

# 600kHz, 1A Switch PWM DC/DC Converter

## FEATURES

- **1A, 0.5Ω, 30V Internal Switch**
- Operates with  $V_{IN}$  as Low as 1.5V
- 600kHz Fixed Frequency Operation
- Low-Battery Detector Stays Active in Shutdown
- Low  $V_{CESAT}$  Switch: 410mV at 800mA
- Pin-for-Pin Compatible with the LT1317B
- Small 8-Lead MSOP and SO Packages

## APPLICATIONS

- LCD Bias Supplies
- GPS Receivers
- Battery Backup
- Portable Electronic Equipment
- Diagnostic Medical Instrumentation

## DESCRIPTION

The LT<sup>®</sup>1949 is a fixed frequency step-up DC/DC converter with a 1A, 0.5Ω internal switch. Capable of generating 10V at 175mA from a 3.3V input, the LT1949 is ideal for generating bias voltages for large screen LCD panels. Constant frequency 600kHz operation results in a low noise output that is easy to filter and the 30V switch rating allows output voltage up to 28V using a single inductor. An external compensation pin gives the user flexibility in optimizing loop compensation, allowing small low ESR ceramic capacitors to be used at the output. The 8-lead MSOP and SO packages ensure a low profile overall solution.

The LT1949 includes a low-battery detector that stays alive when the device goes into shutdown. Quiescent current in shutdown is 25μA, while operating current is 4.5mA.

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## TYPICAL APPLICATION

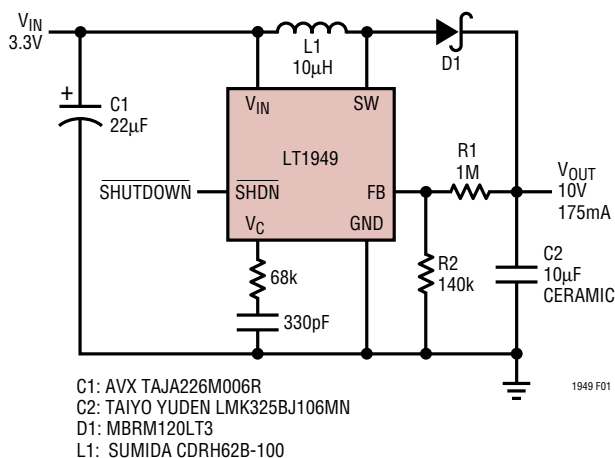


Figure 1. 3.3V to 10V/175mA DC/DC Converter

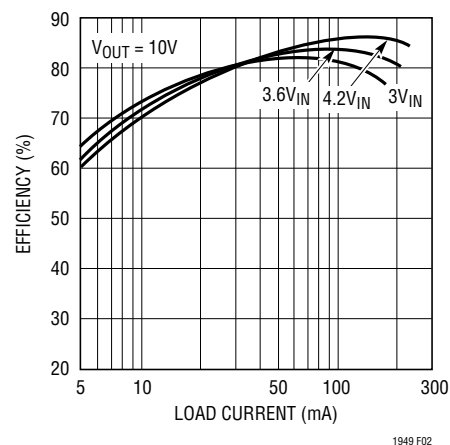
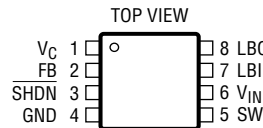
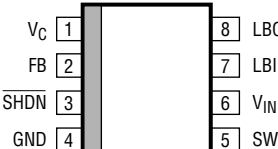


Figure 2. 3.3V to 10V Converter Efficiency

## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                              |                           |                                           |                |
|------------------------------|---------------------------|-------------------------------------------|----------------|
| $V_{IN}$ , LBO Voltage ..... | 12V                       | Junction Temperature .....                | 125°C          |
| SW Voltage .....             | -0.4V to 30V              | Operating Temperature Range (Note 2)      |                |
| FB Voltage .....             | $V_{IN} + 0.3V$           | LT1949EMS8 .....                          | -40°C to 85°C  |
| $V_C$ Voltage .....          | 2V                        | LT1949ES8/LT1949IS8 .....                 | -40°C to 85°C  |
| LBI Voltage .....            | $0V \leq V_{LBI} \leq 1V$ | Storage Temperature .....                 | -65°C to 150°C |
| SHDN Voltage .....           | 6V                        | Lead Temperature (Soldering, 10sec) ..... | 300°C          |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                  |                   |                                                                                                                                                                                                                |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|  <p>MS8 PACKAGE<br/>8-LEAD PLASTIC MSOP<br/><math>T_{JMAX} = 125^{\circ}C</math>, <math>\theta_{JA} = 120^{\circ}C/W</math></p> | ORDER PART NUMBER |  <p>S8 PACKAGE<br/>8-LEAD PLASTIC SO<br/><math>T_{JMAX} = 125^{\circ}C</math>, <math>\theta_{JA} = 120^{\circ}C/W</math></p> | ORDER PART NUMBER      |
|                                                                                                                                                                                                                  | LT1949EMS8        |                                                                                                                                                                                                                | LT1949ES8<br>LT1949IS8 |
|                                                                                                                                                                                                                  | MS8 PART MARKING  |                                                                                                                                                                                                                | S8 PART MARKING        |
|                                                                                                                                                                                                                  | LTJC              |                                                                                                                                                                                                                | 1949E<br>1949I         |

