

# MAX14699

# High-Accuracy, Surge-Protected Overvoltage Protectors

## General Description

The MAX14699 overvoltage protection (OVP) device features a low  $38\text{m}\Omega$  (typ) on-resistance ( $R_{ON}$ ) internal FET and protects low-voltage systems against voltage faults up to  $+28\text{V}_{DC}$ . An internal clamp also protects the device from surges up to  $+100\text{V}$ . The MAX14699 features a  $100\text{ns}$  (typ) overvoltage response time to minimize voltage rise on OUT during an overvoltage event. When the input voltage exceeds the overvoltage threshold, the internal FET is quickly turned off to prevent damage to the protected downstream components.

The overvoltage protection threshold can be adjusted with optional external resistors to any voltage between  $4\text{V}$  and  $20\text{V}$ . With the OVLO input set below the external OVLO select voltage, the MAX14699 automatically selects the accurate internal trip threshold. The internal overvoltage threshold (OVLO) is preset to  $13.75\text{V}$  (typ). The device features an open-drain  $\overline{\text{ACOK}}$  output, indicating a stable supply between minimum supply voltage and  $\text{V}_{OVLO}$ . The MAX14699 is protected against overcurrent events by an internal thermal shutdown.

The MAX14699 is offered in a small, 12-bump WLP package and operates over the  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  extended temperature range.

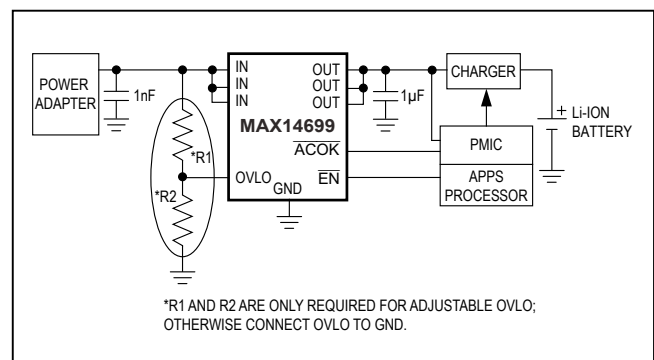
## Applications

- Smartphones
- Tablet PCs
- Portable Media Players

## Benefits and Features

- Protects High-Power Portable Devices
  - Wide Operating Input Voltage Protection from  $+2.1\text{V}$  to  $+28\text{V}$
  - $4.5\text{A}$  Continuous Current Capability
  - Integrated  $38\text{m}\Omega$  (typ) n-Channel MOSFET Switch
  - Fast  $100\text{ns}$  (typ) Response Time
- Flexible Design
  - Adjustable Overvoltage-Protection Trip Level
  - Wide Adjustable OVLO Threshold Range from  $+4\text{V}$  to  $+20\text{V}$
  - Preset Internal Accurate OVLO Threshold:  $13.75\text{V}$
  - Microphone Mode for Microphone Signals on IN
- Additional Protection Features Increase System Reliability
  - Surge Immunity to  $+100\text{V}$
  - Soft-Start to Minimize In-Rush Current
  - Internal  $21\text{ms}$  Startup Debounce
  - Thermal-Shutdown Protection
- Minimize PCB Area
  - 12-Bump WLP ( $1.3\text{mm} \times 2\text{mm}$ ) Package
- $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  Operating Temperature Range

## Typical Application Circuit



**Ordering Information** appears at end of data sheet.



### Absolute Maximum Ratings

(All voltages referenced to GND.)

|  |                                   |
|--|-----------------------------------|
| IN (Note 1).....                                     | -0.3V to +29V                     |
| OUT.....   | -0.3V to (V <sub>IN</sub> + 0.3V) |
| OVLO, ACOK.....                                      | -0.3V to +14V                     |
| EN.....  | -0.3V to +6V                      |
| Continuous IN, OUT Current.....                      | 4.5A                              |
| (Note: Continuous Current Limited by Thermal Design) |                                   |
| Peak IN, OUT Current (10ms).....                     | 8A                                |

|   |                 |
|---|-----------------|
| Continuous Power Dissipation (T <sub>A</sub> = +70°C) |                 |
| WLP (derate 13.7mW/°C above +70°C).....               | 1095mW          |
| Operating Temperature Range.....                      | -40°C to +85°C  |
| Junction Temperature.....                             | +150°C          |
| Storage Temperature Range.....                        | -65°C to +150°C |
| Soldering Temperature (reflow).....                   | +260°C          |

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 Thermal Characteristics (Note 2)

