LED Drivers for High Power LEDs

ILD6070

60 V / 0.7 A High Efficiency Step-Down LED Driver

Data Sheet

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Preliminary

Power Management and Multimarket

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Revision History	
Page or Item	**Subjects (major changes since previous revision)**
Revision 2.0, 2013-02-25	
All	Initial release of preliminary data sheet

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1 Features

- Wide input voltage range from 4.5 V to 60 V
- Capable to provide up to 0.7 A average output current
- Up to 1 MHz switching frequency
- Soft-start capability
- Separate enable and PWM dimming pins
- Analog and PWM dimming possible
- Integrated PWM generator for analog dimming input
- Typical 3% output current accuracy
- Very low LED current drift over temperature
- Adjustable over-temperature protection
- Undervoltage lockout
- Over-current protection
- Thermally optimized package: PG-DSO-8-27

RoHS

Applications

- LED driver for general lighting
- Retail, office and residential downlights
- Street and tunnel lighting
- LED ballasts

Product Name	Package	Marking
ILD6070	PG-DSO-8-27	ILD6070

2 Product Brief

The ILD6070 is a hysteretic buck LED driver IC for driving high power LEDs in general lighting applications with average currents up to 0.7 A.

The ILD6070 is suitable for LED applications with a wide range of supply voltages from 4.5 V to 60 V. The enable signal can be used to activate the standby mode. A multifunctional PWM input signal allows dimming of the LEDs with an analog DC voltage or an external PWM signal. To minimize colorshifts of the LEDs an analog PWM voltage is converted to an internal 1.6 kHz PWM signal modulating the LED current.

The ILD6070 incorporates an undervoltage lock-out that will shut down the IC when the minimum supply voltage threshold is exceeded. The over-current protection turns off the output stage once the output current exceeds the current threshold. An integrated over-temperature protection circuit will start to reduce the LED current by internal PWM modulation once the adjustable junction temperature threshold of the IC is exceeded. Realizing a thermal coupling between LED driver and LEDs this feature eliminates the need of external temperature senors as NTCs or PTCs.

Thanks to the hysteretic concept the current control is extremely fast and always stable. A maximum contrast ratio of 3000:1 can be achieved depending of the dimensioning of the external components. The efficiency of the LED driver is remarkable high, reaching up to 98% of efficiency over a wide range. The output current accuracy from device to device and under all load conditions and over temperature is limited to a minimum, making ILD6070 the perfect fit for LED ballasts.

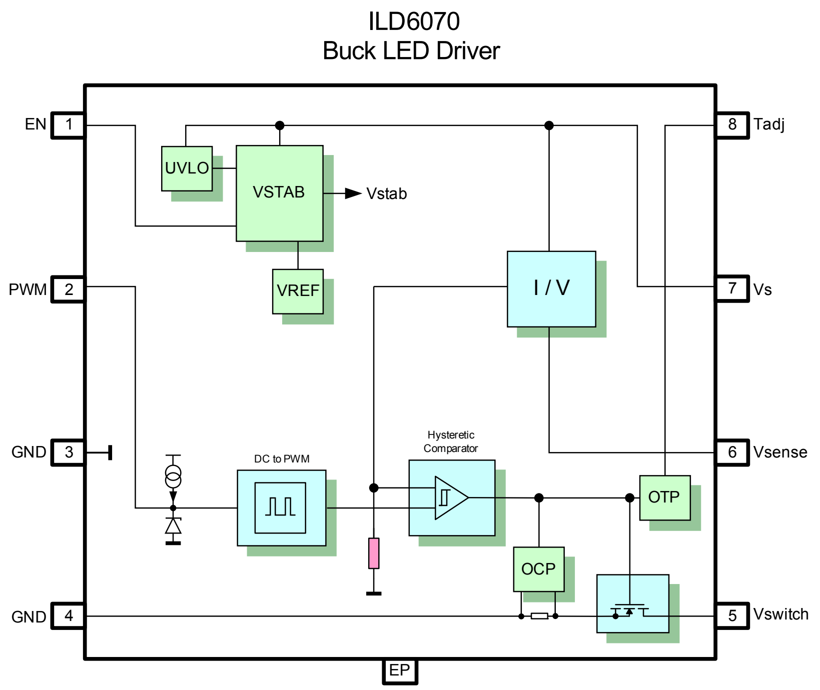


Figure 1 Block Diagram

Pin Definition

Table 1 Pin Definition and Function

Pin No.	Name	Pin Type	Buffer Type	Function
1	EN	Input	–	IC enable signal
2	PWM	Input	–	Dimming signal: • Analog dimming • PWM dimming
3	GND	GND	–	IC ground
4	GND	GND	–	IC ground
5	Vswitch	Output	–	Power switch output
6	Vsense	Input	–	LED current sense input
7	VS	Input	–	Supply voltage
8	Tadj	Output	–	Over-temperature adjustment
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	-0.3	–	60	V	–
EN voltage	V_{EN}	-0.3	–	60	V	–
PWM voltage	V_{PWM}	-0.3	–	5.5	V	–
Tadj voltage	V_{Tadj}	-0.3	–	3.5	V	–
Sense voltage	V_{sense}	V_S - 0.3	–	V_S	V	–
Switch voltage	V_{switch}	-0.3	–	60	V	–
Average switch output current	I_{out}	–	–	0.7	A	–
Total power dissipation, $T_S \leq 118°C$	P_{tot}	–	–	1.6	W	–
Junction temperature	T_J	-40	–	150	°C	–
Storage temperature range	T_{STG}	-65	–	150	°C	–
ESD capability at all pins[1)]	$V_{ESD\ HBM}$	-2	–	2	kV	HBM acc. to JESD22 - A114

1) Two different classes of ESD protection elements are implemented within ILD6070:
1. ESD protection at pin 7 (VS) gets triggered once the slew rate of the applied voltage signal exceeds a threshold of approximately 10 V/ns. In this case ESD protection will be triggered independently from the applied voltage level and won't turn off until supply voltage gets zero. If ESD protection gets triggered while V_S is supplied the ESD protection respective the IC might be damaged. Therefore a V_S blocking capacitor close to pin 7 is required to keep the slew rate at pin 7 below the threshold and to filter events as turning on the supply voltage or V_S voltage spikes.
2. ESD protection at all other pins is triggered once the connected voltage signal exceeds a threshold higher than the maximum voltage rating specified for each pin. No preventions regarding slew rate control need to be taken for these pins.

