FEATUERS
- Precise Control of Peak Switch Current
- Quiescent Current:
  - 33µA in Active Mode
  - 3µA in Shutdown Mode
- Low-Battery Detector Active in Shutdown
- Low Switch VCESAT: 300mV at 500mA
- 8-Lead MSOP and SO Packages
- Operates with VIN as Low as 1.5V
- Logic Level Shutdown Pin

DESCRIPTION
The LT®1316 is a micropower step-up DC/DC converter that operates from an input voltage as low as 1.5V. A programmable input current limiting function allows precise control of peak switch current. Peak switch current can be set to any value between 30mA and 500mA by adjusting one resistor. This is particularly useful for DC/DC converters operating from high source impedance inputs such as lithium coin cells or telephone lines.

The fixed off-time, variable on-time regulation scheme results in quiescent current of only 33µA in active mode. Quiescent current decreases to 3µA in shutdown with the low-battery detector still active.

The LT1316 is available in 8-lead MSOP and SO packages.

APPLICATIONS
- Battery Backup
- LCD Bias
- Low Power –48V to 5V/3.3V Converters

TYPICAL APPLICATION

2-Cell to 5V Step-Up Converter

Efficiency vs Load Current
LT1316

**ABSOLUTE MAXIMUM RATINGS**

- **Vin Voltage**: .......................... 12V
- **SW Voltage**: .......................... – 0.4V to 30V
- **FB Voltage**: .......................... VIN + 0.3V
- **RSET Voltage**: .......................... 5V
- **SHDN Voltage**: .......................... 6V
- **LBI Voltage**: .......................... VIN
- **LBO Voltage**: .......................... 12V
- **Maximum Switch Current**: ........... 750mA
- **Maximum Junction Temperature**: ....... 125°C
- **Operating Temperature Range**
  - Commercial: .......................... 0°C to 70°C
  - Extended Commercial (Note 1): ...... – 40°C to 85°C
  - Industrial (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**

<table>
<thead>
<tr>
<th>ORDER PART NUMBER</th>
<th>MS8 PART MARKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1316CMS8</td>
<td>LTCD</td>
</tr>
<tr>
<td>LT1316CS8</td>
<td>LT1316IS8</td>
</tr>
<tr>
<td>S8 PART MARKING</td>
<td></td>
</tr>
<tr>
<td>1316</td>
<td></td>
</tr>
<tr>
<td>1316I</td>
<td></td>
</tr>
</tbody>
</table>

Consult factory for Military grade parts.

**ELECTRICAL CHARACTERISTICS**

Commercial grade 0°C to 70°C, Industrial grade –40°C to 85°C, VIN = 2V, VSHDN = VIN, TA = 25°C unless otherwise noted. (Notes 1, 2)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Operating Voltage</td>
<td></td>
<td>1.5</td>
<td>1.65</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Maximum Operating Voltage</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>VSHDN = 2V, Not Switching</td>
<td></td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>45</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>5</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>10</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>30</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.04</td>
<td>0.15</td>
<td></td>
<td>%/V</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>VIN = 1.8V to 12V</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>1.17</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>20</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>65</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>0.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.01</td>
<td>0.1</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>SHDN Input Voltage High</td>
<td>LBO = 1.7V, LBO = 5V</td>
<td>1.4</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>SHDN Input Voltage Low</td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>SHDN Pin Bias Current</td>
<td>VSHDN = 5V</td>
<td>2</td>
<td>5</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1</td>
<td>-3</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS

