Overvoltage-Protection Controllers with Internal FET

ABSOLUTE MAXIMUM RATINGS

IN ....-0.3V to +30V
OUT ....-0.3V to (IN + 0.3V)
GP...-0.3V to +12V
IN to GP ....-0.3V to +22V
$\overline{ACOK}$ ....-0.3V to +6V
Continuous Power Dissipation (T_A = +70°C)
8-Pin µDFN (derate 4.8mW/°C above +70°C) 381mW

Operating Temperature Range ....-40°C to +85°C
Junction Temperature ....+150°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°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.

ELECTRICAL CHARACTERISTICS

(V_{IN} = +5V (MAX4943/MAX4944_/MAX4945_/MAX4949), V_{IN} = +3V (MAX4946), T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			2.2		28.0	V
Input Supply Current	I_{IN}	V_{IN} = 3V (MAX4946)			50	150	µA
		V_{IN} = 5V, all remaining parts			50	150	
UVLO Supply Current	I_{UVLO}	V_{IN} = 2.2V				30	µA
IN Undervoltage Lockout	V_{UVLO}	(V_{IN} falling)	MAX4943/MAX4944/ MAX4944B/MAX4945/ MAX4945A/ MAX4945B	3.90	4.15	4.40	V
			MAX4944L/MAX4945L/ MAX4946/MAX4949	2.30	2.45	2.60	
IN Undervoltage-Lockout Hysteresis					1		%
Overvoltage Trip Level	V_{OVLO}	(V_{IN} rising)	MAX4943	7.00	7.4	7.80	V
			MAX4944_	6.00	6.35	6.70	
			MAX4945/MAX4945B/L	5.50	5.80	6.10	
			MAX4945A	5.50	5.80	6.00	
			MAX4946	4.30	4.56	4.82	
			MAX4949	8.20	8.90	9.60	
IN Overvoltage Hysteresis					1		%
Switch On-Resistance	R_{ON}	V_{IN} = 3V (MAX4946), I_{OUT} = 1A			80	200	mΩ
		V_{IN} = 5V, all remaining parts, I_{OUT} = 1A			80	200	
Overcurrent Protection Threshold	I_{LIM}	MAX4943–MAX4946	T_A = +25°C	1.2	1.7	4.0	A
			T_A = T_{MIN} to T_{MAX}	1.2	1.7	4.0	
		MAX4949	T_A = +25°C	2.0	3.5	5.0	
			T_A = T_{MIN} to T_{MAX}	2.0	3.0	5.0	
GP Clamp Voltage	I_{GPD}	(V_{IN} - V_{GP}), V_{IN} = 28V		13	16	19	V
GP Pulldown Resistor	R_{GPD}				50		kΩ

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = +5V (MAX4943/MAX4944_/MAX4945_/MAX4949), V_{IN} = +3V (MAX4946), T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

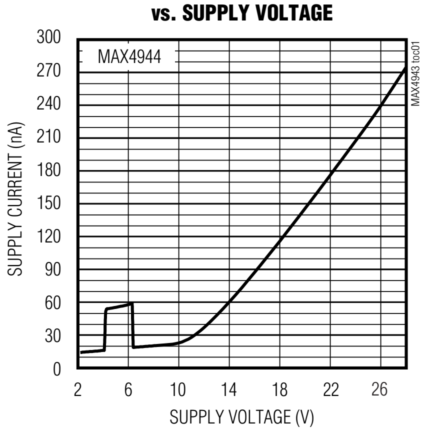
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
$\overline{ACOK}$ Output-Low Voltage	V_{OL}	I_{SINK} = 1mA			0.4	V
$\overline{ACOK}$ High-Leakage Current		$V_{\overline{ACOK}}$ = 5.5V			1	µA
Thermal Shutdown				+175		°C
Thermal-Shutdown Hysteresis				40		°C
Load Capacitor					300	µF
TIMING CHARACTERISTICS (Figure 2)						
Debounce Time	t_{INDBC}	Time from V_{UVLO} < V_{IN} < V_{OVLO} to charge-pump enable		15		ms
Switch Turn-On Time	t_{ON}	V_{UVLO} < V_{IN} < V_{OVLO}, R_{LOAD} = 100Ω, C_{LOAD} = 300µF, V_{OUT} = from 10% of V_{OUT} to 80% of V_{OUT}		6		ms
$\overline{ACOK}$ Assertion Time	$t_{\overline{ACOK}}$	V_{UVLO} < V_{IN} < V_{OVLO}, to $\overline{ACOK}$ low		30		ms
Switch Turn-Off Time	t_{OFF}	V_{IN} < V_{UVLO} or V_{IN} > V_{OVLO}, to internal switch off		2	20	µs
		Overcurrent fault to internal switch turn-off		10		µs
Autoretry Time	t_{RETRY}	From overcurrent fault to internal switch turn-on		15		ms

