

5W 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
 - 5W/ch into 2Ω loudspeaker (TDFN-8L)
- Loudspeaker efficiency
 - 90% @ 8Ω, THD+N=10%
 - 85% @ 4Ω, THD+N=10%
 - 74% @ 2Ω, THD+N=10%
- MSOP-8L, TDFN-8L and 0.4mm ball pitch WLCSP-9L packages
- Integrated Feedback Resistor of 300kΩ

Applications

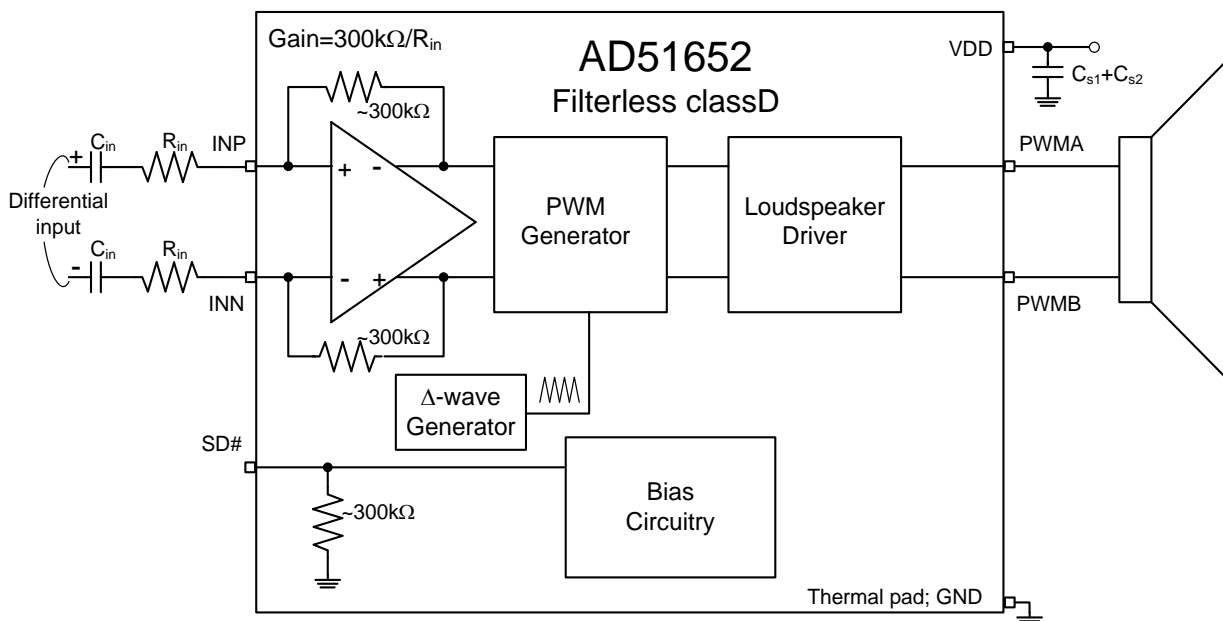
- Monitor audio
- PDA
- Portable multimedia devices
- Notebook computer
- Mobile phone

Description

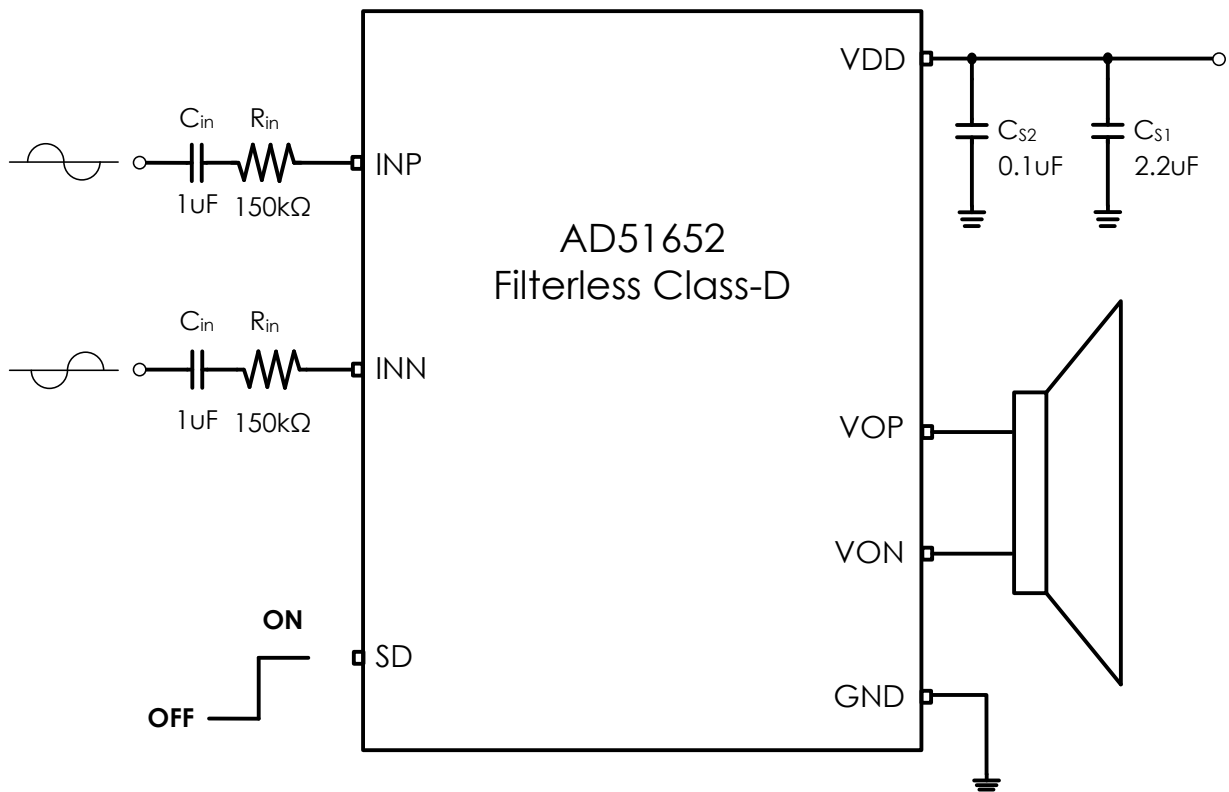
The AD51652 is a 5.0W mono, filter-less Class-D audio amplifier. Operating with 5.0V loudspeaker driver supply, it can deliver 5.0W output power into 2 Ω loudspeaker within 10% THD+N or 4.3W at 1% THD+N.

