Differential Microphone Preamplifier 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) ..... ±10mA
Continuous Power Dissipation (T_A = +70°C)
14-Pin TSSOP (derate 10.0mW/°C above +70°C) 796.8mW
16-Pin TQFN (derate 25.0mW/°C above +70°C) 2000mW
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow) .....+260°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, V_{GND} = 0V, $V_{\overline{SHDN}}$ = V_{CC}, $V_{\overline{INT}/AUX}$ = 0V, R_G = 11.11kΩ, R_L = 100kΩ to 1.5V, R_{BIAS} = ∞, V_{OUT} is measured between OUT and $\overline{OUT}$. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Inferred from PSRR test		2.4		5.5	V
Supply Current	I_{CC}				0.75	1.1	mA
Output Common-Mode Voltage	V_{OCM}			1.25	1.5	1.75	V
Slew Rate	SR	A_V = 20V/V			±1		V/µs
Supply Current in Shutdown	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = 0V			0.001	1	µA
Output Short-Circuit Current	I_{SC}	To GND			30		mA
		To V_{CC}			30		
DIFFERENTIAL INPUT ($V_{\overline{INT}/AUX}$ = 0V)							
Input Offset Voltage	V_{OS}	T_A = +25°C			±1		mV
Common-Mode Input Voltage Range	V_{CM}	Inferred from CMRR test		1		2	V
Maximum Differential Input Voltage	$V_{DIFFMAX}$	A_V = 2V/V			1		V
Small-Signal Bandwidth	BW_{-3dB}				600		kHz
Input Resistance	R_{IN}	Either differential input			100		kΩ
Input Resistance Match	R_{MATCH}				1		%
Input Noise-Voltage Density	e_n	A_V = 20V/V, f = 1kHz			70		nV/√Hz
		A_V = 200V/V, f = 1kHz			12		
RMS Output Noise Voltage	V_{NRMS}	A_V = 20V/V, BW = 22Hz to 22kHz			225		$µV_{RMS}$
Total Harmonic Distortion Plus Noise	THD+N	A_V = 20V/V, f = 1kHz, V_{OUT} = 0.7V_{RMS}, BW = 22Hz to 22kHz			0.05		%
Differential Gain	A_{VDIFF}	1V < V_{CM} < 2V, V_{OUT} = 0.7V_{RMS}	R_G = open		2		V/V
			R_G = 11.11kΩ	19.2	20	20.8	
			R_G = 1.01kΩ		200		
Common-Mode Rejection Ratio	CMRR	V_{CM} = 500mV_{P-P}, f = 1kHz			70		dB
Power-Supply Rejection Ratio	PSRR	T_A = +25°C			95		dB
		T_A = T_{MIN} - T_{MAX}			85		
		V_{CC} = 5V ±100mV, f = 1kHz			86		

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 3V, V_{GND} = 0V, $V_{\overline{SHDN}}$ = V_{CC}, $V_{\overline{INT}/AUX}$ = 0V, R_G = 11.11kΩ, R_L = 100kΩ to 1.5V, R_{BIAS} = ∞, V_{OUT} is measured between OUT and $\overline{OUT}$. T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Notes 1 and 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
AUXILIARY INPUT ($\overline{INT}$/AUX = V_{CC})						
Small-Signal Bandwidth	BW_{-3dB}			230		kHz
Input Resistance	R_{IN}			100		kΩ
Input Noise-Voltage Density	e_n	f = 1kHz		200		$nV/\sqrt{Hz}$
RMS Output Noise Voltage	V_{NRMS}	BW = 22Hz to 22kHz		620		μV_{RMS}
Total Harmonic Distortion Plus Noise	THD+N	f = 1kHz, BW = 22Hz to 22kHz		0.007		%
Power-Supply Rejection Ratio	PSRR	T_A = +25°C	80	100		dB
		T_A = T_{MIN} - T_{MAX}	72			
Voltage Gain	A_{VAUX}	V_{OUT} = $0.7V_{RMS}$	-19.5	-20	-20.5	V/V
BIAS OUTPUT						
Output Voltage	V_{OUT}	I_{BIAS} = 0.5mA to GND	2	2.2		V
Output Resistance	R_{OUT}	I_{BIAS} = 0.5mA to GND		16	30	Ω
Output Noise Voltage	V_{NRMS}	I_{BIAS} = 0.5mA to GND, BW = 22Hz to 22kHz		20		μV_{RMS}
Power-Supply Rejection Ratio	PSRR	I_{BIAS} = 0.5mA to GND, V_{CC} = 2.4V to 5.5V	60	74		dB
		I_{BIAS} = 0.5mA, V_{CC} = 3V + $100mV_{P-P}$, f = 1kHz		71		
DIGITAL INPUTS ($\overline{SHDN}$ and $\overline{INT}$/AUX)						
Input Leakage Current	I_{IN}	V_{IN} = 0V or V_{CC}			±1	µA
Input Voltage High	V_{INH}		0.7 × V_{CC}			V
Input Voltage Low	V_{INL}				0.3 × V_{CC}	V
Shutdown Enable Time	t_{ON}			10		µs
Shutdown Disable Time	t_{OFF}			10		µs

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

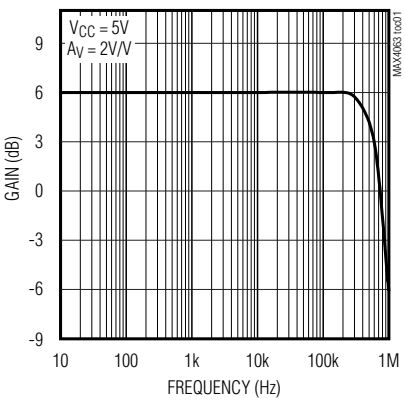
Note 2: MAX4063 requires a 1µF capacitor from BIAS to ground and a 10pF capacitor from ADJ to OUT.

