19-4478; Rev 0; 10/09

MAXIM

Active Noise-Cancelling Solution for Stereo Headsets

General Description

The MAX9895A is a complete audio subsystem for active noise-cancelling (ANC) stereo headsets. The device features three stages for each right and left channel. A microphone preamplifier, an analog sound processing block, and a headphone amplifier combine to create a simple and very flexible active noise-canceling system.

The MAX9895A features a feed-forward architecture, where outside microphones sense the ambient noise and on-board analog sound processing generates the compensation signal needed for noise reduction. This further supports the mechanical isolation of the headset by attenuating sound that leaks through the mechanics of the headphone.

The microphone preamplifiers feature programmable gain, allowing alignment of the microphone and driver tolerances and left-right channel matching. The headphone amplifiers are output capacitorless and can deliver 33mW into a 16Ω transducer.

The MAX9895A has three modes of operation: ANC on, PTL, and ANC off. The ANC-on mode demonstrates the noise-canceling performance of the device. PTL (push-to-listen) mode sends the microphone signals directly to the headphones to temporarily listen to the surroundings. ANC off disables noise-canceling, but allows use of the headphone amplifiers during music playback.

The MAX9895A is available in a space-saving WLP or TQFN package and is specified over the -40°C to +85°C extended temperature range.

Applications

Noise-Cancelling Headphones/Headsets

Headsets for Mobile Communication

Mobile Phones

Portable Gaming Devices

E-Books

Features

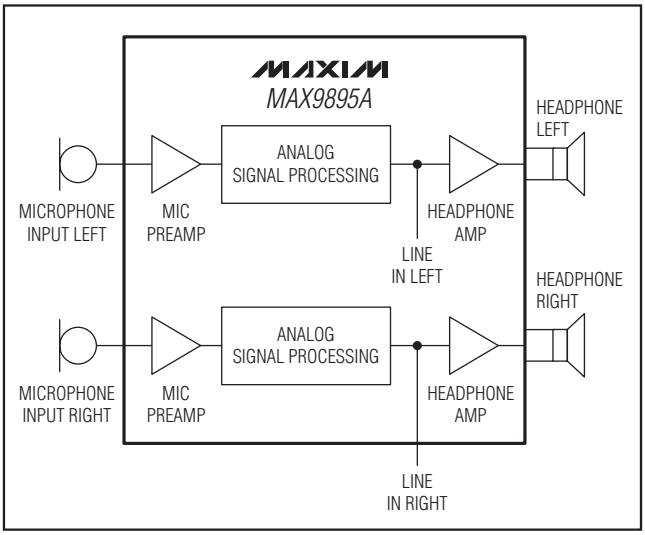
- **2.7V to 4.5V Operation**
- **Low Headphone Amplifier Noise**
- **Low-Noise Microphone Preamplifiers with 2.2V Bias**
- **Stereo 33mW into 16Ω Capacitorless Headphone Amplifiers**
- **Microphone Output Path Available for Speech Transmission**
- **Adjustable Microphone Gain by I²C Interface or External Resistors**
- **Low External Component Count**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	GAIN (V/V)
MAX9895AEWX+	-40°C to +85°C	36 WLP	1
MAX9895AETL+	-40°C to +85°C	40 TQFN-EP*	1

+Denotes a lead(Pb)-free/RoHS-compliant package.
**EP = Exposed pad.*

Simplified Block Diagram



Pin Configurations appear at end of data sheet.

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ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND .....-0.3V to +6V
PVDD to PGND .....-0.3V to +6V
PVDD to V_{DD} .....-0.1V to +0.1V
CPVDD to PVDD .....Internally shorted
PGND to GND .....-0.1V to +0.1V
SDA, SCL .....-0.3V to +6V
LINEIN_ .....-0.3V to +6V
Any Other Pin .....-0.3V to (V_{DD} + 0.3V)
Duration of Short Circuit Between HPOUT_ and GND .....Continuous
Duration of Short Circuit Between MICBIAS and V_{DD}, GND .....Continuous
Duration of Short Circuit Between V_{MID} and V_{DD}, GND .....Continuous
Continuous Current into HPOUT_ 200mA
Continuous Input Current (all other pins) .....±20mA
Continuous Power Dissipation (T_A = +70°C)
36-Bump, 0.4mm-Pitch WLP Single-Layer Board (derate 17mW/°C above +70°C) 1360mW
Maximum Current per Bump (10k hrs at +120°C) 1.7A
TQFN Package (derate 22mW/°C above +70°C) 1777mW
ESD Protection, Human Body Model .....±2kV
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°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_{DD} = V_{PVDD} = V_{CPVDD} = 3.3V, R_L = ∞, C_{VDD} = 10µF connected between V_{DD} and PGND, C_{BIAS} = 1µF connected between V_{BIAS} and GND, C_{FLY} = 1µF connected between C1P and C1N. C_{HOLD} = 1µF connected between V_{MID} and PGND, $R_{PREIN\_}$ = 10kΩ, $R_{PREFB\_}$ = 50kΩ, $R_{MICBIAS}$ = 3.3kΩ, MIC signal gain in ANC mode ANC_GAIN = -11.5dB, MIC signal gain in PTL mode PTL_GAIN = -5.5dB, V_{GAIN} = +1V/V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
GENERAL						
Supply Voltage Range	V_{DD}	Inferred by PSRR test	2.7	3.3	4.5	V
	PVDD					
	CPVDD					
Quiescent Supply Current	I_{DD}	ANC = on		3.4	4.6	mA
		ANC = off, PTL = off		2.5	3.4	
		PTL = on		3.4	4.6	
Shutdown Supply Current	I_{SHDN}	I^2C mode, T_A = +25°C			12	µA
Internal Reference	V_{BIAS}	Voltage on V_{BIAS}	1.25	1.3	1.35	V
Startup Time	t_{ON}	Input from LINEIN_		37		ms
		Input from MICIN_		390		
Undervoltage Lockout	UVLO	Falling threshold	2.27		2.65	V
HEADPHONE OUTPUTS						
Line Input Resistance	R_{IN}	MAX9895A	7	10	14	kΩ
Output Offset Voltage	V_{OS}	T_A = +25°C		0.3	±3	mV
Total Harmonic Distortion plus Noise	THD+N	R_L = 32Ω, P_{OUT} = 10mW, f = 1kHz from LINEIN_		0.002		%
		R_L = 16Ω, P_{OUT} = 10mW, f = 1kHz from LINEIN_		0.002		
Power-Supply Rejection Ratio (Note 2)	PSRR	V_{DD} = 2.5V to 4.5V, T_A = +25°C	60	70		dB
		f ≤ 1kHz, V_{IN} = 200mV_{P-P}		65		
		f = 10kHz, V_{IN} = 200mV_{P-P}		55		

ELECTRICAL CHARACTERISTICS (continued)

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PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Power	P_{OUT}	R_L = 16Ω, THD+N = 1%, T_A = +25°C (Note 3)		20	38		mW
		R_L = 32Ω, THD+N = 1%, T_A = +25°C			26		
Output Noise Voltage	V_{ON}	ANC = off, PTL = off BW = 20Hz to 20kHz			9		$µV_{RMS}$
		ANC = off, PTL = off A-weighted			6		
		ANC = on, A-weighted			6.5		
Slew Rate	SR				0.2		V/µs
Maximum Capacitive Load	$C_{MAXLOAD}$	No sustained oscillations (capacitance between HPOUT_ and V_{MID})			100		pF
Click-and-Pop Level	KCP	Turn on	R_L = 32Ω, peak voltage, A-weighted, 32 samples/sec, T_A = +25°C (Note 4)		-73		dBV
		Turn off			-72		
Crosstalk		f = 1kHz, R_L = 32Ω, P_{OUT} = 10mW, TQFN			57		dB
		WLP			70		
MICROPHONE INPUTS							
Preamplifier Feedback Resistance	R_{PREFB}	External		10		100	kΩ
Preamplifier Input Resistance	R_{PREIN}	External		1		10	kΩ
Input Bias Current	I_{BIAS}	Measured at MICIN, T_A = +25°C			1	10	nA
Microphone Input Noise Voltage	e_N	BW = 20Hz to 20kHz measured at MICOUT_			6		µV
Minimum ANC Gain	ANCG_MIN	MICOUT_ to HPOUT_, measured at DC		-18.0	-17.5	-17.0	dB
Maximum ANC Gain	ANCG_MAX			-6.0	-5.5	-5.0	dB
Minimum PTL Gain	PTLG_MIN			-12.0	-11.5	-11.0	dB
Maximum PTL Gain	PTLG_MAX			0	0.5	1	dB
ANC/PTL Gain Stepsize	AG_STEP	MICOUT_ to HPOUT_, measured at DC			0.5		dB
OPA Offset		Measured at SPR1 and SPR2 with respect to V_{BIAS}		-30		+30	mV
Maximum Capacitive Load	$C_{MAXLOAD}$	Allowed capacitance to GND on MICOUT_ and all signal processing filter I/O except SPC3			15		pF
Dynamic Range	MICDYN	Swing of all internal and external nodes of preamplifier, signal processing, and filter with respect to V_{BIAS}			±1		V

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ELECTRICAL CHARACTERISTICS (continued)

