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Verification of the uninterrupted transition from grid parallel to island grid operation of the Virtual Synchronous Machine in a microgrid

Steven Reineke[1], Dirk Turschner[2], Ines Hauer[3] and Hans-Peter Beck[4]

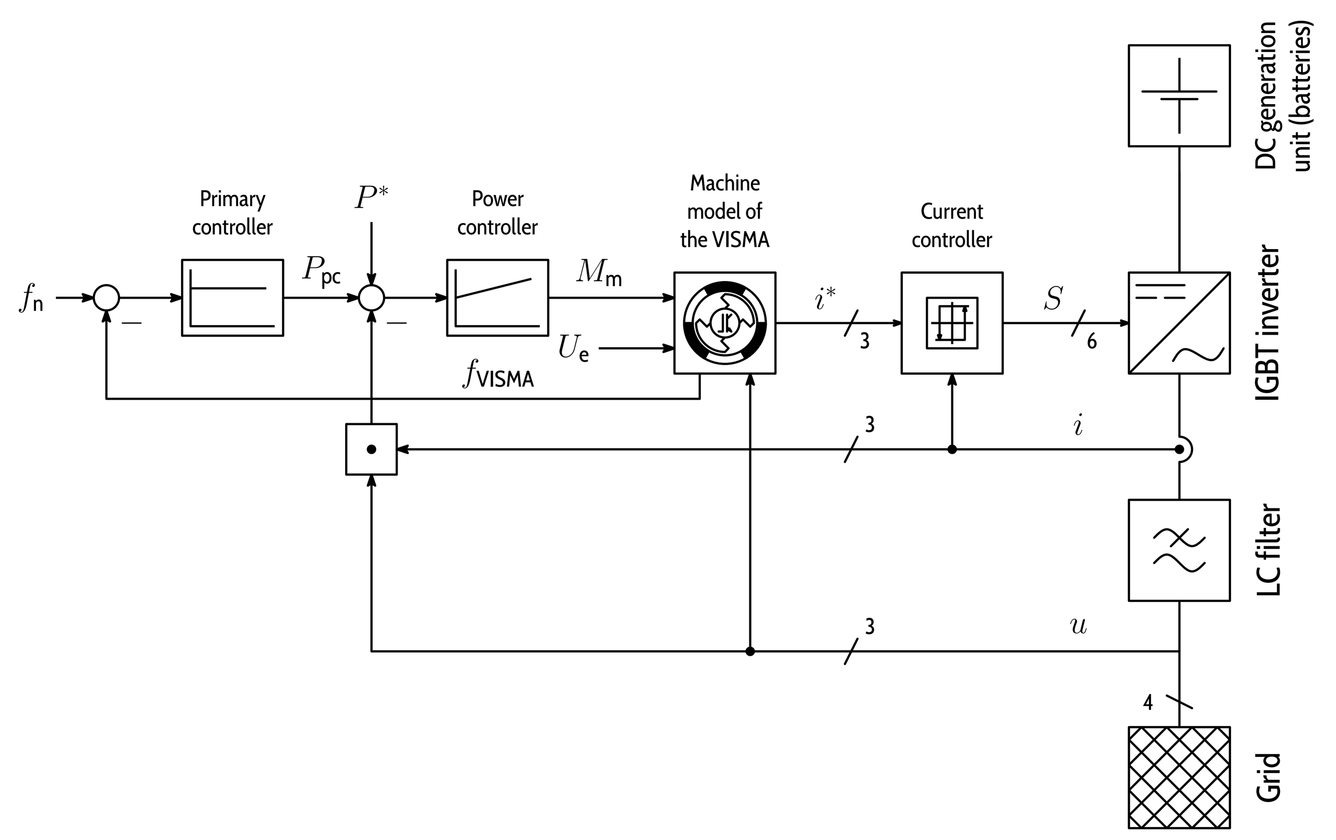
Institute of Electrical Power Engineering and Energy Systems, Clausthal University of Technology
Leibnizstraße 28, 38678 Clausthal-Zellerfeld (Germany)
[1]Phone number: +49-5323-72-2929, e-mail: steven.reineke@tu-clausthal.de
[2]Phone number: +49-5323-72-2592, e-mail: dirk.turschner@tu-clausthal.de
[3]Phone number: +49-5323-72-2299, e-mail: ines.hauer@tu-clausthal.de
[4]Phone number: +49-5323-72-2570, e-mail: hans-peter.beck@tu-clausthal.de

The concept of the Virtual Synchronous Machine

- the fundamental idea behind the Virtual Synchronous Machine (VISMA) concept is based on replicating the behaviour of an electromechanical synchronous machine by combining an inverter with an energy storage device and a digital signal processor (DSP hardware)
- the DSP calculates the electrical, magnetic and mechanical machine variables in real time using a mathematical model of the synchronous machine
- the inverter consists of a self-commutated IGBT power module with a LC output filter and a hysteresis current controller

