

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND

$V_{CC}$ , A, B, C, and ENABLE ..... -0.3V to +4.6V

Voltage at Any Other Terminal  
(Note 1) ..... -0.3V to ( $V_{CC}$  + 0.3V)

Continuous Current into A, B, C, ENABLE .....  $\pm 10$ mA

Continuous Current into X, Y, Z,  $X_{-}$ ,  $Y_{-}$ ,  $Z_{-}$  .....  $\pm 150$ mA

Peak Current into X, Y, Z,  $X_{-}$ ,  $Y_{-}$ ,  $Z_{-}$   
(pulsed at 1ms, 10% duty cycle) .....  $\pm 300$ mA

Continuous Power Dissipation

16-Pin Thin QFN (derate 16.9mW/°C above +70°C) ... 1349mW

16-Pin TSSOP (derate 5.7mW/°C above +70°C) ..... 457mW

Operating Temperature Range ..... -40°C to +85°C

Junction Temperature ..... +150°C

Storage Temperature Range ..... -65°C to +150°C

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

**Note 1:** Signals on X, Y, Z,  $X_{-}$ ,  $Y_{-}$ , and  $Z_{-}$  exceeding  $V_{CC}$  or GND 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 +3V Supply

( $V_{CC}$  = +2.7V to +3.6V, GND = 0,  $V_{IH}$  = 1.4V,  $V_{IL}$  = 0.5V,  $T_A$  =  $T_{MIN}$  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
<b>ANALOG SWITCH</b>							
Analog Signal Range	$V_X, V_Y, V_Z,$ $V_{X-}, V_{Y-}, V_{Z-}$			0		$V_{CC}$	V
On-Resistance (Note 4)	$R_{ON}$	$V_{CC}$ = +2.7V; $I_{X-}, I_{Y-}, I_{Z-}$ = 100mA; $V_X, V_Y, V_Z$ = 1.7V	+25°C $T_{MIN}$ to $T_{MAX}$	0.7 1.2	1		$\Omega$
On-Resistance Match Between Channels (Notes 4, 5)	$\Delta R_{ON}$	$V_{CC}$ = +2.7V; $I_{X-}, I_{Y-}, I_{Z-}$ = 100mA; $V_X, V_Y, V_Z$ = 1.7V	+25°C $T_{MIN}$ to $T_{MAX}$	0.3 0.6	0.4		$\Omega$
On-Resistance Flatness (Note 6)	$R_{FLAT(ON)}$	$V_{CC}$ = +2.7V; $I_{X-}, I_{Y-}, I_{Z-}$ = 100mA; $V_X, V_Y, V_Z$ = 0, 0.7V, 1.7V	+25°C $T_{MIN}$ to $T_{MAX}$	0.1 0.2	0.2		$\Omega$
$X_{-}, Y_{-}, Z_{-}$ Off-Leakage Current	$I_{X(OFF)}$ $I_{Y(OFF)}$ $I_{Z(OFF)}$	$V_{CC}$ = +3.6V; $V_{X-}, V_{Y-}, V_{Z-}$ = 3.3V, 0.3V; $V_X, V_Y, V_Z$ = 0.3V, 3.3V	+25°C $T_{MIN}$ to $T_{MAX}$	-2 -7	0.002	+2 +7	nA
X Off-Leakage Current (MAX4781 Only)	$I_{X(OFF)}$	$V_{CC}$ = +3.6V; $V_{X-}$ = 3.3V, 0.3V; $V_{X-}$ = 0.3V, 3.3V	+25°C $T_{MIN}$ to $T_{MAX}$	-2 -50	0.002	+2 +50	nA
X On-Leakage Current (MAX4781 Only)	$I_{X(ON)}$	$V_{CC}$ = +3.6V $V_{X-}$ = 0.3V, 3.3V; $V_{X-}$ = 0.3V, 3.3V or floating	+25°C $T_{MIN}$ to $T_{MAX}$	-2 -50	0.002	+2 +50	nA
X, Y, Z Off-Leakage Current (MAX4782/MAX4783 Only)	$I_{X(OFF)}$ $I_{Y(OFF)}$ $I_{Z(OFF)}$	$V_{CC}$ = +3.6V; $V_{X-}, V_{Y-}, V_{Z-}$ = 3.3V, 0.3V; $V_X, V_Y, V_Z$ = 0.3V, 3.3V	+25°C $T_{MIN}$ to $T_{MAX}$	-2 -25	0.002	+2 +25	nA
X, Y, Z On-Leakage Current (MAX4782/MAX4783 Only)	$I_{X(ON)}$ $I_{Y(ON)}$ $I_{Z(ON)}$	$V_{CC}$ = +3.6V; $V_X, V_Y, V_Z$ = 0.3V, 3.3V; $V_X, V_Y, V_Z$ = 0.3V, 3.3V or floating	+25°C $T_{MIN}$ to $T_{MAX}$	-2 -25	0.002	+2 +25	nA

