

## Class-D Audio Power Amplifier with USB Interface

### Features

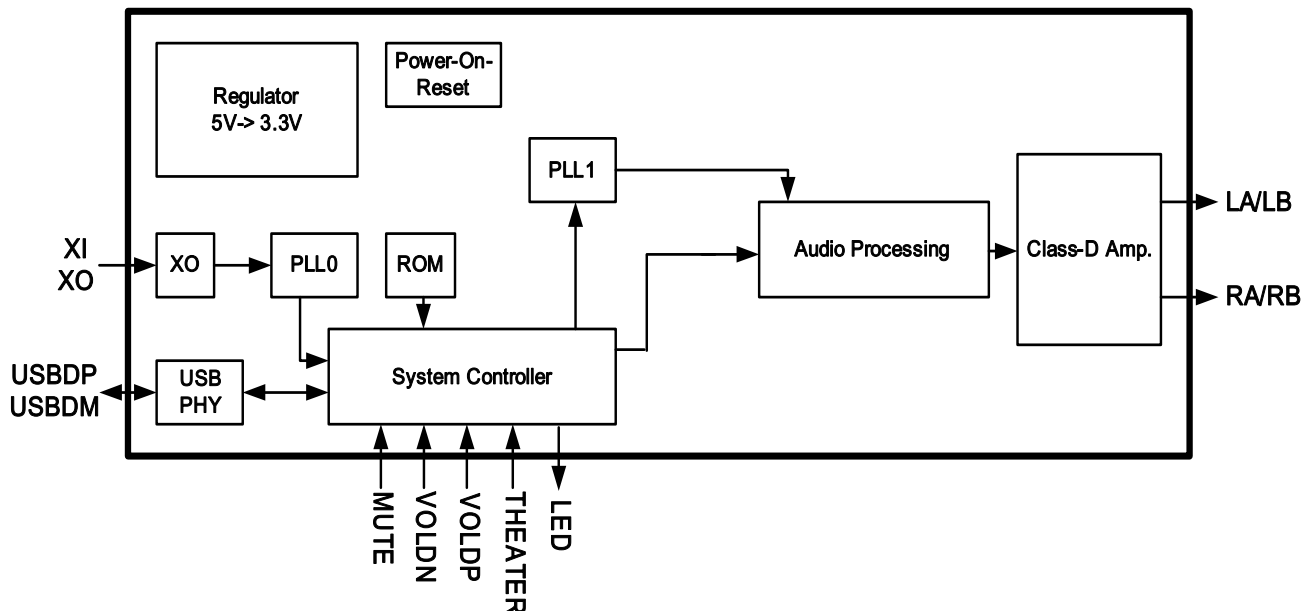
- True plug-and-play application, no driver is required for basic USB speaker application
- Supports Windows Me/2000/XP/Vista/7 and Mac OS
- Integration circuit quality meet **Windows 7 and Vista Hardware Logo** requirement
- Compliant with USB Specification v1.1, and USB 2.0 full speed
- Can work directly with a USB3.0 port
- Embedded high efficiency, high performance Class-D stereo amplifier
- Support both bus-powered and self-powered operation
- +6dB Gain enhancement (Theater function)
- Support volume/mute control with external button
- LED indicator function
- 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
- Embedded Power-On-Reset circuit
- 12 MHz crystal input
- 3.3V operation with 5V tolerate I/O
- 24-pin E-TSSOP Pb-free package

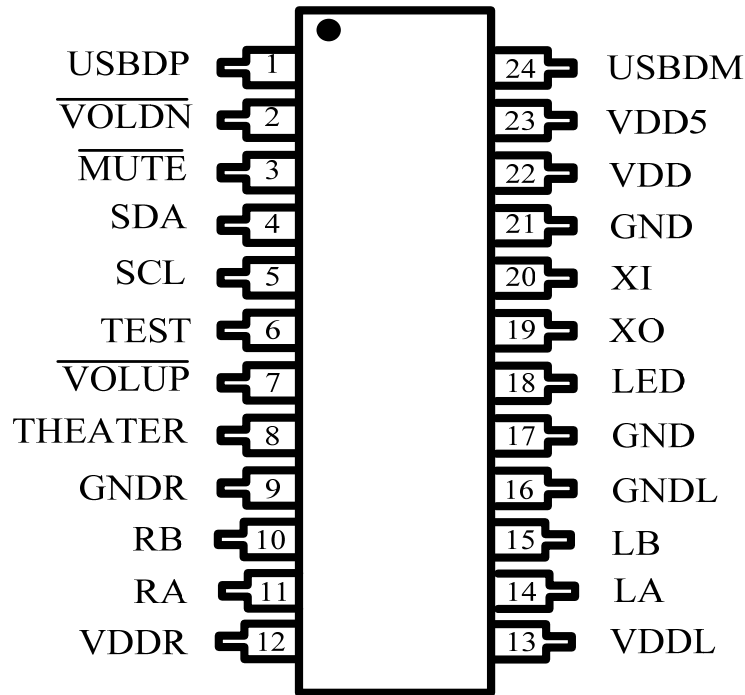
### Description

AD62555 is a monolithic Class-D audio amplifier with USB interface. When powered by the USB port, AD62555 can drive a pair of up to 1W speakers due to the built-in, high efficiency and high performance Class-D amplifiers.

