Advanced Datasheet
AAT5102

2.5W/CH Stereo Class D Audio Power Amplifier

General Description

The AAT5102 is a high efficiency, high performance stereo class D audio amplifier. It is designed to operate in a wide supply voltage range from 2.1V to 5.5V and is targeted to deliver up to 2.5W output power to a 4Ω load with 5V power supply. Its up to 90.5% efficiency and space saving Wafer-level Chip Scale Package (WCSP) make it ideal for portable applications.

AAT5102 has four adjustable amplifier gains with 6, 12, 18 and 24dB programmed by two external pins. Two enable control pins are employed to control the left and right channels independently.

AAT5102 also integrates over-temperature and output short circuit protection circuitries to prevent the internal junction temperature over-heat and over-current case. The device will recover to normal operation when the fault condition is removed.

The AAT5102 is offered in a Pb-free, thermally enhanced, space-saving 1.61mmx 1.61mm 16-pin WCS package, and is specified for operation over the -40°C to +85°C ambient temperature range.

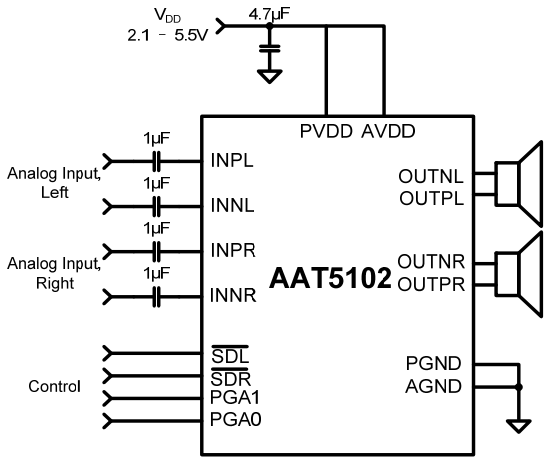
Features

- Wide Supply Voltage Range (2.1V to 5.5V)
- Maximum Battery Life and Minimum Heat
  - 4.28mA Quiescent Current at 3.6V V_{DD}
  - <1μA Shutdown Current
  - Up to 90.5% Efficiency
- Output Power at 10% THD+N
  - 2.5W x2 to 4Ω at 5V V_{DD}
  - 1.6W x2 to 8Ω at 5V V_{DD}
- High Performance
  - THD+N of 0.03%, at 5V V_{DD}, 8Ω Load and P_{OUT} = 1.0W
  - SNR of 98dB at 5V V_{DD}, 8Ω Load and 1% THD+N
- Shutdown Control
  - Independent Control per Channel
  - Internal 300kΩ Pull-down Resistors
- Filter-less Capability
- Four Programmable Gains: 6, 12, 18 and 24dB
- Thermal and Short-circuit Protection with Auto-recovery
- Excellent PSRR
- Building-in Pop-click Suppression Circuitry
- 1.61mm x 1.61mm 16-Pin WCS Package

