LED Drivers for High Power LEDs

ILD4120

1200 mA Step Down LED Driver

Data Sheet

Revision 6.0, 2011-10-10

Industrial and Multimarket

Edition 2011-10-10

Published by
Infineon Technologies AG
81726 Munich, Germany

Legal Disclaimer

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, 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.

Information

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

Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

Revision History	
Page or Item	**Subjects (major changes since previous revision)**
Revision 6.0, 2011-10-10	
All	Preliminary data sheet version replaced by final data sheet version
Table 2	Max. output current and power dissipation updated
Figure 2	Power dissipation updated
Table 4	EN propagation delay added
Table 5	PWM propagation delay added
Figure 4	Figure about maximum LED current contrast ratio added
Chapter 6.4	Figures with 100 mΩ sense resistor updated
Revision 5.0, 2011-08-23	
All	Initial version of preliminary data sheet

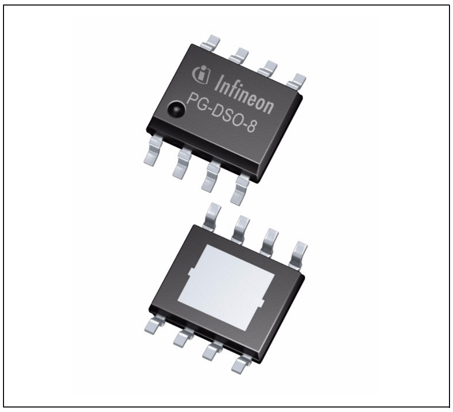
Table of Contents

List of Figures

List of Tables

1200 mA Step Down LED Driver with Internal Switch
ILD4120

1 Features



- Wide input voltage range: 4.5 V ... 40 V
- Internal switch for up to 1200 mA average LED current
- Up to 95 % efficiency
- Over current protection
- Over voltage protection
- Temperature protection mechanism
- Inherent open-circuit LED protection
- Soft-start capability
- Low shut down current
- Analog and PWM dimming possible
- Typical 3 % output current accuracy
- Minimum external components required
- Package: DSO-8 with exposed pad

RoHS

Applications

- LED driver for general lighting applications
- Retail, office and residential luminaires
- Spot light / downlight
- LED replacement lamps
- Architectural lighting
- Street lighting

Product Name	Package	Marking
ILD4120	DSO-8-27	ILD4120

2 Product Brief

ILD4120 is a hysteretic step down LED driver IC for general lighting applications, which is capable to drive high power LEDs with average currents up to 1200 mA.

The IC incorporates a wide input voltage range and an internal power switch. The output current level can be adjusted with an external sense resistor.

The IC can be switched on and off by an external enable signal at the EN pin. The PWM pin is the input pin for PWM and analog dimming of the LED current.

Depending on the value of the switching inductor the switching frequency and the voltage ripple can be set. The precise internal bandgap stabilizes the circuit and provides stable current conditions over temperature range.

To ensure a long lifetime of the LED system the ILD4120 incorporates an overvoltage and an overcurrent protection. In addition the integrated thermal protection will reduce the output current to protect the LEDs and the IC against thermal stress.

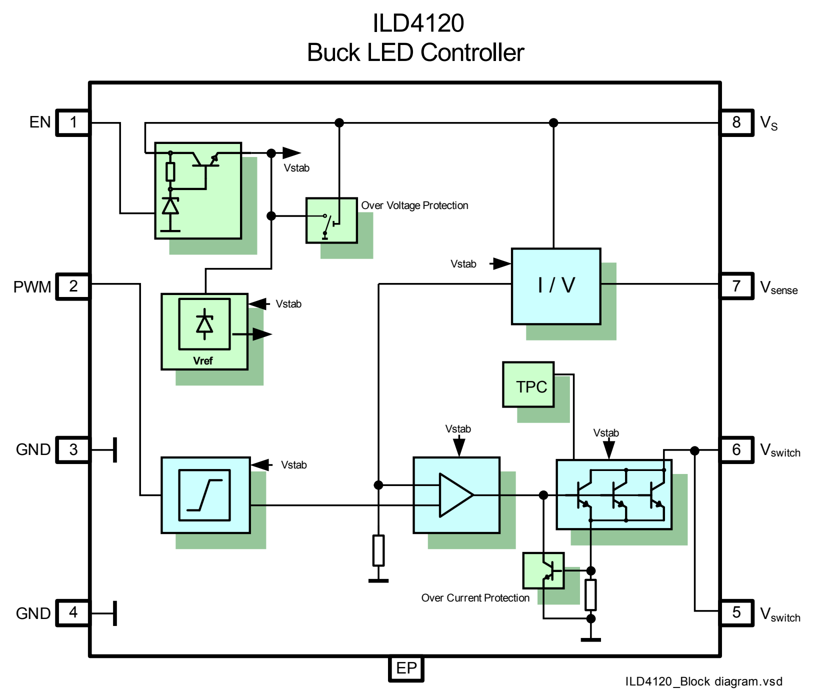


Figure 1 Block Diagram

Pin Definition

Table 1 Pin Definition and Function

Pin No.	Name	Pin Type	Buffer Type	Function
1	EN	Input	–	Chip enable signal
2	PWM	Input	–	Dimming signal: • Analog dimming • PWM dimming
3	GND	GND	–	IC ground
4	GND	GND	–	IC ground
5	V_{switch}	Output	–	Power switch output
6	V_{switch}	Output	–	Power switch output
7	V_{sense}	Input	–	LED current sense input
8	V_S	Input	–	Supply voltage
EP	Exposed Pad	GND	–	Heat spreader

3 Maximum Ratings

Table 2 Maximum Ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Supply voltage	V_S	–	–	45	V	–
Average output current	I_{Switch}	–	–	1200	mA	–
Total power dissipation, $T_S \leq 120°C$	P_{tot}	–	–	2000	mW	–
Junction temperature	T_J	–	–	150	°C	–
Storage temperature range	T_{STG}	-65	–	150	°C	–
ESD capability at all pins	$V_{ESD\ HBM}$	–	–	4	kV	HBM acc. to JESD22-A114

Attention: Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

4 Thermal Characteristics

Table 3 Maximum Thermal Resistance

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Junction - soldering point[1)]	R_{thJS}	–	–	15	K/W	–

1) For calculation of R_{thJA} please refer to application note AN077 (Thermal Resistance Calculation)

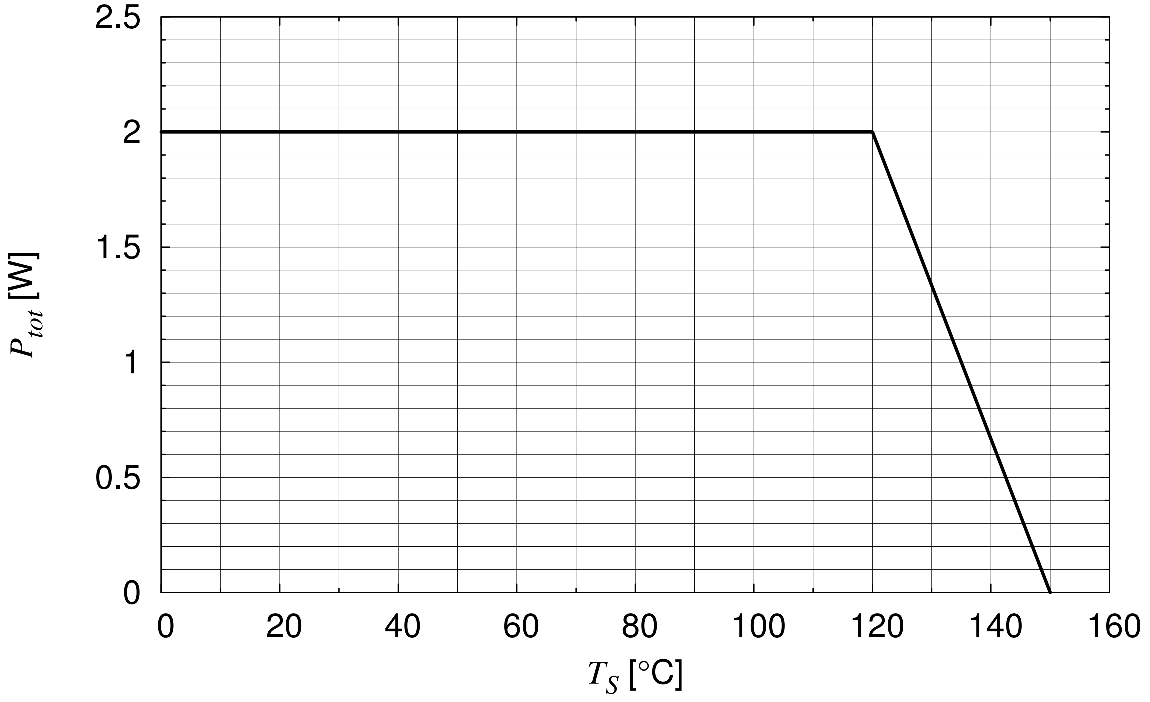


Figure 2 Total Power Dissipation

5 Electrical Characteristics

5.1 DC Characteristics

All parameters at T_A = 25 °C, unless otherwise specified.
V_S = 12 V, V_{EN} = 3 V, V_{PWM} = 3 V