### Functional Block Diagram



**Pin Assignment**



**Pin Description**

Pin	Name	Type	Description	Characteristics
1	USBDP	I/O	USB data D+	With internal pull-up resistor
2	$\overline{\text{VOLDN}}$	I	Volume down, low active	With internal pull-up resistor
3	$\overline{\text{MUTE}}$	I	Power-down and mute of Class-D, Low active	With internal pull-up resistor
4	SDA	I/O	I <sup>2</sup> C's SDA of master mode	5V tolerant Schmitt trigger TTL input buffer
5	SCL	O	I <sup>2</sup> C's SCL of master mode	
6	TEST	O	Reserved for testing purpose, no need to connect it during normal application	
7	$\overline{\text{VOLUP}}$	I	Volume up, low active	With internal pull-up resistor
8	THEATER	I	Theater mode, high active	5V tolerant Schmitt trigger TTL input buffer
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	GND	P	Ground	
18	LED	O	LED indicator	
19	XO	O	Crystal output	
20	XI	I	Crystal input	
21	GND	P	Ground	
22	VDD	P	3.3V Regulator output	
23	VDD5	P	5V supply voltage	
24	USBDM	I/O	USB data D-	

**Ordering Information**

Product ID	Package	Packing	Comments
AD62555-QE24NAT	E-TSSOP 24L	62 Units/ Tube 100 Tubes/ Small Box	Green

**Available Package**

Package Type	Device No.	$\theta_{ja}(\text{°C/W})$	$\theta_{jc}(\text{°C/W})$
E-TSSOP 24L	AD62555	32.3	17

**Note 1:**  $\theta_{ja}$  is measured on a room temperature ( $T_A=25\text{°C}$ ), 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:**  $\theta_{jc}$  represents the heat resistance for the heat flow between the chip and the package's top surface.

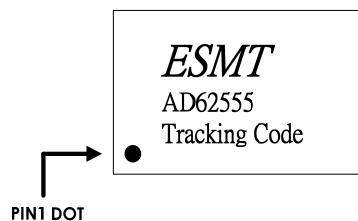
**Marking Information**

AD62555

Line 1 : LOGO

Line 2 : Product no.

Line 3 : Tracking Code



**Absolute Maximum Ratings**

Symbol	Parameter	Min	Max	Units
VDD5	Supply for regulator input	0	5.5	V
VDDL(R)	Supply for Left (Right) Channel	0	5.5	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/ $\mu$ s

**Recommended Operating Conditions**

Symbol	Parameter	Typ	Units
VDD5	Supply for regulator input	4.5~5.0	V
VDDL(R)	Supply for Driver Stage	3.0~5.0	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	VDD5=5V		44		mA
	Regulator current limit (for VDD)	$4.5V \leq VDD5$ $\leq 5.5V$			150	mA
$T_{SENSOR}$	Junction temperature for driver shutdown			150		°C
	Temperature hysteresis for recovery			30		°C
$UV_H$	Under voltage disabled (For VDD5)			3.8		V
$UV_L$	Under voltage enabled (For VDD5)			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 ( <b>Note3</b> )	VDDR(L)=5V		2.8	3.2	$\Omega$

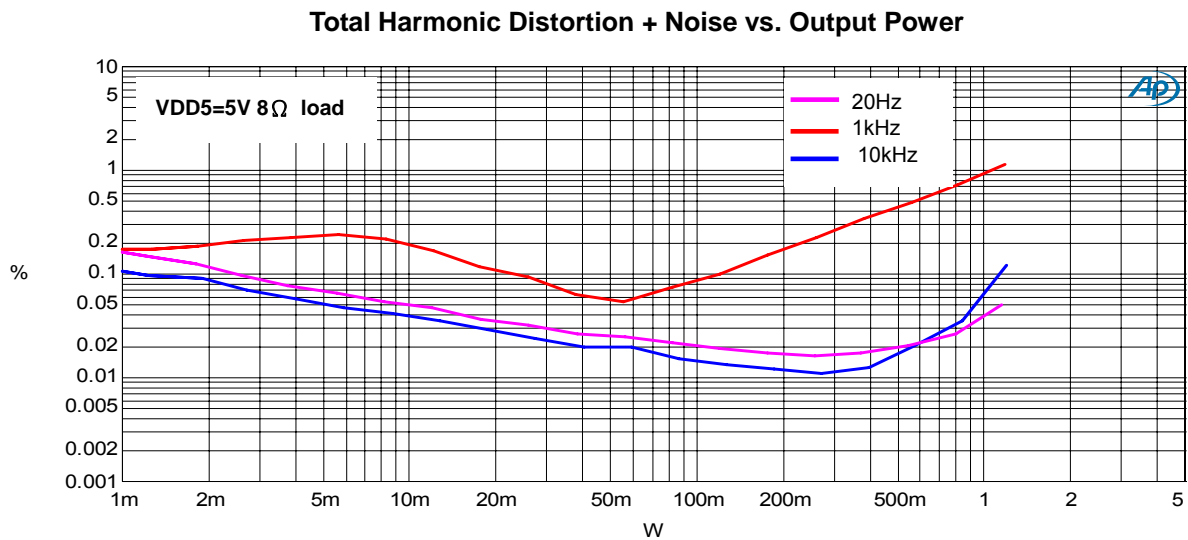
**Note 3: Loudspeaker short-circuit protection circuit is effective only when ferrite bead filters are properly used. Prolonged short-circuit condition will reduce device reliability.**

