AUDIO Design Guide

11th Edition October 2008

New solutions to portable audio design challenges

Inside

MAXIM 1983 • 2008 25 YEARS OF ENGINEERING SUCCESS

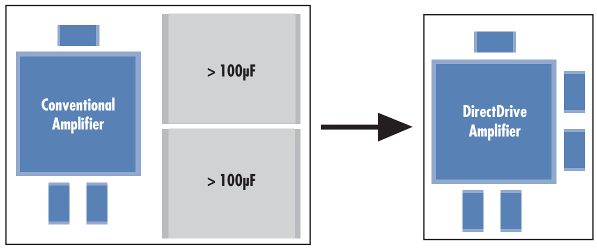
MAXIM

Reducing form factors

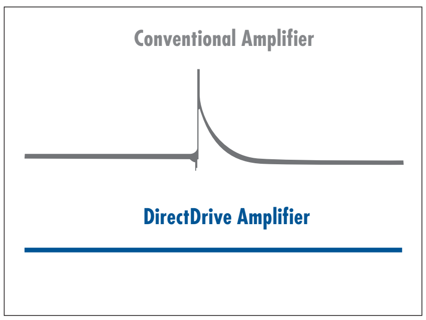
With consumers demanding ever-smaller form factors, the space available for circuitry is continuously decreasing. Compound the decreased size with the increasing complexity of devices, and the space available for each function is shrinking at an amazing rate.

DirectDrive® technology reduces headphone amplifier solution size...

Typical headphone amplifiers require DC-blocking capacitors at each output. Maxim's patented, DirectDrive technology eliminates the need for these capacitors by integrating an inverting charge pump with the headphone amplifier.* The charge pump creates dual power supplies centered around ground, eliminating the need for large DC-blocking capacitors.



DirectDrive technology replaces two large 100µF capacitors with two small 1µF capacitors.



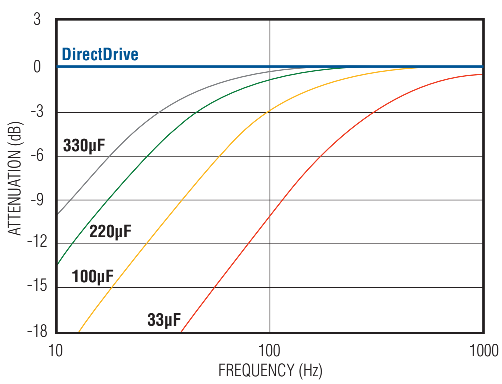
Instead of loud clicks and pops, DirectDrive amplifiers ensure quiet turn on and turn off.

eliminates clicks and pops...

Eliminating DC-blocking capacitors has other advantages besides just saving space. DC-blocking capacitors must be charged every time the amplifier is enabled, which creates an audible click as current is pulled through the headphones. By dispatching of the blocking capacitors, DirectDrive eliminates this major source of clicks and pops.

and improves bass response.

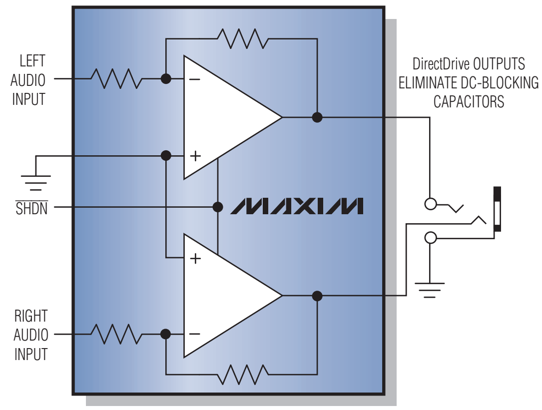
DirectDrive technology also eliminates the highpass filter created by DC-blocking capacitors. Since the capacitors are quite large, many designers choose to sacrifice bass response by using capacitors with less than ideal values. DirectDrive amplifiers eliminate the need for this compromise.



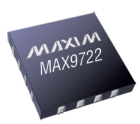
Undersized DC-blocking capacitors noticeably reduce bass output from the system.

*U.S. Patent 7,061,327.
DirectDrive is a registered trademark of Maxim Integrated Products, Inc.

Space-saving, capless headphone amps



High-performance, DirectDrive headphone amplifier



3mm x 3mm x 0.8mm,
16-Pin TQFN

MAX9722

- High output power (130mW)
- Low distortion (0.009% THD+N)
- 2.5V to 5.5V single-supply operation
- Fixed- and adjustable-gain versions

Low-cost, DirectDrive headphone amplifier

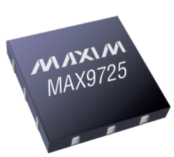
3mm x 3mm x 0.8mm,
12-Pin TQFN

2mm x 1.5mm x 0.6mm,
12-Bump UCSP™

MAX9724

- RF-immune design
- 2.7V to 5.5V single-supply operation
- Low-power (< 0.1µA) shutdown mode
- High PSRR (80dB at 1kHz) eliminates LDO
- Fixed- and adjustable-gain versions

Low-power, DirectDrive headphone amplifier with shutdown



4mm x 4mm x 0.8mm,
12-Pin TQFN

2mm x 1.5mm x 0.6mm,
12-Bump UCSP

MAX9725

- Low power (2.1mA quiescent)
- Lowest click and pop
- 0.9V to 1.8V single-supply operation
- Fixed- and adjustable-gain versions

UCSP is a trademark of Maxim Integrated Products, Inc.

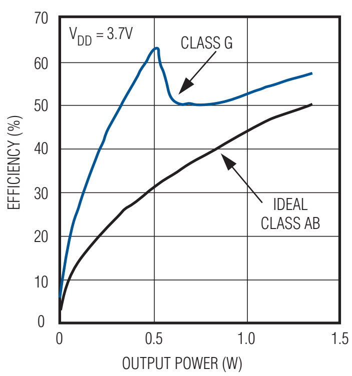
Maximizing sound-pressure level from small form factors

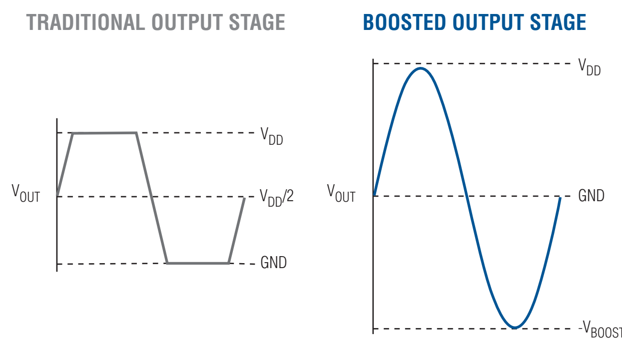
Lithium-ion (Li+) batteries (3.7V, nom) are typically used to power speaker amplifiers in portable applications. While a 3.7V supply is sufficient to run most elements of the system, speaker amplifiers typically require more voltage to generate an acceptable sound-pressure level (SPL).

Innovative boosted amplifiers enable high voltage swing...

Maxim's innovative boosted amplifiers solve the SPL problem by significantly increasing the voltage at the output stage, while operating from a single Li+ battery. They effectively double the SPL and quadruple the output power vs. traditional single-supply linear amplifiers.

