



# Precision, Quad, SPST Analog Switches

MAX391/MAX392/MAX393

## 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 ( $t_{ON} \leq 130ns$ ,  $t_{OFF} \leq 75ns$ ). 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
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

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



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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)
VIN, VCOM, VNC, VNO (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 (TA = +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, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
<b>ANALOG SWITCH</b>							
Analog Signal Range	VCOM, VNO, VNC	(Note 3)		V-		V+	V
On-Resistance	RON	V+ = 4.5V, V- = -4.5V, ICOM = -10mA, VNO or VNC = ±3.5V	TA = +25°C	C, E	20	35	Ω
				M	20	30	
			TA = TMIN to TMAX			45	
On-Resistance Match Between Channels (Note 4)	ΔRON	V+ = 5V, V- = -5V, ICOM = -10mA, VNO or VNC = ±3V	TA = +25°C		0.3	2	Ω
			TA = TMIN to TMAX			4	
On-Resistance Flatness (Note 5)	RFLAT(ON)	V+ = 5V, V- = -5V, ICOM = -10mA, VNO or VNC = ±3V	TA = +25°C		1	4	Ω
			TA = TMIN to TMAX			6	
NO or NC Off Leakage Current (Note 6)	INO(OFF) or INC(OFF)	V+ = 5.5V, V- = -5.5V, VCOM = ±4.5V, VNO or VNC = ∓4.5V	TA = +25°C		-0.1	0.01	nA
			TA = TMIN to TMAX	C, E	-2.5	2.5	
				M	-5	5	
COM Off Leakage Current (Note 6)	ICOM(OFF)	V+ = 5.5V, V- = -5.5V, VCOM = ±4.5V, VNO or VNC = ∓4.5V	TA = +25°C		-0.1	0.01	nA
			TA = TMIN to TMAX	C, E	-2.5	2.5	
				M	-5	5	
COM On Leakage Current (Note 6)	ICOM(ON)	V+ = 5.5V, V- = -5.5V, VCOM = ±4.5V, VNO or VNC = ±4.5V	TA = +25°C		-0.2	0.01	nA
			TA = TMIN to TMAX	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
<b>LOGIC INPUT</b>							
Input Current with Input Voltage High	I <sub>INH</sub>	IN = 2.4V, all others = 0.8V		-0.5	0.005	0.5	μA
Input Current with Input Voltage Low	I <sub>INL</sub>	IN = 0.8V, all others = 2.4V		-0.5	0.005	0.5	μA
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>COM</sub> = ±3V, Figure 2	TA = +25°C	65	130	ns	
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>		175		
Turn-Off Time	t <sub>OFF</sub>	V <sub>COM</sub> = ±3V, Figure 2	TA = +25°C	35	75	ns	
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>		100		
Break-Before-Make Time Delay (Note 3)	t <sub>D</sub>	MAX393 only, RL = 300Ω, CL = 35pF, Figure 3		5	10	ns	
Charge Injection (Note 3)	Q	CL = 1.0nF, V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0Ω, Figure 4	TA = +25°C	2	5	pC	
Off Isolation (Note 7)	OIRR	RL = 50Ω, CL = 5pF, f = 1MHz, Figure 5	TA = +25°C	72		dB	
Crosstalk (Note 8)		RL = 50Ω, CL = 5pF, f = 1MHz, Figure 6	TA = +25°C	85		dB	
NC or NO Capacitance	C <sub>(OFF)</sub>	f = 1MHz, Figure 7	TA = +25°C	9		pF	
COM Off Capacitance	C <sub>COM(OFF)</sub>	f = 1MHz, Figure 7	TA = +25°C	9		pF	
COM On Capacitance	C <sub>COM(ON)</sub>	f = 1MHz, Figure 8	TA = +25°C	22		pF	
<b>SUPPLY</b>							
Power-Supply Range				-8.0		+8.0	V
Positive Supply Current	I+	V+ = 5.5V, V- = -5.5V, VIN = 0V or V+, All channels on or off	TA = T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	μA
Negative Supply Current	I-	V+ = 5.5V, V- = -5.5V, VIN = 0V or V+, All channels on or off	TA = T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	μA

