

LTC3260
Low Noise Dual Supply
Inverting Charge Pump

FEATURES

- \(V_{\text{IN}}\) Range: 4.5V to 32V
- Inverting Charge Pump Generates \(-V_{\text{IN}}\)
- Charge Pump Output Current Up to 100mA
- Low Noise Negative LDO Post Regulator \((I_{\text{LDO}^{-}} = 50\text{mA Max})\)
- Low Noise Independent Positive LDO Regulator \((I_{\text{LDO}^{+}} = 50\text{mA Max})\)
- 100\(\mu\)A Quiescent Current in Burst Mode\(^\circ\) Operation with Both LDO Regulators On
- 50kHz to 500kHz Programmable Oscillator Frequency
- Stable with Ceramic Capacitors
- Short-Circuit/Thermal Protection
- Low Profile 3mm \(\times\) 4mm 14-Pin DFN and Thermally Enhanced 16-Pin MSOP Packages

APPLICATIONS

- Low Noise Bipolar/Inverting Supplies
- Industrial/Instrumentation Low Noise Bias Generators
- Portable Medical Equipment
- Portable Instruments

DESCRIPTION

The LTC\(^\circ\)3260 is a low noise dual polarity output power supply that includes an inverting charge pump with both positive and negative LDO regulators. The charge pump operates over a wide 4.5V to 32V input range and can deliver up to 100mA of output current. Each LDO regulator can provide up to 50mA of output current. The negative LDO post regulator is powered from the charge pump output. The LDO output voltages can be adjusted using external resistor divider.

The charge pump employs either low quiescent current Burst Mode operation or low noise constant frequency mode. In Burst Mode operation the charge pump \(V_{\text{OUT}}\) regulates to \(-0.94 \times V_{\text{IN}}\), and the LTC3260 draws only 100\(\mu\)A of quiescent current with both LDO regulators on. In constant frequency mode the charge pump produces an output equal to \(-V_{\text{IN}}\) and operates at a fixed 500kHz or to a programmed value between 50kHz to 500kHz using an external resistor. The LTC3260 is available in low profile (0.75mm) 3mm \(\times\) 4mm 14-pin DFN and thermally enhanced 16-pin MSOP packages.

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TYPICAL APPLICATION

±12V Outputs from a Single 15V Input

LDO Rejection of \(V_{\text{OUT}}\) Ripple

\(V_{\text{IN}} = 15V\)
\(V_{\text{LDO}^{+}} = 12V\)
\(V_{\text{LDO}^{-}} = -12V\)
\(f_{\text{OSC}} = 500kHz\)
\(I_{\text{LDO}^{+}} = 50\text{mA}\)
\(I_{\text{LDO}^{-}} = -50\text{mA}\)
LTC3260

**ABSOLUTE MAXIMUM RATINGS** (Notes 1, 3)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Maximum Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN, EN+</td>
<td>–0.3V to 36V</td>
</tr>
<tr>
<td>LDO+</td>
<td>–16V to 36V</td>
</tr>
<tr>
<td>VOUT, LDO−</td>
<td>–36V to 0.3V</td>
</tr>
<tr>
<td>RT, ADJ+</td>
<td>–0.3V to 6V</td>
</tr>
<tr>
<td>BYP+</td>
<td>–0.3V to 2.5V</td>
</tr>
<tr>
<td>ADJ−</td>
<td>–6V to 0.3V</td>
</tr>
<tr>
<td>BYP−</td>
<td>–2.5V to 0.3V</td>
</tr>
</tbody>
</table>

