2.5W/CH Stereo Filter-less Class-D Audio Amplifier with Power Limit Function

Features

- Supply voltage range: 3.0 V to 5.0 V
- 2.5W power limit function
- 10mA static operation current
- <1uA shutdown current
- 64-step DC volume control from mute to +24dB
- Overload and thermal protection
- Loudspeaker output power @ 1% THD+N
  - 1.4W/CH into 8Ω loudspeaker
  - 2.45W/CH into 4Ω loudspeaker

Applications

- Monitor audio
- Portable multimedia devices
- Mobile phone

Description

The AD52655 is a stereo, filter-less class-D audio amplifier with 2.5W power limit. Operating with 5.0V loudspeaker driver supply, it can deliver 2.45W/CH output power into 4Ω loudspeaker within 1% THD+N.

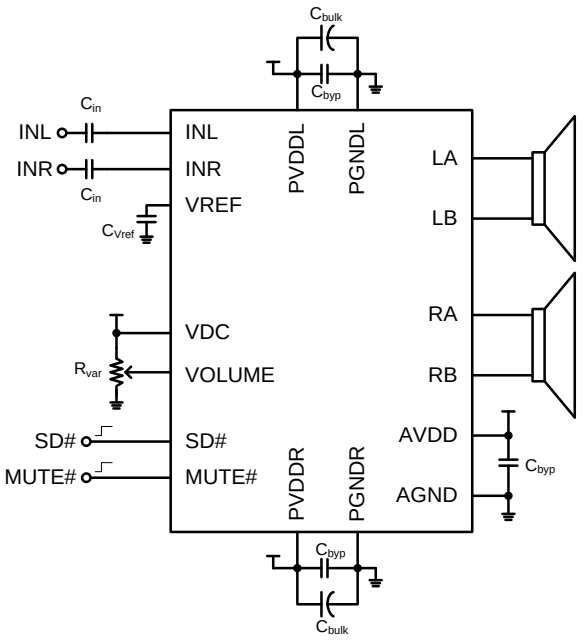
The AD52655 has not only a 64-step DC volume controller, but also a 2.5W power limiter, which implement with an automatic gain controller (AGC).

The AD52655 is packaged as SSOP-24L(150mil) is a stereo audio amplifier with high efficiency, which leads to longer battery life, less heat sink requirement, smaller board size and lower system cost, and suitable for the notebook computer, and portable multimedia devices.

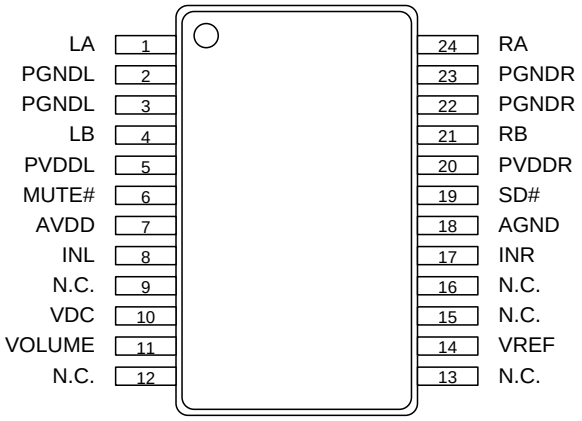
Ordering Information

Product ID	Package	Packing	Comments
AD52655-ST24NAT	SSOP-24L	56 Units/ Tube 100 Tubes/ Small Box	Green
AD52655-ST24NAR	SSOP-24L	3K Units/ Reel	Green

Typical Application Circuit



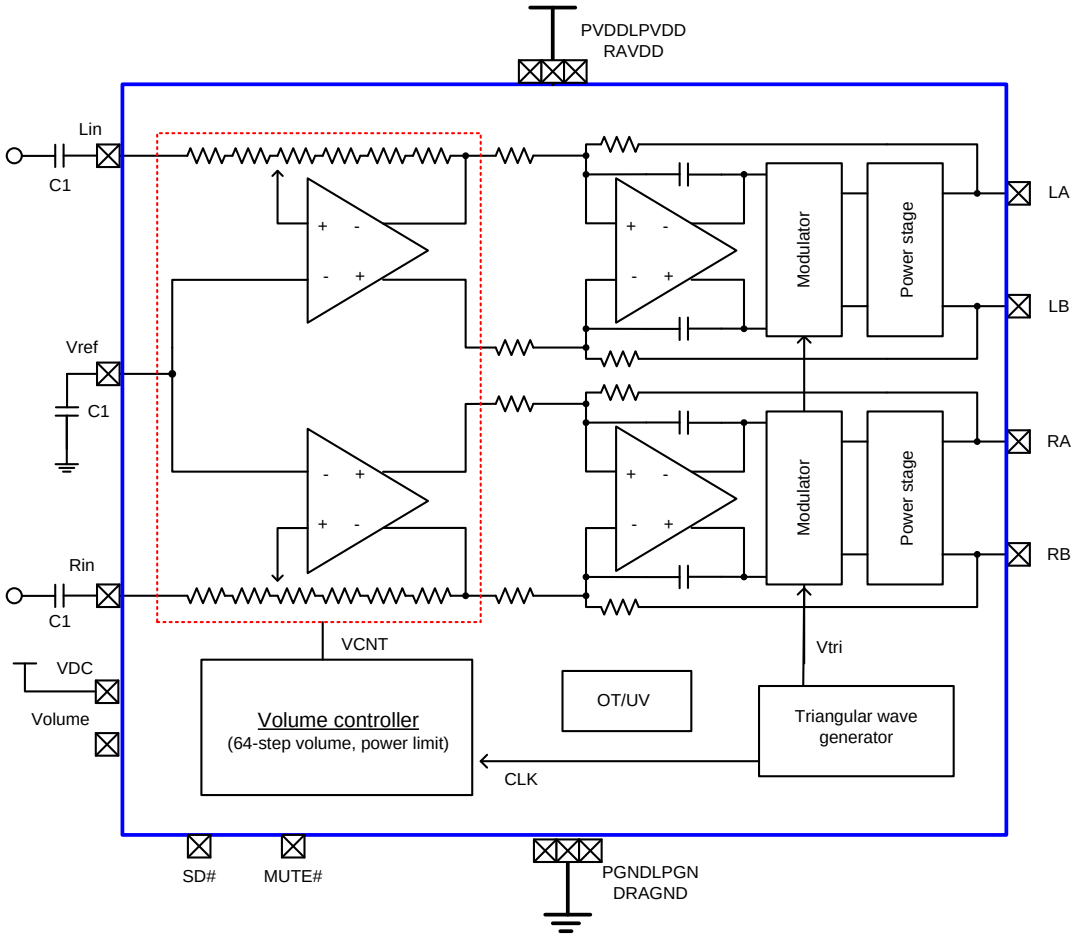
Pin Assignments



Pin Description

NAME		TYP	DESCRIPTION	CHARACTERISTIC
1	LA	O	Speaker driver_Left (+)	
2	PGNDL	G	Power ground_Left	
3	PGNDL	G	Power ground_Left	
4	LB	O	Speaker driver_Left (-)	
5	PVDDL	P	Power supply_Left	
6	MUTE#	I	Mute(low active)	Internal pull-up
7	AVDD	P	Analog power supply	
8	INL	I	Single-ended audio input_Left	
9	N.C.	x	No connection	
10	VDC	I	Full scale level for gain control section	Internal pull-up
11	VOLUME	I	DC voltage for gain setting	Internal pull-up
12	N.C.	x	No connection	
13	N.C.	x	No connection	
14	VREF	I	AVDD/2 reference voltage_Right	
15	N.C.	x	No connection	
16	N.C.	x	No connection	
17	INR	I	Single-ended audio input_Right	
18	AGND	G	Analog power ground	
19	SD#	I	Shutdown(low active)	Internal pull-down
20	PVDDR	P	Power supply_Right	
21	RB	O	Speaker driver_Right (-)	
22	PGNDR	G	Power ground_Right	
23	PGNDR	G	Power ground_Right	
24	RA	O	Speaker driver_Right (+)	

Functional Block Diagram



Available Package

Package Type	Device No.	θ ja(℃/W)	θ jc(℃/W)
SSOP-24	AD52655	90	17

Note 1: θ ja is measured on a room temperature (T_A=25 ℃), 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

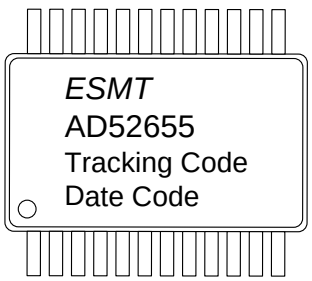
AD52655

Line 1 : LOGO

Line 2 : Product no.

