FEATURES
- 5V at 200mA from a 2V Input
- Supply Voltage As Low As 1.8V
- Up to 88% Efficiency
- 120µA Quiescent Current
- Low-Battery Detector
- Low VCESAT Switch: 170mV at 1A Typ
- Uses Inexpensive Surface Mount Inductors
- 8-Lead PDIP or SO Package

APPLICATIONS
- EL Panel Drivers
- 2-Cell and 3-Cell to 5V Conversion
- Palmtop Computers
- Portable Instruments
- Bar-Code Scanners
- PDAs
- Wireless Systems

DESCRIPTION
The LT®1303/LT1303-5 are micropower step-up high efficiency DC/DC converters using Burst Mode™ operation. They are ideal for use in small, low-voltage battery-operated systems. The LT1303-5 accepts an input voltage between 1.8V and 5V and converts it to a regulated 5V. The LT1303 is an adjustable version that can supply an output voltage up to 25V. Quiescent current is only 120µA from the battery and the shutdown pin further reduces current to 10µA. The low-battery detector provides an open-collector output that goes low when the input voltage drops below a preset level. The on-chip NPN power switch has a low 170mV saturation voltage at a switch current of 1A. The LT1303/LT1303-5 are available in 8-lead PDIP or SO packages, easing board space requirements.

For higher output current, please see the LT1305 or LT1302.

LTC and LT are registered trademarks of Linear Technology Corporation.
Burst Mode is a trademark of Linear Technology Corporation.

TYPICAL APPLICATION

Figure 1. 2-Cell to 5V DC/DC Converter with Low-Battery Detect
LT1303/LT1303-5

ABSOLUTE MAXIMUM RATINGS

V_{IN} Voltage .......................................................... 10V
SW1 Voltage ............................................................ 25V
Sense Voltage (LT1303-5) ........................................... 20V
FB Voltage (LT1303) .................................................. 10V
Shutdown Voltage ...................................................... 10V
LBO Voltage ............................................................. 10V
LBI Voltage .............................................................. 10V
Maximum Power Dissipation ................................. 500mW
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
LT1303CN8
LT1303CS8
LT1303CN8-5
LT1303CS8-5

S8 PART MARKING
1303
13035

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS  \( T_{A} = 25°C, V_{IN} = 2.0V, \) unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_{Q} )</td>
<td>Quiescent Current</td>
<td>( V_{SHDN} = 0.5V, V_{SEL} = 5V, V_{SENSE} = 5.5V ) ( V_{SHDN} = 1.8V )</td>
<td>●</td>
<td>120</td>
<td>200</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>7</td>
<td>15</td>
<td>µA</td>
</tr>
<tr>
<td>( V_{IN} )</td>
<td>Input Voltage Range</td>
<td></td>
<td>●</td>
<td>1.8</td>
<td>1.55</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>2.0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td>LT1303</td>
<td>●</td>
<td>1.22</td>
<td>1.24</td>
<td>1.26</td>
<td>V</td>
</tr>
<tr>
<td>Output Sense Voltage</td>
<td>LT1303-5</td>
<td>●</td>
<td>4.8</td>
<td>5.0</td>
<td>5.2</td>
<td>V</td>
</tr>
<tr>
<td>Comparator Hysteresis</td>
<td>LT1303 (Note 1)</td>
<td>●</td>
<td>6</td>
<td>12.5</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Output Hysteresis</td>
<td>LT1303-5 (Note 1)</td>
<td>●</td>
<td>22</td>
<td>50</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Feedback Pin Bias Current</td>
<td>LT1303, ( V_{FB} = 1V )</td>
<td>●</td>
<td>7</td>
<td>20</td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>Oscillator Frequency</td>
<td>Current Limit Not Asserted</td>
<td></td>
<td></td>
<td>120</td>
<td>155</td>
<td>185</td>
</tr>
<tr>
<td>Oscillator TC</td>
<td></td>
<td></td>
<td></td>
<td>0.2</td>
<td></td>
<td>%/°C</td>
</tr>
<tr>
<td>DC</td>
<td>Maximum Duty Cycle</td>
<td>Current Limit Not Asserted</td>
<td>●</td>
<td>75</td>
<td>86</td>
<td>95</td>
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<tr>
<td>( I_{ON} )</td>
<td>Switch On Time</td>
<td></td>
<td></td>
<td>5.6</td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td>Output Line Regulation</td>
<td>( 1.8V &lt; V_{IN} &lt; 6V )</td>
<td>●</td>
<td>0.06</td>
<td>0.15</td>
<td></td>
<td>%/V</td>
</tr>
<tr>
<td>( V_{CESAT} )</td>
<td>Switch Saturation Voltage</td>
<td>( I_{SW} = 700mA )</td>
<td>●</td>
<td>130</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Switch Leakage Current</td>
<td>( I_{SW} = 5V, ) Switch Off</td>
<td>●</td>
<td>0.1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Peak Switch Current</td>
<td>( V_{IN} = 2V ) ( V_{IN} = 5V )</td>
<td></td>
<td>●</td>
<td>0.75</td>
<td>1.0</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>0.65</td>
<td>0.9</td>
<td>1.15</td>
</tr>
<tr>
<td>LBI Trip Voltage</td>
<td></td>
<td></td>
<td>●</td>
<td>1.21</td>
<td>1.24</td>
<td>1.27</td>
</tr>
<tr>
<td>LBI Input Bias Current</td>
<td>( V_{LBI} = 1V )</td>
<td>●</td>
<td>7</td>
<td>20</td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>LBO Output Low</td>
<td>( I_{LOAD} = 100µA )</td>
<td>●</td>
<td>0.11</td>
<td>0.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>LBO Leakage Current</td>
<td>( V_{LBI} = 1.3V, V_{LBO} = 5V )</td>
<td>●</td>
<td>0.1</td>
<td>5</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>( V_{SHDNH} )</td>
<td>Shutdown Pin High</td>
<td></td>
<td>●</td>
<td>1.8</td>
<td></td>
<td>V</td>
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<tr>
<td>( V_{SHDNL} )</td>
<td>Shutdown Pin Low</td>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( I_{SHDN} )</td>
<td>Shutdown Pin Bias Current</td>
<td>( V_{SHDN} = 5V ) ( V_{SHDN} = 2V ) ( V_{SHDN} = 0V )</td>
<td>●</td>
<td>8.0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>3.0</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>0.1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The ● denotes specifications which apply over the 0°C to 70°C operating temperature range.

