



Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

General Description

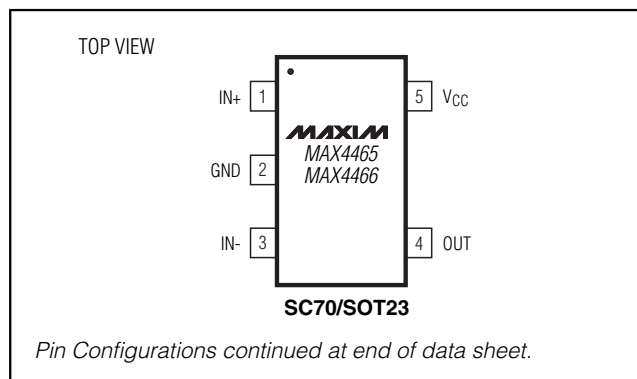
The MAX4465–MAX4469 are micropower op amps optimized for use as microphone preamplifiers. They provide the ideal combination of an optimized gain bandwidth product vs. supply current, and low-voltage operation in an ultra-small package. The MAX4465/MAX4467/MAX4469 are unity-gain stable and deliver a 200kHz gain bandwidth from only 20 μ A of supply current. The MAX4466/MAX4468 are decompensated for a minimum stable gain of +5V/V and provide a 500kHz gain bandwidth product. In addition these amplifiers feature Rail-to-Rail® outputs, plus excellent power-supply rejection and common-mode rejection ratios for operation in noisy environments.

The MAX4467/MAX4468 include a complete shutdown mode. In shutdown, the amplifiers' supply current is reduced to 10nA and the bias current to the external microphone is cut off for ultimate power savings. The single MAX4465/MAX4466 are offered in the ultra-small SC70-5 package, while the single with shutdown MAX4467/MAX4468 and dual MAX4469 are available in the space-saving SOT23-8 package.

Applications

Microphone Preamplifiers
Hearing Aids
Cellular Phones
Voice-Recognition Systems
Digital Dictation Devices
Headsets
Portable Computing

Pin Configurations



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

Features

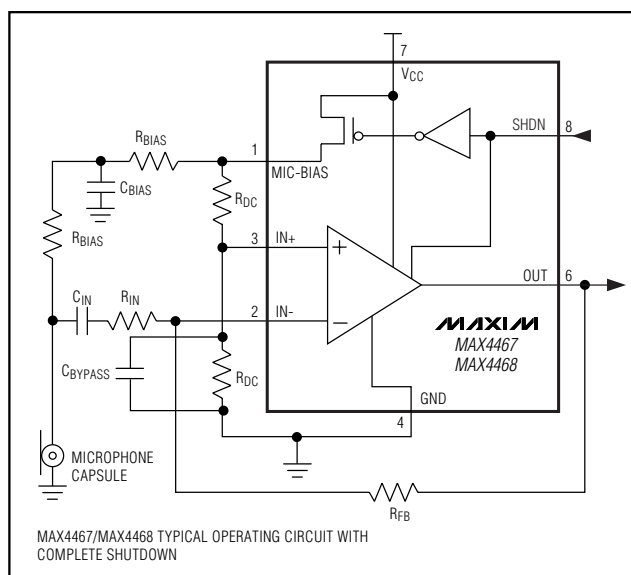
- ◆ +2.4V to +5.5V Supply Voltage Operation
- ◆ Version with 10nA Shutdown Available (MAX4467/MAX4468)
- ◆ Excellent Power-Supply Rejection Ratio: 112dB
- ◆ Excellent Common-Mode Rejection Ratio: 80dB
- ◆ Rail-to-Rail Outputs
- ◆ Gain Bandwidth Product:
200kHz (MAX4465/MAX4467/MAX4469)
500kHz (MAX4466/MAX4468)
- ◆ Low 20 μ A Quiescent Supply Current
- ◆ Available in Space-Saving Packages
5-Pin SC70 (MAX4465/MAX4466)
8-Pin SOT23 (MAX4467/MAX4468/MAX4469)

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4465EXK-T	-40°C to +85°C	5 SC70-5
MAX4465EUK-T	-40°C to +85°C	5 SOT23-5
MAX4466EXK-T	-40°C to +85°C	5 SC70-5
MAX4466EUK-T	-40°C to +85°C	5 SOT23-5

Ordering Information continued at end of data sheet.

Typical Operating Circuit



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ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to GND).....+6V
 All Other Pins to GND.....-0.3V to ($V_{CC} + 0.3V$)
 Output Short-Circuit Duration
 OUT Shorted to GND or V_{CC}Continuous
 Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)
 5-Pin SC70 (derate 2.5mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)200mW
 5-Pin SOT23 (derate 7.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)571mW

8-Pin SOT23 (derate 5.3mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)421mW
 8-Pin SO (derate 5.88mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)471mW
 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+150 $^\circ\text{C}$
 Lead Temperature (soldering, 10s)+300 $^\circ\text{C}$

