

## ZXLD383

### Single or multi cell LED driver with enable/rectifier input for solar charged lamp applications

#### Description

##### Summary

The ZXLD383 is a single or multi cell LED driver designed for applications requiring step-up voltage conversion from a very low input voltage. The IC generates constant current pulses that are ideal for driving single or multiple LEDs over a wide range of operating voltages. It includes an on/off enable input that can be driven directly from a photocell array or an open collector/drain logic output. The enable input features an ultra-low voltage drop diode to ground, eliminating the need for a photocell array isolation diode in Garden Light applications.

The ZXLD383 uses a PFM control technique to drive an internal switching transistor which exhibits a low saturation resistance. This ensures high efficiency, even for input voltages as low as 1.0V.

The IC can start up under full load and operates down to an input voltage of below 0.9V.

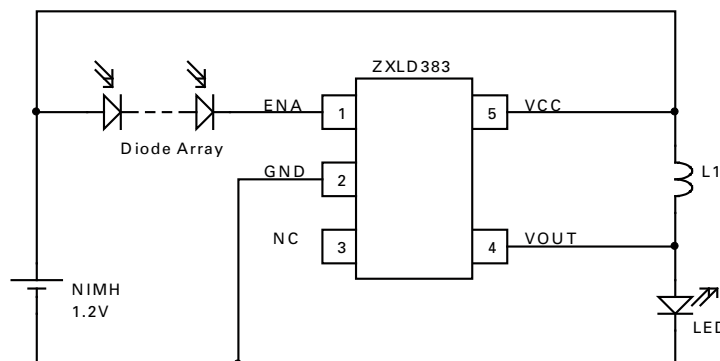
The ZXLD383 is offered in the space saving TSOT23-5 package or in die form, offering an excellent cost vs performance solution for single cell LED driving applications.

##### Features

- 85% efficiency
- User adjustable output current
- Single cell operation
- Low saturation voltage
- TSOT23-5 package
- Available also in die form
- Simple application circuit

##### Applications

- Garden lights
- Door/pathway illumination
- LED flashlight and torches
- LED backlights
- White LED driver
- Gated boost supply generator



