CONTROL ALGORITHMS FOR NON-CONVENTIONAL DISTRIBUTED ENERGY RESOURCES

by

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ABSTRACT

There is a growing interest in the application of small and medium size generators to distribution networks. This interest is enabled by the changing regulatory and market environment and driven by new technologies that offer the potential for energy savings, reduced carbon emissions and service improvements. Extensive research on this topic has been reported in the literature especially in Europe, the United States, Japan, and Canada. In addition, market incentives are beginning to promote the application of Distributed Generation (DG) for small renewable energy technologies.

DG units are typically defined as small energy sources located close to the point of use. In addition to small conventional generation, such as reciprocating engines and gas turbines, new DG technologies have emerged based on non-conventional energy sources. These non-conventional generators are commonly built around energy sources that are fundamentally incompatible with a 50 Hz or 60 Hz power grid. Consequently, these sources require a Power Electronic (PE) converter to interface with the power grid. There is strong interest in enabling these non-conventional DG systems to provide backup power capability and grid independent operation. The literature has referred to such systems of autonomous generators and loads as Microgrids.

In practice, these applications are complicated by the extremely broad and nonlinear nature of Microgrid systems. This research work focuses on developing an asymptotically stable control strategy for non-conventional distributed generation in Microgrid applications. To enable this capability a Dynamic Frequency Control (DFC) strategy is developed and evaluated. The research defines the generalized conditions under which stability is ensured for a large system space. Further, the DG control design incorporates constrains on the power, current, voltage, frequency, V/Hz, and power ramp rates.

Performance is tested in simulation for a variety of routine and stressful Microgrid operating conditions. These test cases demonstrate the fundamental characteristics of the control for both grid interactive and grid independent operation. Stressful test conditions explore the voltage, current and power limit boundaries of operation. These cases include grid faults resulting in voltage dips, impedance jumps, and grid-connected to island transitions. Grid faults and load steps in island mode are also examined.