Inverting 600kHz Switching Regulator

July 1998

FEATURES

- **Better Regulation Than a Charge Pump**
- **0.1Ω Effective Output Impedance**
- **–5V at 200mA from a 5V Input**
- 600kHz Fixed Frequency Operation
- Operates with V_{IN} as Low as 1V
- 1mA Quiescent Current
- Low Shutdown Current: 10µA
- Low-Battery Detector
- Low V_{CESAT} Switch: 295mV at 500mA

APPLICATIONS

- MR Head Bias
- LCD Bias
- GaAs FET Bias
- Positive-to-Negative Conversion

DESCRIPTION

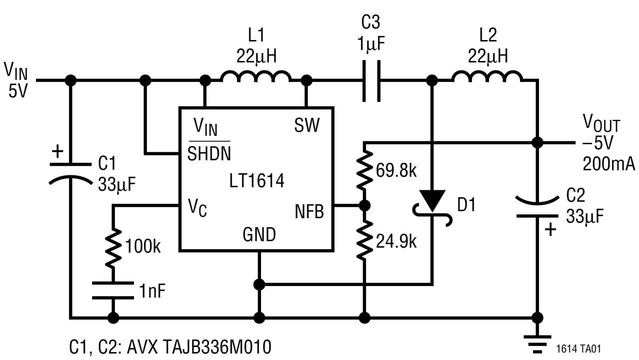
The LT®1614 is a fixed frequency, inverting mode switching reglator that operates from an input voltage as low as 1V. Utilizing a low noise topology, the LT1614 can generate a negative output down to –24V from a 1V to 5V input. Fixed frequency switching ensures a clean output free from low frequency noise. The device contains a low-battery detector with a 200mV reference and shuts down to less than 10µA. No load quiescent current of the LT1614 is 1mA and the internal NPN power switch handles a 500mA current with a voltage drop of just 295mV.

High frequency switching enables the use of small inductors and capacitors. Ceramic capacitors can be used in many applications, eliminating the need for bulky tantalum types.

The LT1614 is available in 8-lead MSOP or SO packages.

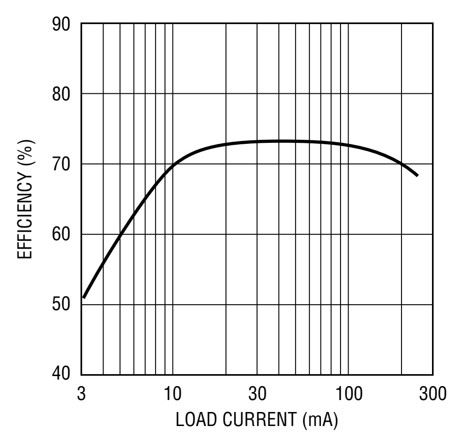
TYPICAL APPLICATION

5V to –5V Converter



C1, C2: AVX TAJB336M010
C3: AVX 1206CY106
D1: MBR0520
L1, L2: MURATA LQH3C220

5V to –5V Converter Efficiency

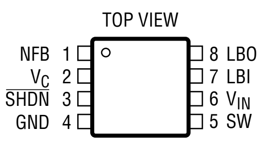
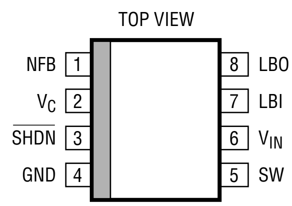


ABSOLUTE MAXIMUM RATINGS

V_{IN}, $\overline{SHDN}$, LBO Voltage 12V
SW Voltage .... −0.4V to 30V
NFB Voltage .... −3V
V_C Voltage 2V
LBI Voltage .... $0V \le V_{LBI} \le 1V$
Current into FB Pin .... ±1mA
Junction Temperature .... 125°C

Operating Temperature Range
LT1614C .... 0°C to 70°C
LT1614I .... −40°C to 85°C
Extended Commercial
Temperature Range (Note 1) .... −40°C to 85°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER		ORDER PART NUMBER
 MS8 PACKAGE 8-LEAD PLASTIC MSOP T_{JMAX} = 125°C, θ_{JA} = 160°C/W	LT1614CMS8	 S8 PACKAGE 8-LEAD PLASTIC SO T_{JMAX} = 125°C, θ_{JA} = 120°C/W	LT1614CS8 LT1614IS8
	MS8 PART MARKING		S8 PART MARKING
	LTEJ		1614 1614I

