BL6331

MONAURAL 3W Non-Clip DIGITAL AUDIO POWER AMPLIFIER

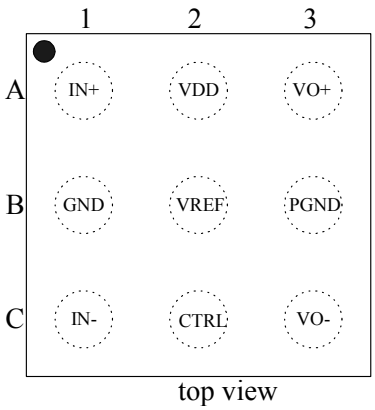
Features

- Professional non-clip output control function:
  Maximum non-clip output
  800mW(V_{DD}=4.2v, R_L=8Ω,NC1 mode)
- Four mode can be selected with CTRL terminal: NC1(NonClip1), NC2 (nonClip2), NC_OFF (NonClip-off), shutdown
- Maximum output (work in nonclip-off mode)
  3W（V_{DD}=5.0V, R_L=4Ω, THD+N=10%）
  0.82W（V_{DD}=3.6V, R_L=8Ω, THD+N=10%）
- THD+N
  0.06% (V_{DD} = 3.6V, R_L=8Ω, P_O=0.4W, 1kH_Z)
- Efficiency With an 8Ω Speaker:
  88% at 400 mW
  80% at 150 mW
- Optimized PWM Output Stage Eliminates LC Output Filter
- Improved PSRR (−75 dB) and Wide Supply Voltage (2.5 V to 5.5 V) Eliminates Need for a Voltage Regulator
- Over-current and Thermal Protection function
  Low voltage Malfunction prevention function
- Available in space-saving package:
  9-bump WLCSP

Applications

- Mobile phone, PDA
- MP3/4, PMP, GPS
- Portable electronic devices

Pin Diagrams



top view

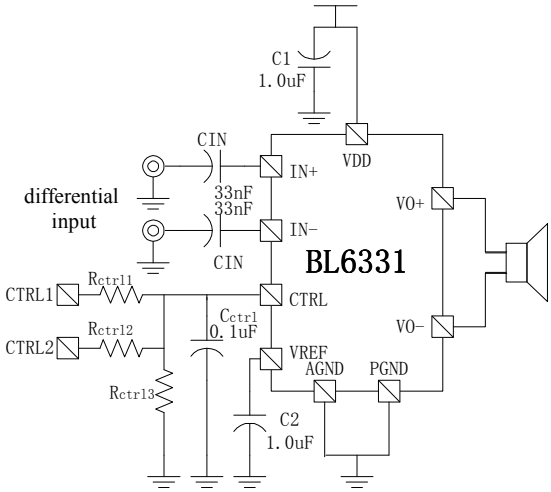
General Description

BL6331 is a 3-W (V_{DD}=5.0V, R_L=4Ω) high efficiency filter-free class-D audio power amplifier in a wafer chip scale package (WLCSP).

BL6331 has a “Professional non-clip output control circuit” which reducing distortion of output signal due to either the over level input signal or power supply voltage down with battery,

Features like 88% efficiency, −75dB PSRR, and improved RF-rectification immunity make the BL6331 ideal for cellular handsets. In cellular handsets, the earpiece, speakerphone, and melody ringer can each be driven by the BL6331.

Application Circuit

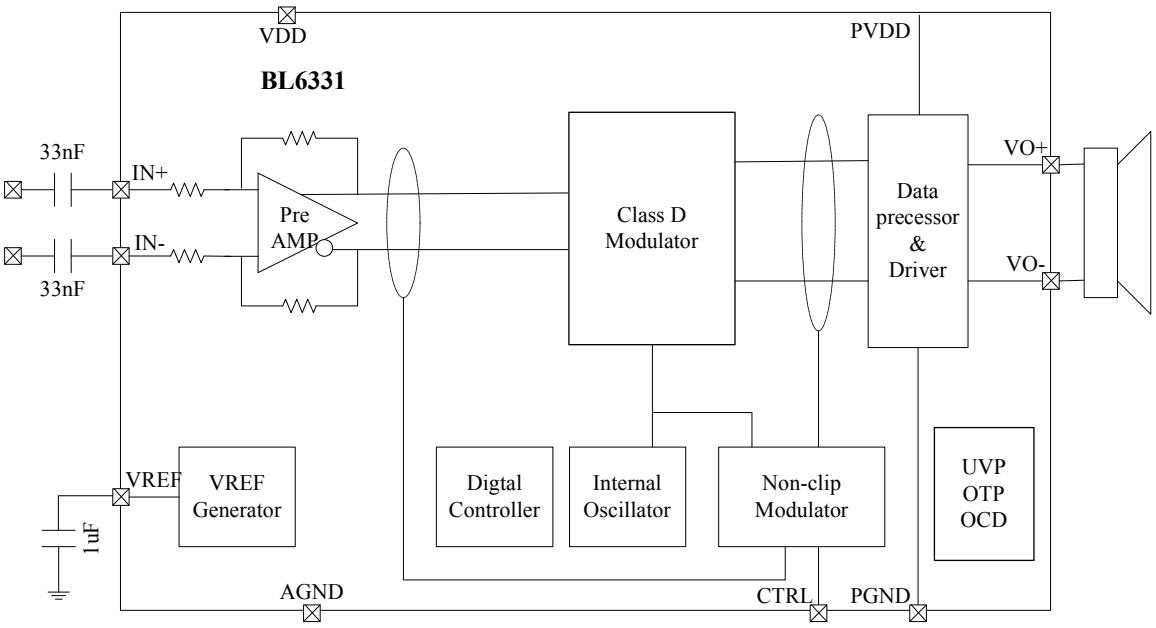


Pin Description

Notice: CTRL terminal function is described in page 4.

