

## FEATURES

- Adjustable Pushbutton On/Off Timers
- Low Supply Current: 6 $\mu$ A
- Wide Operating Voltage Range: 2.7V to 26.4V
- EN Output (LTC2950-1) Allows DC/DC Converter Control
- $\overline{\text{EN}}$  Output (LTC2950-2) Allows Circuit Breaker Control
- Simple Interface Allows Graceful  $\mu$ P Shut Down
- High Input Voltage  $\overline{\text{PB}}$  Pin with Internal Pull Up Resistor
- $\pm 10\text{kV}$  ESD HBM on  $\overline{\text{PB}}$  Input
- Accurate 0.6V Threshold on  $\overline{\text{KILL}}$  Comparator Input
- 8-Pin 3mm  $\times$  2mm DFN and ThinSOT™ Packages

## APPLICATIONS

- Portable Instrumentation Meters
- Blade Servers
- Portable Customer Service PDA
- Desktop and Notebook Computers

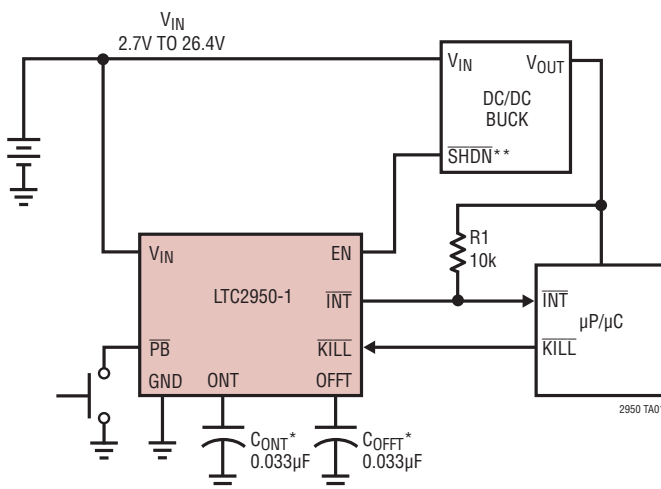
## DESCRIPTION

The LTC®2950 is a micropower, wide input voltage range, pushbutton ON/OFF controller. The part contains a pushbutton input with independently programmable ON and OFF debounce times that control the toggling of an open drain enable output. The part also contains a simple microprocessor interface to allow for proper system housekeeping prior to power down. Under system fault conditions, an internal KILL timer ensures proper power down.

The LTC2950 operates over a wide 2.7V to 26.4V input voltage range to accommodate a wide variety of input power supplies. Very low quiescent current (6 $\mu$ A typical) makes the LTC2950 ideally suited for battery powered applications. Two versions of the part are available to accommodate either positive or negative enable polarities. The parts are available in either 8-lead 3mm  $\times$  2mm DFN or ThinSOT packages.

LT, LTC, LTM, Linear Technology and the Linear logo are registered trademarks and ThinSOT and PowerPath are trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

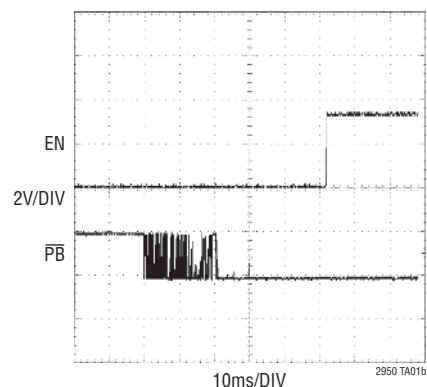
## TYPICAL APPLICATION



\*OPTIONAL

\*\*SHDN INTERNALLY PULLED UP BY DC/DC

Turn On Debounce



# LTC2950-2

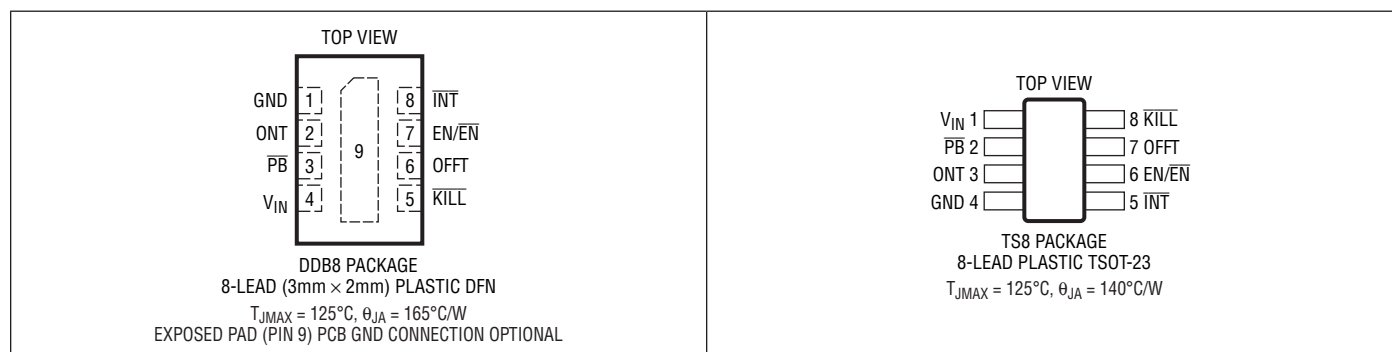
## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                             |               |
|-----------------------------|---------------|
| Supply Voltage ( $V_{IN}$ ) | –0.3V to 33V  |
| Input Voltages              |               |
| $\overline{PB}$             | –6V to 33V    |
| ONT                         | –0.3V to 2.7V |
| OFFT                        | –0.3V to 2.7V |
| $\overline{KILL}$           | –0.3V to 7V   |
| Output Voltages             |               |
| $\overline{INT}$            | –0.3V to 10V  |
| EN/ $\overline{EN}$         | –0.3V to 10V  |

|                                      |                |
|--------------------------------------|----------------|
| Operating Temperature Range          |                |
| LTC2950C-1                           | 0°C to 70°C    |
| LTC2950C-2                           | 0°C to 70°C    |
| LTC2950I-1                           | –40°C to 85°C  |
| LTC2950I-2                           | –40°C to 85°C  |
| Storage Temperature Range            |                |
| DFN Package                          | –65°C to 125°C |
| TSOT-23                              | –65°C to 150°C |
| Lead Temperature (Soldering, 10 sec) | 300°C          |

## PIN CONFIGURATION



## ORDER INFORMATION

### Lead Free Finish

| TAPE AND REEL (MINI)  | TAPE AND REEL        | PART MARKING* | PACKAGE DESCRIPTION    | TEMPERATURE RANGE |
|-----------------------|----------------------|---------------|------------------------|-------------------|
| LTC2950CDDDB-1#TRMPBF | LTC2950CDDDB-1#TRPBF | LBKP          | 8-Lead Plastic DFN     | 0°C to 70°C       |
| LTC2950CDDDB-2#TRMPBF | LTC2950CDDDB-2#TRPBF | LBNG          | 8-Lead Plastic DFN     | 0°C to 70°C       |
| LTC2950IDDB-1#TRMPBF  | LTC2950IDDB-1#TRPBF  | LBKP          | 8-Lead Plastic DFN     | –40°C to 85°C     |
| LTC2950IDDB-2#TRMPBF  | LTC2950IDDB-2#TRPBF  | LBNG          | 8-Lead Plastic DFN     | –40°C to 85°C     |
| LTC2950CTS8-1#TRMPBF  | LTC2950CTS8-1#TRPBF  | LTBKN         | 8-Lead Plastic TSOT-23 | 0°C to 70°C       |
| LTC2950CTS8-2#TRMPBF  | LTC2950CTS8-2#TRPBF  | LBNF          | 8-Lead Plastic TSOT-23 | 0°C to 70°C       |
| LTC2950ITS8-1#TRMPBF  | LTC2950ITS8-1#TRPBF  | LTBKN         | 8-Lead Plastic TSOT-23 | –40°C to 85°C     |
| LTC2950ITS8-2#TRMPBF  | LTC2950ITS8-2#TRPBF  | LBNF          | 8-Lead Plastic TSOT-23 | –40°C to 85°C     |

TRM = 500 pieces. \*Temperature grades are identified by a label on the shipping container.

Consult LTC Marketing for parts specified with wider operating temperature ranges.

Consult LTC Marketing for information on lead based finish parts.