# High-Speed, Low-Voltage, 0.7Ω CMOS Analog Switches/Multiplexers

MAX4781/MAX4782/MAX4783

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

(V<sub>CC</sub> = +2.7V to +3.6V, GND = 0, V<sub>IH</sub> = 1.4V, V<sub>IL</sub> = 0.5V, 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.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>SWITCH DYNAMIC CHARACTERISTICS</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>X</sub> , V <sub>Y</sub> , V <sub>Z</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 1	+25°C		11	25	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			27	
Turn-Off Time	t <sub>OFF</sub>	V <sub>X</sub> , V <sub>Y</sub> , V <sub>Z</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 1	+25°C		4	15	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			20	
Address Transition Time	t <sub>TRANS</sub>	V <sub>X</sub> , V <sub>Y</sub> , V <sub>Z</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 2	+25°C		11	25	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			27	
Break-Before-Make Time (Note 7)	t <sub>BBM</sub>	V <sub>X</sub> , V <sub>Y</sub> , V <sub>Z</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 3	+25°C		18		ns
			T <sub>MIN</sub> to T <sub>MAX</sub>	2			
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1nF, Figure 4	+25°C		-110		pC
Input Off-Capacitance	C <sub>X(OFF)</sub> , C <sub>Y(OFF)</sub> , C <sub>Z(OFF)</sub>	f = 1MHz, Figure 6	+25°C		38		pF
Output Off-Capacitance	C <sub>X(OFF)</sub> , C <sub>Y(OFF)</sub> , C <sub>Z(OFF)</sub>	f = 1MHz, Figure 6	+25°C		310		pF
					158		
					75		
Output On-Capacitance	C <sub>X(ON)</sub> , C <sub>Y(ON)</sub> , C <sub>Z(ON)</sub>	f = 1MHz, Figure 6	+25°C		380		pF
					224		
					140		
Off-Isolation (Note 8)	V <sub>ISO</sub>	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 35pF, Figure 5			-75		dB
					-90		
Channel-to-Channel Crosstalk (Note 9)	V <sub>CT</sub>	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 35pF, Figure 5			-65		dB
					-80		
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 0.5V <sub>p-p</sub> , R <sub>L</sub> = 32Ω			0.045		%
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>		T <sub>MIN</sub> to T <sub>MAX</sub>	1.4			V
Input Logic Low	V <sub>IL</sub>		T <sub>MIN</sub> to T <sub>MAX</sub>			0.5	V
Input Leakage Current	I <sub>INL</sub>	V <sub>A</sub> , V <sub>B</sub> , V <sub>C</sub> = V <sub>ENABLE</sub> = 0 or 3.6V	T <sub>MIN</sub> to T <sub>MAX</sub>	-1	0.0005	+1	μA
<b>POWER SUPPLY</b>							
Power-Supply Range	V <sub>CC</sub>			+1.6		+3.6	V
Positive Supply Current	I <sub>CC</sub>	V <sub>CC</sub> = 3.6V; V <sub>A</sub> , V <sub>B</sub> , V <sub>C</sub> ; V <sub>ENABLE</sub> = 3.6V or 0				1	μA

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## ELECTRICAL CHARACTERISTICS—Single +1.8V Supply

( $V_{CC} = +1.8V$ ,  $GND = 0$ ,  $V_{IH} = 1V$ ,  $V_{IL} = 0.4V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	$T_A$	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Analog Signal Range	$V_{X-}, V_{Y-}, V_{Z-}, V_X, V_Y, V_Z$			0		$V_{CC}$	V
On-Resistance (Note 4)	$R_{ON}$	$V_{CC} = 1.8V$ ; $I_{X-}, I_{Y-}, I_{Z-} = 10mA$ ; $V_X, V_Y, V_Z = 1.0V$	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		1.6	2.5 3.5	$\Omega$
On-Resistance Match Between Channels (Notes 4, 5)	$\Delta R_{ON}$	$V_{CC} = 1.8V$ ; $I_{X-}, I_{Y-}, I_{Z-} = 10mA$ ; $V_X, V_Y, V_Z = 1.0V$	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		0.3	0.4 0.6	$\Omega$
<b>SWITCH DYNAMIC CHARACTERISTICS</b>							
Turn-On Time	$t_{ON}$	$V_{X-}, V_{Y-}, V_{Z-} = 1.0V$ ; $R_L = 50\Omega$ ; $C_L = 35pF$ ; Figure 1	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		17	30 32	ns
Turn-Off Time	$t_{OFF}$	$V_{X-}, V_{Y-}, V_{Z-} = 1.0V$ ; $R_L = 50\Omega$ ; $C_L = 35pF$ ; Figure 1	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		8	20 22	ns
Address Transition Time	$t_{TRANS}$	$V_{X-}, V_{Y-}, V_{Z-} = 1.0V$ ; $R_L = 50\Omega$ ; $C_L = 35pF$ ; Figure 2	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		17	30 32	ns
Break-Before-Make Time (Note 7)	$t_{BBM}$	$V_{X-}, V_{Y-}, V_{Z-} = 1V$ ; $R_L = 50\Omega$ ; $C_L = 35pF$ ; Figure 3	$+25^\circ C$ $T_{MIN}$ to $T_{MAX}$		26 1		ns
Charge Injection	$Q$	$V_{GEN} = 0$ , $R_{GEN} = 0$ , $C_L = 1nF$ , Figure 4	$+25^\circ C$		-40		pC
<b>DIGITAL I/O</b>							
Input Logic High	$V_{IH}$		$T_{MIN}$ to $T_{MAX}$	1			V
Input Logic Low	$V_{IL}$		$T_{MIN}$ to $T_{MAX}$			0.4	V
Input Leakage Current	$I_{IN-}$	$V_A, V_B, V_C = V_{ENABLE} = 0$ or $3.6V$	$T_{MIN}$ to $T_{MAX}$	-1	0.000	+1	$\mu A$
<b>POWER SUPPLY</b>							
Power-Supply Range	$V_{CC}$			1.6		3.6	V
Positive Supply Current	$I_{CC}$	$V_{CC} = 3.6V$ ; $V_A, V_B, V_C, V_{ENABLE} = 0$ or $3.6V$				1	$\mu A$

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 3:** Devices are tested at maximum hot temperature and are guaranteed by design and correlation at  $T_A = +25^\circ C$  and  $-40^\circ C$  specifications.

**Note 4:**  $R_{ON}$  and  $\Delta R_{ON}$  matching specifications for thin QFN-packaged parts are guaranteed by design.

