2 X 4W Digital Audio Amplifier with Headphone Switching

Features

- 16/18/20/24-bit input with I^2S data format
- PSNR (A-weighting)
  Loudspeaker: 101dB
  Headphone: 93dB
- Multiple sampling frequencies (Fs)
  8KHz, 12KHz, 16KHz, 22.05KHz, 24KHz
  32KHz, 44.1KHz, 48KHz,
  64KHz, 88.2KHz and 96KHz
- System clock = 256Fs
- Single or dual supply
  Single supply: 3.0~3.3V for the whole chip
  Dual supply: 3.0~5V for loudspeaker driver
  3.0~3.3V for others
- 2.5~5.5V tolerant input interface
- Loudspeaker power and power efficiency (η)
  1.5W into 8Ω@1KHz and 1% THD+N (η=94%)
  2.8W into 4Ω@1KHz and 1% THD+N (η=91%)
  3.5W into 3Ω@1KHz and 1% THD+N (η=90%)
  4W into 3Ω @1KHz and 10% THD+N (η=90%)
- Headphone power and power efficiency (η)
  30mW into 32Ω@1KHz and 1% THD+N (η=65%)
  60mW into 16Ω@1KHz and 1% THD+N (η=75%)
  115mW into 8Ω@1KHz and 1% THD+N (η=83%)
  200mW into 4Ω@1KHz and 1% THD+N (η=84%)
- Volume control
  53steps:+6~-34dB(1dB/step)-36~-58dB(2dB/step)
  33steps:+6~-34dB(2dB/step)-36~-58dB(2dB/step)
- Mute function
- Power down function
- Anti-pop design
- Over-temperature protection
- Under-voltage protection
- Short circuit protection

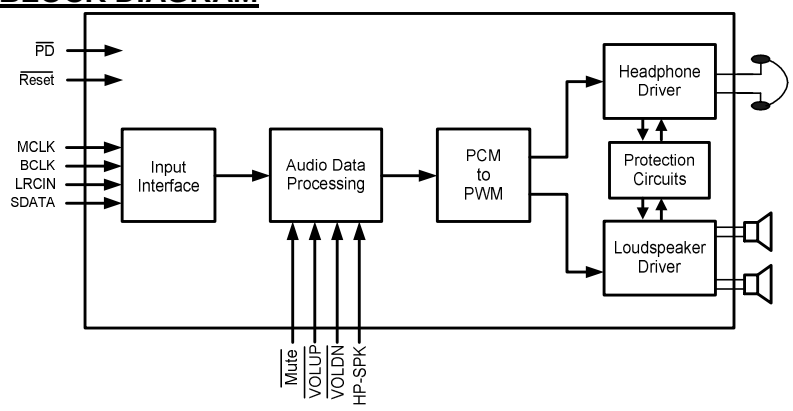
Applications

- CD and DVD
- TV audio
- USB speaker
- MP3
- Headphone Amplifier
- PDA
- Portable / Handheld
- Mobile phone
- Car audio

Description

This is a stereo digital audio amplifier with high power efficiency, which leads to longer battery life, less heat sink requirement, smaller board size and lower system cost. AD8255 can detect headphone connection and choose to drive either stereo loudspeakers or stereo headphones. Operating with 3.0/3.3/5V loudspeaker driver supply, each loudspeaker channel can typically deliver 0.54/0.65/1.5W to 8Ω, 1/1.22/2.8W to 4Ω and 1.25/1.52/3.5W to 3Ω loudspeakers, respectively, with less than 1% THD+N. Operating with 3.0/3.3V headphone driver supply, each headphone channel can typically deliver 25/30mW to 32Ω, 50/60mW to 16Ω and 80/100mW to 8Ω, respectively, with less than 1% THD+N.

FUNCTIONAL BLOCK DIAGRAM



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Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units
DVDD	Supply for Digital Circuit	0	3.6	V
AVDD	Supply for Analog Circuit	0	3.6	V
VDDL(R)	Supply for Left (Right) Channel	0	5.5	V
V_i	Input Voltage	0	5.5	V
T_{stg}	Storage Temperature	-45	150	^oC
T_a	Ambient Operating Temperature	0	70	^oC

Recommended Operating Conditions

Symbol	Parameter	Typ	Units
DVDD	Supply for Digital Circuit	3.0~3.3	V
AVDD	Supply for Analog Circuit	3.0~3.3	V
VDDL(R)	Supply for Driver Stage	3.0~5.0	V

