ILD8150 high-frequency operation

Operation, design guide and performance

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Scope and purpose

Many engineers are trying to increase the switching frequency in order to shrink the size and cost of passive components such as the inductor and capacitors. This application note explains how to choose the operating frequency, and how it affects losses and efficiency.

Intended audience

This document is intended for engineers and students designing highly efficient LED drivers with a wide dimming range.

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1 Loss calculation, efficiency considerations, power dissipation

The total losses in the IC are determined by the following equation:

$$P_{IC} = P_C + P_{SW} + P_{IQ}$$

Where P_C is conduction losses, P_{SW} is switching losses, P_{IQ} is IC consumption and gate charge dissipation.

- Conduction losses:

$$P_C = I_{LED}^2 \cdot R_{ON} \cdot D \cdot \left(1 + \frac{1}{3}\left(\frac{\Delta I}{I_{LED}}\right)^2\right)$$

Where D is the duty cycle, R_{ON} – internal MOSFET resistance, $\Delta I_{OUT} = \frac{V_{CSH} - V_{CSL}}{R_{CS}}$. Note that R_{ON} depends on the junction temperature, which should be counted on in the calculation.

- Switching losses:

$$P_{SW} = \frac{1}{2} V_{IN} \cdot I_{LED} \cdot f_{SW} \cdot (t_R + t_F)$$

Where f_{SW} is switching frequency, $t_R$and t_F are rise and fall time accordingly by 20 ns of each.

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Power dissipated for IC supply and gate charging:

$$P_{IQ} = V_{IN} \cdot (I_{VIN_{DO}} + Q_G \cdot f_{SW})$$

Where $I_{VIN_{DO}}$ is operating current, Q_G – total gate charge 2.5 nC.

Switching frequency is determined by the following equation:

$f_{SW} = \frac{R_{CS}}{L(V_{CSH} - V_{CSL}) + R_{CS} V_{IN} t_{delay}} \cdot \frac{V_{OUT}(V_{IN} - V_{OUT})}{V_{IN}}$, where $R_{CS} V_{IN} t_{delay}$ is the delay contribution, with

$t_{delay} \approx t_{CSSW} + R_{fltr} C_{fltr}$. R_{fltr} and C_{fltr} are the RC filter, which reduces the noise from R_{CS}.

IC temparature rise is determined by the following equation:

$\Delta T_{IC} = P_{IC} \cdot R_{thJA}$ Where R_{thJA} is junction to ambient thermal resistance.

Using Figure 1 we define R_{thJA}. It shows R_{thJA} dependency from the cooling area for exposed and non-exposed pad versions. The reference design board has a cooling area of about 600 mm^2, which according to the curve is 66 K/W.