Note 1: All specifications are 100% production tested at T_A = +25°C, unless otherwise noted. Specifications are over -40°C to +85°C and are guaranteed by design.

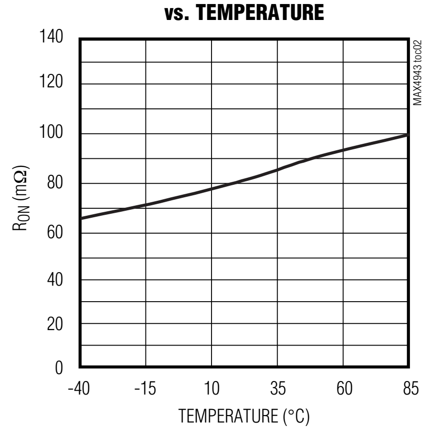
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

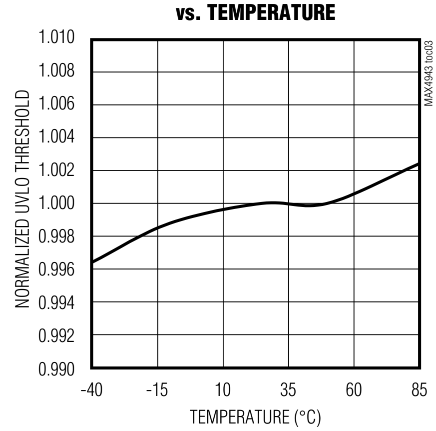
SUPPLY CURRENT vs. SUPPLY VOLTAGE



R_{ON} vs. TEMPERATURE



NORMALIZED UVLO THRESHOLD vs. TEMPERATURE

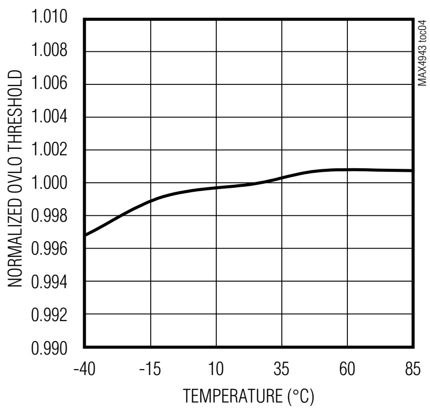


Overvoltage-Protection Controllers with Internal FET

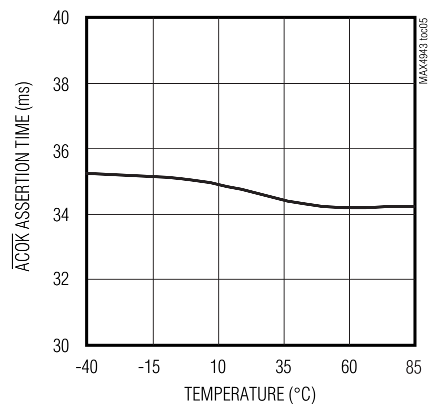
Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

