SINGLE OR MULTI CELL LED DRIVER SOLUTION

DESCRIPTION

The ZXSC300 is a single or multi cell LED driver designed for applications where step-up voltage conversion from very low input voltages is required. These applications mainly operate from single 1.5V or 1.2V battery cells. The circuit generates constant current pulses that are ideal for driving single or multiple LED's over a wide range of operating voltages.

The ZXSC300 is a PFM controller IC that drives an external Zetex switching transistor with a very low saturation resistance. These transistors are the best switching devices available for this type of switching conversion enabling high efficiency conversion with input voltages below 1 volt. The drive output of the ZXSC controller generates a dynamic drive signal for the switching transistor.

The circuit can start up under full load and operates down to an input voltage of 0.8 volts. The solution configuration ensures optimum efficiency over a wide range of load currents, several circuit configurations are possible depending on battery life versus brightness considerations.

The ZXSC300 is offered in the SOT23-5 package which, when combined with a SOT23 switching transistor, generates a high efficiency small size circuit solution. The IC and discrete combination offers the ultimate cost vs performance solution for single cell LED driving applications.

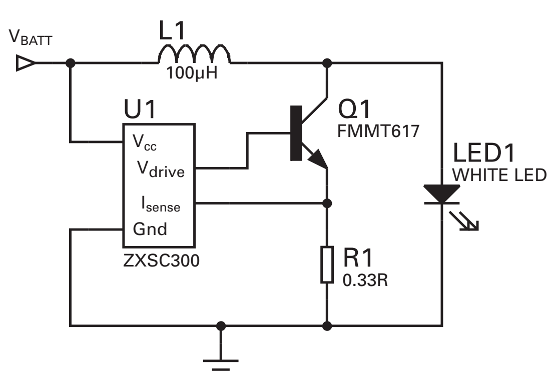
FEATURES

- 94% efficiency
- Minimum operating input voltage 0.8V
- Fixed output current
- Low saturation voltage switching transistor
- SOT23-5 package

APPLICATIONS

- LED flashlights and torches
- LED backlights
- White LED driving
- Multiple LED driving
- Solar Equipment

TYPICAL APPLICATION CIRCUIT



ORDERING INFORMATION

DEVICE	Reel	Tapewidth	Quantity per reel
ZXSC300E5TA	7″	8mm	3,000

DEVICE MARKING C300

Package SOT23-5

ZETEX SEMICONDUCTORS

ABSOLUTE MAXIMUM RATING

Supply Voltage	-0.3 to 10V	Operating Temperature	-40 to 85°C
Maximum Voltage Other Pins	-0.3 to V_{CC}+0.3V	Storage Temperature	-55 to 150°C
Power Dissipation	450mW		

ELECTRICAL CHARACTERISTICS: Test conditions unless otherwise stated: V_{CC}=1.5V, T_{AMB}=25°C

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
η	Efficiency(1)				94	%
V_{CC}	Recommended supply voltage range		0.8		8	V
$V_{CC(min)}$	Minimum startup and operating voltage	I_{DRIVE}=-600μA, V_{DRIVE}=0.7V I_{DRIVE}=-600μA, V_{DRIVE}=0.7V, T_{AMB}=-10°C(3)		0.8 0.9	0.92	V
I_Q	Quiescent current(2)			0.2		mA
I_{VDRIVE}	Base drive current	V_{DRIVE} = 0.7V, V_{ISENSE} = 0V	1.5		3.6	mA
I_{CC}	Supply current(3)	V_{DRIVE} = 0.7V, V_{ISENSE} = 0V	2		4	mA
$V_{VDRIVE(high)}$	High level drive voltage	V_{ISENSE} = 0V, I_{VDRIVE} =-0.5mA	V_{CC}-0.3		V_{CC}	V
$V_{VDRIVE(low)}$	Low level drive voltage	V_{ISENSE} = 50mV, I_{VDRIVE} = 5mA	0		0.2	V
V_{ISENSE} (threshold)	Output current reference voltage		14	19	24	mV
$T_{CVISENSE}$	I_{SENSE} voltage temp co.[2]			0.4		%/°C
I_{ISENSE}	I_{SENSE} input current	V_{ISENSE} = 0V	0	-30	-65	μA
T_{DRV}	Discharge pulse width		1.2	1.7	3.2	μs

OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
F_{OSC}	Recommended operating frequency(4)				200	kHz

[1] Application dependent, see reference designs.
[2] These parameters guaranteed by design and characterisation
[3] Total supply current =I_Q + I_{VDRIVE}, see typical characteristics
[4] Operating frequency is application circuit dependent. See applications section.

