19-1539; Rev 0; 2/00

MAXIM

High-Speed, Single-Supply, Quad, SPST Analog Switches

General Description

The MAX4591/MAX4592/MAX4593 are high-speed, precision, quad, single-pole/single-throw (SPST) analog switches designed to operate at +12V or +15V. The MAX4591 has four normally closed (NC) switches, and the MAX4592 has four normally open (NO) switches. The MAX4593 has two NO and two NC switches. All three devices offer low leakage (100pA max) and fast switching speeds (t_{ON} ≤ 80ns, t_{OFF} ≤ 45ns).

With a +12V supply, the MAX4591/MAX4592/MAX4593 offer guaranteed 1Ω max channel-to-channel matching, 20Ω max on-resistance (R_{ON}), and 1.75Ω max R_{ON} flatness over the specified range.

These switches are also fully specified for single +15V operation, with 16Ω max R_{ON}, 1.5Ω max R_{ON} match, and 1.5Ω max flatness. For low-voltage or dual-supply operation, refer to the MAX391 data sheet.

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

Applications

Test Equipment
Disk Drives
Tape Drives
Audio and Video Switching
Heads-Up Displays
Sample-and-Hold Circuits
Guidance and Control Systems
Military Radios
Communications Systems
PBX, PABX

Features

- **Low 16Ω On-Resistance**
- **Fast Switching Times: t_{ON} = 50ns, t_{OFF} = 30ns**
- **Guaranteed 1Ω max On-Resistance Match Between Channels**
- **Guaranteed 1.75Ω max On-Resistance Flatness over Signal Range**
- **Guaranteed 5pC max Charge Injection**
- **Improved Leakage over Temperature: 5nA max at +85°C**
- **ESD >2000V per Method 3015.7**
- **+12V or +15V Single-Supply Operation**
- **Pin Compatible with DG611/DG612/DG613, DG211/DG212/DG213**

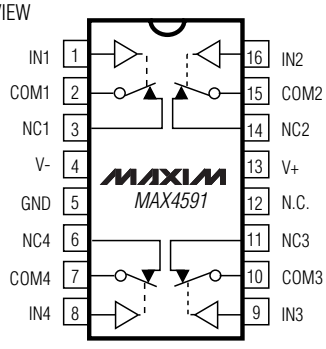
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4591CUE	0°C to +70°C	16 TSSOP
MAX4591CSE	0°C to +70°C	16 Narrow SO
MAX4591CPE	0°C to +70°C	16 Plastic DIP
MAX4591EUE	-40°C to +85°C	16 TSSOP
MAX4591ESE	-40°C to +85°C	16 Narrow SO
MAX4591EPE	-40°C to +85°C	16 Plastic DIP

Ordering Information continued at end of data sheet.

Pin Configurations/Functional Diagrams/Truth Tables

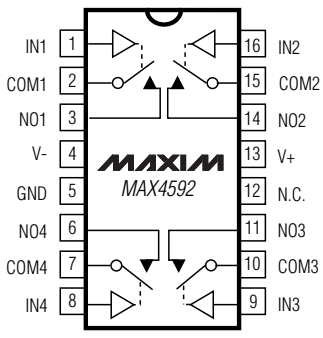
TOP VIEW



TSSOP/SO/DIP

MAX4591	
LOGIC	**SWITCH**
0	ON
1	OFF

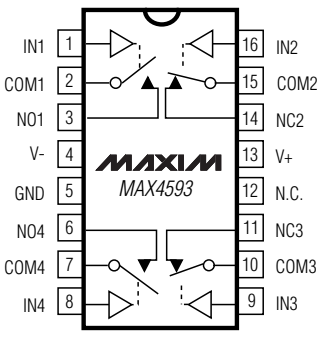
N.C. = NO CONNECTION



TSSOP/SO/DIP

MAX4592	
LOGIC	**SWITCH**
0	OFF
1	ON

SWITCHES SHOWN FOR LOGIC "0" INPUT



TSSOP/SO/DIP

MAX4593		
LOGIC	**SWITCHES 1, 4**	**SWITCHES 2, 3**
0	OFF	ON
1	ON	OFF

High-Speed, Single-Supply, Quad, SPST Analog Switches

ABSOLUTE MAXIMUM RATINGS

V+ to GND .....-0.3V to +17V
$V_{IN\_}$, $V_{COM\_}$, $V_{NC\_}$, $V_{NO\_}$ (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)
16-Pin TSSOP (derate 5.70mW/°C above +70°C) 457mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C)....696mW
16-Pin Plastic DIP (derate 10.53mW/°C above+70°C) ...842mW
Operating Temperature Ranges
MAX459_C_ E .....0°C to +70°C
MAX459_E_ E .....-40°C to +85°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—Single +12V Supply

