

# ZXLD1366EV2 USER GUIDE

## DESCRIPTION

The ZXLD1366EV2, Figure 1, is a PCB constructed using an aluminium base for evaluating the ZXLD1366 LED driver with internal switch, in DFN633 package [1]. The evaluation board can be used to drive an external choice of LEDs; the total forward voltage across the LEDs depending on the number and type connected.

The operating voltage is nominally higher than 30V for the external LEDs, and can be raised to 60V maximum, which will reduce the supply current.

Please refer to the Zetex ZXLD1360 and ZXLD1350 products for applications requiring input voltages lower than 30V.

The nominal current for the evaluation board is set at 1A with a  $0.2\Omega$  sense resistor, R1.

The 150uH inductor used in the circuit is based on a 30V nominal supply, which should be connected across +VIN and GND pins.

Test point 'ADJ' provides a connection point for DC or PWM dimming and shutdown.

**Note:** The evaluation board does not have reverse polarity protection

Warning: with 1A output, the connected LED will be hot and very bright

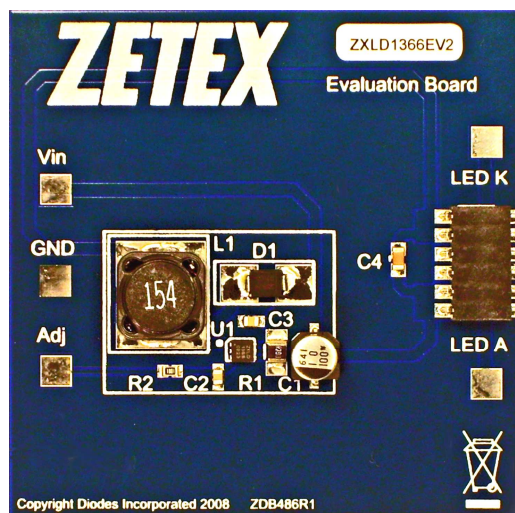


Figure 1: ZXLD1366EV2 evaluation board

## ZXLD1366 DEVICE DESCRIPTION

The ZXLD1366 is a continuous mode inductive driver both in a TSOT23-5 package and DFN633 package, for driving one or more series connected LEDs efficiently from a voltage source higher than the LED voltage. The device includes the output switch and a current sense circuit, which requires an external sense resistor to set the nominal current up to 1A.

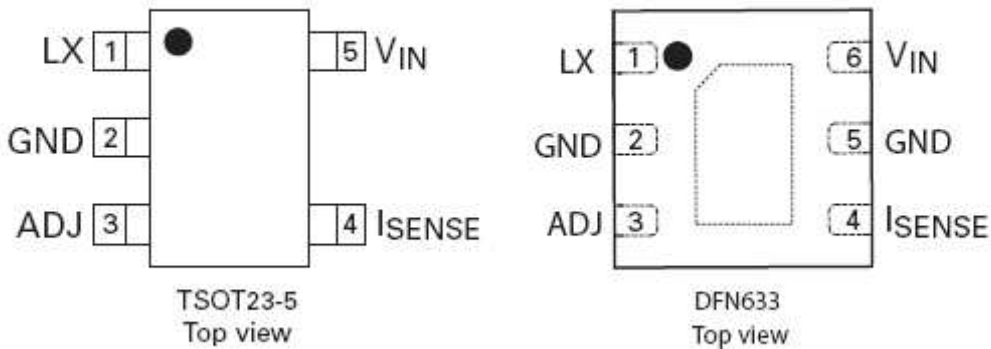
### ZXLD1366 DEVICE FEATURES

- Typical accuracy better than 0.8%
- Enhanced thermal capability in DFN633 package
- Drives one or more series-connected LEDs
- LEDs up to 1A.
- Internal 60V switch.
- Wide input voltage: 7V to 60V.
- Inherent open circuit LED protection.
- Brightness control using DC or PWM.
- Internal PWM filter.

### DEVICE APPLICATIONS

- LED flashlights.
- High Power LED driving.
- Low-voltage halogen replacement LEDs.
- Automotive lighting.
- Illuminated signs.

