19-1202; Rev 0; 4/97

MAXIM

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

General Description

The MAX4541–MAX4544 are precision, dual analog switches designed to operate from a single +2.7V to +12V supply. Low power consumption (5µW) makes these parts ideal for battery-powered equipment. These switches offer low leakage currents (100pA max) and fast switching speeds (t_{ON} = 150ns max, t_{OFF} = 100ns max).

When powered from a +5V supply, the MAX4541–MAX4544 offer 2Ω max matching between channels, 60Ω max on-resistance (R_{ON}), and 6Ω max R_{ON} flatness.

These switches also offer 5pC max charge injection and a minimum of 2000V ESD protection per Method 3015.7.

The MAX4541/MAX4542/MAX4543 are single-pole/single-throw (SPST) devices, and the MAX4544 is a single-pole/double-throw (SPDT) device. The MAX4541 has two normally open (NO) switches, and the MAX4542 has two normally closed (NC) switches. The MAX4543 has one NO and one NC switch and can be used as a SPDT, while the MAX4544/MAX4545 are SPDT.

Applications

Battery-Operated Systems	Sample-and-Hold Circuits
Heads-Up Displays	Guidance and Control Systems
Audio and Video Switching	Military Radios
Test Equipment	Communications Systems
+3V/+5V DACs and ADCs	PBX, PABX

Features

- **Low On-Resistance (R_{ON}): 60Ω Max (33Ω typ)**
- **R_{ON} Matching Between Channels: 2Ω Max**
- **R_{ON} Flatness: 6Ω Max**
- **Guaranteed Charge Injection: 5pC Max**
- **Single-Supply Operation (+2.7V to +12V)**
- **Low Power Consumption: <5µW**
- **Low Leakage Current Over Temperature: 10nA Max at +85°C**
- **Fast Switching: t_{ON} = 35ns, t_{OFF} = 25ns**
- **Guaranteed Break-Before-Make (MAX4543/MAX4544 only)**
- **TTL/CMOS-Logic Compatible**
- **Pin Compatible with MAX323–MAX325**
- **MAX4544 Available in SOT23-6**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4541CPA	0°C to +70°C	8 Plastic DIP
MAX4541CSA	0°C to +70°C	8 SO
MAX4541CUA	0°C to +70°C	8 µMAX
MAX4541C/D	0°C to +70°C	Dice*
MAX4541EPA	-40°C to +85°C	8 Plastic DIP
MAX4541ESA	-40°C to +85°C	8 SO
MAX4541EUA	-40°C to +85°C	8 µMAX

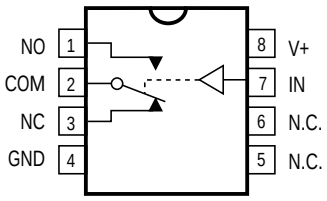
Ordering Information continued at end of data sheet.

**Dice are tested at T_A = +25°C.*

Pin Configurations/Functional Diagrams/Truth Tables

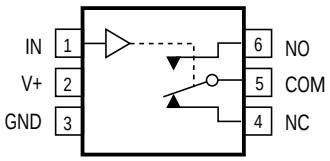
TOP VIEW

MAXIM
MAX4544



DIP/SO/µMAX

MAXIM
MAX4544

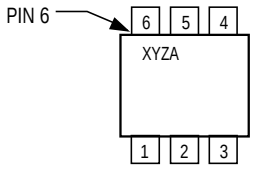


SOT23-6*

MAX4544		
LOGIC	**NC**	**NO**
0	ON	OFF
1	OFF	ON

SWITCHES SHOWN FOR "0" INPUT

MAXIM
MAX4544



*NOTE: SOT23-6 PACKAGE HAS LETTERING NEAREST PIN 6

N.C. = NOT INTERNALLY CONNECTED

MAX4541/MAX4542/MAX4543 SHOWN AT END OF DATA SHEET.

ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to GND
V+ .....-0.3V to +13V
IN_, COM_, NC_, NO_ (Note 1).....-0.3V to (V+ + 0.3V)
Continuous Current (any terminal).....±10mA
Peak Current, COM_, NO_, NC_
(pulsed at 1ms, 10% duty cycle max).....±20mA
ESD per Method 3015.7 .....>2000V
Continuous Power Dissipation
Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
Narrow SO (derate 5.88mW/°C above +70°C) 471mW
µMAX (derate 4.10mW/°C above +70°C) 330mW
SOT23-6 (derate 7.1mW/°C above +70°C).....571mW
Operating Temperature Ranges
MAX454_C_ _ .....0°C to +70°C
MAX454_E_ _.....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: Signals on NC, NO, COM, or IN exceeding V+ or V- are clamped by internal diodes. Limit forward diode current to maximum current rating.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = 5V ±10%, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 9)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH								
Analog Signal Range	V_{COM}, V_{NO}, V_{NC}	(Note 3)			0		V+	V
On-Resistance	R_{ON}	V+ = 4.5V, I_{COM} = 1.0mA, V_{NO} or V_{NC} = 3.5V	T_A = +25°C			30	60	Ω
			T_A = T_{MIN} to T_{MAX}				75	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	V+ = 5V, I_{COM} = 1.0mA, V_{NO} or V_{NC} = 3.5V	T_A = +25°C			0.8	2	Ω
			T_A = T_{MIN} to T_{MAX}				4	
On-Resistance Flatness (Notes 3, 5)	$R_{FLAT(ON)}$	V+ = 5V, I_{COM} = 1.0mA, V_{NO} or V_{NC} = 1V, 2V, 3V	T_A = +25°C			2	6	Ω
			T_A = T_{MIN} to T_{MAX}				8	
NO or NC Off Leakage Current (Note 6)	$I_{NO(OFF)}$ or $I_{NC(OFF)}$	V+ = 5.5V; V_{COM} = 1V, 4.5V; V_{NO} or V_{NC} = 4.5V, 1V	T_A = +25°C		-0.1	0.01	0.1	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-5		5	
COM Off Leakage Current (Note 6)	$I_{COM(OFF)}$	V+ = 5.5V; V_{COM} = 4.5V, 1V; V_{NO} or V_{NC} = 1V, 4.5V	T_A = +25°C		-0.1		0.1	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-5		5	
COM On Leakage Current (Note 6)	$I_{COM(ON)}$	V+ = 5.5V, V_{COM} = 1V, 4.5V or V_{NO} or V_{NC} = 1V, 4.5V	T_A = +25°C		-0.2		0.2	nA
			T_A = T_{MIN} to T_{MAX}	C, E	-10		10	

ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = 5V ±10%, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 9)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
DYNAMIC							
Turn-On Time	t_{ON}	V_{NO} or V_{NC} = 3V	T_A = +25°C		35	100	ns
			T_A = T_{MIN} to T_{MAX}			240	
Turn-Off Time	t_{OFF}	V_{NO} or V_{NC} = 3V	T_A = +25°C		25	75	ns
			T_A = T_{MIN} to T_{MAX}			150	
Break-Before-Make Time Delay (Note 3)	t_D	MAX4543/MAX4544 only, R_L = 300Ω, C_L = 35pF		2	10		ns
Charge Injection (Note 3)	Q	C_L = 1.0nF, V_{GEN} = 0V, R_{GEN} = 0V, T_A = +25°C, Figure 4			1	5	pC
Off Isolation (Note 7)	OIRR	R_L = 50Ω, C_L = 5pF, f = 1MHz, T_A = +25°C, Figure 5			-76		dB
Crosstalk (Note 8)		R_L = 50Ω, C_L = 5pF, f = 1MHz, T_A = +25°C, Figure 6			-90		dB
NC or NO Capacitance	C_{OFF}	f = 1MHz, T_A = +25°C, Figure 7			8		pF
COM Off Capacitance	$C_{COM(OFF)}$	f = 1MHz, T_A = +25°C, Figure 7			8		pF
COM On Capacitance	$C_{COM(ON)}$	f = 1MHz, T_A = +25°C, Figure 8	MAX4541/2/3		13		pF
			MAX4544		20		
SUPPLY							
Power-Supply Range	V+			2.7		12	V
Positive Supply Current	I+	V+ = 5.5V, V_{IN} = 0V or V+, all channels on or off		-1	0.0001	1	µA
LOGIC INPUT							
Input Voltage Low	V_{INL}					0.8	V
Input Voltage High	V_{INH}			2.4			V

ELECTRICAL CHARACTERISTICS—Single +3.3V Supply

(V+ = 3.0V to 3.6V, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 9)

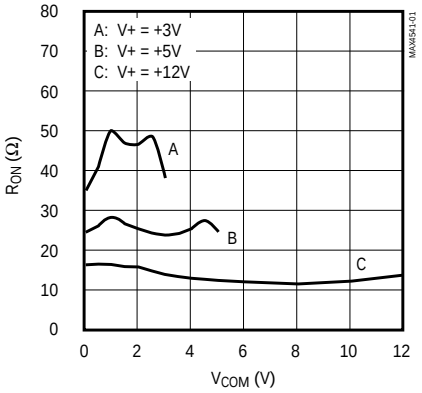
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	V_{COM}, V_{NO}, V_{NC}	(Note 3)		0		V+	V
Channel On-Resistance	R_{ON}	V+ = 3V, I_{COM} = 1.0mA, V_{NO} or V_{NC} = 1.5V	T_A = +25°C		50	125	Ω
			T_A = T_{MIN} to T_{MAX}			275	
DYNAMIC							
Turn-On Time (Note 3)	t_{ON}	V_{NO} or V_{NC} = 1.5V	T_A = +25°C		80	400	ns
			T_A = T_{MIN} to T_{MAX}			500	
Turn-Off Time (Note 3)	t_{OFF}	V_{NO} or V_{NC} = 1.5V	T_A = +25°C		50	125	ns
			T_A = T_{MIN} to T_{MAX}			175	
Break-Before-Make Time Delay (Note 3)	t_D	MAX4543/MAX4544 only, R_L = 300Ω, C_L = 35pF	T_A = +25°C	2	30		ns
Charge Injection (Note 3)	Q	C_L = 1.0nF, V_{GEN} = 0V, R_{GEN} = 0V	T_A = +25°C		1	5	pC
SUPPLY							
Positive Supply Current	I+	V+ = 3.6V, V_{IN} = 0V or V+, all channels on or off		-1		1	µA

Note 2: The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.
Note 3: Guaranteed by design.
Note 4: $\Delta R_{ON} = \Delta R_{ON}$ max - ΔR_{ON} min.
Note 5: Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.
Note 6: Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.
Note 7: Off Isolation = 20 $\log_{10}$ [V_{COM} / (V_{NC} or V_{NO})], V_{COM} = output, V_{NC} or V_{NO} = input to off switch.
Note 8: Between the two switches.
Note 9: SOT packaged parts are 100% tested at +25°C only and guaranteed by correlation at the full hot rated temperature.

