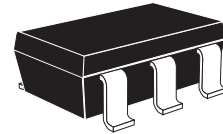


# ZXSC410 ZXSC420

## VOLTAGE MODE BOOST CONVERTER

### DESCRIPTION

The ZXSC410 is voltage mode boost converter in SOT23-6 package. Its excellent load and line regulation means that for the full supply range from lithium ion cells, the output voltage will typically change by less than 1%. Using high efficiency Zetex switching transistors allow output voltages of tens of volts depending on the selected transistor. The ZXSC420 includes a battery low indicator. This operates by indicating when the converter is no longer able to maintain the regulated output voltage rather than setting a preset threshold, thereby making it suitable for various battery options and load currents.



SOT23-6

### FEATURES

- 1.65V to 8V supply range
- Typical output regulation of  $\pm 1\%$
- Over 85% typical efficiency
- Output currents up to 300mA
- 4.5 $\mu$ A typical shutdown current ZXSC410
- End of regulation output ZXSC420

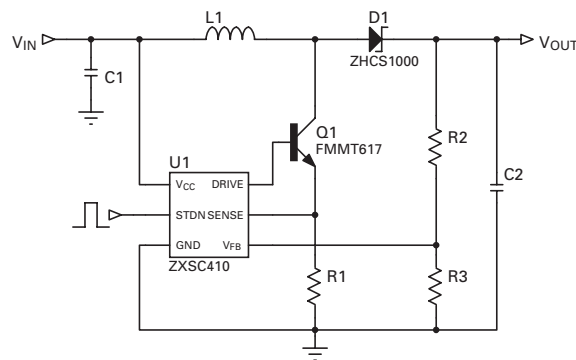
### ORDERING INFORMATION

| DEVICE      | REEL SIZE | TAPE WIDTH | QUANTITY PER REEL |
|-------------|-----------|------------|-------------------|
| ZXSC410E6TA | 7"        | 8mm        | 3000 units        |
| ZXSC420E6TA | 7"        | 8mm        | 3000 units        |

### APPLICATIONS

- System power for battery portable products
- LCD bias
- Local voltage conversion

### TYPICAL APPLICATIONS DIAGRAM



### DEVICE MARKING

- C410 ZXSC410
- C420 ZXSC420

# ZXSC410

# ZXSC420

## ABSOLUTE MAXIMUM RATINGS

|                         |                                                           |                  |
|-------------------------|-----------------------------------------------------------|------------------|
| V <sub>CC</sub>         | -0.3V to +10V                                             |                  |
| DRIVE                   | -0.3V to V <sub>CC</sub> + 0.3V                           |                  |
| EOR                     | -0.3V to V <sub>CC</sub> + 0.3V                           | * (ZXSC420 only) |
| STDN                    | -0.3V to The lower of (+5.0V) or (V <sub>CC</sub> + 0.3V) | * (ZXSC410 only) |
| V <sub>FB</sub> , SENSE | -0.3V to The lower of (+5.0V) or (V <sub>CC</sub> + 0.3V) |                  |
| Operating Temp.         | -40°C to +85°C                                            |                  |
| Storage Temp.           | -55°C to +125°C                                           |                  |
| Power Dissipation       | 450mW                                                     |                  |

## ELECTRICAL CHARACTERISTICS

Test Conditions V<sub>CC</sub>= 3V, T= -40°C to 85°C unless otherwise stated.

