19-2184; Rev 0; 10/01

MAXIM

10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

General Description

Maxim's MAX312L/MAX313L/MAX314L analog switches feature low on-resistance (10Ω max) and 1.5Ω on-resistance matching between channels. These switches are +3V logic compatible when powered from ±15V or +12V supplies. The switches conduct equally well in either direction, and offer low leakage over temperature (2.5nA at +85°C).

The MAX312L/MAX313L/MAX314L are quad, single-pole/single-throw (SPST) analog switches. The MAX312L is normally closed (NC), and the MAX313L is normally open (NO). The MAX314L has two NC switches and two NO switches. All three devices operate from a single +4.5V to +36V supply or from dual ±4.5V to ±20V, and are available in 16-pin TSSOP, SO, and DIP packages.

Applications

Test Equipment

Communication Systems

PBX, PABX Systems

Audio Signal Routing

Avionics

Sample-and-Hold Circuits

Data-Acquisition Systems

xDSL Modems

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

Features

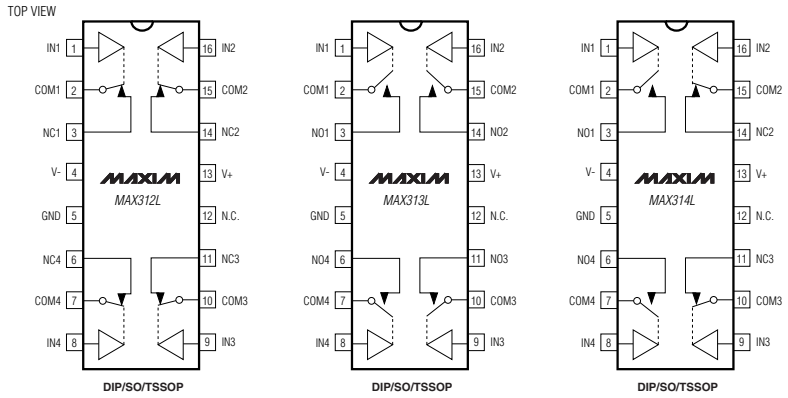
- **+3V Logic-Compatible Digital Inputs**
  V_{IH} = 2.0V
  V_{IL} = 0.8V
- **Pin Compatible with MAX312/MAX313/MAX314 and DG411/DG412/DG413**
- **Low On-Resistance (10Ω max)**
- **Guaranteed R_{ON} Match Between Channels (1.5Ω max)**
- **Guaranteed R_{ON} Flatness over Specified Signal Range (2Ω max)**
- **Crosstalk > 96dB at 20kHz**
- **Single-Supply Operation: +4.5V to +36V Dual-Supply Operation: ±4.5V to ±20V**
- **Rail-to-Rail® Signal Handling**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX312LCUE	0°C to +70°C	16 TSSOP
MAX312LCSE	0°C to +70°C	16 Narrow SO
MAX312LCPE	0°C to +70°C	16 Plastic DIP
MAX312LEUE	-40°C to +85°C	16 TSSOP
MAX312LESE	-40°C to +85°C	16 Narrow SO
MAX312LEPE	-40°C to +85°C	16 Plastic DIP

Ordering Information continued at end of data sheet.

Pin Configurations



MAX312L	
LOGIC	SWITCH
0	ON
1	OFF

MAX313L	
LOGIC	SWITCH
0	OFF
1	ON

SWITCHES SHOWN FOR LOGIC "0" INPUT

MAX314L		
LOGIC	SWITCHES 1, 4	SWITCHES 2, 3
0	OFF	ON
1	ON	OFF

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)
V+ .....-0.3V to +44V
V- .....+0.3V to -44V
V+ to V-.....-0.3V to +44V
$V_{IN_}$ to V- .....-0.3V to +44V
All Other Pins (Note 1).....(V- - 0.3V) to (V+ + 0.3V)
Continuous Current (COM_, NO_, NC_) .....±100mA
Peak Current (COM_, NO_, NC_)
(pulsed at 1ms, 10% duty cycle max).....±300mA

Continuous Power Dissipation (T_A = +70°C)
TSSOP (derate 6.7mW/°C above +70°C) 457mW
Narrow SO (derate 8.70mW/°C above +70°C) 696mW
Plastic DIP (derate 10.53mW/°C above +70°C) 842mW
Operating Temperature Ranges
MAX31_LC_E .....0°C to +70°C
MAX31_LE_E .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Junction Temperature.....+150°C
Lead Temperature (soldering, 10s).....+300°C

Note 1: Signals on COM_, NO_, or NC_ 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—Dual Supplies