## Absolute maximum ratings

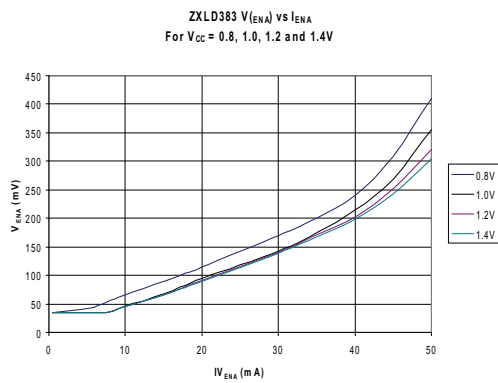
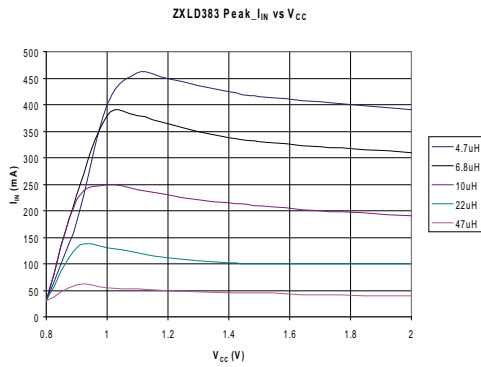
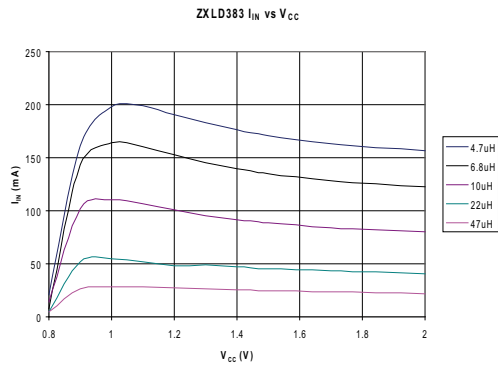
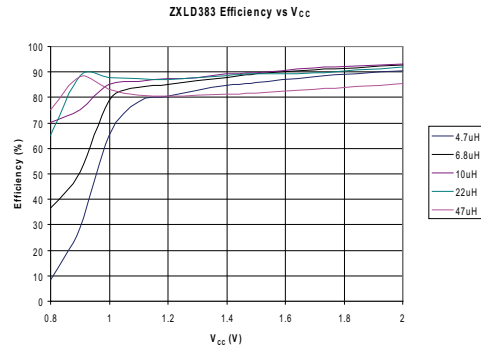
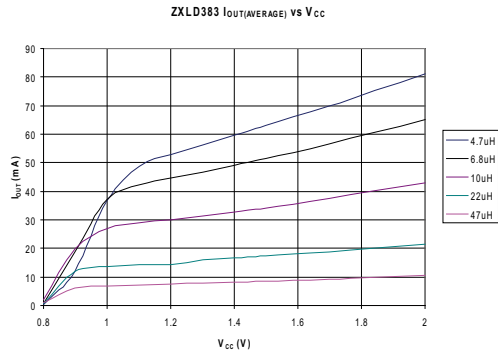
Supply Voltage (Vcc)	-0.6V to 6V
Output Voltage (Vout)	-0.6V to 20V
Enable Voltage (Vena)	-1V to 3.5V
Supply Current	20mA
Output Switch Current	800mA
Power Dissipation (TSOT23-5)	450mW
Power Dissipation Die	1W
Operating Temperature Range	-20°C to +85°C
Storage Temperature Range	-55°C to +150°C

## Electrical Characteristics

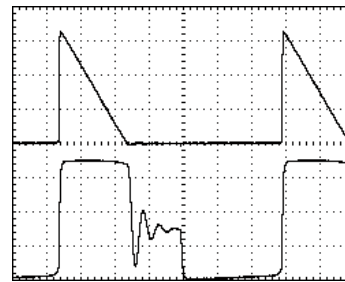
Measured at  $T_{AMB} = 25^{\circ}\text{C}$ ,  $L = 6.8\mu\text{H}$ ,  $I_{ENA} = 0$  and  $V_{CC} = 1.5\text{V}$  unless otherwise specified.

Parameter	Conditions	Limits			Units
		Min	Typ	Max	
Supply Voltage Operating Range	$L = 10\mu\text{H}$	0.9		3.3	V
Minimum Supply Start-up Voltage	$L = 10\mu\text{H}$		0.8	0.9	V
Supply Current Quiescent		2	4	8	mA
Supply Current Shutdown	$V_{ENA} = V_{CC} - 0.8\text{V}$		17	30	uA
Supply Current Under-Voltage	$V_{CC} = 0.6\text{V}$			20	uA
Switch Current	At turn-off	250	320	400	mA
Switch Saturation Voltage	$I_{OUT} = 200\text{mA}$		100	300	mV
Switch Leakage Current	$V_{OUT} = 20\text{V}$ , $V_{ENA} = 0\text{V}$			10	uA
Mean LED Current	$V_{LED} = 3.5\text{V}$	40	50	65	mA
Efficiency	$V_{LED} = 3.5\text{V}$		85		%
Operating Frequency	$V_{LED} = 3.5\text{V}$		330		kHz
Discharge Pulse Width		0.7	1.5	2.5	us
Enable Input Threshold		$V_{CC} - 0.8$	$V_{CC} - 0.6$	$V_{CC} - 0.2$	V
Enable Input Current	$V_{ENA} = 0.2\text{V}$	0	-11	-20	uA
Enable Input Voltage	$I_{ENA} = -20\text{mA}$	0	-90	-250	mV

