



# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

MAX4711/MAX4712/MAX4713

## General Description

The MAX4711/MAX4712/MAX4713 are fault-protected, Rail-to-Rail®, low-voltage analog switches featuring low on-resistance and guaranteed on-resistance flatness over the specified signal range. Due to the fault protection feature the analog switch input (NO\_ or NC\_) and output (COM\_) pins are not symmetrical. The fault protection feature allows for the analog input to go beyond the plus or minus supplies without the device drawing excessive amounts of current from the analog inputs. When the analog inputs are driven beyond the supply rails when the switch is on, it will sense a fault and turn itself off and the analog switch output will be clamped to the same polarity supply as the input signal and will not go beyond the supply rails. This feature protects any electronic circuitry connected to the output from excessive voltages present on the analog inputs.

The MAX4711/MAX4712/MAX4713 are quad, single-pole/single-throw (SPST) analog switches. The MAX4711 has four normally closed switches (NC), the MAX4712 has four normally open switches (NO), and the MAX4713 has two NO and two NC switches. Switching times are less than 125ns for  $t_{ON}$ , and less than 80ns for  $t_{OFF}$ . These switches operate from a single +2.7V to +11V supply or from dual  $\pm 2.7V$  to  $\pm 5.5V$  supplies. All digital inputs have +0.8V to +2.4V logic thresholds, ensuring both TTL and CMOS logic compatibility when using  $\pm 4.5V$  to  $\pm 5.5V$  or single +4.5V to +11V supplies.

## Applications

Communication Systems  
 Battery-Operated Systems  
 Signal Routing  
 Test Equipment  
 Data-Acquisition  
 Industrial and Process Control Systems  
 Avionics  
 Redundant/Backup Systems

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

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



## Features

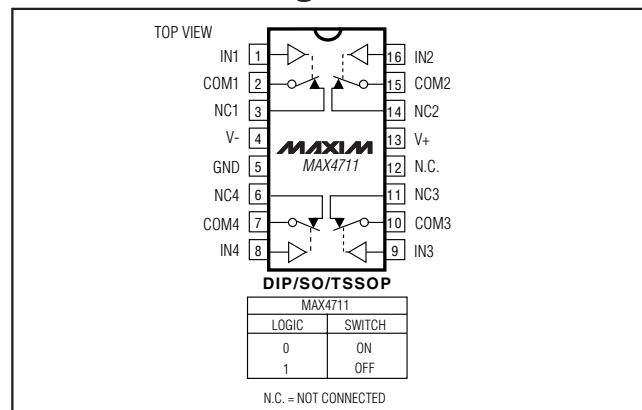
- ◆ Fault-Protected Analog Inputs
- ◆  $\pm 12V$  Fault Protection with Power Off
- ◆  $\pm 7V$  Fault Protection with  $\pm 5V$  Supplies
- ◆ +12V and -7V Fault Protection with +5V Supply
- ◆ +12V and -9V Fault Protection with +3V Supply
- ◆ Fault-Protected Digital Inputs May Exceed  $V+$  Supply Rail
- ◆ All Switches Off with Power Off
- ◆ Rail-to-Rail Signal Handling
- ◆ Output Clamped to Appropriate Supply Voltages During Fault Condition
- ◆  $25\Omega$  max  $R_{ON}$  at +25°C
- ◆  $1\Omega$  max On-Resistance Match Between Channels
- ◆ Single and Dual Supply Operation
- ◆ Pin-Compatible with Industry Standard MAX391/MAX392/MAX393
- ◆ TTL and CMOS Compatible Logic Inputs

## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4711CUE	0°C to +70°C	16 TSSOP
MAX4711CSE	0°C to +70°C	16 Narrow SO
MAX4711CPE	0°C to +70°C	16 Plastic Dip
MAX4711EUE	-40°C to +85°C	16 TSSOP
MAX4711ESE	-40°C to +85°C	16 Narrow SO
MAX4711EPE	-40°C to +85°C	16 Plastic Dip

Ordering Information continued at end of data sheet.

## Pin Configurations/Functional Diagrams/Truth Tables



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## ABSOLUTE MAXIMUM RATINGS

V+ .....	-0.3V to +13V	Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
V- .....	-13V to +0.3V	TSSOP (derate 5.70mW/°C above +70°C) .....	457mW
V+ to V- .....	-0.3V to +13V	Narrow SO (derate 8.70mW/°C above +70°C) .....	696mW
IN <sub>-</sub> .....	(V- + 12V) to (V- - 0.3V)	Plastic Dip (derate 10.53mW/°C above +70°C) .....	842mW
COM <sub>-</sub> (Note 1) .....	(V- - 0.3V) to (V+ + 0.3V)	Operating Temperature Ranges	
NO <sub>-</sub> , NC <sub>-</sub> (Note 2) .....	(V+ - 12V) to (V- + 12V)	MAX471_C_E .....	0°C to +70°C
Continuous Current into Any Terminal .....	±40mA	MAX471_E_E .....	-40°C to +85°C
Peak Current, into Any Terminal		Junction Temperature .....	+150°C
(pulsed at 1ms, 10% duty cycle) .....	±70mA	Storage Temperature Range .....	-65°C to +150°C
		Lead Temperature (soldering, 10s) .....	+300°C

**Note 1:** COM<sub>-</sub> pin is not fault-protected. Signals on COM<sub>-</sub> exceeding V+ or V- are clamped by internal diodes. Limit forward diode current to maximum current rating.

**Note 2:** NO<sub>-</sub> and NC<sub>-</sub> pins are fault-protected. Signals on NO<sub>-</sub> or NC<sub>-</sub> exceeding -12V to +12V may damage device. These limits apply with V+ = V- = 0.

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+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Fault-Free Analog Signal Range	V <sub>COM<sub>-</sub></sub> , V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub>	Applies with power on	C, E	V-		V+	V
On-Resistance	R <sub>ON</sub>	V+ = +4.5V, V- = -4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ±3.5V, I <sub>OUT</sub> = 10mA	+25°C		16	25	Ω
			C, E			30	
On-Resistance Match Between Channels (Note 4)	ΔR <sub>ON</sub>	V+ = +4.5V, V- = -4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ±3.5V, I <sub>OUT</sub> = 10mA	+25°C		0.2	1	Ω
			C, E			2	
On-Resistance Flatness	R <sub>FLAT</sub>	V+ = +4.5V, V- = -4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ±3.5V, I <sub>OUT</sub> = 10mA	+25°C		1.3	4	Ω
			C, E			5	
NO <sub>-</sub> , NC <sub>-</sub> Off-Leakage Current (Note 5)	I <sub>NO<sub>-</sub>(OFF)</sub> , I <sub>NC<sub>-</sub>(OFF)</sub>	V+ = +5.5V, V- = -5.5V, V <sub>COM<sub>-</sub></sub> = ±4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ∓4.5V	+25°C	-0.5		0.5	nA
			C, E	-5		5	
COM <sub>-</sub> Off-Leakage Current (Note 5)	I <sub>COM<sub>-</sub>(OFF)</sub>	V+ = +5.5V, V- = -5.5V, V <sub>COM<sub>-</sub></sub> = ±4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ∓4.5V	+25°C	-0.5		5	nA
			C, E	-5		5	
COM <sub>-</sub> On-Leakage Current (Note 5)	I <sub>COM<sub>-</sub>(ON)</sub>	V+ = +5.5V, V- = -5.5V, V <sub>COM<sub>-</sub></sub> = ±4.5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ±4.5V or floating	+25°C	-0.5		0.5	nA
			C, E	-20		20	
<b>FAULT</b>							
Fault-Protected Analog Signal Range	V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub>	Applies with power on	C, E	-12 + V+		+12 + V-	V
Fault-Protected Analog Signal Range	V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub>	Applies with power off	C, E	-12		+12	V
COM <sub>-</sub> Output-Leakage Current, Supplies ON (Note 5)	I <sub>COM</sub>	All channels off V+ = +5V, V- = -5V, V <sub>NO<sub>-</sub></sub> , V <sub>NC<sub>-</sub></sub> = ±7V	+25°C	-50		50	nA
			C, E	-500		500	