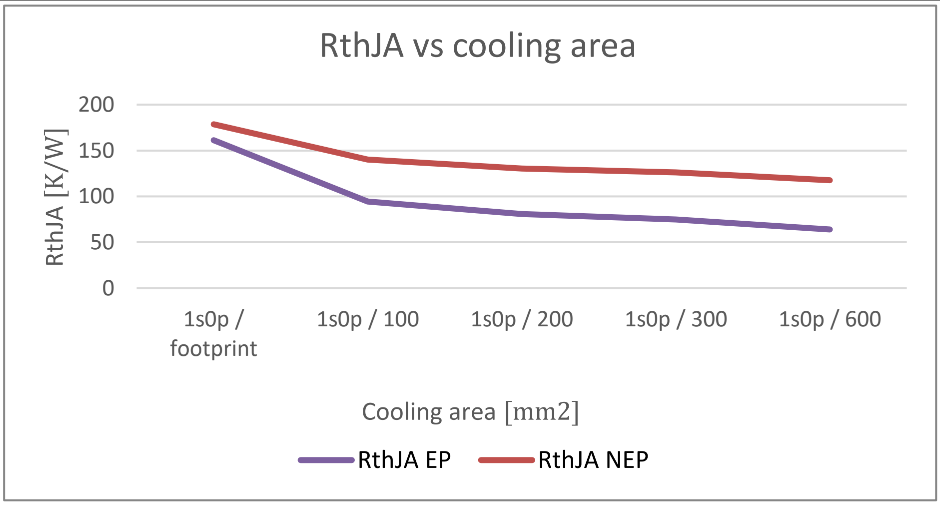

Figure 1 R_{thJA} **vs. cooling area for ILD8150E and ILD8150**

Loss calculation, efficiency considerations, power dissipation

If we assume that the ambient temperature in the closed LED driver is about 65°C and limit the junction temperature at 130°C the ΔT_{IC} will be 65°C, which is 0.98 W. If we limit thermal dissipation at this level we can get the result shown in Figure 2, at V_{IN} = 70 V, V_{LED} = 58 V, which is most typical for this application. This curve shows the IC's maximum output current capability at different frequencies with limited dissipated power of 0.98 W and a cooling area of 600 mm^2.

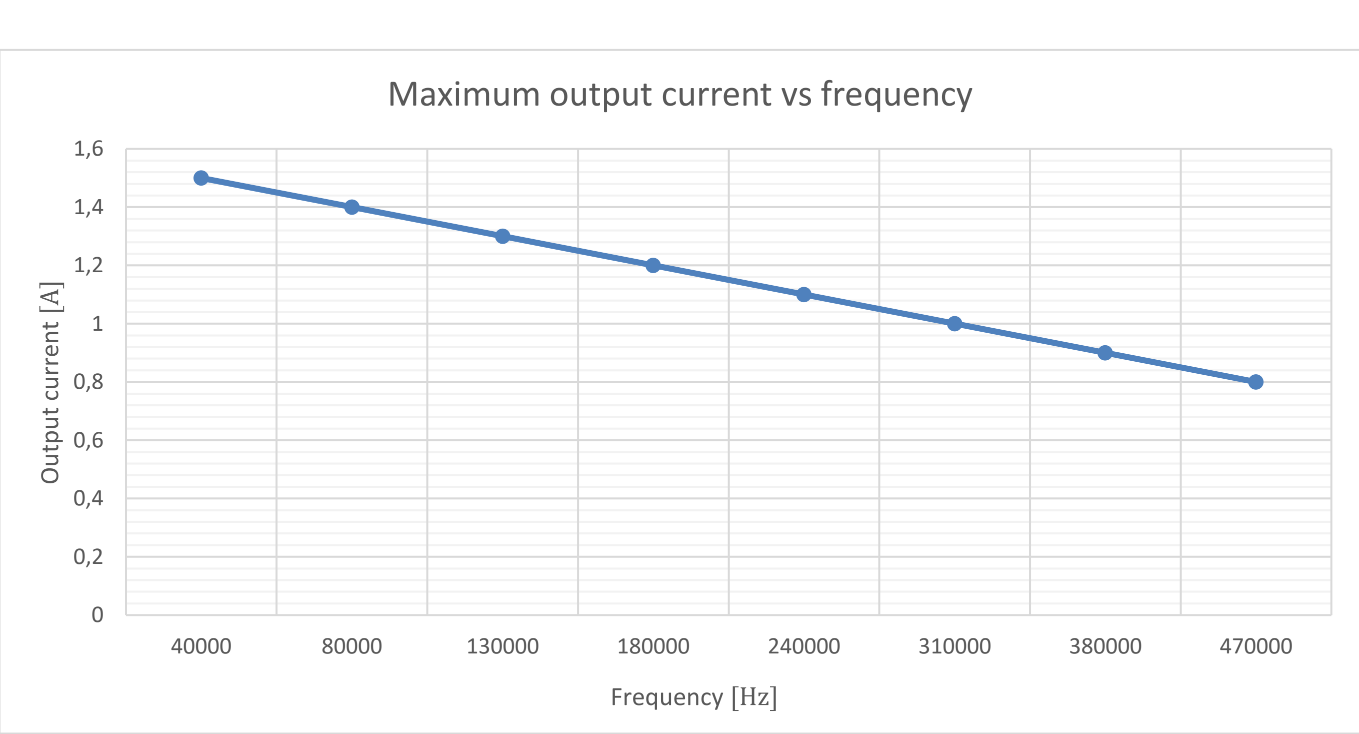

Figure 2 **IC maximum output current capability at different frequencies with limited dissipated power, 0.98 W, and cooling area of 600 mm^2**