Consult factory for Military grade parts.

## ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are  $T_A = 25^{\circ}C$ .  $V_{IN} = 2V$ ,  $V_{SHDN} = 2V$  unless otherwise noted.

| SYMBOL           | PARAMETER                       | CONDITIONS                                      |        | MIN          | TYP          | MAX          | UNITS    |
|------------------|---------------------------------|-------------------------------------------------|--------|--------------|--------------|--------------|----------|
| I <sub>Q</sub>   | Quiescent Current               | V <sub>SHDN</sub> = 0V                          | ●<br>● |              | 4.5<br>25    | 7.5<br>40    | mA<br>μA |
| V <sub>FB</sub>  | Feedback Voltage                |                                                 | ●<br>● | 1.22<br>1.20 | 1.24<br>1.24 | 1.26<br>1.26 | V<br>V   |
| I <sub>B</sub>   | FB Pin Bias Current (Note 3)    |                                                 | ●      |              | 12           | 80           | nA       |
|                  | Input Voltage Range             |                                                 | ●      | 1.7          |              | 12           | V        |
| g <sub>m</sub>   | Error Amp Transconductance      | ΔI = 5μA                                        | ●      | 70           | 140          | 240          | μmhos    |
| A <sub>V</sub>   | Error Amp Voltage Gain          |                                                 |        |              | 700          |              | V/V      |
|                  | Maximum Duty Cycle              |                                                 | ●      | 80           | 85           |              | %        |
|                  | Switch Current Limit (Note 4)   | V <sub>IN</sub> = 2.5V, Duty Cycle = 30%        | ●      | 1            | 1.13         | 1.5          | A        |
|                  |                                 | V <sub>IN</sub> = 2.5V, Duty Cycle = 30%        | ●      | 0.95         |              | 1.5          | A        |
| f <sub>osc</sub> | Switching Frequency             |                                                 | ●      | 500          | 600          | 750          | kHz      |
|                  | Shutdown Pin Current            | V <sub>SHDN</sub> = V <sub>IN</sub>             | ●      |              | 0.015        | 0.1          | μA       |
|                  |                                 | V <sub>SHDN</sub> = 0V                          | ●      |              | −2.3         | −7           | μA       |
|                  | LBI Threshold Voltage           |                                                 | ●      | 190<br>180   | 200<br>200   | 210<br>220   | mV<br>mV |
|                  | LBO Output Low                  | I <sub>SINK</sub> = 10μA                        | ●      |              | 0.15         | 0.25         | V        |
|                  | LBO Leakage Current             | V <sub>LBI</sub> = 250mV, V <sub>LBO</sub> = 5V | ●      |              | 0.02         | 0.1          | μA       |
|                  | LBI Input Bias Current (Note 5) | V <sub>LBI</sub> = 150mV                        | ●      |              | 5            | 60           | nA       |
|                  | Low-Battery Detector Gain       | 1MΩ Pull-Up                                     |        |              | 2000         |              | V/V      |
|                  | Switch Leakage Current          | V <sub>SW</sub> = 5V                            | ●      |              | 0.01         | 3            | μA       |

# ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are  $T_A = 25^\circ\text{C}$ .  $V_{IN} = 2\text{V}$ ,  $V_{SHDN} = 2\text{V}$  unless otherwise noted.