## ZXLD1366 Device Packages, Pin and Definitions



### TSOT23-5 and DFN633 package options

#### ZXLD1366 Device Pin Definition

Name	Pin No	Description
LX	1	Drain of NDMOS switch.
GND	2	Ground (0V).
ADJ	3	Internal voltage ref. pin (1.25V) : <ul style="list-style-type: none"> <li>• Leave floating for normal operation.</li> <li>• Connect to GND to turn off output current.</li> <li>• Drive with a DC voltage (0.3V to 1.25V) or with a PWM signal to adjust output current</li> <li>• Connect a capacitor from this pin to ground to set the soft-start time.</li> </ul>
ISENSE	4	Connect a sense resistor, $R_s$ , from the ADJ pin to VIN to sense the nominal output current. Nominal $I_{out} = 0.2 / R_1$
VIN	5	Input voltage: 6V to 60V. Decouple to ground with a 100nF and a 10uF or higher ceramic capacitor depending on the input voltage[1].

#### ORDERING INFORMATION

EVALBOARD ORDER NUMBER
ZXLD1366EV2

DEVICE ORDER NUMBER
ZXLD1366DAC
ZXLD1366E5TA

Please note: Evaluation boards are subject to availability and qualified leads.

#### ZXLD1366EV2 EVALUATION BOARD REFERENCE DESIGN

The ZXLD1366EV2 is an evaluation board configured to be used with the ZXLD1366 in DFN633 package, as in Figure 2. The target application is a driver for one or more series-connected LEDs for luminaires in both commercial and automotive applications.

The maximum operating voltage is 60V, and the nominal current is set at 1A with a 0.2Ω sense resistor R1. The device operates in continuous mode at approximately 70kHz, with a 150uH inductor, when the system drives a single LED.

An accurate way of determining the current, avoiding the need to insert an ammeter in the current path, is to measure the voltage on the sense resistor. A 10K resistor and a 1uF capacitor can be used to form a low pass filter and the voltage across the capacitor represents a more stable dc reading of current. Using this method, 200mV represents 1Amp when using a 0.2Ω sense resistor.

The ADJ pin connects to a low pass filter within the ZXLD1366 chip to provide some decoupling, but the external capacitor C2 (100nF) is used to provide additional decoupling to reduce any high frequency noise as well as enabling the soft start function.

Both DC and PWM dimming can be achieved by driving the ADJ pin. For DC dimming, the ADJ pin may be driven between 0.3V and 1.25V. Driving the ADJ pin below 0.2V will shut down the output current. For PWM dimming, an external open-collector NPN transistor or open-drain N-channel MOSFET can be used to drive the ADJ pin. The PWM frequency can be low, around 100Hz to 1 kHz, or high between 10 kHz to 50 kHz. For low frequency, PWM capacitor C2 should be removed on the evaluation board, to give a more accurate duty cycle.

Shorting R2 will connect the test pin ADJ to device pin ADJ if needed.

The external capacitor C2 on the ADJ pin sets the soft start time. The amount of soft start time achievable is approximately 0.1ms/nF.

For other reference designs or further applications information, please refer to the ZXLD1366 datasheet.

## Schematic Diagram

Figure 2 shows the schematic for the ZXLD1366EV2 evaluation board.

