



# PAM8302A

## 2.5W Filterless Class-D Mono Audio Amplifier

### Key Features

- 2.5W Output at 10% THD with a 4Ω Load and 5V Power Supply
- Filterless, Low Quiescent Current and Low EMI
- High Efficiency up to 88%
- Superior Low Noise
- Short Circuit Protection
- Thermal Shutdown
- Few External Components to Save Space and Cost
- MSOP-8, SOP-8 and DFN3x3 Packages Available
- Pb-Free Package

### General Description

The PAM8302A is a 2.5W class-D mono audio amplifier. Its low THD+N feature offers high-quality sound reproduction. The new filterless architecture allows the device to drive speaker directly instead of using low-pass output filters, therefore save system cost and PCB area.

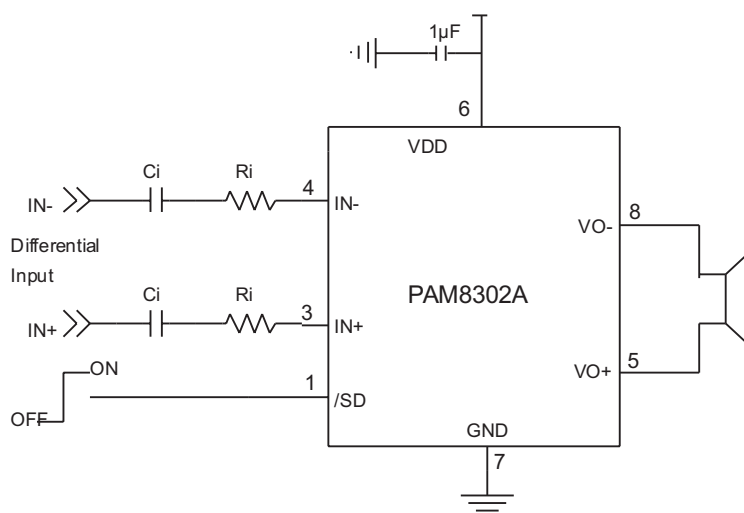
With the same number of external components, the efficiency of the PAM8302A is much better than that of class-AB cousins. It can optimize battery life thus is ideal for portable applications.

The PAM8302A is available in MSOP-8, SOP-8 and DFN3x3 packages.

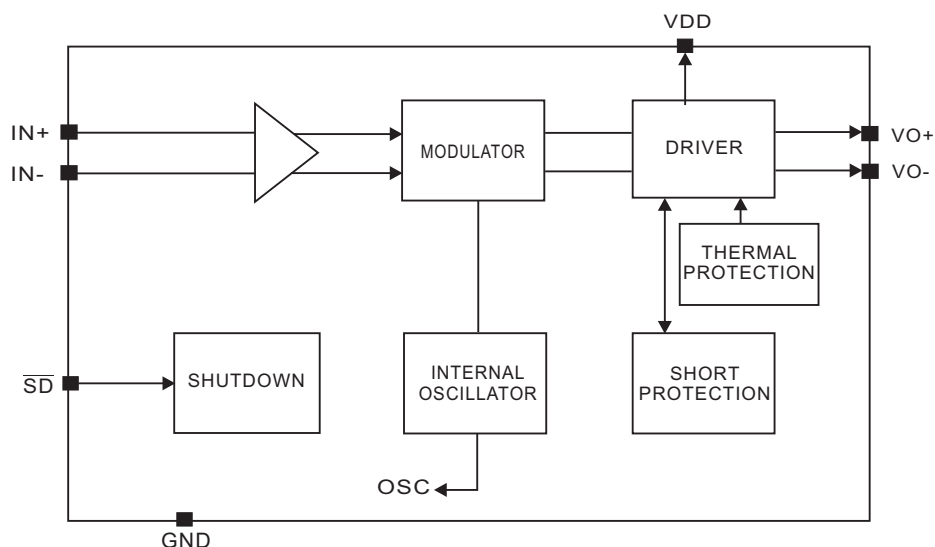
### Applications

- PMP/MP4
- GPS
- Portable Speakers
- Walkie Talkie
- Handsfree phones/Speaker Phones
- Cellular Phones

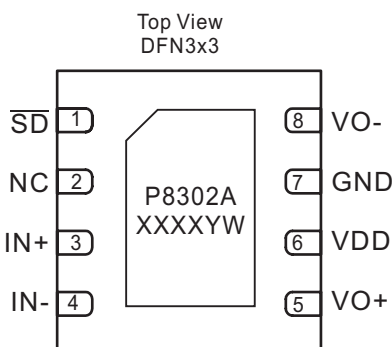
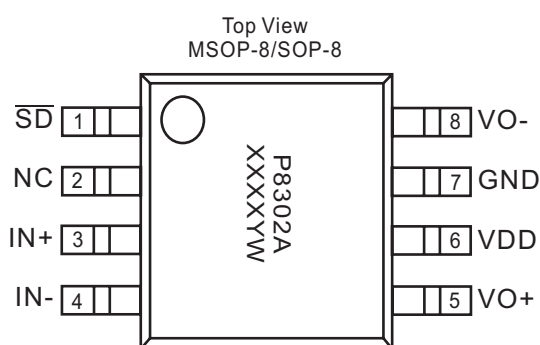
### Typical Application



### Block Diagram



### Pin Configuration & Marking Information



X: Internal Code  
Y: Year  
W: Week

| Pin Number | Pin name        | Description                   |
|------------|-----------------|-------------------------------|
| 1          | $\overline{SD}$ | Shutdown terminal ,active low |
| 2          | NC              | No connection                 |
| 3          | IN+             | Positive differential input   |
| 4          | IN-             | Negative differential input   |
| 5          | VO+             | Positive BTL output           |
| 6          | VDD             | Analog power supply           |
| 7          | GND             | Ground                        |
| 8          | VO-             | Negative BTL output           |