Commercial grade 0°C to 70°C, Industrial grade –40°C to 85°C, VIN = 2V, V_{SHDN} = V_{IN}, T_A = 25°C unless otherwise noted. (Notes 1, 2)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch OFF Time</td>
<td>FB &gt; 1V</td>
<td>1.4</td>
<td>2.0</td>
<td>2.6</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>FB &lt; 1V</td>
<td>1.1</td>
<td>3.0</td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>Switch ON Time</td>
<td>Current Limit Not Asserted</td>
<td>4.4</td>
<td>6.3</td>
<td>8.2</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>1V &lt; FB &lt; 1.2V</td>
<td>3.4</td>
<td>9.5</td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td>Current Limit Not Asserted</td>
<td>74</td>
<td>76</td>
<td>90</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>1V &lt; FB &lt; 1.2V</td>
<td>73</td>
<td></td>
<td>90</td>
<td>%</td>
</tr>
<tr>
<td>Switch Saturation Voltage</td>
<td>I_{SW} = 0.5A</td>
<td></td>
<td>0.30</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>I_{SW} = 0.1A</td>
<td></td>
<td>0.06</td>
<td>0.15</td>
<td>V</td>
</tr>
<tr>
<td>Switch Leakage</td>
<td>Switch Off, V_{SW} = 5V</td>
<td></td>
<td>0.1</td>
<td>5</td>
<td>µA</td>
</tr>
</tbody>
</table>

Commercial grade 0°C to 70°C, VIN = 2V, V_{SHDN} = V_{IN}, T_A = 25°C unless otherwise noted.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>1.21</th>
<th>1.23</th>
<th>1.25</th>
<th>V</th>
</tr>
</thead>
</table>

Peak Switch Current

- R_{SET} = 27.4k, T_A = 25°C
- R_{SET} = 27.4k, T_A = 0°C
- R_{SET} = 27.4k, T_A = 70°C

- R_{SET} = 10k
- R_{SET} = 121k

Industrial grade –40°C to 85°C, VIN = 2V, V_{SHDN} = V_{IN}, T_A = 25°C unless otherwise noted.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>1.205</th>
<th>1.23</th>
<th>1.255</th>
<th>V</th>
</tr>
</thead>
</table>

Peak Switch Current

- R_{SET} = 27.4k,
- R_{SET} = 10k

The ● denotes specifications which apply over the specified temperature range.

Note 1: C grade device specifications are guaranteed over the 0°C to 70°C temperature range. In addition, C grade device specifications are assured over the –40°C to 85°C temperature range by design or correlation, but are not production tested.

Note 2: I grade device specifications are guaranteed over the –40°C to 85°C temperature range.

TYPICAL PERFORMANCE CHARACTERISTICS

Load Transient Response

Burst Mode™ Operation

Burst Mode IS A TRADEMARK OF LINEAR TECHNOLOGY CORPORATION.
**PIN FUNCTIONS**

LBO (Pin 1): Low-Battery Detector Output. Open collector can sink up to 500µA. Low-battery detector remains active in shutdown mode.

LBI (Pin 2): Low-Battery Detector Input. When voltage at this pin drops below 1.17V, LBO goes low.

RSET (Pin 3): A resistor between RSET and GND programs peak switch current. The resistor value should be between 3k and 150k. Do not float or short to ground. This is a high impedance node. Keep traces at this pin as short as possible. Do not put capacitance at this pin.

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

SW (Pin 5): Collector of NPN Power Transistor. Keep traces at this pin as short as possible.

VIN (Pin 6): Input Supply. Must be bypassed close to the pin.

SHDN (Pin 7): Shutdown. Ground this pin to place the part in shutdown mode (only the low-battery detector remains active). Tie to a voltage between 1.4V and 6V to enable the device. SHDN pin is logic level and need only meet the logic specification (1.4V for high, 0.4V for low).

FB (Pin 8): Feedback Pin. Reference voltage is 1.23V. Connect resistive divider tap here. Minimize trace area at FB. Set VOUT according to: \[ V_{OUT} = 1.23V \left(1 + \frac{R1}{R2}\right) \].

---

**BLOCK DIAGRAM**

Figure 1. LT1316 Block Diagram
APPLICATIONS INFORMATION

Table 1 simplifies component selection for commonly used input and output voltages. The methods used in determining these values are discussed in more detail later in this data sheet.

\[ V_{\text{OUT}} = 1.23 \left( \frac{R_2 + R_1}{R_2} \right) \]