PIN #	Name	Description
A1	IN+	Positive differential input
A2	VDD	Power Supply
A3	VO+	Positive BTL output
B1	AGND	Analog Ground
B2	VREF	Bypass capacitor connected
B3	PGND	Power Ground
C1	IN-	Negative differential input
C2	CTRL	Mode select
C3	VO-	Negative BTL output

Function Block Diagram



Description of operating functions &Component Recommended

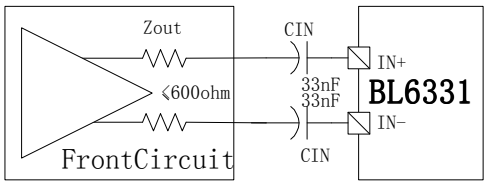
1、 Digital amplifier function

BL6331 The BL6311 is a 3-W high efficiency filter-free class-D audio power amplifier in a wafer chip scale package (WLCSP) that requires only four external components.

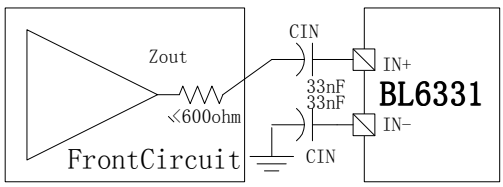
- Use a capacitor (1μF or more) with low enough ESR between VDD and GND as a decoupling capacitor.
- Use a capacitor (1μF) between VREF and GND to stabilize the VDD/2 Common-mode voltage.
- Use a capacitance of 0.1μF or less (e.g. 33nF), ±10% as a DC-cut capacitor (C_{IN}) to reduce pop noise.

For a differential input, input signal to IN+ and IN- pins via DC-cut capacitor (C_{IN}). For a single-ended input, input a signal to IN+ via DC-cut capacitor (C_{IN}). At this time, IN- pin should be connected to AGND via a DC-cut capacitor (C_{IN}) with the same capacitance.

Differential input



Singe input



Notice：Please start up the former source circuit first to stabilize the DC bias point and then cancel the shutdown state of BL6331. The time required to stabilize the voltage is decided by C_{IN}, Z_{OUT} of front circuit and the input impedance of BL6331 (28.6K Ω typ.). The cut-off frequency of an input signal is 169Hz at C_{IN}=33nF.

2、 Non-clip control Function

The non-clip function can control the gain of class-D amplifier to obtain a maximum output level (P_o =800mW,V_{DD}=4.2v, R_L=8Ω) without distortion. When the output clip which is arisen from the over lever input signal or power supply voltage down with buttery is detected, BL6331 lowers the Gain of the digital amplifier to an appropriate value so as not to cause the clipping at the differential signal output. This is the difference from the traditional AGC (Auto Gain Control) or ALC (Auto Level Control).

The non-clip performance is depended on three factors:

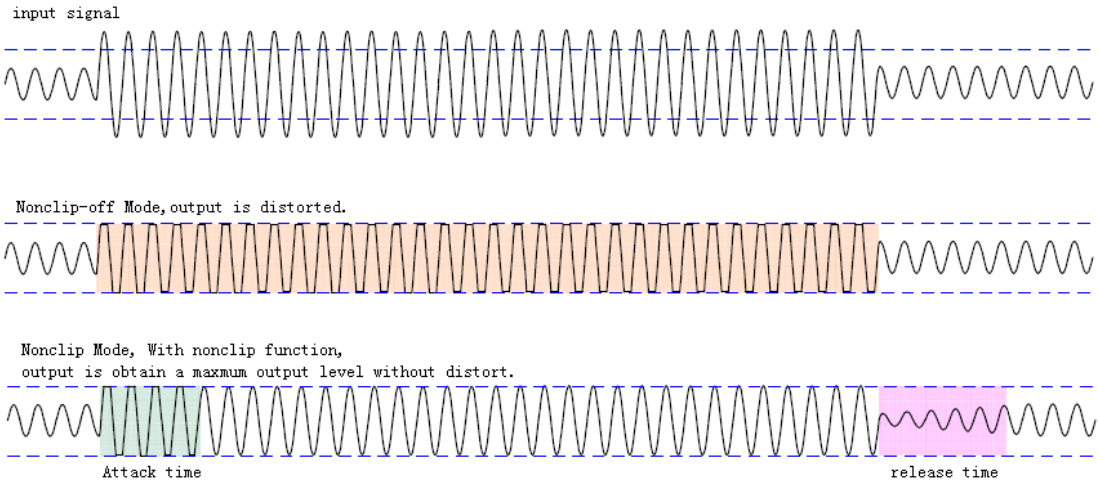
1、TH_{NC}(the threshold THD+N of non-clip) ： The non-clip output control circuit detects the THD+N of output. When the THD+N of output is up to the threshold THD+N of non-clip (0.5%), the amplifier gain is adjusted.

