

## Quad, SPST Analog Switch

MAX4613

### General Description

The MAX4613 quad analog switch features on-resistance matching ( $4\Omega$  max) between switches and guarantees on-resistance flatness over the signal range ( $9\Omega$  max). This low on-resistance switch conducts equally well in either direction. It guarantees low charge injection (10pC max), low power consumption (35 $\mu$ W max), and an electrostatic discharge (ESD) tolerance of 2000V minimum per Method 3015.7. The new design offers lower off leakage current over temperature (less than 5nA at +85°C).

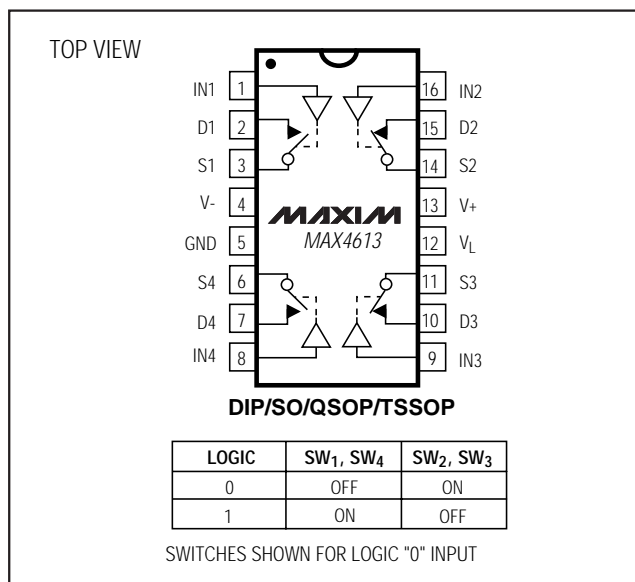
The MAX4613 quad, single-pole/single-throw (SPST) analog switch has two normally closed switches and the two normally open switches. Switching times are less than 250ns for  $t_{ON}$  and less than 70ns for  $t_{OFF}$ . Operation is from a single +4.5V to +40V supply or bipolar  $\pm 4.5V$  to  $\pm 20V$  supplies.

### Applications

Sample-and-Hold Circuits	Communication Systems
Test Equipment	Battery-Operated Systems
Heads-Up Displays	PBX, PABX
Guidance and Control Systems	Audio Signal Routing
Military Radios	Modems/Faxes

### Pin Configuration/

### Functional Diagram/Truth Table



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

### Features

- ◆ Pin Compatible with Industry-Standard DG213
- ◆ Guaranteed  $R_{ON}$  Match Between Channels ( $4\Omega$  max)
- ◆ Guaranteed  $R_{FLAT(ON)}$  Over Signal Range ( $9\Omega$  max)
- ◆ Guaranteed Charge Injection (10pC max)
- ◆ Low Off Leakage Current Over Temperature (<5nA at +85°C)
- ◆ Withstands 2000V min ESD, per Method 3015.7
- ◆ Low  $R_{DS(ON)}$  ( $85\Omega$  max)
- ◆ Single-Supply Operation +4.5V to +40V  
Bipolar-Supply Operation  $\pm 4.5V$  to  $\pm 20V$
- ◆ Low Power Consumption (35 $\mu$ W max)
- ◆ Rail-to-Rail<sup>®</sup> Signal Handling
- ◆ TTL/CMOS-Logic Compatible

### Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4613CPE	0°C to +70°C	16 Plastic DIP
MAX4613CSE	0°C to +70°C	16 Narrow SO
MAX4613CEE	0°C to +70°C	16 QSOP
MAX4613CUE	0°C to +70°C	16 TSSOP**
MAX4613C/D	0°C to +70°C	Dice*
MAX4613EPE	-40°C to +85°C	16 Plastic DIP
MAX4613ESE	-40°C to +85°C	16 Narrow SO
MAX4613EEE	-40°C to +85°C	16 QSOP
MAX4613EUE	-40°C to +85°C	16 TSSOP**

\*Contact factory for dice specifications.

\*\*Contact factory for availability.