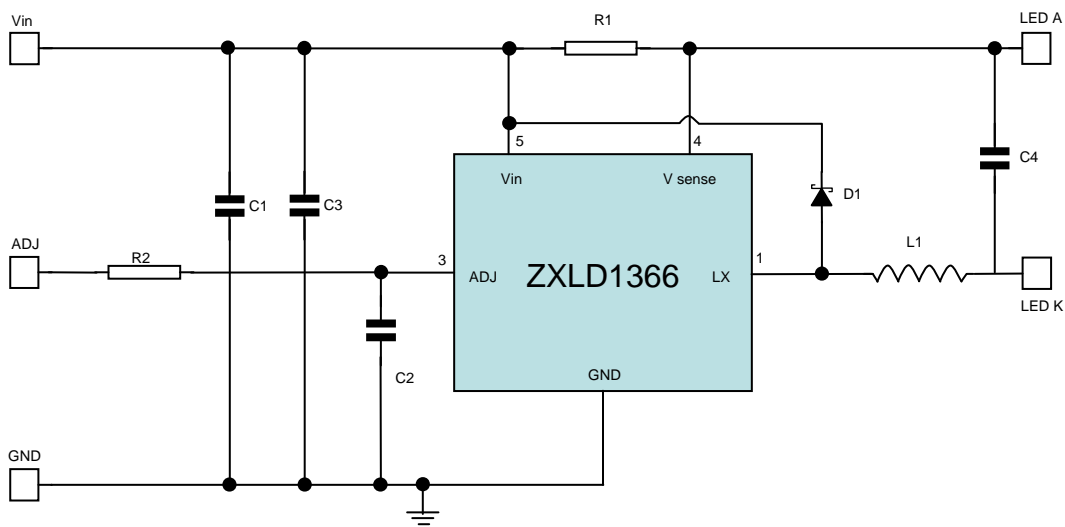


Figure 2: Schematic for the evaluation board ZXLD1366EV2

## ZXLD1366 Operation

In normal operation, when voltage is applied at +VIN, the ZXLD1366 internal NDMOS switch is turned on. Current starts to flow through sense resistor R1, inductor L1, and the LEDs. The current ramps up linearly, and the ramp rate is determined by the input voltage +VIN and the inductor L1. This rising current produces a voltage ramp across R1. The internal circuit of the ZXLD1366 senses the voltage across R1 and applies a proportional voltage to the input of the internal comparator. When this voltage reaches an internally set upper threshold, the NDMOS switch is turned off. The inductor current continues to flow through R1, L1, the LEDs, the Schottky diode D1, and back to the supply rail, but it decays, with the rate of decay determined by the forward voltage drop of the LEDs and the Schottky diode. This decaying current produces a falling voltage at R1, which is sensed by the ZXLD1366. A voltage proportional to the sense voltage across R1 is applied at the input of the internal comparator. When this voltage falls to the internally set lower threshold, the NDMOS switch is turned on again. This switch-on-and-off cycle continues to provide an average current (set by the sense resistor R1) to the LEDs. Please refer to the datasheet for the threshold limits, ZXLD1366 internal circuits, electrical characteristics and parameters.

**ZXLD1366EV2 Evaluation Board - BOM**

Ref	Value	Package	Part Number	Manufacturer	Notes
R1	0.2R	1210	SR732ETTDR200F	KOA	1%, 100ppm
R2	1kΩ	0805	Generic	-	-
C1	10uF 100V	SMD	NACEW100M1006.3x8TR13F	NIC	Electrolytic - 20%
C2,C3	100nF, 100V	0805	NMC0805X7R104K100TRPLPF	NIC	20%
C4	100nF 100V	1206	NMC1206X7R104K100TRPLP3KF	NIC	
L1	150uH	-	MSS1246-154ML NPIS27H151LTRF	Coilcraft NIC	150uH
D1	100V, 2A	SMB	B2100	DIODES inc	Schottky diode
U1	ZXLD1366	DFN633	ZXLD1366DAC	ZETEX	DC-DC converter

The Aluminium PCB design guarantees a good thermal dissipation for the ZXLD1366 device. Other sources of heat are the Schottky diode, the inductor and the sense resistor. Care must be taken in their placement.