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PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Output Current	I_{OUT}	Current capability of preamplifier, signal processing, and filter output		±500		µA
PTL Attenuation		Attenuation from LINEIN_ to HPOUT_ in PTL mode		40		dB
MICROPHONE BIAS (MICBIAS Pin)						
MIC Bias Voltage	$V_{MICBIAS}$	V_{DD} = 3.3V; 100µA < $I_{MICBIAS}$ < 1mA	2.1	2.2	2.3	V
MIC Bias Current Limit	I_{MICLM}			35		mA
Maximum Capacitive Load	$C_{MAXLOAD}$			100		pF
MICBIAS PSRR	MB_PSRR	V_{DD} from 2.7V to 4.5V	55	62		dB
		f = 20kHz		60		
MICBIAS Noise	MB_N			6		µV
CHARGE PUMP						
Charge-Pump Frequency	f_{OSC}		225	250	275	kHz
V_{MID} Output Resistance	R_{VMID}			4		Ω
DIGITAL INPUT SDA (SCL Tied to GND: I²C Interface Disabled)						
Input Leakage	I_L	V_{SDA} = 0V to 3.3V T_A = +25°C			±16	µA
Input Voltage High	V_{IH}		1.8			V
Input Voltage Low	V_{IL}				0.8	V
SCL/SDA (I²C Interface Enabled)						
Input Voltage High	V_{IH}	1.8V CMOS compatibility	1.4			V
Input Voltage Low	V_{IL}	1.8V CMOS compatibility			0.4	V
Input Hysteresis	V_{IHIST}			0.2		V
Input High Leakage Current	I_{IH}	V_{IN} = 3V; T_A = +25°C			±1	µA
Input Low Leakage Current	I_{IL}	V_{IN} = 0; T_A = +25°C			±1	µA
Input Capacitance	C_{IN}			10		pF
Output Voltage Low	V_{OL}	I_{OL} = 3mA; T_A = +25°C			0.4	V
I²C INTERFACE						
Serial-Clock Frequency	f_{SCL}				400	kHz
Bus Free Time Between STOP and START Conditions	t_{BUF}		1.3			µs
Hold Time (REPEATED) START Condition	$t_{HD:STA}$		0.6			µs
Setup Time for a REPEATED START Condition	$t_{SU:STA}$		0.6			µs

ELECTRICAL CHARACTERISTICS (continued)

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PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCL Pulse-Width Low	t_{LOW}		1.3			µs
SCL Pulse-Width High	t_{HIGH}		0.6			µs
Data Setup Time	$t_{SU:DAT}$		100			ns
Data Hold Time	$t_{HD:DAT}$		0		900	ns
SDA and SCL Receiving Rise Time	t_R	(Note 5)	20 + 0.1C_B		300	ns
SDA and SCL Receiving Fall Time	t_F	(Note 5)	20 + 0.1C_B		300	ns
SDA Transmitting Fall Time	t_F	(Note 5)	20 + 0.1C_B		250	ns
Setup Time for STOP Condition	$t_{SU,STO}$		0.6			µs
Bus Capacitance	C_B				400	pF
Pulse Width of Suppressed Spike	t_{SP}		0		50	ns

Note 1: All devices are 100% production tested at T_A = +25°C. Specifications over temperature limits are guaranteed by design.

Note 2: PSRR at any frequency is limited by resistor matching (common-mode sense architecture used to reject the modulation on VMID).

Note 3: Output power is guaranteed by measuring the RDSON of all power MOSFETs (headphone driver and charge pump).

Note 4: Line inputs AC-coupled to GND.

Note 5: C_B is in pF.

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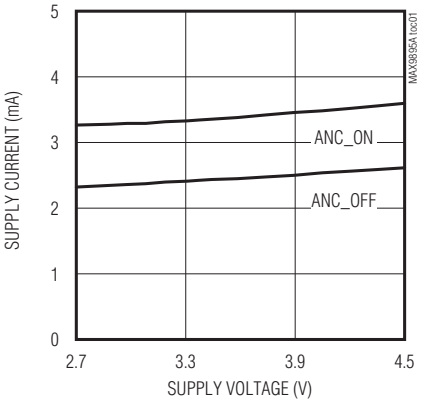
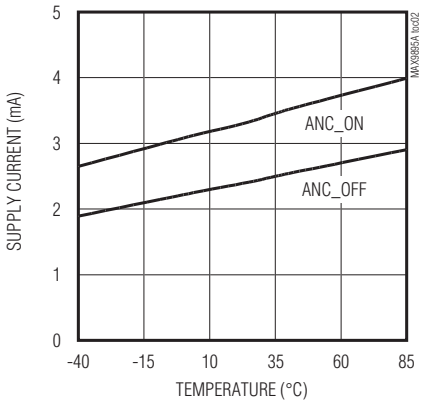
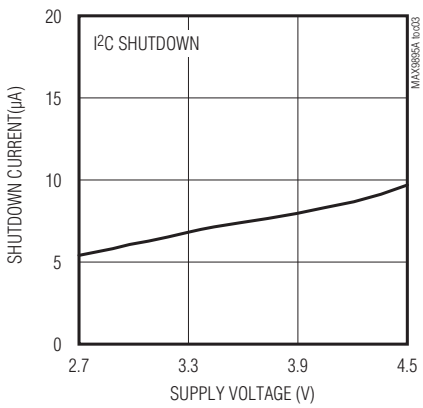
SUPPLY CURRENT vs. SUPPLY VOLTAGE



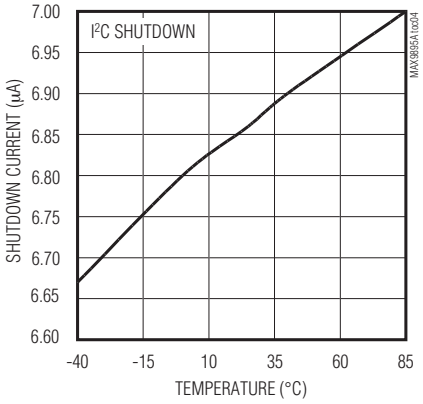
SUPPLY CURRENT vs. TEMPERATURE



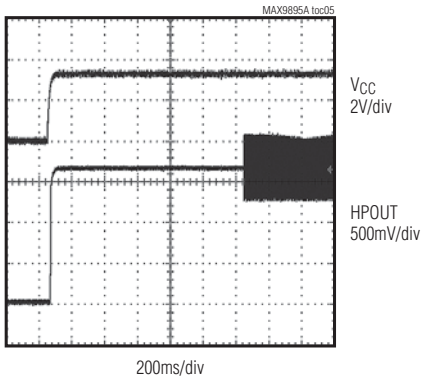
SHUTDOWN CURRENT vs. SUPPLY VOLTAGE



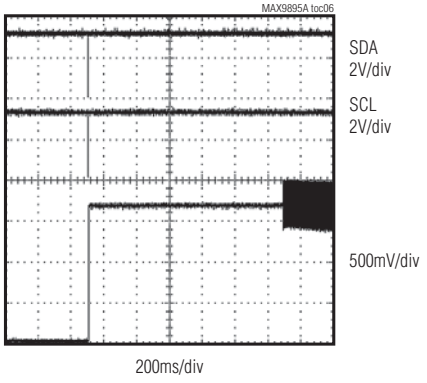
SHUTDOWN CURRENT vs. TEMPERATURE



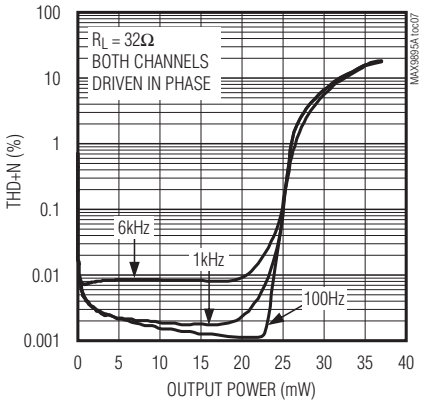
HARDWARE TURN-ON



SOFTWARE TURN-ON



TOTAL HARMONIC DISTORTION PLUS NOISE vs. OUTPUT POWER



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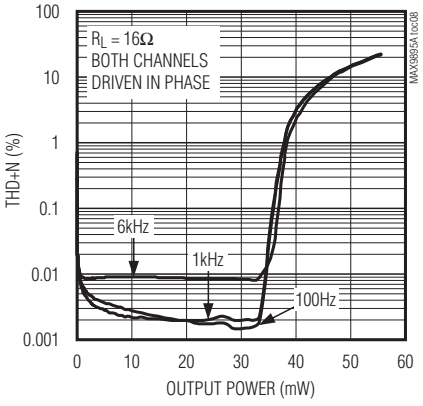

Typical Operating Characteristics (continued)

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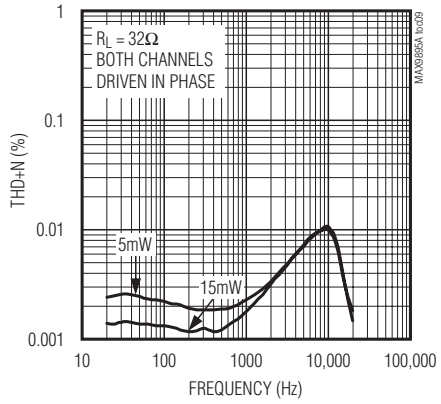
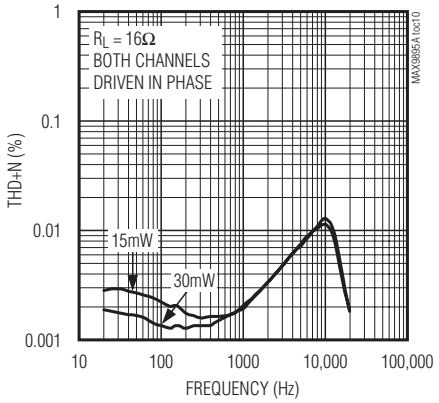
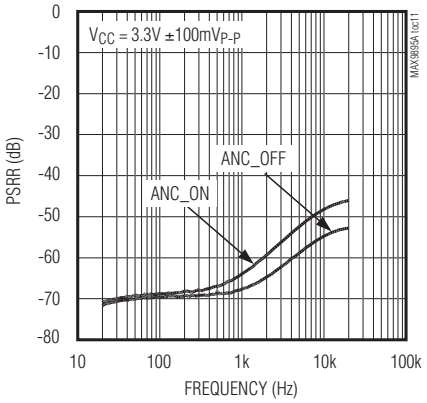
TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



