2.5W/CH STEREO FILTER-FREE CLASS-D AUDIO POWER AMPLIFIER

DESCRIPTION

The IT2012 is a high efficiency stereo filter-free class-D audio amplifier which can deliver maximum 2.5W/CH RMS power to 4Ω load with 5.5V supply in a Bridge Tied Load (BTL) configuration.

The IT2012 features independent shutdown controls for each channel. The gain can be selected to 6, 12, 18, or 24dB utilizing the G0 and G1 gain select pins. Fully differential design eliminates two input coupling capacitors and provide increased immunity to noise.

The IT2012 contains Over Current and Over Temperature Protection, preventing IT2012 from damages of short current and over-heating. It also features good THD+N and self gain-adjusting depop scheme, achieving high sound quality.

The high performance, low cost characteristics make IT2012 well suitable for cellular phones, portable electronic devices, PDAs, smart phones and portable computers.

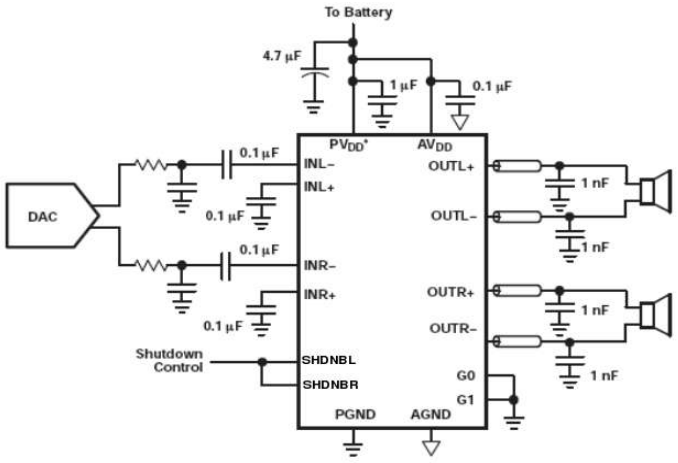
FEATURES

- Filterless Capability
- Only Two External Component Required
- Fully Differential Design Eliminates Two Input Coupling Capacitors
- Internally Generated 300k-Hz Switching Frequency Eliminates Capacitor and Resistor
- Independent Shutdown Control for Each Channel
- Selectable Gain of 6, 12, 18, and 24dB
- 2.5V to 5.5V Wide Supply Voltage Range
- Ultra-Low Distortion: 0.025% THD+N at Po=1W and 8Ω Load
- Large Output Power Capability: 2W with 4Ω Load and THD<1%
- Low Supply Current and Shutdown Current
- Self Gain-adjusting Depop Mechanism
- External Gain Configuration Capability
- OCP (Over Current Protection)
- OTP (Over Temperature Protection)

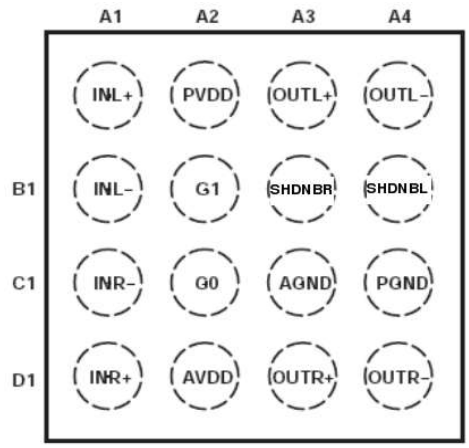
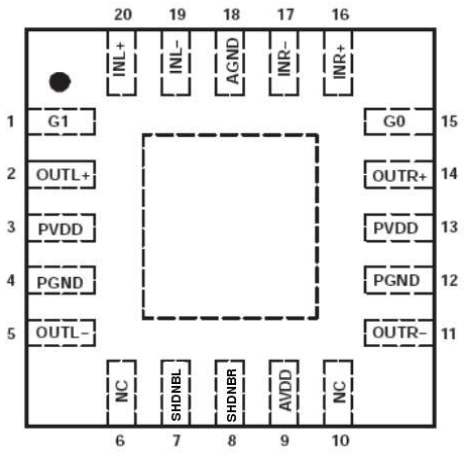
APPLICATIONS

- Wireless or Cellular Handsets and PDAs
- General Portable Audio Devices
- Portable Computers

TYPICAL APPLICATION



PACKAGE REFERENCE

Package Type	WCSP TOP VIEW	QFN TOP VIEW
Pin Configuration		

PIN FUNCTIONS

PIN			I/O/P[1]	DESCRIPTION
NAME	QFN	WCSP		
INR+	16	D1	I	Right channel positive input
INR-	17	C1	I	Right channel negative input
INL+	20	A1	I	Left channel positive input
INL-	19	B1	I	Left channel negative input
SHDNBR	8	B3	I	Right channel shutdown terminal (active low)
SHDNBL	7	B4	I	Left channel shutdown terminal (active low)
G0	15	C2	I	Gain select (LSB)
G1	1	B2	I	Gain select (MSB)
PVDD	3, 13	A2	P	Power supply (Must be same voltage as AVDD)
AVDD	9	D2	P	Analog supply (Must be same voltage as PVDD)
PGND	4, 12	C4	P	Power ground
AGND	18	C3	P	Analog ground
OUTR+	14	D3	O	Right channel positive differential output
OUTR-	11	D4	O	Right channel negative differential output
OUTL+	2	A3	O	Left channel positive differential output
OUTL-	5	A4	O	Left channel negative differential output
NC	6, 10	N/A		No internal connection
Thermal Pad				Connect the thermal pad of QFN package to PCB GND

