DN78
ZXSC310 with reverse polarity protection

Ray Liu - Applications Engineer, Zetex Semiconductors

Description

The schematic diagram shown in Figure 1 is a typical example of the ZXSC310 used in a LED flashlight application. The input voltage can either be one or two alkaline cells. If the battery is put in the flashlight the wrong way, the reverse polarity can damage the ZXSC310 and switching transistor, Q1. Implementing a mechanical reverse protection method can be expensive, and not always reliable. This paper describes methods of electronic reverse protection, without efficiency loss, for the ZXSC series ICs and related LED flashlight application circuits.

Circuit problems caused by the reverse polarity battery

If a negative voltage appears at the input terminal of Figure 1 then reverse current will flow from the ground pin of the ZXSC310 to the V_{CC} terminal and back to the battery. This current is high and will damage the ZXSC310. Some of this reverse current will also flow through the V_{DRIVE} terminal of the ZXSC310 and into Q1 base-collector completing the circuit to the battery.

The reverse current through base-collector of Q1 turns the transistor on in the reverse direction and causes high current to flow from ground, through emitter-collector to the battery, resulting in battery drainage and possible damage to the switching transistor, Q1.

A common method of reverse polarity protection

A common method of reverse protection is to add a Schottky diode in series with the battery positive. The problem with this method of reverse protection is that there is a loss of efficiency due to the forward voltage drop of the diode, typically 5% to 10% depending upon input voltage, reducing the usable battery life. The proposed method of reverse protection for the ZXSC series IC's gives full protection with **no** loss of efficiency.

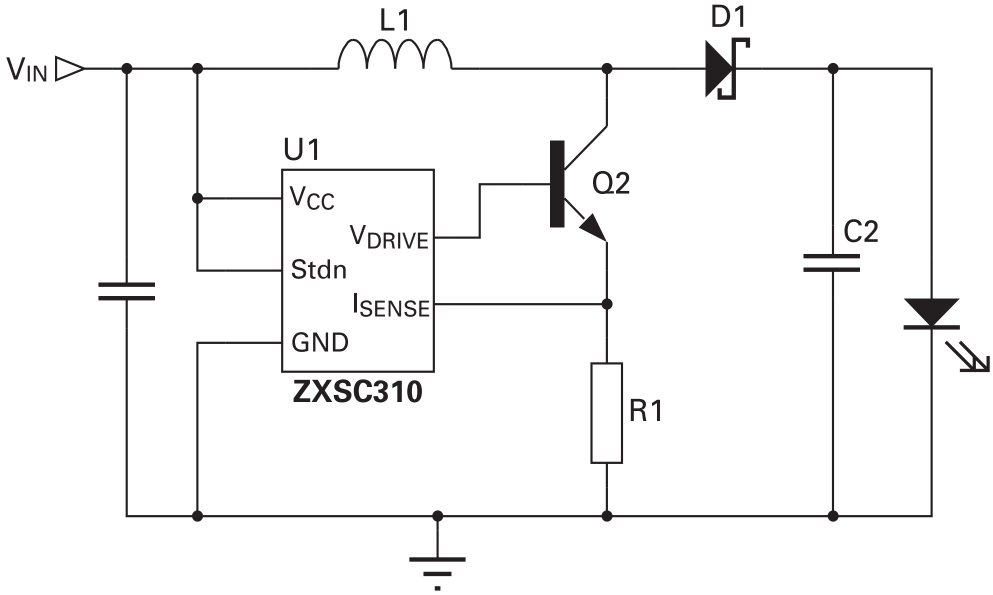

Figure 1 Schematic diagram

Reverse protection without efficiency loss

By adding current limiting resistor and Schottky diode, the reverse current flow can be eliminated without a loss of efficiency.

Flashlight circuit with bootstrap

For the bootstrap circuit in Figure 2, the current through the ZXSC310 is blocked by the reversed biased Schottky diode, D1.

The current from V_{DRIVE}, which turns on Q1 in the reverse direction, is diverted via D2 back to the battery so that Q1 does not turn on. R2 is a current limiting resistor to control this V_{DRIVE} current. This value is typically set to 100Ω to 500Ω to minimize battery current drain without affecting the normal operation of the circuit.

