

## MAX16150

# nanoPower Pushbutton On/Off Controller and Battery Freshness Seal

### General Description

The MAX16150A/MAX16150B are extremely low-power, pushbutton, on/off controllers with a switch debouncer and built-in latch. These devices accept a noisy input from a mechanical switch and produce a clean, latched output, as well as a one-shot interrupt output, in response to a switch closure exceeding the debounce period at  $\overline{\text{PB\_IN}}$ . The MAX16150A de-asserts the latched output when the switch closure period exceeds the shutdown period, while the MAX16150B does not de-assert the latched output in response to switch closure. For the MAX16150B, a longer switch closure results in a longer interrupt signal.

The MAX16150A/MAX16150B operate from a supply range of +1.3V to +5.5V and consume less than 20nA of supply current to ensure minimal battery drain in low-power applications, as well as to allow use as a battery "freshness seal". The robust switch input ( $\overline{\text{PB\_IN}}$ ) accepts up to  $\pm 60\text{V}$  levels and is  $\pm 15\text{kV}$  ESD-protected for use in harsh environments. The latched output can serve as a logic signal to control a regulator, or it can serve as a switch to connect the load directly to the power supply when load current is low, providing 20mA of output current with less than 100mV voltage drop. A separate  $\overline{\text{INT}}$  output provides a system interrupt whenever a valid pushbutton signal is detected. An asynchronous  $\overline{\text{CLR}}$  input allows an external signal to force the latched output to the off state.

The MAX16150A and MAX16150B operate over the  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  temperature range are available in a 1mm x 1.5mm, 6-bump wafer-level package (WLP) and a 6-pin thin SOT-23 package.

### Applications

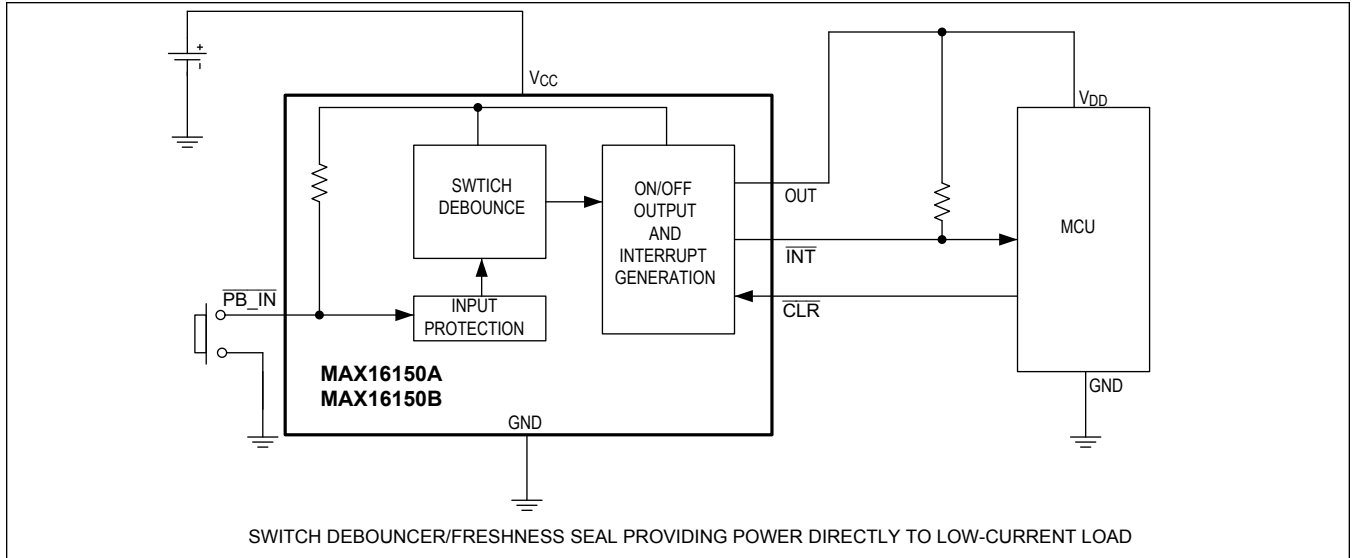
- Portable Instruments
- Handheld Consumer Electronics
- Industrial Equipment
- Disposable Low-Power Electronics

### Benefits and Features

- Low Power
  - 20nA (Max) Standby Current
- Debounces Noisy Switches
  - 50ms and 2s Debounce Timing Options
  - 8s and 16s Shutdown Timing Periods
- Latched Output Supplies 20mA Load Current With Less Than 100mV Drop
- One-Shot  $\overline{\text{INT}}$  Output on Each Switch Closure
- 32ms  $\overline{\text{INT}}$  Duration
- Pushbutton Input Handles Up to  $\pm 60\text{V}$
- $\pm 15\text{kV}$  HBM ESD Protection
- SOT23-6 and 1mm x 1.5mm, 6-bump WLPs

[Ordering Information](#) appears at end of data sheet.