CLASS G vs. CLASS AB EFFICIENCY





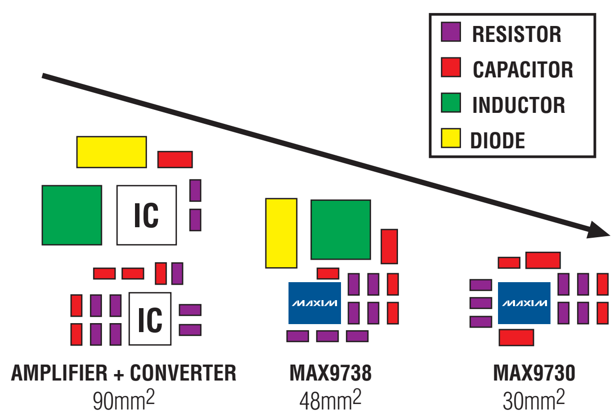
while extending battery life...

Additionally, Class G boosted amplifiers offer improved efficiency over traditional Class AB amplifiers. They integrate a boosted rail that is enabled only when needed—resulting in increased efficiency and longer battery life.

and minimizing solution size.

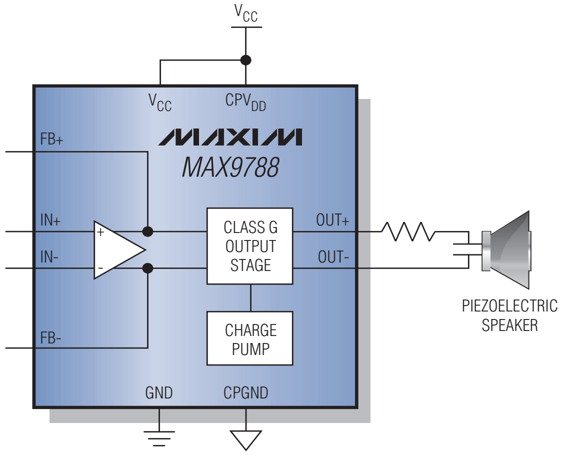
Traditional solutions require the addition of an external DC-DC boost converter to increase the 3.7V supply voltage. This external converter adds cost, complexity, and size to the system.

Boosted amplifiers, however, eliminate the need for this external converter to enable the smallest possible form factor.



Enhance your design with boosted amps

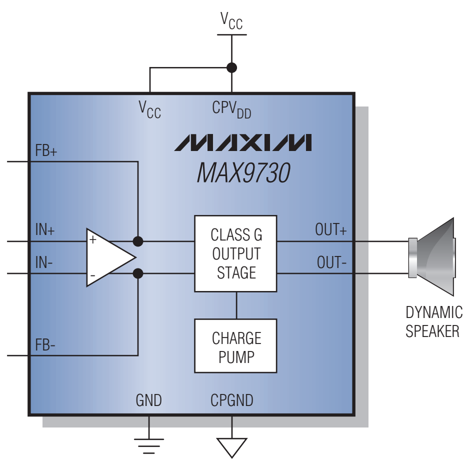
Boosted amplifier for ceramic speaker drive



MAX9788

- Up to $20V_{P-P}$ output swing
- 2.7V to 5.5V single-supply operation
- Low click-and-pop noise
- 2mm x 2.5mm, 20-bump WLP

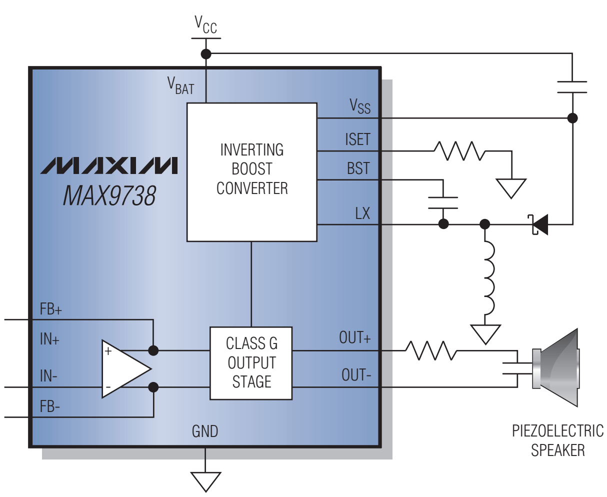
Boosted amplifier for high-output-power, dynamic speaker drive



MAX9730

- 1.3W output power (V_{DD} = 3.7V, R_L = 8Ω)
- 2.4W output power (V_{DD} = 5V, R_L = 8Ω)
- High-efficiency Class G amplifier
- 2.7V to 5.5V single-supply operation
- Low click-and-pop noise
- 2mm x 2.5mm, 20-bump WLP

Boosted amplifier maintains fixed output as battery voltage decays



MAX9738

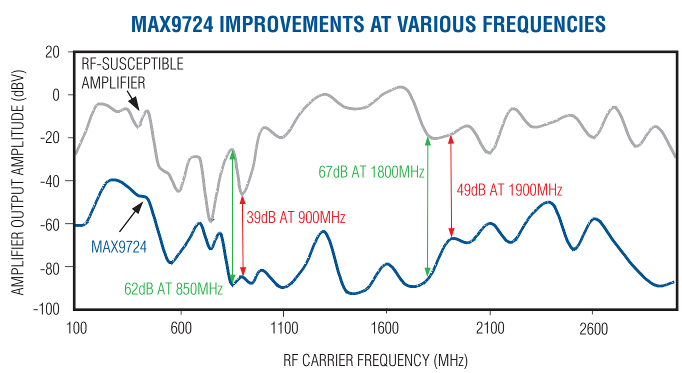
- Up to $16V_{P-P}$ across a ceramic speaker
- Small-profile, 3mm x 3mm x 1mm solution with 2.2µH inductor
- 2.7V to 5.5V single-supply operation
- Low click-and-pop noise
- 2mm x 2.5mm, 20-bump WLP

Enhancing RF immunity in wireless products

Many consumer products are wirelessly enabled, making it critical that each chosen IC, and its application circuit, not pollute the RF environment. Additionally, the IC and application circuit should reject all RF interference.

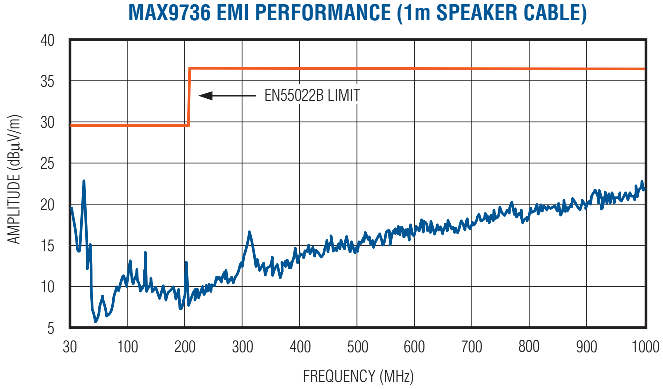

RF-immune audio ICs reject wireless-induced noises, buzzes, and clicks

Considering RF immunity in a modern audio design is as important as PSRR, THD+N, and SNR in the world of cellular phones, MP3 players, and notebook computers. Consumers will not tolerate annoying RF-induced noises, buzzes, and clicks in today's differentiated product offerings. Maxim's extensive process and IC design expertise, coupled with our knowledgeable applications support, enables audio ICs with enhanced RF immunity.



The MAX9724 offers better RF immunity at all carrier frequencies than competitive devices.

