Pushbutton On/Off Controller Includes Optional Automatic Turn-On When Handheld Device is Plugged In

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It is well-known that most mechanical pushbutton switches bounce when pressed, and that a debounce circuit is required to produce a clean, usable signal from the pushbutton. There are many debounce solutions available—common ones use flip-flops or R-S latches—but designing and implementing a debounce circuit is not as trivial as it might seem, especially for handheld devices.

Because a pushbutton debounce circuit must remain on all the time, a low supply current is critical for battery-powered handheld devices. Additionally, the circuit should be capable of accepting power from any available standby supply voltage without requiring a linear regulator. Furthermore, the pushbutton input should be able to withstand high ESD levels during operation since it is usually connected where contact with the human finger is possible. And finally, the circuit must be small enough to fit into whatever little space is left on the printed circuit board.

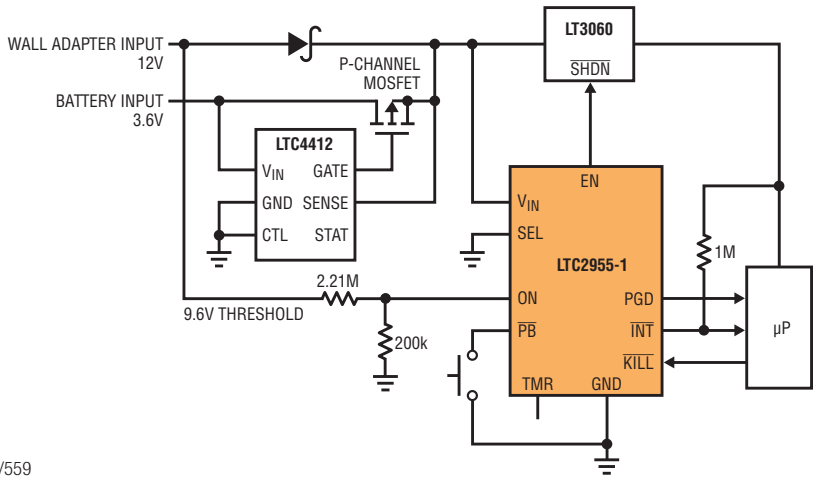
The LTC2955 pushbutton controller covers all of these requirements. It generates a latched enable output from the noisy pushbutton input. The enable output comes in both active high (LTC2955-1) or active low (LTC2955-2) options, allowing it to drive the on/off input of any system or regulator.

The LTC2955 features a voltage monitor pin (ON) that can be used for automatic system turn-on when the device is plugged into a secondary supply such as a wall adapter or car battery. This is a common feature found in handheld devices where, if you plug in the wall adapter or charger cable, the device automatically powers up by itself without a press of the on/off switch.

The LTC2955 is designed to interface with a microprocessor via the LTC2955's $\overline{\text{INT}}$ (interrupt) output pin and $\overline{\text{KILL}}$ input pin. The LTC2955's $\overline{\text{INT}}$ output alerts the microprocessor that the pushbutton is pressed, allowing the microprocessor to perform any power-down tasks. Once these tasks are complete, the microprocessor can communicate—via the $\overline{\text{KILL}}$ pin—that the system is ready to be switched off. The user can also force the system to power-down if the microprocessor fails to respond to the interrupt signal ($\overline{\text{KILL}}$ pin remains high). This is the familiar user-holds-the-button-down for a duration greater than the defined power-off period. The power-off period is adjustable through the capacitor at the TMR pin and it can be made as long as required to prevent accidental turn-off.

The LTC2955 is also designed with blanking times after each pushbutton event, during which all inputs are ignored. This prevents the EN output from turning on and off continuously if the pushbutton is held down or stuck low. These blanking times ensure sufficient time for the voltage regulator to fully charge up or discharge its output and allow the system or microprocessor time to perform power on/off tasks. In addition, the power-down debounce time is adjustable using an external capacitor. This allows the designer to extend the power-down

Figure 1. Pushbutton on/off control for battery-powered device, with automatic turn-on when the device is plugged in



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time in cases where some systems need more time to perform power-down tasks.

The LTC2955 minimizes components by operating directly from inputs as low as a 1.5V single-cell battery up to a 36V multicell stack—with no additional boost regulator or LDO required. The low quiescent current of 1.2µA extends the battery life. The device is available in a space-saving 10-lead 3mm × 2mm DFN package and 8-lead ThinSOT™ package.

HANDHELD WITH AUTOMATIC TURN-ON WHEN PLUGGED IN

Figure 1 shows a typical LTC2955-1 application for a handheld device. The 3.6V supply is produced directly from the handheld's battery; the 12V secondary supply comes from a wall adapter. Both the 3.6V and 12V inputs are connected to the LT3060 regulator input via diode-OR so that either supply can power the system. The LTC4412 is an ideal diode controller that controls the P-channel MOSFET to reduce the voltage drop across the diode connected to the 3.6V supply.

The LTC2955-1 ON pin monitors the 12V input through the resistive divider R1 and R2. When the user plugs in the wall adapter, the 12V supply becomes present. The LTC2955-1 detects that the ON pin is high and pulls the EN (enable) pin high after a 32ms debounce time and turns on the voltage regulator, applying power to the system. This allows automatic system turn-on when the user plugs in the wall adapter. The system can also be turned on by pressing the pushbutton. The LTC2955 alerts the microprocessor that the 12V supply is present or absent by pulling the PGD output pin high or low, respectively.

