**FEATURES**

- Extremely Compact Triple-Rail Solution
- Burst Mode® Operation, I_Q = 15μA
- 1.5MHz Fixed Frequency Operation
- Power Good Indicators
- 700mA Synchronous Step-Up DC/DC
  - 0.65V to 5V V_IN Range
  - 1.5V to 5.25V V_OUT Range
  - 94% Peak Efficiency
  - V_IN > V_OUT Operation
  - Output Disconnect
- 250mA Synchronous Step-Down DC/DC
  - 1.8V to 5.5V V_IN Range
  - 0.6V to 5.5V V_OUT Range
- LDO (V_IN Internally Tied to V_BST)
  - 0.6V to 2.5V V_OUT Range
  - 200mV Dropout Voltage at 100mA
- Available in a 16-Lead 3mm × 3mm QFN Package

**APPLICATIONS**

- Bar Code Readers
- Medical Instruments
- Low Power Portable Electronic Devices

**DESCRIPTION**

The LTC®3100 combines a high efficiency 700mA synchronous step-up converter, a 250mA synchronous step-down converter and a 100mA LDO regulator. The LTC3100 features a wide input voltage range of 0.65V to 5V. The step-down converter can be powered by the output of the step-up converter or from a separate power source between 1.8V and 5.5V. The LDO can also be used as a sequencing switch on the output of the boost.

A switching frequency of 1.5MHz minimizes solution footprint by allowing the use of tiny, low profile inductors and ceramic capacitors. The switching regulators use current mode control and are internally compensated, reducing external parts count. Each converter automatically transitions to Burst Mode operation to maintain high efficiency over the full load range. Burst Mode operation can be disabled for low noise applications. The integrated LDO provides a third low noise, low dropout supply.

Anti-ringing circuitry reduces EMI by damping the boost inductor in discontinuous mode. Additional features include shutdown current of under 1μA and overtemperature shutdown. The LTC3100 is housed in a 16-lead 3mm × 3mm 0.75mm QFN package.

LT, LTC, LTM and Burst Mode are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.
**ABSOLUTE MAXIMUM RATINGS**

(Note 1)

- $V_{\text{INBST}}$ and $V_{\text{INBK}}$ Voltage ...................... $-0.3$ to $6V$
- $SWBST$, $SWBK$ DC Voltage .................................. $-0.3$ to $6V$
- $SWBST$, $SWBK$ Pulsed ($<100\text{ns}$) Voltage ....... $-0.3$ to $7V$
- $FBBST$, $FBBK$, $FBLDO$, $PGBST$, $PGBK$ Voltage  ... $-0.3$ to $6V$
- $MODE$, $RUNBST$, $RUNBK$, $RUNLDO$ Voltage....... $-0.3$ to $6V$
- $V_{\text{BST}}$, $V_{\text{LDO}}$ ............................................. $-0.3$ to $6V$
- Operating Temperature (Notes 2, 5) ........ $-40^\circ\text{C}$ to $85^\circ\text{C}$
- Storage Temperature Range ......................... $-65^\circ\text{C}$ to $125^\circ\text{C}$

**PIN CONFIGURATION**

- **TOP VIEW**
- **UD PACKAGE**
- 16-LEAD (3mm x 3mm) PLASTIC QFN

**ELECTRICAL CHARACTERISTICS: STEP-UP CONVERTER**

The $\bullet$ denotes the specifications which apply over the full operating temperature range. Extended commercial grade: $-40^\circ\text{C}$ to $85^\circ\text{C}$, $V_{\text{INBST}} = 1.2V$, $V_{\text{BST}} = 3.3V$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

<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 Start-Up Voltage</td>
<td>$I_{\text{LOAD}} = 1\text{mA}$</td>
<td>$\bullet$</td>
<td>0.65</td>
<td>0.90</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>After Start-Up (Minimum Voltage Is Load Dependent)</td>
<td>$\bullet$</td>
<td>0.5</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Adjust Range</td>
<td></td>
<td></td>
<td>1.5</td>
<td>5.25</td>
<td>V</td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td></td>
<td></td>
<td>1.182</td>
<td>1.200</td>
<td>1.218</td>
</tr>
<tr>
<td>Feedback Input Current</td>
<td>$FBBST = 1.2V$</td>
<td></td>
<td>1</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>Quiescent Current ($V_{\text{INO}}$): Shutdown</td>
<td>$RUNBST = 0V$, Not Including Switch Leakage, $V_{\text{BST}} = 0V$, $V_{\text{INBK}} = 0V$</td>
<td></td>
<td>0.01</td>
<td>1</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Quiescent Current: Active</td>
<td>Measured on $V_{\text{BST}}$ (Note 4), $RUNBK = 0V$, $RUNLDO = 0V$</td>
<td></td>
<td>300</td>
<td>500</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Quiescent Current: Burst Mode Operation</td>
<td>Measured on $V_{\text{BST}}$, $FBBST &gt; 1.25V$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\text{MODE} = 1V$, $RUNLDO = 0V$</td>
<td></td>
<td>15</td>
<td>25</td>
<td>$\mu$A</td>
</tr>
<tr>
<td></td>
<td>$\text{MODE} = 1V$, $RUNLDO = 1V$</td>
<td></td>
<td>28</td>
<td>45</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>N-Channel MOSFET Switch Leakage Current</td>
<td>$SWBST = 5V$, $V_{\text{BST}} = 5V$</td>
<td></td>
<td>0.1</td>
<td>5</td>
<td>$\mu$A</td>
</tr>
<tr>
<td>P-Channel MOSFET Switch Leakage Current</td>
<td>$SWBST = 0V$, $V_{\text{BST}} = 5V$</td>
<td></td>
<td>0.1</td>
<td>10</td>
<td>$\mu$A</td>
</tr>
</tbody>
</table>
### ELECTRICAL CHARACTERISTICS: STEP-UP CONVERTER

The ● denotes the specifications which apply over the full operating temperature range. Extended commercial grade: –40°C to 85°C, $V_{INBK} = 3.3V$, $T_A = 25°C$, unless otherwise noted.

