内置BOOST升压和防破音功能的9.0W D类音频功率放大器

9.0W Anti-Clipping Mono Class D Audio Amplifier with Boost Converter

■ FEATURES

・Anti-Clipping Function (ACF)
・Filter-less Modulation, Eliminating Output Filter
・Output Power
HT8692H/S: 9W (VBAT=4.2V, PVDD = 7.5V, RL=3Ω, THD+N=10%)
HT8692: 8.0W (VBAT=4.2V, PVDD = 7.0V, RL=3Ω, THD+N=10%)
HT8692: 6.5W (VBAT=4.2V, PVDD = 7.0V, RL=4Ω, THD+N=10%)
HT8692: 3.5W (VBAT=4.2V, PVDD = 7.0V, RL=8Ω, THD+N=10%)
・Power Supply
-Boost Input VBAT：2.5V to 5.5V
-Boost Output PVDD：VBAT to 7.5V
・Adjustable BOOST Output Voltage
・Class AB / Class D
・Over Current Protection, Thermal Protection, Low voltage malfunction prevention function included
・Pb-Free Packages , SOP16L-PP

・防削顶失真功能(Anti-Clipping Function, ACF)
・免滤波器数字调制，直接驱动扬声器
・输出功率
HT8692H/S: 9W (VBAT=4.2V, PVDD = 7.5V, RL=3Ω, THD+N=10%)
HT8692: 8.0W (VBAT=4.2V, PVDD = 7.0V, RL=3Ω, THD+N=10%)
HT8692: 6.5W (VBAT=4.2V, PVDD = 7.0V, RL=4Ω, THD+N=10%)
HT8692: 3.5W (VBAT=4.2V, PVDD = 7.0V, RL=8Ω, THD+N=10%)
・电源
-升压输入VBAT：2.5V至5.5V
-升压输出PVDD：VBAT至7.5V
・BOOST输出电压可调
・AB/D类可切换
・保护功能:过流/过热/欠压异常保护功能
・无铅封装，SOP16L-PP

■ APPLICATIONS

・Bluetooth Speakers ・Portable Speakers
・2.1 Channel Speakers ・Megaphone
・iphone/ipod/ipod docking ・MP4/GPS
・Tablet PC/Note Book ・Smart Phones
・LCD TV/Monitor ・Portable Gamers

・蓝牙音箱 ・便携式音箱
・2.1声道小音箱 ・扩音器
・iphone/ipod/ipod docking ・MP4，导航仪
・平板电脑，笔记本电脑 ・智能手机
・小尺寸LCD电视/监视器 ・便携式游戏机

■ ORDERING INFORMATION

Part Number	Package Type	Marking	Operating Temperature Range	MOQ/Shipping Package
HT8692SPET	SOP16L-PP	HT8692SP UVWXYZ[1]	-40℃～85℃	50pcs Tube
HT8692SPER	SOP16L-PP	HT8692SP UVWXYZ	-40℃～85℃	2500pcs Tape and Reel
HT8692HSPET	SOP16L-PP	HT8692SP UVWXYZ	-40℃～85℃	50pcs Tube
HT8692HSPER	SOP16L-PP	HT8692SP UVWXYZ	-40℃～85℃	2500pcs Tape and Reel
HT8692SSPET	SOP16L-PP	HT8692SSP UVWXYZ	-40℃～85℃	50pcs Tube
HT8692SSPER	SOP16L-PP	HT8692SSP UVWXYZ	-40℃～85℃	2500pcs Tape and Reel

[1] UVWXYZ is production tracking code

■ DESCRIPTION

HT8692 integrates a boost converter with a filter-less stereo class D audio power amplifier to provide 6.5W continuous power into a 4Ω speaker, or 8.0W continuous power into a 3Ω speaker. Meanwhile, the boost output voltage is adjustable.

HT8692 features Anti-Clipping Function (ACF) which detects output signal clip due to the over input signal and suppresses the output signal clip automatically. Also, the ACF function can adapt the output clip caused by power supply voltage down with battery. It can significantly improve the sound quality, creating a very comfortable musical enjoyment, and to protect the speakers from overload damage. It also supplies ACF OFF mode.

Class AB amplifier mode is also available for HT8692. Once the EMI Interference from class D and Boost Converter becomes an annoying problem, HT8692 can be changed into Class AB mode.

HT8692 has a filter-less modulation circuit which directly drives speakers while realizes low distortion and low noise characteristics. Thanks to filter-less, circuit design with fewer external parts can be made in portable applications.

HT8692 has the independent Shutdown function which can minimize the power consumption at standby and MUTE function. As for protection function, over current protection function for speaker output terminals, over temperature protection function, and low supply voltage malfunction preventing function are also prepared.

HT8692 has 3 different versions, which are HT8692, HT8692S and HT8692H. All the following specifications are based on HT8692, unless otherwise noted.

HT8692是一款内置BOOST升压模块的D类音频功率放大器。内置的BOOST升压模块可通过外置电阻调节升压值，即使是锂电池供电，在升压至7.0V时，10% THD+N，4Ω负载条件下能连续输出6.5 W功率，3Ω负载条件下则能连续输出8.0W功率。其支持外部设置调节BOOST输出电压。

HT8692的最大特点是防削顶失真（ACF）输出控制功能，可检测并抑制由于输入音乐、语音信号幅度过大所引起的输出信号削顶失真（破音），也能自适应地防止在BOOST升压电压下降所造成的输出削顶，显著提高音质，创造非常舒适的听音享受，并保护扬声器免受过载损坏。同时芯片具有ACF-Off 模式。

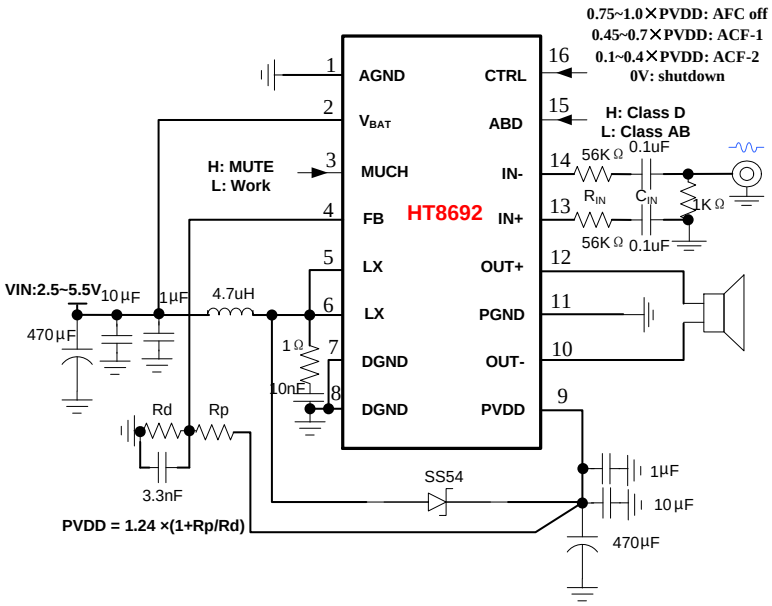
HT8692具有AB类和D类的自由切换功能，在受到D类功放EMI干扰困扰时，可随时切换至AB类音频功放模式。

HT8692内部集成免滤波器数字调制技术，能够直接驱动扬声器，并最大程度减小脉冲输出信号的失真和噪音。输出无需滤波网络，极少的外部元器件节省了系统空间和成本，是便携式应用的理想选择。

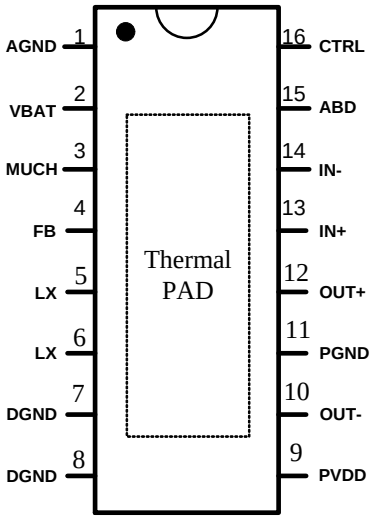
此外，HT8692内置的关断功能使待机电流最小化，还集成了输出端过流保护、片内过温保护和电源欠压异常保护等功能。

HT8692具有二个版本，分别是HT8692S, HT8692H，除非特别说明，下文参数均是基于HT8692S的实际测试值，HT8692L和H8692S的参数可能会略有不同。

■ TYPICAL APPLICATION



■ TERMINAL CONFIGURATION



SOP16L-PP

■ TERMINAL FUNCTION

Terminal No.	Name	I/O[1]	Description
1	AGND	G	Analog Ground. 模拟地
2	VBAT	P	Power Supply. 电池电源电压
3	MUCH	I	Mute Control Terminal. 静音逻辑，H 静音
4	FB	I	Regulator Feedback Input. 电压反馈取样点
5,6	LX	I	Internal Switch Input.升压调整管输入
7,8	DGND	G	Power Ground for Boost converter. 功率地
9	PVDD	P	Boost Converter Output Voltage.升压转换器输出电压
10	OUT-	O	Negative Output Terminal (BTL-). 反相输出端（BTL-）
11	PGND	G	Power Ground for Audio Amplifier.功率地
12	OUT+	O	Positive Output (BTL+). 同相输出端（BTL+）
13	IN+	I	Positive Input Terminal (differential +). 同相输入端（差分+）
14	IN-	I	Negative Input Terminal (differential -). 反相输入端（差分-）
15	ABD	I	Class D or Class AB Amplifier Mode Control Terminal. AB 类和 D 类工作模式切换
16	CTRL	I	Shutdown and ACF Control Terminal. ACF 模式和关断模式控制端

[1] I: Input; O: Output; G: Ground; P: Power

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings[2]

PARAMETER	Symbol	MIN	MAX	UNIT
Power supply voltage range	V_{BAT}	-0.3	6.0	V
BOOST converter output voltage range	PVDD	V_{BAT}	7.8	V
Input terminal voltage range (IN+, IN-)	V_{IN}	V_{SS}−0.6	PVDD+0.6	V
Input terminal voltage range (except IN+, IN-)	V_{IN}	V_{SS}−0.3	PVDD+0.3	V
Operating Ambient Temperature	T_A	-40	85	℃
Junction Temperature	T_J	-40	150	℃
Storage Temperature	T_{STG}	-50	150	℃

● Recommended Operating Condition

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Power Supply Voltage	V_{BAT}		2.5	3.6	5.5	V
BOOST converter output voltage range	PVDD		V_{BAT}	7.0	7.5	V
Operating Ambient Temperature	T_a		-40	25	85	℃
Speaker Impedance	R_L		2			Ω

[1] Depending on parts and PCB layout, characteristics may be changed.

