PMP20637 RevA

Test Report

- 390V – 48V/1kW high frequency resonant converter
- 950kHz resonant frequency with less than 210g weight
- Utilize TI HV GaN FETs as input switches
- Optimized LLC SR conduction with UCD7138/UCD3138A
- Achieve peak 97.6% efficiency
- Power Stage dimension: 2” x 2.1” x 1.7”

Test Completion Date: May 1, 2017
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1. Board Photos


1.1 Whole board top view
1.2 Whole board bottom view
1.3 Whole board side view
1.4 Whole board - weight
1.5 Transformer structure

The LLC transformer of PMP20637Rev A consist of a “U” shape core with Hitachi ML91S core material, PMP20637 RevB windings, PMP20637 RevD load card. The transformer is gapped to have 28μH primary inductance (@1MHz measured frequency). Transformer structure is shown in the figure below. Notice the Winding sequence is 1-3-2-4 from very top.
1.6 Transformer side view 1
1.7 TRANSFORMER SIDE VIEW 2
2. Efficiency

The efficiency curves are shown in the tables and graph below. A 12V Fan (Delta FFB03612EHN at full speed) is applied to provide air cooling to the board. Bias (5V & 12V) power dissipations are excluded from the efficiency calculation.

![Efficiency Graph]

### 2.1 Efficiency Data @ 380Vin

<table>
<thead>
<tr>
<th>Vin(V)</th>
<th>Iin(A)</th>
<th>Pin(W)</th>
<th>Vout(V)</th>
<th>Iout(mV)</th>
<th>Iout(A)</th>
<th>Pout(W)</th>
<th>Eff(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>380</td>
<td>0.02</td>
<td>7.98</td>
<td>48.30</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00%</td>
</tr>
<tr>
<td>380</td>
<td>0.28</td>
<td>104.50</td>
<td>48.20</td>
<td>3.96</td>
<td>1.98</td>
<td>95.56</td>
<td>91.44%</td>
</tr>
<tr>
<td>380</td>
<td>0.53</td>
<td>200.98</td>
<td>48.12</td>
<td>7.94</td>
<td>3.97</td>
<td>191.27</td>
<td>95.17%</td>
</tr>
<tr>
<td>379.9</td>
<td>0.78</td>
<td>297.54</td>
<td>48.04</td>
<td>11.93</td>
<td>5.97</td>
<td>286.92</td>
<td>96.43%</td>
</tr>
<tr>
<td>379.9</td>
<td>1.04</td>
<td>393.99</td>
<td>47.96</td>
<td>15.92</td>
<td>7.97</td>
<td>382.24</td>
<td>97.02%</td>
</tr>
<tr>
<td>379.8</td>
<td>1.29</td>
<td>490.40</td>
<td>47.89</td>
<td>19.91</td>
<td>9.97</td>
<td>477.34</td>
<td>97.34%</td>
</tr>
<tr>
<td>379.7</td>
<td>1.55</td>
<td>586.71</td>
<td>47.81</td>
<td>23.90</td>
<td>11.96</td>
<td>572.04</td>
<td>97.50%</td>
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<tr>
<td>379.7</td>
<td>1.80</td>
<td>683.16</td>
<td>47.73</td>
<td>27.69</td>
<td>13.96</td>
<td>666.43</td>
<td>97.55%</td>
</tr>
<tr>
<td>379.7</td>
<td>2.05</td>
<td>779.14</td>
<td>47.64</td>
<td>31.88</td>
<td>15.96</td>
<td>760.33</td>
<td>97.59%</td>
</tr>
<tr>
<td>379.6</td>
<td>2.31</td>
<td>875.36</td>
<td>47.55</td>
<td>35.87</td>
<td>17.96</td>
<td>853.87</td>
<td>97.55%</td>
</tr>
<tr>
<td>379.6</td>
<td>2.56</td>
<td>971.78</td>
<td>47.47</td>
<td>39.86</td>
<td>19.95</td>
<td>947.26</td>
<td>97.48%</td>
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<tr>
<td>379.5</td>
<td>2.70</td>
<td>1024.65</td>
<td>47.40</td>
<td>42.05</td>
<td>21.05</td>
<td>997.83</td>
<td>97.38%</td>
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### 2.2 Efficiency Data @ 390Vin

