A7010

1.3W Mono ClassAB Audio Power Amplifier

1.3 Watt Audio Power Amplifier

FEATURES

- 2.7V - 5.5V operation
- Power output at 5.0V & 1% THD 1.3W (typ)
- Power output at 3.6V & 1% THD 0.7W (typ)
- Ultra low shutdown current 0. 1 µA (typ)
- Improved pop & click circuitry eliminates noises during turn-on and turn-off transitions
- Thermal overload protection circuitry
- No output coupling capacitors, bootstrap capacitors required
- Unity-gain stable
- External gain configuration capability
- Available in space-saving packages: WLCSP9
  RoHS compliant and 100% lead (Pb)-free

CSP9 Package
1.5mm x1.5mm

APPLICATIONS

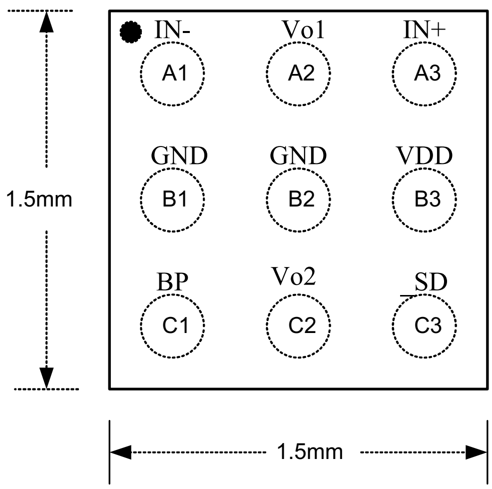
- Wireless handsets
- Portable audio devices
- PDAs
- Digital Camera

Description

The A7010 is an audio power amplifier designed for demanding audio applications. It is capable of delivering 1.3 watt of continuous average power to an 8Ω BTL load with less than 1% distortion (THD+N) from a 5V battery voltage. It operates from 2.7V to 5.5V.

Features like excellent RF-rectification immunity, the space-saving CSP9 packages, the advanced pop & click circuitry, a minimal count of external components and low-power shutdown mode make A7010 ideal for wireless handsets and other portable device.

CONNECTION DIAGRAMS (Top view)



WLCSP Pin definition

Pin Definition

CSP9	Symbol	Description
C3	SD	Shutdown Pin, active low.
C1	BP	Bypass pin, Common mode voltage. The value is about VDD/2.
A3	IN+	Positive differential input.
A1	IN-	Negative differential input.
A2	VO1	Negative differential output.
B3	VDD	Power supply.
B1,B2	GND	Ground.
C2	VO2	Positive differential output.

