LTC2951-1/LTC2951-2
Pushbutton On/Off Controller

FEATURES
- Adjustable Pushbutton Debounce and Delay Timers
- Low Supply Current: 6µA
- Wide Operating Voltage Range: 2.7V to 26.4V
- EN Output (LTC2951-1) Allows DC/DC Converter Control
- EN Output (LTC2951-2) Allows Circuit Breaker Control
- Simple Interface Allows Graceful µP Shutdown
- 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®2951 is a micropower, wide input voltage range pushbutton ON/OFF controller. The part contains a pushbutton input which controls the toggling of an open-drain enable output. The pushbutton turn OFF debounce time is externally programmable, while the turn ON debounce time is fixed at 128ms. A simple microprocessor interface allows for proper system housekeeping prior to power-down. Under system fault conditions, an adjustable KILL timeout delay ensures proper power-down.

The LTC2951 operates over a 2.7V to 26.4V input voltage range to accommodate a variety of input power supplies. Very low quiescent current (6µA typical) makes the LTC2951 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 8-pin 3mm × 2mm DFN and ThinSOT packages.

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**ABSOLUTE MAXIMUM RATINGS** *(Note 1)*

Supply Voltage (V\textsubscript{IN}) ......... \(-0.3\) V to 33 V  
Input Voltages  
\(\text{PB}\) ................. \(-6\) V to 33 V  
\(\text{KILLT}\) ............... \(-0.3\) V to 2.7 V  
\(\text{OFFT}\) ................. \(-0.3\) V to 2.7 V  
\(\text{KILL}\) .................. \(-0.3\) V to 7 V  
Output Voltages  
\(\text{INT}\) ................. \(-0.3\) V to 10 V  
\(\text{EN/EN}\) ............... \(-0.3\) V to 10 V  
Operating Temperature Range  
LTC2951C-1 .................. 0°C to 70°C  
LTC2951C-2 .................. 0°C to 70°C  
LTC2951I-1 ............... \(-40\)°C to 85°C  
LTC2951I-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**

![Pin Diagram]

**TOP VIEW**

DDB PACKAGE  
8-LEAD (3mm \(\times\) 2mm) PLASTIC DFN  
\(T_{J,\text{MAX}} = 125^\circ\text{C}, \theta_{JA} = 165^\circ\text{C/W}\)  
EXPOSED PAD (PIN 9) PCB GND CONNECTION OPTIONAL

![Pin Diagram]

**TOP VIEW**

TS8 PACKAGE  
8-LEAD PLASTIC TSOT-23  
\(T_{J,\text{MAX}} = 125^\circ\text{C}, \theta_{JA} = 140^\circ\text{C/W}\)

**ORDER INFORMATION**

<table>
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<tr>
<th>LEAD FREE FINISH</th>
<th>TAPE AND REEL</th>
<th>PART MARKING*</th>
<th>PACKAGE DESCRIPTION</th>
<th>TEMPERATURE RANGE</th>
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</thead>
<tbody>
<tr>
<td>LTC2951CDDB-1#PBF</td>
<td>LTC2951CDDB-1#TRPBF</td>
<td>LBTB</td>
<td>8-Lead (3mm (\times) 2mm) Plastic DFN</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>LTC2951CDDB-2#PBF</td>
<td>LTC2951CDDB-2#TRPBF</td>
<td>LBTD</td>
<td>8-Lead (3mm (\times) 2mm) Plastic DFN</td>
<td>0°C to 70°C</td>
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<tr>
<td>LTC2951DDDB-1#PBF</td>
<td>LTC2951DDDB-1#TRPBF</td>
<td>LBTB</td>
<td>8-Lead (3mm (\times) 2mm) Plastic DFN</td>
<td>(-40)°C to 85°C</td>
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<tr>
<td>LTC2951DDDB-2#PBF</td>
<td>LTC2951DDDB-2#TRPBF</td>
<td>LBTD</td>
<td>8-Lead (3mm (\times) 2mm) Plastic DFN</td>
<td>(-40)°C to 85°C</td>
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<tr>
<td>LTC2951CTS8-1#PBF</td>
<td>LTC2951CTS8-1#TRPBF</td>
<td>LTBTC</td>
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<td>LTC2951ITS8-1#TRPBF</td>
<td>LTBTC</td>
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<td>(-40)°C to 85°C</td>
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<td>LTC2951ITS8-2#TRPBF</td>
<td>LTBTF</td>
<td>8-Lead Plastic TSOT</td>
<td>(-40)°C to 85°C</td>
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Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.