[2] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability

Electrical Characteristics

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
BOOST Converter							
Boost converter output voltage	PVDD			V_{BAT}	7.0	7.5	V
Boost converter frequency	f_{SW}				410		kHz
Boost converter input current limit	$I_{LIMTRIP}$	HT8692			3.2		A
		HT8692S/H			4.6		A
Class D Channel VSS=0V, VBAT =3.6V, R_{IN} = 56K, Ta=25ºC, C_{IN}=1uF, ACF-Off mode, unless otherwise specified							
Carrier clock frequency	f_{PWM}				410		kHz
Over current protection	Imax					5	A
System Gain	Av_0	R_{IN}=56 kΩ for HT8692 R_{IN} = 28 kΩ for HT8692H R_{IN} = 6.2k for HT8692S			26		dB
Start-up time (power-on or shutdown release)	t_{STUP}				280		ms
ACF attenuation gain	Aa			-16		0	dB
Consumption current in shutdown mode	I_{SD}	CTRL=VSS			25		μA
PVDD = 6.5V							
Output Power	PO	RL=4Ω	VBAT=4.2V, f=1kHz, THD+N=10%		5.6		W
		RL=3Ω			7.0		
		RL=8Ω			3.1		
		RL=4Ω	VBAT=4.2V, f=1kHz, THD+N=1%		4.5		
		RL=3Ω			5.6		
		RL=8Ω			2.5		
Total Harmonic Distortion plus Noise	THD+N	PO=0.1W	RL=4Ω, f=1kHz		0.23		%
		PO=1.0W			0.12		%
		PO=3.0W			0.15		%
Output Noise	V_N	f=20Hz~20kHz, A weighted, Av=26dB			150		μV_{rms}
Signal to Noise Ratio	SNR	A weighted, Av=26dB, THD+N = 1%			90		dB
Output offset voltage	V_{OS}				±2		mV
Efficiency (Class D + Boost)	η	VBAT=3.6V, RL=4Ω+22uH, THD+N = 10%			70		%
		VBAT=3.6V, RL=8Ω+33uH, THD+N = 10%			75		%
Quiescent current	I_{BAT}	No Load	Input Grounded		20		mA
		With Load*6			20		mA
Quiescent current in mute mode	I_{MUTE}	No Load	Input Grounded, MUCH = H		8		mA
		With Load*6			8		mA
Maximum Input Signal	V_{IN}max	f_{IN} = 1kHz, THD+N≤10%, ACF-1 ON			1.2		Vrms
PVDD = 7.0V							
Output Power	PO	RL=4Ω	VBAT=4.2V, f=1kHz, THD+N=10%		6.6		W
		RL=3Ω			8.2		
		RL=8Ω			3.5		
		RL=4Ω	VBAT=4.2V, f=1kHz, THD+N=1%		5.3		
		RL=3Ω			6.6		
		RL=8Ω			2.9		
Total Harmonic Distortion plus Noise	THD+N	PO=0.1W	RL=4Ω, f=1kHz		0.23		%
		PO=1.0W			0.12		%

		PO=3.0W			0.15		%
Output Noise	V_N	f=20Hz~20kHz, A weighted, Av=26dB			150		μV_{rms}
Signal to Noise Ratio	SNR	A weighted, Av=26dB, THD+N = 1%			90		dB
Output offset voltage	V_{OS}				±2		mV
Efficiency (Class D + Boost)	η	VBAT=3.6V, RL=4Ω+22uH, THD+N = 10%			70		%
		VBAT=3.6V, RL=8Ω+33uH, THD+N = 10%			75		%
Quiescent current	I_{BAT}	No Load	Input Grounded		30		mA
		With Load*6			30		mA
Consumption current in mute mode	I_{MUTE}	No Load	Input Grounded, MUCH = H		10		mA
		With Load*6			10		mA
Maximum Input Signal	$V_{IN}max$	f_{IN} = 1kHz, THD+N≤10%, ACF-1 ON			1.35		Vrms
Class AB Channel*7 VSS=0V, VBAT =3.6V, Av=20dB, Ta=25ºC, C_{IN}=1uF, unless otherwise specified							
Output Power	PO	RL=4Ω, VBAT=3.6V	f=1kHz, THD+N=10%		1.3		W
		RL=4Ω, VBAT=4.2V			1.8		
		RL=4Ω, VBAT=5.0V			2.65		W
		RL=4Ω, VBAT=3.6V	f=1kHz, THD+N=1%		1.0		W
		RL=4Ω, VBAT=4.2V			1.5		
		RL=4Ω, VBAT=5.0V			2.1		W
Total Harmonic Distortion plus Noise	THD+N	PO=0.01W	RL=4Ω, f=1kHz		0.12		%
		PO=0.1W			0.1		%
Output Noise	V_N	f=20Hz~20kHz, A weighted, Av=20dB			75		μV_{rms}
Signal to Noise Ratio	SNR	A weighted, Av=20dB, THD+N = 1%			90		dB
Output offset voltage	V_{OS}				±4		mV
Efficiency	η	RL=4Ω+22uH, THD+N = 10%			70		%
		RL=8Ω+33uH, THD+N = 10%			74.5		%
Quiescent current	I_{BAT}	No Load	Input Grounded		20		mA
		With Load			20		mA
Consumption current in mute mode	I_{MUTE}	No Load	Input Grounded, MUCH = H		2.0		mA
		With Load			2.0		mA
Consumption current in shutdown mode	I_{SD}	CTRL=VSS			36		μA
System Gain	Av_0	R_{IN}=56 kΩ for HT8692 R_{IN} = 33 kΩ for HT8692H R_{IN} = 10kΩ for HT8692S			20		dB
Start-up time (power-on, shutdown release, or switch from Class D to Class AB)	t_{STUP}				270		ms
Digital Input/Output							
ACF-Off mode setting threshold voltage	VMOD1			0.75× PVDD		PVDD	V
ACF-1 mode setting threshold voltage	VMOD2			0.45× PVDD		0.70× PVDD	V
ACF-2 mode setting threshold voltage*8	VMOD3			0.10× PVDD		0.40× PVDD	V
SD mode setting threshold voltage	VMOD4			VSS		0.06× PVDD	V
SD wake up voltage	V_{CTRL_ON}			0.8			

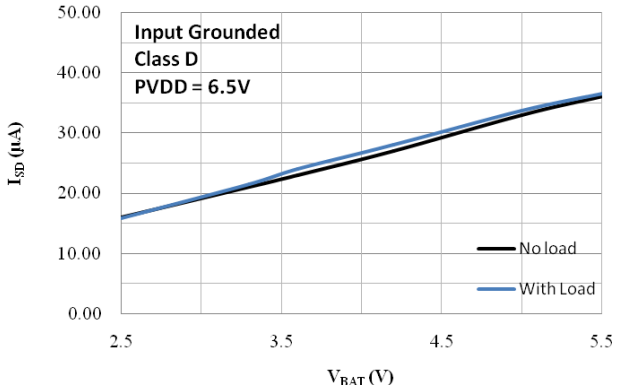
Internal pull-down Resistor of CTRL	R_{CTRL}	Class D		125		K Ω
		Class AB		+∞		
ABD, MUCH Input High	V_{IH}		1.5			V
ABD, MUCH Input Low	V_{IL}				0.4	V
Internal pull-down Resistor of ABD	R_{ABD}			250		K Ω
Internal pull-down Resistor of MUCH	R_{MUCH}			300		K Ω
MISCELLANEOUS						
VBAT start-up threshold voltage	VUVLH			2.5		V
VBAT shut-down threshold voltage	VUVLL			2.3		V

■ TYPICAL OPERATING CHARACTERISTICS

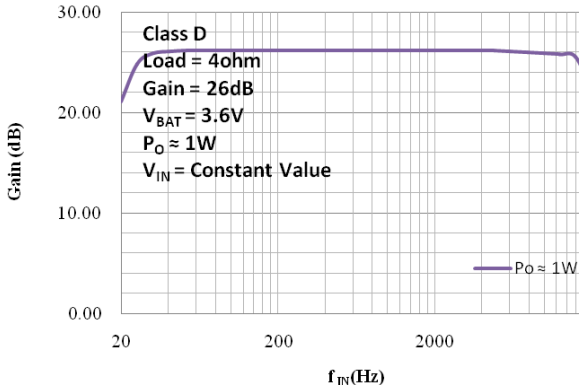
Class D Channel

Condition: Class D mode, V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 26dB, ACF off, Load = 4ohm, unless otherwise specified