Low-EMI Class D audio amplifiers extend battery life



The MAX9736 demonstrates a wide margin to EN55022B EMI limits.

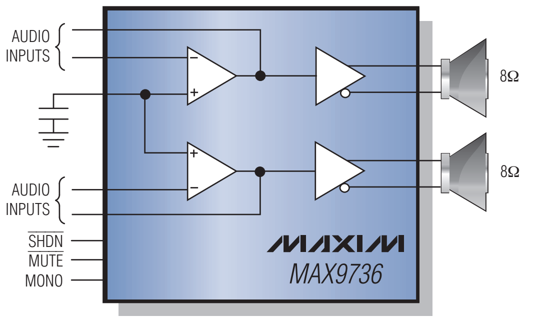
Minimizing supply current is critical for the small batteries used in today's shrinking form factors. Although Class D amplifiers offer the high efficiencies needed to extend battery life, they can contribute to EMI-related RF interference. And, while inductor-capacitor output filters may help reduce this interference, they are costly and bulky.

Maxim's Class D amplifiers use patented spread-spectrum modulation techniques in conjunction with sophisticated edge-rate control technology to minimize EMI emissions.* With no need for LC filters to clean up RF interference, your design will be compact, perform well, and cost less.

*U.S. Patent 6,847,257 (spread-spectrum modulation).

Maxim's audio ICs interfere very little—reject a lot

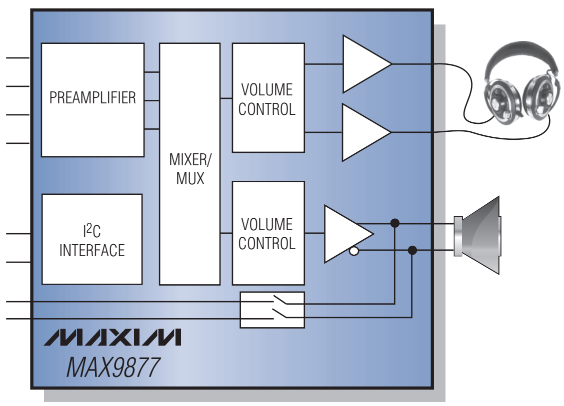
Direct-from-battery, high-efficiency 2 x 15W Class D amplifier



MAX9736

- Wide, 8V to 28V single-supply voltage
- Passes CE EMI limits with low-cost ferrite-bead/capacitor filter
- Integrated input-filter op amps
- Input resistors and capacitors select gain and cutoff frequency

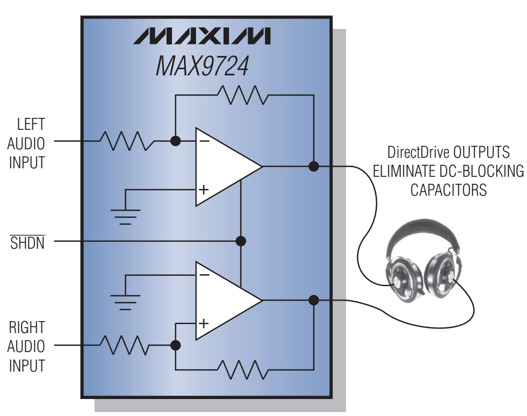
RF-immune audio subsystem with DirectDrive headphone amplifier



MAX9877

- Best-in-class RF immunity (TDMA noise rejection)
- Industry's smallest subsystem
- Filterless 1.2W Class D amplifier with bypass switch
- Achieves > 10dB EN55022B EMI margin in typical application*
- 2.7V to 5.5V single-supply voltage

RF-immune DirectDrive headphone amplifier



MAX9724

- 2.7V to 5.5V single-supply voltage
- DirectDrive technology eliminates output capacitors
- Low system solution cost
- Low click-and-pop noise

*See data sheet for detailed test conditions.

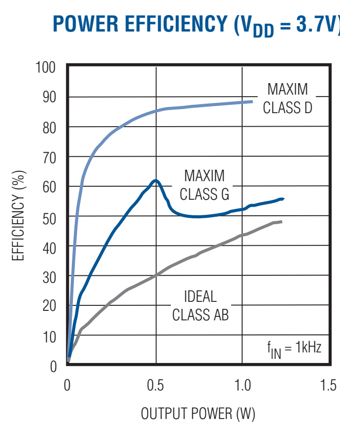
Extending playback time in portable audio applications

Today's portable audio devices must support numerous multimedia functions that put a strain on battery life, reducing audio playback time. Proper amplifier selection can significantly improve system efficiency, allowing designers to deliver a richer multimedia experience.

Efficient speaker amplifier technology increases playback time

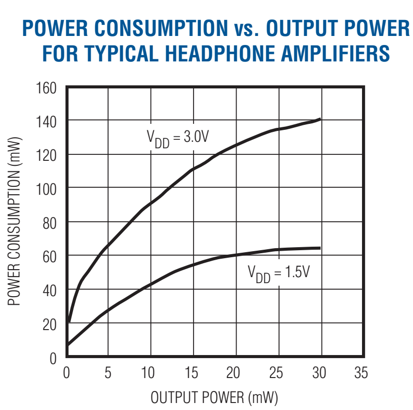
Whereas conventional Class AB amplifiers offer efficiencies in the 30% to 50% range, Class D amplifiers employ a pulse-width modulation (PWM) scheme to achieve 80% to 90% efficiency, greatly increasing playback time.

A boosted amplifier may be needed in applications that require high output-voltage swing. Maxim's boosted Class G products offer an efficiency improvement of up to 30% over conventional Class AB amplifiers.



This graph shows the efficiency of common amplifier classes.

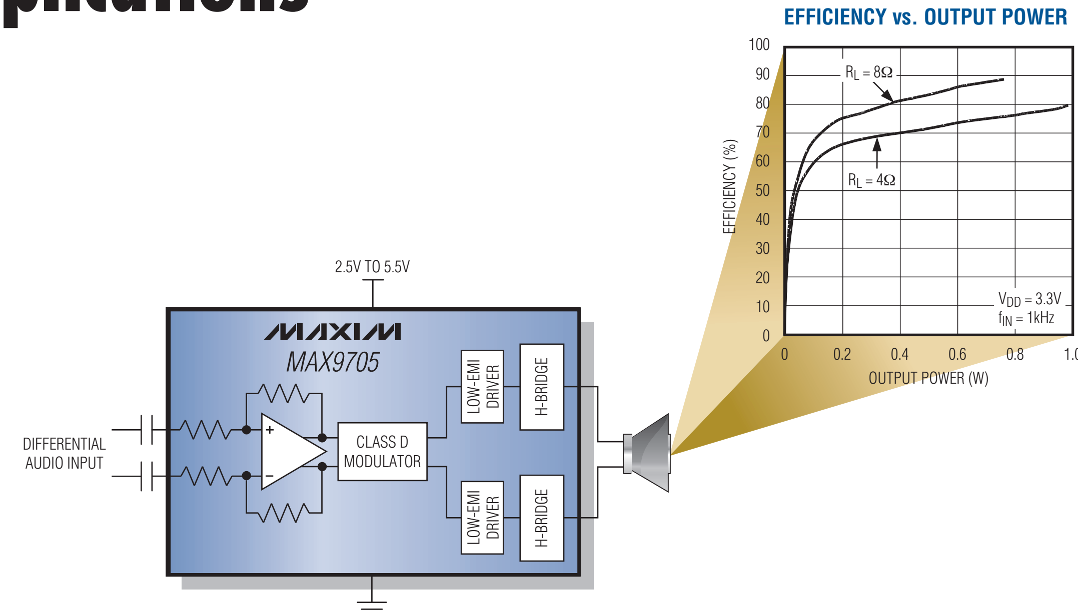
Decrease power consumption by reducing the supply voltage



Power consumption is reduced by lowering the supply voltage from 3.0V to 1.5V.

