# 内置BOOST升压的2×5.5W立体声音频功率放大器

## ■ 特点

- 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

  2×5.5W($V_{BAT}$ = 4V, PVDD = 7V, $R_L$=4Ω, THD+N=10%)
- 电源

  -升压输入$V_{BAT}$：2.5V至5.5V

  -升压输出PVDD：$V_{BAT}$至7.0V
- BOOST输出电压可调
- AB/D类切换
- 过流/过热/欠压异常保护功能
- 无铅封装，SOP16L-PP

| 芯片料号 | 内置输入电阻$R_{IN}$ | 工作模式 |
|---|---|---|
| HT8699RSPEx | 17.8K ohm | D类和AB类 |
| HT8699B6SPEx | 10 ohm | D类 |

## ■ 概述

HT8699是一款内置BOOST升压模块的立体声音频功率放大器。在D类模式下，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7V时，10% THD+N，4Ω负载条件下，能连续输出2×5.5W 的功率。

HT8699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。

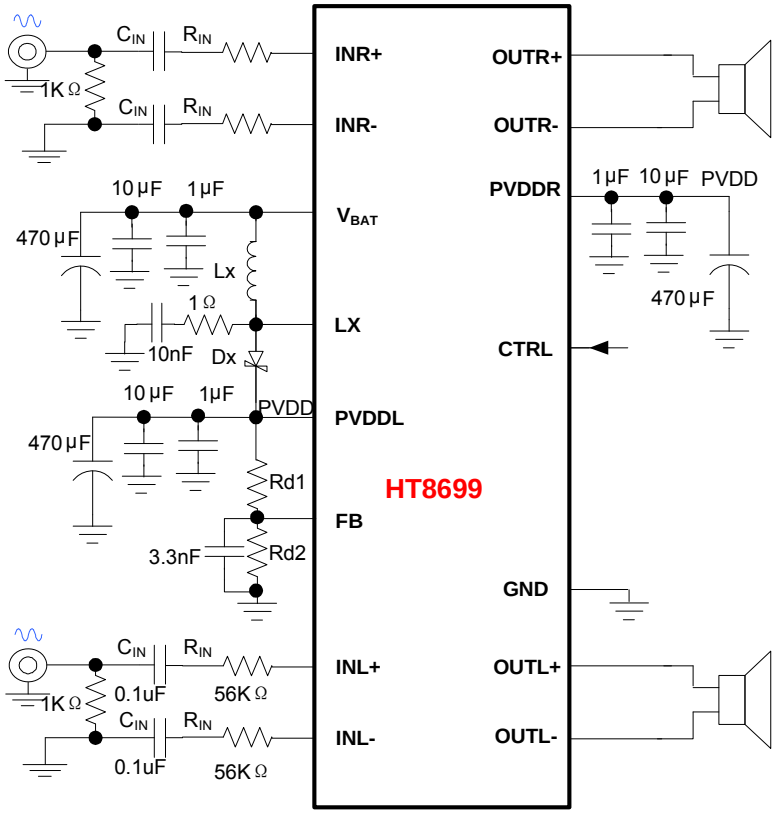
HT8699内部集成免滤波器数字调制技术，能够直接驱动扬声器，并最大程度减小脉冲输出信号的失真和噪音。输出无需滤波网络，极少的外部元器件节省了系统空间和成本，是便携式应用的理想选择。

此外，HT8699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。

## ■ 应用

- 蓝牙音箱
- 2.1声道小音箱
- iphone/ipod/ipod docking
- 便携式音箱
- 扩音器
- 便携式游戏机

## ■ 典型应用图





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# 2×5.5W Stereo Audio Amplifier with Boost Converter

## ■ FEATURE

- Anti-Clipping Function (ACF)
- Filter-less Modulation, Eliminating Output Filter
- Output Power

  2×5.5W($V_{BAT}$=4V, PVDD = 7V, $R_L$=4Ω, THD+N=10%)
- -BOOST Input $V_{BAT}$：2.5V to 5.5V

  -BOOST Output PVDD：$V_{BAT}$ to 7.5V
- Adjustable BOOST Output Voltage
- Class AB /Class D available
- Thermal Protection, Over current protection, Low voltage malfunction prevention function included
- Pb-Free Packages，SOP16L-PP

| Part No. | Internal Input Resistor $R_{IN}$ | Working Mode |
|---|---|---|
| HT8699RSPEx | 17.8K ohm | Class D & Class AB |
| HT8699B6SPEx | 10 ohm | Class D |

## ■ APPLICATIONS

- Bluetooth Speakers
- Portable Speakers
- iPhone/iPod/iPod docking
- Megaphone

## ■ GENERAL DESCRIPTION

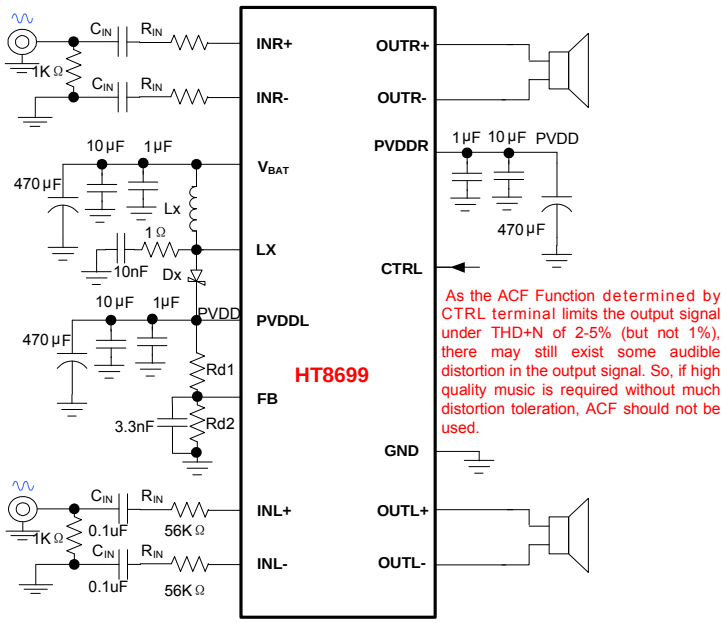
HT8699 integrates a boost converter with a filter-less stereo class D audio power amplifier to provide 2×5.5W continuous power into a 4Ω speaker when operating from a Li-battery voltage boosted to 7V. Meanwhile, the boost output voltage is adjustable.

Class AB amplifier mode is also available for HT8699. Once the EMI Interference from class D and Boost Converter becomes an annoying problem, HT8699 can be switched into Class AB mode.

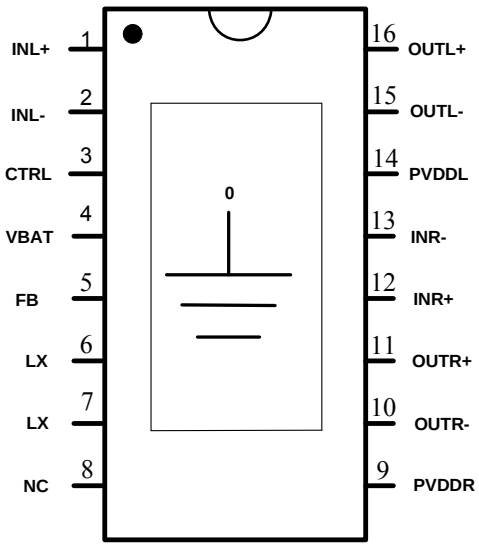
HT8699 has a filter-less modulation circuit which directly drives speakers while realizes low distortion and low noise characteristics. Thanks to filter-less, circuit design with fewer external parts can be made in portable applications.

HT8699 has the independent Shutdown function which can minimize the power consumption at standby and MUTE function. As for protection function, over current protection, over temperature protection function, and low supply voltage malfunction preventing function are also prepared.