| SYMBOL | PARAMETER                                   | CONDITIONS                                         | MIN | TYP  | MAX  | UNITS    |
|--------|---------------------------------------------|----------------------------------------------------|-----|------|------|----------|
|        | Switch $V_{CESAT}$                          | $I_{SW} = 800\text{mA}$<br>$I_{SW} = 500\text{mA}$ |     | 410  | 400  | mV<br>mV |
|        | Reference Line Regulation                   | $1.8\text{V} \leq V_{IN} \leq 12\text{V}$          |     | 0.08 | 0.15 | %/V      |
|        | $\overline{\text{SHDN}}$ Input Voltage High |                                                    | 1.4 |      | 6    | V        |
|        | $\overline{\text{SHDN}}$ Input Voltage Low  |                                                    |     |      | 0.4  | V        |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

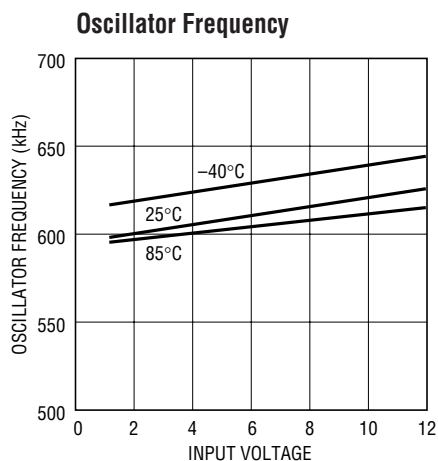
**Note 2:** The LT1949E is guaranteed to meet performance specifications from  $0^\circ\text{C}$  to  $70^\circ\text{C}$ . Specifications over the  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  operating temperature range are assured by design, characterization and correlation with statistical process controls.

**Note 3:** Bias current flows into FB pin.

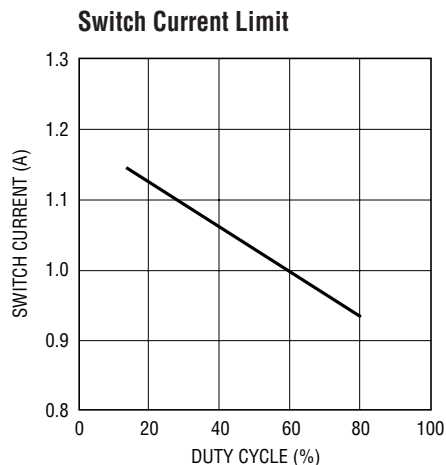
**Note 4:** Switch current limit guaranteed by design and/or correlation to static tests. Duty cycle affects current limit due to ramp generator.