(V+ = +12V, V- = GND = 0, V_{INH} = 5V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$	(Note 3)	C, E	V-		V+	V
On-Resistance	R_{ON}	$I_{COM\_}$ = -10mA, $V_{NO\_}$ or $V_{NC\_}$ = 10V	T_A = +25°C		16	20	Ω
			C, E			24	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	$I_{COM\_}$ = -10mA, $V_{NO\_}$ or $V_{NC\_}$ = 10V	T_A = +25°C		0.5	1	Ω
			C, E			1.5	
On-Resistance Flatness (Note 5)	$R_{FLAT(ON)}$	$I_{COM\_}$ = -10mA; $V_{NO\_}$ or $V_{NC\_}$ = 3V, 6V, 9V	T_A = +25°C		1	1.75	Ω
			C, E			2	
NO or NC Off-Leakage Current (Note 6)	$I_{NO\_(OFF)}$ or $I_{NC\_(OFF)}$	V+ = 15.5V; $V_{COM\_}$ = 14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ = 1V, 14V	T_A = +25°C	-0.1	0.01	0.1	nA
			C, E	-5		5	
COM Off-Leakage Current (Note 6)	$I_{COM\_(OFF)}$	V+ = 15.5V; $V_{COM\_}$ = 14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ = 1V, 14V	T_A = +25°C	-0.1	0.01	0.1	nA
			C, E	-5		5	
COM On-Leakage Current (Note 6)	$I_{COM\_(ON)}$	V+ = 15.5V; $V_{COM\_}$ = 14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ = 14V, 1V, or floating	T_A = +25°C	-0.2	0.01	0.2	nA
			C, E	-10		10	

ELECTRICAL CHARACTERISTICS—Single +12V Supply (continued)

(V+ = +12V, V- = GND = 0, V_{INH} = 5V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
LOGIC INPUT							
Input Current with Input Voltage High	I_{INH}	IN_ = V+, all others = 0.8V		-0.5	0.005	0.5	µA
Input Current with Input Voltage Low	I_{INL}	IN_ = 0.8V, all others = V+		-0.5	0.005	0.5	µA
DYNAMIC							
Turn-On Time	t_{ON}	$V_{COM\_}$ = 10V, Figure 2	T_A = +25°C		50	80	ns
			C, E			90	
Turn-Off Time	t_{OFF}	$V_{COM\_}$ = 10V, Figure 2	T_A = +25°C		30	45	ns
			C, E			50	
Break-Before-Make Time Delay (Note 3)	t_D	MAX4593 only, R_L = 300Ω, C_L = 35pF, Figure 3		5	20		ns
Charge Injection (Note 3)	Q	C_L = 1nF, V_{GEN} = 0, R_{GEN} = 0Ω, Figure 4	T_A = +25°C		2	5	pC
Off-Isolation (Note 7)	OIRR	R_L = 50Ω, C_L = 5pF, f = 10MHz, Figure 5	T_A = +25°C		72		dB
Crosstalk (Note 8)		R_L = 50Ω, C_L = 5pF, f = 10MHz, 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				3		16	V
Positive Supply Current	I+	V+ = 15V, $V_{IN\_}$ = 0 or V+, all channels on or off	C, E	-1	0.001	1	µA

High-Speed, Single-Supply, Quad, SPST Analog Switches

ELECTRICAL CHARACTERISTICS—Single +15V Supply

(V+ = +15V, V- = GND = 0, V_{INH} = 5V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

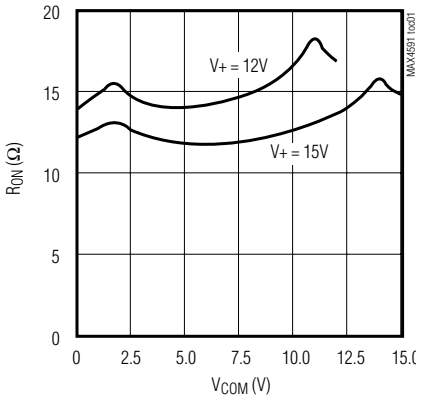
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$	(Note 3)		0		V+	V
On-Resistance	R_{ON}	$I_{COM\_}$ = -10mA, $V_{NO\_}$ or $V_{NC\_}$ = 10V	T_A = +25°C		12	16	Ω
			C, E			2.0	
On-Resistance Match Between Channels (Notes 3, 4)	ΔR_{ON}	$I_{COM\_}$ = -10mA, $V_{NO\_}$ or $V_{NC\_}$ = 10V	T_A = +25°C		0.5	1.5	Ω
			C, E			2.0	
On-Resistance Flatness (Notes 3, 5)	$R_{FLAT(ON)}$	$I_{COM\_}$ = -10mA; $V_{NO\_}$ or $V_{NC\_}$ = 3V, 6V, 9V	T_A = +25°C		0.7	1.5	Ω
			C, E			2.0	
NO_ or NC_ Off-Leakage Current (Note 6)	$I_{NO\_(OFF)}$ or $I_{NC\_(OFF)}$	V+ = 15.5V; $V_{COM\_}$ = 14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ 1V, 14V	T_A = +25°C	-0.1	0.01	0.1	nA
			C, E	-5		5	
COM_ Off-Leakage Current (Note 6)	$I_{COM\_(OFF)}$	V+ = 15.5V; $V_{COM\_}$ = 14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ = 1V, 14V	T_A = +25°C	-0.1	0.01	0.1	nA
			C, E	-5		5	
COM_ On-Leakage Current (Note 6)	$I_{COM\_(ON)}$	V+ = 15.5V; $V_{COM\_}$ =14V, 1V; $V_{NO\_}$ or $V_{NC\_}$ = 14V, 1V, or floating	T_A = +25°C	-0.2	0.02	0.2	nA
			C, E	-10		10	
DYNAMIC							
Turn-On Time	t_{ON}	$V_{NO\_}$ or $V_{NC\_}$ = 10V, Figure 2	T_A = +25°C		60	80	ns
			C, E			90	
Turn-Off Time	t_{OFF}	$V_{NO\_}$ or $V_{NC\_}$ = 10V, Figure 2	T_A = +25°C		30	40	ns
			C, E			50	
Break-Before-Make Time Delay (Note 3)	t_D	MAX4593 only, R_L = 300Ω, C_L = 35pF		5	20		ns
Charge Injection (Note 3)	Q	C_L = 1nF, V_{GEN} = 0, R_{GEN} = 0Ω, Figure 4	T_A = +25°C		2	5	pC
SUPPLY							
Positive Supply Current	I+	V+ = 15V, $V_{IN\_}$ = 0 or V+, all channels on or off		-1	0.001	1	µA
Negative Supply Current	I-	V+ = 15V, $V_{IN\_}$ = 0 or V+, all channels on or off		-1	0.001	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 - ΔR_{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} or V_{NO})], V_{COM} = output, V_{NC} or V_{NO} = input to off switch.
Note 8: Between any two switches.

