ILD4035

350 mA LED Driver

ILD4035

Data Sheet

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Revision History	
Page or Item	**Subjects (major changes since previous revision)**
Revision 1.0, 2010-11-11	
<Revision X.Y>, <yyyy-mm-dd>	

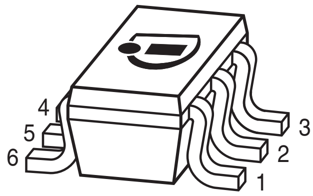
Table of Contents

List of Figures

List of Tables

350 mA LED Driver with Internal Switch
ILD4035

1 Features



- Wide input voltage range: 4.5 V ... 42 V
- Internal switch
- 350 mA LED output current
- Over current protection
- Over voltage protection
- Reversible temperature shut down mechanism
- Inherent open- circuit LED protection
- Soft- start capability
- Low shut down current < 100 nA in operating voltage range
- Analog voltage and PWM dimming possible
- Typical 3% output current accuracy
- Very low LED current drift over temperature
- Minimum external components required
- Small Package: SC74

2 Applications

- LED Driver for general lighting applications
- Indoor illumination, residential lighting
- Outdoor illumination, street lighting
- Office lighting, downlights
- Architectural lighting

Product Name	Package	Pin Configuration				Marking
ILD4035	SC74-6-4					35

3 Product Brief

The ILD4035 is a hysteretic Step down LED converter IC for general lighting applications, which is capable to drive high power LEDs with currents up to 350 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.

According to the multifunctional control pin the IC can be switched on and off by an external signal, which is also suitable to regulate brightness of the LEDs by PWM or analog voltage dimming.

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 ILD4035 incorporates an overvoltage and an overcurrent protection.

In addition, the integrated thermal shutdown will protect the LEDs and the IC against thermal stress.

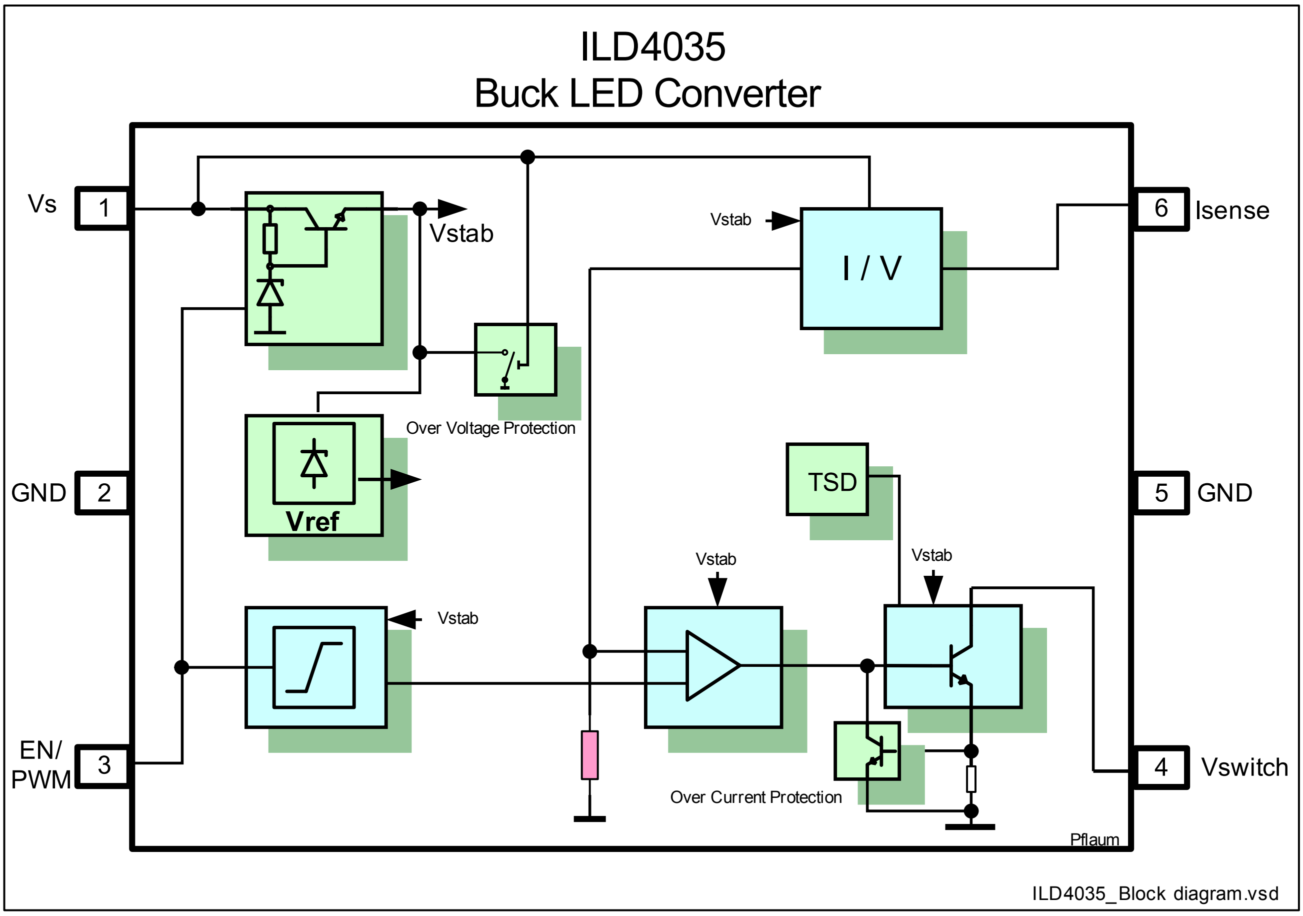


Figure 1 Block Diagram

Pin Definition

Table 1 Pin Definition and Function

Pin Number	Pin Symbol	Function
1	V_s	Supply Voltage
2	*GND*	IC ground
3	*EN / PWM*	Multifunctional Pin; Power On control voltage pin *(PWM input)*
4	V_{switch}	Power Switch Output
5	*GND*	IC ground
6	I_{sense}	LED current sense pin

Maximum Ratings

Table 2 Maximum Ratings

Parameter	Symbol	Limit Value	Unit
Supply voltage	V_s	45	V
Peak Output current	I_{out}	600	mA
Total Power Dissipation; T_s= 85°C	P_{tot}	1000	mW
Junction temperature	T_J	125	°C
Solder Temperature of GND pins	T_{SGND}	110	°C
Storage temperature range	T_{STG}	-65... 150	°C
ESD capability all pins[1)]	V_{ESD_HBM}	4	kV

1) Refer to HBM: JESD22 - A114

Thermal Resistance

Table 3 Maximum Thermal Resistance

Parameter	Symbol	Value	Unit
Junction - solder point	R_{thJS}	65	K/W

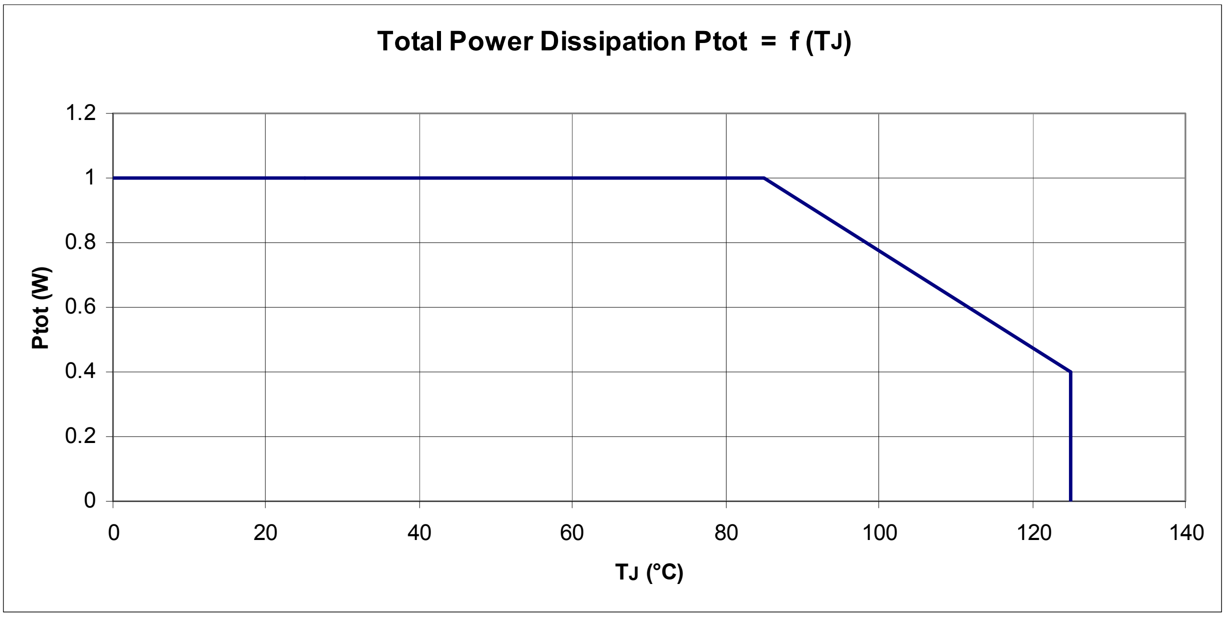


Figure 2 ILD4035; Total Power Dissipation

This formula is a first estimation to calculate the Power Dissipation of the IC

$$P_{tot} = 1.1\text{ V} * I_{LED} * \text{duty cycle} + F_{OSC} * 1\mu\text{W} * I_{LED} / 350\text{mA} \quad (1)$$

For more precise analysis please measure T_S of ILD4035 at GND pin and use **Figure 2** as a reference.

