



Precision, Quad, SPST Analog Switches

General Description

The MAX391/MAX392/MAX393 are precision, quad, single-pole/single-throw (SPST) analog switches designed to operate at +3V, +5V, or ±5V. The MAX391 has four normally closed (NC) switches, and the MAX392 has four normally open (NO) switches. The MAX393 has two NO and two NC switches. All three devices offer low leakage (100pA max) and fast switching speeds ($t_{ON} \leq 130\text{ns}$, $t_{OFF} \leq 75\text{ns}$). Power consumption is just $1\mu\text{W}$ —ideal for battery-operated equipment. All devices operate from a single +3V to +15V supply or from dual ±3.0V to ±8V supplies.

With ±5V supplies, the MAX391/MAX392/MAX393 offer guaranteed 2Ω max channel-to-channel matching, 30Ω max on-resistance (R_{ON}), and 4Ω max R_{ON} flatness over the specified range.

These switches are also fully specified for single +5V operation, with 2Ω max R_{ON} match, 60Ω max R_{ON} , and 6Ω max flatness.

These low-voltage switches also offer 5pC max charge injection, and ESD protection is greater than 2000V, per method 3015.7.

Applications

Battery-Operated Systems	Sample-and-Hold Circuits
Heads-Up Displays	Guidance and Control Systems
Audio and Video Switching	Military Radios
Test Equipment	Communications Systems
±5V DACs and ADCs	PBX, PABX

Features

- ◆ Low On-Resistance, 20Ω Typical
- ◆ Guaranteed On-Resistance Match Between Channels, $<2\Omega$
- ◆ Guaranteed On-Resistance Flatness Over Signal Range, 4Ω Max
- ◆ Guaranteed Charge Injection, $<5\text{pC}$
- ◆ Improved Leakage Over Temperature, $<2.5\text{nA}$ at $+85^\circ\text{C}$
- ◆ Electrostatic Discharge $>2000\text{V}$ per Method 3015.7
- ◆ Single-Supply Operation (+3V to +15V)
Bipolar-Supply Operation ($\pm 3\text{V}$ to $\pm 8\text{V}$)
- ◆ Low Power Consumption, $<1\mu\text{W}$
- ◆ TTL/CMOS-Logic Compatible

Ordering Information

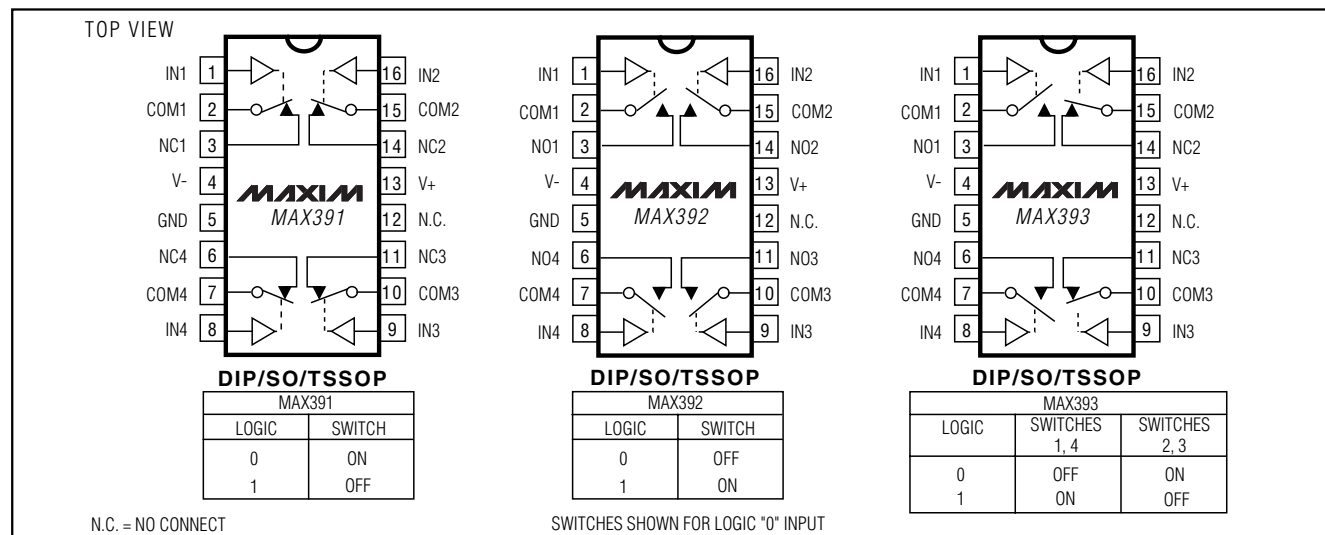
PART	TEMP. RANGE	PIN-PACKAGE
MAX391CPE	0°C to $+70^\circ\text{C}$	16 Plastic DIP
MAX391CSE	0°C to $+70^\circ\text{C}$	16 Narrow SO
MAX391CUE	0°C to $+70^\circ\text{C}$	16 TSSOP
MAX391C/D	0°C to $+70^\circ\text{C}$	Dice*
MAX391EPE	-40°C to $+85^\circ\text{C}$	16 Plastic DIP
MAX391ESE	-40°C to $+85^\circ\text{C}$	16 Narrow SO
MAX391EUE	-40°C to $+85^\circ\text{C}$	16 TSSOP

Ordering Information continued at end of data sheet.

