A SINGLE-PHASE HIGH-POWER FUEL CELL CONVERTER WITH DIRECT DOUBLE-FREQUENCY RIPPLE CURRENT CONTROL WITH FLC STRATEGY

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ABSTRACT:This paper proposes an immediate double-frequencyripple current command in a single phase high power fuel cell converter which can easily accomplish low frequency ripple free input current without using big electrolytic capacitors.In this proposed technique the content of ripples in present is actually reduced with no necessity of additional switching devices. A fuel cell power system which has a dc-acinverter tends to bring an ac ripple up at two times the output frequency. Such a ripple present could reduce feedback fuel celllifespan an innovative power control strategy is actually suggested to add a present control loop in the dc dc converter for ripple reduction. get rid of the double frequency ripple present disturbance lead by the single phase inverter load an In order to an In order tofuzzy controller and proportional-resonant controller is actually put together to complete an additional superior control gain at designed resonant frequency. This can reduce both size and price of the system. The system is created and simulated usingMATLAB/ Simulink Software.

KEYWORDS: Current-fed three-phase dc–dc converter, direct double-frequency ripple current control, electrolyticcapacitor free, fuel cell, zero voltage switching (ZVS).

I. INTRODUCTION

Recently, software of the fuel cell engineering wasaccelerated in manufacturing, transportation, and residential sectorsobligations to strong governmental assistance in several advanced nations, like Japan [1]. Rated strength of a fuel cell powerproduct could be in the range from a number of 100 watts to 100 kilowatts or perhaps even greater, based on application.Hence, low cost converters designed for high energy programs are actually of an excellent interest in this particular area [2].Fuel cells typically feature comparatively low voltage and highpresent at the output terminals and hence need isolated power electronic screen. Current-fed (CF) converters are actually used morefrequently compared to their voltage fed (VF) counterparts, since lowtoday's ripple operation has a favorable effect over gas cell lifetime as well as effort yield. Hence, this particular paper focuses on CFinterface converters for high power systems and medium. Insome instances, a single phase converter implementation is notfeasible due to limits of current thermal management and power semiconductors. There are many conventionalchoices to conquer the limitations. First, severalconverters with independent transformers may be attached in parallel at the input as well as output sides [3] [9]. Output side of theparalleled converters can be additionally attached in series to be able to attain increased DC voltage gain [ten], [eleven]. design that is Such enableshigher energy operation, modularity, interleaved functioning with lesser present and voltage ripples, (N+1) redundancy, etc.

In certain significant and moderate power programs, when single phase converter implementation is actually complicated, three-phaseDC-DC converter can easily be viewed as a suitable fix. Athree-phase isolated DC DC converters were initially suggested to overcome limits of a single phase counterparts in [12].This strategy doesn't supply as a lot of benefits as multiphase parallel converters, while it will take just a singleisolation transformer and hence can offer lower cost as well ashigher energy density .

Among the crucial problems in fuel cell system would be that the entire mobilecurrent low frequency ripple exhibits a hysteresis conduct and results a winter issue among stacks [19]. A straightforwardoption would be applying the bulky electrolytic capacitor as the big energy buffer to decrease the ripple current. Nevertheless, the electrolytic capacitor reduces the system lifetime and raises the systemvolume and price [20]. Thus, to control the low-frequencyripple without needing electrolytic capacitors is actually essential to fuel cell methods. Lately, some literature have explored onthe ways to mitigate fuel cell low frequency ripple current without needing electrolytic capacitors [14] [18]. Nevertheless, thosesolutions can't be exclusively used for the high power fuelcells, which typically call for the multiphase dc dc converter as the front end.In fuel cell high power systems, research has beenfocused on the three phase dc-dc-converter-based power conditioning process since it provides much better functionality over its singlephase version in terminology of higher energy density, lower switching unit existing anxiety, reduced size of passive elements, etc [21] [25]. The kind of three phase dc-dcconverter might be possibly current fed or maybe voltage fed. Based onthe analysis done in [23] [25], current fed topology is bettersuited to low voltage high current energy cell program where higher voltage step up ratio is actually required. Furthermore, the currentfed topology gains from the precise and direct input currentmanagement.

Previous research on three phase dc dc converters for fuelcells mostly centered on the high effectiveness and high energy density. The strategy to decrease the fuel cell low frequency ripplepresent has been rarely discussed. Reference [26] presents thevoltage-fed high power fuel cell converter, that consists of a V6 converter [22] along with a full bridge inverter. It proposes theripple current mitigation strategy by making use of a current loop command within the current voltage loop to mitigate the fuel cell lowfrequency ripple. Nevertheless, the big electrolytic capacitor isstill needed as an energy buffer. Up to date, there have been nopublished literature that study the techniques to decrease the lowfrequency ripple up in the current fed three phase dc-dcconverter-based fuel cell system.This paper proposes a three phase current fed interleavedstructure based HFL fuel cell process.

