实时音频跟踪的高效内置升压2×10W免电感立体声AB/D类音频功放

2×10W Inductor Free, Stereo Class AB/D Amplifier with High-Efficiency Adaptive Audio-Tracking Boost Converter

■ FEATURES

・Output Power (f_{IN} = 1kHz, R_L=4Ω, BTL)
V_{BAT} = 4V, 2×10.6W (VOUT=9V, THD+N = 10%)
V_{BAT} = 4V, 2×8.6W (VOUT=9V, THD+N= 1%)
・Selectable mode for Integrated boost converter: Adaptive Audio-Tracking Output (increasing playback time by more than 50%) or forced boost output
・Selectable maximum output voltage VOUT (7V, 8V, 9V) and adjustable switch peak current limit
・ACF (Anti-Clipping Function) Integrated
・Class D or Class AB mode
・Differential / Single-ended Analog Input
・Over current protection/ Over temperature protection / Overvoltage protection / Low voltage malfunction prevention function with auto recovery
・Pb-free Packages, ETSSOP28

・输出功率(f_{IN}=1kHz, R_L=4Ω, BTL)
VBAT = 4V, 2×10.6W (VOUT=9V, THD+N = 10%)
VBAT = 4V, 2×8.6W (VOUT=9V, THD+N= 1%)
・内置升压电路模式可选择：自适应实时音频跟踪升压（可提升播放时间50%以上）、强制升压；
・最大升压值可选择，升压限流值可设置
・ACF防破音功能
・D类或AB类可选
・模拟差分/单端输入
・保护功能：过流/过热/欠压异常/过压保护功能
・无铅无卤封装，ETSSOP28

■ APPLICATIONS

・Bluetooth/Wi-Fi Speakers	・Portable Speakers	・蓝牙/ Wi-Fi音箱	・便携式音箱
・Smart speakers	・Smart Home	・智能音箱	・智能家居
・Sound Bars	・TV/Monitor	・声霸	・TV/监视器

■ DESCRIPTION

The HTA8998 is a stereo Class AB/D audio amplifier integrated a boost converter. With wide input voltage range, HTA8998 supports applications with single cell, two cell Lithium batteries, or 5V power supply and so on, and can drive two speakers in BTL mode. It can also work in Class AB mode without boost converter.

HTA8998 built-in boost converter supports selectable output voltage by VSET pin for different applications with different power requirements. It also implements an adjustable switching peak current limit function through external resistors.

The boost converter has two modes: Adaptive Audio-Tracking Mode (AATM) or forced mode. Once in forced mode, the output voltage driving the audio power amplifier is directly boosted to the preset voltage (by VSET pin). If the device is set in AATM, the boost converter can provide an adaptive audio tracking power supply for audio power amplifier with maximum value of preset voltage (by VSET pin) so that the system can always keep high efficiency in the whole output power range. The battery endurance can be improved by more than 50%, compared to forced mode[1].

HTA8998 has a filter-less modulation circuit which can directly drive speakers. HTA8998 can be shut down so that the power consumption can be minimized. As for protection function, over current protection function for speaker output terminals, over temperature protection function, low supply voltage malfunction preventing function and over boost voltage protection are also prepared.

HTA8998 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. It can significantly improve the sound quality, creating a very comfortable musical enjoyment, and to protect the speakers from overload damage.

HTA8998是一款内置升压的立体声AB/D类音频功率放大器，其支持单节锂电、双节锂电串联、5V等多种输入，升压后的电压提供给功放供电，功放支持双通道立体声BTL输出。其也可工作在AB类模式，此时无升压。

HTA8998内置的升压电路，可通过VSET脚设置最大升压值，以满足不同的输出功率需求。其还可通过外置电阻调节开关峰值电流限值。

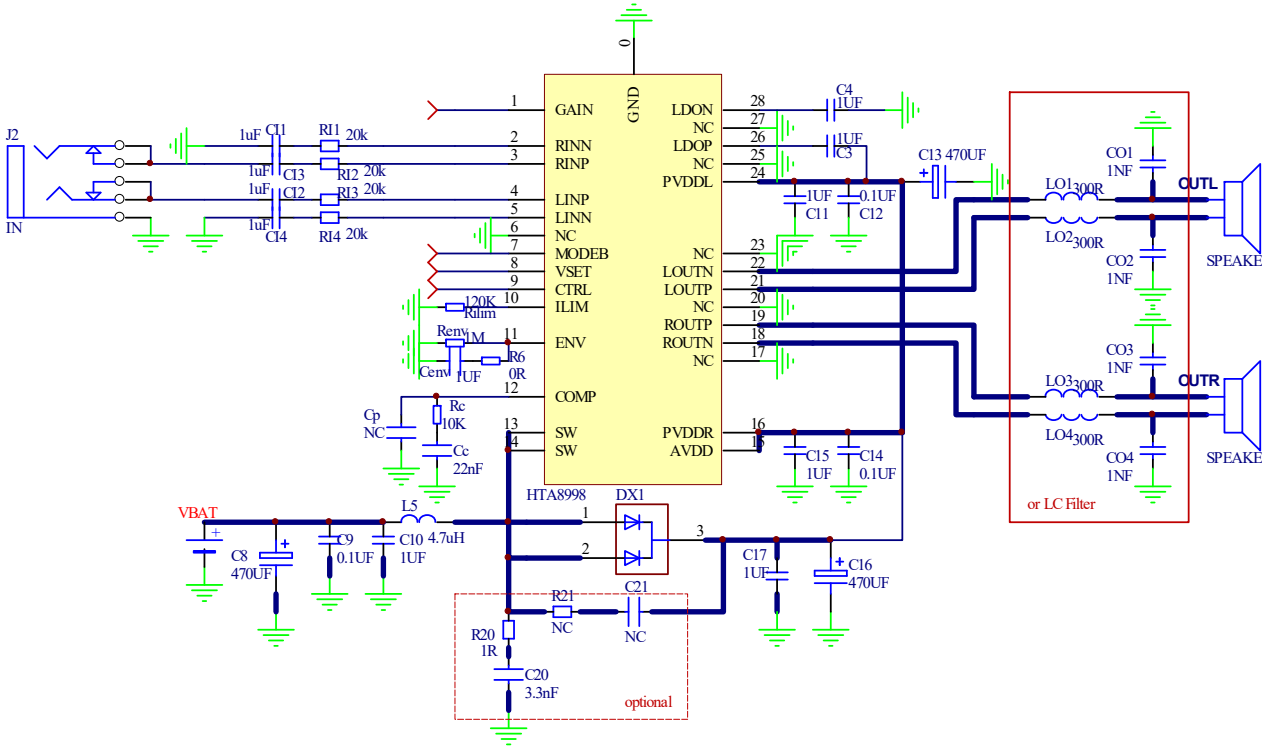
HTA8998内置的升压电路，具有两种模式：自适应音频跟踪模式，及强制升压模式。在强制升压模式，升压电路直接升压至预设的电压（VSET脚设置）并提供给音频功放；在自适应音频跟踪模式，升压电路件可为音频功率放大器提供实时跟随音源信号的电源供电，从而在整个功率段内使整个系统保持在高效率。该方式供电相比直接强制升压供电方式，电池续航时间预计可提升50%以上。