(1) I = input, O = output, P = power

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)

	IT2012
V_{DD} Supply voltage	-0.3V to 6V
V_I Input Voltage	-0.3V to VDD + 0.3V
T_A Operating free-air temperature	-40°C to 85°C
T_J Operating junction temperature	-40°C to 150°C
T_{stg} Storage temperature	-65°C to 150°C

RECOMMENDED OPERATING CONDITIONS

		MIN	TYP	MAX	UNIT
V_{DD} Supply voltage		2.5		5.5	V
V_{IH} High-level input voltage		1.3		V_{DD}	V
V_{IL} Low-level input voltage		0		0.35	V
V_{IC} Common mode input	V_{DD}=2.5V, 5.5V	0.5		V_{DD}-0.8	V
T_A Operating free-air temperature		-40		85	°C

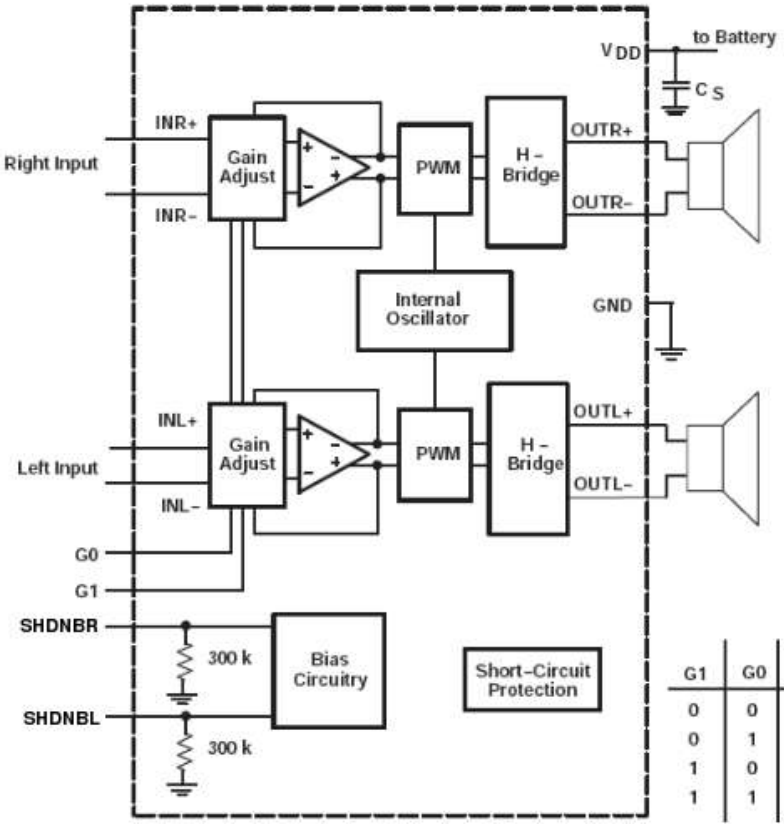
ELECTRICAL CHARACTERISTICS

T_A=25 °C (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{DD} Operating Supply Voltage		2.5	-	5.5	V
I_Q Supply Quiescent Current	V_{DD}=5.5V, no load	-	3.6	-	mA
	V_{DD}=3.6V, no load	-	2.5	-	
	V_{DD}=2.5V, no load	-	2.1	-	
V_H Shutdown Voltage High	-	1.2	-	-	V
V_L Shutdown Voltage Low	-	-	-	0.4	V
F_{SW} Switching Frequency	V_{DD}=2.5V to 5.5V	250	300	350	kHz
V_{OS} Output offset voltage	Inputs ac grounded, A_V=6dB, V_{DD}=2.5 to 5.5V	-	5	25	mV

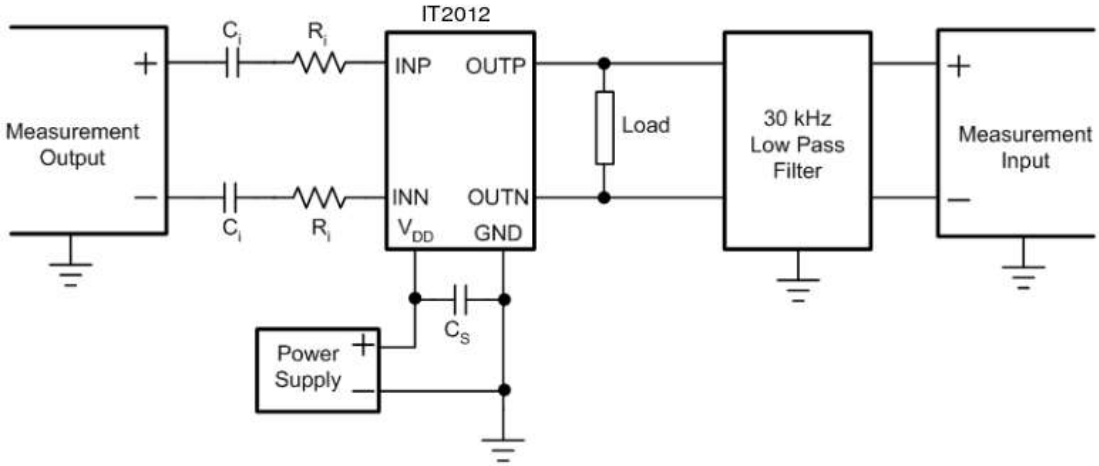
PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
R_{SD} Resistance from SHDNB to GND	-		-	300	-	kΩ
Efficiency	V_{DD}=5V, R_L=8Ω, Pout=1W		-	86	-	%
T_{SD} Thermal Shutdown Temperature	-		-	150	-	°C
R_{DS}(on) Static drain-source on-stage resistance	V_{DD}=5.5V		-	450	-	mΩ
	V_{DD}=3.6V		-	550	-	
	V_{DD}=2.5V		-	700	-	
SNR Signal-to-noise-ratio	V_{DD}=5V, Po=1W, R_L=8Ω		-	98	-	dB
Vn Output voltage noise	V_{DD}=5V, f=20Hz to 20kHz, Inputs ac-grounded with C_I=1uF	No weighting	-	32	-	uV
		A weighting	-	21	-	
THD+N Total Harmonic Distortion+ Noise	V_{DD}=5V, Po=1W, R_L=8Ω, f=1kHz		-	0.025	-	%
	V_{DD}=3.6V, Po=0.5W, R_L=8Ω, f=1kHz		-	0.021	-	
	V_{DD}=2.5V, Po=200mW, R_L=8Ω, f=1kHz		-	0.07	-	
Po Output Power	THD+N=1%, f=1kHz, R_L=8Ω	V_{DD}=5V	-	1.3	-	W
		V_{DD}=3.6V	-	0.63	-	
		V_{DD}=2.5V	-	0.29	-	
	THD+N=10%, f=1kHz, R_L=8Ω	V_{DD}=5V	-	1.6	-	W
		V_{DD}=3.6V	-	0.79	-	
		V_{DD}=2.5V	-	0.36	-	
	THD+N=1%, f=1kHz, R_L=4Ω	V_{DD}=5V	-	2	-	W
		V_{DD}=3.6V	-	1	-	
		V_{DD}=2.5V	-	0.43	-	
	THD+N=10%, f=1kHz, R_L=4Ω	V_{DD}=5V	-	2.5	-	W
		V_{DD}=3.6V	-	1.25	-	
		V_{DD}=2.5V	-	0.52	-	

FUNCTIONAL BLOCK DIAGRAM



G1	G0	Gain V/V	Gain dB
0	0	2	6
0	1	4	12
1	0	8	18
1	1	16	24

TEST SETUP FOR GRAPHS



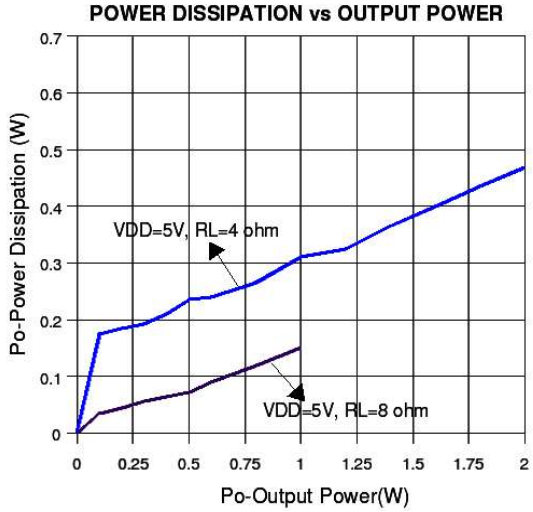
Notes:

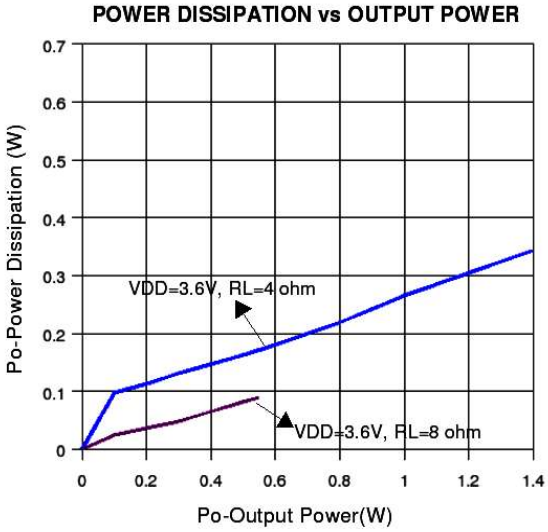
(1) C_i is connected in series with R_i as ac coupling for any common-mode input voltage measurements

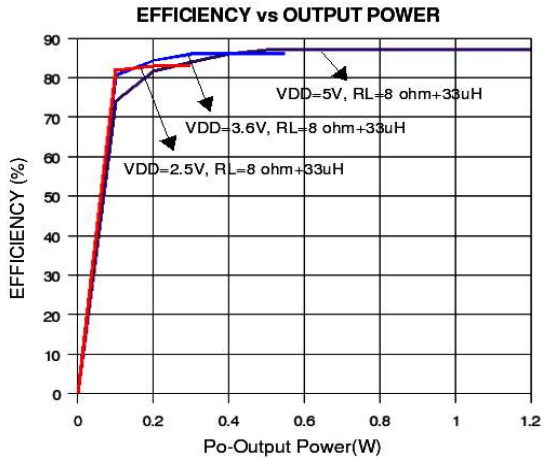
(2) A 33-μH inductor was placed in series with the load resistor to work as a small speaker for efficiency measurements