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

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = \infty$ to $V_{CC}/2$, SHDN = GND (MAX4467/MAX4468 only). $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values specified at $T_A = +25^\circ\text{C}$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Inferred from PSRR test	2.4		5.5	V
Supply Current (per Amplifier)	I_{CC}	$T_A = +25^\circ\text{C}$		20	48	μA
		$T_A = T_{MIN}$ to T_{MAX}			60	
Supply Current in Shutdown	I_{SHDN}	SHDN = V_{CC} (Note 2)		10	1000	nA
Input Offset Voltage	V_{OS}				± 5	mV
Input Bias Current	I_B	$V_{CM} = -0.1V$		10	± 100	nA
Input Offset Current Range	I_{OS}	$V_{CM} = -0.1V$		1	± 10	nA
Input Common-Mode	V_{CM}	Inferred from CMRR test	-0.1		$V_{CC} - 1$	V
Common-Mode Rejection	CMRR	$-0.1V \leq V_{CM} \leq V_{CC} - 1V$	80	126		dB
Power-Supply Rejection	PSRR	$2.4V \leq V_{CC} \leq 5.5V$	80	112		dB
		MAX4465/MAX4467/MAX4469, $f = 3.4\text{kHz}$		75		
		MAX4466/MAX4468, $f = 3.4\text{kHz}$		80		
Open-Loop Gain	A_{VOL}	$R_L = 100k\Omega$ to $V_{CC}/2$, $0.05V \leq V_{OUT} \leq V_{CC} - 0.05V$	110	125		dB
		$R_L = 10k\Omega$ to $V_{CC}/2$, $0.1V \leq V_{OUT} \leq V_{CC} - 0.1V$	80	95		
Output Voltage Swing High	V_{OH}	$ V_{CC} - V_{OH} $	$R_L = 100k\Omega$	10		mV
				20	50	
Output Voltage Swing Low	V_{OL}		$R_L = 100k\Omega$	10		mV
			$R_L = 10k\Omega$	20	50	
Output Short-Circuit Current		To either supply rail		15		mA
Output Leakage Current in Shutdown		SHDN = V_{CC} , $0 \leq V_{OUT} \leq V_{CC}$ (Notes 2, 3)		1	100	nA
SHDN Logic Low	V_{IL}	(Note 2)		$V_{CC} \times 0.3$		V
SHDN Logic High	V_{IH}	(Note 2)	$V_{CC} \times 0.7$			V
SHDN Input Current		(Note 2)		± 1		μA
Gain Bandwidth Product	GBWP	MAX4465/MAX4467/MAX4469		200		kHz
		MAX4466/MAX4468		500		
Phase Margin	ϕ_M	$R_L = 100k\Omega$		70		Degrees

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = \infty$ to $V_{CC}/2$, $SHDN = GND$ (MAX4467/MAX4468 only). $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values specified at $T_A = +25^\circ C$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Gain Margin		$R_L = 100k\Omega$			20		dB
Slew Rate	SR	Output step = 4V	MAX4465/MAX4467/ MAX4469, $A_V = +1$		45		mV/ μs
			MAX4466/MAX4468, $A_V = +5$		300		
Input Noise Voltage Density	e_n	$f = 1kHz$			80		nV/ $\sqrt{Hz}$
Total Harmonic Distortion	THD	$f = 1kHz$, $R_L = 10k\Omega$, $V_{OUT} = 2V_{p-p}$	MAX4465/MAX4467/ MAX4469		0.02		%
			MAX4466/MAX4468		0.03		
Capacitive Load Stability	C_{LOAD}	MAX4465/MAX4467/MAX4469, $A_V = +1$			100		pF
		MAX4466/MAX4468, $A_V = +5$			100		
SHDN Delay Time	t_{SHDN}	(Note 2)			1		μs
Enable Delay Time	t_{EN}	(Note 2)			50		μs
Power-On Time	t_{ON}	(Note 2)			40		μs
Bias Switch On-Resistance	R_S	$I_S = 5mA$ (Note 2)			25	40	Ω

Note 1: All specifications are 100% tested at $T_A = +25^\circ C$. All temperature limits are guaranteed by design.

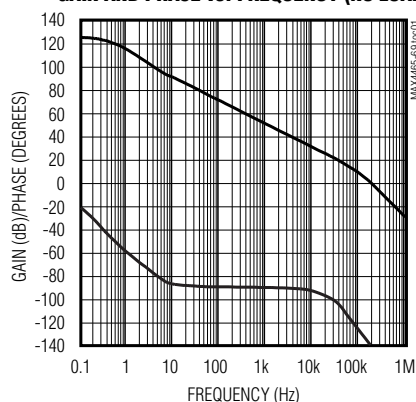
Note 2: Shutdown mode is available only on the MAX4467/MAX4468.

Note 3: External feedback networks not considered.

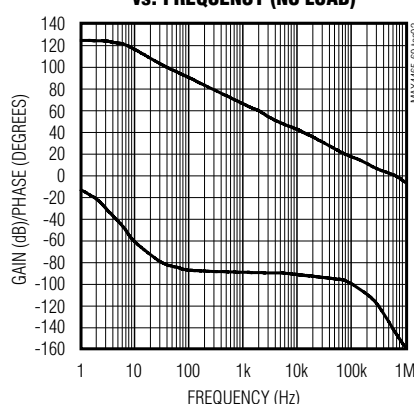
Typical Operating Characteristics

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = 100k\Omega$ to $V_{CC}/2$, $SHDN = GND$ (MAX4467/MAX4468 only). $T_A = +25^\circ C$, unless otherwise noted.)

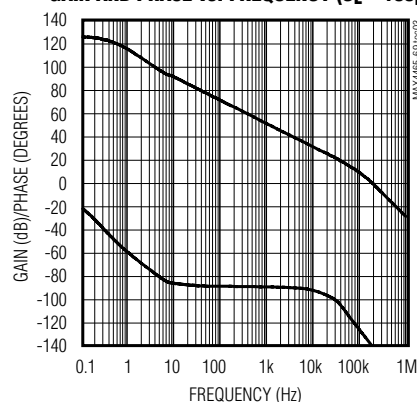
**MAX4465/MAX4467/MAX4469
GAIN AND PHASE vs. FREQUENCY (NO LOAD)**



**MAX4466/MAX4468 GAIN AND PHASE
vs. FREQUENCY (NO LOAD)**



**MAX4465/MAX4467/MAX4469
GAIN AND PHASE vs. FREQUENCY ($C_L = 100pF$)**

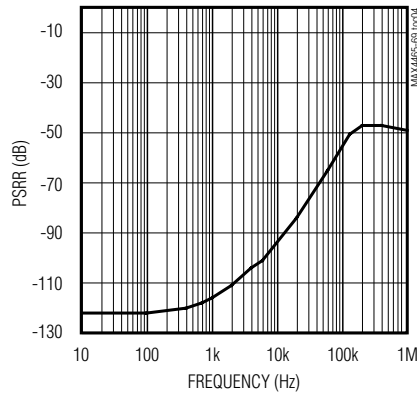


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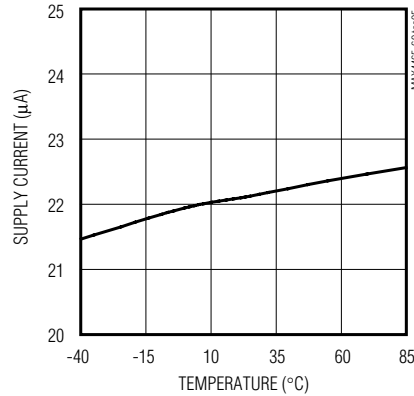
Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = 100k\Omega$ to $V_{CC}/2$, SHDN = GND (MAX4467/MAX4468 only). $T_A = +25^\circ C$, unless otherwise noted.)