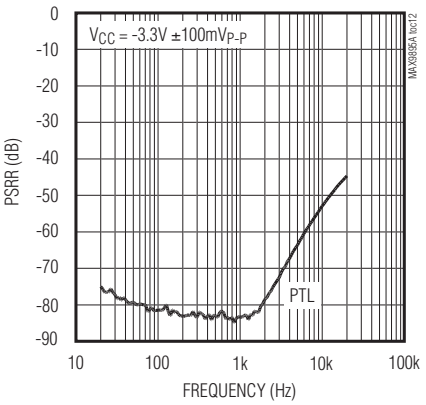
TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



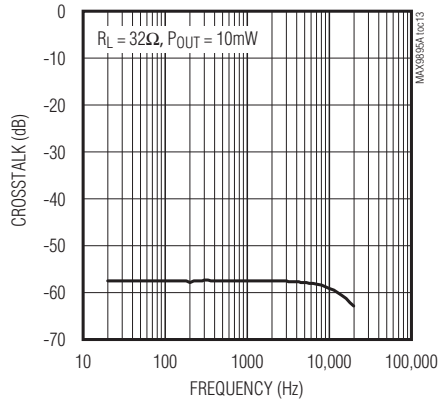
POWER-SUPPLY REJECTION RATIO



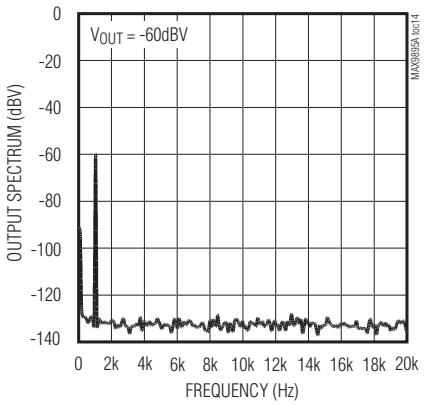
POWER-SUPPLY REJECTION RATIO



CROSSTALK vs. FREQUENCY



OUTPUT SPECTRUM vs. FREQUENCY



Active Noise-Cancelling Solution for Stereo Headsets

Typical Operating Characteristics (continued)

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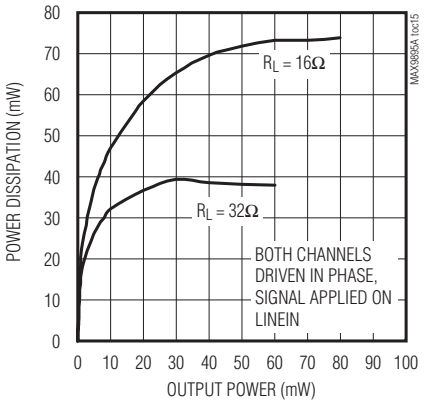
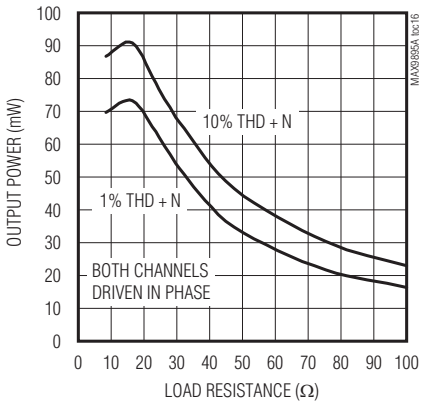
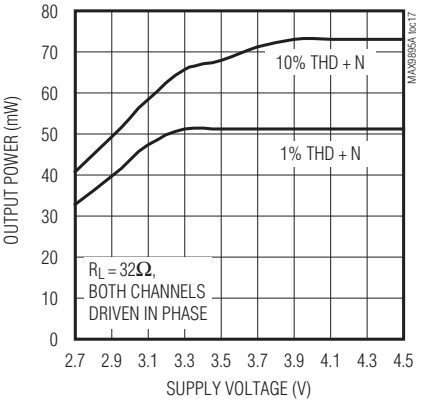
POWER DISSIPATION vs. OUTPUT POWER



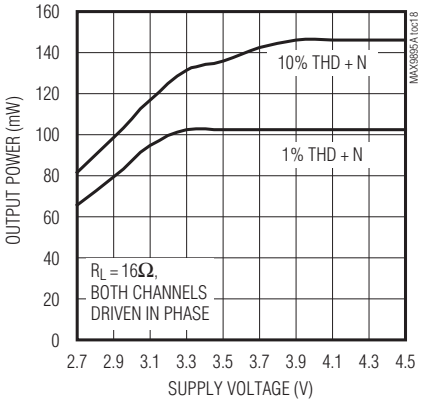
OUTPUT POWER vs. LOAD RESISTANCE



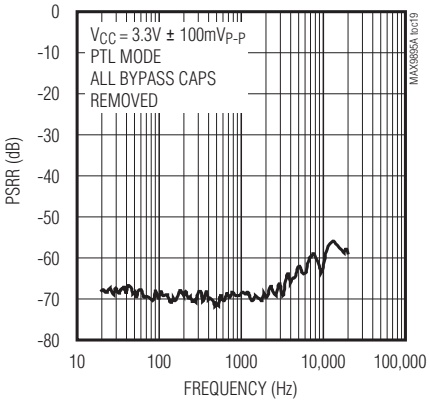
TOTAL OUTPUT POWER vs. SUPPLY VOLTAGE



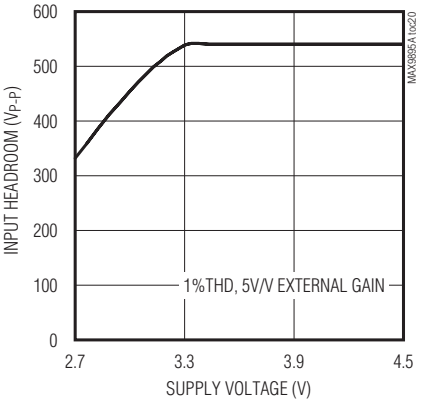
OUTPUT POWER vs. SUPPLY VOLTAGE



MICBIAS POWER-SUPPLY REJECTION RATIO



MICIN INPUT HEADROOM vs. SUPPLY VOLTAGE



Pin Description

PIN		NAME	FUNCTION
TQFN	WLP		
1	A6	SPR1_L	Left-Channel Signal Processing
2	C5	MICOUT_L	Left-Channel Microphone Preamplifier Output. Apply feedback resistor to set input gain. See the *Microphone Output* section for more details.
3	B6	MICIN_L	Left-Channel Microphone Input
4	C6	MICBIAS	Microphone Supply Voltage. Use separate left/right MICBIAS resistors.
5	C4	LINEIN_L	Left-Channel Audio Line Input
6	D4	LINEIN_R	Right-Channel Audio Line Input
7, 8	D6	GND	Signal Ground (Reference for V_{BIAS}, MICBIAS, and LINEIN)
9	E6	MICIN_R	Right-Channel Microphone Input
10	D5	MICOUT_R	Right-Channel Microphone Preamplifier Output. Apply feedback resistor to set input gain.
11	F6	SPR1_R	Right-Channel Signal Processing
12	E5	SPC1_R	Right-Channel Signal Processing
13	F5	SPC2_R	Right-Channel Signal Processing
14	E4	SPC3_R	Right-Channel Signal Processing
15	F4	SPC4_R	Right-Channel Signal Processing
16	E3	SPR2_R	Right-Channel Signal Processing
17	F3	V_{BIAS}	Internal Reference. Bypass V_{BIAS} to GND with a 1µF capacitor. Used for MICIN and LINEIN.
18	E2	SPFC2_R	Right-Channel Signal Processing
19	F2	SPFC1_R	Right-Channel Signal Processing
20	D2	SPFO_R	Right-Channel Signal Processing
21	F1	HPOUT_R	Right-Channel Headphone Output
22	E1	V_{DD}	Positive Supply Voltage
23		PVDD	
24		CPVDD	
25	D1	C1P	Charge-Pump Flying Capacitor Positive
26	C1	C1N	Charge-Pump Flying Capacitor Negative
27	B1	V_{MID}	Charge-Pump Output Voltage. Connect to common return of headphone. Bypass V_{MID} with a 1µF capacitor to PGND.
28	—	N.C.	No Connection
29	A1	PGND	Power Ground
30	D3	SDA/NC-MODE	I²C Interface Data Line. Also used as MODE select in hardware mode (SCL = GND). See Table 1.
31	C3	SCL	I²C Interface Clock Line. Connect to GND for hardware mode.
32	A2	HPOUT_L	Left-Channel Headphone Output

Active Noise-Cancelling Solution for Stereo Headsets

Pin Description

PIN		NAME	FUNCTION
TQFN	WLP		
33	C2	SPFO_L	Left-Channel Signal Processing
34	B2	SPFC1_L	Left-Channel Signal Processing
35	A3	SPFC2_L	Left-Channel Signal Processing
36	B3	SPR2_L	Left-Channel Signal Processing
37	A4	SPC4_L	Left-Channel Signal Processing
38	B4	SPC3_L	Left-Channel Signal Processing
39	A5	SPC2_L	Left-Channel Signal Processing
40	B5	SPC1_L	Left-Channel Signal Processing
—	—	EP	Exposed Pad. Must be connected to PGND.