此外，HTA8998内部集成免滤波器调制技术，能够直接驱动扬声器，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、输入电源欠压异常保护、升压电压过压保护等功能。

HTA8998具有防削顶失真（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。

[1] Depends on different types of music, different values of powers and voltages, the real battery endurance could be highly different.

■ TYPICAL APPLICATION



1. 系统增益设置

GAIN pin	D类增益	D类时芯片内部输入电阻RIN与反馈电阻RF	AB类增益	AB类时芯片内部输入电阻RIN与反馈电阻RF
High (接LDON)	40倍（32dB）	RF = 800k, RIN = 20k	32倍（30dB）	RF = 640k, RIN = 20k

外部增加输入电阻 R_I 时，增益 $(\text{dB}) = 20 \times log\frac{RF}{RIN+R_I}$

2. MODEB脚设置升压模式

MODEB pin	升压模式
High (接LDON)	自适应实时音频跟踪升压
Low (接GND)	强制升压

3. VSET脚设置升压的最高输出电压

VSET pin	强制升压模式时，输出电压	音频实时跟踪模式时，最高输出电压	OVP电压
High (接LDON)	9.2V	9.5V	10V
Float	8.2V	8.4V	9V
Low(接GND)	7.2V	7.4V	8V

4. CTRL 脚设置芯片的工作模式

CTRL pin	工作模式
>2V	Class D, ACF off
1.6~1.9V	Class D, ACF on
0.8~1.5V	Class AB, ACF off
Low	Shutdown

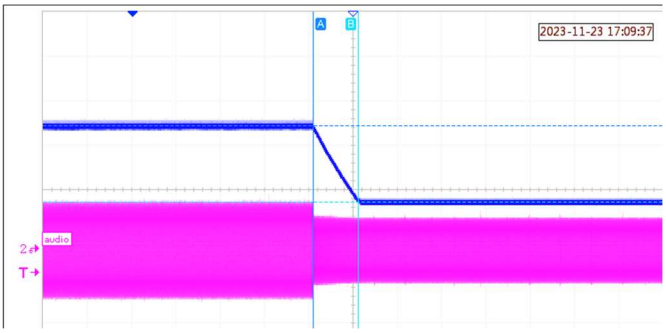
5. ILIM 脚设置升压电感的峰值电流限值

R_{ILIM}电阻值	升压电感的峰值电流限值	
	强制升压模式	音频实时跟踪模式
330k	不使用	9A
150k	10A	6A
120k	9A	5.1A
100k	7.8A	4.6A
75k	5A	3.2A

6. ENV 引脚设置自适应实时音频跟踪升压模式下的音频跟踪释放时间

MODEB 设置为自适应实时音频跟踪升压时，ENV 引脚可用来设置音频跟踪的释放时间，如下图所示。推荐的 ENV 网络值 C_{ENV}=1uF, R_{ENV}=1M，可在大部分情况下使用。

