Royal Belgian Society for Electricians 2021

Webinar kick-off

ABB HITACHI POWER GRIDS

elia group
Elia | 50Hertz | EGI

SIEMENS energy

Royal Belgian Society for Electricians 2021

Webinar kick-off

The webinar will start in a few minutes

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Welcome!

- **Introduction KBVE/SRBE** Frédéric Dunon
- **Presentation of the E Review** Raf Steyaert and Albert Van Ranst
- **Announcement of the Sinave Award** François Vallée
- **Presentation of the selected thesis** Laureate

Introduction

Frédéric Dunon

Chairman SRBE-KBVE

Introduction

- **Challenging context with Covid19**
- **Digitalization of our events**
- **Reflection on the evolution of KBVE/SRBE**
- **Partnership with SEE and collaboration with other organizations**
- **Secretary**

Our mission

Our mission is to share information on the electrical sector, facilitate its members' knowledge and encourage networking.

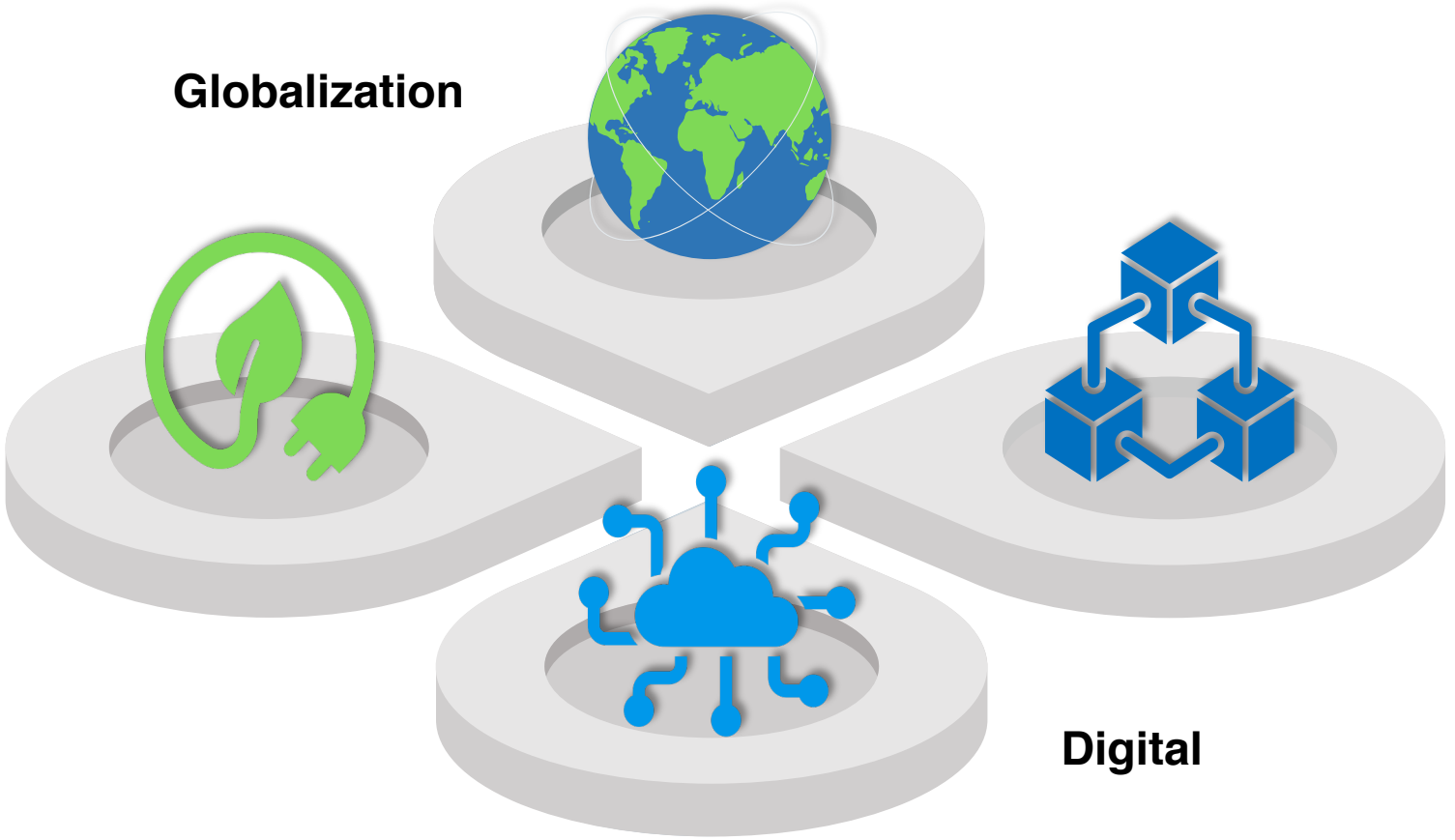
Key trends

Globalization

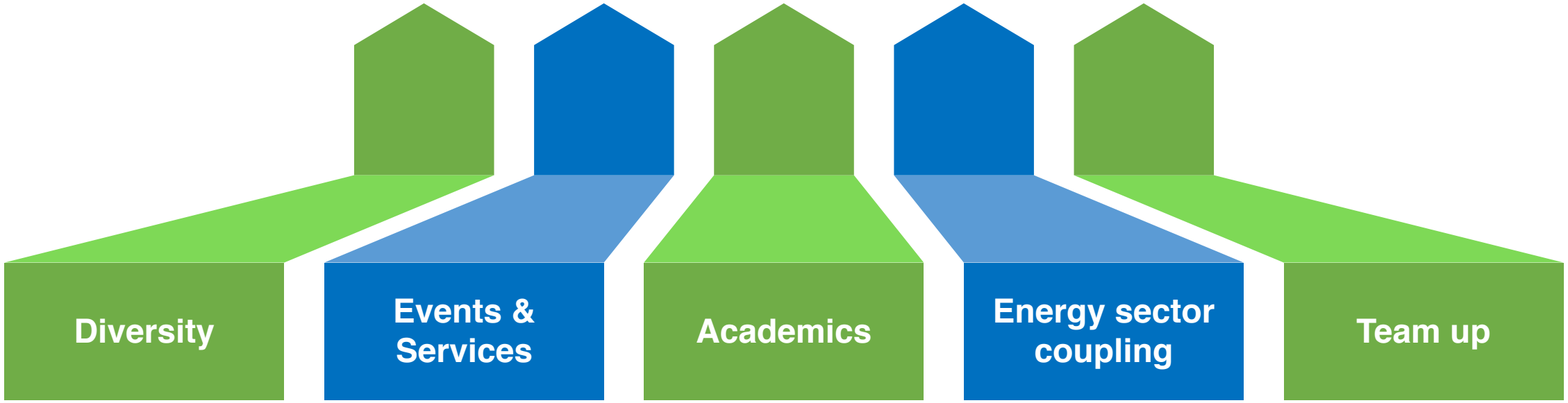
Renewables

Decentralization

Digital



Our five pillars



Agenda

23/04

Study Day "Cybersecurity of electrical installations in industry"

04/06

Study Day "Local Communities of energy"
Session 1

11/06

Study Day "Local Communities of energy"
Session 2

18/06

Study Day "Local Communities of energy"
Session 3

22/04

Webinar "Balancing the Grid"
Session 1

HORIZON 238

20/05

Webinar "Balancing the Grid"
Session 2

HORIZON 238

10/06

Webinar "Balancing the Grid"
Session 3

HORIZON 238

Later on Q3 and Q4

- Study day *"MV & HV Substations"*
- JICABLE Conference
- Study day *"Electricity pricing"*

E Review

Raf Steyaert

Coordinator of the study

Albert Van Ranst

Power System Expert

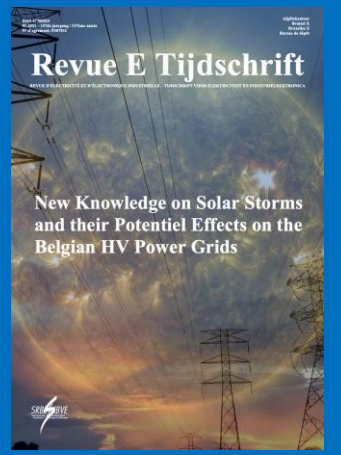
Royal Belgian Society for Electricians 2021

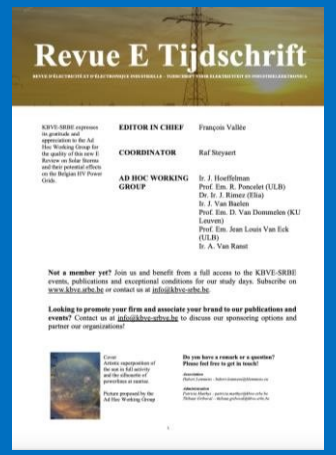
Revue E 02-2021

New Knowledge on Solar Storms and their Potential Effects on the Belgian HV Power Grids