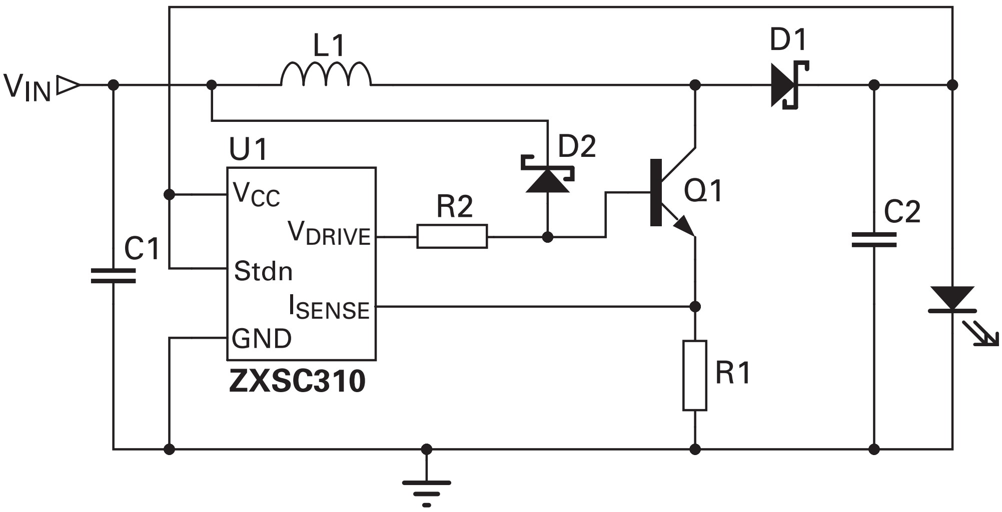

Figure 2

Ref	Value	Part number	Manufacturer	Comments
U1		ZXSC310E5	Zetex	LED driver in SOT23-5
Q1		ZXTN25012EFL	Zetex	Low sat. NPN in SOT23
D1	750mA	BAT750	Zetex	750mA Schottky in SOT23
D2(1)	200mA	BAT54	Zetex	200mA Schottky in SOT23
L1	68µH	Generic	Generic	I_{SAT}>0.4A, R<0.8Ω
R1	270mΩ	Generic	Generic	0805 size
R2(1)	100Ω	Generic	Generic	0805 size
C1	10µF/6.3V	Generic	Generic	
C2	22µF/6.3V	Generic	Generic	

Table 1 Bill of materials

NOTES:
(1) Add for reverse protection

Typical operating characteristics

(For typical application circuit where T_{amb} = 25°C unless otherwise stated)

