



Effect of electrostatic induction and space charges on the audible corona noise of hybrid AC/DC transmission lines

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Motivation

Background:

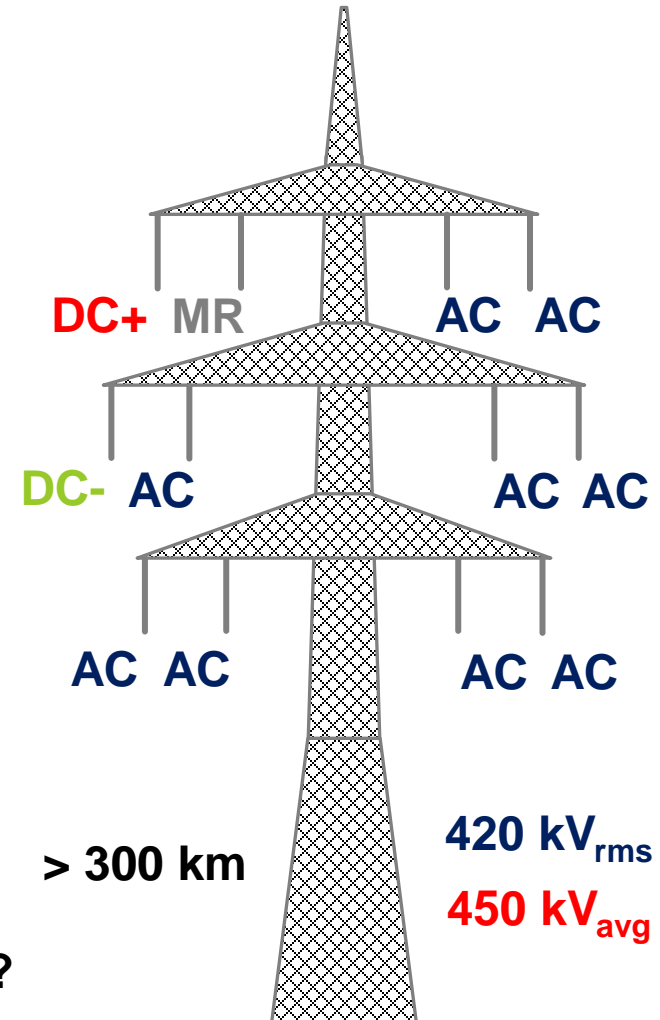
- Demand for higher transmission capacity
- Low public acceptance for new lines

Concept & advantages:

- Conversion to DC for bulk transmission
- Retain one AC system for grid stability
- Low visual impact, higher acceptance

Challenges:

- Integration of DC in AC grid
- Fixed tower geometry
 - Small separation distances
 - Coupling between AC & DC
 - **Effect on corona & audible noise (AN)?**

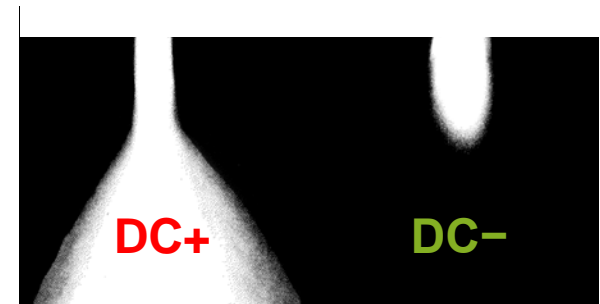


Source: based on [Rusek et al. 2013]

Fundamentals of AC/DC corona

Corona & audible noise (AN):

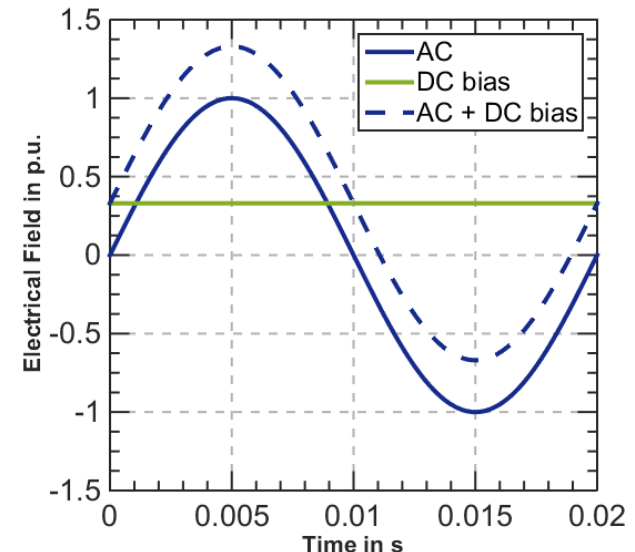
- Local field enhancement (Drops, Particles)
- Ionization → space charges, noise, interference
- AN & RIV depend on impulse amplitude
 - Influence of defect shape
 - Polarity effect



Source: based on [Trinh1995]

Difference between AC & DC corona:

- Only positive pole relevant (DC)
- AC ions move in alternating field
 - Additional hum component, worst in rain
- DC ions move in steady field
 - Critical number of sources in dry summer
 - Ion current to adjacent AC system
 - **Impact of field & ion coupling on AN?**