Table 4 DC Characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Operating supply voltage	V_S	4.5	–	40	V	
Overall current consumption open load	$I_{S\ open\ load}$	2.3	3.0	4.1	mA	V_S = 4.5 V I_{LED} = 0 mA
Overall current consumption open load	$I_{S\ open\ load}$	2.3	3.2	4.2	mA	V_S = 12 V I_{LED} = 0 mA
Overall current consumption open load	$I_{S\ open\ load}$	2.4	3.8	4.6	mA	V_S = 40 V I_{LED} = 0 mA
Overall standby current consumption	$I_{S\ standby}$	–	–	1	µA	V_{EN} = 0 V V_S = 4.5..40 V
Enable voltage for standby mode	$V_{EN,\ Off}$	-0.3	–	0.4	V	
Enable voltage for operating mode	$V_{EN,\ On}$	2.5	–	40	V	
EN delay time	$t_{d,\ EN,\ On}$	–	3	–	µs	V_{PWM} = 3 V V_{EN} = 0 V → 3 V V_{Switch} = high → low
	$t_{d,\ EN,\ Off}$	–	0.4	–	µs	V_{PWM} = 3 V V_{EN} = 3 V → 0 V V_{Switch} = low → high
Input current of enable pin	I_{EN}	–	47	100	µA	V_{EN} = 3 V V_S = 4.5..40 V
Current of sense input	I_{sense}	–	20	–	µA	V_{sense} = 12 V

5.2 Analog and Digital Dimming Control

All parameters at T_A = 25 °C, unless otherwise specified.

Table 5 Control Parameter at Pin PWM

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
PWM voltage logic low	$V_{PWM.\ Low}$	-0.3	–	0.4	V	
PWM voltage logic high	$V_{PWM,\ High}$	2.5	–	40	V	full LED current
PWM voltage for analog dimming	V_{PWM}	1	–	2		linear dimming range

Table 5 Control Parameter at Pin PWM

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
PWM delay time	$t_{d,\ PWM,\ On}$	–	0.8	–	µs	V_{EN} = 3 V V_{PWM} = 0 V → 3 V V_{Switch} = high → low
	$t_{d,\ PWM,\ Off}$	–	0.4	–	µs	V_{EN} = 3 V V_{PWM} = 3 V → 0 V V_{Switch} = low → high
Input current of PWM pin	I_{PWM}	–	1.4	5	µA	V_{PWM} = 3 V

5.3 Switching Characteristics

All parameters at T_A = 25 °C, unless otherwise specified.

V_S = 12 V, 3 LEDs, V_{fLED} = 3 V, R_{sense} = 187 mΩ (I_{LED} = 625 mA), L = 68 µH, V_{EN} = 3 V, V_{PWM} = 3 V

Table 6 Switching Characteristics 12 V

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Switching frequency	f_{Switch}	–	77	–	kHz	
Maximum switching frequency	$f_{Switch\ max}$	–	–	500	kHz	for any coil value
Mean current sense threshold voltage	V_{sense}	–	117	–	mV	voltage offset below V_S
Sense threshold hysteresis	$V_{sensehys}$	–	±14	–	%	
Residual voltage at collector of power transistor	$V_{switch\ on}$	–	0.92	–	V	output switch turned on
Output current accuracy	I_{outacc}	–	±3	–	%	
Over temperature protection	$T_{S,\ TSD}$	–	106	–	°C	T_S for 10 % I_{LED} reduction, defined by T_J

V_S = 24 V, 6 LEDs, V_{fLED} = 3 V, R_{sense} = 100 mΩ (I_{LED} = 1070 mA), L = 47 µH, V_{EN} = 3 V, V_{PWM} = 3 V

Table 7 Switching Characteristics 24 V

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Switching frequency	f_{Switch}	–	110	–	kHz	
Maximum switching frequency	$f_{Switch\ max}$	–	–	500	kHz	for any coil value
Mean current sense threshold voltage	V_{sense}	–	107	–	mV	voltage offset below V_S
Sense threshold hysteresis	$V_{sensehys}$	–	±22	–	%	
Residual voltage at collector of power transistor	$V_{switch\ on}$	–	1.03	–	V	output switch turned on
Output current accuracy	I_{outacc}	–	±3	–	%	
Over temperature protection	$T_{S,\ TSD}$	–	87	–	°C	T_S for 10 % I_{LED} reduction, defined by T_J

6 Basic Application Information

This section covers the basic information required for calculating the parameters for a certain LED application. For detailed application information please check Application Note **AN270** (Driving 2 W LEDs with ILD4120) or visit our web site **http://www.infineon.com/led.appnotes**

6.1 Setting the average LED current

The average output current for the LEDs is set by the external sense resistor R_{sense}. To calculate the value of this resistor a first approximation can be calculated using **Equation (1)**.

V_{sense} is dependent on the supply voltage V_S and the number of LEDs in series.

$$R_{sense} = \frac{V_{sense}}{I_{LED}} \tag{1}$$

Example calculation 1

V_S = 12 V, L = 68 µH, V_{fLED} = 3 V, 3 LEDs in series

$\rightarrow V_{\text{sense}}$ = 117 mV

I_{LED} = 625 mA

$\rightarrow R_{\text{sense}}$ = 187 mΩ

Example calculation 2

V_S = 24 V, L = 47 µH, V_{fLED} = 3 V, 6 LEDs in series

$\rightarrow V_{\text{sense}}$ = 107 mV

I_{LED} = 1070 mA

$\rightarrow R_{\text{sense}}$ = 100 mΩ

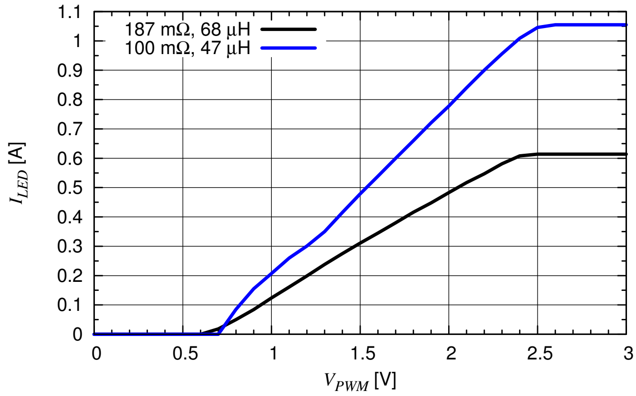
An easy way to achieve these resistor values is to connect standard resistors in parallel.

6.2 Dimming of the LEDs

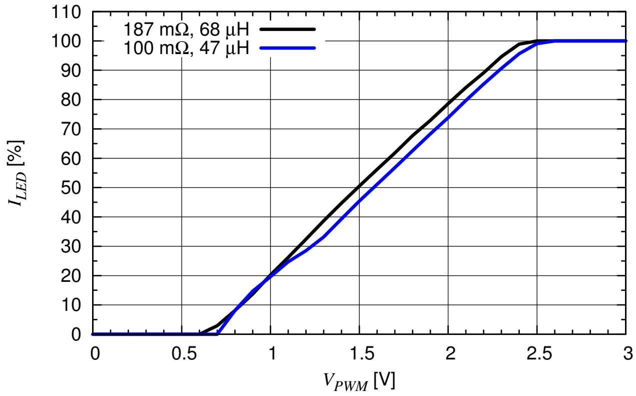
Analog voltage dimming

The PWM pin can be used for analog dimming of the LED current applying an analog control voltage. To achieve a linear change in LED current versus control voltage the recommended voltage range is 1 V to 2 V. The maximum achievable LED current is defined by resistor R_{sense}. The maximum LED current will be achieved for $V_{\text{PWM}} \geq 2.5$ V.

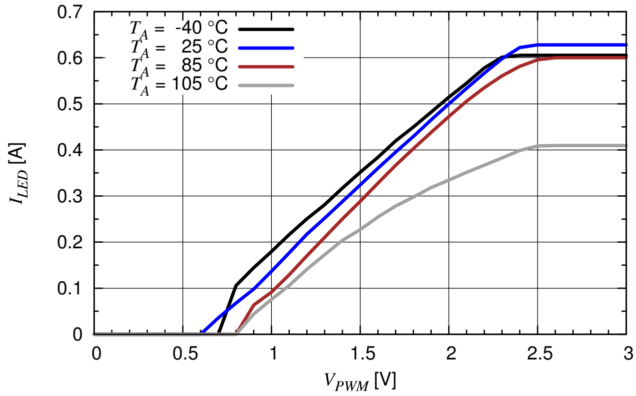
I_{LED} versus V_{PWM}, T_A=25 °C



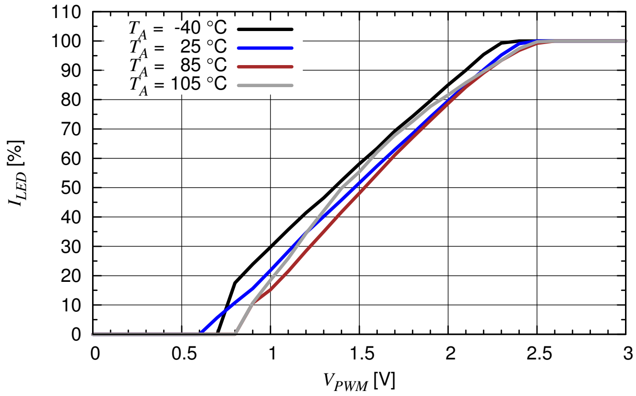
I_{LED} (relative) versus V_{PWM}, T_A=25 °C



I_{LED} versus V_{PWM}, R_{sense} = 187 mΩ, L = 68 µH



I_{LED} (relative) vs. V_{PWM}, R_{sense} = 187 mΩ, L = 68 µH



PWM Dimming

Besides the analog dimming functionality the PWM pin acts as the input for a pulse width modulated (PWM) signal to control the dimming of the LED current.

