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19-0563; Rev 0; 5/06

Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

General Description

The MAX4744/MAX4744H/MAX4745/MAX4745H dual SPDT (single pole/double throw) audio switches feature negative signal capability that allows signals as low as V_{CC} - 5.5V to pass through without distortion. These analog switches have a low on-resistance, low supply current, and operate from a single +1.8V to +5.5V supply.

The MAX4744/MAX4744H have internal shunt resistors that automatically discharge the capacitance at the normally open (NO) and normally closed (NC) terminals when they are not connected. This reduces click-and-pop sounds that occur when switching audio signals between pre-charged points. A break-before-make feature further reduces popping. The MAX4744/MAX4745 control the switches with two control bits CB1 and CB2. The MAX4744H/MAX4745H have one control bit to switch both switches and an enable input $\overline{EN}$ to put the switches in a high-impedance mode. The MAX4744H/MAX4745H also have an internal protection network against voltages applied to COM_ when V_{CC} = 0V.

These devices are available in a space-saving 10-pin µDFN (2mm x 2mm) package and operate over the -40°C to +85°C extended temperature range.

Applications

Speaker Switching

Power Routing

Cellular Phones

MP3 Players

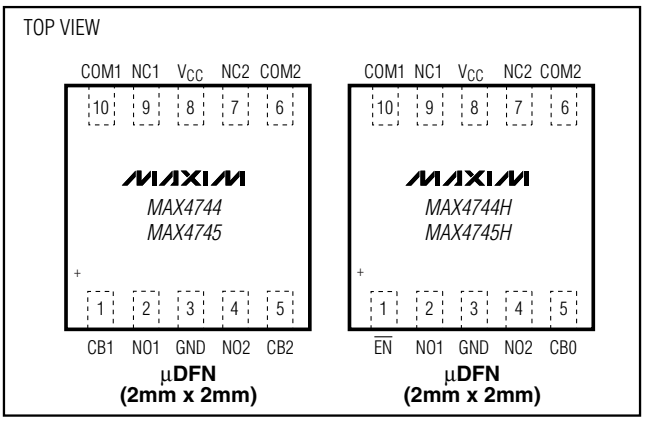
PDAs and other Handheld Devices

Notebook Computers

Features

- **Distortion-Free Negative Signal Throughput Down to V_{CC} - 5.5V**
- **Internal Shunt Resistor Reduces Click/Pop (MAX4744/MAX4744H)**
- **0.6Ω (typ) Low On-Resistance**
- **0.1Ω (max) Channel-to-Channel Matching**
- **0.55Ω (max) On-Resistance Flatness**
- **+1.8V to +5.5V Single-Supply Voltage**
- **0.01% (typ) Total Harmonic Distortion**
- **-75dB (typ) Crosstalk (100kHz)**
- **-68dB (typ) Off-Isolation (100kHz)**
- **Available in 10-pin µDFN Package (2mm x 2mm)**

Pin Configurations



Ordering Information

PART	PIN-PACKAGE	TOP MARK	CLICKLESS	COM PROTECTION	PKG CODE
MAX4744ELB+T	10 µDFN-10	+AAF	Yes	No	L1022-1
MAX4744HELB+T	10 µDFN-10	+AAG	Yes	Yes	L1022-1
MAX4745ELB+T	10 µDFN-10	+AAH	No	No	L1022-1
MAX4745HELB+T	10 µDFN-10	+AAI	No	Yes	L1022-1

Note: *All devices are specified over the -40°C to +85°C operating temperature range.*
+Denotes lead-free package.

Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)
V_{CC}, CB_, $\overline{EN}$ .....-0.3V to +6.0V
NC_, NO_ .....(V_{CC} - 6V) to (V_{CC} + 0.3V)
COM_ (MAX4744/MAX4745).....(V_{CC} - 6V) to (V_{CC} + 0.3V)
COM_ (MAX4744H/MAX4745H).....(Note 1)
Continuous Current NO_, NC_, COM_. .....±300mA
Peak Current NO_, NC_, COM_ (Pulsed at 1ms, 50% Duty Cycle).....±400mA
Peak Current NO_, NC_, COM_ (Pulsed at 1ms, 10% Duty Cycle).....±500mA
ESD Protection per Method 3015.7
NO_, NC_, COM_, V_{CC}, GND, CB_, $\overline{EN}$.....±2kV
Continuous Power Dissipation (T_A = +70°C)
10-Pin µDFN (derate 5mW/°C above +70°C) 403mW
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C

Note 1: If V_{CC} > 0.5V, limits are (V_{CC} - 6V) to (V_{CC} + 0.3V). If V_{CC} < 0.5V, limits are (V_{CC} - 6.0V) to +6.0V.