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## ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to GND

V+	+44V
V-	-44V
V+ to V-	+44V
V <sub>L</sub>	(GND - 0.3V) to (V+ + 0.3V)
Digital Inputs V <sub>S</sub> , V <sub>D</sub> (Note 1)	(V- - 2V) to (V+ + 2V) or 30mA (whichever occurs first)

Continuous Current (any terminal) .....30mA

Peak Current, S<sub>-</sub> or D<sub>-</sub>  
(pulsed at 1ms, 10% duty cycle max) .....100mA

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

Plastic DIP (derate 10.53mW/°C above +70°C)	842mW
Narrow SO (derate 8.70mW/°C above +70°C)	696mW
QSOP (derate 8.3mW/°C above +70°C)	667mW
TSSOP (derate 5.7mW/°C above +70°C)	457mW

Operating Temperature Ranges

MAX4613C\_ \_ .....0°C to +70°C

MAX4613E\_ \_ .....-40°C to +85°C

Storage Temperature Range .....-65°C to +165°C

Lead Temperature (soldering, 10sec) .....+300°C

**Note 1:** Signals on S<sub>-</sub>, D<sub>-</sub>, or IN<sub>-</sub> exceeding V+ or V- are clamped by internal diodes. Limit forward 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+ = 15V, V- = -15V, V<sub>L</sub> = 5V, GND = 0V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Note 2)	MAX	UNITS	
<b>SWITCH</b>							
Analog Signal Range	V <sub>ANALOG</sub>	(Note 3)	-15		15	V	
Drain-Source On-Resistance	R <sub>DS(ON)</sub>	V <sub>D</sub> = ±10V, I <sub>S</sub> = 1mA	T <sub>A</sub> = +25°C	55	70	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		85		
On-Resistance Match Between Channels (Note 4)	ΔR <sub>DS(ON)</sub>	V <sub>D</sub> = ±10V, I <sub>S</sub> = 1mA	T <sub>A</sub> = +25°C		4	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		5		
On-Resistance Flatness (Note 4)	R <sub>FLAT(ON)</sub>	V <sub>D</sub> = ±5V, I <sub>S</sub> = 1mA	T <sub>A</sub> = +25°C		9	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		15		
Source Leakage Current (Note 5)	I <sub>S(OFF)</sub>	V <sub>D</sub> = ±14V, V <sub>S</sub> = ∓14V	T <sub>A</sub> = +25°C	-0.50	0.01	0.50	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Drain-Off Leakage Current (Note 5)	I <sub>D(OFF)</sub>	V <sub>D</sub> = ±14V, V <sub>S</sub> = ∓14V	T <sub>A</sub> = +25°C	-0.50	0.01	0.50	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Drain-On Leakage Current (Note 5)	I <sub>D(ON)</sub> or I <sub>S(ON)</sub>	V <sub>D</sub> = ±14V, V <sub>S</sub> = ±14V	T <sub>A</sub> = +25°C	-0.50	0.08	0.50	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-10		10	
<b>INPUT</b>							
Input Current with Input Voltage High	I <sub>INH</sub>	V <sub>IN</sub> = 2.4V, all others = 0.8V	-0.5	-0.00001	0.5	μA	
Input Current with Input Voltage Low	I <sub>INL</sub>	V <sub>IN</sub> = 0.8V, all others = 2.4V	-0.5	-0.00001	0.5	μA	
<b>SUPPLY</b>							
Power-Supply Range	V+, V-		±4.5		±20.0	V	
Positive Supply Current	I+	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	0.001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Negative Supply Current	I-	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	0.001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	