<table>
<thead>
<tr>
<th>( V_{\text{IN}} )</th>
<th>( V_{\text{OUT}} )</th>
<th>( \text{LOAD CURRENT} )</th>
<th>( R_{\text{SET}} )</th>
<th>( \text{INDUCTOR} )</th>
<th>( \text{PEAK SWITCH CURRENT} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5</td>
<td>10mA</td>
<td>36.8k</td>
<td>100( \mu )H</td>
<td>80mA</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>25mA</td>
<td>18.2k</td>
<td>68( \mu )H</td>
<td>165mA</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>50mA</td>
<td>10k</td>
<td>47( \mu )H</td>
<td>320mA</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>75mA</td>
<td>6.81k</td>
<td>33( \mu )H</td>
<td>500mA</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>100mA</td>
<td>6.81k</td>
<td>82( \mu )H</td>
<td>490mA</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>1mA</td>
<td>75k</td>
<td>100( \mu )H</td>
<td>56mA</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>5mA</td>
<td>22.1k</td>
<td>100( \mu )H</td>
<td>140mA</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>10mA</td>
<td>10k</td>
<td>100( \mu )H</td>
<td>270mA</td>
</tr>
</tbody>
</table>

**Operation**

To understand operation of the LT1316, first examine Figure 1. Comparator A1 monitors FB voltage which is \( V_{\text{OUT}} \) divided down by resistor divider network R1/R2. When voltage at the FB pin drops below the reference voltage (1.23V), A1’s output goes high and the oscillator is enabled. The oscillator has an off-time fixed at 2\( \mu \)s and an on-time limited to 6.3\( \mu \)s. Power transistor Q1 is cycled on and off by the oscillator forcing current through the inductor to alternately ramp up and down (see Figure 2).

During the portion of the switch cycle when Q1 is turned off, current is forced through D1 to C1 causing output voltage to rise. This switching action continues until output voltage rises enough to overcome A1’s hysteresis. Peak switch current is set by a resistor from the R\(_{\text{SET}}\) pin to ground. Voltage at the R\(_{\text{SET}}\) pin is forced to 0.5V by A4 and is used to set up a constant current through R5. This current also flows through R3 which sets the voltage at the positive input of comparator A2. When Q1 turns on, the SW pin goes low and current ramps up at the rate \( V_{\text{IN}}/L \). Current through Q2 is equal to Q1’s current divided by 200. When current through Q2 causes the voltage drop across R4 and R3 to be equal, A2 changes state and resets the oscillator, causing Q1 to turn off. Shutdown is accomplished by grounding the SHDN pin.

The low-battery detector A3 has its own 1.17V reference and is always on. The open collector output device can sink up to 500\( \mu \)A. Approximately 35mV of hysteresis is built into A3 to reduce “buzzing” as the battery voltage reaches the trip level.

**Current Limit**

During active mode when the part is switching, current in the inductor ramps up each switch cycle until reaching a preprogrammed current limit. This current limit value must be set by placing the appropriate resistor from the R\(_{\text{SET}}\) pin to ground. This resistance value can be found by using Figure 3 to locate the desired DC current limit and

\[ V_{\text{OUT}} = 1.23 \left( \frac{R_2 + R_1}{R_2} \right) \]
then adding in the amount of overshoot that will occur due to turn-off delay of the power transistor. This turn-off delay is approximately 300ns.

Peak switch current = DC current limit from graph + \( V_{\text{IN}}/L \times \text{(turn-off delay)} \)

**Example:**

Set peak switch current to 100mA for: \( V_{\text{IN}} = 2V \), \( L = 33\mu\text{H} \) 
Overshoot = \( V_{\text{IN}}/L \times \text{(turn-off delay)} = (2/33\mu\text{H})(300\text{ns}) = 18.2\text{mA} \) 
Refer to \( R_{\text{SET}} \) graph and locate \( (100\text{mA} - 18.2\text{mA}) \approx 82\text{mA} \) 
\( R_{\text{SET}} \approx 33k \)

**Calculating Duty Cycle**

For a boost converter running in continuous conduction mode, duty cycle is constrained by \( V_{\text{IN}} \) and \( V_{\text{OUT}} \) according to the equation:

\[
\text{DC} = \frac{V_{\text{OUT}} - V_{\text{IN}} + V_D}{V_{\text{OUT}} - V_{\text{SAT}} + V_D}
\]

where \( V_D \) = diode voltage drop = 0.4V and \( V_{\text{SAT}} \) = switch saturation voltage = 0.2V.