# Precision, Quad, SPST Analog Switches

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

# Precision, Quad, SPST Analog Switches

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
<b>ANALOG SWITCH</b>							
Analog Signal Range	VCOM, VNO, VNC	(Note 3)		0		V+	V
Channel On-Resistance	RON	V+ = 3V, ICOM = -1.0mA, VNO or VNC = 1.5V	TA = +25°C	83	175		Ω
			TA = TMIN to TMAX		275		
<b>DYNAMIC</b>							
Turn-On Time (Note 3)	tON	VNO or VNC = 1.5V	TA = +25°C	160	400		ns
			TA = TMIN to TMAX		500		
Turn-Off Time (Note 3)	tOFF	VNO or VNC = 1.5V	TA = +25°C	40	125		ns
			TA = TMIN to TMAX		175		
Break-Before-Make Time Delay (Note 3)	tD	MAX393 only, RL = 300Ω, CL = 35pF	TA = +25°C	20			ns
Charge Injection (Note 3)	Q	CL = 1.0nF, VGEN = 0V, RGEN = 0V	TA = +25°C		1	5	pC
<b>SUPPLY</b>							
Positive Supply Current	I+	V+ = 3.6V, VIN = 0V or V+, all channels on or off		-1		1	μA
Negative Supply Current	I-	V+ = 3.6V, VIN = 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.

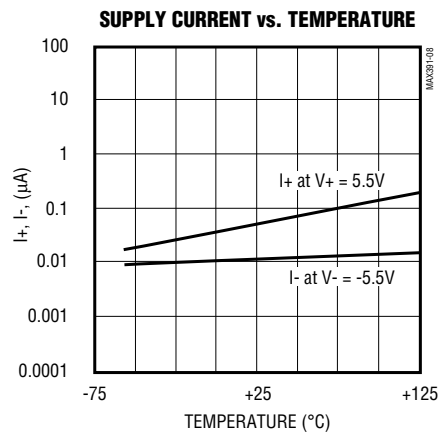
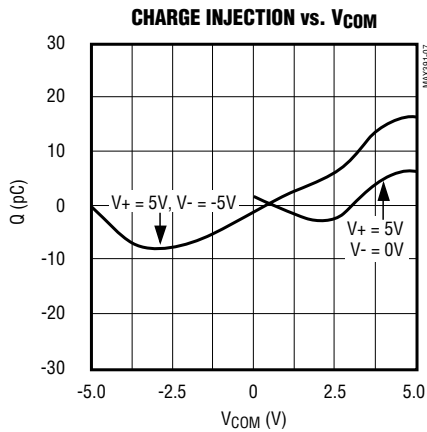
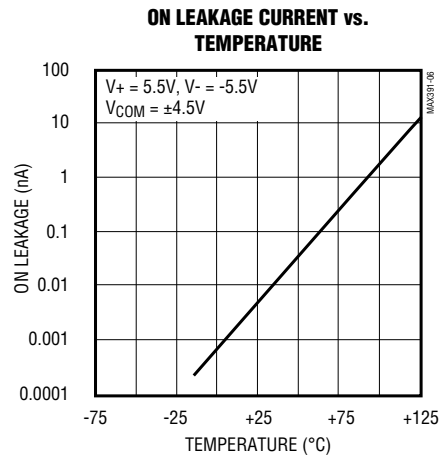
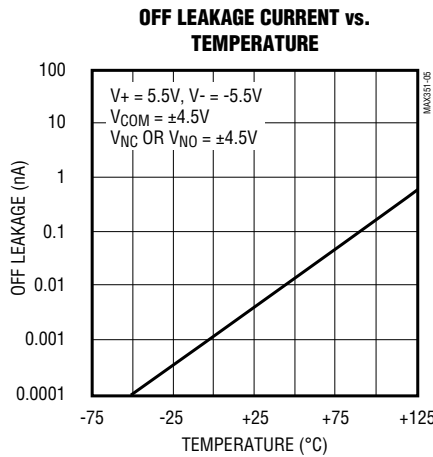
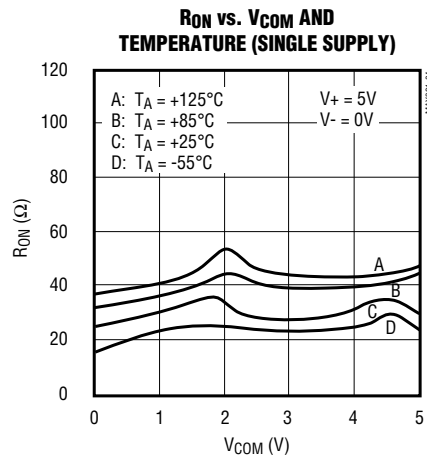
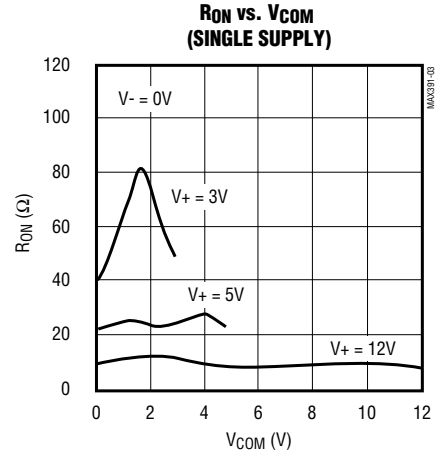
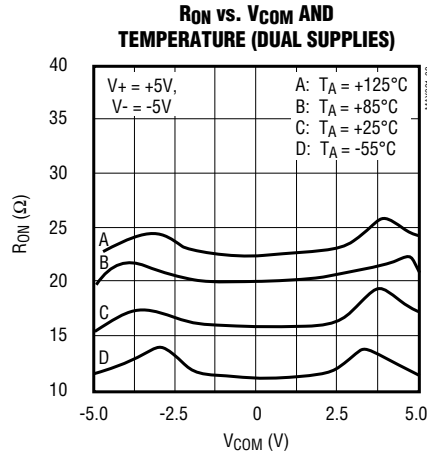
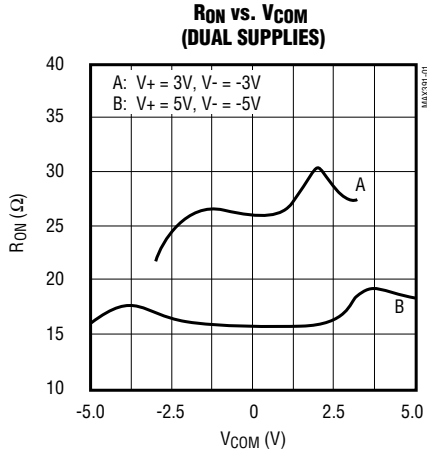
**Note 8:** Between any two switches.