* Contact factory for dice specifications.

** Contact factory for availability and processing to MIL-STD-883.

Pin Configurations/Functional Diagrams/Truth Tables



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ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

V+	-0.3V to +17V
GND	-0.3V to +17V
GND	-0.3V to (V+ + 0.3V)
V _{IN} , V _{COM} , V _{NC} , V _{NO} (Note 1)	V- to V+
Current (any terminal)	30mA
Peak Current, COM, NO, NC (pulsed at 1ms, 10% duty cycle max)	100mA
ESD per Method 3015.7	>2000V

Continuous Power Dissipation (T_A = +70°C)

Plastic DIP (derate 10.53mW/°C above +70°C)	842mW
Narrow SO (derate 8.70mW/°C above +70°C)	696mW
TSSOP (derate 6.7mW/°C above +70°C)	457mW
CERDIP (derate 10.00mW/°C above +70°C)	800mW

Operating Temperature Ranges

MAX39_C _ _	0°C to +70°C
MAX39_E _ _	-40°C to +85°C
MAX39_M _ _	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

Note 1: Signals on NC, NO, COM, or IN exceeding V+ or V- are clamped by internal diodes. Limit forward diode current to maximum current rating.

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—Dual Supplies

(V+ = +5V ±10%, V- = -5V ±10%, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH								
Analog Signal Range	V _{COM} , V _{NO} , V _{NC}	(Note 3)			V-		V+	V
On-Resistance	R _{ON}	V+ = 4.5V, V- = -4.5V, I _{COM} = -10mA, V _{NO} or V _{NC} = ±3.5V	T _A = +25°C	C, E	20		35	Ω
				M	20		30	
			T _A = T _{MIN} to T _{MAX}				45	
On-Resistance Match Between Channels (Note 4)	ΔR _{ON}	V+ = 5V, V- = -5V, I _{COM} = -10mA, V _{NO} or V _{NC} = ±3V	T _A = +25°C		0.3		2	Ω
			T _A = T _{MIN} to T _{MAX}				4	
On-Resistance Flatness (Note 5)	R _{FLAT(ON)}	V+ = 5V, V- = -5V, I _{COM} = -10mA, V _{NO} or V _{NC} = ±3V	T _A = +25°C		1		4	Ω
			T _A = T _{MIN} to T _{MAX}				6	
NO or NC Off Leakage Current (Note 6)	I _{NO(OFF)} or I _{NC(OFF)}	V+ = 5.5V, V- = -5.5V, V _{COM} = ±4.5V, V _{NO} or V _{NC} = ∓4.5V	T _A = +25°C		-0.1	0.01	0.1	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-2.5		2.5	
				M	-5		5	
COM Off Leakage Current (Note 6)	I _{COM(OFF)}	V+ = 5.5V, V- = -5.5V, V _{COM} = ±4.5V, V _{NO} or V _{NC} = ∓4.5V	T _A = +25°C		-0.1	0.01	0.1	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-2.5		2.5	
				M	-5		5	
COM On Leakage Current (Note 6)	I _{COM(ON)}	V+ = 5.5V, V- = -5.5V, V _{COM} = ±4.5V, V _{NO} or V _{NC} = ±4.5V	T _A = +25°C		-0.2	0.01	0.2	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-5.0		5.0	
				M	-20		20	

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ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +5V ±10%, V- = -5V ±10%, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
LOGIC INPUT							
Input Current with Input Voltage High	I _{INH}	I _N = 2.4V, all others = 0.8V		-0.5	0.005	0.5	μA
Input Current with Input Voltage Low	I _{INL}	I _N = 0.8V, all others = 2.4V		-0.5	0.005	0.5	μA
DYNAMIC							
Turn-On Time	t _{ON}	V _{COM} = ±3V, Figure 2	T _A = +25°C	65	130	ns	
			T _A = T _{MIN} to T _{MAX}		175		
Turn-Off Time	t _{OFF}	V _{COM} = ±3V, Figure 2	T _A = +25°C	35	75	ns	
			T _A = T _{MIN} to T _{MAX}		100		
Break-Before-Make Time Delay (Note 3)	t _D	MAX393 only, R _L = 300Ω, C _L = 35pF, Figure 3		5	10	ns	
Charge Injection (Note 3)	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω, Figure 4	T _A = +25°C	2	5	pC	
Off Isolation (Note 7)	OIRR	R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 5	T _A = +25°C	72		dB	
Crosstalk (Note 8)		R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 6	T _A = +25°C	85		dB	
NC or NO Capacitance	C _(OFF)	f = 1MHz, Figure 7	T _A = +25°C	9		pF	
COM Off Capacitance	C _{COM(OFF)}	f = 1MHz, Figure 7	T _A = +25°C	9		pF	
COM On Capacitance	C _{COM(ON)}	f = 1MHz, Figure 8	T _A = +25°C	22		pF	
SUPPLY							
Power-Supply Range				-8.0	+8.0	V	
Positive Supply Current	I ₊	V ₊ = 5.5V, V ₋ = -5.5V, V _{IN} = 0V or V ₊ , All channels on or off	T _A = T _{MIN} to T _{MAX}	-1	1	μA	
Negative Supply Current	I ₋	V ₊ = 5.5V, V ₋ = -5.5V, V _{IN} = 0V or V ₊ , All channels on or off	T _A = T _{MIN} to T _{MAX}	-1	1	μA	