The AD51652 is a mono audio amplifier with high efficiency and suitable for the notebook computer, and portable multimedia device.

Functional Block Diagram



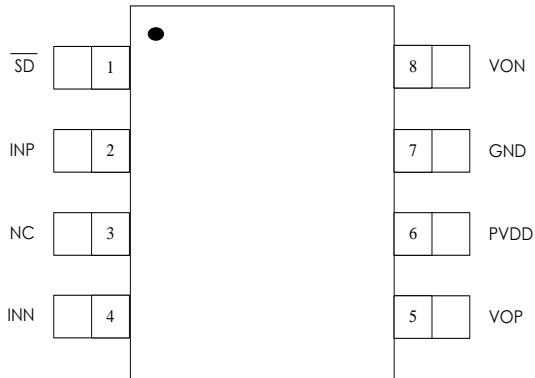
Typical Application Circuit



Note. Gain=2 V/V

Pin Assignments

MSOP-8



Order information

AD51652-MH08NRR

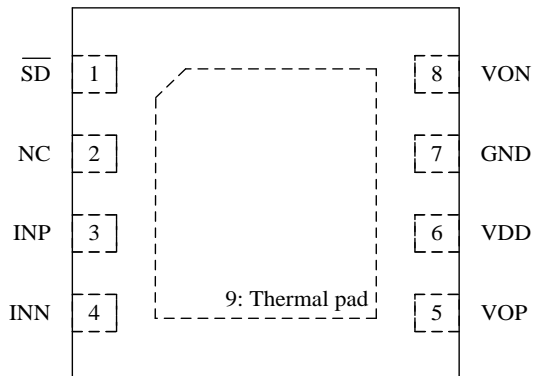
MH08 MSOP-8 Package

NRR RoHS & Halogen free

Rating: -40 to 85°C

Package in Tape & Reel

TDFN-8



Order information

AD51652-FH08NRR

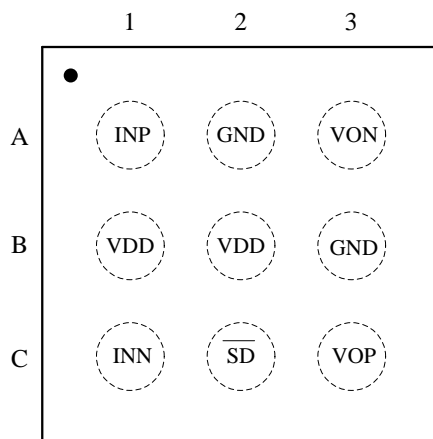
FH08 TDFN-8 Package

NRR RoHS & Halogen free

Rating: -40 to 85°C

Package in Tape & Reel

WLCSP-9



Order information

AD51652-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
	MSOP-8	TDFN-8	WLCSP-9		
SD	1	1	C2	I	Shutdown AD51652 (Low active logic)
INP	2	3	A1	I	Positive differential input
NC	3	2	N/A	NC	No internal connect
INN	4	4	C1	I	Negative differential input
VOP	5	5	C3	O	Positive output
VDD	6	6	B1,B2	P	Power supply
GND	7	7	A2, B3	G	Power ground
VON	8	8	A3	O	Negative output
Thermal pad	N/A	9	N/A	G	Must be connected the package thermal pad to PCB thermal land.