Line 3 : Tracking Code

Line 4 : Date Code



Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
AVDD	Power supply for lower power analog circuits	3.0	5.5	V
PVDDL(R)	Power supply for loudspeaker driver	3.0	5.5	V
	Input voltage	-0.3	AVDD	V
T_{stg}	Storage temperature	-65	150	^{o}C
T_a	Ambient operating temperature	0	70	^{o}C

Recommended Operating Conditions

SYMBOL	PARAMETER	TYP	UNIT
AVDD	Power supply for lower power analog cells	3.0~5.0	V
PVDDL(R)	Power supply for Driver Stage	3.0~5.0	V
V_{IH}	High-Level Input Voltage	1.2	V
V_{IL}	Low-Level Input Voltage	0.4	V
T_a	Ambient Operating Temperature	0~70	^{o}C

General Electrical Characteristics

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
I_{SD}	Supply current during Shut-down mode	AVDD=PVDDR(L)=VDD VDD=5.0V SD#=0.4V			1	μA
I_{MUTE}	Supply current during MUTE mode	AVDD=PVDDR(L)=VDD VDD=5.0V SD#=VDD, MUTE#=0.4V		2.5	4	mA
I_Q	Supply current during operating mode	AVDD=PVDDR(L)=VDD VDD=5.0V SD#=MUTE#=VDD, no load		10	15	mA
V_{offset}	Output offset voltage	Input ac grounded,		10	50	mV
	Junction temperature for driver shutdown			160		^{o}C
	Temperature hysteresis for recovery from shutdown			125		^{o}C
f_{sw}	Switching frequency	AVDD=3.0V~5.0V	200	250	330	kHz
I_{SC}	Loudspeaker short-circuit detect resistance	PVDDR(L)=5.0V		2.2		A

Electrical Characteristics and Specifications of Loudspeaker Driver

- AVDD=PVDDL=PVDDR=VDD Gain=2 V/V, Load=8Ω, f_{in}=1 kHz, T_A=25°C (unless otherwise noted)

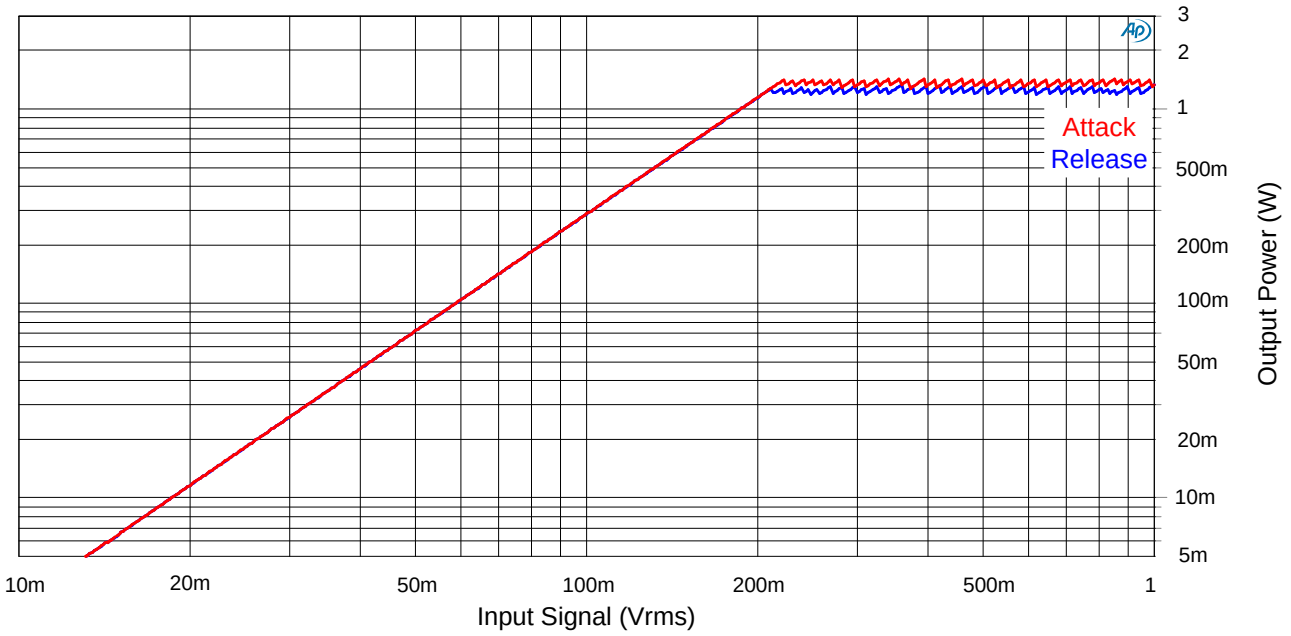
SYMBOL	PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
P_O	RMS Output Power per Channel	VDD=5.0V	THD+N = 1%		1.4		W
		VDD=3.6V	THD+N = 1%		0.7		W
		VDD=3.0V	THD+N = 1%		0.45		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, Po=1.0W			0.1		%
		VDD=3.6V, Po=0.5W			0.2		%
		VDD=3.0V, Po=0.3W			0.5		%
SNR	Signal to Noise Ratio	VDD=5.0V, Po=1.0W			96		dB
PSRR	Power Supply Rejection Ratio	VDD=5.0V, Gain=6dB, V_{ripple}=200mVpp, Inputs ac grounded with Ci=470nF f=1kHz			-55		dB
Crosstalk	Crosstalk	VDD=5.0V, f_{in}=1kHz			-100		dB
V_n	Output integrated noise (A-weighted)	VDD=5.0V f_{in}=20Hz ~ 20kHz			80		μV

- AVDD=PVDDL=PVDDR=VDD Gain=2 V/V, Load=4Ω, f_{in}=1 kHz, T_A=25°C (unless otherwise noted)

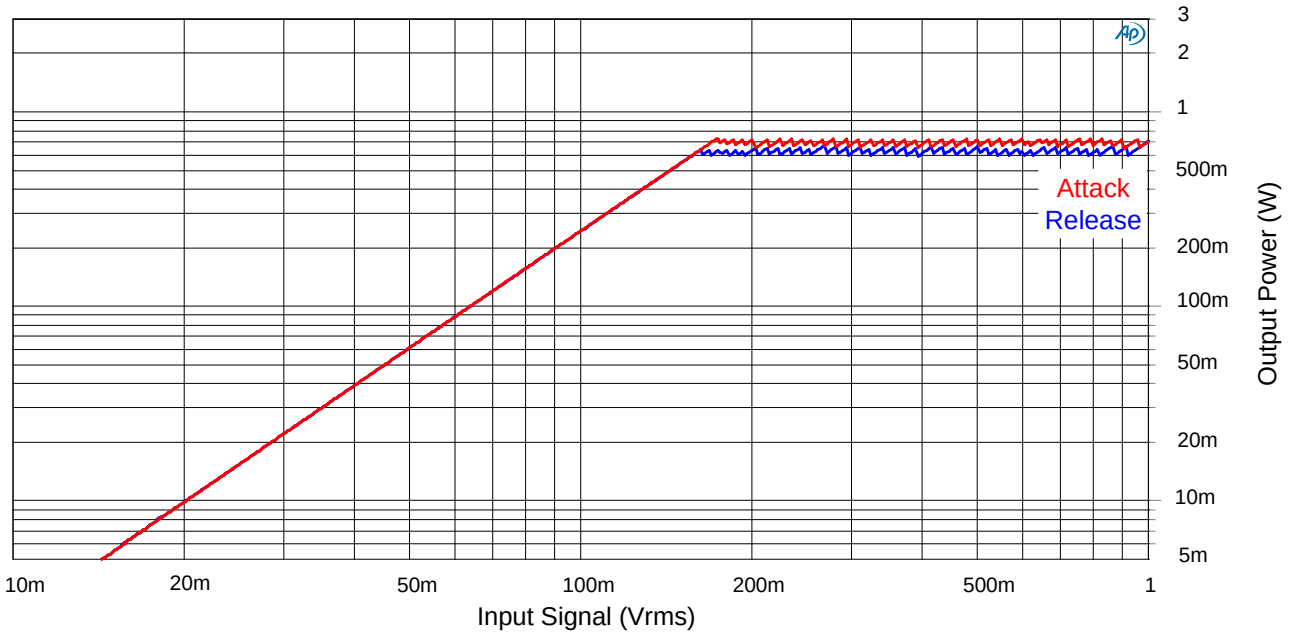
SYMBOL	PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
P_O	RMS Output Power per Channel	VDD=5.0V	THD+N = 1%		2.45		W
		VDD=3.6V	THD+N = 1%		1.2		W
		VDD=3.0V	THD+N = 1%		0.8		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, Po=2.0W			0.2		%
		VDD=3.6V, Po=1.0W			0.3		%
		VDD=3.0V, Po=0.6W			0.6		%
SNR	Signal to Noise Ratio	VDD=5.0V, Po=1.8W			96		dB
PSRR	Power Supply Rejection Ratio	VDD=5.0V, Gain=6dB, V_{ripple}=200mVpp, Inputs ac grounded with Ci=470nF f=1kHz			-55		dB
Crosstalk	Crosstalk	VDD=5.0V, f_{in}=1kHz			-100		dB
V_n	Output integrated noise (A-weighted)	VDD=5.0V f_{in}=20Hz ~ 20kHz			80		μV