<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>N-Channel MOSFET Switch-On Resistance</td>
<td>$V_{BST} = 3.3V$</td>
<td>0.3</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>P-Channel MOSFET Switch-On Resistance</td>
<td>$V_{BST} = 3.3V$</td>
<td>0.4</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>N-Channel MOSFET Current Limit</td>
<td></td>
<td>●</td>
<td>700</td>
<td>850</td>
<td>mA</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td>$V_{FBBST} = 1.15V$</td>
<td>●</td>
<td>87</td>
<td>90</td>
<td>%</td>
</tr>
<tr>
<td>Minimum Duty Cycle</td>
<td>$V_{FBBST} = 1.3V$</td>
<td>●</td>
<td>0</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td></td>
<td>●</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8 MHz</td>
</tr>
<tr>
<td>RUNBST Input High Voltage</td>
<td></td>
<td>●</td>
<td>0.9</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>RUNBST Input Low Voltage</td>
<td></td>
<td>●</td>
<td>0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>RUNBST Input Current</td>
<td>RUNBST = 1.2V</td>
<td>0.8</td>
<td>2</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Soft-Start Time</td>
<td></td>
<td>0.8</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>PGBST Threshold, Falling</td>
<td>Referenced to Feedback Voltage</td>
<td>–8</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>PGBST Hysteresis</td>
<td>Referenced to Feedback Voltage</td>
<td>3</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>PGBST Voltage Low</td>
<td>5mA Load</td>
<td>65</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>PGBST Leakage Current</td>
<td>$P_{GBST} = 5.5V$</td>
<td>0.01</td>
<td>10</td>
<td></td>
<td>μA</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS: STEP-DOWN CONVERTER

The ● denotes the specifications which apply over the full operating temperature range. Extended commercial grade: –40°C to 85°C, $V_{INBK} = 3.3V$, $T_A = 25°C$, unless otherwise noted.

<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>Input Voltage Range</td>
<td></td>
<td>●</td>
<td>1.8</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Adjust Range</td>
<td></td>
<td>●</td>
<td>0.61</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td></td>
<td>●</td>
<td>590</td>
<td>600</td>
<td>610 mV</td>
</tr>
<tr>
<td>Feedback Input Current</td>
<td>$F_{BBK} = 600mV$</td>
<td>1</td>
<td>30</td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>Quiescent Current: Shutdown</td>
<td>Measured on $V_{INBK}, R_{UNBK} = 0V, V_{INBK} = 0V, V_{BST} = 0V$</td>
<td>0.01</td>
<td>1</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Quiescent Current: Active</td>
<td>Measured on $V_{INBK}$ (Note 4), RUNBST = 0V</td>
<td>240</td>
<td>350</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Quiescent Current: Burst Mode Operation</td>
<td>Measured on $V_{INBK}$, $F_{BBK} = 620mV$, MODE = OPEN, RUNBST = 0V</td>
<td>16</td>
<td>30</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>N-Channel MOSFET Switch Leakage Current</td>
<td>$V_{INBK} = SWBK = 5V$</td>
<td>0.1</td>
<td>5</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>P-Channel MOSFET Switch Leakage Current</td>
<td>$SWBK = 0V, V_{INBK} = 5V$</td>
<td>0.1</td>
<td>5</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>N-Channel MOSFET Switch-On Resistance</td>
<td>$V_{INBK} = 3.3V$</td>
<td>0.45</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>P-Channel MOSFET Switch-On Resistance</td>
<td>$V_{INBK} = 3.3V$</td>
<td>0.55</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>P-Channel MOSFET Current Limit</td>
<td></td>
<td>●</td>
<td>340</td>
<td>450</td>
<td>mA</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td>$F_{BBK} &lt; 590mV$</td>
<td>●</td>
<td>100</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Minimum Duty Cycle</td>
<td>$F_{BBK} &gt; 610mV$</td>
<td>●</td>
<td>0</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td></td>
<td>●</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8 MHz</td>
</tr>
</tbody>
</table>
### LTC3100

#### ELECTRICAL CHARACTERISTICS: STEP-DOWN CONVERTER

<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>RUNBK Input High Voltage</td>
<td></td>
<td>0.9</td>
<td>1</td>
<td>1.2V</td>
<td></td>
</tr>
<tr>
<td>RUNBK Input Low Voltage</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.6V</td>
<td></td>
</tr>
<tr>
<td>RUNBK Input Current</td>
<td>RUNBK = 1.2V</td>
<td>0.8</td>
<td>0.8</td>
<td>2μA</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time</td>
<td></td>
<td>1.3</td>
<td>1.3</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>PGBK Threshold, Falling</td>
<td>Referenced to Feedback Voltage</td>
<td>–8</td>
<td>–8</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PGBK Hysteresis</td>
<td>Referenced to Feedback Voltage</td>
<td>3</td>
<td>3</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PGBK Voltage Low</td>
<td>5mA Load</td>
<td>65</td>
<td>65</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>PGBK Leakage Current</td>
<td>PGBK = 5.5V</td>
<td>0.01</td>
<td>0.01</td>
<td>μA</td>
<td></td>
</tr>
</tbody>
</table>

*The ● denotes the specifications which apply over the full operating temperature range. Extended commercial grade: −40°C to 85°C, V_{INBK} = 3.3V, T_A = 25°C, unless otherwise noted.*

#### ELECTRICAL CHARACTERISTICS: LDO REGULATOR

<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>Input Voltage Range</td>
<td></td>
<td>1.8</td>
<td>2.5</td>
<td>5.25V</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Adjust Range</td>
<td>(Note 3)</td>
<td>0.618</td>
<td>1</td>
<td>5.25V</td>
<td></td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td></td>
<td>582</td>
<td>600</td>
<td>618</td>
<td>mV</td>
</tr>
<tr>
<td>Maximum Output Current</td>
<td></td>
<td>100</td>
<td>120</td>
<td>120</td>
<td>mA</td>
</tr>
<tr>
<td>Feedback Input Current</td>
<td>FBLDO = 600mV</td>
<td></td>
<td>1</td>
<td>30</td>
<td>nA</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>V_{IN} = 3.3V to 5.25V</td>
<td>0.1</td>
<td>0.1</td>
<td>%V</td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td>From 10mA to 100mA Load</td>
<td></td>
<td>0.1</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>I_{OUT} = 100mA</td>
<td></td>
<td>130</td>
<td>200</td>
<td>mV</td>
</tr>
<tr>
<td>Ripple Rejection (PSRR)</td>
<td>Frequency = 1.5MHz at I_{LOAD} = 50mA, C_{OUT} = 2.2μF (Note 3)</td>
<td>35</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Short-Circuit Current Limit</td>
<td>FBLDO &lt; 582mV</td>
<td>120</td>
<td>160</td>
<td>160</td>
<td>mA</td>
</tr>
<tr>
<td>Soft-Start Time</td>
<td></td>
<td>0.3</td>
<td>0.5</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>RUNLDO Input High Voltage</td>
<td></td>
<td>0.9</td>
<td>0.9</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>RUNLDO Input Low Voltage</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>RUNLDO Input Current</td>
<td>RUNLDO = 1.2V</td>
<td>0.8</td>
<td>0.8</td>
<td>2μA</td>
<td></td>
</tr>
<tr>
<td>Quiescent Current—Active</td>
<td>RUNLDO = 3.3V, Measured on V_{BST} RUNBST = RUNBK = 0V, V_{INBK} = 0V</td>
<td>26</td>
<td>26</td>
<td>μA</td>
<td></td>
</tr>
</tbody>
</table>

*The ● denotes the specifications which apply over the full operating temperature range. Extended commercial grade: −40°C to 85°C, V_{BST} = 3.3V, V_{LDO} = 3V, T_A = 25°C, unless otherwise noted.*

