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Micro grid stabilization using the Virtual Synchronous Machine (VISMA)

- abstract -

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Key words

VISMA, Virtual Synchronous Machine, renewable energy, grid integration, power quality

1. Interest of the work

- Combination of the unique VISMA [1] features with a broad band power conditioning functionality
- Both VISMA and conditioning function on one high-speed hysteresis controlled inverter stage with low self-interference
- Strong power quality improvement in micro grids
- Real time compensation based on a carrier recovery approach leading to a disturbance compensation by super-position
- Compensation approach specially suitable for weak micro grids with increased susceptibility to spurious oscillations
- Compensation approach tested in a multi generator island grid stressed by electromechanical oscillations due to combustion engine powered CHPs

2. Objectives

- Operating distributed generators as VISMA
- Enlargement of the VISMA by additional functions without inverter hardware upgrade

3. References

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4. Abstract

Structural changes in the fiel of electric power provision lead to new demands on the electrical equipment of the supply network.

To operate a decentralized, spacious and intermeshed powered grid with a large number of scattered generators safety, independently and without device-to-device communication, the VISMA concept [1] was introduced. It represents a specially controlled inverter that acts on the grid completely as electromechanical synchronous machine in static as well as dynamic manner. The local CHP appears as independent power plant and interacts on the grid regarding frequency and voltage changes like a conventional power feeding unit, which dominates the electrical grids up to now. Also the typical dynamic properties just like damping and transient current responses are available. Furthermore, all parameters of the virtual machine are free changeable continuously.

The device contains a high-speed hysteresis controlled inverter stage and an embedded process-control computer to evaluate the machine model – the virtual machine – on it. The process starts reading the grid voltage to feed the virtual machine input. The machine algorithm generates the stator current of a complete, electrical exitated synchronous machine with damper in dependence on the read voltage. The computed current signals drive the inverter as real time set values.

The VISMA system inverter is able to drive some instantaneous current courses in the frequency range DC to approximately 1 kHz to the grid. Thus, apart from the fundamental VISMA function, the inverter can be utilized to provide distortion compensation current.
This paper presents the additional broad band power conditioning functionality of the VISMA using the system inverter.
The compensation algorithm consists of a PLL, three phase separat RMS functions, the distortion demodulator and a compen-sation level weighting. PLL and RMS functions reproduce an ideal three phase grid voltage course in sync with the original grid and with its ideal RMS value. To separate the whole disturbance share of the original voltage course, the original-reproduction difference signal is determined. This signal contains all components that causes a deviation of the original voltage course from the ideal one. After phase inverting this disturbance signal, it can be applied for the direct compensation of the grid voltage distortion feeding it into the grid as current weighted signal. The VISMA system inverter meets the required fastness conditions to achieve a real time cancellation of the grid voltage disturbance by superposition.

The described method was implemented on the process-control computer of a 50 kVA-VISMA system used to compensate 8 Hz grid flicker in a multi generator feeded, highly intermeshed micro grid of a manu-facturing technology research company.

Driving the company grid in island mode, the 8 Hz flicker oscillation reaches 50 V amplitude referred to the peak value of the voltage. Without countermeasure, this results in mains failure.

The measurements show the compensation effect of the VISMA in broad band power conditioning mode in the described grid.