Test Report: PMP21479
65W Active clamp flyback with Si FETs reference design for a high power density 5-20V AC/DC adapter

Description

PMP21479 uses the UCC28780 active clamp flyback controller to generate a 20V/15V/9V/5V adjustable output voltage. The maximum power rating is 65W at 20V output, and up to 3A at all other output voltage settings. This design reaches a peak efficiency of over 93% using silicon MOSFETs. The average efficiency and standby power levels are designed to meet DoE level VI limits. Board dimensions are 1.9” x 1.9” x 1” (49mm x 49mm x 25mm).
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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Input Voltage Range</td>
<td>90VACrms – 265VACrms</td>
</tr>
<tr>
<td>Line Input Frequency</td>
<td>50Hz/60Hz</td>
</tr>
</tbody>
</table>

1.2 Required Equipment

- AC voltage source
- AC power meter
- Electronic load
- Multi-meters
- Oscilloscope
2 Testing and Results

2.1 Efficiency

2.1.1 Average Efficiency

![Average Efficiency Chart]

2.1.2 20V Output

![20V Output Chart]
### 90VAC/60Hz Load Increasing

<table>
<thead>
<tr>
<th>Load Current (Amps)</th>
<th>Power Loss (W)</th>
<th>90VAC/60Hz Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USB-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0250</td>
<td>19.98</td>
<td>90.2</td>
<td>0.0253 0.693</td>
<td>0.50 0.19</td>
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<tr>
<td>0.321</td>
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<tr>
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<tr>
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<td>90.0</td>
<td>0.642 26.82</td>
<td>0.464 24.47</td>
</tr>
<tr>
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<td>19.99</td>
<td>89.9</td>
<td>0.795 35.38</td>
<td>0.495 32.50</td>
</tr>
<tr>
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<td>89.9</td>
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</tr>
<tr>
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<td>90.1</td>
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<tr>
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<td>90.0</td>
<td>1.247 61.31</td>
<td>0.546 56.95</td>
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<tr>
<td>3.253</td>
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<td>90.0</td>
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<td>0.557 65.06</td>
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### 120VAC/60Hz Load Increasing

<table>
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<th>Power Loss (W)</th>
<th>120VAC/60Hz Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USB-C</th>
</tr>
</thead>
<tbody>
<tr>
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<td>120.0</td>
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<td>0.50 0.20</td>
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<tr>
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<td>0.172 7.26</td>
<td>0.351 6.44</td>
</tr>
<tr>
<td>0.803</td>
<td>19.99</td>
<td>120.1</td>
<td>0.380 17.76</td>
<td>0.389 16.05</td>
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<tr>
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<td>0.427 32.54</td>
</tr>
<tr>
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<td>0.450 40.62</td>
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<tr>
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<td>19.99</td>
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<td>0.470 48.76</td>
</tr>
<tr>
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<td>0.487 57.04</td>
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<td>1.156 69.46</td>
<td>0.501 65.02</td>
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TIDT096 - March 2019

65-W active clamp flyback reference design using silicon FETs for an AC/DC adapter

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## 230VAC/50Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout (A)</th>
<th>Vout (V)</th>
<th>Vout USB-C (V)</th>
<th>Vin (V)</th>
<th>lin (A)</th>
<th>Pin (W)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USBC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0249</td>
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<td>19.98</td>
<td>229.7</td>
<td>0.0201</td>
<td>0.868</td>
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<td>0.50</td>
<td>0.37</td>
<td>57.3%</td>
<td>57.3%</td>
<td></td>
</tr>
<tr>
<td>0.319</td>
<td>19.99</td>
<td>19.99</td>
<td>230.0</td>
<td>0.116</td>
<td>7.65</td>
<td>0.288</td>
<td>6.38</td>
<td>6.38</td>
<td>1.27</td>
<td>83.4%</td>
<td>83.4%</td>
</tr>
<tr>
<td>0.803</td>
<td>19.99</td>
<td>19.98</td>
<td>230.3</td>
<td>0.241</td>
<td>18.15</td>
<td>0.327</td>
<td>16.05</td>
<td>16.04</td>
<td>2.11</td>
<td>88.4%</td>
<td>88.4%</td>
</tr>
<tr>
<td>1.221</td>
<td>19.99</td>
<td>19.98</td>
<td>230.2</td>
<td>0.346</td>
<td>27.30</td>
<td>0.343</td>
<td>24.41</td>
<td>24.40</td>
<td>2.90</td>
<td>89.4%</td>
<td>89.4%</td>
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<td>1.629</td>
<td>19.99</td>
<td>19.98</td>
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<td>0.353</td>
<td>32.56</td>
<td>32.55</td>
<td>3.58</td>
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<td>90.1%</td>
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<td>19.98</td>
<td>230.2</td>
<td>0.533</td>
<td>44.40</td>
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<td>40.40</td>
<td>4.00</td>
<td>91.1%</td>
<td>91.0%</td>
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<tr>
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<td>20.00</td>
<td>19.98</td>
<td>230.2</td>
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<td>0.369</td>
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<td>92.0%</td>
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<tr>
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<td>19.97</td>
<td>230.2</td>
<td>0.708</td>
<td>61.41</td>
<td>0.377</td>
<td>56.94</td>
<td>56.85</td>
<td>4.56</td>
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<td>92.6%</td>
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<td>20.00</td>
<td>19.97</td>
<td>230.1</td>
<td>0.789</td>
<td>69.87</td>
<td>0.385</td>
<td>65.10</td>
<td>65.00</td>
<td>4.87</td>
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<td>93.0%</td>
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</tbody>
</table>

