DN93

Wide input voltage range SEPIC LED driver using ZXLD1321 with external power switch

Ray Liu, Applications Engineer, Diodes Incorporated

Introduction

Some LED lighting applications like the solar and automotive system, require an LED driver with a wide input voltage range where the LED voltage falls between minimum and maximum input voltage. In this case, neither boost nor buck topology would be a suitable solutions. SEPIC (Single Ended Primary Inductance Converter) resolves this issue and provide reasonable efficiency with relatively simple topology.

The following is a design example of a SEPIC LED driver which is capable of driving multi-chip LEDs with forward voltage up to 17V and LED current of 1A . The input voltage is wide with range from 8V to 30V.

1A Multi-chips LED driver with external SEPIC MOSFET switch

Figure 1 and Table 1 show the schematic and bill of materials of the design respectively.

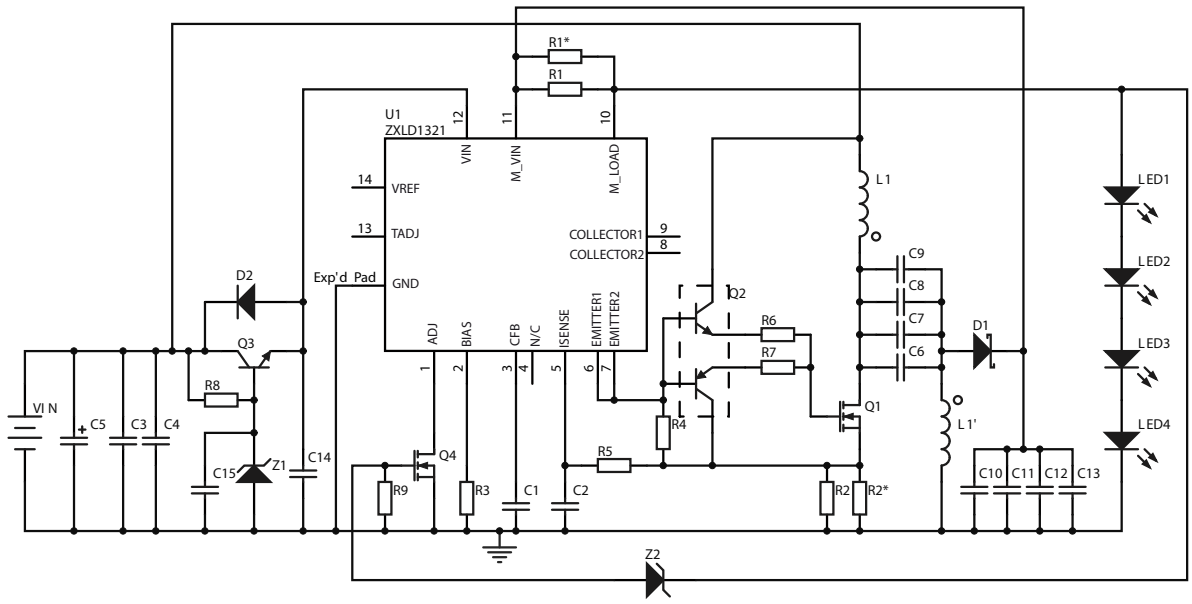

Figure 1 - Schematic

Ref No.	Value	Part No.	Manufacturer	Note
U1	LED Driver IC	ZXLD1321	Diodes Zetex	www.diodes.com www.zetex.com
Q1	60V 10A Mosfet	ZXMN6A25K	Diodes Zetex	www.diodes.com www.zetex.com
Q2	Gate Driver Pairs	ZXTC2045	Diodes Zetex	www.diodes.com www.zetex.com
Q3	50V NPN	ZXTN2031	Diodes Zetex	www.diodes.com www.zetex.com
D1	100V 5A Schottky Rectifier	PDS5100H	Diodes Zetex	www.diodes.com www.zetex.com
D2	100V 1A Rectifier	S1B	Diodes Zetex	www.diodes.com www.zetex.com
Z1	12V 350mW Zener	BZX84C12	Diodes Zetex	www.diodes.com www.zetex.com
Z2	18V 350mW Zener	BZX84C18	Diodes Zetex	www.diodes.com www.zetex.com
L1	22uH 5.2A SEPIC Inductor	NPIS25DW220MTRF 744870220 MSD1278-223ML	NIC Components Wurth Electronik Coilcraft	www.niccomp.com www.we-online.com www.coilcraft.com
C1	10nF 50V SMD 0603	NMC0603X7R103K50TRPF GRM188R71E103KA01	NIC Components Murata	www.niccomp.com www.murata.com
C2 C15	47nF 50V SMD 0603	NMC0603X7R473K50TRPF GRM188R71E473KA01	NIC Components Murata	www.murata.com
C5	470uF 50V	Generic Electrolytic		
C3 C4 C6 C7 C8 C9 C10 C11 C12 C13 C14	4.7uF 50V X7R SMD 1206	GRM31CR71H475KA12	Murata	www.murata.com
R1 R1*	200mΩ	NCST12GR200GTRF SMD 1206	NIC Components	www.niccomp.com
R2 R2*	20mΩ	SMD 1206		
R3	0Ω	SMD 0805 / 0603		
R4	1.2KΩ	SMD 0805 / 0603		
R5	33Ω	SMD 0805 / 0603		
R6	18Ω	SMD 0805 / 0603		
R7	10Ω	SMD 0805 / 0603		
