



$\pm 15\text{kV}$ ESD-Protected, Single/Dual/Octal, CMOS Switch Debouncers

General Description

The MAX6816/MAX6817/MAX6818 are single, dual, and octal switch debouncers that provide clean interfacing of mechanical switches to digital systems. They accept one or more bouncing inputs from a mechanical switch and produce a clean digital output after a short, preset qualification delay. Both the switch opening bounce and the switch closing bounce are removed. Robust switch inputs handle $\pm 25\text{V}$ levels and are $\pm 15\text{kV}$ ESD-protected for use in harsh industrial environments. They feature single-supply operation from $+2.7\text{V}$ to $+5.5\text{V}$. Undervoltage lockout circuitry ensures the output is in the correct state upon power-up.

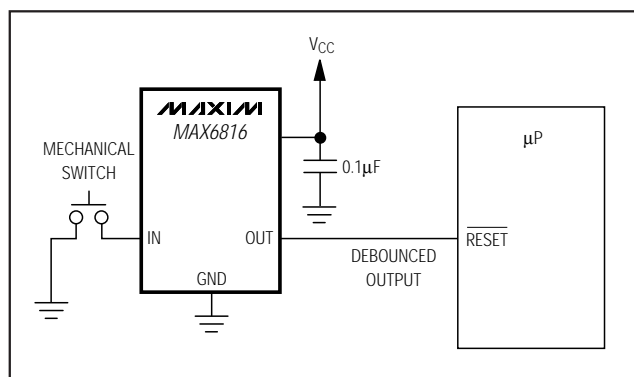
The single MAX6816 and dual MAX6817 are offered in SOT packages and require no external components. Their low supply current makes them ideal for use in portable equipment.

The MAX6818 octal switch debouncer is designed for data-bus interfacing. The MAX6818 monitors switches and provides a switch change-of-state output (CH), simplifying microprocessor (μP) polling and interrupts. Additionally, the MAX6818 has three-state outputs controlled by an enable ($\overline{\text{EN}}$) pin, and is pin-compatible with the 'LS573 octal latch (except for the CH pin), allowing easy interfacing to a digital data bus.

Applications

- μP Switch Interfacing
- Industrial Instruments
- PC-Based Instruments
- Portable Instruments
- Automotive Applications
- Membrane Keypads

Typical Operating Circuit



Features

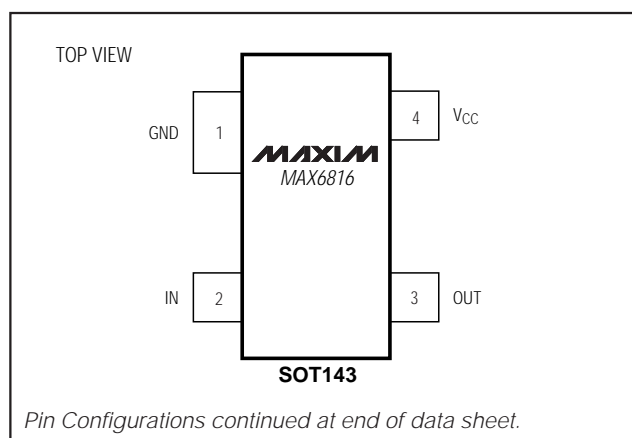
- ◆ Robust Inputs can Exceed Power Supplies up to $\pm 25\text{V}$
- ◆ ESD Protection for Input Pins
 - $\pm 15\text{kV}$ —Human Body Model
 - $\pm 8\text{kV}$ —IEC 1000-4-2, Contact Discharge
 - $\pm 15\text{kV}$ —IEC 1000-4-2, Air-Gap Discharge
- ◆ Small SOT Packages (4 and 6 pins)
- ◆ Single-Supply Operation from $+2.7\text{V}$ to $+5.5\text{V}$
- ◆ Single (MAX6816), Dual (MAX6817), and Octal (MAX6818) Versions Available
- ◆ No External Components Required
- ◆ $6\mu\text{A}$ Supply Current
- ◆ Three-State Outputs for Directly Interfacing Switches to μP Data Bus (MAX6818)
- ◆ Switch Change-of-State Output Simplifies Polling and Interrupts (MAX6818)
- ◆ Pin-Compatible with 'LS573 (MAX6818)

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	SOT TOP MARK
MAX6816EUS-T	-40°C to $+85^{\circ}\text{C}$	4 SOT143	KABA
MAX6817EUT-T	-40°C to $+85^{\circ}\text{C}$	6 SOT23-6	AAAU
MAX6818EAP	-40°C to $+85^{\circ}\text{C}$	20 SSOP	—

Note: There is a minimum order increment of 2500 pieces for SOT packages.

Pin Configurations



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ABSOLUTE MAXIMUM RATINGS

Voltage (with respect to GND)

V _{CC}	-0.3V to +6V
IN ₋ (Switch Inputs)	-30V to +30V
$\overline{\text{EN}}$	-0.3V to +6V
OUT ₋ , $\overline{\text{CH}}$	-0.3V to (V _{CC} + 0.3V)

OUT Short-Circuit Duration

(One or Two Outputs to GND).....Continuous

Continuous Power Dissipation (T_A = +70°C)

4-Pin SOT143 (derate 4.0mW/°C above +70°C).....	320mW
6-Pin SOT23 (derate 8.7mW/°C above +70°C).....	691mW
20-Pin SSOP (derate 8.0mW/°C above +70°C)	640mW
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-65°C to +160°C
Lead Temperature (soldering, 10sec)	+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_{CC} = +2.7V to +5.5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = +5V, T_A = +25°C.) (Note 1)

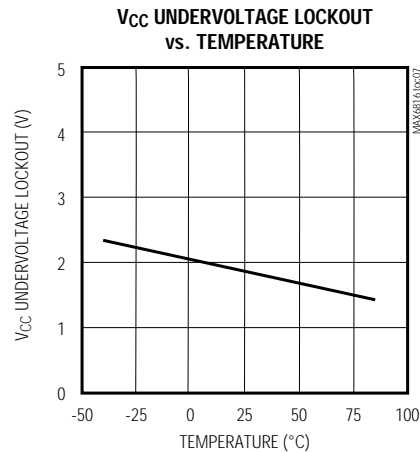
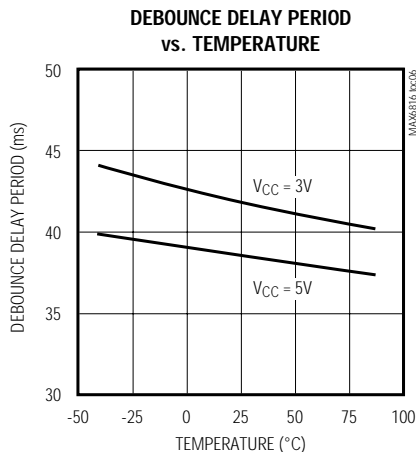
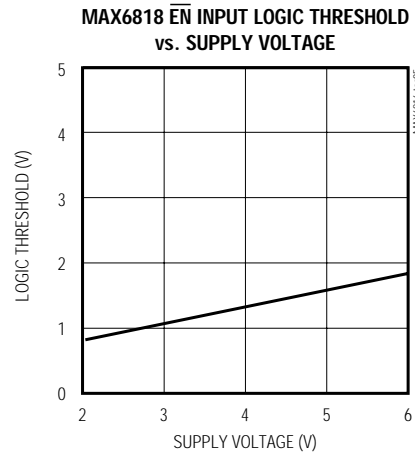
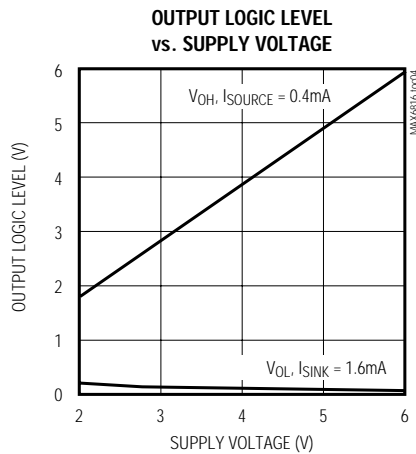
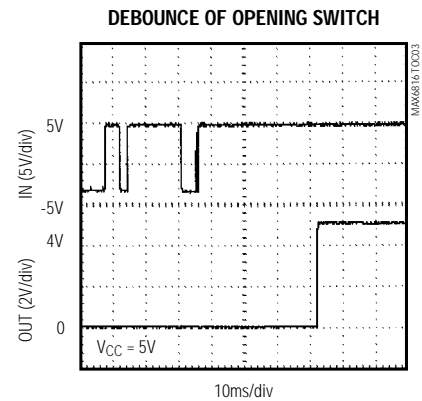
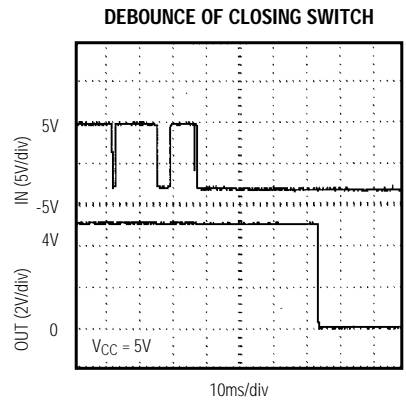
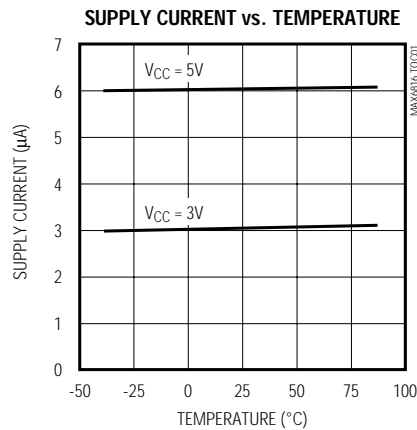
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	V _{CC}		2.7		5.5	V
Supply Current	I _{CC}	V _{CC} = 5V, I _{OUT} = 0, IN ₋ = V _{CC}		6	20	μA
Debounce Duration	t _{DP}	MAX6818	20	40	60	ms
		MAX6816/MAX6817	20	50	80	
Input Threshold	V _{IL}				0.8	V
	V _{IH}	V _{CC} = 5V	2.4			V
		V _{CC} = 2.7V	2.0			
Input Hysteresis				300		mV
Input Pull-Up Resistance			32	63	100	kΩ
IN Input Current	I _{IN}	V _{IN} = ±15V			±1	mA
Input Voltage Range	V _{IN}		-25		25	V
Undervoltage-Lockout Threshold				1.9	2.6	V
OUT ₋ , $\overline{\text{CH}}$ Output Voltage	V _{OL}	I _{SINK} = 1.6mA			0.4	V
	V _{OH}	I _{SOURCE} = 0.4mA	V _{CC} - 1.0			
$\overline{\text{EN}}$ Pulse Width	t _{EN}		200			ns
$\overline{\text{EN}}$ Threshold		V _{CC} = 5V	0.8	1.7	2.4	V
		V _{CC} = 2.7V	0.8	1.1	2.0	
$\overline{\text{EN}}$ Input Current	I _{IL}				±1	μA
$\overline{\text{EN}}$ Low to Out Active Propagation Delay	t _{PE}	R _L = 10kΩ, C _L = 100pF			100	ns
$\overline{\text{EN}}$ High to Out Three-State Propagation Delay	t _{PD}	R _L = 1kΩ, C _L = 15pF			100	ns
$\overline{\text{EN}}$ Low to $\overline{\text{CH}}$ Out High Propagation Delay	t _{PC}	R _L = 10kΩ, C _L = 50pF			100	ns
OUT ₋ Three-State Leakage Current		V _{OUT} = 0 or V _{CC}			±10	μA
ESD CHARACTERISTICS						
ESD Protection	IN ₋	IEC1000-4-2 Air Discharge		±15		kV
		IEC1000-4-2 Contact Discharge		±8		
		Human Body Model		±15		

Note 1: MAX6816 and MAX6817 production testing is done at T_A = +25°C; over-temperature limits are guaranteed by design.

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Typical Operating Characteristics

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



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Pin Description

PIN			NAME	FUNCTION
MAX6816	MAX6817	MAX6818		
1	2	10	GND	Ground
2	—	—	IN	Switch Input
—	1, 3	—	IN1, IN2	Switch Inputs
—	—	2–9	IN1–IN8	Switch Inputs
3	—	—	OUT	CMOS Debounced Output
—	4, 6	—	OUT2, OUT1	CMOS Debounced Outputs
—	—	12–19	OUT8–OUT1	CMOS Debounced Outputs
4	5	20	V _{CC}	+2.7V to +5.5V Supply Voltage
—	—	1	$\overline{\text{EN}}$	Active-Low, Three-State Enable Input for outputs. Resets $\overline{\text{CH}}$. Tie to GND to “always enable” outputs.
—	—	11	$\overline{\text{CH}}$	Change-of-State Output. Goes low on switch input change of state. Resets on $\overline{\text{EN}}$. Leave unconnected if not used.

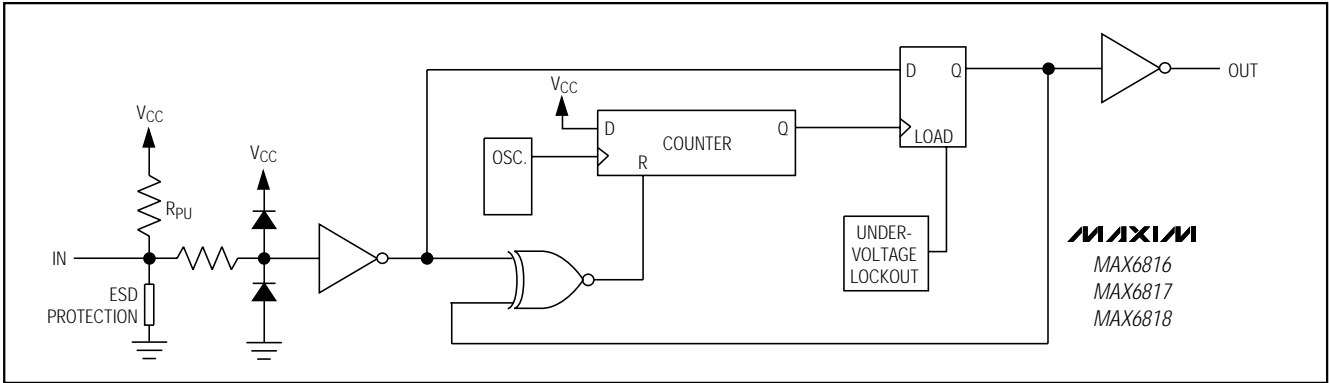


Figure 1. Block Diagram

Detailed Description

Theory of Operation

The MAX6816/MAX6817/MAX6818 are designed to eliminate the extraneous level changes that result from interfacing with mechanical switches (switch bounce). Virtually all mechanical switches bounce upon opening or closing. These switch debouncers remove bounce when a switch opens or closes by requiring that sequentially clocked inputs remain in the same state for a number of sampling periods. The output does not change until the input is stable for a duration of 40ms.

