

3W Mono Filter-less Class-D Audio Amplifier

Features

- Supply voltage range: 2.5 V to 5.5 V
- Support single-ended or differential analog input
- Low Quiescent Current
- Low Output Noise
- Low shut-down current
- Short power-on transient time
- Internal pull-low resistor on shut-down pins
- Short-circuit protection
- Over-temperature protection
- Loudspeaker power within 10% THD+N
 - 1.8W/ch into 8Ω loudspeaker
 - >3W/ch into 4Ω loudspeaker
- Loudspeaker efficiency
 - 93% @ 8Ω, THD+N=10%
 - 90% @ 4Ω, THD+N=10%
- WLCSP-9L package
- Integrated Feedback Resistor of 300kΩ

Applications

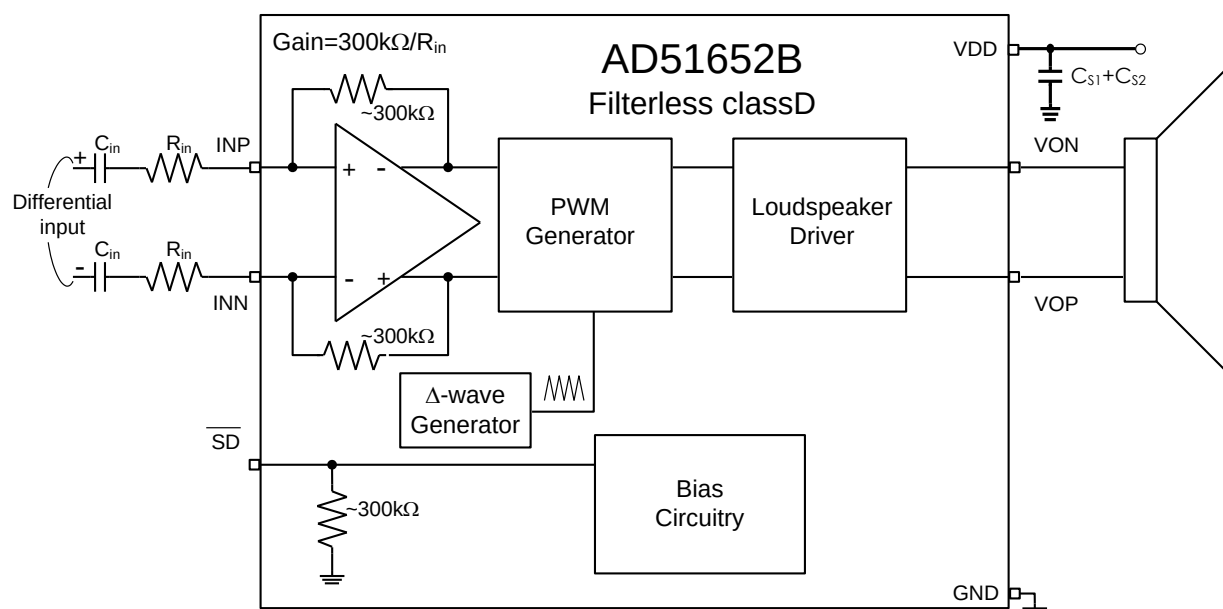
- Monitor audio
- PDA
- Portable multimedia devices
- Notebook computer
- Mobile phone

