

2.2MHz Step-Up DC/DC Converter in SOT-23

November 2000

FEATURES

- **2.2MHz Switching Frequency**
- **Low V_{CESAT} Switch: 400mV at 1A**
- **High Output Voltage: Up to 34V**
- Wide Input Range: 2.6V to 16V
- Uses Small Surface Mount Components
- 5V at 450mA from 3.3V Input
- 12V at 250mA from 5V Input
- Low Shutdown Current: $< 1\mu\text{A}$
- 5-Lead SOT-23 Package
- Pin-for-Pin Compatible with the LT1613 and LT1930

APPLICATIONS

- Digital Cameras
- Cordless Phones
- Battery Backup
- LCD Bias
- Medical Diagnostic Equipment
- Local 5V or 12V Supply
- External Modems
- PC Cards
- xDSL Power Supply

DESCRIPTION

The LT[®]1930A is the industry's fastest switching SOT-23 current mode DC/DC converter. With its 2.2MHz switching frequency and 1A integrated switch, the LT1930A can provide high current outputs in a small footprint. Intended as a drop-in substitute for the LT1930, it switches at 2.2MHz, allowing further reductions in the size and cost of external capacitors and inductors. Multiple output power supplies can now use a separate regulator for each output voltage, replacing cumbersome quasi-regulated approaches using a single regulator and custom transformers.

A constant frequency internally compensated current mode PWM architecture results in low, predictable output noise that is easy to filter. Low ESR ceramic capacitors can be used on the output, further reducing noise to the millivolt level. The high voltage switch on the LT1930A is rated at 36V, making the device ideal for boost converters up to 34V as well as for single-ended primary inductance converter (SEPIC) and flyback designs. The device can generate 5V at up to 450mA from a 3.3V supply or 12V at 250mA from a 5V supply.

The LT1930A is available in the 5-lead SOT-23 package.

 LTC and LT are registered trademarks of Linear Technology Corporation.

TYPICAL APPLICATION

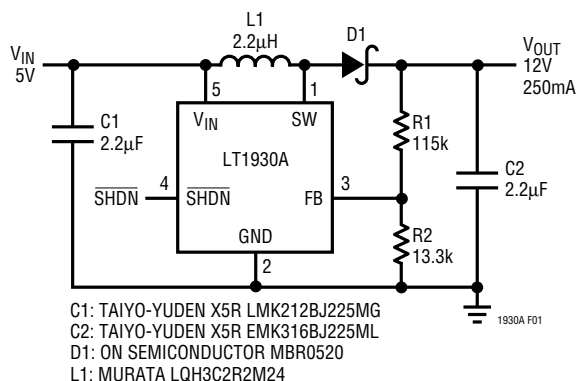
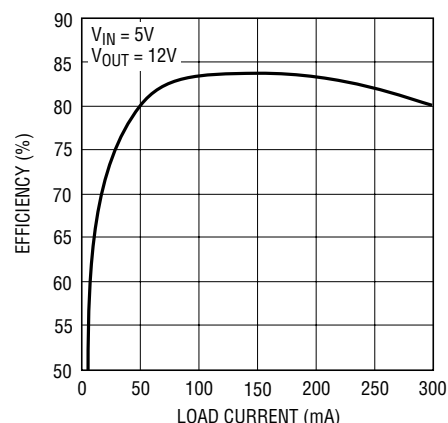


Figure 1. 5V to 12V, 250mA Step-Up DC/DC Converter

Efficiency



1930A TA01

ABSOLUTE MAXIMUM RATINGS

(Note 1)

V_{IN} Voltage	16V
SW Voltage	-0.4V to 36V
FB Voltage	2.5V
Current Into FB Pin	± 1 mA
SHDN Voltage	10V
Maximum Junction Temperature	125°C
Operating Temperature Range (Note 2) ..	-40°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

<p>TOP VIEW</p> <p>SW 1 5 V_{IN}</p> <p>GND 2</p> <p>FB 3 4 SHDN</p> <p>S5 PACKAGE 5-LEAD PLASTIC SOT-23</p> <p>$T_{JMAX} = 125^{\circ}\text{C}$, $\theta_{JA} = 256^{\circ}\text{C/W}$</p>	ORDER PART NUMBER
	LT1930AES5
	S5 PART MARKING
	LTSQ