Two designs, REF_ILD8150_DC_1.5A (SP002798058) and REF_ILD8150_DC_1.5A_SMD (SP005351260), give comparison at conditions V_{IN} = 70 V, V_{LED} = 51 V, I_{LED} = 1 A with L = 860 µH (80 kHz) and L = 100 µH (460 kHz):

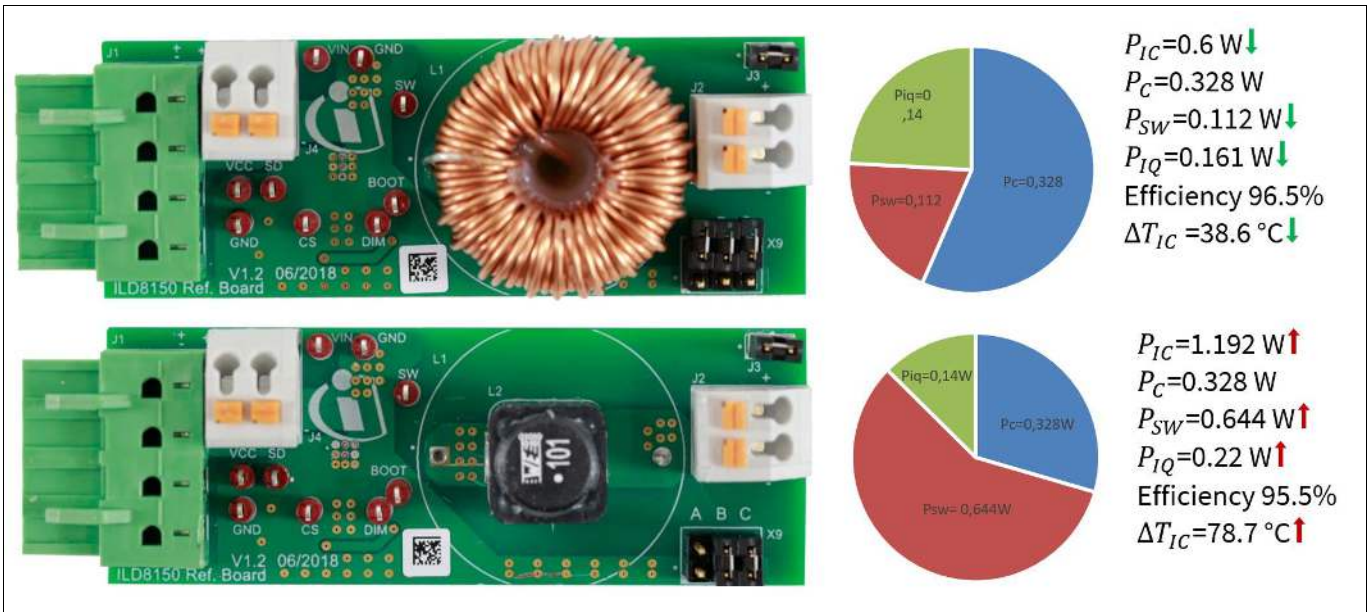

Figure 3 **REF_ILD8150_DC_1.5A (SP002798058) and REF_ILD8150_DC_1.5A_SMD (SP005351260) comparison**

Loss calculation, efficiency considerations, power dissipation

As we can see, junction temperature ΔT_{IC} at 460 kHz has risen by 78.7°C. If we assume that the ambient temperature inside an LED driver is 65°C, it means that the IC's junction temperature is close to 143°C, which is close to the thermal protection level. According to Figure 2, output current should be limited at 0.8 A at this condition. Figure 3 shows efficiency/frequency change vs. input voltage and LED voltage/number.

