



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

General Description

The MAX4781/MAX4782/MAX4783 are high-speed, low-voltage, low on-resistance, CMOS analog multiplexers/switches configured as an 8-channel multiplexer (MAX4781), two 4-channel multiplexers (MAX4782), and three single-pole/double-throw (SPDT) switches (MAX4783).

These devices operate with a +1.6V to +3.6V single supply. When powered from a +3V supply, MAX4781/MAX4782/MAX4783 feature a 0.7Ω on-resistance (R_{ON}), with 0.3Ω R_{ON} matching between channels, and 0.1Ω R_{ON} flatness. These devices handle rail-to-rail analog signals while consuming less than $3\mu W$ of quiescent power. They are available in space-saving 16-pin thin QFN (3mm x 3mm) and TSSOP packages.

Applications

Battery-Operated Equipment
Audio Signal Routing
Low-Voltage Data-Acquisition Systems
Communications Circuits

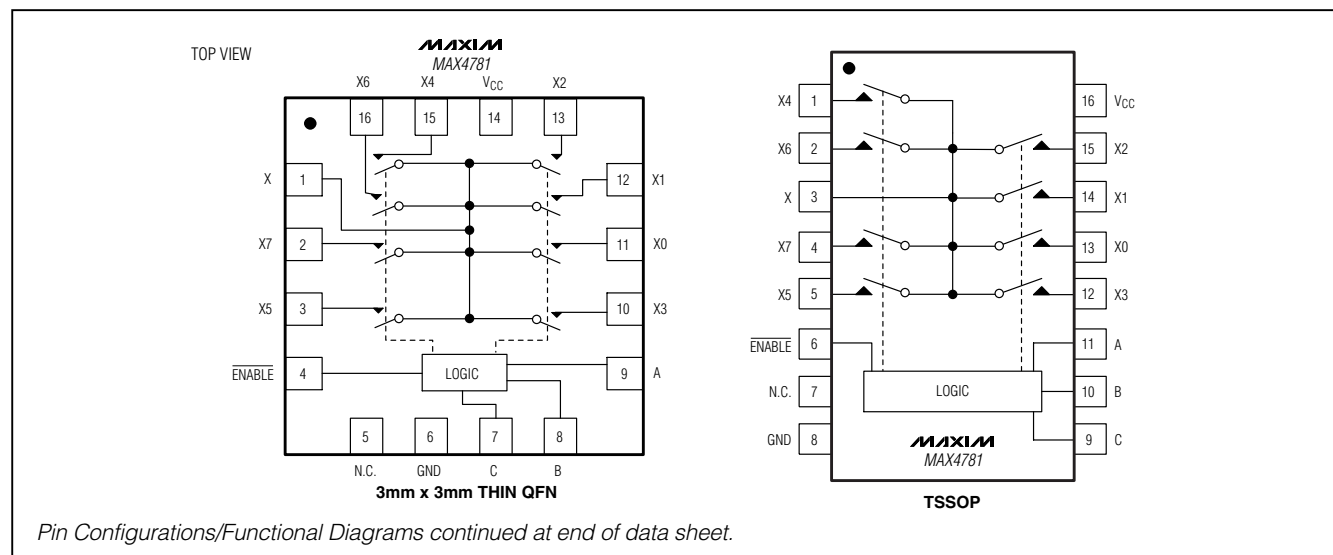
Features

- ◆ On-Resistance
 0.7Ω (+3V Supply)
 1.6Ω (+1.8V Supply)
- ◆ On-Resistance Match Between Channels
 0.3Ω (+3V Supply)
- ◆ On-Resistance Flatness
 0.1Ω (+3V Supply)
- ◆ Single-Supply Operation Down to 1.6V
- ◆ High-Current Handling Capacity (150mA Continuous)
- ◆ +1.8V CMOS-Logic Compatible
- ◆ Fast Switching Times: $t_{ON} = 11ns$, $t_{OFF} = 4ns$
- ◆ Pin Compatible with Industry-Standard 74HC4051/74HC4052/74HC4053 and MAX4617/MAX4618/MAX4619
- ◆ Available in 3mm x 3mm 16-Pin Thin QFN Packages

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX4781EUE	-40°C to +85°C	16 TSSOP
MAX4781ETE	-40°C to +85°C	16 Thin QFN (3mm x 3mm)
MAX4782EUE	-40°C to +85°C	16 TSSOP
MAX4782ETE	-40°C to +85°C	16 Thin QFN (3mm x 3mm)
MAX4783EUE	-40°C to +85°C	16 TSSOP
MAX4783ETE	-40°C to +85°C	16 Thin QFN (3mm x 3mm)

Pin Configurations/Functional Diagrams



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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 ± 10 mA

Continuous Current into X, Y, Z, X_{-} , Y_{-} , Z_{-} ± 150 mA

Peak Current into X, Y, Z, X_{-} , Y_{-} , Z_{-}
(pulsed at 1ms, 10% duty cycle) ± 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
ANALOG SWITCH							
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		Ω
On-Resistance Match Between Channels (Notes 4, 5)	ΔR_{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		Ω
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		Ω
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