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_{CC} = +2.7V to +5.5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Supply-Voltage Range	V_{CC}			1.8		5.5	V
Supply Current	I_{CC}	V_{CC} = 5.5V, $V_{CB\_}$ = 0V or V_{CC}			0.3	1	µA
		V_{CC} = 5.5V, $V_{CB\_}$ = 0.5V or 1.4V				8	
		V_{CC} = 2.7V, $V_{CB\_}$ = 0.5V or 1.4V				4	
ANALOG SWITCH							
Analog Signal Range (Note 3)	$V_{NC\_}$, $V_{NO\_}$, $V_{COM\_}$,			V_{CC} - 5.5V		V_{CC}	V
On-Resistance (Note 4)	R_{ON}	V_{CC} = 2.7V; $V_{NC\_}$ or $V_{NO\_}$ = V_{CC} - 5.5V, -1V, 0V, 1V, 2V, V_{CC}; $I_{COM\_}$ = 100mA	T_A = +25°C		0.6	0.95	Ω
			T_A = T_{MIN} to T_{MAX}			1.0	
On-Resistance Match Between Channels (Notes 4 and 5)	ΔR_{ON}	V_{CC} = 2.7V, $V_{NC\_}$ or $V_{NO\_}$ = 0V, $I_{COM\_}$ = 100mA	T_A = +25°C			0.1	Ω
			T_A = T_{MIN} to T_{MAX}			0.1	
On-Resistance Flatness (Note 6)	R_{FLAT}	V_{CC} = 2.7V, $V_{NC\_}$ or $V_{NO\_}$ = V_{CC} - 5.5V, - 1V, 0V, 1V, 2V, V_{CC}; $I_{COM\_}$ = 100mA	T_A = +25°C			0.55	Ω
			T_A = T_{MIN} to T_{MAX}			0.6	
Shunt Switch Resistance	R_{SH}	MAX4744/MAX4744H only, V_{CC} = 2.7V		2		5	kΩ
NC_, NO_ Off-Leakage Current (Note 3)	$I_{NO\_(OFF)}$, $I_{NC\_(OFF)}$	V_{CC} = 2.7V switch open; $V_{NC\_}$ or $V_{NO\_}$ = -2.5, +2.5V (MAX4745/MAX4745H only)	T_A = +25°C	-15		+15	nA
			T_A = T_{MIN} to T_{MAX}	-50		+50	
COM_ On-Leakage Current (Note 3)	$I_{COM\_(ON)}$	V_{CC} = 2.7V switch closed; $V_{NC\_}$ or $V_{NO\_}$ = -2.5, +2.5V; $V_{COM\_}$ = -2.5, +2.5V	T_A = +25°C	-15		+15	nA
			T_A = T_{MIN} to T_{MAX}	-100		+100	

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.7V to +5.5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
COM_ Leakage Under Protection Conditions	$I_{L(PROT)}$	V_{CC} = 0V; $V_{COM\_}$ = +5.5V; $V_{NC\_}$ and $V_{NO\_}$ are unconnected or connected to GND; $V_{CB\_}$ = 0V (MAX4744H/MAX4745H only)	T_A = +25°C		30		nA
			T_A = T_{MIN} to T_{MAX}		500		
DYNAMIC CHARACTERISTICS							
Turn-On Time	t_{ON}	V_{CC} = 2.7V, R_L = 32Ω, C_L = 35pF, Figure 2	For NO_, $V_{NO\_}$ = 1.5V, $V_{CB\_}$ = 0V to V_{CC}		55		ns
			For NC_, $V_{NC\_}$ = 1.5V, $V_{CB\_}$ = V_{CC} to 0V		560		
Turn-Off Time	t_{OFF}	V_{CC} = 2.7V, R_L = 32Ω, C_L = 35pF, Figure 2	For NO_, $V_{NO\_}$ = 1.5V, $V_{CB\_}$ = V_{CC} to 0V		540		ns
			For NC_, $V_{NC\_}$ = 1.5V, $V_{CB\_}$ = 0V to V_{CC}		36		
Break-Before-Make Delay Time	t_D	V_{CC} = 2.7V, $V_{NC\_}$ = $V_{NO\_}$ = 1.5V; for NO_, $V_{CB\_}$ = V_{CC} to 0V; for NC_, $V_{CB\_}$ = 0V to V_{CC}; R_L = 32Ω; C_L = 35pF; Figure 3			20		ns
Power-Supply Rejection Ratio	PSRR	f = 100kHz, $V_{COM\_}$ = $1V_{RMS}$, R_L = 50Ω, C_L = 5pF			52		dB
Charge Injection	Q	$V_{GEN\_}$ = 0V; R_{GEN} = 0Ω, C_L = 1nF, Figure 4			450		pC
Off-Isolation (Note 7)	V_{ISO}	C_L = 5pF; R_L = 50Ω; f = 100kHz; $V_{COM\_}$ = $1V_{RMS}$; Figure 5			-68		dB
Crosstalk	V_{CT}	C_L = 5pF; R_L = 50Ω; f = 100kHz; $V_{COM\_}$ = $1V_{RMS}$; Figure 5			-75		dB
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, $V_{COM\_}$ = $0.5V_{P-P}$, R_L = 50Ω			0.01		%
NO_, NC_ Off-Capacitance	$C_{NO\_(OFF)}$, $C_{NC\_(OFF)}$	f = 1MHz, Figure 6			90		pF
COM On-Capacitance	$C_{COM\_(ON)}$	f = 1MHz, Figure 6			300		pF

Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.7V to +5.5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 2)

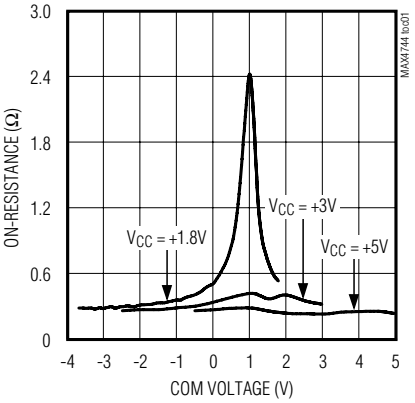
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DIGITAL INPUTS (CB_, $\overline{EN}$)						
Input-Logic High	V_{IH}		1.4			V
Input-Logic Low	V_{IL}				0.5	V
Input Leakage Current	I_{LEAK}	$V_{CB\_}$ or $V_{\overline{EN}}$ = 0V or V_{CC}	-1		+1	µA

Note 2: All parameters are production tested at T_A = +25°C and guaranteed by design over the specified temperature range.
Note 3: Signals on COM_, NO_, or NC_ exceeding V_{CC} are clamped by internal diodes. Limit forward-diode current to maximum current ratings.
Note 4: Guaranteed by design; not production tested.
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: Off-isolation = $20\log_{10}[VC_{OM\_}/V_{NO\_}]$, $V_{COM\_}$ = output, $V_{NO\_}$ = input to off switch.

