MAXIM

Low-Voltage, 4Ω, Quad, SPST, CMOS Analog Switches

MAX4651/MAX4652/MAX4653

General Description

The MAX4651/MAX4652/MAX4653 quad analog switches feature 4Ω max on-resistance (R_{ON}) when operating from a single +5V supply. R_{ON} is matched between switches to 0.2Ω (max) and is flat (0.8Ω max) over the specified signal range. Each switch can handle Rail-to-Rail® analog signals. Off-leakage current is 0.1nA at +25°C. These switches are ideal in low-distortion applications and are the preferred solution over mechanical relays in automated test equipment or applications where current switching is required. They have low power requirements, require less board space, and are more reliable than mechanical relays.

The MAX4651/MAX4652/MAX4653 operate from a single +1.8V to +5.5V supply, making them ideal for use in battery-powered applications.

The MAX4651 has four normally closed (NC) switches, the MAX4652 has four normally open (NO) switches, and the MAX4653 has two NO and two NC switches. These devices are available in 16-pin TSSOP and SO packages.

Applications

Battery-Powered Systems

Audio and Video Signal Routing

Low-Voltage Data-Acquisition Systems

Sample-and-Hold Circuits

Communications Circuits

Relay Replacement

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

Features

♦ **On-Resistance**
   4Ω **max at 5V**
   7Ω **max at 3V**

♦ **On-Resistance Flatness**
   0.8Ω **max at 5V**
   2.5Ω **max at 3V**

♦ **On-Resistance Matching**
   0.2Ω **max (+2.7V to +5.5V)**

♦ **+1.8V to +5.5V Single-Supply Voltage**

♦ **+1.8V Operation**
   On-Resistance 30Ω (typ) Over Temperature
   t_{ON} **20ns typ, t_{OFF} 12ns (typ)**

♦ **TTL/CMOS-Logic Compatible**

♦ **Crosstalk**
   -100dB at 1MHz

♦ **Off-Isolation**
   -75dB at 1MHz

♦ **Rail-to-Rail Signal Range**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4651EUE	-40°C to +85°C	16 TSSOP
MAX4651ESE	-40°C to +85°C	16 SO
MAX4652EUE	-40°C to +85°C	16 TSSOP
MAX4652ESE	-40°C to +85°C	16 SO
MAX4653EUE	-40°C to +85°C	16 TSSOP
MAX4653ESE	-40°C to +85°C	16 SO

Pin Configurations/Functional Diagrams/Truth Tables

MAX4651	
LOGIC	SWITCH
0	ON
1	OFF

MAX4652	
LOGIC	SWITCH
0	OFF
1	ON

MAX4653		
LOGIC	SWITCHES 1, 4	SWITCHES 2, 3
0	OFF	ON
1	ON	OFF

SWITCHES SHOWN FOR LOGIC "0" INPUT
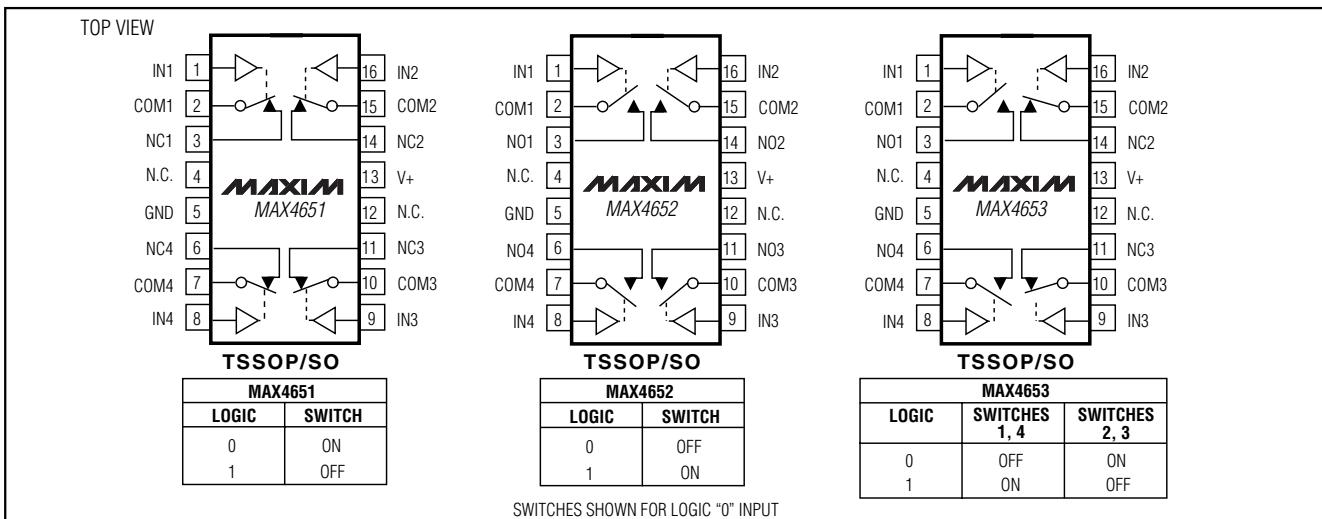
MAXIM