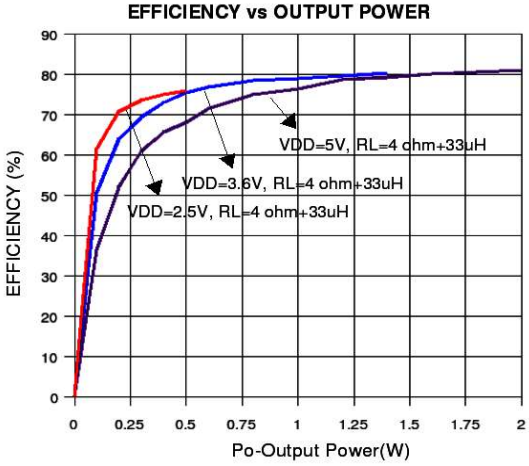
(3) The 30-kHz low-pass filter is required even if the analyzer has an internal low-pass filter. An RC low pass filter (100Ω, 47nF) is used on each output for the data sheet graphs

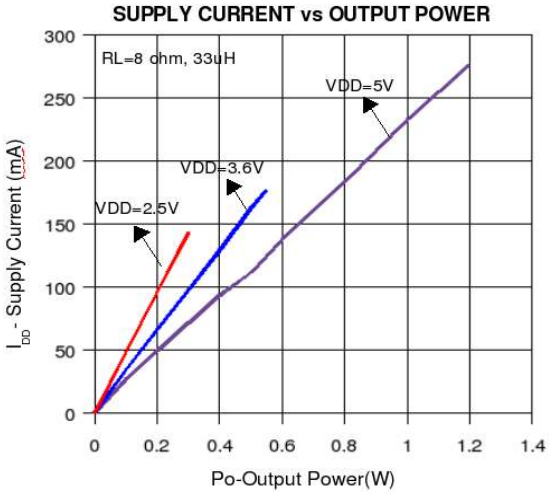
TYPICAL CHARACTERISTICS

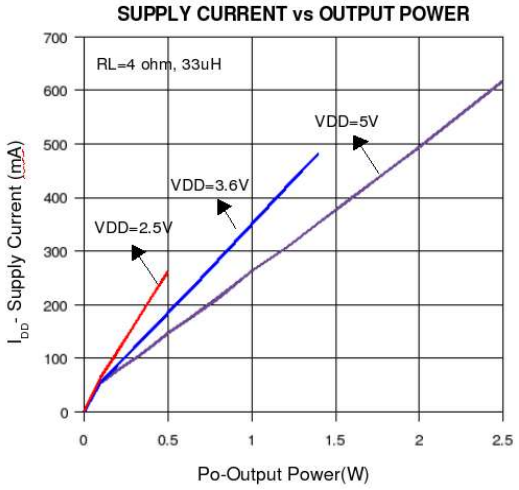


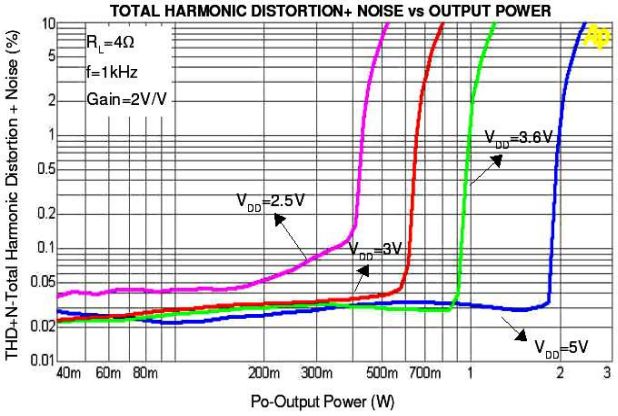


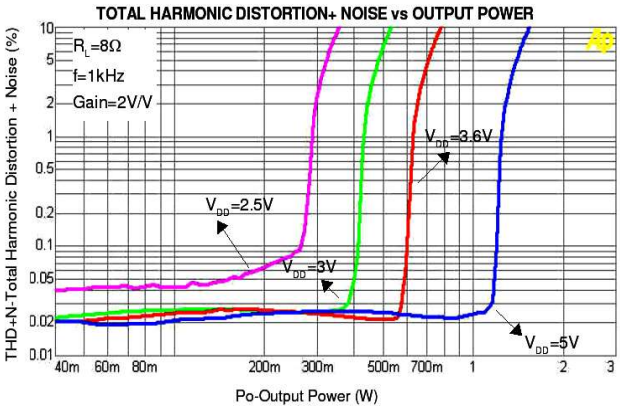


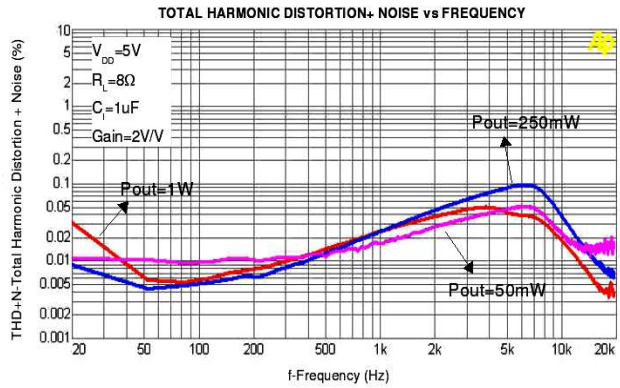


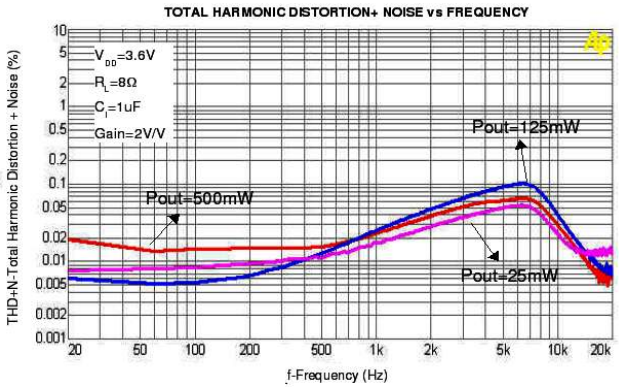


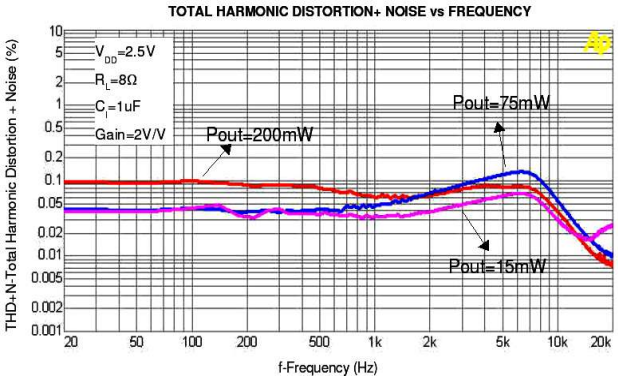


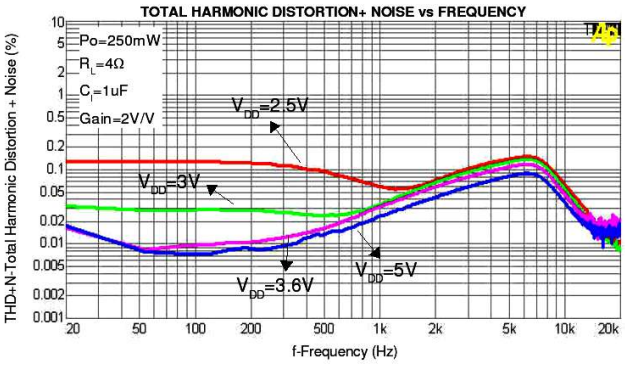

TOTAL HARMONIC DISTORTION+ NOISE vs OUTPUT POWER
THD+N-Total Harmonic Distortion + Noise (%)
Po-Output Power (W)
RL=4Ω
f=1kHz
Gain=2V/V
VDD=3.6V
VDD=2.5V
VDD=3V
VDD=5V