**Note 5:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 6:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.

**Note 7:** Guaranteed by design; not production tested.

**Note 8:** Off-isolation =  $20\log_{10}(V_{COM-} / V_{NO})$ ,  $V_{COM-}$  = output,  $V_{NO}$  = input to off switch.

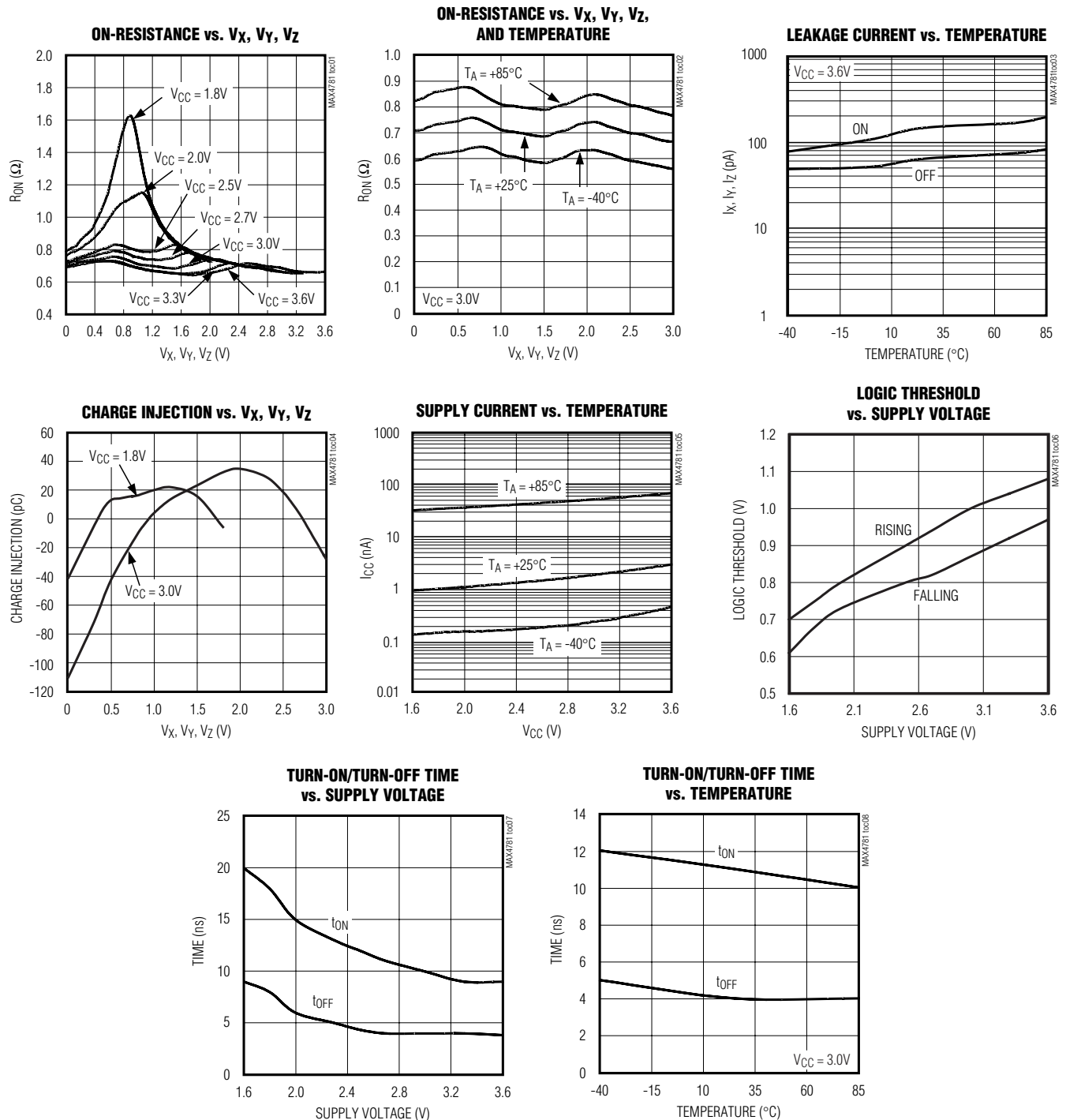
**Note 9:** Between any two channels.

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Typical Operating Characteristics

(GND = 0,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

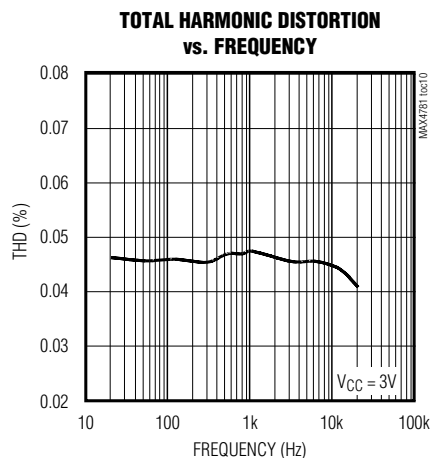
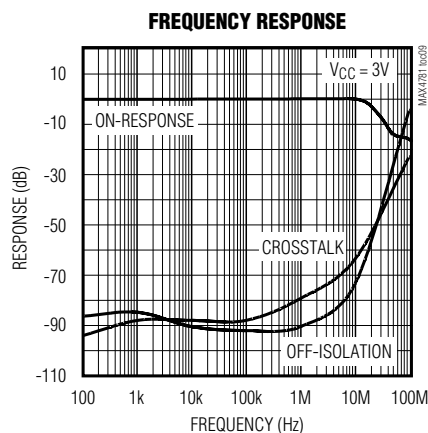
MAX4781/MAX4782/MAX4783



# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Typical Operating Characteristics (continued)

(GND = 0,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



## MAX4781 Pin Description

PIN		NAME	FUNCTION
TSSOP	THIN QFN		
3	1	X	Analog Switch Output
6	4	$\overline{\text{ENABLE}}$	Digital Enable Input. Normally connect to GND. Drive to logic high to set all switches off.
7	5	N.C.	No Connection. Not internally connected.
8	6	GND	Ground
9	7	C	Digital Address C Input
10	8	B	Digital Address B Input
11	9	A	Digital Address A Input
13, 14, 15, 12, 1, 5, 2, 4	11, 12, 13, 10, 15, 3, 16, 2	X0–X7	Analog Switch Inputs X0–X7
16	14	$V_{CC}$	Positive Analog and Digital Supply Voltage Input
—	EP	PAD	Exposed Pad. Connect to GND.

# High-Speed, Low-Voltage, 0.7Ω CMOS Analog Switches/Multiplexers

## MAX4782 Pin Description

PIN		NAME	FUNCTION
TSSOP	THIN QFN		
1, 5, 2, 4	15, 3, 16, 2	Y0–Y3	Analog Switch Y Inputs Y0–Y3
3	1	Y	Analog Switch Y Output
6	4	$\overline{\text{ENABLE}}$	Digital Enable Input. Normally connect to GND. Drive to logic high to set all switches off.
7	5	N.C.	No Connection. Not internally connected.
8	6	GND	Ground
9	7	B	Digital Address B Input
10	8	A	Digital Address A Input
12, 14, 15, 11	10, 12, 13, 9	X0–X3	Analog Switch X Inputs X0–X3
13	11	X	Analog Switch X Output
16	14	VCC	Positive Analog and Digital Supply Voltage Input