**Note 5:** Bias current flows out of LBI pin.

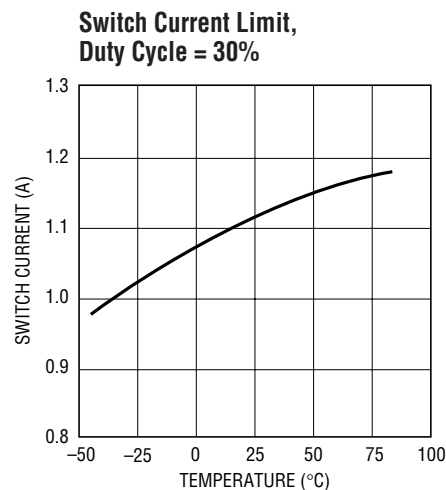
## TYPICAL PERFORMANCE CHARACTERISTICS



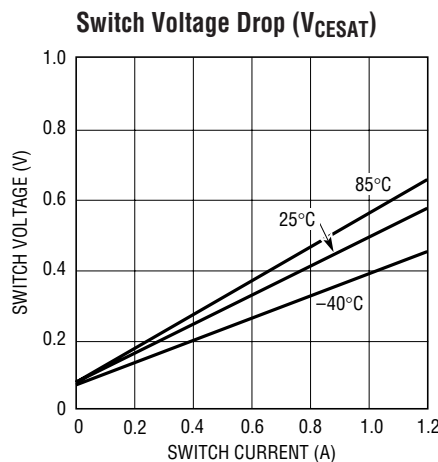
1949 G01



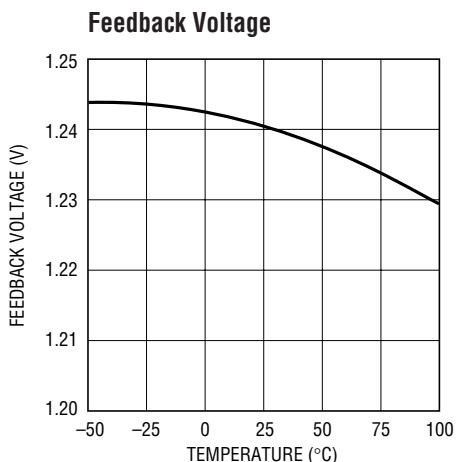
1949 G02



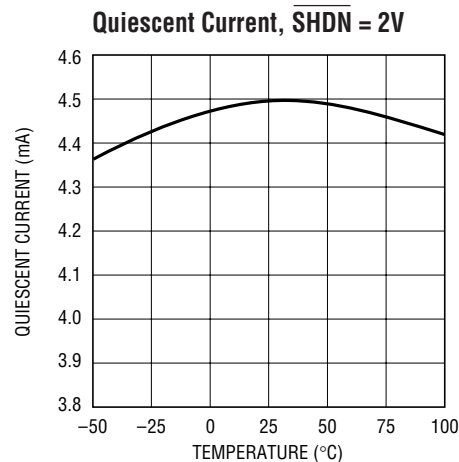
1949 G03



1949 G04

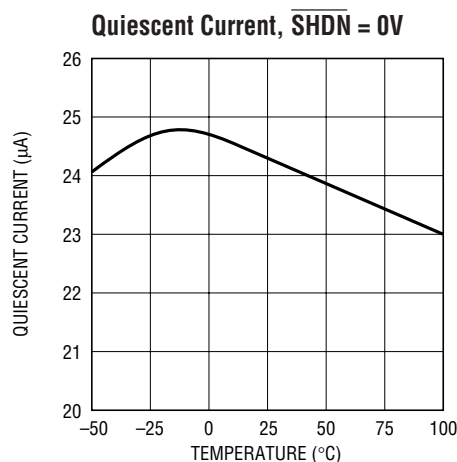


1949 G05

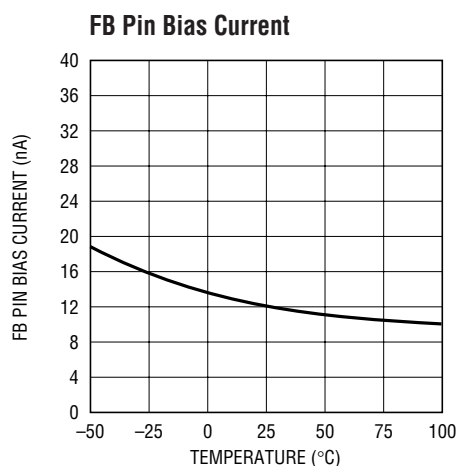


1949 G06

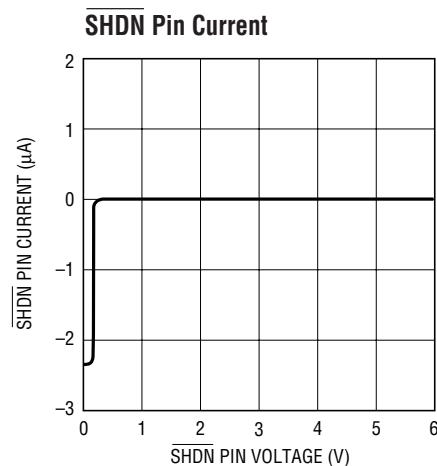
## TYPICAL PERFORMANCE CHARACTERISTICS



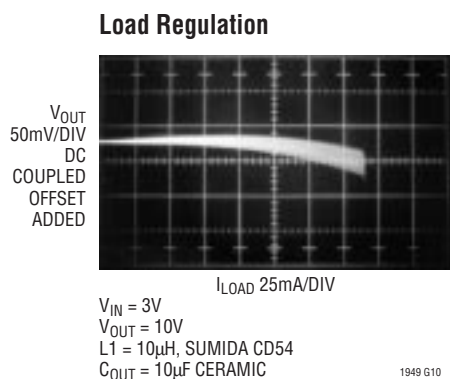
1317 TPC10



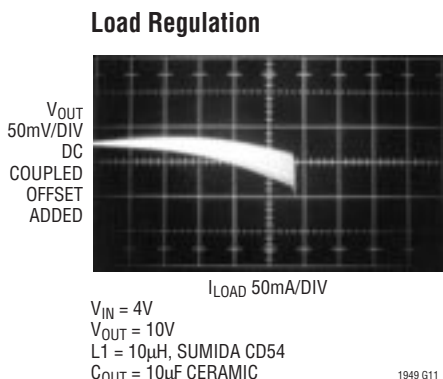
1317 TPC11



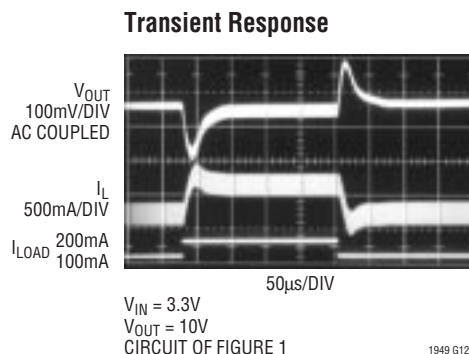
1317 TPC12



1949 G10



1949 G11



1949 G12

## PIN FUNCTIONS

**$V_C$  (Pin 1):** Compensation Pin for Error Amplifier. Connect a series RC network from this pin to ground. Typical values for compensation are a 68k/330pF combination when using ceramic output capacitors. Minimize trace area at  $V_C$ .

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