The achievable dimming ratio of the LED current depends mainly on the rise and fall time of the LED current and is thus dependent on supply voltage, LED string forward voltage and inductance value. Due to rise / fall times the LED current will be lower than PWM duty cycle and difference increases the lower PWM duty cycle becomes.

Figure 3 shows the PWM duty cycle at which average LED current is 3 dB lower than PWM duty cycle. As an example the average LED current will be 3 dB lower at 280 Hz PWM frequency and 1:100 duty cycle.

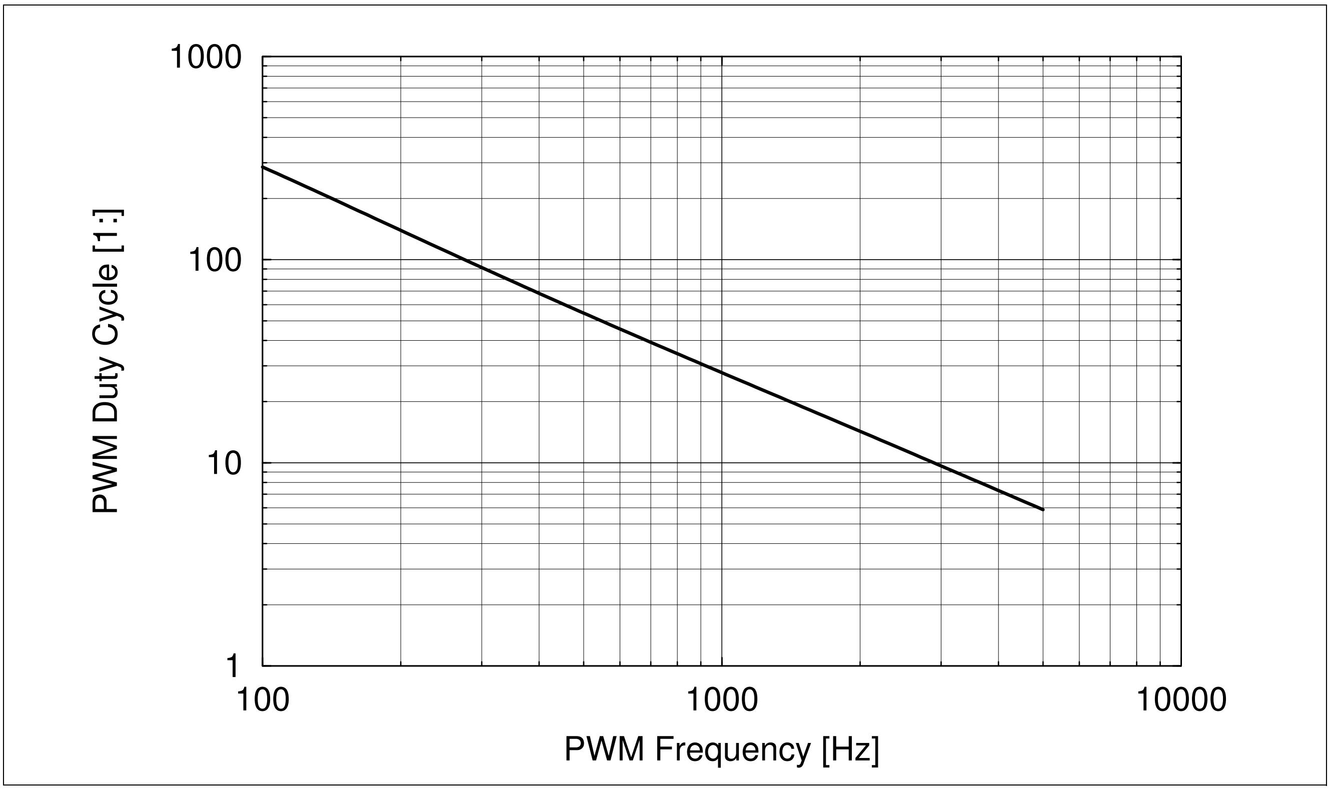


Figure 3 3 dB LED Current Deviation (12 V, 68 µH, 187 mΩ, 3 LEDs)

As shown in **Figure 4** higher LED current contrast ratios can be still achieved if higher deviations between PWM duty cycle and LED current ratio are accepted.

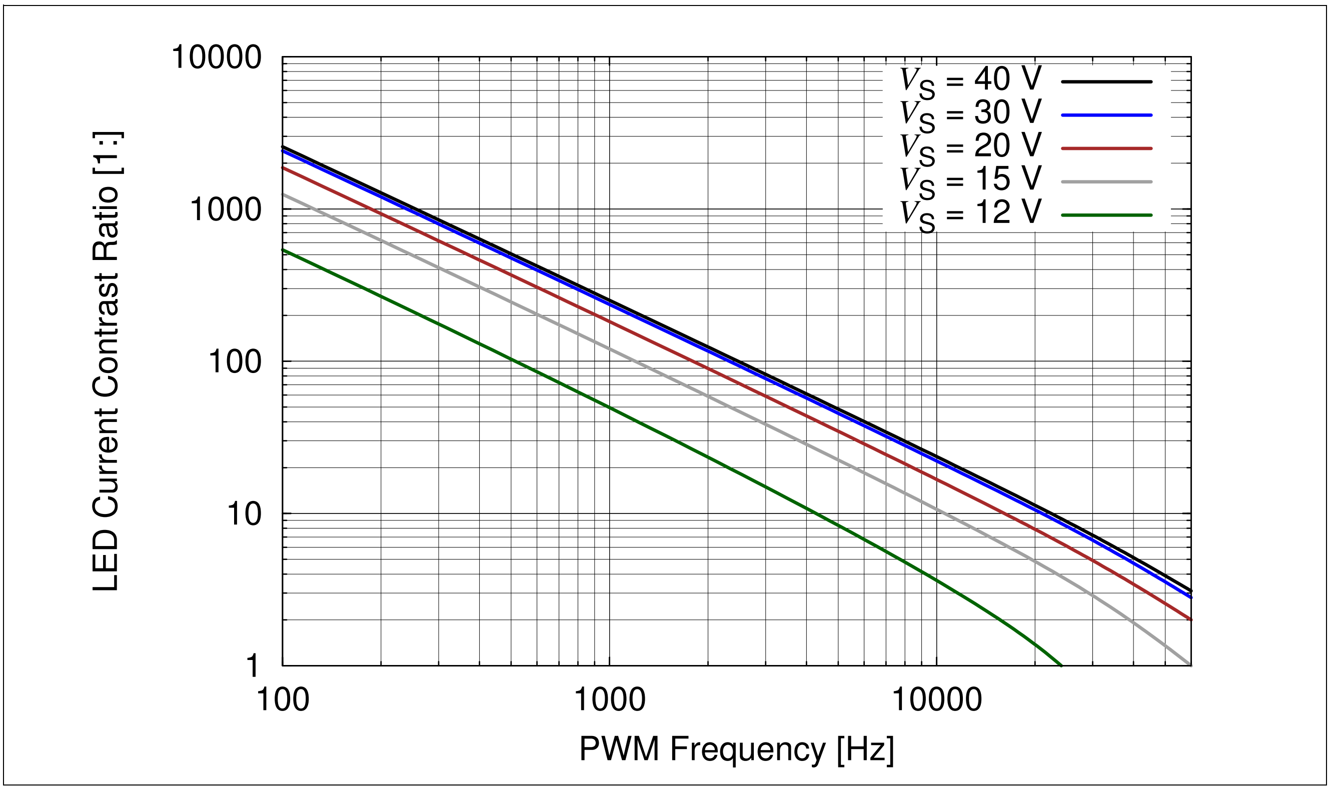


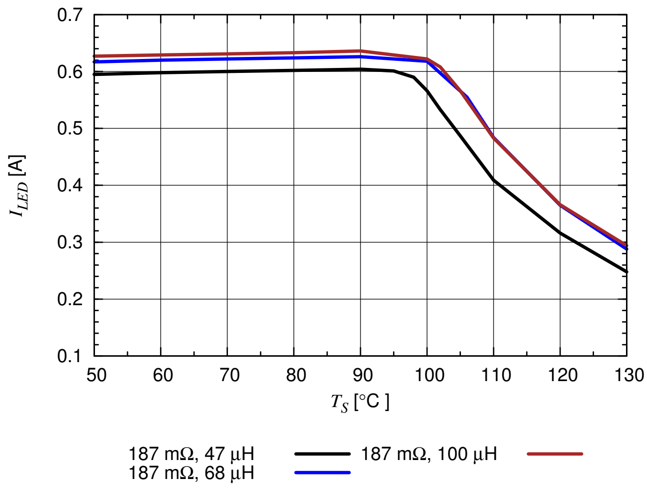
Figure 4 Maximum LED Current Contrast Ratio (68 µH, 187 mΩ, 3 LEDs)

6.3 Temperature Protection Circuit

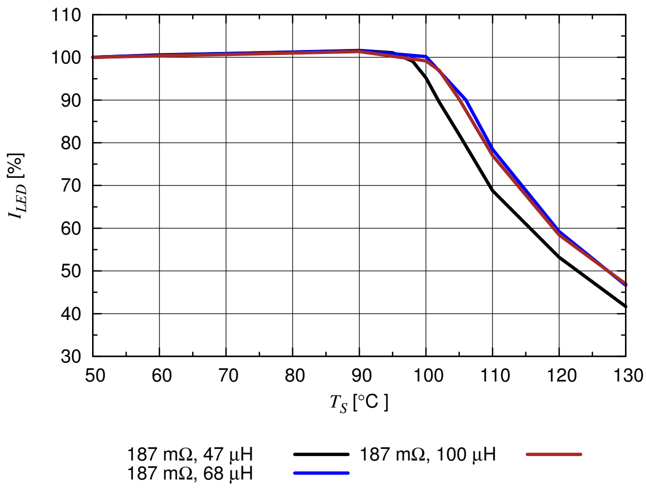
ILD4120 incorporates a temperature protection circuit referring to the junction temperature of ILD4120. The higher the junction temperature of ILD4120 the lower the current of the LEDs. This feature helps to reduce the power dissipation of ILD4120 and the LEDs. Yet still the product specific maximum ratings for junction temperature need to be observed to avoid a permanent damage of the devices.