## ■ 典型应用图



## ■ TERMINAL CONFIGURATION




SOP16L-PP Top View

## ■ TERMINAL FUNCTION[1]

| Terminal No. | Name | I/O | ESD Protection | Function |
|---|---|---|---|---|
| 0 | GND | GND | - | Power Ground. Do connect to the system Ground. |
| 1 | INL+ | I | PN | Left channel positive input (differential +) |
| 2 | INL- | I | PN | Left channel negative input (differential -) |
| 3 | CTRL | I | PN | Shutdown and ACF control terminal |
| 4 | $V_{BAT}$ | Power | PN | Logic Power Supply |
| 5 | FB | I | PN | Regulator Feedback Input |
| 6,7 | LX | I | - | Internal Switch Input |
| 8 | NC | | | No connection. Connect to GND for better thermal performance |
| 9 | PVDDR | Power | - | Boost Converter Output Voltage, Power Supply for Class D Right Channel |
| 10 | OUTR- | O | - | Right channel negative output (BTL-) |
| 11 | OUTR+ | O | | Right channel positive output (BTL+) |
| 12 | INR+ | I | PN | Right channel positive input (differential +) |
| 13 | INR- | I | PN | Right channel negative input (differential -) |
| 14 | PVDDL | Power | - | Boost Converter Output Voltage, Power Supply for Class D Left Channel |
| 15 | OUTL- | O | - | Left channel negative output (BTL-) |
| 16 | OUTL+ | O | | Left channel positive output (BTL+) |

[1] I: Input O: Output

## ■ ORDERING INFORMATION

| Part Number | Available Working Mode | Internal Input Resistor $R_{IN}$[1] | Package Type | Marking | Operating Temperature Range | MOQ/Shipping Package |
|---|---|---|---|---|---|---|
| HT8699RSPER | Class AB & Class D | 17.8k ohm | SOP16L-PP | HT8699R$_{SP}$ | -40℃～85℃ | Tube / 50 PCS |
| HT8699RSPET | Class AB & Class D | 17.8k ohm | SOP16L-PP | HT8699R$_{SP}$ | -40℃～85℃ | Tape and Reel 2500PCS |
| HT8699B6SPET | Class D | 10ohm | SOP16L-PP | HT8699$_{SP}$ | -40℃～85℃ | Tube / 50 PCS |
| HT8699B6SPER | Class D | 10ohm | SOP16L-PP | HT8699$_{SP}$ | -40℃～85℃ | Tape and Reel 2500PCS |

## ■ ELECTRICAL CHARACTERISTIC

### ● Absolute Maximum Ratings [2]

| Item | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Power supply voltage range | $V_{BAT}$ | -0.3 | 5.5 | V |
| BOOST converter output voltage range | PVDD | $V_{BAT}$ | 7.0 | 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

| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Power Supply Voltage [3] | $V_{BAT}$ | | 2.5 | 3.6 | 5.5 | V |
| BOOST converter output voltage range | PVDD | | $V_{BAT}$ | 6.0 | 7.0 | V |
| Operating Ambient Temperature | $T_a$ | | -40 | 25 | 85 | ℃ |
| Speaker Impedance | $R_L$ | | 4 | | | Ω |

[1] See Fig. 3 in Page 12 for detail.
[2] Absolute Maximum Ratings is values which must not be exceeded to guarantee device reliability. With a system in which supply voltage might exceed supply voltage of PVDD/GND, external diodes are recommended to be used to assure that the voltage does not exceed the absolute maximum rating.
[3] The rising time of $V_{BAT}$ should be more than 1μs.

## Electrical Specification[1]

| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **BOOST Converter** | | | | | | |
| Boost converter output voltage | PVDD | | $V_{BAT}$ | 6.0 | 7.0 | V |
| Boost converter frequency | $f_{SW}$ | | | 420 | | kHz |
| Boost converter input current limit | $I_{LIMTRIP}$ | | | 4.6 | | A |
| **Class D Channel** $V_{SS}$=0V, $V_{BAT}$ =3.6V, PVDD = 6.0V, $R_{IN}$ = 56K, Ta=25ºC, $C_{IN}$=1uF, ACF-Off mode, unless otherwise specified | | | | | | |
| Carrier clock frequency | $f_{PWM}$ | | | 420 | | kHz |
| Over current protection | Imax | | | | 5 | A |
| System Gain | $Av_0$ | External $R_{IN}$=56 kΩ, for HT8699B6SPEx | | 26 | | dB |
| | | External $R_{IN}$=0, for HT8699RSPEx | | 27.5 | | |
| Start-up time (power-on or shutdown release) | $t_{STUP}$ | | | 260 | | ms |
| ACF attenuation gain | Aa | | -16 | | 0 | dB |
| Consumption current in shutdown mode | $I_{SD}$ | CTRL=$V_{SS}$ | | 23 | | μA |
| Output Power | $P_O$ | $R_L$=4Ω, $V_{BAT}$=3.6V, f=1kHz, THD+N=10% | | 2×4.5 | | W |
| | | $R_L$=8Ω, $V_{BAT}$=3.6V, f=1kHz, THD+N=10% | | 2×2.6 | | |
| | | $R_L$=4Ω, $V_{BAT}$=3.6V, f=1kHz, THD+N=1% | | 2×3.7 | | |
| | | $R_L$=8Ω, $V_{BAT}$=3.6V, f=1kHz, THD+N=1% | | 2×2.1 | | |
| Total Harmonic Distortion plus Noise | THD+N | PVDD = 6V, $P_O$=1.0W, $R_L$=4Ω, f=1kHz | | 0.12 | | % |
| | | PVDD = 6.5V, $P_O$=1.0W, $R_L$=4Ω, f=1kHz | | 0.11 | | % |
| | | PVDD = 7V, $P_O$=1.0W, $R_L$=4Ω, f=1kHz | | 0.11 | | % |
| Output Noise | $V_N$ | f=20Hz~20kHz, A weighted, Av=26dB | | 155 | | $μV_{rms}$ |
| Signal to Noise Ratio | SNR | A weighted, Av=26dB, THD+N = 1% | | 88 | | dB |
| Output offset voltage | $V_{OS}$ | | | ±2 | | mV |
| Crosstalk | CS | L -> R, f = 1kHz, Po = 1W | | -100 | | dB |
| | | R -> L, f = 1kHz, Po = 1W | | -85 | | |
| Efficiency (Class D + Boost) | η | $V_{BAT}$=3.6V, $R_L$=4Ω+22uH, THD+N = 1% | | 70 | | % |
| | | $V_{BAT}$=3.6V, $R_L$=8Ω+33uH, THD+N = 1% | | 77 | | % |
| Quiescent current | $I_{BAT}$ | No Load, Input Grounded | | 27 | | mA |
| | | With Load[2], Input Grounded | | 26 | | mA |
| Maximum Input Signal | $V_{IN}$max | $f_{IN}$ = 1kHz, THD+N≤10%, ACF-1 ON | | 1.5 | | Vrms |

[1] Depending on parts and pattern layout, characteristics may be changed.
[2] 4ohm resistor and 22uH coil are used as an output load in order to simulate a speaker.

| Item | Symbol | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| **Class AB Channel** $V_{SS}$=0V, $V_{BAT}$ =3.6V, Av=20dB, Ta=25ºC, $C_{IN}$=1uF, HT8699RSPEx, unless otherwise specified | | | | | | | |
| Output Power | $P_O$ | f=1kHz, THD+N=10% | $R_L$=4Ω, $V_{BAT}$=3.6V | | 1.3 | | W |
| | | | $R_L$=4Ω, $V_{BAT}$=4.2V | | 1.8 | | W |
| | | | $R_L$=4Ω, $V_{BAT}$=5.0V | | 2.65 | | W |
| | | f=1kHz, THD+N=1% | $R_L$=4Ω, $V_{BAT}$=3.6V | | 1.0 | | W |
| | | | $R_L$=4Ω, $V_{BAT}$=4.2V | | 1.5 | | W |
| | | | $R_L$=4Ω, $V_{BAT}$=5.0V | | 2.1 | | W |
| Total Harmonic Distortion plus Noise | THD+N | $P_O$=0.01W | $R_L$=4Ω, f=1kHz | | 0.12 | | % |
| | | $P_O$=0.1W | | | 0.1 | | % |
| Output Noise | $V_N$ | f=20Hz~20kHz, A weighted Av=20dB | | | 75 | | $\mu V_{rms}$ |
| Signal to Noise Ratio | SNR | A weighted, Av=20dB, THD+N = 1% | | | 90 | | dB |
| Output offset voltage | $V_{OS}$ | | | | ±4 | | mV |
| Efficiency | η | $R_L$=4Ω+22uH, THD+N = 10% | | | 70 | | % |
| | | $R_L$=8Ω+33uH, THD+N = 10% | | | 74.5 | | % |
| Quiescent current | $I_{BAT}$ | Input Grounded | No Load | | 20 | | mA |
| | | | With Load | | 20 | | mA |
| Current consumption in Mute mode | $I_{MUTE}$ | Input Grounded, MUCH = H | No Load | | 2.0 | | mA |
| | | | With Load | | 2.0 | | mA |
| Current consumption in Shutdown mode | $I_{SD}$ | CTRL=$V_{SS}$ | | | 36 | | μA |
| System Gain | $Av_0$ | External $R_{IN}$=0 | | | 21.5 | | dB |
| Start-up time (power-on, shutdown release, or shift between Class D and Class AB) | $t_{STUP}$ | | | | 260 | | ms |
| **MISCELLANEOUS** | | | | | | | |
| $V_{BAT}$ start-up threshold voltage | $V_{UVLH}$ | | | | 2.5 | | V |
| $V_{BAT}$ shut-down threshold voltage | $V_{UVLL}$ | | | | 2.2 | | V |

