inductances)

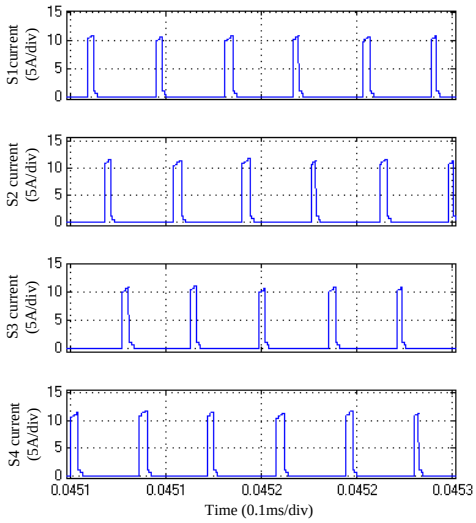

Fig.15 Waveforms of power devices S11, S12, S21 and S22

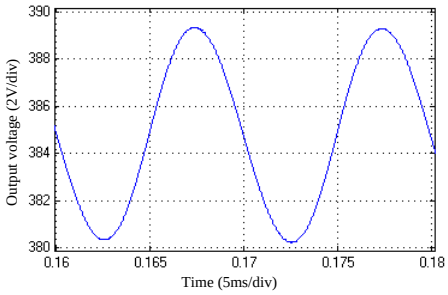

Fig.16 Waveform of DC output voltage

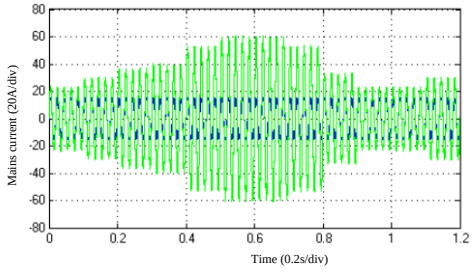

Fig.17 Waveforms of mail voltage and mains current under varying load

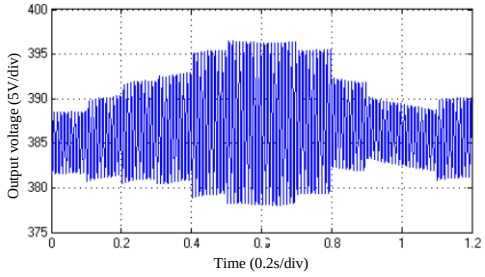

Fig.18 Waveform of DC output voltage under varying load

Also from the simulated results, with the premise of the steady system, to increase appropriate injection damping, the THD of mains current can be reduced, and the rising time of output voltage can also decline.

2x2 APFC can make the design of boost inductor easier and the total input current ripple lower. But for a practical APFC system, the currents of boost inductors are likely to be unbalanced, due to different device parameters and line impedances. The APFC will malfunction when the situation becomes more serious.

In order to expose the robustness of passivity control method for 2x2 APFC, some of the major parameters are changed. Take the boost inductors for instance, their inductances deviate at 20% of the rated inductance, i.e. L1 is 0.8mH, and L2 is 1.2mH.

Fig.19 shows the waveforms of inductor currents and their synthesized current for the 2x2 APFC. Intuitively, the two inductor currents are basically consistent in view of form and amplitude, and the average values in every switching period are identical. The ripple of synthesized current behind the diode rectifier is reduced dramatically, which lowers the difficulty of design of the inductor. Obviously, passivity control methods can bring about satisfactory effect on current sharing. Though the inductor with larger inductance can lead to lower peak to peak ripple, they deliveries the same energy in any switching period.

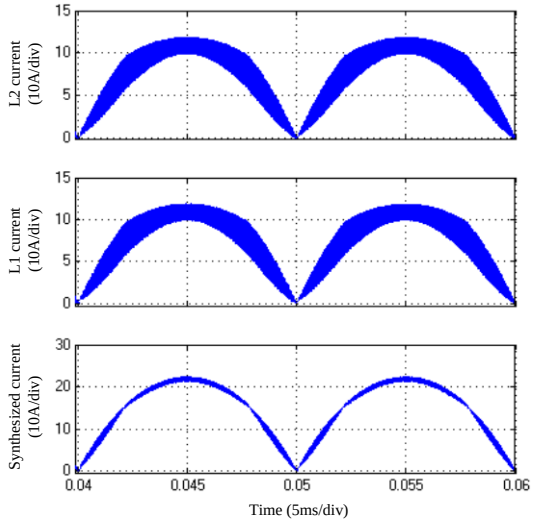

Fig.19 Waveforms of individual inductor current and total inductor current (when different inductance)

4.2 Experimental research

Experimental parameters and conditions are

stated as follows: the input is single-phase AC sinusoidal voltage, the desired output voltage is 385V, the rated load is 3.5kW, and the estimated overall efficiency is 95%,

As a consequence, the maximum RMS value of fundamental mains current is 16.75A, i.e. its peak value is 23.68A. DSP TMS320F28335 is selected as the kernel controller, and the switching frequency is 25kHz. The two inductors is made of magnetic material FeSiAl in the form of 2 in 1, and their inductances are 0.35mH under rated load and rated switching frequency. The AC capacitor is 2.2μF.

