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AN64

Common anode topology with Zetex hysteretic converters

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Introduction

ZETEX hysteretic converters are widely used to drive LEDs due to their ease of use and inherent stability. While this simple topology can be used in different configurations, a simple variant of the buck configuration is the 'common anode topology' that provides several advantages including; ease of wiring, linear or PWM dimming control, and regulation. Common Anode topology can be easily implemented with the family of ZETEX hysteretic converters; the choice depending on the level of current and voltage required. In particular, ZXLD1350 and ZXLD1360 are suited for 30V applications with currents from 350mA to 1A, while ZXLD1356, ZXLD1362 and ZXLD1366 are suited for 60V application with currents from 550mA to 1A. Finally, for applications that require a voltage lower than 20V with a current up to 1.5A, the ZXLD1320 is suggested.

Description

This application note specifically describes a driver solution developed using the Zetex ZXLD1360 LED driver IC to drive a series of LEDs in common anode topology, in conjunction with the high thermally stable Super Barrier Rectifier SBR2A40P1 with 2A 40V capability and housed in the proprietary PowerDI123 package.

The **ZXLD1360** hysteretic converter features can be summarized as:

- wide input voltage range 7V to 30V, with internal switch
- Up to 1A output current
- Capable of driving up to 8 series connected 3 Watt LEDs
- High efficiency
- Brightness control using DC voltage or PWM (low or high frequency)
- Optional soft-start; up to 1MHz switching frequency

For more details about the hysteretic converter, please refer to the web site applications page.

Common anode connection

For Buck LED controllers high sided current sense is preferred which usually positions the LED after the current sense resistor and inductor. The simplicity of the hysteretic converters provides flexibility to drive LEDs with a common anode scheme. The common anode circuit is shown in Figure 1, and consists of connecting the anode of the LED directly to the supply voltage. The LED string is still in series with the sense resistor and the inductor allowing for higher accuracy. The Common Anode name usually refers to a configuration with a single LED (or a set of LEDs in parallel), but the concept could be extended to a series of LEDs, or several chains of LED that share the same V+ rail.

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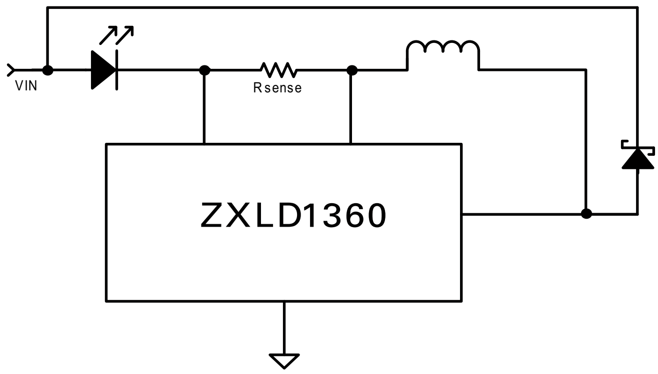

Figure 1 - Common anode connection

This configuration has several advantages mainly related to the circuit performance, but also to installation convenience and component count in the system. From the performance point of view, the circuit shows an improved load regulation compared to the standard buck topology. Thermal management also becomes simpler for multiple LED chain systems as the anodes can all sit on one heat sink at the same potential. Finally, since the voltage variation on the input is reduced, the common anode configuration allows for a smaller input capacitor.

The common anode topology simplifies the installation in signage and light wall applications, where drivers are usually separated from the LED chains. In this case, the first anode of each chain is directly connected to the power supply, so a single wire is needed to connect all the chains nonetheless a separate wire is still needed to connect the cathodes of each chain.

Finally, the common anode enables savings not only in the wiring side, but also on the component side. There is usually a capacitor in parallel with the string of LEDs which is not necessary, since the input capacitor already filters the ripple across the LEDs.

The main disadvantage of the common anode connection is that the amount of voltage available for the load is lower compared to the standard buck configuration.This reduces the number of LEDs that can be driven by the system, since $V_{LOADmax} = V_{SUPPLY} - V_{INmin.}$

An application example of the common anode configuration has been chosen with ZXLD1360 driving a set of LEDs from 1 to 6.

