2022 Second International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT 2022)

Bhilai, India
21-22 April 2022

Pages 1-619

IEEE Catalog Number: CFP22T24-POD
ISBN: 978-1-6654-1121-9

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IEEE Catalog Number:	CFP22T24-POD
ISBN (Print-On-Demand):	978-1-6654-1121-9
ISBN (Online):	978-1-6654-1120-2

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Performance Analysis of PV-Fuel cell hybrid system in small scale DC system

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***Abstract*—Reduction of greenhouse gases without hampering economic growth has become a matter of great concern in present scenario. Most of the energy extraction techniques extensively depend on fossil fuels and so the researchers are engaged in finding an alternate eco-friendly economic path since last few decades. Although renewable sources are environment-friendly but major challenge with these is lower energy density and costly extraction process. Among several renewable resources, solar PV and fuel cell are two promising way for meeting up energy demand. Photovoltaic system operating under variable weather condition provide a reasonable output if operated at maximum power point. This operating point is the global maxima of the P-V curve operating under dynamic weather conditions. On the other hand, fuel cell also plays a vital role particularly for small scale DC applications. Fuel cell converts chemical energy to electricity unlike IC engine which utilizes combustion causing emission of greenhouse gases. In present study, a hybrid PV-fuel system is developed in MATLAB/Simulink environment and the results are analyzed.**

Keywords— PV array, MPPT, Fuel Cell, Hill climbing algorithm, Boost converter

I. INTRODUCTION

In present scenario energy is an integral part in view of economic growth. However, most of the energy extraction techniques practice in modern world are hazardous for environment as they emit green house gases. Since last few decades growing concerns has led the researchers to work in the field of eco-friendly energy extraction techniques [1-2]. It has been observed that almost all the renewable resources are of intermittent nature and possess very low energy density. Among them PV and fuel cell are relatively promising approaches.

PV system are gaining much more acceptance due to its versatile nature. A PV system can generate electricity in small scale as well on large scale basis either in islanded or in grid connected mode [3-4]. Besides, maintenance of PV system is cost-effective [5]. However, main problem with PV system is reliability issue of PV cell as it cannot generate satisfactorily except bright sunlight. On the other hand, efficiency of such a system is poor and the output is highly depended on the irradiation level and ambient temperature [6]. Hence, research can be focused either on focusing on the fabrication formalities or on proper modeling and simulation of the proposed system before commissioning. The former is a cost-effective approach whereas the later one helps in designing an efficient system and provides a brie insight of a proposed installation before its erection.

Output from a PV system is satisfactory when the ambient temperature and the irradiance level are high. However, solar irradiance and temperature are changing at every instant and so a fixed output is not obtained from such a system. This is undesirable from reliability point of view. Therefore, adoption of maximum power point tracking (MPPT) is a common point of interest to extract maximum power from the existing PV system [7]. In order to extract maximum power under instantaneous operation, a power electronic interface is embedded in the system so that the system impedance can be matched with the load impedance under all circumstances.

On the other hand, fuel cell possesses significant importance particularly in small scale DC applications due to its cost-effectiveness [8-10] and higher efficiency of operation [11-13]. Electrochemical energy conversion takes place in fuel cell by oxidation of fuel without any stage in between. A fuel cell can deliver power as far as it is supplied with air and fuel as inputs. Fuel cells covert internal chemical energy of fuel to electricity unlike IC engines in an emission free noiseless manner. Besides, it is eco-friendly way of energy conversion as water is produced as by product [14]. The only similarity of fuel cell with battery is that both produce electricity through electrochemical energy conversion. However, the former works as a storage element whereas the later one is basically an energy conversion element. Another way of comparison can be carried out between these two based on their size. A fuel cell having 10 kg of propane as its fuel can give nearly 3400 Ah whereas a lead-acid battery of 15 kg can provide only 80 Ah [15]. In fuel cell energy conversion takes place without combustion. In any kind of fuel hydrogen is present which have good energy density and so fuel cell can be used in various stationary, portable and transportation applications, particularly in automobile sector [16-19]. Intensive research works shows that fuel cells are even efficient in combined cooling, heating and power (CCHP) applications [20]. Advancement in science and technology has made different types of fuel cell construction since its inception. Out of them, proton exchange membrane (PEM) and solid oxide fuel cell (SOFC) are found to more effective in most of the applications. Output of fuel cell is low and hence different fuel cells are connected in suitable series parallel combination to achieve significant power. For further