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS

Commercial Grade 0°C to 70°C. V_{IN} = 1.5V, $V_{\overline{SHDN}} = V_{IN}$, T_A = 25°C unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Quiescent Current	 $V_{\overline{SHDN}}$ = 0V			1 5	2 10	mA µA
Feedback Voltage		●	−1.21	−1.24	−1.27	V
NFB Pin Bias Current (Note 2)	V_{NFB} = −1.24V	●	−2.5	−4.5	−7	µA
Reference Line Regulation	$1V \le V_{IN} \le 2V$ $2V \le V_{IN} \le 6V$			0.6 0.3	1.1 0.8	%/V %/V
Minimum Input Voltage				0.92	1	V
Maximum Input Voltage		●			6	V
Error Amp Transconductance	ΔI = 5µA			16		µmhos
Error Amp Voltage Gain				100		V/V
Switching Frequency		●	500	600	750	kHz
Maximum Duty Cycle		 ●	73 70	80 80		% %
Switch Current Limit (Note 3)			0.75	1.2		A

ELECTRICAL CHARACTERISTICS

Commercial Grade 0°C to 70°C. V_{IN} = 1.5V, $V_{\overline{SHDN}}$ = V_{IN}, T_A = 25°C unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Switch V_{CESAT}	I_{SW} = 500mA (25°C, 0°C) I_{SW} = 500mA (70°C)			295	350 400	mV mV
Shutdown Pin Current	$V_{\overline{SHDN}}$ = V_{IN} $V_{\overline{SHDN}}$ = 0V			10 −5	20 −10	µA µA
LBI Threshold Voltage		 ●	190 185	200	210 215	mV mV
LBO Output Low	I_{SINK} = 10µA			0.1	0.25	V
LBO Leakage Current	V_{LBI} = 250mV, V_{LBO} = 5V			0.01	0.1	µA
LBI Input Bias Current (Note 4)	V_{LBI} = 150mV			10	50	nA
Low-Battery Detector Gain	1MΩ Load			1000		V/V
Switch Leakage Current	V_{SW} = 5V			0.01	3	µA

Industrial Grade −40°C to 85°C. V_{IN} = 1.5V, $V_{\overline{SHDN}}$ = V_{IN} unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Quiescent Current	 $V_{\overline{SHDN}}$ = 0V			1 5	2 10	mA µA
Feedback Voltage		●	−1.21	−1.24	−1.27	V
NFB Pin Bias Current (Note 2)	V_{NFB} = −1.24V	●	−2	−4.5	−7.5	µA
Reference Line Regulation	1V ≤ V_{IN} ≤ 2V 2V ≤ V_{IN} ≤ 6V			0.6 0.3	1.1 0.8	%/V %/V
Minimum Input Voltage	−40°C 85°C			1.1 0.8	1.25 1.0	V V
Maximum Input Voltage		●			6	V
Error Amp Transconductance	ΔI = 5µA			16		µmhos
Error Amp Voltage Gain				100		V/V
Switching Frequency		●	500	600	750	kHz
Maximum Duty Cycle		●	70	80		%
Switch Current Limit (Note 3)			0.75	1.2		A
Switch V_{CESAT}	I_{SW} = 500mA (−40°C) I_{SW} = 500mA (85°C)			250 330	350 400	mV mV
Shutdown Pin Current	$V_{\overline{SHDN}}$ = V_{IN} $V_{\overline{SHDN}}$ = 0V			10 −5	20 −10	µA µA
LBI Threshold Voltage		●	180	200	220	mV
LBO Output Low	I_{SINK} = 10µA			0.1	0.25	V
LBO Leakage Current	V_{LBI} = 250mV, V_{LBO} = 5V			0.1	0.3	µA
LBI Input Bias Current (Note 4)	V_{LBI} = 150mV			5	30	nA
Low-Battery Detector Gain	1MΩ Load			1000		V/V
Switch Leakage Current	V_{SW} = 5V			0.01	3	µA

The ● denotes specifications which apply over the full operating temperature range.

