



# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## General Description

The MAX4060–MAX4063 are differential-input microphone preamplifiers optimized for notebook/PDA audio systems. These devices feature Rail-to-Rail® outputs with excellent power-supply rejection and common-mode rejection ratios, making them ideal for low-noise applications in portable audio systems.

The MAX4060/MAX4062/MAX4063 are capable of switching their output between the differential input and a single-ended auxiliary microphone amplifier input. In addition, the MAX4060/MAX4062/MAX4063 have a low-noise microphone bias generator. The differential gain of the MAX4061/MAX4062/MAX4063 is set with a single resistor. The MAX4060 has a fixed gain of 10V/V and is PC99/2001 compliant. The MAX4063 has a complementary output allowing CODECs with differential inputs to be optimally driven. The MAX4061/MAX4063 include a complete shutdown mode. In shutdown, the supply current is reduced to 0.3μA and the current to the microphone bias is cut off for ultimate power saving.

The MAX4060 operates from a 4.5V to 5.5V single supply and the MAX4061/MAX4062/MAX4063 operate from 2.4V to 5.5V. All devices are specified over the extended operating temperature range, -40°C to +85°C. The MAX4060/MAX4061 are available in tiny 8-pin QFN and 8-pin μMAX packages. The MAX4062 is available in a 10-pin μMAX package and the MAX4063 in a 14-pin TSSOP package.

## Applications

Notebook Audio Systems	AES-42 Compliant Microphones
PDA Audio Systems	Signal Conditioning
USB Audio Peripherals	

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4060EGA	-40°C to +85°C	8 QFN	ABY
MAX4060EUA	-40°C to +85°C	8 μMAX	—
MAX4061EGA	-40°C to +85°C	8 QFN	ABZ
MAX4061EUA	-40°C to +85°C	8 μMAX	—
MAX4062EUB	-40°C to +85°C	10 μMAX	—
MAX4063EUD*	-40°C to +85°C	14 TSSOP	—

\*Future product—contact factory for availability.

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.



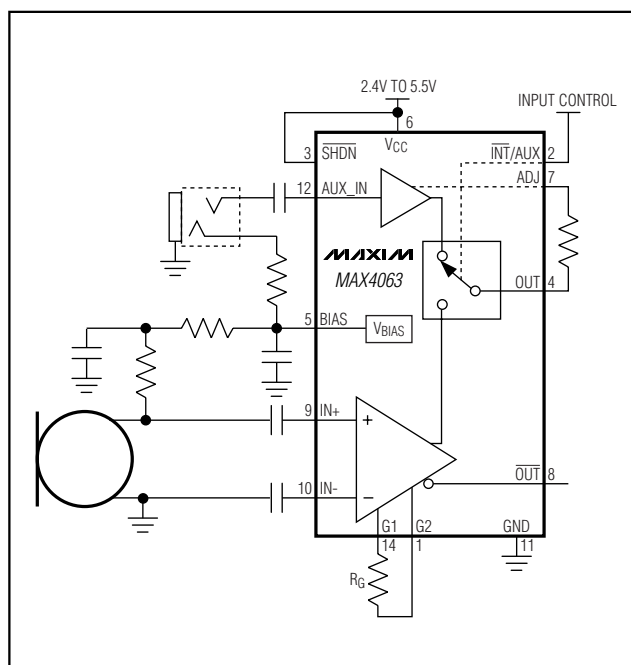
Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

## Features

- ◆ 2.4V to 5.5V Single-Supply Operation
- ◆ Adjustable Gain
- ◆ High PSRR (86dB at 1kHz)
- ◆ High CMRR (70dB at 1kHz)
- ◆ Low Input-Referred Noise
- ◆ On-Board Microphone Bias
- ◆ 750μA Supply Current
- ◆ 0.3μA Shutdown Current
- ◆ ±4kV ESD Protection (AUX\_IN)
- ◆ Complementary Output (MAX4063)
- ◆ Rail-to-Rail Outputs
- ◆ THD + N: 0.04% at 1kHz
- ◆ Available in Space-Saving Packages
  - 8-Pin QFN (MAX4060/MAX4061)
  - 8-Pin μMAX (MAX4060/MAX4061)
  - 10-Pin μMAX (MAX4062)
  - 14-Pin TSSOP (MAX4063)

## Typical Operating Circuit



Pin Configurations and Selector Guide appear at end of data sheet.

MAX4060–MAX4063

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{CC}$  to GND) ..... -0.3V to +6V  
 Any Other Pin to GND ..... -0.3V to ( $V_{CC} + 0.3V$ )  
 Duration of Short Circuit to GND or  $V_{CC}$  ..... Continuous  
 Continuous Input Current (any pin) .....  $\pm 10mA$   
 Continuous Power Dissipation ( $T_A = +70^\circ C$ )  
   8-Pin QFN (derate 4.7mW/ $^\circ C$  above  $+70^\circ C$ ) ..... 379mW  
   8-Pin  $\mu MAX$  (derate 4.1mW/ $^\circ C$  above  $+70^\circ C$ ) ..... 330mW

10-Pin  $\mu MAX$  (derate 5.6mW/ $^\circ C$  above  $+70^\circ C$ ) ..... 444mW  
 14-Pin TSSOP (derate 8.3mW/ $^\circ C$  above  $+70^\circ C$ ) ..... 667mW  
 Operating Temperature Range .....  $-40^\circ C$  to  $+85^\circ C$   
 Storage Temperature Range .....  $-65^\circ C$  to  $+150^\circ C$   
 Lead Temperature (soldering, 10s) .....  $+300^\circ C$

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

( $V_{CC} = 3V$  for MAX4061/MAX4062/MAX4063,  $V_{CC} = 5V$  for MAX4060, GND = 0,  $\overline{SHDN} = V_{CC}$ ,  $\overline{INT}/AUX = 0$ ,  $R_G = 11.1k\Omega$ ,  $R_L = 100k\Omega$  to 1.5V,  $R_{BIAS} = \infty$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V <sub>CC</sub>	Inferred from PSRR test	MAX4061/MAX4062/MAX4063	2.4		5.5	V
			MAX4060	4.5		5.5	
Supply Current	I <sub>CC</sub>				0.75	1.2	mA
Output Voltage Swing	V <sub>OUT</sub>	R <sub>L</sub> = 100kΩ	V <sub>CC</sub> - V <sub>OH</sub>		2	50	mV
			V <sub>OL</sub> - GND		2	50	
		R <sub>L</sub> = 2kΩ	V <sub>CC</sub> - V <sub>OH</sub>		50	200	
			V <sub>OL</sub> - GND		50	200	
Output Common-Mode Voltage	V <sub>OCM</sub>			1.25	1.5	1.75	V
Slew Rate	SR	A <sub>V</sub> = 10V/V			±1		V/μs
Supply Current in Shutdown	I <sub>SHDN</sub>	V <sub>SHDN</sub> = 0, MAX4061/MAX4063		0.001		1	μA
Output Short-Circuit Current	I <sub>SC</sub>	To GND			30		mA
		To V <sub>CC</sub>			30		
DIFFERENTIAL INPUT ( $\overline{INT}/AUX = 0$ for MAX4060/MAX4062/MAX4063, default for MAX4061)							
Input Offset Voltage	V <sub>OS</sub>				±0.1	±5	mV
Common-Mode Input Voltage Range	V <sub>CM</sub>	Inferred from CMRR test		1		2	V
Maximum Differential Input Voltage	V <sub>DIFFMAX</sub>	A <sub>V</sub> = 1V/V, MAX4061/MAX4062/MAX4063			1		V
Small-Signal Bandwidth	BW-3dB				600		kHz
Input Resistance	R <sub>IN</sub>	Either differential input			100		kΩ
Input Resistance Match	R <sub>MATCH</sub>				1		%

