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# Low Frequency Current Ripple Reduction Technique With Active Control In A Power System With Inverter Load

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**Abstract -** During the next few years there will be a profound change in the generation and usage of energy, influenced factors such as environment, capital and production costs as well as geopolitical factors, old power stations in the world will be phased out. Newer power stations, having large output capacity will be difficult to permit in many existing political climates. With global warming now apparent, environment and efficient fuel utilization have become significant factors in the adaptation of newer and emerging energy conversion technologies. High installation cost is the major obstacle of the commercialization of fuel cell for distributed power generation. A fuel cell power system that contains a dc–ac inverter tends to draw an ac ripple current at twice the output frequency. Such a ripple current may shorten input cell lifespan and worsen the efficiency and output capacity. In this paper, an advanced active control technique is proposed to incorporate a current control loop in the dc–dc converter for ripple reduction. This will reduce both size and cost of the system. The proposed active ripple reduction method has been verified with MATLAB simulation.

**Index terms -** Ripple reduction, low frequency current ripple.

## I. INTRODUCTION.

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. The main problem is fuel cell output voltage is generally low voltage dc, but the output load is relatively high-**I.** voltage ac. An example system that has been the target development of the U.S. Department of Energy (DOE) Solid-State Energy Conversion Alliance (SECA) is to have a nominal 5 kW single phase ac output for residential power system using the low-voltage solid oxide fuel cell (SOFC), which has an output voltage ranges from 20 to 50 V. Some existing commercial a proton exchange membrane type fuel cell using a 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 input cell to generate 50/60 Hz, 120/240 V ac voltage for residential applications, a dc–dc converter is needed to boost the cell voltage to a level that can be converted to the desired ac output.

Adding energy storage capacitor either on the high-side dc bus or on the low-side input 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.

## II. LOW FREQUENCY CURRENT RIPPLE.

Fig.1 shows a single-phase full-bridge dc–ac inverter circuit that has been used in the study. The inverter is implemented with a sinusoidal pulse width modulation (PWM) method to ensure a perfect output voltage. With a linear load, the output current has the same frequency and sinusoidal wave shape as the output voltage. The inverter input voltage and current are dc, but the current contains high frequency switching noises and a low frequency ripple component.

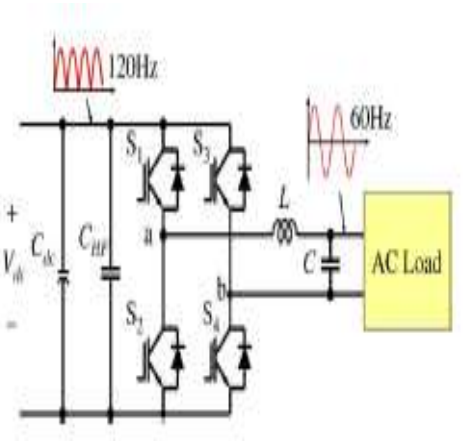

Fig.1: Low Frequency Current Ripple Generation by a Single – Phase Full Bridge Inverter

The ripple component in the input dc side is considered as the rectification effect through the inverter switches, and thus it appears to be a pulsating current with frequency double that of the output frequency (120 Hz).The PWM switching noise is filtered with a high-frequency dc bus capacitor, but the energy of the 120 Hz ripple is too high to be absorbed. A bulky dc bus capacitor can then be used to smooth the 120-Hz ripple, but a significant part of the120-Hz ripple remains and continues to propagate through the entire dc–dc converter and back to the input dc supply.

## III. ACTIVE RIPPLE CURRENT REDUCTION TECHNIQUE.

Fig.2 shows the system structure that contains a dc power system with inverter load. It consists of a low voltage high current dc-dc converter and a dc-ac inverter. A bridge converter, high frequency transformer and a ac-dc rectifier together constitute the dc-dc converter. The output of dc-dc converter or the input of dc-ac inverter for 120 V ac is typically 200 V; and for 240 V ac is about 400 V.

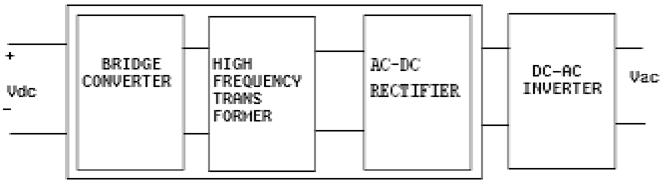

Fig.2: Block Diagram of Power System with Inverter Load

## Bridge Converter

The bridge converter is a full bridge dc-ac inverter which converts 50 V input dc to 120 V ac output. A single phase dc-ac inverter consists of four switches. Here the a sinusoidal PWM method is used for switching .In this method a fixed dc voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter switches.