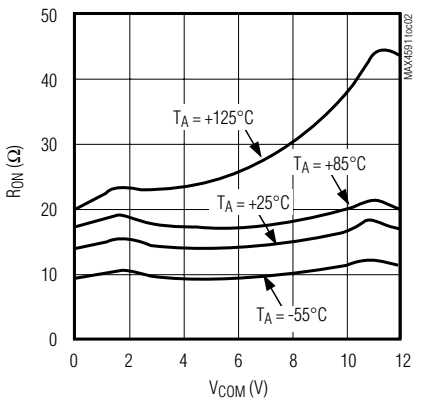
Typical Operating Characteristics

(V- = GND = 0, IN_ = 0 or V+, T_A = +25°C, unless otherwise noted.)

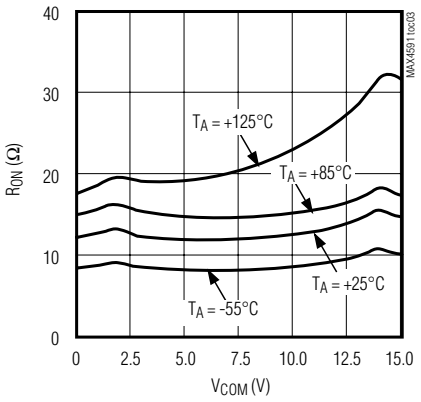
RON vs. VCOM



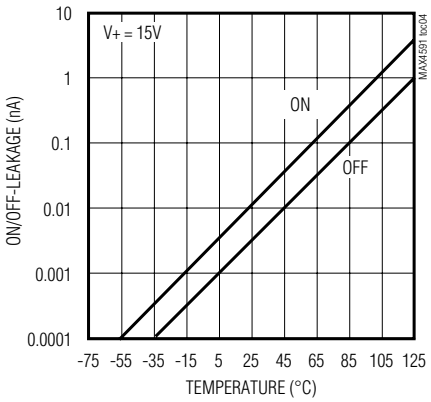
RON vs. VCOM AND TEMPERATURE (V+ = 12V)



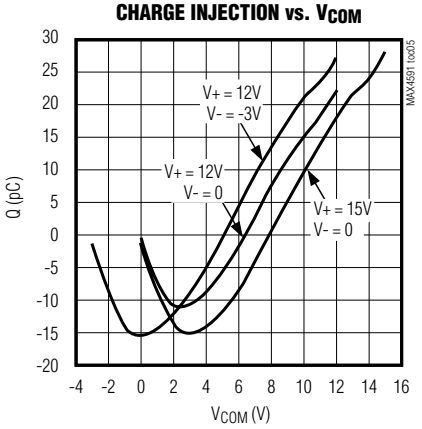
RON vs. VCOM AND TEMPERATURE (V+ = 15V)