**$\overline{\text{SHDN}}$  (Pin 3):** Shutdown. Pull this pin low for shutdown mode (only the low-battery detector remains active). Leave this pin floating or tie to a voltage between 1.4V and 6V to enable the device.  $\overline{\text{SHDN}}$  pin is logic level and need only meet the logic specification (1.4V for high, 0.4V for low).

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

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

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

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

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

## BLOCK DIAGRAM

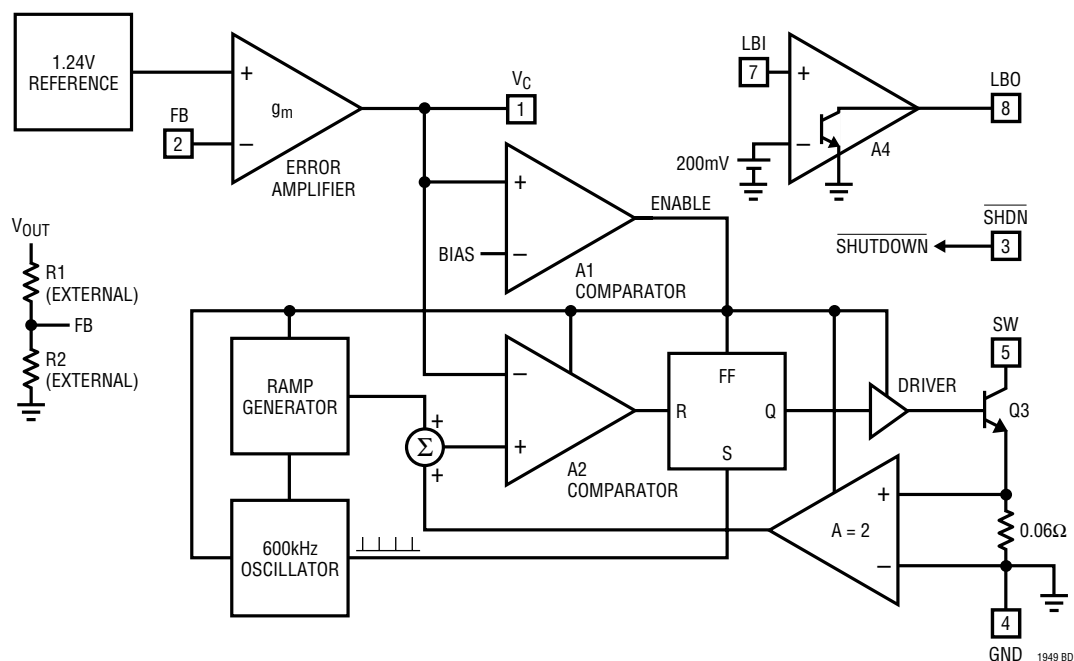


Figure 3. LT1949 Block Diagram

## OPERATION

The LT1949 is a current mode, fixed frequency step-up DC/DC converter with an internal 1A NPN power transistor. Operation can best be understood by referring to the Block Diagram.