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}	–	20	–	K/W	–

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

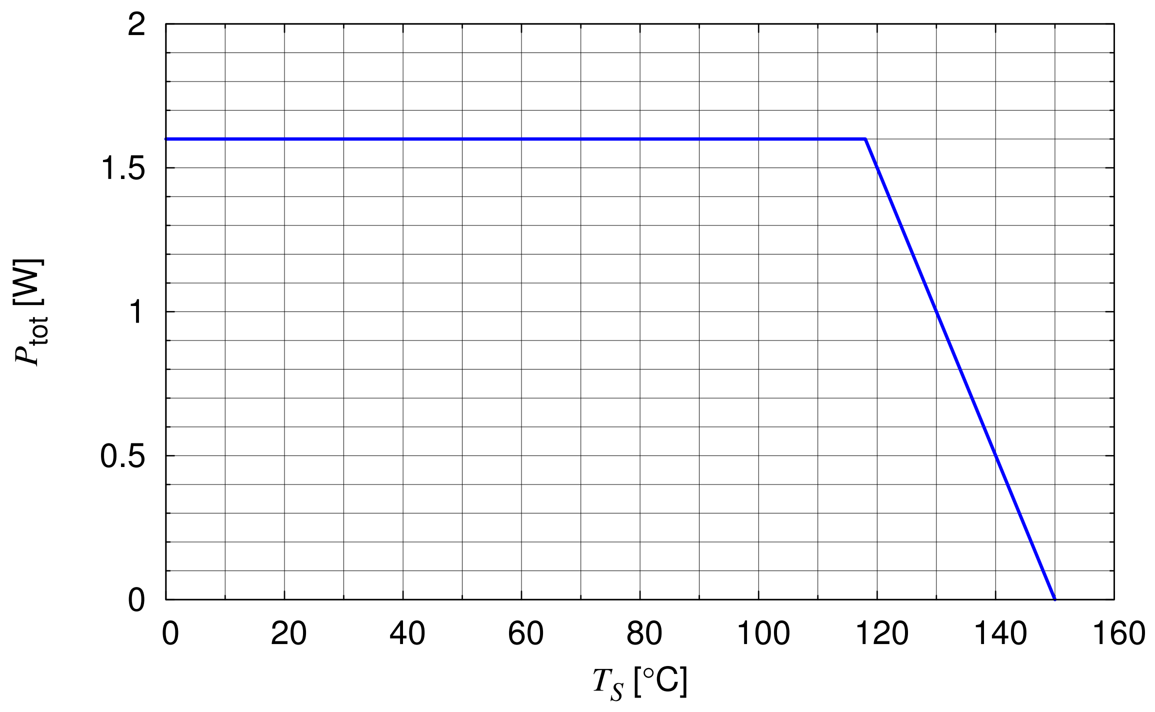


Figure 2 Total Power Dissipation

The major part of the IC power dissipation is caused by the switch resistance in conductive state. Therefore **Equation (1)** is a first estimation to calculate the power dissipation of the IC

$$P_{tot} = R_{ON} \cdot I_{out}^{\ 2} \cdot D + I_S \cdot V_S \quad (1)$$

D: Duty cycle of the output switch (2)

For a more precise analysis please measure soldering point temperature T_S of ILD6070 at GND pin and use **Figure 2** as a reference.

5 Electrical Characteristics

5.1 DC Characteristics

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

Table 4 DC Characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Operating supply voltage	V_S	4.5	–	60	V	–
Under Voltage Lock Out	$V_{S, UV, off}$	–	4.2	–	V	IC deactivated[1)]
	$V_{S, UV, on}$	–	4.3	–	V	IC operative
Supply current consumption open load	$I_{S,open load}$	–	2.2	–	mA	V_S = V_{sense} I_{LED} = 0 mA
Supply voltage reset time	$t_{S, reset}$	–	130	–	µs	Reset time after V_S power up[2)]
Supply standby current consumption	$I_{S,stby,12V}$	–	0.2	–	mA	V_S = V_{sense}= 12 V V_{EN} = 0 V
	$I_{S,stby,60V}$	–	0.5	–	mA	V_S = V_{sense}= 60 V V_{EN} = 0 V
Current of V_{sense} input	I_{sense}	–	17	–	µA	At any LED current
Output over current protection threshold	$I_{out, OCP}$	–	1.4	–	A	
Output over current protection delay time	$t_{delay, OCP}$	–	0.2	–	µs	turn off delay
Output over current protection time out	$t_{timeout, OCP}$	–	33	–	µs	turn off duration[3)]
Over temperature protection threshold range (typical), 10 % reduction	$T_{OTP, range}$	75	–	145	°C	R_{Tadj} = 35 kΩ ... 0 Ω[4)]
Over temperature protection threshold open, 10 % reduction	$T_{OTP, open}$	–	115	–	°C	R_{Tadj} ≥ 150 kΩ
Over temperature protection threshold short, 10 % reduction	$T_{OTP, short}$	–	145	–	°C	R_{Tadj} = 0 Ω
Tadj pin current source to GND	$I_{Tadj, short}$	–	57	–	µA	R_{Tadj} = 0 Ω

1) IC gets deactivated once the supply voltage drops below $V_{S, UV, off}$ and gets operative once supply voltage rises above $V_{S, UV, on}$.
2) Reset timer starts after supply voltage exceeds the lower limit of the supply voltage. Output stage gets enabled once reset timer expires.
3) Once the over current protection threshold has been exceeded the output switch gets disabled. It's enabled again once the time out expired.
4) Output current gets reduced using internal PWM generator once chip junction temperature exceeds the temperature threshold. Temperature threshold is defined by resistor R_{Tadj}. Valid R_{Tadj} resistor range is 0 to 35 kΩ. Resistors R_{Tadj} ≥ 150 kΩ are treated as open connection. Typical temperature tuning range is specified.