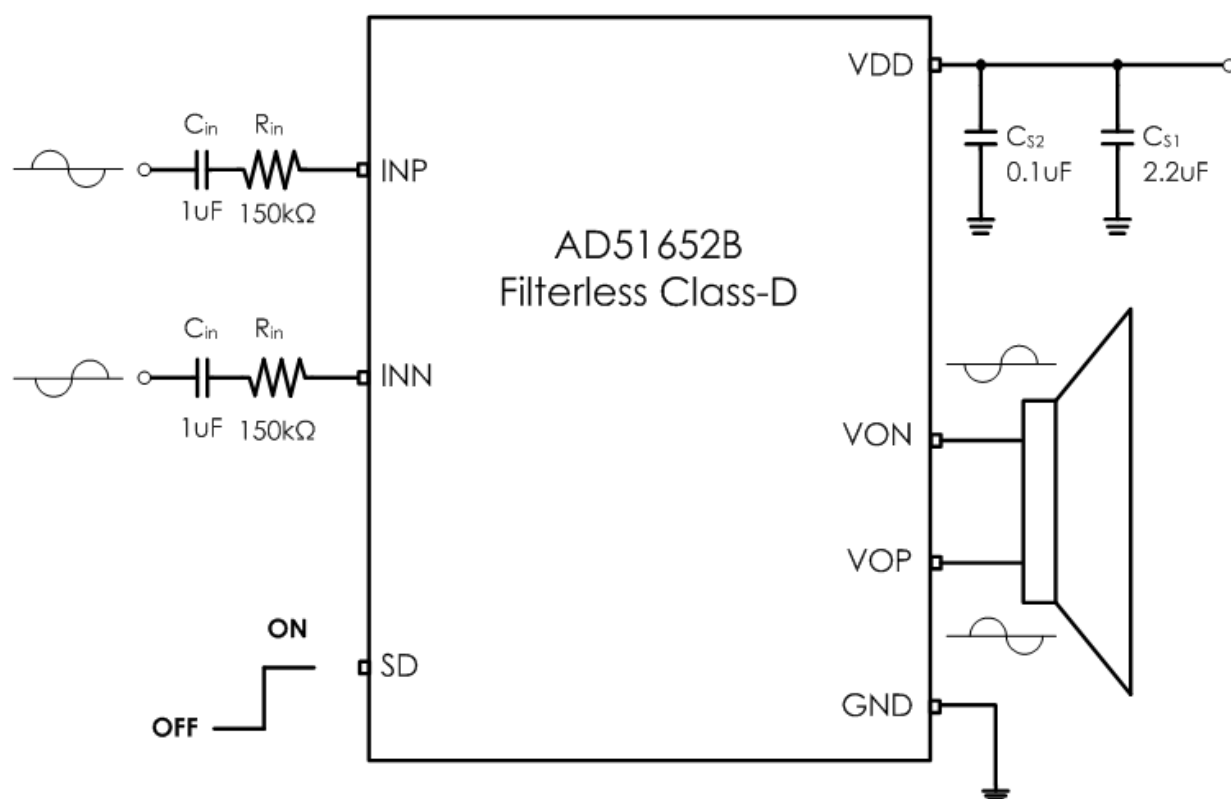
Description

The AD51652B is a 3W mono, filter-less Class-D audio amplifier. Operating with 5.0V loudspeaker driver supply, it can deliver 3W output power into 4 Ω loudspeaker within 10% THD+N.

The AD51652B is a mono audio amplifier with high efficiency and suitable for the notebook computer, and portable multimedia device.

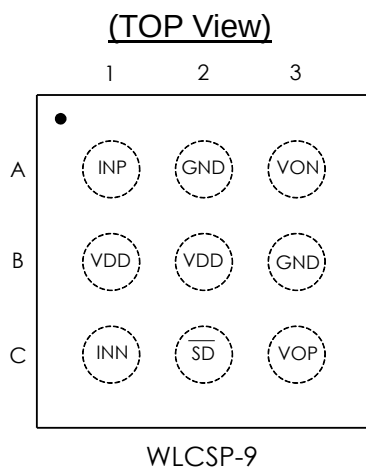
Functional Block Diagram



Typical Application Circuit

Note. Gain=2 V/V

Pin Assignments



Order information

AD51652B-WL09NRR

WL09 WLCSP-9 Package
NRR RoHS & Halogen free
Rating: -40 to 85°C
Package in Tape & Reel

Pin Description

NAME	PIN	IO TYPE	DESCRIPTION
	WLCSP-9		
INP	A1	I	Positive differential input.
GND	A2, B3	G	Power ground.
VON	A3	O	Negative output.
VDD	B1,B2	P	Power supply.
INN	C1	I	Negative differential input.
$\overline{\text{SD}}$	C2	I	Shutdown AD51652B (Low active logic).
VOP	C3	O	Positive output.

