内置自适应同步升压和防破音功能的6.5W D类及AB类音频功率放大器

6.5W Boosted Class D and Class AB Audio Amplifier

■ FEATURES

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

3W (V_{BAT}=3.3V, R_{L}=4Ω, THD+N<1%, 20-20kHz full band)
2.0W (V_{BAT}=3.3V, R_{L}=8Ω, THD+N<1%, 20-20kHz full band)
6.5W (V_{BAT}=4.2V, R_{L}=2Ω, THD+N=10%, f=1kHz)

- Efficiency: 83% (V_{BAT} = 4.2V, f = 1kHz, Load = 4ohm+22uH, Po = 0.6W)

79% (V_{BAT} = 4.2V, f = 1kHz, Load = 4ohm+22uH, Po = 4W)

- Power Supply V_{BAT}: 2.7V~5.5V
- Adaptive Sync Boost Converter

  -Extends the playing time in battery supply applications

  -Adjustable switch peak current limit to avoid over-pulling on battery current
- Class AB / Class D
- Over Current Protection, Thermal Protection, Low voltage malfunction prevention function included
- Pb-Free Packages, SSOP10L-PP, QFN3×3-16L

- 防削顶失真功能(防破音, Anti-Clipping Function, ACF)
- 免滤波器数字调制，直接驱动扬声器
- 输出功率

3W (V_{BAT}=3.3V, R_{L}=4Ω, THD+N<1%, 20-20kHz full band)
2.0W (V_{BAT}=3.3V, R_{L}=8Ω, THD+N<1%, 20-20kHz full band)
6.5W (V_{BAT}=4.2V, R_{L}=2Ω, THD+N=10%, f=1kHz)

- 效率: 83% (V_{BAT} = 4.2V, f = 1kHz, Load = 4ohm+22uH, Po = 0.6W)

79% (V_{BAT} = 4.2V, f = 1kHz, Load = 4ohm+22uH, Po = 4W)

- V_{BAT}供电范围：2.7V至5.5V
- 高效自适应同步升压功能

-延长电池播放时间

-可调节最大限流值，有效防止电池拉死

- 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，SSOP10L-PP, QFN3×3-16L

■ APPLICATIONS

- Bluetooth/Wi-Fi Speakers
- Portable Speakers
- Smart speakers
- Smart Home
- 蓝牙/ Wi-Fi音箱
- 便携式音箱
- 智能音箱
- 智能家居

■ DESCRIPTION

HT8513, HT8515, integrated with adaptive sync boost converter, is a mono Class D audio amplifier that drives up to continuous 3W (<1% THD+N, 20-20kHz full band) into 4ohm speaker and 6.5W (10% THD+N, 1kHz) into 2ohm speaker from a Li-battery voltage. It also integrates Class AB amplifier.

The built-in sync boost converter generates a supply voltage of 6.2V for the audio amplifier. The boost converter is adaptive and is automatically active only when the peak output audio signal exceeds a preset voltage threshold, which is optimized to prevent clipping while maximizing system efficiency.

HT8513, HT8515 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.

Class AB amplifier mode is also available for HT8513, HT8515. Once the EMI Interference from class D and Boost Converter becomes an annoying problem, HT8513 can be changed into Class AB mode.

HT8513, HT8515 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.

As for protection function, over current protection function for speaker output terminals, over temperature protection function are also prepared.

HT8513, HT8515是一款内置自适应同步升压的单声道D类音频功率放大器，由锂电池供电时， THD+N<1%、20-20kHz全频段信号条件下，能连续输出3W功率（4Ω负载），THD+N=10%、1kHz信号下，能连续输出6.5W功率（2Ω负载）；另外，其还支持AB类模式。

HT8513, HT8515内置的同步升压，提供6.2V输出电压给功放。其小音乐信号时不升压，仅当功率较大时，才升压给D类功放，其可大幅提高系统效率，延长电池续航时间。

HT8513, HT8515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。

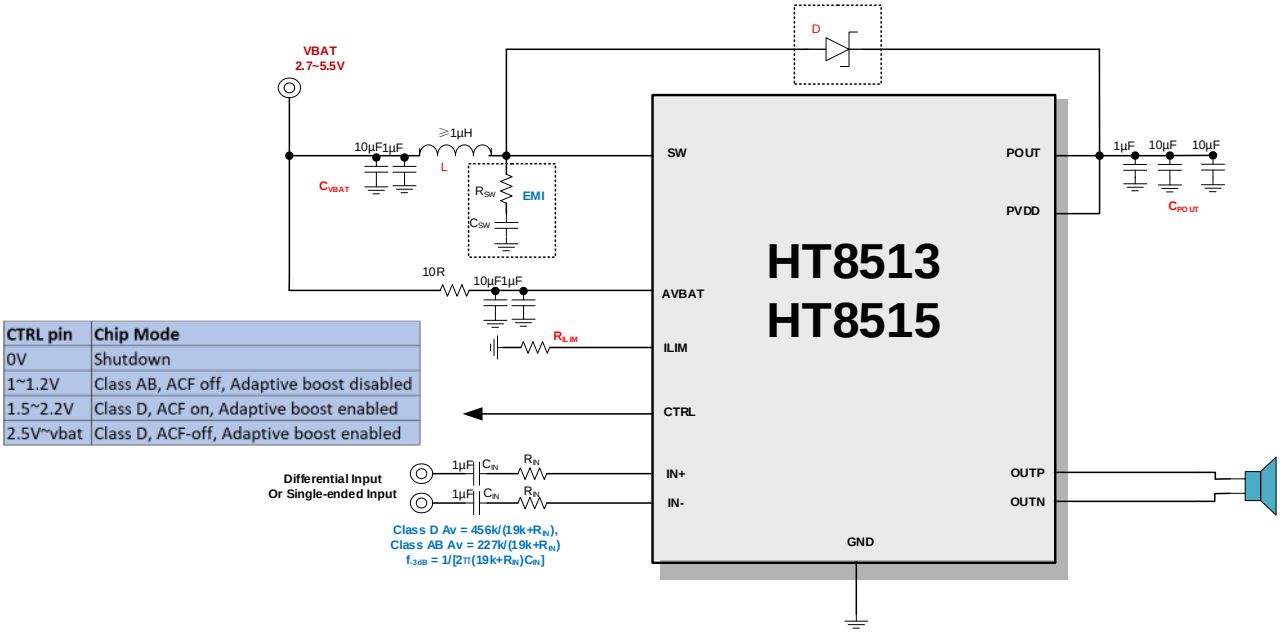
HT8513, HT8515具有AB类和D类的自由切换功能，在受到D类功放EMI干扰困扰时，可随时切换至AB类音频功放模式。

HT8513, HT8515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，HT8513, HT8515集成了输出端过流保护、片内过温保护等功能。

■ TYPICAL APPLICATION

Typical Application	R_{ILIM}	IPEAK	L	D	C_{BAT}	C_{POUT}
2ohm Load	82k	4.5A	4.7uH	SS32	1uF//10uF//100uF	1uF//10uF//470uF
3ohm Load	82k	4.5A	4.7uH	SS32	1uF//10uF//100uF	1uF//10uF//470uF
4ohm Load, Po>3W, THD+N>1%	82k~100k	3.5-3.8A	1uH~4.7uH	SS32	1uF//10uF	1uF//10uF//220uF
4ohm Load, Po≤3W, THD+N<1%	110k	3.5A	1uH	NC	1uF//10uF	1uF//10uF//10uF
8ohm Load	200k	2.2A	1uH	NC	1uF//10uF	1uF//10uF

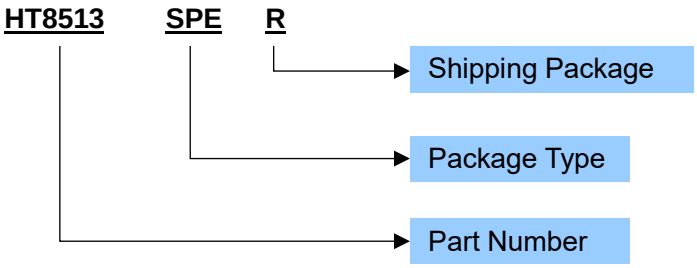


CTRL pin	Chip Mode
0V	Shutdown
1~1.2V	Class AB, ACF off, Adaptive boost disabled
1.5~2.2V	Class D, ACF on, Adaptive boost enabled
2.5V~vbat	Class D, ACF-off, Adaptive boost enabled

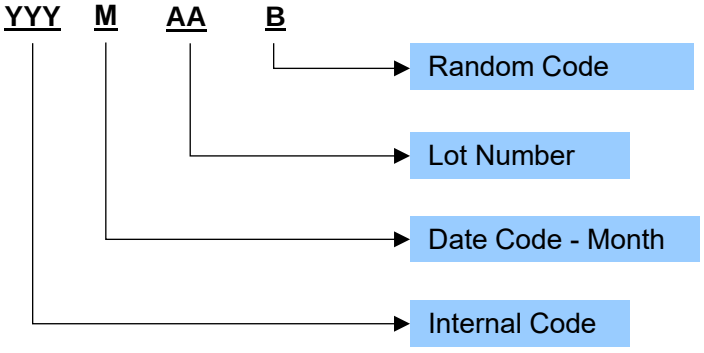
■ ORDERING INFORMATION

Ordering Number	Package Type	Marking	Operating Temperature Range	Shipping Package / MOQ
HT8513SPE	SSOP10L-PP(SPE)	HT8513 YYYMAAB[1]	-40℃～85℃	Tape and Reel (R) / 2500pcs
HT8515SQE	QFN3×3-16L(SQE)	HT8515 YYYMAAB	-40℃～85℃	Tape and Reel (R) / 5000pcs

Ordering Number

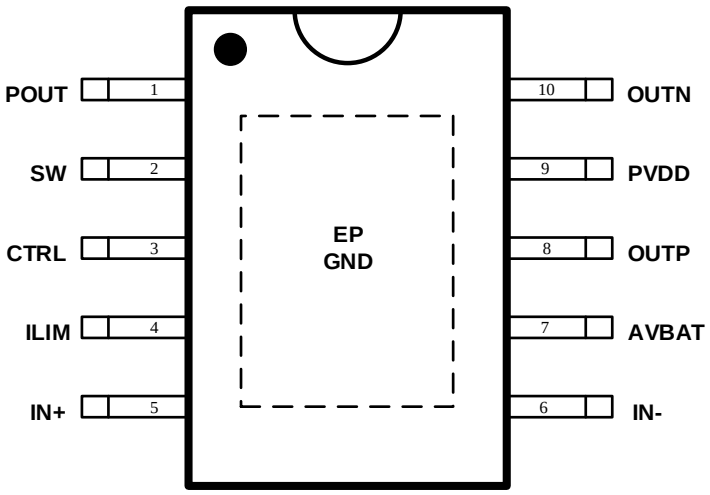


Production Tracking Code

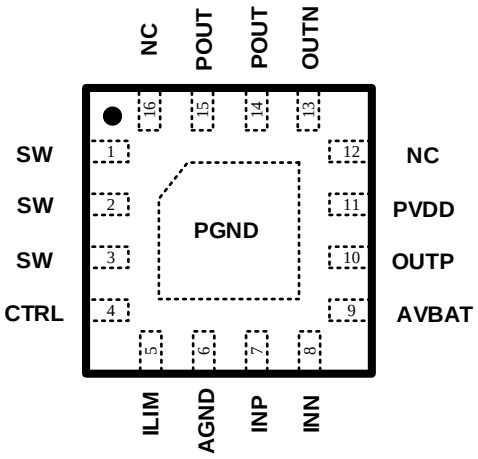


[1] YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION



SSOP10L-PP(SPE) Top View



QFN3×3-16L(SQE) Top View

■ TERMINAL FUNCTION

Terminal No.		Name	I/O[1]	Description
SPE	SQE			
1	14,15	POUT	P	Boosted output voltage. 升压输出端
2	1,2,3	SW	I	Boost and rectifying switch input. 升压整流开关输入端
3	4	CTRL	I	Mode Control Terminal. 模式控制脚
4	5	ILIM	I	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。
5	7	IN+	I	Positive input (differential+) for audio amplifier. 输入负端
6	8	IN-	I	Negative input (differential-) for audio amplifier. 输入正端
7	9	AVBAT	P	Power supply for internal analog circuitry. 模拟电源端
8	10	OUTP	O	Positive pin for differential speaker amplifier. 输出正端
9	11	PVDD	P	Power supply for internal power circuitry. 功率电源
10	13	OUTN	O	Negative pin for differential speaker amplifier. 输出负端
/	12,16	NC	/	No connection. 内部无电气连接
EP	6	AGND	G	Ground for analog circuitry. 模拟电路地
	EP	PGND	G	Ground for power circuitry, and Thermal Pad. A matching ground pad should be provided on the PCB and the device connected to it via solder. 地。

