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GRID FORMING INVERTER CONTROL FOR WIND TURBINES

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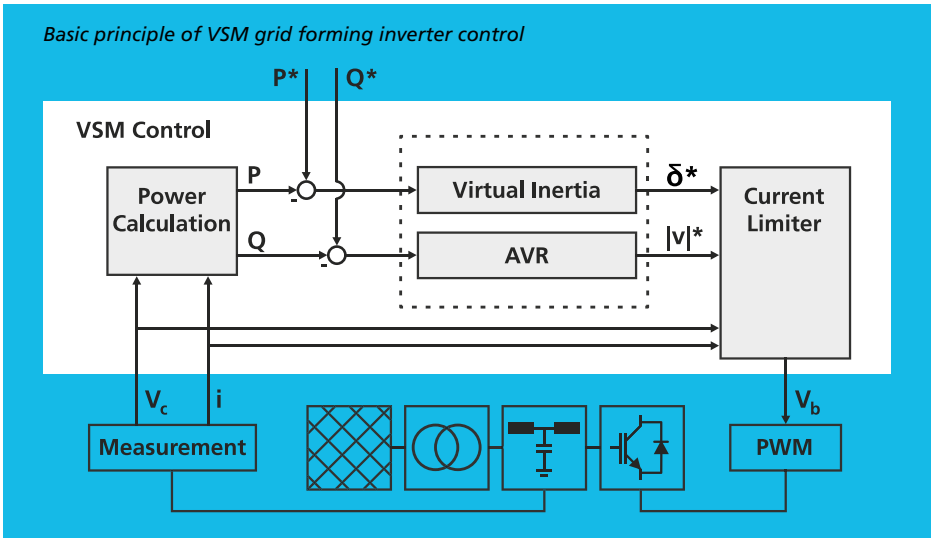
Basic principle of VSM grid forming inverter control

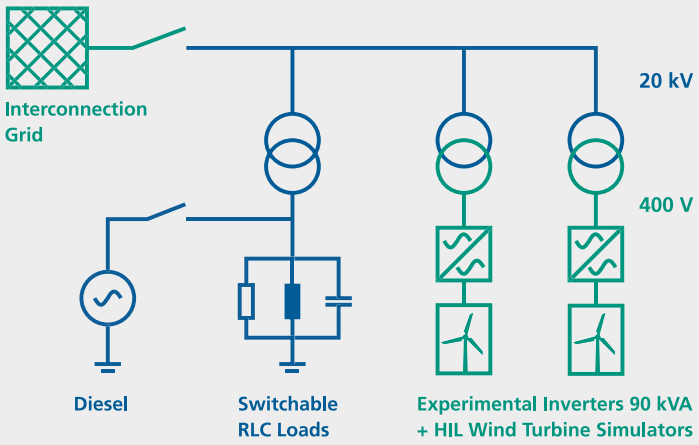


New grid forming inverter control

Based on many years of experience, Fraunhofer IEE has developed a grid forming inverter control scheme that operates both in grid parallel as well as in island grid operation. The algorithm works especially well in conjunction with wind turbines and has been adapted to overcome many of the challenges of grid forming inverter control.

Principle

As shown in the figure above, the control strategy is based on the principle of a »Virtual Synchronous Machine« (VSM). The inverter is operated as voltage source, impressing a local »inner« voltage vector which is coupled to a virtual inertia.



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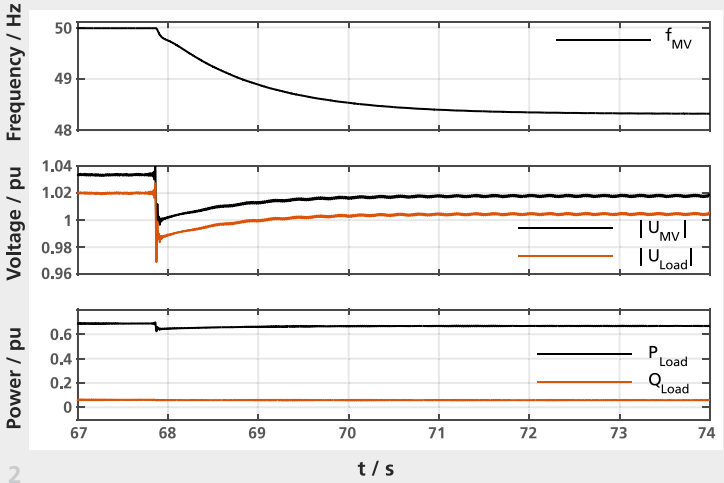

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Advantageous properties of the VSM

- Grid forming – black start capable
- Stable for grid situations from 0 to 100% inverter penetration
- Compatible with other types of generation and different storages
- Inherently grid supporting for frequency and voltage disturbances, without measurement delay and reliance on local voltage measurement
- Parameterizable regarding the effective synthetic inertia, damping etc.
- Ideal for wind turbines to make use of the physically present rotor inertia

Over-current limitation

The main challenge for applying grid forming control schemes to power electronic inverters lies in the high over-currents resulting from fast voltage disturbances. Fraunhofer IEE has worked on solutions to overcome these problems, providing:

- Safe limitation of short-circuit and inrush-currents
- Preserving grid forming properties during voltage sags
- Continuous operation without switching control schemes

Parallel operation of multiple VSM

The developed algorithm allows for operating multiple inverters in parallel without communication. It is compatible with synchronous machines and Diesel generators.

Experimental validation

The new inverter control schemes, so far, have been tested at the Fraunhofer IEE SysTec facility in combination with real-time wind turbine simulators. As shown in figure 1, the SysTec facility includes two experimental inverters with 90 kVA rating connected to a medium voltage test grid. This test grid can be operated both as island grid or linked to the interconnection grid.

So far, the following experimental tests cases have been completed successfully:

- Parallel operation at the interconnection grid
- Islanding of the test grid, dynamic load sharing
- Parallel operation with Diesel genset
- Black start of the test grid, synchronization of second inverter and stepwise connection of loads
- Response to transient voltage dips and load switching events

Figure 2 shows a measured time series for an islanding event of the test grid. The grid is stabilized and the power supply is sustained by the VSMs alone.

1 *Scheme of experimental set-up at Fraunhofer IEE SysTec.*

2 *Measured time series for an islanding event of the test grid: the grid is stabilized and the power supply is sustained by the VSMs alone.*