PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

How to reduce the size of platforms with HVDC GIS?

2019-11-27, WindEurope Offshore 2019, Copenhagen
Michael Gatzsche (PROMOTioN WP15, ABB Power Grids)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

- What is Gas-Insulated Switchgear (GIS) and its benefit for platforms?
- What is special about HVDC GIS?
- What is PROMOTioN WP15‘s mission on HVDC GIS?
- Conclusion & Summary

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What is Gas-Insulated Switchgear (GIS) and its benefit for platforms?

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Basics

- Using pressurized gas instead of ambient air for insulation (sulfur hexafluoride or eco-efficient alternatives)
- Massive space savings (up to 90 %)
- Very robust against environmental impacts
- Alternating Current (AC): GIS introduced in 1967, today: proven technology with 100 000+ GIS bays in operation

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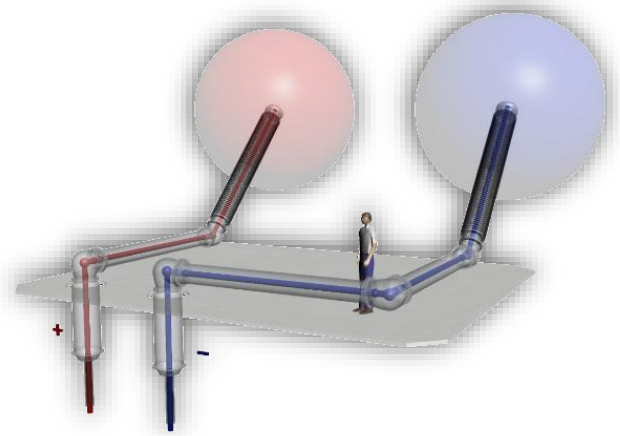
GIS Advantages for Platforms

HVDC GIS

A GIS installation can be built with a much **higher degree of compactness** and significantly **lower sensitivity to ambient factors** than with air-insulated switchgear (AIS).

The most obvious cost-saving potential can be found on **off-shore converter platforms** where the required air-clearance for AIS leads to much larger and heavier off-shore structures.

By applying HVDC GIS, the **volumetric space** of the switchgear installation can be **drastically reduced** e.g. by 70%- 90%, the platform size by 10 %.



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What is special about HVDC GIS?

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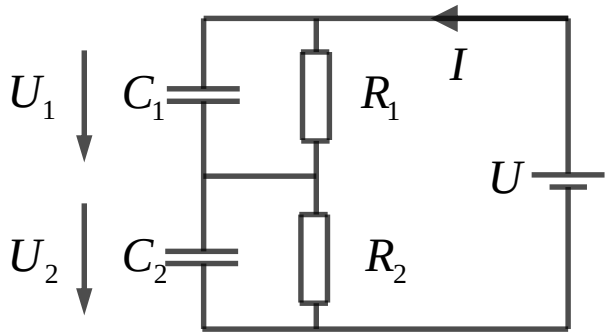
AC DC: Electrical Field

