

### FEATURES

- “Clickless” Bilateral Audio Switching
- Four SPST Switches in a 20-Pin Package
- Ultralow THD+N: 0.0008% @ 1 kHz (2 V rms,  $R_L = 100\text{ k}\Omega$ )
- Low Charge Injection: 35 pC typ
- High OFF Isolation: -100 dB typ ( $R_L = 10\text{ k}\Omega$  @ 1 kHz)
- Low Crosstalk: -94 dB typ ( $R_L = 10\text{ k}\Omega$  @ 1 kHz)
- Low ON Resistance: 28  $\Omega$  typ
- Low Supply Current: 900  $\mu\text{A}$  typ
- Single or Dual Supply Operation: +11 V to +24 V or  $\pm 5.5\text{ V}$  to  $\pm 12\text{ V}$
- Guaranteed Break-Before-Make
- TTL and CMOS Compatible Logic Inputs
- Low Cost-Per-Switch

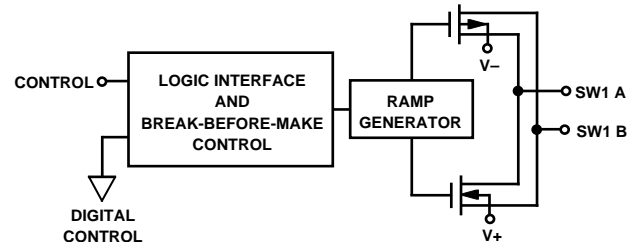
### GENERAL DESCRIPTION

The SSM2404 integrates four SPST analog switches in a single 20-pin package. Developed specifically for high performance audio applications, distortion and noise are negligible over the full operating range of 20 Hz to 20 kHz. With very low charge injection of 35 pC, “clickless” audio switching is possible, even under the most demanding conditions.

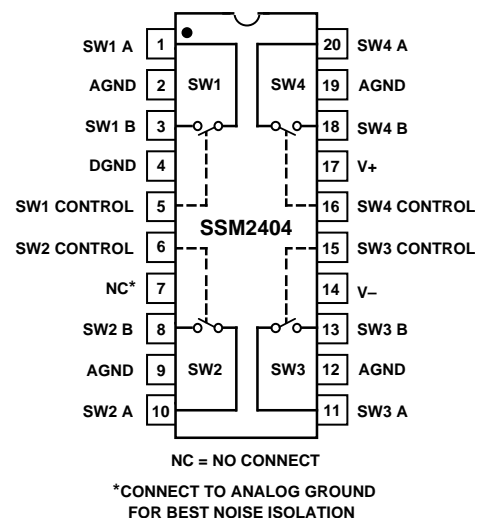
Switch control is realized by conventional TTL or CMOS logic. Guaranteed “break-before-make” operation assures that all switches in a large system will open before any switch reaches the ON state.

Single or dual supply operation is possible. Additional features include -100 dB OFF isolation, -94 dB crosstalk and 28  $\Omega$  ON resistance. Optional current-mode switching permits an extended signal-handling range. Although optimized for large load impedances, the SSM2404 maintains good audio performance even under low load impedance conditions.