Digital Characteristics

Symbol	Parameter	Min	Typ	Max	Units
V_{IH}	High-Level Input Voltage	0.7*DVDD			V
V_{IL}	Low-Level Input Voltage			0.3*DVDD	V
V_{OH}	High-Level Output Voltage	0.7*DVDD			V
V_{OL}	Low-Level Output Voltage			0.3*DVDD	V
C_I	Input Capacitance		6.4		pF

General Electrical Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
I_{PD}	Supply Current during Power Down				50	μA
	Junction Temperature for Driver Shutdown			150		^oC
	Junction Temperature for Recovery from Shutdown			130		^oC
UV_H	Under Voltage Disabled (For AVDD)	UVSEL=Low UVSEL=High		2.88 2.61		V
UV_L	Under Voltage Enabled (For AVDD)	UVSEL=Low UVSEL=High		2.79 2.51		V
R_{SC}	Loudspeaker Output Short-Circuit Protection(Note)			3		Ω
R_{SCH}	Headphone Output Short-Circuit Protection(Note)	Power ON/OFF Transient Steady State		12 6		Ω

Note: Short circuit protection is effective when loudspeaker and headphone drivers are properly connected with external LC filters.

Thermal Characteristics (condition: still air)

Package	Symbol	Parameter	Power (W)	THETA Ja(°C/W)	Tj(°C)	Heat Dissipated From PWB	Heat Dissipated From Top	Heat Dissipated From Other
SOP	Θ_{JA}	Thermal Resistance	1.00	40.37	103.4	0.847W, 85%	0.033W, 3%	0.093W, 9%
SSOP	Θ_{JA}	Thermal Resistance	1.00	58.49	103.5	0.910W, 91%	0.020W, 2%	0.07W, 7%
TSSOP	Θ_{JA}	Thermal Resistance	1.00	56.98	102	0.934W, 93%	0.015W, 2%	0.05W, 5%

Electrical Characteristics and Specifications for Loudspeaker

Condition: DVDD=AVDD=3.3V, VDDL=VDDR=5V, F_S=48 KHz, Load=8Ω with passive LC lowpass filter (L=22 μH, C=470nF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel	THD=1%		1.5		W
		THD=10%		1.7		W
I_{cc}	Peak Supply Current			1.2		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=1.2W		0.1		%
SNR	Signal to Noise Ratio(Note)	P_o=1.2W		100		dB
DR	Dynamic Range(Note)	-60dB input		100		dB
	Channel Separation	-1dB input		80		dB
h	Efficiency	P_O=1.5W		94		%

Condition: DVDD=AVDD=3.3V, VDDL=VDDR=5V, F_S=48 KHz, Load=4Ω with passive LC lowpass filter (L=10µH, C=1µF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel	THD=1%		2.8		W
		THD=10%		3.1		W
I_{cc}	Peak Supply Current			2.5		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=2.4W		0.22		%
SNR	Signal to Noise Ratio(Note)	P_o=2.4W		100		dB
DR	Dynamic Range(Note)	-60dB input		100		dB
	Channel Separation	-1dB input		80		dB
h	Efficiency	P_O=2.8W		90		%

Condition: DVDD=AVDD=3.3V, VDDL=VDDR=5V, F_S=48 KHz, Load=3Ω with passive LC lowpass filter (L=10µH, C=1µF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel	THD=1%		3.5		W
		THD=10%		4		W
I_{cc}	Peak Supply Current			3		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=3W		0.28		%
SNR	Signal to Noise Ratio(Note)	P_o=3W		100		dB
DR	Dynamic Range(Note)	-60dB input		100		dB
	Channel Separation	-1dB input		80		dB
h	Efficiency	P_O=3.5W		90		%

Note: Measured with A-weighting filter

Electrical Characteristics and Specifications for Headphone

Condition: DVDD=AVDD=3.3V, F_S=48 KHz, Load=32Ω with DC decoupling capacitor (C_{DC}=220μF) and passive LC lowpass filter (L=100μH, C=0.15μF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel			30		mW
I_{cc}	Peak Supply Current			0.2		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=30mW		0.05		%
SNR	Signal to Noise Ratio(Note)	P_o=30mW		93		dB
DR	Dynamic Range(Note)	-60dB input		93		dB
	Channel Separation	-1dB input		63		dB
h	Efficiency			62		%

Condition: DVDD=AVDD=3.3V, F_S=48 KHz, Load=16Ω with DC decoupling capacitor (C_{DC}=220μF) and passive LC lowpass filter (L=100μH, C=0.15μF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel			60		mW
I_{cc}	Peak Supply Current			0.4		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=60mW		0.1		%
SNR	Signal to Noise Ratio(Note)	P_o=60mW		93		dB
DR	Dynamic Range(Note)	-60dB input		93		dB
	Channel Separation	-1dB input		61		dB
h	Efficiency			76		%

