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Dynamic Wind Power Plant Control for System Integration

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Abstract

This project presents a holistic wind farm control approach that enables wind power plant to provide the full range of ancillary services including synthetic inertia at the wind farm level rather than single turbine level. In order to detect a power system event and select the magnitude of the service provision from the wind farm, a fully instrumented small/medium generator is used. By slaving the wind farm output to the generator natural response during power system events, the wind farm is able to provide a stable scaled-up range of ancillary services without relying in delayed or noisy grid frequency measurements.

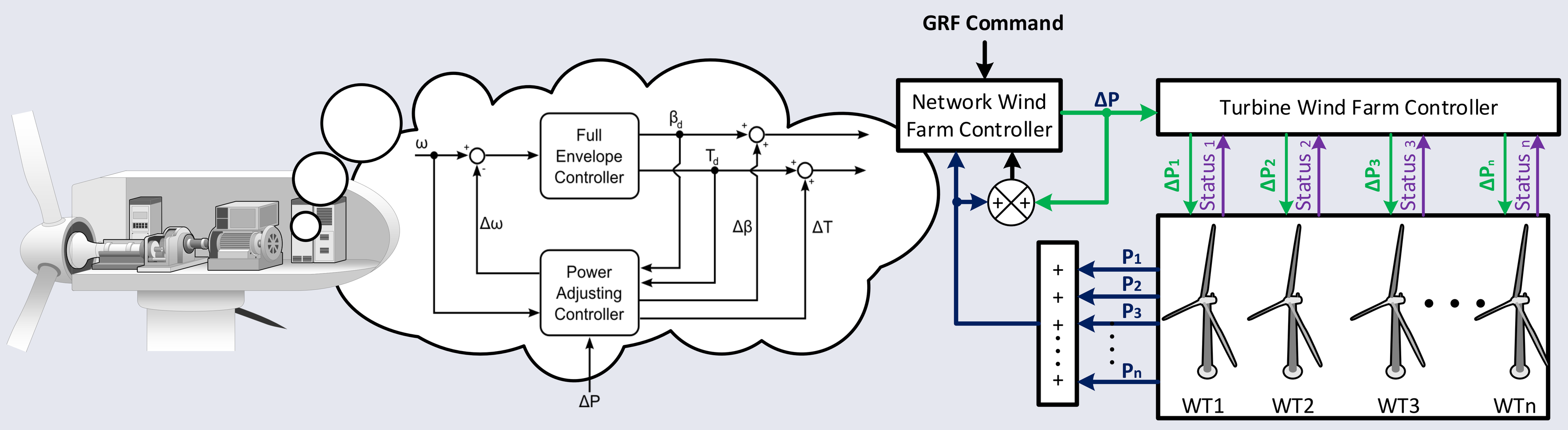
Objectives

- Use the Power Adjusting Controller (PAC) hierarchical control approach to enable the provision of ancillary services at wind farm level rather than single turbine.
- Provide ancillary services from the offshore wind farm by slaving the PAC-enhaced wind farm controller output of a fully instrumented small generator during frequency event. This is called the Generator-Response Following (GRF) concept.
- Applying the Generator-Response Following (GRF) as a power system event-detection mechanism. This avoid the use of conventional frequency measurement devices prone to high noise, lack of accuracy and delay.
- Provide immediate response from the HVDC onshore wind power substation during a frequency event by applying a feed forward controller to deal with the delay in transmission of the GRF signal to the offshore wind farm.