The inverter input voltage and current are dc, but the current contains high frequency switching noise and a low frequency ripple component. The ripple component is considered as the rectification effect through the inverter switches and thus it appears to be double that of the output frequency. The high frequency PWM switching noise can be easily filtered with a with a high frequency dc bus capacitor, but the energy of low frequency ripple is too high to be absorbed. For an output frequency of 60 Hz this ripple has a frequency of 120 Hz.

A bulky dc bus capacitor can then be used to smooth the 120-Hz ripple, but a significant part of the 120-Hz ripple remains and continues to propagate through the entire converter and back to the input side.

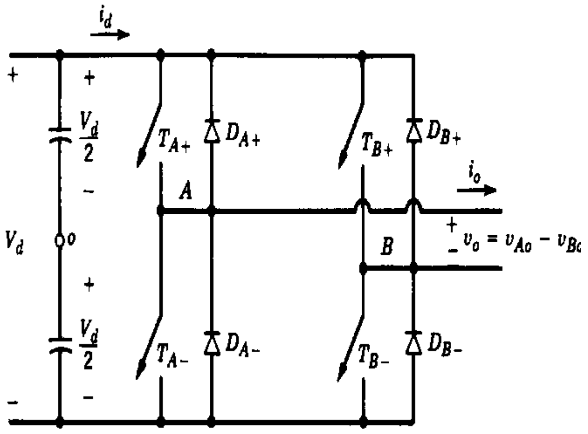

Fig.3: Single – Phase Full Bridge Inverter

The basic circuit diagram of a single – phase full bridge inverter is shown in fig.3.It consists of four controlled switches and four diodes. When $T_{A+}$ and $T_{B-}$ conduct the load voltage is $V_d$. When $T_{B+}$ and $_{TA-}$ conduct the load voltage is $-V_d$. The frequency of output voltage can be controlled by varying the periodic time

The sinusoidal PWM is most widely used method of voltage control in inverters. Here the widths of the pulses are different. The SPWM technique used for switching is shown in fig.2.3. The width of each pulse is weighted by the amplitude of sine wave at that instant. In this a high frequency carrier triangular wave of frequency ‘$f_c$’ and amplitude ‘$\upsilon_{tri}$’ is compared with a sinusoidal reference wave of frequency ‘f ’ and amplitude ‘$\upsilon_{control}$’. The control signal is also called as modulation signal. The intersection of $\upsilon_{tri}$ and $\upsilon_{control}$ waves determines the switching instants and commutation of modulated pulse.

The carrier and reference waves are mixed in a comparator. When sinusoidal wave has magnitude higher than the triangular wave, the comparator output is high, otherwise it is low. The comparator output is processed in a trigger pulse generator in such a manner that the output wave of the inverter has a pulse width agreement with the comparator output pulse width. The ratio of $\upsilon_{control}$ and $\upsilon_{tri}$ is called modulation index.

$$\text{Modulation index, } m = \upsilon_{control} / \upsilon_{tri}$$

The number of pulses depends upon frequency of the carrier.

$$P = f_c / 2f = m_f / 2$$

$$m_f = f_c / f$$

where $m_f$ is frequency modulation ratio.

The output voltage waveform of single – phase full bridge inverter using PWM switching is shown in fig.5.

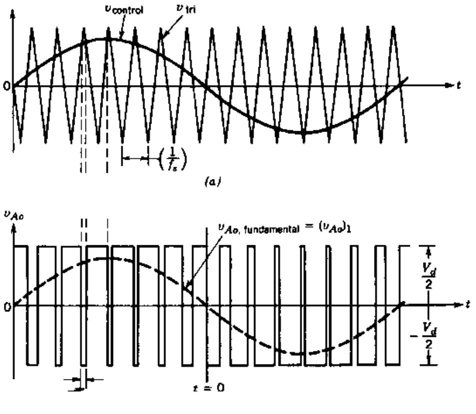

Fig.4: Sinusoidal Pulse Width Modulation

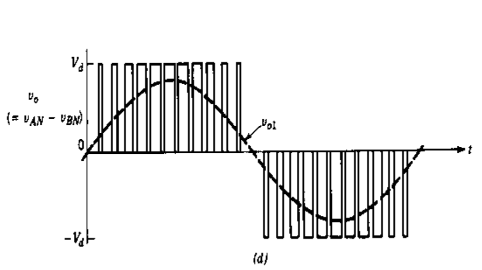

Fig.5: Output Voltage Waveform of Single – Phase Full Bridge Inverter using PWM Switching

## High Frequency Transformer

High frequency transformer is used for reducing ripple current, hysterisis and eddy current losses.