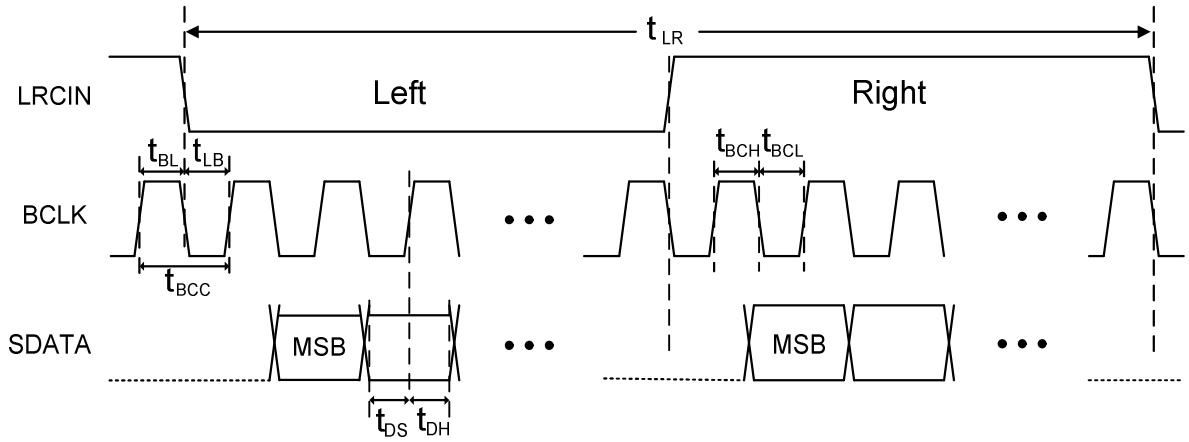
Condition: DVDD=AVDD=3.3V, F_S=48 KHz, Load=8Ω with DC decoupling capacitor (C_{DC}=880μF) and passive LC lowpass filter (L=25μH, C=0.6μF); Input is 0dB 1 KHz sinewave unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Units
P_o	RMS Output Power for Each Channel			115		mW
I_{cc}	Peak Supply Current			0.8		A
THD+N	Total Harmonic Distortion+Noise(Note)	P_o=115mW		0.15		%
SNR	Signal to Noise Ratio(Note)	P_o=115mW		93		dB
DR	Dynamic Range(Note)	-60dB input		93		dB
	Channel Separation	-1dB input		58		dB
h	Efficiency			83		%

Note: Measured with A-weighting filter

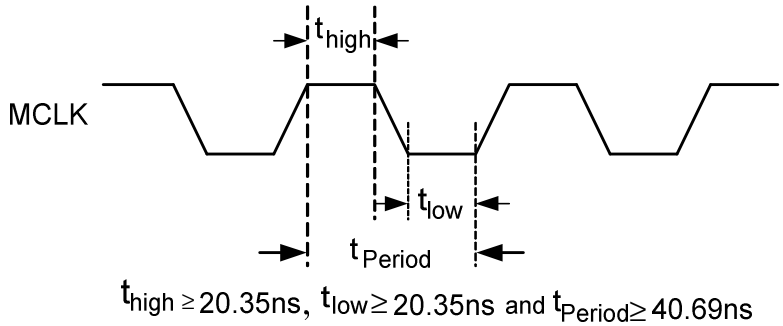
Interface Configuration

I I^2S



Symbol	Parameter	Min	Typ	Max	Units
t_{LR}	LRCIN Period ($1/F_S$)	10.41		125	µs
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