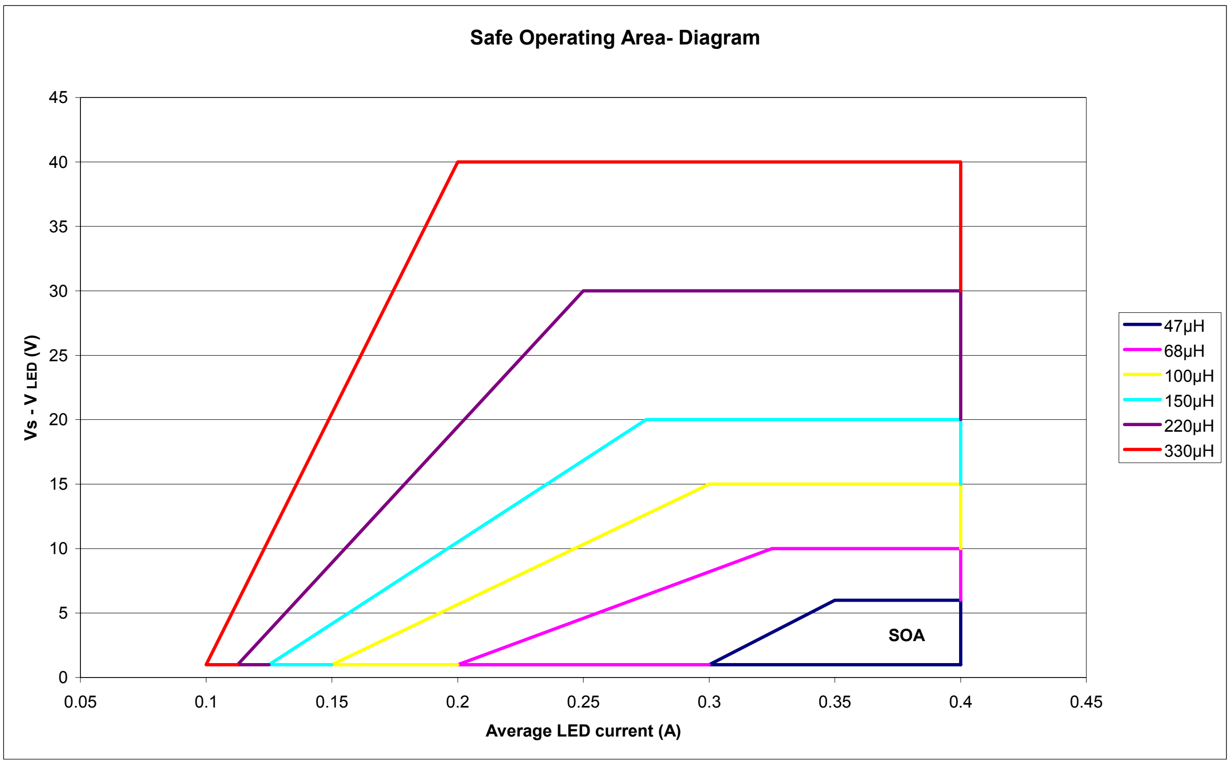


Figure 3 ILD4035; Safe Operating Area

This diagram shows the area of safe operation for the respective inductance values.

The safe area of operation consists of the minimum and maximum allowed average LED current and the resulting voltage overhead.

The voltage overhead is the difference between the sum of the LED forward voltages and the supply voltage.

Example Calculation 1

3 LEDs in series; I_{LED} = 350 mA; V_S = 12 V

$V_{overhead} = V_S - V_{fLED}$ = 12 V - 9 V = 3 V

=> every coil value could be used

Example Calculation 2

6 LEDs in series;

I_{LED} = 250 mA; V_S = 24 V

$V_{overhead} = V_S - V_{fLED}$ = 24 V - 18 V = 6 V

=> the coil values should be equal or above 100 uH

If $V_{overhead}$ is above the boundary of a certain coil value at wanted average LED current, the switching frequency and the associated power dissipation of the ILD4035 will increase beyond maximum ratings.

4 Electrical Characteristics

4.1 DC Characteristics

All voltages with respect to ground; positive; current flowing into pin; unless otherwise specified

All parameters have been measured at T_{amb} = 25 °C, unless otherwise specified.

V_{en} = 3 V

Table 4 DC Characteristics at T_A = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Supply voltage	Vs	4.5		42	V	
Overall current consumption open load	$Is_{open\ load}$	2.1	2.7	3.5	mA	V_s = 4.5 V I_{LED} = 0 mA
Overall current consumption open load	$Is_{open\ load}$	2.7	3.5	4.3	mA	V_s = 40 V I_{LED} = 0 mA
Overall current consumption open load	$Is_{open\ load}$	2.0	8.4	13.0	mA	V_s = 45 V I_{LED} = 0 mA
Overall standby current consumption	$Is_{standby}$			1000	nA	V_{en} = 0 V; V_s= 12 V
Overall standby current consumption	$Is_{standby}$			50	µA	V_{en} = 0 V; V_s = 40 V
Input Current of multifunctional control pin	I_{EN}		140	200	µA	V_{en} =3 V V_S = 4.5..42 V
Current of Sense input	I_{sense}		20		µA	At any LED current
Temperature shut down	Th_{TSD}[1)]	85	90	95	°C	I_{out} -> 0 A; value refers to T_S under condition V_s = 12 V; 3 LEDs L = 100 µH; R_{sense} = 333 mΩ

1) This specified value corresponds to solder temperature when the IC goes into shut down mode. Operating ambient temperature depends on Rth_{SA} of the PCB.

4.2 AC Characteristics

All parameters have been measured at T_{amb} = 25 °C, unless otherwise specified.

V_s = 12 V, V_{fLED} = 3 V

R_{sense} = 333 mΩ –> I_{LED} = 350 mA

V_{en} = 3 V

L = 100 µH, unless otherwise specified

Table 5 AC Characteristics at T_A = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Mean current sense threshold voltage	ΔVsense	115	118	121	mV	3 LEDs in series verified by sample test
Switching frequency	F_{sw}		180		kHz	3 LEDs in series
Maximum switching frequency	F_{swmax}		500		kHz	Recommended, depends on coil value
Sense threshold hysteresis	$V_{sensehys}$		+/- 7.5		%	Not subject to production test - verified by design/characteri-zation
Residual voltage at collector of power transistor	VCE		1.1		V	Internal power transistor is switched on
Output current accuracy	$I_{outaccVs}$		+/- 3		%	3 LEDs in series not subject to production test - verified by design/characteri-zation
Temperature drift of average LED current	$I_{driftTemp}$		+ 3		%	3 LEDs in series T_J : 70 -> 110 °C not subject to production test - verified by design/characteri-zation

4.3 Digital Signals

All parameters have been measured at T_{amb} = 25 °C, unless otherwise specified.

Table 6 AC Characteristics, V_{CE} = 3 V, f = 150 MHz

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Multifunctional control pin voltage range	U_{Pon}	-0.3		42	V	
Control voltage for power on	U_{On}	2.2	2.5	42	V	Full LED current
Control voltage for power off	U_{Off}	-0.3		0.7	V	
Control voltage for analog dimming	U_{dim}	1		2.5	V	Linear dimming range

5 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 the Application Note **AN215** (Driving 1 W LEDs with ILD4035) or visit our web site **http://www.infineon.com/led.appnotes**

5.1 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 this formula.

