

MAX14653/MAX14654/ MAX14655

High-Current Overvoltage Protectors with Adjustable OVLO

General Description

The MAX14653/MAX14654/MAX14655 overvoltage protection devices feature a low $38\text{m}\Omega$ (typ) R_{ON} internal FET and protect low-voltage systems against voltage faults up to $+28\text{V}_{\text{DC}}$. An internal clamp also protects the devices from surges up to $+80\text{V}$. When the input voltage exceeds the overvoltage threshold, the internal FET is 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 4V and 20V . With the OVLO input set below the external OVLO select voltage, the MAX14653/MAX14654/MAX14655 automatically choose the accurate internal trip thresholds. The internal overvoltage thresholds (OVLO) are preset to 15.5V typical (MAX14653), 6.8V typical (MAX14654), or 5.825V typical (MAX14655). The devices feature an open-drain $\overline{\text{ACOK}}$ output indicating a stable supply between minimum supply voltage and V_{OVLO} . The MAX14653/MAX14654/MAX14655 are also protected against over-current events by an internal thermal shutdown.

The MAX14653/MAX14654/MAX14655 are offered in a small 12-bump WLP package and operate over the -40°C to $+85^{\circ}\text{C}$ extended temperature range.

Applications

- Smartphones
- Tablet PCs
- Mobile Internet Devices

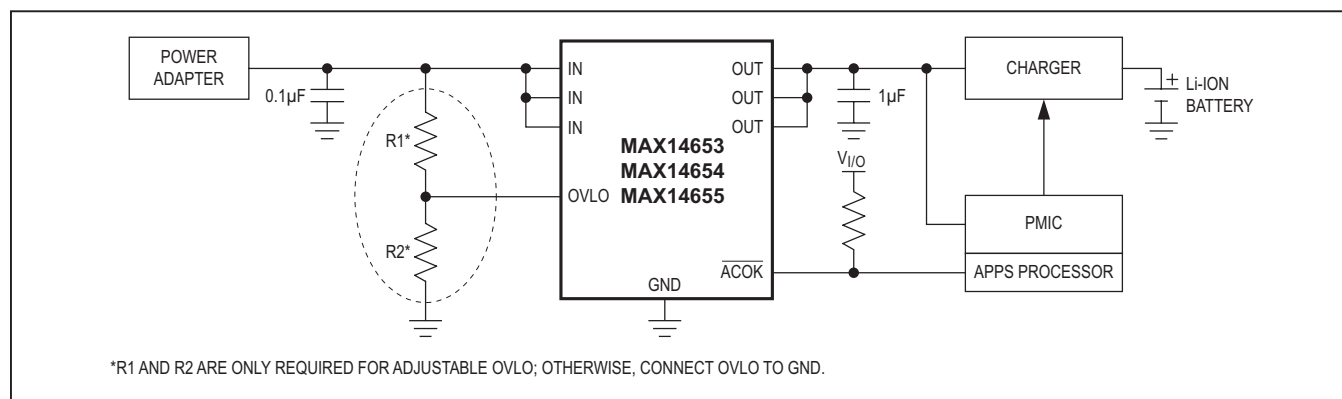
Benefits and Features

- Protect High-Power Portable Devices
 - Wide Operating Input Voltage Protection from $+2.5\text{V}$ to $+28\text{V}$
 - Integrated $38\text{m}\Omega$ (typ) n-Channel MOSFET Switch
- Flexible Overvoltage Protection Design
 - Adjustable Overvoltage-Protection Trip Level
 - Wide Adjustable OVLO Threshold Range from $+4\text{V}$ to $+20\text{V}$
 - Preset Internal Accurate OVLO Thresholds:
 - $15.5\text{V} \pm 3.3\%$ (MAX14653)
 - $6.8\text{V} \pm 2.9\%$ (MAX14654)
 - $5.825\text{V} \pm 3\%$ (MAX14655)
- Additional Protection Features Increase System Reliability
 - Surge Immunity to $+80\text{V}$
 - Soft-Start to Minimize In-Rush Current
 - Internal 15ms Startup Debounce
 - Thermal-Shutdown Protection
- Minimize PCB Area
 - 12-Bump WLP ($1.29\text{mm} \times 1.83\text{mm}$) Package
- -40°C to $+85^{\circ}\text{C}$ Operating Temperature Range

Ordering Information/Selector Guide appears at end of data sheet.

