

AS3561

Class-H Stereo Headphone Amplifier

General Description

The AS3561 is a Class-H stereo headphone amplifier optimized for usage within portable devices. The Class-H supply rail adaptation is implemented by an integrated DC/DC buck converter that takes its input directly from the battery. The continuous adaptation of supply rails is done according to the input signal swing and load conditions. This architecture implements significant power savings compared to traditional Class-AB amplifiers.

An I²C control interface is implemented for a 32-step volume control including a mute function for each channel separately.

The integrated charge pump generates a symmetric negative supply for true ground output signal levels without the need of output coupling capacitors. In addition it helps to lower the overall pop noise of the amplifier.

A supervisory circuit is included for overtemperature and short-circuit protection.

Differential inputs together with output ground sensing guarantees very low noise sensitivity.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of the AS3561 Class-H stereo headphone amplifier, are listed below:

Figure 1:
Added Value of Using AS3561

Benefits	Features
<ul style="list-style-type: none"> Highly optimized system power consumption 	<ul style="list-style-type: none"> H-Class amplifier with integrated DC/DC buck converter <ul style="list-style-type: none"> 2x30mW, 0.02% THD @ 16Ω 100dB SNR @ 0.9Vrms 1mA quiescent with both channels enabled
<ul style="list-style-type: none"> Popless startup and mute/unmute 	<ul style="list-style-type: none"> Ultra low DC offset
<ul style="list-style-type: none"> Full digital system control 	<ul style="list-style-type: none"> I²C control interface
<ul style="list-style-type: none"> Direct Li-Ion battery operation 	<ul style="list-style-type: none"> Wide supply range 2.3V to 5.5V
<ul style="list-style-type: none"> No DC blocking capacitors 	<ul style="list-style-type: none"> Charge pump for true ground headphone operation
<ul style="list-style-type: none"> Highest Noise Immunity 	<ul style="list-style-type: none"> Two fully differential stereo inputs with ground sensing input
<ul style="list-style-type: none"> PCB area optimized 	<ul style="list-style-type: none"> Package: 0.4mm Pitch WL-CSP (1.615mm x 1.615mm)

Applications

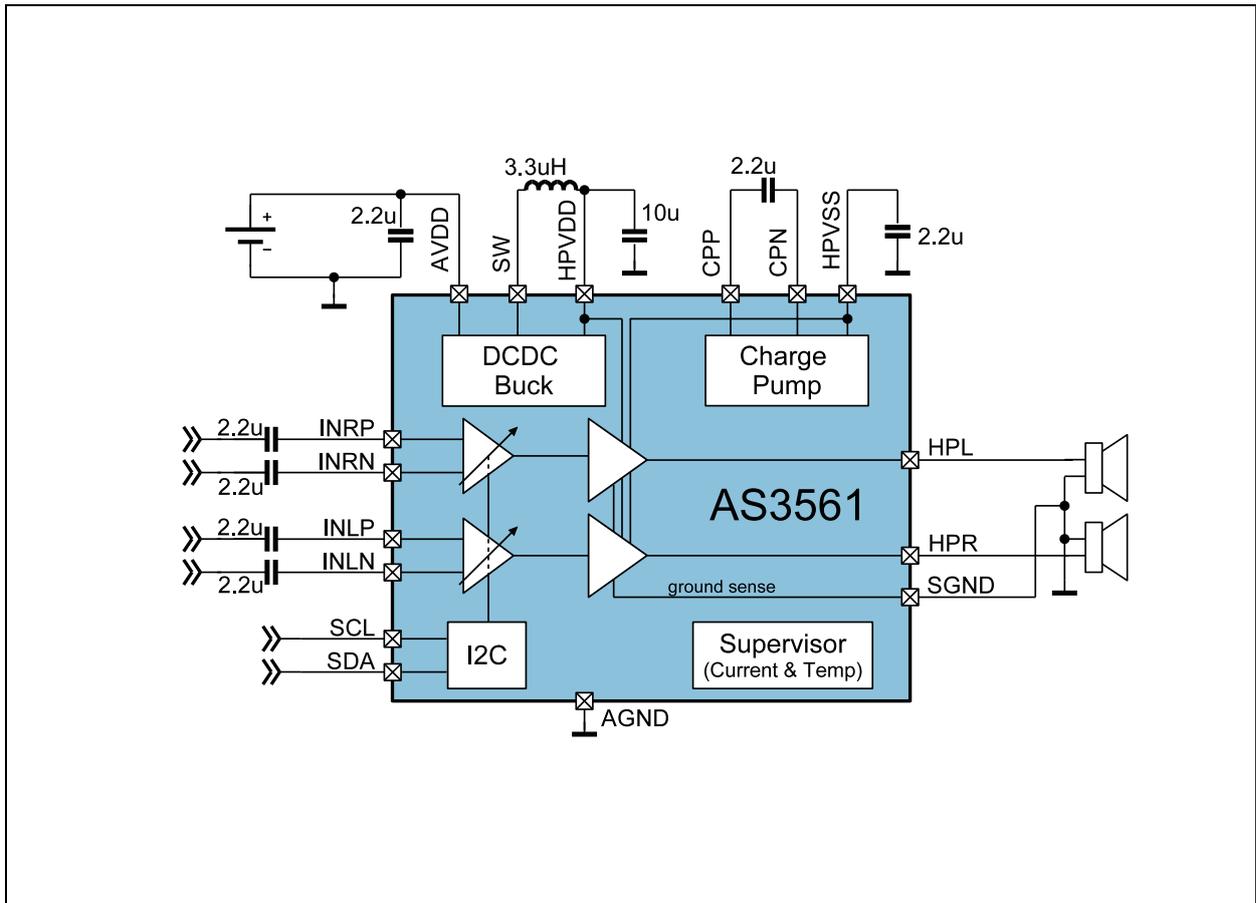
The AS3561 applications include:

- Mobile Phones
- Portable Navigation Devices
- Media Devices

Block Diagram

The functional blocks of this device are shown below:

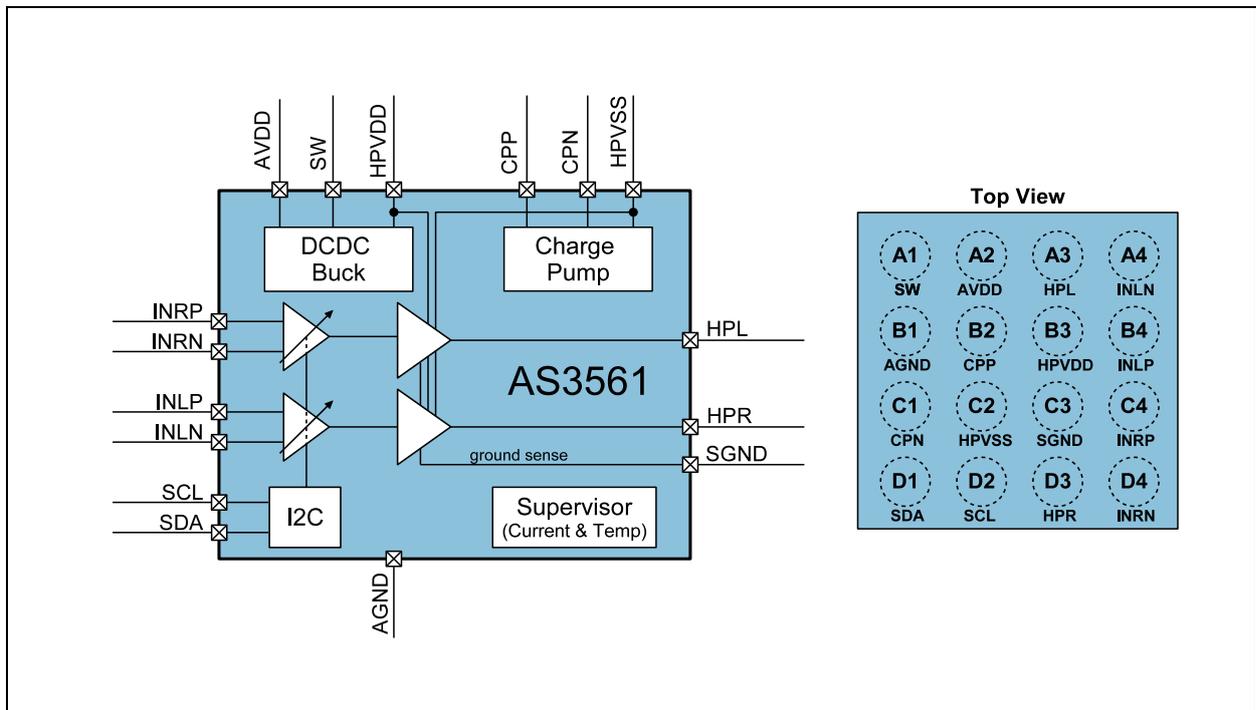
Figure 2:
AS3561 Block Diagram



Pin Assignments

The AS3561 pin assignments are described below:

Figure 3:
Pin Assignments (Top View)



Pin Descriptions

Figure 4:
Pin Descriptions

Pin Name	Pin Number	Description
SW	A1	Buck converter switching node
AVDD	A2	Primary power supply for device
HPL	A3	Left channel headphone amplifier output
INLN	A4	Inverting left input for differential signals; Connect to left input signal through 2.2µF capacitor for single-ended input applications
AGND	B1	Main Ground for headphone amplifiers, DC/DC converter, and charge pump
CPP	B2	Charge pump positive flying cap; connect to 2.2µF flying capacitor
HPVDD	B3	Power supply for headphone amplifier (DC/DC output node)
INLP	B4	Non-inverting left input for differential signals; Connect to ground through 2.2µF capacitor for single-ended input applications
CPN	C1	Charge pump negative flying cap; connect to 2.2µF flying capacitor

Pin Name	Pin Number	Description
HPVSS	C2	Charge pump output; connect 2.2 μ F capacitor to GND
SGND	C3	Ground sense; connect to headphone jack ground
INRP	C4	Non-Inverting right input for differential signals; Connect to right input signal through 2.2 μ F capacitor for single-ended input applications
SDA	D1	I ² C Data; 1.8V logic compliant
SCL	D2	I ² C Clock; 1.8V logic compliant
HPR	D3	Right channel headphone amplifier output
INRN	D4	Inverting right input for differential signals; Connect to ground through 2.2 μ F capacitor for single-ended input applications

Absolute Maximum Ratings

Stresses beyond those listed under [Absolute Maximum Ratings](#) may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under [Operating Conditions](#) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 5:
Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit	Comments
AVDD	Supply voltage	-0.3	7	V	For 1ms peaks
HPVDD	Amplifier supply voltage	-0.3	2.0	V	
SGND		-0.3	0.3	V	
	Differential Input voltage	HPVSS - 0.3V	HPVDD + 0.3V	V	
	Input voltage at SCL, SDA	-0.3	7.0	V	
	Breakdown voltage at amplifier outputs	-0.5	HPVDD + 0.5	V	
	Input current (latchup immunity)		±200	mA	JEDEC 78
Continuous Power Dissipation					
	Continuous power dissipation		TBD	mW	$P_T^{(1)}$
	Continuous power dissipation derating factor		TBD	mW/°C	$P_{\text{DERATE}}^{(2)}$
Electrostatic Discharge					
ESD _{HBM}		±2		kV	MIL 883 E Method 3015
ESD _{MM}		±100		V	JEDEC JESD 22-A115-A level A
ESD _{CDM}		±500		V	JEDEC JESD 22-C101C

Symbol	Parameter	Min	Max	Unit	Comments
Temperature Range and Storage Conditions					
T _J	Junction Temperature		150	°C	Internally limited (overtemperature protection) auto shutdown at 140°C
T _{STRG}	Storage Temperature Range	-55	125	°C	
RH _{NC}	Relative Humidity (non-condensing)	5	85	%	
MSL	Moisture Sensitivity Level	1			Represents a max. floor life time of unlimited
	Package Body Temperature		260	°C	The reflow peak soldering temperature (body temperature) specified is in accordance with IPC/JEDEC J-STD-020 "Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices".

Note(s):

- Depending on actual PCB layout and PCB used
- P_{DERATE} derating factor changes the total continuous power dissipation (P_T) if the ambient temperature is not 70°C.
Therefore for e.g. T_{AMB}=85°C calculate P_T at 85°C = P_T · P_{DERATE} * (85°C - 70°C)

Electrical Characteristics

All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

AVDD=3.6V, T_A=25°C, R_{load} = 32Ω unless otherwise specified.

Figure 6:
Operating Conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
General Operating Conditions						
AVDD	Supply Voltage		2.3		5.5	V
	Rail Voltages HPVDD, HPVSS (Buck and CP output)		0.8	0.9	1.0	V
			1.15	1.25	1.35	V
			1.7	1.8	1.9	V
I _{DD}	Quiescent Current	Both channels enabled, no audio signal		0.9	1.5	mA
I _{SD}	Shutdown Current	SW shutdown		1.8	5	μA
I _S	Supply Current	Output: 2 × 100μW @ 3dB Crest Factor		1.7	2.3	mA
		Output: 2 × 500μW @ 3dB Crest Factor		2.85	3.6	mA
		Output: 2 × 1mW @ 3dB Crest Factor		3.7	4.6	mA
T _A	Operating Temperature Range		-30	25	85	°C
t _{WAKEUP}	Wakeup Time			10	15	ms
Input Interfaces						
V _{IL}	Low-level input voltage (SCL, SDA)	AVDD 2.9V to 4.5V			0.6	V
V _{IH}	High-level input voltage (SCL, SDA)	AVDD 2.9V to 4.5V	1.2			V
V _{HYST}	Hysteresis (SCL, SDA)		50	100	200	mV
Z _{IN}	Input Impedance Line Inputs	Differential	20			kΩ
		Single Ended	10			kΩ

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
HPA Output						
V_{OUT}	Output Voltage	Rload=16 Ω , THD + N=1%, L+R out of phase	0.7			V_{rms}
		Rload=32 Ω , THD + N=1%, L+R in phase	0.9			V_{rms}
	Output DC Offset	Both channels enabled			500	μV
Z_{OUT}	Output Impedance	In HiZ mode < 40KHz		10		k Ω
		In HiZ mode for 6MHz		500		Ω
		In HiZ mode for 36MHz		75		Ω
	Voltage applied to Output; HPR, HPL	When SWS = 0, HiZ_L = HiZ_R = 1, device in HI-Z mode	-1.8		1.8	V
C_{LOAD}	Capacitive Load	Ext. cap, 15 Ω series resistor	0.8	5	100	nF
		Ext. cap, directly connected			100	pF
$Z_{OOT,SD}$	Output impedance in shutdown	SWS = 1		8		k Ω
	Voltage applied to Output; HPR, HPL	When SWS = 1, device disabled	-0.3		3.6	V
Audio Parameters						
THD + N	Total Harmonic Distortion + Noise	700mV $_{rms}$, 1KHz		0.02	0.04	%
PSRR	Power Supply Rejection Ratio	Gain 0dB @ 217Hz		90		dB
SNR	Signal-to-Noise Ratio	900mV $_{rms}$, 1KHz		104		dB
	Channel Separation	>16 Ω (Headset)		60		dB
		>10k Ω (Lineout)		80		dB
V_N	Output Noise	Gain 0dB, A-weighted		5.3	9	μV_{rms}
Other Parameters						
	Thermal Shutdown	Threshold		140		$^{\circ}C$
		Hysteresis		20		

Detailed Operating Characteristics

$T_A = 25^\circ\text{C}$, AVDD (VDD) = 3.6V, GAIN = 0dB, $C_{HPVDD} = 10\mu\text{F}$, $C_{HPVSS} = 2.2\mu\text{F}$, $C_{INPUT} = C_{FLYING} = 2.2\mu\text{F}$. $R_L = 32\Omega$ unless otherwise specified.