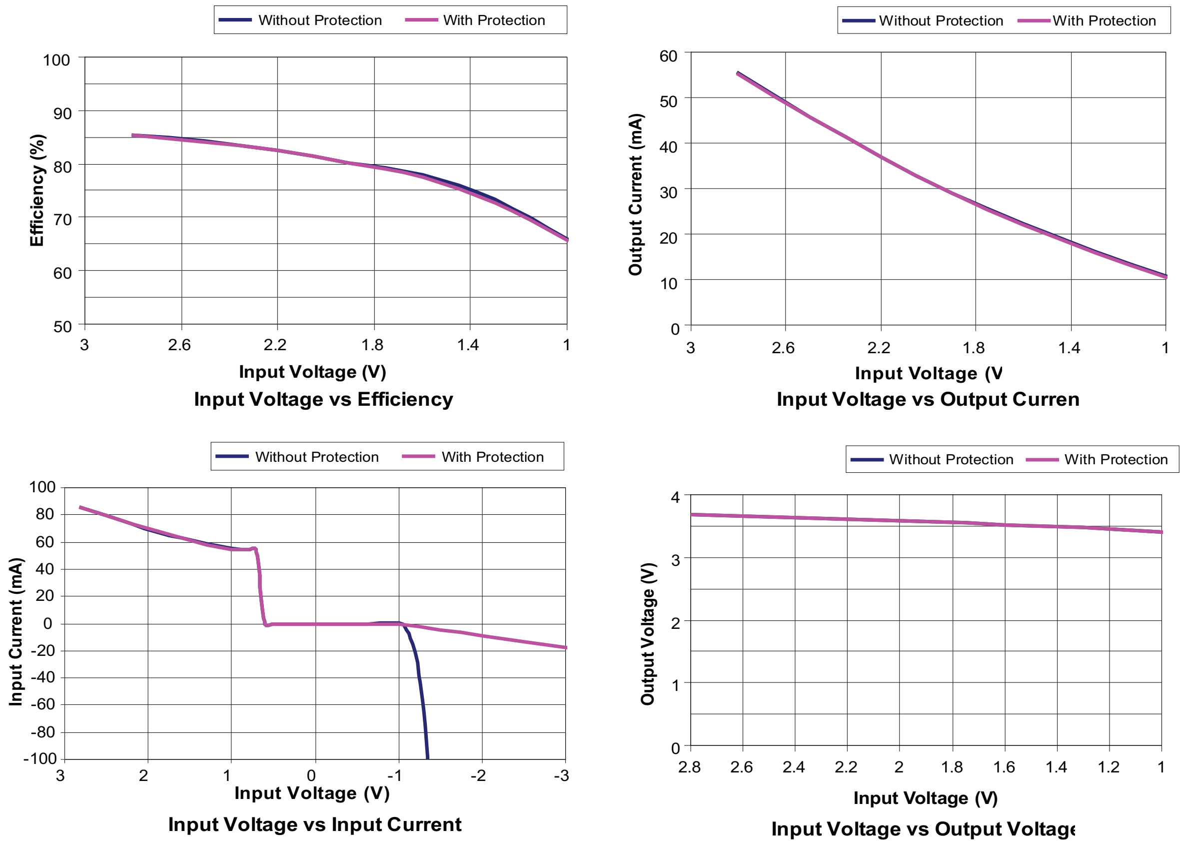

Figure 3 Performance graphs

Other circuit examples using reverse polarity protection

Flashlight circuit without bootstrap

The circuit shown in Figure 4 is for an LED flashlight application without bootstrap. As described previously, reverse current can flow from the GND terminal to V_{CC} and back to the battery. To block this current path an extra diode, D2b, is added. It is recommended that a Schottky diode be used for this application to maximize the start-up input voltage from $V_{CC(MAX)}$ to $V_{CC(MIN)}$ + D2b V_F, 3V to 1V. The Schottky diode, D2a, and resistor, R2, work in the same way as described in the bootstrap circuit in Figure 2. A dual Schottky diode, BAT54S, is recommended for D2 in order to achieve low component count.