For related parts and recommended products to use with this part, refer to www.maximintegrated.com/MAX14653.related.

Typical Application Circuit



Absolute Maximum Ratings

(All voltages referenced to GND.)

| | |
|----------------------------|--------------------------|
| IN (Note 1) | -0.3V to +29V |
| OUT | -0.3V to $V_{IN} + 0.3V$ |
| OVLO | -0.3V to +24V |
| ACOK | -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 ($T_A = +70^\circ\text{C}$) | |
| WLP (derate 13.7mW/°C above +70°C) | 1096mW |
| 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_{JA}) 73°C/W

Note 1: Survives burst pulse up to 80V 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.

Electrical Characteristics

($V_{IN} = +2.5V$ to +28V, $C_{IN} = 0.1\mu\text{F}$, $T_A = -40^\circ\text{C}$ to +85°C, unless otherwise noted. Typical values are at $V_{IN} = +5.0V$, $I_{IN} \leq 3A$, and $T_A = +25^\circ\text{C}$.) (Note 3)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------|--------------------|------------------------------------------------------------|----------|------|-------|-------|
| Input Voltage Range | V_{IN} | | 2.5 | | 28 | V |
| Input Clamp Voltage | V_{IN_CLAMP} | $I_{IN} = 10\text{mA}$, $T_A = +25^\circ\text{C}$ | | 33 | | V |
| Input Supply Current | I_{IN} | $V_{IN} = 5V$ | | 70 | 120 | μA |
| OVLO Supply Current | I_{IN_Q} | $V_{OVLO} = 3V$, $V_{IN} = 5V$, $V_{OUT} = 0V$ | | 63 | 120 | μA |
| Internal Overvoltage Trip Level | V_{IN_OVLO} | V_{IN} rising | MAX14653 | 15 | 15.5 | 16 |
| | | | MAX14654 | 6.6 | 6.8 | 7.0 |
| | | | MAX14655 | 5.65 | 5.825 | 6.00 |
| | | V_{IN} falling | MAX14653 | 14.5 | | |
| | | | MAX14654 | 6.5 | | |
| | | | MAX14655 | 5.55 | | |
| OVLO Set Threshold | V_{OVLO_TH} | MAX14653 | 1.22 | 1.26 | 1.30 | V |
| | | MAX14654 and MAX14655 | 1.18 | 1.22 | 1.26 | |
| Adjustable OVLO Threshold Range | | | 4 | | 20 | V |
| External OVLO Select Threshold | V_{OVLO_SELECT} | | 0.2 | | 0.3 | V |
| Switch On-Resistance | R_{ON} | $V_{IN} = 5V$, $I_{OUT} = 1A$, $T_A = +25^\circ\text{C}$ | | 38 | 53 | mΩ |
| OUT Load Capacitance | C_{OUT} | $V_{IN} = 5V$ | | | 1000 | μF |
| OVLO Input Leakage Current | I_{OVLO} | $V_{OVLO} = V_{OVLO_TH}$ | -100 | | 100 | nA |

Electrical Characteristics (continued)

($V_{IN} = +2.5V$ to $+28V$, $C_{IN} = 0.1\mu F$, $T_A = -40^\circ C$ 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 | UNITS |
|-------------------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------|-----|----------|-----|------------|
| IN Leakage Voltage by OVLO | V_{IN_LEAK} | $V_{OVLO} = 20V$, V_{IN} = unconnected, $R_{OVLO} = 1M\Omega$ | | | 0.5 | V |
| Thermal Shutdown | | | | 130 | | $^\circ C$ |
| Thermal-Shutdown Hysteresis | | | | 20 | | $^\circ C$ |
| DIGITAL SIGNALS (\overline{ACOK}) | | | | | | |
| \overline{ACOK} Output Low Voltage | V_{OL} | $V_{I/O} = 3.3V$, $I_{SINK} = 1mA$, see the <i>Typical Application Circuit</i> | | | 0.4 | V |
| \overline{ACOK} Leakage Current | V_{ACOK_LEAK} | $V_{I/O} = 3.3V$, \overline{ACOK} deasserted, see the <i>Typical Application Circuit</i> | -1 | | +1 | μA |
| TIMING CHARACTERISTICS (Figure 1) | | | | | | |
| Debounce Time | t_{DEB} | Time from $2.5V < V_{IN} < V_{IN_OVLO}$ to $V_{OUT} = 10\%$ of V_{IN} | | 15 | | ms |
| Soft-Start Time | t_{SS} | $V_{OUT} = 10\%$ of V_{IN} to soft-start off | | 30 | | ms |
| Switch Turn-On Time | t_{ON} | $V_{IN} = 5V$, $R_L = 100\Omega$, $C_{LOAD} = 100\mu F$, V_{OUT} from 10%, V_{IN} to 90% V_{IN} | | 2 | | ms |
| Switch Turn-Off Time | t_{OFF} | $V_{IN} > V_{OVLO}$ to $V_{OUT} = 80\%$ of V_{IN} , $R_L = 100\Omega$, V_{IN} rising at $2V/\mu s$ | | 2 | | μs |
| ESD PROTECTION | | | | | | |
| Human Body Model | | All pins | | ± 2 | | kV |
| IEC 61000-4-2 Contact Discharge | | IN pin | | ± 8 | | kV |
| IEC 61000-4-2 Air Gap Discharge | | IN pin | | ± 15 | | 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.