MODEB 固定设置为其他模式时，ENV 引脚可悬空。



音频跟踪的释放时间

7. COMP 引脚设置升压的环路补偿电路，Rc = 10k, Cc = 22nF，可在大部分情况下使用。

8 为减小 SW 毛刺和辐射，SW 端建议预留 R20+C20 (1R+3.3nF)到地的网络，以及 R21 和 C21（1R+3.3nF）的 RC 网络。

9. 电感选择：推荐使用 4.7uH 电感，饱和电流应大于设置的 ILIM 值。

10. 二极管选择：反向电压 V_R 推荐 > 15V，额定电流 I_F 推荐>2ch*最高升压值/负载电阻值，推荐使用 SS1020，或两个 SS52 并联。

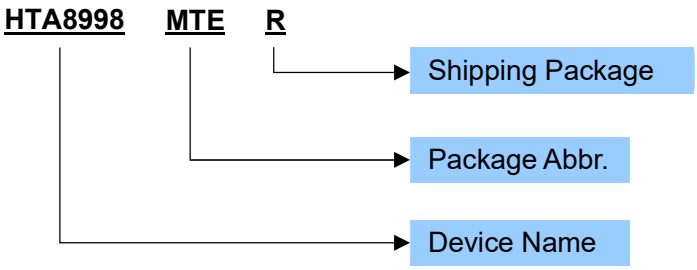
11. PVDD 电容：一般的，为保证低频的功率，在靠近二极管的输出电压处放置 1uF//470uF，并尽可能靠近相邻的 PVDDR 且使用粗走线连接，靠近 PVDDR 处再放置 1uF//0.1uF；靠近 PVDDL 处再放置 1uF//0.1uF//470uF。

12. 辐射和传导是关注项时，输出建议预留 LC 滤波器，即 LO 改成电感 10uH，CO 改成电容 0.68uF。

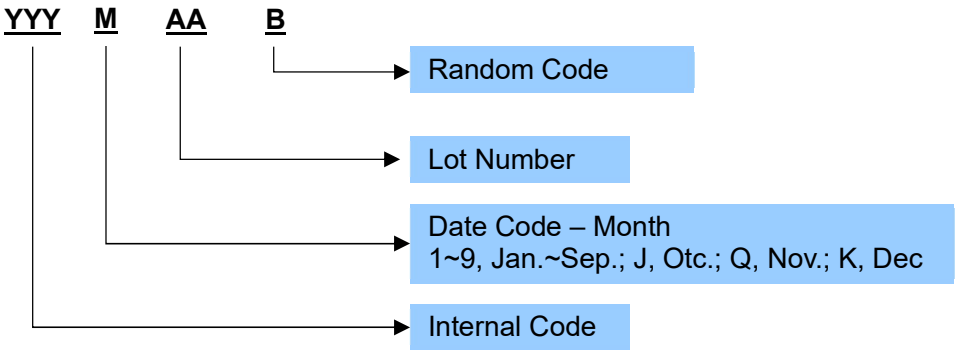
■ ORDERING INFORMATION

Part Number	Package Type	Package Abbr.	Eco Plan	MSL Level	Marking	Shipping Package / MOQ
HTA8998MTER	ETSSOP28	MTE	RoHS	MSL3	HTA8998 YYYMAAB[1]	Tape and Reel (R) / 3000pcs

Part Number

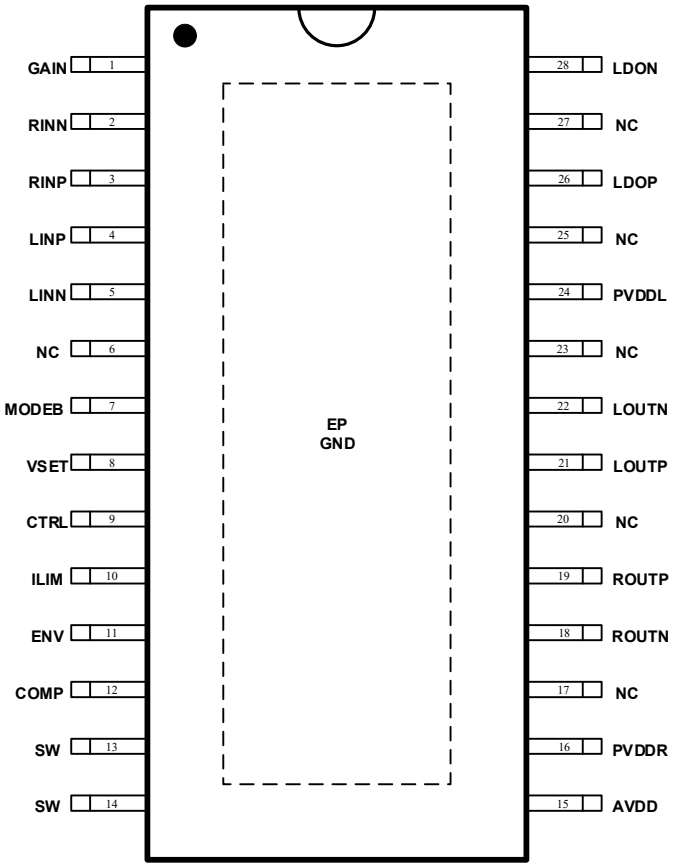


Production Tracking Code



[1] YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION



Top View

■ TERMINAL FUNCTION

Terminal No.	Name	Description
1	GAIN	Gain select pin. 增益选择。
2	RINN	Negative input (differential-) for audio amplifier of right channel. 音频右声道输入负端。
3	RINP	Positive input (differential+) for audio amplifier of right channel. 音频右声道输入正端
4	LINP	Positive input (differential+) for audio amplifier of left channel. 音频左声道输入正端。
5	LINN	Negative input (differential-) for audio amplifier of left channel. 音频左声道输入负端。
6, 17, 20, 23, 25, 27	NC	No internal connection, connect to GND for better thermal performance. 内部无连接，连接到地。
7	MODEB	Boost converter mode selection. 升压模式选择
8	VSET	Select the (max) output voltage of the boost converter.升压输出最高电压选择
9	CTRL	Select the working mode. 工作模式选择
10	ILIM	Adjustable switch peak current limit. An external resistor should be connected between this pin and GND. 最大限流值设置端，外部接电阻到地。
11	ENV	Release time network setting for audio tracking. 音频跟踪释放时间设置
12	COMP	Output of the internal error amplifier, the loop compensation network should be connected between this pin and the GND pin. 接阻容补偿网络到地。
13, 14	SW	The switching node pin of the converter. 升压开关节点。
15	AVDD	Analog power supply for amplifier 功放模拟供电
16	PVDDR	Power Supply for internal power circuitry of Channel R. 右声道功率电源