Consult factory for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are $T_A = 25^{\circ}\text{C}$. $V_{IN} = 3\text{V}$, $V_{SHDN} = V_{IN}$ unless otherwise noted. (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Minimum Operating Voltage				2.45	2.6	V
Maximum Operating Voltage					16	V
Feedback Voltage			1.240	1.255	1.270	V
		●	1.230		1.280	V
FB Pin Bias Current	$V_{FB} = 1.255\text{V}$	●		240	720	nA
Quiescent Current	$V_{SHDN} = 2.4\text{V}$, Not Switching			5.5	8	mA
Quiescent Current in Shutdown	$V_{SHDN} = 0\text{V}$, $V_{IN} = 3\text{V}$			0.01	1	μA
Reference Line Regulation	$2.6\text{V} \leq V_{IN} \leq 16\text{V}$			0.01	0.05	%/V
Switching Frequency			1.9	2.2	2.5	MHz
		●	1.7		2.8	MHz
Maximum Duty Cycle		●	75	90		%
Switch Current Limit	(Note 3)		1	1.2		A
Switch V_{CESAT}	$I_{SW} = 1\text{A}$			400	600	mV
Switch Leakage Current	$V_{SW} = 5\text{V}$			0.01	1	μA
SHDN Input Voltage High			2.4			V
SHDN Input Voltage Low					0.5	V
SHDN Pin Bias Current	$V_{SHDN} = 3\text{V}$			35	70	μA
	$V_{SHDN} = 0\text{V}$			0	0.1	μA

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

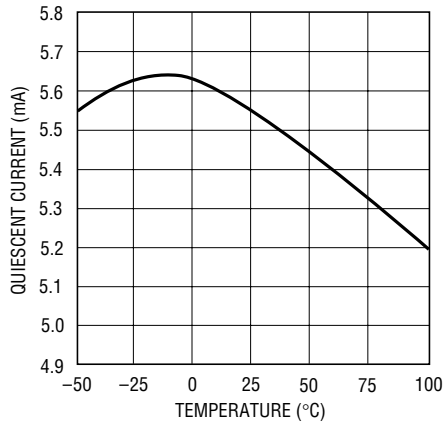
Note 2: The LT1930AES5 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C

operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: Current limit guaranteed by design and/or correlation to static test.