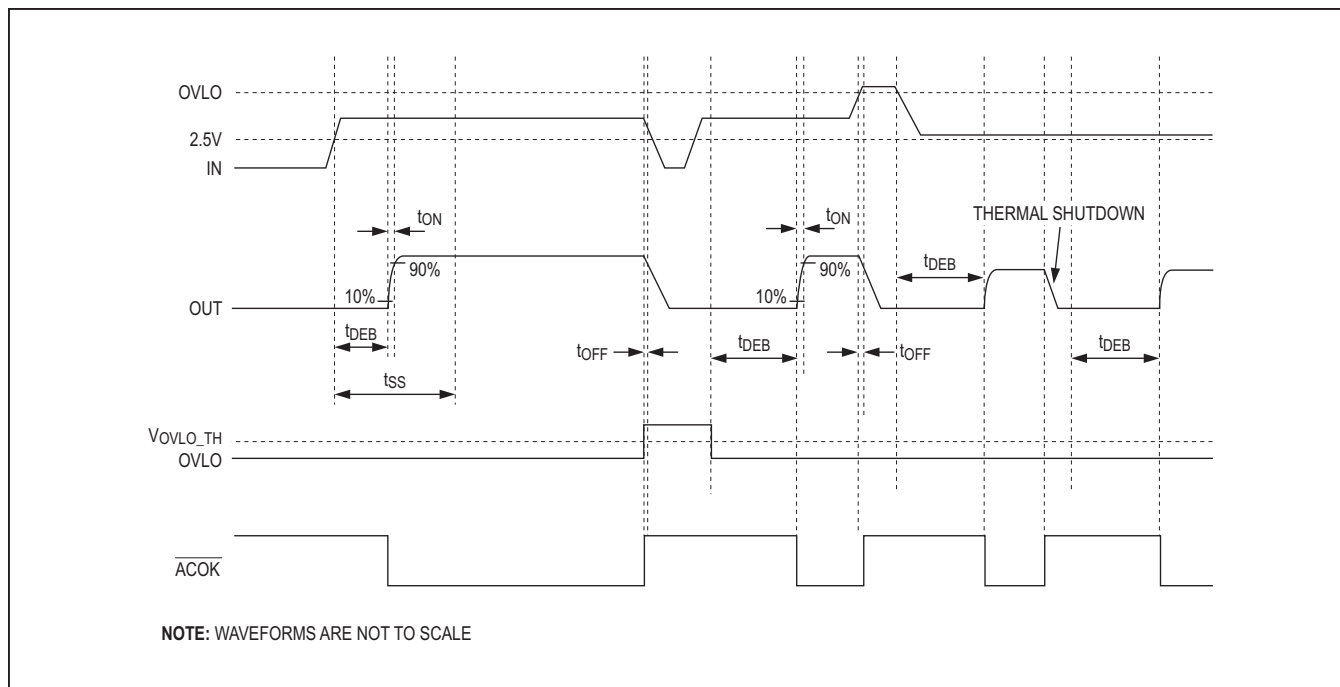
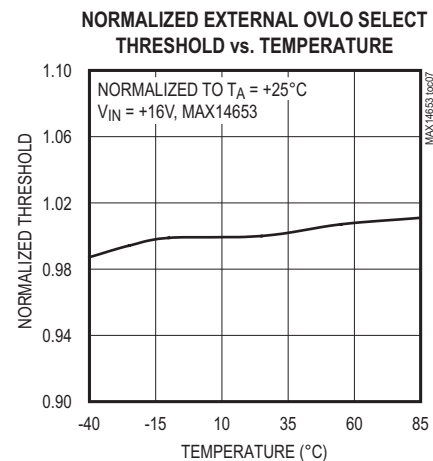
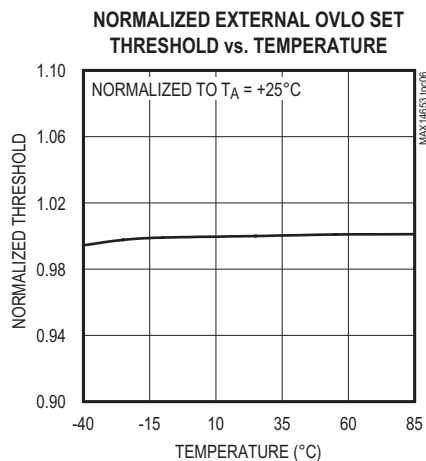
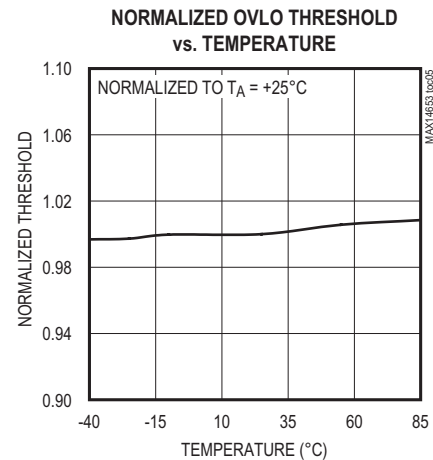