FMMT617

For the circuits described in the applications section, Zetex FMMT617 is the recommended pass transistor. The following indicates outline data for the transistor, more detailed information can be found at www.zetex.com/FMMT617

ELECTRICAL CHARACTERISTICS (at T_A = 25°C unless otherwise stated).

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	CONDITIONS
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$		8 70 150	14 100 200	mV mV mV	I_C=0.1A, I_B=10mA* I_C=1A, I_B=10mA* I_C=3A, I_B=40mA*
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	15	18		V	I_C=10mA*

*Measured under pulsed conditions. Pulse width=300µs. Duty cycle ≤ 2%

ZHCS1000

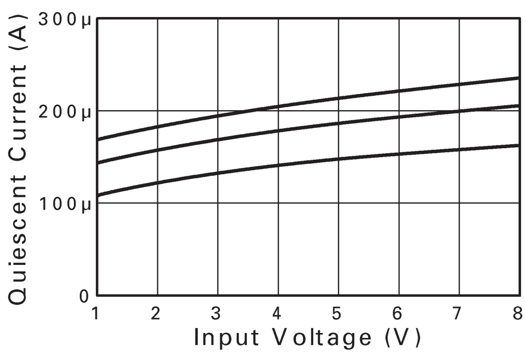
For the circuits described in the applications section Zetex ZHCS1000 is the recommended Schottky diode. The following indicates outline data for the diode, more detailed information is available at www.zetex.com

ELECTRICAL CHARACTERISTICS (at T_{amb} = 25°C unless otherwise stated).

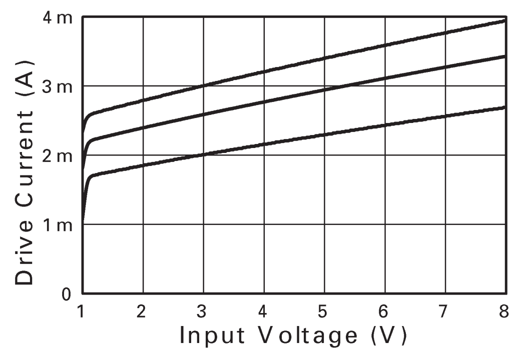
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	CONDITIONS
Forward Voltage	V_F			400 500	mV mV	I_F=500mA I_F=1A
Reverse Current	I_R		50	100	µA	V_R=30V
Reverse Recovery Time	t_{rr}		12		ns	Switched from I_F = 500mA to I_R = 500mA. Measured at I_R=50mA

