



Distributor of Diodes Incorporated: Excellent Integrated System Limited
Datasheet of ZXSC300E5TA - IC LED Driver DC DC Controller Backlight SOT-23-5

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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.

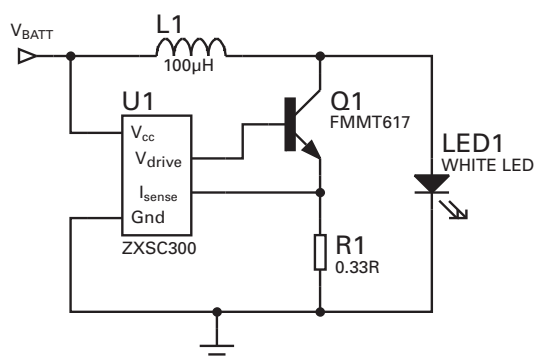
FEATURES

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

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

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 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} =-600 μ A, V _{DRIVE} =0.7V I _{DRIVE} =-600 μ A, 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 _{ISENSE} voltage temp co. ² | | | 0.4 | | %/°C |
| I _{ISENSE} | I _{ISENSE} input current | V _{ISENSE} = 0V | 0 | -30 | -65 | μ A |
| T _{DRV} | Discharge pulse width | | 1.2 | 1.7 | 3.2 | μ s |

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.

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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 at www.zetex.com/FMMT617

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

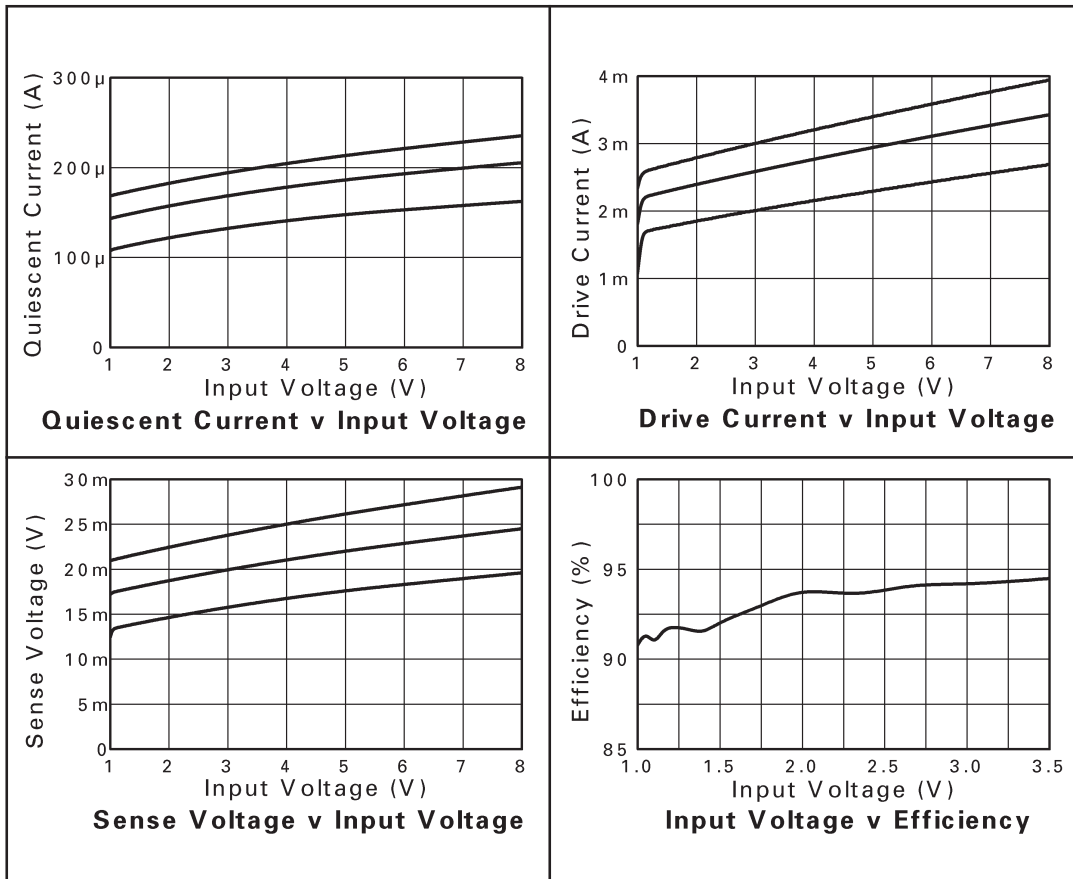
ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25^\circ\text{C}$ unless otherwise stated).

| 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 $I_R=50\text{mA}$ |

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

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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.

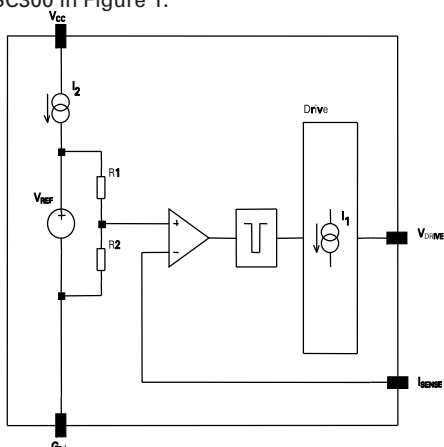
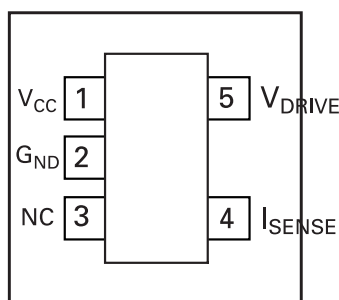


Figure 1 ZXSC300 Block Diagram

With every on pulse the switching transistor is kept on until the voltage across the current-sense resistor exceeds the threshold of the ISENSE 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



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

The Voltage at ISENSE 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.