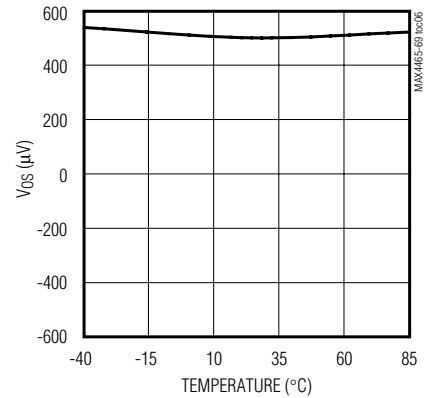
**POWER-SUPPLY REJECTION RATIO
vs. FREQUENCY**



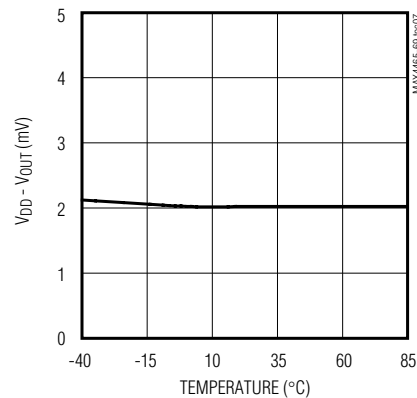
SUPPLY CURRENT vs. TEMPERATURE



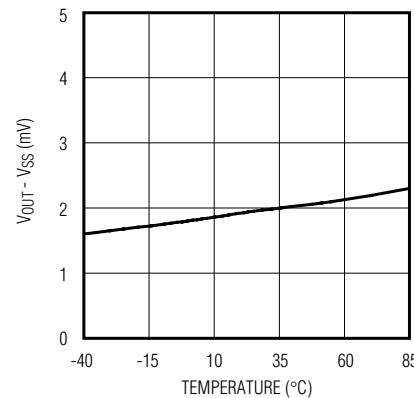
**INPUT OFFSET VOLTAGE
vs. TEMPERATURE**



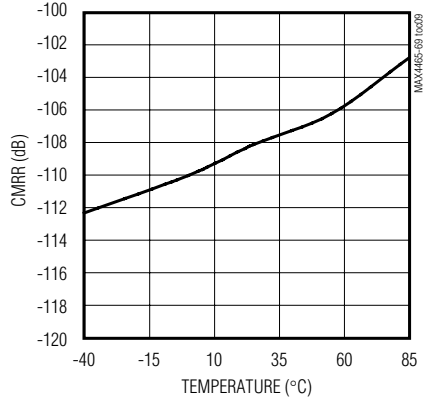
**OUTPUT VOLTAGE SWING HIGH
vs. TEMPERATURE**



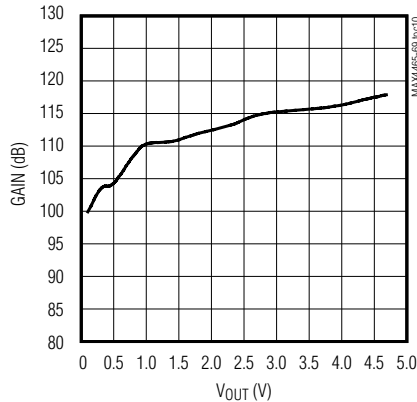
**OUTPUT VOLTAGE SWING LOW
vs. TEMPERATURE**



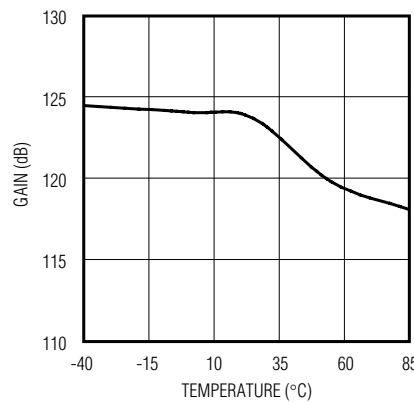
**COMMON-MODE REJECTION RATIO
vs. TEMPERATURE**



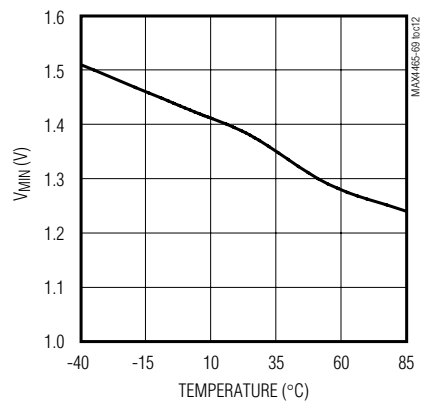
**LARGE-SIGNAL GAIN
vs. OUTPUT VOLTAGE**



**LARGE-SIGNAL GAIN
vs. TEMPERATURE**



**MINIMUM OPERATING VOLTAGE
vs. TEMPERATURE**

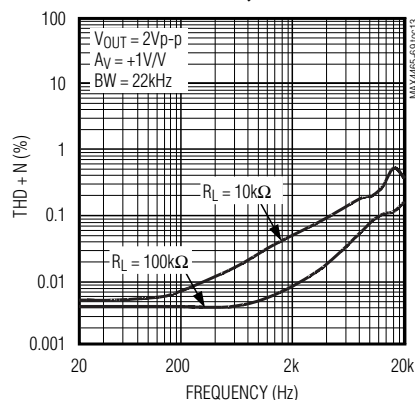


Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

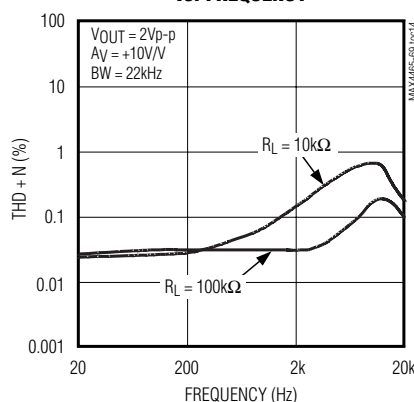
Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = 100k\Omega$ to $V_{CC}/2$, SHDN = GND (MAX4467/MAX4468 only). $T_A = +25^\circ C$, unless otherwise noted.)

