ML0308A/B - Tiny Package, High Efficiency, White LED Driver and Step-up DC/DC Converter

FEATURES

◆ 1.2MHz Switching Frequency Furnishes the Use of Tiny Surface Mount Components

◆ High Output Voltage: Up To 16V

◆ Automatic Softstart

◆ Drives Up To Four White LEDs From 3.6V Supply

APPLICATIONS

◆ LCD Bias

◆ Handheld Computers

◆ Battery Backup

◆ Digital Cameras

DESCRIPTION

The ML0308 are high efficiency, white LED driver and step-up DC/DC converters in a tiny SOT23 5-lead package. The ML0308 switches at 1.2MHz. High switching frequency permits the use of tiny, low profile inductors and capacitor to minimize footprint and cost in space-conscious portable applications.

The 18V switch allows high output voltage up to 16V to be easily generated in a simple boost topology avoiding the use of costly transformers.
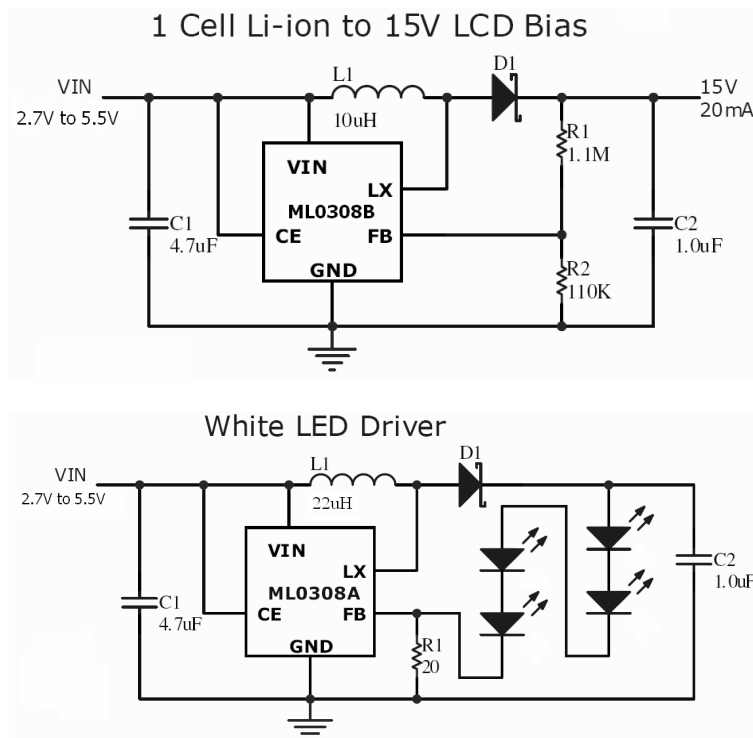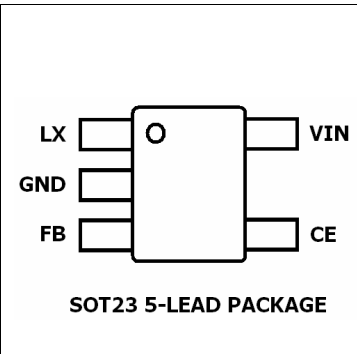
TYPICAL APPLICATIONS

Figure 1: One-cell Li-ion to 15V Converter and White LED Driver

MiniLogic Device Corporation

ABSOLUTE MAXIMUM RATINGS

V_{IN}, FB, CE voltage	6.0V
L_X Voltage	18.0V
Junction Temperature	125°C
Operating Temperature (Note 2)	-30°C to 85°C
Storage Temperature	-40°C to 150°C
Lead Temperature (soldering 10 seconds)	300°C

PACKAGE/ORDER INFORMATION

SOT23 5-LEAD PACKAGE

ORDER PART NUMBER
ML0308AMRG
ML0308BMRG
PART MARKING
L30C (ML0308AMRG)
L36A (ML0308BMRG)

ELECTRICAL CHARACTERISTICS The "X" denotes the specifications which apply over the full operating temperature range, otherwise specifications are at TA = 25°C. V_{IN} = 3.0V, V_{CE} = 3.0V unless otherwise noted.

| PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage			2.7		5.5	V
Quiescent Current	Non-switching			100	150	uA
	V_{CE} = 0V				0.1	uA
Feedback Voltage	ML0308A	X	186	198	210	mV
	ML0308B	X	1.205	1.230	1.255	V
Lx Leakage Current	V_{CE} = 0V , V_{LX} = 5.5V			0.1	1.0	uA
Lx ON Resistance	V_{IN} = 3.0V, I_{DS}=100mA					Ω
Lx Current Limit				180	250	mA
Lx Voltage Limit (Note 3)				16.5	17.5	V
Switching Frequency			0.9	1.2	1.5	MHz
Duty Ratio		X	72	75	78	%
CE Pin Input High Voltage			1.5			V
CE Pin Input LOW Voltage					0.3	V

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: The ML0308 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the –40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: If Lx pin exceeds the voltage limit, the ML0308 will stop switching for about 40us.

PIN FUNCTION DESCRIPTION

Pin	Description
LX (Pin 1)	Switch Pin. This is the drain of the internal power MOSFET. Minimize the metal trace area connected to this pin to minimize EMI.
GND (Pin 2)	Ground. Tie this pin directly to the local ground plane.
FB (Pin 3)	Feedback Pin. Set the output voltage by selecting values for R1 and R2: $VOUT = \dfrac{R1+R2}{R2} \times 0.198V$ (ML0308A) or $VOUT = \dfrac{R1+R2}{R2} \times 1.23V$ (ML0308B)
CE (Pin 4)	This pin is the chip-enable Pin. Ground this pin to shutdown the chip. Apply a clock with different duty ratio to control brightness of the LEDs.
VIN (Pin 5)	The external voltage supply is connected to this pin. A high quality reservoir capacitor must be connected across pin 5 and pin 2 (ground) to achieve the specified output voltage parameters. A 4.7uF/6.3 V, low ESR capacitor must be connected as close as possible across pin 5 and pin 2 (ground).