V_{BAT} vs I_{SD}

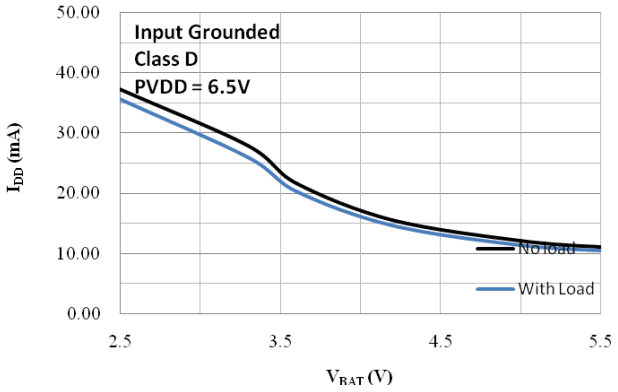


f_{IN} vs Gain

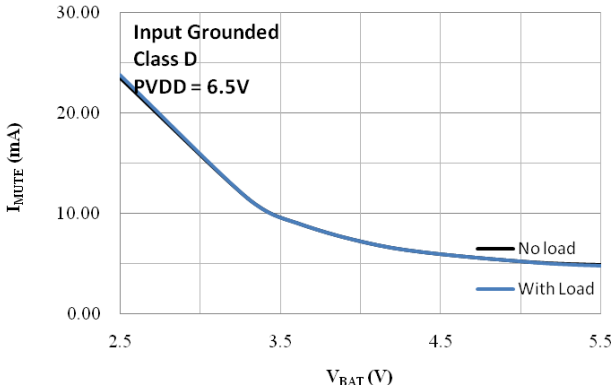


PVDD = 6.5V

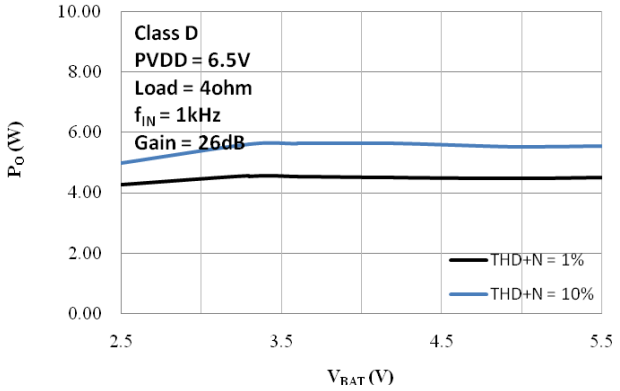
V_{BAT} vs I_{DD}



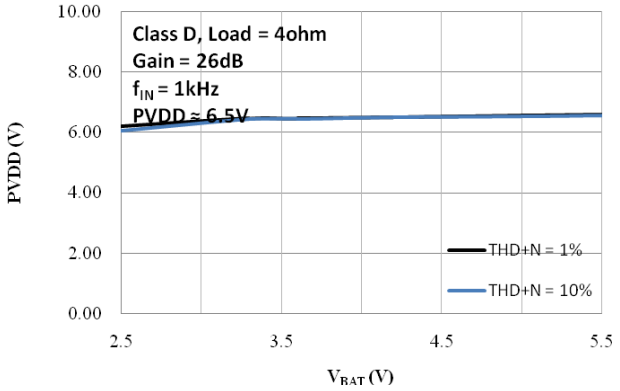
V_{BAT} vs I_{MUTE}



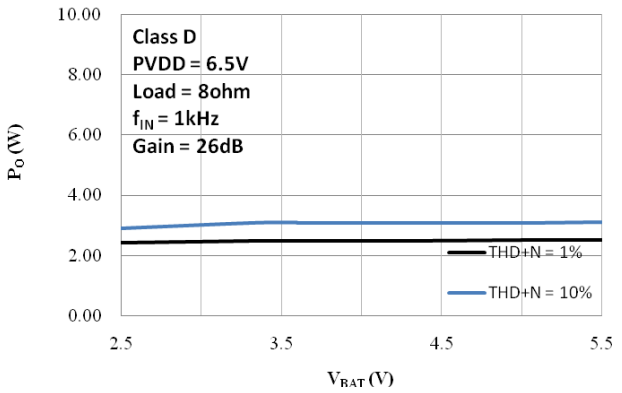
V_{BAT} vs P_O



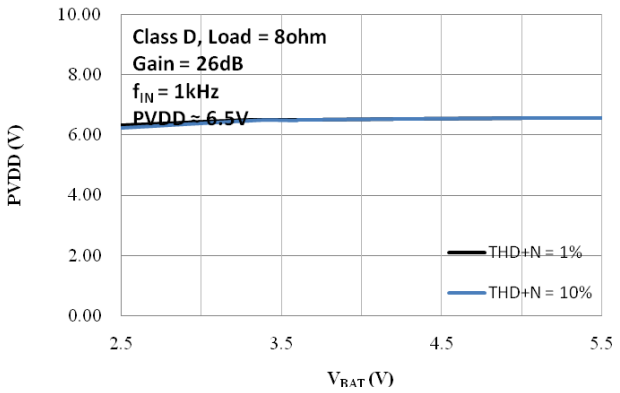
V_{BAT} vs PVDD



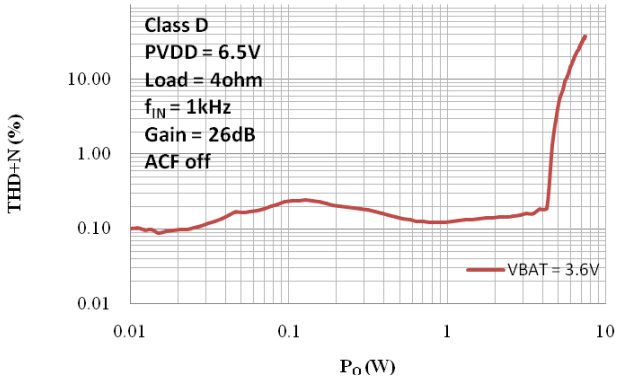
V_{BAT} vs P_O



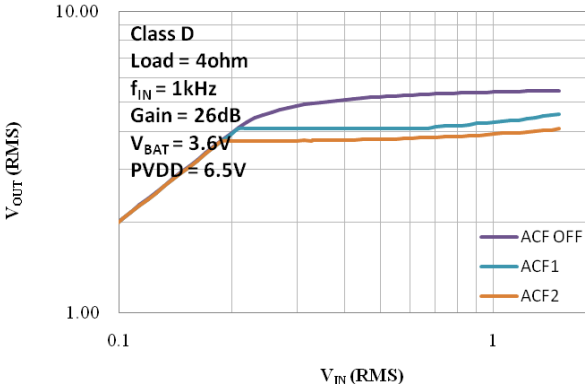
V_{BAT} vs PVDD



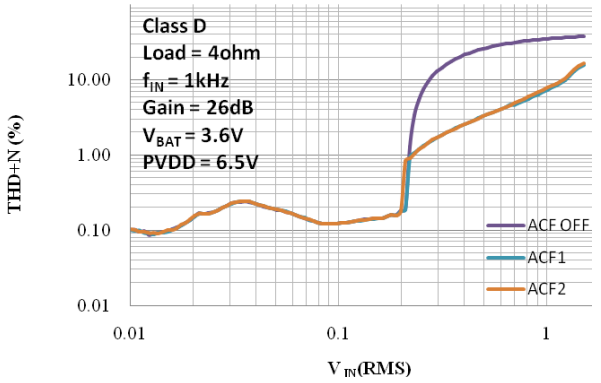
P_O vs THD+N



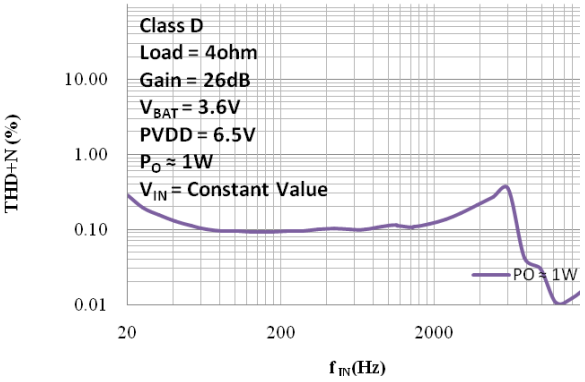
V_{IN} vs V_{OUT}



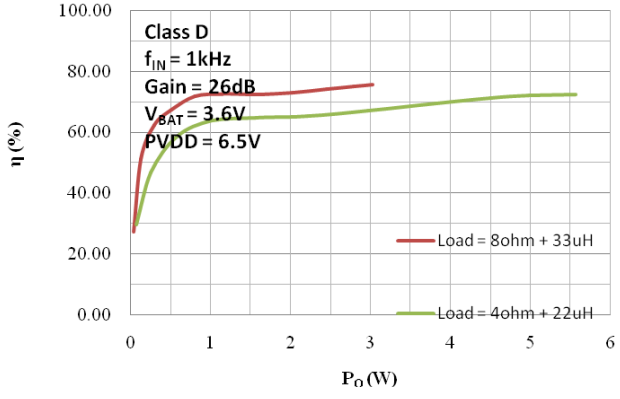
V_{IN} vs THD+N



f_{IN} vs THD+N

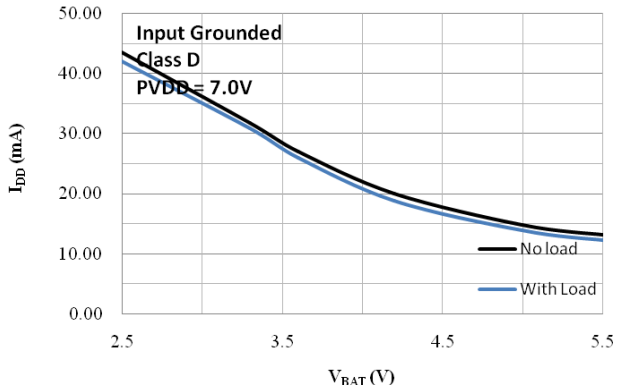


P_O vs η

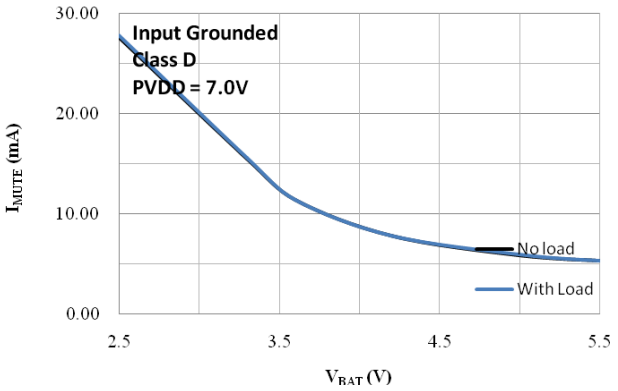


PVDD = 7.0V

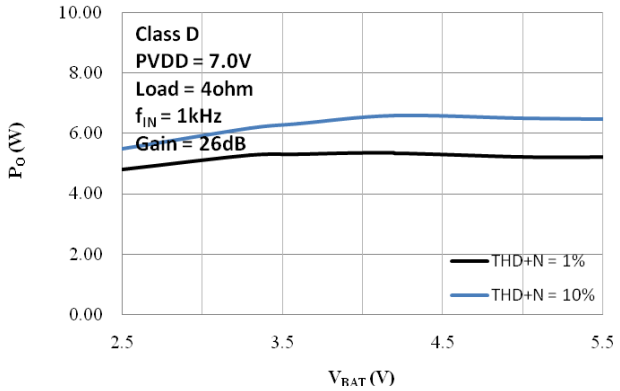
V_{BAT} vs I_{DD}