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## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V<sub>+</sub> = 15V, V<sub>-</sub> = -15V, V<sub>L</sub> = 5V, GND = 0V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
Logic Supply Current	I <sub>L</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	0.001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Ground Current	I <sub>GND</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
<b>DYNAMIC</b>							
Turn-On Time (Note 3)	t <sub>ON</sub>	V <sub>S</sub> = ±10V, Figure 2	T <sub>A</sub> = +25°C		150	250	ns
Turn-Off Time (Note 3)	t <sub>OFF</sub>	V <sub>S</sub> = ±10V, Figure 2	T <sub>A</sub> = +25°C		90	120	ns
Break-Before-Make Time Delay (Note 3)	t <sub>D</sub>	Figure 3	T <sub>A</sub> = +25°C	5	20		ns
Charge Injection (Note 3)	Q	C <sub>L</sub> = 1nF, V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, Figure 4	T <sub>A</sub> = +25°C		5	10	pC
Off-Isolation Rejection Ratio (Note 6)	OIRR	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 5	T <sub>A</sub> = +25°C		60		dB
Crosstalk (Note 7)		R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 6	T <sub>A</sub> = +25°C		100		dB
Source-Off Capacitance	C <sub>S(OFF)</sub>	f = 1MHz, Figure 7	T <sub>A</sub> = +25°C		4		pF
Drain-Off Capacitance	C <sub>D(OFF)</sub>	f = 1MHz, Figure 7	T <sub>A</sub> = +25°C		4		pF
Source-On Capacitance	C <sub>S(ON)</sub>	f = 1MHz, Figure 8	T <sub>A</sub> = +25°C		16		pF
Drain-On Capacitance	C <sub>D(ON)</sub>	f = 1MHz, Figure 8	T <sub>A</sub> = +25°C		16		pF

## ELECTRICAL CHARACTERISTICS—Single Supply

(V<sub>+</sub> = 12V, V<sub>-</sub> = 0V, V<sub>L</sub> = 5V, GND = 0V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
<b>SWITCH</b>							
Analog Signal Range	V <sub>ANALOG</sub>			0		12	V
Drain-Source On-Resistance	R <sub>DS(ON)</sub>	V <sub>L</sub> = 5V; V <sub>D</sub> = 3V, 8V; I <sub>S</sub> = 1mA	T <sub>A</sub> = +25°C		100	160	Ω
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			200	
<b>SUPPLY</b>							
Power-Supply Range	V <sub>+</sub> , V <sub>-</sub>			4.5		40	V
Power-Supply Current	I <sub>+</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	0.001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Negative Supply Current	I <sub>-</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Logic Supply Current	I <sub>L</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	0.001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Ground Current	I <sub>GND</sub>	All channels on or off, V <sub>IN</sub> = 0 or 5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	

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## ELECTRICAL CHARACTERISTICS—Single Supply (continued)

( $V_+ = 12V$ ,  $V_- = 0$ ,  $V_L = 5V$ ,  $GND = 0V$ ,  $V_{INH} = 2.4V$ ,  $V_{INL} = 0.8V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Note 2)	MAX	UNITS
<b>DYNAMIC</b>						
Turn-On Time (Note 3)	$t_{ON}$	$V_S = 8V$ , Figure 2		300	400	ns
Turn-Off Time (Note 3)	$t_{OFF}$	$V_S = 8V$ , Figure 2		60	200	ns
Charge Injection (Note 3)	Q	$C_L = 1nF$ , $V_{GEN} = 0$ , $R_{GEN} = 0$ , Figure 4		5	10	pC

**Note 2:** Typical values are for **design aid only**, are not guaranteed and are not subject to production testing. 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:** On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation. Flatness is defined as the difference between the maximum and the minimum value of on-resistance as measured at the extremes of the specified analog signal range.