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## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS	
NO <sub>-</sub> or NC <sub>-</sub> Off-Leakage Current, Supplies ON (Note 5)	I <sub>NO-</sub> , I <sub>NC-</sub>	V+ = +5V, V- = -5V, V <sub>NO-</sub> , V <sub>NC-</sub> = ±7V	+25°C	-50		50	nA	
			C, E	-500		500		
NO <sub>-</sub> or NC <sub>-</sub> Input-Leakage Current, Supplies OFF (Note 5)	I <sub>NO-</sub> , I <sub>NC-</sub>	V <sub>NO-</sub> , V <sub>NC-</sub> = ±12V, V± = 0	+25°C	-0.5		0.5	μA	
			C, E	-5		5		
Output Clamp Current	I <sub>COM-</sub>	V <sub>NO-</sub> , V <sub>NC-</sub> = +7V, V+ = +5V, V- = -5V	C, E		9	20	33	mA
					-33	-16	-9	
Output Clamp Resistance	R <sub>CLAMP-</sub>	V <sub>NO-</sub> , V <sub>NC-</sub> = ±7V	+25°C		200		Ω	
Fault Trip Threshold			+25°C	V- - 0.4V		V+ + 0.4V	V	
±Fault Output Turn-On Delay Time		V <sub>NO-</sub> , V <sub>NC-</sub> = ±7V, R <sub>COM</sub> = 1kΩ	+25°C		200		ns	
±Fault Recovery Time		V <sub>NO-</sub> , V <sub>NC-</sub> = ±7V, R <sub>COM</sub> = 1kΩ	+25°C		700		ns	
<b>LOGIC INPUT</b>								
Input Logic High	V <sub>IH</sub>		C, E	2.4			V	
Input Logic Low	V <sub>IL</sub>		C, E			0.8	V	
Input-Leakage Current (Note 5)	I <sub>IN</sub>	V <sub>IN-</sub> = 0 or V+	+25°C	-1		1	μA	
			C, E	-5		5		
<b>SWITCH DYNAMICS</b>								
Turn-On Time	t <sub>ON</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = ±3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		80	125	ns	
			C, E			150		
Turn-Off Time	t <sub>OFF</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = ±3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		50	80	ns	
			C, E			100		
Break-Before-Make Time Delay (MAX4713 only)	t <sub>BBM</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = ±3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C	15	30		ns	
			C, E	5				
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1nF, Figure 4	+25°C		25		pC	
NO <sub>-</sub> or NC <sub>-</sub> Off-Capacitance	C <sub>N(OFF)</sub>	f = 1MHz, Figure 5	+25°C		8		pF	
COM <sub>-</sub> Off-Capacitance	C <sub>COM(OFF)</sub>	f = 1MHz, Figure 5	+25°C		8		pF	
COM <sub>-</sub> On-Capacitance	C <sub>COM(ON)</sub>	f = 1MHz, Figure 5	+25°C		30		pF	
Off-Isolation (Note 6)	V <sub>ISO</sub>	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 15pF, P <sub>IN</sub> = 0, f = 1MHz, Figure 6	+25°C		-59		dB	
Channel-to-Channel Crosstalk (Note 7)	V <sub>CT</sub>	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 15pF, P <sub>IN</sub> = 0, f = 1MHz, Figure 6	+25°C		-87		dB	

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>POWER SUPPLY</b>							
Power-Supply Range	V+, V-		C, E	±2.7		±5.5	V
V+ Supply Current	I+	All V <sub>IN</sub> = 0 or V+	+25°C		38	75	μA
			C, E			100	
V- Supply Current	I-	All V <sub>IN</sub> = 0 or V+	+25°C		38	75	μA
			C, E			100	
GND Supply Current	I <sub>GND</sub>	All V <sub>IN</sub> = 0 or V+	+25°C		0	1	μA
			C, E			10	

## ELECTRICAL CHARACTERISTICS—+5V Single Supply

(V+ = +4.5V to +5.5V, V- = 0, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Fault-Free Analog Signal Range	V <sub>COM</sub> , V <sub>NO</sub> , V <sub>NC</sub>	Power on	C, E	V-		V+	V
On-Resistance	R <sub>ON</sub>	V+ = +4.5V V <sub>NO</sub> , V <sub>NC</sub> = +3.5V, I <sub>OUT</sub> = 10mA	+25°C		30	40	Ω
			C, E			50	
On-Resistance Match Between Channels (Note 4)	ΔR <sub>ON</sub>	V+ = +4.5V V <sub>NO</sub> , V <sub>NC</sub> = +3.5V, I <sub>OUT</sub> = 10mA	+25°C		0.3	2	Ω
			C, E			3	
On-Resistance Flatness	R <sub>FLAT</sub>	V+ = +4.5V V <sub>NO</sub> , V <sub>NC</sub> = +1.5V, +2.25V, +3.5V, I <sub>OUT</sub> = 10mA	+25°C		2	5	Ω
			C, E			6	
NO-, NC_ Off-Leakage Current (Note 5)	I <sub>NO(OFF)</sub> , I <sub>NC(OFF)</sub>	V+ = +5.5V V <sub>COM</sub> = +1V, +4.5V; V <sub>NO</sub> , V <sub>NC</sub> = +4.5V, +1V	+25°C	-0.5		0.5	nA
			C, E	-5		5	
COM_ Off-Leakage Current (Note 5)	I <sub>COM(OFF)</sub>	V+ = +5.5V V <sub>COM</sub> = +1V, +4.5V; V <sub>NO</sub> , V <sub>NC</sub> = +4.5V, +1V	+25°C	-0.5		0.5	nA
			C, E	-5		5	
COM_ On-Leakage Current (Note 5)	I <sub>COM(ON)</sub>	V+ = +5.5V V <sub>COM</sub> = +1V, +4.5V; V <sub>NO</sub> , V <sub>NC</sub> = +1V, +4.5V, or floating	+25°C	-0.5		0.5	nA
			C, E	-20		20	
<b>FAULT</b>							
Fault-Protected Analog Signal Range	V <sub>NO</sub> , V <sub>NC</sub>	Power on	C, E	-12 + V+		+12	V

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## ELECTRICAL CHARACTERISTICS—+5V Single Supply (continued)

(V+ = +4.5V to +5.5V, V- = 0, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
Fault-Protected Analog Signal Range	V <sub>NO_</sub> , V <sub>NC_</sub>	Power off	C, E	-12		+12	V
COM_ Output-Leakage Current, Supplies ON (Note 5)	I <sub>COM_</sub>	All channels off; V <sub>NO_</sub> , V <sub>NC_</sub> = +12V or -7V, V+ = +5V	+25°C C, E	-50 -500		50 500	nA
NO_ or NC_ Off-Leakage Current, Supplies ON (Note 5)	I <sub>NO_</sub> , I <sub>NC_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = +12V or -7V V+ = +5V	+25°C C, E	-50 -500		50 500	nA
NO_ or NC_ Input-Leakage Current, Supplies OFF (Note 5)	I <sub>NO_</sub> , I <sub>NC_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = ±12V, V± = 0	+25°C C, E	-0.5 -5		0.5 5	μA
Output Clamp Current	I <sub>COM_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, V+ = 5V	C, E	2	6	11	mA
Output Clamp Resistance	R <sub>CLAMP_</sub>	Clamp on	+25°C		500		Ω
+Fault Output Turn-On Delay Time		V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, R <sub>L</sub> = 300Ω, V+ = +5V	+25°C		200		ns
+Fault Recovery Time		V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, R <sub>L</sub> = 300Ω, V+ = +5V	+25°C		500		μs
<b>LOGIC INPUT</b>							
Input Logic High	V <sub>IH</sub>		C, E	2.4			V
Input Logic Low	V <sub>IL</sub>		C, E			0.8	V
Input-Leakage Current (Note 5)	I <sub>IN</sub>	V <sub>IN_</sub> = 0 or V+	C, E	-1		1	μA
<b>SWITCH DYNAMICS</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO_</sub> or V <sub>NC_</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C C, E		170 230	275	ns
Turn-Off Time	t <sub>OFF</sub>	V <sub>NO_</sub> or V <sub>NC_</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C C, E		55	100 125	ns
Break-Before-Make Time Delay (MAX4713 only)	t <sub>BBM</sub>	V <sub>NO_</sub> or V <sub>NC_</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C C, E	30 20	115		ns
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1nF, Figure 4	+25°C		-1		pC
<b>POWER SUPPLY</b>							
Power-Supply Range	V+		C, E	+2.7		+11	V
V+ Supply Current	I+	All V <sub>IN_</sub> = 0 or V+	+25°C C, E		34	65 75	μA

