COMPARISON BETWEEN BOOST CONVERTER AND ZETA CONVERTER FOR HARMONIC REDUCTION OF FUEL CELL SYSTEM

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Abstract -: *This paper deals with the modeling, analysis and control scheme of fuel cell system using DC converter. The output of the Fuel Cell system is connected to the DC side of the Voltage Source Inverter (VSI) for interfacing to the utility Grid. The behavior of a fuel cell by varying DC link voltage which makes change in the output of the active power has been investigated. The DC to DC converter is a Quadratic Boost Converter (QBC), implemented with fixed frequency Pulse Width Modulation (PWM) based sliding-Mode Control technique which enables a tight voltage regulation besides offering a good dynamic performance. Finally, the work will present the main obtained conclusions, indicating the main aspects of FUEL CELL, which must be considered in the application of this device USING DC Converter.*

Key Words: ***Fuel cell, DC DC Converter, Boost converter, ZETA Converter***

1. INTRODUCTION

According to the rate of the increasing population our requirement of everything is also increased. To meet the basic necessities the large number of sources is required to fulfil our all needs. According to our present requirement we suggest to utilize the fuel cell in the form of energy generation [1]. It will give better generation of energy among all others various resources. This form of energy is highly efficient, economical, and flexible and pollution free. Fuel cell is device which is used for the conversion of chemical energy into electrical energy with the help of electrochemical reaction. Fuel Cell is an electro chemical device which converts fuel and oxidant into DC electricity [2]. Cells that take up oxygen, for the cathode reaction, from ambient air by passive means are known as “air-breathing” fuel cells (ABFC. In the ABFC, hydrogen and oxygen are fed at anode and cathode respectively as reactants.

The electrons will move to the cathode through external load and protons travel through the electrolyte membrane as shown in Fig. 1.

Anode side reaction:

H2 4H+ + 4e-

Cathode side reaction:

O2 + 4H+ + 4e- 2H2O

Overall reaction:

2H2 + O2 2H2O + Electricity + Heat

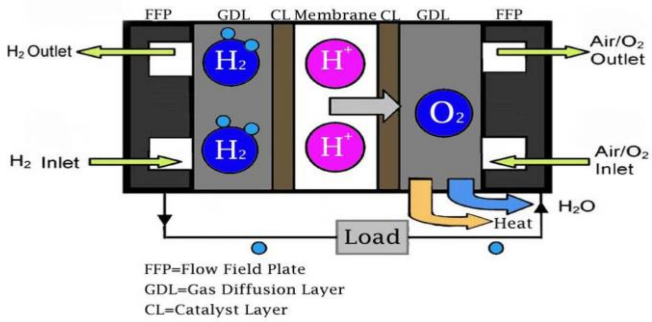

Fig. 1: Work process and reaction principle of an ABFC

The overall ABFC power system includes fuel cell stack, power conditioning units, and control units. The power conditioning circuits (PCU) includes DC to DC converter , a boost converter ,ZETA Converter and the Multi level inverter. The boost converter produces output voltage more than the input voltage and controls the unregulated voltage output of the fuel cell stack(60V) and maintains the desired value (230V) using sliding -mode control The boost converter in closed loop mode can achieve good dynamic performance, in addition to load as well as line regulation[3],[4]. The other part of the PC includes Multi level inverter for converting DC to AC. The Multilevel power conversion is a sophisticated technology with excellent potential for further growth.

2. BASIC FUEL CELL SYSTEM

A fuel cell is defined as an electrical cell, which unlike other storage devices can be continuously fed with a fuel in order that the electrical power can be maintained. fuel cells convert hydrogen or hydrogen-containing fuels, directly into electrical energy, heat, and water through the electrochemical reaction of hydrogen and oxygen[5]. As illustrated in this figure, the fuel such as natural gas, coal, methanol, etc. is fed to the fuel electrode (anode) and oxidant (oxygen) is supplied to the air electrode (cathode). The oxygen fed to the cathode allows electrons from the external electrical circuit to produce oxygen ions. The ionized oxygen goes to the anode through the solid electrolyte and combines with hydrogen to form water. Even though chemical reactions at anode and cathode may be a little different according to the types of fuel cells, the overall reaction can be described as follows:

Overall reaction: 2 H_2 (gas) + O_2 (gas) → 2 H_2O + energy (electricity, heat)

Since hydrogen and oxygen gases are electrochemically converted into water and energy as shown in the above overall reaction, fuel cells have many advantages over heat engines: high efficiency and actually quiet operation and, if hydrogen is the fuel, no pollutants are released into the atmosphere[6]. As a result, fuel cells can continuously generate electric power as long as hydrogen and oxygen are available. Among several types of the fuel cells categorized by the electrolyte used, four types are promising for distributed generation systems: Phosphoric Acid fuel cell (PAFC), Solid Oxide fuel cell (SOFC), Molten Carbonate fuel cell (MCFC), Proton-Exchange Membrane fuel cell (PEMFC). All types of the fuel cells produce electricity by electrochemical reaction of hydrogen and oxygen, and the oxygen can be easily obtained from compressing air[7],[8]. On the contrary, hydrogen gas required to produce DC power is indirectly gained from the reformer using fuels such as natural gas, propane, methanol, gasoline or from the electrolysis of water.