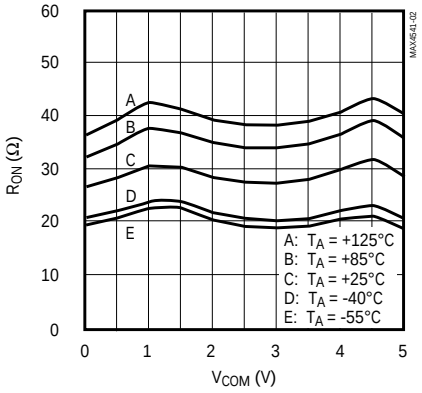
Typical Operating Characteristics

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

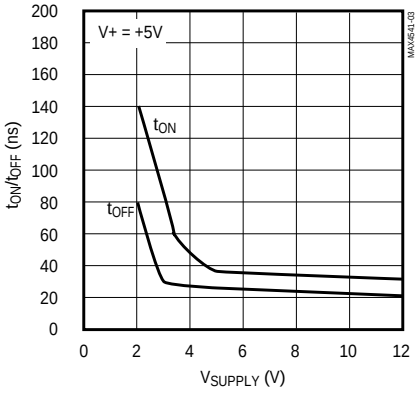
ON-RESISTANCE vs. COM VOLTAGE



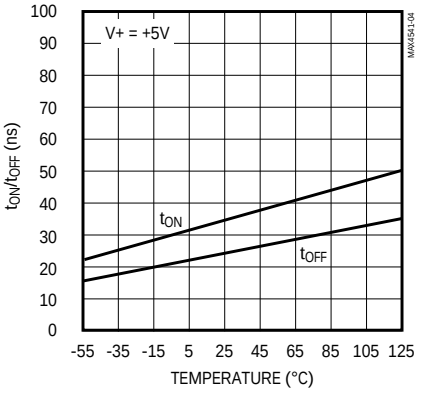
ON-RESISTANCE vs. COM VOLTAGE OVER TEMPERATURE