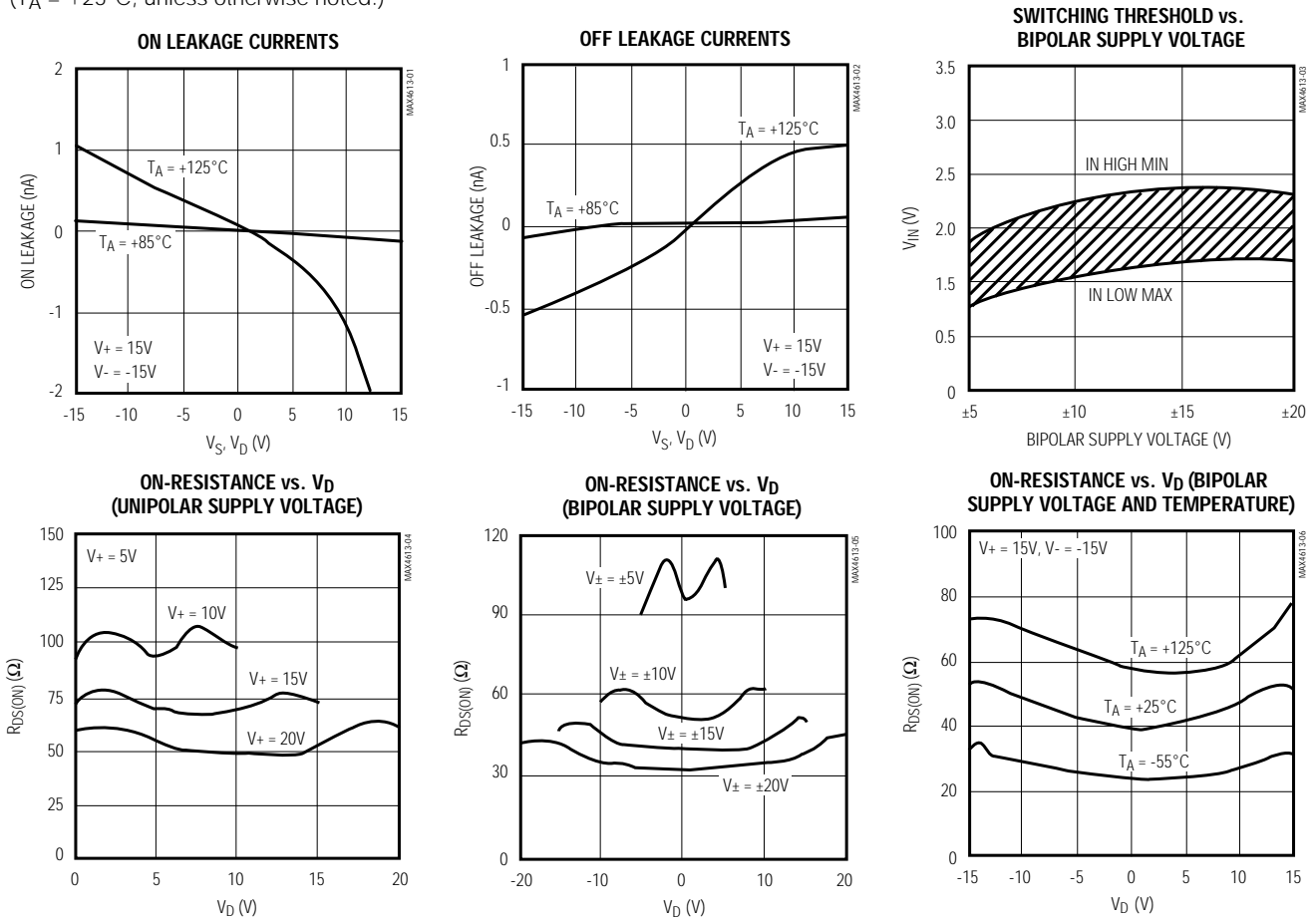
**Note 5:** Leakage parameters  $I_{S(OFF)}$ ,  $I_{D(OFF)}$ ,  $I_{D(ON)}$ , and  $I_{S(ON)}$  are 100% tested at the maximum rated hot temperature and guaranteed at  $+25^\circ C$ .