The power consumption of audio circuitry decreases with a reduction in supply voltage. A circuit's quiescent current does not change much with supply voltage. Powering circuitry from a lower supply voltage immediately improves power consumption. Typical portable applications have a 1.8V supply available, which is perfect for powering low-voltage headphone amplifiers.

Efficient audio amplifiers for portable applications



High-efficiency, filterless Class D amplifier

1.5mm x 2mm x 0.6mm,
12-Bump UCSP

MAX9705

- High output power: 2.3W into 4Ω
- No EMI filters needed
- Active edge-rate control circuitry

Low-voltage, low-power DirectDrive headphone amplifier

1.5mm x 2mm x 0.6mm,
12-Bump UCSP

MAX9725

- Low supply voltage: 0.9V to 1.8V
- Internal gain network increases RF immunity
- Low power consumption: 3.78mW with a 1.8V supply
- Eliminates the need for DC-blocking capacitors

High output-voltage swing boosted amplifiers

2mm x 2.5mm,
20-Bump WLP

MAX9788/MAX9730

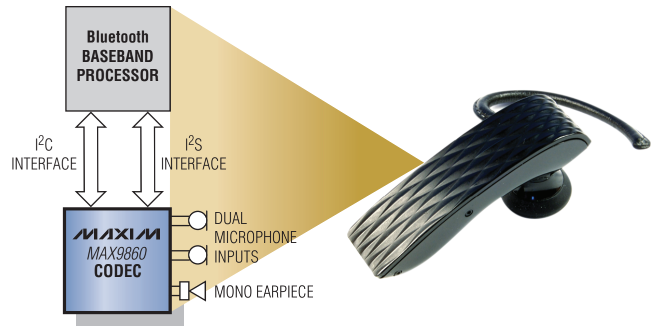
- Class G operation provides higher efficiency when compared to a Class AB amplifier
- Output swing perfect for driving ceramic speakers (MAX9788)
- High output power: 2.4W into 8Ω (MAX9730)

Enabling accessory solutions

Consumers increasingly demand accessory solutions that offer more features and longer battery life in smaller form factors, making component selection a key consideration for accessory designers. Finding more efficient, smaller, and targeted devices is crucial to the success of accessory products in today's market.

Targeted audio codec adds value to Bluetooth headsets

Today's Bluetooth® headsets need to perform well in any situation. Features like automatic gain control, noise reduction, and long battery life are crucial to creating a robust solution. Maxim combines all of these features with ultra-low power consumption and UCSP packaging technology to create devices that are perfect for today's Bluetooth headset market.



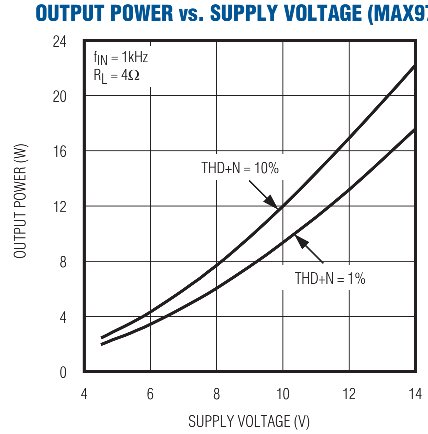
Filterless Class D amplifiers enable smaller, thinner docking stations

Docking station amplifiers must live up to the performance standards of today's consumers while getting smaller and thinner. Maxim's patented filterless, spread-spectrum modulation scheme eliminates large output filters while maintaining industry-leading efficiency. Without requiring bulky heatsinks, these Class D amplifiers deliver the power that consumers expect while enabling extremely small form factors.

Flexible supply range allows battery or wall-power operation

Docking stations need to achieve high output power, regardless of whether they use batteries or wall power. In order to achieve this performance, an amplifier must be able to take full advantage of a wide supply range while maintaining high efficiency. This capability allows docking stations to be small and loud whether operating from battery power or plugged into the wall.

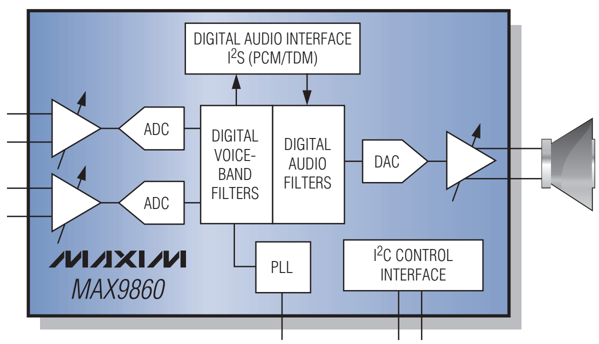
OUTPUT POWER vs. SUPPLY VOLTAGE (MAX9744)



Bluetooth is a registered trademark of Bluetooth SIG, Inc.

Flexible devices for accessory solutions

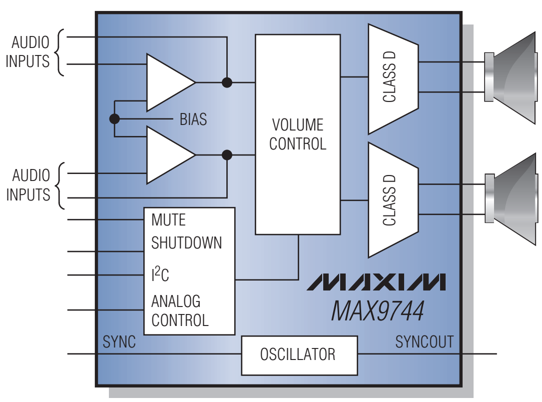
16-bit, mono audio codec for digital headsets



MAX9860

- Low power: 4.5mW (48kHz DAC playback)
- Two low-noise microphone inputs
- One speaker amplifier
- I^2C control interface, I^2S digital audio interface
- Integrated voice filters, automatic gain control, and noise gate

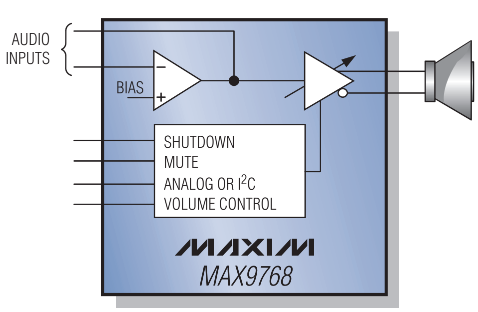
20W, stereo Class D speaker amplifier with volume control



MAX9744

- Wide, 4.5V to 14V power-supply range
- Filterless, low-EMI modulation scheme
- Integrated volume control (I^2C or analog)
- High 93% efficiency eliminates bulky heatsinks
- High 75dB PSRR, low 0.04% THD+N