| Symbol                        | Parameter                | Conditions                                               | Limits |       |                      | Units |
|-------------------------------|--------------------------|----------------------------------------------------------|--------|-------|----------------------|-------|
|                               |                          |                                                          | Min    | Typ   | Max                  |       |
| Supply parameters             |                          |                                                          |        |       |                      |       |
| V <sub>CC</sub>               | V <sub>CC</sub> Range    |                                                          | 1.8    |       | 8                    | V     |
| I <sub>q</sub> <sup>1</sup>   | Quiescent Current        | V <sub>CC</sub> = 8V                                     |        |       | 220                  | μA    |
| I <sub>STDN</sub>             | Shutdown Current         |                                                          |        | 4.5   |                      | μA    |
|                               |                          |                                                          |        |       |                      |       |
| Eff <sup>2</sup>              | Efficiency               | 50mA > I <sub>OUT</sub> > 300mA                          |        | 85    |                      | %     |
| Acc <sub>REF</sub>            | Reference tolerance      | 1.8V < V <sub>CC</sub> < 8V                              | -3.0   |       | 3.0                  | %     |
| TCO <sub>REF</sub>            | Reference Temp Co        |                                                          |        | 0.005 |                      | %/°C  |
| T <sub>DRV</sub>              | Discharge pulse width    | 1.8V < V <sub>CC</sub> < 8V                              |        | 1.7   |                      | μs    |
| F <sub>OSC</sub>              | Operating Frequency      |                                                          |        |       | 200                  | kHz   |
| Input parameters              |                          |                                                          |        |       |                      |       |
| V <sub>SENSE</sub>            | sense voltage            |                                                          | 22     | 28    | 34                   | mV    |
| I <sub>SENSE</sub>            | sense input current      | V <sub>FB</sub> =0V;V <sub>SENSE</sub> =0V               | -1     | -7    | -15                  | μA    |
| V <sub>FB</sub>               | Feedback voltage         | T <sub>A</sub> = 25°C                                    | 291    | 300   | 309                  | mV    |
| I <sub>FB</sub> <sup>2</sup>  | Feedback input current   | V <sub>FB</sub> =0V;V <sub>SENSE</sub> =0V               | -1.2   |       | -4.5                 | μA    |
| V <sub>IH</sub>               | Shutdown high voltage    |                                                          | 1.5    | 1     | V <sub>CC</sub>      | V     |
| V <sub>IL</sub>               | Shutdown low voltage     |                                                          | 0      |       | 0.55                 | V     |
| dV <sub>LN</sub>              | Line voltage regulation  |                                                          |        | 0.5   |                      | %/V   |
| Output parameters             |                          |                                                          |        |       |                      |       |
| I <sub>OUT</sub> <sup>3</sup> | Output current           | V <sub>IN</sub> > 2V, V <sub>OUT</sub> = V <sub>IN</sub> | 300    |       |                      | mA    |
| I <sub>DRIVE</sub>            | Transistor drive current | V <sub>DRIVE</sub> = 0.7V                                | 2      | 3.4   | 5                    | mA    |
| V <sub>DRIVE</sub>            | Transistor voltage drive | 1.8V < V <sub>CC</sub> < 8V                              | 0      |       | V <sub>CC</sub> -0.4 | V     |
| C <sub>DRIVE</sub>            | Mosfet gate drive cpbty  |                                                          |        | 300   |                      | pF    |
| VOH <sub>EOR</sub>            | EOR Flag output high     | I <sub>EOR</sub> = -300nA                                | 2.5    |       | V <sub>CC</sub>      | V     |
| VOL <sub>EOR</sub>            | EOR Flag output low      | I <sub>EOR</sub> = 1mA                                   | 0      |       | 1.15                 | V     |
| T <sub>EOR</sub>              | EOR delay time           | T <sub>A</sub> = 25°C                                    | 70     | 195   | 250                  | μs    |
| dI <sub>LD</sub>              | Load current regulation  |                                                          |        |       | 0.01                 | %mA   |