_____ *Maxim Integrated Products* **1**

Low-Voltage, 4Ω, Quad, SPST, CMOS Analog Switches

ABSOLUTE MAXIMUM RATINGS

V+ to GND ....-0.3 to +6V
IN_, COM_, NO_, NC_ to GND (Note 1).......-0.3V to (V+ + 0.3V)
Continuous Current (NO_, NC_, COM_)..........................±50mA
Peak Current (NO_, NC_, COM_, pulsed at 1ms
   10% duty cycle)..±100mA

Continuous Power Dissipation (T$_A$ = +70°C)
   16-Pin TSSOP (derate 5.7mW/°C above +70°C) 457mW
   16-Pin SO (derate 8mW/°C above +70°C)...................640mW
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C

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

(V+ = 4.5V to 5.5V, V$_{IH}$ = 2.4V, V$_{IL}$ = 0.8V, T$_A$ = T$_{MIN}$ to T$_{MAX}$, unless otherwise specified. Typical values are at V+ = 5V, T$_A$ = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Input Voltage Range	V$_{COM\_}$, V$_{NO\_}$, V$_{NC\_}$			0		V+	V
COM_ to NO_ or NC_ On-Resistance	R$_{ON}$	I$_{COM}$ = 10mA, V$_{NO\_}$ or V$_{NC\_}$ = 0 to V+, V+ = 4.5V	T$_A$ = +25°C		2.5	4	Ω
			T$_A$ = T$_{MIN}$ to T$_{MAX}$			4.5	
COM_ to NO_ or NC_ On-Resistance Match Between Channels (Note 3)	ΔR$_{ON}$	I$_{COM}$ = 10mA, V$_{NO\_}$ or V$_{NC\_}$ = 0 to V+, V+ = 4.5V	T$_A$ = +25°C		0.05	0.2	Ω
			T$_A$ = T$_{MIN}$ to T$_{MAX}$			0.3	
On-Resistance Flatness (Note 4)	R$_{FLAT(ON)}$	I$_{COM}$ = 10mA, V$_{NO\_}$ or V$_{NC\_}$ = 0 to V+, V+ = 4.5V	T$_A$ = +25°C		0.5	0.8	Ω
			T$_A$ = T$_{MIN}$ to T$_{MAX}$			1	
Off-Leakage Current (NO_ or NC_) (Note 5)	I$_{NO\_}$, I$_{NC\_}$	V$_{COM}$ = 1V, 4.5V; V$_{NO\_}$ or V$_{NC\_}$ = 4.5V, 1V; V+ = 5.5V	T$_A$ = +25°C	-0.1	0.01	0.1	nA
			T$_A$ = T$_{MIN}$ to T$_{MAX}$	-0.2		0.2	
COM_ Off-Leakage Current (Note 5)	I$_{COM\_(OFF)}$	V$_{COM}$ = 1V, 4.5V; V$_{NO\_}$ or V$_{NC\_}$ = 4.5V, 1V; V+ = 5.5V	T$_A$ = +25°C	-0.1	0.01	0.1	nA
			T$_A$ = T$_{MIN}$ to T$_{MAX}$	-0.2		0.2	
COM_ On-Leakage Current (Note 5)	I$_{COM\_(ON)}$	V+ = 5.5V, V$_{COM}$ = 1V, 4.5V; V$_{NO\_}$ or V$_{NC\_}$ = 1V, 4.5V or floating	T$_A$ = +25°C	-0.1	0.01	0.1	nA
			T$_A$ = T$_{MIN}$ to T$_{MAX}$	-0.2		0.2	
LOGIC INPUT (IN_)							
Input High	V$_{IH}$			2.4			V
Input Low	V$_{IL}$					0.8	V
Logic Input Current	I$_{IN}$			-100	5	100	nA

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Low-Voltage, 4Ω, Quad, SPST, CMOS Analog Switches

ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = 4.5V to 5.5V, V_{IH} = 2.4V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at V+ = 5V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time (Note 5)	t_{ON}	$V_{NO\_}$ = $V_{NC\_}$ = 3V, R_L = 300Ω, C_L = 35pF, Figure 2	T_A = +25°C		11	14	ns
			T_A = T_{MIN} to T_{MAX}			16	
Turn-Off Time (Note 5)	t_{OFF}	$V_{NO\_}$ = $V_{NC\_}$ = 3V, R_L = 300Ω, C_L = 35pF, Figure 2	T_A = +25°C		6	8	ns
			T_A = T_{MIN} to T_{MAX}			10	
Break-Before-Make (MAX4653 only) (Note 5)		$V_{NO\_}$ = $V_{NC\_}$ = 3V, R_L = 300Ω, C_L = 35pF	T_A = +25°C	1	6		ns
			T_A = T_{MIN} to T_{MAX}	1			
Charge Injection	Q	V_{GEN} = 2V, C_L = 1.0nF, R_{GEN} = 0, Figure 3			2		pC
NO_ or NC_ Off-Capacitance	C_{OFF}	$V_{NO\_}$ = $V_{NC\_}$ = GND, f = 1MHz, Figure 6			16		pF
COM_ Off-Capacitance	$C_{COM(OFF)}$	$V_{COM\_}$ = GND, f = 1MHz, Figure 6			16		pF
COM_ On-Capacitance	$C_{COM(ON)}$	$V_{COM\_}$ = $V_{NO\_}$, $V_{NC\_}$ = GND, f = 1MHz, Figure 7			32		pF
Off-Isolation (Note 6)	V_{ISO}	R_L = 50Ω, C_L = 5pF, f = 10MHz, Figure 4			-50		dB
		R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 4			-75		
Crosstalk (Note 7)	V_{CT}	R_L = 50Ω, C_L = 5pF, f = 10MHz, Figure 5			-80		dB
		R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 5			-100		
Total Harmonic Distortion	THD	R_L = 600Ω, f = 20Hz to 20kHz			0.02		%
POWER SUPPLY							
Positive Supply Current	I+	V+ = 5.5V, V_{IN} = 0 or V+			0.001	1.0	µA

ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = 2.7V to 3.3V, V_{IH} = 2.0V, V_{IL} = 0.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at V+ = 3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Input Voltage Range	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$			0		V+	V
COM_ to NO_ or NC_ On-Resistance	R_{ON}	V+ = 2.7V, I_{COM} = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		5	7	Ω
			T_A = T_{MIN} to T_{MAX}			8	
COM_ to NO_ or NC_ On-Resistance Match Between Channels (Note 3)	ΔR_{ON}	V+ = 2.7V, I_{COM} = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		0.1	0.2	Ω
			T_A = T_{MIN} to T_{MAX}			0.3	
On-Resistance Flatness (Note 4)	$R_{FLAT(ON)}$	V+ = 2.7V, I_{COM} = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		1.2	2.5	Ω
			T_A = T_{MIN} to T_{MAX}			3	

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Low-Voltage, 4Ω, Quad, SPST, CMOS Analog Switches

ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(V+ = 2.7V to 3.3V, V_{IH} = 2.0V, V_{IL} = 0.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at V+ = 3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
LOGIC INPUT (IN_)							
Input High	V_{IH}			2.0			V
Input Low	V_{IL}					0.4	V
Logic Input Current	I_{IN}			-100	5	100	nA
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time (Note 5)	t_{ON}	$V_{NO\_}$ = $V_{NC\_}$ = 2V, R_L = 300Ω, C_L = 35pF, Figure 2	T_A = +25°C		13	16	ns
			T_A = T_{MIN} to T_{MAX}			20	
Turn-Off Time (Note 5)	t_{OFF}	$V_{NO\_}$ = $V_{NC\_}$ = 2V, R_L = 300Ω, C_L = 35pF, Figure 2	T_A = +25°C		7	10	ns
			T_A = T_{MIN} to T_{MAX}			12	
Break-Before-Make (MAX4653 only) (Note 5)		$V_{NO\_}$ = $V_{NC\_}$ = 2V, R_L = 300Ω, C_L = 35pF	T_A = +25°C	1	7		ns
			T_A = T_{MIN} to T_{MAX}	1			
Charge Injection	Q	V_{GEN} = 1.5V, C_L = 1.0nF, R_{GEN} = 0, Figure 3			2		pC
NO_ or NC_ Off-Capacitance	C_{OFF}	$V_{NO\_}$ = $V_{NC\_}$ = GND, f = 1MHz, Figure 6			16		pF
COM_ Off-Capacitance	$C_{COM(OFF)}$	$V_{COM\_}$ = GND, f = 1MHz, Figure 6			16		pF
COM_ On-Capacitance	$C_{COM(ON)}$	$V_{COM\_}$ = $V_{NO\_}$, $V_{NC\_}$ = GND, f = 1MHz, Figure 7			32		pF
Off-Isolation (Note 6)	V_{ISO}	R_L = 50Ω, C_L = 5pF, f = 10MHz, Figure 4			-50		dB
		R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 4			-75		
Crosstalk (Note 7)	V_{CT}	R_L = 50Ω, C_L = 5pF, f = 10MHz, Figure 5			-80		dB
		R_L = 50Ω, C_L = 5pF, f = 1MHz, Figure 5			-100		
Total Harmonic Distortion	THD	R_L = 600Ω, f = 20Hz to 20kHz			0.02		%
POWER SUPPLY							
Positive Supply Current	I+	V+ = 3.3V, V_{IN} = 0 or V+			0.001	1.0	µA

Note 2: The algebraic convention, where the most negative value is a minimum and the most positive value is a maximum, is used in this data sheet.
Note 3: ΔR_{ON} = $R_{ON(MAX)}$ - $R_{ON(MIN)}$.
Note 4: Flatness is defined as the difference between the maximum and the minimum value of on-resistance as measured over the specified analog signal ranges.
Note 5: Guaranteed by design.
Note 6: Off-Isolation = $20\log_{10}(V_{COM} / V_{NO})$, where V_{COM} = output and V_{NO} = input to off switch.
**Note 7:** Between any two switches.

