Synthesizing Virtual Oscillators for Inverter-Based Power Systems (20160422, Dr. Sairaj Dhople)

Technology No. 20160422

IP Status: Pending US Patent; **Application #:** 15/581,824

Alternative to droop control for microgrids

This technology is an alternative strategy to droop control to enable the design of scalable microgrids and systems containing large numbers of power electronics inverters. Virtual Oscillator Control (VOC) is a decentralized control strategy for AC systems where inverters are modulated to emulate the dynamics of weakly nonlinear oscillators. This new design methodology enables VOC deployment on digital controllers and allows straightforward translation of a set of AC power system performance specifications directly into control parameters. A coordinate transformation is also leveraged to enable the user to obtain tunable relationships between the real and reactive power delivered by the inverter and the system voltage and frequency. This design flexibility essentially allows VOC to subsume the functionality of traditional droop controllers while enabling enhanced speed and responsiveness to dynamic conditions.

Satisfies standard AC performance specifications

Microgrids are a collection of energy sources interfaced to an AC electric distribution network that can be operated independently from the bulk AC system. Energy conversion is accomplished by power-electronics inverters, which are typically controlled to regulate the voltage amplitude and frequency of the inverters’ terminal voltage. Typically, the strategy employed to do this is droop control, which is only well defined in a sinusoidal steady-state and linearly trades off the inverter-voltage amplitude and frequency with real- and reactive-power output. Compared to droop control, Virtual Oscillator Control (VOC) is a time-domain controller that enables interconnected inverters to stabilize arbitrary initial conditions to a synchronized sinusoidal limit-cycle. The resulting models form a VOC design procedure such that the inverter satisfies standard AC performance specifications related to voltage regulation, frequency regulation, dynamic response and harmonic content.

Phase of Development

- Prototype developed

Benefits

- Facilitates design of highly distributed systems with no communication between devices
- Ultra-fast response enables stabilization of volatile systems
- Capable of working on controllers with different power, voltage and current ratings
- No modifications required to power electronics hardware
- Enables modular system design and construction
- Enables future infrastructure powered by electronics

Features

- Decentralized control strategy for AC systems
- Synchronizes interconnected inverters to form an interconnected AC system
- Inverters are modulated to emulate dynamics of weakly nonlinear oscillators
- Time-domain controller enables interconnected inverters to stabilize arbitrary initial conditions to a synchronized sinusoidal limit-cycle

Applications

- Distributed large-scale infrastructure (utilities)
- Microgrids (military or third world applications)
- Firmware development and low cost microcontrollers
- Power electronics and hardware design

Researchers

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Publications

Nonlinear supersets to droop control
2015 IEEE 16th Workshop on Control and Modeling for Power Electronics, COMPEL 2015, 12-15 July 2015
Synthesizing Virtual Oscillators to Control Islanded Inverters

IEEE Transactions on Power Electronics, Volume: 31, Issue: 8, Aug. 2016

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