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ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = +5V ±10%, V- = 0V ±10%, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH								
Analog Signal Range	V _{COM} , V _{NO} , V _{NC}	(Note 3)			0		V+	V
On-Resistance	R _{ON}	V+ = 4.5V, I _{COM} = -10mA, V _{NO} or V _{NC} = 3.5V	T _A = +25°C		30		60	Ω
			T _A = T _{MIN} to T _{MAX}				75	
On-Resistance Match Between Channels (Note 4)	ΔR _{ON}	V+ = 5V, I _{COM} = -1.0mA, V _{NO} or V _{NC} = 3V	T _A = +25°C		0.8		2	Ω
			T _A = T _{MIN} to T _{MAX}				4	
On-Resistance Flatness (Notes 3, 5)	R _{FLAT(ON)}	V+ = 5V, I _{COM} = -1.0mA, V _{NO} or V _{NC} = 1V, 3V	T _A = +25°C		2		6	Ω
			T _A = T _{MIN} to T _{MAX}				8	
NO or NC Off Leakage Current (Note 9)	I _{NO(OFF)} or I _{NC(OFF)}	V+ = 5.5V, V _{COM} = 0V, V _{NO} or V _{NC} = 4.5V	T _A = +25°C		-0.25	0.01	0.25	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-0.1		0.1	
				M	-2.5		2.5	
COM Off Leakage Current (Note 9)	I _{COM(OFF)}	V+ = 5.5V, V _{COM} = 0V, V _{NO} or V _{NC} = 4.5V	T _A = +25°C		-0.1		0.1	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-2.5		2.5	
				M	-5.0		5.0	
COM On Leakage Current (Note 9)	I _{COM(ON)}	V+ = 5.5V, V _{COM} = 5V, V _{NO} or V _{NC} = 4.5V	T _A = +25°C		-0.2		0.2	nA
			T _A = T _{MIN} to T _{MAX}	C, E	-5.0		5.0	
				M	-20		20	
DYNAMIC								
Turn-On Time	t _{ON}	V _{NO} or V _{NC} = 3V	T _A = +25°C		85		170	ns
			T _A = T _{MIN} to T _{MAX}				240	
Turn-Off Time	t _{OFF}	V _{NO} or V _{NC} = 3V	T _A = +25°C		25		50	ns
			T _A = T _{MIN} to T _{MAX}				100	
Break-Before-Make Time Delay (Note 3)	t _D	MAX393 only, R _L = 300Ω, C _L = 35pF			10			ns
Charge Injection (Note 3)	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω, Figure 4	T _A = +25°C		1		5	pC
SUPPLY								
Positive Supply Current	I+	V+ = 5.5V, V _{IN} = 0V or V+, all channels on or off			-1		1	μA
Negative Supply Current	I-	V+ = 5.5V, V _{IN} = 0V or V+, all channels on or off			-1		1	μA

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ELECTRICAL CHARACTERISTICS—Single +3.3V Supply

(V+ = +3.0V to +3.6V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	V _{COM} , V _{NO} , V _{NC}	(Note 3)		0		V+	V
Channel On-Resistance	R _{ON}	V+ = 3V, I _{COM} = -1.0mA, V _{NO} or V _{NC} = 1.5V	T _A = +25°C	83	175	Ω	
			T _A = T _{MIN} to T _{MAX}		275		
DYNAMIC							
Turn-On Time (Note 3)	t _{ON}	V _{NO} or V _{NC} = 1.5V	T _A = +25°C	160	400	ns	
			T _A = T _{MIN} to T _{MAX}		500		
Turn-Off Time (Note 3)	t _{OFF}	V _{NO} or V _{NC} = 1.5V	T _A = +25°C	40	125	ns	
			T _A = T _{MIN} to T _{MAX}		175		
Break-Before-Make Time Delay (Note 3)	t _D	MAX393 only, R _L = 300Ω, C _L = 35pF	T _A = +25°C	20		ns	
Charge Injection (Note 3)	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0V	T _A = +25°C	1	5	pC	
SUPPLY							
Positive Supply Current	I+	V+ = 3.6V, V _{IN} = 0V or V+, all channels on or off		-1	1	μA	
Negative Supply Current	I-	V+ = 3.6V, V _{IN} = 0V or V+, all channels on or off		-1	1	μA	

Note 2: The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.

Note 3: Guaranteed by design.

Note 4: $\Delta R_{ON} = \Delta R_{ON\ max} - \Delta R_{ON\ min}$.

Note 5: Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

Note 6: Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.

Note 7: Off Isolation = $20\log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$, VCOM = output, VNC or VNO = input to off switch.