Methods

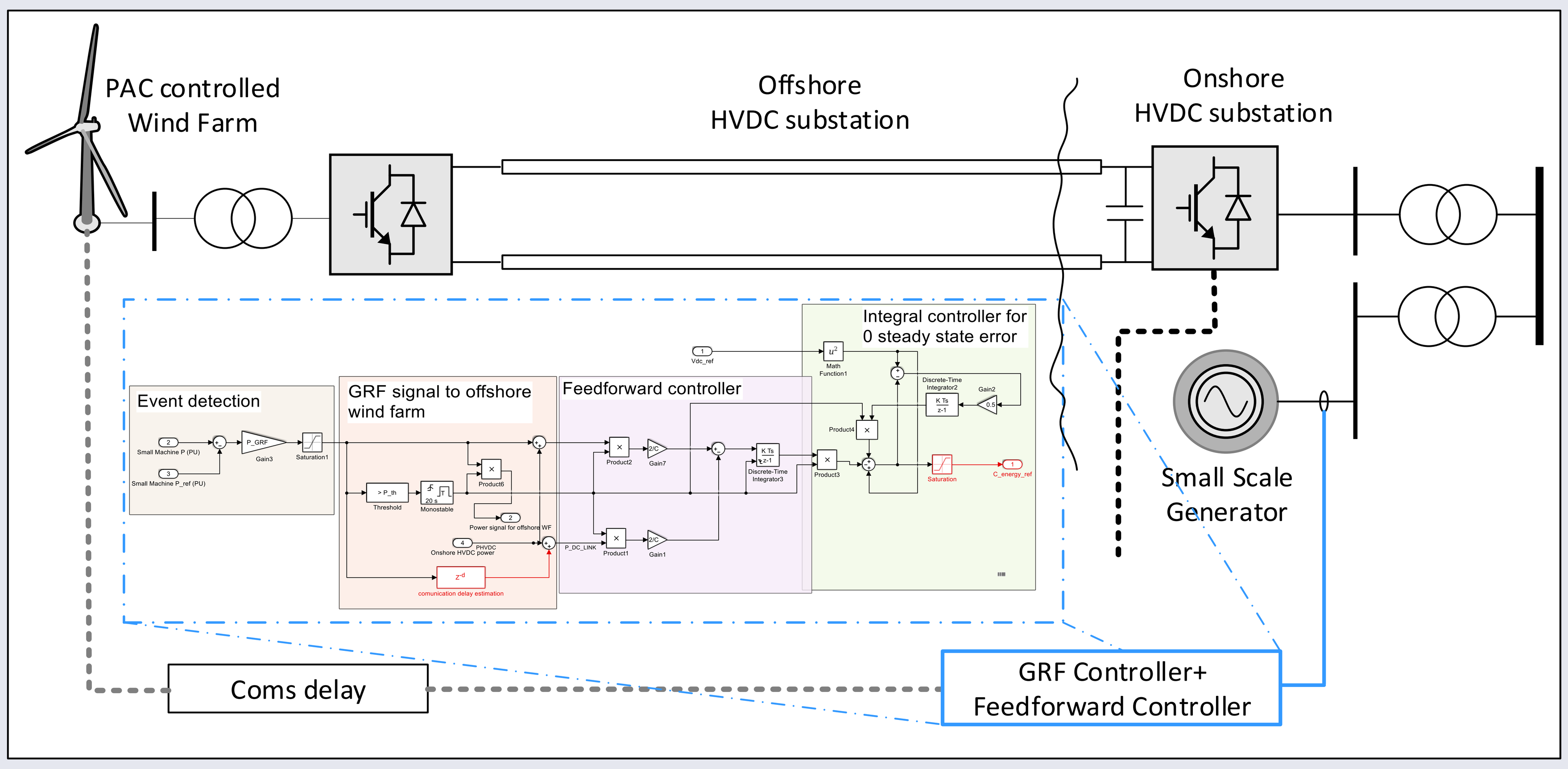
The PAC controller:

- **Allows the wind turbine power output to be adjusted via an input AP**
- **Is a generic controller that can be applied to any asynchronous variable speed horizontal axis wind turbine without alteration to nor knowledge of the turbine MPPT controller.**
- **does not affect the normal operation of the turbine.**