If the duty cycle exceeds the LT1316’s minimum specified duty cycle of 0.73, the part cannot operate in continuous conduction mode and must be designed for discontinuous mode operation.

**Inductor Selection and Peak Current Limit for Continuous Conduction Mode**

Peak current and inductance determine available output power. Both must be chosen properly. If peak current or inductance is increased, output power increases. Once output power or current and duty cycle are known, peak current can be set by the following equation, assuming continuous mode operation:

\[
I_{\text{PEAK}} = \frac{2(I_{\text{OUT}})}{1 - \text{DC}}
\]  

(1)

Inductance can now be calculated using the peak current:

\[
L = \frac{V_{\text{OUT}} - V_{\text{IN}} + V_D}{0.4(I_{\text{PEAK}})} \times t_{\text{OFF}}
\]  

(2)

where \( t_{\text{OFF}} = 2\mu\text{s} \) and \( V_D = 0.4V \).

As a result of equations 1 and 2, ripple current during switching will be 40% of the peak current (see Figure 2). Using these equations at the specified \( I_{\text{OUT}} \), the part is delivering approximately 60% of its maximum output power. In other words, the part is operating on a 40% reserve. This is a safe margin to use and can be decreased if input voltage and output current are tightly controlled.

For some applications, this recommended inductor size may be too large. Inductance can be reduced but available output power will decrease. Also, ripple current during switching will increase and may cause discontinuous operation. Discontinuous operation occurs when inductor current ramps down to zero at the end of each switch cycle (see Figure 4). Shown in Figure 5 is minimum inductance vs peak current for the part to remain in continuous mode.
Discontinuous Mode Operation

A boost converter with a high VOUT:VIN ratio operates with a high duty cycle in continuous mode. For duty cycles exceeding the LT1316’s guaranteed minimum specification of 0.73, the circuit will need to be designed for discontinuous operation. Additionally, very low peak current limiting below 50mA may necessitate operating in this mode unless high inductance values are acceptable. When operating in discontinuous mode, a different equation governs available output power. For each switch cycle, the inductor current ramps down to zero, completely releasing the stored energy. Energy stored in the inductor at any time is equal to \( \frac{1}{2} L I_{PEAK}^2 \). Because this energy is released each cycle, the equation for maximum power out is:

\[
POUT(MAX) = \frac{1}{2} L (I_{PEAK})^2 f
\]

Where
\[
f = \left( \frac{1}{I_{PEAK}(L)} \right) \left( \frac{V_{IN} - V_{SAT}}{t_{OFF}} \right)
\]

When designing for very low peak currents (<50mA), the inductor size needs to be large enough so that on-time is at least 1\( \mu \)s. On-time can be calculated by the equation:

\[
On-Time = \left( \frac{I_{PEAK} \cdot L}{V_{IN} - V_{SAT}} \right)
\]

where \( V_{SAT} = 0.2V \).

Also, at these low current levels, current overshoot due to power transistor turn-off delay will be a significant portion of peak current. Increasing inductor size will keep this to a minimum.

**Design Example 1**

Requirements: \( V_{IN} = 2V \), \( V_{OUT} = 5V \) and \( I_{LOAD} = 10mA \).

1. Find duty cycle

\[
DC = \left( \frac{V_{OUT} - V_{IN} + V_{D}}{V_{OUT} - V_{SAT} + V_{D}} \right) = \left( \frac{5 - 2 + 0.4}{5 - 0.2 + 0.4} \right) = 0.654
\]

Because duty cycle is less than the LT1316 minimum specification (0.73), the circuit can be designed for continuous operation.

2. \( I_{PEAK} = \frac{2(I_{OUT})}{1 - DC} = \frac{2(10mA)}{1 - 0.654} = 58mA \)

3. Find \( L \)

\[
L = \left( \frac{V_{OUT} - V_{IN} + V_{D}}{0.4(I_{PEAK})} \right) t_{OFF}
\]

\[
= \left( \frac{5 - 2 + 0.4}{0.4(58mA)} \right) 2\mu s
\]

\[
= 293\mu H
\]

4. Find \( R_{SET} \) resistor

\[
Overshoot = \left( \frac{V_{IN}}{L} \right) 300ns
\]

\[
= \left( \frac{2}{330\mu H} \right) = 1.8mA
\]

Find \( R_{SET} \) from Figure 3 for 58mA – 1.8mA = 56.2mA

\[
R_{SET} \approx 47k
\]

**Design Example 2**

Requirements: \( V_{IN} = 3.3V \), \( V_{OUT} = 28V \) and \( I_{LOAD} = 5mA \).