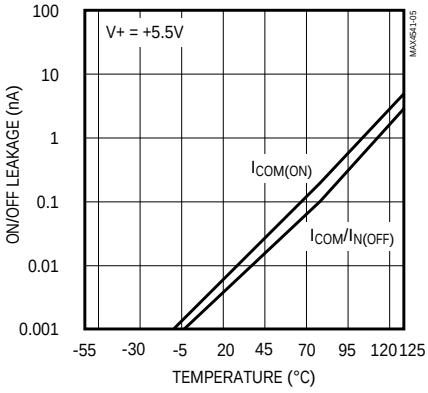
TURN-ON/OFF TIMES vs. SUPPLY VOLTAGE



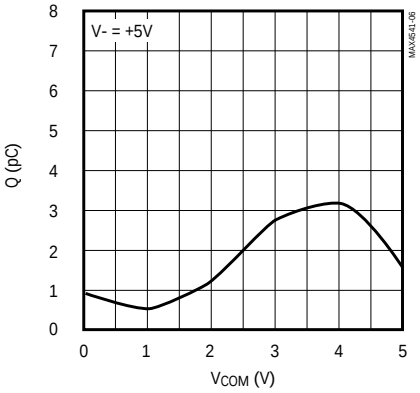
TURN-ON/OFF TIMES vs. TEMPERATURE



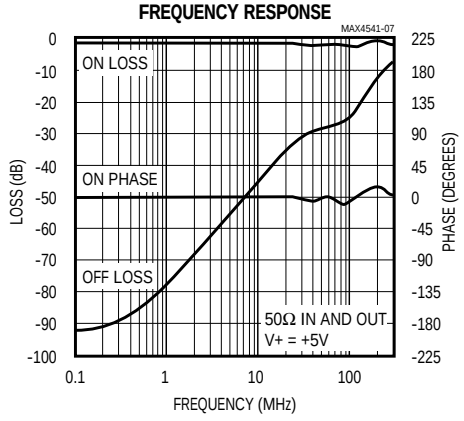
ON/OFF LEAKAGE CURRENT vs. TEMPERATURE



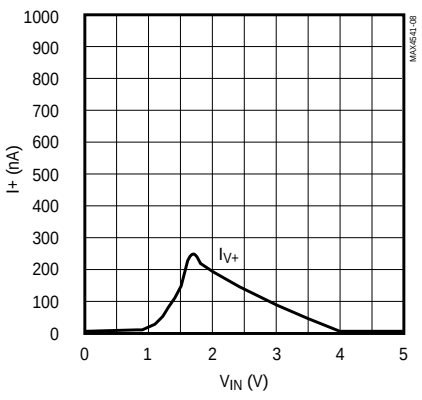
CHARGE INJECTION vs. COM VOLTAGE



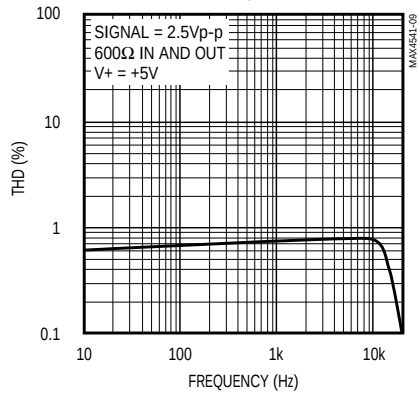
FREQUENCY RESPONSE



INPUT VOLTAGE vs. SUPPLY CURRENT



TOTAL HARMONIC DISTORTION vs. FREQUENCY



Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Pin Description

MAX4541	MAX4542	MAX4543	MAX4544 DIP/SO/µMAX	MAX4544 SOT23-6	NAME	FUNCTION
1	—	1	—	—	NO1	Analog Switch 1—Normally Open
2	2	2	—	—	COM1	Analog Switch 1—Common
3	3	3	—	—	IN2	Digital Control Input 2
4	4	4	4	3	GND	Ground—Negative Supply Input
5	—	—	—	—	NO2	Analog Switch 2—Normally Open
6	6	6	—	—	COM2	Analog Switch 2—Common
7	7	7	—	—	IN1	Digital Control Input 1
8	8	8	8	2	V+	Positive Supply Voltage Input
—	1	—	—	—	NC1	Analog Switch 1—Normally Closed
—	5	5	—	—	NC2	Analog Switch 2—Normally Closed
—	—	—	1	6	NO	Analog Switch—Normally Open
—	—	—	2	5	COM	Analog Switch—Common
—	—	—	3	4	NC	Analog Switch—Normally Closed
—	—	—	5, 6	—	N.C.	Not Connected (open circuit)
—	—	—	7	1	IN	Digital Control Input

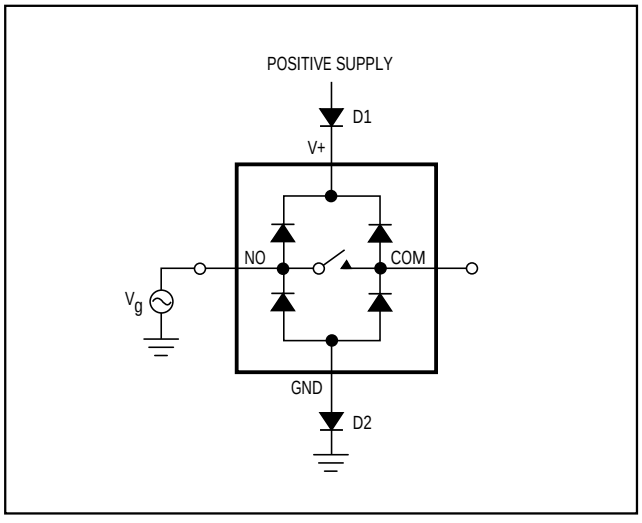


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

Applications Information

Logic Levels

The MAX4541–MAX4544 are TTL compatible when powered from a single +5V supply. When powered from other supply voltages, TTL compatibility is guaranteed, and the logic inputs can be driven from Rail-to-Rail®. For example, with a +12V supply, IN1 and IN2 can be driven low to 0V and high to 12V. With a +3.3V supply, IN1 and IN2 should be driven low to 0V and high to 3.3V.

Driving IN1 and IN2 rail-to-rail minimizes power consumption.

Analog Signal Levels

Analog signals that range over the entire supply voltage (V+ to GND) can be switched with very little change in on-resistance over the entire voltage range (see *Typical Operating Characteristics*). All the switches are bidirectional, so the NO_, NC_, and COM_ pins can be used as either inputs or outputs.

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

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 <10mA, 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.

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.

Test Circuits/Timing Diagrams

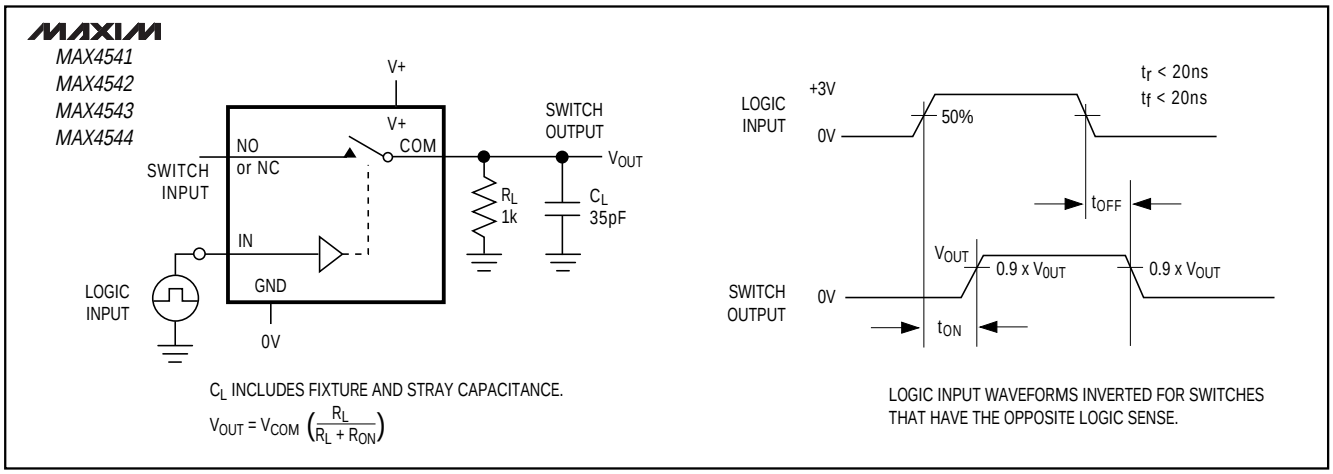


Figure 2. Switching Time

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Test Circuits/Timing Diagrams (continued)