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<th>Vin(V)</th>
<th>Iin(A)</th>
<th>Pin(W)</th>
<th>Vout(V)</th>
<th>Iout(mV)</th>
<th>Iout(A)</th>
<th>Pout(W)</th>
<th>Eff(%)</th>
</tr>
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<tbody>
<tr>
<td>389.7</td>
<td>2.70</td>
<td>1052.19</td>
<td>48.72</td>
<td>42.05</td>
<td>21.05</td>
<td>1025.62</td>
<td>97.47%</td>
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<tr>
<td>389.8</td>
<td>2.56</td>
<td>997.89</td>
<td>48.77</td>
<td>39.85</td>
<td>19.95</td>
<td>972.95</td>
<td>97.50%</td>
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<tr>
<td>389.8</td>
<td>2.33</td>
<td>909.01</td>
<td>48.85</td>
<td>36.26</td>
<td>18.15</td>
<td>886.76</td>
<td>97.55%</td>
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<tr>
<td>389.9</td>
<td>2.08</td>
<td>810.21</td>
<td>48.94</td>
<td>32.28</td>
<td>16.16</td>
<td>790.88</td>
<td>97.61%</td>
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<tr>
<td>389.9</td>
<td>1.82</td>
<td>710.79</td>
<td>49.02</td>
<td>28.27</td>
<td>14.15</td>
<td>693.76</td>
<td>97.60%</td>
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<tr>
<td>390</td>
<td>1.57</td>
<td>611.91</td>
<td>49.12</td>
<td>24.28</td>
<td>12.16</td>
<td>597.06</td>
<td>97.57%</td>
</tr>
<tr>
<td>390</td>
<td>1.32</td>
<td>512.85</td>
<td>49.18</td>
<td>20.29</td>
<td>10.16</td>
<td>499.55</td>
<td>97.41%</td>
</tr>
<tr>
<td>390.1</td>
<td>1.05</td>
<td>409.21</td>
<td>49.26</td>
<td>16.10</td>
<td>8.06</td>
<td>397.04</td>
<td>97.02%</td>
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<tr>
<td>390.1</td>
<td>0.80</td>
<td>310.13</td>
<td>49.34</td>
<td>12.11</td>
<td>6.06</td>
<td>299.13</td>
<td>96.45%</td>
</tr>
<tr>
<td>390.1</td>
<td>0.54</td>
<td>211.04</td>
<td>49.41</td>
<td>8.12</td>
<td>4.07</td>
<td>200.85</td>
<td>95.17%</td>
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<tr>
<td>390.2</td>
<td>0.28</td>
<td>107.31</td>
<td>49.49</td>
<td>3.93</td>
<td>1.97</td>
<td>97.37</td>
<td>90.74%</td>
</tr>
<tr>
<td>390.2</td>
<td>0.02</td>
<td>8.19</td>
<td>49.57</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00%</td>
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### 2.3 Efficiency Data @ 400Vin

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<th>Vin(V)</th>
<th>Iin(A)</th>
<th>Pin(W)</th>
<th>Vout(V)</th>
<th>Iout(mV)</th>
<th>Iout(A)</th>
<th>Pout(W)</th>
<th>Eff(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400.2</td>
<td>0.02</td>
<td>8.80</td>
<td>50.84</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00%</td>
</tr>
<tr>
<td>400.1</td>
<td>0.28</td>
<td>110.03</td>
<td>50.76</td>
<td>3.93</td>
<td>1.97</td>
<td>99.87</td>
<td>90.77%</td>
</tr>
<tr>
<td>400.1</td>
<td>0.54</td>
<td>216.85</td>
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<td>8.12</td>
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<td>400.1</td>
<td>0.80</td>
<td>318.48</td>
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<td>12.11</td>
<td>6.06</td>
<td>306.83</td>
<td>96.34%</td>
</tr>
<tr>
<td>400</td>
<td>1.05</td>
<td>420.00</td>
<td>50.54</td>
<td>16.10</td>
<td>8.06</td>
<td>407.35</td>
<td>96.99%</td>
</tr>
<tr>
<td>400</td>
<td>1.30</td>
<td>521.20</td>
<td>50.46</td>
<td>20.09</td>
<td>10.06</td>
<td>507.50</td>
<td>97.37%</td>
</tr>
<tr>
<td>400</td>
<td>1.56</td>
<td>622.80</td>
<td>50.38</td>
<td>24.08</td>
<td>12.06</td>
<td>607.33</td>
<td>97.52%</td>
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<tr>
<td>400</td>
<td>1.81</td>
<td>724.40</td>
<td>50.30</td>
<td>28.07</td>
<td>14.05</td>
<td>706.84</td>
<td>97.58%</td>
</tr>
<tr>
<td>399.9</td>
<td>2.07</td>
<td>826.19</td>
<td>50.22</td>
<td>32.05</td>
<td>16.04</td>
<td>805.78</td>
<td>97.53%</td>
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<tr>
<td>399.9</td>
<td>2.32</td>
<td>927.37</td>
<td>50.14</td>
<td>36.04</td>
<td>18.04</td>
<td>904.65</td>
<td>97.55%</td>
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<tr>
<td>399.8</td>
<td>2.57</td>
<td>1028.69</td>
<td>50.05</td>
<td>40.03</td>
<td>20.04</td>
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<td>399.8</td>
<td>2.70</td>
<td>1079.46</td>
<td>50.01</td>
<td>42.02</td>
<td>21.04</td>
<td>1052.02</td>
<td>97.46%</td>
</tr>
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</table>
3. Thermal Performance