1. Find duty cycle:

\[
DC = \left( \frac{V_{OUT} - V_{IN} + V_{D}}{V_{OUT} - V_{SAT} + V_{D}} \right) = \left( \frac{28 - 3.3 + 0.4}{28 - 0.2 + 0.4} \right) = 0.89
\]

Because duty cycle exceeds LT1316 minimum specification of 73%, the circuit must be designed for discontinuous operation.

2. Find \( P_{OUT(MAX)} \)

Multiply \( P_{OUT} \) by 1.4 to give a safe operating margin

\[
P_{OUT(MAX)} = P_{OUT}(1.4) = (5mA)(28V)(1.4) = 0.196W
\]

3. Set the on-time to the data sheet minimum of 3.4\( \mu \)s and find \( L \)

\[
L = \frac{(t_{ON})^2(V_{IN} - V_{SAT})^2}{2P_{OUT(MAX)}(t_{ON} + t_{OFF})}
\]

\[
= \frac{(3.4\mu s)^2(3.3 - 0.2)^2}{2(0.196W)(3.4\mu s + 2\mu s)} = 52\mu H
\]
Applications Information

4. Find $I_{\text{PEAK}}$ for 3.4µs on-time

$$I_{\text{PEAK}} = \frac{t_{\text{ON}}(V_{\text{IN}} - V_{\text{SAT}})}{L} = \frac{3.4\mu\text{s}(3.3 - 0.2)}{52\mu\text{H}} = 0.202\text{A}$$

5. Find $R_{\text{SET}}$ resistor

$$\text{Overshoot} = \left(\frac{V_{\text{IN}}}{L}\right) 300\text{ns} = \left(\frac{3.3}{52\mu\text{H}}\right) 300\text{ns} = 19\text{mA}$$

Find $R_{\text{SET}}$ from Figure 3 for $0.202\text{A} - 19\text{mA} = 0.183\text{A}$

$$R_{\text{SET}} \approx 13\text{k}\Omega$$

These discontinuous mode equations are designed to minimize peak current at the expense of inductor size. If smaller inductors are desired peak current must be increased.

Capacitor Selection

Low ESR (Equivalent Series Resistance) capacitors should be used at the output of the LT1316 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 $R_{\text{SET}}$ 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. This 0.5A, low drop diode suits the LT1316 well. 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 output voltage 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.

Lowering Output Ripple Voltage

To obtain lower output ripple voltage, a small feedforward capacitor of about 50pF to 100pF may be placed from $V_{\text{OUT}}$ to FB as detailed in Figure 6. Ripple voltages with and without the added capacitor are pictured in Figures 7 and 8.
Applications Information

Figure 7. Switching Waveforms for the Circuit Shown in Figure 7 Without C1. The Output Ripple Voltage is Approximately 140mV_{P-P}

Figure 8. By Adding C1, Output Ripple Voltage is Reduced to Less Than 80mV_{P-P}

Layout/Input Bypassing

The LT1316’s high speed switching mandates careful attention to PC board layout. Suggested component placement is shown in Figure 9. The input supply must have low impedance at AC and the input capacitor should be placed as indicated in the figure. The value of this capacitor depends on how close the input supply is to the IC. In situations where the input supply is more than a few inches away from the IC, a 47µF to 100µF solid tantalum bypass capacitor is required. If the input supply is close to the IC, a 1µF ceramic capacitor can be used instead. The LT1316 switches current in pulses up to 0.5A, so a low impedance supply must be available. If the power source (for example, a 2 AA cell battery) is within 1 or 2 inches of the IC, the battery itself provides bulk capacitance and the 1µF ceramic capacitor acts to smooth voltage spikes at switch turn-on and turn-off. If the power source is far away from the IC, inductance in the power source leads results in high impedance at high frequency. A local high capacitance bypass is then required to restore low impedance at the IC.

