Comparison of Planar Transformers and Newly Designed WCM Transformers for Electric Vehicles

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Introduction

A collaboration between Kettering University and West Coast Magnetics was to build a high-efficiency level-2 battery charger for electric vehicles. The target efficiency is >97%, which is a significant advance over existing chargers that commonly have efficiencies of 94%. The technical specifications for the new design include:

- Input voltage: single-phase 208VAC,
- Output voltage: 200~450VDC
- Power Rating: 7.2kW.
- Target efficiency is >97%
  - 3% improvement over existing chargers

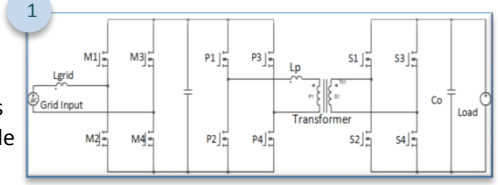
Design

The selected topology is shown (Fig. 1). All devices P1~P4 and S2~S4 are GaN HEMTs provided by GaN Systems. The switching frequency is up to 500kHz.

For the planar transformer (130mm*90mm*40mm), Lp=10uH is a stand-alone inductor placed outside of the transformer.

For WCM transformer, Lp is integrated inside the transformer thereby saves space.

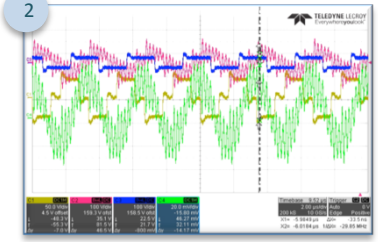
1



Planar Transformer Testing

When the output voltage is 400V, Fig 2 shows is experimental waveform with the planar transformer equipped, where the green curve is the secondary-side current of the transformer measured by the Rogowski coil.

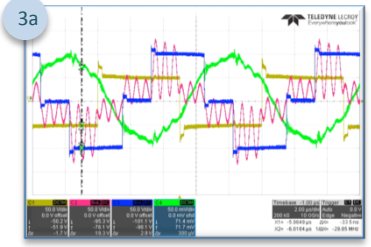
2



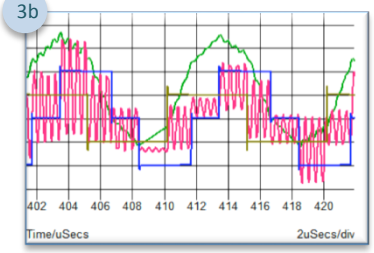
High-frequency Oscillation of the Planar Transformer

Shown in Fig 2, the significant oscillation is caused by the winding capacitance. 3nF capacitance is measured across the secondary-side winding. In our simulation, once this 3nF capacitance is placed in the model, we observe exactly the same current waveform, shown in Fig 3. Here the purple line is the secondary-side current. Such high-frequency oscillation makes the system unable to work.

3a



3b



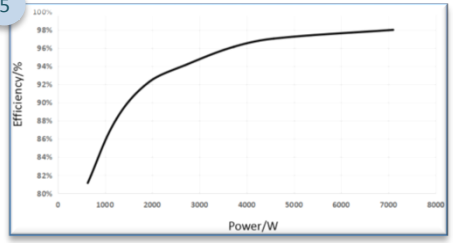
Elimination of High-Frequency Oscillation with the WCM Transformer

4

With the WCM transformer to suppress the winding capacitance, such oscillation disappeared, shown in Fig 4.

Efficiency Gain with the WCM Design

5



With no current oscillation(Fig 5), the designed charger successfully reached 7.2kW@98% efficiency.