Applications

- Cellular Phones
- MP4s
- Notebook Computers
- PDAs
- Portable DVD Players

Typical Application Circuits

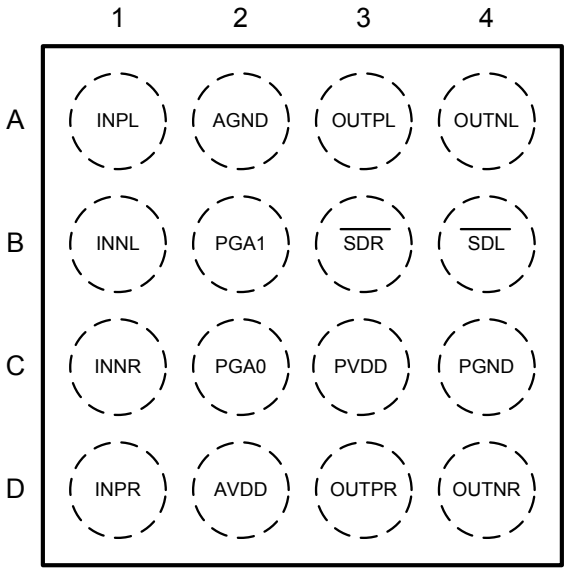


Pin Descriptions

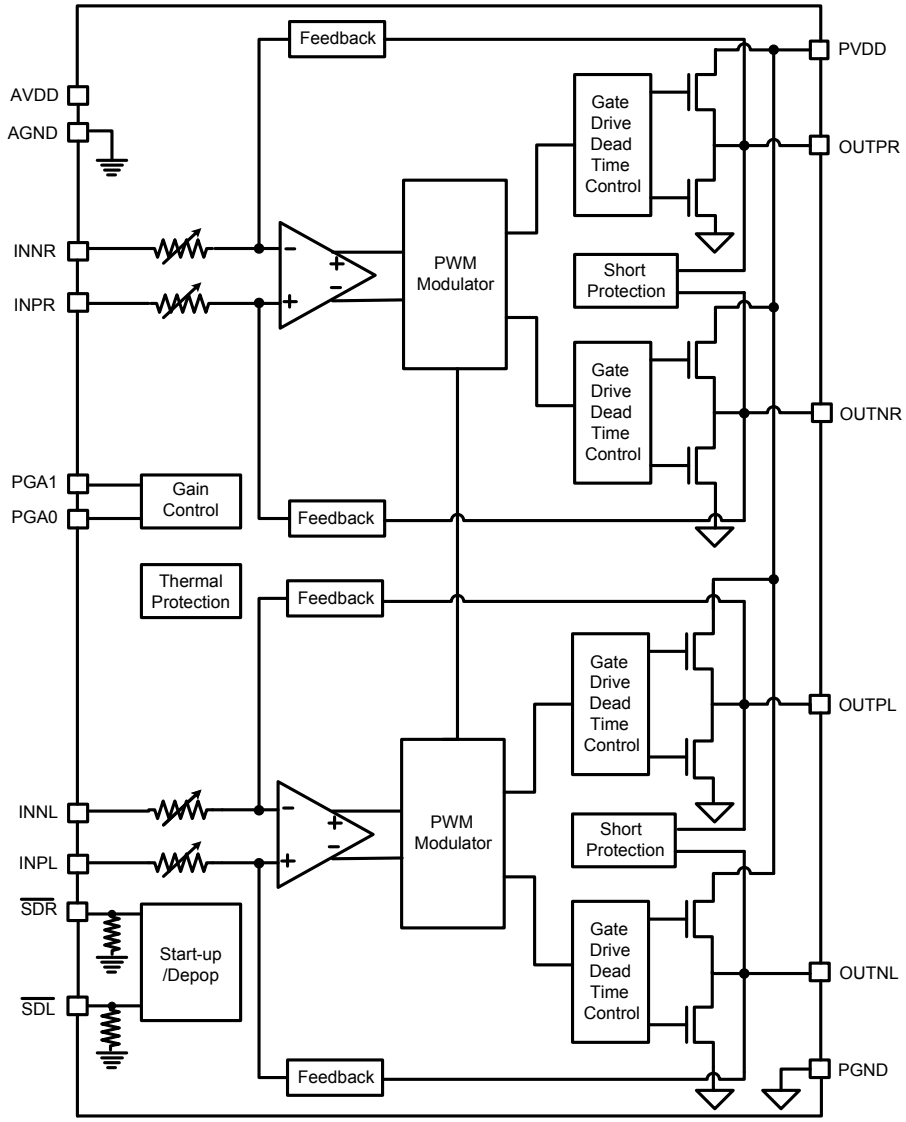
Pin #	Symbol	Description
A1	INPL	Analog positive input, left channel
B1	INNL	Analog negative input, left channel
D1	INPR	Analog positive input, right channel
C1	INNR	Analog negative input, right channel
A3	OUTPL	Power stage positive output, left channel
A4	OUTNL	Power stage negative output, left channel
D3	OUTPR	Power stage positive output, right channel
D4	OUTNR	Power stage negative output, right channel
B2	PGA1	PGA gain control, TTL compatible
C2	PGA0	PGA gain control, TTL compatible
B3	$\overline{\text{SDR}}$	Right channel shutdown control (active low)
B4	$\overline{\text{SDL}}$	Left channel shutdown control (active low)
D2	AVDD	Analog power supply
C3	PVDD	Power supply for output drivers
A2	AGND	Analog power ground
C4	PGND	Power ground for output drivers

Pin Configurations

WCSP-16
TOP VIEW



Functional Block Diagram



Absolute Maximum Ratings[1]

T_A = 25°C unless otherwise noted.