#### ELECTRICAL CHARACTERISTICS: COMMON CIRCUITRY

<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>MODE Input High Voltage</td>
<td></td>
<td>0.9</td>
<td>0.9</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>MODE Input Low Voltage</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>MODE Input Current</td>
<td>MODE = 0V</td>
<td>−3.3</td>
<td>−3.3</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td>MODE = 5V</td>
<td>1.7</td>
<td>1.7</td>
<td></td>
<td>μA</td>
</tr>
</tbody>
</table>

*The ● denotes the specifications which apply over the full operating temperature range. Extended commercial grade: −40°C to 85°C, V_{BST} or V_{INBK} = 3.3V, T_A = 25°C, unless otherwise noted.*
**ELECTRICAL CHARACTERISTICS**

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** The LTC3100E is guaranteed to meet performance specifications from 0°C to 85°C. Specifications over −40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

**Note 3:** Specification is guaranteed by design and not 100% tested in production.

**Note 4:** Current measurements are made when the output is not switching.

**Note 5:** This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Junction temperature will exceed 125°C when overtemperature protection is active. Continuous operation above the specified maximum operating junction temperature may result in device degradation or failure.

**Note 6:** Failure to solder the exposed backside of the package to the PC board ground plane will result in a thermal resistance much higher than 68°C/W.

**TYPICAL PERFORMANCE CHARACTERISTICS** $T_A = 25°C$, unless otherwise specified.

**Step-Up DC/DC Converter**

**Efficiency vs Load Current and $V_{IN}$ for $V_O = 1.8V$**

![Graph showing efficiency vs load current for $V_O = 1.8V$](image1)

**Efficiency vs Load Current and $V_{IN}$ for $V_O = 3.3V$**

![Graph showing efficiency vs load current for $V_O = 3.3V$](image2)

**Efficiency vs Load Current and $V_{IN}$ for $V_O = 5V$**

![Graph showing efficiency vs load current for $V_O = 5V$](image3)

**3.3V, 100mA Efficiency vs $V_{IN}$**

![Graph showing efficiency vs $V_{IN}$ for 3.3V, 100mA](image4)
TYPICAL PERFORMANCE CHARACTERISTICS  $T_A = 25^\circ C$, unless otherwise specified.

Step-Up DC/DC Converter

- No-Load Input Current vs $V_{IN}$, Mode = Open, LDO and Buck Off
- Maximum Output Current vs $V_{IN}$
- Maximum Load Current During Start-Up vs $V_{IN}$
- Burst Mode Threshold Current vs $V_{IN}$
- Start-Up Voltage vs Temperature
- $V_{OUT}$ and $I_{IN}$ During Soft-Start
- Output Voltage Ripple in Fixed Frequency and Burst Mode Operation
TYPICAL PERFORMANCE CHARACTERISTICS  \( T_A = 25^\circ C, \) unless otherwise specified.

Step-Up DC/DC Converter

Load Step Response, 50mA-150mA
Fixed Frequency Mode

Load Step Response, 5mA-100mA
Burst Mode Operation Enabled

LDO Regulator

Dropout Voltage vs \( V_{OUT} \) and Temperature (\( I_{OUT} = 100mA \))

Ripple Rejection

Soft-Start Time

Burst Mode Operation
Ripple Rejection

Load Step Response, 10mA-60mA
LTC3100

TYPICAL PERFORMANCE CHARACTERISTICS  \( T_A = 25^\circ C, \) unless otherwise specified.

Step-Down DC/DC Converter

Efficiency vs Load Current and \( V_{IN} \)
for \( V_O = 1.2V \)

Efficiency vs Load Current and \( V_{IN} \)
for \( V_O = 1.8V \)

No-Load Input Current
vs \( V_{INBK} \) (Mode = Open)

Burst Mode Operation Threshold
Current vs \( V_{IN} \)

Load Step Response,
Fixed Frequency Mode
10mA to 100mA

Load Step Response,
Burst Mode Operation Enabled
10mA to 100mA
**TYPICAL PERFORMANCE CHARACTERISTICS**  
$T_A = 25^\circ C$, unless otherwise specified.

### PIN FUNCTIONS

**SWBST (Pin 1):** Switch Pin for the Boost Converter. Connect the boost inductor between SWBST and $V_{INBST}$. Keep PCB trace lengths as short and wide as possible to reduce EMI. If the inductor current falls to zero, an internal anti-ringing switch is connected from SWBST to $V_{INBST}$ to minimize EMI.

**$V_{BST}$ (Pin 2):** Output Voltage for the Boost Converter (which is the drain of the internal synchronous rectifier) and Input Voltage for the LDO. PCB trace length from $V_{BST}$ to the output filter capacitor (10μF minimum) should be as short and wide as possible.

**$V_{LDO}$ (Pin 3):** Output Voltage of the LDO Regulator. Connect a 1μF ceramic capacitor between $V_{LDO}$ and GND. Larger values of capacitance may be used for higher PSRR or improved transient response.

**SWBK (Pin 4):** Switch Pin for the Buck Converter. Connect the buck inductor between SWBK and the buck output filter capacitor. Keep PCB trace lengths as short and wide as possible to reduce EMI.

**$V_{INBK}$ (Pin 5):** Input Voltage for the Buck Converter. Connect a minimum of 4.7μF ceramic decoupling capacitor from this pin to ground.

**PGBK (Pin 6):** Open-Drain Output That Pulls Low When FBBK Is More Than 8% Below Its Regulated Voltage. Connect a pull-up resistor from this pin to a positive supply less than 6V.

**GND (Pin 7):** Signal Ground. Provide a short, direct PCB path between GND and the PC board ground plane connected to the Exposed Pad.

**RUNBK (Pin 8):** Logic-Controlled Shutdown Input for the Buck Converter. There is an internal 4MΩ pull-down on this pin.

  - **RUNBK = High:** Normal operation
  - **RUNBK = Low:** Shutdown

**FBBK (Pin 9):** Feedback Input to the $g_m$ Error Amplifier for the Buck Converter. Connect the resistor divider tap to this pin. The output voltage can be adjusted from 0.6V to 5.5V by:

$$V_{OUT\_BUCK} = 0.600V \times \left(1+\frac{R6}{R5}\right)$$

**RUNLDO (Pin 10):** Logic-Controlled Shutdown Input for the LDO Regulator. There is an internal 4MΩ pull-down on this pin.

  - **RUNLDO = High:** Normal operation
  - **RUNLDO = Low:** Shutdown
LTC3100

**PIN FUNCTIONS**

FBLDO (Pin 11): Feedback Input to the gm Error Amplifier for the LDO Regulator. Connect the resistor divider tap to this pin. The output voltage can be adjusted from 0.6V to 5.25V by:

\[ V_{OUT\_LDO} = 0.600V \cdot \left(1 + \frac{R4}{R3}\right) \]

FBBST (Pin 12): Feedback Input to the gm Error Amplifier for the Boost Converter. Connect the resistor divider tap to this pin. The output voltage can be adjusted from 1.5V to 5.25V by:

\[ V_{OUT\_BOOST} = 1.20V \cdot \left(1 + \frac{R2}{R1}\right) \]

MODE (Pin 13): Logic-Controlled Mode Select Pin for Both the Boost and Buck Converters. There is an internal 1MΩ pull-up on this pin to the higher of \( V_{IN\_BST} \), \( V_{BST} \) or \( V_{IN\_BK} \).