18	ROUTN	Negative pin for differential speaker amplifier output R. 右声道输出负端
19	ROUTP	Positive pin for differential speaker amplifier output R. 右声道输出正端
21	LOUTP	Positive pin for differential speaker amplifier output L. 左声道输出正端
22	LOUTN	Negative pin for differential speaker amplifier output L. 左声道输出负端
24	PVDDL	Power Supply for internal power circuitry of Channel L. 左声道功率电源
26	LDOP	Internal LDO output, connect 1uF to PVDD 内部LDO输出，连接1uF到PVDD
28	LDON	Internal LDO output, connect 1uF to GND 内部LDO输出，连接1uF到地
EP	GND	Provides both electrical and thermal connection from the device to the board. A matching ground pad must be provided on the PCB and the device connected to it via solder. For proper electrical operation, this ground pad must be connected to the system ground. 既是地，又是散热PAD

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings[2]

PARAMETER		Symbol	MIN	MAX	UNIT
Voltage range	VOUT, PVDD, AVDD	V_{IN}	-0.3	10	V
	SW	V_{SW}	-0.3	18	V
	LINP, LINN, RINP, RINN, ENA, GAIN, CTRL, MODEB, VSET, ENV, COMP, ILIM	V_I	-0.3	5.8	V
Operating temperature range		T_A	-40	85	℃
Operating junction temperature range		T_J	-40	150	℃
Storage temperature range		T_{STG}	-50	150	℃

● Recommended Operating Condition

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
V_{BAT} supply voltage range	V_{IN}		2.7		8.5	V
Inductance	L		2.2		10	μH
Operating temperature	T_a		-40	25	85	℃
Load impedance	R_L			4		Ω

● Electrical Characteristics

Item		Symbol	CONDITION	MIN	TYP	MAX	UNIT
Input and Output							
Input voltage for CTRL terminal	MODE1	V_{MODE1}	Class D, ACF off	2.0		5.0	V
	MODE2	V_{MODE2}	Class D, ACF on	1.6		1.9	V
	MODE3	V_{MODE3}	Class AB, ACF off	0.8		1.5	V
	MODE4	V_{MODE4}	shutdown	0	0	0.5	V

Boost Converter

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Output voltage range	V_{OUT}	VSET = H, Class D, MODEB = L		9.2		V
		VSET = Float, Class D, MODEB = L		8.2		V
		VSET = L, Class D, MODEB = L		7.2		V
		VSET = H, Class D, MODEB = H, max output voltage		9.5		V
		VSET = Float, Class D, MODEB = H, max output voltage		8.4		V
		VSET = L, Class D, MODEB = H, max output voltage		7.4		V
Boost converter frequency	f_{BOOST}	VIN = 3.7V, VOUT = 9V		300		kHz
Boost converter input current limit	I_{L_MAX}	R_{ILIM} = 120k, Forced mode		9		A
		R_{ILIM} = 330k, Adaptive Audio-Tracking Mode		9		

[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

Audio Amplifier (Class D and Class AB)

V_{BAT} =4V, PVDD = 9V, Ta=25ºC, C_{IN}=1uF, Gain = 26dB, Class D mode, RILIM = 150k, ACF-Off mode, unless otherwise specified

