A New Fuzzy Control Strategy of Switching Regulators for Fuel-Cell Power Applications

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Abstract- **It is typically assumed that the input supply voltage to a switch-mode power supply is constant or shows negligible small variations. However, the last assumption isn't any longer valid once a fuel-cell stack is employed as input supply. A fuel-cell stack is characterized by low and unregulated DC output voltage, additionally, this voltage decrease in a very non-linear fashion once the demanded current increases; henceforward, an appropriate controller is needed to cope the said problems. during this study, an average current-mode controller is intended employing a combined model for a fuel-cell stack and power converter; what is more a selection procedure for the controller gains guaranteeing system stability and output voltage regulation is developed. The projected energy system uses a fuel-cell module (polymer solution membrane fuel cells) and a power convertor delivering a power of 900 W. In existing method, we used pi controller to produce the pulses to control the switches, but pi controller doesn't control the initial voltage with in the limit, to maintain it with in limit we introduced fuzzy logic controller. Simulation results make sure the projected controller performance for output voltage regulation via closed-loop gain measurements and step load changes. Additionally, a comparison between open- and closed-loop measurements is created, where the controller hardiness is tested for giant load variations and fuel-cell stack output voltage changes moreover.**

I. INTRODUCTION

The synchronization of renewable energy and distributed energy generation to the main grid has becomes more popular for subsidiary services loads, within the last years. let's say, the DC energy sources that perform a very important role these days are: electrical phenomenon modules and fuel-cell stacks. These DC sources generate low and unregulated output voltage levels; then, series and parallel combination unit organized to get higher terminal voltage (and current), subsequently power electronic devices area unit utilized to extend, regulate and in some cases invert the output voltage. A electrical circuit uses primarily element assist energy supply which is regenerate to voltage through a chemical science reaction with element or another oxidizing agent. as compared to other energy production sources, like thermal and nuclear hydral power plants, power generation from this method is a lot of economical and green, since solely heat and water area unit the waste products; thus, this technology represents gorgeous different for power generation.

II.FUEL-CELL STACK WITH BOOST CONVERTER

A cell is Associate in nursing hydrogen-based voltage supply that generates low and unregulated DC voltage, wherever the output voltage decreases in a very non-linear fashion once the demanded current will increase. The stack output voltage terminals are connected to a DC/DC power convertor to finally offer a voltage needed to feed either a DC or a AC load. Within the following, an overall mathematical description capturing exactly the coupling between the fuel-cell stack and a DC/DC boost convertor is shown intimately.

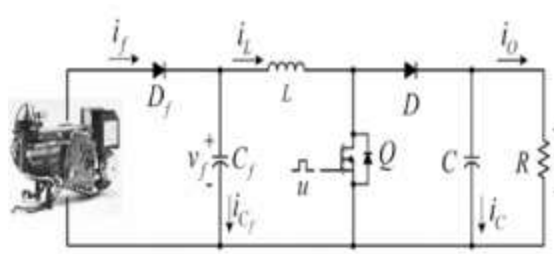


Fig. 1 Fuel-cell stack/boost converter system

A. Fuel-cell stack static properties

Several expressions are projected within the open literature to predict the chemical and thermal changing behavior of PEM fuel cells. However, for the aim of this work, an acceptable and easy-to-handle fuel-cell stack expression together with electrical properties compatible with power conversion is employed.

B. Average current-mode controller

Average CMC could be a helpful technique for relieving the planning and improving the dynamic performance of switch-mode converters. Since the common inductor current is employed for output voltage regulation, a faster response is obtained once step changes are applied to the load. Additionally, sensing the electrical device current also can be used for preventing overload current through the device. This management technique uses a high-gain compensator, a low-pass filter and a PI controller/fuzzy logic controller to warrant: (i) that the common electrical device current follows the current reference, and (ii) output voltage regulation. The advantage of this approach is that any modification within the input voltage source has a right away impact within the controller (fast propagation property).The overall controller style procedure could be a twofold problem:(i) gain choice for the present loop, and (ii) gain choice for the voltage loop. so as to derive the controller expressions, a configuration for this system is projected in Fig. 2. As can be seen, the common CMC employs current and voltage loops. For the current loop, N is that the current detector gain, G(s) a high-gain compensator, F(s) a low-pass filter and at last VP the height magnitude of the ramp wont to generate the management pulses. For the voltage loop, H stands for the voltage detector gain, Vref the specified output voltage and K(s) the transfer operate resembling the PI controller that generates the present reference Iref.