Note 1: Hysteresis specified is DC. Output ripple may be higher if output capacitance is insufficient or capacitor ESR is excessive.
TYPICAL PERFORMANCE CHARACTERISTICS

**VCESAT vs Switch Current**

- **VCESAT (mV)** vs **Switch Current (A)**

**VCESAT vs Temperature**

- **VCESAT (mV)** vs **Temperature (°C)**

**LT1303 FB Voltage**

- **Feedback Voltage (V)** vs **Temperature (°C)**

**LT1303-5 Sense Voltage**

- **Sense Voltage (V)** vs **Temperature (°C)**

**LT1303-5 Sense Pin Resistance to Ground**

- **Resistance (kΩ)** vs **Temperature (°C)**

**Low Battery Detect Trip Point**

- **LBI Voltage (V)** vs **Temperature (°C)**

**LBI Pin Bias Current**

- **Bias Current (nA)** vs **Temperature (°C)**

**FB Pin Bias Current**

- **Bias Current (nA)** vs **Temperature (°C)**

**Switch Current Limit**

- **Switch Current (A)** vs **Temperature (°C)**

**LBI Pin Bias Current**

- **Bias Current (nA)** vs **Temperature (°C)**

**Vin = 2V**

- **Switch Current Limit (V)** vs **Temperature (°C)**
**Typical Performance Characteristics**

### Switch On-Time
![Switch On-Time Graph](image)

### Oscillator Frequency
![Oscillator Frequency Graph](image)

### Maximum Duty Cycle
![Maximum Duty Cycle Graph](image)

### Quiescent Current
![Quiescent Current Graph](image)

### Switch Current Limit
![Switch Current Limit Graph](image)

### Transient Response
**Figure 1 Circuit**
- `V_{IN} = 2V`
- `V_{OUT} = 5V`
- `I_{LOAD} = 200mA`
- `0mA`
- `200μA/Div`
- `100mV/Div`
- `AC COUPLED`

### Shutdown Pin Response
![Shutdown Pin Response Graph](image)

### Low Battery Detector Transient Response
- `RL = 100Ω`
- `V_{IN} = 2V`
- `V_{OUT} = 5V`
- `C_{OUT} = 100μF`
- `V_{LBO} = 2V/Div`
- `V_{TRIP} +10mV`
- `V_{LBI} = 5V/Div`
- `V_{RIP} -10mV`
- `RPULL-UP = 47k`
- `5μA/DIV`
**PIN FUNCTIONS**

GND (Pin 1): Signal Ground. Tie to PGND under the package.

LBO (Pin 2): Open-Collector Output of Low-Battery Comparator. Can sink 100µA. Disabled when device is in shutdown.