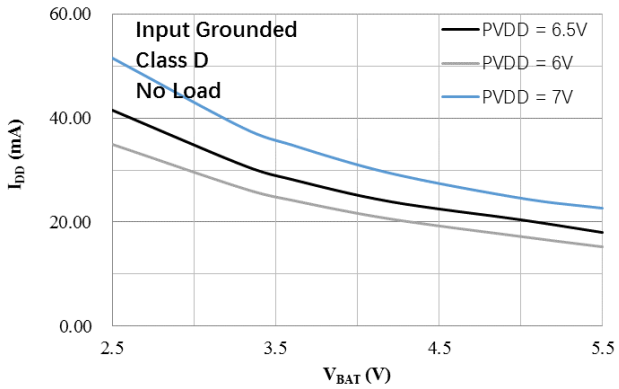
| Item | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| SD wake up voltage | $V_{CTRL\_ON}$ | | 0.9 | | | V |
| **CTRL Terminal Voltage for** HT8699B6SPEx | | | | | | |
| Class D mode in ACF-Off with Boost Converter | $V_{MOD1}$ | | 0.75× PVDD | | PVDD | V |
| Class D mode in ACF-1 with Boost Converter | $V_{MOD2}$ | | 0.45× PVDD | | 0.70× PVDD | V |
| Class D mode in ACF-2 with Boost Converter | $V_{MOD3}$ | | 0.10× PVDD | | 0.40× PVDD | V |
| SD mode | $V_{MOD4}$ | Shutdown mode | $V_{SS}$ | | 0.06× ($V_{BAT}$-$V_F$[1]) | V |
| Internal pull-down Resistor of CTRL | $R_{CTRL}$ | | | 60 | | KΩ |
| **CTRL Terminal Voltage for** HT8699RSPEx | | | | | | |
| Class D mode in ACF-Off with Boost Converter | $V_{MOD1}$ | | 2.4 | | VBAT | V |
| Class D mode in ACF-1 with Boost Converter | $V_{MOD2}$ | | 1.6 | | 2.2 | V |
| Class AB mode in ACF-off without Boost Converter | $V_{MOD3}$ | | 0.4 | | 1.4 | V |
| SD mode | $V_{MOD4}$ | Shutdown mode | $V_{SS}$ | | 0.2 | V |
| Internal pull-down Resistor of CTRL | $R_{CTRL}$ | | | 150 | | KΩ |

[1] $V_F$ is the forward voltage of external diode.

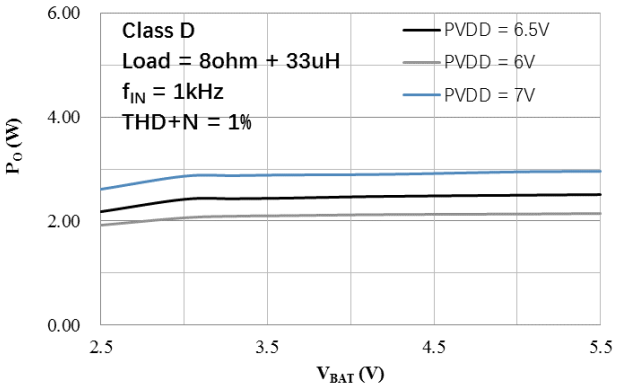
## ■ TYPICAL OPERATING CHARACTERISTICS

Condition: Class D mode, $V_{BAT}$ = 3.6V, $f_{IN}$ = 1kHz, $C_{IN}$ = 1uF, ACF off, Load = 4ohm+33uH, unless otherwise specified