Ordering Information

Product ID	Package	Packing / MPQ	Comments
AD51652-MH08NRR	MSOP-8	3K units Tape & Reel	Green
AD51652-FH08NRR	TDFN-8	5K units Tape & Reel	Green
AD51652-WL09NRR	WLCSP-9	3K units Tape & Reel	Green

Available Package

Package Type	Device no.	θ_{JA} (°C/W)	Exposed Thermal Pad
MSOP-8	AD51652	190	No
TDFN-8 (3x3mm)		45.8	Yes
WLCSP-9		128	No

Marking Information

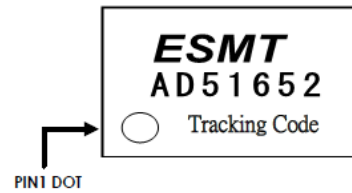
AD51652

- MSOP-8L Package Marking Information

Line 1 : Company Mark

Line 2 : Product No

Line 3 : Tracking Code

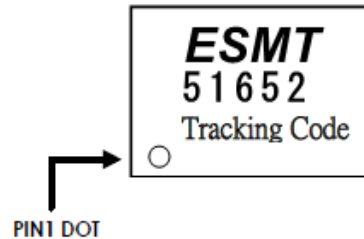


- TDFN-8 (3x3mm) Package Marking Information

Line 1 : Company Mark

Line 2 : Product No

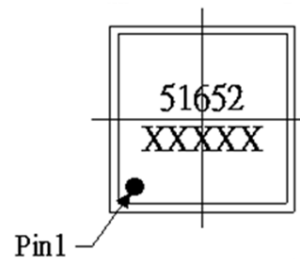
Line 3 : Tracking Code



- WLCSP-9 Package Marking Information

Line 1 : Product No

Line 2 : Tracking Code



Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver	-0.3	6.0	V
	Input pins voltage	-0.3	5.5	V
T _{stg}	Storage temperature	-65	150	°C
T _J	Junction operating temperature	-40	150	°C
ESD	Human Body Model	-	±2K	V
	Charged Device Model	-	±750	V

Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Supply for analog cells & loudspeaker driver (8Ω and 4Ω)	2.5	5.5	V
	Supply for analog cells & loudspeaker driver (2Ω)	3.0	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	°C
T _A	Ambient Operating Temperature	-40	85	°C

General Electrical Characteristics (T_A=25°C)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
I _q	Operating current	VDD=SD=5V, Output switching		3		mA
I _{PD}	Supply current during power-down mode	VDD=5.5V; SD#=0		<1		μA
V _{offset}	Output offset voltage	Input ac grounded, VDD=2.5V ~ 5.5V		< 1	2	mV
T _{sd}	Junction temperature for driver shutdown			165		°C
T _{hys}	Temperature hysteresis for recovery from shutdown			20		°C
f _{sw}	Switching rate of loudspeakers driver		250	300	350	kHz
A _v	Gain		$\frac{270k\Omega}{R_{\#}}$	$\frac{300k\Omega}{R_{\#}}$	$\frac{330k\Omega}{R_{\#}}$	V/V
T _{on}	Turn-on time	VDD = 3.6 V		1.7	4	msec
R _{sc}	Loudspeaker short-circuit detect resistance	VDD = 5.0 V			1.6	ohm

Electrical Characteristics and Specifications for Loudspeaker

- Gain= 2 V/V, Load=8Ω, 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 %		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		0.04	%	
		VDD=2.5V, P _O =0.2W		0.07	%	
SNR	Signal to Noise Ratio	VDD=5.0V, P _O =1.0W		100	dB	
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V _{ripple} =200mVpp Inputs ac grounded with C _i =2μF f=217 Hz		74	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		23	μV	
η	Efficiency (TDFN-8L)	VDD=5V, THD+N=10%		90	%	