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_____Typical Operating Characteristics

(V+ = 5V, T_A = +25°C, unless otherwise noted.)

**ON-RESISTANCE vs. V_COM
AND SUPPLY VOLTAGE**

**ON-RESISTANCE vs. V_COM
AND TEMPERATURE**

**ON-/OFF-LEAKAGE CURRENT
vs. TEMPERATURE**

**SUPPLY CURRENT vs.
SUPPLY VOLTAGE AND TEMPERATURE**

**TURN-ON/TURN-OFF TIMES
vs. TEMPERATURE**

**TURN-ON/TURN-OFF TIMES
vs. SUPPLY VOLTAGE**

TURN-ON/TURN-OFF TIMES vs. V_COM

TURN-ON/TURN-OFF TIMES vs. V_COM

CHARGE INJECTION vs. V_COM
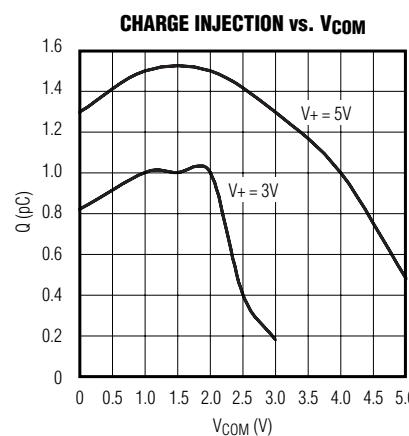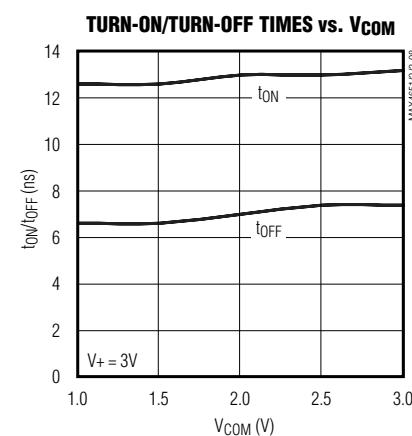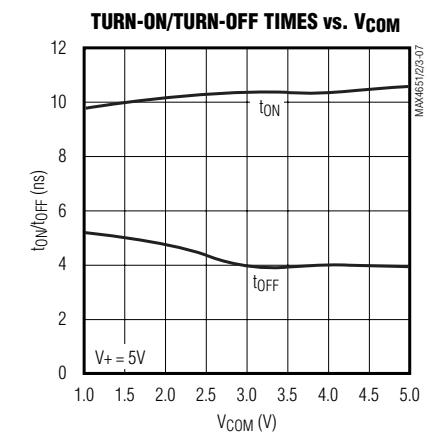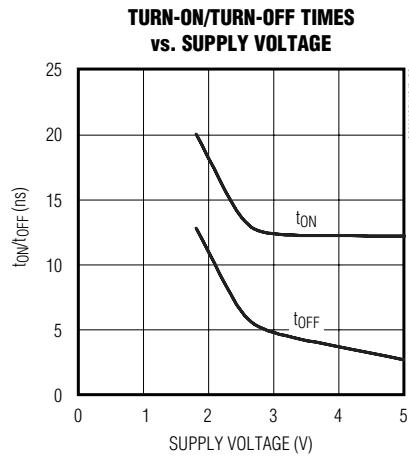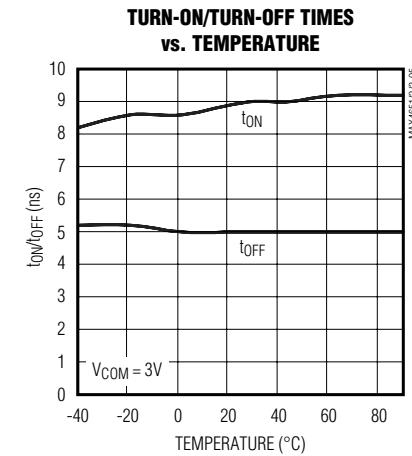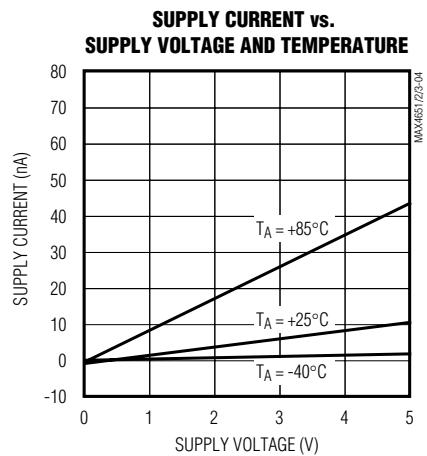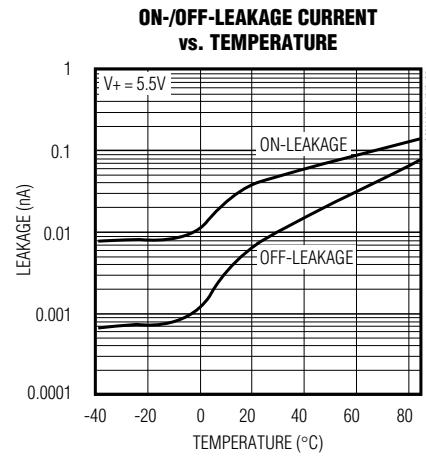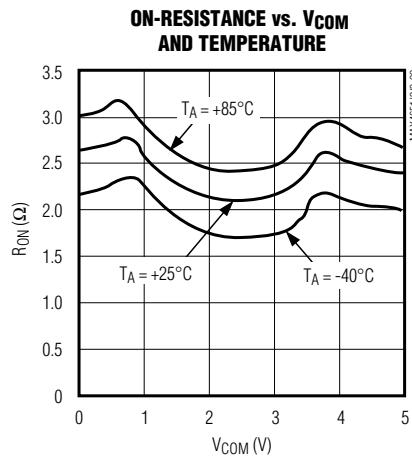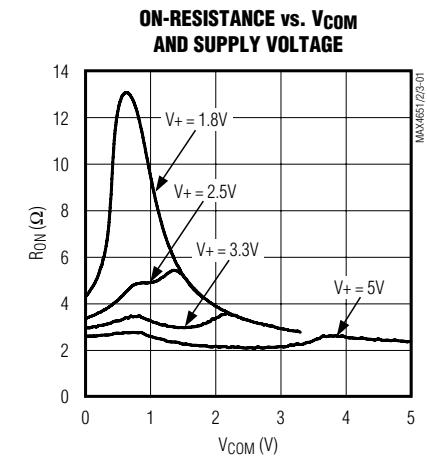
MAX4651/MAX4652/MAX4653