Typical Characteristics of Loudspeaker Driver

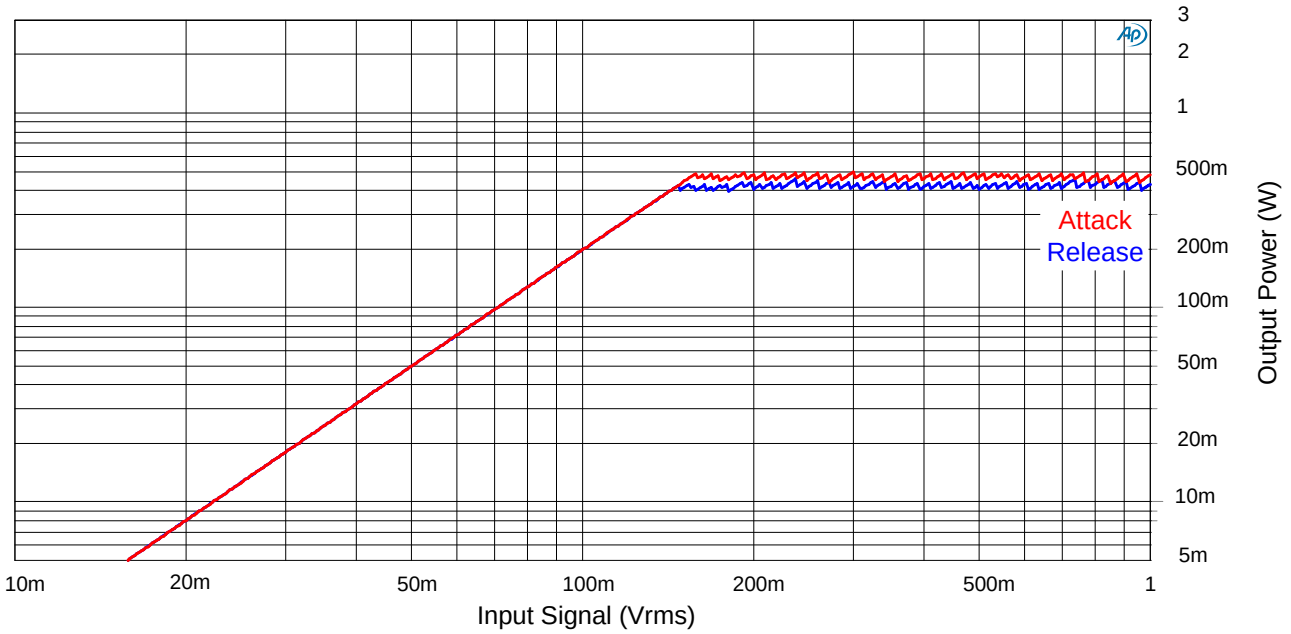
- Input Signal vs. Output Power (5.0V, +24dB, 8Ω)



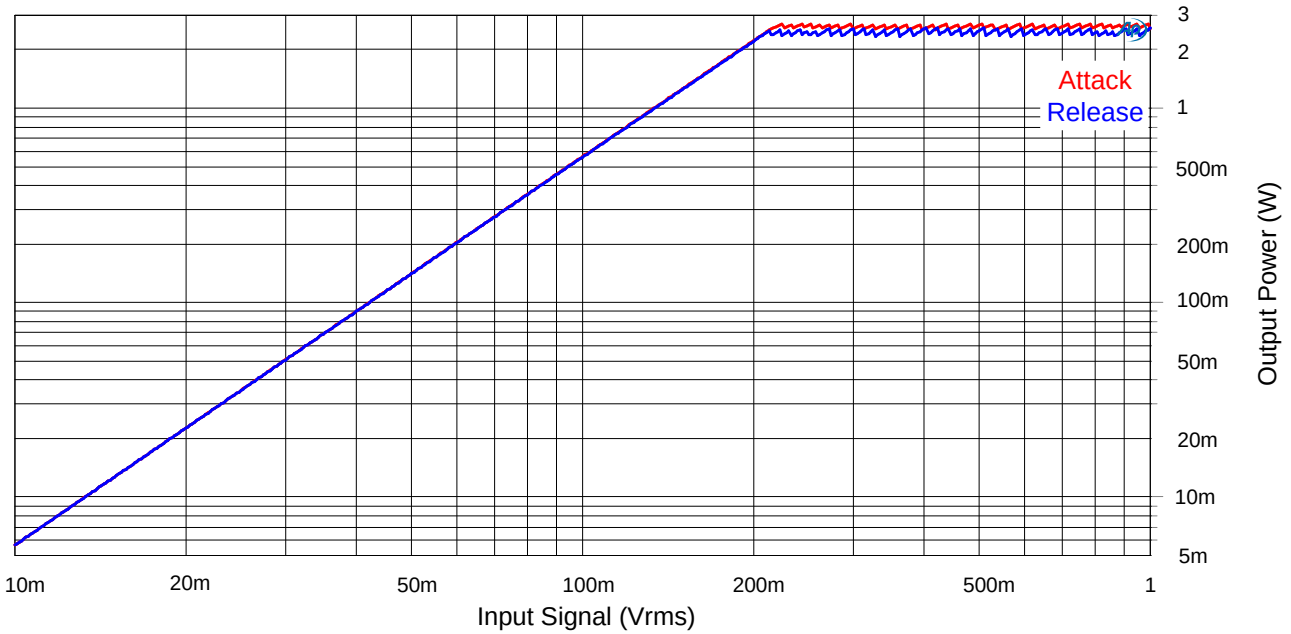
- Input Signal vs. Output Power (3.6V, +24dB, 8Ω)



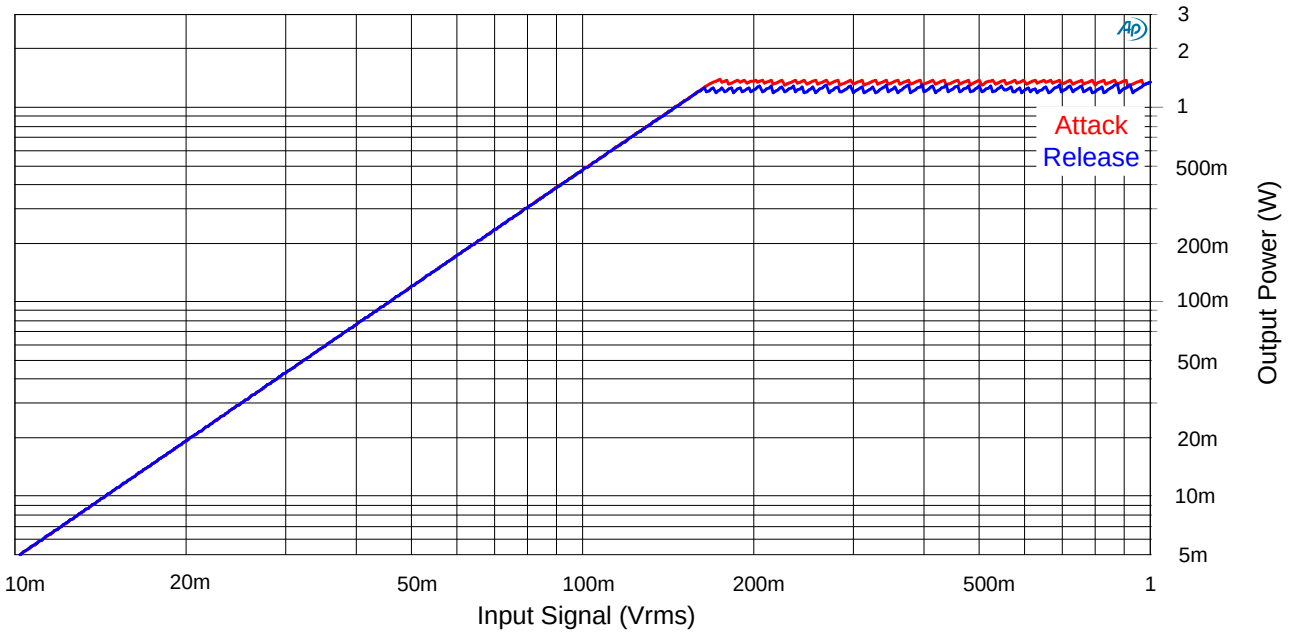
- Input Signal vs. Output Power (3.0V, +24dB, 8Ω)



