Pushbutton On/Off Controller with Automatic Turn-On

FEATURES

- **Automatic Turn-On Via Voltage Monitor Input**
- **Wide Input Supply Range: 1.5V to 36V**
- **Low Supply Current: 1.2µA**
- **±25kV ESD HBM on $\overline{PB}$ Input**
- **±36V Wide Input Voltage for $\overline{PB}$ Input**
- Low Leakage EN Output Allows DC/DC Converter Control (LTC2955-1)
- High Voltage $\overline{EN}$ Output Drives External P-Channel MOSFET (LTC2955-2)
- Simple Interface Allows Graceful µP Shutdown
- Adjustable Turn-Off Timer
- 10-Lead 3mm × 2mm DFN and 8-Lead ThinSOT™ Packages

APPLICATIONS

- Desktop and Notebook Computers
- GPS Devices
- Portable Instruments
- Automotive Electronics

DESCRIPTION

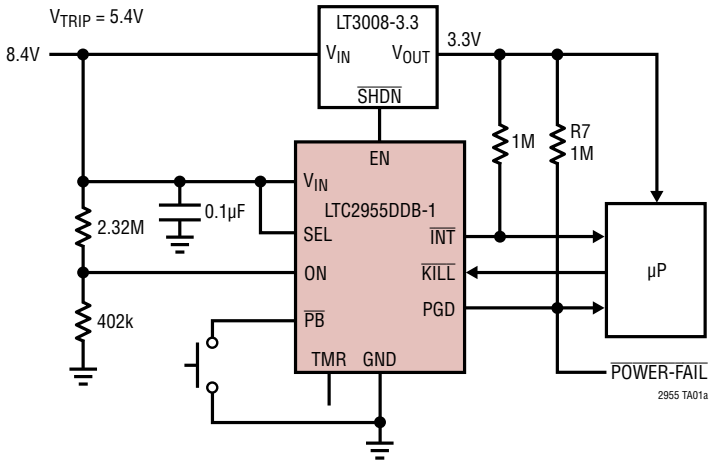
The LTC®2955 is a micropower, pushbutton on/off controller that manages system power by generating a clean enable output from the supply monitor input and the debounced pushbutton input. It features an interrupt output that notifies the system of a pushbutton or low supply event. When the system is ready, it may use the power kill input to shut off power. If the pushbutton remains pressed for more than the configurable turn-off duration, the system power is forced off.

The supply input covers a wide range from 1.5V to 36V. The robust pushbutton input handles wide voltage swings of ±36V and ESD strikes to ±25kV (human body model) without latchup or damage. A low 1.2µA supply current maximizes battery run time. Separate versions are available for positive or negative enable polarities.

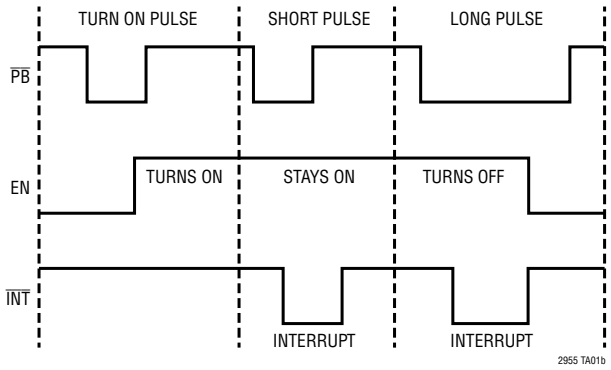
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TYPICAL APPLICATION

Automatic Turn-On with Power-Fail Indication



Pushbutton On/Off with Interrupt



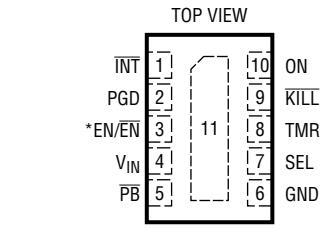
ABSOLUTE MAXIMUM RATINGS

(Note 1)

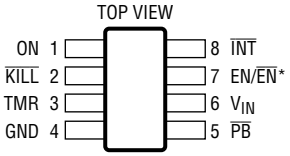
V_{IN} ..... –0.3V to 40V
Input Voltages
  $\overline{PB}$ ..... –40V to 40V
  ON ..... –0.3V to 40V
  SEL ..... –0.3V to 40V
  $\overline{KILL}$ ..... –0.3V to 6V
Output Voltages
  EN/$\overline{EN}$ ..... –0.3V to 40V
  $\overline{INT}$ ..... –0.3V to 6V
  PGD ..... –0.3V to 6V
  TMR ..... –0.3V to 2.7V

Operating Temperature Range
  LTC2955C ..... 0°C to 70°C
  LTC2955I ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec)
  TSOT-23 Package ..... 300°C

PIN CONFIGURATION



DDB PACKAGE
10-LEAD (3mm × 2mm) PLASTIC DFN
T_{JMAX} = 125°C, θ_{JA} = 55°C/W
EXPOSED PAD (PIN 11) PCB GND CONNECTION OPTIONAL
*PIN 3 IS EN FOR LTC2955-1
AND IS $\overline{EN}$ FOR LTC2955-2



TS8 PACKAGE
8-LEAD PLASTIC TSOT-23
T_{JMAX} = 125°C, θ_{JA} = 195°C/W
*PIN 7 IS $\overline{EN}$ FOR LTC2955-1
AND IS $\overline{EN}$ FOR LTC2955-2

ORDER INFORMATION (http://www.linear.com/product/LTC2955#orderinfo)

Lead Free Finish

TAPE AND REEL (MINI)	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC2955CDDB-1#TRMPBF	LTC2955CDDB-1#TRPBF	LGBJ	10-Lead (3mm × 2mm) Plastic DFN	0°C to 70°C
LTC2955CDDB-2#TRMPBF	LTC2955CDDB-2#TRPBF	LGBM	10-Lead (3mm × 2mm) Plastic DFN	0°C to 70°C
LTC2955IDDB-1#TRMPBF	LTC2955IDDB-1#TRPBF	LGBJ	10-Lead (3mm × 2mm) Plastic DFN	–40°C to 85°C
LTC2955IDDB-2#TRMPBF	LTC2955IDDB-2#TRPBF	LGBM	10-Lead (3mm × 2mm) Plastic DFN	–40°C to 85°C
LTC2955CTS8-1#TRMPBF	LTC2955CTS8-1#TRPBF	LTGBK	8-Lead Plastic TSOT-23	0°C to 70°C
LTC2955CTS8-2#TRMPBF	LTC2955CTS8-2#TRPBF	LTGBN	8-Lead Plastic TSOT-23	0°C to 70°C
LTC2955ITS8-1#TRMPBF	LTC2955ITS8-1#TRPBF	LTGBK	8-Lead Plastic TSOT-23	–40°C to 85°C
LTC2955ITS8-2#TRMPBF	LTC2955ITS8-2#TRPBF	LTGBN	8-Lead Plastic TSOT-23	–40°C to 85°C

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

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

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

For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 7V unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Supply							
V_{IN}	Supply Voltage Range		●	1.5		36	V
I_{IN}	V_{IN} Supply Current		●	0.5	1.2	3	µA
V_{UVL}	V_{IN} Undervoltage Lockout	V_{IN} Rising	●	1.0	1.15	1.3	V
$V_{UVL(HYST)}$	V_{IN} Undervoltage Lockout Hysteresis		●	30	85	200	mV
Input Pins							
$V_{PB(MIN(MAX))}$	$\overline{PB}$ Voltage Range		●	–36		36	V
V_{PB}	$\overline{PB}$ Input Threshold	$\overline{PB}$ Falling	●	0.6	0.8	1	V
$V_{PB(HYST)}$	$\overline{PB}$ Input Threshold Hysteresis (Note 3)				40		mV
$V_{PB(VOC)}$	$\overline{PB}$ Open Circuit Voltage	I = –1µA	●	3.0	4.3	5.5	V
I_{PB}	$\overline{PB}$ Input Leakage Current	6V < $\overline{PB}$ < 36V $\overline{PB}$ = 1V $\overline{PB}$ = –36V	● ● ●	 –1 	 –4 	±10 –8 –400	µA µA µA
V_{ON}	ON Threshold	ON Rising	●	0.76	0.80	0.84	V
$V_{ON(HYST)}$	ON Hysteresis	DFN Package Only			40		mV
I_{ON}	ON Input Leakage Current	ON = 1V ON = 36V	● ●	 	 	±10 ±100	nA nA
V_{KILL}	$\overline{KILL}$ Input Threshold Voltage	$\overline{KILL}$ Falling	●	0.76	0.80	0.84	V
$V_{KILL(HYST)}$	$\overline{KILL}$ Input Threshold Hysteresis (Note 3)				30		mV
I_{KILL}	$\overline{KILL}$ Input Leakage Current	$\overline{KILL}$ = 1V	●			±50	nA
V_{SEL}	SEL Input Threshold		●	0.4	0.8	1.2	V
I_{SEL}	SEL Input Current	SEL = 1V SEL = 36V	● ●	 	 	±50 ±100	nA nA
Output Pins							
$V_{EN/\overline{EN}(VOL)}$	EN/$\overline{EN}$ Voltage Output Low	I = 1mA	●		0.175	0.4	V
$V_{EN(VOH)}$	EN Voltage Output High (LTC2955-1)	I = 0µA, –0.5µA	●	1.5		5.5	V
$V_{\overline{EN}(VOH)}$	$\overline{EN}$ Voltage Output High (LTC2955-2)	I = 0µA, –0.5µA	●	V_{IN} – 1.5			V
I_{EN}	EN Pull-Up Current (LTC2955-1)	EN = 0V	●	–1.2	–2	–2.8	µA
$I_{\overline{EN}}$	$\overline{EN}$ Pull-Up Resistance (LTC2955-2)		●	0.45	0.9	1.35	MΩ
$V_{INT(VOL)}$	$\overline{INT}$ Voltage Output Low	I = 3mA	●			0.4	V
I_{INT}	$\overline{INT}$ Leakage Current	$\overline{INT}$ = 5V	●			±50	nA
$V_{PGD(VOH)}$	PGD Voltage Output High	I = 0µA, –0.5µA	●	1.5		5.5	V
$V_{PGD(VOL)}$	PGD Voltage Output Low	I = 3mA	●			0.4	V
I_{PGD}	PGD Pull-Up Current	PGD = 0V	●	–1.2	–2	–2.8	µA
$I_{TMR(PU)}$	TMR Pull-Up Current	TMR = 0V	●	–2	–3	–4	µA
$I_{TMR(PD)}$	TMR Pull-Down Current	TMR = 1.5V	●	2	3	4	µA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 7V unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Timing							
$t_{DB(ON)}$	$\overline{PB}$, ON Turn-On Debounce Time	$\overline{PB}$ Falling or ON Rising → Enable Asserted	●	19	32	45	ms
$t_{DB(OFF)}$	$\overline{PB}$ Interrupt Debounce Time	$\overline{PB}$ Falling → $\overline{INT}$ Falling	●	19	32	45	ms
t_{TMR}	Additional Turn-Off Debounce Time	C_{TMR} = 2200pF	●	5.8	11.5	17.2	ms
$t_{INT(MIN)}$	Minimum $\overline{INT}$ Pulse Width	$\overline{INT}$ Falling → TMR Rising	●	19	32	45	ms
$t_{ON(PD)}$	ON Interrupt Delay	ON Falling → $\overline{INT}$ Falling, V_{SEL} > 0.8V	●			200	µs
$t_{PGD(PD)}$	PGD Propagation Delay	ON Falling → PGD Falling	●			200	µs
$t_{KILL(PD)}$	$\overline{KILL}$ Propagation Delay	$\overline{KILL}$ Falling → Enable Released	●			60	µs
$t_{KILL(PW)}$	$\overline{KILL}$ Minimum Pulse Width		●	60			µs
$t_{KILL(ON\ BLANK)}$	$\overline{KILL}$ Turn-On Blanking (Note 4)	$\overline{KILL}$ Low, Enable Asserted → Enable Released	●	304	512	720	ms
$t_{EN(LOCK\ OUT)}$	EN/$\overline{EN}$ Lockout Time (Note 5)	Enable Released → Enable Asserted	●	0.6	1	1.4	s

