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Investigation of the voltage quality at PCC of grid connected PV system

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Abstract

In this paper, we present and discuss the behavior of the voltage in the Algerian Low-Voltage distribution network and the influence of the PV generation. This intermittent availability characteristic will have a local impact on the power quality. Hence, a statistical analysis of the voltage characteristics is shows to evaluation the grid at Point of Common Coupling (PCC) according to the EN 50160 and IEC 61000-2-2 standards. The voltage variation, unbalance, flicker severity, total and individual harmonic are presented. It has been found that the voltage at the PCC is in accordance with standards requirement.

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Keywords: PV system, volatge variation, voltage unbalance, flicker, THD, EN 5010 standard, IEC 6100-2-2 standard ;

1. Introduction

The current political, economic and energy context supports the development of the production, transport, distribution and consumption of electrical energy in Algeria. This development supports the implementation of the national renewable energy and energy efficiency program, which clearly indicates the undertaking the use of both efficient and low-carbon electricity. Hence the challenge of integrating renewable energies into electricity grids in the best technical, economic and security conditions. The renewable energy potential in Algeria is strongly dominated by solar resource [1]. The sunshine duration exceeds 2 000 h annually over the quasi-totality of the country territory and may reach 3500 h annually in the Sahara [2]. The photovoltaic energy appears to be less expensive compared to other renewable energies and more profitable for rural areas, especially to supply farms by PV energy. The production cost and market prices of the photovoltaic have dropped dramatically over the years, and are now close to break-even compared to fossil fuels for decentralized applications. Between 1976 and 2010, the average price of photovoltaic watt globally fell from 65 to 1.4 dollar per watt [1, 3-4]. The liberalization of the electricity market (Law No. 02-01 of February 5, 2002) introduced major changes in the field of electric power

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generation in Algeria. The national renewal energy program, adopted by the government in February 2012 and updated in February 2015, is the main consequence. The program foresees 22,000 MW, which would represent 27% of Algeria's overall energy mix by 2030, including 13,750 MW of solar photovoltaic (PV). One of the unique aspects of PV is the ability to distribute generation at several levels of the power system and specifically at the distribution level. In Algeria, the rate of electrification is approaching the 99% and more than 80% of produced power is consumed at low-voltage (LV) level. Thus, the development of the PV systems in the LV distribution network can be an appropriate solution to reduce the peak demand of the householders and participate to the electric network services Nevertheless, its characteristic of intermittence and variability with meteorological conditions, can make ineffective the used of traditional voltage regulation methods. During high generation and low load periods, there is a possibility of reverse power flow in the LV feeder. Several studies indicate that the voltage will rise when there is reverse power flow in the feeder due to distributed generators interconnected to the LV distribution network [5]. In [6] the experimental investigation based on the measurements was performed at Point of Common Coupling (PCC) of the installed PV system. It has been found that the low PV generation has a significant impact on the power quality generated by the PV inverter. The impact of this cannot be considered due to the very low power range. The analysis of the data indicates the high harmonics content in the grid current waveform. Meanwhile, the PV inverter has led to a decrease of these harmonics during the high PV power injection. The current is distributed in the Algerian LV distribution network at nominal voltage of 230/ 400 volts. The operating conditions specifically provide the voltage and the frequency characteristics of the LV network. The maximum tolerance is ±5% around the nominal voltage (230V) for urban areas with predominant lighting use. The frequency of the distributed current is set at 50 Hertz; it must not vary by more than 1.5 Hertz more or less than its nominal value. Utilities around the world are trying to determine how best to accommodate the increasing percentage of solar PV power generation on their electric grids. Utilities are uncertain about the effects of high levels of variable renewable power generation on system reliability, power quality, and the safety of workers and equipment, but recent advances in inverter technology have made them valuable tools for managing these aspects of grid operation [7].

In this context, the main contribution of this paper is to present and to discuss the behavior of the voltage in the Algerian LV distribution network and the influence of the PV generation. This intermittent availability characteristic will have a local impact on the power quality. Hence, a statistical analysis of the voltage characteristics is shows to evaluation the grid at PCC according to the EN 50160 and IEC 61000-2-2 standards. The voltage variation, unbalance, flicker severity, total and individual harmonic are presented.

2. PCC and PQ monitoring structure

2.1. PCC structure

Figure 1 (a) shows the connection diagram of the PV system and the laboratory loads to the LV electrical network. The PCC can be an import or injection point of the active power according to the solar irradiation and the demand of the connected loads at this PCC. The grid-connected PV system installation, currently in service, is located at “Centre de Développement des Energies Renouvelables” (CDER) in Bouzaréah, Algiers (latitude 36.8 °N, longitude 3 °E and 345 m of altitude). It started operating on June 2004, the installation operates without storage system. The electricity produced by the PV array feeds our laboratory loads, meanwhile in case of good weather conditions the extra PV generation is injected into the grid, otherwise, the backup is assured by the grid. The grid-connected PV system includes 90 modules covering a total area of 76 m² with an installed capacity of 9.45 kWp. The PV generator was designed in three equal PV arrays, of 30 modules for rated power around 3.18 kWp; each one was built interconnecting 15 modules in series and 2 in parallel. Three single-phase inverters, of 3 kW nominal power, were used to connect the PV arrays each phase of the CDER’s LV network.

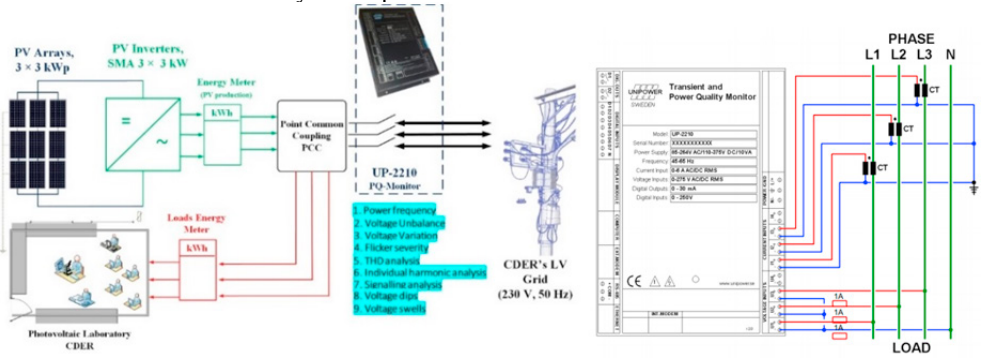

Fig. 1. (a) Structure of the PCC and the power quality monitoring system; (b) Wiring diagram of the PQ unit in LV networks.