Ordering Information

Product ID	Package	Packing / MPQ	Comments
AD51652B-WL09NRR	WLCSP-9	3K units Tape & Reel	Green

Marking Information

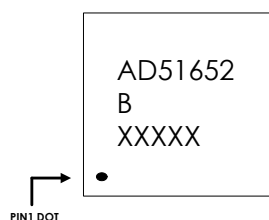
AD51652B

- WLCSP-9 Package Marking Information

Line 1 : Product No

Line 2 : Version

Line 3 : Tracking Code



Available Package

Package Type	Device No.	$\theta_{JA} (^{\circ}\text{C/W})$	$\theta_{JT} (^{\circ}\text{C/W})$	$\Psi_{JT} (^{\circ}\text{C/W})$
WLCSP-9	AD51652B	128	0.9	3.8

Note 1.1: The thermal pad is located at the bottom of the package. To optimize thermal performance, soldering the thermal pad to the PCB's ground plane is necessary.

Note 1.2: θ_{JA} is simulated on a room temperature ($T_A=25^{\circ}\text{C}$), natural convection environment test board, which is constructed with a thermally efficient, 4-layers PCB (2S2P). The measurement is simulated using the JEDEC51-5 thermal measurement standard.

Note 1.3: θ_{JT} represents the thermal resistance for the heat flow between the chip junction and the package's top surface. It's extracted from the simulation data with obtaining a cold plate on the package top.

Note 1.4: Ψ_{JT} represents the thermal parameter for the heat flow between the chip junction and the package's top surface center. It's extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-5.

Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver	-0.3	6.0	V
V_I	Input pins voltage	-0.3	5.5	V
T_{stg}	Storage temperature	-65	150	$^{\circ}\text{C}$
T_J	Junction operating temperature	-40	150	$^{\circ}\text{C}$
R_L	Minimum load resistance	3.2		Ω
ESD	Human Body Model	-	$\pm 2\text{K}$	V
	Charged Device Model	-	$\pm 1\text{K}$	V

Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver	2.5	5.5	V
V_{IH}	High-Level Input Voltage	1.3	-	V
V_{IL}	Low-Level Input Voltage	-	0.35	V
T_J	Junction operating temperature	-40	125	$^{\circ}\text{C}$
T_A	Ambient operating temperature	-40	85	$^{\circ}\text{C}$

General Electrical Characteristics (T_A=25°C)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
I _q	Operating current	VDD=SD=5V, Output switching		2.3		mA
I _{PD}	Supply current during power-down mode	VDD=5.5V; SD#=0		<1		uA
V _{offset}	Output offset voltage	Input ac grounded, VDD=2.5V ~ 5.5V		< 1	2	mV
T _{sd}	Junction temperature for driver shutdown			155		°C
Thys	Temperature hysteresis for recovery from shutdown			25		°C
f _{sw}	Switching rate of loudspeakers driver		250	300	350	kHz
A _v	Gain		$\frac{285k\Omega}{R_{in}}$	$\frac{300k\Omega}{R_{in}}$	$\frac{315k\Omega}{R_{in}}$	V/V
Ton	Turn-on time	VDD = 3.6 V		1.7	4	msec

Electrical Characteristics and Specifications for Loudspeaker

- Gain= 2 V/V, Load=8Ω, f_{in}=1 kHz, C_{S1}=2.2uF, C_{S2}=0.1uF, T_A=25°C (unless otherwise noted)