(V+ = +15V, V- = -15V, GND = 0, V_{IH} = 2.0V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM_}$, $V_{NO_}$, $V_{NC_}$			V-		V+	V
On-Resistance	R_{ON}	$I_{COM_}$ = 10mA, $V_{NO_}$ or $V_{NC_}$ = ±10V	+25°C		6.5	10	Ω
			T_{MIN} to T_{MAX}			15	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	$I_{COM_}$ = 10mA, $V_{NO_}$ or $V_{NC_}$ = ±10V	+25°C		0.3	1.5	Ω
			T_{MIN} to T_{MAX}			3	
On-Resistance Flatness (Note 5)	$R_{FLAT(ON)}$	$I_{COM_}$ = 10mA, $V_{NO_}$ or $V_{NC_}$ = -5V, 0, 5V	+25°C		0.2	2	Ω
			T_{MIN} to T_{MAX}			4	
Off-Leakage Current (NO_ or NC_) (Note 6)	I_{NO} I_{NC}	$V_{COM_}$ = ∓10V, $V_{NO_}$ or $V_{NC_}$ = ±10V	+25°C	-0.5	-0.02	0.5	nA
			T_{MIN} to T_{MAX}	-2.5		2.5	
COM Off-Leakage Current (Note 6)	$I_{COM(OFF)}$	$V_{COM_}$ = ±10V, $V_{NO_}$ or $V_{NC_}$ = ∓10V	+25°C	-0.5	-0.02	0.5	nA
			T_{MIN} to T_{MAX}	-2.5		2.5	
COM On-Leakage Current (Note 6)	$I_{COM(ON)}$	$V_{NO_}$ or $V_{NC_}$ = ±10V, $V_{COM_}$ = ±10V	+25°C	-1	-0.04	1	nA
			T_{MIN} to T_{MAX}	-5		5	
DYNAMIC							
Turn-On Time	t_{ON}	$V_{COM_}$ = ±10V, R_L = 300Ω, C_L = 35pF, Figure 1	+25°C		115	225	ns
			T_{MIN} to T_{MAX}			275	
Turn-Off Time	t_{OFF}	$V_{COM_}$ = ±10V, R_L = 300Ω, C_L = 35pF, Figure 1	+25°C		100	185	ns
			T_{MIN} to T_{MAX}			235	
Break-Before-Make Time Delay (MAX314L only, Note 7)	t_D	R_L = 300Ω, C_L = 35pF, Figure 2	+25°C	1	10		ns
Charge Injection (Note 7)	Q	V_{GEN} = 0, R_{GEN} = 0, C_L = 1.0nF, Figure 3	+25°C	-30	20	30	pC

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, GND = 0, V_{IH} = 2.0V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
Off-Isolation (Note 8)	V_{ISO}	f = 1MHz, R_L = 50Ω, C_L = 5pF, Figure 4	+25°C		-75		dB
Crosstalk (Note 9)	V_{CT}	f = 1MHz, R_L = 50Ω, C_L = 5pF, Figure 5	+25°C		-85		dB
NC_ or NO_ Off-Capacitance	C_{OFF}	f = 1MHz, Figure 6	+25°C		15		pF
COM_ Off-Capacitance	$C_{COM_(OFF)}$	f = 1MHz, Figure 6	+25°C		15		pF
On-Capacitance	C_{ON}	f = 1MHz, Figure 6	+25°C		47		pF
LOGIC INPUT							
Input Logic High	V_{IH}			2.0			V
Input Logic Low	V_{IL}					0.8	V
Input Current with Input Logic High	I_{INH}	IN_ = 2.0V		-0.5	0.005	0.5	µA
Input Current with Input Logic Low	I_{INL}	IN_ = 0.8V		-0.5	0.005	0.5	µA
POWER SUPPLY							
Power-Supply Range	V+, V-			±4.5		±20.0	V
Positive Supply Current	I+	V+ = +16.5V, V- = -16.5V, V_{IN} = 0 or V+	+25°C		0.01	1	µA
			T_{MIN} to T_{MAX}			5	
		V+ = +16.5V, V- = -16.5V, V_{IN} = 5V	+25°C		130	200	
			T_{MIN} to T_{MAX}			300	
Negative Supply Current	I-	V+ = +16.5V, V- = -16.5V, V_{IN} = 0 or 5V	+25°C			1	µA
			T_{MIN} to T_{MAX}			5	
Ground Current	I_{GND}	V+ = +16.5V, V- = -16.5V, V_{IN} = 0 or V+	+25°C		0.01	1	µA
			T_{MIN} to T_{MAX}			5	
		V+ = +16.5V, V- = -16.5V, V_{IN} = 5V	+25°C		130	200	
			T_{MIN} to T_{MAX}			300	

ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = +12V, V- = 0, GND = 0, V_{IH} = 2.0V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM_}$, $V_{NO_}$, $V_{NC_}$			0		V+	V
On-Resistance	R_{ON}	$I_{COM_}$ = 10mA, $V_{NC_}$ or $V_{NO_}$ = +10V	+25°C		12.5	25	Ω
			T_{MIN} to T_{MAX}			35	