WLP

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>) .....73°C/W

**Note 1:** Survives burst pulse up to 100V with 2Ω series resistance.

**Note 2:** 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<sub>IN</sub> = +2.1V to +28V, C<sub>IN</sub> = 1nF, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>IN</sub> = +5.0V, I<sub>IN</sub> ≤ 3A, and T<sub>A</sub> = +25°C.)  
(Note 3)

| PARAMETER                       | SYMBOL                   | CONDITIONS  | MIN   | TYP   | MAX   | UNIT |
|---------------------------------|--------------------------|---|-------|-------|-------|------|
| <b>POWER SUPPLY</b>             |                          |   |       |       |       |      |
| Input Voltage Range             | V <sub>IN</sub>          |   | 2.1   |       | 28    | V    |
| Input Clamp Voltage             | V <sub>IN_CLAMP</sub>    | I <sub>IN</sub> = 10mA, T <sub>A</sub> = +25°C            |       | 33    |       | V    |
| Input Supply Current            | I <sub>IN</sub>          | V <sub>IN</sub> = 5V, V <sub>IN</sub> < V <sub>OVLO</sub> |       | 116   | 180   | μA   |
| <b>OVP</b>                      |                          |   |       |       |       |      |
| Internal Overvoltage Trip Level | V <sub>IN_OVLO</sub>     | V <sub>IN</sub> rising, T <sub>A</sub> = +25°C            | 13.70 | 13.75 | 13.80 | V    |
|                                 |                          | V <sub>IN</sub> falling                                   | 13.50 |       |       |      |
| OVLO Set Threshold              | V <sub>OVLO_TH</sub>     |   | 1.18  | 1.204 | 1.22  | V    |
| Adjustable OVLO Threshold Range |                          |   | 4     |       | 20    | V    |
| External OVLO Select Threshold  | V <sub>OVLO_SELECT</sub> |   | 0.2   |       | 0.3   | V    |

**Electrical Characteristics (continued)**

( $V_{IN} = +2.1V$  to  $+28V$ ,  $C_{IN} = 1nF$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{IN} = +5.0V$ ,  $I_{IN} \leq 3A$ , and  $T_A = +25^\circ C$ .)  
(Note 3)

| PARAMETER   | SYMBOL                      | CONDITIONS  | MIN  | TYP      | MAX  | UNIT       |
|---|-----------------------------|---|------|----------|------|------------|
| OVLO Switch On-Resistance                             | $R_{ON}$                    | $V_{IN} = 5V$ , $I_{OUT} = 1A$ ,<br>$T_A = +25^\circ C$                     |      | 38       | 53   | m $\Omega$ |
| OUT Leakage Current                                   | $I_{OUT\_LEAK}$             | $V_{IN} = V_{IN\_OVLO}$ , $V_{OUT} = 5V$                                    |      | 7.6      | 12   | $\mu A$    |
| OUT Load Capacitance                                  | $C_{OUT}$                   | $V_{IN} = 5V$   |      |          | 100  | $\mu F$    |
| OVLO Input Leakage Current                            | $I_{OVLO}$                  | $V_{OVLO} = V_{OVLO\_TH}$   | -100 |          | +100 | nA         |
| IN Leakage Voltage by OVLO                            | $V_{IN\_LEAK}$              | $V_{OVLO} = 14V$ , $V_{IN} =$ unconnected,<br>$R_{OVLO} = 1M\Omega$         |      |          | 0.25 | V          |
| <b><math>\overline{EN}</math></b>                     |                             |   |      |          |      |            |
| $\overline{EN}$ Input Low Current                     | $I_{\overline{EN}}$         | $0V < V_{\overline{EN}} < 5.5V$   | -1   | 0        | +1   | $\mu A$    |
| $\overline{EN}$ Input Voltage High                    | $V_{IH}$                    |   | 1.4  |          |      | V          |
| $\overline{EN}$ Input Voltage Low                     | $V_{IL}$                    |   |      |          | 0.4  | V          |
| <b>DIGITAL SIGNALS (<math>\overline{ACOK}</math>)</b> |                             |   |      |          |      |            |
| $\overline{ACOK}$ Output Low Voltage                  | $V_{OL}$                    | $V_{I/O} = 3.3V$ , $I_{SINK} = 1mA$   |      |          | 0.4  | V          |
| $\overline{ACOK}$ Leakage Current                     | $I_{\overline{ACOK\_LEAK}}$ | $V_{I/O} = 3.3V$ , $\overline{ACOK}$ deasserted                             | -1   |          | +1   | $\mu A$    |
| <b>TIMING CHARACTERISTICS (Figure 1)</b>              |                             |   |      |          |      |            |
| Debounce Time   | $t_{DEB}$                   | Time from $2.1V < V_{IN} < V_{IN\_OVLO}$<br>to $V_{OUT} = 10\%$ of $V_{IN}$ |      | 21       |      | ms         |
| Soft-Start Time                                       | $t_{SS}$                    | $V_{OUT} = 10\%$ of $V_{IN}$ to soft-start off                              |      | 1.26     |      | ms         |
| Switch Turn-Off Response Time                         | $t_{OFF\_RES}$              | $V_{IN} > V_{OVLO}$ to $V_{OUT}$ stop rising                                |      | 100      |      | ns         |
| <b>THERMAL PROTECTION</b>                             |                             |   |      |          |      |            |
| Thermal Shutdown                                      |                             |   |      | 150      |      | $^\circ C$ |
| Thermal-Shutdown Hysteresis                           |                             |   |      | 20       |      | $^\circ C$ |
| <b>ESD PROTECTION</b>                                 |                             |   |      |          |      |            |
| IN  |                             | Human Body Model  |      | $\pm 15$ |      | kV         |
|   |                             | IEC 61000-4-2 Air-Gap   |      | $\pm 15$ |      |            |
|   |                             | IEC 61000-4-2 Contact Discharge   |      | $\pm 8$  |      |            |
| All Pins  |                             | Human Body Model  |      | $\pm 2$  |      | kV         |

**Note 3:** All specifications are 100% production tested at  $T_A = +25^\circ C$ , unless otherwise noted. Specifications are over  $-40^\circ C$  to  $+85^\circ C$  and are guaranteed by design.