## MAX4783 Pin Description

PIN		NAME	FUNCTION
TSSOP	THIN QFN		
1	15	Y1	Analog Switch Y Normally Open Input
2	16	Y0	Analog Switch Y Normally Closed Input
3	1	Z1	Analog Switch Z Normally Open Input
4	2	Z	Analog Switch Z Output
5	3	Z0	Analog Switch Z Normally Closed Input
6	4	$\overline{\text{ENABLE}}$	Digital Enable Input. Normally connect to GND. Drive to logic high to set all switches off.
7	5	N.C.	No Connection. Not internally connected.
8	6	GND	Ground
9	7	C	Digital Address C Input
10	8	B	Digital Address B Input
11	9	A	Digital Address A Input
12	10	X0	Analog Switch X Normally Closed Input
13	11	X1	Analog Switch X Normally Open Input
14	12	X	Analog Switch X Output
15	13	Y	Analog Switch Y Output
16	14	VCC	Positive Analog and Digital Supply Voltage Input

MAX4781/MAX4782/MAX4783

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Applications Information

### Power-Supply Considerations

#### Overview

The MAX4781/MAX4782/MAX4783 construction is typical of most CMOS analog switches. There are two supply inputs:  $V_{CC}$  and GND.  $V_{CC}$  and GND drive the internal CMOS switches and set the limits of the analog voltage on any switch. Internal reverse ESD-protection diodes are connected between each analog signal input and both  $V_{CC}$  and GND. If any analog signal exceeds  $V_{CC}$  or GND, one of these diodes conducts. During normal operation, these and other reverse-biased ESD diodes leak, forming the only current drawn from  $V_{CC}$  or GND.

Virtually all the analog leakage current comes from the ESD diodes. Although the ESD diodes on a given signal input are identical and therefore fairly well balanced, they are reverse-biased differently. Each diode is biased by either  $V_{CC}$  or GND and the analog signal. Their leakages vary as the signal varies. The difference in the two diodes' leakages to  $V_{CC}$  and GND constitutes the analog-signal-path leakage current. All analog leakage current flows between each input and one of the supply terminals, not to the other switch terminal. Both sides of a given switch can show leakage currents of either the same or opposite polarity.

$V_{CC}$  and GND power the internal logic and set the input logic limits. Logic inputs have ESD-protection diodes to ground.

#### Power Supply

The MAX4781/MAX4782/MAX4783 operate from a single supply between +1.6V and +3.6V. Switch on-resistance increases as the supply voltage is lowered.

### High-Frequency Performance

In  $50\Omega$  systems, signal response is reasonably flat up to 50MHz (see the *Typical Operating Characteristics*). Above 20MHz, the on-response has several minor peaks that are highly layout dependent. In the off state, the switch acts like a capacitor and passes higher frequencies with less attenuation. At 10MHz, off-isolation is approximately -50dB in  $50\Omega$  systems, becoming worse (approximately 20dB per decade) as frequency increases. Higher circuit impedance also degrades off-isolation. Adjacent channel attenuation is approximately 3dB above that of a bare IC socket and is entirely because of capacitive coupling.

### Pin Nomenclature

The MAX4781/MAX4782/MAX4783 are pin compatible with the industry-standard 74HC4051/74HC4052/74HC4053 and the MAX4617/MAX4618/MAX4619. In single-supply applications, they function identically and have identical logic diagrams, although these parts differ electrically. The pin designations and logic diagrams in this data sheet conform to the original 1972 specifications published by RCA for the CD4051/CD4052/CD4053. These designations differ from the standard Maxim switch and mux designations found on other Maxim data sheets such as the MAX4051/MAX4052/MAX4053. Designers who are more comfortable with Maxim's standard designations are advised that the pin designations and logic diagrams on the MAX4051/MAX4052/MAX4053 data sheet can be applied to the MAX4781/MAX4782/MAX4783.

# High-Speed, Low-Voltage, 0.7Ω CMOS Analog Switches/Multiplexers

MAX4781/MAX4782/MAX4783

Table 1. Truth Table/Switch Programming

ENABLE INPUT	SELECT INPUT			ON SWITCHES		
	C*	B	A	MAX4781	MAX4782	MAX4783
H	✓	✓	✓	All switches open	All switches open	All switches open
L	L	L	L	X-X0	X-X0 Y-Y0 Z-Z0	X-X0 Y-Y0 Z-Z0
L	L	L	H	X-X1	X-X1 Y-Y1	X-X1 Y-Y0 Z-Z0
L	L	H	L	X-X2	X-X2 Y-Y2	X-X0 Y-Y1 Z-Z0
L	L	H	H	X-X3	X-X3 Y-Y3	X-X1 Y-Y1 Z-Z0
L	H	L	L	X-X4	X-X0 Y-Y0	X-X0 Y-Y0 Z-Z1
L	H	L	H	X-X5	X-X1 Y-Y1	X-X1 Y-Y0 Z-Z1
L	H	H	L	X-X6	X-X2 Y-Y2	X-X0 Y-Y1 Z-Z1
L	H	H	H	X-X7	X-X3 Y-Y3	X-X1 Y-Y1 Z-Z1

✓ = Don't care.