Detailed Description

The MAX9895A is a complete audio subsystem for active noise-cancelling stereo headsets. The device features a microphone preamplifier, an analog sound processing block, and a headphone amplifier combining to create a simple and very flexible active noise-canceling system. The MAX9895A uses feed-forward architecture, creating a headphone signal that has the same amplitude, but opposite phase as outside noise that leaks through the mechanical isolation of the earphones. These two signals cancel each other and provide noise suppression at the ear. The device consists of an ultra-low noise microphone preamplifier to set input impedance and gain, followed by an analog signal processing block, and a capacitorless headphone amplifier. The headphone amplifier does not require the large output-coupling capacitors used by conventional single-supply headphone amplifiers, and can output 33mW into a 16Ω headphone. The product also features undervoltage lockout and comprehensive click-and-pop suppression circuitry. See the *Functional Diagram/Typical Applications Circuit* for further details.

Modes of Operation

The MAX9895A features three modes of operation; active noise canceling (ANC) on or off, and push-to-listen (PTL). The ANC-on mode provides full noise canceling and provides line-input mixing to the headphones. This allows music to be played while noise canceling is operational. The ANC-off mode disables the microphone preamplifiers and noise processing blocks, but allows the line inputs to operate normally. This gives flexibility to the design such that music can still be played through the headphones while noise canceling is inactive.

The PTL mode connects the microphone preamplifier directly to the headphone amplifier, bypassing the noise cancellation, and attenuates the line-input signal. PTL mode gives the user the option of listening to the surroundings without removing the headphones. See Table 1 for hardware mode settings.

Microphone Preamplifier

The MAX9895A features an ultra-low noise microphone input preamplifier. Using an inverting op amp design with external input and feedback resistors allows flexibility in setting input impedance and gain. The microphone gain can be adjusted in two ways: adjust the feedback resistor in the preamplifier stage by use of a potentiometer or setting I²C registers using a microcontroller to adjust the gain after the analog processing stage.

Microphone Bias Supply

The MAX9895A provides a low-noise voltage bias designed for biasing electret condenser microphones (ECM). The bias output is regulated to 2.5V.

Table 1. Mode Selection (in Hardware Mode)

SDA LEVEL	CONFIGURATION
GND	(PTL Mode) LINEIN_ is attenuated, MICOUT_ signal is passed directly to the headphone driver without filtering and phase reversal.
Hi-Z	ANC on
V_{DD}	ANC off (only HP amps are active)

Microphone Output

The outputs of the microphone preamplifiers are provided to allow for external adjustment of the gain of the preamplifier and to provide a path for voice transmission (headset) applications.

Programmable Gain

The second gain stage can be programmed in 0.5dB steps to compensate for microphone and headphone sensitivity. This requires a microcontroller connected to the I²C bus, which operates in slave mode. An alternate solution for gain setting is to add a trim-pot to the feedback resistor of the microphone preamplifier. See the *Typical Application Circuit*.

Analog Signal Processing

This block creates the noise cancellation signal. The signal processing block uses the output of the microphone preamp and external components to create a headphone signal that has the same amplitude, but opposite phase as outside noise that leaks through the mechanical isolation of the earphones, so both waves cancel each other. **Note:** The choice of external components depends on the headset characteristics. Please contact your local Maxim sales office for more information on determining the proper component values for the *Analog Signal Processing* section.

Headphone Amplifier

The stereo headphone amplifier is capable of delivering 33mW into 16Ω loads and has a gain (line in to headphone out) of 1V/V for the MAX9895AA. The input to the headphone amplifier is a linear sum of three signals: line in (external input), mic gain (output of analog signal processing block) and PTL gain (ANC bypass).

Unlike conventional single-supply, single-ended amplifiers, the MAX9895A headphone amplifier does not need large DC-blocking caps, as the outputs are referred to $V_{CC}/2$, which is the bias output voltage of the amplifier. Conventional single-supply headphone amplifiers require large coupling capacitors to block the output DC bias from the headphone. The MAX9895A architecture uses a high-efficiency charge pump to create an internal midbias supply voltage (V_{MID}). This keeps supply current low and allows the amplifier outputs to be connected directly to the headphones without the need for these large coupling capacitors.

Serial Interface

The MAX9895A features an I²C, 2-wire serial interface consisting of a serial-data line (SDA) and a serial-clock line (SCL). SDA and SCL facilitate communication between the MAX9895A and the master at clock rates up to 400kHz. Figure 1 shows the 2-wire interface timing diagram. The MAX9895A is a receive-only slave device relying on the master to generate the SCL signal. The MAX9895A cannot write to the SDA bus except to acknowledge the receipt of data from the master. The master, typically a microcontroller, generates SCL and initiates data transfer on the bus. If the serial interface is not used, the SCL pin must be tied to GND to disable this feature and allow the device to be used in hardware mode (no microcontroller).

A master device communicates to the MAX9895A by transmitting the proper address followed by the data word. Each transmit sequence is framed by a START (S) or REPEATED START (Sr) condition and a STOP (P) con-

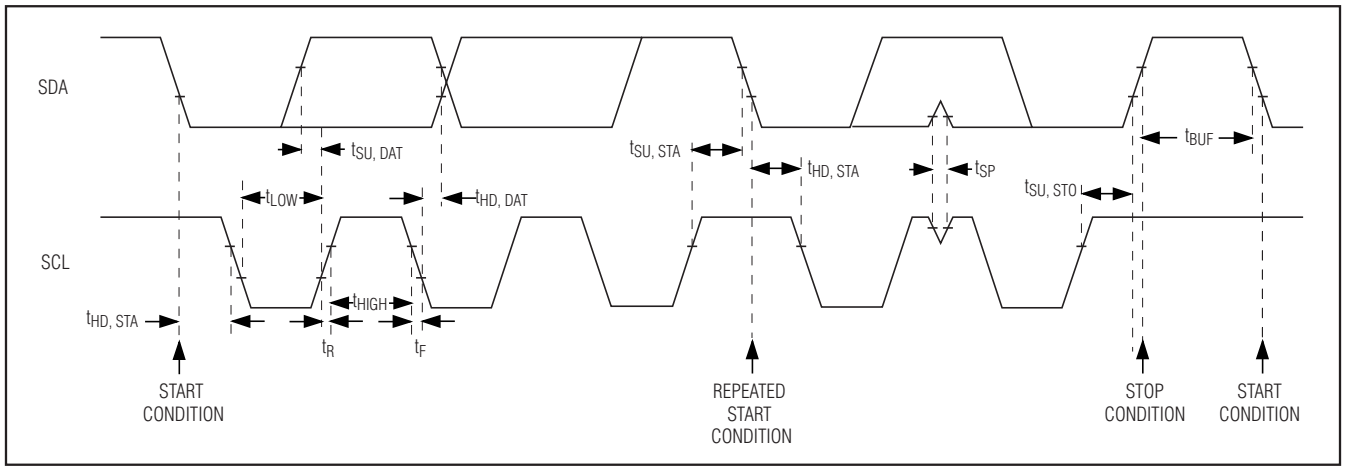


Figure 1. 2-Wire Serial-Interface Timing Diagram

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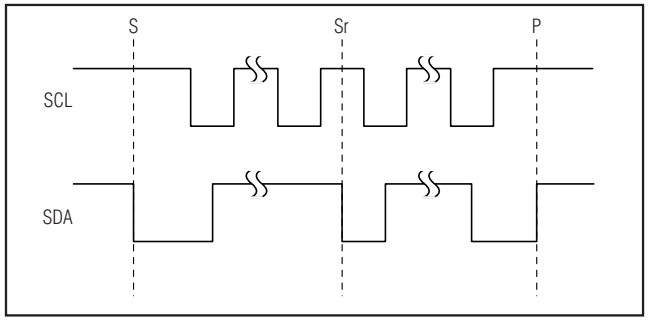

Figure 2. START, STOP, and REPEATED START Conditions

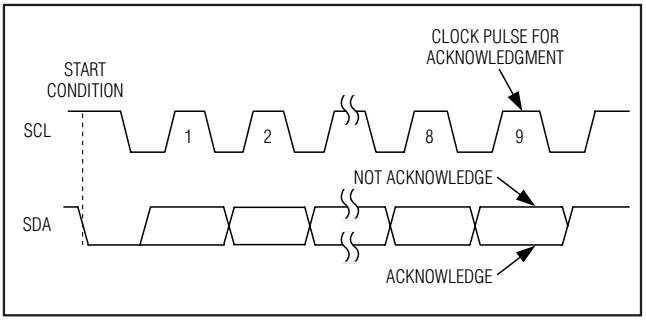

Figure 3. Acknowledge

dition. Each word transmitted over the bus is 8 bits long and is always followed by an acknowledge clock pulse.

The MAX9895A SDA line operates as both an input and an open-drain output. A pullup resistor, greater than 500Ω, is required on the SDA bus. The MAX9895A SCL line operates as an input only. A pullup resistor, greater than 500Ω, is required on SCL if there are multiple masters on the bus, or if the master in a single-master system has an open-drain SCL output. Series resistors in line with SDA and SCL are optional. Series resistors protect the digital inputs of the MAX9895A from high-voltage spikes on the bus lines, and minimize crosstalk and undershoot of the bus signals.

Bit Transfer

One data bit is transferred during each SCL cycle. The data on SDA must remain stable during the high period of the SCL pulse. Changes in SDA while SCL is high are control signals (see the *START and STOP Conditions* section). SDA and SCL idle high when the I²C bus is not busy.

START and STOP Conditions

SDA and SCL idle high when the bus is not in use. A master device initiates communication by issuing a START (S) condition. A START condition is a high-to-low transition on SDA with SCL high. A STOP (P) condition is a low-to-high transition on SDA while SCL is high (Figure 2). A START condition from the master signals the beginning of transmission to the MAX9895A. The master terminates transmission and frees the bus by issuing a STOP condition. The bus remains active if a REPEATED START (Sr) condition is generated instead of a STOP condition.