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

MAX4060-MAX4063

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 3V$  for MAX4061/MAX4062/MAX4063,  $V_{CC} = 5V$  for MAX4060,  $GND = 0$ ,  $\overline{SHDN} = V_{CC}$ ,  $\overline{INT}/AUX = 0$ ,  $R_G = 11.11k\Omega$ ,  $R_L = 100k\Omega$  to  $1.5V$ ,  $R_{BIAS} = \infty$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Noise-Voltage Density	$e_n$	$A_V = 10V/V$ , $f = 1kHz$		100			$nV/\sqrt{Hz}$
		$A_V = 100V/V$ , $f = 1kHz$ , MAX4061/MAX4062/MAX4063 only		20			
RMS Output Noise Voltage	$V_{NRMS}$	$A_V = 10V/V$ , $BW = 22Hz$ to $22kHz$		125			$\mu V_{RMS}$
Total Harmonic Distortion Plus Noise	THD + N	$A_V = 10V/V$ , $f = 1kHz$ , $V_{OUT} = 0.7V_{RMS}$ , $BW = 22Hz$ to $22kHz$		0.04			%
Differential Gain	$A_{VDIFF}$	$1V < V_{CM} < 2V$ , $V_{OUT} = 0.7V_{RMS}$ , MAX4061/MAX4062/ MAX4063	$R_G = open$	1	1.13	1.3	V/V
			$R_G = 11.11k\Omega$	9.6	10	10.4	
			$R_G = 1.01k\Omega$	96	100	104	
		$1V < V_{CM} < 2V$ , $V_{OUT} = 0.7V_{RMS}$ , MAX4060		9.6	10.0	10.4	
Common-Mode Rejection Ratio	CMRR	$V_{CM} = 500mV_{P-P}$ , $f = 1kHz$		70			dB
Power-Supply Rejection Ratio	PSRR	$T_A = +25^{\circ}C$		72	86	dB	
		$T_A = T_{MIN} - T_{MAX}$		60			
		$V_{CC} = 5V \pm 100mV$ , $f = 1kHz$		86			
AUXILIARY INPUT (MAX4060/MAX4062/MAX4063, INT/AUX = $V_{CC}$ )							
Small-Signal Bandwidth	$BW_{-3dB}$			200			kHz
Input Resistance	$R_{IN}$			100			$k\Omega$
Input Noise-Voltage Density	$e_n$	$f = 1kHz$		45			$nV/\sqrt{Hz}$
RMS Output Noise Voltage	$V_{NRMS}$	$BW = 22Hz$ to $22kHz$		385			$\mu V_{RMS}$
Total Harmonic Distortion Plus Noise	THD + N	$f = 1kHz$ , $BW = 22Hz$ to $22kHz$		0.05			%
Power-Supply Rejection Ratio	PSRR	$T_A = +25^{\circ}C$		65	90	dB	
		$T_A = T_{MIN} - T_{MAX}$		50			
Voltage Gain (Note 4)	$A_{VAUX}$	$V_{OUT} = 0.7V_{RMS}$		-10.7	-10	-9.3	V/V
BIAS OUTPUT (MAX4060/MAX4062/MAX4063)							
Output Voltage	$V_{OUT}$	$I_{BIAS} = 0.8mA$ to GND, MAX4060		2	2.2	V	
		$I_{BIAS} = 0.5mA$ to GND, MAX4062/MAX4063		2	2.2		

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 3V$  for MAX4061/MAX4062/MAX4063,  $V_{CC} = 5V$  for MAX4060,  $GND = 0$ ,  $\overline{SHDN} = V_{CC}$ ,  $\overline{INT}/AUX = 0$ ,  $R_G = 11.11k\Omega$ ,  $R_L = 100k\Omega$  to  $1.5V$ ,  $R_{BIAS} = \infty$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Resistance	R <sub>OUT</sub>	I <sub>BIAS</sub> = 0.8mA to GND, MAX4060		2	2.5		kΩ
		I <sub>BIAS</sub> = 0.5mA to GND, MAX4062/MAX4063			22	40	Ω
Output Noise Voltage	V <sub>NRMS</sub>	I <sub>BIAS</sub> = 0.8mA to GND, BW = 22Hz to 22kHz, MAX4060			50		μV <sub>RMS</sub>
		I <sub>BIAS</sub> = 0.5mA to GND, BW = 22Hz to 22kHz, MAX4062/MAX4063 (Note 3)			20		
Power-Supply Rejection Ratio	PSRR	MAX4060	I <sub>BIAS</sub> = 0.8mA to GND, V <sub>CC</sub> = 4.5V to 5.5V	50	80		dB
			I <sub>BIAS</sub> = 0.8mA, V <sub>CC</sub> = 5V + 100mV <sub>P-P</sub> , f = 1kHz		70		
		MAX4062/MAX4063 (Note 3)	I <sub>BIAS</sub> = 0.5mA to GND, V <sub>CC</sub> = 2.4V to 5.5V	50	74		
			I <sub>BIAS</sub> = 0.5mA, V <sub>CC</sub> = 3V + 100mV <sub>P-P</sub> , f = 1kHz		71		
DIGITAL INPUTS (SHDN for MAX4061/MAX4063 and INT/AUX for MAX4060/MAX4062/MAX4063)							
Input Leakage Current	I <sub>IN</sub>	V <sub>IN</sub> = 0 or V <sub>CC</sub>				±1	μA
Input Voltage High	V <sub>INH</sub>				0.7 × V <sub>CC</sub>		V
Input Voltage Low	V <sub>INL</sub>					0.3 × V <sub>CC</sub>	V
Shutdown Enable Time	t <sub>ON</sub>	MAX4061/MAX4063			10		μs
Shutdown Disable Time	t <sub>OFF</sub>	MAX4061/MAX4063			10		μs

**Note 1:** All specifications are 100% tested at  $T_A = +25^\circ C$ . Specification limits over temperature ( $T_A = T_{MIN}$  to  $T_{MAX}$ ) are guaranteed by design, not production tested.

**Note 2:** MAX4062/MAX4063 require a  $1\mu F$  capacitor from BIAS to ground.

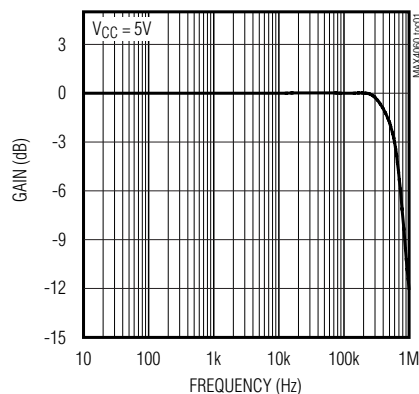
**Note 3:** The ADJ pin is open circuit (MAX4063 only).

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

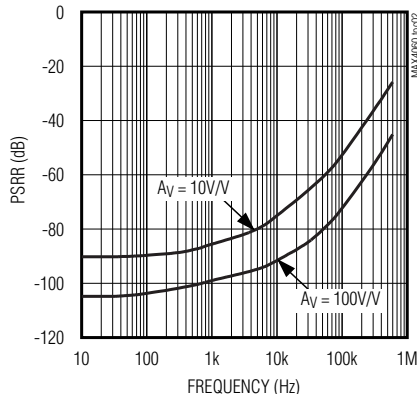
## Typical Operating Characteristics

( $V_{CC} = 3V$  (MAX4061/MAX4062/MAX4063),  $V_{CC} = 5V$  for MAX4060,  $A_V = 10V/V$ ,  $R_L \geq 100k\Omega$  to  $1.5V$ ,  $SHDN = V_{CC}$  (MAX4061/MAX4063 only),  $T_A = +25^\circ C$ .)

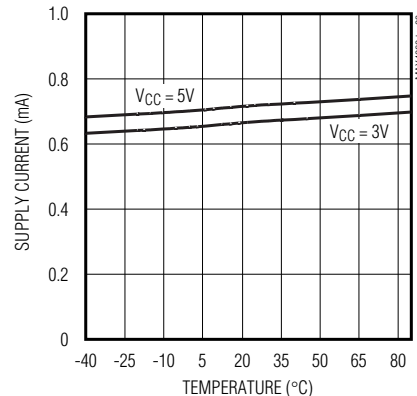
**GAIN vs. FREQUENCY  
(NO LOAD)**



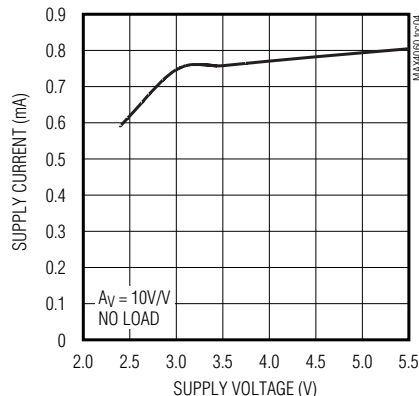
**POWER-SUPPLY REJECTION RATIO  
vs. FREQUENCY (DIFF INPUT)**