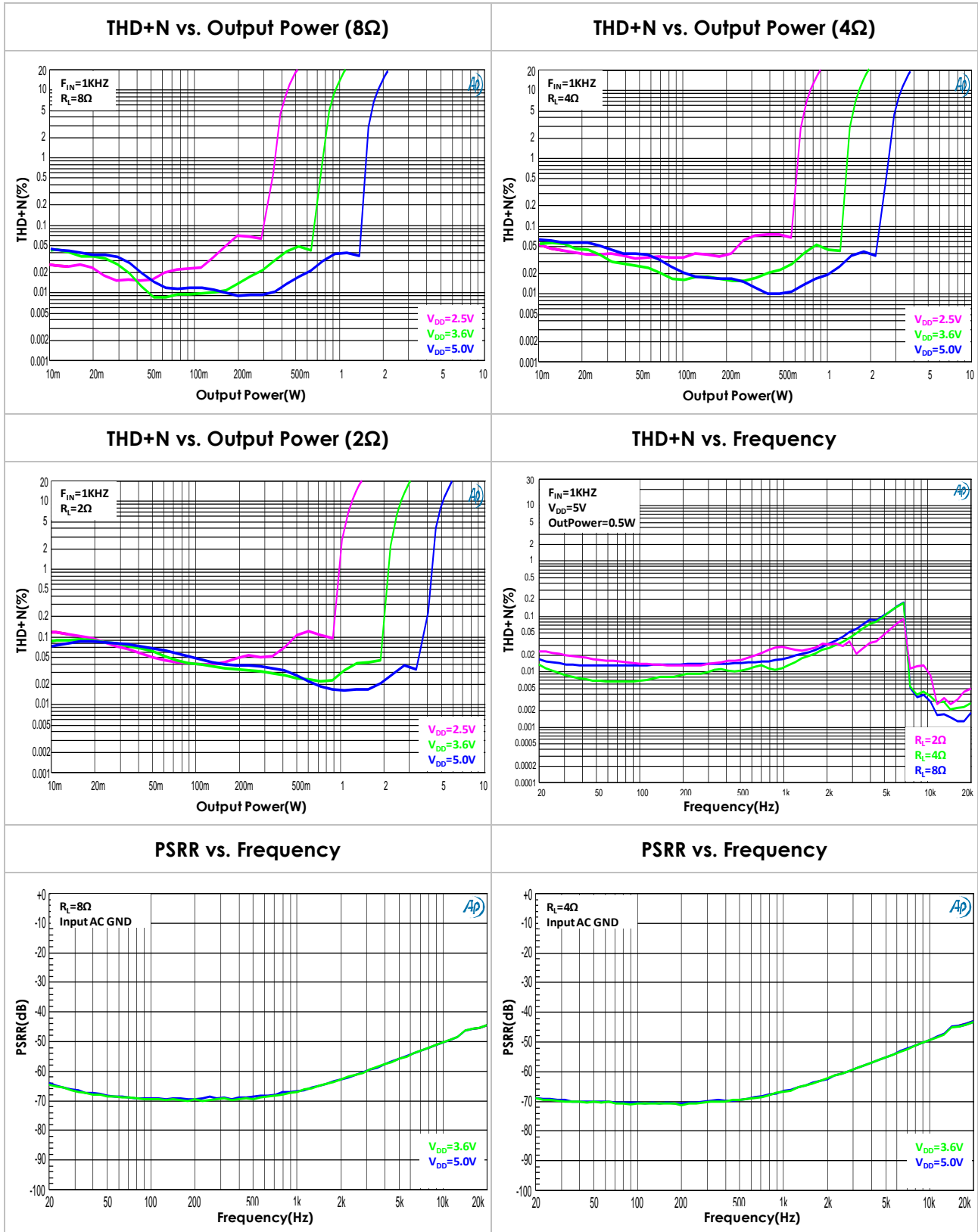
- Gain= 2 V/V, Load=4Ω, $f_{in}=1$ kHz, $C_{S1}=2.2\mu F$, $C_{S2}=0.1\mu F$, $T_A=25^\circ C$ (unless otherwise noted)

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		0.04		%
		VDD=2.5V, P _O =0.5W		0.02		%
SNR	Signal to Noise Ratio	VDD=5.0V, P _O =1.8W		98		dB
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V _{ripple} =200mVpp Inputs ac grounded with C _i =2μF f=217 Hz		75		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		22		μV
η	Efficiency (TDFN-8L)	VDD=5.0V, THD+N=10%		85		%

