

### FEATURES

- Adjustable Push Button Debounce and Delay Timers
- Low Supply Current: 6 $\mu$ A
- Wide Operating Voltage Range: 2.7V to 26V
- EN Output (LTC2951-1) Allows DC/DC Converter Control
- $\overline{\text{EN}}$  Output (LTC2951-2) Allows Circuit Breaker Control
- Simple Interface Allows Graceful  $\mu$ P Shut Down
- High Input Voltage  $\overline{\text{PB}}$  Pin with Internal Pull Up Resistor
- $\pm 10$ 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

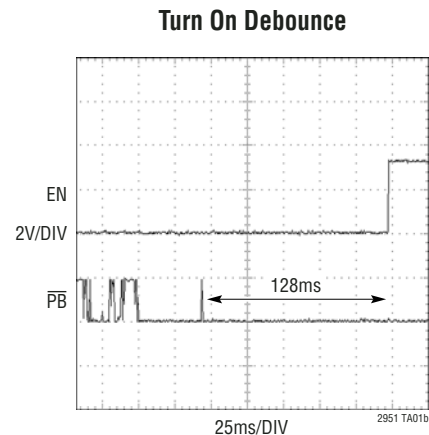
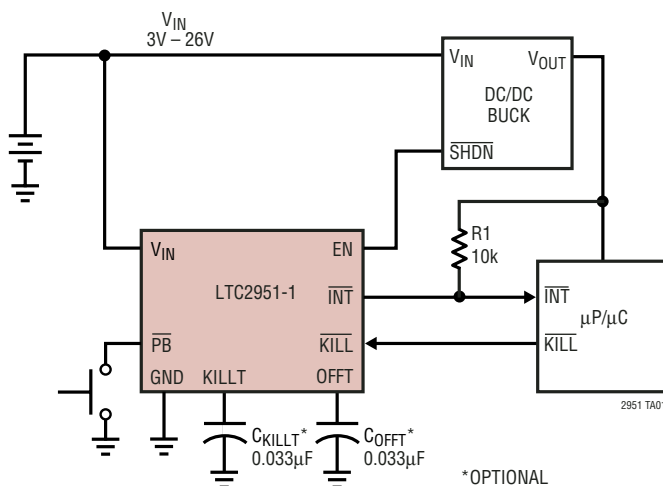
### DESCRIPTION

The LTC<sup>®</sup>2951 is a micropower, wide input voltage range push button ON/OFF controller. The part contains a push button input which controls the toggling of an open drain enable output. The push button 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  $\overline{\text{KILL}}$  timeout delay ensures proper power down.

The LTC2951 operates over a 2.7V to 26V input voltage range to accommodate a variety of input power supplies. Very low quiescent current (6 $\mu$ A 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  $\times$  2mm DFN and ThinSOT packages.

**LT**, LT, LTC and LTM are registered trademarks of Linear Technology Corporation. ThinSOT is a trademark of Linear Technology Corporation. All other trademarks are the property of their respective owners.

### TYPICAL APPLICATION



# LTC2951-1/LTC2951-2

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage ( $V_{IN}$ ) .....	-0.3V to 33V	Operating Temperature Range	
Input Voltages		LTC2951C-1 .....	0°C to 70°C
$\overline{PB}$ .....	-6V to 33V	LTC2951C-2 .....	0°C to 70°C
KILLT .....	-0.3V to 2.7V	LTC2951I-1 .....	-40°C to 85°C
OFFT .....	-0.3V to 2.7V	LTC2951I-2 .....	-40°C to 85°C
KILL .....	-0.3V to 7V	Storage Temperature Range	
Output Voltages		DFN Package.....	-65°C to 125°C
$\overline{INT}$ .....	-0.3V to 10V	TSOT-23.....	-65°C to 150°C
EN/ $\overline{EN}$ .....	-0.3V to 10V	Lead Temperature (Soldering, 10 sec) .....	300°C

## PACKAGE/ORDER INFORMATION

<p>DDB8 PACKAGE 8-LEAD (3mm × 2mm) PLASTIC DFN <math>T_{JMAX} = 125^{\circ}\text{C}</math>, <math>\theta_{JA} = 165^{\circ}\text{C/W}</math> EXPOSED PAD (PIN 9) UNCONNECTED</p>		<p>TS8 PACKAGE 8-LEAD PLASTIC TSOT-23 <math>T_{JMAX} = 125^{\circ}\text{C}</math>, <math>\theta_{JA} = 140^{\circ}\text{C/W}</math></p>	
ORDER PART NUMBER	DDB PART* MARKING	ORDER PART NUMBER	TS8 PART* MARKING
LTC2951CDDB-1	LBTB	LTC2951CTS8-1	LTBTC
LTC2951CDDB-2	LBDT	LTC2951CTS8-2	LTBTF
LTC2951IDDB-1	LBTB	LTC2951ITS8-1	LTBTC
LTC2951IDDB-2	LBDT	LTC2951ITS8-2	LTBTF
<b>Order Options</b> Tape and Reel: Add #TR Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF Lead Free Part Marking: <a href="http://www.linear.com/leadfree/">http://www.linear.com/leadfree/</a>			

Consult factory for parts specified with wider operating temperature ranges.

\* The temperature grade is identified by a label on the shipping container.

