19-4793; Rev 0; 1/99

MAXIM

Low-Voltage, Quad, SPST CMOS Analog Switches

General Description

The MAX4610/MAX4611/MAX4612 quad, low-voltage, single-pole/single-throw (SPST) analog switches are pin-compatible with the industry-standard 74HC4066 analog switch. On-resistance (100Ω max) is matched between switches to 4Ω max and is flat (4Ω max) over the specified signal range. Each switch handles V+ to GND analog signal levels. Maximum off-leakage current is only 1nA at T_A = +25°C and 2nA at T_A = +85°C.

The MAX4610 has four normally open (NO) switches, and the MAX4611 has four normally closed (NC) switches. The MAX4612 has two NO switches and two NC switches. These CMOS switches operate from a single +2V to +12V supply. All digital inputs have +0.8V and +2.4V logic thresholds, ensuring TTL/CMOS-logic compatibility when using a single +5V supply.

Applications

Battery-Operated Equipment

Audio/Video Signal Routing

Low-Voltage Data-Acquisition Systems

Sample-and-Hold Circuits

Communication Circuits

Features

- **Pin-Compatible with Industry-Standard 74HC4066**
- **Guaranteed On-Resistance**
  100Ω max (5V Supply)
  46Ω max (12V Supply)
- **Guaranteed Match Between Channels (4Ω max)**
- **Guaranteed Flatness Over Signal Range (18Ω max)**
- **Off-Leakage Current Over Temperature**
  <2nA at T_A = +85°C
- **>2kV ESD Protection per Method 3015.7**
- **Rail-to-Rail® Signal Handling**
- **TTL/CMOS-Logic Compatible**

Ordering Information

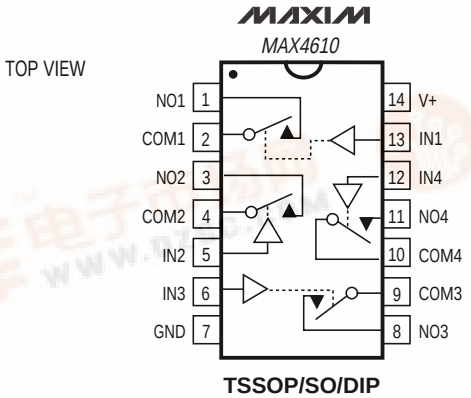
PART	TEMP. RANGE	PIN-PACKAGE
MAX4610CUD	0°C to +70°C	14 TSSOP**
MAX4610CSD	0°C to +70°C	14 Narrow SO
MAX4610CPD	0°C to +70°C	14 Plastic DIP
MAX4610C/D	0°C to +70°C	Dice*
MAX4610EUD	-40°C to +85°C	14 TSSOP**
MAX4610ESD	-40°C to +85°C	14 Narrow SO
MAX4610EPD	-40°C to +85°C	14 Plastic DIP

Ordering Information continued at end of data sheet.

** Contact factory for dice specifications.*

***Contact factory for availability.*

Pin Configurations/Truth Tables



TSSOP/SO/DIP

INPUT	SWITCH STATE
LOW	OFF
HIGH	ON

MAX4611/MAX4612 Pin Configurations/Truth Tables appear at end of data sheet.

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

Low-Voltage, Quad, SPST CMOS Analog Switches

ABSOLUTE MAXIMUM RATINGS

(Voltages referenced to GND)
V+ .....-0.3V to +13V
IN_, COM_, NO_, NC_ (Note 1).....-0.3V to (V + +0.3V)
Continuous Current (any terminal)
(pulsed at 1ms, 10% duty cycle) 20mA
Peak Current (any terminal)
(pulsed at 1ms, 10% duty cycle) 40mA
ESD per Method 3015.7.....>2kV

Continuous Power Dissipation (T_A = +70°C)
TSSOP (derate 6.3mW/°C above +70°C) 500mW
Narrow SO (derate 8.00mW/°C above +70°C) 640mW
Plastic DIP (derate 10.00mW/°C above +70°C) 800mW
Operating Temperature Ranges
MAX461_C_ _ .....0°C to +70°C
MAX461_E_ _.....-40°C to +85°C
Storage Temperature Range .....-65°C to +160°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: Signals on NO_, NC_, COM_, or IN_ exceeding V+ or GND 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 +5V Supply