Early STOP Conditions

The MAX9895A recognizes a STOP condition at any point during data transmission except if the STOP condition occurs in the same high pulse as a START condition.

Slave Address

The MAX9895A is available with 0x40 preset slave addresses. The address is defined as the seven most significant bits (MSBs) followed by the read/write (R/W) bit. The address is the first byte of information sent to the MAX9895A after the START condition. The MAX9895A is a slave device only capable of being written to. The sent R/W bit must always be a zero when configuring the MAX9895A.

The MAX9895A acknowledges the receipt of its address even if R/W is set to 1. However, the MAX9895A does not drive SDA. Addressing the MAX9895A with R/W set to 1 causes the master to receive all 1s regardless of the contents of the command register.

Acknowledge

The acknowledge bit (ACK) is a clocked 9th bit that the MAX9895A uses to handshake receipt of each byte of data (see Figure 3). The MAX9895A pulls down SDA during the master-generated 9th clock pulse. The SDA line must remain stable and low during the high period of the acknowledge clock pulse. Monitoring ACK allows for detection of unsuccessful data transfers. An unsuccessful data transfer occurs if a receiving device is busy or if a system fault has occurred. In the event of an unsuccessful data transfer, the bus master can reattempt communication.

Write Data Format

A write to the MAX9895A includes transmission of a START (S) condition, the slave address with the R/W bit reset to 0, one byte of data to configure the command register, and a STOP (P) condition. Figure 4 illustrates the proper format for one frame.

The MAX9895A only accepts write data, but it acknowledges the receipt of its address byte with the R/W bit set high. The MAX9895A does not write to the SDA bus

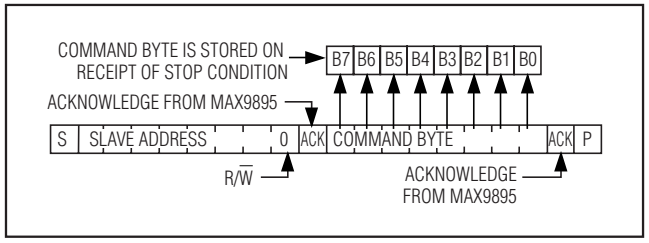

Figure 4. Write Data Format Example

in the event that the R/W bit is set high. Subsequently, the master reads all 1s from the MAX9895A. Always reset the R/W bit to 0 to avoid this situation.

I²C-Enabled Software Mode

The MAX9895A can operate with or without an external microcontroller (µC). When a µC is present, commands are sent through the I²C protocol (SCL, SDA).

I²C-Disabled Hardware Mode

By tying SCL to ground, the I²C interface is disabled and the device operates in hardware mode. In this case, the SDA pin operates as a MODE select. Table 1 shows different configurations with the SDA level.

Application Information

Input-Coupling Capacitor

The input capacitor (C_{IN}), in conjunction with the input resistor (R_{IN}), forms a highpass filter that removes the DC bias from an incoming signal (see the *Functional Diagram/Typical Applications Circuit*). The AC-coupling capacitor allows the device to bias the signal to an optimum DC level. Assuming zero-source impedance, the -3dB point of the highpass filter is given by:

$$f_{-3dB} = \frac{1}{2\pi R_{IN} C_{IN}}$$

Choose the CIN so that f_{-3dB} is well below the lowest frequency of interest. Setting f_{-3dB} too high affects the device's low-frequency response. Use capacitors whose dielectrics have low-voltage coefficients, such as tantalum or aluminum electrolytic. Capacitors with high-voltage coefficients, such as ceramics, can result in increased distortion at low frequencies.

Apply same method for microphone input-coupling capacitor ($C_{PREIN\_}$). The R_{IN} for microphone input is $R_{PREIN\_}$.

Setting the Gains

The gains of the microphone input preamplifiers are set through the feedback using the following equation:

$$A_V\ (V/V) = -(R_F/R_{IN})$$

In stand-alone control mode, the internal gain stage for MIC GAIN is fixed at 11.5dB and the PTL GAIN stage is fixed at -5.5dB. In software control mode (I²C mode), the internal gain stage stages, MIC GAIN and PTL GAIN, are programmable through the I²C registers. See the *Serial Interface* section for more information.

The LINE IN and HEADPHONE AMP stages each have fixed voltage gain of 0dB.

Charge-Pump Capacitor Selection

Use ceramic capacitors with a low ESR for optimum performance. For optimal performance over the extended temperature range, select capacitors with an X7R dielectric. Table 2 lists suggested manufacturers.

Layout and Grounding

Proper layout and grounding are essential for optimum performance. Connect PGND and GND together at a single point on the PCB. Place the power-supply bypass capacitor and the charge-pump hold capacitor as close as possible to the MAX9895A. Route PGND and all traces that carry switching transients away from GND and the audio signal path. The thin QFN package features an exposed pad that improves thermal efficiency. Ensure that the exposed pad is electrically connected to PGND and is isolated from V_{DD}, PVDD, and CPVDD.

Table 2. Suggest Capacitor Manufacturers

SUPPLIER	PHONE	FAX	WEBSITE
Taiyo Yuden	800-348-2496	847-925-0899	www.t-yuden.com
TDK	847-803-6100	847-390-4405	www.component.tdk.com
Murata	770-436-1300	770-436-3030	www.murata.com

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Table 3. I²C Register Table

ADDRESS	TYPE	POR	NAME	7	6	5	4	3	2	1	0
0x00	R/W	0x0B	ANC_GAIN_LEFT	X	X	X	ANC GAIN setting for LEFT CHANNEL				
0x01	R/W	0x0B	ANC_GAIN_RIGHT	X	X	X	ANC GAIN setting for RIGHT CHANNEL				
0x02	R/W	0x0B	PTL_GAIN_LEFT	X	X	X	PTL GAIN setting for LEFT CHANNEL				
0x03	R/W	0x0B	PTL_GAIN_RIGHT	X	X	X	PTL GAIN setting for RIGHT CHANNEL				
0x04	R/W	0x00	MODE	X				0	PTL	$\overline{ANC}$	$\overline{SHDN}$

Table 4. Gain Setting Register 0x00, 0x01, 0x02, 0x03

HEX	0x00, 0x01 ANC GAIN [dB]	HEX	0x00, 0x01 ANC GAIN [dB]	HEX	0x00, 0x01 ANC GAIN [dB]
0x00	-6.0	0x08	-10.0	0x10	-14.0
0x01	-6.5	0x09	-10.5	0x11	-14.5
0x02	-7.0	0x0A	-11.0	0x12	-15.0
0x03	-7.5	0x0B (POR)	-11.5	0x13	-15.5
0x04	-8.0	0x0C	-12.0	0x14	-16.0
0x05	-8.5	0x0D	-12.5	0x15	-16.5
0x06	-9.0	0x0E	-13.0	0x16	-17.0
0x07	-9.5	0x0F	-13.5	0x17	-17.5
HEX	**0x02, 0x03 PTL GAIN [dB]**	**HEX**	**0x02, 0x03 PTL GAIN [dB]**	**HEX**	**0x02, 0x03 PTL GAIN [dB]**
0x00	-0.0	0x08	-4.0	0x10	-8.0
0x01	-0.5	0x09	-4.5	0x11	-8.5
0x02	-1.0	0x0A	-5.0	0x12	-9.0
0x03	-1.5	0x0B (POR)	-5.5	0x13	-9.5
0x04	-2.0	0x0C	-6.0	0x14	-10.0
0x05	-2.5	0x0D	-6.5	0x15	-10.5
0x06	-3.0	0x0E	-7.0	0x16	-11.0
0x07	-3.5	0x0F	-7.5	0x17	-11.5

