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New Integrated Converter for Hydrogen Buffer Interfacing in Distributed Energy Systems

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Abstract. This paper presents a new integrated (multiport) DC/DC converter for hydrogen buffer interfacing in renewable energy systems. In comparison with traditional solutions based on individual converters for interfacing of electrolyser and fuel cell the proposed topology features the reduced energy conversion stages. The paper analyzes and discusses the operating principle of a new converter. Several guidelines are presented for the new converter design. Finally, theoretical background was verified by the simulations.

Key words

Distributed energy systems, electrolyser, fuel cell, interface converter, multiport converter

1. Introduction

The energy conversion from renewable energy sources, such as wind turbines or photovoltaic arrays can play an important role in the development and operation of distributed energy systems (DES) [1, 2]. Due to the unpredicted nature of primary power sources (wind, solar) power fluctuations could appear in DES. Moreover, electrical production is not subject to the demand, which usually results in an unbalanced system [3]. The way to overcome these problems is to implement the long-term energy storage within the DES.

In recent years, implementation of hydrogen-based long-term energy storages in distributed energy systems has attracted much attention [2, 4-6]. Typically, the main components of such a system are an electrolyser (EL), hydrogen storage system and fuel cell (FC) (Fig. 1). Since the FC has a slow response time and also prefers to be operated under constant power, a battery is often used as additional energy storage in order to compensate the peak power demands.

As it seen from Fig. 1, for the proper voltage matching the main components of the hydrogen buffer should be connected to the DC-bus of DES via different power electronic converters: electrolyser is interfaced by help of step-down DC/DC converter, while the fuel cell is connected by help of step-up DC/DC converter. Typically, the battery is placed on the secondary side of the power conditioner of a fuel cell and its charging/discharging processes could also be more conveniently controlled by the power electronic interface.

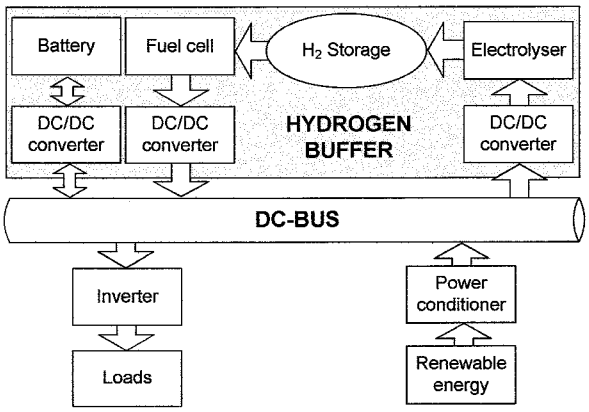

Fig. 1. Typical structure of the distributed energy system with hydrogen buffer interfaced via individual converters.

Traditionally, individual converters are used to provide interfaces for the power inputs and outputs of the hydrogen buffer. In principle, any basic power converter topology can be used to design a power interface for a fuel cell and electrolyser. All these converters should have a high-frequency voltage matching transformer, which could also perform a function of galvanic isolation demanded in several applications. It finally leads to complex multiconverter systems (Fig. 1) with a high number of energy conversion stages, complex control and reduced efficiency.

This paper proposes the new integrated DC/DC converter for hydrogen buffer interfacing in distributed energy systems (Fig. 2). Thanks to the implemented multiport converter concept (Fig. 3) the number of energy conversion stages was significantly reduced. The resulting advantages of that include reduced component