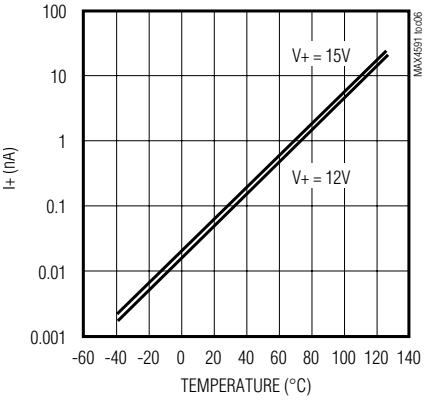
ON/OFF-LEAKAGE CURRENT vs. TEMPERATURE



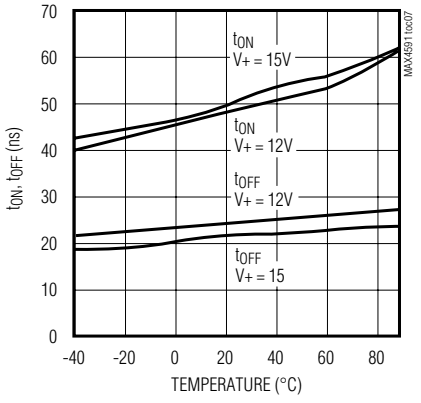
CHARGE INJECTION vs. VCOM



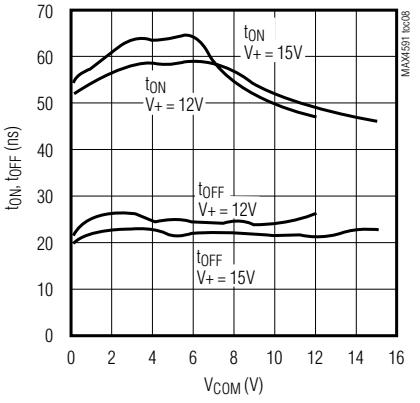
POWER-SUPPLY CURRENT vs. TEMPERATURE



TURN-ON/OFF TIME vs. TEMPERATURE



TURN-ON/OFF TIME vs. VCOM

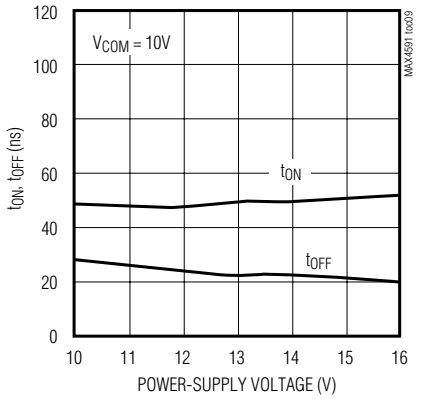


High-Speed, Single-Supply, Quad, SPST Analog Switches

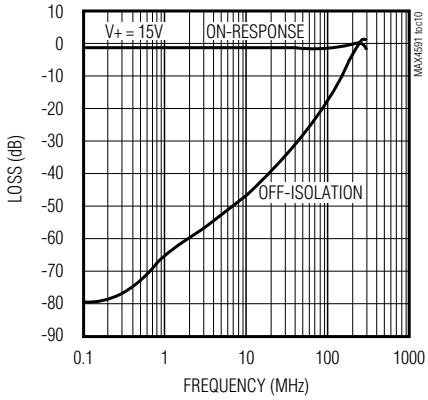
Typical Operating Characteristics (continued)

(V- = GND = 0, IN_ = 0 or V+, T_A = +25°C, unless otherwise noted.)

TURN-ON/OFF TIME vs. POWER-SUPPLY VOLTAGE



FREQUENCY RESPONSE



Pin Description

PIN	NAME	FUNCTION
1, 16, 9, 8	IN1–IN4	Switch Input Terminals. Drive ≤ 0.8V for logic “0”; drive ≥ 5V for logic “1”.
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. Normally connected to ground.
5	GND	Ground
12	N.C.	No Connection. 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 the logic inputs. If power-supply sequencing is not possible, add a small signal diode in series with V+ for overvoltage protection (Figure 1). Adding a diode reduces the analog signal range to 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.