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeandreel/>

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{IN} = 2.7\text{V}$  to  $26.4\text{V}$ , unless otherwise noted. (Note 2)

| SYMBOL          | PARAMETER                                | CONDITIONS  |   | MIN | TYP | MAX  | UNITS         |
|-----------------|--|---|---|-----|-----|------|---------------|
| $V_{IN}$        | Supply Voltage Range                     | Steady State Operation                                  | ● | 2.7 |     | 26.4 | V             |
| $I_{IN}$        | $V_{IN}$ Supply Current                  | System Power On, $V_{IN} = 2.7\text{V}$ to $24\text{V}$ | ● |     | 6   | 12   | $\mu\text{A}$ |
| $V_{UVL}$       | $V_{IN}$ Undervoltage Lockout            | $V_{IN}$ Falling  | ● | 2.2 | 2.3 | 2.4  | V             |
| $V_{UVL(HYST)}$ | $V_{IN}$ Undervoltage Lockout Hysteresis |   |   | 50  | 300 | 600  | mV            |

### Pushbutton, Enable ( $\overline{\text{PB}}$ , $\text{EN}/\overline{\text{EN}}$ )

|  |   |   |             |          |          |                       |   |
|--|---|---|-------------|----------|----------|-----------------------|---|
| $V_{\overline{\text{PB}}}(\text{MIN, MAX})$      | $\overline{\text{PB}}$ Voltage Range                    | Single-Ended  | ●           | -1       |          | 26.4                  | V   |
| $I_{\overline{\text{PB}}}$                       | $\overline{\text{PB}}$ Input Current                    | $2.5\text{V} < V_{\overline{\text{PB}}} < 26.4\text{V}$<br>$V_{\overline{\text{PB}}} = 1\text{V}$<br>$V_{\overline{\text{PB}}} = 0.6\text{V}$ | ●<br>●<br>● | -1<br>-3 | -6<br>-9 | $\pm 1$<br>-12<br>-15 | $\mu\text{A}$<br>$\mu\text{A}$<br>$\mu\text{A}$ |
| $V_{\overline{\text{PB}}}(\text{VTH})$           | $\overline{\text{PB}}$ Input Threshold                  | $\overline{\text{PB}}$ Falling  | ●           | 0.6      | 0.8      | 1                     | V   |
| $V_{\overline{\text{PB}}}(\text{VOC})$           | $\overline{\text{PB}}$ Open Circuit Voltage             | $I_{\overline{\text{PB}}} = -1\mu\text{A}$  |             | 1        | 1.6      | 2                     | V   |
| $t_{\text{EN}/\overline{\text{EN}}}$ , Lock Out  | $\text{EN}/\overline{\text{EN}}$ Lock Out Time (Note 5) | Enable Released $\rightarrow$ Enable Asserted   | ●           | 200      | 256      | 325                   | ms  |
| $I_{\text{EN}/\overline{\text{EN}}}(\text{LKG})$ | $\text{EN}/\overline{\text{EN}}$ Leakage Current        | $V_{\text{EN}/\overline{\text{EN}}} = 1\text{V}$ , Sink Current Off   | ●           |          |          | $\pm 0.1$             | $\mu\text{A}$                                   |
| $V_{\text{EN}/\overline{\text{EN}}}(\text{VOL})$ | $\text{EN}/\overline{\text{EN}}$ Voltage Output Low     | $I_{\text{EN}/\overline{\text{EN}}} = 3\text{mA}$   | ●           |          | 0.11     | 0.4                   | V   |

### Debounce Timing Pins ( $\text{ONT}$ , $\text{OFFT}$ )

|                                   |  |  |   |      |      |      |               |
|-----------------------------------|--|--|---|------|------|------|---------------|
| $I_{\text{ONT, OFFT}}(\text{PU})$ | $\text{ONT}/\text{OFFT}$ Pull Up Current   | $V_{\text{ONT, OFFT}} = 0\text{V}$   | ● | -2.4 | -3   | -3.6 | $\mu\text{A}$ |
| $I_{\text{ONT, OFFT}}(\text{PD})$ | $\text{ONT}/\text{OFFT}$ Pull Down Current | $V_{\text{ONT, OFFT}} = 1.3\text{V}$   | ● | 2.4  | 3    | 3.6  | $\mu\text{A}$ |
| $t_{\text{DB, On}}$               | Internal Turn On Debounce Time             | $\text{ONT}$ Pin Float, $\overline{\text{PB}}$ Falling $\rightarrow$ Enable Asserted       | ● | 26   | 32   | 41   | ms            |
| $t_{\text{ONT}}$                  | Additional Adjustable Turn On Time         | $C_{\text{ONT}} = 1500\text{pF}$   | ● | 9    | 11.5 | 13.5 | ms            |
| $t_{\text{DB, Off}}$              | Internal Turn Off Debounce Time            | $\text{OFFT}$ Pin Float, $\overline{\text{PB}}$ Falling $\rightarrow$ $\text{INT}$ Falling | ● | 26   | 32   | 41   | ms            |
| $t_{\text{OFFT}}$                 | Additional Adjustable Turn Off Time        | $C_{\text{OFFT}} = 1500\text{pF}$  | ● | 9    | 11.5 | 13.5 | ms            |

### $\mu\text{P}$ Handshake Pins ( $\text{INT}$ , $\text{KILL}$ )

|                                |  |   |   |      |      |           |               |
|--------------------------------|--|---|---|------|------|-----------|---------------|
| $I_{\text{INT}}(\text{LKG})$   | $\text{INT}$ Leakage Current             | $V_{\text{INT}} = 3\text{V}$  | ● |      |      | $\pm 1$   | $\mu\text{A}$ |
| $V_{\text{INT}}(\text{VOL})$   | $\text{INT}$ Output Voltage Low          | $I_{\text{INT}} = 3\text{mA}$   | ● |      | 0.11 | 0.4       | V             |
| $V_{\text{KILL}}(\text{TH})$   | $\text{KILL}$ Input Threshold Voltage    | $\text{KILL}$ Falling   | ● | 0.57 | 0.6  | 0.63      | V             |
| $V_{\text{KILL}}(\text{HYST})$ | $\text{KILL}$ Input Threshold Hysteresis |   |   | 10   | 30   | 50        | mV            |
| $I_{\text{KILL}}(\text{LKG})$  | $\text{KILL}$ Leakage Current            | $V_{\text{KILL}} = 0.6\text{V}$   |   |      |      | $\pm 0.1$ | $\mu\text{A}$ |
| $t_{\text{KILL}}(\text{PW})$   | $\text{KILL}$ Minimum Pulse Width        |   | ● | 30   |      |           | $\mu\text{s}$ |
| $t_{\text{KILL}}(\text{PD})$   | $\text{KILL}$ Propagation Delay          | $\text{KILL}$ Falling $\rightarrow$ Enable Released                               | ● |      |      | 30        | $\mu\text{s}$ |
| $t_{\text{KILL, On Blank}}$    | $\text{KILL}$ Turn On Blanking (Note 3)  | $\text{KILL} = \text{Low}$ , Enable Asserted $\rightarrow$ Enable Released        | ● | 400  | 512  | 650       | ms            |
| $t_{\text{KILL, Off Delay}}$   | $\text{KILL}$ Turn Off Delay (Note 4)    | $\text{KILL} = \text{High}$ , $\text{INT}$ Asserted $\rightarrow$ Enable Released | ● | 800  | 1024 | 1300      | ms            |

**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:** All currents into pins are positive; all voltages are referenced to GND unless otherwise noted.

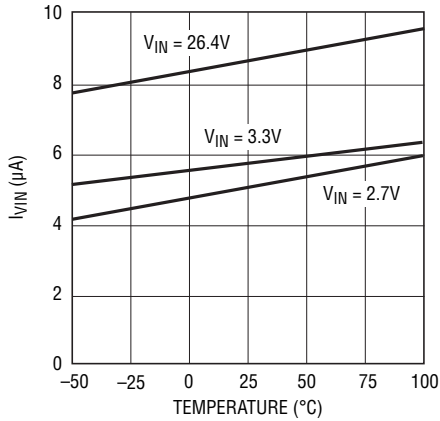
**Note 3:** The  $\text{KILL}$  turn on blanking timer period is the waiting period immediately after the enable output is asserted. This blanking time allows sufficient time for the DC/DC converter and the  $\mu\text{P}$  to perform power up tasks. The  $\text{KILL}$  and  $\overline{\text{PB}}$  inputs are ignored during this period. If  $\text{KILL}$  remains low at the end of this time period, the enable output is released, thus turning off system power. This time delay does not include  $t_{\text{DB, ON}}$  or  $t_{\text{ONT}}$ .