Symbol	Description	Value	Units
V_{DD}	Supply Voltage	-0.3 to 6.0	V
V_{IN}	Digital Input to Ground ($\overline{SDR}$, $\overline{SDL}$,PGA1 and PGA0 Pins)	-0.3 to V_{DD}+0.3	
T_J	Maximum Junction Operating Temperature Range	-40 to +150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	300	
T_{STG}	Storage Temperature Range	-65 to 150	

Recommended Operating Conditions

Description	Symbol	Min	Max	Unit
Supply Voltage	V_{DD}	2.1	5.5	V
High-level Input Voltage	V_{IH}	1.3	V_{DD}	V
Low-level Input Voltage	V_{IL}	0	1.2	V
Operating Temperature	T_A	-40	85	°C

Thermal Information[2]

Symbol	Description		Value	Units
Θ_{JA}	Thermal Resistance	WCSP-16	TBD	°C/W
P_D	Maximum Power Dissipation	WCSP-16	TBD	W

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum Rating should be applied at any one time.
2. Mounted on 1.6mm thick FR4 material printed circuit board.

Electrical Characteristics

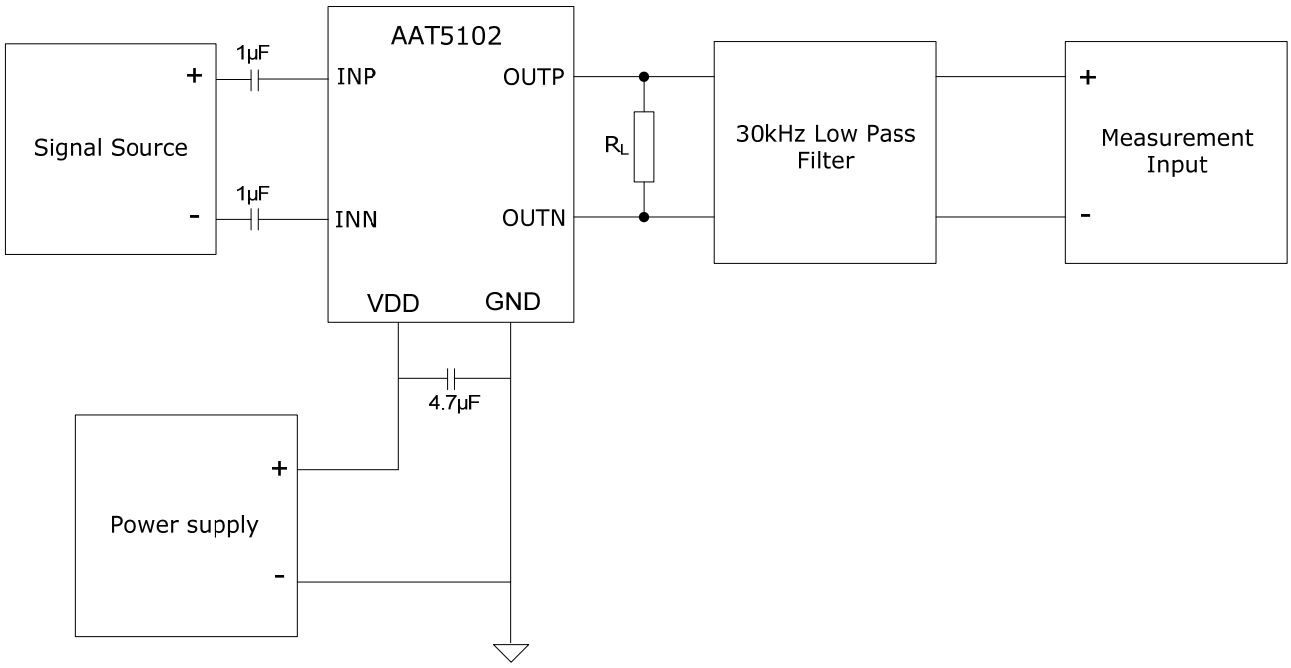
V_{DD}=5.0V, C_S=4.7µF, C_I=1µF, R_L=8Ω and Gain=6dB. T_A = 25°C unless otherwise noted.