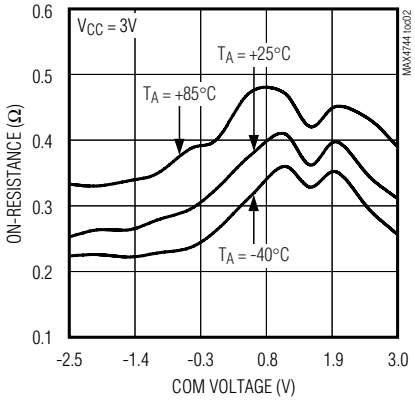
Typical Operating Characteristics

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted.)

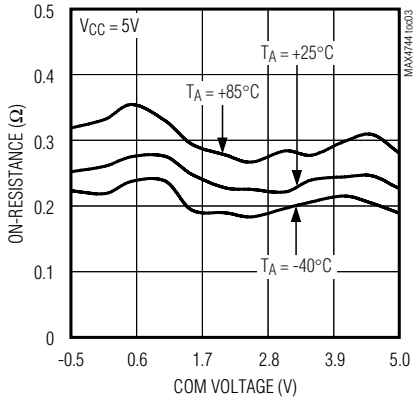
ON-RESISTANCE vs. COM VOLTAGE



ON-RESISTANCE vs. COM VOLTAGE



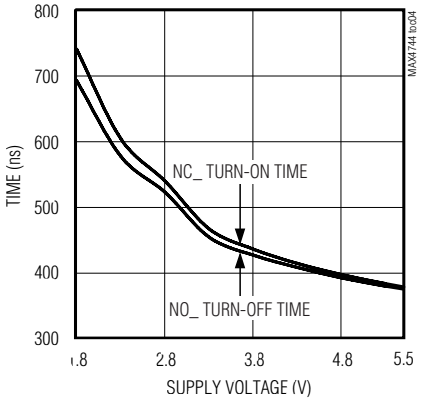
ON-RESISTANCE vs. COM VOLTAGE



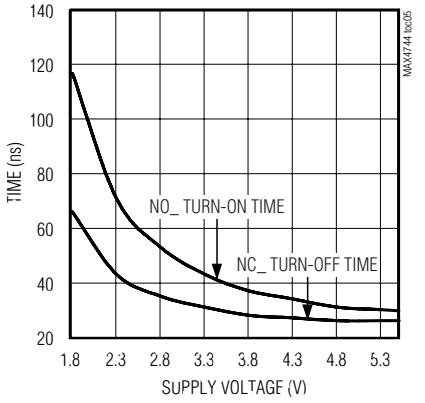
Typical Operating Characteristics

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted.)

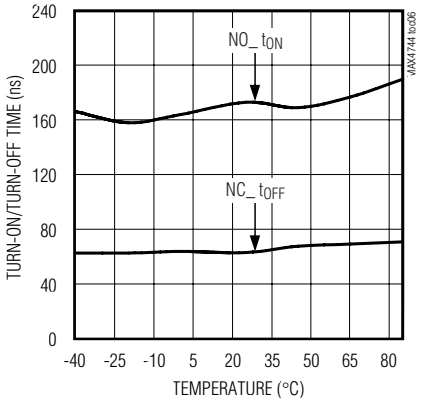
NC_ TURN-ON/NO_ TURN-OFF TIME vs. SUPPLY VOLTAGE



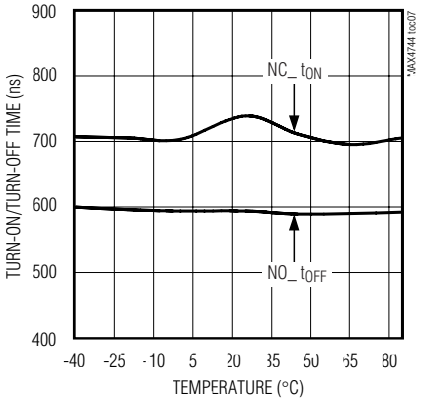
NO_ TURN-ON/NC_ TURN-OFF TIME vs. SUPPLY VOLTAGE



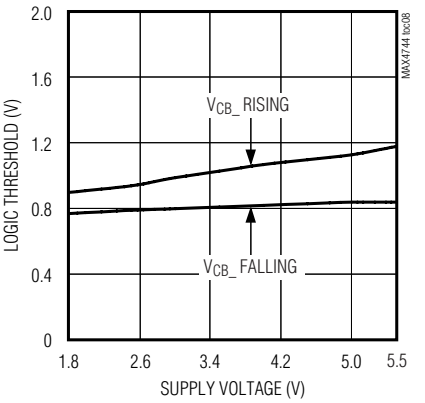
NO_ TURN-ON/NC_ TURN-OFF TIME vs. TEMPERATURE



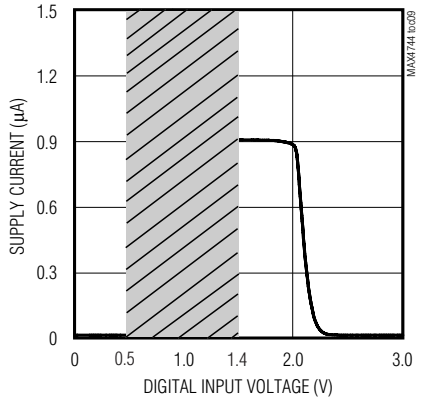
NO_ TURN-ON/NC_ TURN-OFF TIME vs. TEMPERATURE