## 265VAC/50Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout (A)</th>
<th>Vout (V)</th>
<th>Vout USB-C (V)</th>
<th>Vin (V)</th>
<th>lin (A)</th>
<th>Pin (W)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USBC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0247</td>
<td>19.98</td>
<td>19.98</td>
<td>265.4</td>
<td>0.0193</td>
<td>0.907</td>
<td>0.49</td>
<td>0.49</td>
<td>0.41</td>
<td>54.4%</td>
<td>54.4%</td>
<td></td>
</tr>
<tr>
<td>0.325</td>
<td>20.00</td>
<td>19.99</td>
<td>265.4</td>
<td>0.110</td>
<td>8.07</td>
<td>0.275</td>
<td>6.50</td>
<td>6.50</td>
<td>1.57</td>
<td>80.6%</td>
<td>80.6%</td>
</tr>
<tr>
<td>0.809</td>
<td>20.00</td>
<td>19.99</td>
<td>265.4</td>
<td>0.229</td>
<td>19.26</td>
<td>0.317</td>
<td>16.18</td>
<td>16.17</td>
<td>3.09</td>
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<td>84.0%</td>
</tr>
<tr>
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<td>265.4</td>
<td>0.320</td>
<td>28.15</td>
<td>0.331</td>
<td>24.62</td>
<td>24.61</td>
<td>3.54</td>
<td>87.5%</td>
<td>87.4%</td>
</tr>
<tr>
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<td>19.98</td>
<td>265.3</td>
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<td>0.341</td>
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<td>32.53</td>
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<td>88.9%</td>
</tr>
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<td>19.98</td>
<td>265.3</td>
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<td>44.80</td>
<td>0.349</td>
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<td>40.40</td>
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<td>90.2%</td>
</tr>
<tr>
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<td>19.98</td>
<td>265.3</td>
<td>0.564</td>
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<td>0.355</td>
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<td>48.65</td>
<td>4.56</td>
<td>91.5%</td>
<td>91.4%</td>
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<td>19.98</td>
<td>265.3</td>
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<td>61.94</td>
<td>0.362</td>
<td>57.16</td>
<td>57.10</td>
<td>4.84</td>
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<td>92.2%</td>
</tr>
<tr>
<td>3.252</td>
<td>20.00</td>
<td>19.97</td>
<td>265.3</td>
<td>0.719</td>
<td>70.10</td>
<td>0.367</td>
<td>65.04</td>
<td>64.94</td>
<td>5.16</td>
<td>92.8%</td>
<td>92.6%</td>
</tr>
</tbody>
</table>

### 2.1.3 15V Output

![Graph showing efficiency vs. load current for different input voltages at 15V output.](image)
65-W active clamp flyback reference design using silicon FETs for an AC/DC adapter

