Micropower, 600kHz PWM DC/DC Converters

January 1998

FEATURES

- **100μA Quiescent Current**
- **Operates with V_{IN} as Low as 1.5V**
- 600kHz Fixed Frequency Operation
- Starts into Full Load
- **Low-Battery Detector Active in Shutdown**
- Automatic Burst Mode Operation at Light Load (LT1317)
- Continuous Switching at Light Loads (LT1317B)
- Low V_{CESAT} Switch: 300mV at 500mA
- Pin for Pin Compatible with the LT1307/LT1307B

APPLICATIONS

- Pagers
- Cordless Telephones
- GPS Receivers
- Battery Backup
- Portable Electronic Equipment
- Glucose Meters
- Diagnostic Medical Instrumentation

DESCRIPTION

The LT®1317/LT1317B are micropower, fixed frequency step-up DC/DC converters that operate over a wide input voltage range of 1.5V to 12V. The LT1317 features automatic shifting to power saving Burst Mode™ operation at light loads. High efficiency is maintained over a broad 300μA to 100mA load range. Peak switch current during Burst Mode operation is kept below 250mA for most operating conditions which results in low output ripple voltage, even at high input voltages. The LT1317B does not shift into Burst Mode operation at light loads, eliminating low frequency output ripple at the expense of light load efficiency.

The LT1317/LT1317B contain an internal low-battery detector with a 200mV reference that stays alive when the device goes into shutdown.

No-load quiescent current of the LT1317 is 100μA and shuts down to 30μA. The internal NPN power switch handles a 650mA current with a voltage drop of just 350mV.

The LT1317/LT1317B are available in MS8 and SO-8 packages.

TYPICAL APPLICATION

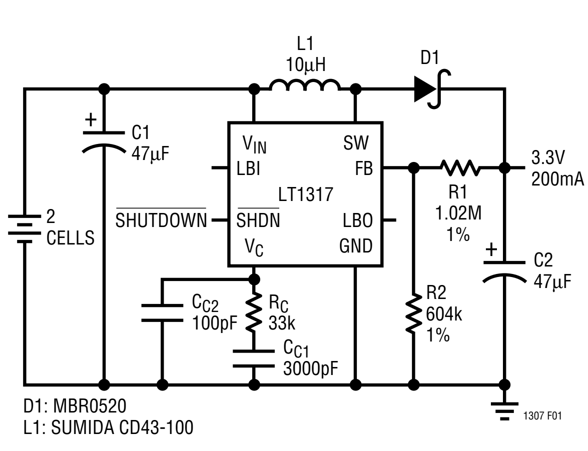
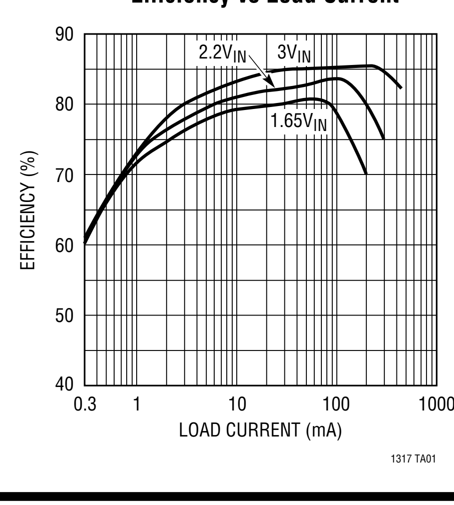


Figure 1. 2-Cell to 3.3V Boost Converter

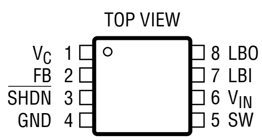
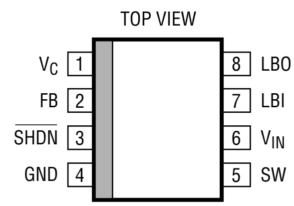
Efficiency vs Load Current



ABSOLUTE MAXIMUM RATINGS

V_{IN}, LBO Voltage 12V
SW Voltage 30V
FB Voltage .... V_{IN} + 0.3V
V_C Voltage 2V
LBI Voltage .... 0V ≤ V_{LBI} ≤ 1V
$\overline{SHDN}$ Voltage 6V
Current into FB Pin .... ±1mA
Junction Temperature .... 125°C
Operating Temperature Range .... 0°C to 70°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	LT1317CMS8 LT1317BCMS8	 S8 PACKAGE 8-LEAD PLASTIC SO T_{JMAX} = 125°C, θ_{JA} = 120°C/W	LT1317CS8 LT1317BCS8
	MS8 PART MARKING		S8 PART MARKING
	LTBZ LTDL		1317 1317B