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

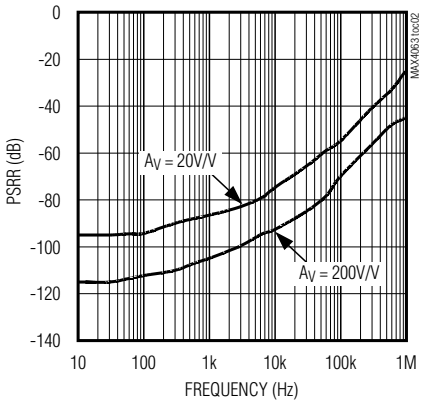
Typical Operating Characteristics

(V_{CC} = 3V, A_V = 20V/V, $R_L \geq 100k\Omega$ to 1.5V, $V_{\overline{SHDN}} = V_{CC}$, V_{OUT} is measured between OUT and $\overline{OUT}$. T_A = +25°C, unless otherwise noted.)

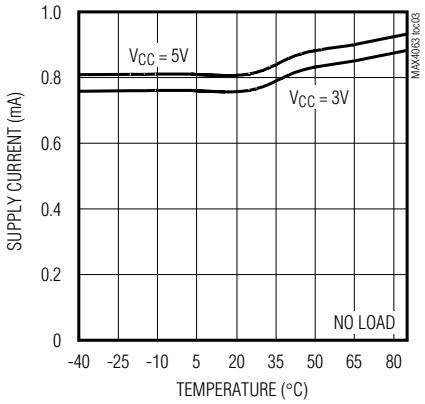
GAIN vs. FREQUENCY (NO LOAD)



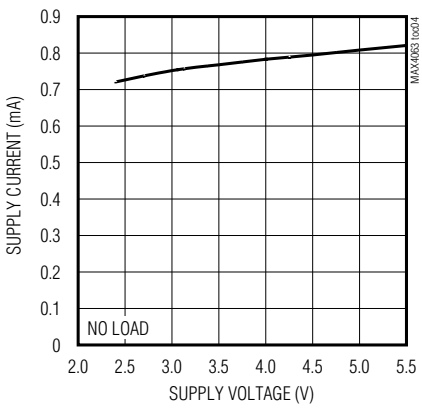
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY (DIFF INPUT)



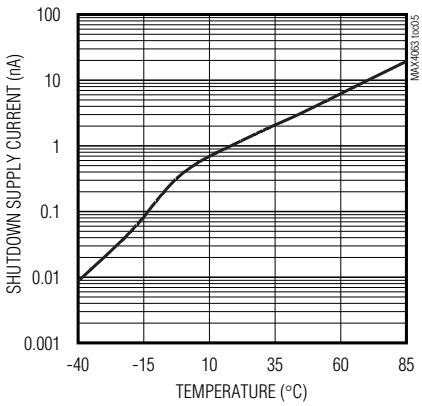
SUPPLY CURRENT vs. TEMPERATURE



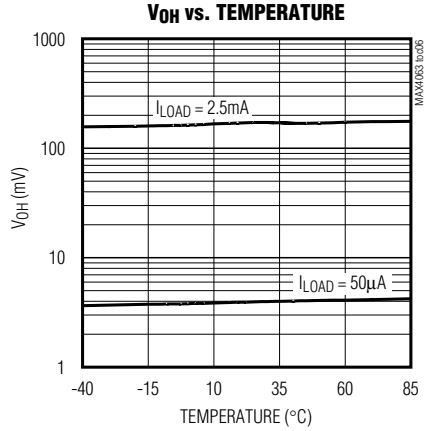
SUPPLY CURRENT vs. SUPPLY VOLTAGE



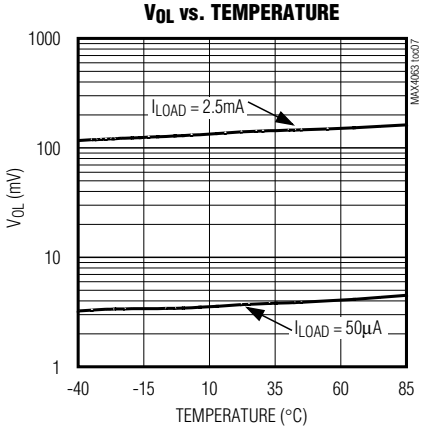
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE



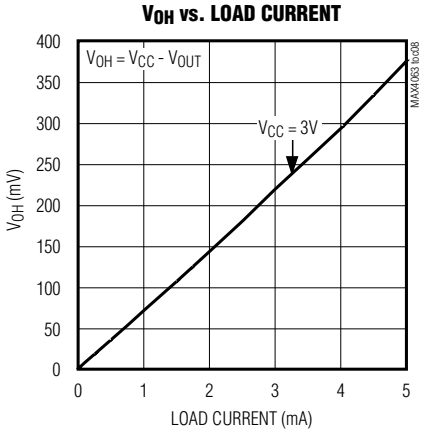
VOH vs. TEMPERATURE



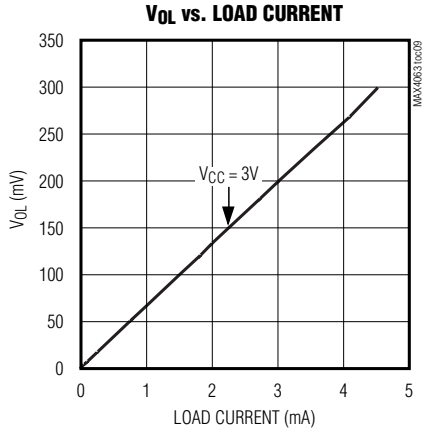
VOL vs. TEMPERATURE



VOH vs. LOAD CURRENT



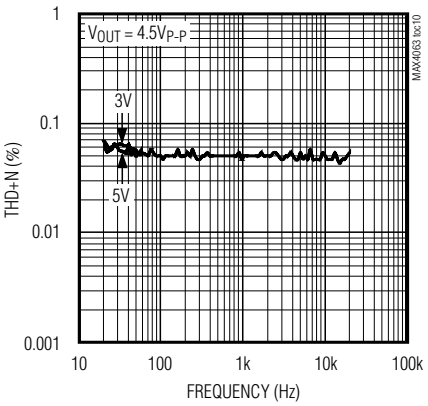
VOL vs. LOAD CURRENT



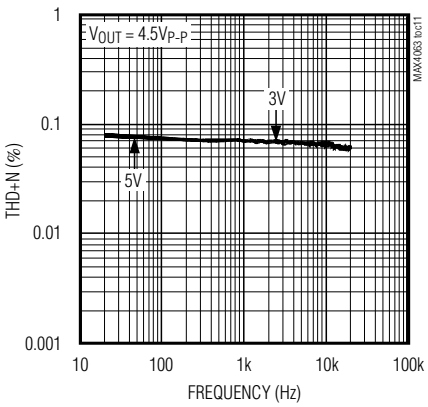
Typical Operating Characteristics (continued)

(V_{CC} = 3V, A_V = 20V/V, $R_L \geq 100k\Omega$ to 1.5V, $V_{\overline{SHDN}} = V_{CC}$, V_{OUT} is measured between OUT and $\overline{OUT}$. T_A = +25°C, unless otherwise noted.)

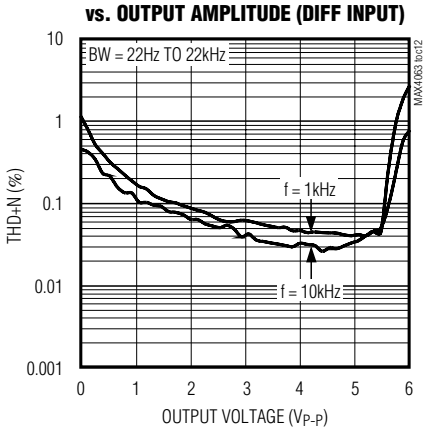
TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY (DIFF INPUT)



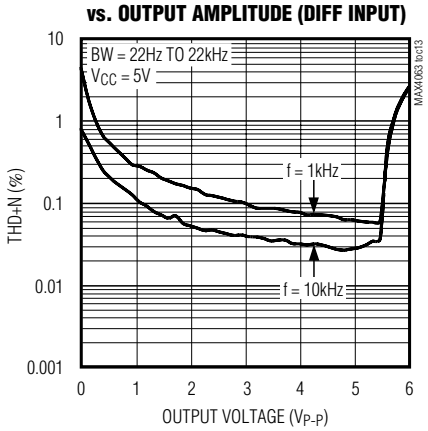
TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY (AUX INPUT)



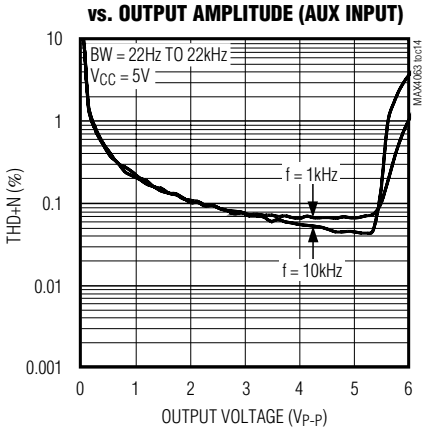
TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (DIFF INPUT)



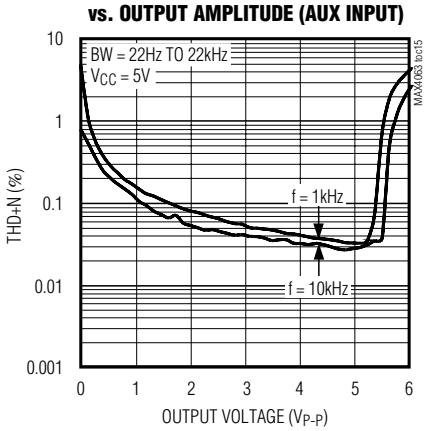
TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (DIFF INPUT)



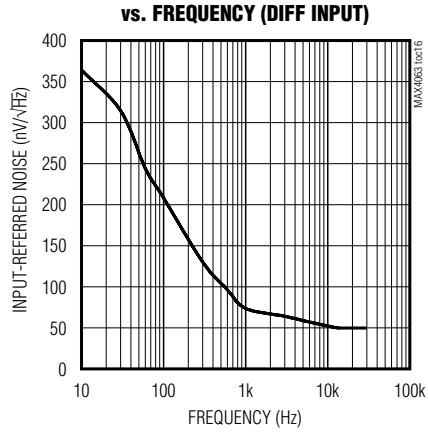
TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (AUX INPUT)



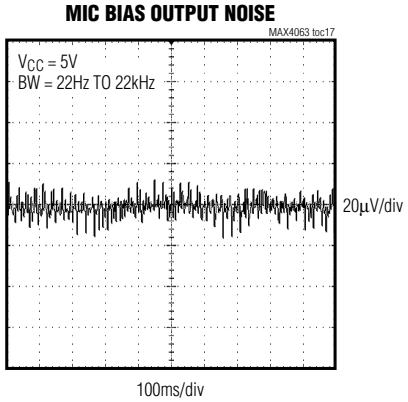
TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT AMPLITUDE (AUX INPUT)



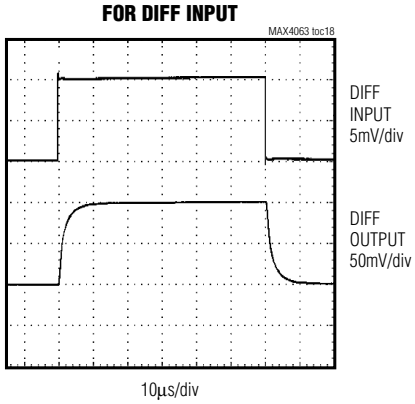
INPUT-REFERRED NOISE vs. FREQUENCY (DIFF INPUT)



MIC BIAS OUTPUT NOISE



SMALL-SIGNAL TRANSIENT RESPONSE FOR DIFF INPUT

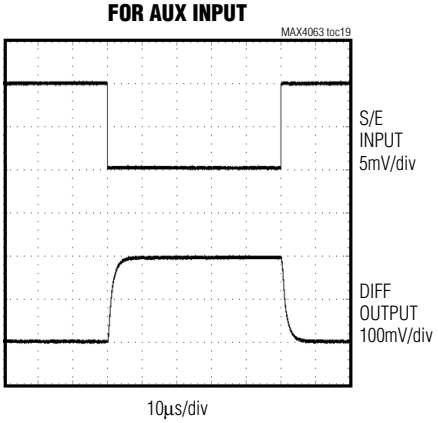


Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

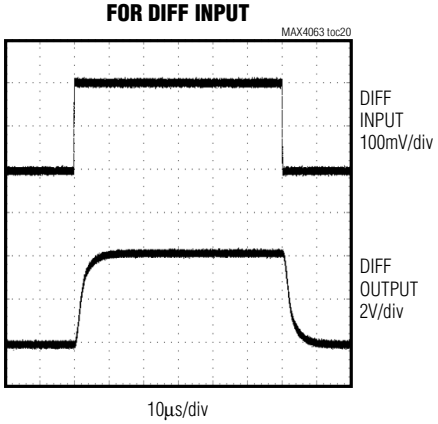
Typical Operating Characteristics (continued)

(V_{CC} = 3V, A_V = 20V/V, R_L ≥ 100kΩ to 1.5V, $V_{\overline{SHDN}}$ = V_{CC}, V_{OUT} is measured between OUT and $\overline{OUT}$. T_A = +25°C, unless otherwise noted.)

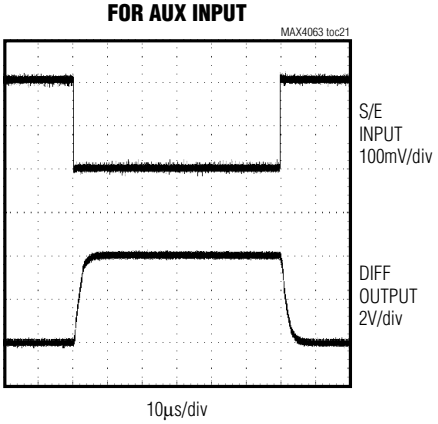
SMALL-SIGNAL TRANSIENT RESPONSE FOR AUX INPUT



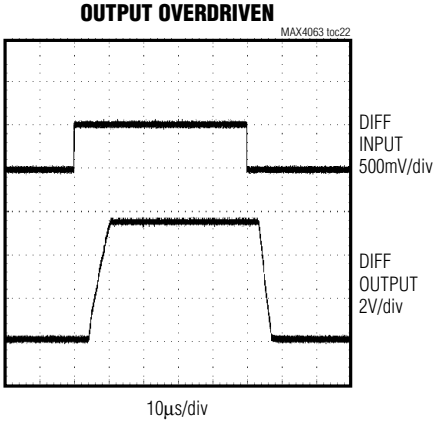
LARGE-SIGNAL TRANSIENT RESPONSE FOR DIFF INPUT



LARGE-SIGNAL TRANSIENT RESPONSE FOR AUX INPUT



OUTPUT OVERDRIVEN



Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Pin Description

PIN		NAME	FUNCTION
TSSOP	TQFN		
1	15	G2	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier (see *Adjustable Differential Gain-Setting* section).
2	16	$\overline{INT}$/AUX	Internal (Differential) or Auxiliary (Single-Ended) Input Select. Drive $\overline{INT}$/AUX low to select differential in or high to select auxiliary in.
3	1	$\overline{SHDN}$	Shutdown Input. Drive $\overline{SHDN}$ high for normal operation. Drive $\overline{SHDN}$ low for shutdown mode.
4	2	OUT	Amplifier Output. OUT is high impedance when in shutdown mode.
5	3	BIAS	External Electret Microphone Capsule Bias Output. Bypass BIAS with a 1µF capacitor to ground.
6	4	V_{CC}	Power Supply. Bypass the V_{CC} to GND with a 0.1µF capacitor.
7	5	ADJ	Adjustable Gain Select for AUX_IN (see *Auxiliary Input-Gain Adjustment* section). Connect a 10pF capacitor between OUT and ADJ.
8	7	$\overline{OUT}$	Complementary Amplifier Output. $\overline{OUT}$ is high impedance in shutdown mode.
9	9	IN+	Noninverting Differential Amplifier Input. AC-couple the audio signal into IN+.
10	10	IN-	Inverting Differential Amplifier Input. AC-couple the audio signal into IN-.
11	11	GND	Ground
12	12	AUX_IN	Single-Ended Input for Auxiliary Microphone. AC-couple the audio signal into AUX_IN.
13	6, 8, 14	N.C.	No Connection. Not internally connected.
14	13	G1	Gain-Selectable Input. Connect an external resistor between G1 and G2 to set the gain for the differential amplifier.
—	—	EP	Exposed Pad (TQFN Only). Internally connected to GND. Connect to a large ground plane to maximize thermal performance. Not intended as an electrical connection point.