## 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

295112fa

## 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
<b>Push Button Pin (<math>\overline{\text{PB}}</math>)</b>							
$V_{\overline{\text{PB}}}(\text{MIN, MAX})$	$\overline{\text{PB}}$ Voltage Range	Single-Ended	●	-1		26.4	V
$I_{\overline{\text{PB}}}$	$\overline{\text{PB}}$ Input Current	$2.5\text{V} < V_{\overline{\text{PB}}} < 26.4\text{V}$	●			$\pm 1$	$\mu\text{A}$
		$V_{\overline{\text{PB}}} = 1\text{V}$	●	-1	-6	-12	$\mu\text{A}$
		$V_{\overline{\text{PB}}} = 0.6\text{V}$	●	-3	-9	-15	$\mu\text{A}$
$V_{\overline{\text{PB}}}(\text{VTH})$	$\overline{\text{PB}}$ 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
<b>Timing Pins (KILLT, OFFT)</b>							
$I_{\text{KILLT, OFFT}}(\text{PU})$	KILLT/OFFT Pull Up Current	$V_{\text{KILLT, OFFT}} = 0\text{V}$	●	-2.4	-3	-3.6	$\mu\text{A}$
$I_{\text{KILLT, OFFT}}(\text{PD})$	KILLT/OFFT Pull Down Current	$V_{\text{KILLT, OFFT}} = 1.3\text{V}$	●	2.4	3	3.6	$\mu\text{A}$
$t_{\text{DB, ON}}$	Turn On Debounce Time	$\overline{\text{PB}}$ Falling $\rightarrow$ Enable Asserted	●	100	128	163	ms
$t_{\text{DB, OFF}}$	Internal Turn Off Debounce Time	OFFT Pin Float, $\overline{\text{PB}}$ Falling $\rightarrow$ $\overline{\text{INT}}$ 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
<b><math>\mu\text{P}</math> Handshake Pins (<math>\overline{\text{INT}}</math>, KILL)</b>							
$I_{\overline{\text{INT}}}(\text{LKG})$	$\overline{\text{INT}}$ Leakage Current	$V_{\overline{\text{INT}}} = 3\text{V}$	●			$\pm 1$	$\mu\text{A}$
$V_{\overline{\text{INT}}}(\text{VOL})$	$\overline{\text{INT}}$ Output Voltage Low	$I_{\overline{\text{INT}}} = 3\text{mA}$	●		0.11	0.4	V
$V_{\overline{\text{KILL}}}(\text{TH})$	$\overline{\text{KILL}}$ Input Threshold Voltage	$\overline{\text{KILL}}$ Falling	●	0.57	0.6	0.63	V
$V_{\overline{\text{KILL}}}(\text{HYST})$	$\overline{\text{KILL}}$ Input Threshold Hysteresis		●	10	30	50	mV
$I_{\overline{\text{KILL}}}(\text{LKG})$	$\overline{\text{KILL}}$ Leakage Current	$V_{\overline{\text{KILL}}} = 0.6\text{V}$	●			$\pm 0.1$	$\mu\text{A}$
$t_{\overline{\text{KILL}}}(\text{PW})$	$\overline{\text{KILL}}$ Minimum Pulse Width		●	30			$\mu\text{s}$
$t_{\overline{\text{KILL}}}(\text{PD})$	$\overline{\text{KILL}}$ Propagation Delay	$\overline{\text{KILL}}$ Falling $\rightarrow$ Enable Released	●			30	$\mu\text{s}$
$t_{\overline{\text{KILL, ON BLANK}}}$	$\overline{\text{KILL}}$ Turn On Blanking (Note 3)	$\overline{\text{KILL}} = \text{Low}$ , Enable Asserted $\rightarrow$ Enable Released	●	400	512	650	ms
$t_{\overline{\text{KILL, OFF DELAY}}}$	Internal $\overline{\text{KILL}}$ Turn Off Delay (Note 4)	KILLT Pin Float, $\overline{\text{KILL}} = \text{High}$ , $\overline{\text{INT}}$ Asserted $\rightarrow$ Enable Released	●	100	128	163	ms
$t_{\overline{\text{KILL, OFF DELAY, ADDITIONAL}}}$	Additional Adjustable $\overline{\text{KILL}}$ Turn Off Delay (Note 4)	$C_{\text{KILLT}} = 1500\text{pF}$	●	9	11.5	13.5	ms
$t_{\text{EN}/\overline{\text{EN}}}$ , Lock Out	EN/ $\overline{\text{EN}}$ Lock Out Time (Note 5)	Enable Released $\rightarrow$ Enable Asserted	●	200	256	325	ms
$I_{\text{EN}/\overline{\text{EN}}}(\text{LKG})$	EN/ $\overline{\text{EN}}$ Leakage Current	$V_{\text{EN}/\overline{\text{EN}}} = 1\text{V}$ , Sink Current Off	●			$\pm 0.1$	$\mu\text{A}$
$V_{\text{EN}/\overline{\text{EN}}}(\text{VOL})$	EN/ $\overline{\text{EN}}$ Voltage Output Low	$I_{\text{EN}/\overline{\text{EN}}} = 3\text{mA}$	●		0.11	0.4	V

**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.

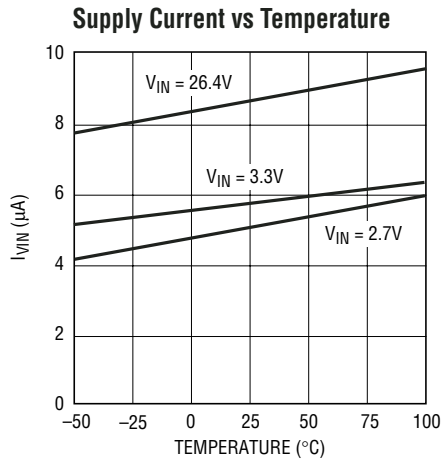
**Note 2:** All currents into pins are positive; all voltages are referenced to GND unless otherwise noted.

**Note 3:** The  $\overline{\text{KILL}}$  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  $\overline{\text{KILL}}$  and  $\overline{\text{PB}}$  inputs are ignored during this period. If  $\overline{\text{KILL}}$  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  $t_{\text{DB, ON}}$ .