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: Guaranteed by design, not subject to test.

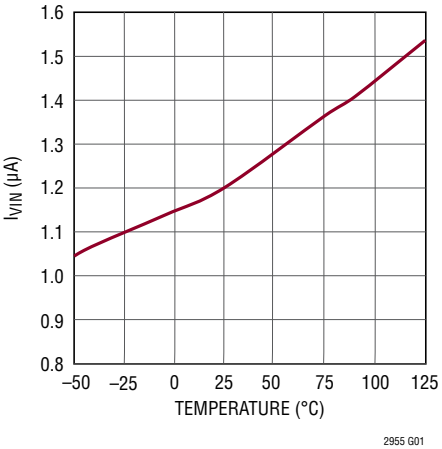
Note 4: The $\overline{KILL}$ turn-on blanking time is the waiting period immediately after the enable output is asserted. This blanking time allows sufficient time for the regulator and the µP to perform power-up tasks. The $\overline{KILL}$, $\overline{PB}$, and ON inputs are ignored during this period.

Note 5: The enable lockout time is the waiting period immediately after the enable output is released. It allows an application to properly power-down such that the next power-up sequence starts from a consistent powered down configuration. $\overline{PB}$ and ON are ignored during this period.

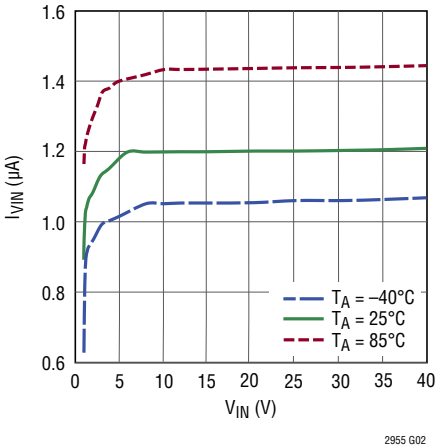
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 7V, T_A = 25°C, unless otherwise noted.

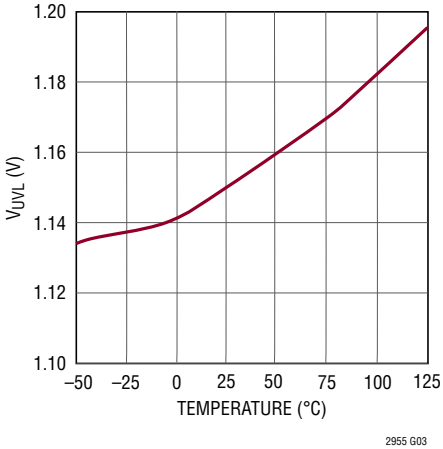
Supply Current vs Temperature



Supply Current vs Supply Voltage



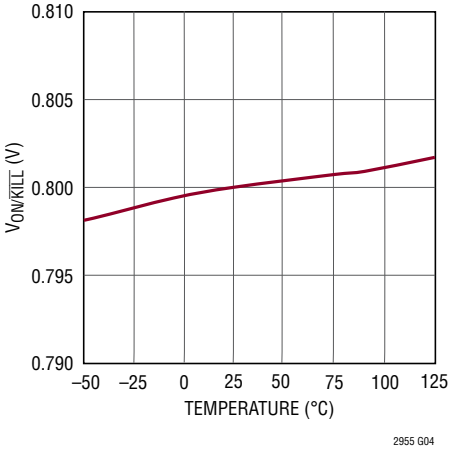
Undervoltage Lockout vs Temperature



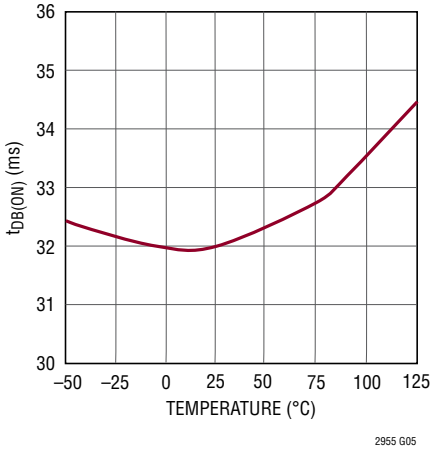
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 7V, T_A = 25°C, unless otherwise noted.

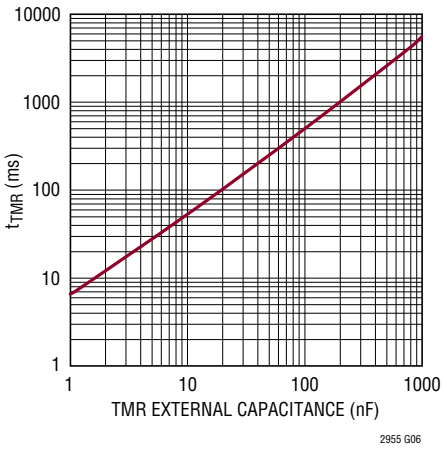
ON/$\overline{KILL}$ Threshold vs Temperature



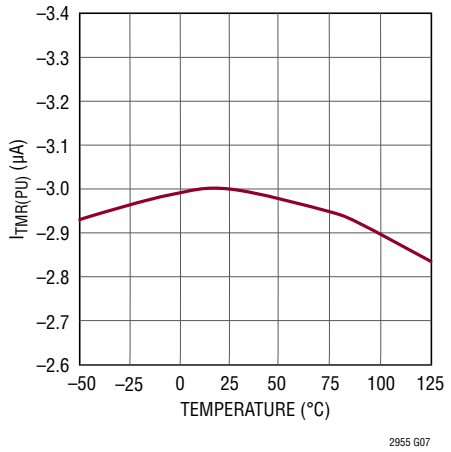
Turn-On Debounce Time vs Temperature



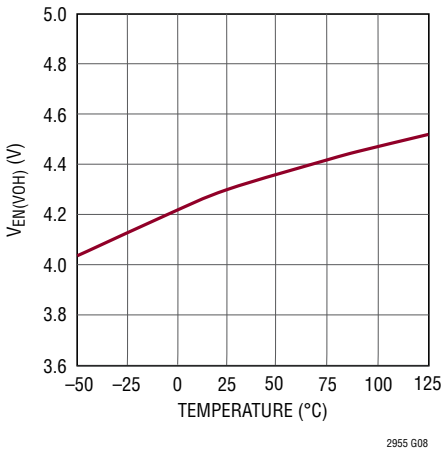
Additional Turn-Off Debounce Time vs TMR External Capacitance



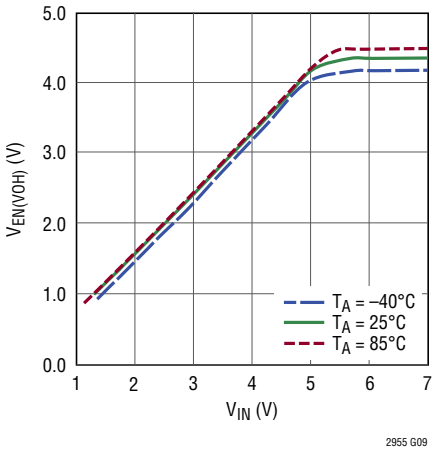
TMR Pull-Up Current vs Temperature



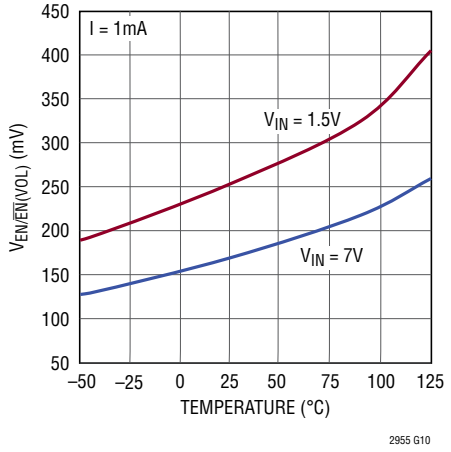
EN Output High Voltage vs Temperature



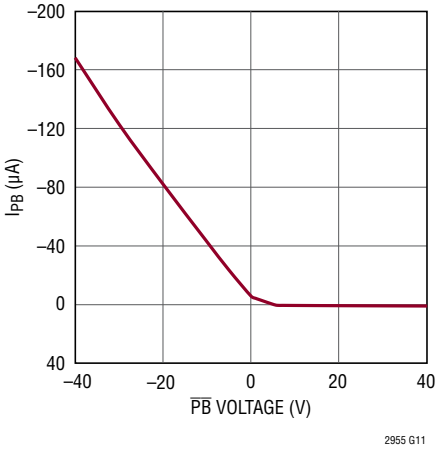
EN Output High Voltage vs Supply Voltage