**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.)



# Precision, Quad, SPST Analog Switches

## 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

MAX391/MAX392/MAX393

## 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.

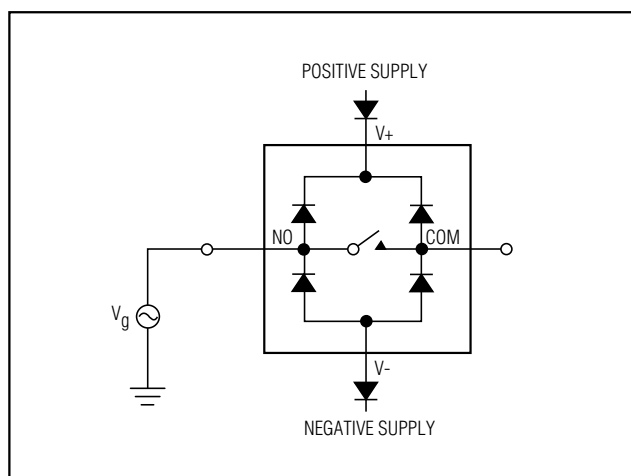


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

# Precision, Quad, SPST Analog Switches

## Test Circuits/Timing Diagrams

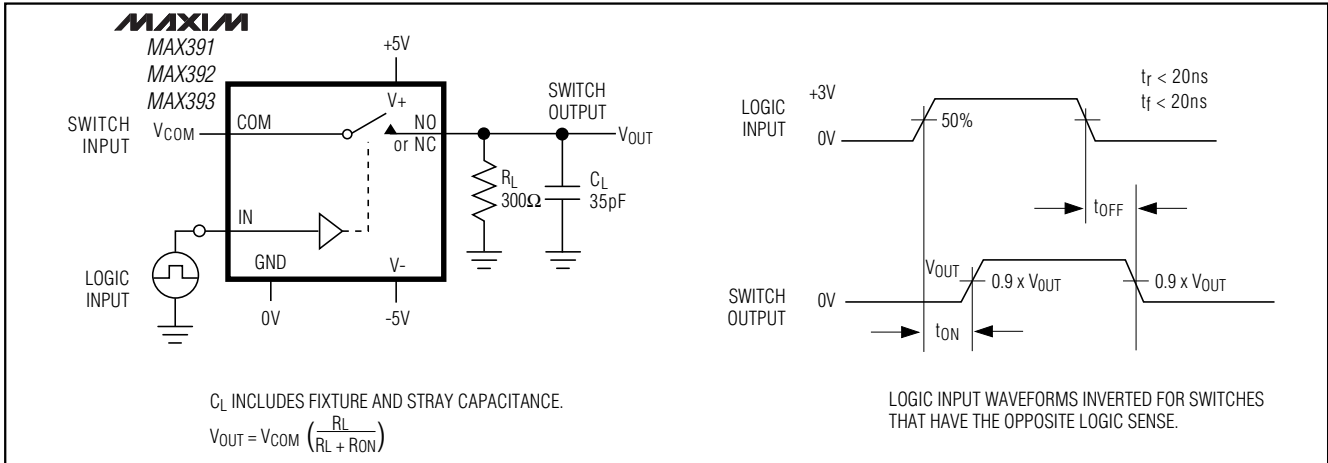


Figure 2. Switching Time

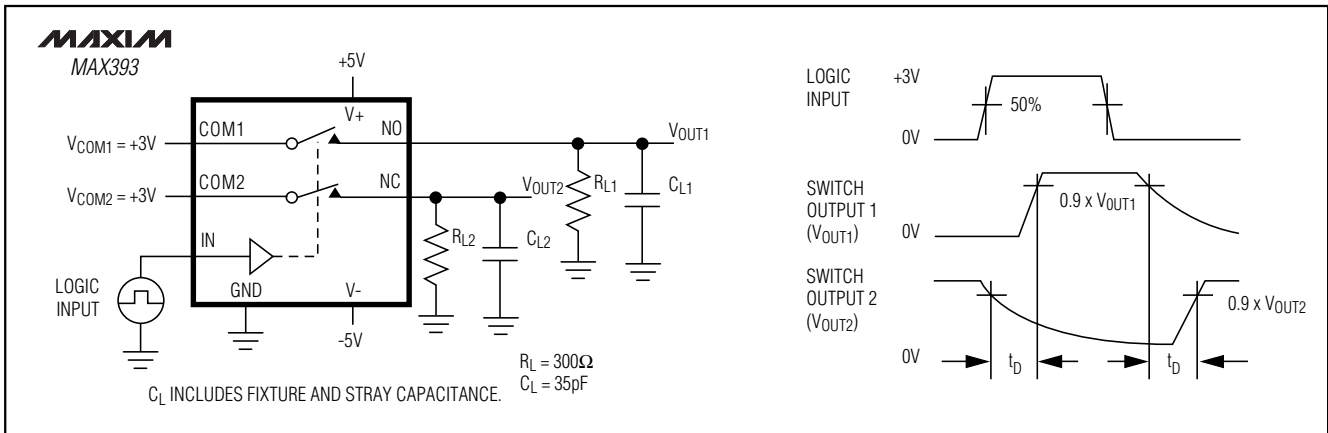


Figure 3. Break-Before-Make Interval (MAX393 only)