Note 1: The LT1614C is guaranteed to meet specified performance from 0°C to 70°C and is designed, characterized and expected to meet these extended temperature limits, but is not tested at −40°C and 85°C. The LT1614I is guaranteed to meet the extended temperature limits.

Note 2: Bias current flows out of NFB pin.

Note 3: Switch current limit guaranteed by design and/or correlation to static tests. Duty cycle affects current limit due to ramp generator.

Note 4: Bias current flows out of LBI pin.

PIN FUNCTIONS

NFB (Pin 1): Negative Feedback Pin. Reference voltage is –1.24V. Connect resistive divider tap here. The suggested value for R2 is 24.9k. Set R1 and R2 according to:

$$R1 = \frac{|V_{OUT}| - 1.24}{\frac{1.24}{R2} + \left(4.5 \bullet 10^{-6}\right)}$$

V_C (Pin 2): Compensation Pin for Error Amplifier. Connect a series RC from this pin to ground. Typical values are 100kΩ and 1nF. Minimize trace area at V_C.

$\overline{SHDN}$ (Pin 3): Shutdown. Ground this pin to turn off switcher. Must be tied to V_{IN} (or higher voltage) to enable switcher. Do not float the $\overline{SHDN}$ pin.

GND (Pin 4): Ground. Connect directly to local ground plane.

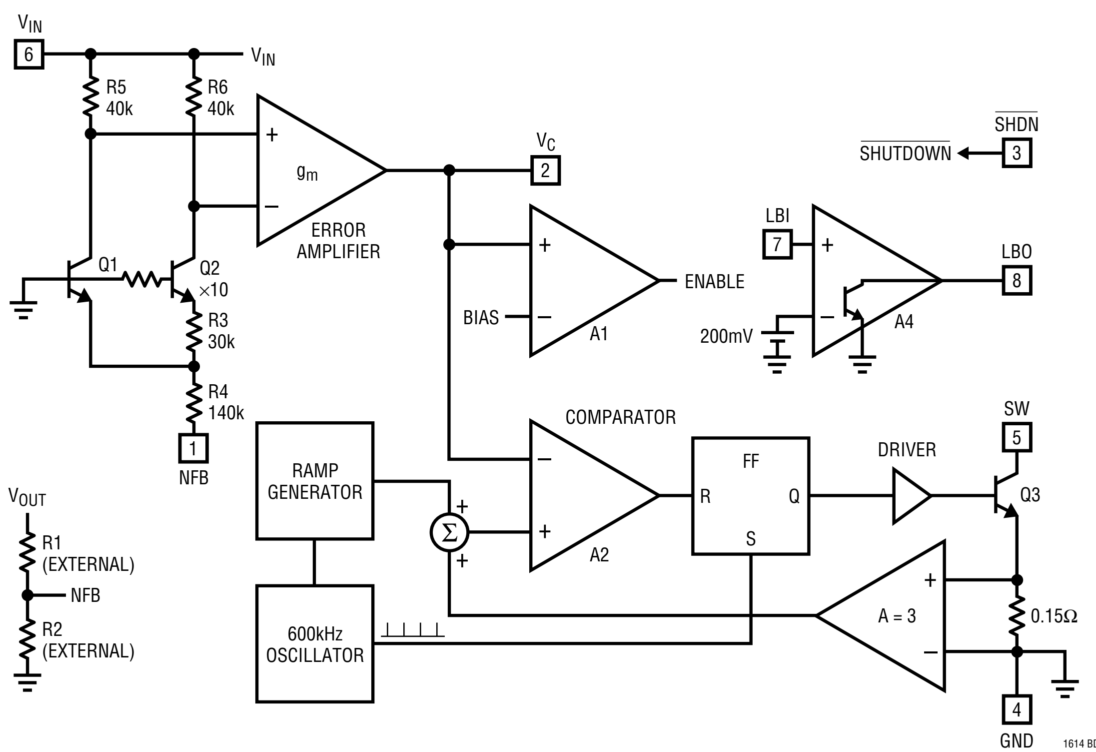
SW (Pin 5): Switch Pin. Minimize trace area at this pin to keep EMI down.

