C4 Power System Technical Performance

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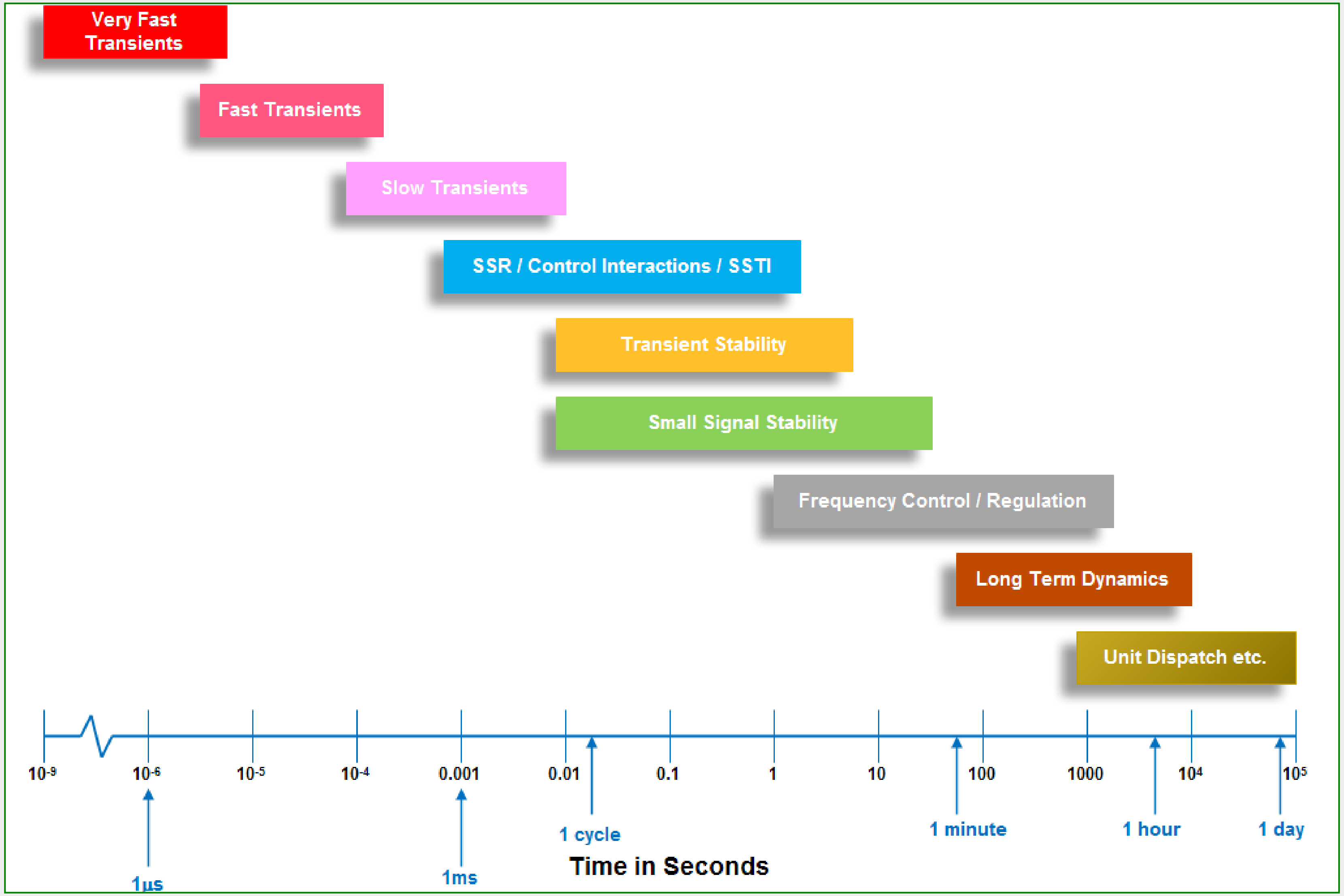
Outline

1. Introduction
2. Workshop System Strength
3. Dutch papers
4. Dutch working groups

Introduction

- Power Quality;
- Electromagnetic Compatibility/Electromagnetic Interference (EMC/EMI);
- Insulation Co-ordination;
- Lightning and its impact on power system equipment;
- Power system dynamics and numerical analysis.

- 4 Nederlandse papers
- In ca. 10 C4 werkgroepen Nederlanders actief
- Nationale SC 17 members (Appendix 1)



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Workshop System Strength incl. PS1

