**Test Report: PMP40980**

*Multiple Output Isolated SiC Driver Bias Supply Reference Design for Onboard Charger Applications*

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**Description**

This reference design is an open-loop LLC converter, which provides four 18 V and 2.5 V outputs, up to 2.4 W for onboard charger applications. The UCC25800-Q1 device is used here as the controller. The LLC topology allows the transformer to have significant leakage inductance, but a much smaller primary-secondary capacitance, which significantly reduces common-mode current injection through the bias transformer.

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**Features**

- Small size, open-loop LLC
- Reinforced insulation
- Compact PCB size (55 mm × 45 mm)

**Applications**

- On-board (OBC) and wireless charger
- IGBT and SiC gate transformer driver bias supply

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![Top of Board](image1)

![Bottom of Board](image2)

![Block Diagram](image3)
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 range</td>
<td>12 V</td>
</tr>
<tr>
<td>Output voltage and current</td>
<td>4 × (18 V and −2.5 V, 30 mA), 2.4 W maximum</td>
</tr>
<tr>
<td>Nominal switching frequency</td>
<td>400 kHz</td>
</tr>
<tr>
<td>Isolation</td>
<td>Yes, 3000 V_{AC}, 1 min</td>
</tr>
<tr>
<td>Topology</td>
<td>Open-loop LLC</td>
</tr>
</tbody>
</table>

1.2 Required Equipment

- Multimeter (voltage): Fluke 287C
- Multimeter (current): Fluke 287C
- DC Source: Chroma 62012P-100-50
- E-Load: Chroma 63110 module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

1.3 Dimensions

The board dimensions are 55 mm (length) × 45 mm (width) × 25 mm (height).

Figure 1-1. Dimensions
2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

![Efficiency Graph](image)

**Figure 2-1. Efficiency Graph**

2.2 Efficiency Data

Efficiency data is shown in the following table.

<table>
<thead>
<tr>
<th>$V_{IN}/V$</th>
<th>$I_{IN}/A$</th>
<th>$V_{OUT1}/V$</th>
<th>$I_{OUT1}/A$</th>
<th>$V_{OUT2}/V$</th>
<th>$I_{OUT2}/A$</th>
<th>$V_{OUT3}/V$</th>
<th>$I_{OUT3}/A$</th>
<th>$P_{IN}/W$</th>
<th>$P_{OUT}/W$</th>
<th>$P_{Loss}/W$</th>
<th>Eff/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.036</td>
<td>0.0621</td>
<td>21.492</td>
<td>0.0038</td>
<td>21.505</td>
<td>0.0043</td>
<td>21.52</td>
<td>0.0035</td>
<td>21.521</td>
<td>0.0037</td>
<td>0.7474</td>
<td>0.3291</td>
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<tr>
<td>12.033</td>
<td>0.0911</td>
<td>21.277</td>
<td>0.0081</td>
<td>21.297</td>
<td>0.0076</td>
<td>21.31</td>
<td>0.0077</td>
<td>21.314</td>
<td>0.0078</td>
<td>1.0962</td>
<td>0.6645</td>
</tr>
<tr>
<td>12.028</td>
<td>0.1241</td>
<td>21.015</td>
<td>0.0123</td>
<td>21.029</td>
<td>0.0128</td>
<td>21.05</td>
<td>0.012</td>
<td>21.059</td>
<td>0.0122</td>
<td>1.4927</td>
<td>1.0372</td>
</tr>
<tr>
<td>12.024</td>
<td>0.1525</td>
<td>20.737</td>
<td>0.0165</td>
<td>20.761</td>
<td>0.0162</td>
<td>20.783</td>
<td>0.0162</td>
<td>20.793</td>
<td>0.0163</td>
<td>1.8337</td>
<td>1.3541</td>
</tr>
<tr>
<td>12.018</td>
<td>0.1834</td>
<td>20.496</td>
<td>0.0208</td>
<td>20.519</td>
<td>0.0205</td>
<td>20.549</td>
<td>0.0205</td>
<td>20.562</td>
<td>0.0205</td>
<td>2.2041</td>
<td>1.6897</td>
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<tr>
<td>12.015</td>
<td>0.2067</td>
<td>20.32</td>
<td>0.0241</td>
<td>20.344</td>
<td>0.0238</td>
<td>20.377</td>
<td>0.0236</td>
<td>20.396</td>
<td>0.0237</td>
<td>2.4835</td>
<td>1.9382</td>
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<tr>
<td>12.009</td>
<td>0.2376</td>
<td>20.072</td>
<td>0.0282</td>
<td>20.098</td>
<td>0.028</td>
<td>20.142</td>
<td>0.0278</td>
<td>20.159</td>
<td>0.0277</td>
<td>2.8533</td>
<td>2.2471</td>
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<tr>
<td>12.01</td>
<td>0.2529</td>
<td>19.955</td>
<td>0.0301</td>
<td>19.982</td>
<td>0.0301</td>
<td>20.023</td>
<td>0.03</td>
<td>20.05</td>
<td>0.0298</td>
<td>3.0373</td>
<td>2.4003</td>
</tr>
</tbody>
</table>

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2.3 Load Regulation

Load regulation is shown in the following table.

