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Load sharing control of parallel operated single phase inverters

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Abstract

The parallel operation of inverter for distributed generation application that operates under different load conditions was investigated in this paper. A dual loop control in combination with conventional droop control was developed to control the module of inverter independently. The focus of the work is to attain proper load sharing among inverters through a simple yet efficient control strategy. The independent communication less control is achieved. Simulation is carried out in MATLAB/Simulink environment active and reactive power sharing of inverters were presented as simulation results.

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Keywords: Parallel Inverter; Distributed control; Droop control; Dual loop control;

1. Introduction

The growing energy crisis and the adverse effect of fossil fuel, necessitates the need for augmentation of power generation via renewable energy sources. The energy sources like solar-PV, wind turbine and fuel cells are largely used in a distributed network to meet the load demand which can be of either serving loads locally or injecting a clean power to utility grid/main grid. This can be termed as microgrid / minigrid [1]. The distributed energy sources are equipped with a power electronic interface like a DC/AC converter so as to integrate with the load, besides replacing a bulky and lossy transformers. The microgrid can be operated on grid and off conditions, termed as islanded and grid connected modes respectively [2]. Critical customer requirements such as increased power level at

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the output, reliability, expandability can be attained through parallel operation of DG with its power electronic interface [3]. Different architectural patterns of microgrid were suggested in the literature [4]. The structure of microgrid that serves the load demand of commercial and residential customers forming a class of microgrid as "Utility microgrid". Since the structure does not dictate the size, scale and growth rate of microgrid, proves to be a prerogative factor in microgrid research. The enigma of phase difference at the output affects the power quality issues like load sharing capability, harmonics due to circulating currents, voltage regulation. Hence, a control strategy that pulls off the power quality issues effectively is needed.

Review of different control strategies were inoculated in the literature [5]. The centralized architecture of microgrid constitutes a control mechanism at remote centre and are destined to serve concentrated loads. The aspects of resilience and reliability are in stake, during fault conditions [6]. The Hierarchical control architecture of microgrid put forth the scope of control and communication bandwidth between different layers of control as challenge [7]. The decentralized control architecture of microgrid, the DG could follow a prerogative approach in critical load management without communication pertaining to the capability of DGs [8]. The decentralized control supports the top notched qualities of microgrid like autonomy, compatibility, stability, flexibility, scalability, economics and peer to peer model in terms of control and operation.

In decentralized control, the droop control mechanism proved to be prolific and efficient in terms of independent control and power sharing in parallel inverter [9]. Eventually the droop concept arose the behaviour of synchronous generator whose frequency varies with load demand [10]. Now a days, augmentation of uneven loads poses problems of power quality, especially in balancing the active and reactive power among the inverter units [11]. A Virtual impedance or resistive loop which shares the harmonic current dynamically was proposed in [12]. The control of parallel units based on critical computation of the harmonic currents using algorithm was proposed in [13] whose system stability is at stake. Based on the core theory of conventional droop strategy, modified droop strategy evolved with auxiliary loops being added and constraints of the droop included to tackle dynamic load problem [14-17]. A universal droop controller was designed irrespective of the variation in output impedance with the use of absolute quantity as a feedback [18]. The bounded characteristics of droop in combination with zero gain property was proposed in [19]. Nevertheless all the control techniques requires complex computation of harmonic currents and addition of loops, with inherent trade-off between the voltage regulation and stability. Although conventional droop based control of parallel units inherits regulation and stability problem, the same with uneven loads was seldom addressed in the literature either without any auxiliary loops added to the control structure or with simple computations and control loop.

The paper seeks to provide a simple dual loop feedback control strategy based on the conventional droop reference for parallel inverter. The advantages of the proposed technique can be summarized as: Accurate load sharing with simple control logic, low THD with reduced impact of circulating current, simple design of tie line for parallel operation. Since the focus is on inverter stage control, the simulation is carried out on single phase inverter with the combination of droop and PI controller. The active and reactive power sharing under equal and unequal load were establishes as results. The Paper is organized as follows: Section 2 provides the system overview .Section 3 gives the control design of the system's Individual module. The simulation results were presented in the section 4.

2. System overview

The structure of parallel inverter in the islanded microgrid is shown in Fig 1[20]. The model assumes micro sources whose equivalent output is a constant dc source fed to a power electronic interface like an inverter. The inverters feeding independent load are connected in parallel with a tie line inductor.

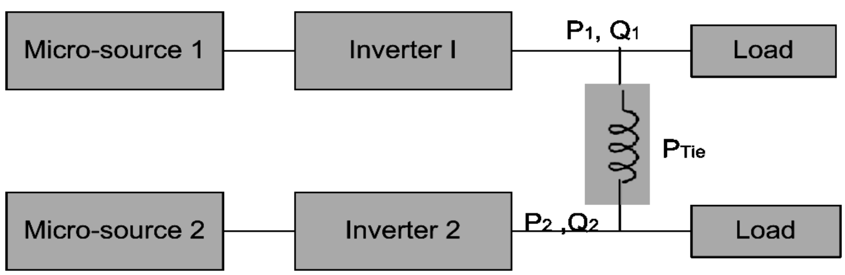

Fig 1. System of parallel Inverter feeding independent load [20]