2.6W/CH Stereo Filter-less Class-D Audio Amplifier

Features

- Supply voltage range: 3.0 V to 5.5 V
- 10mA static operation current
- <1uA shutdown current
- 64 step DC volume control from -75 to +24dB
- Overload and thermal protection
- Loudspeaker Output power @ 10% THD+N
  - 1.6W/CH into 8Ω loudspeaker
  - 2.6W/CH into 4Ω loudspeaker

Applications

- Monitor audio
- Portable multimedia devices
- Mobile phone

Description

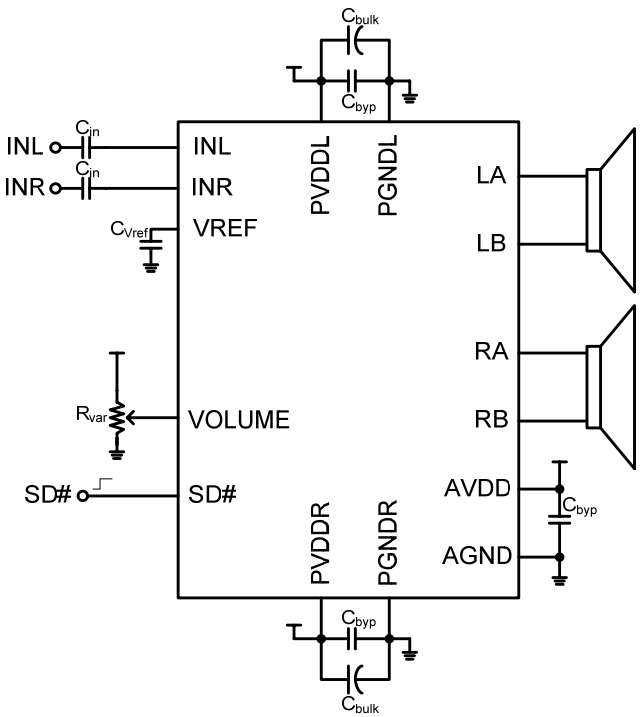
The AD52653 is a stereo, filter-less class-D audio amplifier and has a 64-steps DC volume control. Operating with 5.0V loudspeaker driver supply, it delivers 2.6W/CH power into 4 Ω loudspeaker within 10% THD+N.

The AD52653 is a stereo audio amplifier with high efficiency, which leads to longer battery life, less heat sink, smaller board size, lower system cost, and suitable for the notebook, and portable multimedia devices.

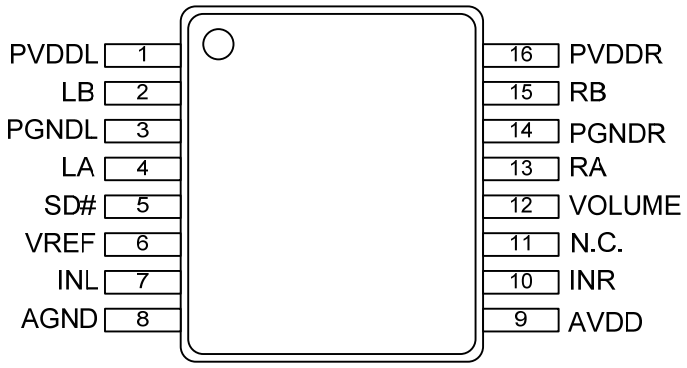
Ordering Information

Product ID	Package	Packing	Comments
AD52653-SA16NAT	SOP-16L (150mil)	56 Units / Tube 100 Tubes / Small Box	Green

Typical Application Circuit



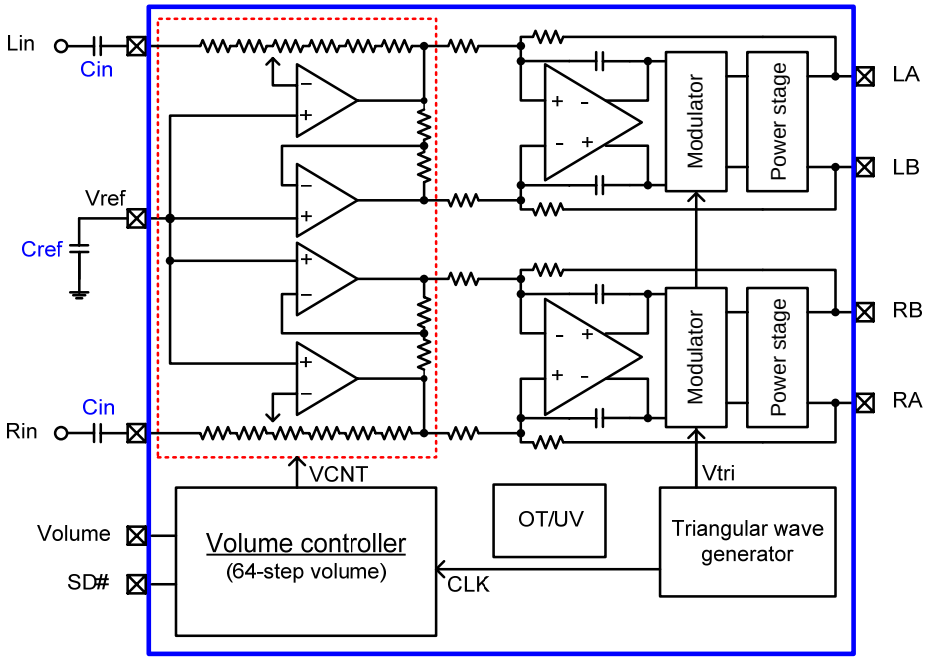
Pin Assignments



Pin Description

NAME		TYP	DESCRIPTION	CHARACTERISTIC
1	PVDDL	P	Power supply_Left	
2	LB	O	Speaker driver_Left (-)	
3	PGNDL	G	Power ground_Left	
4	LA	O	Speaker driver_Left (+)	
5	SD#	I	Shutdown(low active)	Internal pull-up
6	VREF	I	AVDD/2 reference voltage	
7	INL	I	Single-ended audio input_Left	
8	AGND	G	Analog power ground	
9	AVDD	P	Analog power supply	
10	INR	I	Single-ended audio input_Right	
11	N.C.	N.C.	No connection	
12	VOLUME	I	Volume level setting by DC voltage	Do not keep it floating
13	RA	O	Speaker driver_Right (+)	
14	PGNDR	G	Power ground_Right	
15	RB	O	Speaker driver_Right (-)	
16	PVDDR	P	Power supply_Right	

