

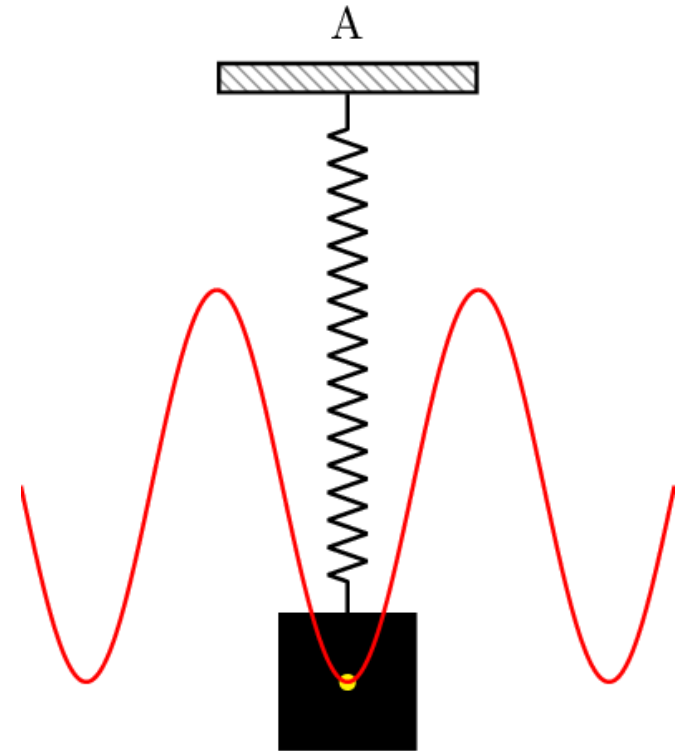
Power converters interactions in AC networks

ESR 7: Luis Orellana



What does resonance stand for?

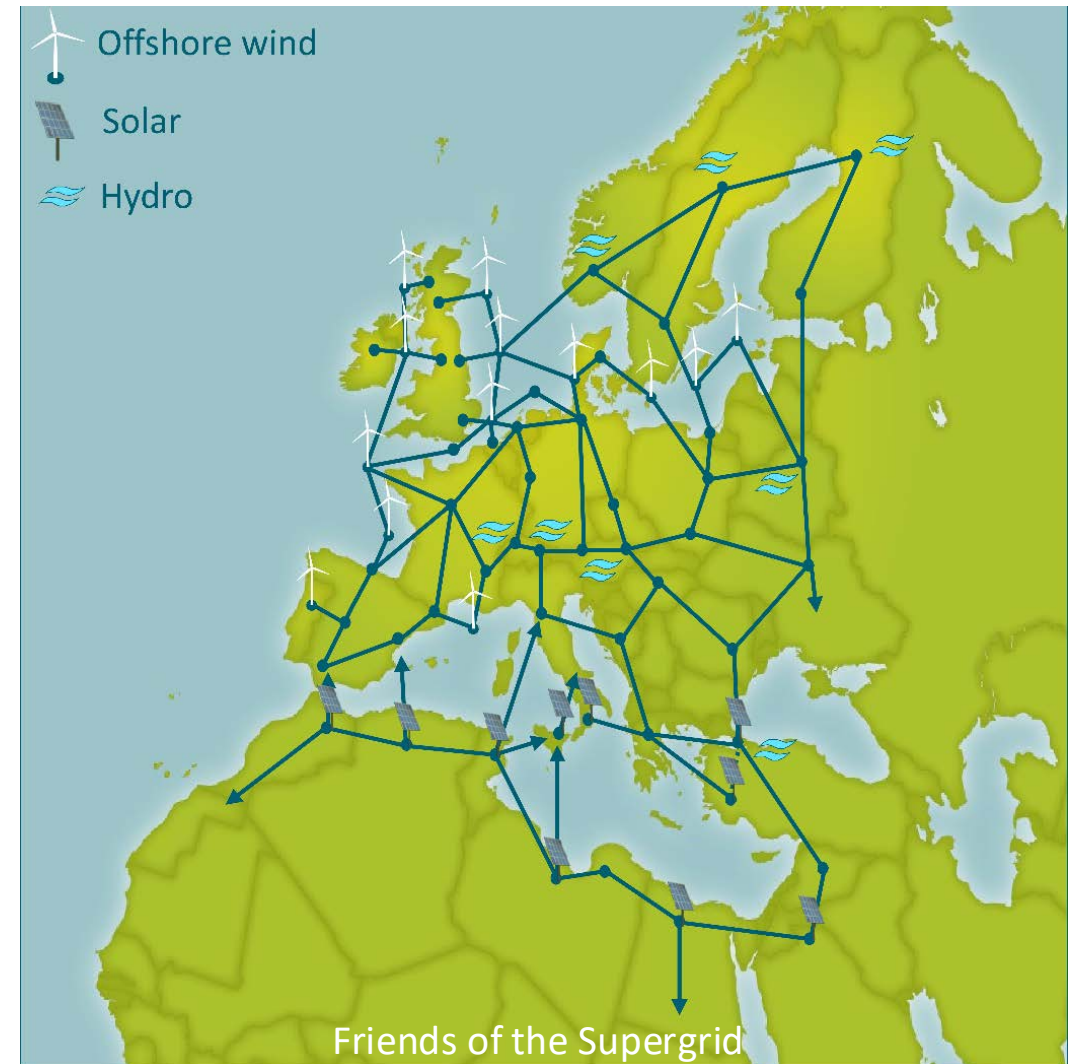
- Resonance describes the phenomena that occurs when **an external periodically force causes a system to oscillate** in a greater amplitude at a specific frequency.
- This frequency is equal or close the natural frequency of the system.