Note

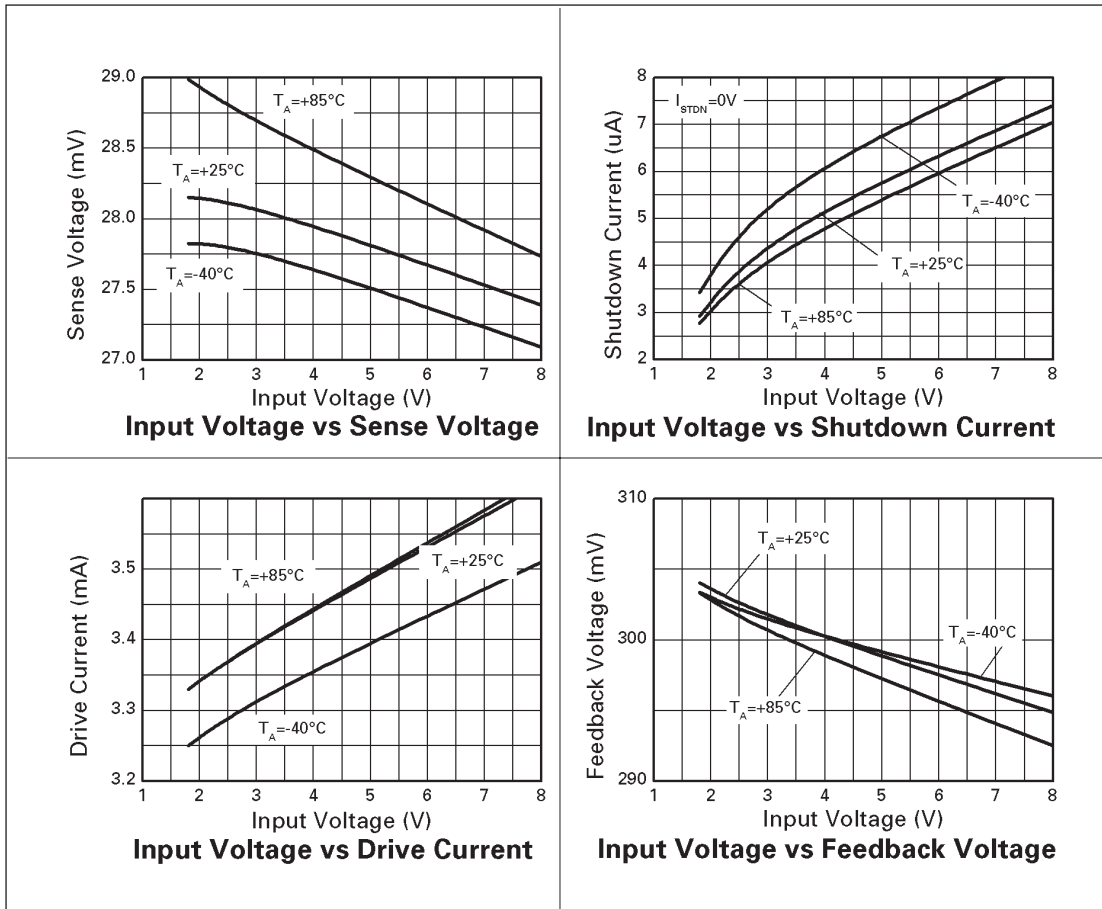
<sup>1</sup> Excluding gate/base drive current.

<sup>2</sup> I<sub>FB</sub> is typically half of these values at 3V

<sup>3</sup> System not device spec, including recommended transistors.

# ZXSC410 ZXSC420

## TYPICAL CHARACTERISTICS



# ZXSC410 ZXSC420

## DEVICE DESCRIPTION

### Bandgap Reference

All threshold voltages and internal currents are derived from a temperature compensated bandgap reference circuit with a reference voltage of 1.22V nominal.

### Dynamic Drive Output

Depending on the input signal, the output is either "LOW" or "HIGH". In the high state a 2.5mA current source (max drive voltage =  $V_{CC} - 0.4V$ ) drives the base or gate of the external transistor. In order to operate the external switching transistor at optimum efficiency, both output states are initiated with a short transient current in order to quickly discharge the base or the gate of the switching transistor.

### Switching Circuit

The switching circuit consists of two comparators, Comp1 and Comp2, a gate U1, a monostable and the drive output. Normally the DRIVE output is "HIGH"; the external switching transistor is turned on. Current ramps up in the inductor, the switching transistor and external current sensing resistor. This voltage is sensed by comparator, Comp2, at input  $I_{SENSE}$ . Once the current sense voltage across the sensing resistor exceeds 20mV, comparator Comp2 through gate U1 triggers a re-triggerable monostable and turns off the output drive stage for 2 $\mu$ s. The inductor discharges to the load of the application. After 2 $\mu$ s a new charge cycle begins, thus ramping the output voltage. When the output voltage reaches the nominal value and  $V_{FB}$  gets an input voltage of more than 300mV, the monostable is forced "on" from Comp1 through gate U1, until the feedback voltage falls below 300mV. The above action continues to maintain regulation.

### EOR, End of Regulation Detector

The EOR circuit is a retriggerable 120 $\mu$ s monostable, which is re-triggered by every down regulating action of comparator Comp1. As long as regulation takes place, output EOR is "HIGH" (high impedance, 100K to  $V_{CC}$ ). Short dips of the output voltage of less than 120 $\mu$ s are ignored. If the output voltage falls below the nominal value for more than 120 $\mu$ s, output EOR goes "LOW". The reason for this to happen is usually a slowly progressing drop of input voltage from the discharging battery. Therefore the output voltage will also start to drop slowly. With the EOR detector, batteries can be used to the ultimate end of discharge, with enough time left for a safe shutdown.