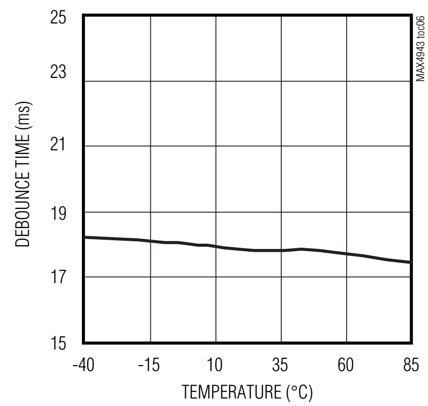
NORMALIZED OVLO THRESHOLD vs. TEMPERATURE



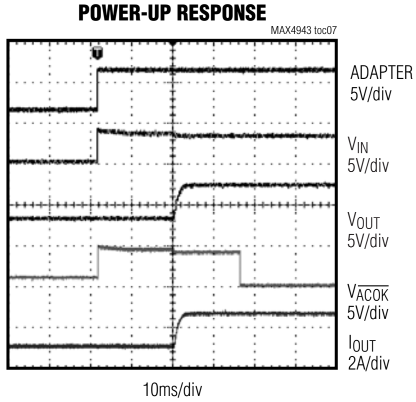
ACOK ASSERTION TIME vs. TEMPERATURE



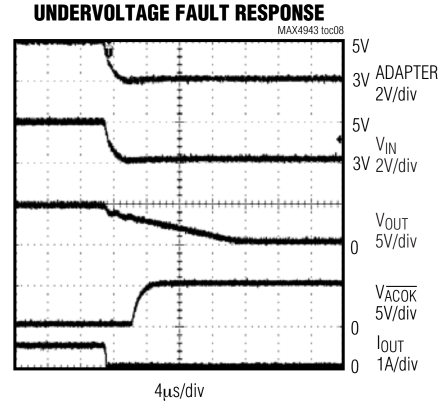
DEBOUNCE TIME vs. TEMPERATURE



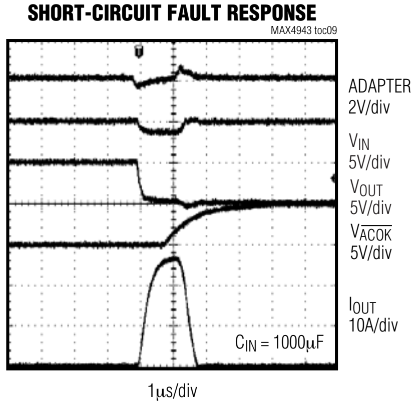
POWER-UP RESPONSE



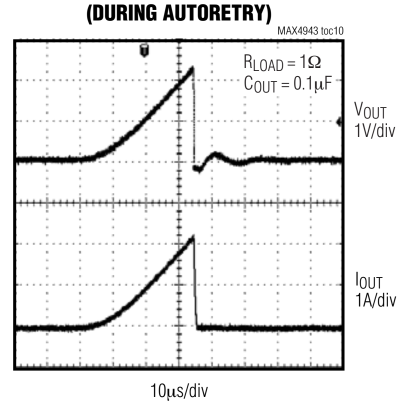
UNDERVOLTAGE FAULT RESPONSE



SHORT-CIRCUIT FAULT RESPONSE



OVERCURRENT DURATION TIME (DURING AUTORETRY)



Pin Description

PIN	NAME	FUNCTION
1, 2	IN	Voltage Input. IN powers the charge pump required to turn on the internal switch. When the correct adapter is plugged in, a 15ms (typ) debouncer prevents false turn-on of the internal switch. Bypass IN to GND with a 1µF ceramic capacitor as close as possible to the device to enable ±15kV (HBM) ESD protection on IN.
3	GP	pFET Gate-Drive Output. GP pulls the external pFET gate down when the input is above ground.
4	$\overline{ACOK}$	Active-Low Open-Drain Adapter-Voltage Indicator Output. $\overline{ACOK}$ is driven low after the adapter voltage is stable between V_{UVLO} and V_{OVLO} for 30ms (typ). Connect a pullup resistor from $\overline{ACOK}$ to the logic I/O voltage of the host system.
5	GND	Ground
6, 7, 8	OUT	Output Voltage. Output of internal switch. Short all pins together for proper operation.