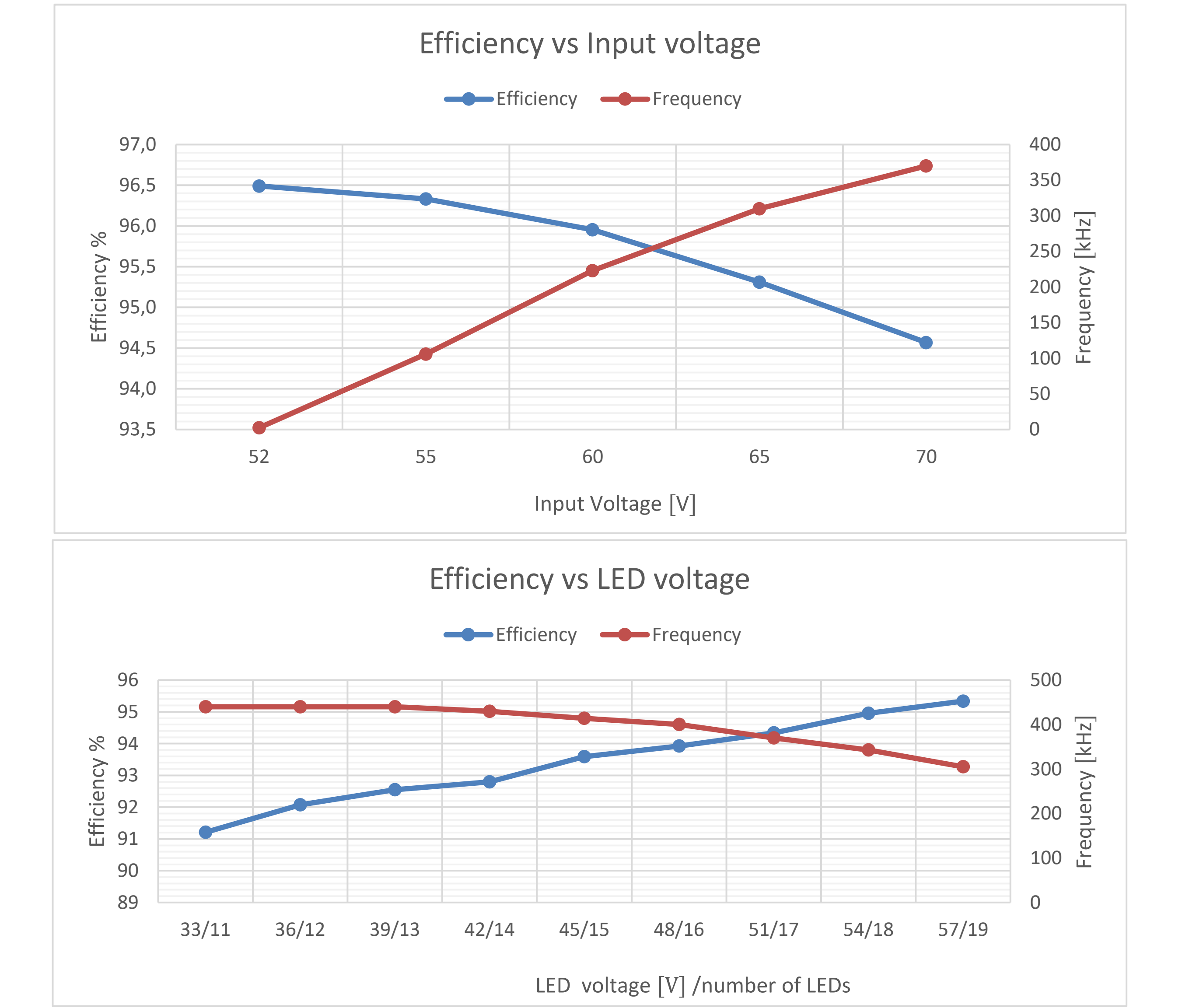

Figure 4 **Efficiency/frequency vs. input voltage V_{LED} = 51 V, I_{LED} = 1 A , efficiency/frequency vs. LED voltage/number V_{IN} = 70 V, I_{LED} = 1 A. L = 100 µH.**

Note: *If the output current is known we can define switching frequency and inductance, optimizing inductor size and cost. At the same time, the cooling condition must be considered, such as the polygonal area under the IC.*

2 References

Please refer to the ILD8150 datasheet for more information:

ILD8150 datasheet
ILD8150 application note

Revision history

Document version	Date of release	Description of changes
V1.0	05-08-2019	First release

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