Description

This reference design is a 3-kW, two-phase, interleaved half-bridge inductor-inductor-capacitor (LLC) using the LMG3422 and F280039C devices. The design can achieve 98.1% peak efficiency and 313 W / in$^3$ power density. This design can be used as the output stage of a common redundant power supply (CRPS) server power supply and can be used to evaluate the control method for two paralleled LLC stages, such as interleaving and current balance.

Features

- Two-phase interleaved LLC reference design
- High efficiency with gallium nitride (GaN), peak 98.1%
- Ultra compact size, 64 (width) mm × 35 mm (height) × 70 mm (length)
- High-power density, 313 W / in$^3$

Applications

- Server PSU with 12-V output
- Merchant telecom rectifiers
- Industrial AC-DC
1 Test Prerequisites

1.1 Voltage and Current Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>340 VDC – 420 VDC</td>
</tr>
<tr>
<td>Input Current</td>
<td>0 A – 9 A</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>12 VDC</td>
</tr>
<tr>
<td>Output Current</td>
<td>0 A – 250 A</td>
</tr>
</tbody>
</table>

1.2 Required Equipment

- Computer with Code Composer Studio™ and DigitalPower SDK installed
- TMDCNCD280039C daughter card
- Chroma 62050H-600, programmable DC power supply
- IT6010c-80-300, used as electronic load
- Dual-channel isolated DC power supply, 12 V, 3 A
- WT500, power analyzer
- Oscilloscope (minimum 100-MHz bandwidth)
- Current probe (minimum 100-kHz bandwidth)
- Multichannel temperature tester

1.3 Considerations

**CAUTION**
Consider adding a 820-μF, 450-V electronic capacitor near the board input port. This capacitance is not considered in this design because the capacitance is the end stage after a PFC stage.

**WARNING**
Do not touch the board or the electrical circuits while the PMP41017A board is energized because of high voltages capable of causing an electrical shock hazard. Make sure the high voltage is fully discharged, before handling the board.

1.4 Dimensions
64 (width) mm × 35 mm (height) × 70 mm (length)

1.5 Test Setup

1. Install the TMDCNCD280039C daughter card to the power board with the C2000™ MCU interposer board
2. Connect two isolated 12-V DC power supplies to the "12VP / GNDp" and "12VS / GNDs" on the C2000 interposer board
3. Connect a 400-V, 10-A power supply to the "HVBUS / PBGND" on the primary board
4. Connect a 12-V, 250-A electronic load to the “12Vout / Vo-out” golden finger on the primary board
5. Install power analyzer voltage and current meters, if you want to test the efficiency
2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

![Efficiency Graph](image)

Figure 2-1. Efficiency Test

2.2 Efficiency Data

Efficiency data is shown in the following table.

<table>
<thead>
<tr>
<th>V\text{IN} (V)</th>
<th>I\text{IN} (A)</th>
<th>V\text{OUT} (V)</th>
<th>I\text{OUT} (A)</th>
<th>P\text{IN} (W)</th>
<th>P\text{OUT} (W)</th>
<th>P\text{LOSS} (W)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>385.79</td>
<td>0.658</td>
<td>12.294</td>
<td>20</td>
<td>253.89</td>
<td>245.88</td>
<td>8.01</td>
<td>96.85%</td>
</tr>
<tr>
<td>385.72</td>
<td>1.2966</td>
<td>12.235</td>
<td>40</td>
<td>499.8</td>
<td>489.4</td>
<td>10.4</td>
<td>97.92%</td>
</tr>
<tr>
<td>385.65</td>
<td>1.9338</td>
<td>12.192</td>
<td>60</td>
<td>745.7</td>
<td>731.52</td>
<td>14.18</td>
<td>98.10%</td>
</tr>
<tr>
<td>385.59</td>
<td>2.5703</td>
<td>12.154</td>
<td>80</td>
<td>991.3</td>
<td>972.32</td>
<td>18.98</td>
<td>98.09%</td>
</tr>
<tr>
<td>385.54</td>
<td>3.8447</td>
<td>12.0733</td>
<td>120</td>
<td>1482.5</td>
<td>1448.76</td>
<td>33.74</td>
<td>97.72%</td>
</tr>
<tr>
<td>385.53</td>
<td>5.1168</td>
<td>11.991</td>
<td>160</td>
<td>1973</td>
<td>1918.56</td>
<td>54.44</td>
<td>97.24%</td>
</tr>
<tr>
<td>385.44</td>
<td>6.384</td>
<td>11.884</td>
<td>200</td>
<td>2461</td>
<td>2376.8</td>
<td>84.2</td>
<td>96.58%</td>
</tr>
</tbody>
</table>
3 Waveforms

3.1 Output Current Ripple

The ripple current of this design was tested on the output capacitors with different phase shifting. The following list shows the primary current of each phase and the ripple current in output capacitors, with 0 degree shift and 90 degree shift.

- Channel 1, is the primary current of phase A
- Channel 4, is the primary current of phase B
- Channel 3, is the ripple current on the output capacitors

Figure 3-1. Waveform With 0 Degree Shift at 133-A Load

Figure 3-2. Waveform With 90 Degree Shift at 133-A Load
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