(V+ = +5V ±10%, V_{IN_H} = 2.4V, V_{IN_L} = 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 (Note 3)	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$			0		V+	V
On-Resistance	R_{ON}	V+ = 4.5V, $I_{COM\_}$ = 1mA, $V_{NO\_}$ = $V_{NC\_}$ = 3V	T_A = +25°C		70	100	Ω
			T_A = T_{MIN} to T_{MAX}			150	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	V+ = 4.5V, $I_{COM\_}$ = 1mA, $V_{NO\_}$ = $V_{NC\_}$ = 3V	T_A = +25°C		1.0	4	Ω
			T_A = T_{MIN} to T_{MAX}			8	
On-Resistance Flatness (Note 5)	$R_{FLAT(ON)}$	V+ = 4.5V; $I_{COM\_}$ = 1mA; $V_{NO\_}$ = $V_{NC\_}$ = 3V, 2V, 1V	T_A = +25°C		12	18	Ω
			T_A = T_{MIN} to T_{MAX}			25	
NO or NC Off-Leakage Current (Note 6)	$I_{NO(OFF)}$	V+ = 5.5V; $V_{COM\_}$ = 1V, 4.5V; V_{NO} = 4.5V, 1V	T_A = +25°C				nA
			T_A = T_{MIN} to T_{MAX}	-2		2	
COM Off-Leakage Current (Note 6)	$I_{COM(OFF)}$	V+ = 5.5V; $V_{COM\_}$ = 1V, 4.5V; $V_{NO\_}$ = $V_{NC\_}$ = 4.5V, 1V	T_A = +25°C	-0.1		0.1	nA
			T_A = T_{MIN} to T_{MAX}	-2		2	
COM On-Leakage Current (Note 6)	$I_{COM(ON)}$	V+ = 5.5V; V_{COM} = 1V, 4.5V; $V_{NO\_}$ = $V_{NC\_}$ = 1V, 4.5V, or floating	T_A = +25°C	-0.2		0.2	nA
			T_A = T_{MIN} to T_{MAX}	-4		4	

ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +5V ±10%, V_{IN_H} = 2.4V, V_{IN_L} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
LOGIC INPUT							
Input Current with Input Voltage High	I_{IN_H}	$V_{IN\_}$ = 2.4V, all others = 0.8V		-0.1	0.001	0.1	µA
Input Current with Input Voltage Low	I_{IN_L}	$V_{IN\_}$ = 0.8V, all others = 2.4V		-0.1	0.001	0.1	µA
Input High Voltage	V_{IN_H}			2.4	1.5		V
Input Low Voltage	V_{IN_L}				1.4	0.8	V
DYNAMIC (Note 3)							
Turn-On Time	t_{ON}	$V_{COM\_}$ = 3V, Figure 2	T_A = +25°C		35	60	ns
			T_A = T_{MIN} to T_{MAX}			80	
Turn-Off Time	t_{OFF}	$V_{COM\_}$ = 3V, Figure 2	T_A = +25°C		15	20	ns
			T_A = T_{MIN} to T_{MAX}			30	
On-Channel Bandwidth	BW	Signal = 0dBm, Figure 4, 50Ω in and out	T_A = +25°C		300		MHz
Charge Injection	V_{CTE}	C_L = 1.0nF, V_{GEN} = 0, R_{GEN} = 0, Figure 3	T_A = +25°C		1	5	pC
Off-Isolation (Note 7)	V_{ISO}	R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 4	T_A = +25°C		-60		dB
Crosstalk (Note 8)	V_{CT}	R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 5	T_A = +25°C		-80		dB
NO_ or NC_ Capacitance	$C_{(OFF)}$	f = 1MHz, Figure 6	T_A = +25°C		16		pF
COM_ Off-Capacitance	$C_{COM(OFF)}$	f = 1MHz, Figure 6	T_A = +25°C		16		pF
COM_ On-Capacitance	$C_{COM(ON)}$	f = 1MHz, Figure 6	T_A = +25°C		23		pF
Total Harmonic Distortion	THD	600Ω IN and OUT, 20Hz to 20kHz, 2Vp-p	T_A = +25°C		0.009		%
SUPPLY							
Power-Supply Range				2		12	V
Supply Current	I+	V_{IN} = 0 or V+, all switches on or off		-1	0.001	1	µA

ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +3V, V_{IN_H} = 2.4V, V_{IN_L} = 0.5V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range (Note 3)	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$			0		V+	V
On-Resistance	R_{ON}	V+ = 2.7V, $I_{COM\_}$ = 1mA, $V_{NO\_}$ = $V_{NC\_}$ = 1V	T_A = +25°C		175	360	Ω
			T_A = T_{MIN} to T_{MAX}			450	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	V+ = 2.7V, $I_{COM\_}$ = 1mA, $V_{NO\_}$ = $V_{NC\_}$ = 1V	T_A = +25°C		2	5	Ω
			T_A = T_{MIN} to T_{MAX}			10	
NO_ or NC_ Off-Leakage Current (Notes 3, 6)	$I_{NO(OFF)}$	V+ = 3.6V; $V_{COM\_}$ = 0.5V, 3V; $V_{NO\_}$ = $V_{NC\_}$ = 3V, 0.5V	T_A = +25°C	-0.1		0.1	nA
			T_A = T_{MIN} to T_{MAX}	-2		2	
COM_ Off-Leakage Current (Notes 3, 6)	$I_{COM(OFF)}$	V+ = 3.6V; $V_{COM\_}$ = 0.5V, 3V; $V_{NO\_}$ = $V_{NC\_}$ = 3V, 0.5V	T_A = +25°C	-0.1		0.1	nA
			T_A = T_{MIN} to T_{MAX}	-2		2	
COM_ On-Leakage Current (Notes 3, 6)	$I_{COM(ON)}$	V+ = 3.6V; $V_{COM\_}$ = 0.5V, 3V; $V_{NO\_}$ = $V_{NC\_}$ = 0.5V, 3V, or floating	T_A = +25°C	-0.2		0.2	nA
			T_A = T_{MIN} to T_{MAX}	-4		4	
LOGIC INPUTS							
Input High Voltage	V_{IN_H}			2.4	1.0		V
Input Low Voltage	V_{IN_L}				1.0	0.5	V
DYNAMIC (Note 3)							
Turn-On Time	t_{ON}	$V_{COM\_}$ = 1.5V, Figure 2	T_A = +25°C		50	90	ns
			T_A = T_{MIN} to T_{MAX}			120	
Turn-Off Time	t_{OFF}	$V_{COM\_}$ = 1.5V, Figure 2	T_A = +25°C		30	45	ns
			T_A = T_{MIN} to T_{MAX}			60	

