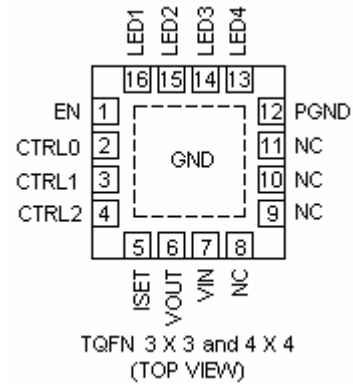


## 4-Channel Ultra Low Dropout No Noise LED Driver

### FEATURES

- Ultra-low dropout PowerLite™ Current Regulator\*
- Drives up to 4 LEDs at 30 mA each
- PWM brightness control
- Power efficiency > 95%
- Low input noise & ripple
- Low current shutdown mode
- Load disconnect in shutdown mode
- Short circuit protection
- Thermal shutdown protection
- Available in 4 x 4 x 0.8 mm and 3 x 3 x 0.8 mm 16-pin TQFN packages



LED current is easily adjustable by an external resistor up to 30 mA per channel.

The CTRL0, CTRL1, and CTRL2 logic inputs function as a LED enable and a PWM mode LED brightness control.

The driver supports a wide range of input voltages from 2.7 V to 5.5 V.

The thermal and short circuit protection guarantee high device reliability.

The device is available in a 16-lead TQFN 4 x 4 mm and 3 x 3 mm packages with a max height of 0.8 mm

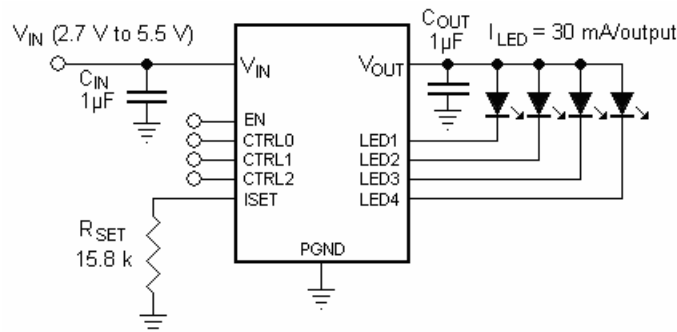
### APPLICATION

- Keypad and Display Backlight
- Cellular Phones
- Digital Still Cameras
- PDAs and Smartphones

### DESCRIPTION

The LDS8846 is a high efficiency ultra-low dropout current regulator that can drive up to four LEDs. The

### TYPICAL APPLICATION CIRCUIT



## ABSOLUTE MAXIMUM RATINGS

Parameter	Rating	Unit
V <sub>IN</sub> , LEDx voltage	-0.3 to 6	V
V <sub>OUT</sub> voltage	-0.3 to 6	V
EN, CTRL0, CTRL1, CTRL2 voltage	V <sub>IN</sub> + 0.7V	V
Storage Temperature Range	-65 to +150	°C
Junction Temperature Range	-40 to +125	°C
Soldering Temperature (10s)	300	°C
ESD protection HBM	2	kV

**NOTE:** Stresses listed above may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

Parameter	Rating	Unit
V <sub>IN</sub>	2.7 to 5.5	V
Ambient Temperature Range	-40 to +85	°C

## ELECTRICAL OPERATING CHARACTERISTICS

(Over recommended operating conditions unless specified otherwise) V<sub>IN</sub> = 3.6V, EN = High, T<sub>AMB</sub> = 25°C

Name	Conditions	Min	Typ	Max	Units	
Quiescent Current	I <sub>LED</sub> = 20mA per channel		1.3	1.5	mA	
Shutdown Current	EN = 0V		0.1	1	µA	
LED Current	R <sub>SET</sub> = 24k		20		mA	
	R <sub>SET</sub> = 96k		5			
LED Current Setting Range	2.7 < V <sub>IN</sub> < 5.5V	2		30	mA	
LED Current Accuracy	To set value	-8	3	+8	%	
LED Channel Matching	$(I_{LED\ MAX} - I_{LED\ MIN}) / (I_{LED\ MAX} + I_{LED\ MIN})$	-5	3	+5	%	
Current Sink Dropout Voltage*			20	30	mV	
Short Circuit Output Current Limit	V <sub>OUT</sub> = 0V		22	25	mA	
EN, CTRL0, CTRL1, CTRL2 pins	Leakage Current	High	Input Voltage = V <sub>IN</sub>		1	µA
		Low	Input Voltage = 0	-1		
	Logic Level Threshold	High		1.3		V
		Low			0.4	
PWM frequency		100		100000	Hz	
PWM duty cycle		1		100	%	
Thermal Shutdown			150		°C	
Thermal Hysteresis			20			
Under Voltage Lockout (UVLO)			2.4		V	