ILD4120 has been characterized on ILD4120 application board heated from the backside without additional air flow on the circuit board surface besides natural convection. Design and layout of the circuit board as well as the air flow influence the thermal resistance junction to ambient R_{thJA} of ILD4120 and thus its junction temperature. Below figures show the LED current versus soldering point temperature T_S.

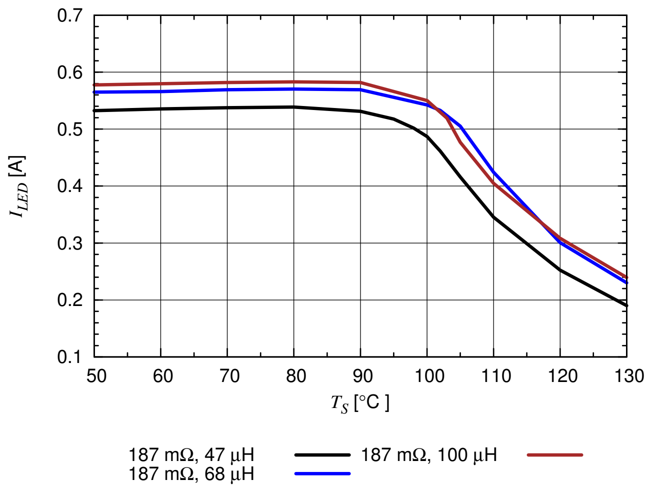
I_{LED} versus T_S, V_S = 12 V, R$_{sense}$ = 187 mΩ



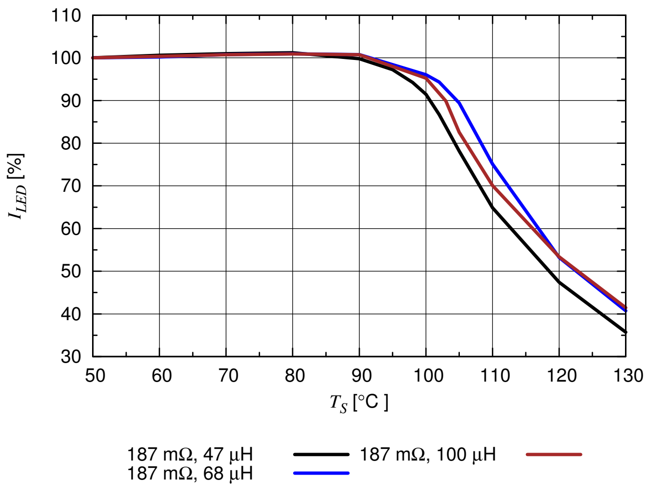
I_{LED} (relative) versus T_S, V_S = 12 V, R$_{sense}$ = 187 mΩ



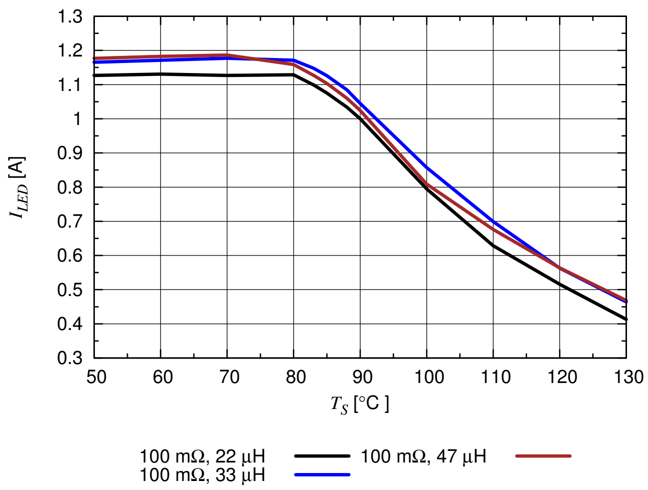
I_{LED} versus T_S, V_S = 24 V, R$_{sense}$ = 187 mΩ



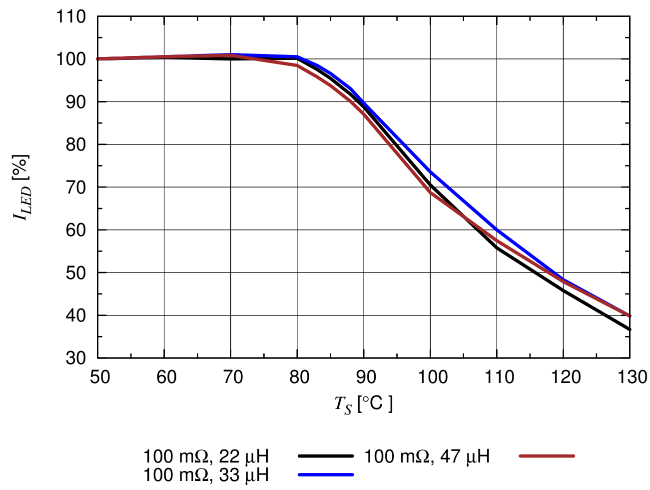
I_{LED} (relative) versus T_S, V_S = 24 V, R$_{sense}$ = 187 mΩ



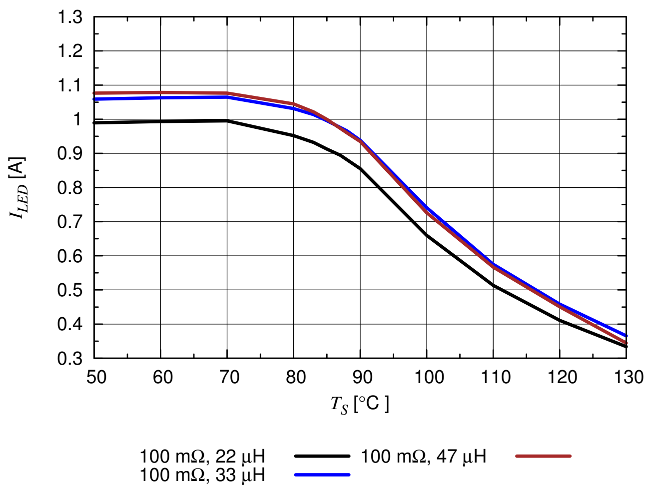
I_{LED} **versus** T_S**,** V_S **= 12 V,** R_{sense} **= 100 mΩ**



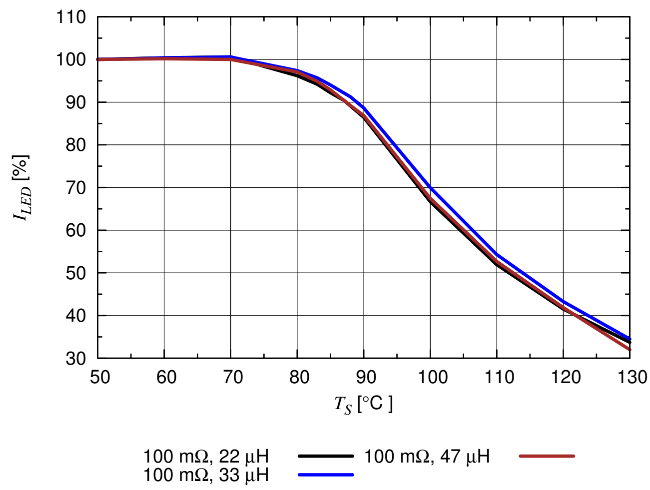
I_{LED} **(relative) versus** T_S**,** V_S **= 24 V,** R_{sense} **= 100 mΩ**