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

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings[2]

Item	Symbol	Min.	Max.	Unit
Supply voltage range	V_{BAT}	-0.3	5.5	V
Input terminal voltage range	V_{IN}	−0.3	AVBAT+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
Supply voltage range	V_{BAT}		3.0		5.5	V
Operating Ambient Temperature	T_a		-40	25	85	℃
High-level input voltage	V_{IH}		1.0			V
Low-level input voltage	V_{IL}				0.3	V
Speaker Impedance	R_L		2	4		Ω

● Electrical Specification[3]

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
BOOST Converter						
Boost converter output voltage	PVDD			6.2		V
Boost converter frequency	f_{SW}			750		kHz
Boost on threshold voltage	V_{B_TH1}	Amplifier Output V_P		1.625		V_{RMS}
Boost startup time	t_{BOOST_ON}			25		us
Boost shut off time	t_{BOOST_OFF}			320		ms
Peak current limit	I_{LIM}	Adjustable, R_{ILIM}=100k		3.8		A
		Adjustable, R_{ILIM}=200k		2.1		A

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

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
Class D Channel V_{SS}=0V, V_{BAT} =3.7V, R_{IN} = 10kohm, Ta=25ºC, C_{IN}=1uF, ACF-Off mode, unless otherwise specified							
Carrier clock frequency	f_{PWM}				360		kHz
Over current protection	Imax				3.5		A
System Gain	Av	External R_{IN}=0Ω			27.5		dB
Start-up time (power-on, shutdown release or shift between class D and Class AB)	t_{STUP}				90		ms
Shutdown fade out time	T_{FO}				50		ms
ACF attenuation gain	Aa			-16		0	dB
Consumption current in shutdown mode	I_{SD}	CTRL=V_{SS}			1		μA
Total Harmonic Distortion plus Noise	THD+N	P_O=1.0W, R_L=4Ω, f=1kHz			0.15		%
Output Noise	V_N	f=20Hz~20kHz, A weighted, Av=22dB			80		μV_{rms}
Output offset voltage	V_{OS}				±2		mV
Quiescent current	I_{BAT}				3.2		mA
Output Power	P_O	R_L=4Ω	V_{BAT}=3.7V, f=1kHz, THD+N=10%		4.7		W
		R_L=8Ω			2.7		
		R_L=3Ω			5.5		
		R_L=2Ω			6.3		
		R_L=4Ω	V_{BAT}=3.7V, f=1kHz, THD+N=1%		3.8		
		R_L=8Ω			2.1		
		R_L=3Ω			4.5		
		R_L=4Ω	THD+N<1%, 20-20kHz full band		3		W
		R_L=8Ω			2		W
Efficiency (Class D + Boost)	η	V_{BAT}=4.2V, R_L=4Ω+22uH, THD+N = 10%			79		%
		V_{BAT}=4.2V, R_L=8Ω+22uH, THD+N = 10%			85		%

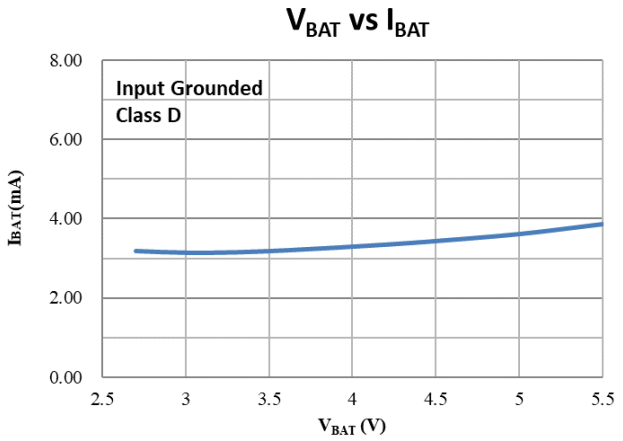
Item	Symbol	Conditions		Min.	Typ.	Max.	Unit
Class AB Channel [1] V_{SS}=0V, V_{BAT} =3.6V, C_{IN} = 1uF, R_{IN} = 15ohm, Ta=25ºC, unless otherwise specified							
Output Power	P_O	R_L=4Ω, V_{BAT}=3.6V	f=1kHz, THD+N=10%		1.3		W
		R_L=4Ω, V_{BAT}=4.2V			1.9		W
		R_L=4Ω, V_{BAT}=5.0V			2.8		W
		R_L=4Ω, V_{BAT}=3.6V	f=1kHz, THD+N=1%		1.1		W
		R_L=4Ω, V_{BAT}=4.2V			1.5		W
		R_L=4Ω, V_{BAT}=5.0V			2.2		W
Total Harmonic Distortion plus Noise	THD+N	P_O=0.01W	R_L=4Ω, f=1kHz		0.15		%
		P_O=0.1W			0.08		%
Output Noise	V_N	f=20Hz~20kHz, A weighted, Av=20dB			45		μV_{rms}
Output offset voltage	V_{OS}				±1		mV
Efficiency	η	R_L=4Ω, THD+N = 10%			73		%
		R_L=8Ω, THD+N = 10%			78		%

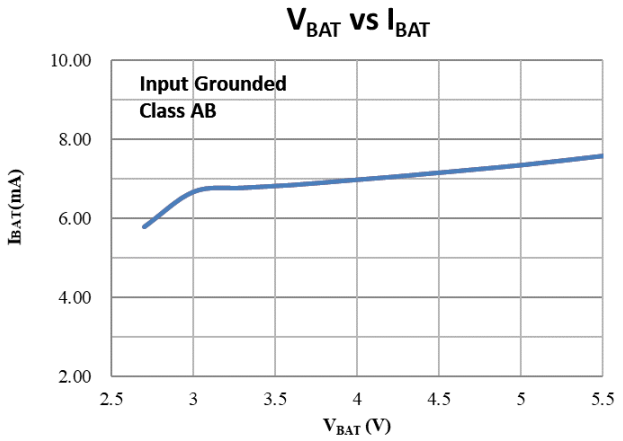
[1] In Class AB amplifier mode, boost converter is shutdown automatically. Due to the schottky rectifier, the voltage of PVDD terminal can be lower than VBAT, depending on the forward voltage of the rectifier V_F.

System Gain	Av_0	External R_{IN}=0Ω		21.5		dB
Quiescent current	I_{BAT}			8		mA

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
CTRL Terminal Voltage						
ACF Off (Class D, Adaptive boost enabled) mode setting threshold voltage	V_{MOD1}		2.5		Vbat	V
ACF On (Class D, adaptive boost enabled) mode setting threshold voltage	V_{MOD2}		1.5		2.2	V
ACF Off (Class AB, boost disabled) mode setting threshold voltage	V_{MOD4}		1.0		1.2	V
SD mode setting threshold voltage	V_{MOD5}		0		0.3	V
SD wake up voltage	V_{CTRL_ON}		1.0			V

■ TYPICAL OPERATING CHARACTERISTICS





Class D, VBAT = 3.7V, f_{IN} = 1kHz, R_{IN} = 0R, C_{IN} = 1uF, R_{ILIM} = 82k, ACF off, Load = 4ohm, unless otherwise specified.

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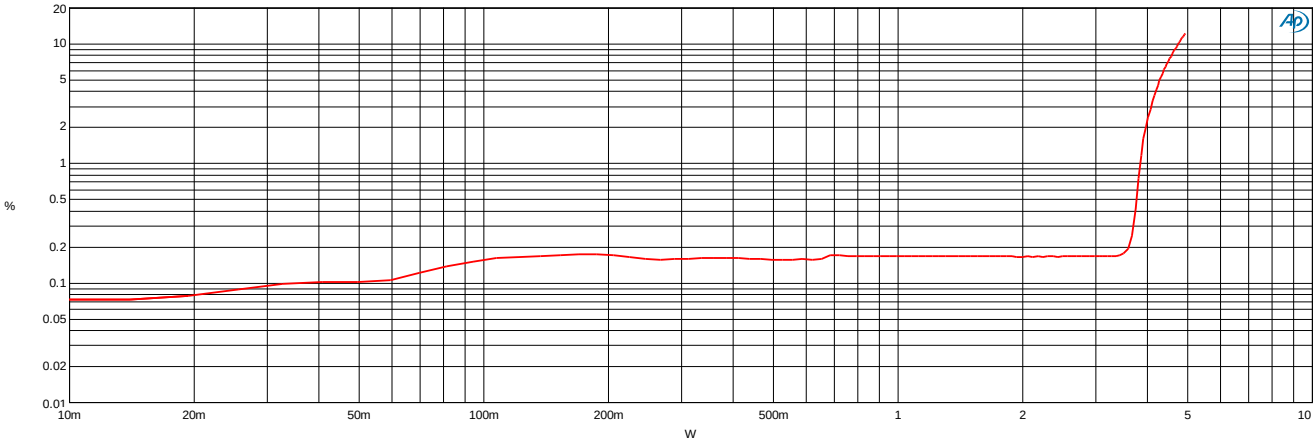

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	1kHz 4R LOAD

Po vs THD+N

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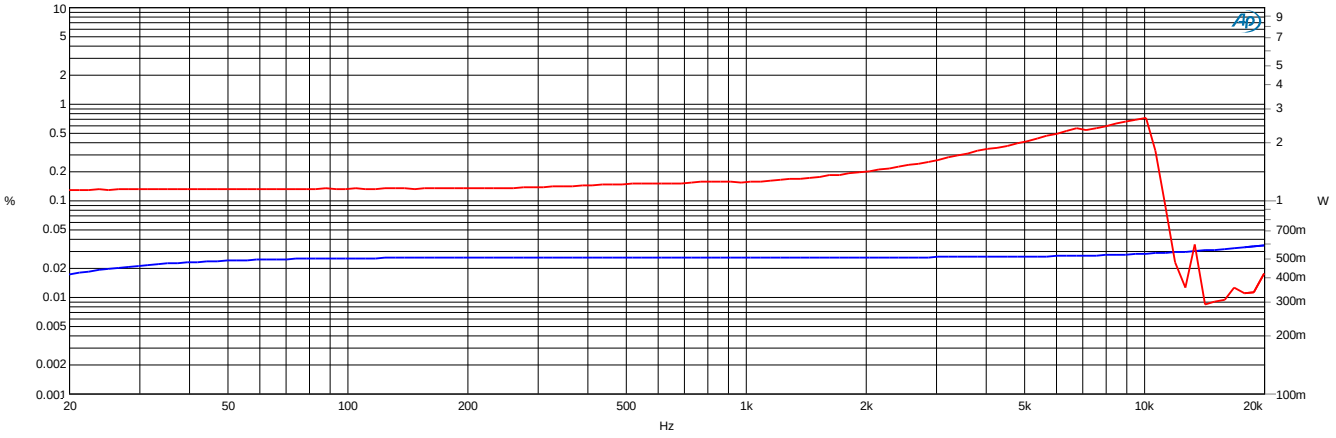