Typical Application Circuit

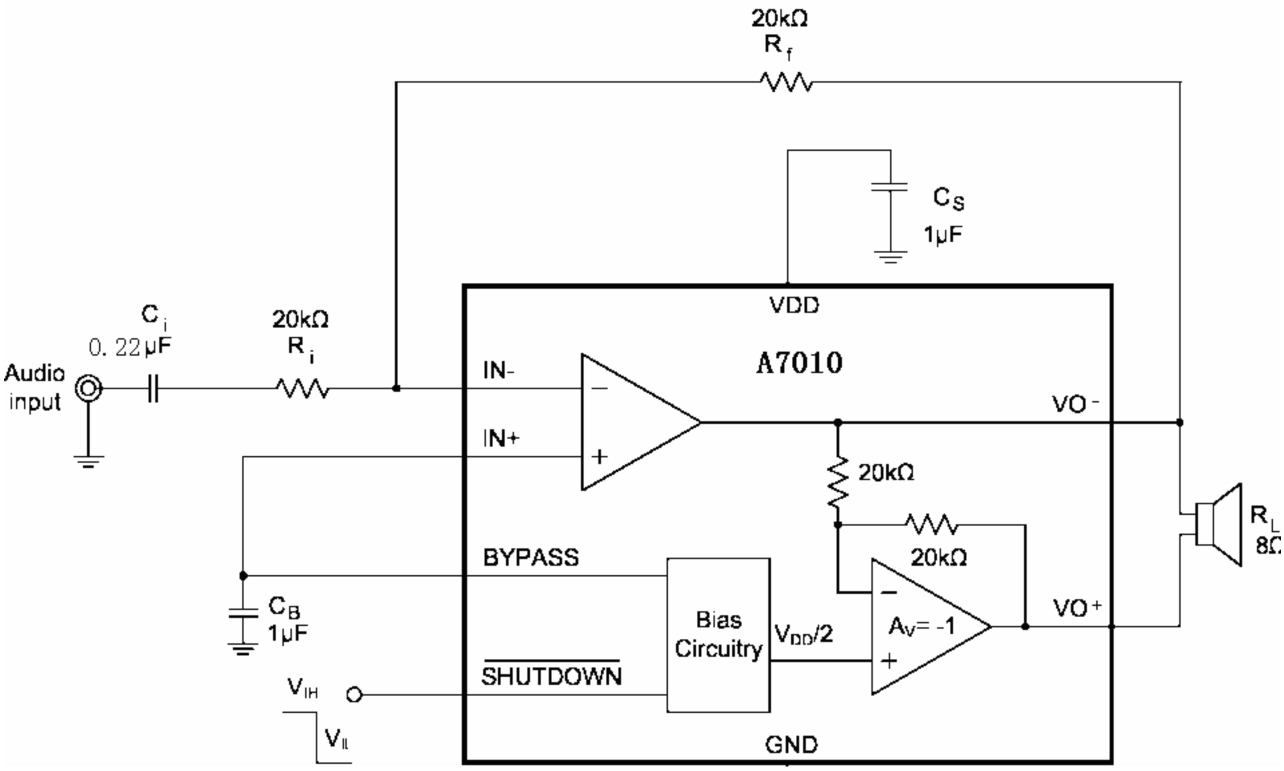


Figure 1. Single-Ended Input application Circuit

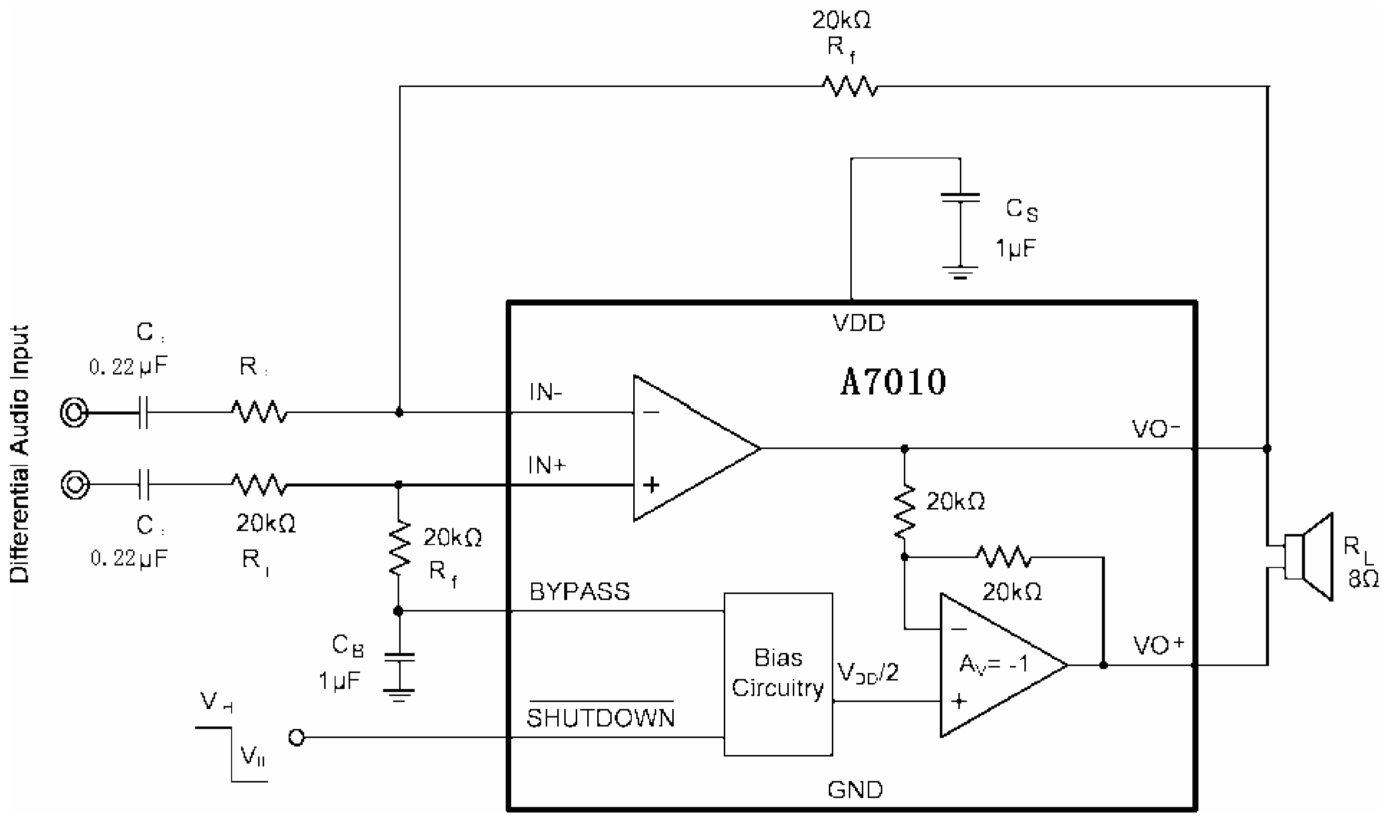


Figure 2. Differential Input application Circuit

External Components Description

Components	Functional Description
Ri	Inverting input resistance which sets the closed-loop gain in conjunction with Rf..
Ci	Input coupling capacitor which blocks the DC voltage at the amplifiers input terminates. Also creates a high-pass filter with Ri at fc =1/(2πRi*Ci).
Rf	Feedback resistance which sets the closed-loop gain in conjunction with Ri.
Cs	Supply bypass capacitor which provides power supply decoupling.
C_B	Bypass pin capacitor which provides half-supply filtering.

