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Refined Hybrid Microgrid Architecture for the Improvement of Voltage Profile

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Abstract

Hybrid microgrid is emerging as a flexible and modular solution that integrates various heterogeneous energy resources and loads. This conventional hybrid microgrid architecture can also reduce the number of power conversion stages, when compared to other architectures of microgrid such as, centralized DC bus and centralized AC bus architectures. But, these conventional hybrid microgrid architectures are having poor fault tolerant capacity that leads to severe power imbalances in the microgrid system. With this aspect, this paper propose the refined hybrid microgrid architecture that can handle system uncertainties and improves the voltage profile. The proposed refined hybrid microgrid architecture consists of two layers (AC layer and DC layer) through which each and every constituent of the microgrid is connected. This provides continuity in power supply to the microgrid loads via the possibility of bi-directional power flow between AC layer and DC layer. The proposed architecture is simulated using MATLAB/Simulink®. From the results, it is observed that, this proposed refined hybrid microgrid architecture improves the voltage profile of the system during faults.

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Keywords: Microgrid architecture; DC and AC buses; Voltage profile; Fault tolerant.

1. Introduction

Microgrid has appeared as an attractive for integration of renewable energy sources in the distribution networks which has advantages in terms of reliability and power quality. Therefore, microgrids are a suitable, reliable and clean

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solution to use local generation and also to the utility grid. Microgrids are present in different architectures based on AC and DC systems. They are AC microgrid, DC microgrid, hybrid microgrid. In AC microgrid [1] only AC main bus was exist which is connected with a utility grid through a PCC; sources, loads are connected to AC bus. An AC microgrid with DC storage was presented in [2], which has separate DC storage. In DC microgrid only DC main bus was exist which is connected with a utility grid [3], sources, loads are connected to DC bus. DC zonal microgrid architecture also presented in [4]. It has DC zonal busses are connected to a main AC bus.

The combination of AC and DC microgrid forms hybrid microgrid, [5], [6]. The AC and DC buses separated by an AC-DC bi-directional interlinking converter. The AC sources and loads are connected to AC bus through a transformer, DC sources and loads are connected to DC bus through a DC-DC converter. The battery storage system also connected to DC bus through a DC-DC bidirectional converter. The conventional hybrid micro grid is shown in Fig. 1, in which red colored line represents DC power flow and blue colored line represents AC power flow. A solid state transformer (SST) based microgrid system was presented in [7]. SST has a converter and high frequency transformer which provides power to AC and DC buses. AC and DC source, loads are connected to corresponding buses through a proper converter.

The conventional system was implemented based on [8-12]. Loads and sources are connected to either AC (or DC) bus through a bidirectional converter. The control logic and design of bidirectional converter was developed using [13]. The AC, DC filter specifications and design model was discussed in [14]. The integration of renewable energy sources to microgrid are discussed in [15, 16].

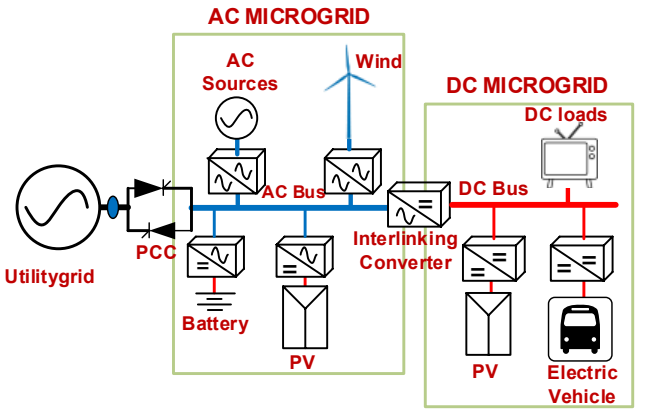

Fig. 1. Conventional microgrid architecture [5, 6].

The main drawback of a conventional hybrid microgrid architecture given in [5, 6] are:

- Power conversion losses ranges from 8-12% because of power electronic converters [17].
- If any fault occurred in AC (or DC) bus the fault part of DC (or AC) system is isolated from main system.
- Power imbalance in system because of weather conditions, i.e., PV generate DC power in daytime and wind generate AC power in presence of wind flow.
- In island operation, the difficulty in control of interlinking converter because of droop characteristics.

This paper presents a novel two bus hybrid microgrid architecture design for reliable power distribution system by considering the drawbacks of conventional hybrid microgrid structure. The main contribution of this paper are:

- Design of two bus/layer hybrid microgrid architecture.
- Design of a converters suitable for the proposed architecture.
- Control scheme for the inverter which is switches between AC and DC buses.
- Comparison of proposed architecture with existing architecture.