Functional Block Diagram



Available Package

Package Type	Device No.	θ_{ja}(℃/W)	θ_{jc}(℃/W)
SOP-16	AD52653	105	22

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

AD52653

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	6.0	V
PVDDL(R)	Power supply for loudspeaker driver	3.0	6.0	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	3.0~5.5	V
PVDDL(R)	Power supply for Driver Stage	3.0~5.5	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)=5.0V, SD# =0.4V			1	μA
I_Q	Supply current during operating mode	AVDD=PVDDR(L)=SD# =5.0V, no load		5.5		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
Ron	Total R_{DS-ON} resistance	AVDD=PVDDR(L)=5.0V, I=500mA		760		mΩ
I_{SC}	Loudspeaker short-circuit detect current	PVDDR(L) = 5.0V		2.2		A

Electrical Characteristics and Specifications

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

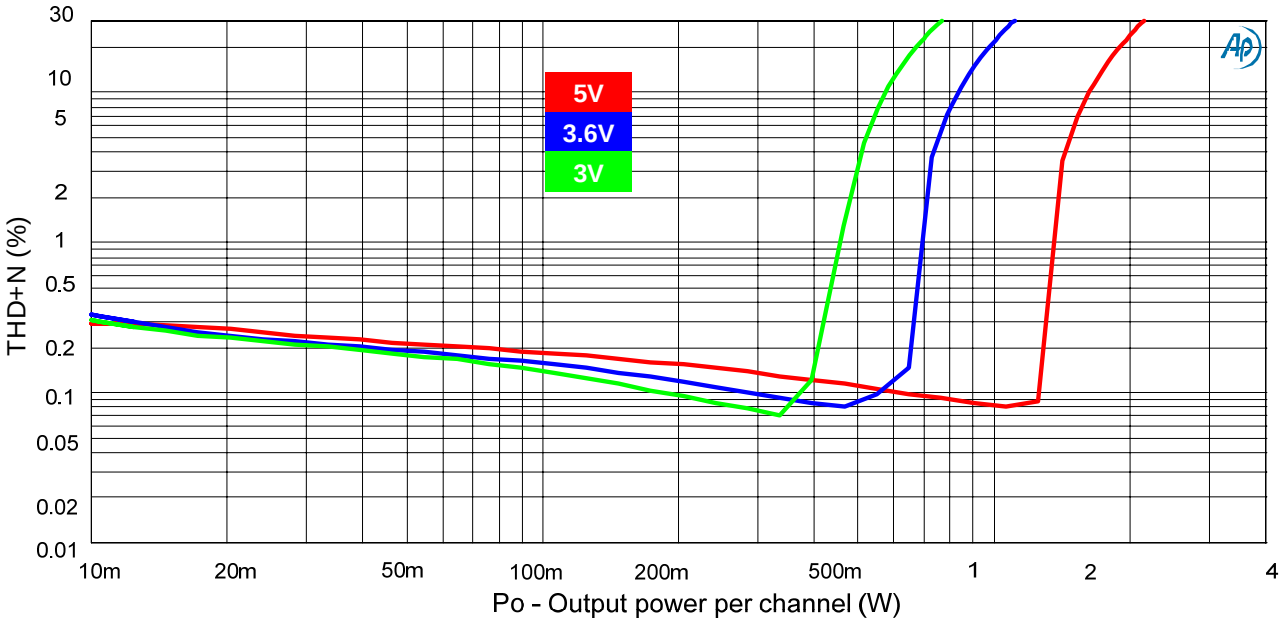
SYMBOL	PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
P_O	RMS Output Power per Channel	VDD=5.0V	THD+N = 10 %		1.6		W
			THD+N = 1 %		1.3		W
		VDD=3.6V	THD+N = 10 %		0.84		W
			THD+N = 1 %		0.7		W
		VDD=3.0V	THD+N = 10 %		0.58		W
			THD+N = 1 %		0.45		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, Po=1.0W			0.08		%
		VDD=3.6V, Po=0.5W			0.08		%
		VDD=3.0V, Po=0.2W			0.10		%
SNR	Signal to Noise Ratio	VDD=5.0V, Po=1.0W			94		dB
PSRR	Power Supply Rejection Ratio	VDD=5.0V, Gain=6dB, Ci=1uF, Cref=1uF, V_{ripple}=200mVpp, inputs ac grounded, f=1kHz			-65		dB
Crosstalk	Crosstalk	VDD=5V, f_{in}=1kHz			-96		dB
V_n	Output integrated noise (A-weighted)	VDD=5.0V, Gain=6dB f_{in}=20Hz ~ 20kHz			40		μV

