

Class-D Audio Power Amplifier with USB/I²S Interface

Features

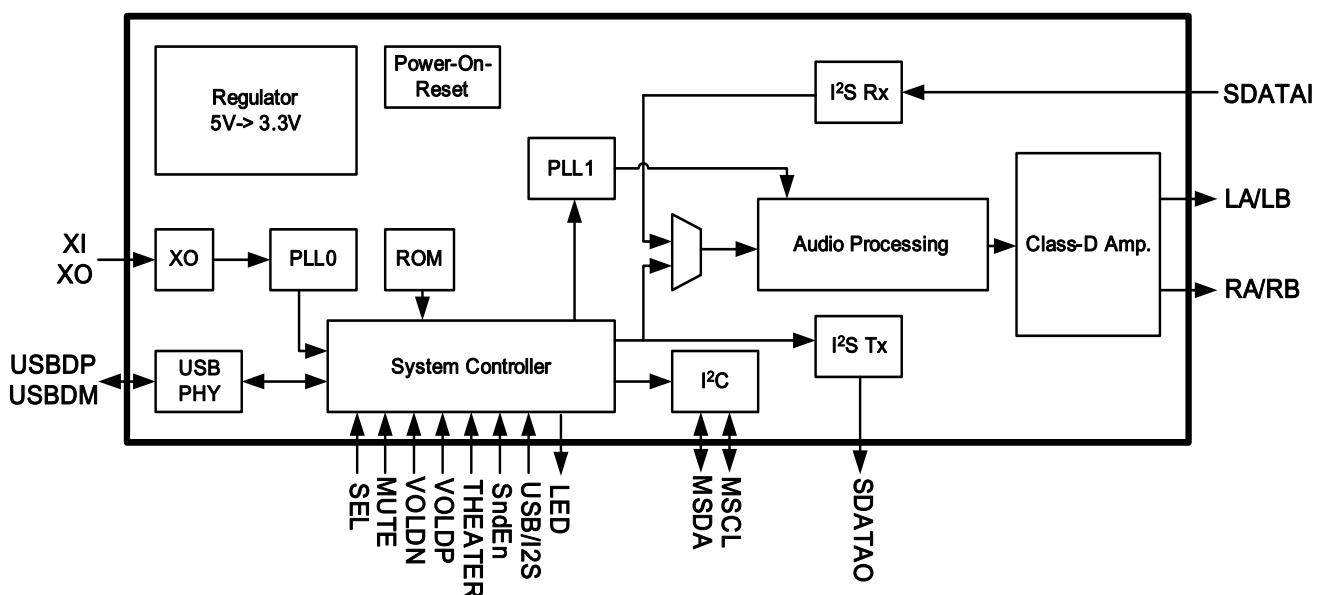
- True plug-and-play application, no driver is required for basic USB speaker application
- Supports Windows Me/2000/XP/Vista/7 and Mac OS
- Integration circuit quality meet **Windows 7 and Vista Hardware Logo** requirement
- Compliant with USB Specification v1.1, and USB 2.0 full speed
- Can work directly with a USB3.0 port
- Embedded high efficiency, high performance Class-D stereo amplifier
- Support both bus-powered and self-powered operation
- Support I²S input and I²S output interface of master mode
- +6dB Gain enhancement (Theater function)
- Sampling frequency 44.1/48KHz
- Support volume/mute control with external button
- LED indicator function
- Support 3D surround sound
- Built-in 5V to 3.3V regulator for internal device operation
- Loudspeaker PSNR & DR (A-weighting) 91dB (PSNR), 92dB (DR) with Bead filter

- Anti-pop design
- Over-temperature protection
- Under-voltage shutdown
- Short-circuit detection
- External EEPROM interface for vendor specific and hardware configuration
- Embedded Power-On-Reset circuit
- The I²S output port allows other high performance audio device (i.e. AD8356/AD82581B)
- 12 MHz crystal input
- 3.3V operation with 5V tolerate I/O
- 32-pin LQFP Pb-free package

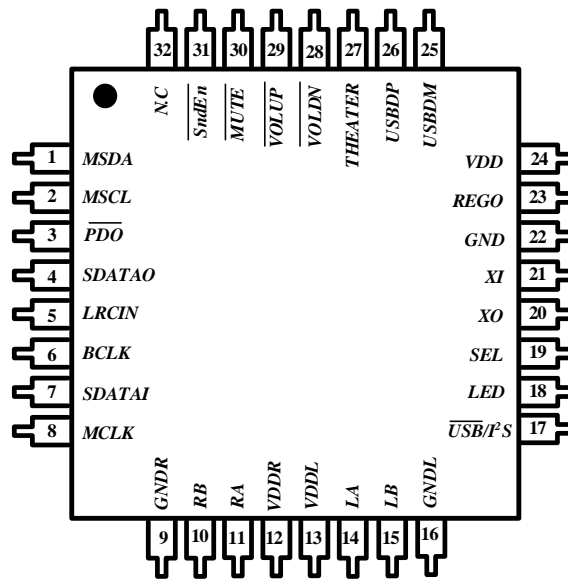
Description

AD62550 is a single chip of Class-D audio amplifier with USB/I²S interface. When using the power supplied from the USB port, AD62550 can drive a pair of up to 1W speakers due to the built-in, high efficiency and high performance Class-D amplifiers. The device also has an I²S input port and I²S output port. The I²S input port allows other external audio sources to use the Class-D amplifier to share the speakers. The I²S output port allows other high performance audio device (i.e. AD8356/AD82581B).

Functional Block Diagram



Pin Assignment



Pin Description

Pin	Name	Type	Description	Characteristics
1	MSDA	I/O	I ² C's SDA of master mode	5V tolerant Schmitt trigger TTL input buffer
2	MSCL	O	I ² C's SCL of master mode	
3	PDO	O	Power-down output	
4	SDATAO	O	Serial audio output	
5	LRCIN	O	L/R clock output	
6	BCLK	O	BCLK output	
7	SDATAI	I	Serial audio data input	5V tolerant Schmitt trigger TTL input buffer
8	MCLK	O	Master clock(256xFs)	
9	GNDR	P	Ground for right channel	
10	RB	O	Right channel output-	
11	RA	O	Right channel output+	
12	VDDR	P	Supply for right channel	
13	VDDL	P	Supply for left channel	
14	LA	O	Left channel output+	
15	LB	O	Left channel output-	
16	GNDL	P	Ground for left channel	
17	USB/I ² S	I	Signal input mode selection 0: USB mode; 1: I ² S mode	5V tolerant Schmitt trigger TTL input buffer
18	LED	O	LED indicator	
19	SEL	I	The external amplifier adopted 0: AD8356; 1: AD82581B	5V tolerant Schmitt trigger TTL input buffer With internal pull-up resistor

20	XO	O	Crystal output	
21	XI	I	Crystal input	
22	GND	P	Ground	
23	REGO	P	3.3V Regulator output	
24	VDD	P	5V supply voltage	
25	USBDM	I/O	USB data D-	
26	USBDP	I/O	USB data D+	With internal pull-up resistor
27	THEATER	I	Theater mode, high active	5V tolerant Schmitt trigger TTL input buffer
28	$\overline{\text{VOLDN}}$	I	Volume down, low active	With internal pull-up resistor
29	$\overline{\text{VOLUP}}$	I	Volume up, low active	With internal pull-up resistor
30	$\overline{\text{MUTE}}$	I	Power-down and mute of Class-D, Low active	With internal pull-up resistor
31	$\overline{\text{SndEn}}$	I	Surround enable, low active	With internal pull-up resistor
32	N.C.			