10W, mono Class D speaker amplifier with volume control



MAX9768

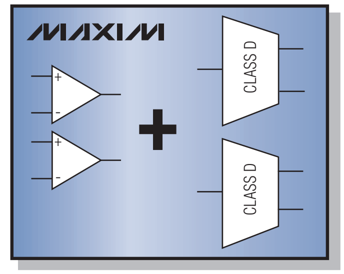
- Wide, 4.5V to 14V power-supply range
- Filterless, low-EMI modulation scheme
- Integrated volume control (I^2C or analog)
- High 87% efficiency eliminates bulky heatsinks
- High 77dB PSRR, low 0.08% THD+N

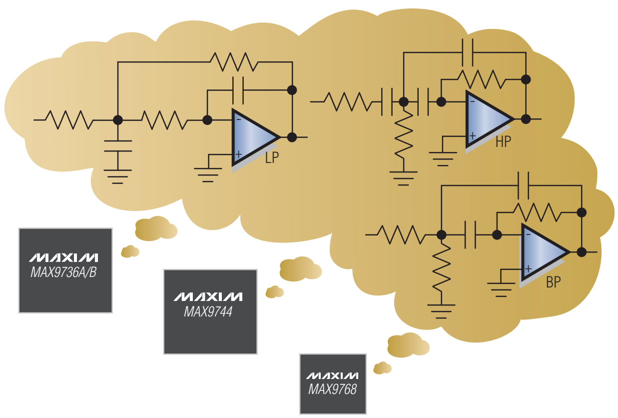
Addressing equalization problems

As the form factors for speakers continue to get smaller, equalization has become a pressing problem for audio designers. Amplifier solutions that provide flexible filtering options can help designers meet the performance demands of these space-constrained applications.

Active speaker equalization and filtering offer...

The MAX9736A/B, MAX9744, and MAX9768 offer both power and flexibility to the audio-speaker system designer. In addition to providing high-efficiency Class D amplifiers, they integrate operational amplifiers that can be used for active speaker equalization and filtering.



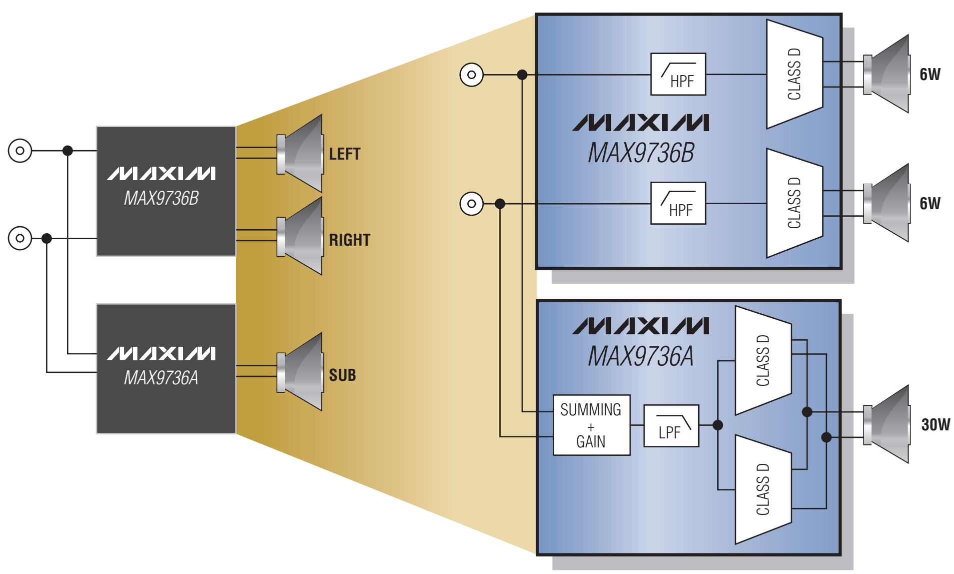


higher performance in less space...

The uncommitted operational amplifiers enable the creation of active filters to address the growing equalization problems of small speaker drivers in ever-shrinking enclosures. The inverting and output pins of each operational amplifier are accessible to the designer, enabling many possible filter configurations such as highpass (HP), lowpass (LP), bandpass (BP), and summing.

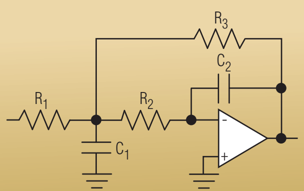
and greater flexibility.

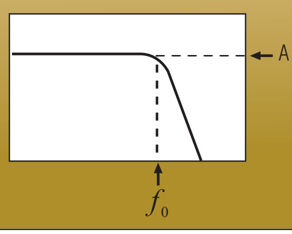
The MAX9736A and MAX9736B also feature a mono mode, which allows the outputs to be connected in parallel for higher output-current drive in lower-impedance loads. This capability maximizes system flexibility, enabling the MAX9736A/B to be combined to form a complete 2.1 system with active crossover.



Reference sheet for MFB topology LP, HP, BP filters

LOWPASS





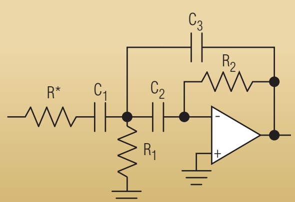
$$T(s) = -A\frac{\omega_o^2}{s^2+\alpha\omega_o s+\omega_o^2}$$

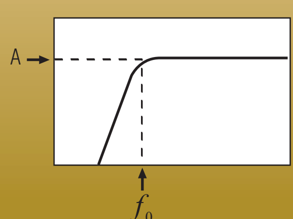
$$\frac{V_o}{V_i} = \frac{-A\left(\dfrac{1}{C_1C_2R_2R_3}\right)}{s^2+s\dfrac{1}{C_1}\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)+\dfrac{1}{C_1C_2R_2R_3}}$$

$$\alpha = \frac{1}{Q} \qquad C_1 = C_2\frac{4}{\alpha^2}(A+1) \qquad R_1 = \frac{\alpha}{4\pi f_0 A C_2}$$

$$R_2 = \frac{\alpha}{(A+1)4\pi f_0 C_2} \qquad R_3 = \frac{\alpha}{4\pi f_0 C_2}$$

HIGHPASS





$$T(s) = -A\frac{s^2}{s^2+\alpha\omega_o s+\omega_o^2}$$

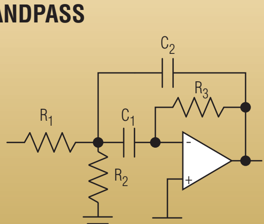
$$\frac{V_o}{V_i} = \frac{-s^2\left(\dfrac{C_1}{C_3}\right)}{s^2+s\dfrac{(C_1+C_2+C_3)}{C_2C_3R_2}+\dfrac{1}{C_2C_3R_1R_2}}$$

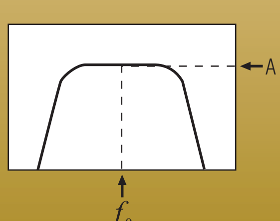
$$\alpha = \frac{1}{Q} \qquad C_2 = C_1 \qquad C_3 = \frac{C_1}{A}$$

$$R_1 = \frac{\alpha}{\left(2+\dfrac{1}{A}\right)2\pi f_0 C_1} \qquad R_2 = A\frac{\left(2+\dfrac{1}{A}\right)}{2\pi f_0 \alpha C_1}$$

*Resistor needed to minimize capacitive loading caused by the filter stage—typ value is on the order of 470Ω.