Typical Application Circuit



## Absolute Maximum Ratings

|   |              |                                      |                 |
|---|--------------|--------------------------------------|-----------------|
| $V_{CC}$ to GND.....  | -0.3V to +6V | Operating Temperature Range .....    | -40°C to +125°C |
| PB_IN to GND .....  | -60V to +60V | Junction Temperature .....           | +150°C          |
| CLR, INT, OUT to GND .....  | -0.3V to +6V | Storage Temperature Range .....      | -40°C to +150°C |
| Continuous Power Dissipation (Multilayer Board) SOT23-6 ( $T_A = +70^\circ\text{C}$ , derate 8.70mW/°C above +70°C.)..... | 696mW        | Soldering Temperature (reflow) ..... | +260°C          |
| Continuous Power Dissipation (Multilayer Board) WLP ( $T_A = +70^\circ\text{C}$ , derate 10.50mW/°C above +70°C.).....    | 840mW        |                                      |                 |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Package Information

### SOT23-6

|   |                         |
|---|-------------------------|
| Package Code  | U6+1                    |
| Outline Number  | <a href="#">21-0058</a> |
| Land Pattern Number                                   | <a href="#">90-0175</a> |
| <b>Thermal Resistance, Single Layer Board:</b>        |                         |
| Junction-to-Ambient ( $\theta_{JA}$ )                 | N/A                     |
| Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) | 80°C/W                  |
| <b>Thermal Resistance, Four Layer Board:</b>          |                         |
| Junction-to-Ambient ( $\theta_{JA}$ )                 | 115°C/W                 |
| Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) | 80°C/W                  |

### WLP-6

|   |  |
|---|--|
| Package Code  | W60C1+2  |
| Outline Number  | <a href="#">21-100258</a>                      |
| Land Pattern Number                                   | Refer to <a href="#">Application Note 1891</a> |
| <b>Thermal Resistance, Four-Layer Board:</b>          |  |
| Junction-to-Ambient ( $\theta_{JA}$ )                 | 95.15°C/W                                      |
| Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) | N/A  |

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## Electrical Characteristics

( $V_{CC} = V_{MIN}$  to  $V_{MAX}$ ,  $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , Limits over the operating temperature range and relevant supply voltage range are guaranteed by production and/or characterization. Typical values are at  $T_A = +25^{\circ}\text{C}$  and  $V_{CC} = +3.3\text{V}$ )

| PARAMETER   | SYMBOL         | CONDITIONS   | MIN             | TYP     | MAX  | UNITS         |
|---|----------------|--|-----------------|---------|------|---------------|
| Operating Voltage Range   | $V_{CC}$       |  | 1.3             |         | 5.5  | V             |
| Power Supply Current  | $I_{SB}$       | $V_{CC} = 5\text{V}$ , OUT not asserted, $\overline{\text{PB\_IN}}$ not connected. $-40^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ |                 |         | 20   | nA            |
|   |                | $V_{CC} = 5\text{V}$ , OUT not asserted, $\overline{\text{PB\_IN}}$ not connected. $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ |                 | 10      | 40   |               |
|   | $I_{CC}$       | During $\overline{\text{PB\_IN}}$ detection or $\overline{\text{INT}}$ assertion   |                 | 15      | 30   | $\mu\text{A}$ |
|   | $I_{SB\_UVLO}$ | $V_{CC} < 1.3\text{V}$ , $I_{OUT} = 0$ , $\overline{\text{PB\_IN}}$ not connected, $\overline{\text{CLR}}$ not asserted                    |                 | 2       | 5    | $\mu\text{A}$ |
| Timing Accuracy   |                | Deviation from nominal value of debounce time ( $t_{DB}$ ), shutoff time ( $t_{SO}$ ), and interrupt time ( $t_{INT}$ )                    | -20             | $\pm 5$ | +20  | %             |
| Input High Voltage  | $V_{IH}$       | $\overline{\text{CLR}}$ and $\overline{\text{PB\_IN}}$   | 2.7V to 5.5V    | 70      |      | % $V_{CC}$    |
|   |                |  | 1.3V to 2.7V    | 80      |      |               |
| Input Low Voltage   | $V_{IL}$       | $\overline{\text{CLR}}$ and $\overline{\text{PB\_IN}}$   |                 |         | 30   | % $V_{CC}$    |
| Minimum Input High Time Detected                                  |                | $\text{PB\_IN}$  |                 | 600     |      | $\mu\text{s}$ |
| $\overline{\text{PB\_IN}}$ Hysteresis                             |                |  |                 | 100     |      | mV            |
| $\overline{\text{PB\_IN}}$ PullUp Resistance                      |                | $0 > V_{\overline{\text{PB\_IN}}} < V_{CC}$  | 1200            | 1400    | 2000 | k $\Omega$    |
| $\overline{\text{PB\_IN}}$ Input Current                          | $I_{IN}$       | $V_{\overline{\text{PB\_IN}}} = \pm 60\text{V}$  | -170            |         | +170 | $\mu\text{A}$ |
| $\overline{\text{PB\_IN}}$ Voltage Range                          |                | Continuous; $0\text{V} \leq V_{CC} \leq 5.0\text{V}$   | -60             |         | +60  | V             |
|   |                | Transient; $0\text{V} \leq V_{CC} \leq 5.5\text{V}$  | -60             |         | +60  |               |
| $\overline{\text{CLR}}$ Input Current                             | $I_{CLR}$      |  | -10             | $\pm 1$ | +10  | nA            |
| $\overline{\text{CLR}}$ Falling Edge to OUT Low Propagation Delay | $t_{CO}$       | $R_L = 10\text{k}\Omega$ , $C_L = 100\text{pF}$  |                 | 200     |      | ns            |
| $\overline{\text{CLR}}$ Lockout Time                              |                | Period following rising edge of OUT during which transitions on $\overline{\text{CLR}}$ are ignored.                                       | 51.2            | 64      | 76.8 | ms            |
| OUT Output Voltage  | $V_{OL}$       | $V_{CC} = 3.3\text{V}$ , $I_{SINK} = 1.6\text{mA}$   |                 |         | 0.4  | V             |
|   |                | $V_{CC} = 1.3\text{V}$ , $I_{SINK} = 200\mu\text{A}$   |                 |         | 0.2  |               |
|   | $V_{OH}$       | $V_{CC} = 3.3\text{V}$ , $I_{SOURCE} = 20\text{mA}$  | $V_{CC} - 0.1$  |         |      |               |
|   |                | $V_{CC} = 2.0\text{V}$ , $I_{OUT} = 2\text{mA}$  | $V_{CC} - 0.02$ |         |      |               |
| $\overline{\text{INT}}$ Output Voltage                            | $V_{OL\_INT}$  | $V_{CC} = 3.3\text{V}$ , $I_{SINK} = 1\text{mA}$   |                 |         | 0.2  | V             |
|   |                | $V_{CC} = 1.3\text{V}$ , $I_{SINK} = 200\mu\text{A}$   |                 |         | 0.2  |               |
| $\overline{\text{INT}}$ Leakage Current                           |                |  | -10             | $\pm 1$ | +10  | nA            |