## Block Diagrams

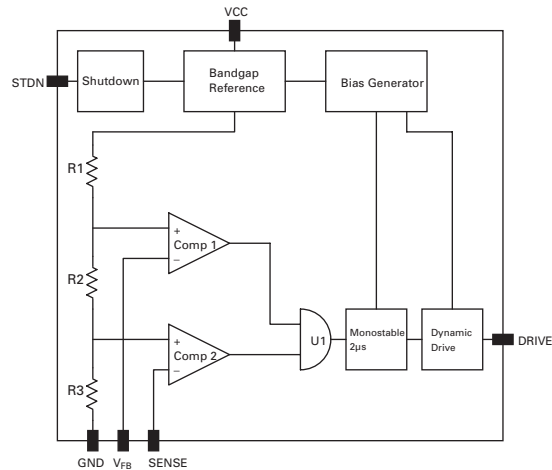


Fig. 1 ZXSC410

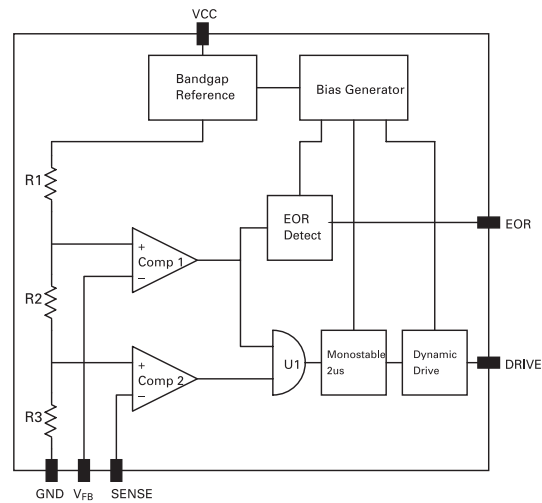


Fig. 1 ZXSC420

## PIN DESCRIPTIONS

| Pin No. | Name            | Description                                                                                                  |
|---------|-----------------|--------------------------------------------------------------------------------------------------------------|
| 1       | V <sub>CC</sub> | Supply voltage, 1.8V to 8V.                                                                                  |
| 2       | GND             | Ground                                                                                                       |
| 3       | STDN/EOR        | Shutdown ZXSC410 / End of regulation ZXSC420                                                                 |
| 4       | SENSE           | Inductor current sense input. Internal threshold voltage set to 28mV. Connect external sense resistor.       |
| 5       | V <sub>FB</sub> | Reference voltage. Internal threshold set to 300mV. Connect external resistor network to set output voltage. |
| 6       | DRIVE           | Drive output for external switching transistor. Connect to base or gate of external switching transistor.    |

## APPLICATIONS INFORMATION

### 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<sub>CE(SAT)</sub> and high gain is required. The V<sub>CEO</sub> of the switching transistor is also an important parameter as this sees the full output voltage when the transistor is switched off. Zetex SuperSOT™ transistors are an ideal choice for this application.

### Schottky diode selection

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 rating 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 ZHCS Series meet these needs.

### Combination devices

To minimise the external component count Zetex recommends the ZX3CDBS1M832 combination of low NPN transistor and Schottky diode in a 3mm x 2mm MLP package. This device is recommended for use in space critical applications.

The IC is also capable of driving MOSFETs. Zetex recommends the ZXMNS3BM832 combination of low threshold voltage N-Channel MOSFET and Schottky diode in a 3mm x 2mm MLP package. This device is recommended for use in space critical applications.

### Inductor Selection

The inductor value must be chosen to satisfy performance, cost and size requirements of the overall solution.

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.

A list of recommended inductors is listed in the table below:

| Part No.      | Manufacture             | L    | I <sub>PK</sub><br>(A) | R <sub>DC</sub><br>(Ω) |
|---------------|-------------------------|------|------------------------|------------------------|
| CMD4D11-100MC | Sumida                  | 10μH | 0.5                    | 0.457                  |
| CMD4D11-220MC | Sumida                  | 22μH | 0.4                    | 0.676                  |
| LPO2506OB-103 | Coilcraft               | 10μH | 1.0                    | 0.24                   |
| ST2006103     | Standex Electronics Inc | 10μH | 0.6                    | 0.1                    |

### Peak current definition

In general, the I<sub>PK</sub> value must be chosen to ensure that the switching transistor, Q1, is in full saturation with maximum output power conditions, assuming worst-case input voltage and transistor gain under all operating temperature extremes.