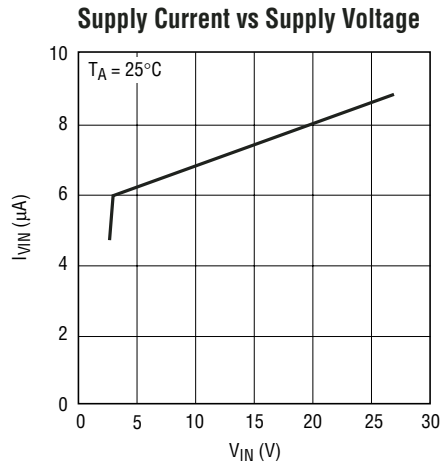
**Note 4:** The internal  $\overline{\text{KILL}}$  turn off delay ( $t_{\overline{\text{KILL, OFF DELAY}}}$ ) is the default delay from the initiation of a power off sequence ( $\overline{\text{INT}}$  falling,  $\overline{\text{KILL}} = \text{high}$ ), to the release of the enable output. The additional,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

**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  $t_{\text{DB, ON}}$ .

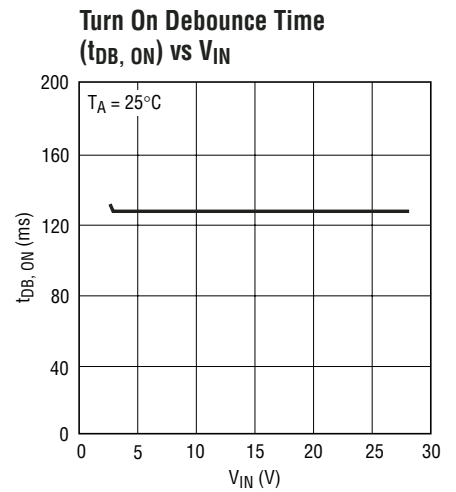
**TYPICAL PERFORMANCE CHARACTERISTICS**



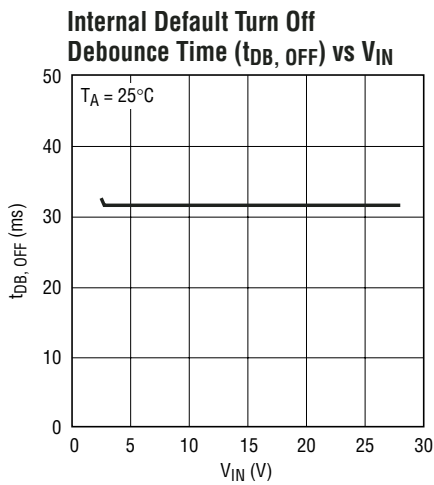
2951 G01



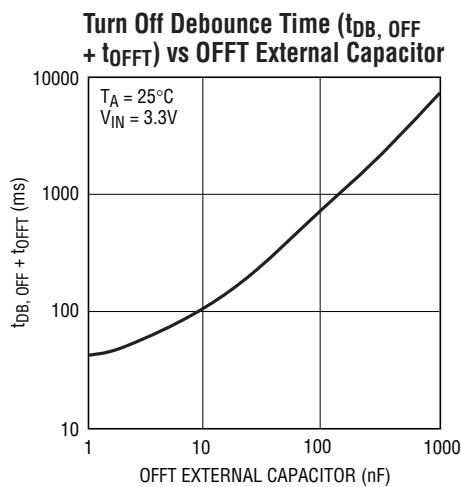
2951 G02



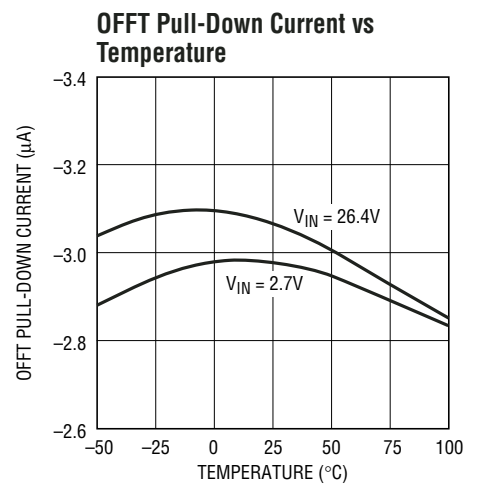
2951 G14



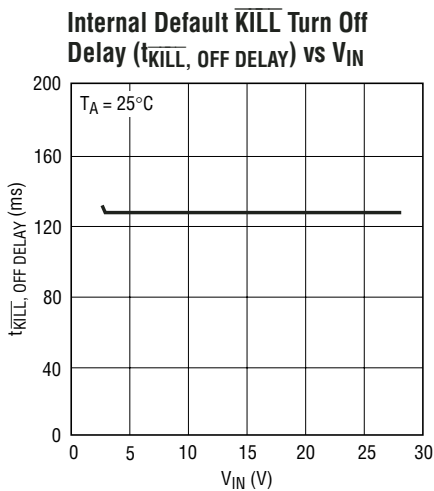
2951 G06



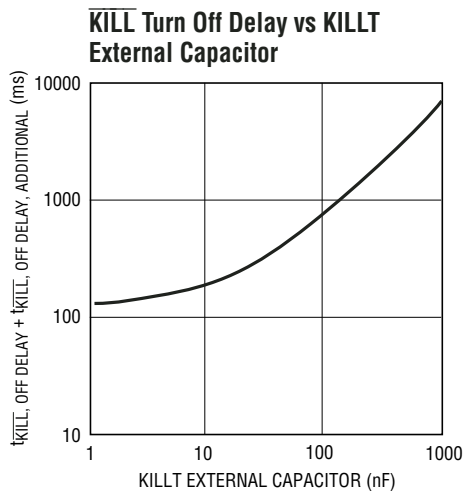
2951 G07



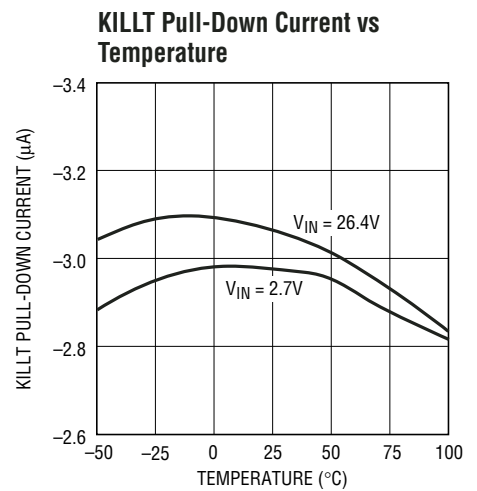
2951 G08



2951 G03

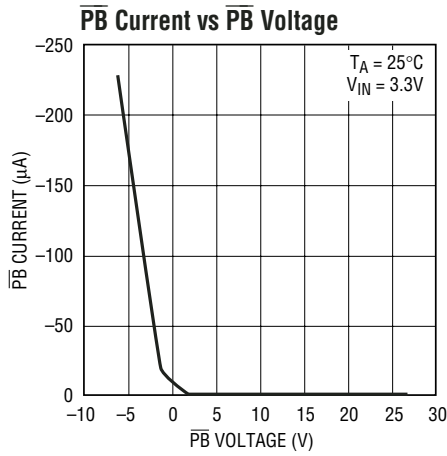


2951 G04

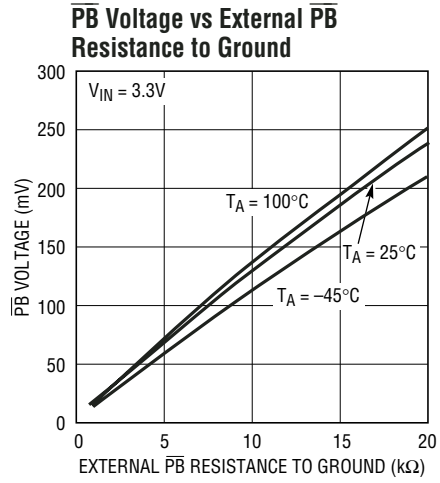


2951 G05

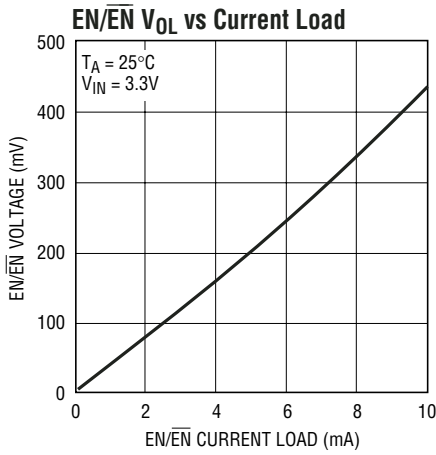
# TYPICAL PERFORMANCE CHARACTERISTICS



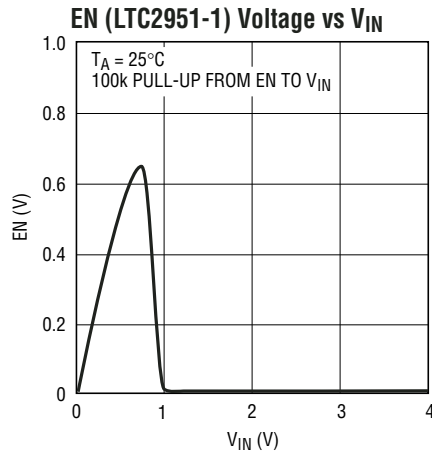
2951 G09



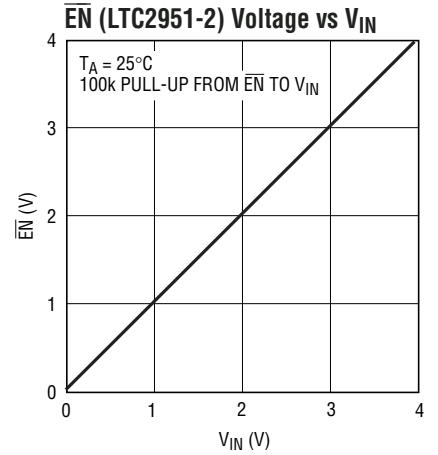
2951 G10



2951 G11



2951 G12



2951 G13

## PIN FUNCTIONS (TSOT-23/DFN)

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

**$\overline{\text{PB}}$  (Pin 2/Pin 3):** Push Button 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.

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

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

**$\overline{\text{INT}}$  (Pin 5/Pin 8):** Open Drain Interrupt Output. After a push button turn-off event is detected ( $t_{\text{DB, OFF}} + t_{\text{OFFT}}$ ), the LTC2951 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 period ( $t_{\text{KILL, OFF DELAY}} + t_{\text{KILL, OFF DELAY, ADDITIONAL}}$ )  $\overline{\text{KILL}}$  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 (LTC2951-1, Pin 6/Pin 7):** Open Drain Enable Output. This pin is intended to enable system power. EN goes high

after a valid  $\overline{\text{PB}}$  turn on event ( $t_{\text{DB, ON}}$ ). EN goes low if: a)  $\overline{\text{KILL}}$  is not driven high within 512ms of the initial valid  $\overline{\text{PB}}$  power turn-on event, b)  $\overline{\text{KILL}}$  is driven low during normal operation, or c) a second valid  $\overline{\text{PB}}$  event (power turn-off) is detected. The operating range for this pin is 0V to 10V. A 100k pull-up is recommended if not available in the DC/DC converter.