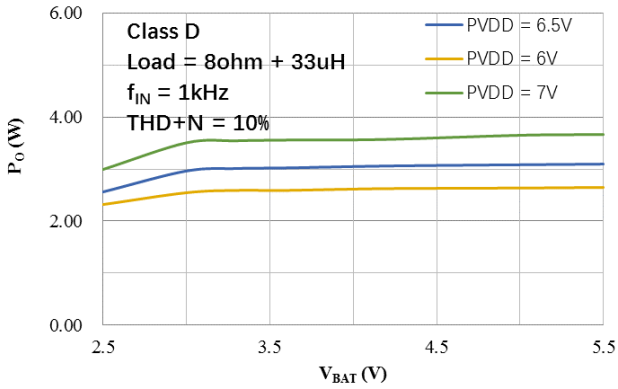
### $V_{BAT}$ vs $I_{DD}$



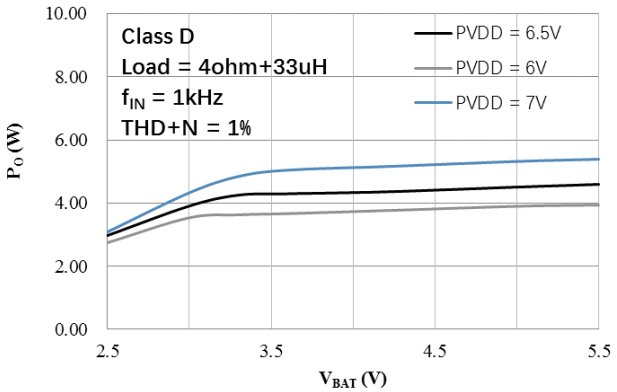

### $V_{BAT}$ vs $P_O$



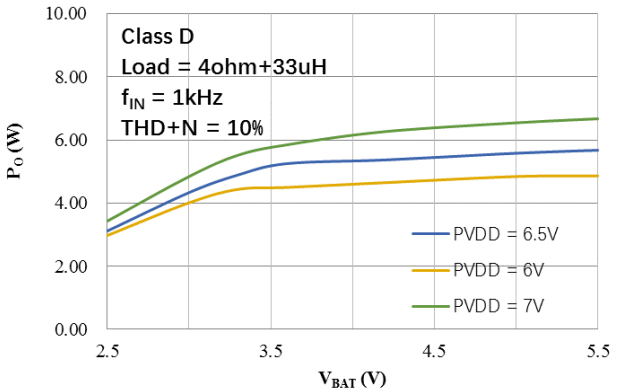

### $V_{BAT}$ vs $P_O$



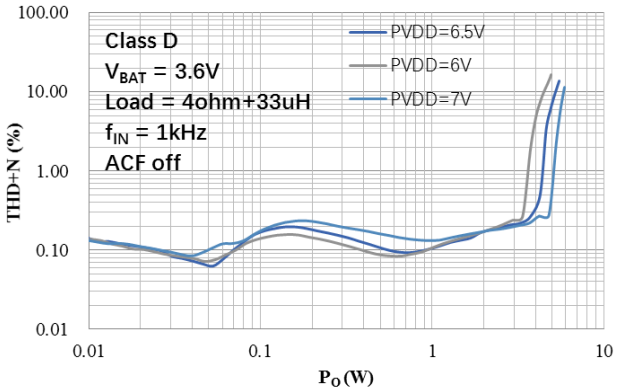

### $V_{BAT}$ vs $P_O$



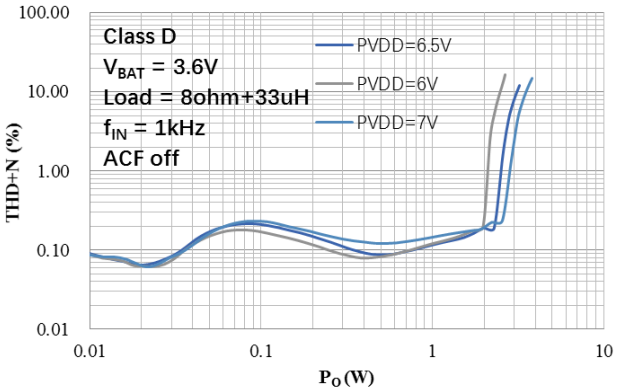

### $V_{BAT}$ vs $P_O$



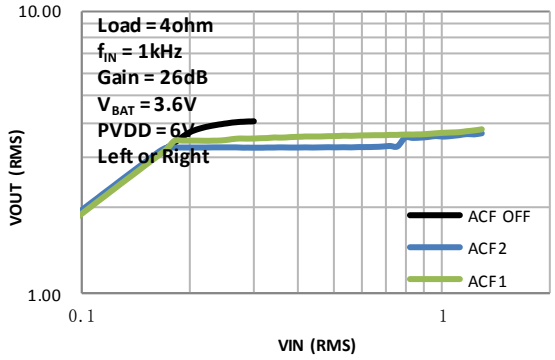
## $P_O$ vs THD+N



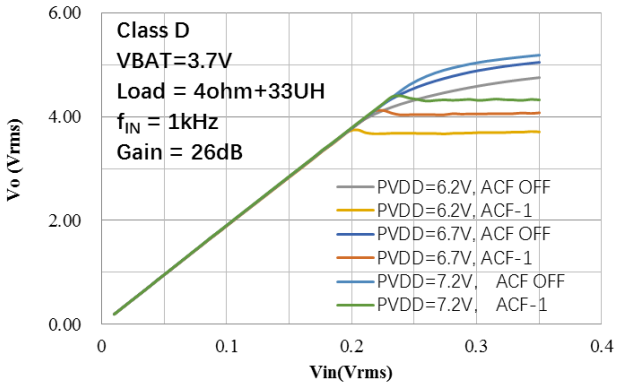

## $P_O$ vs THD+N



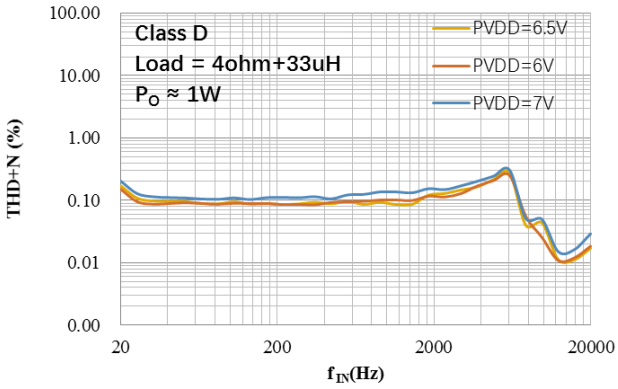

## VIN vs VOUT



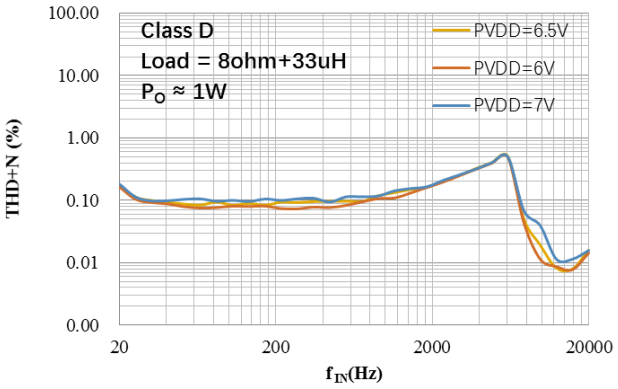

## $V_{in}$ vs $V_o$



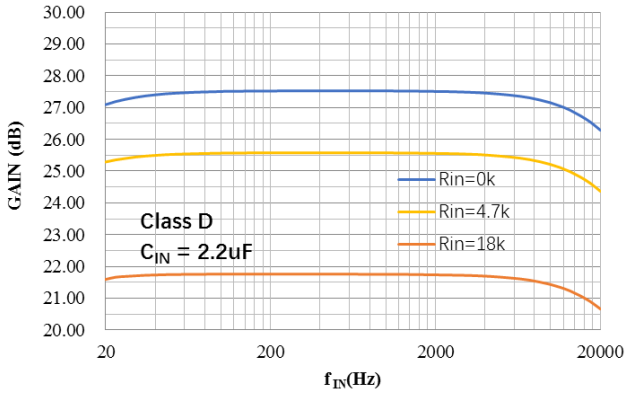

## $f_{IN}$ vs THD+N

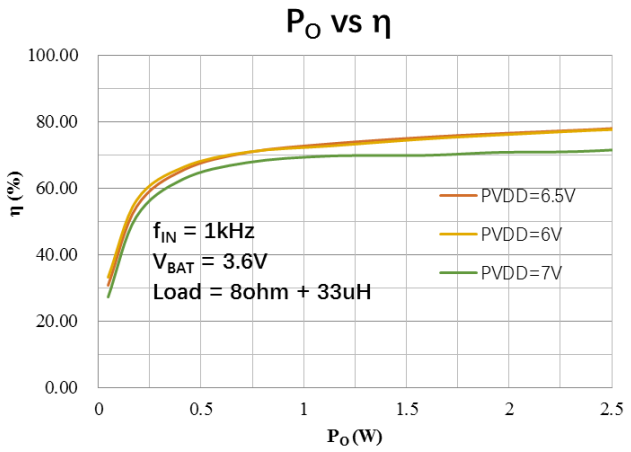


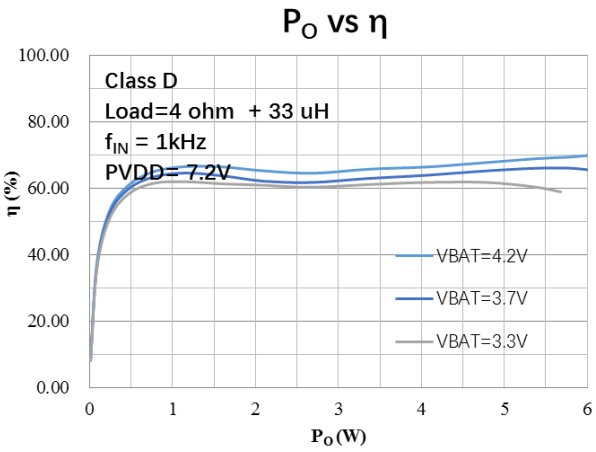

## $f_{IN}$ vs THD+N

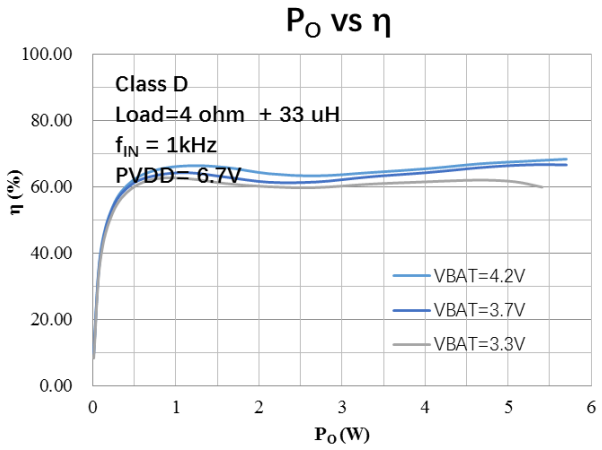


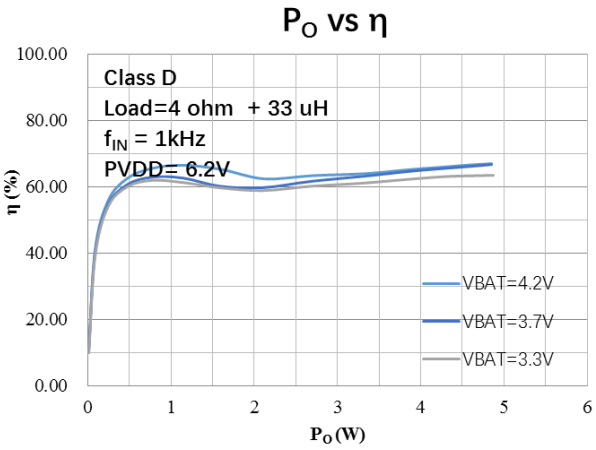

## $f_{IN}$ vs Gain




Po vs η
100.00
80.00
60.00
40.00
20.00
0.00
η (%)
0
0.5
1
1.5
2
2.5
Po (W)
fIN = 1kHz
VBAT = 3.6V
Load = 8ohm + 33uH
PVDD=6.5V
PVDD=6V
PVDD=7V