BLOCK DIAGRAM – ML0308A
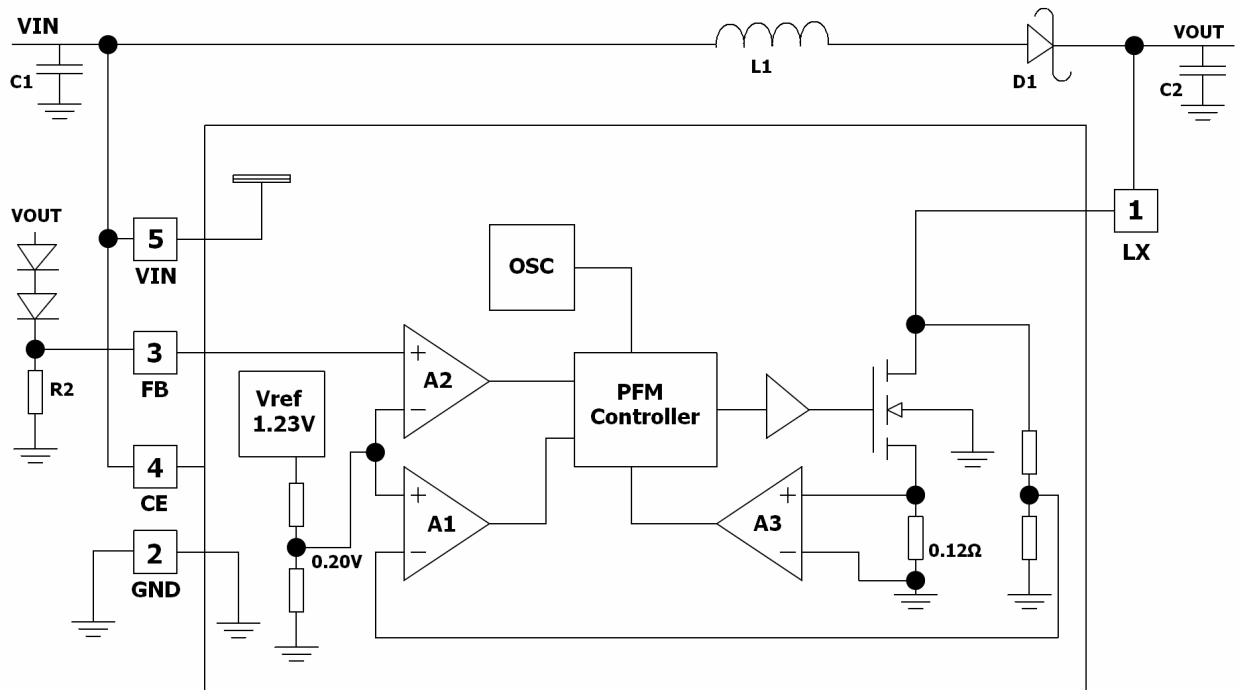
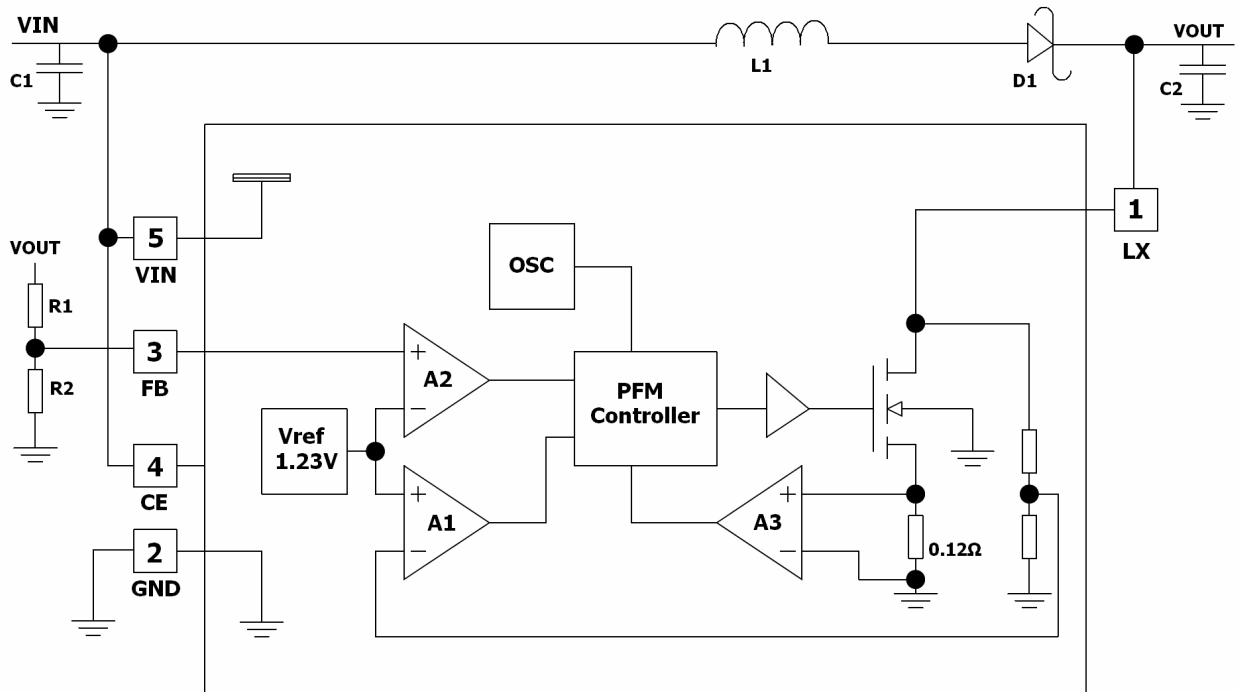## BLOCK DIAGRAM – ML0308B

Figure 2: Internal Block Diagram of ML0308B

OPERATION

The ML0308 uses a pulse-skipping PFM, current mode control scheme to provide excellent line and load regulation. Its operation can be best explained with reference to figure 2 and figure 1. The oscillator generates a clock of 1.2MHz with 75% duty ratio for the PFM controller. When CE pin goes HIGH, the power MOSFET switches at 1.2 MHz to charge the inductor and boost the output voltage to the target level specified by R1 and R2. The output voltage is set as follow:

$$VOUT = \frac{R1 + R2}{R2} \times 1.23V \text{ (ML0308B)}$$

When the inductor current reaches the current limit, comparator A3 will toggle and the control circuit will turn off the MOSFET immediately. So the inductor current is limited. Therefore, soft-start is achieved and potential hazards like current and voltage overshoot are avoided. When output voltage reaches and rises over the regulation point, amplifier A2 will amplify the error. The chip will adjust its pulse-skipping rate to monitor the output voltage.

APPLICATION INFORMATION

Choosing an Inductor

Several recommended inductors that work well with the ML0308. Consult each manufacturer for more detailed information and for their entire selection of related parts. Many different sizes and shapes are available. Use the equations and recommendations in the next few sections to find the correct inductance value for your design.