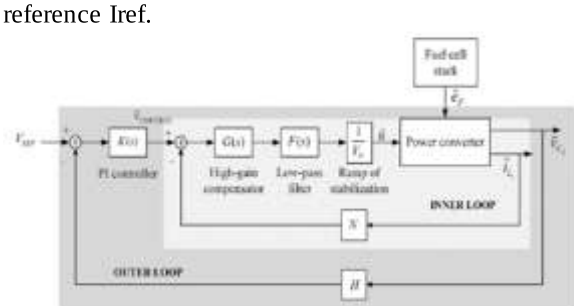


Fig. 2 Average CMC scheme for a switching regulator

III. SIMULATION MODEL

Block Diagram:

Power circuit: it consists of a fuel cell stack and a boost converter, the voltage which is produced from fuel cell is very low it is not enough to drive heavy loads so to make it usable for heavy loads we used a power electronic converter which is boost converter instead of connecting several fuel cells in parallel.so that cost will reduce. Boost converter consists of a MOSFET, diode, inductor and a capacitor connected as shown in fig.1. By changing the duty cycle of MOSFET we will get the different voltage levels at output side or load side.

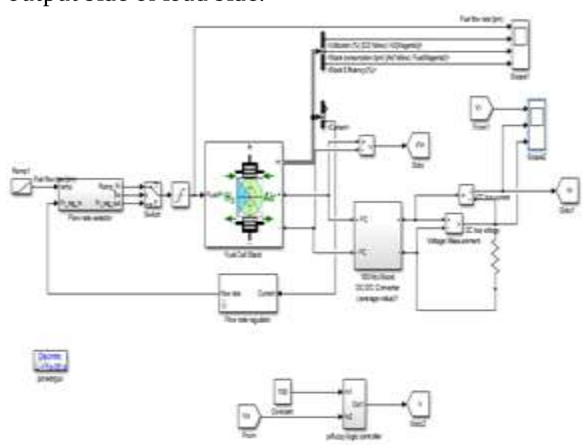


Fig. 3 The simulation model

IV.CONTROL SYSTEM OF THE CIRCUIT

In this project we used closed loop control strategy , as we know closed loop control system has greater advantageous over open loop control system.as it has the feedback element and PI controller, actuator, the changes or variations in the output has a effect on input so that we can call it as automatic control system.

Control strategy with fuzzy logic control:

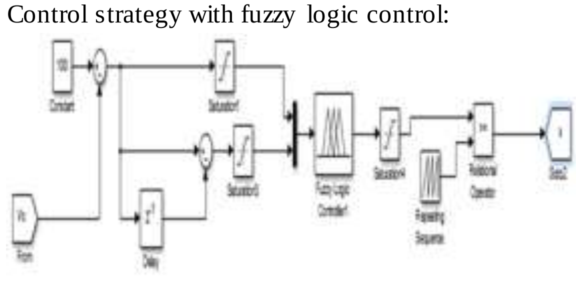


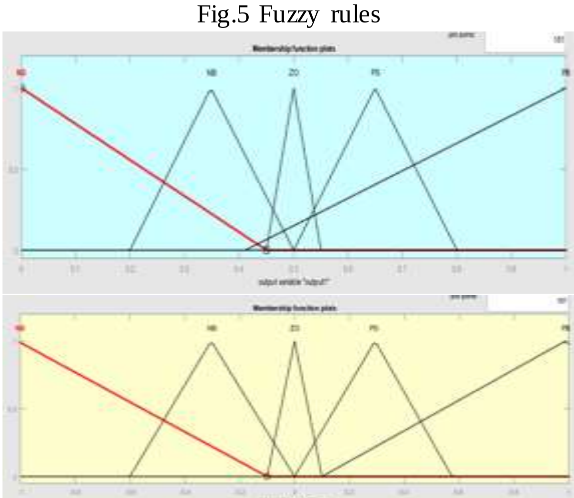
Fig. 4 The control system of the boost converter using fuzzy logic

In this method we just replaced PI controller block with fuzzy logic controller, error signal is the input to PI controller ,but for fuzzy logic controller we can gave as many signal as we required, in this project we took the two input signals to fuzzy logic controller ,one is error signal and the other is rate of change of signal and each input signal has a membership functions , based on the Rules given on the membership functions the output will generate nothing but a driving signal after generating the driving signal the process is same as pi method , giving this signal as input to actuator SPWM , which will generate the signals which is required to turn on the switch to get the required output. According to the changes in the fuzzy logic controller the output will be vary with in the range only. If error is NB in the range of (-45 -30 -15) and rate of change of error is NB in the range of(-0.6005 -0.304 0) then the output is NB in the range of (0.1995 0.3479 0.5).If error is NB in the range of (-45 -30 -15) and rate of change of error is NS in the range of(-1.5 -1 -0.0947) then the output1 is NB in the range of(0.1995 0.3479 0.5).like this we have defined 25 rule which are mentioned in the below table.