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

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

Figure 4 ILD4035; Rsense Calculation

Example Calculation 1

V_s = 12 V, V_{fLED} = 3 V, 3 LEDs in series

=> V_{sense} = 118 mV

I_{LED} = 350 mA

=> R_{sense} = 337 mΩ

Example Calculation 2

V_s = 24 V, V_{fLED} = 3 V, 6 LEDs in series

=> V_{sense} = 100 mV

I_{LED} = 350 mA

=> R_{sense} = 286 mΩ

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

5.2 Dimming of the LEDs

Typical operating conditions

All parameters have been measured at T_{amb} = 25 °C, unless otherwise specified.

Analog voltage dimming

The analog dimming characteristic graph is shown in **Figure 5**. To achieve a linear change in LED current versus control voltage, the recommended range of voltage at En/PWM pin 3 is from 0.8 V to 2.5 V

$\boldsymbol{R_{sense}}$ **= 333** mΩ, **L= 100** µH

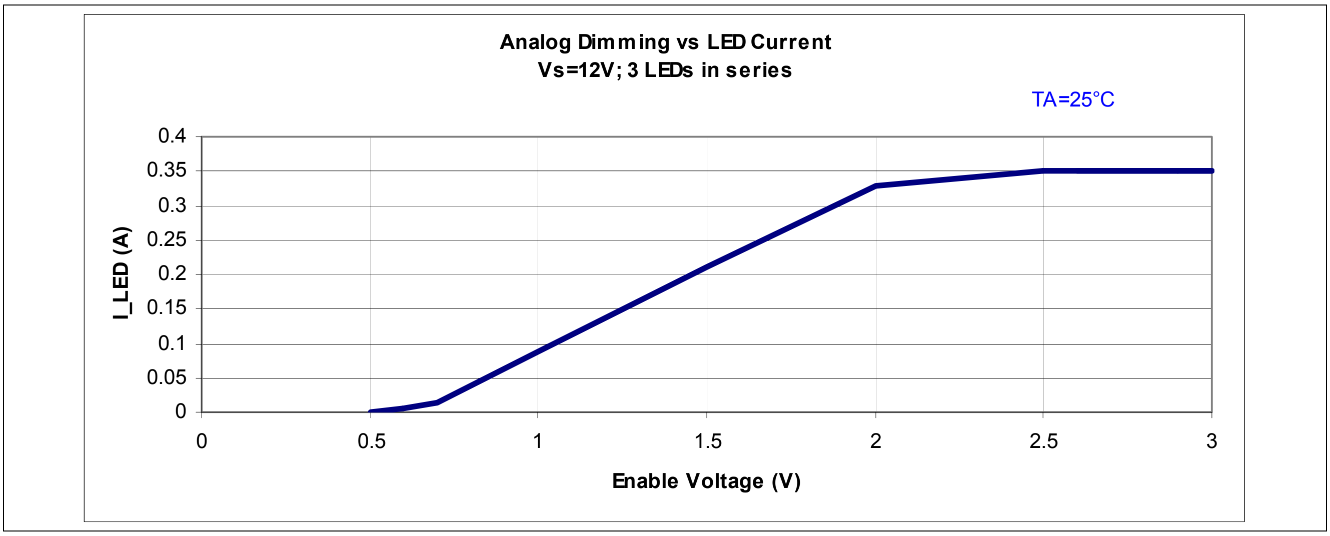


Figure 5 ILD4035; Analog Voltage Dimming

Table 7 Percentage of Max. LED Current vs. DC Voltage at Pin 3

$V_{en / PWM}$	Percentage of max. LED current %	$V_{en / PWM}$	Percentage of max. LED current %
< 0.3	0	1.9	75
0.8	10	2.2	90
1.0	25	> 2.5	100
1.4	50		

Analog voltage dimming characteristics with different Rsense resistors

The maximum LED current is set by R_{sense}. The three different graphs show the behaviour of the analog dimming. Maximum LED current will be achieved at approx. 2.3 Volts in every case.

L= 100 µH

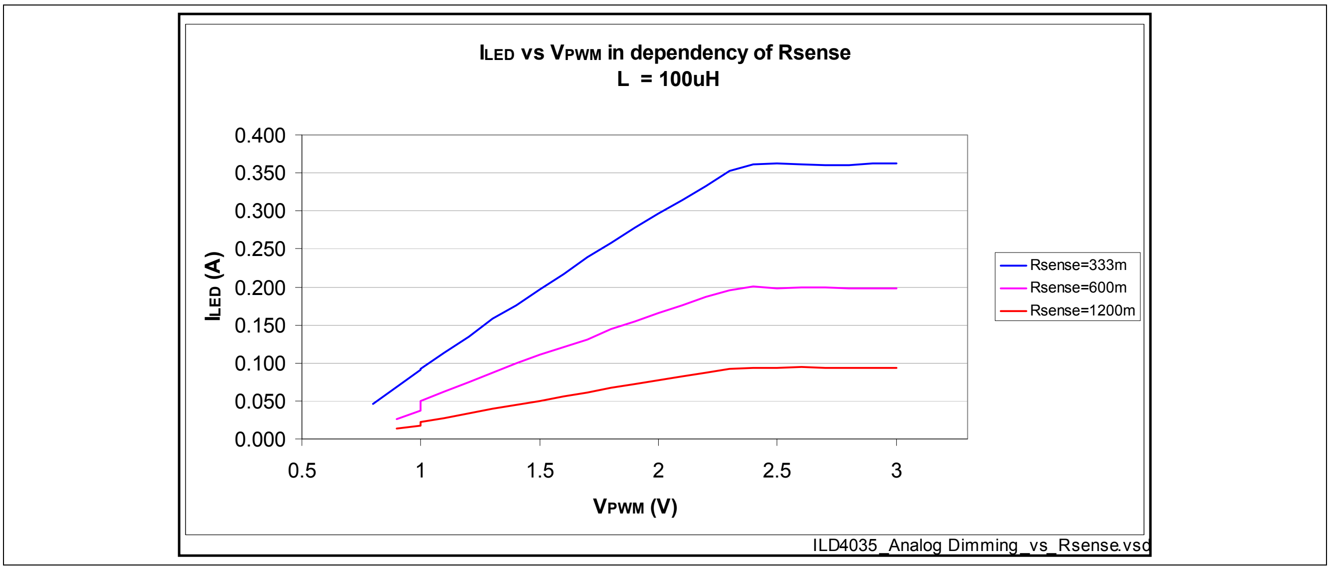


Figure 6 ILD4035; Analog Voltage Dimming with Different Rsense

PWM Dimming

The EM/PWM terminal on the PCB is an input for the pulse width modulated (PWM) signal to control the dimming of the LED string. The PWM signal's logic high level should be at least 2.6 V or higher. The period of this PWM signal should be higher than 200 us. For the default demo board circuit, a dimming frequency less than 300 Hz is recommended to maintain a maximum contrast ratio of at least 100:1. The maximum contrast ratio is shown on Figure 7, and the minimum is based on the measured average LED current at 3dB below the linear reference. The maximum contrast ratio depends largely on the rise time of the inductor current, and hence is dependent on input voltage, inductor size, and LED string forward voltage.

