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Performance and Analysis of Distributed Power Electronics in Photovoltaic Systems

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ABSTRACT: DC-DC converters & Distributed Power Electronics can help to reduce mismatch and shading losses in photovoltaic (PV) systems. Under partially shaded conditions, the use of distributed power electronics can recover between 10%–30% of annual performance loss or more, depending on the system configuration and type of device used. Additional value- added features may also increase the benefit of using per-panel distributed power electronics; these include increased safety, reduced system design constraints, and added monitoring and diagnostics. The economics of these devices will also become more favorable as production volume increases and integration within the solar panel's junction box reduces part count and installation time some potential liabilities of per-panel devices include increased PV system cost, additional points of failure, and an insertion loss that may or may not offset performance gains under particular mismatch conditions.

Keywords: PV system, DC-DC converters, distributed power electronics.

I. INTRODUCTION

Any change that takes place in the universe is accompanied by a change in a quantity that we name energy. We do not know what energy exactly is, we use this term to describe a capacity of a physical or biological system for movement or change. Energy comes in many forms, such as electrical energy, chemical energy, or mechanical energy, and it can be used to realize many forms of change, such as movement, heating, or chemical change. Any activity, and human activity as well, requires energy. Human beings need it to move their bodies, to cook, to heat and light houses, or to drive vehicles. Human being is a greedy consumer of energy. An active young man needs about 2500 kcal (2.9 kWh) per day to fulfil his daily energy requirements. This means the energy of about 1060 kWh per year. The present global energy consumption is around 19 000 kWh per inhabitant per year. It means that on average a man consumes about 19 times more energy than is needed for his survival and satisfactory health. Presents an overview of the present primary energy. The primary energy sources can be divided in two groups. The first group includes those energy sources that will be exhausted by exploiting them. These energy sources are called the depleting energy sources and they are the fossil fuels and nuclear energy. The fossil fuels and nuclear power are the main source of energy in today's energy system and they supply 78% of the energy demand. Under the assumption that the population of mankind does not change drastically and it consumes energy at the current level, the fossil fuel reserves will be exhausted within 320 years and the nuclear energy within 260 years.

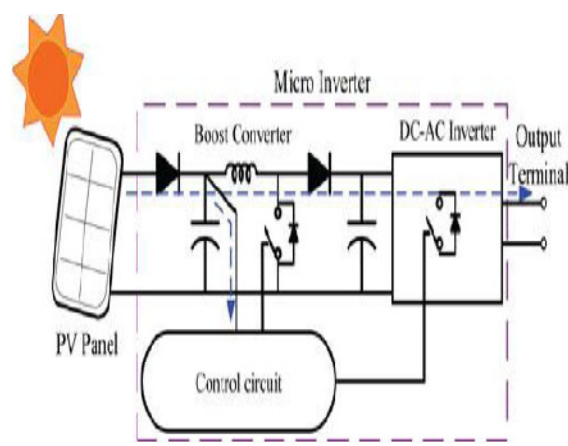

Fig. 1. Potential difference on the output terminal of inverter.

Renewable sources is quickly developing. The present pace of innovative improvement makes it financially suitable to bridle energy from sun, wind, [4] geothermal and numerous other renewable sources. On account of the negative effects of the surroundings, the economy, ordinary energy sources like natural gas, crude petroleum.

This can seem a very long time for us. However, when we compare this period of time to the time span of existence of the Earth or the human civilisation, it is a negligible fraction of time. We have to be aware that the reserves of fossil fuels on the Earth are limited and will be exhausted. The accumulation of dust on the surface of a photovoltaic module decreases the radiation reaching the solar cell and produces losses in the generated power.