<table>
<thead>
<tr>
<th>Load Increasing</th>
<th>90VAC/60Hz</th>
<th>120VAC/60Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iout (A)</td>
<td>Vin (V)</td>
<td>lin (V)</td>
</tr>
<tr>
<td>0.0255</td>
<td>15.04</td>
<td>15.04</td>
</tr>
<tr>
<td>0.299</td>
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<td>15.04</td>
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<td>0.749</td>
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<tr>
<td>1.124</td>
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<td>15.03</td>
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<tr>
<td>1.500</td>
<td>15.04</td>
<td>15.03</td>
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<td>15.04</td>
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<tr>
<td>2.625</td>
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<tr>
<td>3.000</td>
<td>15.04</td>
<td>15.02</td>
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<table>
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<tr>
<th>Load Increasing</th>
<th>230VAC/50Hz</th>
<th>265VAC/50Hz</th>
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</thead>
<tbody>
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<td>Iout (A)</td>
<td>Vin (V)</td>
<td>lin (V)</td>
</tr>
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<td>0.0255</td>
<td>15.04</td>
<td>15.04</td>
</tr>
<tr>
<td>0.297</td>
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<td>15.04</td>
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<tr>
<td>0.750</td>
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<tr>
<td>1.126</td>
<td>15.04</td>
<td>15.04</td>
</tr>
<tr>
<td>1.501</td>
<td>15.04</td>
<td>15.03</td>
</tr>
<tr>
<td>1.875</td>
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<td>15.03</td>
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<td>15.03</td>
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<tr>
<td>2.625</td>
<td>15.05</td>
<td>15.02</td>
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<tr>
<td>3.000</td>
<td>15.05</td>
<td>15.02</td>
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</table>
### 230VAC/50Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout (A)</th>
<th>Vout AC/DC (V)</th>
<th>Vout USB-C (V)</th>
<th>Vin (V)</th>
<th>lin (mA)</th>
<th>Pin (mA)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USBC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0258</td>
<td>15.04</td>
<td>15.04</td>
<td>229.6</td>
<td>0.0167</td>
<td>0.660</td>
<td>0.39</td>
<td>0.39</td>
<td>0.27</td>
<td>58.8%</td>
<td>58.8%</td>
<td></td>
</tr>
<tr>
<td>0.295</td>
<td>15.04</td>
<td>15.04</td>
<td>230.0</td>
<td>0.090</td>
<td>5.56</td>
<td>0.269</td>
<td>4.44</td>
<td>1.12</td>
<td>79.8%</td>
<td>79.8%</td>
<td></td>
</tr>
<tr>
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<td>15.04</td>
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<td>0.313</td>
<td>11.25</td>
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<td>87.2%</td>
<td>87.2%</td>
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<tr>
<td>1.125</td>
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<td>15.03</td>
<td>230.0</td>
<td>0.251</td>
<td>18.95</td>
<td>0.328</td>
<td>16.92</td>
<td>2.04</td>
<td>89.3%</td>
<td>89.2%</td>
<td></td>
</tr>
<tr>
<td>1.499</td>
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<td>15.03</td>
<td>230.0</td>
<td>0.322</td>
<td>25.05</td>
<td>0.338</td>
<td>22.54</td>
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<td>90.0%</td>
<td>89.9%</td>
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<td>1.874</td>
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<td>15.03</td>
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<td>0.393</td>
<td>31.31</td>
<td>0.347</td>
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<td>3.14</td>
<td>90.0%</td>
<td>90.0%</td>
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</tr>
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<td>2.250</td>
<td>15.04</td>
<td>15.03</td>
<td>229.9</td>
<td>0.456</td>
<td>37.02</td>
<td>0.353</td>
<td>33.84</td>
<td>3.20</td>
<td>91.4%</td>
<td>91.3%</td>
<td></td>
</tr>
<tr>
<td>2.625</td>
<td>15.04</td>
<td>15.02</td>
<td>229.9</td>
<td>0.520</td>
<td>42.81</td>
<td>0.358</td>
<td>39.48</td>
<td>3.38</td>
<td>92.2%</td>
<td>92.1%</td>
<td></td>
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<tr>
<td>3.002</td>
<td>15.04</td>
<td>15.02</td>
<td>229.9</td>
<td>0.582</td>
<td>48.68</td>
<td>0.363</td>
<td>45.15</td>
<td>3.59</td>
<td>92.7%</td>
<td>92.6%</td>
<td></td>
</tr>
</tbody>
</table>