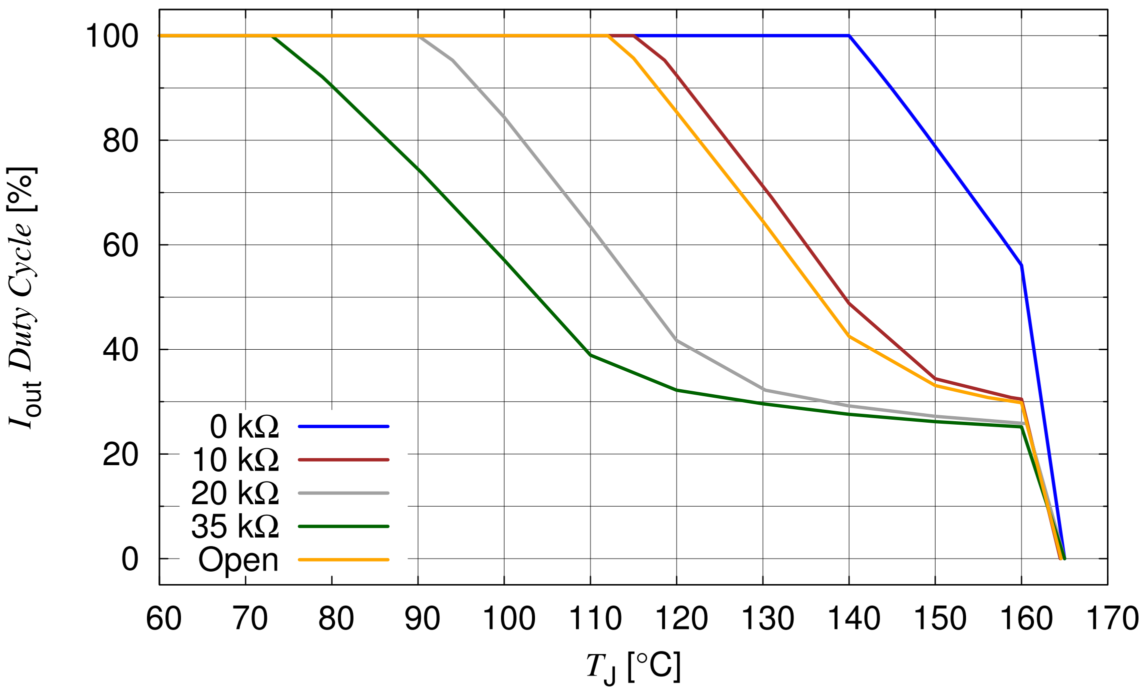


Figure 3 Typical Output Current Duty Cycle of Over-Temperature Protection vs. T_J and R_{Tadj}

5.2 Switching Characteristics

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

Table 5 Switching Characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Switching frequency	f_{switch}	–	–	1	MHz	
Mean current sense threshold voltage	V_{sense}	–	125	–	mV	f_{switch} = 100 kHz
Sense threshold hysteresis	$V_{sensehys}$	–	±20	–	%	peak to average V_S = 12 V, f_{switch} = 100 kHz
Output current drift over supply voltage	$I_{out, Vs}$	–	±3	–	%	
Output current drift over temperature	$I_{out, Ts}$	–	±4	–	%	for temperatures below OTP threshold
Output current drift over load	$I_{out, load}$	–	±3	–	%	fixed V_S
Switch on resistance	$R_{ON, 25°C}$	–	0.43	–	Ω	I_{SW} = 0.2 A, T_J = 25 °C
	$R_{ON, 125°C}$	–	0.82	–	Ω	I_{SW} = 0.2 A, T_J = 125 °C

5.3 Digital ControlSignals

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

Table 6 Digital Control Parameter at Enable Pin EN[1)]

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
EN voltage logic high level	$V_{EN, high}$	2.5	–	60	V	IC operative
EN voltage logic low level	$V_{EN, low}$	-0.3	–	0.5	V	IC in standby
Input current of EN pin	$I_{EN, 3V}$	–	10	–	µA	V_{EN} = 3 V
	$I_{EN, 60V}$	–	55	–	µA	V_{EN} = 60 V

1) EN pin doesn't have an internal biasing and requires connection to an external voltage signal for operation

Table 7 Digital Control Parameter at Pin PWM[1)]

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
PWM voltage logic high level	$V_{PWM, high}$	2.6	–	5.5	V	output stage enabled
PWM voltage logic low level	$V_{PWM, low}$	-0.3	–	0.5	V	output stage disabled
PWM output current	$I_{CC,PWM}$	–	18	–	µA	V_{PWM} = 0 V
PWM delay time	$t_{d, PWM, on}$	–	0.8	–	µs	V_{EN} = 3 V V_{PWM} = rising to 2.5 V V_{switch} = falling to 1 V
	$t_{d, PWM, off}$	–	0.5	–	µs	V_{EN} = 3 V V_{PWM} = falling to 0.5 V V_{switch} = rising to 1 V
PWM signal frequency	$f_{PWM, ext}$	–	–	25	kHz	

1) PWM pin has an internal pull-up circuit to high level if not connected externally on PCB