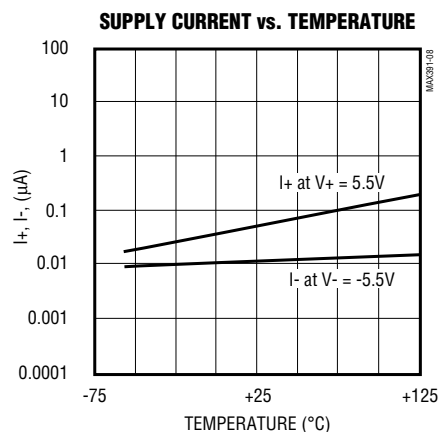
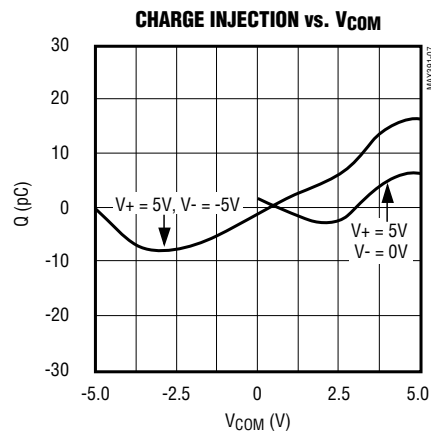
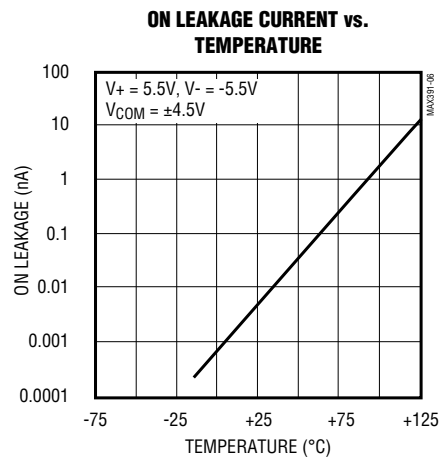
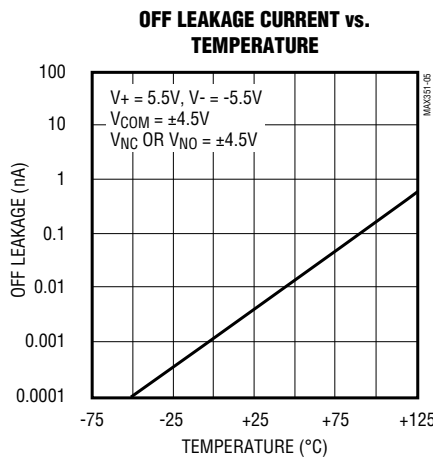
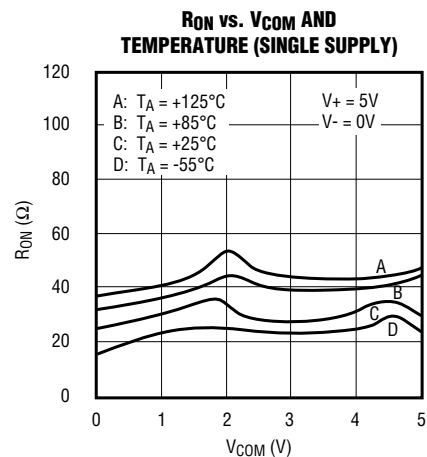
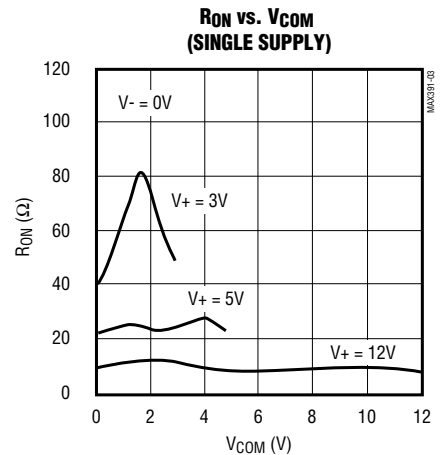
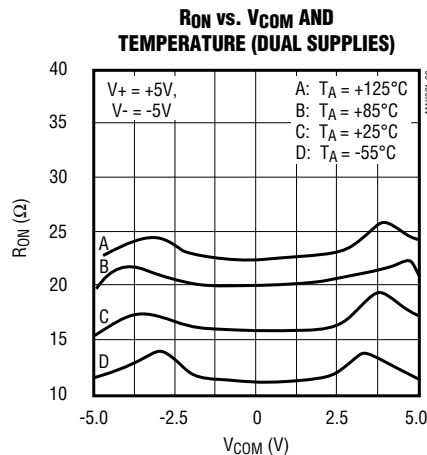
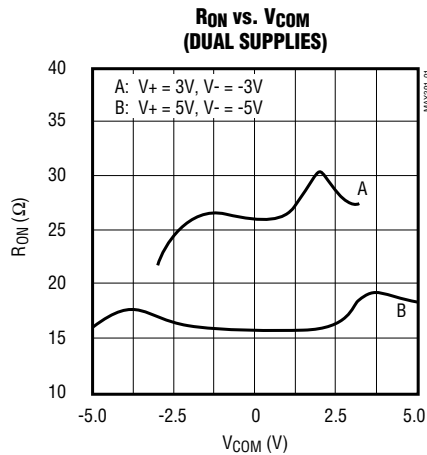
Note 8: Between any two switches.

Note 9: Leakage testing at single supply is guaranteed by testing with dual singles.

Precision, Quad, SPST Analog Switches

Typical Operating Characteristics

($T_A = +25^\circ\text{C}$, unless otherwise noted.)