Once I<sub>PK</sub> is decided the value of R<sub>SENSE</sub> can be determined by:

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

# ZXSC410

# ZXSC420

## Sense Resistor

A low value sense resistor is required to set the peak current. Power in this resistor is negligible due to the low sense voltage threshold,  $V_{SENSE}$ . Below is a table of recommended sense resistors:

| Manufacture | Series | $R_{DC}(\Omega)$<br>Range | Size | Tolerance | URL                                                       |
|-------------|--------|---------------------------|------|-----------|-----------------------------------------------------------|
| Cyntec      | RL1220 | 0.022 - 10                | 0805 | ±5%       | <a href="http://www.cyntec.com">http://www.cyntec.com</a> |
| IRC         | LR1206 | 0.010 - 1.0               | 1206 | ±5%       | <a href="http://www.icct.com">http://www.icct.com</a>     |

## Output power calculation

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

$$P_{OUT} = I_{AV} \times V_{IN} \times \eta = (\text{Watts})$$

where

$$I_{AV} = \frac{I_{PK}}{2} \times \frac{(T_{ON} + T_{DIS})}{(T_{ON} + T_{OFF})}$$

and

$$T_{ON} = \frac{I_{PK} \times L}{V_{IN}}$$

and

$$T_{DIS} = \frac{I_{PK} \times L}{V_{OUT} - V_{IN}}$$

and

$$T_{OFF} \approx 1.7\mu s \text{ (internally set by ZXSC410)}$$

and

$$\eta = \text{efficiency i.e. } 100\% = 1$$

Operating frequency can be derived by:

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

## Output capacitors

Output capacitors are a critical choice in the overall performance of the solution. They are required to filter the output and supply load transient currents. There are three parameters which are paramount in the selection of the output capacitors, capacitance,  $I_{RIPPLE}$  and ESR. The capacitance value is selected to meet the load transient requirements. The capacitors  $I_{RIPPLE}$  rating must meet or exceed the current ripple of the solution.

The ESR of the output capacitor can also affect loop stability and transient performance. The capacitors selected for the solutions, and indicated in the reference designs, are optimised to provide the best overall performance.

## Input capacitors

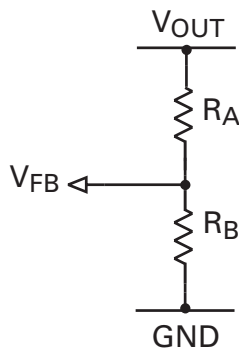
The input capacitor is chosen for its voltage and RMS current rating. The use of low ESR electrolytic or tantalum capacitors is recommended. Capacitor values for optimum performance are suggested in the reference design section

Also note that the ESR of the input capacitor is effectively in series with the input and hence contributes to efficiency losses in the order of  $I_{RMS}^2 \cdot ESR$ .

# ZXSC410 ZXSC420

## Output voltage adjustment

The ZXSC410/420 are adjustable output converters allowing the end user the maximum flexibility. For adjustable operation a potential divider network is connected as follows:



The output voltage is determined by the equation:

$$V_{OUT} = V_{FB} \left( 1 + \frac{R_A}{R_B} \right)$$

where  $V_{FB}=300\text{mV}$

The resistor values,  $R_A$  and  $R_B$ , should be maximised to improve efficiency and decrease battery drain. Optimisation can be achieved by providing a minimum current of  $I_{FB(MAX)}=200\text{nA}$  to the  $V_{FB}$  pin. Output is adjustable from  $V_{FB}$  to the  $(BR)V_{CEO}$  of the switching transistor, Q1.

Note: For the reference designs,  $R_A$  is assigned the label R2 and  $R_B$  the label R3.

## Layout issues

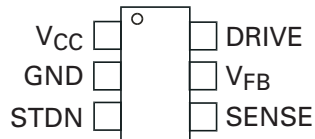
Layout is critical for the circuit to function in the most efficient manner in terms of electrical efficiency, thermal considerations and noise.

For 'step-up converters' there are four main current loops, the input loop, power-switch loop, rectifier loop and output loop. The supply charging the input capacitor forms the input loop. The power-switch loop is defined when Q1 is 'on', current flows from the input through the inductor, Q1,  $R_{SENSE}$  and to ground. When Q1 is 'off', the energy stored in the inductor is transferred to the output capacitor and load via D1, forming the rectifier loop. The output loop is formed by the output capacitor supplying the load when Q1 is switched back off.

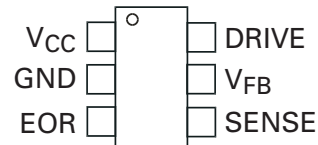
To optimise for best performance each of these loops kept separate from each other and interconnected with short, thick traces thus minimising parasitic inductance, capacitance and resistance. Also the  $R_{SENSE}$  resistor should be connected, with minimum trace length, between emitter lead of Q1 and ground, again minimising stray parasitics.