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MAX4781/MAX4782/MAX4783

ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(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
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time	t _{ON}	V _X , V _Y , V _Z = 1.5V; R _L = 50Ω; C _L = 35pF; Figure 1	+25°C	11	25		ns
			T _{MIN} to T _{MAX}			27	
Turn-Off Time	t _{OFF}	V _X , V _Y , V _Z = 1.5V; R _L = 50Ω; C _L = 35pF; Figure 1	+25°C	4	15		ns
			T _{MIN} to T _{MAX}			20	
Address Transition Time	t _{TRANS}	V _X , V _Y , V _Z = 1.5V; R _L = 50Ω; C _L = 35pF; Figure 2	+25°C	11	25		ns
			T _{MIN} to T _{MAX}			27	
Break-Before-Make Time (Note 7)	t _{BBM}	V _X , V _Y , V _Z = 1.5V; R _L = 50Ω; C _L = 35pF; Figure 3	+25°C	18			ns
			T _{MIN} to T _{MAX}	2			
Charge Injection	Q	V _{GEN} = 0, R _{GEN} = 0, C _L = 1nF, Figure 4	+25°C	-110			pC
Input Off-Capacitance	C _{X(OFF)} , C _{Y(OFF)} , C _{Z(OFF)}	f = 1MHz, Figure 6	+25°C	38			pF
Output Off-Capacitance	C _{X(OFF)} , C _{Y(OFF)} , C _{Z(OFF)}	f = 1MHz, Figure 6	+25°C	310			pF
				158			
				75			
Output On-Capacitance	C _{X(ON)} , C _{Y(ON)} , C _{Z(ON)}	f = 1MHz, Figure 6	+25°C	380			pF
				224			
				140			
Off-Isolation (Note 8)	V _{ISO}	R _L = 50Ω, C _L = 35pF, Figure 5	f = 10MHz	-75			dB
			f = 1MHz	-90			
Channel-to-Channel Crosstalk (Note 9)	V _{CT}	R _L = 50Ω, C _L = 35pF, Figure 5	f = 10MHz	-65			dB
			f = 1MHz	-80			
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 0.5V _{p-p} , R _L = 32Ω		0.045			%
DIGITAL I/O							
Input Logic High	V _{IH}		T _{MIN} to T _{MAX}	1.4			V
Input Logic Low	V _{IL}		T _{MIN} to T _{MAX}	0.5			V
Input Leakage Current	I _{INL}	V _A , V _B , V _C = V _{ENABLE} = 0 or 3.6V	T _{MIN} to T _{MAX}	-1	0.0005	+1	μA
POWER SUPPLY							
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} = 3.6V or 0			1		μA

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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
ANALOG SWITCH							
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	Ω
On-Resistance Match Between Channels (Notes 4, 5)	ΔR_{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	Ω
SWITCH DYNAMIC CHARACTERISTICS							
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
DIGITAL I/O							
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	μA
POWER SUPPLY							
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	μA

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 ΔR_{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.

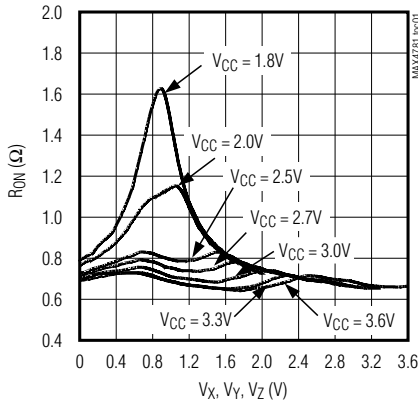
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Typical Operating Characteristics

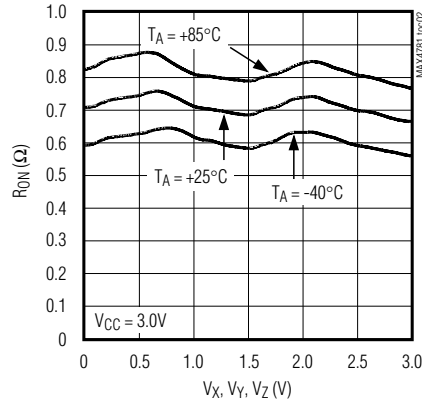
(GND = 0, $T_A = +25^\circ\text{C}$, unless otherwise noted.)

MAX4781/MAX4782/MAX4783

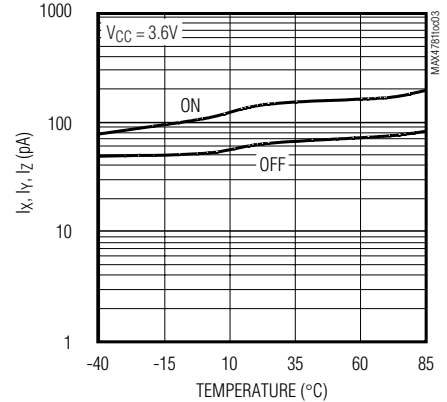
ON-RESISTANCE vs. V_X , V_Y , V_Z



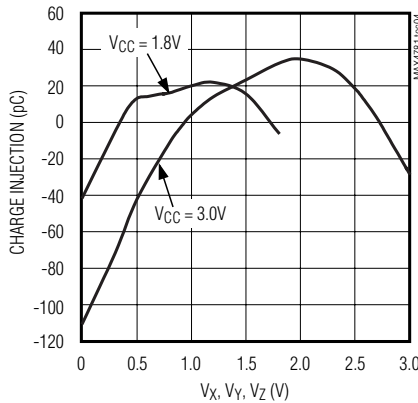
ON-RESISTANCE vs. V_X , V_Y , V_Z , AND TEMPERATURE