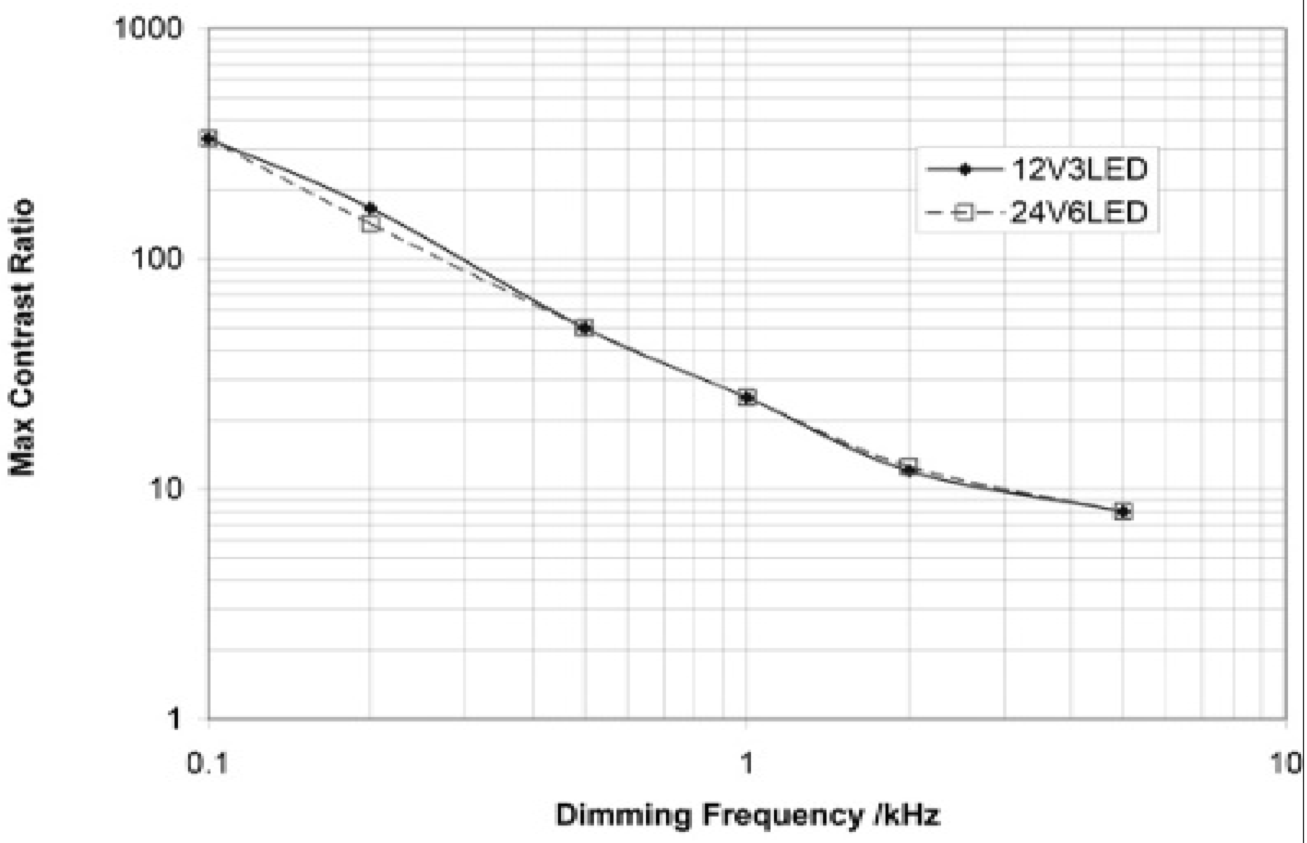


Figure 7 ILD4035; PWM Dimming

5.3 Temperature Characteristics of the ILD4035 Demo Board

The two charts below are related by the same supply voltage, V_s and number of LEDs.

For the same V_s and number of LEDs, the "solder point temperature at the ground pin" T_s and the "ambient temperature" T_A are measured at the same time.

Each curve on the charts defines two areas of operation.

The area below each curve defines normal operation.

The area above each curve defines the triggering of internal thermal shutdown.

When thermal shutdown is triggered, the LEDs start to flicker.

Conditions of Measurements

ILD4035 LED-Less board with

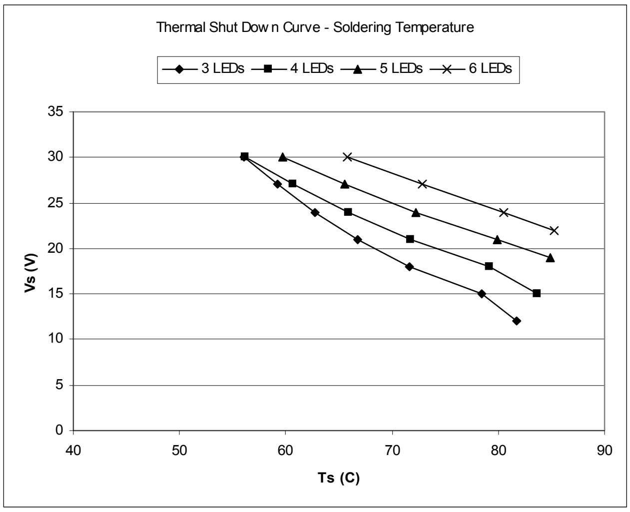
BAS3010A Schottky Diode,

Inductance=100uH (EPCOS 6x6mm)

Rsense=0.333 Ohm

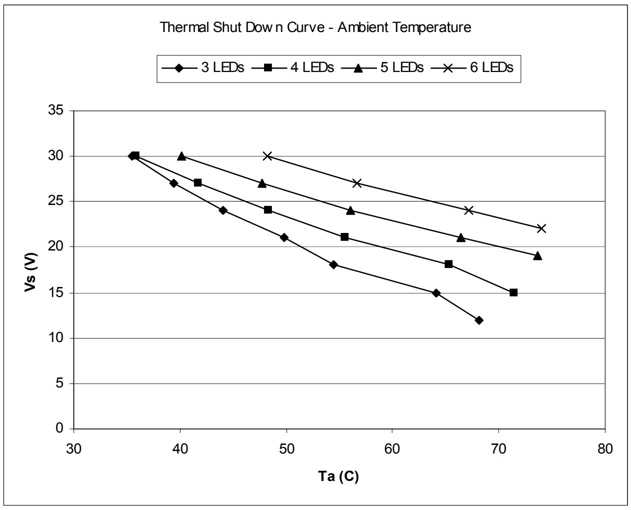
Environment = Inside chamber with force convection air flow.

Thermal shutdown vs. solder temperature T_S



ILD4035_TSD_over_Ts.vsd

Thermal shutdown vs. ambient temperature T_A



ILD4035_TSD_over_Ta.vsd

5.4 AC- Parameter

Typical operating conditions

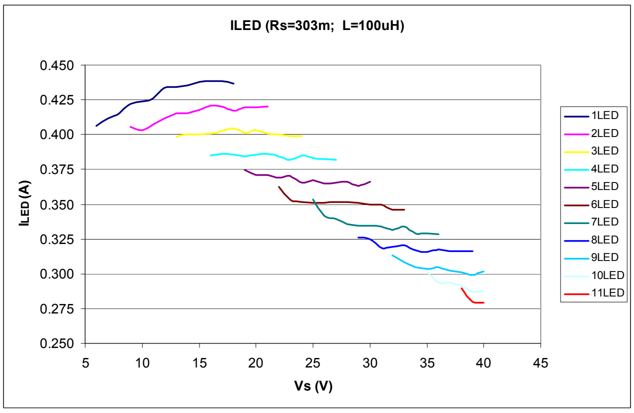
All parameters have been measured at T_{amb} = 25 °C, unless otherwise specified.

ILD4035 IC has been measured in test bench with undefined high thermal resistance

This is valid for all diagramed AC- Parameters.

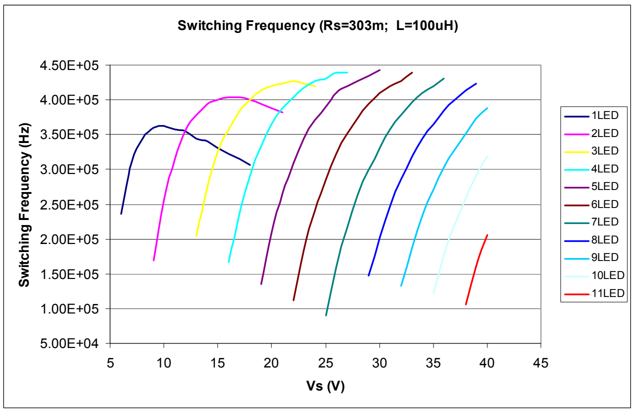
R_{sense} = 303 mΩ, L= 100 µH
V_s = 24 V, 6 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



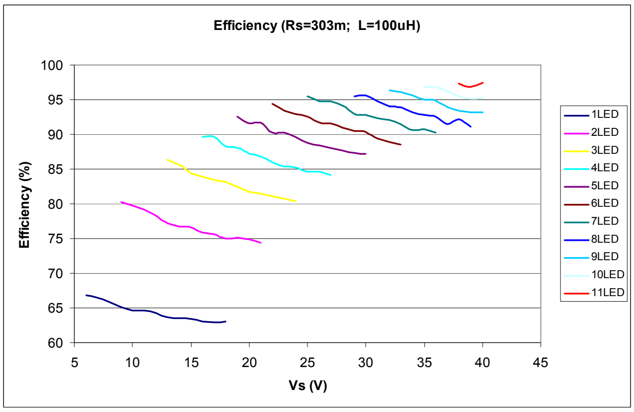
ILD4035_ILED_303m_100u.vsd

F_{Switch} vs. V_{Supply} and number of LEDs



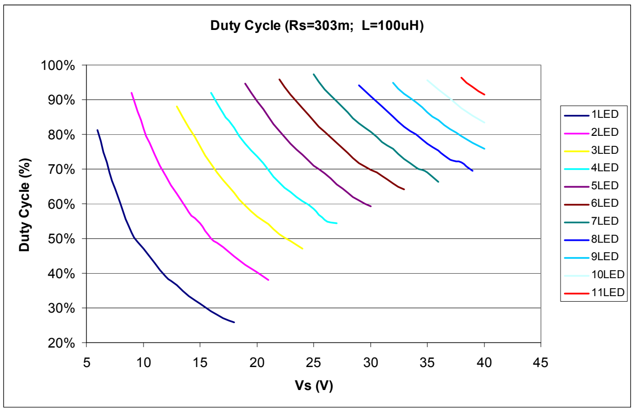
ILD4035_Switching_Frequency_303m_100u.vsd