Detailed Description

The MAX4063 is a differential microphone preamplifier providing high-quality amplification, optimized for use in computer and mobile applications. This device features adjustable gain, very high power-supply rejection (95dB), and common-mode rejection (79dB), making it ideal for low-noise applications. The MAX4063 provides a differential input stage, making the device particularly effective when layout constraints force the microphone amplifier to be physically remote from the ECM microphone.

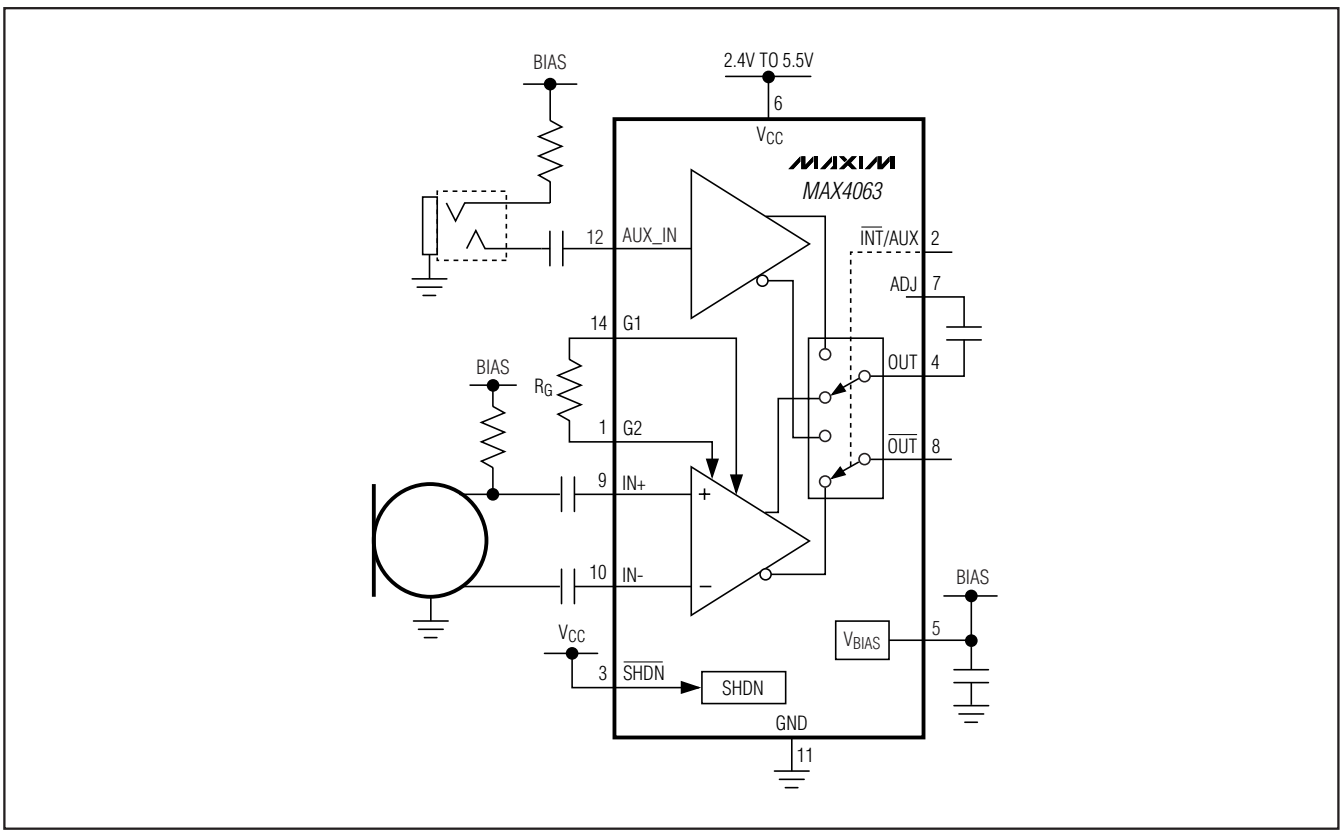
The MAX4063 is capable of switching its output between the differential input and an inverting single-ended input. $\overline{INT}$/AUX selects either the differential input or single-ended auxiliary input. In addition, the MAX4063 has an integrated microphone bias source, simplifying system design and eliminating the need for external components. The MAX4063 has a complementary output allowing CODECs and other devices with differential inputs to be optimally driven (see *Functional Diagram*). The MAX4063 includes a 0.3µA shutdown mode for ultimate power savings. The differential gain of the MAX4063 is set with a single resistor connected between the G1 and G2 pins. The MAX4063 has an internal default gain of 20V/V on the AUX_IN input. The AUX_IN gain can be increased with a single external resistor (see the *Differential-Gain Adjustment and Auxiliary Input-Gain Adjustment* sections).

Differential Input

The main microphone amplifier 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-

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Functional Diagram



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.
- The microphone and preamplifier may be placed physically further apart, easing PC board layout restrictions.

