19-2387; Rev 3; 11/05

1.4W and 1W, Ultra-Small, Audio Power Amplifiers with Shutdown

General Description

The MAX4364/MAX4365 are bridged audio power amplifiers intended for portable audio devices with internal speakers. The MAX4364 is capable of delivering 1.4W from a single 5V supply and 500mW from a single 3V supply into an 8Ω load. The MAX4365 is capable of delivering 1W from a single 5V supply and 450mW from a single 3V supply into an 8Ω load. The MAX4364/MAX4365 feature 0.04% THD+N at 1kHz, 68dB PSRR at 217Hz, and only 10nA of supply current in shutdown mode.

The MAX4364/MAX4365 bridged outputs eliminate the need for output-coupling capacitors, minimizing external component count. The MAX4364/MAX4365 also include internal DC bias generation, clickless operation, short-circuit and thermal-overload protection. Both devices are unity-gain stable, with the gain set by two external resistors.

The MAX4364 is available in a small 8-pin SO package. The MAX4365 is available in tiny 8-pin TDFN (3mm × 3mm × 0.8mm) and µMAX® packages.

Applications

Cellular Phones

PDAs

Two-Way Radios

General-Purpose Audio

Features

- **1.4W into 8Ω Load (MAX4364)**
- **1W into 8Ω Load (MAX4365)**
- **0.04% THD+N at 1kHz**
- **68dB PSRR at 217Hz**
- **2.7V to 5.5V Single-Supply Operation**
- **5mA Supply Current**
- **Low-Power, 10nA Shutdown Mode**
- **Pin Compatible with the LM4861/LM4862/LM4864 (MAX4364)**
- **Clickless Power-Up and Shutdown**
- **Thermal-Overload and Short-Circuit Protection**
- **Available in TDFN, µMAX, and SO Packages**

Ordering Information

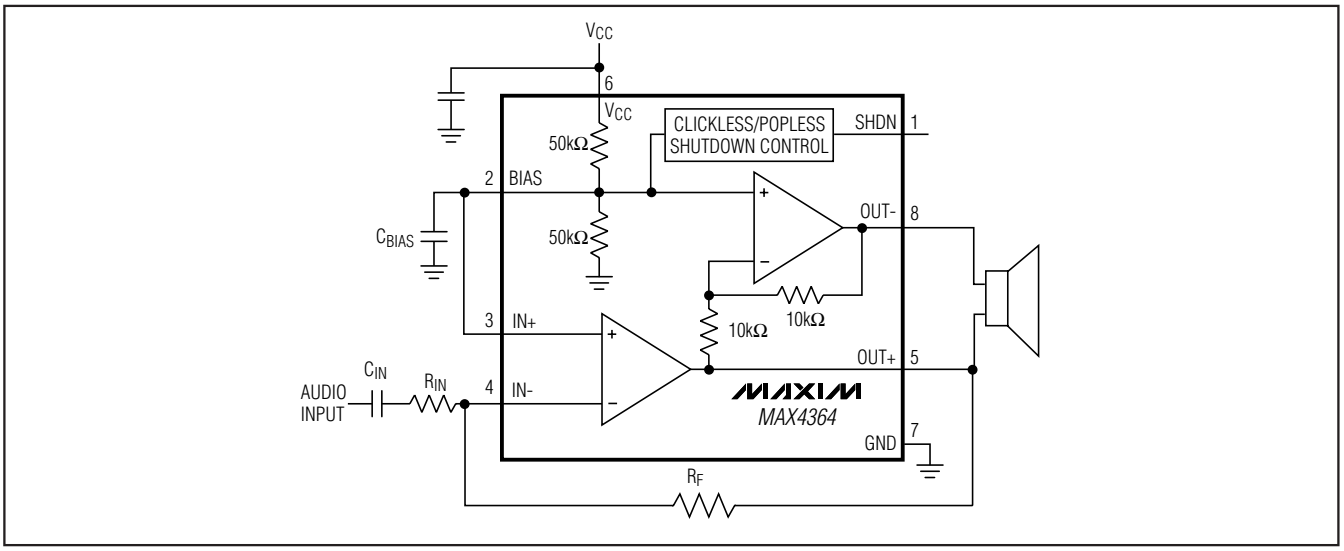
PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4364ESA	-40°C to +85°C	8 SO	—
MAX4365EUA	-40°C to +85°C	8 µMAX	—
MAX4365ETA	-40°C to +85°C	8 TDFN-EP*	ACD

**EP = Exposed paddle.*

Pin Configurations appear at end of data sheet.

µMAX is a registered trademark of Maxim Integrated Products, Inc.