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 \( T_A = 25^\circ \text{C}, V_{IN} = 2.7 \text{V} \) to 24.6\text{V}, unless otherwise noted. (Note 2)

<table>
<thead>
<tr>
<th>SYMBOL, PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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</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>
</tr>
<tr>
<td>( I_{IN} )</td>
<td>( V_{IN} ) Supply Current</td>
<td>System Power-On, ( V_{IN} = 2.7 \text{V} ) to 24\text{V}</td>
<td>•</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>( V_{UVL} )</td>
<td>( V_{IN} ) Undervoltage Lockout</td>
<td>( V_{IN} ) Falling</td>
<td>•</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>( V_{UVL(HYST)} )</td>
<td>( V_{IN} ) Undervoltage Lockout Hysteresis</td>
<td>•</td>
<td>50</td>
<td>300</td>
<td>600</td>
</tr>
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**Pushbutton, Enable (PB, EN/EN)**

<table>
<thead>
<tr>
<th>SYMBOL, PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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<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>
</tr>
<tr>
<td>( I_{PB} )</td>
<td>PB Input Current</td>
<td>( 2.5 \text{V} &lt; V_{PB} &lt; 26.4 \text{V} )</td>
<td>•</td>
<td>–1</td>
<td>2.4</td>
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<tr>
<td></td>
<td></td>
<td>( V_{PB} = 1 \text{V} )</td>
<td>•</td>
<td>–6</td>
<td>–12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( V_{PB} = 0.6 \text{V} )</td>
<td>•</td>
<td>–3</td>
<td>–9</td>
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<tr>
<td>( V_{PB(VTH)} )</td>
<td>PB Input Threshold</td>
<td>PB Falling</td>
<td>•</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>( I_{EN/EN} )</td>
<td>EN/EN Lockout Time (Note 5)</td>
<td>Enable Released → Enable Asserted</td>
<td>•</td>
<td>200</td>
<td>256</td>
</tr>
<tr>
<td>( I_{EN/EN(LKG)} )</td>
<td>EN/EN Leakage Current</td>
<td>( V_{EN/EN} = 1 \text{V}, ) Sink Current Off</td>
<td>•</td>
<td>±0.1</td>
<td></td>
</tr>
<tr>
<td>( V_{EN/EN(VOL)} )</td>
<td>EN/EN Voltage Output Low</td>
<td>( I_{EN/EN} = 3 \text{mA} )</td>
<td>•</td>
<td>0.11</td>
<td>0.4</td>
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<tr>
<td>( I_{PB(VOC)} )</td>
<td>PB Open-Circuit Voltage</td>
<td>( I_{PB} = –1 \mu \text{A} )</td>
<td>•</td>
<td>1</td>
<td>1.6</td>
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**Timing Pins (KILL, OFFT)**

<table>
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<tr>
<th>SYMBOL, PARAMETER</th>
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<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{KILL, OFFT(PU)} )</td>
<td>KILL/OFFT Pull-Up Current</td>
<td>( V_{KILL, OFFT} = 0 \text{V} )</td>
<td>•</td>
<td>–2.4</td>
<td>–3</td>
</tr>
<tr>
<td>( t_{KILL, OFFT(PD)} )</td>
<td>KILL/OFFT Pull-Down Current</td>
<td>( V_{KILL, OFFT} = 1.3 \text{V} )</td>
<td>•</td>
<td>2.4</td>
<td>3</td>
</tr>
<tr>
<td>( t_{DB, ON} )</td>
<td>Turn-On Debounce Time</td>
<td>PB Falling → Enable Asserted</td>
<td>•</td>
<td>100</td>
<td>128</td>
</tr>
<tr>
<td>( t_{DB, OFF} )</td>
<td>Internal Turn-Off Debounce Time</td>
<td>OFF Pin Float, PB Falling → INT Falling</td>
<td>•</td>
<td>26</td>
<td>32</td>
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<tr>
<td>( t_{OFF} )</td>
<td>Additional Adjustable Turn-Off Time</td>
<td>( C_{OFF} = 1500 \mu \text{F} )</td>
<td>•</td>
<td>9</td>
<td>11.5</td>
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</table>

