Reduction in Power Fluctuation when PV modules are connected to Grid by using PI controllers

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Abstract - *This topic presents economical method to reduce power fluctuations generated from grid connected photo voltaic modules. Normally there are three methods to reduce power fluctuations. 1. By using Battery storage systems, 2. By using dump load, 3. By operating PV module below MPP. The increase in the utilization of renewable energy leads to the well literacy about the need of renewable energy and its effective and efficient use. The more concentration is in the comparative analysis of methods to reduce solar fluctuations by using a very economical and cost effective method called P-I Controlled solar system. Moreover, the effect of varying different parameters of the problem is investigated through sensitivity analysis. MATLAB/SIMULINK is used to verify the performance of the proposed.*

1. INTRODUCTION

Nowadays electrical power systems are becoming very complex due to introducing new and advanced renewable energy generating units [1]. Such systems when loaded cause small disturbances in the systems. These small disturbances affect the stability of the power systems. In short power quality of the system is affected to great extent [2].

PV Panels generate fluctuating power. These fluctuations have a negative impact on stability and power quality in electrical power system. This disturbance travels through system and can cause a flicker. On the PV system side, energy storage devices like batteries can be used as smoothing devices for a PV system's output. There have been investigations aimed at improving the performance of PV systems equipped with batteries [3]. However, energy storage device. increases capital cost, as it needs maintenance. The maintenance cost mainly depends on charge/discharge action of battery. Therefore, controlling the charge/discharge action along with maintaining the energy storage ratio near 50% is a issue need to be addressed. Besides, optimal capacity and minimum capital cost of the ESS needed to reduce the PV out put Power fluctuations should also be investigated. However, in previous investigations, the optimal size of battery and battery parameters for charge/discharge action are not considered. In this paper, to address the above given issue, a control methodology for ESS along with PV generator is presented, which will maintain storage energy ratio of the battery up to 50% and will select optimal size of the battery needed for smoothing PV output power fluctuations. From the simulation results, it has been found that the proposed method works well to reduce the PV output power fluctuations and also selects the optimal ESS capacity needed for it maintaining the energy storage ratio near 50%.

1.1 Background

One of the objectives of this paper is to examine the economical aspect of installing a battery-based storage (BS) system to reduce the power fluctuations of a large PV system, with rating in the order of megawatts. This can be achieved by estimating the maximum revenues that the system owner can obtain after installing the BS system. To achieve this task, a linear programming (LP) problem that can calculate the revenues of selling the PV energy to the grid is formulated. The optimization problem also enables the estimation of the battery power and energy ratings. Another objective of this paper is to investigate other methods that can be used to reduce the power fluctuations. One of these methods is to install a dump load to dissipate the excess PV power. Another method is to curtail the PV power by operating below the maximum power point (MPP). For all investigated methods, the revenues are compared with those obtained from the PV system without any reduction in the fluctuations, which is considered the base case.

1.2 Need

To develop a method that considers the fluctuations in the PV output power when studying the impacts of installing large PV systems on the performance of

Distribution networks prior to installing these systems. The method used in such a study can provide accurate evaluation of the possible impacts by covering the following aspects:

• Estimating the profile of the output power of the PV system using long historical time series data of irradiance and temperature. Hence, the estimated profile will retain information about the fluctuations present in the output power of the system, and thus, can be utilized in the chronological simulations.
• Considering the actual data of the electric network in the analysis in order to provide realistic results about the performance of the network.
• Utilizing the long historical time series data of the output power generated from the PV system efficiently by reducing its size while retaining the useful information it contains.

2. Objectives

To study the possible solutions that can be adopted to reduce the negative impacts of installing a large PV system on the performance of the electric network, especially due to power fluctuations. These solutions include:

• Selecting the appropriate penetration level of the PV system for a specific distribution network.
• Selecting the suitable location for installing the system, from a number of candidate locations.
• Studying the economical value of using energy storage devices, such as batteries, to control the power injected into the grid.
• Studying the effectiveness of operating the PV system below the maximum power point and its economical impact.

3. System Description

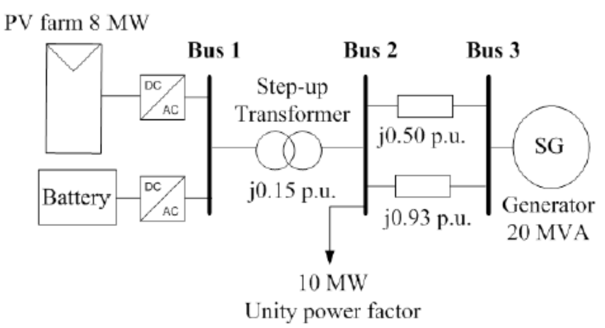

Figure: 3.1 Topology of Photovoltaic Grid Connection

The grid-connected PV system used in this paper can be illustrated in Fig. 3.1. The system consists of a PV farm with the BESS, connected to the utility grid through a step-up transformer located at bus 1. The utility grid is modeled as a synchronous generator at bus 3. A constant power load with unity power factor is located at bus 2.

Mathematical models of each part will be described in the following sequence, PV system's model, Grid-connected PV model, and lead-acid battery model.

