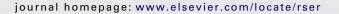
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A review on islanding operation and control for distribution network connected with small hydro power plant

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ABSTRACT

Hydro power generation is the oldest generation and provides the largest contribution among the renewable energy types of generation. In distribution system, most of the distributed generation (DG) is small scale hydro generation of which utilizes the natural flowing water of the river. This generation requires governor and excitation control unit to control and sustain the power generation when subjected to any changes of load behavior. More advanced control strategy is critically expected when considering the recent interest in distribution system to perform islanding operation of DG. Many of the literature have clearly highlighted this issue, but only a few have discussed on the islanding operation of small hydro generation. This paper therefore reviews this topic and relates the discussion with the controller designed for other type of turbines interfaced with synchronous generator. To strengthen the knowledge on islanding operation, the background of islanding is also presented in this paper.

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1. Introduction

Over the last decades, numbers of distributed generation (DG) that are being connected to a distribution grid has substantially increased to meet an increased power demand from the industry. The DG are using renewable energy sources (water, solar, wind, biomass, etc.) and non-renewable sources (diesel, natural gas, etc.) to produce power which range from as low as 1 kW to as large as 1000 MW [1]. Their presence benefits the end user, the power utilities and the DG's owner in terms of reliability, efficiency of power, economics and etc. However, the interconnection of the DG with the grid changes the traditional power flow in a radial distribution system (from source to load) and thus affects the existing protection coordination setting. Moreover, the interconnection has emerged several technical issues. One of which is the islanding. Islanding or loss of main (LOM) is established when a part of the utility system (load section) is energized by the DG after being isolated from the rest of the utility system [2].

Considering the severe consequences islanding can bring, IEEE STD 929-2000 [3] and IEEE STD 1547-2003 [4] agreed that islanding should be prevented. However, benefits of DG will not be fully explored if the DG always needs to trip off every time the utility loses supply. With the high penetration level of DG expected in the near future, this tripping scenario is inappropriate and causes inconvenience for customers. Implementing an intentional islanding operation of DG will establish continuity of supply whereby the DG must be viable to take over the role of grid by independently feeding the whole island. Thus, this helps to improve reliability of supply to customers.

Realizing the benefit of intentional islanding could offer, in 2004, IEEE 1547 group has developed a draft series of guide referred as P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island System with Electric Power System [5]. This document will serve as a guide for practicing an intentional islanding operation in electric power system.

Recently, there have been many research works reported on intentional islanding operation of DG. Most of the islanding operation were designed and modeled based upon the type of DG connected in the island. The DG can generally be categorized as rotating type and inverter type. For each type, different angles of research have been explored and tested. These research emphasized on achieving a good dynamic response during islanding operation. This factor helps to sustain the island within the power quality. To achieve it, the DG's controllers were designed specifically to operate in two modes of operation: grid connected and islanded. For synchronous DG, the dynamic response varies from turbine to turbine. Due to water inertia, a hydro turbine exhibits the slowest response than a diesel, gas and steam turbine when subjected to a disturbance or when the network is islanded. This has given researchers a challenge in designing a speed governor controller for the hydro turbine generator. The governor must capable to control the speed of the turbine so as the island frequency during transient condition is within the acceptable range of frequency protection setting.

Conventional governor such as mechanical-hydraulic and electro-hydraulic type with PID [6,7] are well known with their widespread used in the hydro power plant. However, these governors are unable to give their best performance for all operating condition particularly during transient. Over the years, to improve reliability, more advanced governor models for hydro turbine categorized as digital/electronics governors have been developed [8] to replace the conventional electro-hydraulic with PID. This governor's controllers have been designed/analyzed using several methods. Most of which using an adaptive control (i.e. using fuzzy logic [9,10]), intelligent control (i.e. artificial intelligence (AI)) and micro-controller based [11]. It is a normal practice to adopt this

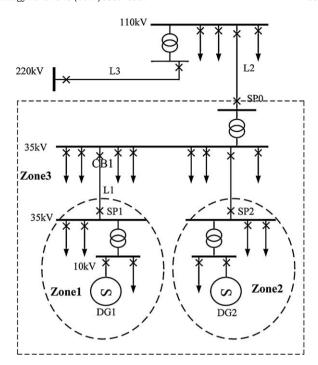


Fig. 1. An example of different zones of islanding area [12].

type of governor in facilitating various applications in an islanding operation.

The primary objective of this paper is to review research works on intentional islanding operation for small hydro power plant. Since not many research works have described specifically on the control technique deployed for the hydro turbine governor to facilitate islanding operation, this paper extends the review on control techniques adopted for different types of governor(diesel and gas generator) which would be feasible for the hydro governor's application. The operation of single unit of DG as well as multiple and mix type of DG units are discussed. This paper will also presents an overview on islanding, islanding detection technique for rotating type DG and the current practice on islanding.

2. The background studies: islanding

2.1. Islanding formation

Islanding also known as loss of mains or loss of grid, is formed when a part of the distribution network that connected with a DG/DGs becomes electrically isolated from the utility supply but continue to be energized by the DG for supplying power to the loads. The formation is only possible with a condition that there is sufficient generation to meet the island loads. Otherwise, load shedding can be taken in place. A wider islanding coverage can be formed with a numbers of interconnected DGs in a distribution network. Fig. 1 illustrates an example of different islanding coverage (areas) which are formed with the opening of associate circuit breakers. The islanding area can be based of substation, one or more distribution feeder and voltage levels.

2.2. Concerns of unintentional islanding

Unintentional islanding is the state that one or more DG units unintentionally continue energizing a section of distribution network when the network loses supply. The system can be exposed to hazards and risks particularly when it is not being designed to

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