**µP Handshake Pins (INT, KILL)**

<table>
<thead>
<tr>
<th>SYMBOL, 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>( I_{INT} = 3 \text{mA} )</td>
<td>•</td>
<td>±1</td>
<td></td>
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<tr>
<td>( I_{INT(VOL)} )</td>
<td>INT Output Voltage Low</td>
<td>( I_{INT} = 3 \text{mA} )</td>
<td>•</td>
<td>0.11</td>
<td>0.4</td>
</tr>
<tr>
<td>( V_{KILL(TH)} )</td>
<td>KILL Input Threshold Voltage</td>
<td>KILL Falling</td>
<td>•</td>
<td>0.57</td>
<td>0.6</td>
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<tr>
<td>( V_{KILL(HYST)} )</td>
<td>KILL Input Threshold Hysteresis</td>
<td>•</td>
<td>10</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>( I_{KILL(LKG)} )</td>
<td>KILL Leakage Current</td>
<td>( V_{KILL} = 0.6 \text{V} )</td>
<td>•</td>
<td>±0.1</td>
<td></td>
</tr>
<tr>
<td>( I_{KILL(PW)} )</td>
<td>KILL Minimum Pulse Width</td>
<td>•</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{KILL(PDO)} )</td>
<td>KILL Propagation Delay</td>
<td>KILL Falling → Enable Released</td>
<td>•</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>( t_{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>
</tr>
<tr>
<td>( t_{KILL, OFF DELAY} )</td>
<td>Internal KILL Turn-Off Delay (Note 4)</td>
<td>KILL Pin Float, KILL = High, INT Asserted → Enable Released</td>
<td>•</td>
<td>100</td>
<td>128</td>
</tr>
<tr>
<td>( t_{KILL, OFF DELAY, ADDITIONAL} )</td>
<td>Additional Adjustable KILL Turn-Off Delay (Note 4)</td>
<td>( C_{KILL} = 1500 \mu \text{F} )</td>
<td>•</td>
<td>9</td>
<td>11.5</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 \( t_{DB, ON} \).

**Note 4:** The internal KILL turn-off delay \( (t_{KILL, OFF DELAY}) \) is the default delay from the initiation of a power-off sequence (INT falling, KILL = high), to the release of the enable output. The additional, adjustable KILL turn-off delay \( (t_{KILL, OFF DELAY, ADDITIONAL}) \) uses an optional external capacitor \( (C_{KILL}) \) to provide extra delay from INT falling to the release of the enable output. If the KILL input switches low at any time during KILL turn-off delay, enable is released, thus turning off system power.

**Note 5:** The enable lockout 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 lockout time. This time delay does not include \( t_{DB, ON} \).
TYPICAL PERFORMANCE CHARACTERISTICS

PB Current vs PB Voltage

PB Voltage vs External PB Resistance to Ground

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

EN (LTC2951-1) Voltage vs V<sub>IN</sub>

EN (LTC2951-2) Voltage vs V<sub>IN</sub>
PIN FUNCTIONS (TSOT-23/DFN)

V\textsubscript{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/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.

KILLT (Pin 3/Pin 2): Additional, Adjustable KILL Turn-Off Delay Input (t\textsubscript{KILL, OFF DELAY, ADDITIONAL}). A capacitor to ground provides additional delay time (beyond the internal default 128ms, t\textsubscript{KILL, OFF DELAY}) from INT falling to the automatic release of the enable output. The KILL turn-off delay feature ensures the release of the enable pin under system fault conditions, such as the \mu P not responding to the LTC2951 interrupt signal (\textit{INT} low).

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

\textit{INT} (Pin 5/Pin 8): Open-Drain Interrupt Output. After a pushbutton turn-off event is detected (t\textsubscript{DB, OFF} + t\textsubscript{OFFT}), the LTC2951 interrupts the system (\mu P) by bringing the \textit{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 period (t\textsubscript{KILL, OFF DELAY} + t\textsubscript{KILL, OFF DELAY, ADDITIONAL}) KILL is still high, the enable output is released immediately. \textit{INT} may optionally be tied to KILL to release the enable output immediately after the turn-off event has been detected (\textit{INT} low).