**Note 6:** Off-Isolation Rejection Ratio =  $20\log(V_D/V_S)$ .

**Note 7:** Between any two switches.

## Typical Operating Characteristics

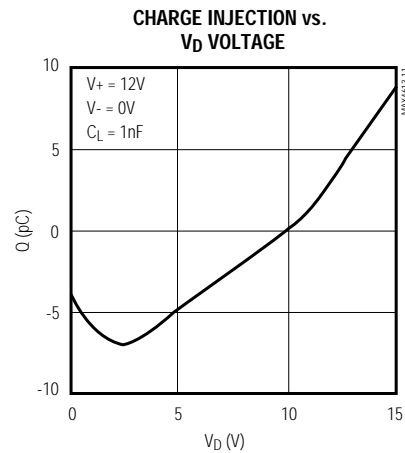
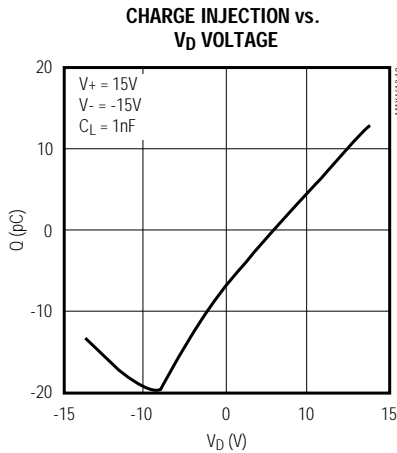
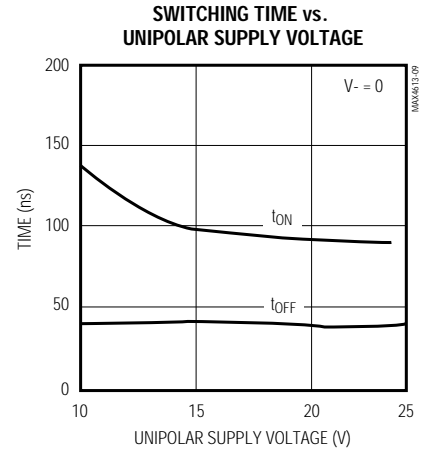
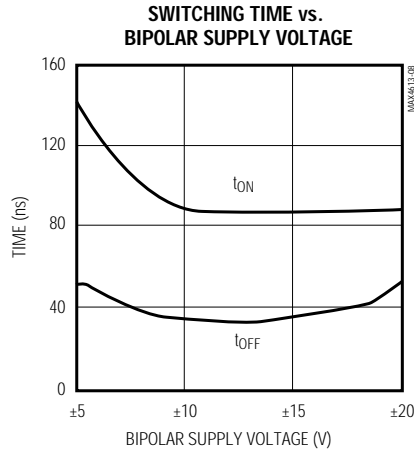
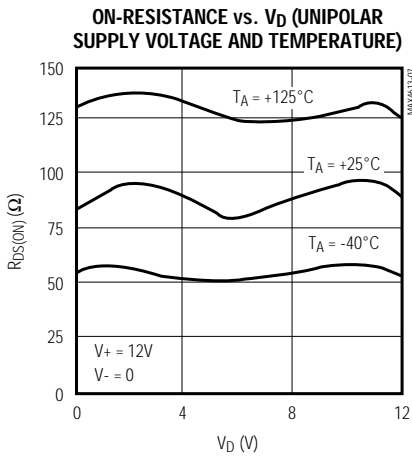
( $T_A = +25^\circ C$ , unless otherwise noted.)



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## Typical Operating Characteristics (continued)

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



### Pin Description

PIN	NAME	FUNCTION
1, 16, 9, 8	IN1–IN4	Logic Control Inputs
2, 15, 10, 7	D1–D4	Drain Outputs
3, 14, 11, 6	S1–S4	Source Outputs
4	V-	Negative Supply-Voltage Input
5	GND	Ground
12	V <sub>L</sub>	Logic Supply-Voltage Input
13	V+	Positive Supply-Voltage Input—connected to substrate

### Applications Information

#### General Operation

- 1) Switches are open when power is off.
- 2) IN<sub>-</sub>, D<sub>-</sub>, and S<sub>-</sub> should not exceed V<sub>+</sub> or V<sub>-</sub>, even with the power off.
- 3) Switch leakage is from each analog switch terminal to V<sub>+</sub> or V<sub>-</sub>, not to other switch terminals.