Ordering Information

Order Number	Temperature Range	Package	RoHS	Marking	Shipping Type
A7010M	-40°C~85 °C	CSP9	Y	AAM	3000 pcs / Tape & Reel

Absolute Maximum Ratings[1]

Parameter	Unit
Supply voltage (VDD)	-0.3V to 6.0V
Input voltage	-0.3V to VDD+0.3V
Power dissipation[2]	Internally Limited
PackageThermal Resistance θ_{JA}(CSP9)	180ºC /W
Maximum Junction Temperature	150ºC
Storage Temperature Range	-65ºC to 150ºC
ESD Rating [3]	
Human Body Model	2KV

(1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX}(T_{JMAX}-T_A)/\theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower.

(3) The human body model is a 100pF capacitor discharged through a 1.5kohm resistor into each pin.

Recommend Operation Conditions

Parameter	Unit
Supply voltage (VDD)	2.7V to 5.5V
Operating temperature range (T_A)	-40°C to 85°C

Electrical Characteristics

Test Condition: VDD=5.0V,T_A=25°C, A_V=2V/V, The following specifications apply for 8ohm load (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{DD}	Quiescent Power Supply Current	VIN=0V, no load		2.2		mA
		VIN=0V, R_L=8ohm		2.4		
I_{SD}	Shutdown Current	_SD=0V. R_L=8ohm		0.4	2	μA
P_O	Output Power	THD=1 %(max); f=1 kHz	1.25	1.32		W
THD+N	Total Harmonic Distortion + Noise	P_O=0.5Wrms; f=1kHz		0.08		%
PSRR	Power Supply Rejection Ratio	V_{ripple}=200mVp-p				dB
		f=217Hz (Note1)		-69		
		f=1 KHz (Note1)		-78		
		f=217Hz (Note2)		-67		
		f=1 KHz (Note2)		-76		
V_{OS}	Output Offset	Vin=0V	-25	6.5	25	mV
V_{SDIH}	Shutdown Voltage Input High		1.46			V
V_{SDIL}	Shutdown Voltage Input Low				1.24	V
T_{WU}	Wake Up time			120		ms
Rout	Resistor Output to GND			6.4		kΩ

Note1: Unterminated input

Note2: 10Ω terminated input

Test Condition: VDD=3.0V,T_A= 2 5 °C, A_V=2V/V, The following specifications apply for 8ohm load (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{DD}	Quiescent Power Supply Current	VIN=0V, no load		1.65		mA
		VIN=0V, R_L=8ohm		2		
I_{SD}	Shutdown Current	_SD=0V. R_L=8ohm		0.1	2	μA
P_O	Output Power	THD=1 %(max); f=1 kHz		0.47		W
THD+N	Total Harmonic Distortion + Noise	P_O=0.25Wrms; f=1kHz		0.09		%
PSRR	Power Supply Rejection Ratio	V_{ripple}=200mVp-p				dB
		f=217Hz (Note1)		-68		
		f=1 KHz (Note1)		-77		
		f=217Hz (Note2)		-67		
		f=1 KHz (Note2)		-76		
V_{OS}	Output Offset	VIN=0V	-20	5.8	20	mV
V_{SDIH}	Shutdown Voltage Input High		1.15			V
V_{SDIL}	Shutdown Voltage Input Low				1.04	V
T_{WU}	Wake Up time			80		ms
Rout	Resistor Output to GND			6.4		kΩ