\*) Voltage drop at led pin, at which LED current falls 10% below set value

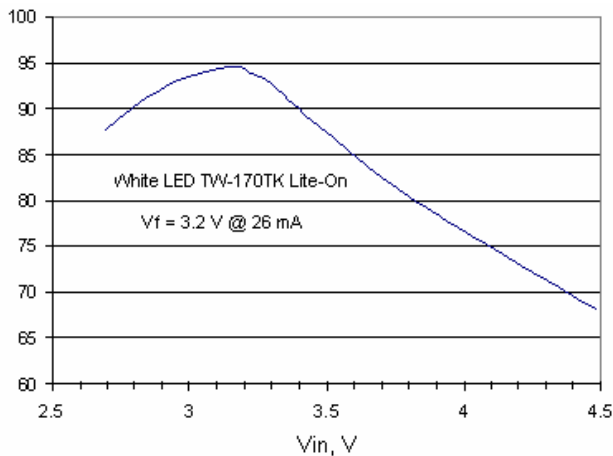
## CONTROL INPUTS FUNCTION

Control Inputs			Output States			
CTRL2	CTRL1	CTRL0	LED4	LED3	LED2	LED1
0	0	0	OFF	OFF	OFF	ON
0	0	1	OFF	OFF	ON	OFF
0	1	0	OFF	ON	OFF	OFF
0	1	1	ON	OFF	OFF	OFF
1	0	0	OFF	OFF	ON	ON
1	0	1	OFF	ON	ON	ON
1	1	0	ON	ON	ON	ON
1	1	1	OFF	OFF	OFF	OFF

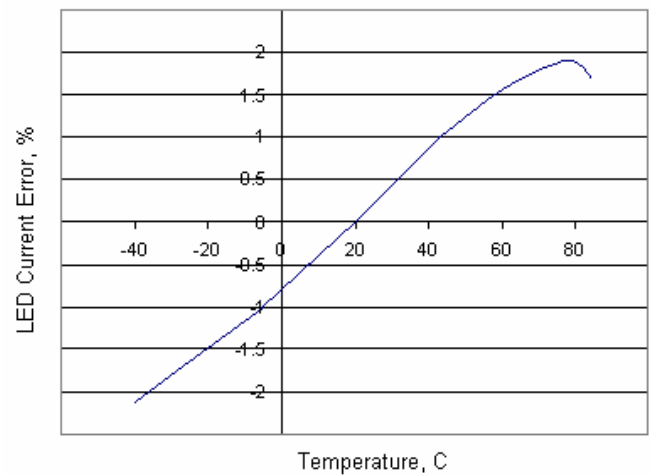
## TYPICAL CHARACTERISTICS

$V_{IN} = 3.6V$ ,  $I_{OUT} = 104\text{ mA}$  (4 LEDs at 26 mA each),  $C_{IN} = C_{OUT} = 1\ \mu F$ ,  $V_f = 3.2\text{ V}$ ,  $T_{AMB} = 25\ ^\circ C$