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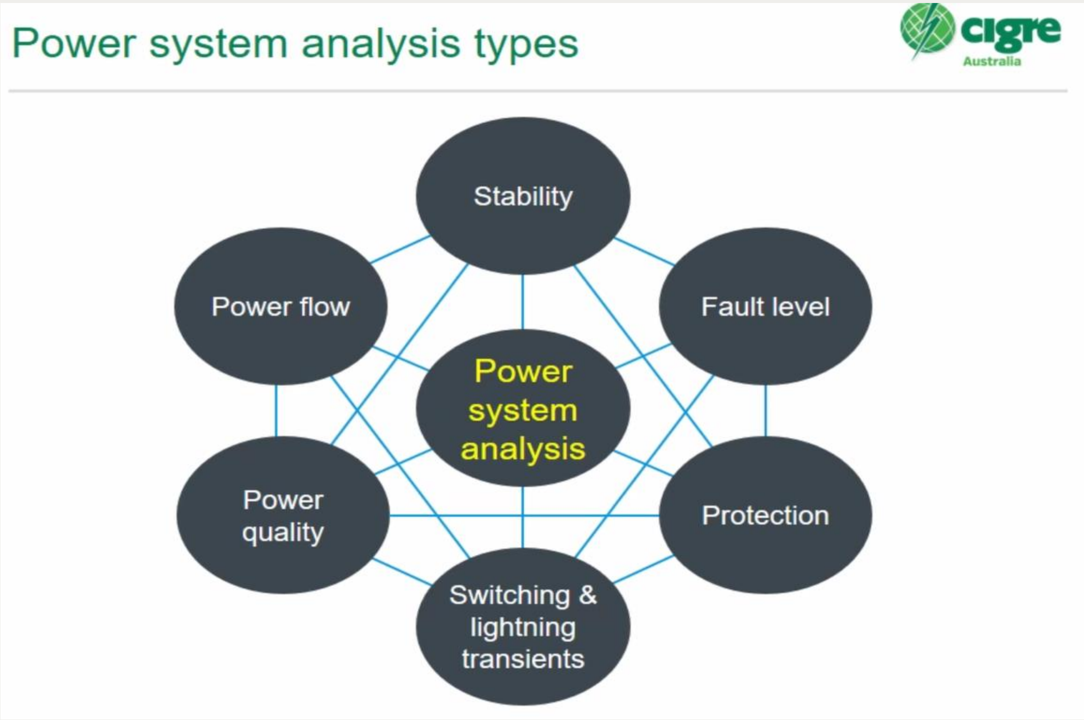
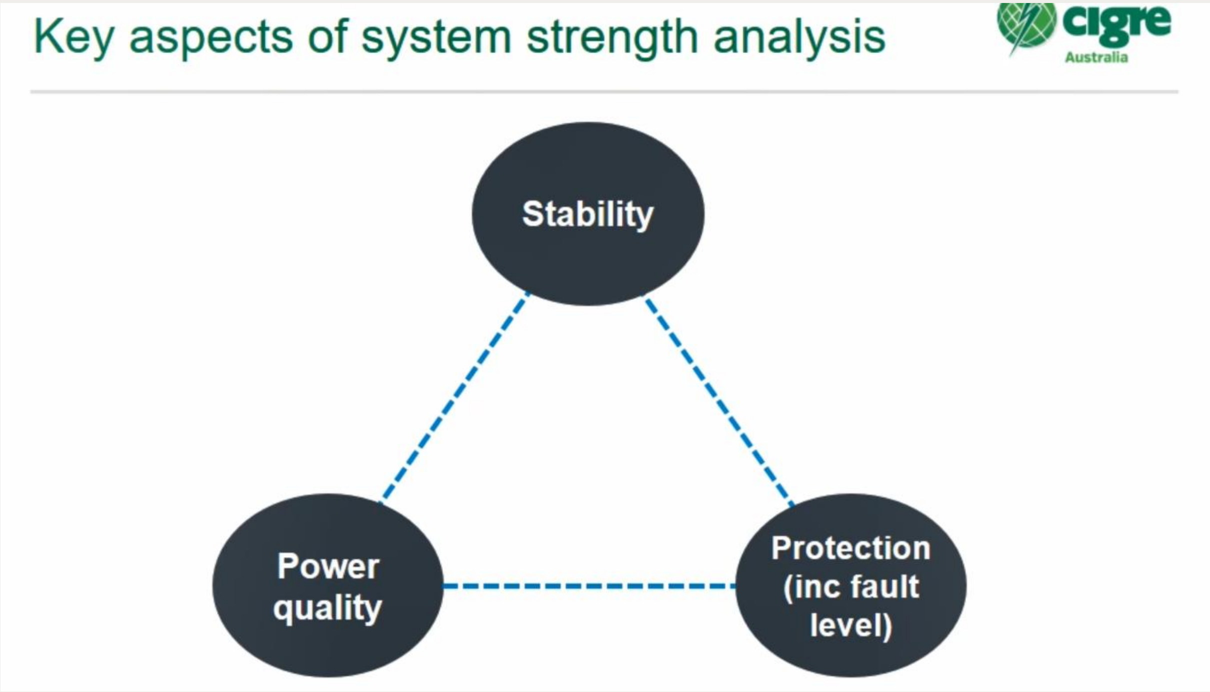
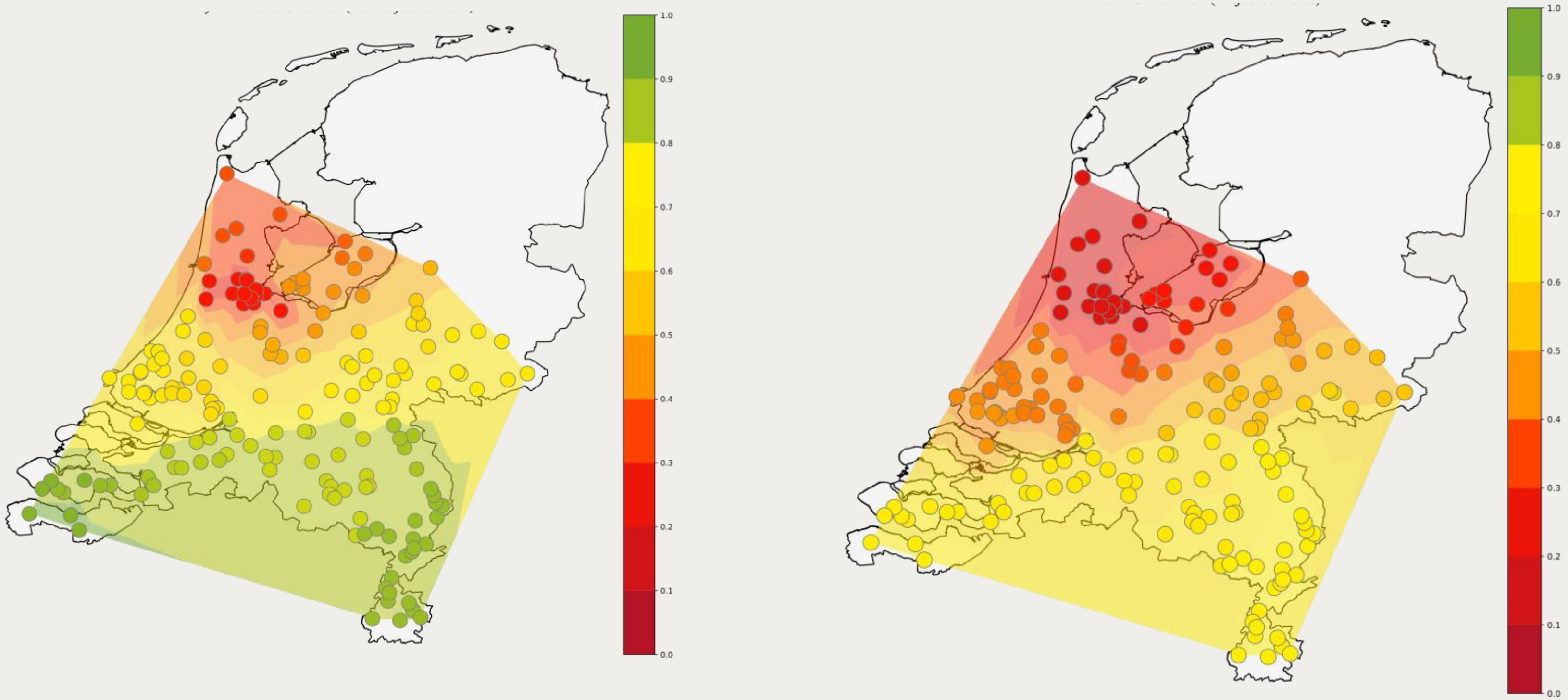
Importance of System Strength