Differential-Gain Adjustment

The MAX4063 allows the user to alter the differential 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:

$$R_G = \frac{200k\Omega}{A_{VD} - 2}$$

where A_V is the required voltage gain.

Hence, an 11.11kΩ resistor yields a gain of 20V/V, or 26dB. Leaving the pins unconnected results in a gain of 2V/V. Gain is defined as:

For differential out:

$$A_{VD} = \frac{V_{OUT} - V_{OUT}}{V_{IN+} - V_{IN-}}$$

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

The MAX4063 provides an option to increase the AUX_IN (see Figure 3). To increase the gain, connect resistor R_{ADJ} between the ADJ and AUX_IN pins. R_{ADJ} is calculated from the following formula:

$$R_{ADJ} = \frac{2M\Omega}{AV_{AUX} - 20} \text{ (to increase the gain)}$$

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

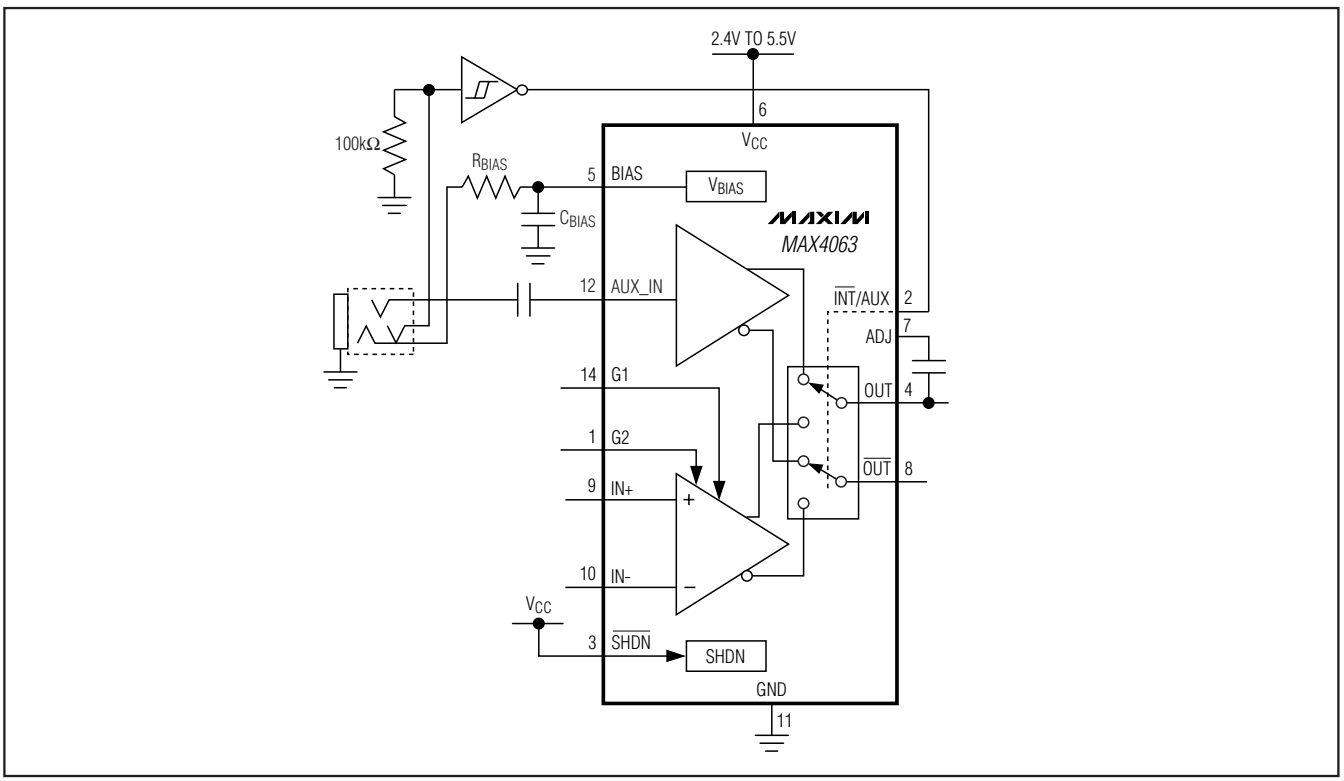


Figure 1. MAX4063 with Auxiliary Input Configuration

where:

$$AV_{AUX} = \frac{V_{OUT} - \overline{V_{OUT}}}{V_{AUX\_IN}}$$

R_{ADJ} is placed between AUX_IN and ADJ.

Input Capacitors

The two differential microphone inputs and the single-ended auxiliary input of the MAX4063 have on-chip bias components, allowing the user to AC-couple any signals into the input. The input resistance is 100kΩ (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 is 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:

$$CMRR(dB) = A_{DM} / A_{CM}$$

where A_{DM} is the differential gain, A_{CM} is the common-mode gain.

Input voltages should be sufficiently small such that the output is not clipped in either differential or common-

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

mode application. The topology used in the 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

On the MAX4063 thin QFN package, connect the exposed paddle (backside of PRS) to the ground plane. The MAX4063 has an integrated low-noise, low-output impedance bias voltage. An optimum electret bias resistor can be set externally. This gives a low-noise, flexible solution that can run from 2.4V to 5.5V, which is suitable for hand-held devices such as PDAs that typically have audio power supplies in the 3V region (Figure 2).

Output

DC Bias

In shutdown mode, the bias voltage is disabled. OUT and OUT have a low-noise, DC-bias voltage independent of the power supplies, resulting in superior PSRR performance. The MAX4063 outputs are high impedance when the part is in shutdown mode.