**VOUT, LDO+**, **LDO−** Short-Circuit Duration ........... Indefinite

**Operating Junction Temperature Range**

(Note 2) ........................................... –55°C to 150°C

**Storage Temperature Range** ............................. –65°C to 150°C

**Lead Temperature (Soldering, 10 sec)**

MSE Only ........................................ 300°C

**PIN CONFIGURATION**

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**ORDER INFORMATION**

<table>
<thead>
<tr>
<th>Lead Free Finish</th>
<th>Tape and Reel</th>
<th>Part Marking*</th>
<th>Package Description</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTC3260EDE#PBF</td>
<td>LTC3260EDE#TRPBF</td>
<td>3260</td>
<td>14-Lead (4mm × 3mm) Plastic DFN</td>
<td>–40°C to 125°C</td>
</tr>
<tr>
<td>LTC3260IDE#PBF</td>
<td>LTC3260IDE#TRPBF</td>
<td>3260</td>
<td>14-Lead (4mm × 3mm) Plastic DFN</td>
<td>–40°C to 125°C</td>
</tr>
<tr>
<td>LTC3260EMSE#PBF</td>
<td>LTC3260EMSE#TRPBF</td>
<td>3260</td>
<td>16-Lead Plastic MSOP</td>
<td>–40°C to 125°C</td>
</tr>
<tr>
<td>LTC3260IMSE#PBF</td>
<td>LTC3260IMSE#TRPBF</td>
<td>3260</td>
<td>16-Lead Plastic MSOP</td>
<td>–40°C to 125°C</td>
</tr>
<tr>
<td>LTC3260HMSE#PBF</td>
<td>LTC3260HMSE#TRPBF</td>
<td>3260</td>
<td>16-Lead Plastic MSOP</td>
<td>–40°C to 150°C</td>
</tr>
<tr>
<td>LTC3260MPMSE#PBF</td>
<td>LTC3260MPMSE#TRPBF</td>
<td>3260</td>
<td>16-Lead Plastic MSOP</td>
<td>–55°C to 150°C</td>
</tr>
</tbody>
</table>

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container. Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: [http://www.linear.com/leadfree/](http://www.linear.com/leadfree/)

For more information on tape and reel specifications, go to: [http://www.linear.com/tapeandreel/](http://www.linear.com/tapeandreel/)
## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at $T_A = 25^\circ C$ (Note 2). $V_{IN} = EN^+ = EN^- = 12V$, $MODE = 0V$, $RT = 200k\Omega$.

### SYMBOL PARAMETER CONDITIONS MIN TYP MAX UNITS

#### Charge Pump

<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>$V_{IN}$</td>
<td>Input Voltage Range</td>
<td>●</td>
<td>4.5</td>
<td>32</td>
<td>V</td>
</tr>
<tr>
<td>$V_{UVLO}$</td>
<td>$V_{IN}$ Undervoltage Lockout Threshold $V_{IN}$ Rising $V_{IN}$ Falling</td>
<td>●</td>
<td>3.8</td>
<td>4</td>
<td>V</td>
</tr>
<tr>
<td>$I_{VIN}$</td>
<td>$V_{IN}$ Quiescent Current</td>
<td>●</td>
<td>3.4</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{RT}$</td>
<td>RT Regulation Voltage</td>
<td></td>
<td>1.200</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>$V_{OUT}$ Regulation Voltage</td>
<td>MODE = 12V MODE = 0V</td>
<td>$V_{IN} - 0.94 \cdot V_{IN}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{OSC}$</td>
<td>Oscillator Frequency</td>
<td>RT = GND</td>
<td>450</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>$R_{OUT}$</td>
<td>Charge Pump Output Impedance</td>
<td>MODE = 0V, RT = GND</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{SHORT_CKT}$</td>
<td>Max $I_{OUT}$ Short-Circuit Current $V_{OUT} = GND$</td>
<td>●</td>
<td>100</td>
<td>160</td>
<td>250</td>
</tr>
<tr>
<td>$V_{MODE(H)}$</td>
<td>MODE Threshold Rising</td>
<td></td>
<td>1.1</td>
<td>2.0</td>
<td>V</td>
</tr>
<tr>
<td>$V_{MODE(L)}$</td>
<td>MODE Threshold Falling</td>
<td></td>
<td>0.4</td>
<td>1.0</td>
<td>V</td>
</tr>
<tr>
<td>$I_{MODE}$</td>
<td>MODE Pin Internal Pull-Down Current $V_{IN} = MODE = 32V$</td>
<td>●</td>
<td>0.4</td>
<td>0.7</td>
<td>μA</td>
</tr>
</tbody>
</table>