**Electrical Characteristics and Specifications for Loudspeaker**

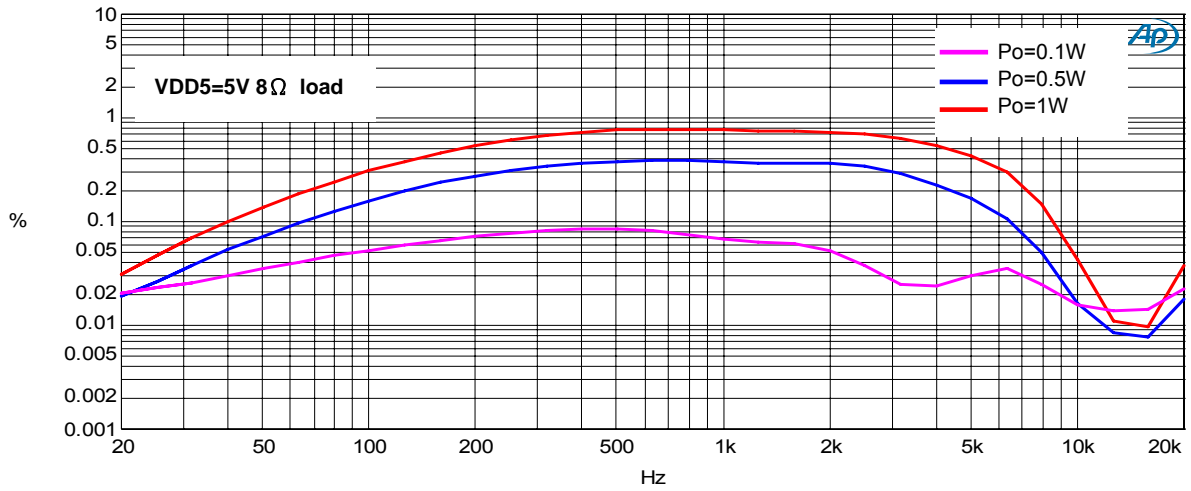
- Condition: VDD5=VDDL=VDDR=5V; F<sub>S</sub>=48kHz; Load=8Ω with Bead filter; Input is 1kHz sinewave; THETER=H

Symbol	Parameter	Condition	Input Level	Min	Typ	Max	Units
P <sub>O</sub>	RMS Output Power for Each Channel	THD+N=10%			1.55		W
		THD+N=1%			1.27		W
		THD+N=0.7%	I <sub>USB</sub> =500mA		0.9		W
		I <sub>USB</sub> =500mA			0.71		%
SNR	Signal to Noise Ratio <b>(Note4)</b>	P <sub>O</sub> =1.1W			91		dB
DR	Dynamic Range <b>(Note4)</b>		-66dB		92		dB
PSRR	Power Supply Rejection Ratio		-66dB		74		dB
	Channel Separation		-7dB		106		dB
η	Efficiency	THD+N=1%			78		%