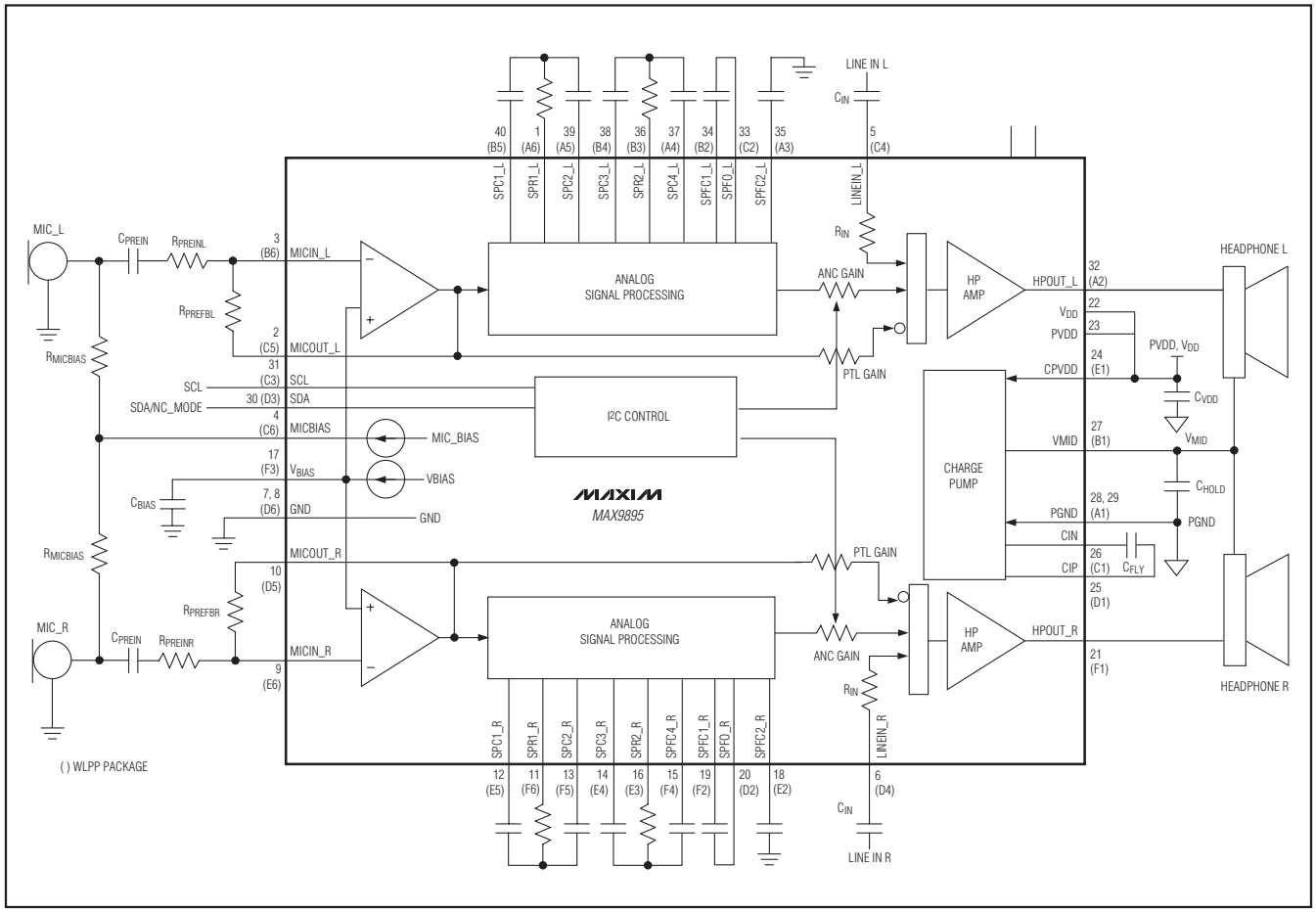
Table 5. Mode Register 0x04

BIT	NAME	POR	FUNCTION
0	$\overline{SHDN}$	0	0: Shut down 1: Play
1	ANC	0	0: Noise cancelling on 1: Noise cancelling off (microphone muted)
2	PTL	0	0: LINEIN routed to HPOUT 1: LINEIN attenuated; MICOUT routed to HPOUT

Table 6. Source Select

INPUT	MODE		
	ANC ON	ANC OFF	PTL
Microphone In	NC mode, inverting, gain defined by I²C REG 01 and 02	Muted	Noninverting, gain defined by I²C REG 03 and 04
Line In	Noninverting, 0db	Noninverting, 0dB	Attenuated

Functional Diagram/Typical Applications Circuit



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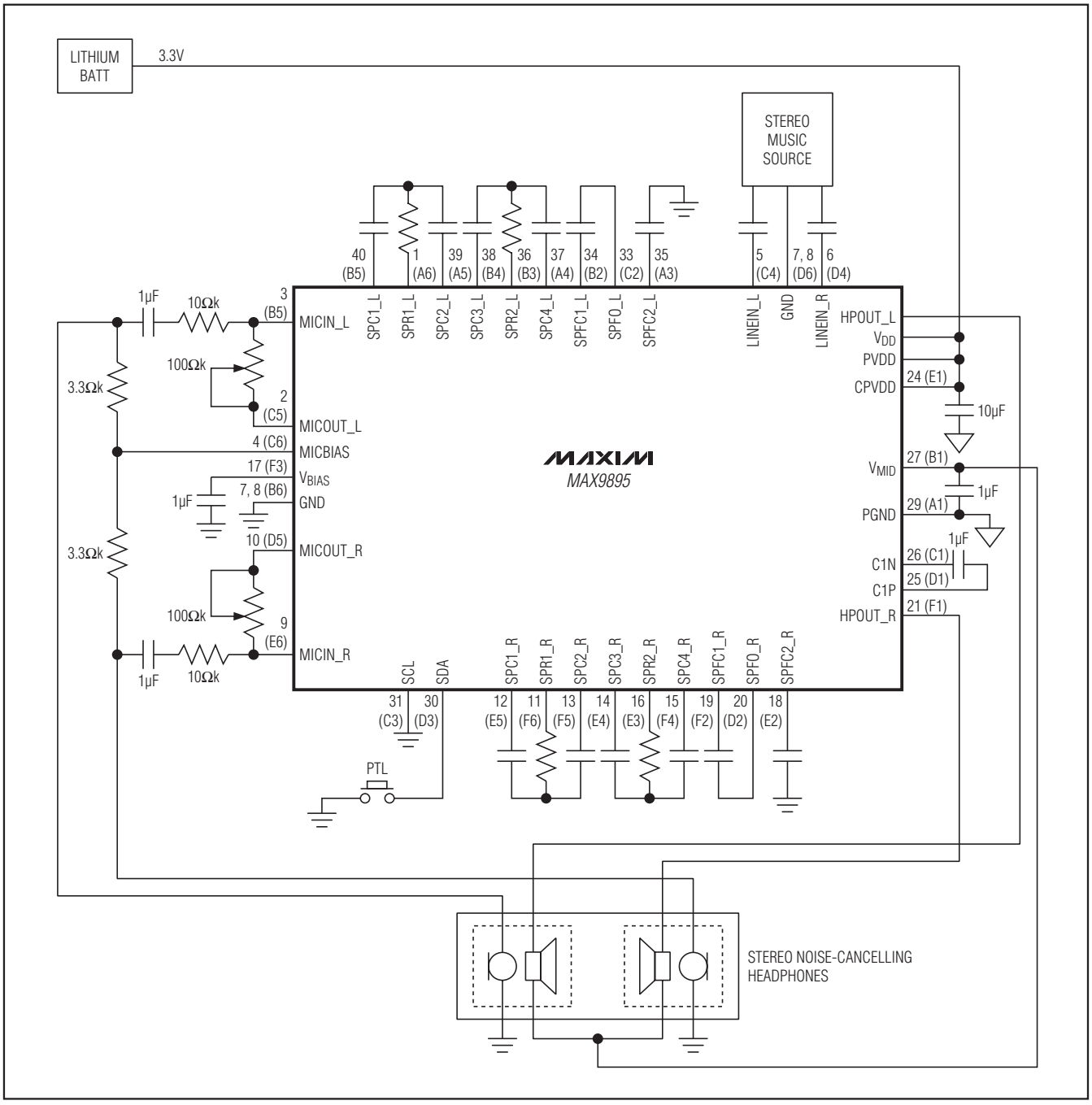
Typical Applications Circuit (Hardware Mode)



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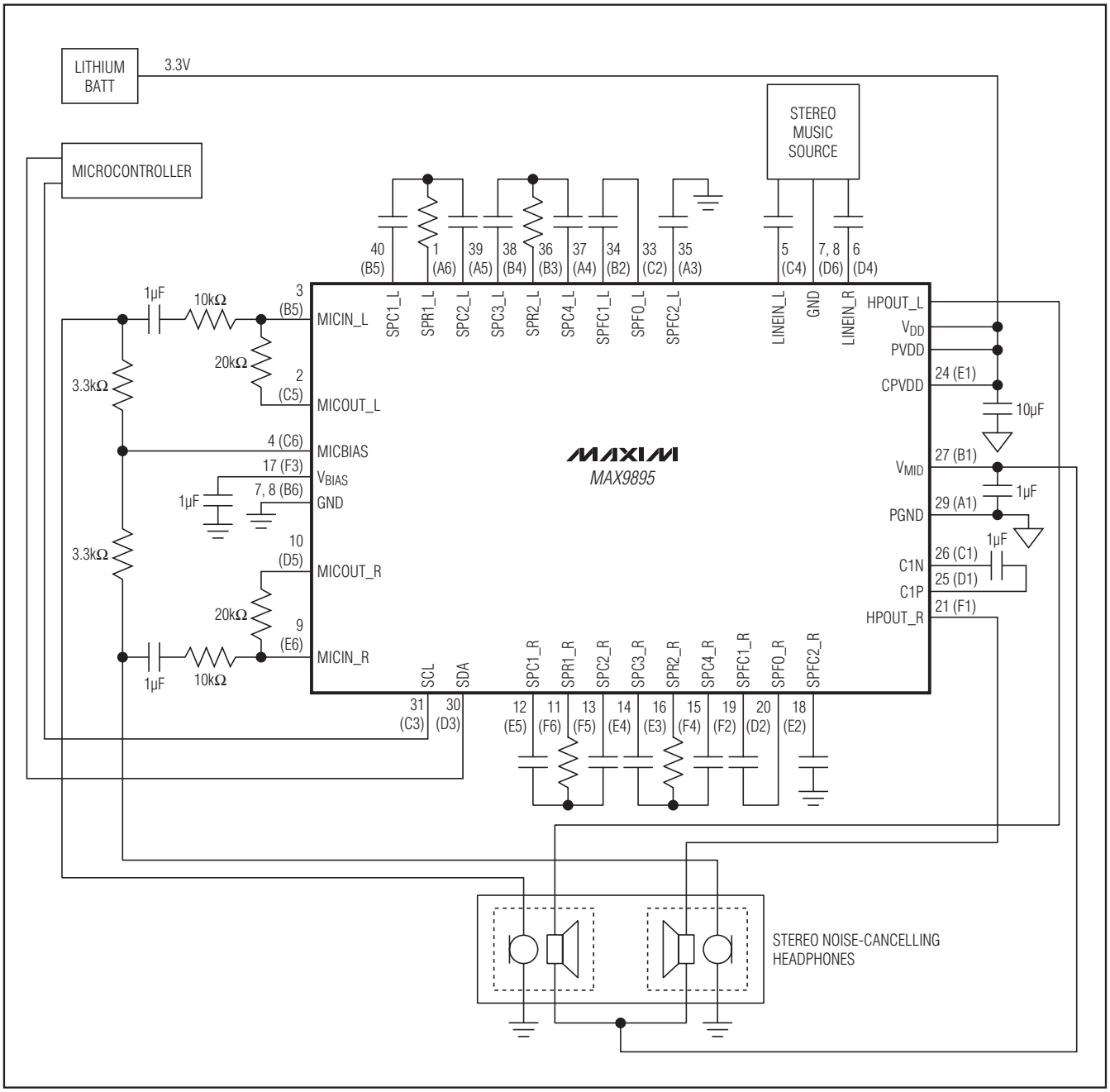
Typical Applications Circuit (Software Mode)