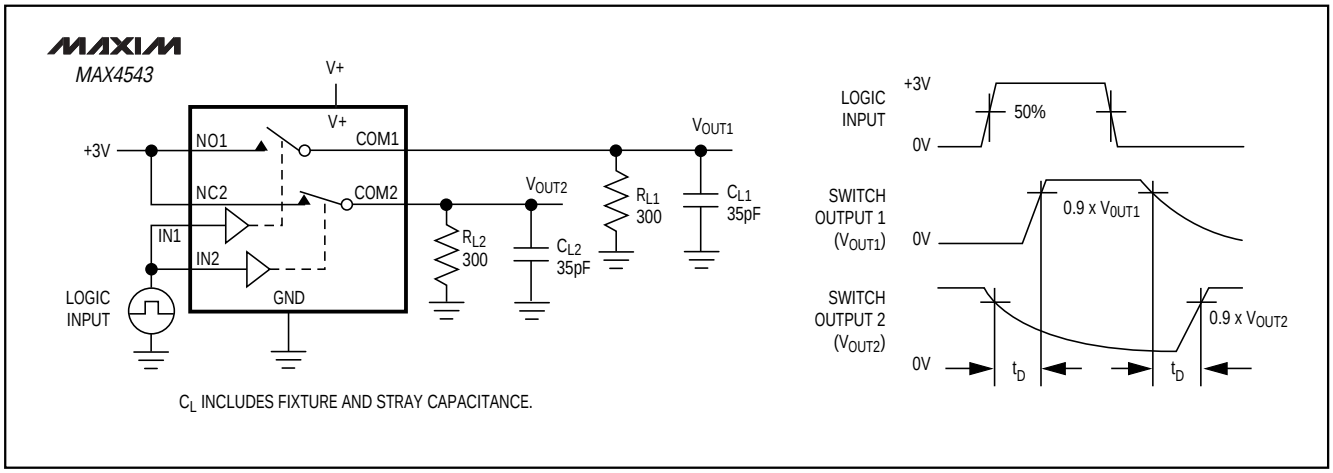


Figure 3a. Break-Before-Make Interval (MAX4543 only)

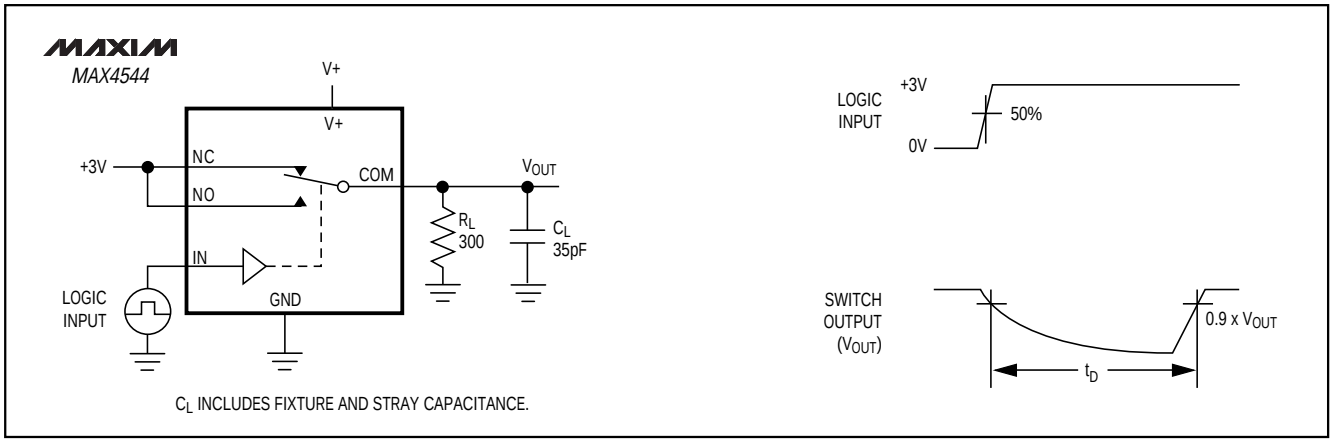


Figure 3b. Break-Before-Make Interval (MAX4544 only)

