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Simulation Study of Grid Connected Fuel Cell

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Abstract: ***In this paper we are study of simulation of grid connected fuel cell using MATLAB software . Three main tasks of the proposed PCS are DC link voltage regulation, power flow control and power quality improvement. Correspondingly, PCS is composed of DC/DC converters. The modeling process and stability analysis of each part are presented in this thesis. This dissertation focuses on load/grid connected fuel cell power system (FCPS) which can be used as a backup power source for household and commercial units. This backup power source will be efficient and will provide energy at an affordable per unit cost. Load/grid connected fuel cell power system mainly comprises of a fuel cell module,***

Keywords: Boost converter, Inverter; Fuel cell model; Fuel cell connected with Grid.

1. Introduction

This One of Recently, energy sources such as wind power systems, photovoltaic cells, and fuel cells have been extensively studied in response to global warming and environmental issues. The fuel cell is an important technology for new mobile applications and power grid distribution systems. For power distribution, fuel cell system requires a grid interconnection converter to supply power to the power grid. A grid interconnection converter using an isolation transformer is preferable for power grid distribution systems in terms of surge protection and noise reduction. In addition, size reduction and high efficiency are essential requirements. One of the problems in the fuel cell system is that the lifetime is decreased by the ripple current. Therefore, in order to extend the lifetime, the fuel cell ripple current must be reduced in the grid interconnection converter. However, when a single-phase pulse width-modulated (PWM) inverter is used for grid connection system, the power ripple is twice the frequency of the power grid. Fuel cells offer numerous advantages over conventional power plants to help them achieve that goal and widespread adoption, such as:

- High efficiency, even at part-load
- Few moving parts resulting in quiet operation, higher reliability, lower maintenance and longer operating life
- Fuel diversity
- Zero or low emission of greenhouse gases
- Combined Heat and Power (CHP) capability, without the need for additional systems (i.e., low temperature fuel cells can provide district heating while high temperature fuel cells can provide high-quality industrial steam)
- Flexible, modular structure
- Increased energy security by reducing reliance on large central power plants and oil imports

2. Fuel Cell & Fuel Cell Model

2.1 Fuel Cell

Fuel cell is a static device that converts the chemical energy of hydrogen and oxygen directly into electricity with by-product as water and heat.

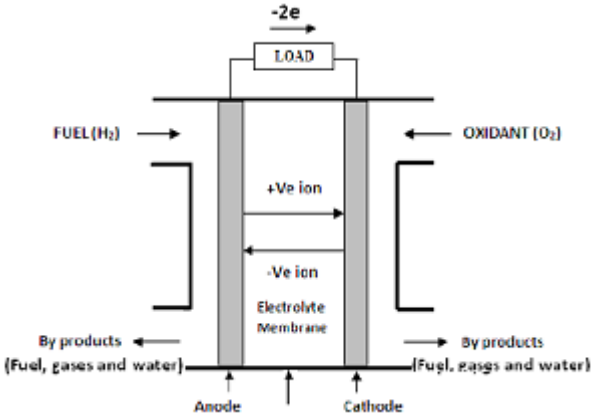

Figure 2.1: Basic working principle of fuel cell

2.1 Advantages of Fuel Cell System

2.2 Disadvantages of Fuel Cell System

2.3 Applications of Fuel Cell System

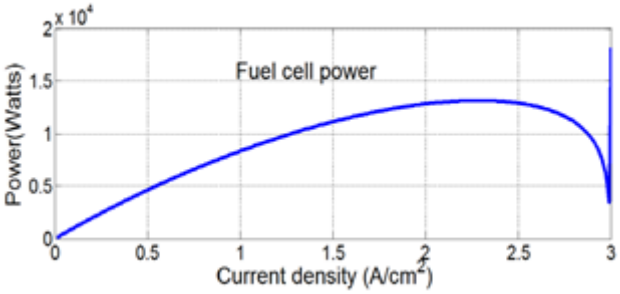

Figure 2.2: P-I characteristics of fuel cell

2.4 Mathematical Model of Solid Oxide Fuel Cell:

The following limitations are made in developing the mathematical model of fuel cell stack:

- Fuel cell is fed with hydrogen and oxygen.
- The gases considered are ideal, that is, their chemical and physical properties are not co-related to the pressure.
- Nernst equation is applicable.
- Fuel cell temperature is stable all times.
- The pressure drop across the electrode channels is negligible.