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Pin Description

PIN	NAME	FUNCTION
1, 16, 9, 8	IN1–IN4	Inputs
2, 15, 10, 7	COM1–COM4	Analog Switch Common Terminal
3, 14, 11, 6	NO1–NO4 or NC1–NC4	Switch Inputs
4	V-	Negative Supply-Voltage Input
5	GND	Ground
12	N.C.	No Connect—not internally connected
13	V+	Positive Supply-Voltage Input—connected to substrate

Applications Information

Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V+ on first, followed by V-, and then logic inputs. If power-supply sequencing is not possible, add two small signal diodes in series with supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below V+ and 1V below V-, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ and V- should not exceed 17V.

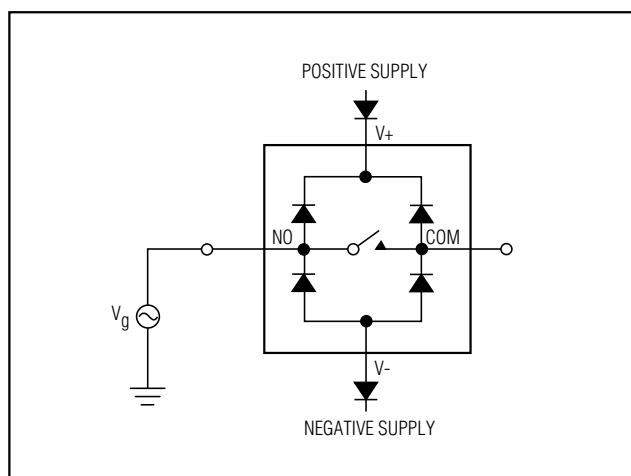


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

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Test Circuits/Timing Diagrams

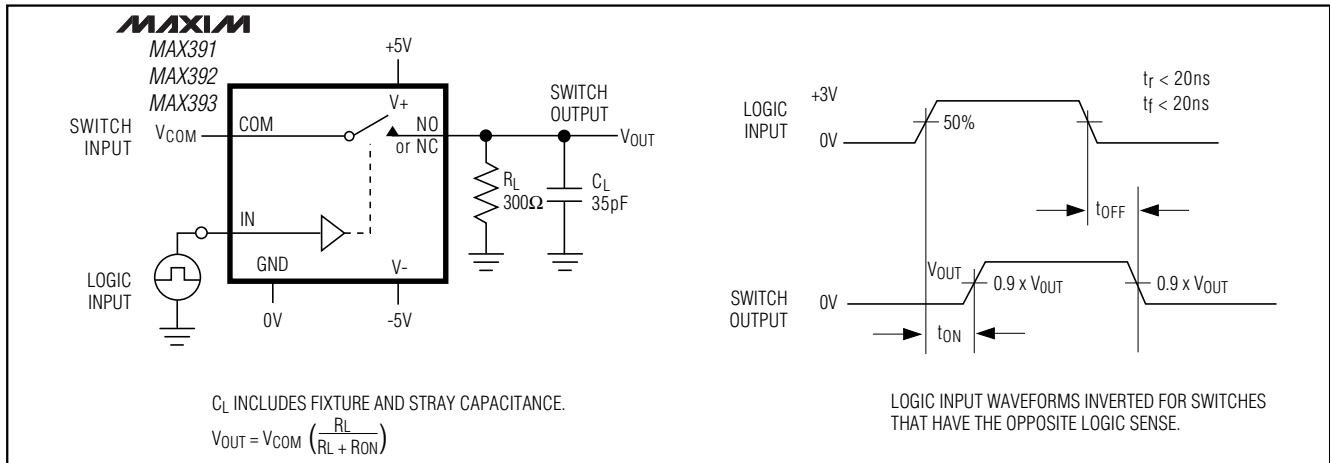


Figure 2. Switching Time

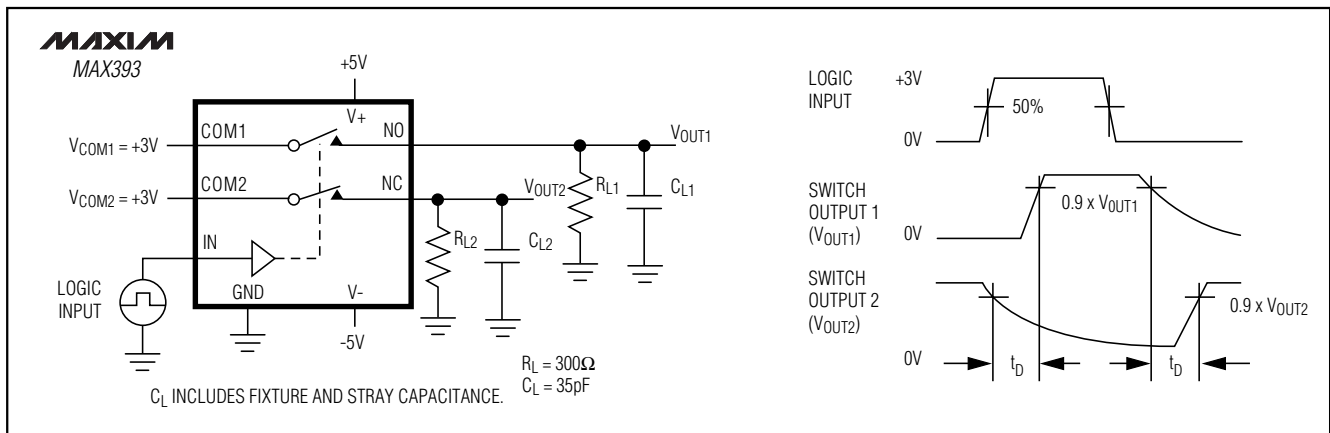


Figure 3. Break-Before-Make Interval (MAX393 only)