PUSHBUTTON PIN ESD PROTECTION

The LTC2955 $\overline{PB}$ (pushbutton) input is protected to ESD levels of up to ±25kV HBM with respect to ground. This protection level exists during all modes of operation including power-down, power-up or when the supply is disconnected from the battery. When the pushbutton pin is hit with an ESD strike during operation, the part remains in its current logic state. The device does not reset or latch up and there is no need to cycle the supply to recover.

VERSATILE PUSHBUTTON INPUT

The LTC2955 requires only a few external components for most applications, as shown in Figure 1. Except for the logic-level pins used to interface with the microprocessor, most of the pins can withstand a maximum voltage of 36V, precluding the need for external supplies or resistor dividers. Designs remain flexible in the face of high input supply voltages, especially when no typical board-level supply (e.g., 5V) is available.

The $\overline{PB}$ input is designed to operate in harsh and noisy environments. The pin

Figure 2. LTC2955-1 waveforms

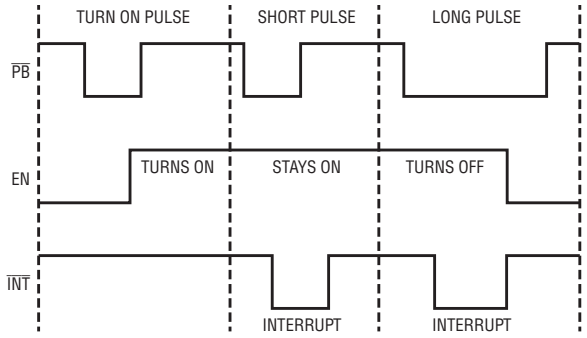
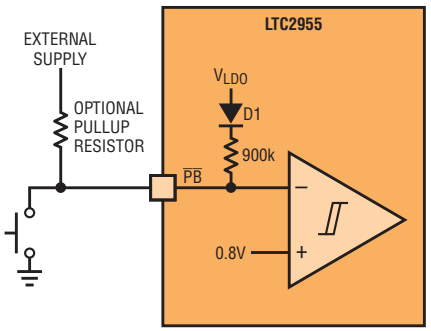


Figure 3. Pushbutton input



The $\overline{PB}$ input is designed to operate in harsh and noisy environments. The pin can withstand both positive and negative voltages up to ±36V. This allows for long cable runs between the pushbutton switch and the LTC2955, where even if the input rings, it will not cause damage to the part.

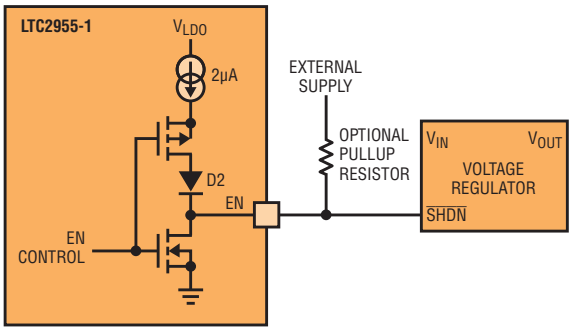


Figure 4. LTC2955-1 EN output

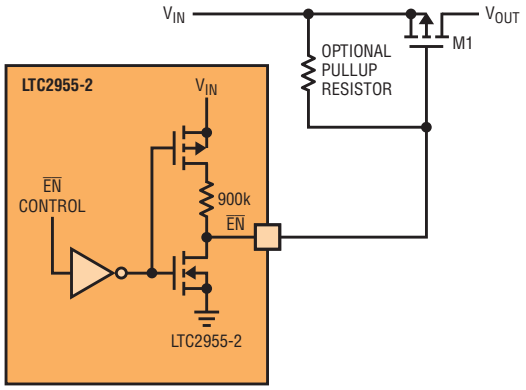


Figure 5. LTC2955-2 $\overline{EN}$ output

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Figure 3 shows the pushbutton pin connection and internal circuitry. The internal 900k pull-up resistor allows connection of the pin directly to the pushbutton switch (with the other terminal grounded) without requiring an external pull-up resistor. If an external pull-up resistor is desired in applications where the pushbutton switch is leaky, this optional pull-up resistor can be tied to any voltage up to the 36V maximum as shown. The internal diode D1 blocks the external supply current from flowing into the device, preventing unnecessary current consumption.

VERSATILE ENABLE OUTPUT

Figure 4 shows the LTC2955-1 active high EN pin driving the SHUTDOWN input of a voltage regulator. The LTC2955-1 EN pin pulls high to 4.3V with an internal 2µA pull-up current in active mode. If a higher V_{OH} voltage is required, an optional external pull-up resistor can be added to pull this pin above 4.3V as shown. The diode D2 blocks the external supply current from flowing into the device. The EN pin can be pulled high up to 36V.

Figure 5 shows the LTC2955-2 active low $\overline{EN}$ pin driving a P-channel MOSFET to control the system supply. The LTC2955-2 $\overline{EN}$ pin pulls high through an internal 900k resistor during the inactive mode. In the active mode with the pin low, this 900k resistor is disconnected from the supply to minimize the quiescent current consumed by the 900k resistor. If a V_{OH} lower than the supply voltage is required, this pin can be tied to the external supply through an optional pull-up resistor as shown.

The ON input and SEL inputs can withstand voltages up to 36V. This makes it easy to connect these pins directly to the high voltage supply without requiring a resistive divider, and thus minimize the quiescent current consumed by the resistive divider.

CONCLUSION

The LTC2955 is a family of micropower (1.2µA), wide input voltage range (1.5V to 36V) pushbutton controllers. These parts lower system cost and preserve battery life by integrating a rugged pushbutton input, a flexible enable output and a simple microprocessor interface that provides intelligent power-up and power-down. The device is available in space-saving 10-lead 3mm × 2mm DFN and 8-lead ThinSOT packages. ■