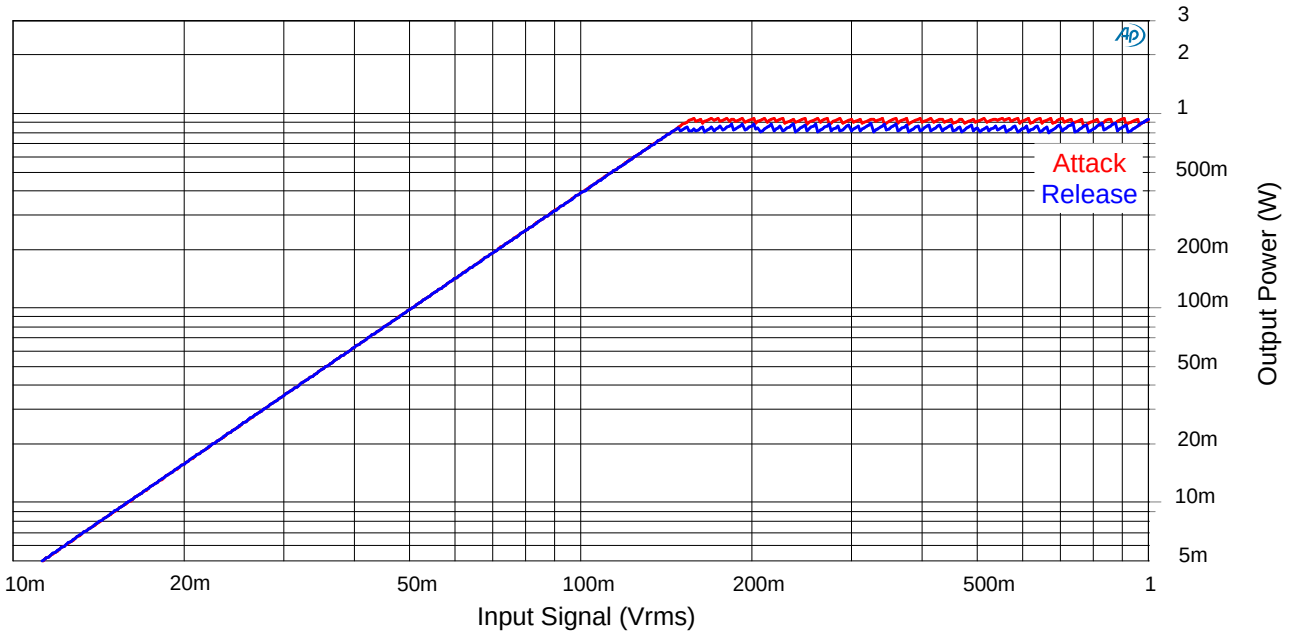
- Input Signal vs. Output Power (5.0V, +24dB, 4Ω)



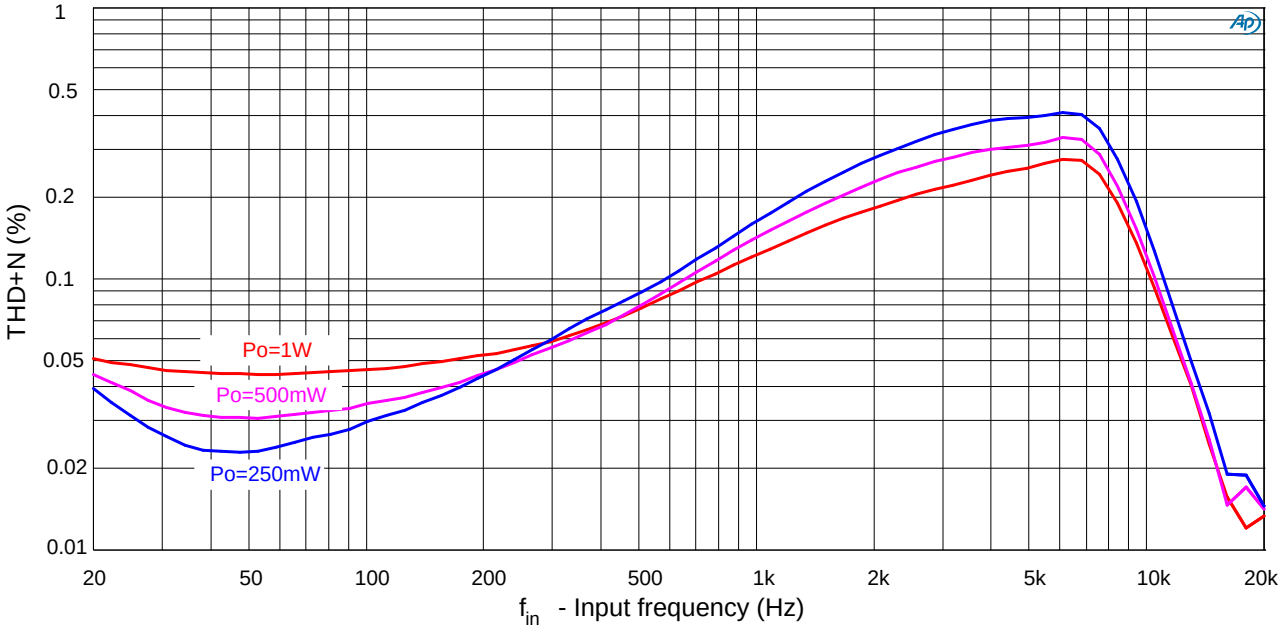
- Input Signal vs. Output Power (3.6V, +24dB, 4Ω)



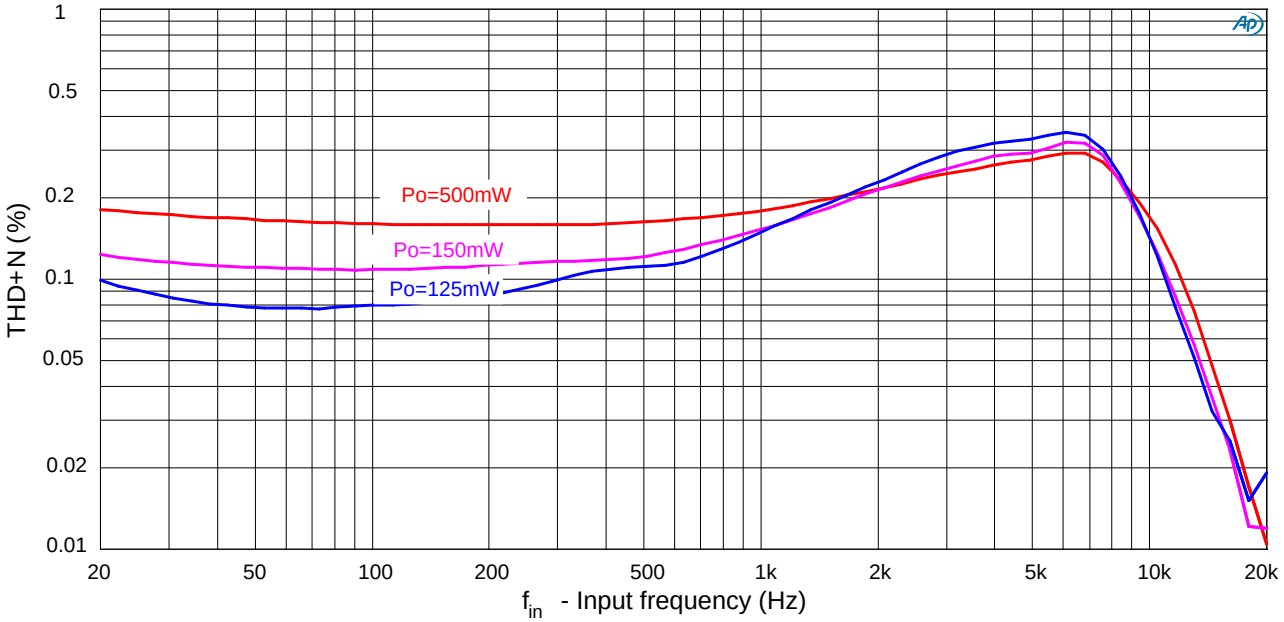
- Input Signal vs. Output Power (3.0V, +24dB, 4Ω)



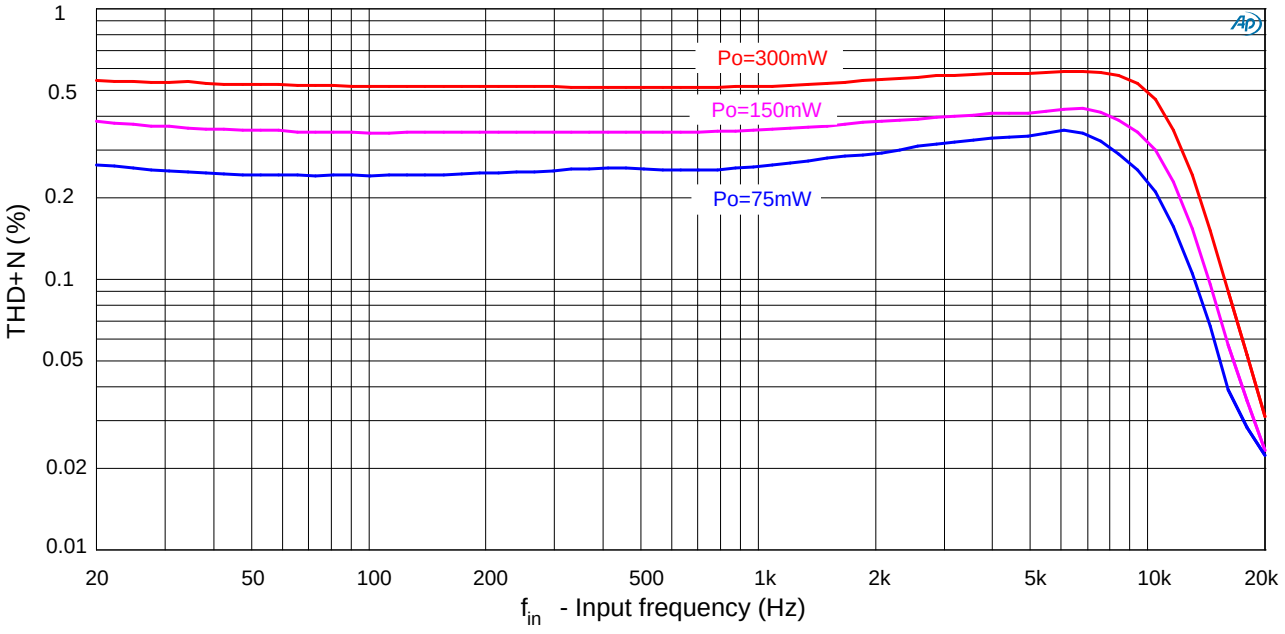
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (5.0V, 8Ω)