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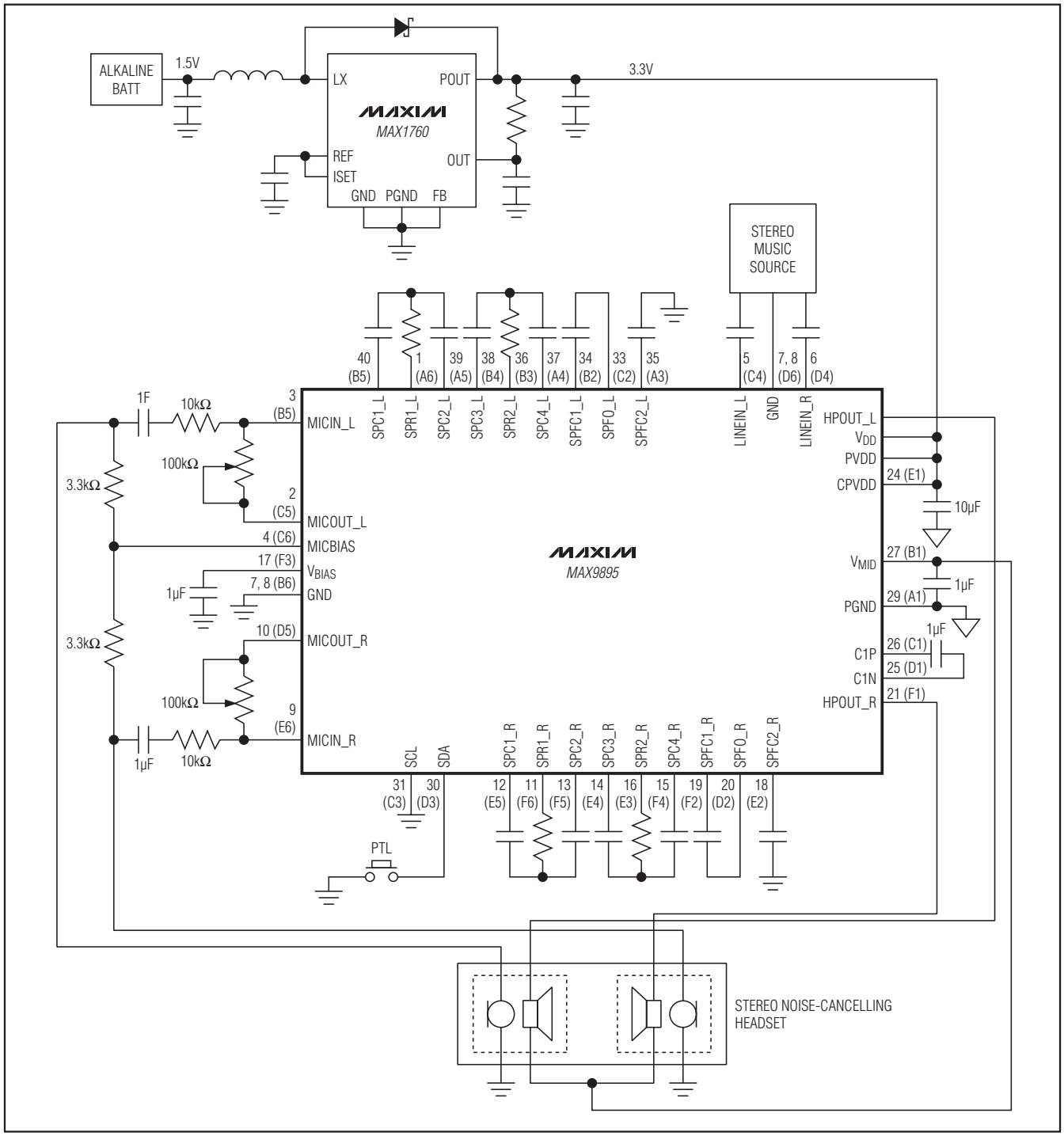
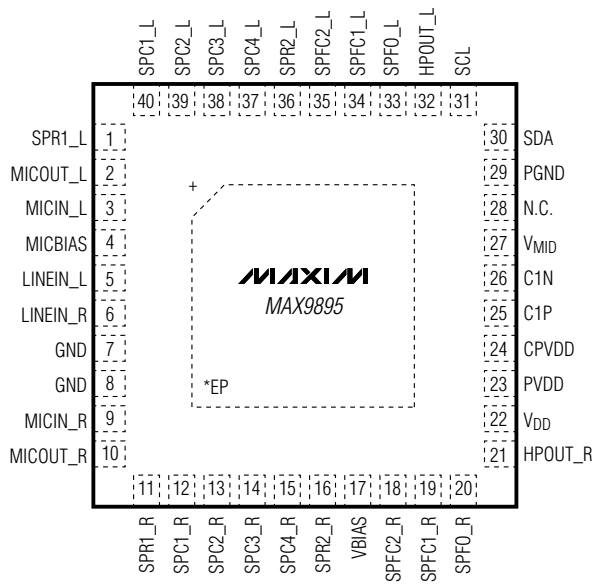
Typical Applications Circuit (AAA Battery, Hardware Mode)



Active Noise-Cancelling Solution for Stereo Headsets

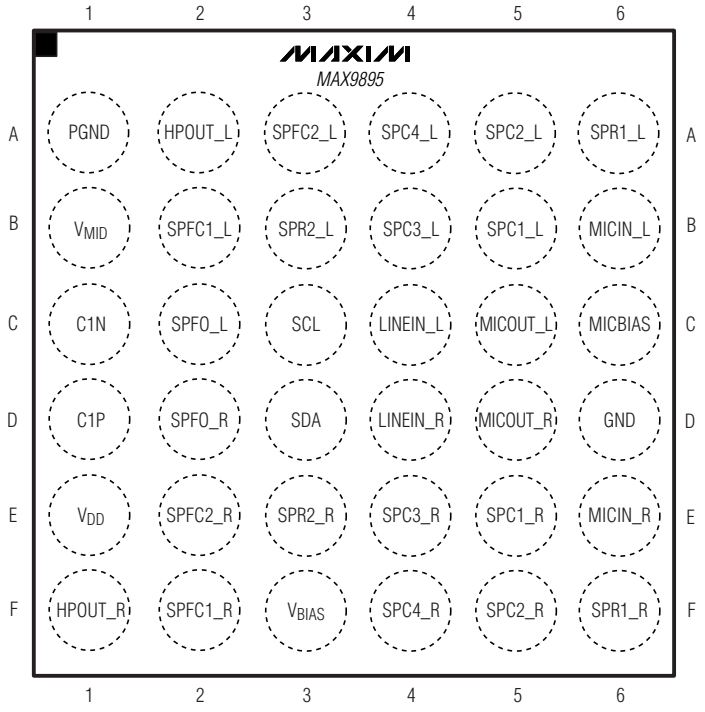
Pin Configurations

TOP VIEW



TQFN-EP
5mm x 5mm

TOP VIEW
(BUMPS ON BOTTOM)



WLP (0.4mm pitch)
2.54mm x 2.54mm

*EP = EXPOSED PAD; CONNECT TO PGND.

Chip Information

PROCESS: BiCMOS

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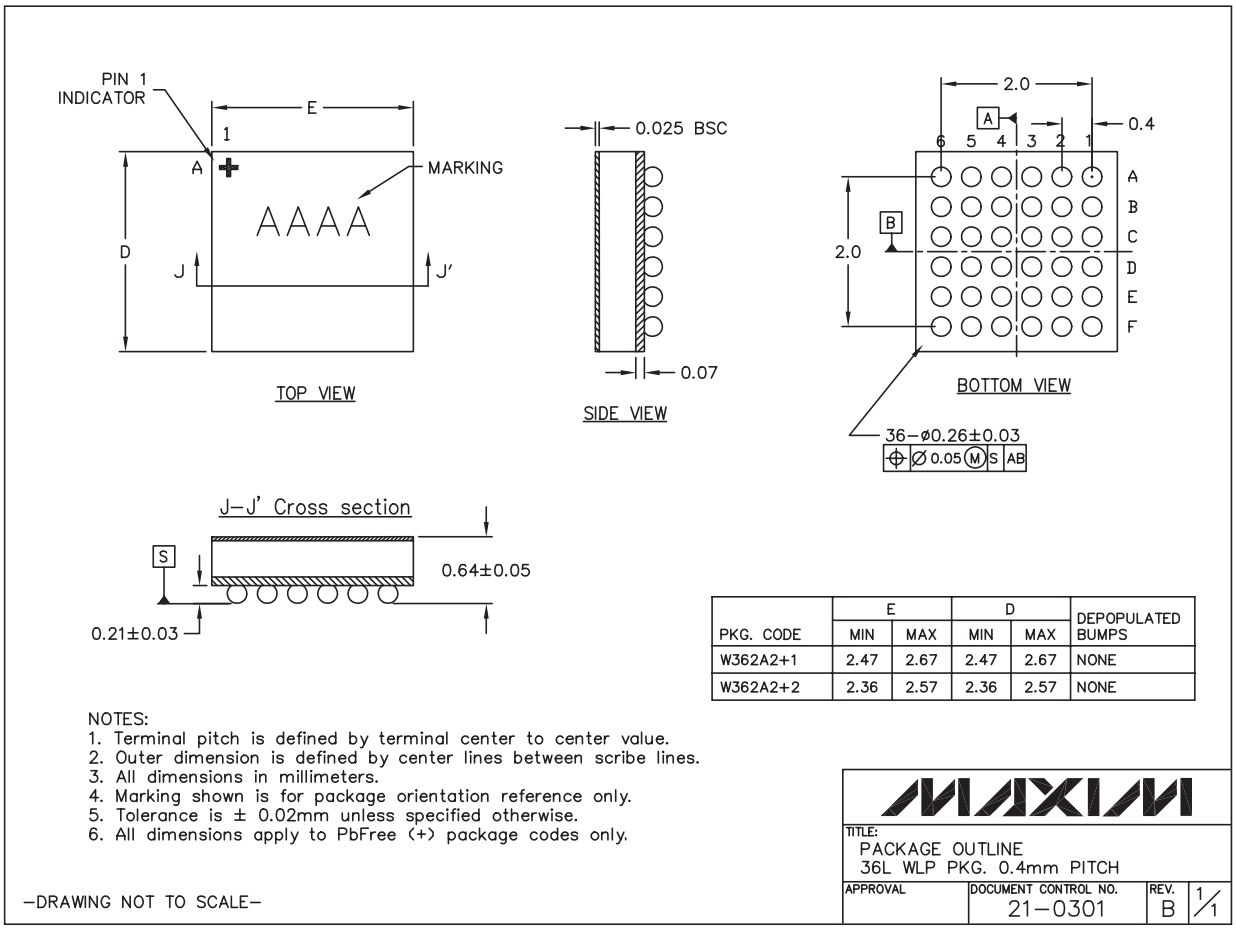
Package Information