When compared with otherthree-phase dc-dc-converter-based fuel cell methods, the special benefits of our proposal fall into the following 3 elements.For starters, a strong double frequency ripple current control basedon the current fed three phase HFL converter is suggested to get the low frequency ripple free input current. Next, the suggested strategy is applying a control oriented ripplepresent mitigation program without adding any additional circuit components. The tiny movie capacitor could be followed to replacethe bulky electrolytic capacitor. Third, the management system canrealize the whole utilization of capacitive ripple sources of energy inthe recommended fuel cell process, which benefits an additional decrease in dc bus capacitance. Additionally, with all of the contributionsmentioned above, the zero-voltage-switching (ZVS) functioning of allswitching products in the dc dc stage could really be maintained without adding some additional circuits.

II. PROPOSEDCONTROL STRATEGY

This paper presents the proposed direct double-frequency ripple current control system shows in the Fig 1diagram. The proposed control system contains duty cycle control and phase shift control. The duty cycle D = D0 + Dr,as illustrated. First, the dc component of D, D0 is set to be 0.5. This is because the three-phase HFL converter has theoptimized operation efficiency at 50% duty cycle. Second, the ripple component of D, Dr is generated bysynchronizing the LVS dc-bus voltage Vdwith the primary-referred HVS dc-bus voltage Vdc. The purpose is to realtime balance the transformer primary- and secondary-side voltages in order to make sure the ZVS operation of allswitching devices in the dc–dc converter. The proportional–resonant (PR) controller is adopted for GDr(s) to regulatethe swing of Vd.

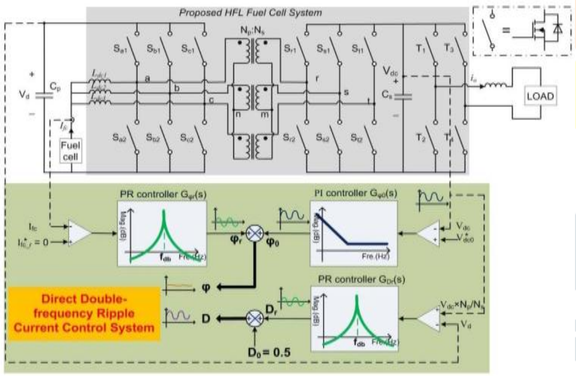

Fig. 1 Proposed direct double-frequency ripple current control system diagram

The design guideline of controller GDr(s). The real-time primary-referred Vdc is employed as thevoltage reference. The LVS dc-bus voltage Vdis equal to Vfc/D due to the LVS half-bridge boost function. Vfc is aconstant value if Ifc has no low-frequency ripple current. Therefore, D will contain a double-frequency ripple in orderto keep Vdsynchronized with primary-referred Vdc, which has the double-frequency variation.

Fuzzy Logic Controller (FLC) is a fuzzy logic based control system, it is a non-mathematical decision algorithm that isbased on an operator's experience. This controller analyses analog input value in terms of logical variables that can takeon continuous values between 0and 1.The First inputs of the Fuzzy Logic Controller is error and second input is changein error. Fig.2 shows the Fuzzy logic controller.

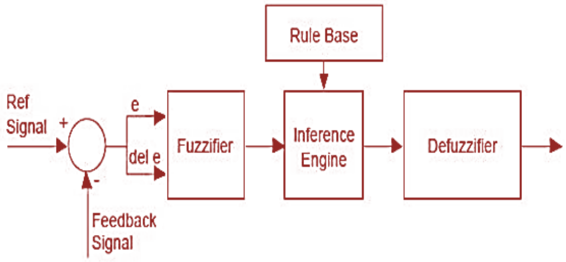

Fig.2 Show the Structure of Fuzzy Logic Controller.

Fig 2 shows the structure of fuzzy logic controller there are four basic elements in the fuzzy controller systemstructure there are fuzzifier, rule base, inference engine and defuzzifier. Input output control passes through a preprocessor while output passes through a post-processor.

1. Fuzzifier: Linguistic variables used by Fuzzy Logic instead of numerical variables. The process of changing a numericalvalue into a linguistic label is called "Fuzzification". For closed loop control system, the error (e) between the referencevoltage and the output voltage, and the rate of change of error (Del e) can be named as zero (ZE), positive small (PS),negative small (NS), etc.

2. Inference:In conventional PI controllers having control laws, whereas the Fuzzy Controller contains rules. Rules are linguistic innature and they permit the operator to develop a control design in a more familiar human environment. A typical rulecan be written as below: The member ship functions are used to Fuzzy inputs shows in Fig 3. The membership valuecan take from 0 to 1 for every Linguistic label. For each of the input and output variables, the following sevenLinguistic labels are given to the membership functions:

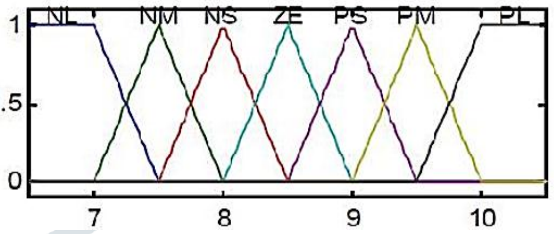

Fig.3 Show the Fuzzy Logic Rule table.