Future super grids

High-penetration of power electronics in conventional AC

- **Widely use of power electronic converters** to integrate renewable energies.



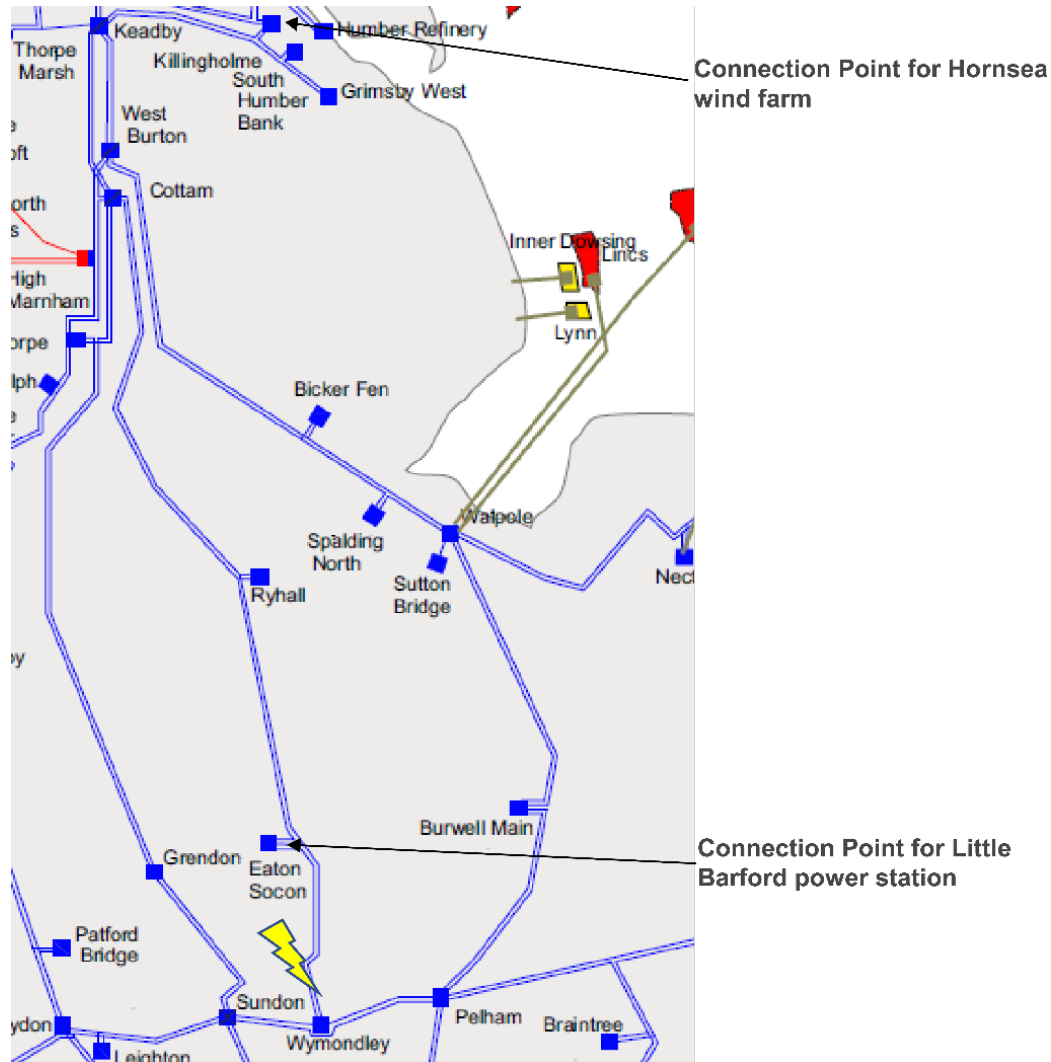
Future super grids

High-penetration of power electronics in conventional AC

- **Widely use of power electronic converters** to integrate renewable energies.
- **Interactions** between the converters and electrical networks.
- **Oscillations** in a wide range of frequencies and **instabilities** might appear.