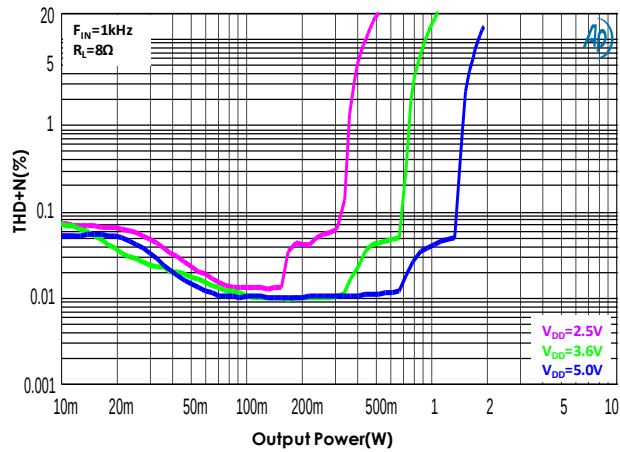
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P _O	RMS Output Power	VDD=5.0V	THD+N = 10 %	1.80		W
			THD+N = 1 %	1.50		W
		VDD=3.6V	THD+N = 10 %	0.93		W
			THD+N = 1 %	0.75		W
		VDD=2.5V	THD+N = 10 %	0.44		W
			THD+N = 1 %	0.36		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, P _O =1.0W		0.04		%
		VDD=3.6V, P _O =0.5W		0.045		%
		VDD=2.5V, P _O =0.2W		0.04		%
SNR	Signal to Noise Ratio	VDD=5.0V, P _O =1.0W		97		dB
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V _{ripple} =200mVpp Inputs ac grounded with C _i =2μF f=217 Hz		76		dB
CMRR	Common-Mode Rejection	VDD=3.6V, V _{IC} =1Vpp, f=217Hz		68		dB
V _n	Output integrated noise (A-weighted)	VDD=3.6V f _{in} =20Hz ~ 20kHz		31		uV
η	Efficiency	VDD=5V, THD+N=10%		93		%

- Gain= 2 V/V, Load=4Ω, f_{in} =1 kHz, C_{S1} =2.2μF, C_{S2} =0.1μF, T_A =25°C (unless otherwise noted)

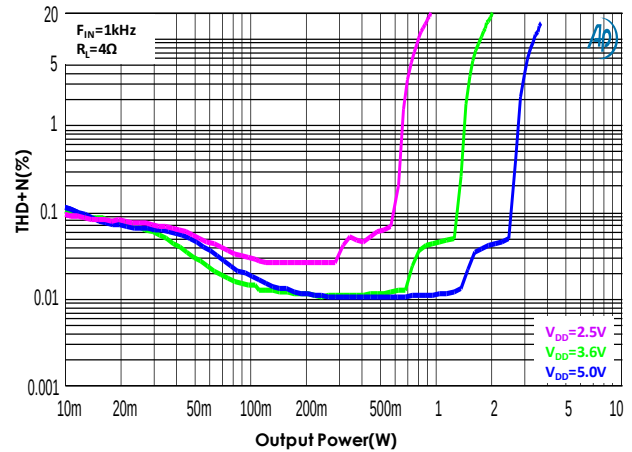
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P_O	RMS Output Power	VDD=5.0V	THD+N = 10 %	3.2		W
			THD+N = 1 %	2.65		W
		VDD=3.6V	THD+N = 10 %	1.65		W
			THD+N = 1 %	1.35		W
		VDD=2.5V	THD+N = 10 %	0.7		W
			THD+N = 1 %	0.6		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, P_O =2.0W		0.04		%
		VDD=3.6V, P_O =1.0W		0.045		%
		VDD=2.5V, P_O =0.5W		0.06		%
SNR	Signal to Noise Ratio	VDD=5.0V, P_O =1.8W		97		dB
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V_{ripple} =200mVpp Inputs ac grounded with C_i =2μF f =217 Hz		76		dB
CMRR	Common-Mode Rejection	VDD=3.6V, V_{IC} =1Vpp, f =217Hz		68		dB
V_n	Output integrated noise (A-weighted)	VDD=3.6V f_{in} =20Hz ~ 20kHz		31		μV
η	Efficiency	VDD=5.0V, THD+N=10%		90		%