## CONNECTION DIAGRAMS

### ZXSC410 SOT23-6



### ZXSC420 SOT23-6



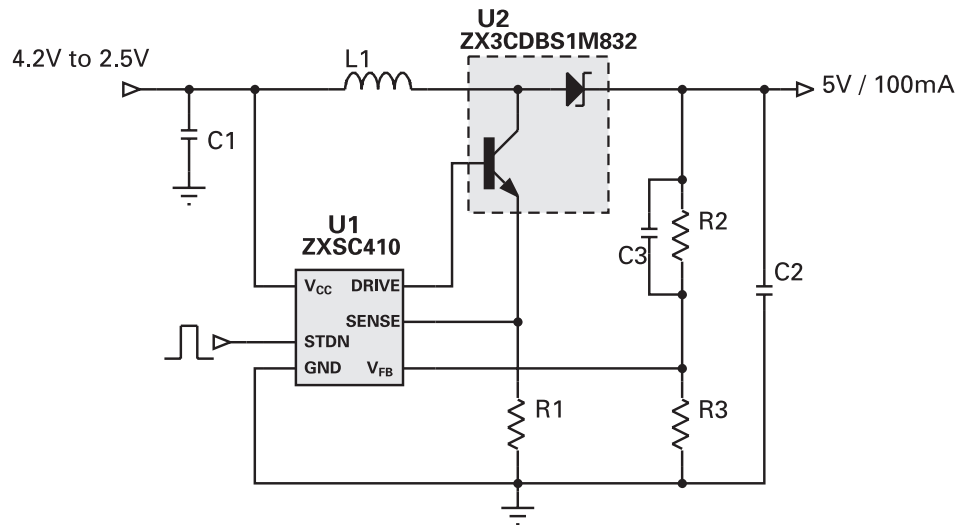
# ZXSC410 ZXSC420

## REFERENCE DESIGNS

### ZXSC410 DC-DC Controller

$V_{IN}=2.5V$  to  $4.2V$

$V_{OUT}=5V$ ;  $I_{LOAD}=100mA$

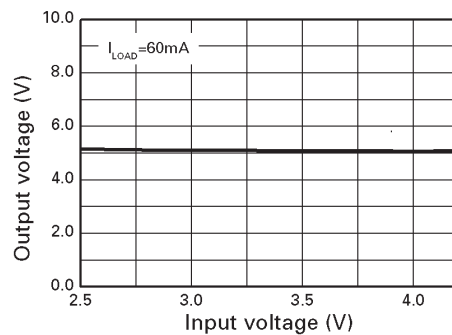


## Bill of Materials

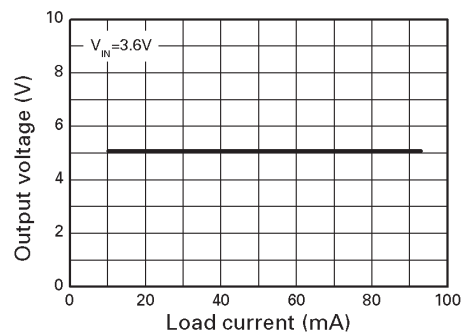
| Ref | Value          | Part Number     | Manufacture  | Comments                  |
|-----|----------------|-----------------|--------------|---------------------------|
| U1  |                | ZXSC410E6       | Zetex        | DC-DC converter IC        |
| U2  |                | ZX3CDBS1M832    | Zetex        | Low sat NPN + 1A Schottky |
| L1  | 22 $\mu$ H     | CMD4D11-220     | Sumida       | 1mm height profile        |
| R1  | 100m $\Omega$  | LR1206 / RL1220 | IRC / Cyntec | 1206 / 0805 size          |
| R2  | 16k $\Omega$   | Generic         | Generic      | 0603 size                 |
| R3  | 1k $\Omega$    | Generic         | Generic      | 0603 size                 |
| C1  | 22 $\mu$ F/6V3 | GRM Series      | Murata       | 1206 size                 |
| C2  | 22 $\mu$ F/6V3 | GRM Series      | Murata       | 1206 size                 |
| C3  | 1nF            | Generic         | Generic      | 0603 size                 |

