FEATURES

- Adjustable Pushbutton On/Off Timers
- Low Supply Current: 6µA
- Wide Operating Voltage Range: 2.7V to 26.4V
- EN Output (LTC2950-1) Allows DC/DC Converter Control
- EN Output (LTC2950-2) Allows Circuit Breaker Control
- Simple Interface Allows Graceful µP Shut Down
- High Input Voltage PB Pin with Internal Pull Up Resistor
- ±10kV ESD HBM on PB Input
- Accurate 0.6V Threshold on KILL Comparator Input
- 8-Pin 3mm × 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 (6µA 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 × 2mm DFN or ThinSOT packages.

TYPICAL APPLICATION

![Typical Application Diagram]

- **V_OUT**
- **DC/DC BUCK**
- **SRDN**
- **R1 10k**
- **0.033µF**
- **COFF**
- **COFF**
- **INT**
- **µP/µC**
- **PB**
- **INT**
- **KILL**
- **KILL**
- **SHDN**

*SHDN INTERNALLY PULLED UP BY DC/DC

*OPTIONAL

Engineering Note: 2950 TA01

Turn On Debounce

![Turn On Debounce Graph]

EN
2V/DIV

PB
10ms/DIV
**LTC2950-1/LTC2950-2**

**ABSOLUTE MAXIMUM RATINGS**

(Note 1)

Supply Voltage ($V_{IN}$) .................................. –0.3V to 33V

Input Voltages
PB .................................................................. –6V to 33V
ONT ...................................................... –0.3V to 2.7V
OFFT ..................................................... –0.3V to 2.7V
KILL ........................................................ –0.3V to 7V

Output Voltages
INT .................................................................. –0.3V to 10V
EN/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

<table>
<thead>
<tr>
<th>TAPE AND REEL (MINI)</th>
<th>TAPE AND REEL</th>
<th>PART MARKING*</th>
<th>PACKAGE DESCRIPTION</th>
<th>TEMPERATURE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTC2950CDDB-1#TRMPBF</td>
<td>LTC2950CDDB-1#TRPBF</td>
<td>LBKP</td>
<td>8-Lead Plastic DFN</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LTC2950CDDB-2#TRMPBF</td>
<td>LTC2950CDDB-2#TRPBF</td>
<td>LBNG</td>
<td>8-Lead Plastic DFN</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LTC2950IDDB-1#TRMPBF</td>
<td>LTC2950IDDB-1#TRPBF</td>
<td>LBKP</td>
<td>8-Lead Plastic DFN</td>
<td>–40°C to 85°C</td>
</tr>
<tr>
<td>LTC2950IDDB-2#TRMPBF</td>
<td>LTC2950IDDB-2#TRPBF</td>
<td>LBNG</td>
<td>8-Lead Plastic DFN</td>
<td>–40°C to 85°C</td>
</tr>
<tr>
<td>LTC2950CTS8-1#TRMPBF</td>
<td>LTC2950CTS8-1#TRPBF</td>
<td>LTBKN</td>
<td>8-Lead Plastic TSOT-23</td>
<td>0°C to 70°C</td>
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<tr>
<td>LTC2950CTS8-2#TRMPBF</td>
<td>LTC2950CTS8-2#TRPBF</td>
<td>LTBNF</td>
<td>8-Lead Plastic TSOT-23</td>
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<tr>
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<td>LTC2950ITS8-2#TRPBF</td>
<td>LTBNF</td>
<td>8-Lead Plastic TSOT-23</td>
<td>–40°C to 85°C</td>
</tr>
</tbody>
</table>