2、t_{AT} (attack time) ： The time from the output clip is detected to the amplifier gain is adjusted. Normally, attack time is 1ms～100ms。

3、t_{RT} (release time)： The time from the THD+N of output is lower than TH_{NC} to the amplifier gain is back to normal level. Normally, release time is 20ms～5s。

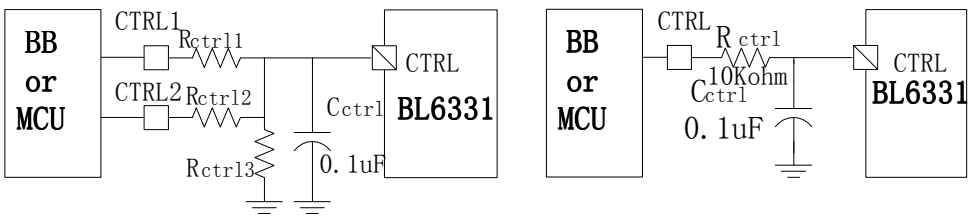
The classic music is in well harmonious with long t_{AT} and t_{RT}. The rock and roll music is in well harmonious with short t_{AT} and t_{RT}.

The non-clip performance is shown in the following graph：



The attack time and release time of Non-clip control are fixation two levels, and selects with the CTRL terminal.

CTRL terminal function



CONFIG 1 of CTRL　　CONFIG 2 of CTRL

In CONFIG 1 of CTRL, by connection external resistors (Rctrl1、Rctrl2 and Rctrl3: Accuracy of 1%) to CTRL terminal, and impression setting threshold voltage of each mode to CTRL terminal, the following can be set: NonClip1, Nonclip2, Nonclip-off, and shutdown mode.

CTRL1	CTRL2	Mode
H	H	NonClip1
H	GND	NonClip2
GND	H	NonClip-off
GND	GND	SHUTDOWN

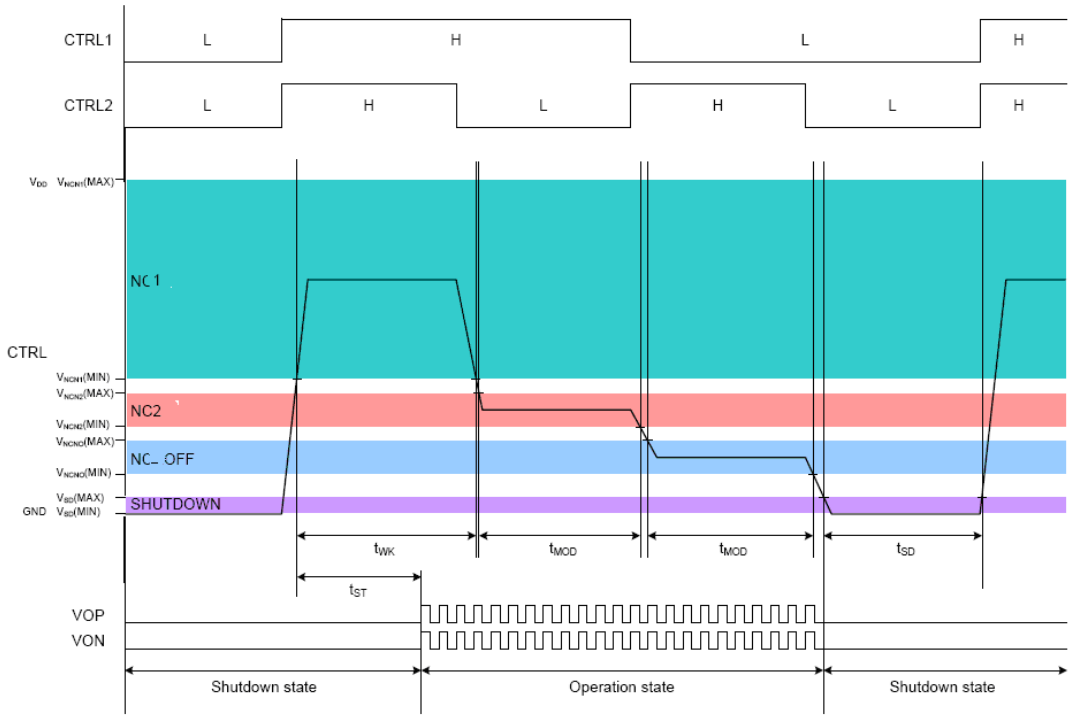
"H" level indicates a microcomputer's I/O port H level output voltage. "GND" level indicates a GND level output voltage. According to different "H" level output voltage of microcomputer, different external resistors (Rctrl1、Rctrl2 and Rctrl3) should be taken.
Connect the CTRL terminal to the GND through a capacitor C_{ctrl}.

"H"level output voltage of MCU or BB	1.8V	2.6V	3.0V	3.3V	5.0V
Rctrl1	27kΩ	33KΩ	33KΩ	33KΩ	56KΩ
Rctrl2	56KΩ	68KΩ	68KΩ	68KΩ	120KΩ
Rctrl3	82KΩ	27KΩ	22KΩ	18KΩ	15KΩ

In CONFIG 2 of CTRL, A RC filter with time constant of 1m sec or more is used to eliminate noise at transmission side such as Micon etc. (Example. R_{ctrl}=10kΩ and C_{ctrl}=0.1Mf). Only the following two mode can be set: NonClip1, and shutdown mode. When CTRL1 is "H" level voltage, BL6331 work in NonClip1 mode. When CTRL1 is "L" level voltage, BL6331 work in shutdown mode.