**Note 4:** The  $\text{KILL}$  turn off delay is the maximum delay from the initiation of a shutdown sequence ( $\text{INT}$  falling), to the release of the enable output. If the  $\text{KILL}$  input switches low at any time during this period, enable is released, thus turning off system power. This time is internally fixed at 1024ms. This time delay does not include  $t_{\text{DB, OFF}}$  or  $t_{\text{OFFT}}$ .

**Note 5:** The enable lock out time is designed to allow an application to properly power down such that the next power up sequence starts from a consistent powered down configuration.  $\overline{\text{PB}}$  is ignored during this lock out time. This time delay does not include  $t_{\text{DB, ON}}$  or  $t_{\text{ONT}}$ .

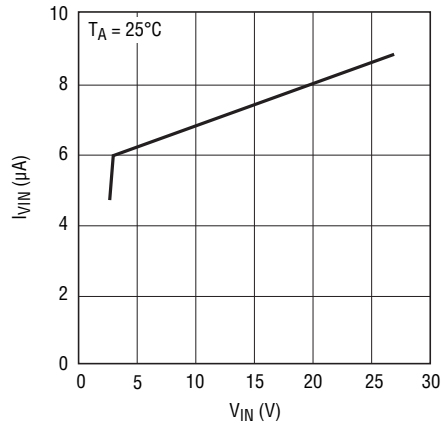
## TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Temperature

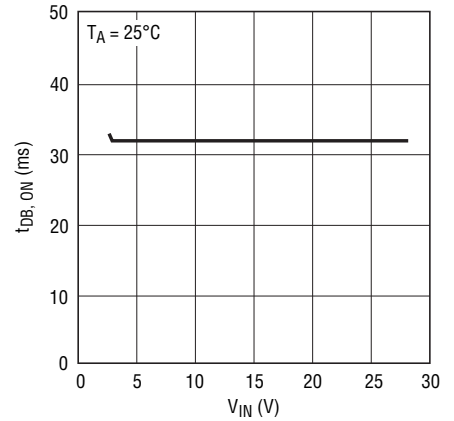


2950 G01

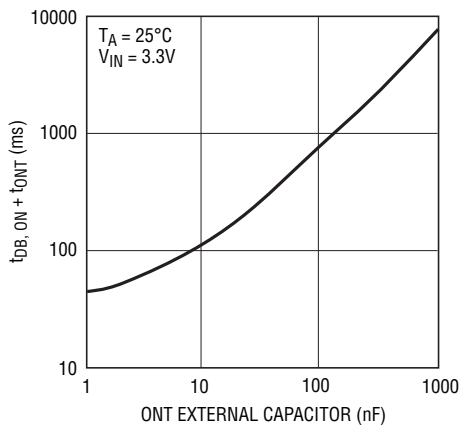
Supply Current vs Supply Voltage



2950 G02

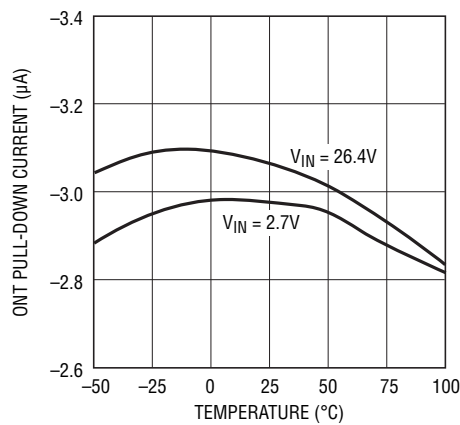
Internal Default Turn On Debounce Time ( $t_{DB, ON}$ ) vs  $V_{IN}$ 

2950 G03

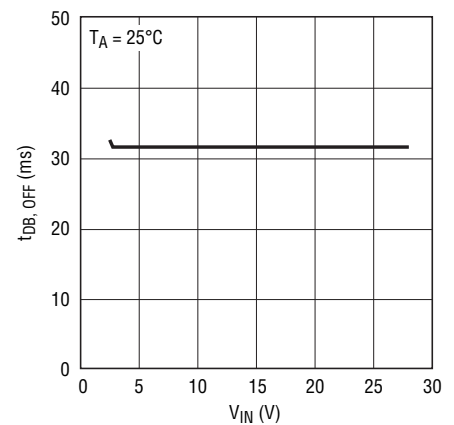
Turn On Debounce Time ( $t_{DB, ON} + t_{ONT}$ ) vs ONT External Capacitor

2950 G04

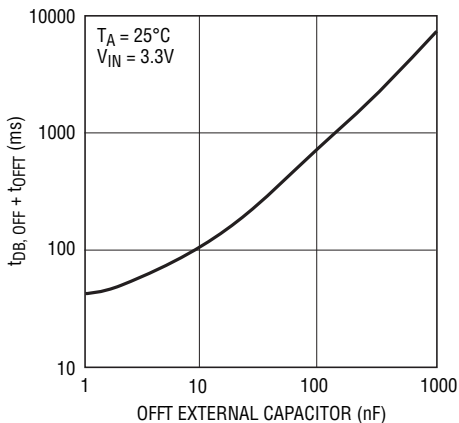
ONT Pull-Down Current vs Temperature



2950 G05

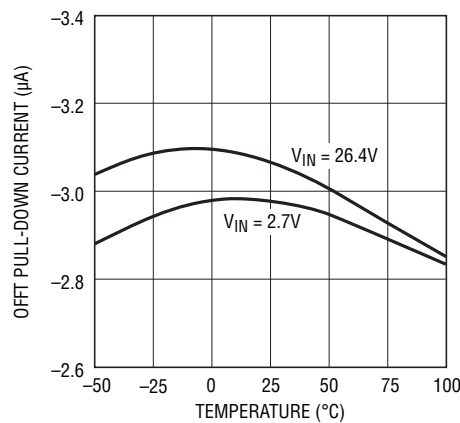
Internal Default Turn Off Debounce Time ( $t_{DB, OFF}$ ) vs  $V_{IN}$ 

2950 G06

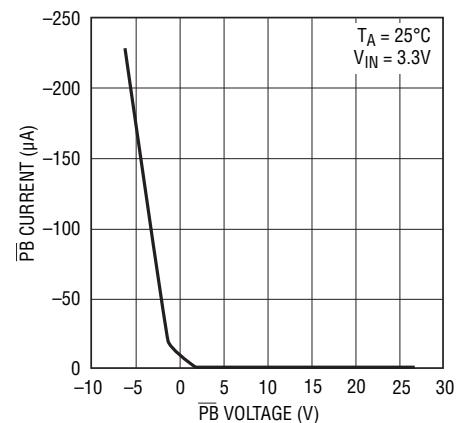
Turn Off Debounce Time ( $t_{DB, OFF} + t_{OFFT}$ ) vs OFFT External Capacitor