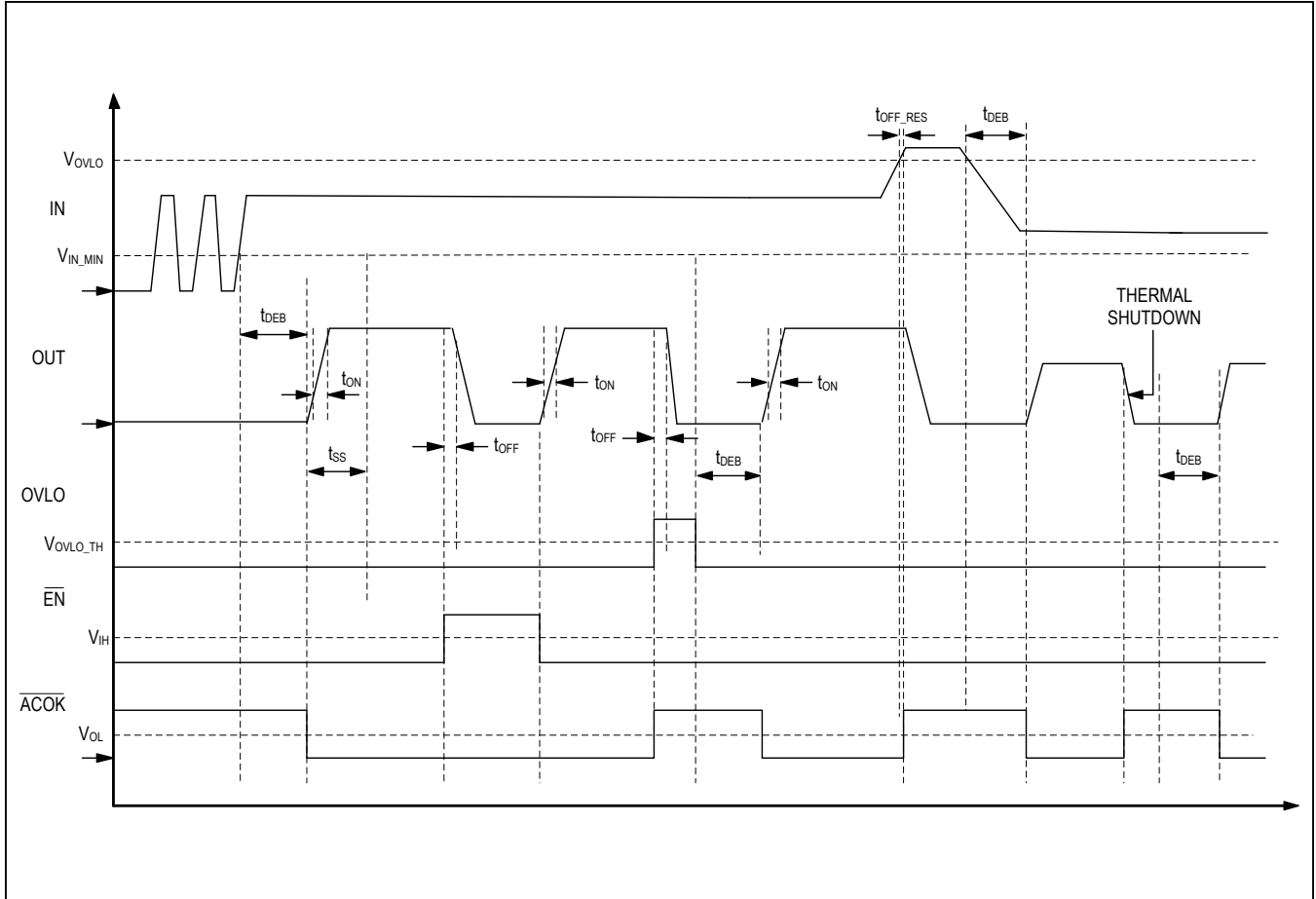
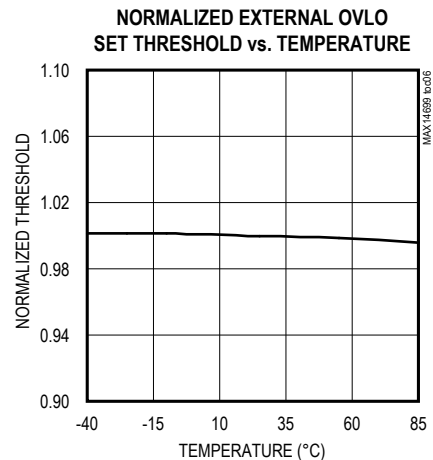
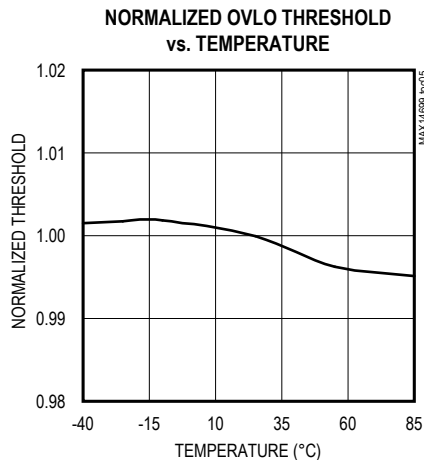
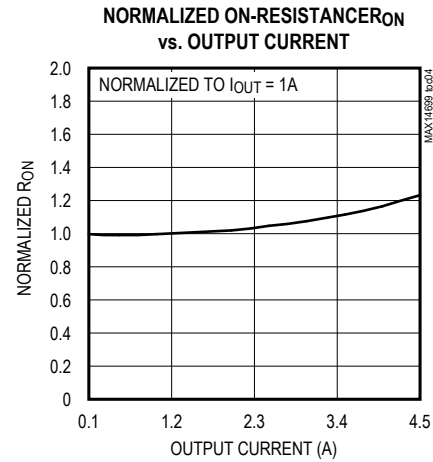
