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Hybrid Grid Forming and Grid Following Converter

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Abstract – This contribution presents a possible answer to question S.1: "Which challenges are foreseen with large integration of PE-based ancillary services?" In fact, large integration of PE-based renewable energy in the power system is a big challenge as these inverter-based resources (IBR) use converters controlled as grid follower (GFL). This use of GFL controller is basically important to operate with maximum power tracking (MPPT) and, therefore, optimize energy generation from wind or solar. However, this makes the control of the grid more difficult as GFL does not have a fast grid support ability. Therefore, the challenge is how to increase the presence of grid forming (GFM) converters in the grid, to support it during transient conditions.

GFL controlled converters, as the name shows, need a grid to operate and are connected to this grid synchronized by a PLL (phase-locked loop) block. On the other hand, the GFM controlled converter does not need a grid voltage reference to operate or a PLL and, theoretically, can operate without being connected to a grid, provided it has an energy source on its DC side. It has an internal VCO (Voltage Controlled Oscillator) to generate its own frequency reference. The GFL converter is necessary to maximize the wind and solar and inject them in the grid. The GFM is basically necessary when a transient condition happens in the grid, such as a quick change in load or even more severe transients like a fault somewhere in the grid.

The solution proposed here is to have a Hybrid Control Converter (HCC), in which both GFL and GFM controllers are used in the same converter. The two control systems are merged in such a way that they work in parallel, continuously, and seamlessly. This way, the HCC has the fast active power capability of the GFL, needed for MPPT operation. At the same time, it presents the GFM characteristics of black-start and fast frequency support, to help in transient conditions where the grid frequency varies. One of the key aspects of the HCC is that the GFL and GFM control systems are continuously operating in parallel, so there is no need to switch the operating mode of the converter between GFL and GFM, which could result in a slower response.

Simulation results for a simple grid consisting of one generator, a wind turbine, and a load are presented. The wind turbine is connected to the grid using an HCC, and in steady state its GFL-part ensures the optimal power generation. The GFM-part of the HCC is always operating but in a neutral state of zero output power if the grid is at nominal conditions of voltage and frequency. A transient situation is then created by step changing the load which results in a frequency decrease. The GFM-part automatically and quickly increases the HCC output power by taking energy from the DC link. After a while, when the frequency falls a bit more, a PLL can detect the frequency drop, activating the wind turbine synthetic inertia control, and increasing the energy delivered from the wind turbine generator into the DC link. It is important to note that the increase of power due to the GFM operation starts before the synthetic

inertia operation is started. This leads to a momentary decrease of the DC-link voltage (that depends on the amount of power and the capacitance value), which in some cases may be detrimental to the power control.

In summary, it is shown that the HCC can be a very effective option for providing fast grid support while maintaining MPPT capabilities. Simulations showed that the extra power injection due to the GFM-part of the HCC resulted in significantly reduced RoCoF (rate of change of frequency) and frequency variation. While the simulated controller can still be tuned to optimize its dynamic response, the principle of operation is simple and clear, showing positive results and possibilities.