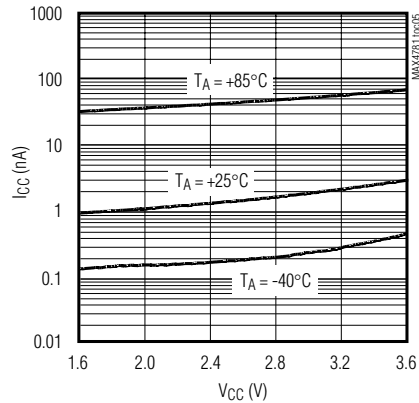
LEAKAGE CURRENT vs. TEMPERATURE



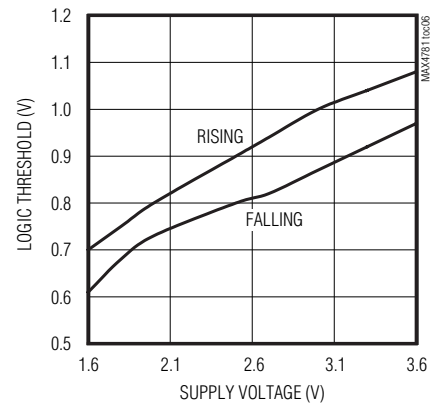
CHARGE INJECTION vs. V_X , V_Y , V_Z



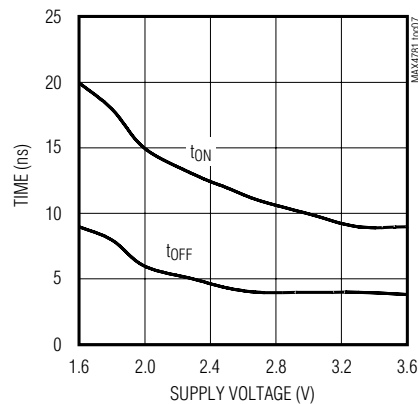
SUPPLY CURRENT vs. TEMPERATURE



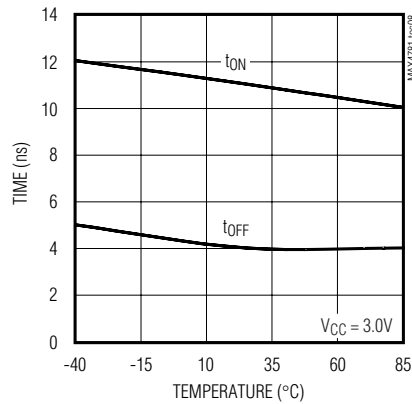
LOGIC THRESHOLD vs. SUPPLY VOLTAGE



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



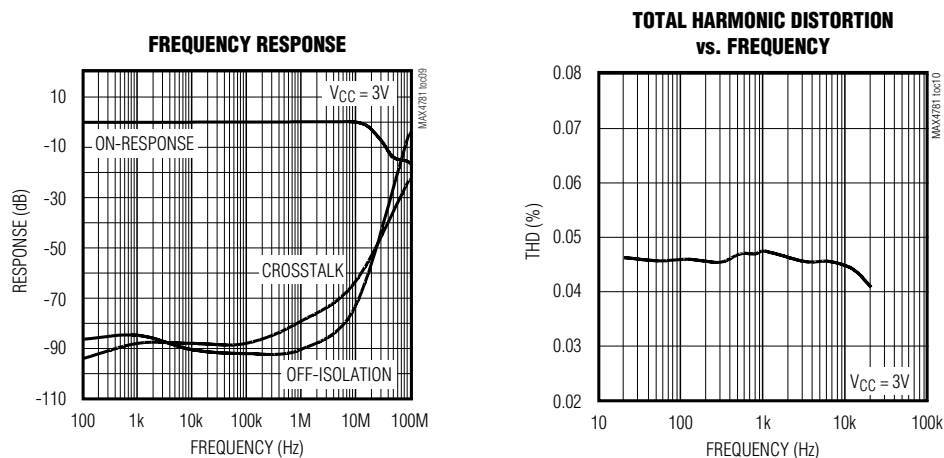
TURN-ON/TURN-OFF TIME vs. TEMPERATURE



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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.

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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, 0.7Ω 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 50Ω 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 50Ω 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.