ELECTRICAL CHARACTERISTICS—Single +12V Supply

(V+ = +12V, V_{IN_H} = 4V, V_{IN_L} = 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 (Note 3)	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$,			0		V+	V
On-Resistance	R_{ON}	V+ = 12V, I_{COM} = 2mA, $V_{NO\_}$ = $V_{NC\_}$ = 10V	T_A = +25°C		30	45	Ω
			T_A = T_{MIN} to T_{MAX}			60	
LOGIC INPUTS							
Input High Voltage	V_{IN_H}			4.0	2.8		V
Input Low Voltage	V_{IN_L}				2.5	0.8	V
SUPPLY							
Positive Supply Current	I+	$V_{IN\_}$ = 0 or V+, all switches on or off		-1	0.001	1	µA

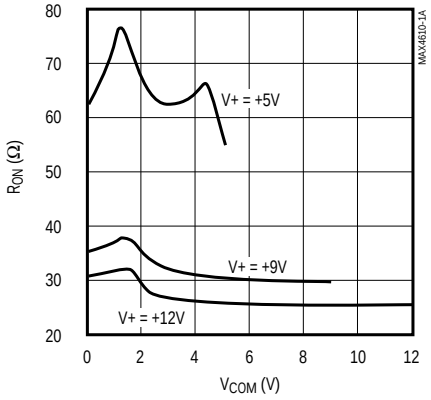
Note 2: The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.
Note 3: Guaranteed by design.
Note 4: $\Delta R_{ON} = R_{ON}$ (max) - R_{ON} (min).
Note 5: Flatness is defined as the difference between the maximum and minimum 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 = $20\log_{10}$ ($V_{COM\_}$ / $V_{NO\_}$), $V_{COM\_}$ = output, $V_{NO\_}$ = input to off switch.
Note 8: Between any two switches.

Low-Voltage, Quad, SPST CMOS Analog Switches

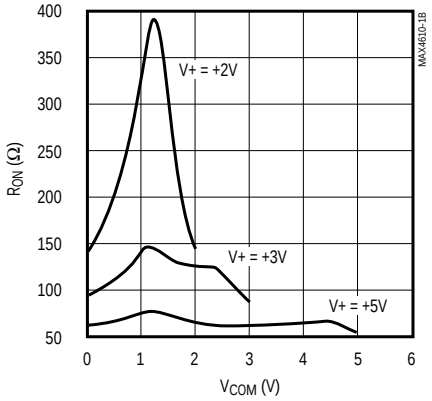
Typical Operating Characteristics

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

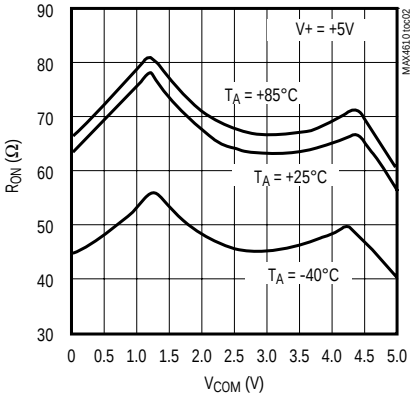
ON-RESISTANCE vs. V_{COM}



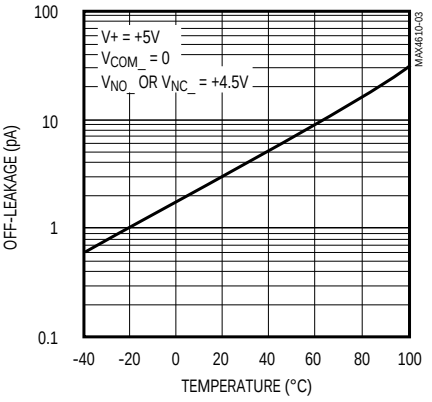
ON-RESISTANCE vs. V_{COM}



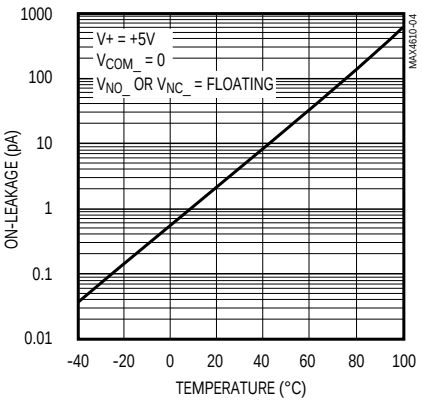
ON-RESISTANCE vs. V_{COM} AND TEMPERATURE