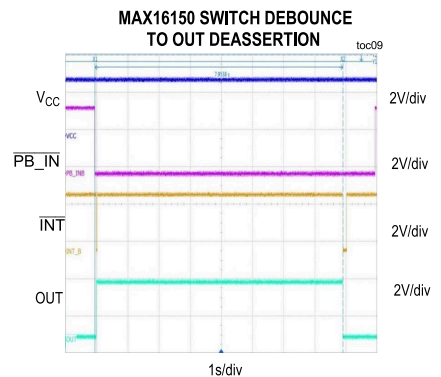
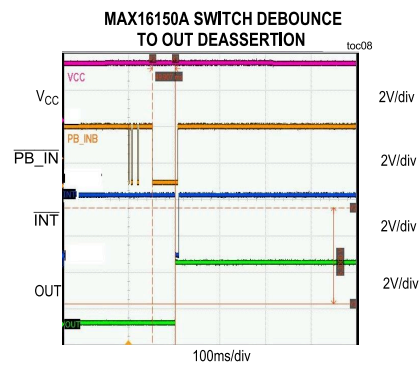
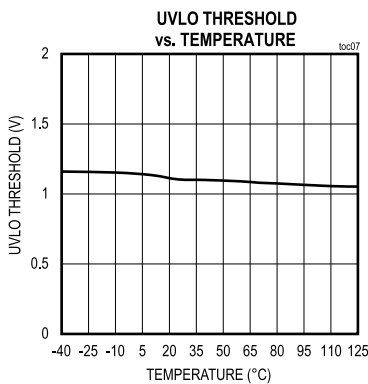
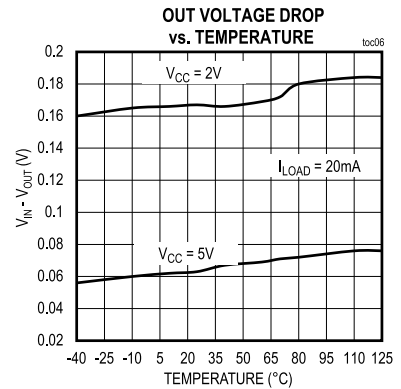
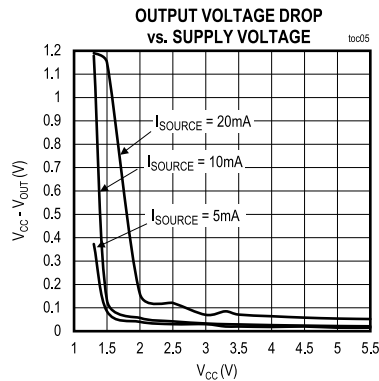
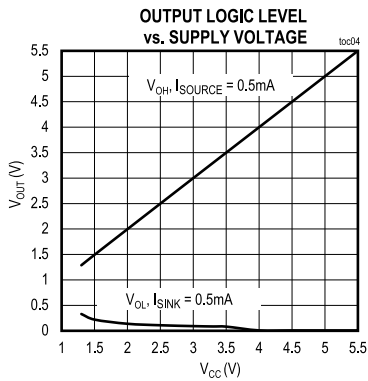
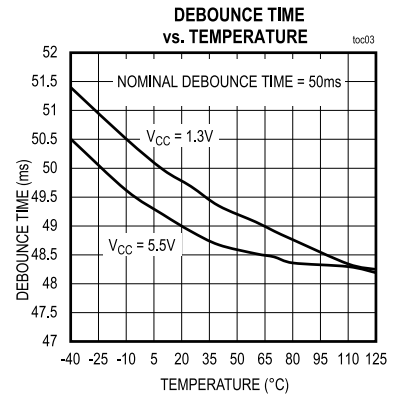
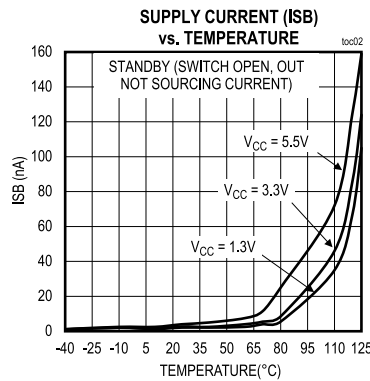
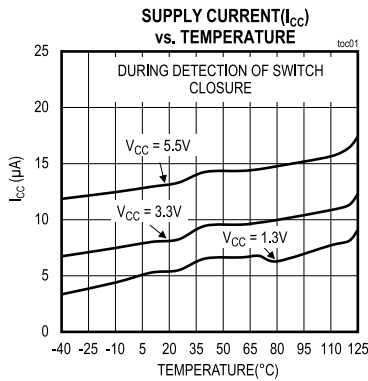
**Electrical Characteristics (continued)**