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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

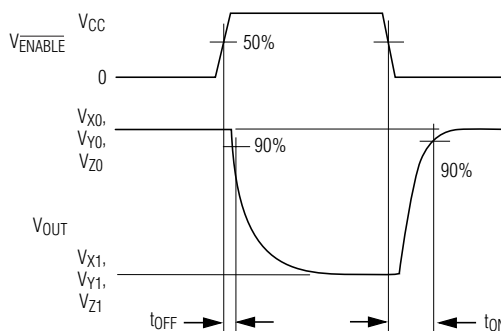
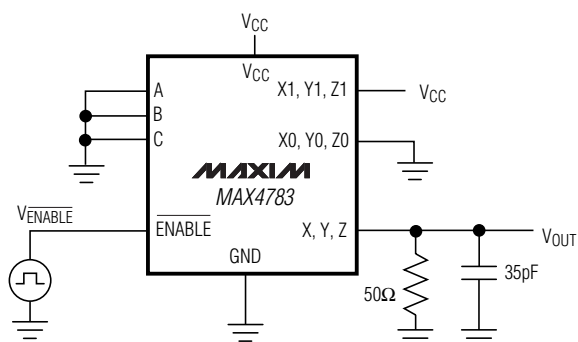
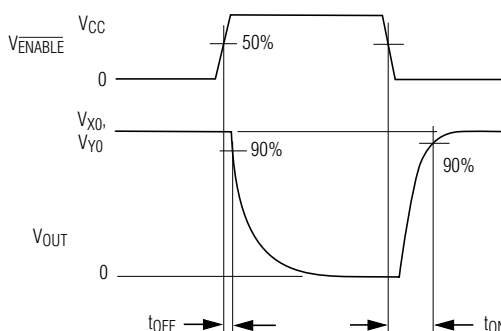
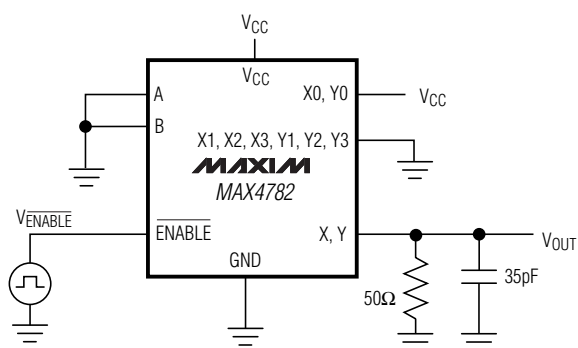
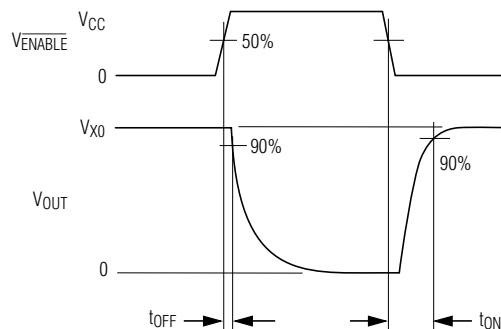
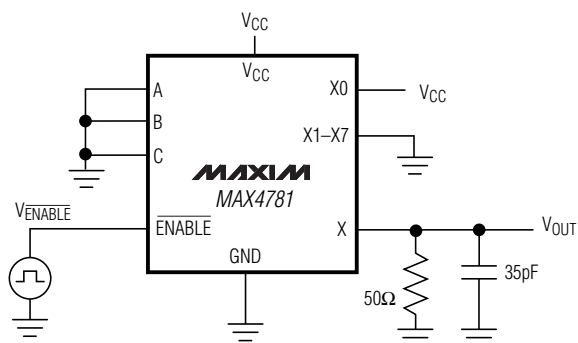
✓ = Don't care.

*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, 0.7Ω CMOS Analog Switches/Multiplexers