EN (LTC2951-1, Pin 6/Pin 7): Open-Drain Enable Output. This pin is intended to enable system power. EN goes high after a valid PB turn-on event (t\textsubscript{DB, ON}). EN goes low if: a) KILL is not driven high within 512ms of the initial valid PB power turn-on event, b) KILL is driven low during normal operation, or 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.

EN (LTC2951-2, Pin 6/Pin 7): Open-Drain Enable Output. This pin is intended to enable system power. EN is asserted low after a valid PB turn-on event (t\textsubscript{DB, ON}). EN releases high if: a) KILL is not driven high within 512ms of the initial valid PB power turn-on event, b) KILL is driven low during normal operation, or 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 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, t\textsubscript{DB, OFF}) that the PB pin must be held low before initiating a power-down sequence (\textit{INT} falling). Floating this pin results in a default turn-off debounce time of 32ms.

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 (t\textsubscript{KILL, ON BLANK}) 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).

Exposed Pad (Pin 9): Exposed Pad may be left open or connected to device ground.
LTC2951-1/LTC2951-2

TIMING DIAGRAMS

Power-On Timing

PB & KILL IGNORED

PB, ON BLANK

PB, ON
Power-Off Timing, \( KIL \) > 0.6V
**Description**

The LTC2951 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 part incorporates all the flexible timing needed to debounce the pushbutton input (PB). The LTC2951 also provides a simple interface (INT output, KILL input) to allow a system to power on and power off in a controlled manner. The wide input voltage range allows a system designer to operate from single cell to multi-cell battery stacks. Very low quiescent current makes the LTC2951 ideal for continuously monitoring the on/off pushbutton of a handheld device.

**Turn-On**

When power is first applied to the LTC2951, the part initializes the output pins. Any DC/DC converters connected to the EN/EN pin will, therefore, be off. To assert the enable output, PB must be held low for a minimum of 128ms (t\textsubscript{DB, ON}).

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 the succeeding 512ms blanking time (t\textsubscript{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\textsubscript{DB, OFF}). Additional turn-off debounce time may be added via an optional capacitor connected to the OFFT pin (t\textsubscript{OFFT}). The following equation describes the additional time that PB must be held low to initiate a power-off sequence. C\textsubscript{OFFT} is the OFFT external capacitor:

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

Once PB has been validly pressed, INT is switched low. This alerts the µP to perform its power-down and housekeeping tasks.

**KILL Turn-Off Delay**

The LTC2951 provides a failsafe feature that allows the user to turn off system power (via PB) under system fault conditions. During a normal power-down sequence, the LTC2951 first interrupts the µP by setting INT low. The µP then performs power-down and housekeeping tasks and drives KILL low when done. The LTC2951 releases the enable output, thus turning off system power. The KILL turn-off timer starts when INT is driven low. If the µP fails to respond during this timeout period, the enable output will automatically release. The default power-down timeout period is 128ms (t\textsubscript{KILL, OFF DELAY}), which can be extended by placing an optional capacitor on the KILLT pin (t\textsubscript{KILL, OFF DELAY, ADDITIONAL}). The following equation describes the additional power-down timeout period. C\textsubscript{KILLT} is the KILLT external capacitor:

\[
C_{KILLT} = 1.56e-4 \text{ [µF/ms]} \cdot (t_{KILL, OFF DELAY, ADDITIONAL} - 1\text{ms})
\]

Note that KILL can be driven low (thereby releasing the enable output) at any time after t\textsubscript{KILL, ON BLANK} period.
**Applications Information**

**Simplified Power-On/-Off Sequence**

Figure 1 shows a simplified LTC2951-1 power-on and power-off sequence. A high to low transition on PB (t1) 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 128ms (t2−t1). Once EN goes high (t2), 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 LTC2951 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 (t4), the release of the PB pin is then debounced with an internal 32ms timer. The system has now properly powered on and the LTC2951 monitors PB and KILL (for a turnoff command) while consuming only 6µA of supply current.