Raf STEYAERT & Albert VAN RANST

18/03/2021



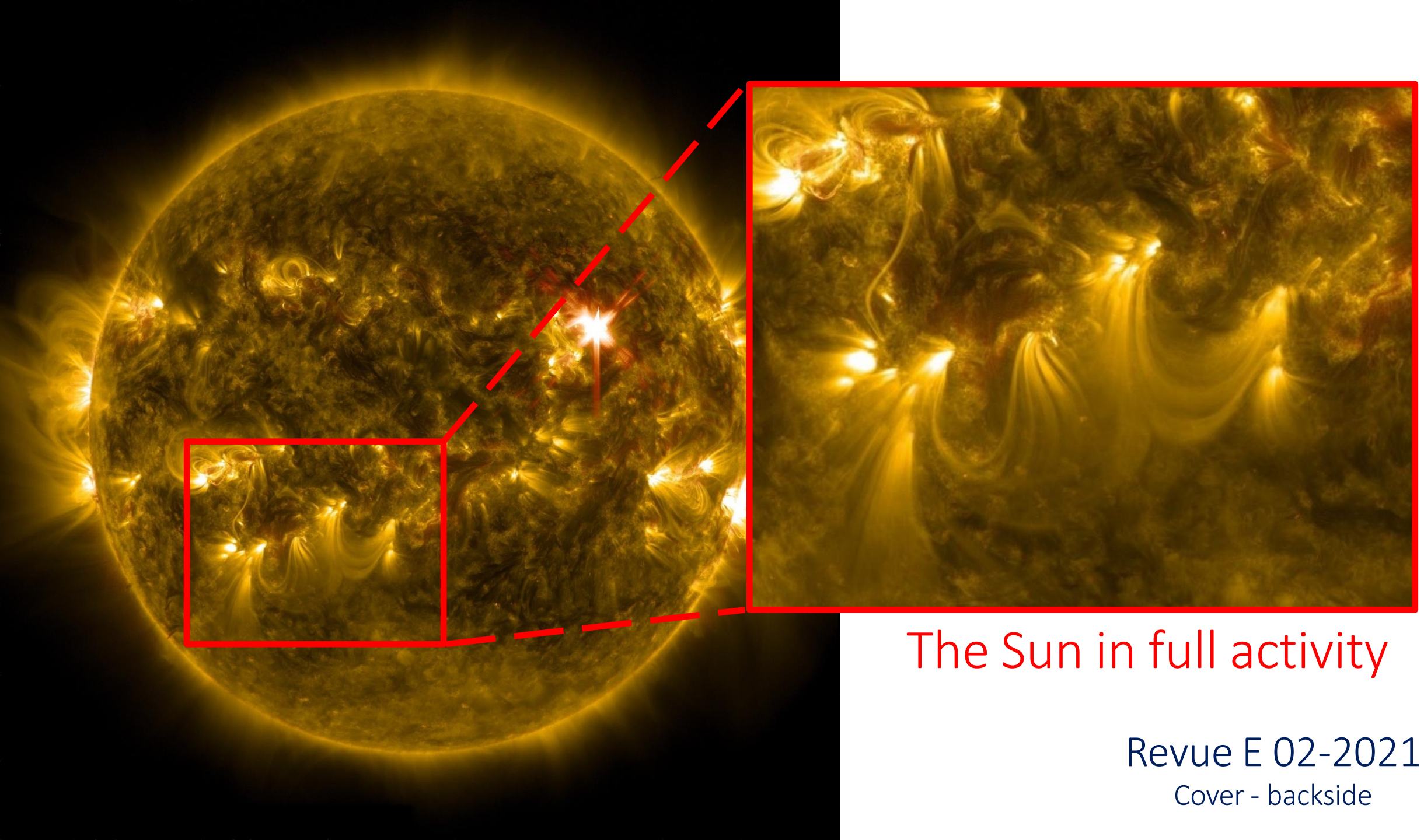


Ad Hoc Working Group:

**J. Hoeffelman, R. Poncelet,
J. Rimez, R. Steyaert,
D. Van Dommelen,
J. Van Balen, J.L. Van Eck,
A. Van Ranst**

Revue E 02-2021

Cover - front



The Sun in full activity

Revue E 02-2021

Cover - backside

Content & Key elements

- **Article 1 – Johan Van Baelen**

  Additional insights in the geomagnetic storm environment for high voltage power grids

  .

  ➡ New Knowledge on Solar Storms

- **Article 2 – Jean Louis Van Eck**

  Calculation of the electric field induced in the ground of Belgium during a potential solar storm

  ➡ Practical calculation method

- **Article 3 – Jean Louis Van Eck**

  Currents induced in high-voltage lines by some solar storms

  ➡ Quantification of the effects on HV (Belgian) grid based on measurements and calculation

- **Article 4 – Albert Van Ranst**

  Potential effects of geomagnetic induced currents on power grids in Belgium

  ➡ Assessment of the potential effects on the Belgian HV Power Grids

Art. 1 – Additional insights in the geomagnetic storm environment for HV power grids (**Johan Van Baelen**)

- **CIGRE WG 'Understanding of geomagnetic storm environment for high voltage power grids'**
- **New insights:**
  - Not only power grids at high latitudes can be affected by certain storms. The influence of certain storm types can be felt at all latitudes.
  - Not only east-west oriented high voltage lines are sensitive to geomagnetic disturbances but also others.

Art. 2 – Calculation of the electric field induced in the ground of Belgium during a potential solar storm - (Jean Louis Van Eck)

- **Crucial relationship E = f (ΔB)**

  ΔB, variation of geomagnetic field (caused by the storm)
  E, electric field induced at the Earth's surface

- **Rigorous but complex approach:**
  (see a.o. J. Van Baelen, Revue E 2014/2)

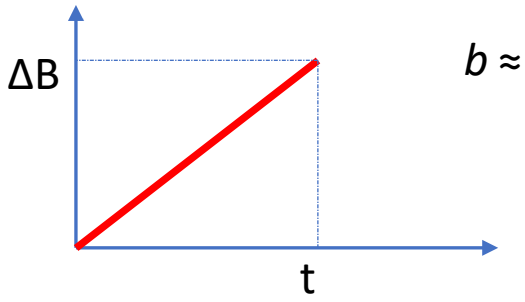
$$E_y = -\frac{Z}{\mu_0} B_x$$

E_y and B_x are phasors (complex quantities) of pulsation ω.
Z is the surface impedance of the earth:

$$Z_n = Z_{nn} \frac{1 + \frac{Z_{n+1}}{Z_{nn}} \left(coth\, d_n \sqrt{j\mu_0\omega\sigma_n}\right)}{\frac{Z_{n+1}}{Z_{nn}} + \left(coth\, d_n \sqrt{j\mu_0\omega\sigma_n}\right)} \qquad Z_{nn} = \sqrt{\frac{j\mu_0\omega}{\sigma_n}}$$

- **After approximation, simplification and application to the Belgian resistivity model**

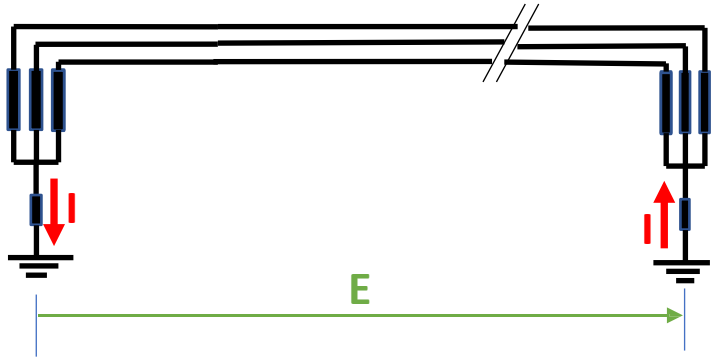
$$E_y(t) = -7.59\ 10^4\ b\ t^{0.141}\ u\ (t)$$



$b \approx \Delta B/t$

Art. 3 – Currents induced in high-voltage lines by some solar storms - (**Jean Louis Van Eck**)

- **Analysis B-measurements from 1990 to 2020 at Dourbes (Belgium): ΔB**
- **Application simplified formula of article 2: E**
- **Geomagnetic induced current (GIC): I = E/r (GIC is quasi DC)**



- **MAX GIC in long lines during solar storms between 1990 to 2000:**

Date	I (150 kV)	I (380 kV)
24/03/1991	48 A	120 A
30/10/2003	17 A	43 A
26/07/2004	14 A	35 A

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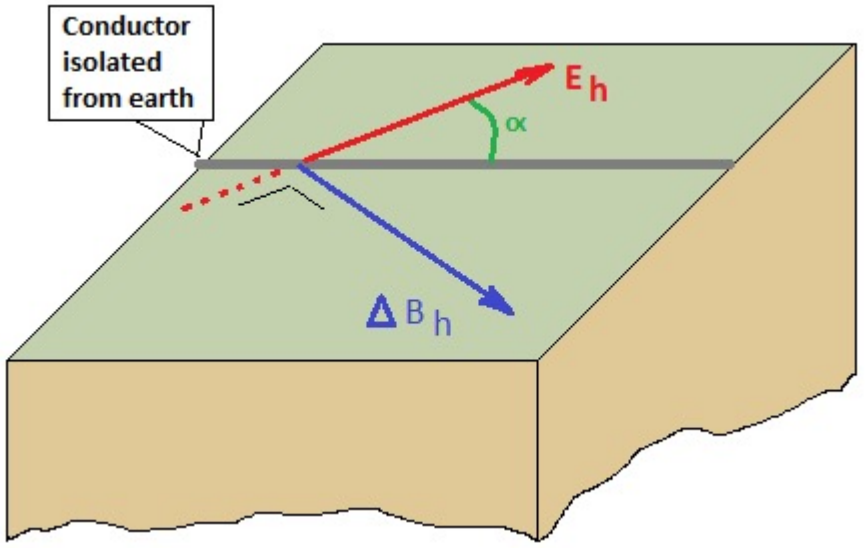
Geomagnetic effects
On power grids in Belgium

Albert Van Ranst

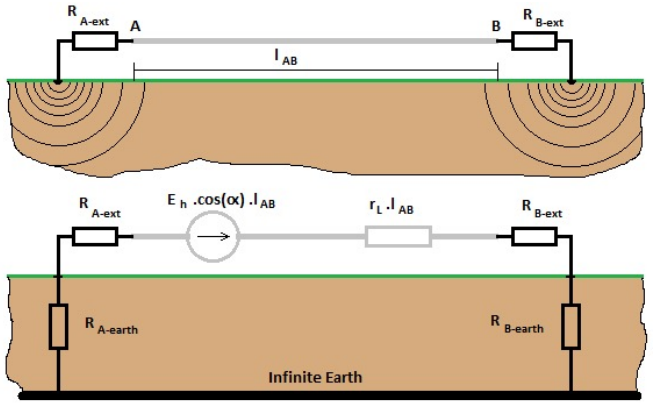
The origin

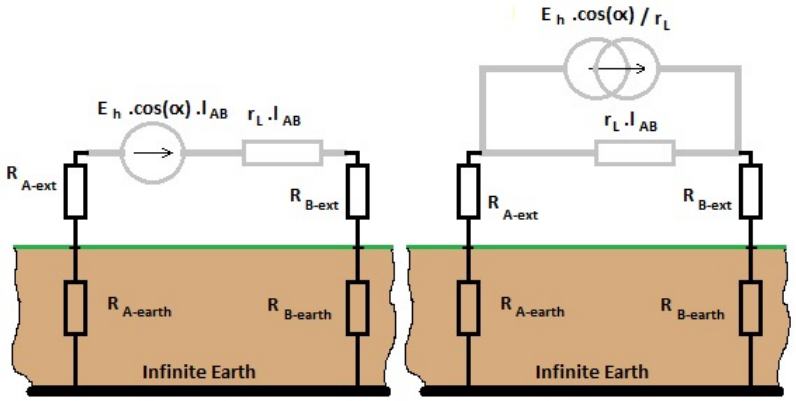
- Variation of the earth's horizontal B-field

