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Advanced Active Filter (AAF) with Reduced DC Link Voltage

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ABSTRACT

In recent years voltage and current harmonics are become serious problem in transmission and distribution system. To eliminate these voltage and current harmonics and to achieve clean grids, AAF are been used. The existing AAF technology requires a higher dc link voltage to achieve the THD requirement therefore; this paper presents an Advanced Active Filter (AAF) for IGBT and LCL network in order to maintain voltage balance among dc-link. This method is well capable of balancing charging and discharging of dc-link voltage without increasing circuit complexity. This modulation technique is very effective in terms of voltage balancing as well as for maintaining voltage output THD at low level. The proposed system is implemented in Simulink platform of MATLAB software and performance shows its effectiveness over conventional IGBT used for inverter

Keywords: *Advanced Active Filter, IGBT, LCL network*

I. INTRODUCTION

Now in many systems connected to the grid and PWM rectifiers, LCL filters are used more and more. LCL filters give advantage in costs and dynamic since smaller inductors are needed to achieve required performance in damping the switching harmonics comparing with L or LC filters. Especially in large power systems whose frequency is low, the advantages of LCL filter are more significant. Because LCL filter need smaller inductance value comparing to L type filter at the same performance in harmonic suppression, it is gradually used in high-power and low frequency current source controlled grid-connected converters[1-4]. However design work of LCL filter parameter not only related to switch frequency ripple attenuation, but also impacted on performance of grid-connected current controller. First of all, this paper introduced a harmonic model of LCL filter in grid-connected operation, secondly researched the variable relationship among LCL filter's parameter and resonance frequency and high-frequency ripple attenuation. In order to achieve optimal effect under the precondition of saving inductance magnetic core of LCL filter, a reasonable design method was brought out Based on above analysis. Furthermore the method could guarantee the resonance frequency of LCL filter was not too small lest impacted current controller resign. Finally this design method was verified by the experimental results.

II. THE MODEL OF GRID-CONNECTED INVERTER

A. Main Circuit Topology

The main circuit topology can be seen as fig.1, where R1 and R2 are the resistors associated with inverter side and grid side inductors respectively. L1 , C2 and L2 compose the LCL filter

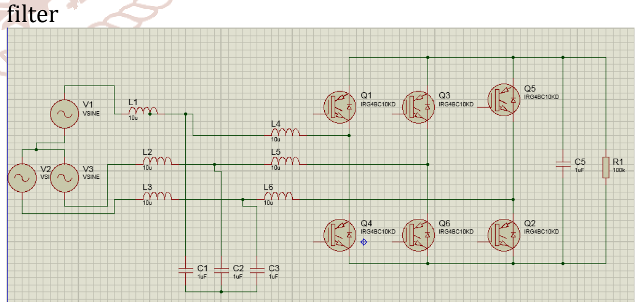

Fig.1 topology of three-phase inverter

B. The mathematical model of LCL Filter

In the grid-connected system with LCL filter, the relationship

between grid-connected current i_{grid} and inverter output voltage u_{inv} is shown as (1). (R_1 and R_2 are ignored since they are smaller comparing with the impedance of L_1, L_2.)

$$G_1(s)=\frac{I_{grid}(s)}{U_{inv}(s)}=\frac{1}{s^3L_1L_2C_2+s(L_1+L_2)} \quad (1)$$

In the grid-connected system with L filter, the relationship between grid-connected current i_{grid} and inverter output voltage u_{inv} is shown as (2)

$$G_T(s)=\frac{I_{grid}(s)}{U_{inv}(s)}=\frac{1}{sL_T} \quad (2)$$

III. THE CHARACTERISTIC ANALYSIS OF LCLFILTER

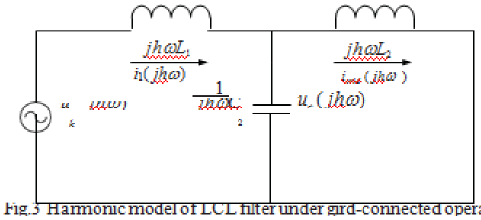

Fig.3 Harmonic model of LCL filter under grid-connected operation

According to the harmonic model of LCL filter which is seen as fig.3, the relationship between grid-connected current i_{grid} and inverter output voltage u_{inv} can be gained as (3).

$$\frac{I_{grid}(jh\omega)}{U(jh\omega)} = \frac{-j}{h\omega(-h^2\omega^2 L_1 L_2 C + L_1 + L_2)} \quad (3)$$

$|H_{LCL}(jh\omega)|$ is shown as (4).

$$|H_{LCL}(jh\omega)| = \left|\frac{I_{grid}(jh\omega)}{U_k(jh\omega)}\right| = \frac{1}{h\omega(-h^2\omega^2 L_1 L_2 C_2 + L_1 + L_2)} \quad (4)$$

IV. EXPERIMENTAL RESULT

To verify the proposed design method, a three-phase experimental platform based on DSP TMS320LF2407 is established. Based on 20% ripple wave RMS strict condition, the inductance value of L1 can be calculated. Then in the paper L1 = 5.5mH, L2 = 1.0mH, and C2=20 μf. Under the two-current-loop control, the system is connected to the grid safely. The waveforms of the grid-connected current with the designed LCL filter. The harmonic analysis of grid-connected current. The harmonic above resonant frequency was suppressed