Efficiency vs. V_{Supply} and number of LEDs



ILD4035_Efficiency_303m_100u.vsd

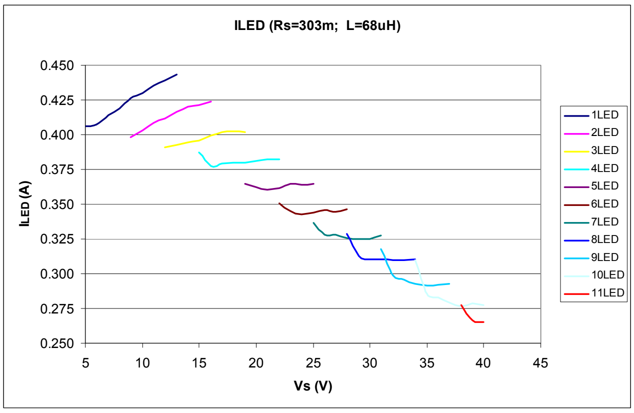
Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_303m_100u.vsd

R_{sense} = 303 mΩ, L= 68 µH
V_s = 24 V, 6 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



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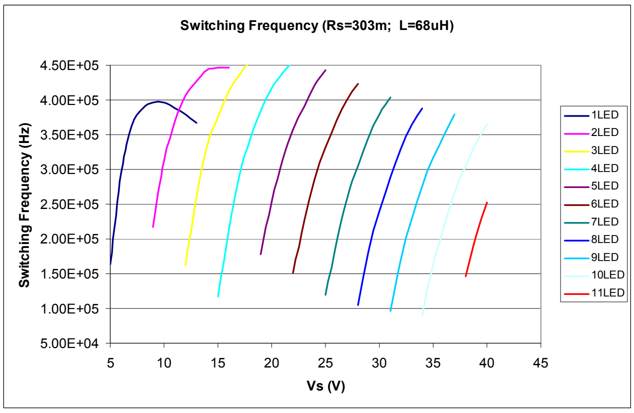
F_{Switch} vs. V_{Supply} and number of LEDs



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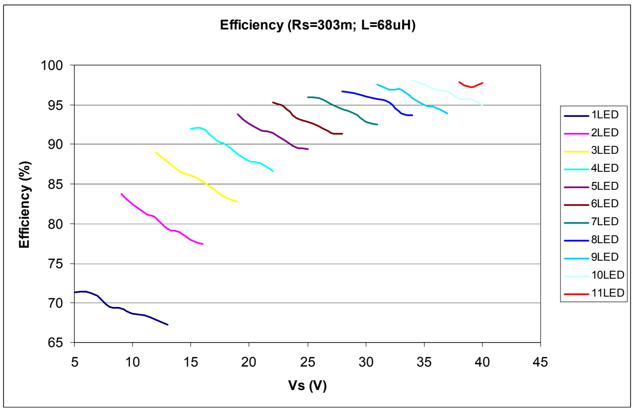
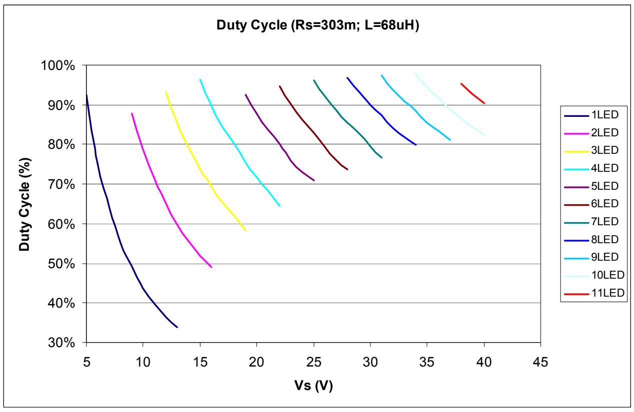
Efficiency vs. V_{Supply} and number of LEDs



ILD4035_Efficiency_303m_68u.vsd

Duty Cycle vs. V_{Supply} and number of LEDs

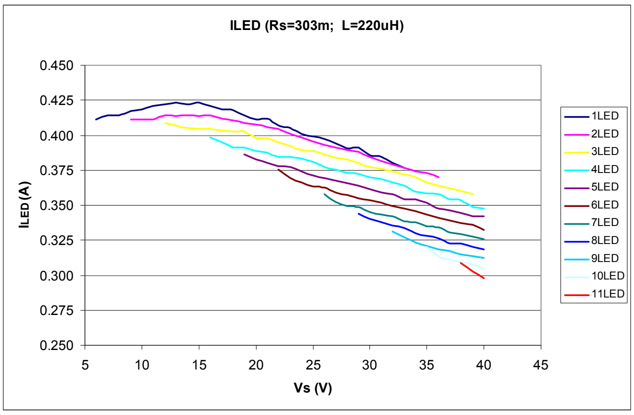


ILD4035_Duty_Cycle_303m_68u.vsd

R_{sense} **= 303 mΩ, L= 220 µH**

V_s **= 24 V, 6 LED with typ.** V_F **= 3 V**

I_{LED} vs. V_{Supply} and number of LEDs



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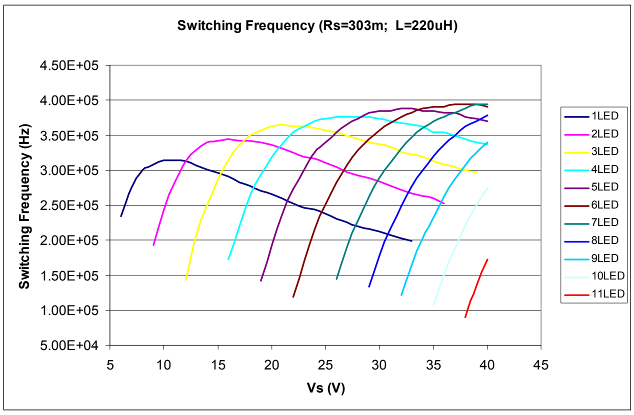
F_{Switch} vs. V_{Supply} and number of LEDs



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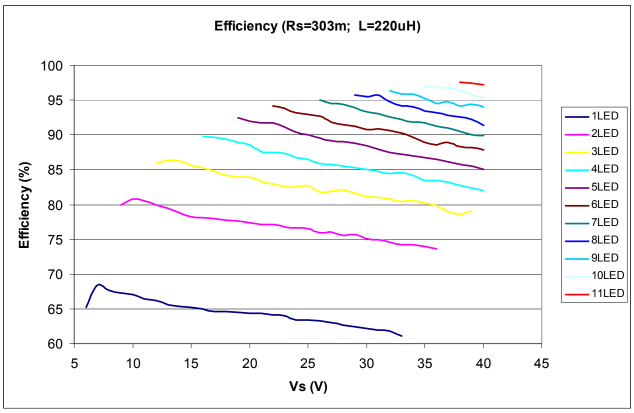
Efficiency vs. V_{Supply} and number of LEDs



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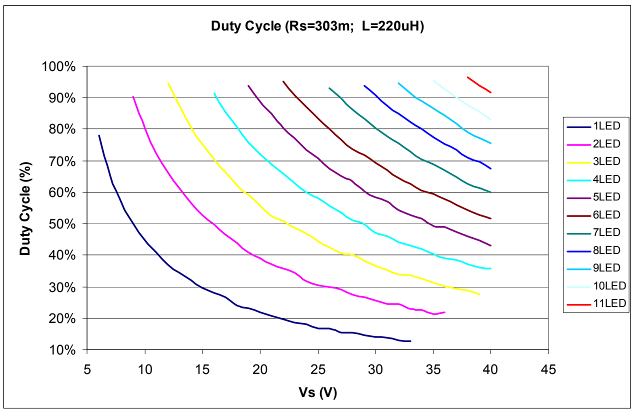
Duty Cycle vs. V_{Supply} and number of LEDs