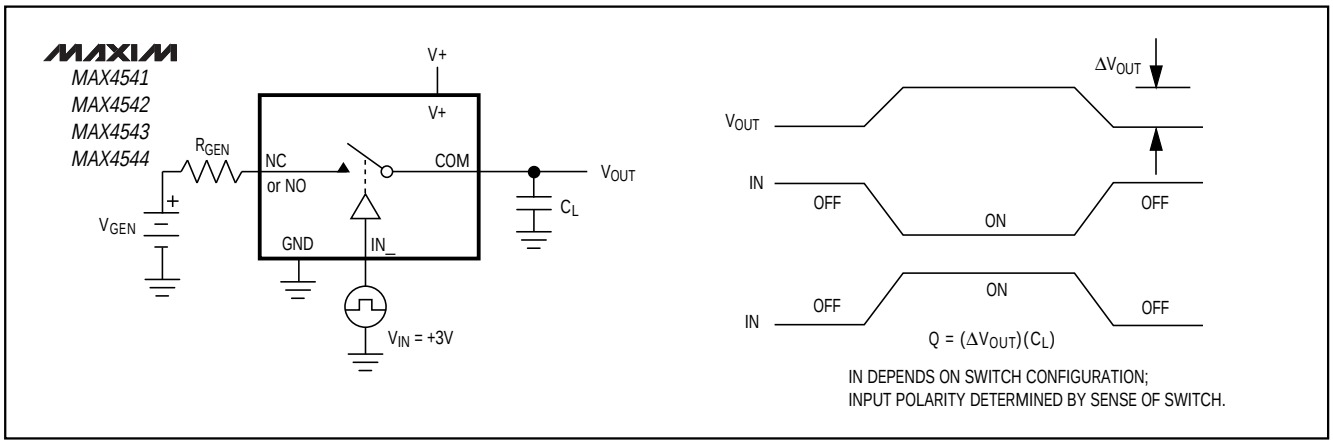


Figure 4. Charge Injection

Test Circuits/Timing Diagrams (continued)

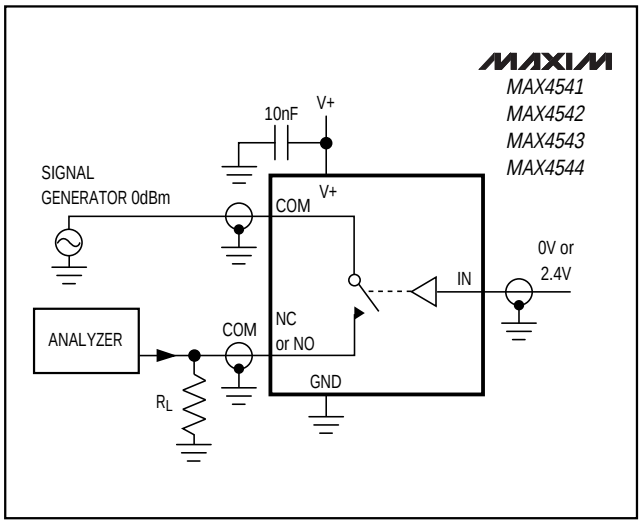


Figure 5. Off Isolation

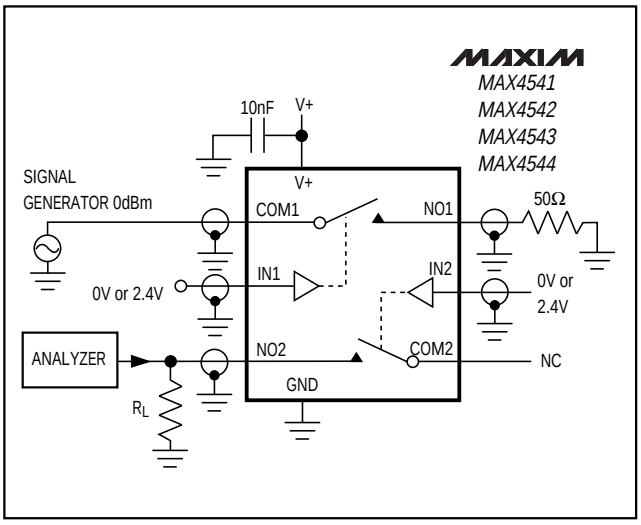


Figure 6. Crosstalk

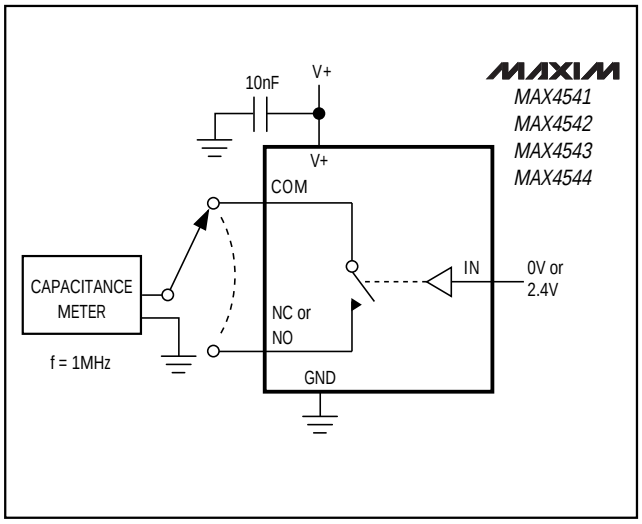


Figure 7. Channel Off/On Capacitance

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

_Ordering Information (continued)

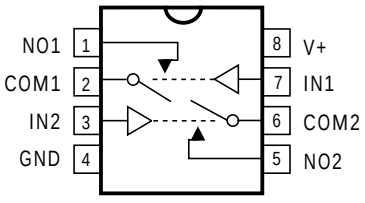
PART	TEMP. RANGE	PIN-PACKAGE
MAX4542CPA	0°C to +70°C	8 Plastic DIP
MAX4542CSA	0°C to +70°C	8 SO
MAX4542CUA	0°C to +70°C	8 µMAX
MAX4542C/D	0°C to +70°C	Dice*
MAX4542EPA	-40°C to +85°C	8 Plastic DIP
MAX4542ESA	-40°C to +85°C	8 SO
MAX4542EUA	-40°C to +85°C	8 µMAX
MAX4543CPA	0°C to +70°C	8 Plastic DIP
MAX4543CSA	0°C to +70°C	8 SO
MAX4543CUA	0°C to +70°C	8 µMAX
MAX4543C/D	0°C to +70°C	Dice*
MAX4543EPA	-40°C to +85°C	8 Plastic DIP
MAX4543ESA	-40°C to +85°C	8 SO
MAX4543EUA	-40°C to +85°C	8 µMAX
MAX4544CPA	0°C to +70°C	8 Plastic DIP
MAX4544CSA	0°C to +70°C	8 SO
MAX4544CUA	0°C to +70°C	8 µMAX
MAX4544C/D	0°C to +70°C	Dice*
MAX4544EPA	-40°C to +85°C	8 Plastic DIP
MAX4544ESA	-40°C to +85°C	8 SO
MAX4544EUA	-40°C to +85°C	8 µMAX
MAX4544EUT-T	-40°C to +85°C	6 SOT23