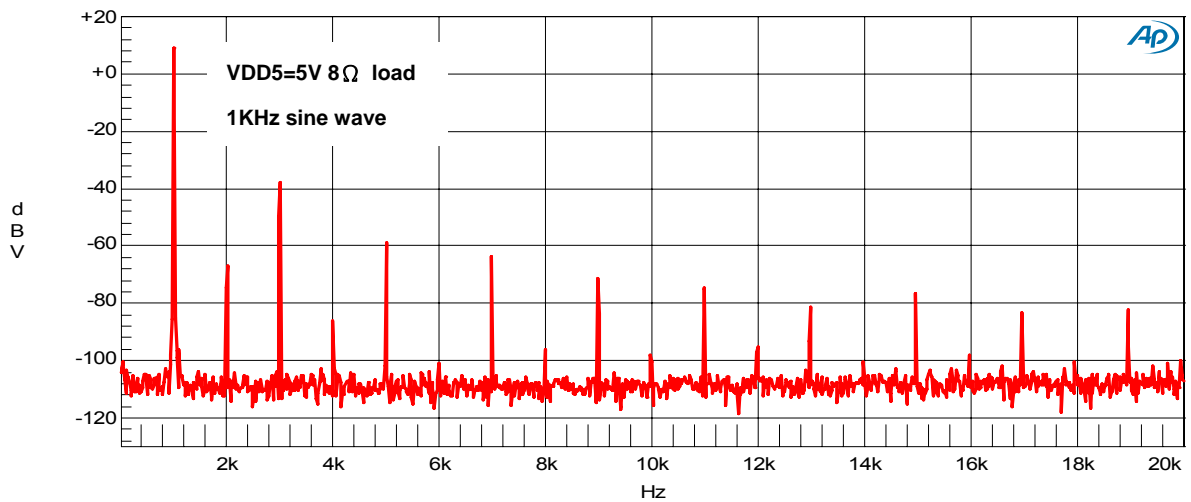
**Note 4: Measured with A-weighting filter and external power.**



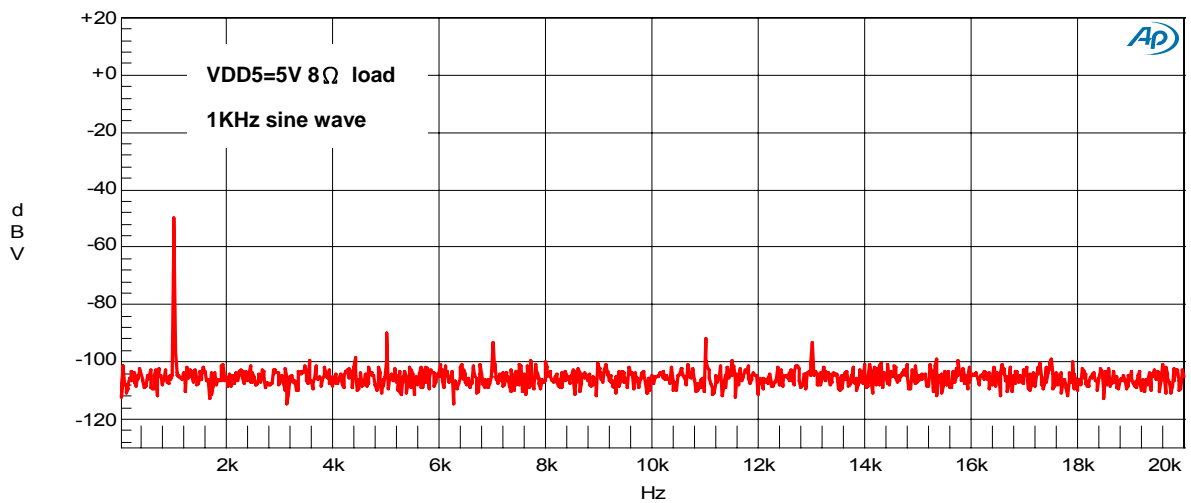
Total Harmonic Distortion + Noise vs. Frequency



Spectrum at Peak SNR



Spectrum at -66dB Signal Input Level

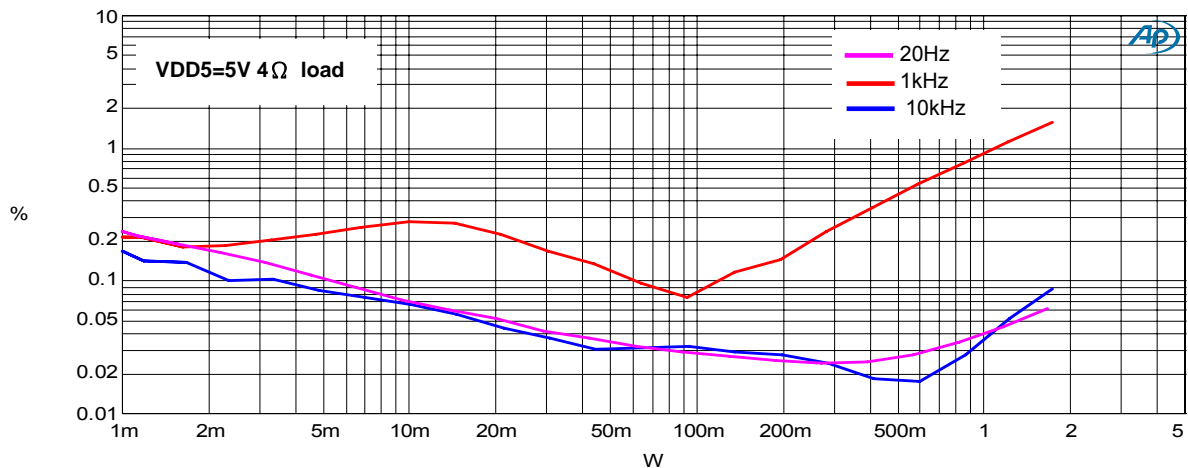


- Condition: VDD5=VDDL=VDDR=5V; F<sub>S</sub>=48kHz; Load=4Ω with Bead filter; Input is 1kHz sinewave; THETER=H