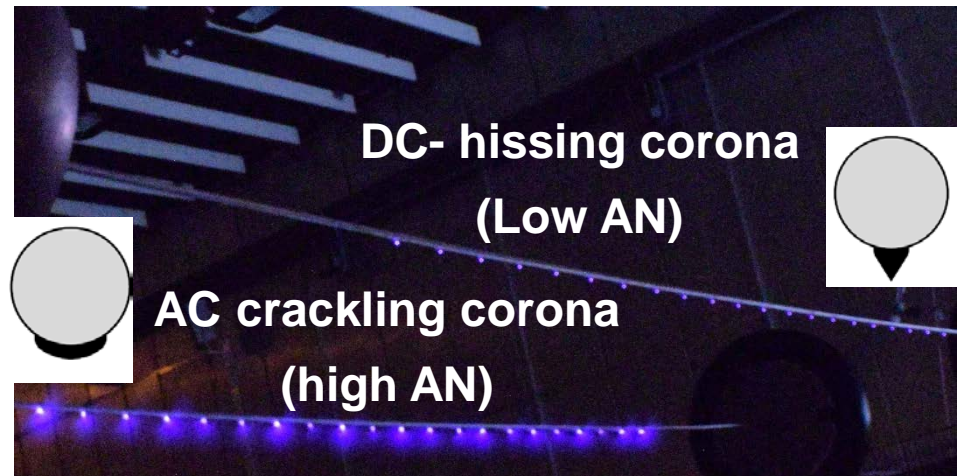
Design of hybrid test setup

Small scale setup:

- Two single conductors (22.4mm)
 - $h = 1.33 \text{ m}$, $s = 2.10 \text{ m}$
- Audible noise measured at fence
- UV cam to verify state of corona
- Current sensor on HV

Artificial corona sources:

- Problems of rain simulator
 - Background noise of rain
 - Rain onset & dry-off phases
- Individual control of corona state
 - Impact of space charges
 - Crackling & hissing state



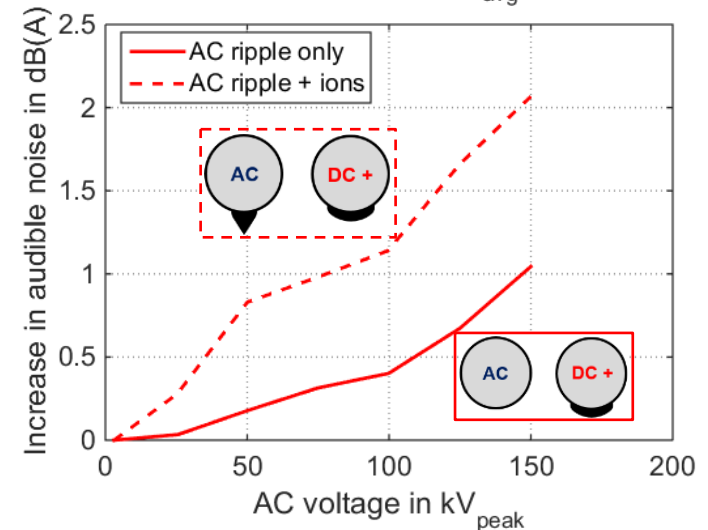
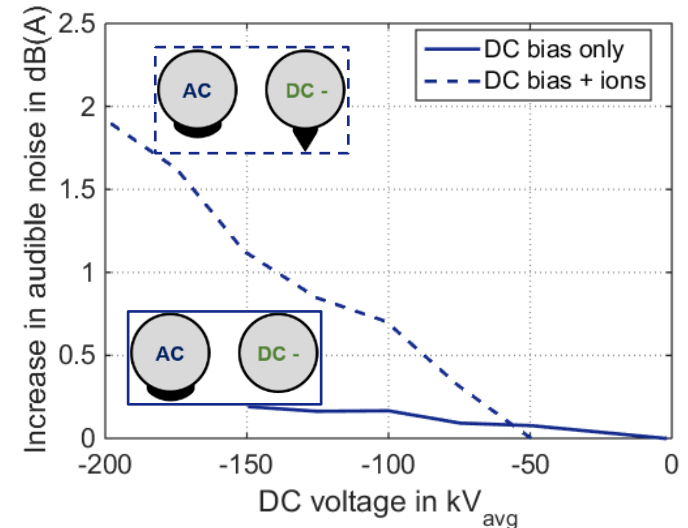
Effect of field induction & space charge on AN

AC audible noise affected by adjacent DC

- DC- verified to produce negligible AN
- DC bias strongly reduces AC corona onset
- Impact of pure bias barely measurable
- Higher AC AN in case of DC corona
 - Increase of AC gradient by DC ions?

DC audible noise affected by adjacent AC

- AC hissing is negligible compared to DC
- Ripple also affects DC corona onset
- Effect of ripple on AN small but measurable
- Increase in DC AN for adjacent AC corona
 - Drift of negative ions from AC to DC?



Conclusion & Outlook

Conclusion:

- Both, DC bias and AC ripple, strongly reduce onset on adjacent bundle
- Only small impact of DC bias on AC AN, higher with additional space charges
- DC AN is affected by induced AC ripple, increases with AC corona
- Increase in total is relatively small for tested gradients

Outlook:

- Verification for higher range of gradients & relative coupling

Next steps:

- Detailed study on indoor small-scale setup
- Construction of outdoor yard in Switzerland
- Cooperation with EPRI Lenox

Thank you for your attention

Acknowledgements for support & cooperation:

