



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 1μW—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, <2Ω
- ◆ Guaranteed On-Resistance Flatness Over Signal Range, 4Ω Max
- ◆ Guaranteed Charge Injection, <5pC
- ◆ Improved Leakage Over Temperature, <2.5nA at +85°C
- ◆ Electrostatic Discharge >2000V per Method 3015.7
- ◆ Single-Supply Operation (+3V to +15V)
Bipolar-Supply Operation (±3V to ±8V)
- ◆ Low Power Consumption, <1μW
- ◆ TTL/CMOS-Logic Compatible

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX391CPE	0°C to +70°C	16 Plastic DIP
MAX391CSE	0°C to +70°C	16 Narrow SO
MAX391CUE	0°C to +70°C	16 TSSOP
MAX391CGE	0°C to +70°C	16 QFN
MAX391C/D	0°C to +70°C	Dice*
MAX391EPE	-40°C to +85°C	16 Plastic DIP
MAX391ESE	-40°C to +85°C	16 Narrow SO
MAX391EUE	-40°C to +85°C	16 TSSOP
MAX391EGE	-40°C to +85°C	16 QFN

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

TOP VIEW

DIP/SO/TSSOP

MAX391	
LOGIC	SWITCH
0	ON
1	OFF

N.C. = NO CONNECT

DIP/SO/TSSOP

MAX392	
LOGIC	SWITCH
0	OFF
1	ON

SWITCHES SHOWN FOR LOGIC "0" INPUT

DIP/SO/TSSOP

MAX393		
LOGIC	SWITCHES 1, 4	SWITCHES 2, 3
0	OFF	ON
1	ON	OFF

Pin Configurations/
Functional Diagrams/
Truth Tables continued
at end of data sheet.



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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
QFN (derate 18.5mW/°C above +70°C)	1481mW

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		
				M	20	30		
			T _A = T _{MIN} to T _{MAX}			45		
On-Resistance Match Between Channels (Note 4)	R _{ON}	V+ = 5V, V- = -5V, I _{COM} = -10mA, V _{NO} or V _{NC} = ±3V	T _A = +25°C		0.3	2		
			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		
			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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MAX391/MAX392/MAX393

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.