Note1: Unterminated input
Note2: 10Ω terminated input

TYPICAL OPERATING CHARACTERISTICS

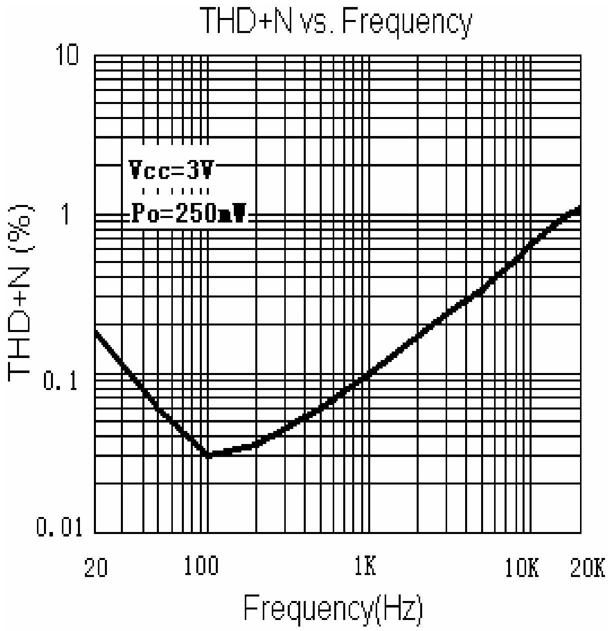
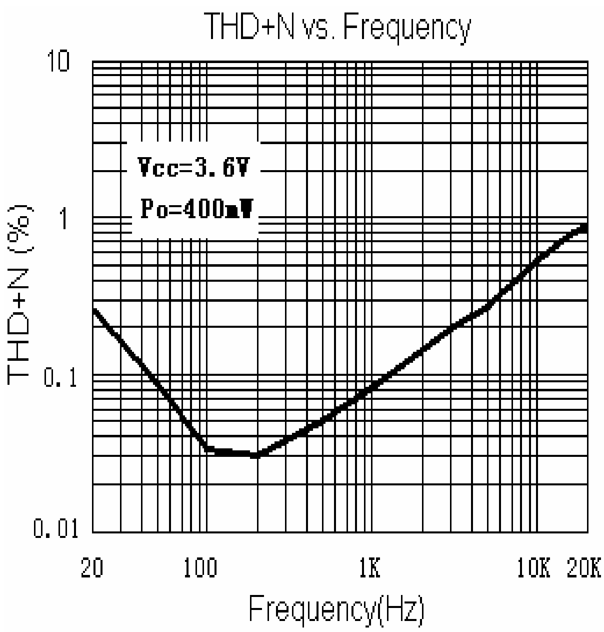


Figure 3.



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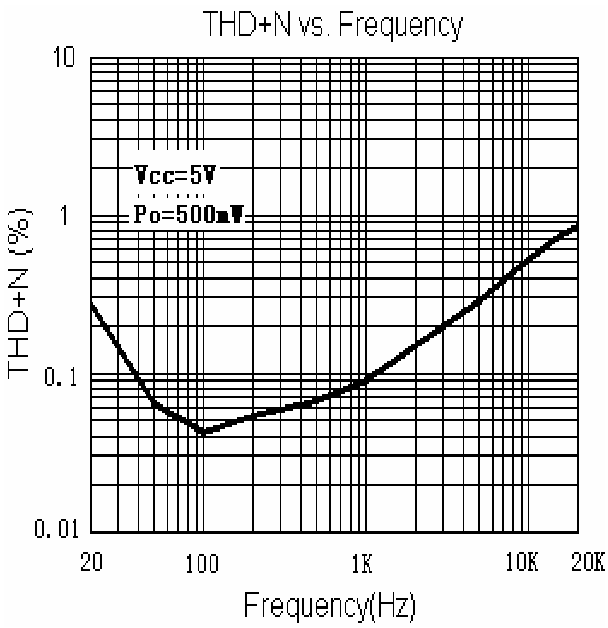

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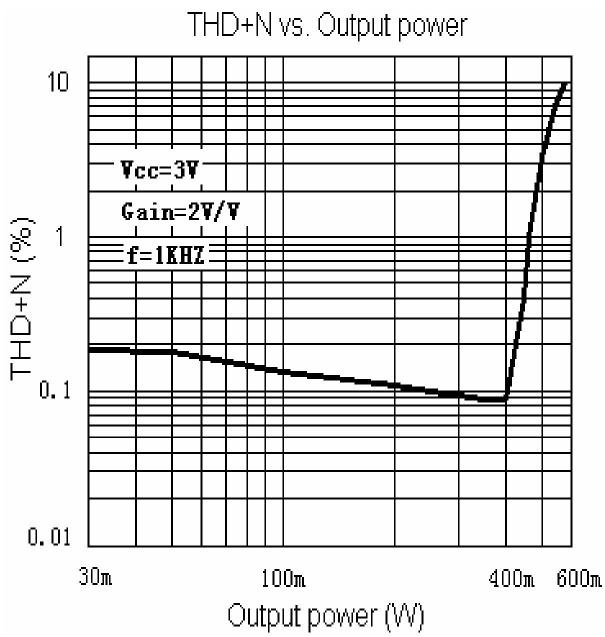

