DVAC on Multi terminal VSC-HVDC grids

A novel distributed supplementary control of MTDC grids for static and dynamic stability enhancement of AC/DC systems, aiming to minimize the interaction with the DC voltage.

CONTEXT

MTDC grids with constant power references do not intrinsically enhance the rotor angle stability of its surrounding AC system as an AC transmission line does (due to its power flowing as function of the transport angle). It is possible to take advantage of the VSC controllability to provide stability at least like an AC line does.
If powers of different VSCs in the MTDC are modulated to provide AC services, the DC voltage can be impacted. The power references should be coordinated so as not to interfere with the DC voltage.

TECHNOLOGY DESCRIPTION

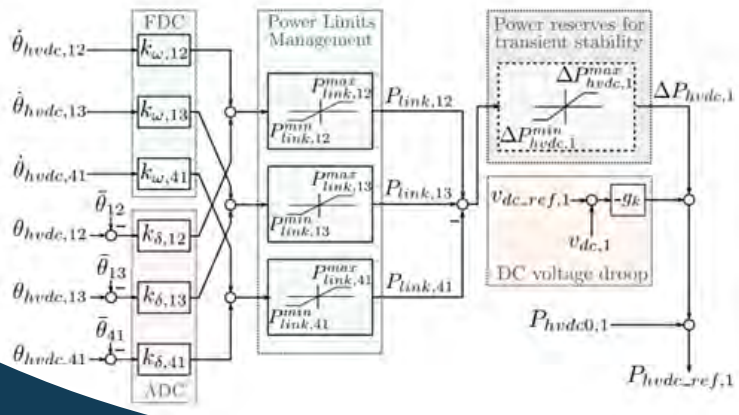
The solution consists in a decentralized control architecture to enhance AC transient stability while keeping the power balance of the DC grid even if converters reach their active power limits.
The idea behind the proposed strategy is to match the control actions and limits of each pair (i, j) of converters. If converter i modulates its power, then converter j modulates the same amount of power in the opposite direction. The concept of virtual links is used to represent this matching. The proposed control uses frequency and angle measurements at the Point of Common Coupling (PCCs) of the converters (through PMUs).
If power as function of the angle difference between two converters (synchronizing power as an AC line does) is absorbed by converter i and evacuated by converter j, form the AC grid perspective there is an emulated AC line between converter i and j. If more than 2 converters are used, a network of AC lines can be emulated. The part of the control using angle differences is known as Angle Difference Controller (ADC). The generalization of the ADC to MTDC is protected in the patent FR1906968.
The same logic can be followed using the frequency measurements and providing pure damping to the grid, thus emulating a network of "electromechanical dampers". This part of the control is known as Frequency Difference Control (FDC). If converter i modulates the same amount of power than converter j but in the opposite direction (Virtual Link ij), the power balance of the DC grid is kept equal to zero, therefore the DC voltage is not affected. Besides, the reference of the virtual link ij can be limited by locally limiting references at converter i and j. If the virtual link ij reaches its limits, references in converter i and j are therefore stopped (i.e. limited and kept constant), so the zero power balance of the DC side is kept, until the limiting converters can once again deliver the power calculated by the proposed controller. There can be many virtual links connected to one station, so the sum of the limits of virtual links must not be superior to the rating power of the converter. The generalization of the FDC to MTDC together the management of converters limits is protected in the patent FR1906969.

SCIENTIFIC REFERENCES

J.C. Gonzalez-Torres et al. "A novel distributed supplementary control of Multi-Terminal VSC-HVDC grids for rotor angle stability enhancement of AC/DC systems." Submitted to Transactions on Power Systems on December 2019.

J.C. Gonzalez-Torres et al. "Dynamic control of embedded HVDC to contribute to transient stability enhancement" Accepted in CIGRE 2020 session.

J.C. Gonzalez-Torres. "Transient stability of high voltage AC-DC electric transmission systems." PhD diss., Paris Saclay, 2019.



APPLICATION DOMAIN

Multi-Terminal VSC-HVDC grids embedded or partially embedded in an AC grid (at least two terminals in the same synchronous grid)

ADVANTAGES

Increasing the security of the overall system (AC rotor angle and DC voltage). FR1906968 and FR1906969

Automatic dispatch of stations in the same synchronous grid. This feature helps to avoid power loops in the grid, therefore to avoid unnecessary losses. FR1906968

In case of AC asynchronous grids connected through an MTDC, the solution can help to synchronize the systems. FR1906968

Supplementary control references for dynamic stability enhancement of the surrounding AC grid. Power oscillation damping and Transient stability enhancement. FR1906968.

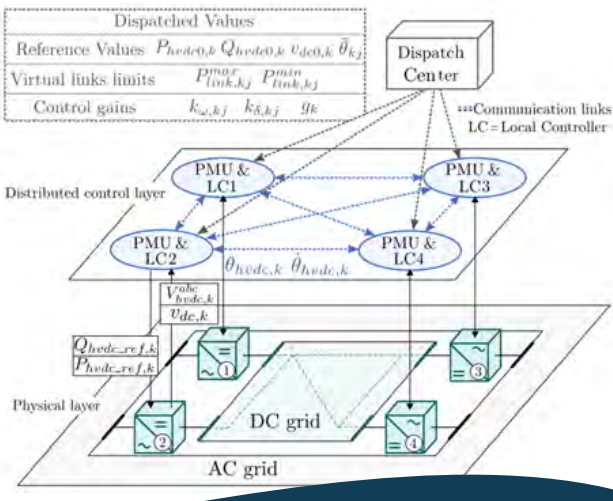
Supplementary power references do not interact with the DC voltage control, even when power references reach converter limits. This principle can be used for other supplementary controllers, not only the FDC and ADC. FR1906969

TRL SCALE

Proof-of-Concept demonstrated analytically and experimentally. EMT simulations using detailed models.

DELIVERABLES

Patent applications (FR1906969, FR1906968), Technical reports, Virtual mock-ups



Shaping power transmission

Contact: sebastien.silvant@supergrid-institute.com