### 265VAC/50Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout (A)</th>
<th>Vout AC/DC (V)</th>
<th>Vout USB-C (V)</th>
<th>Vin (V)</th>
<th>lin (mA)</th>
<th>Pin (mA)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USBC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0247</td>
<td>15.04</td>
<td>15.04</td>
<td>265.4</td>
<td>0.0163</td>
<td>0.671</td>
<td>0.37</td>
<td>0.37</td>
<td>0.30</td>
<td>55.4%</td>
<td>55.4%</td>
<td></td>
</tr>
<tr>
<td>0.297</td>
<td>15.04</td>
<td>15.04</td>
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<td>89.5%</td>
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<td>15.03</td>
<td>264.5</td>
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<td>3.44</td>
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<td>90.8%</td>
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<tr>
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<td>15.03</td>
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<td>43.00</td>
<td>0.346</td>
<td>39.46</td>
<td>3.56</td>
<td>91.8%</td>
<td>91.7%</td>
<td></td>
</tr>
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<td>3.001</td>
<td>15.05</td>
<td>15.02</td>
<td>264.5</td>
<td>0.526</td>
<td>48.89</td>
<td>0.351</td>
<td>45.17</td>
<td>3.81</td>
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<td>92.2%</td>
<td></td>
</tr>
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</table>

### 2.1.4 9V Output

[Graph showing efficiency vs. load current for different AC/DC voltages.]

---

**Note**: The table and graph above illustrate the performance of a 65-W active clamp flyback reference design using silicon FETs for an AC/DC adapter. The data includes measurements under various load conditions for 230VAC/50Hz and 265VAC/50Hz, showing efficiency and losses at different output currents. The graph visualizes efficiency across a range of load currents for 9V output under different AC/DC voltage settings.
### 90VAC/60Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout</th>
<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0244</td>
<td>8.95</td>
<td>8.95</td>
<td>89.9</td>
<td>0.0134</td>
<td>0.326</td>
<td></td>
<td>0.22</td>
<td>0.22</td>
<td>0.11</td>
<td>67.0%</td>
<td>67.0%</td>
</tr>
<tr>
<td>0.299</td>
<td>8.95</td>
<td>8.95</td>
<td>90.1</td>
<td>0.101</td>
<td>3.14</td>
<td>0.346</td>
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<td>2.68</td>
<td>0.46</td>
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<td>85.2%</td>
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<tr>
<td>0.749</td>
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<td>8.94</td>
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<td>0.220</td>
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<td>0.380</td>
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<td>6.70</td>
<td>0.83</td>
<td>89.0%</td>
<td>89.0%</td>
</tr>
<tr>
<td>1.126</td>
<td>8.95</td>
<td>8.94</td>
<td>90.0</td>
<td>0.314</td>
<td>11.23</td>
<td>0.398</td>
<td>10.08</td>
<td>10.07</td>
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<td>89.7%</td>
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<td>8.95</td>
<td>8.94</td>
<td>90.0</td>
<td>0.400</td>
<td>14.82</td>
<td>0.411</td>
<td>13.43</td>
<td>13.41</td>
<td>1.41</td>
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<td>90.6%</td>
</tr>
<tr>
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<td>8.93</td>
<td>89.9</td>
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<td>18.46</td>
<td>0.426</td>
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<td>16.77</td>
<td>1.69</td>
<td>91.1%</td>
<td>91.1%</td>
</tr>
<tr>
<td>2.252</td>
<td>8.95</td>
<td>8.93</td>
<td>89.9</td>
<td>0.555</td>
<td>22.04</td>
<td>0.441</td>
<td>20.16</td>
<td>20.11</td>
<td>1.93</td>
<td>91.4%</td>
<td>91.2%</td>
</tr>
<tr>
<td>2.625</td>
<td>8.95</td>
<td>8.93</td>
<td>89.9</td>
<td>0.623</td>
<td>25.58</td>
<td>0.457</td>
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<td>23.44</td>
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<td>91.6%</td>
</tr>
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<td>3.000</td>
<td>8.95</td>
<td>8.93</td>
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### 120VAC/60Hz Load Increasing