Table 1. Fuzzy controller rules

CE \ E	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	ZE
NS	NB	NB	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	ZE	PB	PB	PB
PB	ZE	PS	PB	PB	PB

Fig.5 Fuzzy rules



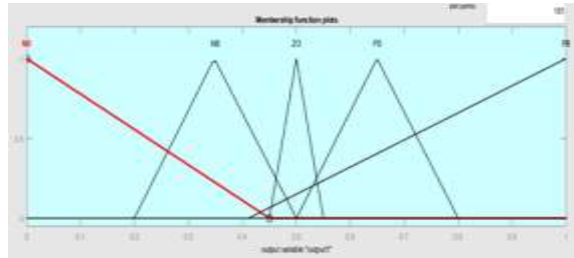


Fig. 6 Membership functions of inputs and output

V. SIMULATION RESULTS

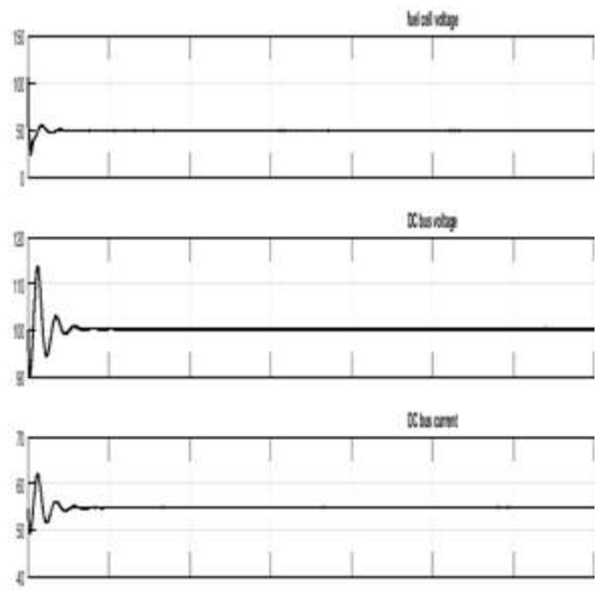


Fig. 7 Simulation results with PI controller

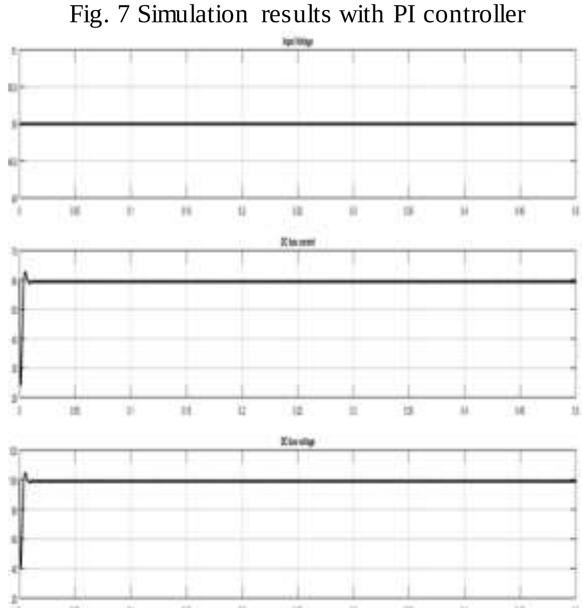


Fig. 8 Simulation of results with fuzzy logic controller

VI CONCLUSION

This paper deals with the output voltage regulation of a fuel-cell stack/boost device system. The projected management strategy is based on average CMC wherever 2 loops ar enforced, namely the inner loop wherever the electrical device current is fed back employing a high gain compensator and a low-pass filter, and therefore the outer loop wherever the output voltage is fed back via a PI controller for steady-state error regulation. the choice procedure for the controller parameters is expressly careful. the factors given among guarantee system stability and output voltage regulation. The poles and zeros for the controller are set in the main from the operational shift frequency of the device. to boot, thanks to the high-gain compensator of the inner loop, the device performance is a smaller amount sensitive to parameter uncertainties and variations of the fuel-cell stack voltage. Hence simulation results proved that fuzzy logic controller is superior than PI controller as it reduces the peak over shoot and less complex.

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