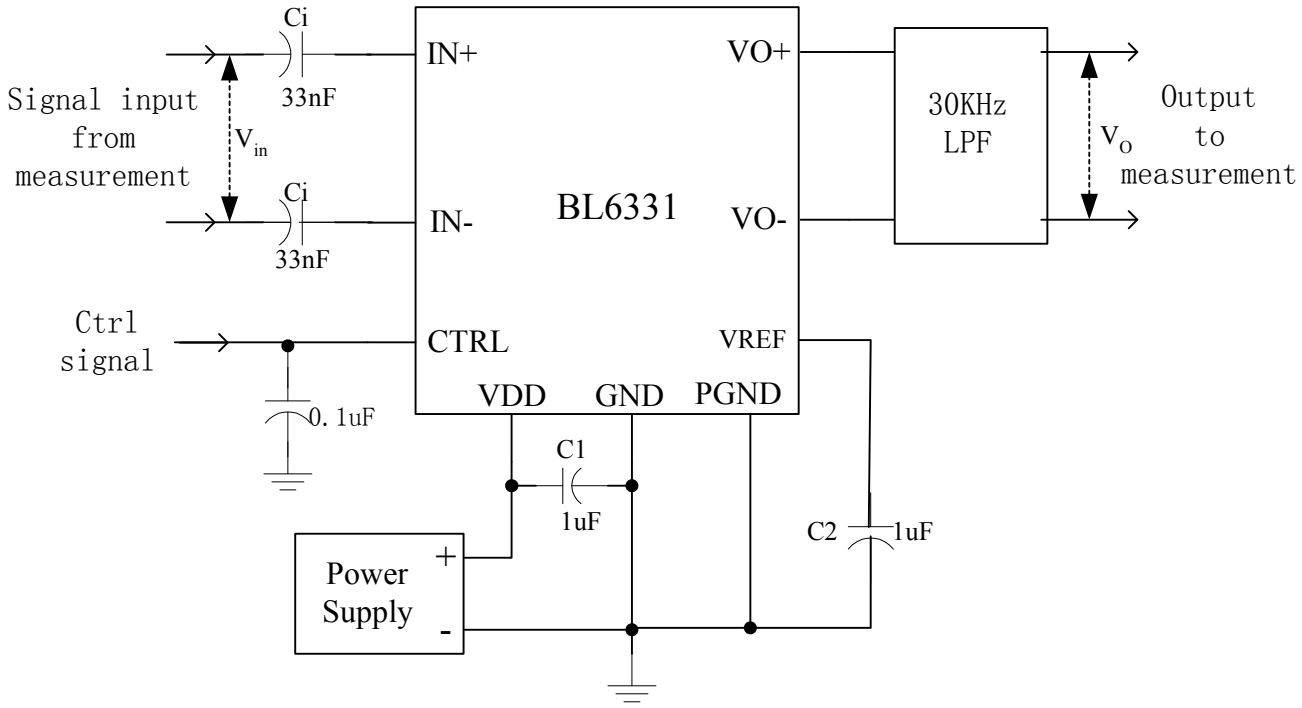
Work mode switch

When CTRL terminal is connected to GND potential, BL6331 work in "shutdown" mode. The entire circuit function stop and its current consumption becomes the lowest. **At startup, the CTRL must be first set to "Nonclip1" mode（CTRL1 and CTRL2 is "H"）。The shutdown mode is cancelled and IC starts up after startup time (t_{stup}). Then, by setting the voltage of CTRL1 or CTRL2，IC can switch to nonclip2 or nonclip-off MODE.** When IC works in shutdown mode, the IC must restart after t_{SD}. The switching of work mode is shown in the following graph.

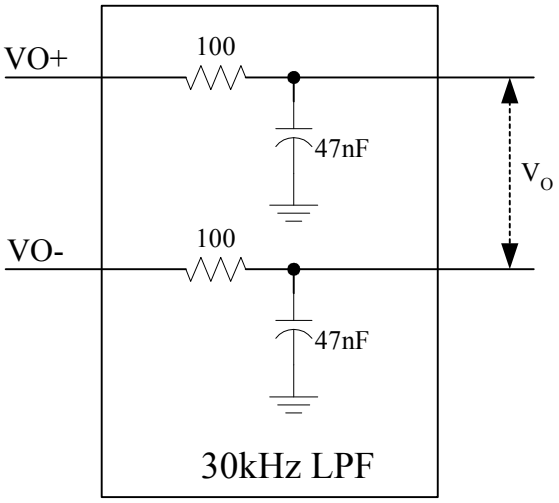


The timing of work mode switch

Test Circuit



BL6331 Test Circuit



30-kHz LPF for BL6331 test

Notes: 1>. C_1 should be placed as close as possible to VDD/GND pad of the device
2>. Ci should be shorted for any Common-Mode input voltage measurement
3>. A 33uH inductor should be used in series with R_L for efficiency measurement
4>. The 30 kHz LPF (shown in figure 5) is required even if the analyzer has an internal LPF

Absolute Maximum Ratings

Item	Symbol	Min.	Max.	Unit
Power supply terminal voltage range	V_{DD}	-0.3	6.0	V
Input terminal voltage range (IN+, IN-, CTRL)	V_{IN}	Vss-0.3	V_{DD}+0.3	V
Allowable dissipation (Ta=25℃)	P_{D25}		1.67	W
Allowable dissipation (Ta=85℃)	P_{D85}		0.67	W
Junction Temperature	T_{JMAX}		125	℃
Storage Temperature	T_{STG}	-50	125	℃

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

RECOMMENDED OPERATING CONDITIONS

Item	Symbol	Min.	Typ.	Max.	Unit
Positive DC Supply Voltage	V_{DD}	2.5	3.6	5.5	V
Analog Input Voltage (IN+, IN-, CTRL)	V_{IN}	0		V_{DD}	V
Operating Temperature Range	T_A	-40		85	℃
Speaker Impedance	R_L	4			Ω

ELECTRICAL CHARACTERISTICS

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Class D Amplifier performance						
Maximum output (NC_OFF)	Po	R_L=4Ω, V_{DD}=5V f=lkHz,		3.0		W
		R_L=8Ω, V_{DD}=3.6V THD+N=10%		0.82		W
Total Harmonic Distortion Rate (BW:20kHz)	THD+N	R_L=4Ω, Po=0.65W, f=lkHz		0.06		%
		R_L=8Ω, Po=0.4W, f=lkHz		0.06		%
Signal/Noise Ratio (BW:20kHz A-Filter)	SNR	Av=18dB		84		dB
Power supply rejection ratio	PSRR	217Hz		-75		dB
Maximum Efficiency	η	R_L=8Ω, Po=0.6W		88		%
		R_L=8Ω, Po=0.15W		80		%
Output offset voltage	Vos			±5		mV
Frequency characteristics	F_{SW}	V_{DD}=2.5V to 5.5V		500		KHz
Voltage Gain	A_V			18		dB
Quiescent Current	I_{DD}	V_{DD}=3.6V,no input, no load		2.0		mA
Shutdown Current	I_{SD}	CTRL=0		0.1		uA
Input impedance	Z_I			28.6		kΩ
Nonclip Modulator performance						
Nonclip maximum attenuation gain	Aa			-10		dB
Nonclip1 mode setting threshold voltage	V_{NC1}		1.20		V_{DD}	V
Nonclip2 mode setting threshold voltage	V_{NC2}		0.8		1.1	V

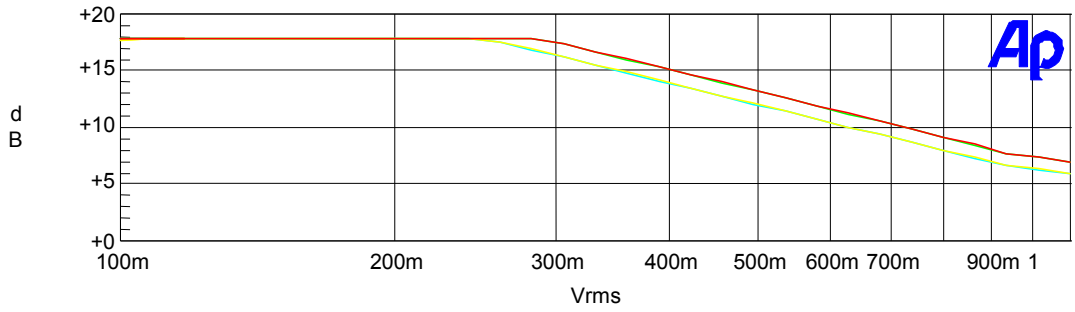
Nonclip-off mode setting threshold voltage	V_{NC_OFF}		0.36		0.68	V
Shutdown mode setting threshold voltage	V_{SD}		0		0.14	V
Attack time of Nonclip1 mode	t_{AT1}	V_{DD}=3.6V,g=10dB		50		ms
Release time of Nonclip1 mode	t_{RL1}	V_{DD}=3.6V,g=10dB		2.0		s
Attack time of Nonclip2 mode	t_{AT2}	V_{DD}=3.6V,g=10dB		14		ms
Release time of Nonclip2 mode	t_{RL2}	V_{DD}=3.6V,g=10dB		1.0		s
Wake-up mode setting time	t_{WK}		6			ms
Start time (Shutdown release)	t_{STUP}		3.5			ms
Shutdown setting time	T_{SD}	Ta(Min.)=-20℃	50			ms
		Ta(Min.)=-30℃	80			ms
Each mode setting time (Except shutdown)	t_{MOD}		0.1			ms

ORDERING INFORMATION

Device	Marking	Package	Shipping
BL6331CP	6331	CSP9	3000 / Tape & Reel

Typical Performance Characteristics

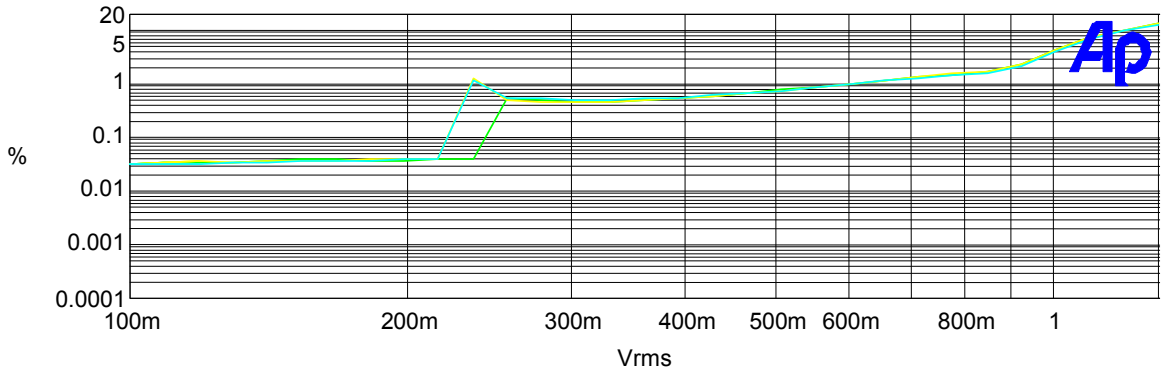
Audio Precision



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.Ratio B	Left	8ohm_mode1
2	1	Green	Solid	1	Analyzer.Ratio B	Left	no load_mode1
3	1	Yellow	Solid	1	Analyzer.Ratio B	Left	8ohm_mode2
4	1	Red	Solid	1	Analyzer.Ratio B	Left	no load_mode2

