Island microgrids pristina

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Olivia Gieger is a science journalist covering climate change, ecosystem science, and conservation.

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The increasing investment in renewable energy sources has created greater urgency for inverters to improve in terms of efficiency and dependability. Multiple inverters must be operated in parallel at peak efficiency to satisfy the frequency, voltage, and power quality requirements of loads with diverse characteristics and qualities1,2. Various academic articles have classified methods for controlling parallel inverters. These studies have divided control systems into two categories: centralized and decentralized1,3,4,5. The modules in parallel inverter systems are frequently dissimilar, which leads to an imbalance in the distribution of load current. Therefore, certain modules may be carrying an excessively large current.

A master-slave controller will enhance system efficiency while minimizing circulating currents25,26. A simple analytical optimizer based on system parameters will also be proposed, along with a straightforward online estimator to estimate system losses. The master inverter regulates the output voltage via a PID voltage control loop. The controller continuously compares the measured output voltage with the reference signal to maintain the desired voltage level. The controller regulates power distribution among parallel inverters to ensure optimal efficiency. Synchronizing the currents of slave inverters with the master inverter eliminates circulating currents.

A review of related research reveals that prior studies have primarily concentrated on addressing specific issues, such as minimizing circulating currents, achieving equitable power distribution among inverters, maximizing system efficiency, or evaluating the reliability of paralleled inverters. These studies have typically relied on complex controller designs to address singular problems. This study aims to introduce an analytical optimization technique to maximize system efficiency while simultaneously minimizing circulating currents, all within a simplified control system.

Equation(1) utilizes the Park transformation to convert the voltages and currents of the three-phase inverter to stationary d-q axes. This simplifies the control system, allowing for separate control of active and reactive power and separate control of voltage and frequency29. After completing the control procedures, Eq.(2) converts the d-q values back to three-phase values. These values are then utilized to generate control signals for the inverters" power electronic switches.

According to Eqs. (3) and (4), the sum of the three-phase load currents and the three-phase currents of all N inverters in Fig.1 is zero. At the start of operation, the capacitor output voltages and capacitive currents are both equal to zero. To simplify the model of parallel voltage-source inverters, Eq.(5) shows a stationary d-q-o form of the system. The voltage on the capacitive AC bus remains constant, meaning that the voltage component vc0 is always zero.

where: the voltages vtdk, vtqk with k 1, ..., n are brought into the model as voltages drop and losses in inverter switches.

Equation(9) uses a filter for the differential component of the controller, which helps prevent system instability caused by noise. There are numerous techniques for determining the values of constants, such as Roth Horizon30,31.

Optimization is a process aimed at identifying the optimal solution from a set of possible solutions. This process encompasses two primary categories. The first category, known as deterministic optimization, relies on mathematical analysis of the objective function to identify the optimal solution. The second category, stochastic optimization, involves using heuristics that leverage random variables to determine the next steps in the optimization process34. In this part, several well-known optimization methods will be introduced, with which the proposed method will be compared.

The interior point method is a well-known deterministic optimization algorithm for optimization problems with nonlinear constraints. This method is a modification of several traditional optimization techniques, including Newton''s optimization method35,36,37. Hence, it will be employed in this study as a representation of deterministic methods.

The artificial neural network simulates the function of neural networks in the human body. The commonly used feed-forward type is designed for a control process that employs fixed weighted values to attain a predetermined solution. The recurrent neural network optimization algorithm modifies weighted functions to find the optimal solution by initially assuming random input values and weights. The system output is fed back to the input until the optimal function value is achieved42. Equation(18) enables the neurons to select new x values and compute function values using the random values for particles and weight functions in Eq.(19). Weight functions move towards the optimal weight through Eq.(20).