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Dynamic Properties of the Virtual Synchronous Machine (VISMA)

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Abstract

The increasing integration of decentralized electrical sources is attended by problems with power quality, safe grid operation and grid stability.

The concept of the Virtual Synchronous Machine (VISMA) [1] discribes an inverter to particularly connect renewable electrical sources to the grid that provides a wide variety of static an dynamic properties they are also suitable to achieve typical transient and oscillation phenomena in decentralized as well as weak grids.

Furthermore in static operation, power plant controlled VISMA systems are capable to cope with critical surplus production of renewable electrical energy without additional communication systems only conducted by the grid frequency.

This paper presents the dynamic properties "damping" and "virtual mass" of the VISMA and their contribution to the stabilization of the grid frequency and the attenuation of grid oscillations examined in an experimental grid set.

Keywords

Virtual Synchronous Machine (VISMA), virtual mass, damping, frequency stabilization, inverter, decentralized energy generation

1. Introduction

The VISMA concept describes a new type of grid feeding inverter entirely operating as electromechanical synchronous machine. It consists of a generator and an energy storage on the DC side, a hysteresis controlled three phase inverter and a process computer including voltage and current transducers. The inverter needs a coupling inductance at the AC side to operate the hysteresis control mode. The basic principle of a VISMA is demonstrated in Fig. 1.

Three subprocesses amount to a complete VISMA functional chain. It starts with the real-time measurement of the grid voltage (1) to feed the virtual synchronous machine algorithm (2) on the process computer that performs the mathematical model of an electromechanical synchronous machine also under real-time condition. The results are the stator currents of the virtual synchronous machine present as process variables. To complete the cycle, the calculated currents have to take effect at the grid. For this purpose the fast hysteresis controlled inverter (3) carries over the current signals to drive these currents at the grid immediately.

The performance of the virtual synchronous machine is adjustable by modification of the VISMA model parameters at the computer any time while the process is running. The variation of the parameters directly affects the calculated stator currents and thus the operation of the inverter.

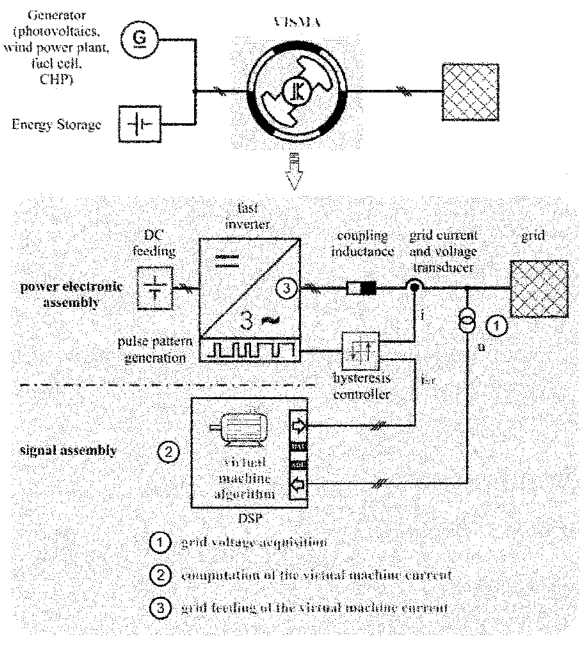

Fig. 1. Basic principle of the VISMA

In the course of the research of VISMA systems, two different machine models, a d-q [1] and a three-phase model shown below, were considered with the focus on practical applicability. It became clear that in case of unsymmetrical load or rapidly occurrences in the grid, d-q based models tended to unsteady states due to AC components in the d-q input voltages of the machine model caused by the standard d-q transformation. Therefore a more robust three-phase model was applied