During the thermal test, a 12V Fan (Delta FFB03612EHN at full speed) is applied to provide air cooling to the board.

3.1 380VDC input, 47.4V/21A output

<table>
<thead>
<tr>
<th>Spot analysis</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb Temperature</td>
<td>28.3°C</td>
</tr>
<tr>
<td>Area analysis</td>
<td>Value</td>
</tr>
<tr>
<td>Q300_1Max</td>
<td>49.0°C</td>
</tr>
<tr>
<td>XFMR coreMax</td>
<td>39.4°C</td>
</tr>
<tr>
<td>TI GaN FETMax</td>
<td>51.0°C</td>
</tr>
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</table>
3.2 390VDC Input, 48.7V/21A Output

<table>
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<tr>
<th>Spot analysis</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb Temperature</td>
<td>26.6°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area analysis</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q300_1Max</td>
<td>46.7°C</td>
</tr>
<tr>
<td>XFMR coreMax</td>
<td>38.2°C</td>
</tr>
<tr>
<td>TI GaN FETMax</td>
<td>46.9°C</td>
</tr>
</tbody>
</table>
3.3 400VDC INPUT, 50V/21A OUTPUT

<table>
<thead>
<tr>
<th>Spot analysis</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb Temperature</td>
<td>27.1°C</td>
</tr>
<tr>
<td>Area analysis</td>
<td>Value</td>
</tr>
<tr>
<td>Q300_1Max</td>
<td>46.6°C</td>
</tr>
<tr>
<td>XFMR coreMax</td>
<td>38.5°C</td>
</tr>
<tr>
<td>TI GaN FETMax</td>
<td>46.1°C</td>
</tr>
</tbody>
</table>
4. StartUp Transient

Oscilloscope channel assignments during the startup transient tests are C1: SR $V_{DS}$, C2: $V_{out}$, C3: $I_{out}$, C4: $V_{in}$.

4.1 380VDC INPUT, 48V NO LOAD
4.2 390VDC INPUT, 48V NO LOAD

4.3 400VDC INPUT, 48V NO LOAD
4.4 380VDC INPUT, 48V/4A

4.5 390VDC INPUT, 48V/4A
4.6 400VDC INPUT, 48V/4A
4.7 380VDC INPUT, 48V/6A

4.8 390VDC INPUT, 48V/6A
4.9 400VDC INPUT, 48V/6A
4.10 380VDC INPUT, 48V/8A

4.11 390VDC INPUT, 48V/8A
4.12 400VDC INPUT, 48V/8A

4.13 380VDC INPUT, 48V/10A
4.14 390VDC INPUT, 48V/10A

4.15 400VDC INPUT, 48V/10A
5. Turn Off Transient

Oscilloscope channel assignments during the turn off transient tests are C1: SR $V_{DS}$, C2: $V_{out}$, C4: $V_{in}$.

5.1 380V DC Input, 48V/4A
5.2 390VDC INPUT, 48V/4A

5.3 400VDC INPUT, 48V/4A
5.4 380VDC INPUT, 48V/10A
5.5 390VDC INPUT, 48V/10A

5.6 400VDC INPUT, 48V/10A
6. Key Waveforms

Oscilloscope channel assignments in these tests are C1: SR FET $V_{DS}$ voltage, C2: Output voltage ripple, C4: Primary switching node.

6.1 380V in, 48V no load
6.2 390V in, 48V NO LOAD

6.3 400V in, 48V NO LOAD
6.4 380Vin, 48V/21A

6.4 390Vin, 48V/21A
6.4 400V\textsubscript{IN}, 48V/21A
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