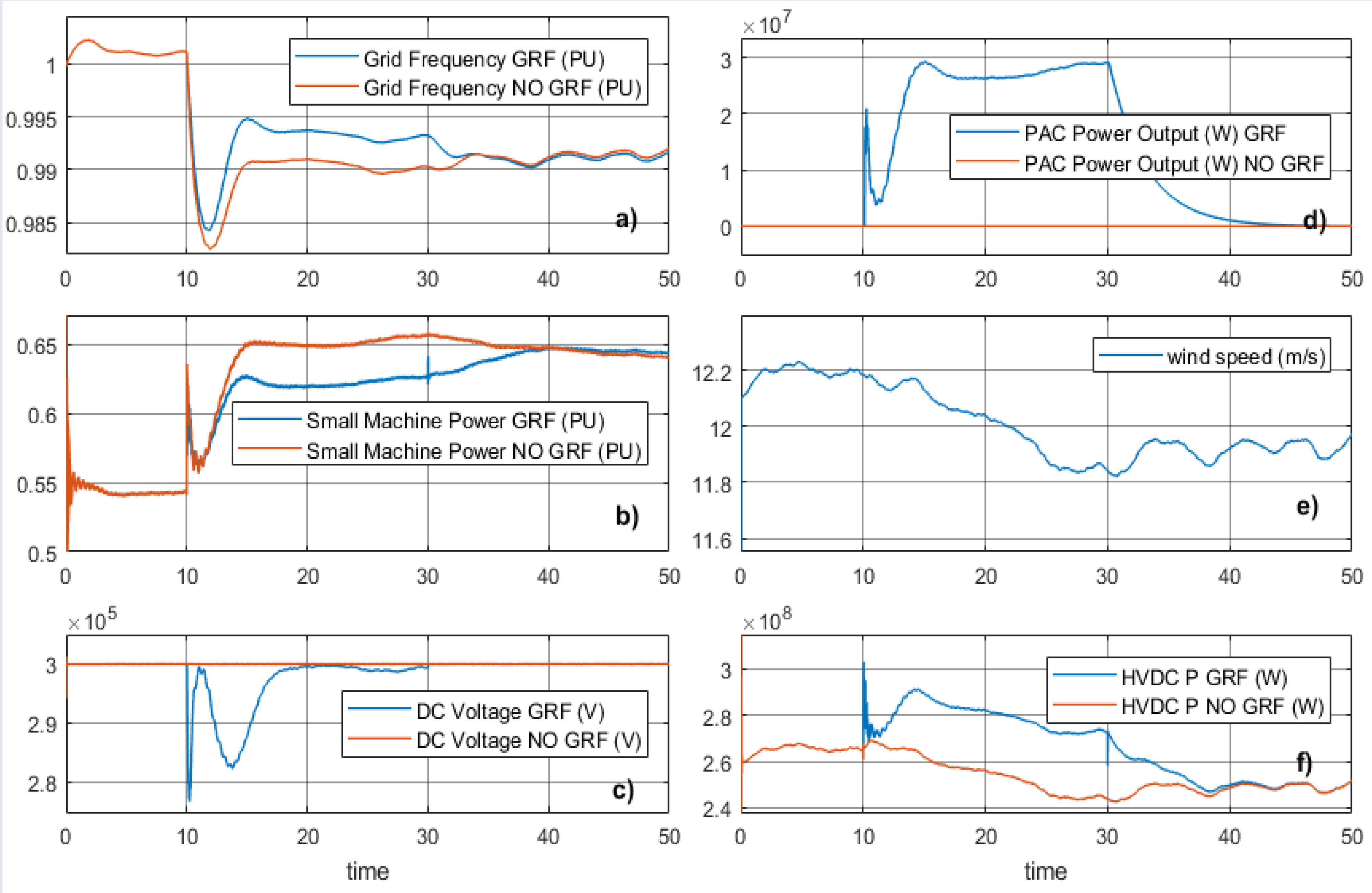
The GRF concept:

- **A small fully-instrumented (PSS, AVR) generation unit at the wind plant point of connection**
- **A Master-slave controller for provision of ancillary services from the wind turbine that mimics the natural response, droop control and inertia of the small generator at a much greater scale level.**
- **A feedforward controller for immediate response of the wind farm based in the control of the energy of the HVDC capacitors at the onshore substation.**

