

# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

**MAX4735**

## General Description

The MAX4735 quad-SPDT switch routes audio signals in portable applications. Each channel has a 0.31Ω typical on-resistance, allowing the MAX4735 to drive 8Ω loudspeakers with less than 0.02% distortion.

The MAX4735 is configured as a quad-SPDT switch with two common control inputs. Each digital input controls two pairs of SPDT switches. The switches are fully bidirectional, allowing both multiplexing and demultiplexing operation. Break-before-make operation is guaranteed.

The device operates from a +1.6V to +3.6V supply and over the extended -40°C to +85°C temperature range. It is offered in both 16-pin 3mm x 3mm TQFN and TSSOP packages.

## Features

- ◆ Low 0.31Ω  $R_{ON}$
- ◆ 0.06Ω On-Resistance Flatness
- ◆ Excellent 0.015Ω On-Resistance Matching
- ◆ Low 0.02% THD into 8Ω
- ◆ Low 0.015% THD into 32Ω
- ◆ Audio Signal Routing
- ◆ Space-Saving, 3mm x 3mm TQFN Package
- ◆ 1.8V Logic Compatible

## Applications

Cell Phones  
Digital Still Cameras  
PDAs and Palmtop Devices  
MP3 Players

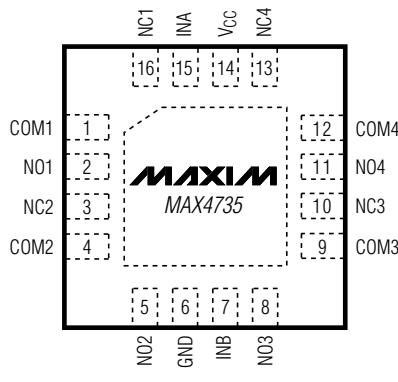
## Ordering Information

PART	PIN-PACKAGE	TOP MARK	PKG CODE
MAX4735ETE	16 TQFN	ACT	T1633-4
MAX4735EUE	16 TSSOP	—	U16-2

**Note:** All products specified across the -40°C to +85°C temperature range.

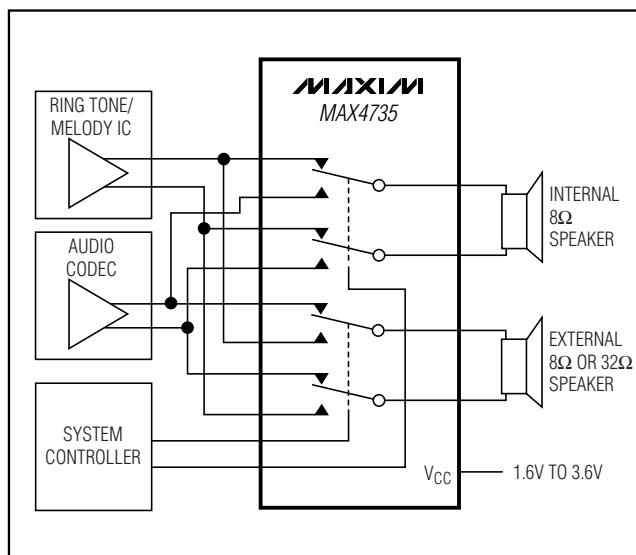
## Pin Configurations

TOP VIEW



Pin Configurations continued at end of data sheet.

## Typical Application Circuit



# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> , INA, INB to GND	-0.3V to +4.0V
All Other Pins to GND (Note 1)	-0.3V to (V <sub>CC</sub> + 0.3V)
Continuous Current (NO <sub>+</sub> , NC <sub>+</sub> , COM <sub>+</sub> )	±300mA
Peak Current (NO <sub>+</sub> , NC <sub>+</sub> , COM <sub>+</sub> ) (pulsed at 1ms, 50% duty cycle)	±400mA
Peak Current (NO <sub>+</sub> , NC <sub>+</sub> , COM <sub>+</sub> ) (pulsed at 1ms, 10% duty cycle)	±500mA

Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
16-Pin TQFN (derate 15.6mW/°C above +70°C)	1.25W
16-Pin TSSOP (derate 9.4mW/°C above +70°C)	755mW
Operating Temperature Range	-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 NO<sub>+</sub>, NC<sub>+</sub>, COM<sub>+</sub> exceeding V<sub>CC</sub> or GND are clamped by internal diodes. IN<sub>+</sub> is clamped to GND by an internal diode. 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

(V<sub>CC</sub> = 2.7V to 3.6V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>CC</sub> = 3V, T<sub>A</sub> = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER SUPPLY</b>						
Supply Voltage Range	V <sub>CC</sub>		1.6	3.6		V
Supply Current	I <sub>CC</sub>	V <sub>CC</sub> = 3.6V, V <sub>IN+</sub> = 0 or V <sub>CC</sub> , NO <sub>+</sub> = NC <sub>+</sub> = COM <sub>+</sub> = floating	0.015	1		µA
<b>ANALOG SWITCH</b>						
Analog Signal Range		NO <sub>+</sub> , NC <sub>+</sub> , COM <sub>+</sub>	0	V <sub>CC</sub>		V
On-Resistance	R <sub>ON</sub>	V <sub>CC</sub> = 2.7V, I <sub>COM+</sub> = 100mA, V <sub>NO+</sub> or V <sub>NC+</sub> = 0 to V <sub>CC</sub> (Note 3)	TA = +25°C	0.31	0.4	Ω
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>		0.45	
On-Resistance Match	ΔR <sub>ON</sub>	V <sub>CC</sub> = 2.7V, I <sub>COM+</sub> = 100mA, V <sub>NO+</sub> or V <sub>NC+</sub> = 1.5V (Notes 3, 4)	TA = +25°C	0.015	0.03	Ω
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>		0.03	
On-Resistance Flatness	R <sub>FLAT</sub>	V <sub>CC</sub> = 2.7V; I <sub>COM+</sub> = 100mA; V <sub>NO+</sub> or V <sub>NC+</sub> = 0.6V, 1.2V, 1.8V (Note 5)	TA = +25°C	0.06	0.75	Ω
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>		0.080	
NO <sub>+</sub> or NC <sub>+</sub> Off-Leakage Current	I <sub>OFF</sub>	V <sub>CC</sub> = 3.3V; V <sub>COM+</sub> = 3V, 0.3V or floating; V <sub>NO+</sub> or V <sub>NC+</sub> = 0.3V, 3V or floating	TA = +25°C	20	20	nA
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>	100	100	
COM <sub>+</sub> On-Leakage Current	I <sub>ON</sub>	V <sub>CC</sub> = 3.3V; V <sub>NO+</sub> or V <sub>NC+</sub> = 0.3V, 3V or floating; V <sub>COM+</sub> = 0.3V, 3V or floating	TA = +25°C	20	20	nA
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>	100	100	

# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC}$  = 2.7V to 3.6V,  $T_A$  =  $T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC}$  = 3V,  $T_A$  = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DYNAMIC CHARACTERISTICS</b>						
Turn-On Time	$t_{ON}$	$V_{CC}$ = 2.7V, $V_{NO\_}$ or $V_{NC\_}$ = 1.5V, $R_L$ = 50Ω, $C_L$ = 35pF, Figure 1	$T_A$ = +25°C	40	200	ns
			$T_A$ = $T_{MIN}$ to $T_{MAX}$		200	
Turn-Off Time	$t_{OFF}$	$V_{CC}$ = 2.7V, $V_{NO\_}$ or $V_{NC\_}$ = 1.5V, $R_L$ = 50Ω, $C_L$ = 35pF, Figure 1	$T_A$ = +25°C	20	180	ns
			$T_A$ = $T_{MIN}$ to $T_{MAX}$		180	
Break-Before-Make Time	$t_{BBM}$	$V_{CC}$ = 2.7V, $V_{NO\_}$ or $V_{NC\_}$ = 1.5V, $R_L$ = 50Ω, $C_L$ = 35pF, Figure 2 (Note 6)	$T_A$ = +25°C	2	15	ns
			$T_A$ = $T_{MIN}$ to $T_{MAX}$	2		
Charge Injection	Q	$V_{GEN}$ = 0V, $R_{GEN}$ = 0Ω, $C_L$ = 1nF, Figure 3		100		pC
On-Channel Bandwidth -3dB	BW	$R_L$ = 50Ω, Figure 4		20		MHz
Off-Isolation	$V_{ISO}$	$V_{COM\_}$ = 1VRMS, $R_L$ = 50Ω, $f$ = 100kHz, $C_L$ = 5pF, Figure 4 (Note 7)		-66		dB
Crosstalk	$V_{CT}$	$V_{COM\_}$ = 1VRMS, $R_L$ = 50Ω, $f$ = 100kHz, $C_L$ = 5pF, Figure 4 (Note 8)		-86		dB
Total Harmonic Distortion Plus Noise	THD+N	$f$ = 20Hz to 20kHz; $V_{NC\_}$ , $V_{NO\_}$ , $V_{COM\_}$ = 0.5V <sub>P-P</sub> ; $R_L$ = 32Ω		0.02		%
NC_ or NO_ Off-Capacitance	$C_{NC\_}(OFF)$ , $C_{NO\_}(OFF)$	$f$ = 1MHz, $V_{NO\_}$ = $V_{NC\_}$ = $V_{COM\_}$ = 1.5V, Figure 5		70		pF
COM_ On-Capacitance	$C_{COM\_}(ON)$	$f$ = 1MHz, $V_{NO\_}$ = $V_{NC\_}$ = $V_{COM\_}$ = 1.5V, Figure 5		250		pF
Power-Supply Rejection Ratio	PSRR	$V_{AC}$ = 100mV <sub>P-P</sub> , $V_{COM\_}$ = 1.5V, $R_L$ = 50Ω, $f$ = 100kHz		-34		dB
<b>DIGITAL INPUTS (INA,</b>						
Input-Logic High	$V_{IH}$		1.4			V
Input-Logic Low	$V_{IL}$			0.5		V
Input Leakage Current	$I_{IN}$	$V_{IN\_}$ = 0 or $V_{CC}$		±200		nA

**Note 2:** Devices are 100% tested at  $T_A$  = +85°C. Limits across the full temperature range are guaranteed by design and correlation.

**Note 3:**  $R_{ON}$  and  $R_{OFF}$  matching specifications are guaranteed by design for MAX4735ETE only.

**Note 4:**  $\Delta R_{ON}$  =  $R_{ON(MAX)}$  -  $R_{ON(MIN)}$ .

**Note 5:** Flatness is defined as the difference between the maximum and minimum value of on-resistance, as measured over the specified analog signal ranges.

**Note 6:** Guaranteed by design, not production tested.

**Note 7:** Off-isolation =  $20\log_{10} [V_{COM\_} / (V_{NO\_} \text{ or } V_{NC\_})]$ ,  $V_{COM\_}$  = output,  $V_{NO\_}$  or  $V_{NC\_}$  = input to off switch.

**Note 8:** Between any two switches.

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## Timing Circuits/Timing Diagrams