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

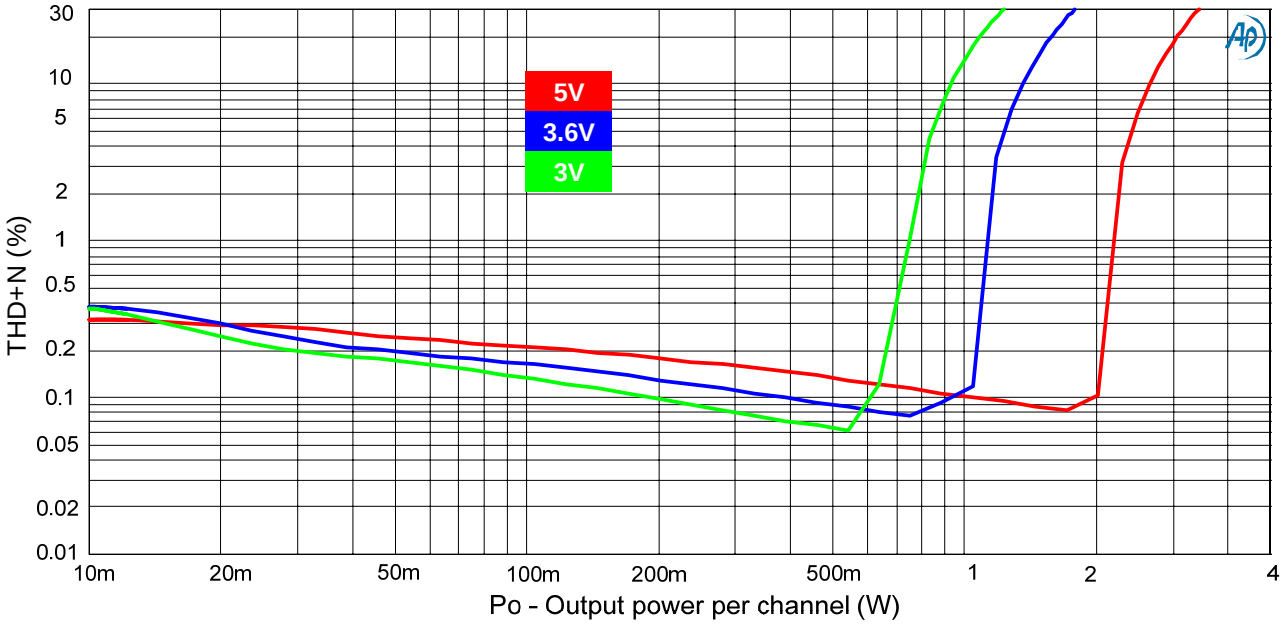
SYMBOL	PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
P_O	RMS Output Power per Channel	VDD=5.0V	THD+N = 10 %		2.6		W
			THD+N = 1 %		2.2		W
		VDD=3.6V	THD+N = 10 %		1.37		W
			THD+N = 1 %		1.14		W
		VDD=3.0V	THD+N = 10 %		0.94		W
			THD+N = 1 %		0.75		W
THD+N	Total Harmonic Distortion plus Noise	VDD=5.0V, Po=1.8W			0.09		%
		VDD=3.6V, Po=0.9W			0.08		%
		VDD=3.0V, Po=0.5W			0.06		%
SNR	Signal to Noise Ratio	VDD=5.0V, Po=1.8W			94		dB
PSRR	Power Supply Rejection Ratio	VDD=5.0V, Gain=6dB, Ci=1uF, Cref=1uF, V_{ripple}=200mVpp, inputs ac grounded, f=1kHz			-65		dB
Crosstalk	Crosstalk	VDD=5V, f_{in}=1kHz			-93		dB
V_n	Output integrated noise (A-weighted)	VDD=5.0V, Gain=6dB f_{in}=20Hz ~ 20kHz			40		μV

Typical Characteristics of Loudspeaker Driver

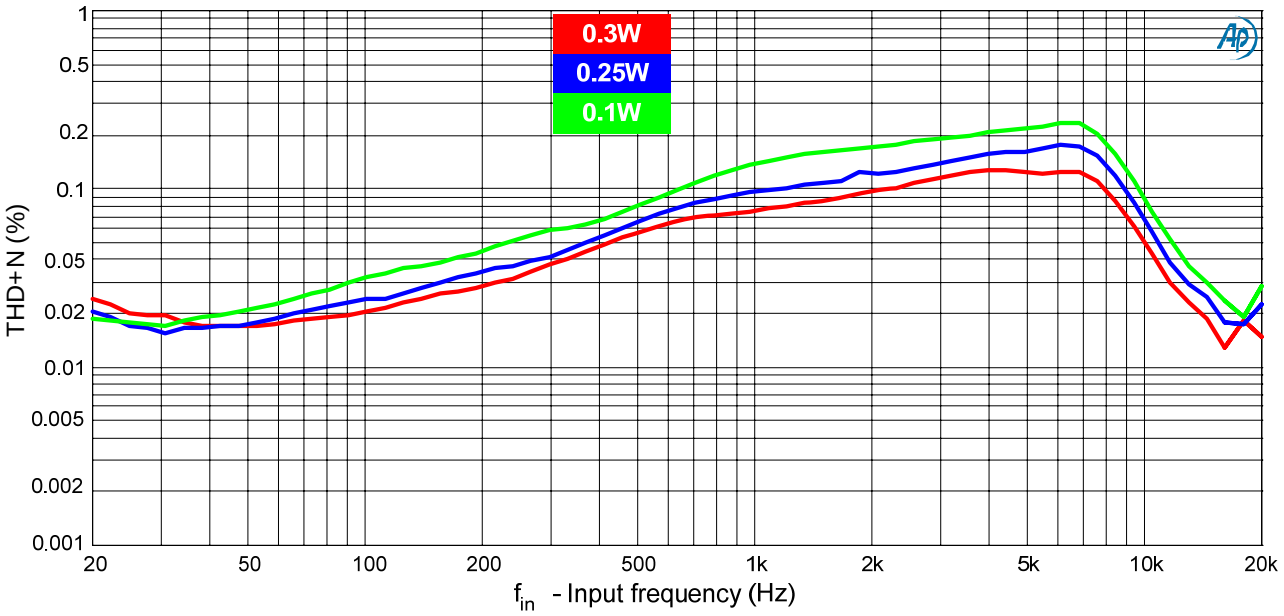
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (+24dB, 8Ω)