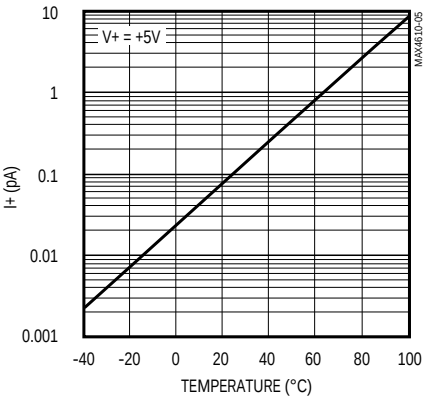
OFF-LEAKAGE vs. TEMPERATURE



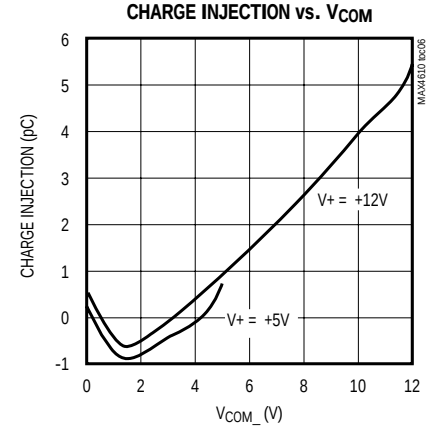
ON-LEAKAGE vs. TEMPERATURE



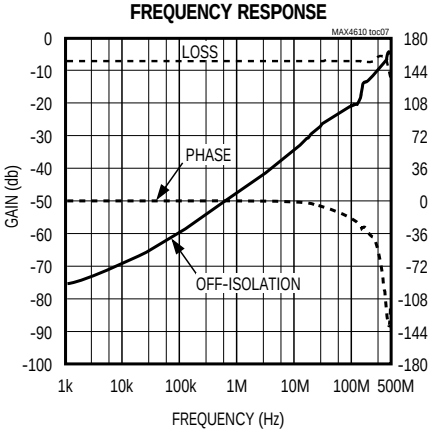
SUPPLY CURRENT vs. TEMPERATURE



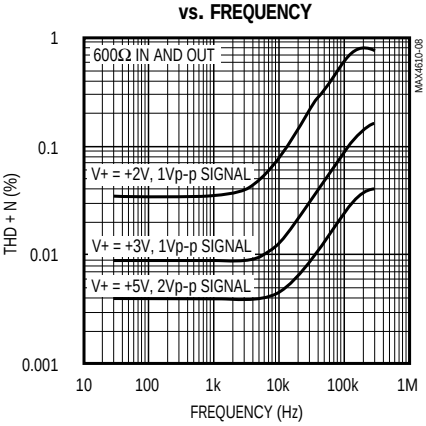
CHARGE INJECTION vs. V_{COM}



FREQUENCY RESPONSE



TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



Pin Description

PIN			NAME	FUNCTION
MAX4610	MAX4611	MAX4612		
1, 3, 8, 11	—	—	NO1, NO2, NO3, NO4	Analog Switch Normally Open Terminals
—	1, 3, 8, 11	—	NC1, NC2, NC3, NC4	Analog Switch Normally Closed Terminals
2, 4, 9, 10	2, 4, 9, 10	2, 4, 9, 10	COM1, COM2, COM3, COM4	Analog Switch Common Terminals
13, 5, 6, 12	13, 5, 6, 12	13, 5, 6, 12	IN1, IN2, IN3, IN4	Logic-Control Digital Inputs
—	—	1, 3	NO1, NO2	Analog Switch Normally Open Terminals
—	—	8, 11	NC3, NC4	Analog Switch Normally Closed Terminals
7	7	7	GND	Ground
14	14	14	V+	Positive Analog Supply Input
—	—	—	N.C.	No Connection. Not internally connected.

Applications Information

Power-Supply Sequencing and Overvoltage Protection

Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings may cause permanent damage to the devices.

Proper power-supply sequencing is recommended for all CMOS devices. Always apply V+ before applying analog signals or logic inputs, especially if the analog or logic signals are not current limited. If this sequencing is not possible, and if the analog or logic inputs are not current limited to 20mA, add a small-signal diode (D1) as shown in Figure 1. If the analog signal can dip below GND, add D2. Adding protection diodes reduces the analog signal range to a diode drop (about 0.7V) below V+ (for D1), and to a diode drop above ground (for D2). Leakage is unaffected by adding the diodes. On-resistance increases by a small amount at low supply voltages. Maximum supply voltage (V+) must not exceed 13V.

Adding protection diodes causes the logic thresholds to be shifted relative to the power-supply rails. This can be significant when low supply voltages (+5V or less) are used. With a +5V supply, TTL compatibility is not guaranteed when protection diodes are added. Driving IN1 and IN2 all the way to the supply rails (i.e., to a diode drop higher than the V+ pin, or to a diode drop lower than the GND pin) is always acceptable.