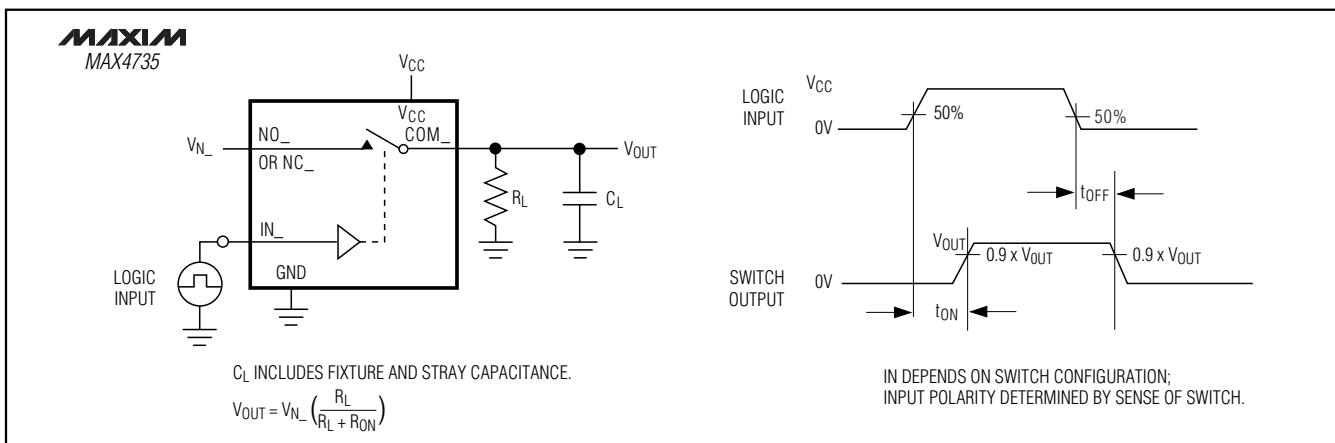


Figure 1. Switching Time

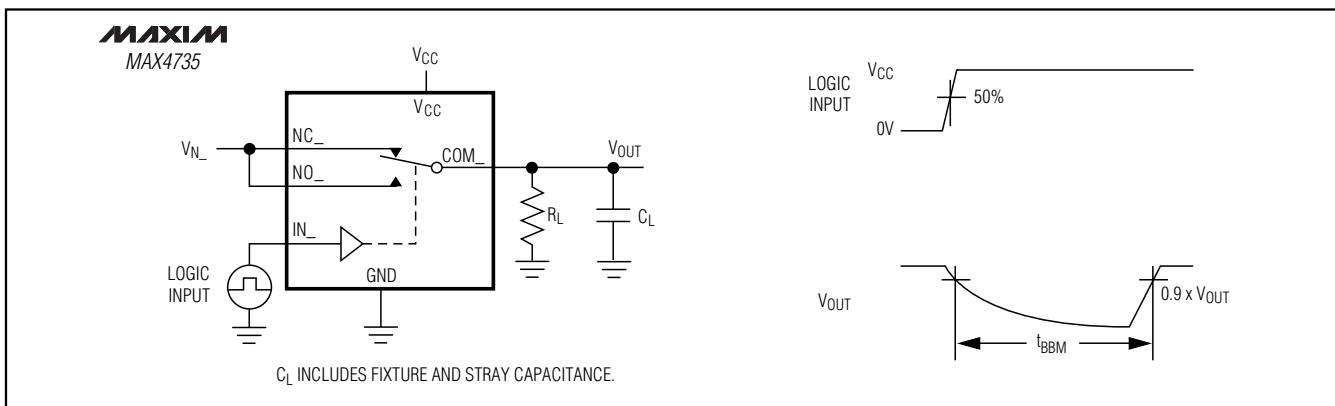


Figure 2. Break-Before-Make Interval

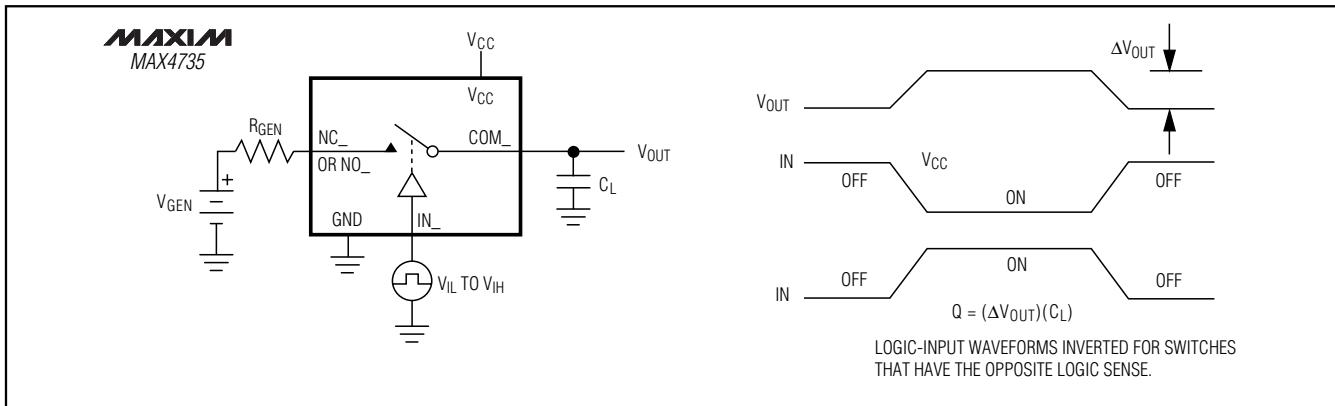


Figure 3. Charge Injection

# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## Timing Circuits/Timing Diagrams (continued)