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/](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 temperature range, otherwise specifications are at $T_A = 25^\circ C$. $V_{IN} = 2.7V$ to 26.4V, unless otherwise noted. (Note 2)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>Supply Voltage Range</td>
<td>Steady State Operation</td>
<td>●</td>
<td>2.7</td>
<td>26.4</td>
<td>V</td>
</tr>
<tr>
<td>$I_{IN}$</td>
<td>$V_{IN}$ Supply Current</td>
<td>System Power On, $V_{IN} = 2.7V$ to 24V</td>
<td>●</td>
<td>6</td>
<td>12</td>
<td>µA</td>
</tr>
<tr>
<td>$V_{UVL}$</td>
<td>$V_{IN}$ Undervoltage Lockout</td>
<td>$V_{IN}$ Failing</td>
<td>●</td>
<td>2.2</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>$V_{UVL(HYST)}$</td>
<td>$V_{IN}$ Undervoltage Lockout Hysteresis</td>
<td></td>
<td></td>
<td>50</td>
<td>300</td>
<td>600</td>
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</table>

### Pushbutton, Enable (PB, EN/EN)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{PB(MIN, MAX)}$</td>
<td>PB Voltage Range</td>
<td>Single-Ended</td>
<td>●</td>
<td>–1</td>
<td>26.4</td>
<td>V</td>
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<tr>
<td>$I_{PB}$</td>
<td>PB Input Current</td>
<td></td>
<td>●</td>
<td>±1</td>
<td>–12</td>
<td>µA</td>
</tr>
<tr>
<td>$V_{PB(VTH)}$</td>
<td>PB Input Threshold</td>
<td>PB Failing</td>
<td>●</td>
<td>0.6</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>$V_{PB(VOC)}$</td>
<td>PB Open Circuit Voltage</td>
<td>$I_{PB} = –1µA$</td>
<td></td>
<td>1</td>
<td>1.6</td>
<td>2</td>
</tr>
<tr>
<td>$I_{EN/EN, Lock Out}$</td>
<td>EN/EN Lock Out Time (Note 5)</td>
<td>Enable Released → Enable Asserted</td>
<td>●</td>
<td>200</td>
<td>256</td>
<td>325</td>
</tr>
<tr>
<td>$I_{EN/EN(LKG)}$</td>
<td>EN/EN Leakage Current</td>
<td>$V_{EN/EN} = 1V$, Sink Current Off</td>
<td>●</td>
<td>±0.1</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>$V_{EN/EN(VOL)}$</td>
<td>EN/EN Voltage Output Low</td>
<td>$I_{EN/EN} = 3mA$</td>
<td>●</td>
<td>0.11</td>
<td>0.4</td>
<td>V</td>
</tr>
</tbody>
</table>

### Debounce Timing Pins (ONT, OFFT)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{ONT(OFFT(PU))}$</td>
<td>ONT/OFFT Pull Up Current</td>
<td>$V_{ONT(OFFT) = 0V}$</td>
<td>●</td>
<td>–2.4</td>
<td>–3</td>
<td>–3.6</td>
</tr>
<tr>
<td>$I_{ONT(OFFT(PD))}$</td>
<td>ONT/OFFT Pull Down Current</td>
<td>$V_{ONT(OFFT) = 1.3V}$</td>
<td>●</td>
<td>2.4</td>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>$I_{DB, On}$</td>
<td>Internal Turn On Debounce Time</td>
<td>ONT Pin Float, PB Failing → Enable Asserted</td>
<td>●</td>
<td>26</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>$I_{DB, Off}$</td>
<td>Internal Turn Off Debounce Time</td>
<td>OFFT Pin Float, PB Falling → INT Falling</td>
<td>●</td>
<td>26</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>$I_{ONF}$</td>
<td>Additional Adjustable Turn Off Time</td>
<td>$C_{OFFT} = 1500pF$</td>
<td>●</td>
<td>9</td>
<td>11.5</td>
<td>13.5</td>
</tr>
<tr>
<td>$I_{OFF}$</td>
<td>Additional Adjustable Turn On Time</td>
<td>$C_{ONF} = 1500pF$</td>
<td>●</td>
<td>9</td>
<td>11.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