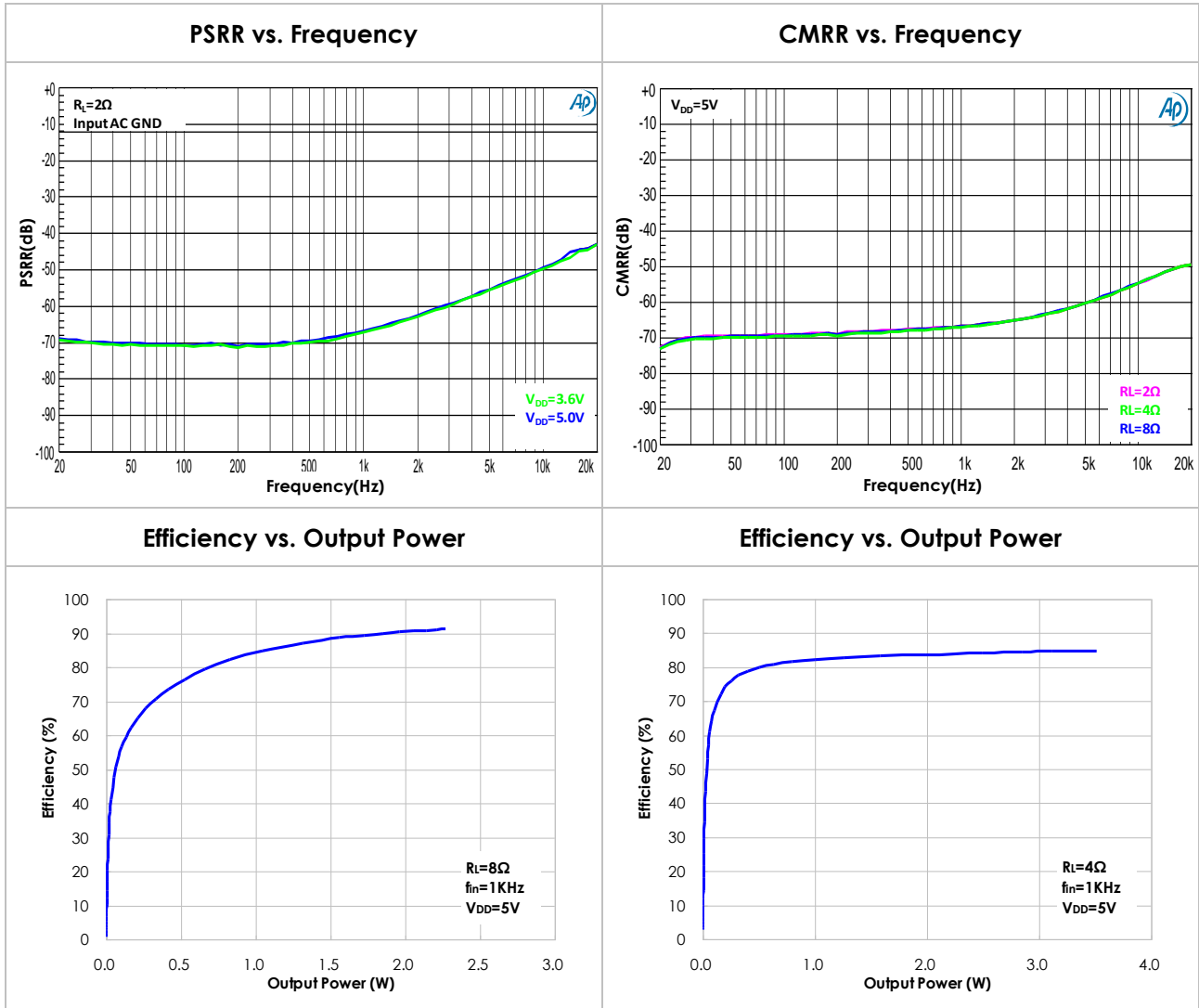
- Gain= 2 V/V, Load=2Ω, $f_{in}=1$ kHz, $C_{S1}=2.2\mu F$, $C_{S2}=0.1\mu F$, $T_A=25^\circ C$ (unless otherwise noted)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P _O	RMS Output Power (for TDFN-8L package option only with 2ohm load supports)	VDD=5.0V	THD+N = 10 %		5	W
			THD+N = 1 %		4.3	W
		VDD=3.6V	THD+N = 10 %		2.6	W
			THD+N = 1 %		2.1	W
		VDD=2.5V	THD+N = 10 %		1.2	W
			THD+N = 1 %		0.98	W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, P _O =2.0W		0.04		%
		VDD=3.6V, P _O =1.0W		0.04		%
		VDD=2.5V, P _O =0.5W		0.04		%
SNR	Signal to Noise Ratio	VDD=5.0V, P _O =1.8W		100		dB
PSRR	Power Supply Rejection Ratio	VDD=3.6V, V _{ripple} =200mVpp Inputs ac grounded with C _i =2μF f=217 Hz		70		dB
CMRR	Common-Mode Rejection	VDD=3.6V, V _{IC} =1Vpp, f=217Hz		65		dB
V _n	Output integrated noise (A-weighted)	VDD=3.6V f _{in} =20Hz ~ 20kHz		25		μV
η	Efficiency (TDFN-8L)	VDD=5.0V, THD+N=10%		74		%

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



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



Operation Descriptions

- Self-protection circuits (Typical values are used below.)
AD51652 has built-in over-temperature, overload and under-voltage detectors.
 - (i) If the internal junction temperature is higher than 165°C, the outputs of loudspeaker drivers will be disabled and connected to ground and the temperature hysteresis for AD51652 to return to normal operation is about 20°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 or shorted to GND, circuits for the detection of output loading are built in the AD51652. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. Once overload detector is active, loudspeaker drivers will be disabled and at low state. AD51652 will be recovery from overload fault by pulling SD# down to low and back to high after removing the short. Once the lines connected to loudspeakers are shorted to VDD, AD51652 will be burnt.
 - (iii) When the VDD voltage is lower than 2.3V, AD51652 will disable and loudspeaker drivers are at low state, cease AD51652 beside voltage detector circuit. When VDD becomes larger than 2.4V, AD51652 will return to normal operation.
- Anti-pop design
AD51652 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, AD51652 will internally generate appropriate control signals to suppress pop sounds.