10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

ELECTRICAL CHARACTERISTICS—Single Supply (continued)

(V+ = +12V, V- = 0, GND = 0, V_{IH} = 2.0V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 2, 3)

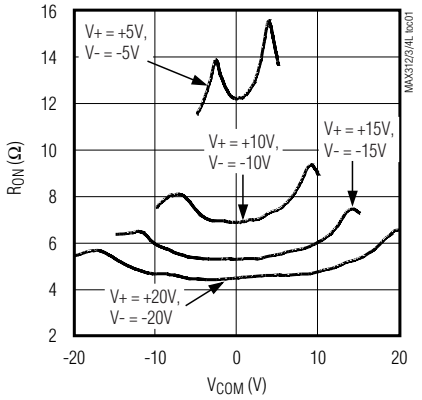
PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	$I_{COM_}$ = 10mA, $V_{NO_}$ or $V_{NC_}$ = +10V	+25°C		0.3	2	Ω
			T_{MIN} to T_{MAX}			2.5	
On-Resistance Flatness (Note 5)	$R_{FLAT(ON)}$	$I_{COM_}$ = 10mA, $V_{NO_}$ or $V_{NC_}$ = +2V, +6V, +10V	+25°C		1.7	3.5	Ω
			T_{MIN} to T_{MAX}			4.5	
DYNAMIC							
Turn-On Time	t_{ON}	$V_{COM_}$ = 8V, R_L = 300Ω, C_L = 35pF, Figure 1	+25°C		165	325	ns
			T_{MIN} to T_{MAX}			425	
Turn-Off Time	t_{OFF}	$V_{COM_}$ = 8V, R_L = 300Ω, C_L = 35pF, Figure 1	+25°C		117	175	ns
			T_{MIN} to T_{MAX}			225	
Break-Before-Make Time Delay (MAX314L only, Note 7)	t_D	R_L = 300Ω, C_L = 35pF, Figure 2	+25°C	1	5		ns
Charge Injection	Q	Figure 3, C_L = 1.0nF, V_{GEN} = 0, R_{GEN} = 0,	+25°C		-10		pC
LOGIC INPUT							
Input Logic High	V_{IH}			2.0			V
Input Logic Low	V_{IL}					0.8	V
Input Current with Input Logic High	I_{INH}	IN_ = 2.0V		-0.5	0.005	0.5	µA
Input Current with Input Logic Low	I_{INL}	IN_ = 0.8V		-0.5	0.005	0.5	µA
POWER SUPPLY							
Power-Supply Range	V+			+4.5		+36	V
Positive Supply Current	I+	V+ = +13.2V, V_{IN} = 0 or V+	+25°C		0.01	1	µA
			T_{MIN} to T_{MAX}			5	
		V+ = +13.2V, V_{IN} = 5V	+25°C		25	125	
			T_{MIN} to T_{MAX}			175	

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: -40°C specifications are 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: Guaranteed by design.
Note 8: 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 9: Between any two switches.

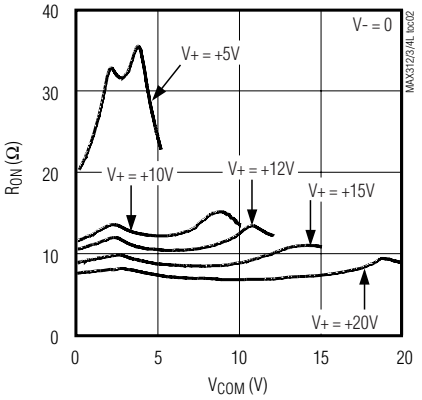
Typical Operating Characteristics

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

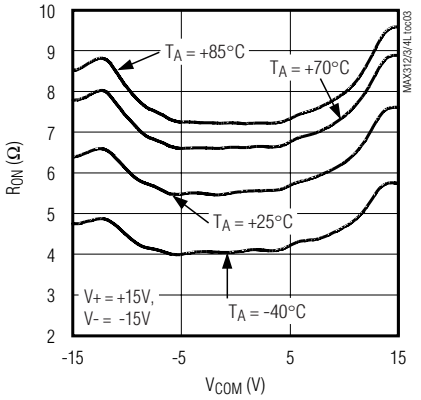
ON-RESISTANCE vs. V_{COM} (DUAL SUPPLIES)