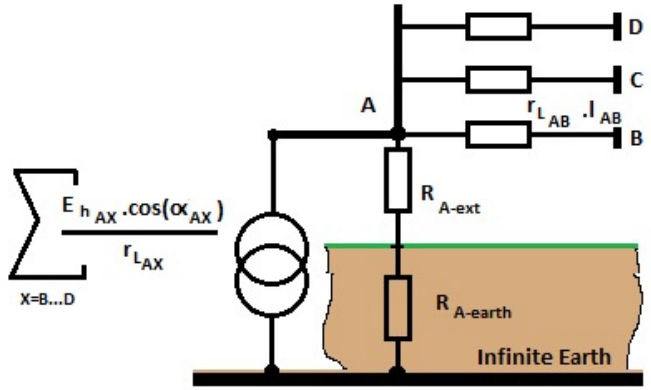
- Induces electric field in conducting structures



From line effect to grid effect

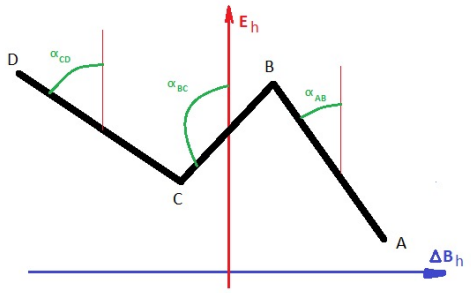


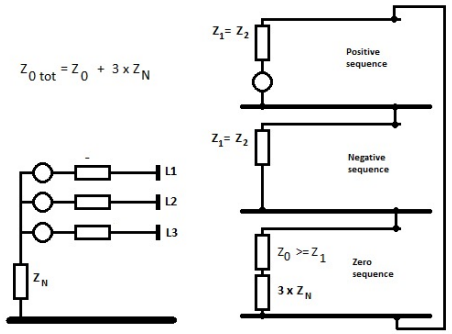


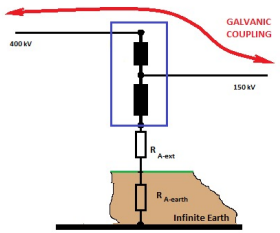


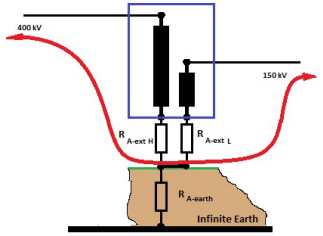
Important factors

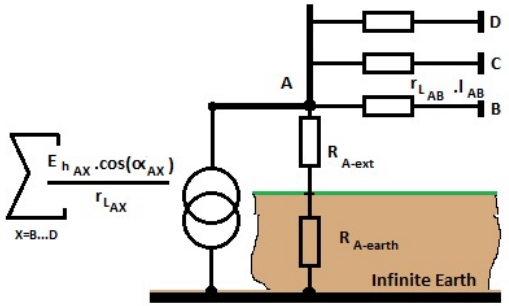
- Physical orientation of individual lines
- Network grounding philosophy
- Network topology and grounding locations
- Local earth resistances
- Specific ground current limitation (if any)





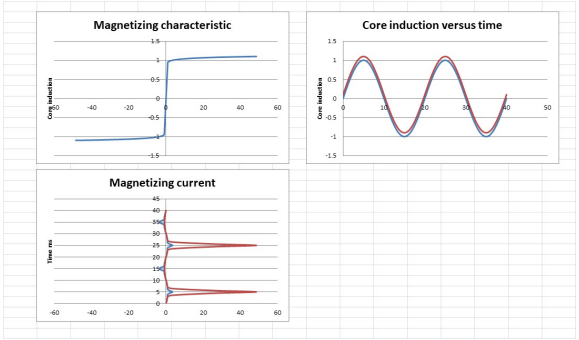


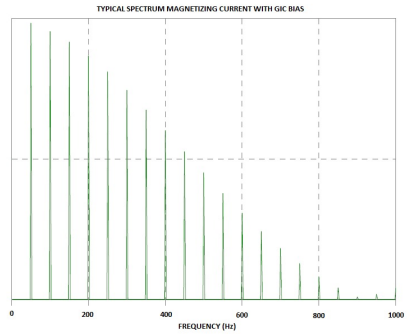




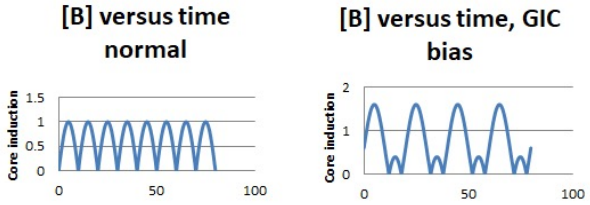
Potential effects : transformer saturation

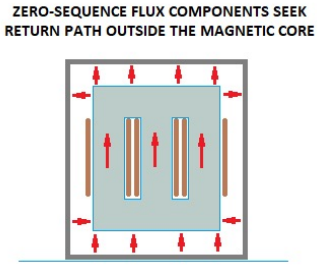
- Transformer DC saturation



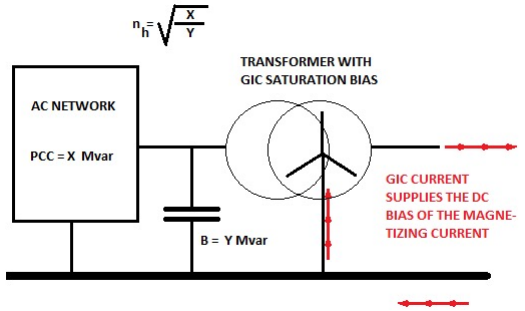


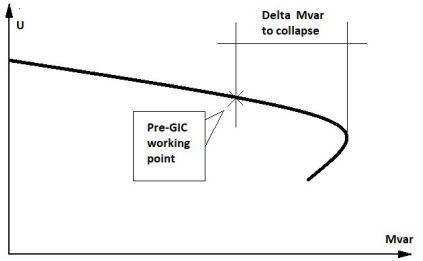
- Effects in the transformers themselves
  - Noise effects
  - Stray flux in steel parts
  - Eddy currents and additional losses





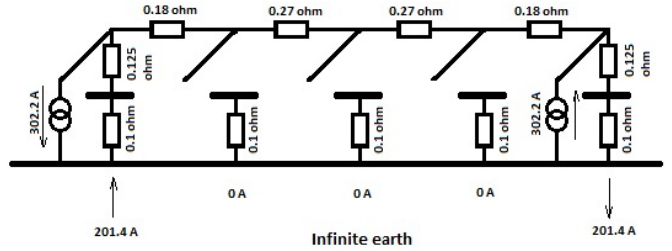
- Effects in the network
  - Harmonic disturbance and resonance effects
  - Mvar unbalance and risk for voltage collapse



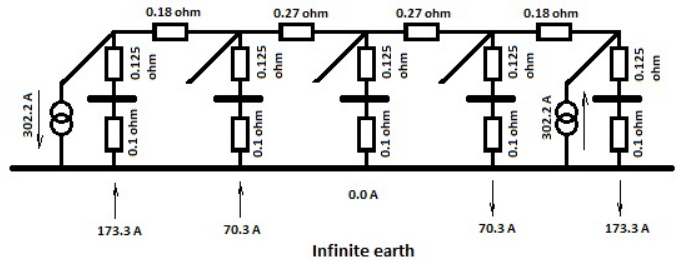


The Belgian situation : beneficial factors

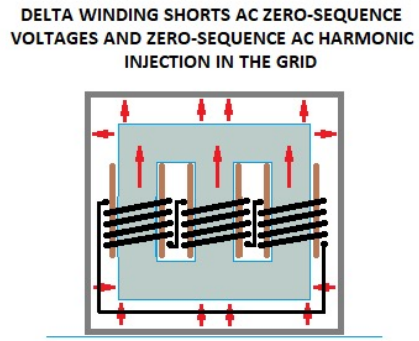
- Short lines, densely meshed, multiple earthing points



- Dedicated ground current limitation policy since ~1990
  - Selected earthing locations
  - Additional earth resistance



- Almost systematic presence of delta winding on transformers exposed to GIC



Geomagnetic effects, a threat for the Belgian grid ?

- **Warning** : Evaluation of magnetic recordings (see companion papers) at Dourbes of past geomagnetic events (1989, 1991) indicate levels of induced voltage and current with small to moderate (thermal) impact on transformers.
- **However** : Up to now no correlation has been found between neutral current measurements in the Belgian grid and simultaneous readings at Dourbes.
- **And more important** : Up to now, no single dysfunction or damage in the Belgian grid has been associated with a documented geomagnetic event.
- Based on present knowledge **the threat may be considered as low.**
- If further analysis and observations lead to more vigilance, **there is still room for further mitigation actions.**

Sinave Award

François Vallée

Editor in Chief
KBVE-SRBE

Sinave Award

Sinave Award

Willem Leterme

Ultrafast protection is the key to a secure and sustainable grid full of power electronic components

Sinave Award

Willem Leterme

Research Expert

KU Leuven

Communication-less Protection Algorithms for meshed VSC HVDC Cable Grids

Willem Leterme, 25/03/2021, KVBE-SRBE Sinave Award

Increased use of renewable energy sources requires fundamental transmission system upgrades

“There needs to be further focus on the timely completion of the Trans-European Energy Networks.”