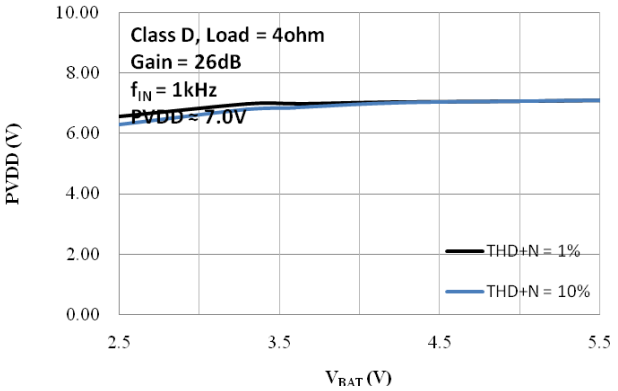
V_{BAT} vs I_{MUTE}



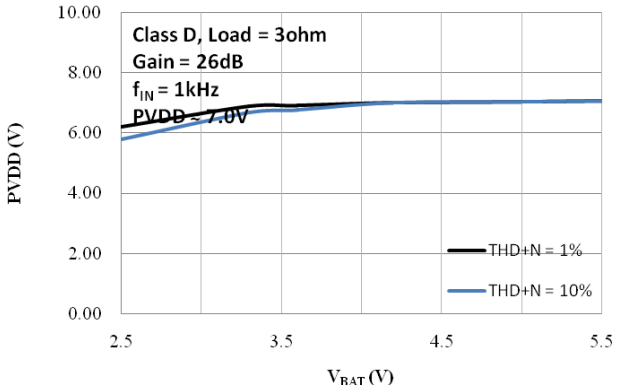
V_{BAT} vs P_O



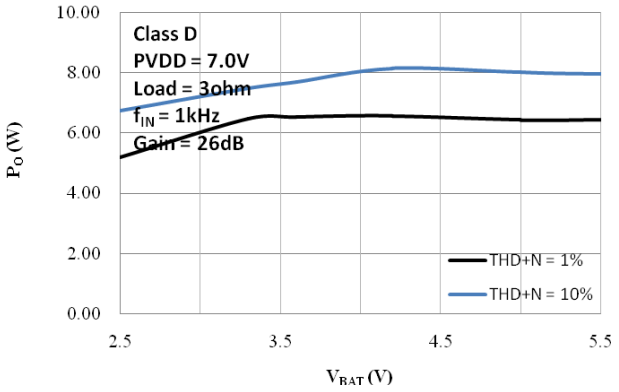
V_{BAT} vs PVDD



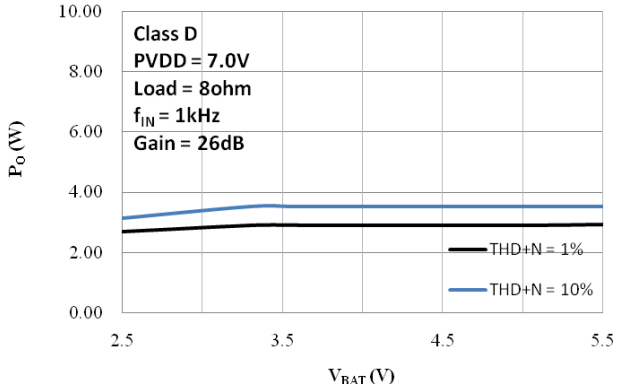
V_{BAT} vs PVDD



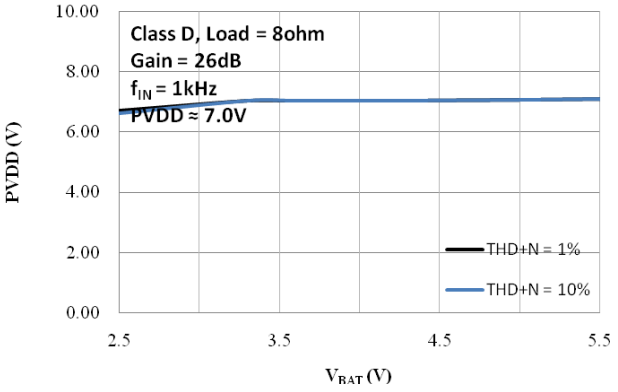
V_{BAT} vs P_O



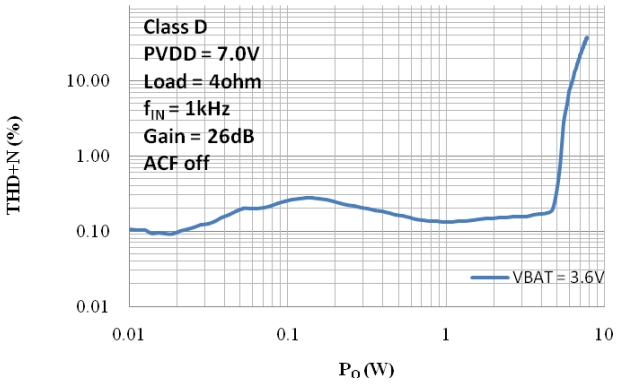
V_{BAT} vs P_O



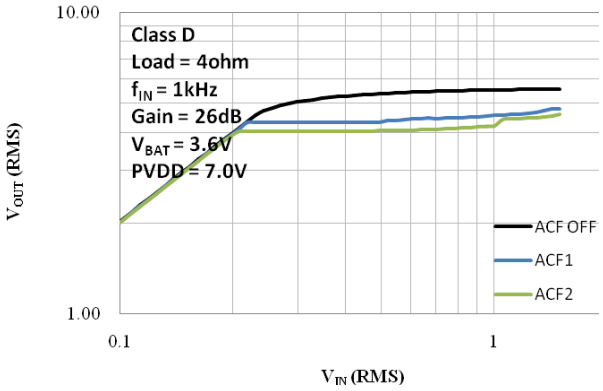
V_{BAT} vs PVDD



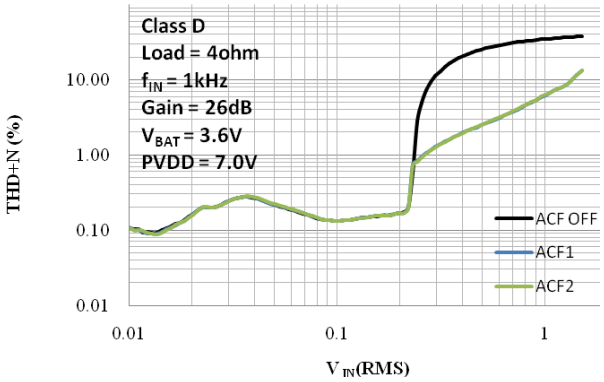
P_O vs THD+N



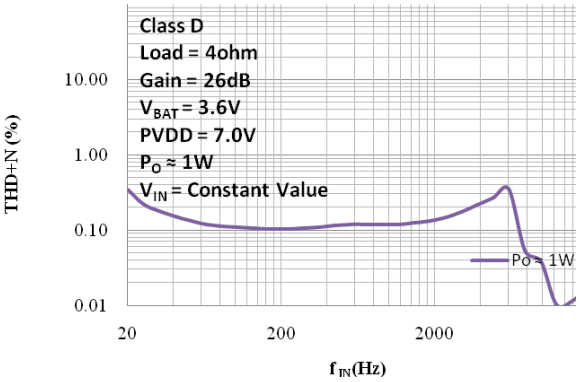
V_{IN} vs V_{OUT}



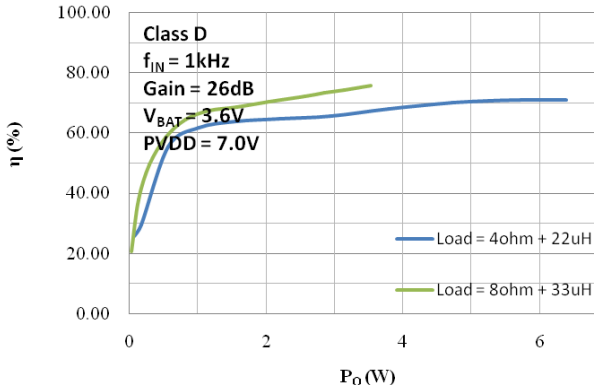
V_{IN} vs THD+N



f_{IN} vs THD+N



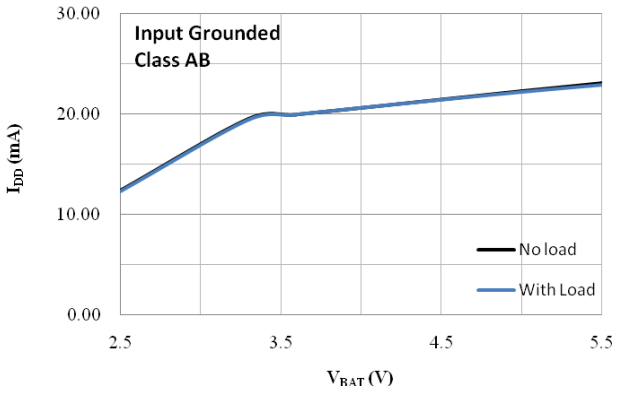
P_O vs η



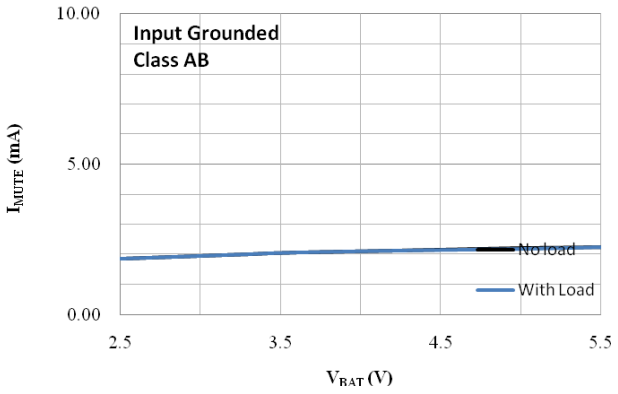
Class AB Channel

Condition: Class AB mode, V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 20dB, Load = 4ohm, unless otherwise specified