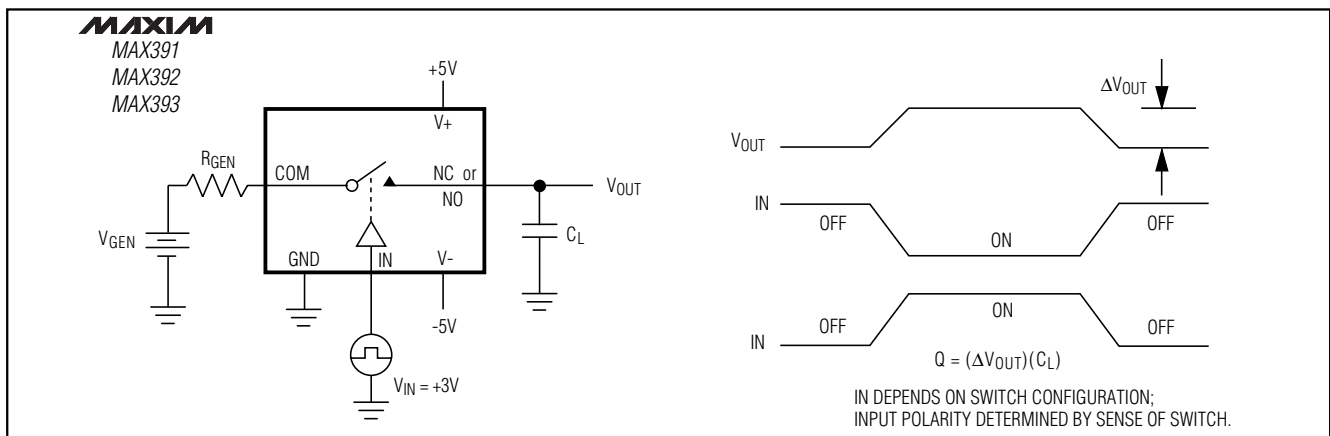


Figure 4. Charge Injection

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Test Circuits/Timing Diagrams (continued)