The circuit block diagram (Figure 1) shows the functional blocks consisting of an on-chip oscillator, counter, exclusive-NOR gate, and D flip-flop. When the

input does not equal the output, the XNOR gate issues a counter reset. When the switch input state is stable for the full qualification period, the counter clocks the flip-flop, updating the output. Figure 2 shows the typical opening and closing switch debounce operation. On the MAX6818, the change output ($\overline{\text{CH}}$) is updated simultaneously with the switch outputs.

Undervoltage Lockout

The undervoltage lockout circuitry ensures that the outputs are at the correct state on power-up. While the supply voltage is below the undervoltage threshold (typically 1.9V), the debounce circuitry remains transparent. Switch states are present at the logic outputs without delay.

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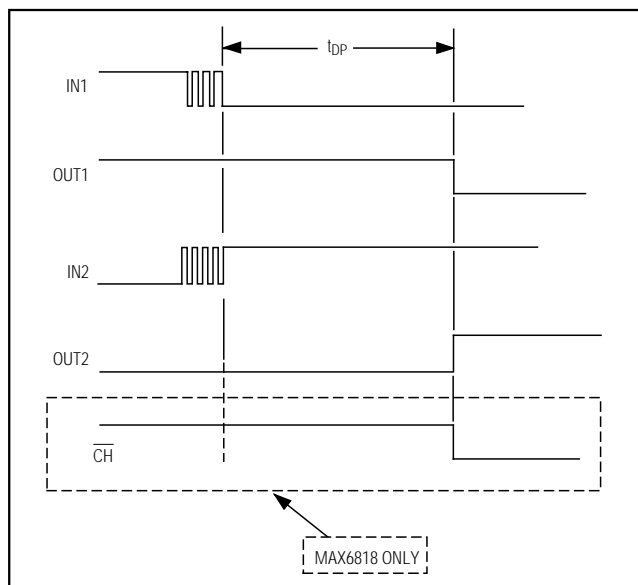


Figure 2. Input Characteristics

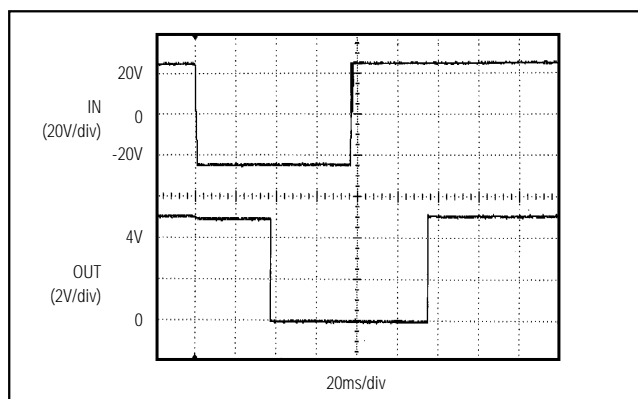


Figure 3. Switch Input $\pm 25\text{V}$ Fault Tolerance

Robust Switch Inputs

The switch inputs on the MAX6816/MAX6817/MAX6818 have overvoltage clamping diodes to protect against damaging fault conditions. Switch input voltages can safely swing $\pm 25\text{V}$ to ground (Figure 3). Proprietary ESD-protection structures protect against high ESD encountered in harsh industrial environments, membrane keypads, and portable applications. They are designed to withstand $\pm 15\text{kV}$ per the IEC1000-4-2 Air Gap Discharge Test and $\pm 8\text{kV}$ per the IEC1000-4-2 Contact Discharge Test.

Since there are $63\text{k}\Omega$ (typical) pull-up resistors connected to each input, driving an input to -25V will draw

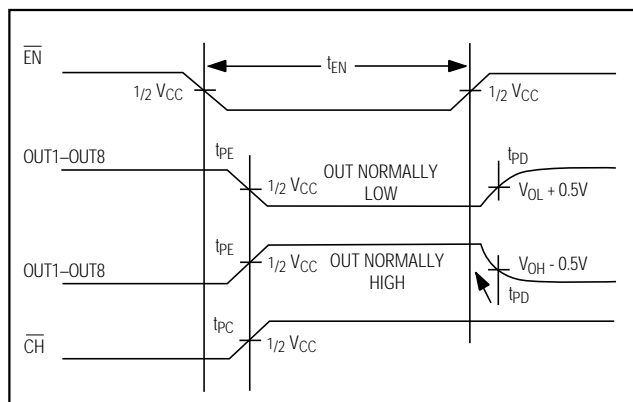


Figure 4. MAX6818 μP -Interface Timing Diagram

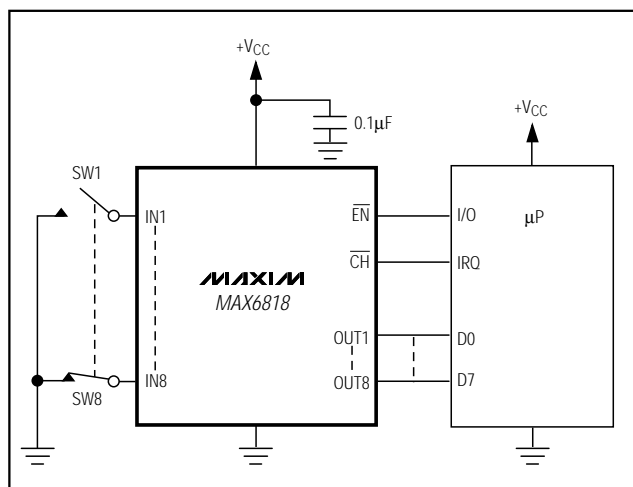


Figure 5. MAX6818 Typical μP Interfacing Circuit

approximately 0.5mA (up to 4mA for eight inputs) from the V_{CC} supply. Driving an input to $+25\text{V}$ will cause approximately 0.32mA of current (up to 2.6mA for eight inputs) to flow back into the V_{CC} supply. If the total system V_{CC} supply current is less than the current flowing back into the V_{CC} supply, V_{CC} will rise above normal levels. In some low-current systems, a zener diode on V_{CC} may be required.

$\pm 15\text{kV}$ ESD Protection

As with all Maxim devices, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The MAX6816/MAX6817/MAX6818 have extra protection against static electricity. Maxim's engineers have developed state-of-the-art structures to protect against ESD of $\pm 15\text{kV}$ at the switch inputs without

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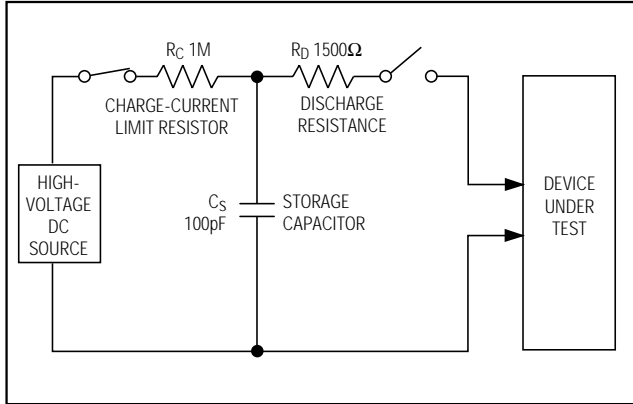


Figure 6a. Human Body ESD Test Model

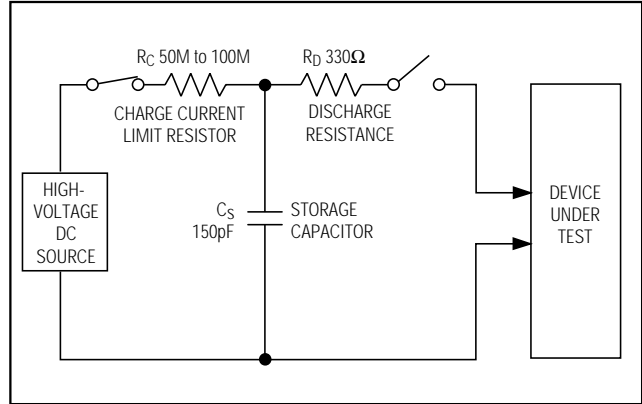


Figure 7a. IEC1000-4-2 ESD Test Model

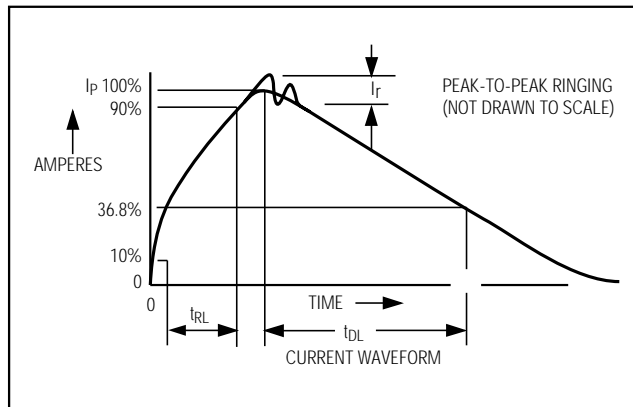


Figure 6b. Human Body Current Waveform

damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, the MAX6816/MAX6817/MAX6818 keep working without latchup, whereas other solutions can latch and must be powered down to remove latchup.

ESD protection can be tested in various ways; these products are characterized for protection to the following limits:

- 1) $\pm 15\text{kV}$ using the Human Body Model
- 2) $\pm 8\text{kV}$ using the Contact-Discharge method specified in IEC1000-4-2
- 3) $\pm 15\text{kV}$ using IEC1000-4-2's Air-Gap method.

ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

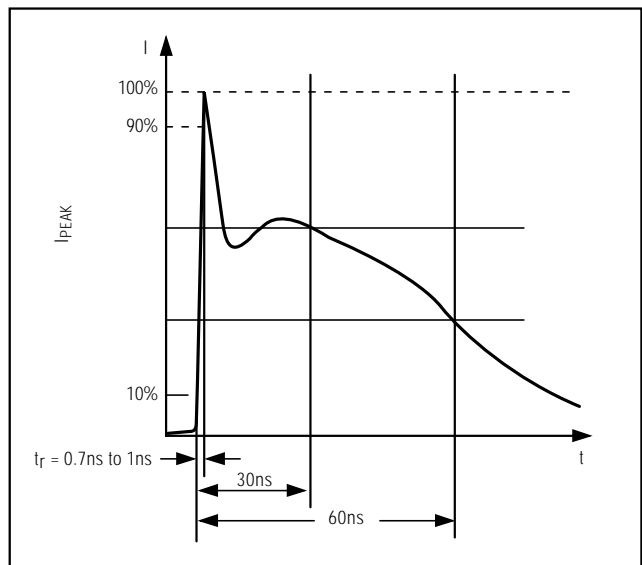


Figure 7b. IEC1000-4-2 ESD Generator Current Waveform

Human Body Model

Figure 6a shows the Human Body Model and Figure 6b 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 $1.5\text{k}\Omega$ resistor.

