Single-Phase Current-Source AC/DC/AC Conversion System with Reduced Switching Device Counts

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***Abstract*—Single-phase current source AC/DC/AC conversion system with reduced switching device counts is presented in the paper. Since current-source type has natural short circuit protection and switching device becomes more reliable, as well as new magnetic materials that allow to build more efficient and dense inductors, this technology is proposed as alternative solution for power electronic circuits. By applying duality principle to the single-phase voltage-source conversion system, the proposed conversion system can convert 100V/60Hz to 220V/50Hz with 84% efficiency as a result of the circuit simulation.**

Keywords—current-source; duality principle; voltage-source; circuit simulation

I. INTRODUCTION

The Voltage Source Converters (VSCs) have been widely studied since researchers developed switching device with low conduction losses, i.e. IGBT. Alongside the IGBTs, the VSCs include capacitors which are a reliable component and having relatively high-power density. Meanwhile, the Current Source Converters (CSCs) are less applied due to two main drawbacks: high conduction losses and its low-power density. Nevertheless, the advantages of CSCs family such as low input current harmonics, natural protection from short circuit, and boost capability cannot be denied [1].

Researchers recently have developed Reverse Blocking IGBT (RB-IGBT), which is presenting lower conduction losses [2]. This device will assist continuing investigation in CSC technologies. Moreover, advance magnetic material application makes inductors become more dense and efficient [3]. Therefore, CSC has a good prospect to be developed again. The CSCs family that derived from VSCs can be used as an alternative solution for power electronics circuits

This paper will propose single-phase current source half-bridge AC/DC/AC converters as the duality circuit of single phase voltage source half-bridge AC/DC/AC converters and present its performance according to the simulation results.

II. SINGLE-PHASE CURRENT SOURCE HALF-BRIDGE AC/DC/AC CONVERTERS

Fig.1 shows the proposed single-phase current source half-bridge AC/DC/AC converters as duality principle [4] of single-phase voltage source half-bridge AC/DC/AC converters [5]. The AC input current is rectified and then inverted with different amplitude and frequency compared to the input. The proposed system has three operation modes: charging, circulating, and discharging. Fig.2 describes the operation mode of rectifier side that will happen when Q1 and Q2 are activated alternately. When the current flows in one direction, Q1 on and Q2 off, the current in L1 will be circulating and the current in L2 will be discharged. In contrary, the L1 will be charged and the current in L2 will be circulating. When the current flows in opposite direction, the events that happen in L1 and L2 will be exchanged.

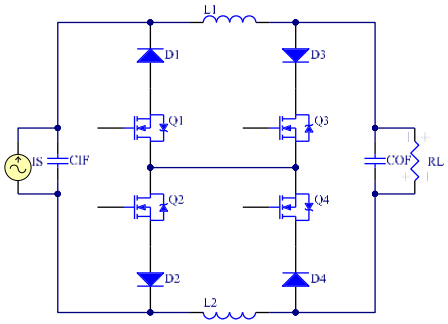

Fig. 1. Single-phase current-source half bridge AC/DC/AC converters.

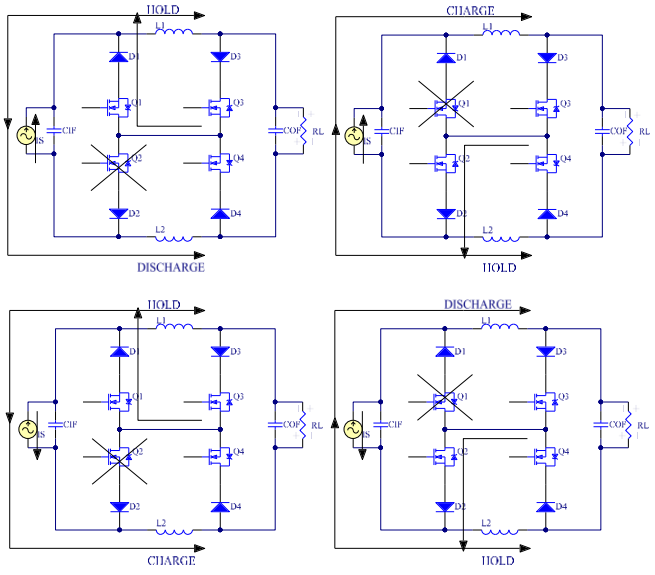

Fig. 2. Rectifier side operation modes.