_____Typical Operating Characteristics (continued)

(V+ = 5V, T$_A$ = +25°C, unless otherwise noted.)

FREQUENCY RESPONSE

TOTAL HARMONIC DISTORTION vs. FREQUENCY

MAXIM
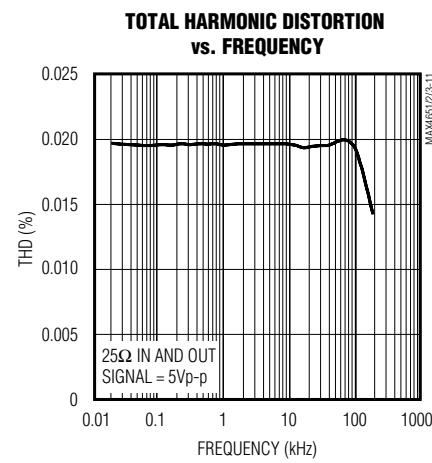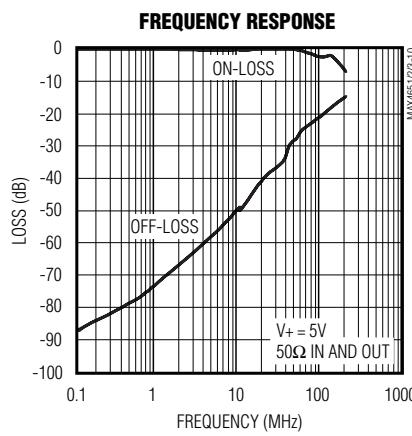
PIN			NAME	FUNCTION
MAX4651	MAX4652	MAX4653		
1	1	1	IN1	Digital Control Input 1
2	2	2	COM1	Analog Switch 1, Common
3	–	–	NC1	Analog Switch 1, Normally Closed
–	3	3	NO1	Analog Switch 1, Normally Open
4, 12	4, 12	4, 12	N.C.	No Connection. Not internally connected.
5	5	5	GND	Ground, Negative Supply Input
6	–	–	NC4	Analog Switch 4, Normally Closed
–	6	6	NO4	Analog Switch 4, Normally Open
7	7	7	COM4	Analog Switch 4, Common
8	8	8	IN4	Digital Control Input 4
9	9	9	IN3	Digital Control Input 3
10	10	10	COM3	Analog Switch 3, Common
11	–	11	NC3	Analog Switch 3, Normally Closed
–	11	–	NO3	Analog Switch 3, Normally Open
13	13	13	V+	Positive Supply Voltage Input
14	–	14	NC2	Analog Switch 2, Normally Closed
–	14	–	NO2	Analog Switch 2, Normally Open
15	15	15	COM2	Analog Switch 2, Common
16	16	16	IN2	Digital Control Input 2

MAX4651/MAX4652/MAX4653

Detailed Description

The MAX4651/MAX4652/MAX4653 are low on-resistance, low-voltage analog switches that operate from a single +1.8V to +5.5V supply. CMOS switch construction allows processing analog signals that are within the supply voltage range (GND to V+).