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	0.5W 4R THD
1	2	Blue	Solid	2	Analyzer.Level A	Right	0.5W 4R Po

f vs THD+N (Po = 0.5W)

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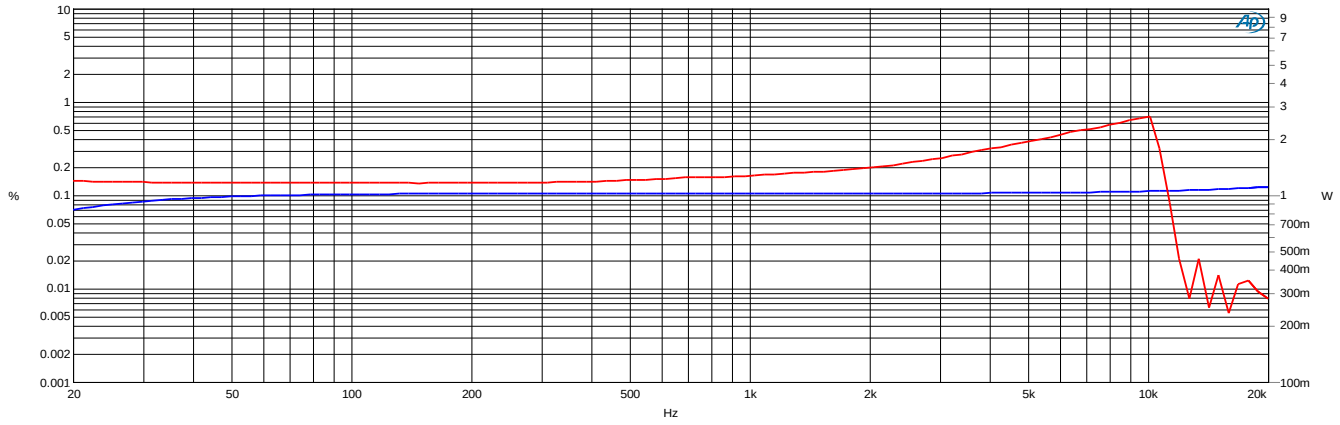

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	1W 4R THD
1	2	Blue	Solid	2	Analyzer.Level A	Right	1W 4R Po

f vs THD+N (Po = 1.0W)

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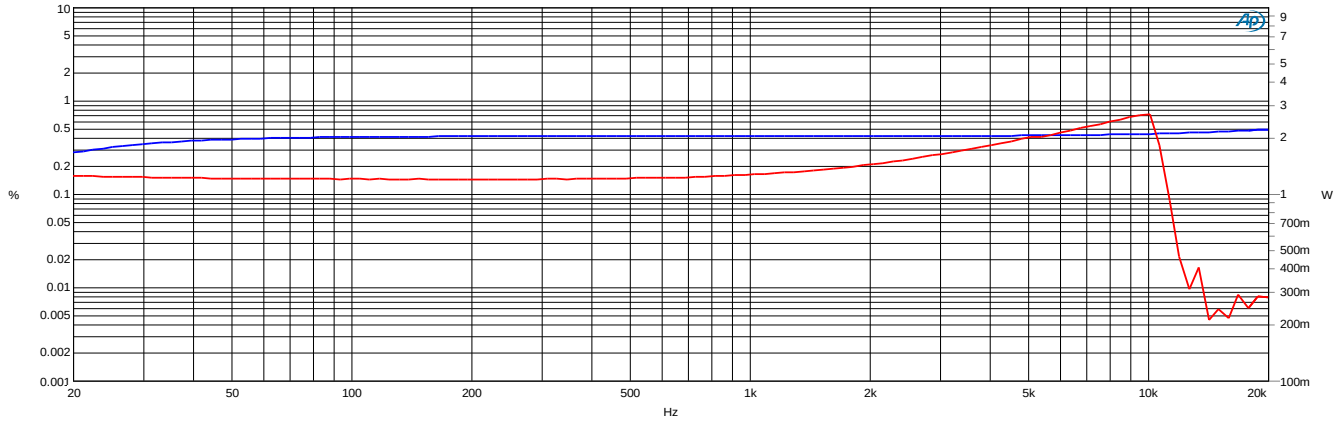

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	2W 4R THD
1	2	Blue	Solid	2	Analyzer.Level A	Right	2W 4R Po

f vs THD+N (Po = 2.0W)

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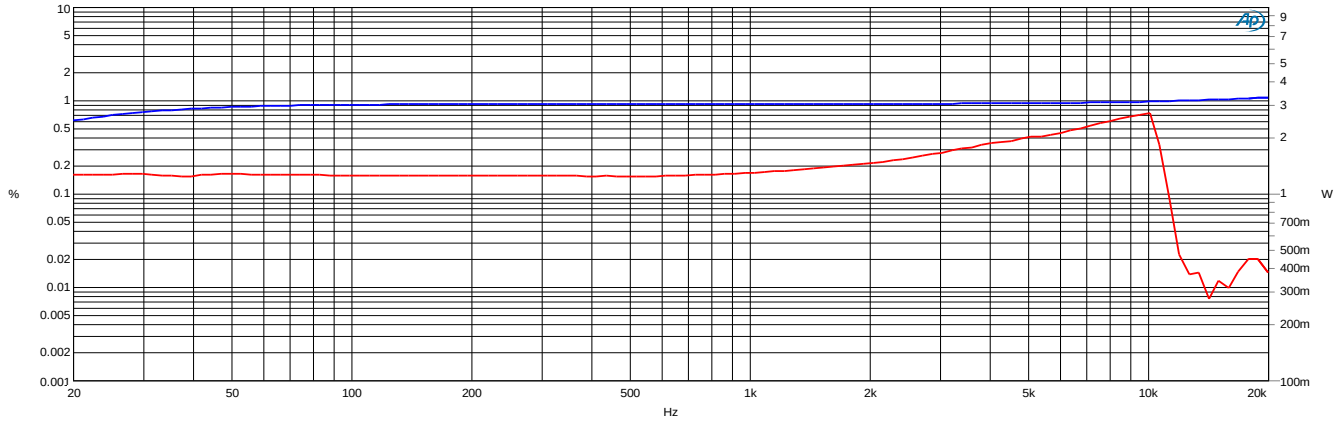

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	3W 4R THD
1	2	Blue	Solid	2	Analyzer.Level A	Right	3W 4R Po

f vs THD+N (Po = 3.0W)

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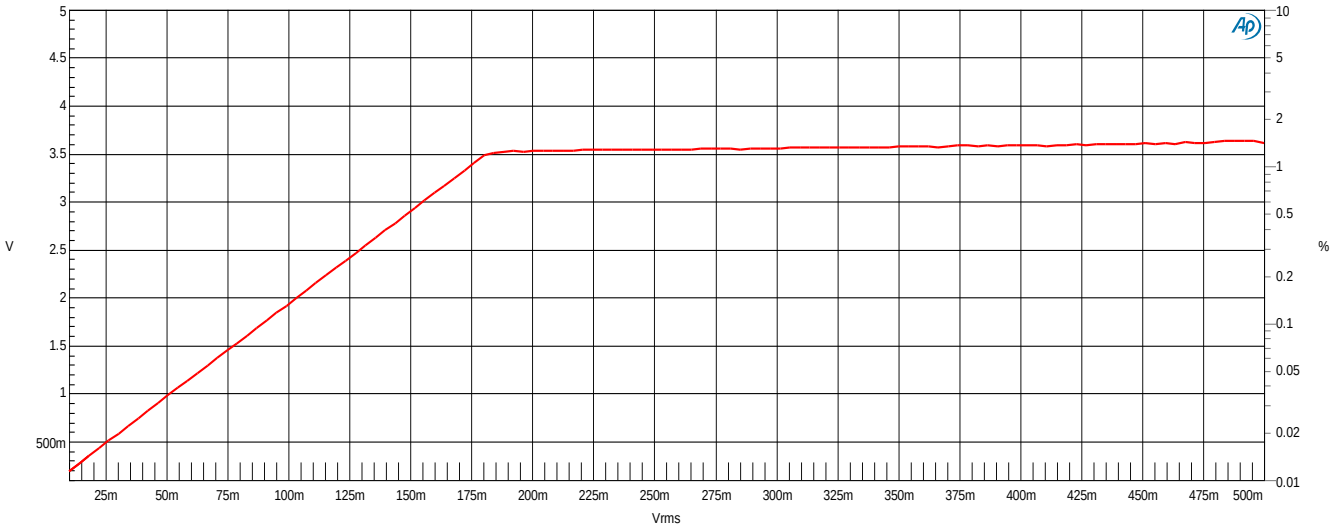
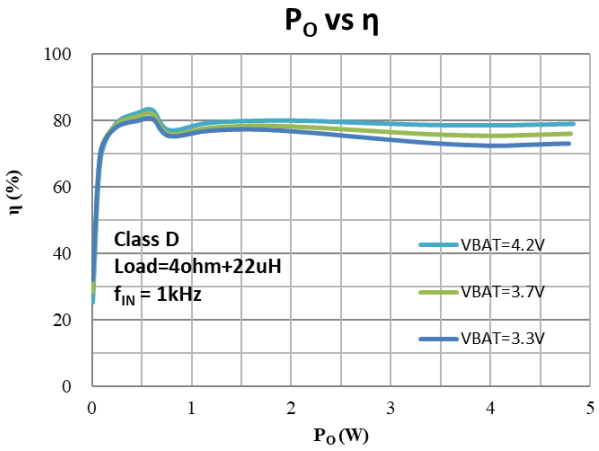
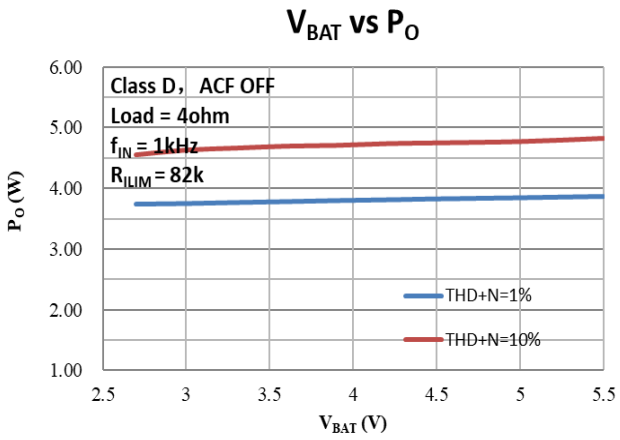


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.Level A	Left	

V_{IN} vs VOUT (R_{IN} = 0R, ACF on)





Class D, VBAT = 3.7V, f_{IN} = 1kHz, R_{IN} = 0R, C_{IN} = 1uF, R_{ILIM} = 82k, ACF off, Load = 3ohm, unless otherwise specified.