IEC1000-4-2

The IEC1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX6816/MAX6817/MAX6818 help you design equipment that

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meets Level 4 (the highest level) of IEC1000-4-2, without the need for additional ESD-protection components.

The major difference between tests done using the Human Body Model and IEC1000-4-2 is higher peak current in IEC1000-4-2, because series resistance is lower in the IEC1000-4-2 model. Hence, the ESD withstand voltage measured to IEC1000-4-2 is generally lower than that measured using the Human Body Model. Figure 7a shows the IEC1000-4-2 model and Figure 7b shows the current waveform for the 8kV, IEC1000-4-2, Level 4, ESD Contact-Discharge test.

The Air-Gap test involves approaching the device with a charged probe. The Contact-Discharge method connects the probe to the device before the probe is energized.

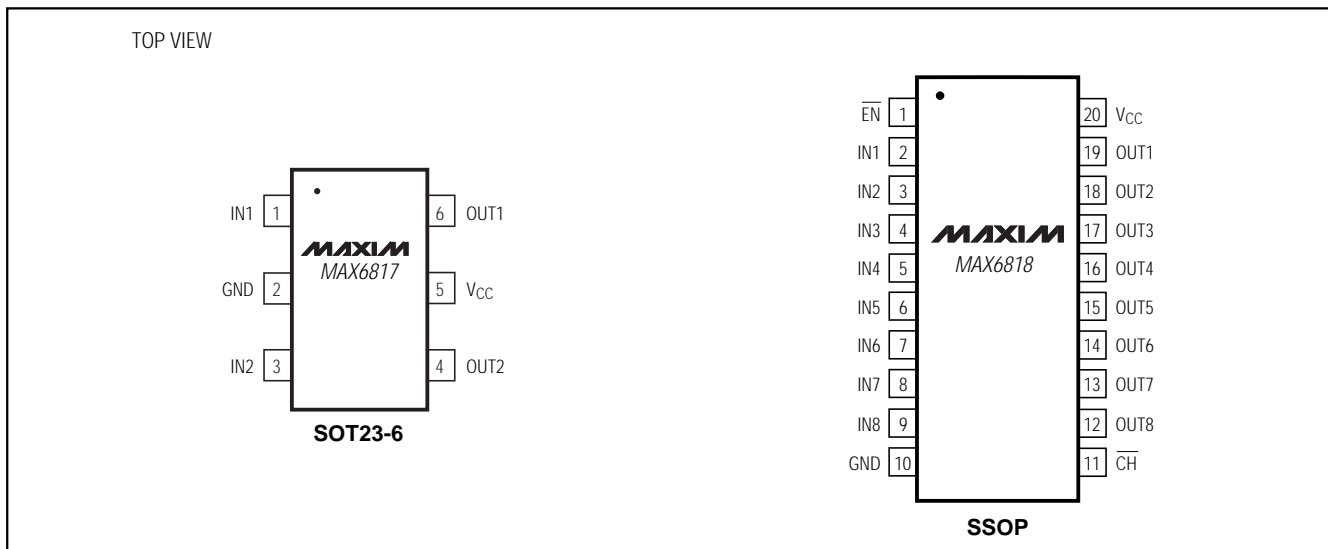
Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused by contact that occurs with handling and assembly during manufacturing.

MAX6818 μ P Interfacing

The MAX6818 has an output enable (\overline{EN}) input that allows switch outputs to be three-stated on the μ P data bus until polled by the μ P. Also, state changes at the switch inputs are detected, and an output (\overline{CH}) goes low after the debounce period to signal the μ P. Figure 4 shows the timing diagram for enabling outputs and reading data. If the output enable is not used, tie \overline{EN} to GND to "always enable" the switch outputs. If \overline{EN} is low, \overline{CH} is always high. If a change of state is not required, leave CH unconnected.