Symbol	Description	Conditions	Min	Typ	Max	Units
DC Characteristics						
V_{DD}	Supply Voltage		2.1		5.5	V
V_{OS}	Output Offset Voltage			5		mV
I_Q	Operation Quiescent Current	V_{DD} = 5.5V, $\overline{SDR}$ = $\overline{SDL}$ = high, No Load		5.01		mA
		V_{DD} = 3.6V, $\overline{SDR}$ = $\overline{SDL}$ = high, No Load		4.28		
		V_{DD} = 2.1V, $\overline{SDR}$ = $\overline{SDL}$ = high, No Load		3.27		
$I_{SD(OFF)}$	Shutdown Supply Current	$\overline{SDR}$ = $\overline{SDL}$ = low, No load		0.1	1	µA
R_I	Input Impedance	PGA1=low, PGA0=high		15		kΩ
		PGA1=high, PGA0=low		30		
		PGA1=high, PGA0=high		15		
		PGA1=low, PGA0=high		15		
Gain	Amplifier Closed Loop Voltage Gain	PGA1=low, PGA0=low		6		dB
		PGA1=low, PGA0=high		12		dB
		PGA1=high, PGA0=low		18		dB
		PGA1=high, PGA0=high		24		dB
$R_{DS(ON)}$	Output On-Resistance	V_{DD}=5V		345		mΩ
$R_{\overline{SD}}$	Resistance from $\overline{SDR}$ / $\overline{SDL}$ to GND			300		kΩ
V_{IH}	High-level Input Voltage	$\overline{SDR}$, $\overline{SDL}$,PGA1, PGA0	1.5			V
V_{IL}	Low-level Input Voltage	$\overline{SDR}$, $\overline{SDL}$,PGA1, PGA0			0.5	
T_{SD}	Over Temperature Shutdown Threshold			150		°C
T_{HYS}	Over Temperature Shutdown Hysteresis			20		

V_{DD}=5.0V, C_S=4.7µF, C_I=1µF, R_L=8Ω and Gain=6dB. T_A = 25°C unless otherwise noted.

Symbol	Description	Conditions		Min	Typ	Max	Units
AC Characteristics							
F_{SW}	Switch Frequency				300		kHz
P_{OUT}	Output Power	THD+N=10%, f=1kHz, R_L = 8Ω	V_{DD}=5.0V		1.61		W
			V_{DD}=3.6V		0.82		
		THD+N=1%, f=1kHz, R_L = 8Ω	V_{DD}=5.0V		1.31		
			V_{DD}=3.6V		0.66		
		THD+N=10%, f=1kHz, R_L = 4Ω	V_{DD}=5.0V		2.66		
			V_{DD}=3.6V		1.35		
		THD+N=1%, f=1kHz, R_L = 4Ω	V_{DD}=5.0V		2.13		
			V_{DD}=3.6V		1.08		
η	Output Power Efficiency	V_{DD}=5.0V,f=1kHz,P_{OUT}=1.2W			90.5		%
THD+N	Total Harmonic Distortion + Noise	f=1kHz, R_L=8Ω, Gain=6dB	V_{DD}=5.0V, P_{OUT}=1W		0.03		%
			V_{DD}=3.6V, P_{OUT}=0.5W		0.04		
V_{NO}	Noise Output Voltage	V_{DD}=3.6V,f=20Hz~20kHz, Inputs AC-grounded	A-weighting		28		µV
SNR	Signal to Noise Ratio	V_{DD}=5.0V,f=1kHz,THD+N=1%			98		dB
Crosstalk	Channel Separation	V_{DD}=5.0V,f=1kHz			TBD		dB
PSRR	Power Supply Ripple Rejection Ratio	V_{DD}=3.6V, V_{RIPPLE} =200mV_{pp}, f=217Hz, Inputs AC- grounded			-63		dB
CMRR	Common Mode Ripple Rejection Ratio	V_{DD}=3.6V, V_{RIPPLE} = 1V_{pp}, f=217Hz			-70		dB
T_{ON}	Turn-On time				2		ms
T_{OFF}	Turn-Off time				3		ms