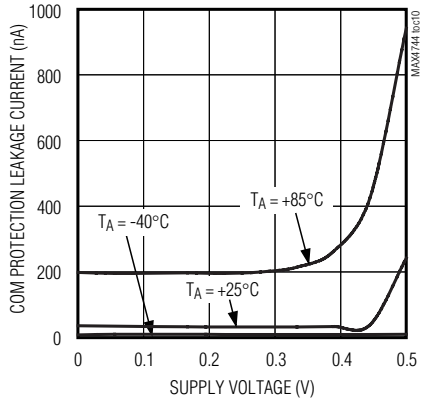
LOGIC THRESHOLD vs. SUPPLY VOLTAGE



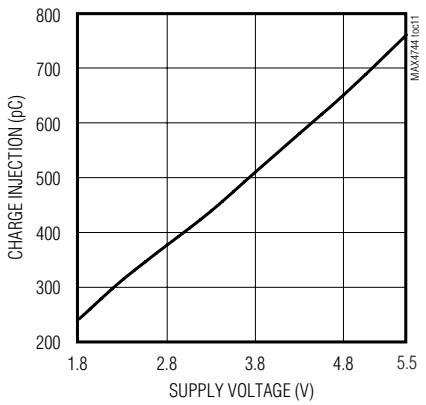
SUPPLY CURRENT vs. LOGIC-INPUT VOLTAGE



COM PROTECTION LEAKAGE CURRENT vs. SUPPLY VOLTAGE



CHARGE INJECTION vs. SUPPLY VOLTAGE

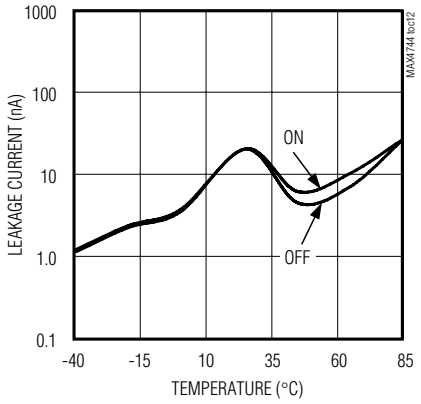


Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

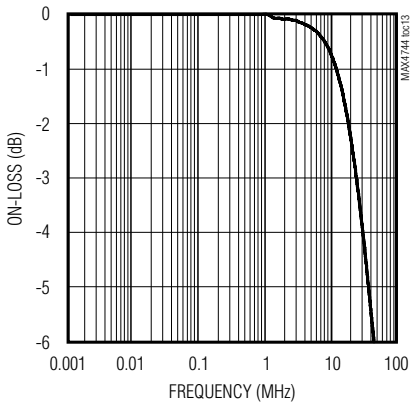
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted.)

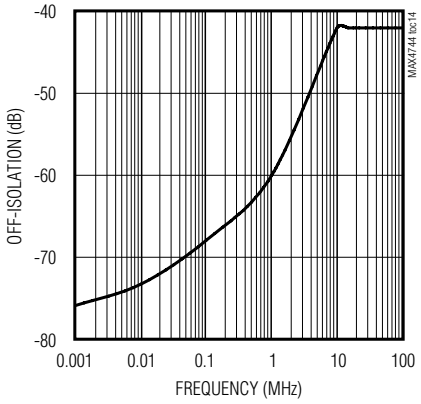
LEAKAGE CURRENT vs. TEMPERATURE



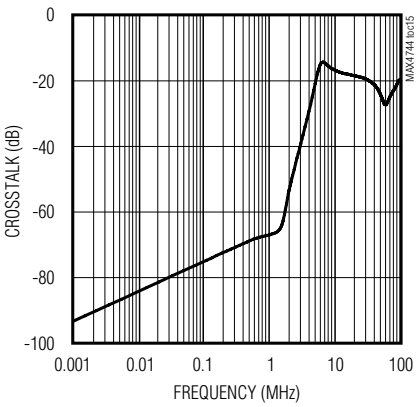
FREQUENCY RESPONSE



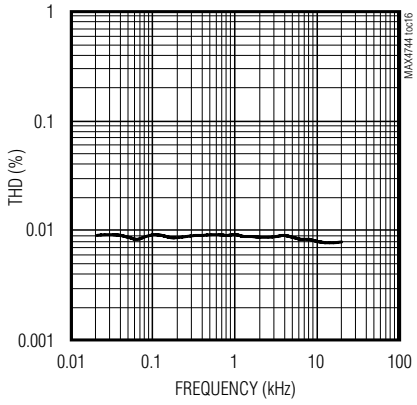
OFF-ISOLATION vs. FREQUENCY



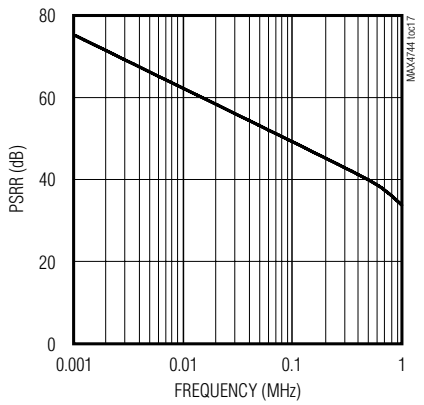
CROSSTALK vs. FREQUENCY



TOTAL HARMONIC DISTORTION vs. FREQUENCY



POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



Pin Description

PIN		NAME	FUNCTION
MAX4744/ MAX4745	MAX4744H/ MAX4745H		
1	—	CB1	Digital Control Input for Analog Switch 1
—	1	$\overline{EN}$	Enable Input. Driving $\overline{EN}$ high causes all switches to be high impedance. Pull $\overline{EN}$ low for normal operation.
2	2	NO1	Analog Switch 1 – Normally Open Terminal
3	3	GND	Ground
4	4	NO2	Analog Switch 2 – Normally Open Terminal
5	—	CB2	Digital Control Input for Analog Switch 2
—	5	CB0	Digital Control Input for Analog Switches 1 and 2
6	6	COM2	Analog Switch 2 – Common Terminal
7	7	NC2	Analog Switch 2 – Normally Closed Terminal
8	8	V_{CC}	Positive Supply Voltage from +1.8V to +5.5V
9	9	NC1	Analog Switch 1 – Normally Closed Terminal
10	10	COM1	Analog Switch 1 – Common Terminal