From Workshop Cigre C4: System Strength – A story about not enough shepherds and too many sheep, 24-8-2020

Fictitious example: Calculated Voltage dip propagation



Left: Base case.

Right: Base case but with significant integration of renewables.

(R. Torkzadeh)

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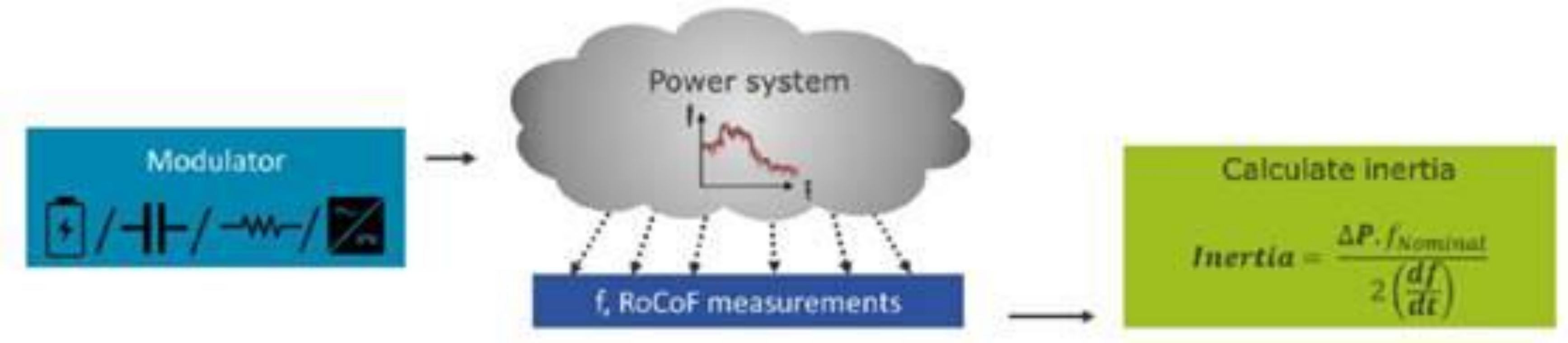
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

