



Design and Prototyping of a Grid-Forming Inverter for a Microgrid

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The penetration of renewable energy resources in power systems is steadily increasing, leading to a transition from traditional centralized power systems to decentralized architectures incorporating microgrids. In microgrids, maintaining voltage and frequency stability is particularly challenging during off-grid operation, commonly referred to as islanded mode. To address this challenge, grid-forming inverters—inverters equipped with advanced control strategies that emulate grid characteristics—are required. This paper presents the design and laboratory prototyping of a grid-forming inverter capable of regulating voltage and frequency in an islanded microgrid. The proposed solution is achieved through a comprehensive control architecture consisting of outer-loop active and reactive power droop controllers and an inner-loop voltage regulation scheme. The system has been modeled and validated through extensive computer simulations. The system's dynamic performance, stability, and disturbance ride-through capability are evaluated under various operating conditions, including load variations, secondary control operation, and fault scenarios. The simulation results demonstrate that the proposed grid-forming inverter can significantly enhance the stability and reliability of renewable energy-based microgrids. A hardware prototype has been developed using a microcontroller, isolated sensing circuits, an intelligent power module, and an LC output filter. The laboratory prototyping procedure is presented, followed by preliminary experimental results required to validate the signal processing and pulse width modulation of the grid-forming inverter.

Keywords: Grid-forming inverter, Microgrid, Islanded operation, Voltage and frequency control