Figure 7:
THD + N vs. Output Power for AVDD = 2.5V, $R_L = 32\Omega$

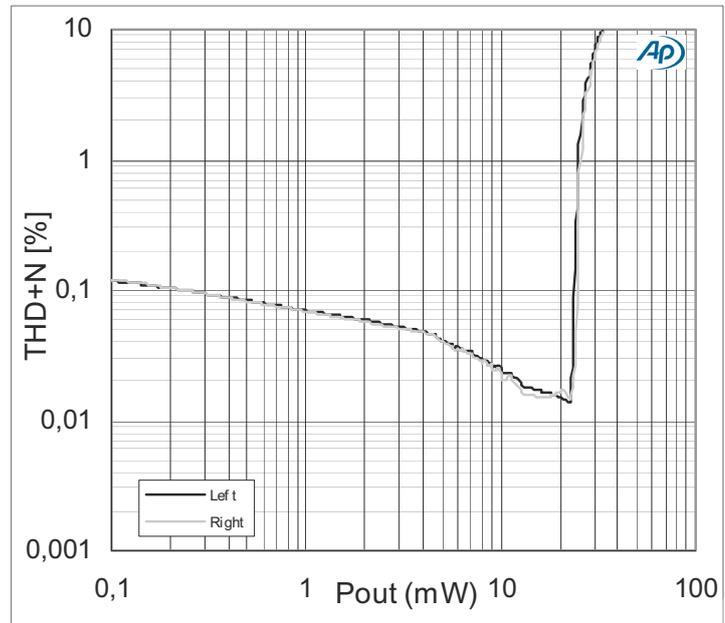


Figure 8:
THD + N vs. Output Power for AVDD = 2.5V, $R_L = 16\Omega$

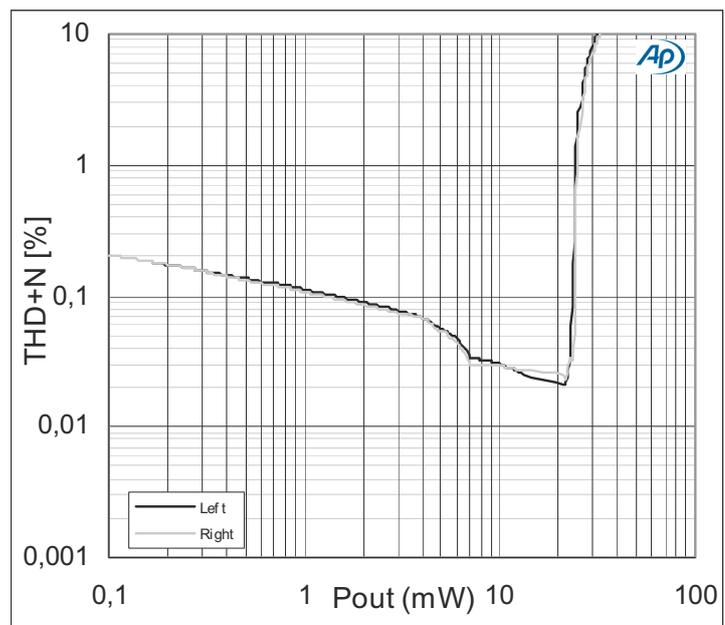


Figure 9:
THD + N vs. Output Power for AVDD = 3.6V, RL = 32Ω

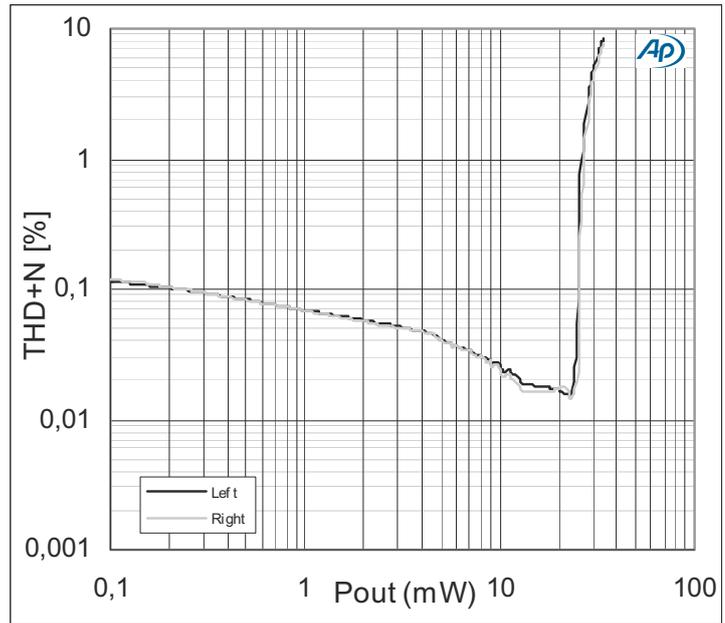


Figure 10:
THD+ N vs. Output Power for AVDD = 3.6V, RL = 16Ω

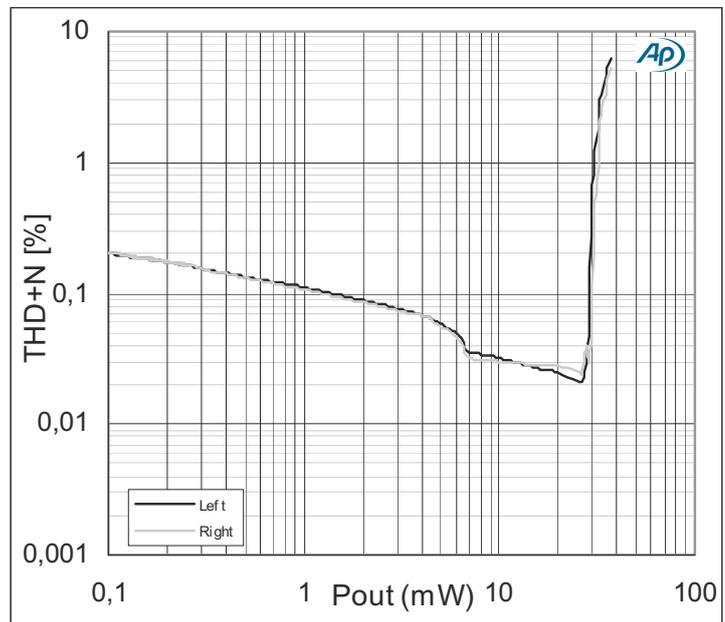


Figure 11:
THD + N vs. Output Power for AVDD = 5.5V, RL = 32Ω

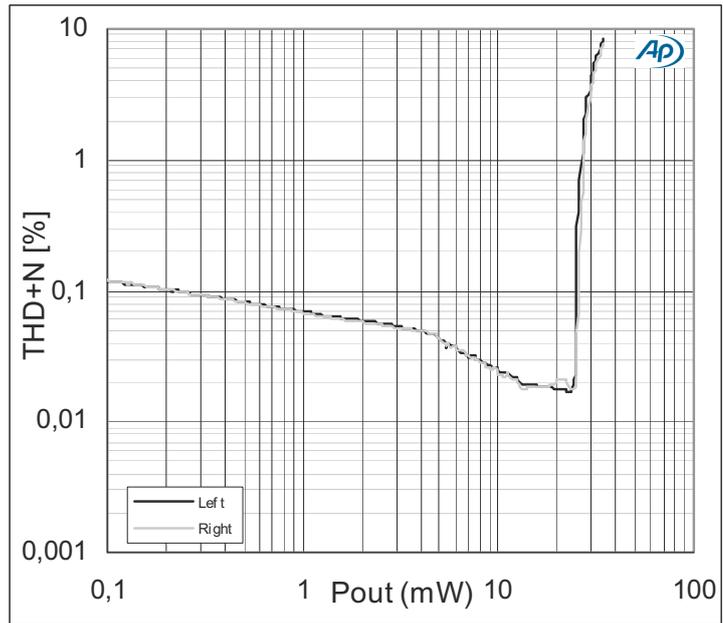


Figure 12:
THD + N vs. Output Power for AVDD = 5.5V, RL = 16Ω

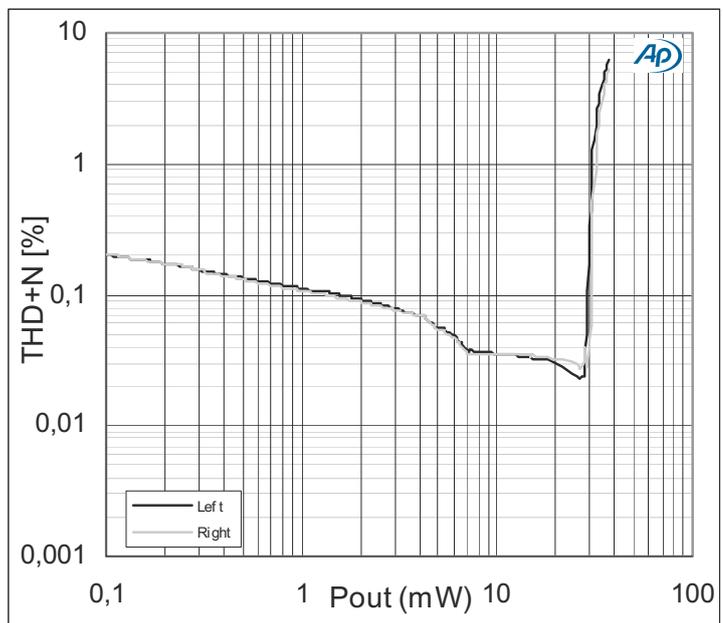


Figure 13:
THD + N vs. Frequency for AVDD = 2.5V, RL = 32Ω

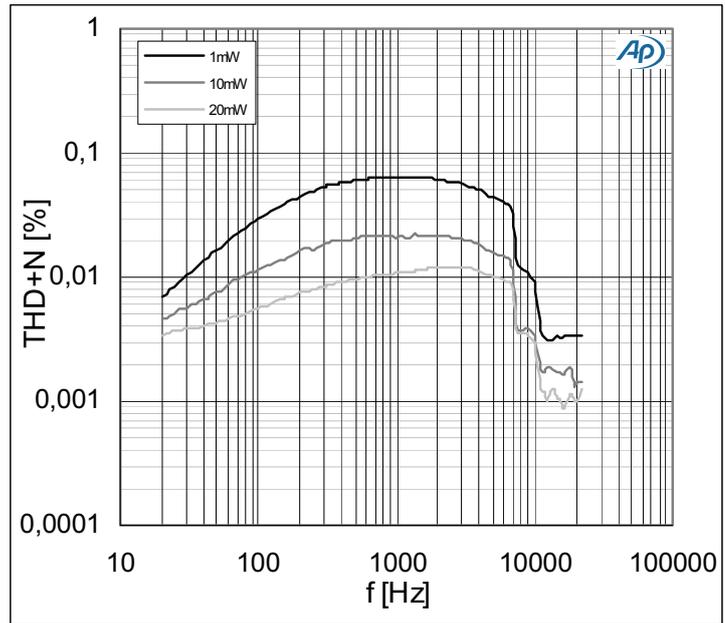


Figure 14:
THD + N vs. Frequency for AVDD = 2.5V, RL = 16Ω

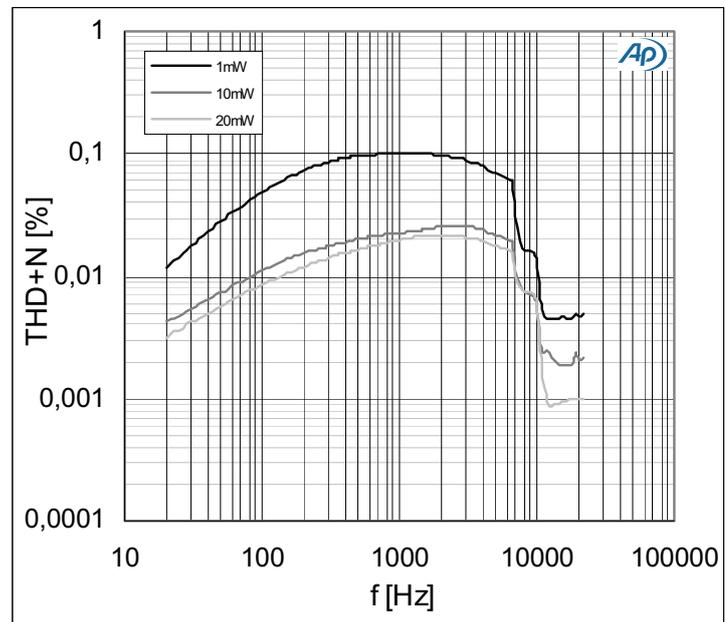


Figure 15:
THD + N vs. Frequency for AVDD = 3.6V, RL = 32Ω

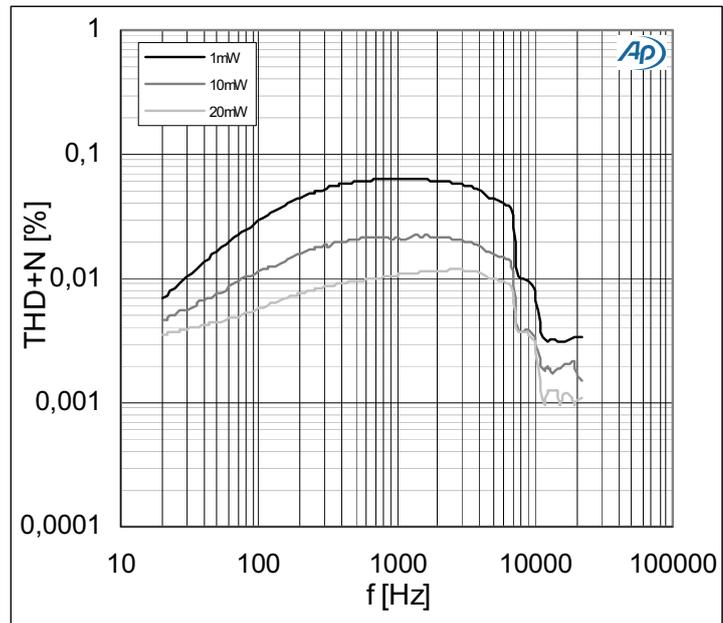


Figure 16:
THD + N vs. Frequency for AVDD = 3.6V, RL = 16Ω

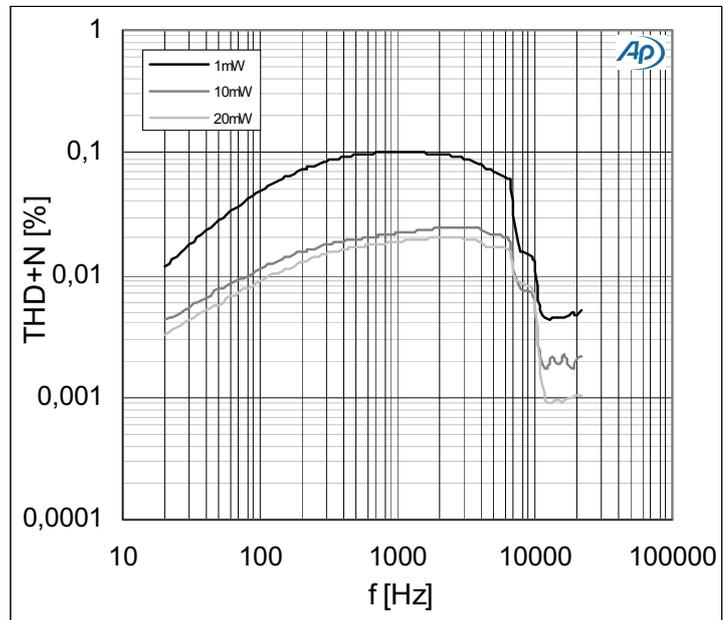


Figure 17:
THD + N vs. Frequency for AVDD = 5.5V, RL = 32Ω

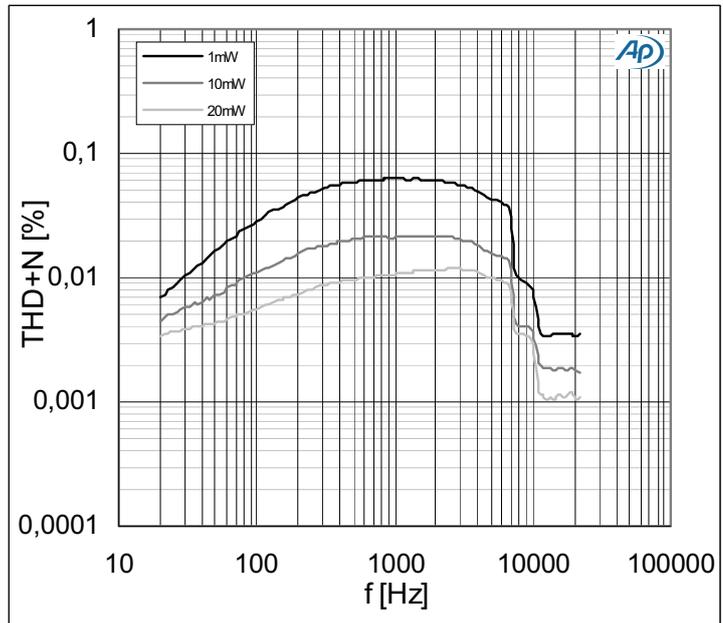


Figure 18:
THD + N vs. Frequency for AVDD = 5.5V, RL = 16Ω

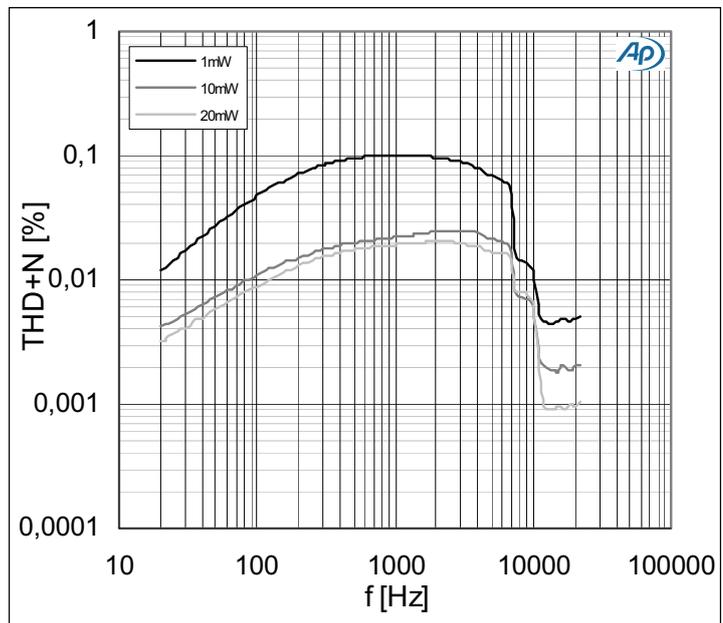


Figure 19:
Supply Current vs. POUT for AVDD=2.5V
 (POut is the output power per channel)