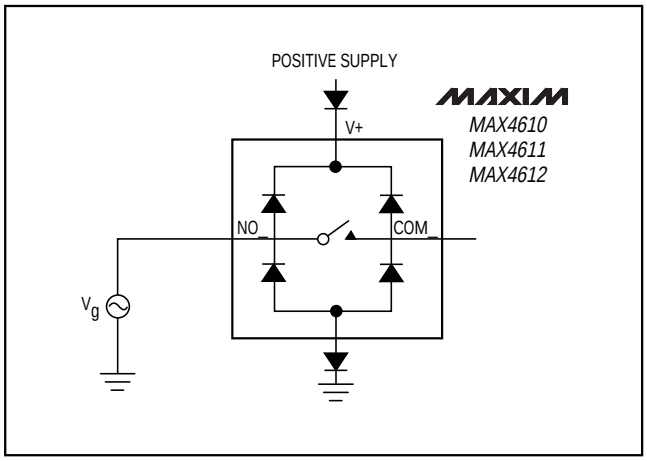


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

Protection diodes D1 and D2 also protect against some overvoltage situations. With Figure 1's circuit, if the supply voltage is below the absolute maximum rating, and if a fault voltage up to the absolute maximum rating is applied to an analog signal pin, no damage will result.

Low-Voltage, Quad, SPST CMOS Analog Switches

Operating Considerations for High-Voltage Supply

The MAX4610/MAX4611/MAX4612 are pin-compatible with the industry-standard 74HC4066 and the MAX4066, and are optimized for +5V single-supply operation. The MAX4610 family is capable of +12V single-supply operation with some precautions. The absolute maximum rating for V+ is +13.2V (referenced to GND). When operating near this region, bypass V+ with a minimum 0.1µF capacitor to ground as close to the IC as possible.

Caution: The absolute maximum V+ to V- differential voltage is 13.0V. Typical ±6V or 12V supplies with ±10% tolerances can be as high as 13.2V. This voltage can damage the MAX4610/MAX4611/MAX4612. Even ±5% tolerance supplies may have overshoot or noise spikes that exceed 13.0V.

