

ZXSC300

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.

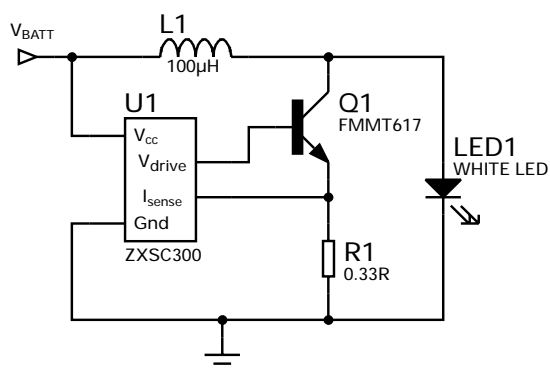
The circuit can start up under full load and operates down to an input voltage of 0.8 volts. The solution configuration ensures optimum efficiency over a wide range of load currents, several circuit configurations are possible depending on battery life versus brightness considerations.

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

TYPICAL APPLICATION CIRCUIT



ORDERING INFORMATION

DEVICE	Package	Partmarking
ZXSC300E5	SOT23-5	C300

ZXSC300

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 125°C
Power Dissipation	450mW		

ELECTRICAL CHARACTERISTICS:

Test conditions unless otherwise stated: $V_{CC}=1.5V$, $T_{AMB}=25^{\circ}C$

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	$I_{DRIVE}=-600\mu A$, $V_{DRIVE}=0.7V$ $I_{DRIVE}=-600\mu A$, $V_{DRIVE}=0.7V$, $T_{AMB}=-10^{\circ}C^3$		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		%/ $^{\circ}C$
I_{ISENSE}	I_{SENSE} input current	$V_{ISENSE} = 0V$	0	-30	-65	μA

ELECTRICAL CHARACTERISTICS: AC PARAMETERS²

TEST CONDITIONS (Unless otherwise stated))

$V_{CC}=1.5V$, $T_{AMB} = 0$ to $70^{\circ}C$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
T_{DRV}	Discharge Pulse Width		1.2	1.7	3.2	μs
F_{OSC}	Recommended operating frequency ⁴				200	kHz

¹ Application dependent, see reference designs.

² These parameters guaranteed by Design

³ Total supply current $= I_Q + I_{VDRIVE}$, see typical characteristics

⁴ Operating frequency is application circuit dependent. See applications section.

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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 in the Zetex surface mount data book or at www.zetex.com

ELECTRICAL CHARACTERISTICS (at $T_A = 25^\circ\text{C}$ unless otherwise stated).

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

*Measured under pulsed conditions. Pulse width=300 μs . Duty cycle $\leq 2\%$

ZHCS1000

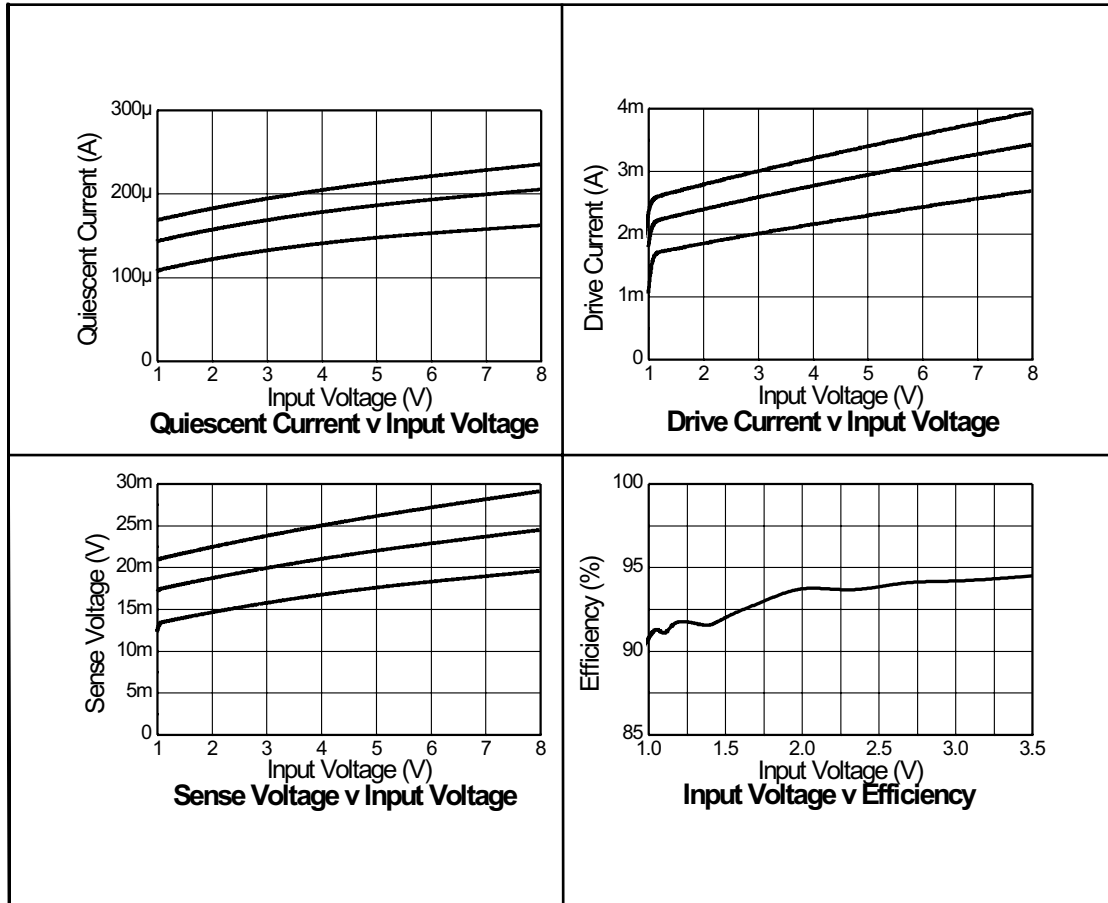
For the circuits described in the applications section Zetex ZHCS1000 is the recommended Schottky diode. The following indicates outline data for the diode, more detailed information is available at www.zetex.com

ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25^\circ\text{C}$ unless otherwise stated).

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

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TYPICAL CHARACTERISTICS



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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.

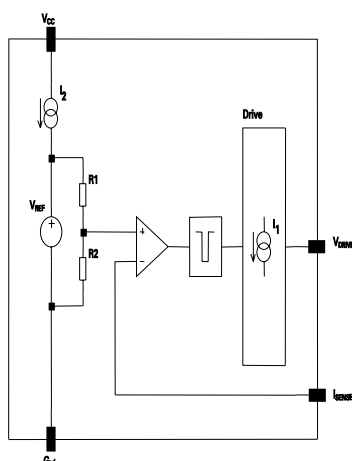


Figure 1
ZXSC300 Block Diagram

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 1.7 μ s. This ensures that there is sufficient time to discharge the inductor coil before the next on period.

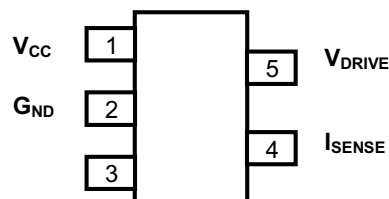
Pin Descriptions

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.

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.

Pin out Diagram



Top View

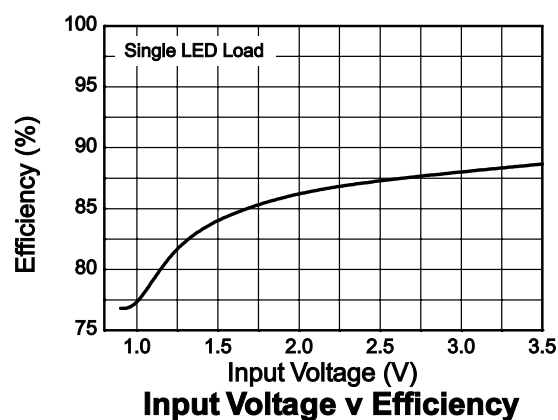
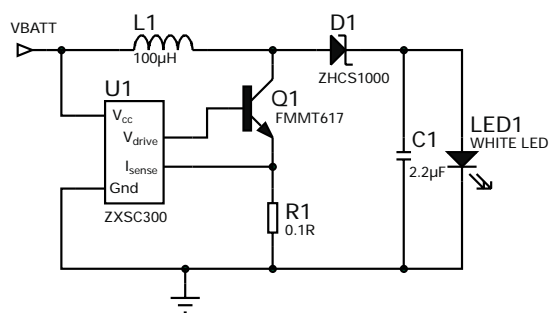
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REFERENCE DESIGNS

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.



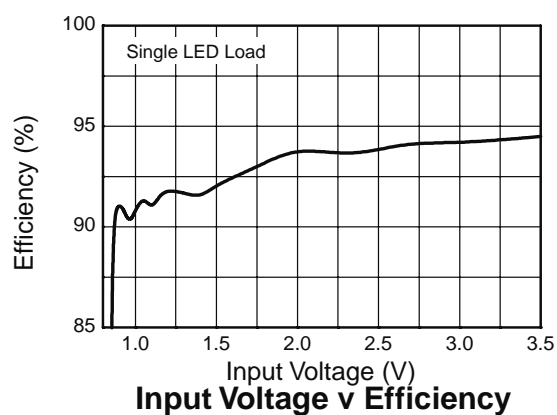
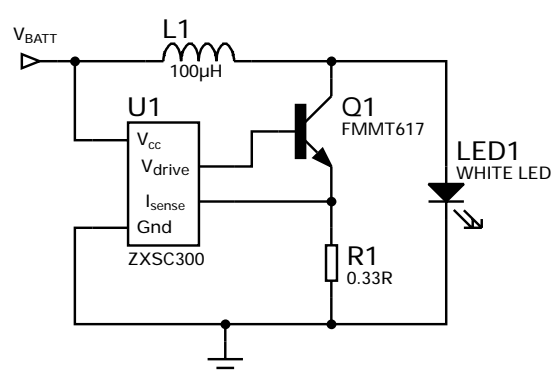
Material List

Ref	Value	Part Number	Manufacture	Comments
U1	N/A	ZXSC300E5	Zetex Plc	Single cell converter, SOT23-5
Q1	N/A	FM6T617	Zetex Plc	Low $V_{CE(sat)}$ NPN, SOT23
D1	1A	ZHCS1000	Zetex Plc	1A Schottky diode, SOT23
R1	100mΩ	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

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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.