TOTAL HARMONIC DISTORTION+ NOISE vs OUTPUT POWER
THD+N-Total Harmonic Distortion + Noise (%)
Po-Output Power (W)
RL=8Ω
f=1kHz
Gain=2V/V
VDD=3.6V
VDD=2.5V
VDD=3V
VDD=5V

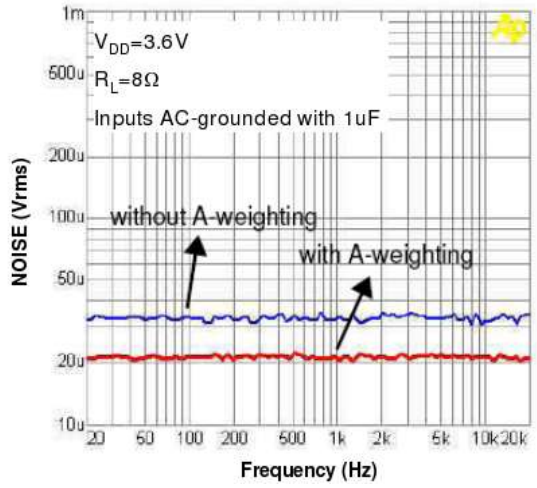

TOTAL HARMONIC DISTORTION+ NOISE vs FREQUENCY
THD+N-Total Harmonic Distortion + Noise (%)
f-Frequency (Hz)
VDD=5V
RL=8Ω
CI=1uF
Gain=2V/V
Pout=250mW
Pout=1W
Pout=50mW


TOTAL HARMONIC DISTORTION+ NOISE vs FREQUENCY
THD+N-Total Harmonic Distortion + Noise (%)
f-Frequency (Hz)
VDD=3.6V
RL=8Ω
CI=1uF
Gain=2V/V
Pout=125mW
Pout=500mW
Pout=25mW

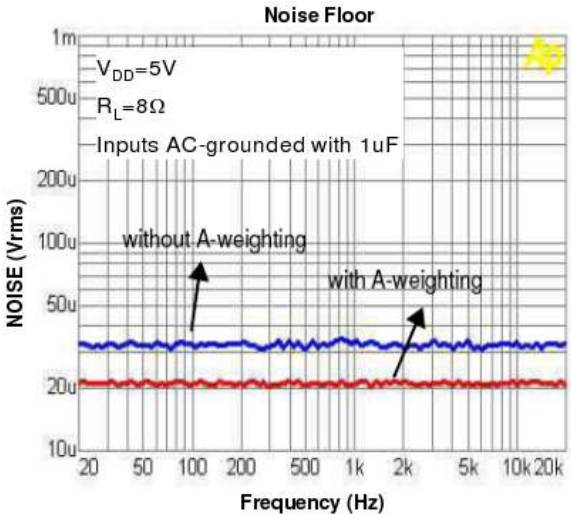

TOTAL HARMONIC DISTORTION+ NOISE vs FREQUENCY
THD+N-Total Harmonic Distortion + Noise (%)
f-Frequency (Hz)
VDD=2.5V
RL=8Ω
CI=1uF
Gain=2V/V
Pout=75mW
Pout=200mW
Pout=15mW