( $V_{CC} = V_{MIN}$  to  $V_{MAX}$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ , Limits over the operating temperature range and relevant supply voltage range are guaranteed by production and/or characterization. Typical values are at  $T_A = +25^{\circ}C$  and  $V_{CC} = +3.3V$ )

| PARAMETER                | SYMBOL    | CONDITIONS                   | MIN   | TYP                          | MAX   | UNITS |
|--------------------------|-----------|------------------------------|-------|------------------------------|-------|-------|
| Interrupt Pulse Duration | $t_{INT}$ | Beginning at $t_{DB}$ .      | 25.6  | 32                           | 38.4  | ms    |
|                          |           | Beginning at end of $t_{SO}$ | 102.4 | 128                          | 153.6 |       |
| ESD Protection           |           | $\overline{PB\_IN}$          |       | Human Body Model<br>$\pm 15$ |       | kV    |

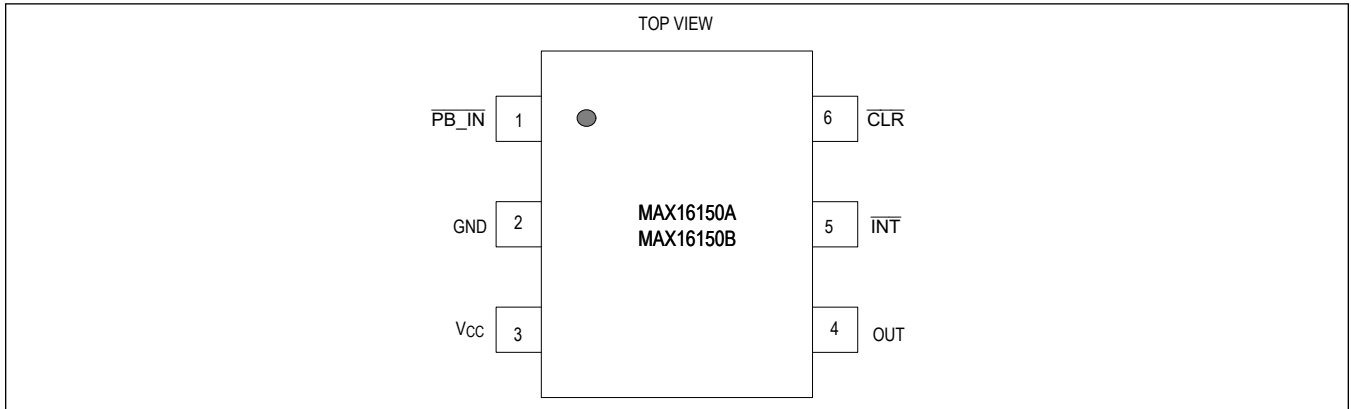
Typical Operating Characteristics

( $V_{CC} = +3.3V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)