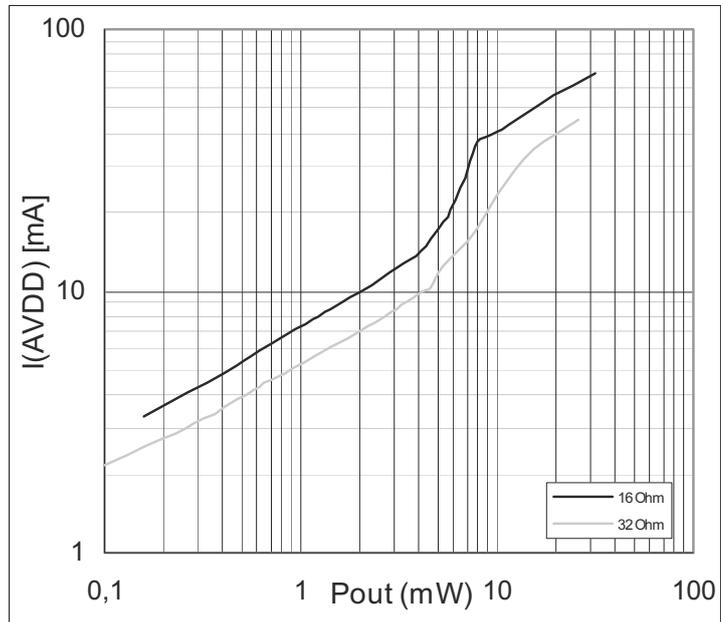


Figure 20:
Ptotal vs. POUT for AVDD = 2.5V
 (POut is the output power per channel)

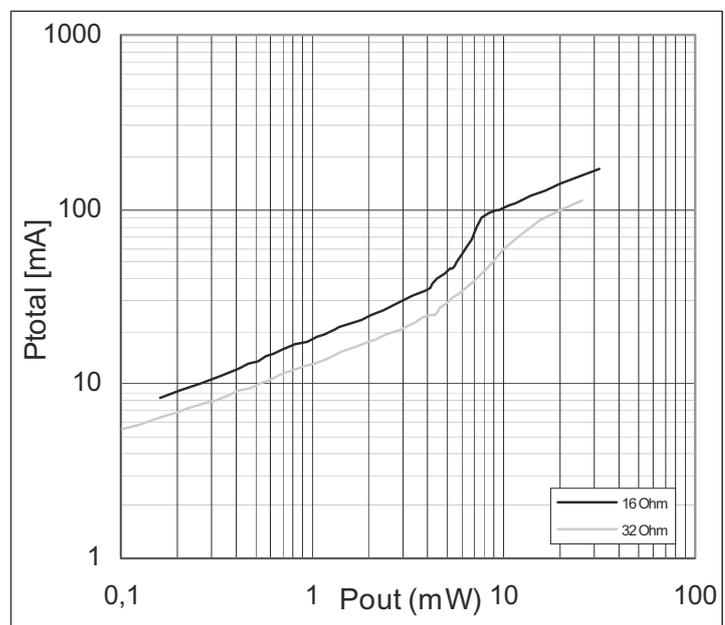


Figure 21:
Supply Current vs. POUT for AVDD=3.6V
 (Pout is the output power per channel)

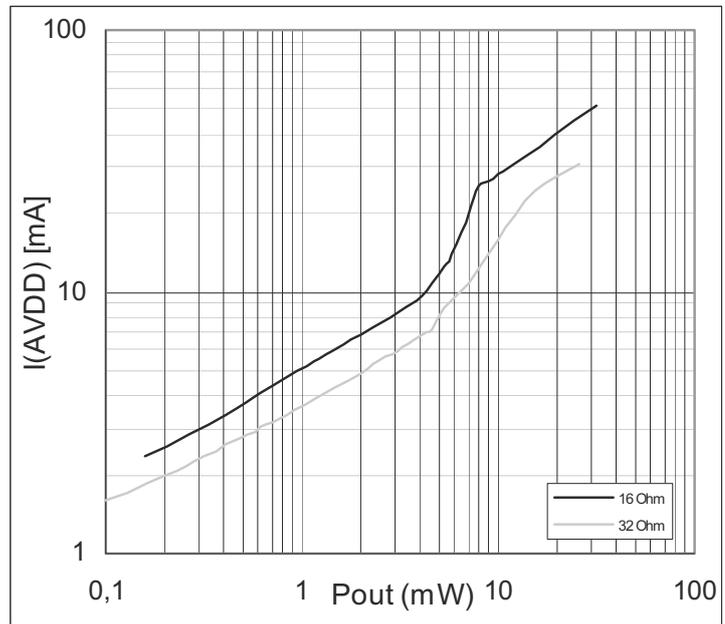


Figure 22:
Ptotal vs. POUT for AVDD = 3.6V
 (Pout is the output power per channel)

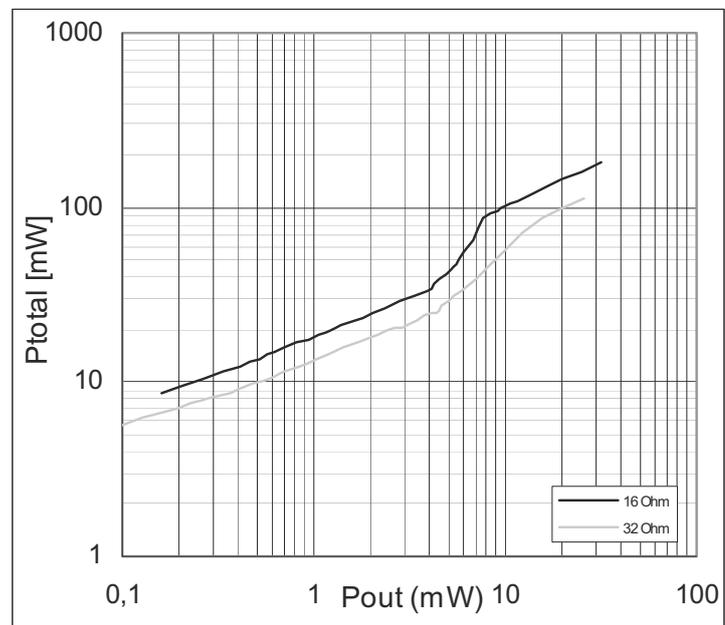


Figure 23:
Supply Current vs. POUT for AVDD=5.5V
 (POut is the output power per channel)

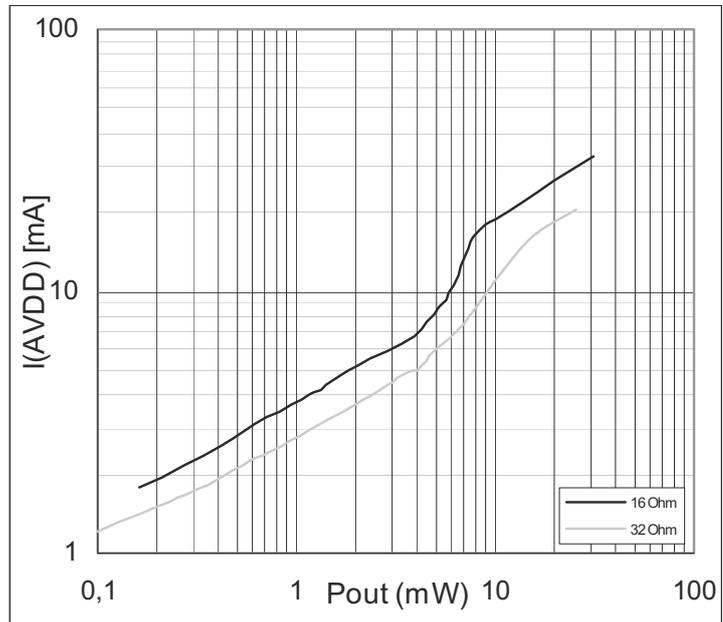


Figure 24:
Ptotal vs. POUT for AVDD = 5.5V
 (POut is the output power per channel)