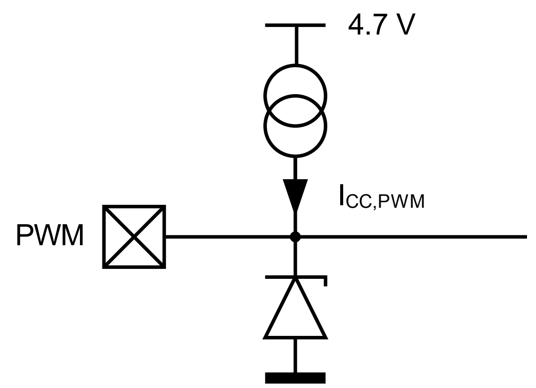


Figure 4 PWM Input

Analog PWM input voltage signals activate modulation of the LED current by the integrated PWM generator. PWM duty cycle versus PWM control voltage is shown in **Figure 5**.

Table 8 Analog Control Parameter at Pin PWM

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
PWM input voltage for 0% duty cycle	$V_{PWM, 0\%}$	–	0.67	–	V	
PWM input voltage for 50% duty cycle	$V_{PWM, 50\%}$	–	1.55	–	V	
PWM input voltage for 100% duty cycle	$V_{PWM, 100\%}$	–	2.43	–	V	
Sensitivity of PWM duty cycle vs. PWM input voltage	D.C./V_{PWM}	–	57	–	%/V	
Integrated PWM generator frequency	$f_{PWM, int}$	–	1.6	–	kHz	

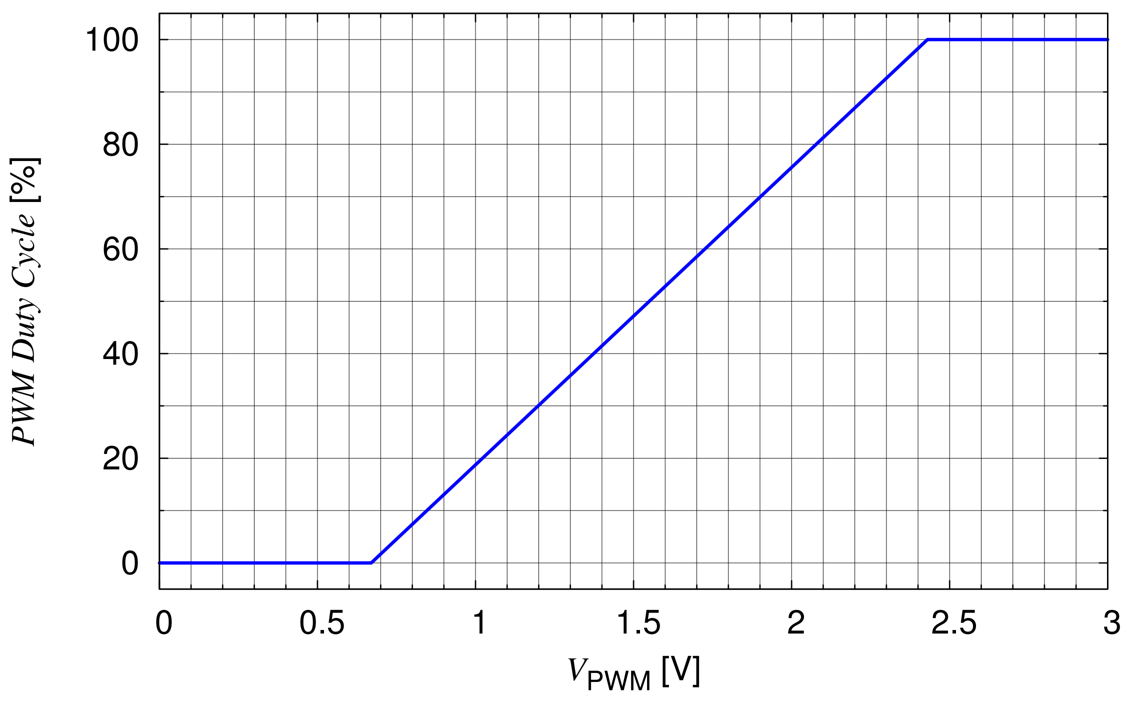
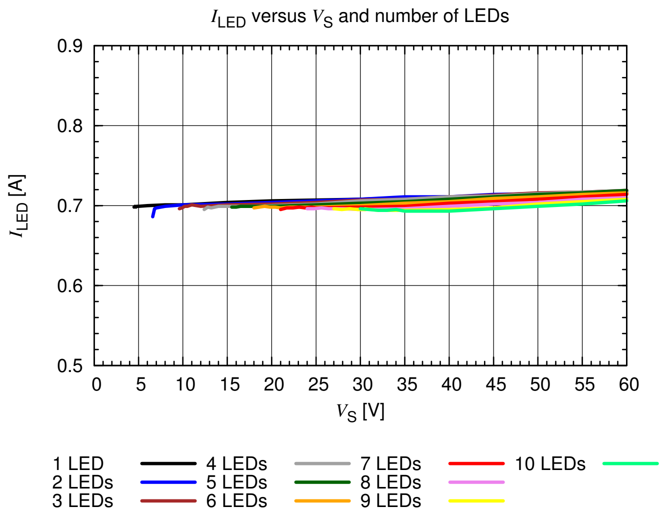