Electric Engineering

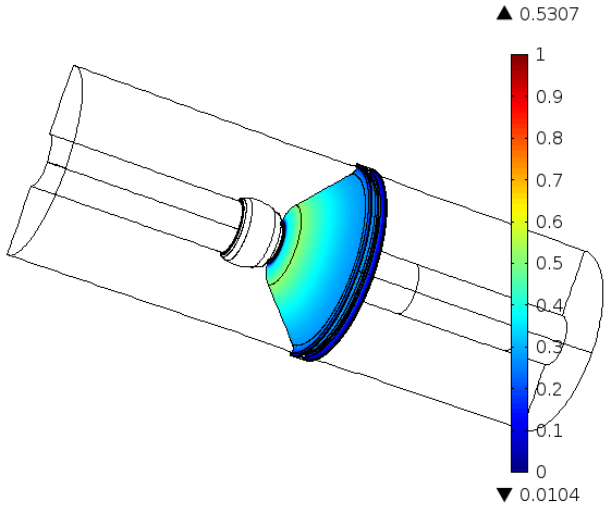


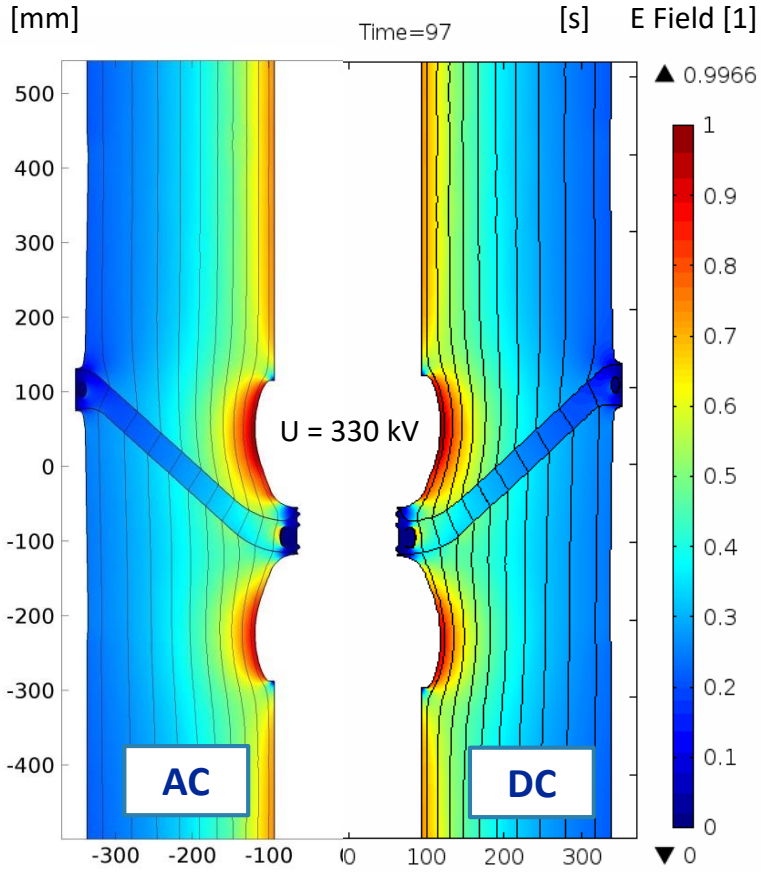
$$I = \frac{U}{R} + C\frac{d(U)}{dt}$$

$$\tau = RC = \frac{\varepsilon_0 \varepsilon_r}{\sigma}$$

$$t = 0 \quad (\text{"AC"}) \qquad t \to \infty \quad (\text{"DC"})$$

Implications for GIS





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What is special about HVDC GIS?

20 Years HVDC GIS

First 150 kV GIS Gotland 2

First long-term test BPA (USA)-ABB

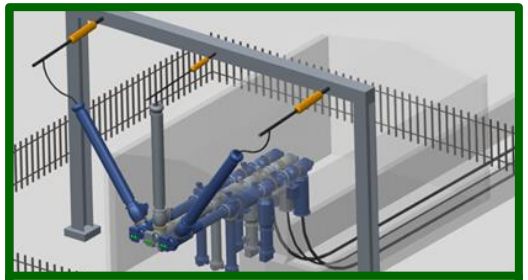
First 250 (500) kV GIS KII – link (Japan)

New generation (DE)

First research

150 kV GIS Gotland 3

First long-term test (Japan)



New generation (CH)

New generation (Japan)

1980 1983 1987 1990 1995 2000 2013 2014 2018

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What is PROMOTioN WP15‘s mission on HVDC GIS?

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Main objectives (WP15)

Full scale technology demonstrations of HVDC gas insulated systems

- To increase the **Technology Readiness Level (TRL) from 6 to 8 (out of 9)** for HVDC GIS equipment
- To carry out **long term testing of full power HVDC GIS** according to developed test requirements/procedures and using developed monitoring and diagnostic methods
- To develop **recommendations for specifying** gas-insulated (GIS) HVDC systems
- To develop **testing requirements, procedures and methods** based on simulation analysis, real HVDC onshore and offshore experiences, and also based on CIGRE work (JWG D1/B3.57: Dielectric Testing of Gas-Insulated HVDC Systems).
- To **develop monitoring and diagnostic methods** for HVDC GIS to ensure a safe operation.
- To **evaluate performance of SF_6 alternatives.**
- Use results to improve models and develop **understanding of failure modes.**

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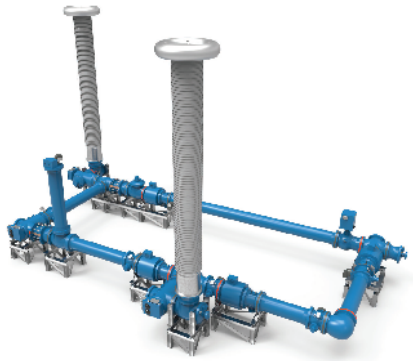
What is PROMOTioN WP15‘s mission on HVDC GIS?