### µP Handshake Pins (INT, KILL)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{INT(LKG)}$</td>
<td>INT Leakage Current</td>
<td>$V_{INT} = 3V$</td>
<td>●</td>
<td>±1</td>
<td>µA</td>
<td></td>
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<tr>
<td>$I_{INT(VOL)}$</td>
<td>INT Output Voltage Low</td>
<td>$I_{INT} = 3mA$</td>
<td>●</td>
<td>0.11</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>$I_{KILL(TH)}$</td>
<td>KILL Input Threshold Voltage</td>
<td>KILL Failing</td>
<td>●</td>
<td>0.57</td>
<td>0.6</td>
<td>0.63</td>
</tr>
<tr>
<td>$I_{KILL(HYST)}$</td>
<td>KILL Input Threshold Hysteresis</td>
<td></td>
<td>10</td>
<td>30</td>
<td>50</td>
<td>mV</td>
</tr>
<tr>
<td>$I_{KILL(LKG)}$</td>
<td>KILL Leakage Current</td>
<td>$V_{KILL} = 0.6V$</td>
<td>●</td>
<td>±0.1</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>$I_{KILL(PW)}$</td>
<td>KILL Minimum Pulse Width</td>
<td></td>
<td>●</td>
<td>30</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$I_{KILL(PD)}$</td>
<td>KILL Propagation Delay</td>
<td>KILL Failing → Enable Released</td>
<td>●</td>
<td>30</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$I_{KILL, On Blank}$</td>
<td>KILL Turn On Blanking (Note 3)</td>
<td>KILL = Low, Enable Asserted → Enable Released</td>
<td>●</td>
<td>400</td>
<td>512</td>
<td>650</td>
</tr>
<tr>
<td>$I_{KILL, Off Delay}$</td>
<td>KILL Turn Off Delay (Note 4)</td>
<td>KILL = High, INT Asserted → Enable Released</td>
<td>●</td>
<td>800</td>
<td>1024</td>
<td>1300</td>
</tr>
</tbody>
</table>

**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 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 µP to perform power up tasks. The KILL and PB inputs are ignored during this period. If 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 $I_{DB, On}$ or $I_{ONT}$.

**Note 4:** The KILL turn off delay is the maximum delay from the initiation of a shutdown sequence (INT falling), to the release of the enable output. If the 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 $I_{DB, Off}$ or $I_{OFF}$.

**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. PB is ignored during this lock out time. This time delay does not include $I_{DB, On}$ or $I_{ONT}$. 
TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Temperature

Supply Current vs Supply Voltage

Internal Default Turn On Debounce Time (tDB, ON) vs VIN

Turn On Debounce Time (tDB, ON + tONT) vs ONT External Capacitor

ONT Pull-Down Current vs Temperature

Internal Default Turn Off Debounce Time (tDB, OFF) vs VIN

Turn Off Debounce Time (tDB, OFF + tOFFT) vs OFFT External Capacitor

OFFT Pull-Down Current vs Temperature

PB Current vs PB Voltage
TYPICAL PERFORMANCE CHARACTERISTICS

PB Voltage vs External PB Resistance to Ground

EN/EN Voltage vs Current Load

EN (LTC2950-1) Voltage vs VIN

EN (LTC2950-2) Voltage vs VIN

VIN = 3.3V

TA = 25°C

TA = 100°C

TA = –45°C

EN/EN CURRENT LOAD (mA)

PB VOLTAGE (mV)

EXTERNAL PB RESISTANCE TO GROUND (kΩ)

VIN (V)

EN (V)

0 1 2 3 4

1.0

100k PULL-UP FROM EN TO VIN

1.0

0.5

0.0

0

0 1 2 3 4

4

3

2

1

0

TA = 25°C

100k PULL-UP FROM EN TO VIN

TA = 25°C

TA = 100°C

TA = –45°C

TA = 25°C

VIN = 3.3V
**PIN FUNCTIONS** (TSOT-23/DFN)

**V\text{IN} (Pin 1/Pin 4):** Power Supply Input: 2.7V to 26.4V.

**PB (Pin 2/Pin 3):** Pushbutton Input. Connecting PB to ground through a momentary switch provides on/off control via the EN/\text{EN} pin. An internal 100k pull-up resistor connects to an internal 1.9V bias voltage. The rugged 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 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.