Test Set-up for Typical Characteristics Graphs (per channel)[1] [2]

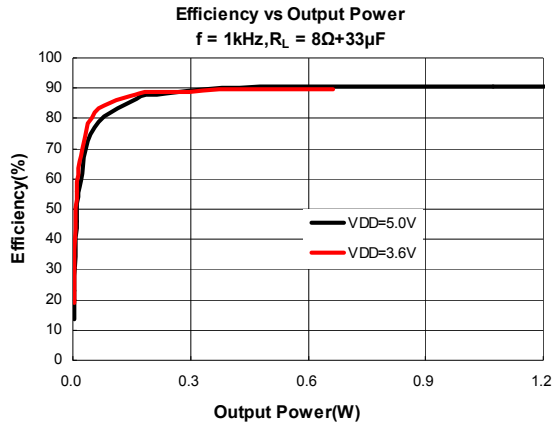


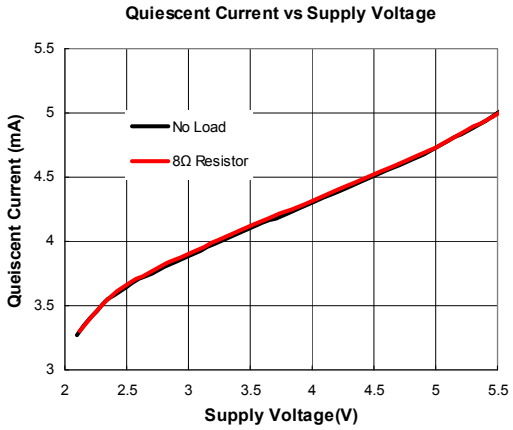
Test Set-up for Typical Characteristics Graphs.

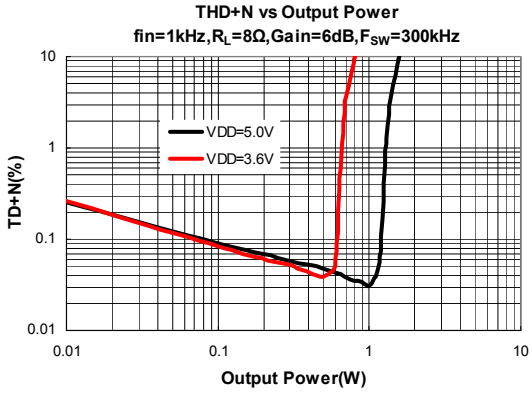
[1] A 33µH inductor was placed in series with load resistor to emulate a small speaker for efficiency measurement.

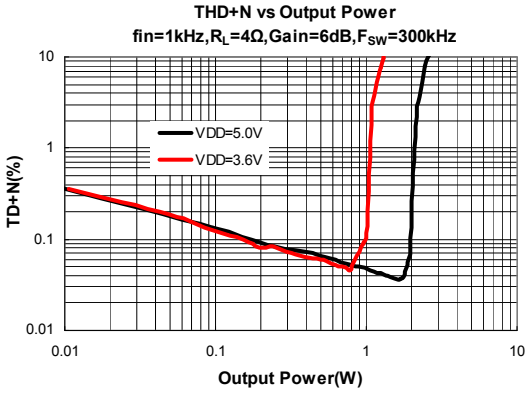
[2] The 30 kHz low-pass filter is required even if the analyzer has an internal low-pass filter. An RC low pass filter (100Ω, 47nF) is used on each output for the data sheet graphs.