## Typical characteristics



**ZXLD383 Operating Waveforms for L = 6.8μH, V<sub>CC</sub> = 1.5V**



Channel -1 (Upper): I<sub>LED</sub>@ 100mA/cm  
Channel -2 (Lower): V<sub>OUT</sub>@ 1V/cm  
Timebase: 500ns/cm

Note V<sub>LED</sub> = 3.5V for all graphs

## Device description

The ZXLD383 is a simple PFM, DC-DC controller combined with a high performance internal switching transistor, enabling the production of a high efficiency boost converter for use in single cell applications. It includes a dual function Enable input which serves both as an operation inhibit control and an ultra-low voltage drop isolation diode for battery charging purposes in Garden Light applications. A block diagram is shown for the ZXLD383 in Figure 1.

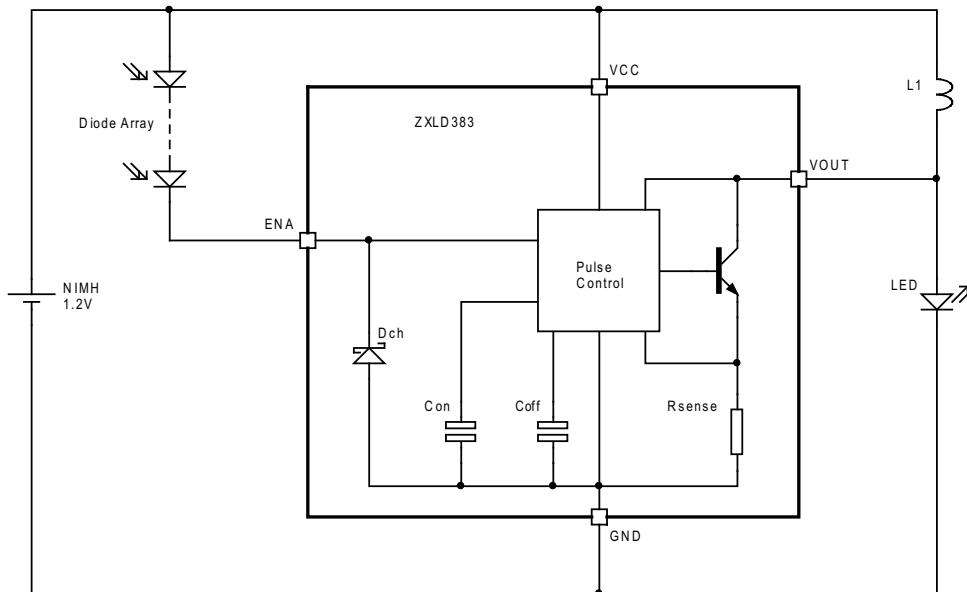


Figure 1 - ZXLD383 block diagram

With power applied and the enable pin held at  $V_{CC}$ , an oscillator within the pulse control block forces the internal switching transistor to switch on to start an energy charge cycle. The low saturation voltage switch pulls the  $V_{OUT}$  pin close to ground which forces the supply voltage across the external inductor L1. This causes a current to build up, storing energy in the inductor. During this phase, switch current and supply voltage are monitored and used by the pulse control circuit to determine the optimum drive conditions and on-time. At the end of the energy charge cycle, the internal switch is turned off rapidly, interrupting the current flow through L1 which causes the voltage on  $V_{OUT}$  to rise dramatically. When the voltage on  $V_{OUT}$  reaches the load LED's forward (on) voltage, the inductor current is transferred from the internal switch to the LED, starting the energy discharge cycle. With the voltage across the inductor reversed, the current flowing through it (and the LED) now falls. When the inductor current reaches zero, the voltage on the  $V_{OUT}$  pin falls back towards  $V_{CC}$ . This action is sensed by the pulse control circuit and is combined with the output of an off-period timer to initiate the next energy charge cycle. Except for low level losses, all the energy stored in the inductor during a charge cycle is channelled to the load LED during the following discharge cycle.