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MAX4711/MAX4712/MAX4713

## ELECTRICAL CHARACTERISTICS—+3V Single Supply

(V+ = +2.7V to +3.6V, V- = 0, V<sub>IH</sub> = +2.0V, V<sub>IL</sub> = +0.6V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Fault-Free Analog Signal Range	V <sub>COM_</sub> , V <sub>NO_</sub> , V <sub>NC_</sub>	Power on	C, E	V-		V+	V
On-Resistance	R <sub>ON</sub>	V+ = +2.7V V <sub>NO_</sub> , V <sub>NC_</sub> = +1V, I <sub>OUT</sub> = 1mA	+25°C C, E		54	75 100	Ω
On-Resistance Match Between Channels (Note 4)	ΔR <sub>ON</sub>	V+ = +2.7V V <sub>NO_</sub> , V <sub>NC_</sub> = +1V, I <sub>OUT</sub> = 1mA	+25°C C, E		1	7 9	Ω
NO_, NC_ Off-Leakage Current (Note 5)	I <sub>NO_(OFF)</sub> , I <sub>NC_(OFF)</sub>	V+ = +3.6V V <sub>COM_</sub> = +0.7V, +3V; V <sub>NO_</sub> , V <sub>NC_</sub> = +3V, +0.7V	+25°C C, E	-0.5 -5		0.5 5	nA
COM_ Off-Leakage Current (Note 5)	I <sub>COM_(OFF)</sub>	V+ = +3.6V V <sub>COM_</sub> = +0.7V, +3V; V <sub>NO_</sub> , V <sub>NC_</sub> = +3V, +0.7V	+25°C C, E	-0.5 -5		0.5 5	nA
COM_ On-Leakage Current (Note 5)	I <sub>COM_(ON)</sub>	V+ = +3.6V V <sub>COM_</sub> = +0.7, +3V; V <sub>NO_</sub> , V <sub>NC_</sub> = +0.7V, +3V, or floating	+25°C C, E	-0.5 -20		0.5 20	nA
<b>FAULT</b>							
Fault-Protected Analog Signal Range	V <sub>NO_</sub> , V <sub>NC_</sub>	Power on	C, E	-12 + V+		+12	V
Fault-Protected Analog Signal Range	V <sub>NO_</sub> , V <sub>NC_</sub>	Power off	C, E	-12		+12	V
COM_ Output-Leakage Current, Supplies ON (Note 5)	I <sub>COM</sub>	All channels off; V <sub>NO_</sub> , V <sub>NC_</sub> = +12V or -9V, V+ = +3V	+25°C C, E	-50 -500		50 500	nA
NO_ or NC_ Off-Leakage Current, Supplies ON (Note 5)	I <sub>NO_</sub> , I <sub>NC_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = +12V or -9V, V+ = +3V	+25°C C, E	-50 -500		50 500	nA
NO_ or NC_ Input-Leakage Current, Supplies OFF (Note 5)	I <sub>NO_</sub> , I <sub>NC_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = ±12V, V± = 0	+25°C C, E	-0.5 -5		0.5 5	μA
Output Clamp Current	I <sub>COM_</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, V+ = +3V	C, E	0.5		3.0	mA
Output Clamp Resistance	R <sub>CLAMP_</sub>	V+ = +3V, V <sub>NO_</sub> , V <sub>NC_</sub> = +12V; clamp on	+25°C		600		kΩ
+Fault Output Turn-On Delay Time		V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, R <sub>L</sub> = 300Ω, V+ = +3V	+25°C		200		ns
+Fault Recovery Time		V <sub>NO_</sub> , V <sub>NC_</sub> = +12V, R <sub>L</sub> = 300Ω, V+ = +3V	+25°C		2.2		μs

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

MAX4711/MAX4712/MAX4713

## ELECTRICAL CHARACTERISTICS—+3V Single Supply (continued)

(V+ = +2.7V to +3.6V, V- = 0, V<sub>IH</sub> = +2.0V, V<sub>IL</sub> = +0.6V, GND = 0, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>LOGIC INPUT</b>							
Input Logic High	V <sub>IH</sub>		C, E	2			V
Input Logic Low	V <sub>IL</sub>		C, E			0.6	V
Input-Leakage Current (Note 5)	I <sub>IN-</sub>	V <sub>IN-</sub> = 0 or V+	C, E	-5		5	μA
<b>SWITCH DYNAMICS</b>							
Turn-On Time	t <sub>ON</sub>	V+ = +2.7V, V <sub>NO-</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		340	500	ns
			C, E			600	
Turn-Off Time	t <sub>OFF</sub>	V+ = +2.7V, V <sub>NO-</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		100	175	ns
			C, E			225	
Break-Before-Make Time Delay (MAX4713 only)	t <sub>BBM</sub>	V+ = +2.7V, V <sub>NO-</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C	60	240		ns
			C, E	50			
<b>POWER SUPPLY</b>							
Power-Supply Range	V+		C, E	+2.7		+11	V
V+ Supply Current	I+	All V <sub>IN-</sub> = 0 or V+	+25°C		8	15	μA
			C, E			20	

**Note 3:** Algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 4:**  $\Delta R_{ON} = \Delta R_{ON}(MAX) - \Delta R_{ON}(MIN)$

**Note 5:** Leakage parameters are 100% tested at maximum rated temperature and with dual supplies. Leakage parameters with single supply are guaranteed by correlation at +25°C.