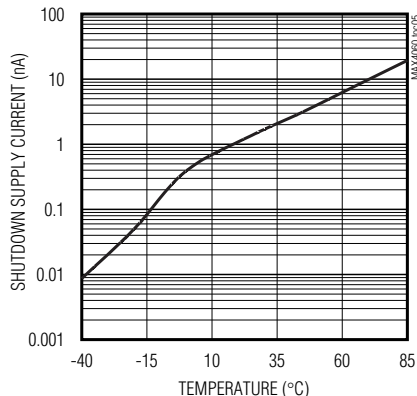
**SUPPLY CURRENT vs. TEMPERATURE**



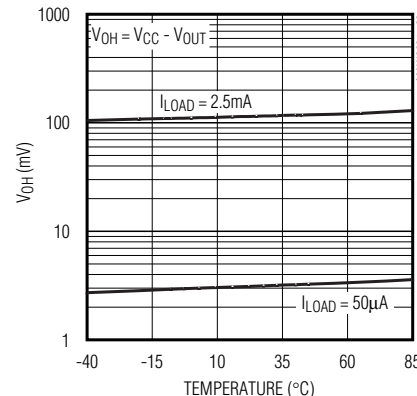
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



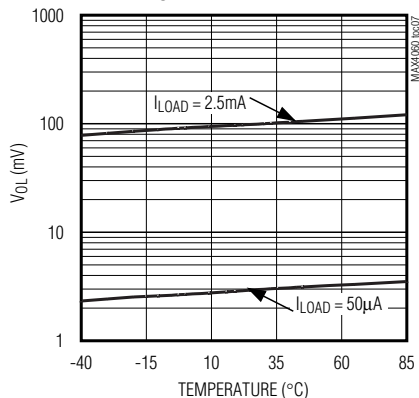
**SHUTDOWN SUPPLY CURRENT  
vs. TEMPERATURE**



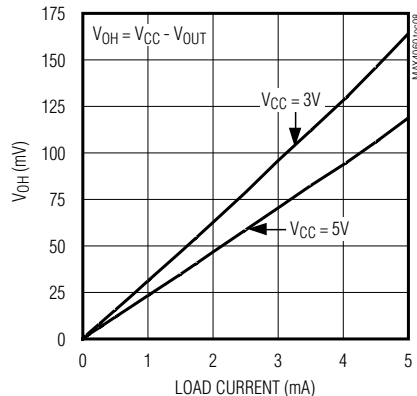
**$V_{OH}$  vs. TEMPERATURE**



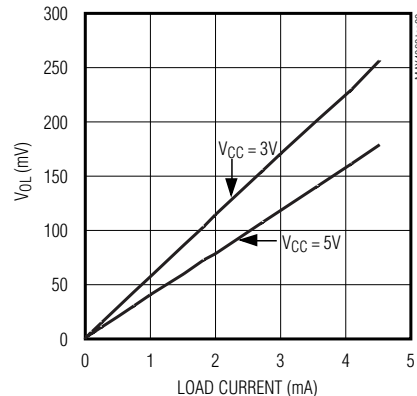
**$V_{OL}$  vs. TEMPERATURE**



**$V_{OH}$  vs. LOAD CURRENT**



**$V_{OL}$  vs. LOAD CURRENT**

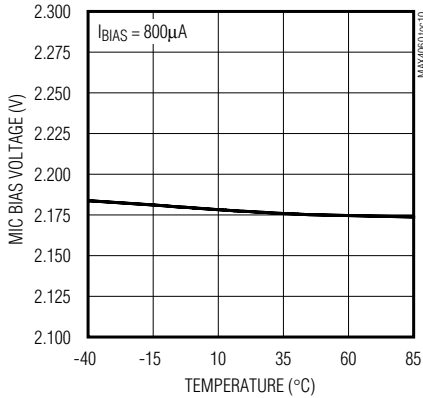


# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

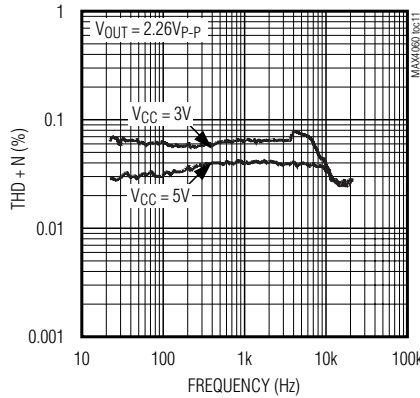
## Typical Operating Characteristics (continued)

( $V_{CC} = 3V$  (MAX4061/MAX4062/MAX4063),  $V_{CC} = 5V$  for MAX4060,  $A_V = 10V/V$ ,  $R_L \geq 100k\Omega$  to 1.5V,  $\overline{SHDN} = V_{CC}$  (MAX4061/MAX4063 only),  $T_A = +25^\circ C$ .)

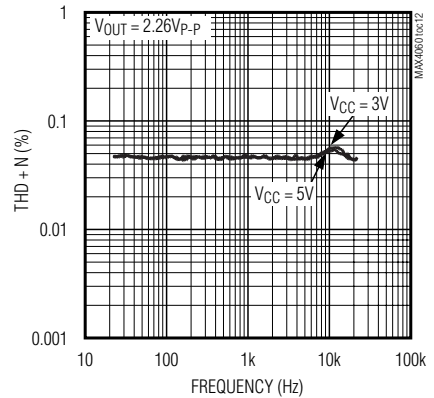
**MAX4060**  
**MIC BIAS VOLTAGE vs. TEMPERATURE**



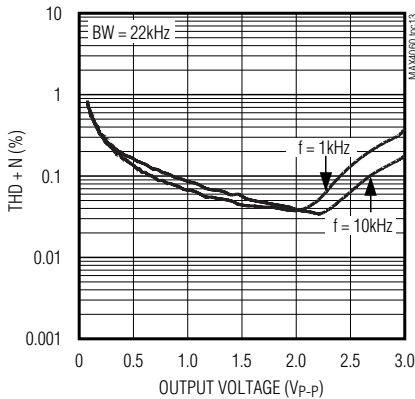
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY (DIFF INPUT)**



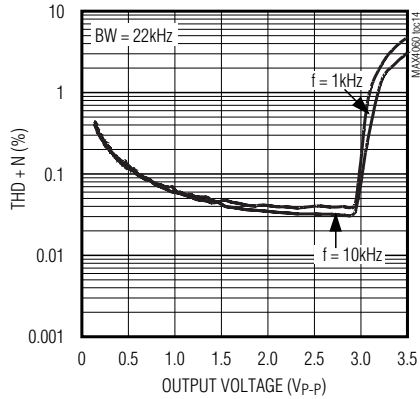
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY (AUX INPUT)**



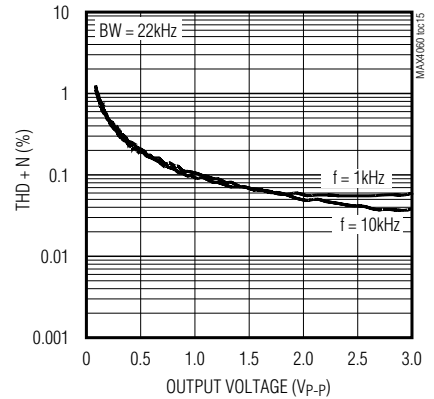
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (DIFF INPUT,  $V_{CC} = 3V$ )**



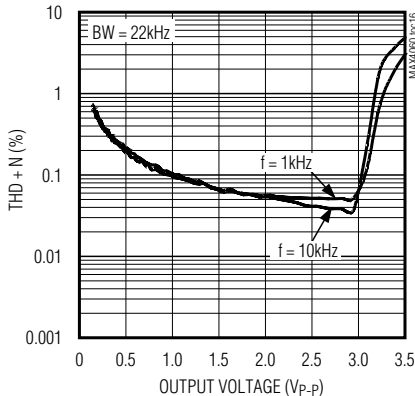
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (DIFF INPUT,  $V_{CC} = 5V$ )**



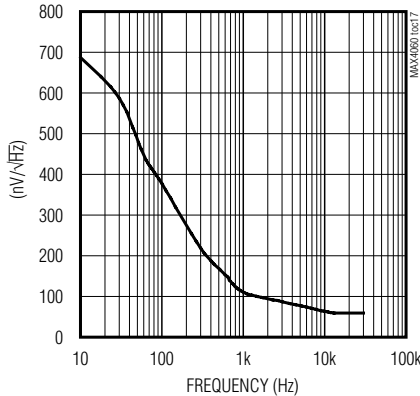
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (AUX INPUT,  $V_{CC} = 3V$ )**