<table>
<thead>
<tr>
<th>Iout</th>
<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USBC</th>
</tr>
</thead>
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<td>0.0246</td>
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<td>0.0114</td>
<td>0.336</td>
<td></td>
<td>0.22</td>
<td>0.22</td>
<td>0.12</td>
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<td>65.5%</td>
</tr>
<tr>
<td>0.300</td>
<td>8.95</td>
<td>8.95</td>
<td>120.0</td>
<td>0.082</td>
<td>3.18</td>
<td>0.323</td>
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<td>2.69</td>
<td>0.50</td>
<td>84.4%</td>
<td>84.4%</td>
</tr>
<tr>
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<td>8.95</td>
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<td>7.61</td>
<td>0.354</td>
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<td>6.72</td>
<td>0.89</td>
<td>88.3%</td>
<td>88.3%</td>
</tr>
<tr>
<td>1.125</td>
<td>8.95</td>
<td>8.94</td>
<td>120.0</td>
<td>0.253</td>
<td>11.22</td>
<td>0.370</td>
<td>10.07</td>
<td>10.06</td>
<td>1.16</td>
<td>89.7%</td>
<td>89.6%</td>
</tr>
<tr>
<td>1.500</td>
<td>8.95</td>
<td>8.94</td>
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<td>0.323</td>
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<td>0.383</td>
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<td>13.41</td>
<td>1.41</td>
<td>90.6%</td>
<td>90.5%</td>
</tr>
<tr>
<td>1.878</td>
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<td>8.94</td>
<td>120.0</td>
<td>0.393</td>
<td>18.48</td>
<td>0.391</td>
<td>16.81</td>
<td>16.79</td>
<td>1.69</td>
<td>91.0%</td>
<td>90.9%</td>
</tr>
<tr>
<td>2.251</td>
<td>8.95</td>
<td>8.94</td>
<td>120.0</td>
<td>0.461</td>
<td>22.03</td>
<td>0.399</td>
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<td>20.12</td>
<td>1.91</td>
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<td>91.3%</td>
</tr>
<tr>
<td>2.624</td>
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<td>8.93</td>
<td>119.9</td>
<td>0.525</td>
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<td>0.406</td>
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<td>26.81</td>
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<td>92.1%</td>
</tr>
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</table>
### 230VAC/50Hz Load Increasing

<table>
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<tr>
<th>Iout (A)</th>
<th>Vout (V)</th>
<th>Pin (W)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USB-C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0256</td>
<td>8.95</td>
<td>8.95</td>
<td>229.7</td>
<td>0.0130</td>
<td>0.439</td>
<td>0.23</td>
<td>52.2%</td>
<td>52.2%</td>
</tr>
<tr>
<td>0.300</td>
<td>8.95</td>
<td>8.95</td>
<td>230.0</td>
<td>0.066</td>
<td>3.74</td>
<td>0.245</td>
<td>71.8%</td>
<td>71.8%</td>
</tr>
<tr>
<td>0.750</td>
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<td>8.95</td>
<td>230.0</td>
<td>0.121</td>
<td>8.11</td>
<td>0.291</td>
<td>82.8%</td>
<td>82.8%</td>
</tr>
<tr>
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<td>8.94</td>
<td>230.0</td>
<td>0.163</td>
<td>11.59</td>
<td>0.309</td>
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<td>86.9%</td>
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<td>8.94</td>
<td>230.0</td>
<td>0.205</td>
<td>15.22</td>
<td>0.323</td>
<td>88.3%</td>
<td>88.2%</td>
</tr>
<tr>
<td>1.875</td>
<td>8.95</td>
<td>8.93</td>
<td>230.0</td>
<td>0.248</td>
<td>18.86</td>
<td>0.330</td>
<td>89.0%</td>
<td>88.8%</td>
</tr>
<tr>
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<td>8.93</td>
<td>230.0</td>
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<td>22.39</td>
<td>0.337</td>
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<tr>
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<td>8.93</td>
<td>230.0</td>
<td>0.328</td>
<td>25.79</td>
<td>0.342</td>
<td>91.1%</td>
<td>90.9%</td>
</tr>
<tr>
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<td>8.93</td>
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### 265VAC/50Hz Load Increasing

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<th>Vout (V)</th>
<th>Pin (W)</th>
<th>PF</th>
<th>Pout AC/DC (W)</th>
<th>Pout USB-C (W)</th>
<th>Losses (W)</th>
<th>Efficiency AC/DC (%)</th>
<th>Efficiency USB-C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0255</td>
<td>8.95</td>
<td>8.95</td>
<td>264.4</td>
<td>0.0131</td>
<td>0.451</td>
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<td>50.6%</td>
</tr>
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<td>8.95</td>
<td>8.95</td>
<td>264.5</td>
<td>0.065</td>
<td>3.98</td>
<td>0.233</td>
<td>67.5%</td>
<td>67.5%</td>
</tr>
<tr>
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<td>8.95</td>
<td>264.5</td>
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<td>0.276</td>
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</tr>
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<td>264.5</td>
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<td>11.98</td>
<td>0.295</td>
<td>84.0%</td>
<td>84.0%</td>
</tr>
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<td>264.5</td>
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<td>0.307</td>
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<td>87.6%</td>
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<td>8.94</td>
<td>264.5</td>
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<td>19.17</td>
<td>0.317</td>
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<td>88.5%</td>
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<tr>
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<td>8.93</td>
<td>264.5</td>
<td>0.299</td>
<td>25.97</td>
<td>0.328</td>
<td>90.5%</td>
<td>90.3%</td>
</tr>
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<td>264.5</td>
<td>0.334</td>
<td>29.44</td>
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<td>91.2%</td>
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</table>