#### Operation with Supply Voltages

##### Other than ±15V

Using supply voltages less than ±15V will reduce the analog signal range. The MAX4613 operates with ±4.5V to ±20V bipolar supplies or with a +4.5V to +40V single

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supply; connect V- to GND when operating with a single supply. Also, all device types can operate with unbalanced supplies such as +24V and -5V. V<sub>L</sub> must be connected to +5V to be TTL compatible, or to V+ for CMOS-logic level inputs. The *Typical Operating Characteristics* graphs show typical on-resistance with ±20V, ±15V, ±10V, and ±5V supplies. (Switching times increase by a factor of two or more for operation at ±5V.)

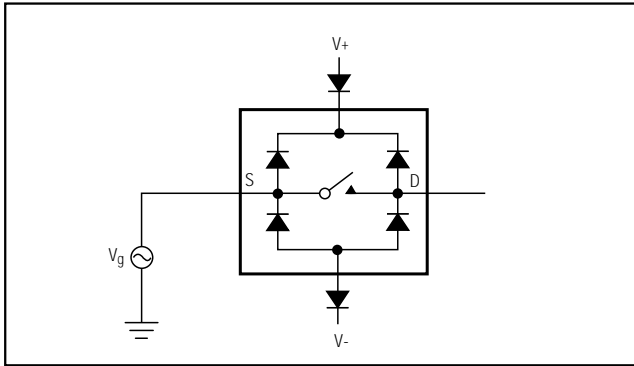


Figure 1. Overvoltage Protection Using External Blocking Diodes

## 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<sub>L</sub>, V-, and logic inputs. If power-supply sequencing is not possible, add two small, external 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 above 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 +44V.