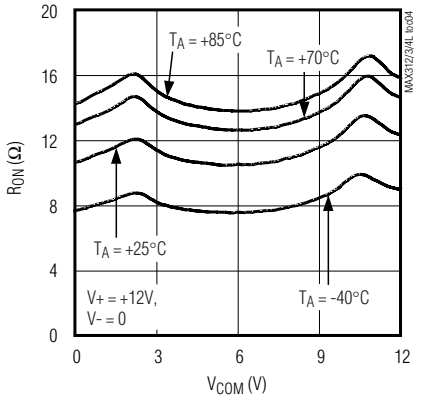
ON-RESISTANCE vs. V_{COM} (SINGLE SUPPLY)



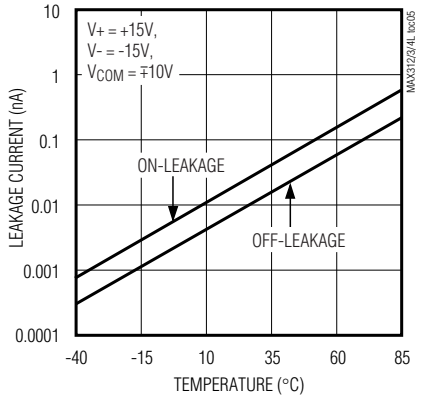
ON-RESISTANCE vs. V_{COM} AND TEMPERATURE (DUAL SUPPLIES)



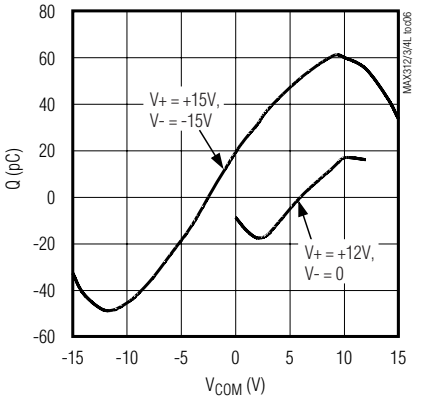
ON-RESISTANCE vs. V_{COM} AND TEMPERATURE (SINGLE SUPPLY)



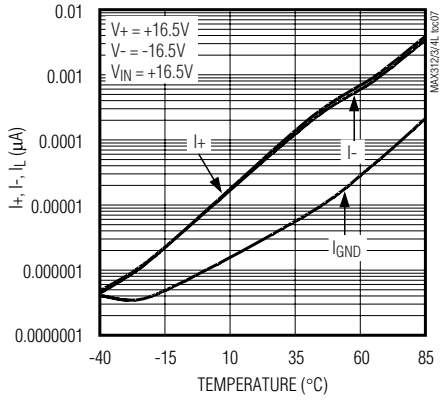
OFF- AND ON-LEAKAGE CURRENT vs. TEMPERATURE



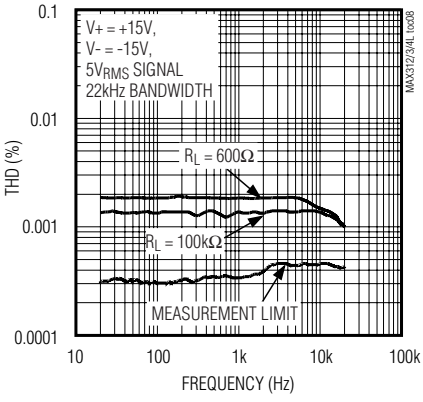
CHARGE INJECTION vs. V_{COM}



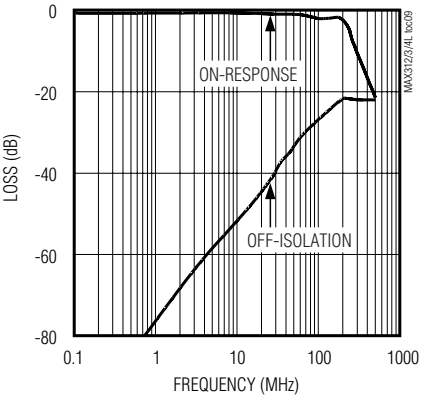
SUPPLY CURRENT vs. TEMPERATURE



TOTAL HARMONIC DISTORTION vs. FREQUENCY



FREQUENCY RESPONSE

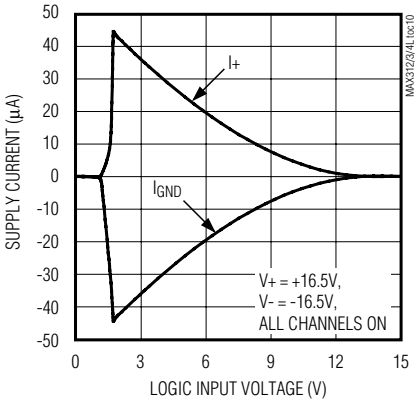


10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

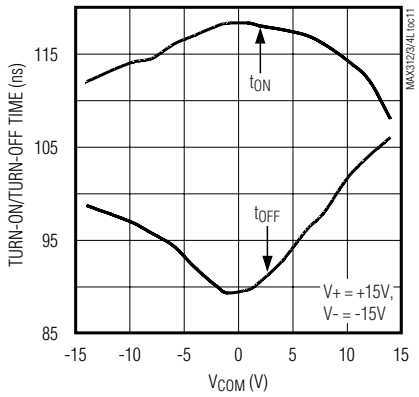
Typical Operating Characteristics (continued)