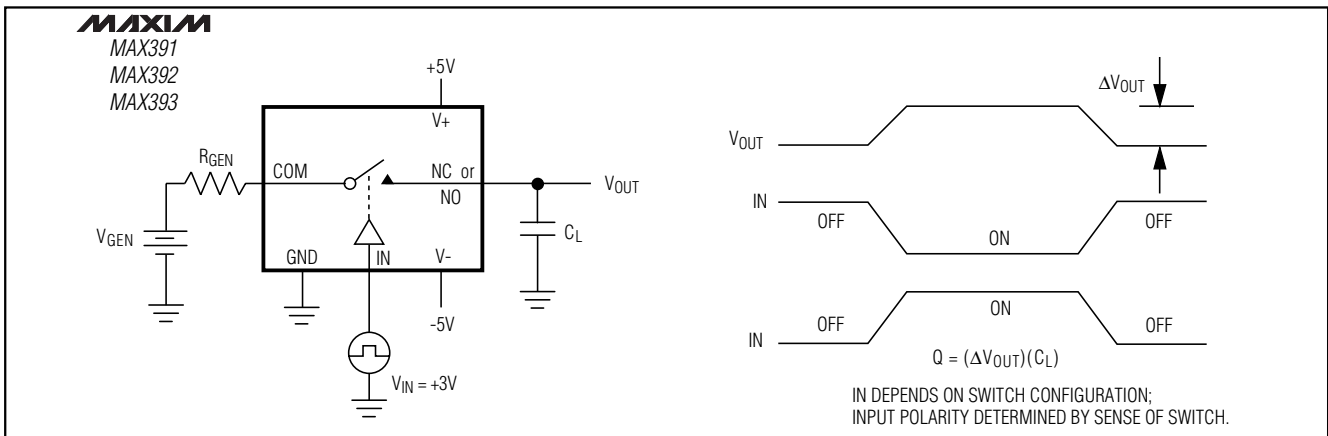


Figure 4. Charge Injection



# Precision, Quad, SPST Analog Switches

## Test Circuits/Timing Diagrams (continued)

**MAX391/MAX392/MAX393**

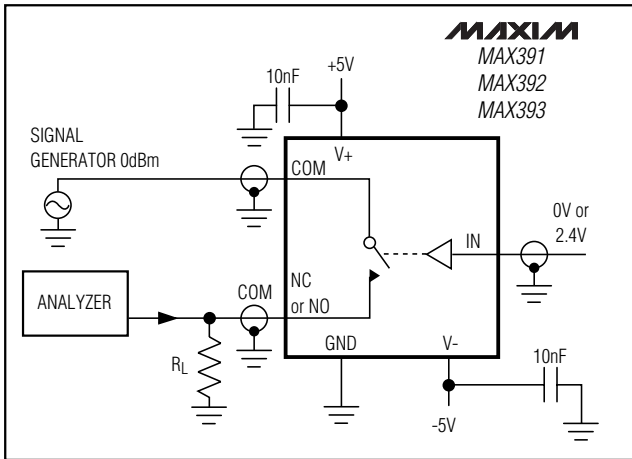


Figure 5. Isolation

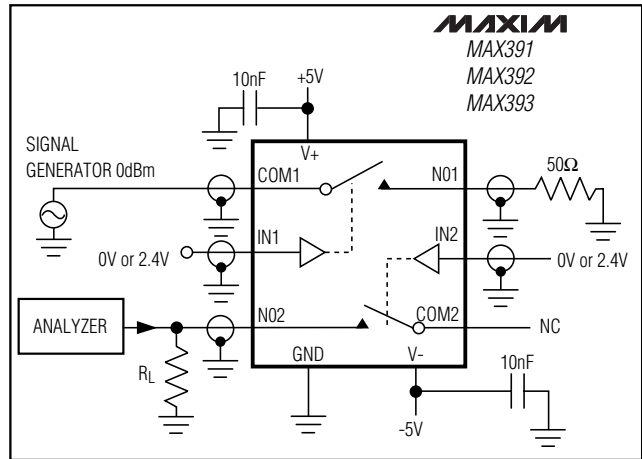


Figure 6. Crosstalk

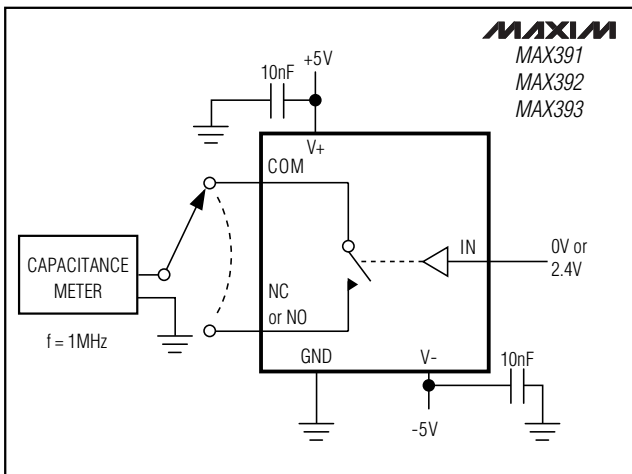


Figure 7. Channel-Off Capacitance

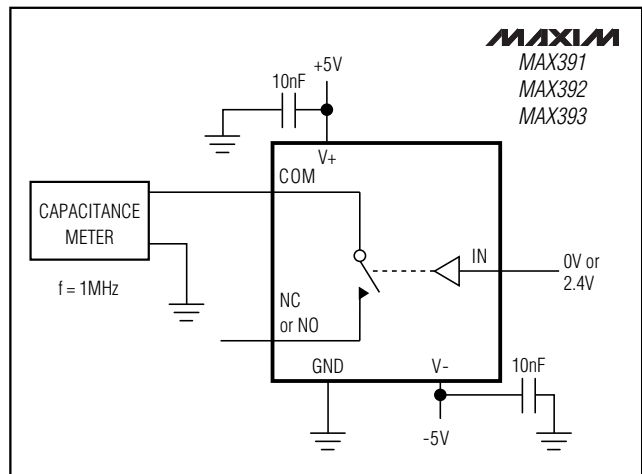


Figure 8. Channel-On Capacitance

# Precision, Quad, SPST Analog Switches

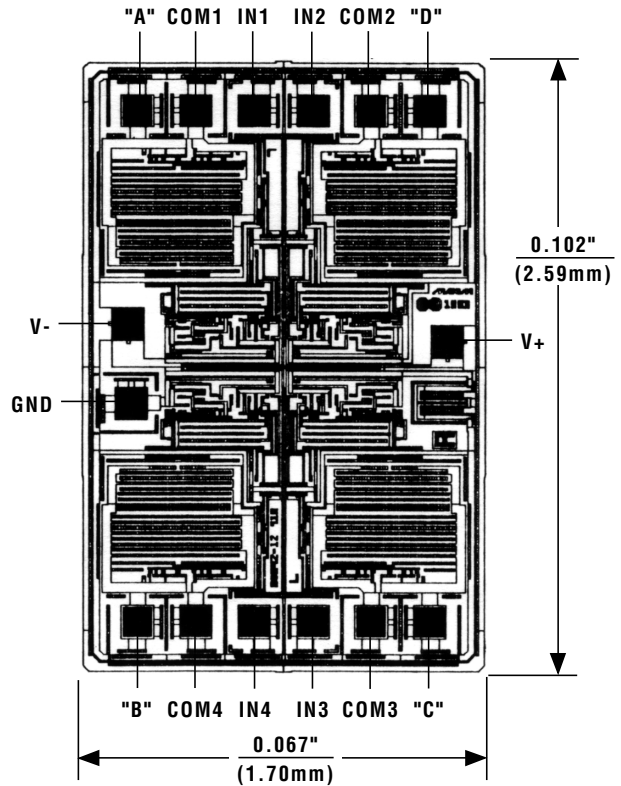
## Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX391EJE	-40°C to +85°C	16 CERDIP
MAX391MJE	-55°C to +125°C	16 CERDIP**
<b>MAX392CPE</b>	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**
<b>MAX393CPE</b>	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+

# Precision, Quad, SPST Analog Switches

## Package Information

MAX391/MAX392/MAX393

TSSOP EPSS

DIMENSION	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	—	1.10	—	.043
A <sub>1</sub>	0.05	0.15	.002	.006
A <sub>2</sub>	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b <sub>1</sub>	0.19	0.25	.007	.010
c	0.090	0.20	.0035	.008
c <sub>1</sub>	0.090	0.135	.0035	.0053
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 BSC		.026 BSC	
H	6.25	6.50	.246	.256
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
Y	2.85	3.15	.112	.124
⊙	0°	8°	0°	8°

JEDEC	N		VARIATIONS			