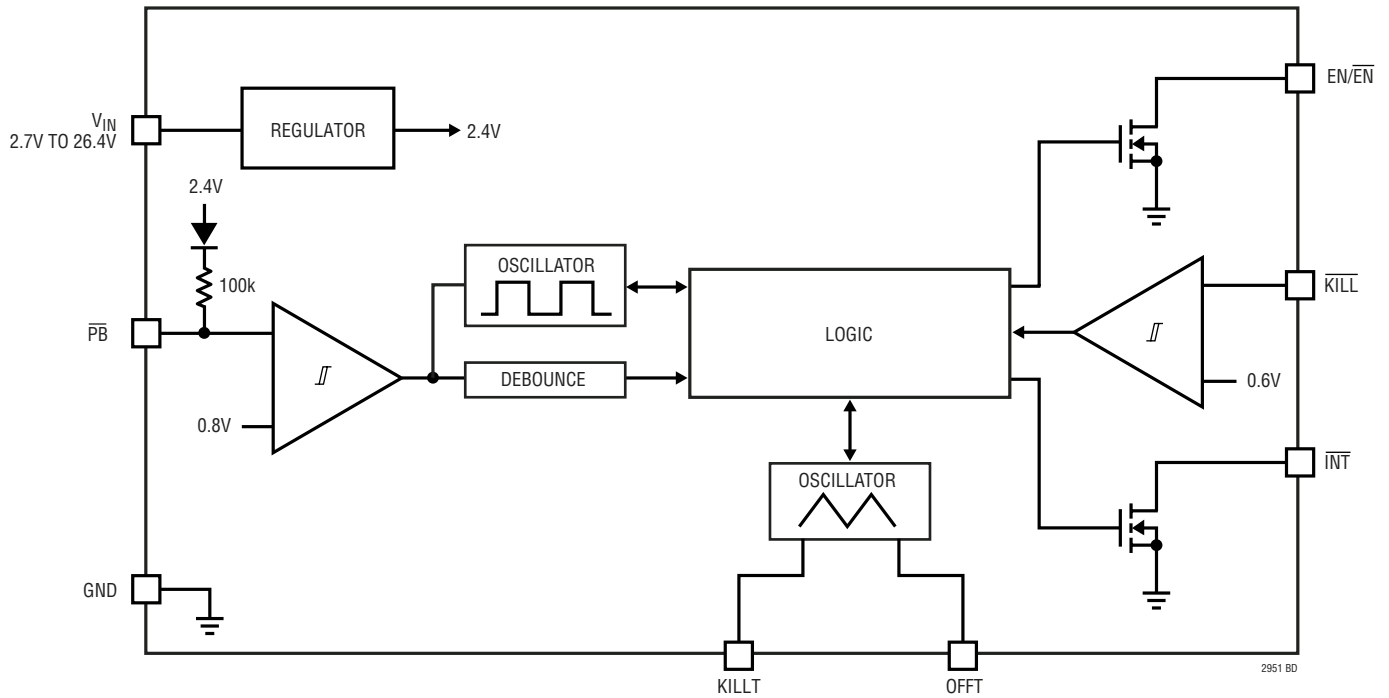
**$\overline{\text{EN}}$  (LTC2951-2, Pin 6/Pin 7):** Open Drain Enable Output. This pin is intended to enable system power.  $\overline{\text{EN}}$  is asserted low after a valid  $\overline{\text{PB}}$  turn-on event ( $t_{\text{DB, ON}}$ ).  $\overline{\text{EN}}$  releases high if: a)  $\overline{\text{KILL}}$  is not driven high within 512ms of the initial valid  $\overline{\text{PB}}$  power turn-on event, b)  $\overline{\text{KILL}}$  is driven low during normal operation, or c) a second valid  $\overline{\text{PB}}$  event (power turn-off) is detected. The operating range of this pin is 0V to 10V. A 100k pull-up is recommended if not available in the DC/DC converter.

**OFFT (Pin 7/Pin 6):** Additional Adjustable Turn Off Time Input ( $t_{\text{OFFT}}$ ). A capacitor to ground determines the additional time (beyond the internal default 32ms,  $t_{\text{DB, OFF}}$ ) 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 debounce time of 32ms.

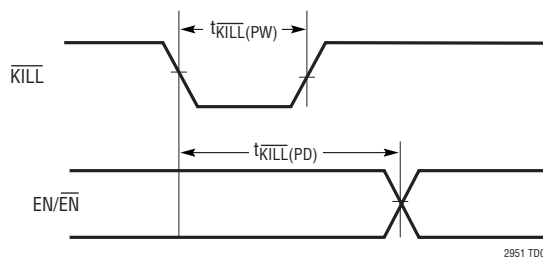
**$\overline{\text{KILL}}$  (Pin 8/Pin 5):**  $\overline{\text{KILL}}$  Input. Forcing  $\overline{\text{KILL}}$  low releases the enable output. During system turn on, this pin is blanked by a 512ms internal timer ( $t_{\text{KILL, ON BLANK}}$ ) to allow the system to pull  $\overline{\text{KILL}}$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