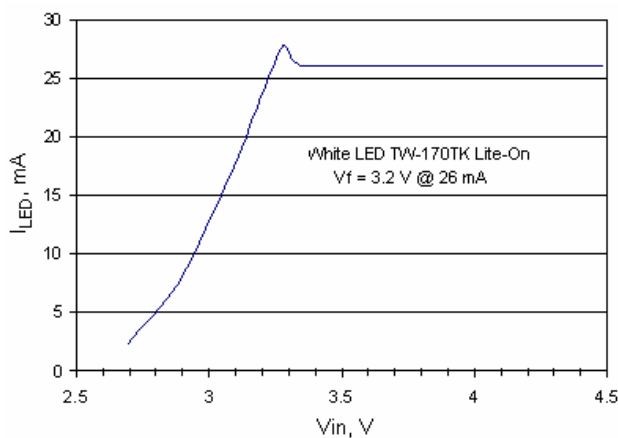
**Power Efficiency vs. Input Voltage**



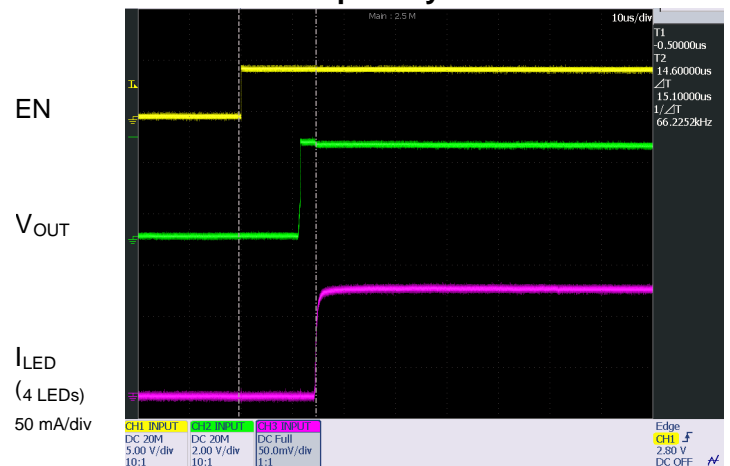
**LED Current vs. Temperature**



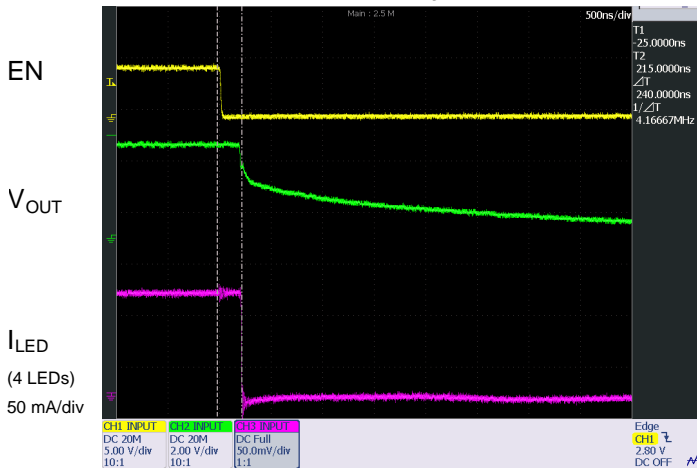
**LED Current vs. Input Voltage**



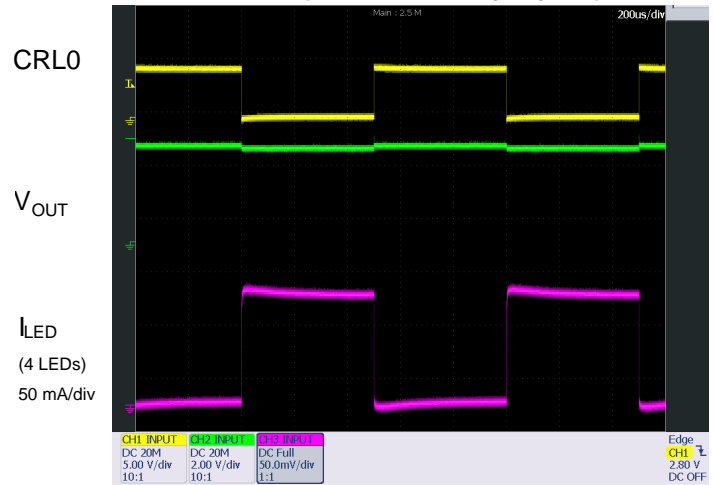
**Power-Up Delay Time**



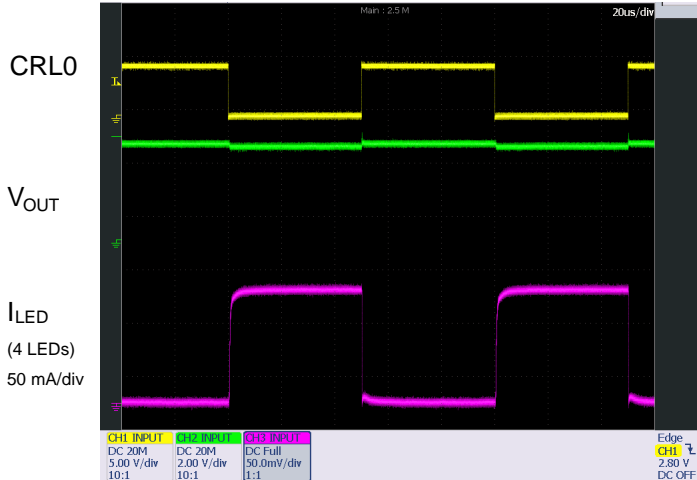
### Power-Down Delay Time



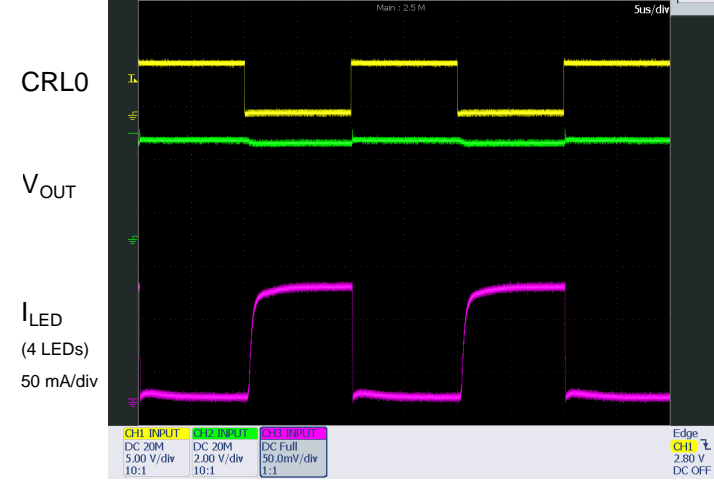
### PWM Mode (1 kHz, 50 Duty Cycle)



