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sense and simplicity

High Efficiency Driving Electronics for General Illumination LED Luminaires

Philips LED Systems
Rosemont, IL

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Sanjay Pradhan, Shruti yalamarty
Objective

The objective is to prepare the first of a new generation of LED drivers for production. The products will be switch-mode power supplies, similar to the LED drivers of today, but with new topologies and improved design to yield higher efficiency (≥90%), smaller size (volume less than 6 in³ for a 40W supply: 0.15 in³/Watts) and lower cost ($4.8 for a 40W supply i.e. 12 Cents/Watt, in high volumes).

• The objective of the first phase (Phase 1-A) of the project is to investigate hard-switched, switch-resonant and load-resonant SMPS’s, and select the best topology for the product.
• In Phase 1-B, the objective is to develop the platform for product development with the selected topologies.
• The objective of the second half (Phase 2) of the project is to bring the topology selected in the first half (Phase 1) through a complete development cycle to product release.
# Project Timeline

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<tbody>
<tr>
<td>1. Review conventional topologies</td>
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<td>2. Design and model hard-switched and switch-resonant circuits</td>
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<td>3. Build and test selected hard-switched and switch-resonant circuits</td>
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<td>4. Identify most promising hard-switched and/or switch-resonant topology</td>
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<td>5. Build and test selected load-resonant circuits</td>
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<td>6. Compare results and select final topology for product</td>
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<td>Phase 2: Develop product</td>
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<td>7. Design product from selected topology, according to specifications. Estimate cost</td>
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<td>8. Define Quality test plan</td>
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<td>9. Perform tolerance analysis</td>
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<td>10. Conduct PMEA, stress testing, job review</td>
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<td>11. Design completed (1.1)</td>
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<td>12. Complete factory preparations for sample build</td>
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<td>13. Perform sample build in factory</td>
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<td>14. Test (meet safety, performance, EMC, and stress requirements)</td>
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<td>15. Perform approbation testing (DIL, FCC)</td>
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<td>16. Execute pilot run (100 units) (1.2)</td>
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<td>17. Test pilot run units, complete approbation, prepare reports</td>
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<td>18. Release product for limited production (2.0)</td>
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Notes:
1. Low Efficiency
2. Comparable part counts to two stage design with complex control scheme
3. Narrow output voltage range (⇒ narrow application load range)
4. High Cost
5. Highly promising in meeting the requirements
Product Deliverables

We are making following product platforms from this project:

1. 40W Single-stage Flyback 120V/277V:
2. 40W (Intellivolt voltage) dual stage (PFC+LLC):
3. 75W (Intellivolt voltage) dual stage (PFC+LLC):
4. 150W (Intellivolt voltage) dual stage (PFC+LLC):

![Diagram showing the relationship between Fly-Back Topology, LLC Resonant Topology, and Cost Per Wattage ($/W)]
Single-stage Flyback Driver Platform

TRANSITION MODE FLY-BACK LED DRIVER
**Comparison between the current and new 40W, 120Vac drivers**

<table>
<thead>
<tr>
<th><strong>XITANIUM 120Vac,40W/1.75A-24V</strong></th>
<th><strong>120Vac,37W/0.7A-53V</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(Current Product)</em></td>
<td><em>(New Design)</em></td>
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**Cost**
- Very High

**Size**
- Volume of the unit ~ 223cm³
- Volume of the unit ~ 114cm³

**Performance**
- Efficiency ~ 83%
- Meets 2KV surge rating
- No dimming capability, fixed output current
- Efficiency ~ 90%,
- Meets 4KV surge rating
- Optional 0-10VDC Dimming
LLC Design Platform

Mains Input PFC Stage (Power Factor Correction)

HB driver

Half Bridge

LLC converter (isolated)

LED-array

120 – 277Vac, 60Hz: NAM
230Vac, 50/60Hz: EU, APR

Analogue IC
EMC Performance Improvements/75W

The new topology improves the EMI by about 10 to 15dB across the board, with a smaller EMI filter and 2 layer PCB versus the 4-layer PCB.
Efficiency Improvements/75W

- 75W LLC Driver
- 75W PWM Driver

Efficiency (%) vs. Output Voltage (V)
75W LED Driver Size Improvement

- Current driver housing dimensions are 55mmX210X36mm
- New housing dimensions are 55mmX135mmX36mm
- This means about a 36% size reduction in terms of length and volume.
- The pictures on the right illustrate the decrease in size.
150W LLC LED Driver

(Current PWM based Driver)

Cost
• Close

Size
• PCB board dimensions are 52mm X 206mm.

Performance
• Efficiency : 86 -90%

(New LLC Design)

Cost
• Lower Product Cost

Size
• New PCB Dimension 38mm X 206mm
• 27% reduction in PCB size feasible

Performance
• Efficiency on bench > 90% at all load ranges.
• EMI Improvement >10 dB
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40W LLC LED Driver

(Current PWM based Driver)

Cost
- High

Size
- Dimension 106.7 × 76.4 × 30 mm³.

Performance
- Efficiency: 86-89%

(New LLC Design)

Cost
- Significantly Lower Product Cost

Size
- New driver dimension 124.2 × 43 × 30 mm³
- 34% reduction in size

Performance
- Efficiency on bench > 90% at all load ranges.
- EMI Improvement >10 dB

40 W PFC-Half Bridge driver
(106.7 × 76.4 × 30 mm³)

40 W PFC-LLC driver
(124.2 × 43 × 30 mm³)
Additional Features /Enhancements

- **Rset Interface for customer to set the full load current at any point on the defined Rset curve**
- **Thermal Feedback using NTC thermistor to reduce output current in case of excessive temperature on the LED module**
- **Precise adjustment of the dimming curve from 1V-8V and precise current in the dimming leads to enable the use of resistor for dimming**
- **Shutdown the driver by applying 15V at the dimming leads and very low standby power in shutdown mode (<200mW)**
## Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>Efficiency Improvement</th>
<th>Size Reduction</th>
<th>Cost Reduction</th>
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</thead>
<tbody>
<tr>
<td>40W Flyback 120V</td>
<td>7%</td>
<td>49%</td>
<td>✓✓✓</td>
</tr>
<tr>
<td>40W dual stage LLC</td>
<td>1%-5% (over the load range)</td>
<td>34%</td>
<td>✓✓</td>
</tr>
<tr>
<td>75W dual stage LLC</td>
<td>1%-5% (over the load range)</td>
<td>33%</td>
<td>✓✓</td>
</tr>
<tr>
<td>150W dual stage LLC</td>
<td>1%-5% (over the load range)</td>
<td>-</td>
<td>✓</td>
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