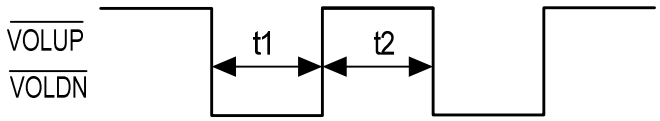
I System Clock Timing



Operation Descriptions

I Volume control

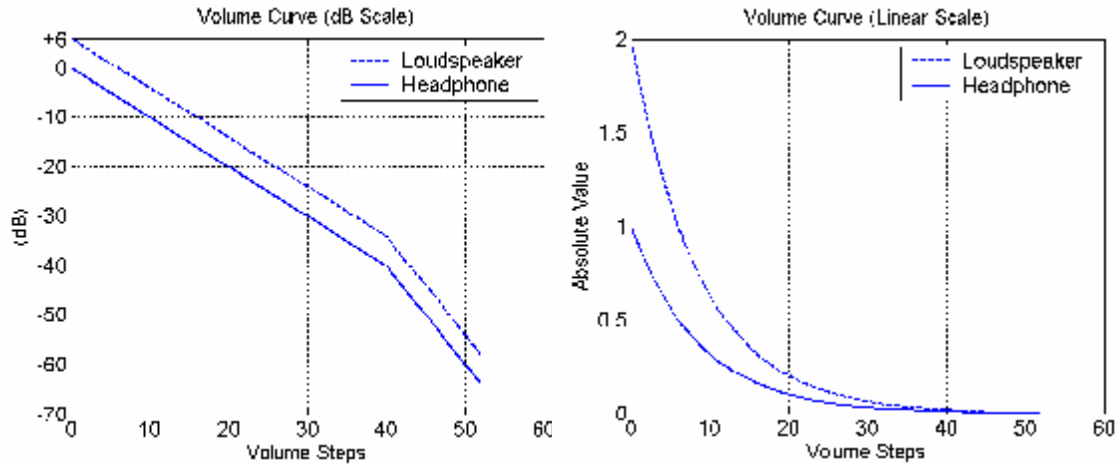
Audio volume can be increased or decreased by sending a high **à** low **à** high transition pulse to $\overline{\text{VOLUP}}$ pin or $\overline{\text{VOLDN}}$ pin, respectively. The volume range is from +6dB to -58dB. The default volume levels are -18dB for loudspeaker and -24dB for headphone, respectively. The volume control timing diagram is shown below, $t_1 \geqq (10/Fs)$ and $t_2 \geqq (2/Fs)$ where Fs = 8KHz ~ 96KHz.



Two kinds of volume level control example are described below. Other choices can be provided depending on users' control.

(i) 53-step

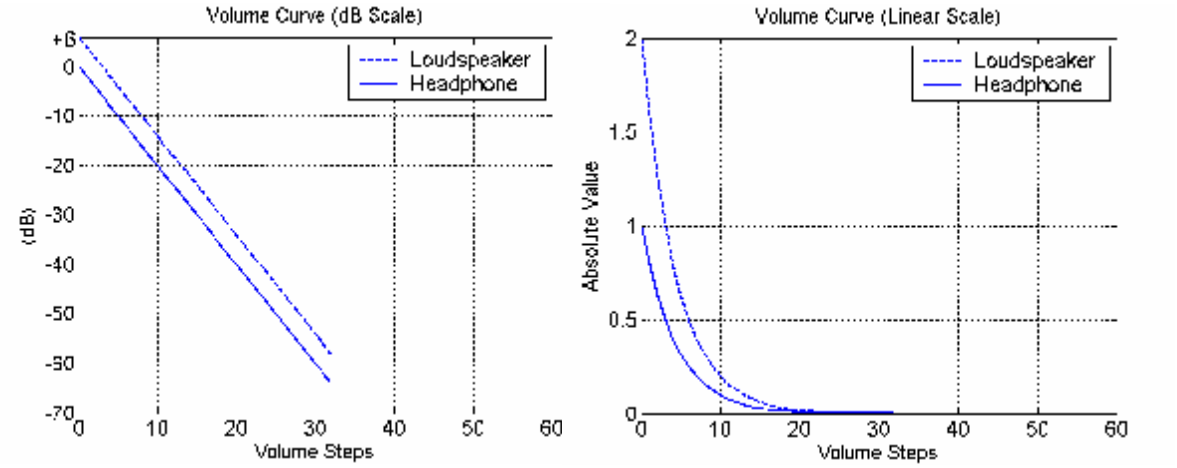
AD8255 has 53 volume levels. Volume level 0~40 have the step size of 1dB/step (+6dB, +5dB, +4dB …., -33dB, -34dB for loudspeaker and 0dB, -1dB, -2dB …., -39dB, -40dB for headphone). Volume level 42~52 have the step size of 2dB/step (-36dB, -38dB, -40dB…, -56dB, -58dB for loudspeaker and -42dB, -44dB, -46dB…, -62dB, -64dB for headphone).



(ii) 33-step

Linearization of the volume levels in dB scale can be done via external control. The original volume level 0~40 (1dB/step) can be mapped to new volume level 0~20 (2dB/step), and the original volume level 41~52 (2dB/ step) can be mapped to new volume level 21~32 (2dB/step). The compressed volume level 0~32 becomes +6

dB, +4 dB, …, -56 dB, -58dB for loudspeaker and 0 dB, -2 dB, …, -62 dB, -64dB for headphone.



- Volume gain

  The highest volume gain is 6dB, referred to the original input signal level.