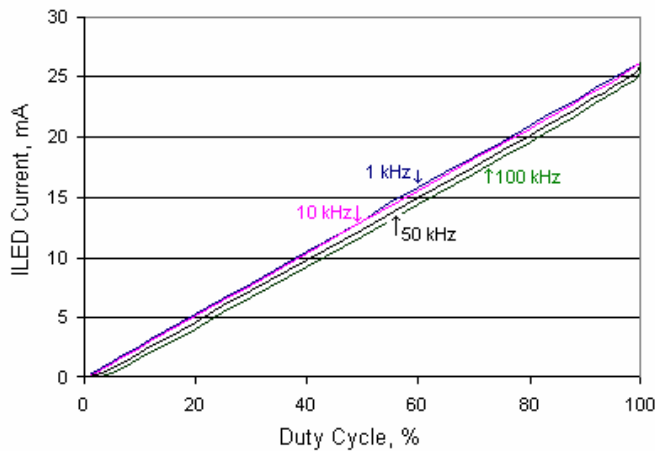
### PWM Mode (10 kHz, 50 Duty Cycle)



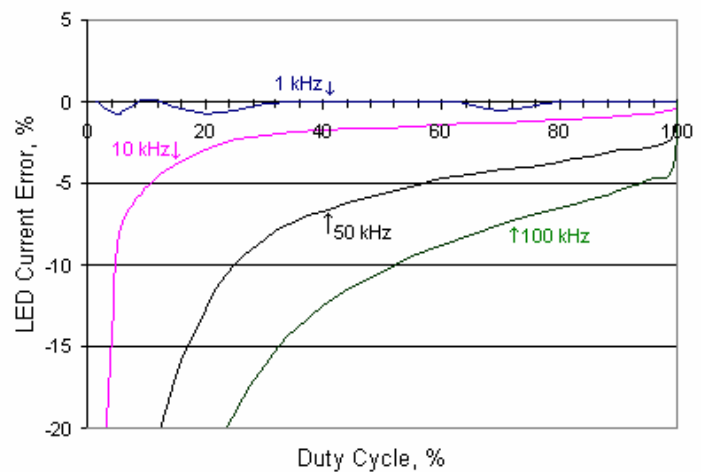
### PWM Mode (50 kHz, 50 Duty Cycle)



### I<sub>LED</sub> Current vs. Duty Cycle

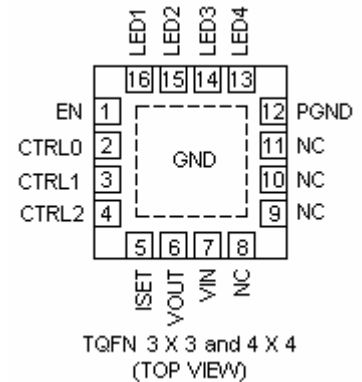


### I<sub>LED</sub> Current Error vs. Duty Cycle



## PIN DESCRIPTION

Pin #	Name	Function
1	EN	Device Enable.
2	CTRL0	Output Control Bit 0 (See Table Control Pin Function)
3	CTRL1	Output Control Bit 1 (See Table Control Pin Function)
4	CTRL2	Output Control Bit 2 (See Table Control Pin Function)
5	ISET	LED current setting pin
6	V <sub>OUT</sub>	Output voltage to the LED anodes
7	V <sub>IN</sub>	Input Voltage
8 - 11	NC	No internal connect
12	PGND	Power Ground
13	LED4	LED4 Cathode Terminal
14	LED3	LED3 Cathode Terminal
15	LED2	LED2 Cathode Terminal
16	LED1	LED1 Cathode Terminal
PAD	PAD	Connect to GND on the PCB



## PIN FUNCTION

**EN** is a Device Enable. This pin is high impedance. There should be a pull down resistor <100k when control signal is floating.

**CTRL0, CTRL1, CTRL2** are Output Control Bits (See Table 2) and PWM LED brightness control logic inputs. Guaranteed levels of logic high and logic low are set at 1.3 V and 0.4 V respectively. CTRL0 and CTRL1 pins are high impedance, and they should be pull down by resistor <100k when control signal is floating. CTRL2 pin has internal pull-up resistor ~100k.

**ISET** is a LED current setting pin. Resistor R<sub>SET</sub> connected from this pin to ground controls LED current. Connect this pin to ground directly for factory preset LED current value 30 mA.

**V<sub>IN</sub>** is the device supply pin. A small 1μF ceramic bypass capacitor is required between the V<sub>IN</sub> pin and ground at the device. The operating input voltage range is from 2.7 V to 5.5 V. Whenever the input

supply falls below the under-voltage threshold (2.2 V), all the LED channels are disabled, and the device enters shutdown mode.

**V<sub>OUT</sub>** is the charge pump output. Connect it to the LED anodes. A small 1μF ceramic bypass capacitor is required between the V<sub>OUT</sub> pin and ground near the device.

**GND** is the current regulators ground current source. Connect this pin to the ground plane on the PCB as close to the package as possible.

**LED1 – LED4** provide the internal regulated current sink for each of the LED cathodes. These pins enter a high-impedance zero current state when the device is in shutdown mode.