Applications Information

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings because stresses beyond the listed ratings can cause permanent damage to the devices. Always sequence V+ on first, followed by the logic inputs, NO or COM. If power-supply sequencing is not possible, add two small signal diodes (D1, D2) in series with the supply pins for overvoltage protection (Figure 1). Adding these diodes reduces the analog signal by one diode drop below V+ and one diode drop above GND, but does not affect the devices' low switch resistance and low leakage characteristics. Device operation is unchanged, and the difference between V+ and GND should not exceed 6V.

Although it is not required, power-supply bypassing improves noise margin and prevents switching noise from propagating from the V+ supply to other components. A 0.1µF capacitor connected from V+ to GND is adequate for most applications.
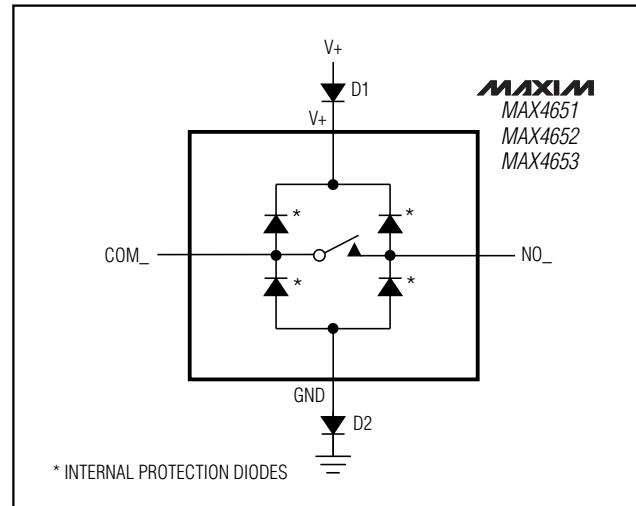