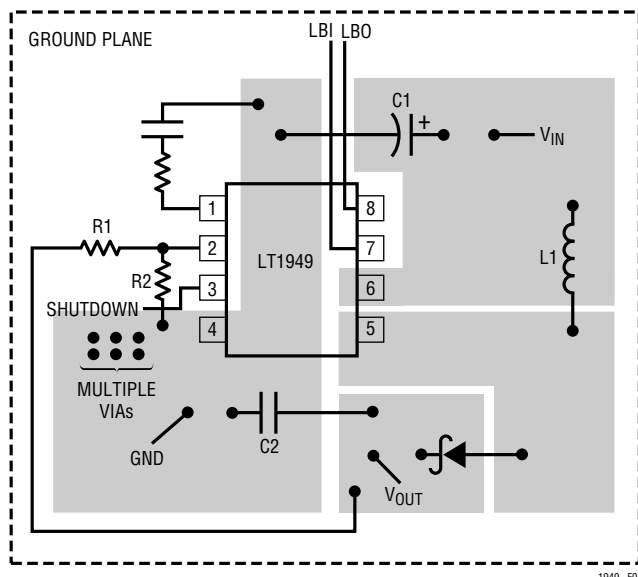
At the beginning of each oscillator cycle, the flip-flop is set and the switch is turned on. Current in the switch ramps up until the voltage at A2's positive input reaches the  $V_C$  pin voltage, causing A2's output to change state and the switch to be turned off. The signal at A2's positive input is a summation of a signal representing switch current and a ramp generator (introduced to avoid subharmonic oscillations at duty factors greater than 50%). If the load increases,  $V_{OUT}$  (and FB) will drop slightly and the error amplifier will drive  $V_C$  to a higher voltage, causing current in the switch to increase. In this way, the error amplifier drives the  $V_C$  pin to the voltage necessary to satisfy the load. Frequency compensation is provided by an external series RC network connected between the  $V_C$  pin and ground.

### Layout Hints

The LT1949 switches current at high speed, mandating careful attention to layout for proper performance. *You will not get advertised performance with careless layouts.* Figure 4 shows recommended component placement for a boost (step-up) converter. Follow this closely in your PC layout. Note the direct path of the switching loops. Input capacitor C1 *must* be placed close (<5mm) to the IC package. As little as 10mm of wire or PC trace from  $C_{IN}$  to  $V_{IN}$  will cause problems such as inability to regulate or oscillation.

The ground terminal of output capacitor C2 should tie close to Pin 4 of the LT1949. Doing this reduces  $di/dt$  in the ground copper which keeps high frequency spikes to a minimum. The DC/DC converter ground should tie to the PC board ground plane at one place only, to avoid introducing  $di/dt$  in the ground plane.

## OPERATION

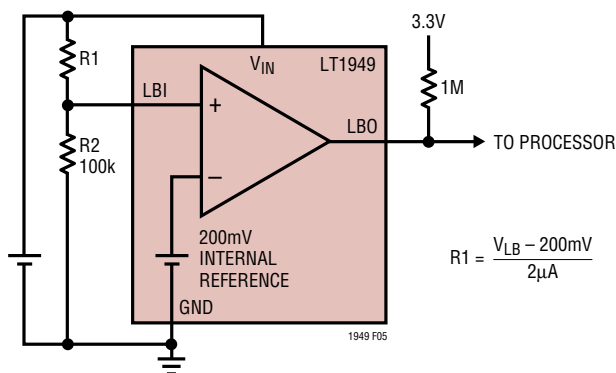


**Figure 4. Recommended Component Placement for Boost Converter. Note Direct High Current Paths Using Wide PC Traces. Minimize Trace Area at Pin 1 ( $V_C$ ) and Pin 2 (FB). Use Multiple Vias to Tie Pin 4 Copper to Ground Plane. Use Vias at One Location Only to Avoid Introducing Switching Currents into the Ground Plane**

## APPLICATIONS INFORMATION

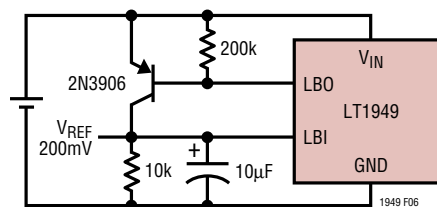
### Low-Battery Detector

The LT1949's low-battery detector is a simple PNP input gain stage with an open collector NPN output. The negative input of the gain stage is tied internally to a 200mV  $\pm 5\%$  reference. The positive input is the LBI pin. Arrangement as a low-battery detector is straightforward.