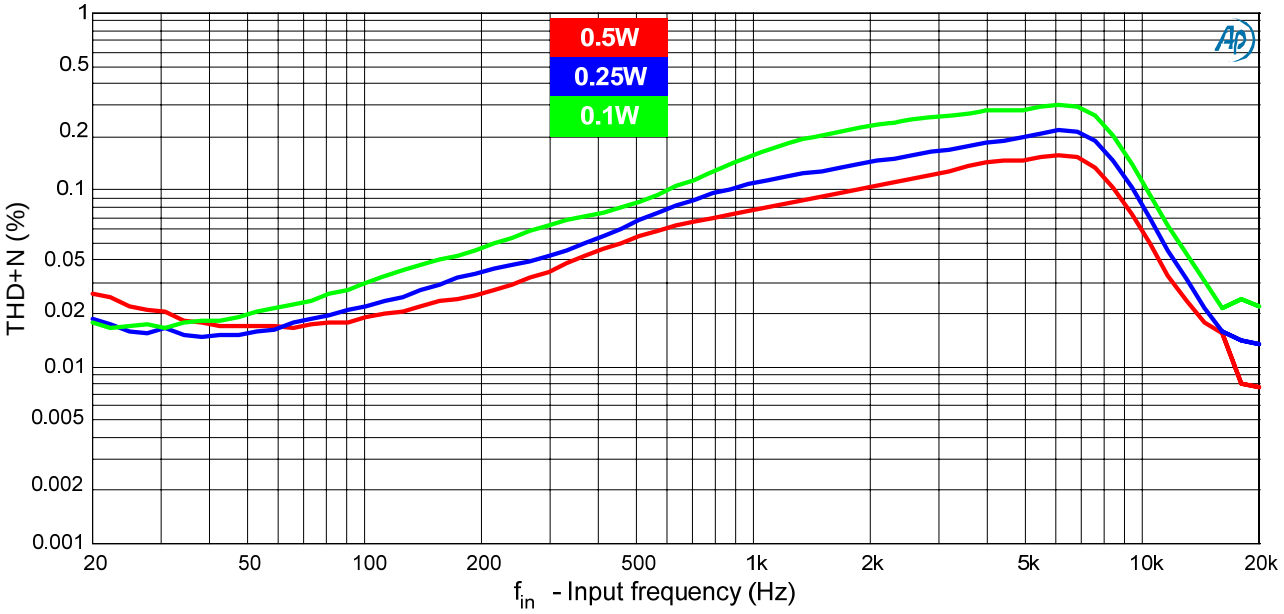
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (+24dB, 4Ω)



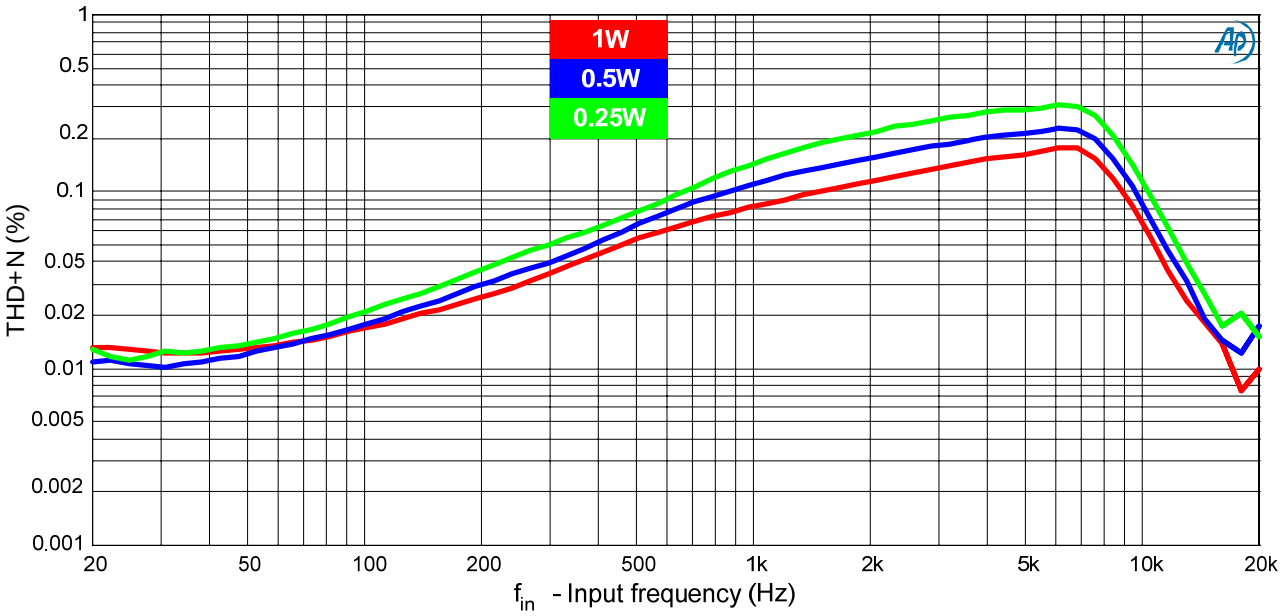
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.0V, 8Ω)