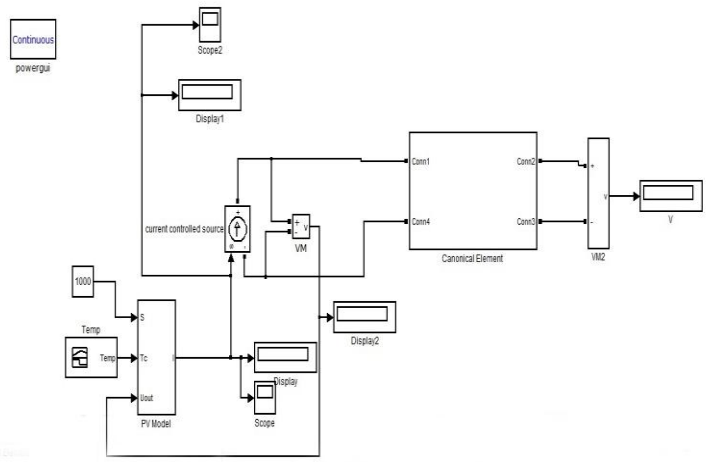

Figure 3.2 Simulink Model

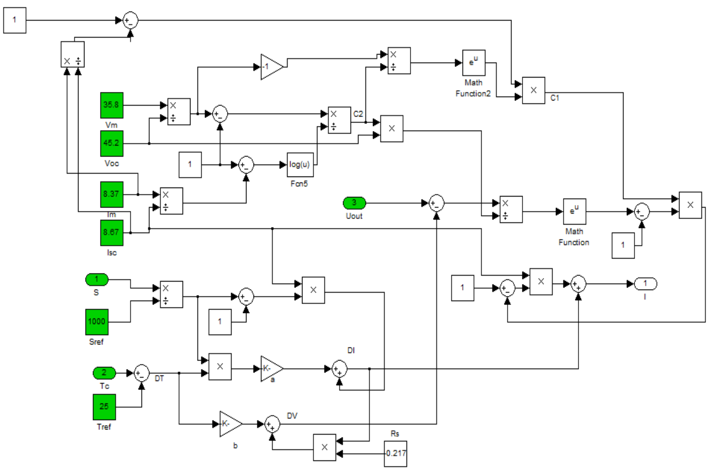

Figure 3.3 Internal Circuitry of PV Panel Simulink Model.

4. Equations Used to Design the System :

$$I = (1 - A) \times I_{sc} + C \qquad (1)$$

Where,

$$A = (e^{y} - 1) \times B$$

$$y = \frac{U_{out} - D}{X}$$

$$B = \left(\frac{V_m}{V_{oc}} - 1\right) \Big/ \log\left(1 - \frac{I_m}{I_{sc}}\right)$$

$$C = \left\{\left[S \big/ S_{ref} \times \left(T_c - T_{ref}\right) \times K_a \right] + \left[\left(S \big/ S_{ref} - 1\right) \times I_{sc}\right]\right\}$$

$$D = \left\{\left[\left(T_c - T_{ref}\right) \times K_b\right] + \left(R_s \times C\right)\right\}$$

5.Result:

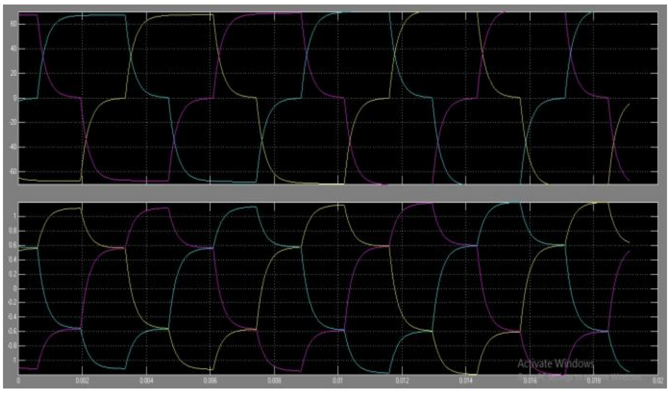

Figure 5.1 Current & Voltage waveform when PV panels are connected to grid.

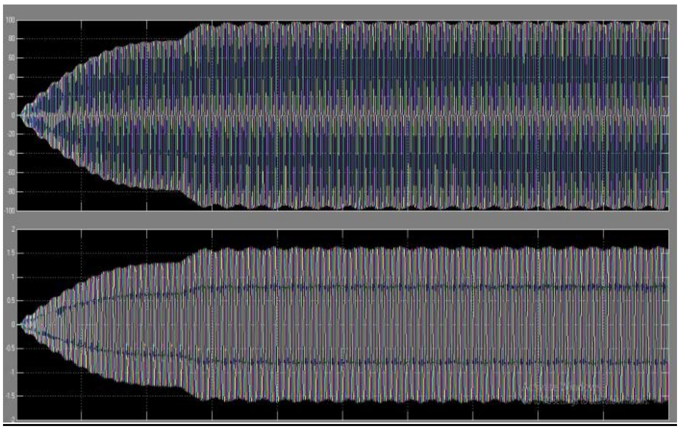

Figure 5.2. Reduced Fluctuations in current and voltage waveforms.

Conclusion:

This work explains how PI controller is economical to reduce fluctuations generated when large PV modules are connected to the grid. This paper will help to provide Renewable power with high power quality and cost effective manner.

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