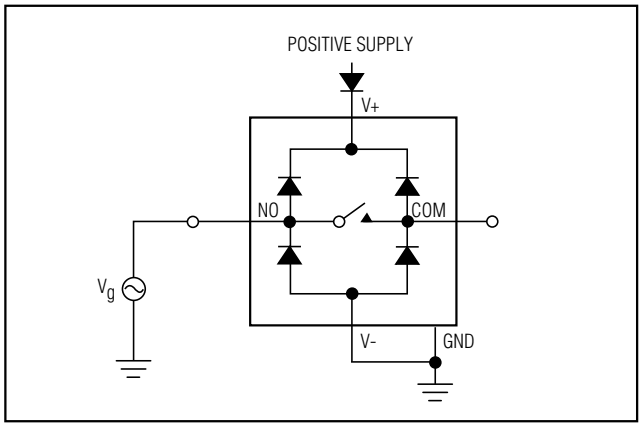


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

Test Circuits/Timing Diagrams

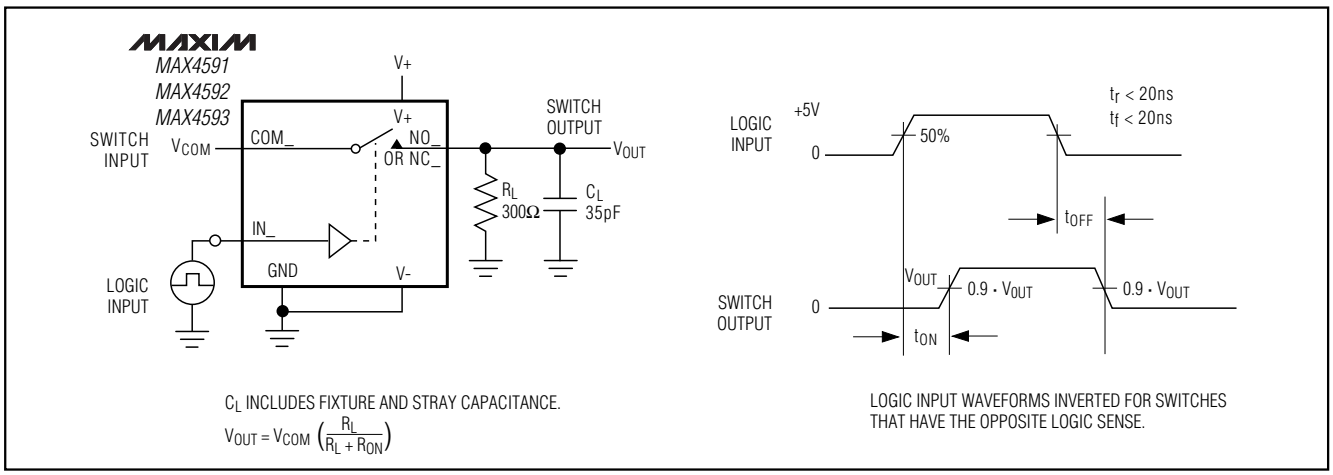


Figure 2. Switching Time

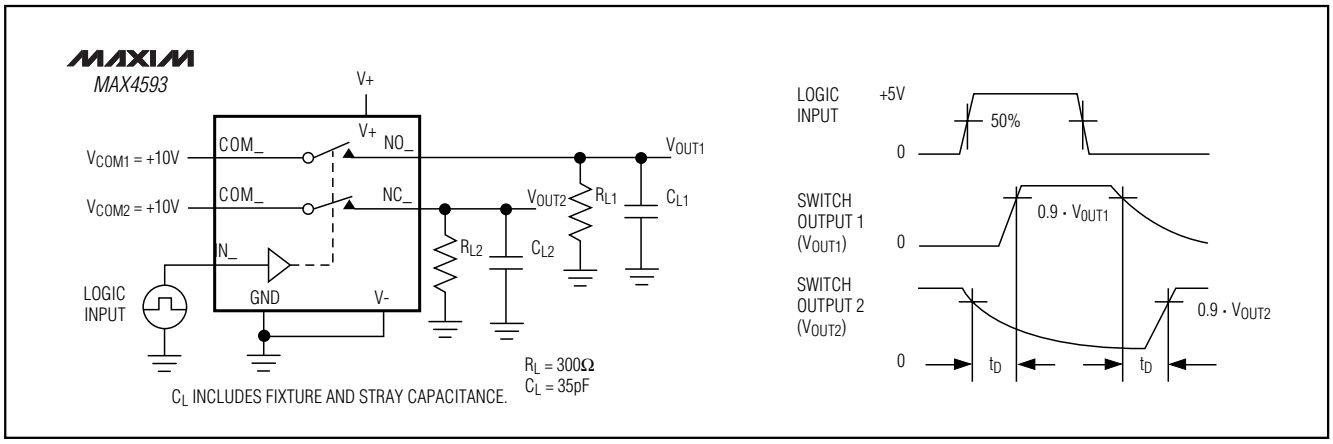


Figure 3. Break-Before-Make Interval (MAX4593 Only)

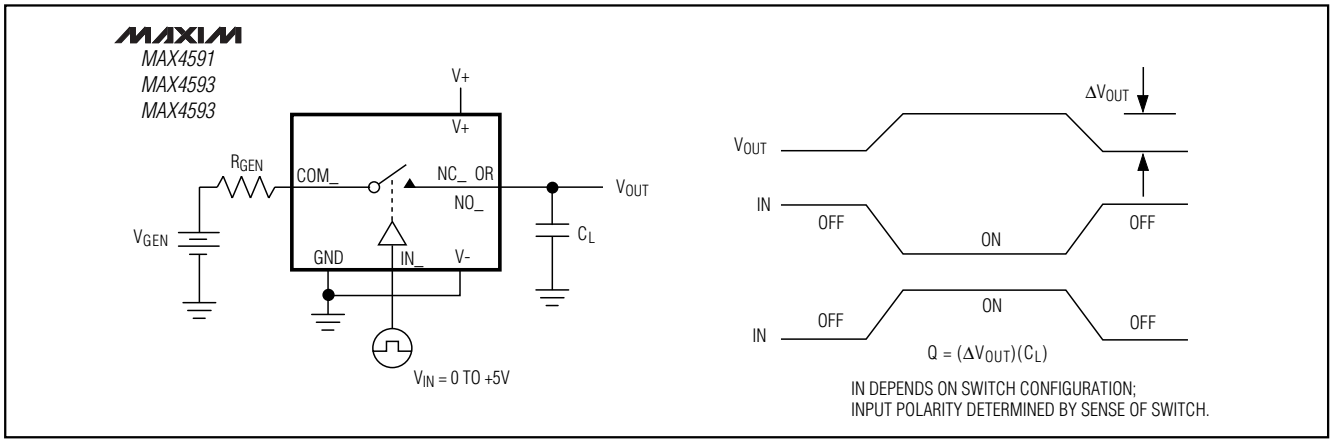


Figure 4. Charge Injection

High-Speed, Single-Supply, Quad, SPST Analog Switches

Test Circuits/Timing Diagrams (continued)