- Reset

  When the level of $\overline{\text{Reset}}$ pin becomes low, AD8255 will perform the initialization sequence (clear internal storage elements) and set the default volume level. The default volume level is -18dB for loudspeaker (-24dB for headphone). An external RC circuit with time constant larger than 0.4sec is suggested to connect to $\overline{\text{Reset}}$ pin.

- Power down control

  When the $\overline{\text{PD}}$ pin becomes low, AD8255 will turn off the power stages. Then AD8255 will stop clock signals (MCLK, BCLK, LRCIN) from feeding into digital circuit and turn off the analog bias, digital circuit will enter the low power consumption mode (power down mode) since no switching in digital circuit. When the $\overline{\text{PD}}$ pin becomes high, AD8255 will establish the analog circuits' bias and feed the clock signals (MCLK, BCLK, LRCIN) into the digital circuit. Then, AD8255 will return to its operation without power down.

- Self-protection Circuits (Typical values are used below.)

  AD8255 has build-in protection circuits including thermal sensor, short-circuit protection and under-voltage detection circuits.

  (i) If the internal junction temperature is higher than 150^{o}C, loudspeaker and

headphone power stages will be turned off and return to normal operation once the internal junction temperature becomes below 130°C.

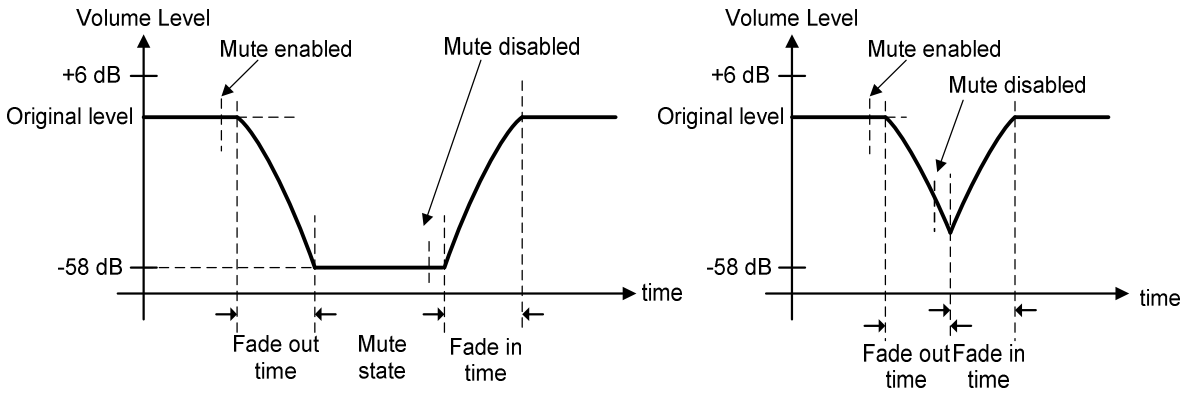
(ii) To avoid irrecoverable damage of loudspeaker and headphone power stages when their output pins are shorted each other, to VDD or to GND, circuits for the detection of output loading is built in the AD8255. Both loudspeaker and headphone power stages will be turned off when either (a) the loudspeaker driver output loading is less than 3Ω or (b) the headphone driver output loading is less than 12Ω during power-on transient (6Ω after power-on transient).

(iii) Once the AVDD voltage is lower than 2.79V, AD8255 will turn off its loudspeaker and headphone power stages and cease the operation of digital processing circuits. When AVDD becomes larger than 2.88V, AD8255 will return to normal operation.

l Mute function

AD8255 has build-in volume fade-in/fade-out design for mute function. When mute function is disabled, AD8255 will perform volume fade-in and return to original volume level. The relative mute timing diagrams are shown below.

AD8255 will detect $\overline{\text{Mute}}$ pin once a LRCIN cycle. When AD8255 detects 9 consecutive zeros, it will enter the fade-out procedure. The volume level will be slowly changed to -58 dB in several LRCIN cycles. Function of volume up and volume down will be disabled when AD8255 is mute enabled. When AD8255 detects 9 consecutive ones, the mute function will be disabled and the fade-in procedure is then activated. If the mute function is disabled in the midway of the fade-out procedure, AD8255 will enter the fade-in procedure. Volume level will be the same before mute and after mute.