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

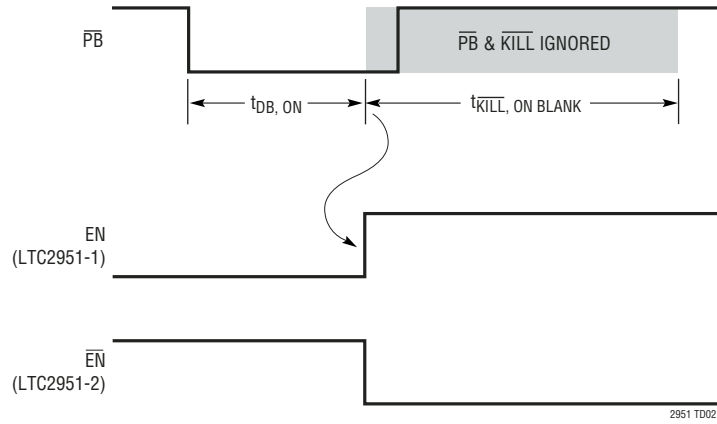
## BLOCK DIAGRAM



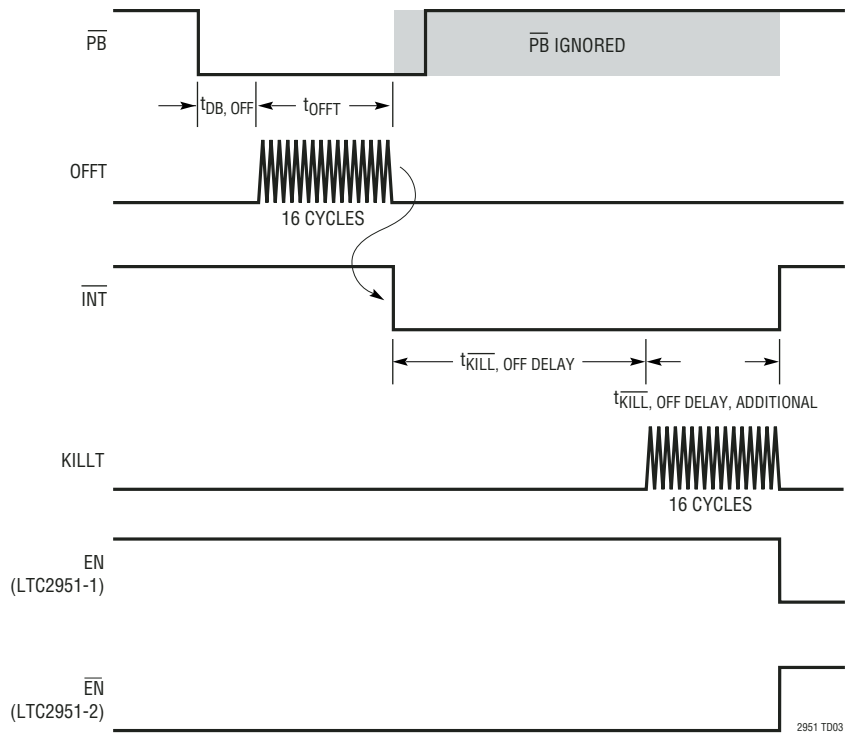
## TIMING DIAGRAMS



## TIMING DIAGRAMS



Power On Timing



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



## APPLICATIONS INFORMATION

### Description

The LTC2951 is a low power (6 $\mu$ A), wide input voltage range (2.7V to 26.4V), push button On/Off controller that can interface to a  $\mu$ P and a power supply. The part incorporates all the flexible timing needed to debounce the push button input ( $\overline{\text{PB}}$ ). The LTC2951 also provides a simple interface ( $\overline{\text{INT}}$  output,  $\overline{\text{KILL}}$  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 push button 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/ $\overline{\text{EN}}$  pin will therefore be off. To assert the enable output,  $\overline{\text{PB}}$  must be held low for a minimum of 128ms ( $t_{\text{DB, ON}}$ ).

Once the enable output is asserted, any DC/DC converters connected to this pin are turned on. The  $\overline{\text{KILL}}$  input from the  $\mu$ P is ignored during the 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  $\mu$ P. 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  $\mu$ P to perform its power down and house-keeping tasks.

### $\overline{\text{KILL}}$ Turn Off Delay

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

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

Note that  $\overline{\text{KILL}}$  can be driven 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 LTC2951-1 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 128ms ( $t_2 - t_1$ ). 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  $\mu$ P 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 LTC2951 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 LTC2951 monitors  $\overline{\text{PB}}$



## APPLICATIONS INFORMATION

and  $\overline{\text{KILL}}$  (for a turnoff command) while consuming only  $6\mu\text{A}$  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 after the  $\overline{\text{KILL}}$  turn off ( $t_{\overline{\text{KILL}}}$ , OFF DELAY +  $t_{\overline{\text{KILL}}}$ , OFF DELAY, ADDITIONAL) timeout period. 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  $\overline{\text{KILL}}$  turn off 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 LTC2951 is in low power mode ( $6\mu\text{A}$ ).  $\overline{\text{PB}}$  is monitored for a high to low transition.

### 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  $t_{\overline{\text{KILL}}}$ ,  $\overline{\text{KILL}}$  is set low by the

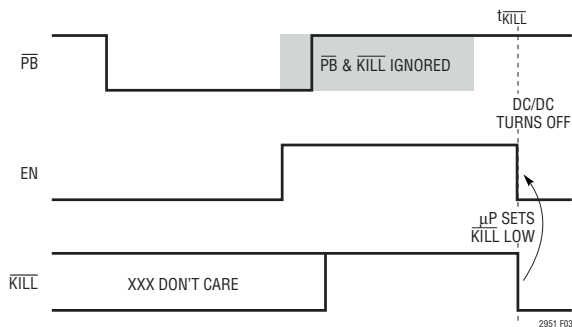


Figure 3.  $\mu\text{P}$  Turns Off Power (LTC2951-1)

$\mu\text{P}$ . 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  $\mu\text{P}$  has always powered down completely before it is restarted.

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

### LTC2951-1, LTC2951-2 Versions

The LTC2951-1 (high true EN) and LTC2951-2 (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 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  $\overline{\text{KILL}}$  turn off timer,  $t_{\overline{\text{KILL}}}$ , OFF DELAY, ADDITIONAL, by connecting an optional external capacitor on the KILLT pin. The default  $\overline{\text{KILL}}$  turn off delay time is 128ms,  $t_{\overline{\text{KILL}}}$ , OFF DELAY.

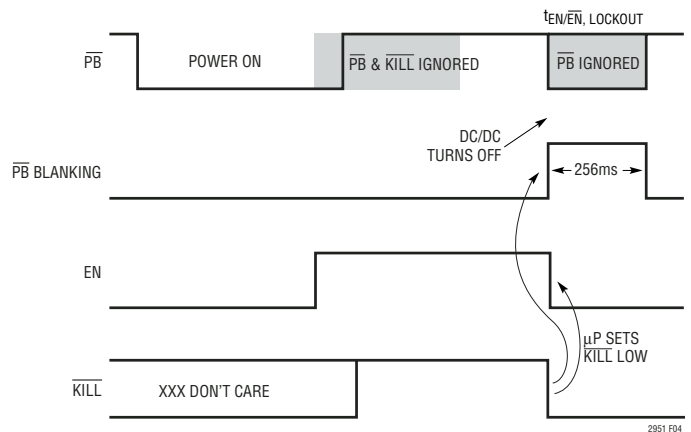


Figure 4. DC/DC Turn Off Blanking (LTC2951-1)

## APPLICATIONS INFORMATION

### 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 push button switch connected to  $\overline{PB}$  exhibits high leakage current, then an external pull-up resistor to  $V_{IN}$  is recommended. Furthermore, if the push button switch is physically located far from the LTC2951  $\overline{PB}$  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 push button 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.