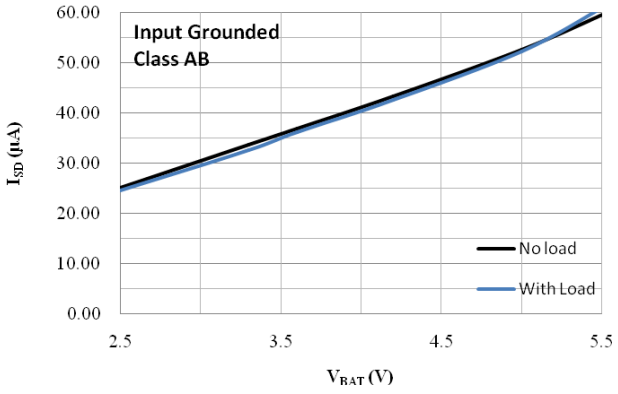
V_{BAT} vs I_{DD}



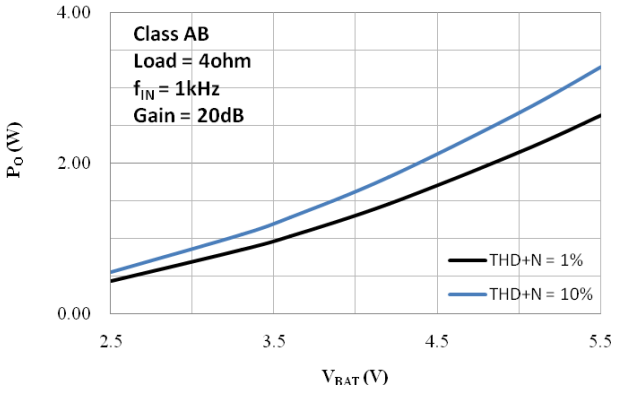
V_{BAT} vs I_{MUTE}



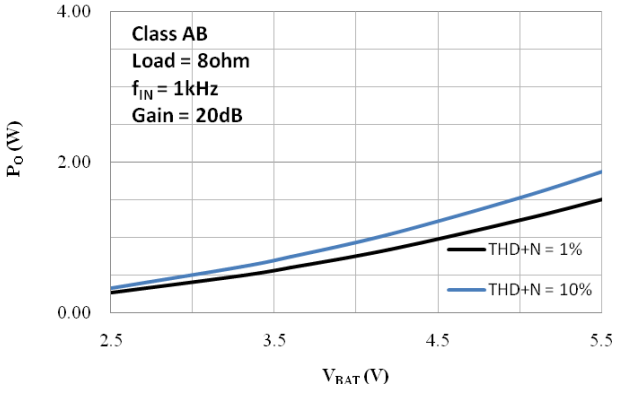
V_{BAT} vs I_{SD}



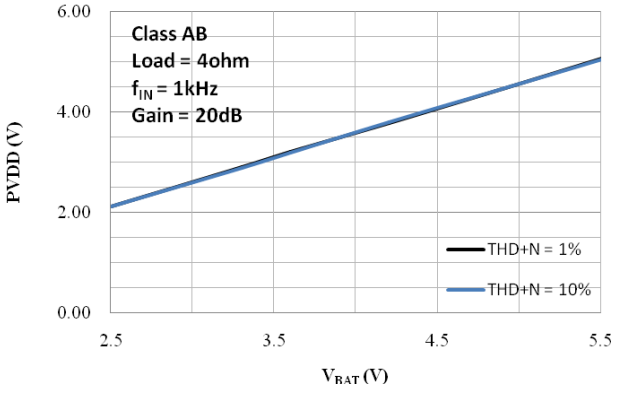
V_{BAT} vs P_O



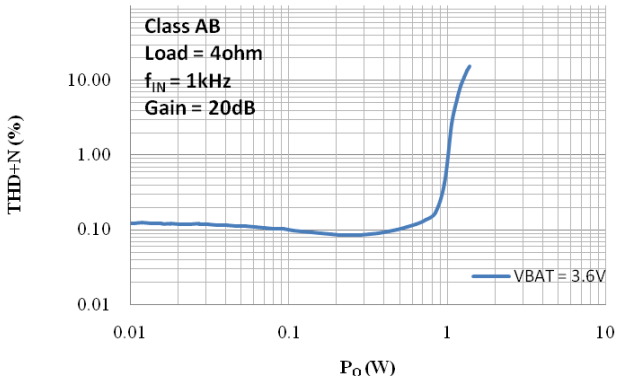
V_{BAT} vs P_O



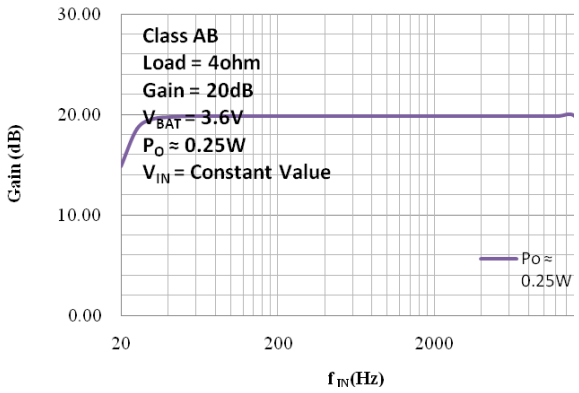
V_{BAT} vs PVDD



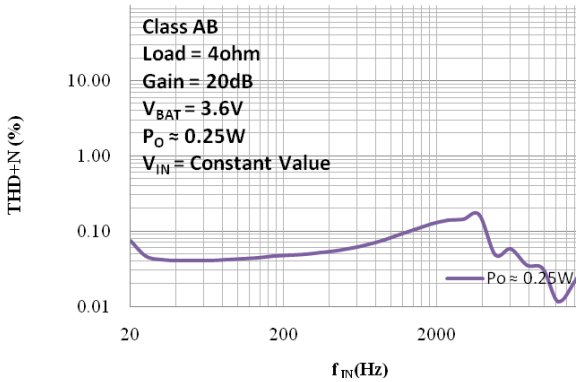
P_O vs THD+N



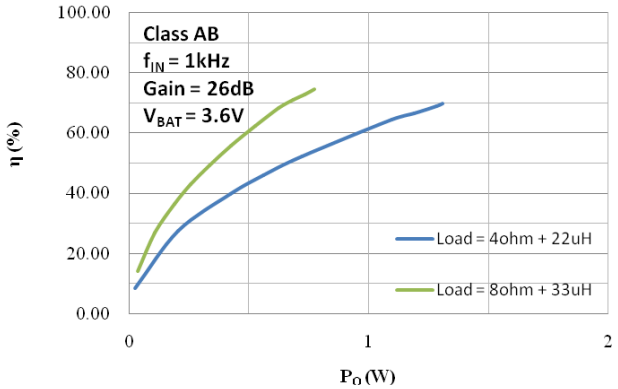
f_{IN} vs Gain



f_{IN} vs THD+N



P_O vs η



■ APPLICATION INFORMATION

1. *BOOST Converter*

1.1. *Setting Output Voltage*

The output voltage is set by a resistive voltage divider from the output voltage to FB terminal, which is shown below. The output voltage can be calculated by PVDD = 1.24*(Rd1+Rd2)/Rd2.

Boost 升压模块的输出电压 PVDD 可由外部配置，如下图所示，PVDD = 1.24*(Rd1+Rd2)/Rd2。

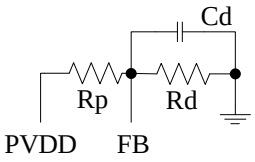


Fig. 1 FB Terminal Configuration

Table 1. Output Voltage Setting

PVDD	Rp	Rd	Cd
5.0V	120K	39.5K	3.3nF
6.5V	120K	28K	3.3nF
7.0V	120K	25.5K	3.3nF

1.2. *LX Terminal*

It is strongly recommended to place an RC circuit from the terminal of LX to Ground, shown as following, so that the ripple current of Boost Converter can be decreased. Meanwhile, the total consumption current of the system will be larger so that the efficiency of the system will be lower. Specifications in this file is measured under the condition with RC.

Notes: RC should be placed as closely to LX pin as possible.

在输出 PVDD 较大、使用功率较大、音乐波动较大的情况下，建议在 LX 端加入 RC，如图 2，能起到稳定 DCDC 的作用。引入此 RC，将增加板级的静态电流、并降低系统的效率，说明书中的相关数据均是在加入此 RC 后测得。

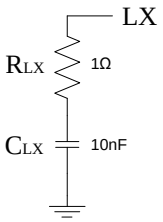


Fig. 2 LX Terminal Configuration

1.3. *Capacitor Selection*

The input and output capacitor (C_{IN} and C_{OUT}) is required to maintain the DC voltage. Low ESR capacitors are preferred to reduce the output voltage ripple. 1uF//10uF//470uF (paralleled) is highly recommended to be placed in both input and output terminal as closely to the pin as possible.