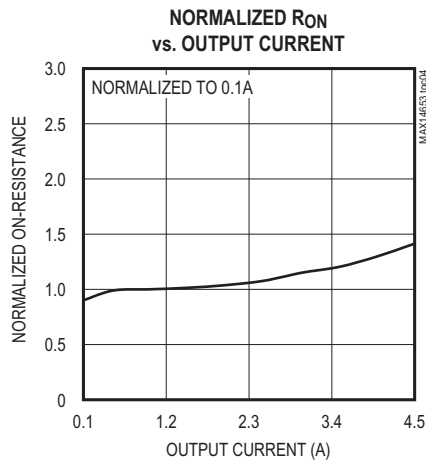
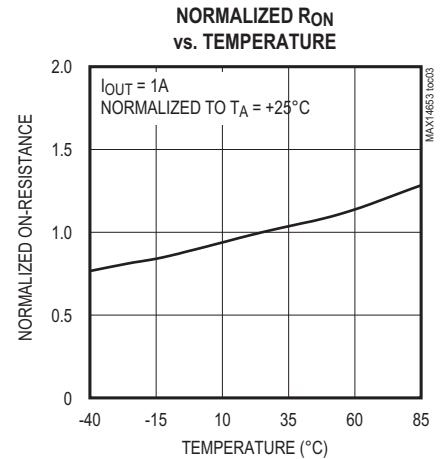
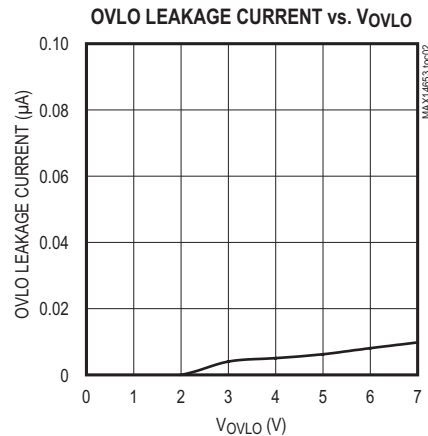
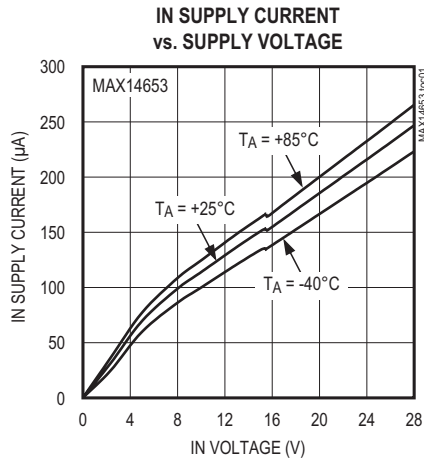