3. BOOST CONVERTER

A Boost converter is a DC to DC converter in which the output voltage is higher than the voltage reference. It is referred to as a step-up converter. Boost converter's main operating theory is that the inductor in the input circuit resists sudden changes in input current. The inductor stores energy in the form of magnetic energy when switch is on, and discharges it when switch is closed [9]. The capacitor in the output circuit is assumed to be large enough that the RC circuit time constant is high in the output. The general configuration of boost converter is shown:

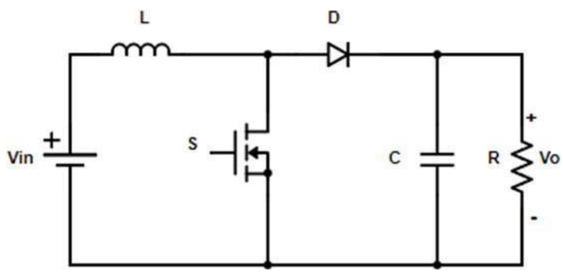

Fig 3.1: Circuit diagram of Boost Converter

3.1. SIMULATION OF BOOST CONVERTER

The Matlab Simulink model of Boost converter is shown in Fig.3.2,

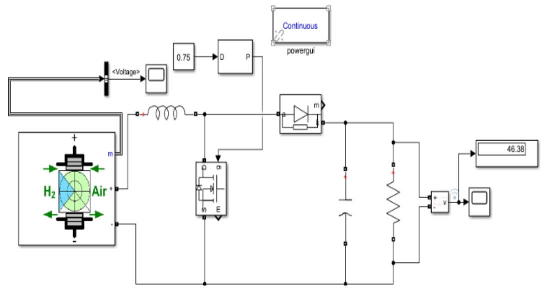

Fig 3.2: Simulation model of Boost converter with Fuel cell

4. ZETA CONVERTER

A ZETA converter is a fourth order Nonlinear system being that, with regard to energy input, it can be seen as buck-boost-buck converter and with regard to the output, it can be seen as boost-buck-boost converter[10]. The general configuration of ZETA converter is shown:

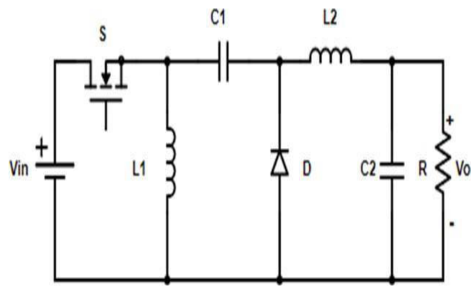

Fig. 4.1 : Circuit diagram of ZETA CONVERTER

4.1. Simulation of ZETA CONVERTER

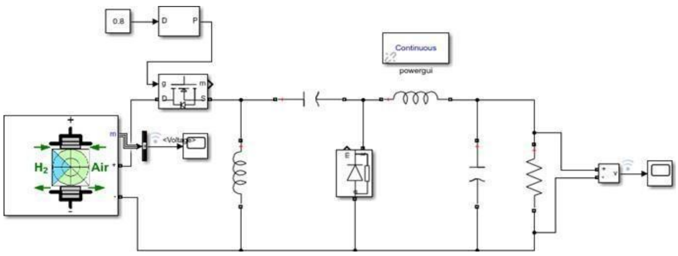

Fig. 4.2 : Simulation model of ZETA CONVERTER with Fuel cell

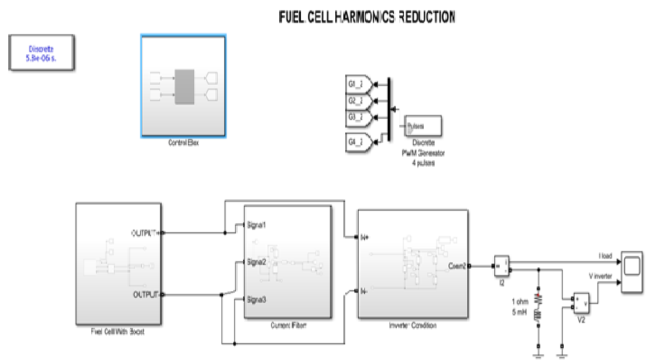

Figure 4.3: Simulink model of harmonic reduction of fuel cell

This model in figure 4.3, defines the fuel cell as the source in which we are trying to reduce the harmonics. Clearly we can see that the DC output of the fuel cell is connected to the current filter and ultimately to the inverter condition unit of the model[11]. The loads are connected at the output end.