**Figure 5. Setting Low-Battery Detector Trip Point**

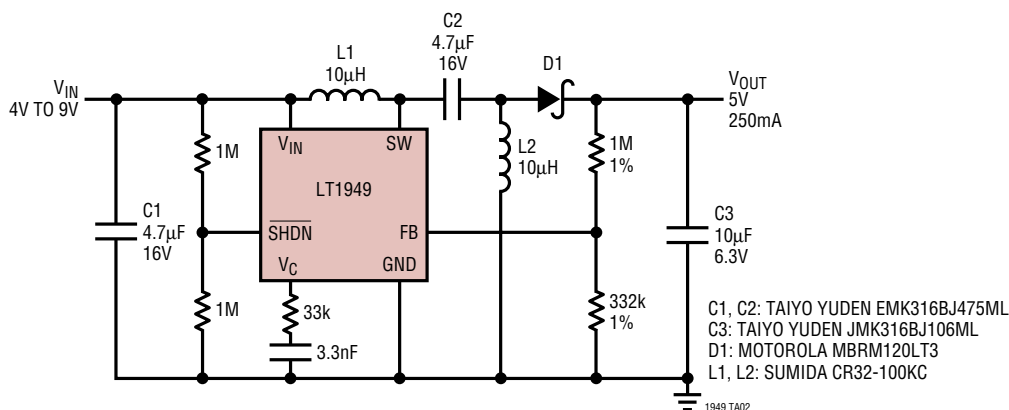
Figure 5 details hookup. R1 and R2 need only be low enough in value so that the bias current of the LBI pin doesn't cause large errors. For R2, 100k is adequate. The 200mV reference can also be accessed as shown in Figure 6. The low-battery detector remains active in shutdown.



**Figure 6. Accessing 200mV Reference**

# TYPICAL APPLICATION

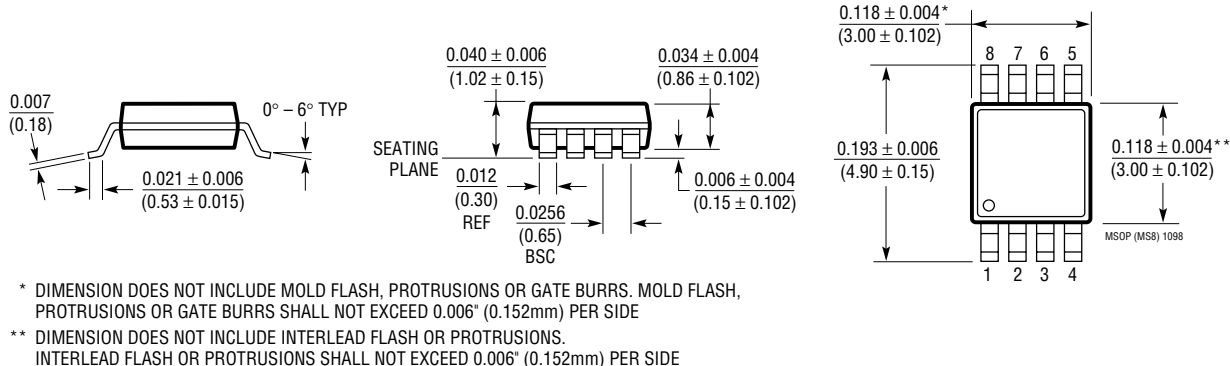
## 4 Cell to 5V SEPIC Converter



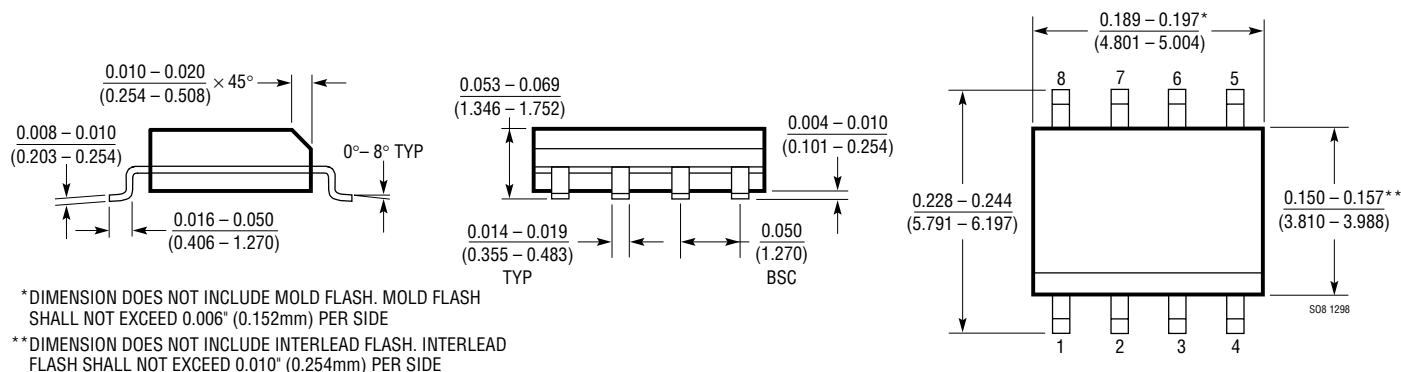
# PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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