BANDPASS





$$T(s) = -A\frac{\omega_o s}{s^2+\alpha\omega_o s+\omega_o^2}$$

$$\frac{V_o}{V_i} = \frac{-s\left(\dfrac{1}{R_1C_2}\right)}{s^2+s\dfrac{(C_1+C_2)}{C_1C_2R_3}+\dfrac{1}{C_1C_2R_3}\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}\right)}$$

$$\alpha = \frac{1}{Q} \qquad C_2 = C_1 \qquad R_2 = \frac{1}{(2Q-A)2\pi f_0 C_1}$$

$$R_1 = 2\pi f_0 A C_1 \qquad R_3 = \frac{Q}{\pi f_0 C_1}$$

Audio selector guide

Capless, DirectDrive headphone amplifiers

Part	Supply Voltage (V)		Supply Current (mA)	Output Offset (mV)	Output Power at 1% THD+N (W)		Features	Package (mm x mm)
	Min	Max			32Ω	16Ω		
MAX9725	0.9	1.8	2.1	0.3	20	25	Lowest quiescent current	12-TQFN (4 x 4), 12-UCSP (1.5 x 2)
MAX9723	1.8	3.6	4.0	0.7	59	60	Bass boost, I^2C volume	16-TQFN (4 x 4), 16-UCSP (2 x 2)
MAX9729	1.8	3.6	5.5	0.7	52	49	Three stereo inputs, bass boost	28-TQFN (5 x 5)
MAX4409	1.8	3.6	5.0	0.5	65	80	Ground-noise rejection	20-TQFN (4 x 4)
MAX4410/11	1.8	3.6	5.0	0.5	65	80	Ultra-low distortion	16-UCSP (2 x 2), 20-TQFN (4 x4)
MAX9722	2.4	5.5	5.5	0.5	130	70	Differential inputs	16-TQFN (3 x 3)
MAX9724	2.7	5.5	3.5	1.5	63	42	Lowest RF susceptibility	12-TQFN (3 x 3), 12-UCSP (1.5 x 2)
MAX9726	2.7	5.5	5.5	3.0	104	124	Bass boost, I^2C volume	20-TQFN (4 x 4), 20-UCSP (2 x 2.5)
MAX9728	4.5	5.5	3.5	1.5	63	42	Low system cost	12-TQFN (3 x 3)

Low-power, linear speaker amplifiers

Part	Supply Voltage (V)		Output Power at 1% THD+N (W)		Features		Package (mm x mm)
	Min	Max	32Ω	16Ω	Gain	Other	
MAX9716/17	2.7	5.5	1.1	1.4	Adjustable/fixed	Headphone sense	8-TDFN (3 x 3), 9-UCSP (1.5 x 1.5)
MAX9718	2.7	5.5	1.1	1.4	Adjustable/fixed	Differential inputs	10 -TDFN (3 x 3), 9-UCSP (1.5 x 1.5)
MAX9719	2.7	5.5	2 x 1.1	2 x 1.4	Adjustable/fixed	Differential inputs	10 -TDFN (3 x 3), 9-UCSP (1.5 x 1.5)
MAX9730	2.7	5.5	2.4	—	Adjustable	Charge-pump boosted amplifier for dynamic speakers	28-TQFN (4 x 4), 20-UCSP (2 x 2.5)
MAX9738	2.7	5.5	$16V_{P-P}$	$16V_{P-P}$	Adjustable	DC-DC boosted amplifier for ceramic speakers	20-UCSP (2 x 2.5)
MAX9788	2.7	5.5	$14V_{P-P}$	$14V_{P-P}$	Adjustable	Charge-pump boosted amplifier for ceramic speakers	28-TQFN (4 x 4), 20-UCSP (2 x 2.5)
MAX9710	4.5	5.5	2 x 1.4	2 x 2.6	Adjustable	Mute	20-TQFN (5 x 5)
MAX9711	4.5	5.5	1.4	2.6	Adjustable	Mute	12-TQFN (4 x 4)

Low-power, Class D speaker amplifiers (filterless)

Part	Supply Voltage (V)		Output Power at 1% THD+N (W)		Features			Package (mm x mm)
	Min	Max	8Ω	4Ω	Spread-Spectrum Modulation/ Edge-Rate Control	Gain	Differential Input	
MAX9705	2.5	5.5	1.3	2.3	✓/✓	Fixed	✓	10-TDFN (3 x 3), 12-UCSP (1.5 x 2)
MAX9773	2.5	5.5	2 x 1.3	2 x 1.8	✓/✓	Pin programmable	✓	24-TQFN (4 x 4), 20-UCSP (2 x 2.5)
MAX9830	2.6	5.5	1.2	2	✓/✓	Fixed	✓	8-TDFN (2 x 2), 9-WLP (1.2 x 1.2)
MAX9759	3.0	5.5	1.4	2.6	✓/—	Pin programmable	✓	16-TQFN (4 x 4)
MAX9715	4.5	5.5	2 x 1.4	2 x 2.3	✓/—	Pin programmable		16-TQFN (5 x 5)

High-power, Class D speaker amplifiers

Part	Supply Voltage (V)		Output Power at 1% THD+N (W)		Features		Package (mm x mm)
	Min	Max	8Ω	4Ω	Gain	Other	
MAX9744	4.5	14	2 x 13	2 x 20	Set by external resistors	I^2C/analog volume control	44-TQFN (7 x 7)
MAX9768	4.5	14	10	9.5	Set by external resistors	I^2C/analog volume control	24-TQFN (4 x 4), 20-UCSP (2 x 2.5)
MAX9736A	8	28	2 x 15	30	Set by external resistors	Mute function	32-TQFN (7 x 7)
MAX9736B	8	28	2 x 6	12	Set by external resistors	Mute function	32-TQFN (7 x 7)
MAX9703	10	25	15	10	Pin programmable	Differential input	32-TQFN (5 x 5)
MAX9708	10	18	2 x 20	40	Pin programmable	Programmable thermal flag	56-TQFN (8 x 8)
MAX9709	10	22	2 x 25	50	Pin programmable	Programmable thermal flag	56-TQFN (8 x 8)
MAX9713	10	25	6	—	Pin programmable	Differential input	32-TQFN (5 x 5)
MAX9714	10	25	2 x 6	—	Pin programmable	Differential input	32-TQFN (7 x 7)
MAX9742	20	40	2 x 20	2 x 16	Set by external resistors	Single-ended output	36-TQFN (6 x 6)