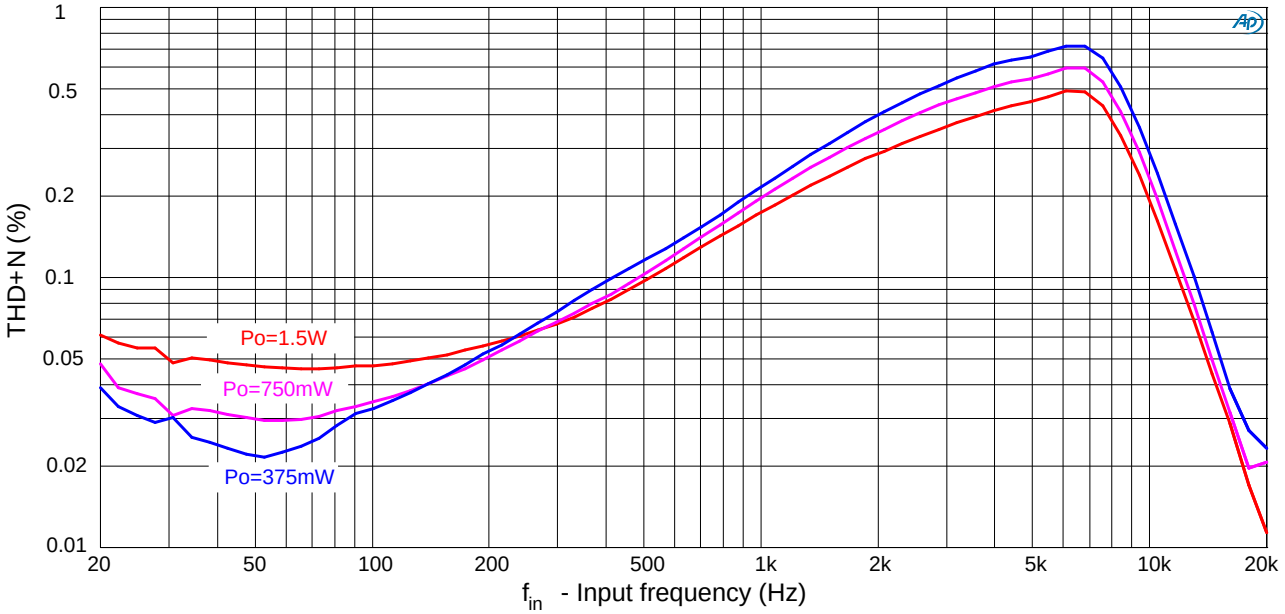
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.6V, 8Ω)



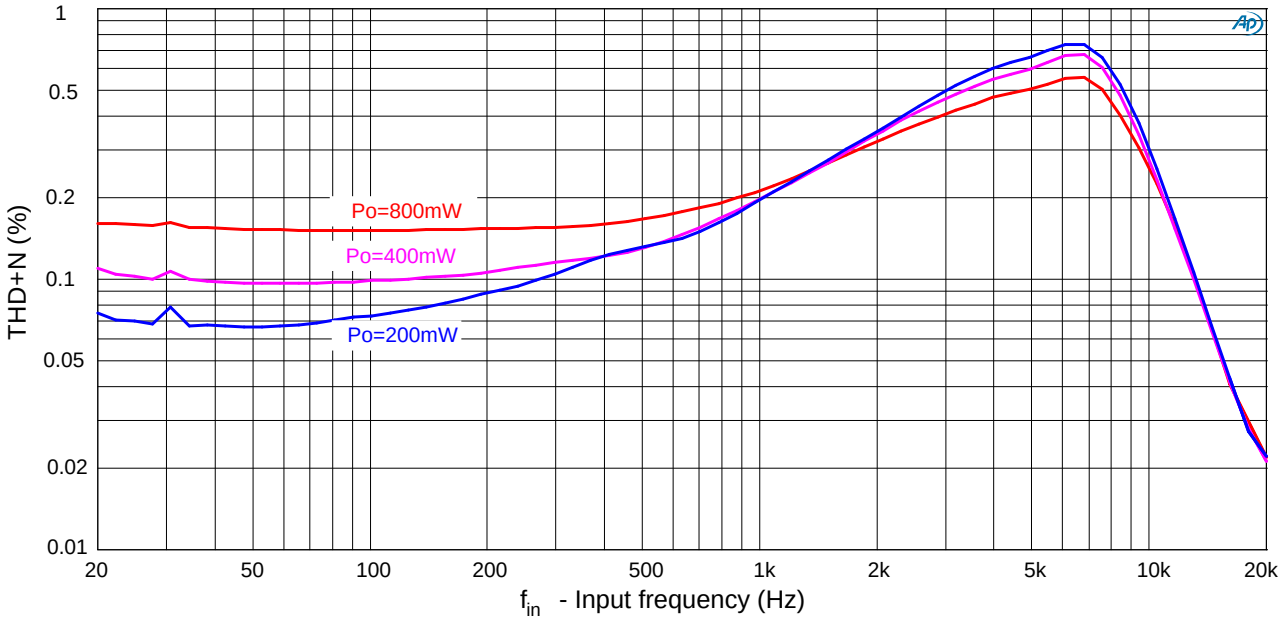
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.0V, 8Ω)



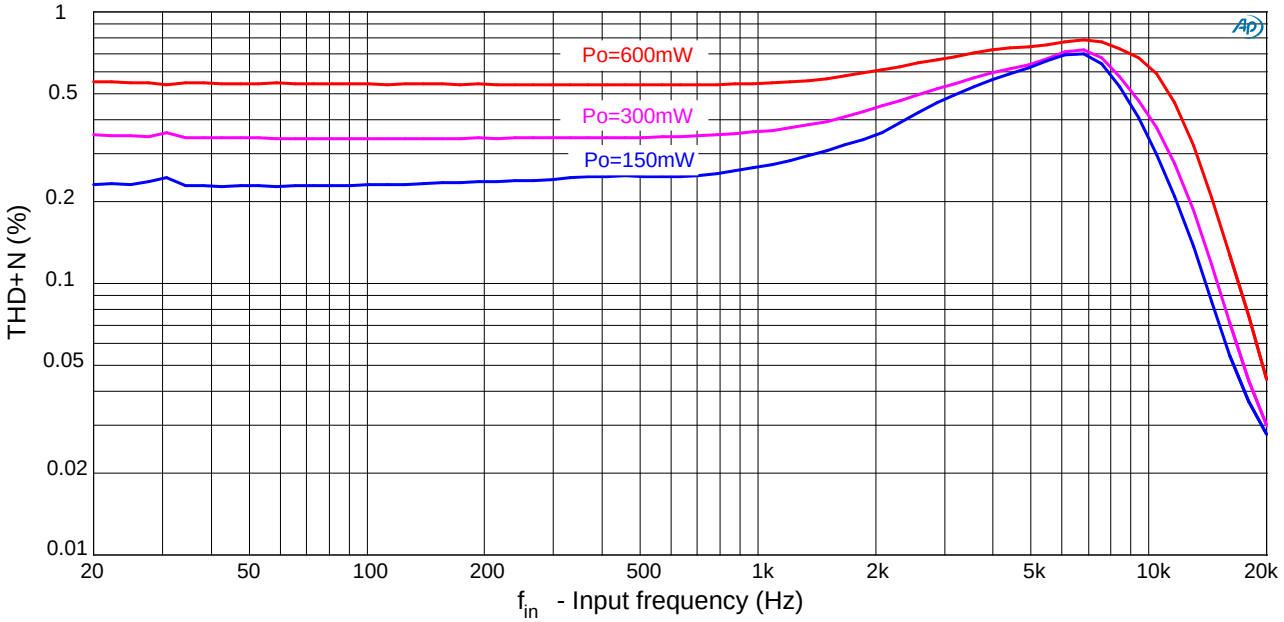
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (5.0V, 4Ω)