#### 50mA Positive 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>$V_{ADJ^+}$</td>
<td>ADJ$^+$ Reference Voltage</td>
<td>●</td>
<td>1.2</td>
<td>32</td>
<td>V</td>
</tr>
<tr>
<td>$I_{ADJ^+}$</td>
<td>ADJ$^+$ Input Current</td>
<td>$V_{ADJ^+} = 1.2V$</td>
<td>–50</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>$I_{LDO^+(SC)}$</td>
<td>LDO$^+$ Short-Circuit Current</td>
<td>●</td>
<td>50</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>Line Regulation</td>
<td></td>
<td>0.04</td>
<td>mV/V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td></td>
<td>0.03</td>
<td>mV/mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{DROPOUT^+}$</td>
<td>LDO$^+$ Dropout Voltage</td>
<td>$I_{LDO^+} = 50mA$</td>
<td>400</td>
<td>800</td>
<td>mV</td>
</tr>
<tr>
<td>Output Voltage Noise</td>
<td>$C_{BYP^+} = 10\text{nF}$</td>
<td>100</td>
<td>$\mu V_{RMS}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{EN^+(H)}$</td>
<td>EN$^+$ Threshold Rising</td>
<td>●</td>
<td>1.1</td>
<td>2.0</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EN^+(L)}$</td>
<td>EN$^+$ Threshold Falling</td>
<td>●</td>
<td>0.4</td>
<td>1.0</td>
<td>V</td>
</tr>
<tr>
<td>$I_{EN^+}$</td>
<td>EN$^+$ Pin Internal Pull-Down Current $V_{IN} = EN^+ = 32V$</td>
<td>●</td>
<td>0.7</td>
<td></td>
<td>μA</td>
</tr>
</tbody>
</table>

#### 50mA Negative 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>$V_{ADJ^-}$</td>
<td>ADJ$^-$ Reference Voltage</td>
<td>●</td>
<td>–1.2</td>
<td>–2.24</td>
<td>V</td>
</tr>
<tr>
<td>$I_{ADJ^-}$</td>
<td>ADJ$^-$ Input Current</td>
<td>$V_{ADJ^-} = –1.2V$</td>
<td>–50</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>$I_{LDO^-(SC)}$</td>
<td>LDO$^-$ Short-Circuit Current</td>
<td>●</td>
<td>50</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>Line Regulation</td>
<td></td>
<td>0.002</td>
<td>mV/V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td></td>
<td>0.02</td>
<td>mV/mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{DROPOUT^-}$</td>
<td>LDO$^-$ Dropout Voltage</td>
<td>$I_{LDO^-} = 50mA$</td>
<td>200</td>
<td>500</td>
<td>mV</td>
</tr>
<tr>
<td>Output Voltage Noise</td>
<td>$C_{BYP^-} = 10\text{nF}$</td>
<td>100</td>
<td>$\mu V_{RMS}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{EN^-(H)}$</td>
<td>EN$^-$ Threshold Rising</td>
<td>●</td>
<td>1.1</td>
<td>2.0</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EN^-(L)}$</td>
<td>EN$^-$ Threshold Falling</td>
<td>●</td>
<td>0.4</td>
<td>1.0</td>
<td>V</td>
</tr>
<tr>
<td>$I_{EN^-}$</td>
<td>EN$^-$ Pin Internal Pull-Down Current $V_{IN} = EN^- = 32V$</td>
<td>●</td>
<td>1.4</td>
<td></td>
<td>μA</td>
</tr>
</tbody>
</table>
TYPICAL PERFORMANCE CHARACTERISTICS

\( (T_A = 25^\circ \text{C}, \ C_{FLY} = 1 \mu\text{F}, \ C_{IN} = C_{OUT} = C_{LDO^+} = C_{LDO^-} = 10 \mu\text{F} \text{ unless otherwise noted}) \)

**Oscillator Frequency vs Supply Voltage**

**Oscillator Frequency vs \( R_T \)**

**Shutdown Current vs Temperature**

**Quiescent Current vs Temperature**

**Quiescent Current vs Supply Voltage (Constant Frequency Mode)**

**Quiescent Current vs Temperature (Constant Frequency Mode)**
TYPICAL PERFORMANCE CHARACTERISTICS

\((T_A = 25^\circ C, C_{FLY} = 1\mu F, C_{IN} = C_{OUT} = C_{LDO^+} = C_{LDO^-} = 10\mu F\) unless otherwise noted)

- Effective Open-Loop Resistance vs Temperature
- VOUT Short-Circuit Current vs Supply Voltage
- Voltage Loss (\(V_{IN} - |V_{OUT}|\)) vs Output Current (Constant Frequency Mode)
- ADJ+ Pin Voltage vs Temperature
- LDO+ Dropout Voltage vs Temperature
- LDO+ Supply Rejection
- LDO+ GND Pin Current vs ILOAD
- LDO+ Load Regulation
TYPICAL PERFORMANCE CHARACTERISTICS