**Dice are tested at T_A = +25°C.*

_____Pin Configurations/Functional Diagrams/Truth Tables (continued)

TOP VIEW

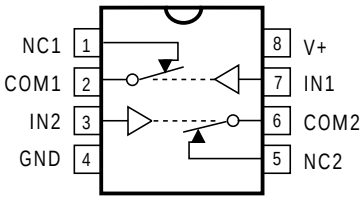
MAX4541



DIP/SO/µMAX

MAX4541	
LOGIC	SWITCH
0	OFF
1	ON

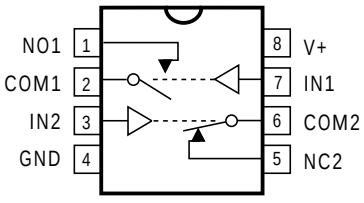
MAX4542



DIP/SO/µMAX

MAX4542	
LOGIC	SWITCH
0	ON
1	OFF

MAX4543



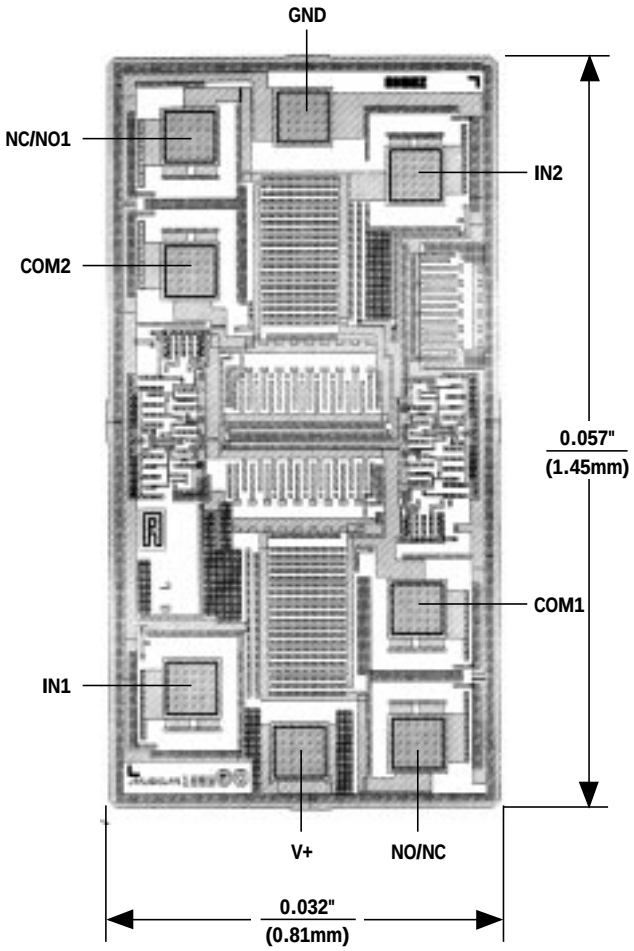
DIP/SO/µMAX

MAX4543		
LOGIC	SWITCH 1	SWITCH 2
0	OFF	ON
1	ON	OFF

SWITCHES SHOWN FOR LOGIC "0" INPUT

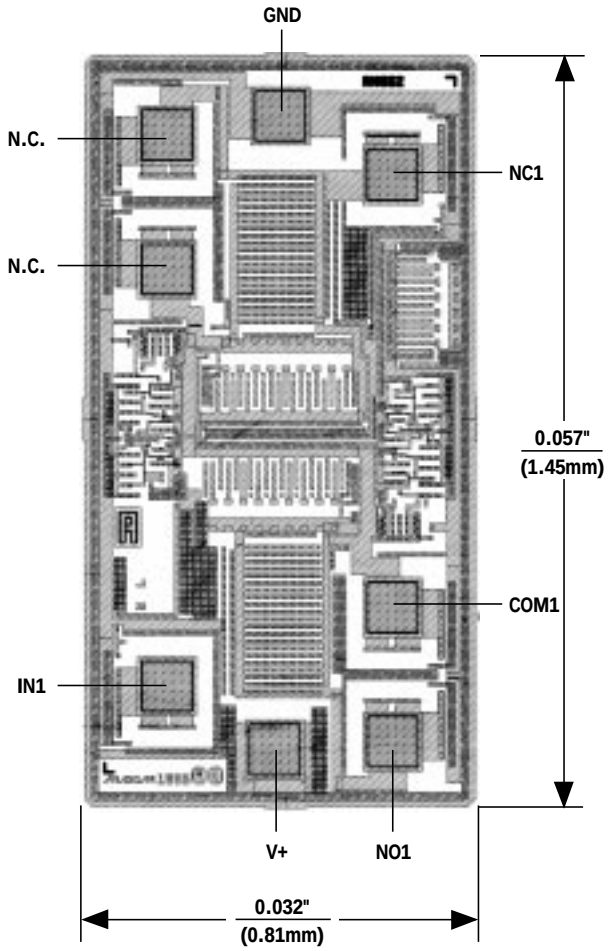
Chip Topographies

MAX4541/2/3



TRANSISTOR COUNT: 76