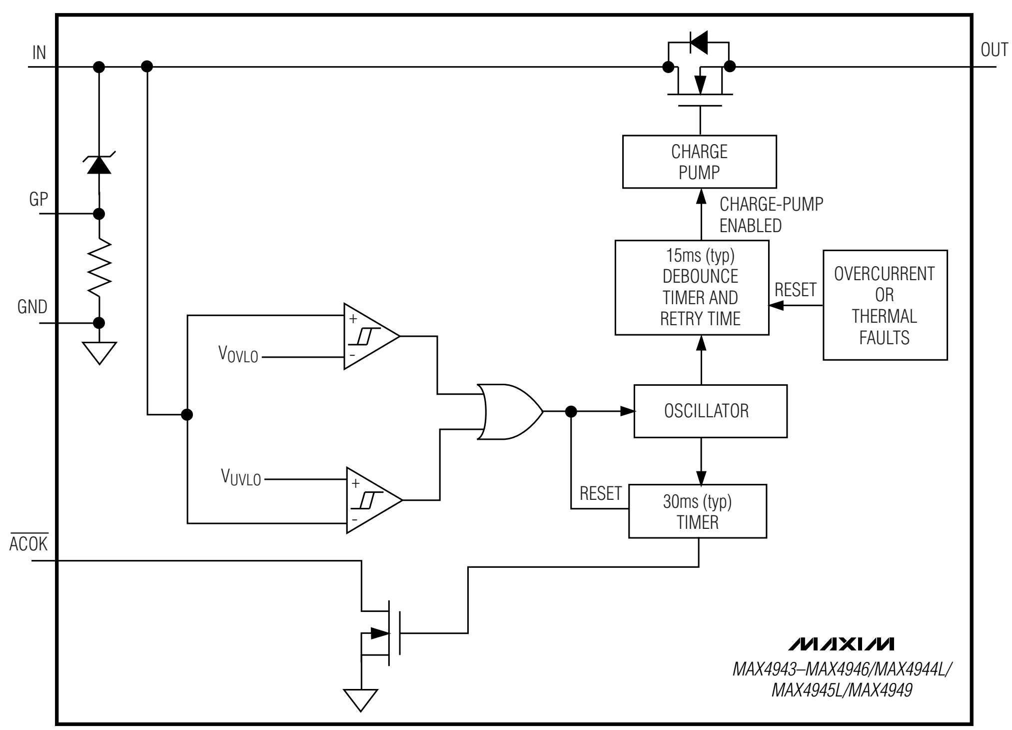


Figure 1. Functional Diagram

Detailed Description

The MAX4943–MAX4946/MAX4949 overvoltage-protection devices feature a low R_{ON} internal FET and protect low-voltage systems against voltage faults up to +28V. If the input voltage exceeds the overvoltage threshold, the internal MOSFET is turned off to prevent damage to the protected components. These devices also drive an optional external pFET to protect down to -28V. If the adapter voltage drops below ground, the pFET turns off to prevent damage to the protected components due to negative voltage exposure. The internal charge pump's 15ms (typ) debounce time prevents false turn-on of the internal switch during startup. An open-drain, active-low logic output is available to signal that a successful power-up has occurred.