European Commission

Figure source: FOSG

VSC HVDC grids are considered for this Trans-European network

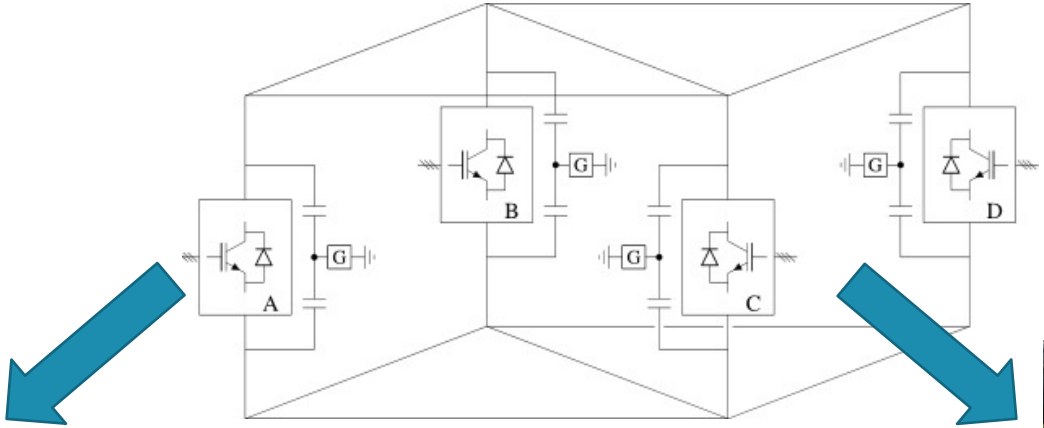
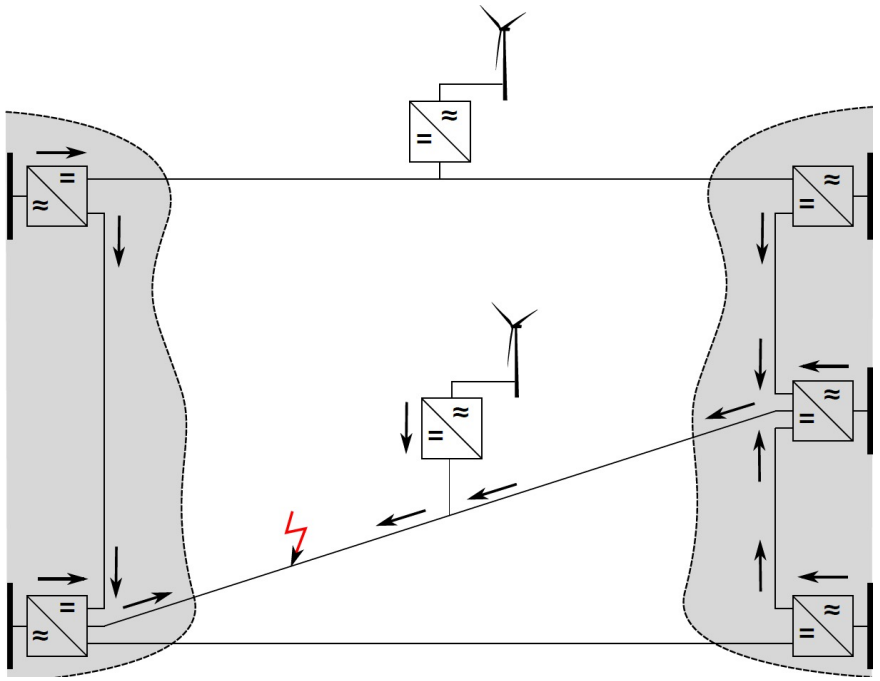
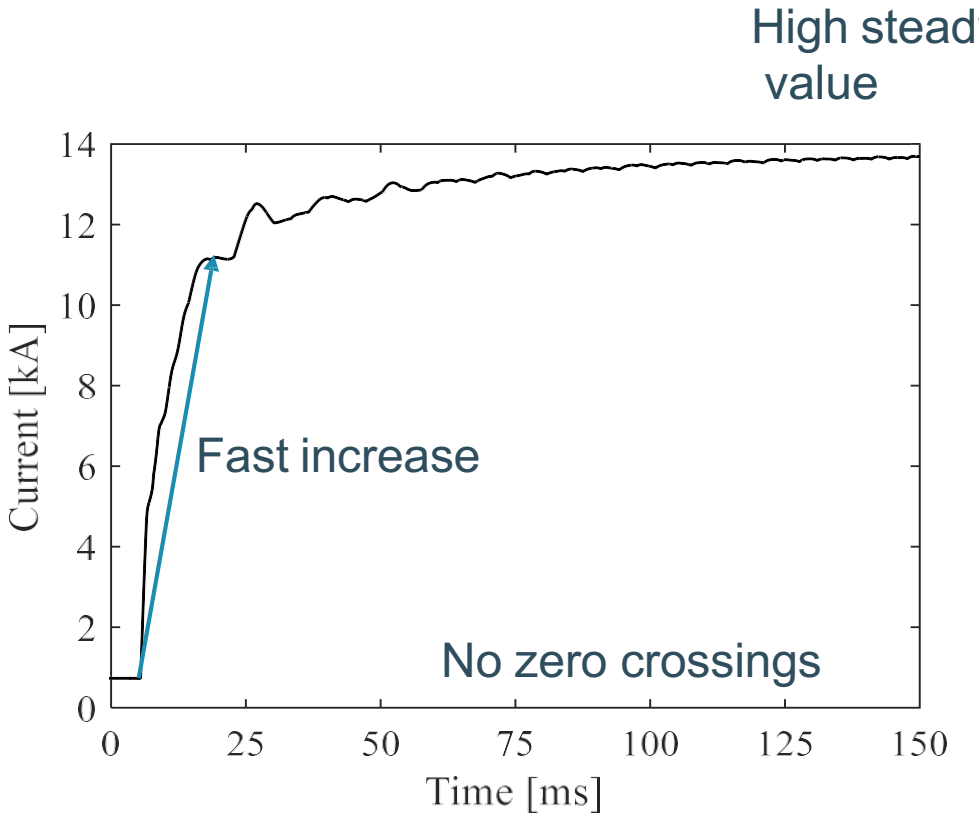


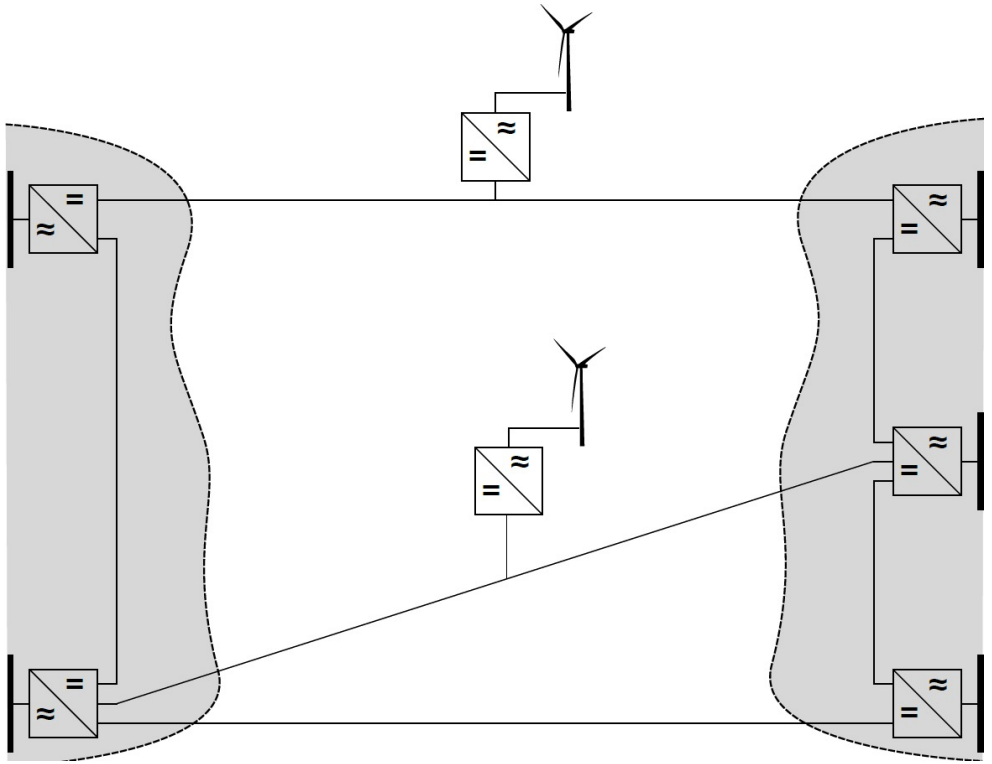
Figure source: Siemens, ABB

Protecting a HVDC grid against short-circuit faults was considered a main barrier





Protecting a HVDC grid against short-circuit faults was considered a main barrier



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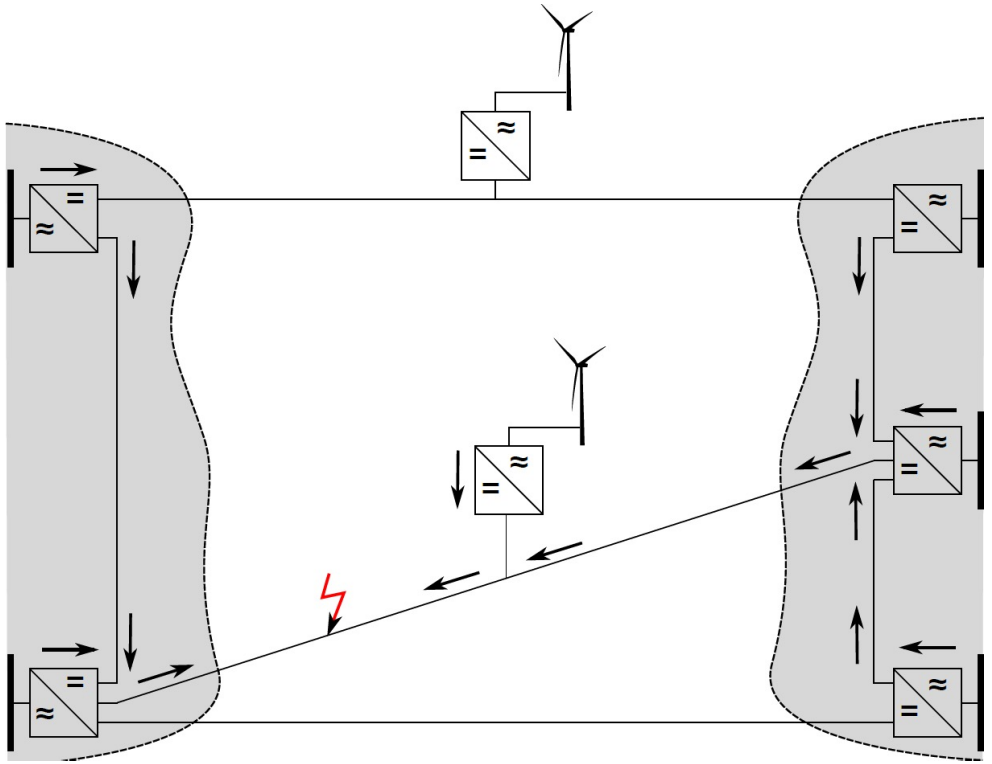
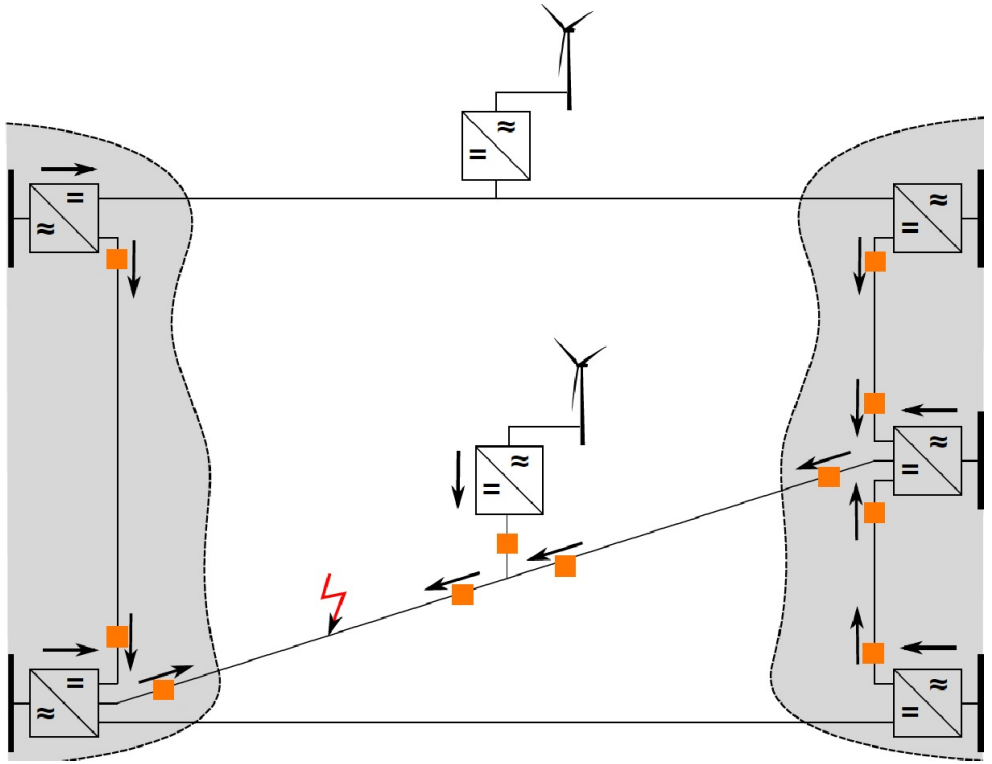