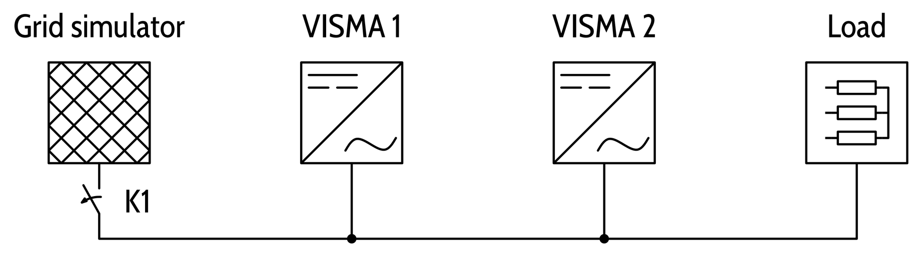
Control strategy of the VISMA

- the manipulable variables of the VISMA are the virtual mechanical torque M_{m} on the shaft for the active power and the virtual excitation voltage U_{e} for the reactive power
- the manipulable variables are independent of the operating mode of the VISMA – grid-parallel or island grid operation
- for these investigations, the virtual synchronous machine has a cascaded control consisting of a power plant control in the form of a P-controller with a downstream power control
- the primary controller receives the frequency deviation between the nominal grid frequency and the rotor frequency of the VISMA, which corresponds to the grid frequency, as an input variable
- depending on the set gain, the controller outputs a target active power to be fed into the grid by the VISMA



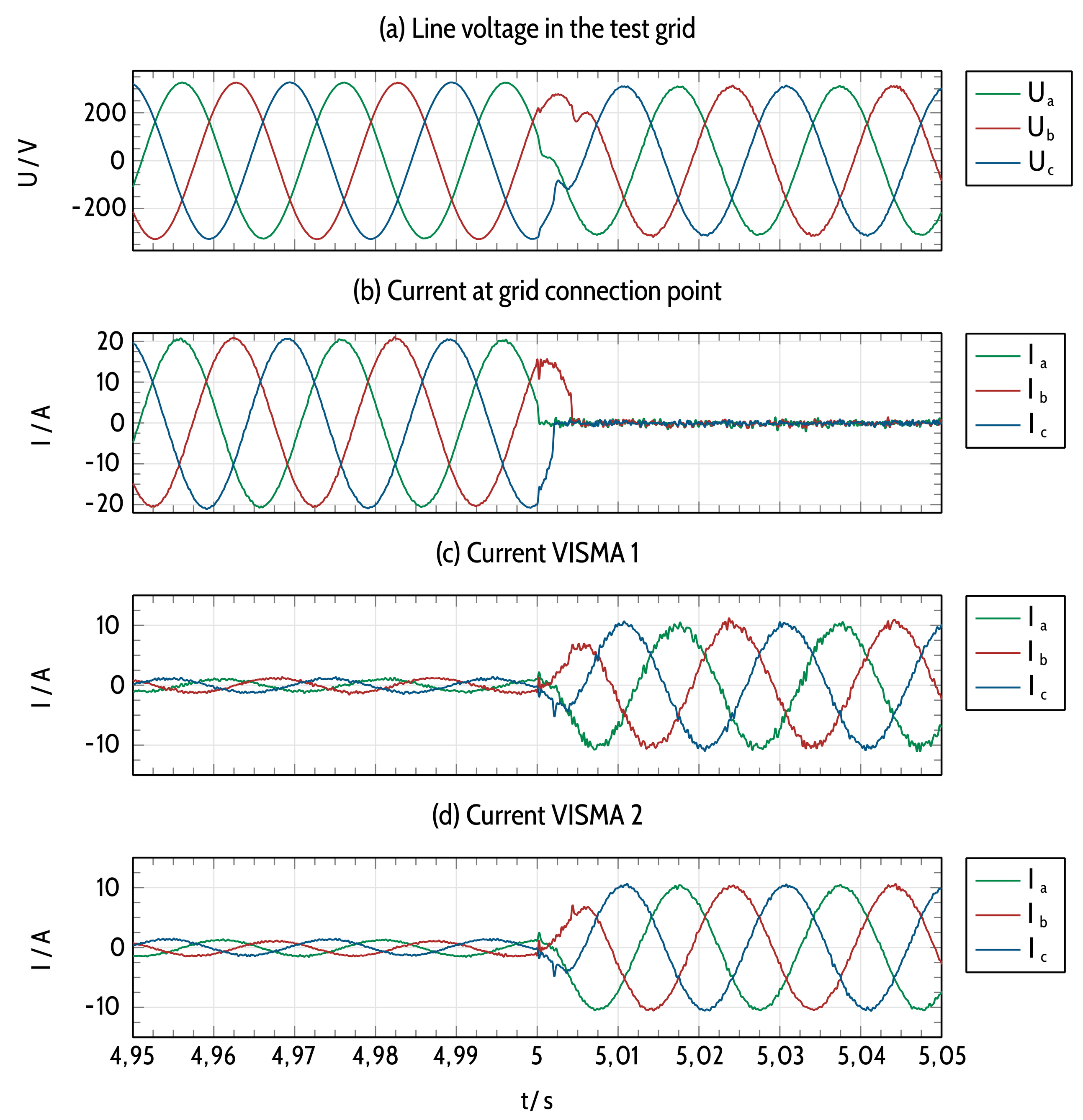
Trial grid setup

- the experimental grid is set up with two VISMA systems (both systems are parameterised identically), a load and a grid simulator to simulate the wide area synchronous grid
- during the test, the coupling switch K1 is opened and the grid simulator is disconnected from the test grid
- thus, the investigated grid is transferred from grid parallel operation to island grid operation