由于输入电压 VBAT 经 BOOST 升压后的 PVDD 直接供电给音频功放，而音频功放在工作时对电源本身具有较大扰动，这时，电源端的滤波就非常重要。我们建议，在 VBAT 和 PVDD 端至少放置一组 1uF//10uF//470uF 电容到地。这些电容应以最短的路径连接至安静可靠的地，以有效滤波。

1.4. Inductor Selection

Inductance value is decided based on different condition. L≥4.7uH, DCR<1ohm, I_{SAT}≥3.5 A is recommended for general application circuit.

为保证芯片的正常工作，建议使用 L≥4.7uH, DCR<1ohm, I_{SAT} ≥ 3.5 A。在输出 PVDD 较大、使用功率较大、音乐波动较大的情况下，应适当选择 L 较大的电感

1.5. Schottky Diode Selection

V_{RRM} > 12V, V_{FM}＜0.5V, I_F≥2 A is recommended for general application circuit.

为保证芯片的正常工作，建议使用 V_{RRM} > 12V, V_{FM}＜0.5V, I_F≥2 A 的肖特基二极管。在输出 PVDD 较大、使用功率较大、音乐波动较大的情况下，应适当选择 IF 较大的肖特基二极管。

1.6. Layout Consideration

(1) The power traces, consisting of the GND, LX, VBAT and PVDD trace should be kept short, direct, wide, and as closely to the pin as possible. The switching node LX should be paid more attention for EMI and reliability consideration.

(2) Place CIN and COUT near VBAT and PVDD as closely as possible to maintain voltage steady and filter out the pulsing current.

(3) The resistive divider R should be connected to pin directly as closely as possible. FB is a sensitive node. Please keep it away from switching node, LX.

(4) The GND of the IC, C_{IN} and C_{OUT} should be connected close together directly to ground plane.

电源线（VBAT, PVDD，包括电源地回路），LX 线，应尽可能使用短、粗、无弯折的引线连接；应特别注意 LX 端引线，其开关频率会影响 EMI；

VBAT 和 PVDD 端 C_{IN} 应尽可能靠近芯片引脚，以保证电压的稳定；

分压反馈电阻 Rp 和 Rd 应尽量靠近 FB，FB 引线应尽量远离干扰源，如 LX 端所连的电感、二极管等；

IC 的所有地，应尽可能以最短的路径和星形结构连接至稳定可靠的地。

2. Analog Signal Input Configuration

HT8692 is an amplifier with analog input (single-ended or differential). For a differential input between IN+ and IN- pins, signals input via DC-cut capacitors (C_{IN}). The input signal gain is calculated by

Av ≈ $\frac{1200k}{R_{IN}}$ (Class D mode, HT8692);

Av ≈ $\frac{550k}{R_{IN}}$ (Class D mode, HT8692H);

Av ≈ $\frac{550k}{22k+R_{IN}}$ (Class D mode, HT8692S);

Av ≈ $\frac{600k}{R_{IN}}$ (Class AB mode, HT8692);

Av ≈ $\frac{330k}{R_{IN}}$ (Class AB mode, HT8692H);

Av ≈ $\frac{330k}{22k+R_{IN}}$ (Class AB mode, HT8692S).

And, the low pass cut-off frequency of input signal, can be calculated by $f_c = \frac{1}{(2\pi R_{IN} C_{IN})}$ or $f_c = \frac{1}{(2\pi(22k+R_{IN})C_{IN})}$ (HT8692S).

For a single-ended input at IN+ pin, signal input via a DC-cut capacitor (C_{IN}). IN- pin should be connected to ground via a DC-cut capacitor (with the same value of C_{IN}). The Gain and low pass Cut-off frequency are the same as the above case.

HT8692 接受模拟差分或单端音频信号输入，产生 PWM 脉冲输出信号（D 类模式）或音频信号（AB 类模式）驱动扬声器。

对差分输入，通过隔直电容 C_{IN} 和输入电阻 R_{IN} 分别输入到 IN+和 IN-端。系统增益：

Av ≈ $\frac{1200k}{R_{IN}}$ (Class D mode, HT8692);

Av ≈ $\frac{550k}{R_{IN}}$ (Class D mode, HT8692H);

Av ≈ $\frac{550k}{22k+R_{IN}}$ (Class D mode, HT8692S);

Av ≈ $\frac{600k}{R_{IN}}$ (Class AB mode, HT8692);

Av ≈ $\frac{330k}{R_{IN}}$ (Class AB mode, HT8692H);

Av ≈ $\frac{330k}{22k+R_{IN}}$ (Class AB mode, HT8692S).

输入 RC 高通滤波器的截止频率：$f_c = \frac{1}{(2\pi R_{IN} C_{IN})}$ or $f_c = \frac{1}{(2\pi(22k+R_{IN})C_{IN})}$ (HT8692S).

对单端输入，则通过 C_{IN} 耦合到 IN+端。IN-端必须通过输入电阻和电容（与 C_{IN}、R_{IN} 值相同）接地。增益 Av 和截止频率 fc 与差分输入时相同。

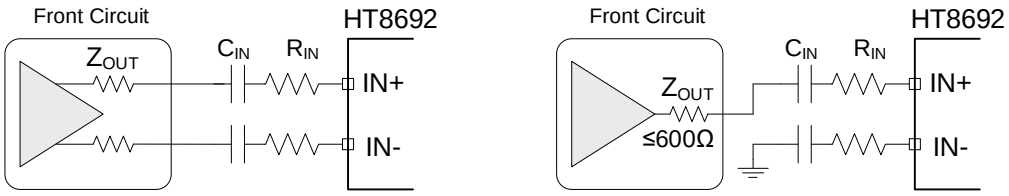


Fig. 3 (1) Differential Input; (2) Single-ended Input

3. *Output Configuration*

As mentioned, HT8692 can directly drive speakers without any other components. But there are exceptions. Once HT8692 works in class D mode, the cable lined to the speaker is very long, and EMI is concerned, ferrite beads or L-C filter is needed.

一般而言，输出端可直接连接负载喇叭。如果输出端的输出线较长，或者对 EMI 的要求较高，则可选择添置铁氧体磁珠或 LC 滤波器。

4. *CTRL Terminal Mode Control*

HT8692 can work in different modes by setting the CTRL terminal, shown as follow.

在 CTRL 端输入不同电压值，能实现 4 种工作模式，即防削顶模式 1（ACF-1），防削顶模式 2（ACF-2），防削顶功能关闭模式（ACF-Off）和芯片关断模式（SD），详见下表。

Table. 2 CTRL Terminal Mode Control

MODE	SYMBOL	MIN.	TYP.	MAX.	UNIT
CTRL voltage for ACF-Off	V_{MOD1}	0.75×PVDD		PVDD	V
CTRL voltage for ACF-1	V_{MOD2}	0.45×PVDD		0.70×PVDD	V
CTRL voltage for ACF-2	V_{MOD3}	0.10×PVDD		0.40×PVDD	V
CTRL voltage for SD(Shutdown)	V_{MOD4}	VSS		0.06×PVDD	V

Notes: ACF-1 and ACF-2 mode can only be worked in class D mode. A 120kΩ pull-down resistor are inside of the CTRL terminal, shown as follows, but the pull-down resistor will be gone in Class AB mode. An outside pull down resistor is still needed for stability.

需要注意的是，ACF-1 和 ACF-2 模式仅对 D 类模式有效，在 AB 类模式下，其对应电平所在模式仍为 ACF-Off。在配置 CTRL 端外部电压时，需要注意的是，其内部有一个 120Kohm 下拉电阻，如下图示。在 AB 类模式下，无该下拉电阻。CTRL 外部仍需要下拉电阻，以保证稳定性。

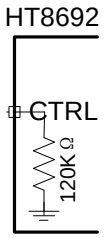


Fig. 4 CTRL Terminal

To wake up from SD mode to other working modes, the voltage of CTRL terminal should be no less than 0.8V..

芯片从SD唤醒至其他模式，CTRL电压需要0.8V以上。

5. *Ani-Clipping Function (ACF) Configuration*

5.1. *ACF ON mode*

In ACF-1 and ACF-2 modes, HT8692 attenuates system gain to an appropriate value when an excessive input is applied, so as not to cause the clipping at the differential signal output. In this way, the output audio signal is controlled in order to obtain a maximum output level without distortion. And HT8692 also follows to the clips of the output waveform due to the decrease in the power-supply voltage.

在 ACF-1、ACF-2 模式下，当电路检测到输入信号幅度过大而产生输出削顶时，HT8692 通过自动调整系统增益，控制输出达到一种最大限度的无削顶失真功率水平，由此大大改善了音质效果。此外，当电源电压下降时，HT8692 也能自动衰减输出增益，实现与 PVDD 下降值相匹配的最大限度无削顶输出水平。