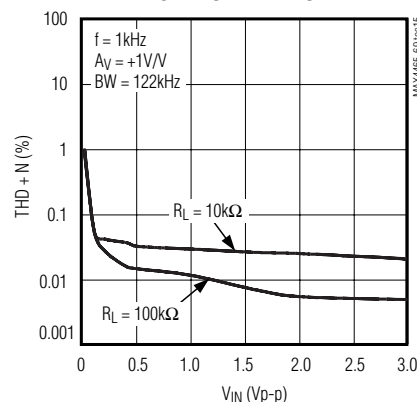
MAX4465/MAX4467/MAX4469
TOTAL HARMONIC DISTORTION PLUS NOISE
vs. FREQUENCY



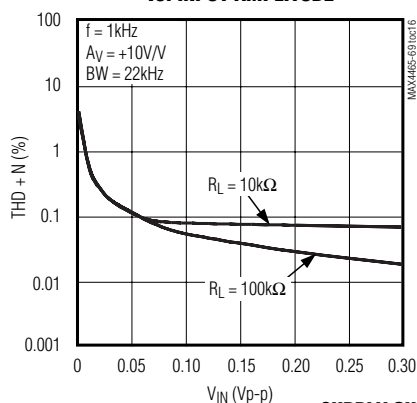
MAX4466/MAX4468
TOTAL HARMONIC DISTORTION
vs. FREQUENCY



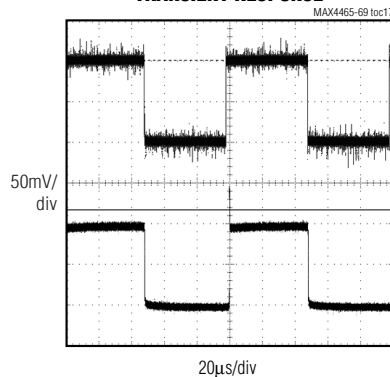
MAX4465/MAX4467/MAX4469
TOTAL HARMONIC DISTORTION PLUS NOISE
vs. INPUT AMPLITUDE



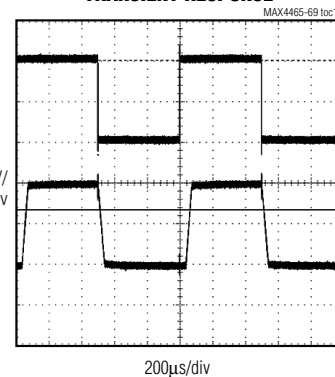
MAX4466/MAX4468
TOTAL HARMONIC DISTORTION PLUS NOISE
vs. INPUT AMPLITUDE



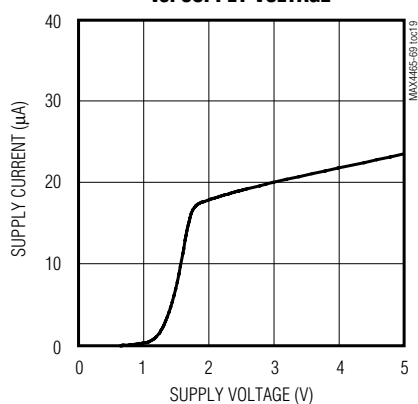
NONINVERTING SMALL-SIGNAL
TRANSIENT RESPONSE



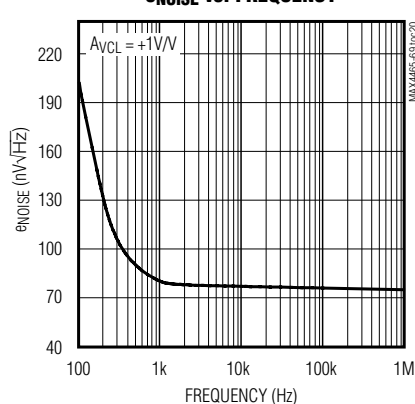
NONINVERTING LARGE-SIGNAL
TRANSIENT RESPONSE



SUPPLY CURRENT
vs. SUPPLY VOLTAGE



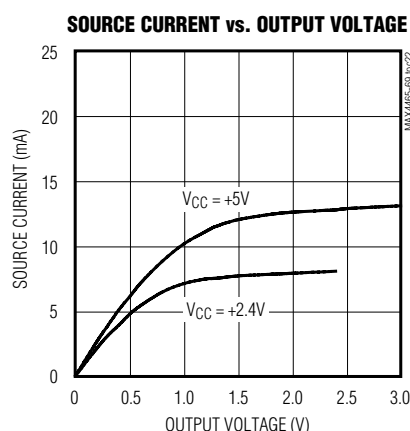
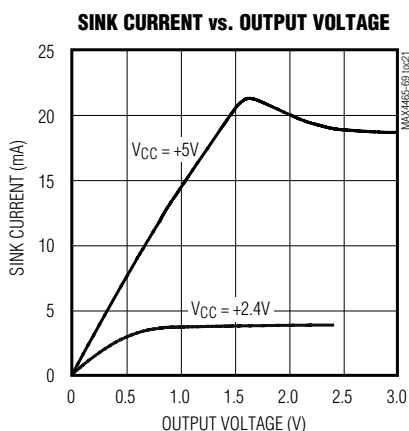
eNOISE vs. FREQUENCY



Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Typical Operating Characteristics (continued)

($V_{CC} = +5V$, $V_{CM} = 0$, $V_{OUT} = V_{CC}/2$, $R_L = 100k\Omega$ to $V_{CC}/2$, $SHDN = GND$ (MAX4467/MAX4468 only). $T_A = +25^\circ C$, unless otherwise noted.)



Pin Description

PIN			NAME	FUNCTION
MAX4465 MAX4466	MAX4467 MAX4468	MAX4469		
4	6 (8)	—	OUT	Amplifier Output
—	—	1	OUTA	Amplifier Output A
—	1 (4)	—	MIC_BIAS	External Microphone Bias Network Switch Output
3	2 (3)	—	IN-	Inverting Amplifier Input
1	3 (2)	—	IN+	Noninverting Amplifier Input
2	4 (1)	4	GND	Ground
5	7 (7)	8	V_{CC}	Positive Supply. Connect a 0.1 μF capacitor to GND.
—	—	2	INA-	Inverting Amplifier Input A
—	—	3	INA+	Noninverting Amplifier Input A
—	—	6	INB-	Inverting Amplifier Input B
—	—	5	INB+	Noninverting Amplifier Input B
—	—	7	OUTB	Amplifier Output B
—	8 (6)	—	SHDN	Active-Low Shutdown Input. Connect to GND for normal operation. Connect to V_{CC} for shutdown. Do not leave floating.
—	5 (5)	—	N.C.	No Connection. Not internally connected.