PS1: IMPROVING POWER SYSTEM TECHNICAL PERFORMANCE THROUGH THE USE OF ADVANCED METHODS, MODELS AND TOOLS

- Reducing system strength
  - Fault levels
  - Inertia levels
- New method to determine system inertia
  - real time measurements (UK)
    - small (10 MW) injected perturbations causing frequency changes 1-20mHz used to measure inertia



- EMT vs. RMS simulations
  - Increased need for EMT simulations
  - RMS not sufficient in low system strength situations
  - Need for model verification
    - NERC identified four PV related disturbances which behaviour could not be reproduced by models
      - Examples found where RMS results in stable response whilst EMS results were unstable
      - New recommendations for industry on model validation
- Mitigation measures:
  - synchronous condensors
    - new state of the art machines including flywheel -> inertia
      - will be installed by AEMO (AU), combined with must-run obligation to meet minimum inertia requirement
    - conversion of existing units
  - innovative VSC control
    - Amended converter control algorithm to uphold AC voltage at the PCC, slowing PLL response

PS3

METHODS, MODELS, AND TECHNIQUES FOR EVALUATING LIGHTNING, POWER QUALITY, AND INSULATION COORDINATION TO ENHANCE THE PERFORMANCE OF THE EVOLVING GRID

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CIGRE e-Session 2020

C4-302

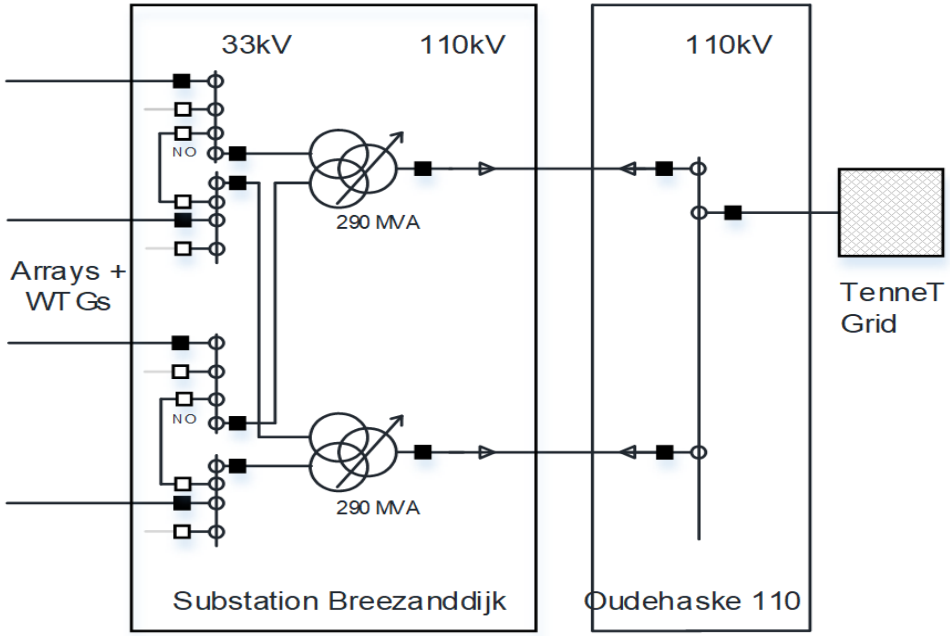
Impact of WTG converter impedance model on harmonic amplification factor of the Dutch 110 kV transmission network using a 383 MW wind farm case study

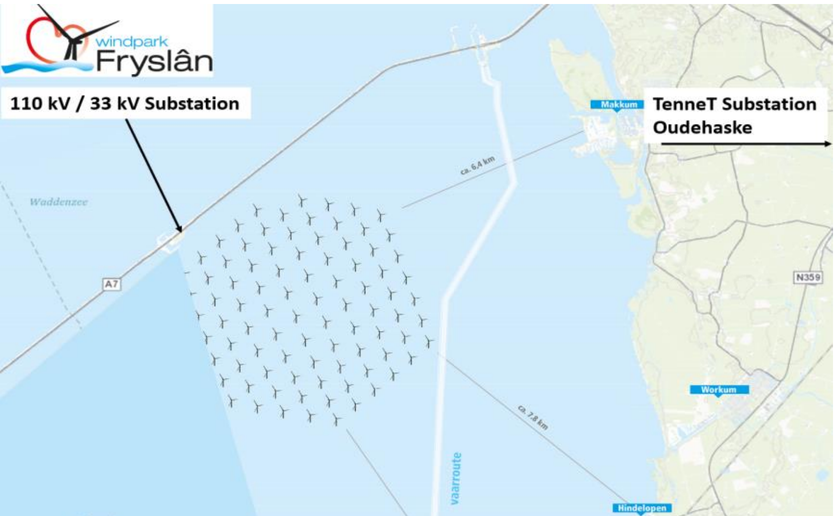
Daniël Vree

Presenter: Daniël Vree; D.Vree@Ensol.NL

24-09-2020

Introduction





- Long cable lengths combined with the low short-circuit power of the 110 kV network

Risk: significant harmonic voltage distortion

- Early assessment of this risk is required to quantify need for harmonic filters
- Electrical design not yet available at that time → relevant data to be *estimated*

How to estimate WTG harmonic model without the WTG OEM or type selected?

Conclusion

Harmonic voltage amplification of low harmonic orders (h=2 to h=10).