A high to low transition on PB (t5) initiates the power-off sequence. PB must stay low continuously (PB high resets debounce timer) for a period controlled by the default 32ms

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**Figure 1. Simplified Power-On/-Off Sequence for LTC2951-1**
and the external OFFT capacitor (t6–t5). At the completion of the OFF timing (t6), an interrupt (INT) is set, signifying that EN will be switched low after the KILL turn-off (tKILL, OFF DELAY + tKILL, OFF DELAY, ADDITIONAL) timeout period. Once a system has finished performing its power-down operations, it can set KILL low (t7) and thus immediately set EN low, terminating the KILL turn-off 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 LTC2951 is in low power mode (6µA). PB is monitored for a high to low transition.

**Figure 2. Aborted Power-On Sequence for LTC2951-1**

**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_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_KILL, KILL is set low by the µP. This immediately pulls EN low, thus turning off the DC/DC converter.

**Figure 3. µP Turns Off Power (LTC2951-1)**
**APPLICATIONS INFORMATION**

**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, PB is ignored during the internal 256ms timer period. This is shown as $t_{\text{EN/EN, LOCKOUT}}$ in Figure 4.

**LTC2951-1, LTC2951-2 Versions**

The LTC2951-1 (high true EN) and LTC2951-2 (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-off sequence. An external capacitor placed on the OFFT pin adds additional time to the turn-off debounce time. If no capacitor is placed on the OFFT pin, then the turn-off debounce time is given by an internally fixed 32ms timer.

Both versions of the LTC2951 provide extendable KILL turn-off timer, $t_{\text{KILL, OFF DELAY, ADDITIONAL}}$, by connecting an optional external capacitor on the KILLT pin. The default KILL turn-off delay time is 128ms, $t_{\text{KILL, OFF DELAY}}$.

**High Voltage Pins**

The $V_{\text{IN}}$ 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 $V_{\text{IN}}$ is recommended. Furthermore, if the pushbutton switch is physically located far from the LTC2951 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.

**Figure 4. DC/DC Turn-Off Blanking (LTC2951-1)**

![Figure 4. DC/DC Turn-Off Blanking (LTC2951-1)](image-url)
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 ($V_{IN}$). 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 below 0.6V, then an appropriate bypass capacitor should be connected to the KILL pin.
**TYPICAL APPLICATIONS**

**PowerPath™ Switching**

The \( \text{EN} \) open-drain output of the LTC2951-2 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 \( \text{PB} \) pin. Figure 7 shows the LTC2951-2 controlling a two cell Li-Ion battery application. The \( \text{INT} \) and \( \text{KILL} \) pins are connected to the output of the PFET through a resistor divider. The \( \text{KILL} \) pin serves as a voltage monitor. When \( V_{\text{OUT}} \) drops below 6V, the \( \text{EN} \) pin is open-circuited 30µs later.

**PB Pin in a Noisy Environment**

The rugged \( \text{PB} \) pin is designed to operate in noisy environments. Transients below ground (\( >-6V \)) and above \( V_{\text{IN}} \) (\( <33V \)) will not damage the rugged \( \text{PB} \) pin. Additionally, the \( \text{PB} \) pin can withstand ESD HBM strikes up to ±10kV.

In order to keep external noise from coupling inside the LTC2951, place an RC network close to the \( \text{PB} \) pin. A 5k resistor and a 0.1µF capacitor should suffice for most noisy applications (see Figure 8).

![Figure 7. PowerPath Control with 6V Undervoltage Detect](image1)

![Figure 8. Filtering for Noisy PB Traces](image2)
TYPICAL APPLICATIONS

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 \( V_{\text{IN}} \) is recommended (see Figure 9).

Reverse-Battery Protection

To protect the LTC2951 from a reverse-battery connection, place a 1k resistor (R8) in series with the \( V_{\text{IN}} \) 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)

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
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

PACKAGE DESCRIPTION

TS8 Package
8-Lead Plastic TSOT-23
(Reference LTC DWG # 05-08-1637)
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Figure 10. Reverse-Battery Protection Using R8

### 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/LTC905</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>LTC2950</td>
<td>Micropower Pushbutton On/Off Controller</td>
<td>High Voltage Pushbutton Controller with µP Interface and Adjustable On-Time</td>
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<tr>
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<td>Pushbutton On/Off Controller with Voltage Monitoring</td>
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<td>Pushbutton On/Off Controller with MP Interrupt</td>
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<td>Pushbutton PowerPath Controller with Supervisor</td>
<td>Automatic Low Loss Switchover Between DC Sources</td>
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<tr>
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<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>
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<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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