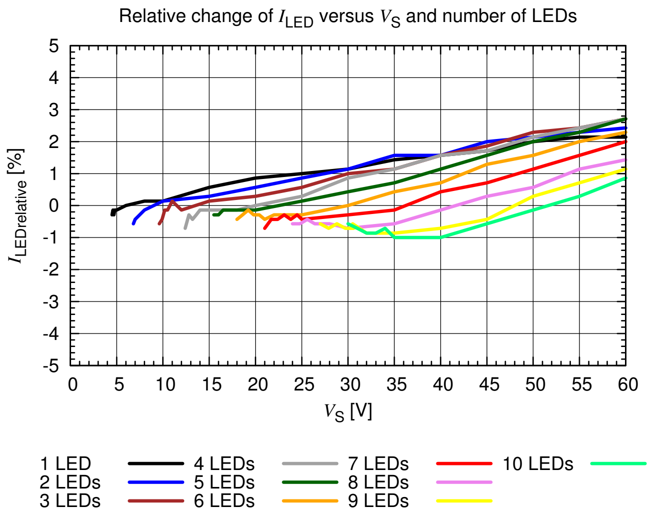
Figure 5 Typical Integrated PWM Duty Cycle vs. PWM Control Voltage

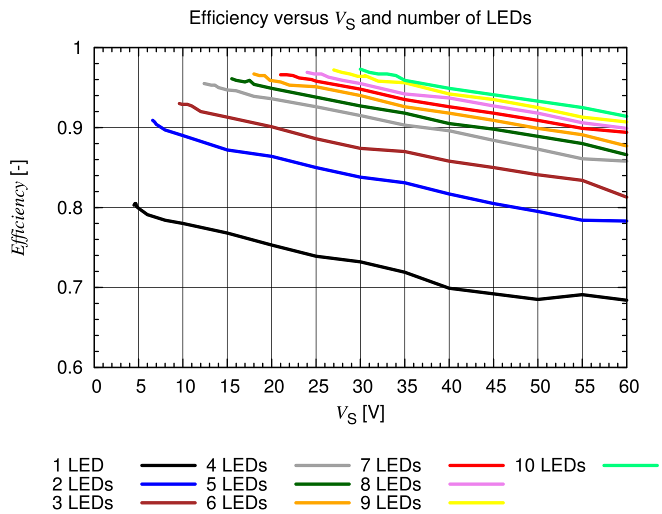
5.3.1 Switching Parameters

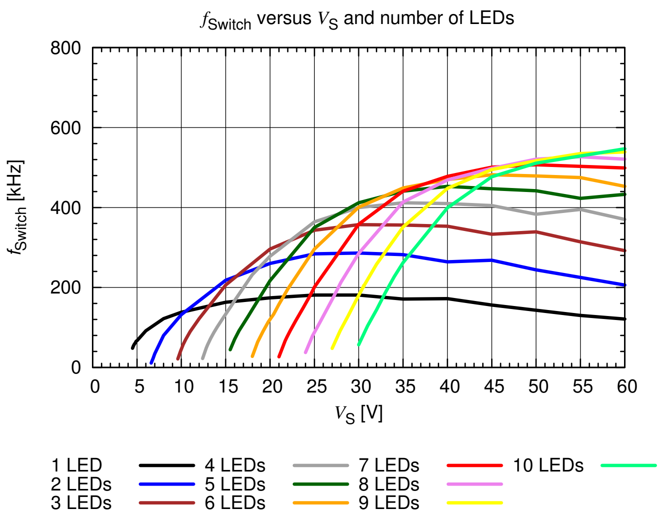
For all shown switching parameters ILD6070 has been measured on evaluation board ILD6070 at T_A = 25 °C. Used LEDs have a typical V_{fLED} of 3 V. Efficiency figure shows total efficiency of the application board including losses of external components as inductor or Schottky diode. See the application note for further details.

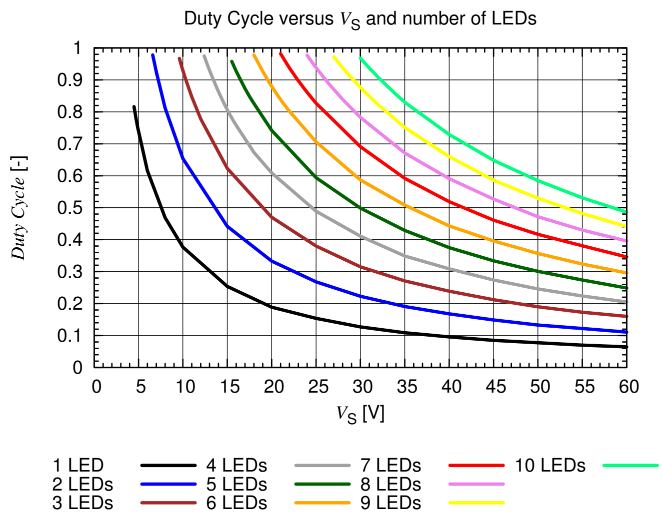
Performance vs. supply voltage and number of LEDs: R_{sense} = 178 mΩ, L = 68 µH, V_{fLED} = 3 V