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

V_{IN} = 2V, $V_{\overline{SHDN}}$ = 2V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_Q	Quiescent Current	Not Switching, $V_{\overline{SHDN}}$ = 2V (LT1317) $V_{\overline{SHDN}}$ = 0V (LT1317/LT1317B) (LT1317B)	● ●		100 25 3.5	160 40 6.5	µA µA mA
V_{FB}	Feedback Voltage		 ●	1.22 1.20	1.24 1.24	1.26 1.26	V V
I_B	FB Pin Bias Current (Note 1)		●		12	40	nA
	Input Voltage Range		●	1.5		12	V
g_m	Error Amp Transconductance	ΔI = 5µA	●	70	140	240	µmhos
A_V	Error Amp Voltage Gain				700		V/V
	Maximum Duty Cycle		●	80	85		%
	Switch Current Limit (Note 2)	V_{IN} = 2.5V	●	650	900		mA
	Burst Mode Operation Switch Current Limit	(LT1317)			200		mA
f_{OSC}	Switching Frequency		●	520	620	720	kHz
	Shutdown Pin Current	$V_{\overline{SHDN}}$ = V_{IN} $V_{\overline{SHDN}}$ = 0V	● ●		0.015 –2.3	0.06 –6	µA µA

ELECTRICAL CHARACTERISTICS

V_{IN} = 2V, $V_{\overline{SHDN}}$ = 2V, T_A = 25°C unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
	LBI Threshold Voltage		 ●	190 180	200 200	210 220	mV mV
	LBO Output Low	I_{SINK} = 10µA	●		0.15	0.25	V
	LBO Leakage Current	V_{LBI} = 250mV, V_{LBO} = 5V	●		0.02	0.1	µA
	LBI Input Bias Current (Note 3)	V_{LBI} = 150mV	●		5	40	nA
	Low-Battery Detector Gain	1MΩ Load			2000		V/V
	Switch Leakage Current	V_{SW} = 5V	●		0.01	3	µA
	Switch V_{CE} Sat	I_{SW} = 500mA	 ●		300	350 400	mV mV
	Reference Line Regulation	1.8V ≤ V_{IN} ≤ 12V	●		0.08	0.15	%/V
	SHDN Input Voltage High		●	1.4		6	V
	SHDN Input Voltage Low		●			0.4	V

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

Note 1: Bias current flows into FB pin.

Note 2: Switch current limit guaranteed by design and/or correlation to static tests. Duty cycle affects current limit due to ramp generator.

Note 3: Bias current flows out of LBI pin.

PIN FUNCTIONS

V_C (Pin 1): Compensation Pin for Error Amplifier. Connect a series RC network and a capacitor from this pin to ground. Typical values for compensation are a 33k/3000pF combination for the RC network and 100pF for the capacitor. Minimize trace area at V_C.

FB (Pin 2): Feedback Pin. Reference voltage is 1.24V. Connect resistor divider tap here. Minimize trace area at FB. Set V_{OUT} according to: $V_{OUT} = 1.24V(1 + R1/R2)$.

$\overline{SHDN}$ (Pin 3): Shutdown. Pull this pin low for shutdown mode (only the low-battery detector remains active). Tie to a voltage between 1.4V and 6V to enable the device. $\overline{SHDN}$ pin is logic level and need only meet the logic specification (1.4V for high, 0.4V for low). Unlike the LT1307, $\overline{SHDN}$ does not need to be tied to V_{IN} for proper operation. Do not float the $\overline{SHDN}$ pin.