Test Circuits/Timing Diagrams



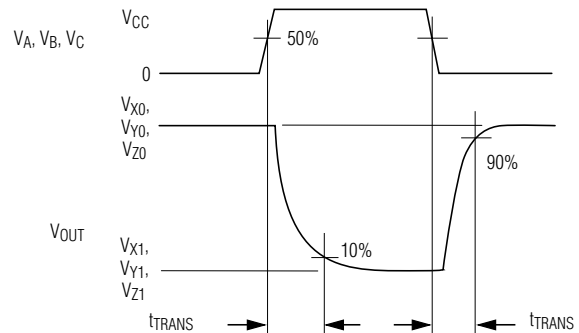
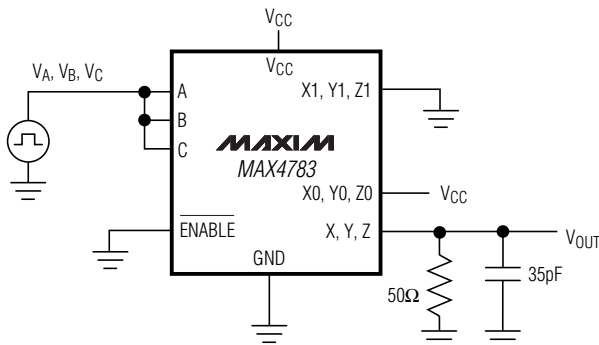
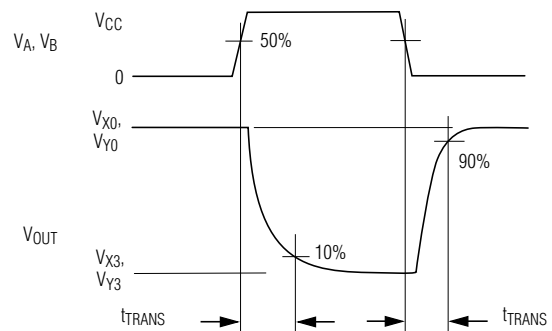
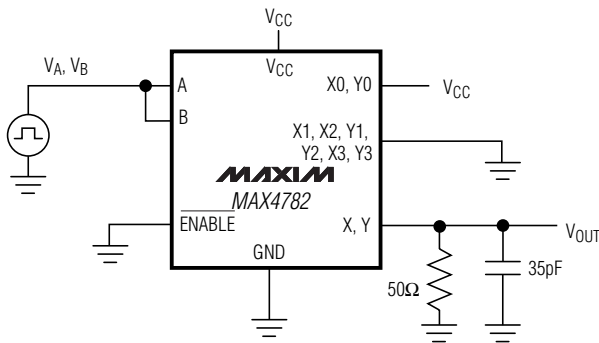
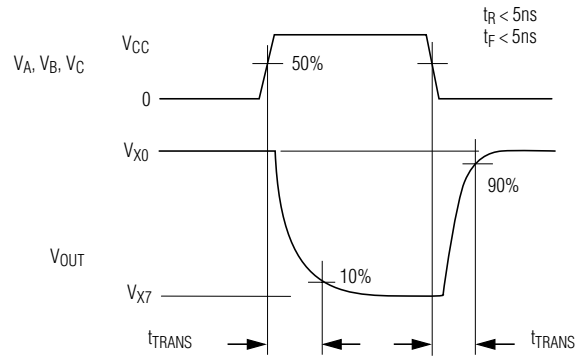
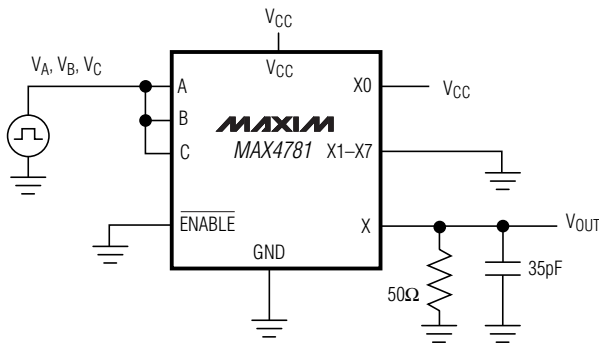
TEST EACH SECTION INDIVIDUALLY.

Figure 1. Enable Switching Times

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

Test Circuits/Timing Diagrams (continued)