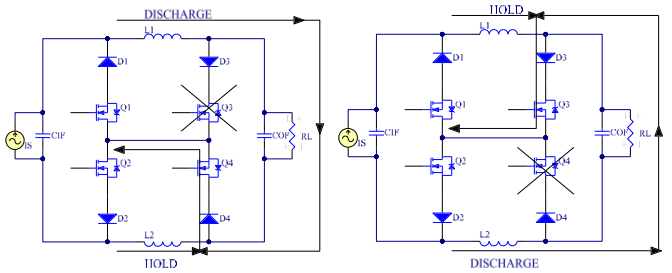

Fig. 3. Inverter side operation modes.

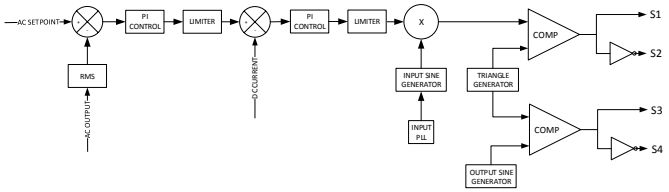

Fig. 4. Control system of proposed converters.

Fig.3 describes the operation mode of inverter side that will happen when Q3 and Q4 are activated alternately. When the Q3 on and Q4 off, the current in L1 will be circulating and the current in L2 will be discharged. In contrary, the L1 will be discharged and the current in L2 will be circulating.

Fig.4 describes this proposed converter's control system. The output rms voltage is maintained by controlling DC currents. Therefore, Q1 and Q2 are driven by PWM generator which is its reference affected by output voltage error, DC current error, and input sinusoidal waveform. Meanwhile, Q3 and Q4 are driven by independent PWM generator with fixed modulation index of 0.8.

III. Simulation Results

In order to verify the proposed converters performance, a simulation was conducted. In the simulation, several parameters were determined such as the AC input uses 100V/60Hz and it will be converted to 220V/50Hz, reactor L1 and L2 use 100mH each, and the heavy inductive load uses R = 13.9Ω and L = 10mH. Fig.5 shows the simulation results. The upper graph is DC link current that consists of L1 current and L2 current. The middle graph indicates the input voltage-current and the lower graph indicates output voltage-current.

It is shown that the output voltage was generated arbitrarily and higher than its input. Meanwhile, in Fig.6 input current showed unity power factor with relatively low harmonics. Table 1 summaries the electrical measurements of the simulation results. From Table 1, the efficiency of this proposed converters can be calculated as 84.21%.

TABLE I. Electrical Measurements.

	Freq	Voltage	THD-V	Current	THD-I
Input	60 Hz	100 V	0.1%	38.69 A	3.84%
Output	50 Hz	215.5 V	1.94%	15.12 A	0.69%

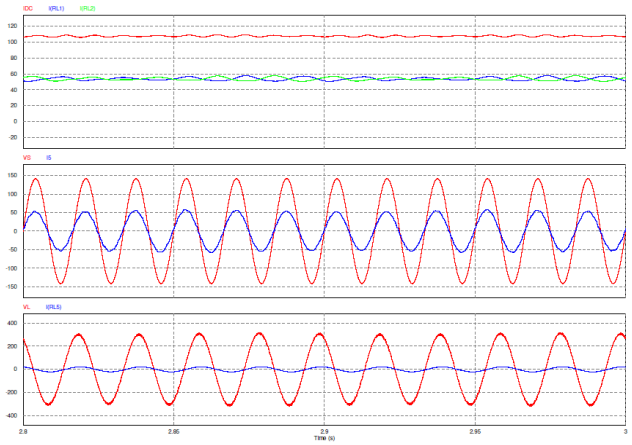

Fig. 5. Simulation results.

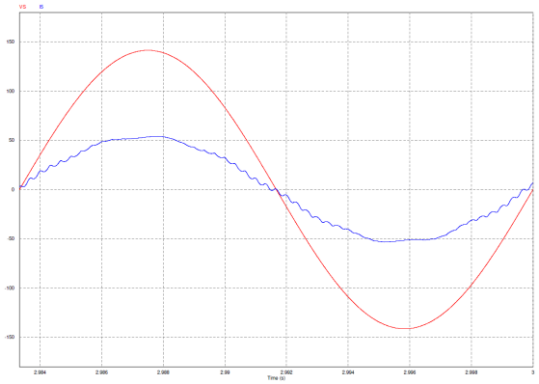

Fig. 6. Enlarged input simulation result.

IV. Conclusion

The single-phase current source AC/DC/AC conversion system with reduced switching device counts has been presented with simulation results. By providing boost capability, unity power factor, low input harmonics, and high efficiency, the converters can be applied as an alternative solution for power electronics circuit. In order to verify the simulation, the proposed circuit is currently being investigated in several experiments.

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