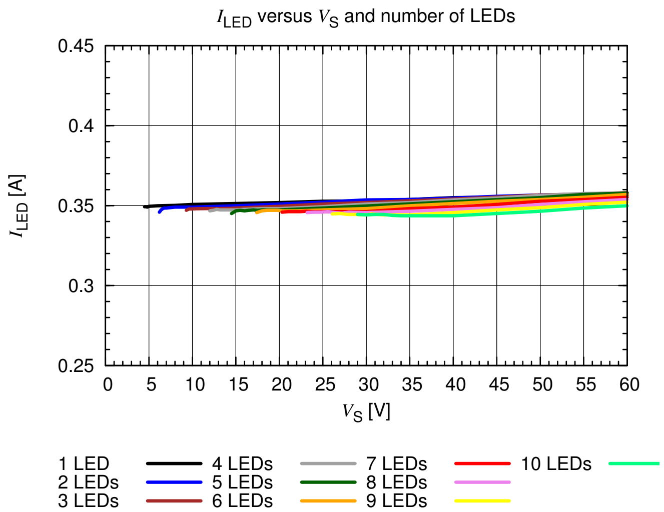


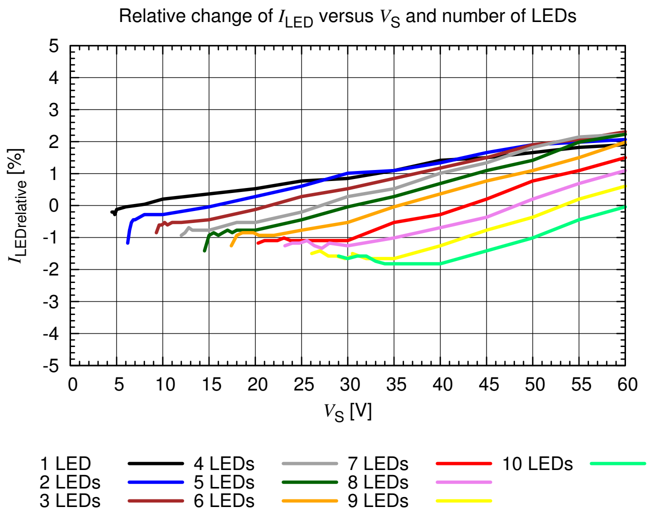


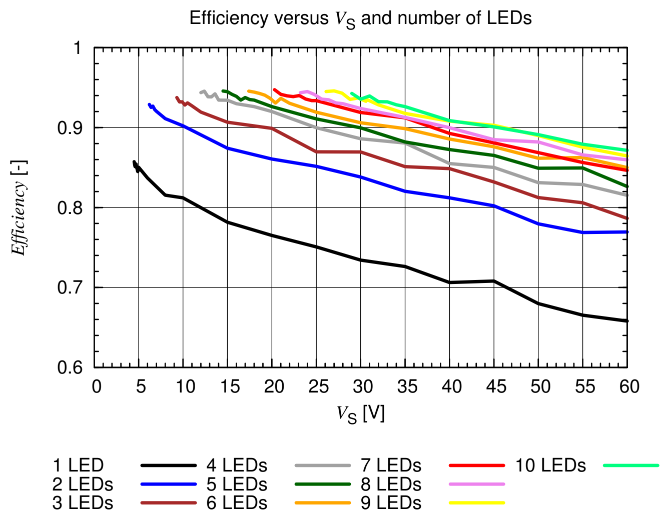


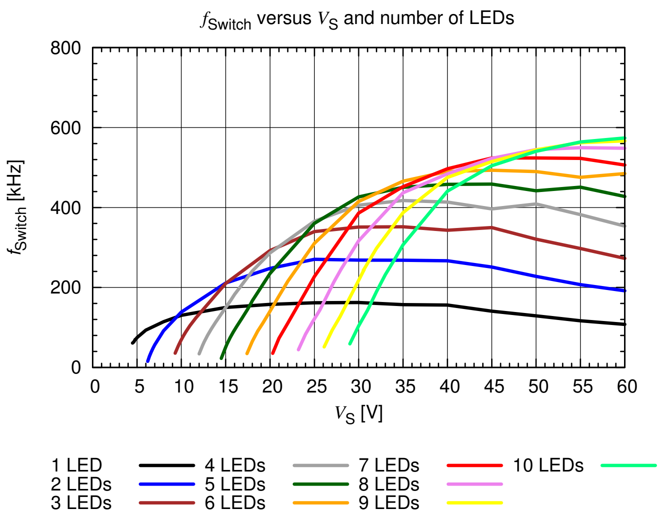


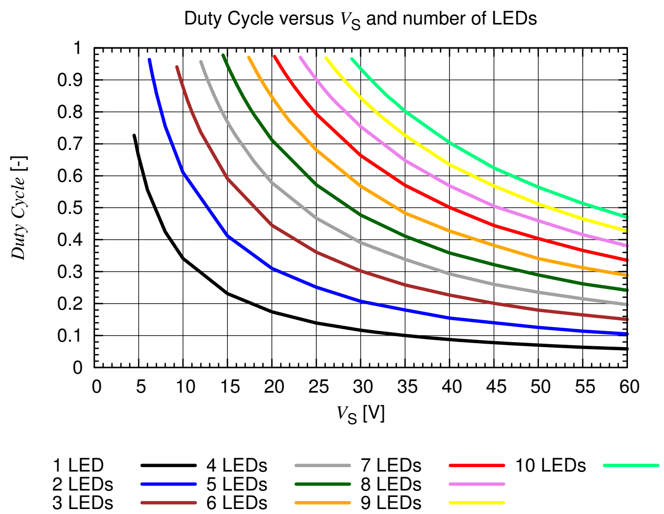
Performance vs. supply voltage and number of LEDs: R_{sense} = 353 mΩ, L = 150 µH, V_{fLED} = 3 V