Detailed Description

The MAX4744/MAX4744H/MAX4745/MAX4745H are low on-resistance, low-voltage, dual-SPDT analog switches that operate from a +1.8V to +5.5V single supply. These devices feature a negative signal capability that allows signals as low as V_{CC} - 5.5V to pass through without distortion.

The MAX4744/MAX4745 feature two digital control bits to control each switch independently (see Table 1). The MAX4744H/MAX4745H have one control bit to switch both switches and an enable input $\overline{EN}$ to put the switches in a high-impedance mode. Driving $\overline{EN}$ low takes the switches out of high impedance and CB0 controls both switches (see Table 2).

The MAX4744/MAX4744H have internal shunt resistors on all NO and NC terminals to suppress click-and-pop sounds that can occur when switching audio signals between pre-charged points.

Applications Information

Digital Control Inputs

The MAX4744/MAX4744H/MAX4745/MAX4745H logic inputs accept up to +5.5V, regardless of supply voltage. For example, with a +3.3V supply, CB0, CB1, CB2, and $\overline{EN}$ can be driven low to GND and high to +5.5V, allowing for mixed logic levels in a system.

Table 1. MAX4744/MAX4745 Truth Table

CONTROL		SWITCH STATE	
CB1	CB2	Switch 1	Switch 2
0	0	Connected to NC1	Connected to NC2
0	1	Connected to NC1	Connected to NO2
1	0	Connected to NO1	Connected to NC2
1	1	Connected to NO1	Connected to NO2

Table 2. MAX4744H/MAX4745H Truth Table

CONTROL		SWITCH STATE	
$\overline{EN}$	CB0	Switch 1	Switch 2
0	0	Connected to NC1	Connected to NC2
0	1	Connected to NO1	Connected to NO2
1	X	High Impedance	High Impedance

X = Don't Care

Driving CB0, CB1, CB2, and $\overline{EN}$ rail-to-rail minimizes power consumption.

Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

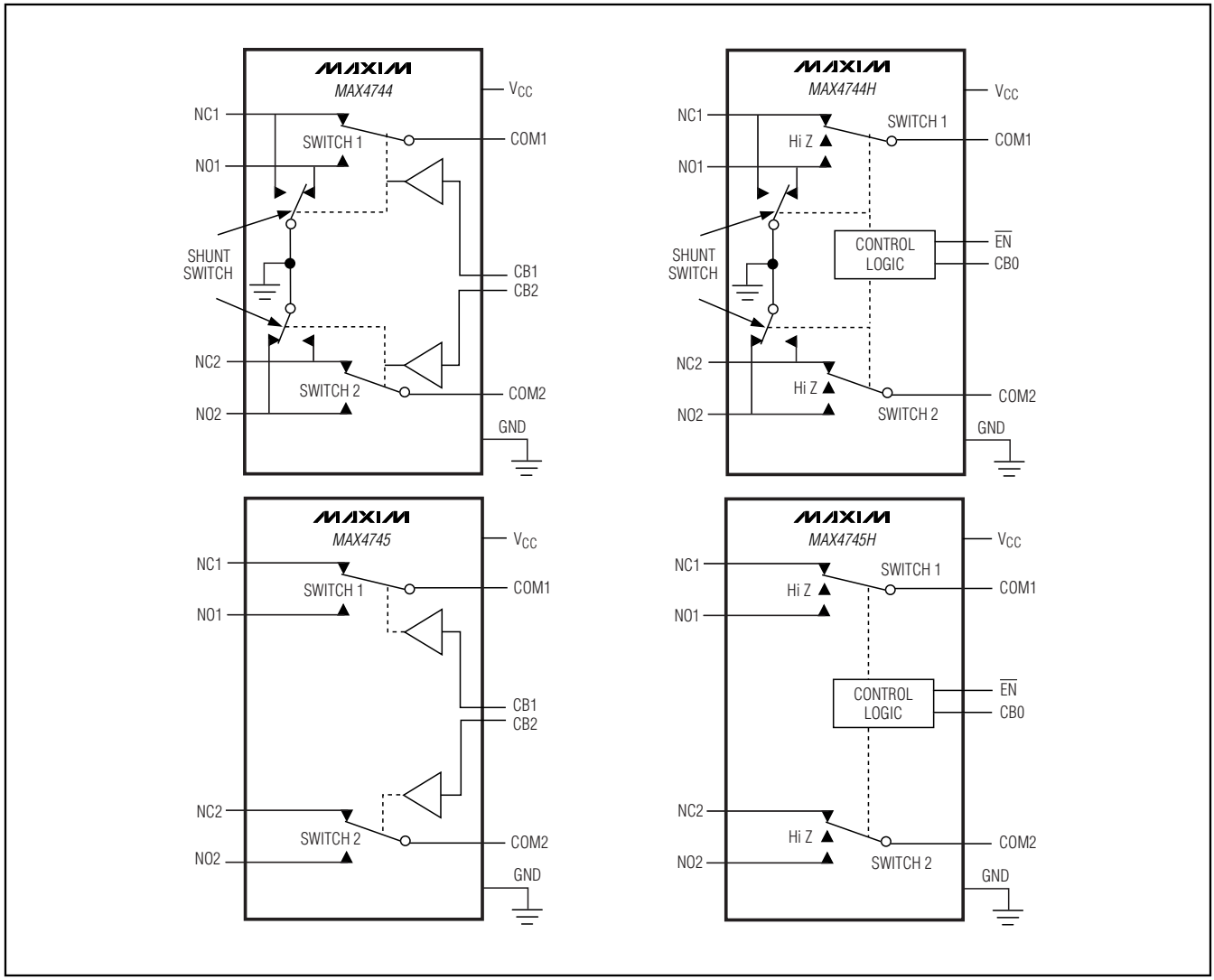


Figure 1. Functional Diagram

Analog Signal Levels

These devices pass signals from V_{CC} to as low as V_{CC} - 5.5V, including signals below ground with minimal distortion and very little change in on-resistance (see the *Typical Operating Characteristics*). The switches are bidirectional, so the NO_, NC_, and COM_ terminals can be used as either inputs or outputs.

COM_ Protection with V_{CC} = 0V (MAX4744H/MAX4745H)

This feature prevents any damage to the device due to improper power-supply sequencing. The protection applies if a signal is applied on COM_ when V_{CC} is less than 0.5V. The switch is not protected if V_{CC} goes above 0.5V due to parasitic capacitive coupling or any leakage between COM_ and V_{CC}. The signal at COM_ ranges between V_{CC} - 6.0V to 6.0V under protection conditions.

Click-and-Pop Suppression

The MAX4744/MAX4744H have a shunt resistor on all their NO and NC terminals to automatically discharge any capacitance when they are not connected to COM. The shunt resistor reduces audible click-and-pop sounds that occur when switching between audio sources. Audible clicks and pops are caused when a

Test Circuits/Timing Diagrams

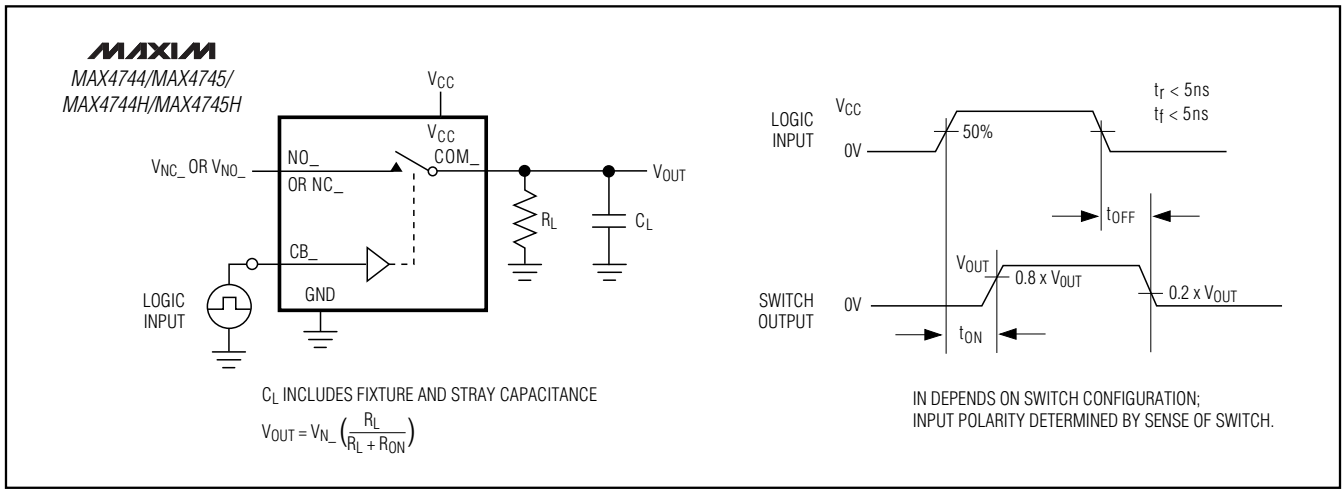


Figure 2. Switching Time

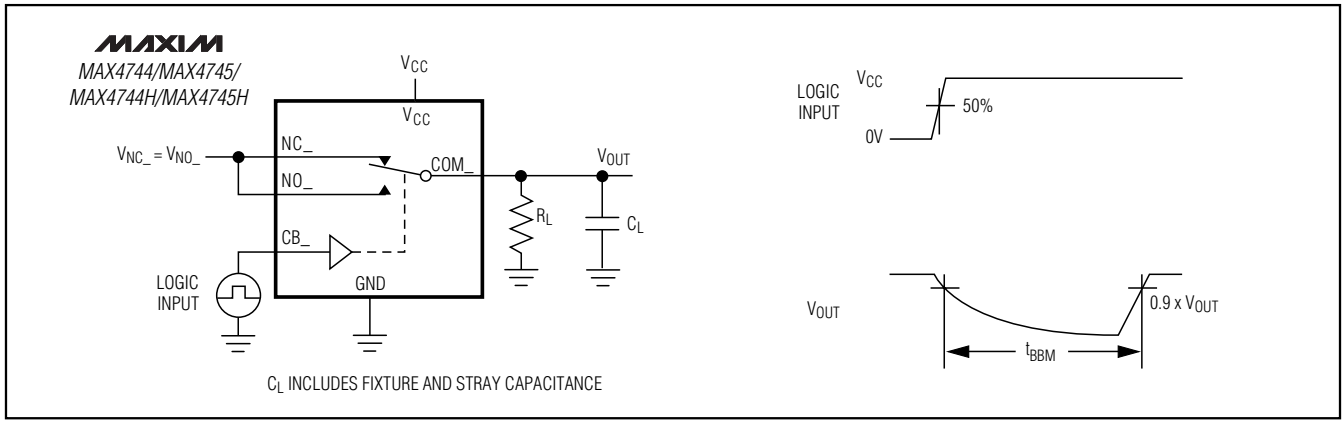


Figure 3. Break-Before-Make Interval

step DC voltage is switched into the speaker. The DC step transients can be reduced by automatically discharging the side that is not connected to the COM terminal, reducing any residual DC voltage and reducing clicks and pops.