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### Absolute Maximum Ratings

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability. All voltages are with respect to ground.

|                                        |                        |                                   |                |
|----------------------------------------|------------------------|-----------------------------------|----------------|
| Supply Voltage at no Input Signal..... | 6.6V                   | Maximum Junction Temperature..... | 150°C          |
| Input Voltage.....                     | -0.3V to $V_{DD}+0.3V$ | Storage Temperature.....          | -65°C to 150°C |
|                                        |                        | Soldering Temperature.....        | 300°C, 5sec    |

### Recommended Operating Conditions

|                                           |              |                                 |                |
|-------------------------------------------|--------------|---------------------------------|----------------|
| Supply voltage Range.....                 | 2.5V to 5.5V | Ambient Operation Temperature   |                |
| Max. Supply Voltage (for Max. duration of |              | Range.....                      | -40°C to 85°C  |
| 30 minutes).....                          | 6.0V         | Junction Temperature Range..... | -40°C to 125°C |

### Thermal Information

| Parameter                                   | Symbol        | Package   | Maximum | Unit |
|---------------------------------------------|---------------|-----------|---------|------|
| Thermal Resistance<br>(Junction to ambient) | $\theta_{JA}$ | SOP-8     | 115     | °C/W |
|                                             |               | MSOP-8    | 180     | °C/W |
|                                             |               | DFN 3x3-8 | 47.9    | °C/W |



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## 2.5W Filterless Class-D Mono Audio Amplifier

### Electrical Characteristic

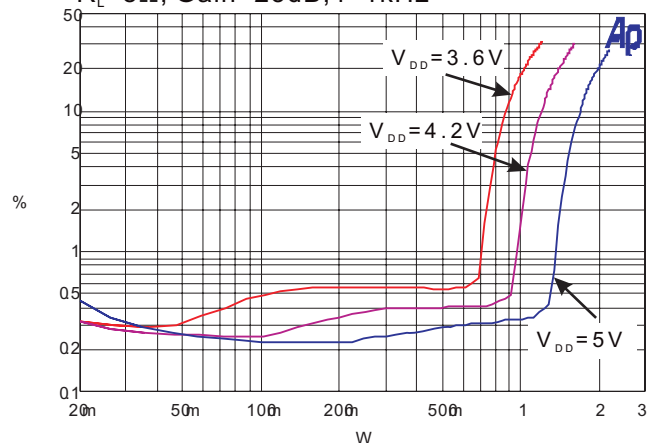
$V_{DD}=5V$ , Gain = 24dB,  $R_L=4\Omega$ ,  $T_A=25^\circ C$ , unless otherwise noted.

| PARAMETER                            | SYMBOL       | CONDITIONS                            |               | MIN | TYP  | MAX | UNITS      |
|--------------------------------------|--------------|---------------------------------------|---------------|-----|------|-----|------------|
| Supply Voltage Range                 | $V_{DD}$     |                                       |               | 2.5 |      | 5.5 | V          |
| Quiescent Current                    | $I_Q$        | No Load                               |               |     | 4    | 8   | mA         |
| Shutdown Current                     | $I_{SHDN}$   | $V_{SHDN}=0V$                         |               |     |      | 1   | $\mu A$    |
| Output Power                         | $P_O$        | f=1kHz, $R_L=4\Omega$                 | $V_{DD}=5V$   |     | 2.50 |     | W          |
|                                      |              | THD+N=10%                             | $V_{DD}=3.6V$ |     | 1.25 |     |            |
|                                      |              | f=1kHz, $R_L=4\Omega$                 | $V_{DD}=5V$   |     | 2.00 |     |            |
|                                      |              | THD+N=1%                              | $V_{DD}=3.6V$ |     | 0.95 |     |            |
|                                      |              | f=1kHz, $R_L=8\Omega$                 | $V_{DD}=5V$   |     | 1.50 |     |            |
|                                      |              | THD+N=10%                             | $V_{DD}=3.6V$ |     | 0.80 |     |            |
|                                      |              | F=1kHz, $R_L=8\Omega$                 | $V_{DD}=5V$   |     | 1.30 |     |            |
|                                      |              | THD+N=1%                              | $V_{DD}=3.6V$ |     | 0.65 |     |            |
| Peak Efficiency                      | $\eta$       | f=1kHz                                |               |     | 85   | 88  | %          |
| Total Harmonic Distortion Plus Noise | THD+N        | $R_L = 8\Omega$ , $P_O=0.1W$ , f=1kHz |               |     | 0.30 |     | %          |
|                                      |              | $R_L = 8\Omega$ , $P_O=0.5W$ , f=1kHz |               |     | 0.45 |     |            |
|                                      |              | $R_L = 4\Omega$ , $P_O=0.1W$ , f=1kHz |               |     | 0.35 |     |            |
|                                      |              | $R_L = 4\Omega$ , $P_O=0.5W$ , f=1kHz |               |     | 0.40 |     |            |
| Gain                                 | Gv           |                                       |               |     | 24   |     | dB         |
| Power Supply Ripple Rejection        | PSRR         | No input, f=1kHz, $V_{pp}=200mV$      |               | 45  | 50   |     | dB         |
| Dynamic Range                        | Dyn          | f=20 to 20kHz                         |               |     | 90   |     | dB         |
| Signal to Noise Ratio                | SNR          | f =20 to 20kHz                        |               |     | 80   |     | dB         |
| Noise                                | $V_n$        | No A-weighting                        |               |     | 180  |     | $\mu V$    |
|                                      |              | A-weighting                           |               |     | 120  |     |            |
| Oscillator Frequency                 | $f_{OSC}$    |                                       |               | 200 | 250  | 300 | kHz        |
| Drain-Source On-State Resistance     | $R_{DS(ON)}$ | $I_{DS}=100mA$                        | P MOSFET      |     | 0.45 |     | $\Omega$   |
|                                      |              |                                       | N MOSFET      |     | 0.20 |     |            |
| $\overline{SHDN}$ Input High         | $V_{SH}$     |                                       |               | 1.2 |      |     | V          |
| $\overline{SHDN}$ Input Low          | $V_{SL}$     |                                       |               |     |      | 0.4 | V          |
| Over Temperature Protection          | OTP          |                                       |               |     | 135  |     | $^\circ C$ |
| Over Temperature Hysteresis          | OTH          |                                       |               |     | 30   |     | $^\circ C$ |