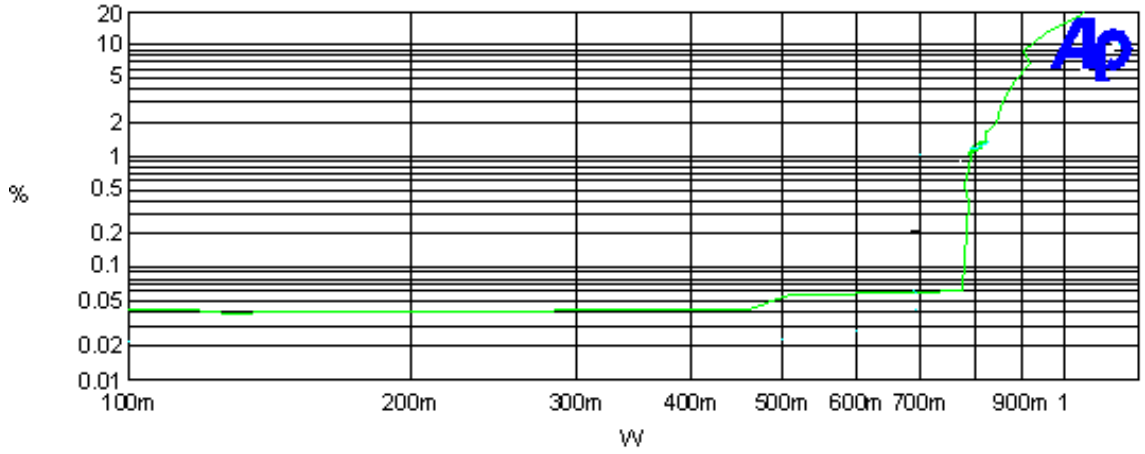
Figure 1 GAIN VS Input Voltage @NC1(mode1)\NC2(mode2) VDD=3.6V RL=8ohm

Audio Precision (3.6v 8ohm)



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.THD+N Ratio B	Left	mode2
2	1	Green	Solid	1	Analyzer.THD+N Ratio B	Left	mode1_1
3	1	Yellow	Solid	1	Analyzer.THD+N Ratio B	Left	mode1_2

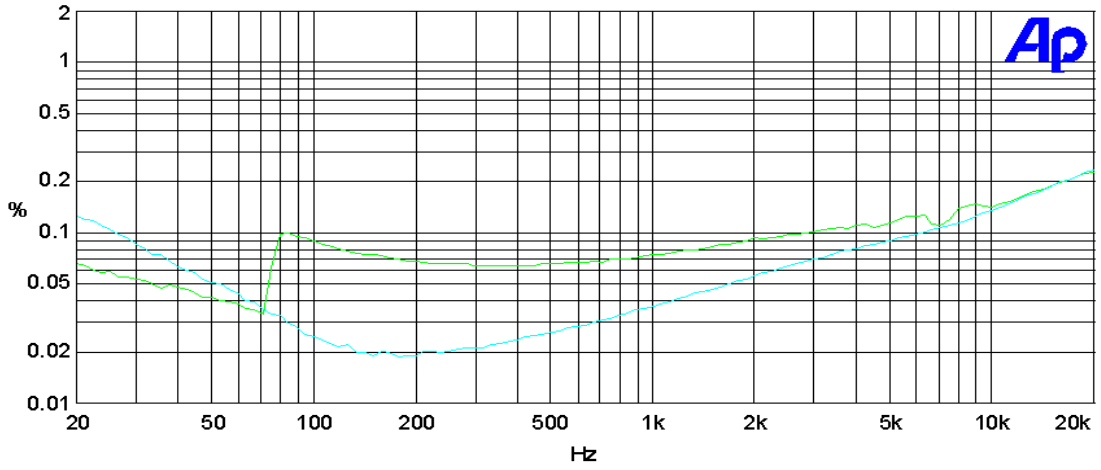
Figure 2 THDN VS Input Voltage @ NC1(mode1)\NC2(mode2) VDD=3.6V RL=8ohm



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Green	Solid	1	Analyzer.THD+N Ratio B	Left	bl6311m11_csp

thdn_po.ats2

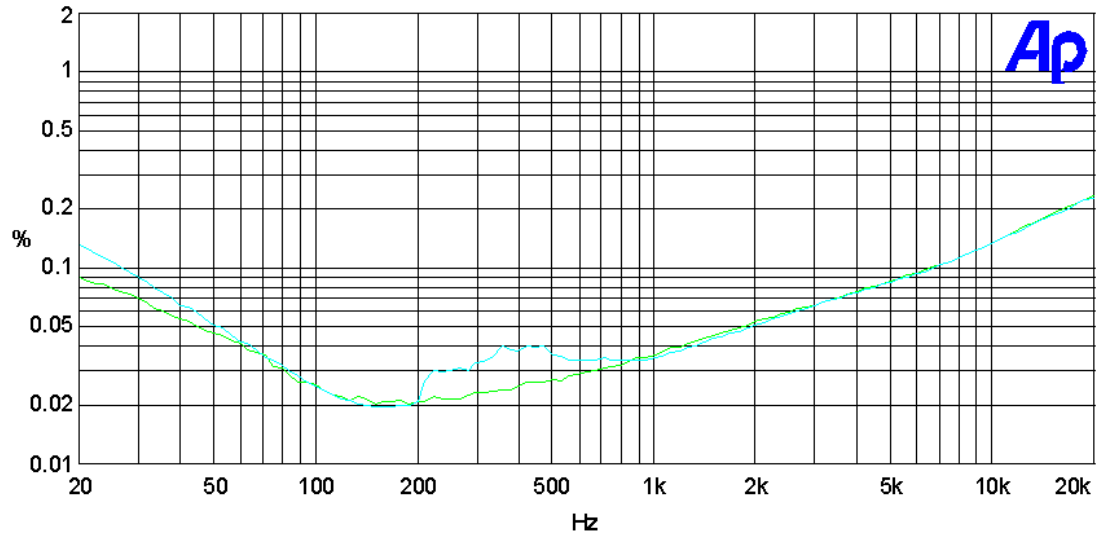
Figure 3 THND VS PO @NC1 VDD=4.2V RL=8ohm