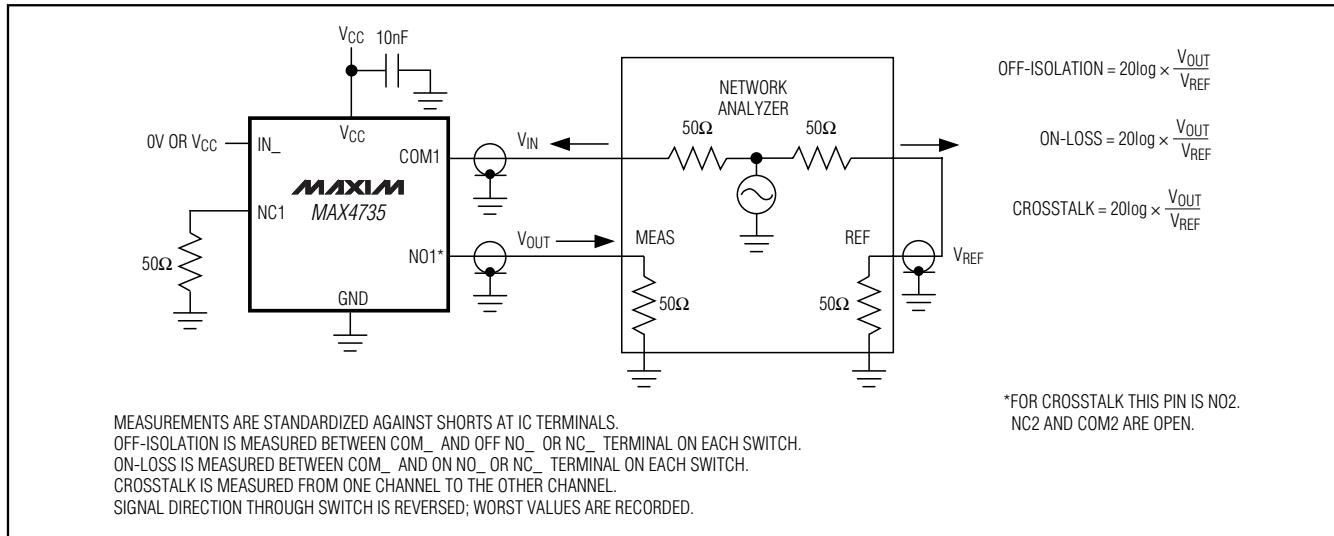


Figure 4. On-Loss, Off-Isolation, and Crosstalk

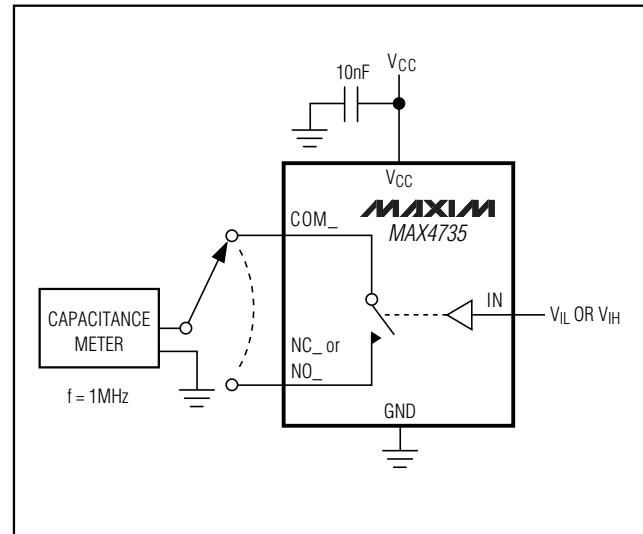
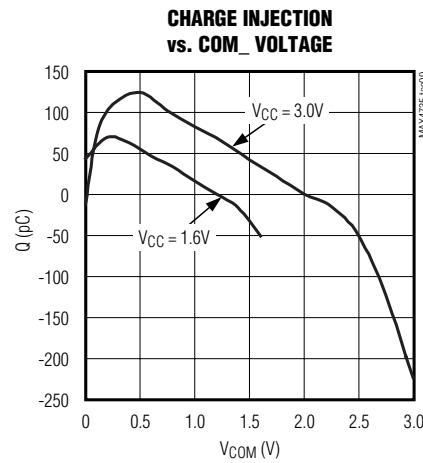
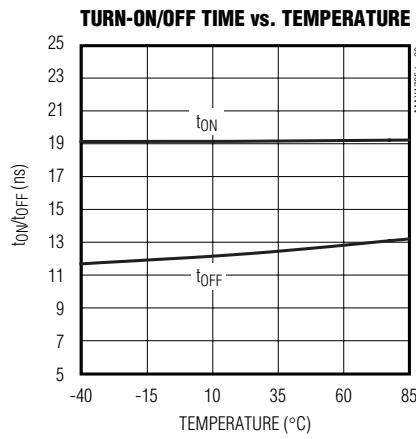
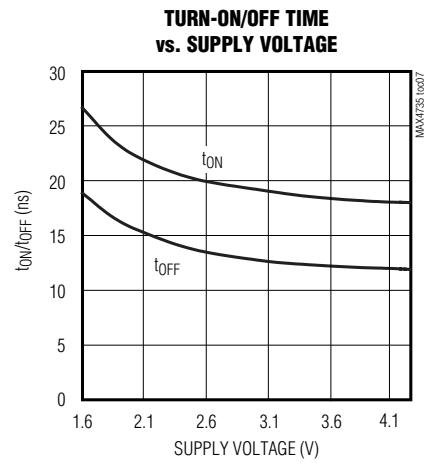
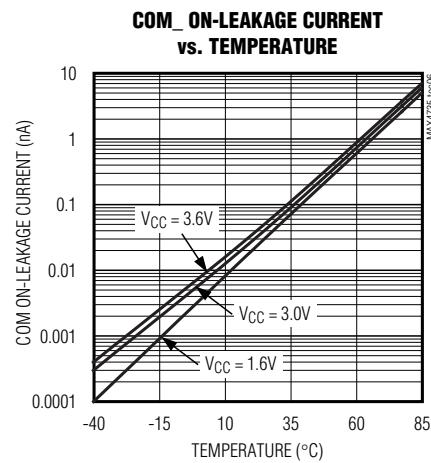
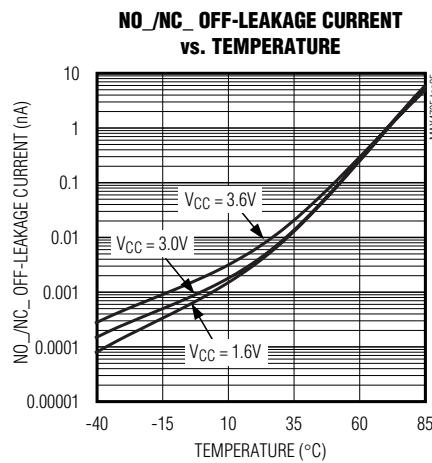
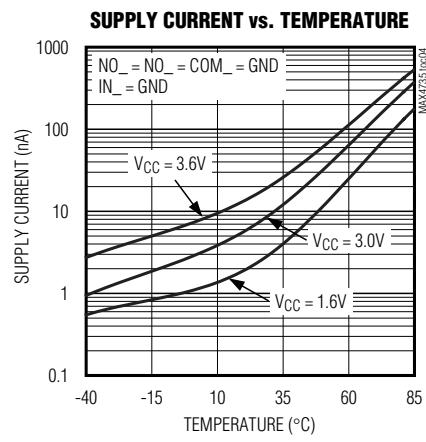
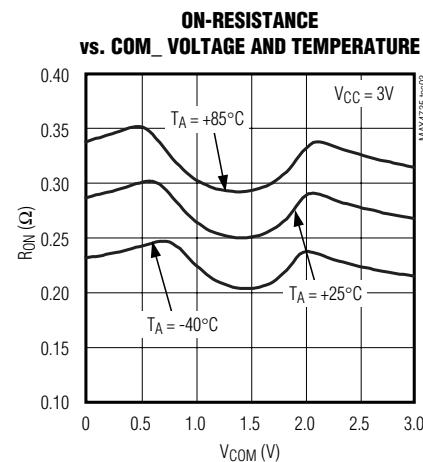
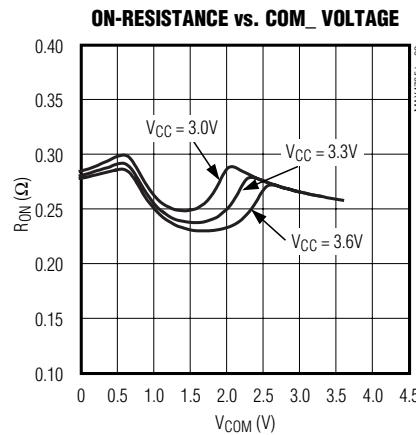
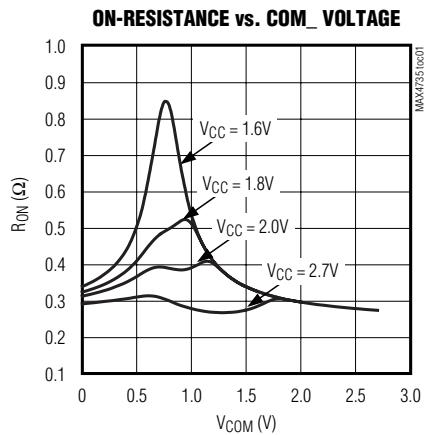