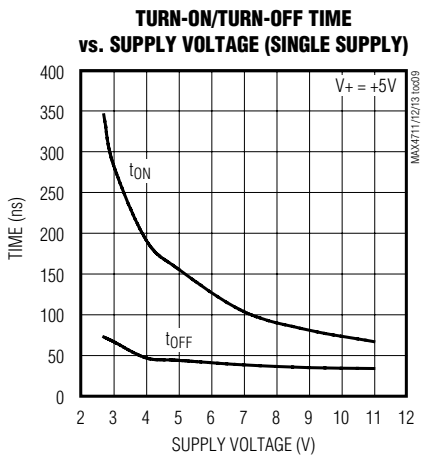
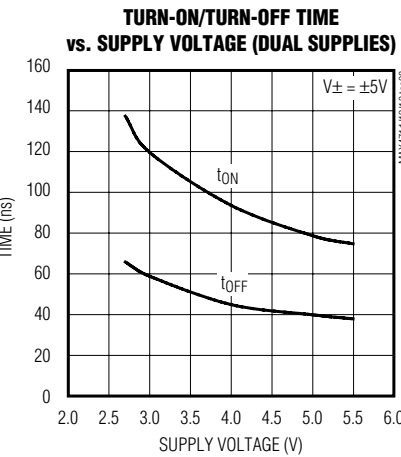
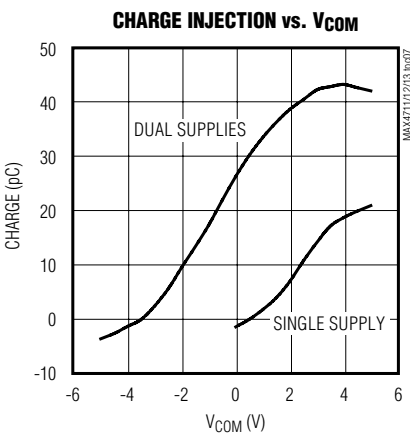
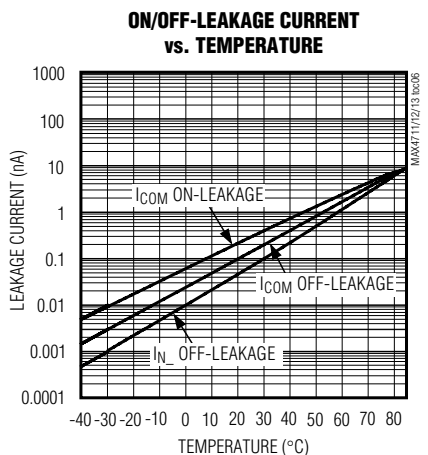
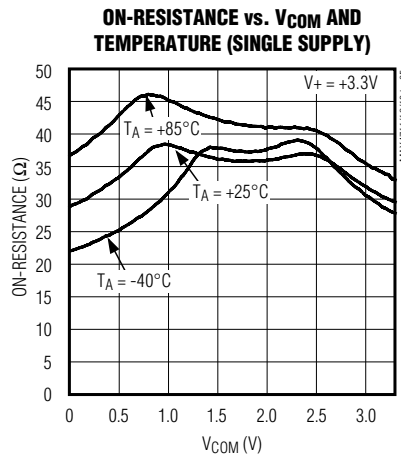
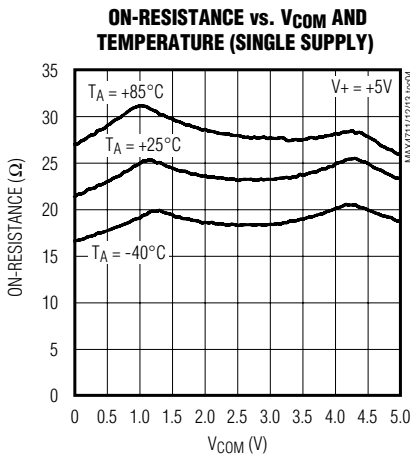
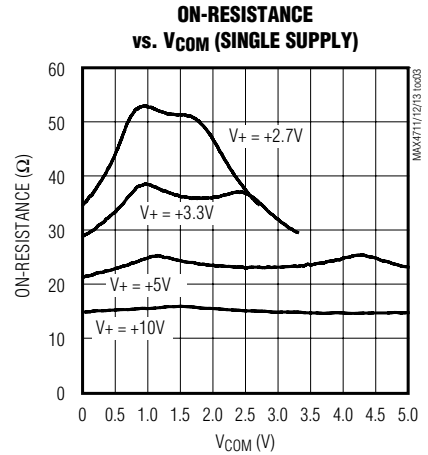
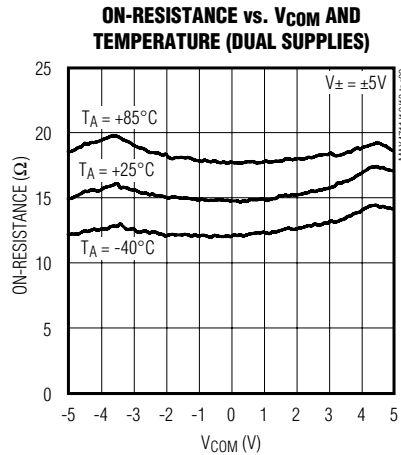
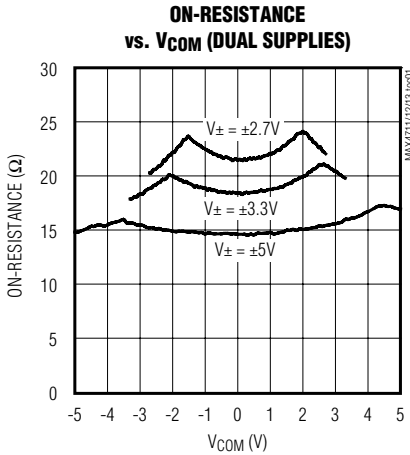
**Note 6:** Off-isolation =  $20 \log_{10} [V_{COM-}/(V_{NO-} \text{ or } V_{NC-})]$ , V<sub>COM-</sub> = output, V<sub>NO-</sub> or V<sub>NC-</sub> = input to off switch.

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

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Typical Operating Characteristics

( $V_+ = +5V$ ,  $V_- = -5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



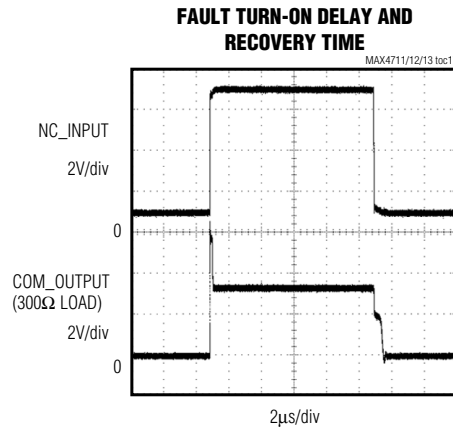
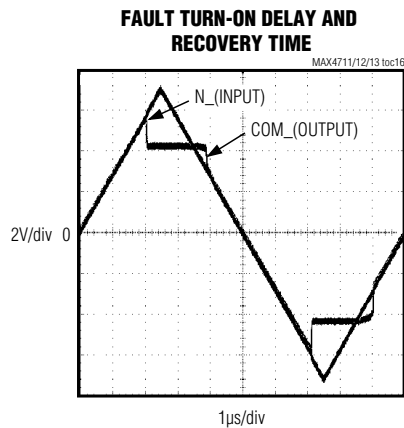
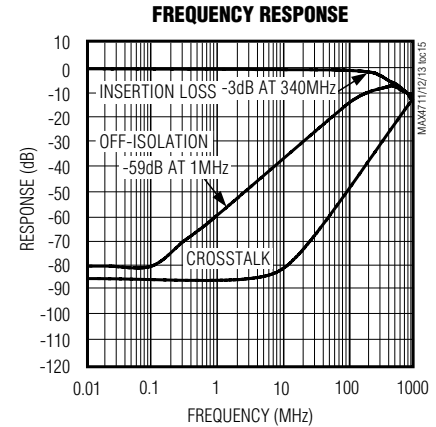
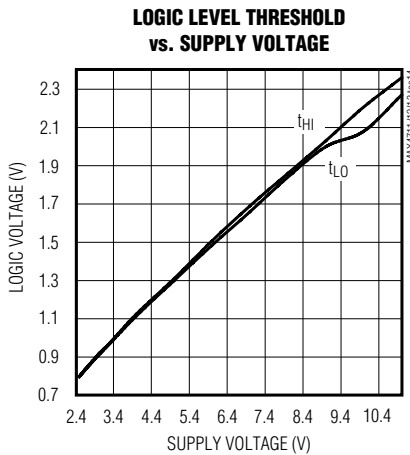
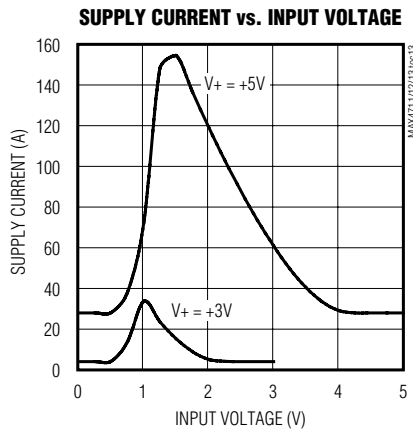
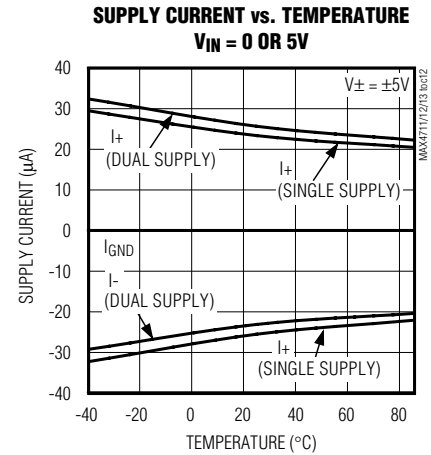
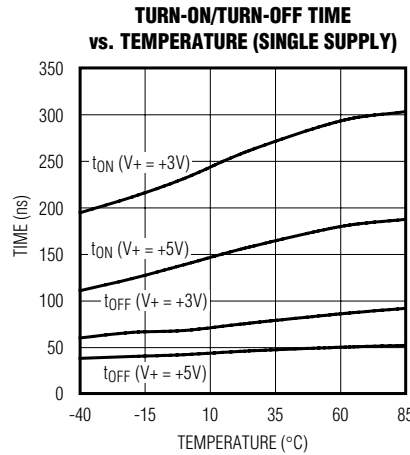
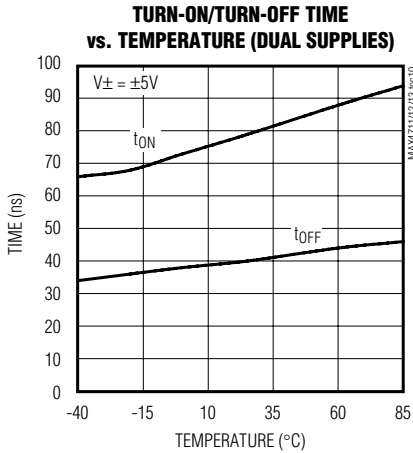


# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Typical Operating Characteristics (continued)

( $V_+ = +5V$ ,  $V_- = -5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4711/MAX4712/MAX4713



# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Pin Description

PIN			NAME	FUNCTION
MAX4711	MAX4712	MAX4713		
1, 16, 9, 8	1, 16, 9, 8	1, 16, 9, 8	IN1, IN2, IN3, IN4	Logic Inputs. Fault-protected to (V- + 12V).
2, 15, 10, 7	2, 15, 10, 7	2, 15, 10, 7	COM1, COM2, COM3, COM4	Analog Switch Common Terminals
3, 14, 11, 6	—	—	NC1, NC2, NC3, NC4	Fault-Protected Analog Switch Normally Closed Terminals
—	3, 14, 11, 6	—	NO1, NO2, NO3, NO4	Fault-Protected Analog Switch Normally Open Terminals
—	—	3, 6	NO1, NO4	Fault-Protected Analog Switch Normally Open Terminals
—	—	14, 11	NC2, NC3	Fault-Protected Analog Switch Normally Closed Terminals
4	4	4	V-	Negative Supply Voltage Input. Connect to GND for single-supply operation.
5	5	5	GND	Ground
12	12	12	N.C.	No Connection. Not internally connected.
13	13	13	V+	Positive Supply Input

### Detailed Description

The MAX4711/MAX4712/MAX4713 differ considerably from traditional fault-protection switches, with several advantages. First, they are constructed with two parallel FET's allowing very low on-resistance. Second, they allow signals on the NC\_ or NO\_ pins that are within or slightly beyond the supply rails to be passed through the switch to the COM terminal, allowing rail-to-rail signal operation. Third, when a signal on NC\_ or NO\_ exceeds the supply rails by about 150mV (a fault condition) the voltage on COM\_ is limited to the same polarity supply voltage. Operation is identical for both fault polarities.

During a fault condition, the NO\_ or NC\_ input becomes high impedance regardless of the switch state or load resistance. If the switch is on, the COM\_ output current is supplied from V+ or V- by the clamp FET's that are connected from COM to each supply. These FET's can typically source or sink up to 15mA. When power is removed, the fault protection is still in effect. In this case, the NO\_ or NC\_ terminals are a virtual open circuit. The fault can be up to  $\pm 12V$ .

The COM\_ pins are not fault-protected, they act as normal CMOS switch terminals. If a voltage source is connected to any COM\_ pin, it should be limited to the supply voltages. Exceeding the supply voltage will

cause high currents to flow through the ESD-protected diodes, possibly damaging the device (see *Absolute Maximum Ratings*).

### Pin Compatibility

These switches have identical pinouts to common non-fault-protected CMOS switches. Care should be exercised while considering them for direct replacements in existing printed circuit boards since only the NO\_ and NC\_ pins of each switch are fault-protected.

### Internal Construction

Internal construction is shown in Figure 1, with the analog signal paths shown in bold. A single NO switch is shown; the NC configuration is identical except the logic-level translator is inverting. The analog switch is formed by the parallel combination of N-channel FET (N1) and P-channel FET (P1), which are driven on and off simultaneously according to the input fault condition and the logic-level state.

### Normal Operation

Two comparators continuously compare the voltage on the NO\_ (or NC\_) pin with V+ and V-. When the signal on NO\_ or NC\_ is between V+ and V- the switch acts normally, with FETs N1 and P1 turning on and off in response to IN\_ signals. The parallel combination of N1 and P1 forms a low-value resistor between NO\_ (or

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

MAX4711/MAX4712/MAX4713

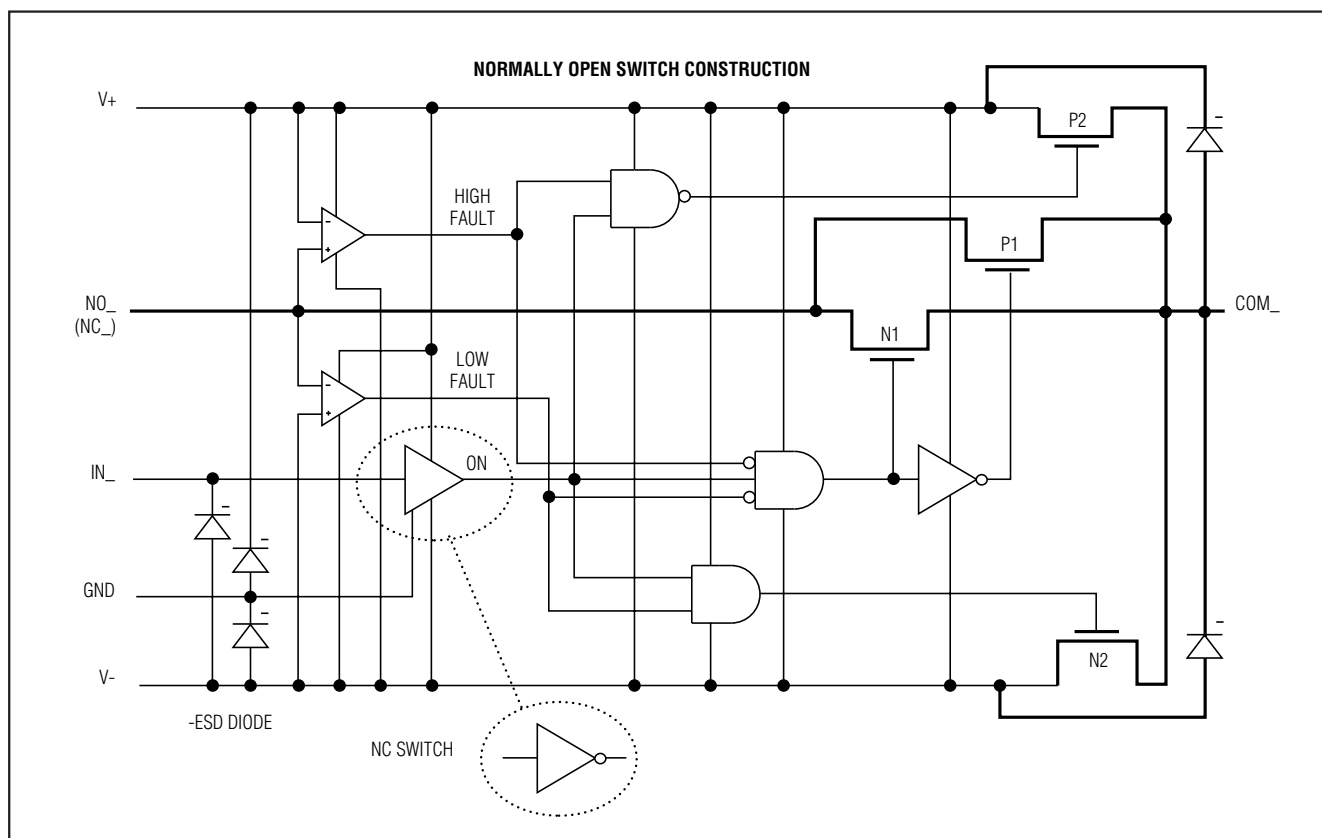


Figure 1. Block Diagram

NC\_) and COM\_ so that signals pass equally well in either direction.