### 2.1.5 5V Output

![Graph showing efficiency vs. load current for different input voltages and frequencies.](chart.png)
90VAC/60Hz  Load Increasing

<table>
<thead>
<tr>
<th>Iout</th>
<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USB-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0250</td>
<td>5.00</td>
<td>5.00</td>
<td>90.0</td>
<td>0.0088</td>
<td>0.196</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>63.8%</td>
<td>63.8%</td>
<td></td>
</tr>
<tr>
<td>0.300</td>
<td>5.01</td>
<td>5.00</td>
<td>90.1</td>
<td>0.062</td>
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<td>1.50</td>
<td>0.32</td>
<td>82.6%</td>
<td>82.4%</td>
</tr>
<tr>
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<td>5.00</td>
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<td>90.0</td>
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<td>0.395</td>
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<td>9.36</td>
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<td>86.1%</td>
</tr>
<tr>
<td>2.250</td>
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<td>90.0</td>
<td>0.354</td>
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<td>0.403</td>
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<td>11.23</td>
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</tr>
<tr>
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<td>90.0</td>
<td>0.403</td>
<td>14.87</td>
<td>0.411</td>
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<td>14.94</td>
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<td>88.2%</td>
</tr>
</tbody>
</table>

120VAC/60Hz  Load Increasing

<table>
<thead>
<tr>
<th>Iout</th>
<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
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<th>Efficiency USB-C</th>
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<td>5.00</td>
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<td>0.0077</td>
<td>0.198</td>
<td>0.12</td>
<td>0.12</td>
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<td>62.4%</td>
<td>62.4%</td>
<td></td>
</tr>
<tr>
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<td>5.01</td>
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<td>1.85</td>
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<td>1.50</td>
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<td>0.348</td>
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<td>5.63</td>
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<td>85.2%</td>
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<td>4.99</td>
<td>120.1</td>
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<td>0.360</td>
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<td>13.07</td>
<td>1.81</td>
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<td>87.9%</td>
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<tr>
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<td>4.98</td>
<td>120.1</td>
<td>0.363</td>
<td>16.88</td>
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### 230VAC/50Hz

<table>
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<tr>
<th>Load Increasing</th>
<th>Iout AC/DC</th>
<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USBC</th>
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<td>5.00</td>
<td>230.0</td>
<td>0.0091</td>
<td>0.252</td>
<td>0.12</td>
<td>0.12</td>
<td>0.13</td>
<td>49.4%</td>
<td>49.4%</td>
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<td></td>
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<tr>
<td>0.301</td>
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<td>5.00</td>
<td>230.2</td>
<td>0.047</td>
<td>2.39</td>
<td>0.220</td>
<td>1.51</td>
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<td>0.89</td>
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<td>63.0%</td>
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<td>3.76</td>
<td>3.76</td>
<td>1.28</td>
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<td>0.316</td>
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### 265VAC/50Hz

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<th>Vout AC/DC</th>
<th>Vout USB-C</th>
<th>Vin</th>
<th>lin</th>
<th>Pin</th>
<th>PF</th>
<th>Pout AC/DC</th>
<th>Pout USB-C</th>
<th>Losses</th>
<th>Efficiency AC/DC</th>
<th>Efficiency USBC</th>
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<tr>
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<td>5.00</td>
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### 2.1.6 Standby

<table>
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<th>Pin (mW)</th>
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<tr>
<td>230V</td>
<td>50</td>
<td>33.2</td>
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</table>
2.2 Thermal Images
All images captured open frame, after a 30-minute warm up period.