2950 G07

OFFT Pull-Down Current vs Temperature



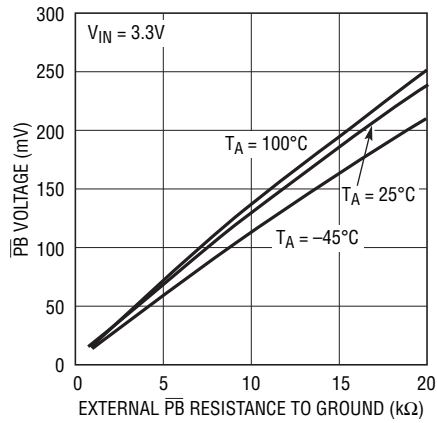
2950 G08

 $\overline{PB}$  Current vs  $\overline{PB}$  Voltage

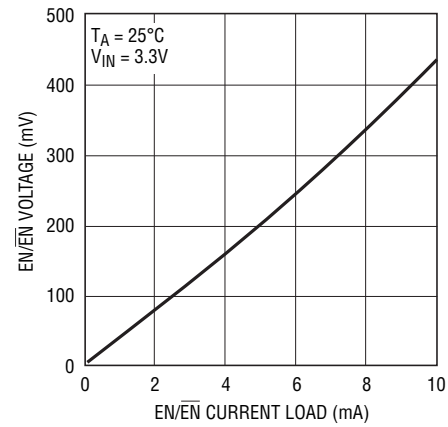
2950 G09

295012fd

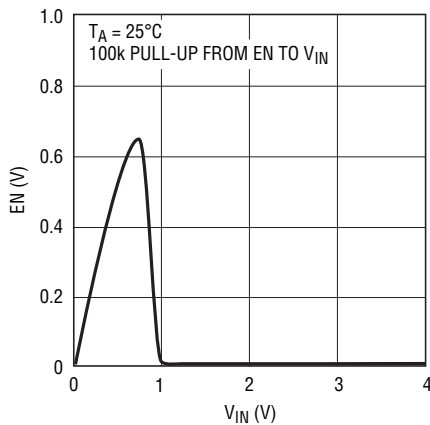
## TYPICAL PERFORMANCE CHARACTERISTICS

**PB Voltage vs External PB Resistance to Ground**

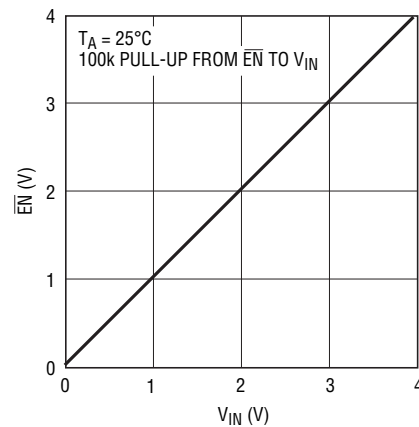
2950 G10

**EN/EN V<sub>OL</sub> vs Current Load**

2950 G11

**EN (LTC2950-1) Voltage vs  $V_{IN}$** 

2950 G12

**EN (LTC2950-2) Voltage vs  $V_{IN}$** 

2950 G13

## PIN FUNCTIONS (TSOT-23/DFN)

**V<sub>IN</sub> (Pin 1/Pin 4):** Power Supply Input: 2.7V to 26.4V.

**PB (Pin 2/Pin 3):** Pushbutton Input. Connecting  $\overline{\text{PB}}$  to ground through a momentary switch provides on/off control via the EN/ $\overline{\text{EN}}$  pin. An internal 100k pull-up resistor connects to an internal 1.9V bias voltage. The rugged  $\overline{\text{PB}}$  input can be pulled up to 26.4V externally without consuming extra current.

**ONT (Pin 3/Pin 2):** Additional Adjustable Turn On Time Input. Placing an external capacitor to ground determines the additional time (beyond the internal default 32ms) the  $\overline{\text{PB}}$  pin must be held low before the enable output is asserted. Floating this pin results in a default turn on debounce time of 32ms.

**GND (Pin 4/Pin 1):** Device Ground.

**$\overline{\text{INT}}$  (Pin 5/Pin 8):** Open Drain Interrupt Output. After a pushbutton turn-off event is detected, the LTC2950 interrupts the system ( $\mu\text{P}$ ) by bringing the  $\overline{\text{INT}}$  pin low. Once the system finishes its power down and housekeeping tasks, it sets  $\overline{\text{KILL}}$  low, which in turn releases the enable output. If at the end of the power down timer (1024ms)  $\overline{\text{KILL}}$  is still high, the enable output is released immediately.  $\overline{\text{INT}}$  may optionally be tied to  $\overline{\text{KILL}}$  to release the enable output immediately after the turn-off event has been detected ( $\overline{\text{INT}}$  = low).

**EN (LTC2950-1, Pin 6/Pin 7):** Open Drain Enable Output. This pin is intended to enable system power. EN is asserted high after a valid  $\overline{\text{PB}}$  turn on event. EN is released low if: a)  $\overline{\text{KILL}}$  is not driven high (by  $\mu\text{P}$ ) within 512ms of the initial valid  $\overline{\text{PB}}$  power turn-on event, b)  $\overline{\text{KILL}}$  is driven low during normal operation, c) a second valid  $\overline{\text{PB}}$  event (power

turn-off) is detected. This pin can connect directly to a DC/DC converter shutdown pin that provides an internal pull-up. Otherwise a pull-up resistor to an external supply is required. The operating range for this pin is 0V to 10V.

**$\overline{\text{EN}}$  (LTC2950-2, Pin 6/Pin 7):** Open Drain Enable Output. This pin is intended to enable system power.  $\overline{\text{EN}}$  is asserted low after a valid  $\overline{\text{PB}}$  turn-on event.  $\overline{\text{EN}}$  releases high if: a)  $\overline{\text{KILL}}$  is not driven high (by  $\mu\text{P}$ ) within 512ms of the initial valid  $\overline{\text{PB}}$  power turn-on event, b)  $\overline{\text{KILL}}$  is driven low during normal operation, c) a second valid  $\overline{\text{PB}}$  event (power turn-off) is detected. This pin can connect directly to a DC/DC converter shutdown pin that provides an internal pull-up. Otherwise a pull-up resistor to an external supply is required. The operating range of this pin is 0V to 10V.

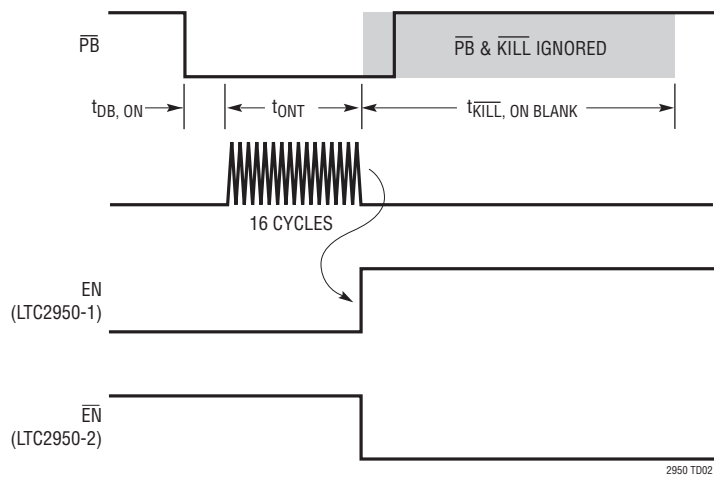
**OFFT (Pin 7/Pin 6):** Additional Adjustable Turn Off Time Input. A capacitor to ground determines the additional time (beyond the internal default 32ms) that the  $\overline{\text{PB}}$  pin must be held low before initiating a power down sequence ( $\overline{\text{INT}}$  falling). Floating this pin results in a default turn off time of 32ms.

**$\overline{\text{KILL}}$  (Pin 8/Pin 5):**  $\overline{\text{KILL}}$  Input. Forcing  $\overline{\text{KILL}}$  low releases the enable output. During system turn on, this pin is blanked by a 512ms internal timer to allow the system to pull  $\overline{\text{KILL}}$  high. This pin has an accurate 0.6V threshold and can be used as a voltage monitor input. If unused, connect to a low voltage output supply (see Figure 6).

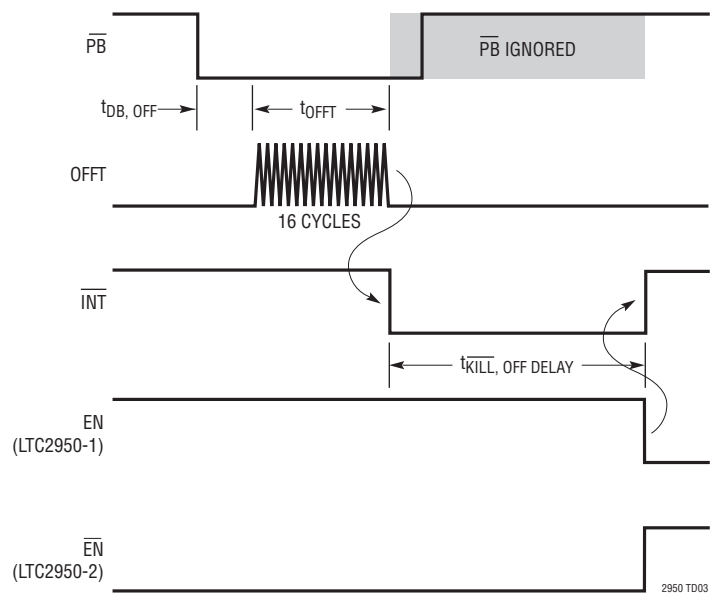
**Exposed Pad (Pin 9):** Exposed Pad may be left open or connected to device ground.