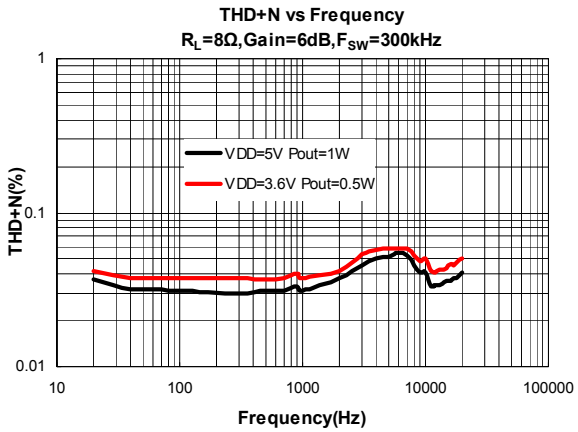
Typical Characteristics

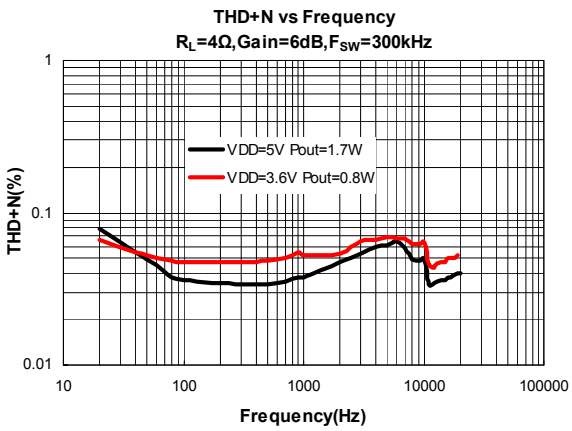












Application Information

AAT5102 is a closed loop pulse-width-modulated switch mode power amplifier for driving bridge-tied load. It features high performance with high efficiency, high SNR and low THD+N. It also builds in protections such as over-temperature and output short protection.

Gain Setting

The AAT5102 voltage gain can be programmed to 6, 12, 18 and 24dB via two inputs, PGA1 and PGA0. See table1 for gain setting.

PGA1	PGA0	Voltage GAIN (dB)	Input Impedance (kΩ)
0	0	6	30
0	1	12	15
1	0	18	30
1	1	24	15

Table1 Gain Setting

Input High-Pass Filter

C_{IN} is the input DC blocking capacitor which forms input high pass filter with amplifier input impedance. The corner frequency is determined from the equation:

$$f_{-3dB} = \frac{1}{2 \cdot \pi \cdot R_I \cdot C_I}$$

Where:

f_{-3dB} is -3dB corner frequency

R_I is the input resistance

C_I is the input capacitance

The value of C_I is important for bass performance of amplifier. The capacitors should have a tolerance of ±10% or better.

Manufacturer	Value (μF)	Voltage (V)	Case Size	Part Number
Murata	1	16	0603	GRM188R71C105KA12

Table 2: Recommended Input Capacitor Selection Information

Power Supply Bypassing

The AAT5102 is a high performance Class-D amplifier, adequate supply decoupling is necessary for overall better performance. A good low equivalent series resistance (ESR) decoupling capacitor of 4.7μF or larger is recommended.

Manufacturer	Value (μF)	Voltage (V)	Case Size	Part Number
Murata	4.7	6.3	0603	GRM188R60J475KE19

Table 3: Recommended Decoupling Capacitor Selection Information

Thermal Protection

The AAT5102 features unlatched over temperature protection. During operation when the device junction temperature exceeds 150ºC (typical), the device enters into shutdown state and outputs are disabled. Once device junction temperature is reduced by 20ºC, the device leaves shutdown state and back to normal operation automatically.

Output Short Protection

The output short protection in AAT5102 provides short protection between output-to-output, output-to-supply and output-to-ground. When output short-circuit detected, the device output stage will be disabled immediately. Once the shorts removed, normal operation will be restored automatically.

Shutdown Mode

When $\overline{SDR}/\overline{SDL}$ is pulled down to low voltage, the device is in its maximum power saving mode. In the shut down mode, outputs are pulled in weak low state. The high logic level applied on $\overline{SDR}/\overline{SDL}$ wakes up the device after turn-on time (T_{ON}).

Output Filter

A ferrite bead should be used to reduce EMI emissions if EMI sensitive devices nearby in the system. The ferrite bead acts essentially as high impedance to a high frequency emissions but very low impedance to low frequency signal. Choose the ferrite bead with high impedance at the frequency range of interest.

.