() denotes SOT23 package of the MAX4467/MAX4468.

Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Detailed Description

The MAX4465–MAX4469 are low-power, micropower op amps designed to be used as microphone preamplifiers. These preamplifiers are an excellent choice for noisy environments because of their high common-mode rejection and excellent power-supply rejection ratios. They operate from a single +2.4V to +5.5V supply.

The MAX4465/MAX4467/MAX4469 are unity-gain stable and deliver a 200kHz gain bandwidth from only 20 μ A of supply current. The MAX4466/MAX4468 have a minimum stable gain of +5V/V while providing a 500kHz gain bandwidth product.

The MAX4467/MAX4468 feature a complete shutdown, which is active-high, and a shutdown-controlled output providing bias to the microphone. The MAX4465/MAX4467/MAX4469 feature a slew rate suited to voice channel applications. The MAX4466/MAX4468 can be used for full-range audio, e.g., PC99 inputs.

Rail-to-Rail Output Stage

The MAX4465–MAX4469 can drive a 10k Ω load and still typically swing within 20mV of the supply rails. Figure 1 shows the output voltage swing of the MAX4465 configured with $A_v = +10$.

Switched Bias Supply

When used as a microphone amplifier for an electret microphone, some form of DC bias for the microphone is necessary. The MAX4467/MAX4468 have the ability to turn off the bias to the microphone when the device is in shutdown. This can save several hundred microamps of supply current, which can be significant in low-power applications. The MIC_BIAS pin provides a switched version of V_{CC} to the bias components. Figure 3 shows some typical values.

Driving Capacitive Loads

Driving a capacitive load can cause instability in many op amps, especially those with low quiescent current. The MAX4465/MAX4467/MAX4469 are unity-gain stable for a range of capacitive loads up to 100pF. Figure 4 shows the response of the MAX4465 with an excessive capacitive load.

Applications Information

Shutdown Mode

The MAX4467 and MAX4468 feature a low-power, complete shutdown mode. When SHDN goes high, the supply current drops to 10nA, the output enters a high-impedance state and the bias current to the microphone is switched off. Pull SHDN low to enable

the amplifier. Do not leave SHDN floating. Figure 5 shows the shutdown waveform.

Common-Mode Rejection Ratio

A microphone preamplifier ideally only amplifies the signal present on its input and converts it to a voltage appearing at the output. When used in noninverting mode, there is a small output voltage fluctuation when both inputs experience the same voltage change in the common mode. The ratio of these voltages is called the common-mode gain. The common-mode rejection ratio is the logarithm of differential-mode gain to common-mode gain. The high CMRR properties of the MAX4465–MAX4469 provide outstanding performances when configured as a noninverting microphone preamplifier.

Power-Up

The MAX4465–MAX4469 outputs typically settle within 1 μ s after power-up. Figure 6 shows the output voltage on power-up.

Power Supplies and Layout

The MAX4465–MAX4469 operate from a single +2.4V to +5.5V power supply. Bypass the power supply with a 1 μ F capacitor to ground. Good layout techniques are necessary for the MAX4465–MAX4469 family. To decrease stray capacitance, minimize trace lengths by placing external components close to the op amp's pins. Surface-mount components are recommended. In systems where analog and digital grounds are available, the MAX4465–MAX4469 should be connected to the analog ground.

An oscilloscope trace of a periodic signal. The vertical scale is 1V/div, and the horizontal scale is 100µs/div. The signal is a periodic waveform with a period of approximately 100µs. The waveform has a peak-to-peak amplitude of approximately 1.5V. The signal is centered around a 0V level.

The diagram shows a MAX4466 microphone amplifier circuit. An electret capsule is connected to a voltage divider consisting of two 2kΩ resistors connected to a +5V supply. The output of the divider is connected to the non-inverting input (IN+) of the MAX4466. A 0.1μF capacitor is connected between the divider and the IN+ input. A 0.01μF capacitor is connected between the IN+ input and the inverting input (IN-). The IN- input is also connected to a 10kΩ resistor and a 1μF capacitor, both connected to ground. The MAX4466 is powered by a +5V supply (VCC) and ground (GND). A feedback network consisting of a 100kΩ resistor and a 100pF capacitor is connected between the output (OUT) and the IN- input. The output is labeled OUT.

MAXIM

Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Test Circuits/Timing Diagrams (continued)