6 Application Circuit

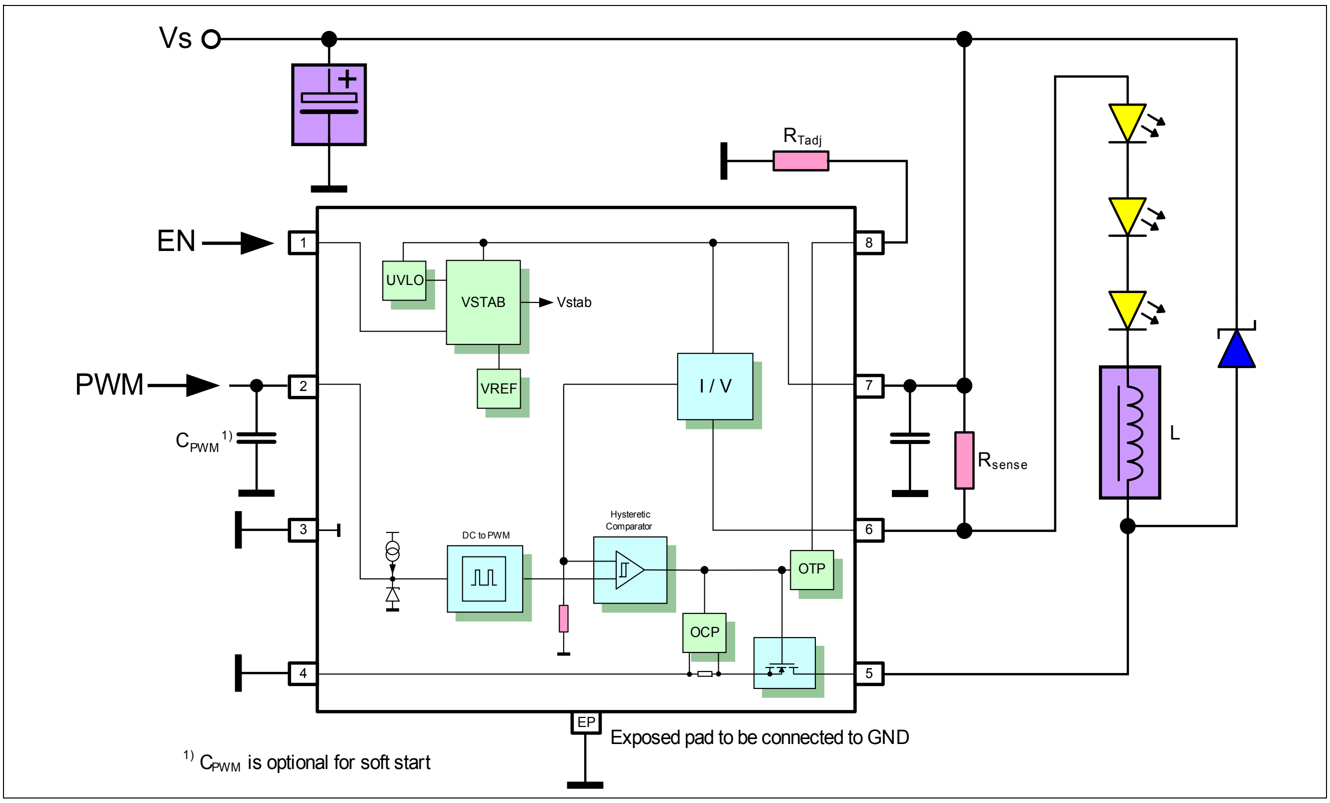


Figure 6 Application Circuit

A V_S blocking capacitor shall be placed close to pin 7 to enable a low ripple V_{sense} measurement and to avoid a false triggering of the V_S ESD protection element inside the IC.

6.1 Inductor Selection Guideline

The inductance of the inductor L, the supply voltage V_S, the number of LEDs driven and their average LED current significantly influence the slew rate of the LED current in on and off condition of the LED driver output switch. Due to the hysteretic current control ILD6070 will toggle the output driver stage each time upper or lower current threshold are reached. To maintain best regulation capability of the LED driver it's reasonable to keep a margin to the minimum switch on and off time defined by internal propagation delay times. Disregard of this recommendation by choosing too small inductor values might result in an increased LED current ripple and loss of LED current regulation accuracy.

Minimum 350 ns on and off time are recommended as a reasonable design target for the inductor selection. Below figures provide a guideline concerning minimum inductance value versus supply voltage and number of LEDs. It's assumed that forward voltage of each LED is within 2.5 V to 3.9 V over temperature and LED production tolerances. Minimum forward voltage (e.g. occuring at high LED temperatures) needs to be considered with respect to the minimum switch on-time while maximum forward voltage (e.g. occuring at low temperatures) needs to be considered with respect to the switch off-time.
The saturation current of the chosen inductor has to be higher than the peak LED current and the rating of it's continous current needs to exceed the average LED current.

0.35 A	Number of LEDs														
V_S [V]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5	15														
10	22	33													
15	47	33	47												
20	68	47	47	47	68										
25	68	68	68	47	68	68									
30	100	100	68	68	68	68	100								
35	100	100	100	100	68	68	100	100							
40	150	100	100	100	100	100	100	100	100	150					
45	150	150	150	100	100	100	100	100	100	150	150				
50	150	150	150	150	150	100	100	100	100	150	150	150			
55	150	150	150	150	150	150	150	100	100	150	150	150	150	220	
60	220	220	150	150	150	150	150	150	150	150	150	150	150	220	220

Inductance in µH; 2.5 V ≤ V_{fLED} ≤ 3.9 V

Figure 7 Minimum Inductance for 0.35 A Average LED Current

0.7 A	Number of LEDs														
V_S [V]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5	6.8														
10	10	15													
15	22	15	22												
20	33	22	22	33	33										
25	33	33	33	33	33	47									
30	47	47	33	33	33	47	47								
35	47	47	47	47	33	47	47	47							
40	68	68	47	47	47	47	47	47	68	68					
45	68	68	68	68	47	47	47	47	68	68	68				
50	68	68	68	68	68	68	47	47	68	68	68	68			
55	100	100	68	68	68	68	68	68	68	68	68	68	100		
60	100	100	100	100	68	68	68	68	68	68	68	68	100	100	100