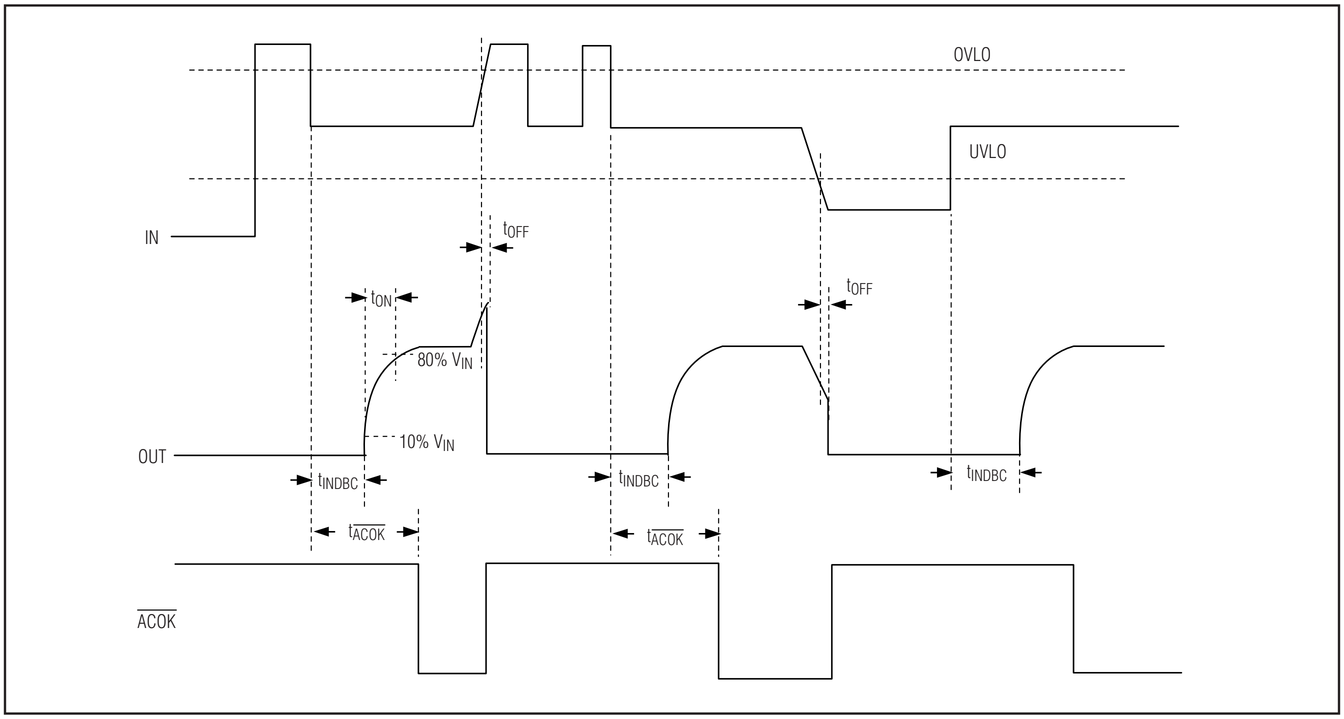


Figure 2. Timing Diagram

Device Operation

The MAX4943–MAX4946/MAX4949 have an internal oscillator and charge pump that control the turn-on of the internal switch. The internal oscillator controls the timers that enable the turn-on of the charge pump and controls the state of the open-drain $\overline{\text{ACOK}}$ output. If $V_{IN} < V_{UVLO}$ or if $V_{IN} > V_{OVLO}$, the internal oscillator remains off, thus disabling the charge pump. If $V_{UVLO} < V_{IN} < V_{OVLO}$, the internal charge pump is enabled. The charge-pump startup, after a 15ms (typ) internal delay, turns on the internal switch (see Figure 2). $\overline{\text{ACOK}}$ is held high during startup until the $\overline{\text{ACOK}}$ 30ms (typ) blanking period expires. At this point, the device is in its on state.

At any time, if V_{IN} drops below V_{UVLO} or rises above V_{OVLO}, $\overline{\text{ACOK}}$ is pulled high and the charge pump is disabled.