Prototype installation test

HIGH VOLTAGE PRODUCTS

HVDC gas-insulated switchgear



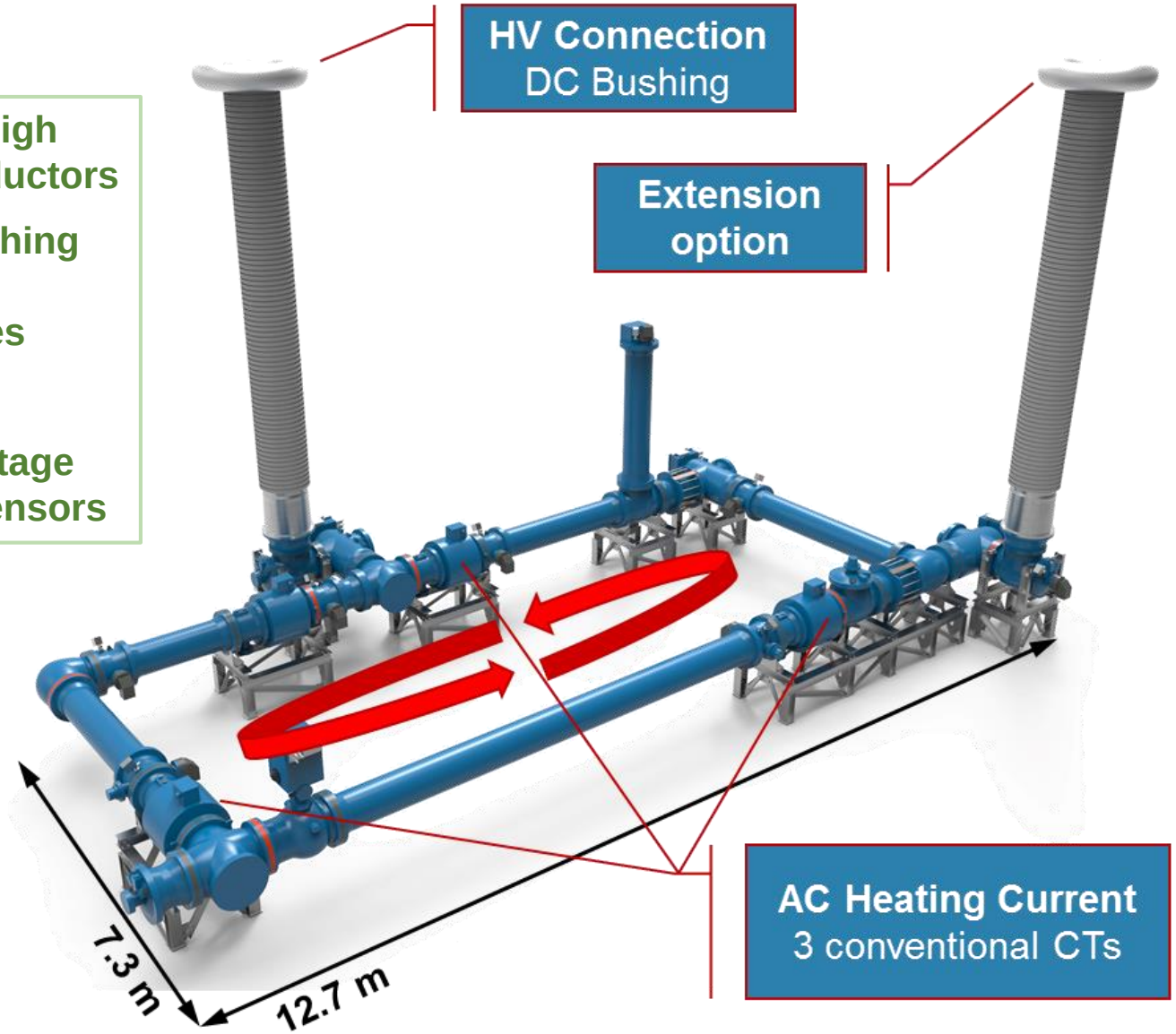
Technical data		
Nominal DC voltage	kV	320
Rated DC voltage	kV	350
Rated lightning impulse withstand voltage	kV	1050
Rated switching impulse withstand voltage	kV	950
Rated DC withstand voltage	kV	610
Rated normal current	A	4000
Rated short-time withstand current	kA	64
Rated duration of short circuit	s	1
Rated peak withstand current	kA	160
Ambient temperature range	°C	-30…+40