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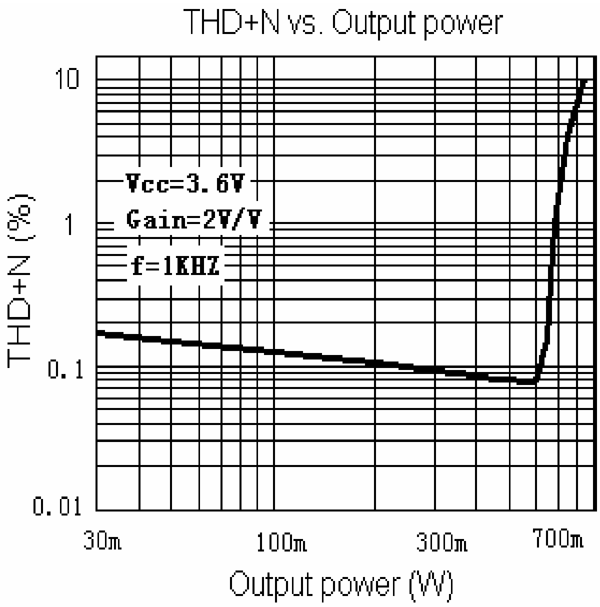

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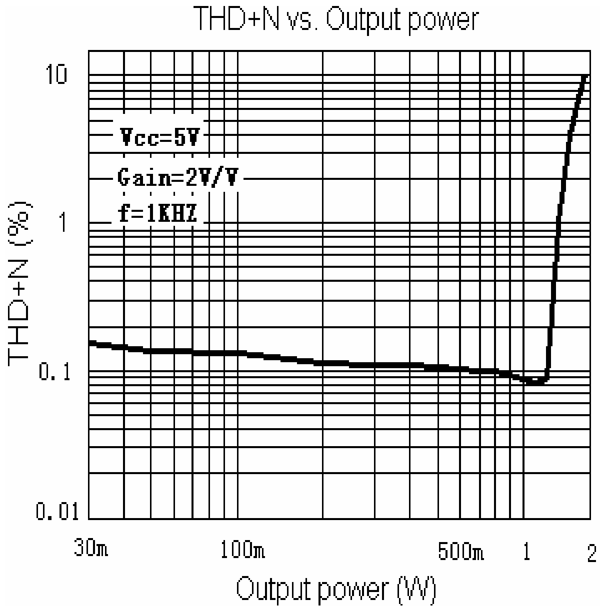

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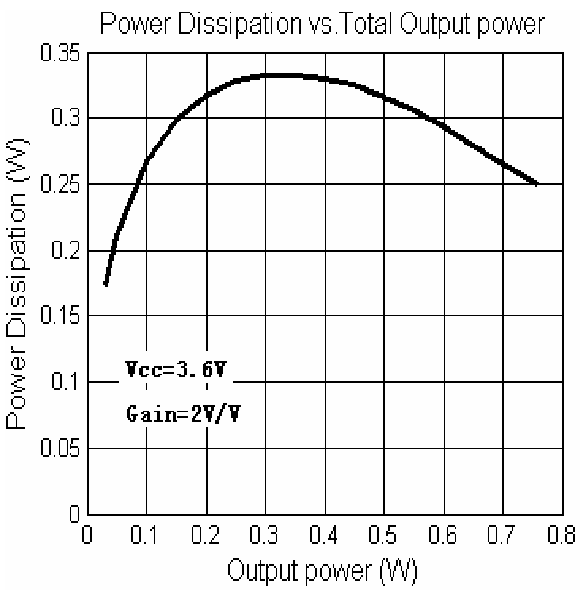

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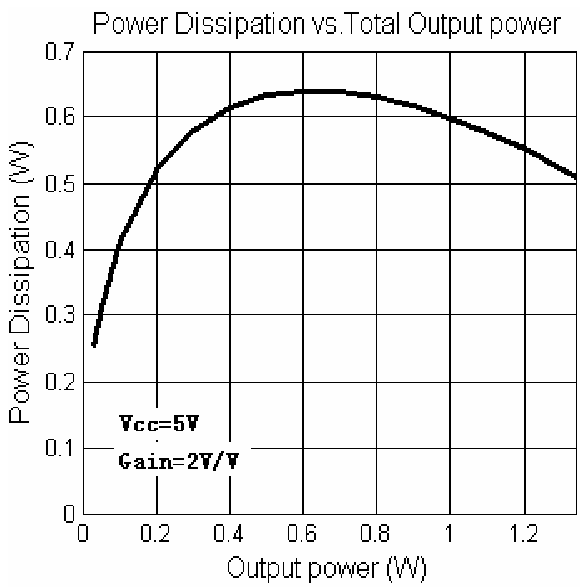
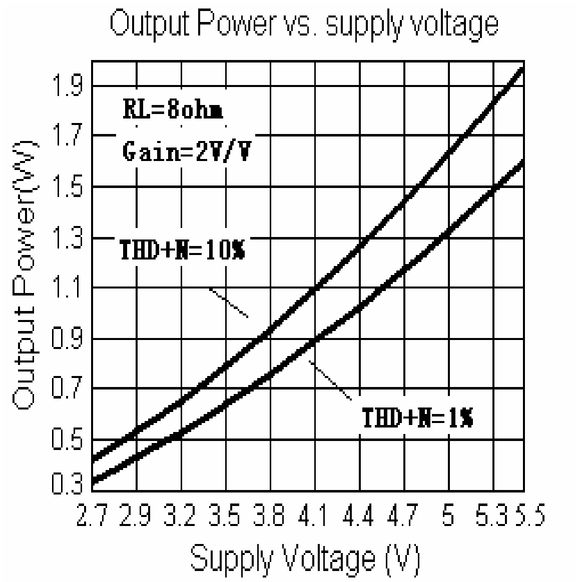