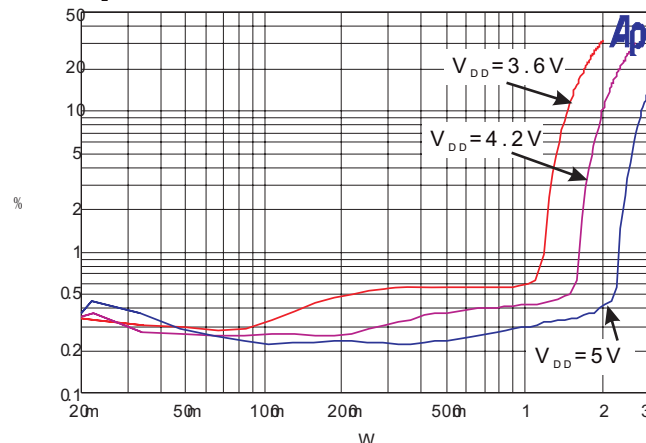
### Typical Performance Characteristics

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

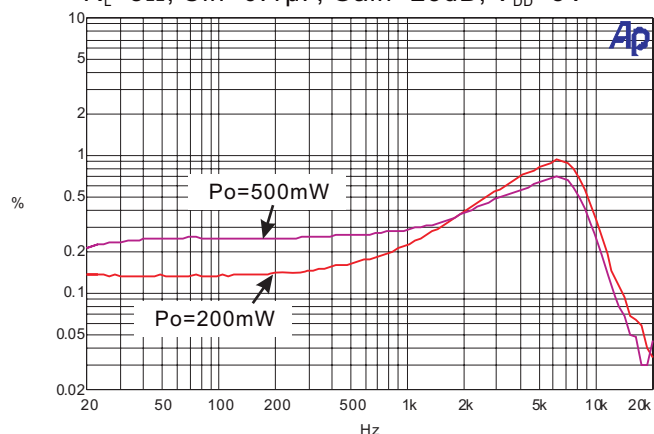
THD+N VS Output Power  
 $R_L = 8\Omega$ , Gain=23dB,  $f = 1\text{kHz}$



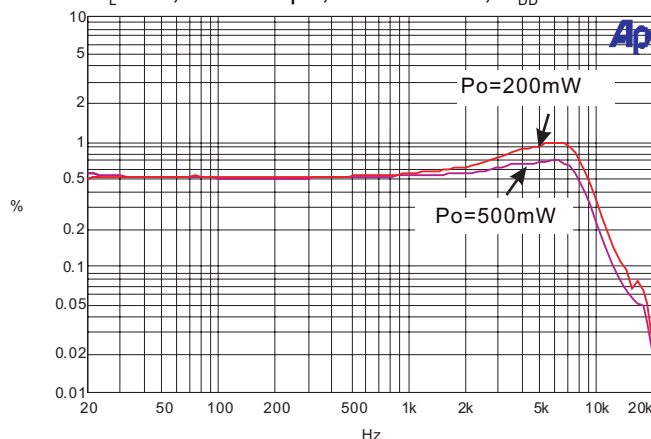
THD+N VS Output Power  
 $R_L = 4\Omega$ , Gain=23dB,  $f = 1\text{kHz}$



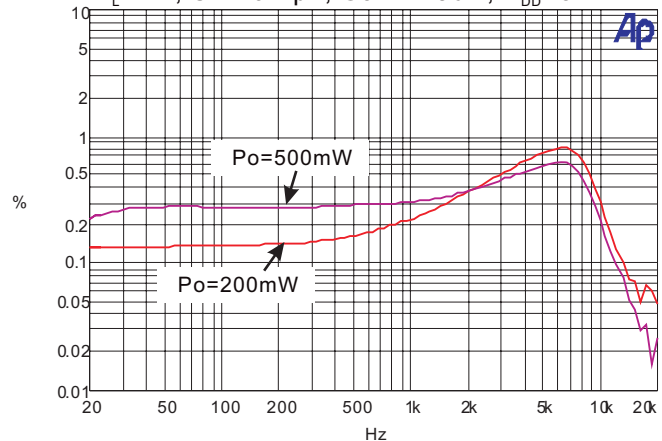
THD+N VS Frequency  
 $R_L = 8\Omega$ ,  $C_{in} = 0.1\mu\text{F}$ , Gain=23dB,  $V_{DD} = 5\text{V}$



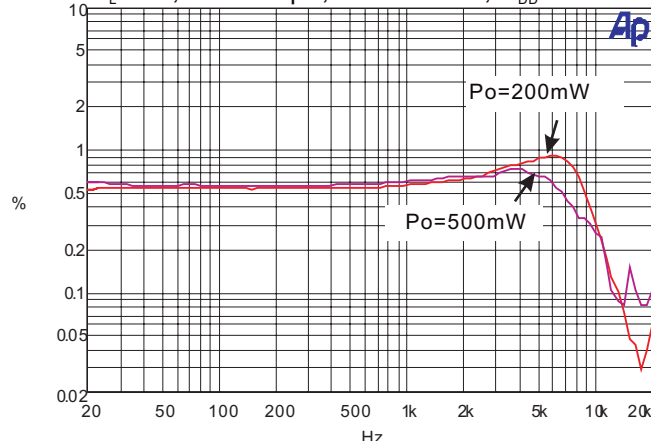
THD+N VS Frequency  
 $R_L = 8\Omega$ ,  $C_{in} = 0.1\mu\text{F}$ , Gain=23dB,  $V_{DD} = 3.6\text{V}$