MODE = Float or High: Enables Burst Mode operation for both the boost and the buck.

MODE = Low: Disables Burst Mode operation. Both converters will operate in fixed frequency mode regardless of load current.

RUNBST (Pin 14): Logic-Controlled Shutdown Input for the Boost Converter. There is an internal 4MΩ pull-down on this pin.

RUNBST = High: Normal operation

RUNBST = Low: Shutdown

PGBST (Pin 15): Open-Drain Output That Pulls to Ground When FBBST Is More Than 8% Below Its Regulated Voltage. Connect a pull-up resistor from this pin to a positive supply less than 6V.

\( V_{IN\_BST} \) (Pin 16): Input Voltage for the Boost Converter. Connect a minimum of 1μF ceramic decoupling capacitor from this pin to ground.

Exposed Pad (Pin 17): The Exposed Pad must be soldered to the PCB ground plane. It serves as the power ground connection, and as a means of conducting heat away from the die.
OPERATION

The LTC3100 includes a 700mA synchronous step-up (boost) converter, a 250mA synchronous step-down (buck) converter and a 100mA low dropout (LDO) linear regulator housed in a 16-lead 3mm × 3mm QFN package. Both converters utilize current mode PWM control for exceptional line and load regulation and operate from the same 1.5MHz oscillator. The current mode architecture with adaptive slope compensation also provides excellent transient load response, requiring minimal output filtering. Both converters have internal soft-start and internal loop compensation, simplifying the design process and minimizing the number of external components.

With its low \( R_{DS(ON)} \) and low gate charge internal MOSFET switches and synchronous rectifiers, the LTC3100 achieves high efficiency over a wide range of load current. Burst Mode operation maintains high efficiency at very light loads, but can be disabled for noise-sensitive applications.

With separate power inputs for the boost and buck converters, along with independent enable and power good functions, the LTC3100 is very flexible. The two converters can operate from the same input supply, or from two different sources, or can even be cascaded by powering the buck converter from the output of the boost converter. By using the LDO as well, three different output voltages can be generated from a single alkaline/NiMH cell (or the LDO can be used for power sequencing the boost output).

Operation can be best understood by referring to the Block Diagram.

BOOST CONVERTER

Low Voltage Start-Up

The LTC3100 boost converter includes an independent start-up oscillator designed to start up at an input voltage of 0.65V (typical). Soft-start and inrush current limiting are provided during start-up, as well as in normal mode.

When either \( V_{\text{INBST}} \) or \( V_{\text{BST}} \) exceeds 1.4V (typical), the IC enters normal operating mode. Once the output voltage exceeds the input by 0.24V, the IC powers itself from \( V_{\text{BST}} \) instead of \( V_{\text{INBST}} \). At this point, the internal circuitry has no dependency on the input voltage, eliminating the requirement for a large input capacitor. The limiting factor for the application becomes the ability of the power source to supply sufficient energy to the output at low input voltages, and maximum duty cycle of the converter, which is clamped at 90% (typical). Note that at low input voltages, even small input voltage drops due to series resistance become critical, and greatly limit the power delivery capability of the converter.

LOW NOISE FIXED FREQUENCY OPERATION

Soft-Start

The internal soft-start circuitry ramps the peak boost inductor current from zero to its peak value of 700mA in approximately 800μs, allowing start-up into heavy loads. The soft-start circuitry is reset in the event of a commanded shutdown or an overtemperature shutdown.

Oscillator

An internal oscillator sets the switching frequency to 1.5MHz. The oscillator allows a maximum duty cycle of 90% (typical) for the boost converter.

Shutdown

The boost converter is shut down by pulling the \( \text{RUNBST} \) pin below 0.3V, and activated by pulling the \( \text{RUNBST} \) pin above 0.9V. Note that \( \text{RUNBST} \) can be driven above \( V_{\text{IN}} \) or \( V_{\text{OUT}} \), as long as it is limited to less than the absolute maximum rating.

Error Amplifier

The error amplifier is a transconductance type. The non-inverting input is internally connected to the 1.20V reference and the inverting input is connected to FBBST. Clamps limit the minimum and maximum error amp output voltage for improved large signal transient response. Power converter control loop compensation is provided internally. A voltage divider from \( V_{\text{BST}} \) to ground programs the output voltage (via FBBST) from 1.5V to 5.25V, according to the formula:

\[
V_{\text{BST}} = 1.20V \cdot \left( 1 + \frac{R_2}{R_1} \right)
\]
**Current Sensing**
Lossless current sensing converts the peak current signal of the N-channel MOSFET switch into a voltage which is summed with the internal slope compensation. The summed signal is compared to the error amplifier output to provide a peak current control command for the PWM.

**Current Limit**
The current limit comparator shuts off the N-channel MOSFET switch once its threshold is reached. Peak switch current is no less than 700mA, independent of input or output voltage, unless VOUT falls below 1V, in which case the current limit is cut in half to minimize power dissipation into a short-circuit.

**Slope Compensation**
Current mode control requires the use of slope compensation to prevent subharmonic oscillations in the inductor current waveform at high duty cycle operation. This is accomplished internally on the LTC3100 through the addition of a compensating ramp to the current sense signal. The LTC3100 performs current limiting prior to addition of the slope compensation ramp and therefore achieves a peak inductor current limit that is independent of duty cycle.

**Zero Current Comparator**
The zero current comparator monitors the boost inductor current to the output and shuts off the synchronous rectifier once this current reduces to approximately 30mA. This prevents the inductor current from reversing in polarity, improving efficiency at light loads.

**Synchronous Rectifier**
To control inrush current and to prevent the inductor current from running away when VOUT is close to VIN, the P-channel MOSFET synchronous rectifier is only fully enabled when VOUT > (VIN + 0.24V).

**Anti-Ringing Control**
The anti-ring circuitry connects a resistor across the boost inductor to prevent high frequency ringing on the SW pin during discontinuous current mode operation. The ringing of the resonant circuit formed by L and CSW (capacitance on SWBST pin) is low energy, but can cause EMI radiation.

**PGOOD Comparator**
The PGBST pin is an open-drain output which indicates the status of the boost converter output voltage. If the boost output voltage falls 8% below the regulation voltage, the PGBST open-drain output will pull low. The output voltage must rise 3% above the falling threshold before the pull-down will turn off. In addition, there is a 60μs (typical) deglitching delay in order to prevent false trips due to voltage transients on load steps. The PGBST output will also pull low if the boost converter is disabled. The typical PGBST pull-down switch resistance is 13Ω when VBST or VINBST equals 3.3V.