Differential Output

The MAX4063 features a differential output stage (OUT and 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 (Figure 4).

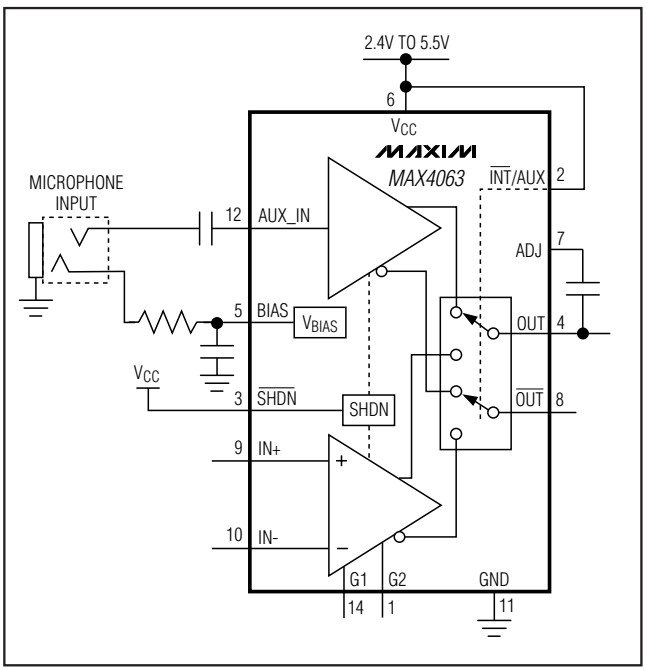


Figure 2. MAX4063 Used for Biasing a Microphone

Applications Information

Shutdown Mode

The MAX4063 features a low-power, complete shutdown mode. When SHDN goes low, the supply current 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 unconnected.

Power Supplies and Layout

The MAX4063 operates 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 MAX4063 should be connected to the analog ground.

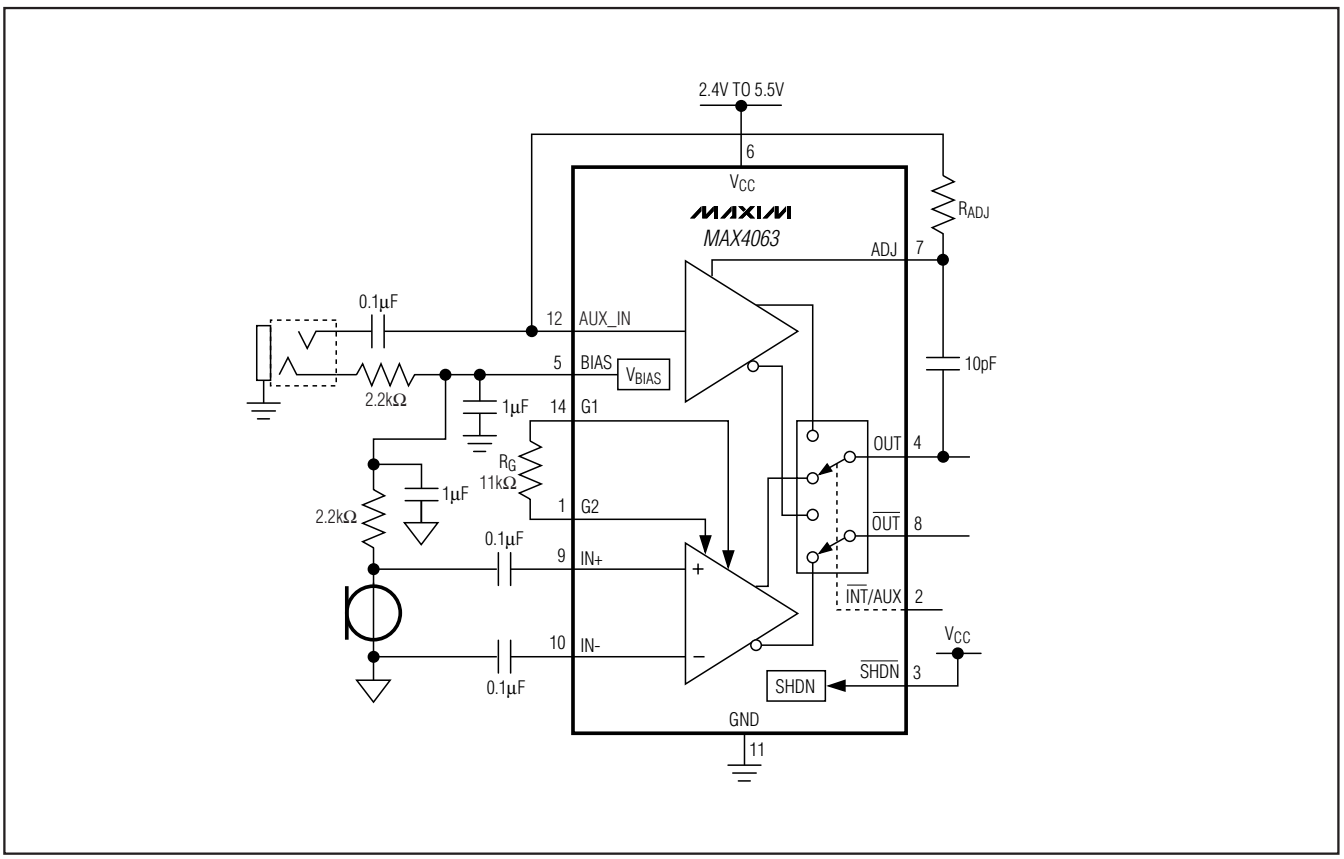


Figure 3. MAX4063 Used to Bias a Microphone Connected to the Auxiliary Input and the Differential Input