Ordering Information

Product ID	Package	Packing	Comments
AD62550-LA32NAY	LQFP-32L 7 x7 mm	250 Units/ Tray 10 Trays/ Small Box	Green

Available Package

Package Type	Device No.	$\theta_{ja} (^{\circ}\text{C}/\text{W})$	$\theta_{jc} (^{\circ}\text{C}/\text{W})$
LQFP-32	AD62550	59.9	17

Note 1: θ_{ja} is measured on a room temperature ($T_A=25^{\circ}\text{C}$), natural convection environment test board, which is constructed with a thermally efficient, 2-layers PCB. The measurement is tested using the JEDEC51-3 thermal measurement standard.

Note 2: θ_{jc} represents the heat resistance for the heat flow between the chip and the package's top surface.

Marking Information

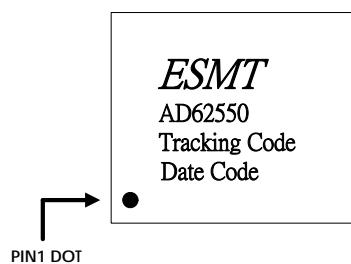
AD62550

Line 1 : LOGO

Line 2 : Product no.

Line 3 : Tracking Code

Line 4 : Date Code



Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units
VDD	Supply for regulator input	0	6	V
VDDL(R)	Supply for Left (Right) Channel	0	6	V
V _i	Input Voltage	-0.3	5.5	V
T _{stg}	Storage Temperature	-65	150	°C
T _a	Ambient Operating Temperature	0	70	°C
	Voltage Difference between V _{DDL} and V _{DDR}	-1	1	V
	Voltage Difference between V _{DDL} (V _{DDR}) and DVDD/AVDD	-3	3	V
	V _{DDL} (V _{DDR}) Power-on Voltage Ramp		0.2	V/μs

Recommended Operating Conditions

Symbol	Parameter	Typ	Units
VDD	Supply for regulator input	4.5~5.5	V
VDDL(R)	Supply for Driver Stage	3.0~5.5	V
T _a	Ambient Operating Temperature	0~70	°C

Digital Characteristics

Symbol	Parameter	Min	Typ	Max	Units
V _{IH}	High-Level Input Voltage	2.0			V
V _{IL}	Low-Level Input Voltage			0.8	V
V _{OH}	High-Level Output Voltage	2.4			V
V _{OL}	Low-Level Output Voltage			0.4	V
C _i	Input Capacitance		6.4		pF

General Electrical Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
I_{PD}	Supply current during suspend mode			300	330	uA
	USB controller operation current	VDD=5V		44		mA
	Regulator current limit (for REGO)	$4.5V \leq VDD$ $\leq 5.5V$			150	mA
T_{SENSOR}	Junction temperature for driver shutdown			150		°C
	Temperature hysteresis for recovery			30		°C
UV_H	Under voltage disabled (For VDD)			3.8		V
UV_L	Under voltage enabled (For VDD)			3.7		V
F_{sw}	Switching rate of loudspeakers		8Fs	8Fs	8Fs	Hz
T_{PWM}	Minimum PWM pulse width		$\frac{2}{1024Fs}$	$\frac{2}{1024Fs}$	$\frac{2}{1024Fs}$	Sec
R_{SC}	Loudspeaker Short-Circuit detection (Note3)	VDDR(L)=5V		2.8	3.2	Ω

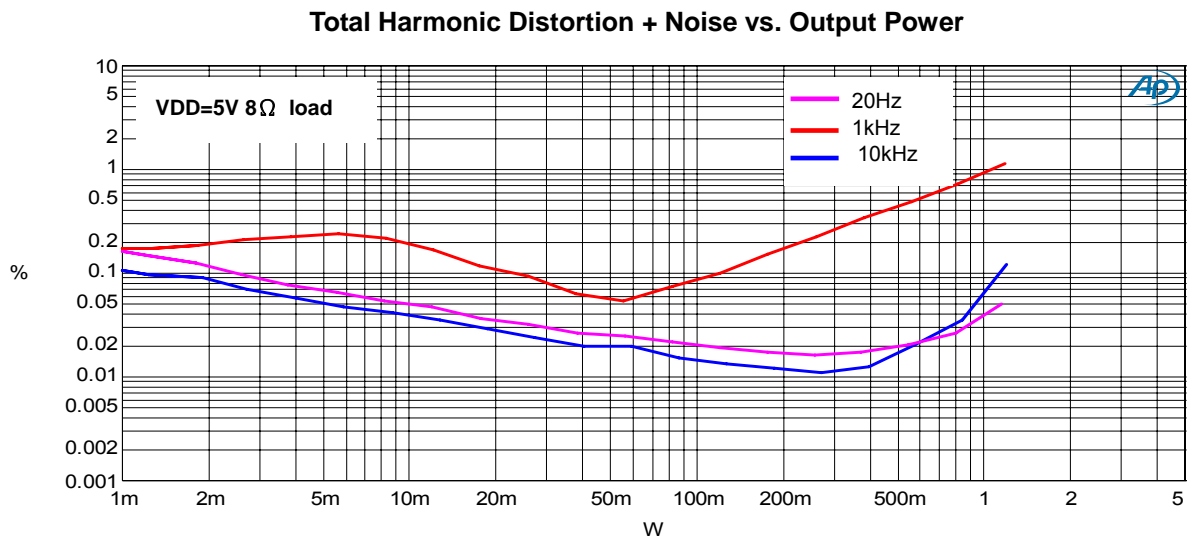
Note 3: Loudspeaker short-circuit protection is effective only when ferrite bead filters are properly used. Long time short-circuit will reduce device reliability.