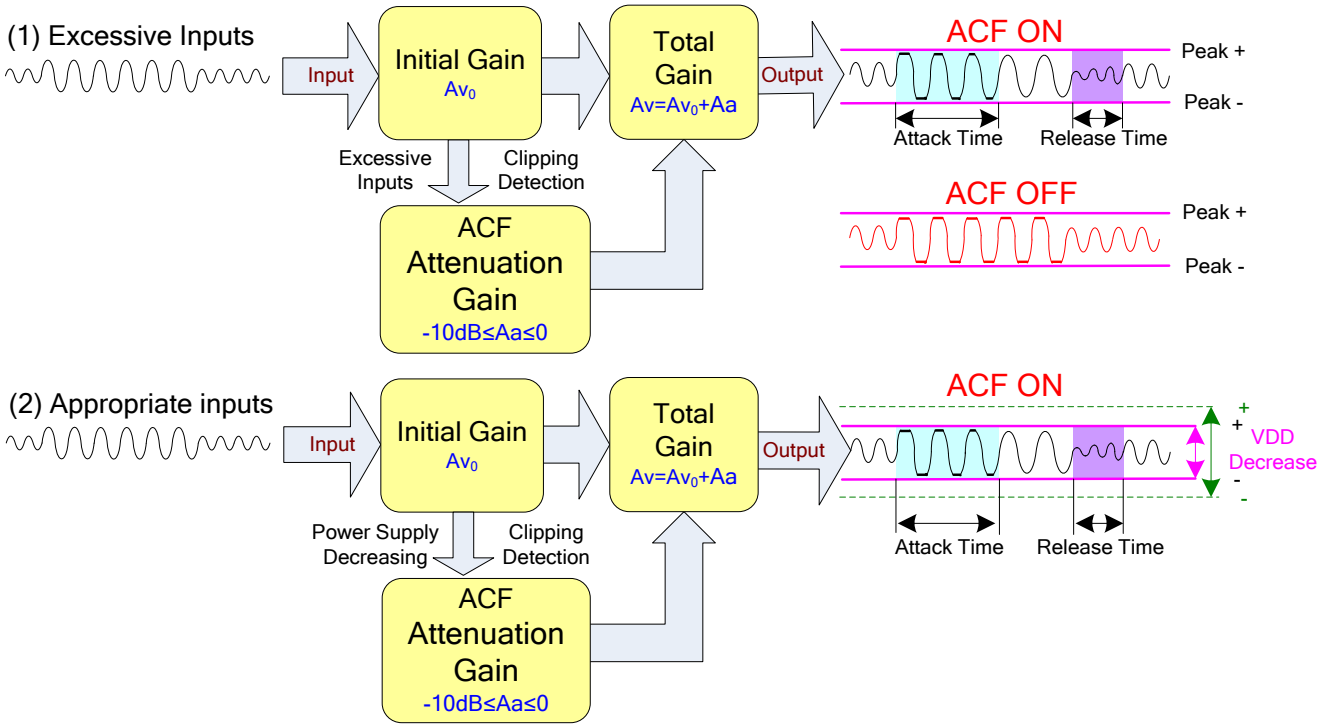


Fig. 5 the ACF Function Operation Outline

The Attack time of ACF Function is a time interval until system gain falls to target attenuation gain -3dB when a big enough signal inputs. And, the Release Time is a time from target attenuation gain to not working of ACF. The maximum attenuation gain is 16dB.

ACF ON模式下的启动时间（Attack time）指在突然输入足够大信号而产生输出削顶的条件下， ACF启动对放大器的增益调整速率，以ms/dB为单位；释放时间（Release time）指产生削顶的输入条件消失，增益退出衰减状态的速率，以ms/dB为单位。HT8692的最大衰减增益为16dB。

ACF-1和ACF-2模式具有不同的启动时间和释放时间（见下表）。

Table 3 Attack time and Release time

ACF mode	Attack time	Release time
ACF-1	50ms	64ms
ACF-2	2.5ms	1200ms

5.2. *ACF OFF mode*

In ACF-Off mode, ACF function is disenabled. HT8692 will not detect output clipping and the system gain is kept to be Av=Av0. The audio quality would worsen due to clipping distortion.

在 ACF-Off 模式下，ACF 功能被关闭，HT8692 不对输出削顶条件作检测，也不对系统增益作自动调整操作，系统增益保持为 Av=Av0=26dB 恒定不变。HT8692 可能因输出存在破音失真而音质变坏。

5.3. *SD Mode*

In shutdown mode, HT8692 shuts all circuit down and minimizes the power consumption. And, the output terminals become Weak Low (A high resistance grounded state).

在关断模式（低功耗待机）下，芯片关闭所有功能并将功耗降低到最小，输出端为弱低电平状态（内部通过电阻接地）。

6. *ABD, MUCH Terminal Setting*

HT8692 can work in different modes by setting the ABD and MUCH terminal, shown as follow.

HT8692 通过 ABD, MUCH 两个管脚的电压控制实现芯片不同状态的设置。具体工作模式如下表。

Table 4 Mode Setting for ABD and MUCH

Logic Level / Terminal	Logic High (H)	Logic Low (L)
ABD	Class D, Boost ON	Class AB, Boost OFF
MUCH	AMP mute	AMP ON

Notes: ABD and MUCH terminal can be floating as pull-up and pull-down resistors are inside them, which is shown as follow.

需要注意的是，ABD 和 MUCH 引脚支持悬空，内部分别存在上拉和下拉电阻，其中，ABD 的上拉电阻约为 250kohm, MUCH 的下拉电阻约为 300kohm。

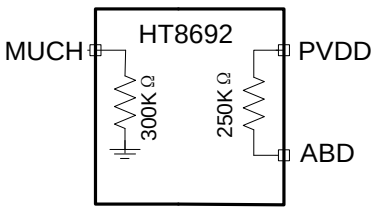


Fig. 6 ABD, MUCH Terminall

To wake up from SD mode to other working modes, the voltage of CTRL terminal should be no less than 0.8V..

芯片从SD唤醒至其他模式，CTRL电压需要0.8V以上。

7. *Pop-Click Noise Reduction*

The Pop-Click Noise Reduction Function of HT8692 works in the cases of Power-on, Power-off, Shutdown on, and Shutdown off. To achieve a more excellent noise reduction performance, it is recommended to use a DC-cut capacitor (C_{IN}) of 0.1μF or less.

Besides, POP noise can be minimal according to the following procedure of shutdown (mute) control.

・During power-on, Shutdown (mute) mode is not cancelled until the power supply is stabilized enough.

・Before Power-off, set Shutdown (mute) mode first.

The pop-click noise: Power-on/-off > Shutdown on/off > Mute on/off

HT8692 内置控制电路实现了全面的杂音抑制效果，有效地抑制住了系统在上电、下电、关断及其唤醒操作过程中出现的瞬态咔嗒-噼噗（Click-Pop）噪声。

为达到更优异的咔嗒-噼噗声消除效果，一般情况下，建议采用 0.1μF 或更小的隔直电容 CIN。同时 POP 噪声还可通过下列上电、下电时关断模式（静音模式）的时序控制措施来达到杂声微乎其微的效果，如下图：

・电源上电时，保持关断模式（静音模式），等电源足够稳定后再解除关断模式。

・电源下电时，提前设为关断模式（静音模式）。

总而言之，Pop 声从小到大依次是：开关 VBAT；开关 CTRL；开关 MUCH。

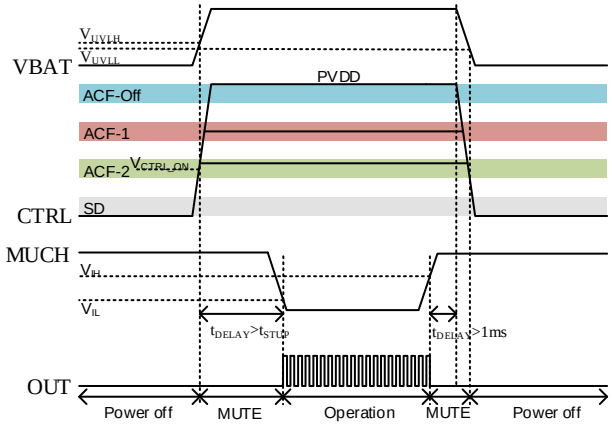


Fig. 7 Pop-Click Noise Reduction by MUTE

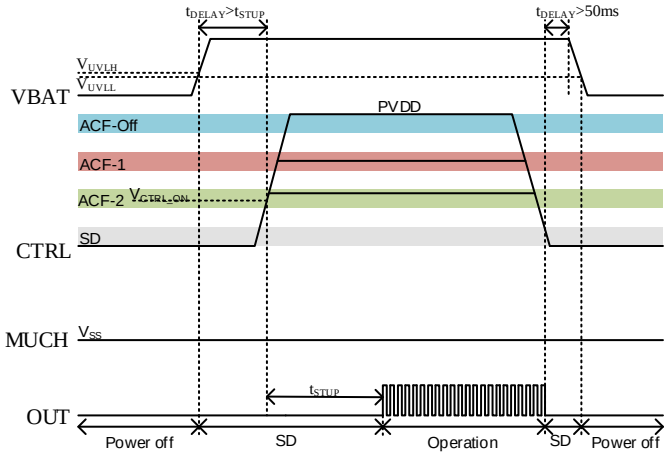


Fig. 8 Pop-Click Noise Reduction by Shutdown

8. Protection Function

8.1. Over-current Protection function

When a short circuit occurs between one output terminal and Ground, Power, or the other output, the over-current protection mode starts up. In the over current protection mode, the differential output terminal becomes a high impedance state. Once the short circuit conditions are eliminated, the over current protection mode can be cancelled automatically.

当检测到一输出端对电源、对地、或对另一输出端短路时，过流保护启动，输出端切换至高阻态，防止芯片烧毁损坏。短路情况消除后，通过关断、唤醒一次芯片，或重新上电均能使芯片退出保护模式。

8.2. Thermal Protection function

When excessive high temperature of HT8692 (150℃) is detected, the thermal protection mode starts up. In the thermal protection mode, the differential output terminal becomes Weak Low state (a state grounded through high impedance).