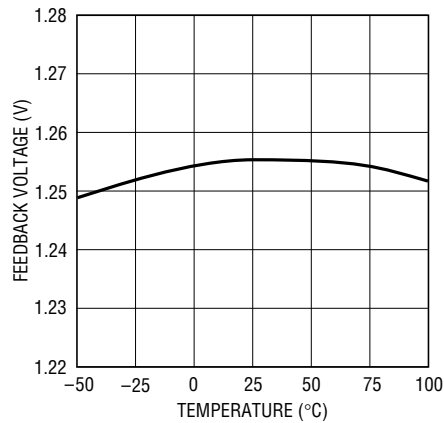
TYPICAL PERFORMANCE CHARACTERISTICS

Quiescent Current



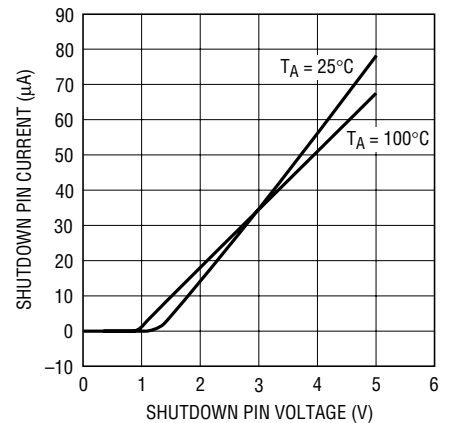
1930A G01

Feedback Pin Voltage



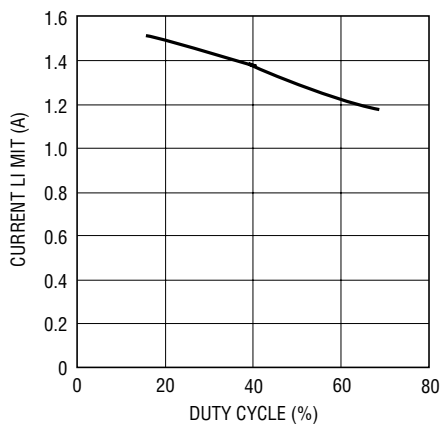
1930A G02

Shutdown Pin Current



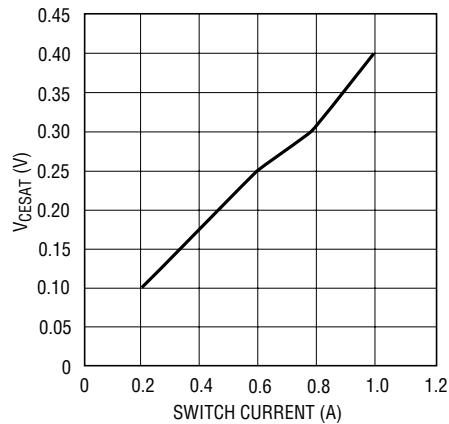
1930A G03

Current Limit



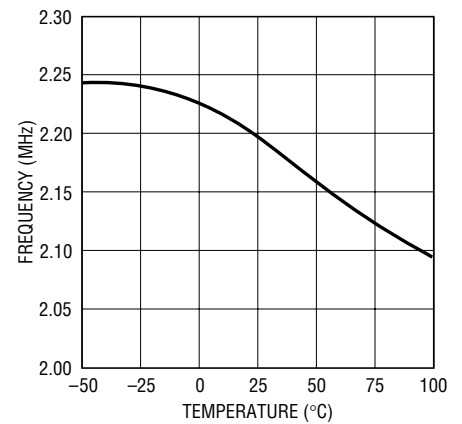
1930A G04

Switch Saturation Voltage



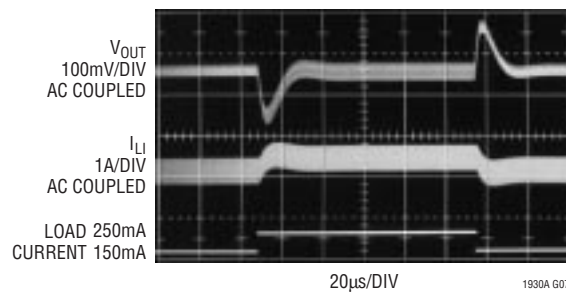
1930A G05

Oscillator Frequency



1930A G06

Transient Response for Figure 1's Circuit



1930A G07

PIN FUNCTIONS

SW (Pin 1): Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to reduce EMI.

GND (Pin 2): Ground. Tie directly to local ground plane.

FB (Pin 3): Feedback Pin. Reference voltage is 1.255V. Connect resistive divider tap here. Minimize trace area at FB. Set V_{OUT} according to $V_{OUT} = 1.255V(1 + R1/R2)$.

SHDN (Pin 4): Shutdown Pin. Tie to 2.4V or more to enable device. Ground to shut down.

V_{IN} (Pin 5): Input Supply Pin. Must be locally bypassed.