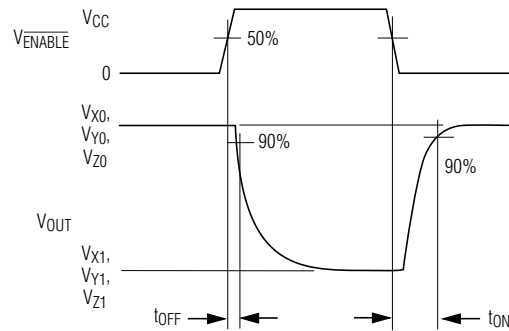
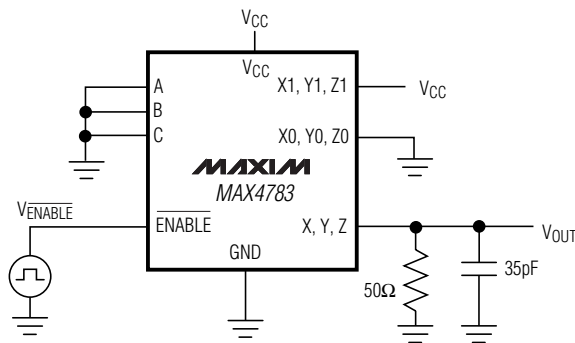
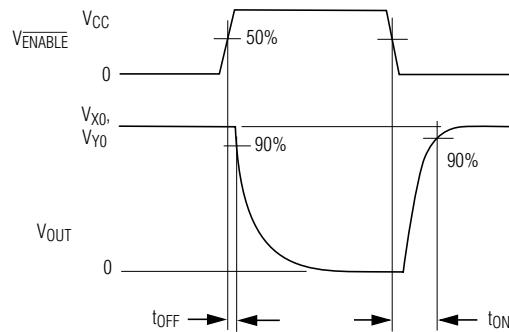
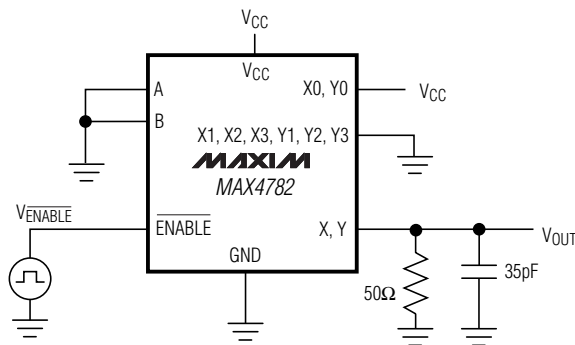
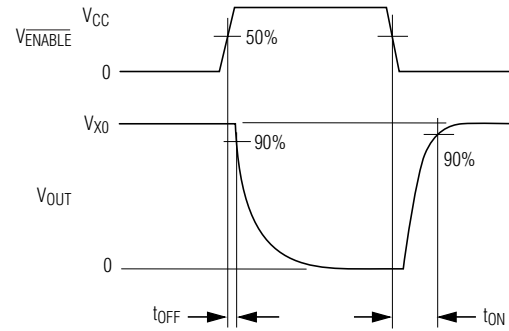
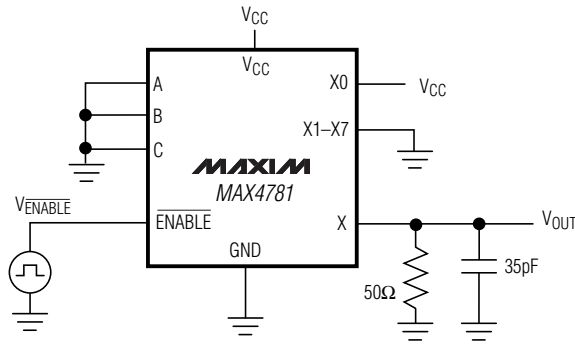
\*Not present on MAX4782.

**Note:** Input and output pins are identical and interchangeable. Either can be considered an input or output. Signals pass equally well in either direction.



# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Test Circuits/Timing Diagrams



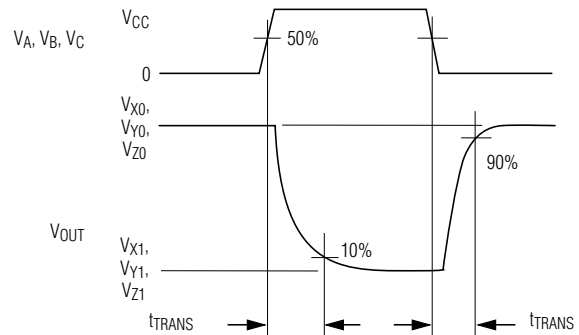
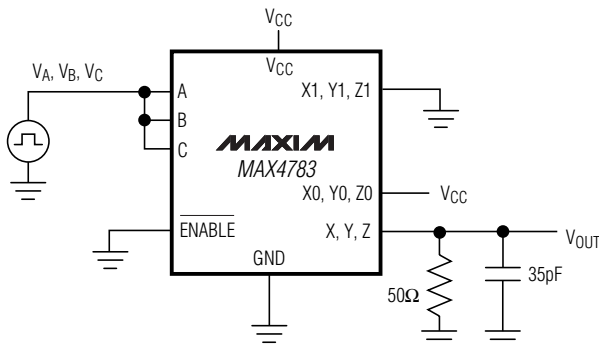
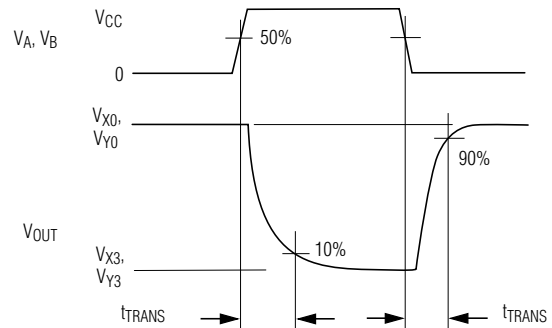
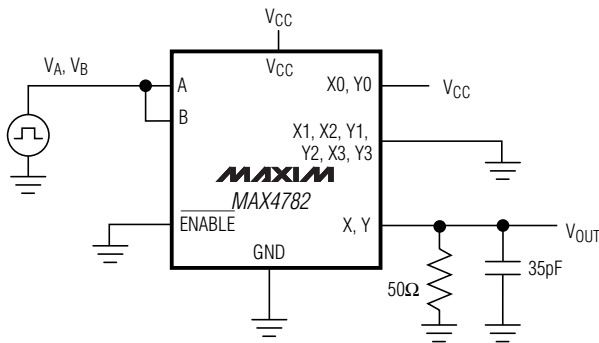
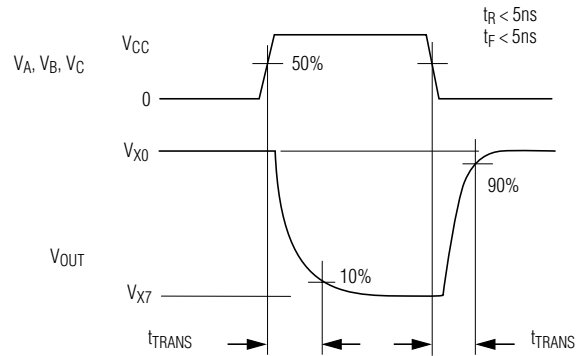
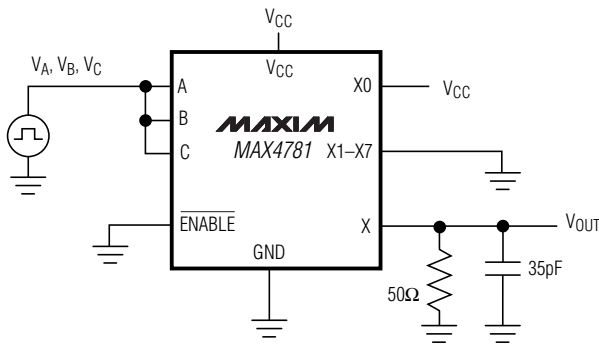
TEST EACH SECTION INDIVIDUALLY.