Electrical Characteristics and Specifications for Loudspeaker

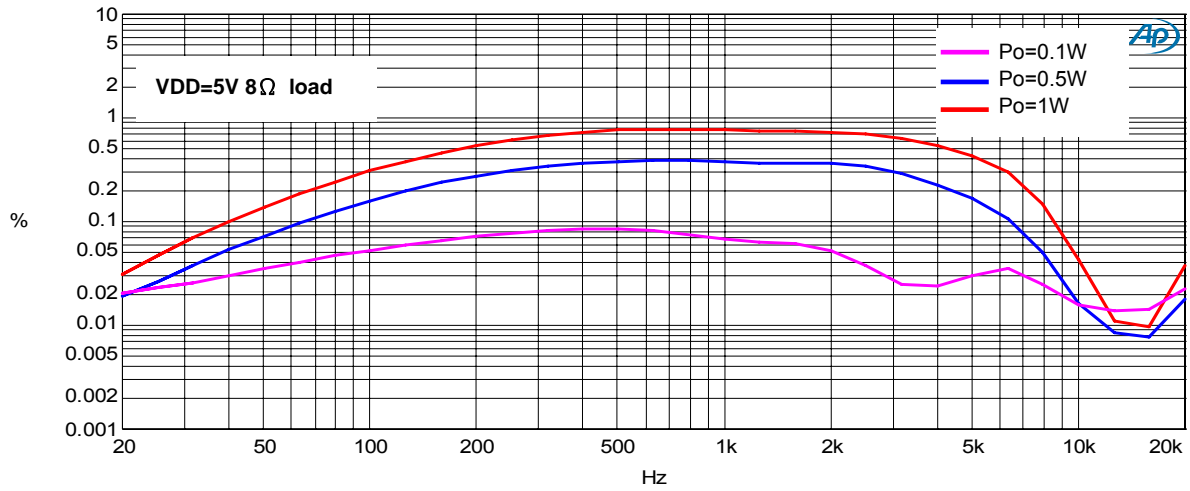
● Condition: VDD=VDDL=VDDR=5V; F_S=48kHz; Load=8Ω with Bead filter; Input is 1kHz sinewave; THETER=H

Symbol	Parameter	Condition	Input Level	Min	Typ	Max	Units
P _O	RMS Output Power for Each Channel	THD+N=10%			1.42		W
		THD+N=1%			1.27		W
		I _{USB} =500mA			0.9		W
THD+N	Total Harmonic Distortion + Noise	I _{USB} =500mA			0.71		%
SNR	Signal to Noise Ratio (Note4)	P _O =1.1W			91		dB
DR	Dynamic Range (Note4)		-66dB		92		dB
PSRR	Power Supply Rejection Ratio		-66dB		74		dB
	Channel Separation		-7dB		106		dB
η	Efficiency	THD+N=1%			78		%

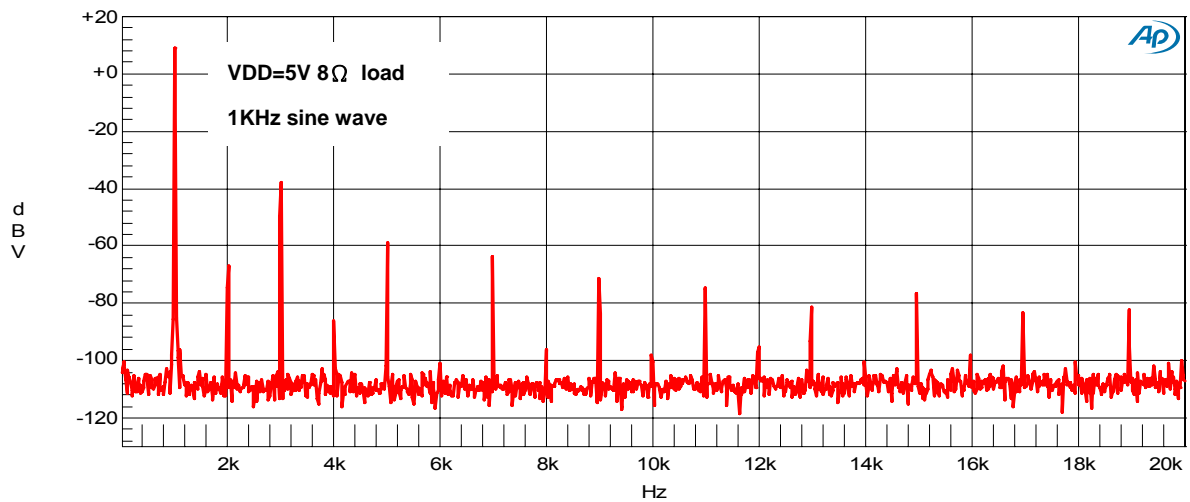
Note 4: Measured with A-weighting filter and external power.



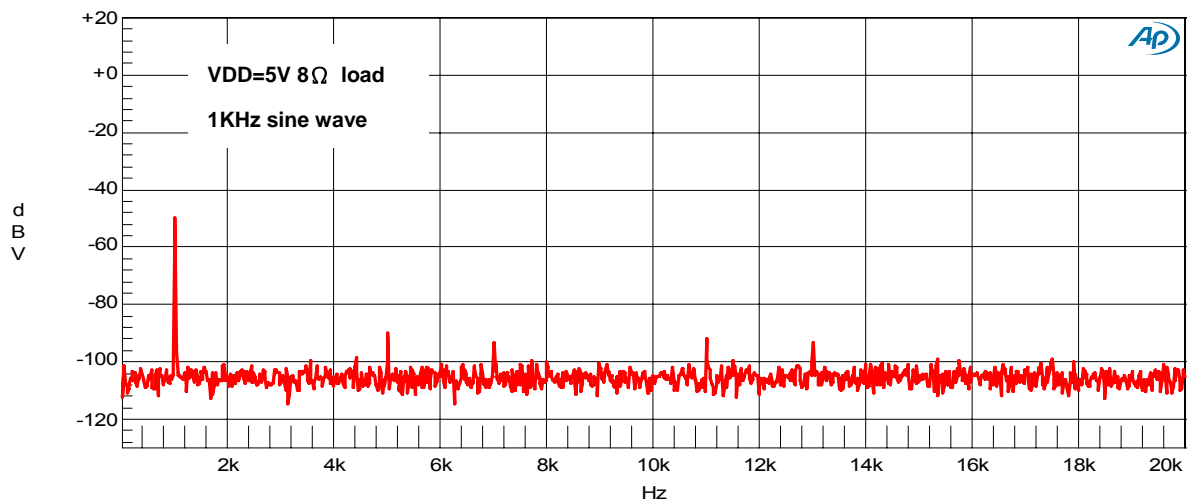
Total Harmonic Distortion + Noise vs. Frequency



Spectrum at Peak SNR



Spectrum at -66dB Signal Input Level

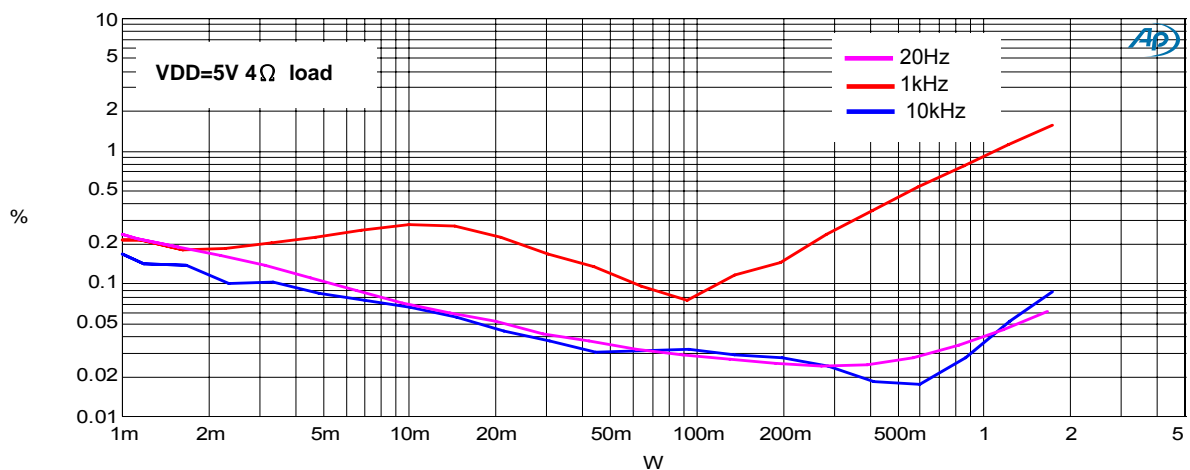


- Condition: VDD=VDDL=VDDR=5V; F_S=48kHz; Load=4Ω with Bead filter; Input is 1kHz sinewave; THETER=H