TIMING DIAGRAMS



Power On Timing



Power Off Timing,  $\overline{KILL} > 0.6V$



## APPLICATIONS INFORMATION

### Description

The LTC2950 is a low power (6μA), wide input voltage range (2.7V to 26.4V), pushbutton on/off controller that can interface to a μP and a power supply. The turn-on and turn-off debounce times are extendable using optional external capacitors. A simple interface ( $\overline{\text{INT}}$  output,  $\overline{\text{KILL}}$  input) allows a system to power on and power off in a controlled manner.

### Turn On

When power is first applied to the LTC2950, the part initializes the output pins. Any DC/DC converters connected to the EN/ $\overline{\text{EN}}$  pin will therefore be held off. To assert the enable output,  $\overline{\text{PB}}$  must be held low for a minimum of 32ms ( $t_{\text{DB, ON}}$ ). The LTC2950 provides additional turn on debounce time via an optional capacitor connected to the ONT pin ( $t_{\text{ONT}}$ ). The following equation describes the additional time that  $\overline{\text{PB}}$  must be held low before asserting the enable output.  $C_{\text{ONT}}$  is the ONT external capacitor:

$$C_{\text{ONT}} = 1.56\text{E-}4 [\mu\text{F/ms}] \cdot (t_{\text{ONT}} - 1\text{ms})$$

Once the enable output is asserted, any DC/DC converters connected to this pin are turned on. The  $\overline{\text{KILL}}$  input from the μP is ignored during a succeeding 512ms blanking time ( $t_{\text{KILL, ON BLANK}}$ ). This blanking time represents the maximum time required to power up the DC/DC converter and the μP. If  $\overline{\text{KILL}}$  is not brought high during this 512ms time window, the enable output is released. The assumption is that 512ms is sufficient time for the system to power up.

### Turn Off

To initiate a power off sequence,  $\overline{\text{PB}}$  must be held low for a minimum of 32ms ( $t_{\text{DB, OFF}}$ ). Additional turn off debounce time may be added via an optional capacitor connected to the OFFT pin ( $t_{\text{OFFT}}$ ). The following equation describes the additional time that  $\overline{\text{PB}}$  must be held low to initiate a power off sequence.  $C_{\text{OFFT}}$  is the OFFT external capacitor:

$$C_{\text{OFFT}} = 1.56\text{E-}4 [\mu\text{F/ms}] \cdot (t_{\text{OFFT}} - 1\text{ms})$$

Once  $\overline{\text{PB}}$  has been validly pressed,  $\overline{\text{INT}}$  is switched low. This alerts the μP to perform its power down and housekeeping tasks. The power down time given to the μP is 1024ms.

Note that the  $\overline{\text{KILL}}$  input can be pulled low (thereby releasing the enable output) at any time after  $t_{\text{KILL, ON BLANK}}$  period.

### Simplified Power On/Off Sequence

Figure 1 shows a simplified LTC2950-1 power on and power off sequence. A high to low transition on  $\overline{\text{PB}}$  ( $t_1$ ) initiates the power on sequence. This diagram does not show any bounce on  $\overline{\text{PB}}$ . In order to assert the enable output, the  $\overline{\text{PB}}$  pin must stay low continuously ( $\overline{\text{PB}}$  high resets timers) for a time controlled by the default 32ms and the external ONT capacitor ( $t_2 - t_1$ ). Once EN goes high ( $t_2$ ), an internal 512ms blanking timer is started. This blanking timer is designed to give sufficient time for the DC/DC converter to reach its final voltage, and to allow the μP enough time to perform power on tasks.

The  $\overline{\text{KILL}}$  pin must be pulled high within 512ms of the EN pin going high. Failure to do so results in the EN pin going low 512ms after it went high. (EN = low, see Figure 2). Note that the LTC2950 does not sample  $\overline{\text{KILL}}$  and  $\overline{\text{PB}}$  until after the 512ms internal timer has expired. The reason  $\overline{\text{PB}}$  is ignored is to ensure that the system is not forced off while powering on. Once the 512ms timer expires ( $t_4$ ), the release of the  $\overline{\text{PB}}$  pin is then debounced with an internal 32ms timer. The system has now properly powered on and the LTC2950 monitors  $\overline{\text{PB}}$  and  $\overline{\text{KILL}}$  (for a turnoff command) while consuming only 6μA of supply current.

A high to low transition on  $\overline{\text{PB}}$  ( $t_5$ ) initiates the power off sequence.  $\overline{\text{PB}}$  must stay low continuously ( $\overline{\text{PB}}$  high resets debounce timer) for a period controlled by the default 32ms and the external OFFT capacitor ( $t_6 - t_5$ ). At the completion of the OFFT timing ( $t_6$ ), an interrupt ( $\overline{\text{INT}}$ ) is set, signifying that EN will be switched low in 1024ms. Once a system has finished performing its power down operations, it can set  $\overline{\text{KILL}}$  low ( $t_7$ ) and thus immediately set EN low), terminating the internal 1024ms timer. The release of the  $\overline{\text{PB}}$  pin is then debounced with an internal 32ms timer.

The system is now in its reset state: where the LTC2950 is in low power mode (6μA).  $\overline{\text{PB}}$  is monitored for a high to low transition.

## APPLICATIONS INFORMATION

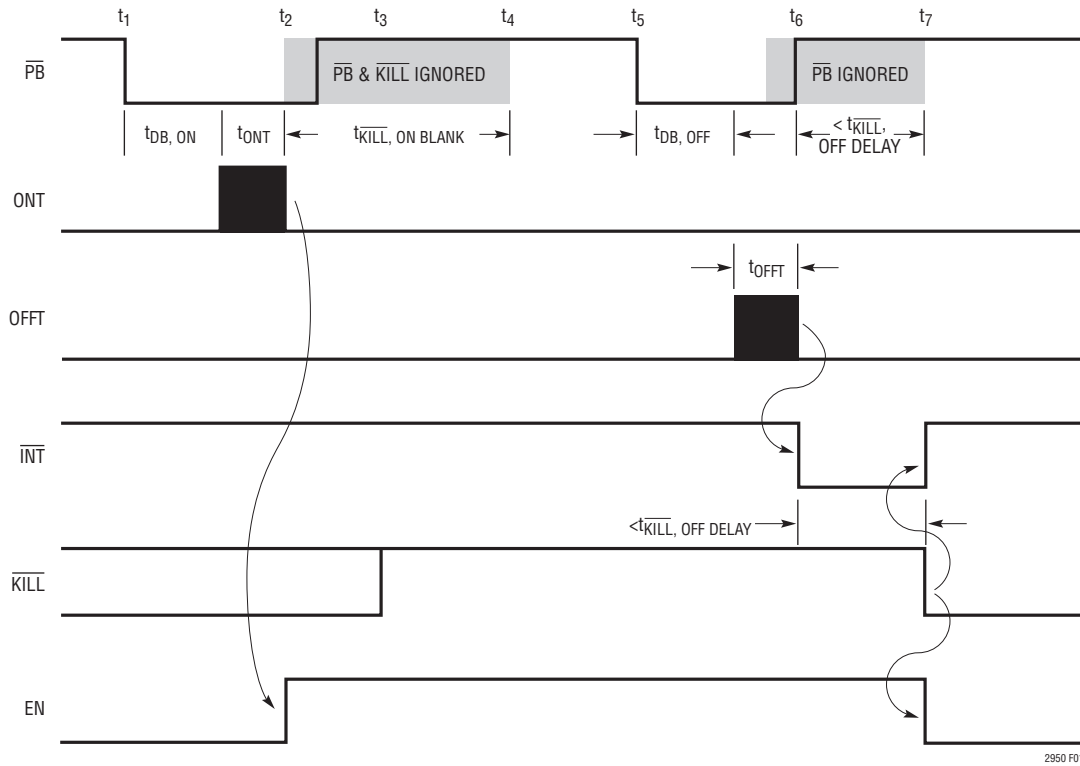


Figure 1. Simplified Power On/Off Sequence for LTC2950-1

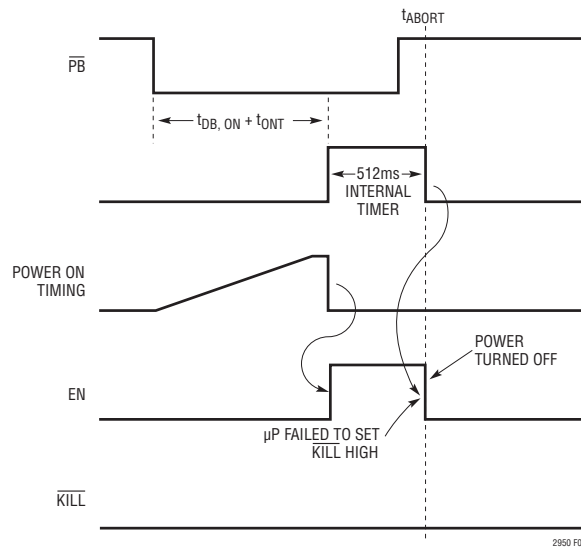


Figure 2. Aborted Power On Sequence for LTC2950-1

## APPLICATIONS INFORMATION

### Aborted Power On Sequence

The power on sequence is aborted when the  $\overline{\text{KILL}}$  remains low after the end of the 512ms blanking time. Figure 2 is a simplified version of an aborted power on sequence. At time  $t_{\text{ABORT}}$ , since  $\overline{\text{KILL}}$  is still low, EN pulls low (thus turning off the DC/DC converter).