Internal Switch

The MAX4943–MAX4946/MAX4949 incorporate an internal nFET with a 80mΩ (typ) R_{ON}. The switch is internally driven by a charge pump that generates a 5V voltage above the input voltage. The internal switch is equipped with 1.2A (min) current-limit protection that turns off the switch within 10µs (typ) during an overcurrent fault condition.

Autoretry

The MAX4943–MAX4946 have an overcurrent autoretry function that turns on the switch again after a 15ms (typ) retry time (see Figure 3). If the faulty load condition is still present after the blanking time, the switch turns off again and the cycle is repeated. The fast turn-off time and 15ms retry time result in a very low duty cycle to keep power consumption low. If the faulty load condition is not present, the switch remains on.

Latch

The MAX4944B/MAX4945B/MAX4949 do not have the autoretry function, and the switch latches off after an overcurrent fault. The switch remains off until the overcurrent fault has been removed. The switch turns back on when the adapter voltage goes below V_{UVLO} and then returns to the valid operating range.

GP GATE Drive

When the input voltage goes above ground, GP pulls low and turns on the pFET. An internal clamp protects the pFET by ensuring that the GP to IN voltage does not exceed 19V (max) when the input (IN) rises to +28V.

Undervoltage Lockout (UVLO)

The MAX4944L/MAX4945L/MAX4946/MAX4949 have a 2.45V (typ) undervoltage-lockout threshold (V_{UVLO}), while the remaining devices have a 4.15V (typ) V_{UVLO} threshold. When V_{IN} is less than V_{UVLO}, $\overline{ACOK}$ is high impedance.

Overvoltage-Lockout Thresholds (OVLO)

The MAX4943 has a 7.4V (typ) overvoltage threshold (V_{OVLO}), the MAX4944_ has a 6.35V (typ) V_{OVLO} threshold, the MAX4945_ has a 5.80V (typ) V_{OVLO} threshold, the MAX4946 has a 4.56V (typ) V_{OVLO} threshold, and the MAX4949 has a 8.90V (typ) V_{OVLO} threshold. When V_{IN} is greater than OVLO, $\overline{ACOK}$ is high impedance.

$\overline{ACOK}$

$\overline{ACOK}$ is an active-low, open-drain output that asserts low when $V_{UVLO} < V_{IN} < V_{OVLO}$ for the 30ms (typ) period. Connect a pullup resistor from $\overline{ACOK}$ to the logic I/O voltage of the host system. During a short-circuit fault, $\overline{ACOK}$ may deassert due to V_{IN} not being in the valid operating voltage range.

Thermal-Shutdown Protection

The MAX4943–MAX4946/MAX4949 feature thermal-shutdown circuitry. The internal switch turns off when the junction temperature exceeds +175°C (typ) and immediately goes into a fault mode. The device exits thermal shutdown after the junction temperature cools by 40°C (typ).

Applications Information

IN Bypass Capacitor

For most applications, bypass IN to GND with a 1µF ceramic capacitor as close as possible to the device to enable ±15kV (HBM) ESD protection on the pin. If ±15kV is not required, there is no capacitor required at IN. If the power source has significant inductance due to long lead length, take care to prevent overshoots due to the LC tank circuit and provide protection if necessary to prevent exceeding the +30V absolute maximum rating on IN.

Reverse Polarity Protection

The optional external pFET can provide reverse polarity protection down to -28V (for a 30V pFET), if the protect-