V_{IN} (Pin 6): Supply Pin. Must have 1μF ceramic bypass capacitor right at the pin, connected directly to ground.

LBI (Pin 7): Low-Battery Detector Input. 200mV reference. Voltage on LBI must stay between ground and 700mV. Float this pin if not used.

LBO (Pin 8): Low-Battery Detector Output. Open collector, can sink 10μA. A 1MΩ pull-up is recommended. Float this pin if not used.

BLOCK DIAGRAM



APPLICATIONS INFORMATION

Shutdown Pin

The LT1614 has a Shutdown pin ($\overline{SHDN}$) that must be grounded to shut the device down or tied to a voltage equal or greater than V_{IN} to operate. The shutdown circuit is shown in Figure 1.

Note that allowing $\overline{SHDN}$ to float turns on both the start-up current (Q2) and the shutdown current (Q3) for V_{IN} > $2V_{BE}$. The LT1614 doesn't know what to do in this situation and behaves erratically. $\overline{SHDN}$ voltage above V_{IN} is allowed. This merely reverse-biases Q3's base emitter junction, a benign condition.

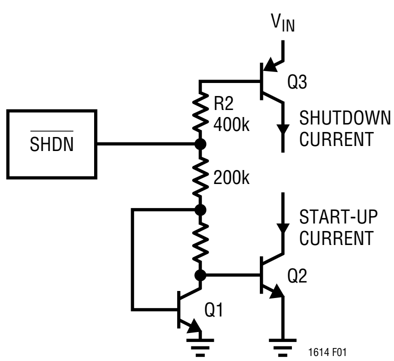


Figure 1. Shutdown Circuit

Low-Battery Detector

The LT1614's low-battery detector is a simple PNP input gain stage with an open collector NPN output. The negative input of the gain stage is tied internally to a 200mV reference. The positive input is the LBI pin. Arrangement as a low-battery detector is straightforward. Figure 2 details hookup. R1 and R2 need only be low enough in value so that the bias current of the LBI pin doesn't cause large errors. For R2, 100k is adequate. The 200mV reference can also be accessed as shown in Figure 3.

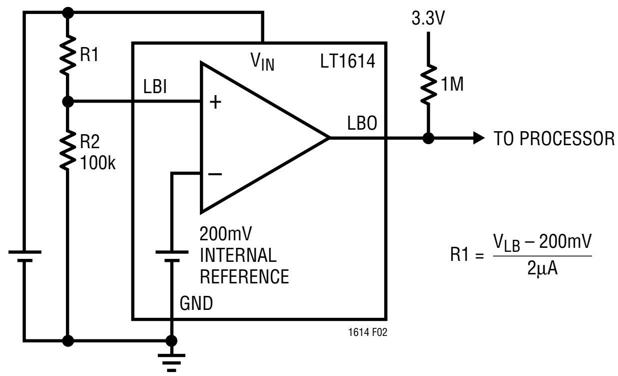


Figure 2. Setting Low-Battery Detector Trip Point

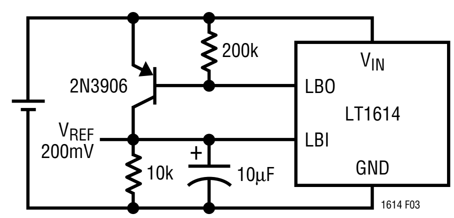
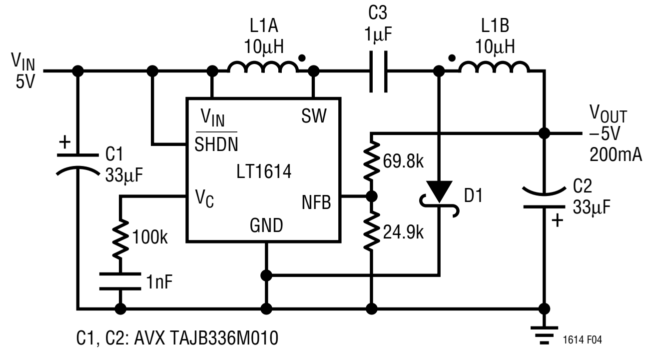


Figure 3. Accessing 200mV Reference

Coupled Inductors

The applications shown in this data sheet use two uncoupled inductors because the Murata units specified are small and inexpensive. This topology can also be used with a coupled inductor as shown in Figure 4. Be sure to get the phasing right.