I_{LED} **versus** T_S**,** V_S **= 24 V,** R_{sense} **= 100 mΩ**



I_{LED} **(relative) versus** T_S**,** V_S **= 24 V,** R_{sense} **= 100 mΩ**

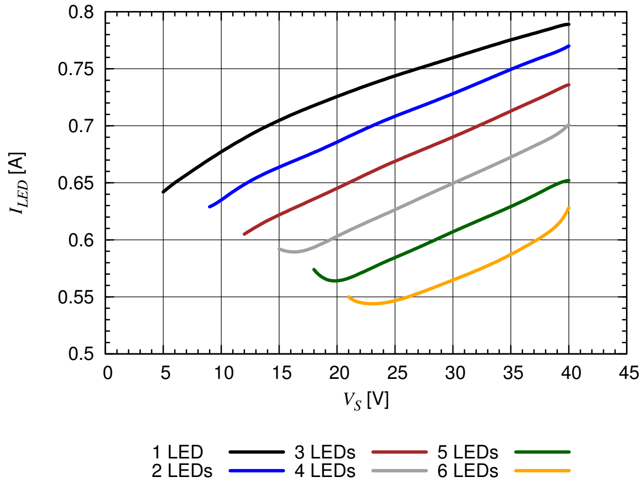


6.4 Switching Parameters

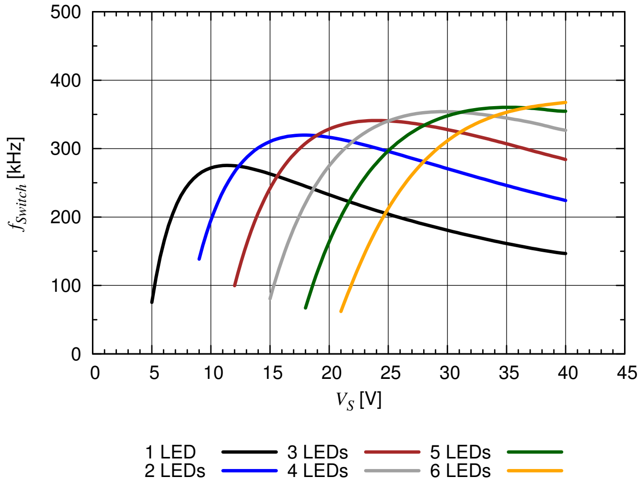
For all shown parameters ILD4120 has been measured on evaluation board ILD4120 at T_A = 25 °C. Used LEDs have a typical forward voltage V_{fLED} of 3 V. For details see Application Note **AN270** (Driving 2 W LEDs with ILD4120) or visit our web site http://www.infineon.com/lowcostleddrivers.

R_{sense} = 187 mΩ, L= 47 µH

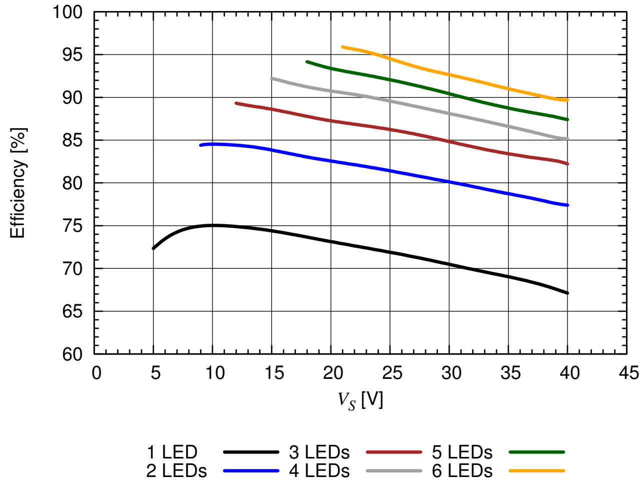
I_{LED} versus V_S and Number of LEDs



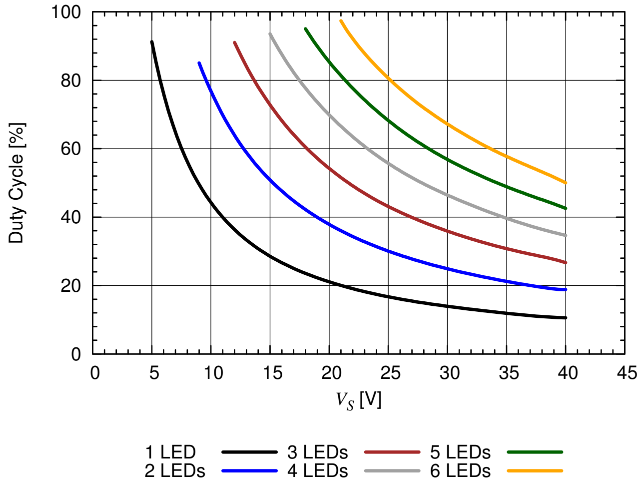
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs

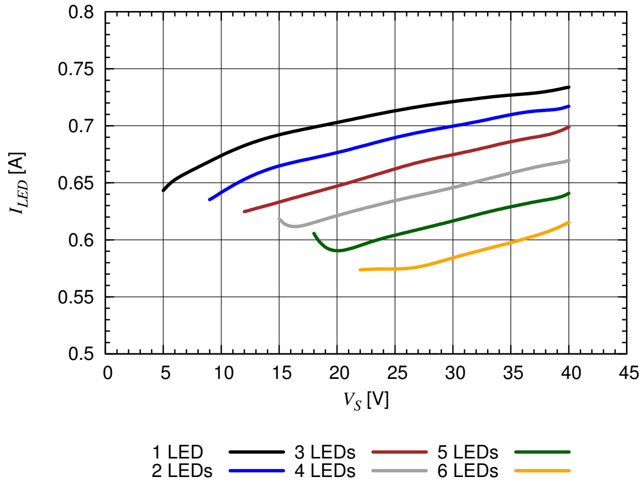


Duty Cycle versus V_S and Number of LEDs

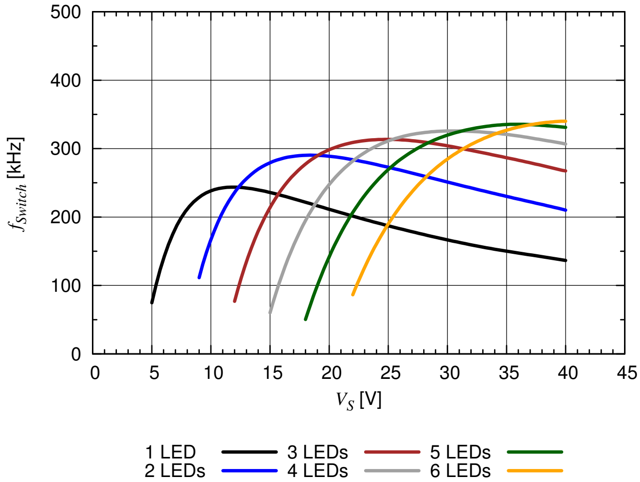


R_{sense} = 187 mΩ, L= 68 µH

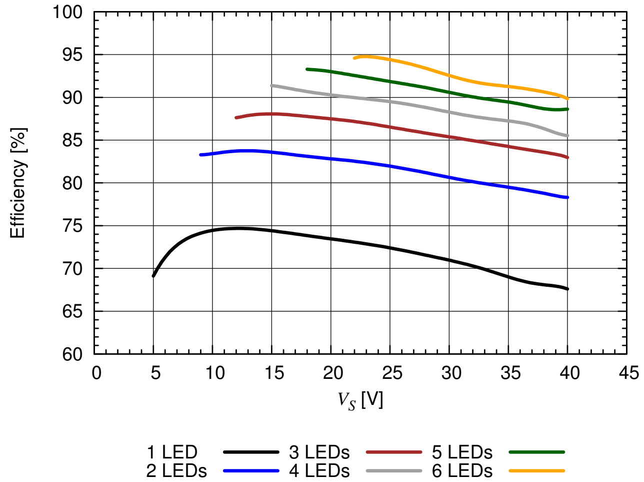
I_{LED} versus V_S and Number of LEDs



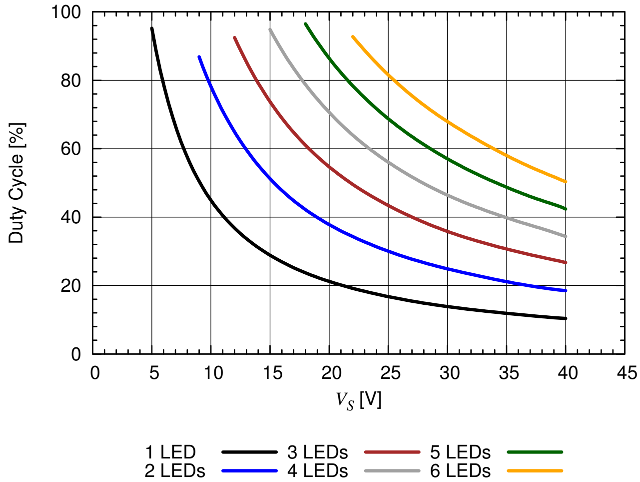
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs

