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Effectiveness of frequency relays on networks with multiple distributed generation

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Abstract

Distributed generation (DG) has gained a vital role in distribution utilities. So, it is important to correctly detect islanding of DG units. Frequency relays are one of the most commonly used loss of mains detection method. However, distribution utilities may be faced by concern related to false operation of these frequency relays. The commercially available frequency relays reported considering standard tight setting. This paper investigates some factors related to relays internal algorithm that contribute to their different operating responses. The factors that will be investigated are frequency measuring techniques, measuring windows, time delays and under voltage interlock function. With the increasing penetration of DG into the network, it is becoming common to have multiple DG units connected at the same network location. Two generators connected at the same location and employing frequency relays with the same setting but different characteristics were simulated. When subjected to the same network disturbances the possible interference between the two relays is analyzed.

Keywords: Distributed generation; Islanding detection; Multiple generation units; Frequency relays

1. Introduction

Nowadays, distributed generation has recently gained a lot of attention related to its connection to distribution network (Xu et al., 2004). Although distributed generation units have many benefits such as stability and economy, it suffers from some critical problems that may affect these benefits. One of these problems is "islanding phenomena" (Jenkins et al., 2000). Islanding occurs when a portion of distribution system becomes electrically isolated from the remainder of power system, yet continued to be energized by distributed generators (Beddoes et al., 2005). Failure to trip islanded generators can lead to safety risks to the utility personnel, deteriorate the quality of supply in the island and cause damage to the distributed generator and loads. In an attempt to minimize such risks, each distributed generator should be equipped with an islanding detection device to disconnect it after islanding occurrence within 250–350 ms

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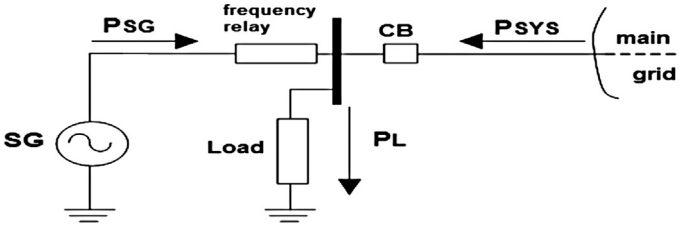

Fig. 1. Equivalent circuit of distributed generator equipped with frequency relay operating in parallel with utility.

(Beddoes et al., 2005). So far, frequency relays have been recognized as one of the most sensitive and economic devices used for islanding detection technique. However, the settings of these relays should be carefully selected to avoid false tripping (Freitas et al., 2005). To avoid this problem it is required to balance between sensitivity and dependability. Variation in performance of commercially available frequency relays lead to difficulty in selecting the right setting of these relays, despite being subjected to the same network disturbance. In this paper different operating responses of frequency relays are being investigated as a result of change in the used internal algorithm, i.e. frequency measuring technique, measuring windows, time delays and under-voltage interlock function. This paper also focuses on the interpretations of these algorithms and its impact on relay's sensitivity. Further, with the increasing penetration of distributed generation into the network, it is becoming common to have multiple distributed generation units connected to the same network location. Two generators are connected to the same feeder and employing frequency relays are simulated. The relays behavior with the same and different setting is analyzed. This paper also analyzes performances of frequency relays when subjected to the same network disturbances to avoid interference between multiple frequency relays. Results of simulated scheme are reported.

This paper is organized as follow: The frequency relays operation is presented in Section 2. Then, the results of simulated scheme are reported in Section 3. In Section 4 simulations with multiple DGs are presented. Finally, in Section 5, the main conclusions are analyzed.

2. Overview of PSCAD software

PSCAD (power system CAD) is a powerful and flexible graphical user interface to the world renowned EMTDC solution engine. PSCAD enables the user to schematically construct a circuit, run a simulation, analyze the results, and manage the data in a completely integrated, graphical environment. Online plotting functions, controls and meters are also included, so that the user can alter system parameters during a simulation run, and view the results directly. PSCAD comes complete with a library of pre-programmed and tested models, ranging from simple passive elements and control functions, to more complex models, such as electric machines, FACTS devices, transmission lines and cables. If a particular model does not exist, PSCAD provides the flexibility of building custom models, either by assembling them graphically using existing models, or by utilizing an intuitively designed Design Editor. PSCAD, and its simulation engine EMTDC, have enjoyed close to 30 years of development, inspired by ideas and suggestions by its ever strengthening, worldwide user base. This development philosophy has helped to establish PSCAD as one of the most powerful and intuitive CAD software packages available.

3. Overview of frequency relay

An equivalent circuit of a distributed generator with frequency relay operating in parallel with a distribution utility is showed in Fig. 1. The distributed generator (DG) is inserted to feed a load. The distribution utility may provide or consume power, this depend on power supplied by distributed generator. Therefore, the system frequency remains constant. If the circuit breaker (CB) opens, due to a fault for example, the system composed by the distributed generator and the load becomes islanded. In this case there is active power mismatch between generation and consumption due to, the loss of main power from utility.

This mismatch in power causes transients in the islanded system and the system frequency starts to vary dynamically. The islanding condition can be detected easily depending on this mismatch or imbalance in active power between source and load. Thus frequency relay can be an effective method in islanding detection in this situation (Hashemi et al., 2012).