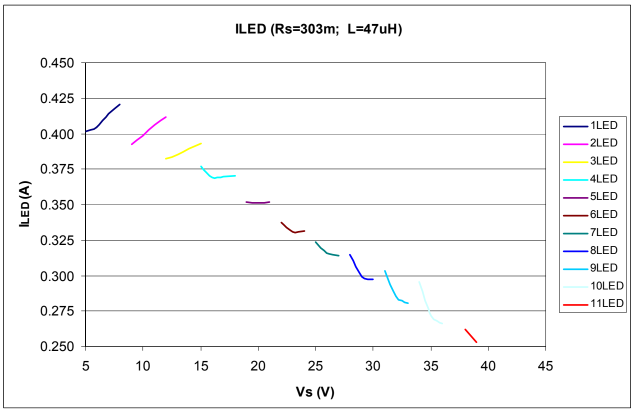


ILD4035_Duty_Cycle_303m_220u.vsd

R_{sense} = 303 mΩ, L= 47 µH

V_s = 24 V, 6 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



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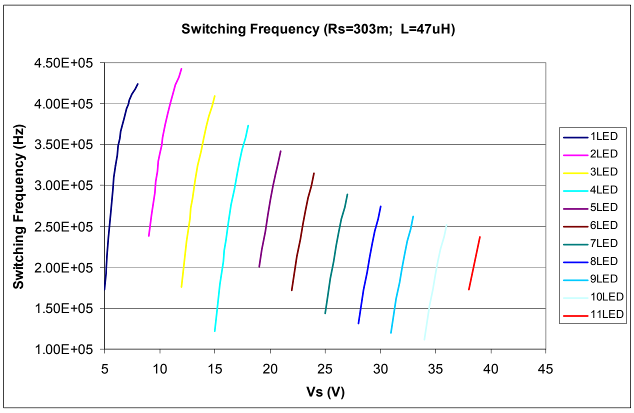
F_{Switch} vs. V_{Supply} and number of LEDs



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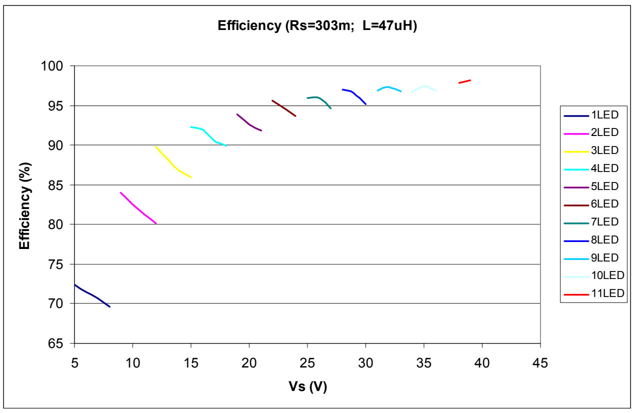
Efficiency vs. V_{Supply} and number of LEDs



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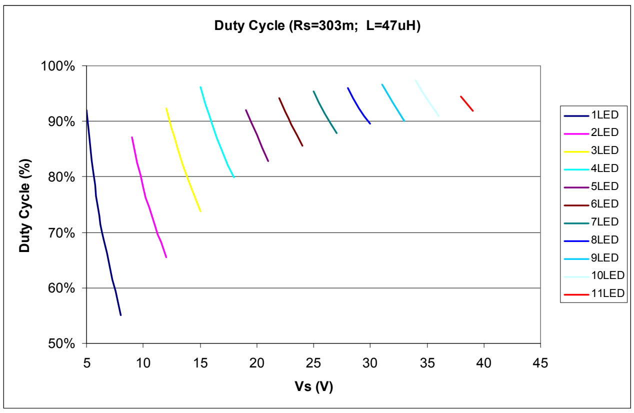
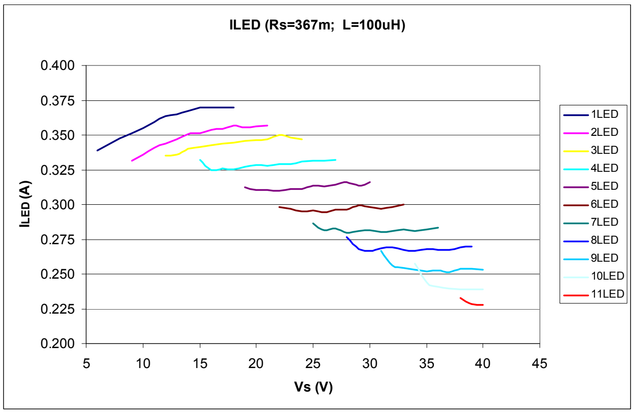
Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_303m_47u.vsd

R_{sense} = 367 mΩ, L= 100 µH
V_s = 24 V, 6 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



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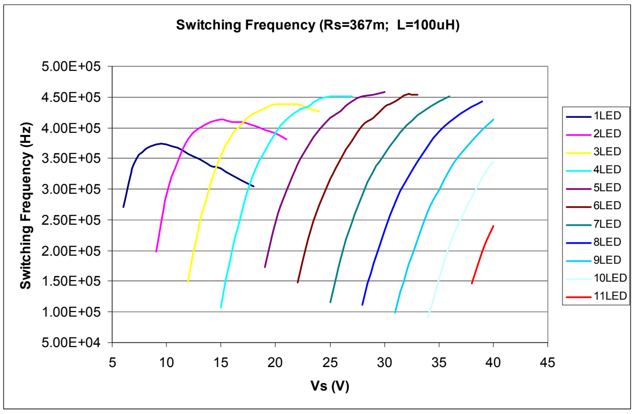
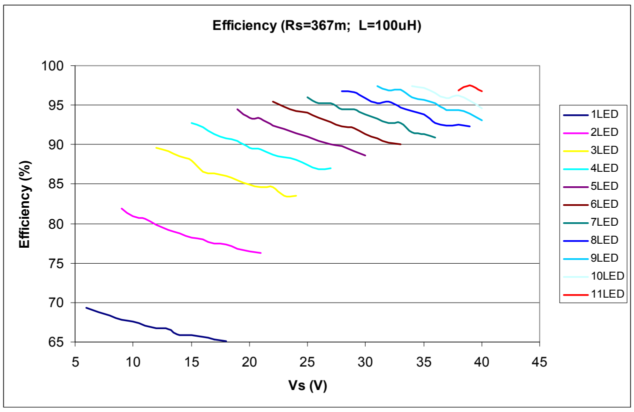
F_{Switch} vs. V_{Supply} and number of LEDs



ILD4035_Switching_Frequency_367m_100u.vsd

Efficiency vs. V_{Supply} and number of LEDs



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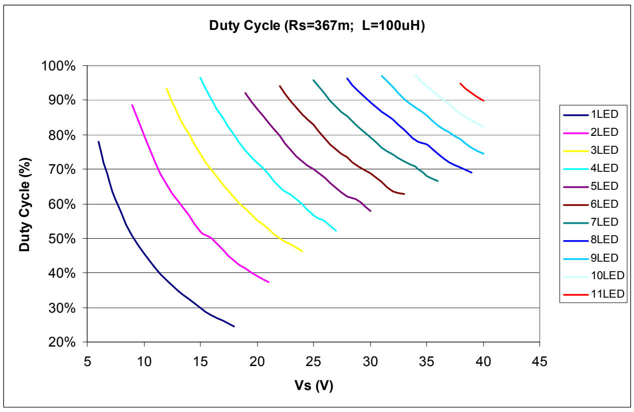
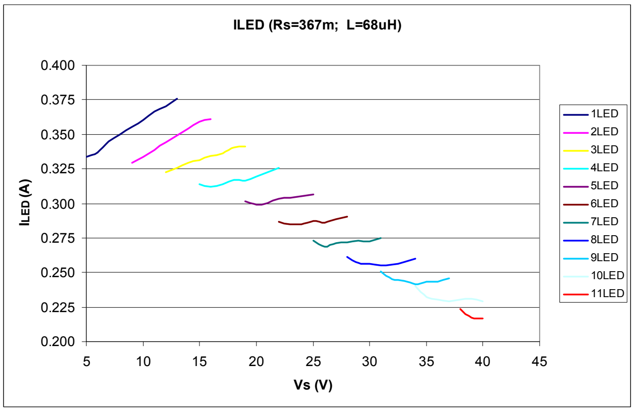
Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_367m_100u.vsd