(T_A = 25°C, C_{FLY} = 1µF, C_{IN} = C_{OUT} = C_{LDO^+} = C_{LDO^-} = 10µF unless otherwise noted)

ADJ^- Pin Voltage vs Temperature

LDO^- Dropout Voltage vs Temperature

LDO^- Power Supply Rejection

LDO^- Load Regulation

LDO^- Rejection of V_{OUT} Ripple

LDO^+ Load Transient

V_{OUT} Transient (Burst Mode Operation, MODE = H)

V_{OUT} Transient (MODE = Low to High)
PIN FUNCTIONS  (DFN/MSOP)

**EN+ (Pin 1/Pin 1):** Logic Input. A logic “high” on the EN+ pin enables the positive low dropout (LDO+) regulator.

**RT (Pin 2/Pin 2):** Input Connection for Programming the Switching Frequency. The RT pin servo to a fixed 1.2V when the EN+ pin is driven to a logic “high”. A resistor from RT to GND sets the charge pump switching frequency. If the RT pin is tied to GND, the switching frequency defaults to a fixed 500kHz.

**BYP− (Pin 3/Pin 3):** LDO− Reference Bypass Pin. Connect a capacitor from BYP− to GND to reduce LDO− output noise. Leave floating if unused.

**ADJ− (Pin 4/Pin 4):** Feedback Input for the Negative Low Dropout Regulator. This pin servo to a fixed voltage of −1.2V when the control loop is complete.

**LDO− (Pin 5/Pin 5):** Negative Low Dropout (LDO−) Linear Regulator Output. This pin requires a low ESR (equivalent series resistance) capacitor with at least 2µF capacitance to ground for stability.

**VOUT (Pin 6/Pin 6):** Charge Pump Output Voltage. In constant frequency mode (MODE = low) this pin is driven to −VIN. In Burst Mode operation, (MODE = high) this pin voltage is regulated to −0.94 • VIN using an internal burst comparator with hysteretic control.

**C− (Pin 7/Pin 7):** Flying Capacitor Negative Connection.

**C+ (Pin 8/10):** Flying Capacitor Positive Connection.

**NC (Pins 8, 9 MSOP Only):** No Connect. These pins are not connected to the LTC3260 die. These pins should be left floating, connected to ground or shorted to adjacent pins.

**VIN (Pin 9/11):** Input Voltage for Both Charge Pump and Positive Low Dropout (LDO+) Regulator. VIN should be bypassed with a low impedance ceramic capacitor.

**LDO+ (Pin 10/12):** Positive Low Dropout (LDO+) Output. This pin requires a low ESR capacitor with at least 2µF capacitance to ground for stability.

**EN− (Pin 11/13):** Logic Input. A logic “high” on the EN− pin enables the inverting charge pump as well as the negative LDO regulator.

**MODE (Pin 12/14):** Logic Input. The MODE pin determines the charge pump operating mode. A logic “high” on the MODE pin forces the charge pump to operate in Burst Mode operation regulating VOUT to approximately −0.94 • VIN with hysteretic control. A logic “low” on the MODE pin forces the charge pump to operate as an open-loop inverter with a constant switching frequency. The switching frequency in both modes is determined by an external resistor from the RT pin to GND. In Burst Mode operation, this represents the frequency of the burst cycles before the part enters the low quiescent current sleep state.

**ADJ+ (Pin 13/15):** Feedback Input for the Positive Low Dropout (LDO+) Regulator. This pin servo to a fixed voltage of 1.2V when the control loop is complete.

**BYP+ (Pin 14/16):** LDO+ Reference Bypass Pin. Connect a capacitor from BYP+ to GND to reduce LDO+ output noise. Leave floating if unused.

**GND (Exposed Pad Pin 15/Exposed Pad Pin 17):** Ground. The exposed package pad is ground and must be soldered to the PC board ground plane for proper functionality and for rated thermal performance.
LTC3260

**BLOCK DIAGRAM**

Note: Pin numbers are as per DFN package. Refer to the Pin Functions section for corresponding MSOP pin numbers.

The LTC3260 is a high voltage low noise dual output regulator. It includes an inverting charge pump and two LDO regulators to generate bipolar low noise supply rails from a single positive input. It supports a wide input power supply range from 4.5V to 32V.