Inductor Selection—Boost Regulator

The formula below calculates the appropriate inductor value to be used for a boost regulator using the ML0308 (or at least provides a good starting point). This value provides a good tradeoff in inductor size and system performance. Pick a standard inductor close to this value. A larger value can be used to slightly increase the available output current, but limit it to around twice the value calculated below, as too large of an inductance will increase the output voltage ripple without providing much additional output current. A smaller value can be used (especially for systems with output voltages greater than 12V) to give a smaller physical size. Inductance can be calculated as:

$$L = \frac{V_{OUT} - V_{IN(MIN)} + V_D}{I_{LIMIT}} t_{OFF}$$

where $V_D = 0.4V$ (Schottky diode voltage), I_{LIMIT} = 180mA, and t_{OFF} = 250ns; for designs with varying V_{IN} such as battery powered applications, use the minimum V_{IN} value in the above equation. For most systems with output voltages below 7V, a 4.7uH inductor is the best choice, even though the equation above might specify a smaller value. This is due to the inductor current overshoot that occurs when very small inductor values are used

(see Current Limit Overshoot section). For higher output voltages, the formula above will give large inductance values. For a 3V to 16V converter (typical LCD Bias application), a 22uH inductor is called for with the above equation, but a 10uH inductor could be used without excessive reduction in maximum output current.

Current Limit Overshoot

For a fixed duty ratio PFM control scheme of the ML0308, the power switch is turned off after 3/4 of a cycle or the 180mA current limit is reached. There is a 100ns delay between the time when the current limit is reached and when the switch actually turns off. During this delay, the inductor current exceeds the current limit by a small amount. The peak inductor current can be calculated by

$$I_{PEAK} = I_{LIMIT} + \left(\frac{V_{IN(MAX)} - V_{DSSAT}}{L} \right) t_d$$

Where $V_{DSSAT} = 0.25V$ (switch saturation voltage) and t_d = 100ns. The current overshoot will be most evident for systems with high input voltages and for systems where smaller inductor values are used. This overshoot can be beneficial as it helps increase the amount of available output current for smaller inductor values. This will be the peak current seen by the inductor (and the diode) during normal operation. For designs using small inductance values (especially at input voltages greater than 5V), the current limit overshoot can be quite high. Although it is internally current limited to 180mA, the power switch of the ML0308 can handle larger currents without problem, but the overall efficiency will suffer.

Best results will be obtained when IPEAK is kept below 300mA.

Capacitor Selection

Low ESR (Equivalent Series Resistance) capacitors should be used at the output to minimize the output ripple voltage. Multilayer ceramic capacitors are the best choice, as they have a very low ESR and are available in very small packages. Their small size makes them a good companion to the ML0308 SOT23 package. Solid tantalum capacitors can be used, but they will occupy more board area than a ceramic and will have a higher ESR. Always use a capacitor with a sufficient voltage rating. Ceramic capacitors also make a good choice for the input decoupling capacitor, which should be placed as close as possible to the ML0308. A 4.7uF input capacitor is sufficient for most applications.

Diode Selection

For most ML0308 applications, the Motorola MBR0520 surface mount Schottky diode (0.5A, 20V) is an ideal choice. Schottky diodes, with their low forward voltage drop and fast switching speed, are the best match for the ML0308. Many different manufacturers make equivalent parts, but make sure that the component is rated to handle at least 0.35A.