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

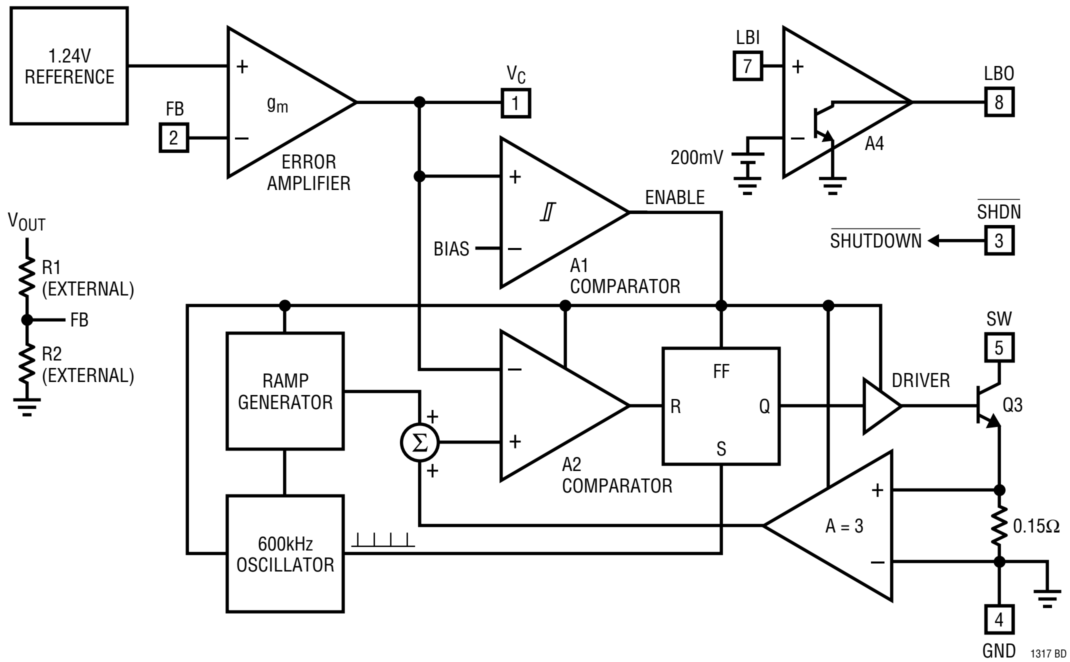
SW (Pin 5): Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to keep EMI down.

V_{IN} (Pin 6): Supply Pin. Must be bypassed close to the pin.

LBI (Pin 7): Low-Battery Detector Input. 200mV reference. Voltage on LBI must stay between ground and 700mV. Low-battery detector remains active in shutdown mode.

LBO (Pin 8): Low-Battery Detector Output. Open collector, can sink 10µA. A 1MΩ pull-up is recommended.

BLOCK DIAGRAM



APPLICATIONS INFORMATION

OPERATION

The LT1317 combines a current mode, fixed frequency PWM architecture with Burst Mode micropower operation to maintain high efficiency at light loads. Operation can best be understood by referring to the Block Diagram. The error amplifier compares voltage at the FB pin with the internal 1.24V bandgap reference and generates an error signal V_C.

When V_C reaches the bias voltage on hysteretic comparator A1, A1's output goes low, turning off all circuitry except the 1.24V reference, error amplifier and low-battery detector. Total current consumption in this state is 100μA. As output loading causes the FB voltage to decrease, A1's output goes high, enabling the rest of the IC. Switch current is limited to approximately 250mA initially after A1's output goes high. If the load is light, the output voltage (and FB voltage) will increase until A1's output goes low, turning off the rest of the LT1317. Low frequency ripple voltage appears at the output. The ripple frequency is dependent on load current and output capacitance. This Burst Mode operation keeps the output regulated and reduces average current into the IC, resulting in high efficiency even at load currents of 300μA or less.

If the output load increases sufficiently, A1's output remains high, resulting in continuous operation. When the LT1317 is running continuously, peak switch current is controlled by V_C to regulate the output voltage. The switch is turned on at the beginning of each switch cycle. When the summation of a signal representing switch current and a ramp generator (introduced to avoid subharmonic oscillations at duty factors greater than 50%) exceeds the V_C signal, comparator A2 changes state, resetting the flip-flop and turning off the switch. Output voltage increases as switch current is increased. The output, attenuated by a resistor divider, appears at the FB pin, closing the overall loop. Frequency compensation is provided by an external series RC network and a capacitor connected between the V_C pin and ground. Low-battery detector A4's open collector

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output (LBO) pulls low when the LBI pin voltage drops below 200mV. There is no hysteresis in A4, allowing it to be used as an amplifier in some applications. The low-battery detector remains active in shutdown. To enable the converter, SHDN must be tied to a voltage between 1.4V and 6V.