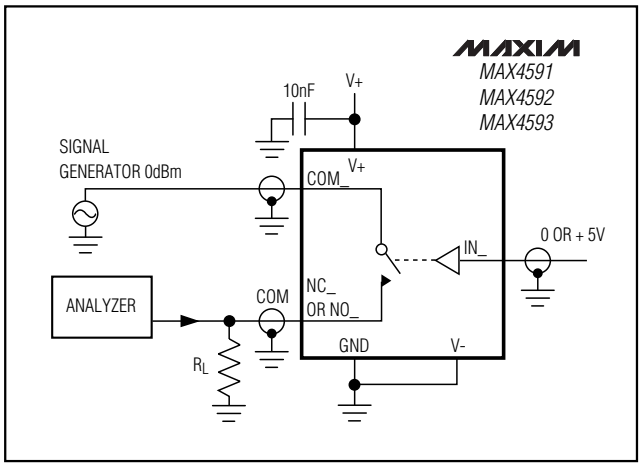


Figure 5. Off-Isolation

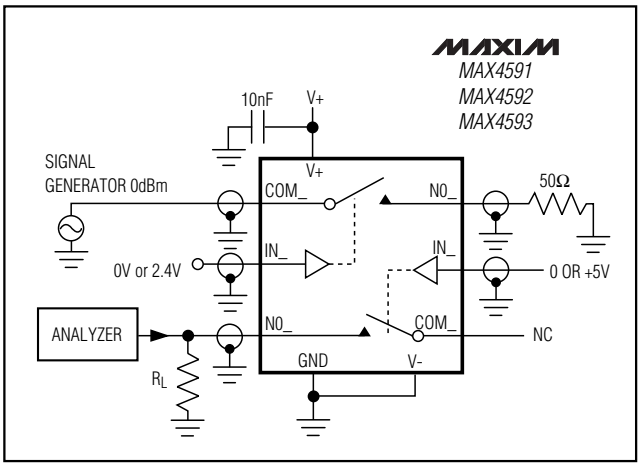


Figure 6. Crosstalk

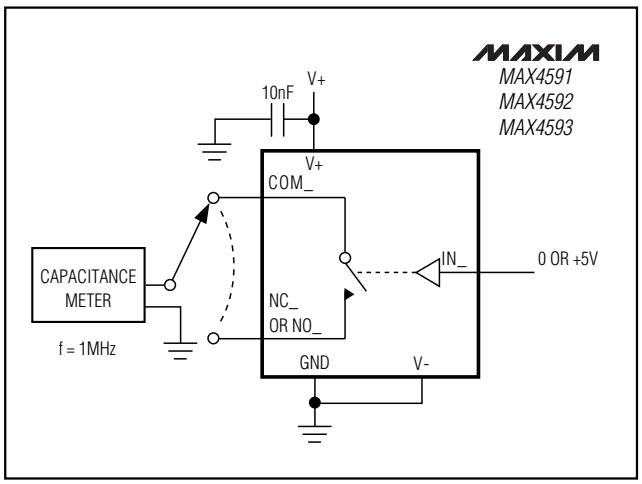


Figure 7. Channel Off-Capacitance

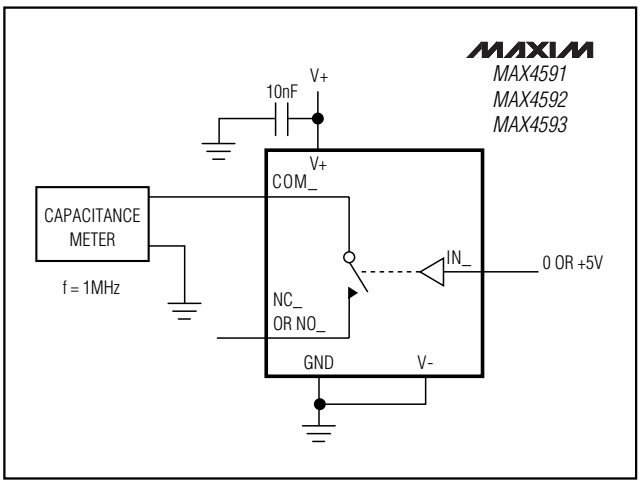


Figure 8. Channel On-Capacitance

High-Speed, Single-Supply, Quad, SPST Analog Switches

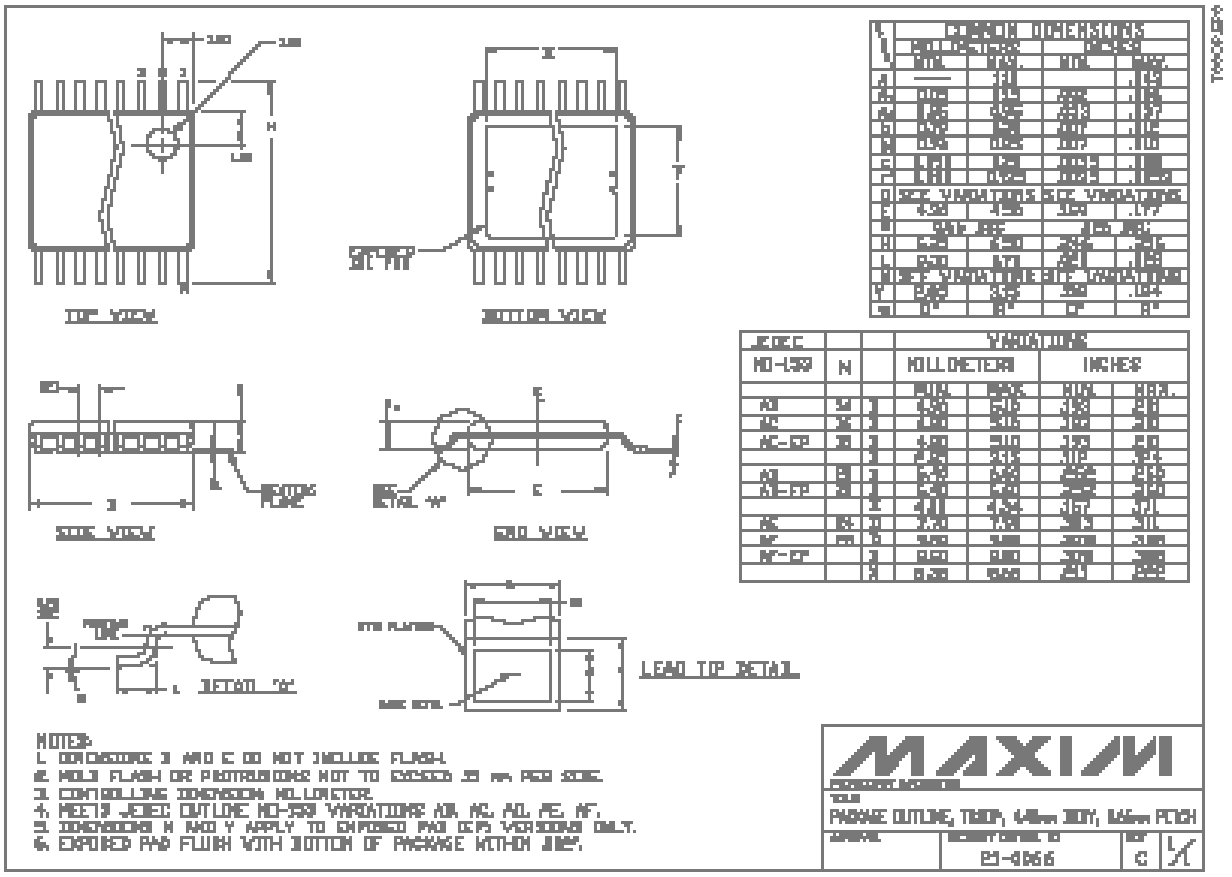
Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX4592CUE	0°C to +70°C	16 TSSOP
MAX4592CSE	0°C to +70°C	16 Narrow SO
MAX4592CPE	0°C to +70°C	16 Plastic DIP
MAX4592EUE	-40°C to +85°C	16 TSSOP
MAX4592ESE	-40°C to +85°C	16 Narrow SO
MAX4592EPE	-40°C to +85°C	16 Plastic DIP
MAX4593CUE	0°C to +70°C	16 TSSOP
MAX4593CSE	0°C to +70°C	16 Narrow SO
MAX4593CPE	0°C to +70°C	16 Plastic DIP
MAX4593EUE	-40°C to +85°C	16 TSSOP
MAX4593ESE	-40°C to +85°C	16 Narrow SO
MAX4593EPE	-40°C to +85°C	16 Plastic DIP

