ZXSC310 WITH REVERSE POLARITY PROTECTION

Introduction

The circuit 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

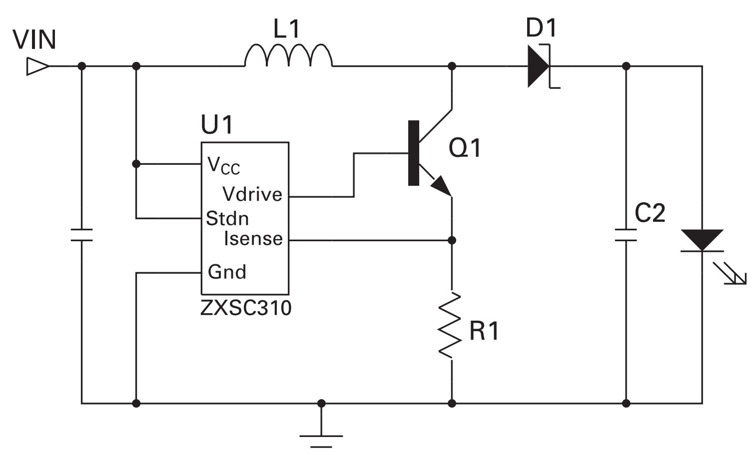
If a negative voltage appears at the input terminal of Figure 1 then reverse current will flow from the ground pin of the ZXSC310 to the V_{CC} terminal and back to battery. This current is high and will damage the ZXSC310. Some of this reverse current will also flow through the V_{DRIVE} terminal of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



Reverse protection without efficiency loss

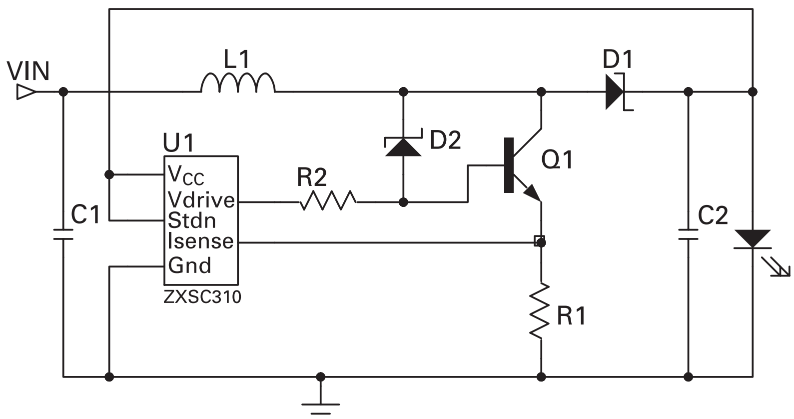
By adding current limiting resistor and Schottky diode,, the reverse current flow can be eliminated without a loss of efficiency.

Torch 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, through L1 and 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



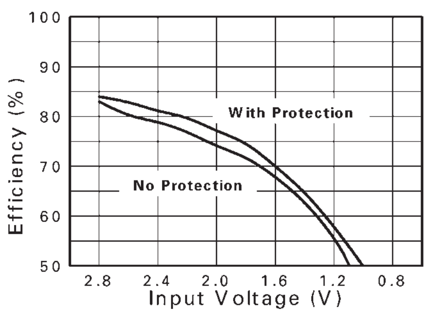
Materials list

Ref	Value	Part Number	Manufacturer	Comments
U1		ZXSC310E5	Zetex	LED driver in SOT23-5
Q1		FMMT617	Zetex	Low sat NPN in SOT23
D1	1A	ZHCS1000	Zetex	1A Schottky in SOT23
D2(1)	1A	ZHCS1000	Zetex	1A Schottky in SOT23
L1	72µH	Generic	Generic	I_{SAT}>0.5A, R<0.3Ω
R1	260mΩ	Generic	Generic	0805 size
R2(1)	100Ω	Generic	Generic	0805 size
C1	10µF	Generic	Generic	
C2	22µF	Generic	Generic	

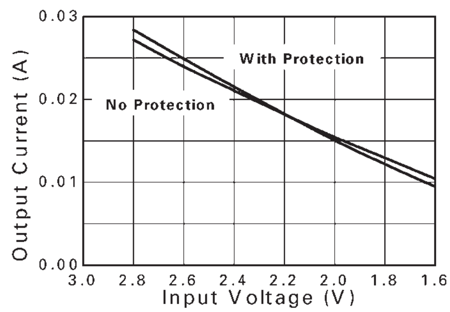
(1) Add for reverse protection

TYPICAL OPERATING CHARACTERISTICS

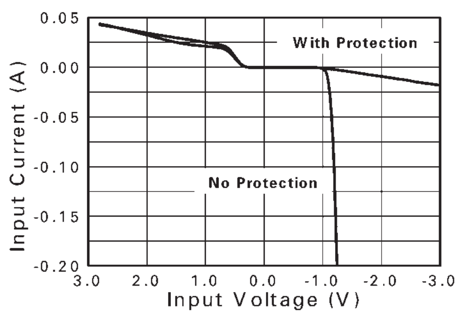
(For typical application circuit where TA=25°C unless otherwise stated)