A. THREE PHASE RECTIFIER WITHOUT FILTER

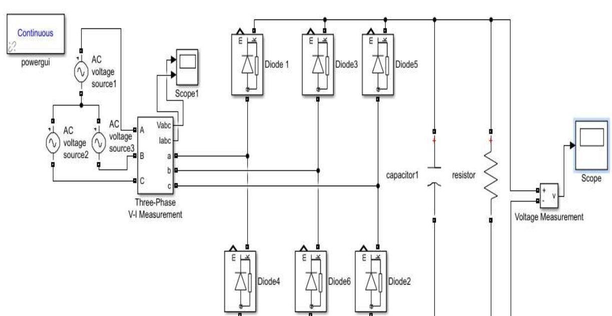

Fig.2 three-phase rectifier without filter

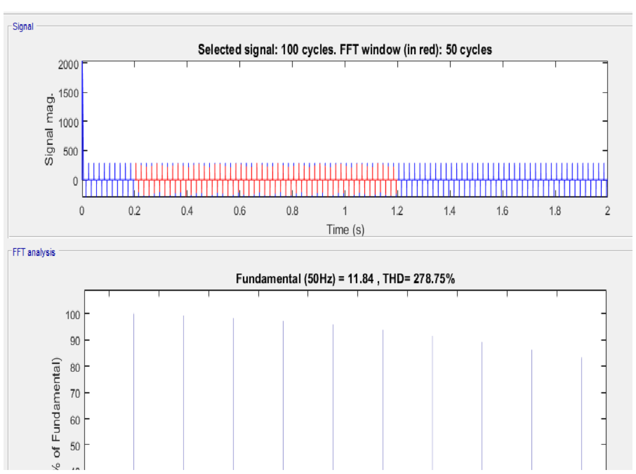

Fig2.1 THD value for three-phase rectifier without filter

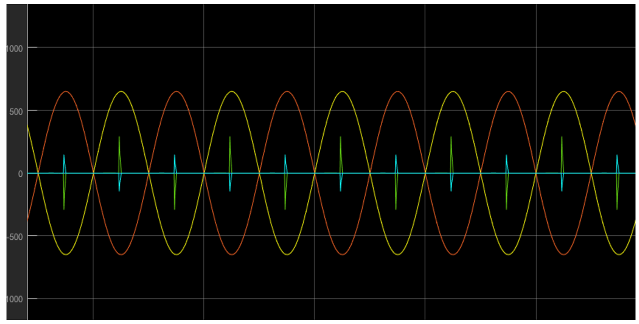

Fig 2.2 Input side of three-phase rectifier without filter

B. THREE PHASE RECTIFIER WITH FILTER

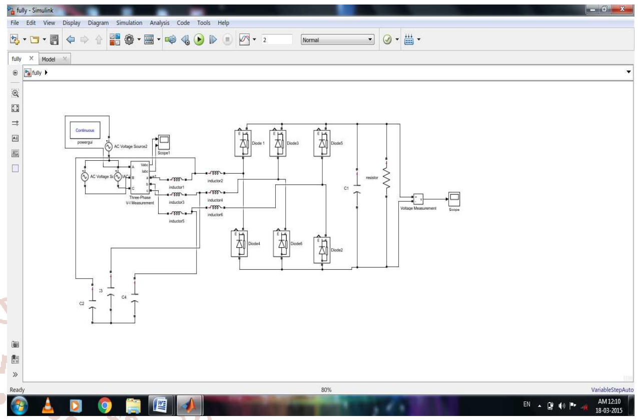

Fig.3 three-phase rectifier with filter

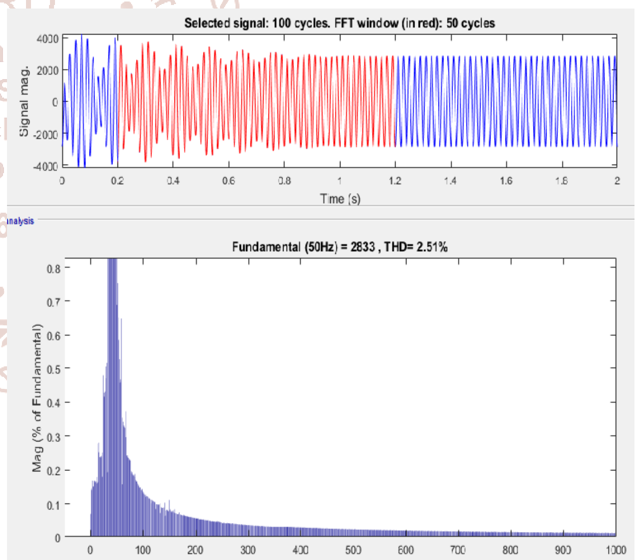

Fig3.1THD value for three-phase rectifier with filter

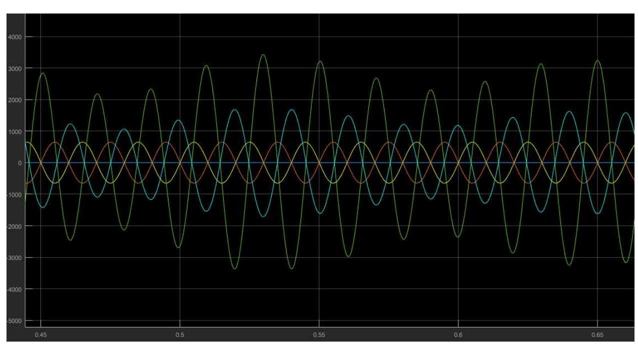

Fig3.2 output of three-phase rectifier with filter

V. CONCLUSIONS

In this paper, a parameter-design method is proposed for a LCL filter used in a three-phase grid-connected inverter system. The practicality of this method is practicability and validity. Experimental results proved the correctness of the adopted parameter-design theory analysis and feasibility of the proposed design method. The adoption of filter-capacitor-current inner loop can damp the resonance of LCL filter as analyzed. The design method made the tuning procedure easier and the system harmonic suppression performance good.

VI. References

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