FB/Sense (Pin 4): On 1303 (adjustable) this pin connects to the main comparator C1 input. On LT1303-5 this pin connects to the resistor string that sets output voltage at 5V.

LBI (Pin 5): Low-Battery Comparator Input. When voltage on this pin below 1.24V, LBO is low.

V\text{IN} (Pin 6): Supply Pin. Must be bypassed with a large value electrolytic to ground. Keep bypass within 0.2” of the device.

SW (Pin 7): Switch Pin. Connect inductor and diode here. Keep layout short and direct to minimize radio frequency interference.

PGND (Pin 8): Power ground. Tie to signal ground (pin1) under the package. Bypass capacitor from \text{V}_{\text{IN}} should be tied directly to PGND within 0.2” of the device.

**BLOCK DIAGRAMS**

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**Figure 2. LT1303 Block Diagram**
Operation of the LT1303 is best understood by referring to the Block Diagram in Figure 2. When C1’s negative input, related to the output voltage by the appropriate resistor-divider ratio, is higher than the 1.24V reference voltage, C1’s output is low. C2, A3 and the oscillator are turned off, drawing no current. Only the reference and C1 consume current, typically 140µA. When C1’s negative input drops below 1.24V and overcomes C1’s 6mV hysteresis, C1’s output goes high, enabling the oscillator, current comparator C2 and driver A3. Quiescent current increases to 2mA as the device goes into active switching mode. Q1 then turns on in controlled saturation for nominally 6µs or until current comparator C2 trips, whichever comes first. The switch then turns off for approximately 1.5µs, then turns on again. The LT1303’s switching causes current to alternately build up in L1 and dump into output capacitor C4 via D1, increasing the output voltage. When the output is high enough to cause C1’s output to go high, switching action ceases. Capacitor C4 is left to supply current to the load until VOUT decreases enough to force C1’s output high, and the entire cycle repeats. Figure 4 details relevant waveforms. C1’s cycling causes low-to-mid-frequency ripple voltage on the output. Ripple can be reduced by making the output capacitor large. The 100µF unit specified results in ripple of 50mV to 100mV on the 5V output. A 220µF capacitor will decrease ripple by approximately 50%.

If switch current reaches 1A, causing C2 to trip, switch on-time is reduced and off-time increases slightly. This allows continuous operation during bursts. C2 monitors the voltage across 3Ω resistor R1 which is directly related to the switch current. Q2’s collector current is set by the emitter-area ratio to 0.6% of Q1’s collector current. When R1’s voltage drop exceeds 18mV, corresponding to 1A switch current, C2’s output goes high, truncating the on-time portion of the oscillator cycle and increasing off-time.
**OPERATION**

to about 2µs. Response time of C2, which determines minimum on-time, is approximately 300ns.

**Low Battery Detector**

The low battery detector is enabled when SHDN is low and disabled when SHDN is high. The comparator has no hysteresis built in, but hysteresis can be added by connecting a high-value resistor from LBI to LBO as shown in Figure 5. The internal reference can be accessed via the comparator as shown in Figure 6.

**APPLICATIONS INFORMATION**

**Inductor Section**

Inductors suitable for use with the LT1303 usually fall in the 5µH to 50µH range. The inductor must: (1) handle current of 1.25A without saturating, (2) have enough inductance to provide a di/dt lower than 400mA/µs, and (3) have low enough DC resistance to avoid excessive heating or efficiency losses. Higher value inductors will deliver more power but tend to be physically larger. Most ferrite core drum or rod inductors such as those specified in Table 1 are suitable for use. It is acceptable to bias open-flux inductors (e.g. Sumida CD54) into saturation by 10 to 20% without adverse effects.

**Table 1. Recommended Inductors**

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>SERIES</th>
<th>APPROPRIATE VALUES</th>
<th>PHONE NUMBERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coilcraft</td>
<td>D03316</td>
<td>10µH to 47µH</td>
<td>(708) 639-6400</td>
</tr>
<tr>
<td></td>
<td>D01608</td>
<td>10µH</td>
<td></td>
</tr>
<tr>
<td>Coiltronics</td>
<td>OCTAPAK</td>
<td>20µH</td>
<td>(407) 241-7876</td>
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<tr>
<td></td>
<td>CTX20-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CTX20-2</td>
<td>20µH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CTX33-4</td>
<td>33µH</td>
<td></td>
</tr>
<tr>
<td>Sumida</td>
<td>CD54</td>
<td>10µH to 33µH</td>
<td>(708) 956-0666</td>
</tr>
<tr>
<td>Gowanda</td>
<td>GA10</td>
<td>10µH to 33µH</td>
<td>(716) 532-2234</td>
</tr>
</tbody>
</table>

