

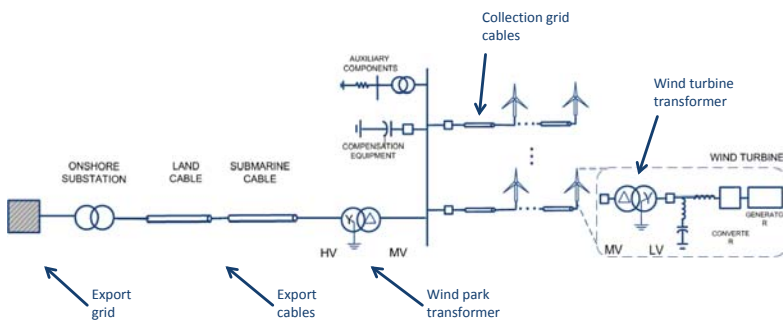
Wind-band model for wind farms

Innovation description

Wide-band model of wind farm collection grid developed by SINTEF Energy Research.

Apply in wide-band frequency analysis to understand resonance phenomena, harmonic interactions, etc.

Two versions: 33 kV and 66 kV collection grid



Component models

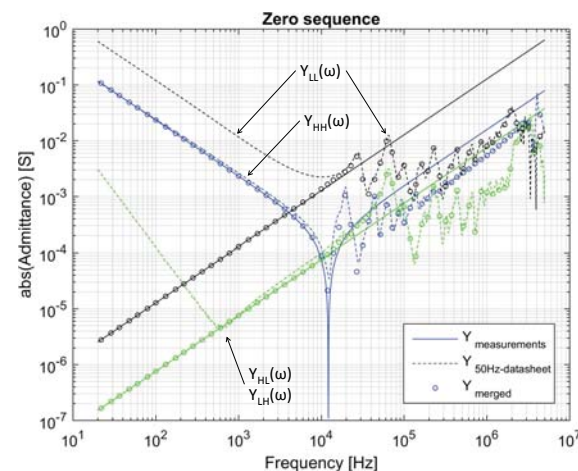
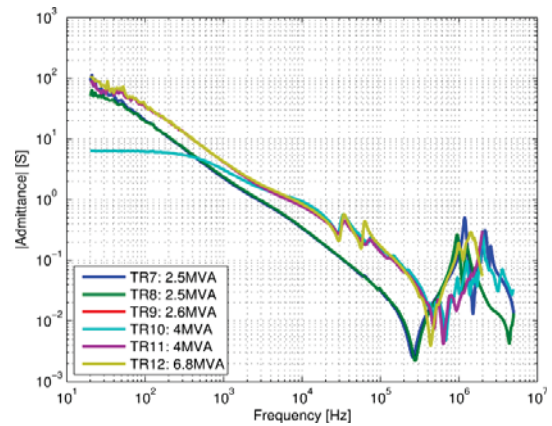
Transformers @ 33 kV:

- Black box models based on admittance matrix measurements in freq. 20 Hz – 2 MHz
- Wide-band models available of both, wind turbine and wind farm transformers @ 33 kV
- Accuracy of models improved for low frequencies by merging with datasheet values

Transformers @ 66 kV:

- Based on 33 kV wide-band models
- Resonance frequencies adjusted by scaling model's poles and residues, based on empirical formula:

$$f(\text{kHz}) = C_1 \cdot \frac{\text{MVA}^{C_2}}{\text{kV}^{C_3}}$$



Impact

- Foresee and avoid unwanted electrical interactions in 66 kV wind farms
- Base for harmonic and transient studies

Further development

- Development of wide-band models for the various components is ongoing. These will be put together to have a complete wind farm collection grid and transmission model for wide frequency-band analyses
- A barrier to the development is the lack of good data for model fitting

References

1. A. Holdyk, B. Gustavsen, I. Arana and J. Holboell, "Wideband Modeling of Power Transformers Using Commercial sFRA Equipment", IEEE Transactions on Power Delivery, vol. 29, pp. 1446-1453, 2014.
2. B. Gustavsen, "A filtering approach for merging transformer high-frequency models with 50/60 Hz low-frequency models", IEEE Transactions on Power Delivery, 2014