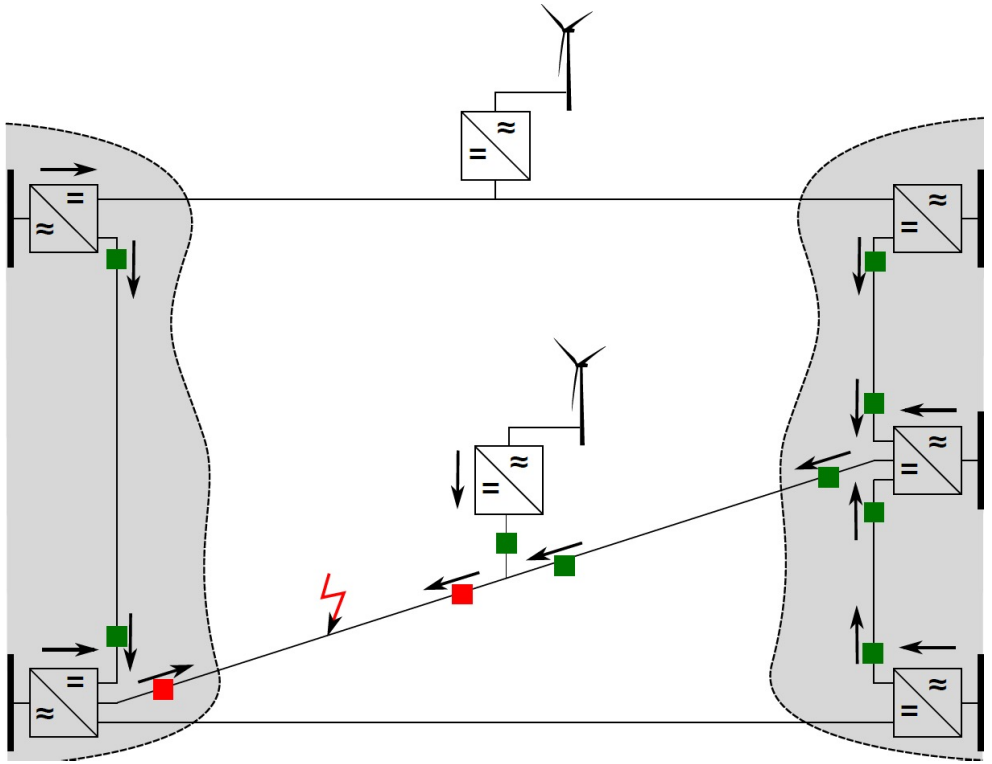
Protecting a HVDC grid against short-circuit faults was considered a main barrier

1. Detect fault



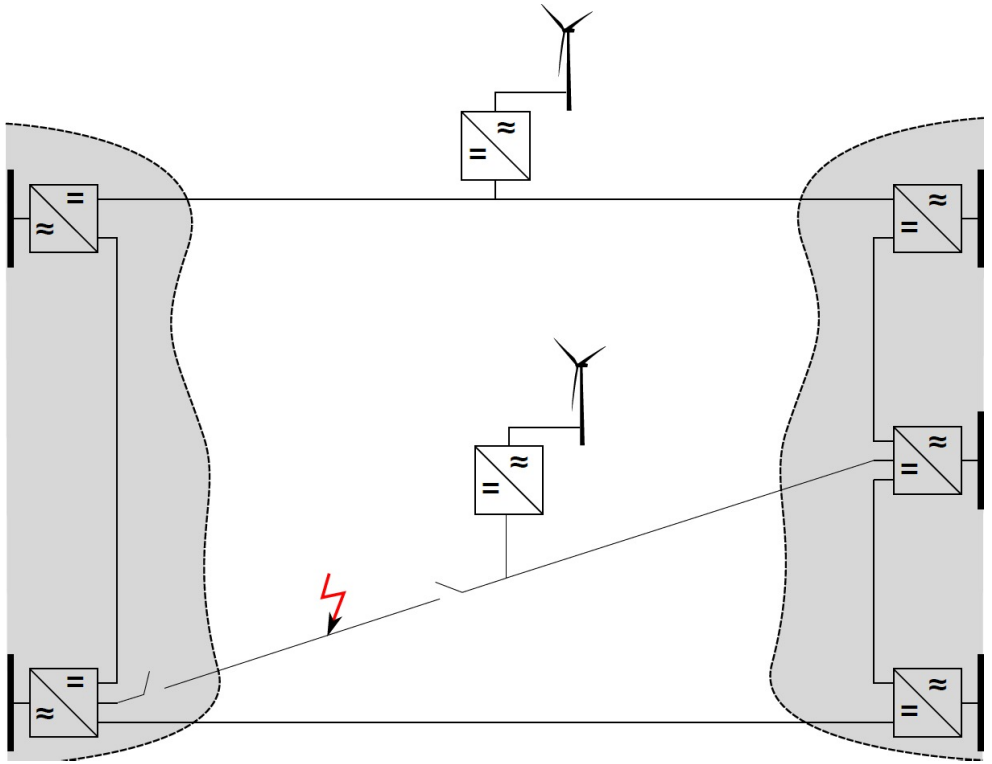
Protecting a HVDC grid against short-circuit faults was considered a main barrier

1. Detect fault
2. Identify faulted line



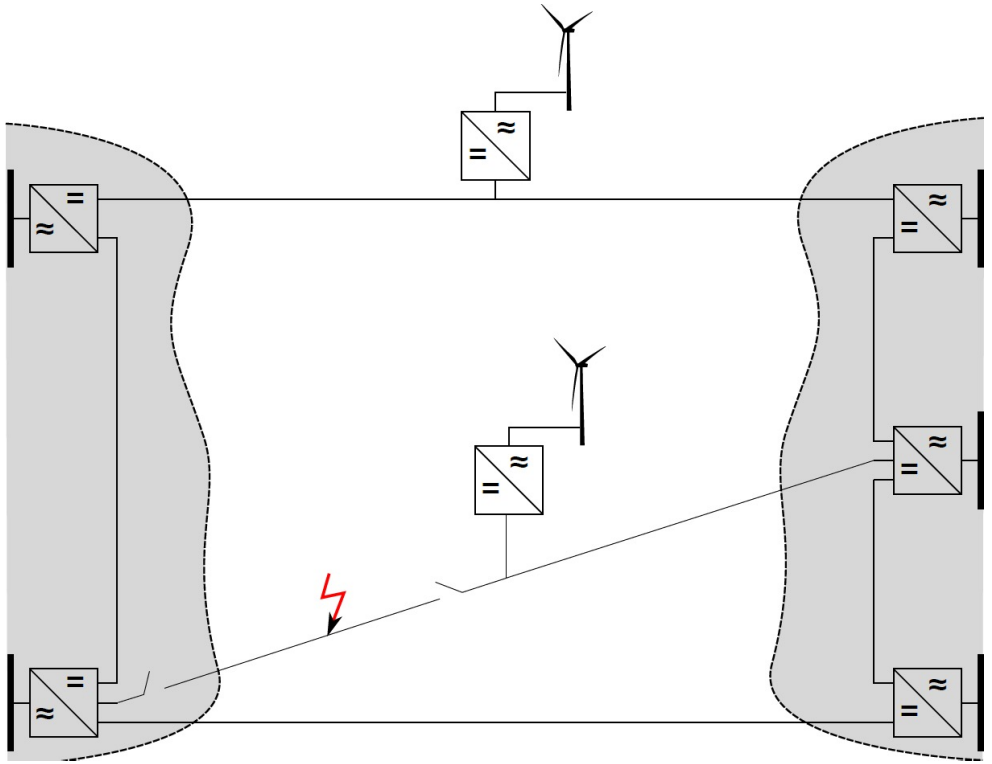
Protecting a HVDC grid against short-circuit faults was considered a main barrier

1. Detect fault
2. Identify faulted line
3. Open breakers



Protecting a HVDC grid against short-circuit faults was considered a main barrier

1. Detect fault
2. Identify faulted line
3. Open breakers
4. Resume operation



Protecting a HVDC grid against short-circuit faults was considered a main barrier