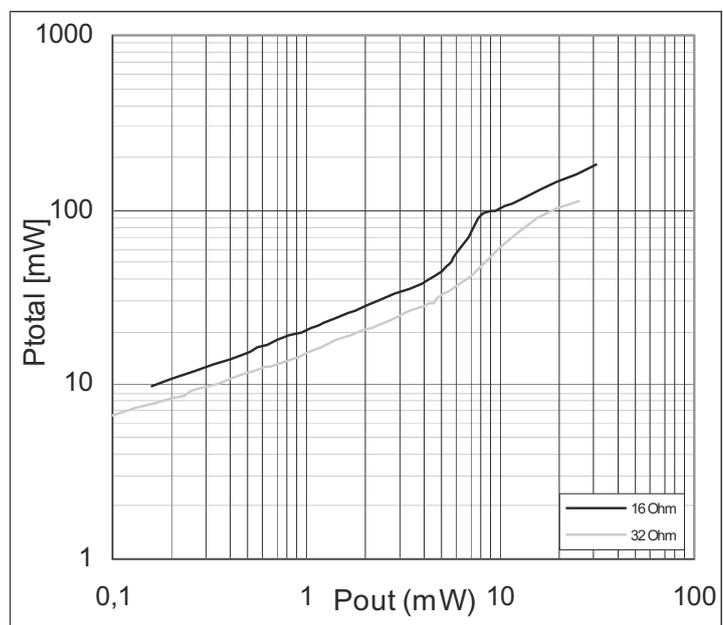


Figure 25:
Quiescent Current Consumption vs. AVDDI

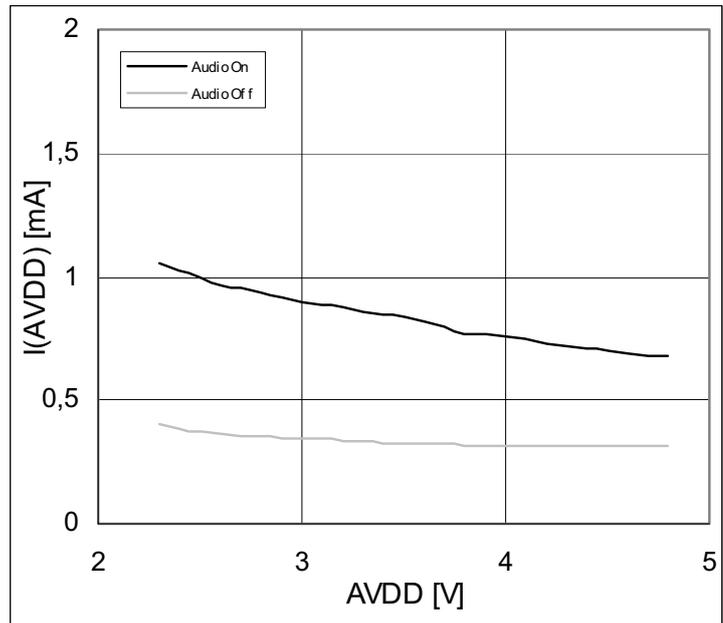


Figure 26:
PSRR vs. Frequency (200mVpkpk supply ripple)

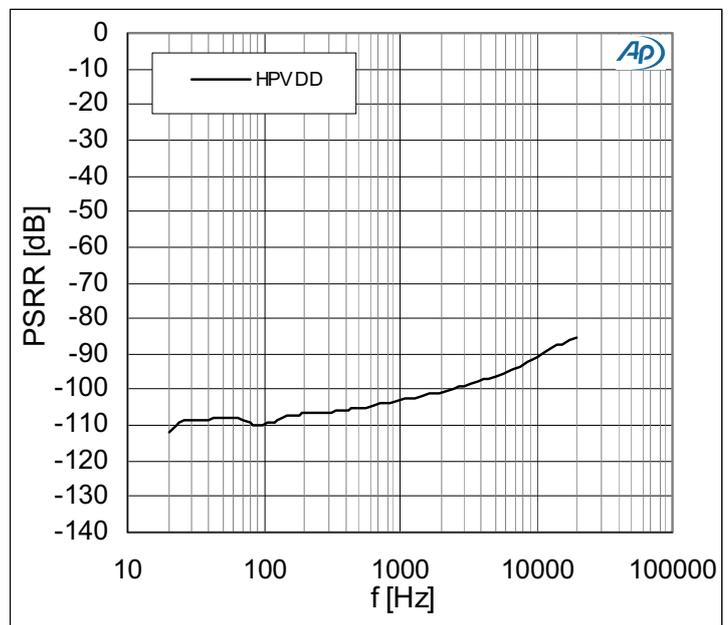


Figure 27:
Crosstalk vs. Frequency (700mVrms, RL = 32Ω)

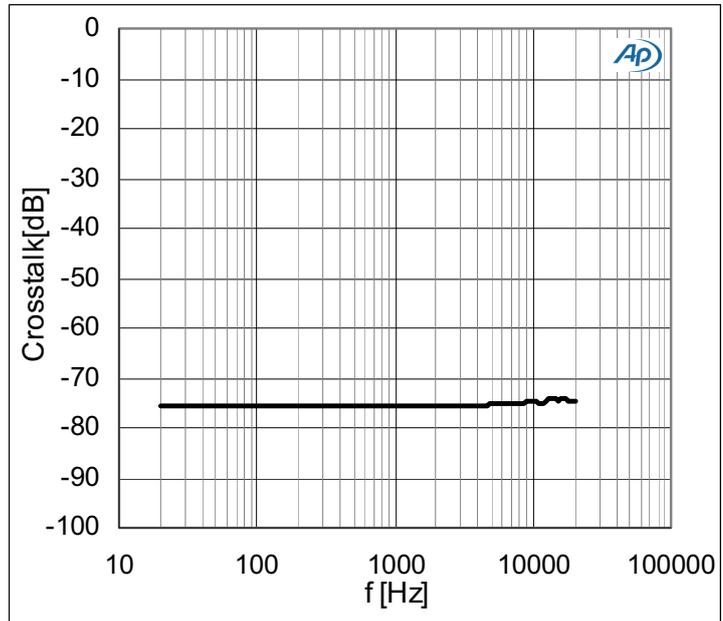


Figure 28:
Startup Pop Noise for AVDD = 3.6V and RL=16Ω

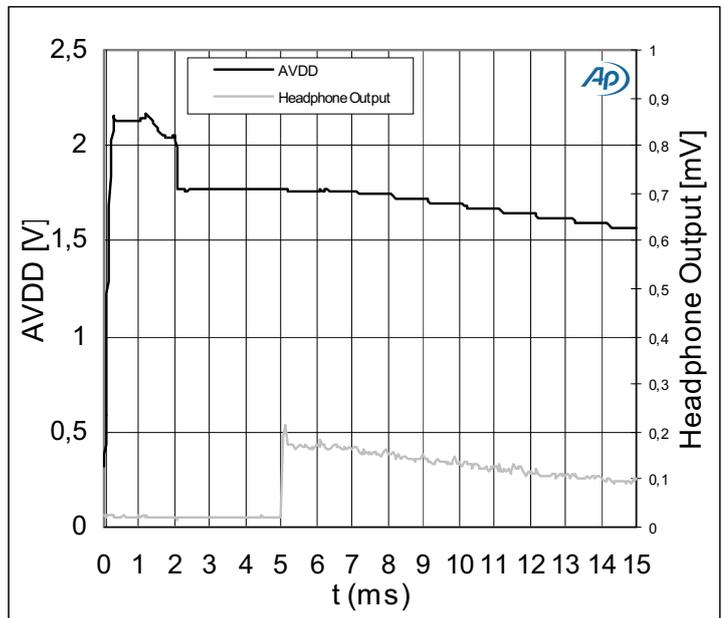
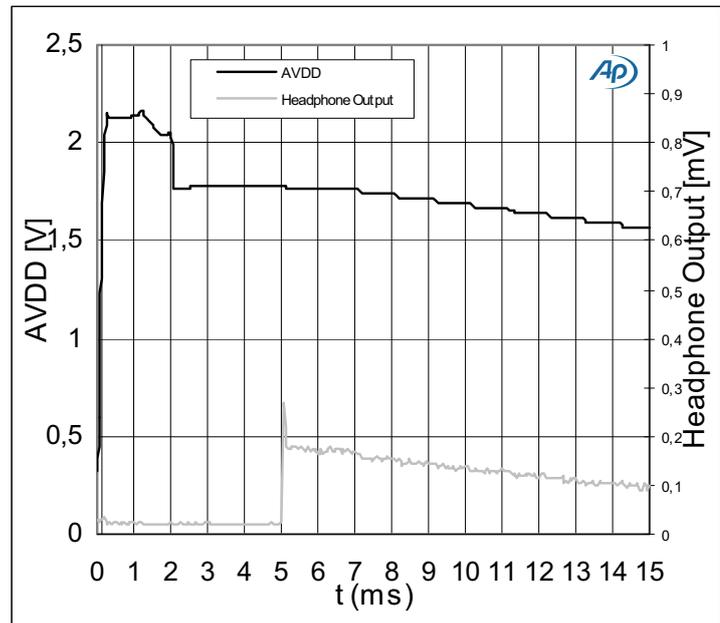


Figure 29:
Startup Pop Noise for AVDD = 3.6V and RL=32Ω



Detailed Description

I²C Control Interface

An I²C slave interface is implemented for read/write access of the internal registers. SCL is the corresponding clock input pin and SDA the data input pin.