### BLOCK DIAGRAM OF ONE SWITCH CHANNEL



### PIN CONNECTIONS Epoxy Mini-DIP (P Suffix) and SOIC (S Suffix)



### REV. B

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# SSM2404–SPECIFICATIONS

( $V_S = \pm 12\text{ V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.  
Typical specifications apply at  $T_A = +25^\circ\text{C}$ .)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
<b>AUDIO PERFORMANCE</b>						
Total Harmonic Distortion Plus Noise	THD+N	@ 1 kHz, with 80 kHz Filter, $R_L = 100\text{ k}\Omega$ , $V_{IN} = 2\text{ V rms}$		0.0008		%
Spectral Noise Density	$e_n$	20 Hz to 20 kHz		0.8		nV/ $\sqrt{\text{Hz}}$
Wideband Noise Density	$e_n$ p-p	20 Hz to 20 kHz		0.6		$\mu\text{V p-p}$
<b>ANALOG SIGNAL SECTION</b>						
Analog Voltage Range	$V_A$	$V_{INH} = 2.4\text{ V}$ , $I_A = \pm 2\text{ mA}$		$\pm 12$		V
Analog Current Range	$I_A$	$V_{INH} = 2.4\text{ V}$ , $V_A = 0\text{ V}$		$\pm 10$		mA
ON Resistance	$R_{ON}$	$I_A = \pm 10\text{ mA}$ , $V_A = \pm 10\text{ V dc}$		28	45	$\Omega$
$R_{ON}$ Matching	$R_{ON}$ Match	$I_A = \pm 10\text{ mA}$ , $V_A = 0\text{ V}$		1		%
ON Leakage Current	$I_{S(ON)}$	$V_A = \pm 10\text{ V}$	-20	0.1	+20	nA
OFF Leakage Current	$I_{S(OFF)}$	$V_A = \pm 10\text{ V}$	-20	0.1	+20	nA
Charge Injection	Q			35		pC
ON-State Input Capacitance	$C_{ON}$	$V_A = 5\text{ V rms}$		31		pF
OFF-State Input Capacitance	$C_{OFF}$	$V_A = 5\text{ V rms}$		17		pF
OFF Isolation	$I_{SO(OFF)}$	$V_A = 50\text{ mV rms}$ , $f = 1\text{ kHz}$ , $R_L = 10\text{ k}\Omega$		-100		dB
Channel-to-Channel Crosstalk	$C_T$	$V_A = 50\text{ mV rms}$ , $f = 1\text{ kHz}$ , $R_L = 10\text{ k}\Omega$		-94		dB
<b>CONTROL SECTION</b>						
Digital Input High	$V_{INH}$	DGND = 0 V	2.4		$V_S$	V
Digital Input Low	$V_{INL}$	DGND = 0 V	0		0.8	V
Turn-On Time <sup>1</sup>	$t_{ON}$	See Test Circuit		8	50	ms
Turn-Off Time <sup>2</sup>	$t_{OFF}$	See Test Circuit		5	30	ms
Break-Before-Make Time Delay	$t_{ON}-t_{OFF}$			3	20	ms
Logic Input Current						
Logic HI		$V_{INH} = 2.4\text{ V}$	-1000	1.3	+1000	nA
Logic LO		$V_{INL} = 0.8\text{ V}$	-1000	1.0	+1000	nA
<b>POWER SUPPLY</b>						
Supply Voltage Range	$V_S$	Single Supply	+11		+24	V
		Dual Supply	$\pm 5.5$		$\pm 12$	V
Positive Supply Current	$I_{SY+}$	All Channels On		0.9	5	mA
Negative Supply Current	$I_{SY-}$	All Channels On	-1.5	-0.6		mA
Ground Current		All Channels On	-2.0	-0.3		mA

## NOTES

<sup>1</sup>Turn-on time is measured from the time the logic input reaches the 50% point to the time the output reaches 50% of the final value.

<sup>2</sup>Turn-off time is measured from the time the logic input reaches the 50% point to the time the output reaches 50% of the initial value.

Specifications subject to change without notice.

## ABSOLUTE MAXIMUM RATINGS

### Supply Voltage

Single Supply ..... +27 V

Dual Supply .....  $\pm 13.5\text{ V}$

Analog Input Voltage ( $V_A$ ) .....  $V_S$

Logic Input Voltage ( $V_{INL}/V_{INH}$ ) .....  $V_S$

Maximum Current Through Any Switch ..... 20 mA

Operating Temperature Range .....  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$

Storage Temperature Range .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$

Junction Temperature ( $T_J$ ) .....  $+150^\circ\text{C}$

Lead Temperature (Soldering, 60 sec) .....  $+300^\circ\text{C}$

Thermal Resistance<sup>1</sup>

20-Pin Plastic DIP (P):  $\theta_{JA} = 74$ ,  $\theta_{JC} = 32$  .....  $^\circ\text{C/W}$

20-Pin SOIC (S):  $\theta_{JA} = 90$ ,  $\theta_{JC} = 27$  .....  $^\circ\text{C/W}$

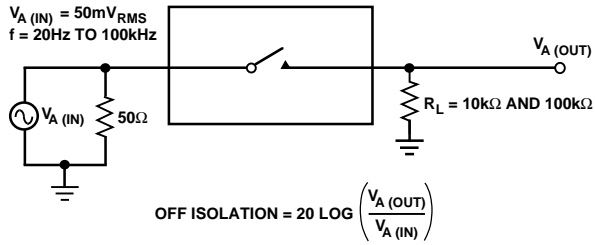
## NOTE

<sup>1</sup> $\theta_{JA}$  is specified for worst case mounting conditions, i.e.,  $\theta_{JA}$  is specified for device in socket for P-DIP package.

