Elimination of Circulating Currents between Two Interleaved PWM Rectifiers Supplied from a Common Single-Phase AC Source

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In this research work, a new switching algorithm is proposed in order to suppress the circulating currents between two interleaved single-phase, voltage-source Pulse Width Modulated (PWM) rectifiers supplied from a common ac source. In general, two 2-level phase-shifted, sinusoidal PWM converters are connected in parallel via a common DC link, by using two isolated windings on the secondary side of a front-end transformer, to ensure a circulating-current free operation of the converters. Such circulating currents would adversely affect the proper operation of the system, and cause malfunctioning of the power converter. However, with the application of the switching algorithm proposed in this work, two interleaved, single-phase PWM rectifiers can be connected to the same input terminals at the ac supply side, without any circulating currents between the converters. The main advantage of such connection is eliminating the need for a bulky, multi-winding transformer at the input of interleaved converters. A dedicated algorithm has been developed for this purpose, which picks up the switching states responsible from circulating currents between converters, defined as invalid switching states, and then substitutes them with some predetermined, valid switching states for an equivalent converter operation in each operating mode. The main application of this algorithm is high power AC locomotive traction converters. High power AC locomotives usually employ a multi-winding step-down traction transformer to supply several traction motors. Utilization of interleaved front-end PWM rectifiers is a common practice to reduce the harmonic content of the input current and current rating of each power semiconductor, and for redundancy. With the proposed method, the number of rectifiers to be interleaved can be increased without the need of any additional secondary windings of conventional traction transformers. Circuit diagram of an interleaved PWM rectifier without an input transformer is shown in Figure 1-a. The proposed switching algorithm has been verified by some computer simulations carried out on MATLAB/Simulink environment and the resultant voltage and current waveforms are shown in Figure 1-b.

(a)   (b)
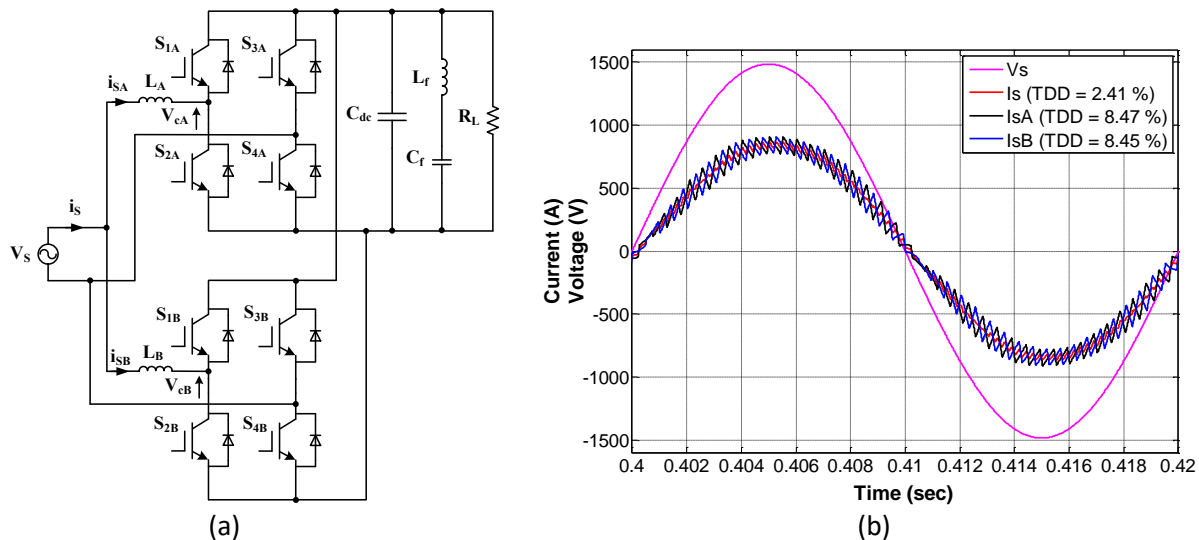
Figure 1. (a) Circuit diagram of an interleaved PWM rectifier without an input transformer, (b) the resultant voltage and current waveforms