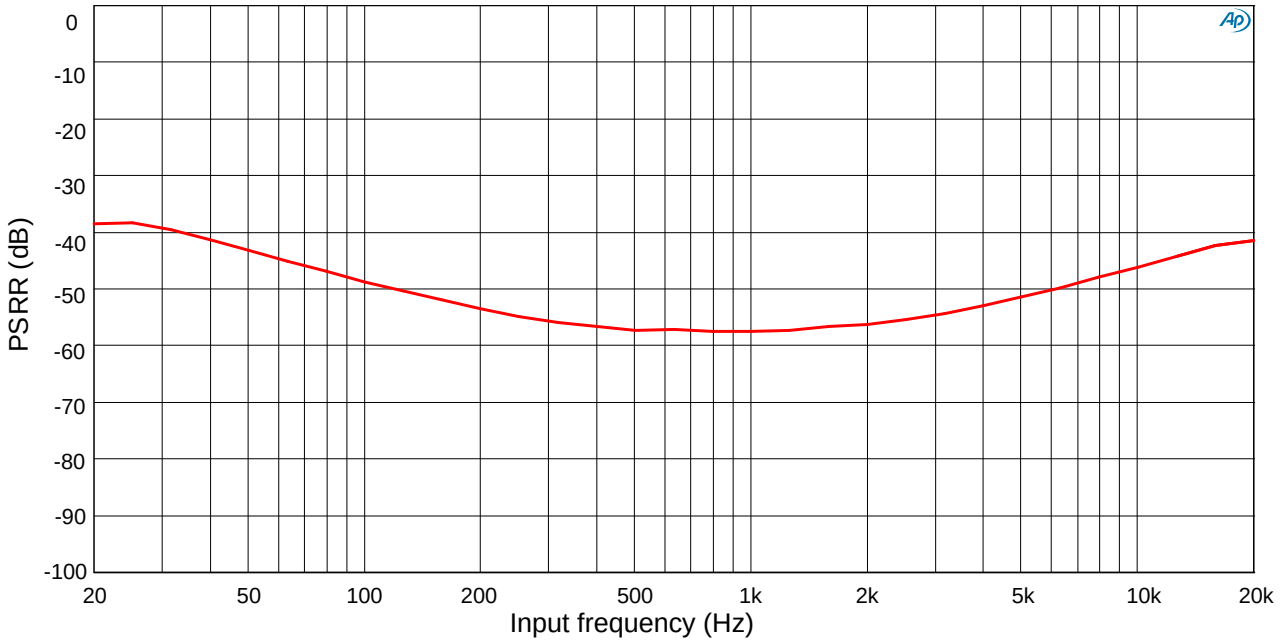
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.6V, 4Ω)



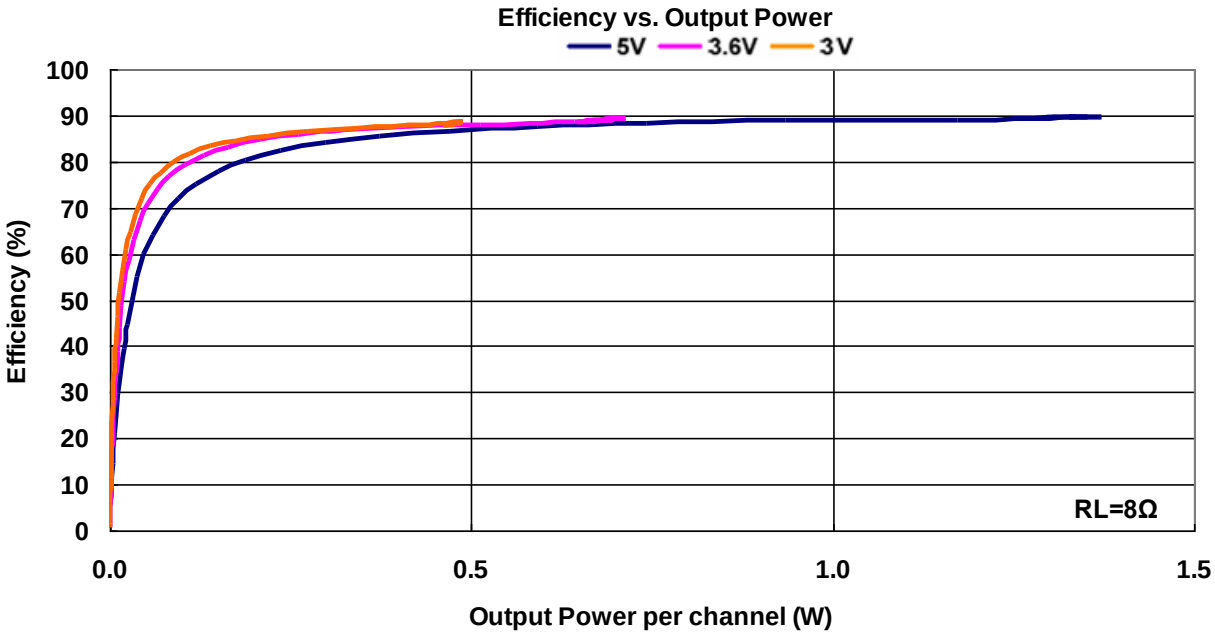
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.0V/4Ω)



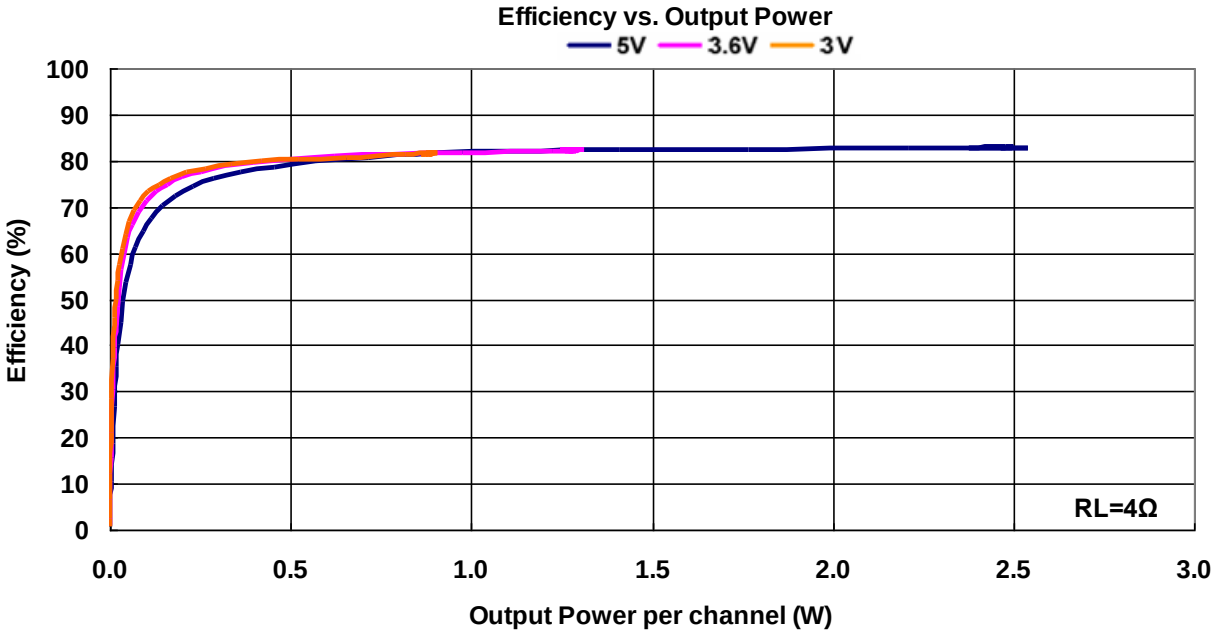
- Power Supply Rejection Ratio vs. Frequency (5V, +6dB)



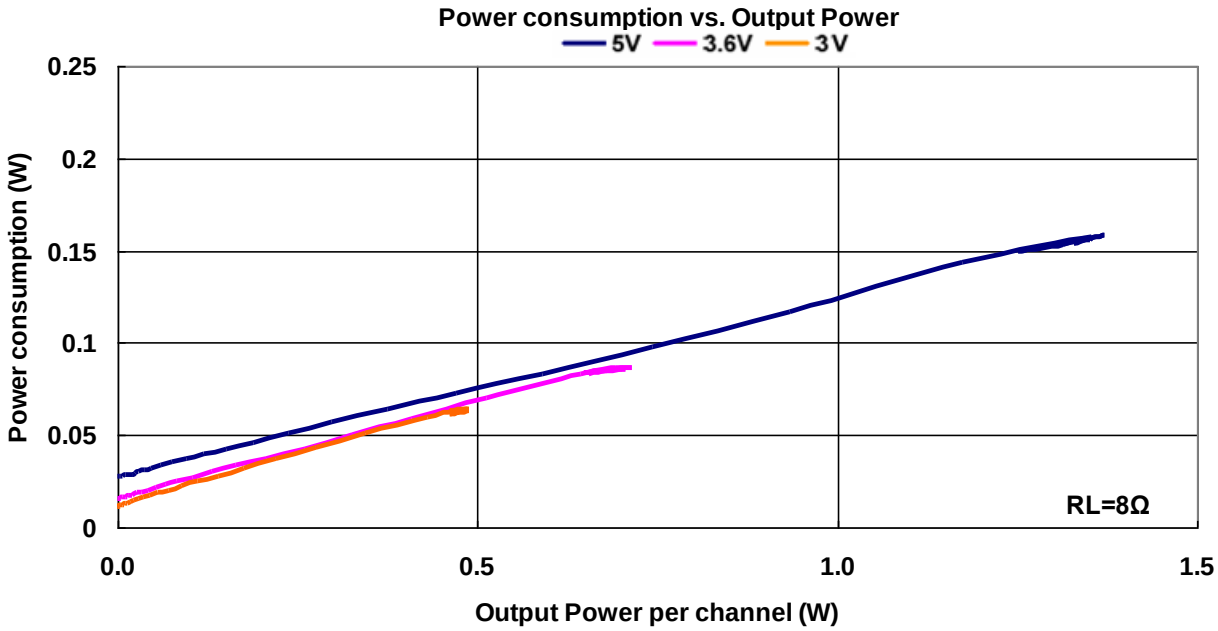
- Efficiency vs. Output Power (8Ω)