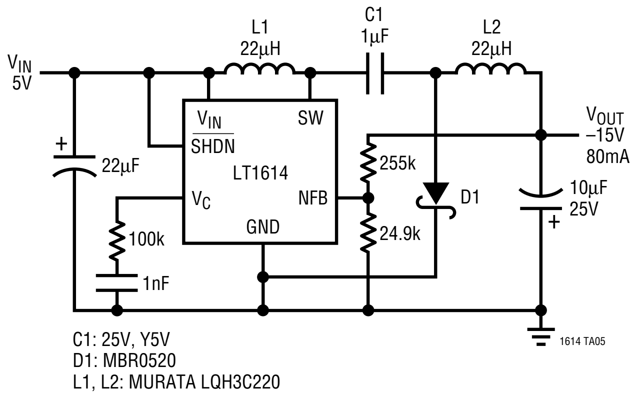


C1, C2: AVX TAJB336M010
C3: AVX 1206CY106
D1: MBR0520
L1: COILTRONICS CTX10-1

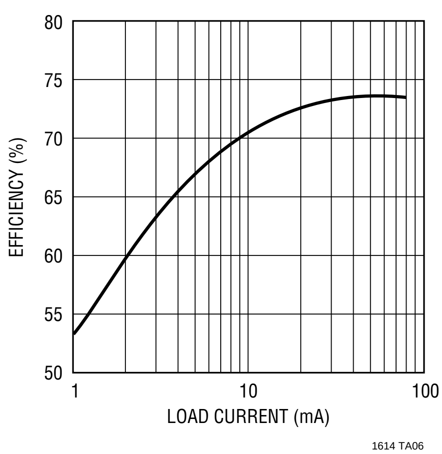
Figure 4. 5V to –5V Converter with Coupled Inductor