### Positive Fault Condition

When the signal on NO\_ (or NC\_) exceeds  $V+$  by about 150mV, the high-fault comparator output is high, turning off FETs N1 and P1. This makes the NO\_ (or NC\_) input high impedance regardless of the switch state. If the switch state is "off", all FETs are turned off and both NO\_ (or NC\_) and COM\_ are high impedance. If the switch state is "on", clamp FET P2 is turned on, sourcing current from  $V+$  to COM\_.

### Negative Fault Condition

When the signal on NO\_ (or NC\_) exceeds  $V-$  by about 150mV, the low-fault comparator output is high, turning off FETs N1 and P1. This makes the NO\_ (or NC\_) input high impedance regardless of the switch state. If the switch state is "off", all FETs are turned off and both NO\_ (or NC\_) and COM\_ are high impedance. If the switch state is "on", clamp FET N2 is turned on, sinking current from COM\_ to  $V-$ .

### Transient Fault Response and Recovery

When a fast rise-time or fall-time transient on NC\_ or NO\_ exceeds  $V+$  or  $V-$ , the output (COM\_) follows the input to the supply rail with only a few nanoseconds delay. This delay is due to the switch on-resistance and circuit capacitance to ground. When the input transient returns to within the supply rails, however, there is a 700ns output recovery delay time. These values depend on the COM\_ output resistance and capacitance, and are not production tested or guaranteed. The delays are not dependent on the fault amplitude. Higher COM\_ output resistance and capacitance increase recovery times.

### COM\_ and IN\_ Pins

FETs N2 and P2 can source about  $\pm 15\text{mA}$  from  $V+$  or  $V-$  to COM\_ in the fault condition. Ensure that if the COM\_ pin is connected to a low-resistance load, the absolute maximum current rating of 40mA is never exceeded both in normal and fault conditions.

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

The COM<sub>n</sub> pins do not have fault protection. Reverse ESD-protection diodes are internally connected between COM<sub>n</sub> and V<sub>+</sub> and V<sub>-</sub>. If a signal on COM<sub>n</sub> exceeds V<sub>+</sub> or V<sub>-</sub> by more than a diode drop, one of these diodes will conduct. The IN<sub>n</sub> pin can exceed the positive supply voltage, but they can go below the negative supply by only a diode drop. The maximum voltage on these pins is 12V if operating from a single supply, regardless of the supply voltage (including 0 volts), and if operating from dual supplies, the maximum voltage is (V<sub>-</sub> + 12V).

### Fault-Protection Voltage and Power Off

The maximum fault voltage on the NC<sub>n</sub> or NO<sub>n</sub> pins is ±12V with power off.

### IN<sub>n</sub> Logic-Level Thresholds

The logic-level thresholds are CMOS and TTL compatible when using ±4.5V to ±5.5V or single +4.5V to +11V supplies. When using a +2.7V supply, the logic thresholds are V<sub>IH</sub> = 2.0V and V<sub>IL</sub> = 0.6V.

### Dual Supplies

The MAX4711/MAX4712/MAX4713 operate with bipolar supplies between ±2.7V and ±5.5V. The V<sub>+</sub> and V<sub>-</sub> supplies need not be symmetrical, but their difference should not exceed 11V.

### Single Supply

The MAX4711/MAX4712/MAX4713 operate from a single supply between +2.7V and +11V when V<sub>-</sub> is connected to GND.

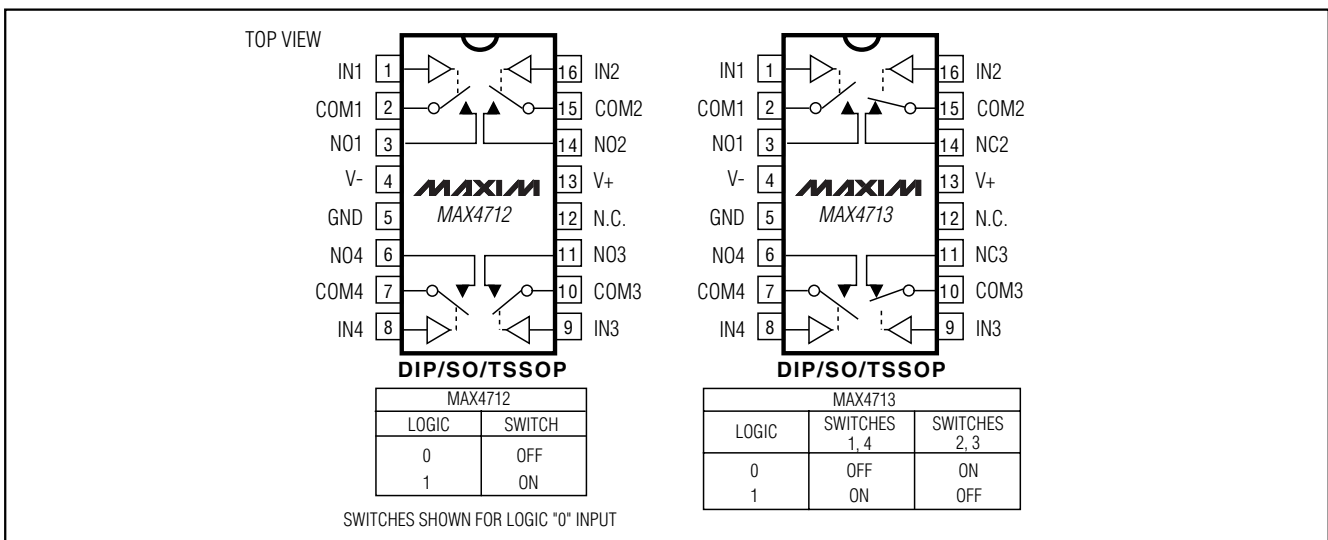
## Chip Information

TRANSISTOR COUNT: 463

## Ordering Information (continued)

MAX4712CUE	0°C to +70°C	16 TSSOP
MAX4712CSE	0°C to +70°C	16 Narrow SO
MAX4712CPE	0°C to +70°C	16 Plastic Dip
MAX4712EUE	-40°C to +85°C	16 TSSOP
MAX4712ESE	-40°C to +85°C	16 Narrow SO
MAX4712EPE	-40°C to +85°C	16 Plastic Dip
MAX4713CUE	0°C to +70°C	16 TSSOP
MAX4713CSE	0°C to +70°C	16 Narrow SO
MAX4713CPE	0°C to +70°C	16 Plastic Dip
MAX4713EUE	-40°C to +85°C	16 TSSOP
MAX4713ESE	-40°C to +85°C	16 Narrow SO
MAX4713EPE	-40°C to +85°C	16 Plastic Dip