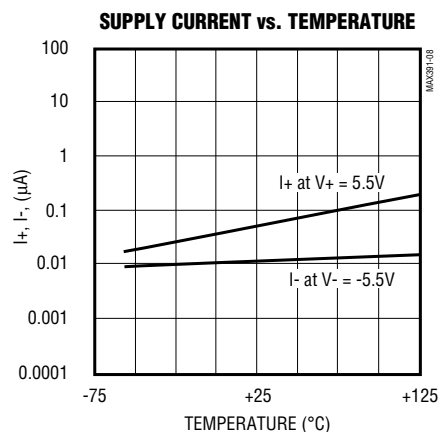
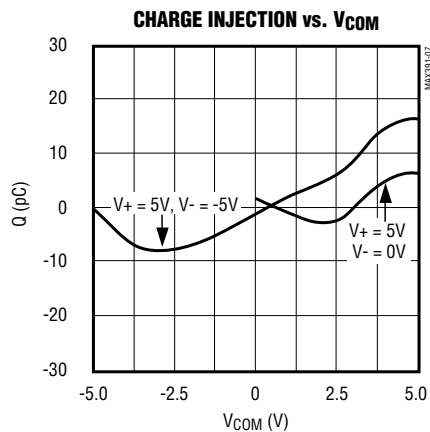
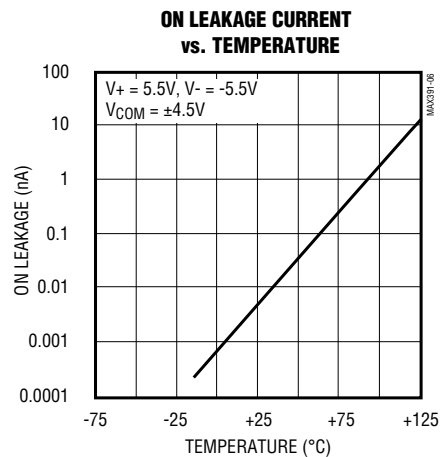
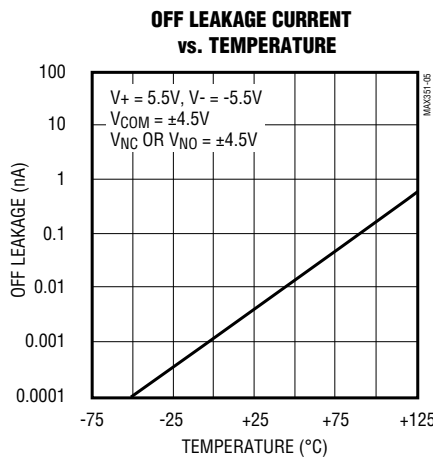
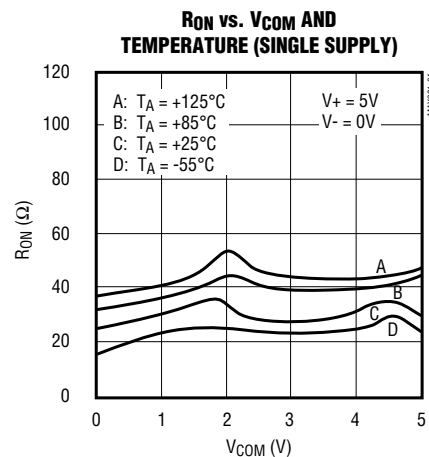
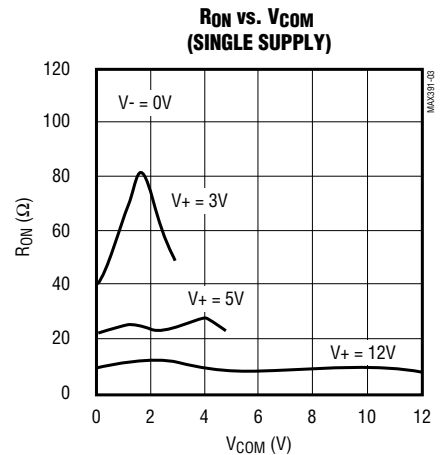
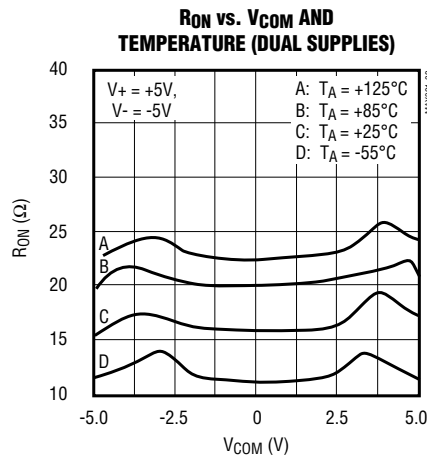
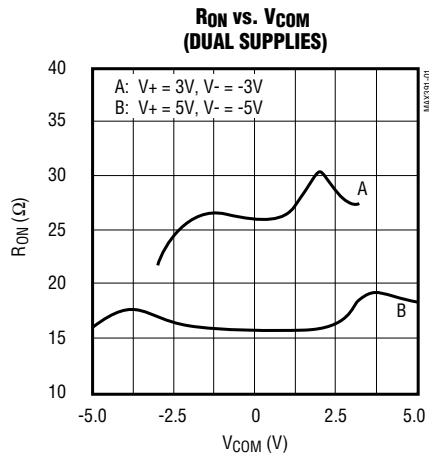
Note 8: Between any two switches.

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

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Typical Operating Characteristics

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



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Pin Description

PIN		NAME	FUNCTION
DIP/SO/TSSOP	QFN		
1, 16, 9, 8	15, 14, 7, 6	IN1–IN4	Logic Control Inputs
2, 15, 10, 7	16, 13, 8, 5	COM1–COM4	Analog-Switch Common Terminal
3, 14, 11, 6	1, 12, 9, 4	NO or NC	Analog-Switch NO or NC Terminal
4	2	V-	Negative-Supply Voltage Input
5	3	GND	Ground
12	10	N.C.	No Connection. Not internally connected.
13	11	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.

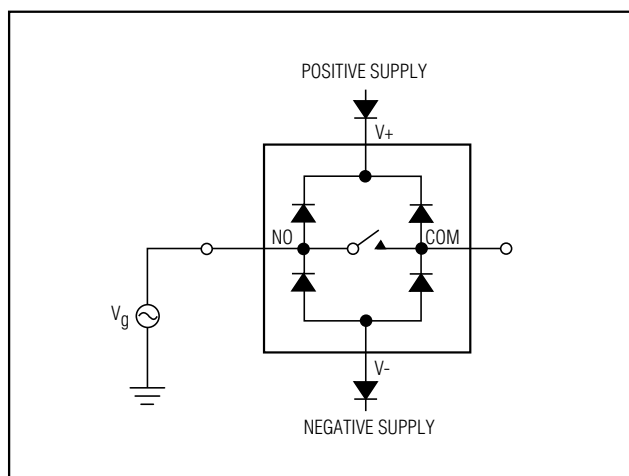


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

MAX391/MAX392/MAX393

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Test Circuits/Timing Diagrams