Typical Application Circuit/Functional Diagram



1.4W and 1W, Ultra-Small, Audio Power Amplifiers with Shutdown

ABSOLUTE MAXIMUM RATINGS

V_{CC}, OUT_ to GND .....-0.3V to +6V
IN+, IN-, BIAS, SHDN to GND .....-0.3V to (V_{CC} + 0.3V)
Output Short Circuit (OUT+ to OUT-) (Note 1) .....Continuous
Continuous Power Dissipation (T_A = +70°C)
8-Pin µMAX (derate 4.1mW/°C above +70°C) 330mW
8-Pin TDFN (derate 24.4mW/°C above +70°C) 1951mW
8-Pin SO (derate 5.88mW/°C above +70°C) 471mW

Junction Temperature .....+150°C
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

Note 1: Continuous power dissipation must also be observed.

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—5V

(V_{CC} = 5V, R_L = ∞, C_{BIAS} = 1µF to GND, SHDN = GND, T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Inferred from PSRR test		2.7		5.5	V
Supply Current	I_{CC}	(Note 3)	MAX4364		7	13	mA
			MAX4364, T_A = T_{MIN} to T_{MAX}			17	
			MAX4365		5	8	
			MAX4365, T_A = T_{MIN} to T_{MAX}			11	
Shutdown Supply Current	I_{SHDN}	SHDN = V_{CC}			0.01	4	µA
SHDN Threshold		V_{IH}	T_A = +25°C	V_{CC} x 0.7			V
			T_A = -40°C to +85°C (Note 7)	V_{CC} x 0.7			
		V_{IL}	T_A = +25°C			V_{CC} x 0.3	
			T_A = -40°C to +85°C (Note 7)			V_{CC} x 0.3	
Common-Mode Bias Voltage	V_{BIAS}	(Note 4)		V_{CC}/2 - 5%	V_{CC}/2	V_{CC}/2 + 5%	V
Output Offset Voltage	V_{OS}	IN- = OUT+, IN+ = BIAS (Note 5)			±1	±10	mV
Power-Supply Rejection Ratio	PSRR	V_{CC} = 2.7V to 5.5V	DC	55	75		dB
		V_{RIPPLE} = 200mV_{P-P}, R_L = 8Ω	217Hz		68		
			1kHz		58		
Output Power	P_{OUT}	R_L = 8Ω, THD+N = 1%, f_{IN} = 1kHz (Note 6)	MAX4364	1200	1400		mW
			MAX4365	800	1000		
Total Harmonic Distortion Plus Noise	THD+N	A_V = -2V/V, R_L = 8Ω, f_{IN} = 1kHz (Notes 7, 8)	MAX4364, P_{OUT} = 1W		0.04		%
			MAX4365, P_{OUT} = 750mW		0.1		
Noise		f_{IN} = 10kHz, BW = 22Hz to 22kHz			12		$µV_{RMS}$
Short-Circuit Current	I_{SC}	OUT+ to OUT- (Note 9)			600		mA
Thermal Shutdown Threshold					160		°C

ELECTRICAL CHARACTERISTICS—5V (continued)

(V_{CC} = 5V, R_L = ∞, C_{BIAS} = 1µF to GND, SHDN = GND, T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Thermal Shutdown Hysteresis				15		°C
Power-Up Time	t_{PU}	T_A = +25°C		50		ms
		C_{BIAS} = 0.22µF, T_A = -40°C to +85°C (Note 7)		14	35	
Shutdown Time	t_{SHDN}			10		µs
Enable Time from Shutdown	t_{ENABLE}	T_A = +25°C		50		ms
		C_{BIAS} = 0.22µF, T_A = -40°C to +85°C (Note 7)		12	35	

ELECTRICAL CHARACTERISTICS—3V

(V_{CC} = 3V, R_L = ∞, C_{BIAS} = 1µF to GND, SHDN = GND, T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Current	I_{CC}	(Note 3)	MAX4364		6		mA
			MAX4365		4.5		
Shutdown Supply Current	I_{SHDN}	SHDN = V_{CC}			10		nA
Output Power	P_{OUT}	R_L = 8Ω, THD + N = 1%, f_{IN} = 1kHz (Note 6)	MAX4364	400	500		mW
			MAX4365	350	450		
Total Harmonic Distortion Plus Noise	THD + N	A_V = -2V/V, R_L = 8Ω, f_{IN} = 1kHz (Notes 7, 8)	MAX4364, P_{OUT} = 400mW		0.05		%
			MAX4365, P_{OUT} = 400mW		0.08		

Note 2: All specifications are 100% tested at T_A = +25°C.

Note 3: Quiescent power-supply current is specified and tested with no load on the outputs. Quiescent power-supply current depends on the offset voltage when a practical load is connected to the amplifier.

Note 4: Common-mode bias voltage is the voltage on BIAS and is nominally $V_{CC}/2$.

Note 5: Maximum differential-output offset voltage is tested in a unity-gain configuration. $V_{OS} = V_{OUT+} - V_{OUT-}$.

Note 6: Output power is specified by a combination of a functional output-current test, and characterization analysis.

Note 7: Guaranteed by design, not production tested.