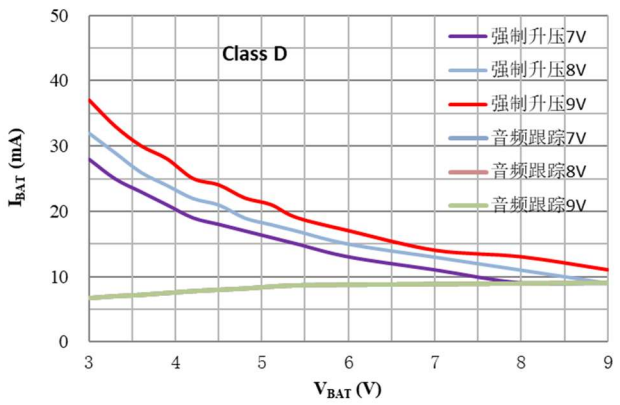
PARAMETER	Symbol	CONDITION		MIN	TYP	MAX	UNIT
Output overvoltage protection for AVDD	V_{OVP}	VSET = H			10		V
		VSET = Float			9		V
		VSET = L			8		V
Under-voltage lockout (UVLO) threshold for AVDD	V_{UVLO}				2		V
Amplifier Output Offset Voltage	V_{OS}	V_I = 0V, Gain = 32dB, Class D			1.5		mV
		V_I = 0V, Gain = 30dB, Class AB			5		mV
Quiescent supply current in SD mode	I_{SD}	V_{BAT} = 4V			16		uA
		V_{BAT} = 8V			24		uA
Operating quiescent current	I_{BAT}	V_{BAT} = 4V, PVDD = 9V, Forced Boost, Class D			28		mA
		VBAT = 4V, PVDD = 9V, AATM, Class D			7.5		mA
System Gain	Gain	GAIN=H, Rin = 0kΩ, Class D			32		dB
		GAIN=H, Rin = 20kΩ, Class D			26		dB
		GAIN=H, Rin = 0kΩ, Class AB			30		dB
		GAIN=H, Rin = 20kΩ, Class AB			24		dB
Turn-on time	t_{on}				220		ms
Total harmonic distortion plus noise	THD+N	P_O=1W, R_L=4Ω, f=1kHz, Class D			0.08		%
		P_O=1W, R_L=4Ω, f=1kHz, Class AB			0.07		%
Noise output voltage	V_N	f=20Hz~20kHz, A-weighted, GAIN=26dB, Class D			120		μV_{rms}
		f=20Hz~20kHz, A-weighted, GAIN=24dB, Class AB			70		μV_{rms}
Class D switching frequency	$f_{Class-D}$				300		kHz
ACF attenuation gain	Aa			-14		0	dB
Common mode rejection ratio	CMRR	V_{IC} = 0.1V, PVDD = 9V			-65		dB
LDO output voltage	LDON	PVDD = 9V, working on			4.9		V
		PVDD = 9V, shutdown			3.6		V
	LDOP	PVDD = 9V, working on			4.0		V
		PVDD = 9V, shutdown			8.9		V
Over current trip point	OCP	Class D			9		A
Output Power in Class D Mode	Po	THD+N=10%	V_{BAT}=4V, f=1kHz, R_L=4Ω PVDD = 9V		10.6		W
		THD+N=1%			8.6		W
		THD+N=10%	V_{BAT}=4V, f=1kHz, R_L=4Ω PVDD = 8V		8.5		W
		THD+N=1%			6.9		W
		THD+N=10%	V_{BAT}=4V, f=1kHz, R_L=4Ω PVDD = 7V		6.5		W
		THD+N=1%			5.3		W
Output Power in Class AB Mode	Po	THD+N=10%	V_{BAT}=3.7V, f=1kHz, R_L=4Ω Boost Disabled		1.6		W
		THD+N=10%	V_{BAT}=7.4V, f=1kHz, R_L=4Ω Boost Disabled		7.5		W
Efficiency (Class D + Boost)	η	V_{BAT}=3.7V, f=1kHz, R_L=4Ω+22uH, PVDD = 9V, THD+N = 10%			72		%
		V_{BAT}=3.7V, f=1kHz, R_L=4Ω+22uH, PVDD = 9V, Po = 2*3W			80		%
Thermal shutdown threshold	T_{SD}				150		℃
Thermal shutdown hysteresis	T_{SD_HYS}				20		℃

■ TYPICAL OPERATING CHARACTERISTICS

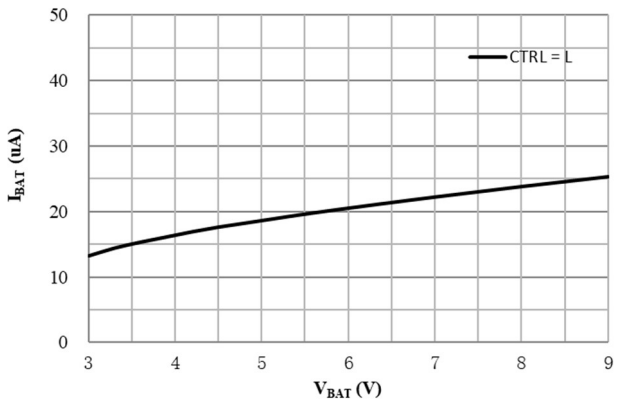
Class D Mode

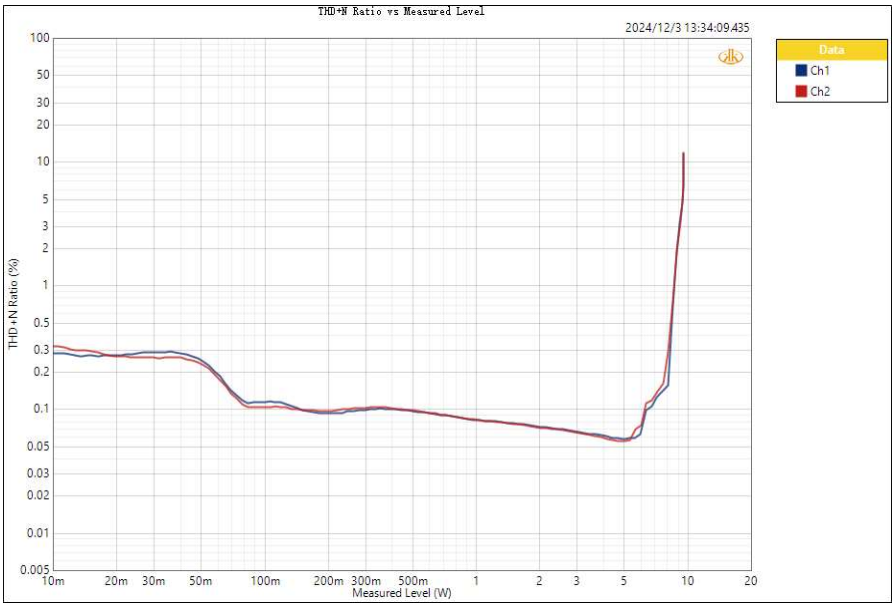
V_{BAT} = 4V, RL = 4ohm, f_{IN} = 1kHz, Forced Boost Mode, Class D Mode, ACF off, unless otherwise specified