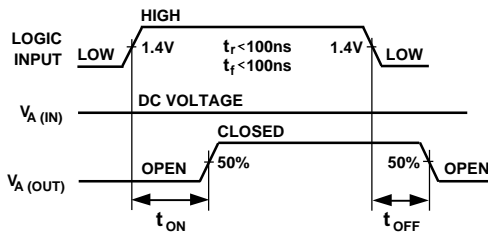
## ORDERING GUIDE

Model	Operating Temperature Range	Package	Package Option*
SSM2404P	$-40^\circ\text{C}$ to $+85^\circ\text{C}$	20-Pin Plastic DIP	N-20
SSM2404S	$-40^\circ\text{C}$ to $+85^\circ\text{C}$	20-Pin SOIC	R-20

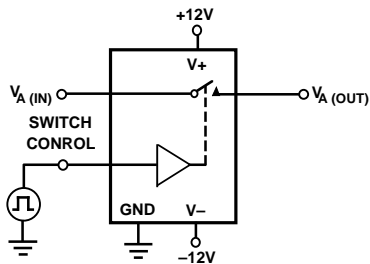
\*N = Plastic DIP, R = SOIC.



OFF Isolation Test Circuit



$t_{ON}/t_{OFF}$  Timing Diagram



Test Circuit for  $t_{ON}/t_{OFF}$  Timing Specification,  $t_{ON}/t_{OFF}$  Switching Response, and ON/OFF Transition Photos

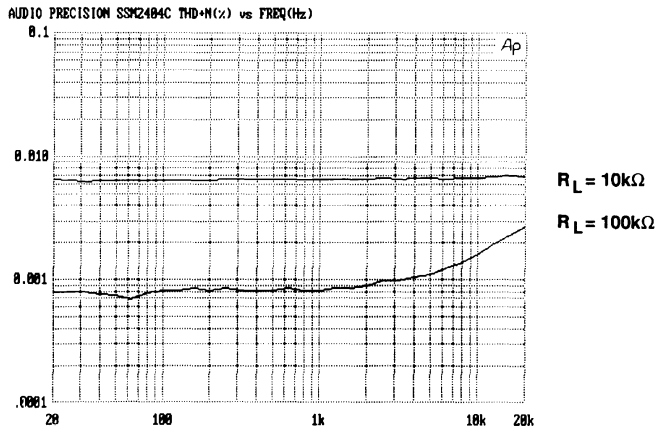


Figure 1. THD+N vs. Frequency ( $V_S = \pm 12 V$ ,  $V_A = 2 V_{rms}$ , with 80 kHz Filter)

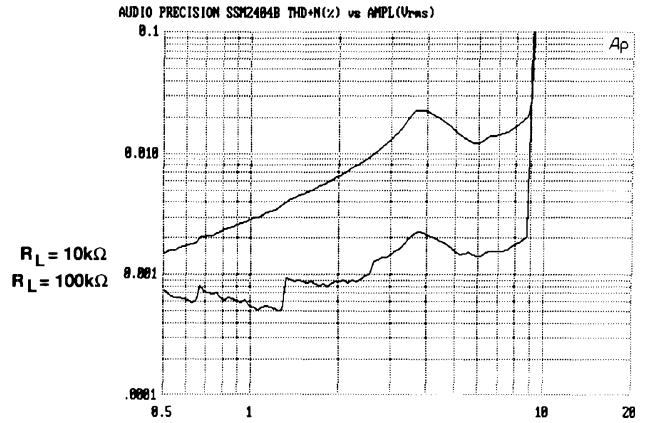


Figure 2. Headroom ( $V_S = \pm 12 V$ ,  $f = 1 kHz$ , with 80 kHz Filter)

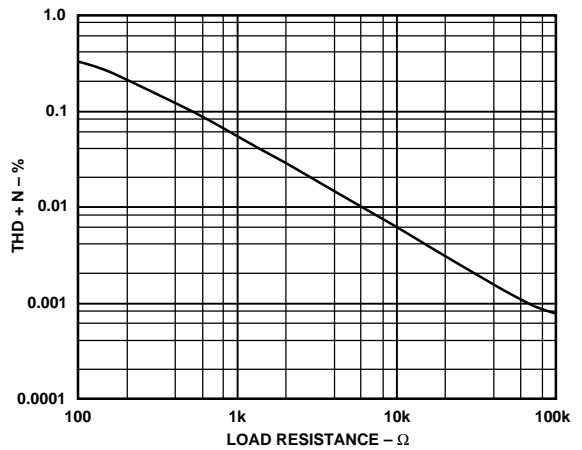


Figure 3. THD+N vs. Load ( $V_S = \pm 12 V$ ,  $V_A = 2 V_{rms}$ ,  $f = 1 kHz$ , with 80 kHz Filter)