2.2.1 90VAC/60Hz Input, 20V/3.25A Output
2.2.2 120VAC/60Hz Input, 20V/3.25A Output

[Thermal image with temperature readings]

Bx1 Max 80.5 °C

Bx1 Max 83.3 °C
2.2.3 230VAC/50Hz Input, 20V/3.25A Output

[Thermal images showing temperature distribution]
2.2.4 265VAC/50Hz Input, 20V/3.25A Output
2.3 Switching Waveforms

2.3.1 Primary Switch Node, 265VAC/50Hz Input, 20V/3.25A Output

2.3.2 Primary Switch Node, 265VAC/50Hz Input, 20V/0A Output
2.3.3 Vds of SR FET (Q7), 265VAC/50Hz Input, 20V/3.25A Output

2.3.4 Vds of SR FET (Q7), 265VAC/50Hz Input, 20V/0A Output
2.4  Output Voltage Ripple at Maximum Load Current

2.4.1  5V/3A Output, 120VAC/60Hz Input

2.4.2  5V/3A Output, 230VAC/50Hz Input
2.4.3 9V/3A Output, 120VAC/60Hz Input

2.4.4 9V/3A Output, 230VAC/50Hz Input
2.4.5 15V/3A Output, 120VAC/60Hz Input

2.4.6 15V/3A Output, 230VAC/50Hz Input
2.4.7 20V/3.25A Output, 120VAC/60Hz Input

2.4.8 20V/3.25A Output, 230VAC/50Hz Input
2.5 Output Voltage Ripple during Burst Mode

2.5.1 5V/2A Output, 120VAC/60Hz Input

2.5.2 5V/2A Output, 230VAC/50Hz Input
2.5.3 9V/2A Output, 120VAC/60Hz Input

2.5.4 9V/2A Output, 230VAC/50Hz Input
2.5.5 15V/1.6A Output, 120VAC/60Hz Input

2.5.6 15V/1.8A Output, 230VAC/50Hz Input
2.5.7 20V/1.5A Output, 120VAC/60Hz Input

2.5.8 20V/1.5A Output, 230VAC/50Hz Input
2.6 Bode Plot

2.6.1 5V/3A Output

Plot #1 - 90VAC/60Hz Input
Plot #2 – 265VAC/50Hz Input

2.6.2 9V/3A Output

Plot #1 - 90VAC/60Hz Input
Plot #2 – 265VAC/50Hz Input
2.6.3 15V/3A Output

2.6.4 20V/3.25A Output
2.7 5V Output Load Transients

2.7.1 5V Output, 0A to 750mA Load Step, 120VAC/60Hz Input

![Graph showing 5V Output Load Transients for 120VAC/60Hz Input]

2.7.2 5V Output, 0A to 750mA Load Step, 230VAC/50Hz Input

![Graph showing 5V Output Load Transients for 230VAC/50Hz Input]
2.7.3 5V Output, 750mA to 1.5A Load Step, 120VAC/60Hz Input

2.7.4 5V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input
2.7.5  5V Output, 1.5A to 2.25A Load Step, 120VAC/60Hz Input

2.7.6  5V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input
2.7.7  5V Output, 2.25A to 3.0A Load Step, 120VAC/60Hz Input

2.7.8  5V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input
2.8 9V Output Load Transients

2.8.1 9V Output, 0A to 750mA Load Step, 120VAC/60Hz Input

2.8.2 9V Output, 0A to 750mA Load Step, 230VAC/50Hz Input
2.8.3 9V Output, 750mA to 1.5A Load Step, 120VAC/60Hz Input

2.8.4 9V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input
2.8.5 9V Output, 1.5A to 2.25A Load Step, 120VAC/60Hz Input

2.8.6 9V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input
2.8.7 9V Output, 2.25A to 3.0A Load Step, 120VAC/60Hz Input

2.8.8 9V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input
2.9 15V Output Load Transients

2.9.1 15V Output, 0A to 750mA Load Step, 120VAC/60Hz Input

2.9.2 15V Output, 0A to 750mA Load Step, 230VAC/50Hz Input
2.9.3 15V Output, 750mA to 1.5A Load Step, 120VAC/60Hz Input

2.9.4 15V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input
2.9.5 15V Output, 1.5A to 2.25A Load Step, 120VAC/60Hz Input

2.9.6 15V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input
2.9.7 15V Output, 2.25A to 3.0A Load Step, 120VAC/60Hz Input

2.9.8 15V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input
2.10 20V Output Load Transients

2.10.1 20V Output, 0A to 750mA Load Step, 120VAC/60Hz Input

2.10.2 20V Output, 0A to 750mA Load Step, 230VAC/50Hz Input
2.10.3 20V Output, 750mA to 1.5A Load Step, 120VAC/60Hz Input

2.10.4 20V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input
2.10.5 20V Output, 1.5A to 2.25A Load Step, 120VAC/60Hz Input

2.10.6 20V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input
2.10.7 20V Output, 2.25A to 3.25A Load Step, 120VAC/60Hz Input

2.10.8 20V Output, 2.25A to 3.25A Load Step, 230VAC/50Hz Input
2.11 Startup
Output voltage measured at connector when USB-C cable inserted with no load.