MAX391/MAX392/MAX393

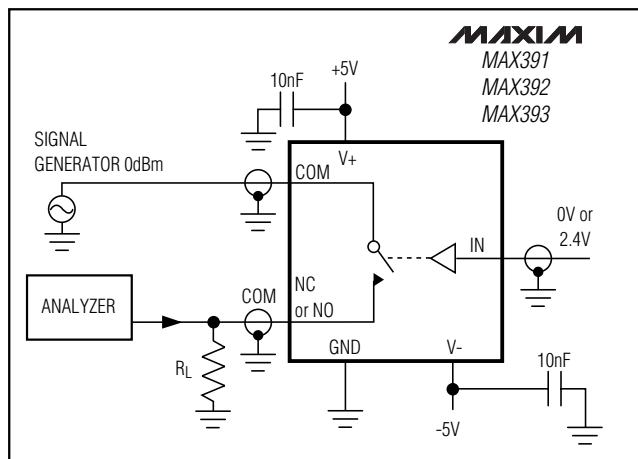


Figure 5. Isolation

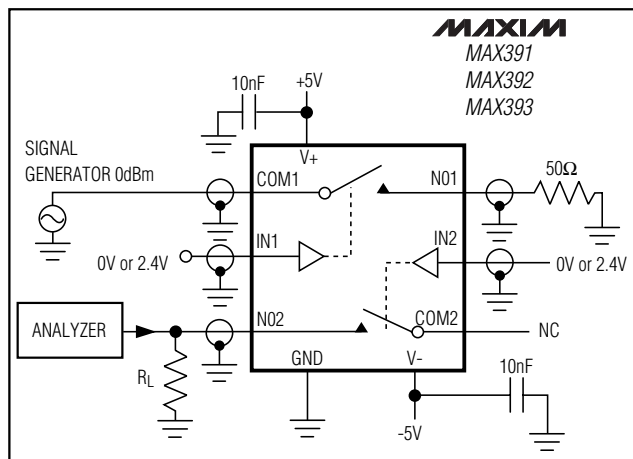


Figure 6. Crosstalk

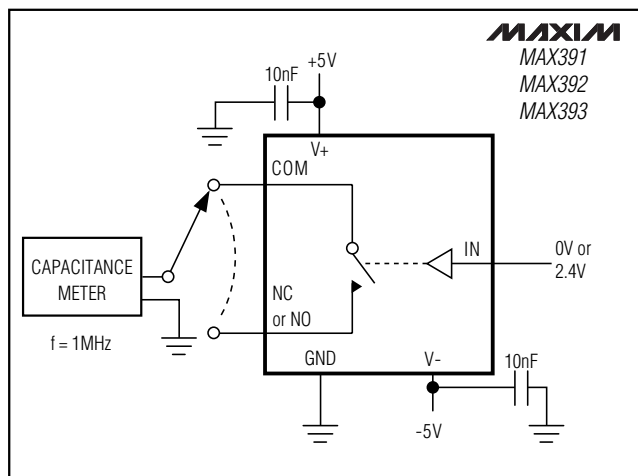


Figure 7. Channel-Off Capacitance

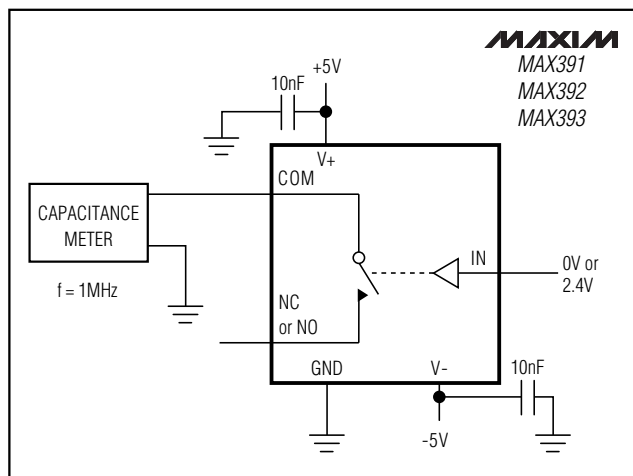


Figure 8. Channel-On Capacitance

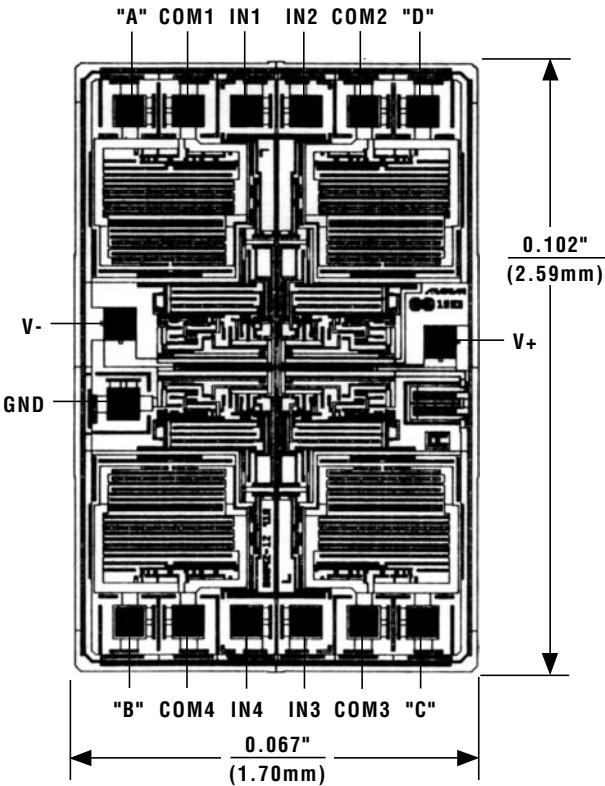
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Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX391EJE	-40°C to +85°C	16 CERDIP
MAX391MJE	-55°C to +125°C	16 CERDIP**
MAX392CPE	0°C to +70°C	16 Plastic DIP
MAX392CSE	0°C to +70°C	16 Narrow SO
MAX392CUE	0°C to +70°C	16 TSSOP
MAX392C/D	0°C to +70°C	Dice*
MAX392EPE	-40°C to +85°C	16 Plastic DIP
MAX392ESE	-40°C to +85°C	16 Narrow SO
MAX392EUE	-40°C to +85°C	16 TSSOP
MAX392EJE	-40°C to +85°C	16 CERDIP
MAX392MJE	-55°C to +125°C	16 CERDIP**
MAX393CPE	0°C to +70°C	16 Plastic DIP
MAX393CSE	0°C to +70°C	16 Narrow SO
MAX393CUE	0°C to +70°C	16 TSSOP
MAX393C/D	0°C to +70°C	Dice*
MAX393EPE	-40°C to +85°C	16 Plastic DIP
MAX393ESE	-40°C to +85°C	16 Narrow SO
MAX393EUE	-40°C to +85°C	16 TSSOP
MAX393EJE	-40°C to +85°C	16 CERDIP
MAX393MJE	-55°C to +125°C	16 CERDIP**

* Contact factory for dice specifications.
** Contact factory for availability and processing to MIL-STD-883B.

Chip Topography



MAX391		MAX392		MAX393	
PIN	NAME	PIN	NAME	PIN	NAME
A	NC1	A	N01	A	N01
B	NC4	B	N04	B	N04
C	NC3	C	N03	C	NC3
D	NC2	D	N02	D	NC2