Inductance in µH; 2.5 V ≤ V_{fLED} ≤ 3.9 V

Figure 8 Minimum Inductance for 0.7 A Average LED Current

7 Package Information

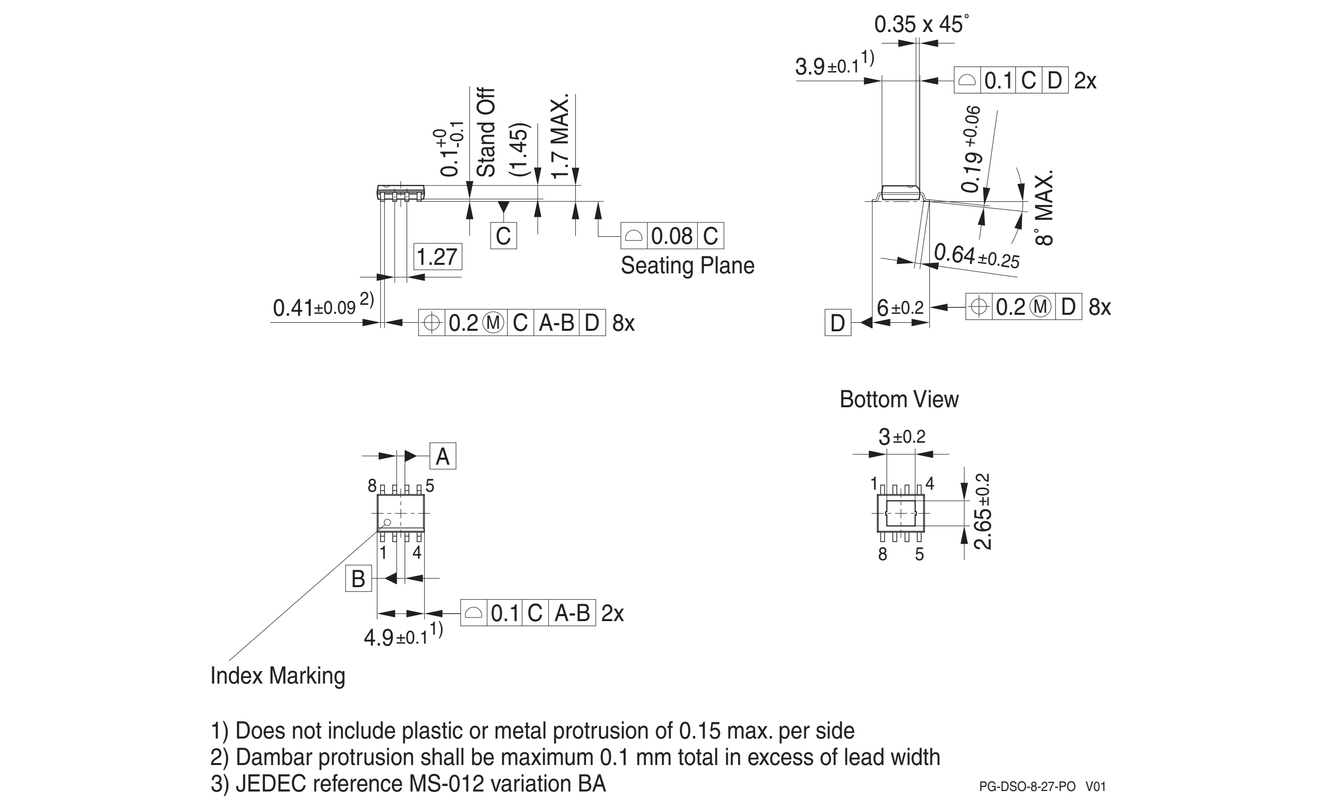


Figure 9 Package outline PG-DSO-8-27 (dimensions in mm)

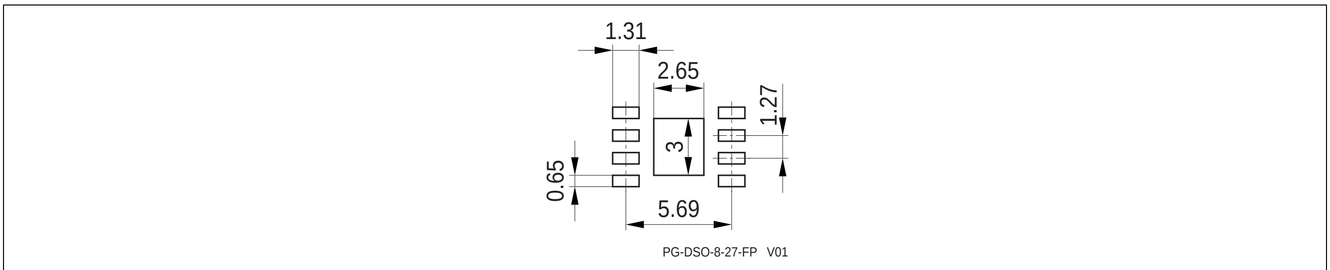


Figure 10 Recommended PCB Footprint for Reflow Soldering (dimensions in mm)

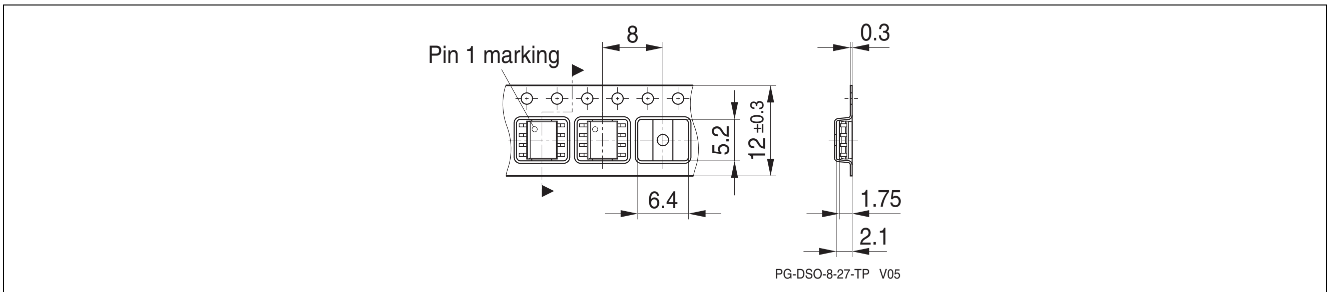


Figure 11 Tape Loading (dimensions in mm)

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