THD+N VS Frequency  
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THD+N VS Frequency  
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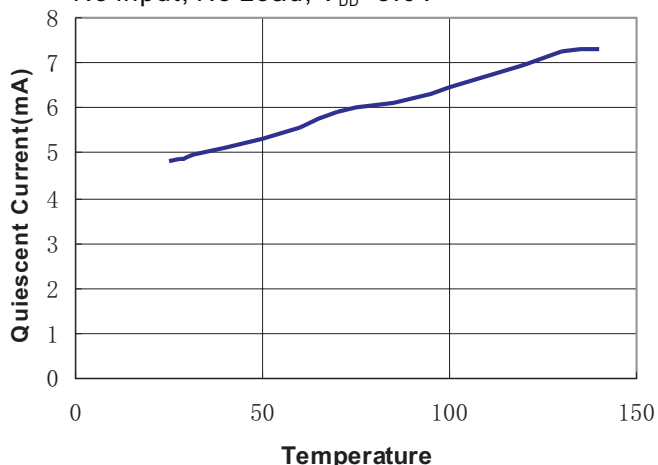
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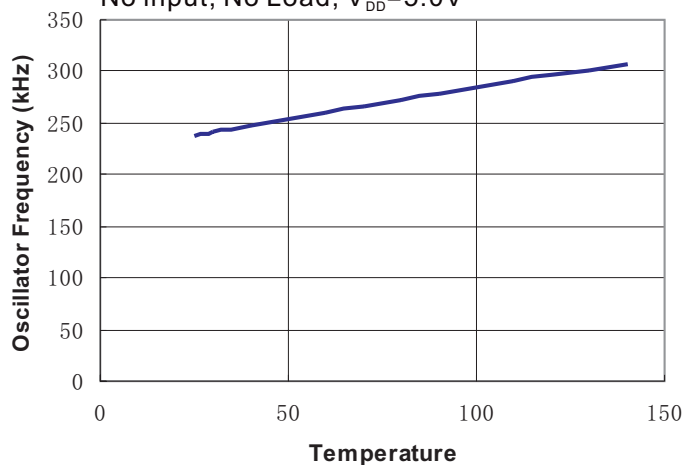
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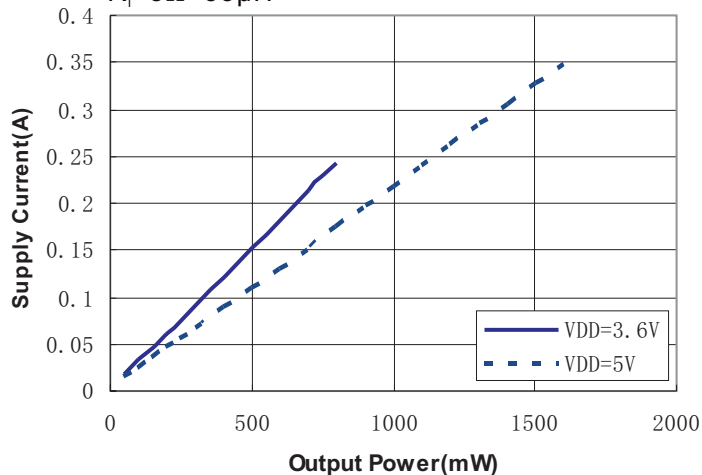
Quiescent Current VS Temperature  
No input, No Load,  $V_{DD} = 5.0\text{V}$



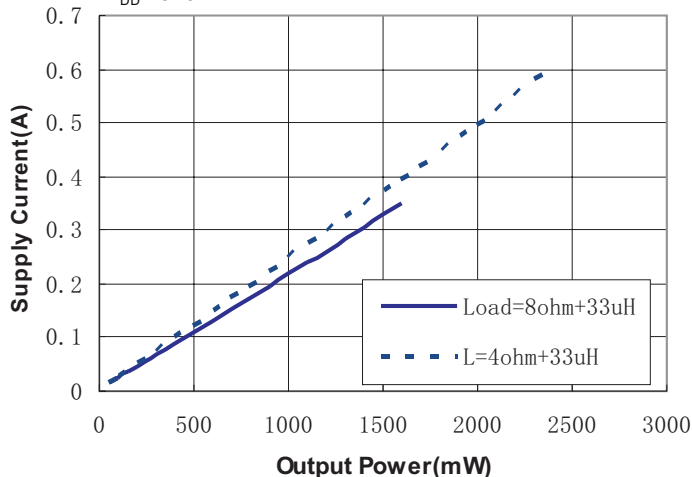
Frequency VS Temperature  
No input, No Load,  $V_{DD} = 5.0\text{V}$



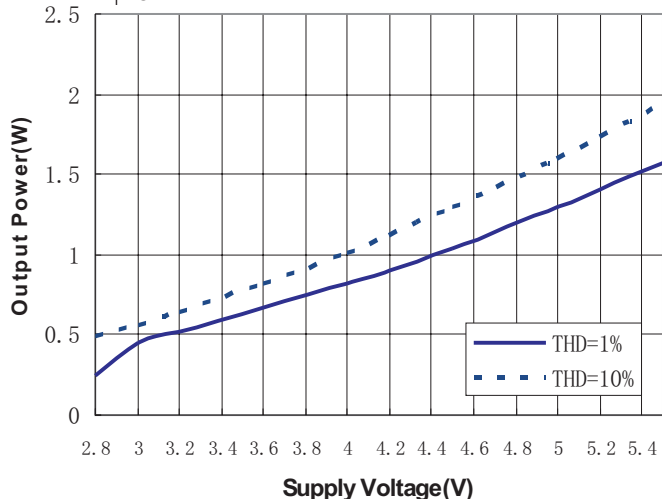
Supply Current VS Output Power  
 $R_L = 8\Omega + 33\mu\text{H}$