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

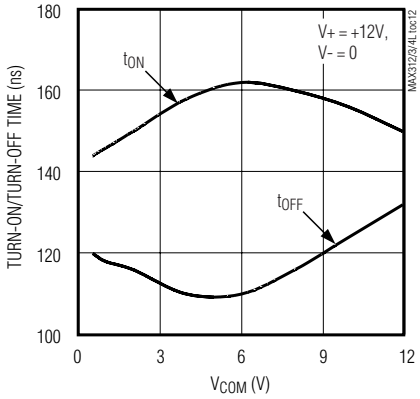
SUPPLY CURRENT vs. LOGIC INPUT VOLTAGE



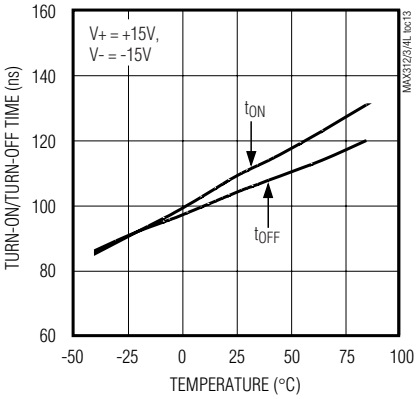
TURN-ON/TURN-OFF TIME vs. V_{COM} (DUAL SUPPLIES)



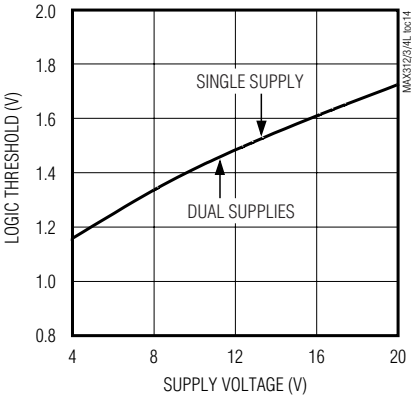
TURN-ON/TURN-OFF TIME vs. V_{COM} (SINGLE SUPPLY)



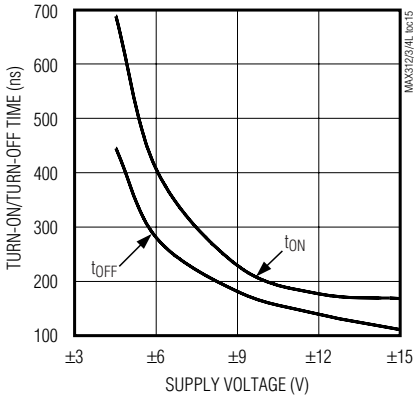
TURN-ON/TURN-OFF TIME vs. TEMPERATURE



LOGIC THRESHOLD vs. SUPPLY VOLTAGE



TURN-ON/TURN-OFF TIME vs. SUPPLY VOLTAGE



Pin Description

PIN			NAME	FUNCTION
MAX312L	MAX313L	MAX314L		
1, 8, 9, 16	1, 8, 9, 16	1, 8, 9, 16	IN1, IN4, IN3, IN2	Logic Inputs
2, 7, 10, 15	2, 7, 10, 15	2, 7, 10, 15	COM1, COM4, COM3, COM2	Analog Signal Common Terminals
3, 6, 11, 14	—	—	NC1, NC4, NC3, NC2	Analog Signal Normally Closed Terminals
—	3, 6, 11, 14	—	NO1, NO4, NO3, NO2	Analog Signal Normally Open Terminals
—	—	3, 6	NO1, NO4	Analog Signal Normally Open Terminals
—	—	11, 14	NC3, NC2	Analog Signal Normally Closed Terminals
4	4	4	V-	Negative Analog Supply 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 Analog Supply Input

Applications Information

Low-Distortion Audio

The MAX312L/MAX313L/MAX314L, having very low R_{ON} and very low R_{ON} variation with signal amplitude, are well suited for low-distortion audio applications. The *Typical Operating Characteristics* show Total Harmonic Distortion (THD) vs. Frequency graphs for several signal amplitudes and impedances. Higher source and load impedances improve THD, but reduce off-isolation.

Off-Isolation at High Frequencies

In 50Ω systems, the high-frequency on-response of these parts extends from DC to above 100MHz with a typical loss of -2dB. When the switch is turned off, however, it behaves like a capacitor, and off-isolation decreases with increasing frequency. (Above 300MHz, the switch actually passes more signal turned off than turned on.) This effect is more pronounced with higher source-and-load impedances.