Bus-ducts and high voltage DC conductors

Disconnect, earthing and fast acting earthing switches

Bushings

Current- and voltage measurement sensors



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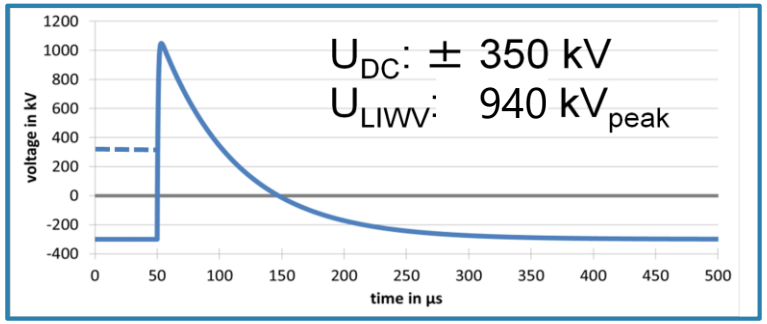
HVDC GIS prototype installation test procedure

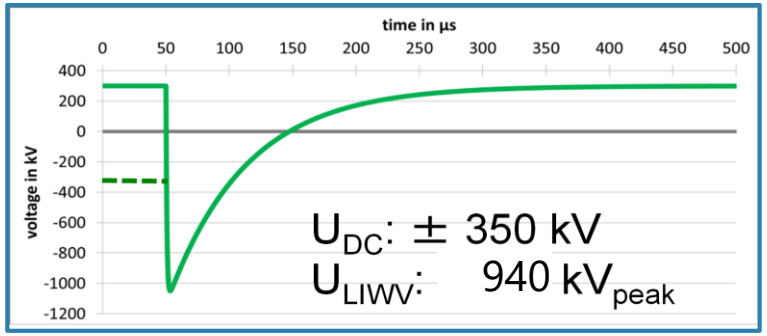
Pre-Tests	BLOCK 1 60 days -DC ZL SIM LI/SI 10 C/O	2 -DC HL SIM C/O	3 +DC ZL SIM C/O	4 +DC HL SIM C/O	AC PD	5 -DC HL SIM C/O	BLOCK 6 60 days +DC HL SIM LI/SI 10 C/O	BLOCK 7 30 days LC (+ and -) SIM LI/SI	Subseq. Tests	add. Tests

Jan 2019 — 14 months — **Nov 2019** — April 2020

Blocks:

- constantly 420 kV DC for 60 days (nominal voltage +30%, rated voltage +20%)
- Cycles with 0 A (ZL → cold) and 4000 A (HL → thermal stress)
- Superimposed Lightning Impulse and Switching Impulse at the end of each block





Monitoring
Gas density
PD: UHF/Optical/HFCT
Arc Detection
Enclosure Temperature

ZL = zero load (zero heating)
HL = high load (continuous heating)
LC = load cycle
SIM = Superimposed switching and lighting impulse voltage test
ACPD = AC partial discharge measurement at U_{ac}

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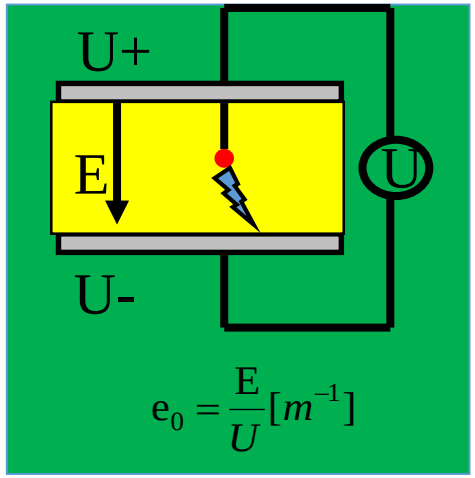
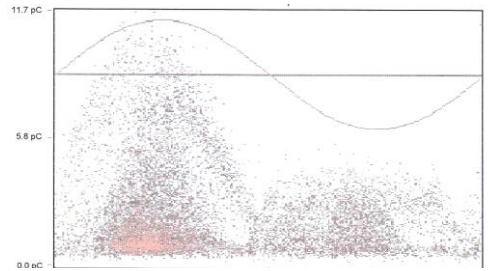
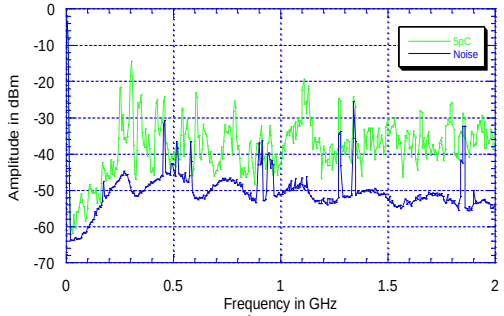
What is PROMOTioN WP15's mission on HVDC GIS?