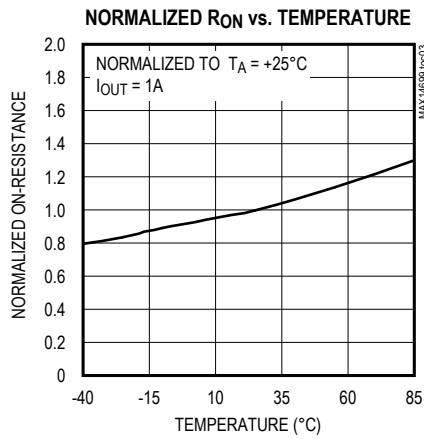
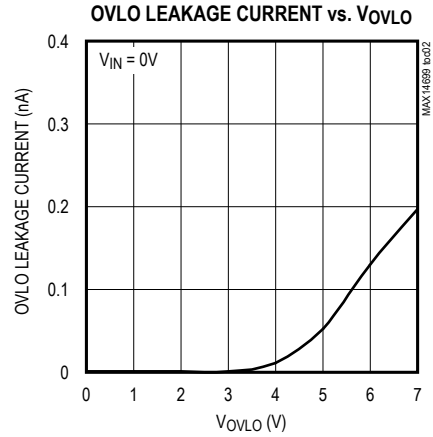
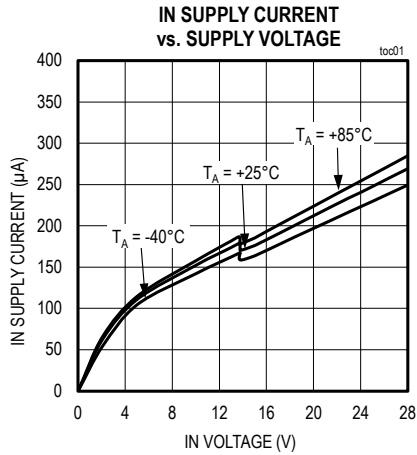