**Shutdown Mode**

In shutdown mode, all circuitry except the internal bias is turned off. The LTC3260 is in shutdown when a logic low is applied to both the enable inputs (EN+ and EN−). The LTC3260 only draws 2µA (typical) from the VIN supply in shutdown.

**Operation** (Refer to the Block Diagram)

Charge Pump Constant Frequency Operation

The LTC3260 provides low noise constant frequency operation when a logic low is applied to the MODE pin. The charge pump and oscillator circuit are enabled using the EN− pin. At the beginning of a clock cycle, switches S1 and S2 are closed. The external flying capacitor across the C+ and C− pins is charged to the VIN supply. In the second phase of the clock cycle, switches S1 and S2 are opened, while switches S3 and S4 are closed. In this configuration the C+ side of the flying capacitor is grounded and charge is delivered through the C− pin to VOUT. In steady state the VOUT pin regulates at –VIN less any voltage drop due to the load current on VOUT or LDO.
The charge transfer frequency can be adjusted between 50kHz and 500kHz using an external resistor on the RT pin. At slower frequencies the effective open-loop output resistance ($R_{OL}$) of the charge pump is larger and it is able to provide smaller average output current. Figure 1 can be used to determine a suitable value of RT to achieve a required oscillator frequency. If the RT pin is grounded, the part operates at a constant frequency of 500kHz.

![Figure 1. Oscillator Frequency vs RT](image)

Charge Pump Burst Mode Operation

The LTC3260 provides low power Burst Mode operation when a logic high is applied to the MODE pin. In Burst Mode operation, the charge pump charges the $V_{OUT}$ pin to $-0.94 \cdot V_{IN}$ (typical). The part then shuts down the internal oscillator to reduce switching losses and goes into a low current state. This state is referred to as the sleep state in which the IC consumes only about 100µA with both LDOs enabled. When the output voltage droops enough to overcome the burst comparator hysteresis, the part wakes up and commences charge pump cycles until output voltage exceeds $-0.94 \cdot V_{IN}$ (typical). This mode provides lower operating current at the cost of higher output ripple and is ideal for light load operation.

The frequency of charging cycles is set by the external resistor on the RT pin. The charge pump has a lower $R_{OL}$ at higher frequencies. For Burst Mode operation it is recommended that the RT pin be tied to GND. This minimizes the charge pump $R_{OL}$, quickly charges the output up to the burst threshold and optimizes the duration of the low current sleep state.

Charge Pump Soft-Start

The LTC3260 has built in soft-start circuitry to prevent excessive current flow during start-up. The soft-start is achieved by internal circuitry that slowly ramps the amount of current available at the output storage capacitor. The soft-start circuitry is reset in the event of a commanded shutdown or thermal shutdown.

Charge Pump Short-Circuit/Thermal Protection

The LTC3260 has built-in short-circuit current limit as well as overtemperature protection. During a short-circuit condition, the part automatically limits its output current to approximately 160mA. If the junction temperature exceeds approximately 175°C the thermal shutdown circuitry disables current delivery to the output. Once the junction temperature drops back to approximately 165°C current delivery to the output is resumed. When thermal protection is active the junction temperature is beyond the specified operating range. Thermal protection is intended for momentary overload conditions outside normal operation. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

Positive Low Dropout Linear Regulator (LDO+)

The positive low dropout regulator (LDO+) supports a load of up to 50mA. The LDO+ takes power from the $V_{IN}$ pin and drives the LDO+ output pin to a voltage programmed by the resistor divider connected between the LDO+, ADJ+ and GND pins. For stability, the LDO+ output must be bypassed to ground with a low ESR ceramic capacitor that maintains a capacitance of at least 2µF across operating temperature and voltage.

The LDO+ is enabled or disabled via the EN+ logic input pin. When the LDO+ is enabled, a soft-start circuit ramps its regulation point from zero to the final value over a period of 75µs, reducing the inrush current on $V_{IN}$. 
LTC3260

OPERATION (Refer to the Block Diagram)

Figure 2 shows the LDO+ regulator application circuit. The LDO+ output voltage \( V_{LDO^+} \) can be programmed by choosing suitable values of \( R_1 \) and \( R_2 \) such that:

\[
V_{LDO^+} = 1.2V \cdot \left( \frac{R_1}{R_2} + 1 \right)
\]

An optional capacitor of 10nF can be connected from the BYP+ pin to ground. This capacitor bypasses the internal 1.2V reference of the LTC3260 and improves the noise performance of the LDO+. If this function is not used the BYP+ pin should be left floating.