The current fed into the load LED has a sawtooth waveform, the average (DC) value of which is kept constant by the pulse control circuit for varying supply voltage and temperature. It is possible to change the output current given by the ZXLD383 by changing the value of inductor L1. The larger the inductance of L1, the lower the output current. A table/graph showing the relationship between inductance and output current is given later in this datasheet. Since the

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output current of the ZXLD383 is a sawtooth waveform, its peak value is substantially larger than the DC/average value. The table also provides this data.

The internal switching transistor has a minimum collector-emitter breakdown voltage of 20V and this sets the maximum load voltage allowable. The minimum value is set by a feature of the pulse control circuit that requires the load voltage to be at least 0.5V greater than  $V_{CC}$ . (The device will function with load voltages smaller than this but output current regulation will be impaired.) Higher than nominal load voltages will lower the average (DC) output current generated for a given inductor value.

The Enable pin inhibits the operation of the output switch if held at a potential of  $V_{CC}-0.8V$  or lower. It also includes a diode to ground which allows the input to be wired directly to a photocell array that will then both enable operation of the converter when in darkness and charge the IC's power source in daylight conditions. The diode function is performed by an active circuit that gives an ultra low forward voltage drop (typically less than 0.1V at 20mA). This allows the use of a lower output voltage photocell array (lower cost) without degrading performance.

## Application Examples

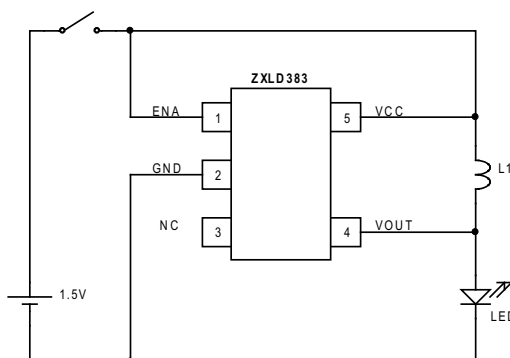
Apart from the Garden Light application circuit shown on the front page of this datasheet, the ZXLD383 may be used in many other ways. The following circuits and notes show some other possibilities and give typical performance details.

### Standard operating mode

The following circuit demonstrates how few components are required to produce a light source using the ZXLD383. Operating from a single cell, this simple circuit is suited for use in car key fobs, novelty products etc. where small size and low cost are critical aspects.

By directly wiring the Ena pin to  $V_{CC}$ , the part is permanently enabled once a power supply is provided. The ZXLD383 is highly tolerant of supply ripple so no decoupling of  $V_{CC}$  should be needed in a compactly constructed circuit. Also, the part's capability of operating with a  $V_{CC}$  below 0.9V means that this simple circuit will make the best use of available battery capacity.

The attached table shows the average LED currents that can be obtained using a range of inductor values. Also shown are the peak currents required to achieve the given currents.

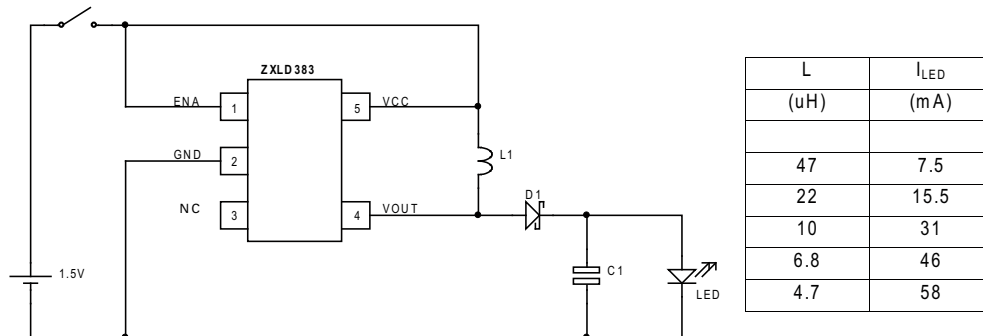


L ( $\mu H$ )	$I_{LED(peak)}$ (mA)	$I_{LED(avg)}$ (mA)
47	45	8.5
22	100	17.3
10	210	34
6.8	330	50
4.7	415	63