<table>
<thead>
<tr>
<th>$\text{V}_{\text{IN}}$(V)</th>
<th>$\text{I}_{\text{OUT}}$(mA)</th>
<th>$\text{V}_{\text{OUT1,18}}$(V)</th>
<th>$\text{V}_{\text{OUT2,18}}$(V)</th>
<th>$\text{V}_{\text{OUT1,2.5}}$(V)</th>
<th>$\text{V}_{\text{OUT2,2.5}}$(V)</th>
<th>$\text{V}_{\text{OUT3,18}}$(V)</th>
<th>$\text{V}_{\text{OUT3,2.5}}$(V)</th>
<th>$\text{V}_{\text{OUT4,18}}$(V)</th>
<th>$\text{V}_{\text{OUT4,2.5}}$(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.028</td>
<td>12</td>
<td>18.983</td>
<td>18.983</td>
<td>2.0452</td>
<td>2.0452</td>
<td>18.98</td>
<td>2.0707</td>
<td>19.025</td>
<td>2.0363</td>
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<tr>
<td>12.024</td>
<td>16</td>
<td>18.715</td>
<td>18.728</td>
<td>2.0354</td>
<td>2.0354</td>
<td>18.725</td>
<td>2.0605</td>
<td>18.764</td>
<td>2.0276</td>
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<tr>
<td>12.018</td>
<td>20</td>
<td>18.478</td>
<td>18.492</td>
<td>2.0316</td>
<td>2.0316</td>
<td>18.495</td>
<td>2.0567</td>
<td>18.541</td>
<td>2.0239</td>
</tr>
<tr>
<td>12.015</td>
<td>24</td>
<td>18.301</td>
<td>18.316</td>
<td>2.0284</td>
<td>2.0284</td>
<td>18.325</td>
<td>2.0539</td>
<td>18.375</td>
<td>2.0213</td>
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<tr>
<td>12.009</td>
<td>28</td>
<td>18.058</td>
<td>18.075</td>
<td>2.0248</td>
<td>2.0248</td>
<td>18.091</td>
<td>2.0505</td>
<td>18.146</td>
<td>2.0169</td>
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<tr>
<td>12.01</td>
<td>30</td>
<td>17.945</td>
<td>17.963</td>
<td>2.0229</td>
<td>2.0229</td>
<td>17.979</td>
<td>2.0482</td>
<td>18.038</td>
<td>2.0155</td>
</tr>
</tbody>
</table>

2.4 Voltage Regulation

The following figure shows the total rectified secondary output voltage of the converter with a 12-V$_{\text{DC}}$ input voltage.

![Figure 2-2. Voltage Regulation](image-url)
2.5 Thermal Images

The thermal image is shown in the following figure.

Figure 2-3. Thermal Image
3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

Figure 3-1. Switching, No Load

Figure 3-2. Switching, Full Load
3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

Figure 3-3. Output Voltage Ripple (18 V Channel), $V_{IN} = 12$ V

Figure 3-4. Output Voltage Ripple (–2.5 V Channel), $V_{IN} = 12$ V
3.3 Short-Circuit Protection

Short-circuit protection is shown in the following figures.

**Figure 3-5. Short-Circuit Protection**

**Figure 3-6. Short-Circuit Protection**
3.4 Load Transients

Load transient response is shown in the following figures. The slew rate is set to 0.16 A/μs. The figure shows the load transient of OUTPUT1 with the other outputs at full load and the input voltage at 12 V. The load current is sourced from the 18 V directly to the –2.5 V with no COM connection.

Figure 3-7. Load Transient From 30 mA to 0 mA
3.5 Start-up Sequence

Start-up behavior is shown in the following figure.

Figure 3-8. Start-up
3.6 Undervoltage Protection

Undervoltage protection is shown in the following figure.

![Undervoltage Waveforms](image)

**Figure 3-9. Undervoltage**
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