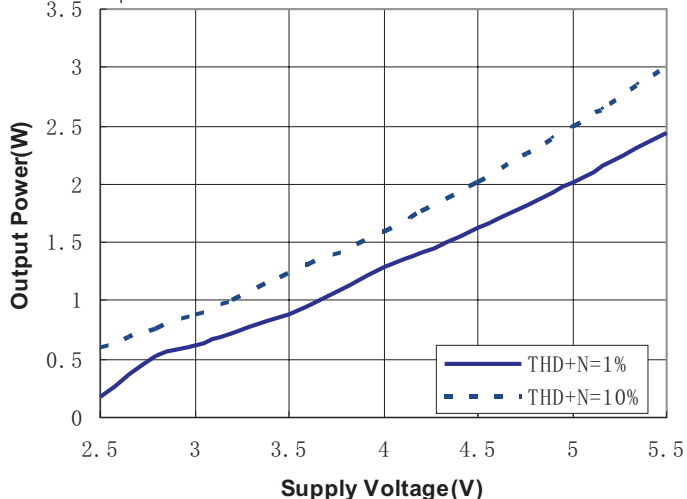
Supply Current VS Output Power  
 $V_{DD} = 5.0\text{V}$



Output Power VS. Supply Voltage  
 $R_L = 8\Omega$



Output Power VS. Supply Voltage  
 $R_L = 4\Omega$

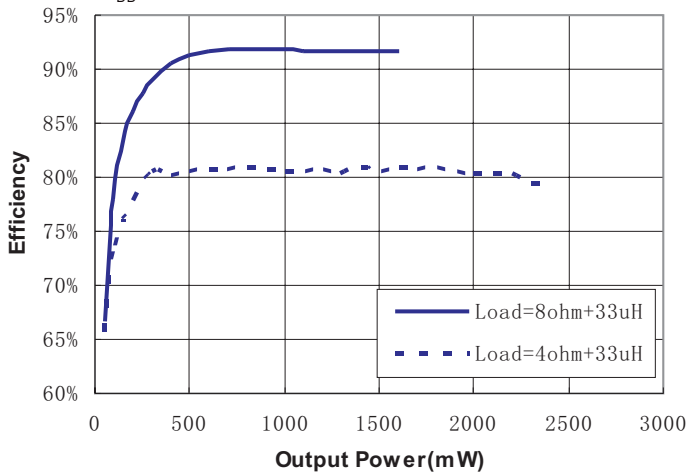


### Typical Performance Characteristics

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

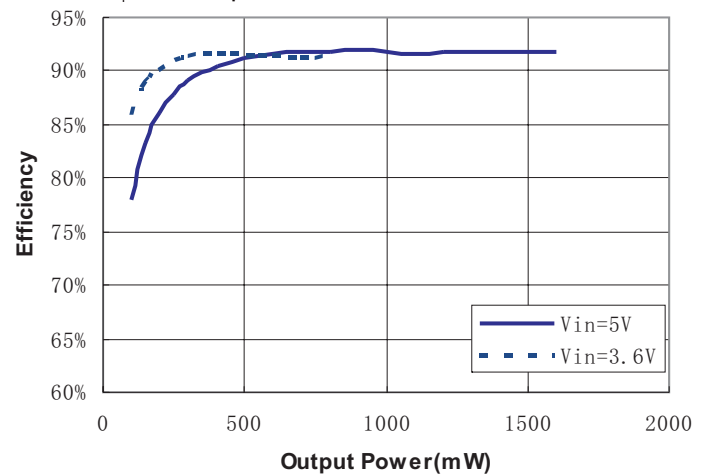
Efficiency VS Output Power

$V_{DD} = 5.0\text{V}$

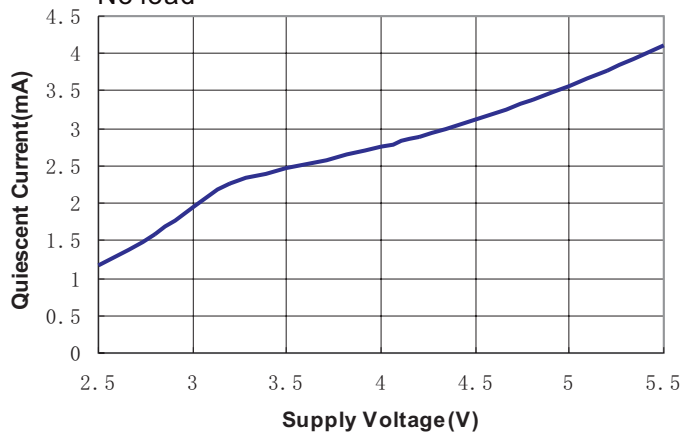


Efficiency VS Output Power

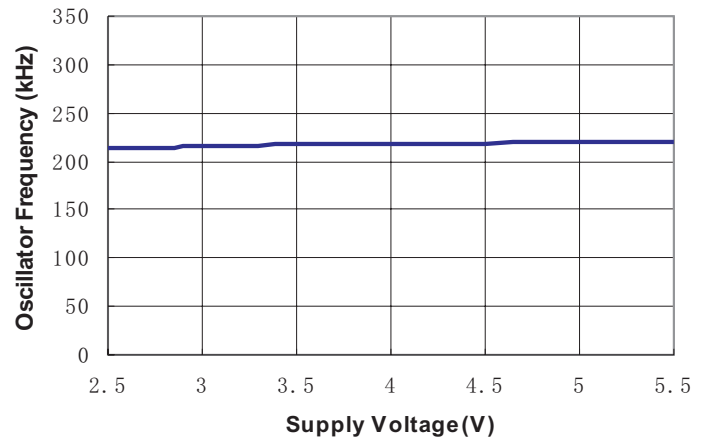
$R_L = 8\Omega + 33\mu\text{H}$



Quiescent Current VS. Supply Voltage  
No load

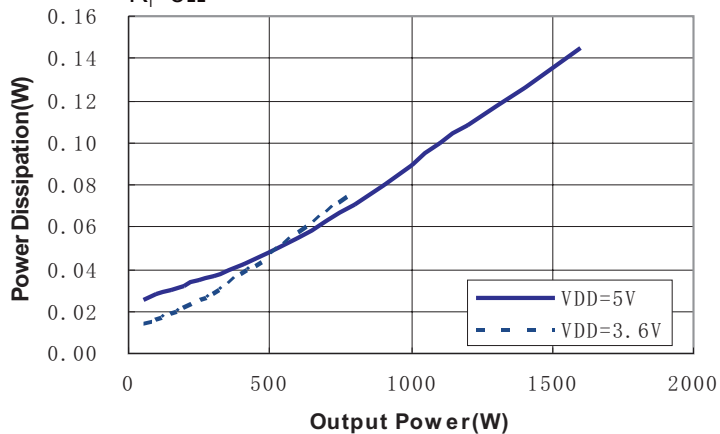


Frequency VS. Supply Voltage

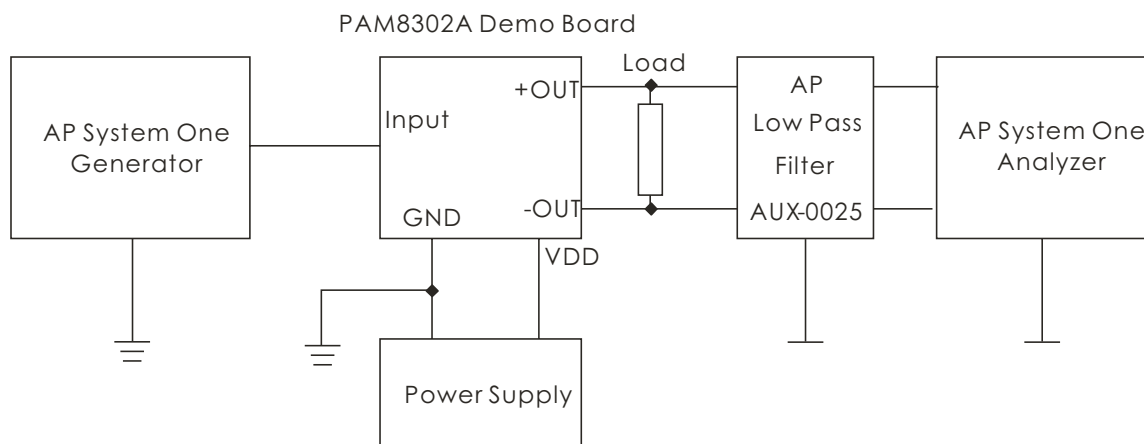


Power Dissipation VS. Output Power

$R_L = 8\Omega$



### Test Setup for Performance Testing



### Notes

1. The AP AUX-0025 low pass filter is necessary for every class-D amplifier measurement with AP analyzer.
2. Two 22 $\mu$ H inductors are used in series with load resistor to emulate the small speaker for efficiency measurement.



### Application Information

#### Maximum Gain

As shown in block diagram (page 2), the PAM8302A has two internal amplifier stages. The first stage's gain is externally configurable, while the second stage's is internally fixed. The closed-loop gain of the first stage is set by selecting the ratio of  $R_f$  to  $R_i$  while the second stage's gain is fixed at 2x. The output of amplifier 1 serves as the input to amplifier 2, thus the two amplifiers produce signals identical in magnitude, but different in phase by 180°. Consequently, the differential gain for the IC is