The LT1317B differs from the LT1317 in that there is no hysteresis in comparator A1. Also, the bias point on A1 is set lower than on the LT1317 so that switching can occur at inductor current less than 100mA. Because A1 has no hysteresis, there is no Burst Mode operation at light loads and the device continues switching at constant frequency. This results in the absence of low frequency output voltage ripple at the expense of efficiency.

The difference between the two devices is clearly illustrated in Figure 2. The top two traces in Figure 2 show an LT1317/LT1317B circuit, using the components indicated in Figure 1, set to a 3.3V output. Input voltage is 2V. Load current is stepped from 2mA to 200mA for both circuits. Low frequency Burst Mode operation voltage ripple is observed on Trace A, while none is observed on Trace B.

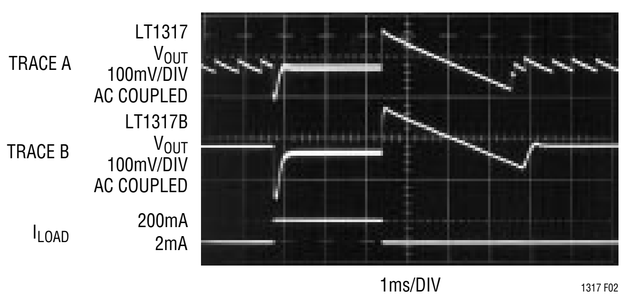

Figure 2. LT1317 Exhibits Ripple at 2mA Load During Burst Mode Operation, the LT1317B Does Not

LAYOUT HINTS

The LT1317 switches current at high speed, mandating careful attention to layout for proper performance. *You will not get advertised performance with careless layouts.* Figure 3 shows recommended component placement. Follow this closely in your PC layout. Note the direct path

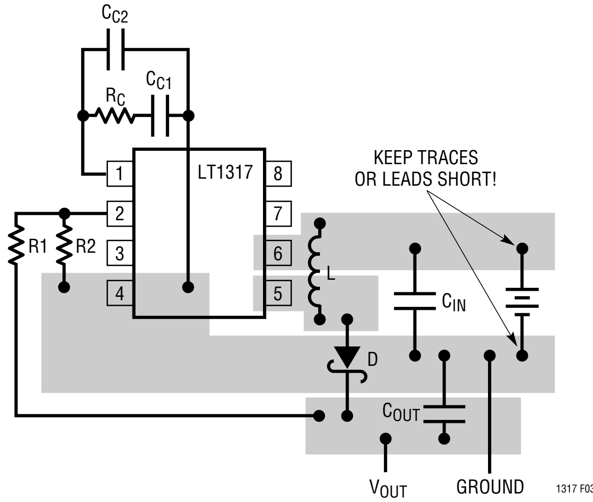

Figure 3. Recommended Component Placement. Traces Carrying High Current Are Direct. Trace Area at FB Pin and V_C Pin is Kept Low. Lead Length to Battery Should be Kept Short.

of the switching loops. Input capacitor C_{IN} *must* be placed close (<5mm) to the IC package. As little as 10mm of wire or PC trace from C_{IN} to V_{IN} will cause problems such as inability to regulate or oscillation.

COMPONENT SELECTION

Inductors

Inductors appropriate for use with the LT1317 must possess three attributes. First, they must have low core loss at 600kHz. Most ferrite core units have acceptable losses at this switching frequency. Inexpensive iron powder cores should be viewed suspiciously, as core losses can cause significant efficiency penalties at 600kHz. Second, the inductor must handle current of 800mA without saturating. This places a lower limit on the physical size of the unit. Molded chokes or chip inductors usually do not have enough core to support 800mA current and are unsuitable for the application. Lastly, the inductor should have low DCR (copper wire resistance) to prevent efficiency-killing I^2R losses. Linear Technology has identified several inductors suitable for use with the LT1317. This is

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not an exclusive list. There are many magnetics vendors whose components are suitable for use. A few vendor's components are listed in Table 1.