BLOCK DIAGRAM

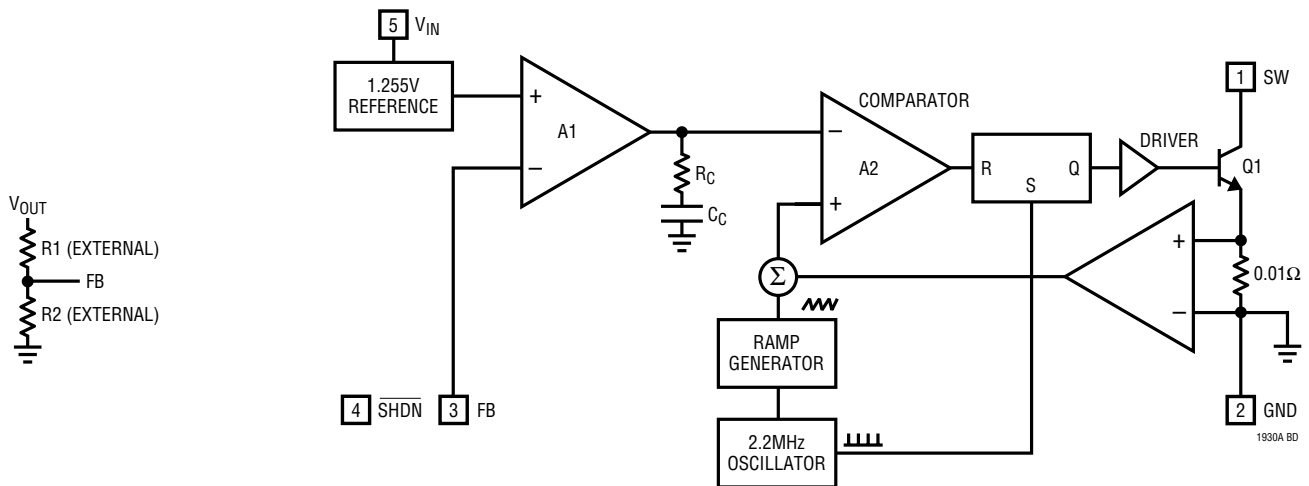


Figure 2. Block Diagram

OPERATION

The LT1930A uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the Block Diagram in Figure 2. At the start of each oscillator cycle, the SR latch is set, turning on the power switch Q1. A voltage proportional to the switch current is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of the PWM comparator A2. When this voltage exceeds the level at the negative input of A2, the SR latch is reset which turns off the power switch. The level at the negative input of A2 is set by the error amplifier (g_m) and is simply an amplified version of the

difference between the feedback voltage and the reference voltage of 1.255V. In this manner, the error amplifier sets the correct peak current level to keep the output in regulation. If the error amplifier's output increases, more current is delivered to the output; if it decreases, less current is delivered. One function not shown in Figure 2, is the current limit. The switch current is constantly monitored and not allowed to exceed the nominal value of 1A. If the switch current reaches 1A, the SR latch is reset regardless of the state of comparator A2. This current limit protects the power switch as well as various external components connected to the LT1930A.

APPLICATIONS INFORMATION

LT1930A AND LT1930 DIFFERENCES

Switching Frequency

The key difference between the LT1930A and LT1930 is the faster switching frequency of the LT1930A. At 2.2MHz, the LT1930A switches at nearly twice the rate of the LT1930. Care must be taken in deciding which part to use. The high switching frequency of the LT1930A allows smaller cheaper inductors and capacitors to be used in a given application, but with a slight decrease in efficiency and maximum output current when compared to the LT1930. Generally, if efficiency and maximum output current are critical, the LT1930 should be used. If application size and cost are more important, the LT1930A will be the better choice. In many applications, tiny inexpensive chip inductors can be used with the LT1930A, reducing solution cost.

Duty Cycle

The maximum duty cycle (DC) of the LT1930A is 75% compared to 82% for the LT1930. The duty cycle for a given application using the boost topology is given by:

$$DC = \frac{|V_{OUT}| - |V_{IN}|}{|V_{OUT}|}$$

For a 5V to 12V application, the DC is 58% indicating that the LT1930A could be used. A 5V to 24V application has a DC of 79% making the LT1930 the right choice. The LT1930A can still be used in applications where the DC is above 75% as calculated above if the part is operated in discontinuous conduction mode (DCM).

INDUCTOR SELECTION

Several inductors that work well with the LT1930A are listed in Table 1, although there are many other manufacturers and devices that can be used. Consult each manufacturer for more detailed information and for their entire selection of related parts, as many different sizes and shapes are available. Ferrite core inductors should be used to obtain the best efficiency, as core losses at 2.2MHz are much lower for ferrite cores than for the cheaper powdered iron ones. Choose an inductor that can handle at

least 1.0A without saturating, and ensure that the inductor has a low DCR (copper wire resistance) to minimize I²R power losses. A 2.2μH to 4.7μH inductor will be the best choice for most LT1930A designs. Note that in some applications, the current handling requirements of the inductor can be lower, such as in the SEPIC topology where each inductor only carries one-half of the total switch current.

Table 1. Recommended Inductors

PART	L (μH)	MAX DCR mΩ	SIZE L × W × H (mm)	VENDOR
LQH3C2R2M24 LQH3C4R7M24	2.2 4.7	126 195	3.2 × 2.5 × 2.0	Murata (404) 573-4150 www.murata.com
GR43-2R2 GR43-3R3	2.2 3.3	71 86	4.5 × 4.0 × 3.0	Sumida (847) 956-0666 www.sumida.com
1008PS-272 1008PS-332	2.7 3.3	100 110	3.7 × 3.7 × 2.6	Coilcraft (800) 322-2645 www.coilcraft.com

CAPACITOR SELECTION

Low ESR (equivalent series resistance) capacitors should be used at the output to minimize the output ripple voltage. Multilayer ceramic capacitors are an excellent choice, as they have an extremely low ESR and are available in very small packages. X5R dielectrics are preferred, followed by X7R, as these materials retain their capacitance over wide voltage and temperature ranges. A 2.2μF to 10μF output capacitor is sufficient for most applications, but systems with very low output currents may need only a 1μF or smaller output capacitor. Solid tantalum or OS-CON 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 LT1930A. A 1μF to 4.7μF input capacitor is sufficient for most applications. Table 2 shows a list of several ceramic capacitor manufacturers. Consult the manufacturers for detailed information on their entire selection of ceramic parts.