Application Circuit Information

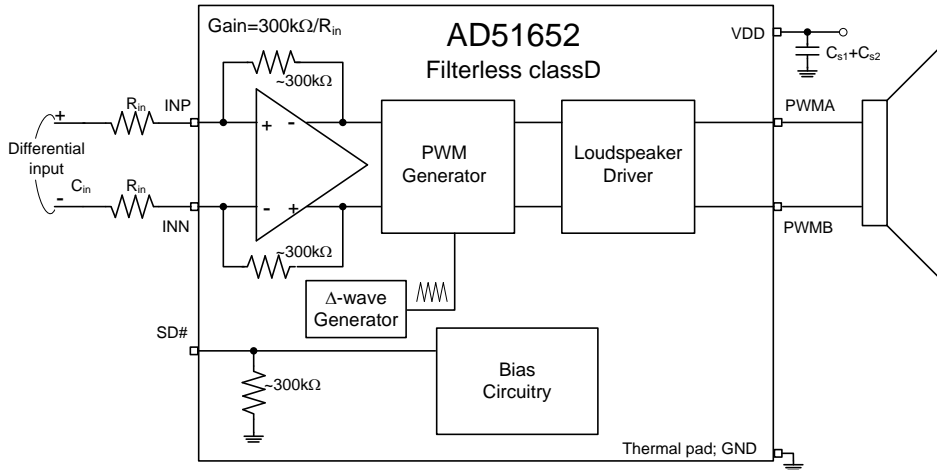
- Input resistors (R_{in}) and input capacitors (C_{in})
The total gain of the audio amplifier (AD51652) is set by input resistor (R_{in}) according to the following equation (a). The performance at low frequency (bass) is affected by the corner frequency (f_c) of the high-pass filter composed of input resistors (R_{in}) and input capacitors (C_{in}), determined in equation (b).

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

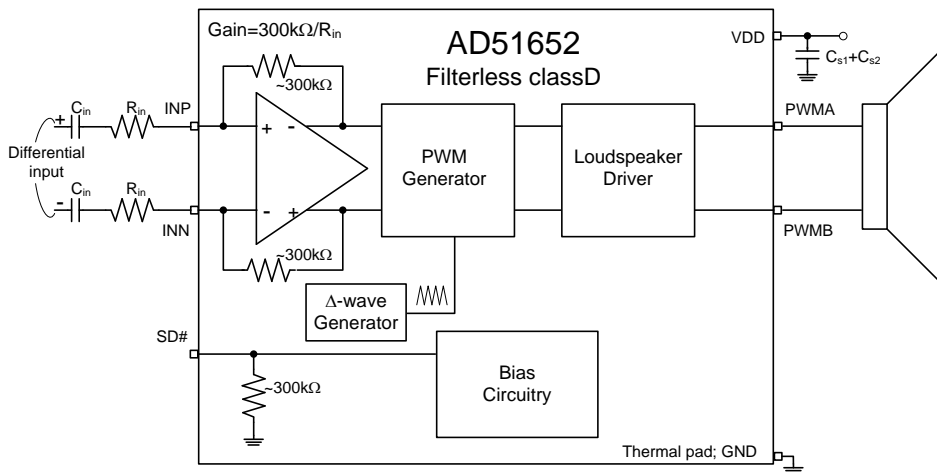
$$f_c = \frac{1}{2\pi R_{in} C_{in}} \text{ (Hz)} \dots \dots \dots (b)$$

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.

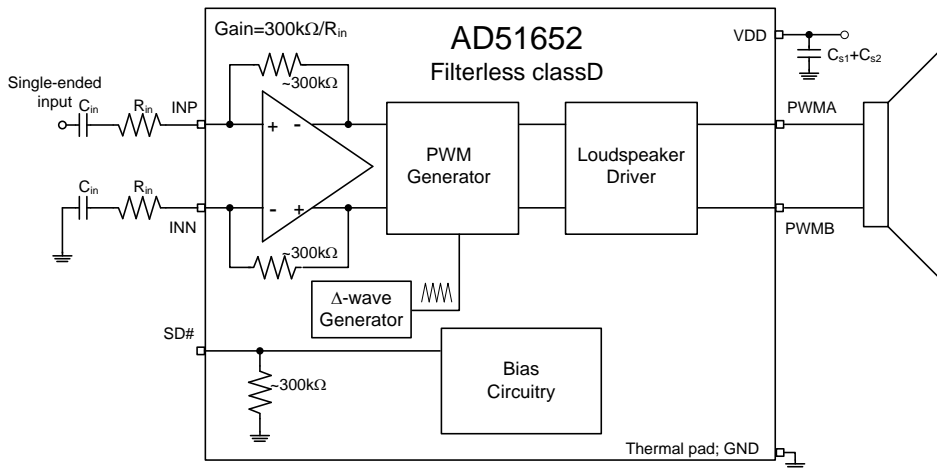
- Cost effective application circuit for fully differential input