TOTAL HARMONIC DISTORTION+ NOISE vs FREQUENCY
THD+N-Total Harmonic Distortion + Noise (%)
f-Frequency (Hz)
Po=250mW
RL=4Ω
CI=1uF
Gain=2V/V
VDD=2.5V
VDD=3V
VDD=5V
VDD=3.6V

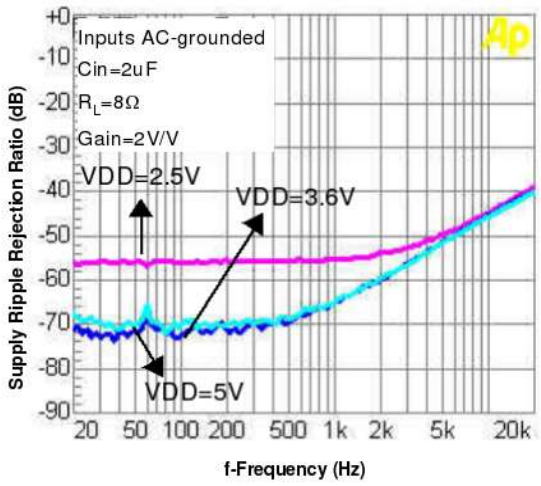
Noise Floor



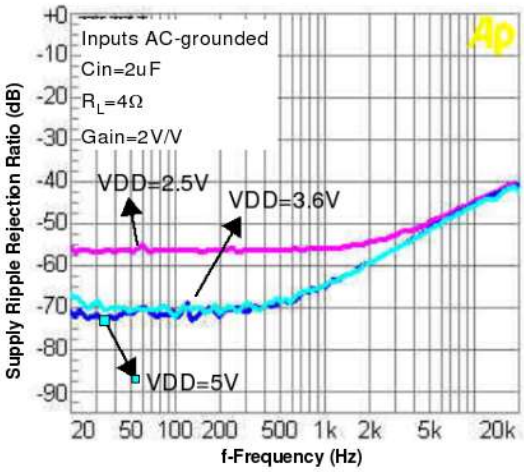
Noise Floor



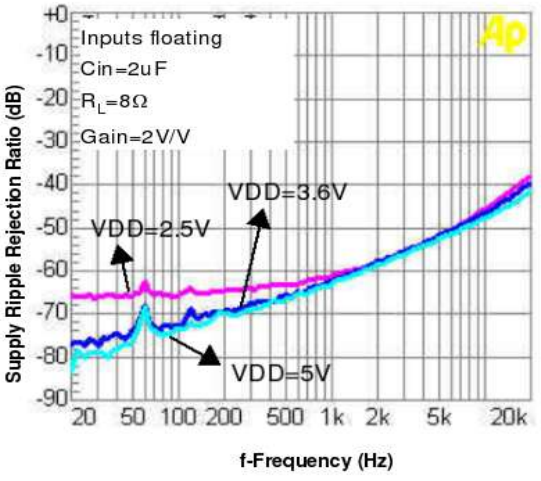
SUPPLY RIPPLE REJECTION RATIO vs. FREQUENCY



SUPPLY RIPPLE REJECTION RATIO vs. FREQUENCY



SUPPLY RIPPLE REJECTION RATIO vs. FREQUENCY



APPLICATION INFORMATION

Detail Description

The IT2012 is a stereo 2.5W filter-free audio power amplifier which consists of a pre-amplifier, a pulse width modulator and power stages configured in BTL. The fully differential design makes IT2012 cost-saving and optimized performance. The IT2012 can also operate with a single-ended input; however, operation in differential input configuration is strongly recommended when in a noisy environment, like a wireless handset, to ensure maximum noise rejection.

Protection Circuit

The IT2012 has built-in protection circuitry to prevent devices from overheating. OCP (Over Current Protection) sends a fault signal to turn the power stage off as output current exceeds its limit due to short circuit or shoot through. And OTP (Over Temperature Protection) shuts down the power stage when the junction temperature reaches 150℃. The IT2012 will return to normal operation and deliver the desired output power once all the faults are removed.

Input Capacitor (C_i)

The IT2012 does not require input coupling capacitors if the differential input voltage is biased from 0.5V to V_{DD}-0.8 V. If the input signal is not biased within the recommended common-mode range, or single-ended input voltage source is used, the input RC high pass filter is needed. The input capacitor is connected in series with input resistor to form a high pass filter, and its corner frequency is