## AC-DC Rectifier

The full bridge ac-dc rectifier which converts 120 V input ac to 200 V dc output. A single phase ac-dc rectifier consists of four switches. An uncontrolled ac-dc rectifier is used in this case. LC filters can be used with the rectifiers to smoothen the dc output.

The basic circuit diagram of a single – phase full bridge uncontrolled rectifier is shown in fig.6. It consists of four diodes. When input voltage $\upsilon_s$ is positive, diodes $D_1$ and $D_2$ conduct and the load voltage follows input voltage. When input voltage is negative, diodes $D_3$ and $D_4$ will conduct. Therefore the output will be a dc voltage for pure resistive load. The input and output waveforms are shown in fig.7.

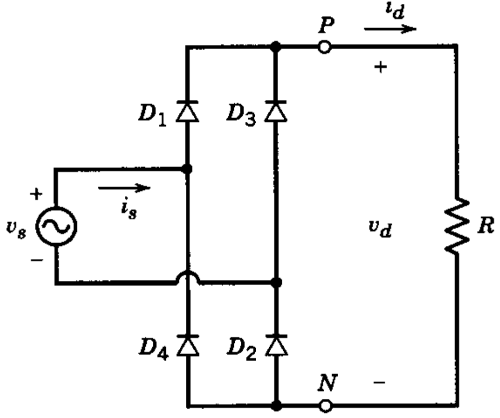

Fig.6: Single – Phase Full Bridge Uncontrolled Rectifier

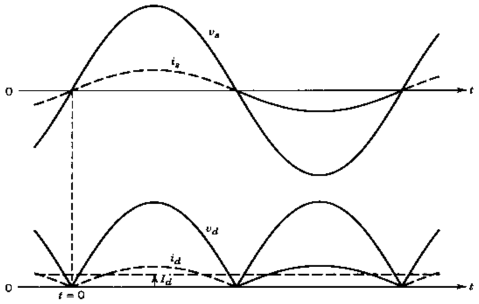

Fig.7: Input and Output Waveforms of Single – Phase Full Bridge Rectifier

## DC-AC Inverter

Another dc-ac inverter is used in the final stage to convert the output from the dc-dc converter to desired ac output voltage for utilization. Filters can be used with the inverter to reduce the noises in the output. The output of dc-dc converter or the input of dc-ac inverter for 120 V ac is typically 200 V; and for 240 V ac is about 400 V. The circuit and waveforms are same as above.

## Voltage Control and Current Control Loops

Although the use of passive energy storage component solution is straightforward and is effective, it will largely increase system volume and cost for a reasonably acceptable ripple. The better solution is to use active control and to avoid any penalty. Since there is an active power switching network between LV and HV sides, it provides a mean to process energy with high frequency switching operation. A properly designed control loop should be able to prevent HV load side ripple current from entering LV source side when the power stage switching frequency is much higher than the frequency of load side ripple current. It should be noticed that to control the ripple current, a single voltage loop is not sufficient since it does not track the current directly. Considering the basic dc–dc operation, with an additional current loop, it is possible to reduce the ripple current. Here voltage loop is outer loop and current loop is inner one.

In voltage and current control loops, the output of first stage inverter is fed back and is compared with the reference wave produced by the Phase Locked Loop System (PLL).The output from the comparator is taken to control the PWM pulses which is in turn applied to the inverter for switching.

## IV. SIMULATION VERIFICATION

Fig.8 shows the simulation results with dc–dc converter operating under voltage-loop closed condition.