$$A_{VD} = 20 \cdot \log [2 \cdot (R_f/R_i)]$$

The PAM8302A sets maximum  $R_f = 80k\Omega$ , minimum  $R_i = 10k\Omega$ , so the maximum closed-gain is 24dB.

#### Input Capacitors ( $C_i$ )

In typical application, an input capacitor,  $C_i$ , is required to allow the amplifier to bias input signals to a proper DC level for optimum operation. In this case,  $C_i$  and the minimum input impedance  $R_i$  (10k internal) form a high pass filter with a corner frequency determined by the following equation:

$$f_c = \frac{1}{(2\pi R_i C_i)}$$

It is important to choose the value of  $C_i$  as it directly affects low frequency performance of the circuit, for example, when an application requires a flat bass response as low as 100Hz. Equation is reconfigured as follows:

$$C_i = \frac{1}{(2\pi R_i f_c)}$$

As the input resistance is variable, for the  $C_i$  value of 0.16 $\mu$ F, one should actually choose the  $C_i$  within the range of 0.1 $\mu$ F to 0.22 $\mu$ F. A further consideration for this capacitor is the leakage path from the input source through the input network ( $R_i$ ,  $R_F$ ,  $C_i$ ) to the load. This leakage current creates a DC offset voltage at the input to the amplifier that reduces useful headroom, especially in high gain application. For this reason, a low leakage tantalum or ceramic

capacitor is the best choice. When a polarized capacitor is used, the positive side of the capacitor should face the amplifier input in most applications as the DC level is held at  $V_{DD}/2$ , which is likely higher than the source DC level. Please note that it is important to confirm the capacitor polarity in the application.