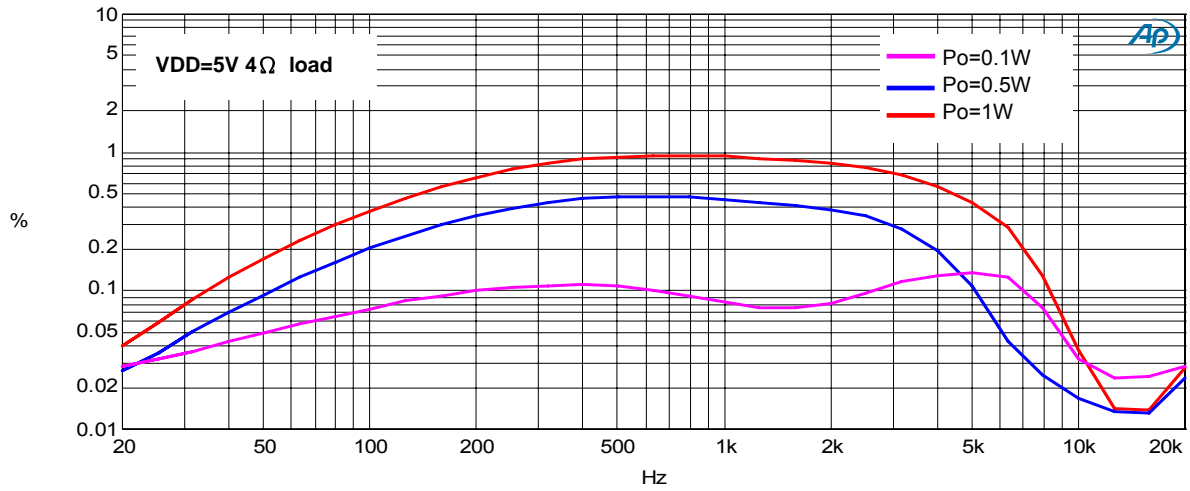
Symbol	Parameter	Condition	Input Level	Min	Typ	Max	Units
P _o	RMS Output Power for Each Channel	THD+N=1%			1.07		W
		I _{USB} =500mA			0.79		W
THD+N	Total Harmonic Distortion + Noise	I _{USB} =500mA			0.81		%
SNR	Signal to Noise Ratio (Note4)	P _O =1.4W			88		dB
DR	Dynamic Range (Note4)		-66dB		91		dB
PSRR	Power Supply Rejection Ratio		-66dB		74		dB
	Channel Separation		-7dB		104		dB
η	Efficiency	THD+N=1%			71		%

Note 4: Measured with A-weighting filter and external power.

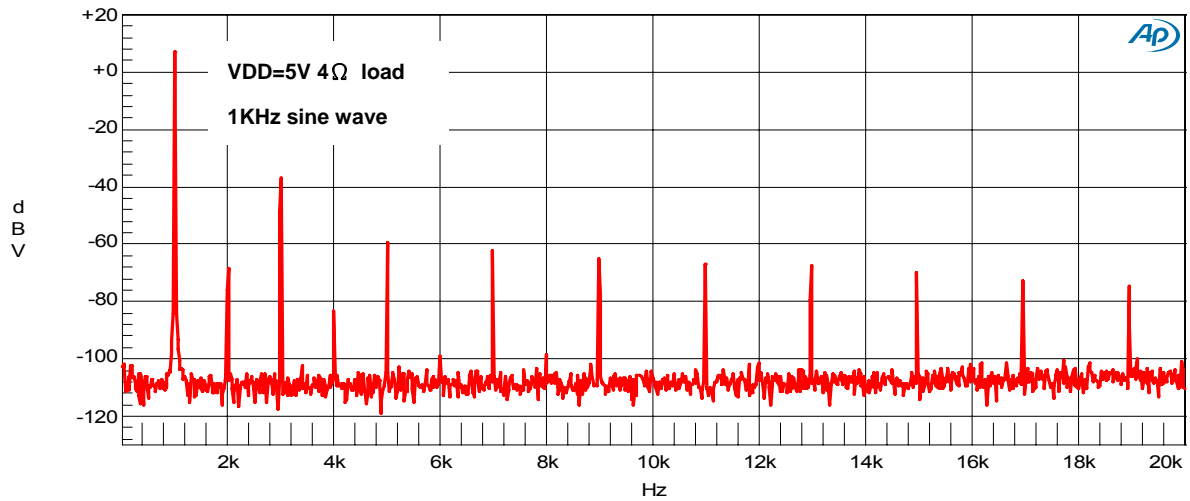
Total Harmonic Distortion + Noise vs. Output Power



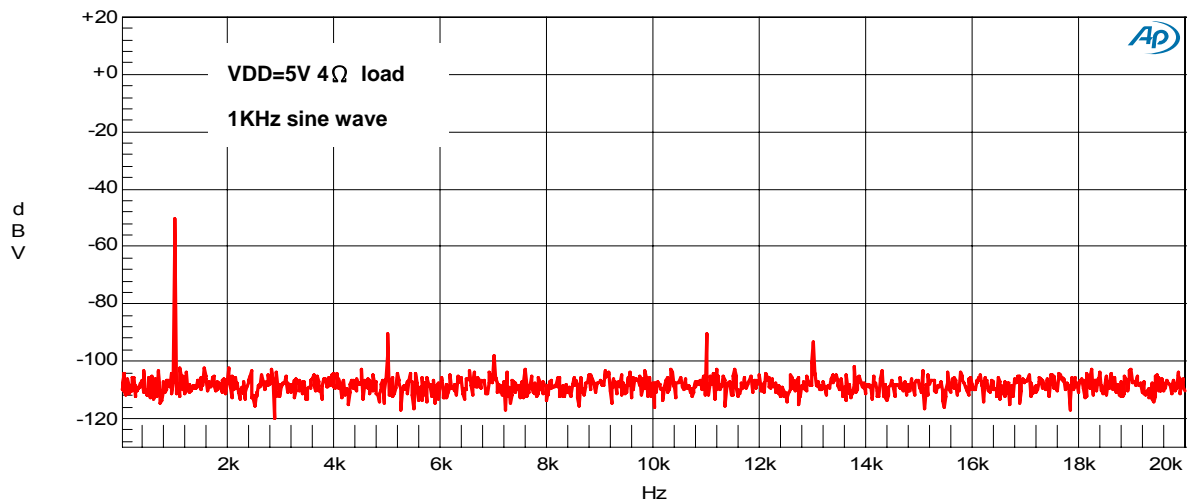
Total Harmonic Distortion + Noise vs. Frequency