NL= Negative Large PS=Positive Small
NM =Negative Medium PM=Positive Medium
NS=Negative Small PL=Positive Large
ZE=Zero

After the member ship functions are found for each linguistic label, an intelligent decision procedure can be made tosense what output should be, is called inference.If the "error" is negative Large (NL), and the "rate of change of error" is negative Large (NL), then the output ispositive large (PL). It is suitable when dealing with large number of inputs, to put rules.The Fig 3 shows the rules done for large number of input combinations. After the rules are evaluated, from each of theoutput membership function having a membership arrange for a numerical value called crisp value called"DeFuzzification".

3. Defuzzification:

DeFuzzification plays a vital role in Fuzzy logic based control system. It is the last process of Fuzzy controlsystem in which the Fuzzy inputs, to put rules. The Fig 3 shows the rules done for large number of input combinations.After the rules are assessed, from each of the output quantities defined for the output membership functions are mappedinto a crisp.

III. SIMULATION AND RESULTS

Using MATLAB/Simulink software, simulation was performed. MATLAB is a high performance language fortechnical computing and it integrates programming in an easy environment.Fig.4 represents Simulink model of proposed high boost ratio transformer dc-dc converter. In this inputvoltage=51v given to this converter. The voltage is stepped up using a three phase transformer and the final DC voltageis obtained at the output side of the circuit.

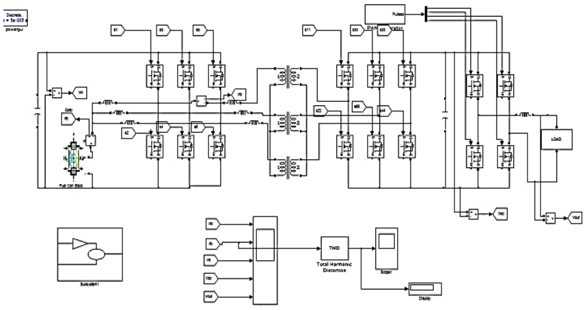

Fig. 4 Proposed direct double-frequency ripple current control system diagram

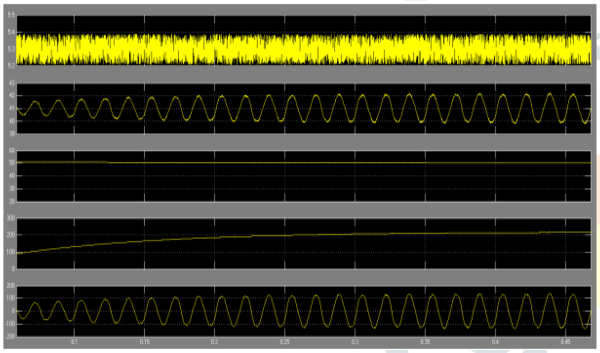

Fig.5Simulation of results without the proposed control method, (A) C_p = 220 µF, C_s=3.18mF

Above figure shows simulation results withoutthe proposed method. In order to suppress the fuel cell currentdouble-frequency ripple, the large electrolytic capacitors are connected to the HVS dc bus. The adopted capacitors forthis case are the following: C_p = 220µF and C_s = 3.18mF. As shown, V_d= 51V, and V_{dc} = 200V, and they both haverelatively very small ripple due to the relatively large capacitor. ira_{rms} = 5.3 A andira_{peak} = 11.4 A.vo = 120 V(RMS).Ifc average value is around 41 A.

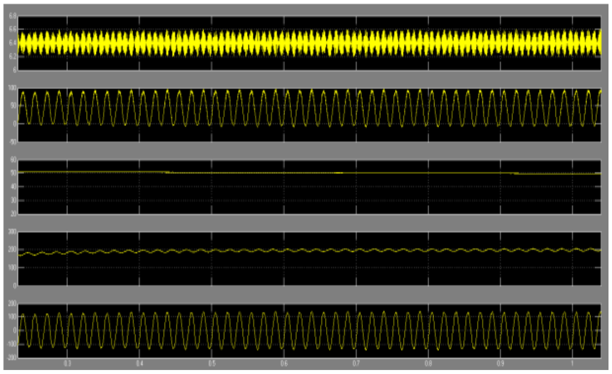

Fig. 6 Simulation of results without the proposed control method C_p=220µF, C_s=180µF.

Fig. 6 shows simulation results without the proposed method. C_p = 220 µF and C_s = 180 µF. The transformercurrent has much larger RMS and peak values compared with Fig. 5 since the double-frequency ripple current ispropagated into the fuel cell stack through the transformer.

IV. CONCLUSION

Three-phase HFL-based fuel cell power conditioning system that can achieve low-frequency ripple-free input currentby making use of direct double-frequency ripple current control. The proposed method can make full utilization ofcapacitive ripple energy sources. To directly eliminate the fuel cell current double-frequency ripple, PR and Fuzzycontrollers are developed to achieve an extra high control gain at 120-Hz resonant frequency.

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