5. RESULT

With the above studies about the fuel cells, an analysis and graphical representations of different parameters of the fuel cells have been plotted considering the simulink model[12]. Figure 5.1 shows the graphical representation of fuel cell voltage in voltage versus time graph, similarly, figure 5.2 depicts the voltage versus time graph of a low pass filter. Figure 5.3 below shows the study carried out in an current filter by current versus time graph[13]. Similarly we can also observe the graphical representation of input current applied in the fuel cell versus time from figure 5.4 and figure 5.5 shows the result obtained at the inverter side with the help of graph plotted between voltage versus time, we demonstrates the values of the Fast Fourier Transform and Total Harmonic Distortion of DC converter of fuel cell.

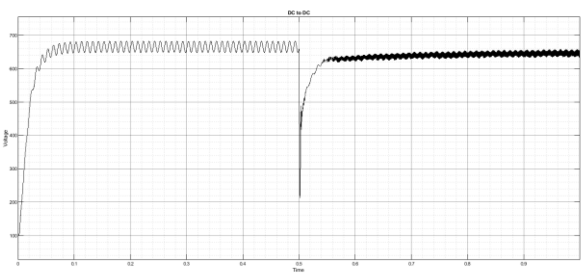

Fig -5.1: Graphical Representation of Fuel cell voltage

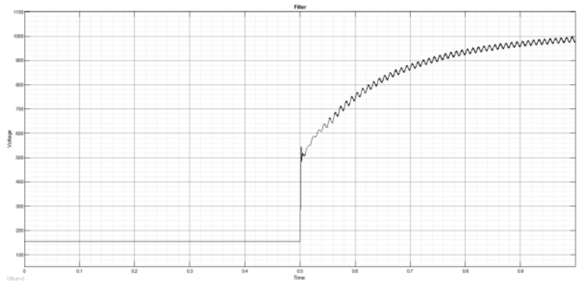

Fig -5.2: Low pass Filter Voltage vs Time Graph

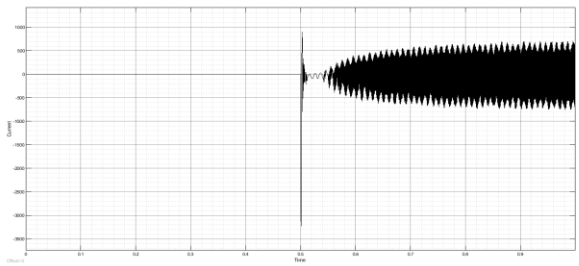

Fig -5.3 : Current v/s Time Graph of Filter

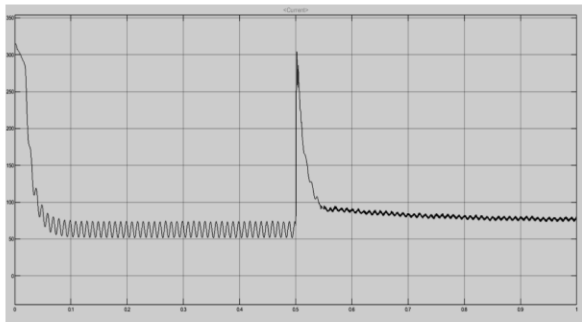

Fig -5.4: Graphical Representation of Fuel Cell input current v/s time

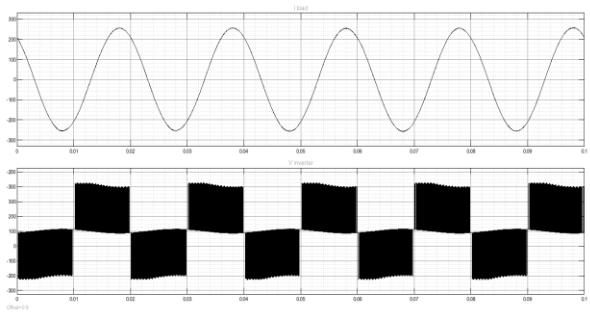

Fig -5.5 : Graphical Representation of Voltage v/s time graph at inverter side

From the graphical plots we can clearly observe the reduction in TDH to nearly 2.86%. The THD analysis of Boost converter is 2.86% and that of ZETA converter is 2.46% with fuel cell as an input source. It is concluded that the THD value of ZETA converter is less than Boost converter. Low THD value of ZETA converter implies that the efficiency of the converter will be improved than the other converter which helps in the reduction of harmonics of the fuel cell system.

6. CONCLUSIONS

The studies summarizes that a fuel cell is one of the recently identified electrical energy resources which undergoes certain chemical reactions to produce electrical power using hydrogen as fuel and oxygen as an oxidizing agent. The features of the converters provide an advantage of having lesser filter capacitor. Converters provide the option of adopting higher switching frequency and thus by reducing the size and cost of the system. The design and simulation of converters such as boost converter and ZETA converter with fuel cell as an input source are carried out using MATLAB simulink. It is concluded that ZETA converter exhibits better performance than Boost converter with respect to the THD

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