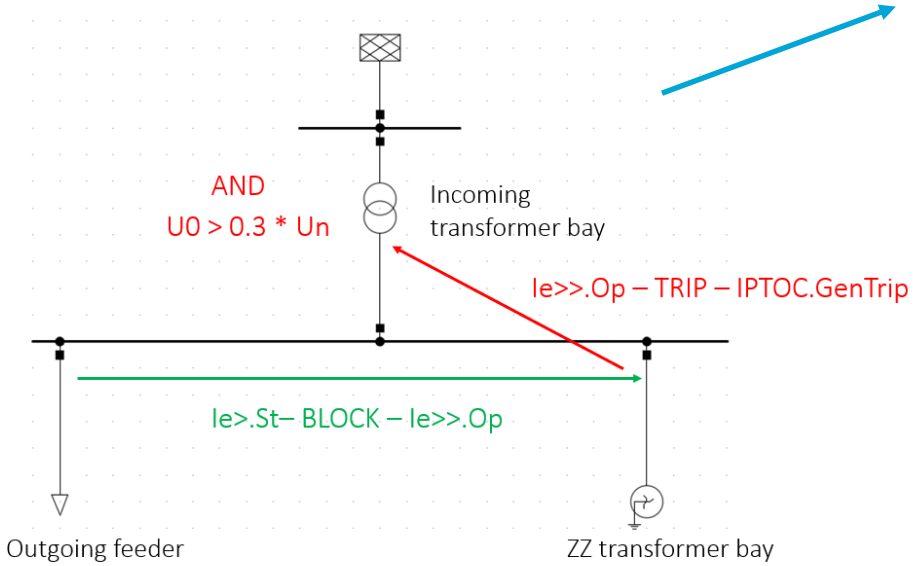
Master student | TU Delft
Faculty of EEMCS | IEPG

Single-phase busbar faults detection in impedance earthed distribution networks

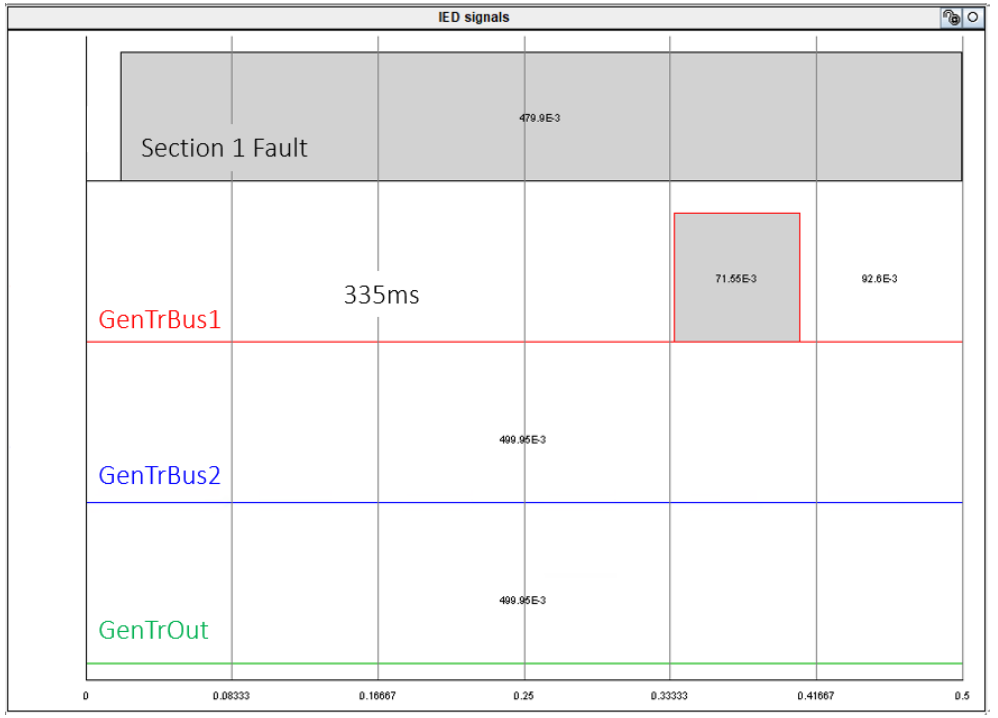
Master Thesis (Thesis start : Dec 2021) Supervisors: Aleksandra TUD/ E. Parabirsing (Stedin)

➢ Thesis goals

- Define and test an IEC 61850 communication-based busbar protection against single-phase faults in impedance grounded networks
  - Tested and showing promising results
- Explore the possibilities for a centralized protection being used as a hybrid busbar protection (back-up protection plus added functionalities).



Principle of operation of the proposed scheme



Obtained results from the RTDS for a single-phase busbar fault