# ZXSC410 ZXSC420

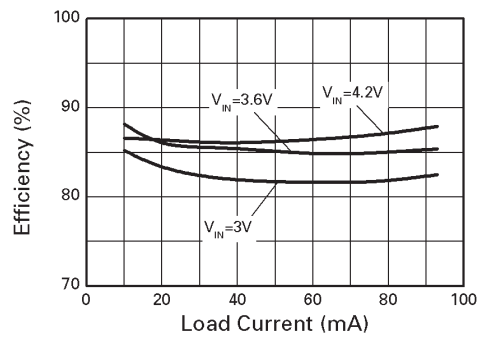
## Performance Graphs



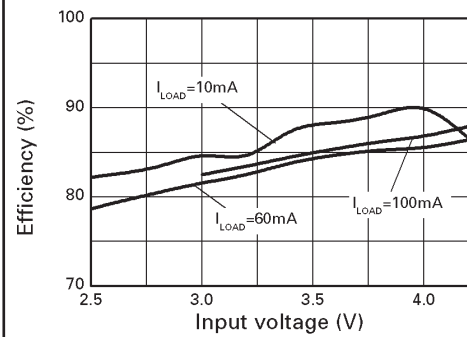
**Line regulation**



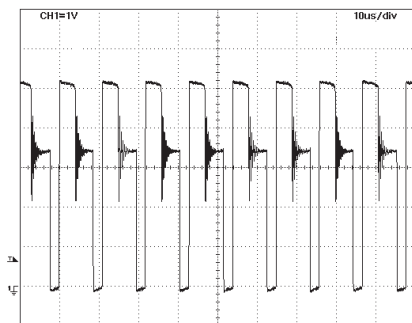
**Load regulation**



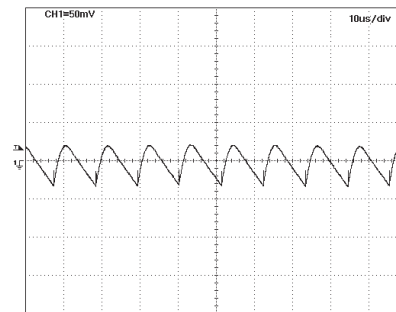
**Load current vs Efficiency**



**Input voltage vs Efficiency**



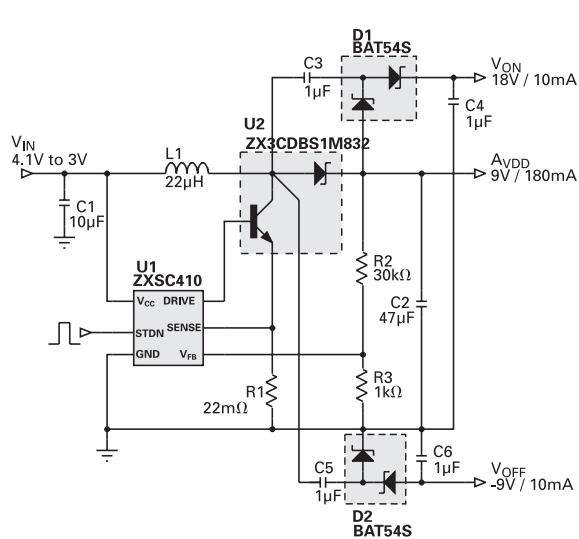
**Switching Waveform**



**Output Ripple**

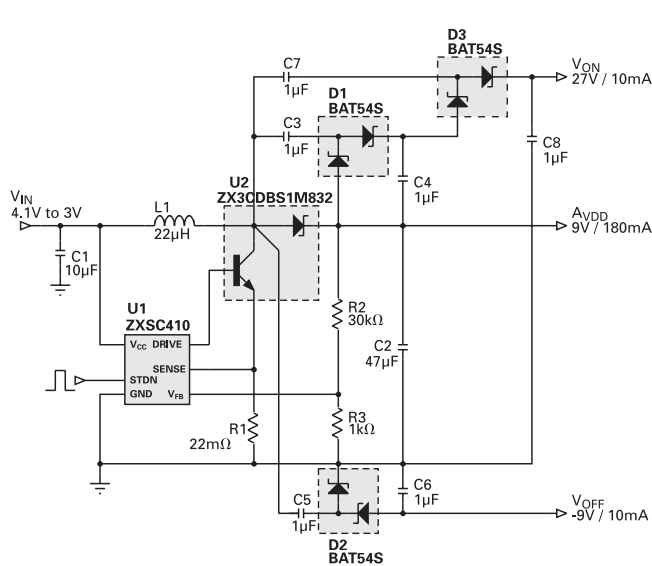
# ZXSC410 ZXSC420

## ZXSC410 as Triple Output TFT Bias



$A_{VDD}=9V/180mA$   
 $V_{ON}=18V/10mA$   
 $V_{OFF}=9V/10mA$

## ZXSC410 as Triple Output TFT Bias



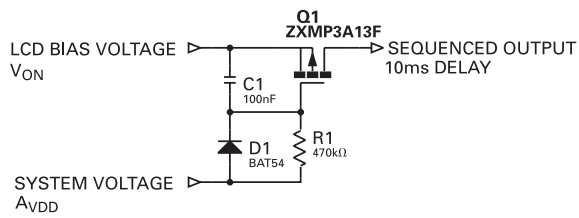
$A_{VDD}=9V/180mA$   
 $V_{ON}=27V/10mA$   
 $V_{OFF}=9V/10mA$

## ZXSC410 ZXSC420

### Sequencing $A_{VDD}$ and $V_{ON}$

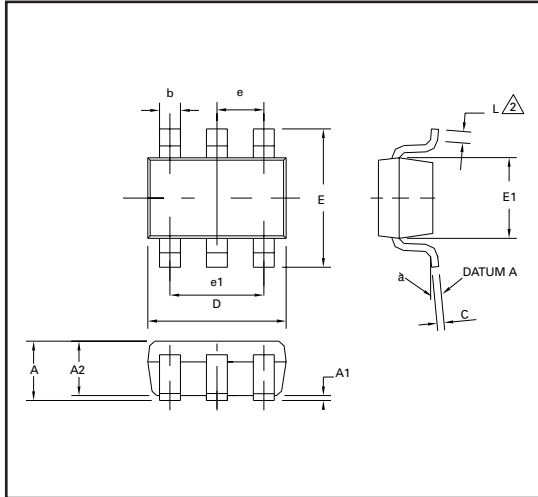
By adding the circuit below to the LCD bias output ( $V_{ON}$ ) of the converter a 10ms delay can be achieved between  $A_{VDD}$  power up and  $V_{ON}$  power up. The circuit operates by a delay in turning the PMOS transistor on, which transfers to a 10ms delay between input and output of the circuit.

