Paris Session 2022

Interactions between fast frequency response and rotor angle stability – The role of HVDC

B2 PS1-3 Question 1.6: Several intelligent systems can be used in a control room. How can we guarantee that they do not compete by using different optimization and counteract each other's actions?

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Interactions between different controls aiming stability enhancement

- Transmission systems are undergoing structural changes → Challenging behavior
- Power electronics devices must be used as actuators to improve system stability.

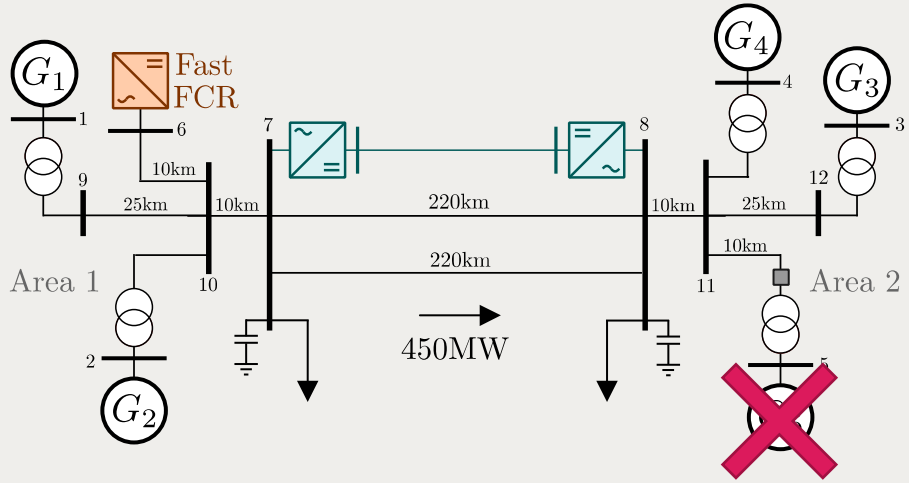
- Controllers to **enhance one stability aspect can degrade other stability aspects. E.g:**
  - Controllers for HVDC dispatch to enhance the static situation of the grid can excite inter-area oscillations [1]
  - Grid-forming controls for enhancing the operation of weak grids come with new low frequency oscillating modes [2]
  - Converters providing fast frequency support can lead to a rotor-angle transient stability issues [3]

Holistic (i.e., that consider several stability aspects) approaches for power system stability analysis and coordinated control design are necessary.

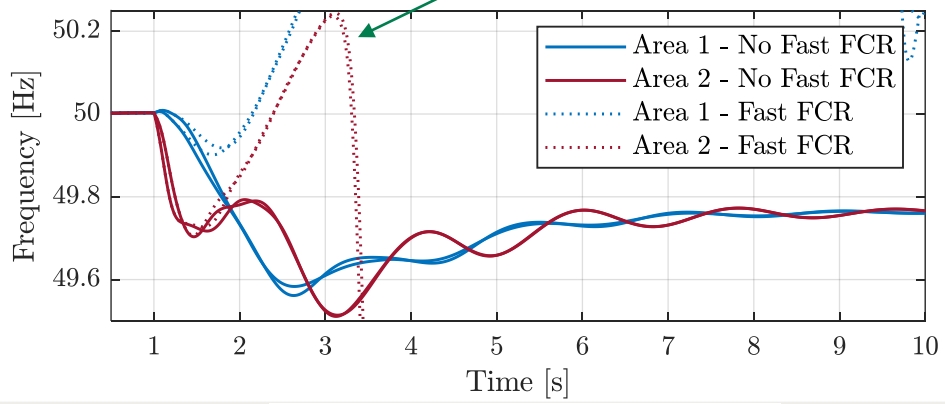
[1] Coronado, L., et al. "INELFE: main description and operational experience over three years in service." 2019 AEIT HVDC International Conference (AEIT HVDC). IEEE, 2019.
[2] Musca, R., et al. "Power System Oscillations with Different Prevalence of Grid-Following and Grid-Forming Converters." Energies 15.12 (2022): 4273.
[3] D. H. Wilson et al., “Advances in Wide Area Monitoring and Control to address Emerging Requirements related to Inertia, Stability and Power Transfer in the GB Power System,” in CIGRE Session 2016, 2016, pp. 1–6.

Interactions between frequency control and rotor angle stability

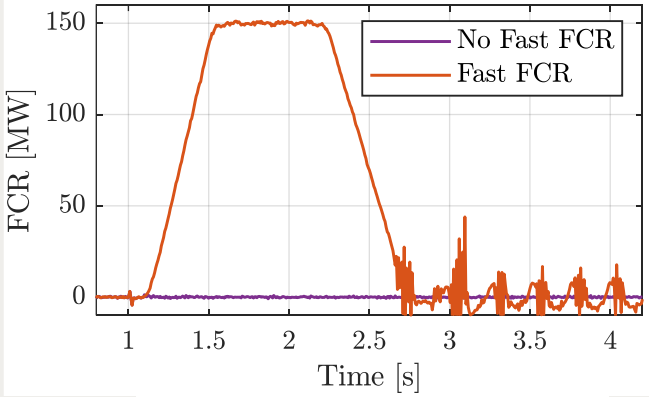
- Fast FCR is recognized as a suitable solution for the operation of low inertia systems.
- A converter with **Fast FCR** capability is connected in **Area 1**
- The simulated event is a **generator tripping** in **Area 2**
- A system split occurs when the Fast FCR is deployed, due to the angular separation necessary to transport the FCR from Area 1 to Area 2.