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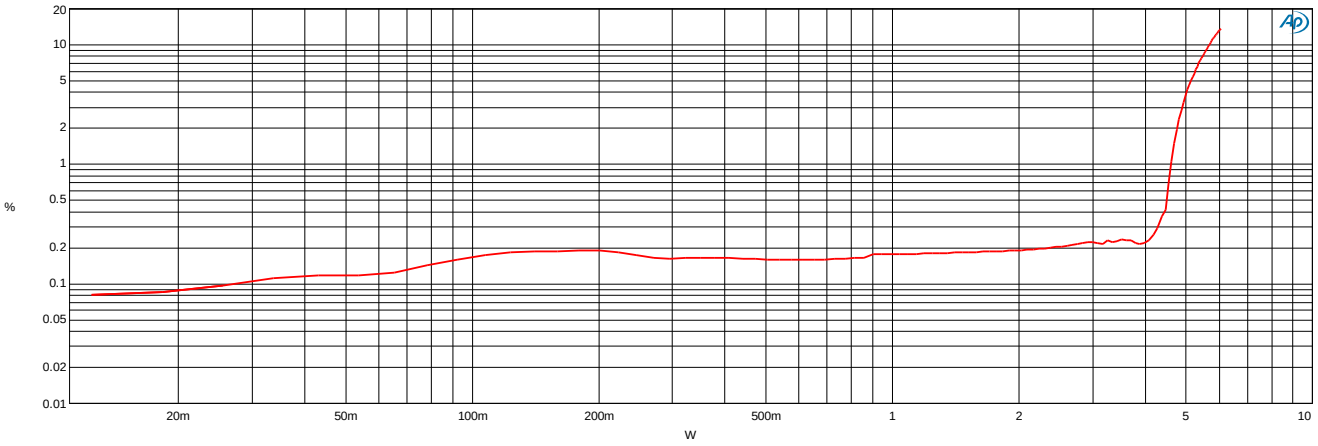

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	1kHz 3R LOAD

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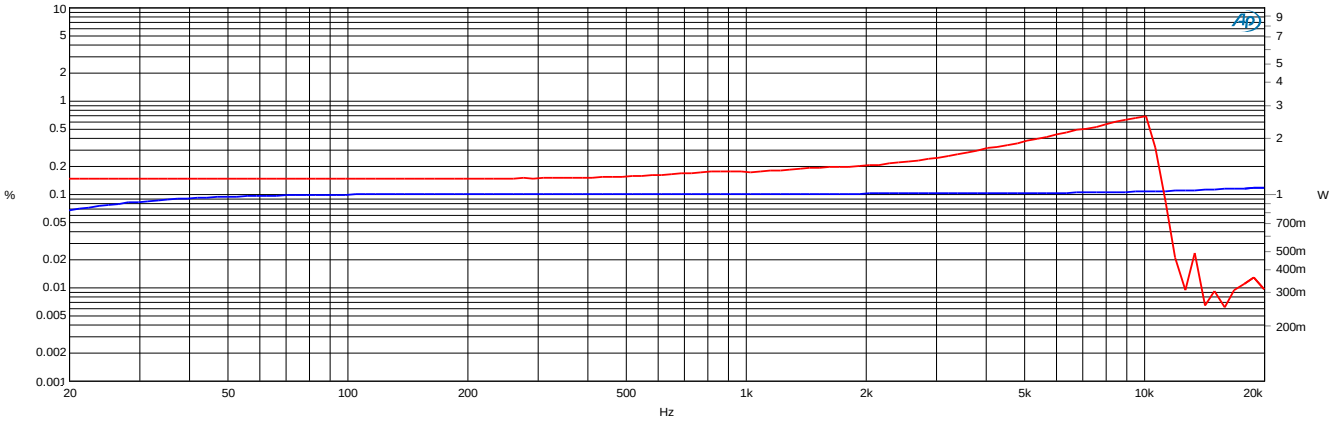
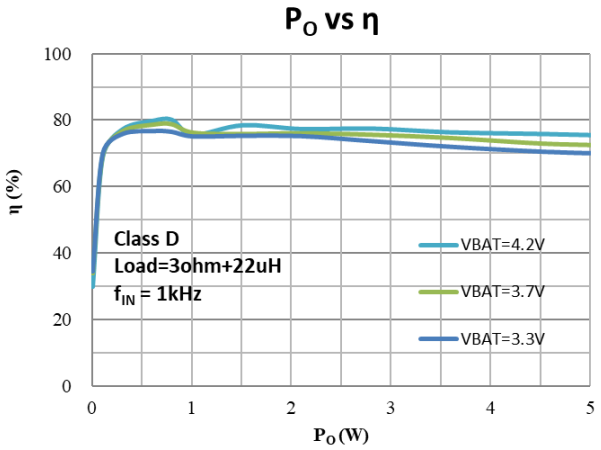
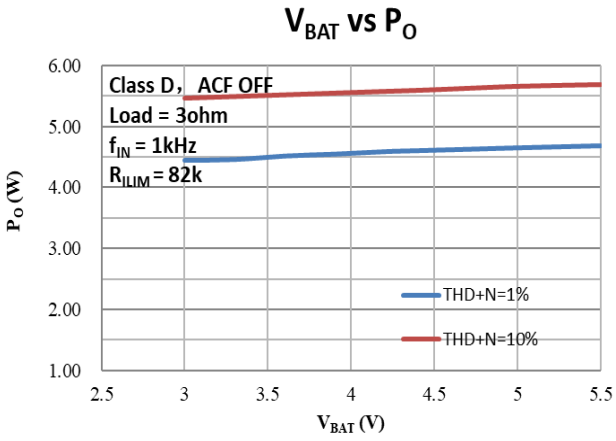


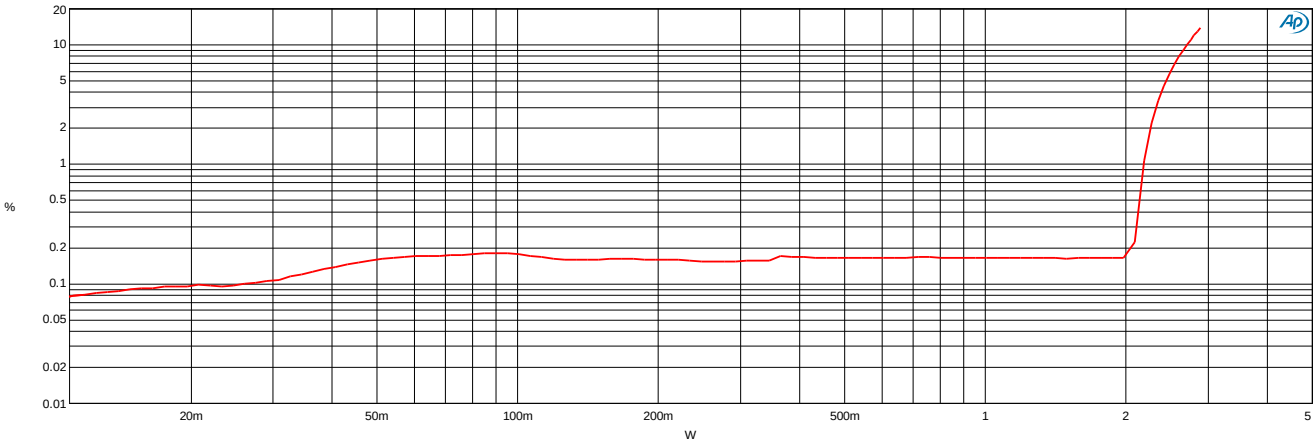
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	1W 3R THD
1	2	Blue	Solid	2	Analyzer.Level A	Right	1W 3R Po

f vs THD+N (Po = 1.0W)

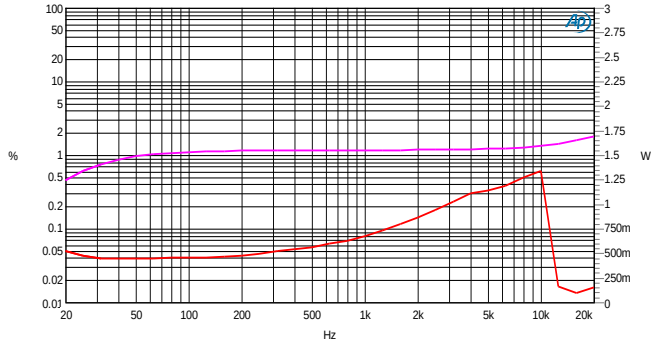




Class D, VBAT = 3.7V, f_{IN} = 1kHz, R_{IN} = 0R, C_{IN} = 1uF, R_{ILIM} = 200k, ACF off, Load = 8ohm, unless otherwise specified.
Audio Precision 03/25/21 10:28:48

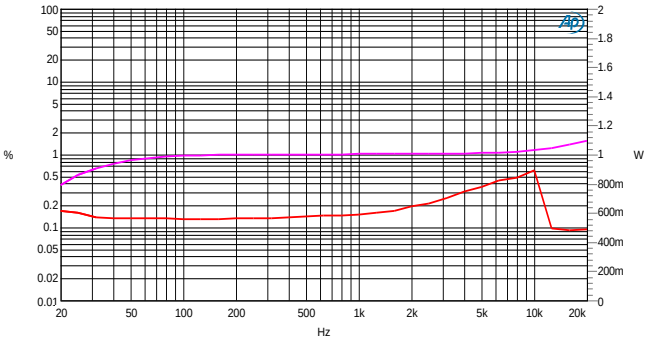


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	1kHz 8R LOAD



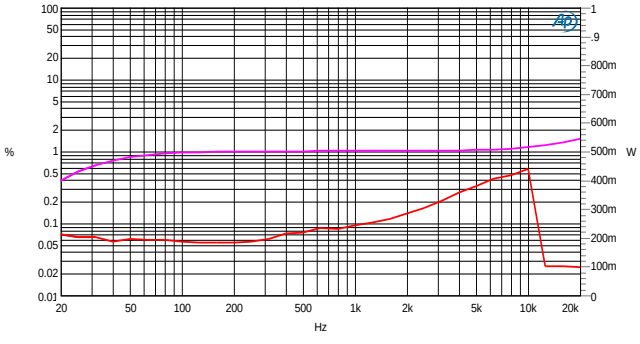
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	3.3V, 8ohm, 1.5W
1	2	Magenta	Solid	2	Analyzer.Level A	Right	3.3V, 8ohm, 1.5W

f vs THD+N _FR.ats2



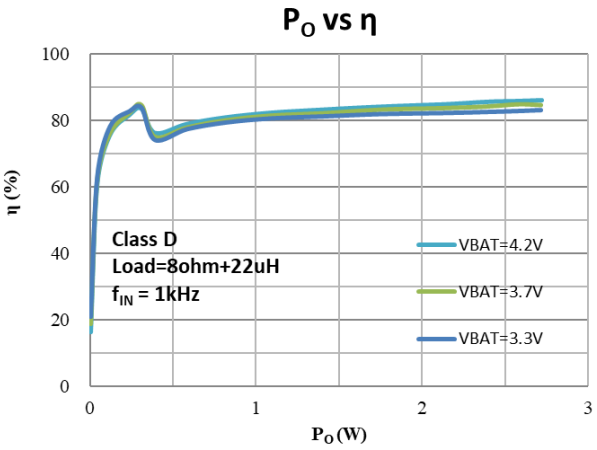
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	3.3V, 8ohm, 1W
1	2	Magenta	Solid	2	Analyzer.Level A	Right	3.3V, 8ohm, 1W

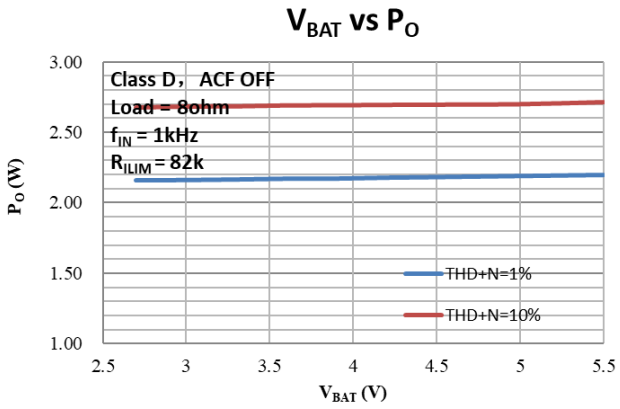
f vs THD+N _FR.ats2



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	3.3V, 8ohm, 0.5W
1	2	Magenta	Solid	2	Analyzer.Level A	Right	3.3V, 8ohm, 0.5W