$$f_c = \frac{1}{2\pi R_i C_i}$$

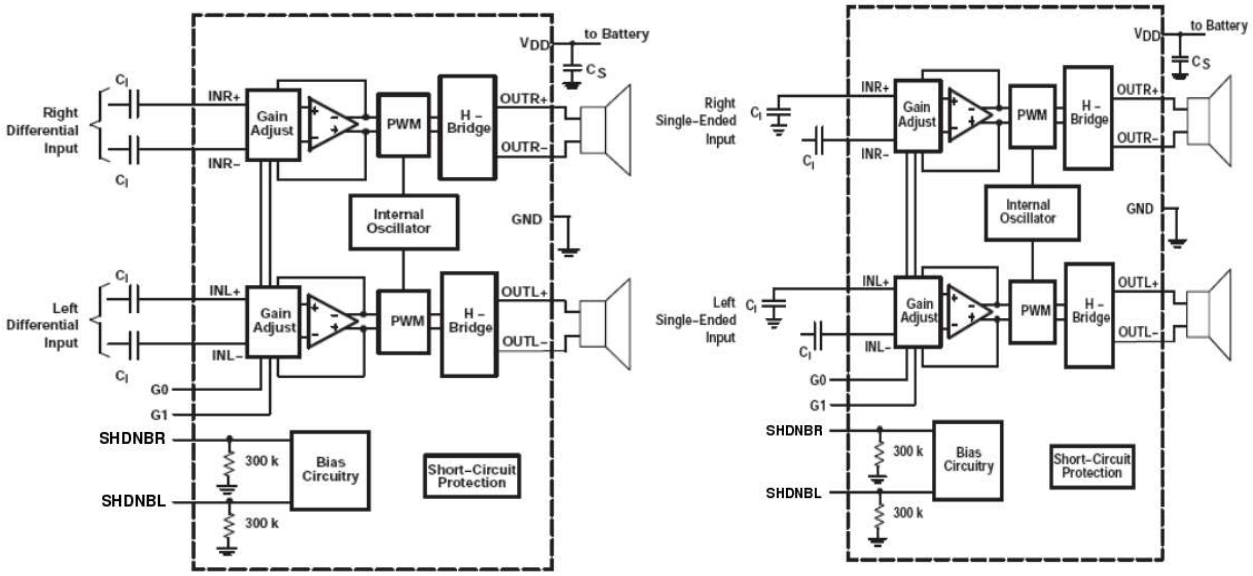
The value of corner frequency is important to consider as it directly affects the bass (low frequency) performance of the system. After choosing the value of input resistor for the desired amplifier gain, the value of input capacitor can be found out by

$$C_i = \frac{1}{2\pi R_i f_c}$$

If the corner frequency is within the audio band, the capacitors should have a tolerance of 10% or better, because any mismatch in capacitance causes an impedance mismatch at the corner frequency and below.

Table 1. Gain Setting

G1	G0	GAIN (V/V)	GAIN (dB)	INPUT IMPEDANCE (R_I)(kΩ)
0	0	2	6	157.5
0	1	4	12	80
1	0	8	18	42.5
1	1	16	24	12.5



Decoupling Capacitor (C_S)

The IT2012 is a high performance class-D audio amplifier that requires adequate power supply decoupling to ensure low THD. A good low equivalent-series-resistance (ESR) capacitor, typically 1 μF, must be placed as close as possible to the device V_{DD} lead for alleviating effect of high frequency, spikes or digital hash. For filtering lower frequency noise signals, a 10 μF or greater capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of the IT2012.

Optional Output Filter

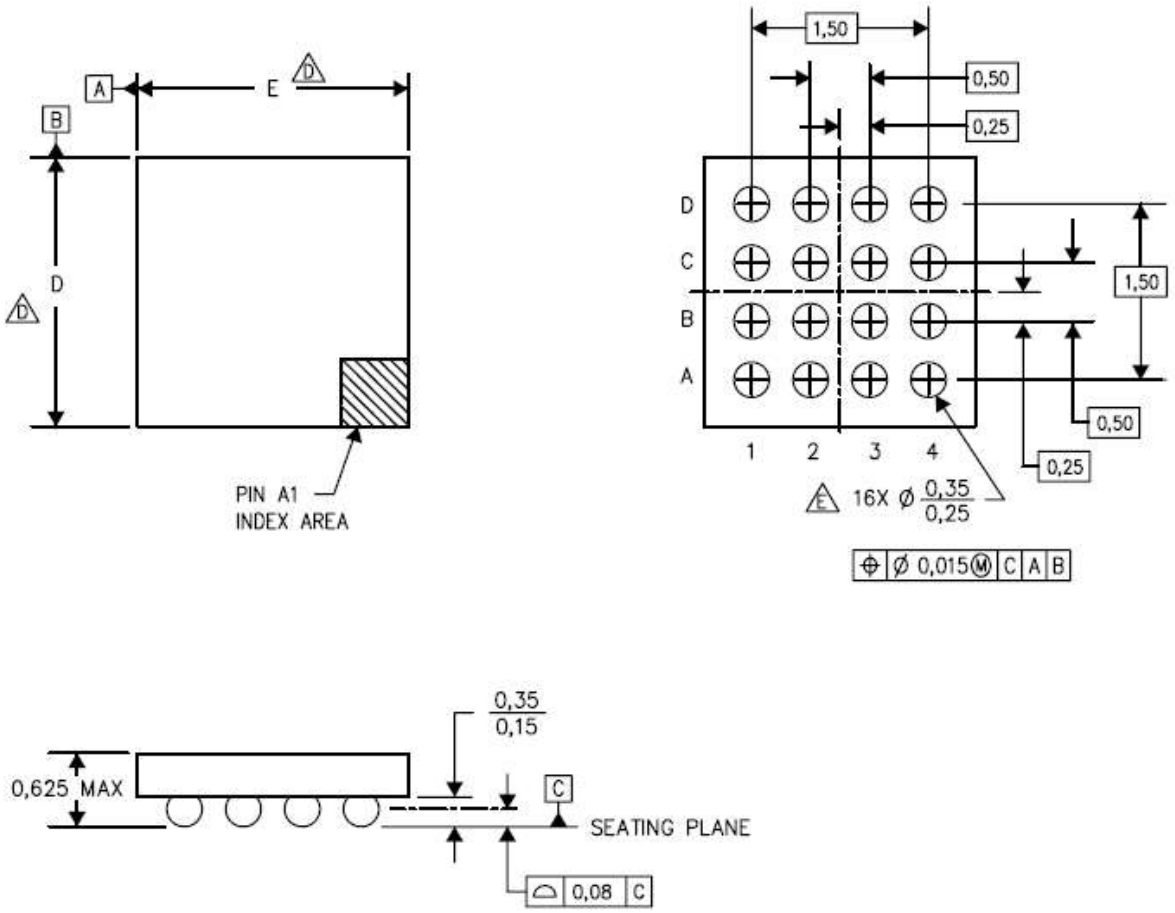
The IT2012 is a filter-free class-D amplifier, which needs no output filter for normal operation. An optional output filter can be used for filtering high frequency signal before the speaker. The output low pass filter consists of two inductors connected with positive and negative amplifier output respectively and a capacitor placed between positive and negative output. The cutoff frequency of this LC low pass filter is