HVDC monitoring and diagnostic methods







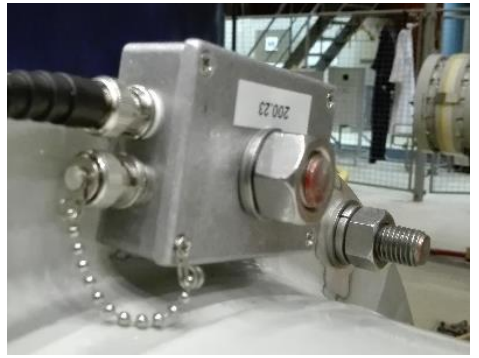
Partial Discharge (PD)

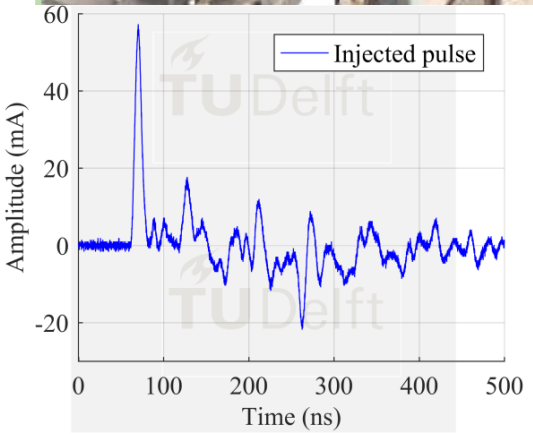
- A localized voltage breakdown in gas
- A current pulse with a very fast rise time <1 ns

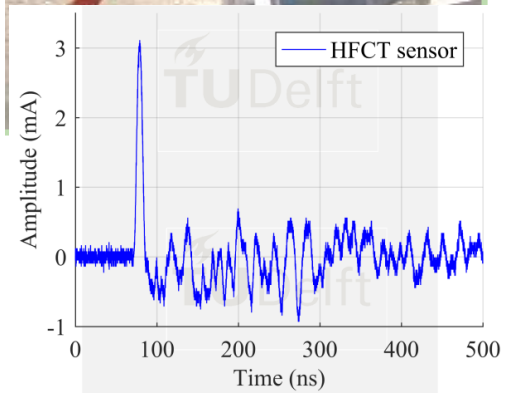
Fundamental Questions

- Type of sensors (HFCT, Antennas)?
- Correlation AC and DC?
- Number and where to install sensors?
- Which other parameters can be monitored?