Lowering Output Voltage Ripple

Using low ESR capacitors will help minimize the output ripple voltage, but proper selection of the inductor and the output capacitor also plays a big role. The ML0308 provides energy to the load in bursts by ramping up the inductor current, then delivering that current to the load. If too large of an inductor value or too small of a capacitor value is used, the output ripple voltage will increase because the capacitor will be slightly overcharged each burst cycle. To reduce the output ripple, increase the output capacitor value or add a 4.7pF feed-forward capacitor in the feedback network of the ML0308 (see the circuits in the Typical Applications section). Adding this small, inexpensive 4.7pF capacitor will greatly reduce the output voltage ripple.
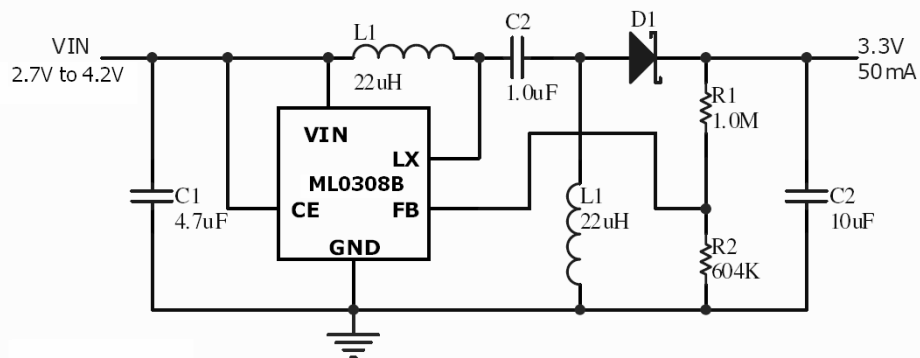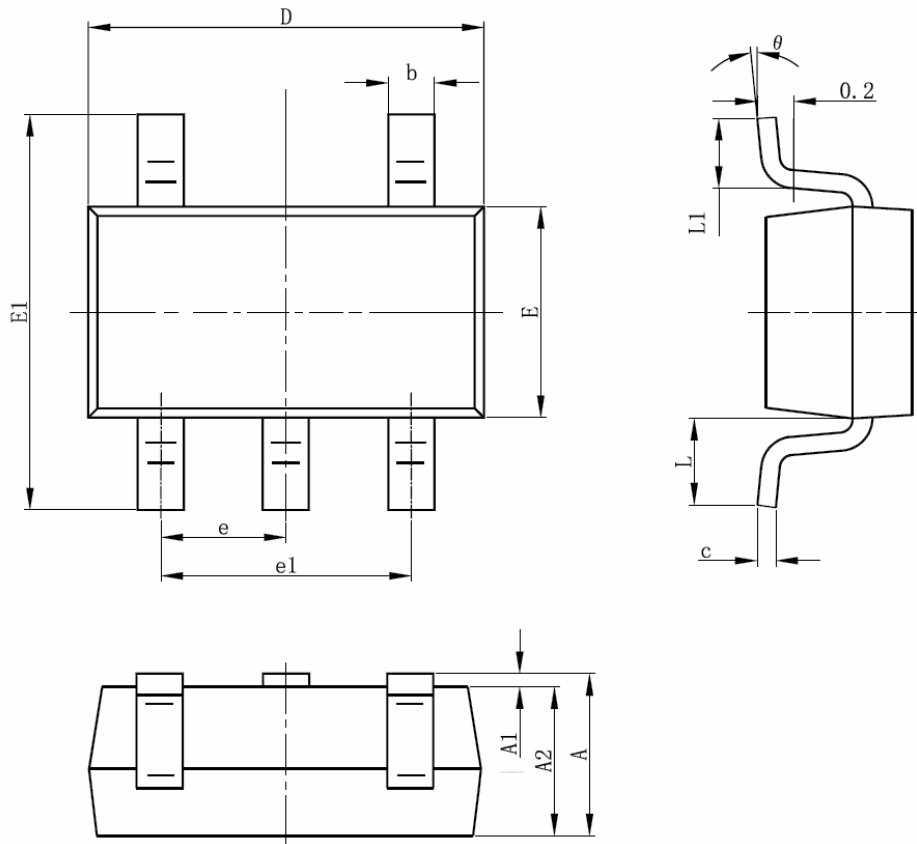
TYPICAL APPLICATIONS