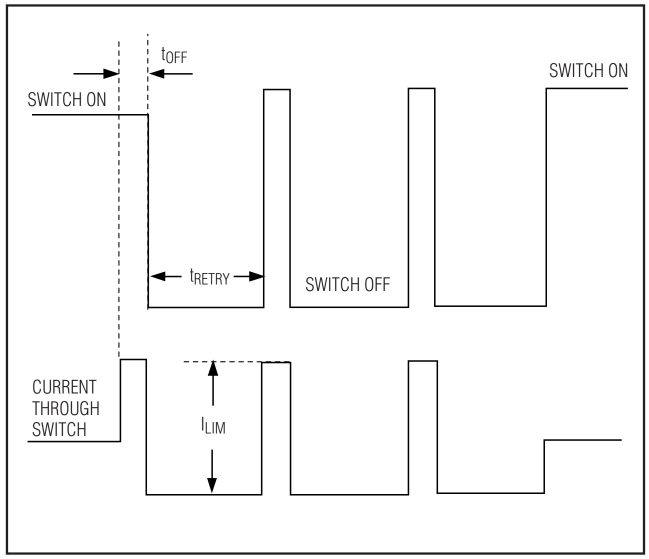


Figure 3. Autoretry Timing Diagram

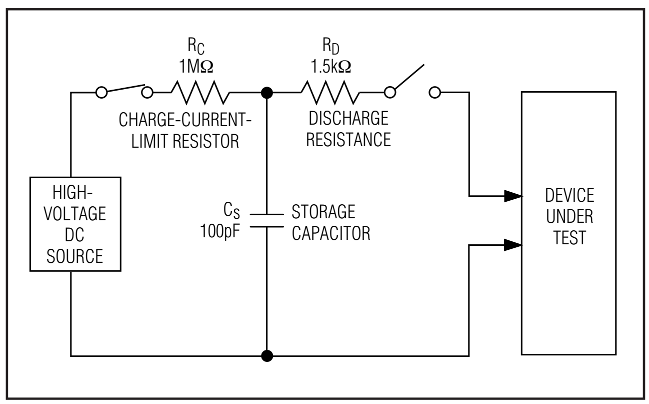


Figure 4. Human Body ESD Test Model

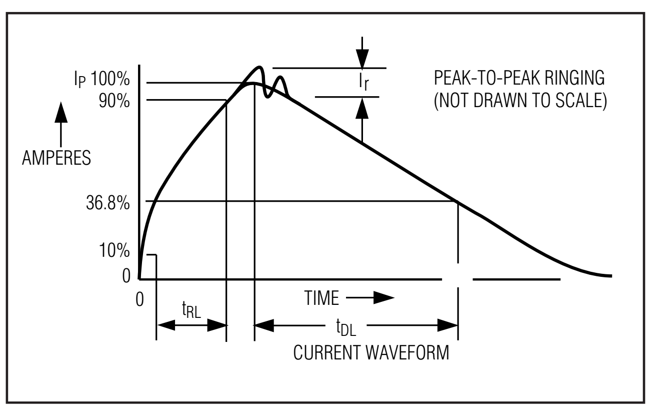


Figure 5. Human Body Current Waveform

Overvoltage-Protection Controllers with Internal FET

ed device does not allow current to flow into OUT. The pFET is turned off when the voltage between GP and IN is less than the pFET gate threshold voltage.

ESD Test Conditions

ESD performance depends on a number of conditions. The MAX4943–MAX4946/MAX4949 are specified for ±15kV (HBM) typical ESD resistance on IN when IN is bypassed to ground with a 1µF ceramic capacitor.

Human Body Model

Figure 4 shows the Human Body Model and Figure 5 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 device through a 1.5kΩ resistor.

IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. It does not specifically refer to integrated circuits. The MAX4943–MAX4946/MAX4949 are specified for ±15kV Air-Gap Discharge and ±8kV Contact Discharge IEC 61000-4-2 on the IN pin when IN is bypassed to ground with a 1µF ceramic capacitor.

The major difference between tests done using the Human Body Model and IEC 61000-4-2 is a higher peak current in IEC 61000-4-2, due to lower series resistance.