**Output Disconnect**
The LTC3100 boost converter is designed to allow true output disconnect by eliminating body diode conduction of the internal P-channel MOSFET rectifier. This allows for VOUT to go to 0V during shutdown, drawing no current from the input source. It also allows for inrush current limiting at turn-on, minimizing surge currents seen by the input supply. Note that to obtain the advantages of output disconnect, there must not be an external Schottky diode connected between SWBST and VBST. The output disconnect feature also allows VOUT to be pulled high without any reverse current into the battery.

**VIN > VOUT Operation**
The LTC3100 boost converter will maintain voltage regulation even when the input voltage is above the desired output voltage. Note that the output current capability is slightly reduced in this mode of operation. Refer to the Typical Performance Characteristics section.

**Burst Mode Operation (for Boost and Buck Converters)**
Burst Mode operation for both converters can be enabled or disabled using the MODE pin. If MODE is grounded, Burst Mode operation is disabled for both the boost and...
buck converters. In this case, both converters will remain in
fixed frequency operation, even at light load currents. If the
load is very light, they will exhibit pulse-skip operation.

If MODE is raised above 0.9V, or left open, Burst Mode
operation will be enabled for both converters. In this case,
either converter may enter Burst Mode operation at light
load, and return to fixed frequency operation when the
load current increases. Refer to the Typical Performance
Characteristics section to see the output load Burst Mode
threshold vs $V_{IN}$ and $V_{OUT}$. The two converters can enter or
leave Burst Mode operation independent of each other.

In Burst Mode operation, each converter still switches at
a frequency of 1.5MHz, using the same error amplifier
and loop compensation for peak current mode control.
This control method eliminates any output transient
when switching between modes. In Burst Mode opera-
tion, energy is delivered to the output until it reaches the
nominal regulation value, then the LTC3100 transitions to
sleep mode where the outputs are off and the LTC3100
consumes only 15μA of quiescent current from $V_{BST}$. Once
the output voltage has dropped slightly, switching resumes
again. This maximizes efficiency at very light loads by
minimizing switching and quiescent losses. Burst Mode
operation output ripple is typically 1% peak-to-peak.

Burst Mode operation for the boost converter is inhibited
during start-up, and until soft-start is complete and $V_{BST}$
is at least 0.24V greater than $V_{INBSt}$.

**Short-Circuit Protection**

The LTC3100 output disconnect feature allows output
short-circuit while maintaining a maximum internally set
current limit. To reduce power dissipation under short-
circuit conditions, the boost peak switch current limit is
reduced to 400mA (typical).

**Schottky Diode**

Although it is not required, adding a Schottky diode from
SWBST to $V_{BST}$ will improve efficiency by about 2%. Note
that this defeats the boost output disconnect and short-
circuit protection features.
**Dropout Operation**

As the input voltage decreases to a value approaching the output regulation voltage, the duty cycle increases toward the maximum on-time. Further reduction of the supply voltage will force the main switch to remain on for more than one cycle until 100% duty cycle operation is reached where the main switch remains on continuously. In this dropout state, the output voltage will be determined by the input voltage less the resistive voltage drop across the main switch and series resistance of the inductor.

**Slope Compensation**

Current mode control requires the use of slope compensation to prevent subharmonic oscillations in the inductor current waveform at high duty cycle operation. This is accomplished internally on the LTC3100 through the addition of a compensating ramp to the current sense signal. In some current mode ICs, current limiting is performed by clamping the error amplifier voltage to a fixed maximum. This leads to a reduced output current capability at low step-down ratios. In contrast, the LTC3100 performs current limiting prior to addition of the slope compensation ramp and therefore achieves a peak inductor current limit that is independent of duty cycle.

**Short-Circuit Protection**

When the buck output is shorted to ground, the error amplifier will saturate high and the P-channel MOSFET switch will turn on at the start of each cycle and remain on until the current limit trips. During this minimum on-time, the inductor current will increase rapidly and will decrease very slowly during the remainder of the period due to the very small reverse voltage produced by a hard output short. To eliminate the possibility of inductor current runaway in this situation, the buck converter switching frequency is reduced to approximately 375kHz when the voltage on FBBK falls below 0.3V.

**Soft-Start**

The buck converter has an internal voltage mode soft-start circuit with a nominal duration of 1.3ms. The converter remains in regulation during soft-start and will therefore respond to output load transients which occur during this time. In addition, the output voltage rise time has minimal dependency on the size of the output capacitor or load current.

**Error Amplifier and Compensation**

The LTC3100 buck converter utilizes an internal transconductance error amplifier. Compensation of the feedback loop is performed internally to reduce the size of the application circuit and simplify the design process. The compensation network has been designed to allow use of a wide range of output capacitors while simultaneously ensuring rapid response to load transients.

**Undervoltage Lockout**

If the $V_{\text{INBK}}$ supply voltage decreases below 1.6V (typical), the buck converter will be disabled. The soft-start for the buck converter will be reset during undervoltage lockout to provide a smooth restart once the input voltage rises above the undervoltage lockout threshold.

**PGOOD Comparator**

The PGBK pin is an open-drain output which indicates the status of the buck converter output voltage. If the buck output voltage falls 8% below the regulation voltage, the PGBK open-drain output will pull low. The output voltage must rise 3% above the falling threshold before the pull-down will turn off. In addition, there is a 60μs typical de-glitching delay in order to prevent false trips due to voltage transients on load steps. The PGBK output will also pull low during overtemperature shutdown and undervoltage lockout to indicate these fault conditions, or if the buck converter is disabled. The typical PGBK pull-down switch resistance is 13Ω when $V_{\text{INBK}} = 3.3V$.

**Schottky Diode**

Although it is not required, adding a Schottky diode from SWBK to the ground plane will improve efficiency by about 2%.
LDO REGULATOR OPERATION

The LDO regulator utilizes an internal 1.3Ω (typical) P-channel MOSFET pass device to supply up to 100mA of load current with a typical dropout voltage of 130mV. The input voltage to the LDO is internally connected to the boost output (V_{BST} pin), and can share the same filter capacitor. The LDO can be operated independently of the boost (or buck) converter, providing a sufficient voltage is present on V_{BST}.

Soft-Start and Current Limit

The LDO has an independent current limit circuit that limits output current to 120mA (typical). To minimize loading on the boost converter output when enabling the LDO, the LDO current limit is soft-started over a 500μs period. Therefore the rise time of the LDO output voltage will depend on the amount of capacitance on the V_{LDO} pin.

Reverse Current Blocking

The LDO is designed to prevent any reverse current from V_{LDO} back to the V_{BST} pin, both in normal operation and in shutdown. If V_{LDO} is pulled above V_{BST} and V_{BST} is above 1V, there will be a small (1μA typical) current from V_{LDO} to ground.

COMMON FUNCTIONS

Oscillator

The 1.5MHz oscillator is shared by the boost and buck converters. It will be oscillating if either converter is enabled. If both converters are enabled, the boost N-channel MOSFET switch will be turned on coincident with the buck P-channel MOSFET switch.

