Modeling the Combination of UPQC and Photovoltaic Arrays with Multi-Input Single-Output DC-DC Converter

M. Davari[#1], *Graduate Student Member, IEEE*, S.M. Aleemran[#2], H. Nafisi[#3],
I. Salabeigi[#4], *Graduate Student Member, IEEE*, G. B. Gharehpetian[#5], *Senior Member, IEEE*
[#] Department of Electrical Engineering, Amirkabir University of Technology, Tehran, Iran
[1] masoud_davari@ieee.org, [2] aleemran2000@gmail.com, [3] nafisi@aut.ac.ir, [4] salabeigi@ieee.org, and
[5] grptian@aut.ac.ir

***Abstract*-In this paper analysis results of a cooperation of the Unified Power Quality Conditioner (UPQC) with the photovoltaic system are presented. The proposed system consists of a series inverter, a shunt inverter, and some photovoltaic arrays connected in the dc link through the Multi-Input Single-Output (MISO) DC-DC converter. A numerical formulation of the proposed control schemes, which are based on the instantaneous power theory, is presented. The proposed system can improve the power quality at the Point of Common Coupling (PCC) on power distribution systems. The performance of the proposed system was analyzed using simulations with Power System Computer Aided Design/ElectroMagnetic Transients DC (PSCAD/EMTDC) analysis program.**

I. Introduction

The increasing applications of electronic equipment that cause electromagnetic disturbances, or that are sensitive to these phenomena, has heightened the interest in power quality in recent years [1]. The quality of the power leads to a direct economic impact on utilities, their customers, and suppliers.

Custom power devices including power electronic interface can be the effective solution for increasing power quality problems because they can provide fast response and flexible compensation. Usually, series and shunt inverter integrated device is called UPQC.

There have been several control schemes of UPQC and the instantaneous power theory is a well-known effective scheme that it has been used herein [2-6]. The UPQC has the prominent capability of improving the quality of voltage and current at the point of installation on power distribution systems or industrial power systems.

Therefore, UPQC is expected to be one of the most powerful solutions to the load which is considered as very important or sensitive to supply voltage disturbances; however, cannot supply large active power to customers steadily due to the limitation of power storage [7].

While, the opening of the energy market under deregulation brings about the interest in Dispersed Generation (DG) because it can provide independence and flexibility to the customer in planning and developing the installation and can give economic benefits in many cases [8]. Photovoltaic (PV) arrays are one of the favorable DGs and being increasingly used to tap into the huge resource of the sun and will play key role in future sustainable energy systems. They offer consumers the ability to generate electricity in a clean, quiet and reliable way. However, PV can cause the negative effects on the existing power systems. That is, some potential problems might he occurred such as voltage variation, protection, harmonics, and personnel safety.

The photovoltaic arrays are interfaced in the AC and DC distributed system by using power electronic circuits. Conventional DC-DC converters, such as push-pull, half bridge and full-bridge converters can be used to boost the low voltage of the photovoltaic to the required level. However, the transformers in these converters have considerable turns ratios (such as 1:20) and hence, high leakage inductances, which results in low energy efficiency and difficulty in control of DC-DC converter [9]. Thus, DC-DC boost converters are usually used to convert the DC output voltage of photovoltaic arrays to a higher output voltage. In this paper MISO DC-DC converter for photovoltaic arrays, which provides well-regulated output voltage, has been presented and analyzed. The advantages of this converter are its simple configuration, fewer component numbers, lowest cost and higher efficiency.

This paper proposes a combined operation system of UPQC and photovoltaic arrays, which is connected to the dc link through a MISO DC-DC converter. The advantage of the proposed system over the UPQC is to compensate the voltage interruption, as well as the voltage sag, voltage swell, harmonics, and reactive power. The operation of the proposed system was verified through simulations with power system computer-aided design/electromagnetic transients dc analysis program (PSCAD/EMTDC).

II. Proposed System

Generally, UPQC has two voltage-source converters. The main purpose of the series converter is harmonic isolation between a subtransmission system and a distribution system. In addition, the series converter has the capability of voltage