The delay is set by the RC time constant of R1 and C1. The diode, D1, discharges the gate of the PMOS when the main system supply is turned off, guaranteeing a delay every turn on cycle.

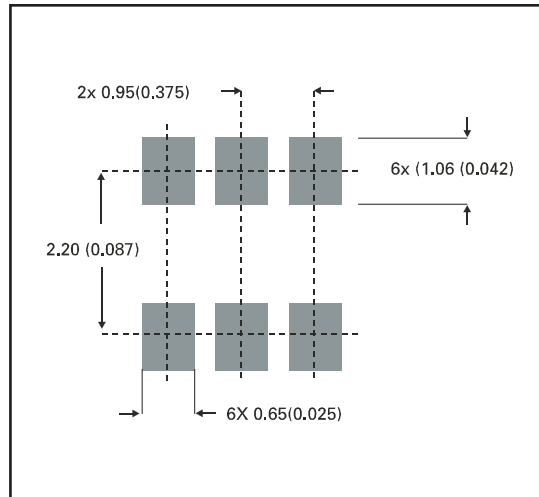


# ZXSC410 ZXSC420

## PACKAGE OUTLINE



## PAD LAYOUT DETAILS



CONTROLLING DIMENSIONS IN MILLIMETRES APPROX CONVERSIONS INCHES.

## PACKAGE DIMENSIONS

| DIM | Millimetres |      | Inches |       | DIM | Millimetres |      | Inches    |       |
|-----|-------------|------|--------|-------|-----|-------------|------|-----------|-------|
|     | Min         | Max  | Min    | Max   |     | Min         | Max  | Min       | Max   |
| A   | 0.90        | 1.45 | 0.35   | 0.057 | E   | 2.60        | 3.00 | 0.102     | 0.118 |
| A1  | 0.00        | 0.15 | 0      | 0.006 | E1  | 1.50        | 1.75 | 0.059     | 0.069 |
| A2  | 0.90        | 1.30 | 0.035  | 0.051 | L   | 0.10        | 0.60 | 0.004     | 0.002 |
| b   | 0.35        | 0.50 | 0.014  | 0.019 | e   | 0.95 REF    |      | 0.037 REF |       |
| C   | 0.09        | 0.20 | 0.0035 | 0.008 | e1  | 1.90 REF    |      | 0.074 REF |       |
| D   | 2.80        | 3.00 | 0.110  | 0.118 | L   | 0°          | 10°  | 0°        | 10°   |

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