Circuit diagram

In this application note, a specific design of a 1A LED driver is chosen to demonstrate the common anode features with a ZETEX based hysteretic converter (figure 2).

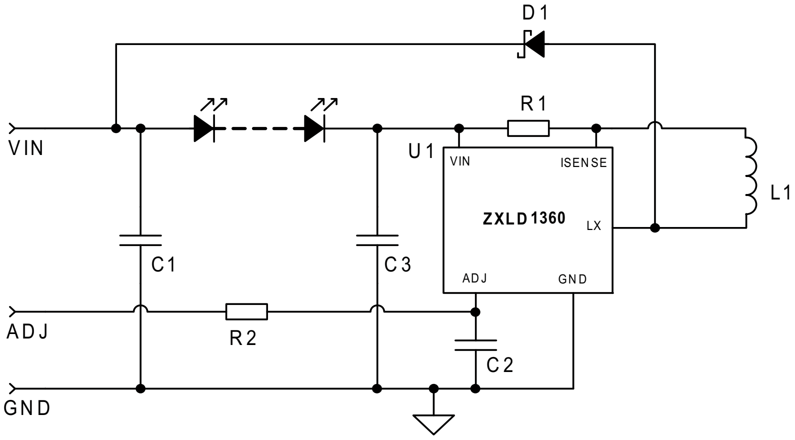

Figure 2 -common anode circuit schematic with ZXLD1360 and SBR2A40P1

Circuit description

In normal operation, when voltage is applied at +VIN, the ZXLD1360 internal NDMOS switch is turned on. Current starts to flow through the LED, sense resistor R1, and the inductor L1. 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 ZXLD1360 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 the LED, R1, L1, and 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 ZXLD1360. 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 the average LED current set by the sense resistor R1. Please refer to the datasheets for the threshold limits, ZXLD1360 internal circuits, electrical characteristics and parameters.

Circuit design

The ZXLD1360 and SBR2A40P1 are configured to the reference design in Figure 2.

The operating voltage is a nominal 30V, while the nominal current is set at 1A with a 0.1W sense resistor R1. With these parameters, the system operates in continuous mode at 150kHz approximately , with a 100uH inductor and a single LED.

The ADJ pin has a low pass filter within the ZXLD1360 chip to provide some decoupling and soft start but an external capacitor C2 (100nF) is used to provide additional decoupling to reduce any high frequency noise as well as providing an extra amount of soft start . The soft-start time will be nominally 0.5ms without capacitor C2. Adding the capacitor C2 will increase the soft start time by approximately 0.5ms/nF.

Component choice and design can be done using the circuit calculator downloadable from the Diodes website.

Circuit performance

The circuit performance is measured in terms of

- Switching frequency
- Duty Cycle
- Load regulation
- Line regulation
- Efficiency

The following trends are worth noting for this system at a given supply voltage.

In this case, the switching frequency increases with the number of LEDs. This idea is clearly confirmed by figure 3, for systems using up to 3 LEDs, but seems to fail for a greater number of LEDs. In fact, systems with 4, 5 and 6 LEDs have a lower frequency than expected when the supply voltage is 25V or 30V.

The reason for this trend is that the voltage VSUPPLY – VLOAD tends to be closer to the minimum driver input voltage, reducing its switching frequency.

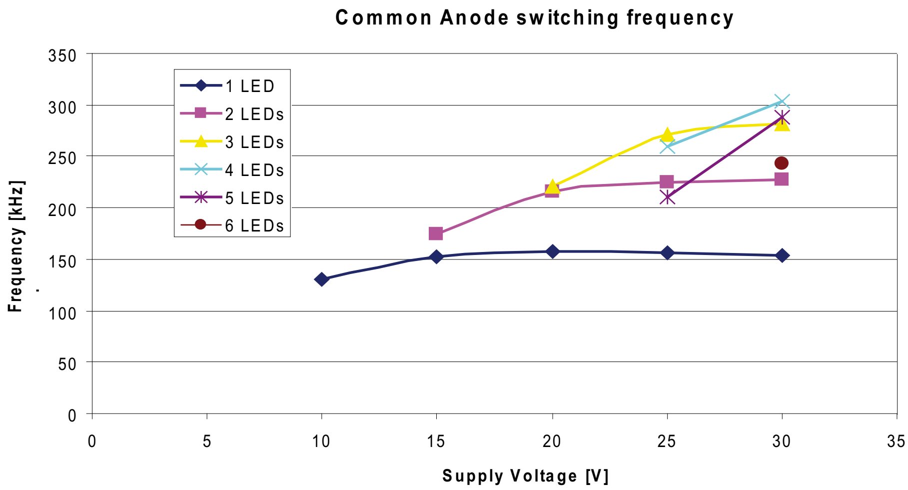

Figure 3

In figure 4, the duty cycle value in relation to the number of LEDs and the input voltage value is shown.