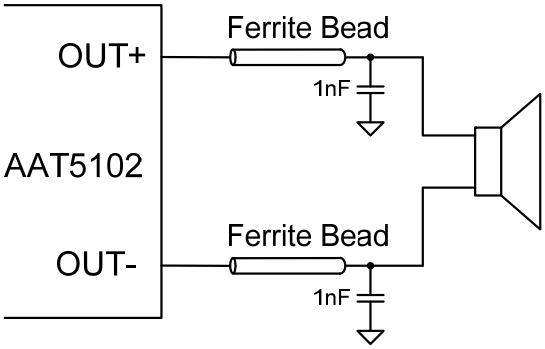


Figure 1.Typical Ferrite Bead Filter

Manufacturer	Part Number	Impedance (Ω)[100MHz]	Rated Current (A) Max	DCR	Thickness (mm)	Case Size
TDK	MPZ1608S221A	220±25%	2	0.05	0.8	0603

Table 4: Recommended Output Ferrite Bead Selection Information.

Thermal Considerations and Max output power

The AAT5102 delivers a 5W power to 4Ω speaker. The limiting characteristic for the maximum output power is essentially package power dissipation and the device internal thermal limit.
At any given ambient temperature (T_A), the maximum package power dissipation can be determined by the following equation:

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

The $T_{J(MAX)}$, the maximum junction temperature for the device is 150°C. The package thermal resistance θ_{JA} is TBD°C/W for the WCSP-16 package. For example, given T_A=25°C, from above formula, the maximum power dissipation is TBDW. With given efficiency η, the max output power can be determined by the following equation:

$$P_{O(MAX)} = \frac{P_{D(MAX)}}{1-\eta}$$

Application Circuits

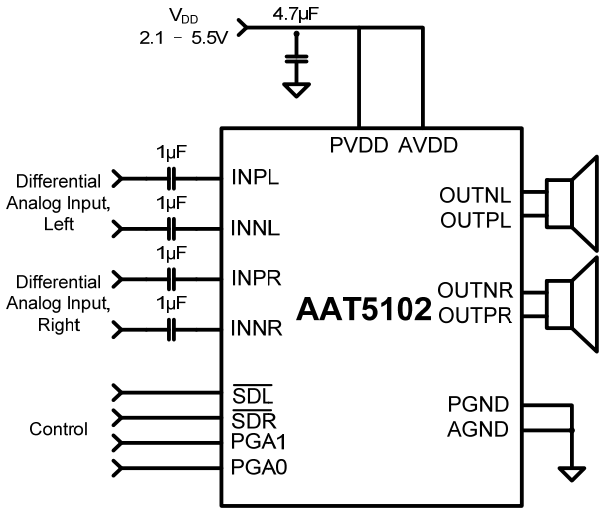


Figure 2. AAT5102 Application Schematic With Differential Input and Input Capacitors

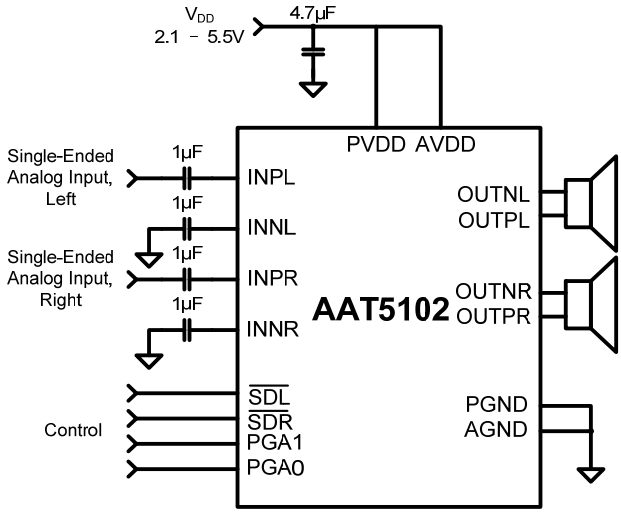


Figure 3. AAT5102 Application Schematic With Single-Ended Input

Evaluation Board Schematics

Evaluation Board Layout

Ordering Information

Package	Part Marking	Part Number
WCSP-16		

Package Information

Advanced Analogic Technologies, Inc.

3230 Scott Blvd., Santa Clara, CA 95043
Phone (408) 737-4600
Fax (408) 737-4611