Figure 7 shows inductor current of a suitable inductor, di/dt is controlled at all times. The rapid rise in current shown in Figure 8 results from this inductor saturating at approximately 1A. Saturation occurs when the inductor cannot hold any more magnetic energy in the core. Current then increases rapidly, limited only by the resistance of the winding. Figure 9’s inductor has high DC resistance which results in the exponential time constant shape of the inductor current.
Diode Selection

The LT1303’s high switching speed demands a high speed rectifier. Schottky diodes are preferred for their low forward drop and fast recovery. Suitable choices include the 1N5817, MBRS120LT3, and MBR0520LT1. Do not use signal diodes such as 1N4148. They cannot carry 1A current. Also avoid “general-purpose” diodes such as 1N4001. These are far too slow and are unsuitable for any switching regulator application. For high temperature applications a silicon diode such as the MUR105 will have less leakage.

Capacitor Selection

Input and output capacitors should have low ESR for best efficiency. Recommended capacitors include AVX TPS series, Sprague 595D series, and Sanyo OS-CON. The output capacitor’s ESR determines the high frequency ripple amplitude. A 100µF capacitor is the minimum recommended for a 5V output. Higher output voltages can use lower capacitance values. For example, a 12V output can use a 33µF or 47µF capacitor. The VIN pin of the LT1303 should be decoupled with a 47µF or 100µF capacitor at the pin. When driving a transformer, an additional decoupling network of 10Ω and 0.1µF ceramic is recommended as shown in Figure 10.

### Table 2. Recommended Capacitors

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>SERIES</th>
<th>TYPE</th>
<th>PHONE NUMBERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVX</td>
<td>TPS</td>
<td>Surface Mount</td>
<td>(803) 448-9411</td>
</tr>
<tr>
<td>Sanyo</td>
<td>OS-CON</td>
<td>Through-Hole</td>
<td>(619) 661-6835</td>
</tr>
<tr>
<td>Panasonic</td>
<td>HFQ</td>
<td>Through-Hole</td>
<td>(201) 348-5200</td>
</tr>
<tr>
<td>Sprague</td>
<td>595D</td>
<td>Surface Mount</td>
<td>(603) 224-1961</td>
</tr>
</tbody>
</table>
TYPICAL APPLICATIONS

Setting Output Voltage on LT1303

\[ V_{\text{OUT}} = 1.24V \left(1 + \frac{R_2}{R_1}\right) \]

5V Step-Up Converter with Reference Output

* SUMIDA CD54-220MC
4-, 5-Cell to 5V Converter with Output Disconnect

3-Cell to 3.3V Boost/Linear Converter with Output Disconnect
EL Panel Driver

VIN
1.5V TO 8V

LT1303

V IN
SHDN
FB
PGND
VIN
1.5V TO 8V

100Hz TO 1000Hz SQUARE WAVE DRIVE

*ADD C1 FOR OPEN-PANEL PROTECTION
**DALE LFS5047-A122 1:15 TURNS RATI0 (605) 666-9301
†R1 ADJUSTS VOUT 83VRMS TO 115VRMS

†R1 ADJUSTS VOUT 83VRMS TO 115VRMS
PACKAGE DESCRIPTION  Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead Plastic DIP

S8 Package
8-Lead Plastic SOIC

*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

*THOSE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

RELATED PARTS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>LT1129</td>
<td>Micropower Low Dropout Regulator</td>
<td>700mA Output Current in SO-8 Package</td>
</tr>
<tr>
<td>LT1182/83/84</td>
<td>LCD and CCFL Backlight Controller</td>
<td>High Efficiency and Excellent Backlight Control Range</td>
</tr>
<tr>
<td>LT1301</td>
<td>5V to 12V/200mA Step-Up DC/DC Converter</td>
<td>120µA Quiescent Current</td>
</tr>
<tr>
<td>LT1302</td>
<td>2-Cell to 5V/600mA Step-Up DC/DC Converter</td>
<td>200µA Quiescent Current</td>
</tr>
<tr>
<td>LT1305</td>
<td>Micropower 2A Switch DC/DC Converter with Low-Battery Detect</td>
<td>2V to 5V at 400mA</td>
</tr>
<tr>
<td>LT1372</td>
<td>500kHz Step-Up PWM, 1.5A Switch</td>
<td>Low Noise, Fixed Frequency Operation</td>
</tr>
<tr>
<td>LTC®1472</td>
<td>PCMCIA Host Switch with Protection</td>
<td>Includes Current Limit and Thermal Shutdown</td>
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