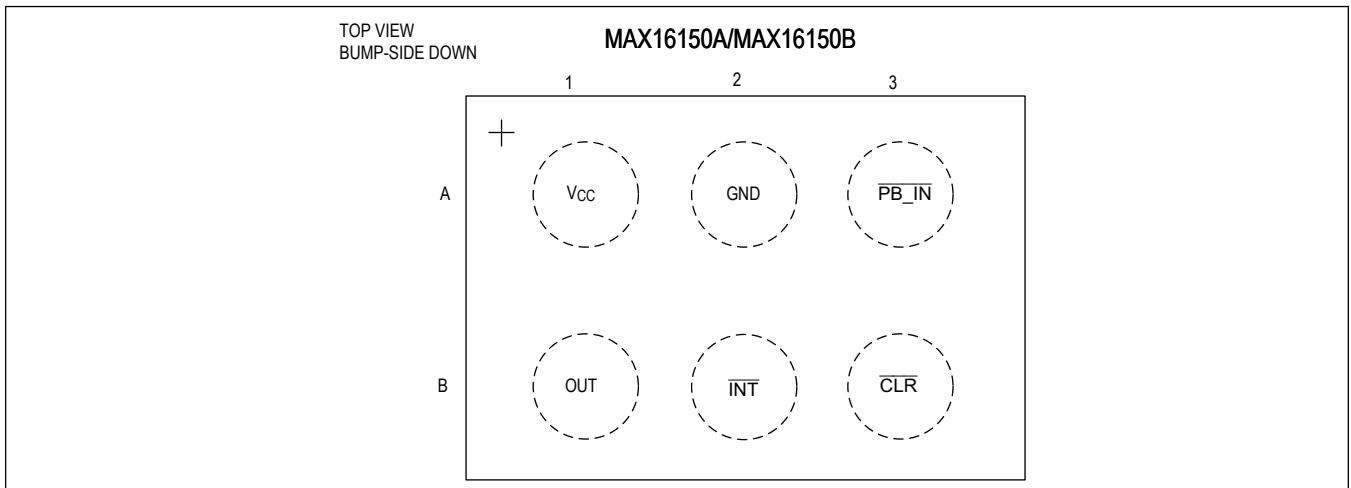


Pin Configurations

SOT23-6



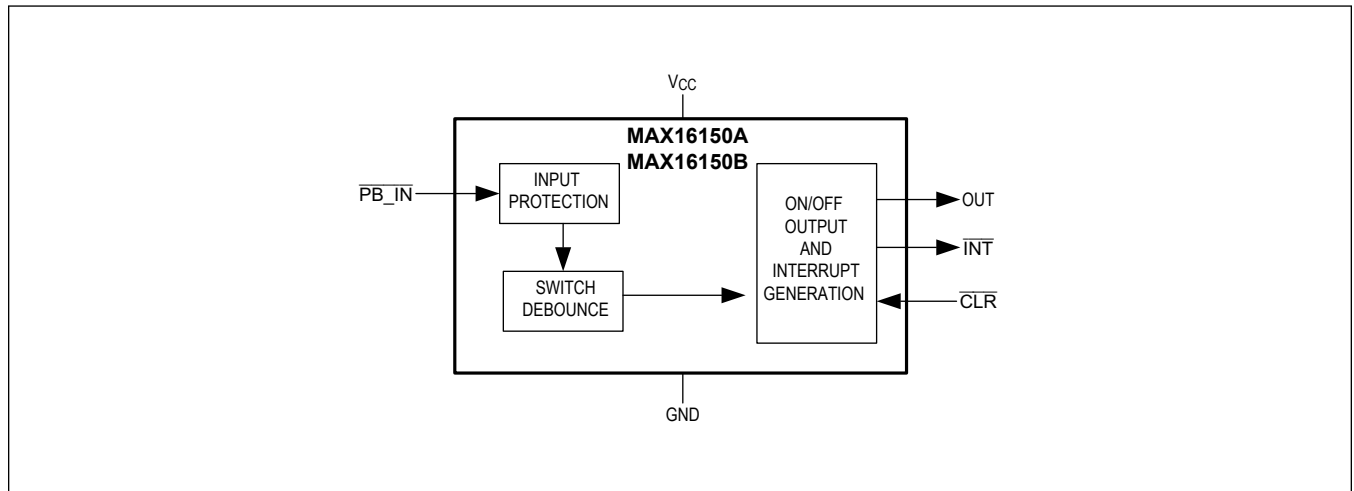
WLP-6



Pin Description

| PIN     |       | NAME                       | FUNCTION   |
|---------|-------|----------------------------|--|
| SOT23-6 | WLP-6 |                            |  |
| 1       | A3    | $\overline{\text{PB\_IN}}$ | Pushbutton Input. $\overline{\text{PB\_IN}}$ is internally pulled up to $V_{CC}$ . Holding $\overline{\text{PB\_IN}}$ low for a period greater than the debounce time ( $t_{DB}$ ) forces $\text{OUT}$ to latch high and generates a one-shot pulse at $\overline{\text{INT}}$ . For the MAX16150A, holding $\overline{\text{PB\_IN}}$ low for a period greater than the shutdown period ( $t_{SO}$ ) de-asserts $\text{OUT}$ . For the MAX16150B, holding $\overline{\text{PB\_IN}}$ low for a period greater than shutdown period ( $t_{SO}$ ) generates an extended interrupt pulse but does not de-assert $\text{OUT}$ . |
| 2       | A2    | GND                        | Ground   |
| 3       | A1    | $V_{CC}$                   | Power Supply Input. Bypass with a 0.1 $\mu\text{F}$ capacitor to ground.   |
| 4       | B1    | OUT                        | Active-High, Push-Pull Latched Output. $\text{OUT}$ is connected to $V_{CC}$ when high.  |
| 5       | B2    | $\overline{\text{INT}}$    | Active-Low, Open-Drain Interrupt/Reset Output. $\overline{\text{INT}}$ is a one-shot output pulse. $\overline{\text{INT}}$ asserts for the interrupt timeout period when $\overline{\text{PB\_IN}}$ is held low for a period greater than the debounce time ( $t_{DB}$ ). $\overline{\text{INT}}$ is high-impedance when de-asserted, even when pulled above $V_{CC}$ .  |
| 6       | B3    | $\overline{\text{CLR}}$    | Clear Input. Pulling $\overline{\text{CLR}}$ low de-asserts the latched $\text{OUT}$ signal. If $\text{OUT}$ is already de-asserted when $\overline{\text{CLR}}$ is pulled low, the state of $\text{OUT}$ is unchanged.  |