Chip Information

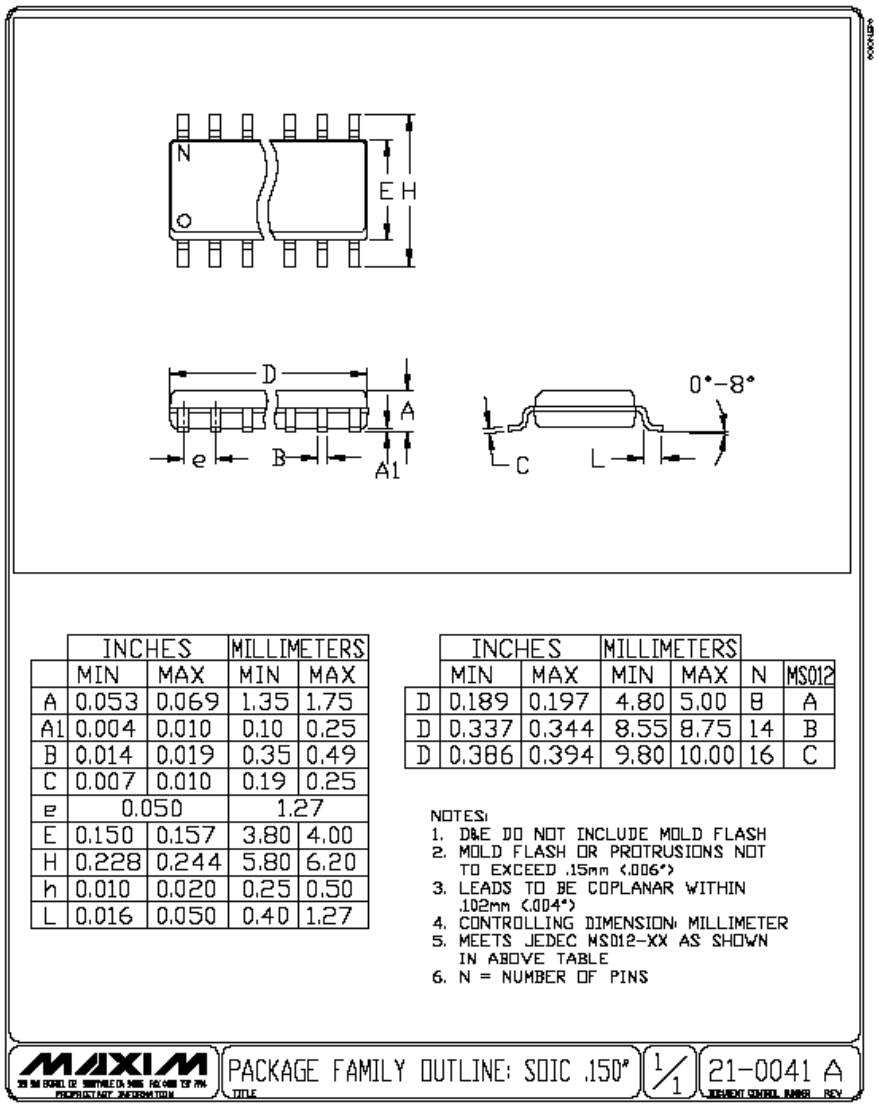
TRANSISTOR COUNT: 76

Package Information



High-Speed, Single-Supply, Quad, SPST Analog Switches

Package Information (continued)



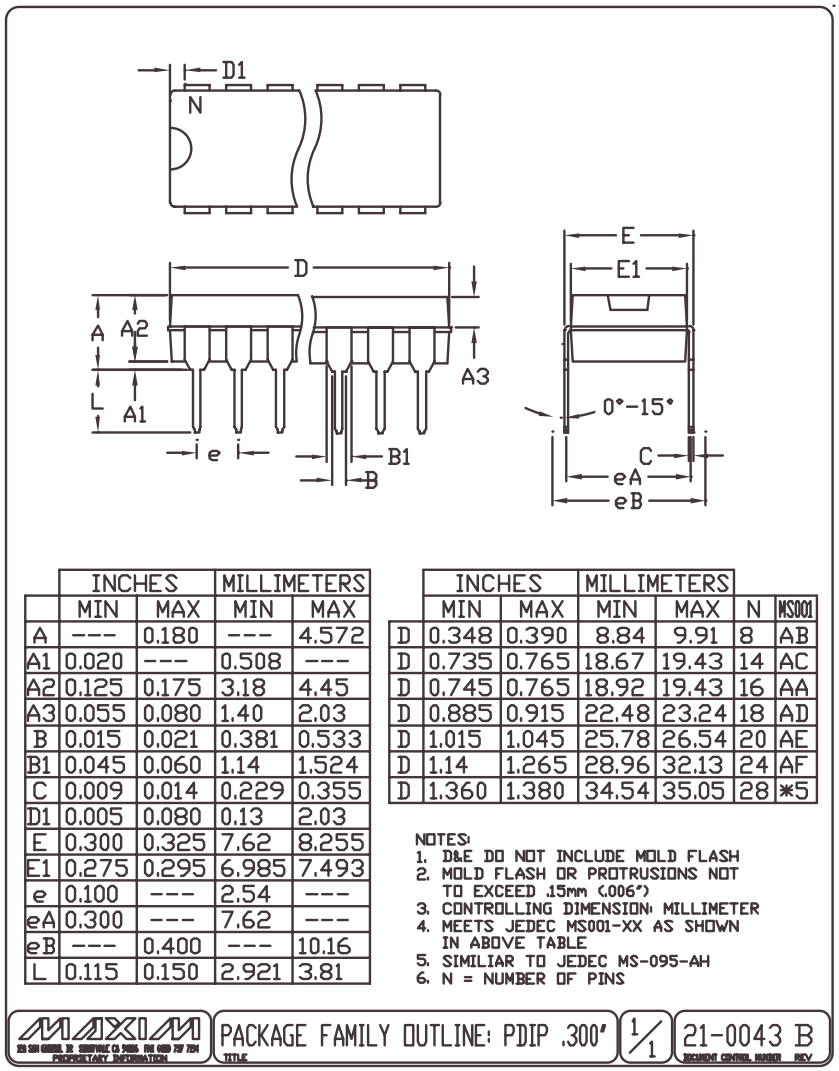
	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
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 | PACKAGE FAMILY OUTLINE: SOIC .150" | 1/1 | 21-0041 A

Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.180	---	4.572
A1	0.020	---	0.508	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.015	0.021	0.381	0.533
B1	0.045	0.060	1.14	1.524
C	0.009	0.014	0.229	0.355
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.255
E1	0.275	0.295	6.985	7.493
e	0.100	---	2.54	---
eA	0.300	---	7.62	---
eB	---	0.400	---	10.16
L	0.115	0.150	2.921	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MS-095-AH
6. N = NUMBER OF PINS

MAXIM | PACKAGE FAMILY OUTLINE: PDIP .300" | 1/1 | 21-0043 B

NOTES