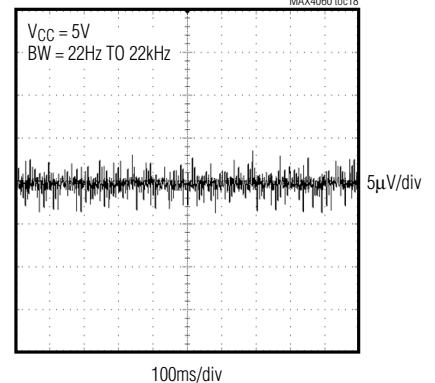
**TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (AUX INPUT,  $V_{CC} = 5V$ )**



**INPUT-REFERRED NOISE vs. FREQUENCY (DIFF INPUT)**



**MAX4060**  
**MIC BIAS OUTPUT NOISE**

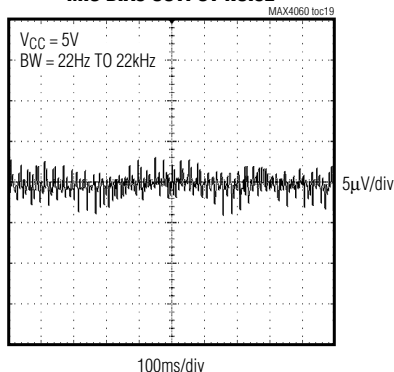


# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

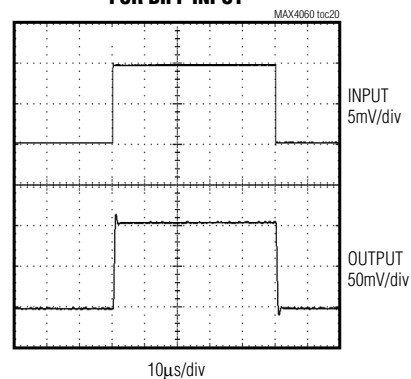
## Typical Operating Characteristics (continued)

( $V_{CC} = 3V$  (MAX4061/MAX4062/MAX4063),  $V_{CC} = 5V$  for MAX4060,  $A_V = 10V/V$ ,  $R_L \geq 100k\Omega$  to 1.5V,  $\overline{SHDN} = V_{CC}$  (MAX4061/MAX4063 only),  $T_A = +25^\circ C$ .)

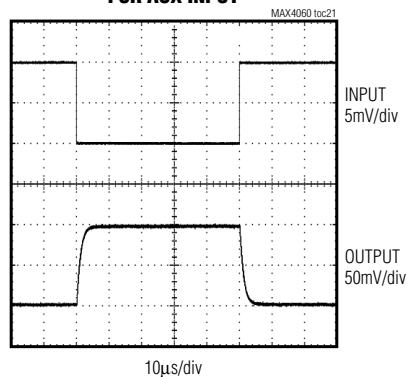
**MAX4062  
MIC BIAS OUTPUT NOISE**



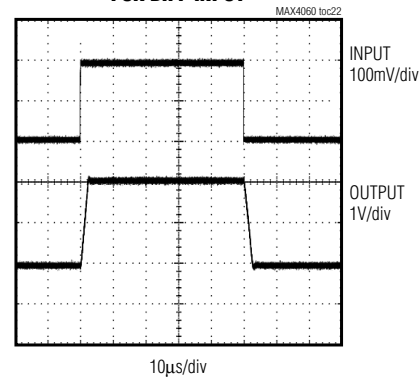
**SMALL-SIGNAL TRANSIENT RESPONSE  
FOR DIFF INPUT**



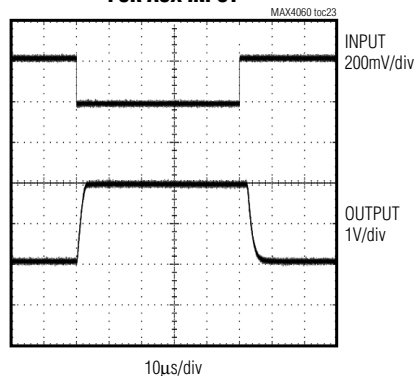
**SMALL-SIGNAL TRANSIENT RESPONSE  
FOR AUX INPUT**



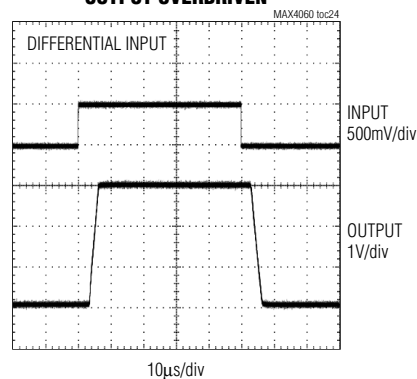
**LARGE-SIGNAL TRANSIENT RESPONSE  
FOR DIFF INPUT**



**LARGE-SIGNAL TRANSIENT RESPONSE  
FOR AUX INPUT**



**OUTPUT OVERDRIVEN**



MAX4060-MAX4063

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Pin Description

PIN				NAME	FUNCTION
MAX4060	MAX4061	MAX4062	MAX4063		
1	—	2	2	$\overline{\text{INT/AUX}}$	Internal (Differential) or Auxiliary (Single-Ended) Input Select. Drive $\overline{\text{INT/AUX}}$ low to select internal or high to select auxiliary mic input.
2	3	3	4	OUT	Amplifier Output. OUT is high impedance when in shutdown mode.
3	—	—	—	BIAS	External Electret Microphone Capsule Bias Output. BIAS has a greater than 2k $\Omega$ output impedance.
4	4	5	6	VCC	Power Supply. Bypass the VCC to GND with a 0.1 $\mu$ F capacitor.
5	5	6	9	IN+	Noninverting Differential Amplifier Input. AC-couple the audio signal into IN+.
6	6	7	10	IN-	Inverting Differential Amplifier Input. AC-couple the audio signal into IN-.
7	7	8	11	GND	Ground
8	—	9	12	AUX_IN	Single-Ended Input for Auxiliary Microphone. AC-couple the audio signal into AUX_IN.
—	1	1	1	G2	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier. (See <i>Adjustable Differential-Gain Setting</i> section).
—	2	—	3	$\overline{\text{SHDN}}$	Shutdown Input. Drive $\overline{\text{SHDN}}$ high for normal operation. Drive $\overline{\text{SHDN}}$ low for shutdown mode.
—	—	4	5	BIAS	External Electret Microphone Capsule Bias Output Bypass BIAS with 1 $\mu$ F Capacitor to Ground
—	—	—	7	ADJ	Adjustable Gain Select for AUX_IN (see <i>Auxiliary Input-Gain Adjustment</i> section).
—	—	—	8	$\overline{\text{OUT}}$	Complementary Amplifier Output. When $\overline{\text{INT/AUX}}$ = low, this is the complement signal of the OUT pin, biased around the internally derived reference. When $\overline{\text{INT/AUX}}$ = high, $\overline{\text{OUT}}$ is a buffered version of the internal DC reference used by the AUX amplifier.
—	—	—	13	N.C.	No Connection. Not internally connected.
—	8	10	14	G1	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier.