**\text{INT} (Pin 5/Pin 8):** Open Drain Interrupt Output. After a pushbutton turn-off event is detected, the LTC2950 interrupts the system (µP) by bringing the \text{INT} pin low. Once the system finishes its power down and housekeeping tasks, it sets KILL low, which in turn releases the enable output. If at the end of the power down timer (1024ms) KILL is still high, the enable output is released immediately. \text{INT} may optionally be tied to KILL to release the enable output immediately after the turn-off event has been detected (\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 PB turn on event. EN is released low if: a) KILL is not driven high (by µP) within 512ms of the initial valid PB power turn-on event, b) KILL is driven low during normal operation, c) a second valid 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.

**KILL (Pin 8/Pin 5):** KILL Input. Forcing 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 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).

**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 PB pin must be held low before initiating a power down sequence (\text{INT} falling). Floating this pin results in a default turn off time of 32ms.

**Exposed Pad (Pin 9):** Exposed Pad may be left open or connected to device ground.
LTC2950-1/LTC2950-2

TIMING DIAGRAMS

Power On Timing

16 CYCLES

Power Off Timing, 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 (INT output, 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/EN pin will therefore be held off. To assert the enable output, PB must be held low for a minimum of 32ms (t_DB, ON). The LTC2950 provides additional turn on debounce time via an optional capacitor connected to the ONT pin (t_ONT). The following equation describes the additional time that PB must be held low before asserting the enable output. C_ONT is the ONT external capacitor:

\[ C_{ONT} = 1.56 \times 10^{-4} \text{ [µF/ms]} \times (t_{ONT} - 1\text{ms}) \]

Once the enable output is asserted, any DC/DC converters connected to this pin are turned on. The KILL input from the µP is ignored during a succeeding 512ms blanking time (t_KILL, ON BLANK). This blanking time represents the maximum time required to power up the DC/DC converter and the µP. If 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, PB must be held low for a minimum of 32ms (t_DB, OFF). Additional turn off debounce time may be added via an optional capacitor connected to the OFFT pin (t_OFFT). The following equation describes the additional time that PB must be held low to initiate a power off sequence. C_OFFT is the OFFT external capacitor:

\[ C_{OFFT} = 1.56 \times 10^{-4} \text{ [µF/ms]} \times (t_{OFFT} - 1\text{ms}) \]

Once PB has been validly pressed, 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 KILL input can be pulled low (thereby releasing the enable output) at any time after t_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 PB (t_1) initiates the power on sequence. This diagram does not show any bounce on PB. In order to assert the enable output, the PB pin must stay low continuously (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 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 KILL and PB until after the 512ms internal timer has expired. The reason 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 PB pin is then debounced with an internal 32ms timer. The system has now properly powered on and the LTC2950 monitors PB and KILL (for a turnoff command) while consuming only 6µA of supply current.

A high to low transition on PB (t_5) initiates the power off sequence. PB must stay low continuously (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 (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 KILL low (t_7) and thus immediately set EN low), terminating the internal 1024ms timer. The release of the 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). PB is monitored for a high to low transition.
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 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 KILL is still low, EN pulls low (thus turning off the DC/DC converter).

µP Turns Off Power During Normal Operation

Once the system has powered on and is operating normally, the µP can turn off power by setting KILL low, as shown in Figure 3. At time $t_{\text{KILL}}$, KILL is set low by the µP. 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 PB) to restart the converter. This condition guarantees that the µP has always powered down completely before it is restarted.

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

LTC2950-1, LTC2950-2 VERSIONS

The LTC2950-1 (high true EN) and LTC2950-2 (low true EN) differ only by the polarity of the EN/EN pin. Both versions allow the user to extend the amount of time that the 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 KILL turn off delay time ($t_{\text{KILL, OFF DELAY}}$) at 1024ms. This means that the EN/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 µP or µC would set KILL low prior to the 1024ms timer period ($t_7$ in Figure 1).
APPLICATIONS INFORMATION

The following equations describe the turn on and turn off times. CONT and COFFT are the external programming capacitors:

\[
\begin{align*}
  t_{BD,ON} + t_{ONT} &= 32\text{ms} + 1\text{ms} + (6.7 \times 10^6) \times C_{ONT} \\
  t_{BD,OFF} + t_{OFFT} &= 32\text{ms} + 1\text{ms} + (6.7 \times 10^6) \times C_{OFFT}
\end{align*}
\]