Typical Characteristics (Gain= 2 V/V, unless otherwise noted)

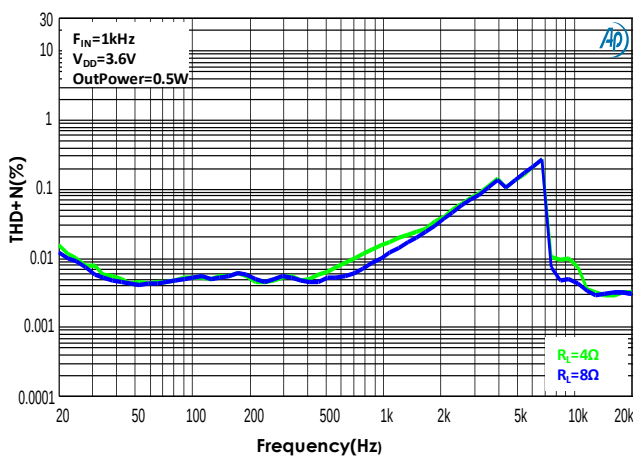
THD+N vs. Output Power (8Ω)



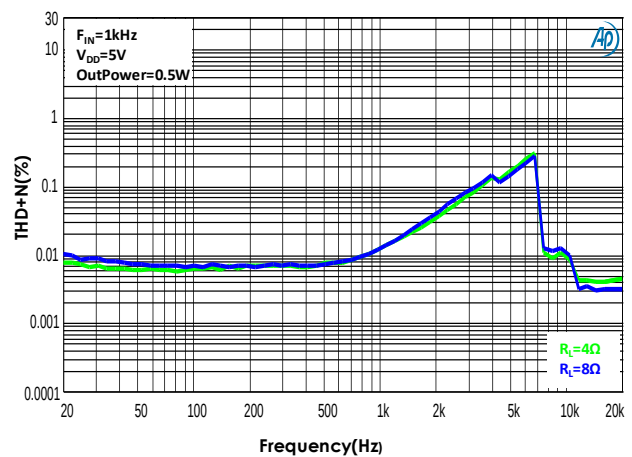
THD+N vs. Output Power (4Ω)



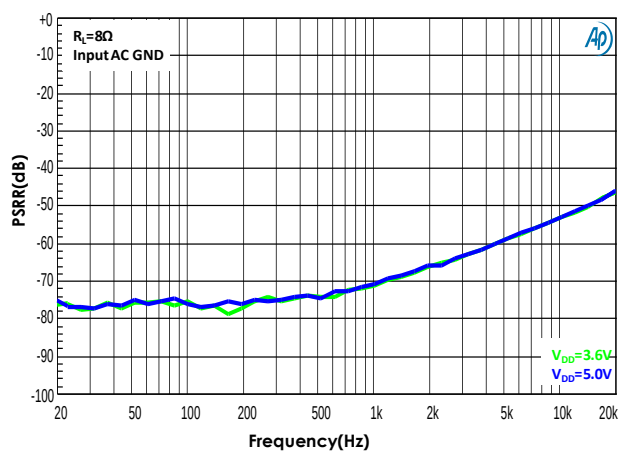
THD+N vs. Frequency (VDD=3.6V)



