

ILD8150 high-frequency operation

Operation, design guide and performance

About this document



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.

Table of contents

About this document	1
Table of contents	1
1 Loss calculation, efficiency considerations, power dissipation	2
2 References	5
Revision history	6

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.

-

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

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

IC temperature rise is determined by the following equation:

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

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.

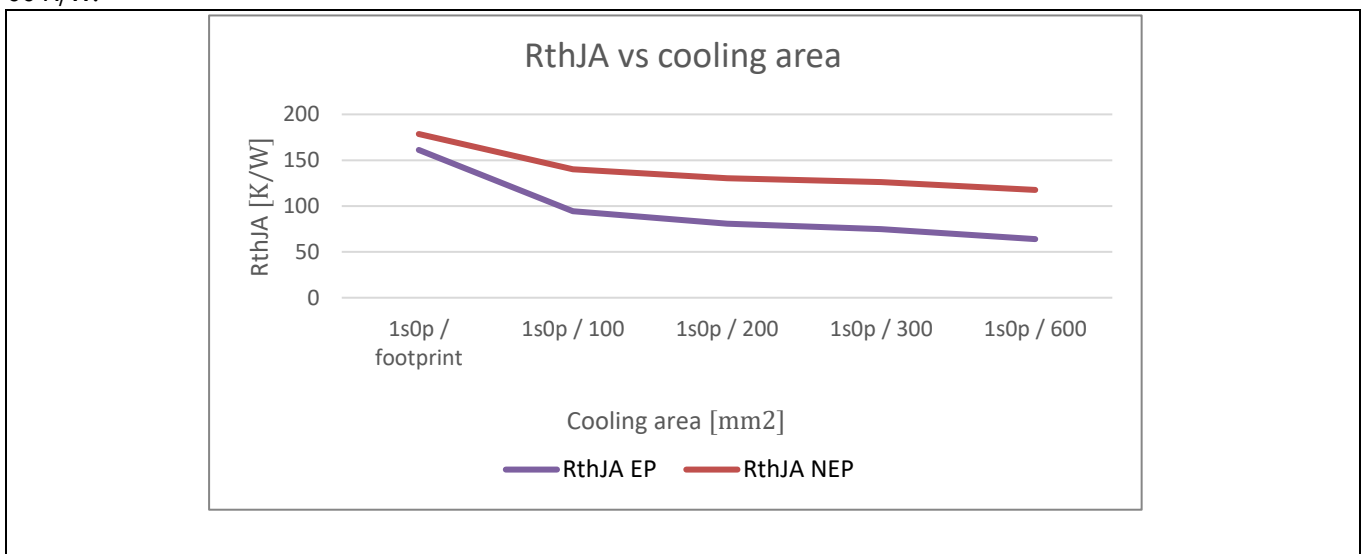


Figure 1 R_{thJA} vs. cooling area for ILD8150E and ILD8150

ILD8150 high-frequency operation

Operation, design guide and performance

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 $V_{IN} = 70\text{ V}$, $V_{LED} = 58\text{ V}$, 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 mm².