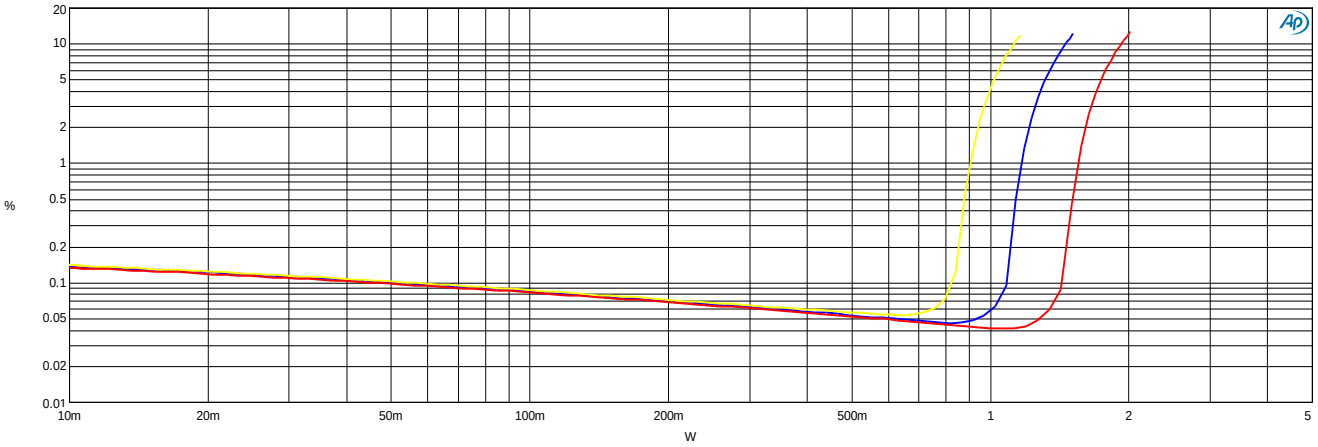
f vs THD+N _FR.ats2




V_{BAT} vs P_O
Class D, ACF OFF
Load = 8ohm
f_{IN} = 1kHz
R_{ILIM} = 82k
THD+N=1%
THD+N=10%
P_O (W)
V_{BAT} (V)
3.00
2.50
2.00
1.50
1.00
2.5
3
3.5
4
4.5
5
5.5

Class AB, VBAT = 3.7V, f_{IN} = 1kHz, R_{IN} = 0R, C_{IN} = 1uF, Load = 4ohm, unless otherwise specified.

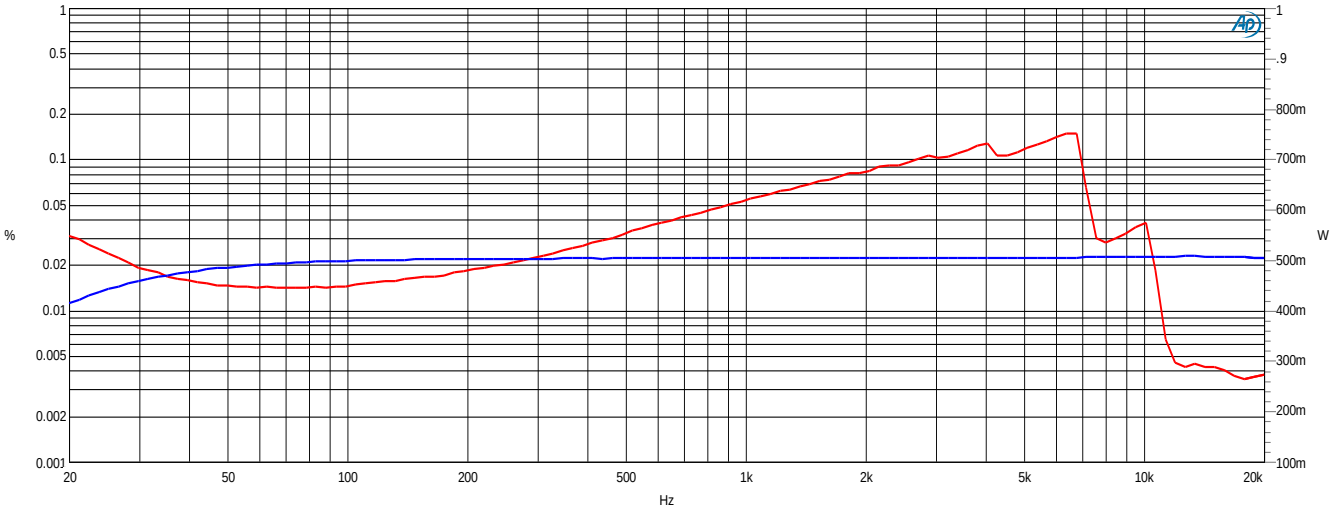
Audio Precision 03/13/21 21:23:44



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	VBAT=4.2V
2	1	Blue	Solid	2	Analyzer.THD+N Ratio A	Left	VBAT=3.7V
3	1	Yellow	Solid	2	Analyzer.THD+N Ratio A	Left	VBAT=3.3V

Po vs THD+N

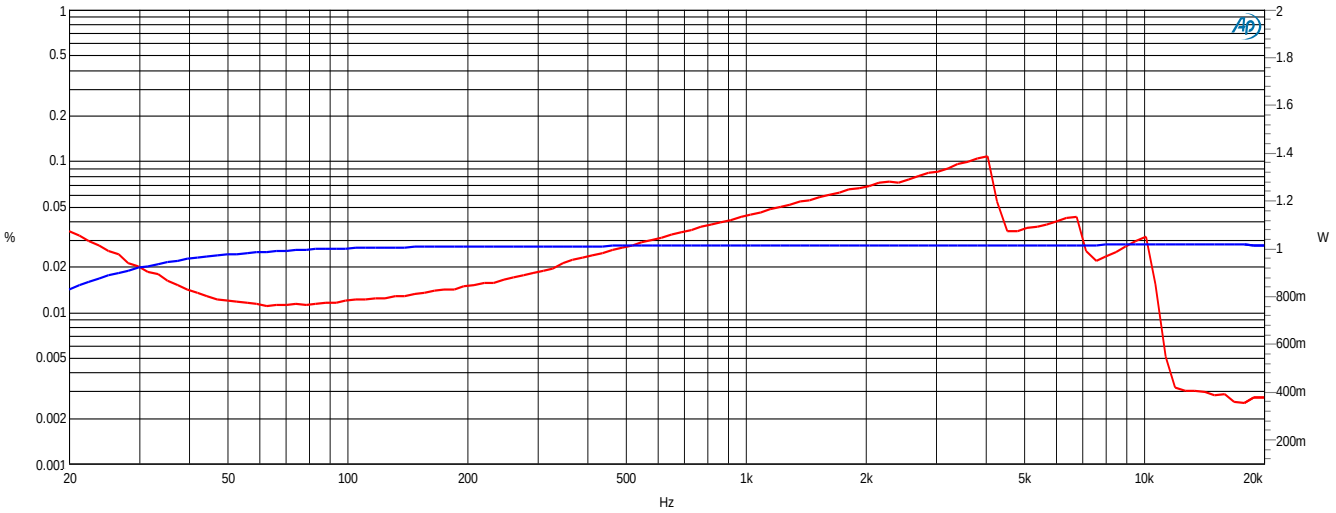
Audio Precision 03/13/21 21:11:43



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	
1	2	Blue	Solid	2	Analyzer.Level A	Right	

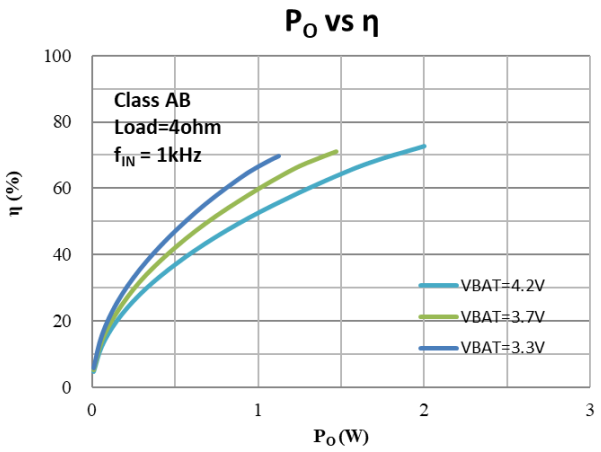
f vs THD+N (Po = 0.5W)

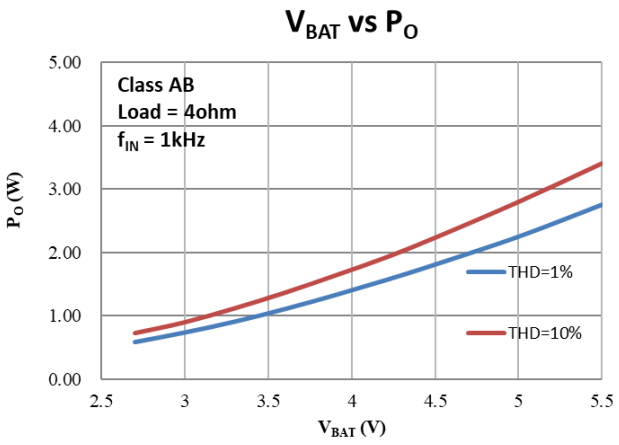
Audio Precision 03/13/21 21:14:49



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.THD+N Ratio A	Left	
1	2	Blue	Solid	2	Analyzer.Level A	Right	

f vs THD+N (Po = 1.0W)





■ APPLICATION INFORMATION

1 Adaptive Boost Converter

The HT8513, HT8515 consists of an adaptive boost converter and an audio amplifier. The boost converter takes the supply voltage, VBAT, and increases it to a higher output voltage to drives the audio amplifier. This improves loudness over non-boosted solutions. An external inductor should be added for the boost converter.

The boost converter is adaptive and activates automatically depending on the output audio signal amplitude. When the output audio signal exceeds a preset voltage threshold (Boost on Threshold Voltage V_{B_TH}), the boost converter is enabled, and the output voltage of boost converter is the preset voltage. When the audio output voltage is lower than the threshold voltage, the boost deactivates automatically.

To avoid an accidental large peak current, an internal cycle-by-cycle current limit is adopted. The low-side switch is turned off immediately as soon as the switch current touches the limit (ILIM). The peak switch current limit (Ipeak) can be set by a resistor (R_{ILIM}) at the ILIM pin to ground, see as the following table. The I_{SAT} of the inductor for the boost converter should be larger than the peak switch current.

HT8513, HT8515 包含一个自适应升压和一个功放。其中自适应升压电路将输入的电池电压 VBAT 升压至更高的电压，以提供给功放。该方法可提升功放的输出功率。该自适应升压需要外部放置电感。

HT8513, HT8515 集成的升压模块具有自适应多段升压功能，即只有当输出信号大于升压阈值 V_{B_TH} 时，HT8513, HT8515 才会进入对应的升压模式，该功能能增加系统整体效率，在播放音乐时大大提高锂电池续航时间。

在 ILIM 脚外接电阻(R_{ILIM})并联一个电容(C_{ILIM})到地，可设置升压的输入最大峰值电流，如下表。升压电感的饱和电流应大于 Ipeak。

Table 1 Component Selection for typical peak switch current

R_{ILIM}	Ipeak
82kΩ	4.5A
100kΩ	3.8A
110kΩ	3.5A
120kΩ	3.3A
130kΩ	3.0A
150kΩ	2.6A
180kΩ	2.3A
200kΩ	2.1A

1.1 BOOST Converter Input and Output Capacitor C_{VBAT}, C_{POUT}

For basic usage with 4ohm or larger load, at least 1uF//10uF (paralleled) is highly recommended to be placed in input terminal as closely to the pin as possible, and at least 1uF//10uF//10uF (paralleled) is highly recommended to be placed in output terminal as closely to the pin as possible.

对于 4ohm 负载或更大阻抗的负载等常规应用，升压输入端至少需要 1uF//10uF 并联，升压输出端至少需要 1uF//10uF//10uF 并联，并尽可能靠近相应端口。

1.2 Inductor selection

Inductor current rating is determined by the requirements of the load. The inductance is determined by two factors: the minimum value required for stability and the maximum ripple current permitted in the application. L ≥ 1uH, DCR < 0.15ohm, I_{SAT} ≥ Ipeak is recommended for general application circuit..