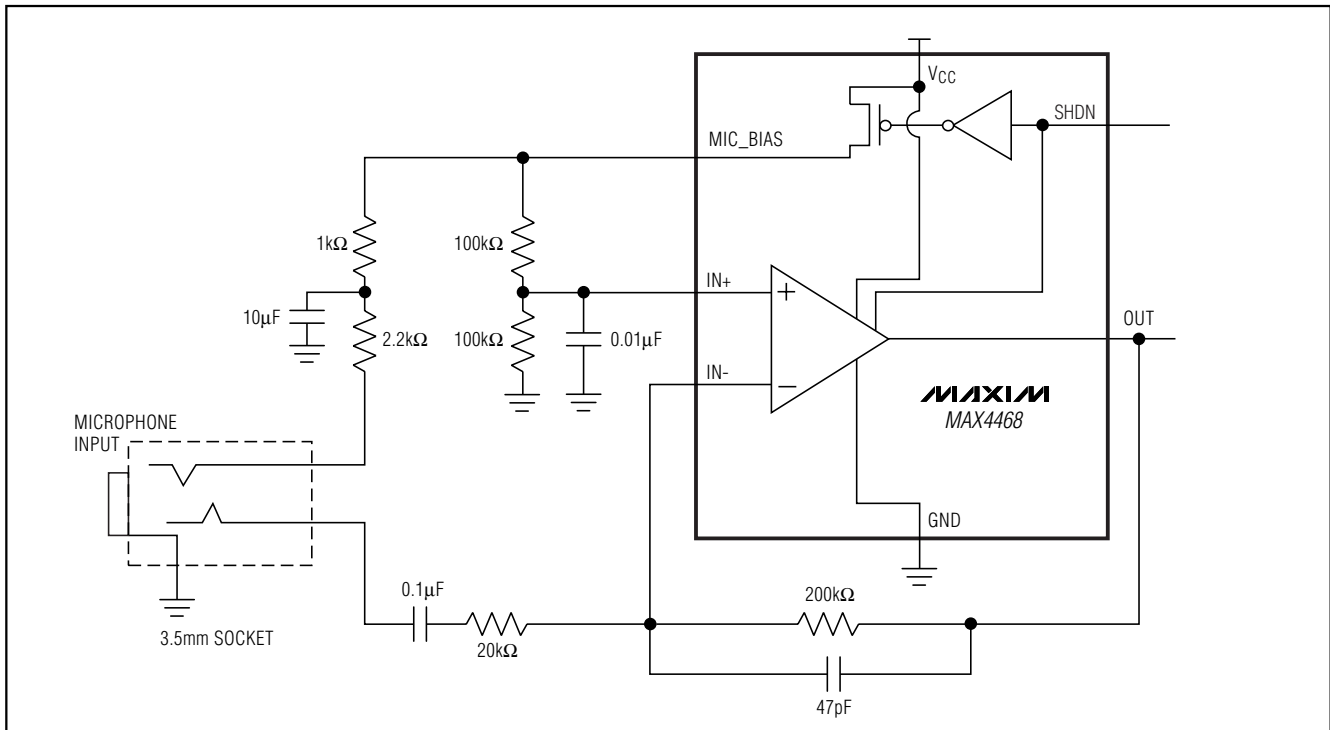


Figure 3. Bias Network Circuit

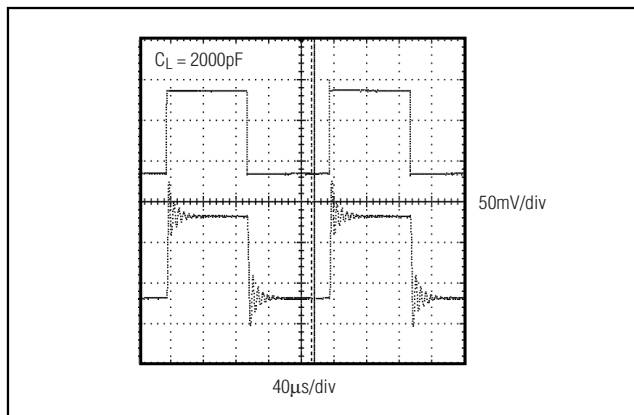


Figure 4. Small-Signal Transient Response with Excessive Capacitive Load

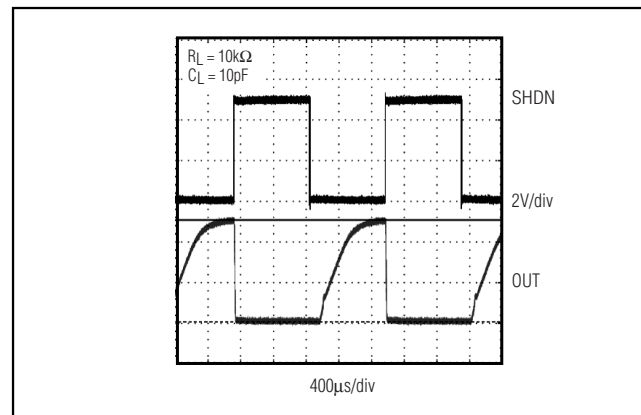


Figure 5. MAX4467/MAX4468 Shutdown Waveform

Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Test Circuits/Timing Diagrams (continued)

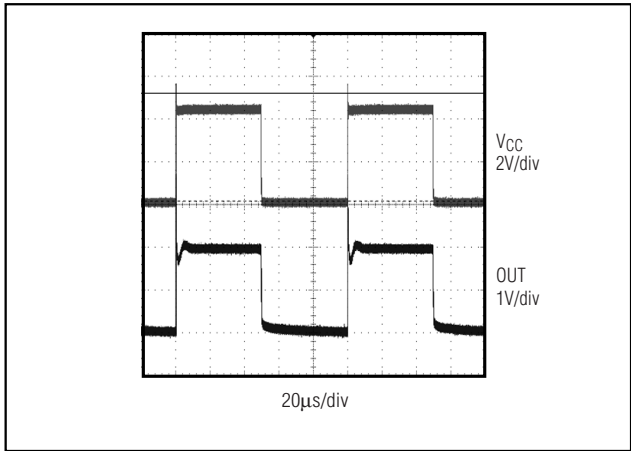


Figure 6. Power-Up/Power-Down Waveform

Chip Information

MAX4465/MAX4466 TRANSISTOR COUNT: 62
 MAX4467/MAX4468 TRANSISTOR COUNT: 72
 MAX4469 TRANSISTOR COUNT: 113
 PROCESS: BiCMOS

Ordering Information (continued)

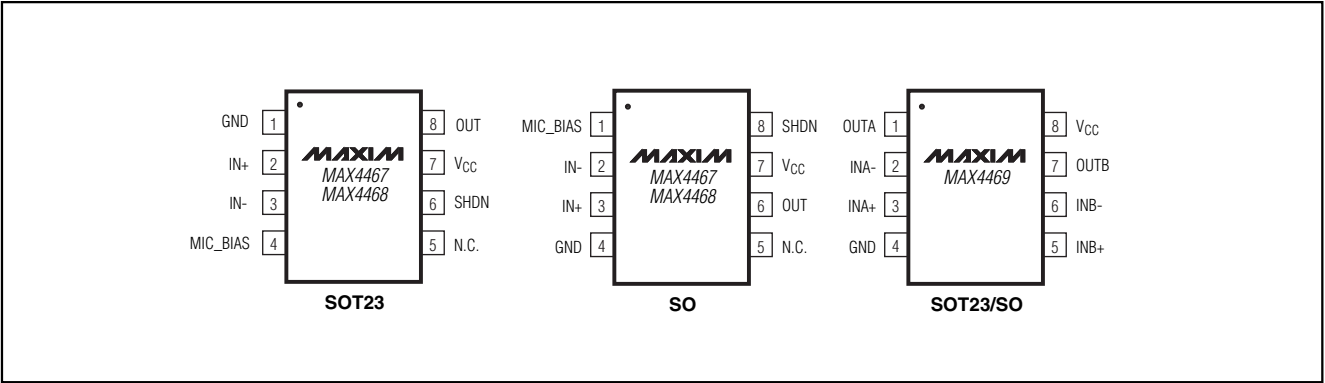
PART	TEMP. RANGE	PIN-PACKAGE
MAX4467EKA-T*	-40°C to +85°C	8 SOT23-8
MAX4467ESA-T*	-40°C to +85°C	8 SO
MAX4468EKA-T*	-40°C to +85°C	8 SOT23-8
MAX4468ESA-T*	-40°C to +85°C	8 SO
MAX4469EKA-T*	-40°C to +85°C	8 SOT23-8
MAX4469ESA-T*	-40°C to +85°C	8 SO