Symbol	Parameter	Condition	Input Level	Min	Typ	Max	Units
P <sub>o</sub>	RMS Output Power for Each Channel	THD+N=10%			2.58		W
		THD+N=1%			1.11		W
		THD+N=0.8%	I <sub>USB</sub> =500mA		0.79		W
THD+N	Total Harmonic Distortion + Noise	I <sub>USB</sub> =500mA			0.81		%
SNR	Signal to Noise Ratio ( <b>Note4</b> )	P <sub>O</sub> =1.4W			88		dB
DR	Dynamic Range ( <b>Note4</b> )		-66dB		91		dB
PSRR	Power Supply Rejection Ratio		-66dB		74		dB
	Channel Separation		-7dB		104		dB
η	Efficiency	THD+N=1%			71		%

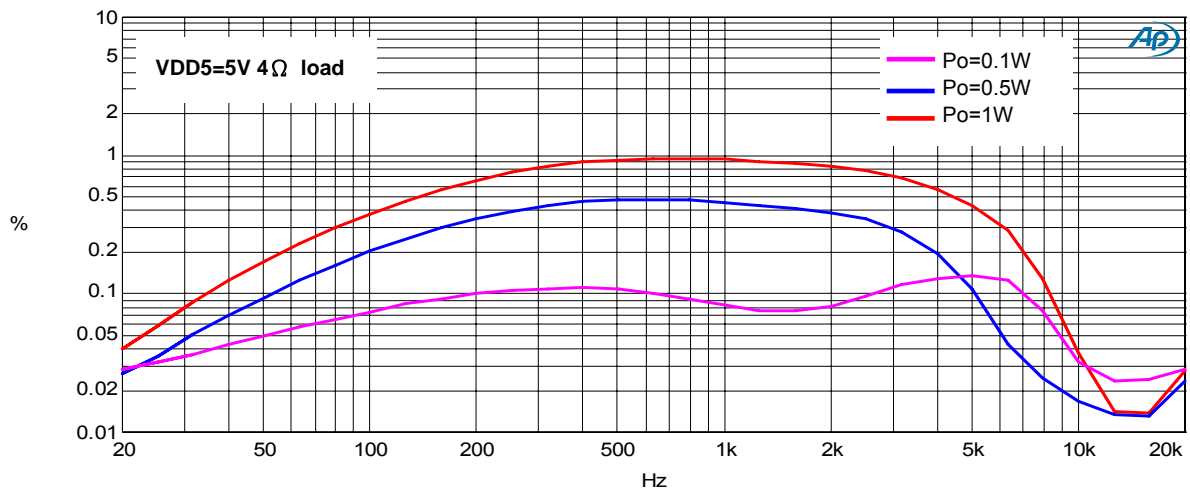
**Note 4:** Measured with A-weighting filter and external power.