Figure 10.



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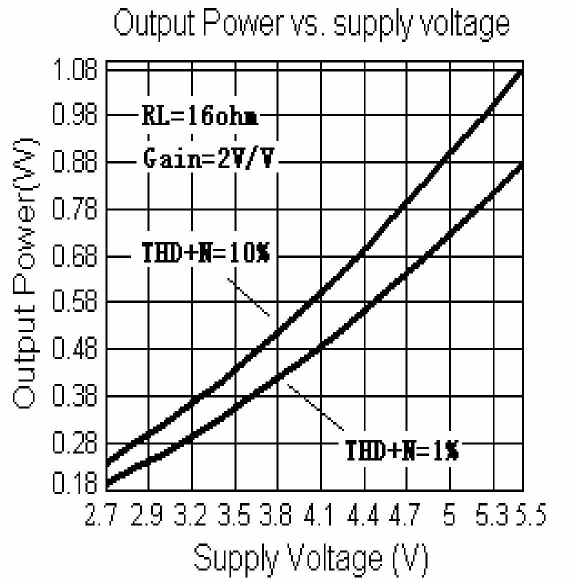

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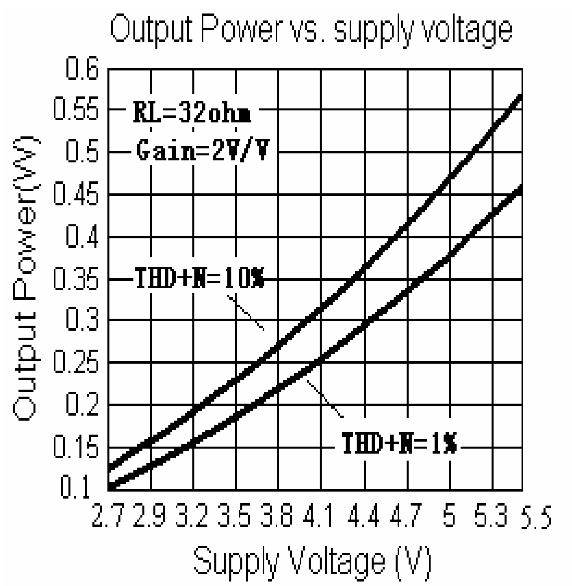

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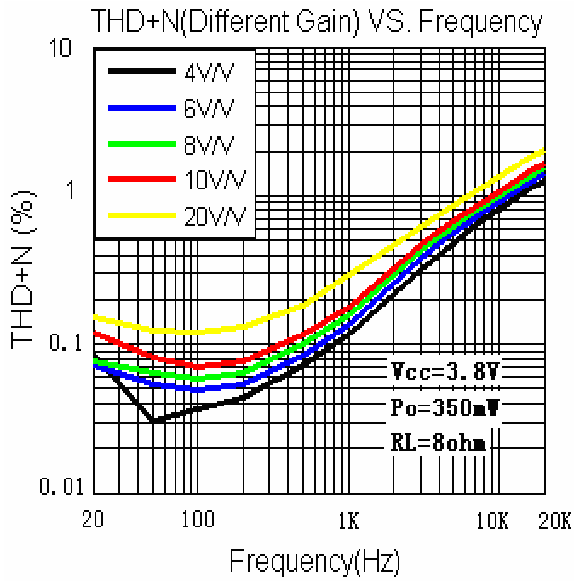

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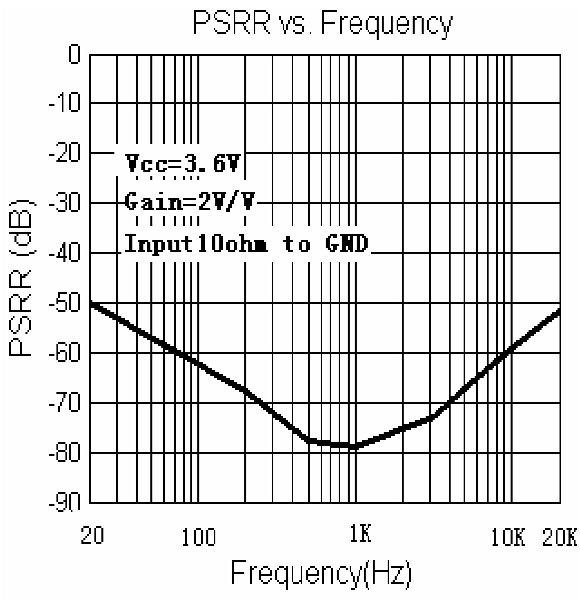