- The ratio of pressure between the inside and outside of the electrode channels is Sufficient to consider choked flow.
- Ohmic, activation, and concentration losses are considered.

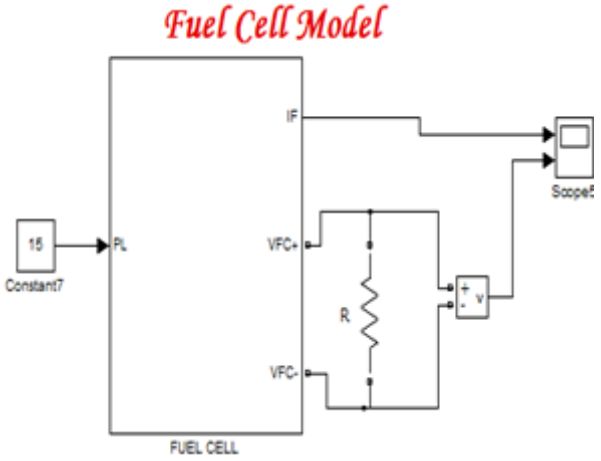

Figure 2.3: Fuel Cell Model

3. DC-DC Boost Converter

A boost converter is a dc to dc voltage converter with an output dc voltage greater than input dc voltage. This is an SMPS containing at least two semiconductor switches (a diode which act as freewheeling diode two ensure a path of the current during the off state of other switch and a transistor connecting in series of the source voltage). Filters made of capacitor and inductor is used to reduce the ripple in voltage and current respectively, is used at the output stage of the converter. The basic operating principle of the converter consists of the two distinct states.

- In on state, switch is closed, resulting in an increase in the inductor current.
- In off state, switch is open, resulting in decrease in the inductor current.