## Detailed Description

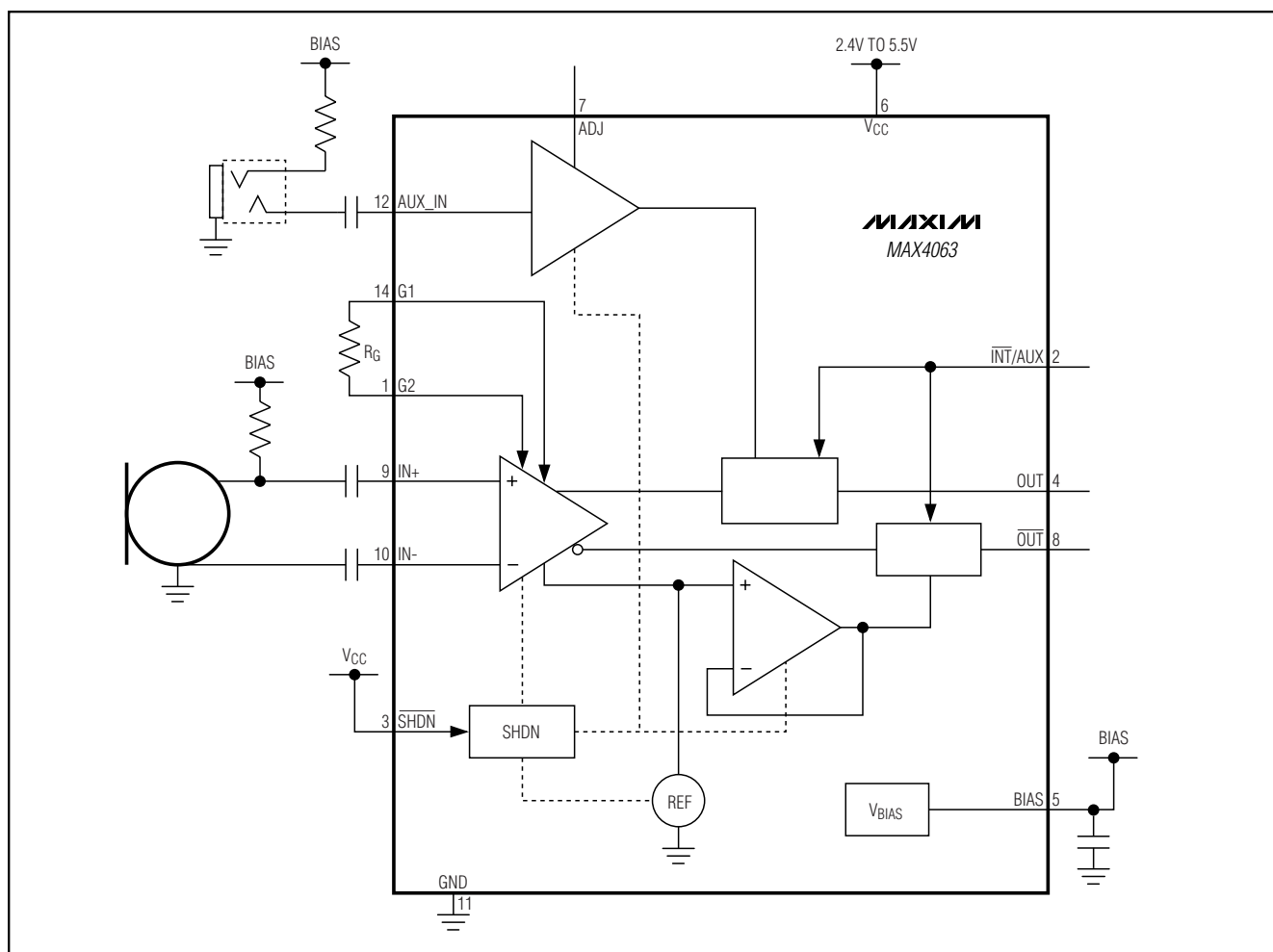
The MAX4060–MAX4063 are differential microphone preamplifiers providing high-quality audio, optimized for use in computer and mobile applications. These devices feature rail-to-rail outputs, very high power-supply rejection, and common-mode rejection, making them ideal for low-noise applications. The MAX4060–MAX4063 are particularly effective when layout constraints force the microphone amplifier to be physically remote from the ECM microphone and/or the rest of the audio circuitry.

The MAX4060/MAX4062/MAX4063 are capable of switching their output between the differential input and an inverting single-ended input.  $\overline{\text{INT/AUX}}$  selects either the differential input or single-ended auxiliary input. In addition, the MAX4060/MAX4061/MAX4063 have an internal bias generator to bias the microphone in either differential or single-ended modes. The MAX4063 has a complementary output allowing CODECs and other devices with differential inputs to be optimally driven (see *Functional Diagram*). The MAX4061/MAX4063



# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Functional Diagram



MAX4060-MAX4063

include a complete 0.3 $\mu$ A shutdown mode for ultimate power savings. The differential gain of the MAX4061/MAX4062/MAX4063 is set with a single resistor connected between the G1 and G2 pins. The MAX4060 has a fixed gain of 10V/V, while the MAX4063 has an internal default gain of 10V/V on the AUX\_IN input, although this can be adjusted to different values (see the Differential Gain-Setting and Auxiliary Input-Gain Adjustment sections).

### Differential Input

The main microphone input is a low-noise, differential input structure. This is an almost essential element when faced with amplification of low-amplitude analog signals in digitally intense environments such as note-

book PCs or PDAs. Used correctly, the advantages over a single-ended solution are:

- Better power-supply noise rejection
- Less degradation from noise in PC board ground planes
- Microphone and preamplifier may be placed physically further apart, easing PC board layout restrictions

### Fixed Differential Gain (MAX4060)

The MAX4060 has an internal fixed gain of 10V/V for its differential input. This feature simplifies design, reduces pin count and footprint, and eliminates external gain-setting resistors.

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Adjustable Differential-Gain Setting

The MAX4061/MAX4062/MAX4063 allow the user to alter the gain to optimize the signal-to-noise ratio (SNR) of their system. The gain is set by a single external resistor ( $R_G$ ) connected between the G1 and G2 pins, where:

$$R_G = 100k\Omega / (A_V - 1)$$

where  $A_V$  is the required voltage gain.

Hence, an 11.11k $\Omega$  resistor yields a gain of 10V/V, or 20dB. Leaving the pins unconnected results in a gain of 1V/V. Gain is defined as:

For MAX4061/MAX4062/MAX4063:

$$A_V = V_{OUT} / (V_{IN+} - V_{IN-})$$

For MAX4063:

$$A_V = (V_{OUT} - \overline{V_{OUT}}) / (V_{IN+} - V_{IN-})$$

The resistor can be either fixed or variable, allowing the use of a digitally controlled potentiometer to alter the gain under software control.

## Auxiliary Input-Gain Adjustment (MAX4063)

On the MAX4060/MAX4061/MAX4062, the voltage gain of the auxiliary input is internally fixed at -10V/V.

The MAX4063 provides the option to adjust this gain. Connect a resistor  $R_{ADJ1}$  between the ADJ and OUT pins to reduce the gain. To increase the gain, connect resistor  $R_{ADJ2}$  between the ADJ and AUX\_IN pins.  $R_{ADJ1}$  and  $R_{ADJ2}$  are calculated from the following formulas:

$$R_{ADJ1} = 2.5M\Omega / ((50 / A_V) - 5)$$

(to decrease the gain)

$$R_{ADJ2} = (0.5M\Omega) / (A_V - 10)$$

(to increase the gain)

where  $A_V$  is the voltage gain.  $R_{ADJ1}$  and  $R_{ADJ2}$  are in  $\Omega$ .

## Input Capacitors

The two differential microphone inputs and the single-ended auxiliary input of the MAX4060–MAX4063 have on-chip bias components, allowing the user to AC-couple any signals on to the input. The input resistance is 100k $\Omega$  (typ), so the capacitor size may be chosen accordingly to define the LF rolloff desired. This can be calculated as:

$$C_{IN} = 1 / (2\pi f_{CUT} R_{IN})$$

This assumes a low source impedance driving the inputs.

A further consideration for the differential input is the effect of these series input capacitors on low-frequency, common-mode rejection. Any mismatch in the values of these two capacitors degrades the CMRR at frequencies where the impedance of the capacitor is significant

compared to the input resistance of the amplifier—this is usually most noticeable at low frequencies. One way to avoid the need for matched or tight tolerance capacitors is to deliberately oversize the values on the differential inputs and to set the lower 3dB point ( $f_{CUT}$ ) of the amplifier by sizing the output capacitor appropriately.

The input impedance matching on the differential input is typically 1%, allowing input capacitor matching to be effective at improving low-frequency PSRR.

## Common-Mode Rejection Ratio

The common-mode rejection ratio (CMRR) refers to the amount of rejection that the amplifier is capable of providing to any signal applied equally to the IN+ and IN- inputs. In the case of amplifying low-level microphone signals in noisy digital environments, it is a key figure of merit. In audio circuits, this is generally measured for  $V_{IN}$  as an AC signal:

$$CMRR(dB) = A_{DM} / A_{CM} = V_{INDIFF} / \Delta V_{INCM}$$

where  $A_{DM}$  is the differential gain,  $A_{CM}$  is the common-mode gain,  $\Delta V_{INCM}$  is the change in input common-mode voltage (IN+ and IN- connected together) and  $V_{INDIFF}$  is the differential input voltage.

Input voltages are sufficiently small such that the output is not clipped in either differential or common-mode application. The topology used in the MAX4061/MAX4062/MAX4063 means that the CMRR actually improves at higher differential gains—another advantage of using differential sensing.

## Auxiliary Input

The auxiliary input is a single-ended input intended to be used with a jack-socket type microphone input (Figure 1). Internal DC-bias components (as on the main inputs) allow the input signal to be AC-coupled. Mechanically switched jack sockets can be used in conjunction with the INT/AUX select pin, allowing the auxiliary microphone input to be automatically selected when a jack socket is inserted.