Above 5MHz, circuit board layout becomes critical, and it becomes difficult to characterize the response of the switch independent of the circuit. The graphs shown in the *Typical Operating Characteristics* were taken using a 50Ω source and load connected with BNC connectors.

Power-Supply Sequencing-Free Operation

Most CMOS switches require specific power-supply sequencing in order to prevent the devices from latching up. The older MAX312/MAX313/MAX314 devices require a proper power-supply sequence of V+, V_L, V-, and so forth. Otherwise, it becomes necessary to add signal diodes to the circuit in order to protect it from potential latchups. The new MAX312L/MAX313L/ MAX314L devices eliminate the need for a V_L pin and permit the user to utilize any power-up sequence that is required. It is, however, important not to exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices.

Chip Information

TRANSISTOR COUNT: 92

PROCESS: CMOS

10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

Test Circuits/Timing Diagrams

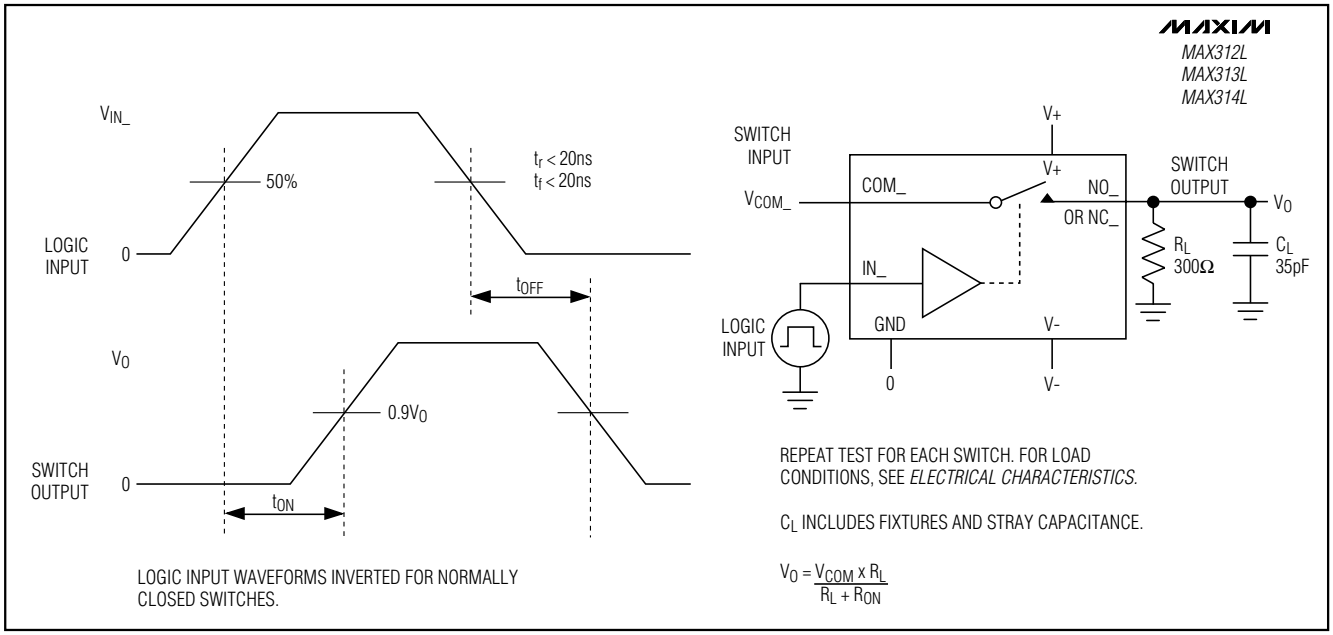


Figure 1. Switching-Time Test Circuit

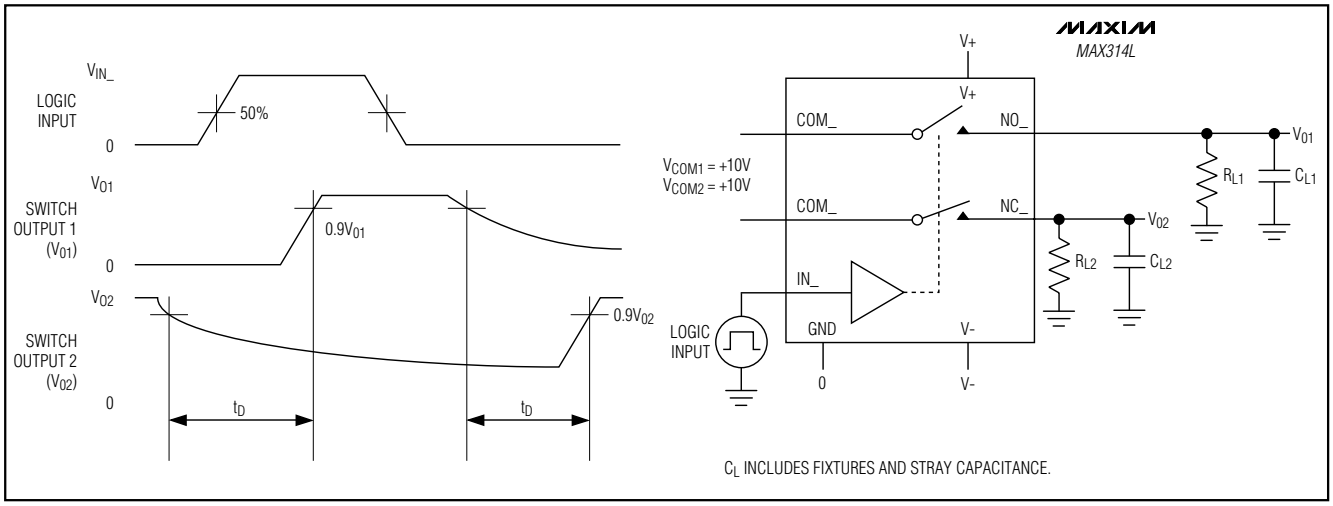


Figure 2. Break-Before-Make Test Circuit (MAX314L only)

Test Circuits/Timing Diagrams (continued)