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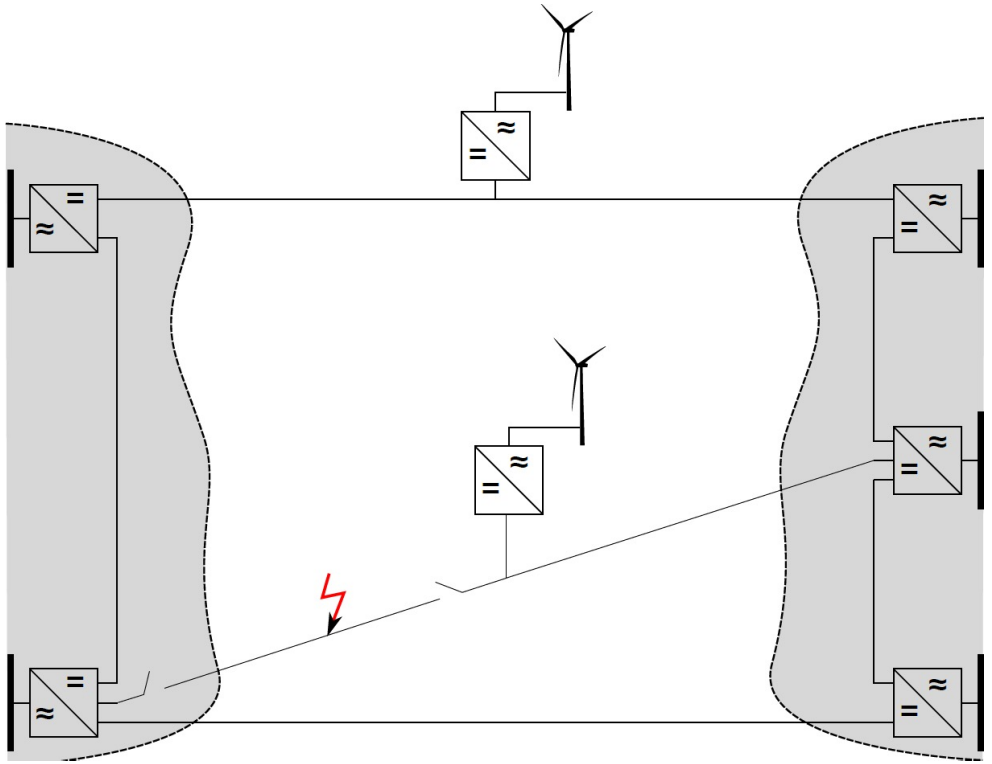
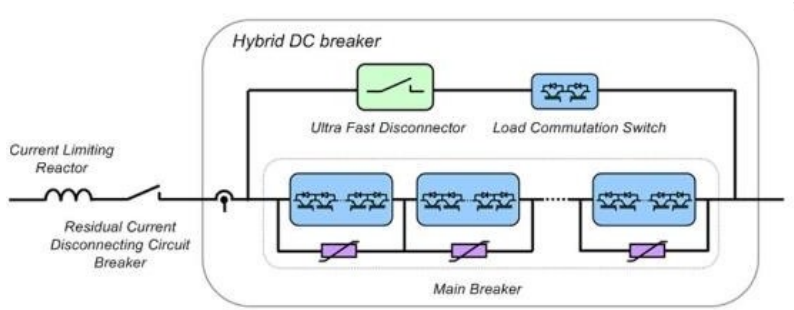


Within a few milliseconds

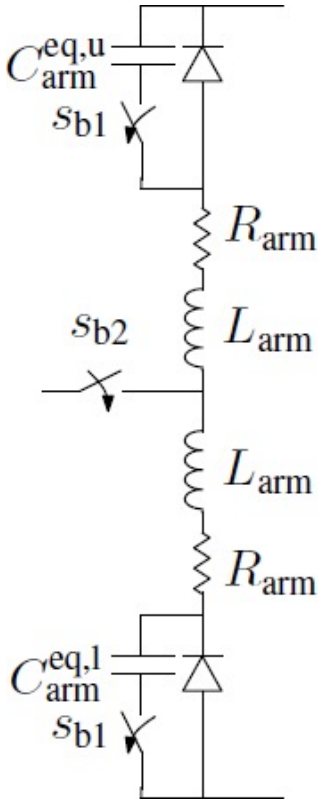
How can we organize HVDC grid protection?

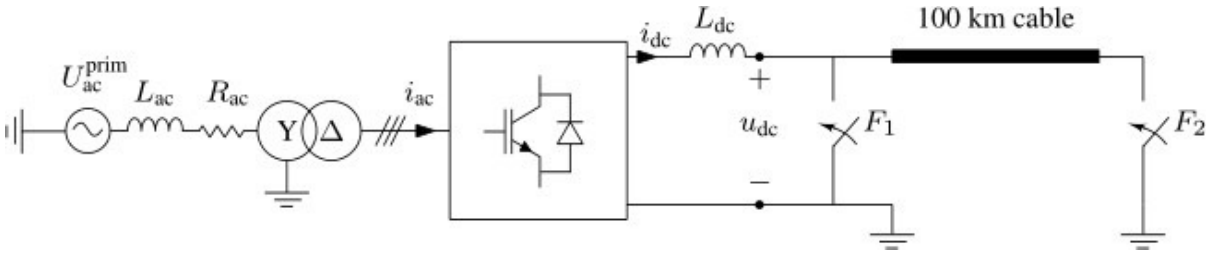
- First prototype of efficient HVDC circuit breaker announced by ABB
  - 2 ms opening time, 9 kA

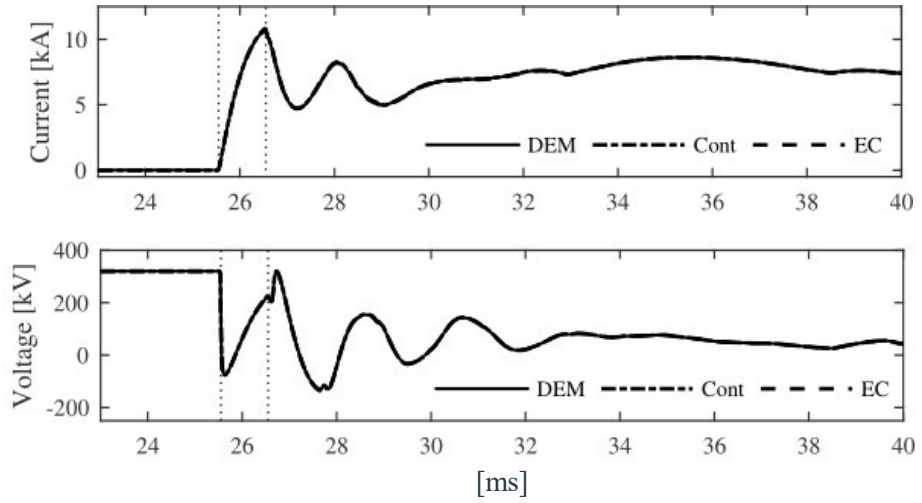
- But… how will we use these breakers?
  - Efficient analysis of DC-side fault currents
  - Choice of HVDC system grounding
  - Achieving selectivity in fault clearing
  - Providing backup functionality



An efficient converter model for DC-side protection studies was developed



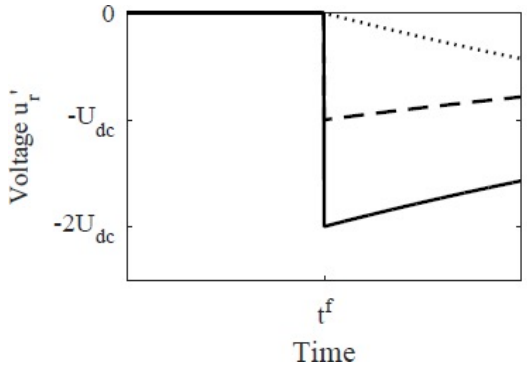


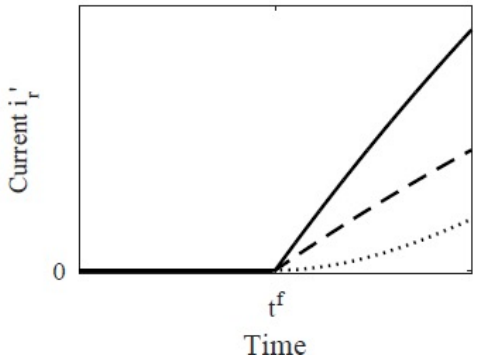


Primary protection algorithms for HVDC grids

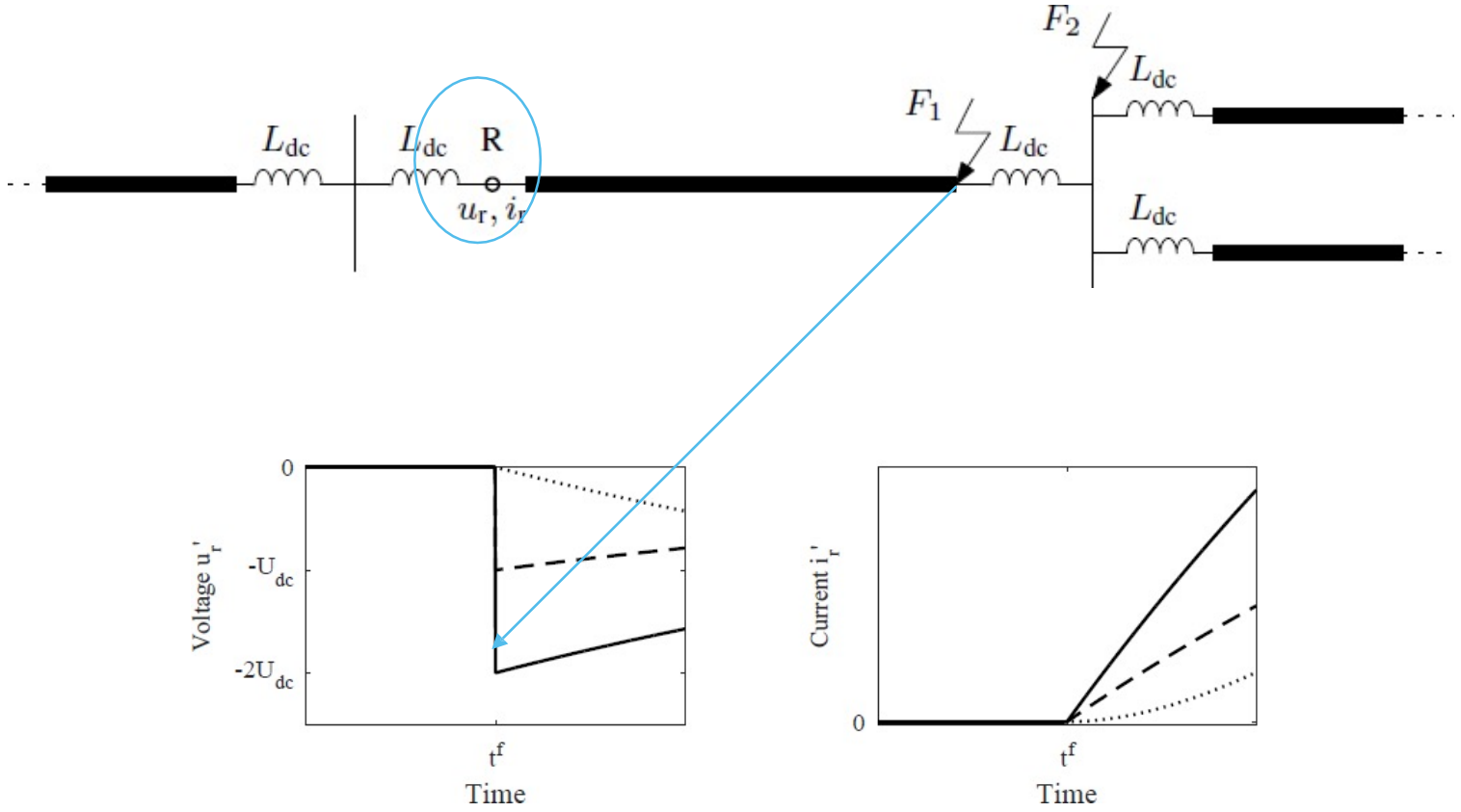
Primary protection algorithms for HVDC grids

