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A novel anti islanding detection method for grid connected fuel cell power generation systems

*Gökay Bayrak**, *Mehmet Cebeci*

Firat University, Faculty of Engineering, Department of Electrical and Electronics Engineering, Elazig 23119, Turkey

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ABSTRACT

Renewable energy sources have been developed rapidly all around the world, and one of these green energy sources is hydrogen energy. The fuel cell systems have become prominent in renewable energy sources because of its minimal dimensions and energy conversion method. There have been developed, some applications, especially in domestic and automotive areas, and fuel cell systems are also have been started to use in grid connected systems. Fuel cell systems must have some electrical connection standards while they connected to an electrical grid. One of these electrical conditions and may be the most important one is unplanned islanding condition. Islanding is a very dangerous situation because it can damage to the fuel cell and related electrical systems and also working people have been at risk in islanding situation on the grid. In this study, a novel islanding detection method was introduced for grid connected fuel cell systems. 0.5 kW solid oxide fuel cell (SOFC) system used in developed experimental system and a novel anti islanding detection method was researched by using an effective method. The proposed method was also developed by using Matlab Simulink and its useful tools. The developed islanding detection method is robust, reliable and has a fast response time, according to present methods. The results confirm the suggested conditions, and it can be seen in this method, it can also be adapted easily to the grid connected fuel cell systems.

Introduction

Hydrogen energy is one of the most promising renewable energy sources in the distributions generation (DG) [1] and Fuel Cell (FC) technology has been rapidly developed in the last decade [2]. In a grid connected FC systems, particularly, the connection of FC stacks and balance of system to the utility grid has to fulfill the technical requirement of interconnects from the utility grid. This is to ensure high power quality; substantial safety interaction and reliability of the utility are achieved.

Therefore, abnormal operating conditions that could affect the grid-connected FC systems have to be prevented [3]. One of the major security issues related is the challenge to avoid unintentional island mode of operation. An islanding mode is a condition in a DG which the energy resource continues to supply to the local load even though the utility grid has been disconnected from the local load [4,5]. Islanding mode of operation makes the utility grid to be disconnected from the

* *Corresponding author*. Tel.: +90 424 2370000.
E-mail addresses: gbayrak@firat.edu.tr, gokaybayrak@gmail.com (G. Bayrak).

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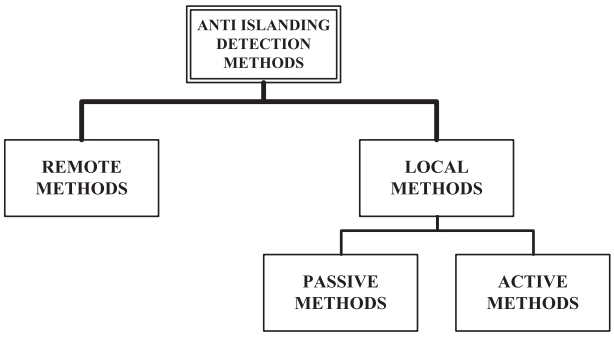

Fig. 1 – Classification of islanding detection methods.

DG in order to prevent any damage in the system. Under this condition, the grid is no longer servicing as a solid voltage and frequency reference. During islanding mode, the utility circuit breaker is opened while the DG is still injecting power to supply the local load (the section between utility circuit breaker and the point of common coupling, PCC). This phenomenon occurs when utility suffers from unpredictable interruption of abnormality, such as voltage shutdown, short-circuit or equipment failure [6].

There are two types of islanding modes, namely the intentional (planned) and the unintentional (unplanned) islanding [7,8]. The purpose of intentional islanding is to sectionalize the utility system in order to create a power 'island' during an occurrence of disturbance. This is a general scenario, especially for maintenance purposes. The local load in the created island will be supplied constantly by DG through a well-planned energy management until the utility is ready to be synchronized with the DG.

Typically, intentional islanding is harmless to the power system because the problem can be solved during or after the grid disconnection [9]. However, unintentional islanding can create a severe impact to the power system stability due to the loss of grid synchronization. Consequently, this makes the DG to be out of the voltage and frequency references. This may damage the electrical devices and systems equipment in the islanded section.

Another issue persists in the islanding mode whereby the technical workers may be placed under safety hazards as they may not be aware that the part is continuously powered by the DG. For this reason, anti-islanding control is essential in order to detect the islanding operation immediately.

Subsequently, control signal should be sent to alert the entire system to perform the disconnection of DG from the local load [10]. Various anti-islanding algorithms and detection methods have been developed [11,12]. The methods can briefly be classified into two families, namely local islanding detection techniques and remote islanding detection techniques. The former method relies on the measurement of system parameters at the DG while the latter is based on the communication between the utility grid and the DG. The other control techniques under the two main families are summarized in Fig. 1 which shows the hierarchy of islanding detection [13].

According to the information gathered from the literature review, none of the islanding detection methods are perfect. Some limitations may include [14–18]:

- Presence of non-detected zone (NDZ) causing possible anti-islanding detection failure,
- Degradation of power quality and system stability,
- False operation in multiple DG,
- Requirement of additional circuitry or equipment,
- High implementation cost.

Therefore, further research and development of anti-islanding detection algorithm still need to be sought to minimize the pitfall of the assisting techniques. In the last decades, there have been also some practical and innovative studies about this subject [19–23].

In this study, a novel islanding detection method was developed for FCPG systems. Developed method is a hybrid method which uses the effective ways of communication based methods and has no NDZ. Also, islanding detection time is faster than lots of other methods, and it can be easily adopted to FCPG systems and has a reliable and robust solution to the islanding situation. For this aim, an experimental study was achieved in the laboratory and FCPG, and utility grid interaction was investigated. All simulations and experimental results were detailed explained in the paper.

Islanding in fuel cell power generating (FCPG) systems

An islanding mode is a condition in a DG which the energy resource continues to supply to the local load even though the utility grid has been disconnected from the local load [3,4]. A general concept of islanding formation is illustrated in Fig. 2.

Islanding mode of operation causes the utility grid to be disconnected from the DG in order to prevent any damage in the system. Under this condition, the grid is no longer servicing as a solid voltage and frequency reference. Defining the islanding detection methods is important for understanding the proposed islanding detection method.

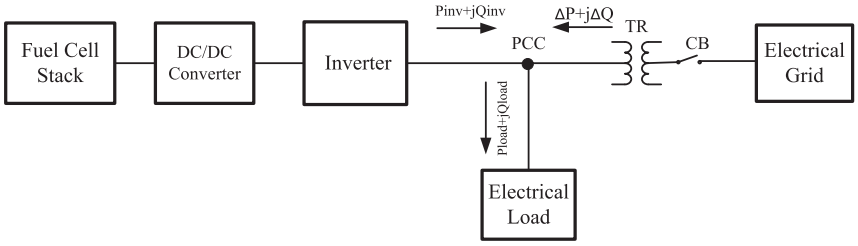

Fig. 2 – Islanding in an FCPG system.