**PAD** is the exposed pad underneath the package. For best thermal performance, the tab should be soldered to the PCB and connected to the ground plane

## BLOCK DIAGRAM

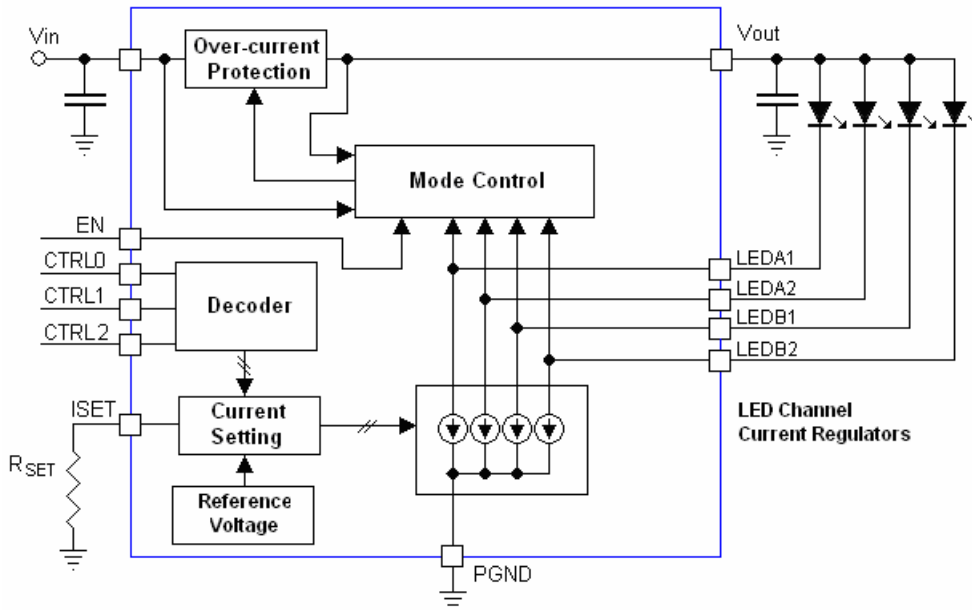


Figure 2. LDS8846 Functional Block Diagram

## BASIC OPERATION

The device starts operating if the EN pin is set logic HIGH and input voltage is higher than under voltage protection lockout threshold.

The low dropout PowerLite™ Current regulator performs well at input voltages up to 50 mV greater than the LED forward voltage significantly increasing the driver's efficiency.

Input pins EN, CTRL0, CTRL1, and CTRL2 may be either logic LOW or HIGH during power-up. However, logic voltage should never exceed input voltage  $V_{IN}$ , and these pins should not be left float.

### LED Current Setting

The desired current value in each of the four LED is set by external resistor  $R_{SET}$  connected between  $I_{SET}$  pin and ground.

The LED current is 400 times greater than the current through  $R_{SET}$  and can be estimated (in mA) by following equation:

$$I_{LED} = 400 \times \frac{V_{SET}}{R_{SET}}, \text{ where } V_{SET} = 1.2V, \text{ and } R_{SET} \text{ is}$$

its resistance in kohms.

$R_{SET}$  value for typical  $I_{LED}$  current is shown at the table below.

$I_{LED}$ , mA	$R_{SET}$ , k $\Omega$	Nearest standard 1% value
5	96	95.3
10	48	47.5
15	32	31.6 or 32.4
20	24	23.7 or 24.3
25	19.2	19.1
30	16	15.8 or 16.2

The average current value may be decreased using PWM signal applied to either CTRL0, CTRL1 or CTRL2 pin. The LDS8846 allows modulation frequencies in the range from 100 Hz to 5 kHz with duty cycles from 100% to 1% and from 5 kHz to 30 kHz with duty cycles from 100% to 10%. Modulation frequencies lower than 100 Hz are not recommended especially at short duty cycles because LED flicker may be visible.

If CTRL1 and CTRL2 pins are logic HIGH and PWM signal applies to CTRL0 pin, then all four LEDs are dimming synchronously.

If CTRL0 and CTRL2 pins are logic HIGH and PWM signal applies to CTRL1 pin, then LEDs from LED1 to LED3 are dimming, while LED4 is always off.

## Unused LED Channels

For applications with only two or three LEDs, unused LED can be disabled via the appropriate CTRL pins logic states. For applications requiring 1 LED only, the unused LED pins should be tied to  $V_{OUT}$ . However, we recommend use of all channels connecting them in parallel with accordingly decreased current per channel. If one LED is used only, current per channel should be decreased four times, or this device may drive one LED with maximum current up to 120 mA with all channels connected in parallel and 30 mA current per channel.