- Suggested application circuit for fully differential input

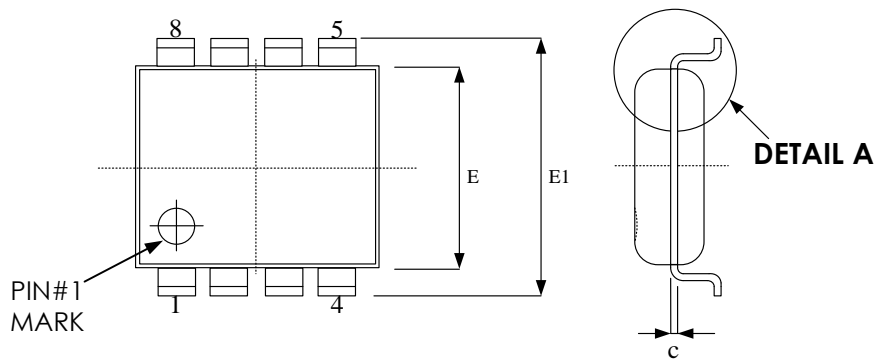


- Suggested application circuit for single-ended input

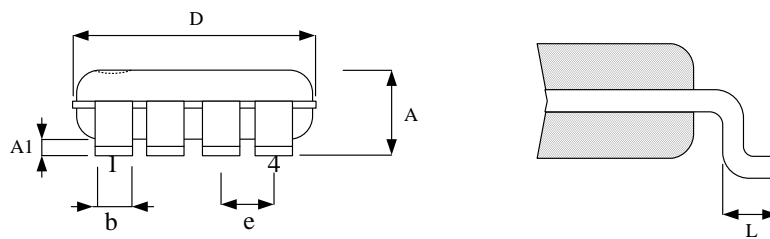


Package Outline Dimensions

- MSOP-8L (118 mil)



TOP VIEW



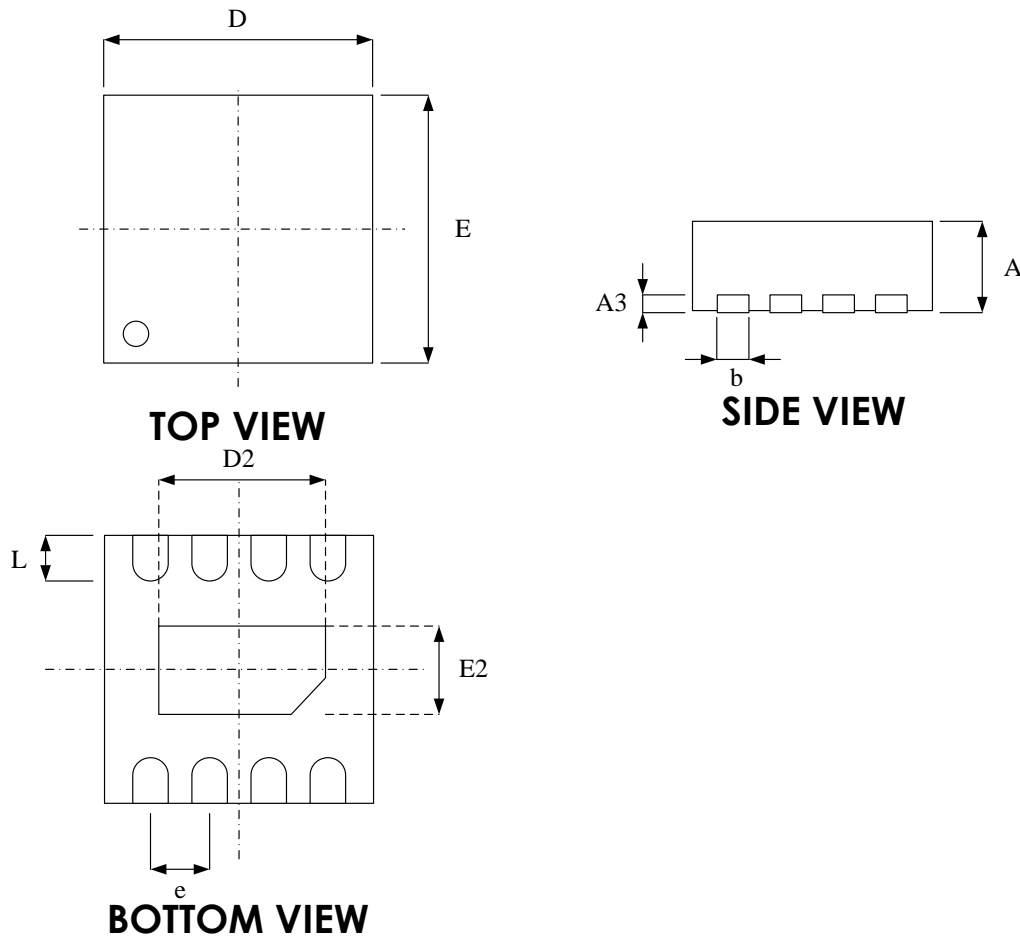
SIDE VIEW

DETAIL A

Symbol	Dimension in mm	
	Min	Max
A	0.81	1.10
A1	0.00	0.15
b	0.22	0.38
c	0.13	0.23
D	2.90	3.10
E	2.90	3.10
E1	4.80	5.00
e	0.65 BSC	
L	0.40	0.80

Package Outline Dimensions

- TDFN – 8L (3x3 mm²)