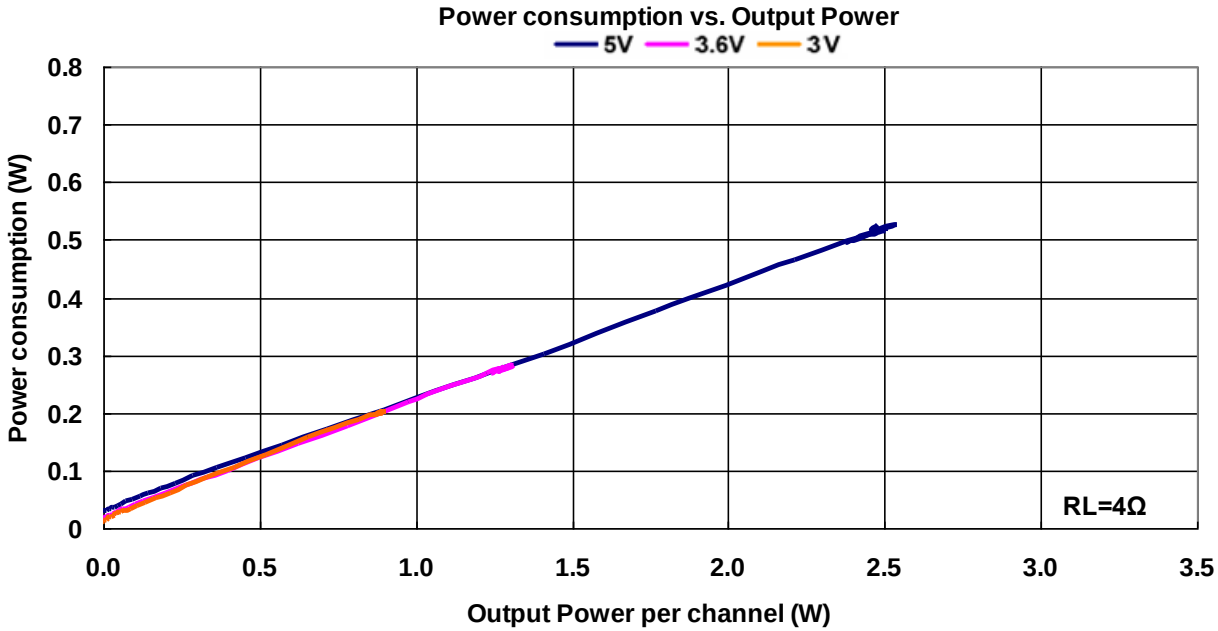
- Efficiency vs. Output Power (4Ω)



- Power Consumption vs. Output Power (8Ω)



- Power Consumption vs. Output Power (4Ω)



Operation Descriptions

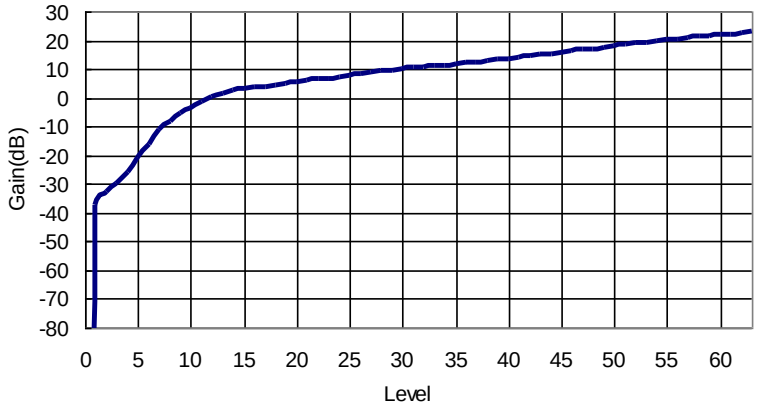
- Volume control

AD52655 is built-in a 64-step DC volume control mode.

(i) DC volume control

The volume level is determined by the voltage ratio of VOLUME to VDC. To avoid volume level oscillation from one to another, the hysteresis voltage between the nearby volume levels is designed in AD52655. For example, the volume level changes from LEVEL14 to LEVEL15 when DC voltage applied on VOLUME increases to 24% of VDC. And, the volume level drops from LEVEL15 to LEVEL14 when DC voltage applied on VOLUME decreases to 22.7% of VDC. The hysteresis voltage is about 60mV when VDC=5V. More volume levels and its DC voltage ratio applied on VOLUME, including volume up and down, are listed in following table.

LEVEL	GAIN (dB)	DC (%VDC)	LEVEL	GAIN (dB)	DC (%VDC)	LEVEL	GAIN (dB)	DC (%VDC)	LEVEL	GAIN (dB)	DC (%VDC)
Mute	-75.0	<0.4	17	4.7	24.4 ~ 26.8	34	12.0	49.4 ~ 51.9	51	19.0	74.5 ~ 76.7
1	-38.0	0.4 ~ 3.0	18	5.1	26.0 ~ 28.3	35	12.3	50.9 ~ 53.4	52	19.5	75.9 ~ 78.2
2	-32.8	2.0 ~ 4.5	19	5.6	27.4 ~ 29.7	36	12.7	52.4 ~ 54.9	53	19.9	77.4 ~ 79.7
3	-29.8	3.4 ~ 6.0	20	6.1	28.8 ~ 31.2	37	13.0	53.8 ~ 56.4	54	20.3	78.9 ~ 81.2
4	-25.7	5.0 ~ 7.5	21	6.5	30.3 ~ 32.7	38	13.4	55.4 ~ 57.8	55	20.7	80.5 ~ 82.7
5	-20.4	642 ~ 9.0	22	7.0	31.8 ~ 34.2	39	13.8	56.8 ~ 59.3	56	21.1	82.0 ~ 84.2
6	-15.6	7.8 ~ 10.4	23	7.5	33.2 ~ 35.6	40	14.2	58.3 ~ 60.8	57	21.5	83.6 ~ 85.7
7	-10.5	9.4 ~ 11.9	24	8.0	34.6 ~ 37.1	41	14.7	59.6 ~ 62.3	58	22.0	85.0 ~ 87.2
8	-7.5	10.9 ~ 13.4	25	8.5	36.2 ~ 38.6	42	15.1	61.2 ~ 63.7	59	22.3	86.5 ~ 88.6
9	-5.0	12.3 ~ 14.8	26	9.0	37.6 ~ 40.1	43	15.5	62.6 ~ 65.2	60	22.6	88.0 ~ 90.1
10	-2.8	13.8 ~ 16.3	27	9.4	39.1 ~ 41.6	44	16.0	64.1 ~ 66.7	61	22.9	89.5 ~ 91.6
11	-0.7	15.4 ~ 17.8	28	9.8	40.6 ~ 43.0	45	16.5	65.6 ~ 68.2	62	23.3	91.0 ~ 93.0
12	0.7	16.9 ~ 19.4	29	10.2	42.1 ~ 44.5	46	16.9	67.1 ~ 69.6	63	23.6	92.4 ~ 94.6
13	2.1	18.4 ~ 20.8	30	10.6	43.6 ~ 46.0	47	17.3	68.5 ~ 71.0	64	24.0	93.9 ~ 100
14	3.3	19.9 ~ 22.3	31	11.0	45.1 ~ 47.5	48	17.7	70.0 ~ 72.4			
15	3.7	21.3 ~ 23.8	32	11.4	46.4 ~ 49.0	49	18.1	71.5 ~ 73.9			
16	4.2	22.9 ~ 25.3	33	11.7	47.9 ~ 50.4	50	18.6	73.0 ~ 75.3			



- Power limit

  The power limit circuit built-in AD52655 is used to keep the power amplifier performs high quality audio into speakers and to prevent the speakers from damage when higher volume level is selected.

- Shut-down control (SD#)

  During shutdown mode, means SD#=0, AD52655 ceases all internal circuits To avoid annoying pop during power on/off, well SD# control, like with a power ready signal, is suggested. And, due to its internal pull-down, there is no pop if let the SD# floating.

- Mute control (MUTE#)

  Like SD# mode, AD52655 ceases output driver, but keep part of internal circuit still working. That could provide quick disable and enable power amplifier.