## Pin Configurations/Functional Diagrams/Truth Tables (continued)



# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

MAX4711/MAX4712/MAX4713

## Test Circuits/Timing Diagrams

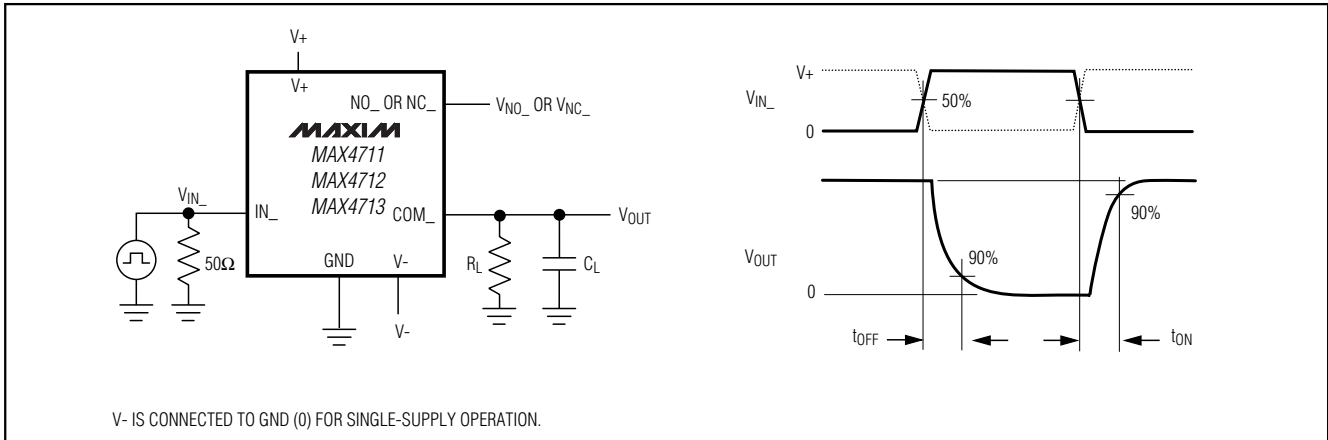


Figure 2. Switch Turn-On/Turn-Off Times

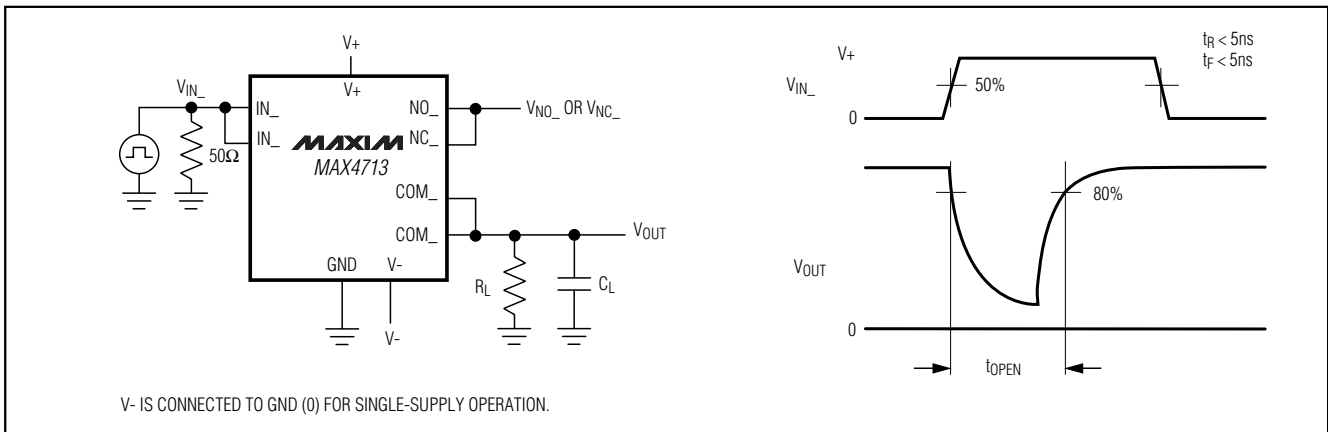


Figure 3. MAX4713 Break-Before-Make Interval

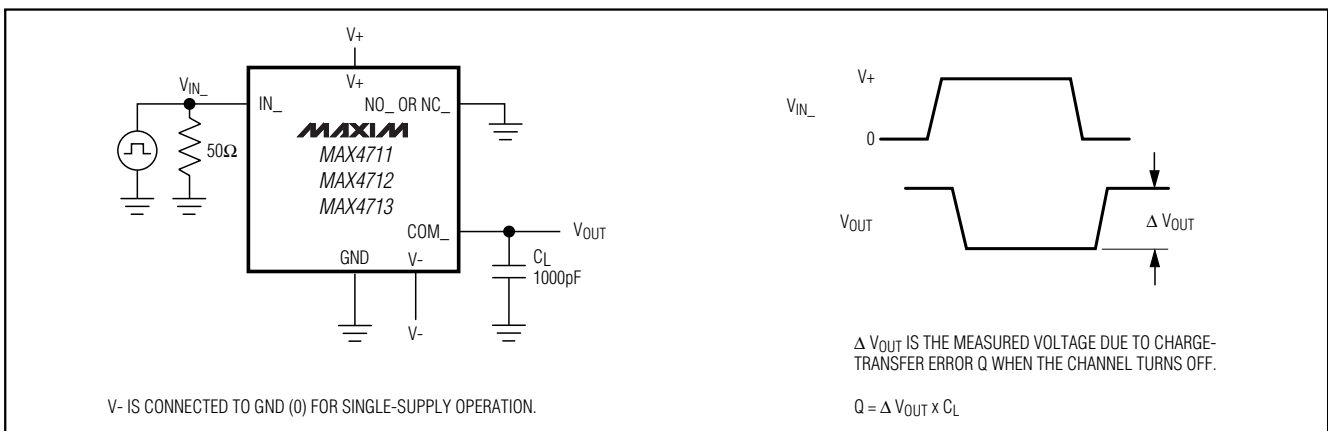


Figure 4. Charge Injection

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Test Circuits/Timing Diagrams (continued)