Quiescent Current

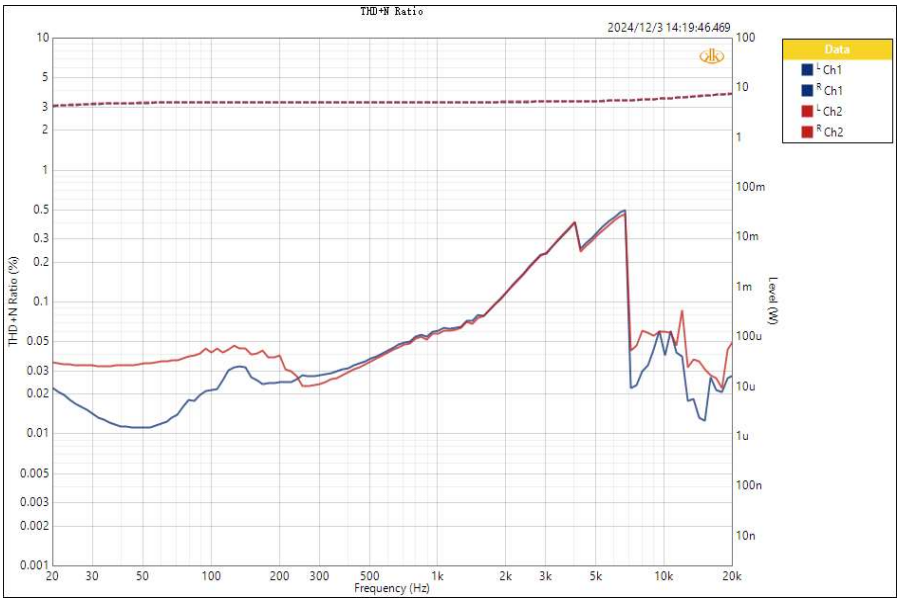


Shutdown Current





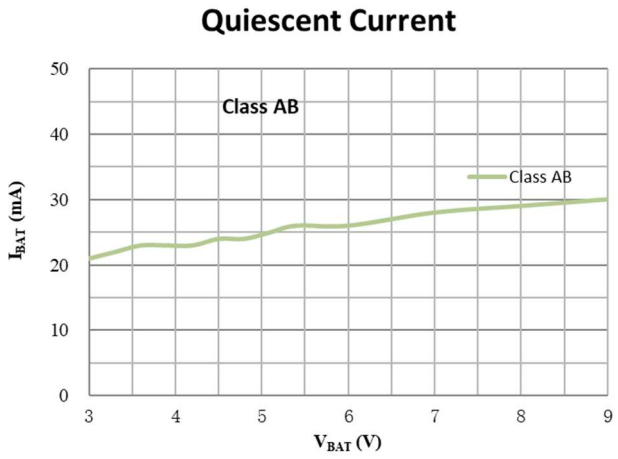
Output power vs THD+N, f = 1kHz

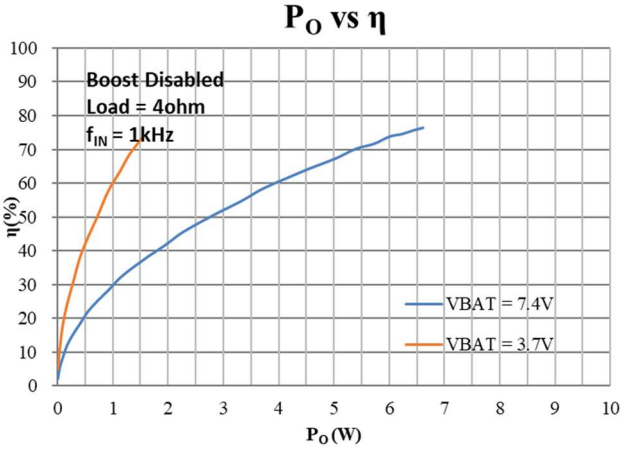


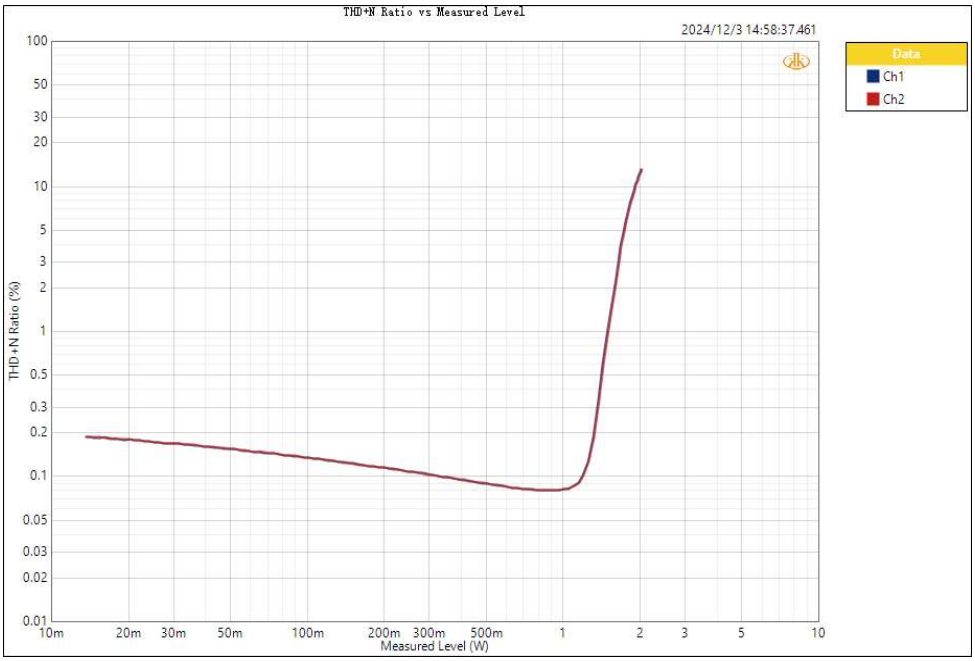
f_{IN} vs THD+N, Po ≈ 2*5W

Class AB Mode

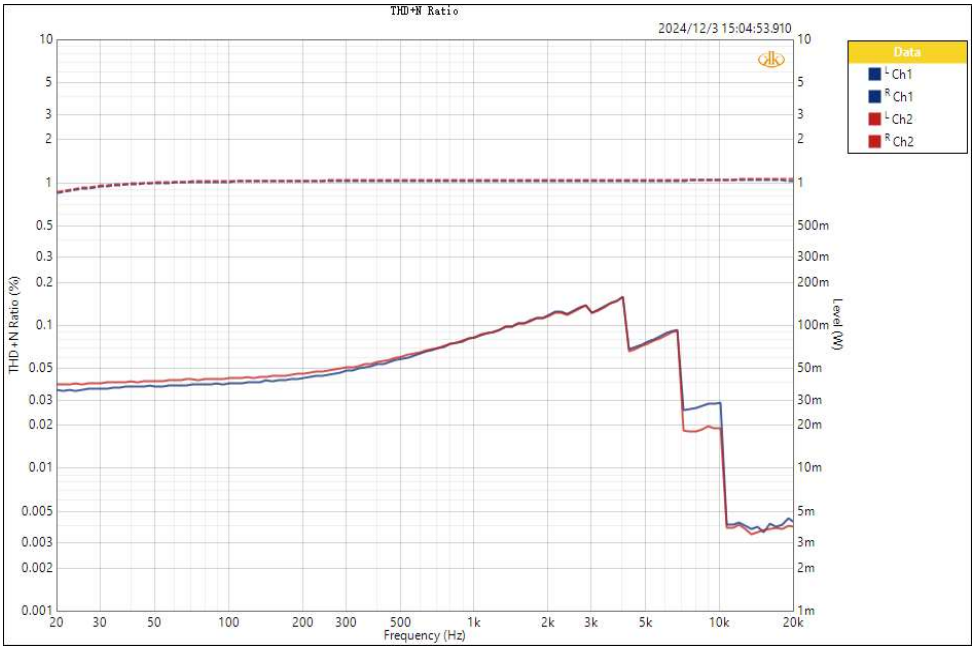
V_{BAT} = 4.2V, RL = 4ohm, f_{IN} = 1kHz, Boost Disabled, Class AB Mode, unless otherwise specified