Figure 1. Enable Switching Times

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Test Circuits/Timing Diagrams (continued)

MAX4781/MAX4782/MAX4783



TEST EACH SECTION INDIVIDUALLY.

Figure 2. Address Transition Times

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

## Test Circuits/Timing Diagrams (continued)

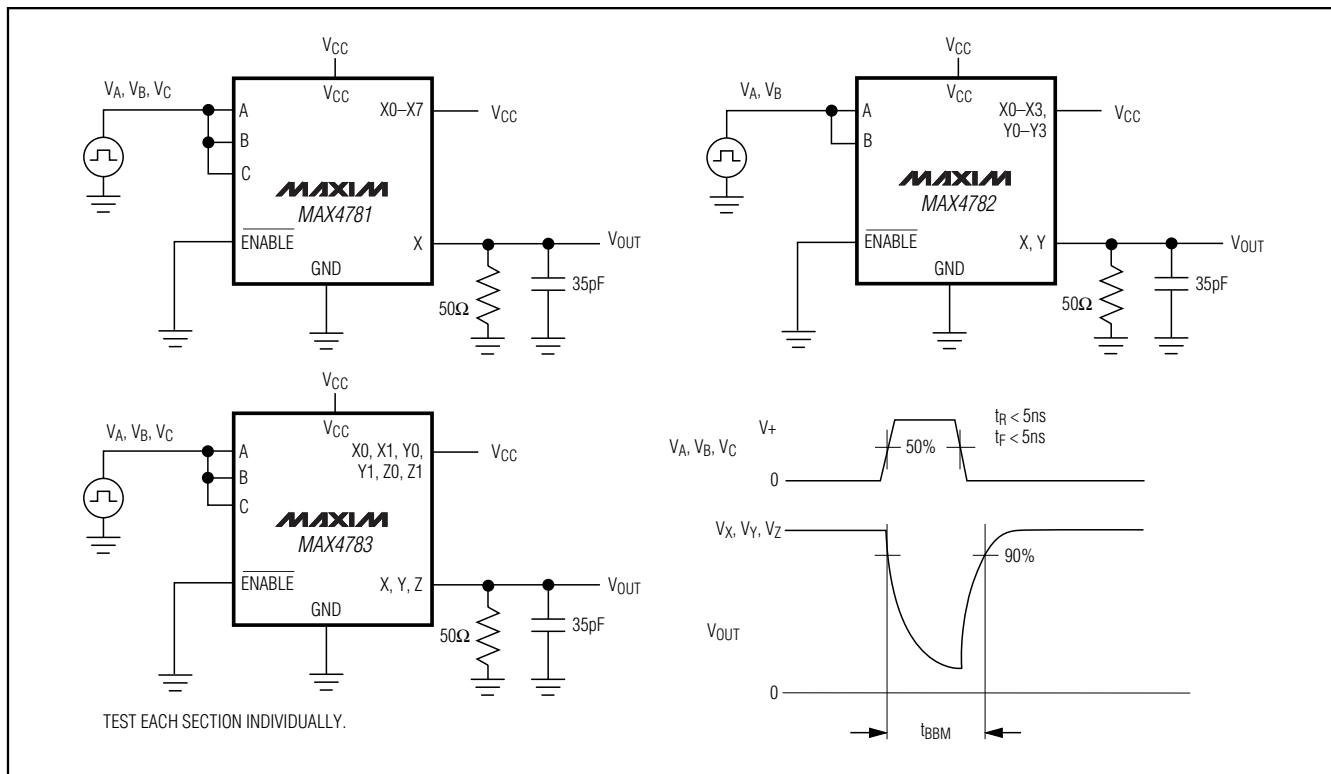