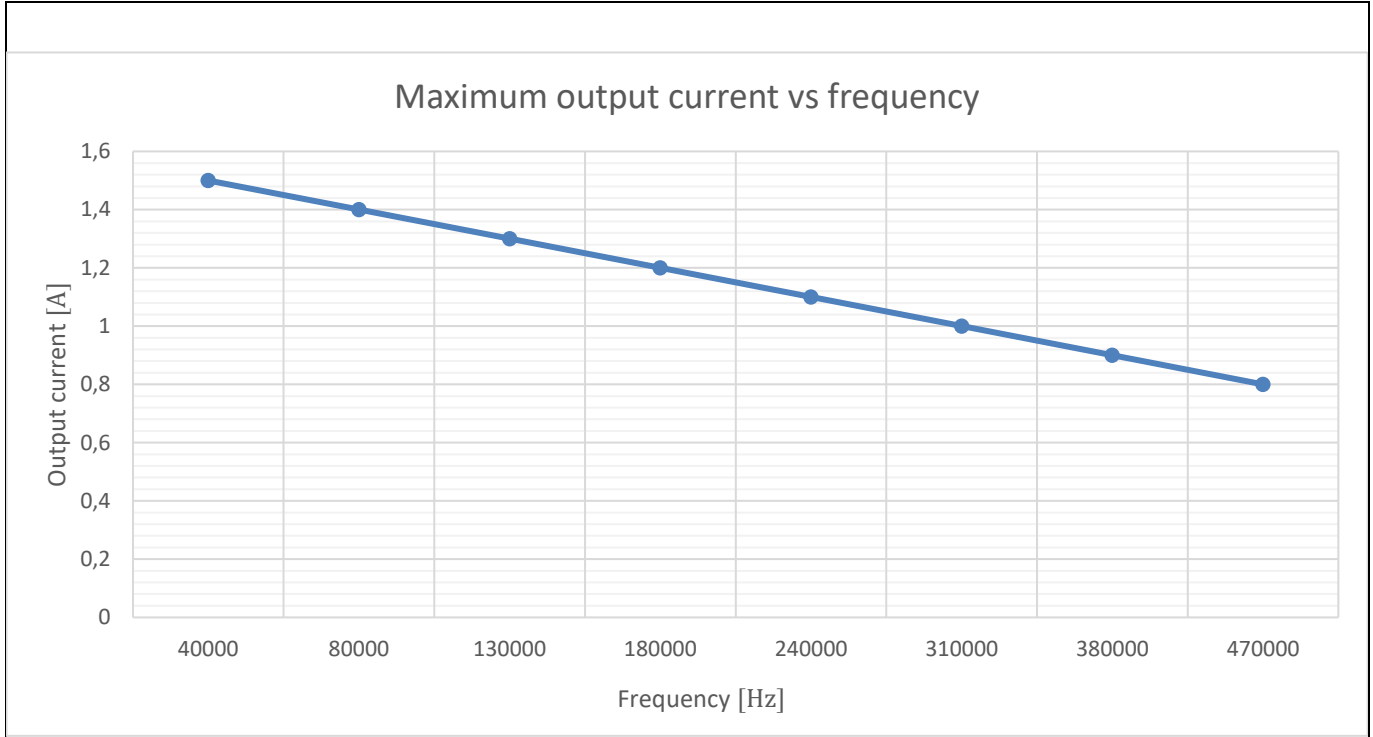


Figure 2 IC maximum output current capability at different frequencies with limited dissipated power, 0.98 W, and cooling area of 600 mm²

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

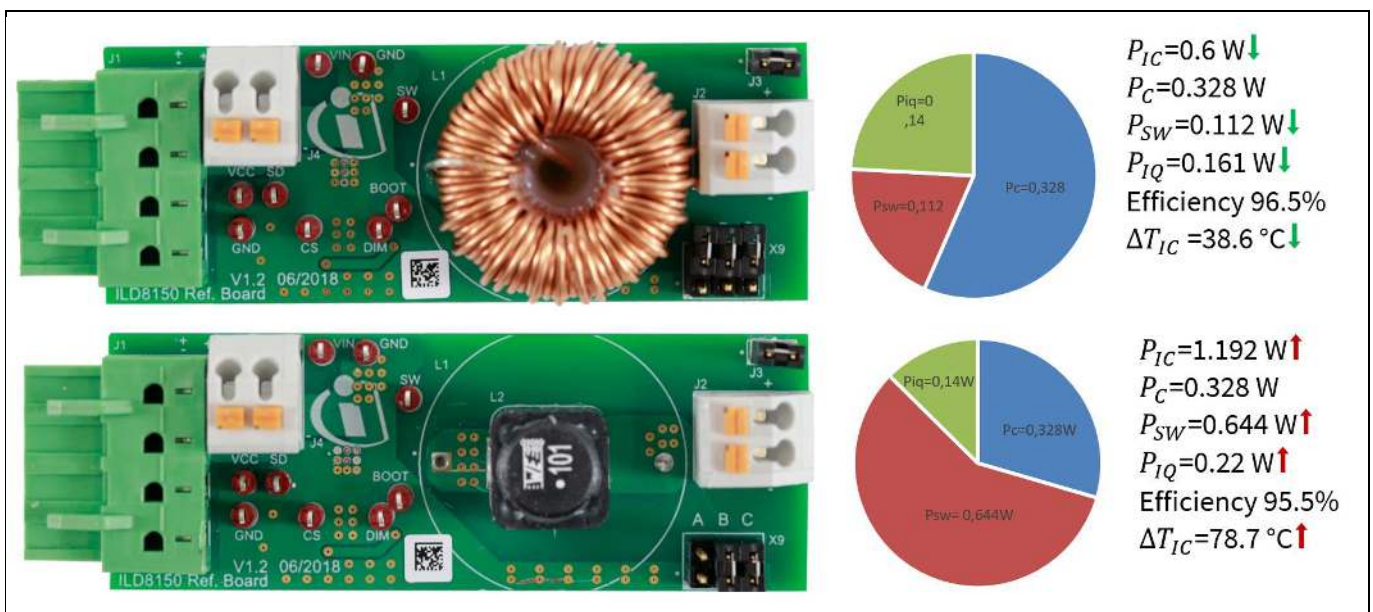


Figure 3 REF_ILD8150_DC_1.5A (SP002798058) and REF_ILD8150_DC_1.5A_SMD (SP005351260) comparison

ILD8150 high-frequency operation

Operation, design guide and performance



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.