Po vs η
100.00
80.00
60.00
40.00
20.00
0.00
η (%)
0
1
2
3
4
5
6
Po (W)
Class D
Load=4 ohm + 33 uH
fIN = 1kHz
PVDD= 7.2V
VBAT=4.2V
VBAT=3.7V
VBAT=3.3V

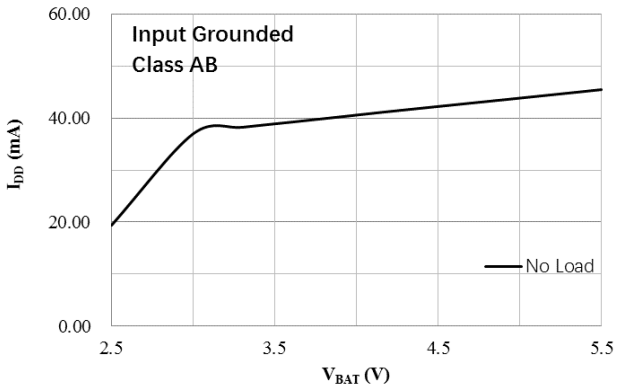

Po vs η
100.00
80.00
60.00
40.00
20.00
0.00
η (%)
0
1
2
3
4
5
6
Po (W)
Class D
Load=4 ohm + 33 uH
fIN = 1kHz
PVDD= 6.7V
VBAT=4.2V
VBAT=3.7V
VBAT=3.3V


Po vs η
100.00
80.00
60.00
40.00
20.00
0.00
η (%)
0
1
2
3
4
5
6
Po (W)
Class D
Load=4 ohm + 33 uH
fIN = 1kHz
PVDD= 6.2V
VBAT=4.2V
VBAT=3.7V
VBAT=3.3V

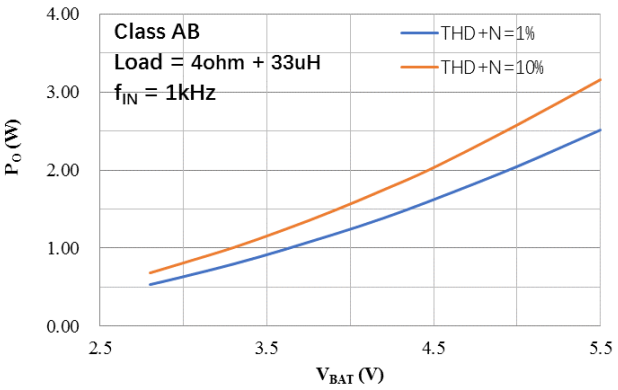
**Class AB Channel**

Condition: Class AB mode (HT8698RSPEx), $V_{BAT}$ = 3.6V, $f_{IN}$ = 1kHz, Load = 4ohm, unless otherwise specified

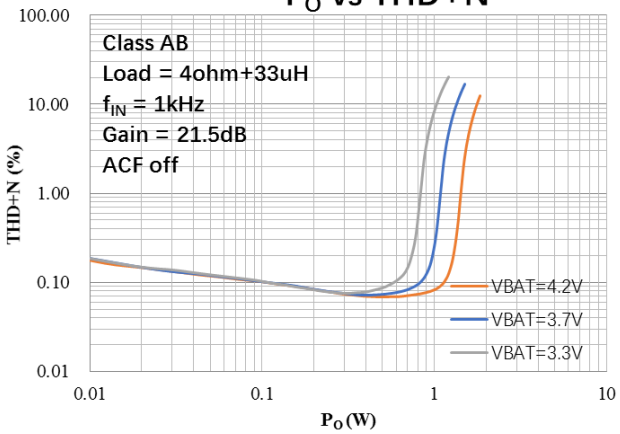
### $V_{BAT}$ vs $I_{DD}$



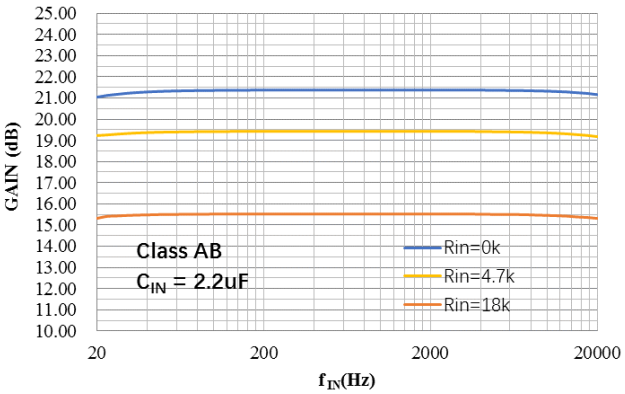

### $V_{BAT}$ vs $P_O$



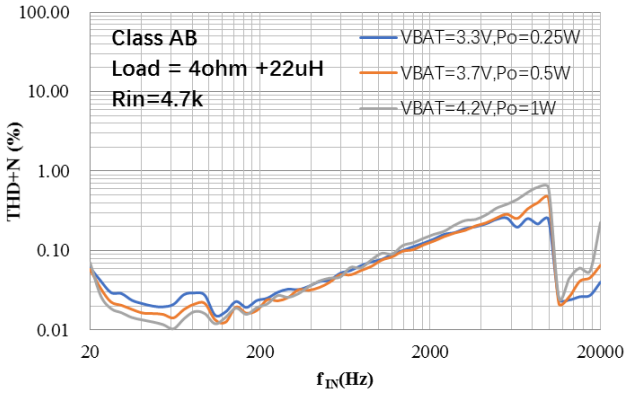

### $P_O$ vs THD+N



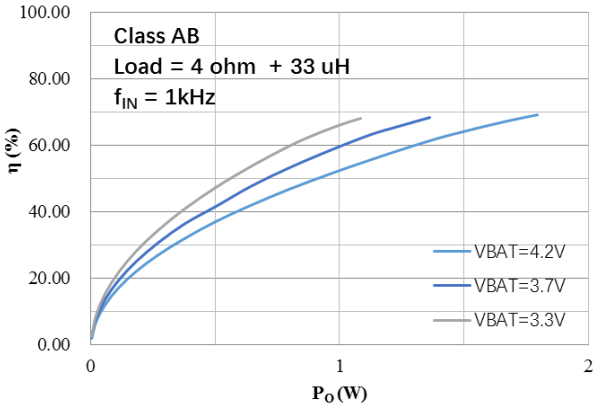

### $f_{IN}$ vs Gain




### $f_{IN}$ vs THD+N




### $P_O$ vs η



## ■ APPLICATION INFORMATION

### ● BOOST Converter

**(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.

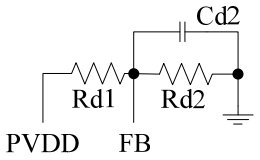



Fig. 1 FB Terminal Configuration

Some typical output voltages can be got by following settings.

Table 1. Output Voltage Setting

| PVDD | Rd1 | Rd2 | Cd2 |
|---|---|---|---|
| 5.0V | 120K | 39.5K | 3.3nF |
| 6.0V | 120k | 31k | 3.3nF |
| 6.5V | 120K | 28K | 3.3nF |
| 7.0V | 120K | 25.5K | 3.3nF |

**(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.

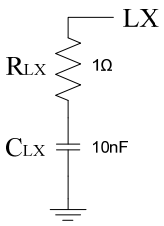



Fig. 2 LX Terminal Configuration

**(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//220uF (paralleled) is highly recommended to be placed in both input and output terminal as closely to the pin as possible. If possible, 470uF is better than 220uF.

**(4) Inductor Selection**

Inductance value is decided based on different condition. L≥10uH, DCR<1ohm, $I_{SAT}$≥5A is recommended for general application circuit.

**(5) Schottky Diode Selection**

$V_{RRM}$ > 12V, $V_{FM}$＜0.5V, $I_F$≥4 A is recommended for general application circuit.

**(6) Layout Consideration**

1. The power traces, consisting of the GND, LX, $V_{BAT}$ 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 $C_{IN}$ and $C_{OUT}$ near $V_{BAT}$ 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.

## ● Analog Signal Input Configuration

HT8699 is an amplifier with analog input (single-ended or differential). For a differential operation, input signals into IN+ and IN- pins via DC-cut capacitors ($C_{IN}$) and external input resistors $R_{IN}$. The input signal gain is calculated by $Gain \approx R_F / (External\ R_{IN} + Internal\ R_{IN})$. And the high pass cut-off frequency of input signal can be calculated by $f_c = \frac{1}{2\pi(External\ R_{IN} + External\ R_{IN}) \times C_{IN}}$.