Block Diagram





Detailed Description

The MAX16150A/MAX16150B are pushbutton on/off controllers with a switch debouncer and latched output for controlling system power. A switch closure that pulls  $\overline{PB\_IN}$  low and is stable for a period greater than or equal to the debounce time ( $t_{DB}$ ) causes OUT to assert high. Driving  $\overline{CLR}$  low causes OUT to de-assert. For the MAX16150A, a switch closure period greater than or equal to the shutdown period ( $t_{SO}$ ) will cause OUT to de-assert. Each debounced switch closure also initiates a one-shot INT output. See [Table 1](#) for details on the values of  $t_{DB}$ ,  $t_{SO}$ , and other timing intervals.

Table 1. MAX16150A vs. MAX16150B INPUT TIMING CHARACTERISTICS

| VERSION   | DEBOUNCE TIME ( $t_{DB}$ ) | SHUTDOWN PERIOD ( $t_{SO}$ ) | INTERRUPT PERIOD (SWITCH CLOSURE > $t_{DB}$ ) | INTERRUPT PERIOD (SWITCH CLOSURE > $t_{SO}$ ) | SWITCH CLOSURE > $t_{SO}$ |
|-----------|----------------------------|------------------------------|---|---|---------------------------|
| MAX16150A | 50ms                       | 8s                           | 32ms  | 128ms   | OUT De-asserts            |
| MAX16150B | 2s                         | 16s                          | 32ms  | 128ms   | OUT Stays Asserted        |

Operation

The MAX16150A/MAX16150B operate from supply voltages between +1.3V and +5.5V, consuming less than 20nA of supply current when OUT is in the de-asserted state and  $\overline{PB\_IN}$  is unconnected. Whenever OUT is de-asserted, the state of  $\overline{CLR}$  is ignored. After asserting OUT,  $\overline{CLR}$  continues to be ignored for a period of 2x the  $\overline{INT}$  period. For low-power applications (up to about 20mA output current), OUT can drive the load directly with minimal voltage drop. Each debounced switch closure causes  $\overline{INT}$  to assert. A switch closure longer than  $t_{SO}$  results in  $\overline{INT}$  asserting for a period that is 4x longer than the nominal  $\overline{INT}$  period. This longer  $\overline{INT}$  can be used to signal the system to perform a specific function, or to initiate a shutdown process. Closing the switch for a time longer than this extended  $\overline{INT}$  period will not cause  $\overline{INT}$  to be re-asserted or the  $\overline{INT}$  period to be extended.

The MAX16150A de-asserts OUT when  $\overline{PB\_IN}$  is held low for a period equal to or greater than the shutdown period,  $t_{SO}$ . Holding  $\overline{PB\_IN}$  of the MAX16150B low for a period equal to or greater than the shutdown period ( $t_{SO}$ ) does not de-assert OUT. Instead the MAX16150B outputs a longer interrupt signal.

Note that, when  $V_{CC}$  is first applied (for example, when the battery is initially installed), OUT may initially be in either the asserted or the de-asserted state. To change the state, use either the  $\overline{PB\_IN}$  or  $\overline{CLR}$  input as appropriate.

Very brief high periods (less than approximately 600µs) at  $\overline{PB\_IN}$  are ignored, so that fast switch bounces don't interrupt the debounce logic, while valid short presses and releases cause the debouncer to reset.

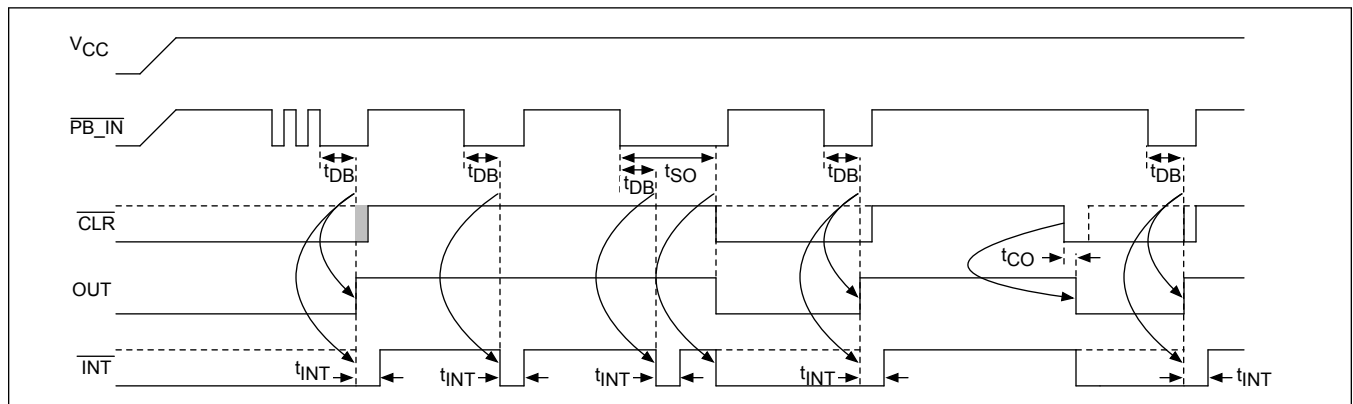


Figure 1. MAX16150A Timing Diagram

Figure 1 shows the timing diagram of the MAX16150A. A switch closure of a duration greater than  $t_{DB}$  causes OUT to

