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Insulation coordination associated with distributed generation connected at distribution level

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ABSTRACT

Insulation coordination is defined as the selection of dielectric strength of equipment, taking into account the over-voltages that could appear in the utility system and with the presence of protective devices. Electromagnetic transient (EMT) over-voltages are regarded as disturbances due to lightning surges and switching surges that result in the disruption and possible damage to equipments. The principal subject of this paper is to perform insulation coordination on the distributed generation (DG) by using methods of modeling lightning surges and switching surges. PSCAD/EMTDC is the main software used for the modeling and simulations.

1. Introduction

Voltage stability is a major concern in planning and operations of power systems. It is well established that voltage Instability and collapse have led to major system failures [1–5]. As technology evolve, changes to the system become inevitable. However, proper study must be conducted to gauge the effects of these new technologies incorporated in the system.

In the past, electromagnetic transient analysis has not been simulated in detailed models for distribution systems in Malaysia. This is due to their past experiences where electromagnetic transient overvoltage does not pose critical problems to the distribution substation equipments [6–8].

Distributed generators (DG) are small generators using renewable energy (RE) resources connected to the distribution system at medium voltage (MV) [9]. In recent years, DG is gaining popularity due to global warming and environmental obligations [10]. DG is a powerful approach for the future to provide clean, efficient and reliable energy system by maximizing the use of affordable energy resources. Therefore, performing insulation coordination is necessary to protect DG equipments. [11].

A sample case distribution system load flow data in PSS/ADEPT and single line diagrams with Kenerong Hydro Power Station interconnected was obtained from Tenaga Nasional Berhad Distribution (TNBD) to perform insulation coordination. The Hydro Power Station consists of two stations known as Upper Kenerong and Lower Kenerong Stations. It is a TNBD 33 kV distribution system located in Ulu Kelantan, north east of Peninsula Malaysia.

2. Lightning surge analysis methodology

PSCAD models were created to perform lightning surge analysis on Kenerong Hydro Power Station. The implementation of lightning surge analysis is based on surge impedances of distributed circuits such as distribution lines and busbars. Surge or stray capacitances measured from the equipments to ground were also considered. Lightning surges frequencies vary from 10 kHz to 1 MHz [12].

When all necessary equipments are being accurately modeled, lightning will be stroked at incoming distribution lines into the DG power stations. Various tests are performed by opening or closing the circuit breakers, connecting the transformers and lines in order to obtain the worst overvoltage from these combinations. These various cases are shown in Tables 2.2b and 2.2c. The highest overvoltage is being monitored at the following locations [13]:

- The Highest line to ground overvoltage at various points in the DG power station.
- The Highest line to ground overvoltage at the incoming of each distribution lines, generator transformers and busbars.

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