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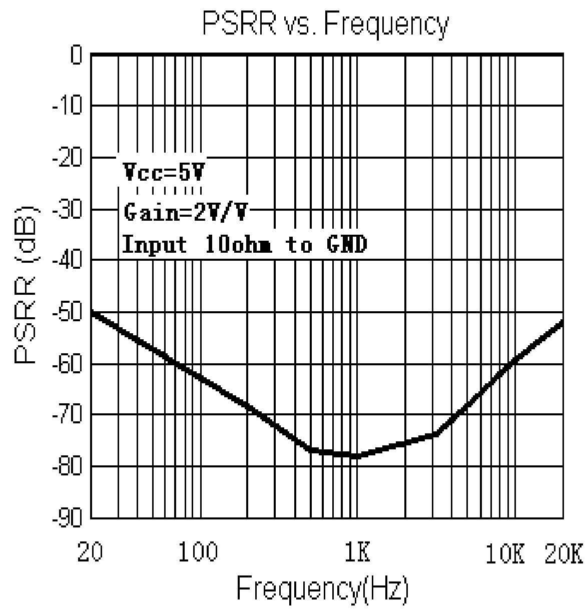


Figure 16.

Application Information

Bridged Configuration Explanation

As shown in Figure 2 or Figure 3, the A7010 is composed of two identical internal power amplifiers. The first amplifier's gain is externally configurable with gain-setting resistors R_i and R_f, while the second amplifier is internally fixed in an inverting unity-gain configuration. The output of the first amplifier serves as the input to the second amplifier, so the load is driven differentially through Vo+ and Vo-, this is BTL (Bridge Tied Load) configuration, the closed-loop gain is

$$Gain = 2*(R_f / R_i) \qquad (1)$$

BTL configuration has two distinct advantages over the single-ended output configuration. BTL configuration doubles possible output swing for a specific supply voltage, so the possible output power is four times larger as compared with a single-ended output configuration under the same conditions. In BTL configuration, Vo+ and Vo- are biased at same potential VDD/2, no net DC voltage exists across the load. This eliminates the need for an output coupling capacitor which is required in a single-ended output configuration.

Proper Selection of external components

The input (R_i) and feedback resistors (R_f) set the gain of the amplifier according to Equation 1. In order to optimize the THD+N and SNR performance, the A7010 should be used in low closed-loop gain configuration and the gain in the range from 2 to 5 is recommended, low gain configurations require large input signals to obtain a given output power. R_f and R_i should be in range from 1kohm to 100kohm.

Input Capacitor (C_i)

The input coupling capacitor blocks the input DC voltage. The C_i and R_i form a high-pass filter with the corner frequency determined in Equation 2:

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

The value of C_i affects the low frequency performance of the system. In many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 100Hz to 150Hz. Thus, using a large input capacitor may not increase actual system performance. For example, assuming R_i is 20kΩ and the specification calls for a flat response down to 100Hz. From Equation 2, C_i is 0.08 μF.

Click and pop performance is affected by the value of C_i, a large input coupling capacitor requires more time to reach its quiescent DC voltage (VDD/2) and can increase the turn-on pops noise. Thus, by minimizing the value of C_i without severe attenuation in low frequency, turn-on pops noise can be minimized. The value of C_i should be in range from 0.068μF to 0.39μF. In most portable applications, 0.1 μF input coupling capacitor is recommended.

A further consideration for C_i is the leakage path from the input source through the input network (R_i, C_i) and the feedback resistor (R_f) to the load. This leakage current creates a DC offset voltage that reduces useful headroom, especially in high gain applications. For this reason, a ceramic capacitor is the best choice.

Bypass Capacitor (C_{BYPASS}) and Start-Up Time

Connecting a capacitor to BYPASS pin filters any noise into this pin and increases the PSRR performance. C_{BYPASS} also determines the rise time of VO+ and VO-, the larger the capacitor, the slower the rise time, the A7010 start to work after the C_{BYPASS} voltage reaches the mid-supply voltage. This capacitor can also minimize the pop & click noise during turn-on and turn-off transitions, the larger the capacitor, the smaller the pop & click noise, 1μF capacitor is recommended for C_{BYPASS}.

Decoupling Capacitor (C_S)

Power supply decoupling is critical for low THD+N and high PSRR performance. A low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1μF to 1μF, placed as close as possible to VDD pin makes the device work better. For filtering lower frequency noise signals, a 10μF or greater capacitor placed near the audio power amplifier also helps.