**Total Harmonic Distortion + Noise vs. Output Power**

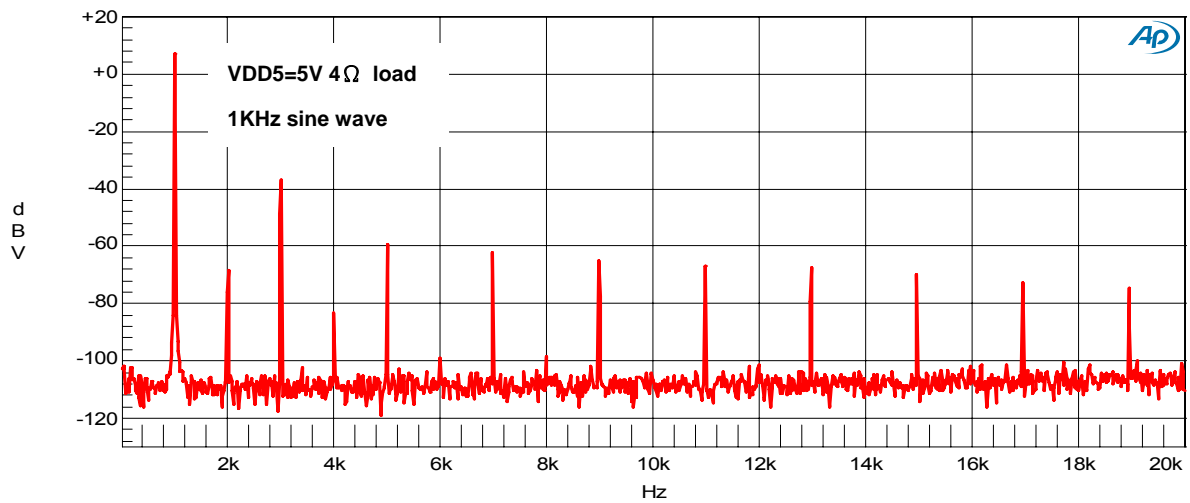




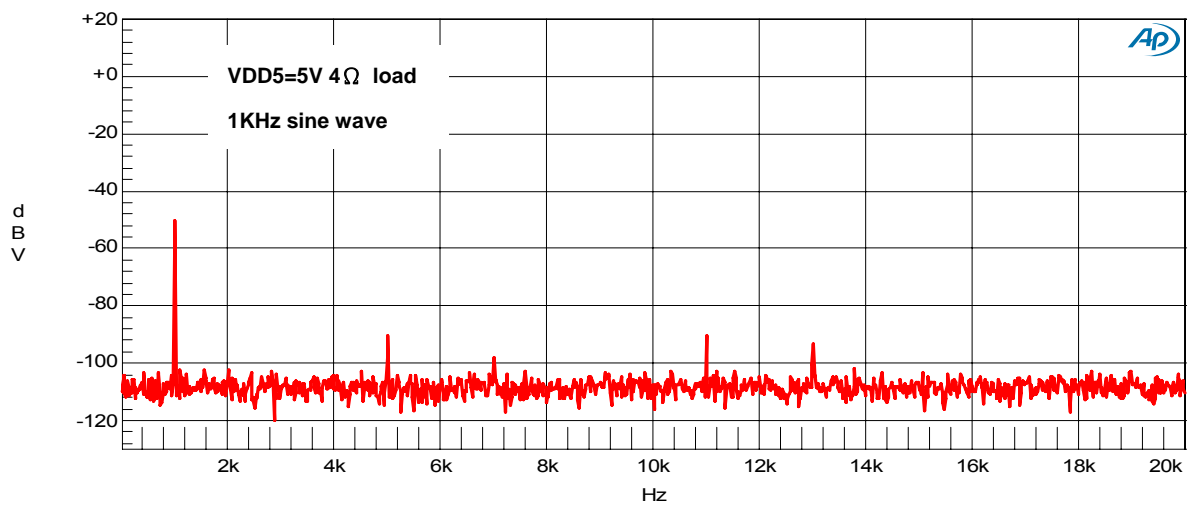
Total Harmonic Distortion + Noise vs. Frequency