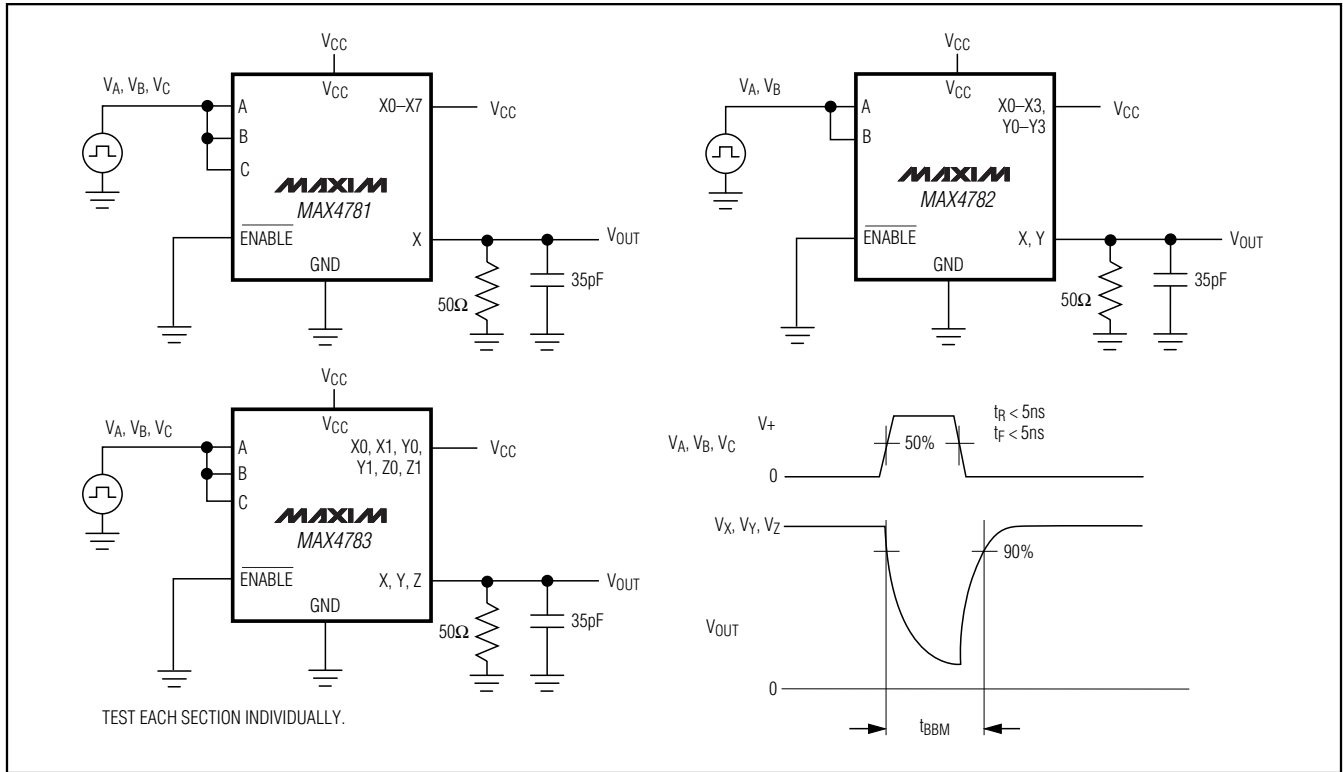


Figure 3. Break-Before-Make Interval

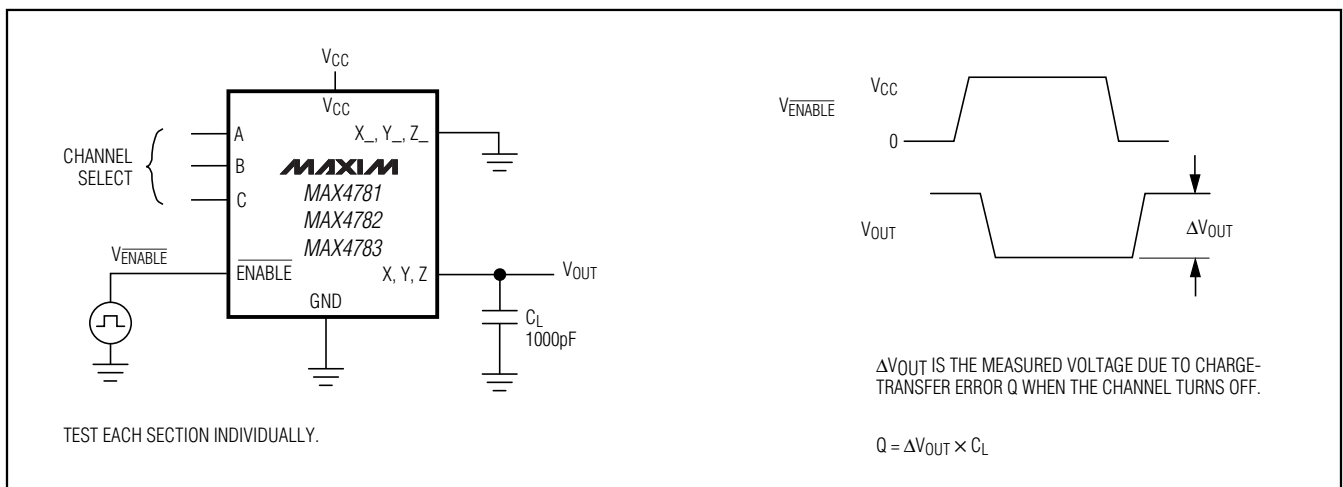
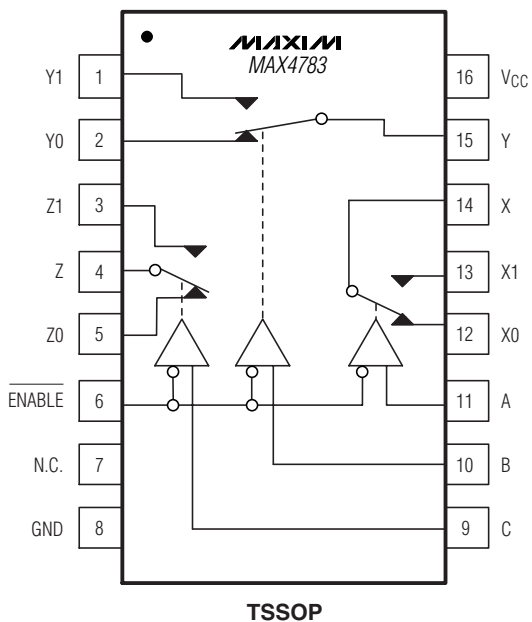