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

| Part No. | Working Mode | Internal $R_{IN}$(ohm) | $R_F$(ohm) |
|---|---|---|---|
| HT8699B6SPEx | Class D mode | 10 | 1200K |
| HT8699RSPEx | Class D mode | 17.8k | 420K |
| HT8699RSPEx | Class AB mode | 17.8k | 210K |

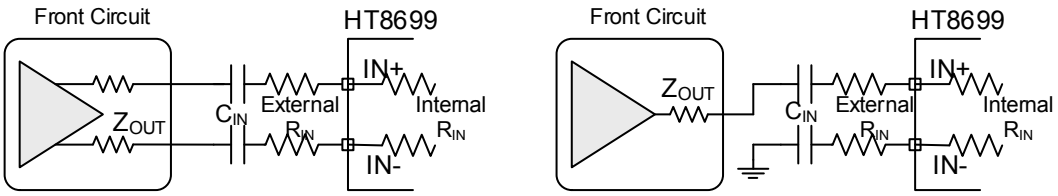



Fig. 3 (1) Differential Input; (2) Single-ended Input

## ● Output Configuration

As mentioned, HT8699 can directly drive speakers without any other components. But there are exceptions. Once HT8699 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.

## ● CTRL Terminal Mode Control

HT8699 can work in different modes by setting the CTRL terminal, shown as follow.

Table. 2 CTRL Terminal Mode Control for HT8699RSPEx

| MODE | SYMBOL | CTRL Voltage | | | |
|---|---|---|---|---|---|
| | | MIN. | TYP. | MAX. | UNIT |
| Class D mode in ACF-Off with Boost Converter | $V_{MOD1}$ | 2.4 | | VBAT | V |
| Class D mode in ACF-1 with Boost Converter | $V_{MOD2}$ | 1.6 | | 2.2 | V |
| Class AB mode in ACF-off without Boost Converter | $V_{MOD3}$ | 0.4 | | 1.4 | V |
| SD(Shutdown) Mode | $V_{MOD4}$ | VSS | | 0.2 | V |

Notes: ACF-1 and ACF-2 mode can only be worked in class D mode. A 150kΩ pull-down resistor ($R_{CTRL}$) are inside of the CTRL terminal, shown as follows.

Table. 3 CTRL Terminal Mode Control for HT8699B6SPEx

| MODE | SYMBOL | CTRL Voltage | | | |
|---|---|---|---|---|---|
| | | MIN. | TYP. | MAX. | UNIT |
| Class D mode in ACF-Off with Boost Converter | $V_{MOD1}$ | 0.75× PVDD | | PVDD | V |
| Class D mode in ACF-1 with Boost Converter | $V_{MOD2}$ | 0.45× PVDD | 0.66× PVDD | 0.70× PVDD | V |
| Class D mode in ACF-2 with Boost Converter | $V_{MOD3}$ | 0.10× PVDD | 0.33× PVDD | 0.40× PVDD | V |
| SD(Shutdown) Mode | $V_{MOD4}$ | GND | | 0.06× × ($V_{BAT}$-$V_F$[1]) | V |

Notes: ACF-1 and ACF-2 mode can only be worked in class D mode. A 60kΩ pull-down resistor ($R_{CTRL}$) are inside of the CTRL terminal, shown as follows.


Fig. 4 CTRL Terminal

- **Anti-Clipping Function (ACF) and mode Configuration**

**(1) ACF ON Mode**

In ACF-ON modes, HT8699 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 HT8699 also follows to the clips of the output waveform due to the decrease in the power-supply voltage.

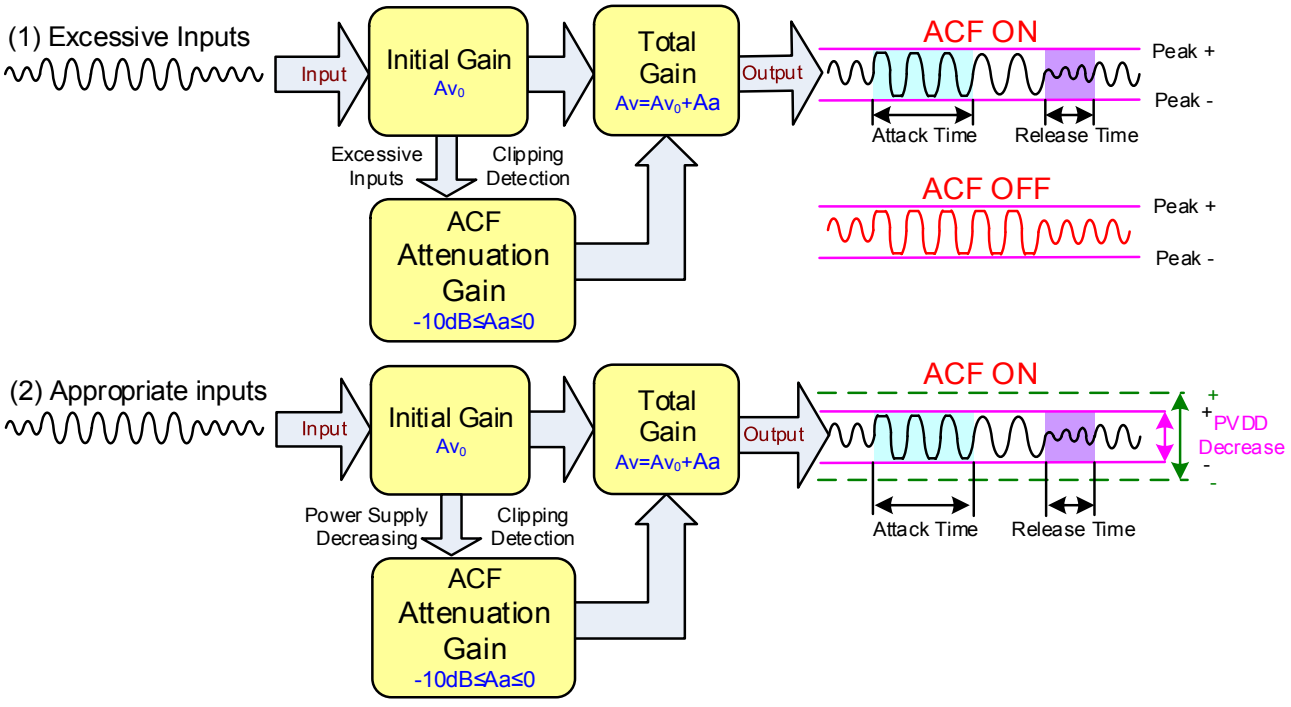



Fig. 5 the ACF Function Operation Outline

[1] $V_F$ is the forward voltage of external diode.

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

Table 4 Attack time and Release time

| ACF mode | Attack time | Release time |
|---|---|---|
| ACF-1 | 6.7ms/dB | 67ms/dB |
| ACF-2 | 0.1ms/dB | 400ms/dB |

Note: As the ACF Function limits the output signal under THD+N of 2-5% (but not 1%), there may still exist some audible distortion in the output signal. So, if high quality music is required without much distortion toleration, ACF should not be used.

**(2) ACF OFF Mode**

In ACF-Off mode, ACF function is disenabled. HT8699 will not detect output clipping and the system gain is kept to be $Av=Av_0$. The audio quality would worsen due to clipping distortion.

**(3) SD Mode**

In shutdown mode, HT8699 shuts all circuit down and minimizes the power consumption. And, the output terminals become Weak Low (A high resistance grounded state).

- **Pop-Click Noise Reduction**

The Pop-Click Noise Reduction Function of HT8699 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 control.

・During power-on, Shutdown mode is not cancelled until the power supply is stabilized enough.
・Before Power-off, set Shutdown mode first.