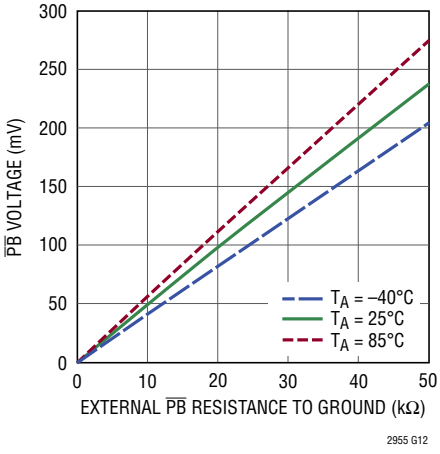
EN/$\overline{EN}$ Output Low Voltage vs Temperature



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



$\overline{PB}$ Voltage vs External $\overline{PB}$ Resistance to Ground



PIN FUNCTIONS

EN: Enable Output (LTC2955-1). EN is an active high output to control the turn-on/off of the system power. Connect this pin to the RUN or $\overline{\text{SHUTDOWN}}$ pin of the voltage regulator. The LTC2955 asserts EN high when the pushbutton is pressed or when ON goes high. The output high voltage follows the internal LDO output which provides sufficient margin for most $\overline{\text{SHUTDOWN}}$ pin thresholds.

$\overline{\text{EN}}$: Inverted Enable Output (LTC2955-2). $\overline{\text{EN}}$ is an active low output to control the turn-on/off of the system power. It may drive a voltage regulator's active low enable input, or it may drive the gate of a P-channel MOSFET. In the turn-off state, the LTC2955 pulls this pin to V_{IN} through an internal 900k resistor. The LTC2955 pulls $\overline{\text{EN}}$ to GND when the pushbutton is pressed or when ON goes high.

Exposed Pad (DFN only): Exposed pad. Leave open or connect to device ground.

GND: Device Ground.

$\overline{\text{INT}}$: Open Drain Interrupt Output. Connect this pin to the interrupt input of the system with a pull-up resistor to the system supply. The LTC2955 asserts the $\overline{\text{INT}}$ pin low when it receives the turn-off command from the pushbutton or the ON pin. The minimum pulse width of the $\overline{\text{INT}}$ signal is 32ms and can be extended through the TMR pin.

$\overline{\text{KILL}}$: Kill Input. A low at $\overline{\text{KILL}}$ releases the enable output (EN/$\overline{\text{EN}}$). This pin can be driven by the microprocessor or it can be used as a voltage monitor input. Tie to the system power supply or an external voltage of 1.2V~5V if unused.

ON: Monitor Input. Connect this pin to an external resistive divider from the monitored voltage. This allows automatic system turn-on when the monitored voltage transitions high. For the DFN part, if the SEL pin is tied high, it also allows automatic system turn-off when the monitored voltage transitions low. Tie to GND if unused.

$\overline{\text{PB}}$: Pushbutton Input. This is an active low input with a 900k pull-up to an internal LDO. Connect one terminal of the pushbutton to this pin and connect the other terminal of the pushbutton to GND. The pin may be left open if unused.

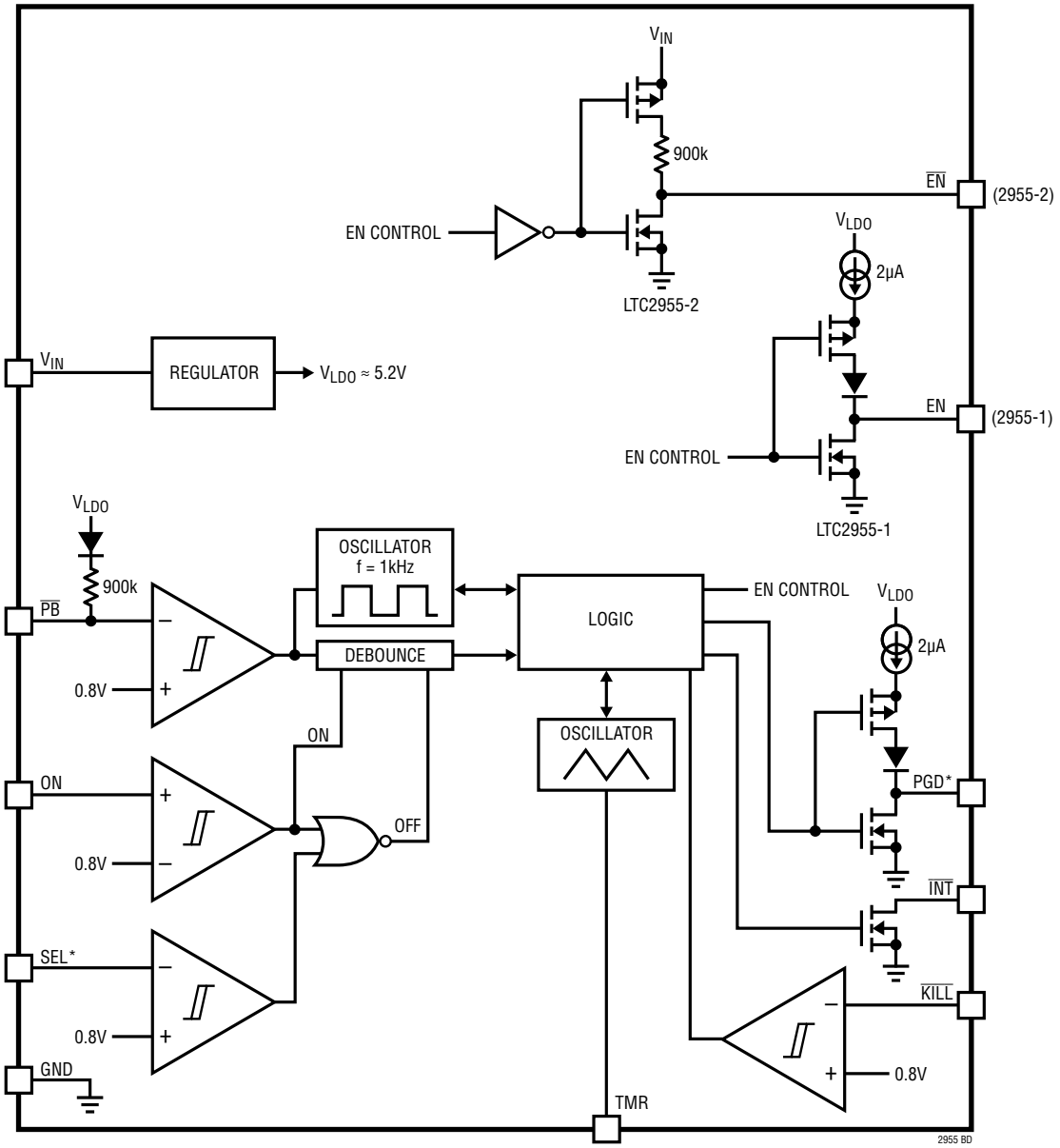
PGD (DFN only): ON Status Output. A high on this pin indicates that the voltage at the ON pin is above the input threshold of 0.8V. This pin can be used as a system input to inform the system whether the turn-on was triggered by the ON pin or the pushbutton pin. Leave open if unused.

SEL (DFN only): Mode Select Input. Connect SEL to GND to block the ON pin falling edge from activating system turn-off. Connect SEL to V_{IN} to allow both the ON pin rising and falling edges to activate system turn-on and turn-off respectively. For the TSOT package, SEL is internally tied to GND. Do not leave open.

TMR: Timer Pin. A capacitor to ground determines the additional time (5.2 seconds/µF) beyond the default 64ms that the pushbutton must be held low before immediately releasing the EN/$\overline{\text{EN}}$ and $\overline{\text{INT}}$ outputs. The turn-off debounce time defaults to 64ms if this pin is left open. To disable the ability to force a system power-down with a pushbutton press, ground the TMR pin.

V_{IN}: Power Supply Input. For > 20V applications, connect V_{IN} to the power source through a 1k resistor and bypass V_{IN} to GND with a 10nF low ESR capacitor.

BLOCK DIAGRAM



*DFN ONLY

OPERATION

Overview

The LTC2955 is a pushbutton on/off controller that manages system power based on a pushbutton input ($\overline{PB}$ pin) and a voltage monitor input (ON pin). In a typical application, the enable output (EN/$\overline{EN}$) turns on system power when the pushbutton is pressed or the supply monitor detects the presence of a primary or secondary supply such as a wall adaptor or car battery.

After the system is powered up, a pushbutton event asserts the interrupt output ($\overline{INT}$) which can be used in menu driven applications to request for a system power-down. A power kill input ($\overline{KILL}$) allows a microprocessor or system to release the enable output immediately, effectively powering down the system. System power is also forced off if the pushbutton remains asserted for more than the forced turn-off activation time configurable via the TMR pin.

The LTC2955 is also designed with a blanking time after each system turn on and off event. During this blanking time, the LTC2955 ignores the $\overline{KILL}$, ON and $\overline{PB}$ pins, thus ensuring that the system stays on/off for a minimum amount of time. This provides sufficient time for the voltage regulator to turn on/off and allows it to charge/discharge its output to the final voltage. It also allows the µP sufficient time to perform power on/off tasks.

The PGD output indicates the status of the ON pin to allow the system to differentiate between pushbutton turn-on or supply plug-in events.

Turn-On Sequence and KILL Blanking Time

The LTC2955-1 asserts the EN output high if the pushbutton is pressed or the ON pin goes high. This is typically used to turn on a DC/DC converter or linear regulator.