Note  $V_{LED} = 3.5V$

## Low ripple LED current mode

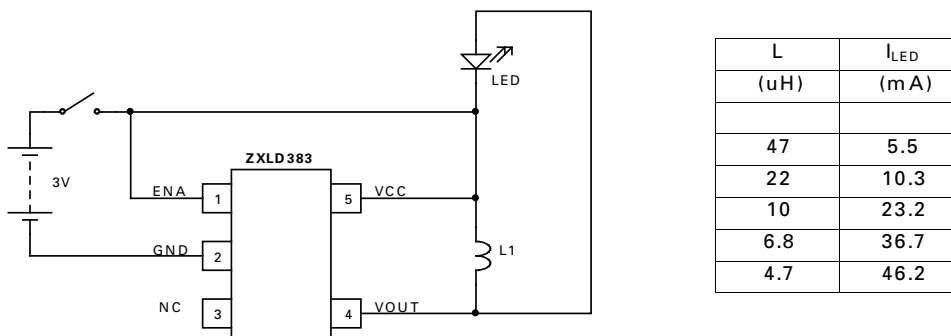
It is possible that the peak LED current required to achieve a given average current is either too high for the LED of choice or it leads to some loss of efficiency (due to LED resistance losses). In these cases, just two extra low cost components can be added to provide a low ripple current supply for the LED. The Schottky diode D1 and capacitor C1 rectifies and smoothes the output of the ZXLD383 giving a low ripple current supply to the load LED. Of course, this circuit could also be used to power loads other than LEDs.



Note:  $V_{LED} = 3.5V$ , D1=ZHCS1000, C1 = 1uF (low ESR)

## Buck-boost mode

Simple boost converters can run into problems when the input supply voltage is similar to or exceeds the intended load voltage as there is usually a direct current path from the power source through to the load via the boost inductor. This path does not require switching action and so is uncontrolled. When using the ZXLD383, this problem can be avoided by wiring the cathode of the load LED to Vcc rather than ground. Without switching action, the LED is reverse-biased and so no current can flow. When switching, the anode of the LED is driven to  $V_{cc} + V_f(led)$ . The higher than normal output voltage reduces the available output current as described earlier and this is shown in the typical data provided.

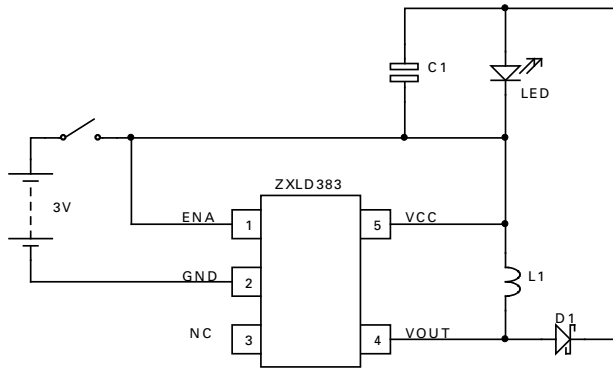


Note:  $V_{LED} = 3.5V$

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## Low ripple buck-boost mode

The output of the Buck-Boost converter can be rectified and smoothed as with the standard circuit to give a low ripple output to improve LED efficiency or to give a DC output for other loads.