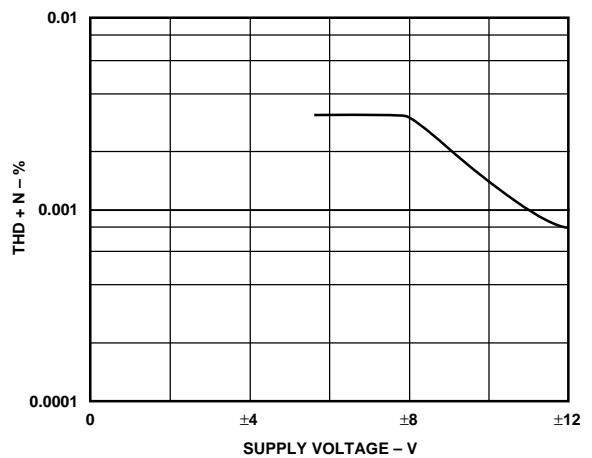


Figure 4. THD+N vs. Supply Voltage ( $V_A = 2 V_{rms}$ ,  $f = 1 kHz$ ,  $R_L = 100 k\Omega$ , with 80 kHz Filter)

# SSM2404

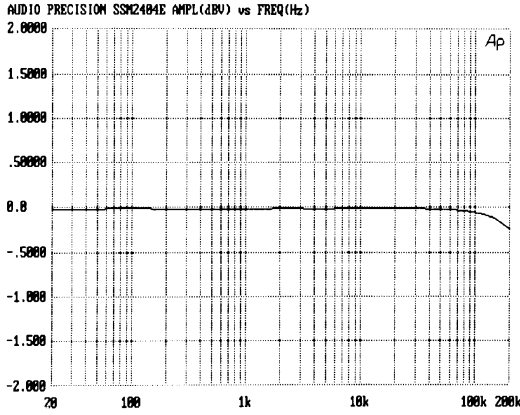


Figure 5. Frequency Response ( $V_S = \pm 12\text{ V}$ ,  $V_A = 1\text{ V rms}$ ,  $R_L = 100\text{ k}\Omega$ )

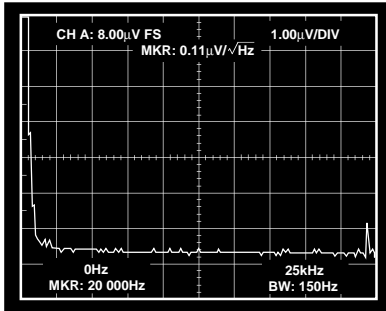


Figure 6. SSM2404 Spectral Noise Density  $e_n$  [5 Devices (20 Switches) Chained Together]

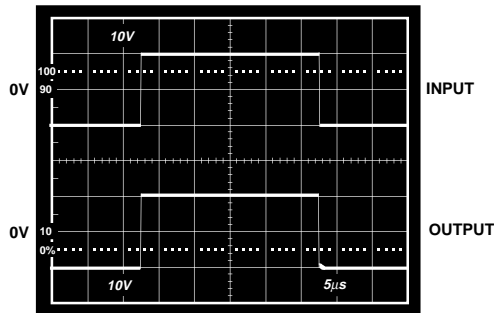


Figure 7. Square Wave Response ( $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 12\text{ V}$ ,  $R_L = 100\text{ k}\Omega$ ,  $f = 20\text{ kHz}$ )