Figure 1 shows the turn-on sequence of the LTC2955-1 initiated by the $\overline{PB}$ pin. When the button is pressed at time t_1, a high to low transition on the $\overline{PB}$ pin initiates the turn-on sequence. The $\overline{PB}$ pin must stay low continuously for a period of 32ms ($t_{DB(ON)}$) before the LTC2955-1 asserts the EN output high. Once EN goes high (t_2), an internal 512ms blanking time ($t_{\overline{KILL}(OnBlank)}$) is started. During this blanking time, the LTC2955-1 ignores the $\overline{KILL}$, ON and $\overline{PB}$ pins and keeps EN high for at least 512ms. This provides sufficient time for the voltage regulator to turn on and charge its output to the final voltage and allows the µP enough time to perform power on tasks. The µP must pull the $\overline{KILL}$ pin high during this 512ms blanking time, or else EN will go low at the end of this time (t_3).

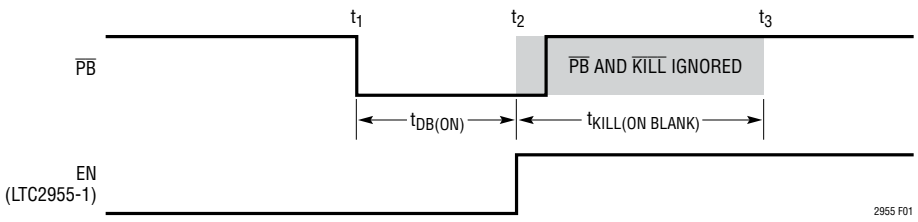


Figure 1. Pushbutton Turn-On Timing

OPERATION

At the end of this blanking time, the LTC2955-1 will check that the $\overline{PB}$ pin is high. If the $\overline{PB}$ pin remains low, it will be ignored until a high is detected on the pin. The next low on the $\overline{PB}$ pin will initiate a turn-off sequence.

Figure 2 shows a similar LTC2955-1 turn-on sequence with the ON pin going high. The timing sequence is very similar to that initiated by the pushbutton. The PGD output follows the ON pin.

$\overline{PB}$ Pin Turn-Off Sequence

Figure 3 shows the turn-off sequence of the LTC2955-1 initiated through the $\overline{PB}$ pin. A turn-off sequence refers to the LTC2955-1 releasing the EN output. This turns off the voltage regulator.

A high to low transition on $\overline{PB}$ (t_1) starts the turn-off sequence. In order to assert $\overline{INT}$ (interrupt output) low, $\overline{PB}$ must stay low continuously for 32ms ($t_{DB(OFF)}$). At the end of the 32ms (t_2), the $\overline{INT}$ pin is asserted low and will stay low for at least 32ms ($t_{INT(MIN)}$), even if the $\overline{PB}$ pin goes high during this period (t_2 to t_4). When the µP receives this interrupt signal, it should start to perform its power-down functions and assert $\overline{KILL}$ low (t_3) once it is done. The LTC2955-1 will then release $\overline{INT}$ and pull EN low, thus turning off the system power, as shown with dotted lines in Figure 3.

The user can also force the system to power-down if the µP fails to respond to the interrupt signal ($\overline{KILL}$ pin remains

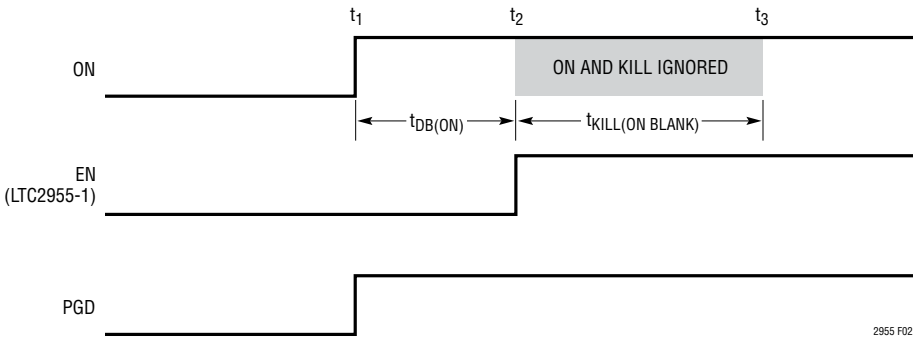


Figure 2.ON Pin Turn-On Timing

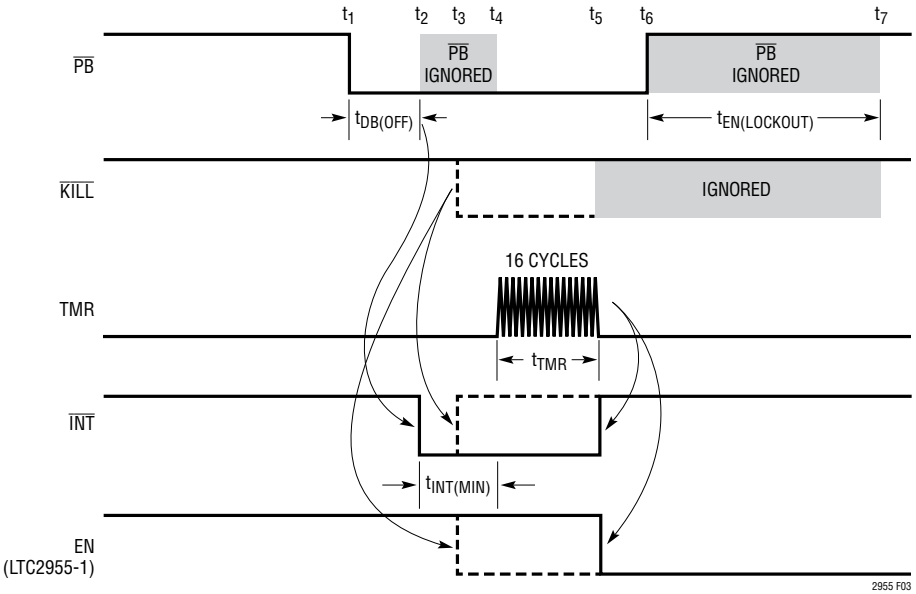


Figure 3. Pushbutton Turn-Off Timing

OPERATION

high). This can be done by holding the pushbutton down for a long period (> $t_{DB(OFF)}$ + $t_{INT(MIN)}$ + t_{TMR}) as shown with the solid lines in Figure 3. If the $\overline{PB}$ pin remains low at the end of the 32ms minimum $\overline{INT}$ pulse width ($t_{INT(MIN)}$), the external timer will start counting (t_4).

The capacitance at the TMR pin determines the duration of this timer and it will count for 16 cycles (t_{TMR}). If the $\overline{PB}$ pin remains low at the end of the 16 cycles (t_5), the LTC2955-1 will force the EN pin low and the $\overline{INT}$ pin high. See Applications Information for adjusting t_{TMR}.

After the EN output goes low and the $\overline{PB}$ pin goes high, the LTC2955-1 starts the one second lockout time ($t_{EN(LOCKOUT)}$). During this lockout time (t_6 to t_7 in Figure 3) the $\overline{PB}$ and ON inputs are ignored. This is to allow time for the voltage regulator to turn off and for its output to decay to 0V. This ensures that the µP has completely powered down before it is allowed to restart. After the one second lockout time, the LTC2955-1 proceeds to the next stage to wait for a turn-on command and the cycle will repeat as above. If the $\overline{PB}$ pin remains low after the EN output goes low, the LTC2955-1 will delay the start of this lockout time until the $\overline{PB}$ pin goes high.

If the $\overline{PB}$ pin goes high when the external timer is still counting, as shown in Figure 4, the turn-off sequence will be aborted. The $\overline{INT}$ pin is forced high immediately and the EN pin remains high.

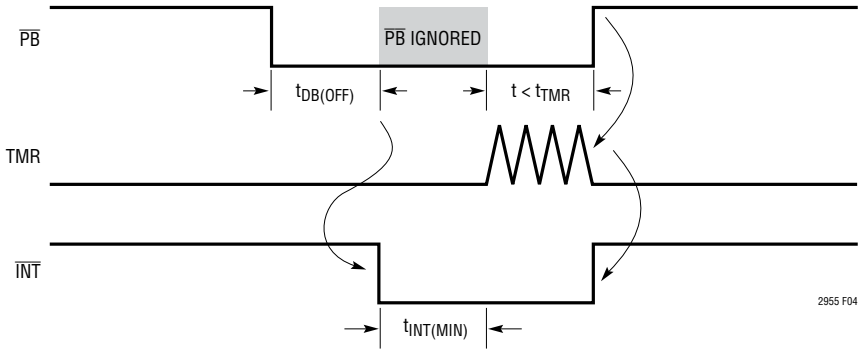


Figure 4. Pushbutton Turn-Off Aborted

OPERATION

ON Pin Turn-Off Sequence (DFN Package Only)

Figure 5 shows the turn-off sequence of the LTC2955-1 initiated by the ON pin. The timing sequence is slightly different from that by the pushbutton as there is no debounce time ($t_{DB(OFF)}$) before the $\overline{INT}$ pin pulls low. The ON pin falling edge can start the turn-off sequence only if the following two conditions are met: (1) The preceding turn-on sequence was initiated by the ON pin rising edge, and (2) The SEL pin must be tied high (>0.8V). For TS8 package, the ON pin falling edge is ignored.

In Figure 5, a high to low transition at ON (t_1) starts the turn-off sequence. The interrupt output ($\overline{INT}$) is asserted immediately when the ON pin goes low. Unlike the $\overline{PB}$ pin turn-off sequence, there is no 32ms debounce time ($t_{DB(FF)}$) for the ON pin going low. This allows the system to initiate a shutdown as soon as the monitored supply is removed and allows the µP the maximum amount of time to perform power-down functions. The $\overline{INT}$ pin will stay low for at least 32ms ($t_{INT(MIN)}$). When the µP receives this interrupt signal, it should start to perform its power-down functions and assert the $\overline{KILL}$ input low (t_2) once it is done. The LTC2955-1 will then release the EN and $\overline{INT}$ outputs, thus turning off the system power, as shown with dotted lines in Figure 5.