*Future product—contact factory for availability.

Selector Guide

PART	MINIMUM STABLE GAIN	EXTERNAL MICROPHONE SHDN	GBWP (kHz)	PIN-PACKAGE
MAX4465	+1	No	200	5-SC70/5-SOT23
MAX4466	+5	No	500	5-SC70/5-SOT23
MAX4467	+1	Yes	200	8-SOT23/8-SO
MAX4468	+5	Yes	500	8-SOT23/8-SO
MAX4469	+1	No	200	8-SOT23/8-SO

Pin Configurations (continued)

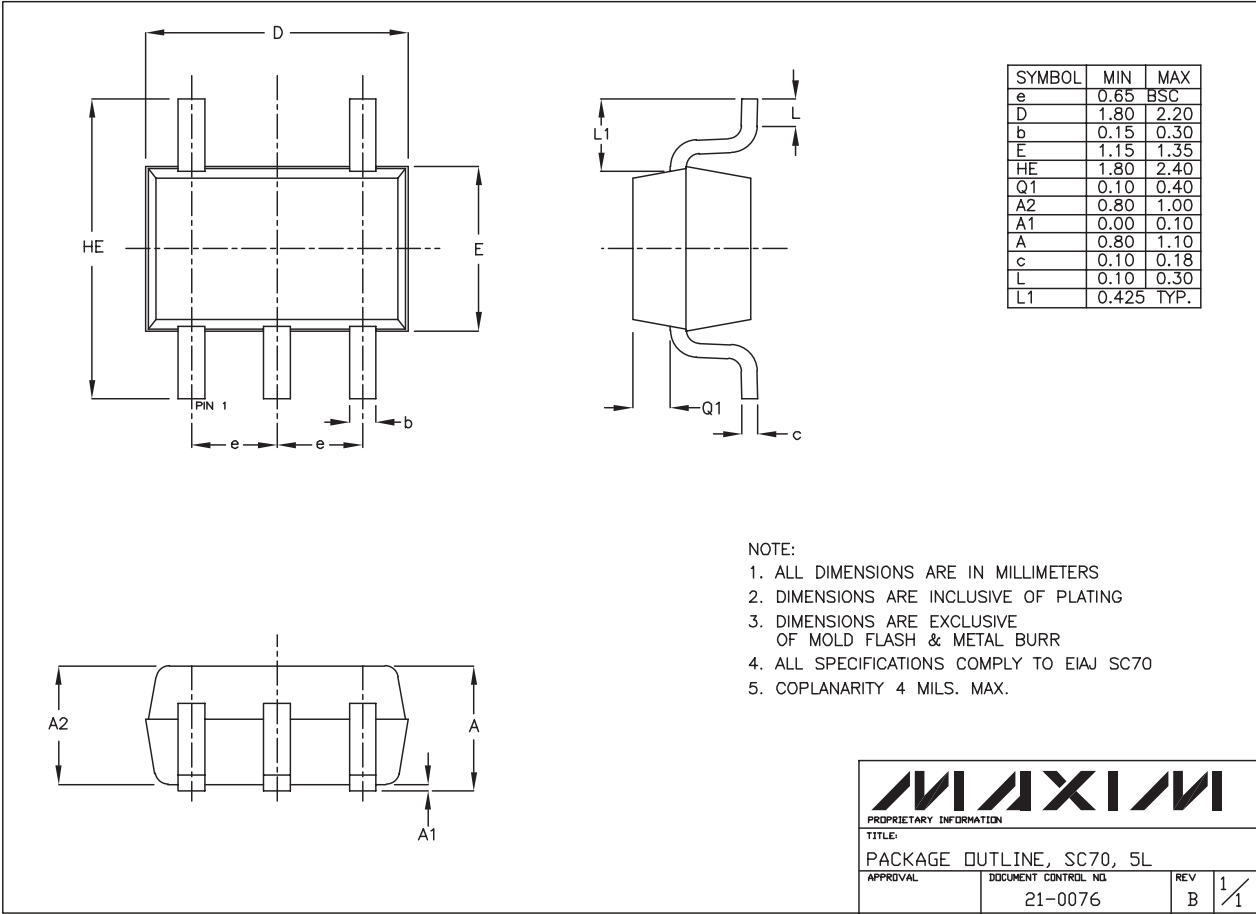


Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Package Information

