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Miniaturization of LED Drivers

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Abstract

With the current trend towards smaller and highly portable consumer electronics and other industrial applications, one area with a great demand for such miniaturization is the lighting industry. The main hinder has been the power supplies, due to their bulky energy storage components. Through the use of soft-switching topologies, with the incorporation of the state of the art devices and combined control, circuits can operate at higher switching frequencies with smaller passive devices, allowing for miniaturized form factors towards added integration.

Brief Description and Figures

The legacy solution for LED drivers is a 2-stage structure comprised of a power factor correction rectifier with an energy storage capacitor, and a point-of-load DC-DC converter. Conventionally, pulse-width-modulated converters are the primary candidates for the AC-DC and DC-DC stages, as they offer high efficiency and are easy to control. However, their operation is based on hard-switching and typically run at low switching frequencies, resulting in the need for larger passives to store and process power. The work performed herein addresses some design considerations towards miniaturized LED drivers.

Topologies: Resonant converters have the advantage of soft-switching operation, and hence they have the potential for operation at higher frequencies, resulting in smaller passive components and overall less weight and size.

Control: Through the combination of several control schemes, e.g. frequency control with burst mode control, high efficiency can be maintained across operational load range.

Devices: The recent advancements in the wide band-gap (WBG) devices promise many advantages over Silicon switches, in terms of lower gate charge, output capacitance, and on-resistance for the same breakdown voltage, which can result in lower gating, conduction, as-well-as switching losses. On the other hand, integrated passive devices (IPDs) technologies show promising advancement towards a highly integrated system in the form of the PSiP and the more compact PwrSoC.

Energy Storage: Today's LED drivers suffer from short lifetime due to the incorporation of electrolytic capacitors for energy storage. Through the use of active ripple port circuits, the size of the capacitor needed to filter-out the double-the-line frequency ripple is reduced, and accordingly more robust capacitor technologies can be employed.

Figure 1 shows measurement results of a class-DE series-resonant converter that can be incorporated for the AC-DC and the DC-DC stages in an LED driver. The converter operates up to 400V input and soft-switching is achieved at high voltages through proper adjustment for the switching signals dead-time. The scope image shows the switching node voltage (blue) and sinusoidal resonant inductor current (green) for 350V input voltage. The graphs following show the efficiency and output power for different output voltages, and illustrate how frequency modulation can be used for line/load regulation. The converter operates around 1 MHz and incorporates high voltage GaN switches and SiC diodes.

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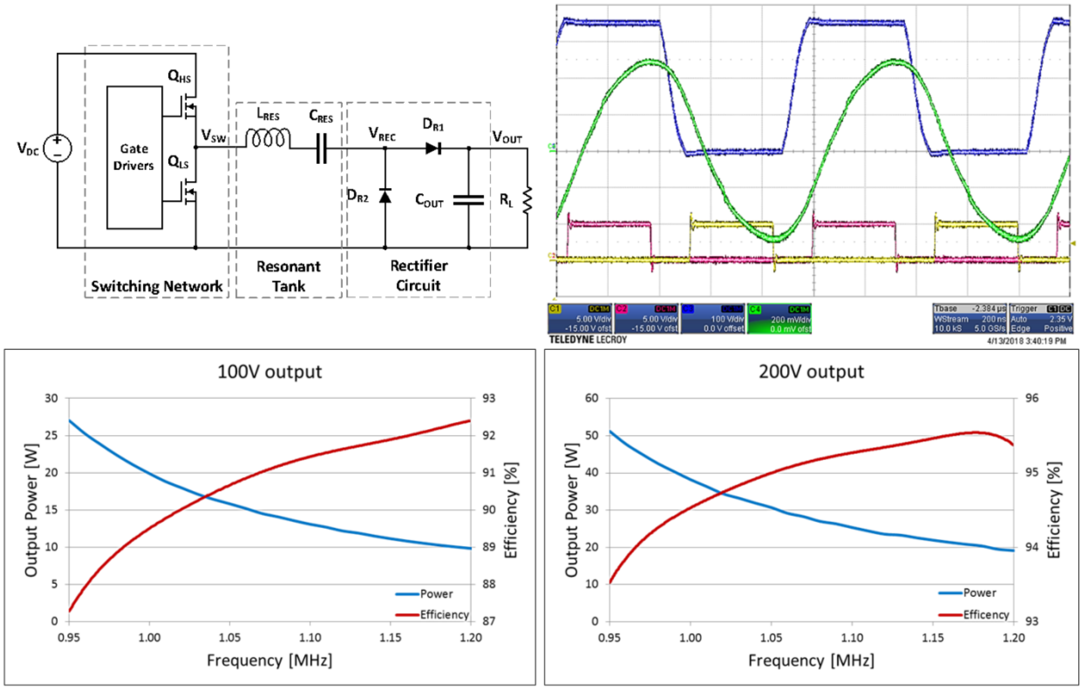

Figure 1 Measured results for Class-DE Series-Resonant Converter.

Key Contributions

There is an increasing demand for smaller, more efficient and longer living LED drivers. Resonant soft-switching topologies operating at high frequencies with combined control schemes, and incorporating wide-bandgap semiconductors and integrated passive devices, in a highly integrated package can promise substantial reduction in the size, weight and cost, as-well-as the extended lifetime of the power converters in LED drivers (Figure 2).

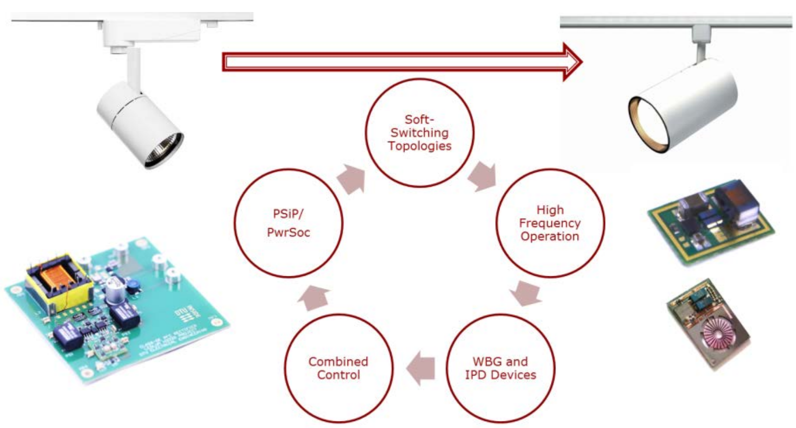

Figure 2 Proposed Miniaturization strategy.

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