If the µP fails to respond ($\overline{KILL}$ pin remains high, as shown with solid line in Figure 5) and the ON pin remains low 32ms after $\overline{INT}$ goes low, the external timer will start counting for 16 cycles (t_{TMR}, t_3 to t_4). If the ON pin remains low at the end of the 16 cycles (t_4), the LTC2955-1 will force the EN pin low and the $\overline{INT}$ pin high. See Applications Information for adjusting t_{TMR}.

After the EN output goes low, the LTC2955-1 starts the one second lockout time ($t_{EN(LOCKOUT)}$). During this lockout time (t_4 to t_5), the $\overline{PB}$ and ON inputs are ignored.

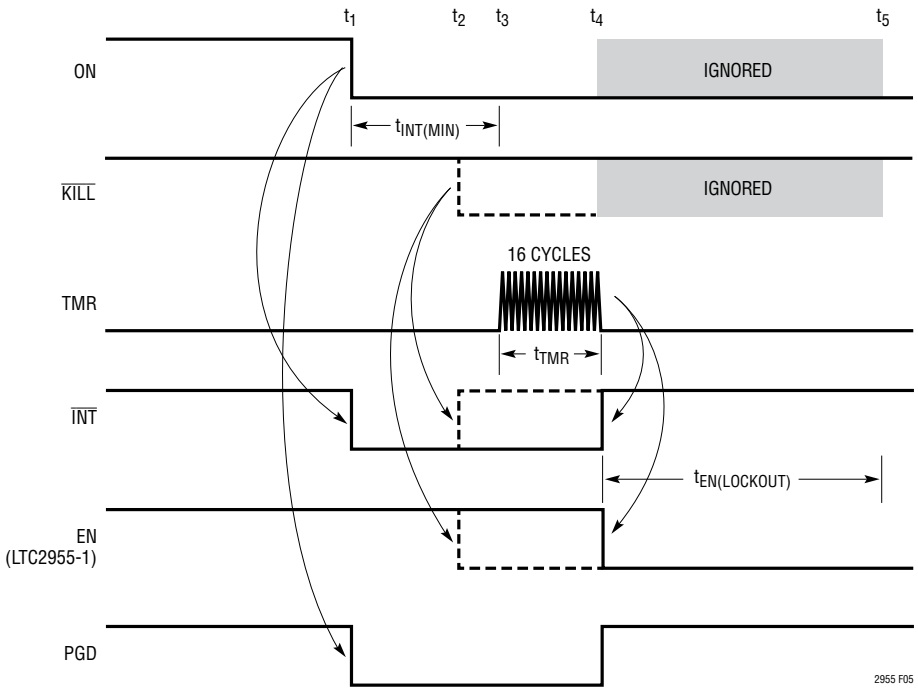


Figure 5. ON Pin Turn-Off Timing (DFN Only, V_{SEL} > 1.2V and the Preceding Turn-On Sequence Was Initiated by the ON Pin Rising Edge

OPERATION

$\overline{PB}$ vs ON Pin

With the DFN package, if the turn-on sequence is initiated by the pushbutton, the ON input is ignored until the pushbutton is pressed again to initiate a turn-off sequence.

As shown in Figure 6, the $\overline{PB}$ pin initiates a turn-on sequence at time t_1 before the ON pin goes high at time t_2. Once EN goes high (t_3), the ON input is ignored, so a falling edge at the ON pin (t_4) will not initiate a turn-off sequence even if the SEL pin is high. This allows the system to remain powered up if it is plugged in and out of a secondary power source while the system is already turned on.

If the turn-on sequence is initiated by the ON pin, both the pushbutton and the ON pin falling edge can initiate the turn-off sequence. For the TS8 package, ON pin falling edge is always ignored regardless of which pins initiate the turn-on.

The $\overline{PB}$ pin has priority over the ON pin, so if the $\overline{PB}$ pin goes low and ON pin goes high at the same time, the LTC2955-1 will monitor the $\overline{PB}$ pin for the 32ms debounce time and ignore the ON pin unless the $\overline{PB}$ pin bounces during the 32ms.

ON Pin Initial Turn-On

If the LTC2955-1 powers up with the ON pin already high, the EN pin will go high after a power-up delay of about one second. Subsequently, if the pushbutton is pressed to force EN low, the LTC2955-1 will not initiate another turn-on even if the ON pin remains high. The LTC2955-1 needs a rising edge at the ON pin or a falling edge on the $\overline{PB}$ pin to initiate the subsequent turn-on.

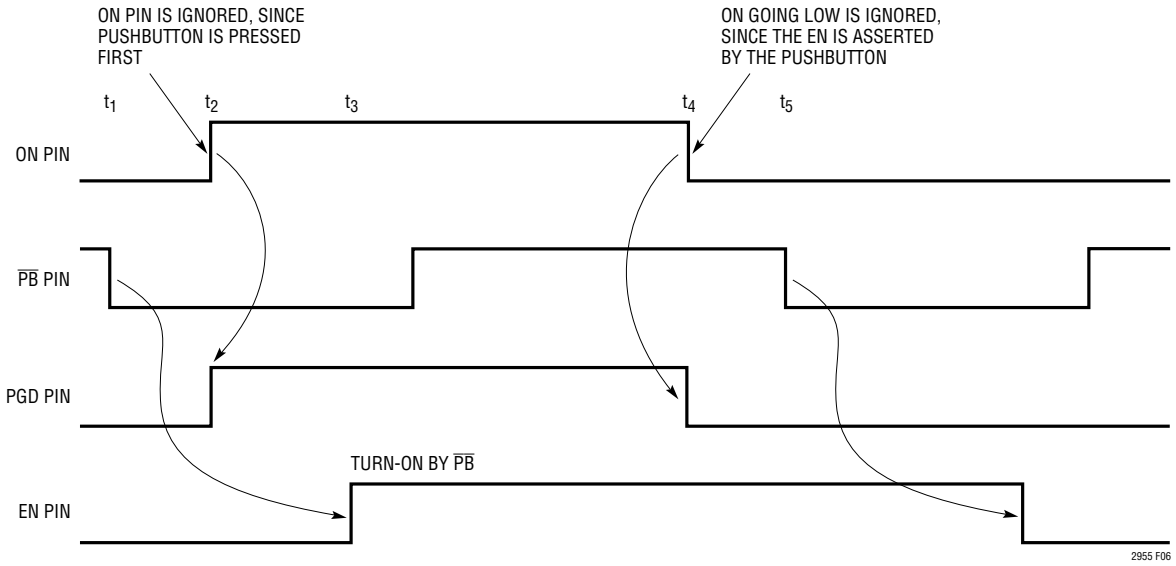


Figure 6. Pushbutton Is Pressed Before the ON Pin Goes High

OPERATION

As shown in Figure 7, if the ON pin is high when power is first applied to the LTC2955-1 at time t_1, the EN pin will go high (at t_2) after the one second EN lockout time. At time t_3, the pushbutton is pressed to activate turn-off while the ON pin remains high. The LTC2955-1 will wait for a rising edge at the ON pin or a low at the $\overline{PB}$ pin to activate the next turn-on. As shown at time t_4, after the one second lockout time, the EN stays low with ON high. At time t_5, only the rising edge of the ON pin or a PB event will trigger the next turn-on again.

LTC2955-1, LTC2955-2 Versions

The LTC2955-1 and LTC2955-2 differ only by the polarity of the high voltage (36V absolute maximum) enable pin. The LTC2955-1 EN pin is a high true output designed to drive the $\overline{SHUTDOWN}$ pin of most voltage regulators. In turn-on mode, this pin is pulled high by a pull-up current of 2µA powered by an internal LDO, which gives a high level output voltage (V_{OH}) of typically 4.3V. In turn-off mode, this pin is pulled low by an internal N-channel MOSFET. If a higher V_{OH} or higher pull-up current is required, connect the EN pin to an external source through a pull-up resistor.

The LTC2955-2 $\overline{EN}$ pin is a low true enable output designed to drive the gate of an external P-channel MOSFET. In turn-on mode, the $\overline{EN}$ pin is pulled low by an internal N-channel MOSFET. In turn-off mode, this pin is pulled high to V_{IN} through an internal 900k resistor. An external pull-up resistor can be connected between this pin and V_{IN} to increase the pull-up current.

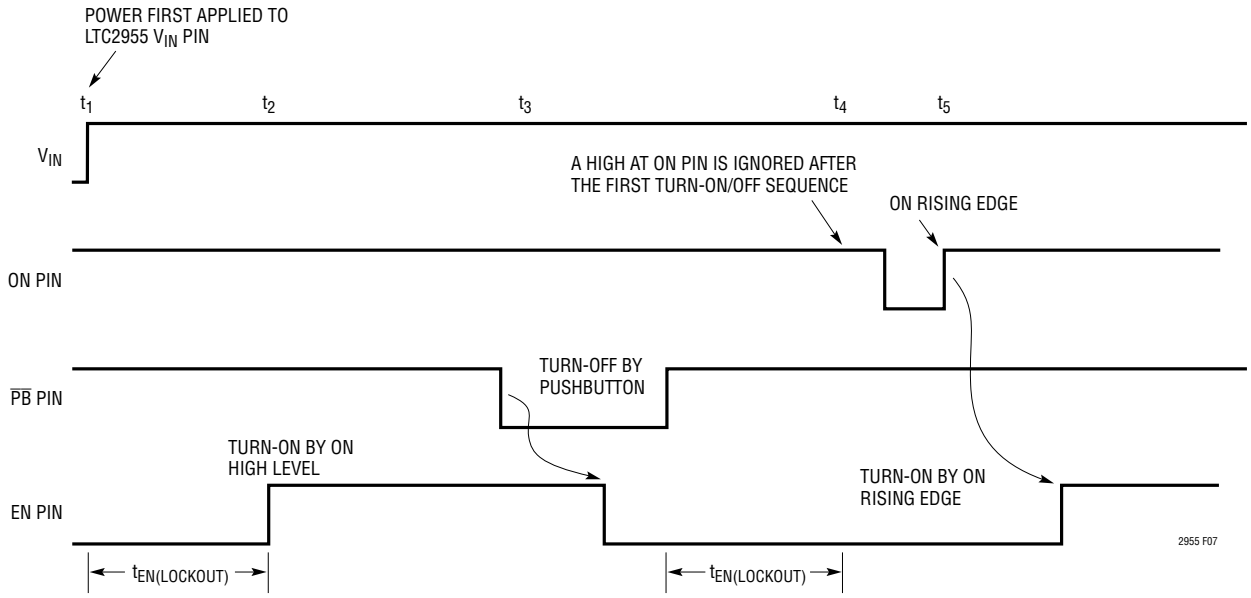


Figure 7. Power First Applied to LTC2955-1

APPLICATIONS INFORMATION

Adjusting the Forced Turn-Off Timing

The LTC2955 allows the user to force the system power to turn off if the µP fails to respond during fault conditions. As shown by the solid lines in Figure 3 and Figure 5, when the µP fails to bring the $\overline{KILL}$ pin low after the interrupt signal is asserted, the user can force a turn-off by holding down the pushbutton. The length of time that $\overline{PB}$ must be held low is given by a fixed 64ms delay ($t_{DB(OFF)}$ + $t_{INT(MIN)}$) plus an adjustable power-down timer delay (t_{TMR}). The adjustable delay is set by placing an optional external capacitor on the TMR pin. Use the following equation to calculate the capacitance for the desired delay. C_{TMR} is the external capacitor at the TMR pin:

$$C_{TMR} = 0.19 \bullet t_{TMR}\ [\mu F/sec]$$

As an example, if the required turn-off debounce time is one second:

$$t_{TMR} = (1000ms - 64ms)$$

$$C_{TMR} = 0.19 \bullet 0.936$$

Required C_{TMR} is 0.178µF

The ON pin turn-off debounce time is 32ms less than the $\overline{PB}$ pin debounce time since there is no $t_{DB(OFF)}$. If the TMR pin is left open, the turn-off debounce time defaults to 64ms for the $\overline{PB}$ pin and 32ms for the ON pin.

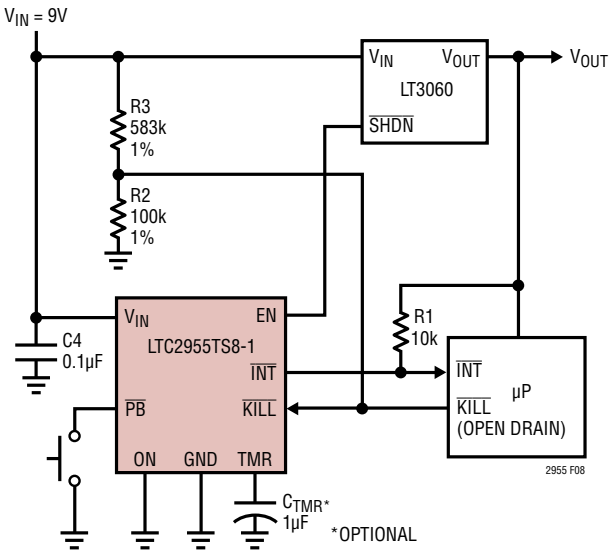


Figure 8. Input Voltage Monitoring with KILL Input

Voltage Monitoring with $\overline{KILL}$ Input

The $\overline{KILL}$ pin can also be used as a voltage monitor input. Figure 8 shows an application where the $\overline{KILL}$ pin has a dual function. It is driven by a low leakage open drain output of the µP. It is also connected to a resistive 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 0.8V 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 0.8V $\overline{KILL}$ comparator.

Operation Without µP

If there is no circuitry available to drive the $\overline{KILL}$ pin, this pin can be connected to a voltage regulator output through a resistive divider or RC network as shown in Figure 9. The $\overline{KILL}$ pin acts as a voltage monitor pin that shuts down the regulator when its output voltage drops below a certain level.

The minimum pulse width needed to trigger $\overline{KILL}$ is 30µs. If there are glitches on the resistor pull-up voltage that are wider than 30µs and transition below 0.8V, then an appropriate bypass capacitor should be connected to the $\overline{KILL}$ pin.

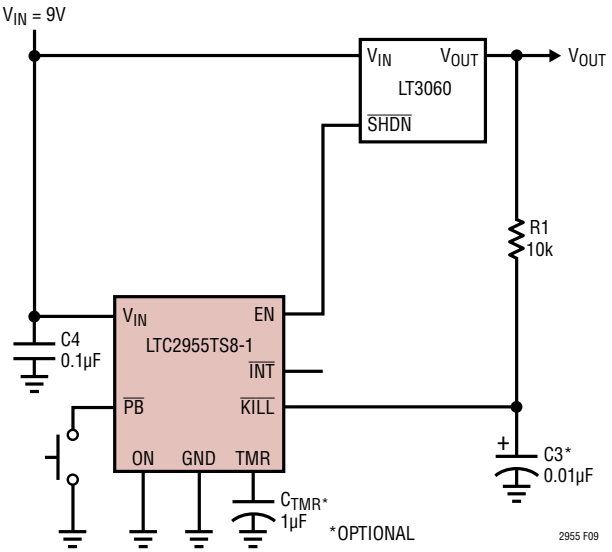


Figure 9. Application without µP

APPLICATIONS INFORMATION

High Voltage PowerPath™ Switching

The high voltage $\overline{EN}$ open drain output of the LTC2955-2 is designed to switch on/off an external power P-channel MOSFET. This allows a user to connect/disconnect a power supply (or battery) to its load by toggling the $\overline{PB}$ pin. Figure 10 shows the LTC2955-2 controlling a two cell Li-Ion battery application. The $\overline{KILL}$ pin is connected to the output of the external MOSFET through a resistive divider. The $\overline{KILL}$ pin serves as a voltage monitor. When V_{OUT} drops below 6V, the $\overline{EN}$ pin is pulled high (to V_{IN}) after 15µs later. R9 slows down the turning on of M1 so as to limit the inrush current when M1 turns on to charge up the capacitor at V_{OUT}. R5 helps to speed up the turning off of M1 and also to keep M1 off when the input voltage rise time is fast.

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

The rugged $\overline{PB}$ pin is designed to operate in noisy environments. Transients below ground and above V_{IN} (–36V < V_{IN} < 36V) will not damage the rugged $\overline{PB}$ pin. Additionally, the $\overline{PB}$ pin can withstand ESD HBM strikes of up to ±25kV.

However, if the pushbutton switch is located physically far from the LTC2955 $\overline{PB}$ pin, the parasitic capacitance and parasitic series inductance of the connecting cable or PCB trace can create problems. The parasitic capacitance can couple external noise onto the $\overline{PB}$ input; placing a 0.1µF capacitor at the pin lessens the impact of this coupling. The parasitic series inductance may cause unpredictable ringing at the $\overline{PB}$ pin; placing a 5.1k resistor from the $\overline{PB}$ pin to the pushbutton switch reduces this ringing. Figure 11 shows an example of this RC network at the $\overline{PB}$ pin.

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

An internal 900k 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 (>1µA), the $\overline{PB}$ voltage may fall close to the threshold window. To

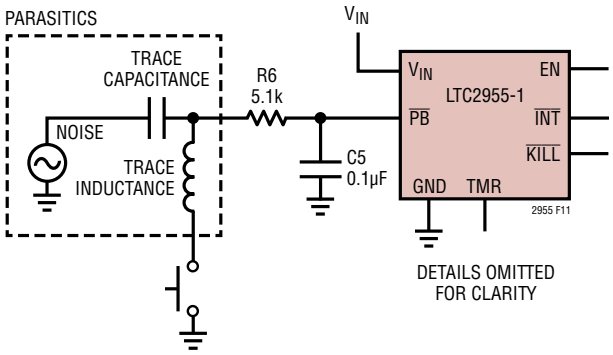


Figure 11. Noisy PB Trace

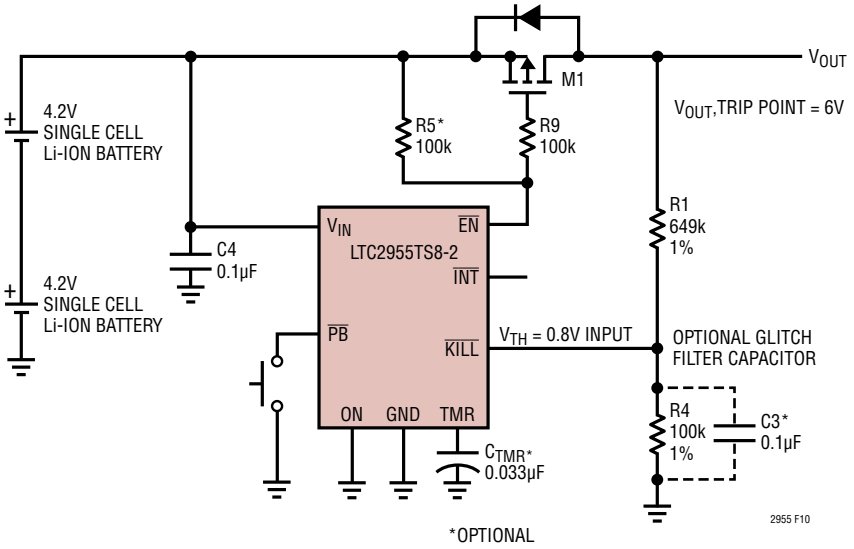


Figure 10. PowerPath Control with 6V Undervoltage Detect

APPLICATIONS INFORMATION

mitigate the effect of the board leakage, a 10k resistor to V_{IN} is recommended (see Figure 12).

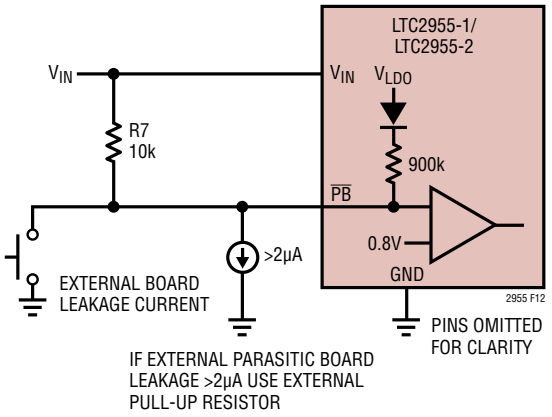


Figure 12. External Pull-Up Resistor on $\overline{PB}$ Pin

Enhancing V_{IN} Ruggedness

Placing a 1k resistor and a 10nF capacitor at the V_{IN} pin can be used to enhance ruggedness in some applications.