Development of M&D System based on HFCT



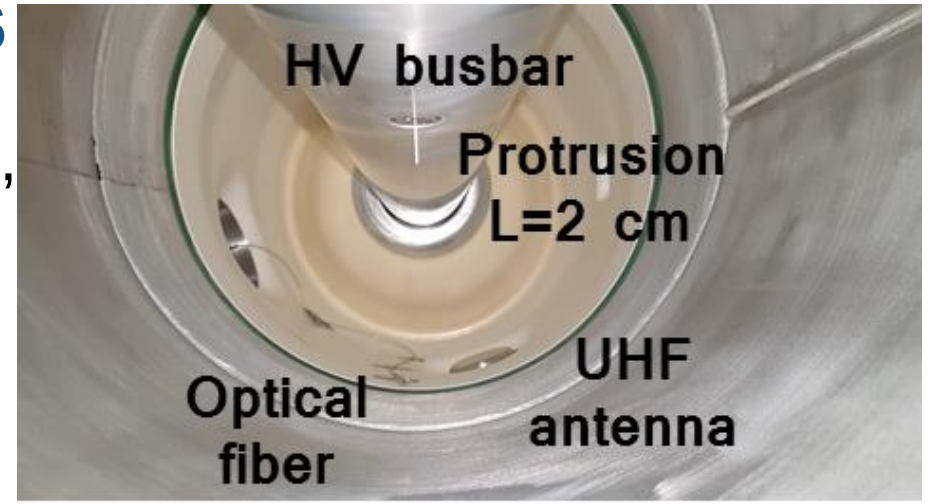




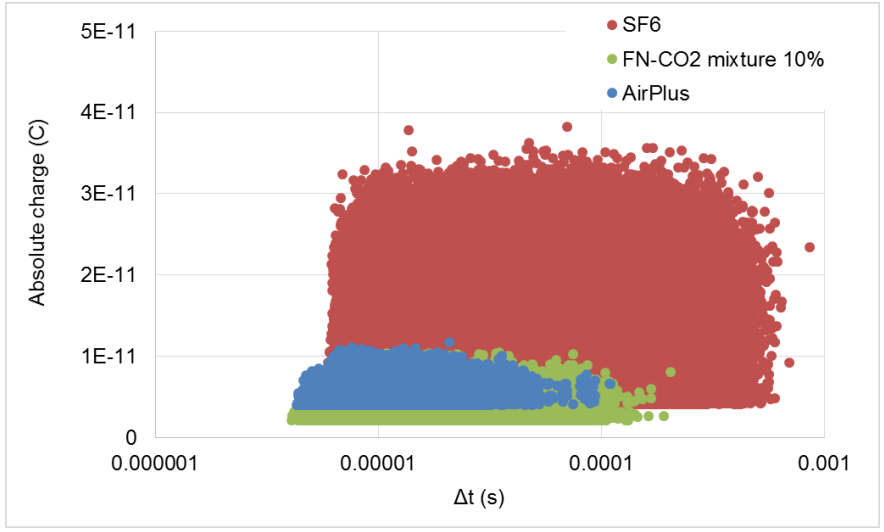
PD behavior for SF6 and alternative gases

SF6 has a very high GWP (23900), thus regulators, manufacturers and users strive to replace it with eco-efficient alternatives

PD behavior is principally comparable to SF6, but differences in polarity effect and time between pulses occur

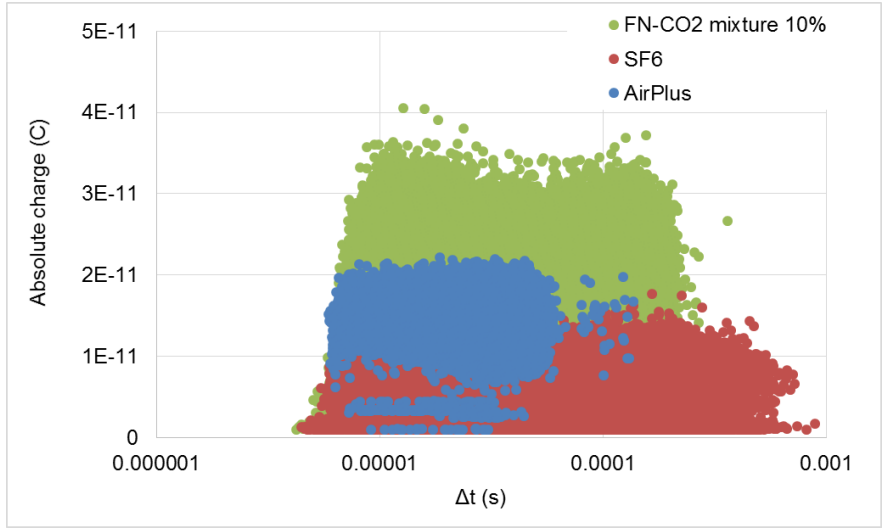


Negative polarity



100kV

Positive polarity



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Summary and Conclusions

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Summary and Conclusions

- High-Voltage Gas-Insulated Switchgear is an efficient and proven technology to reduce the size of AC substations
- HVDC GIS is a new technology about to be introduced to the market
- The size and cost of platforms in meshed HVDC offshore transmission networks can be significantly reduced by utilizing HVDC GIS
- What PROMOTioN‘s WP15 delivers for HVDC GIS technology:
  - Increase the Technology Readiness Level (TRL) from 6 to 8 (out of 9)
  - Specify and carry out a full scale long-term test (+1 year)
  - Investigate and develop monitoring and diagnostic methods as well as eco-efficient SF6 alternatives

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APPENDIX

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