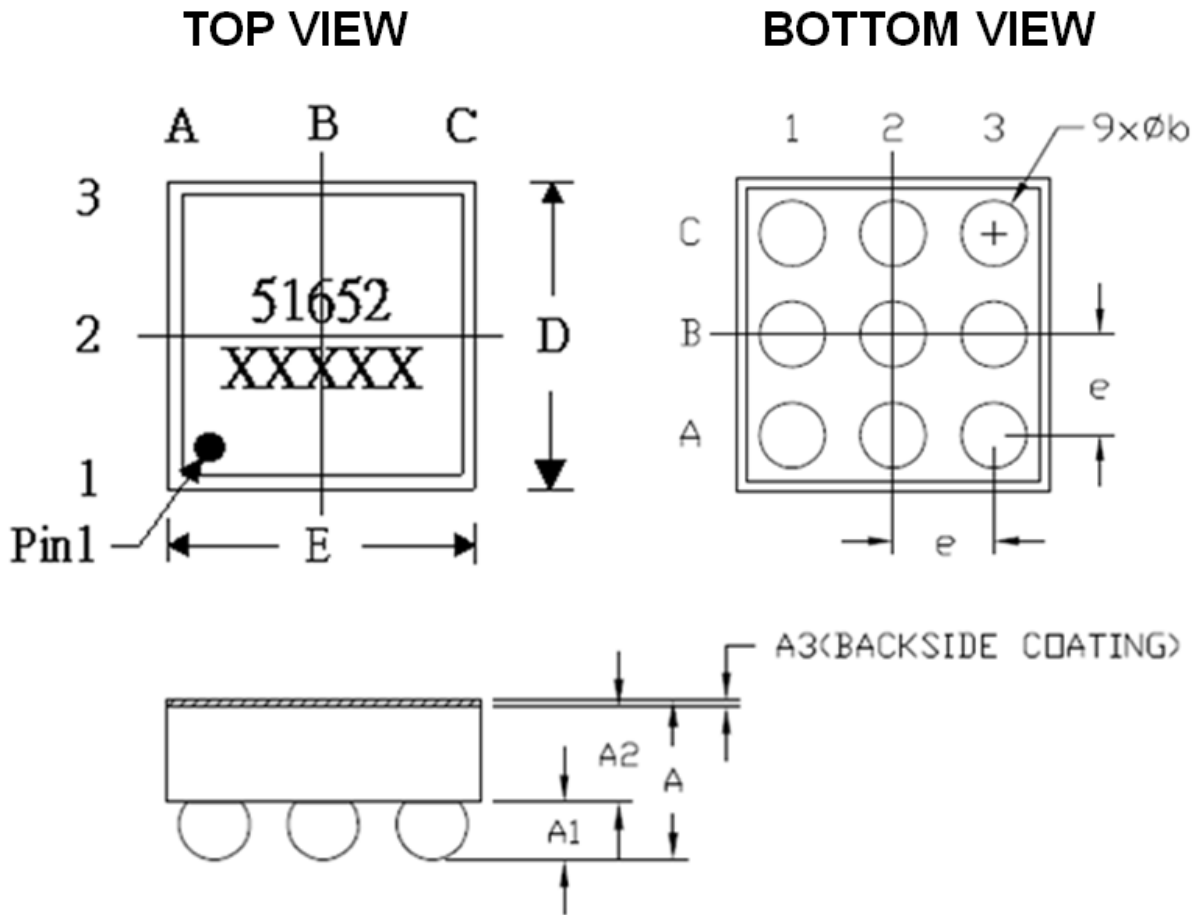
Symbol	Dimension in mm	
	Min	Max
A	0.7	0.8
A3	0.20 REF.	
b	0.25	0.35
D	3.00 BSC	
E	3.00 BSC	
e	0.65 BSC	
L	0.3	0.5

Exposed pad

	Dimension in mm	
	Min	Max
D2	1.6	2.5
E2	1.35	1.75

Package Outline Dimensions

- WCSP – 9L (1.21x1.21 mm²)



Symbol	Datasheet in mm	
	Min	Max
A	0.536	0.634
A1	0.189	0.231
A3	0.022	0.028
D	1.185	1.240
E	1.185	1.240
b	0.234	0.286
e	0.400	

Revision History

Revision	Date	Description
0.1	2014.07.28	Preliminary version.
0.2	2015.05.21	Update Functional Block Diagram.
0.3	2015.08.28	1) Added 2Ω load supports for TDFN-8L package. 2) Updated electrical characteristics. 3) Updated measurement plots.
1.0	2017.03.15	Remove "Preliminary" Add Marking information
1.1	2017.12.06	Add Ordering Information
1.2	2020.05.22	Update pin description
1.3	2021.10.18	Update absolute maximum ratings.
1.4	2021.12.06	Update WLCSP marking information and POD
1.5	2022.06.24	Update gain spec
1.6	2022.08.04	Update gain spec
1.7	2022.10.05	Update absolute maximum ratings.

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