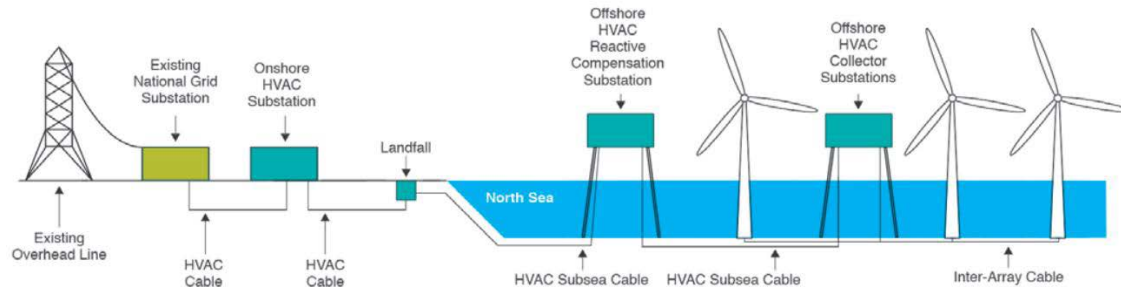


9 August 2019 event

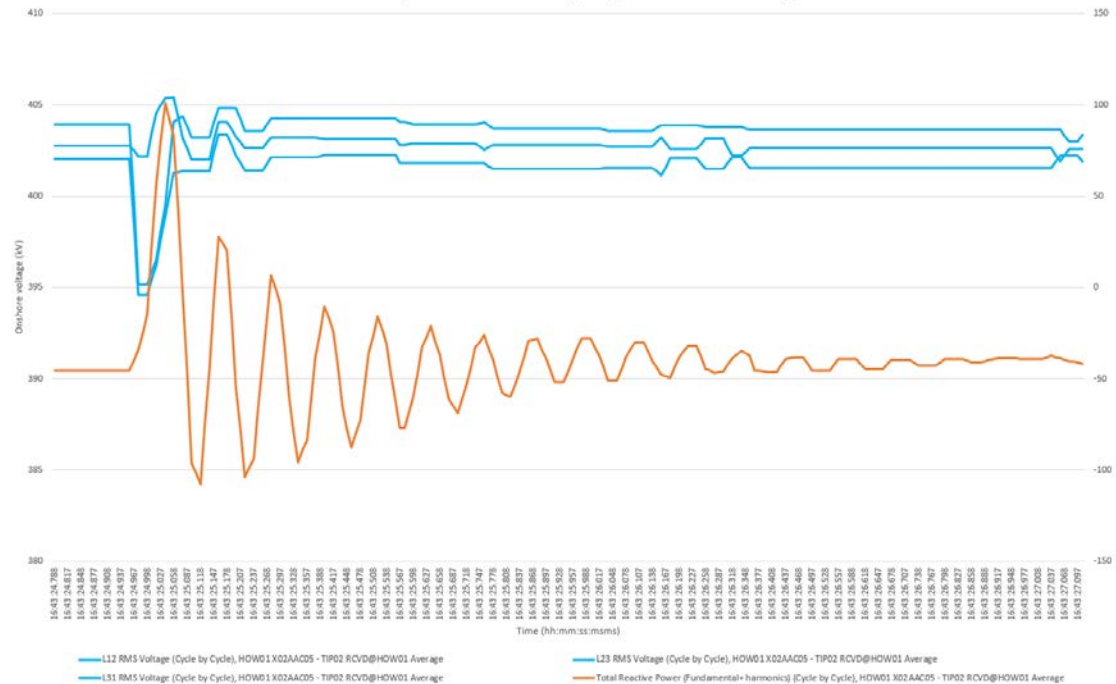


- **Lightning strike** caused a fault on the Eaton Socon – Wymondley 400kV line
- The **voltage control system** at the Hornsea 1 offshore wind farm did not respond to the fault on the transmission system as expected and became unstable.
- Hornsea 1 reduced its power generation from 799MW to 62MW.

9 August 2019 event



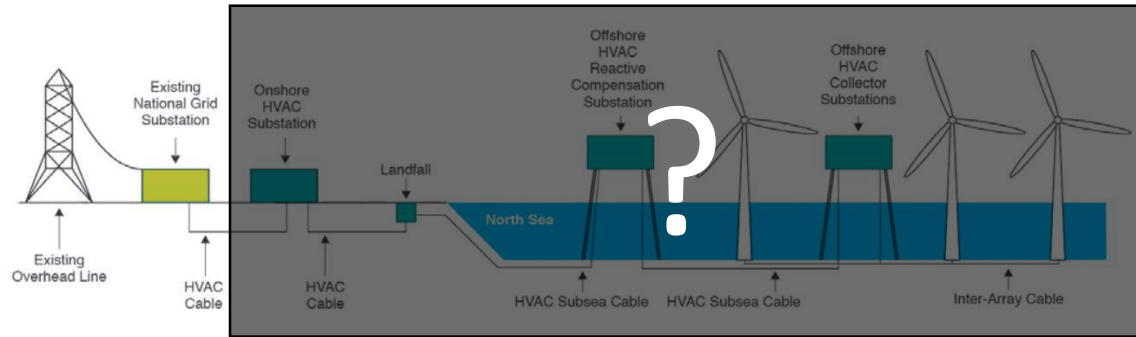
Hornsea Reactive power oscillations following voltage transient 16:43:25 9th August 2019



- Hornsea Project One Offshore Wind Farm
- Cable Corridor / Route
- O&M Base
- Onshore Substation

“..insufficiently damped electrical resonance in the sub-synchronous frequency range”.

