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Modeling and Dynamics Study of Large Scale PV System Connected Malaysian Grid under Different Fault Conditions

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Abstract— **The installation of photovoltaic power plants and integration with electric grid has become more widespread. As there is a significant increase in the size and capacity of grid-connected power plants, the stability and reliability of the grid become more important. A 1.5 MW PV station connected to the distribution side of the Malaysian grid via a voltage source inverter is modeled and simulated using Matlab/Simulink. This study presents the modeling of PV module behavior and characteristics based on the mathematical model equivalent circuit. The Simulink was run to simulate PV array sizing depending on perturb and observed maximum power point technique to enhance the efficiency of modules, and obtain maximum available power using variable perturbation step size dependent on power changes. The simulation result was matched to the results of sizing calculation. The inverter control system modeling and park transformation were carried out. Phase locked loop was used to track the grid frequency and voltage. The Malaysian grid-connected PV system is designed and modeled according to the regulations and guidelines of Tenaga Nasional Berhad concerning grid-integration of PV power generation system to LV and MV networks. Finally, this paper analyzes the dynamic response of the proposed PV plant under various types of symmetrical and non-symmetrical grid faults. The results indicated that the short circuit faults in the distribution grid side had disturbing effects on the optimal operation performance of PV systems. Whereas, the influence of grid faults depends on the fault type. In addition to that, the simulation result proved that the symmetrical fault has higher impact on PV system operation than non-symmetrical faults.**

Keywords— — Fault analysis; PV system modeling; Grid-connected inverter; Malaysian grid; Distribution system.

I. Introduction

Over the past few years, the distribution generation (DG), e.g. fuel cell, wind energy, and PV system, has been significantly connected to the distribution network [1]. The PV system is considered as one of the most important DG due to the bulk photovoltaic power plants (PVPPs) that are installed and interfaced to utility grid, mainly at low and medium voltage levels of distribution system. Today, there are thousands of photovoltaic power plants integrated with power grid in many regions and countries. The increase in use and the significance of PVPP are because it is uncontaminated, has less impact on the environment, freely available , less maintenance requirement as compared to other resources, noiseless, and easy to expand. Therefore, the total installed capacity of photovoltaic generation of electrical energy has increased dramatically from 40 to 177GW between 2010 and 2014, respectively [2, 3].

As the number and size of grid-connected power plants increase, the stability, reliability, and power quality deteriorate [4, 5]. Additionally, as PVPP capacity increases, the load served by these plants increases as well. Therefore, more investigations are required to study and understand the effects of PV-grid integration in order to keep the system secure and stable. As a consequence, the grid code (GC) applied to traditional power plants integrated with power system has been improved due to the continuous changes and new technical requirements such as reactive current injection during the fault in addition to fault ride-through (FRT) capability. FRT is the PV inverters' capability to remain connected to the grid in the event of voltage sag or disturbance due to faults in grid like not supplying any active power during the fault, and delivering active power directly after clearing the fault, thus stabilizing the grid. These new regulations have been newly absorbed to the GCs for large-scale PV plant integration in some countries such as Germany, Italy, US and Spain [3, 6, 7].

Power electronic inverter play an important role in grid-interconnection PV system as inverters need to align with power conversion and control optimization [8]. In general, grid connected pulse width modulation (PWM) voltage source inverters are commonly used in PV system, which at least have two capacities due to the special components of PV modules. Firstly, the DC-link voltage of the inverter is balanced to a particular value because the yield voltage of PV panels fluctuates with weather condition in addition to the impact of MPPT. Secondly, the energy should be fed from the PV panels into the utility network by modifying the DC