R_{sense} = 367 mΩ, L= 68 µH
V_s = 12 V, 3 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



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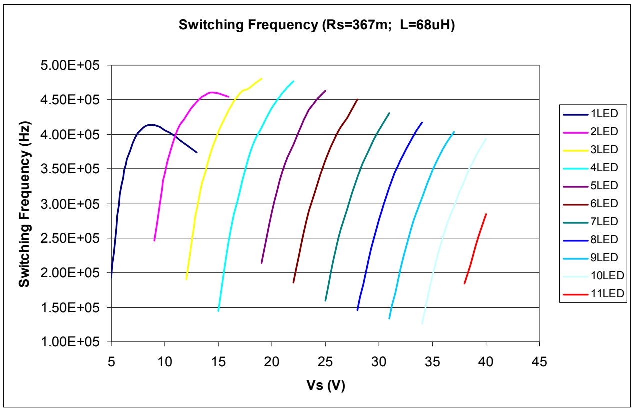
F_{Switch} vs. V_{Supply} and number of LEDs



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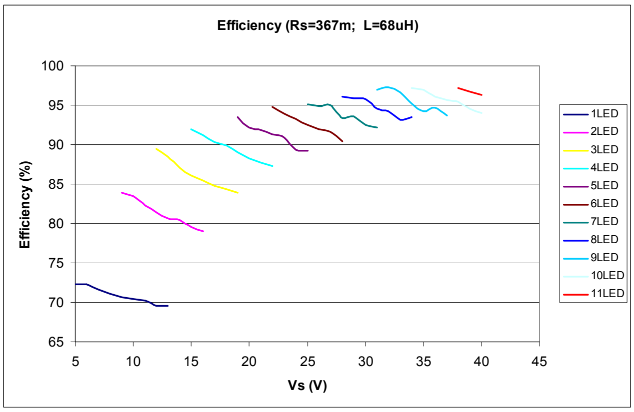
Efficiency vs. V_{Supply} and number of LEDs



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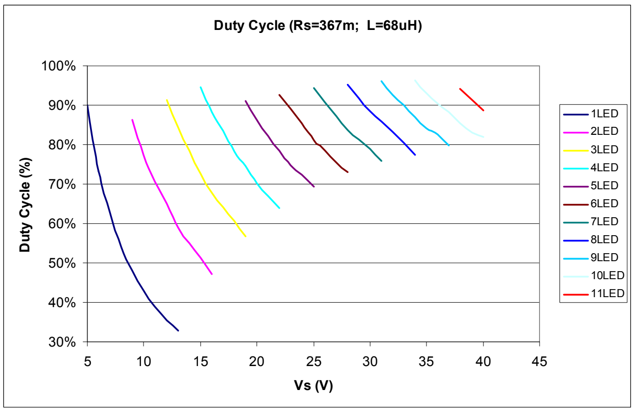
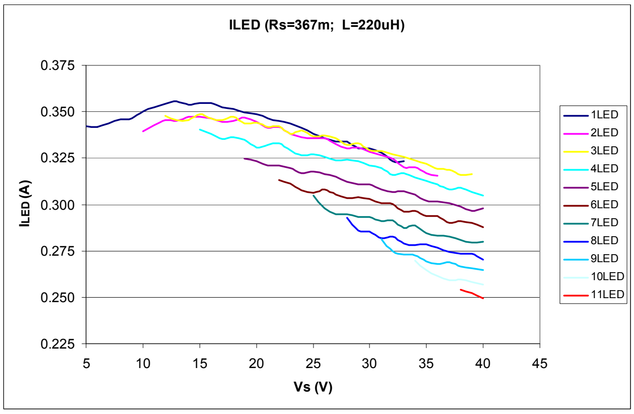
Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_367m_68u.vsd

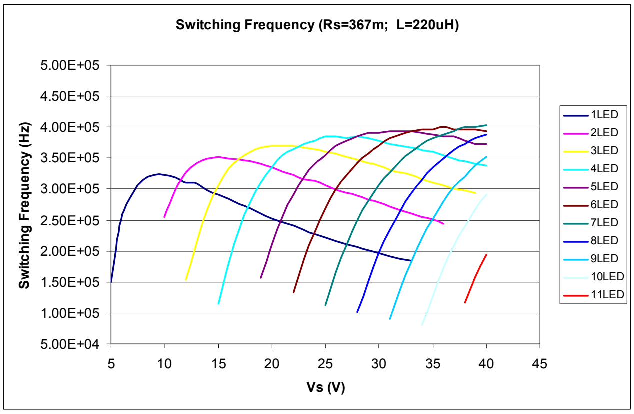
R_{sense} = 367 mΩ, L= 220 µH
V_s = 12 V, 3 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



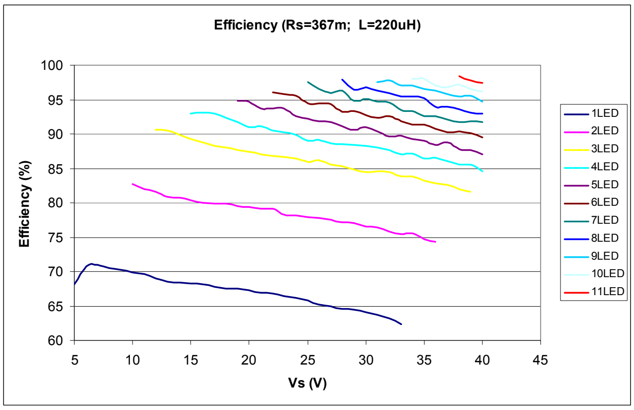
ILD4035_ILED_367m_220u.vsd

F_{Switch} vs. V_{Supply} and number of LEDs



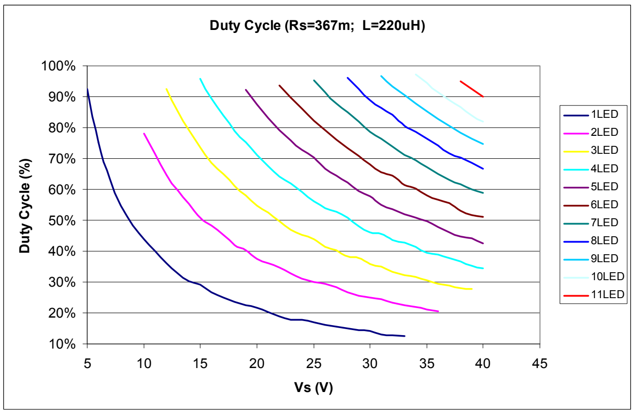
ILD4035_Switching_Frequency_367m_220u.vsd

Efficiency vs. V_{Supply} and number of LEDs



ILD4035_Efficiency_367m_220u.vsd

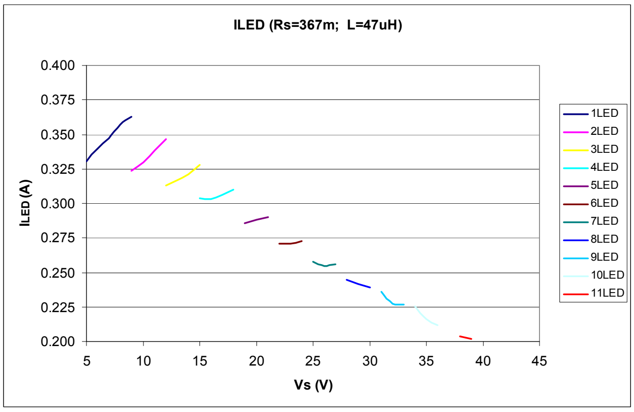
Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_367m_220u.vsd

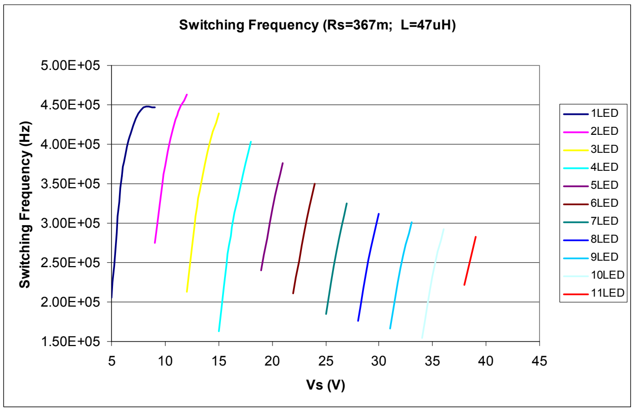
R_{sense} = 367 mΩ, L= 47 µH
V_s = 12 V, 3 LED with typ. V_F = 3 V