$$f_c = \frac{1}{2\pi\sqrt{LC}}$$

Two 15 μH inductor and a 2 μF capacitor can be used for a 4Ω load; two 33 μH inductor and an 1 μF capacitor can be used for a 8Ω load. Cellular phones and portable electronic devices are great applications for filter-free class-D as the track length between the amplifier and the speaker is short. There is usually no need for an EMI filter. A ferrite bead can often be used in order to lower radiated emissions as much as possible when used in filter-free mode.

PACKAGE INFORMATION

WCSP



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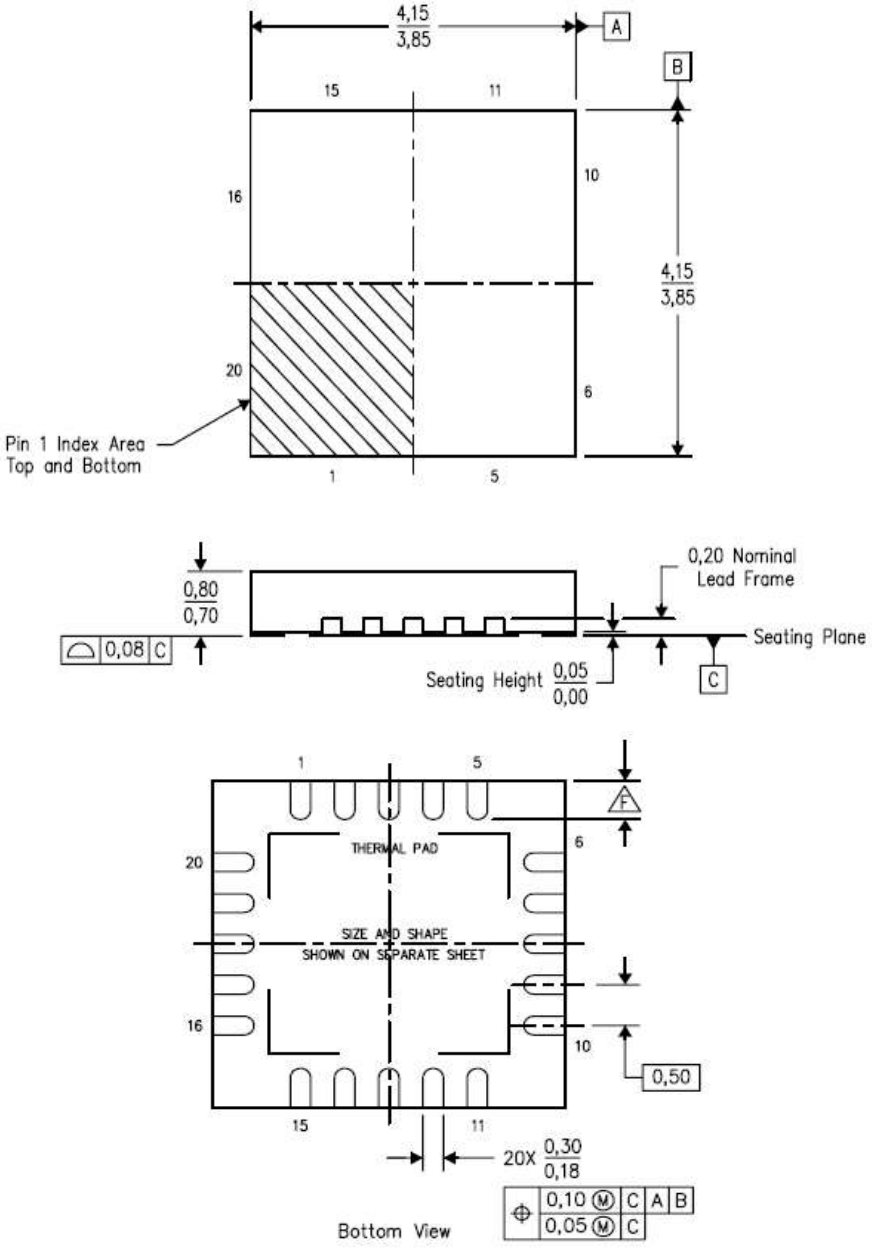
4,15
3,85
A
B
15
11
16
10
20
6
1
5
Pin 1 Index Area
Top and Bottom
0,80
0,70
0,08 C
0,20 Nominal
Lead Frame
Seating Plane
Seating Height 0,05
0,00
C
THERMAL PAD
SIZE AND SHAPE
SHOWN ON SEPARATE SHEET
F
0,50
20X 0,30
0,18
0,10 M C A B
0,05 M C
Bottom View