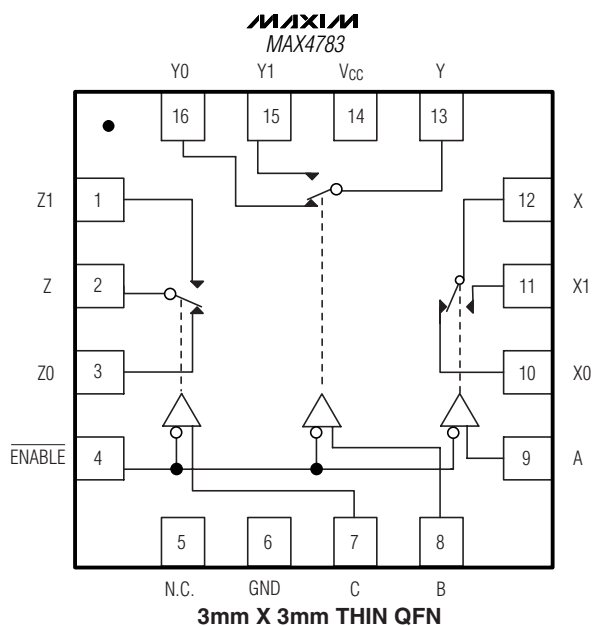
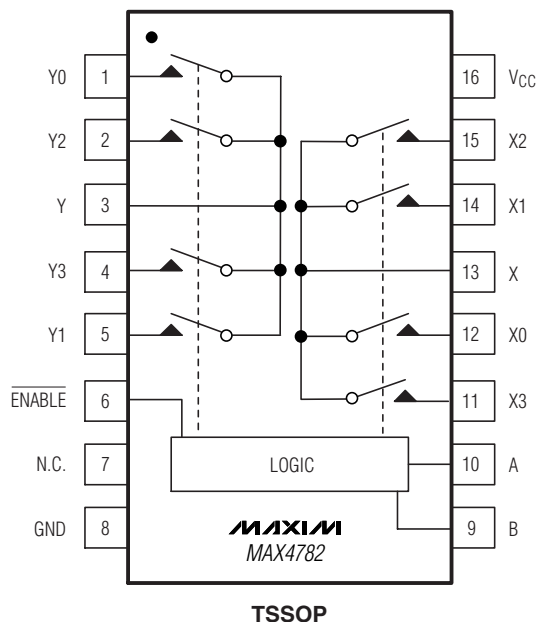
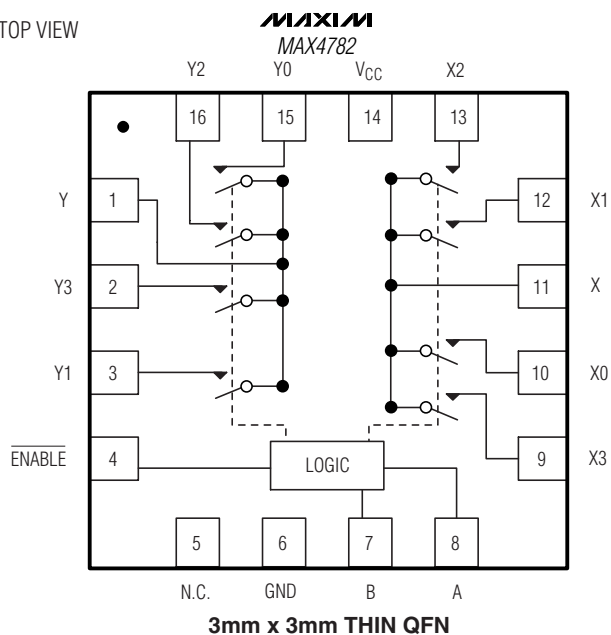