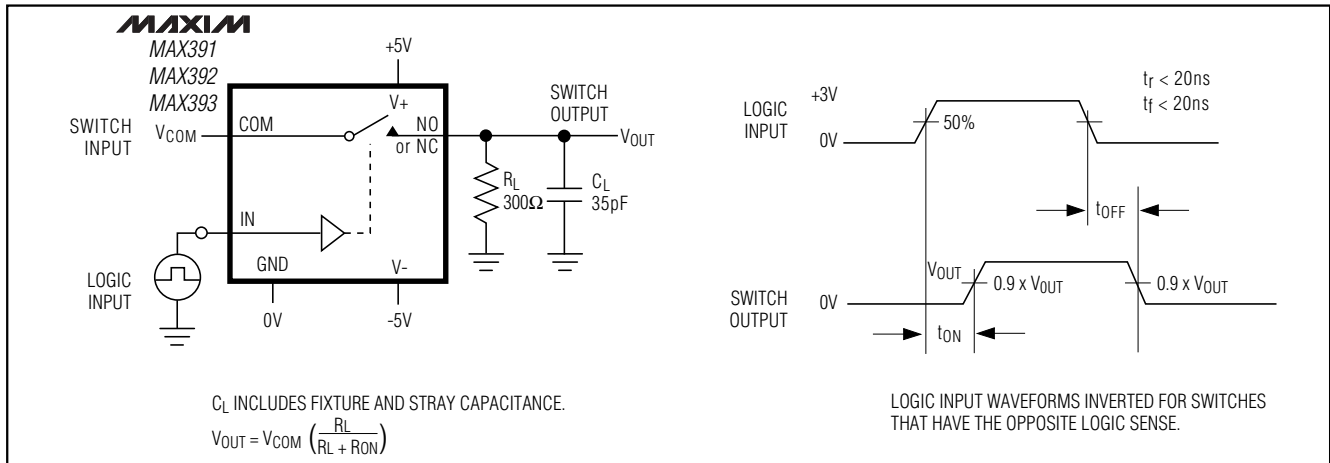


Figure 2. Switching Time

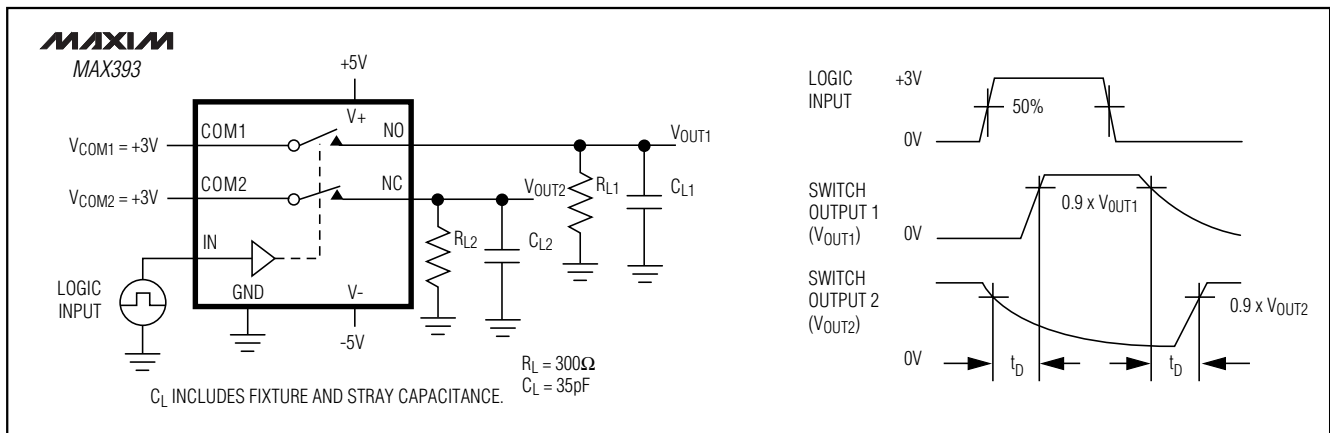


Figure 3. Break-Before-Make Interval (MAX393 Only)