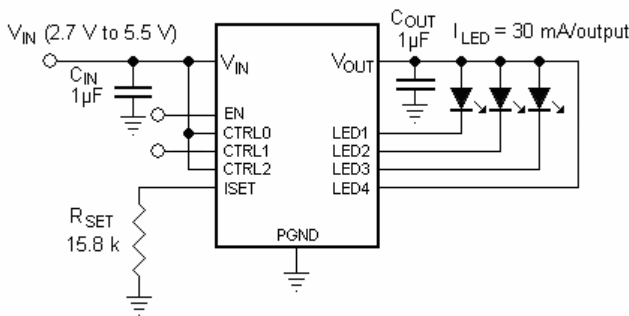


Figure 3. Application circuit with three LEDs

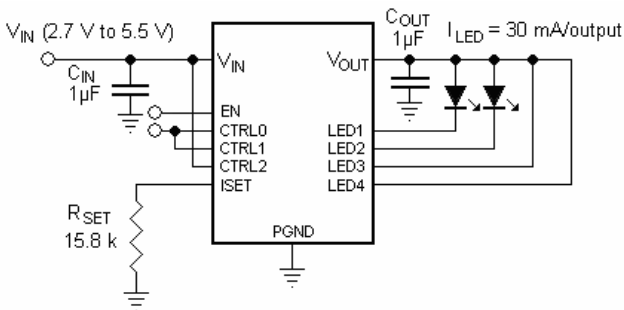


Figure 4. Application circuit with two LEDs

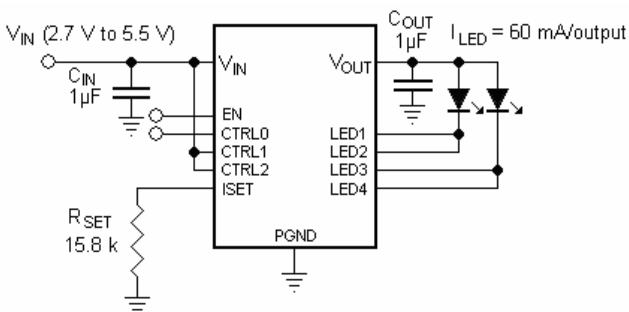


Figure 5. Application circuit with two LEDs

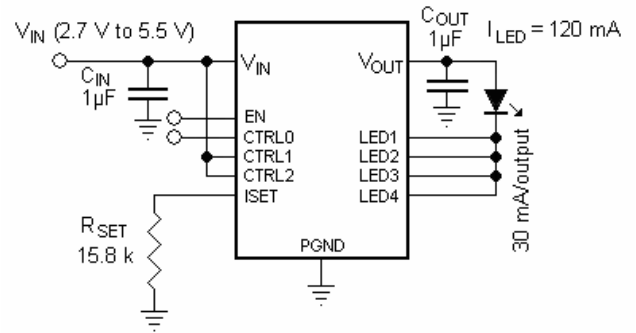


Figure 5. Application circuit with one LED

## Protection Mode

The LDS8846 limits output current if  $V_{OUT}$  pin is shorted to ground either before or after device start. This is to prevent the device from overload in case of short circuit at the output. Device resumes normal operation after short removed.

If the die temperature exceeds  $+150^{\circ}\text{C}$ , the driver will enter thermal protection shutdown mode. When the device temperature drops by about  $20^{\circ}\text{C}$ , the device resumes normal operation.

If the input voltage is below under-voltage protection threshold, device turns into shutdown mode with high impedance state at  $V_{OUT}$  and all LED pins.

## LED Selection

LEDs with forward voltages ( $V_F$ ) ranging from 1.3 V to 4.5 V may be used. The device exhibits the highest efficiency when  $V_F$  voltage is close to  $V_{IN}$ . If the voltage source is a Li-ion battery, we recommend selecting LEDs with  $V_F$  at least 50 mV below minimum expected battery discharging voltage to extend the battery life and achieve highest efficiency.

If the minimum battery discharging voltage is limited at 3 V, recommended  $V_F$  voltage is  $V_F = 3.0 - 0.05 = 2.95 \text{ V}$

## External Components

The driver requires only one external component – current setting resistor  $R_{SET}$ . However, if device is connected to the voltage source (battery) through long traces, or voltage source has high electrical noise due bad performance of other components connected to this source, we recommend 1µF decoupling capacitors at the  $V_{IN}$  and  $V_{OUT}$  pins located as close to the device as possible.

Power dissipates on  $R_{SET}$  resistor is less than  $100\mu\text{W}$  that allows use of very small surface mount component.

# LDS8846

## Recommended Layout

It is recommended to minimize trace length to decoupling capacitors. A ground plane should cover the area under the driver IC as well as the bypass capacitors. Short connection to ground on capacitors  $C_{IN}$  and  $C_{OUT}$  can be implemented with the use of multiple vias. A copper area matching the TQFN exposed pad (PAD) must be connected to the ground plane underneath. The use of multiple via improves the package heat dissipation.