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

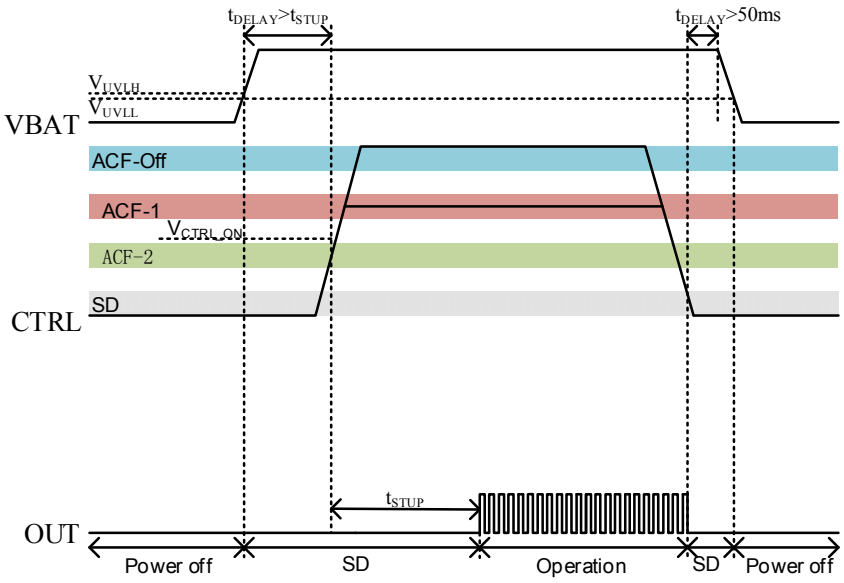



Fig. 6 Pop-Click Noise Reduction by Shutdown

- **Protection Function**

HT8699 has the protection functions such as Thermal Protection function, and Low Voltage Malfunction Prevention function.

**(1) Over-current Protection function**

When a short circuit occurs between one output terminal, 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.

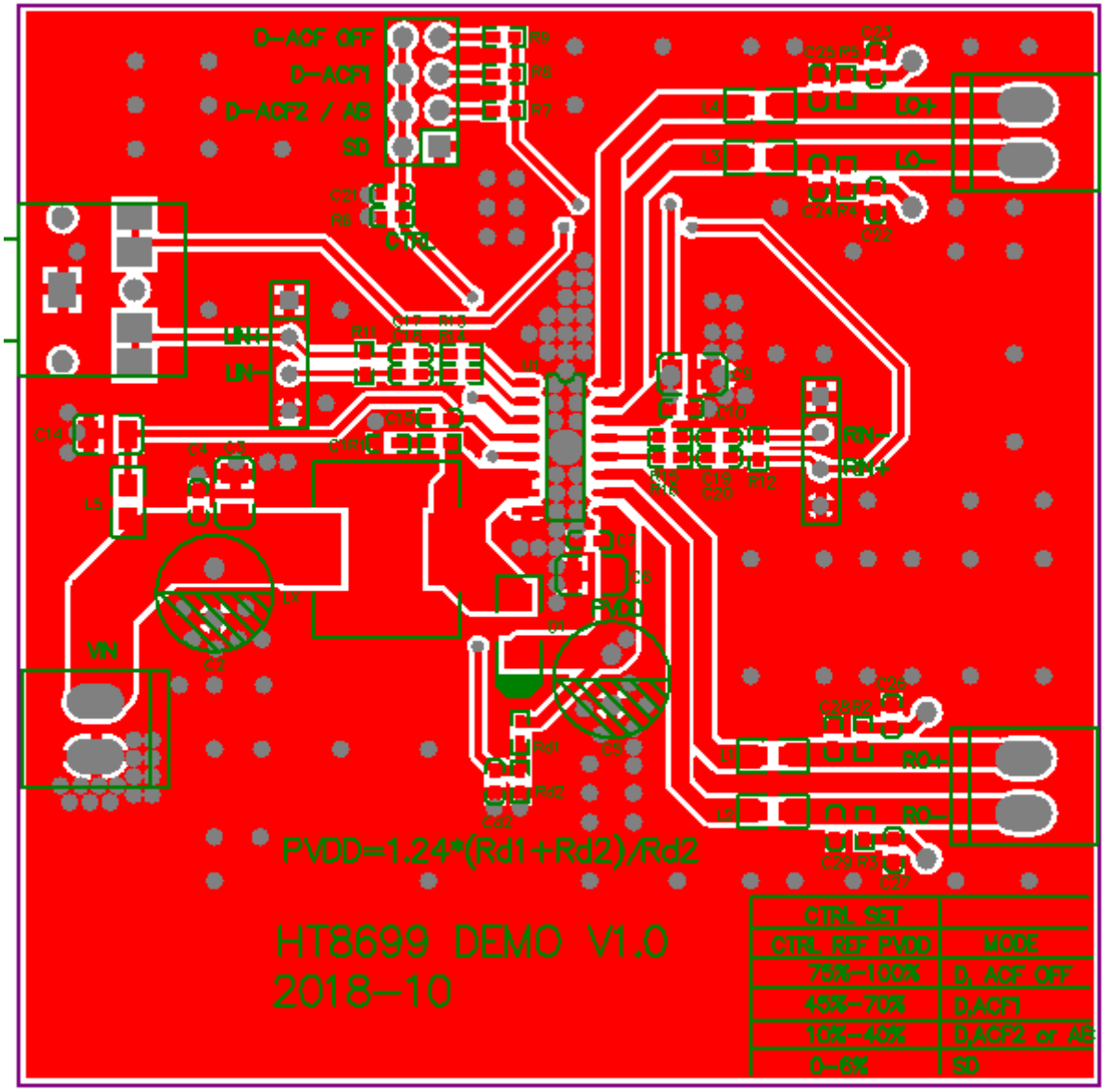
**(2) Thermal Protection function**

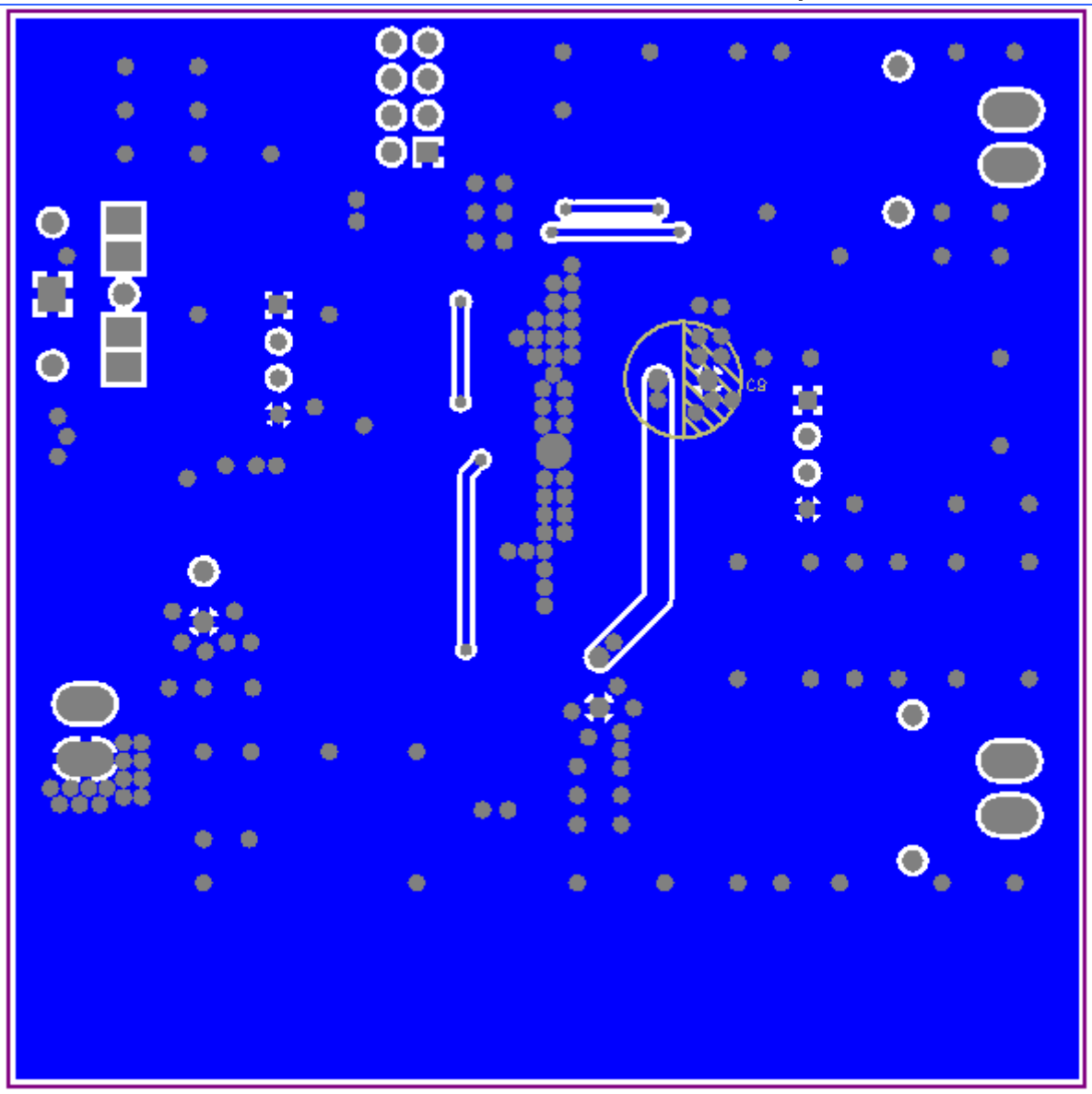
When excessive high temperature of HT8699 (150℃) is detected, the thermal protection mode starts up. In the thermal protection mode, the differential output terminal becomes Weak Low state (a state grounded through high impedance).