Figure 1. Overvoltage Protection Using External Blocking Diodes

Chip Information

TRANSISTOR COUNT: 205

MAXIM

MAX4651/MAX4652/MAX4653
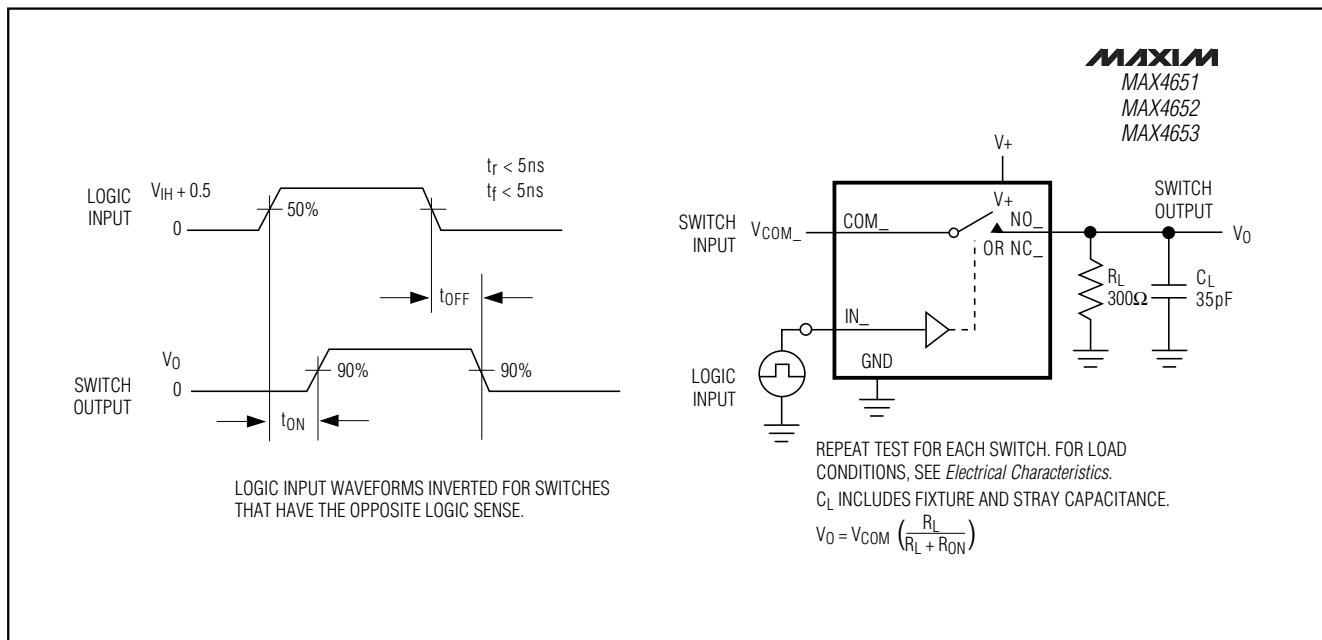
Figure 2. Switching-Time Test Circuit
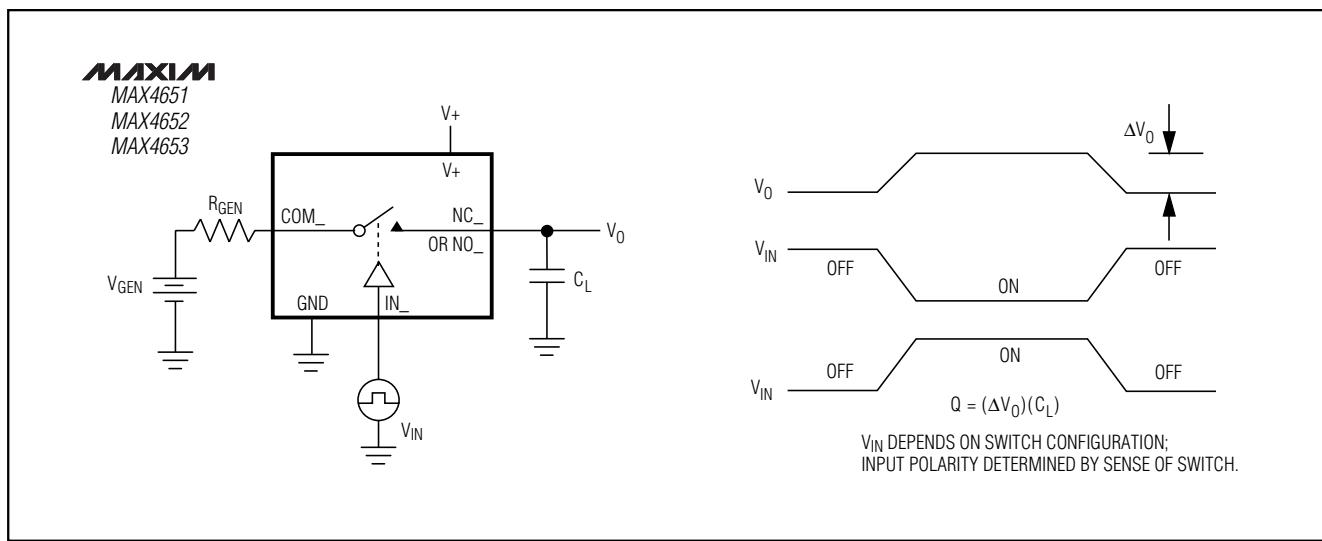
Figure 3. Charge-Injection Test Circuit