R8	4.7KΩ	SMD 0805 / 0603		
R9	2.7KΩ	SMD 0805 / 0603		

Table 1 - Bill of materials

Circuit description

In this design, the ZXLD1321 is used as an LED driver controller to drive the MOSFET power switch through a ZXTC2045 gate drive transistor pair.

Although the input voltage rating of ZXLD1321 is 12V, by using an external 60V Mosfet power switch (ZXMN6A25K) and a simple 12V regulator formed by Q3 (ZXTN2031) and Z1, the system could operate up to 30V supply voltage with absolute maximum rating of 40V.

The SEPIC power stage is formed by Q1, D1, L1, L1' and C6 to C13. The same inductance is used for both L1 and L1' such that a coupled inductor can also be used. Instead of using two inductors for the power stage, a single standard coupled inductor is used to minimize the component count.

The output of the SEPIC stage is connected to the LEDs through the current sensing resistor R1. The voltage drop across R1 provides feedback to the LED controller IC and the sensing threshold is 100mV. Since the rated voltage of ZXLD1321's MVIN and MLOAD pin are limited to 18V, the system is capable of driving LEDs with total LED voltage below 18V. To prevent MVIN and MLOAD pins from over-voltage, Z2 and Q4 formed a voltage detection circuit which will pull down the ADJ pin. This will shutdown the driver IC whenever the LED voltage is above 18V.

Design Considerations

Since the voltage spike caused by the high switching current and stray inductance of PCB's copper track would be high compared to the low I_{SENSE} voltage threshold of ZXLD1321 which is below 55mV, RC filter formed by C2 and R5 is used to prevent false triggering of ISENSE pin. i.e. C2 should be placed as close as possible between the ISENSE pin and the exposed GND pad of the IC.

In SEPIC design, high ripple current appears at the output filtering capacitor (C10 – C13) and the SEPIC coupling capacitor (C6 - C9). Hence, a low ESR capacitor with an appropriate ripple current rating should be used. In this design, we recommend use of a standard X7R ceramic SMD capacitor working in parallel rather than the specialized pulse capacitor.

Performance

The typical efficiency throughout the input voltage range is shown in Figure 2 with average efficiency of 85%.

The line regulation of LED current is shown in Figure 3 with line regulation better than 3%.