## Timing Diagrams/Test Circuits

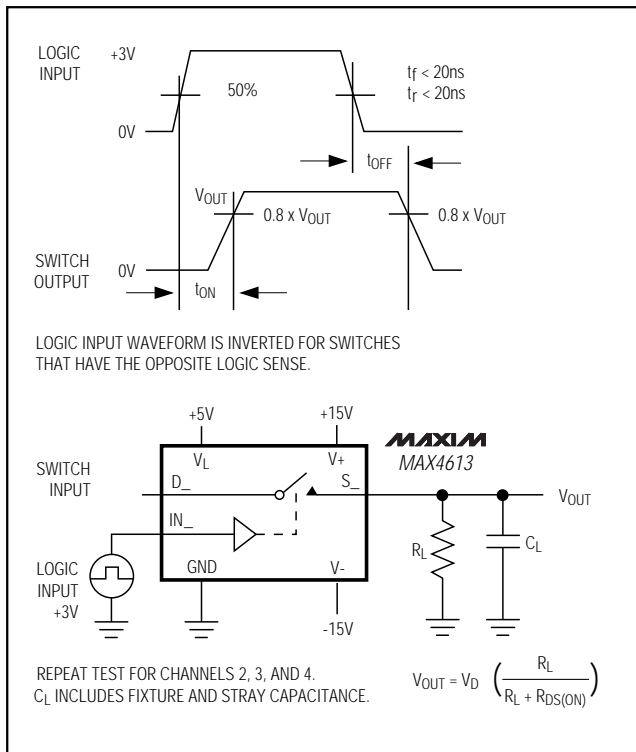


Figure 2. Switching Time

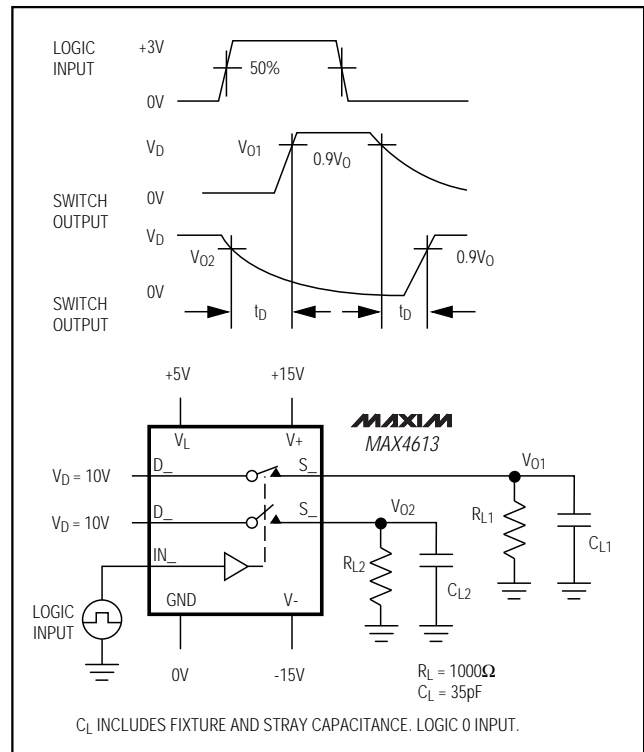


Figure 3. Break-Before-Make Test Circuit

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## Timing Diagrams/Test Circuits (continued)