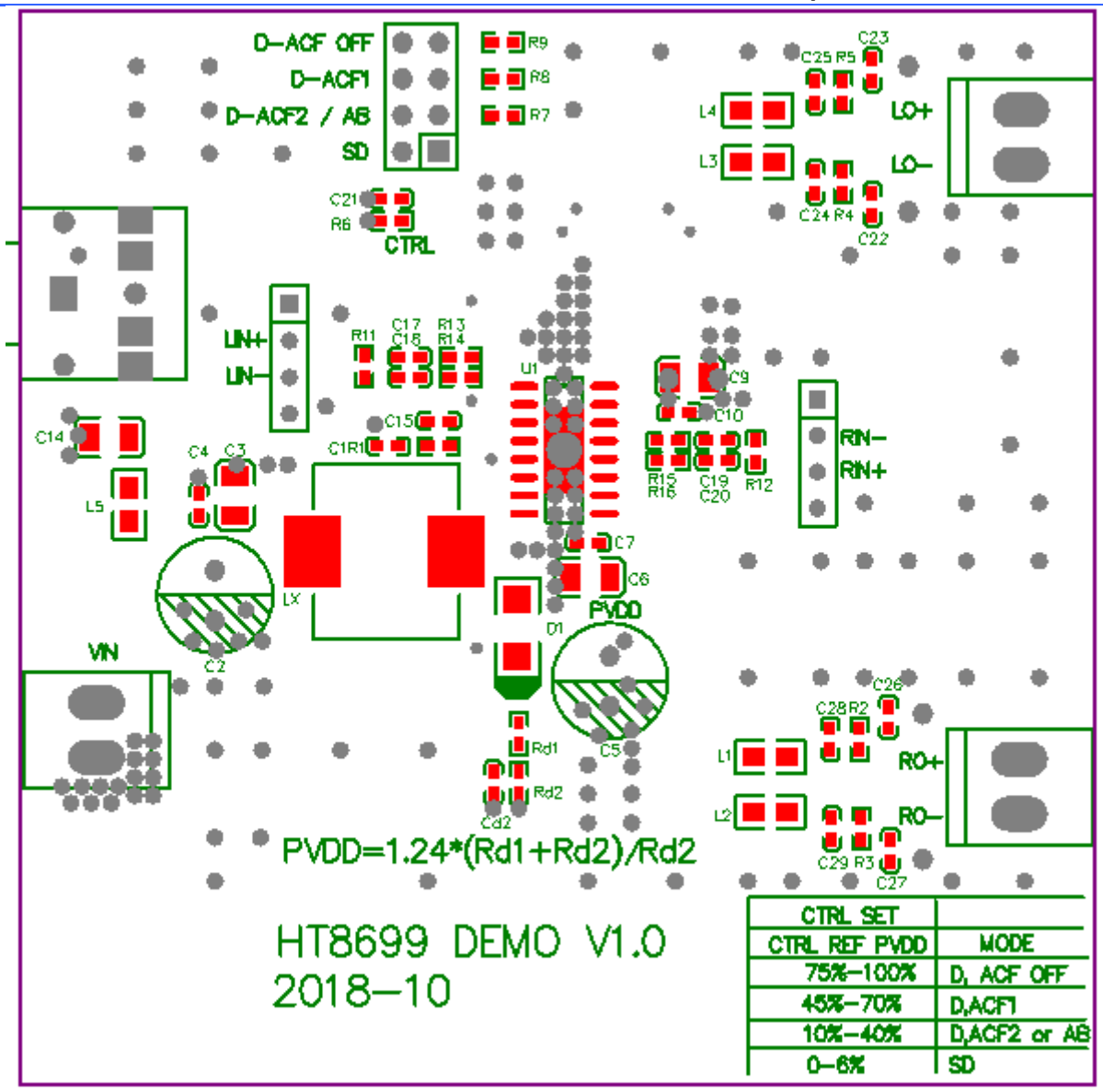
**(3) Low voltage Malfunction Prevention function**

This is the function to establish the low voltage protection mode when Vbat terminal voltage becomes lower than the detection voltage ($V_{UVLL}$) for the low voltage malfunction prevention. And the protection mode is canceled when Vbat terminal voltage becomes higher than the threshold voltage ($V_{UVLH}$). In the low voltage protection mode, the differential output pin becomes Weak Low state (a state grounded through high impedance). HT8699 will start up within the start-up time ($T_{STUP}$) when the low voltage protection mode is cancelled

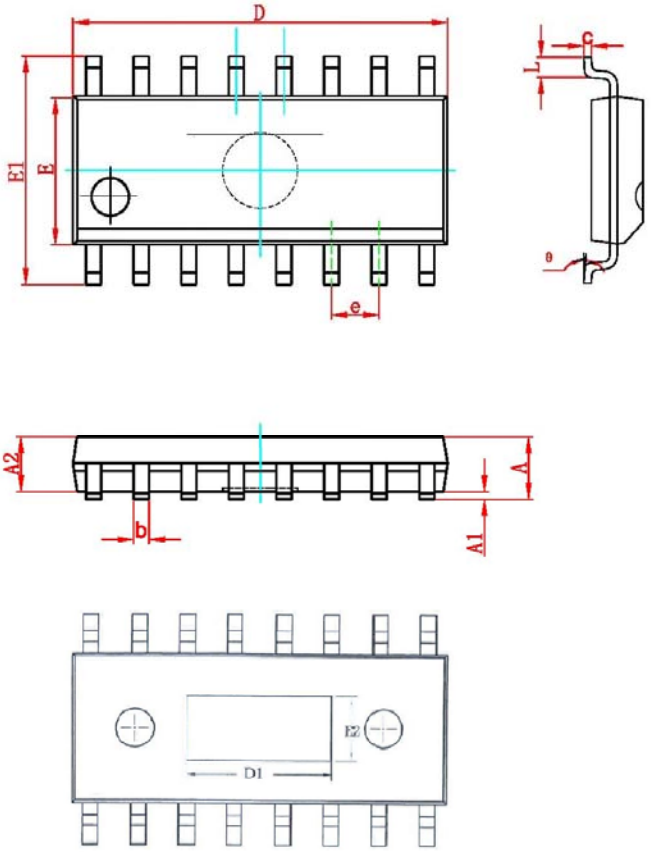
## PCB Layout


D-ACF OFF
D-ACF1
D-ACF2 / AB
SD
CTRL
LIN+
LIN-
VIN
PVDD
LO+
LO-
RO+
RO-
RIN-
RIN+
PVDD=1.24*(Rd1+Rd2)/Rd2
HT8699 DEMO V1.0
2018-10
CTRL SET
CTRL REF PVDD
MODE
75%-100%
D_ ACF OFF
43%-70%
D.ACF1
10%-40%
D.ACF2 or AB
0-6%
SD


C9


D-ACF OFF
D-ACF1
D-ACF2 / AB
SD
R9
R8
R7
C21
R6
CTRL
C23
C25 R5
L4
L3
LO+
LO-
C24 R4
C22
LIN+
LIN-
R11
C17
C18
R13
R14
U1
C9
C10
C15
C1R1
C14
C4
C3
L5
R15
R16
C19
C20
R12
RIN-
RIN+
C7
C6
PVDD
LX
D1
VIN
C2
C5
C26
C28 R2
L1
L2
RO+
RO-
C29 R3
C27
Rd1
Rd2
Cd2
PVDD=1.24*(Rd1+Rd2)/Rd2
HT8699 DEMO V1.0
2018-10
CTRL SET
CTRL REF PVDD
MODE
75%-100%
D, ACF OFF
45%-70%
D,ACF1
10%-40%
D,ACF2 or AB
0-6%
SD

## ■ PACKAGE OUTLINE




| Symbol | Dimensions (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° |