High Voltage Pins

The VIN and PB pins can operate at voltages up to 26.4V. PB can, additionally, operate below ground (–6V) without latching up the device. PB has an ESD HBM rating of ±10kV. If the pushbutton switch connected to PB exhibits high leakage current, then an external pull-up resistor to VIN is recommended. Furthermore, if the pushbutton switch is physically located far from the LTC2950 PB pin, parasitic capacitances may couple onto the high impedance PB input. Additionally, parasitic series inductance may cause unpredictable ringing at the PB pin. Placing a 5k resistor from the PB pin to the pushbutton switch would mitigate parasitic inductance problems. Placing a 0.1µF capacitor on the PB pin would lessen the impact of parasitic capacitive coupling.

TYPICAL APPLICATIONS

Voltage Monitoring with KILL Input

The KILL pin can be used as a voltage monitor. Figure 5 shows an application where the KILL pin has a dual function. It is driven by a low leakage open drain output of the µP. It is also connected to a resistor divider that monitors battery voltage (VIN). When the battery voltage falls below the set value, the voltage at the 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 KILL comparator. The DC/DC converter shown has an internal pull-up current on its SHDN pin. A pull-up resistor on EN is thus not needed.

Operation Without µP

Figure 6 shows how to connect the KILL pin when there is no circuitry available to drive it. The minimum pulse width detected is 30µs. If there are glitches on the resistor pull-up voltage that are wider than 30µs and transition...
TYPICAL APPLICATIONS

below 0.6V, then an appropriate bypass capacitor should be connected to the KILL pin.

PowerPath™ Switching

The 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 PB pin. Figure 7 shows the LTC2950-2 controlling a two cell Li-Ion battery application. The INT and KILL pins are connected to the output of the PFET through a resistor divider. The KILL pin serves as a voltage monitor. When VOUT drops below 6V, the EN pin is open circuited 30µs later.

PB Pin in a Noisy Environment

The rugged PB pin is designed to operate in noisy environments. Transients below ground (>–6V) and above VIN (<30V) will not damage the rugged PB pin. Additionally, the PB pin can withstand ESD HBM strikes up to ±10kV.

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

External Pull-Up Resistor on PB

An internal pull-up resistor on the PB pin makes an external pull-up resistor unnecessary. Leakage current on
the PB board trace, however, will affect the open circuit voltage on the PB pin. If the leakage is too large (>2µA), the PB voltage may fall close to the threshold window. To mitigate the effect of the board leakage, a 10k resistor to VIN 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 VIN pin (see Figure 10).

![Figure 9. External Pull-Up Resistor on PB Pin](image-url)
PACKAGE DESCRIPTION

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

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
## REVISION HISTORY

(Revision history begins at Rev D)

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Figure 10. Reverse Battery Protection

### RELATED PARTS

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<td>Programmable Quad Supply Monitor</td>
<td>Adjustable RESET, 10-Lead MSOP and 3mm × 3mm DFN Packages</td>
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<tr>
<td>LTC2904/LTC2905</td>
<td>Pin-Programmable Dual Supply Monitors</td>
<td>Adjustable RESET and Tolerance, 8-Lead SOT-23 and 3mm × 2mm DFN Packages</td>
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<td>LTC4411</td>
<td>2.6A Low Loss Ideal Diode in ThinSOT</td>
<td>No External MOSFET, Automatic Switching Between DC Sources</td>
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<tr>
<td>LTC4412HV</td>
<td>PowerPath Controller in ThinSOT</td>
<td>Efficient Diode-ORing, Automatic Switching Between DC Sources, 3V to 36V</td>
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<td>LTC4055</td>
<td>USB Power Controller and Li-Ion Charger</td>
<td>Automatic Switchover, Charges 1-Cell Li-Ion Batteries</td>
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<td>Adjustable Power-Off Timer</td>
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<tr>
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<td>Allow Controlled Software System Shutdown</td>
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