Primary protection algorithms for HVDC grids

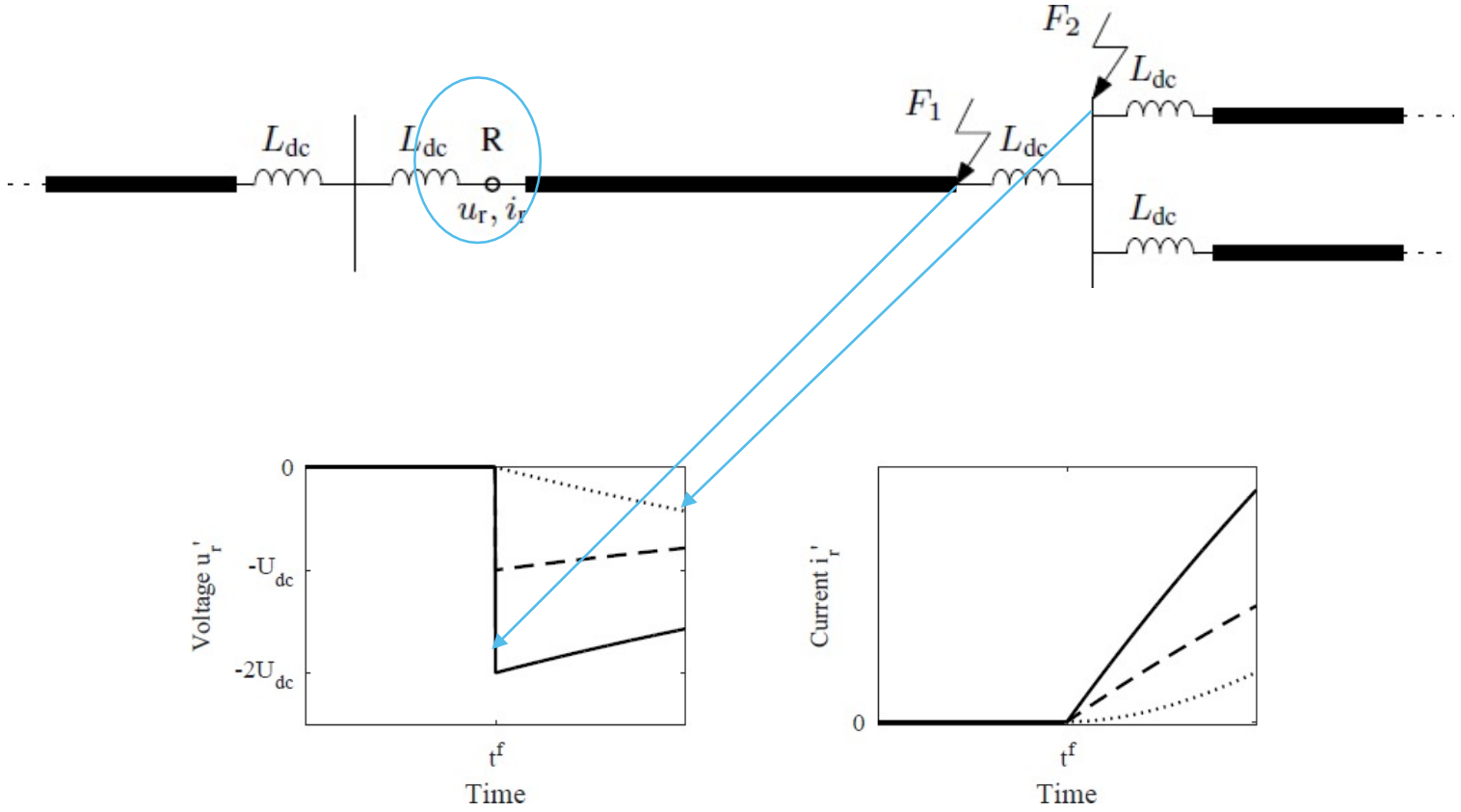




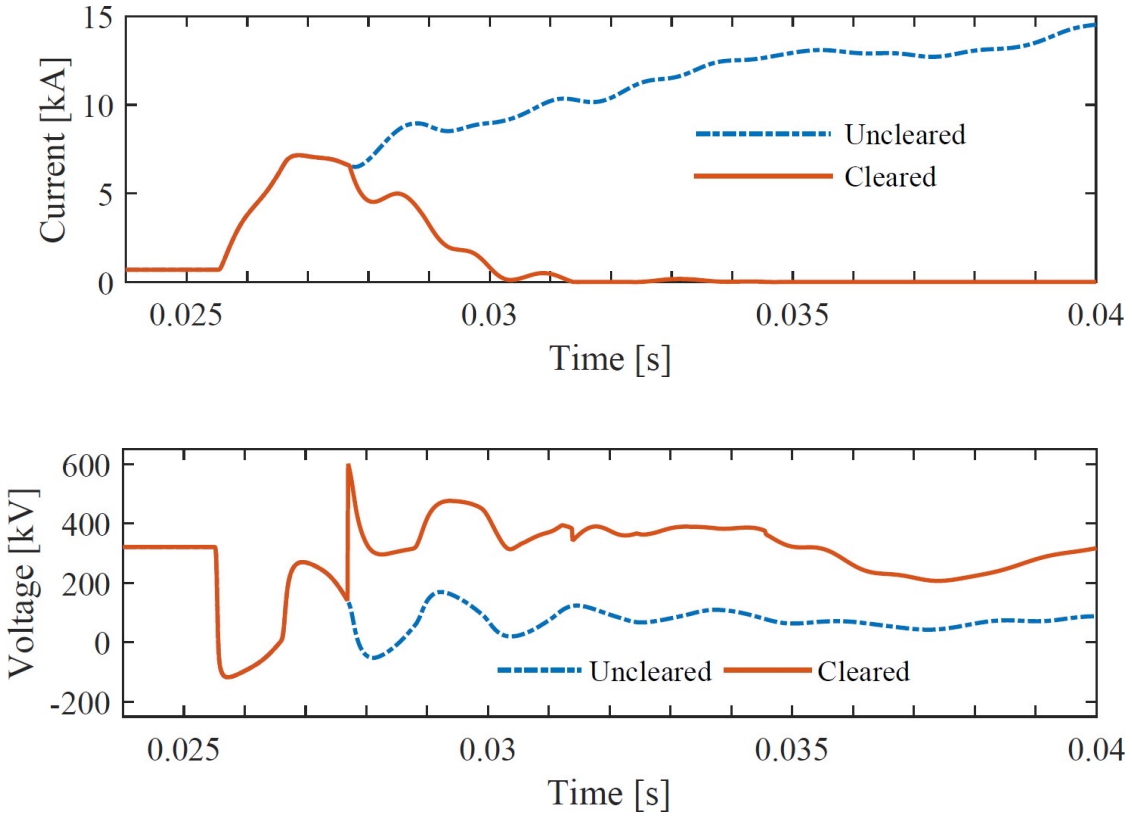
Primary protection algorithms for HVDC grids



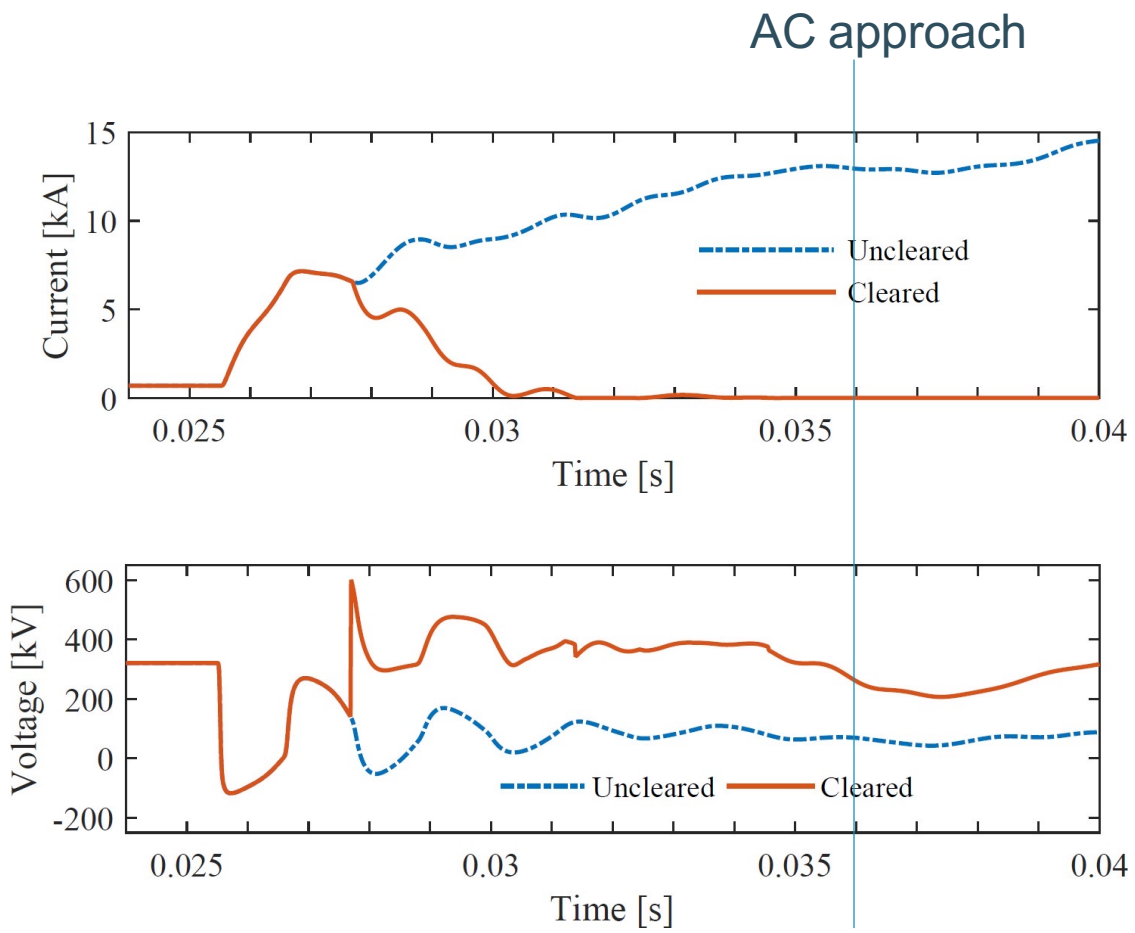
Primary protection algorithms for HVDC grids