*Measured under pulsed conditions. Pulse width=300µs. Duty cycle ≤ 2%

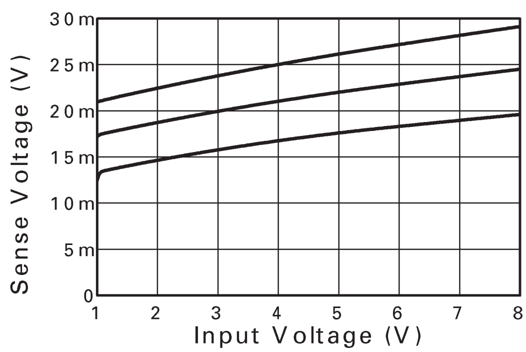
TYPICAL CHARACTERISTICS



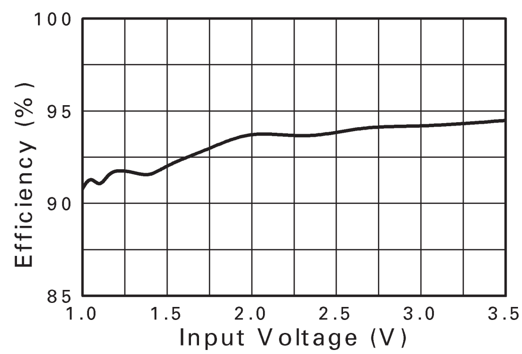
Quiescent Current v Input Voltage



Drive Current v Input Voltage



Sense Voltage v Input Voltage



Input Voltage v Efficiency

DEVICE DESCRIPTION

The ZXSC300 is PFM, controller IC which, when combined with a high performance external transistor, enables the production of a high efficiency boost converter for use in single cell LED driving applications. A block diagram is shown for the ZXSC300 in Figure 1.

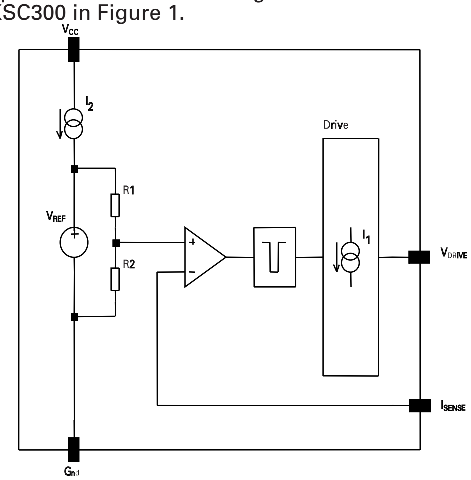


Figure 1 ZXSC300 Block Diagram

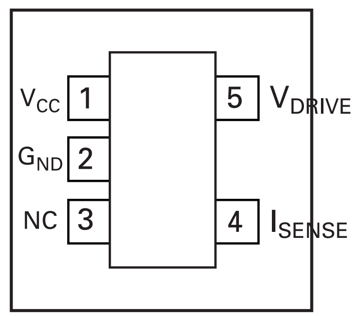
The on chip comparator forces the driver circuit and therefore the external switching transistor off if the voltage at I_{SENSE} exceeds 19mV. This threshold is set by an internal reference circuit and divider.

The Voltage at I_{SENSE} is taken from a current sense resistor connected in series with the emitter of the switching transistor. A monostable following the output of the comparator forces the turn-off time of the output stage to be typically 1.7µs. This ensures that there is sufficient time to discharge the inductor coil before the next on period.

With every on pulse the switching transistor is kept on until the voltage across the current-sense resistor exceeds the threshold of the I_{SENSE} input. The on-pulse length, and therefore the switching frequency, is determined by the programmed peak current, the input voltage and the input to output voltage differential. See applications section for details.

The Driver circuit supplies the external switching transistor with a fixed drive current. To maximise efficiency the external transistor switched quickly, typically being forced off within 30ns.

Pinout Diagram



Pin Descriptions

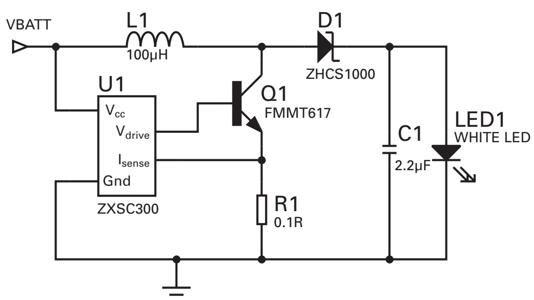
Pin No.	Name	Description
1	V_{CC}	Supply voltage, generally Alkaline, NiMH or NiCd single cell
2	Gnd	Ground
3	N/C	Not connected
4	I_{SENSE}	Inductor current sense input. Internal threshold voltage set to 19mV. Connect external sense resistor
5	V_{DRIVE}	Drive output for external switching transistor. Connect to base of external switching transistor