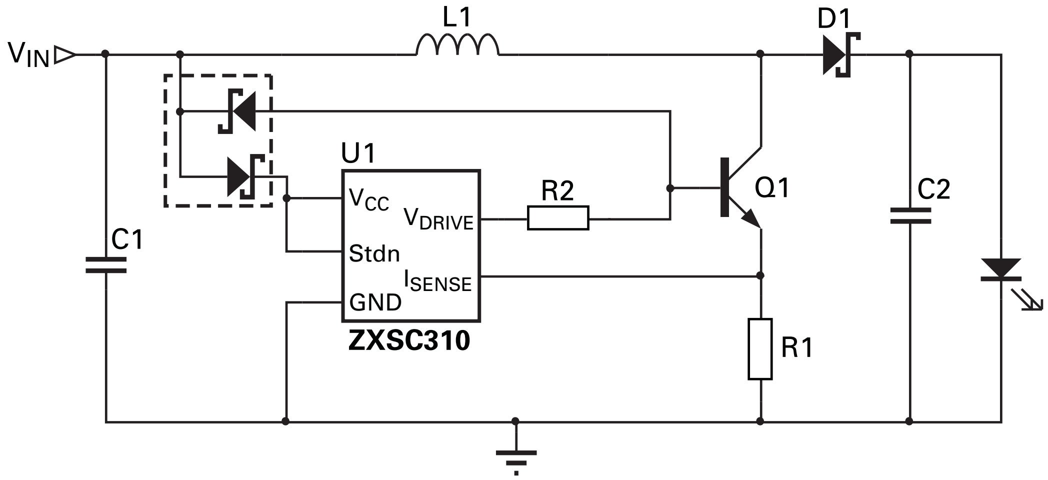

Figure 4 LED flashlight application without bootstrap

Other circuit examples using reverse polarity protection

Flashlight circuit without bootstrap

Figure 5 is a step down converter with reverse polarity protection. The main application for this circuit is a four alkaline cell flashlight driving a high powered LED. Again the protection circuit operates as described above. A dual Schottky diode, BAT54S, is recommended for D2 in order to achieve low component count.

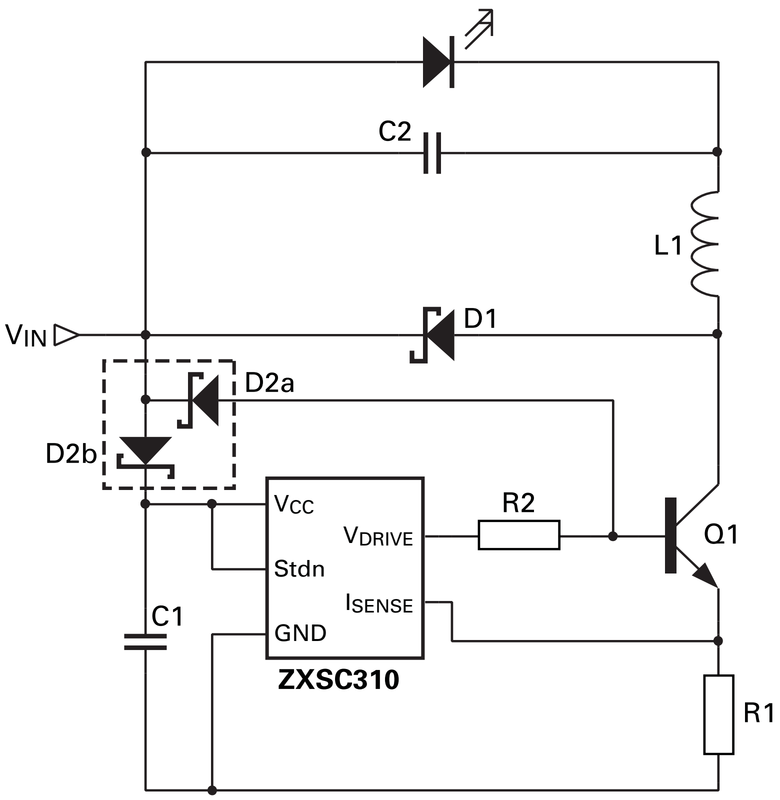

Figure 5 Step down converter with reverse polarity protection

Definitions

Product change

Zetex Semiconductors 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 Zetex 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. Zetex 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

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 Zetex Semiconductors plc. 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 labelling 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 Zetex' 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 Zetex sales office .

Quality of product

Zetex 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/salesnetwork**

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

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 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.

Zetex sales offices

Europe	**Americas**	**Asia Pacific**	**Corporate Headquarters**
Zetex GmbH Kustermann-park Balanstraße 59 D-81541 München Germany Telefon: (49) 89 45 49 49 0 Fax: (49) 89 45 49 49 49 europe.sales@zetex.com	Zetex Inc 700 Veterans Memorial Highway Hauppauge, NY 11788 USA Telephone: (1) 631 360 2222 Fax: (1) 631 360 8222 usa.sales@zetex.com	Zetex (Asia Ltd) 3701-04 Metroplaza Tower 1 Hing Fong Road, Kwai Fong Hong Kong Telephone: (852) 26100 611 Fax: (852) 24250 494 asia.sales@zetex.com	Zetex Semiconductors plc Zetex Technology Park, Chadderton Oldham, OL9 9LL United Kingdom Telephone: (44) 161 622 4444 Fax: (44) 161 622 4446 hq@zetex.com