- Anti-pop design

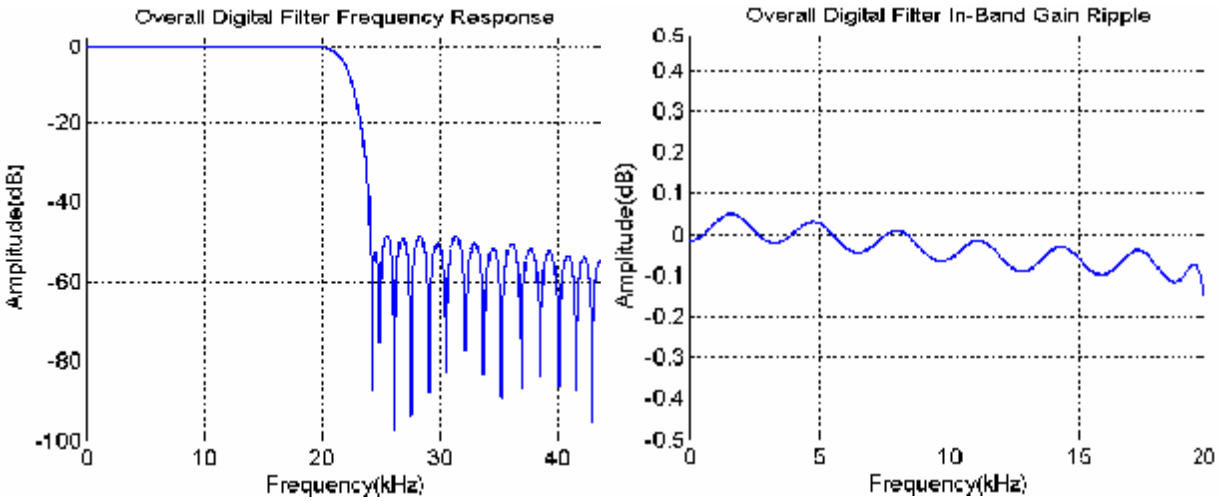
  AD8255 is with anti-pop design. Annoying pop sounds are suppressed during initial power-on, power down/up, mute, power-off and volume level change. When one of the operations mentioned above is applied, AD8255 will generate appropriate control signals internally to suppress pop sounds.

- Loudspeaker and headphone switching

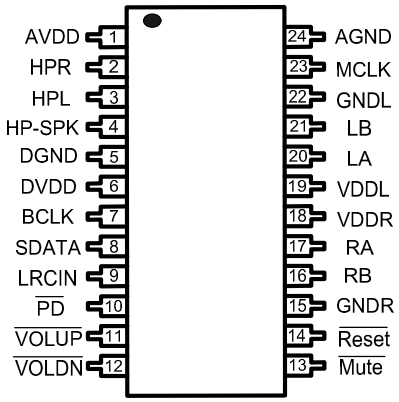
  AD8255 can switch between headphone and loudspeaker mode automatically with the application circuits shown in the application circuit section. When HP-SPK pin is pulled high, AD8255 enters headphone mode and loudspeaker output is muted. When HP-SPK pin is pulled low, AD8255 enters loudspeaker mode and headphone is muted. HP-SPK pin is connected to AVDD via a 500KΩ (typical value) resistor in the chip.

- Digital filter frequency response

  The gain droop in the audio bandwidth of digital filters is compensated by off-chip passive LC filters. Therefore the overall inband gain ripple is approximately within ±0.1dB.