Figure 4. Charge Injection

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

Pin Configurations/Functional Diagrams (continued)

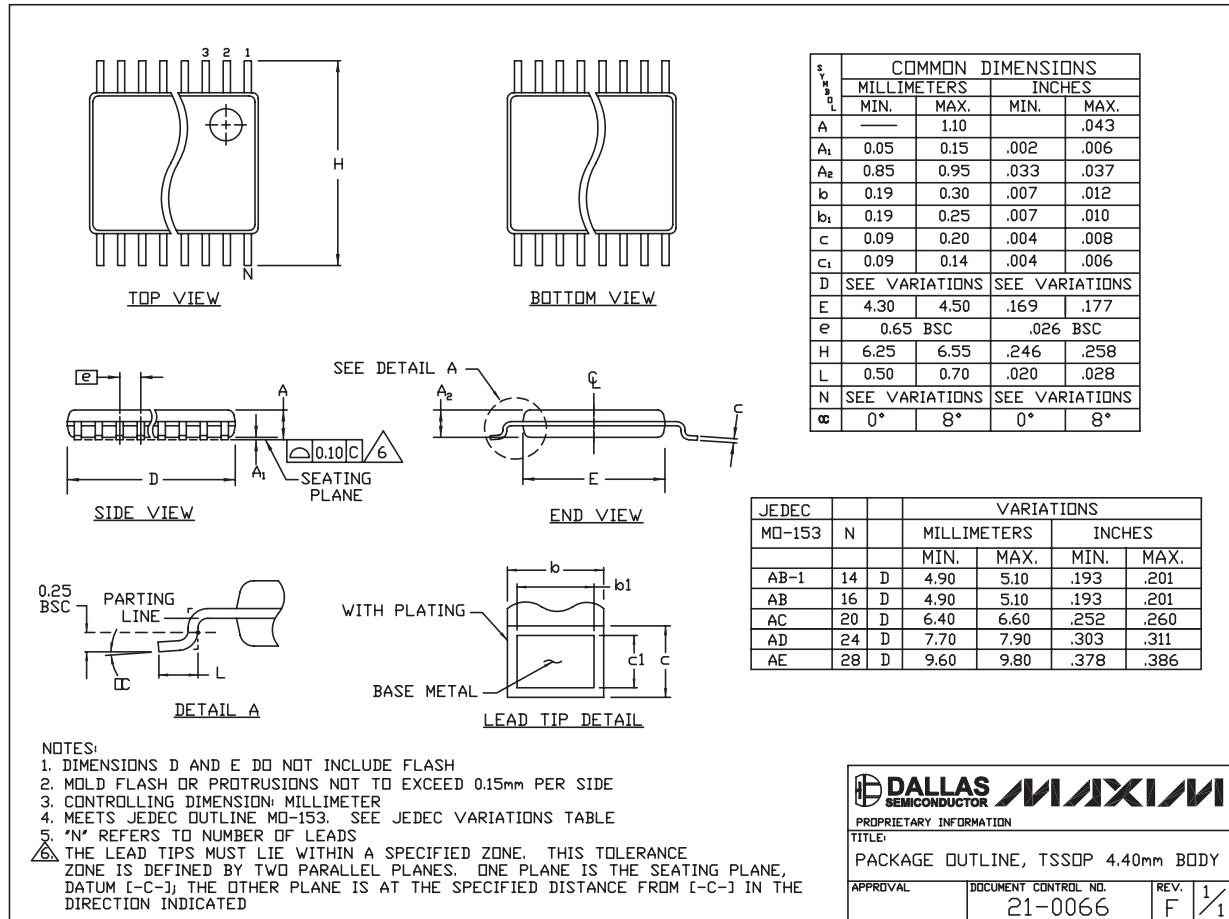
TOP VIEW



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

Package Information

(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.)



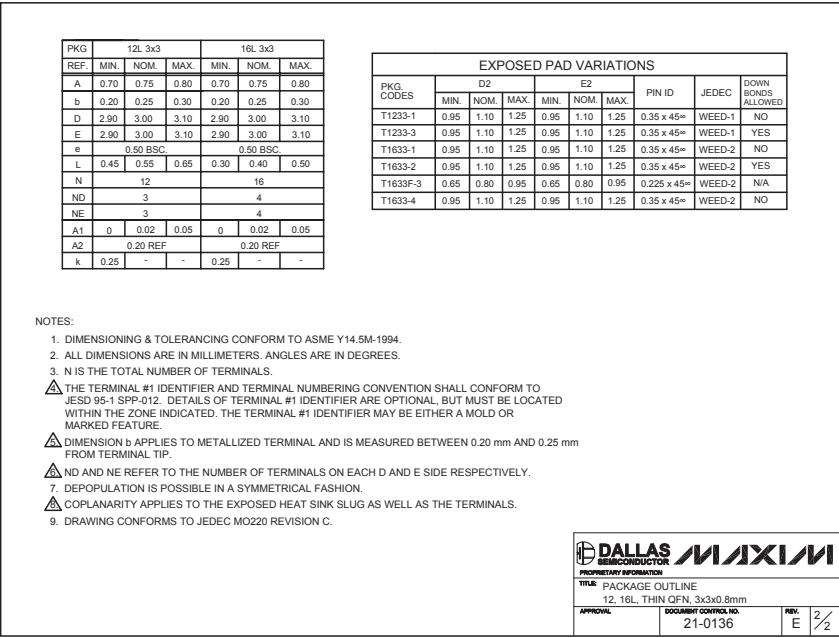
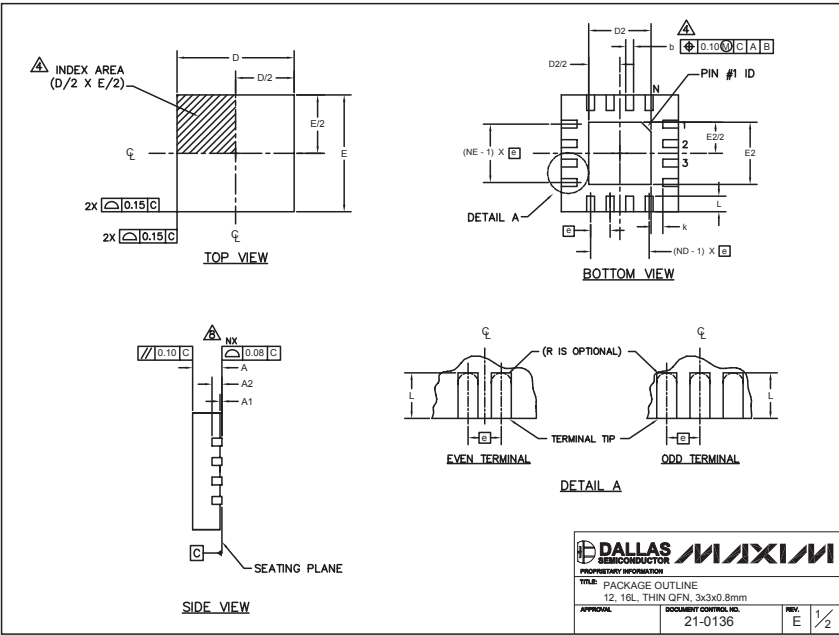
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MAX4781/MAX4782/MAX4783

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.)



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