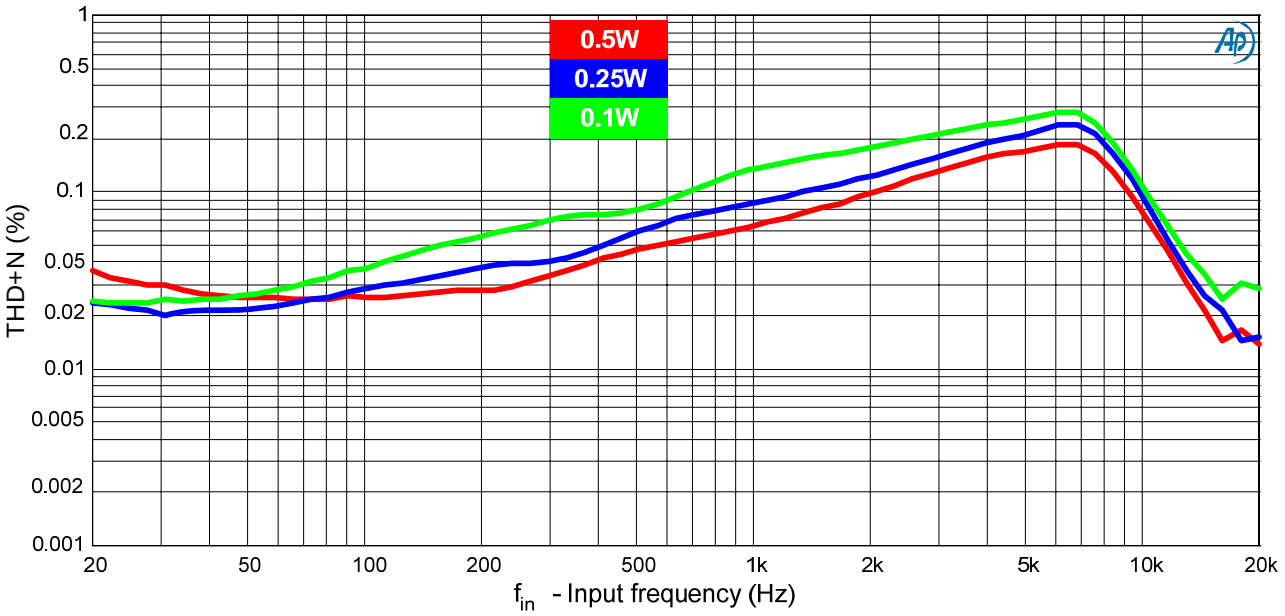
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.6V, 8Ω)



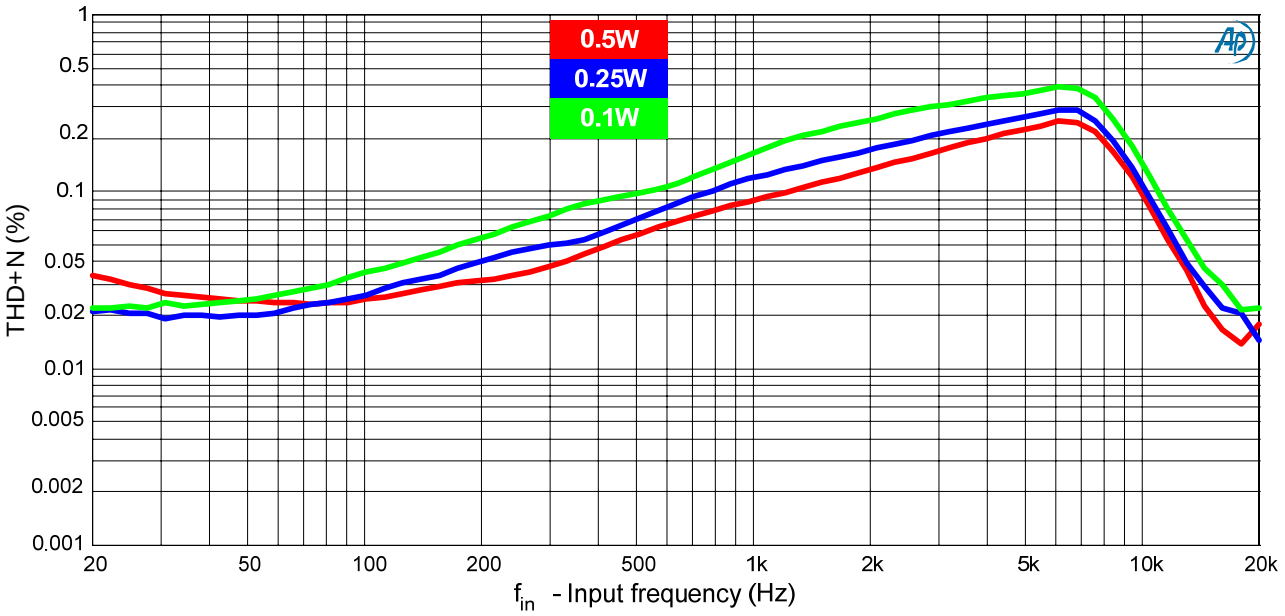
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (5.0V, 8Ω)