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

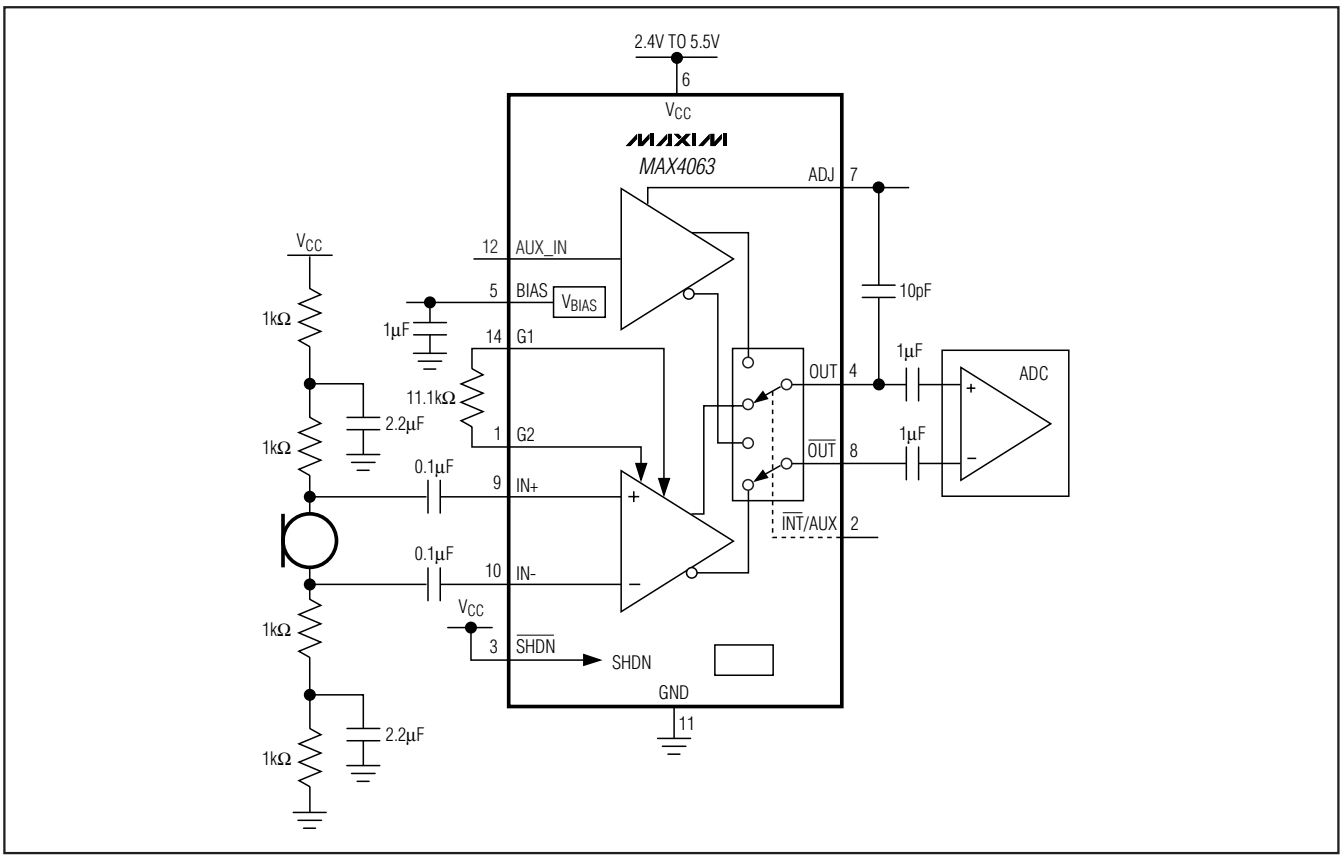
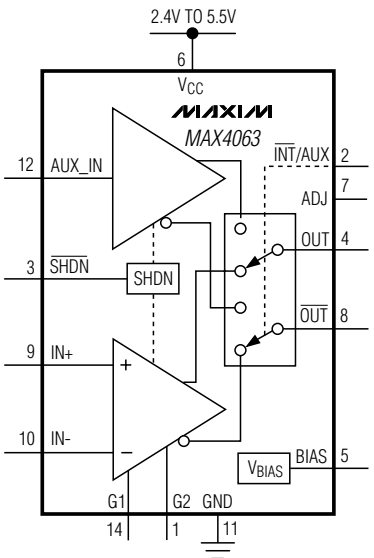


Figure 4. Using the MAX4063 with Differential Input/Differential Output Configuration

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Simplified Block Diagram



Chip Information

PROCESS: BiCMOS

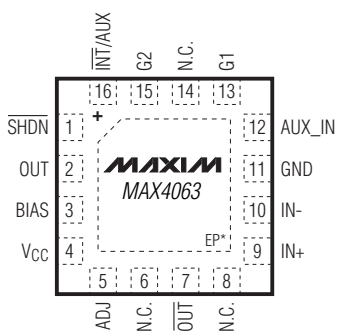
Package Information

For the latest package outline information and land patterns (footprints), go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
14 SSOP	U14+1	21-0066	90-0113
16 TQFN	T1644+4	21-0139	90-0070

Pin Configurations (continued)

TOP VIEW



TQFN

*CONNECT EP TO GND.

Differential Microphone Preamplifier with Internal Bias and Complete Shutdown

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	1/03	Initial release	—
1	6/11	Added EP information to *Pin Description*, updated power dissipation ratings, updated *Ordering Information* and *Pin Configuration* for lead-free parts	1, 2, 7, 13