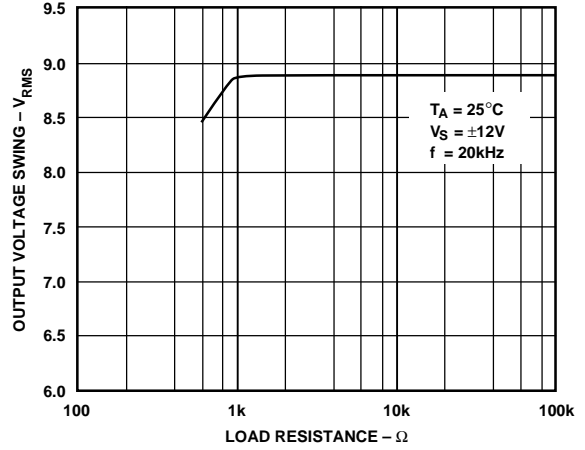


Figure 8. Output Voltage Swing vs. Load Resistance

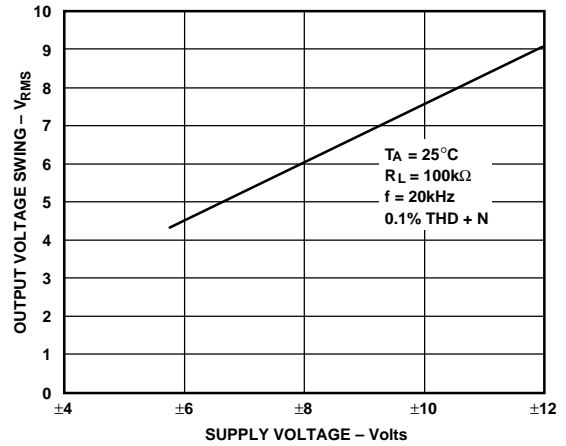


Figure 9. Output Voltage Swing vs. Supply Voltage

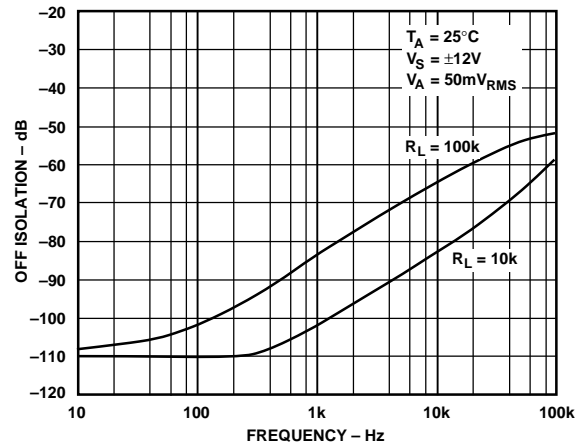


Figure 10. OFF-Isolation vs. Frequency

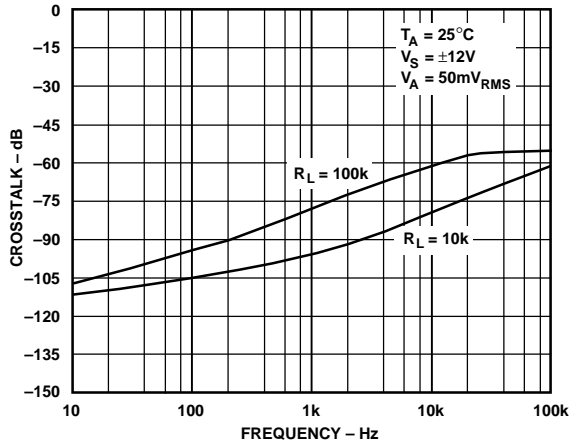


Figure 11. Channel-to-Channel Crosstalk vs. Frequency (Worst Case Conditions, as Measured Between Switches 1 and 4, or 2 and 3)