Negative Low Dropout Linear Regulator (LDO–)

The negative low dropout regulator (LDO–) supports a load of up to 50mA. The LDO– takes power from the VOUT pin (output of the inverting charge pump) and drives the LDO– output pin to a voltage programmed by the resistor divider connected between the LDO–, ADJ– and GND pins. For stability, the LDO– output must be bypassed to ground with a low ESR ceramic capacitor that maintains a capacitance of at least 2µF across operating temperature and voltage.

The LDO– is enabled or disabled via the EN– logic input pin. Initially, when the EN– logic input is low, the charge pump circuitry is disabled and the VOUT pin is at GND. When EN– is switched high, the VOUT pin will be driven negative by the charge pump circuitry. Soft-start circuitry in the charge pump also provides soft-start functionality for the LDO– and prevents excessive inrush currents.

Figure 3 shows the LDO– regulator application circuit. The LDO– output voltage \( V_{LDO^-} \) can be programmed by choosing suitable values of \( R_1 \) and \( R_2 \) such that:

\[
V_{LDO^-} = -1.2V \cdot \left( \frac{R_1}{R_2} + 1 \right)
\]

When the inverting charge pump is in Burst Mode operation (MODE = high), the typical hysteresis on the VOUT pin is 2% of VIN voltage. The LDO– voltage should be set high enough above VOUT in order to prevent LDO– from entering dropout during normal operation.

An optional capacitor of 10nF can be connected from the BYP– pin to ground. This capacitor bypasses the internal –1.2V reference of the LTC3260 and improves the noise performance of the LDO–. If this function is not used the BYP– pin should be left floating.

In order to improve transient response, an optional capacitor, \( C_{ADJ^-} \), may be used as shown in Figure 3. A recommended value for \( C_{ADJ^-} \) is 10pF. Experimentation with capacitor values between 2pF and 22pF may yield improved transient response.
Applications Information

Effective Open-Loop Output Resistance

The effective open-loop output resistance (ROL) of a charge pump is a very important parameter which determines the strength of the charge pump. The value of this parameter depends on many factors such as the oscillator frequency (fOSC), value of the flying capacitor (CFLY), the nonoverlap time, the internal switch resistances (RS) and the ESR of the external capacitors.

Typical ROL values as a function of temperature are shown in Figure 4.

\[ V_{RIPPLE(P-P)} = I_{OUT} \left( \frac{1}{f_{OSC} - t_{ON}} \right) \]

where COUT is the value of the output capacitor, fOSC is the oscillator frequency and tON is the on-time of the oscillator (1µs typical).

Just as the value of COUT controls the amount of output ripple, the value of Cin controls the amount of ripple present at the input (VIN) pin. The amount of bypass capacitance required at the input depends on the source impedance driving VIN. For best results it is recommended that VIN be bypassed with at least 2µF of low ESR capacitance. A high ESR capacitor such as tantalum or aluminum will have higher input noise than a low ESR ceramic capacitor. Therefore, a ceramic capacitor is recommended as the main bypass capacitance with a tantalum or aluminum capacitor used in parallel if desired.

Flying Capacitor Selection

The flying capacitor controls the strength of the charge pump. A 1µF or greater ceramic capacitor is suggested for the flying capacitor for applications requiring the full rated output current of the charge pump.

For very light load applications, the flying capacitor may be reduced to save space or cost. For example, a 0.2µF capacitor might be sufficient for load currents up to 20mA. A smaller flying capacitor leads to a larger effective open-loop resistance (ROL) and thus limits the maximum load current that can be delivered by the charge pump.

Ceramic Capacitors

Ceramic capacitors of different materials lose their capacitance with higher temperature and voltage at different rates. For example, a capacitor made of X5R or X7R material will retain most of its capacitance from −40°C to 85°C whereas a Z5U or Y5V style capacitor will lose considerable capacitance over that range. Z5U and Y5V capacitors may
also have a poor voltage coefficient causing them to lose 60% or more of their capacitance when the rated voltage is applied. Therefore when comparing different capacitors, it is often more appropriate to compare the amount of achievable capacitance for a given case size rather than discussing the specified capacitance value. The capacitor manufacturer’s data sheet should be consulted to ensure the desired capacitance at all temperatures and voltages. Table 1 is a list of ceramic capacitor manufacturers and their websites.