Figure 5. Channel On-/Off-Capacitance

# Low-Voltage, $0.31\Omega$ , Quad-SPDT Analog Switch

( $V_{CC} = 3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

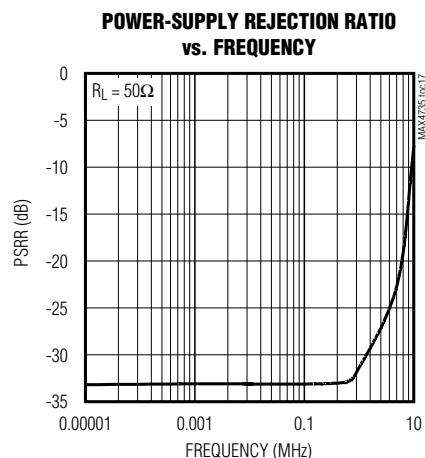
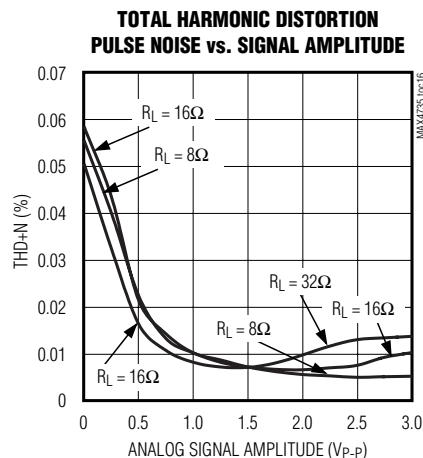
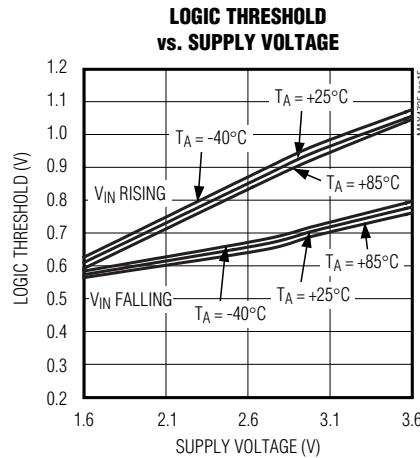
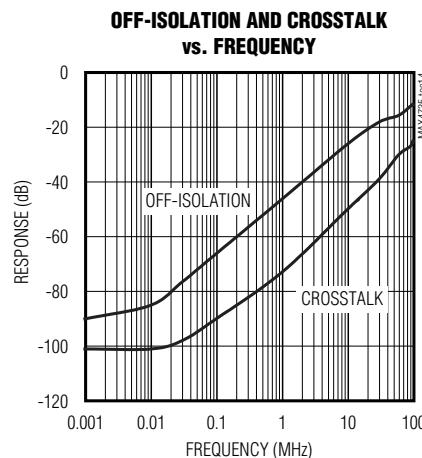
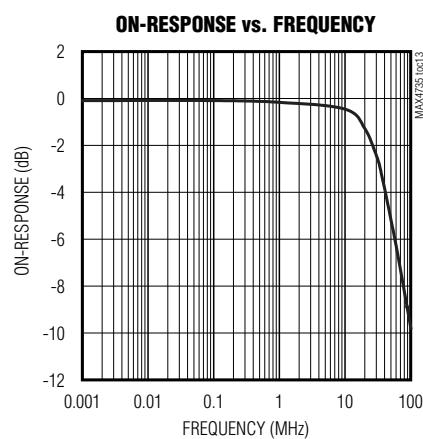
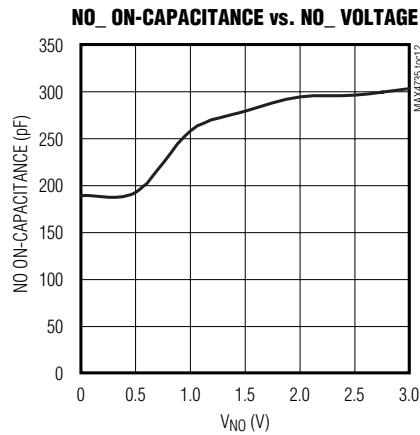
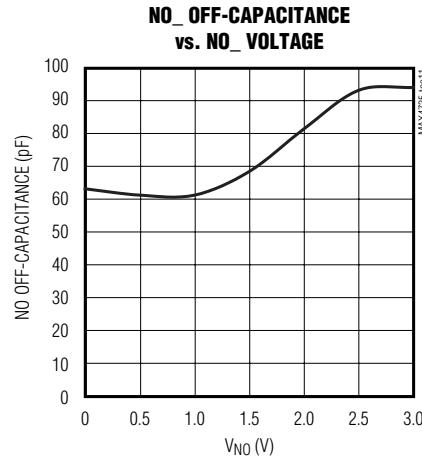
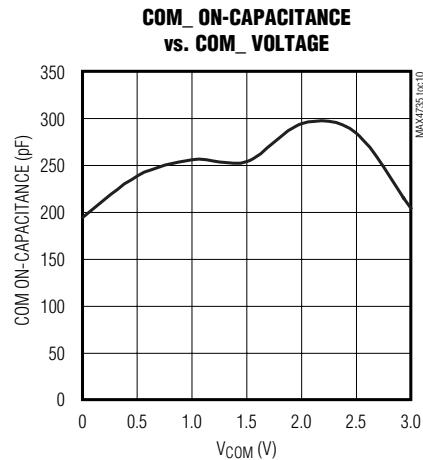
## Typical Operating Characteristics



# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## Typical Operating Characteristics (continued)

( $V_{CC} = 3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## Pin Description

PIN		NAME	FUNCTION
TSSOP	TQFN		
1	15	INA	Select Input A. Controls switch 1 and switch 2.
2	16	NC1	Normally Closed Terminal Switch 1
3	1	COM1	Common Terminal Switch 1
4	2	NO1	Normally Open Terminal Switch 1
5	3	NC2	Normally Closed Terminal Switch 2
6	4	COM2	Common Terminal Switch 2
7	5	NO2	Normally Open Terminal Switch 2
8	6	GND	Ground
9	7	INB	Select Input B. Controls switch 3 and switch 4.
10	8	NO3	Normally Open Terminal Switch 3
11	9	COM3	Common Terminal Switch 3
12	10	NC3	Normally Closed Terminal Switch 3
13	11	NO4	Normally Open Terminal Switch 4
14	12	COM4	Common Terminal Switch 4
15	13	NC4	Normally Closed Terminal Switch 4
16	14	VCC	Positive Power Supply
—	PAD	EP	Exposed Pad. Connect to GND.

## Detailed Description

The MAX4735 quad-SPDT analog switch operates from a single +1.6V to +3.6V supply. These devices are fully specified for +3V applications.

The MAX4735 features fully bidirectional, rail-to-rail CMOS analog switch channels. They can be configured as dual-DPDT switches, dual 4:2 multiplexers/demultiplexers, or as a single 8:4 multiplexer/demultiplexer. See Figure 6.

## Applications Information

### Analog Signal Range

The CMOS switches in the MAX4735 function on any signal within the power-supply voltages. If any channel exceeds V<sub>CC</sub>, it is clamped to V<sub>CC</sub> by a silicon diode. If any channel goes below GND, it is clamped to GND by a silicon diode. Ensure that if either of these diodes becomes forward biased, the continuous and peak currents do not exceed those listed in the *Absolute Maximum Ratings* section of this data sheet.

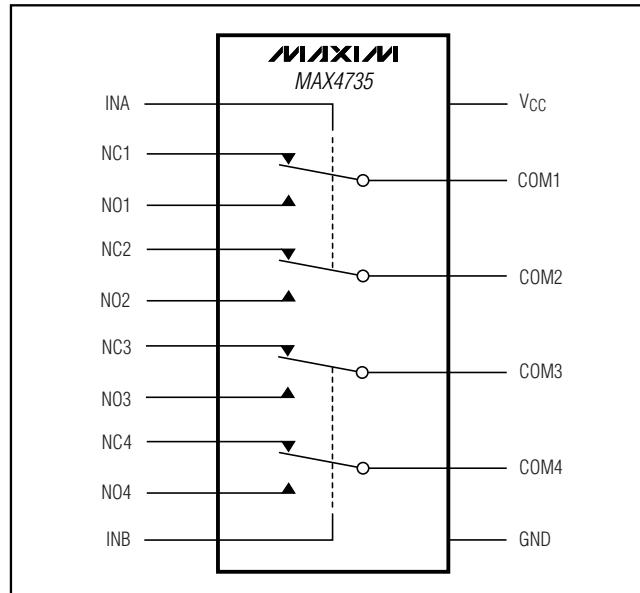


Figure 6. Functional Diagram

# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

As seen in the *Typical Operating Characteristics*, the on-resistance of the MAX4735 is inversely proportional to the supply voltage. Best performance is obtained by using the highest supply voltage available within the +1.6V to +3.6V range.

## Digital Logic Inputs

Digital control inputs INA and INB control the position of the switches in the MAX4735. These inputs are diode clamped to GND only. It is acceptable to leave these pins driven in the absence of a VCC power supply.

For best performance, drive INA and INB to the full supply voltage range of the MAX4735.

The two switch sections of the MAX4735 operate independently. Drive INA low to connect COM1 to NC1 and connect COM2 to NC2. Drive INA high to connect COM1 to NO1 and connect COM2 to NO2. Drive INB low to connect COM3 to NC3 and connect COM4 to NC4. Drive INB high to connect COM3 to NO3 and connect COM4 to NO4. See Table 1.