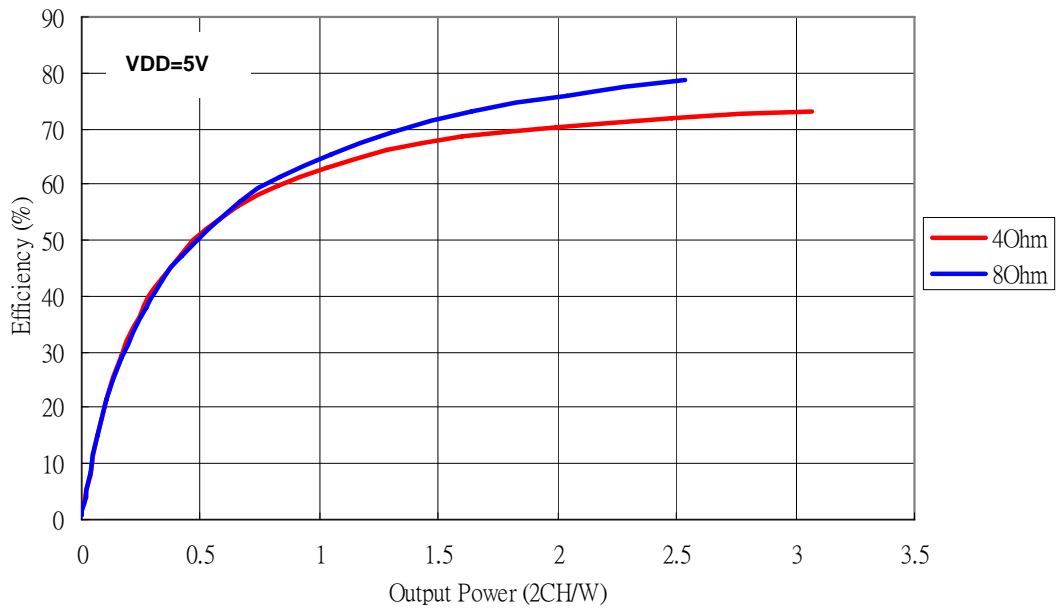
Spectrum at Peak SNR



Spectrum at -66dB Signal Input Level

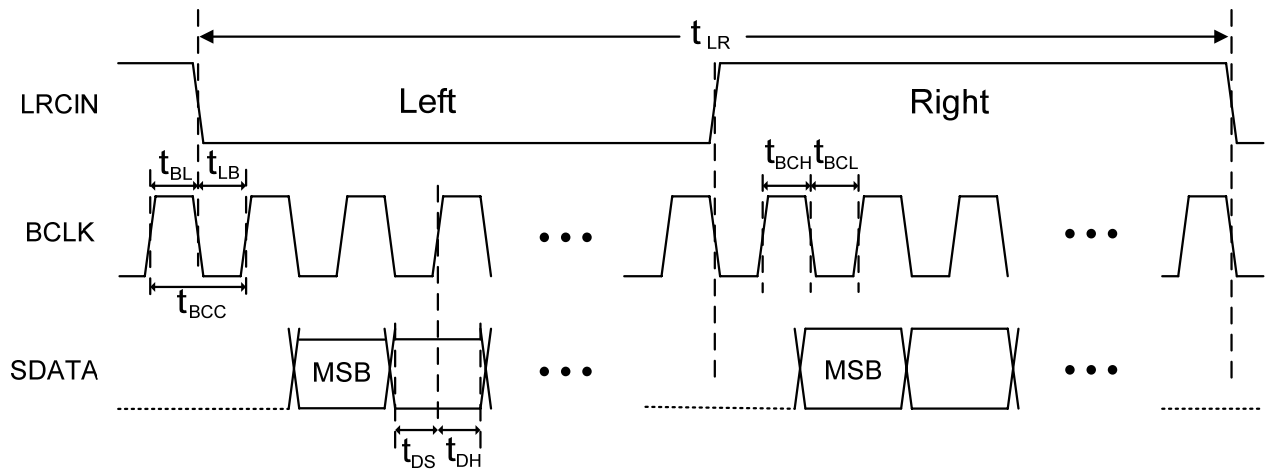


Efficiency with filter-less



Interface Configuration

- I²S

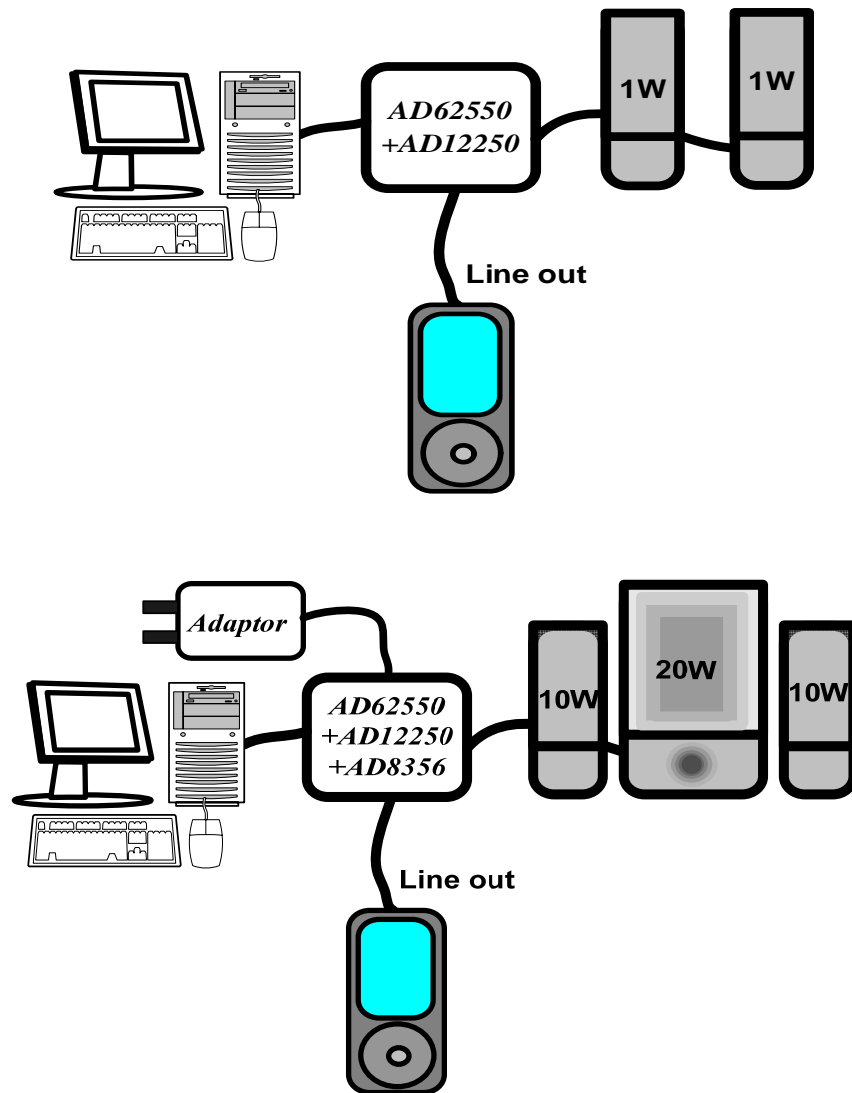


Symbol	Parameter	Min	Typ	Max	Units
t_{LR}	LRCIN Period ($1/F_S$)	10.41		125	μ s
t_{BL}	BCLK Rising Edge to LRCIN Edge	50			ns
t_{LB}	LRCIN Edge to BCLK Rising Edge	50			ns
t_{BCC}	BCLK Period ($1/64F_S$)	162.76		1953	ns
t_{BCH}	BCLK Pulse Width High	81.38		976.5	ns
t_{BCL}	BCLK Pulse Width Low	81.38		976.5	ns
t_{DS}	SDATA Set-Up Time	50			ns
t_{DH}	SDATA Hold Time	50			ns

Operation Descriptions

The following figure illustrates two more advanced applications that use AD62550, together with an external ADC, e.g., AD12250 from ESMT that can convert stereo line-in audio to I²S output to send to AD62550, and/or an external high-end Class-D amplifier such as AD8356/AD82581B.

Both applications, a switch is used to select audio stream from either USB port or I²S port. When the audio stream is from I²S port, the device is operating as “docking station” mode. When the audio stream is from USB port, the device is operating as “USB speaker” mode. When AD8356/AD82581B is used, since it can deliver 10Wx2 + 20W (subwoofer) power or 20Wx2 power, USB bus power may be insufficient and local power supply is required. Functional description follows.

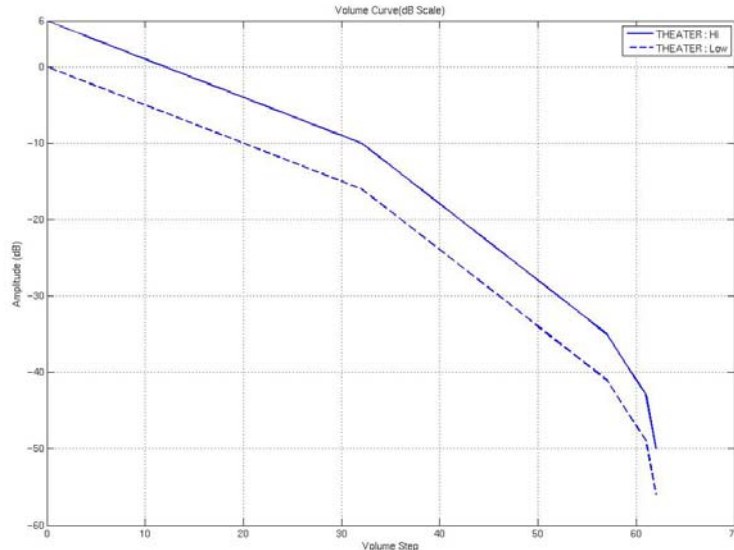


SEL

SEL	0	1
	Using AD8356	Using AD82581B

Volume Control

Audio volume control is low active. Duration of low level must be longer than 3ms. The highest volume gain is +6dB for THEATER is logic high and 0dB for THEATER is logic low, referred to the original input signal level. The volume gain range is from +6 dB to -50 dB at THEATER is high or from +0 dB to -56 dB at THEATER is low.



Mute control

MUTE is low active. Duration of low level must be longer than 3ms.

Self-protection circuit (values used here are typical values)