L ( $\mu$ H)	$I_{LED}$ (mA)
47	5
22	9.7
10	21.7
6.8	34
4.7	43

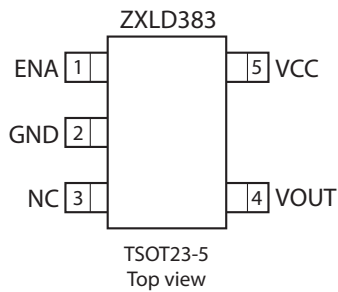
Note:  $V_{LED} = 3.5V$ ,  $D1 = ZHCS1000$ ,  $C1 = 1\mu F$  (low ESR)

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## Pin descriptions

Pin No.	Name	Description
1	ENA	Enable / Photodiode array battery charge input
2	GND	Ground
3	NC	Not connected (internally open circuit)
4	VOUT	Switch output external inductor/LED
5	VCC	Supply voltage, generally Alkaline, NiMH or NiCd single cell

## Pinout diagram

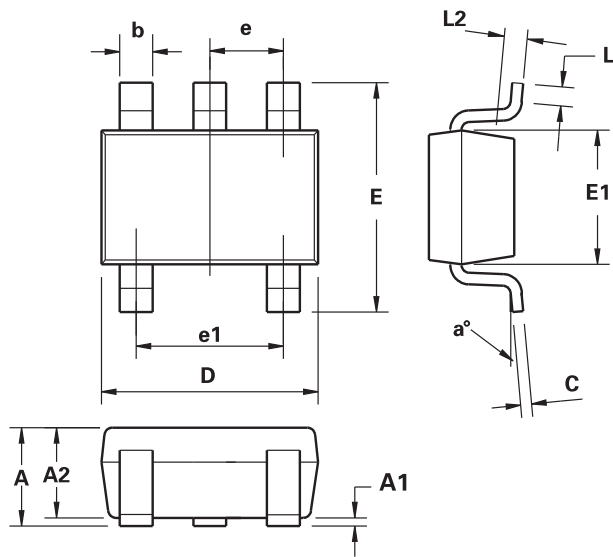


## Ordering information

Device	Reel size (inches)	Reel width (mm)	Quantity per reel	Device mark
ZXLD383ET5TA	7"	8	3,000	383



## Packaging information - TSOT23-5



Dim.	Millimeters		Inches		Dim.	Millimeters		Inches	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
A	-	1.00	-	0.0393	E1	1.60 BSC		0.062 BSC	
A1	0.01	0.10	0.0003	0.0039	e	0.95 BSC		0.037 BSC	
A2	0.84	0.90	0.0330	0.0354	e1	1.90 BSC		0.074 BSC	
b	0.30	0.45	0.0118	0.0177	L	0.10	0.60	0.0039	0.0236
C	0.12	0.20	0.0047	0.0078	L2	0.25 BSC		0.010 BSC	
D	2.90 BSC		0.114 BSC		Q	4°	12°	4°	12°
E	2.80 BSC		0.110 BSC						

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The Americas	Europe	Taiwan	Shanghai	Shenzhen	Korea
3050 E. Hillcrest Drive Westlake Village, CA 91362-3154 Tel: (+1) 805 446 4800 Fax: (+1) 805 446 4850	Kustermann-Park Balanstraße 59, D-81541 München Germany Tel: (+49) 894 549 490 Fax: (+49) 894 549 4949	7F, No. 50, Min Chuan Road Hsin-Tien Taipei, Taiwan Tel: (+886) 289 146 000 Fax: (+886) 289 146 639	Rm. 606, No.1158 Changning Road Shanghai, China Tel: (+86) 215 241 4882 Fax (+86) 215 241 4891	ANLIAN Plaza, #4018 Jintian Road Futian CBD, Shenzhen, China Tel: (+86) 755 882 849 88 Fax: (+86) 755 882 849 99	6 Floor, Changhwa B/D, 1005-5 Yeongtong-dong, Yeongtong-gu, Suwon-si, Gyeonggi-do, Korea 443-813 Tel: (+82) 312 731 884 Fax: (+82) 312 731 885