#### Power Supply Decoupling ( $C_s$ )

The PAM8302A is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output THD and PSRR as low as possible. Power supply decoupling affects low frequency response. Optimum decoupling is achieved by using two capacitors of different types that target different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1.0 $\mu$ F is good, placing it as close as possible to the device  $V_{DD}$  terminal. For filtering lower-frequency noise signals, a capacitor of 10 $\mu$ F or

larger, closely located to near the audio power amplifier is recommended.

#### Shutdown Operation

In order to reduce shutdown power consumption, the PAM8302A contains shutdown circuitry for turn off the amplifier. This shutdown feature turns the amplifier off when a logic low is applied on the  $\overline{SD}$  pin. By switching the shutdown pin over to GND, the PAM8302A supply current draw will be minimized in idle mode.

**For the best power on/off pop performance, the amplifier should be set in the shutdown mode prior to power on/off operation.**

#### Under Voltage Lock-out (UVLO)

The PAM8302A incorporates circuitry to detect low on or off voltage. When the supply voltage drops to 2.1V or below, the PAM8302A goes into a state of shutdown, and the device comes out of its shutdown state and starts to normal operation by reset the power supply or  $\overline{SD}$  pin.

### How to Reduce EMI (Electro Magnetic Interference)

A simple solution is to put an additional capacitor 1000 $\mu$ F at power supply terminal for power line coupling if the traces from amplifier to speakers are short (<20CM).

Most applications require a ferrite bead filter as shown at Figure 1. The ferrite filter depresses EMI of around 1MHz and higher. When selecting a ferrite bead, choose one with high impedance at high frequencies and low impedance at low frequencies.

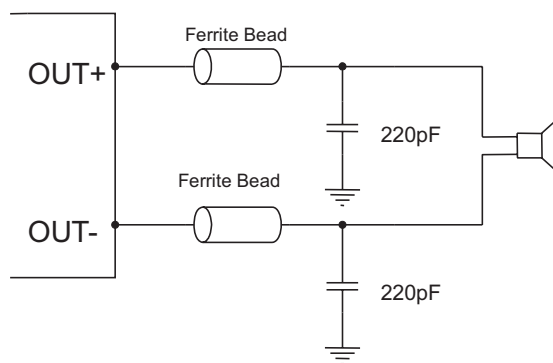


Figure 1: Ferrite Bead Filter to reduce EMI



# PAM8302A

## 2.5W Filterless Class-D Mono Audio Amplifier

### Ordering Information

PAM8302A X X X X

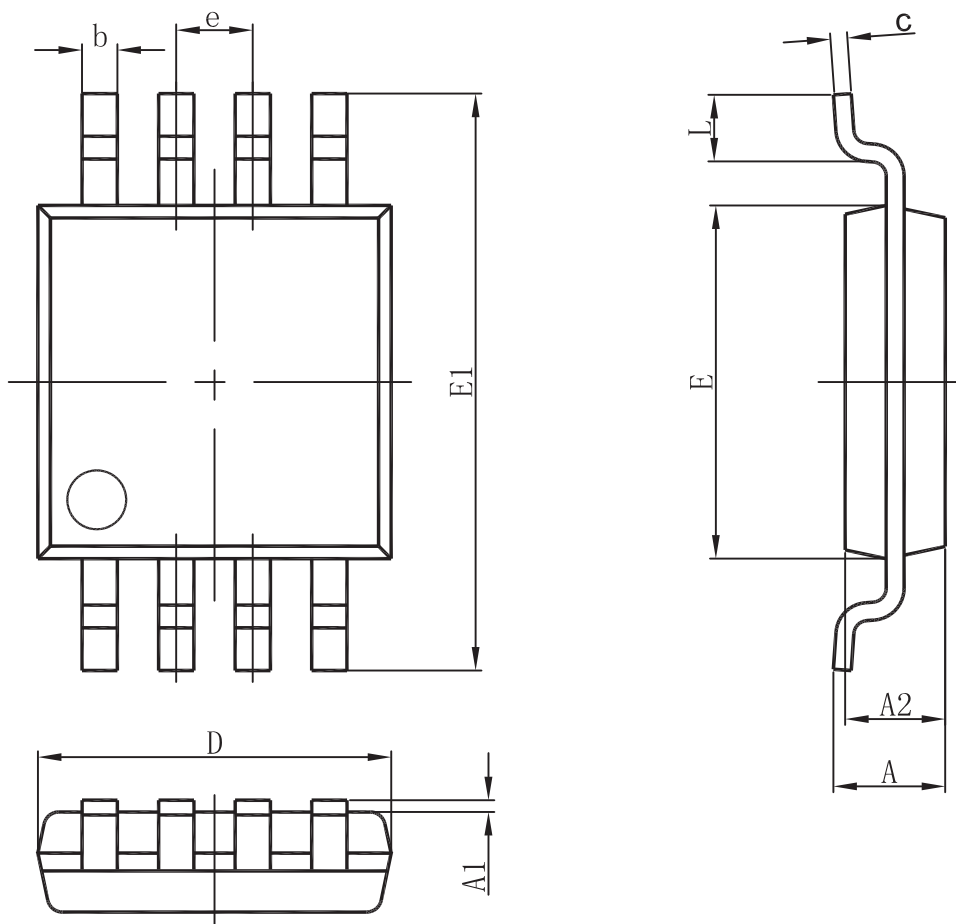
Shipping Package  
Number of pins  
Package Type  
Pin Configuration

| Pin Configuration                                                                             | Package Type                   | Number of pins |
|-----------------------------------------------------------------------------------------------|--------------------------------|----------------|
| A:<br>1: $\overline{SD}$<br>2: NC<br>3: IN+<br>4: IN-<br>5: VO+<br>6: VDD<br>7: GND<br>8: VO- | S: MSOP<br>D: SOP<br>Y: DFN3X3 | C: 8           |

| Part Number  | Package Type | MOQ/Shipping Package    |
|--------------|--------------|-------------------------|
| PAM8302AASCR | MSOP-8       | 2,500 Units/Tape & Reel |
| PAM8302AADCR | SOP-8        | 2,500 Units/Tape & Reel |
| PAM8302AAYCR | DFN3x3-8     | 3,000 Units/Tape & Reel |