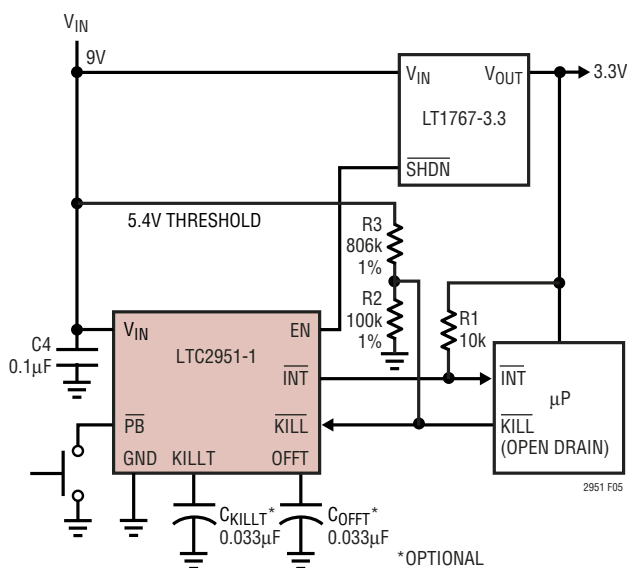


Figure 5. Input Voltage Monitoring with  $\overline{KILL}$  Input

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

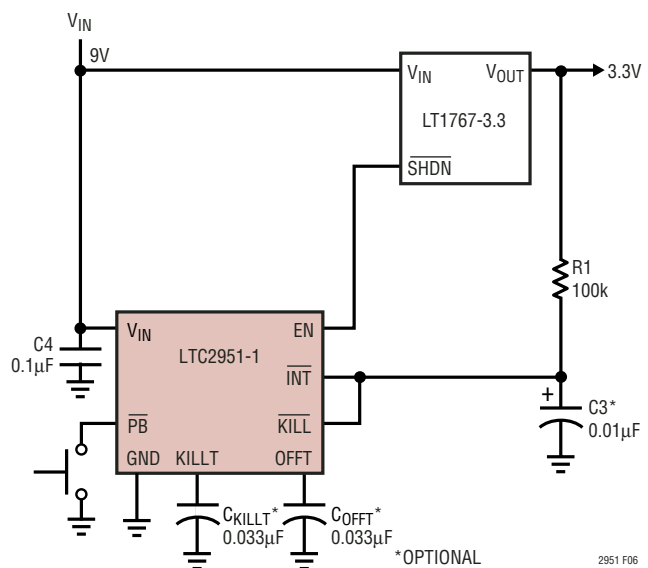


Figure 6. No  $\mu P$  Application

## TYPICAL APPLICATIONS

### Power Path Switching

The  $\overline{\text{EN}}$  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  $\overline{\text{PB}}$  pin. Figure 7 shows the LTC2951-2 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 $\mu\text{s}$  later.

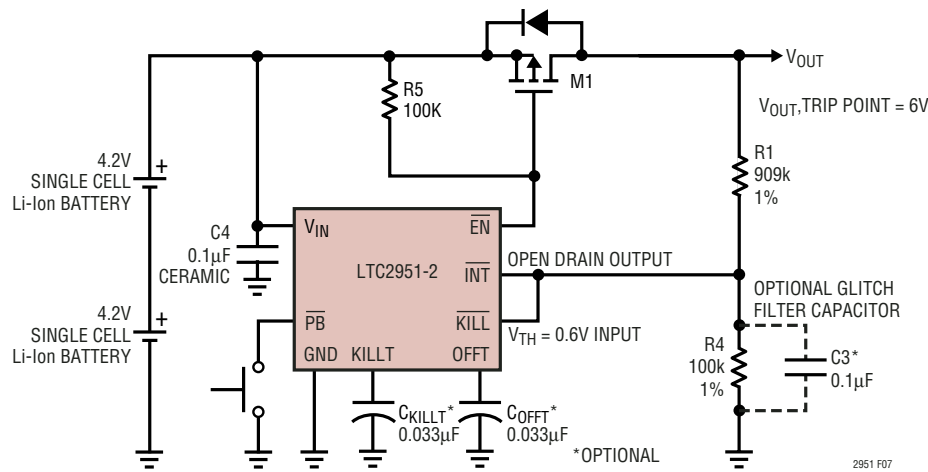


Figure 7. Power Path Control with 6V Under Voltage Detect

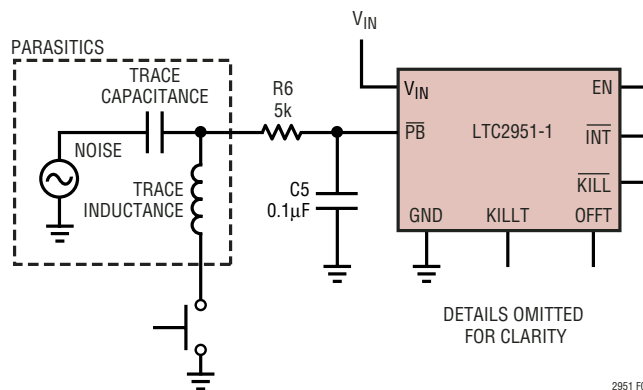


Figure 8. Filtering for Noisy  $\overline{\text{PB}}$  Traces

### $\overline{\text{PB}}$ 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  $V_{\text{IN}}$  ( $< 33\text{V}$ ) 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 LTC2951, 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).

## TYPICAL APPLICATIONS

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

An internal pull-up resistor on the  $\overline{PB}$  pin makes an external pull-up resistor unnecessary. Leakage current on the  $\overline{PB}$  board trace, however, will affect the open circuit voltage on the  $\overline{PB}$  pin. If the leakage is too large ( $>2\mu\text{A}$ ), the  $\overline{PB}$  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).

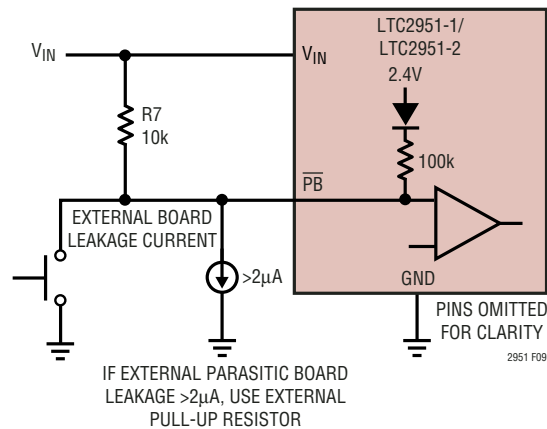
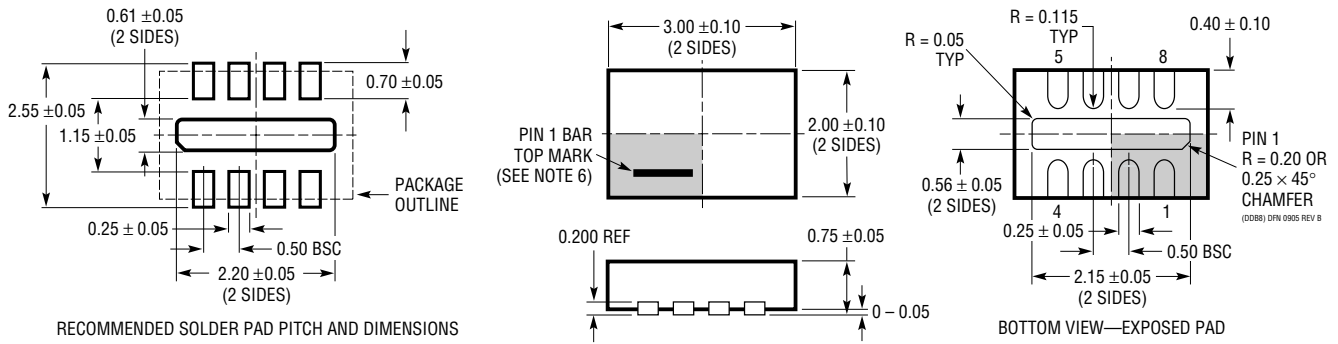