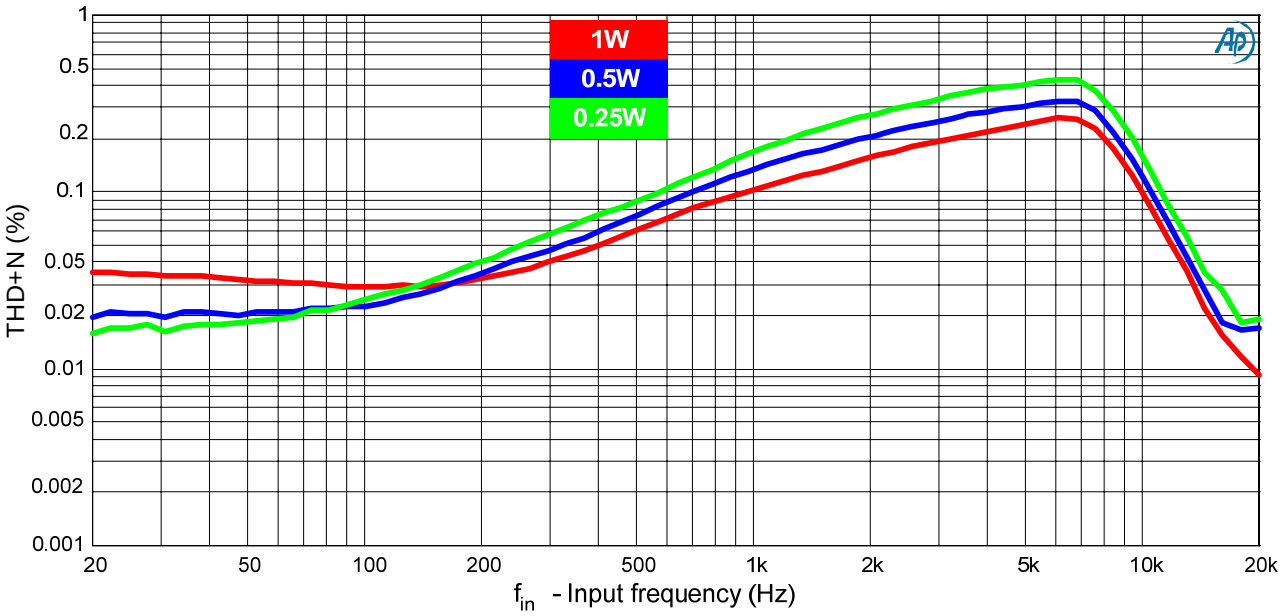
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.0V, 4Ω)



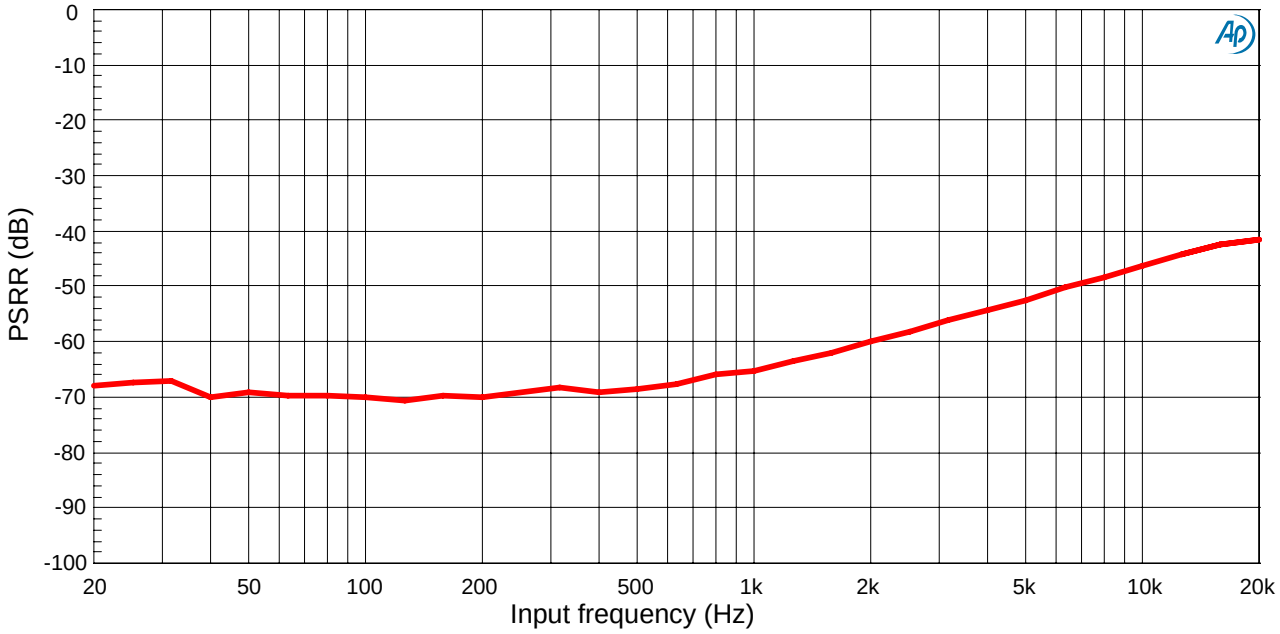
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.6V, 4Ω)



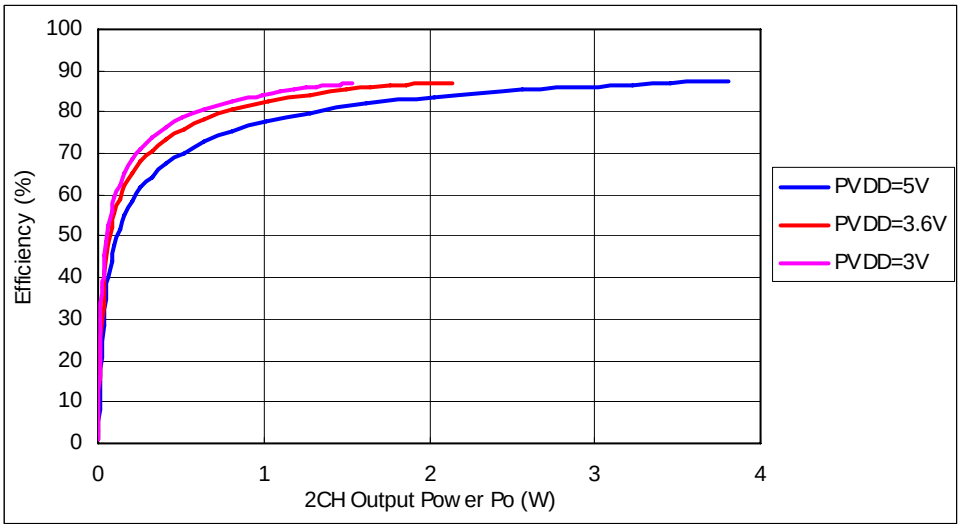
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (5.0V, 4Ω)