APPLICATIONS INFORMATION

Table 2. Ceramic Capacitor Manufacturers

Taiyo-Yuden	(408) 573-4150	www.t-yuden.com
AVX	(803) 448-9411	www.avxcorp.com
Murata	(714) 852-2001	www.murata.com

The decision to use either low ESR (ceramic) capacitors or the higher ESR (tantalum or OS-CON) capacitors can effect the stability of the overall system. The ESR of any capacitor, along with the capacitance itself, contributes a zero to the system. For the tantalum and OS-CON capacitors, this zero is located at a lower frequency due to the higher value of the ESR, while the zero of a ceramic capacitor is at a much higher frequency and can generally be ignored.

DIODE SELECTION

A Schottky diode is recommended for use with the LT1930A. The Motorola MBR0520 is a very good choice. Where the output voltage exceeds 20V, use the MBR0530 (a 30V diode). These diodes are rated to handle an average

forward current of 0.5A. In applications where the average forward current of the diode exceeds 0.5A, a Microsemi UPS5817 rated at 1A is recommended.

SETTING OUTPUT VOLTAGE

To set the output voltage, select the values of R1 and R2 (see Figure 1) according to the following equation:

$$R1 = R2 \left(\frac{V_{OUT}}{1.255V} - 1 \right)$$

A good value for R2 is 13.3k which sets the current in the resistor divider chain to $1.255V/13.3k = 94.4\mu A$.

LAYOUT HINTS

The high speed operation of the LT1930A demands careful attention to board layout. You will not get advertised performance with careless layout. Figure 3 shows the recommended component placement.

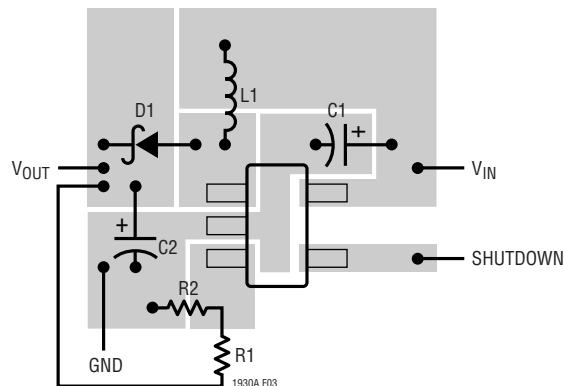
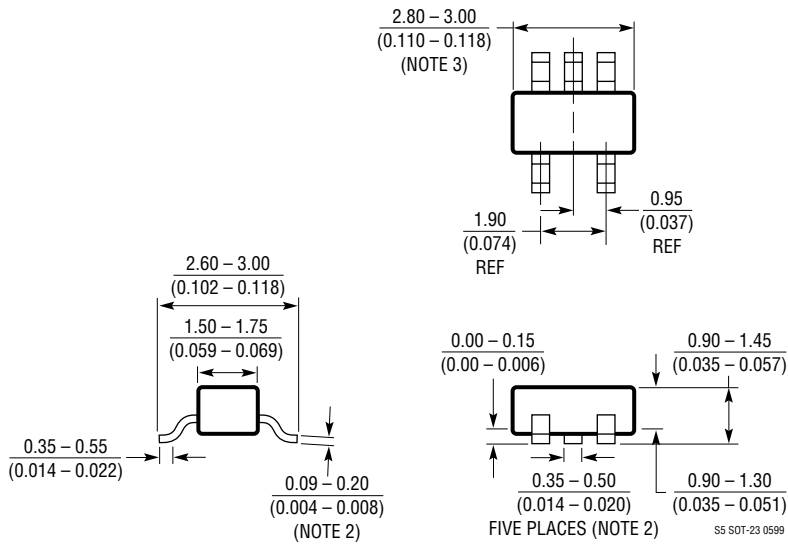