Typical performance graphs

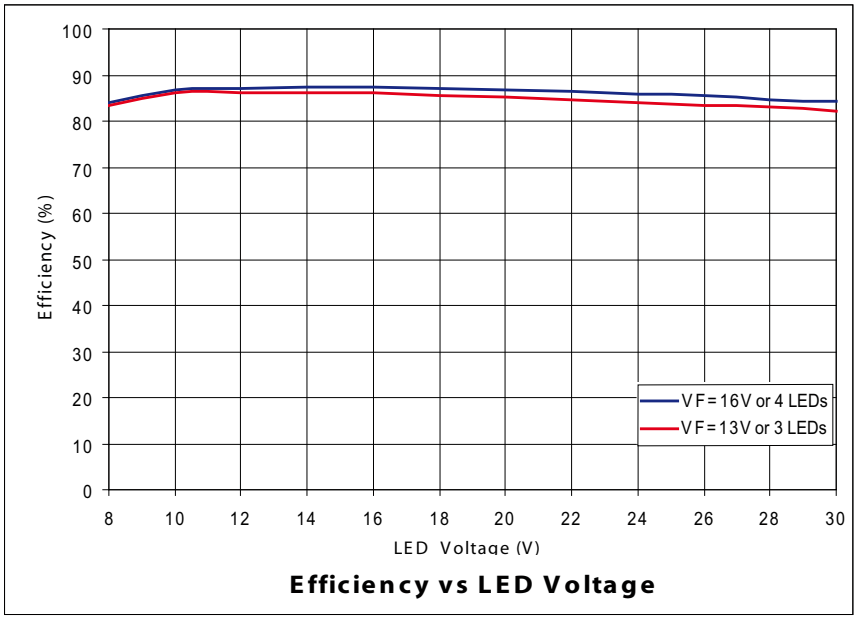

Figure 2

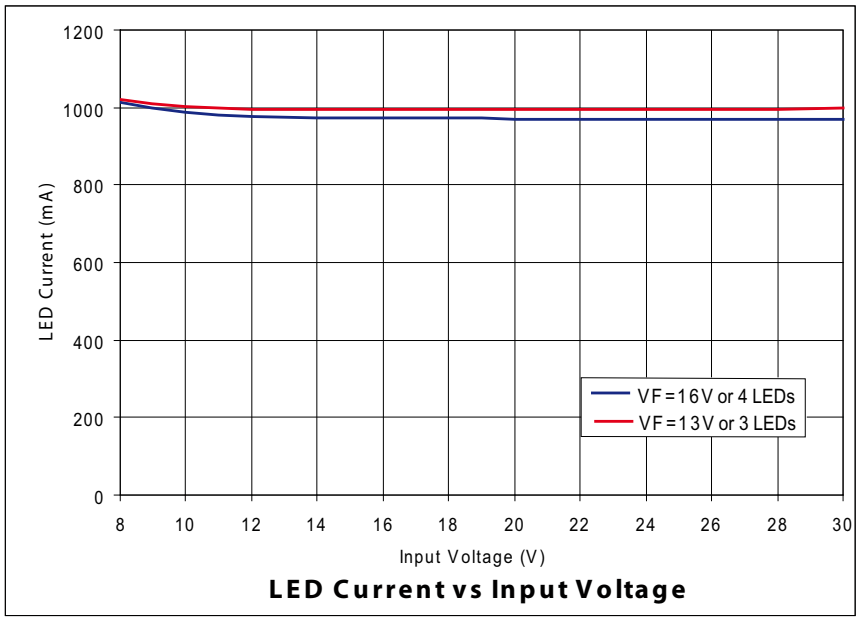

Figure 3

Conclusion

The ZXLD1321 can be used in SEPIC mode to produce a high buck-boost LED driver with scalable output current capability at an efficiency of around 85%. The input voltage can be between 8 and 30V but the number of LEDs must be limited to ensure the output voltage is less than 17V.

Definitions

Product change

Diodes Incorporated 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 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 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 Diodes Inc. or one of our regionally authorized distributors. For a complete listing of authorized distributors please visit: **www.diodes.com**

Diodes Zetex 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

Kustermann-Park
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

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