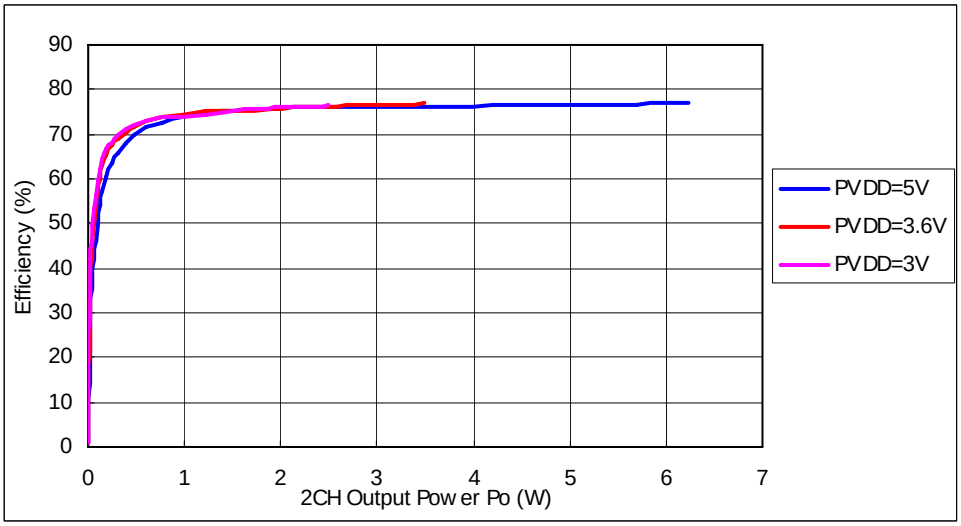
- Power Supply Rejection Ratio vs. Frequency (5V, +6dB)



- Efficiency vs. Output Power (8Ω)



- Efficiency vs. Output Power (4Ω)



Operation Descriptions

- Volume control

AD52653 is built-in a 64-steps DC volume controller.

The volume level is set by the VOLUME DC voltage to AVDD ratio. To avoid volume level oscillation from one to adjacent one, the hysteresis voltage between the nearby volume levels is designed in AD52653. For example, the volume level changes from LEVEL14 to LEVEL15 when DC voltage applied on VOLUME increases to 23.4% of AVDD. And, the volume level drops from LEVEL15 to LEVEL14 when DC voltage applied on VOLUME decreases to 21.6% of VDC. The hysteresis voltage is about 90mV when AVDD=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)	VOLUME (% of AVDD)	Level	Gain (dB)	VOLUME (% of AVDD)	Level	Gain (dB)	VOLUME (% of AVDD)	Level	Gain (dB)	VOLUME (% of AVDD)
0	-76	0 ~ 3.4	16	5.4	23 ~ 26.2	32	11.6	45.4 ~ 48.6	48	18.1	67.8 ~ 70.8
1	-40	3.4 ~ 5.2	17	5.8	24.4 ~ 27.6	33	12.0	46.8 ~ 50	49	18.5	69.2 ~ 72.2
2	-34	3.8~ 6.6	18	6.2	25.8 ~ 29	34	12.4	48.2 ~ 51.4	50	18.9	70.6 ~ 73.6
3	-28	5.2 ~ 8	19	6.6	27.2 ~ 30.4	35	12.8	49.6 ~ 52.8	51	19.3	72 ~ 75
4	-22	6.2~ 9.4	20	7.0	28.6 ~ 31.8	36	13.2	51 ~ 54.2	52	19.7	73.4 ~ 76.4
5	-16	7.6 ~ 10.8	21	7.4	30 ~ 33.2	37	13.6	52.4 ~ 55.6	53	20.1	74.8 ~ 77.8
6	-10	9 ~ 12.2	22	7.8	31.4 ~ 33.2	38	14.0	53.8 ~ 57	54	20.5	76.2 ~ 79.2
7	-7.5	10.4 ~ 13.6	23	8.1	32.8 ~ 36	39	14.4	55.2 ~ 58.4	55	20.9	77.6 ~ 82.2
8	-4.9	11.6 ~ 15	24	8.5	34.2 ~ 37.4	40	14.8	56.6 ~ 59.8	56	21.3	79 ~ 82.2
9	-2.4	13 ~ 16.4	25	8.9	35.6 ~ 38.8	41	15.3	58 ~ 61.2	57	21.7	80.6 ~ 83.6
10	0.1	14.4 ~ 17.8	26	9.3	37 ~ 40.2	42	15.7	59.4 ~ 62.2	58	22.1	82 ~ 85
11	1.6	15.8 ~ 19.2	27	9.7	38.4 ~ 41.6	43	16.1	60.8 ~ 63.8	59	22.5	83.6 ~ 86.4
12	3.2	17.4 ~ 20.6	28	10.1	39.8 ~ 43	44	16.5	62.2 ~ 65.2	60	22.9	85 ~87.8
13	4.1	18.8 ~ 22	29	10.5	41.2 ~ 44.4	45	16.9	63.6 ~ 66.6	61	23.3	86.4 ~ 89.2
14	4.6	20.2 ~ 23.4	30	10.8	42.6 ~ 45.8	46	17.3	65 ~ 68	62	23.7	87.6 ~ 90.6
15	5.0	21.6 ~ 24.8	31	11.2	44 ~ 47.2	47	17.7	66.4 ~ 69.4	63	24.0	> 90.6

- Shut-down control (SD#)

During shutdown mode, means SD#=0, AD52653 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-up, there is no pop if let the SD# floating.