- WTG impedance model has a significant impact
- No model (infinite impedance) will result in both over- and underestimation
- Converter (control) modifications could help mitigate harmonic voltage amplification issues
- In an early stage of wind project development, the proposed analytical model provides a valid alternative

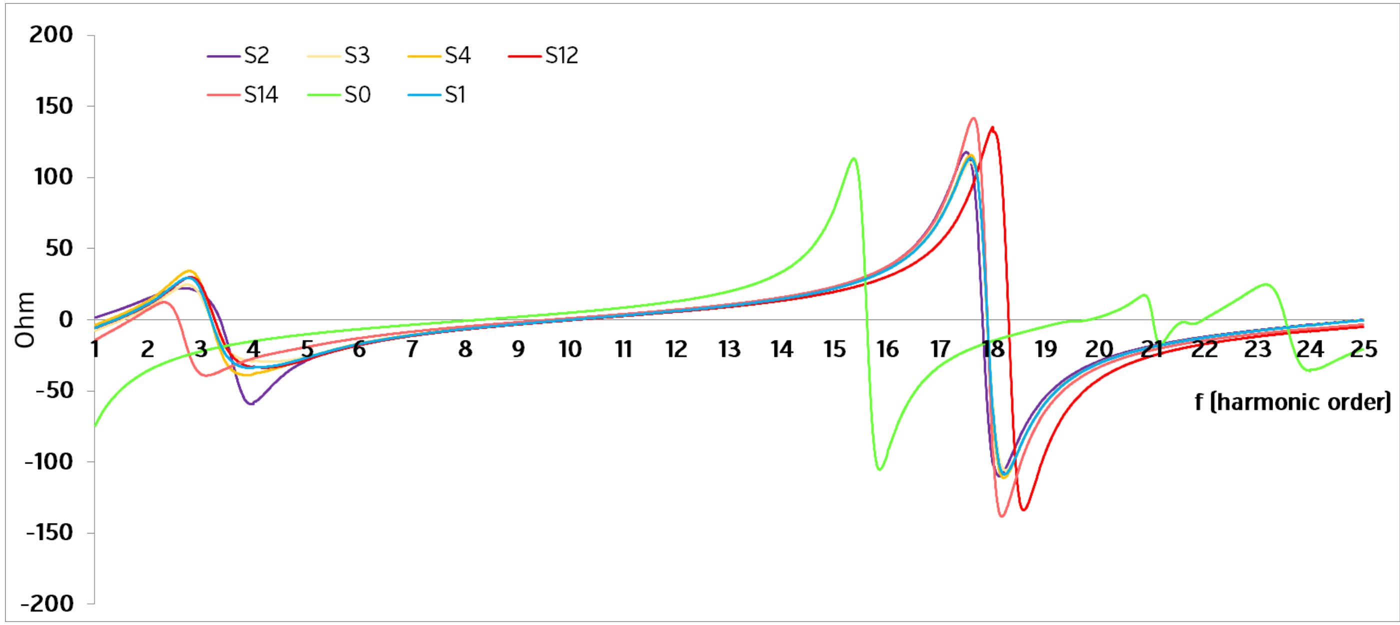


Table 2. Amplification factors k of all cases with a fixed Z_{grid} as determined for case S1

	S1			S2	S3	S4	S7	S11	S12	S13	S14
h	R_{grid} [Ω]	X_{grid} [Ω]	k	k	k	k	k	k	k	k	k
2	0,20	0,70	0,96	0,96	0,96	0,96	0,96	0,96	0,96	0,96	0,98
3	0,20	0,70	0,99	0,99	0,99	0,99	0,99	0,99	0,99	1,00	1,01
4	3,70	16,83	1,16	1,17	1,13	1,18	1,08	1,15	1,13	1,21	1,55
5	2,80	26,71	2,25	3,21	1,99	2,51	2,75	2,24	2,20	2,28	1,84
6	2,80	17,10	2,88	3,60	2,67	3,05	4,07	2,89	2,92	2,82	2,07
7	2,80	10,82	2,63	3,10	2,58	2,67	3,17	2,65	2,73	2,54	1,87
8	2,80	6,49	1,84	2,11	1,86	1,82	1,89	1,86	1,95	1,75	1,27
9	2,80	5,70	0,72	0,74	0,75	0,69	0,54	0,74	0,85	0,63	0,35
10	5,80	5,15	0,06	0,03	0,06	0,06	0,08	0,06	0,07	0,07	0,14

CIGRE e-Session 2020

C4-317_2020

A Parametric Study Towards a Generic Mitigation Against Excessive Circuit Breaker TRVs in Series Reactor Applications in the Netherlands

Presenter: K. Velitsikakis

26-08-2020

Problem definition:

- Future expansion in the 110 kV and 150 kV TenneT grids includes the installation of numerous series reactors.
- Series reactors impose challenges to the circuit breaker interrupting capabilities, by causing excessive TRVs under reactor terminal fault conditions. Such a fault is not covered by the standard IEC test duties.
- This problem is caused by the (very) low stray capacitance value between the circuit breaker and the reactor terminal. A typical remedy is the increase of this capacitance value (e.g. TRV capacitors, short cable sections).