II. PV MODULE

Dust not only reduces the radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. This work presents the results of a study carried out at the University of Malaga to quantify losses caused by the accumulation of dust on the surface of photovoltaic modules. Our results show that the mean of the daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. In long periods without rain, daily energy losses can be higher than 20%. In addition, the irradiance losses are not constant throughout the day and are strongly dependent on the sunlight incident angle and the ratio between diffuse and direct radiations. When studied as a function of solar time, the irradiance losses are symmetric with respect noon, where they reach the minimum value. We also propose a simple theoretical model that, taking into account the percentage of dirty surface and the diffuse/direct radiation ratio, accounts for the qualitative behavior of the irradiance losses during the day. The accumulation of dust on the surface of the photovoltaic modules decreases the incoming irradiance to the cell and produces power losses (see [1] and references therein). Previous studies [2] show that in dry areas, these losses could reach 15%. In these cases the only solution is to clean the modules with water. In large-scale photovoltaic plants this task is often expensive, especially in those areas with water shortage Some approaches to analyze and quantify the effect of dust on photovoltaic modules have been proposed in the literature. The early studies about the relationship between dust and transmittance date back to a few decades ago, all of them in the context of solar thermal collectors. For example, in [3], the effect of dust on the irradiance received by various inclined surfaces of flat-plate collectors have been studied. The performances of one photovoltaic and two thermal panels during several months of outdoor exposure in Saudi Arabia have been measured in [4]. For the photovoltaic panel, the average degradation rate of the efficiency was 7% per month. The authors of [5] made an experimental study of the effect of accumulation of dust on the surface of photovoltaic cells. Several kinds of dust having different physical properties were used. Experiments were performed using a solar simulator. They concluded that the results depend on many factors like the principal dust material, the size of dust particles and dust deposition density. We can see in [6] a computerized microscope system that has been developed for studying the physics of dust particles, which adhere to the surface of solar collectors and photovoltaic modules. The device enables investigators to calculate the particle size distribution of dust and the fraction of surface area covered by dust. Some examples are given for the use of such a measuring system for the study of photovoltaic and solar-thermal collector surfaces. Wind tunnel experiments were described in [7] to study the effect of wind velocity and air dust concentration on the drop of photovoltaic cell performance caused by dust accumulation on such cells. I-V characteristics were determined for various intensities of cell pollution. The evolutions of the I_{sc}, V_{oc}, P_{max} and *FF* were examined. You've seen, or maybe own, photocell-powered devices such as night lights, car coolers, and toys. These generally consist of a small solar panel and a small light or motor. Typically, these run on less than 10V dc and draw only a fraction of an ampere. These kinds of devices are very different from a system that can power a house or interconnect with a utility to offset a building's energy consumption. Consider the sheer size and weight of solar modules for providing electrical power to a building. You're looking at mechanical and site selection issues that may require specialized expertise. The value of these modules also means there are security issues to consider, which may require more than just installing locks. There are also civil and architectural issues to address. In summary, these installations are complicated and require expertise in several non-electrical areas, which the NEC doesn't address. Article 690 focuses on reducing the electrical hazards that may arise from installing and operating a solar photovoltaic system, to the point where it can be considered safe for property and people. To reduce greenhouse effect, environment pollution and the other problems associated with fossil fuels conventional and non-renewable energy sources are more and more often replaced by new, renewable sources like sunlight, wind and biomass [1-4]. Moreover, these traditional resources of energy are run low. The environmental protection regulations play the important role in this problem.

European Parliament and European Council directive, number 2001/77/WE, on the promotion of electricity produced from renewable energy sources imposes an obligation upon members of European Union to develop technologies based on renewable energy sources [5]. Among renewable sources we distinguish [3,4]: solar radiation, wind power, water energy, geothermal energy, biomass energy. The greatest part in obtained electric energy from renewable sources comes from solar radiation. Photovoltaic technology makes use of the abundant energy in the sun and it has little impact on environment. Photovoltaics can be used in a wide range of products, from small items to large commercial solar electric systems [6,7,8]. Technologies of production of solar cells are based on semiconductor materials. The greatest development is observed in technologies based on polycrystalline, monocrystalline or amorphous silicon. The best properties exhibit monocrystalline silicon solar cells. However, technology of this kind of solar cells is the most expensive. The lowest costs are generated in production of amorphous solar cells, but they have no satisfactory properties. Polycrystalline silicon solar cells are cheaper than monocrystalline solar cells and exhibit better properties than amorphous silicon solar cells. For this reason photovoltaic industry, to a large degree, takes advantage of polycrystalline solar cells [9-13]. One single polycrystalline solar cell with an area of approximately 12.5 cm^2 generates a short circuit current of 0.3 A and open circuit voltage 0.5V when exposed to full sunshine. In most practical cases a single crystalline solar cell 12,5 cm^2 generates not enough electric power which reaches approximately 0.12 Wp (peak Watts) at the maximum only. That is why, it is necessary to interconnect greater number of solar cells into solar module. Depending on the requirements, the individual solar cells can be connected in series or parallel only or both in series and parallel [11-14]. Series connection (series circuit) is the connection in which components are connected along a single path, so the same current flows through all of the components. In a series circuit, the current through each of the components is the same, and the voltage across the components is the sum of the partial voltages across the individual components [9,11,14]. It is important to have well matched cells in the series chain, particularly with respect to current. If one cell produces a significantly lower current than the other cells, then a whole chain will operate at that lower current level and the remaining cells will not be operating at their maximum power points [12-14]. Series connection of the solar cells causes also undesired effects when an individual cell or several cells are fully or partially shaded. In general, the weakest link in the chain determines the quality of the whole system. Even when only one cell is shaded, the effect is the same as if all series-connected cells were shaded. Additionally, so called local hot spots may occur in series connection when individual cells are partially shaded. In this case shaded cell represents a diode of a very high resistance compared to the load. Thus, most of the voltage drop generated by the other cells appears at shaded cell. To avoid these undesired effects in ideal solution bypass diodes are connected anti parallel to each individual solar cell such that large voltage difference cannot arise in the reverse-current direction of the solar cell. In industrial practice, one bypass diode is provided for protection of more than one solar cells (approximately 15-20) Under the pressure of limited available energy resources and environmental policies, electrical power generation using renewable energy has rapidly increased in recent years [9]. In China, a large number of remote rural or mountainous inhabitants have no access to the main electricity supply network so it is important to explore the local natural renewable energy resources such as wind or solar for power generation, mainly for local consumptions [9,11,14]. Parallel connection (parallel circuit) is the connection in which components are connected so that the same voltage is applied to each component. In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents through all the components Performed investigations shown that photovoltaic modules under consideration can be successfully used as a renewable source of energy. Some of modules available on the market demonstrate better electric properties than modules under discussion. In the presented solution technological steps used in commercial production process of photovoltaic modules were applied. The investigations performed on two photovoltaic modules allowed to formulate the following statements: It was shown that interconnecting many solar cells that can produced a limited amount of power, it is possible to assembly photovoltaic module fulfilling current-voltage requirements of supplied devices, All materials emit infrared (IR) radiation over a range of wavelengths that depends on the temperature of the material. The infrared heat emitted by a material is quantified by the Stefan-Boltzmann law, and the spectral distribution of the emitted energy is expressed by Planck's distribution [1]. For the components of interest in photovoltaic systems (cells, modules, arrays, bypass diodes, wiring terminals, batteries, etc.) the temperature range of most interest is perhaps 0°C to 150°C.