assert. A switch closure of a duration greater than  $t_{SO}$  causes OUT to de-assert. Typically,  $\overline{INT}$  and  $\overline{CLR}$  are pulled up either to OUT or to a regulated voltage controlled by OUT as depicted in [Figure 1](#). As such,  $\overline{INT}$  and  $\overline{CLR}$  are pulled low while OUT is de-asserted. If pulled up to a constant supply voltage,  $\overline{INT}$  and  $\overline{CLR}$  will behave as shown by the horizontal dashed lines while OUT is de-asserted.

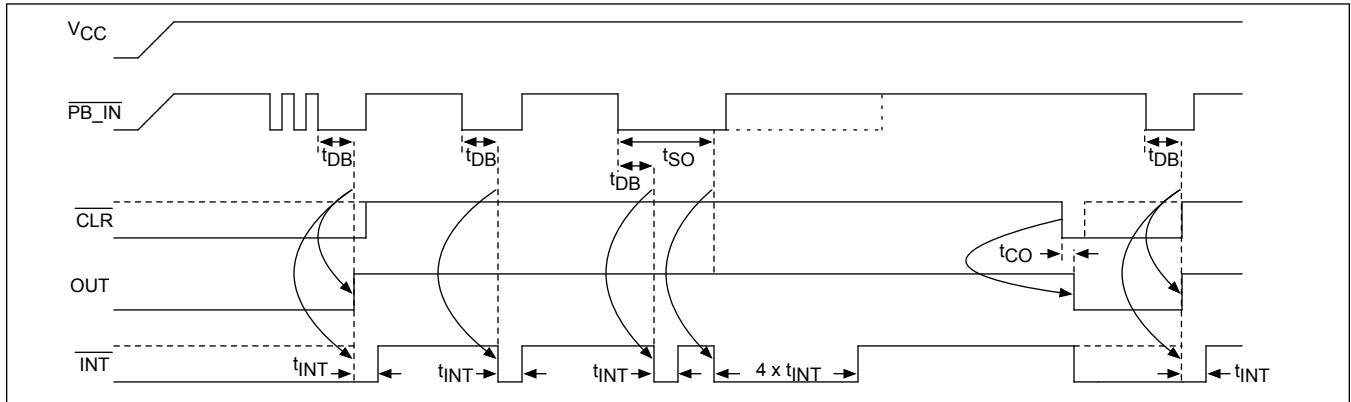


Figure 2. MAX16150B Timing Diagram

[Figure 2](#) shows the timing diagram for the MAX16150B. A switch closure of a duration greater than  $t_{DB}$  causes OUT to assert. A switch closure of a duration greater than  $t_{SO}$  does not cause OUT to de-assert. Instead, it causes an extended interrupt. Typically,  $\overline{INT}$  and  $\overline{CLR}$  are pulled up either to OUT or to a regulated voltage controlled by OUT as depicted in the figure above. As such,  $\overline{INT}$  and  $\overline{CLR}$  are pulled low while OUT is de-asserted. If pulled up to a constant supply voltage,  $\overline{INT}$  and  $\overline{CLR}$  will behave as shown by the horizontal dashed lines while OUT is de-asserted.

### Robust Switch Input

The switch input ( $\overline{PB\_IN}$ ) has overvoltage clamping diodes to protect against damaging fault conditions. Switch input voltages can safely swing  $\pm 60V$  relative to ground.

### $\pm 15kV$ ESD Protection

ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The MAX16150A/MAX16150B have extra protection against static electricity to protect against ESD of  $\pm 15kV$  at the switch input without damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. A design advantage of these devices is that they continue working without latchup after an ESD event, which eliminates the need to power-cycle the device. ESD protection can be tested in various ways; this product is characterized for protection to  $\pm 15kV$  using the Human Body Model.

**Human Body Model**

Figure 3 shows the Human Body Model, while Figure 4 shows the current waveform it generates when discharged into a low-impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