Using Low-ESR Capacitors

Low-ESR capacitors are recommended. A real capacitor can be modeled simply as a resistor in series with an ideal capacitor. The voltage drop across this resistor minimizes the beneficial effects of the capacitor in the circuit. The lower the equivalent value of this resistance the more the real capacitor behaves like an ideal capacitor.

Power Dissipation

Power dissipation is a major concern when designing a successful amplifier, whether the amplifier is bridged or single-ended ouput. Equation 3 states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

$$Po=V_{DD}^2/2\pi^2R_L \quad \text{SE Output} \qquad (3)$$

However, a direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation versus a single-ended amplifier operating at the same conditions.

$$Po=4*V_{DD}^2/2\pi^2R_L \quad \text{BTL Output} \qquad (4)$$

Since the A7010 has bridged outputs, the maximum internal power dissipation is 4 times that of a single-ended amplifier. Even with this substantial increasing in power dissipation, the A7010 does not require additional heat-sinking under most operating conditions and output loading. From Equation 4, assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 625mW. The maximum power dissipation point obtained from Equation 4 must not be greater than the power dissipation results from Equation 5:

$$P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA} \qquad (5)$$

Depending on the ambient temperature, TA, of the system surroundings, Equation 5 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 4 is greater than that of Equation 5, then either the supply voltage must be decreased, the load impedance increased, the ambient temperature reduced, or the θ_{JA} reduced with heat-sinking. In many cases, larger traces near the output, VDD, and GND pins can be used to lower the $\theta_{JA.}$ The larger areas of copper provide a form of heat-sinking allowing higher power dissipation. Recall that internal power dissipation is a function of output power. If the typical operation is not around the maximum power dissipation point, the A7010 can operate at higher ambient temperatures.

Shutdown Function

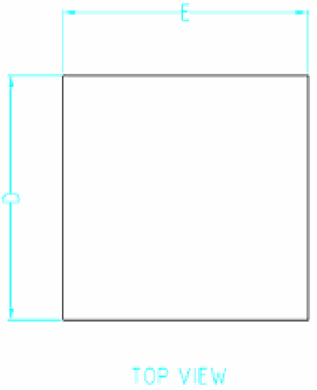
In order to reduce power consumption while not in use, the A7010 contains shutdown circuitry that is used to turn off the amplifier's bias circuitry. The shutdown pin should be tied to a definite voltage to avoid unwanted state changes. In many applications ,a microcontroller output is used to control the shutdown circuitry, which provides a quick, smooth transition to shutdown. Another solution is to use a single-throw switch in conjunction with an external pull-down resistor .This scheme guarantees that the shutdown pin will not float, thus preventing unwanted state changes.

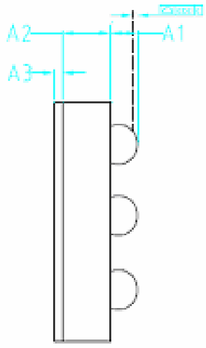
Board Layout Consideration

The residual resistance of the PCB trace between the amplifier output pins and the speaker causes a voltage drop, which results in power dissipated in the PCB trace and not in the speaker as desired. Therefore, to maintain the highest speaker power dissipation and widest output voltage swing, PCB

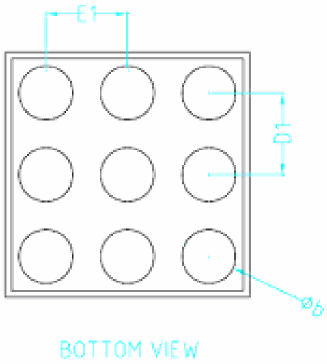
trace that connects the amplifier output pins to the speaker must be as wide as possible.
Poor power supply regulation adversely affects maximum output power. A poorly regulated supply's output voltage decreases with increasing load current. Reduced supply voltage causes decreased headroom, output signal clipping, and reduced output power. Even with tightly regulated supplies, power supply trace resistance creates the same effects as poor supply regulation. Therefore,making the power supply trace as wide as possible helps to maintain full output voltage swing. It is very important to keep the A7010 external components very close to the A7010 to limit noise rise up.

Package information（WLCSP 9 Bump）





9 Bump WLCSP Dimensions (mm)



REF	MIN	TYP	MAX
A1	0.215	0.235	0.255
A2	0.355	0.380	0.405
A3	0.020	0.035	0.050
D	1.485	1.500	1.515
D1		0.500	
E	1.485	1.500	1.515
E1		0.500	
b	0.300	0.320	0.340
CCC		0.080	

Revision History

Revision	Change Date	Description of Change
V0.1	07/20/2008	Preliminary
V0.2	10/08/2008	Engineering