Figure 1. Timing Diagram

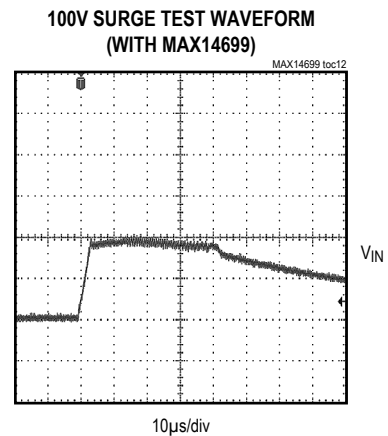
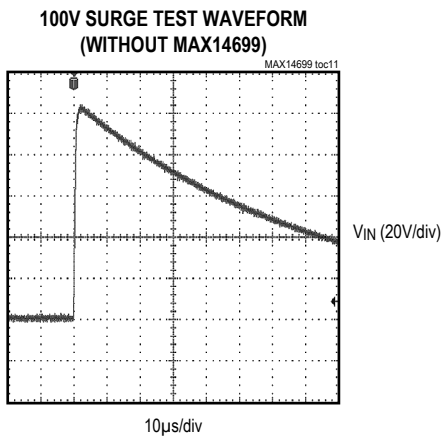
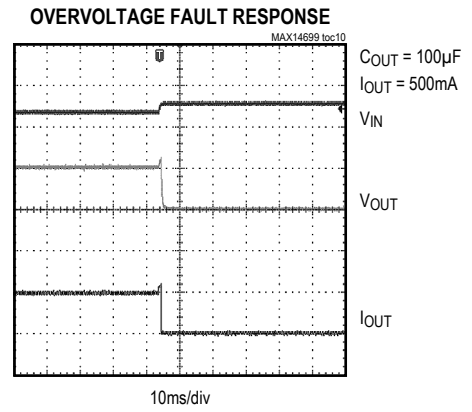
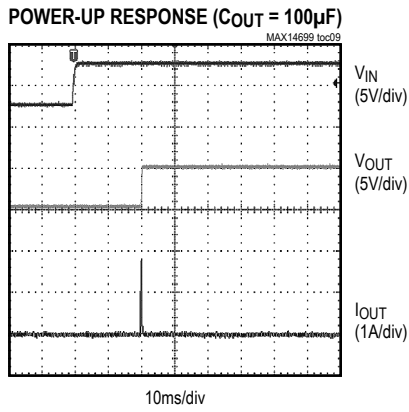
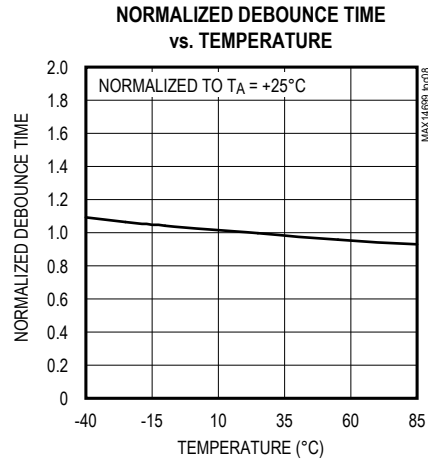
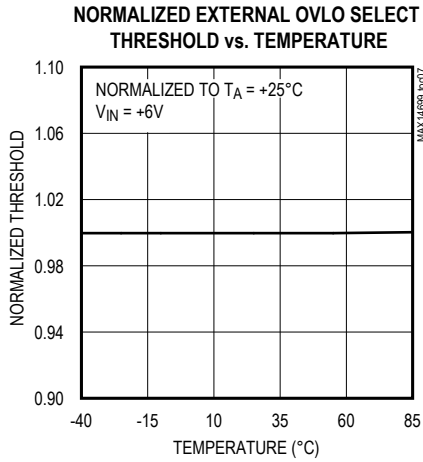
Typical Operating Characteristics

( $V_{IN} = +5.0V$ ,  $C_{IN} = 1nF$ ,  $C_{OUT} = 1\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

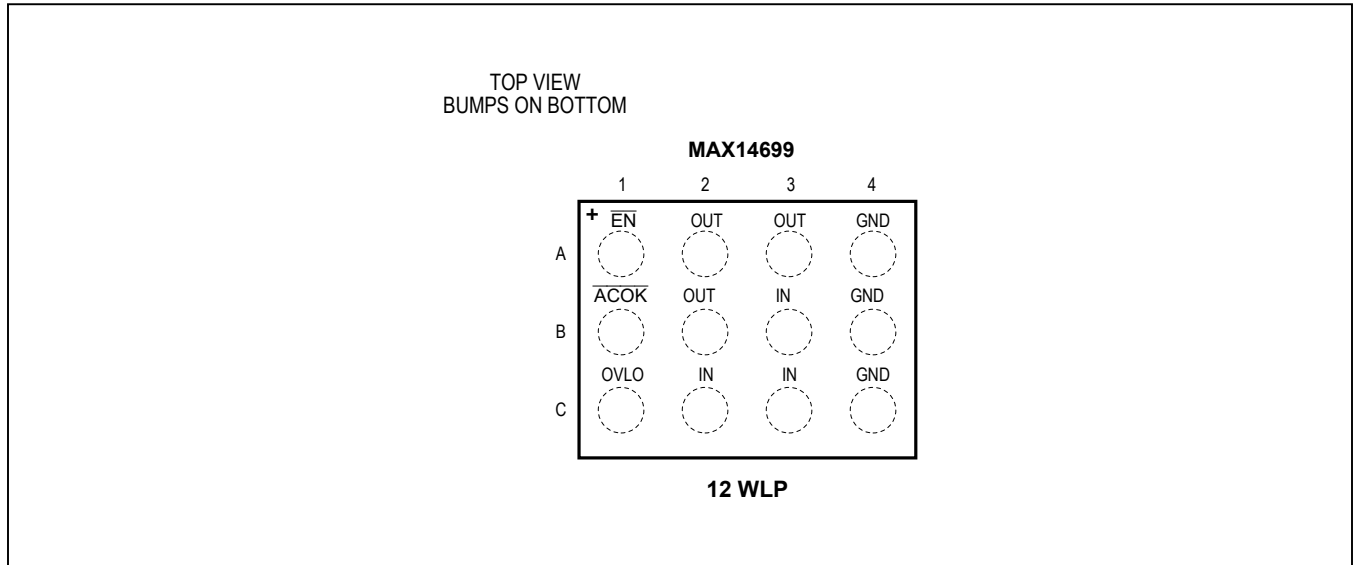


**Typical Operating Characteristics (continued)**

( $V_{IN} = +5.0V$ ,  $C_{IN} = 1nF$ ,  $C_{OUT} = 1\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