Note 8: Measurement bandwidth for THD+N is 22Hz to 22kHz.

Note 9: Extended short-circuit conditions result in a pulsed output.

Detailed Description

The MAX4364/MAX4365 bridged audio power amplifiers can deliver 1.4W into 8Ω (MAX4364) or 1W into 8Ω (MAX4365) while operating from a single 5V supply. These devices consist of two high-output-current op amps configured as a bridge-tied load (BTL) amplifier (see *Typical Application Circuit/Functional Diagram*). The gain of the device is set by the closed-loop gain of the input op amp. The output of the first amplifier serves as the input to the second amplifier, which is configured as an inverting unity-gain follower in both devices. This results in two outputs, identical in magnitude, but 180° out of phase.

BIAS

The MAX4364/MAX4365 feature an internally generated common-mode bias voltage of $V_{CC}/2$ referenced to GND. BIAS provides both click-and-pop suppression and the DC bias level for the audio signal. BIAS is internally connected to the noninverting input of one amplifier, and should be connected to the noninverting input of the other amplifier for proper signal biasing (see *Typical Application Circuit/Functional Diagram*). Choose the value of the bypass capacitor as described in the *BIAS Capacitor* section.

Shutdown

The MAX4364/MAX4365 feature a 10nA, low-power shutdown mode that reduces quiescent current consumption. Pulling SHDN high disables the device's bias circuitry, the amplifier outputs go high impedance, and BIAS is driven to GND. Connect SHDN to GND for normal operation.

Current Limit

The MAX4364/MAX4365 feature a current limit that protects the device during output short circuit and overload conditions. When both amplifier outputs are shorted to either V_{CC} or GND, the short-circuit protection is enabled and the amplifier enters a pulsing mode, reducing the average output current to a safe level. The amplifier remains in this mode until the overload or short-circuit condition is removed.

Applications Information

Bridge-Tied Load

The MAX4364/MAX4365 are designed to drive a load differentially in a BTL configuration. The BTL configuration (Figure 1) offers advantages over the single-ended configuration, where one side of the load is connected to ground. Driving the load differentially doubles the output voltage compared to a single-ended amplifier under similar conditions. Thus, the differential gain of

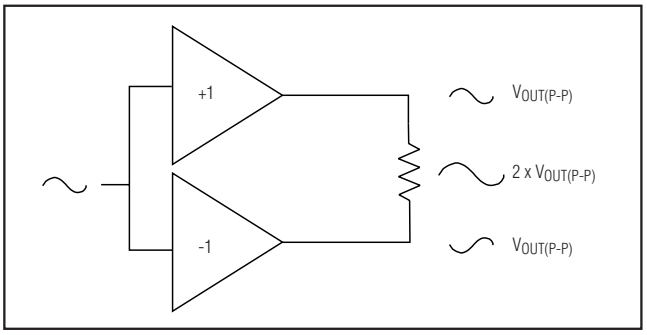


Figure 1. Bridge-Tied Load Configuration

the device is twice the closed-loop gain of the input amplifier. The effective gain is given by:

$$A_{VD} = 2 \times \frac{R_F}{R_{IN}}$$

Substituting $2 \times V_{OUT(P-P)}$ into the following equations yields four times the output power due to doubling of the output voltage.

$$V_{RMS} = \frac{V_{OUT(P-P)}}{2\sqrt{2}}$$

$$P_{OUT} = \frac{V_{RMS}^2}{R_L}$$

Since the differential outputs are biased at midsupply, there is no net DC voltage across the load. This eliminates the need for DC-blocking capacitors required for single-ended amplifiers. These capacitors can be large, expensive, consume board space, and degrade low-frequency performance.

Power Dissipation

Under normal operating conditions, the MAX4364/MAX4365 can dissipate a significant amount of power. The maximum power dissipation for each package is given in the *Absolute Maximum Ratings* section under Continuous Power Dissipation or can be calculated by the following equation:

$$P_{DISSPKG(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

where $T_{J(MAX)}$ is +150°C, T_A is the ambient temperature and θ_{JA} is the reciprocal of the derating factor in °C/W as specified in the *Absolute Maximum Ratings* section. For example, θ_{JA} of the µMAX package is 222°C/W.

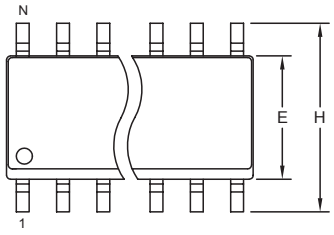
Package Information

SOICN .EPS

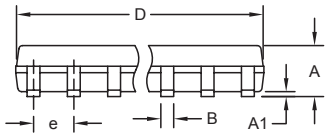
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

VARIATIONS:

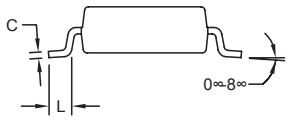
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



TOP VIEW



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0041	B	1/1