The impact of large scale photovoltaic systems on the harmonic increase in distribution networks

I. Etier[1], M. H. Abderrazzaq[2] , A. Al Tarabsheh[3] and M. AlBdour[4]
[1]Energy Engineering Dept., Zarqa University, Zarqa, Jordan
Tel +962799050723, Email: ietier@zu.edu.jo
[2]Hijjaw Faculty for Engineering Technology, Yarmouk University, Irbid, Jordan
[3]Electrical Engineering Dept., American University of Sharjah, Sharjah, UAE
[4]Electrical Engineering Dept., German-Jordan University

ABSTRACT

The significance of electricity generation by Photovoltaic systems comes from the direct conversion of light into electrical energy. Although such system is widely used in small scale, the tendency to apply it in large scale is gaining ground day after day. However, large generation systems of this type are associated with their own problems arising when they are connected to the national grid. One of these problems is the generation of harmonics from control and power conversion devices included in Photovoltaic system. In this paper, the mutual impact between large-scale photovoltaic generation systems and electrical grid will be studied in terms of power quality. This requires building a model of large-scale photovoltaic system, connecting it to the grid and testing it under various conditions. Several scenarios will be proposed for the operation of such system taking into consideration the penetration level of solar system, loading levels and load composition of the examined grid. The key elements, exciting harmonic problem, will be identified in this work and the issues related to such phenomenon will be studied in parallel with other operational patterns dominating in distribution grids. As being relatively intermittent source of energy, photovoltaic will have some means of protection and control which will be considered as parts of this system.

Keywords: Photovoltaic, generation, solar, harmonics, distribution and grid

1. INTRODUCTION

The continuous increase in oil prices and the frequent warnings of limited resources and reserves of such fuel have pushed the decision makers in energy industry to accelerate the use of renewable energy, especially the wind and solar. The intermittent nature of wind makes it unfavorable in many locations, whereas electricity generation by Photovoltaic (PV) is more stable and reliable. Therefore, the installation of PV arrays is not limited to residential load at low voltage, but it extends to include the medium voltage at utility scale. The introduction of this new approach of electricity generation system has its own influence on the performance of distribution networks including the power quality of the supply.

The presence of a high value of Total Harmonic Distortion (THD) is one of the main indices of power quality poorness. On the other hand, the large scale of PV integration into distribution network needs a robust system of control devices, converting equipment and protective relaying. With the increase of non-linear loads within these systems, the harmonic penetration level will be augmented. Therefore, one of the vital concerns of distribution utilities is to take the required precautions and to conduct the necessary research to be immune from the side effects of PV large scale distribution.

Although the main concern in PV development and application was on the improvement of cells efficiency, several researchers were interested in PV integration with electric grid [1-3]. Another group of workers have tried to use suitable simulator to study photovoltaic generation systems and connect them with the grid [4], whereas some investigators have attempted to reduce the harmonic impact by applying new topology for PV generation systems integrating current harmonic compensation by using two inverters. The first one was with a feedback loop to compensate the low order harmonics, and the second one with a feed forward loop for compensating high order harmonics [5].

Despite the importance of the above works, the research of harmonic generation associated with large scale PV systems is still in need for more investigation and further study. In the present work much attention is paid to individual harmonics in addition to the THD for existing distribution systems. In comparison with other works, the present paper demonstrated and tested a model of large scale PV system. In addition, several scenarios were proposed for the operation of such system taking into consideration the