## Microphone Bias Voltage

### MAX4060

The MAX4060 has a microphone bias voltage designed to comply with the Microsoft/Intel PC99/2001 audio standard. It features source impedance of greater than 2k $\Omega$ , and delivers more than 2V of bias when loaded with a current of 800 $\mu$ A. This limits operation of this part to supplies between 4.5V to 5.5V (see Figure 2).

### MAX4061/MAX4062/MAX4063

The MAX4061/MAX4062/MAX4063 have a lower bias voltage and low-impedance outputs (optimum electret bias resistor can then be set externally). This gives a

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

MAX4060-MAX4063

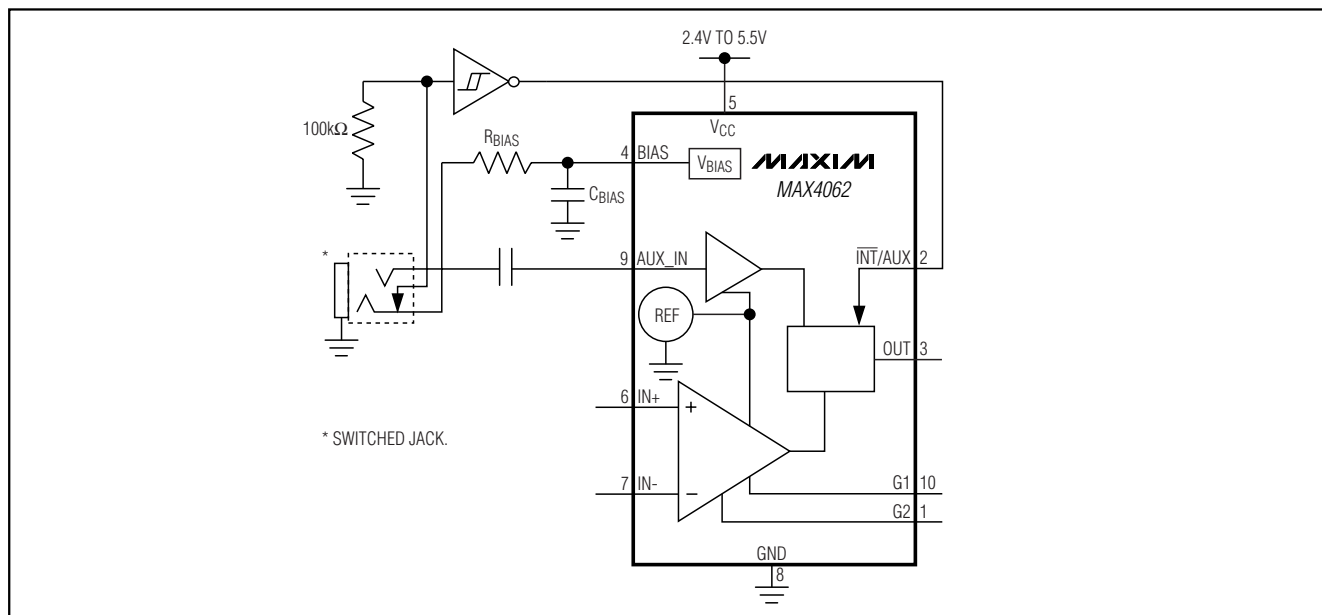


Figure 1. MAX4062 with Auxiliary Input Configuration

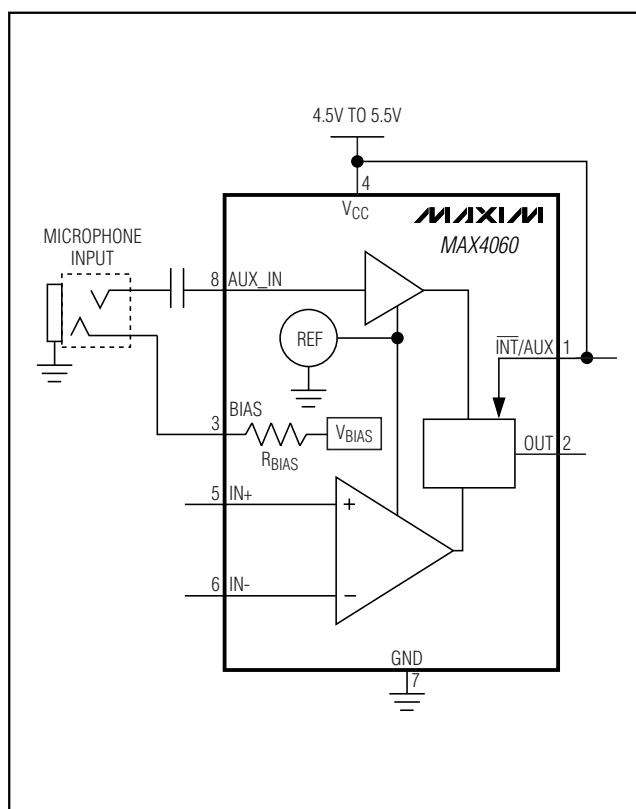


Figure 2. MAX4060 Used for Biasing a Microphone

low-noise, flexible solution that can run from 2.4V to 5.5V, suitable for hand-held devices such as PDAs that typically have audio power supplies in the 3V region.

## Output

### MAX4060/MAX4061/MAX4063 DC Bias

The output voltage has a DC-bias voltage independent of the power supplies, resulting in superior PSRR performance. The MAX4061/MAX4063 outputs are high impedance when the part is in shutdown mode. AC-coupling the output into the next audio stage (e.g., CODEC) is recommended (see Figure 4).

### Differential Output (MAX4063)

The MAX4063 features a differential output stage (OUT and  $\overline{\text{OUT}}$ ), allowing optimum performance when connected to ADCs and CODECs with differential inputs. This differential output is particularly useful in designs where the microphone preamplifier is mounted some distance away from the CODEC/ADC, as the low-impedance, differential line provides excellent noise rejection and immunity (see Figure 4).

When the AUX input is selected,  $\overline{\text{OUT}}$  is a buffered version of the internal DC reference.

## Applications Information

### Shutdown Mode

The MAX4061/MAX4063 feature a low-power, complete shutdown mode. When  $\overline{\text{SHDN}}$  goes low, the supply cur-

## Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

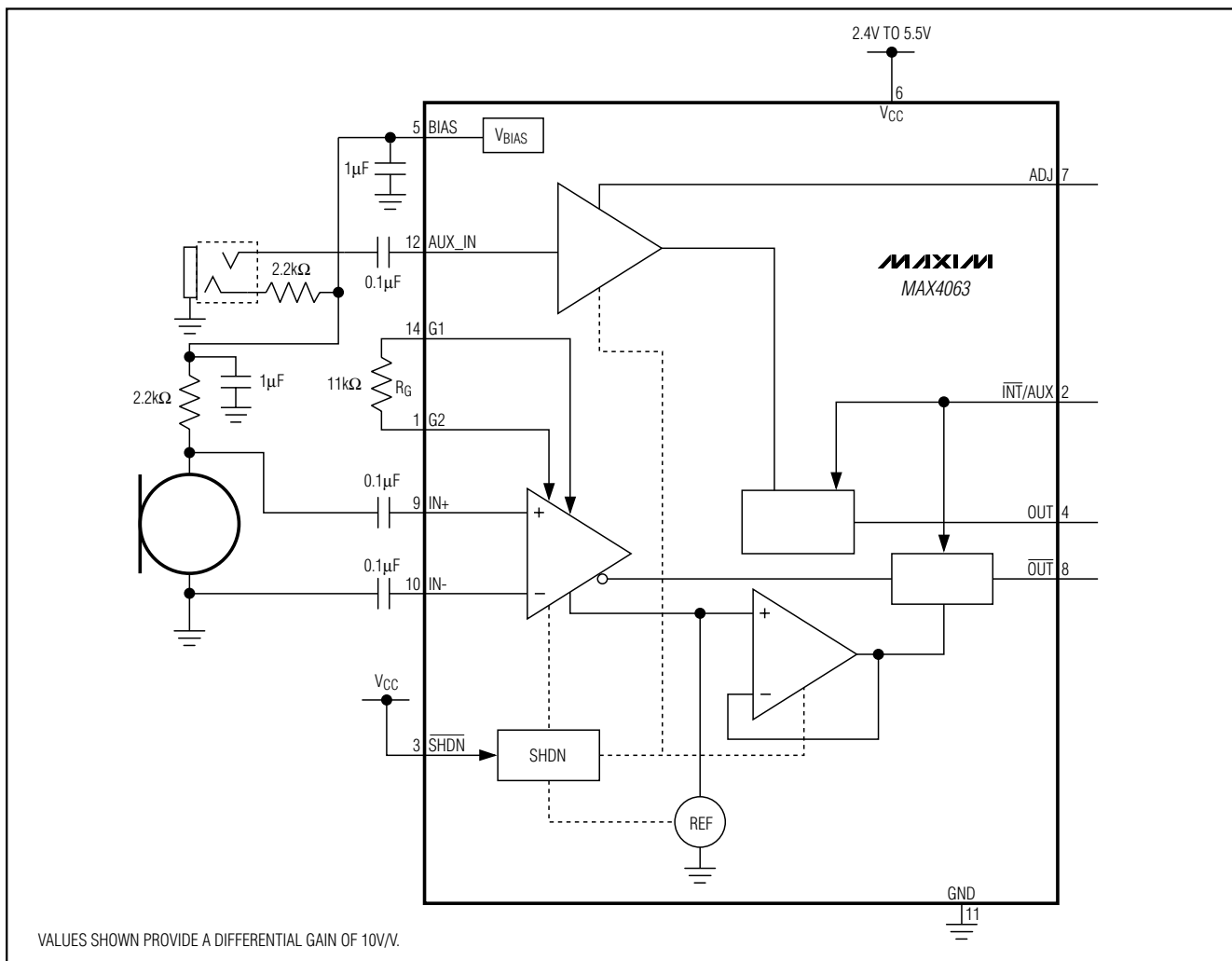


Figure 3. MAX4063 Used to Bias a Microphone Connected to the Auxiliary Input and the Differential Input

rent drops to 0.3μA, the output enters a high-impedance state, and the bias current to the microphone is switched off. Driving SHDN high enables the amplifier. SHDN should not be left floating.

### Power Supplies and Layout

The MAX4060 operates from a 4.5V to 5.5V single supply and the MAX4061/MAX4062/MAX4063 operate from a 2.4V to 5.5V single supply. Bypass the power supply with a 0.1μF capacitor to ground. In systems where

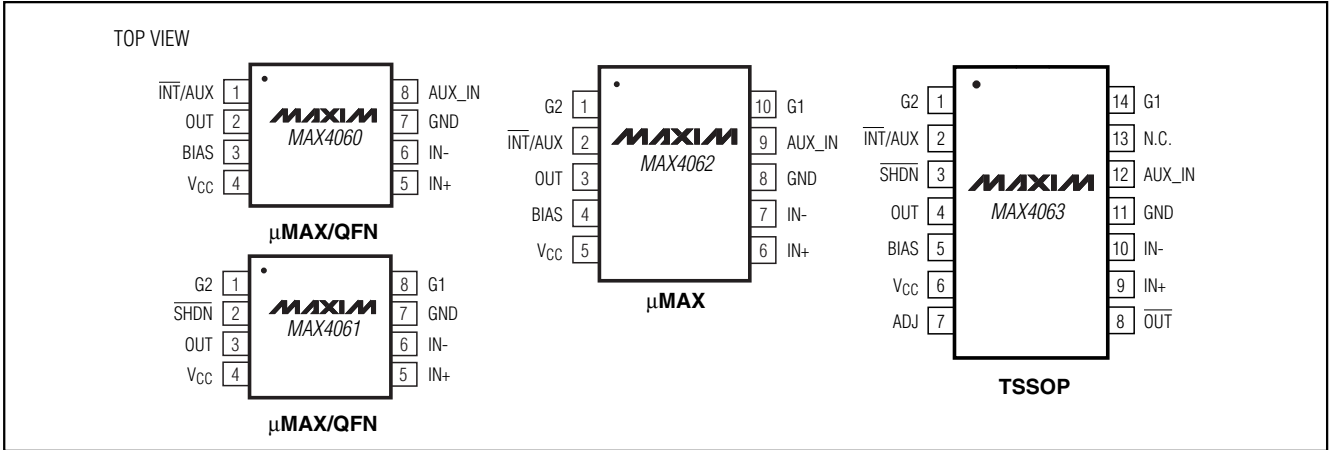
analog and digital grounds are available, the MAX4060/MAX4061/MAX4063 should be connected to the analog ground.

# MAX4060-MAX4063



# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Pin Configurations



## Selector Guide

PRODUCT	AUXILIARY INPUT	DIFF INPUT GAIN	SINGLE-ENDED INPUT GAIN	MICROPHONE BIAS	SHUTDOWN MODE	DIFF OUTPUT	SUPPLY VOLTAGE (V)
MAX4060	✓	20dB	20dB	✓	—	—	4.5 to 5.5
MAX4061	—	ADJ	—	—	✓	—	2.4 to 5.5
MAX4062	✓	ADJ	20dB	✓	—	—	2.4 to 5.5
MAX4063	✓	ADJ	ADJ	✓	✓	✓	2.4 to 5.5

## Chip Information

MAX4060/MAX4061/4062 TRANSISTOR COUNT: 264

MAX4063 TRANSISTOR COUNT: 351

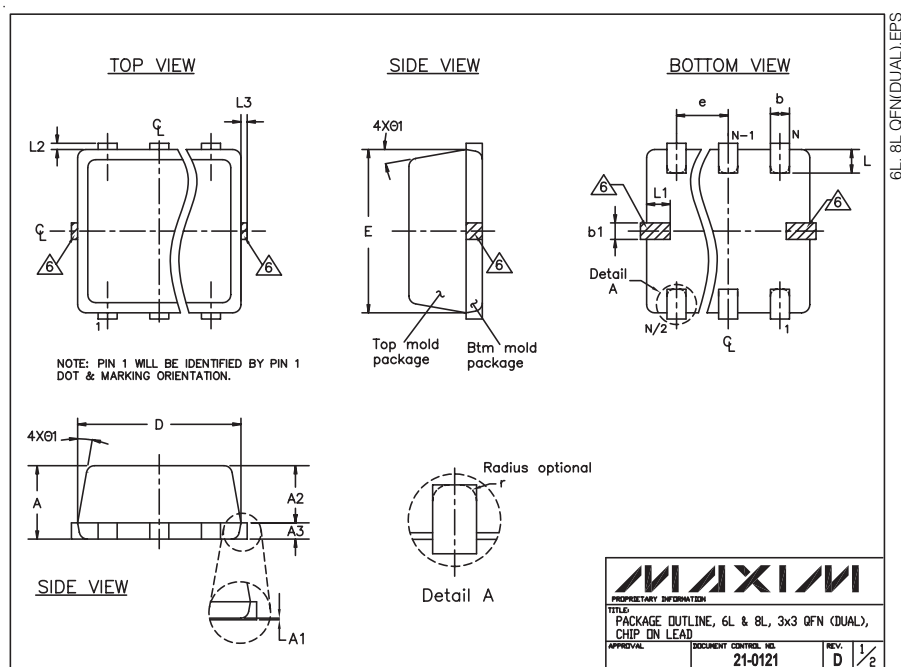
PROCESS: BiCMOS

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## 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).)

MAX4060-MAX4063



COMMON DIMENSIONS		
SYMBOL	MIN	MAX
A	0.80	1.00
A1	0	0.05
A2	0.65	0.90
A3	0.15	0.25
L2	0	0.10
L3	0	0.10
b1	0.17	0.30
Ø1	0"	12"

VARIATIONS				
SYMBOL	MIN	MAX	MIN	MAX
D	2.90	3.10	2.90	3.10
E	2.90	3.10	2.90	3.10
N	6		8	
e	0.95 BSC		0.65 BSC	
b	0.27	0.43	0.25	0.40
L	0.21	0.44	0.21	0.44
L1	0.21	0.37	0.21	0.37
JEDEC SPEC	—		MO-220 VARIATION EEC-2	

- Note:
1. All dimensions are in mm.
  2. Package outline exclusive of mold flash & metal burr.
  3. Package outline inclusive of plating.
  4. N is the total number of terminals.
  5. Package surface finishing of Ra0.4µm max.
- △ Shaded areas are not leads. Do not make electrical contact in this area. Use numbered leads for electrical contact.