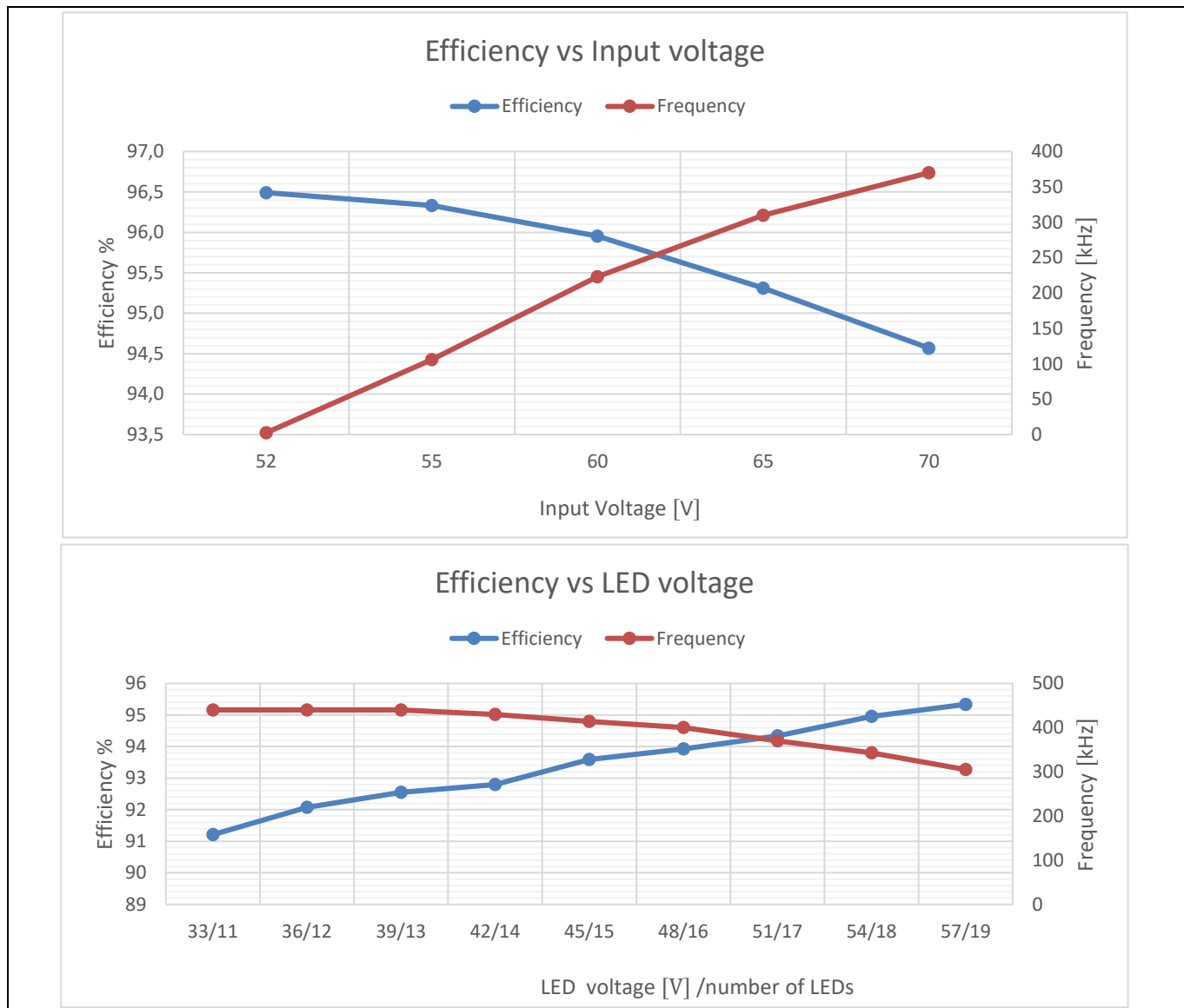


Figure 4 Efficiency/frequency vs. input voltage $V_{LED} = 51\text{ V}$, $I_{LED} = 1\text{ A}$, efficiency/frequency vs. LED voltage/number $V_{IN} = 70\text{ V}$, $I_{LED} = 1\text{ A}$. $L = 100\text{ }\mu\text{H}$.

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

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2019-08-05

Published by

Infineon Technologies AG

81726 Munich, Germany

© 2019 Infineon Technologies AG.

All Rights Reserved.

Do you have a question about this document?

Email: erratum@infineon.com

Document reference

AN_1907_PL39_1907_083934

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (www.infineon.com).

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.