电感的选择主要应考虑电感值、DCR 和饱和电流。推荐 L ≥ 1uH, DCR < 0.15ohm, ISAT ≥ Ipeak 。

1.3 EMI Consideration

Adding an RC snubber across the SW pin and the power ground can help reduce the radiation EMI levels. The RC snubber should be placed as close as possible to the switching node and the power ground.

SW 端加 RC 到地，可有效减少辐射干扰，RC 电路需尽可能靠近 SW 和 GND.

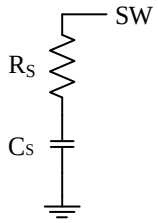


Figure 1 Placement of RC Snubber

The following table shows typical applicaions with different loads for a quick start of design.

下表提供了不同负载应用的典型参数可供参考。

Table 2 Typical Boost Converter Configurations for Different Applications

Typical Application	RILIM	IPEAK	L	D	CBAT	CPOUT
2ohm Load	82k	4.5A	4.7uH	SS32	1uF//10uF//100uF	1uF//10uF//470uF
3ohm Load	82k	4.5A	4.7uH	SS32	1uF//10uF//100uF	1uF//10uF//470uF
4ohm Load, Po>3W, THD+N>1%	82k~100k	3.5-3.8A	1uH~4.7uH	SS32	1uF//10uF	1uF//10uF//220uF
4ohm Load, Po≤3W, THD+N<1%	110k	3.5A	1uH	NC	1uF//10uF	1uF//10uF//10uF
8ohm Load	200k	2.2A	1uH	NC	1uF//10uF	1uF//10uF

2 Analog Signal Input Configuration

HT8513, HT8515 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 . And the high pass cut-off frequency of input signal can be calculated by $Av \approx \frac{R_F}{\text{External } R_{IN}+\text{Internal } R_{IN}}$, R_F = 456k, R_{IN} = 19k in Class D mode. R_F = 227k, R_{IN} = 19k In Class AB mode. And the high pass cut-off frequency of input signal can be calculated by $f_c = \frac{1}{2\pi(External\ R_{IN}+Internal\ R_{IN})\times C_{IN}}$.

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.

HT8513, HT8515 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 $Av \approx \frac{R_F}{\text{External } R_{IN}+\text{Internal } R_{IN}}$，D 类模式下，$R_F$ = 456k，R_{IN} = 19k，AB 类模式下 R_F = 227k，R_{IN} = 19k。高通滤波器截止频率为 $f_c = \frac{1}{2\pi(External\ R_{IN}+Internal\ R_{IN})\times C_{IN}}$。

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。

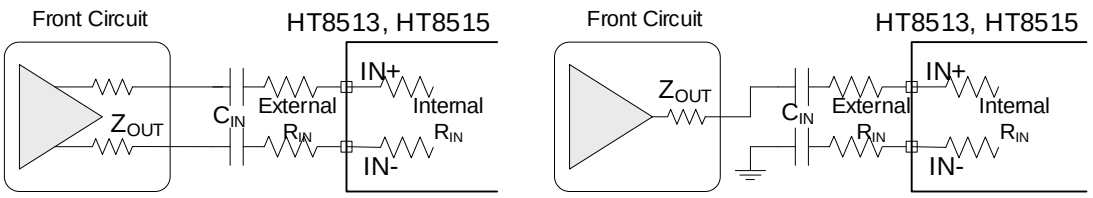


Figure 2 (1) Differential Input; (2) Single-ended Input

3 Output Configuration

As mentioned, HT8513, HT8515 can directly drive speakers without any other components. But there are exceptions. Once HT8513, HT8515 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 Device Functional Modes

HT8513, HT8515 can work in different modes by setting the CTRL terminal, shown as follow.

HT8513, HT8515 在 CTRL 端输入不同电压值，能实现 4 种工作模式，详见下表。

Table 3 CTRL Terminal Configuration

Mode	CTRL Voltage		
	MIN	TYP	MAX
Class D mode in ACF-Off with adaptive Boost Converter enabled	2.5V	3.3V	VBAT
Class D mode in ACF-on with adaptive Boost Converter enabled	1.5V	1.8V	2.2V
Class AB mode in ACF-Off with adaptive Boost Converter disabled	1.0V	1.1V	1.2V
SD(Shutdown) Mode	0V	0V	0.3V

4.1 Anti-Clipping Function (ACF)

In ACF on mode, HT8513, HT8515 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 HT8513, HT8515 also follows to the clips of the output waveform due to the decrease in the power-supply voltage.

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.

在 ACF on 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，HT8513, HT8515 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，HT8513, HT8515 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。

ACF 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。HT8513, HT8515 的最大衰减增益为 16dB。

Table 4 Attack time and Release time

ACF mode	Attack time	Release time
ACF on	50ms	180ms

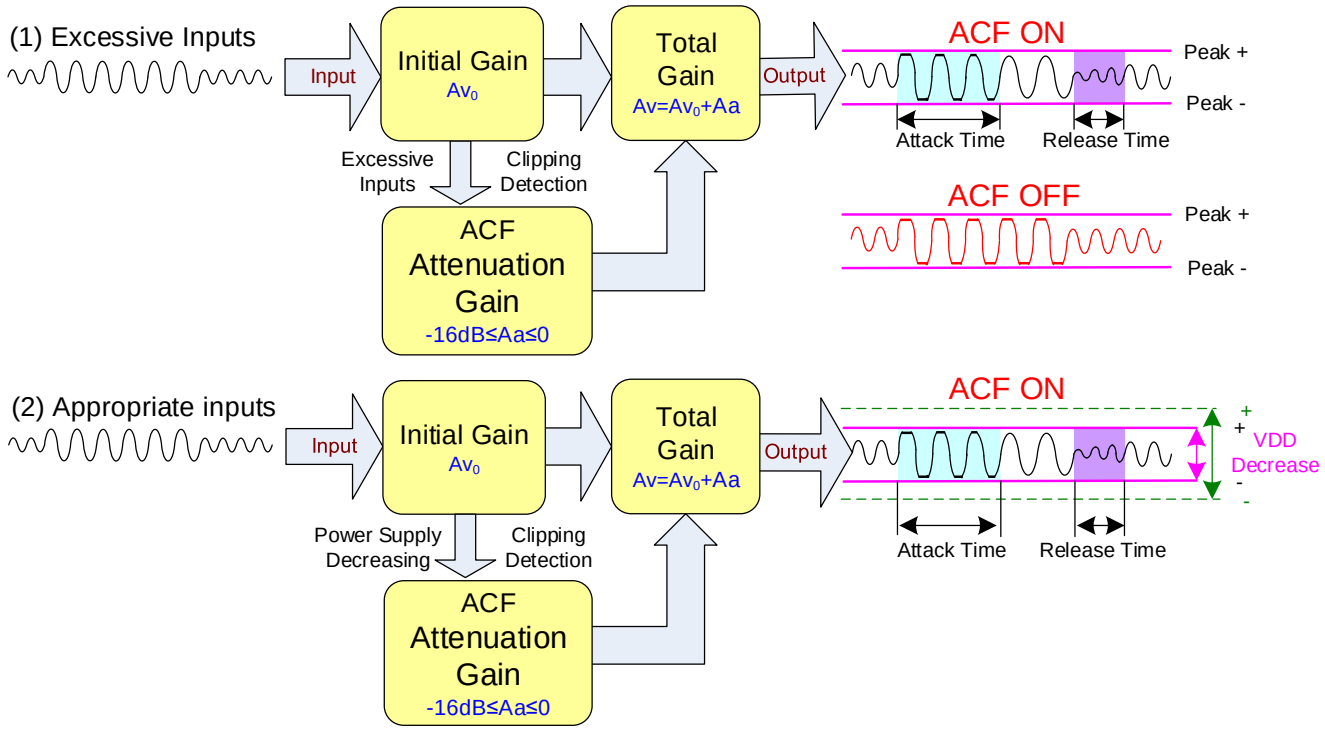


Table 5 the ACF Function Operation Outline

4.2 SD Mode

In shutdown mode, HT8513, HT8515 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）。

5 Protection Function

HT8513, HT8515 has the protection functions such as Over-Current Protection function and Thermal Protection function.

HT8513, HT8515 具有以下几种保护功能：输出端过流保护、片内过温保护、电源欠压异常保护。

(1) Over-current Protection function

When a short circuit occurs between one output terminal and Ground, PVDD, 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.

（1）过流保护

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。

(2) Thermal Protection function

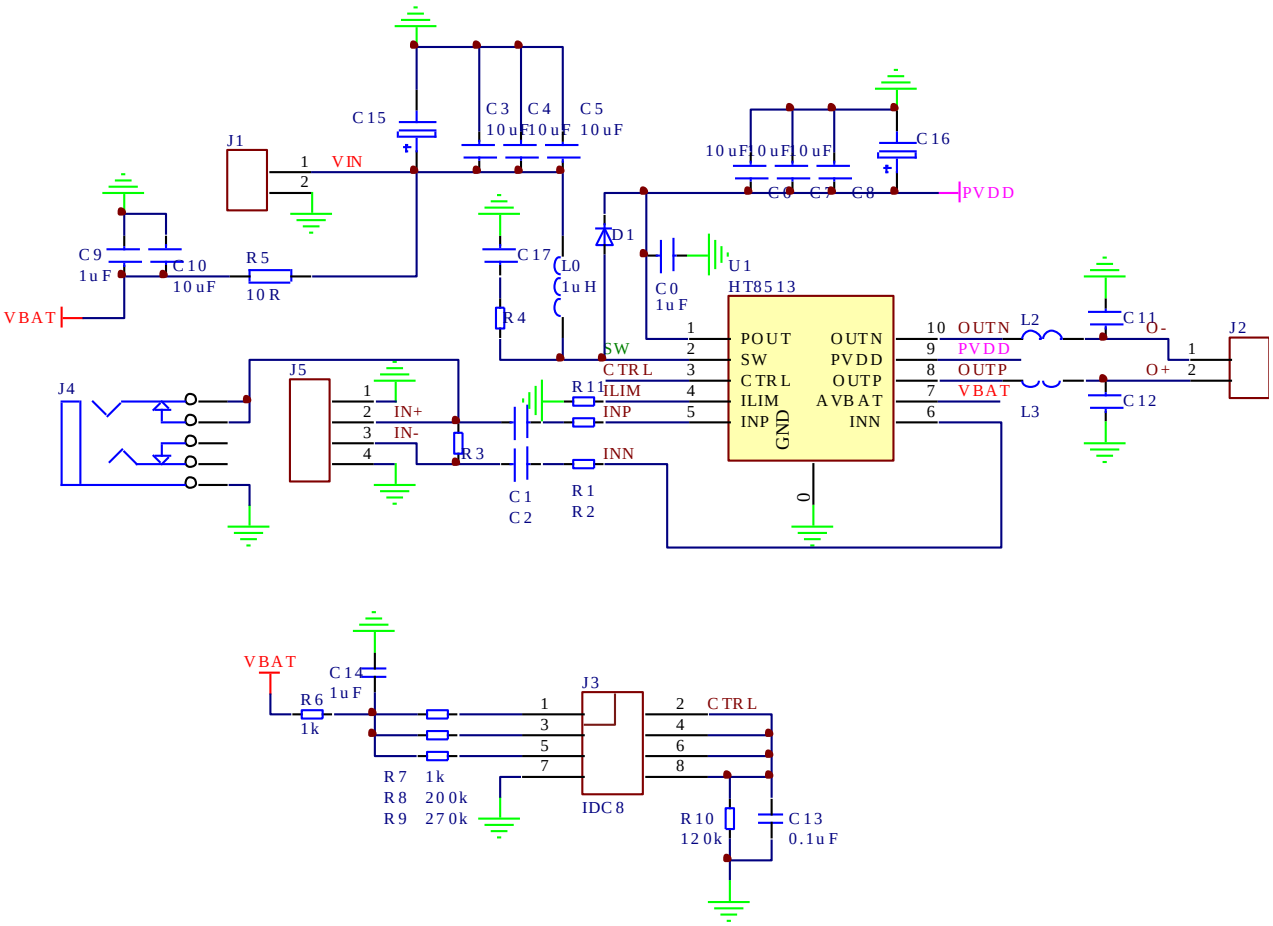
When excessive high temperature of HT8513, HT8515 (150℃) is detected, the thermal protection mode starts up. In the thermal protection mode, the differential output terminal becomes Weak Low state (a state grounded through high impedance).