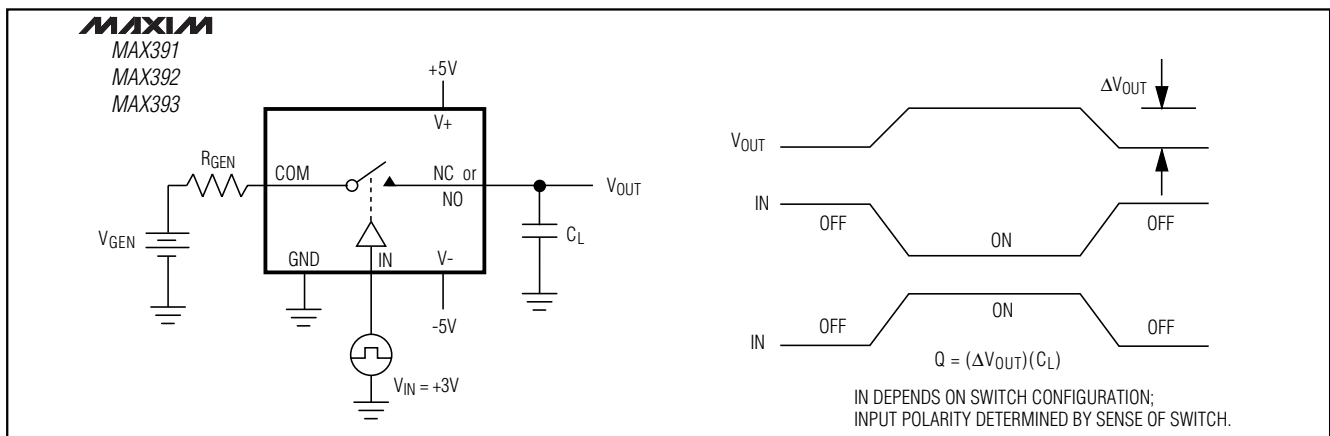


Figure 4. Charge Injection

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Test Circuits/Timing Diagrams (continued)