Figure 3. Break-Before-Make Interval

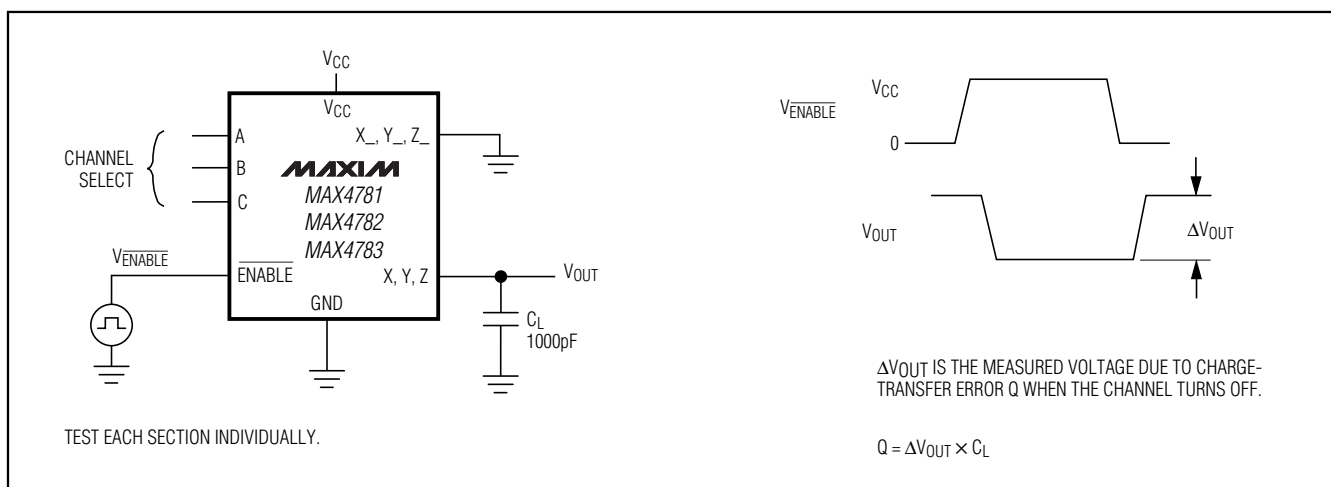


Figure 4. Charge Injection

**MAX4781/MAX4782/MAX4783**

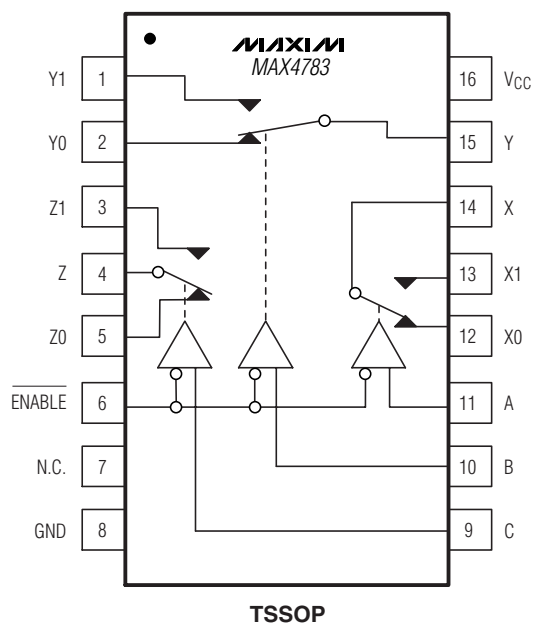
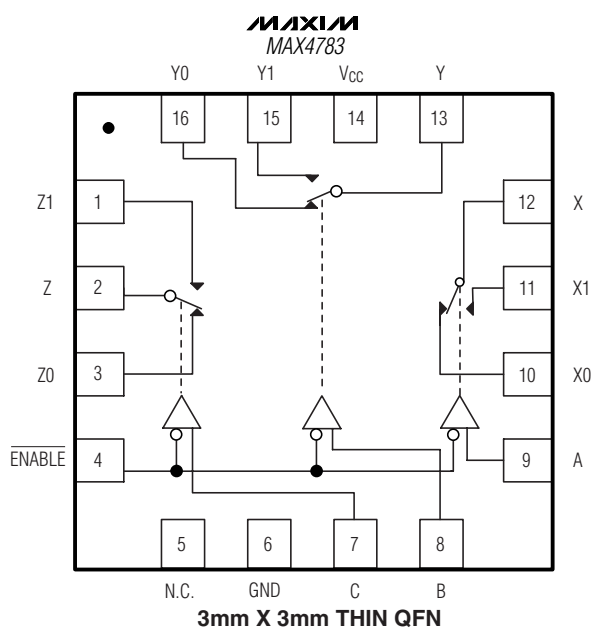
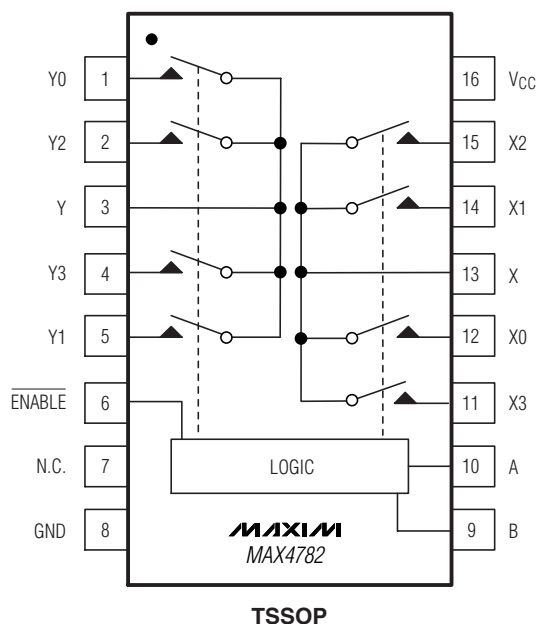
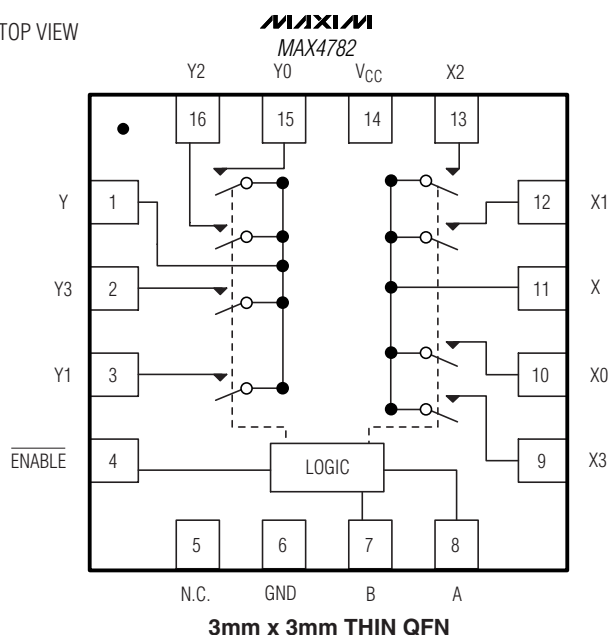
Figure 5. Off-Isolation, On-Loss, and Crosstalk

Downloaded from [Arrow.com](https://arrow.com).

