# "Control for Reliable Fuel Cell Power System with Input Ripple Current Compensation"

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***Abstract**:* This paper work is carried out to reduce ripple current which is flow to the fuel cell/Battery through power electronics devices during dc-ac operation. FCs have advantages such as high efficiency, zero or low emission (of pollutant gases), and flexible modular structure With clean operating environment and high energy conversion efficiency, fuel cell is getting more and more attention, especially for the stationary power application. Such an application, either delivering electricity with utility intertie or directly supplying to residential area as a standalone power source, can be used for future distributed generation systems

This paper initially describes problems associated with the fuel cell due to the ripple current such a ripple current may shorten fuel cell life span and worsen the fuel efficiency due to the hysteresis effect. The most obvious impact is it tends to reduce the fuel cell output capacity because the fuel cell controller trips under instantaneous over-current condition.

This paper consists of Active filter methods through which the ripple current analyses and control.

***Keywords:** Fuel cell, Ripple current, dc-ac conversion, active filter, power electronics*

## I. Introduction

Fuel cells (FCs) are static electric power sources that convert the chemical energy of fuel directly into electrical energy. FCs have advantages such as high efficiency, zero or low emission (of pollutant gases), and flexible modular st FCs are good energy sources to provide reliable power at steady state; however, due to their slow internal electrochemical and thermodynamic characteristics, they cannot respond to electrical load transients as quickly as desired.[1] .They are connected to the power grid through power electronic interfacing devices, and it is possible to control their performance by controlling the interfacing devices. Modelling of FCs can therefore be helpful in evaluating their performance and for designing controllers [1,2].

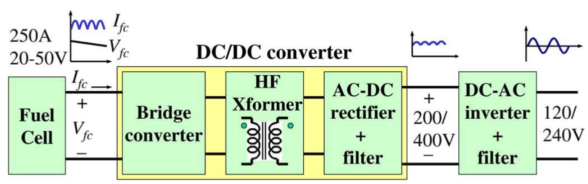


Figure 1 :- Block diagram of a stationary fuel cell power system

Some existing commercial-off-the-shelf proton exchange membrane (PEM) fuel cells also have their nominal voltage set at 48 V and below for either telecommunication or residential applications. In order for low-voltage dc fuel cell to generate 50/60 Hz, 120/240 V ac voltage for residential applications, a dc–dc converter is needed to boost the fuel cell voltage to a level that can be converted to the desired ac output. Fig. 1 shows such a system structure that contains a low-voltage high-current dc–dc converter and a dc–ac inverter. The output of the dc–dc converter, or the input of the dc–ac inverter for 120 V ac is typically 200 V and for 240V ac is about 400 V. For a nominal 20 V, 5 kW fuel cell under full load condition, the voltage is 20

V, and the average current is 250 A. The ripple is added on top of the average current with a peak current that tends to overload the fuel cell periodically. The fuel cell can experience nuisance tripping with such a ripple related overload situation.

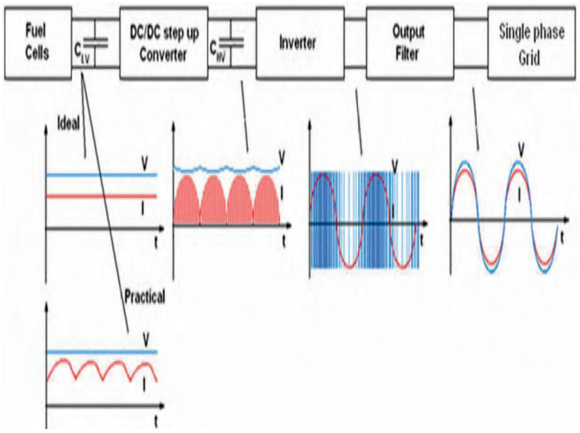


Figure 2 :- Block diagram of ripple current generation in fuel cell power system

## II Methodology

Some approaches have been proposed to prevent this 120 Hz ripple from being imposed on the fuel cell. One of the methods proposed [3] uses a LC series response circuit tuned to twice the output frequency connected in parallel to the DC bus capacitor in a composite PWM voltage source inverter. This approach requires bulky components. A multiloop control for a high frequency link DC-AC inverter system is proposed in [4]. Another topology using a high frequency link and an active filter is proposed in [5]. The high frequency link necessities the use of a high frequency transformer and other switching devices. Method using an active filter for current ripple reduction was proposed in [6, 7]. However these methods are based on using a separate energy storing device like battery or ultra capacitor.

Adding energy storage capacitor either on the high-side dc bus or on the low-side fuel cell dc bus may help reduce the ripple, but the cost and size of added energy storage component are objectionable when the ripple is reduced to an acceptable range. Laboratory test indicated a peak-to-peak Ripple of 34% is obtained with a typical 1.2-kW design. This Ripple current component implies that fuel cell requires a power handling capability 17% higher than its nominal output rating. Current ripple not only affects the fuel cell capacity, but also the fuel consumption and life span [2], [3]. The results indicate that the fuel cell not only needs higher power handling capability, but also consumes 10% more fuels [2]. Furthermore, as pointed out by [3], the 100-Hz harmonic current exhibits a hysteresis Behavior with PEM fuel cells. Injecting ripple current around this frequency to fuel cell may result in thermal problem among stacks and impair the stack lifetime.