Access is done in 7-bit addressing mode, addresses for read and write are defined by

C0h = 11000000b ... write

C1h = 11000001b ... read

Figure 30:
I²C Block Diagram

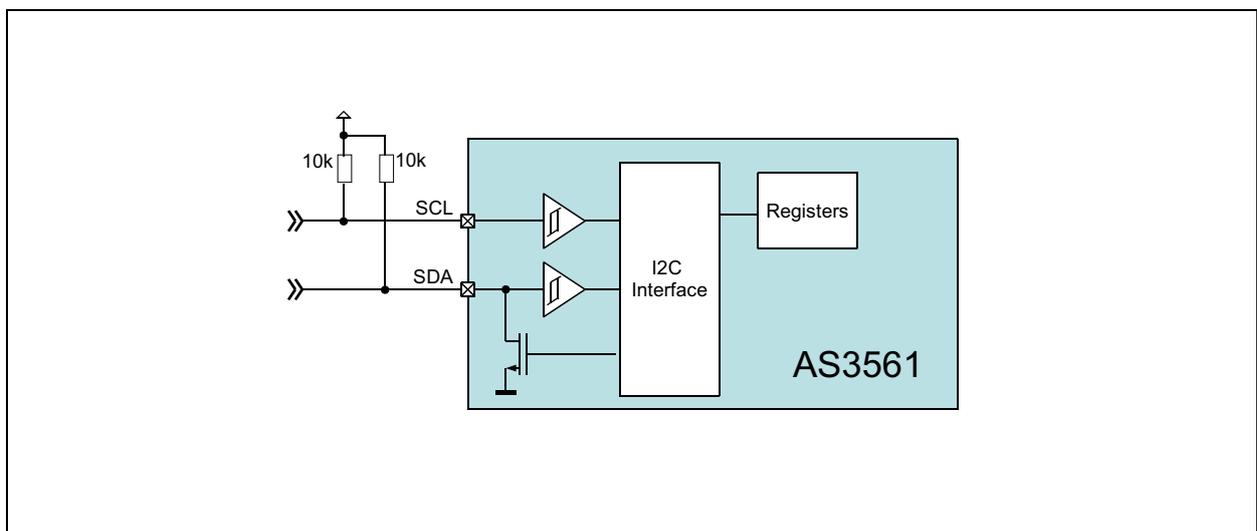


Figure 31:
I²C Timing Definition

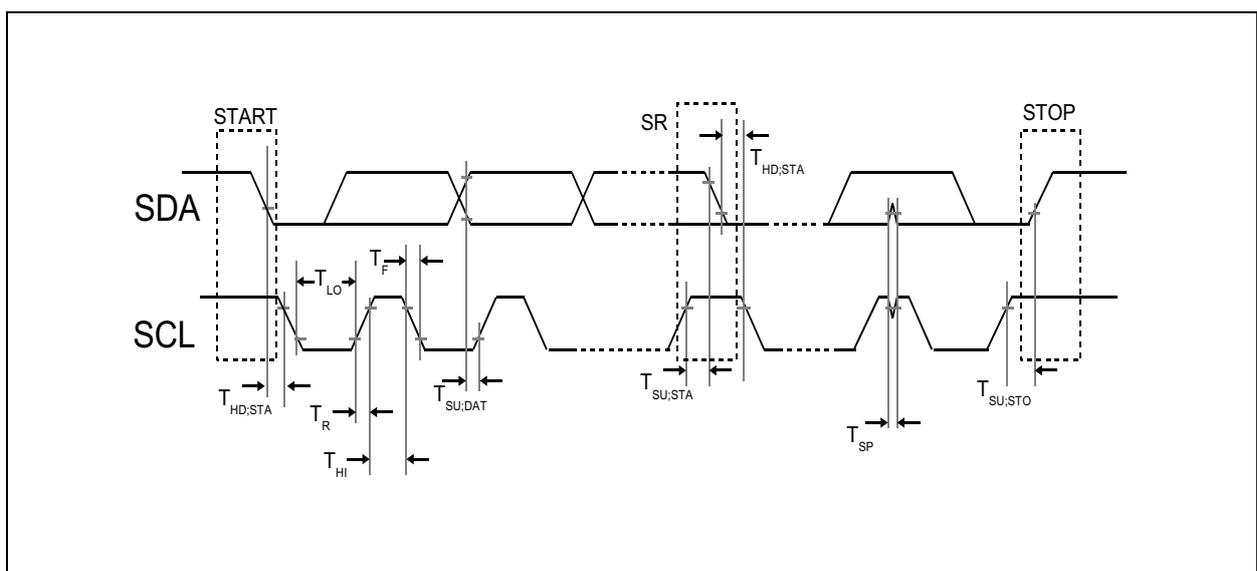


Figure 32:
I²C Timing Parameters

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{SP}	Spike Insensitivity		50	100		ns
T_{HI}	High Clock Time	400KHz clock speed	330			ns
T_{LO}	Low Clock Time		660			ns
T_{SU}		SDA has to change T_{setup} before rising edge of SCLK	30			ns
T_{HD}		No hold time needed for SDA relative to rising edge of SCLK	-40			ns
$T_{HD;STA}$	Within start condition, after low going SDA, SCL has to stay constant for the specified hold time		300			ns
$T_{ST;SUO}$	After high going edge of SCL, SDA has to stay constant for the specified setup time before STOP or repeated start condition is applied		100			ns
$T_{ST;STA}$			100			ns

Register Definition

Register Overview

Figure 33:
Register Overview

Register	Description
Enable Register (1h)	General control register to switch on/off the device and enable the headphone amplifier stages.
Volume Register (2h)	Allows the use to configure the output volume of the headphone amplifier from -59dB up to +4dB.
HiZ Register (3h)	Configures the headphone amplifier for a high impedance output for power optimization.
Info Register (4h)	This register contains general information like IC version number and supplier information.

Detailed Register Descriptions

Figure 34:
Enable Register (1h)

Bit	Bit Name	Default	Access	Bit Description
Bit 7	HP_EN_L	0	RW	0 ... Disable Headphone Left; 1 ... Enable Headphone Left Channel
Bit 6	HP_EN_R	0	RW	0 ... Disable Headphone Right; 1 ... Enable Headphone Right Channel
Bit 5	-	-	-	-
Bit 4	-	-	-	-
Bit 3	-	-	-	-
Bit 2	-	-	-	-
Bit 1	Thermal	0	S_RC	0 ... Normal Operation; 1 ... Thermal Shutdown
Bit 0	SWS	1	RW	0 ... Normal Operation; 1 ... Software Shutdown

Figure 35:
Volume Register (2h)

Bit	Bit Name	Default	Access	Bit Description	
Bit 7	Mute_L	1	RW	0 ... Unmuted Left Channel; 1 ... Mute Left Channel	
Bit 6	Mute_R	1	RW	0 ... Unmuted Right Channel; 1 ... Mute Right Channel	
Bit[5:1]	Vol[4:0]	0	RW	0d ... -55 dB; 1d ... -52 dB; 2d ... -49 dB; 3d ... -46 dB; 4d ... -43 dB; 5d ... -39 dB; 6d ... -35 dB; 7d ... -31 dB; 8d ... -27 dB; 9d ... -25 dB; 10d ... -23 dB; 11d ... -21 dB; 12d ... -19 dB; 13d ... -17 dB; 14d ... -15 dB; 15d ... -13 dB;	16d ... -11 dB; 17d ... -10 dB; 18d ... -9 dB; 19d ... -8 dB; 20d ... -7 dB; 21d ... -6 dB; 22d ... -5 dB; 23d ... -4 dB; 24d ... -3 dB; 25d ... -2 dB; 26d ... -1 dB; 27d ... 0 dB; 28d ... 1 dB; 29d ... 2 dB; 30d ... 3 dB; 31d ... 4 dB
Bit 0	-	-	-	-	-

Figure 36:
HiZ Register (3h)

Bit	Bit Name	Default	Access	Bit Description	
Bit 7	-	-	-	-	
Bit 6	-	-	-	-	
Bit 5	-	-	-	-	
Bit 4	-	-	-	-	
Bit 3	-	-	-	-	
Bit 2	-	-	-	-	
Bit 1	HiZ_L	0	RW	0 ... Normal Operation; 1 ... High Impedance on HPH_Output Left	
Bit 0	HiZ_R	0	RW	0 ... Normal Operation; 1 ... High Impedance on HPH_Output Right	

Figure 37:
Info Register (4h)

Bit	Bit Name	Default	Access	Bit Description
Bit 7	Supplier Bit [1:0]	RO	1	11b ... Default Supplier ID; else ... unused
Bit 6			1	
Bit 5	-	-	-	-
Bit 4	-	-	-	-
Bit 3	Version Bit [3:0]		0	0 ... First Version; else ... unused
Bit 2			0	
Bit 1			0	
Bit 0			0	

GND Connections

The SGND pin is an input reference and must be connected to the headphone ground connector pin. This ensures no turn-on pop and minimizes output offset voltage. Do not connect more than $\pm 0.3\text{V}$ to SGND. AGND is a power ground. Connect supply decoupling capacitors for AVDD, HPVDD, and HPVSS to AGND.