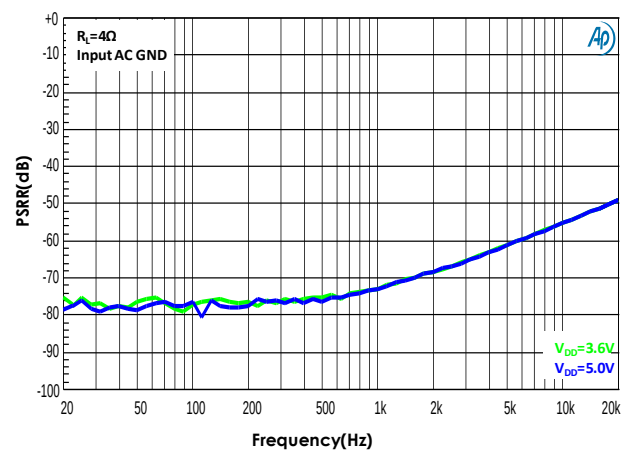
THD+N vs. Frequency (VDD=5V)



PSRR vs. Frequency (8Ω)

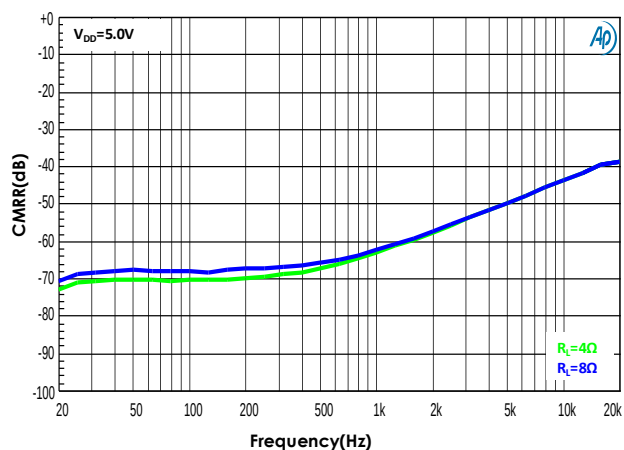


PSRR vs. Frequency (4Ω)

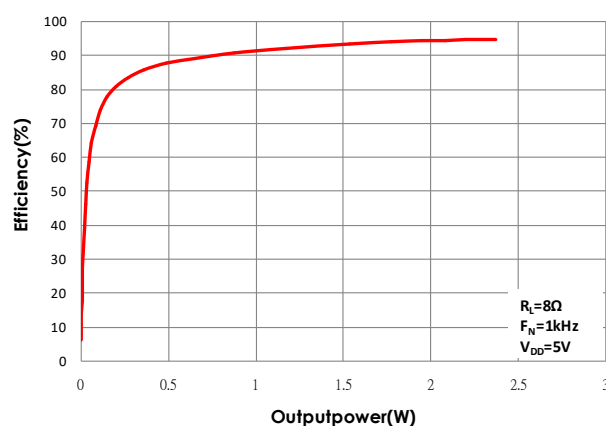


Typical Characteristics (Gain= 2 V/V, unless otherwise noted)

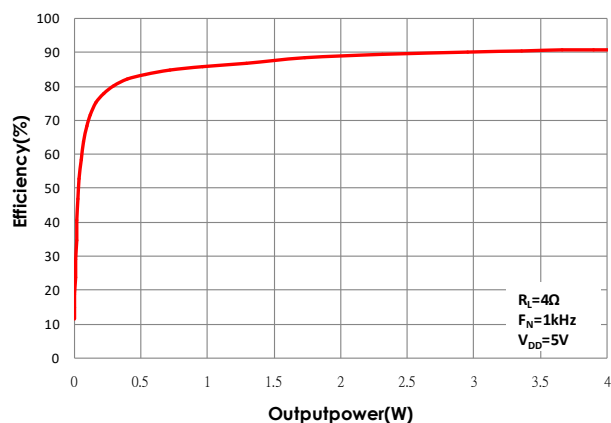
CMRR vs. Frequency



Efficiency vs. Output Power (8Ω)



Efficiency vs. Output Power (4Ω)



Operation Descriptions

- Self-protection circuits (typical values are used below.)

AD51652B has built-in over-temperature, overload and under-voltage detectors.