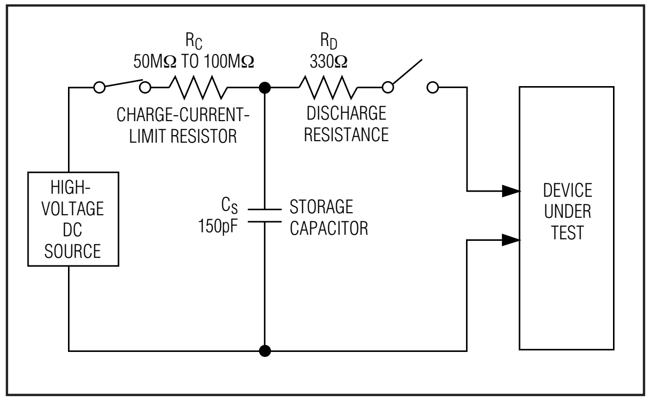


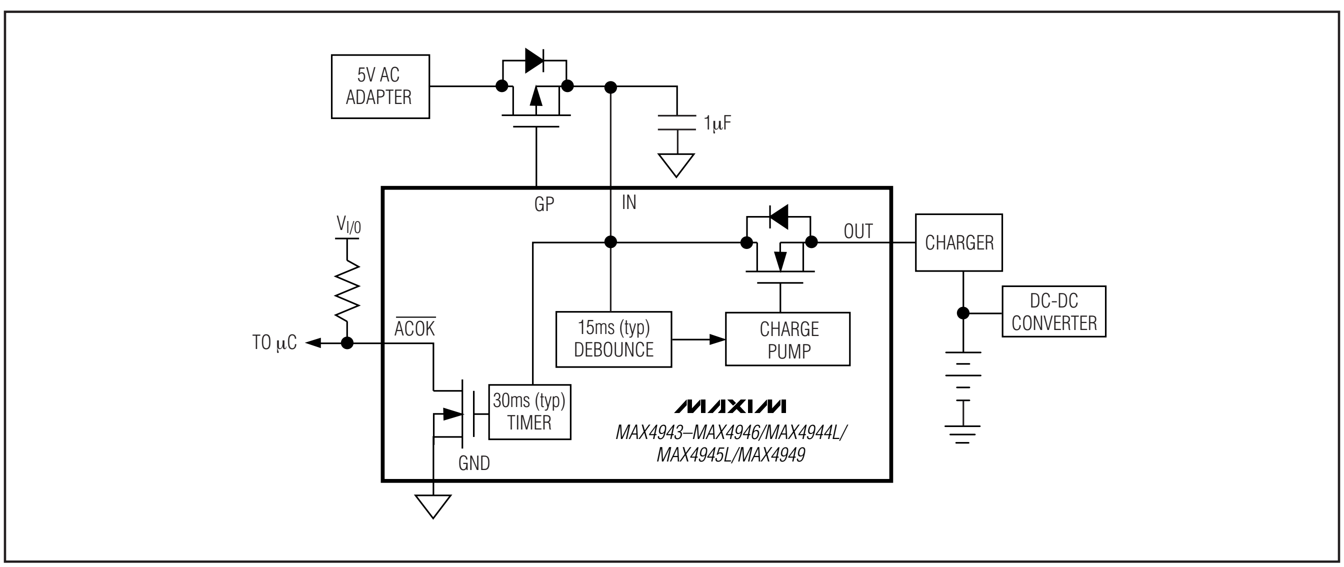
Figure 6. IEC 61000-4-2 ESD Test Model

Hence, the ESD withstand voltage measured to IEC 61000-4-2 generally is lower than that measured using the Human Body Model. Figure 6 shows the IEC 61000-4-2 model. The Contact Discharge method connects the probe to the device before the probe is charged. The Air-Gap Discharge test involves approaching the device with a charged probe.

Chip Information

PROCESS: BiCMOS

Typical Operating Circuit



Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.
8 µDFN	L822-1	**21-0164**

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Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
2	7/07	—	1, 2, 3
3	6/08	Added MAX4945A to the *Ordering Information/Selector Guide* and *Electrical Characterstics* tables	1, 2