Pin Assignment

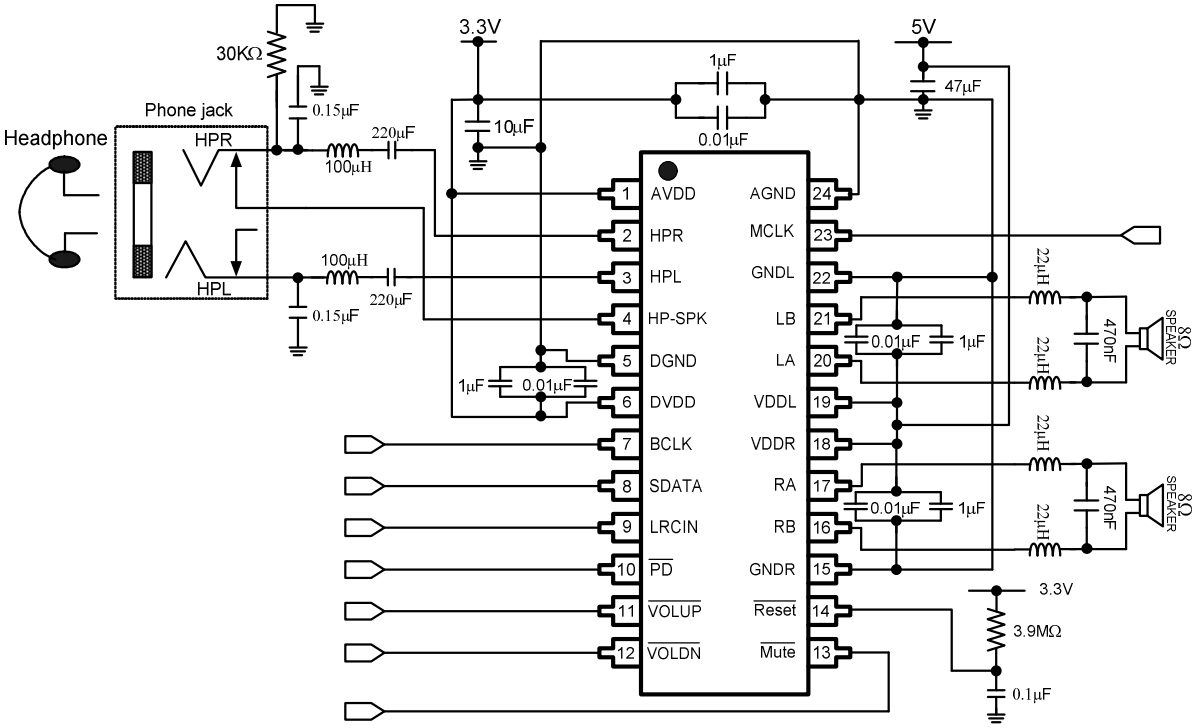


Pin Description

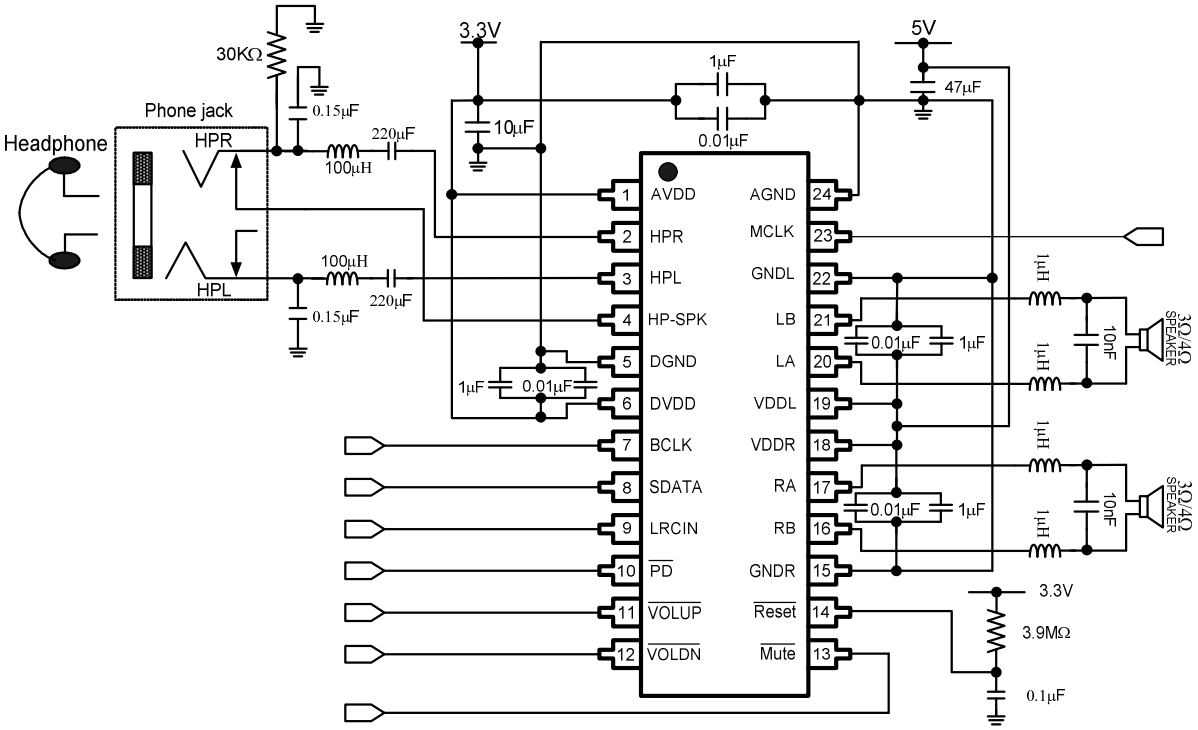
PIN NO.	NAME	TYPE	DESCRIPTION	CHARACTERISTICS
1	AVDD	P	Analog supply	
2	HPR	O	Headphone right channel output	
3	HPL	O	Headphone left channel output	
4	HP-SPK	I	Headphone detection	5V tolerant Schmitt trigger input with pull-up 380KΩ resistor
5	DGND	P	Digital ground	
6	DVDD	P	Digital supply	
7	BCLK	I	64Fs clock input	5V tolerant Schmitt trigger TTL input buffer
8	SDATA	I	Audio data input	5V tolerant Schmitt trigger TTL input buffer
9	LRCIN	I	Fs clock input	5V tolerant Schmitt trigger TTL input buffer
10	$\overline{\text{PD}}$	I	Power down, low active	5V tolerant Schmitt trigger TTL input buffer
11	$\overline{\text{VOLUP}}$	I	Volume up, low active	5V tolerant Schmitt trigger TTL input buffer (Note)
12	$\overline{\text{VOLDN}}$	I	Volume down, low active	5V tolerant Schmitt trigger TTL input buffer (Note)
13	$\overline{\text{Mute}}$	I	Mute control, low active	5V tolerant Schmitt trigger TTL input buffer (Note)
14	$\overline{\text{Reset}}$	I	Reset, low active	5V tolerant Schmitt trigger TTL input buffer
15	GNDR	P	Ground for loudspeaker right channel	
16	RB	O	Loudspeaker right channel output B	
17	RA	O	Loudspeaker right channel output A	
18	VDDR	P	Supply for loudspeaker right channel	
19	VDDL	P	Supply for loudspeaker left channel	
20	LA	O	Loudspeaker left channel output A	
21	LB	O	Loudspeaker left channel output B	
22	GNDL	P	Ground for loudspeaker left channel	
23	MCLK	I	256Fs clock input	5V tolerant Schmitt trigger TTL input buffer
24	AGND	P	Analog ground	