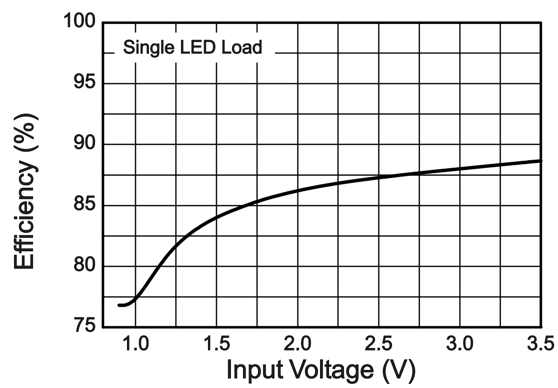
REFERENCE DESIGNS

Two typical LED driving applications are shown. Firstly a maximum brightness solution and secondly an optimised battery life solution.

Maximum brightness solution

This circuit provides a constant current output to the LED by rectifying the switching pulses. This ensures maximum LED brightness.





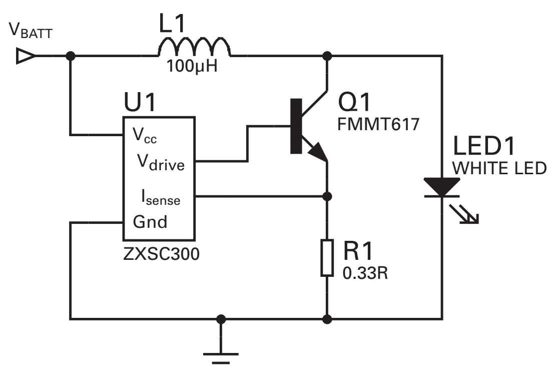
Input Voltage v Efficiency

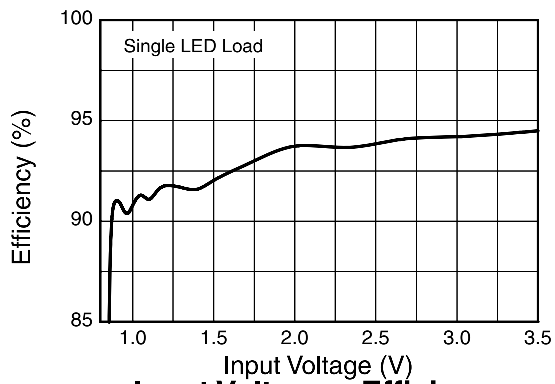
Material List

Ref	Value	Part Number	Manufacture	Comments
U1	N/A	ZXSC300E5	Zetex Plc	Single cell converter, SOT23-5
Q1	N/A	FMMT617	Zetex Plc	Low $V_{CE(sat)}$ NPN, SOT23
D1	1A	ZHCS1000	Zetex Plc	1A Shottky diode, SOT23
R1	100mR	Generic	Various	0805 Size
C1	2.2µF	Generic	Various	Low ESR ceramic capacitor
L1	100µH	DO1608P-104	Coilcraft	Surface mount inductor
LED1	5600mcd	NSPW500BS	Nichia	White LED

Maximum battery life solution

To ensure optimum efficiency, and therefore maximum battery life, the LED is supplied with a pulsed current. Maximum efficiency is ensured with the removal of rectifier losses experienced in the maximum brightness solution.





Input Voltage v Efficiency

Materials list

Ref	Value	Part Number	Manufacture	Comments
U1	N/A	ZXSC300E5	Zetex Plc	Single cell converter, SOT23-5
Q1	N/A	FMMT617	Zetex Plc	Low $V_{CE(SAT)}$ NPN, SOT23
R1	330mW	Generic	Various	0805 Size
L1	100µH	DO1608P-104	Coilcraft	Surface mount inductor
LED1	5600mcd	NSPW500BS	Nichia	White LED

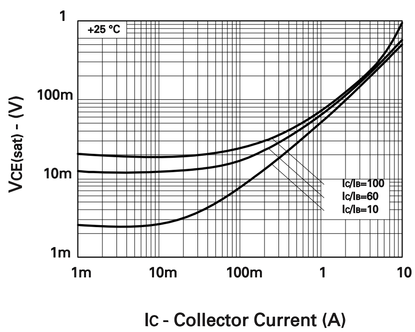
APPLICATIONS INFORMATION

The following section is a design guide for optimum converter performance.