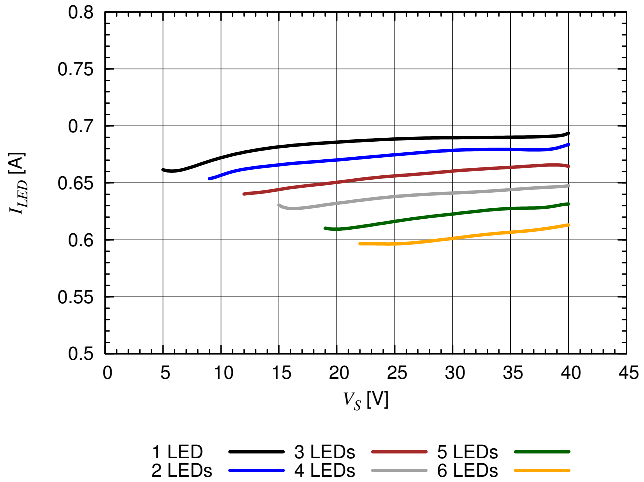


Duty Cycle versus V_S and Number of LEDs

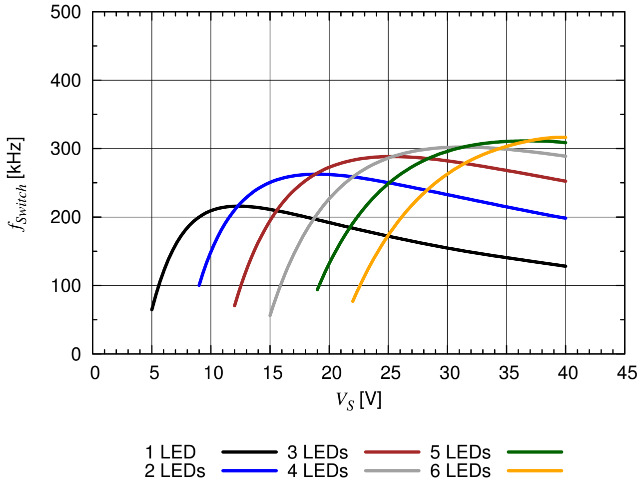


R_{sense} = 187 mΩ, L= 100 µH

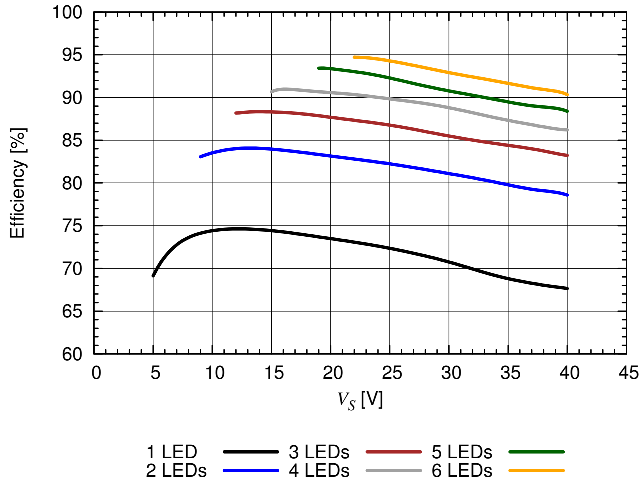
I_{LED} versus V_S and Number of LEDs



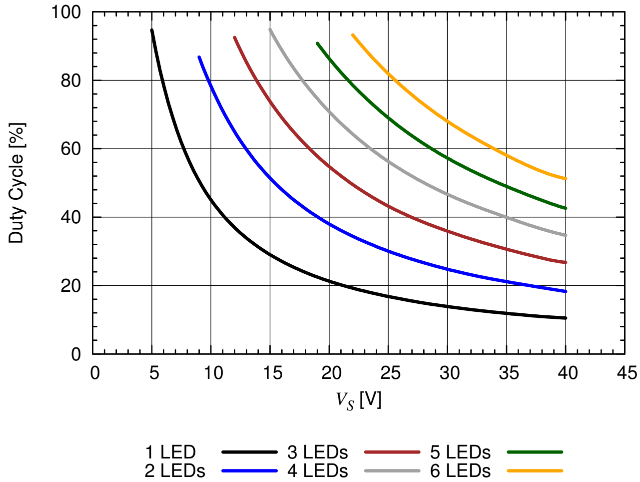
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs

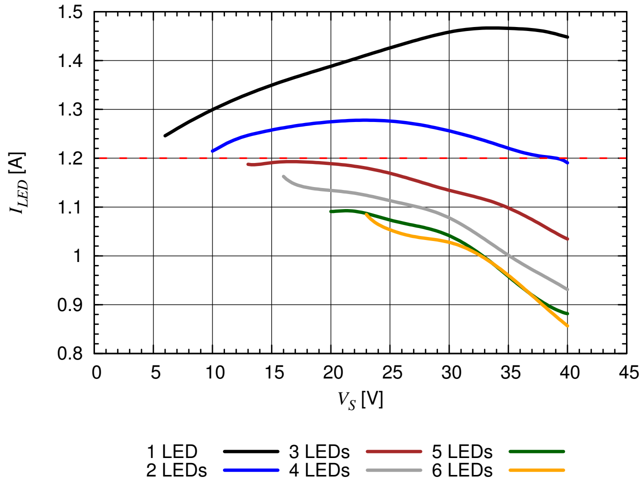


Duty Cycle versus V_S and Number of LEDs

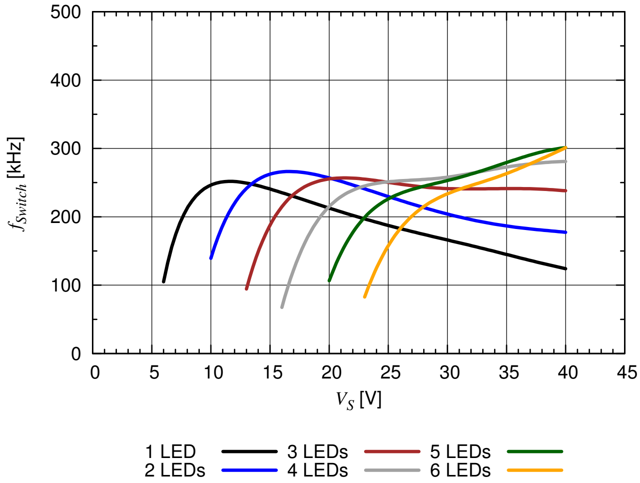


R_{sense} = 100 mΩ, L= 22 µH

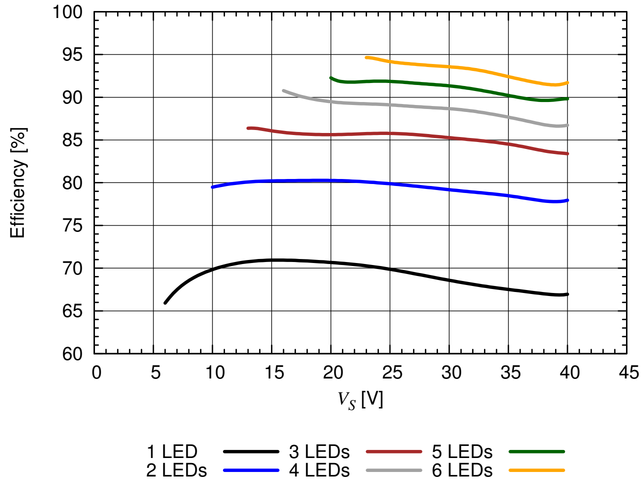
I_{LED} versus V_S and Number of LEDs



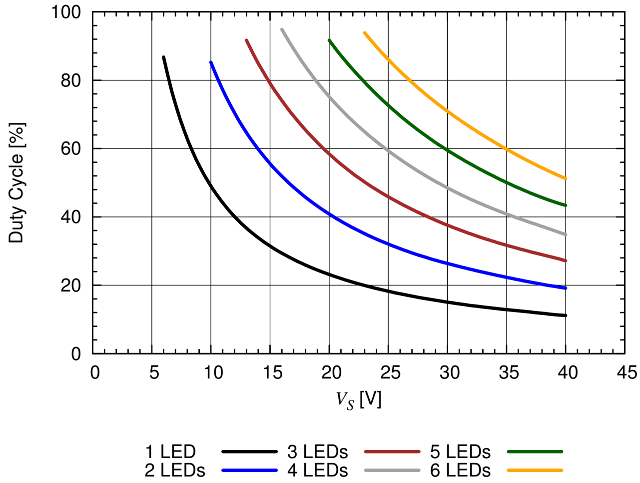
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs