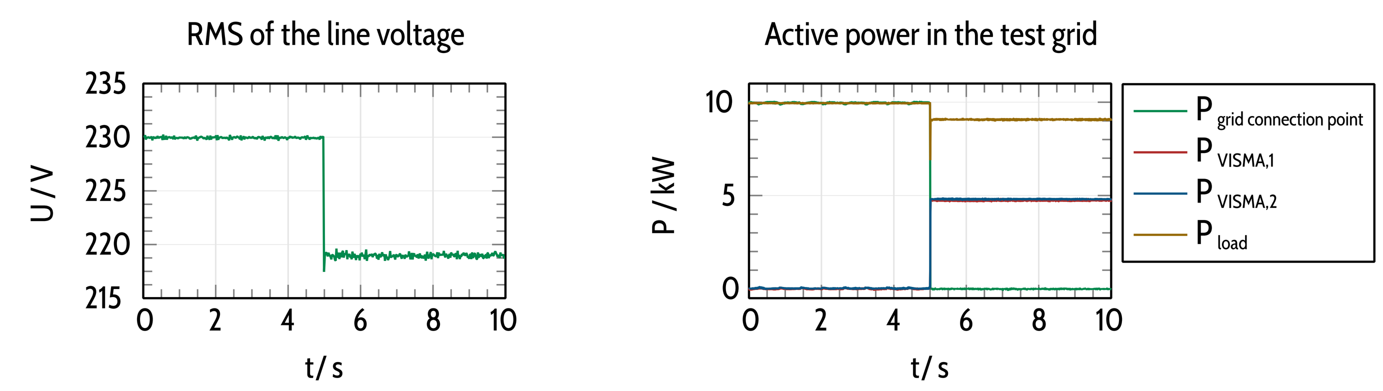
Results

- transfer of the test grid with two VISMA systems from an interconnected grid to an island grid by opening the coupling contactor K1 at 5 s
- the VISMA systems are neutral in terms of active power until the grid is disconnected; the measured current before disconnection corresponds to the capacitive base load of the filter capacity of the inverter
- the stabilisation of the island grid by the VISMA is completed 5 ms after the grid failure

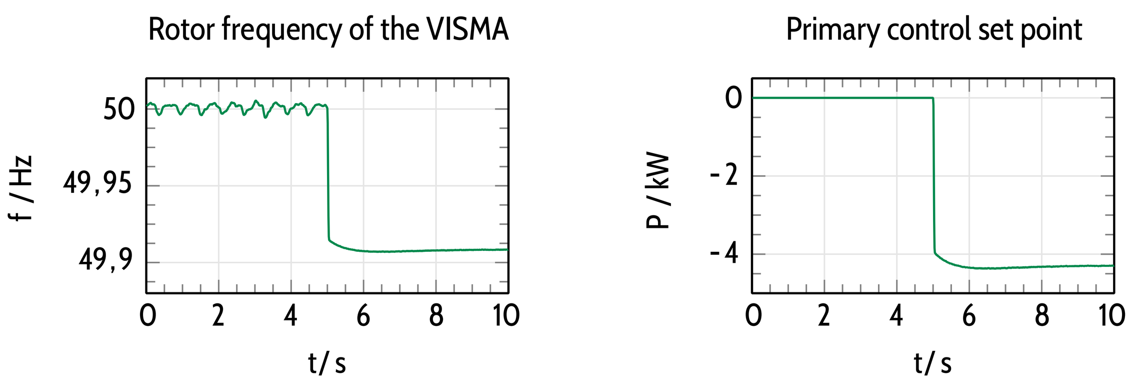


- before the grid is disconnected, the voltage is specified by the grid simulator
- after opening the mains contactor, the voltage drops from 230 V to 220 V
- missing voltage control results in permanent deviation from the set value

- before the grid separation at 5 s, the load is completely supplied by the grid simulator; the VISMA systems do not feed in any active power at this time
- after disconnection, the two VISMA systems take over the supply of the load
- the load is distributed equally to both systems due to the same settings



- before grid disconnection, the grid frequency is specified by the grid simulator; with the transition to island operation, the frequency drops
- the drop activates the primary controller, which outputs a set value
- the grid frequency stabilises after 40 ms when an equilibrium is reached between generated and consumed active power in the test grid



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