Materials list

Ref	Value	Part Number	Manufacture	Comments
U1	N/A	ZXSC300E5	Zetex Plc	Single cell converter, SOT23-5
Q1	N/A	FM617	Zetex Plc	Low $V_{CE(SAT)}$ NPN, SOT23
R1	330mΩ	Generic	Various	0805 Size
L1	100µH	DO1608P-104	Coilcraft	Surface mount inductor
LED1	5600mcd	NSPW500BS	Nichia	White LED

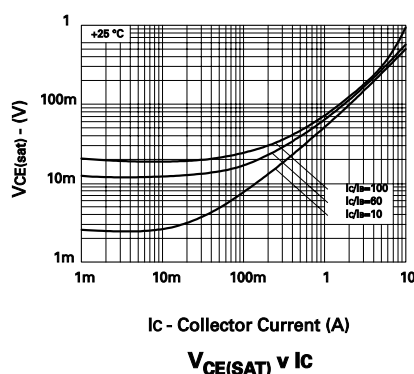
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APPLICATIONS INFORMATION

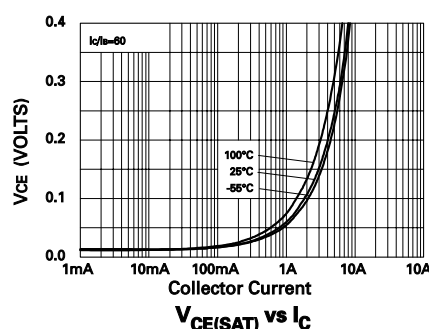
The following section is a design guide for optimum converter performance.

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.



Schottky diode selection

For the maximum battery life solution a Schottky rectifier diode is required. 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 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 $V_{ISENSE} = 19mV$



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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

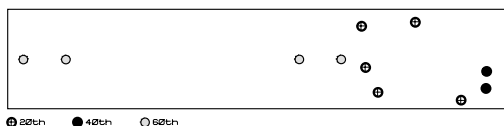
A demonstration board for the Maximum battery life solution, is available upon request. These can be obtained through your local Zetex office or through Zetex web pages. For all reference designs Gerber files and bill of materials can be supplied.

Layout of Maximum battery life solution

Top Copper



Drill Holes



Bottom Copper



Silk Screen



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(Notes)

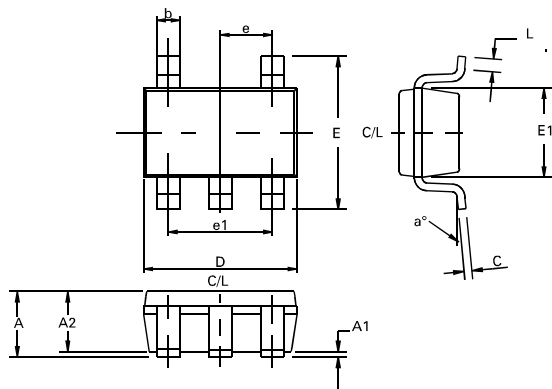
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Supplier Listing

	GERMANY	ASIA	USA	UK
Zetex	Zetex GmbH Munich	Zetex Asia Hong Kong	Zetex Inc Long Island NY	Zetex PLC Chadderton, Oldham
	(49) 894549490	(852) 2610 0611	(1) 631 543 7100	(44) 161 622 4444
	http://www.zetex.com			
AVX		AVX Asia Singapore (65) 258 2833	AVX USA (1) 843 448 9411	AVX UK (44) 1252 770000
	http://www.avxcorp.com			
Coilcraft			Coilcraft Inc (1) 847 639 6400	Coilcraft Europe (44) 1236 730595
	http://www.coilcraft.com			
Nichia Corporation	Nichia Europe B.V. Amsterdam The Netherlands (31) 20 5060900	Nichia Corporation Tokyo Sales Office Tokyo, Japan (81) 3 3456 3784	Nichia America Corporation Head Office (1) 717 285 2323 San Jose (1) 408 573 0933	
	http://www.nichia.co.jp			

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PACKAGE DIMENSIONS SOT23-5



DIM	Millimetres		Inches	
	MIN	MAX	MIN	MAX
A	0.90	1.45	0.035	0.057
A1	0.00	0.15	0.00	0.006
A2	0.90	1.3	0.035	0.051
b	0.35	0.50	0.014	0.020
C	0.09	0.20	0.0035	0.008
D	2.80	3.00	0.110	0.118
E	2.60	3.00	0.102	0.118
E1	1.50	1.75	0.059	0.069
e	0.95 REF		0.037 REF	
e1	1.90 REF		0.075 REF	
L	0.10	0.60	0.004	0.024
a°	0	10	0	10



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