Figure 3. Suggested Layout

PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

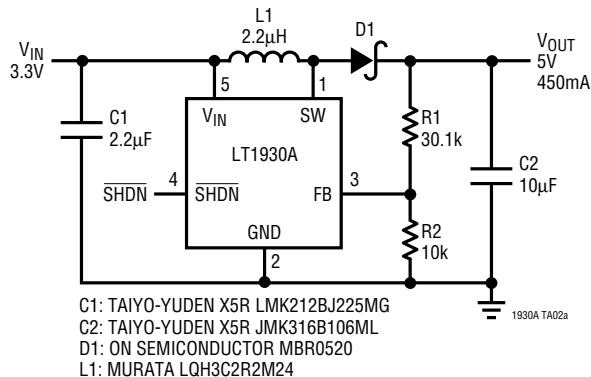
S5 Package
5-Lead Plastic SOT-23
 (LTC DWG # 05-08-1633)



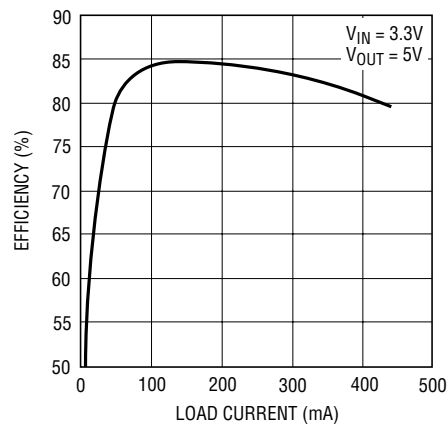
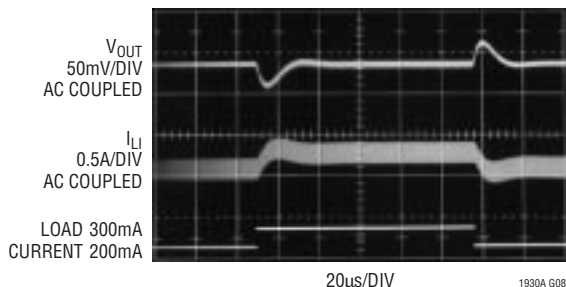
- NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
 2. DIMENSIONS ARE INCLUSIVE OF PLATING
 3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
 4. MOLD FLASH SHALL NOT EXCEED 0.254mm
 5. PACKAGE EIAJ REFERENCE IS SC-74A (EIAJ)

TYPICAL APPLICATION

3.3V to 5V, 450mA Step-Up DC/DC Converter



3.3V to 5V Transient Response



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1307	Single Cell Micropower 600kHz PWM DC/DC Converter	3.3V at 75mA from Single Cell, MSOP Package
LT1316	Burst Mode™ Operation DC/DC Converter with Programmable Current Limit	1.5V Minimum, Precise Control of Peak Current Limit
LT1317	2-Cell Micropower DC/DC Converter with Low-Battery Detector	3.3V at 200mA from 2 Cells, 600kHz Fixed Frequency
LT1610	Single Cell Micropower DC/DC Converter	3V at 30mA from 1V, 1.7MHz Fixed Frequency
LT1611	Inverting 1.4MHz Switching Regulator in 5-Lead SOT-23	-5V at 150mA from 5V Input, Tiny SOT-23 Package
LT1613	1.4MHz Switching Regulator in 5-Lead SOT-23	5V at 200mA from 3.3V Input, Tiny SOT-23 Package
LT1615	Micropower Constant Off-Time DC/DC Converter in 5-Lead SOT-23	20V at 12mA from 2.5V, Tiny SOT-23 Package
LT1617	Micropower Inverting DC/DC Converter in 5-Lead SOT-23	-15V at 12mA from 2.5V Input, Tiny SOT-23 Package
LTC1872	Current Mode Boost Controller in SOT-23	2.5V to 9.8V Input, 550kHz Fixed Frequency
LT1930	1.2MHz, 1A Switching Regulator in 5-Lead SOT-23	12V at 300mA from 5V input, Tiny SOT-23 Package
LT1931/LT1931A	Inverting 1.2MHz/2.2MHz Switching Regulator in 5-Lead SOT-23	-5V at 350mA from 5V input, Tiny SOT-23 Package

Burst Mode is a trademark of Linear Technology Corporation.