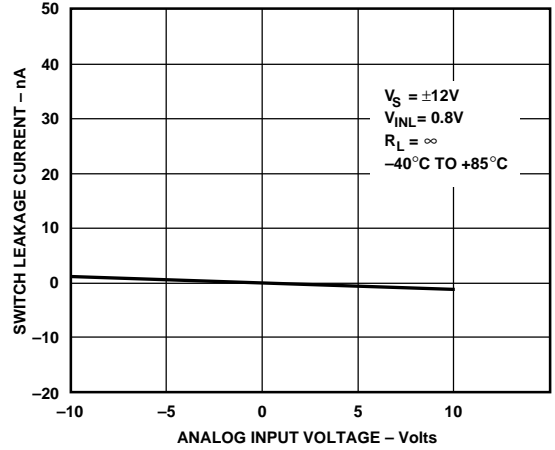


Figure 14. Leakage Current vs. Analog Voltage

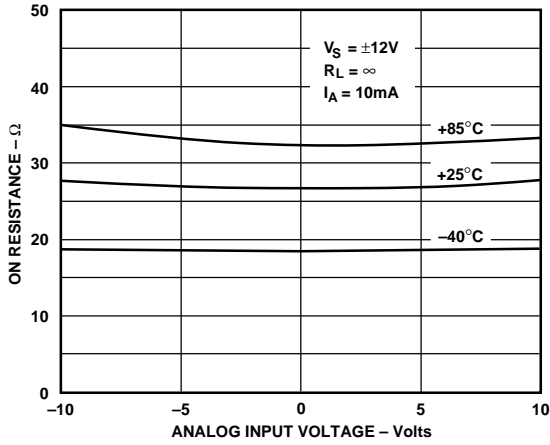


Figure 12. ON Resistance vs. Analog Voltage

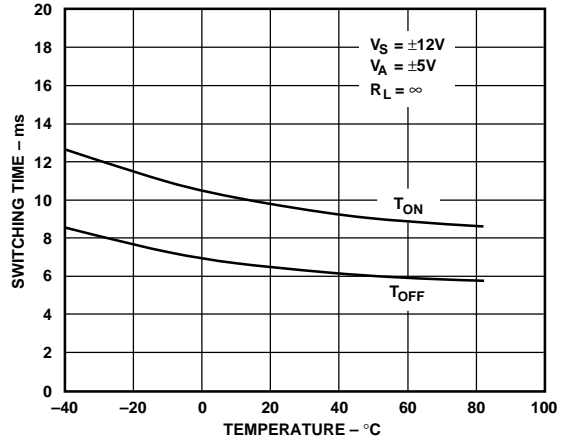


Figure 15. Switching Time vs. Temperature

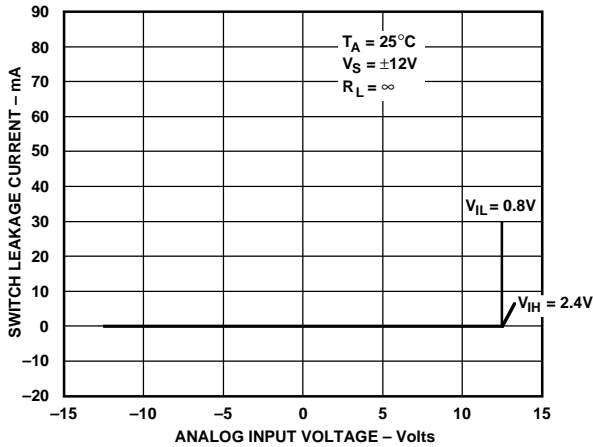


Figure 13. Overvoltage Characteristics

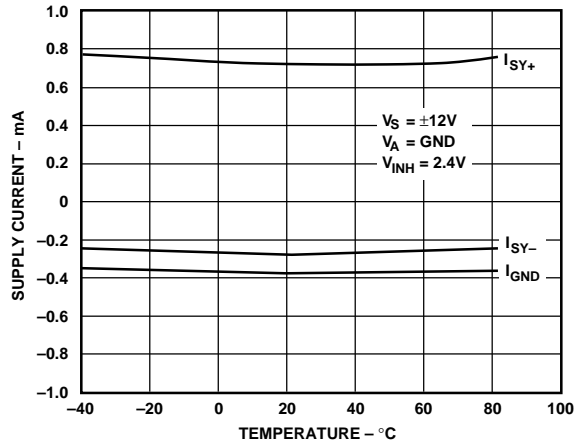


Figure 16. Supply Current vs. Temperature

# SSM2404

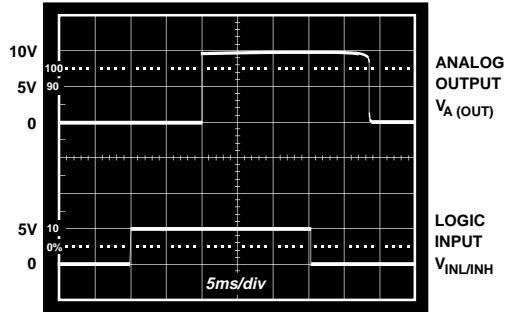


Figure 17.  $t_{ON}/t_{OFF}$  Switching Response

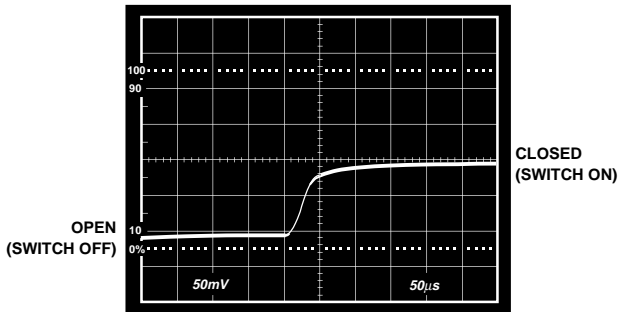


Figure 18. Switch OFF-to-ON Transition ( $R_L = 5\text{ k}\Omega$ )