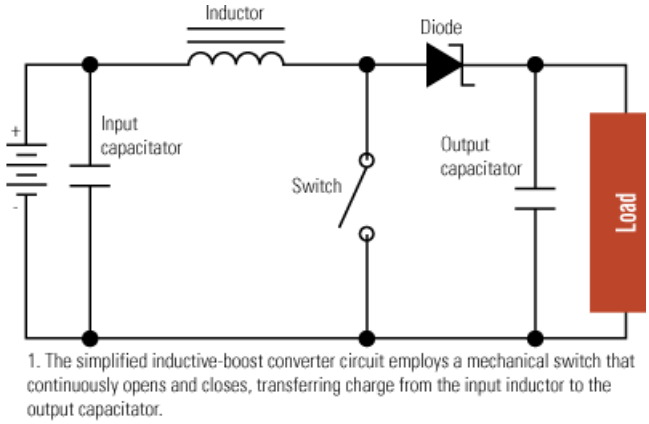

Figure 3.1: Dc-Dc Boost Converter

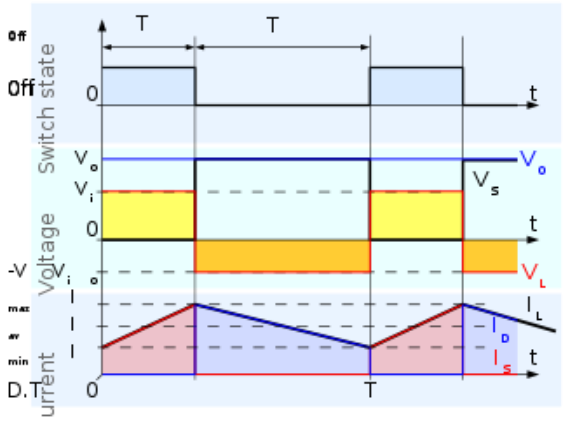

Figure 3.1: Voltage Waveform in Continuous mode

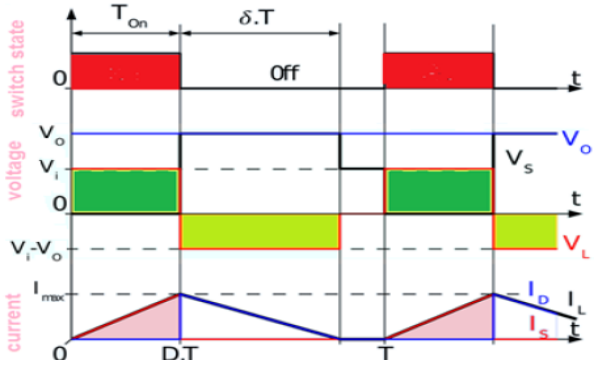

Figure 3.2: Voltage Waveform in Discontinuous mode

4. DC-AC Inverter

Inverters that take DC and produce a constant amplitude sinusoidal output have been studied and designed for many years. Initially, most inverter technology used silicon controlled rectifier (SCR) devices and a transformer coupling to approximate a sine wave via line commutation. As power transistors became More feasible, most low to medium power inverter systems replaced the SCR with the MOSFET or the IGBT. These new transistors lead the way for force commutated inverters that can be classified in terms of their output waveform. A summary of the basic types of line commutated inverters. Significant research and development in the area of pulse width modulation (PWM) has been done in attempt to reduce the passive filter size and create a better sinusoidal output, thus reducing harmonics.

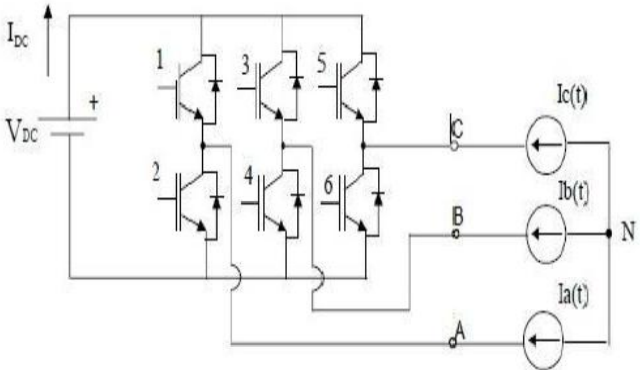

Figure 3.3: Dc-Ac inverter

5. Simulation of Grid Connected Fuel Cell Panel

5.1 Current Controller

The current controller mainly used for getting triggering pulse as per the reference value. Here we take the inverter output current and using by MATLAB software converts the current into direct axis and quadrature axis current. This two currents and current given by power controller outputs compared and using PI controller we get the pulse.