Table 1

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVX</td>
<td><a href="http://www.avxcorp.com">www.avxcorp.com</a></td>
</tr>
<tr>
<td>Kemet</td>
<td><a href="http://www.kemet.com">www.kemet.com</a></td>
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<tr>
<td>Murata</td>
<td><a href="http://www.murata.com">www.murata.com</a></td>
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<tr>
<td>Taiyo Yuden</td>
<td><a href="http://www.t-yuden.com">www.t-yuden.com</a></td>
</tr>
<tr>
<td>Vishay</td>
<td><a href="http://www.vishay.com">www.vishay.com</a></td>
</tr>
<tr>
<td>TDK</td>
<td><a href="http://www.component.tdk.com">www.component.tdk.com</a></td>
</tr>
</tbody>
</table>

**Layout Considerations**

Due to high switching frequency and high transient currents produced by LTC3260, careful board layout is necessary for optimum performance. A true ground plane and short connections to all the external capacitors will improve performance and ensure proper regulation under all conditions. Figure 5 shows an example layout for the LTC3260.

The flying capacitor nodes C⁺ and C⁻ switch large currents at a high frequency. These nodes should not be routed close to sensitive pins such as the LDO feedback pins (ADJ⁺ and ADJ⁻) and internal reference bypass pins (BYP⁺ and BYP⁻).

**Thermal Management**

At high input voltages and maximum output current, there can be substantial power dissipation in the LTC3260. If the junction temperature increases above approximately 175°C, the thermal shutdown circuitry will automatically deactivate the output. To reduce the maximum junction temperature, a good thermal connection to the PC board ground plane is recommended. Connecting the exposed pad of the package to a ground plane under the device on two layers of the PC board can reduce the thermal resistance of the package and PC board considerably.

**Derating Power at High Temperatures**

To prevent an overtemperature condition in high power applications, Figure 6 should be used to determine the maximum combination of ambient temperature and power dissipation.

The power dissipated in the LTC3260 should always fall under the line shown for a given ambient temperature. The power dissipated in the LTC3260 has three components. Power dissipated in the positive LDO:

\[ P_{LDO^+} = (V_{IN} - V_{LDO^+}) \cdot I_{LDO^+} \]

Power dissipated in the negative LDO:

\[ P_{LDO^-} = (|V_{OUT}| - |V_{LDO^-}|) \cdot I_{LDO^-} \]

Power dissipated in the inverting charge pump:

\[ P_{CP} = (V_{IN} - |V_{OUT}|) \cdot (I_{OUT} + I_{LDO^-}) \]

where \( I_{OUT} \) denotes any additional current that might be pulled directly from the \( V_{OUT} \) pin. The \( LDO^- \) current is also supplied by the charge pump through \( V_{OUT} \) and is therefore included in the charge pump power dissipation.

The total power dissipation of the LTC3260 is given by:

\[ P_D = P_{LDO^+} + P_{LDO^-} + P_{CP} \]
The derating curve in Figure 6 assumes a maximum thermal resistance, $\theta_{JA}$, of 43°C/W for the package. This can be achieved with a four layer PCB that includes 2oz Cu traces and six vias from the exposed pad of the LTC3260 to the ground plane.

It is recommended that the LTC3260 be operated in the region corresponding to $T_J \leq 150°C$ for continuous operation as shown in Figure 6. Operation beyond 150°C should be avoided as it may degrade part performance and lifetime. At high temperatures, typically around 175°C, the part is placed in thermal shutdown and all outputs are disabled. When the part cools back down to a low enough temperature, typically around 165°C, the outputs are re-enabled and the part resumes normal operation.
28V Dual Tracking Bipolar Supply with Outputs from ±5V to ±25V
**PACKAGE DESCRIPTION**


---

**DE Package**

14-Lead Plastic DFN (4mm × 3mm)

(Reference LTC DWG # 05-08-1708 Rev B)

---

**NOTES:**

1. DRAWING PROPOSED TO BE MADE VARIATION OF VERSION (WGED-3) IN JEDEC PACKAGE OUTLINE MO-229
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