Note: Becomes bi-directional with less than 30uA output current when " $\overline{\text{Reset}}$ " pin is low.

Application Circuit Example1 (For 8Ω loudspeaker)



Application Circuit Example2 (For 3Ω and 4Ωloudspeaker)



*In most environment, L=100μH and C=0.15μF for headphone can be eliminated.
However, in the very EMI-sensitive environment, the use of the L and C is suggested.

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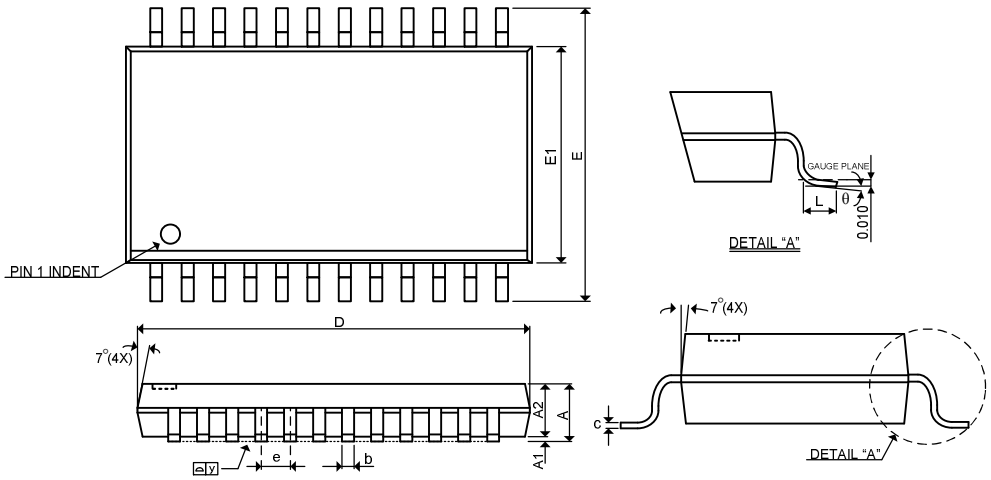
Package Dimensions

I 24L SSOP PACKAGE



SYMBOLS	DIMENSIONS IN MLLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	-	-	2.00	-	-	0.709
A1	0.05	-	0.15	0.002	-	0.008
A2	1.65	1.75	1.85	0.065	0.089	0.073
b	0.22	0.30	0.38	0.0088	0.012	0.015
C	0.09	0.15	0.25	0.0035	0.006	0.0098
D	7.90	8.20	8.50	0.311	0.323	0.335
E	7.40	7.80	5.20	0.291	0.307	0.323
E1	5.00	5.30	5.50	0.197	0.209	0.220
e	-	0.65	-	-	0.0258	-
L	0.55	0.75	0.95	0.022	0.030	0.037
L1	-	1.25			0.0492	-
θ	0°	4°	8°	0°	4°	8°
y	-	-	0.10	-	-	0.004

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