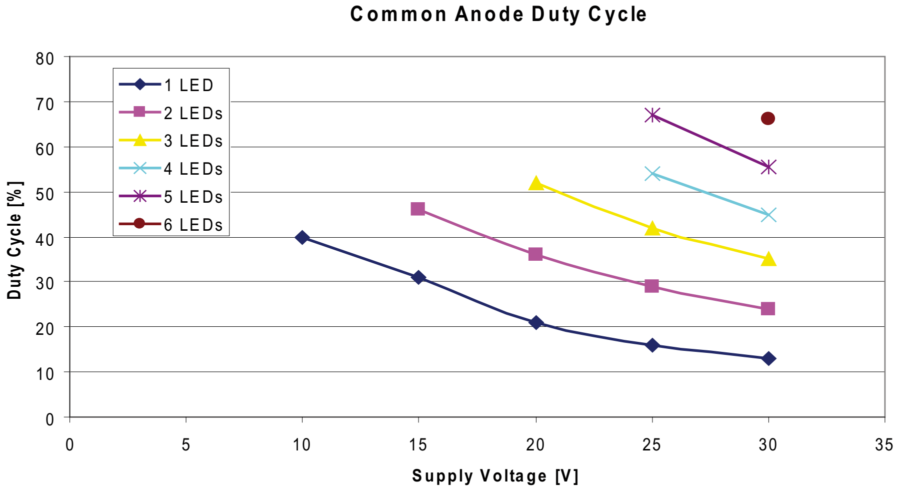

Figure 4

Load and line regulation, have good performance in common anode configuration. Line regulation is in the range of 1mA/V for LEDs between 1 and 5. This means that for this specific case, the percentage variation of output current for each volt of variation of the input voltage is about 0.3%. (Figure 5)

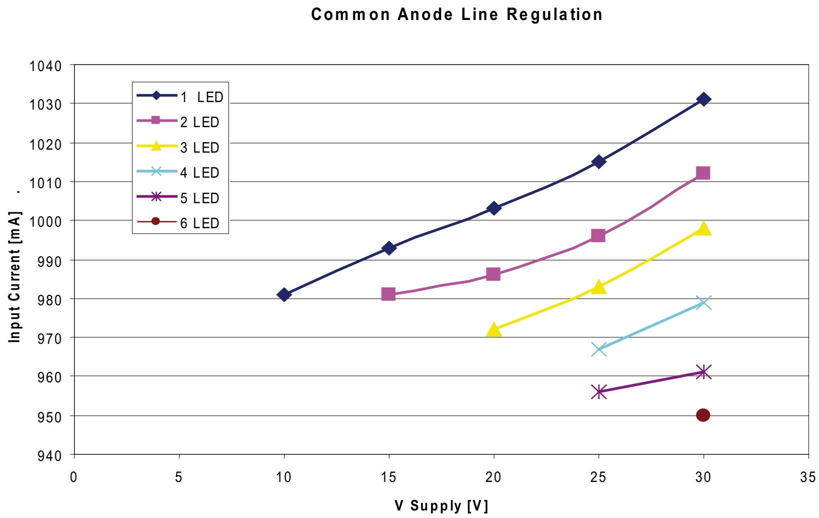

Figure 5

Load regulation is about 5mA for each LED (Figure 6) but this strongly depends on the LED's characteristics, namely its forward voltage drop.