 - (i) If the internal junction temperature is higher than 155°C, the outputs of loudspeaker drivers will be disabled and connected to ground and the temperature hysteresis for AD51652B to return to normal operation is about 25°C. The variation of protected temperature is around 10%.
 - (ii) To protect loudspeaker drivers from current damage when the wires connected to loudspeakers are shorted to one another, shorted to VDD or shorted to GND, circuits for the detection of output loading are built in the AD51652B. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. When a short-circuit event occurs, the AD51652B goes to shutdown mode and activates the integrated auto-recovery process whose aim is to return the device to normal operation once the short-circuit is removed.
 - (iii) When the VDD voltage is lower than 2.3V, AD51652B will disable and loudspeaker drivers are at low state, cease AD51652B beside voltage detector circuit. When VDD becomes larger than 2.4V, AD51652B will return to normal operation.
- Anti-pop design

AD51652B is with anti-pop design. Annoying pop sounds during initial power on and power down/up are suppressed. When one of the operations mentioned above is applied, AD51652B will internally generate appropriate control signals to suppress pop sounds.

Application Circuit Information

- Input resistors (R_{in}) and input capacitors (C_{in})

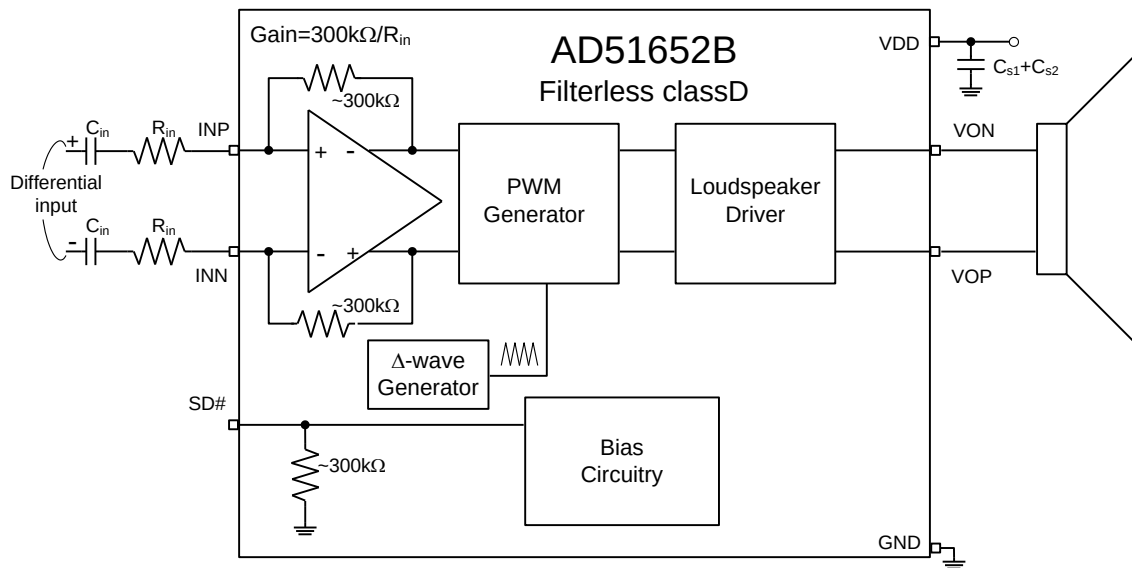
The total gain of the audio amplifier (AD51652B) is set by input resistor (R_{in}) according to the following equation (a). The performance at low frequency (bass) is affected by the corner frequency (f_c) of the high-pass filter composed of input resistors (R_{in}) and input capacitors (C_{in}), determined in equation (b).

$$Gain = \frac{300k\Omega}{R_{in}} \left(\frac{V}{V} \right) \dots\dots\dots (a)$$