# Low-Voltage, 4Ω, Quad, SPST, CMOS Analog Switches
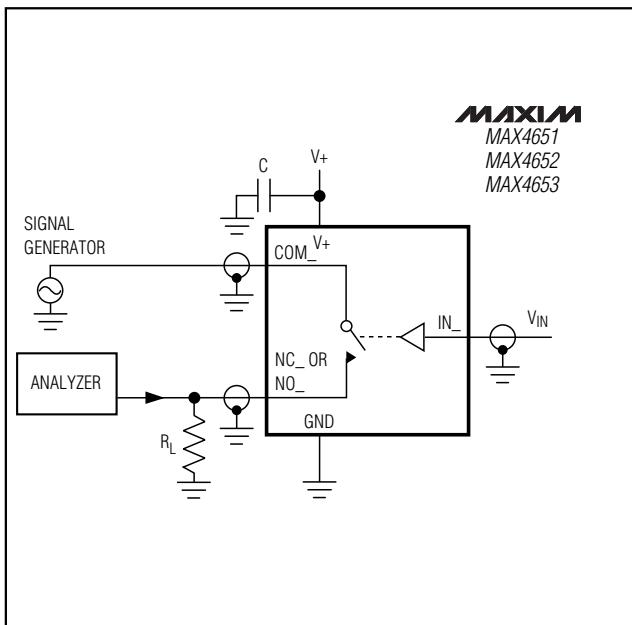
Figure 4. Off-Isolation Test Circuit/On-Channel Bandwidth
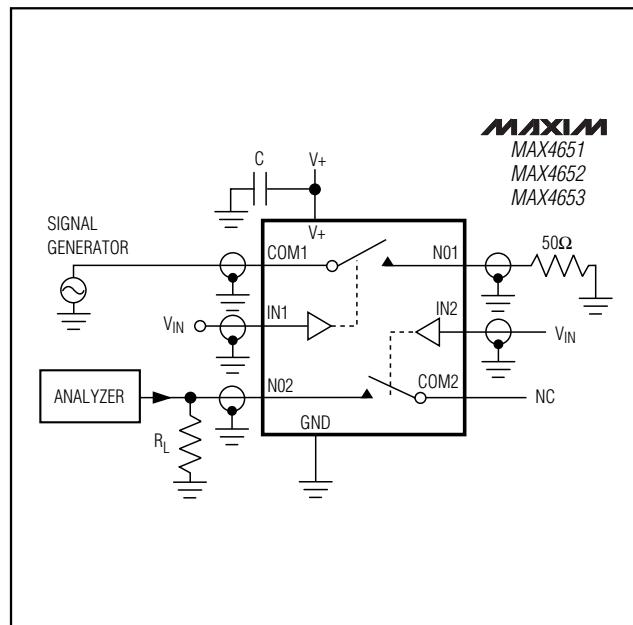
*Figure 5. Crosstalk Test Circuit*
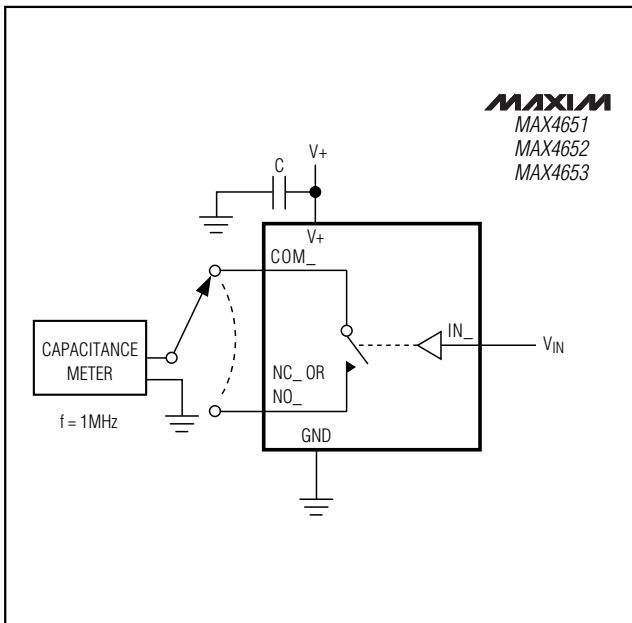

Figure 6. Switch Off-Capacitance Test Circuit
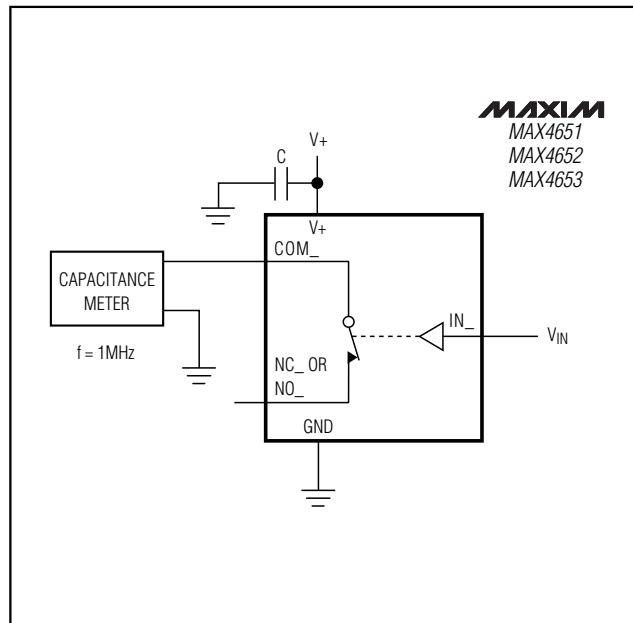
Figure 7. Switch On-Capacitance Test Circuit

Package Information

MAX4651/MAX4652/MAX4653

TSSOP.EPS

TOP VIEW

BOTTOM VIEW

EXPOSED DIE PAD

SIDE VIEW

END VIEW

SEATING PLANE

SEE DETAIL 'A'

DETAIL 'A'

PARTING LINE

0.25 BSC

WITH PLATING

BASE METAL

LEAD TIP DETAIL

COMMON DIMENSIONS

SYMBOL	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	—	1.10		.043
A1	0.05	0.15	.002	.006
A2	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°

VARIATIONS

| JEDEC 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

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

/\/\/\XI/\/

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH

APPROVAL

DOCUMENT CONTROL NO.
21-0066

REV
C

1/1

Note: *The MAX4651/MAX4652/MAX4653 do not come in an exposed-pad package.*

/\/\XI/\/

MAX4651/MAX4652/MAX4653

Package Information (continued)

SOIC4.EPS

	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
120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION

PACKAGE FAMILY OUTLINE: SOIC .150"
TITLE

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21-0041 A
DOCUMENT CONTROL NUMBER   REV.