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 |

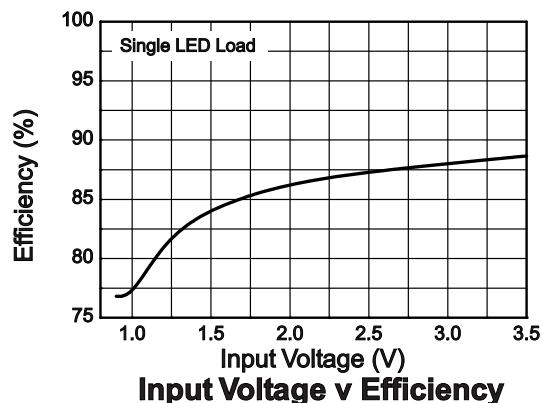
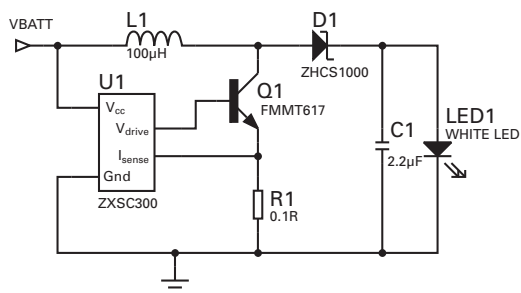
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REFERENCE DESIGNS

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.



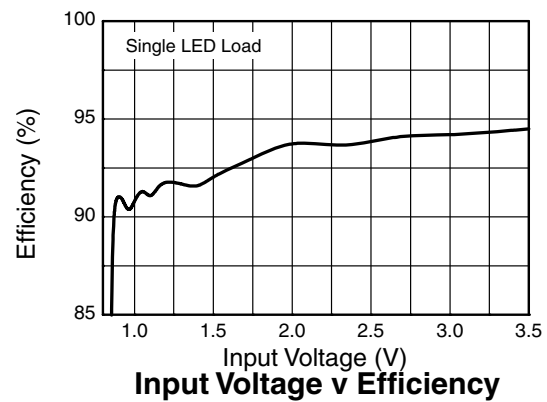
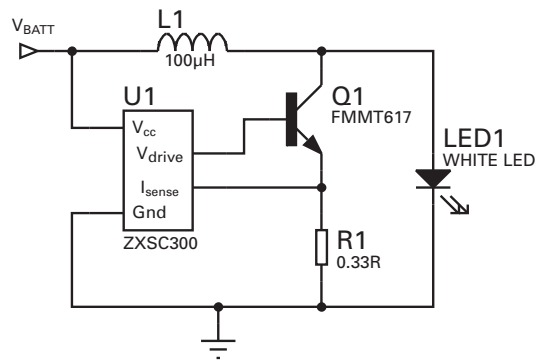
Material List

| 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 | 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 |

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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 | FM6T617 | 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 |

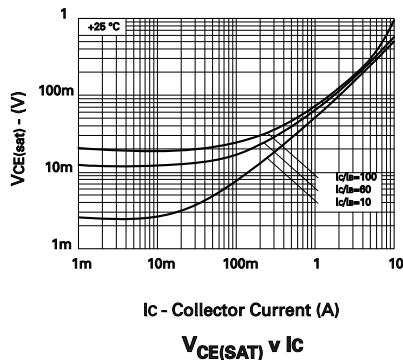
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APPLICATIONS INFORMATION

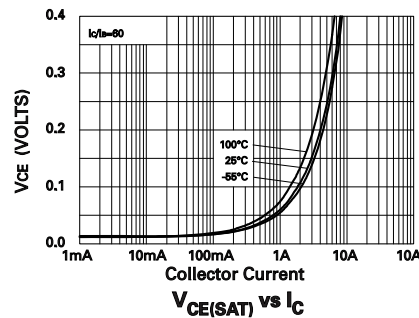
The following section is a design guide for optimum converter performance.

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 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 $V_{ISENSE}=19mV$

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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

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

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

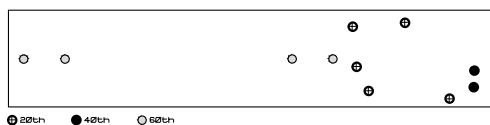
A demonstration board for the Maximum battery life solution, is available upon request. These can be obtained through your local Zetex office or through Zetex web pages. For all reference designs Gerber files and bill of materials can be supplied.

Layout of Maximum battery life solution

Top Copper



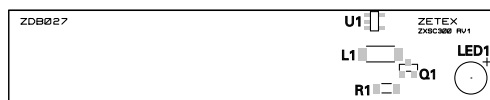
Drill Holes



Bottom Copper



Silk Screen



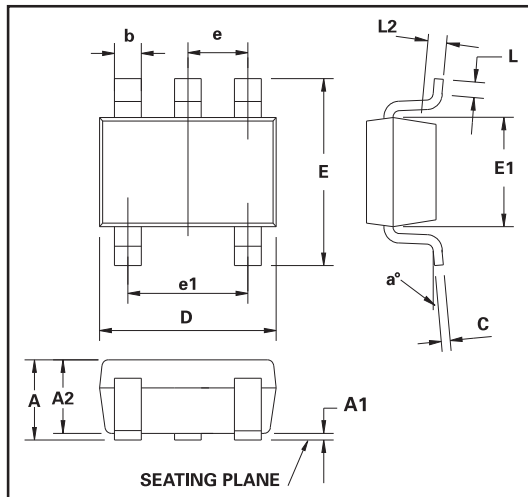
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SUPPLIER LISTING

| 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 | | |

ZXSC300

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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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. |
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