For example, a typical PV module at 50°C emits heat primarily in the wavelength range from 3 µm to 20 µm, with peak emittance at about 9 µm. Commercially available infrared cameras can be purchased with lenses and detectors customized for operation with different wavelengths of light.

III. RESULTS

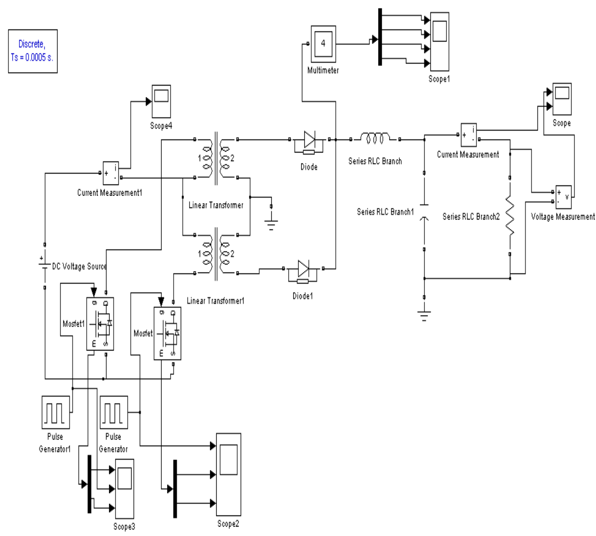

Fig. 2. DC-DC converters & Distributed Power.

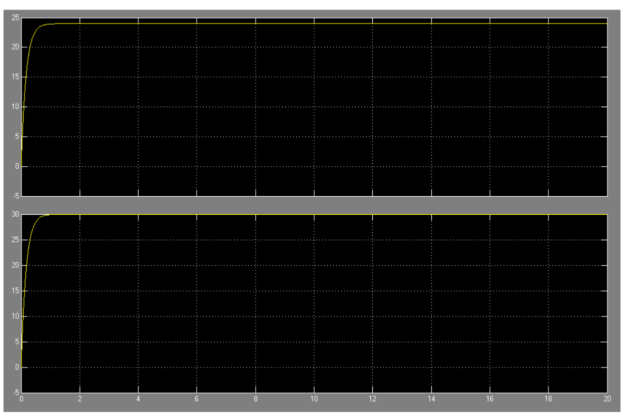

Fig. 3. DC-DC converters Scope.

IV. CONCLUSION

The PV- system is proposed and confirmed that it is possible to combine theory to the three phase PV system connected up to utility. Using simulation analysis, it is theoretically positive to actualize the PV system using instantaneous power theory which is found to be an effective solution for improving power quality. The proposed topology reduces harmonics and provides reactive power compensation due to non-linear load current. As a result source current become sinusoidal and unity power factor is also achieved. As evident from the simulation studies that photovoltaic is effective for power conditioning applications. The THD of the source current after compensation is limiting the total harmonic distortion in distribution networks.

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