**Warning: At 60V operation with 500mA output, the board temperature rises by around 50C from ambient after 30 minutes of operation.**

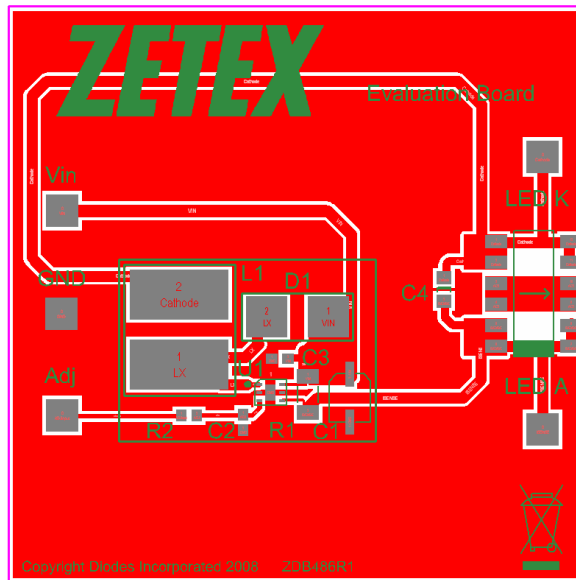


Figure 3: Component layout and circuit board view

ZXLD1366EV2 Connection Point Definition	
Name	Description
+VIN	Positive supply voltage.
GND	Supply Ground (0V).
ADJ	Internal voltage ref. pin (1.25V). This pin can be used to achieve dimming and soft-start, and for switching the output current off. <ul style="list-style-type: none"> <li>• Leave floating for normal operation.</li> <li>• See 'Circuit Features' section to achieve dimming, soft-start and for switching the output current off.</li> </ul>
LED A	LED A connects to the external LED anode
LED K	LED K connects to the external LED cathode

## ZXLD1366EV2 Basic operation at full voltage

1. Connect external LEDs across test pins 'LED A' (anode) and 'LED K' (cathode). The number of external LEDs that can be connected depends on their operating power and forward voltage drop, but typically 16 x 3.4V LEDs can be connected using a 60V rail. For an external load other than LEDs, the positive terminal of the load should be connected the anode and the negative to the cathode.
2. Connect VIN and GND.

Warning: The board does not feature reverse battery/supply protection.

3. Set the PSU to the desired input voltage (usually between 30V and 60V)
4. Turn on the PSU. The external LEDs will illuminate and the current should be approximately 1A
5. LX waveforms can be acquired using the test point J1

Warning: Do not stare at the LEDs directly.

## Circuit features

### N.B. Remove power whilst changing components!

#### Soft-start

1. The evaluation board is fitted with capacitor C2, which performs the soft start function by slowing the rise time of the adjust pin at start-up. The pin output impedance is 50K so CxR is the time constant to reach 66% of output current.

#### PWM

1. Remove the soft start capacitor C2
2. Refer to the datasheet for how to perform PWM

#### Switching off the output current

3. Shorting the ADJ pin to GND will cause the LED current to go to zero. Releasing this pin will switch on the system (creating a soft-start power up sequence if the C2 capacitor is used).

#### Changing the LED current

1. Remove R1
2. Calculate and fit a new sense resistor, R1, the value of which is based on the required LED current without dimming. R1 can be calculated using following equation :

$R1 = 0.2(V / I_{OUT})$  where  $I_{OUT}$  = the LED current.  
R1 = the sense resistor value in ohms.  
0.2V is the nominal sense voltage with ADJ open circuit or set to 1.25V.

## PERFORMANCE

The system efficiency depends on the sense resistor, supply voltage, switching inductor, and the number of LEDs.

With a 60V supply and 15 LEDs, using an inductor of 150uH, the switching frequency is typically 100 kHz and efficiency levels >94% are achievable.

Visit our website [www.zetex.com](http://www.zetex.com) to find useful tools for circuit design and simulation.

## REFERENCE

[1] ZXLD1366 Datasheet – [www.zetex.com](http://www.zetex.com)



## Definitions

### Product change

Diodes Incorporated reserves the right to alter, without notice, specifications, design, price or conditions of supply of any product or service. Customers are solely responsible for obtaining the latest relevant information before placing orders.