Table 1. Inductors Suitable for Use with the LT1317

PART	VALUE	MAX DCR	MFR	HEIGHT (mm)	COMMENT
LQH3C100	10µH	0.57	Murata-Erie	2.0	Smallest Size
DO1608-103	10µH	0.16	Coilcraft	3.0	
CD43-100	10µH	0.18	Sumida	3.2	
CD54-100	10µH	0.10	Sumida	4.5	Best Efficiency
CTX32CT-100	10µH	0.50	Coiltronics	2.2	1210 Footprint

Capacitor Selection

Low ESR (Equivalent Series Resistance) capacitors should be used at the output of the LT1317 to minimize output ripple voltage. High quality input bypassing is also required. For surface mount applications AVX TPS series tantalum capacitors are recommended. These have been specifically designed for switch mode power supplies and have low ESR along with high surge current ratings.

For through-hole applications Sanyo OS-CON capacitors offer extremely low ESR in a small package size. If peak switch current is reduced using the R_{SET} pin, capacitor requirements can be eased and smaller, higher ESR units can be used. Ordinary generic capacitors can generally be used when peak switch current is less than 100mA, although output voltage ripple may increase.

Diodes

Most of the application circuits on this data sheet specify the Motorola MBR0520L surface mount Schottky diode. In lower current applications, a 1N4148 can be used, although efficiency will suffer due to the higher forward drop. This effect is particularly noticeable at low output voltages. For higher voltage output applications, such as LCD bias generators, the extra drop is a small percentage of the output voltage so the efficiency penalty is small. The low cost of the 1N4148 makes it attractive wherever it can be used. In through hole applications the 1N5818 is the all around best choice.

LOW-BATTERY DETECTOR

The LT1317'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 ±5% reference. The positive input is the LBI pin. Arrangement as a low-battery detector is straightforward. Figure 4 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 5. The low-battery detector remains active in shutdown.

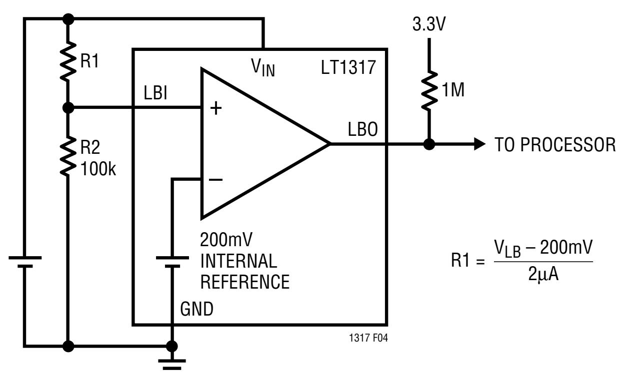


Figure 4. Setting Low-Battery Detector Trip Point

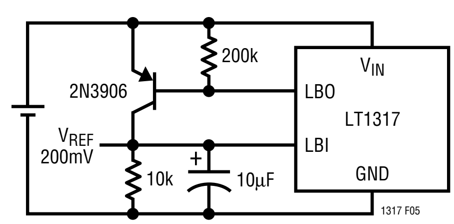
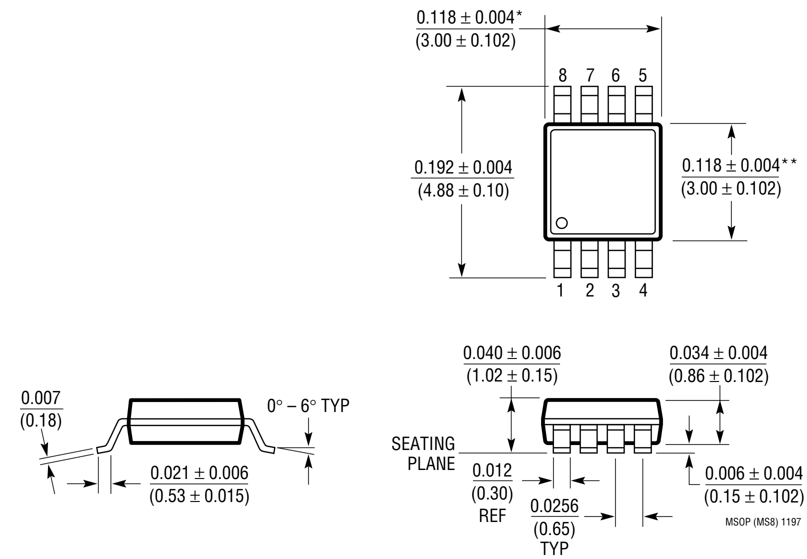