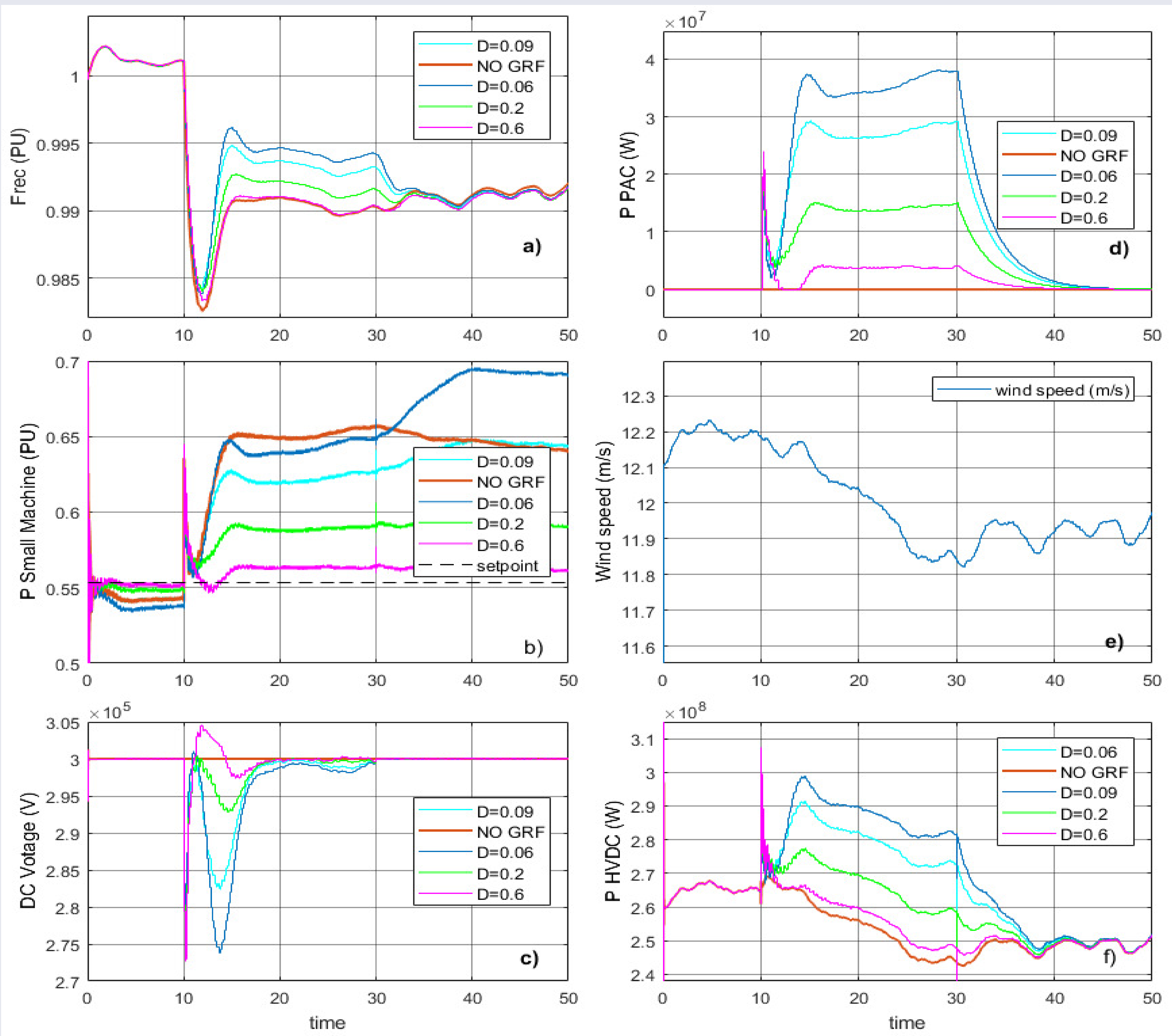


Results

The result is a stable scaled-up synthetic inertia provision from the wind farm during system events that mimics the response of the synchronous generator. This has a noticeable positive impact in the transient dynamics of the grid frequency.



To demonstrate the accuracy of the GRF controller in following the power output of the small-medium machine and the effects of modifying the governor constants of the small machine are shown in figure 2. In this series of experiments the governor droop constant (D) is selected to be 0.06 (most sensitive to frequency variation), 0.09,0.2 and 0.6 (least sensitive to frequency variations). Figure 2 shows the effects of changing D in the grid frequency (Figure 2 a) the power output of the small machine (Figure 2 b) the HVDC dc voltage (Figure 2 c) The power provided by the PAC controller (Figure 2 d) and the HVDC power output (Figure 2 f). A seen in the plot in figure 2. The GRF controller is able to follow the small generator in a wide range of governor settings.



Conclusions

The GRF concept presented offers a novel and timely solution to the ever-increasing need of developing systems that allow meeting renewable energy targets with improved flexibility. The innovation potential is significant when considering that industry and academia have repeatedly expressed the need for tools and strategies, such as the GRF concept, to enable the large-scale integration of wind power to the electric system

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