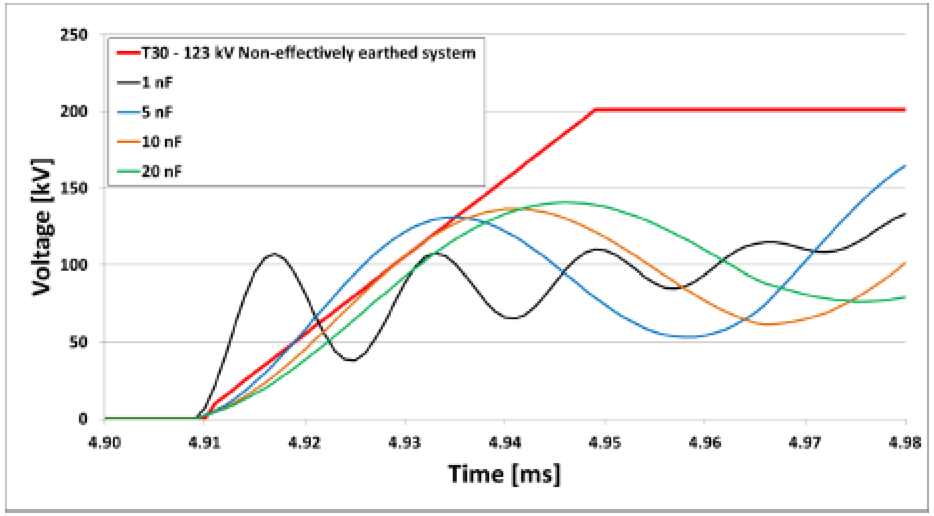


Figure 3. Series reactor terminal fault – Impact of additional capacitance

Study conclusions and future work:

- A parametric study was performed aiming to the definition of a standard solution.

- The standard solution is based on the TRV capacitor option. The study allowed the definition of the range of the capacitance values, which is required for mitigating the excessive TRVs. The study resulted in different ranges in the 110 kV and 150 kV grids.

- Such a generic solution supports the decision making as well as the engineering process, e.g. by developing standard series reactor fields for an existing or a newly built substation.

CIGRE e-Session 2020

C4-318_2020

The comparison of the different methods for the determination of the shielding failure rate of an overhead line

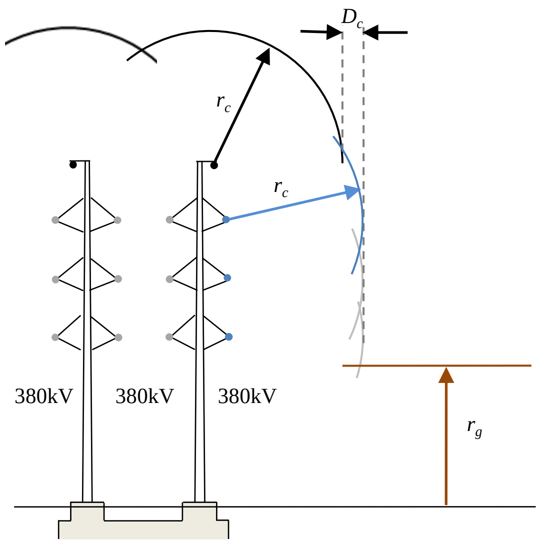
Imre Tannemaat

Presenter: Imre Tannemaat - imre.tannemaat@tennet.eu

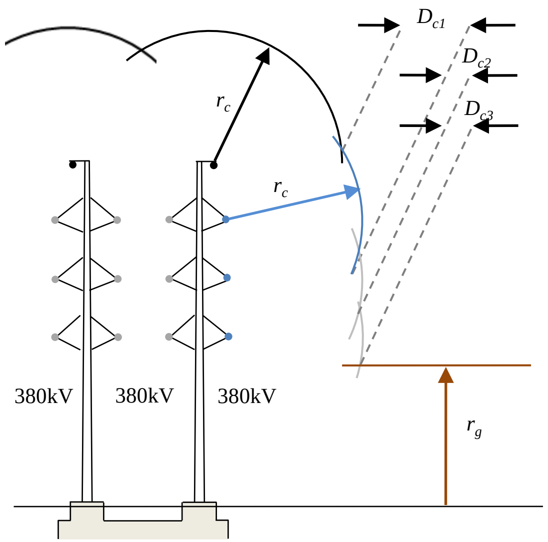
26-08-2020

Different methods compared

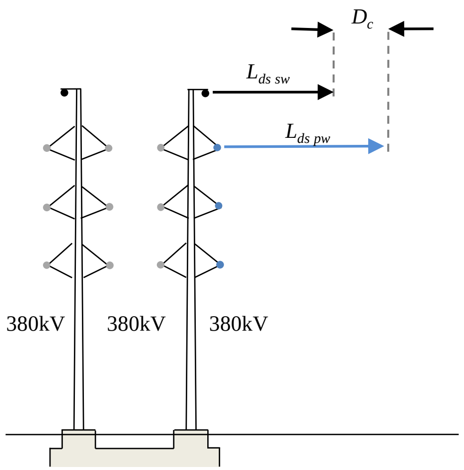
To determine the SFR and SFFOR for the latest Dutch line design