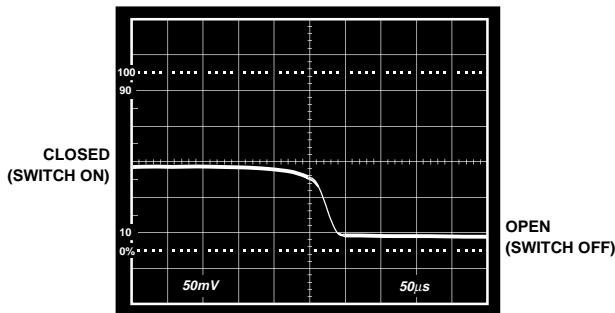


Figure 19. Switch ON-to-OFF Transition ( $R_L = 5\text{ k}\Omega$ )

## APPLICATIONS INFORMATION

The SSM2404 integrates four analog CMOS switches with guaranteed “break-before-make” operation to provide high quality audio switching. Each switch has complementary N-channel and P-channel MOSFETs to allow the analog input voltage range to include the positive and negative rails and improve linearity. In addition, the topology permits fully bilateral switching. When using the SSM2404 there is full flexibility in configuring the switches. For example, they can be used individually as shown in Figure 20, or as a double-pole, double-throw (DPDT) switch, which is explained later. The

SSM2404 can also be configured as a 4:1 multiplexer, or by using additional packages, as 8:1 or 16:1 and up. The break-before-make feature is guaranteed from part to part allowing such multiple-package applications.

As Figure 20 shows, the SSM2404 is easy to use, and no additional devices are needed. The load resistors are recommended for improved OFF-isolation and charge injection. The ON resistance of the switch is only  $28\ \Omega$  typically, which causes very little signal attenuation even with a load resistor.

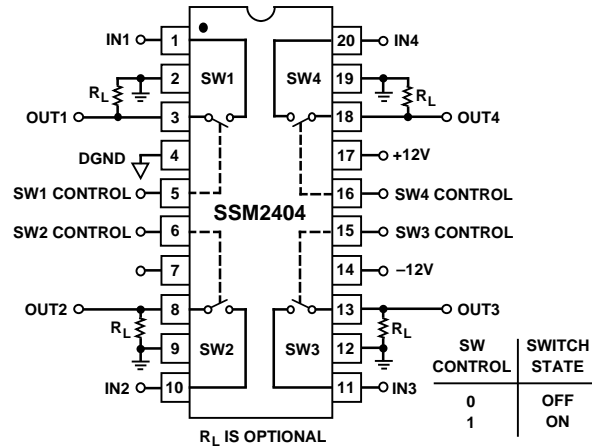


Figure 20. Basic Circuit Configuration

## OPTIMIZING PERFORMANCE

As the performance curves show, the switch is optimized for high impedance loads. The distortion performance is at its best when the switch has a load impedance of  $100\text{ k}\Omega$  or greater as shown in Figure 1. However, even at lower values of load resistances, the 1 kHz distortion performance is still excellent, 0.006% for a  $10\text{ k}\Omega$  load. The main trade-off with THD is OFF-isolation and crosstalk. This is shown in Figures 10 and 11, again with two different load conditions. As these graphs show, the  $10\text{ k}\Omega$  load yields approximately a 16 dB improvement in both characteristics.

Thus, the optimum operating point depends on the most critical parameters. When THD is critical then high load impedances should be used; however, when crosstalk and OFF-isolation are critical, lower impedances on the order of  $10\text{ k}\Omega$  should be used. An additional benefit of using the smaller load resistor is that any charge injected onto the output will be shunted to ground through the resistor. If improved OFF-isolation is needed, the SSM2404 dual audio switch should be considered with its excellent 120 dB OFF-isolation at 20 kHz.

It is important that all of the AGND pins be connected to the system analog ground. These pins isolate the input and output of each switch. Without connecting these pins, the OFF-isolation will degrade significantly.



# SSM2404

The circuit was tested with an SSM2131 high slew rate audio amplifier and the results are shown in Figures 24 and 25. This configuration yields excellent THD performance that is primarily determined by the amplifier. Also, the headroom is now +24 dBu (0 dBu = 0.775 V rms), which is due to the amplifier's output voltage swing. Thus, even though the SSM2404 has a  $\pm 12$  V limitation on its supplies, it can be used in systems with much higher voltage ranges. For example, the double-pole double-throw switch from Figure 22 can be reconfigured in the virtual ground mode to allow higher voltage swings, as shown in Figure 26. This application realizes the excellent performance of Figures 24 and 25 while providing a low cost switching solution.