### Applications disclaimer

The circuits in this design/application note are offered as design ideas. It is the responsibility of the user to ensure that the circuit is fit for the user's application and meets with the user's requirements. No representation or warranty is given and no liability whatsoever is assumed by Diodes Inc. with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Diodes Inc. does not assume any legal responsibility or will not be held legally liable (whether in contract, tort (including negligence), breach of statutory duty, restriction or otherwise) for any damages, loss of profit, business, contract, opportunity or consequential loss in the use of these circuit applications, under any circumstances.

### Life support

Diodes Zetex products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

- A. Life support devices or systems are devices or systems which:
1. are intended to implant into the body
- or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.
- B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

### Reproduction

The product specifications contained in this publication are issued to provide outline information only which (unless agreed by the company in writing) may not be used, applied or reproduced for any purpose or form part of any order or contract or be regarded as a representation relating to the products or services concerned.

### Terms and Conditions

All products are sold subjects to Diodes Inc. terms and conditions of sale, and this disclaimer (save in the event of a conflict between the two when the terms of the contract shall prevail) according to region, supplied at the time of order acknowledgement. For the latest information on technology, delivery terms and conditions and prices, please contact your nearest Diodes sales office.

### Quality of product

Diodes Zetex Semiconductors Limited is an ISO 9001 and TS16949 certified semiconductor manufacturer. To ensure quality of service and products we strongly advise the purchase of parts directly from Zetex Semiconductors or one of our regionally authorized distributors. For a complete listing of authorized distributors please visit: [www.zetex.com](http://www.zetex.com) or [www.diodes.com](http://www.diodes.com). Diodes Zetex Semiconductors does not warrant or accept any liability whatsoever in respect of any parts purchased through unauthorized sales channels.

### ESD (Electrostatic discharge)

Semiconductor devices are susceptible to damage by ESD. Suitable precautions should be taken when handling and transporting devices. The possible damage to devices depends on the circumstances of the handling and transporting, and the nature of the device. The extent of damage can vary from immediate functional or parametric malfunction to degradation of function or performance in use over time. Devices suspected of being affected should be replaced.

### Green compliance

Diodes Zetex Semiconductors is committed to environmental excellence in all aspects of its operations which includes meeting or exceeding regulatory requirements with respect to the use of hazardous substances. Numerous successful programs have been implemented to reduce the use of hazardous substances and/or emissions.

All Diodes Zetex components are compliant with the RoHS directive, and through this it is supporting its customers in their compliance with WEEE and ELV directives.

### Product status key:

"Preview"	Future device intended for production at some point. Samples may be available
"Active"	Product status recommended for new designs
"Last time buy (LTB)"	Device will be discontinued and last time buy period and delivery is in effect
"Not recommended for new designs"	Device is still in production to support existing designs and production
"Obsolete"	Production has been discontinued

### Datasheet status key:

"Draft version"	This term denotes a very early datasheet version and contains highly provisional information, which may change in any manner without notice.
"Provisional version"	This term denotes a pre-release datasheet. It provides a clear indication of anticipated performance. However, changes to the test conditions and specifications may occur, at any time and without notice.
"Issue"	This term denotes an issued datasheet containing finalized specifications. However, changes to specifications may occur, at any time and without notice.

## Sales offices

### The Americas

3050 E. Hillcrest Drive  
Westlake Village,  
CA 91362-3154  
Tel: (+1) 805 446 4800  
Fax: (+1) 805 446 4850

### Europe

Kustermannpark  
Balanstraße 59,  
D-81541 München  
Germany  
Tel: (+49) 894 549 490  
Fax: (+49) 894 549 4949

### Taiwan

7F, No. 50,  
Min Chuan Road  
Hsin-Tien  
Taipei, Taiwan  
Tel: (+886) 289 146 000  
Fax: (+886) 289 146 639

### Shanghai

Rm. 606, No.1158  
Changning Road  
Shanghai, China  
Tel: (+86) 215 241 4882  
Fax (+86) 215 241 4891

### Shenzhen

Room A1103-04,  
ANLIAN Plaza, #4018  
Jintian Road  
Futian CBD,  
Shenzhen, China  
Tel: (+86) 755 882 849 88  
Fax: (+86) 755 882 849 99

### Korea

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