1) Electro-geometrical method (standard)



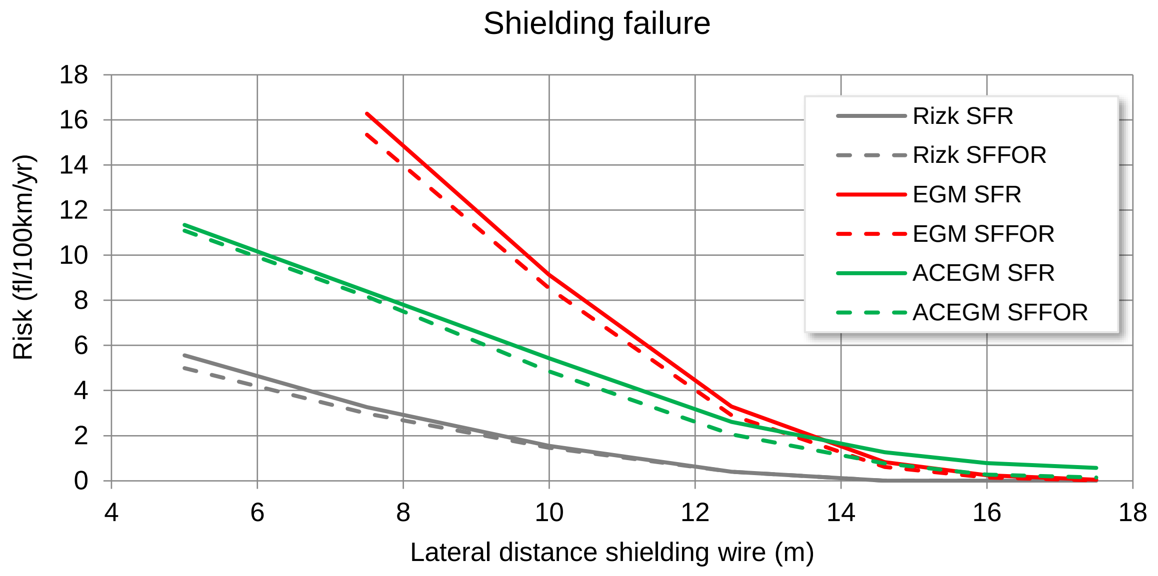
2) Electro-geometrical method (angle corrected)

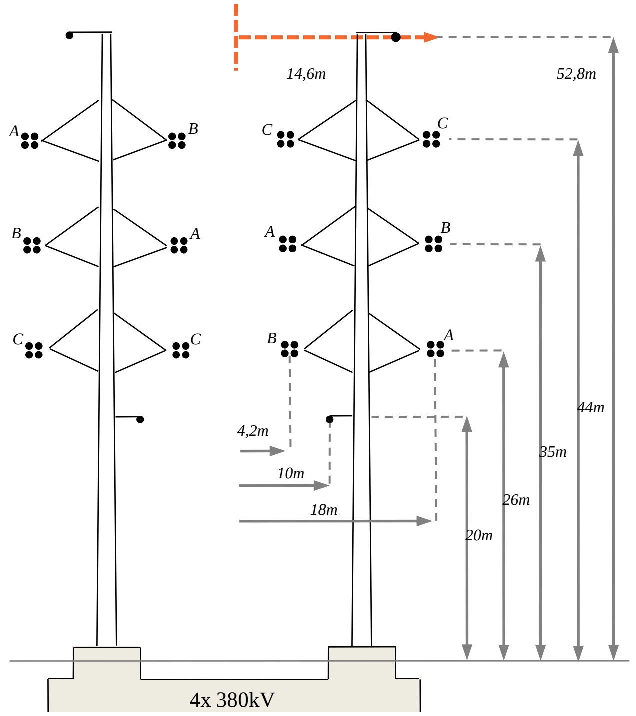


3) Lightning attachment model as proposed by Rizk

Results

- Results for one (standard) line design hardly comparable since the Rizk method results in P=0
- Therefore the lateral position of the shielding wire was varied (along the orange line)





CIGRE e-Session 2020

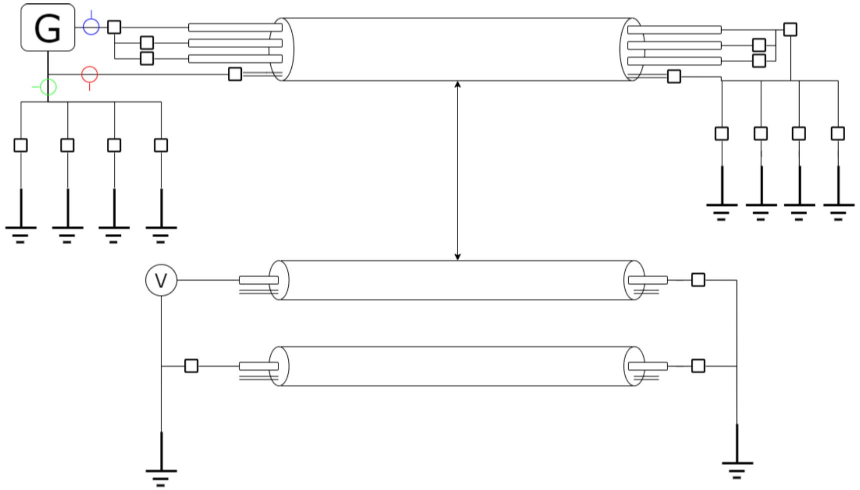
C4-327

Experimental Investigation of Ground Return Currents and Mutual Induction in Extruded Cables