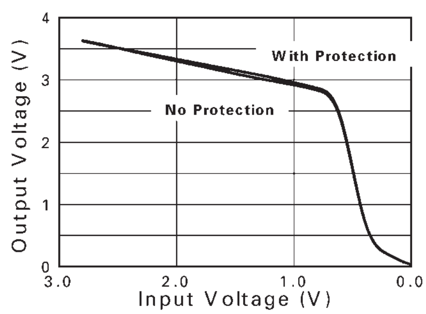
Input Voltage vs Efficiency



Input Voltage vs Output Current



Input Voltage vs Input Current



Input Voltage vs Output Voltage

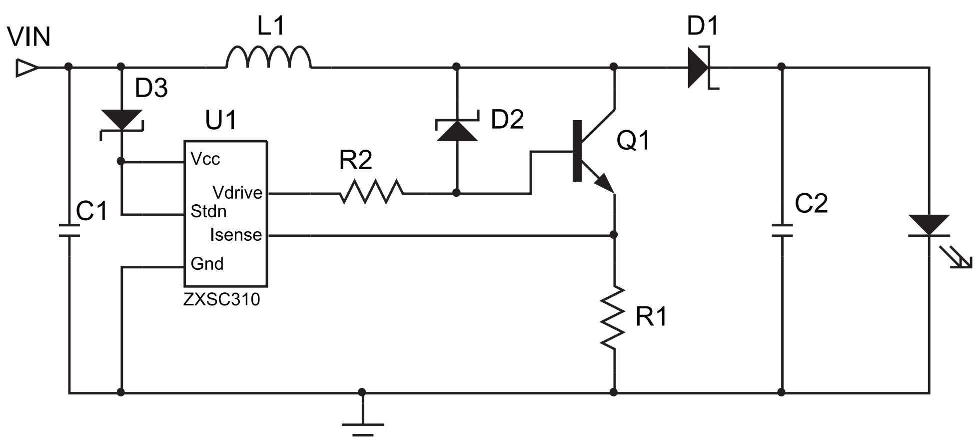
ZETEX SEMICONDUCTORS

Other circuit examples using reverse polarity protection

Torch circuit without bootstrap

The circuit shown in figure 3 is for an LED torch application without bootstrap. As described previously reverse current can flow from the G_{ND} terminal to V_{CC} and back to the battery. To block this current path an extra diode, D3 is added. It is recommended that a Schottky diode be use for this application to maximize the start-up input voltage from $V_{CC(MAX)}$ to $V_{CC(MIN)}$ + D3 V_F, 3V to 1V. The Schottky diode, D2, and resistor, R2, work in the same way as described in the bootstrap circuit in Figure 2.

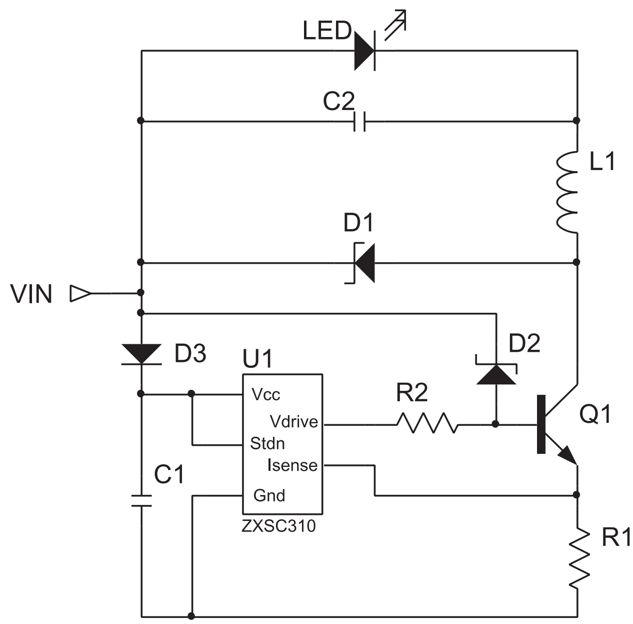
Figure 3



Step down converter for a high powered torch

Figure 4 is a step down converter with reverse polarity protection. The main application for this circuit is a four alkaline cell torch driving a high powered LED. Again the protection circuit operates as described above with the exception of D3. This diode can now be replaced by a low cost signal diode as input voltage is limited to a minimum of 4V.

Figure 4



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