9 August 2019 event

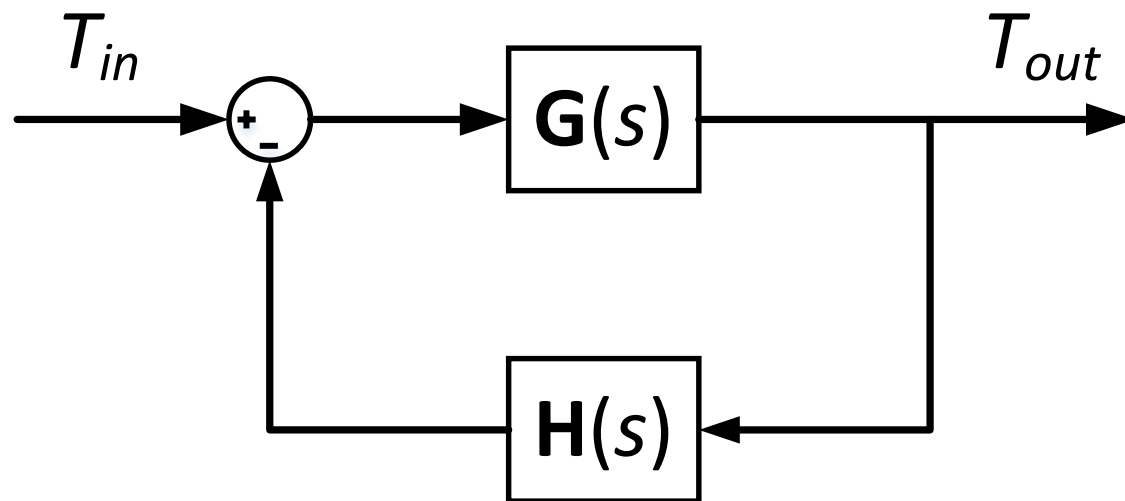
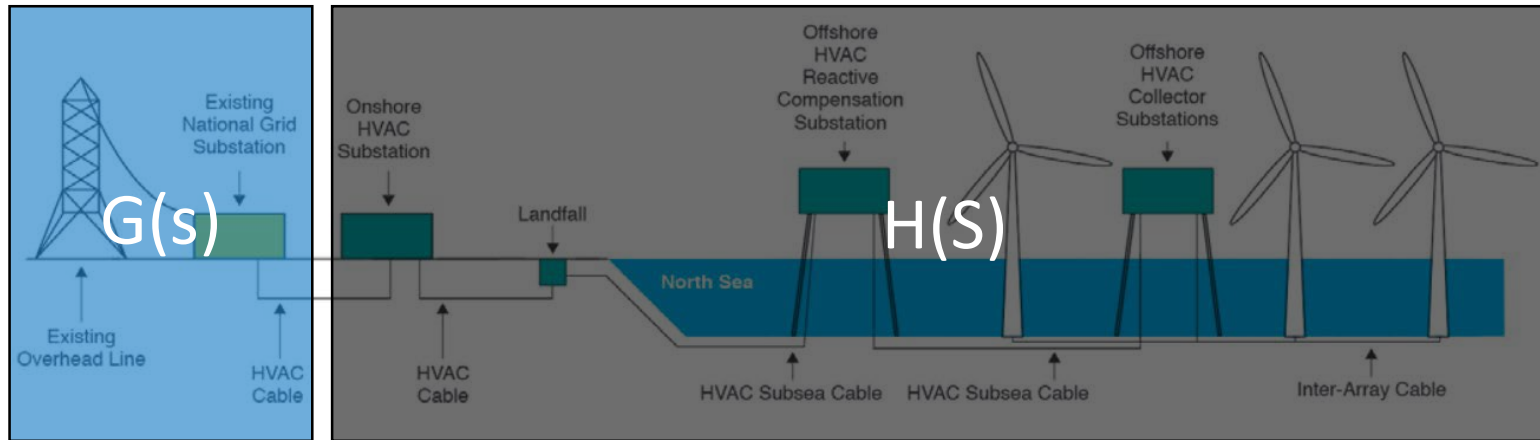


In order to protect their **intellectual property**, not detailed information is provided by the manufacturer



“..insufficiently damped electrical resonance in the sub-synchronous frequency range”.

Closed-loop system stability



$$T(s) = \frac{T_{in}}{T_{out}}$$

$$T(s) = \frac{G(s)}{1 + G(s) \cdot H(s)}$$



CITCEA



Thank you

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<https://innodc.org/>

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