MODE Control

The MODE pin is used to force fixed frequency operation (MODE < 0.3V) or to enable Burst Mode operation (MODE > 0.9V) for both the boost and buck converters. With Burst Mode operation enabled, the two converters will automatically enter or leave Burst Mode operation independently, based on their respective load conditions. There is an internal 1MΩ pull-up on MODE, in the event that the pin is left open.

Overtemperature Shutdown

If the die temperature exceeds 150°C (typical) both converters and the LDO regulator will be disabled. All power devices will be turned off and all switch nodes will be high impedance. The soft-start circuits for both converters and the LDO are reset during overtemperature shutdown to provide a smooth recovery once the overtemperature condition is eliminated. Both converters and the LDO will restart (if enabled) when the die temperature drops to approximately 130°C.
PC Board Layout Guidelines

The LTC3100 switches large currents at high frequencies. Special care should be given to the PC board layout to ensure stable, noise-free operation. You will not get advertised performance with a careless layout. Figure 1 depicts the recommended PC board layout. A large ground pin copper area will help to lower the chip temperature. A multilayer board with a separate ground plane is ideal, but not absolutely necessary.

A few key guidelines follow:

1. All circulating high current paths should be kept as short as possible. Capacitor ground connections should via down to the ground plane in the shortest route possible. The bypass capacitors on all \( V_{\text{IN}} \) and \( V_{\text{OUT}} \) pins should be placed as close to the IC as possible and should have the shortest possible paths to ground.

2. To prevent large circulating currents from disrupting the output voltage sensing, the ground for each resistor divider should be returned directly to the ground plane near the IC.

3. Use of vias in the die attach pad of the IC will enhance the thermal environment of the converter, especially if the vias extend to a ground plane region on the exposed bottom surface of the PC board.

4. Keep the connection from the resistor dividers to the feedback pins as short as possible and away from the switch pin connections.

Figure 1. Recommended Component Placement for Two-Layer PC Board
APPLICATIONS INFORMATION

COMPONENT SELECTION

Boost Output Voltage Programming

The boost output voltage is set by a resistive divider according to the following formula:

\[ V_{\text{OUT}} = 1.200V \times \left( 1 + \frac{R_2}{R_1} \right) \]

The external divider is connected to the output as shown in the Block Diagram. A feedforward capacitor may be placed in parallel with resistor R2 to improve the noise immunity of the feedback node, improve transient response and reduce output ripple in Burst Mode operation. A value of 33pF will generally suffice.

Boost Inductor Selection

The LTC3100 boost converter can utilize small surface mount and chip inductors due to the fast 1.5MHz switching frequency. Inductor values between 2.2μH and 4.7μH are suitable for most applications. Larger values of inductance will allow slightly greater output current capability by reducing the inductor ripple current. Increasing the inductance above 10μH will increase size while providing little improvement in output current capability.

The minimum boost inductance value is given by:

\[ L > \frac{V_{\text{IN(MIN)}} \times (V_{\text{OUT(MAX)}} - V_{\text{IN(MIN)}})}{1.5 \times \text{RIPPLE} \times V_{\text{OUT(MAX)}}} \]

Where:

RIPPLE = Allowable Inductor Current Ripple (Amps Peak-to-Peak)

V_{\text{IN(MIN)}} = Minimum Input Voltage

V_{\text{OUT(MAX)}} = Maximum Output Voltage

The inductor current ripple is typically set for 20% to 40% of the maximum inductor current. High frequency ferrite core inductor materials reduce frequency dependent power losses compared to cheaper powdered iron types, improving efficiency. The inductor should have low DCR (series resistance of the winding) to reduce the \(I^2R\) power losses, and must not saturate at peak inductor current levels. Molded chokes and some chip inductors usually do not have enough core area to support the peak inductor currents of 800mA seen on the LTC3100. To minimize radiated noise, use a shielded inductor. See Table 1 for suggested components and suppliers.

Table 1. Recommended Boost Inductors

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>PART/STYLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coilcraft</td>
<td>LPS4012, LPS4018</td>
</tr>
<tr>
<td></td>
<td>MSS4020, MSS5131</td>
</tr>
<tr>
<td>Coiltronics</td>
<td>SD14, SD3814, SD3118</td>
</tr>
<tr>
<td>FDK</td>
<td>MIPS2520, MIPS3226</td>
</tr>
<tr>
<td>Murata</td>
<td>LQH43C</td>
</tr>
<tr>
<td>Sumida</td>
<td>CDRH2D18, CDRH2D16</td>
</tr>
<tr>
<td></td>
<td>CDRH3D14, CDRH3D16</td>
</tr>
<tr>
<td></td>
<td>CDRH4D14, CDRH4D16</td>
</tr>
<tr>
<td>Taiyo-Yuden</td>
<td>NR3015, NP03SB</td>
</tr>
<tr>
<td>TDK</td>
<td>VLP, VLF, VLCF</td>
</tr>
<tr>
<td>Toko</td>
<td>DS18LC, DS2LC, DP418C</td>
</tr>
<tr>
<td>Würth</td>
<td>WE-TPC Type S, M</td>
</tr>
</tbody>
</table>

Boost Input and Output Capacitor Selection

The internal loop compensation of the LTC3100 boost converter is designed to be stable with output capacitor values of 4.7μF or greater. Low ESR (equivalent series resistance) capacitors should be used to minimize the output voltage ripple. Multilayer ceramic capacitors are an excellent choice as they have extremely low ESR and are available in small footprints. A 4.7μF to 10μF output capacitor is sufficient for most fixed frequency applications. For applications where Burst Mode operation is enabled, a minimum value of 20μF is recommended. Larger values may be used to obtain very low output ripple and to improve transient response. X5R and X7R dielectric materials are preferred for their ability to maintain capacitance over wide voltage and temperature ranges. Y5V types should not be used. Case sizes smaller than 0805 are not recommended due to their increased DC bias effect.
APPLICATIONS INFORMATION

Low ESR input capacitors reduce input switching noise and reduce the peak current drawn from the battery. It follows that ceramic capacitors are also a good choice for input decoupling and should be located as close as possible to the device. A 2.2μF input capacitor on the VINBST pin is sufficient for most applications. Larger values may be used without limitations. For applications where the power source is more than a few inches away, a larger bulk decoupling capacitor is recommended on the input to the boost converter.

Table 2 shows a list of several ceramic capacitor manufacturers. Consult the manufacturers directly for detailed information on their selection of capacitors.

Note that even X5R and X7R type ceramic capacitors have a DC bias effect which reduces their capacitance with a DC voltage applied. This effect is particularly bad for capacitors in the smallest case sizes. Consult the manufacturer’s data for the capacitor you select to be assured of having the necessary capacitance in your application.