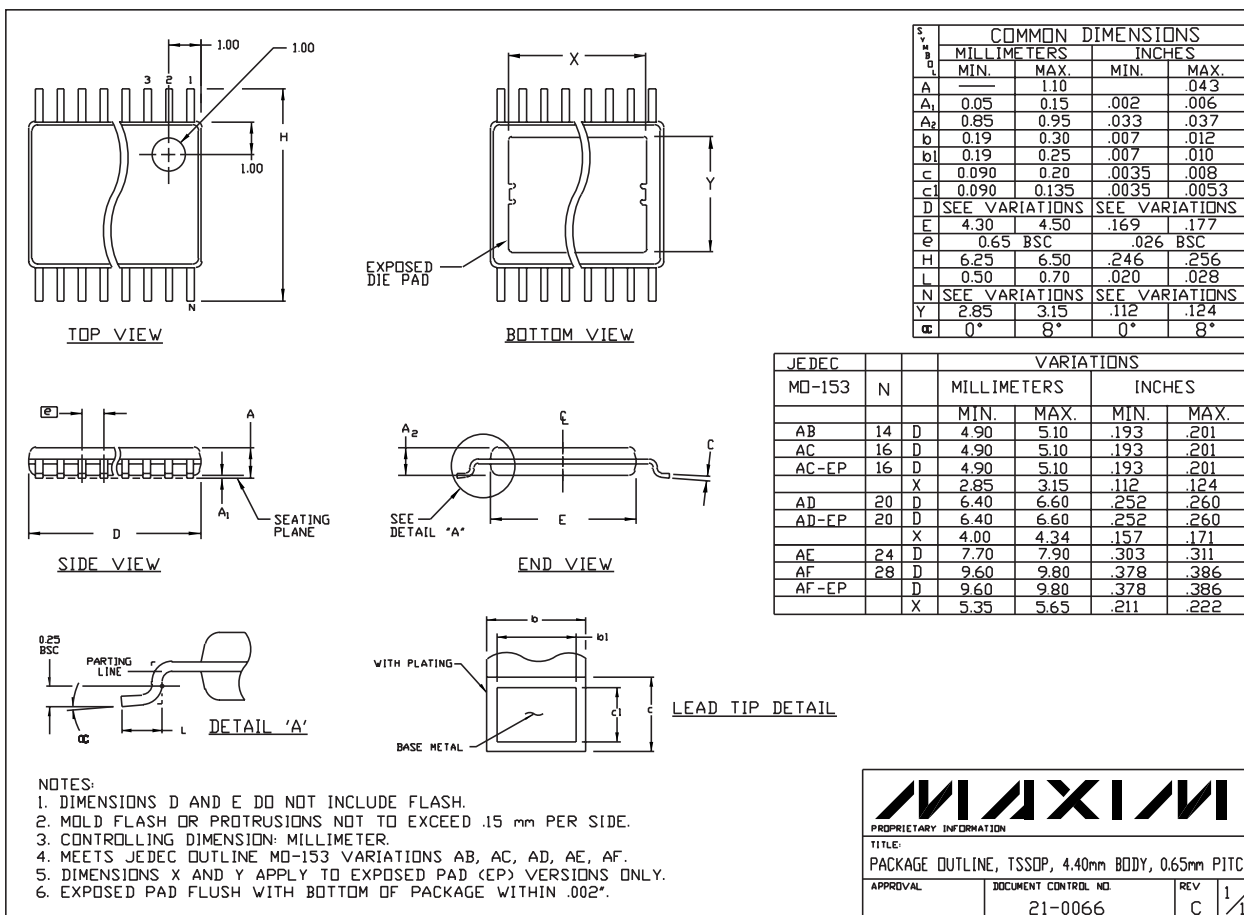
TRANSISTOR COUNT: 76
SUBSTRATE CONNECTED TO V+

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Package Information

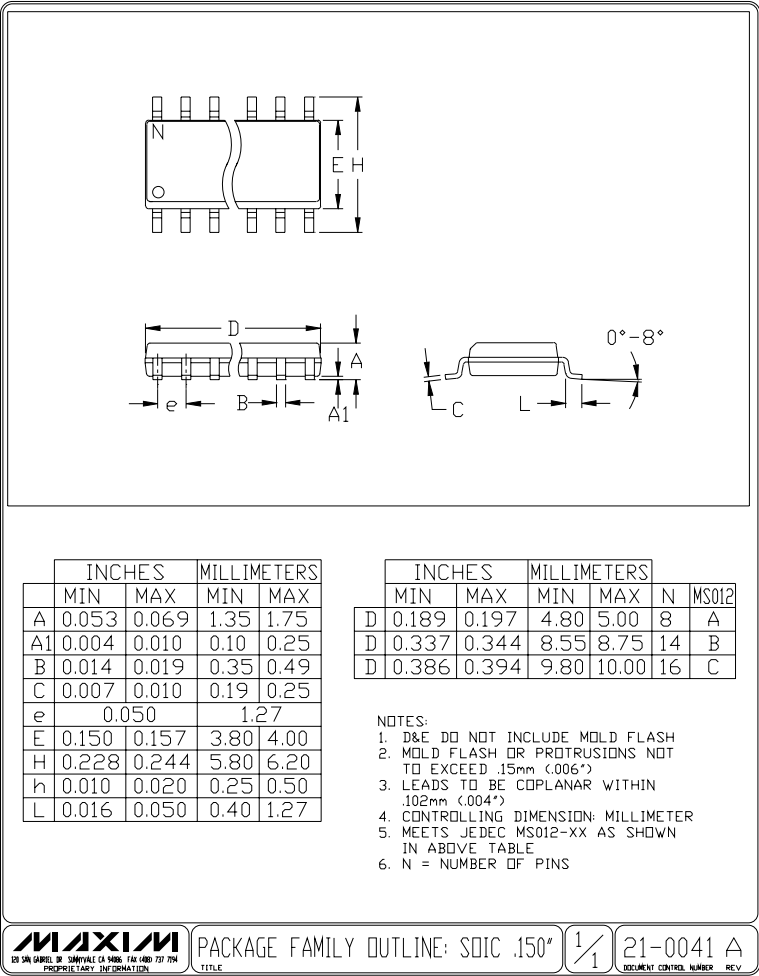
MAX391/MAX392/MAX393

TSSOP EP3



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Package Information (continued)



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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