### $\mu\text{P}$ Turns Off Power During Normal Operation

Once the system has powered on and is operating normally, the  $\mu\text{P}$  can turn off power by setting  $\overline{\text{KILL}}$  low, as shown in Figure 3. At time  $t_{\text{KILL}}$ ,  $\overline{\text{KILL}}$  is set low by the  $\mu\text{P}$ . This immediately pulls EN low, thus turning off the DC/DC converter.

### DC/DC Turn Off Blanking

When the DC/DC converter is turned off, it can take a significant amount of time for its output to decay to ground. It is desirable to wait until the output of the DC/DC converter is near ground before allowing the user (via  $\overline{\text{PB}}$ ) to restart the converter. This condition guarantees that the  $\mu\text{P}$  is always powered down completely before it is restarted.

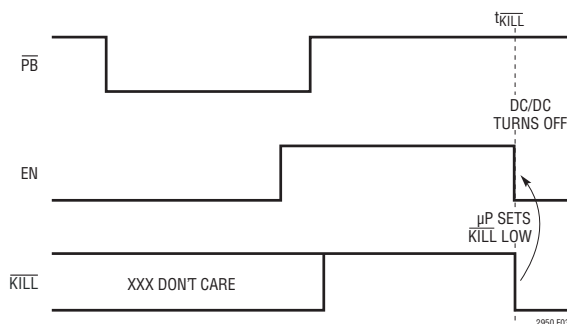


Figure 3.  $\mu\text{P}$  Turns Off Power (LTC2950-1)

Figure 4 shows the  $\mu\text{P}$  turning power off. After a low on  $\overline{\text{KILL}}$  releases enable, the internal 256ms timer ignores the  $\overline{\text{PB}}$  pin. This is shown as  $t_{\text{EN}/\overline{\text{EN}}}$ , LOCKOUT in Figure 4.

### LTC2950-1, LTC2950-2 VERSIONS

The LTC2950-1 (high true EN) and LTC2950-2 (low true  $\overline{\text{EN}}$ ) differ only by the polarity of the EN/ $\overline{\text{EN}}$  pin. Both versions allow the user to extend the amount of time that the  $\overline{\text{PB}}$  must be held low in order to begin a valid power on/off sequence. An external capacitor placed on the ONT pin adds additional time to the turn on time. An external capacitor placed on the OFFT pin adds additional time to the turn off time. If no capacitor is placed on the ONT (OFFT) pin, then the turn on (off) duration is given by an internally fixed 32ms timer.

The LTC2950 fixes the  $\overline{\text{KILL}}$  turn off delay time ( $t_{\text{KILL, OFF DELAY}}$ ) at 1024ms. This means that the EN/ $\overline{\text{EN}}$  pin will be switched low/high a maximum of 1024ms after initiating a valid turn off sequence. Note that in a typical application, a  $\mu\text{P}$  or  $\mu\text{C}$  would set  $\overline{\text{KILL}}$  low prior to the 1024ms timer period ( $t_7$  in Figure 1).

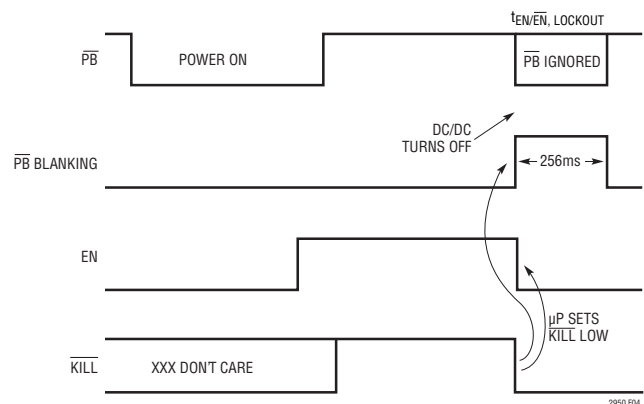


Figure 4. DC/DC Turn Off Blanking (LTC2950-1)

## APPLICATIONS INFORMATION

The following equations describe the turn on and turn off times.  $C_{ONT}$  and  $C_{OFFT}$  are the external programming capacitors:

$$t_{BD,ON} + t_{ONT} = 32ms + 1ms + (6.7 \times 10^6) \cdot C_{ONT}$$

$$t_{BD,OFF} + t_{OFFT} = 32ms + 1ms + (6.7 \times 10^6) \cdot C_{OFFT}$$

### High Voltage Pins

The  $V_{IN}$  and  $\overline{PB}$  pins can operate at voltages up to 26.4V.  $\overline{PB}$  can, additionally, operate below ground (–6V) without latching up the device.  $\overline{PB}$  has an ESD HBM rating of  $\pm 10kV$ .

If the pushbutton switch connected to  $\overline{PB}$  exhibits high leakage current, then an external pull-up resistor to  $V_{IN}$  is recommended. Furthermore, if the pushbutton switch is physically located far from the LTC2950  $\overline{PB}$  pin, parasitic capacitances may couple onto the high impedance  $\overline{PB}$  input. Additionally, parasitic series inductance may cause unpredictable ringing at the  $\overline{PB}$  pin. Placing a 5k resistor from the  $\overline{PB}$  pin to the pushbutton switch would mitigate parasitic inductance problems. Placing a 0.1 $\mu F$  capacitor on the  $\overline{PB}$  pin would lessen the impact of parasitic capacitive coupling.

## TYPICAL APPLICATIONS

### Voltage Monitoring with $\overline{KILL}$ Input

The  $\overline{KILL}$  pin can be used as a voltage monitor. Figure 5 shows an application where the  $\overline{KILL}$  pin has a dual function. It is driven by a low leakage open drain output of the  $\mu P$ . It is also connected to a resistor divider that monitors battery voltage ( $V_{IN}$ ). When the battery voltage falls below the set value, the voltage at the  $\overline{KILL}$  pin falls below 0.6V and the EN pin is quickly pulled low. Note that the resistor values should be as large as possible, but small enough to keep

leakage currents from tripping the 0.6V  $\overline{KILL}$  comparator.

The DC/DC converter shown has an internal pull-up current on its  $\overline{SHDN}$  pin. A pull-up resistor on EN is thus not needed.