MAX4465-MAX4469

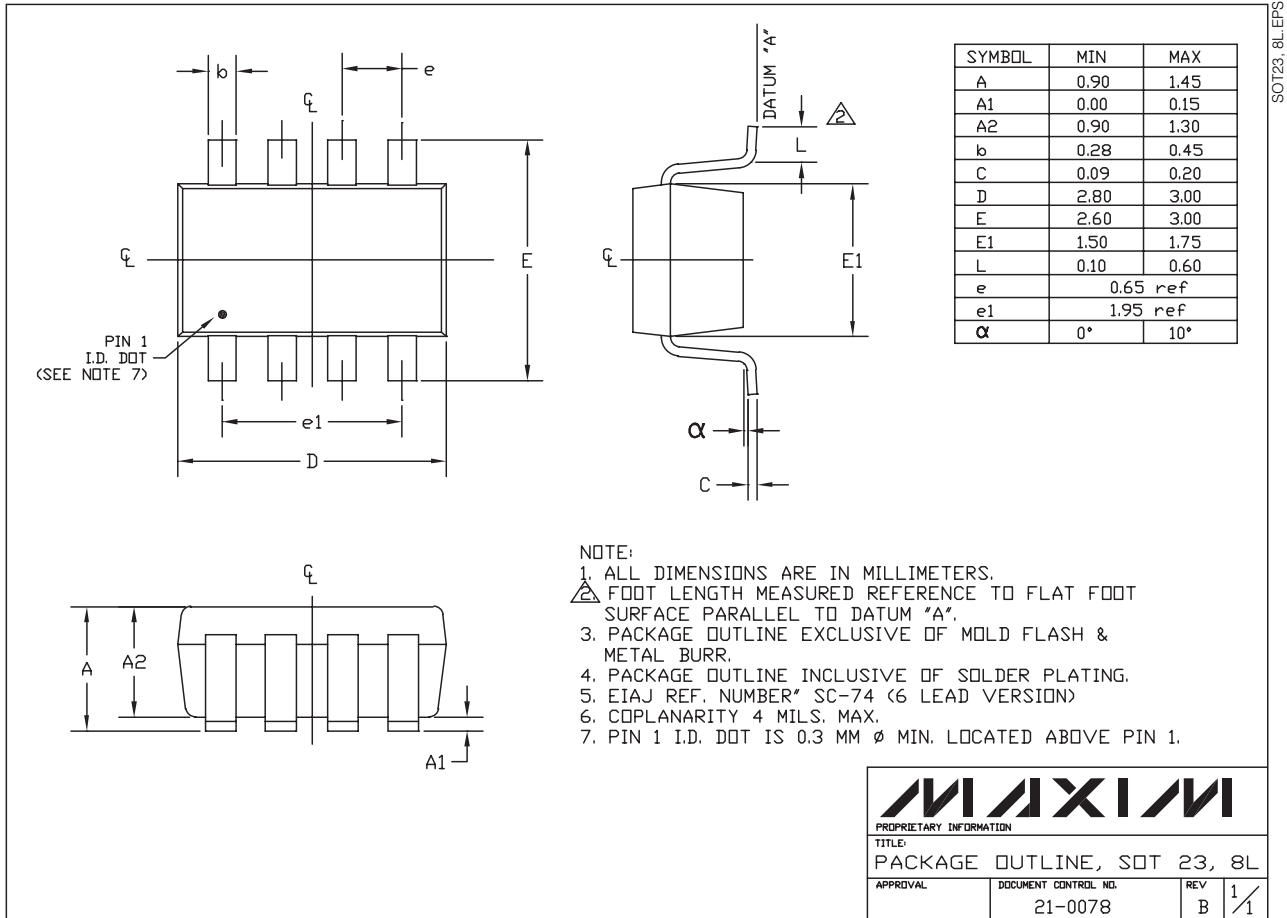
SC70, 5L EPS



Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Package Information (continued)

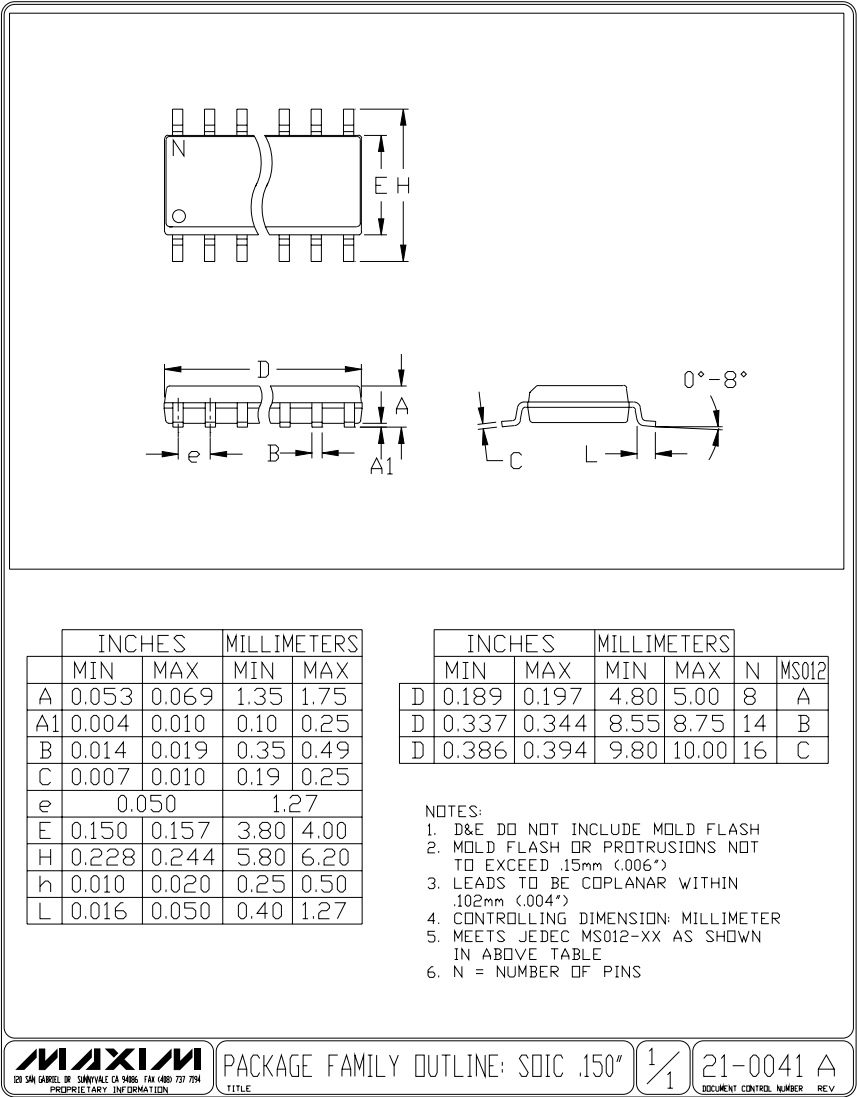
MAX4465-MAX4469



SOT23-8L EPS

Low-Cost, Micropower, SC70/SOT23-8, Microphone Preamplifiers with Complete Shutdown

Package Information (continued)



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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