SUBSTRATE CONNECTED TO V+

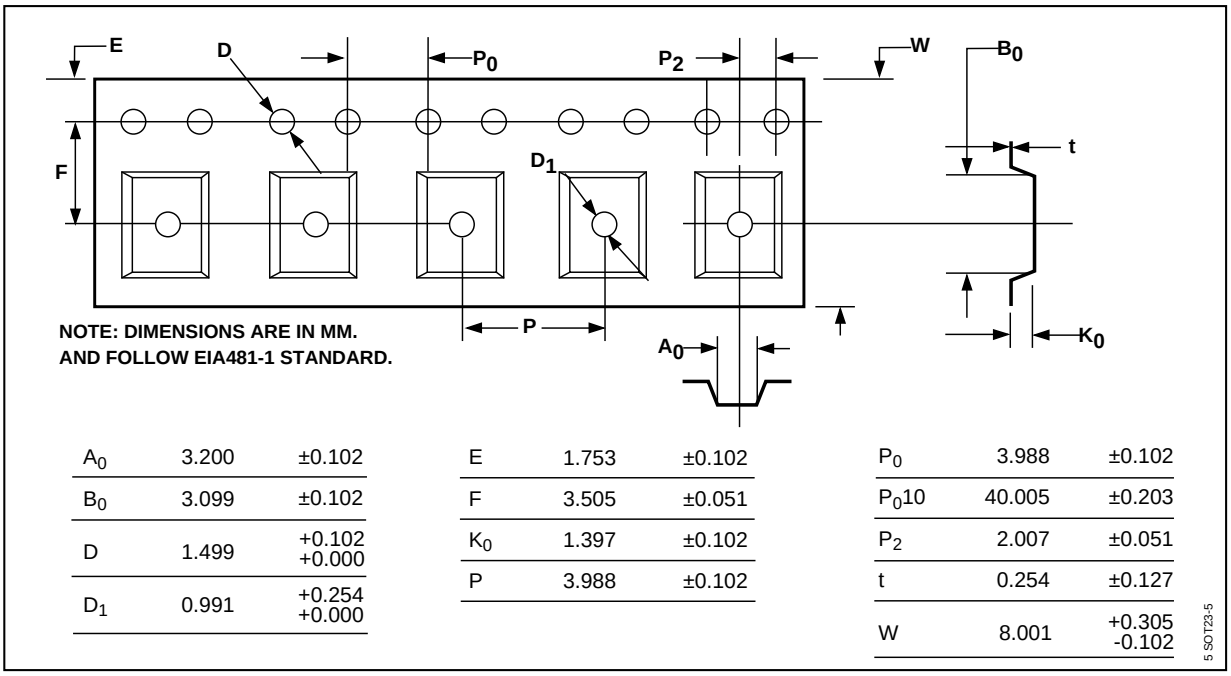
MAX4544



TRANSISTOR COUNT: 76
SUBSTRATE CONNECTED TO V+

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Tape-and-Reel Information

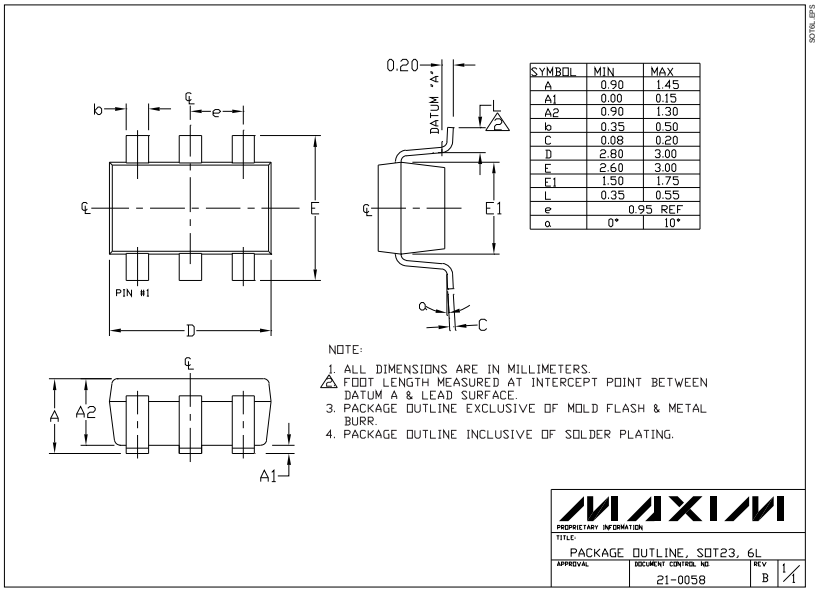


A_0	3.200	±0.102
B_0	3.099	±0.102
D	1.499	+0.102 +0.000
D_1	0.991	+0.254 +0.000

E	1.753	±0.102
F	3.505	±0.051
K_0	1.397	±0.102
P	3.988	±0.102

P_0	3.988	±0.102
$P_0$10	40.005	±0.203
P_2	2.007	±0.051
t	0.254	±0.127
W	8.001	+0.305 -0.102

Package Information



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