### Operation Without $\mu P$

Figure 6 shows how to connect the  $\overline{KILL}$  pin when there is no circuitry available to drive it. The minimum pulse width detected is 30 $\mu s$ . If there are glitches on the resistor pull-up voltage that are wider than 30 $\mu s$  and transition

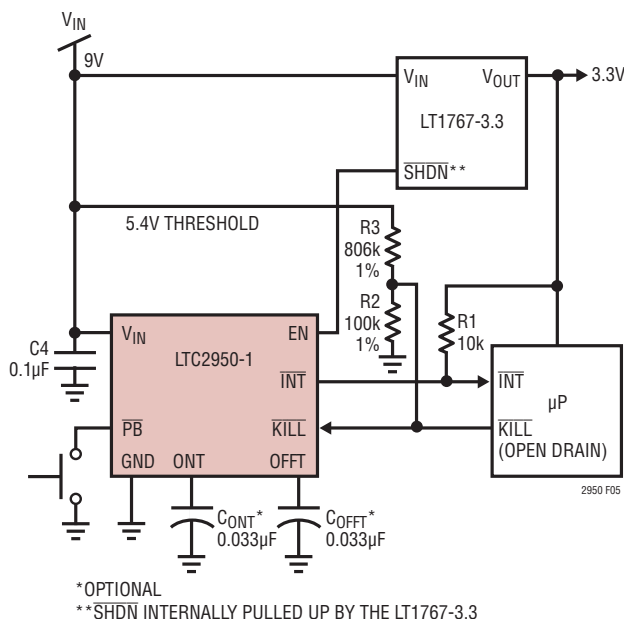


Figure 5. Input Voltage Monitoring with  $\overline{KILL}$  Input

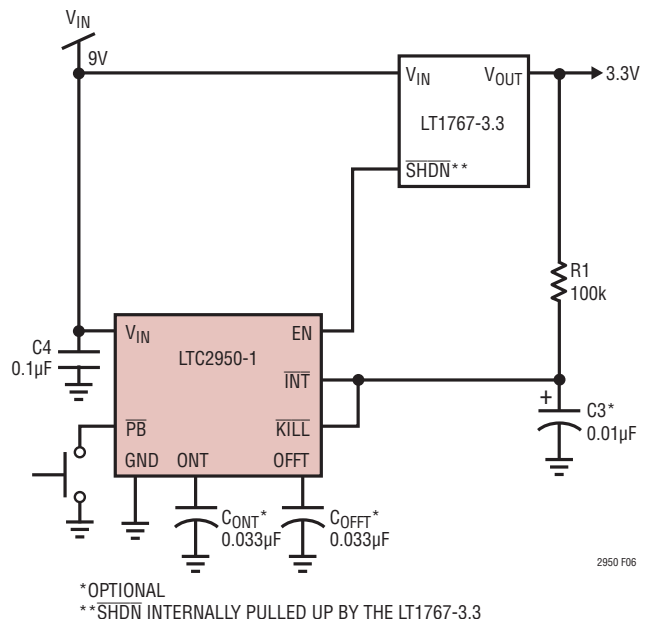


Figure 6. No  $\mu P$  Application

## TYPICAL APPLICATIONS

below 0.6V, then an appropriate bypass capacitor should be connected to the  $\overline{\text{KILL}}$  pin.

### PowerPath™ Switching

The  $\overline{\text{EN}}$  open drain output of the LTC2950-2 is designed to switch on/off an external power PFET. This allows a user to connect/disconnect a power supply (or battery) to its load by toggling the  $\overline{\text{PB}}$  pin. Figure 7 shows the LTC2950-2 controlling a two cell Li-Ion battery application. The  $\overline{\text{INT}}$  and  $\overline{\text{KILL}}$  pins are connected to the output of the PFET through a resistor divider. The  $\overline{\text{KILL}}$  pin serves as a voltage monitor. When  $V_{\text{OUT}}$  drops below 6V, the  $\overline{\text{EN}}$  pin is open circuited 30 $\mu$ s later.

### $\overline{\text{PB}}$ Pin in a Noisy Environment

The rugged  $\overline{\text{PB}}$  pin is designed to operate in noisy environments. Transients below ground ( $>-6\text{V}$ ) and above  $V_{\text{IN}}$  ( $<30\text{V}$ ) will not damage the rugged  $\overline{\text{PB}}$  pin. Additionally, the  $\overline{\text{PB}}$  pin can withstand ESD HBM strikes up to  $\pm 10\text{kV}$ .

In order to keep external noise from coupling inside the LTC2950, place an R-C network close to the  $\overline{\text{PB}}$  pin. A 5k resistor and a 0.1 $\mu\text{F}$  capacitor should suffice for most noisy applications (see Figure 8).

### External Pull-Up Resistor on $\overline{\text{PB}}$

An internal pull-up resistor on the  $\overline{\text{PB}}$  pin makes an external pull-up resistor unnecessary. Leakage current on

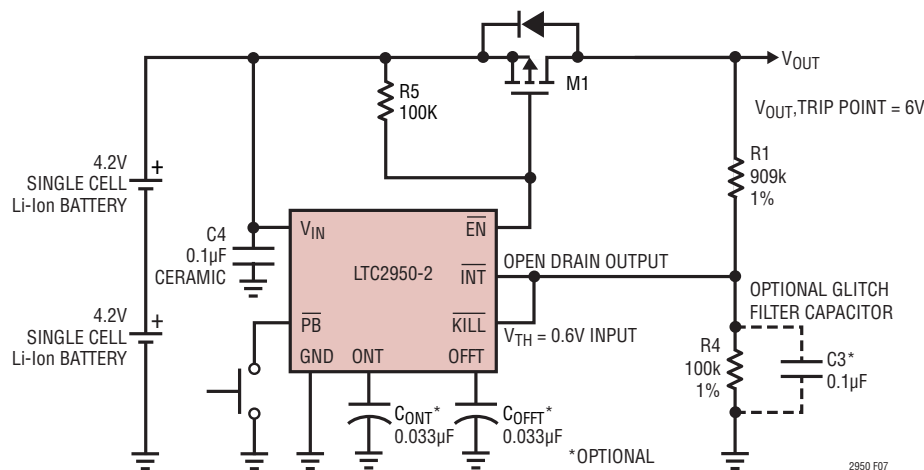


Figure 7. PowerPath Control with 6V Undervoltage Detect

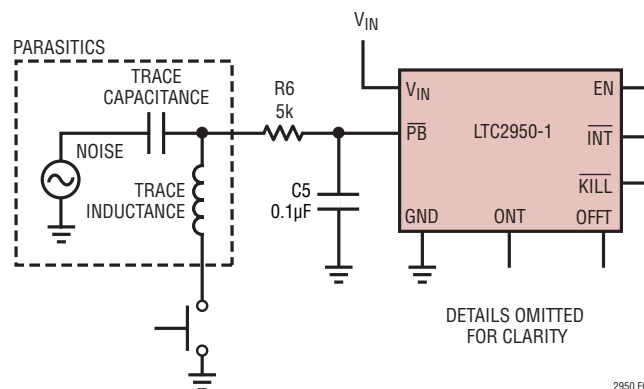


Figure 8. Noisy  $\overline{\text{PB}}$  Trace

## TYPICAL APPLICATIONS

the  $\overline{\text{PB}}$  board trace, however, will affect the open circuit voltage on the  $\overline{\text{PB}}$  pin. If the leakage is too large ( $>2\mu\text{A}$ ), the  $\overline{\text{PB}}$  voltage may fall close to the threshold window. To mitigate the effect of the board leakage, a 10k resistor to  $V_{\text{IN}}$  is recommended (see Figure 9).

### Reverse Battery Protection

To protect the LTC2950 from a reverse battery connection, place a 1k resistor in series with the  $V_{\text{IN}}$  pin (see Figure 10).

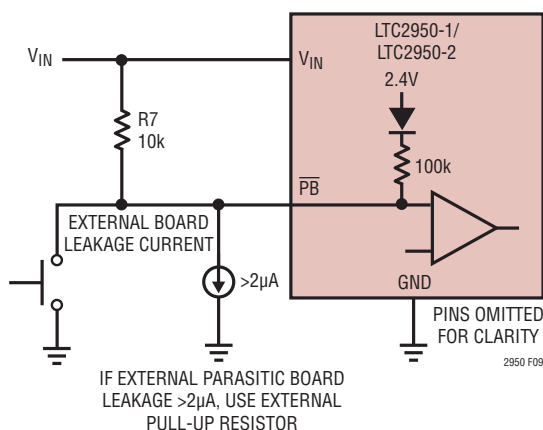
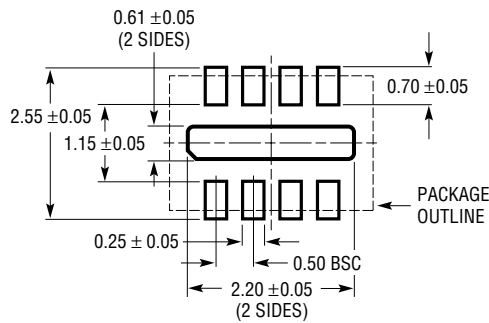