AD62550 has built-in thermal, short-circuit and under-voltage detection circuits. If the internal thermal detection junction temperature is higher than 150°C, the loudspeaker power stages will be turned off. The thermal detection circuit has a temperature hysteric characteristic such that the AD62550 will return to normal operation when the device is cooled down to about 30°C. Due to the process variation, the triggering temperature values can have around 10% variation.

To protect loudspeaker power stages when the loudspeaker output are shorted each other or shorted to GND, the output loading detection circuits are built-in and proper protection action will take place once the short circuit condition is detected.

For normal operation, the loudspeaker output resistance larger than 3.4Ω is required. Once the short-circuit condition is detected, the output power stages will be shut off. After the short-circuit condition is happened, the AD62550 will be auto release the output power stages at every 42ms if the short-circuit condition is removed.

Under Voltage protection circuit (values used here are typical values)

Once the V_{DD} is lower than 3.7V, AD62550 will turn off its loudspeaker power stages and the digital circuit will cease operation. When V_{DD} becomes larger than 3.8V, AD62550 will return to normal operation.

Anti-pop design

AD62550 has an anti-pop circuit to suppress the annoying pop sounds during initial power on, power down/up, mute, power off and volume level change.

Switching between USB speaker mode and docking station mode

When the `USB/I2S` pin is low, the input audio stream is from USB port as USB Speaker mode. When this pin is high, the input audio stream is from I²S input port as docking station mode.

Sound Theater Effect Mode

When THEATER pin is high, Sound Theater Mode is established. In this mode, the audio volume is enhanced by +6dB to simulate the theater effect.