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.THD+N Ratio B	Left	VDD=5V RL=4OHM+30uH
2	1	Green	Solid	1	Analyzer.THD+N Ratio B	Left	VDD=3.6V RL=4OHM+30uH

THDN_F.ats 2

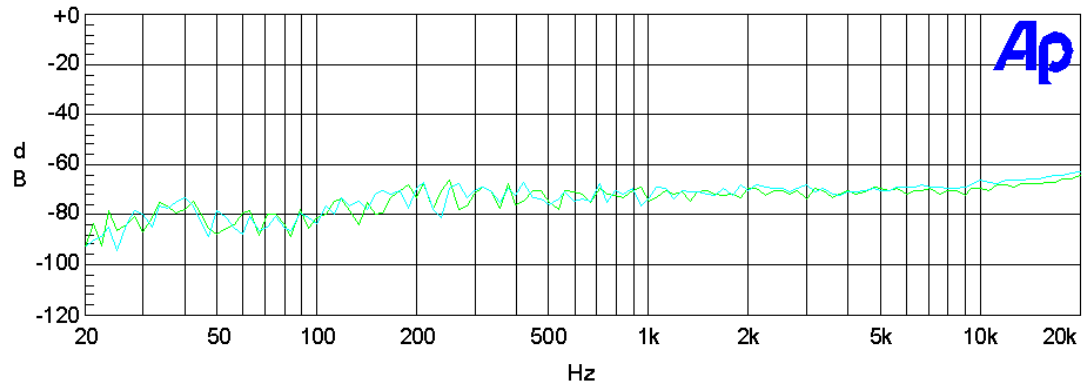
Figure 4 THND VS Frequency @NC_OFF RL=4ohm



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.THD+N Ratio B	Left	VDD=3.6V RL=8OHM+30uH
2	1	Green	Solid	1	Analyzer.THD+N Ratio B	Left	VDD=5V RL=8OHM+30uH

THDN_F.ats 2

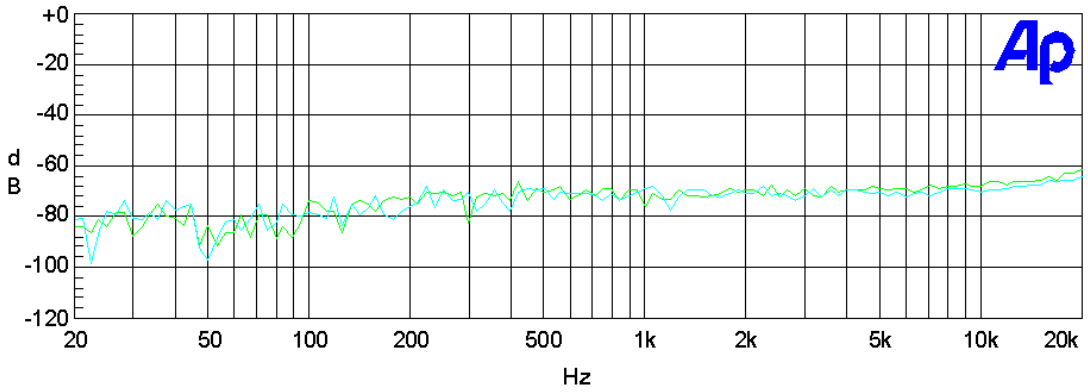
Figure 5 THND VS Frequency @NC_OFF RL=8ohm



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.Crosstalk B	Left	VDD=5V RL=4OHM+30uH
2	1	Green	Solid	1	Analyzer.Crosstalk B	Left	VDD=3.6V RL=4OHM+30uH

psrr_f.ats2

Figure 6 PSRR VS Frequency @NC_OFF RL=4ohm



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.Crosstalk B	Left	VDD=3.6V RL=8OHM+30uH
2	1	Green	Solid	1	Analyzer.Crosstalk B	Left	VDD=5V RL=8OHM+30uH

