DN61
Dual cell powered ZXSC310 solution for a 1W high power white LED

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Description

High power LEDs are increasingly being used in lighting applications (general illumination, portable, signage/security, traffic, automotive, architectural) as lumens, and efficacy of high power LEDs are increasing while the cost per lumens is decreasing.

Low cost, small and simple solutions are important in applications such as flashlight, signage and illuminations where 1W high power LED is powered from a low voltage supply as in single and dual cell batteries.

Figure 1 shows a typical simple low cost solution with a ZXSC310 driving a 1W LED with a typical forward voltage of 3.4V at 300mA from a dual cell battery. A dual cell supply will have a voltage range of 1.8V to 2.5V for NiCd and NiMH type batteries and up to 3V for alkaline type batteries. The component values are tabulated (see Tables 1 and 2), depending on the range of voltage which is defined by the battery chemistry.

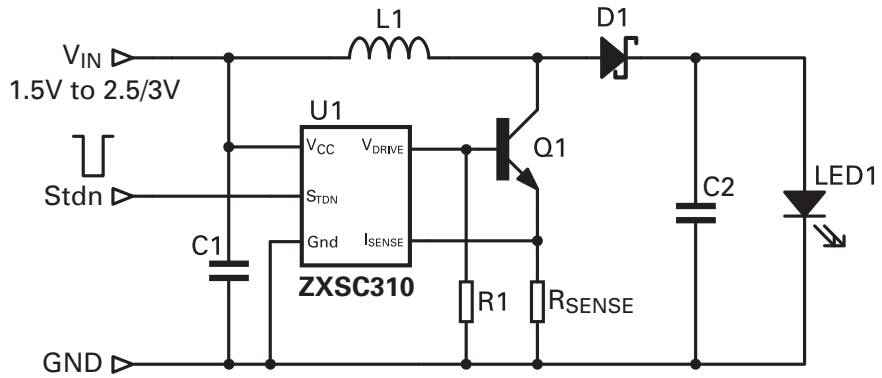

Figure 1 Typical dual cell battery powered 1W LED drive circuit

ZXSC310 is a constant current boost converter in a small SOT23-5 package. It has a typical drive current of 2.3mA at 1.8V. The drive current at 25°C is 1.5mA minimum at 1.5V supply.

The bipolar transistor switch, Q1, should have adequate voltage and peak switching current ratings, a very high transistor gain (h_{fe}), a very low saturation voltage (V_{CE}) and a small device package size with an adequate thermal capability. The transistor, Q1 in this application, is a low saturation voltage transistor, ZXTN25012EFL, with a very high gain of 700 at 1A collector current at 25°C to match the drive current from the Drive pin of the ZXSC310.

Note: If transistors with lower gain are used, then at lower temperatures, it may not support a full switching current and therefore proper operation may not start or may take few seconds to start.

The Schottky diode should have an adequate peak switching current rating and a very low forward voltage. The Zetex ZXSC1000 Schottky diode, SD1, has a low forward voltage. If operation at higher temperature is required then the low leakage, low forward voltage, Zetex ZLLS1000 can be used.

The choice of inductor, L1, depends on the desired switching frequency, the LED current, the input voltage, forward voltage of the Schottky diode, SD1, and the LED forward voltage.

Note: The LED current output is dependent on the input voltage, the LED forward voltage, the sense resistor and the inductor value.

Dual cell NiCd/NiMH battery solution

A dual cell NiCd/NiMH battery voltage range is 1.8V to 2.5V. Table 1 shows the component values for a dual cell NICd/NiMH battery powered ZXSC310 solution for a 1W high power white LED. The efficiency and the LED current versus the input voltage performance are shown in Figures 2 and 3.

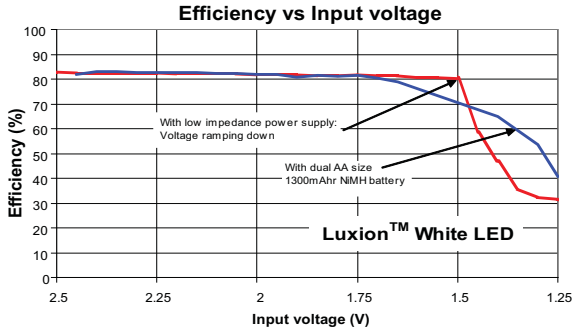

Figure 2 Efficency vs. input supply voltage

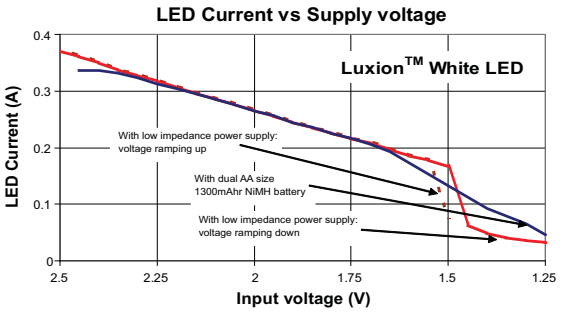

Figure 3 LED current vs. input supply voltage

Reference	Part no.	Value	Manufacturer	Contact details
U1	ZXSC310E5	LED driver	Zetex	www.zetex.com
Q1	ZXTN25012EFH	high gain, low $V_{CE(sat)}$	Zetex	www.zetex.com
SD1	ZHCS1000 or ZLLS1000	low forward voltage V_F	Zetex	www.zetex.com
L1	DO3316P-103	10µH, 2A	Coilcraft	www.coilcraft.com
R_{SENSE}	Generic	33mΩ	Generic	NA
R1	Generic	10kΩ	Generic	NA
C1	Generic	1µF, 6.3V, X7R	Generic	NA
C2	Generic	6.8µF, 6.3V	Generic	NA
LED1	LXHL-NW98	White LED; 3.4V	Lumileds	www.lumileds.com

Table 1 Bill of materials for dual cell NiCd/NiMH battery powered single 1W LED driver

Dual cell alkaline battery solution

The dual cell alkaline battery has a voltage range of up to 3V. Table 2 shows the component values for a dual cell alkaline battery powered ZXSC310 solution for a 1W high power white LED. The efficiency and the LED current versus the input voltage performance are shown in Figures 4 and 5.