3D Surround Sound Mode

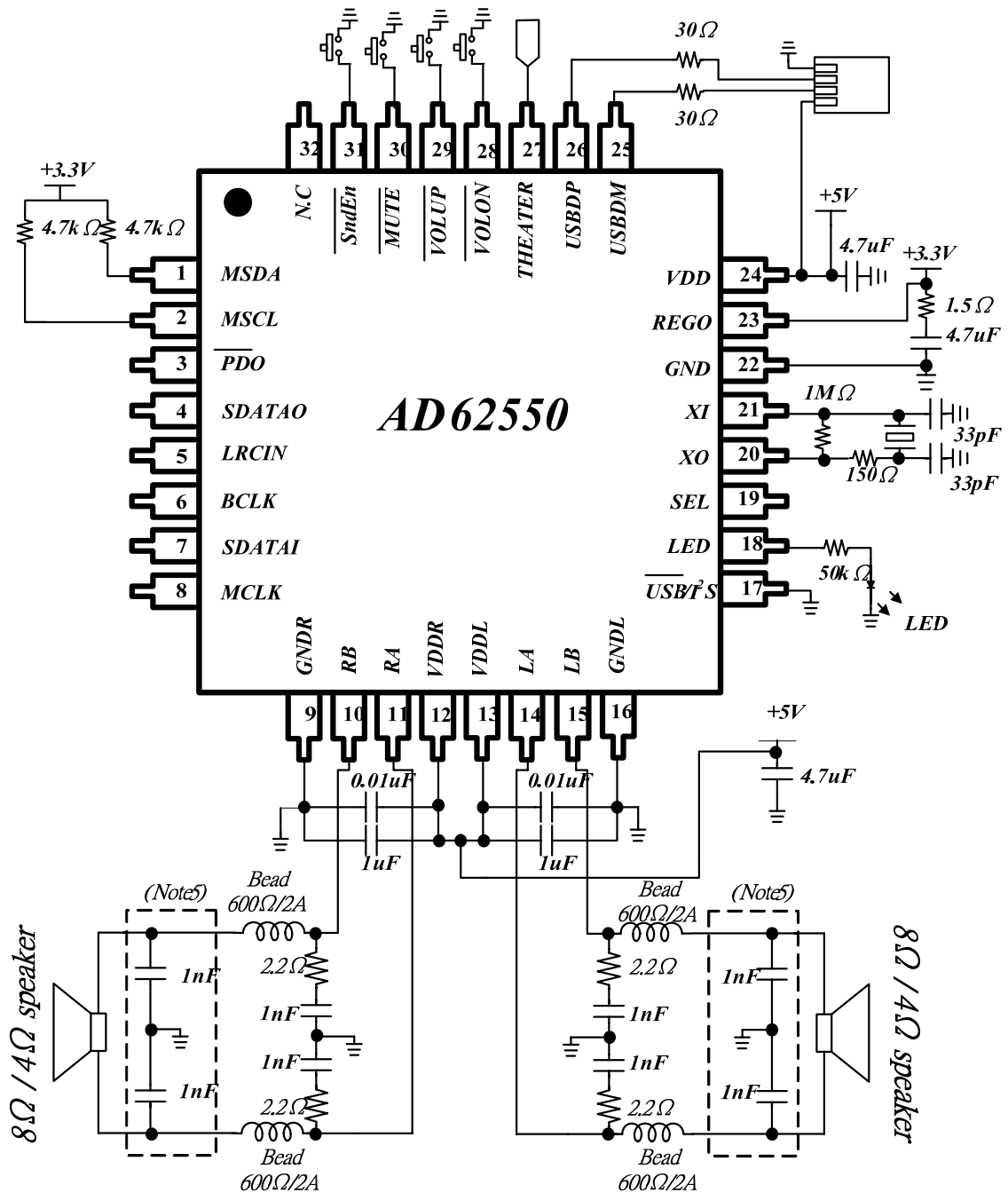
When SndEn pin is low, 3D Surround Sound Mode is enabled. AD62550 provides the virtual surround sound technology with greater separation and depth for stereo signals and synthesizes a 3D stereo sound field.

Power consideration

AD62550 can be powered by the USB port directly. However, the maximum current supplied by each USB port is limited 500mA. If the total power requirement of the USB audio subsystem is higher than this, local power supply, e.g., a local AC adaptor will have to be used. If the audio subsystem is attached to an USB hub, which is not locally powered, the maximum power from each USB port is only limited to 100mA, and local power must be supplied.

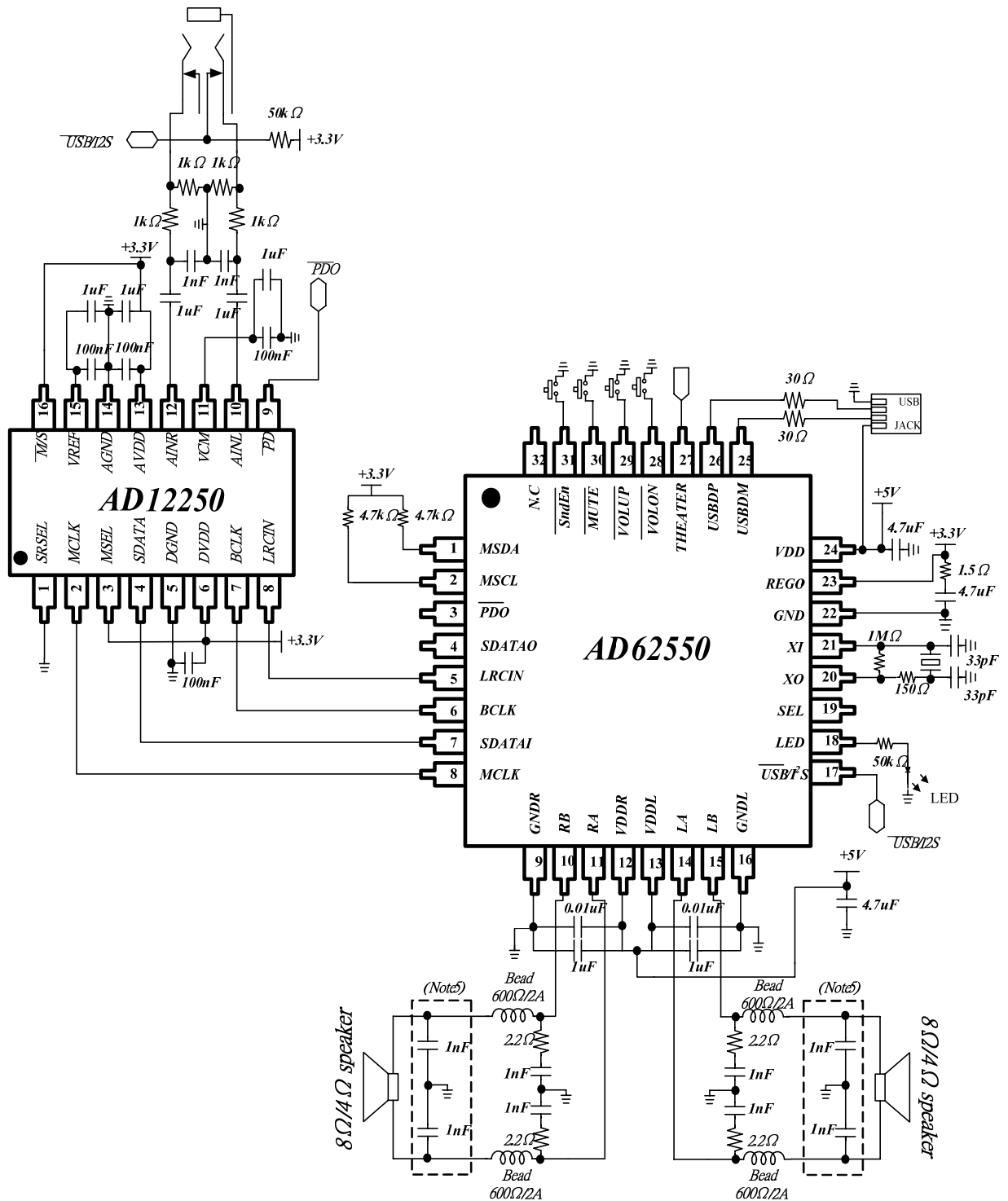
Application Circuit Examples for 8Ω/4Ω loudspeaker