Break-Before-Make Switching

All devices feature break-before-make switching which is configured to break (open) the first set of contacts before engaging (closing) the new contacts. This prevents the momentary connection of the old and new signal paths to the output, reducing click-and-pop sounds.

Power-Supply Sequencing and Overvoltage Protection

Caution: Do not exceed the Absolute Maximum Ratings since stresses beyond the listed ratings may cause permanent damage to the device.

Proper power-supply sequencing is recommended for all CMOS devices. Improper supply sequencing can force the switch into latch-up causing it to draw excessive supply current. The only way out of latch-up is to recycle the power and reapply properly. Connect all ground pins first, then apply power to V_{CC}, and finally apply signals to NO_, NC_, and COM_. Follow the reverse order upon power-down.

Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

Test Circuits/Timing Diagrams

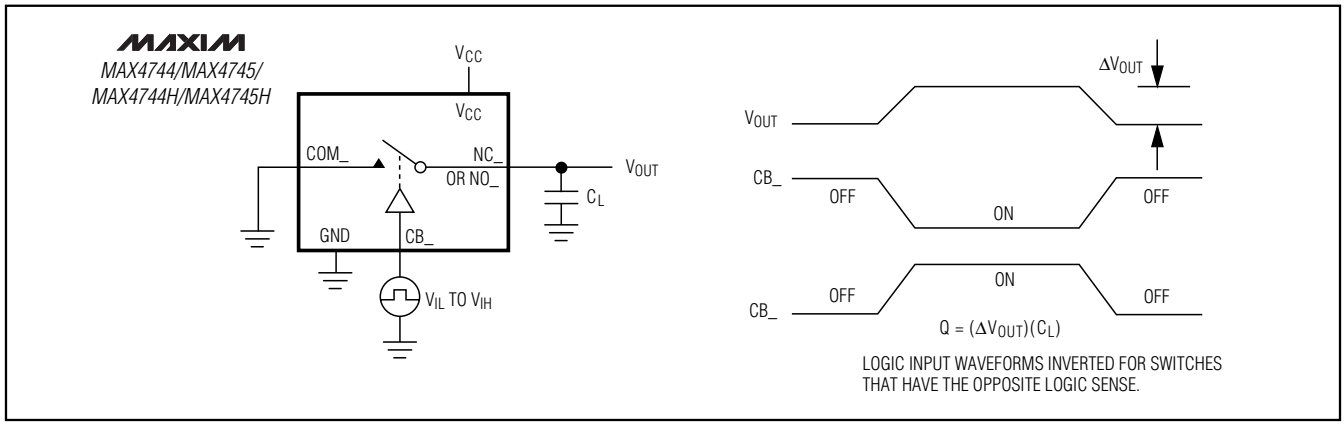


Figure 4. Charge Injection

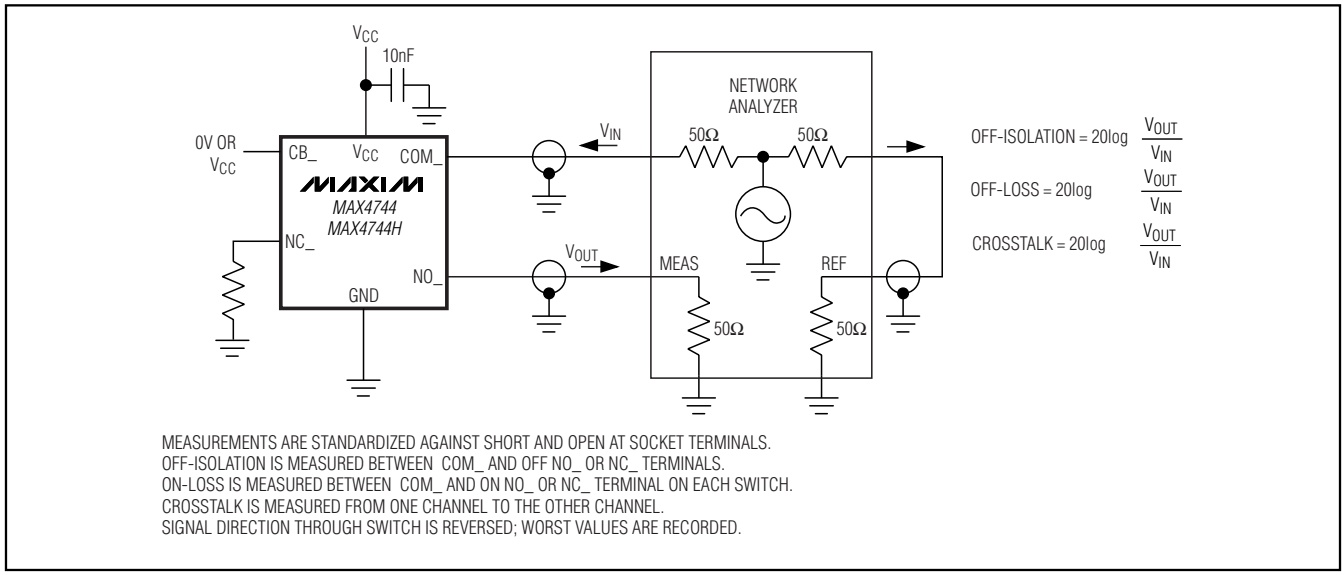


Figure 5. Off-Isolation, On-Loss, and Crosstalk