**MAXIM**

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 6L & 8L, 3x3 QFN (DUAL), CHIP ON LEAD

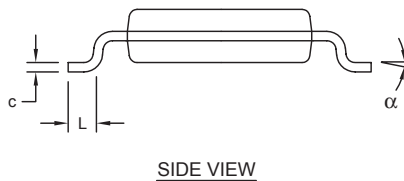
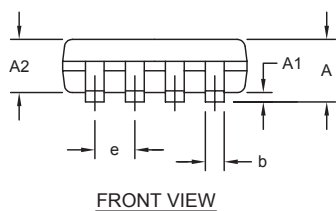
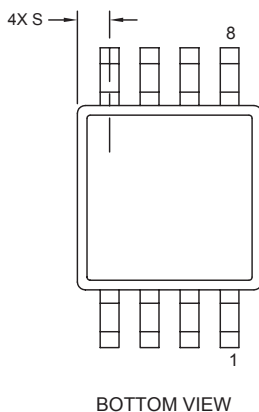
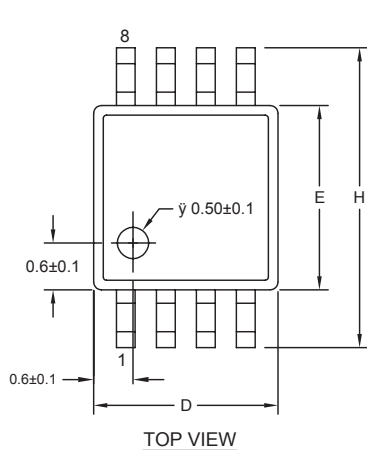
APPROVAL: 21-0121

REVISION: D 2/2

# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Package Information (continued)

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DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0°	6°	0°	6°
S	0.0207 BSC		0.5250 BSC	

### NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

 <b>DALLAS</b> SEMICONDUCTOR			
PROPRIETARY INFORMATION			
TITLE:			
PACKAGE OUTLINE, 8L uMAX/uSOP			
APPROVAL	DOCUMENT CONTROL NO.	REV.	1/1
	21-0036	J	

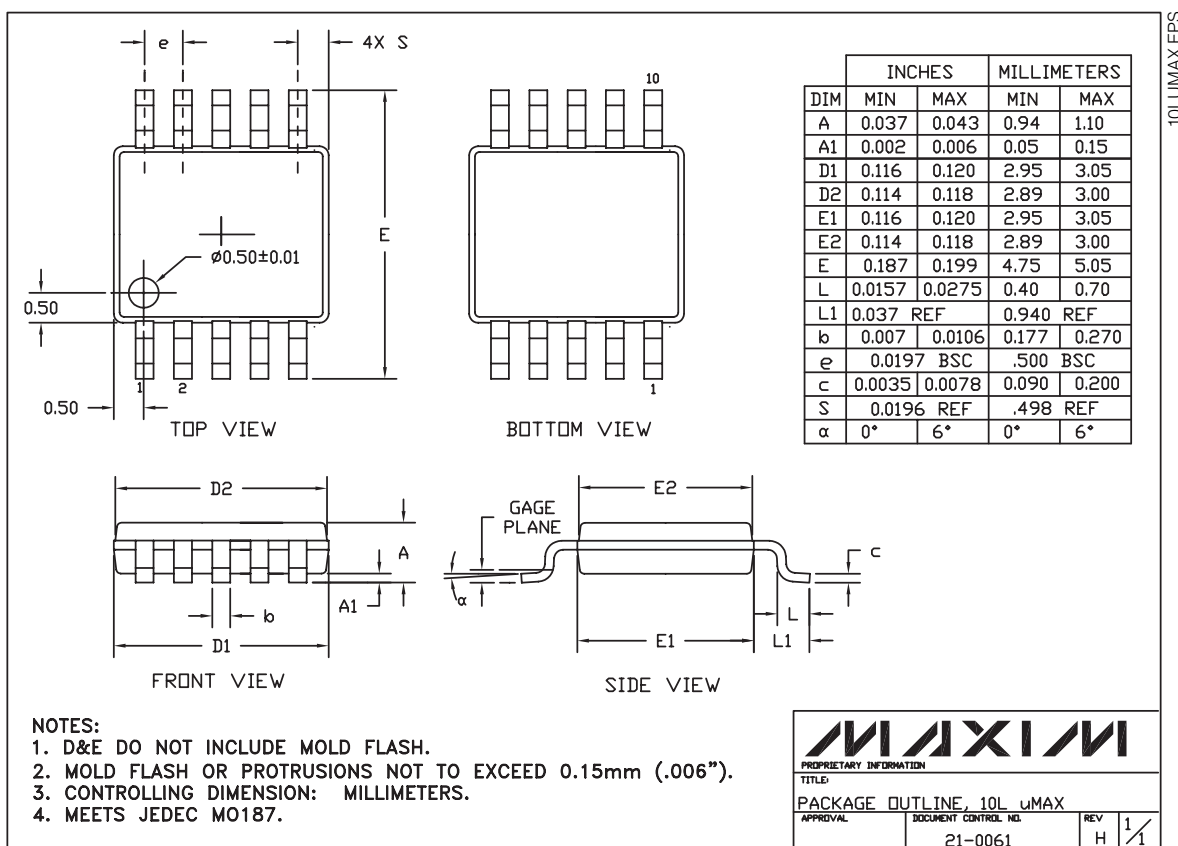
8LUMAXD EPS



# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Package Information (continued)

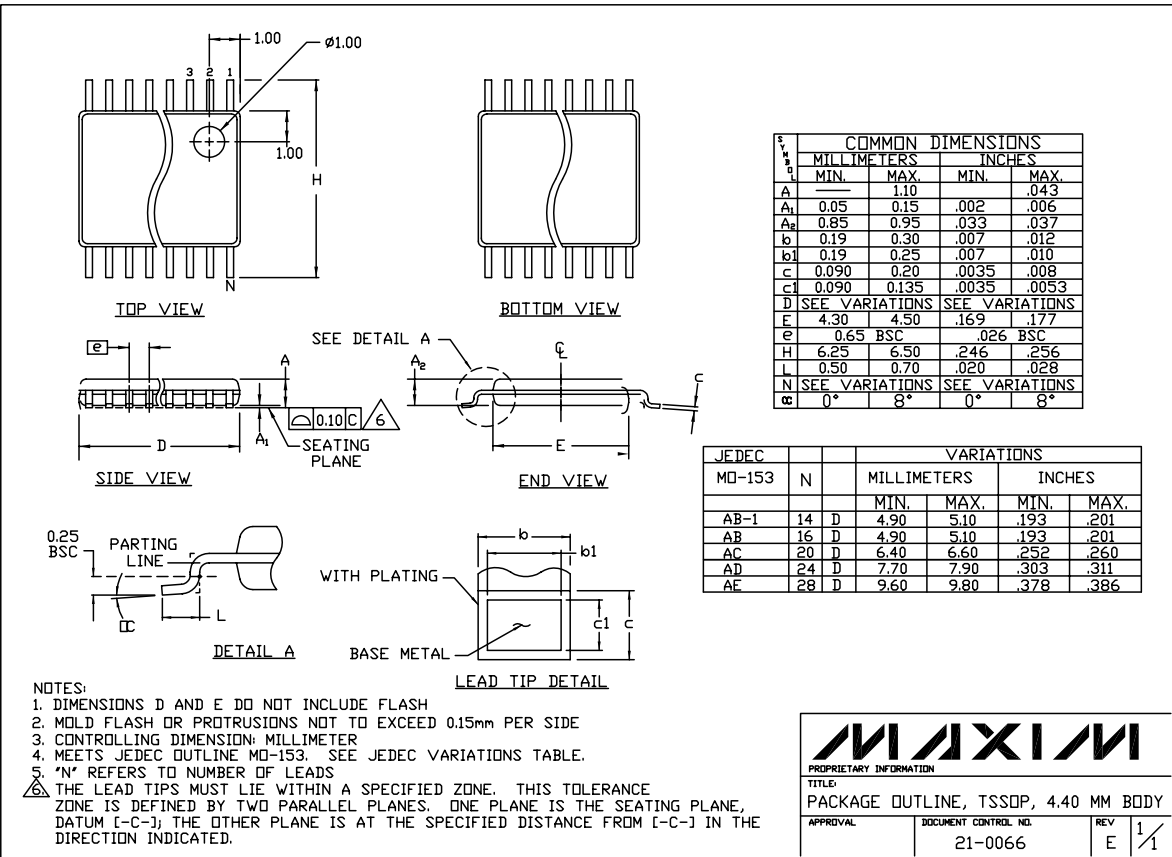
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# Differential Microphone Preamplifiers with Internal Bias and Complete Shutdown

## Package Information (continued)

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