（2）过温保护

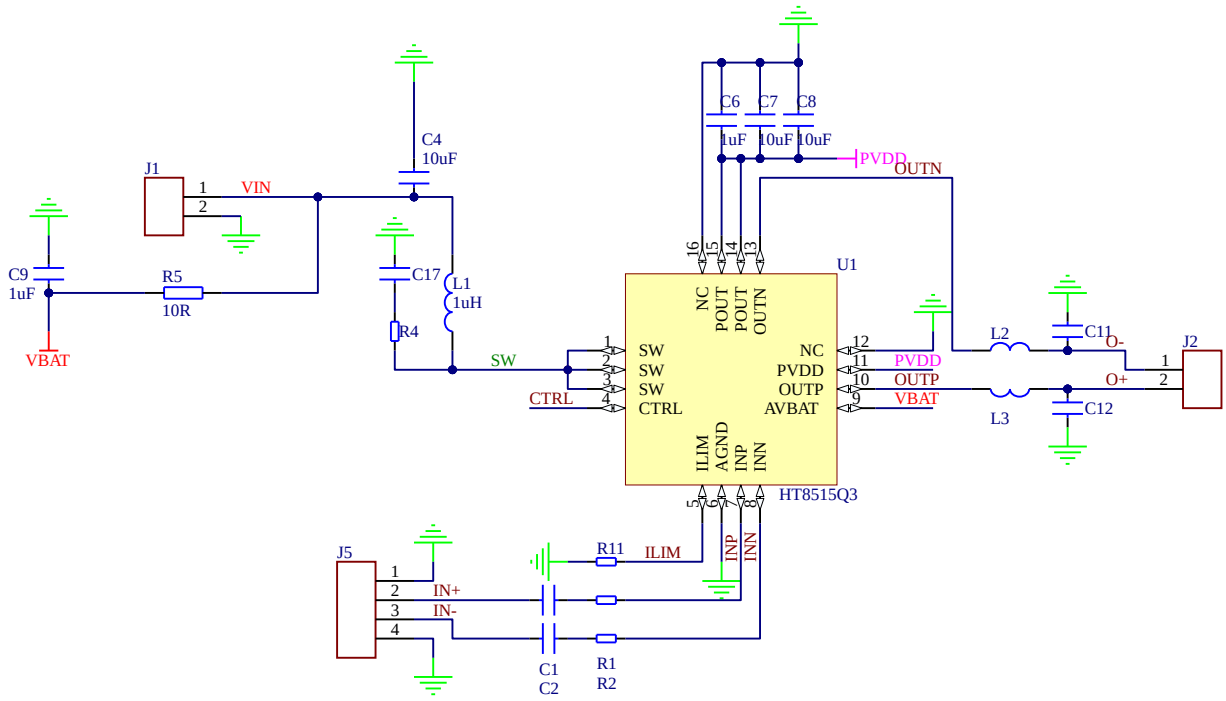
当检测到芯片内温度超过 150℃时，过温保护启动，正负输出端切换至弱低电平状态（内部通过高阻接地），防止芯片被热击穿损坏。

6 Typical Circuit Diagram

SPE (SSOP10L-PP)

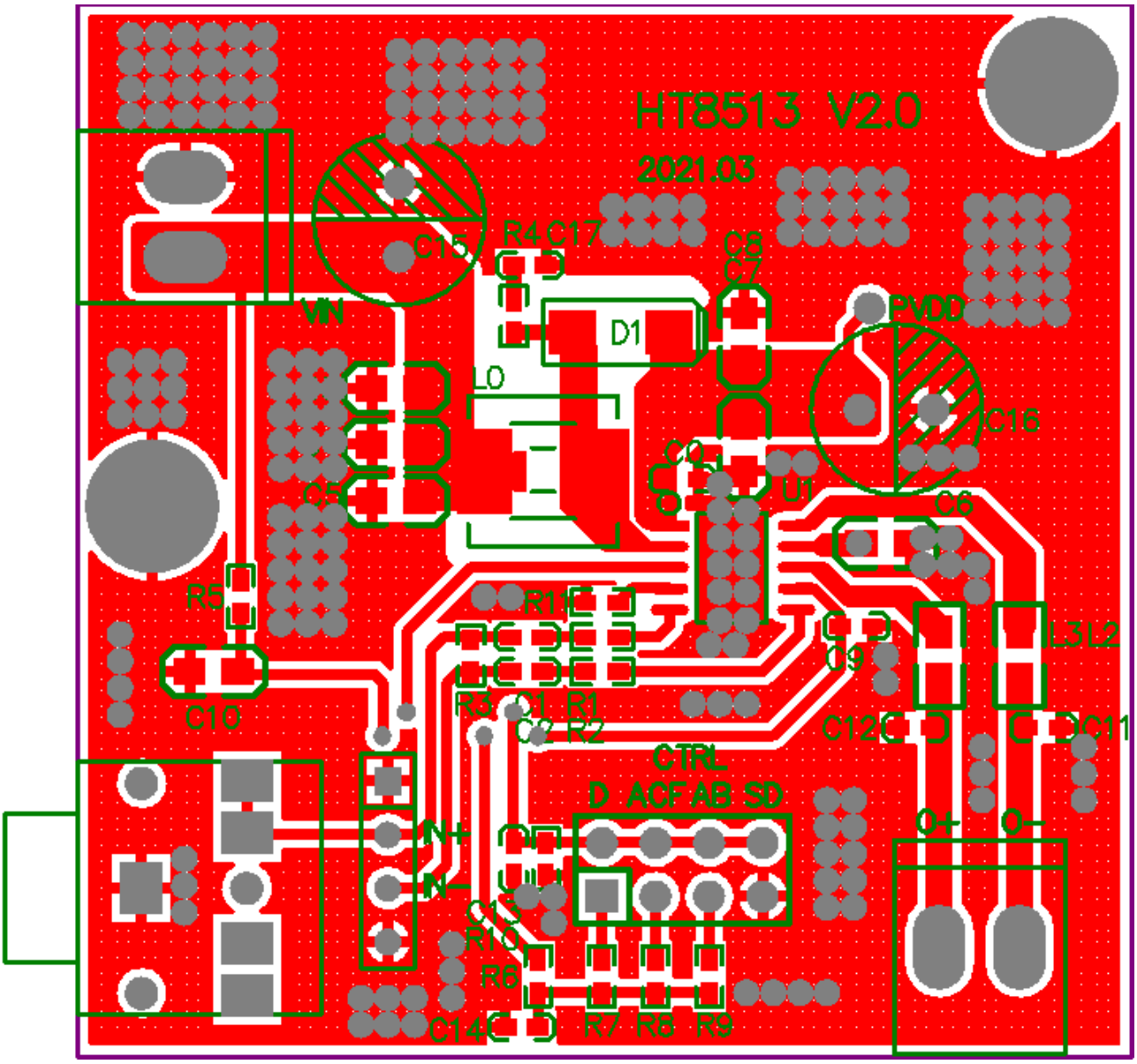


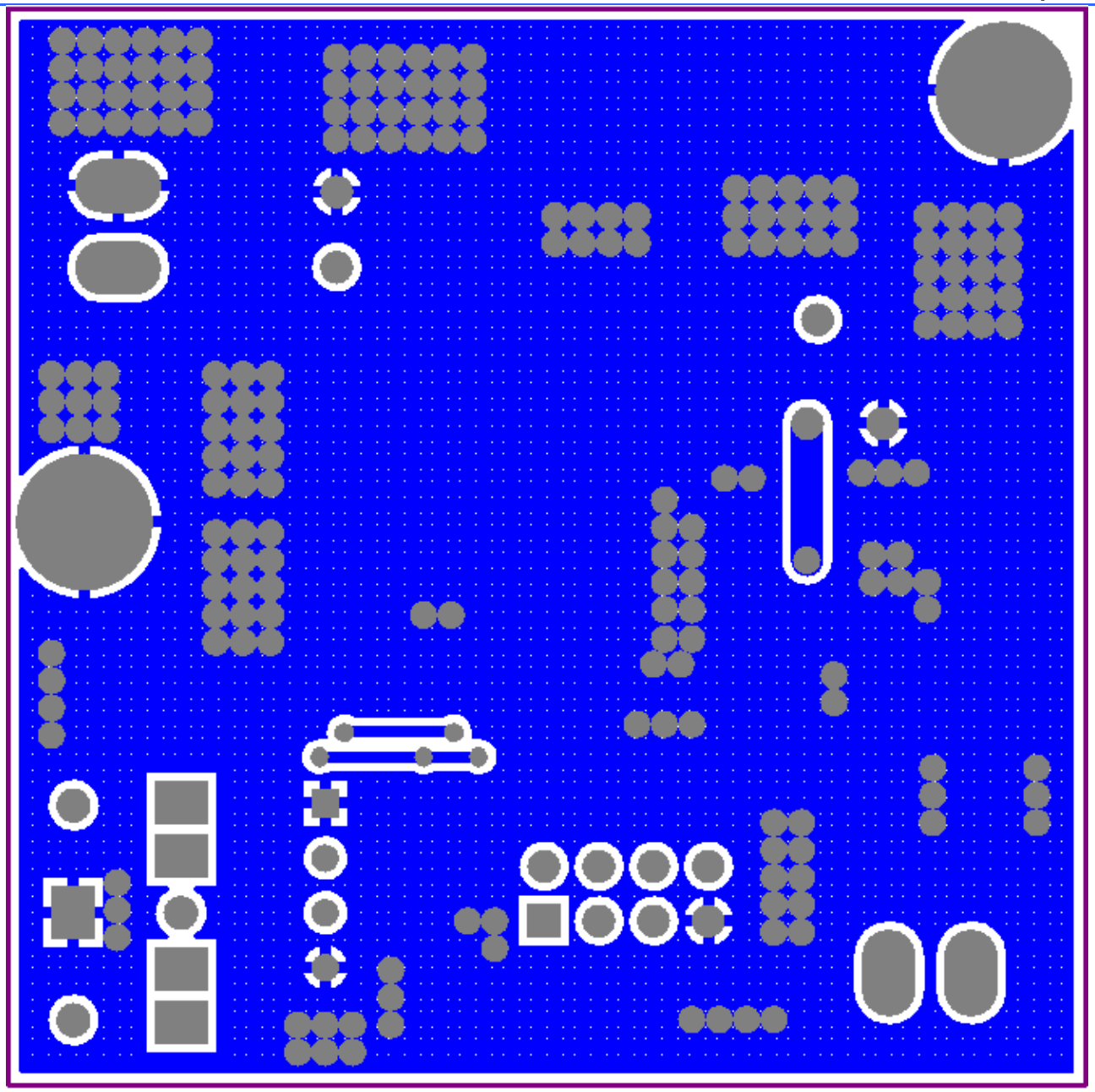
SQE (QFN3×3-16L)