---

**RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS**

APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

MSE Package
16-Lead Plastic MSOP, Exposed Die Pad
(Reference LTC DWG # 05-08-1667 Rev E)

NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS. INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX
6. EXPOSED PAD DIMENSION DOES INCLUDE MOLD FLASH. MOLD FLASH ON E-PAD SHALL NOT EXCEED 0.254mm (.010") PER SIDE.
# Revision History

<table>
<thead>
<tr>
<th>REV</th>
<th>DATE</th>
<th>DESCRIPTION</th>
<th>PAGE NUMBER</th>
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<tbody>
<tr>
<td>A</td>
<td>09/12</td>
<td>Changed Operating Junction Temperature.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add H- and MP-grade options.</td>
<td>Throughout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add Junction to heading of Electrical Characteristics table.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add H- and MP-grade into Note 2.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modified Shutdown Current vs Temperature curve for operation to 150°C.</td>
<td>4</td>
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<tr>
<td></td>
<td></td>
<td>Modified Quiescent Current vs Temperature curve for operation to 150°C.</td>
<td>4</td>
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<tr>
<td></td>
<td></td>
<td>Corrected Figure 5 Pinout R_T and C_BYP.</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removed Thermal Shutdown curve from Figure 6.</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clarified 150°C Operation in Derating Power section.</td>
<td>12, 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Related Parts list.</td>
<td>18</td>
</tr>
</tbody>
</table>
**TYPICAL APPLICATION**

Low Noise ±12V Power Supply from a Single-Ended 15V Input Supply (Frequency = 200kHz)

**RELATED PARTS**

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
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</thead>
<tbody>
<tr>
<td>LTC1144</td>
<td>Switched-Capacitor Wide Input Range Voltage Converter with Shutdown</td>
<td>Wide Input Voltage Range: 2V to 18V, ISD &lt; 8µA, SO8 Package</td>
</tr>
<tr>
<td>LTC1514/LTC1515</td>
<td>Step-Up/Step-Down Switched-Capacitor DC/DC Converters</td>
<td>V IN: 2V to 10V, V OUT: 3.3V to 5V, I Q = 60µA, SO8 Package</td>
</tr>
<tr>
<td>LT®1611</td>
<td>150mA Output, 1.4MHz Micropower Inverting Switching Regulator</td>
<td>V IN: 0.9V to 10V, V OUT = ±34V, ThinSOT™ Package</td>
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<tr>
<td>LT1614</td>
<td>250mA Output, 600kHz Micropower Inverting Switching Regulator</td>
<td>V IN: 0.9V to 6V, V OUT = ±30V, I Q = 1mA, MS8, SO8 Packages</td>
</tr>
<tr>
<td>LTC1911</td>
<td>250mA, 1.5MHz Inductorless Step-Down DC/DC Converter</td>
<td>V IN: 2.7V to 5.5V, V OUT = 1.5V/1.8V, I Q = 180µA, MS8 Package</td>
</tr>
<tr>
<td>LTC3250/LTC3250-1.2/ LTC3250-1.5</td>
<td>Inductorless Step-Down DC/DC Converters</td>
<td>V IN: 3.1V to 5.5V, V OUT = 1.2V, 1.5V, I Q = 35µA, ThinSOT Package</td>
</tr>
<tr>
<td>LTC3251</td>
<td>500mA Spread Spectrum Inductorless Step-Down DC/DC Converter</td>
<td>V IN: 2.7V to 5.5V, V OUT: 0.9V to 1.6V, 1.2V, 1.5V, I Q = 9µA, MS10E Package</td>
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<tr>
<td>LTC3252</td>
<td>Dual 250mA, Spread Spectrum Inductorless Step-Down DC/DC Converter</td>
<td>V IN: 2.7V to 5.5V, V OUT: 0.9V to 1.6V, I Q = 50µA, DFN12 Package</td>
</tr>
<tr>
<td>LT1054/LT1054L</td>
<td>Switched-Capacitor Voltage Converters with Regulator</td>
<td>V IN: 3.5V to 15V/7V, I OUT = 100mA/125mA, N8, SO8, SO16 Packages</td>
</tr>
<tr>
<td>LTC3261</td>
<td>High Voltage, Low Quiescent Current Inverting Charge Pump</td>
<td>V IN: 4.5V to 32V, V OUT = –V IN, I OUT = 100mA, MSOP-12 Package</td>
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</table>