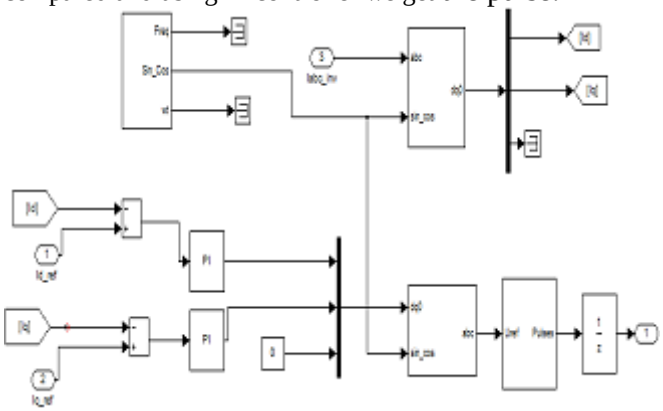

Figure 5.1: Current controller

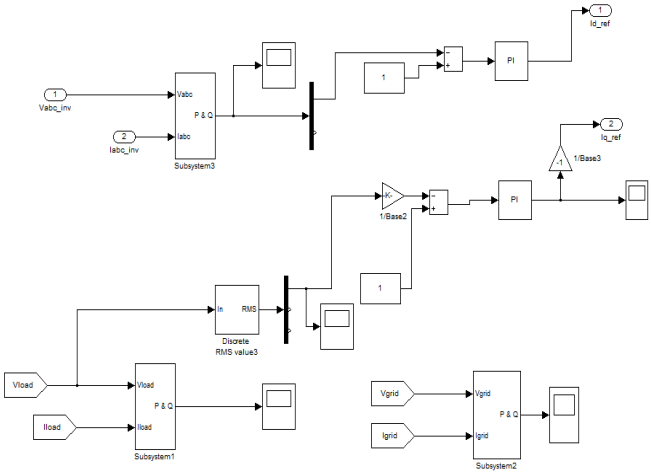

Figure 5.2: Power controller

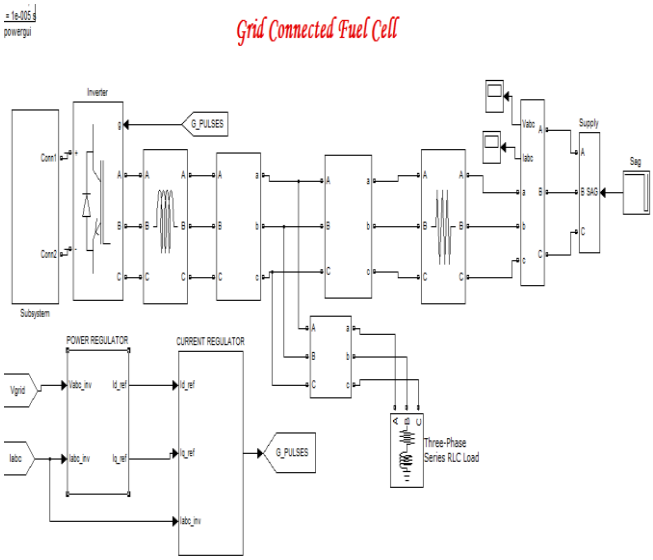

Figure 5.3: Simulink diagram of Grid connected Fuel Cell power generation system

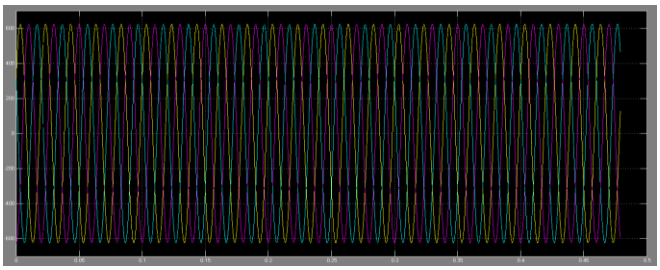

Figure 5.4: Grid voltage waveform

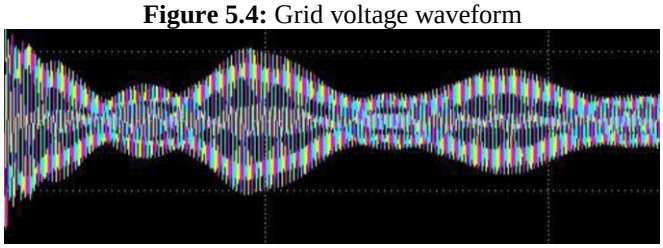

Figure 5.5: Grid Current waveform

6. Conclusion

In this paper we are successfully study of simulation of grid connected fuel cell using MATLAB software. Three main tasks of the proposed power conditioning system (PCS) are DC link voltage regulation, power flow control and power quality improvement. Correspondingly, PCS is composed of DC/DC converters, DC/AC inverter. The modeling process and stability analysis of each part are presented in this thesis. This dissertation focuses on load/grid connected fuel cell power system (FCPS) which can be used as a backup power source for household and commercial units. This backup power source will be efficient and will provide energy at an affordable per unit cost. Load/grid connected fuel cell power system mainly comprises of a fuel cell module.

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