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

  AD52655 has built-in over-temperature, overload and voltage detectors.

  (i) If the internal junction temperature is higher than 160^{o}C, the outputs of loudspeaker drivers will be disabled and at low state. The temperature hysteresis for AD52655 to return to normal operation is about 35^{o}C. The variation of protected temperature is around 10%.

  (ii) AD52655 has built-in overload protection for both right and left channel. To protect loudspeaker drivers from over-current damage when the wires of loudspeaker are shorted to one another, GND or VDD, circuits for the detection of output loading are built in the AD52655. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. Once one of right and left channel is overloaded, both loudspeaker drivers will be disabled. And, AD52655 will be recovery from overload fault by toggling SD# down to low and back to high after removing the short.

Application information

- Input capacitors (C_{in})

  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 (a). And, the resistance of input resistors is different at different volume gain. But there is 20% variation in input resistance from 20% process variation in actual resistance of the input resistors. Typically, a 0.47μF or 1μF ceramic capacitor is suggested.

$$f_c = \frac{1}{2\pi R_{in} C_{in}} \ (Hz) \quad \cdots\cdots\cdots (a)$$

G(dB)	Rin(Ω)
24	15k
18	28k
12	48k
6	75k

- Capacitor on Vref (C_{Vref})

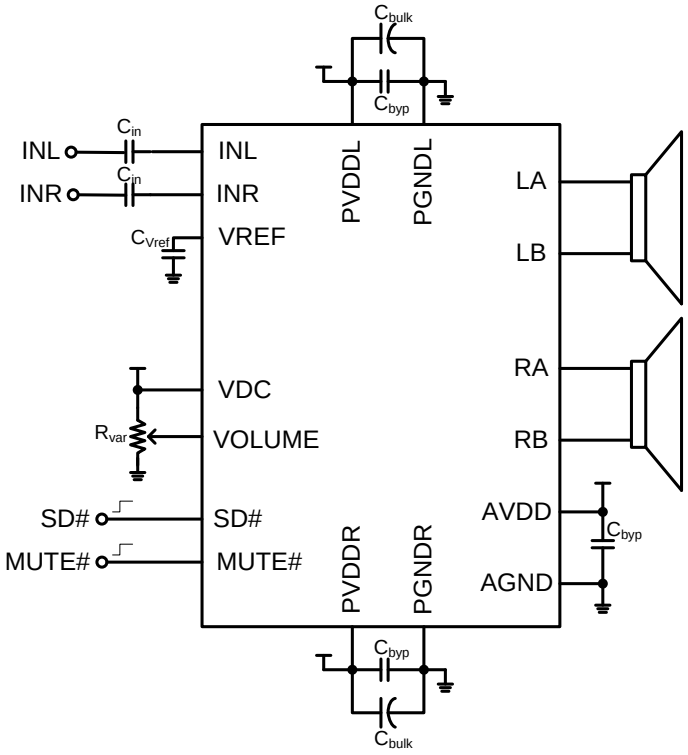
  In order to reduce low-frequency noise produced by power supply, the capacitor (C_{Vref}) on Vref, which is the mid-rail voltage of AVDD, is necessary. It has a good help on PSRR. And, to have less annoying pop, the recommended C_{Vref} is the same with Cin.

- Decoupling capacitor (C_{byp} and C_{bulk})

  Because of the power loss on the trace, which is between the device and decoupling capacitor, the decoupling capacitor should be placed as close as to the device PVDDL (PVDDR) and PGNDL (PGNDR) to reduce any parasitic resistor or inductor between them. And, a low ESR ceramic capacitor (C_{byp}), typically 1μF, is suggested for high frequency transients and as close to AD52655 as possible. For filtering audio band noise signal, a 10μF or greater capacitor (C_{bulk}) (tantalum or electrolytic type) is suggested.

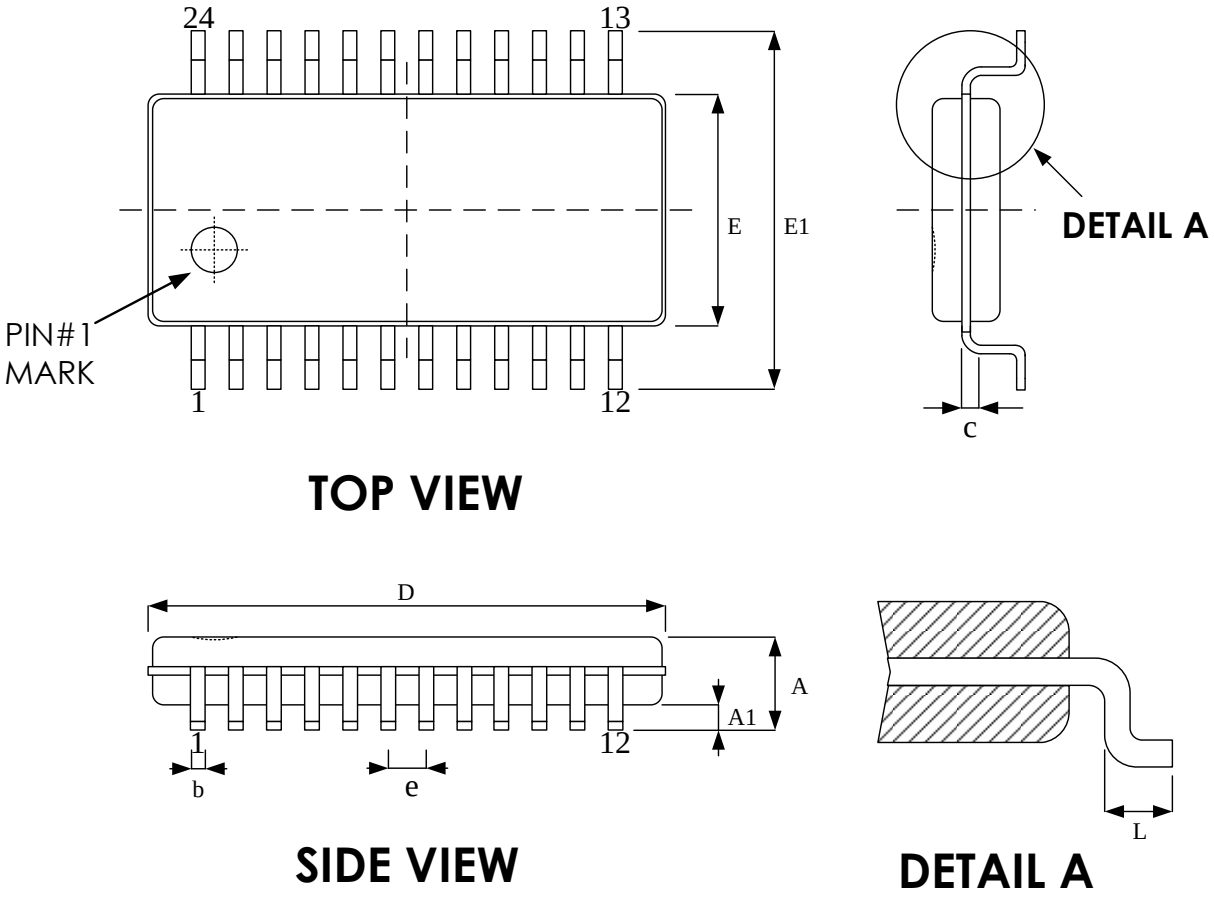
Application Circuit

- Application circuit (DC volume control with external voltage divider)



Package Dimensions

- **SSOP 24 (150mil)**



Symbol	Dimension in mm	
	Min	Max
A	1.35	1.75
A1	0.10	0.25
b	0.20	0.31
c	0.18	0.25
D	8.53	8.74
E	3.80	4.00
E1	5.80	6.20
e	0.635 BSC	
L	0.38	1.27

Revision History

Revision	Date	Description
0.1	2011.03.18	Original
0.2	2011.05.23	1. Modifying Efficiency vs. Output Power 2. Modifying Power Consumption vs. Output Power 3. Modifying the description of Input capacitors (C_{in}) and adding the table of Rin vs. Gain 4. Add Line4 data code information(page3)
0.3	2011.09.09	Revise packing information
1.0	2015.05.07	1.Add T/R packing for ordering information 2.Modify package dimensions 3. Remove preliminary word and modify version to 1.0

Important Notice

The contents contained in this document are believed to be accurate at the time of publication. ESMT assumes no responsibility for any error in this document, and reserves the right to change the products or specification in this document without notice.

The information contained herein is presented only as a guide or examples for the application of our products. No responsibility is assumed by ESMT for any infringement of patents, copyrights, or other intellectual property rights of third parties which may result from its use. No license, either express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of ESMT or others.

Any semiconductor devices may have inherently a certain rate of failure. To minimize risks associated with customer's application, adequate design and operating safeguards against injury, damage, or loss from such failure, should be provided by the customer when making application designs.

ESMT's products are not authorized for use in critical applications such as, but not limited to, life support devices or system, where failure or abnormal operation may directly affect human lives or cause physical injury or property damage. If products described here are to be used for such kinds of application, purchaser must do its own quality assurance testing appropriate to such applications.