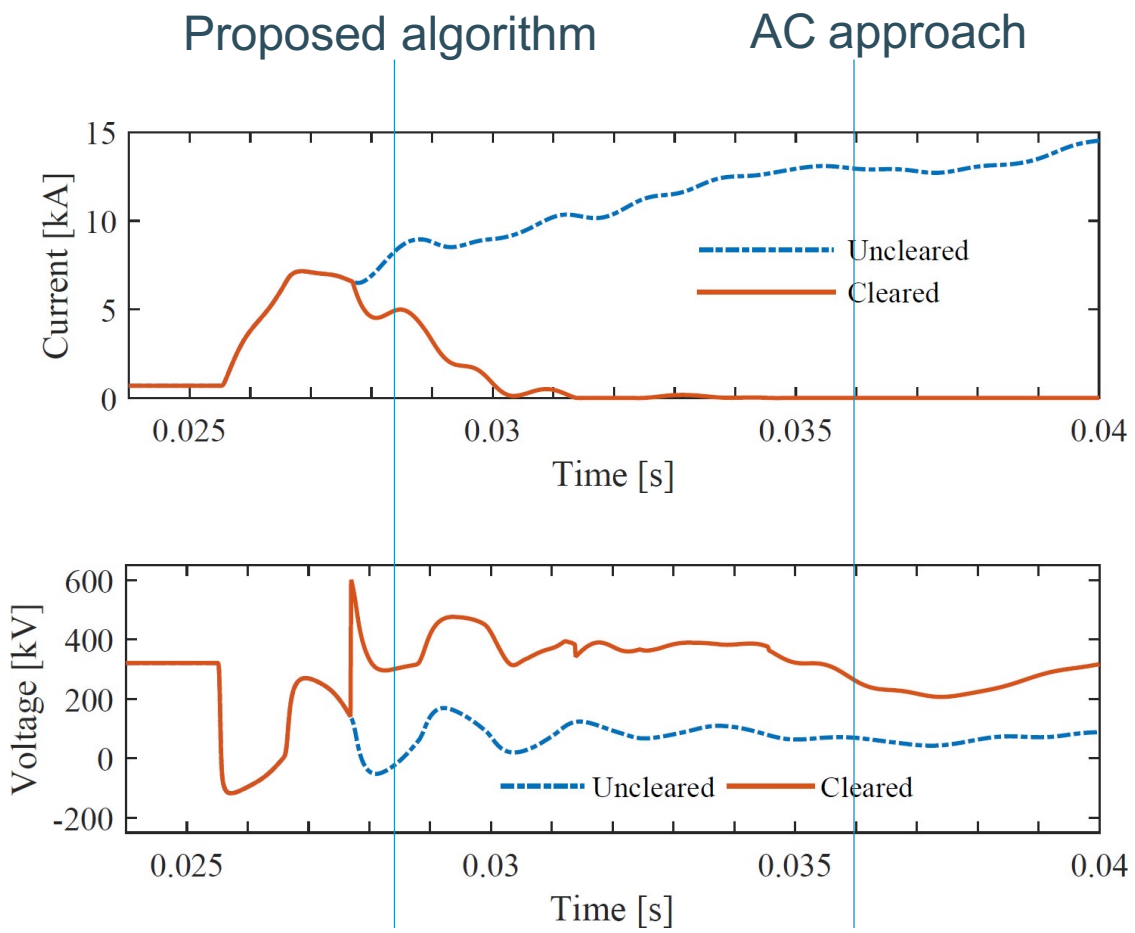
Backup protection algorithms for HVDC grids



Backup protection algorithms for HVDC grids



Backup protection algorithms for HVDC grids



Follow-up on the PhD

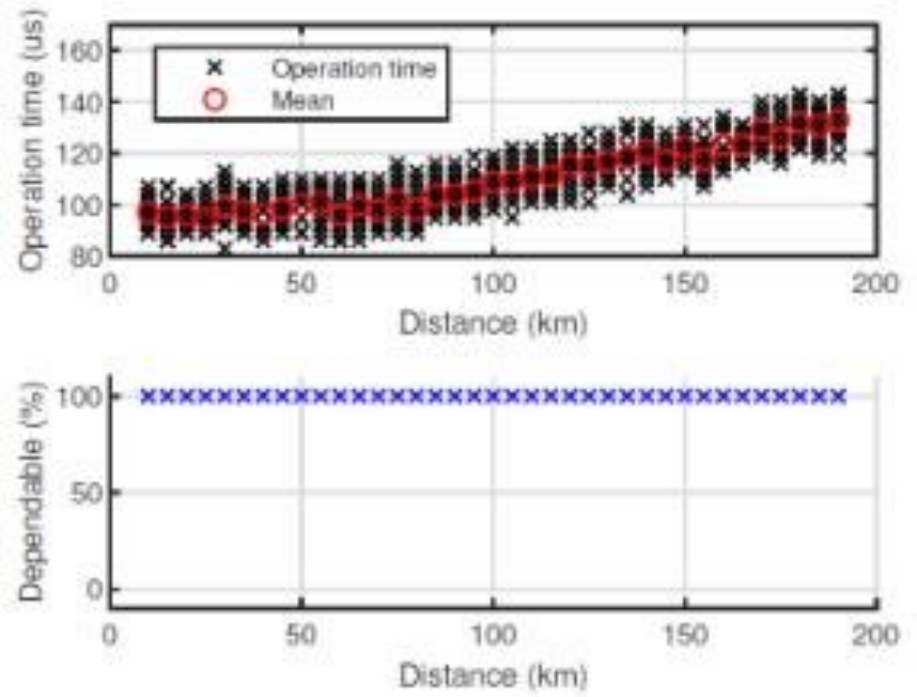
PROMOTioN

PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

Practical implementation of algorithms on real hardware prototype

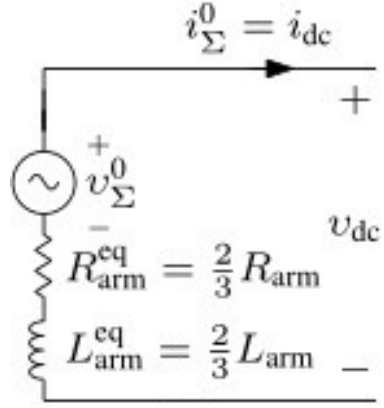
- Operating times in the order of 100 microseconds!

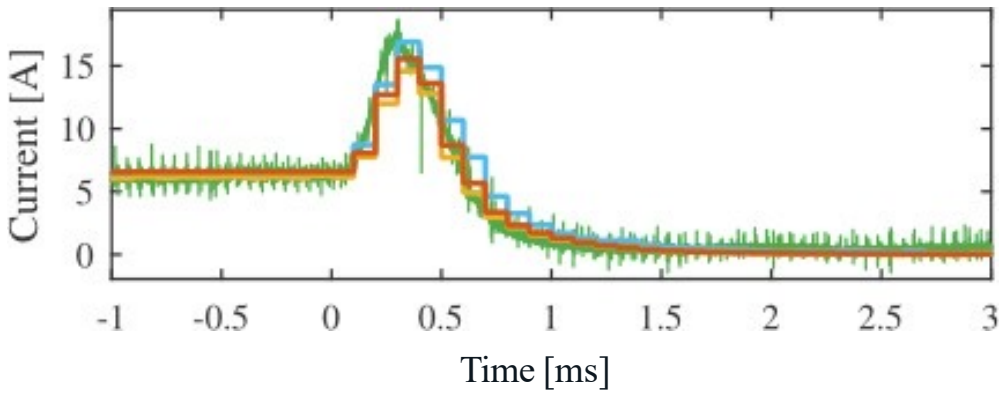
PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS



Modeling of converters with controlled fault blocking capability for DC-side fault studies

Imperial College London





Contributions to IEC TC95

Conclusion

- HVDC grids can facilitate the deployment of massive amounts of renewable energy sources
- My PhD has contributed to the fundamental understanding of fault phenomena and HVDC grid protection
- Protection should not be a barrier towards constructing HVDC grids

Agenda


23/04
Study Day “Cybersecurity of electrical installations in industry”
04/06
Study Day “Local Communities of energy”
Session 1
11/06
Study Day “Local Communities of energy”
Session 2
18/06
Study Day “Local Communities of energy”
Session 3
22/04
Webinar “Balancing the Grid”
Session 1
HORIZON 238
20/05
Webinar “Balancing the Grid”
Session 2
HORIZON 238
10/06
Webinar “Balancing the Grid”
Session 3
HORIZON 238

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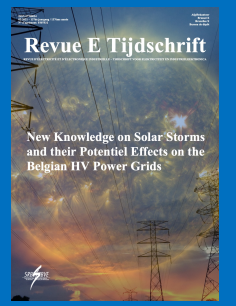

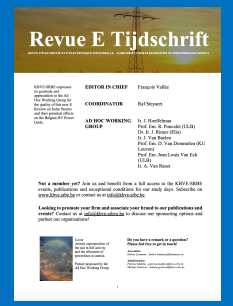

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If you have any questions at all

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Thank you!