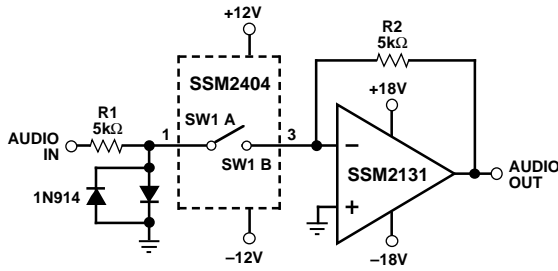


Figure 23. Virtual Ground Switching

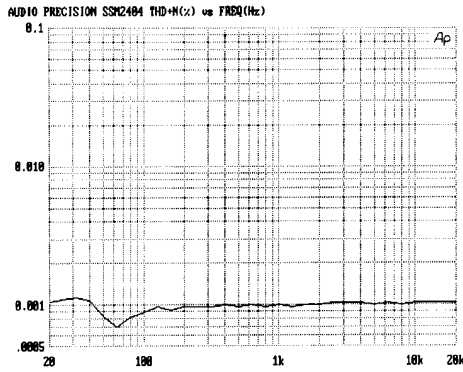


Figure 24. Virtual Ground Switch THD+N vs. Frequency ( $V_S = \pm 12$  V,  $V_A = 2$  V rms, with 80 kHz Filter)

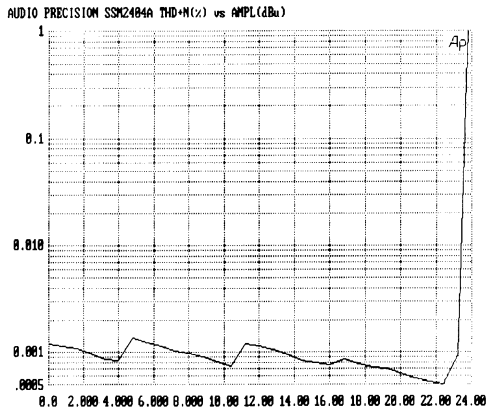


Figure 25. Virtual Ground Switch Headroom ( $V_S = \pm 12$  V for SSM2404;  $V_S = \pm 18$  V for Op Amp,  $f = 1$  kHz, with 80 kHz Filter)

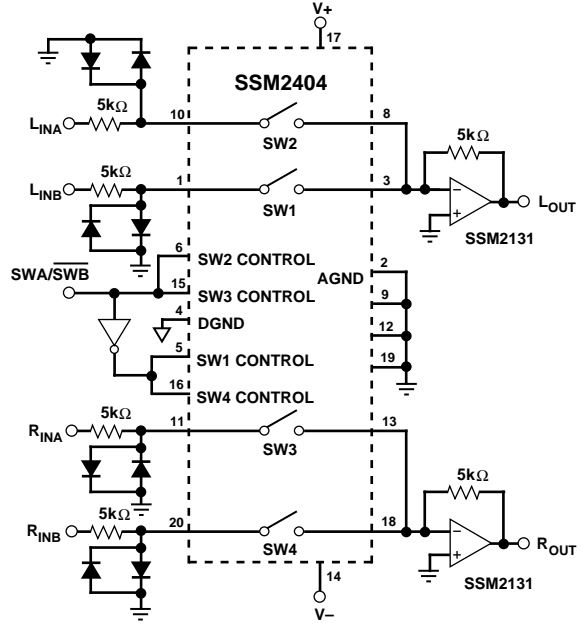
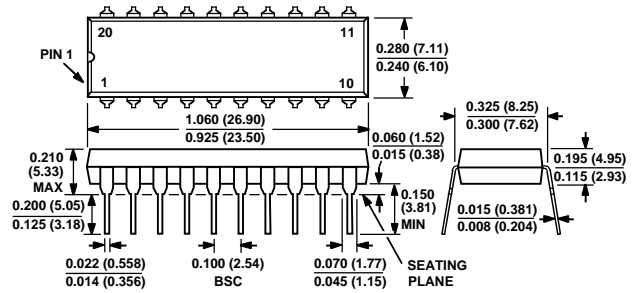


Figure 26. Double-Pole, Double-Throw Stereo Switch Using Virtual Ground Operation

## OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

### Mini-DIP (P Suffix)



### SOIC (S Suffix)