External Elements

1 \times 3.3 μH Coil (SW-HPVDD)

7 \times 2.2 μF $\pm 10\%$ X5R (AVDD, CPP-CPN, HPVSS, INRP, INRN, INLP, INLN)

1 \times 10 μF $\pm 10\%$ X5R (HPVDD)

Software Shutdown

Set software shutdown by writing a logic 1 in [Enable Register \(1h\)](#), bit 0 (SWS bit). Software shutdown places the device in the lowest power state. See [Operating Conditions](#) for values. Engaging software shutdown turns off the buck regulator and charge pump and disables the amplifier outputs. Write a logic 0 to the SWS bit to reactivate the device.

Note(s): When the device is in SWS mode all registers will maintain their values. The HP_EN_L and HP_EN_R bits can be reset because a full word must be used when writing just one bit to the register.

Note that I²C read and write access is still possible in shutdown mode.

Package Drawings & Markings

Figure 39:
WL-CSP (1.615mm x 1.615mm) Marking

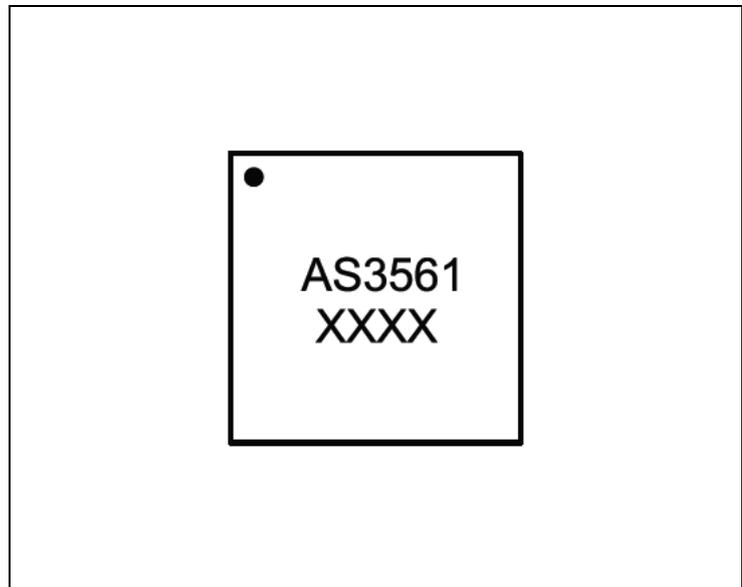


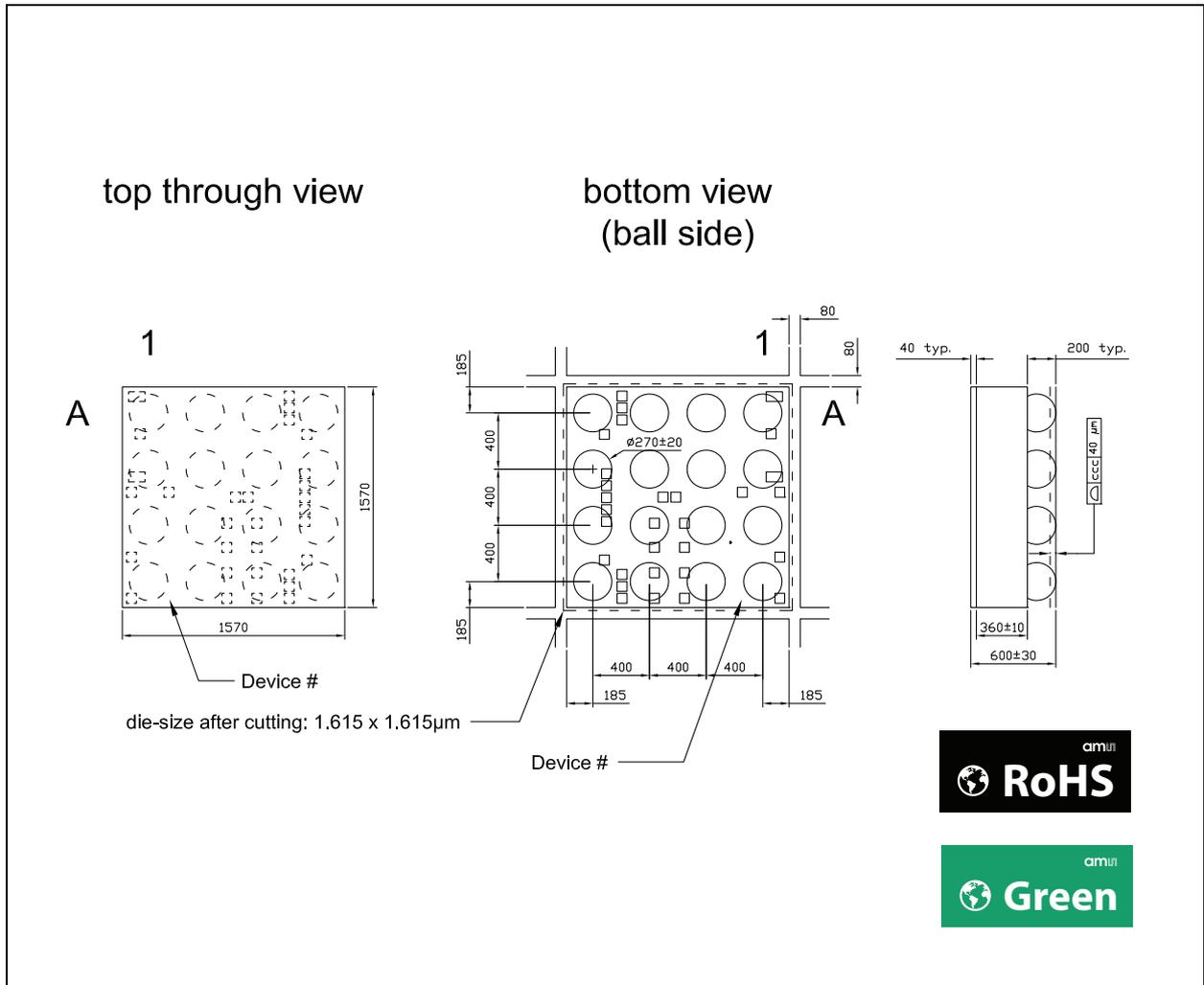
Figure 40:
Packaging Code (XXXX)

XXXX
Tracecode

Note(s):

1. The device is available in a WL-CSP (1.615mm x 1.615mm) package.

Figure 41:
WL-CSP (1.615mm x 1.615mm) Package



Note(s):

1. ccc Coplanarity
2. All dimensions are in μm

Ordering & Contact Information

Figure 42:
Ordering Information

Ordering Code	Description	Delivery Form	Delivery Quantity	Package
AS3561-DWLT	AS3561 Class-H Stereo Headphone Amplifier	Tape & Reel	6500 pcs/reel	WL-CSP 16
AS3561-DWLT-500	AS3561 Class-H Stereo Headphone Amplifier	Tape & Reel	500 pcs/reel	WL-CSP 16

Not Recommended for New Designs!

ams AG is discontinuing production of this device. Final lifetime buy order must be placed by DECEMBER 31, 2017.

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Product Preview	Pre-Development	Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice
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Revision Information

Changes from 1-07 (2014-Sep-26) to current revision 1-08 (2017-Jul-13)	Page
Update of document status	
Update of Ordering Information section	30

Note(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

Content Guide

1	General Description
1	Key Benefits & Features
2	Applications
2	Block Diagram
3	Pin Assignments
3	Pin Descriptions
5	Absolute Maximum Ratings
7	Electrical Characteristics
9	Detailed Operating Characteristics
21	Detailed Description
21	I ² C Control Interface
23	Register Definition
23	Register Overview
23	Detailed Register Descriptions
26	Application Information
27	GND Connections
27	External Elements
27	Software Shutdown
28	Package Drawings and Markings
30	Ordering & Contact Information
31	RoHS Compliant & ams Green Statement
32	Copyrights & Disclaimer
33	Document Status
34	Revision Information

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