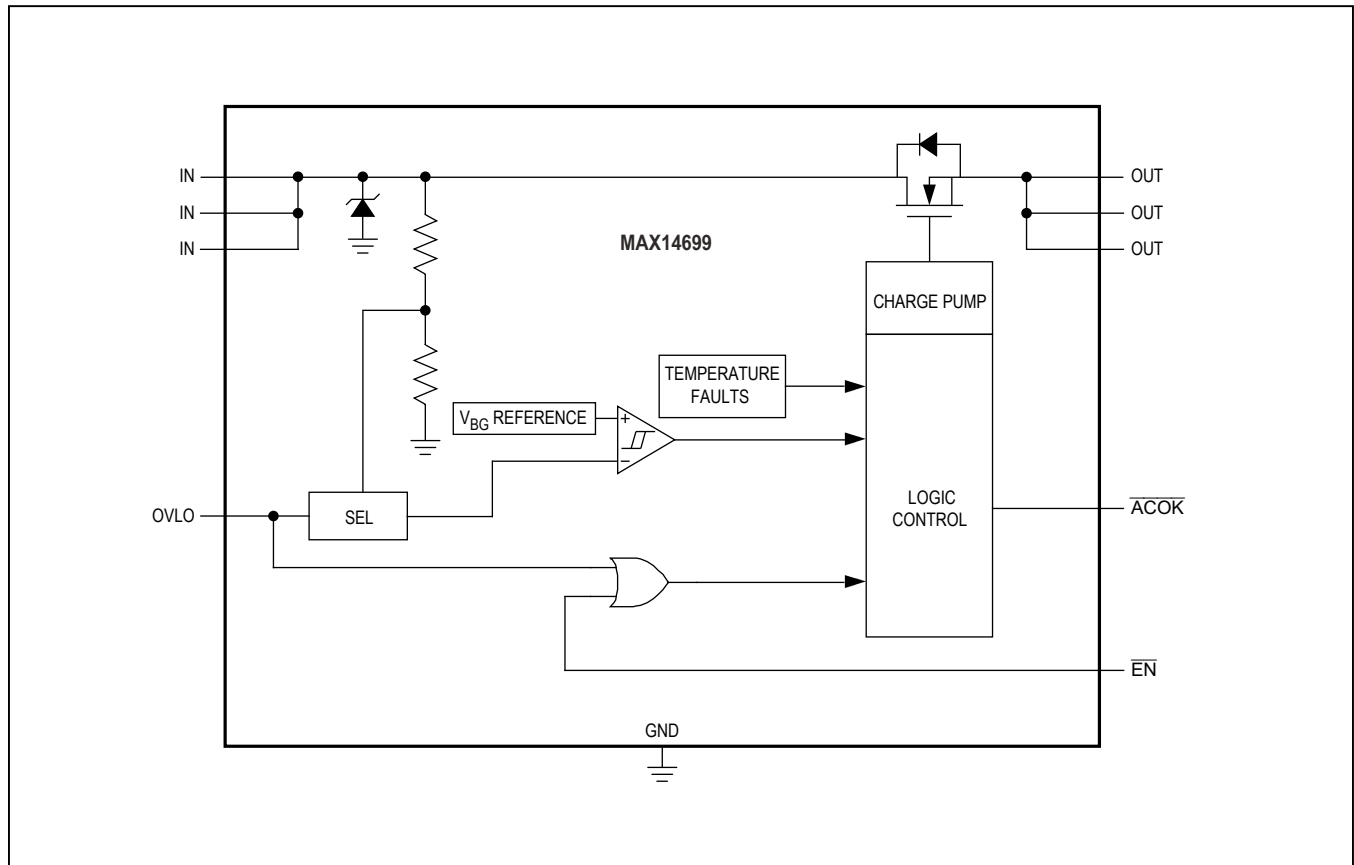
Pin Configuration



Pin Description

| PIN        | NAME                     | FUNCTION   |
|------------|--------------------------|--|
| A1         | $\overline{\text{EN}}$   | Active-Low Enable Input  |
| A2, A3, B2 | OUT                      | Output Voltage. Output of internal switch. Connect OUT pins together for proper operation.   |
| A4, B4, C4 | GND                      | Ground. Connect GND pins together for proper operation.  |
| B1         | $\overline{\text{ACOK}}$ | Open-Drain Flag Output. $\overline{\text{ACOK}}$ is driven low after input voltage is stable between minimum $V_{\text{IN}}$ and $V_{\text{OVLO}}$ after debounce. Connect a pullup resistor from $\overline{\text{ACOK}}$ to the logic I/O voltage of the host system. $\overline{\text{ACOK}}$ is high impedance after thermal shutdown. |
| B3, C2, C3 | IN                       | Voltage Input. Bypass IN with a 1nF ceramic capacitor as close as possible to the device to obtain $\pm 15\text{kV}$ Human Body Model (HBM) ESD protection. Connect IN pins together for proper operation.   |
| C1         | OVLO                     | External OVLO Adjustment. Connect OVLO to GND when using the internal threshold. Connect a resistor-divider to OVLO to set a different OVLO threshold; this external resistor-divider is completely independent of the internal threshold.   |

## Functional Diagram



## Detailed Description

The MAX14699 overvoltage protection (OVP) device features a low 38mΩ (typ) on-resistance ( $R_{ON}$ ) internal FET and protects low-voltage systems against voltage faults up to +28V<sub>DC</sub>. An internal clamp also protects the device from surges up to +100V with minimal voltage rise on OUT. When the input voltage exceeds the overvoltage threshold, the internal FET is quickly turned off to prevent damage to the protected downstream components.