Test Circuits/Timing Diagrams

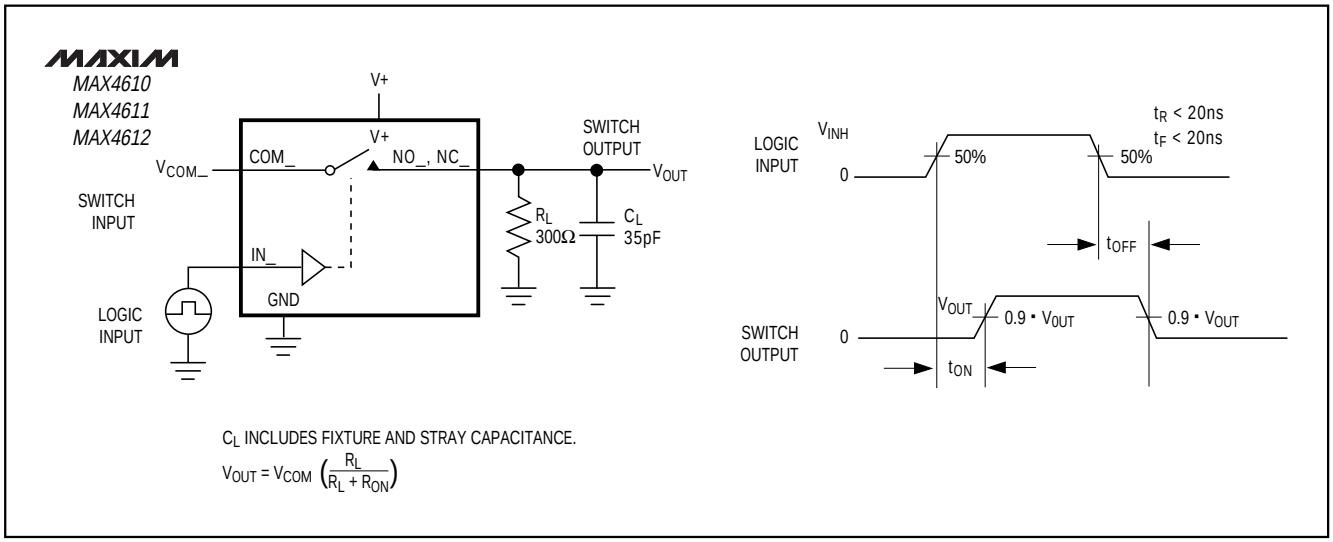


Figure 2. Switching Time

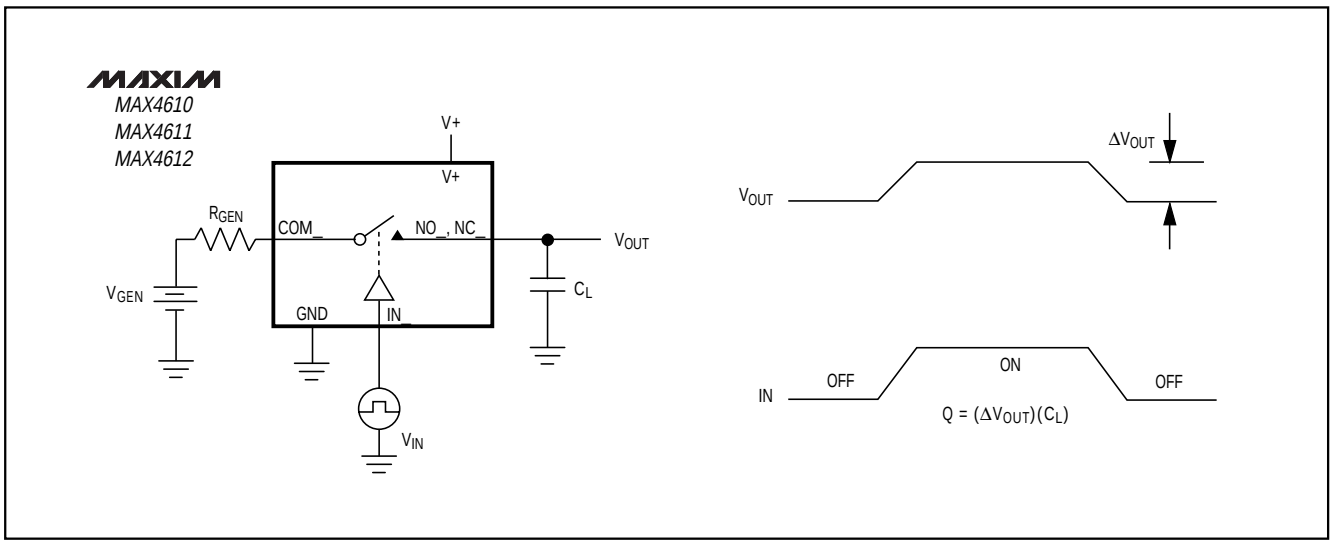


Figure 3. Charge Injection

Test Circuits/Timing Diagrams (continued)