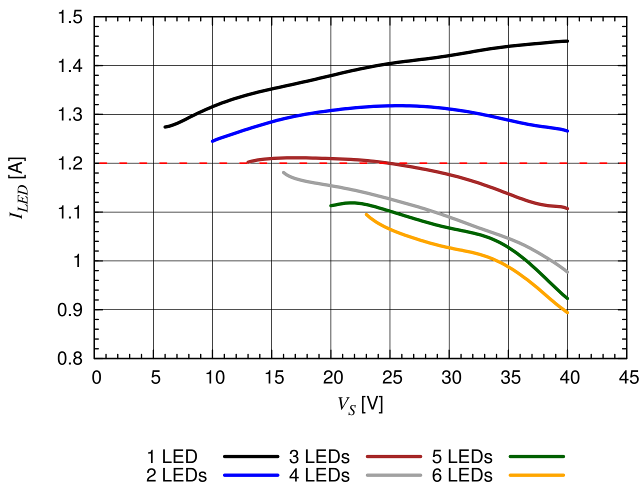


Duty Cycle versus V_S and Number of LEDs

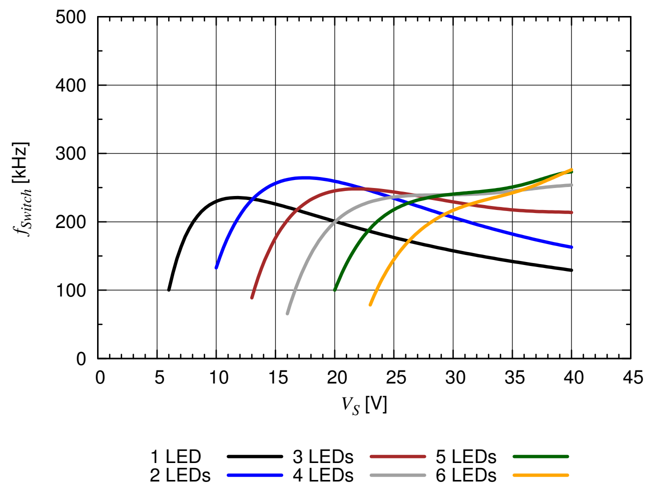


R_{sense} = 100 mΩ, L= 33 µH

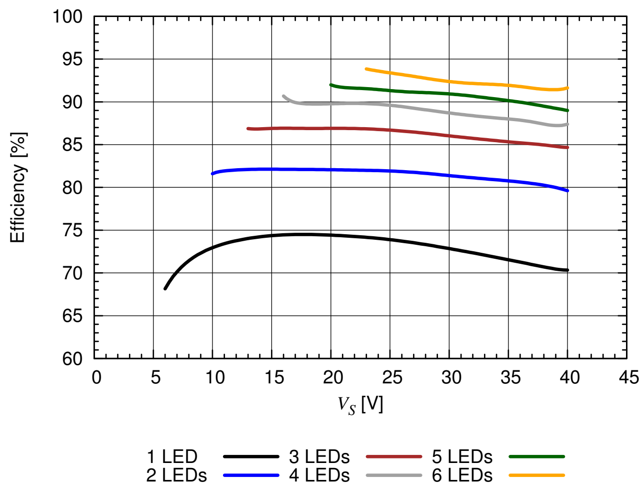
I_{LED} versus V_S and Number of LEDs



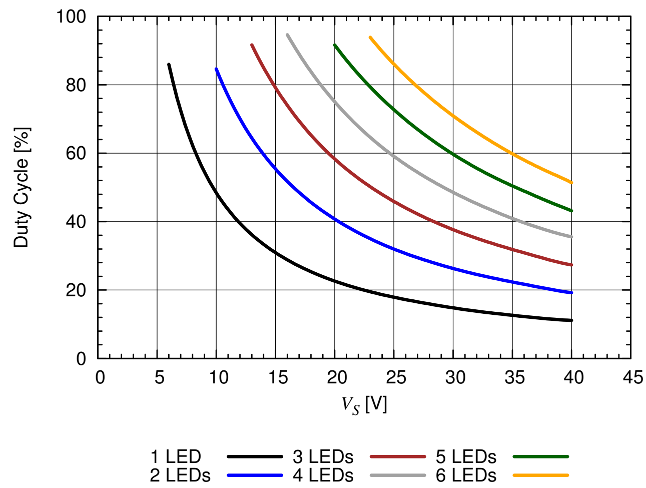
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs

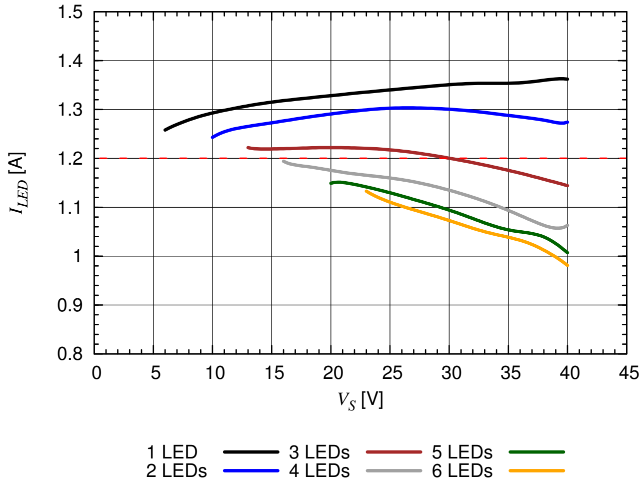


Duty Cycle versus V_S and Number of LEDs

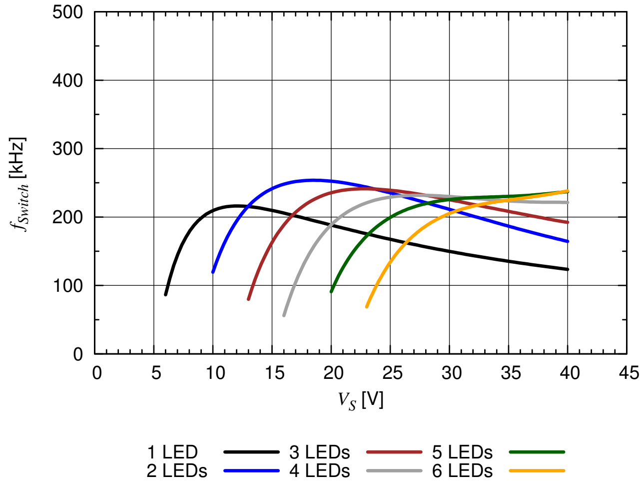


R_{sense} = 100 mΩ, L= 47 µH

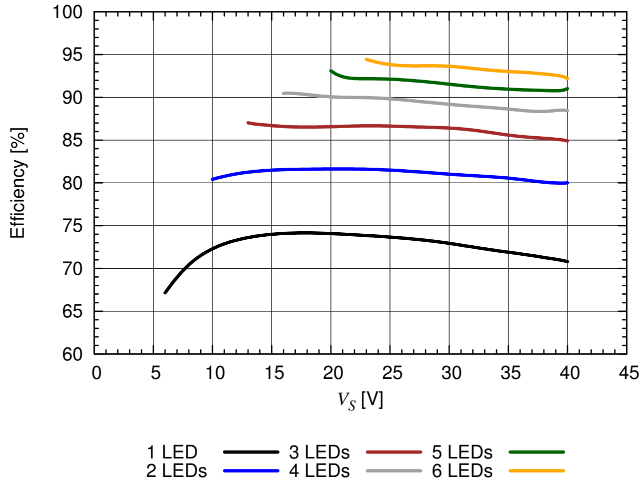
I_{LED} versus V_S and Number of LEDs



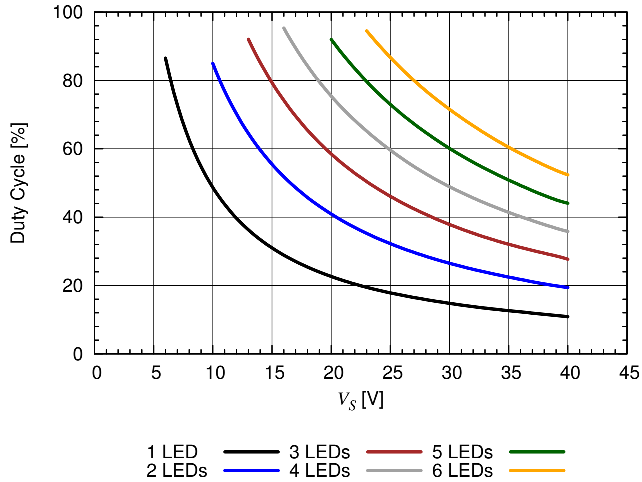
f_{Switch} versus V_S and Number of LEDs