Pin Configurations (continued)



Chip Information

MAX6816 TRANSISTOR COUNT: 284

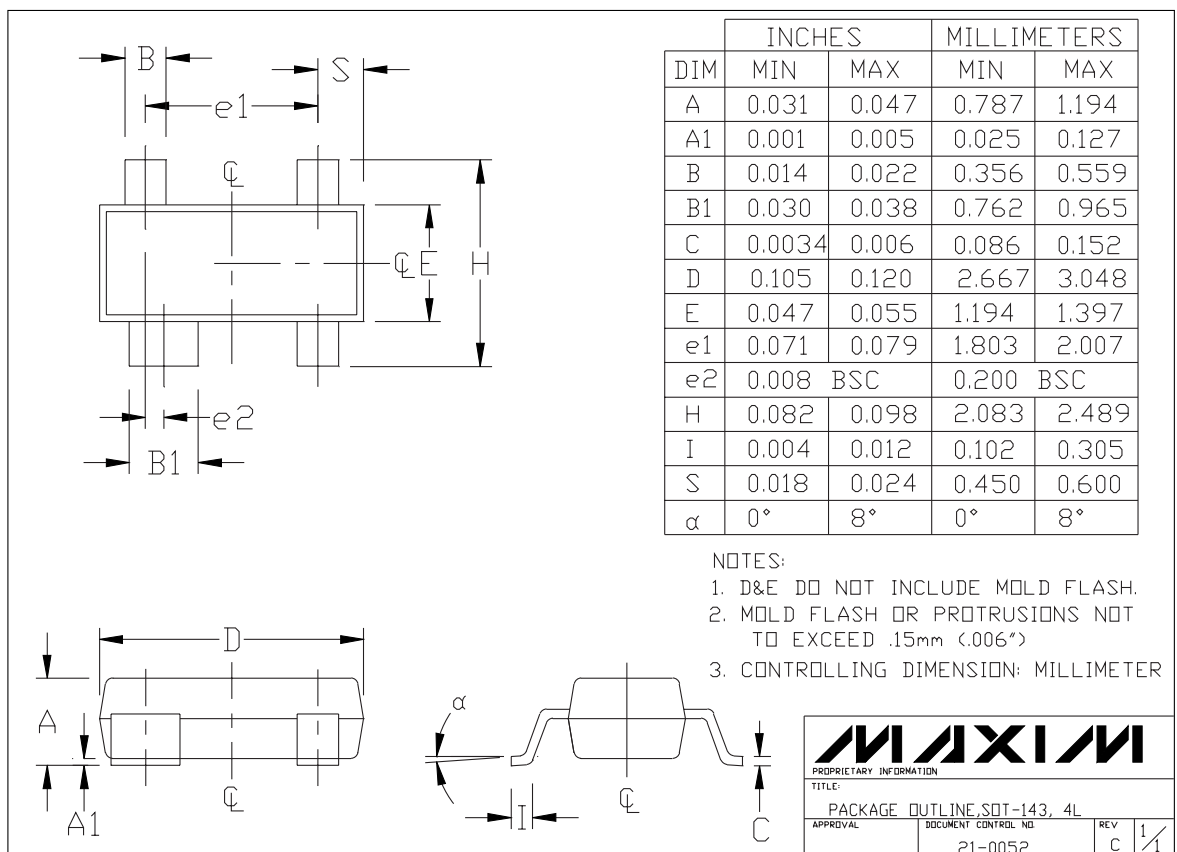
MAX6817 TRANSISTOR COUNT: 497

MAX6818 TRANSISTOR COUNT: 2130

SUBSTRATE CONNECTED TO GND

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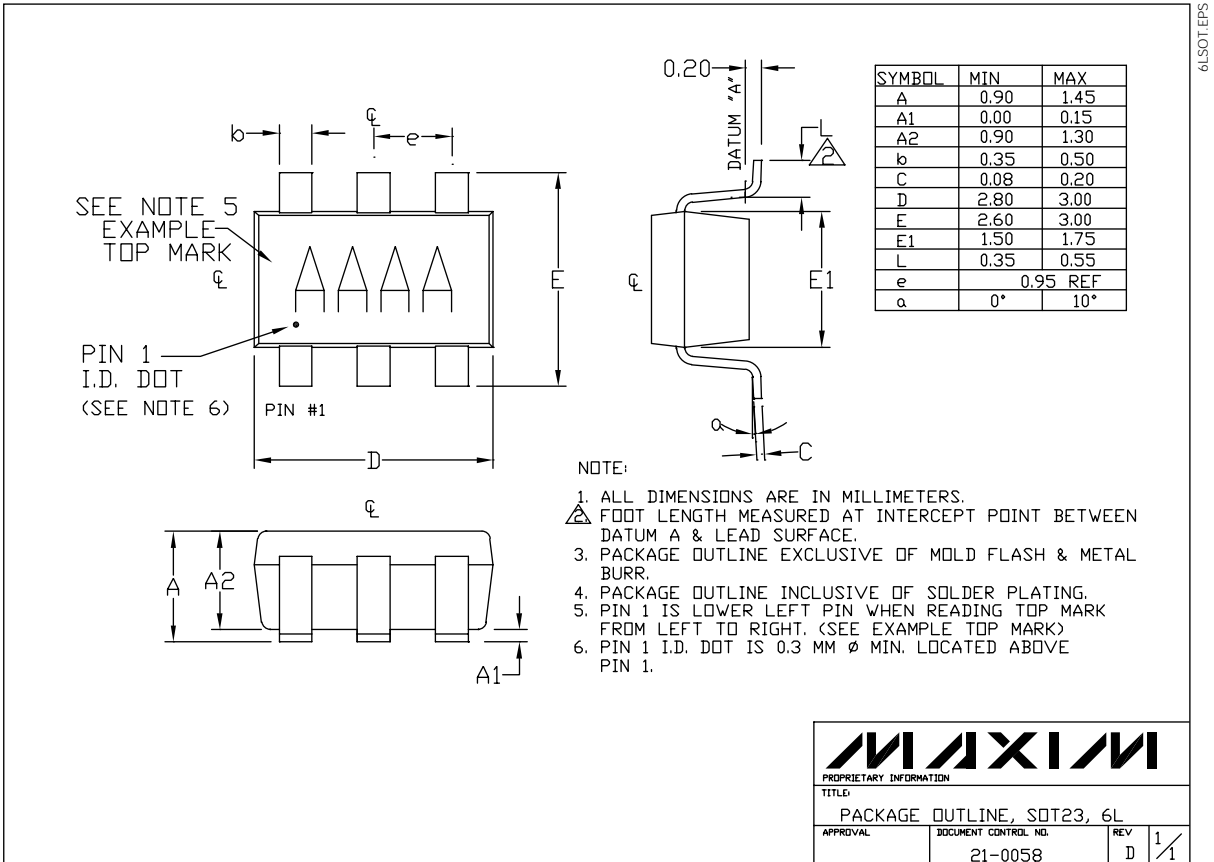
Package Information