MAX391/MAX392/MAX393

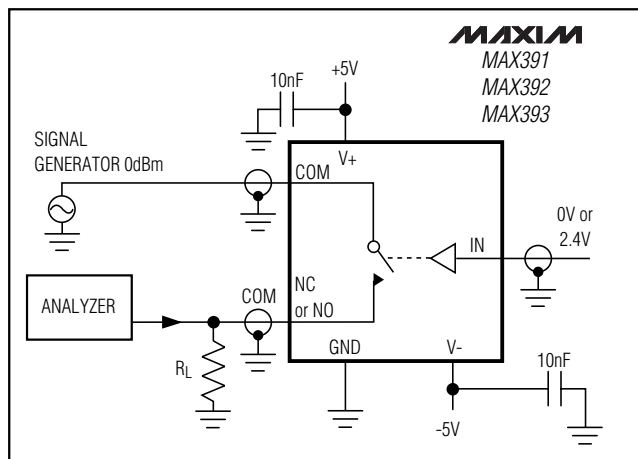


Figure 5. Isolation

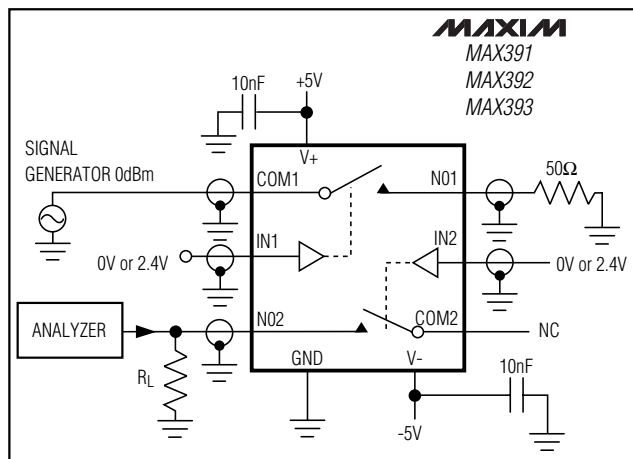


Figure 6. Crosstalk

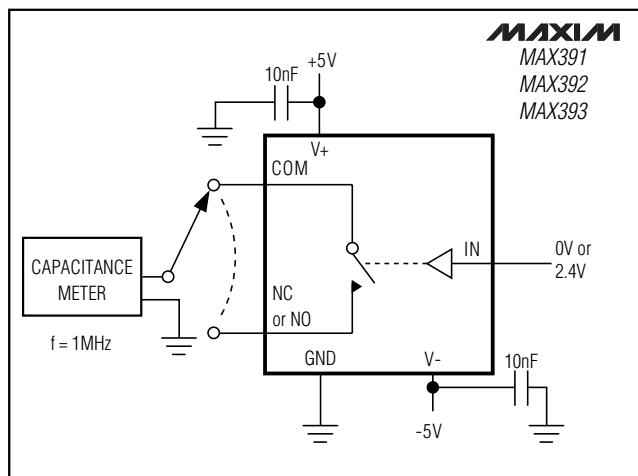


Figure 7. Channel-Off Capacitance

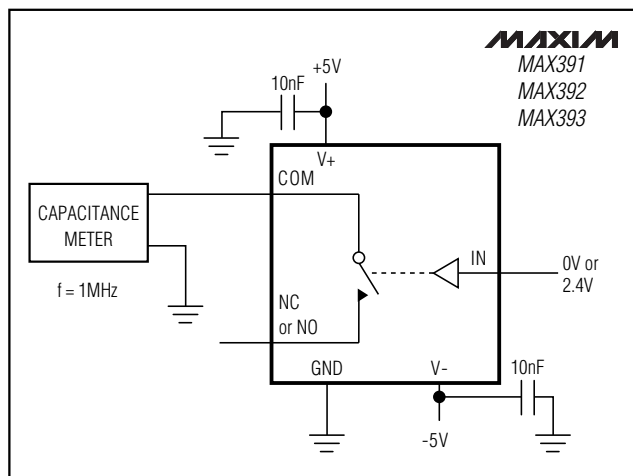


Figure 8. Channel-On Capacitance

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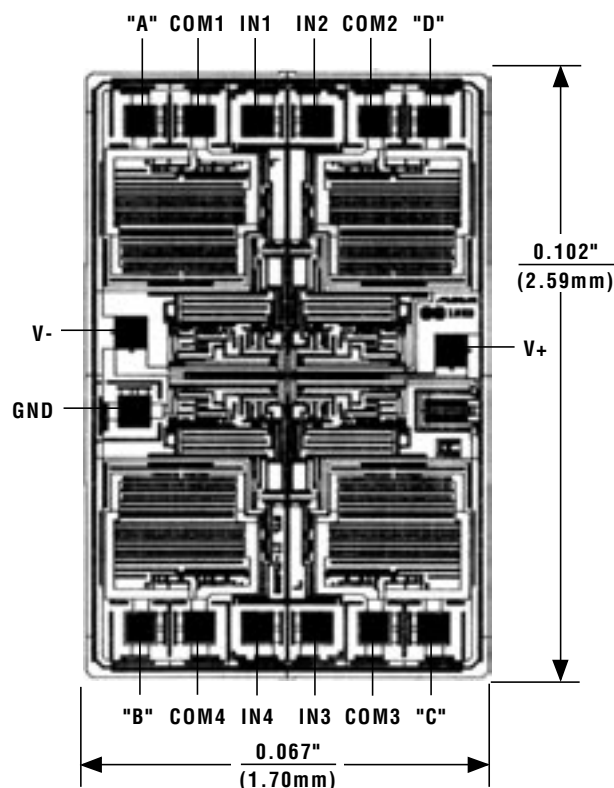
Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX391EJE	-40°C to +85°C	16 CERDIP
MAX391MJE	-55°C to +125°C	16 CERDIP**
MAX392 CPE	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
MAX392CGE	0°C to +70°C	16 QFN
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
MAX392EGE	-40°C to +85°C	16 QFN
MAX392EJE	-40°C to +85°C	16 CERDIP
MAX392MJE	-55°C to +125°C	16 CERDIP**
MAX393 CPE	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
MAX393CGE	0°C to +70°C	16 QFN
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
MAX393EGE	-40°C to +85°C	16 QFN
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