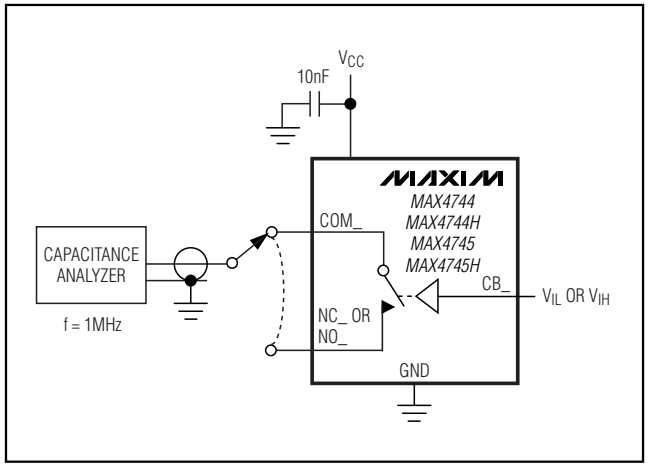
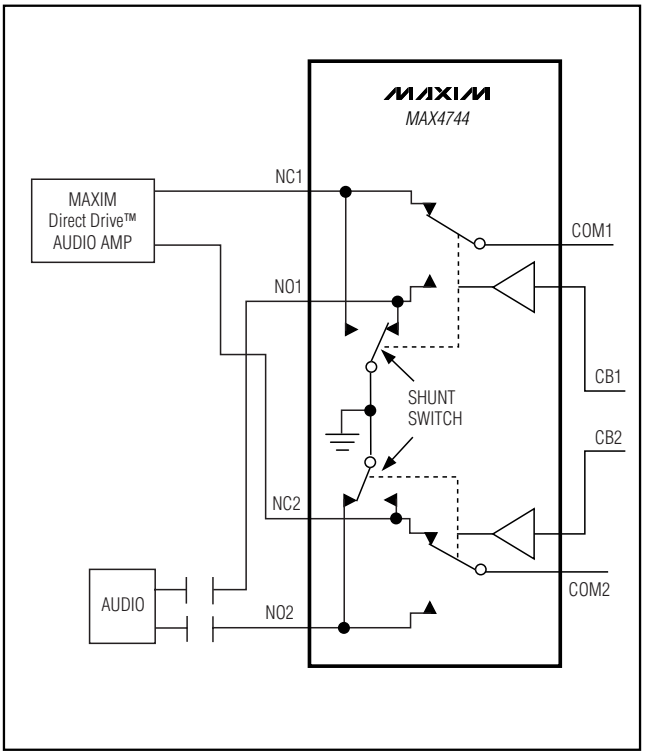


Figure 6. Channel Off-/On-Capacitance

Chip Information

PROCESS: BiCMOS

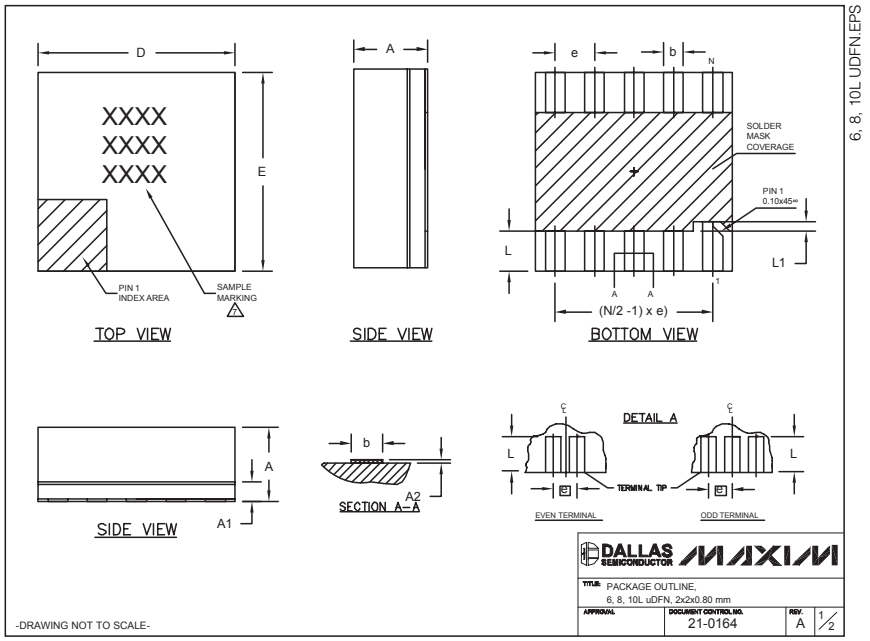
Typical Operating Circuit



Low-Voltage, Dual SPDT, Audio Clickless Switches With Negative Rail Capability

Package Information

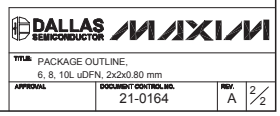
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



COMMON DIMENSIONS			
SYMBOL	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
A1	0.15	0.20	0.25
A2	0.020	0.025	0.035
D	1.95	2.00	2.05
E	1.95	2.00	2.05
L	0.30	0.40	0.50
L1	0.10 REF.		

PACKAGE VARIATIONS				
PKG. CODE	N	e	b	(N/2 -1) x e
L622-1	6	0.65 BSC	0.30±0.05	1.30 REF.
L822-1	8	0.50 BSC	0.25±0.05	1.50 REF.
L1022-1	10	0.40 BSC	0.20±0.03	1.60 REF.

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08mm.
3. WARPAGE SHALL NOT EXCEED 0.10mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. "N" IS THE TOTAL NUMBER OF LEADS.
6. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
7. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.



-DRAWING NOT TO SCALE-