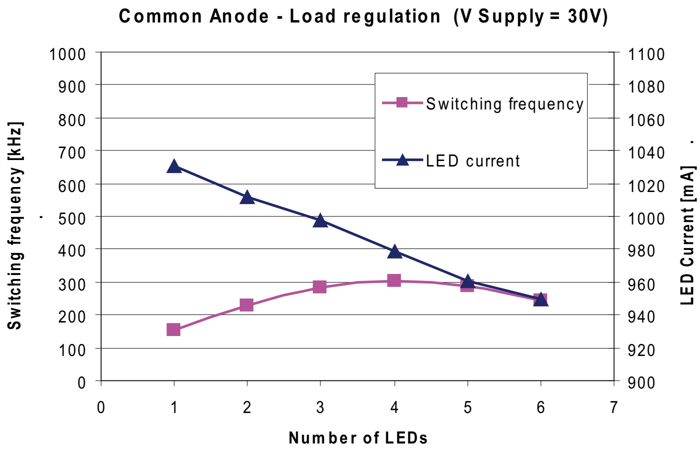

Figure 6

The efficiency is between 70% and 80% in the case of a single LED, while is higher than 90% when the common anode configuration drives three or more LEDs, as shown in figure 7.

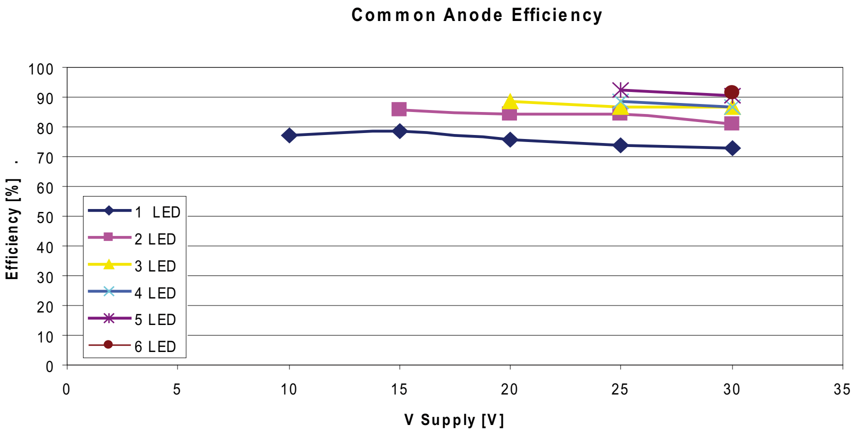

Figure 7

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 with an analog signal. In particular, driving the ADJ pin below 0.2V will shutdown the output current. On the other hand, for PWM dimming, an external open-collector NPN transistor or open-drain N-channel MOSFET can be used to drive the ADJ pin.

Due to the internal filter features, PWM dimming can be performed in two ways. Firstly, if the PWM frequency is low, around 100Hz to 1kHz, the PWM signal effectively turns ON and OFF the LED current, with a maximum PWM resolution of 8bits. Secondly If the PWM frequency is high, between 10kHz to 50kHz, the PWM signal is effectively filtered by the ADJ pin internal filter, providing an analog signal to the input of the internal comparator.

For low frequency PWM, C2 should be removed on the evaluation board to give a more accurate duty cycle. In figure 8, the PWM dimming linearity is shown, in the case of a dimming frequency of 200Hz and a load of 6 LEDs. The system is able to provide good performance in terms of linearity for a duty cycle higher than 3%.

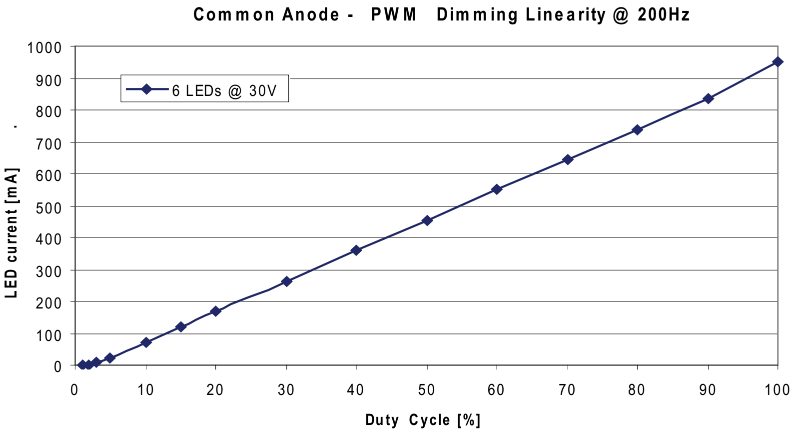

Figure 8

This system is able to guarantee a high level of efficiency for a wide range of duty cycle values (10% to 100%) when PWM dimming is performed. For Duty Cycles lower than 10%, the efficiency tends to be low, but the level of power involved is small, allowing it to keep the system in a thermally safe condition.