Figure 1. Timing Diagram

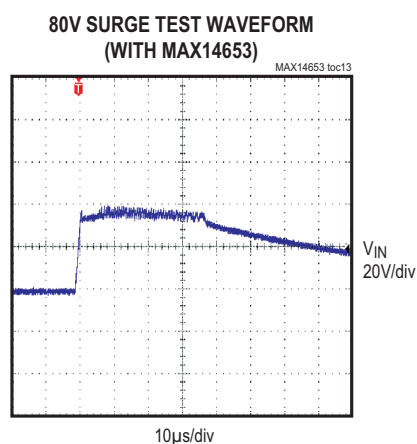
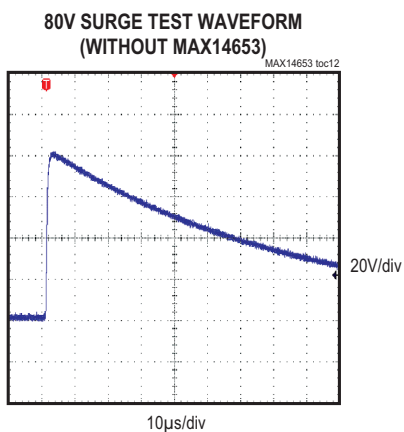
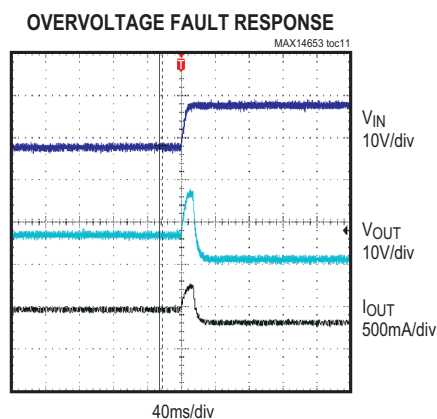
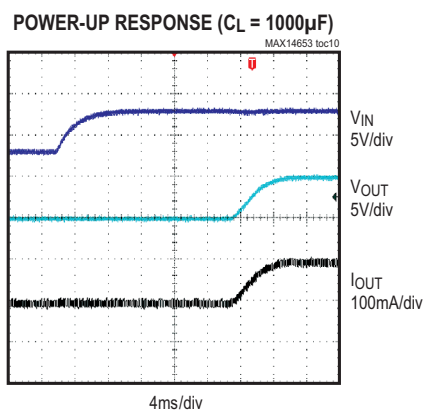
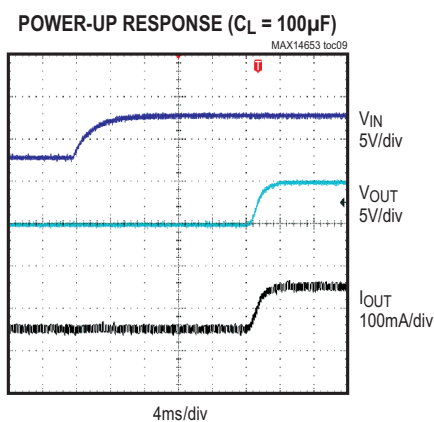
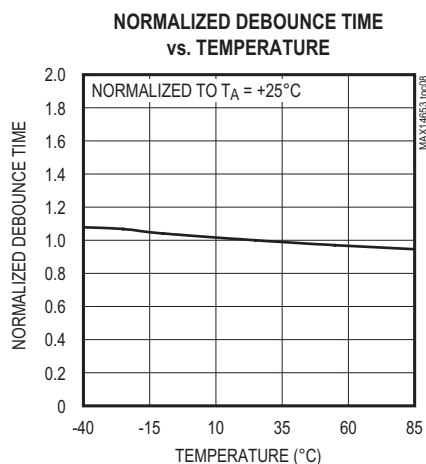
Typical Operating Characteristics

($V_{IN} = +5.0V$, $C_{IN} = 0.1\mu F$, $C_{OUT} = 1\mu F$, $T_A = +25^\circ C$, unless otherwise noted.)



Typical Operating Characteristics (continued)

($V_{IN} = +5.0V$, $C_{IN} = 0.1\mu F$, $C_{OUT} = 1\mu F$, $T_A = +25^\circ C$, unless otherwise noted.)