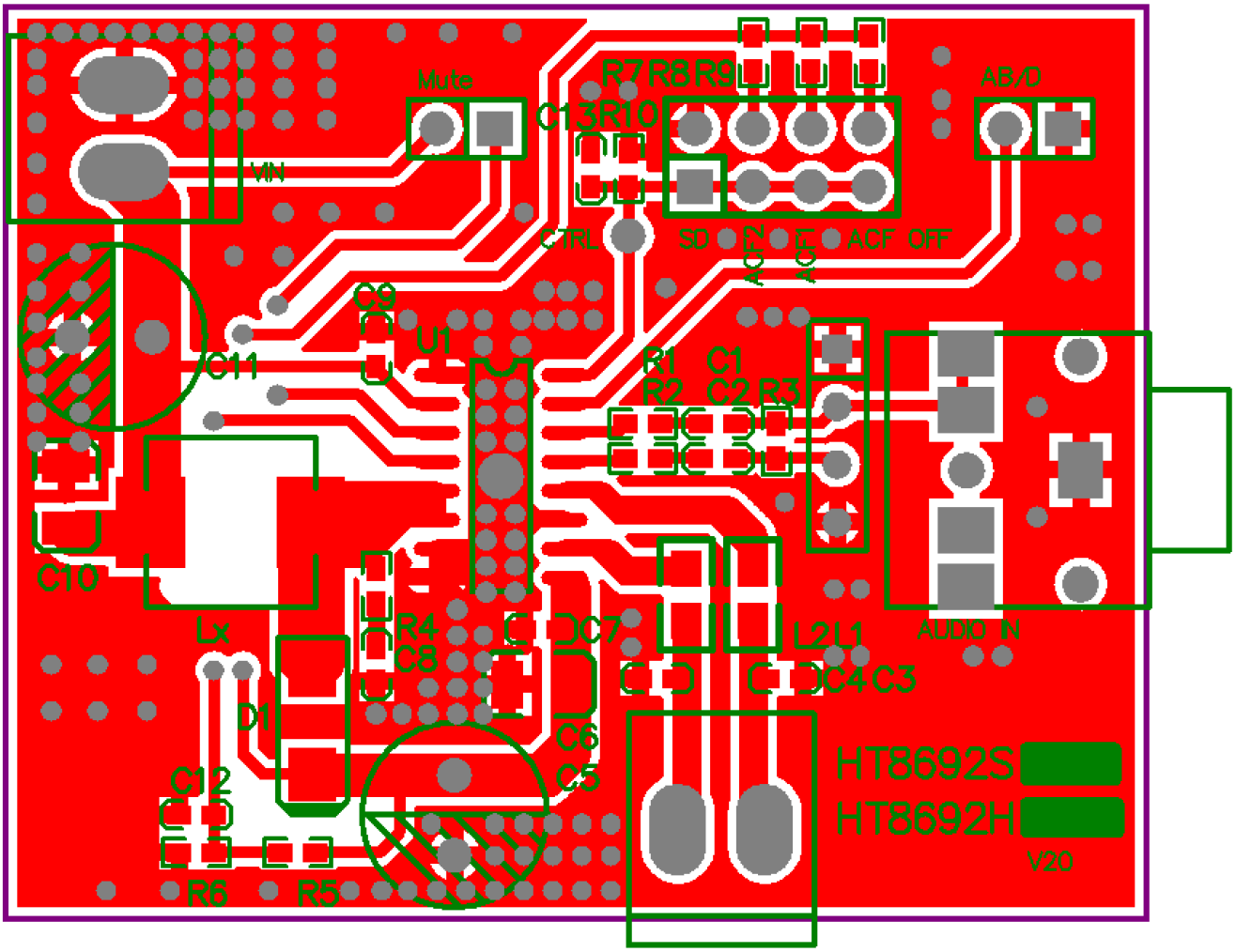
当检测到芯片内温度超过 150℃时，过温保护启动，正负输出端切换至弱低电平状态（内部通过高阻接地），防止芯片被热击穿损坏。

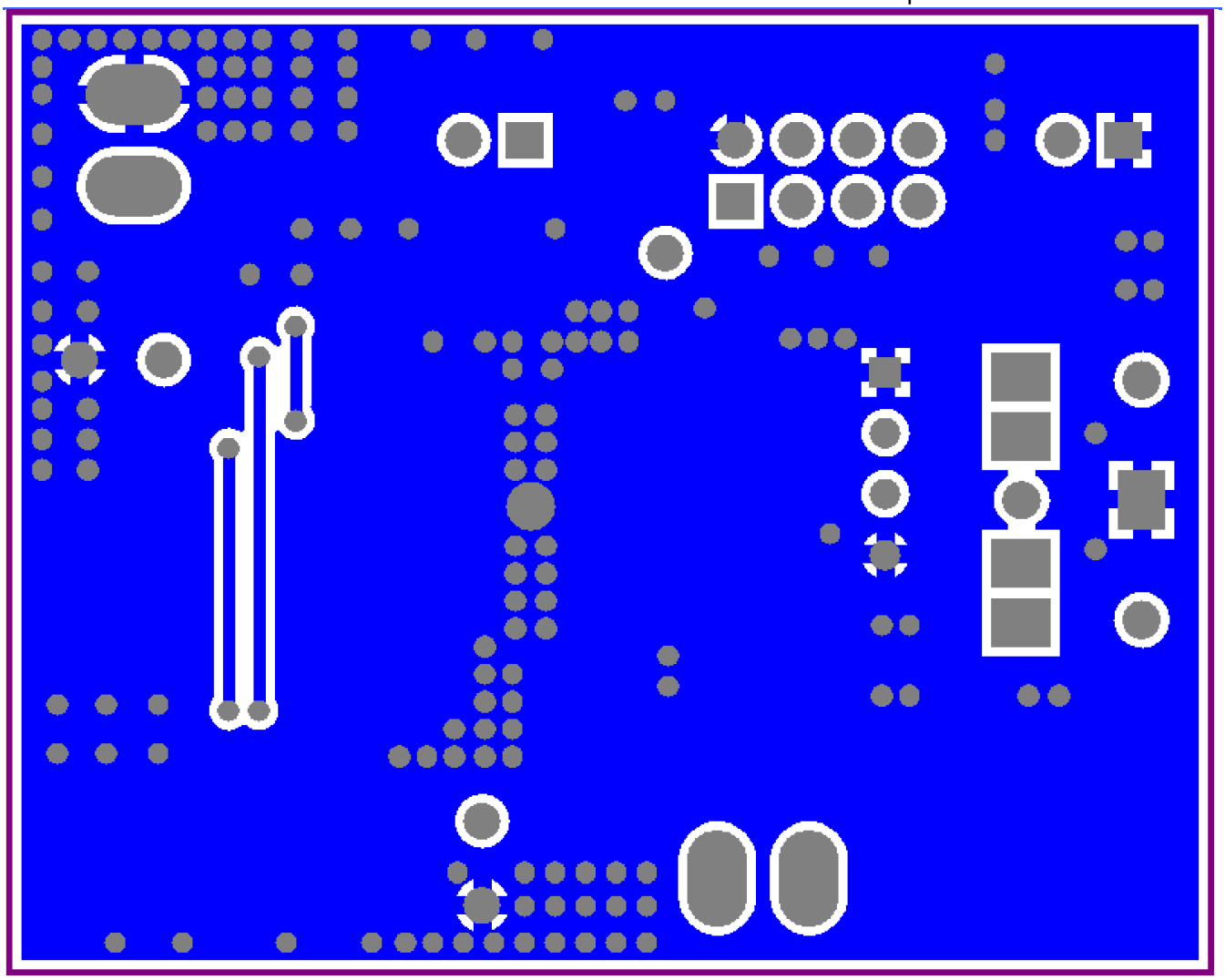
8.3. Low voltage Malfunction Prevention function

This is the function to establish the low voltage protection mode when VDD terminal voltage becomes lower than the detection voltage (VUVLL) for the low voltage malfunction prevention. And the protection mode is canceled when VDD terminal voltage becomes higher than the threshold voltage (VUVLH). In the low voltage protection mode, the differential output pin becomes Weak Low state (a state grounded through high impedance). HT8692 will start up within the start-up time (TSTUP) when the low voltage protection mode is cancelled.

当检测到电源端 VBAT 低于 VUVLL，启动欠压保护，D 类功放输出端为弱低电平状态（内部通过高阻接地）；当检测到 VBAT 高于 VUVLH，保护模式自动解除，经启动时间 TSTUP 后进入正常工作状态。

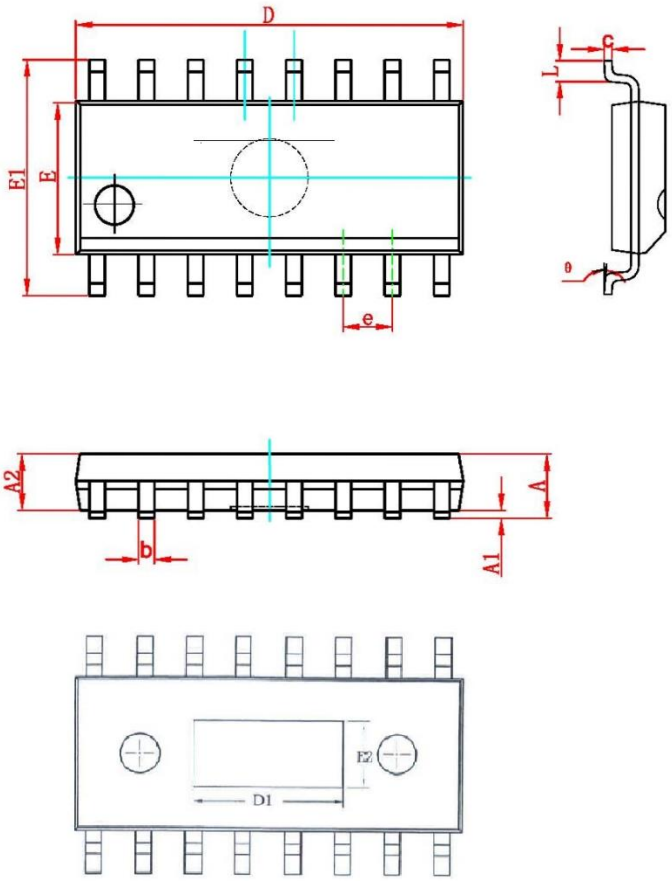
9. *PCB Layout*


Mute
R7 R8 R9
C13 R10
AB/D
VIN
CTRL
SD
ACF
OFF
C9
U1
C11
R1
C1
R2
C2
R3
C10
Lx
R4
C8
C7
L2
L1
C4
C3
D1
C6
C5
C12
HT8692S
HT8692H
V20
R6
R5
AUDIO IN



■ PACKAGE OUTLINE

SOP16L-PP



Symbol	Size (mm)	
	MIN	MAX
A	-	1.75
A1	0.05	0.15
A2	1.30	1.50
b	0.39	0.48
c	0.21	0.26
D	9.70	10.10
D1	4.57(REF)	
E	3.70	4.10
E1	5.80	6.20
E2	2.41(REF)	
e	1.27(BSC)	
L	0.50	0.80
θ	0°	8°

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