A Simplified Power Loss Model of LLC Converter with Accurate Voltage Conversion

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Abstract. The loss estimation accuracy decreases as the switching frequency deviating from the resonant frequency. A DC equivalent impedance model is proposed to improve the accuracy loss estimation, in this paper. The time domain model of LLC is simplified to calculate the average loss of each branches in a switching period, where the DC equivalent impedance can be obtained by circuit manipulation. Then, the equivalent loss model is established, respect to switching frequency, which estimates the loss accurately and describe the relationship between frequency and output voltage succinctly. Through the experiment of a 140W LLC prototype, the error of power loss is basically less than 10%.

Keywords: LLC converter · Simplified time domain model · Loss modeling

1 Introduction

In the trend of high-frequency, miniaturization and integration, the loss problem with high switching frequency has drew more and more attention. Due to the hard switching problem, a series of resonant converters such as LLC and LCC gradually replace DC-DC converters such as Buck converter. The resonant converters have gradually become popular, but this does not mean that the loss problem has been solved. Loss estimation and optimization have received more extensive attention [1, 2].

Now, the power loss calculation has been studied, but the power losses calculation of circuit are divided into multiple branches [3, 4]. The loss circuit of LLC is built in literature [5]. In terms of loss estimation, frequency domain analysis (FDA) and time domain analysis (TDA) are used to calculate the power loss of LLC in the frequency range [6, 7]. In literature [8, 9], the initial value of resonant capacitor voltage and resonant inductor current are calculated iteratively based on time domain equations, which requires computer-assisted calculation and complicated calculation methods. To get the

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