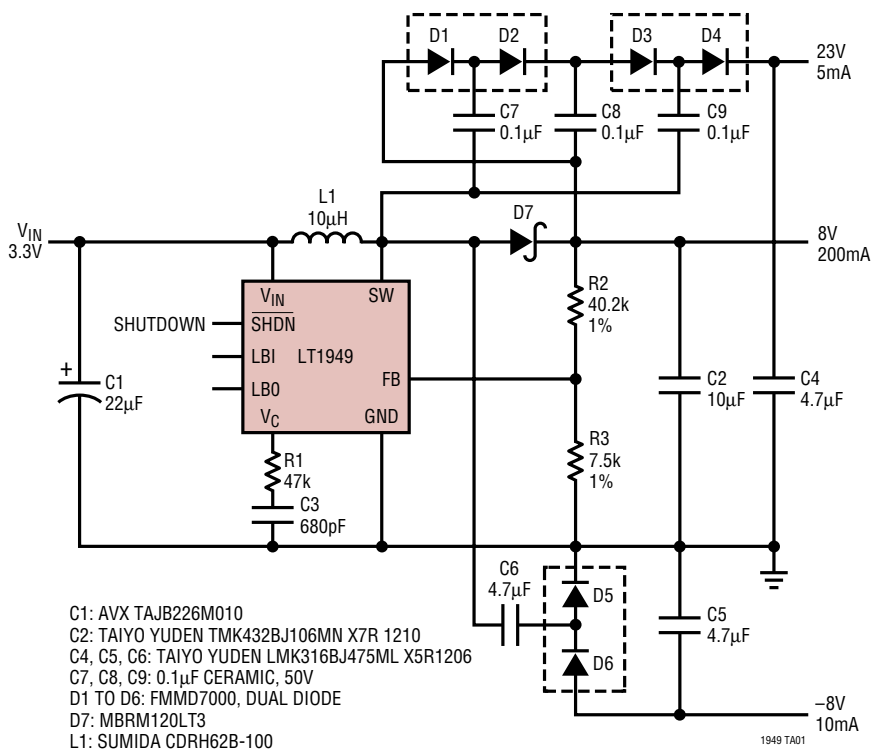


## S8 Package 8-Lead Plastic Small Outline (Narrow 0.150) (LTC DWG # 05-08-1610)



## TYPICAL APPLICATION

## Low Profile Triple Output LCD Bias Generator



## RELATED PARTS

| PART NUMBER | DESCRIPTION                                         | COMMENTS                                                              |
|-------------|-----------------------------------------------------|-----------------------------------------------------------------------|
| LT1054      | High Power Regulated Charge Pump                    | Up to 100mA Output with No Inductors                                  |
| LT1302      | High Output Current Micropower DC/DC Converter      | 5V/600mA from 2V, 2A Internal Switch, 200μA I <sub>Q</sub>            |
| LT1304      | 2-Cell Micropower DC/DC Converter                   | Low-Battery Detector Active in Shutdown                               |
| LT1307B     | Single Cell Micropower 600kHz PWM DC/DC Converter   | 3.3V at 75mA from 1 Cell, MSOP Package                                |
| LT1308B     | 2A 600kHz PWM DC/DC Converter                       | TSSOP Package                                                         |
| LT1317B     | Micropower, 600kHz PWM DC/DC Converter              | 2 Cells to 3.3V at 200mA, MSOP Package                                |
| LTC®1516    | 2-Cell to 5V Regulated Charge Pump                  | 12μA I <sub>Q</sub> , No Inductors, 5V at 50mA from 3V Input          |
| LT1613      | Single Cell 1.4MHz PWM DC/DC Converter              | 3.3V to 5V at 200mA, SOT-23 Package                                   |
| LTC1682     | Doubler Charge Pump with Low Noise Linear Regulator | 3.3V and 5V Outputs with 60μV <sub>RMS</sub> Noise, Up to 80mA Output |
| LTC1754     | Micropower 3.3V/5V Charge Pump with Shutdown        | Up to 50mA Output, I <sub>Q</sub> = 13μA, SOT-23 Package              |