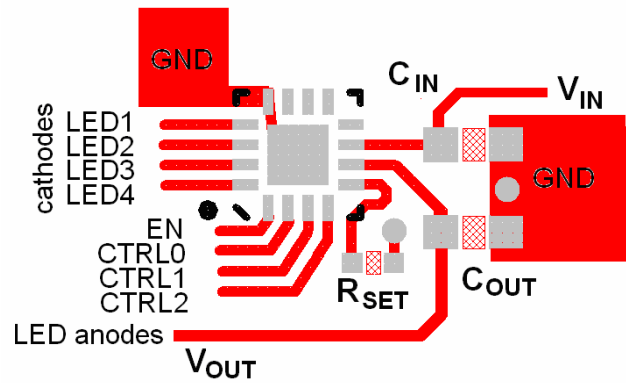
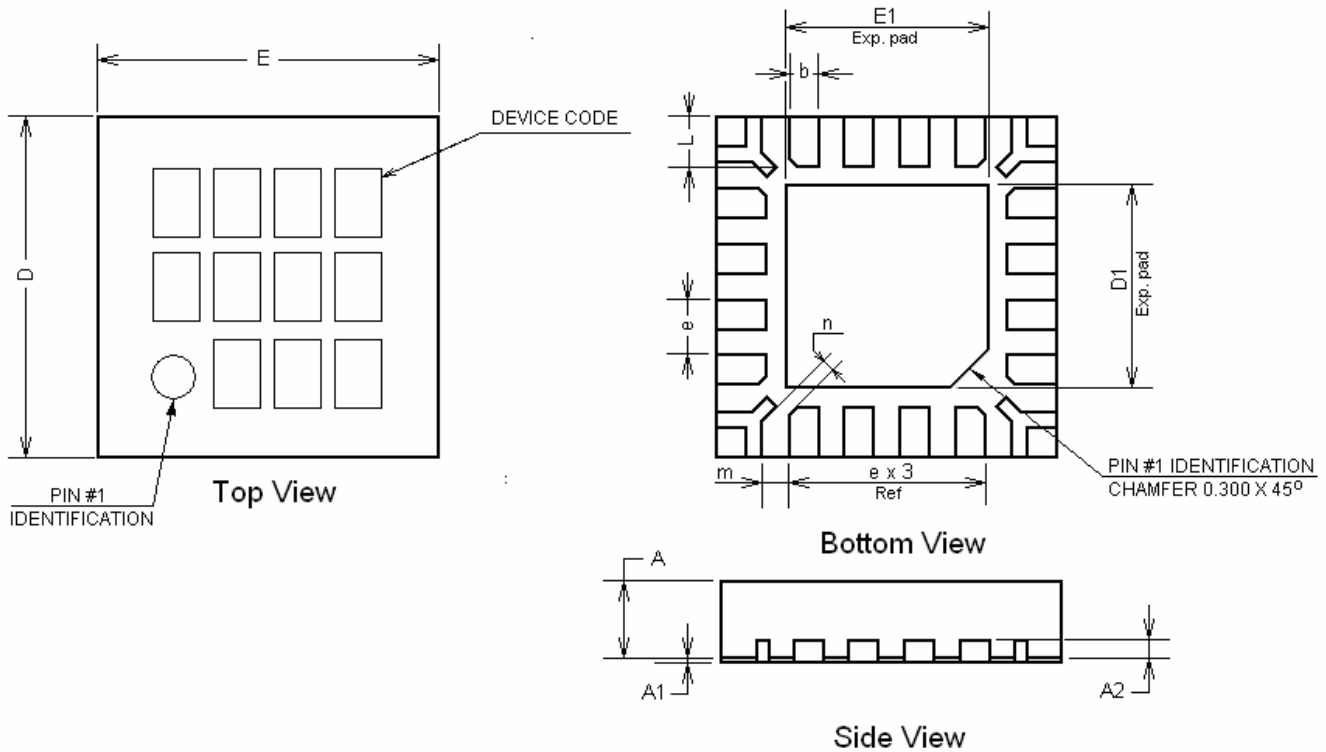