Table 2. Capacitor Vendor Information

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>PHONE</th>
<th>WEB SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVX</td>
<td>(803) 448-9411</td>
<td><a href="http://www.avxcorp.com">www.avxcorp.com</a></td>
</tr>
<tr>
<td>Murata</td>
<td>(714) 852-2001</td>
<td><a href="http://www.murata.com">www.murata.com</a></td>
</tr>
<tr>
<td>Taiyo-Yuden</td>
<td>(408) 573-4150</td>
<td><a href="http://www.t-yuden.com">www.t-yuden.com</a></td>
</tr>
<tr>
<td>TDK</td>
<td>(847) 803-6100</td>
<td><a href="http://www.component.tdk.com">www.component.tdk.com</a></td>
</tr>
</tbody>
</table>

Buck Inductor Selection

The choice of buck inductor value influences both the efficiency and the magnitude of the output voltage ripple. Larger inductance values will reduce inductor current ripple and will therefore lead to lower output voltage ripple. For a fixed DC resistance, a larger value inductor will yield higher efficiency by lowering the peak current to be closer to the average. However, a larger value inductor within the same family will generally have a greater series resistance, thereby offsetting this efficiency advantage. Given a desired peak to peak current ripple, ΔIL, the required inductance can be calculated via the following expression, where f represents the switching frequency in MHz:

\[
L = \frac{1}{f \Delta I_L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \mu H
\]

A reasonable choice for ripple current is ΔIL = 100mA which represents 40% of the maximum 250mA load current. The DC current rating of the inductor should be at least 450mA to avoid saturation under overload or short-circuit conditions. To optimize efficiency the inductor should have a low series resistance. In particularly space restricted applications it may be advantageous to use a much smaller value inductor at the expense of larger ripple current. In such cases, the converter will operate in discontinuous conduction for a wider range of output loads and efficiency will be reduced.

In addition, there is a minimum inductor value required to maintain stability of the current loop (given the fixed internal slope compensation). Specifically, if the buck converter is going to be utilized at duty cycles over 40%, the inductance value must be at least L_MIN as given by the following equation:

\[
L_{MIN} = 2.5 \cdot V_{OUT} \mu H
\]

Table 3 depicts the minimum required inductance for several common output voltages.

Table 3. Buck Minimum Inductance

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE</th>
<th>MINIMUM INDUCTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6V</td>
<td>1.5μH</td>
</tr>
<tr>
<td>0.8V</td>
<td>2μH</td>
</tr>
<tr>
<td>1.2V</td>
<td>3μH</td>
</tr>
<tr>
<td>2V</td>
<td>5μH</td>
</tr>
<tr>
<td>2.7V</td>
<td>6.8μH</td>
</tr>
<tr>
<td>3.3V</td>
<td>8.3μH</td>
</tr>
</tbody>
</table>

Larger values of inductor will also provide slightly greater output current capability before reaching current limit (by reducing the peak-to-peak ripple current).
Table 4. Recommended Buck Inductors

<table>
<thead>
<tr>
<th>VENDOR</th>
<th>PART/STYLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>coilcraft</td>
<td>LPS3008, LPS3010, LPS3015</td>
</tr>
<tr>
<td>Coiltronics</td>
<td>SD3114, SD3118, SD3112</td>
</tr>
<tr>
<td>FDK</td>
<td>MIPF2016, MIPF2520, MIPS2520</td>
</tr>
<tr>
<td>Murata</td>
<td>LOH32C, LQM31P</td>
</tr>
<tr>
<td>Sumida</td>
<td>CDRH2D11, CDRH2D09</td>
</tr>
<tr>
<td></td>
<td>CMD4D06-4R7MC, CMD4D06-3R3MC</td>
</tr>
<tr>
<td>Taiyo-Yuden</td>
<td>NR3010, NR3012</td>
</tr>
<tr>
<td>TDK</td>
<td>VLF3010, VLF3012</td>
</tr>
<tr>
<td></td>
<td>LECM3225, LBC2518</td>
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<tr>
<td>Toko</td>
<td>D3010, DB3015, D312, D301F</td>
</tr>
<tr>
<td>Würth</td>
<td>WE-TPC Type XS, S</td>
</tr>
</tbody>
</table>

Table 5. Buck Output Capacitor Range

<table>
<thead>
<tr>
<th>VOUT (V)</th>
<th>C_MIN (μF)</th>
<th>C_MAX (μF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>15</td>
<td>300</td>
</tr>
<tr>
<td>0.8</td>
<td>15</td>
<td>230</td>
</tr>
<tr>
<td>1.2</td>
<td>10</td>
<td>150</td>
</tr>
<tr>
<td>1.8</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>2.7</td>
<td>6.8</td>
<td>70</td>
</tr>
<tr>
<td>3.3</td>
<td>6.8</td>
<td>50</td>
</tr>
</tbody>
</table>

Buck Output Capacitor Selection

A low ESR output capacitor should be utilized at the buck output in order to minimize voltage ripple. Multilayer ceramic capacitors are an excellent choice as they have low ESR and are available in small footprints. In addition to controlling the output ripple magnitude, the value of the output capacitor also sets the loop crossover frequency and therefore can impact loop stability. There is both a minimum and maximum capacitance value required to ensure stability of the loop. If the output capacitance is too small, the loop crossover frequency will increase to the point where switching delay and the high frequency parasitic poles of the error amplifier will degrade the phase margin. At the other extreme, if the output capacitor is too large, the crossover frequency can decrease too far below the compensation zero and also lead to degraded phase margin. Table 5 provides a guideline for the range of allowable values of low ESR output capacitors. Larger value output capacitors can be accommodated provided they have sufficient ESR to stabilize the loop or by increasing the value of the feedforward capacitor in parallel with the upper resistor divider resistor.

Note that even X5R and X7R type ceramic capacitors have a DC bias effect which reduces their capacitance with a DC voltage applied. This effect is particularly bad for capacitors in the smallest case sizes. Consult the manufacturer’s data for the capacitor you select to be assured of having the necessary capacitance in your application.

Buck Input Capacitor Selection

The V_INBK pin provides current to the buck converter power switch and is also the supply pin for the buck’s internal control circuitry. It is recommended that a low ESR ceramic capacitor with a value of at least 4.7μF be used to bypass this pin. The capacitor should be placed as close to the pin as possible and have a short return to ground. For applications where the power source is more than a few inches away, a larger bulk decoupling capacitor is recommended.

Buck Output Voltage Programming

The output voltage is set by a resistive divider according to the following formula:

$$V_{OUT} = 0.600V \cdot \left(1 + \frac{R6}{R5}\right)$$

The external divider is connected to the output as shown in the Block Diagram. It is recommended that a feedforward capacitor be placed in parallel with resistor R6 to improve the noise immunity of the feedback node and reduce output ripple in Burst Mode operation. A value of 10pF will generally suffice.
APPLICATIONS INFORMATION

LDO Output Capacitor Selection
The LDO is designed to be stable with a minimum 1μF output capacitor. No series resistor is required when using low ESR capacitors. For most applications, a 2.2μF ceramic capacitor is recommended. Larger values will improve transient response, and raise the power supply rejection ratio (PSRR) of the LDO. Refer to the Typical Performance Characteristics for the allowable range of output capacitor to ensure loop stability.