The electrolysis capacitor is 5x680μF/450V, IGTB is IKW50N60H3: 50A/100°C/600V, buried with FWD. FRD is FFAF60UA60DN: 2x30A/45°C/600V. The diode rectifier is D50XB80. The driver of IGBT is TPS2812, powered by +15V single channel power supply.

Eventually the whole 2x2 APFC platform with passivity control is implemented after repeated experiments, including hardware design and software completion. The overall efficiency is not less than 0.98 under light load and higher than 0.98 under rated load.

The mains current is almost perfect with only small ripple, and the average output DC voltage is 385V under light load and 385V with only 10V peak to peak ripple under rated load.

Fig.20 shows the waveforms of mains current of 11.4A RMS value and one of the two driving pulse train for the 2x2 APFC. Fig.21 shows the waveforms of mains voltage and current of 8.69A RMS value and its current spectrum for the 2x2 APFC. Fig.22 shows the waveforms of mains voltage, mains current and relevant data for the 2x2 APFC, when the output power is 3.83kW. Evidently, 2x2 APFC has a better correction results.

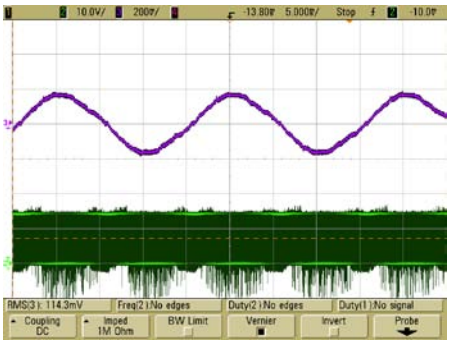

Fig.20 Waveforms of mains current and driving pulse

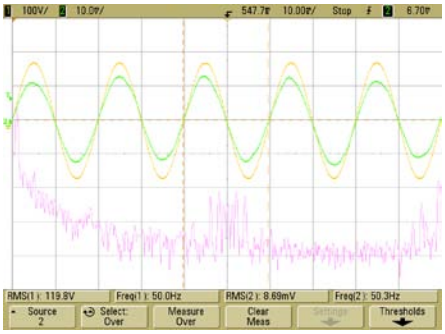

Fig.21 Measured waveforms of mains voltage and mains current

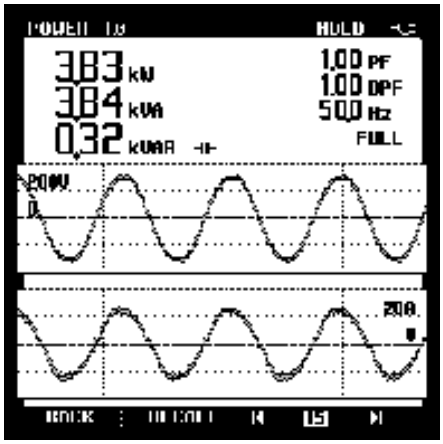

Fig.22 Measured waveforms of mains voltage and mains current

5 Conclusion

In the paper, a M-channel interleaved N-power device paralleling APFC (MxN APFC) is researched, and the phase-shift operation theory is described, including voltage transfer ratio, driving method and control method, which either can help to lower switching frequency of power device and keep unchanged that of boost inductor at the same time, or can help to keep unchanged switching frequency of power device and lower the that of boost inductor at the same time. MxN APFC can solve the IGBT's current sharing when connected in parallel, which can meet the requirements for high power applications.

The EL mathematical model of 2x2 APFC is established, and passivity power controller is designed using damping injection method. The simulation of 2x2 APFC by MATLAB/ SIMULINK is built up, and the 2x2 APFC is proved using F28335, showing the validity of the entire scheme. Passivity control strategy is characteristic of quick response of inductor current and track capability of output voltage. Dynamic

response is fast under the circumstance of fluctuated load. The average output voltage is reluctant to vary, and the mains current keeps in good sinusoidal waveform. Due to direct current control, each channel APFC still undertakes the same delivered power, showing a good current sharing.

Using phase-shift driving and passivity control strategy can simplify the design of 2x2 APFC to a degree, and the overcome the demerits of existing APFC's control strategies.

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