TYPICAL APPLICATION

5V to –15V/80mA DC/DC Converter

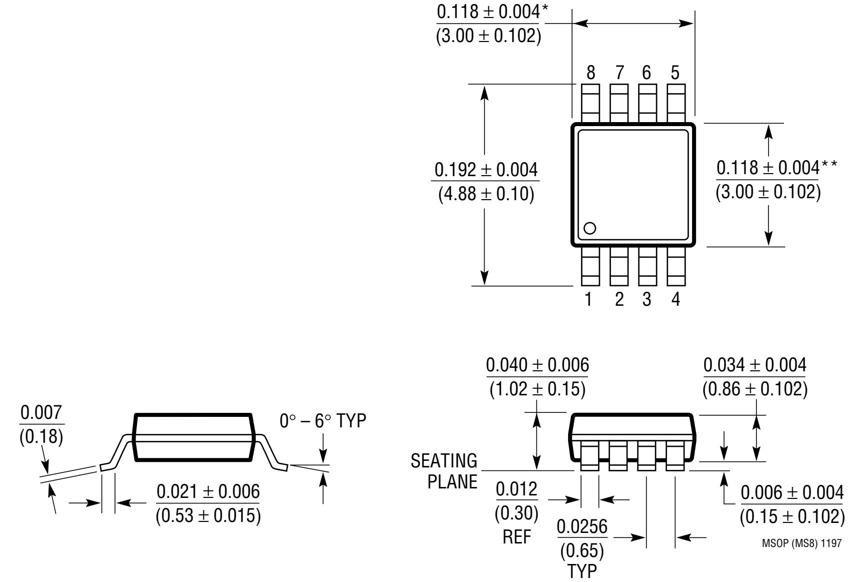


5V to –15V Converter Efficiency



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

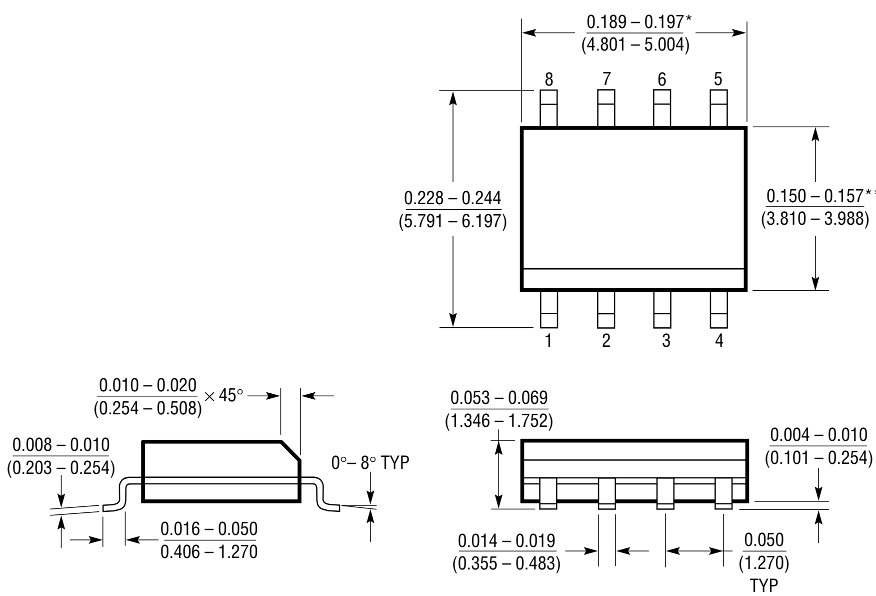
MS8 Package
8-Lead Plastic MSOP
(LTC DWG # 05-08-1660)



* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

** DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS. INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
(LTC DWG # 05-08-1610)



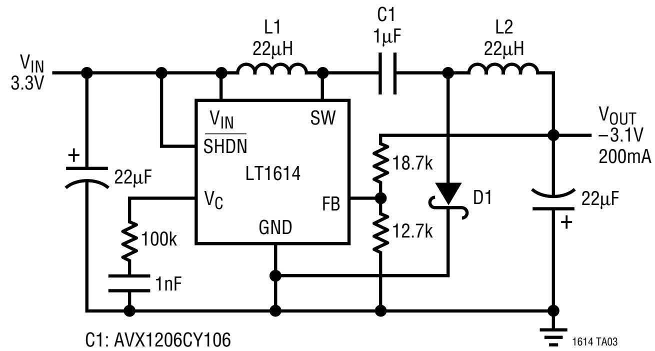
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

SO8 0996

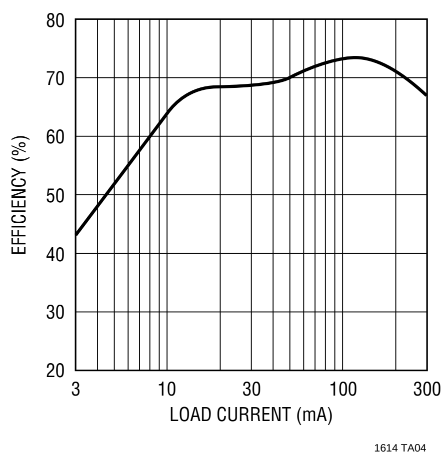
TYPICAL APPLICATION

3.3V to –3.1V/200mA DC/DC Converter



C1: AVX1206CY106
D1: MBR0520
L1, L2: MURATA LQH3C220

3.3V to –3.1V Converter Efficiency



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC®1174	High Efficiency Step-Down and Inverting DC/DC Converter	Selectable I_{PEAK} = 300mA or 600mA
LT1307	Single Cell Micropower 600kHz PWM DC/DC Converter	3.3V at 75mA from 1 Cell, MSOP Package
LT1308	Single Cell High Current Micropower 600kHz Boost Converter	5V at 1A from a Single Li-Ion Cell, SO-8 Package
LT1316	Micropower Boost DC/DC Converter	Programmable Peak Current Limit, MSOP Package
LT1317	Micropower 600kHz PWM DC/DC Converter	2 Cells to 3.3V at 200mA, MSOP Package
LTC1474	Low Quiescent Current High Efficiency DC/DC Converter	I_Q = 10µA, Programmable Peak Current Limit, MSOP
LT1610	1.7MHz Single Cell Micropower DC/DC Converter	5V at 200mA from 3.3V, MSOP Package

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