MAX4613

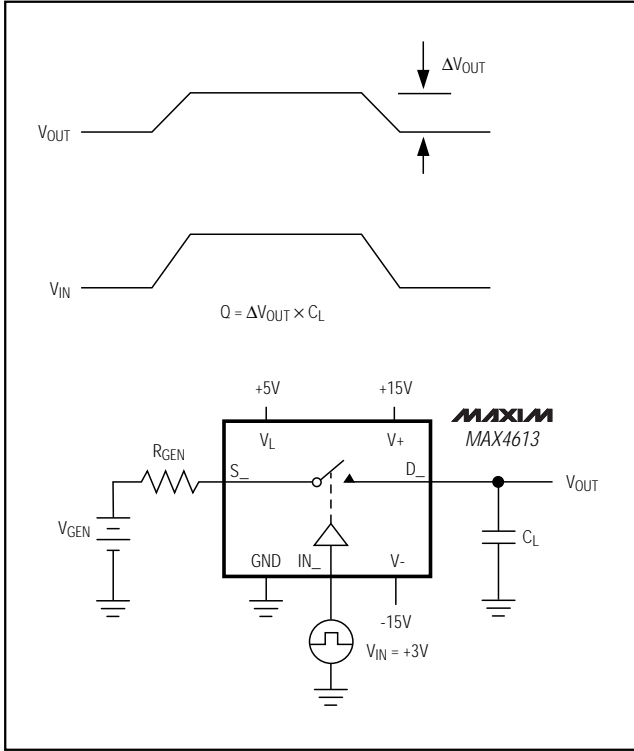


Figure 4. Charge Injection

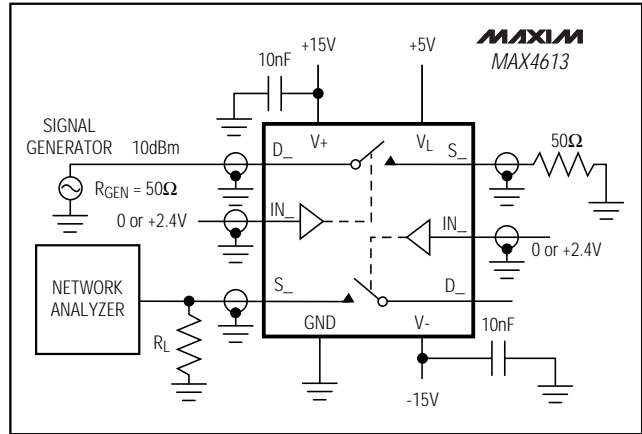


Figure 6. Crosstalk

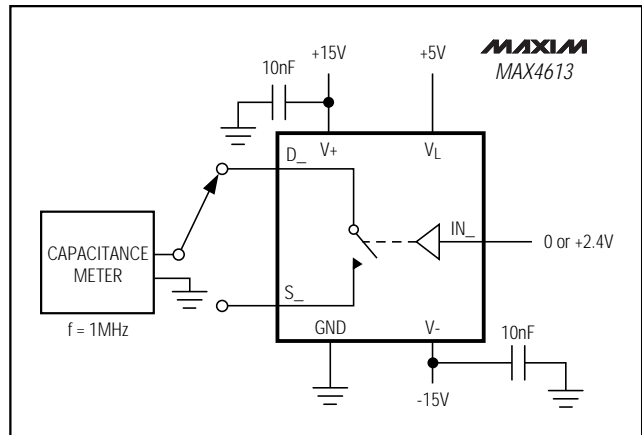


Figure 7. Source/Drain-Off Capacitance

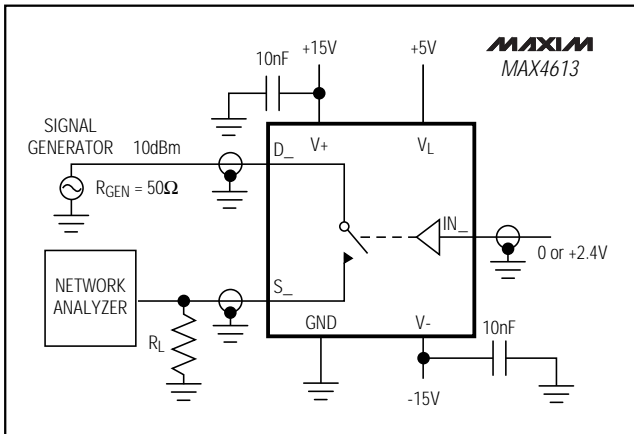


Figure 5. Off-Isolation Rejection Ratio

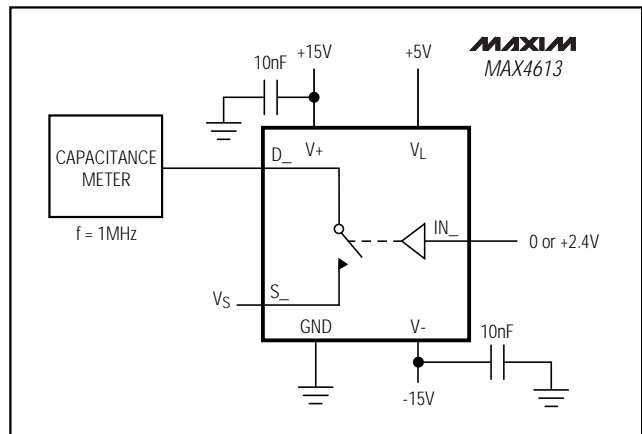
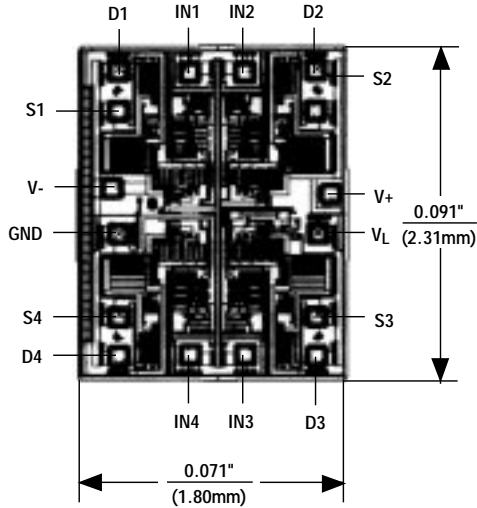


Figure 8. Source/Drain-On Capacitance

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## Chip Topography



TRANSISTOR COUNT: 126  
SUBSTRATE CONNECTED TO V+

## Package Information

COMMON DIMENSIONS				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.10		0.43	
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 <sub>1</sub>	0.65	BSC	.026	BSC
H	6.25	6.50	.246	.256
L	0.50	0.70	.020	.028
N	SEE VARIATIONS SEE VARIATIONS			
Ø	0*	Ø*	0*	Ø*

JEDEC	N	VARIATIONS			
		MILLIMETERS		INCHES	
		MIN	MAX	MIN	MAX
MD-153	N				
AC	16	4.90	5.10	.193	.201
AD	20	6.40	6.60	.252	.260
AD-EP	20	6.40	6.60	.252	.260
	X	4.00	4.34	.157	.171
	Y	2.94	3.15	.116	.124
AE	24	7.70	7.90	.303	.311
AF	28	9.60	9.80	.378	.386

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.
- DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.
- EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

TSSOPLEPS

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