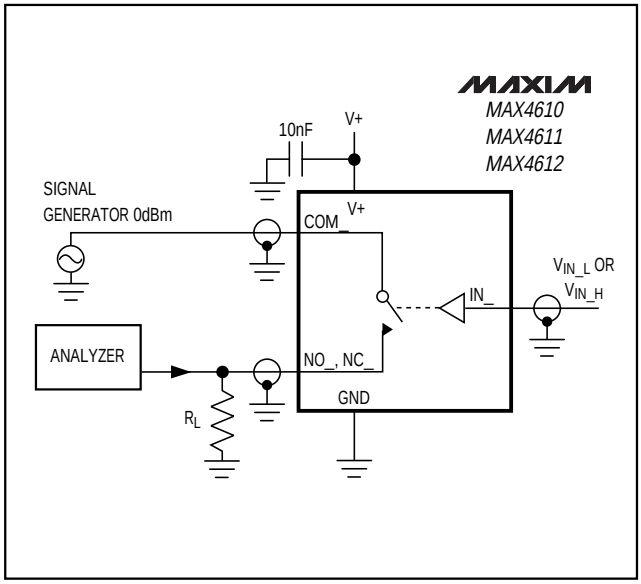


Figure 4. Off-Isolation/On-Channel Bandwidth

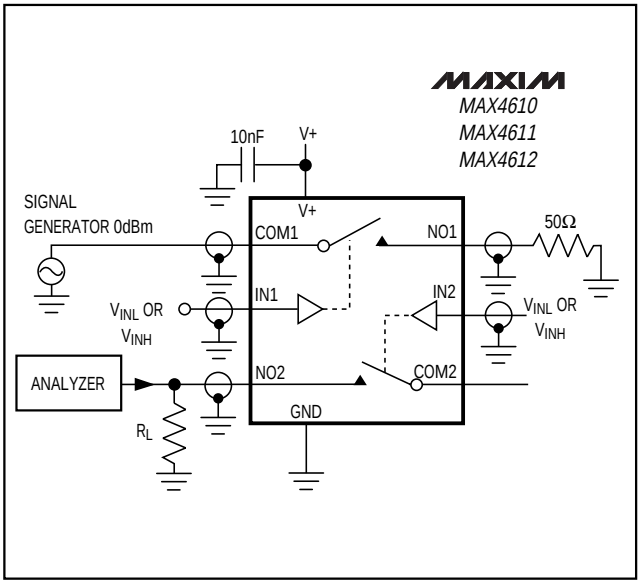


Figure 5. Crosstalk

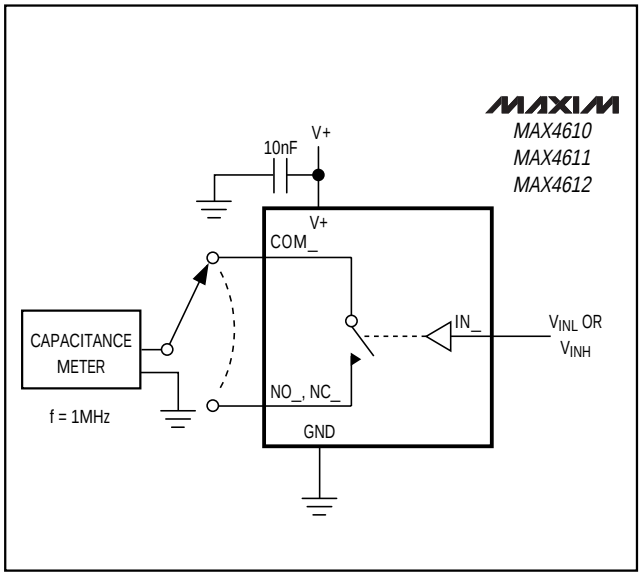


Figure 6. Channel Off/On-Capacitance

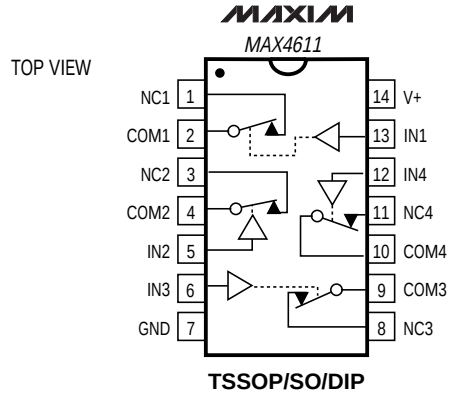
Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX4611CUD	0°C to +70°C	14 TSSOP**
MAX4611CSD	0°C to +70°C	14 Narrow SO
MAX4611CPD	0°C to +70°C	14 Plastic DIP
MAX4611C/D	0°C to +70°C	Dice*
MAX4611EUD	-40°C to +85°C	14 TSSOP**
MAX4611ESD	-40°C to +85°C	14 Narrow SO
MAX4611EPD	-40°C to +85°C	14 Plastic DIP
MAX4612CUD	0°C to +70°C	14 TSSOP**
MAX4612CSD	0°C to +70°C	14 Narrow SO
MAX4612CPD	0°C to +70°C	14 Plastic DIP
MAX4612C/D	0°C to +70°C	Dice*
MAX4612EUD	-40°C to +85°C	14 TSSOP**
MAX4612ESD	-40°C to +85°C	14 Narrow SO
MAX4612EPD	-40°C to +85°C	14 Plastic DIP

** Contact factory for dice specifications.*
*** Contact factory for availability.*

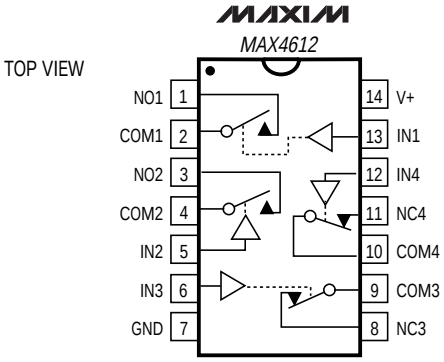
Low-Voltage, Quad, SPST CMOS Analog Switches

Pin Configurations/Truth Tables (continued)