INA and INB have typical hysteresis of 100mV by including positive feedback in the internal buffer. Thus, for applications using DC or very slow ramp rate of the digital input voltage level, connect a 100pF capacitor from IN\_ to GND to limit the  $I_{CC}$  current at the trip point. The switching point is typically 0.7V between  $V_{IL}$  and  $V_{IH}$  levels.

## Power Supply

The MAX4735 operates from a +1.6V to +3.6V power supply. For best results, bypass VCC to GND with a 0.1μF ceramic chip capacitor located close to the IC.

## Audio Signal Routing

The MAX4735's low  $R_{ON}$  makes it an excellent choice for multiplexing loudspeakers in portable equipment. THD performance is inversely proportional to load impedance. Within the audio signal range, there is no frequency component to THD. The only distortion mechanism is the  $R_{ON}$  flatness' modulation of the signal into a load. Therefore, for best distortion performance, use higher impedance transducers.

**Table 1. Truth Table**

INA	INB	SWITCH 1 AND SWITCH 2 STATE	SWITCH 3 AND SWITCH 4 STATE
0	—	COM1 to NC1 COM2 to NC2	—
1	—	COM1 to NO1 COM2 to NO2	—
—	0	—	COM3 to NC3 COM4 to NC4
—	1	—	COM3 to NO3 COM4 to NO4

Each switch channel on the MAX4735 has an absolute maximum rating 300mA continuous current, and 400mA peak current at 50% duty cycle. When driving low-impedance loudspeakers, the peak signal amplitude should be limited so these peak currents are not exceeded. For an 8Ω load, this corresponds to 2.3VRMS. For a 4Ω load, this is 1.1VRMS.

## Package Information

The MAX4735 is offered in 16-pin TSSOP and 3mm x 3mm x 0.8mm TQFN packages. The mechanical drawings for these packages are located at the end of this data sheet. Please check [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages) to ensure working with the latest information.

The TSSOP package is rated for a peak power dissipation of 755mW at +70°C, with a  $\theta_{JA}$  of 106°C/W on a single-layer PC board. The TQFN package is rated for a peak power dissipation of 1.25W at +70°C, with a  $\theta_{JA}$  of 64°C/W on a single-layer PC board. The TQFN package is the T1633-4 package code variant.

# **Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch**

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## **Chip Information**

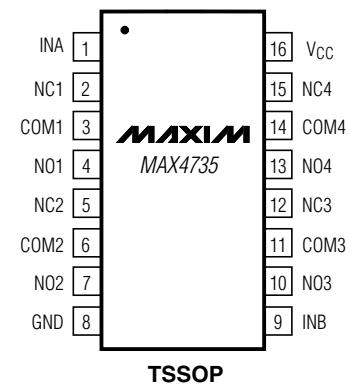
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PROCESS: CMOS

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## **Pin Configurations (continued)**