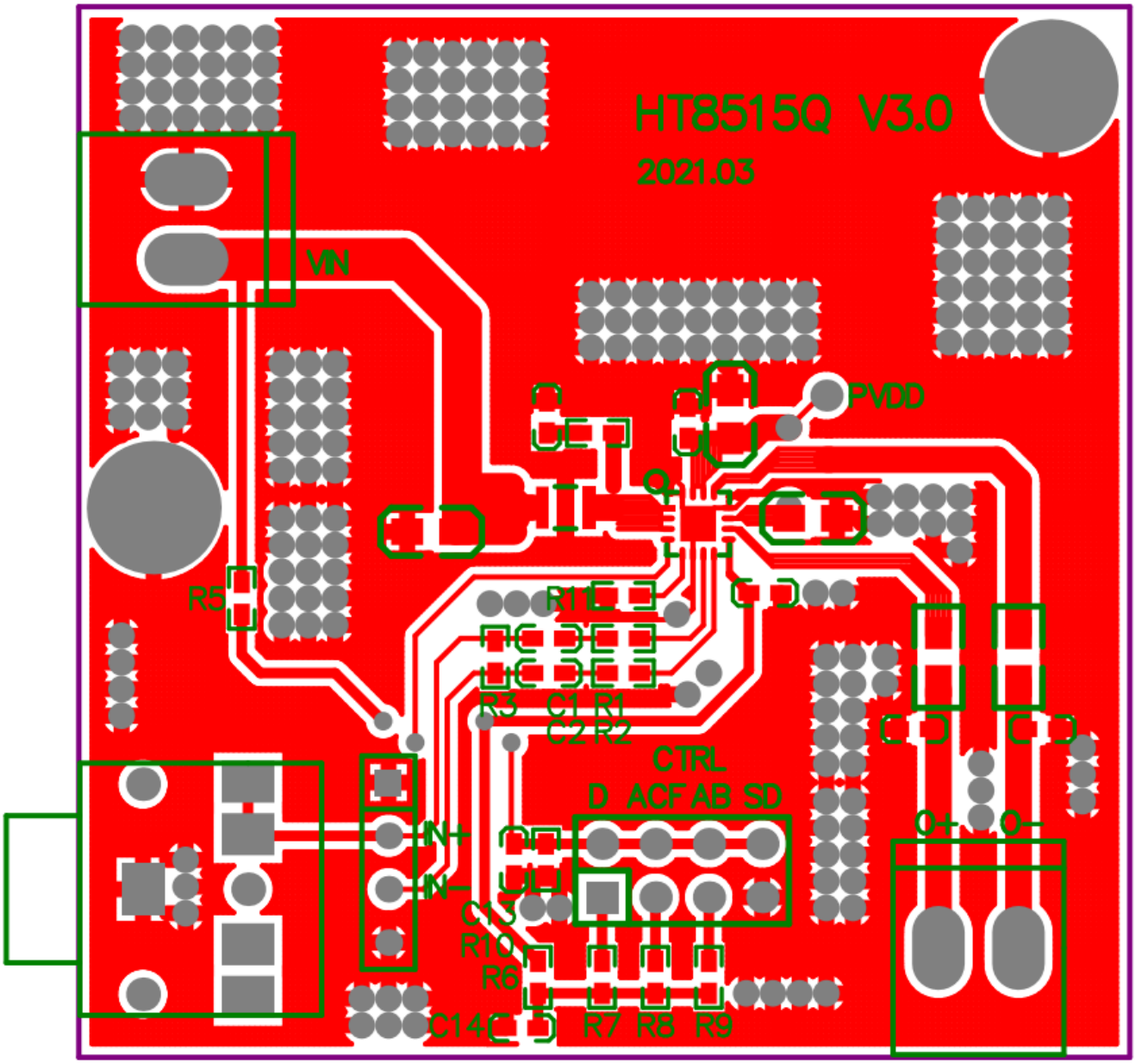
7 PCB Layout

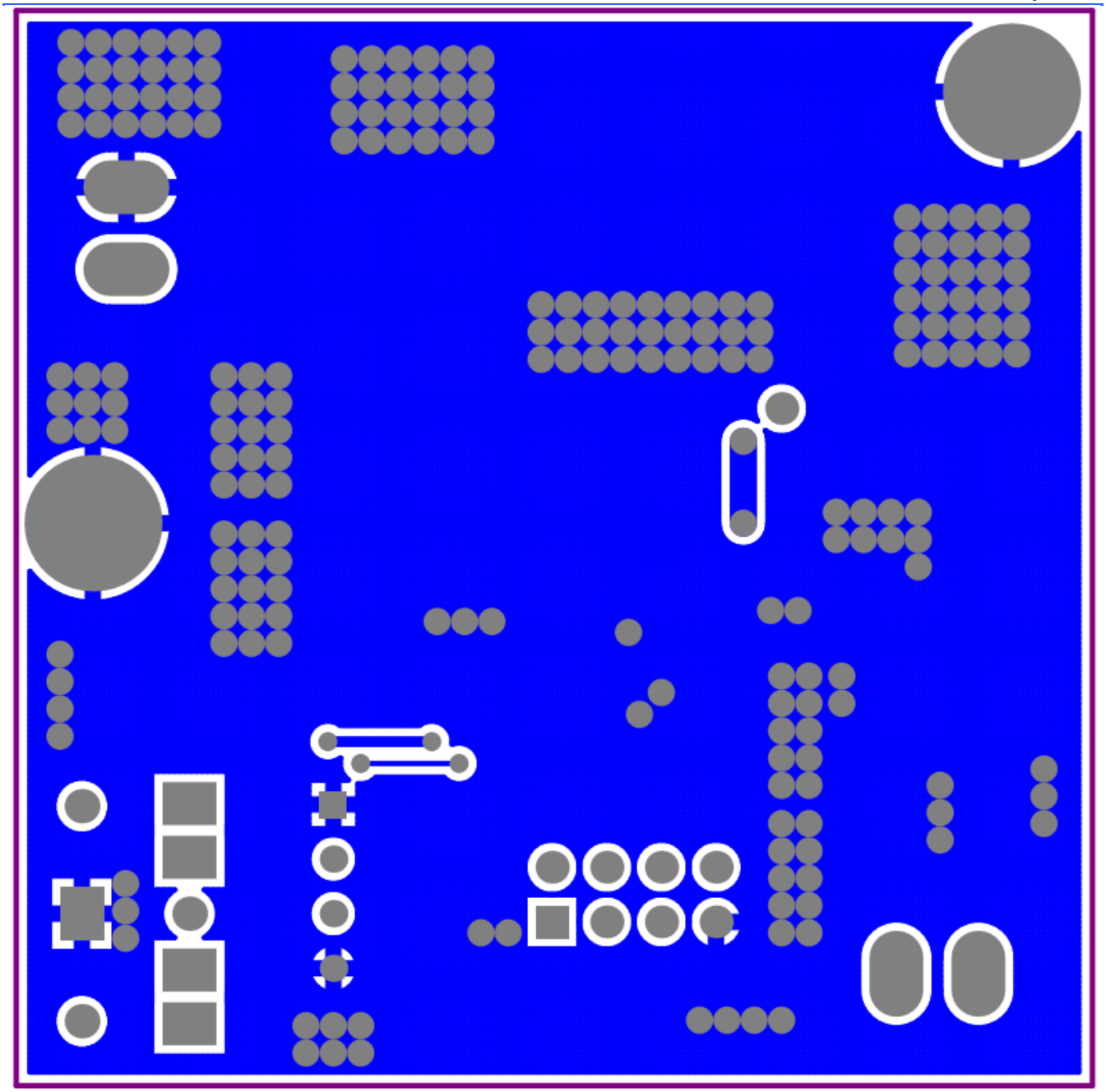
SPE (SSOP10L-PP)





SQE (QFN3×3-16L)

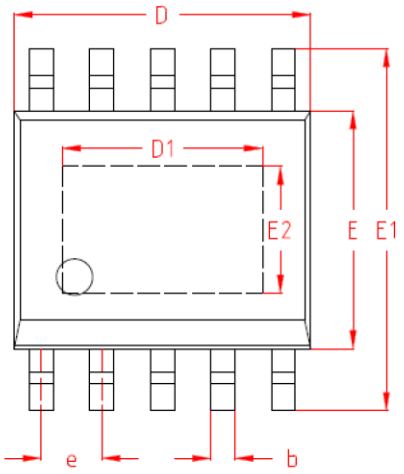




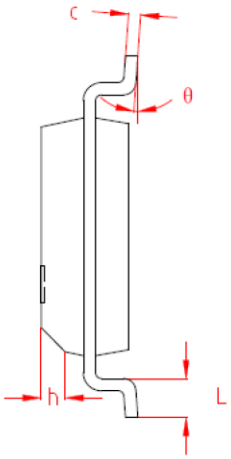
■ PACKAGE OUTLINE

SPE (SSOP10L-PP)

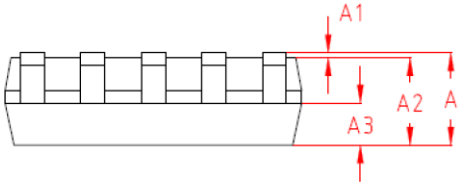
TOP VIEW
正视图



SIDE VIEW
侧视图

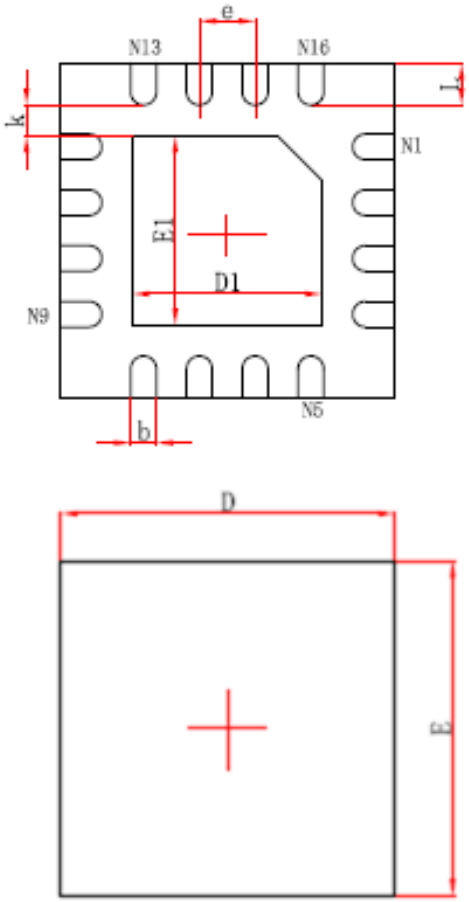


SIDE VIEW
侧视图



机械尺寸/mm Dimensions			
字符 SYMBOL	最小值 MIN	典型值 NOMINAL	最大值 MAX
A	1.50	1.60	1.70
A1	0.04	–	0.12
A2	1.35	1.45	1.55
A3	0.65	0.70	0.75
b	0.35	–	0.50
c	0.19	–	0.25
D	4.80	4.90	5.00
D1	3.20	3.30	3.40
E	3.80	3.90	4.00
E1	5.80	6.00	6.20
E2	2.00	2.10	2.20
e	1.00 BSC		
h	0.30	–	0.50
L	0.50	–	0.80
θ	0°	–	8°

SQE (QFN3×3-16L)



Symbol	Dimension in Millimeters (mm)	
	Min.	Max.
A	0.700	0.900
A1	0.000	0.050
A3	0.203(REF)	
D	2.900	3.100
E	2.900	3.100
D1	1.600	1.800
E1	1.600	1.800
k	0.200MIN	
b	0.180	0.300
e	0.500TYP	
L	0.300	0.500

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嘉兴禾润电子科技有限公司
Jiaxing Heroic Electronic Technology Co., Ltd.
地址: 浙江省嘉兴市凌公塘路3339号JRC大厦A座三层
Add: A 3rd floor, JRC Building, No. 3339, LingGongTang Road, Jiaxing, Zhejiang Province
Sales: 0573-82585539, sales@heroic.com.cn
Support: 0573-82586151, support@heroic.com.cn
Fax: 0573-82585078
Website: www.heroic.com.cn; wap.heroic.com.cn
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