Figure 9. External Pull-Up Resistor on  $\overline{PB}$  Pin

# PACKAGE DESCRIPTION

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

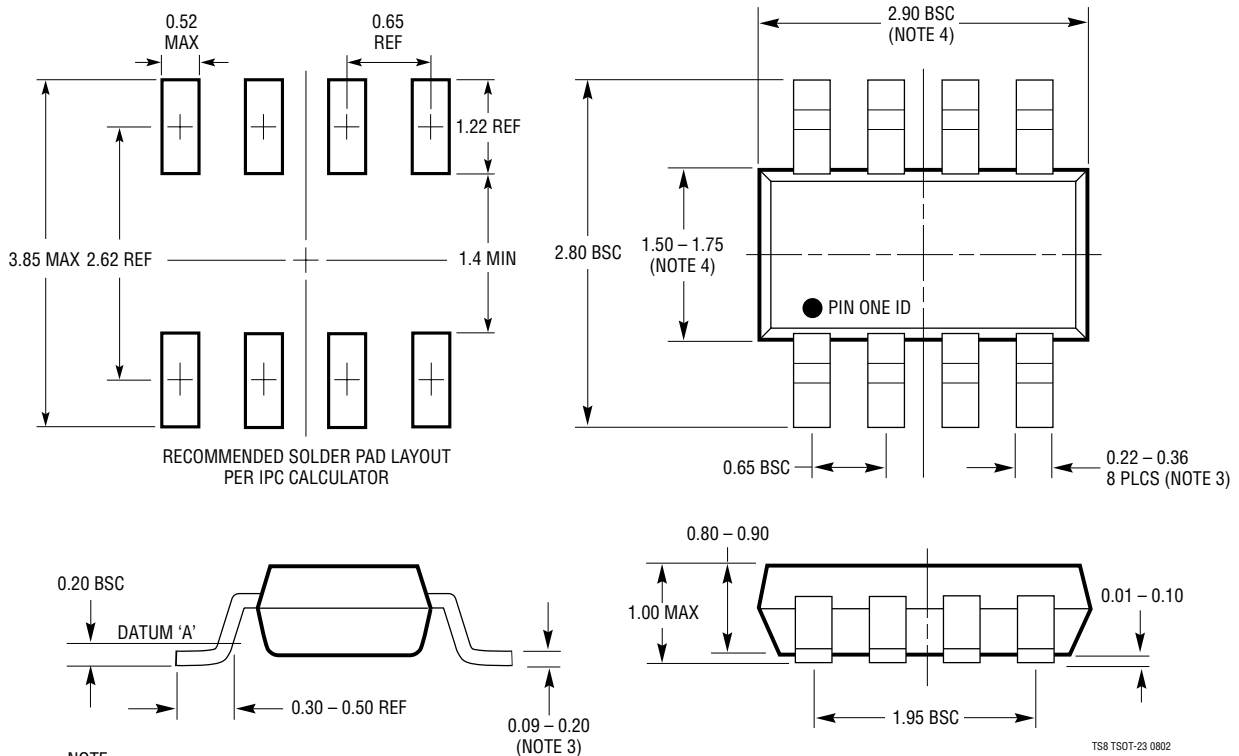


RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS

**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

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



**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 M0-193

# LTC2951-1/LTC2951-2

## TYPICAL APPLICATION

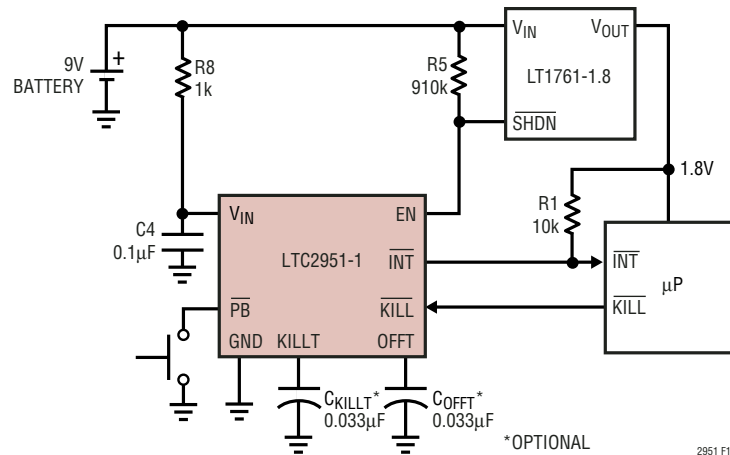


Figure 10. Reverse Battery Protection Using R8

## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC2900	Programmable Quad Supply Monitor	Adjustable $\overline{\text{RESET}}$ , 10-Lead MSOP and 3mm x 3mm DFN Packages
LTC2904/2905	Pin-Programmable Dual Supply Monitors	Adjustable $\overline{\text{RESET}}$ and Tolerance, 8-Lead SOT-23 and 3mm x 2mm DFN Packages
LTC2950	Micropower Push Button On/Off Controller	High Voltage Push Button Controller with $\mu\text{P}$ Interface and Adjustable ON Time
LTC4411	2.6A Low Loss Ideal Diode in ThinSOT	No External MOSFET, Automatic Switching Between DC Sources
LTC4412HV	Power Path 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