psrr_f.ats2

Figure 7 PSRR VS Frequency @NC_OFF RL=8ohm

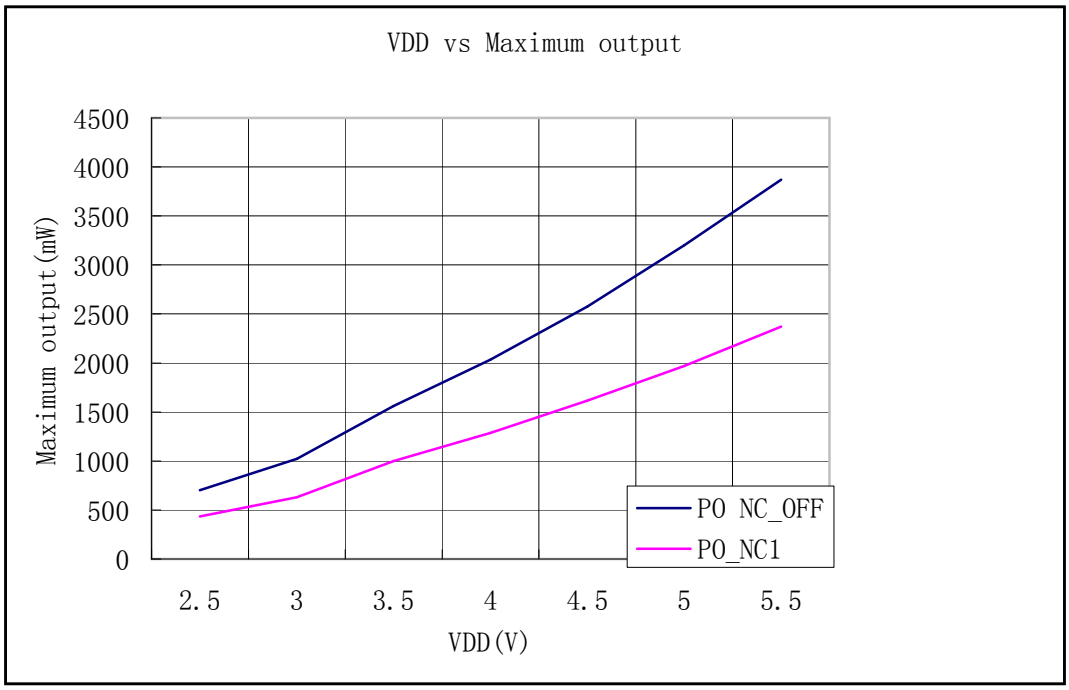


Figure 8 Maximum output VS VDD @ RL=4ohm

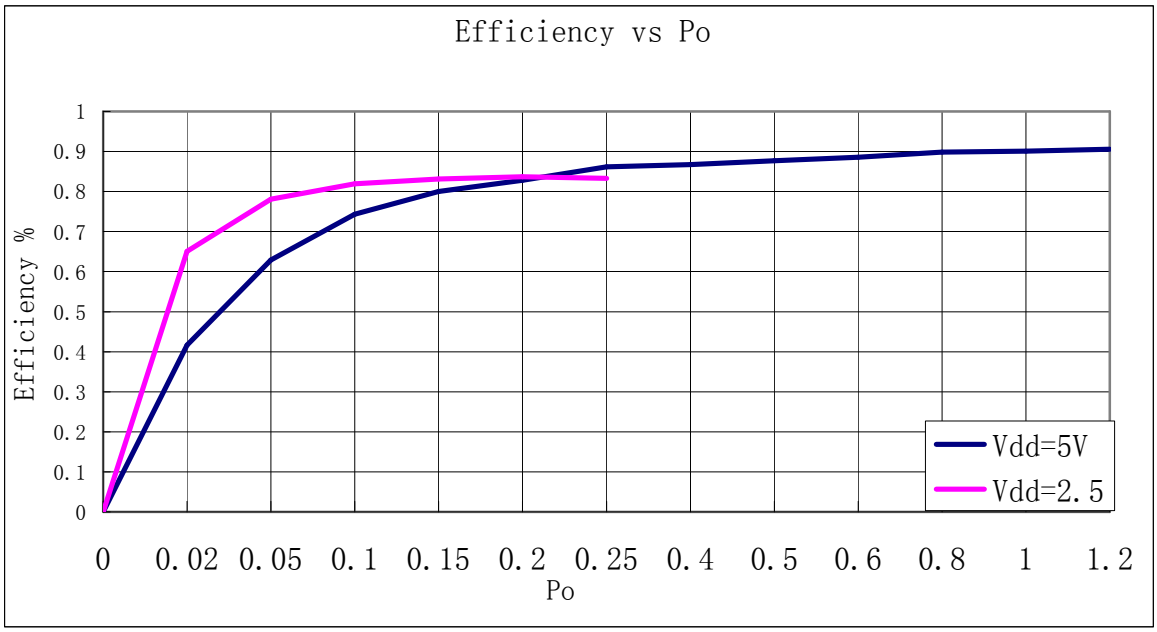
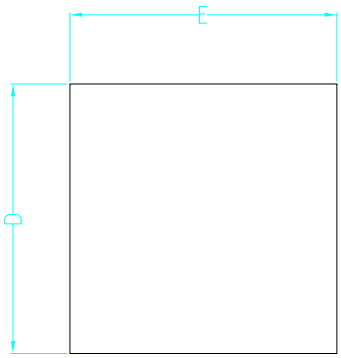


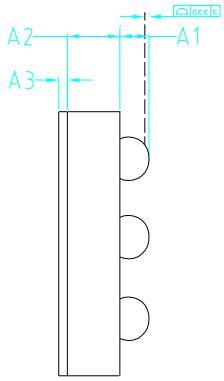
Figure 9 Efficiency VS Po @ RL=8ohm

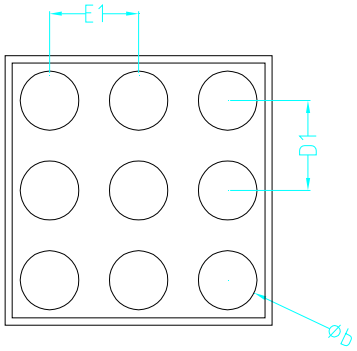
PACKAGE OUTLINE DIMENSIONS

CSP9



TOP VIEW





BOTTOM VIEW

9 Bump WLCSP Dimensions (mm)

REF	MIN	TYP	MAX
A1	0.215	0.235	0.255
A2	0.355	0.380	0.405
A3	0.020	0.035	0.050
D	1.485	1.500	1.515
D1		0.500	
E	1.485	1.500	1.515
E1		0.500	
b	0.300	0.320	0.340
ccc		0.080	