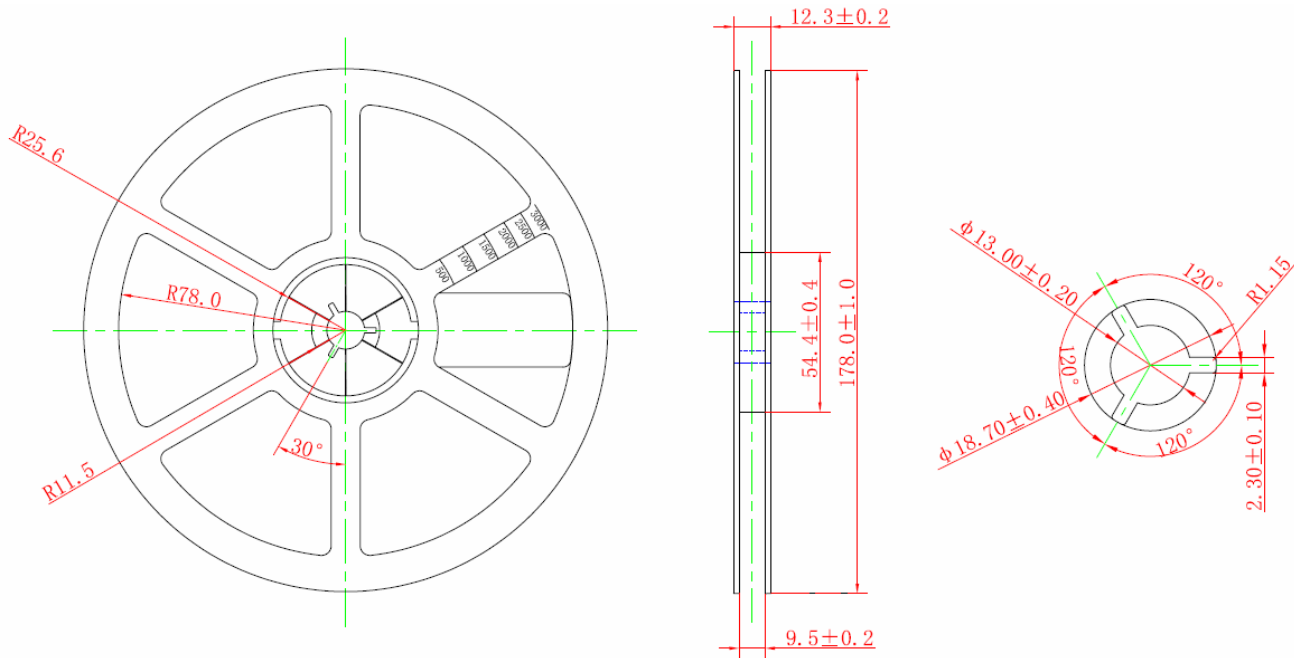### 1 Cell Li-ion to 15V LCD Bias
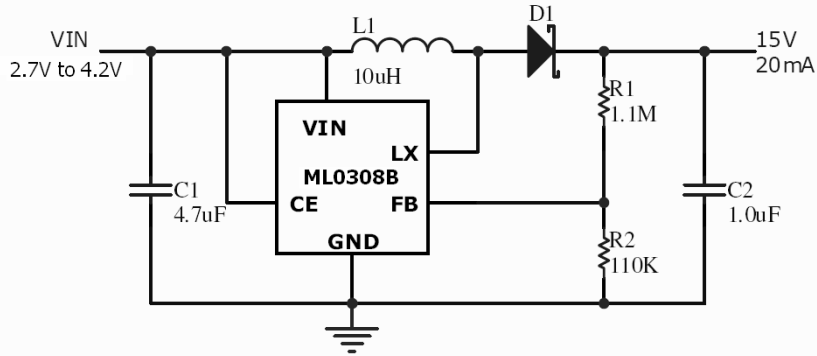
2-Cell to 3.3V Booster
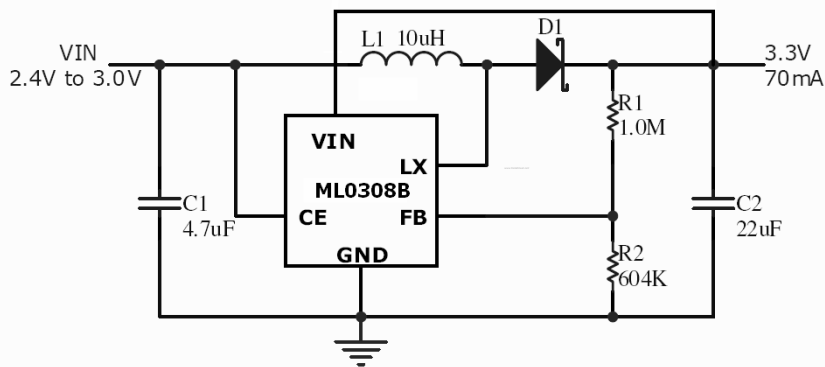
1-Cell Li-ion to 3.3V SEPIC Converter

Rev. B, July 2005

ML0308 PACKAGE OUTLINE - SOT23-5L

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

TAPE DIMENSIONS

REEL DIMENSIONS