SOT1434.EPS

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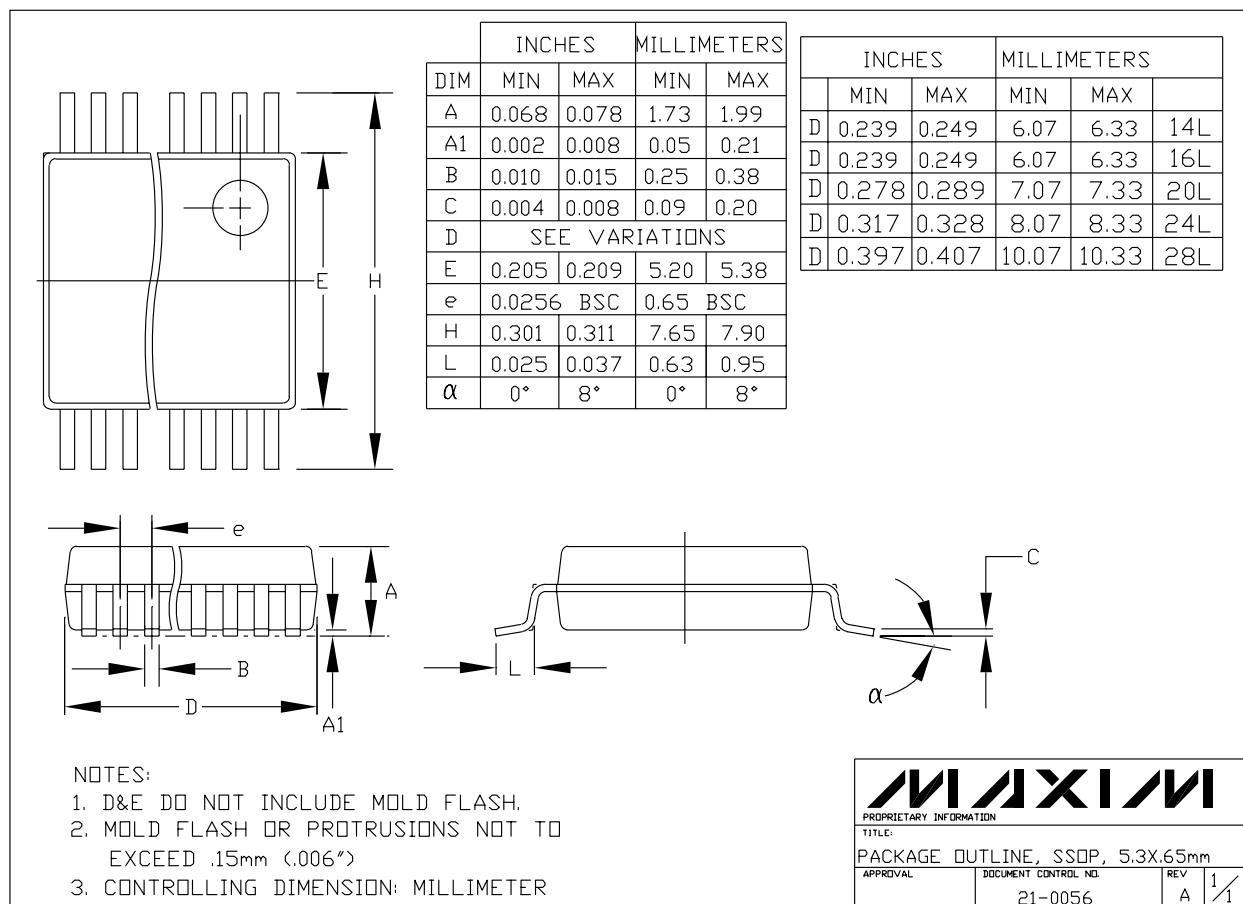
Package Information (continued)



MAX6816/MAX6817/MAX6818

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Package Information (continued)



$\pm 15\text{kV}$ ESD-Protected, Single/Dual/Octal, CMOS Switch Debouncers

NOTES

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NOTES

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