TOP VIEW
(BUMPS ON BOTTOM)

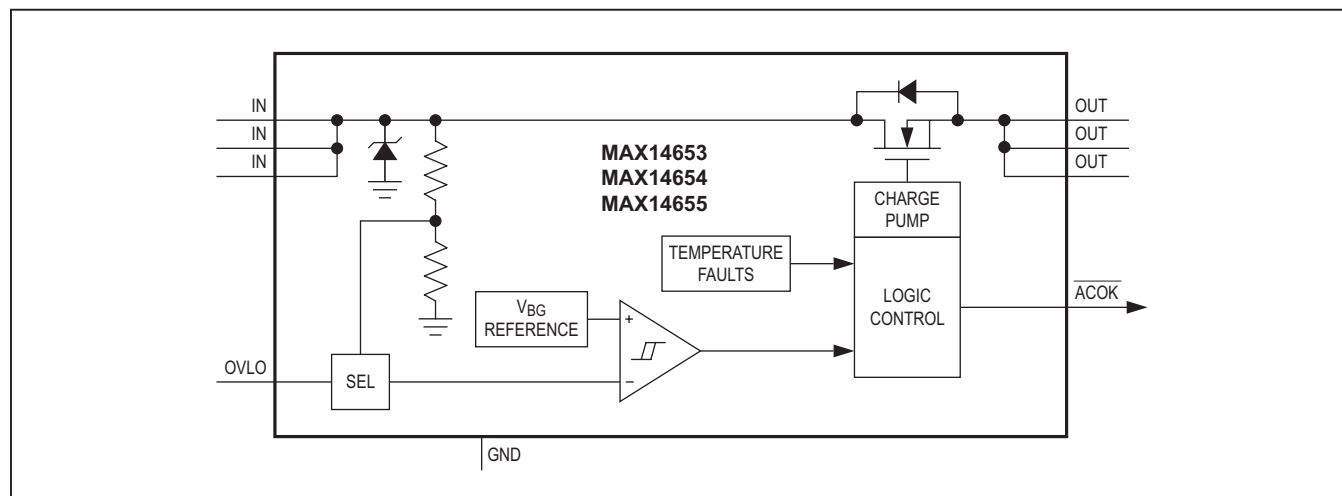
MAX14653
MAX14654
MAX14655

| | 1 | 2 | 3 | 4 |
|---|--------------------------|-----|-----|-----|
| A | + GND | OUT | OUT | GND |
| B | $\overline{\text{ACOK}}$ | OUT | IN | GND |
| C | OVLO | IN | IN | GND |

WLP
(1.3mm x 1.86mm)

| PIN | NAME | FUNCTION |
|----------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1, A4, B4, C4 | GND | Ground. Connect GND pins together for proper operation. |
| A2, A3, B2, | OUT | Output Voltage. Output of internal switch. Connect OUT 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_{IN} and V_{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 $0.1\mu\text{F}$ ceramic capacitor as close as possible to the device. 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 MAX14653/MAX14654/MAX14655 overvoltage protection devices feature a low on-resistance (R_{ON}) internal FET and protect low-voltage systems against voltage faults up to $+28V_{DC}$. An internal clamp also protects the devices from surges up to $+80V$. If the input voltage exceeds the overvoltage threshold, the internal FET is turned off to prevent damage to the protected components. The 15ms debounce time built into the device prevents false turn on of the internal FET during startup.

Device Operation

The devices contain 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 $V_{IN} < \bar{V}_{OVLO_TH}$ if external trip thresholds are used. The charge-pump startup, which occurs after a 15ms debounce delay, turns the internal FET on (see the *Functional Diagram*). After the debounce time, soft-start limits the FET inrush current for 30ms (typ). At any time, if V_{IN} rises above V_{OVLO_THRESH} , OUT is disconnected from IN.

Internal Switch

The MAX14653/MAX14654/MAX14655 incorporate an internal FET with a $38m\Omega$ (typ) R_{ON} . The FET is internally driven by a charge pump that generates a necessary gate voltage above IN.

Overvoltage Lockout (OVLO)

The MAX14653 has a 15.5V (typ) overvoltage threshold (OVLO). The MAX14654 and MAX14655 have 6.8V and 5.825V (typ) OVLO thresholds, respectively.

Thermal-Shutdown Protection

The MAX14653/MAX14654/MAX14655 feature thermal shutdown circuitry. The internal FET turns off when the junction temperature exceeds $+130^{\circ}C$ (typ). The device exits thermal shutdown after the junction temperature cools by $20^{\circ}C$ (typ).