			MILLIMETERS		INCHES	
			MIN.	MAX.	MIN.	MAX.
AB	14	D	4.90	5.10	.193	.201
AC	16	D	4.90	5.10	.193	.201
AC-EP	16	D	4.90	5.10	.193	.201
		X	2.85	3.15	.112	.124
AD	20	D	6.40	6.60	.252	.260
AD-EP	20	D	6.40	6.60	.252	.260
		X	4.00	4.34	.157	.171
AE	24	D	7.70	7.90	.303	.311
AF	28	D	9.60	9.80	.378	.386
AF-EP	28	D	9.60	9.80	.378	.386
		X	5.35	5.65	.211	.222

**NOTES:**

- DIMENSIONS D AND E DO NOT INCLUDE FLASH.
- MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 mm PER SIDE.
- CONTROLLING DIMENSION: MILLIMETER.
- MEETS JEDEC OUTLINE MD-153 VARIATIONS AB, AC, AD, AE, AF.
- DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.
- EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

# Precision, Quad, SPST Analog Switches

## Package Information (continued)

	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS		N	MS012
	MIN	MAX	MIN	MAX		
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:  
 1. D&E DO NOT INCLUDE MOLD FLASH  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")  
 3. LEADS TO BE COPLANAR WITHIN .102mm (.004")  
 4. CONTROLLING DIMENSION: MILLIMETER  
 5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE  
 6. N = NUMBER OF PINS

**MAXIM** 120 SAN GABRIEL DRIVE, SUNNYVALE, CA 94086 FAX (408) 737-7791 PROPRIETARY INFORMATION  
 PACKAGE FAMILY OUTLINE: SOIC .150" 1/1 21-0041 A  
TITLE DOCUMENT CONTROL NUMBER REV

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