Figure 5. Accessing 200mV Reference

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

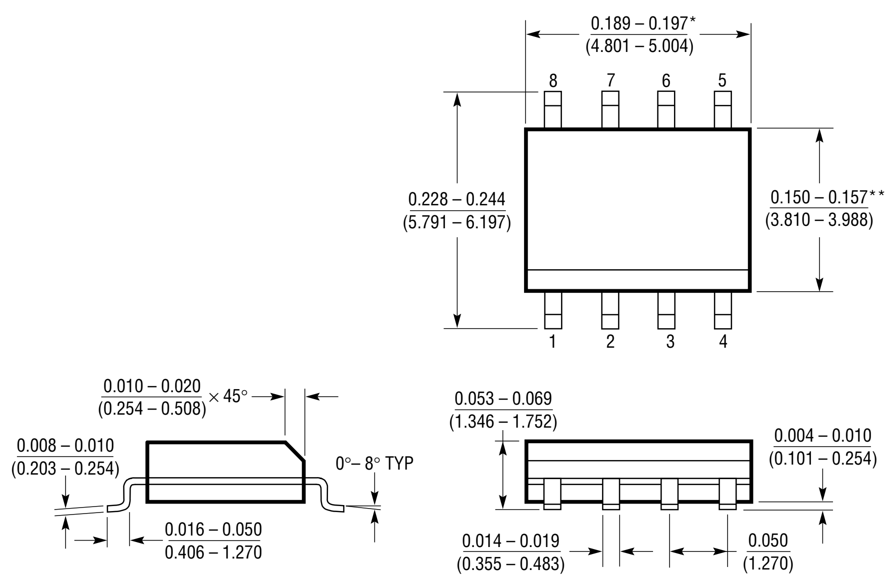
MS8 Package
8-Lead Plastic MSOP
(LTC DWG # 05-08-1660)



* 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)



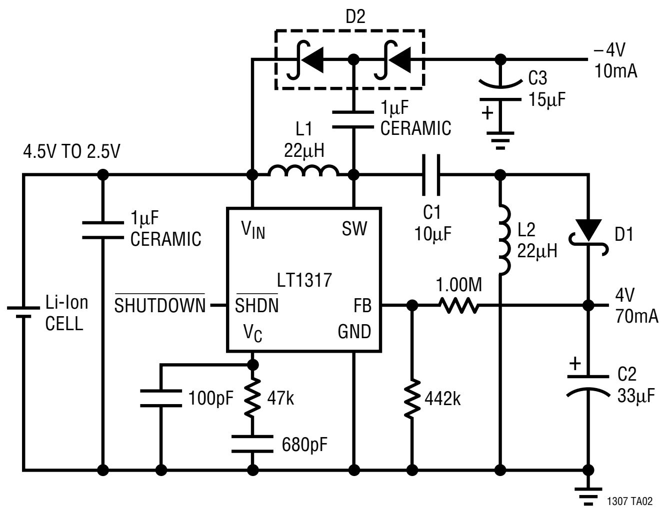
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

SO8 0996

TYPICAL APPLICATION

Single Li-Ion Cell to 4V/70mA, –4V/10mA



C1: MURATA GRM235Y5V106Z01
C2: AVX TAJB336M010
C3: AVX TAJA156M010
D1: MBR0520
D2: BAT54S (DUAL DIODE)
L1, L2: MURATA LQH3C220K04

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC®1163	Triple High Side Driver for 2-Cell Inputs	1.8V Minimum Input, Drives N-Channel MOSFETs
LTC1174	Micropower Step-Down DC/DC Converter	94% Efficiency, 130µA I_Q, 9V to 5V at 300mA
LT1302	High Output Current Micropower DC/DC Converter	5V/600mA from 2V, 2A Internal Switch, 200µA I_Q
LT1304	2-Cell Micropower DC/DC Converter	Low-Battery Detector Active in Shutdown
LT1307	Single Cell Micropower 600kHz PWM DC/DC Converter	3.3V at 75mA from 1 Cell, MSOP Package
LTC1440/1/2	Ultralow Power Single/Dual Comparators with Reference	2.8µA I_Q, Adjustable Hysteresis
LTC1516	2-Cell to 5V Regulated Charge Pump	12µA I_Q, No Inductors, 5V at 50mA from 3V Input
LT1521	Micropower Low Dropout Linear Regulator	500mV Dropout, 300mA Current, 12µA I_Q

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