ACOK Output

An open-drain \overline{ACOK} output gives the MAX14653/MAX14654/MAX14655 the ability to communicate a stable power source to the host system. \overline{ACOK} is driven low after input voltage is stable between minimum V_{IN} and V_{OVLO} after debounce. Connect a pullup resistor from \overline{ACOK} to the logic I/O voltage of the host system. \overline{ACOK} is high impedance after thermal shutdown.

Applications Information

IN Bypass Capacitor

For most applications, bypass IN to GND with a 0.1µF ceramic capacitor as close as possible to the device. If the power source has significant inductance due to long lead length, the device clamps the overshoot due to LC tank circuit.

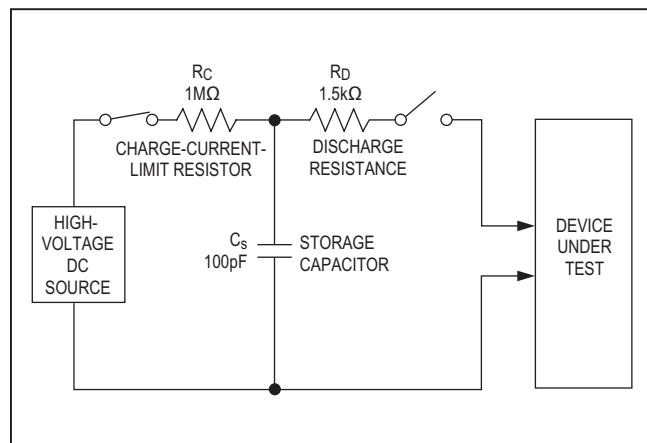


Figure 2a. Human Body ESD Test Model

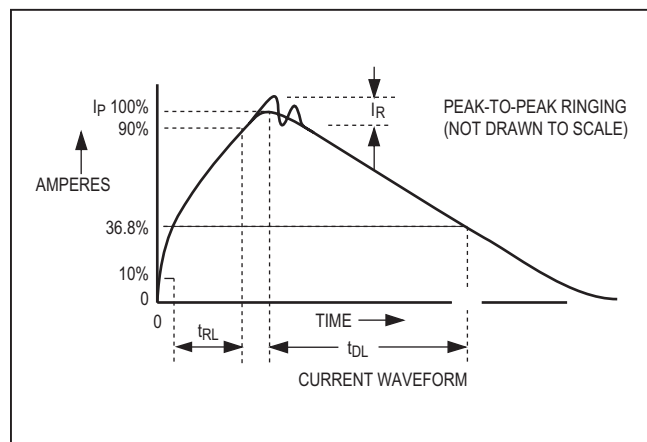


Figure 2b. Human Body Current Waveform

OUT Output Capacitor

The slow turn-on time provides a soft-start function that allows the MAX14653/MAX14654/MAX14655 to charge an output capacitor up to 1000µF 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:

$$V_{IN_OVLO} = V_{OVLO_TH} \times \left[1 + \frac{R_1}{R_2} \right]$$

This external resistor-divider is completely independent from the internal resistor-divider.

ESD Test Conditions

ESD performance depends on a number of conditions. The MAX14653/MAX14654/MAX14655 are specified for ±2kV HBM typical ESD on all pins, Contact and Air-Gap Discharge on pin IN. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

HBM ESD Protection

Figure 2a shows the Human Body Model, and Figure 2b 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.

MAX14653/MAX14654/ MAX14655

High-Current Overvoltage Protectors with Adjustable OVLO

Ordering Information/Selector Guide

| PART | PIN- PACKAGE | TOP MARK | OVLO (V) |
|---------------|-----------------|-------------|-------------|
| MAX14653EWC+T | 12 WLP | ACS | 15.5 |
| MAX14654EWC+T | 12 WLP | ACT | 6.8 |
| MAX14655EWC+T | 12 WLP | ACU | 5.825 |

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.

Package Information

For the latest package outline information and land patterns (footprints), go to 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 | W121G1+1 | 21-0542 | Refer to Application Note 1891 |

Chip Information

PROCESS: BiCMOS

MAX14653/MAX14654/
MAX14655

High-Current Overvoltage Protectors with Adjustable OVLO

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|--------------------|------------------|----------------------------------------------------------------|------------------|
| 0 | 1/13 | Initial release | — |
| 1 | 3/13 | Removed future product asterisks for the MAX14653 and MAX14655 | 10 |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at www.maximintegrated.com.

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