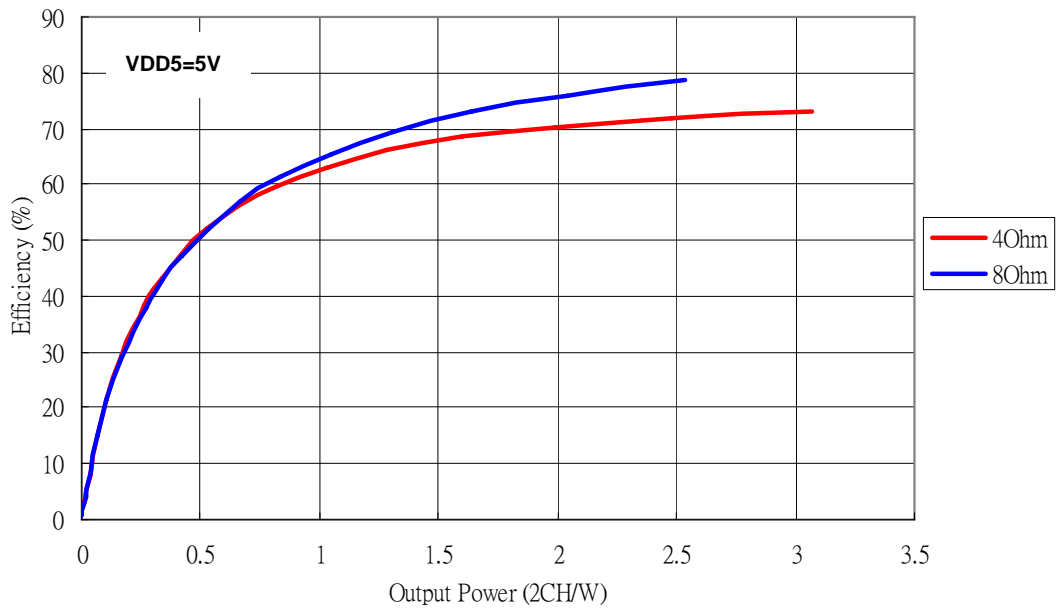
Spectrum at Peak SNR



Spectrum at -66dB Signal Input Level

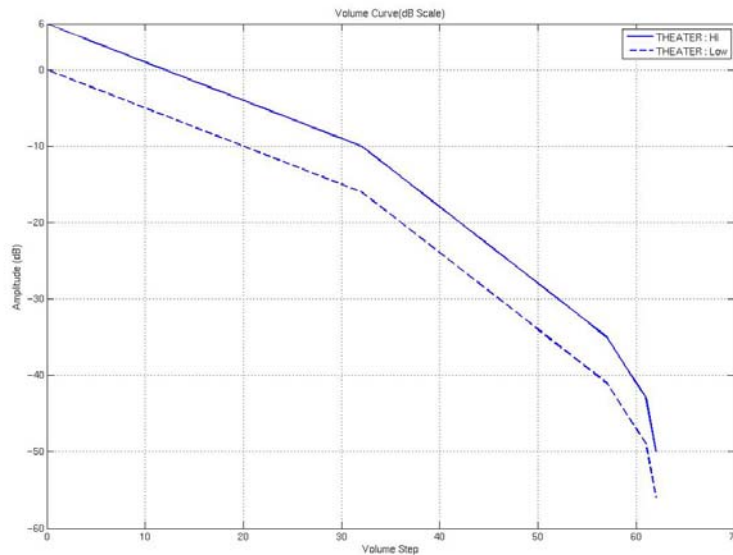


Efficiency vs. Output power with filterless configuration



## 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. Specifically the volume gain range is from +6 dB to -50 dB when THEATER is high or from +0 dB to -56 dB when 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)

AD62555 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 hysteresis characteristic such that the AD62555 will return to normal operation when the device is cooled down by 30°C. Due to the process variation, the triggering temperature values may have around 10% variation.

To protect loudspeaker power stages when the loudspeaker output are shorted each other or shorted to GND, AD62555 has a built-in output loading detection circuit. 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. When the short-circuit condition is detected, the output power stages will be shut off. After about 40ms the output power stage will become functional again when the short-circuit condition is removed.

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

Once VDD5 is lower than 3.7V, AD62555 will turn off its loudspeaker power stages and the digital circuit will cease operation. When VDD5 becomes higher than 3.8V, AD62555 will return to normal operation.

**Anti-pop design**

AD62555 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.

**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.

**Power consideration**

AD62555 can be powered by the USB port directly. However, the maximum current supplied by each USB 1.1 or 2.0 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.

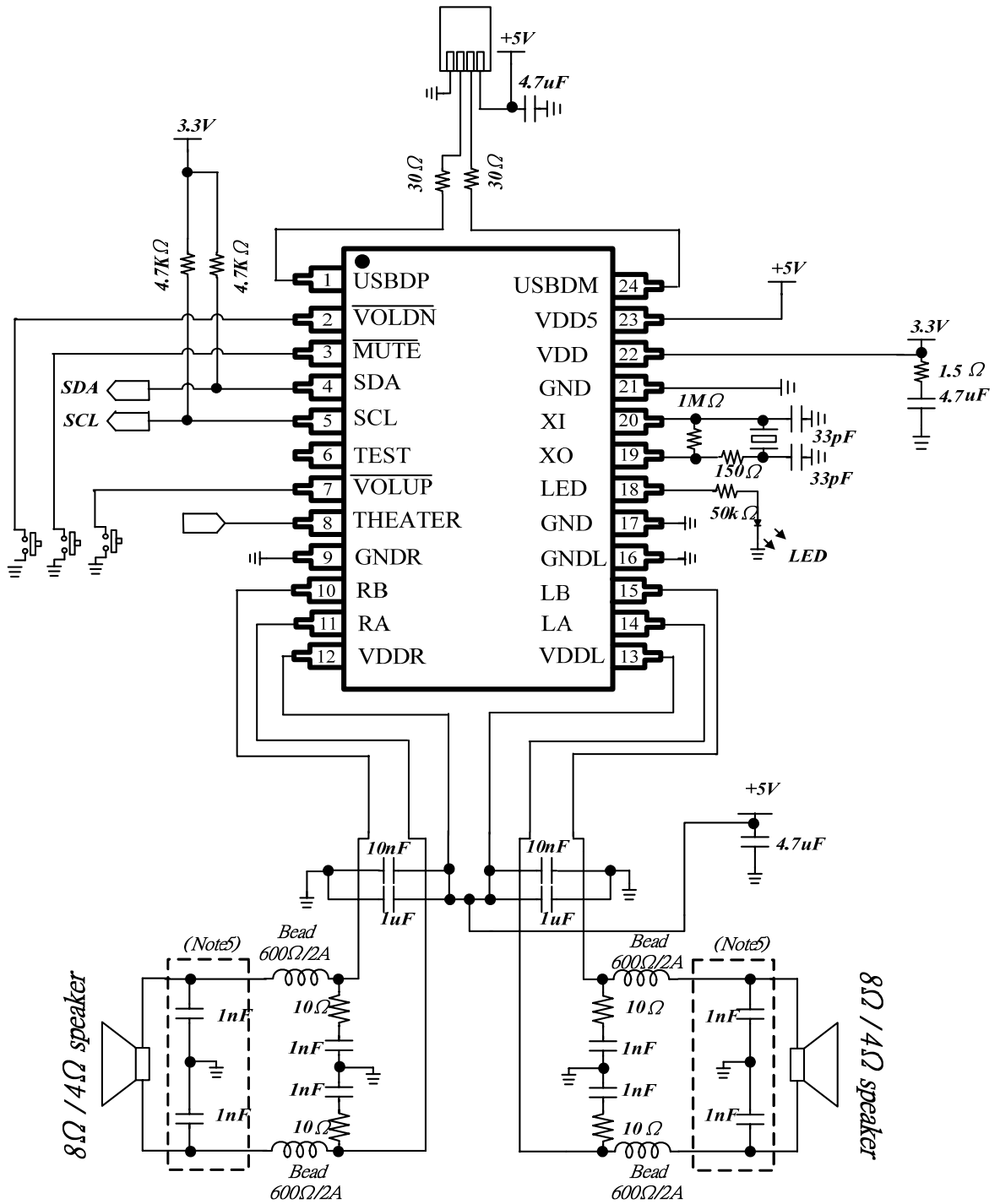
AD62555 can also work directly with USB 3.0 port, which can provide up to 900mA current. Care must be exercised e.g. . THEATER mode shall be turned off, when AD62555 works with a USB 3.0 port to avoid excessive power delivered to the output stage, which might cause large signal distortion.