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

  AD52653 has built-in over-temperature, overload and voltage detectors.

  (i) If the internal junction temperature is higher than 160°C, the outputs of loudspeaker drivers will be disabled and at low state. The temperature hysteresis for AD52653 to return to normal operation is about 35°C. The variation of protected temperature is around 10%.

  (ii) AD52653 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, VDD or GND, circuits for the detection of output loading are built in the AD52653. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. Once both loudspeaker drivers will be disabled due to overload, toggle AD52653 SD# down to low and back to high to wake-up AD52653.

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 resistances of input resistors are different at different volume gains. Typically, R_{in} is 38kΩ during maximum 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.

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

Gain (dB)	Rin (ohm)
24	38k
18	68k
12	110k
6	158k

- Capacitor on Vref (C_{Vref})

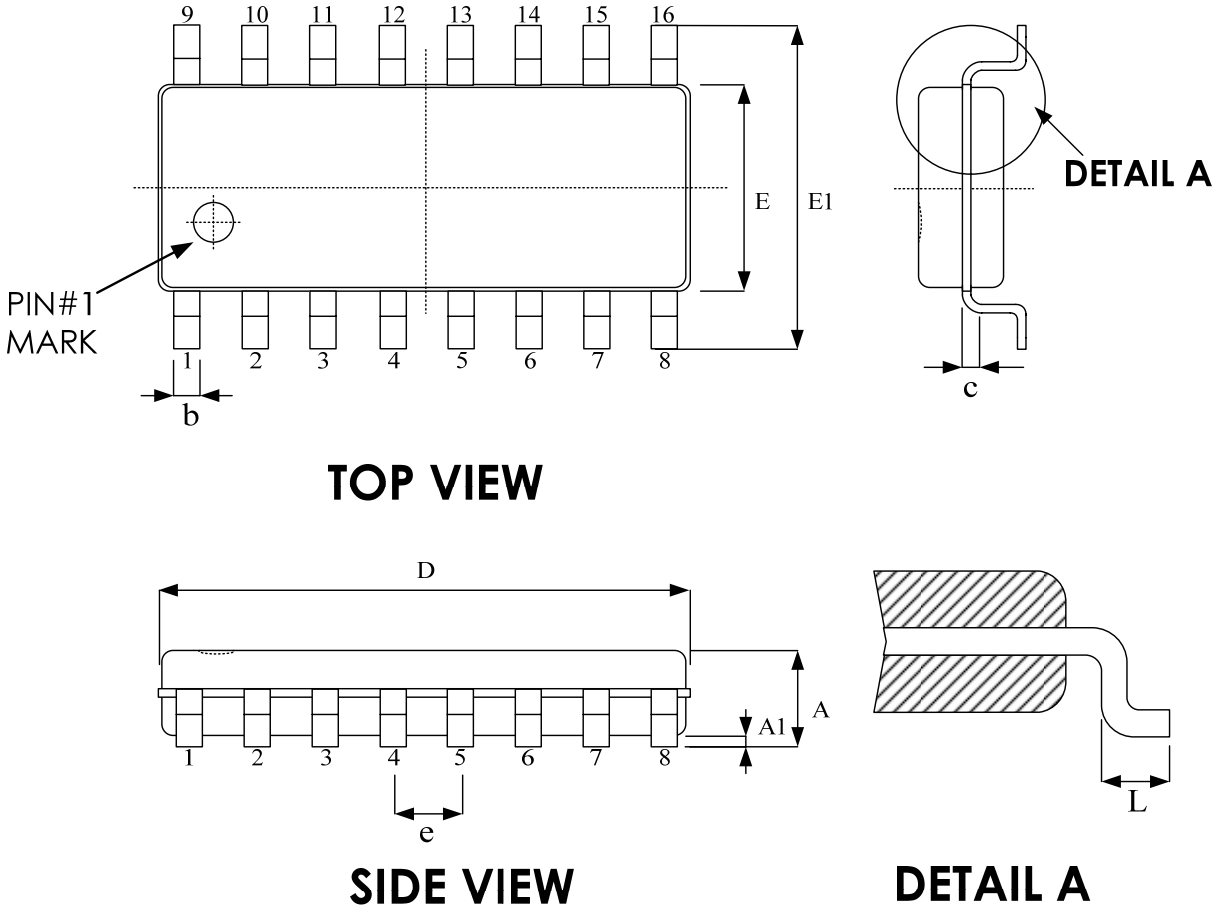
  In order to reduce low-frequency noise produced by power supply, the capacitor (C_{Vref}) on Vref, which is the mid-rail voltage of AVDD, is necessary. It is also good for PSRR. And, to have less annoying pop, the recommended C_{Vref} is the same with Cin.

- 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 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 AD52653 as possible. For filtering audio band noise signal, a 10μF or greater capacitor (C_{bulk}) (tantalum or electrolytic type) is suggested.

Package Dimensions

- **SOP 16 (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	9.80	10.01
E	3.81	3.99
E1	5.79	6.20
e	1.27 BSC	
L	0.41	1.27

Revision History

Revision	Date	Description
0.1	2012.07.04	Original

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.