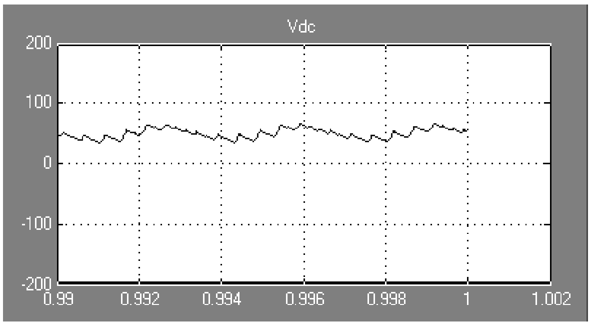

Fig.8: Input DC Voltage

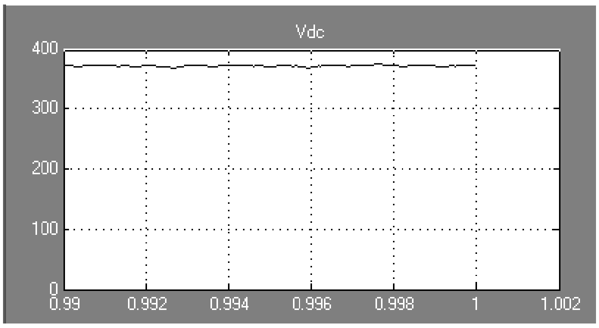

Fig.9: Output of Rectifier

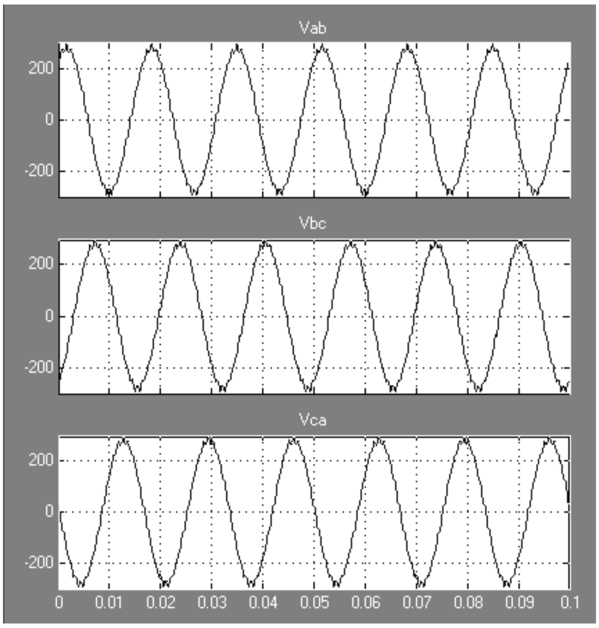

Fig.10: Output of final inverter

## V. CONCLUSION

Low frequency current ripple generated by a single-phase inverter can be filtered by energy storage type passive capacitors or suppressed by active control techniques. This paper has investigated the ripple generation and propagation. The model has been verified with computer simulation. Although the ripple reduction can be achieved by passive capacitors, this paper further suggests an active control method that incorporates a current-loop control within the dc–dc converter voltage loop. The design guideline for the proposed control method is provided, and the simulation is performed to verify the effectiveness of this advanced control method. Without adding system volume and cost, the proposed technique is very attractive for DC power systems.

## REFERENCES

[1] Changrong Liu, and Jih-Sheng Lai, “Low Frequency Current Ripple Reduction Technique With Active Control in a Fuel Cell Power System With Inverter Load” *IEEE Transactions On Power Electronics*, Vol. 22, No. 4, July 2007

[2] W. Choi, P. N. Enjeti, and J. W. Howze, “Development of an equivalent circuit model of a fuel cell to evaluate the effects of inverter ripple current,” in *Proc. IEEE Applied Power Electronics Conf. and Expo.*, Feb. 2004, pp. 355–361.

[3] G. Fontes, C. Turpin, R. Saisset, T. Meynard, and S. Astier, “Interactions between fuel cells and power converters influence of current harmonics on a fuel cell stack,” in *Proc. IEEE Power Electronics Specialists Conf.*, Aachen, Germany, Jun. 2004, pp. 4729–4735.

[4] R. S. Gemmen, “Analysis for the effect of inverter ripple current on fuel cell operating condition,” *J. Fluids Eng.*, vol. 125, no. 3, pp. 576–585, 2003.

[5] M. Schenck, K. Stanton, and J. S. Lai, “Fuel cell and power conditioning system interactions,” in *Proc. IEEE Applied Power Electronics Conf.*, Austin, TX, Mar. 2005, pp. 114–120.