2.12 Voltage Transitions
2.12.1 5V to 9V, 120VAC/60Hz Input, No Load
2.12.2 5V to 9V, 230VAC/50Hz Input, No Load

2.12.3 5V to 15V, 120VAC/60Hz Input, No Load
2.12.4 5V to 15V, 230VAC/50Hz Input, No Load

2.12.5 5V to 20V, 120VAC/60Hz Input, No Load
2.12.6 5V to 20V, 230VAC/50Hz Input, No Load

2.12.7 9V to 5V, 120VAC/60Hz Input, No Load
2.12.8 9V to 5V, 230VAC/50Hz Input, No Load

2.12.9 9V to 15V, 120VAC/60Hz Input, No Load
2.12.10 9V to 15V, 230VAC/50Hz Input, No Load

2.12.11 9V to 20V, 120VAC/60Hz Input, No Load
2.12.12 9V to 20V, 230VAC/50Hz Input, No Load

2.12.13 15V to 5V, 120VAC/60Hz Input, No Load
2.12.14 15V to 5V, 230VAC/50Hz Input, No Load

2.12.15 15V to 9V, 120VAC/60Hz Input, No Load
2.12.16 15V to 9V, 230VAC/50Hz Input, No Load

2.12.17 15V to 20V, 120VAC/60Hz Input, No Load
2.12.18 15V to 20V, 230VAC/50Hz Input, No Load

2.12.19 20V to 5V, 120VAC/60Hz Input, No Load
2.12.20  20V to 5V, 230VAC/50Hz Input, No Load

2.12.21  20V to 9V, 120VAC/60Hz Input, No Load
2.12.22 20V to 9V, 230VAC/50Hz Input, No Load

2.12.23 20V to 15V, 120VAC/60Hz Input, No Load
2.12.24 20V to 15V, 230VAC/50Hz Input, No Load

2.13 Conducted EMI
Results below are using a peak detector with a maximum-hold setting, comparing results to the quasi-peak limit lines. Actual quasi-peak results will be lower than the peak, max-hold results shown here.
2.13.1 120VAC/60Hz Input, 20V/3.25A Output

Peak Detector, Max-Hold
120VAC/60Hz Input; 20Vout/3.25A; Un-earthed Load

Class B QPK
Line
Neutral
2.13.2 230VAC/50Hz Input, 20V/3.25A Output

Peak Detector, Max-Hold
230VAC/50Hz Input; 20Vout/3.25A; Un-earthed Load

Frequency (MHz)
2.13.3 120VAC/60Hz Input, 15V/3A Output

Peak Detector, Max-Hold
120VAC/60Hz Input; 15Vout/3A; Un-earthed Load

- Class B QPK
- Line
- Neutral

Frequency (MHz)
2.13.4 230VAC/50Hz Input, 15V/3A Output

Peak Detector, Max-Hold
230VAC/50Hz Input; 15Vout/3A; Un-earthed Load

- Class B QPK
- Line
- Neutral
2.13.5 120VAC/60Hz Input, 9V/3A Output

Peak Detector, Max-Hold
120VAC/60Hz Input; 9Vout/3A; Un-earthed Load
2.13.6 230VAC/50Hz Input, 9V/3A Output

Peak Detector, Max-Hold
230VAC/50Hz Input; 9Vout/3A; Un-earthed Load

![Graph showing peak detector response for 230VAC/50Hz input, 9V/3A output.]
2.13.7 120VAC/60Hz Input, 5V/3A Output

**Peak Detector, Max-Hold**

120VAC/60Hz Input; 5Vout/3A; Un-earthed Load

![Graph of Peak Detector, Max-Hold](image)

- **Class B QPK**
- **Line**
- **Neutral**

Frequency (MHz) vs. dBmV graph showing the performance of the peak detector in a 120VAC/60Hz input configuration.
2.13.8 230VAC/50Hz Input, 5V/3A Output

Peak Detector, Max-Hold
230VAC/50Hz Input; 5Vout/3A; Un-earthed Load