Sjoerd Nauta, Pieter Kropman, Frans Provoost, Maarten van Riet

24-09-2020

Probleemstelling



- Het bepalen van het gedrag van aardstromen in enkelfasige en driefase kunststofkabels.
- Het bepalen van de mutuele koppeling tussen kabelcircuits met gedeeltelijke retour via de aarde.
- Het onderzoeken van parameters die invloed hebben op het bovenstaande.

Conclusies

- De uitkomsten van de stroommetingen laten zien dat het aandeel van de retourstroom via de aarde kleiner is dan verwacht wordt op basis van analytische modellen of simulaties: een groter deel van de stroom loopt retour via het aardscherm.
- Door de relatieve korte kabellengte (200 m) werd de retourimpedantie via de aarde grotendeels bepaald door de aardverspreidingsweerstanden aan beide zijden.
- Ondanks een relatief goed geleidende grond (8 Ωm), was het zeer uitdagend om een lage aardverspreidingsweerstand te halen op de eindpunten.
- De uitkomsten van de spanningsmetingen konden helaas niet worden gebruikt vanwege een fout in de aarding van de meetapparatuur. De hermeting heeft nog niet kunnen plaatsvinden vanwege de Coronamaatregelen.

Werkgroepen

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CIGRE WG C4.23 – Guide to Procedures for Estimating the Lightning Performance of Transmission Lines

1. **WG Composition**:
   - Chris Engelbrecht (Convener)
   - Imre Tannemaat (Secretary)
   - 25 members/ 16 Countries (17 members active)
2. **WG Output**:
   - Reissue of Cigre Brochure 63 in new Cigre Format for improved readability
   - Complimentary new brochure presenting new information on:
     - Lightning parameters
     - Improved stroke attraction model for shielding failure calculation
     - Guidelines for modelling the backflashover condition

Planning:

- Planned completion date: December 2020
- Publication of Brochure 2021

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CIGRE WG C4.45 – Measuring techniques and characteristics of fast and very fast transient overvoltages in substations and converter stations

1. **WG Composition:**
   - Dr. Shijun Xie (Convener)
   - Few active members
   - *Chinese shadow working group*
2. **WG Output**:
   - Cigre Brochure 63 with an overview of different measurement techniques

Status:

- Content available, however document needs revision for readability
- Proofreading and revisions currently takes place

Planning:

- Publication of Brochure: end of 2020 / early 2021

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CIGRE WG C4.46 – Evaluation of Temporary Overvoltages in Power Systems due to Low Order Harmonic Resonance

1. **WG Composition:**
   - Convener: Filipe Faria da Silva (DK)
   - Secretary: Kostas Velitsikakis (NL)
   - 21 members from 13 countries

2. **WG Timeline:**
   - Start Date: February 2018
   - Expected Date for Submitting Final Report to SC Chairman: 2^{nd} half 2021

3. **WG output:**
   - Review practices of TOV evaluation currently applied by utilities.
   - Specify criteria related to the evaluation of TOVs. The proposed criteria will be related to the dielectric and thermal impact of TOVs on the HV equipment.
   - Specify method(s) for analysing TOVs, as calculated through detailed system simulation models, and evaluating them based on the specified criteria.

CIGRE JWG B1/C4.69 - Recommendations for the Insulation Coordination on AC cable systems

1. **WG Composition:**
   - Convener: Thinus du Plessis (NL)
   - Secretary: Kostas Velitsikakis (NL)
   - 23 members from 17 countries

2. **WG Timeline:**
   - Start Date: March 2019
   - Expected Date for Submitting Final Report to SC Chairman: June 2022

3. **WG output:**
   - Revision update of the TB189
   - Additional information on:
     - Insulation coordination of the complete cable system
     - Modelling techniques
     - Testing protocols
     - Measurement results (lab and/or field tests)
     - Lifetime considerations

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Thank you for your attention!
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Appendix 1: Members NSC C4

- Maarten Berende (Enexis B.V., secr)
- Helko vd Brom(VSL)
- Sjef Cobben (TU Eindhoven)
- Luc van Dort (Royal Haskoning)
- Chris Engelbrecht (Engelbrecht Consulting)
- Frans van Erp (TenneT TSO BV)
- Anton Ishchenko (PhasetoPhase B.V.)
- Patrick Marteijn (The Dow Chemical Company)
- Tim Minkes (Movares Nederland B.V.)
- Peter van Oirsouw (Qirion)
- Frans Provoost (Qirion)
- Imre Tannemaat (TenneT TSO B.V.)
- Konstantinos Velitsikakis (TenneT TSO BV)
- Sjoerd Nauta (Qirion)
- Tongyou Gu (Qirion)
- Vladimir Cuk (TU Eindhoven)
- Jeroen van Waes (TenneT TSO BV, Vz)