LDO Output Voltage Programming
The output voltage is set by a resistive divider according to the following formula:

\[ V_{OUT} = 0.600V \cdot \left(1 + \frac{R4}{R3}\right) \]

The external divider is connected to the output as shown in the Block Diagram. For improved transient response, a feedforward capacitor may be placed in parallel with resistor R4.

TYPICAL APPLICATIONS

Single-Cell Boost and Buck with Voltage Sequencing

Output Voltages During Soft-Start for Sequenced Converter
**LTC3100**

**TYPICAL APPLICATIONS**

Li-Ion Input, Triple Output Converter

- **VIN**: 2.5V to 5V Li-Ion
- **LTC3100**
- **FBST**: 3.3μH
- **R1**: 1.07M
- **C1**: 10μF
- **R2**: 324k
- **C2**: 4.7μF
- **R3**: 301k
- **C3**: 10μF
- **R4**: 20k
- **C4**: 4.7μF
- **USB INPUT**: 0.9V to 3.3V
- **VIN**: 3.6V
- **3.3V**: 100mA for VBATT = 1.2V, 300mA for VBATT = 2.4V, 250mA for USB INPUT

Efficiency vs Load Current

- **VIN** = 3.6V

Single-Cell/Two-Cell or USB Input to 3.3V/1.8V Converter

- **USB INPUT**: 0.9V to 3.3V
- **MBR0520**: 5V USB
- **VIN**: 1.2V
- **3.3V**: 100mA for VBATT = 1.2V, 300mA for VBATT = 2.4V, 250mA for USB INPUT

Efficiency vs Load Current

- **VIN** = 1.2V

- **VIN** = 5V USB
PACKAGE DESCRIPTION

UD Package
16-Lead Plastic QFN (3mm x 3mm)
(Reference LTC DWG # 05-08-1691)

NOTE:
1. DRAWING CONFORMS TO JEDEC PACKAGE OUTLINE MO-220 VARIATION (WEED-2)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE
# RELATED PARTS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTC3442</td>
<td>1.2A (I_{OUT}), 2MHz Synchronous Buck-Boost DC/DC Converter</td>
<td>( V_{IN} : 2.4V ) to 5.5V, ( V_{OUT} (\text{RANGE}) ) : 2.4V to 5.25V, ( I_{Q} = 35\mu A, I_{SD} &lt; 1\mu A, ) DFN Package</td>
</tr>
<tr>
<td>LTC3455</td>
<td>Dual DC/DC Converter with USB Power Manager and Li-Ion Battery Charger</td>
<td>96% Efficiency, Seamless Transition Between Inputs, ( I_{Q} = 110\mu A, I_{SD} &lt; 2\mu A, ) QFN Package</td>
</tr>
<tr>
<td>LTC3456</td>
<td>2-Cell Multi-Output DC/DC Converter with USB Power Manager</td>
<td>92% Efficiency, Seamless Transition Between Inputs, ( I_{Q} = 180\mu A, I_{SD} &lt; 1\mu A, ) QFN Package</td>
</tr>
<tr>
<td>LTC3520</td>
<td>Synchronous 1A Buck-Boost and 600mA Step-Down DC/DC Converter</td>
<td>( V_{IN} : 2.2V ) to 5.5V, ( V_{OUT} (\text{MIN}) ) = 0.6V, ( I_{Q} = 55\mu A, I_{SD} &lt; 1\mu A, ) 4mm ( \times ) 4mm QFN Package</td>
</tr>
<tr>
<td>LTC3522</td>
<td>Synchronous 400mA Buck-Boost and 200mA Step-Down DC/DC Converter</td>
<td>( V_{IN} : 2.4V ) to 5.5V, ( V_{OUT} (\text{MIN}) ) = 0.6V, ( I_{Q} = 25\mu A, I_{SD} &lt; 1\mu A, ) 3mm ( \times ) 3mm QFN-16 Package</td>
</tr>
<tr>
<td>LTC3527/LTC3527-1</td>
<td>Dual (400mA/800mA) Synchronous Boost Converter</td>
<td>( V_{IN} : 0.5V ) to 5V, ( V_{OUT} : 1.5V ) to 5.25V, ( I_{Q} = 12\mu A, I_{SD} &lt; 2\mu A, ) 3mm ( \times ) 3mm QFN Package</td>
</tr>
<tr>
<td>LTC3530</td>
<td>600mA (I_{OUT}), 2MHz Synchronous Buck-Boost DC/DC Converter</td>
<td>( V_{IN} : 1.8V ) to 5.5V, ( V_{OUT} (\text{RANGE}) ) : 1.8V to 5.5V, ( I_{Q} = 40\mu A, I_{SD} &lt; 1\mu A, ) DFN and MSOP Packages</td>
</tr>
<tr>
<td>LTC3532</td>
<td>500mA (I_{OUT}), 2MHz Synchronous Buck-Boost DC/DC Converter</td>
<td>( V_{IN} : 2.4V ) to 5.5V, ( V_{OUT} (\text{RANGE}) ) : 2.4V to 5.25V, ( I_{Q} = 35\mu A, I_{SD} &lt; 1\mu A, ) DFN and MSOP Packages</td>
</tr>
<tr>
<td>LTC3537</td>
<td>600mA (I_{SW}), 2.2MHz Synchronous Boost Converter with 100mA LDO</td>
<td>( V_{IN} : 0.68V ) to 5V, ( V_{OUT} (\text{MAX}) ) = 5.5V, ( I_{Q} = 30\mu A, I_{SD} &lt; 1\mu A, ) 3mm ( \times ) 3mm QFN Package</td>
</tr>
<tr>
<td>LTC3538</td>
<td>600mA (I_{OUT}), 2MHz Synchronous Buck-Boost DC/DC Converter</td>
<td>( V_{IN} : 2.4V ) to 5.5V, ( V_{OUT} (\text{RANGE}) ) : 1.5V to 5.5V, ( I_{Q} = 35\mu A, I_{SD} &lt; 1\mu A, ) DFN Package</td>
</tr>
<tr>
<td>LTC3544/LTC3544B</td>
<td>300mA, 200mA ( \times 2 ), 100mA, 2.25MHz Quad Output Synchronous Step-Down DC/DC Converter</td>
<td>( V_{IN} : 2.25V ) to 5.5V, ( V_{OUT} (\text{MIN}) ) = 0.8V, ( I_{Q} = 70\mu A, I_{SD} &lt; 1\mu A, ) QFN Package</td>
</tr>
<tr>
<td>LTC3545</td>
<td>Triple Output, 2mA ( \times 800mA ), 2.25MHz Synchronous Step-Down DC/DC Converter</td>
<td>( V_{IN} : 2.25V ) to 5.5V, ( V_{OUT} (\text{MIN}) ) = 0.6V, ( I_{Q} = 58\mu A, I_{SD} &lt; 1\mu A, ) QFN Package</td>
</tr>
</tbody>
</table>