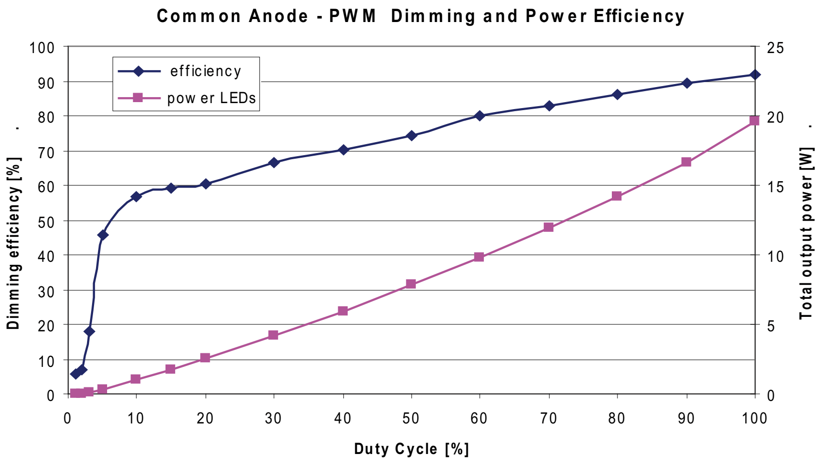

Figure 9

PCB and layout considerations

In Figure 10, the layout of the common anode board is provided. From a layout perspective, the most important suggestions are:

- Current sense resistor R1, has to be connected to the Vin and Vsense pins using short and thin tracks, providing an high impedance path for the currents
- Inductor L1 and freewheeling diode D1, should be connected to ZXLD1360 using short tracks
- The ADJ pin needs special care, since it is a high impedance pin. Therefore, a ground ring around the pin is preferable, and a small capacitor connected to ground (C2) could help to avoid any noise on the pin.

- A small capacitor (C3), should be placed across Vin and GND, to filter any high frequency noise on the Vin pin and improve accuracy.

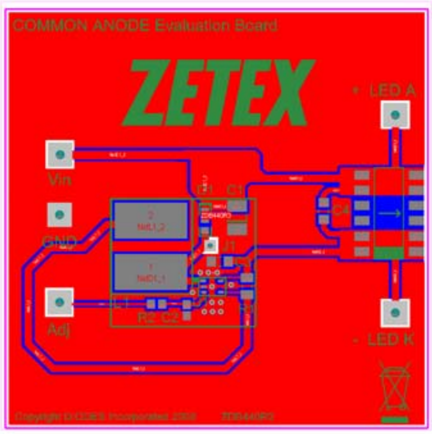

Figure 10

Bill of materials

From table 1, the Bill of Materials for the common anode board, it is evident that the common anode topology maintains the same characteristic of reduced component count as the standard buck configuration.

Table 1

Ref	Value	Part Number	Manufacturer	Notes
R1	0.1R1 1%	NCST12FR100FTRF	NIC components	
R2	1K	generic		
C1	2.2uF, 50V	50V, 1210 X7R NMC1210X7R225K50F	NIC components	
C2	1uF, 50V	50V, 1206 X7R NMC1206X7R105K50F	NIC components	
C3	100nF	50V, 0805 X7R NMC0805X7R104K50F	NIC components	
C4			-	Not fitted
L1	100uH	MSS1038	Coilcraft	1.46A rms Inductor
D1	40V, 1A	SBR2A40P1	Diodes	Super Barrier Rectifier
U1	ZXLD1360	ZXLD1360E5TA	Zetex	DC-DC converter

Conclusion

Common anode is a useful configuration, which when combined with the inherent flexibility of the hysteretic converter, allows us to achieve optimum thermal and electrical performance . This configuration is particularly well suited to installations with long cable runs, reducing the wiring and RF emissions.

Further information on the devices can be found at www.diodes.com

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