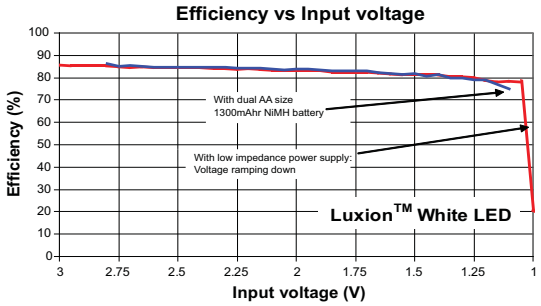

Figure 4 Efficiency vs. input signal voltage

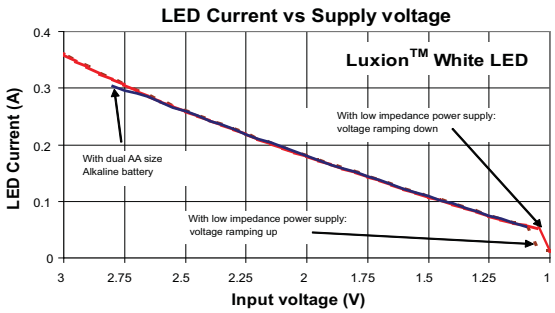

Figure 5 LED current vs. input supply voltage

Reference	Part no.	Value	Manufacturer	Contact details
U1	ZXSC310E5	LED driver	Zetex	www.zetex.com
Q1	ZXTN25012EFL	high gain, low $V_{CE(sat)}$	Zetex	www.zetex.com
SD1	ZHCS1000 or ZLLS1000	low forward voltage V_F	Zetex	www.zetex.com
L1	DO3316P-103	10uH, 2A	Coilcraft	www.coilcraft.com
R_{SENSE}	Generic	50mΩ	Generic	NA
R1	Generic	10kΩ	Generic	NA
C1	Generic	1μF, 6.3V, X7R	Generic	NA
C2	Generic	6.8μF, 6.3V	Generic	NA
LED1	LXHL-NW98	White LED	Lumileds	www.lumileds.com

Table 2 Bill of materials for dual cell alkaline battery powered 1W LED driver

Dimming and shutdown

In Figure 1, the shutdown pin, Stdn, can be tied to V_{CC} pin for normal operation. If the shutdown pin is taken to ground, the ZXSC310 enters standby mode with a low quiescent current of 5μA. The shutdown pin can also be used for PWM dimming by connecting a PWM signal. The LED current is then dependent on PWM duty ratio.

Thermal management

The LED junction temperature should be maintained within the specified maximum or de-derating curve, whichever is lower, by use of proper thermal management for lumens maintenance and LED protection. Size 0805 for the sense resistor is adequate.

Boot-strap operation

In boot-strap mode, the supply to the V_{CC} is from the output stage (cathode of SD1) to maintain the supply to the ZXSC310 at a reasonably constant voltage even when the battery voltage reduces. This improves the ZXSC310 drive pin current capability due to the reasonably constant voltage of 3.4V typical (or the forward voltage of the LED) at the V_{CC} pin, even though the battery voltage may drop below 1.5V.

The boot-strap allows the ZXSC310 to continue driving the LED even with battery supply drops below 0.8V after the initial successful start-up. The boot-strap mode is recommended for a single cell alkaline/NiMH/NiCd battery. The boot-strap mode can also be used in throw-away (single use) dual cell alkaline batteries to draw as much energy as possible before discarding the battery. Figures 6 and 7 show the efficiency and LED current versus battery voltage for a boot-strap mode of operation with an AA size dual cell alkaline battery.

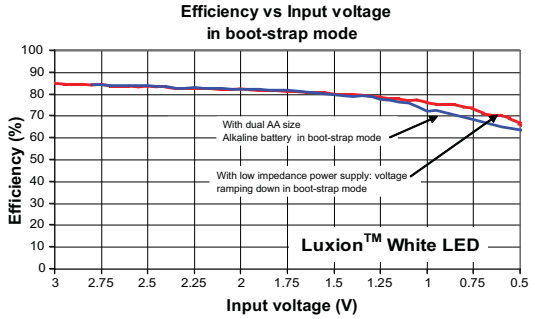

Figure 6 Efficiency vs. input supply voltage

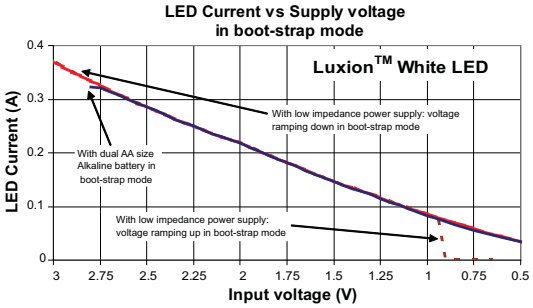

Figure 7 LED current vs. input supply voltage

Note: To prevent rechargeable batteries entering a deep discharge state, ZXSC310 devices can be shut down (by pulling the shutdown pin low to the ground) by an external circuit when the rechargeable battery voltage falls below its recommended minimum voltage. The boot-strap mode is not recommended with a ZXSC310 for dual/three cell NiCd/NiMH rechargeable batteries without a under voltage protection.

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