Split of the system due to a poorly coordinated fast FCR



Frequency behavior



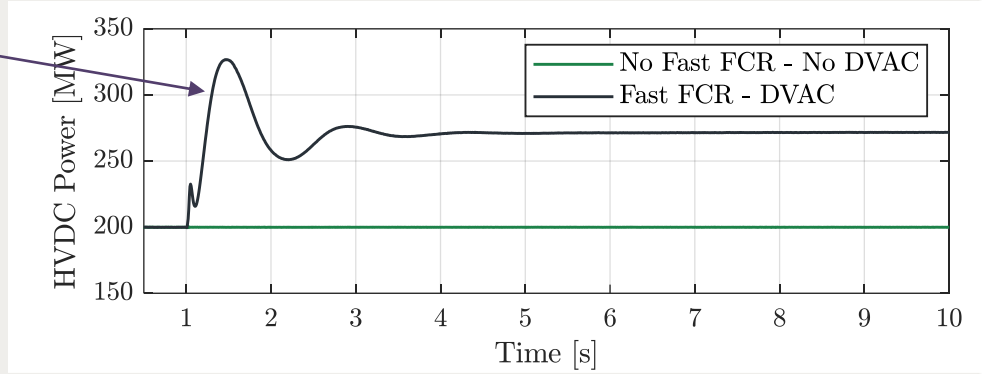
Fast FCR behavior

The role of the embedded HVDC link

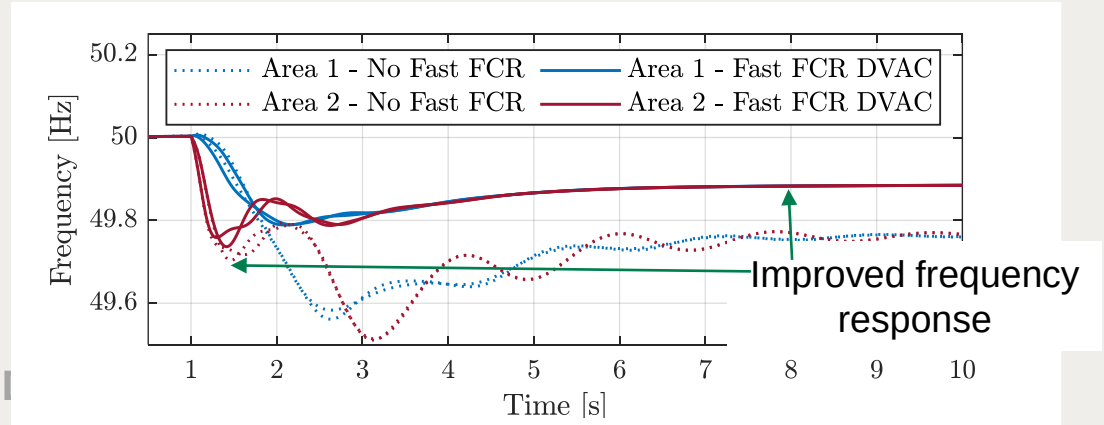
- The fast power control of the HVDC link must be used.
- A controller called DVAC is used for HVDC power modulation

$$\Delta P_{hvdc} = \overbrace{k_\delta(\theta_1 - \theta_2 - \bar{\theta})}^{Synchronizing\ power} + \overbrace{k_\omega(\dot{\theta}_1 - \dot{\theta}_2)}^{Damping\ power} + \text{Disturbances compensation}$$

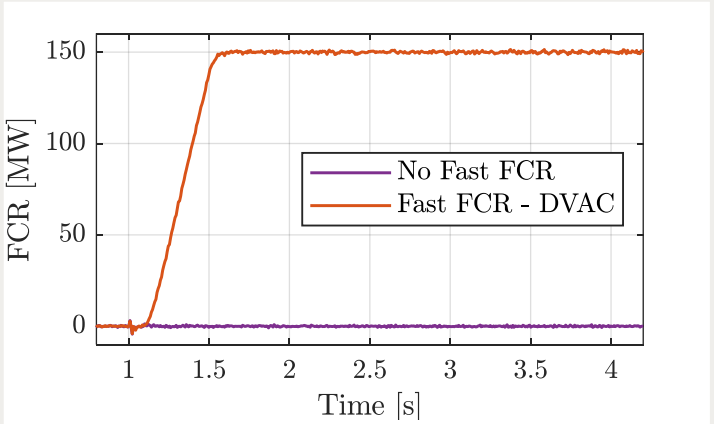
Phase angles — Frequencies



- The supplementary control of the HVDC allows to keep both areas together during the frequency excursion.
- The Fast FCR can be fully deployed



Frequency behavior



Fast FCR behavior