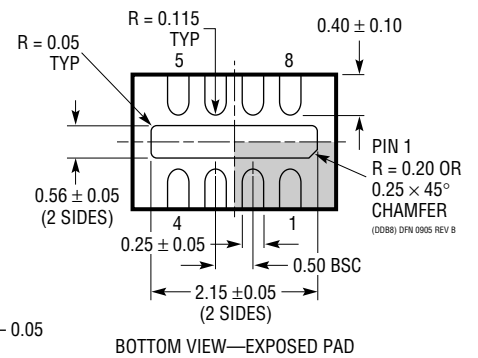
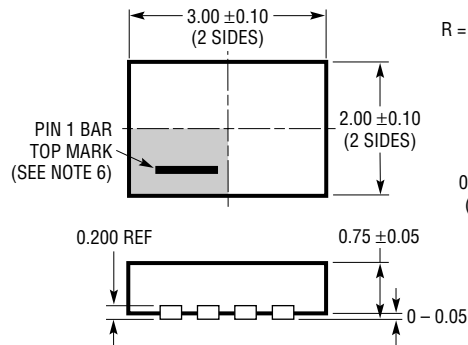
Figure 9. External Pull-Up Resistor on  $\overline{\text{PB}}$  Pin

# PACKAGE DESCRIPTION

**DDB Package**  
**8-Lead Plastic DFN (3mm × 2mm)**  
 (Reference LTC DWG # 05-08-1702 Rev B)



RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS

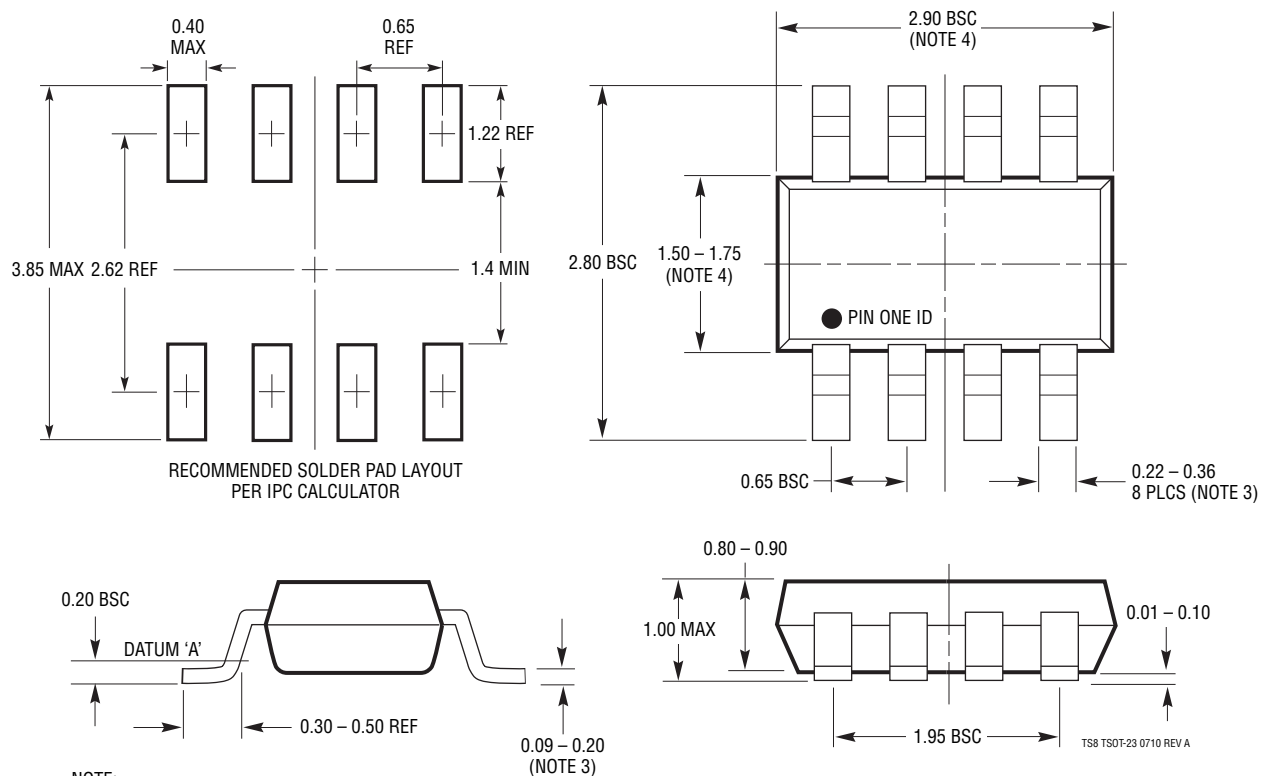


## NOTE:

1. DRAWING CONFORMS TO VERSION (WECD-1) IN JEDEC PACKAGE OUTLINE M0-229
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

# PACKAGE DESCRIPTION

**TS8 Package**  
**8-Lead Plastic TSOT-23**  
 (Reference LTC DWG # 05-08-1637 Rev A)



**NOTE:**

1. DIMENSIONS ARE IN MILLIMETERS
2. DRAWING NOT TO SCALE
3. DIMENSIONS ARE INCLUSIVE OF PLATING
4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
5. MOLD FLASH SHALL NOT EXCEED 0.254mm
6. JEDEC PACKAGE REFERENCE IS MO-193

TS8 TSOT-23 0710 REV A



**REVISION HISTORY** (Revision history begins at Rev D)

| REV | DATE  | DESCRIPTION  | PAGE NUMBER |
|-----|-------|--|-------------|
| D   | 02/11 | Revised Typical Application.   | 1           |
|     |       | Revised Absolute Maximum Ratings and Pin Configuration.                  | 2           |
|     |       | Updated Electrical Characteristics                                       | 3           |
|     |       | Revised EN and $\overline{\text{EN}}$ pin descriptions in Pin Functions. | 6           |
|     |       | Updated Block Diagram  | 7           |
|     |       | Revised Figures 5 and 6.   | 12          |
|     |       | Updated Related Parts.   | 18          |

TYPICAL APPLICATION

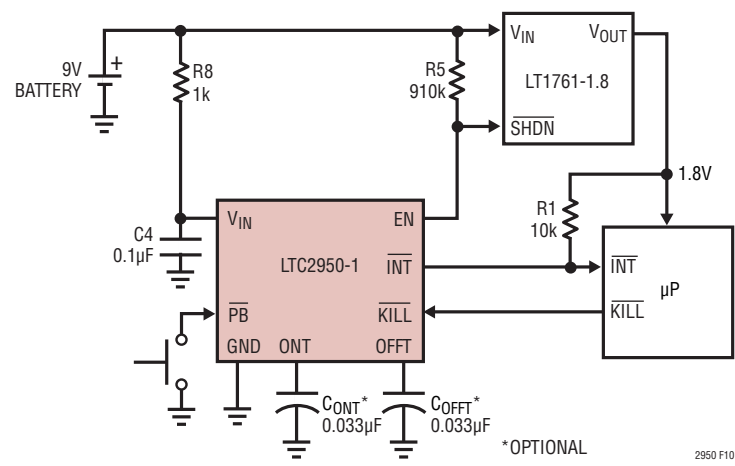


Figure 10. Reverse Battery Protection

RELATED PARTS

| PART NUMBER     | DESCRIPTION  | COMMENTS   |
|-----------------|--|--|
| LTC2900         | Programmable Quad Supply Monitor                     | Adjustable $\overline{\text{RESET}}$ , 10-Lead MSOP and 3mm × 3mm DFN Packages               |
| LTC2904/LTC2905 | Pin-Programmable Dual Supply Monitors                | Adjustable $\overline{\text{RESET}}$ and Tolerance, 8-Lead SOT-23 and 3mm × 2mm DFN Packages |
| LTC4411         | 2.6A Low Loss Ideal Diode in ThinSOT                 | No External MOSFET, Automatic Switching Between DC Sources                                   |
| LTC4412HV       | PowerPath Controller in ThinSOT                      | Efficient Diode-ORing, Automatic Switching Between DC Sources, 3V to 36V                     |
| LTC4055         | USB Power Controller and Li-Ion Charger              | Automatic Switchover, Charges 1-Cell Li-Ion Batteries  |
| LTC2951         | Micropower Pushbutton On/Off Controller              | Adjustable Power-Off Timer   |
| LTC2952         | Pushbutton PowerPath Controller with Supervisor      | Automatic Low Loss Switchover Between DC Sources   |
| LTC2953         | Pushbutton On/Off Controller with Voltage Monitoring | High Voltage Pushbutton Controller with 200ms Voltage Reset Monitor                          |
| LTC2954         | Pushbutton On/Off Controller with μP Interrupt       | Allow Controlled Software System Shutdown  |