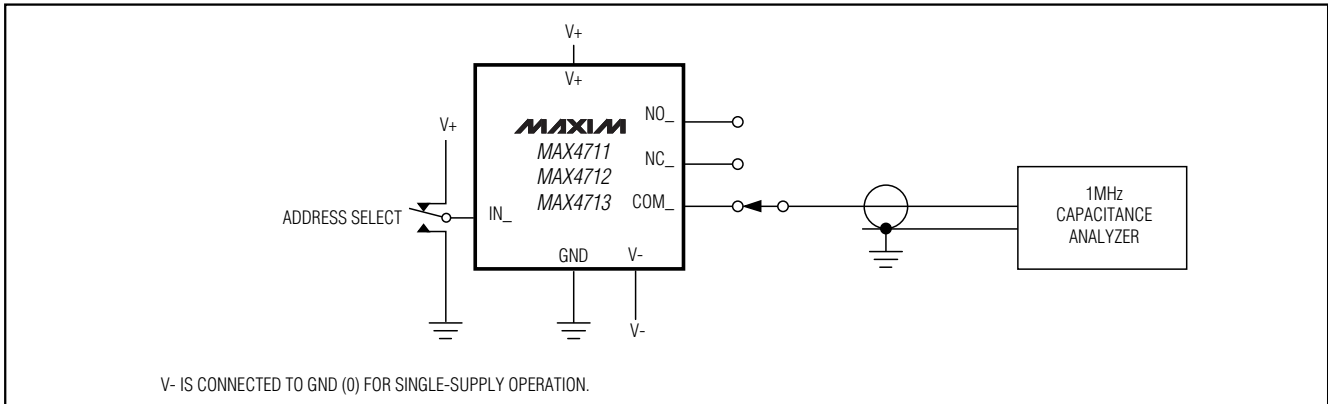


Figure 5. COM\_, NO\_, NC\_ Capacitance

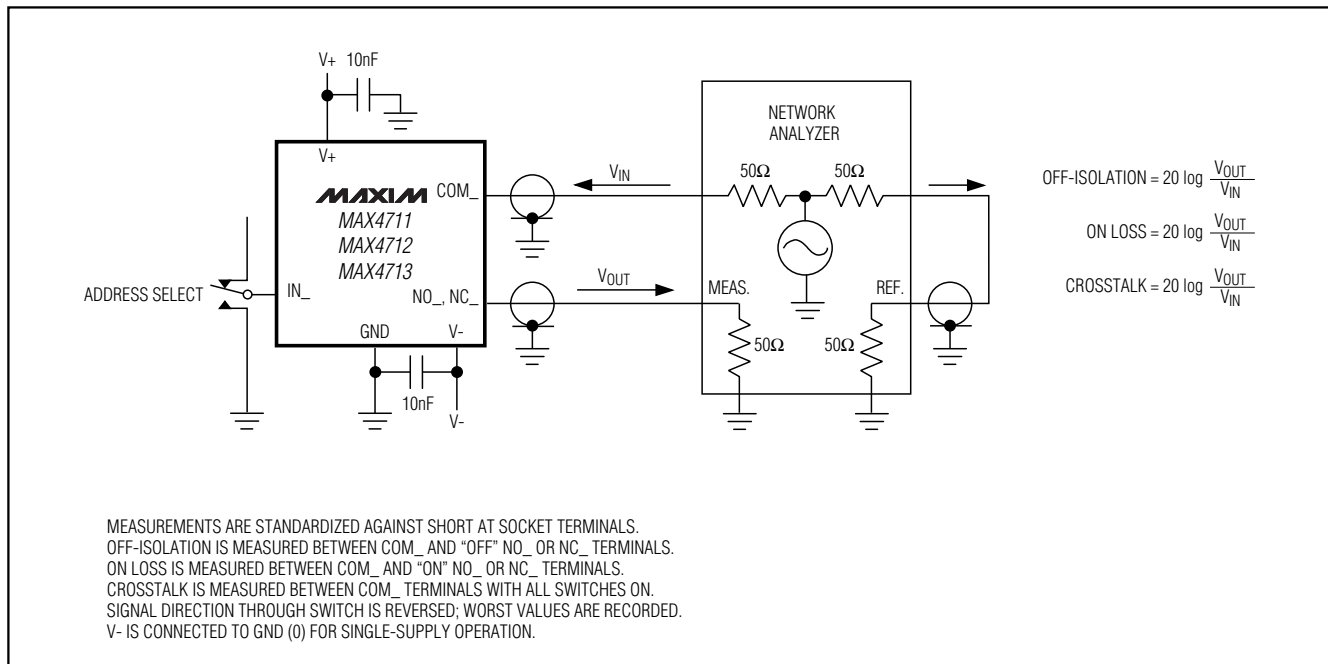


Figure 6. Frequency Response, Off-Isolation, and Crosstalk

# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Package Information

MAX4711/MAX4712/MAX4713

**TOP VIEW**

**BOTTOM VIEW**

**SIDE VIEW**

**END VIEW**

**DETAIL A**

**LEAD TIP DETAIL**

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	.65 BSC		.026 BSC	
H	6.25	6.50	.246	.256
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
α	0°	8°	0°	8°

JEDEC		VARIATIONS			
MD-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
AD	20 D	6.40	6.60	.252	.260
AE	24 D	7.70	7.90	.303	.311
AF	28 D	9.60	9.80	.378	.386

**NOTES:**

- DIMENSIONS D AND E DO NOT INCLUDE FLASH
- MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
- CONTROLLING DIMENSION: MILLIMETER
- MEETS JEDEC OUTLINE MD-153 VARIATIONS- AB, AC, AD, AE, AF
- \*N\* REFERS TO NUMBER OF LEADS
- THE LEAD TIPS MUST LIE WITHIN A SPECIFIED ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL PLANES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED.

**MAXIM**

PROPRIETARY INFORMATION

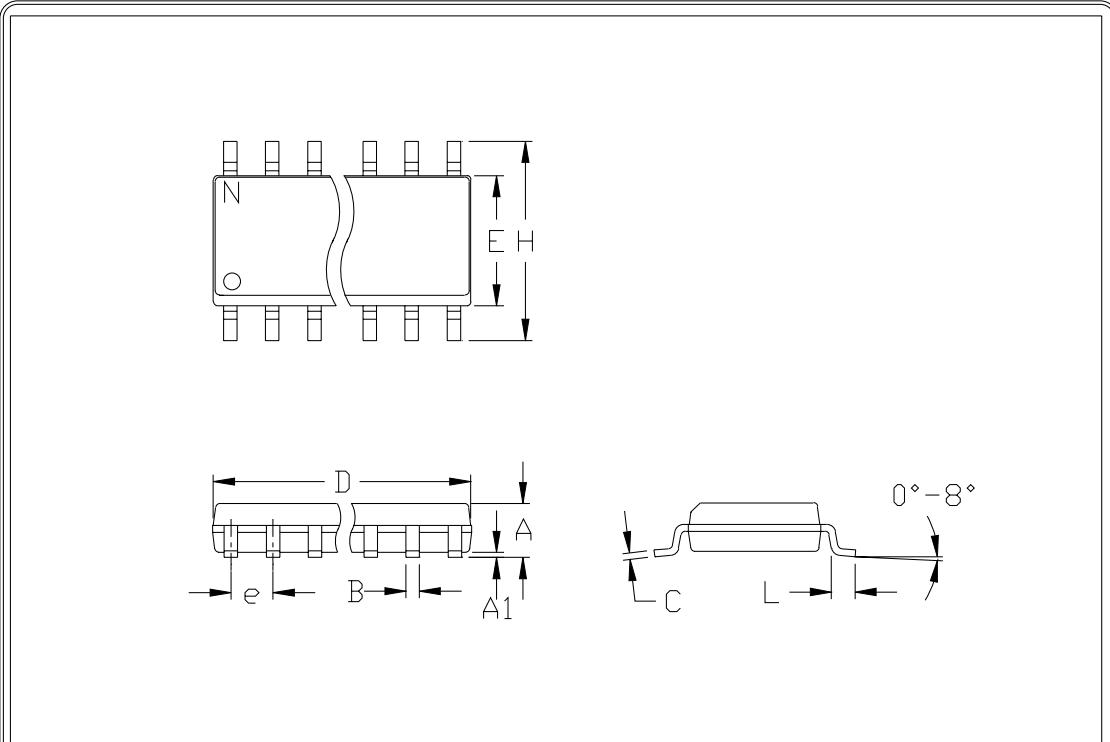
TITLE:  
PACKAGE OUTLINE, TSSOP, 4.40 MM BODY

APPROVAL	DOCUMENT CONTROL NO. 21-0066	REV	D 1/1
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TSSOP, NO PADS, EPS

# Fault-Protected, Low-Voltage, 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



PACKAGE FAMILY OUTLINE: SOIC .150" TITLE

1/1

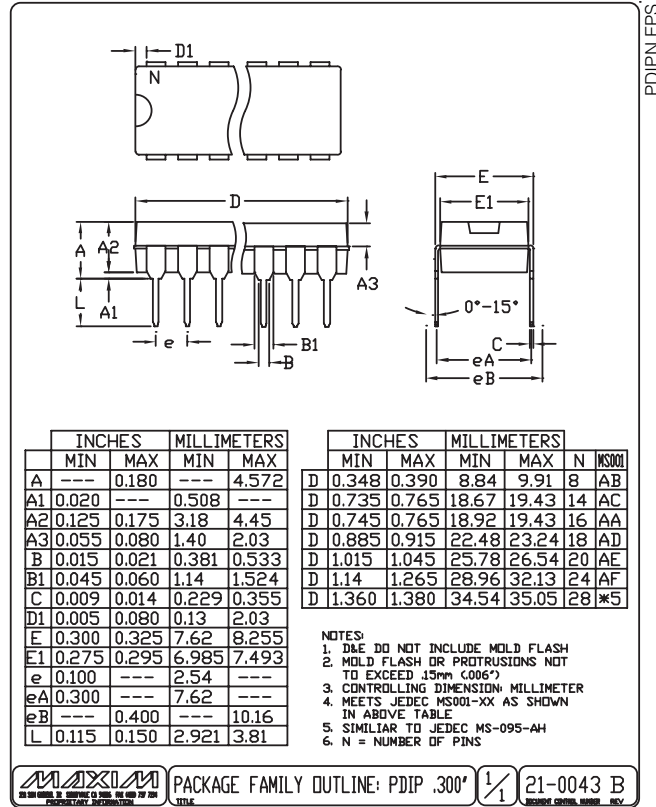
21-0041 A DOCUMENT CONTROL NUMBER REV



# Fault-Protected, Low-Voltage, Quad SPST Analog Switches

## Package Information (continued)

MAX4711/MAX4712/MAX4713



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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