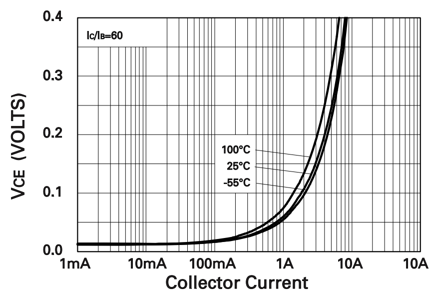
Switching transistor selection

The choice of switching transistor has a major impact on the converter efficiency. For optimum performance, a bipolar transistor with low $V_{CE(SAT)}$ and high gain is required.

The Zetex FMMT617 is an ideal choice of transistor, having a low saturation voltage. A data sheet for the FMMT617 is available on Zetex web site or through your local Zetex sales office. Outline information is included in the characteristics section of this data sheet.



$V_{CE(SAT)}$ v I_C



$V_{CE(SAT)}$ vs I_C

Schottky diode selection

For the maximum efficiency a Schottky rectifier diode is required not a normal silicon diode. As with the switching transistor the Schottky rectifier diode has a major impact on the converter efficiency. A Schottky diode with a low forward voltage and fast recovery time should be used for this application.

The diode should be selected so that the maximum forward current is greater or equal to the maximum peak current in the inductor, and the maximum reverse voltage is greater or equal to the output voltage.

The Zetex ZHCS1000 meets these needs. Datasheets for the ZHCS Series are available on Zetex web site or through your local Zetex sales office. Outline information is included in the characteristics section of this data sheet.

For the maximum brightness solution a pulsed current is supplied to the LED therefore a Schottky rectifier diode is not required.

Inductor selection

The inductor value must be chosen to satisfy performance, cost and size requirements of the overall solution. For the reference designs we recommend an inductor value of 100uH with a core saturation current rating greater than the converter peak current value and low series resistance.

Inductor selection has a significant impact on the converter performance. For applications where efficiency is critical, an inductor with a series resistance of 500mΩ or less should be used.

Peak current definition

The peak current rating is a design parameter whose value is dependent upon the overall application. For the high brightness reference designs, a peak current of 190mA was chosen to ensure that the converter could provide the required output power to the LED.

In general, the I_{PK} value must be chosen to ensure that the switching transistor, Q1, is in full saturation with maximum output power conditions, assuming worse-case input voltage and transistor gain under all operating temperature extremes.

Once I_{PK} is decided the value of R_{SENSE} can be determined by:

$$R_{SENSE} = \frac{V_{ISENSE}}{I_{PK}}$$

where V_{ISENSE}=19mV

Output Power Calculation

By making the above assumptions for inductance and peak current the output power can be determined by:

$$P_{OUT} = \frac{(V_{OUT} V_{IN}) \times (I_{PK} + I_{MIN})}{2} \times \frac{T_{OFF}}{(T_{ON} + T_{OFF})}$$

Note: V_{OUT} = output voltage + Schottky rectifier voltage drop

where

$T_{OFF} \cong 1.7\mu s$ (internally set by ZXSC300)

and

$$T_{ON} = \frac{T_{OFF}(V_{OUT} - V_{IN})}{V_{IN}}$$

and

$$I_{MIN} = I_{PK} - \frac{(V_{OUT} - V_{IN}) \times T_{OFF}}{L}$$

Operating frequency can be derived by:

$$F = \frac{1}{(T_{ON} + T_{OFF})}$$

Capacitor selection

For pulsed operation, as in the maximum battery life solution, no capacitors are required at the output to the LED. For rectified operation, as in the maximum brightness solution, a small value ceramic capacitor is required, typically 2.2uF.

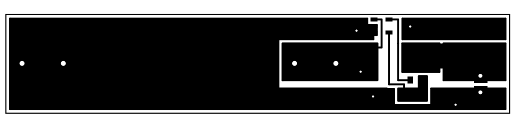
Generally an input capacitor is not required, but a small ceramic capacitor may be added to aid EMC, typically 470nF to 1uF.