A 1k resistor in series with the V_{IN} pin allows the LTC2955 to withstand reverse-input voltages. The LTC2955's V_{IN} pin is internally clamped to one diode voltage below ground. In battery operated applications where a battery could be inserted improperly, this resistor will limit the current and allow internal clamping to protect the pin.

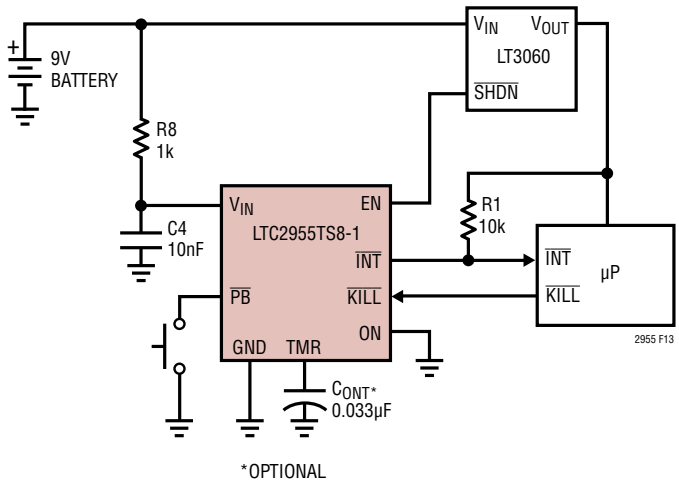


Figure 13. Enhancing V_{IN} Ruggedness

Adding a 10nF capacitor in addition to the 1k resistor can protect against high voltage input transients that would exceed the 40V Absolute Maximum Voltage rating of the V_{IN} pin. These could occur during hot-plugging into a battery or AC adapter. This can also protect against transients that may appear on the PCB ground during large ESD strikes at the $\overline{PB}$ pin.

The maximum operating current of the LTC2955 is less than 3µA, creating an insignificant voltage drop across the resistor. Using a capacitor value of 10nF provides sufficient filtering for most applications and larger values can actually diminish its effectiveness.

Applications with Slide Switch

In some applications, to prevent accidental toggling of the system power, a slide switch is preferred over a pushbutton. Figure 14 shows a slide switch added in series with the pushbutton. The user can slide the switch open to activate the HOLD/LOCK function, where the pushbutton is disabled. Figure 15 shows a slide switch connected to the LTC2955 ON pin resistive divider. If the user slides the switch to the ON position, the LTC2955 ON pin is high

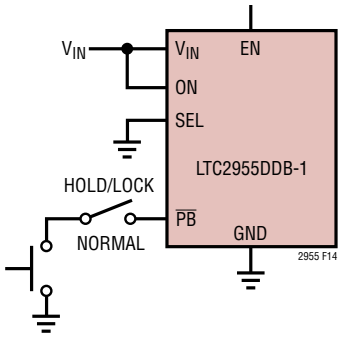


Figure 14. Using a Slide Switch to Prevent Accidental Turn-On/Off

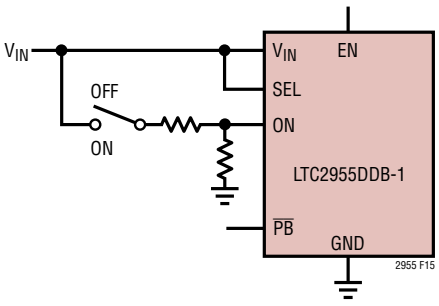


Figure 15. Using a Slide or Toggle Switch to Turn-On/Off

APPLICATIONS INFORMATION

and the device turns on. If the user slides the switch to the OFF position, the ON pin voltage drops to 0V and the LTC2955 activates a turn-off since the SEL pin is high (DFN package only).

Interface with Switching Regulators

The LTC2955-1 EN pin can be connected directly to most switching regulator $\overline{\text{SHUTDOWN}}$ inputs. The EN pin high level output voltage ($V_{EN(VOH)}$) is typically 4.3V with V_{IN} >5V, and $V_{EN(VOH)} = V_{IN} - 0.5V$ if V_{IN} <5V. With a minimum V_{IN} of 1.5V, $V_{EN(VOH)}$ is still higher than most $\overline{\text{SHUTDOWN}}$ thresholds (usually <1.2V). Figure 16 shows one such application. The regulator is a boost converter with a $\overline{\text{SHUTDOWN}}$ high threshold of 0.88V (maximum).

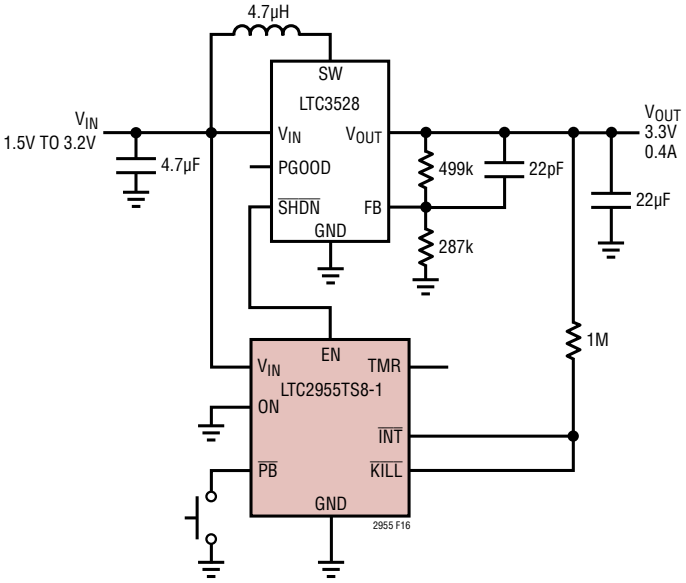


Figure 16. 2-Cell with 3.3V Output

If a higher $V_{EN(VOH)}$ is required, an external pull-up resistor can be connected from the EN pin to any higher voltage (<36V). The EN pin is designed to be able to sink at least 1mA of current during turn-off, so this external pull-up resistor value must be selected to source less than 1mA with EN at 0V.

The LTC2955-1 EN pin can also be connected to switching regulators with a RUN/SS pin. RUN/SS has a dual function of a $\overline{\text{SHUTDOWN}}$ threshold and soft-start, with an internal soft-start pull-up current and an external soft-start capacitor. The LTC2955 EN pin pull-up current of 2µA will add to the soft-start pull-up current of the regulator. The soft-start capacitor may need to be increased to maintain the same soft-start time. The soft-start behavior of the regulator will remain the same.

Figure 17 shows the LTC2955-1 EN pin connected to a DC/DC regulator RUN/SS pin.

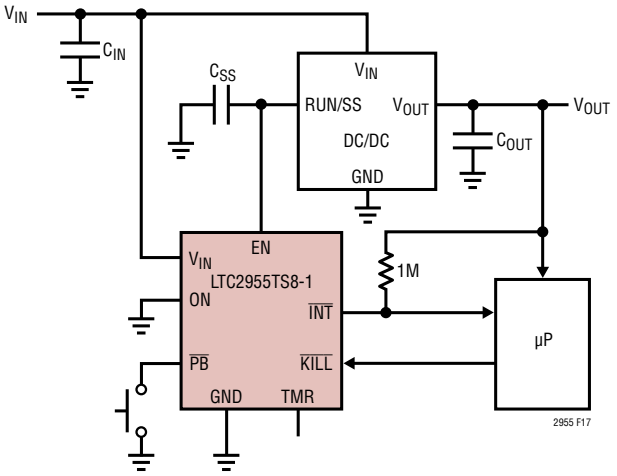


Figure 17. Turn-On/Off a DC/DC Regulator Through the RUN/SS Pin

Layout Considerations

Figure 18 shows example PCB layouts for placing the V_{IN} pin bypass capacitor. Position the bypass capacitor close to the LTC2955 on the same side of the PCB and keep the traces short. For the DFN package, a PCB via should be placed near the LTC2955 to connect the $\overline{\text{PB}}$ pin (Pin 5) to the pushbutton. This allows an unbroken trace to be placed between the V_{IN} pin and the bypass capacitor. Placing the bypass capacitor close to the LTC2955 gives the optimum protection against $\overline{\text{PB}}$ pin ESD transients.

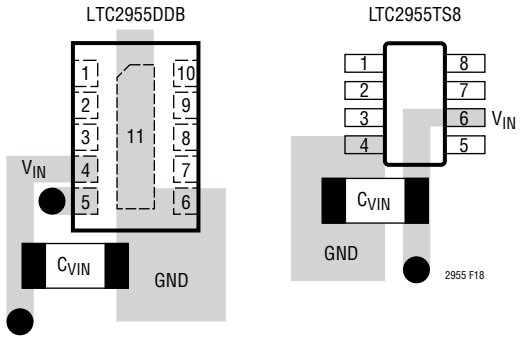
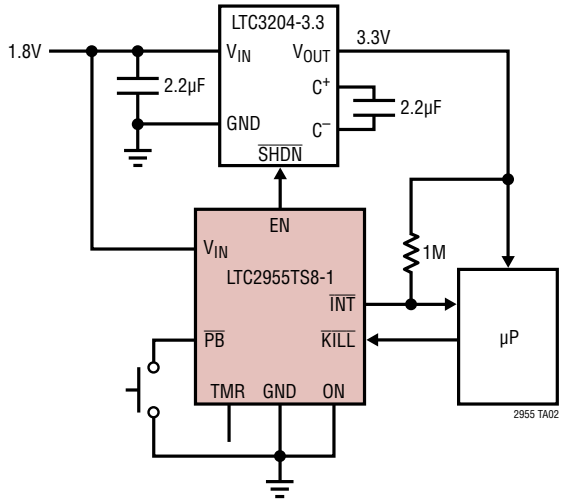