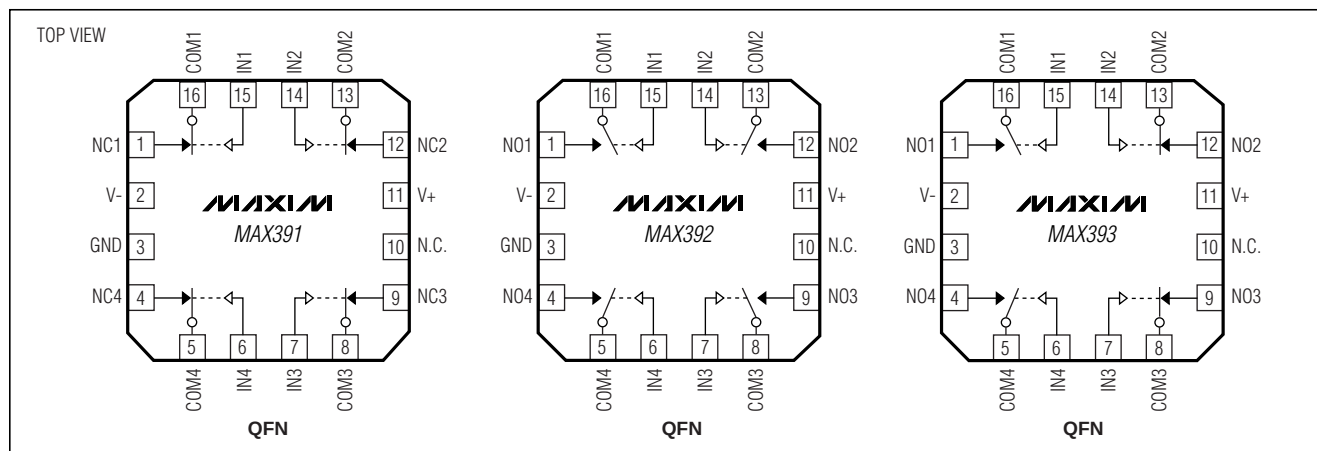
MAX391		MAX392		MAX393	
PIN	NAME	PIN	NAME	PIN	NAME
A	NC1	A	N01	A	N01
B	NC4	B	N04	B	N04
C	NC3	C	N03	C	NC3
D	NC2	D	N02	D	NC2

TRANSISTOR COUNT: 76

SUBSTRATE CONNECTED TO V+

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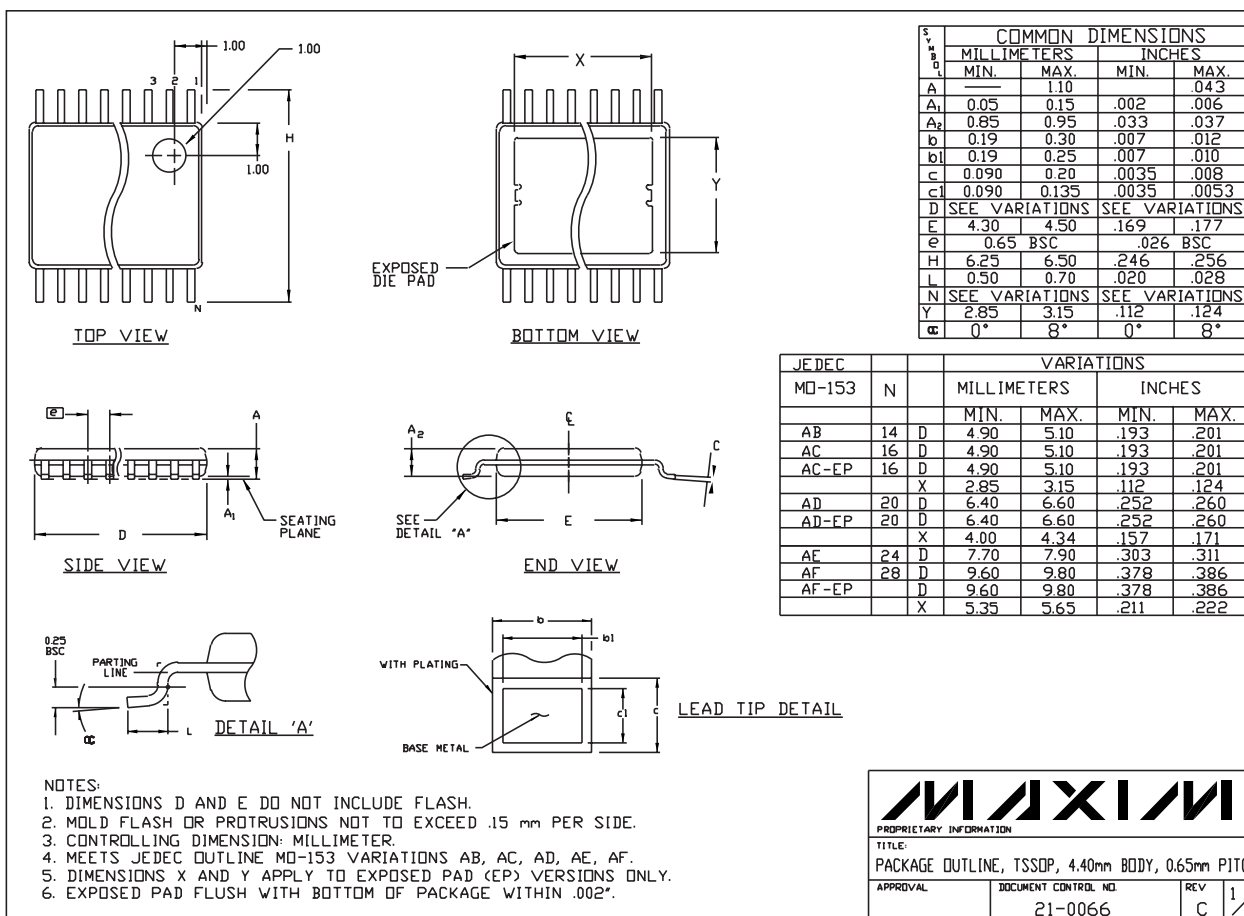
Pin Configurations/Functional Diagrams/Truth Tables (continued)



Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages

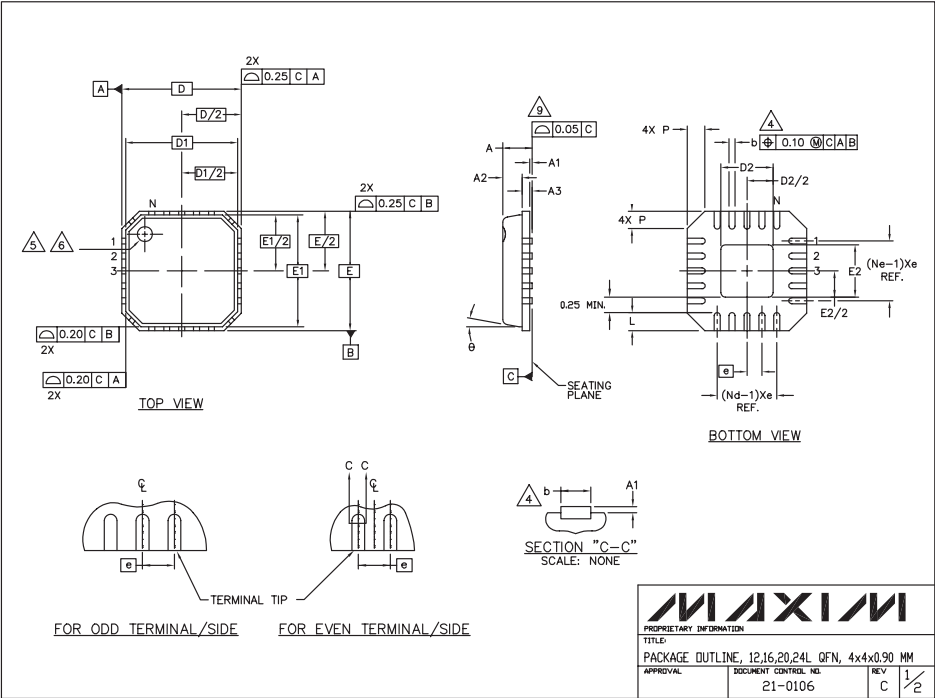
MAX391/MAX392/MAX393



Precision, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)



NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
2. DIMENSIONING & TOLERANCES CONFORM MUST TO ASME Y14.5M. - 1994.
3. N IS THE NUMBER OF TERMINALS.
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION &
Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS.
EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220.
11. THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES) AND TO SAW SINGULATION (STRAIGHT SIDES) QFN STYLES.

	COMMON DIMENSIONS			N _{TER}
	MIN.	NOM.	MAX.	
A	0.80	0.90	1.00	
A1	0.00	0.01	0.05	
A2	0.00	0.65	0.80	
A3	0.20 REF.			
D	4.00 BSC			
D1	3.75 BSC			
E	4.00 BSC			
E1	3.75 BSC			
g	0"		12"	
P	0.00	0.42	0.60	
D2	0.75		2.25	
E2	0.75		2.25	

PITCH VARIATION A				N _{TER}	PITCH VARIATION B				N _{TER}	PITCH VARIATION C				N _{TER}	PITCH VARIATION D				N _{TER}
MIN.	NOM.	MAX.			MIN.	NOM.	MAX.			MIN.	NOM.	MAX.			MIN.	NOM.	MAX.		
12	0.80 BSC			3	16	0.65 BSC			3	20	0.50 BSC			3	24	0.50 BSC			3
Nd	3			3	Nd	4			3	Nd	5			3	Nd	6			3
Ne	3			3	Ne	4			3	Ne	5			3	Ne	6			3
L	0.50	0.60	0.75		L	0.50	0.60	0.75		L	0.50	0.60	0.75		L	0.30	0.40	0.55	
b	0.28	0.33	0.40	4	b	0.23	0.28	0.35	4	b	0.18	0.23	0.30	4	b	0.18	0.23	0.30	4