The fuel cell current Ripple reduction is thus a major issue for the fuel cell converter Design. Reference [4] suggested that the ripple current be limited to less than 10%. Passive energy storage compensation Method was suggested and tested extensively in [5]. Active Compensation with external bidirectional dc–dc converter method was suggested in [6], [7]. These methods require externally Added components or circuits and are not preferred

### Ripple Current Elimination through Active filter

In this a mathematical analysis of a single phase inverter has been presented to verify the appearance of the second harmonics current ripple at the inverter stage. An active filter method to cancel the second harmonics current ripple drawn from the fuel cell source in a single phase fuel cell system is proposed. figure 3 shows the proposed system block diagram along with the second harmonics current path. The proposed system uses an active filter connected across the DC-DC converter.

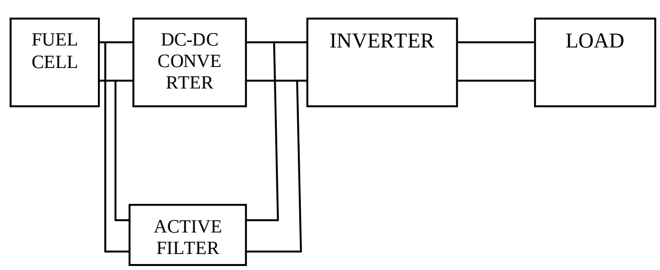


Figure 3 :- Block diagram of the proposed system.

Without filtering

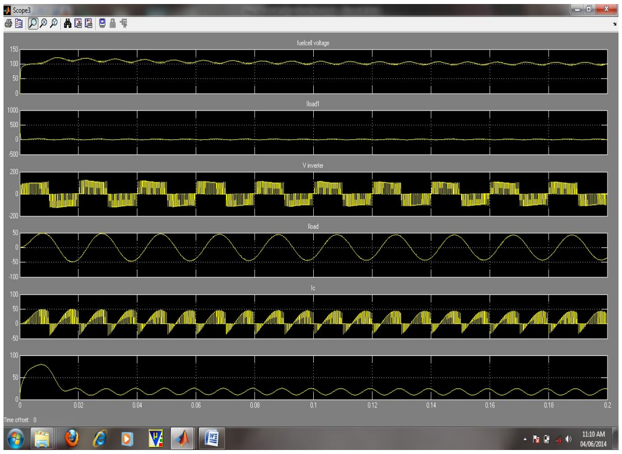

Figure 4 : - simulation of fuel cell current without filtering.

The active filter provides an alternate path for the second harmonics current and prevents the ripple to appear on the fuel cell side. The active filter block consists of two controllable switches and an inductor. The second harmonics current component now flows from the inverter through the boost circuit into the active filter and back to the inverter.

**With filtering**

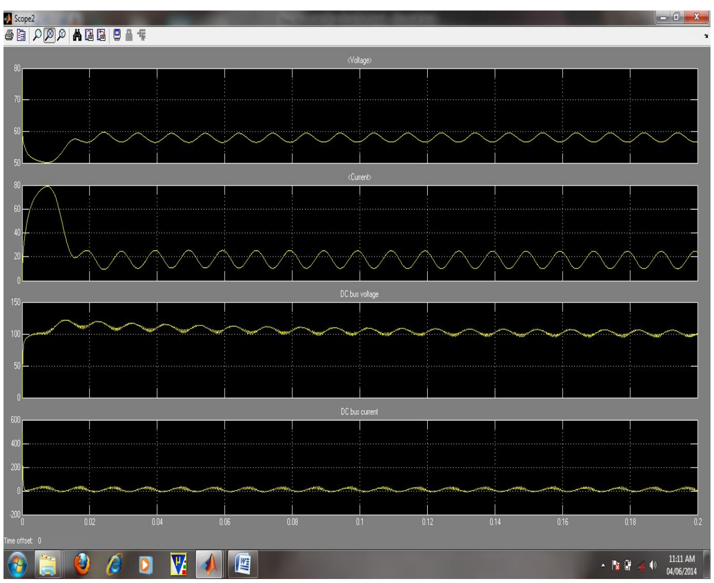

Figure 5 :- Simulation of fuel cell current with filtering.

## III CONCLUSION

Reliable fuel cell power system with input ripple current compensation using an active filter is presented. The proposed system provide an alternate path for the ripple current through the active filter which prevent the ripple current from circulating through the fuel cell source. The cancellation current is derived from the DC bus capacitor itself and hence no external energy storing device is required. Due to ripple compensation efficiency of fuel cell get improve and overloading of fuel cell get reduce also thermal stability of fuel cell improved. Proposed system tested on MATLAB and simulation of smoothing wave represented. For removal of ripple filter technology having vast scope as well as inverter design also having scope to improve further.

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