I_{LED} vs. V_{Supply} and number of LEDs



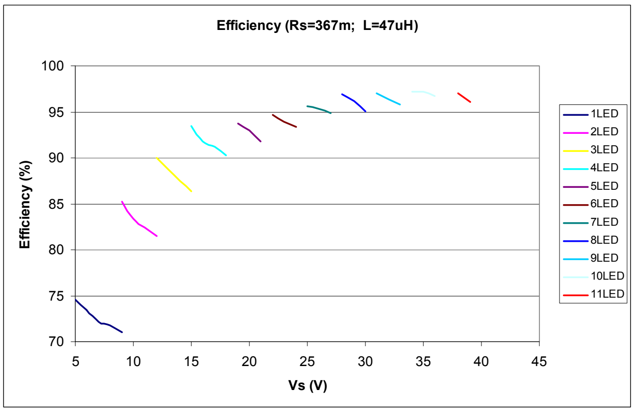
ILD4035_ILED_367m_47u.vsd

F_{Switch} vs. V_{Supply} and number of LEDs



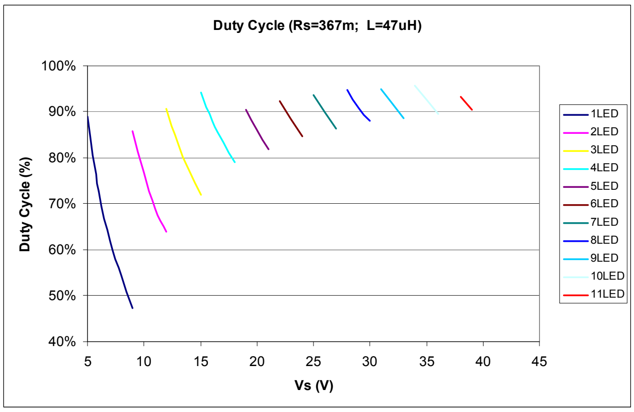
ILD4035_Switching_Frequency_367m_47u.vsd

Efficiency vs. V_{Supply} and number of LEDs



ILD4035_Efficiency_367m_47u.vsd

Duty Cycle vs. V_{Supply} and number of LEDs



ILD4035_Duty_Cycle_367m_47u.vsd

6 Application Circuit

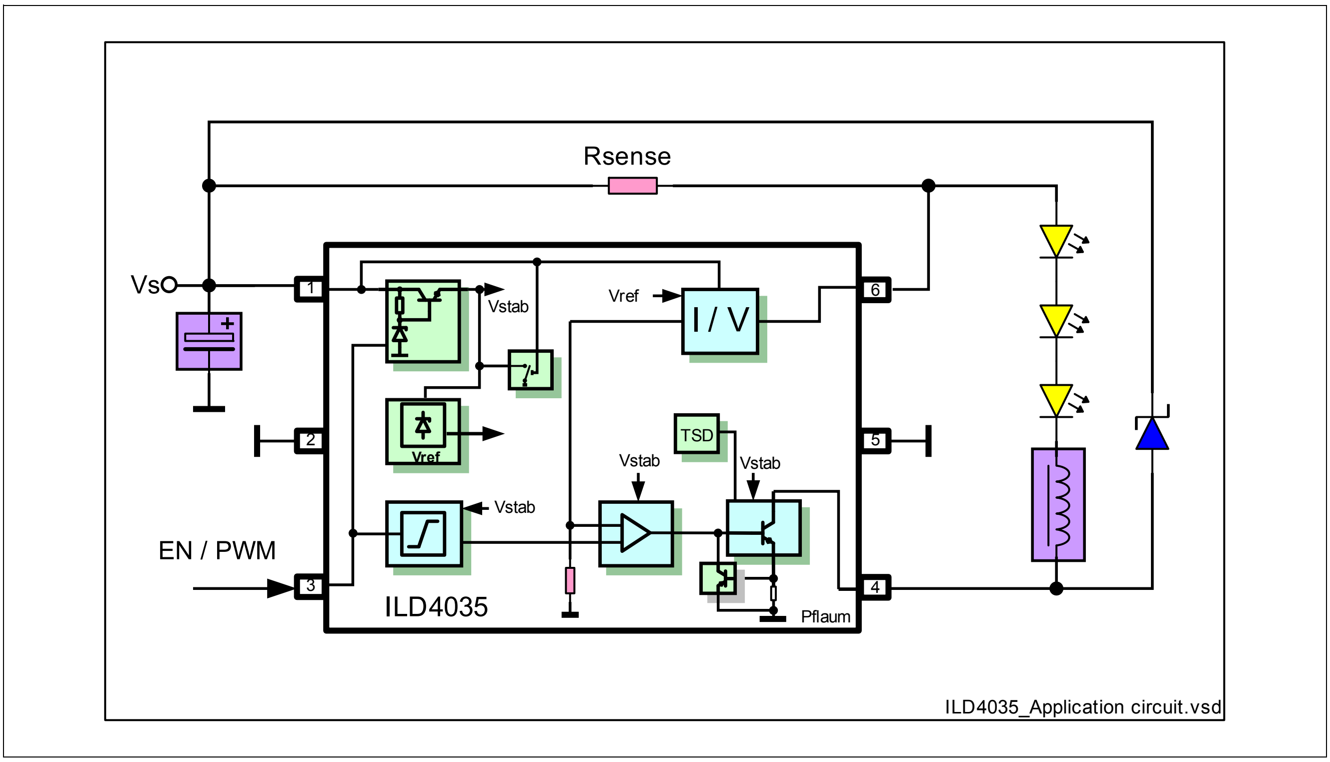


Figure 8 ILD4035; Application Circuit

7 Evaluation Board

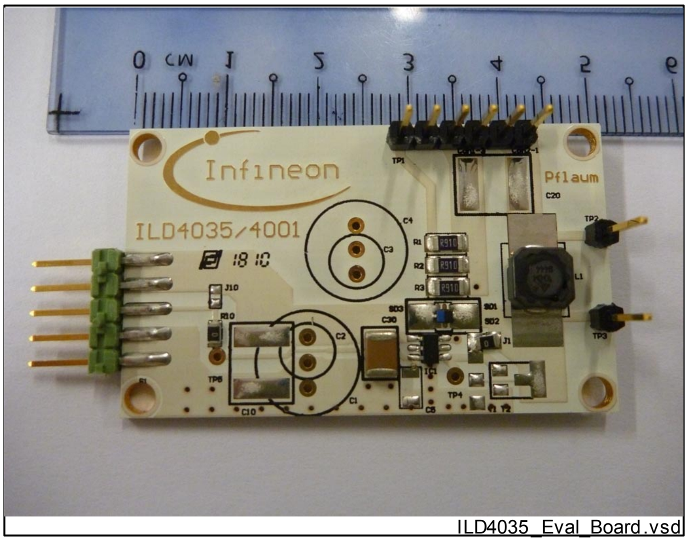


Figure 9 ILD4035; Evaluation- Board

8 Package Information SC74-6-4

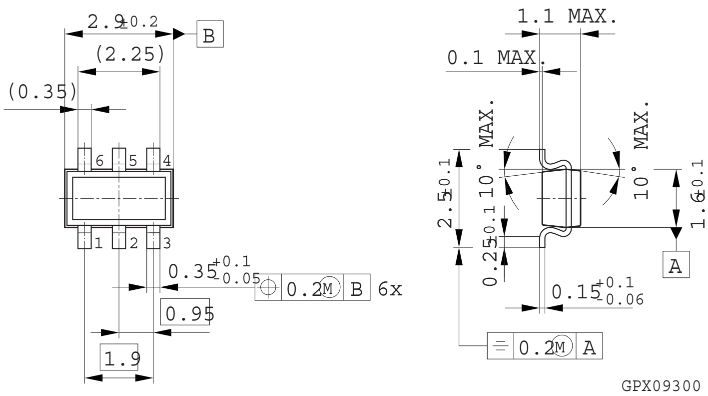


Figure 10 Package Outline

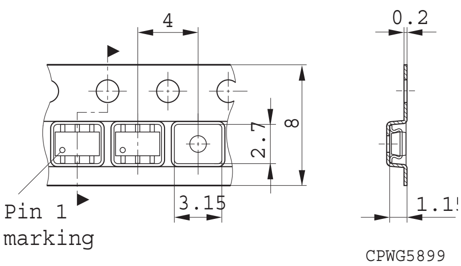


Figure 11 Tape Dimensions

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

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