The overvoltage protection threshold can be adjusted with optional external resistors to any threshold between 4V and 20V. With the OVLO input set below the external OVLO select voltage, the MAX14699 automatically selects the accurate internal trip threshold. The internal overvoltage threshold (OVLO) is preset to 13.75V (typ). The MAX14699 is also protected against overcurrent events by an internal thermal shutdown.

## Device Operation

The device contains timing logic that controls the turn-on of the internal FET. The internal charge pump is enabled when  $V_{IN} < V_{IN\_OVLO}$ , if internal trip thresholds are used, or when  $V_{IN} < V_{OVLO\_TH}$ , if external trip thresholds are used. The charge-pump startup, which occurs after a 21ms debounce delay, turns the internal FET on (see the [Functional Diagram](#)). After the debounce time, soft-start limits the FET inrush current for 1.26ms (typ). At any time, if  $V_{IN}$  rises above the OVLO threshold, OUT is disconnected from IN.



### Internal Switch

The MAX14699 incorporates an internal FET with a 38mΩ (typ)  $R_{ON}$  connecting IN and OUT. The FET is internally driven by a charge pump that generates a necessary gate voltage above IN.

### Overshoot Lockout (OVLO)

The MAX14699 has a 13.75V (typ) overshoot threshold. For voltages on IN above this threshold, the internal FET is turned off and OUT is disconnected from IN.

### Thermal-Shutdown Protection

The MAX14699 contains thermal-shutdown circuitry. The internal FET turns off when the junction temperature exceeds +150°C (typ). The device exits thermal shutdown after the junction temperature cools by +20°C (typ).

## Applications Information

### IN Bypass Capacitor

For most applications, bypass IN to GND with a 1nF ceramic capacitor as close as possible to the device to reduce EMI. There is no capacitor required at IN for ESD. If the power source has significant inductance due to long lead length, the device takes care of overshoots due to the LC tank circuit and provides protection as necessary to prevent exceeding the +29V absolute maximum rating on IN.

### OUT Output Capacitor

The slow turn-on time provides a soft-start function that allows the MAX14699 to charge an output capacitor up to 100μF without turning off due to an overcurrent condition.

### External OVLO Adjustment Functionality

If OVLO is connected to ground, the internal OVLO comparator uses the internally set OVLO value.

If an external resistor-divider is connected to OVLO and  $V_{OVLO}$  exceeds the OVLO select voltage,  $V_{OVLO\_SELECT}$ , the internal OVLO comparator reads the IN fraction fixed by the external resistor-divider.  $R_1 = 1M\Omega$  is a good starting value for minimum current consumption.

Since  $V_{IN\_OVLO}$ ,  $V_{OVLO\_THRESH}$ , and  $R_1$  are known,  $R_2$  can be calculated from the following formula:

$$V_{IN\_OVLO} = V_{OVLO\_THRESH} \times \left[ 1 + \frac{R_1}{R_2} \right]$$

This external resistor-divider is completely independent from the internal resistor-divider. A pure external resistor-divider can slow down the OVLO intervention time, reducing the surge protection voltage. A compensated RC divider must be used to ensure high-speed OVLO. The capacitor can be selected according to the formula:

$$C_1 > 5 \times t_R \times \left[ \frac{R_1 + R_2}{R_1 \times R_2} \right]$$

where  $t_R$  is the rise time of the worst-case input transient as measured from the beginning of the rising edge to the time at which  $V_{IN\_OVLO}$  is reached. See [Figure 2](#).

### ESD Test Conditions

ESD performance depends on a number of conditions. The MAX14699 is specified for ±15kV (HBM) typical ESD resistance on IN without any input capacitor.

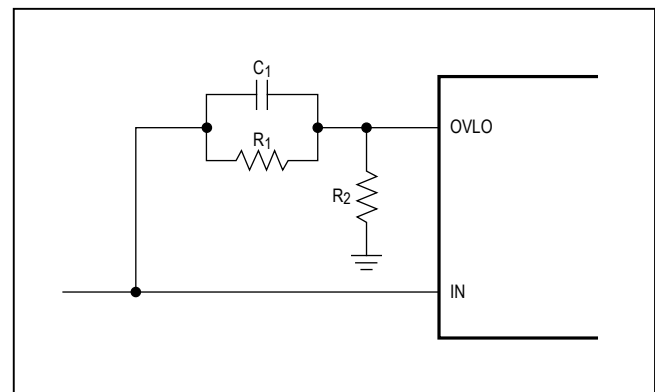


Figure 2. External OVLO Set Circuit

**HBM ESD Protection**

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

**IEC 61000-4-2**

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not

specifically refer to integrated circuits. The major difference between tests done using the Human Body Model and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the Human Body Model. Figure 5 shows the IEC 61000-4-2 model, and Figure 6 shows the current waveform for the IEC 61000-4-2 ESD Contact Discharge test.