**LED indicator**

LED indicator will be turned on (off) whenever the device is connected (disconnected) to the USB port. It will flash when there is data transfer on the USB port. During suspend or mute mode, it will be turned off.

**Application Circuit Examples for 8Ω/4Ω loudspeaker**

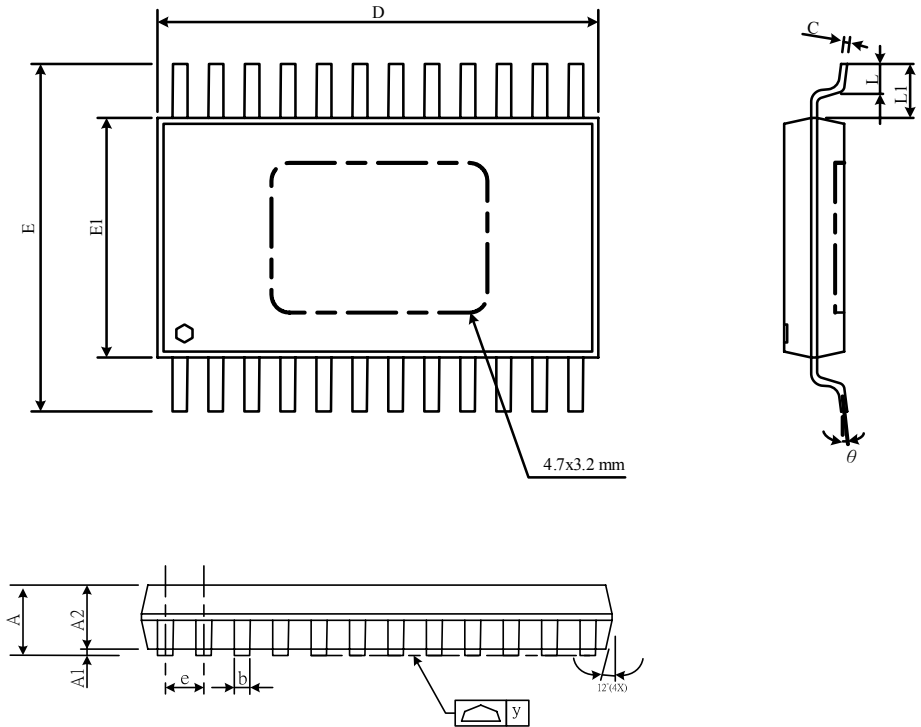
- USB speaker with ferrite bead filter



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

**Package Dimensions**

- E-TSSOP 24L Package



SYMBOLS	DIMENSION IN MILLIMETER			DIMENSION IN INCH		
	MIN	NOM	MAX	MIN	NOM	MAX
A	---	---	1.20	---	---	0.047
A1	0.00	---	0.15	0.000	---	0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19	---	0.30	0.007	---	0.012
C	0.09	---	0.20	0.004	---	0.008
D	7.70	7.80	7.90	0.303	0.307	0.311
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e	---	0.65	---	---	0.026	---
L	0.45	0.60	0.75	0.018	0.024	0.030
Y	---	---	0.10	---	---	0.004
θ	0°	---	8°	0°	---	8°
L1	0.90	1.00	1.10	0.035	0.039	0.043

**Revision History**

<b>Revision</b>	<b>Date</b>	<b>Description</b>
0.1	2010.12.16	Original
0.2	2011.06.17	Remove Note 6
0.3	2011.9.02	Revise packing information

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