### Outline Dimensions

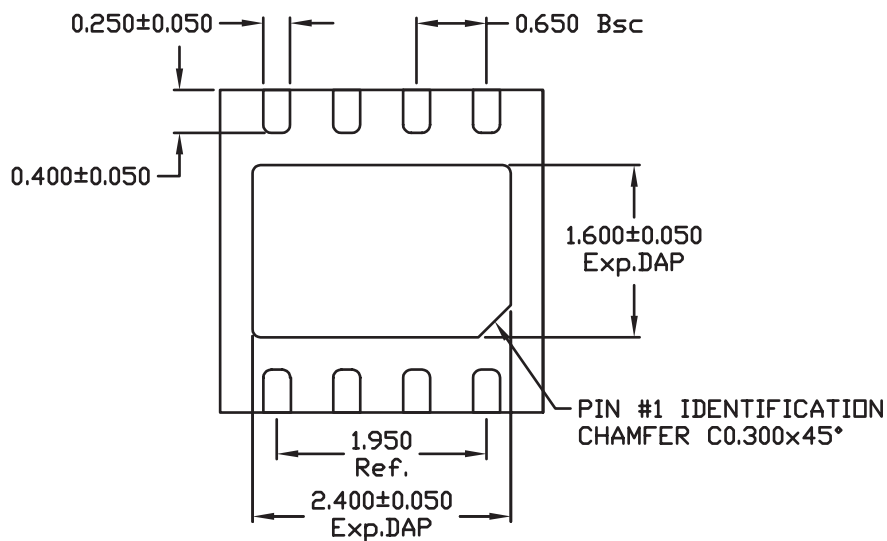
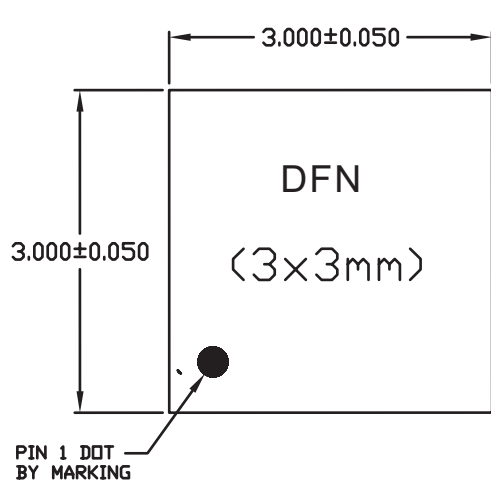
MSOP-8



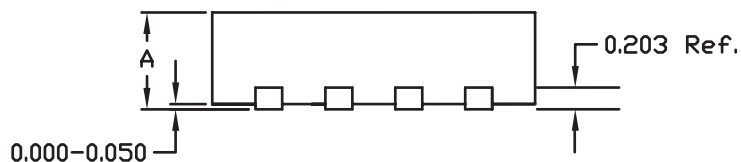
| REF | Millimeter |      |
|-----|------------|------|
|     | Min        | Max  |
| A   | --         | 1.10 |
| A1  | 0.05       | 0.15 |
| A2  | 0.78       | 0.94 |
| b   | 0.22       | 0.38 |
| c   | 0.08       | 0.23 |
| D   | 2.90       | 3.10 |
| E   | 2.90       | 3.10 |
| E1  | 4.75       | 5.05 |
| e   | 0.65BSC    |      |
| L   | 0.40       | 0.70 |

### Outline Dimensions

#### DFN 3x3



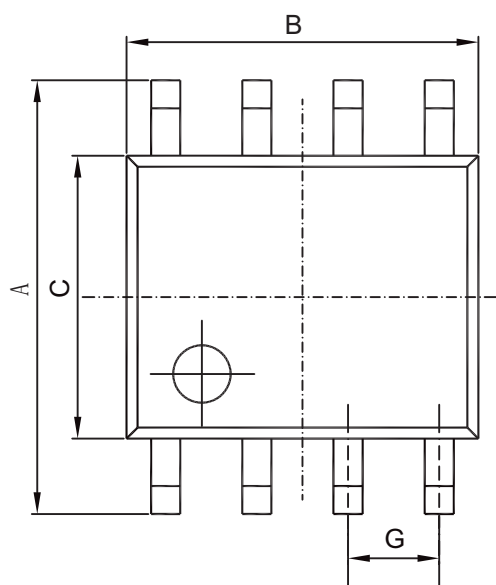
|   |      |       |
|---|------|-------|
| A | MAX. | 0.800 |
|   | NOM. | 0.750 |
|   | MIN. | 0.700 |



Note: All dimensions are in Millimeters.

### Outline Dimensions

SOP-8



| REF | DIMENSIONS  |      |
|-----|-------------|------|
|     | Millimeters |      |
|     | Min         | Max  |
| A   | 5.80        | 6.20 |
| B   | 4.80        | 5.00 |
| C   | 3.80        | 4.00 |
| D   | 0°          | 8°   |
| E   | 0.40        | 0.90 |
| F   | 0.19        | 0.25 |
| M   | 0.10        | 0.25 |
| H   | 0.35        | 0.49 |
| L   | 1.35        | 1.75 |
| J   | 0.375 REF   |      |
| K   | 45°         |      |
| G   | 1.27 TYP    |      |