Integrated audio subsystems

Part	Supply Voltage (V)		Output Power at 1% THD+N				Features			Package (mm x mm)
	Min	Max	HP 32Ω (mW)	HP 16Ω (mW)	SP 8Ω (W)	SP 4Ω (W)	Gain/Volume Control	Speaker Amplifier	Other	
MAX9775	2.7	5.5	50	60	2 x 1.1	2 x 1.5	I^2C	Stereo Class D	6 single-ended or 3 differential audio inputs, 3-D sound	36-UCSP (3 x 3)
MAX9776	2.7	5.5	50	60	1.1	1.5	I^2C	Mono Class D		36-UCSP (3 x 3), 32-TQFN (5 x 5)
MAX9796	2.7	5.5	50	60	1.3	2.3	I^2C	Mono Class D		32-TQFN (5 x 5)
MAX9791	2.7	5.5	180	100	2 x 1.2	2 x 1.7	Adjustable	Stereo Class D	Wake-on-beep, ground sense, integrated LDO	28-TQFN (4 x 4)
MAX9792	2.7	5.5	180	100	1.5	2.5	Adjustable	Mono Class D		
MAX9877	2.7	5.25	27	53	0.725	0.825	I^2C	Mono Class D	2 stereo or 2 mono differential audio inputs	20-WLP (2 x 2.5)
MAX9706	4.5	5.5	50	95	3 x 1.4	3 x 2.3	Pin programmable	Triple Class D	Integrated 2.1 crossover	36-TQFN (6 x 6)
MAX9707	4.5	5.5	—	—	3 x 1.4	3 x 2.3	Pin programmable	Triple Class D	Integrated 2.1 crossover	36-TQFN (6 x 6)
MAX9789	4.5	5.5	55	100	2 x 1	2 x 2	Pin programmable	Stereo Class AB	Integrated LDO	32-TQFN (5 x 5)

Microphone amplifiers with integrated mic bias

Part	Supply Voltage (V)		Supply Current (µA)	Input-Noise Voltage Density ($nV/\sqrt{Hz}$)	Inputs		Gain (dB)	Shutdown	Package (mm x mm)
	Min	Max			Single Ended	Differential			
MAX9810	2.3	5.5	670	16	1	—	24, 27, 30		4-UCSP (1 x 1)
MAX4060	2.4	5.5	750	20	1	1	Adjustable		8-TQFN (3 x 5)
MAX4061	2.4	5.5	750	20	1	1	0, 20, 40		8-TQFN (3 x 5)
MAX4063	2.4	5.5	750	70	1	1	Adjustable		16-TQFN (4 x 4)
MAX4465/66	2.4	5.5	24	80	—	1	Adjustable	✓	5-SC70 (2 x 2), 5-SOT23 (3 x 3)
MAX9814	2.7	5.5	3100	30	1	—	Automatic gain control	✓	14-TDFN (3 x 3)
MAX9812L/13L	2.7	4.5	230	40	2	—	20	✓	6-SC70 (2 x 2.1) (MAX9812)
MAX9812H/13H	3.6	5.5							8-SOT23 (3 x 3) (MAX9813)

Audio data converters

Part	Supply Voltage (V)				48kHz DAC Playback Power Consumption (mW)	Playback Dynamic Range (dB)	Features				Package (mm x mm)
	Core		I/O				Analog I/O	Digital Audio Interface	MCLK Range (MHz)	Supported Sample Rates (kHz)	
	Min	Max	Min	Max							
MAX9867 (Codec)	1.65	1.95	1.65	3.6	5.5	92	2 line inputs, 2 mic inputs, 2 headphone amps, 1 aux ADC	I^2S/TDM	10 to 60	8 to 48	30-WLP (2 x 2.5), 32-TQFN (5 x 5)
MAX9856 (Codec)	1.7	3.6	1.7	3.6	9	91	3 line inputs, 3 mic inputs, 2 line outputs, 2 headphone amps	I^2S/TDM	10 to 60	8 to 96	40-TQFN (6 x 6)
MAX9860 (Codec)	1.7	1.9	1.7	3.6	4.5	90	2 mic inputs, 1 headphone amp	I^2S/TDM	10 to 60	8 to 48	24-TQFN (4 x 4)
MAX9850 (DAC)	1.8	3.6	1.8	3.6	10.1	91	2 line inputs, 2 line outputs, 2 headphone amps	I^2S	8.5 to 40	8 to 48	28-TQFN (5 x 5)
MAX9851 (Codec)	2.6	3.3	1.7	3.3	26	88	2 line inputs, 3 mic inputs, 2 speaker amps, 2 headphone amps	Dual I^2S/TDM	13 or 26	8 to 48	48-TQFN (7 x 7)
MAX9853 (Codec)	2.6	3.3	1.7	3.3	26	88	2 line inputs, 3 mic inputs, 2 line outputs, 2 headphone amps	Dual I^2S/TDM	13 or 26	8 to 48	48-TQFN (7 x 7)

Specialty audio devices

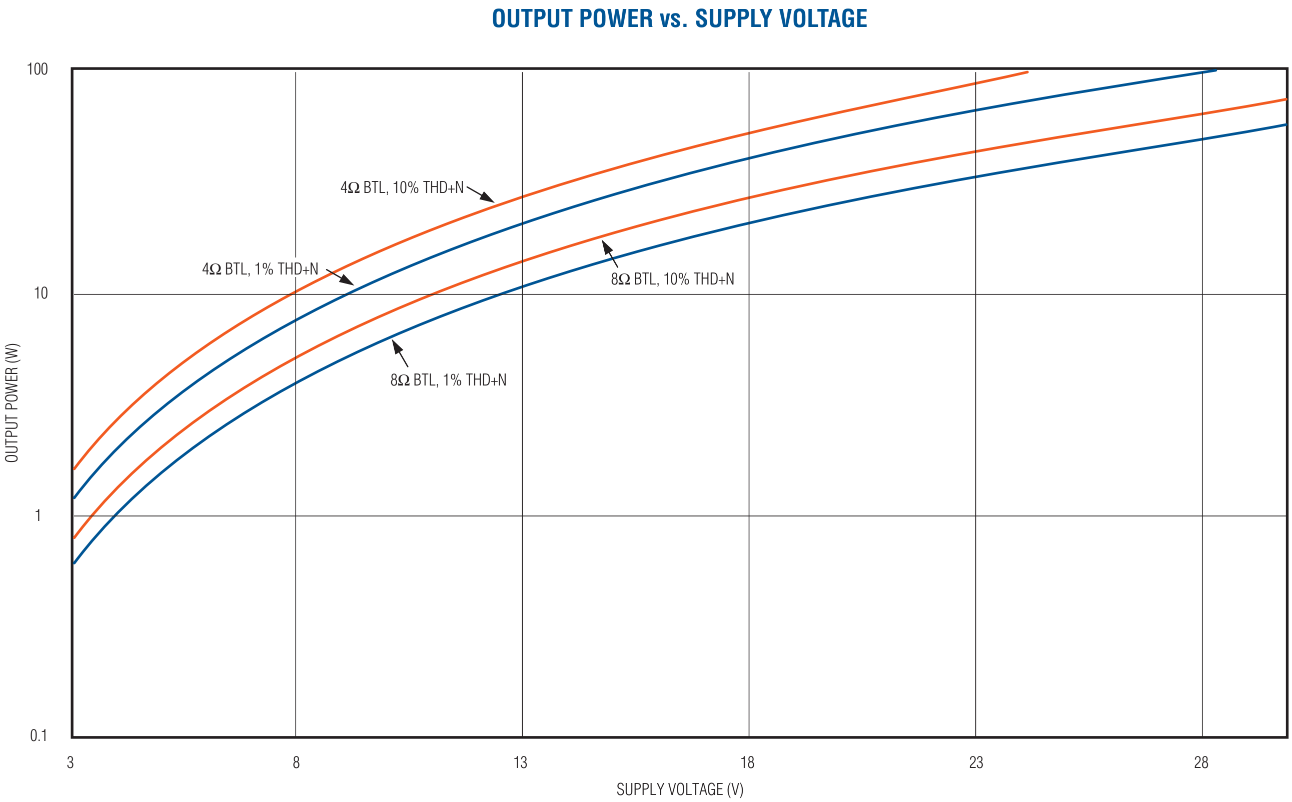
Part	Description	Supply Voltage (V)		Package (mm x mm)
		Min	Max	
MAX9892	Audio shunt-mode click-and-pop suppressor	1.7	5.5	6-UCSP (1 x 1.5), 6-µDFN (2 x 2)
MAX9890	Headphone-amplifier click-and-pop suppressor	2.7	5.5	8-TDFN (3 x 3), 9-UCSP (1.5 x 1.5)
MAX4744	Dual SPDT audio switch	1.8	5.5	10-UDFN (2 x 2)
MAX4764	Dual SPDT audio switch	1.8	5.5	10-TDFN (3 x 3), 10-UCSP (1.5 x 2)
MAX4993/94	DPDT audio switch	1.8	5.5	10-UTQFN (1.4 x 1.8)