For the latest package outline information and land patterns, 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	DOCUMENT NO.
36 WLP	W362A2+2	21-0301
40 TQFN	T4055+1	21-0140



PKG. CODE	E MIN	E MAX	D MIN	D MAX	DEPOPULATED BUMPS
W362A2+1	2.47	2.67	2.47	2.67	NONE
W362A2+2	2.36	2.57	2.36	2.57	NONE

NOTES:
1. Terminal pitch is defined by terminal center to center value.
2. Outer dimension is defined by center lines between scribe lines.
3. All dimensions in millimeters.
4. Marking shown is for package orientation reference only.
5. Tolerance is ± 0.02mm unless specified otherwise.
6. All dimensions apply to PbFree (+) package codes only.

-DRAWING NOT TO SCALE-

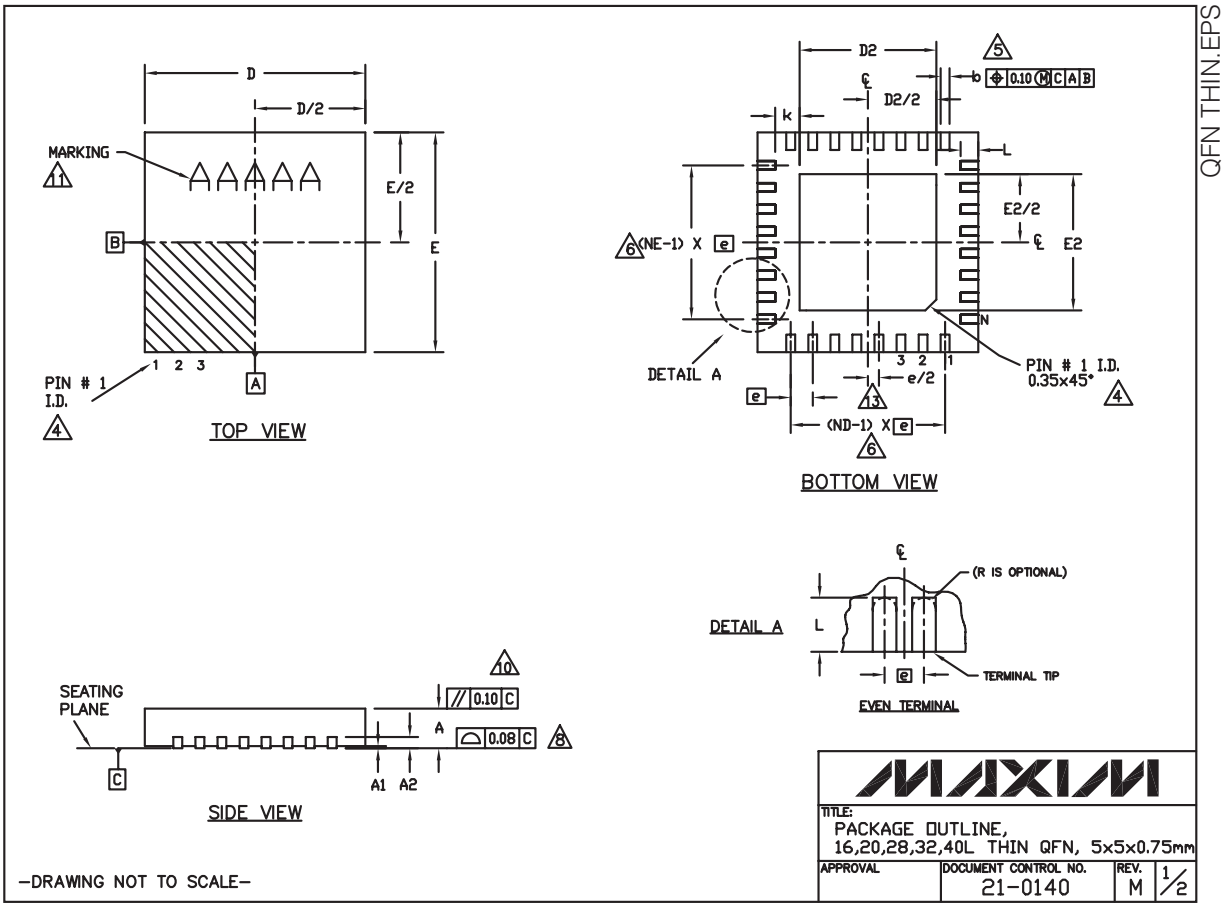
MAXIM

TITLE:
PACKAGE OUTLINE
36L WLP PKG. 0.4mm PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0301	B	1/1

Package Information (continued)

For the latest package outline information and land patterns, 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.



Active Noise-Cancelling Solution for Stereo Headsets

Package Information (continued)

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COMMON DIMENSIONS

PKG.	16L 5x5			20L 5x5			28L 5x5			32L 5x5			40L 5x5		
SYMBOL	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF.			0.20 REF.			0.20 REF.			0.20 REF.			0.20 REF.		
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.20	0.25	0.30	0.15	0.20	0.25
D	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
E	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
e	0.80 BSC.			0.65 BSC.			0.50 BSC.			0.50 BSC.			0.40 BSC.		
k	0.25	–	–	0.25	–	–	0.25	–	–	0.25	–	–	0.25	–	–
L	0.30	0.40	0.50	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50	0.30	0.40	0.50
N	16			20			28			32			40		
ND	4			5			7			8			10		
NE	4			5			7			8			10		
JEDEC	WHHB			WHHC			WHHD-1			WHHD-2			-----		

EXPOSED PAD VARIATIONS

PKG. CODES	D2			E2		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
T1655-2	3.00	3.10	3.20	3.00	3.10	3.20
T1655-3	3.00	3.10	3.20	3.00	3.10	3.20
T1655-4	2.19	2.29	2.39	2.19	2.29	2.39
T165N-1	3.00	3.10	3.20	3.00	3.10	3.20
T2055-3	3.00	3.10	3.20	3.00	3.10	3.20
T2055-4	3.00	3.10	3.20	3.00	3.10	3.20
T2055-5	3.15	3.25	3.35	3.15	3.25	3.35
T2055MN-5	3.15	3.25	3.35	3.15	3.25	3.35
T2855-3	3.15	3.25	3.35	3.15	3.25	3.35
T2855-4	2.60	2.70	2.80	2.60	2.70	2.80
T2855-5	2.60	2.70	2.80	2.60	2.70	2.80
T2855-6	3.15	3.25	3.35	3.15	3.25	3.35
T2855-7	2.60	2.70	2.80	2.60	2.70	2.80
T2855-8	3.15	3.25	3.35	3.15	3.25	3.35
T2855N-1	3.15	3.25	3.35	3.15	3.25	3.35
T3255-3	3.00	3.10	3.20	3.00	3.10	3.20
T3255-4	3.00	3.10	3.20	3.00	3.10	3.20
T3255M-4	3.00	3.10	3.20	3.00	3.10	3.20
T3255-5	3.00	3.10	3.20	3.00	3.10	3.20
T3255N-1	3.00	3.10	3.20	3.00	3.10	3.20
T4055-1	3.40	3.50	3.60	3.40	3.50	3.60
T4055-2	3.40	3.50	3.60	3.40	3.50	3.60
T4055N-1	3.40	3.50	3.60	3.40	3.50	3.60
T4055MN-1	3.40	3.50	3.60	3.40	3.50	3.60

NOTES:
1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT EXPOSED PAD DIMENSION FOR T2855-3, T2855-6, T4055-1 AND T4055-2.
10. WARPAGE SHALL NOT EXCEED 0.10 mm.
11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
12. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
13. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION 'e', ±0.05.
14. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND PbFREE (+) PKG. CODES.

–DRAWING NOT TO SCALE–

MAXIM

TITLE: PACKAGE OUTLINE, 16,20,28,32,40L THIN QFN, 5x5x0.75mm

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0140	M	2/2