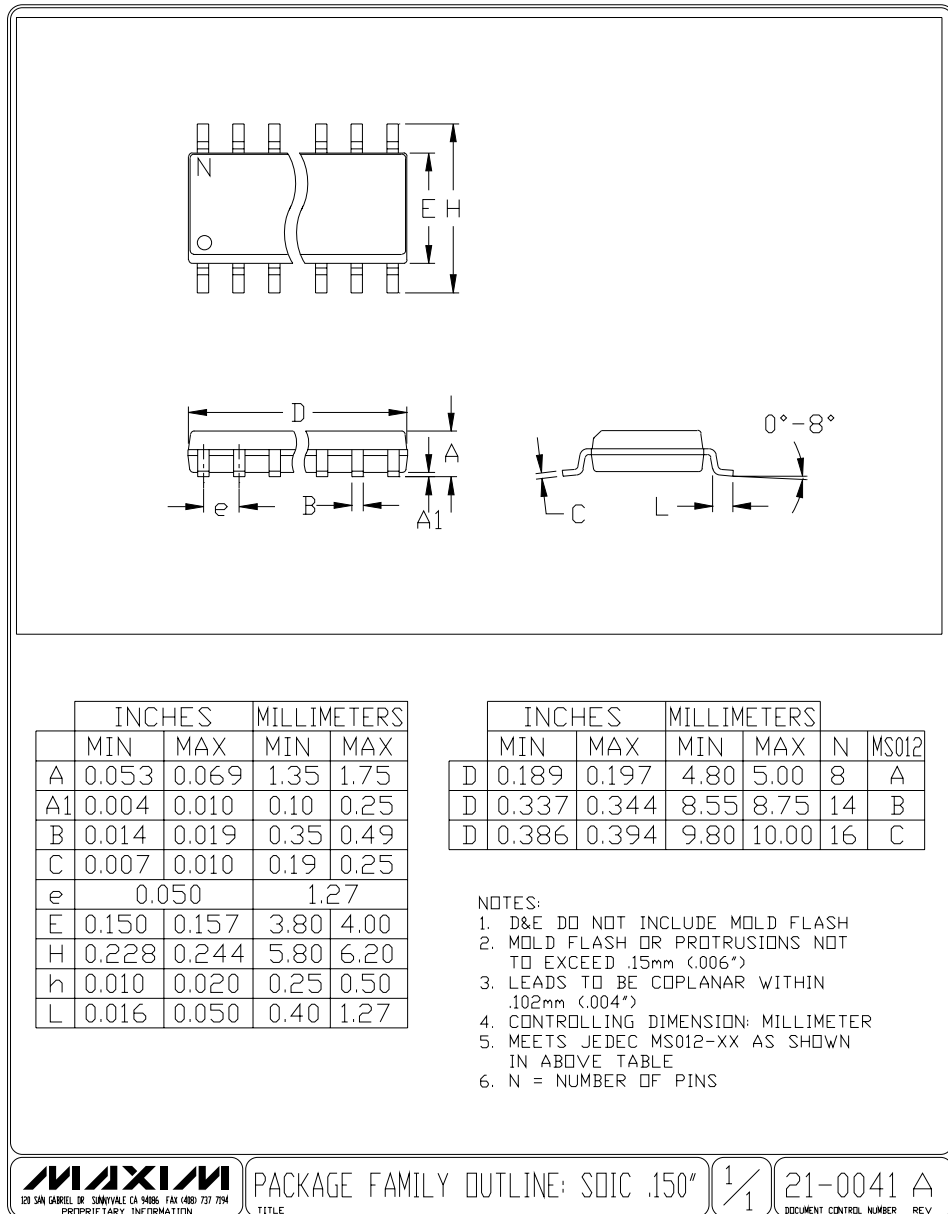
MAXIM			
PROPRIETARY INFORMATION			
TITLE: PACKAGE OUTLINE, 12,16,20,24L QFN, 4x4x0.90 MM			
APPROVAL:	DOCUMENT CONTROL NO. 21-0106	REV C	2/2

Precision, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)

MAX391/MAX392/MAX393



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