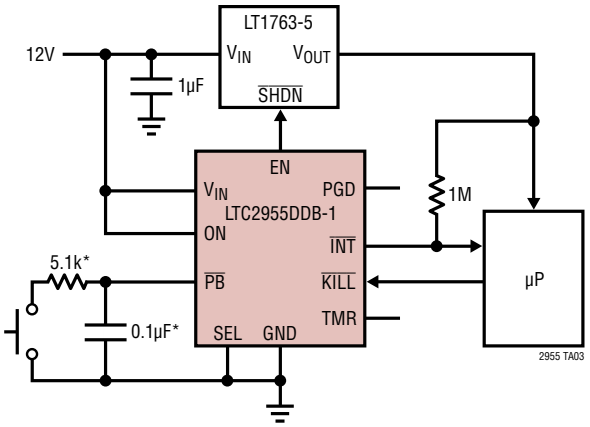
Figure 18. Recommended Layout for the V_{IN} Bypass Capacitor

TYPICAL APPLICATIONS

Low Voltage Pushbutton Controller Enables Charge Pump

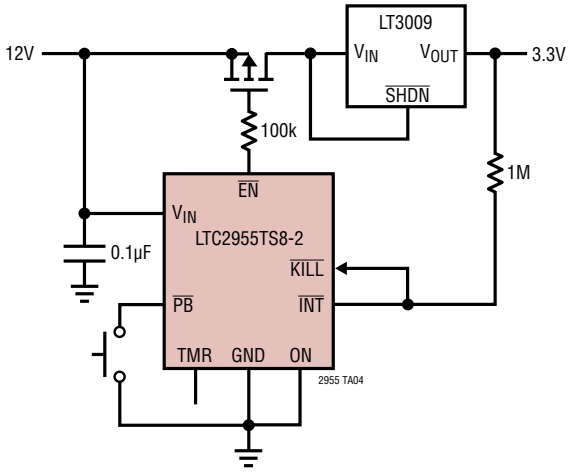


Automatic Power-Up with Pushbutton On/Off



*OPTIONAL RC NETWORK RECOMMENDED TO IMPROVE NOISE IMMUNITY

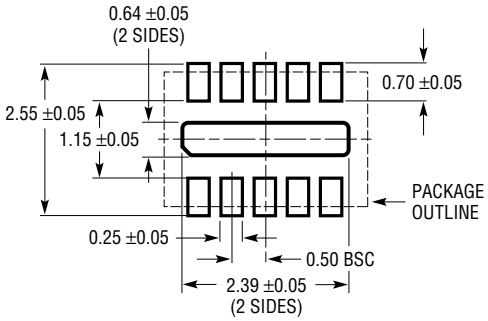
PowerPath Control with Immediate $\overline{\text{KILL}}$



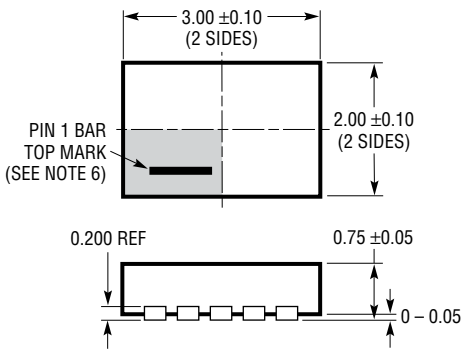
PACKAGE DESCRIPTION

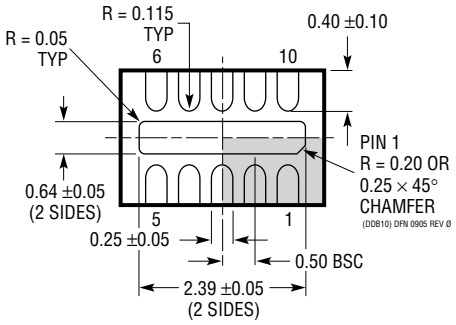
Please refer to http://www.linear.com/product/LTC2955#packaging for the most recent package drawings.

DDB Package
10-Lead Plastic DFN (3mm × 2mm)
(Reference LTC DWG # 05-08-1722 Rev Ø)



RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS



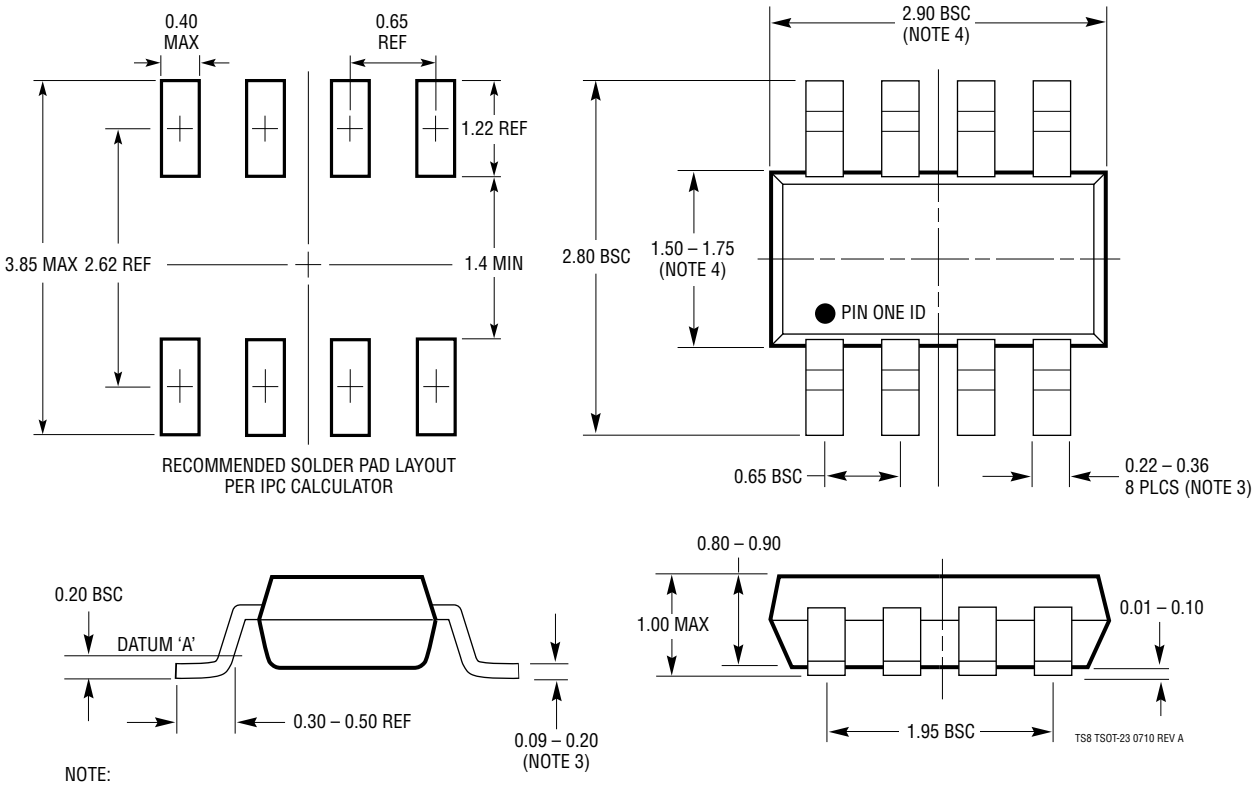


BOTTOM VIEW—EXPOSED PAD

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

Please refer to http://www.linear.com/product/LTC2955#packaging for the most recent package drawings.



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

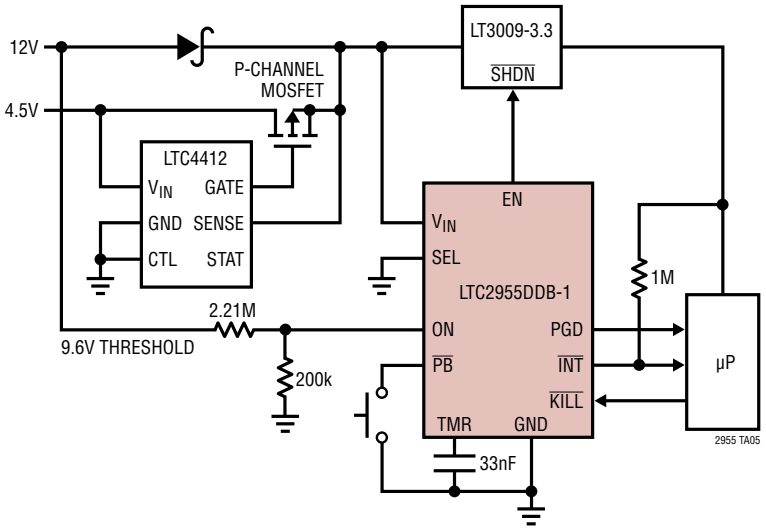
REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
A	04/16	Clarified requirements for turn-on	4, 12

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

TYPICAL APPLICATION

Pushbutton On/Off Control with Automatic Turn-On When 12V Applied



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC2900	Programmable Quad Supply Monitor	Adjustable $\overline{\text{RESET}}$, 10-Lead MSOP and 3mm × 3mm DFN Packages
LTC2904/LTC2905	Pin-Programmable Dual Supply Monitors	Adjustable $\overline{\text{RESET}}$ and Tolerance, 8-Lead SOT-23 and 3mm × 2mm DFN Packages
LTC2909	Precision Triple/Dual Input UV, OV and Negative Voltage Monitor	6.5V Shunt Regulator for High Voltage Operation
LTC2910	Octal Positive/Negative Voltage Monitor	Eight Adjustable Inputs (0.5V)
LTC2914	Quad UV/OV Positive/Negative Voltage Monitor	Adjustable UV and OV Trip Values
LTC2950/LTC2951	Pushbutton On/Off Controllers	High Voltage, Low Power Pushbutton Controllers with Power-Down Fault Detect $\overline{\text{KILL}}$ Timer
LTC2952	Pushbutton PowerPath Controller with Supervisor	Automatic Low Loss Switchover Between DC Sources
LTC2953	Pushbutton Controller with Voltage Monitoring	Adjustable Supply Monitor with 200ms Reset
LTC2954	Pushbutton On/Off Controller with µP Interrupt	Adjustable Turn On/Off Timers
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
LTC4352	Ideal Diode Controller with Monitoring	Controls N-Channel MOSFET, 0V to 18V Operation

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