# High-Speed, Low-Voltage, $0.7\Omega$ CMOS Analog Switches/Multiplexers

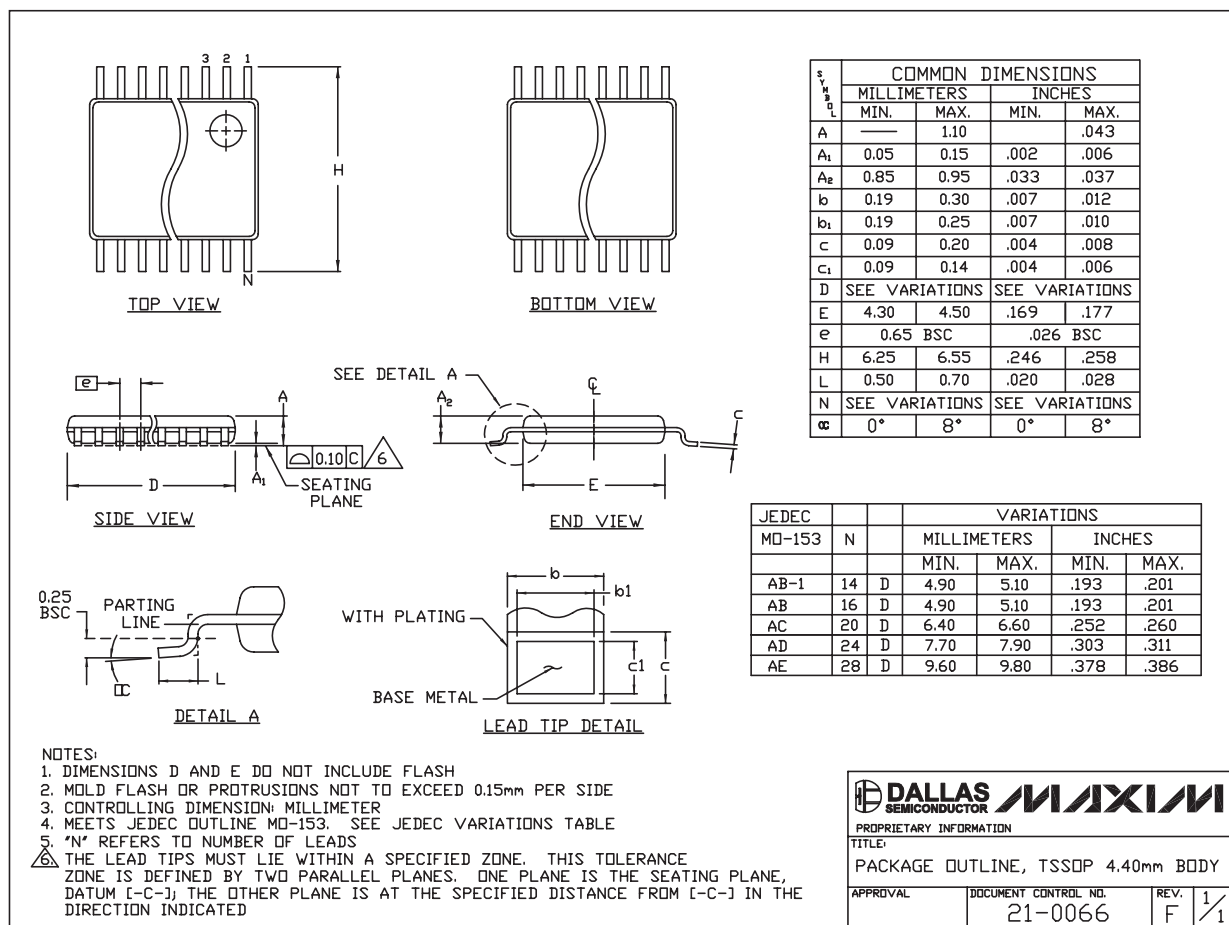
## Pin Configurations/Functional Diagrams (continued)

TOP VIEW



**MAX4781/MAX4782/MAX4783**

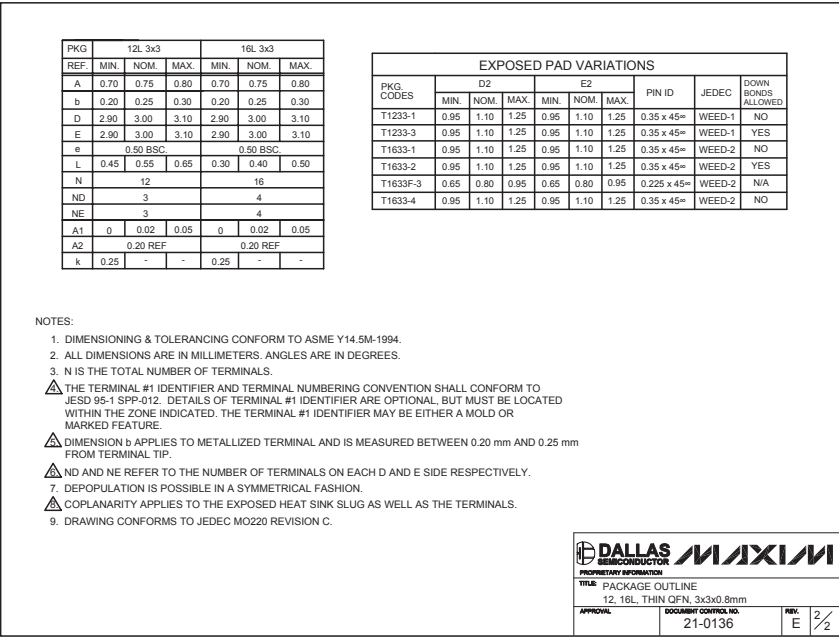
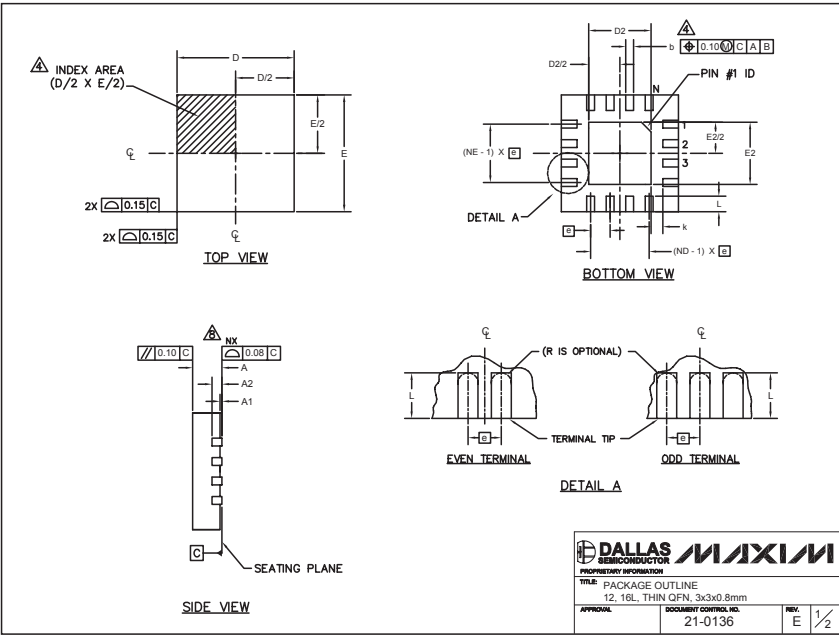
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# High-Speed, Low-Voltage, 0.7Ω CMOS Analog Switches/Multiplexers

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



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