Low-Battery Detector

The LT1316 contains an independent low-battery detector that remains active when the device is shut down. This detector, actually a hysteretic comparator, has an open collector output that can sink up to 500µA. The comparator also operates below the switcher’s undervoltage lockout threshold, operating until VIN reaches approximately 1.4V.
TYPICAL APPLICATIONS

Nonisolated – 48V to 5V Flyback Converter

Efficiency vs Load Current
Positive-to-Negative Converter for LCD Bias

Battery-Powered Solenoid Driver

When Solenoid Is Energized ($V_{\text{ENERGIZE}}$ High) Peak Input Current Remains Low and Controlled, Maximizing Battery Life
TYPICAL APPLICATIONS

Super Cap Backup Supply

LT1316

50V to 6V Isolated Flyback Converter

CIN, COUT: 
CSUP: 
D1: MBR0520LT3
L1: SUMIDA CD43-470
**TYPICAL APPLICATIONS**

**LCD Bias Generator with Output Disconnect in Shutdown**

![Diagram of LCD Bias Generator](Diagram)

- **VIN**: 3.3V
- **L1**: 22µH
- **MBR0540LT1**
- **VOUT**: 17.1V TO 19.8V
- **4mA**
- **C1**: AVX TAJA226M006R
- **C2**: AVX TAJB335M035R
- **L1**: MURATA LOH5C220K34
- **Q1**: MMBT3906LT3

**Universal Serial Bus (USB) to 5V/100mA DC/DC Converter**

![Diagram of USB to 5V/100mA Converter](Diagram)

- **VIN**: 4V TO 7V
- **L1**: 33µH
- **D1**: MBR0520LT1
- **Q1**: MPS1907A

**Component Details**

- **C1**: 10µF 10V AVX TAJB106M010
- **C2**: 33µF 10V AVX TPSC336M010
- **C3**: 10µF ALUMINUM ELECTROLYTIC
- **D1**: MBR0520LT1
- **L1**: 33µH SUMIDA CD43 (OR COILCRAFT D01608)
**PACKAGE DESCRIPTION**

Dimensions in inches (millimeter) unless otherwise noted.

**MS8 Package**

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

**S8 Package**

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

*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

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of circuits as described herein will not infringe on existing patent rights.
Typical Applications

Low Profile 2 Cell-to-28V Converter for LCD Bias

Bipolar LCD Bias Supply

Related Parts

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTC®1163</td>
<td>Triple High Side Driver for 2-Cell Inputs</td>
<td>1.8V Minimum Input, Drives N-Channel MOSFETs</td>
</tr>
<tr>
<td>LTC1174</td>
<td>Micropower Step-Down DC/DC Converter</td>
<td>94% Efficiency, 130μA I_D, 9V to 5V at 300mA</td>
</tr>
<tr>
<td>LT1302</td>
<td>High Output Current Micropower DC/DC Converter</td>
<td>5V/600mA from 2V, 2A Internal Switch, 200μA I_D</td>
</tr>
<tr>
<td>LT1304</td>
<td>2-Cell Micropower DC/DC Converter</td>
<td>Low-Battery Detector Active in Shutdown, 5V at 200mA for 2 Cells</td>
</tr>
<tr>
<td>LT1307</td>
<td>Single Cell Micropower 600kHz PWM DC/DC Converter</td>
<td>3.3V at 75mA from 1 Cell</td>
</tr>
<tr>
<td>LTC1440/1/2</td>
<td>Ultralow Power Single/Dual Comparators with Reference</td>
<td>2.8μA I_D, Adjustable Hysteresis</td>
</tr>
<tr>
<td>LT1516</td>
<td>2-Cell to 5V Regulated Charge Pump</td>
<td>12μA I_D, No Inductors, 5V at 50mA from 3V Input</td>
</tr>
<tr>
<td>LT1521</td>
<td>Micropower Low Dropout Linear Regulator</td>
<td>500mV Dropout, 300mA Current, 12μA I_D</td>
</tr>
</tbody>
</table>