Audio application notes

App Note 4164	Amplifier Considerations in Ceramic Speaker Applications
App Note 4121	Class G and Charge-Pump Technologies Maximize Efficiency in Boosted Amplifiers with Minimal Support Components
App Note 4079	Minimize Noise in Audio Channels with Smart PCB Layout
App Note 4046	Overview of 2.1 (Satellite/Subwoofer) Speaker Systems
App Note 3979	Overview of DirectDrive Technology
App Note 3977	Class D Amplifiers: Fundamentals of Operation and Recent Developments
App Note 3973	Maxim's Active-Emissions-Limiting Circuitry Demystified
App Note 3881	Spread-Spectrum-Modulation Mode Minimizes Electromagnetic Interference in Class D Amplifiers
App Note 3880	Minimizing RF Susceptibility in Cell-Phone Headphone Amplifiers
App Note 3877	ALC Improves Sound Quality While Protecting Speakers
App Note 3878	Reduce EMI from Class D Amplifiers Using New Modulation Techniques and Filter Architectures
App Note 3879	Thermal Considerations for a Class D Amplifier
App Note 3735	Audio-DAC Performance Investigation
App Note 3687	Quantitative Analysis Yields Objective Measurement for Audio Amplifier Click and Pop
App Note 3354	DirectDrive Technology Enables 2V_{RMS} Audio Line Driver from a Single 3.3V Supply
App Note 1762	A Beginners Guide to Filter Topologies

Theoretical output power

The following figures show the theoretical output power possible from a range of supply voltages. Output power is specified at 1% and 10% THD+N with 4Ω and 8Ω loads. Real amplifiers will always output less power than shown in these figures.



Glossary of common audio terms

Active-Emissions Limiting: Active-emissions-limiting technology greatly reduces EMI emissions by actively controlling the output-FET gate transitions under all possible transient output-voltage conditions. The edge rate of each gate transition is intelligently controlled such that the near rail-to-rail swing and the fast switching frequency contribution to emissions is reduced with as little impact on amplifier efficiency as possible.

A-Weighting: A standard weighting curve applied to audio measurements, A-weighting is designed to reflect the response of the human ear. Sound-pressure levels derived using A-weighting are denoted by "dBA," or A-weighted dB levels.

BTL: A bridge-tied load (BTL) is an amplifier configuration that creates twice the output-voltage swing and, thus, provides four times the output power than that possible with a single amplifier output. The load (a speaker, in this case) is connected between two audio amplifier outputs. The second amplifier inverts the first amplifier's output, thereby doubling the output-voltage swing and quadrupling the output power.

Class A: The simplest type of amplifier, Class A amplifiers are those in which the output transistors conduct (i.e., do not fully turn off) irrespective of the output-signal waveform. This type of amplifier is typically associated with high linearity but low efficiency.

Class B: Class B amplifiers are those in which the output transistors only conduct during half (180 degrees) of the signal waveform. To amplify the entire signal, they use two transistors, one conducting for positive output signals and the other conducting for negative outputs. Class B amplifiers are much more efficient than Class A amplifiers, but they have high distortion due to the crossover point when the two transistors transition from on to off.

Class AB: Class AB amplifiers combine Class A and Class B to form an amplifier with more efficiency than Class A but with lower distortion than Class B. This performance is achieved by biasing both transistors to conduct near zero signal output—the point where Class B amplifiers introduce nonlinearities. They then transition to Class B for large excursions. Thus, for small signals, both transistors are active, acting like a Class A amplifier. For large signal excursions, only one transistor is active for each half of the waveform, acting like a Class B amplifier.

Class D: Class D amplifiers are those that output a switching waveform at a frequency far higher than the highest audio signal that needs to be reproduced. The lowpass-filtered, average value of this waveform corresponds to the actual required audio waveform. These amplifiers are highly efficient (often up to 90% or higher) because the output transistors are either fully turned on or off during operation. This approach completely eliminates the use of the linear region of the transistor, which is responsible for the inefficiency of other amplifier types. Modern Class D amplifiers achieve fidelity comparable to Class AB.

Class G: Class G amplifiers are similar to Class AB amplifiers except that they use two or more supply voltages. When operating at low signal levels, the amplifier uses a lower supply voltage. As the signal level increases, the amplifier automatically selects the appropriate supply voltage. Class G amplifiers are more efficient than Class AB amplifiers because they use the maximum supply voltage only when required, while a Class AB amplifier always uses the maximum supply voltage.

Class H: Class H amplifiers modulate the supply voltage to the amplifier output devices so that it is never higher than necessary to support the signal swing. This technique reduces dissipation across the output devices connected to that supply, allowing the amplifier to operate with an optimized Class AB efficiency regardless of output-power level. Class H amplifiers are generally more complex than other designs, with extra control circuitry required to predict and control the supply voltage.

DirectDrive: This proprietary technology employs an integrated charge pump to invert the positive supply, thereby creating an internal negative supply voltage. This architecture allows the amplifier outputs to be biased at ground, thus eliminating the need for bulky DC-blocking capacitors. DirectDrive technology almost doubles the dynamic range of the amplifier, enabling it to provide $2V_{RMS}$ from as little as 3.3V.

Filterless Modulation: Maxim's Class D amplifiers utilize advanced, "filterless" modulation schemes to save board space and reduce solution cost. Through filterless modulation, the Class D amplifier's outputs idle with largely in-phase signals. Since there is little or no differential voltage applied across the load, this approach minimizes quiescent power consumption without the need for an external filter.

PSRR: The power-supply rejection ratio (PSRR) measures the ability of an amplifier to maintain its output voltage as its power-supply voltage is varied.

SNR: Signal-to-noise ratio (SNR) is the ratio of the amplitude of the desired signal to the amplitude of noise signals at a given point in time. The larger the number, the better. SNR is usually expressed in dB.

Spread-Spectrum Modulation: A technology that modulates a signal over many carrier frequencies at once, spread-spectrum modulation can be used to make transmissions more secure, reduce interference, and improve bandwidth-sharing. Spread-spectrum techniques can also be used to reduce electromagnetic interference (EMI) by dithering the clock frequency so that emissions are no longer concentrated at one frequency.

THD+N: Total harmonic distortion plus noise (THD+N) is the sum of the two most important distortion components. THD is the distortion that occurs on harmonics of the original signal—it is correlated with the signal. Noise is the more random, uncorrelated distortion. THD+N is their sum.

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