TOP VIEW

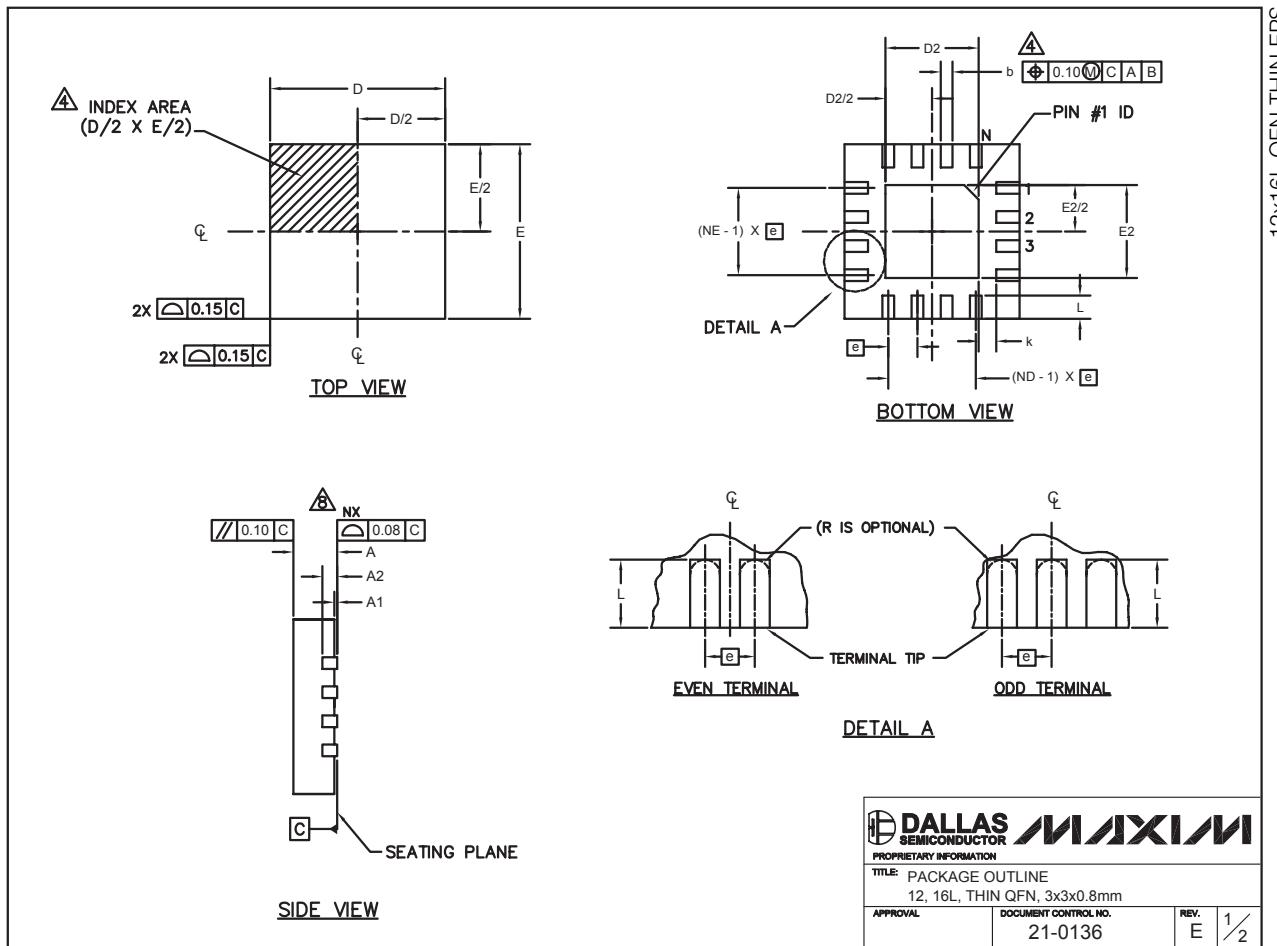


# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

MAX4735

## 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](http://www.maxim-ic.com/packages).)



	<b>DALLAS SEMICONDUCTOR</b>	<b>MAXIM</b>
PROPRIETARY INFORMATION		
TITLE: PACKAGE OUTLINE		
APPROVAL	DOCUMENT CONTROL NO.	REV. E 1/2
	21-0136	

# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## 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).)

PKG	12L 3x3			16L 3x3		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80
b	0.20	0.25	0.30	0.20	0.25	0.30
D	2.90	3.00	3.10	2.90	3.00	3.10
E	2.90	3.00	3.10	2.90	3.00	3.10
e	0.50 BSC.			0.50 BSC.		
L	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16		
ND	3			4		
NE	3			4		
A1	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF			0.20 REF		
k	0.25	-	-	0.25	-	-

PKG, CODES	EXPOSED PAD VARIATIONS						PIN ID	JEDEC	DOWN BONDS ALLOWED			
	D2			E2								
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.						
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45 <sup>∞</sup>	WEED-1	NO			
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45 <sup>∞</sup>	WEED-1	YES			
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45 <sup>∞</sup>	WEED-2	NO			
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45 <sup>∞</sup>	WEED-2	YES			
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45 <sup>∞</sup>	WEED-2	N/A			
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45 <sup>∞</sup>	WEED-2	NO			

### NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.

**⚠** THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.

**⚠** DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.20 mm AND 0.25 mm FROM TERMINAL TIP.

**⚠** ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.

7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.

**⚠** COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.

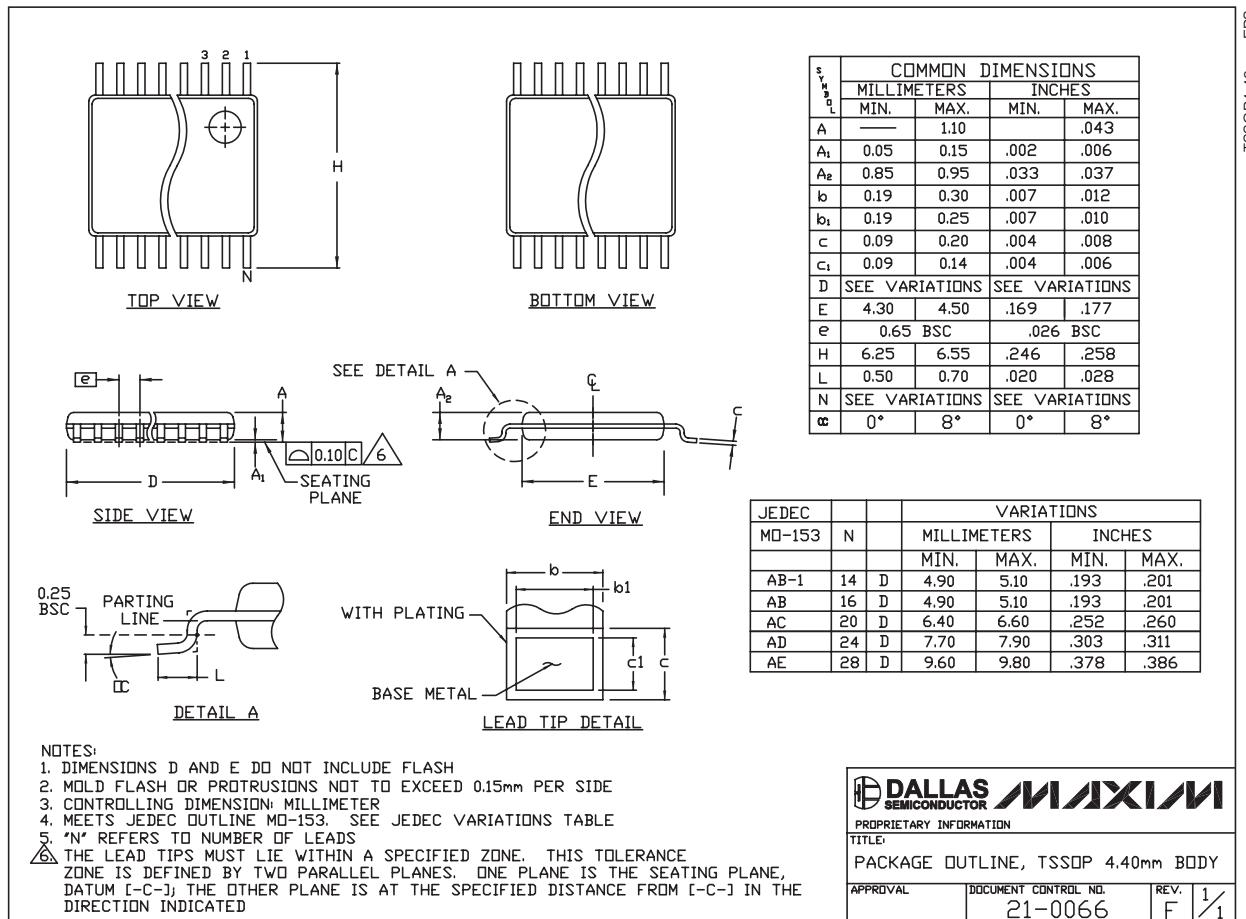
9. DRAWING CONFORMS TO JEDEC MO220 REVISION C.



# Low-Voltage, 0.31Ω, Quad-SPDT Analog Switch

## 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).)



TSSOP4-4.00mm.EPS

MAX4735

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