- USB speaker with ferrite bead filter

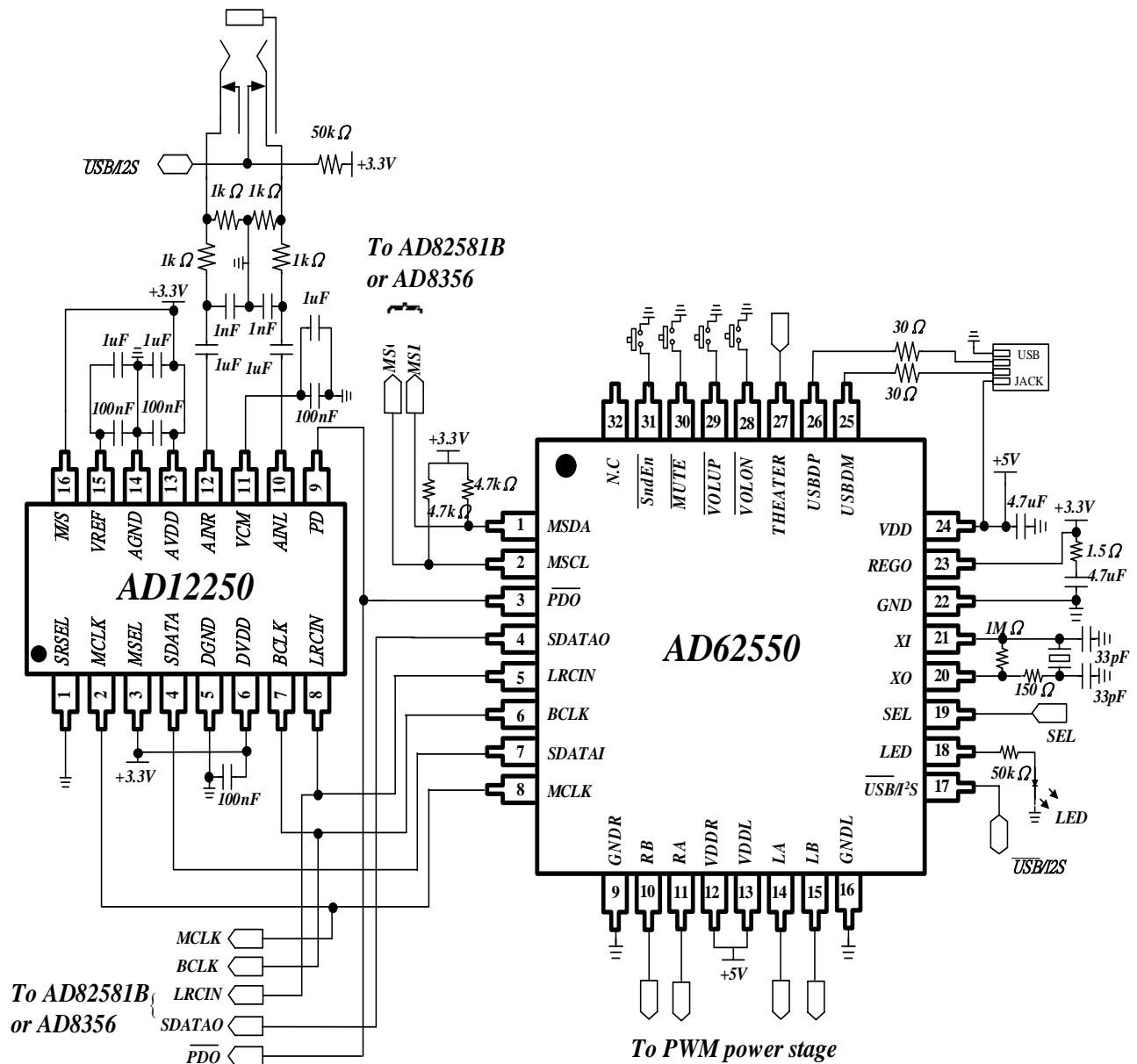


Note 5: These capacitors should be placed close to speaker jack as possible, and their values should be determined according to EMI test results.

● USB speaker with line-in function (with AD12250, ADC)



● USB controller with external Class-D audio amplifier

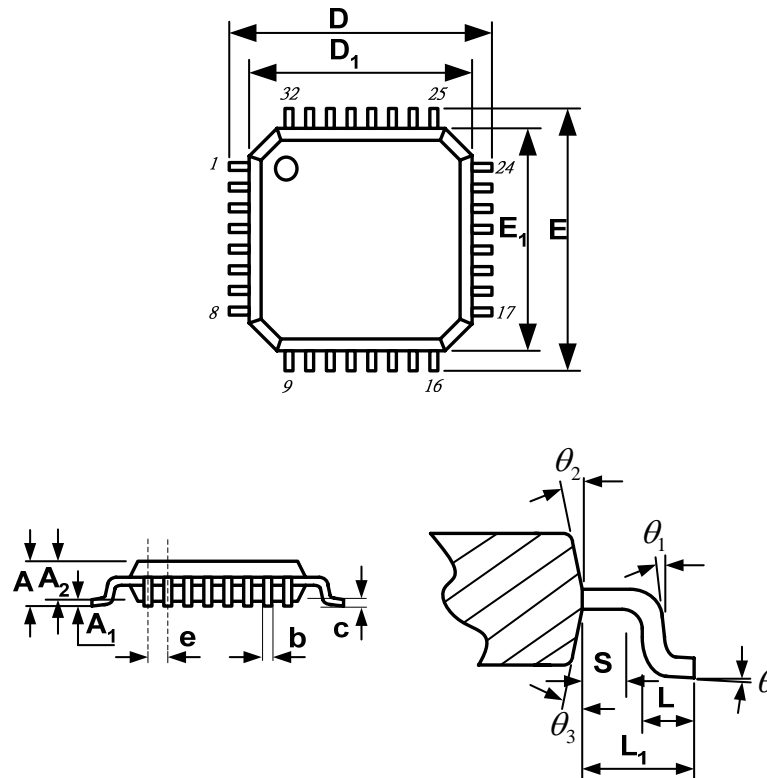


SEL

SEL	0	1	X
	Using AD8356	Using AD82581B	PWM power stage

Package Dimensions

- LQFP-32 Package



Symbol	Dimension in mm			Dimension in inch		
	Min	Nom	Max	Min	Nom	Max
A	-	-	1.6	-	-	0.063
A ₁	0.05	-	0.15	0.002	-	0.006
A ₂	1.35	1.40	1.45	0.053	0.055	0.057
b	0.30	0.37	0.45	0.012	0.015	0.018
c	0.09	-	0.20	0.004	-	0.008
θ	0°	3.5°	7°	0°	3.5°	7°
θ ₁	0°	-	-	0°	-	-
θ ₂	12° TYP			12° TYP		
θ ₃	12° TYP			12° TYP		
D	9.00 BSC			0.354 BSC		
D ₁	7.00 BSC			0.276 BSC		
E	9.00 BSC			0.354 BSC		
E ₁	7.00 BSC			0.276 BSC		
e	0.80 BSC			0.031 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
L ₁	1.00 REF			0.039 REF		
S	0.20	-	-	0.008	-	-

Revision History

Revision	Date	Description
0.1	2010.12.16	Original
0.2	2011.06.17	Remove Note 6
0.3	2011.09.02	Modify VDD range
0.4	2013.02.20	Modify pin description
1.0	2015.02.17	Remove preliminary word and modify version to 1.0

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