Demonstration board

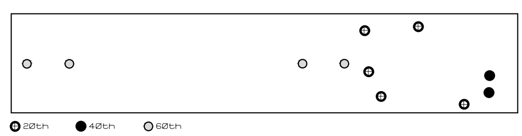
A demonstration board for the Maximum battery life solution, is available upon request. These can be obtained through your local Zetex office or through Zetex web pages. For all reference designs Gerber files and bill of materials can be supplied.

Layout of Maximum battery life solution

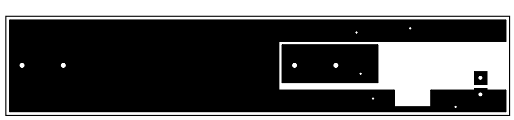
Top Copper



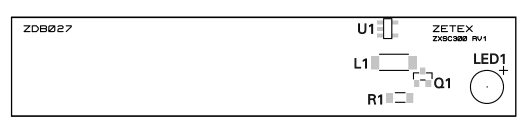
Drill Holes



Bottom Copper



Silk Screen

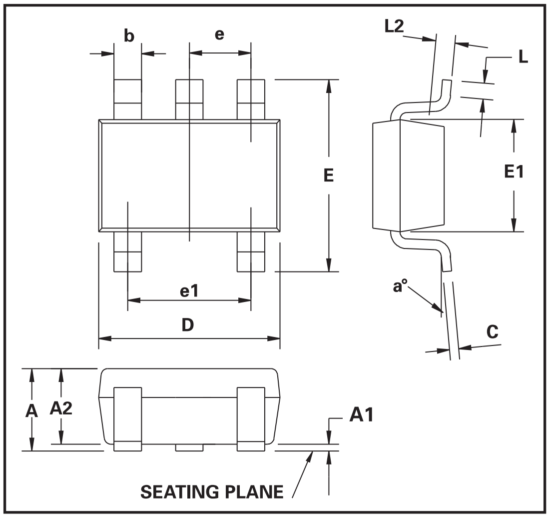


ZETEX SEMICONDUCTORS

SUPPLIER LISTING

Manufacturer	EUROPE	ASIA	USA
Zetex	Zetex GmbH Germany	Zetex Asia Hong Kong	Zetex Inc
Tel:	(49) 894549490	(852) 2610 0611	(1) 631 543 7100
URL:	http://www.zetex.com		
AVX	AVX UK	AVX Asia Singapore	AVX USA
Tel:	(44) 1252 770000	(65) 6286 7555	(1) 843 448 9411
URL:	http://www.avxcorp.com		
Coilcraft	Coilcraft Europe UK		Coilcraft Inc
Tel:	(44) 1236 730595		(1) 847 639 6400
URL:	http://www.coilcraft.com		
Nichia Corporation	Nichia Europe B.V. The Netherlands	Nichia Corporation Japan	Nichia America Corporation
Tel:	(31) 20 5060900	(81) 3 3456 3784	Head Office (1) 717 285 2323 San Jose (1) 408 573 0933
URL:	http://www.nichia.co.jp		

PACKAGE OUTLINE



PACKAGE DIMENSIONS

DIM	Millimeters		Inches	
	MIN.	MAX.	MIN.	MAX.
A	0.90	1.45	0.0354	0.0570
A1	-	0.15	-	0.0059
A2	0.90	1.30	0.0354	0.0511
b	0.20	0.50	0.0078	0.0196
C	0.09	0.26	0.0035	0.0102
D	2.70	3.10	0.1062	0.1220
E	2.20	3.20	0.0866	0.1181
E1	1.30	1.80	0.0511	0.0708
e	0.95 REF		0.0374 REF	
e1	1.90 REF		0.0748 REF	
L	0.10	0.60	0.0039	0.0236
a	0°	30°	0°	30°

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"Not recommended for new designs"	Device is still in production to support existing designs and production
"Obsolete"	Production has been discontinued

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«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

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