TSSOP/SO/DIP

INPUT	SWITCH STATE
LOW	ON
HIGH	OFF

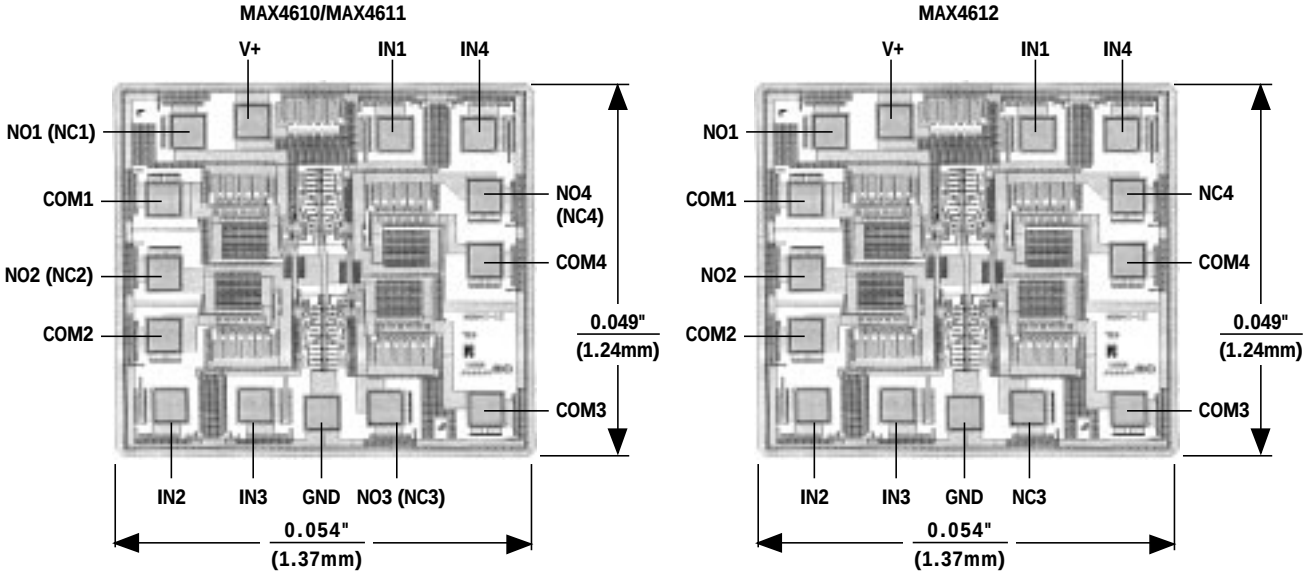


TSSOP/SO/DIP

INPUT	NO1, NO2	NC3, NC4
LOW	OFF	ON
HIGH	ON	OFF

Low-Voltage, Quad, SPST CMOS Analog Switches

Chip Topographies

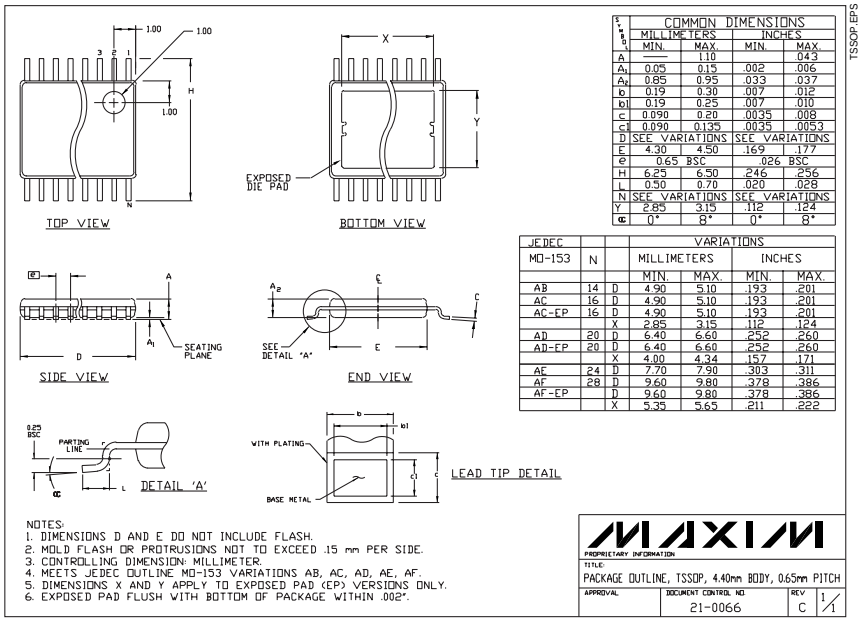


( ) ARE FOR MAX4611

TRANSISTOR COUNT: 132

SUBSTRATE CONNECTED TO V+

Package Information



SYMBOL	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	---	1.10	---	.043
A_1	0.05	0.15	.002	.006
A_2	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b1	0.19	0.25	.007	.010
c	0.090	0.20	.0035	.008
c1	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
α	0°	8°	0°	8°

JEDEC			VARIATIONS			
MO-153	N		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		D	9.60	9.80	.378	.386
		X	5.35	5.65	.211	.222

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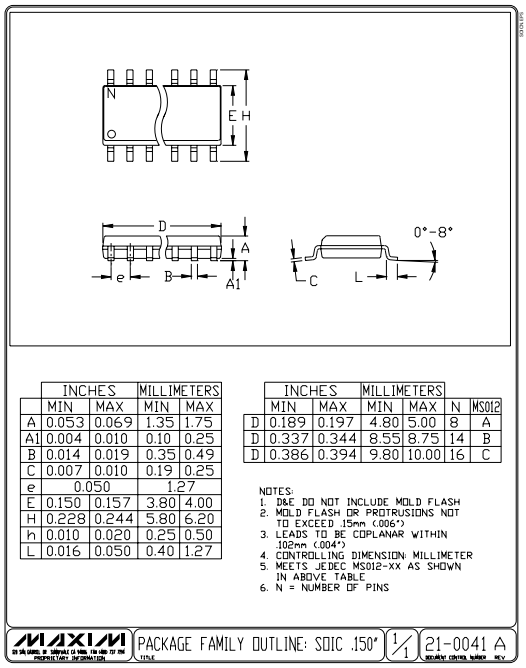
Package Information (continued)

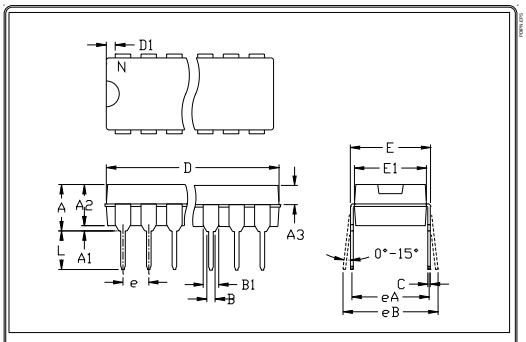


	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	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



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.200	---	5.08
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.012	0.20	0.30
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100	---	2.54	---
eA	0.300	---	7.62	---
eB	---	0.400	---	10.16
L	0.115	0.150	2.92	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 MO-058AB
6. N = NUMBER OF PINS

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