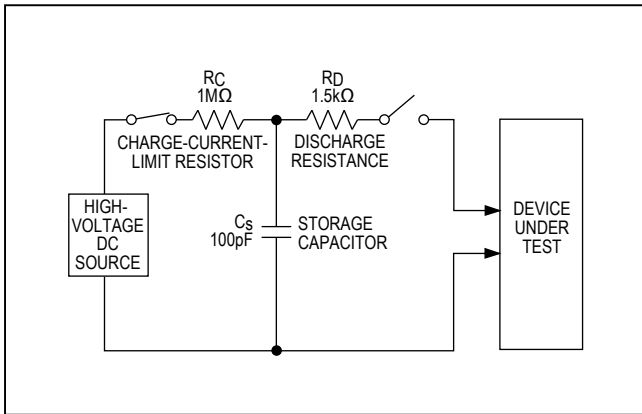


Figure 3. Human Body ESD Test Model

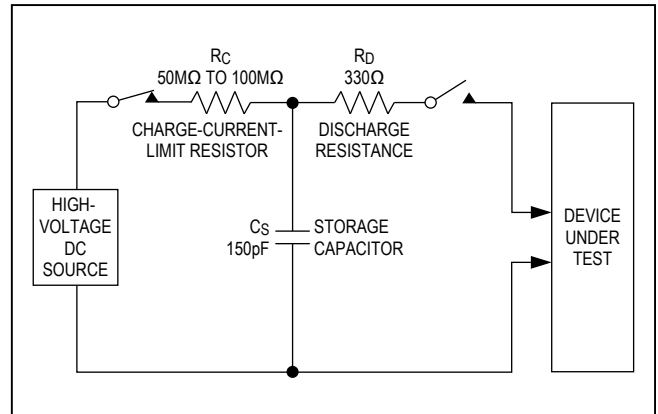


Figure 5. IEC 61000-4-2 ESD Test Model

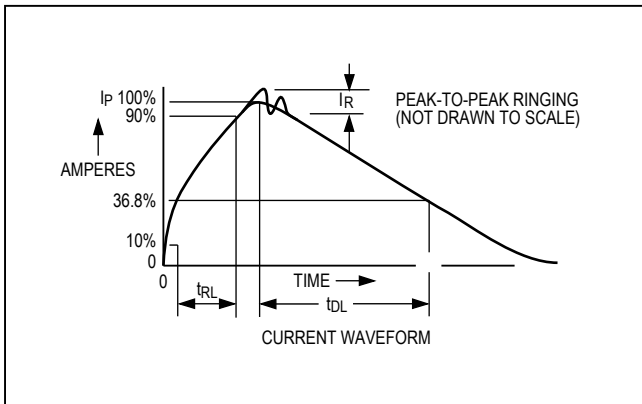


Figure 4. Human Body Current Waveform

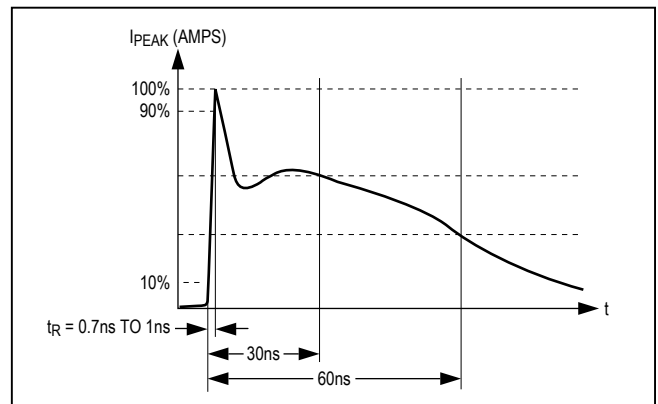


Figure 6. IEC 61000-4-2 ESD Generator Current Waveform

**Ordering Information/Selector Guide**

| PART          | PIN-PACKAGE | TOP MARK | OVLO (V) |
|---------------|-------------|----------|----------|
| MAX14699EWC+T | 12 WLP      | ADC      | 13.75    |

**Note:** All devices are specified over the -40°C to +85°C temperature range.

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

T = Tape and reel.

**Chip Information**

PROCESS: BICMOS

**Package Information**

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 TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.                               |
|--------------|--------------|-------------------------|--|
| 12 WLP       | W121F2+1     | <a href="#">21-0542</a> | Refer to <a href="#">Application Note 1891</a> |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION  | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0               | 12/13         | Initial release  | —             |
| 1               | 1/14          | Corrected A1 bump function description   | 7             |
| 2               | 3/14          | Corrected $\overline{EN}$ voltage range in the <i>Absolute Maximum Ratings</i> section | 2             |
| 3               | 6/14          | Removed MAX14700 from data sheet   | 1-12          |

For information on other Maxim Integrated products, visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

*Maxim Integrated cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim Integrated product. No circuit patent licenses are implied. Maxim Integrated reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.*