Figure 6. LDS8846 Recommended layout



## PACKAGE DRAWING AND DIMENSIONS

16-PIN TQFN, 3mm x 3mm, 0.5mm PITCH



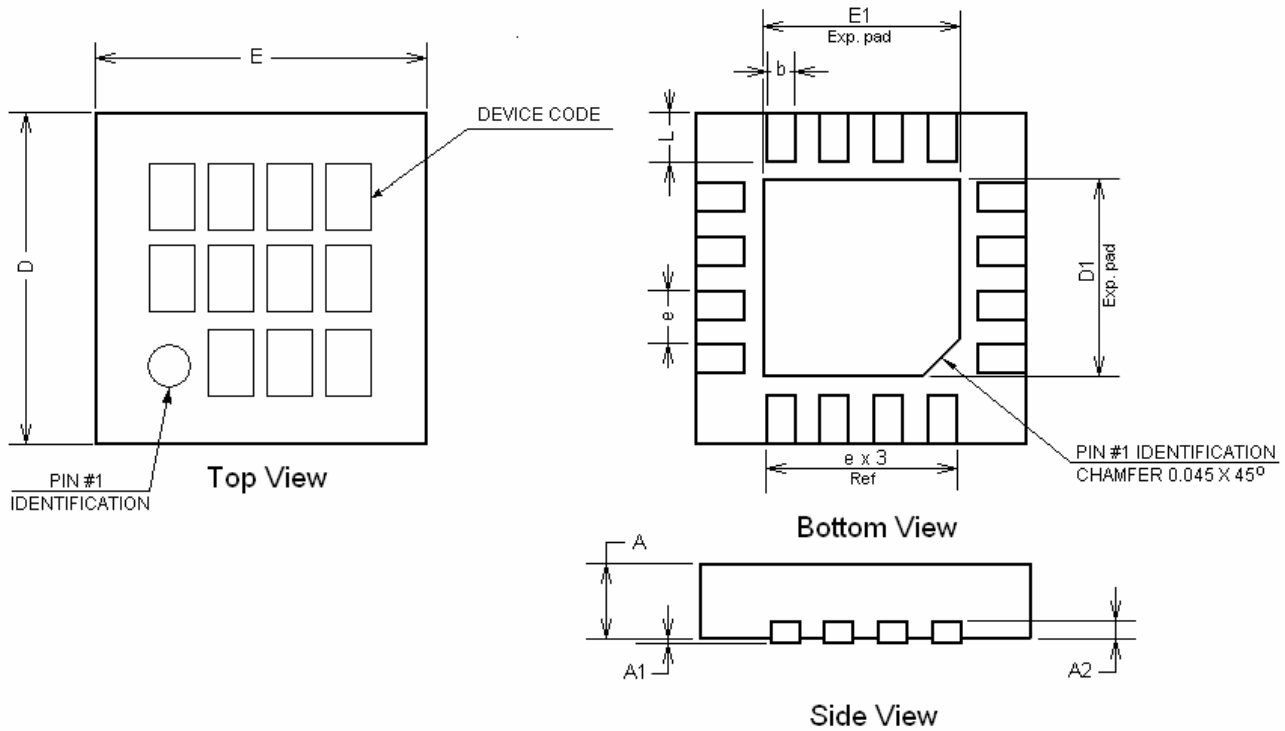
SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.178	0.203	0.228
b	0.20	0.25	0.30
D	2.95	3.00	3.05
D1	1.65	1.70	1.75
E	2.95	3.00	3.05
E1	1.65	1.70	1.75
e		0.50 typ	
L	0.325	0.375	0.425
m		0.150 typ	
n		0.225 typ	

Note:

1. All dimensions are in millimeters
2. Complies with JEDEC Standard MO-220

# LDS8846

## 16-PIN TQFN, 4mm x 4mm, 0.65mm PITCH



SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.178	0.203	0.228
b	0.28	0.33	0.38
D	3.90	4.00	4.10
D1	2.35	2.40	2.45
E	3.90	4.00	4.10
E1	2.35	2.40	2.45
e		0.65 typ	
L	0.55	0.60	0.65

**Note:**

- All dimensions are in millimeters
- Complies with JEDEC Standard MO-220

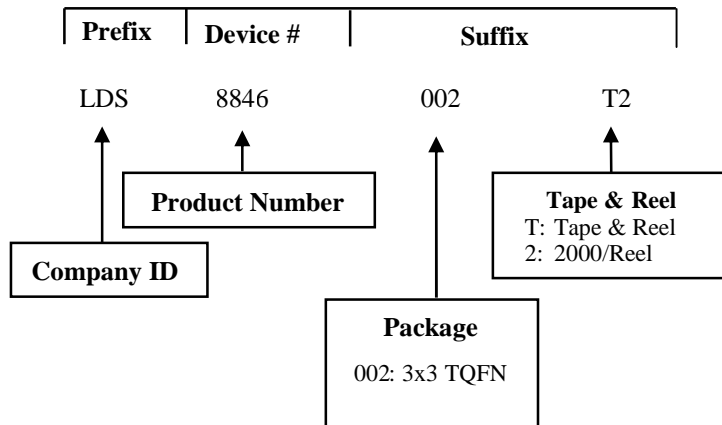
## ORDERING INFORMATION

Part Number	Package	Package Marking
LDS8846 002 -T2	TQFN-16 3 x 3 mm	8846
LDS8846 003 -T2	TQFN-16 4 x 4 mm	8846

**Notes:**

1. Matte-Tin Plated Finish (RoHS-compliant)
2. Quantity per reel is 2000

## EXAMPLE OF ORDERING INFORMATION



**Notes:**

- 1) All packages are RoHS-compliant (Lead-free, Halogen-free).
- 2) The standard lead finish is Matte-Tin.
- 3) The device used in the above example is a LDS8846 002-T2 (3x3 TQFN, Tape & Reel, 32/25/10.5 mA maximum current per LED bank).
- 4) For additional package and temperature options, please contact your nearest Leadis Technology Sales office.

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