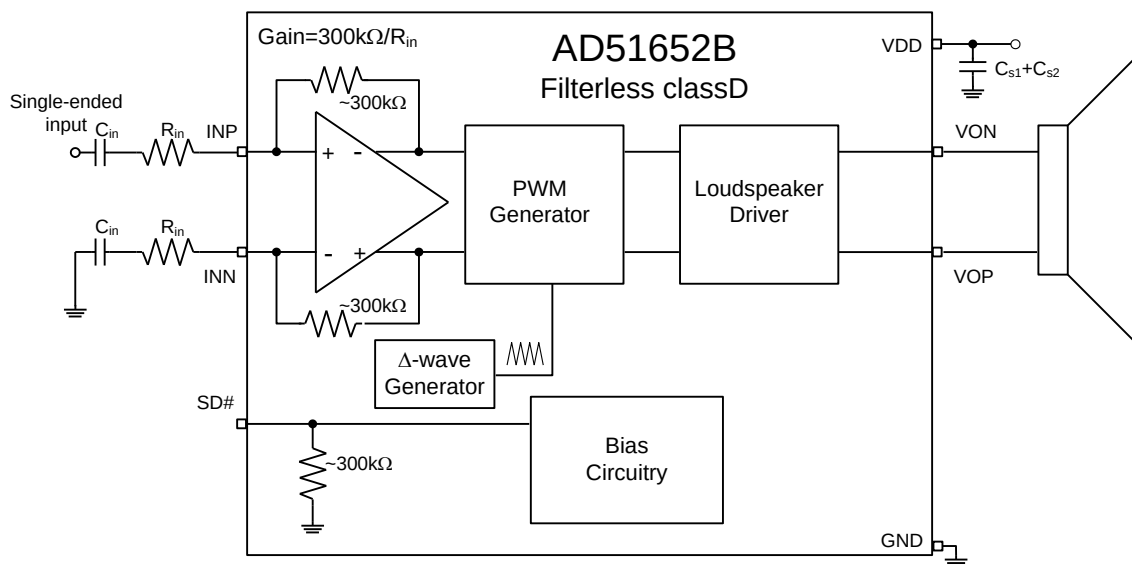
$$f_c = \frac{1}{2\pi R_{in} C_{in}} \text{ (Hz)} \dots\dots\dots (b)$$

For differential audio signal application, the input capacitors (C_{in}), for DC decoupling, are not required. When single-ended audio source is used, the input capacitors (C_{in}) are required.

- Suggested application circuit for fully differential input

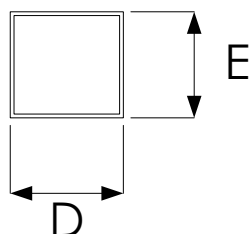


- Suggested application circuit for single-ended input

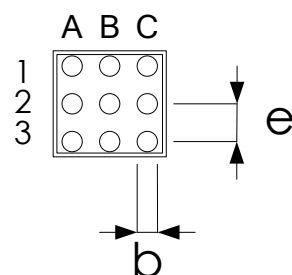


Package Outline Dimensions

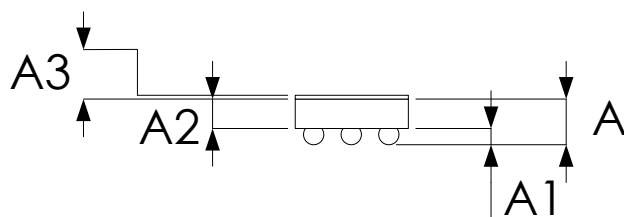
● WLCSP-9



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimension in mm	
	Min	Max
A	0.536	0.634
A1	0.189	0.231
A2	0.325	0.375
A3	0.022	0.028
D	1.190	1.230
E	1.190	1.230
b	0.234	0.286
e	0.400	

Revision History

Revision	Date	Description
0.1	2023.03.21	Preliminary version.
0.2	2023.05.12	Update general electrical characteristics. Page 5–6.

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