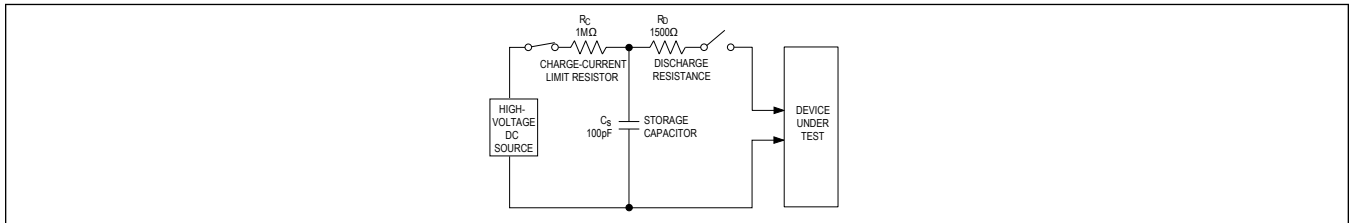


Figure 3. Human Body ESD Test Model

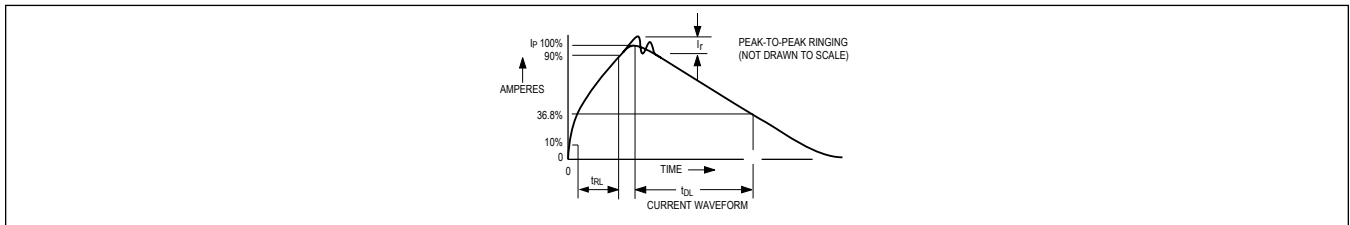


Figure 4. Human Body Current Waveform

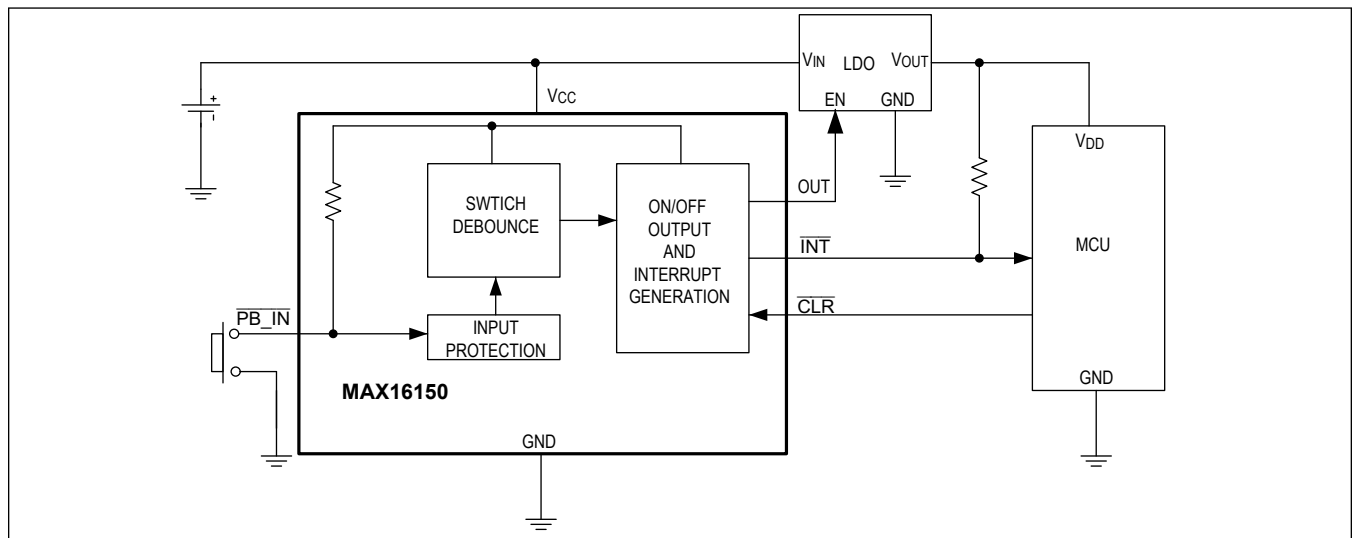
## Applications Information

### Powering the Load

OUT is capable of driving light loads. When the supply current of circuitry is less than about 20mA, the voltage drop from V<sub>CC</sub> to OUT is less than 100mV. The [Typical Application Circuit](#), located at the beginning of this document, shows OUT providing power directly to the load.

Some systems require higher power supply current than the output of the MAX16150 can provide. For those cases, OUT can be used as an enable signal for the voltage regulator powering the system. This [Typical Application Circuit](#) shows an LDO providing power to the load. The LDO's enable input is driven by OUT. A debounced pushbutton at PB\_IN of the MAX16150 causes OUT to assert high, thereby enabling the LDO.

## Typical Application Circuit



## Ordering Information

| PART NUMBER    | TEMP RANGE      | PIN-PACKAGE |
|----------------|-----------------|-------------|
| MAX16150AWT+T* | -40°C to +125°C | 6 WLP       |
| MAX16150AUT+T* | -40°C to +125°C | 6 SOT23     |
| MAX16150BWT+T  | -40°C to +125°C | 6 WLP       |
| MAX16150BUT+T* | -40°C to +125°C | 6 SOT23     |

+ Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape-and-reel.

\*Future product—contact factory for availability.

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION     | PAGES CHANGED |
|-----------------|---------------|-----------------|---------------|
| 0               | 1/19          | Initial release | —             |

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at <https://www.maximintegrated.com/en/storefront/storefront.html>.

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