Efficiency versus V_S and Number of LEDs



Duty Cycle versus V_S and Number of LEDs



7 Application Circuit

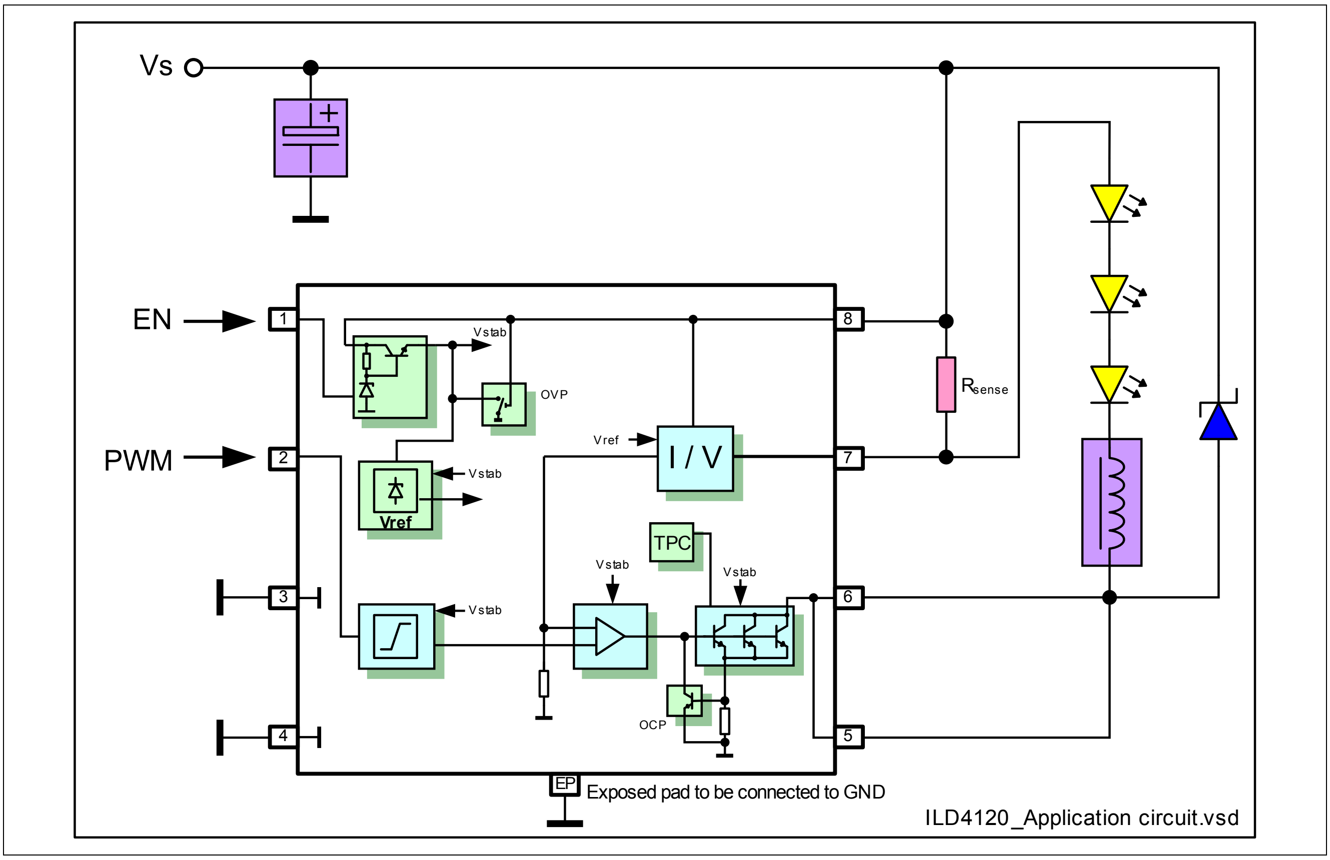


Figure 5 Application Circuit

8 Evaluation Board

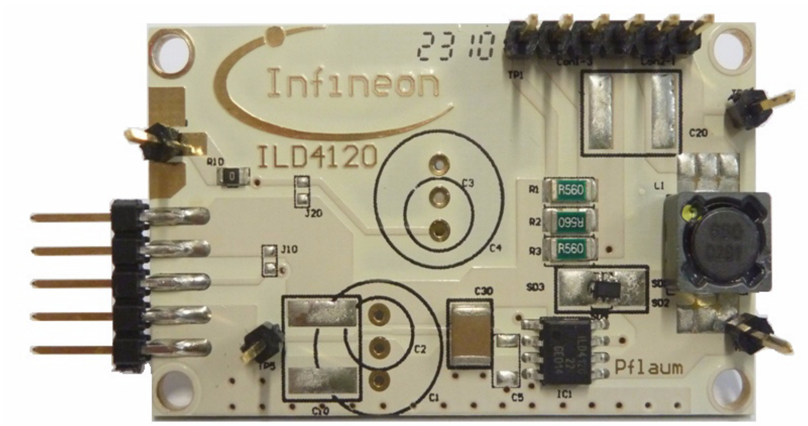


Figure 6 ILD4120 on Evaluation Board

9 Package Information

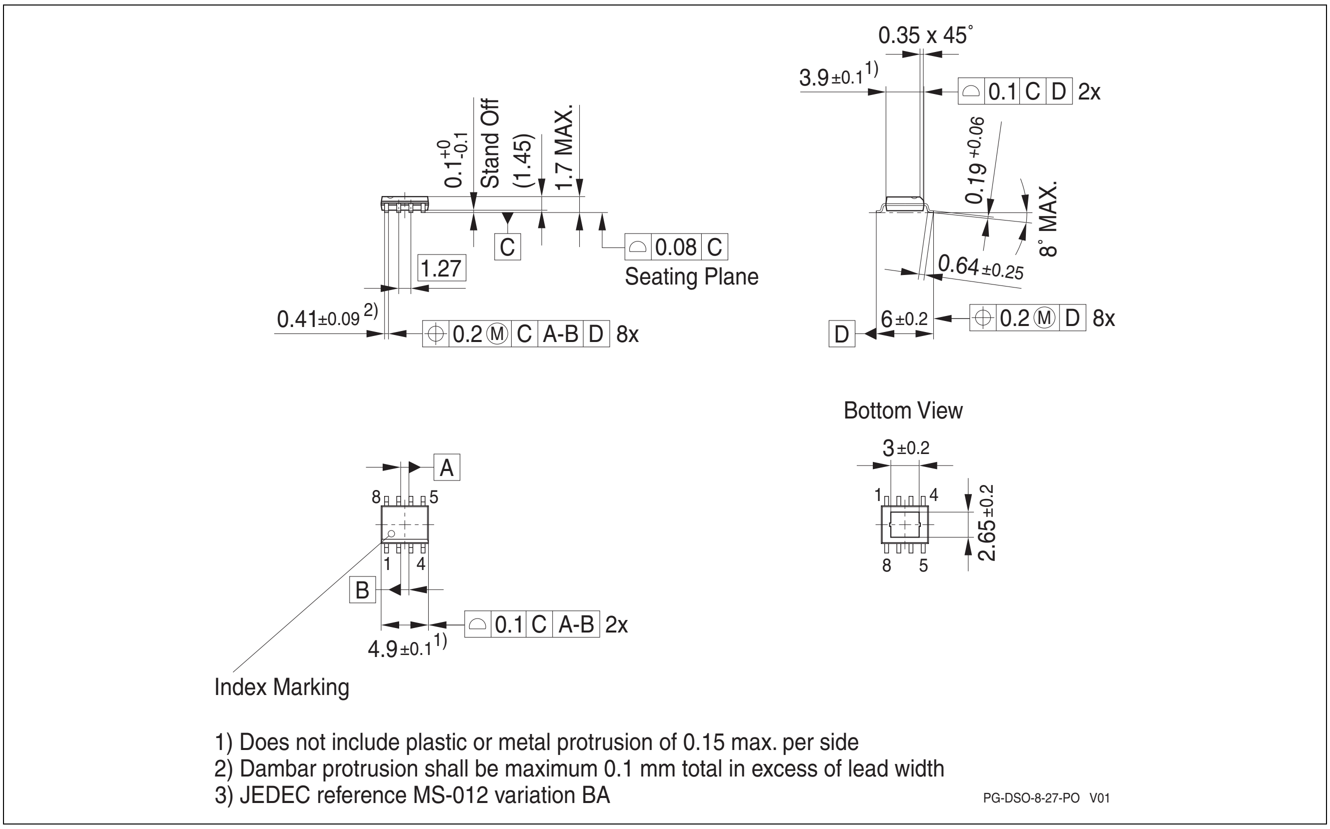


Figure 7 Package Outline (dimensions in mm)

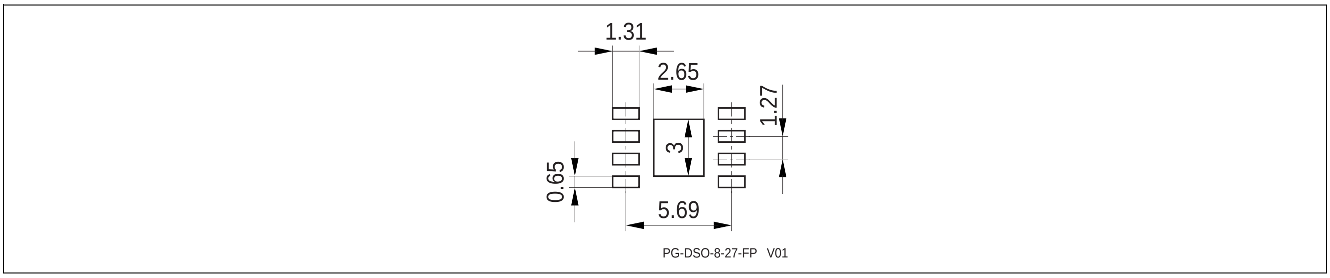


Figure 8 Recommended PCB Footprint for Reflow Soldering (dimensions in mm)

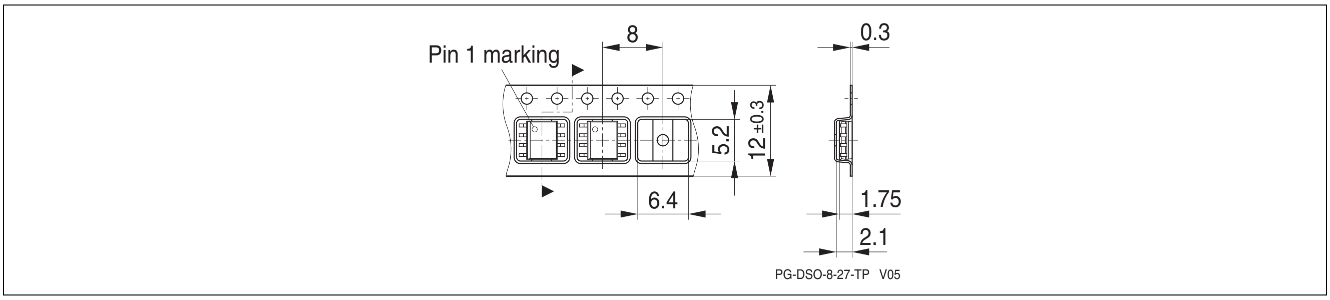


Figure 9 Tape Loading (dimensions in mm)

w w w . i n f i n e o n . c o m

Published by Infineon Technologies AG