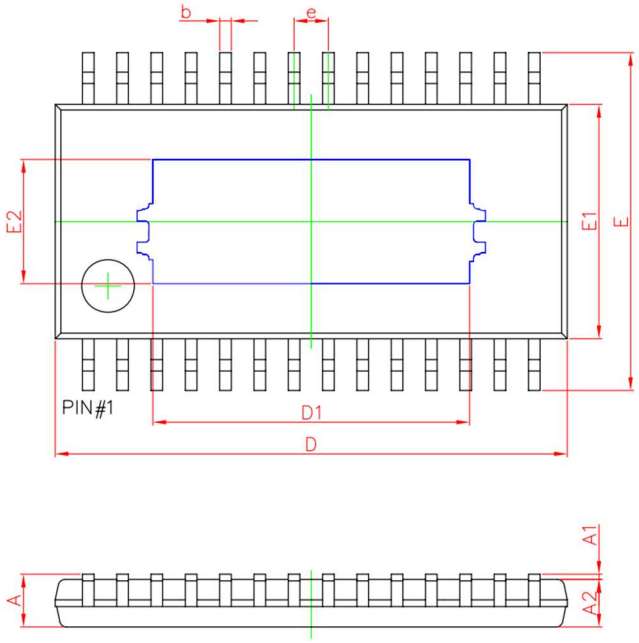


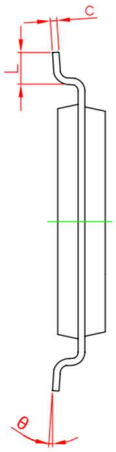
Output power vs THD+N, f = 1kHz



frequency vs THD+N, Po≈2*1W

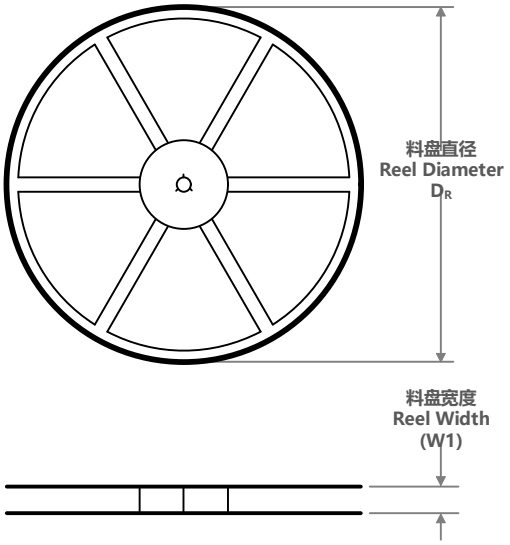
■ PACKAGE OUTLINE

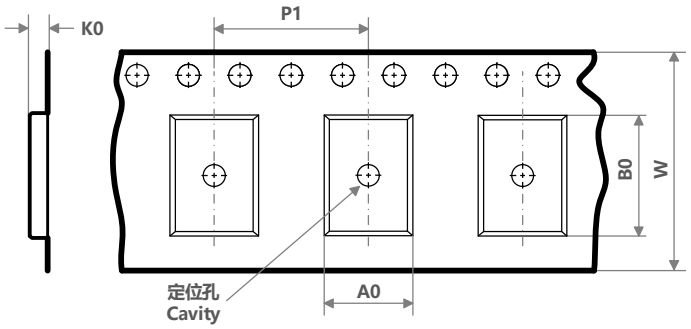




Symbol	Dimensions In Millimeters	
	Min	**Max**
A	——	1.200
A1	0	0.1
A2	0.800	1.050
b	0.190	0.300
c	0.090	0.200
D	9.600	9.800
D1	5.908	6.108
E	6.250	6.550
E1	4.300	4.500
E2	2.253	2.453
e	0.650 (BSC)	
L	0.450	0.750
θ	0°	8°

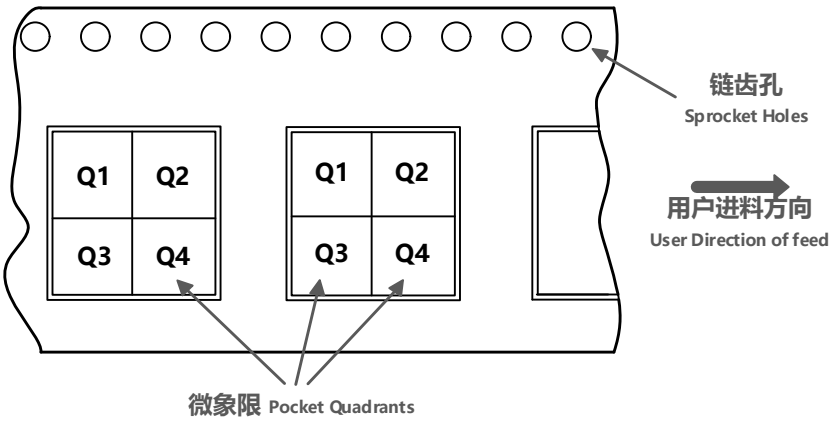
■ TAPE AND REEL INFORMATION





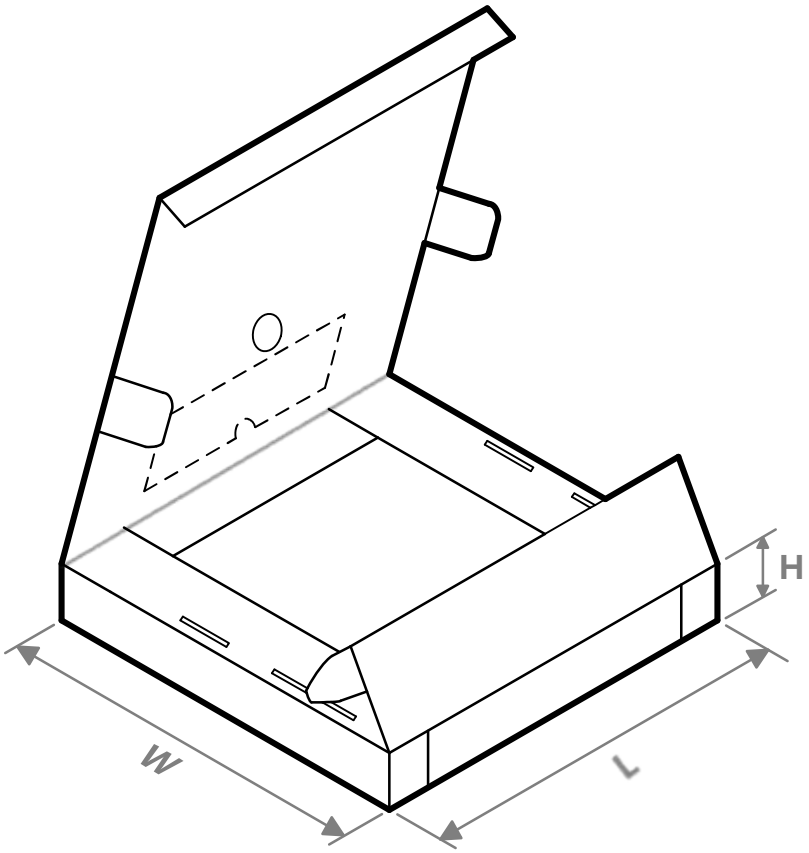
A0	Dimension designed to accommodate the component width; 料槽宽度
B0	Dimension designed to accommodate the component length; 料槽长度
K0	Dimension designed to accommodate the component thickness; 料槽厚度
W	Overall width of the carrier tape; 载带整体宽度
P1	Pitch between successive cavity centers; 相邻槽中心间距

编带 PIN1 方位象限分配
Quadrant Assignments for Pin1 Orientation in Tape



器件料号 Part No.	封装类型 Package Type	封装标识 Package Abbr.	引脚数 Pins	SPQ	料盘直径 D_R(mm)	料盘宽度 W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 象限 Quadrant
HTA8998MTER	ETSSOP	MTE	28	3000	330	16	6.65	6.8	1.5	8	16	Q1

■ TAPE AND REEL BOX INFORMATION



器件料号 Part No.	封装类型 Package Type	封装标识 Package Abbr.	引脚数 Pins	SPQ	长度 Length (mm)	宽度 Width (mm)	高度 Height (mm)
HTA8998MTER	ETSSOP	MTE	28	6000	390	345	55

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