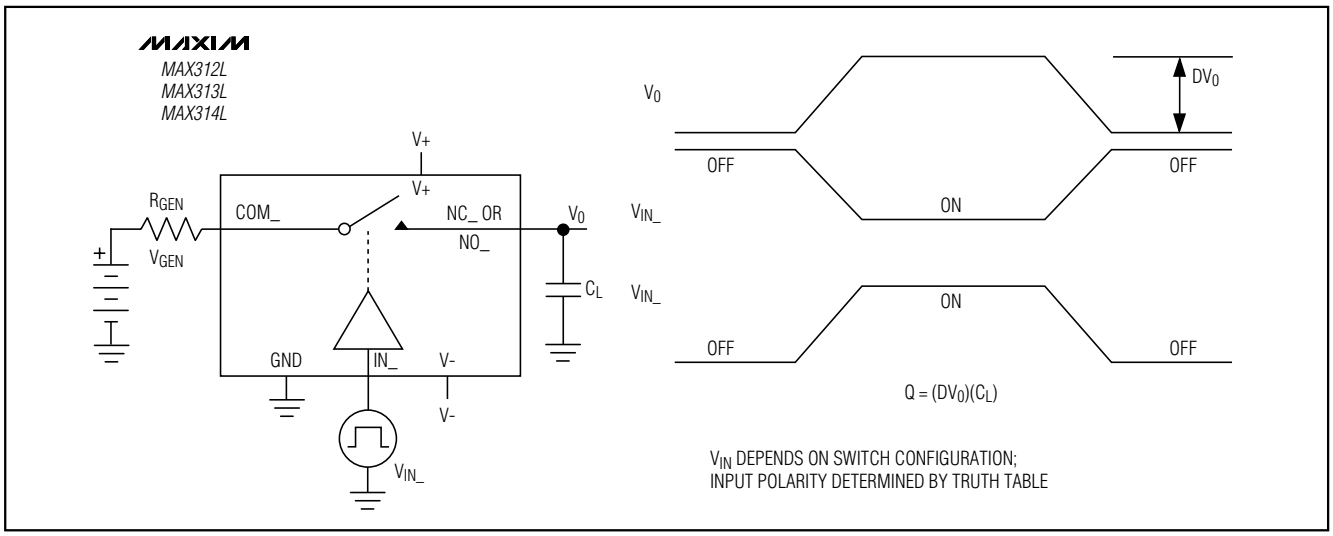


Figure 3. Charge Injection Test Circuit

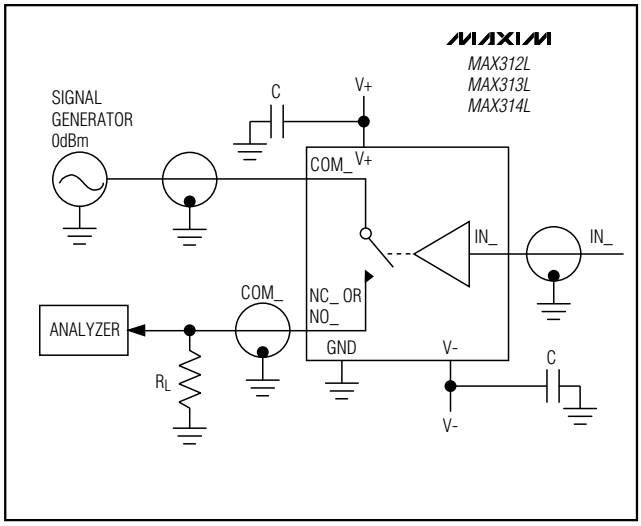


Figure 4. Off-Isolation Test Circuit

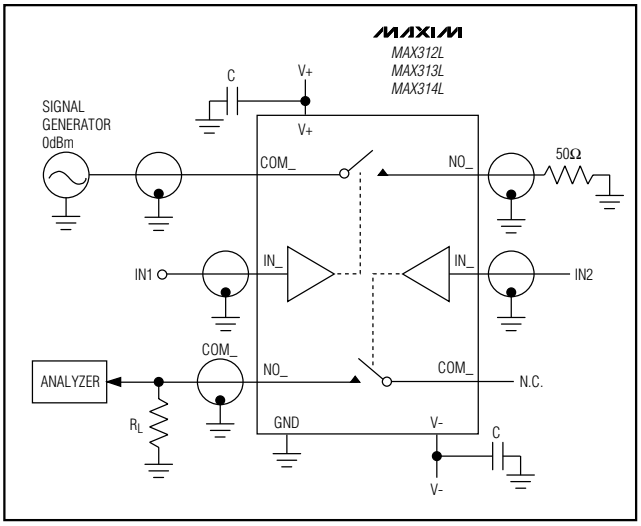


Figure 5. Crosstalk Test Circuit

10Ω, Quad, SPST, +3V Logic-Compatible Analog Switches

Test Circuits/Timing Diagrams (continued)

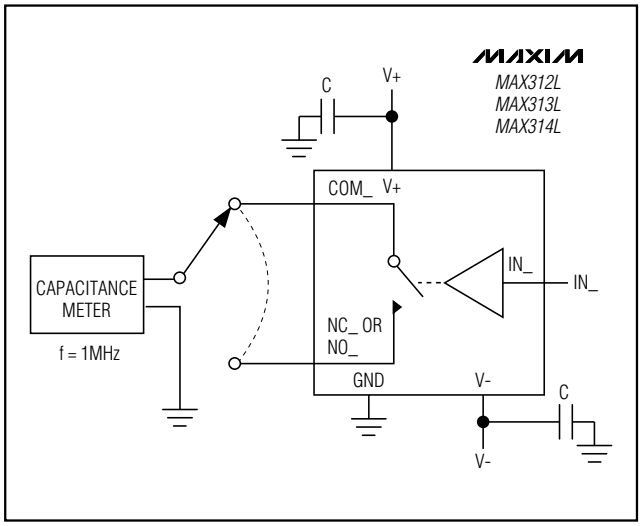


Figure 6. Channel Off-Capacitance Test Circuit

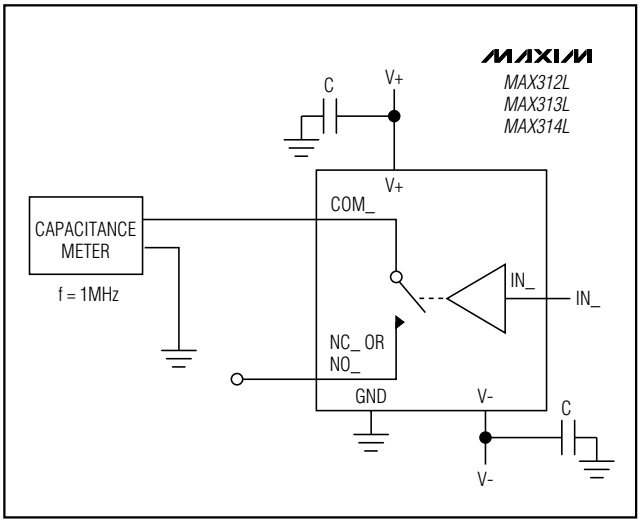


Figure 7. Channel On-Capacitance Test Circuit

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX313LCUE	0°C to +70°C	16 TSSOP
MAX313LCSE	0°C to +70°C	16 Narrow SO
MAX313LCPE	0°C to +70°C	16 Plastic DIP
MAX313LEUE	-40°C to +85°C	16 TSSOP
MAX313LESE	-40°C to +85°C	16 Narrow SO
MAX313LEPE	-40°C to +85°C	16 Plastic DIP
MAX314LCUE	0°C to +70°C	16 TSSOP
MAX314LCSE	0°C to +70°C	16 Narrow SO
MAX314LCPE	0°C to +70°C	16 Plastic DIP
MAX314LEUE	-40°C to +85°C	16 TSSOP
MAX314LESE	-40°C to +85°C	16 Narrow SO
MAX314LEPE	-40°C to +85°C	16 Plastic DIP